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# Lower Lakes Vegetation Condition Monitoring - 2022-23

J.M. Nicol, K.A. Frahn, S.L. Gehrig, K.B. Marsland and L. Bucater

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Report to the Department for Environment and Water

Government of South Australia
Department of Primary Industries and Regions

Government of South Australia
Department for Environment and Water

Australian Government

MURRAY–DARLING BASIN AUTHORITY

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SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

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Cover Photo: *Typha domingensis, Phragmites australis* and *Schoenoplectus tabernaemontani* in The Lower Finniss River near Clayton Bay (J.M. Nicol).



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## EXECUTIVE SUMMARY

The Lower Lakes, Coorong and Murray Mouth region is one of six icon sites under "The Living Murray" (TLM) program and is an indicator site under the "Basin Plan". The Condition Monitoring Plan for the Lower Lakes, Coorong and Murray Mouth (LLCMM) Icon Site (Maunsell Australia Pty Ltd 2009) identified that existing monitoring programs would not adequately assess TLM target V3, *maintain or improve aquatic and littoral vegetation in the Lower Lakes*; therefore, a monitoring program that expanded and built upon existing programs was established in spring 2008. A review undertaken by Robinson (2015) suggested that the initial aquatic and littoral vegetation target for the Lower Lakes could be improved by developing a series of quantitative targets for the site nested under the original target (now included as an objective and reported on using the same index as the Basin Plan environmental outcome reporting (Matter 8). The updated quantitative targets and methodologies are outlined in the Condition Monitoring Plan (Revised) 2017 for the Lower Lakes, Coorong and Murray Mouth Icon Site (Department for Environment, Water and Natural Resources 2017). To develop the quantitative targets the Lower Lakes were divided into five different habitats (Lake Alexandrina, Lake Albert, Goolwa Channel, permanent wetlands and seasonal wetlands), with each habitat comprising zones based on elevation. Targets were developed for species and functional groups in each zone and habitat (see Table 1 to Table 5 for detailed description of targets) and the progress of target achievement through time was assessed. This report presents the findings of the first 14 years of a monitoring program established to evaluate TLM Target Objective V3 from spring 2008 to autumn 2023.

Vegetation surveys were conducted at selected wetlands and lakeshore sites across lakes Alexandrina and Albert, Goolwa Channel, lower Finniss River, lower Currency Creek and the mouths of the Angas and Bremer Rivers. Sites established in spring 2008 and 2009 (Goolwa Channel monitoring sites) were re-surveyed. At each site, transects were established perpendicular to the shoreline and three, 1 x 3 m quadrats, separated by one metre were positioned at regular elevation intervals (defined by plant community) for wetlands or elevations (+0.8, +0.6, +0.4, +0.2, 0 and -0.5 m AHD) for lakeshores. The cover and abundance of each species present in quadrats were estimated using a modified Braun-Blanquet (1932) cover abundance score. Vegetation surveys were undertaken in spring (October 2008, 2009, November 2010, October 2011, 2012, 2013, 2015, in temporary wetlands in December 2016, all sites in November 2017, 2018, 2019, December 2020, 2021, and 2022) and autumn (March 2009 to 2017, April 2018, May 2021, April 2022 and May 2023).

The first two years of the monitoring program coincided with a period of record low water levels in the Lower Lakes. During this period, significant engineering interventions (i.e., construction of the Clayton Regulator and Narrung Bund and pumping of water for the environment into Narrung Wetland) also influenced plant communities and were assessed as part of the monitoring program. In August 2010, water levels in Lake Alexandrina rapidly rose to normal pool level and in September 2010, the Clayton Regulator and Narrung Bund were breached, reconnecting these areas with Lake Alexandrina. Water levels between +1.29 and +0.4 m AHD, and connectivity throughout the system, continued from 2010 throughout the remainder of the monitoring program.

Over the 14 years of condition monitoring (spring 2008 to autumn 2023), a total of 167 taxa (including 77 exotics, two weeds of national significance, five pest plants proclaimed for South Australia and one species listed as rare in South Australia) were recorded throughout the Lower Lakes (Appendix 1). Lake Alexandrina was the most species rich of the habitats with 121 taxa (including 56 exotics) recorded between spring 2008 and autumn 2023, followed by permanent wetlands (99 taxa, including 36 exotics), then temporary wetlands (96 taxa, including 43 exotics), Goolwa Channel (80 taxa, including 30 exotics) and Lake Albert the least species rich with 61 taxa (including 32 exotics).

Changes through time of the plant community in each habitat indicated a shift in floristic composition during the condition monitoring program (nMDS ordination 2008–2023). Furthermore, for each habitat (except seasonal wetlands), there was greater change in the plant community between the early surveys that reduced through time resulting in less change in vegetation between the more recent surveys. The large changes in vegetation between the early surveys were due to the colonisation of terrestrial taxa between 2008 and 2010 and subsequent extirpation and colonisation of submergent, emergent and amphibious taxa after spring 2010. The reduced rate of change between the recent surveys suggests that a stable plant community may be developing. However, sustained small changes over time may result in a significant shift in the plant community in the future. In the seasonal wetlands there were strong seasonal patterns in the plant community after spring 2010 due to seasonal inundation. Submergent species were abundant in spring, when seasonal wetlands were inundated but absent in autumn, replaced by amphibious and emergent taxa.

Achievement of the targets varied among habitats through time; generally, very few targets were achieved in all habitats when water levels were low but shortly after water levels were reinstated the number of targets achieved generally increased. After spring 2010, patterns in achieved targets were variable. In lakes Alexandrina and Albert, the number of targets achieved remained stable until the last eight years when the abundance of several desirable taxa increased such that additional targets were achieved and there was a general increasing trend in habitat condition score. In Goolwa Channel, the number of targets achieved increased until spring 2011, then decreased due to the increase in abundance of *Typha domingensis* and *Phragmites australis* and a decrease in submergent species. There was an increase in submergents in the deep-water zone in autumn 2018 resulting in the target being met for this zone and an increase in the habitat condition score; however, this target was not met in spring 2018 and the habitat condition score decreased but the deep water submergents and other targets were met in subsequent surveys resulting in an increase in habitat condition score. In permanent wetlands, the number of targets achieved has remained constant from spring 2010 to spring 2019 after which there was an increase due to several targets being achieved. In temporary wetlands the condition score peaked in autumn 2011, although it was highly variable with two of the three most recent surveys having the second highest achieved habitat condition score. The Whole of Icon Site Score (WOISS) for assessing the condition of the Lower Lakes has remained relatively stable from autumn 2011 to spring 2018 after which there was an increasing trend. The vegetation of the Lower Lakes has been in good condition using the Matter 8 condition scale for the six most recent surveys with condition scores of 0.62 and 0.67 for the two most recent surveys. Progress of most targets in all habitats (yet to be achieved) shows they are tracking towards being achieved in the future. Therefore, under current hydrological conditions it is likely that the number of targets achieved in the future will further increase (and habitat and WOISS condition will improve) resulting in the TLM Objective V3: *maintain or improve aquatic and littoral vegetation in the Lower Lakes* continuing to be achieved.

**Keywords:** Lake Alexandrina, Lake Albert, Goolwa Channel, aquatic vegetation.

# 1. INTRODUCTION

## 1.1. Background

The Lower Lakes, Coorong and Murray Mouth region is one of six icon sites under "The Living Murray" (TLM) program and is as an indicator site under the "Basin Plan". The Condition Monitoring Plan for the Lower Lakes, Coorong and Murray Mouth Icon Site (herein referred to as the "icon site") outlined a series of 17 condition targets for the icon site (Maunsell Australia Pty Ltd 2009). This report includes results from the first 15 years of the understorey component of the condition monitoring program designed to evaluate TLM Target V3 (now referred to as objective V3): *maintain or improve aquatic and littoral vegetation in the Lower Lakes* (Marsland and Nicol 2009; Gehrig *et al.* 2010; 2011b; 2012; Frahn *et al.* 2013; 2014; Nicol *et al.* 2016a; 2017; 2019a; 2019b; 2020; 2021; 2023).

Marsland and Nicol (2006) identified that monitoring programs in existence in 2006 could not adequately assess TLM target V3; therefore, a monitoring program that expanded and built upon the existing programs was established in spring 2008 (Marsland and Nicol 2009). The understorey vegetation monitoring program, described in this report, uses the same methods and sites as the community wetland monitoring program established by the former River Murray Catchment Water Management Board but includes additional sites in lakeshore habitats (in lakes Alexandrina and Albert), the lower reaches of the Finniss River, Currency Creek and Goolwa Channel (herein referred to as Goolwa Channel) and wetlands that were not part of the original program (Marsland and Nicol 2009). In 2009, eight extra sites in Goolwa Channel were added to assess the impact of the Goolwa Channel Water Level Management Project (Gehrig and Nicol 2010a; Gehrig *et al.* 2011a), and data from this project were subsequently included in TLM Condition Monitoring Program (Gehrig *et al.* 2010; 2011b; 2012; Frahn *et al.* 2013; 2014; Nicol *et al.* 2016a; 2017; 2019a; 2019b; 2020; 2021; 2023).

The 2009 Condition Monitoring Plan for the Lower Lakes, Coorong and Murray Mouth (LLCMM) Icon Site proposed 'indicators for monitoring' that comprised individual taxa and discrete communities: *Melaleuca halmaturorum, Myriophyllum* spp. *Gahnia filum, Schoenoplectus* spp., *Typha domingensis, Phragmites australis* and samphire communities (Maunsell Australia Pty Ltd 2009). However, discussions concluded that the entire understorey aquatic and littoral vegetation assemblage would be monitored with a separate technique used for the dominant tree species *Melaleuca halmaturorum* (which was monitored in spring 2008, autumn 2014 and autumn 2022).

Monitoring aquatic and littoral understorey vegetation involves surveys in spring (high lake levels) and autumn (low lake levels) to determine the current condition, seasonal changes and medium- to long-term changes in floristic composition.

From 1996 to 2010, the Murray-Darling Basin experienced the most severe drought in recorded history (van Dijk *et al.* 2013). Below average stream flows coupled with upstream extraction and river regulation resulted in reduced inflows into South Australia (van Dijk *et al.* 2013), which between January 2007 and August 2010, were insufficient to maintain the pool level downstream of Lock and Weir number 1. Subsequently water levels in lakes Alexandrina and Albert dropped to unprecedented levels (<-0.75 m AHD), fringing wetlands became disconnected and desiccated and extensive areas of acid sulfate soils were exposed; particularly in Lake Albert and the lower reaches of the Finniss River and Currency Creek (Merry *et al.* 2003; Fitzpatrick *et al.* 2009a; 2009b; 2010; 2011).

Prior to 2007, fringing wetlands in the Lower Lakes region contained diverse communities of emergent, amphibious and submergent taxa (Renfrey *et al.* 1989; Holt *et al.* 2005; Nicol *et al.* 2006). For example, in 2004, *Ruppia polycarpa, Althenia* (formerly named *Lepilaena*) sp., *Nitella* sp. and *Myriophyllum* sp. were common in Narrung Wetland; *Myriophyllum salsugineum* and *Vallisneria australis* were common in Dunn's Lagoon; *Ruppia polycarpa, Ruppia tuberosa, Myriophyllum* sp. and *Potamogeton pectinatus* were common in Teringie Wetland and *Myriophyllum caput-medusae* was common in Shadows Lagoon and Boggy Creek (Holt *et al.* 2005). Furthermore, in 2005, *Ranunculus trichophyllus, Vallisneria australis* and *Myriophyllum caput-medusae* were common in Pelican Lagoon; *Ruppia polycarpa* was common in Point Sturt Wetland; *Ruppia tuberosa* and *Myriophyllum caput-medusae* were common in Poltalloch; *Ranunculus trichophyllus* and *Ruppia polycarpa* were common in Loveday Bay Wetland (Jenny's Lagoon) and *Myriophyllum caput-medusae, Myriophyllum salsugineum, Ruppia megacarpa, Ruppia tuberosa* and *Potamogeton pectinatus* were common in Hunters Creek (Nicol *et al.* 2006).

By spring 2008, submergent taxa had been extirpated (except for a small number of *Ruppia tuberosa* plants in Hunters Creek, in Lake Alexandrina near Raukkan and in Loveday Bay Wetland). The charophyte *Lamprothamnium macropogon* was also present in Loveday Bay Wetland. Amphibious taxa had declined in abundance and diversity, stands of emergent taxa were disconnected from remaining water and fringing habitats were dominated by terrestrial taxa and bare soil (Marsland and Nicol 2009). Furthermore, submergent taxa had not colonised the remaining open water areas (Marsland and Nicol 2009).

The loss of submergent vegetation, decline in abundance and diversity of amphibious taxa and disconnection of fringing emergent macrophytes had serious implications for ecosystem dynamics of the Lower Lakes. This is because aquatic vegetation is a critical ecosystem component in the Lower Lakes; plants are major primary producers (e.g. dos Santos and Esteves 2002; Camargo *et al.* 2006; Noges *et al.* 2010), improve water quality (e.g. Webster *et al.* 2001; James *et al.* 2004), provide habitat for invertebrates (e.g. Wright *et al.* 2002; Papas 2007; Bassett *et al.* 2012; Bell *et al.* 2013; Walker *et al.* 2013; Matuszak *et al.* 2014), birds (e.g. Brandle *et al.* 2002; Phillips and Muller 2006) and threatened fish (Wedderburn *et al.* 2007; Bice *et al.* 2008) and stabilise shorelines (Abernethy and Rutherfurd 1998; PIRSA Spatial Information Services 2009).

To mitigate impacts of acid sulfate soils, three regulators were constructed in the Lower Lakes: the Narrung Bund (completed in early 2008), the Clayton Regulator and the Currency Creek Regulator (both completed in August 2009) (Figure 1). However, only the impacts of the Narrung Bund and Clayton Regulator will be discussed in this report due to the Currency Creek Regulator spillway remaining inundated after the Clayton regulator was constructed. The regulators disconnected Goolwa Channel and Lake Albert from Lake Alexandrina, which enabled water levels within each site to be managed independently. An additional hydrological intervention was undertaken at Narrung Wetland, with 250 megalitres (ML) of water for the environment being pumped from Lake Alexandrina into the wetland in October 2009 to provide suitable conditions for the growth of submergent taxa (particularly *Ruppia tuberosa* and charophytes).

In August 2010, flows into South Australia increased, and as a result water levels in Lake Alexandrina were reinstated to historical levels (~+0.75 m AHD) and significant flow through the Murray Barrages (five flow control structures located at Goolwa, Tauwitchere, Ewe Island, Boundary Creek and Mundoo to prevent saltwater intrusion in the Lower Lakes; Figure 1) was possible for the first time since spring 2005 (although there was a small water release in 2006-07 to operate fishways). Furthermore, the Clayton Regulator and Narrung Bund were breached in September 2010, and Lake Alexandrina was reconnected with Goolwa Channel and Lake Albert. After spring 2010, water levels were restored to historical levels ranging from +1.29 m AHD in summer 2022-23 when lakes were surcharged due to the second largest recorded flood in the South Australian River Murray to +0.4 m AHD in autumn during periods of managed draw down. The impacts of the regulators, pumping, unregulated River Murray flows and managed draw down on salinity and water levels throughout the condition monitoring program are outlined in section 2.1.

The period of low flow and subsequent low water levels, regulator construction, pumping, unregulated River Murray flows, regulator breaching, entitlement flows and managed draw-down have resulted in large changes to the hydrological and salinity regime of the Lower Lakes since 2007. Salinity (e.g. Hart *et al.* 1991; Nielsen *et al.* 2003; Nielsen *et al.* 2007; Nielsen and Brock 2009) and water regime (determined by lake levels) (e.g. Brock and Casanova 1997; Blanch *et al.* 1999b; 1999a; 2000; Nicol *et al.* 2003) are two of the primary drivers of plant community composition in freshwater ecosystems. Historically, the various components of the system were connected with relatively stable water levels ranging from +0.4 to +0.8 m AHD and surface water electrical conductivity <2,000 $\mu S.cm^{-1}$ (Kingsford *et al.* 2009; Kingsford *et al.* 2011). Between January 2007 and August 2010, surface water salinity, water regime and connectivity of the study area varied dramatically from historical patterns; however, since September 2010, these factors have largely reflected historical patterns.

## 1.2. Aquatic and littoral vegetation target revision

A review undertaken by Robinson (2015) suggested that the initial aquatic and littoral vegetation target for the Lower Lakes (TLM V3): *maintain or improve aquatic and littoral vegetation in the Lower Lakes* (Maunsell Australia Pty Ltd 2009) could be improved by developing a series of quantitative targets for the site. In response to this, targets were developed for the aquatic and littoral vegetation of the Lower Lakes. Targets were based largely on expert opinion; however, pre-drought vegetation information was available for wetlands through the 2004 (Holt *et al.* 2005) and 2005 (Nicol *et al.* 2006) River Murray wetlands baseline surveys, biological surveys of conservation reserves around the Murray Mouth (Brandle *et al.* 2002), habitat mapping for the entire system (Seaman 2003) and Hindmarsh Island (Renfrey *et al.* 1989). Generally, these studies showed there was a diverse submergent, emergent and amphibious plant community in wetlands, along low energy shorelines in lakes Alexandrina and Albert and in aquatic habitats, on and around Hindmarsh Island, prior to 2007. Whilst these studies represent the only documented baseline (prior to 2007) for the Lower Lakes, they were snapshots that did not provide an indication of temporal variability. The updated quantitative targets and methodologies are outlined in the Condition Monitoring Plan (Revised) 2017 for the Lower Lakes, Coorong and Murray Mouth Icon Site (Department for Environment, Water and Natural Resources 2017). Within this Plan, the original target V3 is now referred to as an objective, with the quantitative targets nested below the objective.

The vegetation condition monitoring review divided the Lower Lakes into different habitats based on hydrology and geomorphology. Five habitats were identified: Lake Alexandrina, Lake Albert, Goolwa Channel, permanent wetlands and seasonal (temporary) wetlands. Within lakes Alexandrina and Albert and Goolwa Channel, three zones were identified based on elevation: the littoral zone (+0.8 to +0.6 m AHD), the aquatic zone (+0.4 to 0 m AHD) and the deep-water zone (deeper than 0 m AHD). Permanent wetlands are typically shallow and have no deep-water zone; hence, they were divided into littoral and aquatic zones. Seasonal wetlands were divided into two zones: the wetland edge and wetland bed. In addition, there was a seasonal component for temporary wetlands with different targets for spring (high water level) and autumn (low water level).

Due to the number of plant species present in the Lower Lakes, native species were classified into functional groups based on water regime using the classification in Gehrig and Nicol (2010; Appendix 1).

Exotic species and potentially invasive native species (e.g., *Typha domingensis and Phragmites australis*) were also monitored. The dominant exotic species in the Lower Lakes are *Cenchrus clandestinus* (formerly named *Pennisetum clandestinum*) and *Paspalum distichum* (Frahn *et al.* 2014). Both are low profile rhizomatous and stoloniferous, warm season growing grasses (Jessop *et al.* 2006) that grow well in the littoral zone throughout the Lower Lakes, except in areas where there is high soil salinity (Frahn *et al.* 2014). Native emergent and amphibious species are often absent when these species are abundant (Frahn *et al.* 2014). *Typha domingensis* and *Phragmites australis* are tall rhizomatous emergent species that are common throughout the Lower Lakes (Frahn *et al.* 2014) and are adapted to stable water levels (Blanch *et al.* 1999b; 2000). They are an important component of the vegetation in the Lower Lakes; however, they often form monospecific stands, and it is undesirable for these species to occupy large areas of the littoral and aquatic zones.

Targets for aquatic and littoral understorey vegetation were based on a minimum proportion of quadrats in each habitat and zone having a minimum cover score of desirable species and a maximum number of quadrats having a maximum cover score of undesirable species in any given survey. Species were classified into water regime functional groups to assess targets except the undesirable species: *Paspalum distichum, Cenchrus clandestinus, Phragmites australis* and *Typha domingensis*.

Vegetation targets for Lake Alexandrina are presented in Table 1. The general objectives of the targets were to improve the abundance of diverse reed beds (shorelines with a diverse assemblage of emergent, submergent and amphibious species) and limit the amount of shoreline dominated by invasive species and to a lesser extent shorelines dominated by *Typha domingensis* and *Phragmites aus*tralis. The deep-water zone in Lake Alexandrina is generally unsuitable for submergent or emergent species; hence, there were no vegetation targets for this zone, but it was recognised that this zone needs to be inundated to maintain the hydrological connection between zones and prevent acid sulfate soil development (Fitzpatrick *et al.* 2009a; 2009b; 2010).

**Table 1:** Revised vegetation targets for Lake Alexandrina.

| Zone | Target |
|---|---|
| Littoral +0.8 to +0.6 m AHD | <40% of quadrats in any given survey containing >75% combined cover (Braun-Blanquet score 5) of *Typha* and *Phragmites* |
| | <20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Paspalum* |
| | Minimum of 50% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (BB score 2 or greater) |
| | Minimum of 50% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| Aquatic +0.4 to 0 m AHD | <40% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Typha* and *Phragmites* |
| | Minimum of 20% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 35% of quadrats in any given survey contain native submergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| Deep-water <0 m AHD | Permanent inundation |

Targets for Lake Albert are presented in Table 2. The targets for Lake Albert were similar to those for Lake Alexandrina except that there was an expectation of a lower proportion of diverse reed beds and lower proportions of submergent, amphibious and emergent species (except *Typha domingensis* and *Phragmites australis*).

**Table 2:** Revised vegetation targets for Lake Albert.

| Zone | Target |
|---|---|
| Littoral +0.8 to +0.6 m AHD | <40% of quadrats in any given survey containing >75% combined cover (Braun-Blanquet score 5 or greater) of *Typha* and *Phragmites* |
| | <20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Paspalum* |
| | Minimum of 35% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 35% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| Aquatic +0.4 to 0 m AHD | <40% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Typha* and *Phragmites* |
| | Minimum of 20% of quadrats in any given survey contain emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 20% of quadrats in any given survey contain submergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| Deep-water <0 m AHD | Permanent inundation |

Targets for Goolwa Channel are presented in Table 3. Targets for Goolwa Channel were also similar to Lake Alexandrina but there was an expectation that submergent species were present in the deep-water zone and a higher proportion of quadrats dominated by *Typha domingensis* and *Phragmites australis*.

**Table 3:** Revised vegetation targets for Goolwa Channel.

| Zone | Target |
|---|---|
| Littoral +0.8 to +0.6 m AHD | <50% of quadrats in any given survey containing >75% combined cover (Braun-Blanquet score 5 or greater) of *Typha* and *Phragmites* |
| | <20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Paspalum* |
| | Minimum of 50% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 50% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| Aquatic +0.4 to 0 m AHD | <50% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Typha* and *Phragmites* |
| | Minimum of 20% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 40% of quadrats in any given survey contain native submergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| Deep-water <0 m AHD | Minimum of 20% of quadrats in any given survey contain native submergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |

Targets for permanent wetlands are presented in Table 4. Prior to 2007, many wetlands contained a diverse assemblage of submergent, emergent and amphibious species (Holt *et al.* 2005; Nicol *et al.* 2006), which was reflected in the targets. The proportion of quadrats dominated by *Typha domingensis* and *Phragmites australis* is lower than Goolwa Channel, Lake Alexandrina and Lake Albert and proportion of quadrats with submergents is higher (Table 5). However, there is a maximum target of 50% cover for submergent species in the aquatic zone, which was related to small-bodied fish habitat (S. Wedderburn pers. com.). The deep-water zone is not included because wetlands are generally shallow and this zone is not present in most wetlands.

**Table 4:** Revised vegetation targets for permanent wetlands (Dunns Lagoon, Hunters Creek, Angas River Mouth and Bremer River Mouth).

| Zone | Target |
|---|---|
| Littoral >+0.6 m AHD | <35% of quadrats in any given survey containing >75% combined cover (Braun-Blanquet score 5 or greater) of *Typha* and *Phragmites* |
| | <20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Paspalum* |
| | Minimum of 50% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 50% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| Aquatic <+0.6 m AHD | <40% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Typha* and *Phragmites* |
| | Minimum of 20% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 50% of quadrats in any given survey contain native submergent species with a combined cover of 5 to 50% (Braun-Blanquet score 2 to 4) |

Targets for seasonal wetlands are presented in Tables 5a and b. Prior to 2007, seasonal wetlands in spring generally contained high numbers of submergent species (submergent r-selected species (*sensu* Casanova 2011) such as *Ruppia tuberosa, Ruppia polycarpa, Althenia cylindrocarpa* and charophytes) (Holt *et al.* 2005; Nicol *et al.* 2006). This is reflected in the spring target of 50% of quadrats containing greater than 25% cover of submergent species (Table 5a) because the regular wetting and drying cycle present in these wetlands favours this functional group (Casanova 2011). Furthermore, the wetting and drying cycle will favour amphibious species that require exposed sediment to germinate but persist as adults whilst standing water is present (Nicol *et al.* 2003; Casanova 2011). *Typha domingensis* and *Phragmites australis* are generally not abundant in seasonal wetlands (Frahn *et al.* 2014); hence, there were no targets relating to these species.

**Table 5:** Revised vegetation targets for seasonal wetlands in a. spring and b. autumn (Goolwa Channel Drive, Milang Wetland, Narrung Wetland, Loveday Bay Wetland, Point Sturt Wetland and Teringie).

a.

| Zone | Target |
|---|---|
| Edge | <20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Paspalum* |
| | Minimum of 50% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 50% of quadrats in any given survey contain native emergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| Bed | Minimum of 20% of quadrats in any given survey contain native emergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 50% of quadrats in any given survey contain native submergent species with a combined cover of ≥25% (Braun-Blanquet score 3 or greater) |
| | Minimum of 25% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |

b.

| Zone | Target |
|---|---|
| Edge | <20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Paspalum* |
| | Minimum of 50% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 50% of quadrats in any given survey contain native emergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| Bed | Minimum of 20% of quadrats in any given survey contain native emergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |
| | Minimum of 25% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater) |

In addition to quantitative aquatic and littoral vegetation targets, habitat and Whole of Icon Site Scores (WOISS) were developed to assess the condition of the lakes. The habitat condition score represents the proportion of targets achieved in a particular habitat and the WOISS represents the proportion of targets achieved in the different habitats. The WOISS is also used for Basin Plan environmental outcome reporting (Matter 8) and will be used to report on objective V3 using the same scale (Table 6) (Department for Environment and Water 2019). A Matter 8 condition rating of good represents aquatic and littoral vegetation being maintained and a rating of very good represents condition is improving.

**Table 6:** Icon site scores for aquatic and littoral vegetation for the Lower Lakes with the condition rating used in Matter 8 Report Cards (Department for Environment and Water 2019).

| Icon site score | Matter 8 condition rating |
|---|---|
| 0.80-1.00 | Very good |
| 0.60-0.79 | Good |
| 0.40-0.59 | Fair |
| <0.40 | Poor |

## 1.3. Objectives

The surveys undertaken in spring 2022 and autumn 2023 builds on data collected between spring 2008 and autumn 2022 and provides information regarding the change in plant communities over this period. However, in spring 2016 surveys were only undertaken in seasonal wetland habitats with all sites surveyed in autumn and spring 2017. From autumn 2018 onwards, surveys were not undertaken in Milang and Waltowa wetlands.

The monitoring program includes a period of record low water levels in Lake Alexandrina, several engineering interventions, three large unregulated River Murray flow events (one in 2010/11 that reinstated historical water levels, one in spring/summer 2016 and in summer 2022/23 that was the second highest flood on record), multiple in-channel flow pulses, entitlement flows, water for the environment provisions (that maintained historical water levels), managed draw-down to +0.5 m AHD in late summer and autumn 2018, surcharge in spring 2019 to +0.9 m AHD and in summer 2022/23 to 1.29 m AHD. Therefore, this monitoring program collected information regarding the change in aquatic and littoral plant communities in response to draw-down, desiccation, increased water levels due to regulated inundation, natural flooding, spring and summer surcharging of the lakes and managed drawn-down and provides an insight into recovery of the system under hydrological restoration. The aims of this project are to:

- continue the statistically robust, quantitative understorey aquatic and littoral vegetation monitoring program in the Lower Lakes to assess TLM Objective V3 (Department for Environment, Water and Natural Resources 2017);
- report on the revised vegetation targets for each habitat and determine habitat condition using the WOISS;
- monitor the recovery of the aquatic plant community after hydrological restoration following extended drought, draw-down, fragmentation and desiccation of aquatic habitats;
- investigate the longevity of the managed draw-down in late summer and autumn 2018

# 2. METHODS

## 2.1. Study site, hydrology and salinity

Vegetation surveys were undertaken over the monitoring program in Goolwa Channel, Lake Alexandrina, Lake Albert and 11 associated wetlands (Figure 1). Between 2008 and 2010, a range of interventions were undertaken in the Lower Lakes to regulate water levels and mitigate acid sulfate soils; primarily the construction of the Narrung Bund and Clayton Regulator (Figure 1). Construction of the Narrung Bund was completed in early 2008 and this disconnected Lake Albert from Lake Alexandrina (Figure 1). Water was then pumped from Lake Alexandrina into Lake Albert to maintain water levels above -0.5 m AHD. Construction of the Clayton Regulator was completed in August 2009, resulting in impounded water from the Finniss River and Currency and Tookayerta Creeks (Figure 1). In addition, water was pumped into Goolwa Channel (Figure 2) from Lake Alexandrina to raise water levels to +0.7 m AHD in spring 2009. Both structures were breached in spring 2010, and from then on water levels were dependent on inflows and barrage operations. Water level and surface water electrical conductivity in the Lower Lakes from August 2008 to May 2023 are presented in Figure 2 and Figure 3 respectively. Details regarding interventions and their impacts on water level and salinity from 2008 to 2010 are outlined in Frahn *et al.* (2014).

Since spring 2010 water levels in the Lower Lakes returned to historical levels and remained at these levels for the remainder of the survey period, except for summer 2022/23 when the highest water levels were recorded (1.29 m AHD) over the monitoring program (Figure 2). Salinity in Lake Alexandrina and Goolwa Channel decreased rapidly after the Clayton Regulator and Narrung Bund were breached; however, salinity remains elevated (but slowly decreasing) in Lake Albert and there have been several short salinity spikes in Goolwa Channel during periods of reverse head (the water level in the Coorong is higher than Lake Alexandrina) (Figure 3).

Since 2011/12, water level management objectives for the Lower Lakes have focused on annual fluctuations within a range from +0.4 to +0.9 m AHD to achieve ecological benefits. In late summer and autumn 2018 water levels were drawn down to around +0.5 m AHD for the longest period since the Millennium Drought. Water levels were also drawn down to a similar level in autumn 2019 and surcharged to +0.9 m AHD in spring 2019 with a similar pattern in autumn 2019 and spring 2020. In autumn 2021, 2022 and 2023 water levels were drawn down to around +0.6 m AHD (Figure 2). It is expected that these management actions will promote the establishment of amphibious species in the littoral zone. Figure 2 indicates that lake levels have generally followed this pattern except for water levels reaching maximum heights of >+0.9 m AHD in spring 2016, 2019, 2020, 2021 and summer 2022/23.

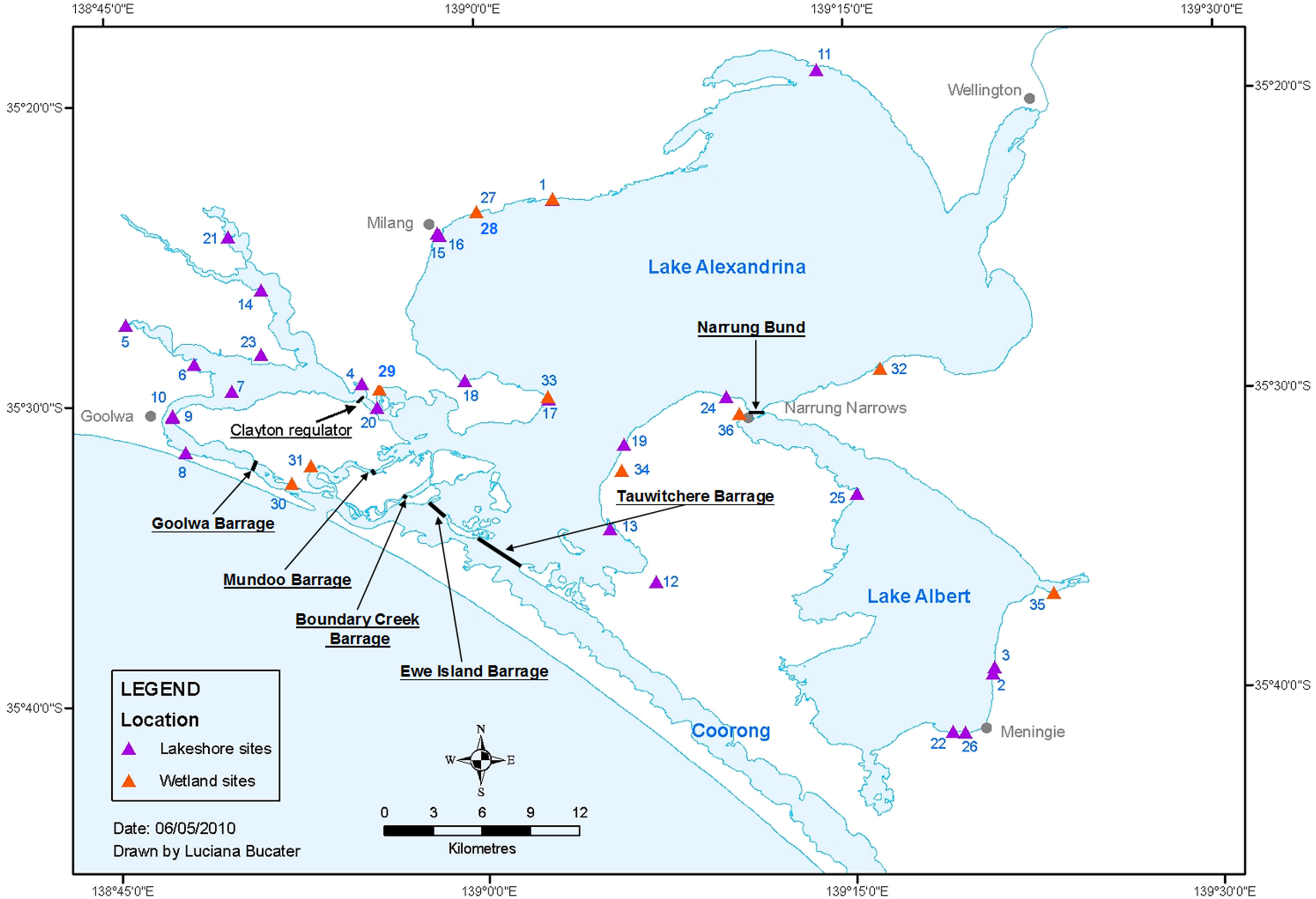



**Figure 1:** Map of Lakes Alexandrina and Albert and Goolwa Channel showing the location of lakeshore and wetland vegetation monitoring sites (site numbers correspond to Table 7) and major flow control structures present in winter 2010 (where sites are in close proximity they may not be visible on map).

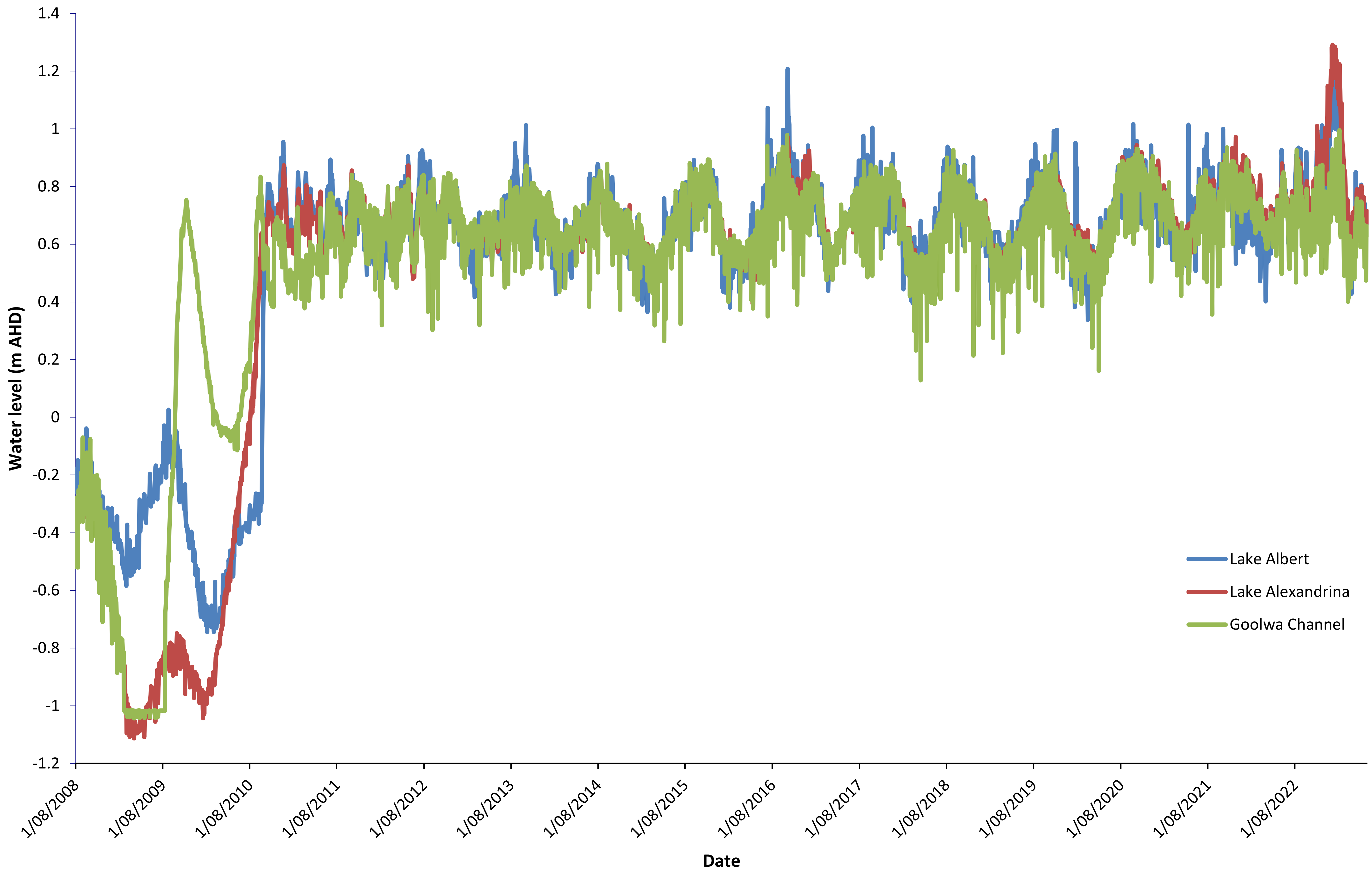



**Figure 2:** Daily mean water levels in Goolwa Channel (Signal Point), Lake Alexandrina (Milang) and Lake Albert (Meningie) from August 2008 to May 2023 (Department for Environment and Water 2023b).

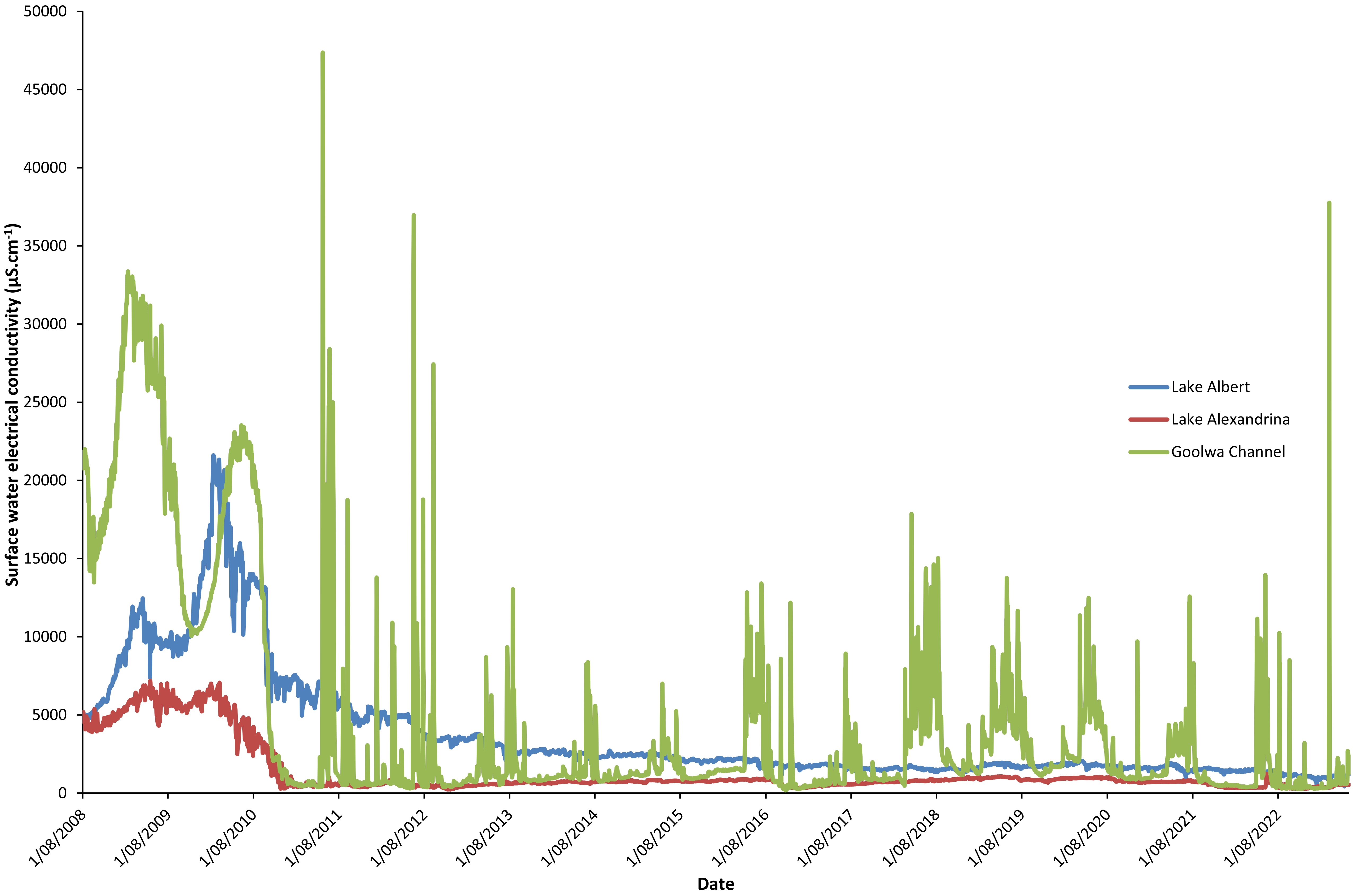



**Figure 3:** Daily mean surface water electrical conductivity (EC) in Goolwa Channel (Signal Point), Lake Alexandrina (Milang) and Lake Albert (Meningie) from August 2008 to May 2023 (Department for Environment and Water 2023a).

## 2.2. Understorey vegetation survey protocol

Monitoring of understorey vegetation was conducted at 11 wetland and 25 lakeshore sites each spring (to correspond with high water levels) and autumn (corresponding to low water levels) from October 2008 to March 2014, March 2015, October 2015, March 2016, December 2016 (temporary wetlands only), March 2017, November 2017, April 2018 (except Milang and Waltowa wetlands), November 2018, November 2019, December 2020, May 2021, December 2021, April 2022, December 2022 and May 2023 (Table 7). Sites were grouped based on habitat (lakeshore, permanent wetland or seasonal wetland) and location (Lake Alexandrina, Lake Albert or Goolwa Channel). GPS coordinates for each site are listed in Appendix 2.

**Table 7:** List of understorey vegetation site numbers (relative to map provided in Figure 1), site name, location, habitat type (wetland or lakeshore), number of survey sites and the year sites were established (SAMDBNRM denotes, South Australian Murray-Darling Basin Natural Resources Management Board).

| Site # | Site Name | Location | Habitat | No. Survey Sites | Year Established |
|---|---|---|---|---|---|
| 1 | Bremer Mouth Lakeshore | Lake Alexandrina | lakeshore | 1 | 2008 |
| 2 | Brown Beach 1 | Lake Albert | lakeshore | 1 | 2008 |
| 3 | Brown Beach 2 | Lake Albert | lakeshore | 1 | 2008 |
| 4 | Clayton Bay | Goolwa Channel | lakeshore | 1 | 2009 |
| 5 | Currency Creek 3 | Goolwa Channel | lakeshore | 1 | 2008 |
| 6 | Currency Creek 4 | Goolwa Channel | lakeshore | 1 | 2008 |
| 7 | Goolwa North | Goolwa Channel | lakeshore | 1 | 2009 |
| 8 | Goolwa South | Goolwa Channel | lakeshore | 1 | 2009 |
| 9 | Hindmarsh Island Bridge 01 | Goolwa Channel | lakeshore | 1 | 2009 |
| 10 | Hindmarsh Island Bridge 02 | Goolwa Channel | lakeshore | 1 | 2009 |
| 11 | Lake Reserve Rd | Lake Alexandrina | lakeshore | 1 | 2008 |
| 12 | Loveday Bay | Lake Alexandrina | seasonal wetland | 4 | 2009 |
| 13 | Loveday Bay Lakeshore | Lake Alexandrina | lakeshore | 1 | 2009 |
| 14 | Lower Finniss 02 | Goolwa Channel | lakeshore | 1 | 2009 |
| 15 | Milang (existing SAMDBNRM Board community monitoring site) | Lake Alexandrina | seasonal wetland | 4 | pre-2008 |
| 16 | Milang Lakeshore | Lake Alexandrina | lakeshore | 1 | 2009 |
| 17 | Pt Sturt Lakeshore | Lake Alexandrina | lakeshore | 1 | 2008 |
| 18 | Pt Sturt Water Reserve | Lake Alexandrina | lakeshore | 1 | 2008 |
| 19 | Teringie Lakeshore | Lake Alexandrina | lakeshore | 1 | 2008 |
| 20 | Upstream of Clayton Regulator | Lake Alexandrina | lakeshore | 1 | 2009 |
| 21 | Wally’s Landing | Goolwa Channel | lakeshore | 1 | 2009 |
| 22 | Warrengie 1 | Lake Albert | lakeshore | 1 | 2009 |
| 23 | Lower Finniss 03 | Goolwa Channel | lakeshore | 1 | 2009 |
| 24 | Narrung Lakeshore | Lake Alexandrina | lakeshore | 1 | 2008 |
| 25 | Nurra Nurra | Lake Albert | lakeshore | 1 | 2008 |
| 26 | Warrengie 2 | Lake Albert | lakeshore | 1 | 2009 |
| 27 | Angas Mouth | Lake Alexandrina | permanent wetland | 1 | 2008 |
| 28 | Bremer Mouth | Lake Alexandrina | permanent wetland | 1 | 2008 |
| 29 | Dunns Lagoon | Lake Alexandrina | permanent wetland | 4 | 2008 |
| 30 | Goolwa Channel Drive | Lake Alexandrina | seasonal wetland | 3 | 2008 |
| 31 | Hunters Creek | Lake Alexandrina | wetland | 5 | 2008 |
| 32 | Poltalloch | Lake Alexandrina | seasonal wetland | 2 | 2008 |
| 33 | Pt Sturt | Lake Alexandrina | seasonal wetland | 2 | 2008 |
| 34 | Teringie (existing SAMDBNRM Board community monitoring site) | Lake Alexandrina | seasonal wetland | 4 | pre-2008 |

| Site # | Site Name | Location | Habitat | No. Survey Sites | Year Established |
|---|---|---|---|---|---|
| 35 | Waltowa (existing SAMDBNRM Board community monitoring site) | Lake Albert | seasonal wetland | 2 | pre-2008 |
| 36 | Narrung (existing SAMDBNRM Board community monitoring site) | Lake Alexandrina | seasonal wetland | 4 | pre-2008 |

## Wetlands

At each survey site (Figure 1, Table 7), a transect running perpendicular to the shoreline and three, 1 x 3 m quadrats, separated by one metre, were established (Figure 4) at regular elevation intervals that represented the dominant plant communities (A. Rumbelow pers. comm.). In wetlands with an established monitoring program (Milang, Waltowa, Teringie and Narrung), existing sites were re-surveyed. For the remaining wetlands (Dunns Lagoon, Point Sturt, Hunters Creek, Goolwa Channel Drive, Bremer River Mouth, Angas River Mouth and Loveday Bay), a transect was established and quadrats placed in each plant community present during the spring 2008 survey. A minimum of one additional transect (but usually two or more in each wetland, except at the Angas and Bremer River mouths) was established, and quadrats were placed at the same elevations (determined using a laser level) as on the first transect. At sites where the elevation gradient was steep (e.g. Angas and Bremer River Mouth, Hunter's Creek) only edge and channel quadrats were surveyed. Cover and abundance of each species present in the quadrat were estimated using the method outlined in Heard and Channon (1997), except that N and T were replaced by 0.1 and 0.5 to enable statistical analyses (Table 8).

**Table 8:** Modified Braun-Blanquet (1932) scale estimating cover/abundance as per Heard and Channon (1997).

| Score | Modified Score | Description |
|---|---|---|
| N | 0.1 | Not many, 1-10 individuals |
| T | 0.5 | Sparsely or very sparsely present; cover very small (less than 5%) |
| 1 | 1 | Plentiful but of small cover (less than 5%) |
| 2 | 2 | Any number of individuals covering 5-25% of the area |
| 3 | 3 | Any number of individuals covering 25-50% of the area |
| 4 | 4 | Any number of individuals covering 50-75% of the area |
| 5 | 5 | Covering more than 75% of the area |

## Lakeshores

Apart from quadrat placement, lakeshores were surveyed using the same technique as wetlands. At each site, a transect running perpendicular to the shoreline was established and three, 1 x 3 m quadrats, separated by one metre, were established at elevation intervals of

+0.8, +0.6, +0.4, +0.2, 0 and -0.5 m AHD (Figure 4) (*sensu* Marsland and Nicol 2009; Gehrig and Nicol 2010a; Gehrig *et al.* 2010).

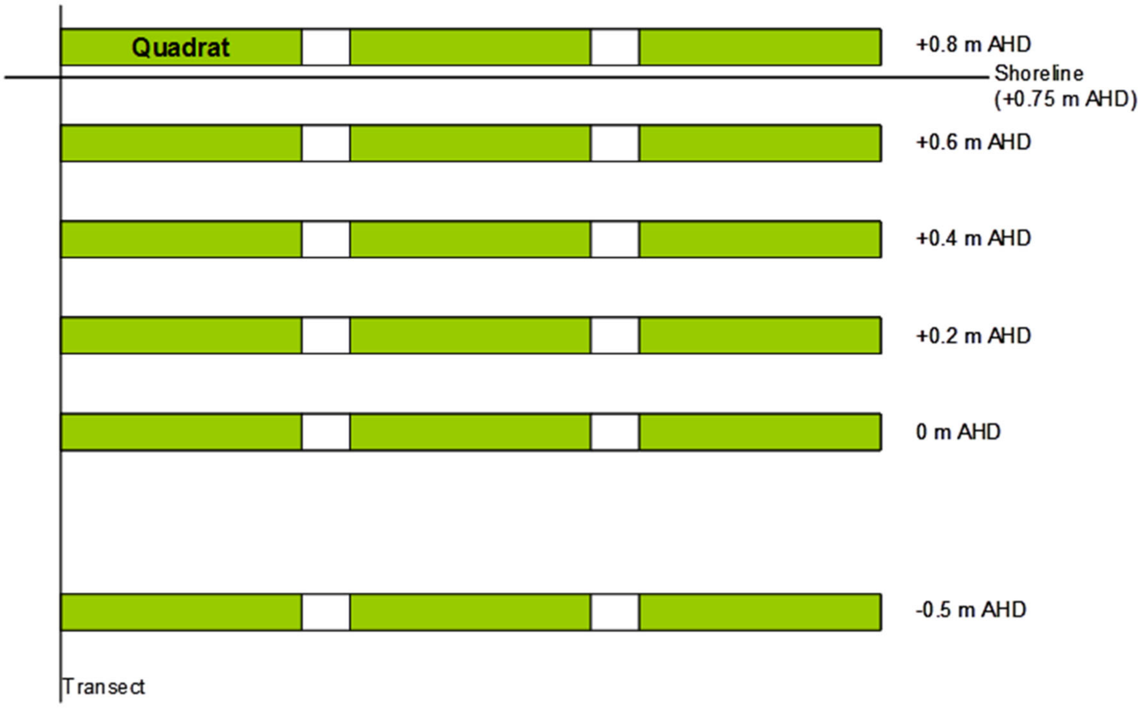



**Figure 4:** Vegetation surveying protocol for lakeshore sites: plan view showing placement of quadrats relative to the shoreline.

The vegetation monitoring protocol described in this section was developed by staff from the South Australian River Murray Catchment Water Management Board (now the Murraylands and Riverland Landscape Board), to monitor aquatic and littoral vegetation in fringing Lower Lakes wetlands. Extensive species area curves were undertaken to determine the most effective quadrat dimensions and quadrat placement was stratified by plant community and elevation to ensure all communities were sampled. Throughout The Living Murray condition monitoring program all species encountered that are not present in quadrats are recorded to give a more accurate estimate of species richness in each habitat; however, it is rare for a species present in a habitat not to be recorded in a quadrat.

## Plant identification and Nomenclature

Plants were identified using keys in Sainty and Jacobs (1981), Jessop and Tolken (1986), Prescott (1988), Cunningham *et al.* (1992), Dashorst and Jessop (1998), Romanowski (1998), Sainty and Jacobs (2003) and Jessop *et al.* (2006). In some cases, due to immature individuals or lack of floral structures, plants were identified to genus only. Nomenclature follows the Centre for Australian National Biodiversity Research and Council of Heads of Australasian Herbaria (2023).

## 2.3. Data Analysis

Changes in floristic composition through time, at all elevations, in each of the five habitats (Lake Alexandrina, Lake Albert, Goolwa Channel, permanent wetlands and temporary wetlands) were assessed by non-metric multidimensional scaling (nMDS) ordination using the package PRIMER version 7.0.12 (Clarke and Gorley 2015). Bray-Curtis (1957) similarities were used to construct the similarity matrices for the nMDS ordinations on untransformed data.

Native species richness at +0.6 and +0.8 m AHD in Lakes Alexandrina, Lake Albert and Goolwa Channel was plotted through time to assess the benefit of the managed draw down in autumn 2018. This elevation was chosen because it represented the zone that was inundated in spring and exposed by the managed draw-down in autumn 2018, 2019 and 2020.

# 3. RESULTS

## 3.1. Change through time of the Lower Lakes plant community from spring 2008 to autumn 2023

Over the 14 years of condition monitoring (spring 2008 to autumn 2023), a total of 167 taxa (including 77 exotics, two weeds of national significance, five proclaimed pest plants in South Australia and one species listed as rare in South Australia) were recorded throughout the Lower Lakes (Appendix 1). Species lists of each habitat (Lake Alexandrina, Lake Albert, Goolwa Channel, permanent wetlands and temporary wetlands) and the surveys they were recorded are presented in Appendices 3 to 7). Lake Alexandrina was the most species rich of the habitats with 121 taxa (including 56 exotics) recorded between spring 2008 and autumn 2022, followed by permanent wetlands (99 taxa, including 36 exotics), then temporary wetlands (96 taxa, including 43 exotics), Goolwa Channel (80 taxa, including 30 exotics) and Lake Albert the least species rich with 61 taxa (including 32 exotics).

Patterns of temporal change in the plant community for each habitat showed a shift in floristic composition over the condition monitoring program (nMDS ordination; Figures 5 to 9). Furthermore, for each habitat except the seasonal wetlands, there was greater change in the plant community between the early surveys that reduced through time with very little change in vegetation among the more recent surveys (Figures 6 to 10).

## Lake Alexandrina

In spring 2008, water levels in Lake Alexandrina were at historical low levels (Figure 2) and the plant community was dominated by terrestrial species (predominantly agricultural weeds). The plant community remained dominated by terrestrial taxa until spring 2010, when water levels were reinstated (Figure 2) and the terrestrial species were extirpated resulting in a large change in floristic composition (Figure 5). From spring 2010 to autumn 2013, there was an increase in the abundance of emergent, amphibious and submergent species (Frahn *et al.* 2014). However, there were also seasonal patterns over this period (Figure 5) with emergent taxa typically more abundant in spring and amphibious taxa in autumn (Frahn *et al.* 2014). From autumn 2013 to spring 2017 the change in the plant community has been small, in comparison to previous years, but seasonal patterns were similar (Figure 5) with emergent taxa more abundant in spring and amphibious and submergent taxa in autumn. There was a small shift in the plant community between spring 2017 and autumn 2018 due to an increase in species richness in the littoral zone and less change between autumn and spring 2018 (compared to previous years) as most of these species persisted, after which there has been little change in the plant community (Figure 5).

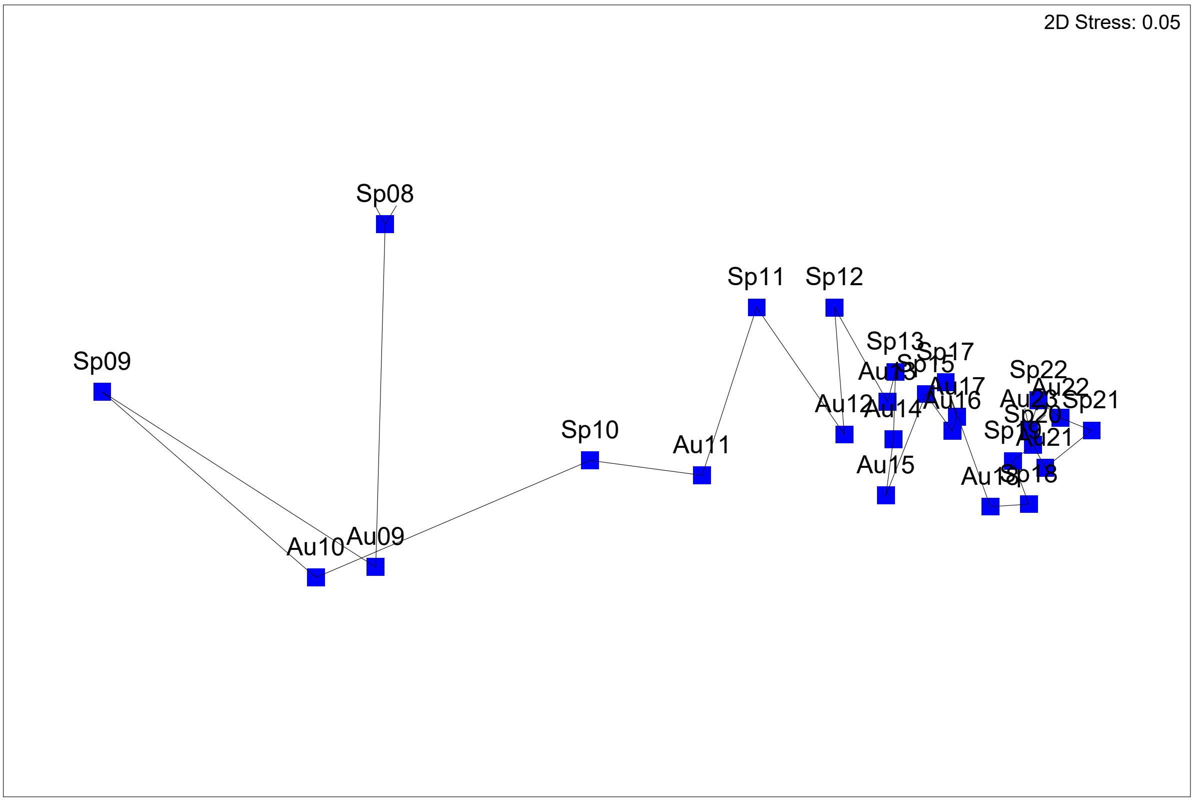



**Figure 5:** nMDS ordination comparing the plant community between spring 2008 and autumn 2023 in Lake Alexandrina (Sp denotes spring; Au denotes autumn).

## Lake Albert

Similar to Lake Alexandrina (Figure 5), the plant community in Lake Albert was dominated by terrestrial species with large changes in floristic composition (Figure 6) whilst water levels were low during the Millennium Drought (Figure 2). After water levels were reinstated in spring 2010 (Figure 2), the change in plant community (Figure 6) was driven by an increase in emergent and amphibious species. Since spring 2010, there has been a gradual change in floristic composition (Figure 6) primarily driven by an increase in the abundance of *Typha domingensis* and other emergent taxa. After autumn 2018 there has been little change in the plant community except in spring 2022 (Figure 6) when there was further increase in emergent species.

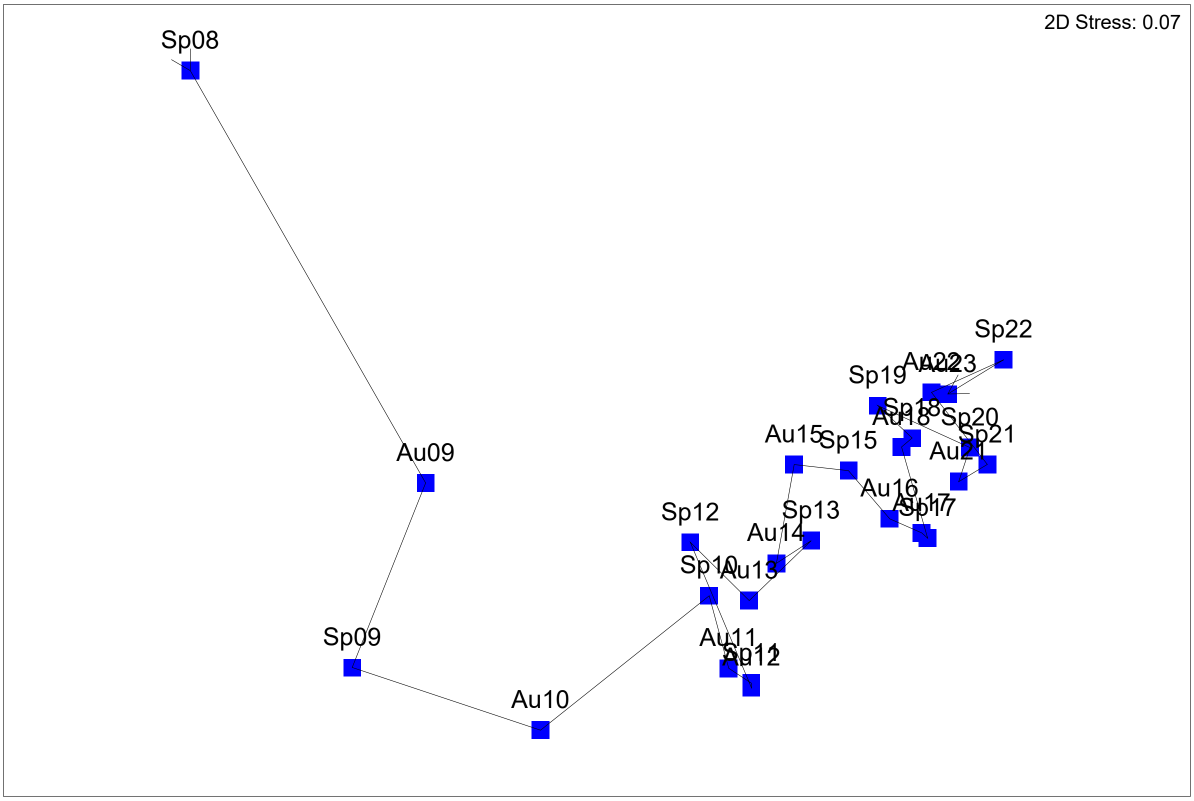



**Figure 6:** nMDS ordination comparing the plant community between spring 2008 and autumn 2023 in Lake Albert (Sp denotes spring; Au denotes autumn).

## Goolwa Channel

Similar to lakes Alexandrina (Figure 5) and Albert (Figure 6), the plant community in Goolwa Channel was dominated by terrestrial taxa whilst water levels were low prior to spring 2009 (Figure 2). Water levels rose to around +0.8 m AHD in spring 2009 (Figure 2) due to the completion of the Clayton Regulator and there was a large change in floristic composition (Figure 7). This change was driven by terrestrial species being extirpated with extensive beds of the submergent species *Potamogeton pectinatus* recruiting throughout Goolwa Channel, the lower Finniss River and lower Currency Creek (Gehrig and Nicol 2010a). There was a significant change in the plant community between spring of 2009 and 2010 (Figure 7), which was a result of the Clayton Regulator being breached and a rapid reduction in surface water salinity (Figure 3). These changes in floristic composition were driven by a decrease in the abundance of *Potamogeton pectinatus* and increase in submergent species adapted to lower salinity environments (e.g., *Ceratophyllum demersum, Potamogeton crispus, Myriophyllum salsugineum* and *Vallisneria australis*) (Bailey *et al.* 2002). After spring 2010, water levels and salinities returned to historic levels (Figure 2 and Figure 3) but the plant community continued to change (Figure 7). The change between spring 2010 and spring 2011 (Figure 7) was driven primarily by an increase in the abundance of *Typha domingensis*. There were seasonal changes in vegetation between spring 2011 spring 2013 (Figure 7) driven by higher abundances of *Typha domingensis* and *Phragmites australis* in autumn. After spring 2013, there was very little change in floristic composition until autumn 2022 when the community was similar to the one observed in autumn 2012 (Figure 7), which was brought about by a decrease in *Typha domingensis* and *Phragmites australis*.

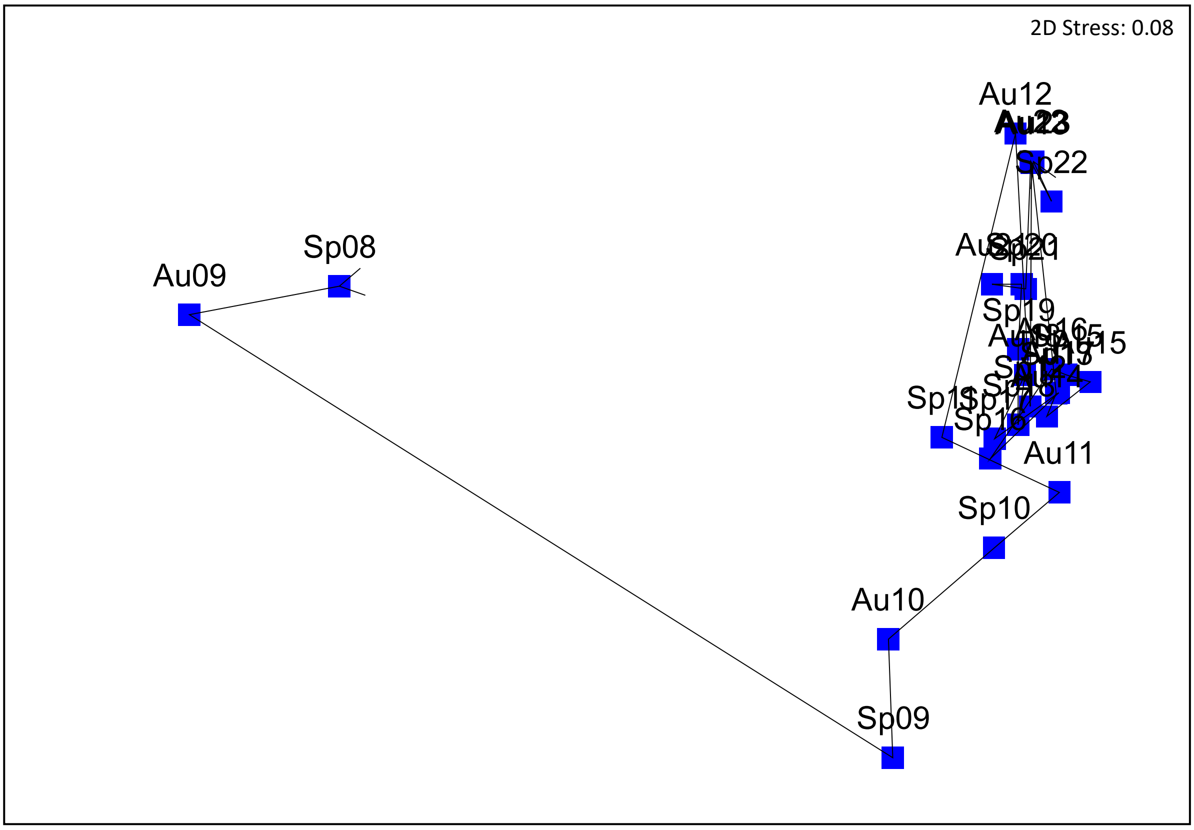



**Figure 7:** nMDS ordination comparing the plant community between spring 2008 and autumn 2023 in Goolwa Channel (Sp denotes spring; Au denotes autumn).

## Permanent Wetlands

All permanent wetlands surveyed in the condition monitoring program are hydrologically connected to Lake Alexandrina; therefore, water levels (and salinities to a lesser degree) in these habitats reflect conditions in Lake Alexandrina (Figures 2 and 3). Similar to the other habitats in the Lower Lakes, permanent wetlands were dominated by terrestrial taxa whilst water levels were low, most of which were extirpated when water levels were reinstated in spring 2010 (Figure 2). Since spring 2010, there has generally been an increase in the abundance of emergent, submergent and amphibious species in permanent wetlands, which has driven the change in floristic composition (Figure 8). Since autumn 2013, the change in the plant community was much smaller than observed in the earlier surveys of the condition monitoring program (Figure 7). However, there has been a gradual change through time (Figure 7) due to an increase submergent species in the aquatic zone and amphibious taxa in the littoral zone.

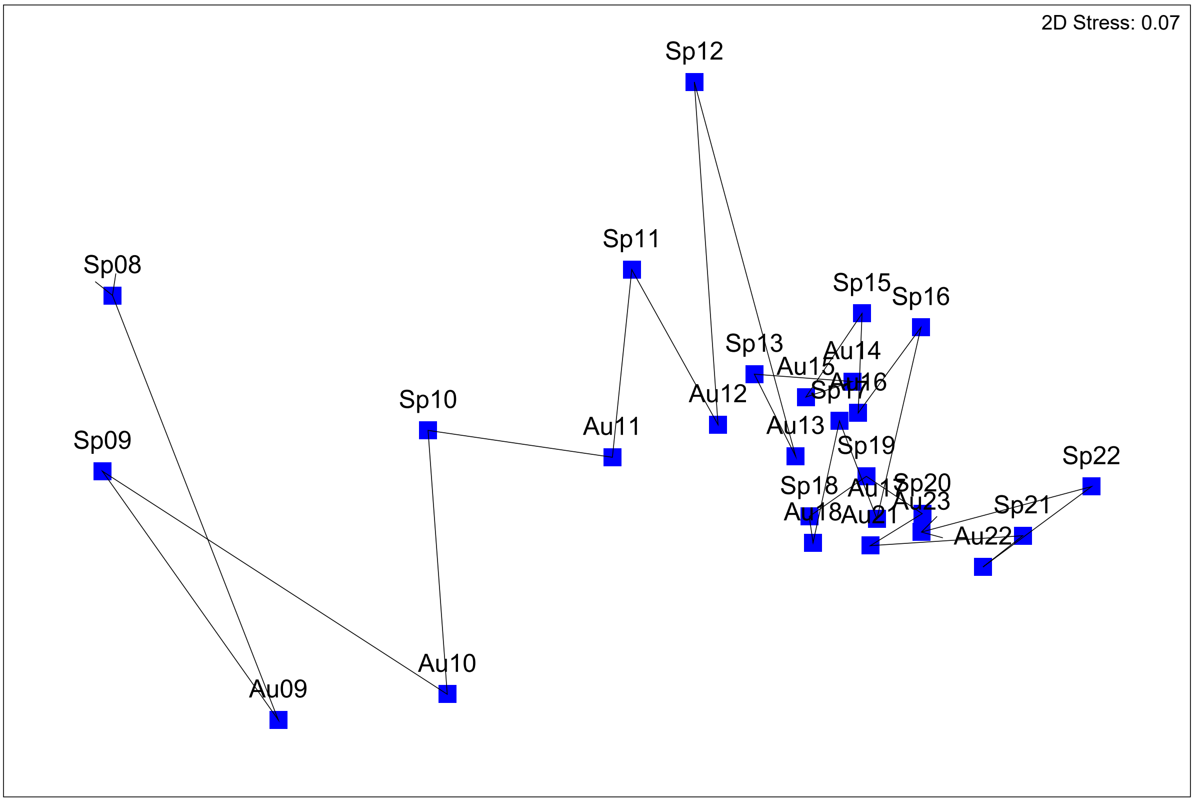



**Figure 8:** nMDS ordination comparing the plant community between spring 2008 and autumn 2023 in permanent wetlands (Sp denotes spring; Au denotes autumn).

## Temporary Wetlands

Strong seasonal changes in vegetation are evident in the seasonal wetlands that were monitored (Figure 9). Despite lack of hydrological connectivity to the Lower Lakes between spring 2008 and autumn 2010, all wetlands were partially inundated in spring 2008 and spring 2009 due to local rainfall and runoff hence the seasonal patterns in floristic composition during this period (Figure 7). The submergent species *Ruppia tuberosa* and *Lamprothamnium macropogon* were present in the inundated areas of several of the seasonal wetlands in spring 2008 and spring 2009 and absent in autumn 2009 and 2010 when the wetlands were dominated by terrestrial taxa. After water levels were reinstated in spring 2010 and the hydrological connection with the lakes restored, in contrast to the other habitats, the plant community was more like the community present in spring 2009 than in spring 2011 (Figure 9). There was, however, a change between spring 2010 and autumn 2011, after which there was very little change in floristic composition between autumn surveys (Figure 7). The change between spring 2010 and autumn 2011 was driven by an increase in the abundance of *Typha domingensis*, *Bolboschoenus caldwellii* and *Schoenoplectus pungens*. The seasonal patterns observed between autumn 2011 and autumn 2023 (Figure 7) were due to the presence of submergent species (*Ruppia tuberosa, Ruppia polycarpa, Myriophyllum verrucosum, Myriophyllum salsugineum, Althenia cylindrocarpa, Chara* sp. and *Lamprothamnium macropogon*) in spring. The evident change through time in spring (Figure 7) is due to the increase in abundance of submergent taxa.

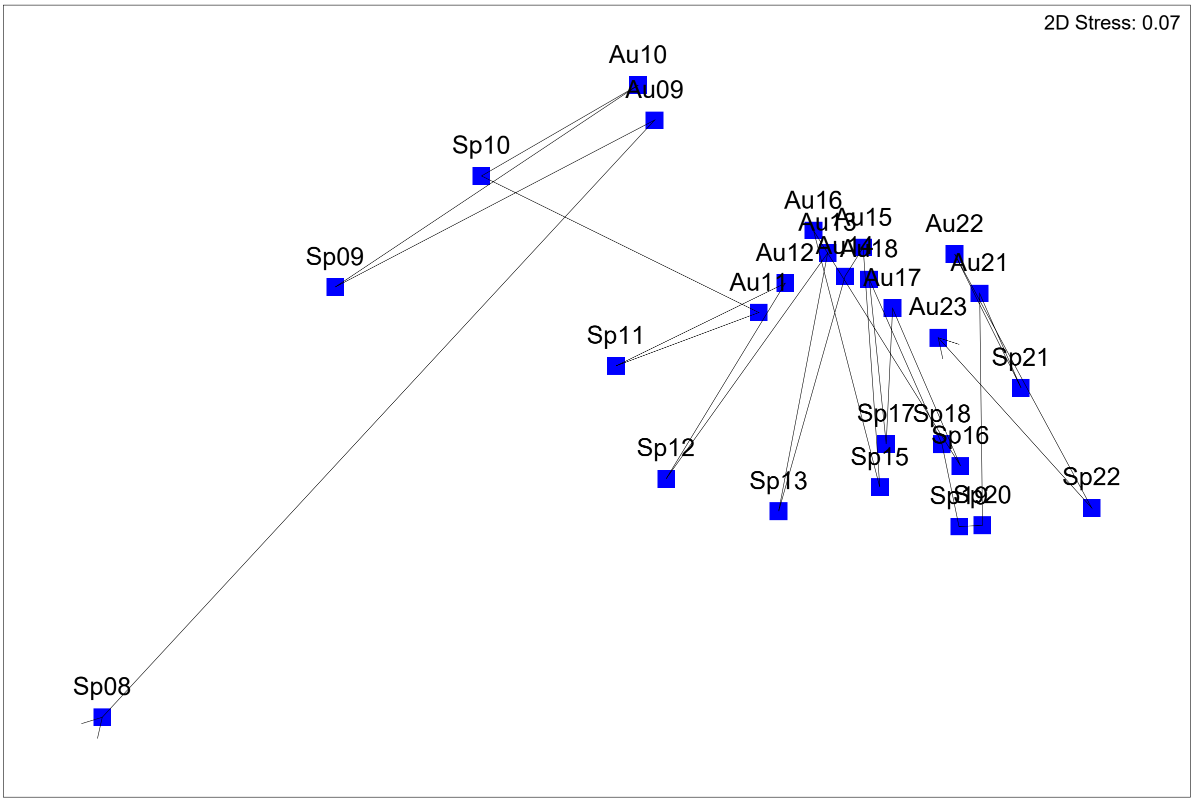


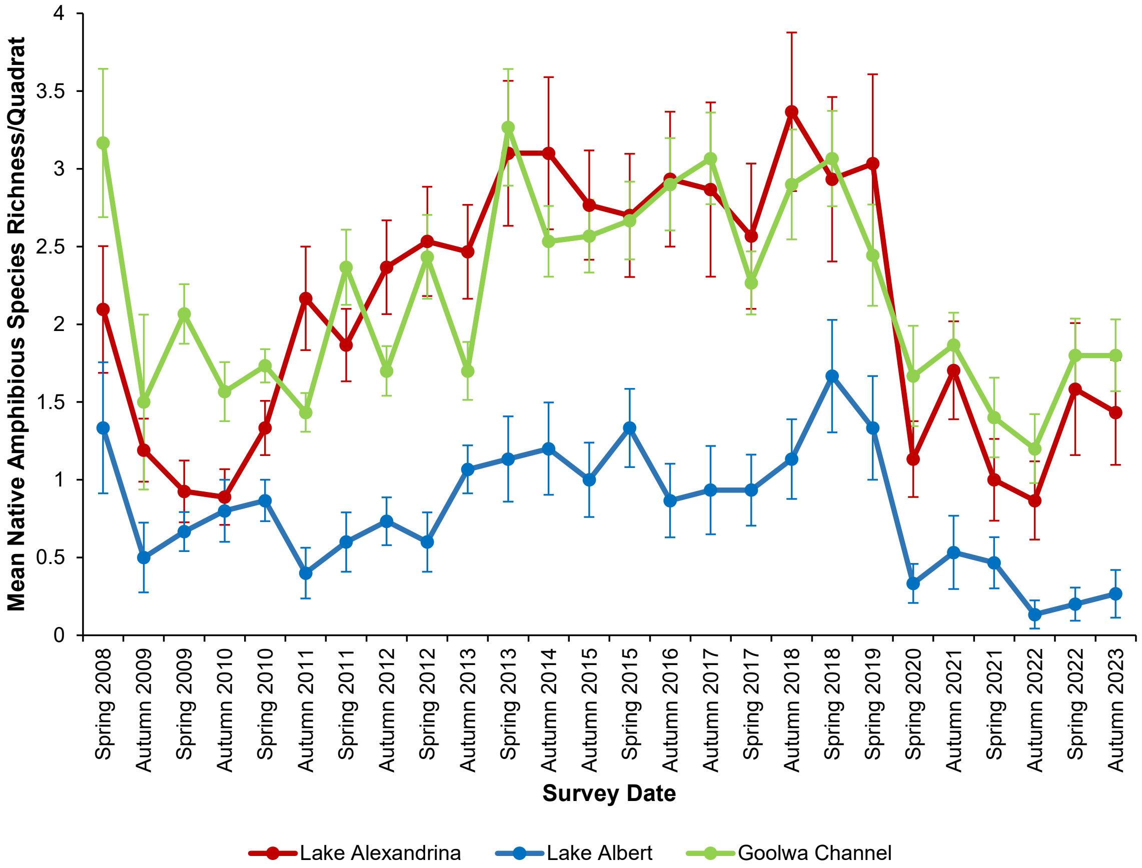

**Figure 9:** nMDS ordination comparing the plant community between spring 2008 and autumn 2023 in seasonal wetlands (Sp denotes spring; Au denotes autumn).

## Effect of variable water levels

Managed water level cycling for ecological outcomes has been undertaken in the Lower Lakes with spring surcharging (when water is available) and draw-down in late summer/autumn being undertaken between autumn 2018 and 2020 (Figure 2). This has resulted in quadrats at +0.6 m AHD being subjected to repeated patterns of inundation and exposure (Figure 2). Native amphibious species richness in Lake Alexandrina, Lake Albert and Goolwa Channel was plotted over the condition monitoring program to assess the benefit of the extended draw-down on the vegetation of the aforementioned habitats (Figure 10a). Native amphibious species richness at +0.6 m AHD declined during the drought but has generally increased since water levels were reinstated peaking in autumn 2018 in Lake Alexandrina and in spring 2018 in Lake Albert and Goolwa Channel (Figure 10). After which, there was a general decline across all habitats with the lowest species richness in autumn 2022 (Figure 10a). There was an increase across all habitats for the two most recent surveys, although species richness is still lower compared to 2018 (Figure 10a). Native amphibious species richness at +0.6 m AHD in Lake Albert is depauperate compared to Lake Alexandrina and Goolwa Channel (Figure 10).

Native amphibious species richness at +0.8 m AHD decreased across all habitats during the drought but there was an increasing trend since water levels were reinstated (Figure 10b). In contrast to +0.6 m AHD, this elevation is exposed more often and for longer so there is a greater opportunity for species that require exposure to recruit but there may be periods of low soil moisture. There are generally less native amphibious species at +0.8 m AHD compared to +0.6 m AHD across all habitats with Lake Albert having the lowest native amphibious species richness (Figure 10b).

a.



b.

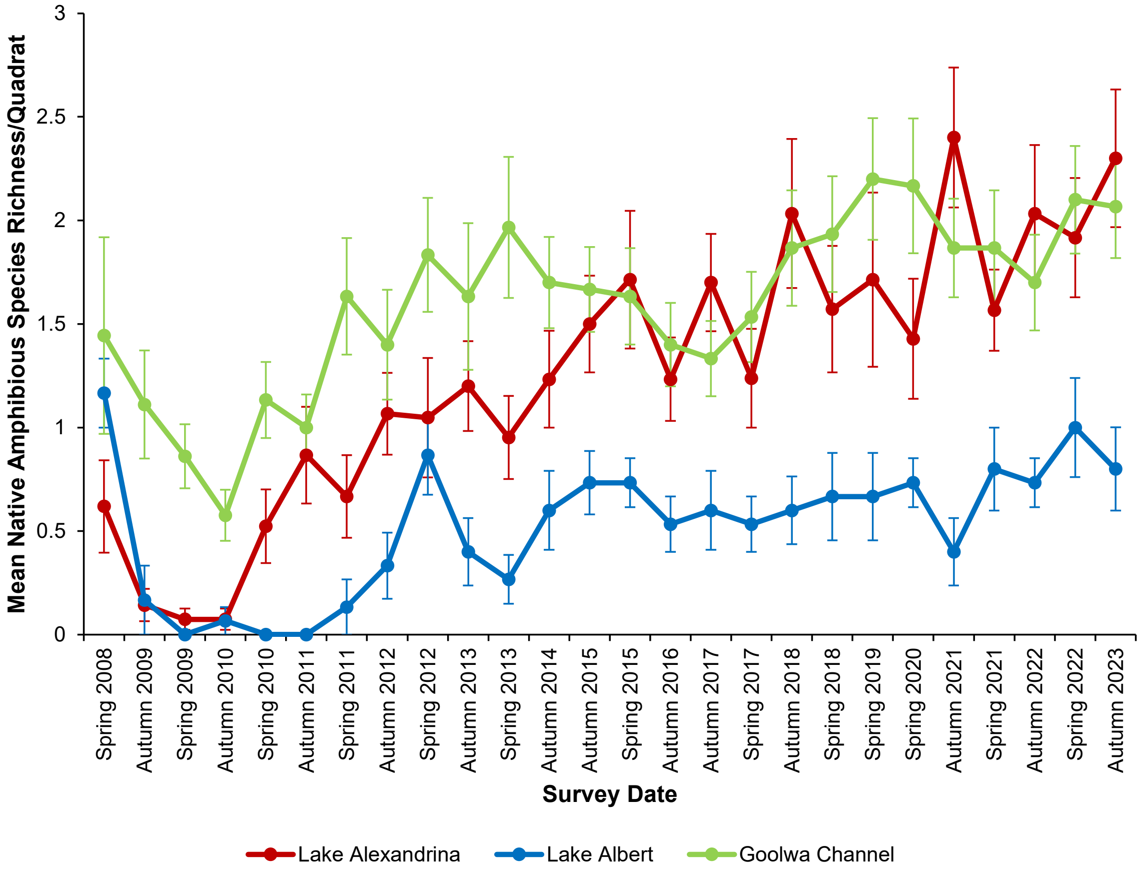



**Figure 10:** Mean native amphibious species richness per quadrat for Lake Alexandrina, Lake Albert and Goolwa Channel at a. +0.6 m and b. +0.8 m AHD over the condition monitoring program (error bars = ±1 S.E.).

## 3.2. TLM targets

The following section graphically presents the progress of achievement for each of the targets for each habitat outlined in Tables 1–5 over the duration of the condition monitoring program (spring 2008 to autumn 2023). Target thresholds were defined by the proportion (percentage) of quadrats containing a species or functional group above a certain percentage cover (Tables 1–5). Target thresholds presented in red on the graphs denote targets that are achieved when the percentage of quadrats is lower than the threshold (undesirable taxa) and thresholds presented in blue are met when the percentage of quadrats is higher than the threshold (desirable taxa). In addition, the habitat condition score calculated from the targets achieved from each habitat and the WOISS (calculated from the habitat condition scores) are presented for the duration of the condition monitoring program.

## Lake Alexandrina targets

### *Littoral Zone*

Figure 11 shows the percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 75% in the littoral zone from spring 2008 to autumn 2023. Prior to spring 2018, there was a seasonal trend with a higher proportion of quadrats containing a combined cover of these species greater than 75% in autumn compared to spring (Figure 11). In addition, there was a general upward trend of the indicator since water levels were reinstated in spring 2010 to autumn 2015, followed by a sharp decline then another general upward trend. The percentage of quadrats with a combined cover greater than 75% did not exceed 40% and the target was consistently achieved (Figure 11).

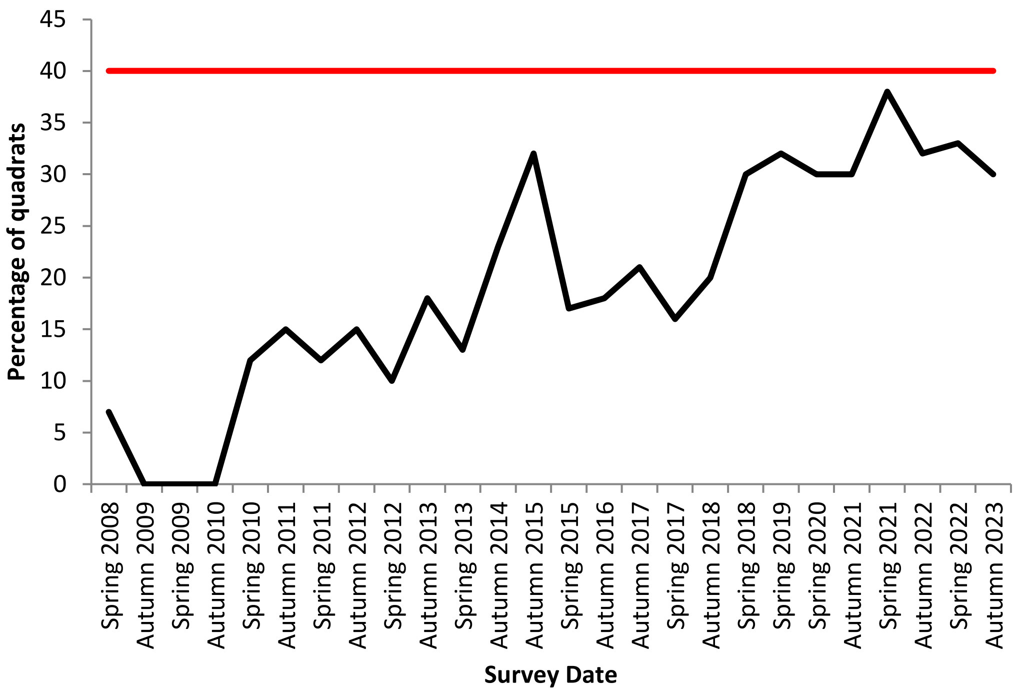



**Figure 11:** Percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 75% in the littoral zone of Lake Alexandrina from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 12 shows the percentage of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone from spring 2008 to autumn 2023. Between autumn 2009 and autumn 2010, more than 20% of quadrats contained a combined cover of these species greater than 50%; hence, the target was not met. However, when water levels were reinstated in spring 2010 the number of quadrats with a combined cover greater than 50% of these species fell below 20%, the target was achieved and there has been a general downward trend (Figure 12). The lowest proportion of quadrats with these species having a combined cover of greater than 50% was in spring 2022 (Figure 12).

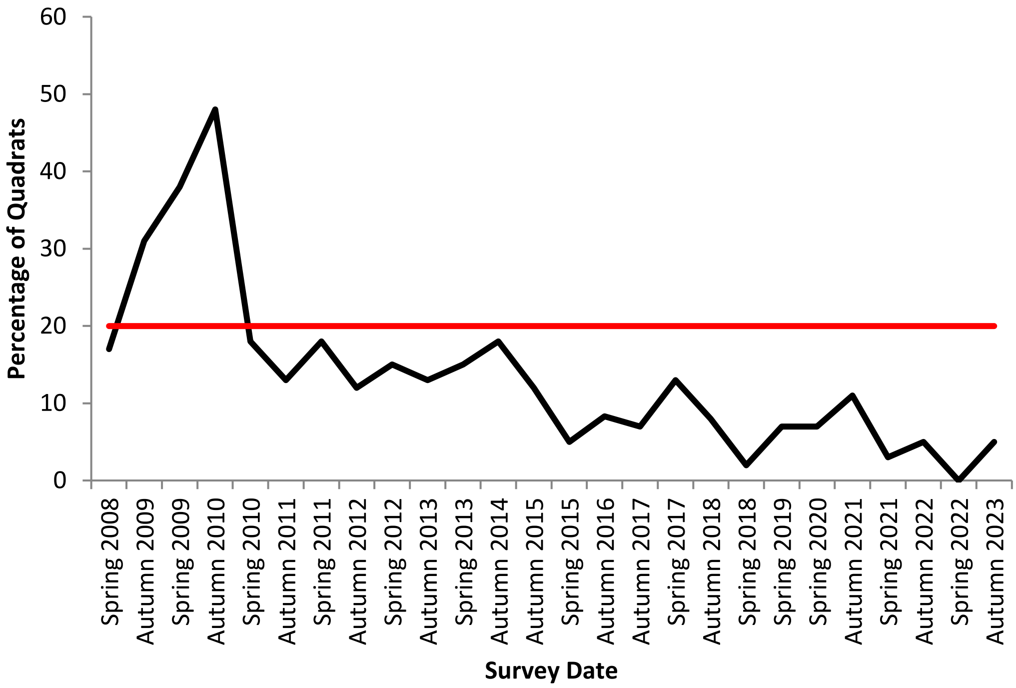



**Figure 12:** Percentage of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone of Lake Alexandrina from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 13 shows the percentage of quadrats containing a cover of native amphibious species ≥5% in the littoral zone from spring 2008 to autumn 2023. There has been an upward trend of the indicator since water levels were reinstated; however, this indicator did not exceed 50% of quadrats until autumn 2015 after which it has been consistently achieved, except in spring 2017 and spring 2022 (Figure 13).

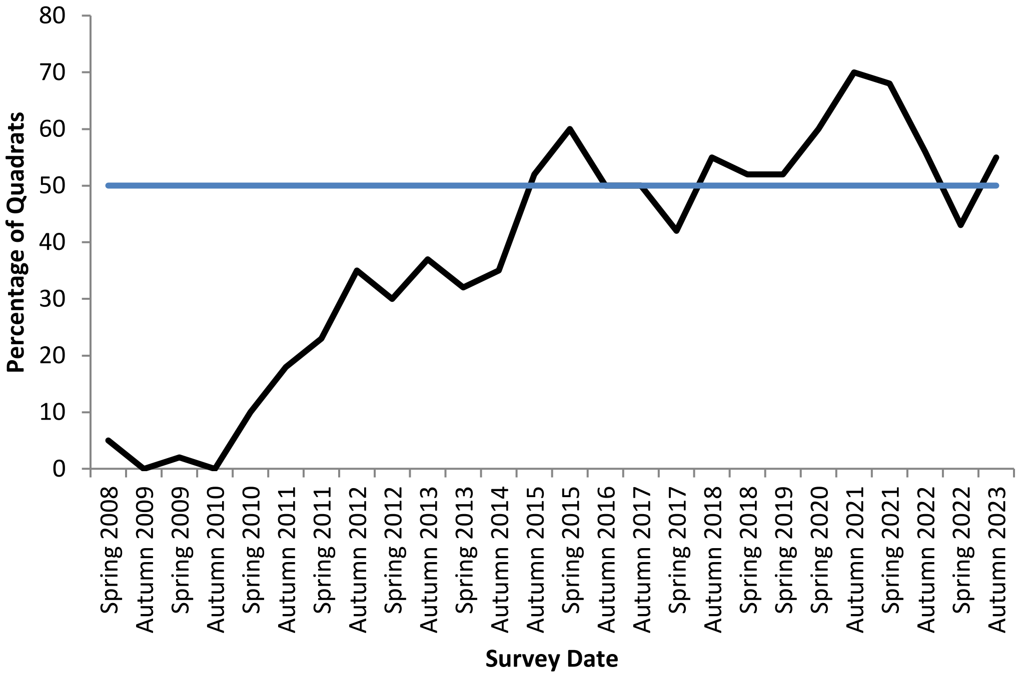



**Figure 13:** Percentage of quadrats containing a cover native amphibious species greater than 5% in the littoral zone of Lake Alexandrina from spring 2008 to autumn 2023 (the blue line represents the target threshold).

Figure 14 shows the percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* ≥5% in the littoral zone from spring 2008 to autumn 2023. The indicator has not exceeded 50% and peaked in autumn 2023 (22% of quadrats). Therefore, this target has not been achieved during the condition monitoring program (Figure 14). When water levels were reinstated the number of quadrats containing a cover of these species ≥5% generally increased until autumn 2017 and then declined in spring 2017. The number of quadrats meeting this cover threshold remained low until autumn 2021, after which there has been a general increase (Figure 14).

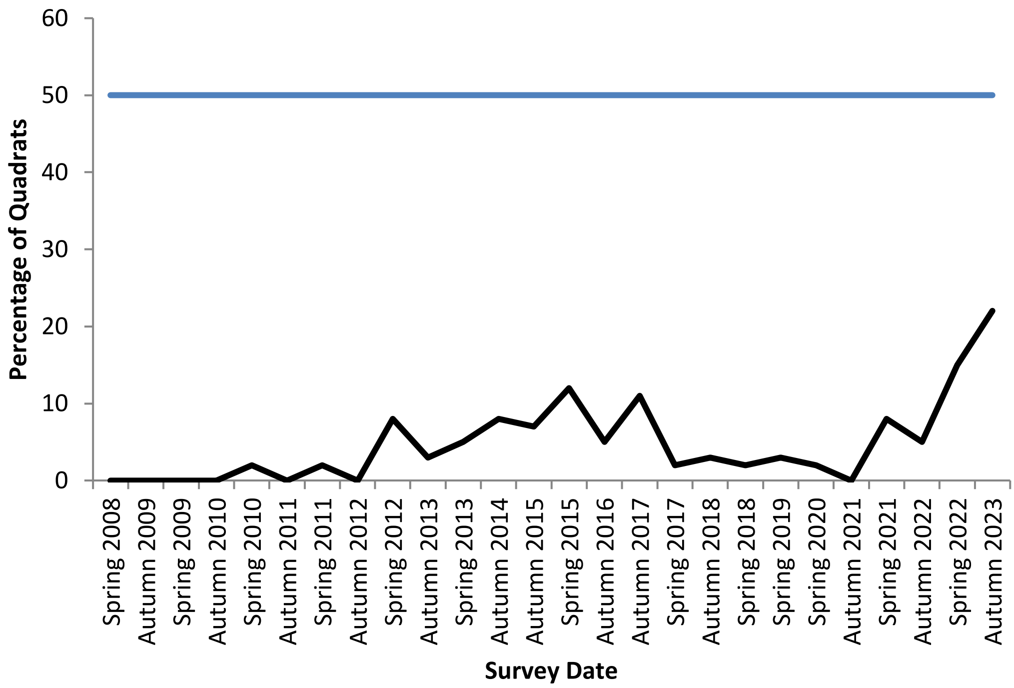



**Figure 14:** Percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* greater than 5% in the littoral zone of Lake Alexandrina from spring 2008 to autumn 2023 (the blue line represents the target threshold).

*Aquatic Zone*

Figure 15 shows the percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 50% in the aquatic zone from spring 2008 to autumn 2023. This indicator generally increased until spring 2017 after which there has been a general decrease. The proportion of quadrats has not exceeded 40% and the target has been achieved since spring 2008 (Figure 15).

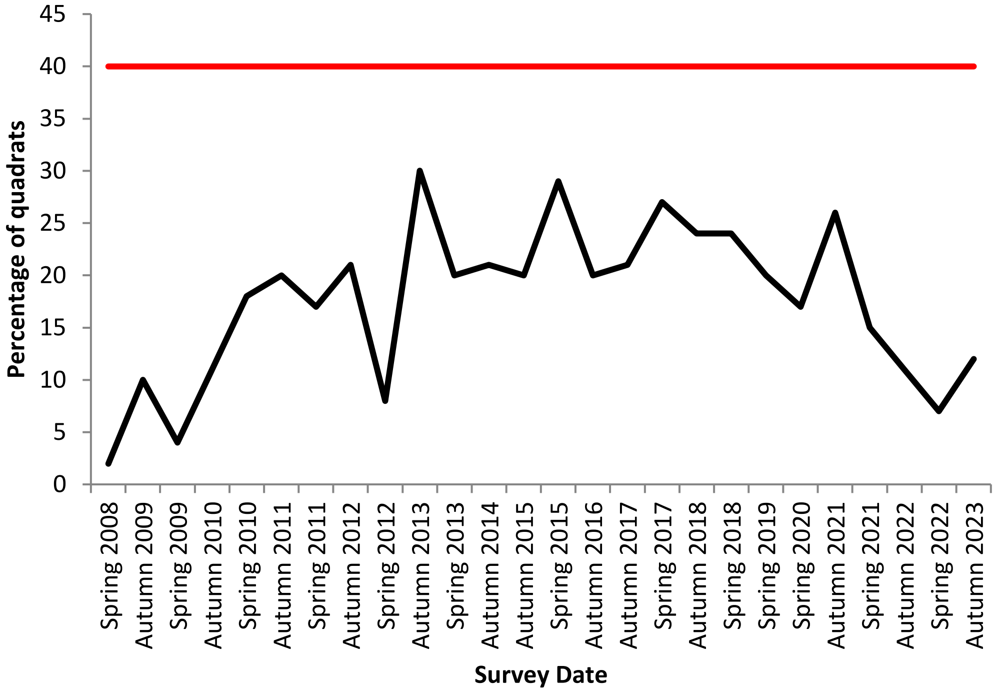



**Figure 15:** Percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 50% in the aquatic zone of Lake Alexandrina from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 16 shows the percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* ≥5% in the aquatic zone from spring 2008 to autumn 2023. This indicator generally increased since water levels were reinstated, peaking in spring 2021 the only time the target was acheived. There was a seasonal pattern after spring 2013 with higher proportions of quadrats containing these species with a cover of greater than 5% in spring compared to autumn (Figure 16).

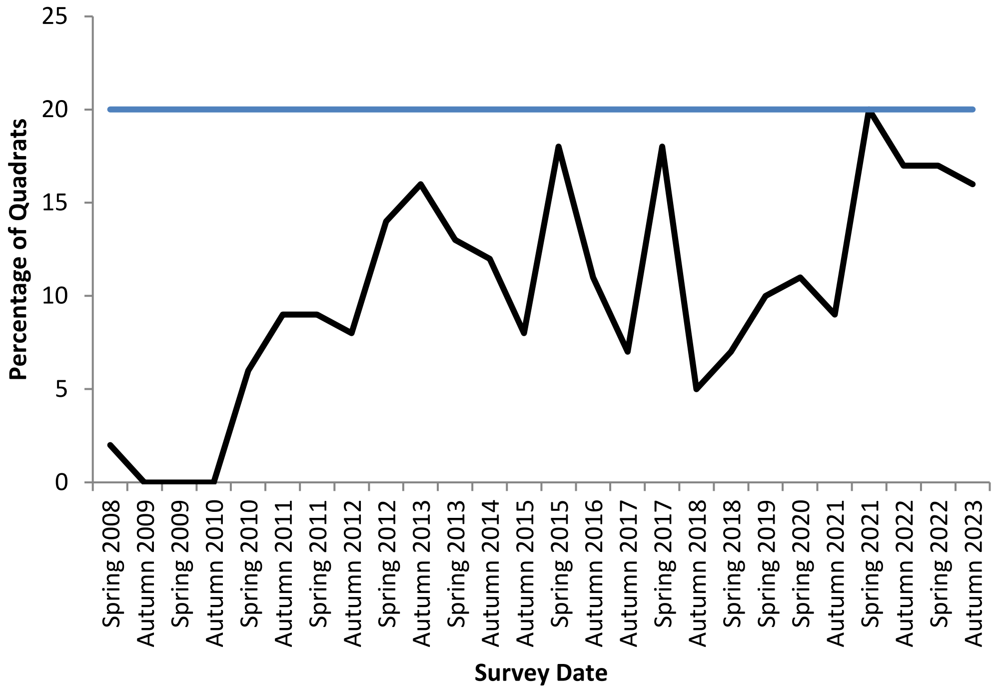



**Figure 16:** Percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* greater than 5% in the aquatic zone of Lake Alexandrina from spring 2008 to autumn 2023 (the blue line represents the target threshold).

Figure 17 shows the percentage of quadrats containing a cover of native submergent species ≥5% in the aquatic zone from spring 2008 to autumn 2023. During the drought, the aquatic zone was dry; hence, no submergent species were present and it was not until spring 2011 before a significant number of quadrats contained native submergent species. There was an increasing trend for this indicator after spring 2011 until autumn 2015, followed by a general decrease until spring 2017 and another increase peaking in spring 2021, the only time the target was achieved (Figure 17).

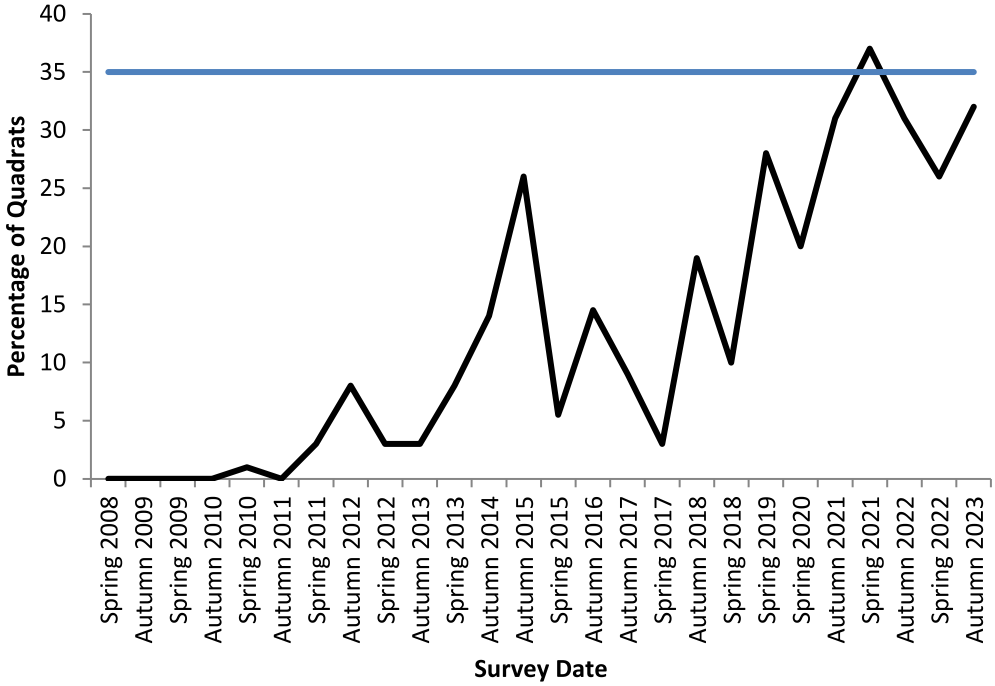



**Figure 17:** Percentage of quadrats containing a cover of native submergent species greater than 5% in the aquatic zone of Lake Alexandrina from spring 2008 to autumn 2023 (the red line represents the target threshold).

*Whole of habitat condition*

The whole of habitat condition score (the proportion of targets achieved) in Lake Alexandrina is shown in Figure 18. The increase between autumn 2010 and spring 2010 was due to water levels being reinstated and the target for the deep-water zone being achieved and the number of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone falling below 20% (Figure 12). No additional targets were achieved until autumn 2015 when the number of quadrats containing cover of native amphibious species ≥5% in the littoral zone exceeded 50% and the target was achieved every year since, except in spring 2017 (Figure 13). The increase in spring 2021 (Figure 18) was due to two targets in the aquatic zone (native emergent other than *Typha domingensis* and *Phragmites australis* and submergents) being achieved for the first time (Figure 16 and Figure 17). These targets have not been achieved since (Figure 16 and Figure 17); hence, the decline and in spring 2022 the native amphibious species target in the littoral zone was also not achieved (Figure 13) resulting in further decline (Figure 18). The native amphibious species target in the littoral zone was achieved in autumn 2023 (Figure 13) resulting in an increase in condition score (Figure 18).

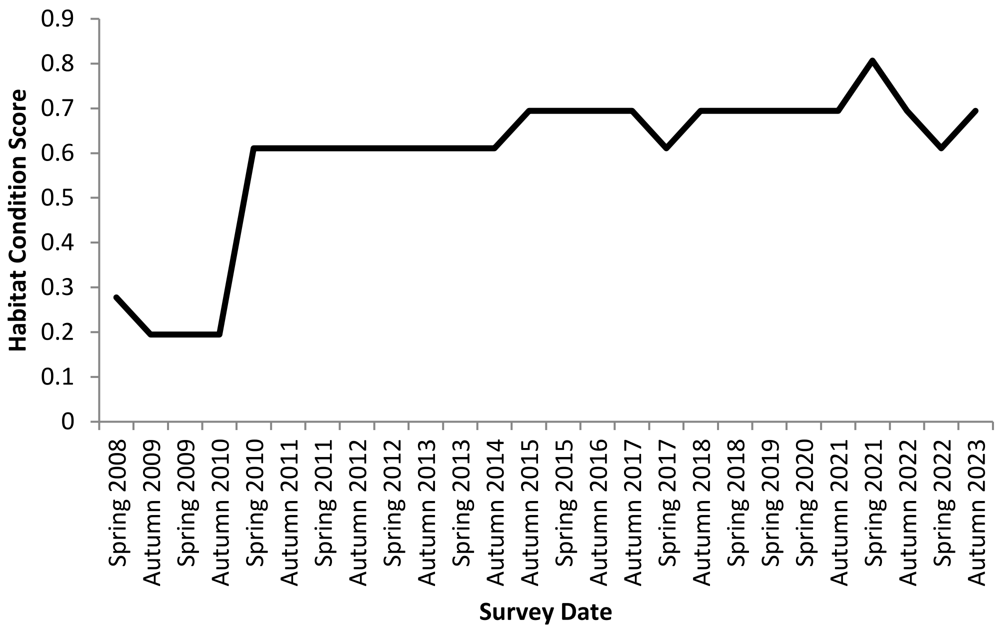



**Figure 18:** Whole of habitat condition score for Lake Alexandrina from spring 2008 to autumn 2023.

## Lake Albert

### *Littoral Zone*

Figure 19 shows the percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 75% in the littoral zone from spring 2008 to autumn 2023. There were no quadrats containing a combined cover of these species greater than 75% in the littoral zone until spring 2013, after which, there was a general upward trend peaking at 33% in spring 2022 (Figure 19). The number of quadrats has remained well below 40%; therefore, the target has consistently been achieved since spring 2008.

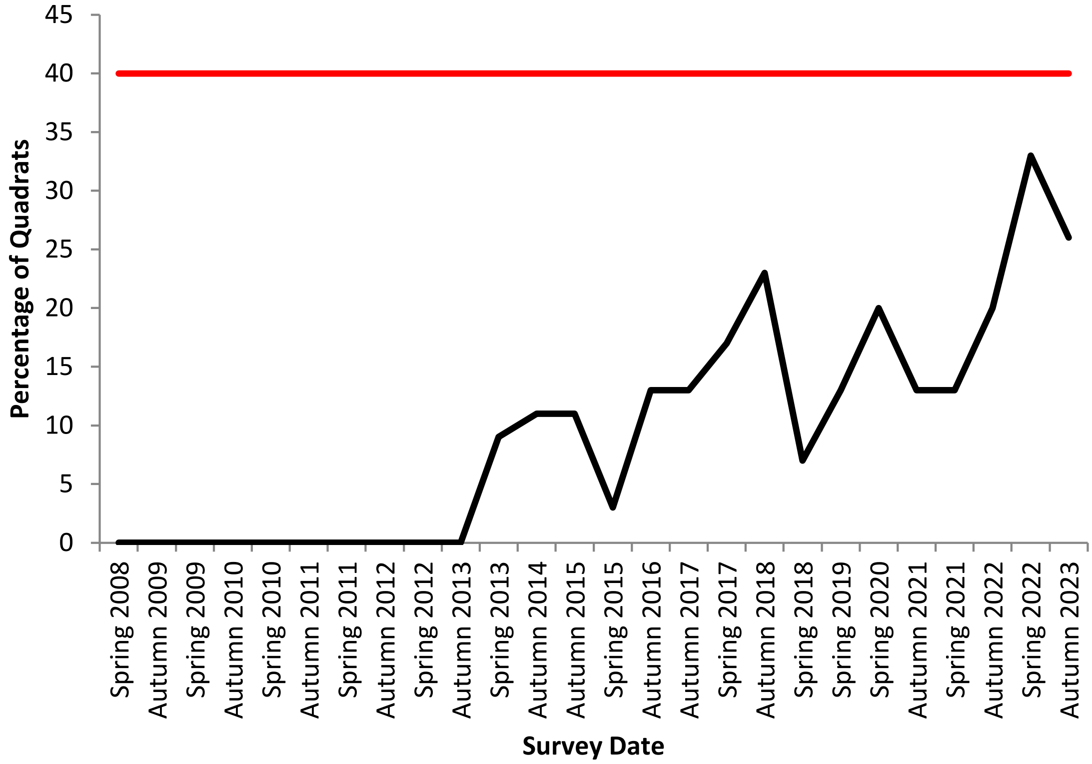



**Figure 19:** Percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 75% in the littoral zone of Lake Albert from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 20 shows the percentage of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone from spring 2008 to autumn 2023. Since autumn 2010 this indicator has generally decreased, with the number of quadrats falling below 20% in spring 2015 and the target achieved thereafter except in autumn 2018 (Figure 20). There were no quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone in spring 2018, spring 2020, autumn 2021, spring 2022 and autumn 2023 (Figure 20).

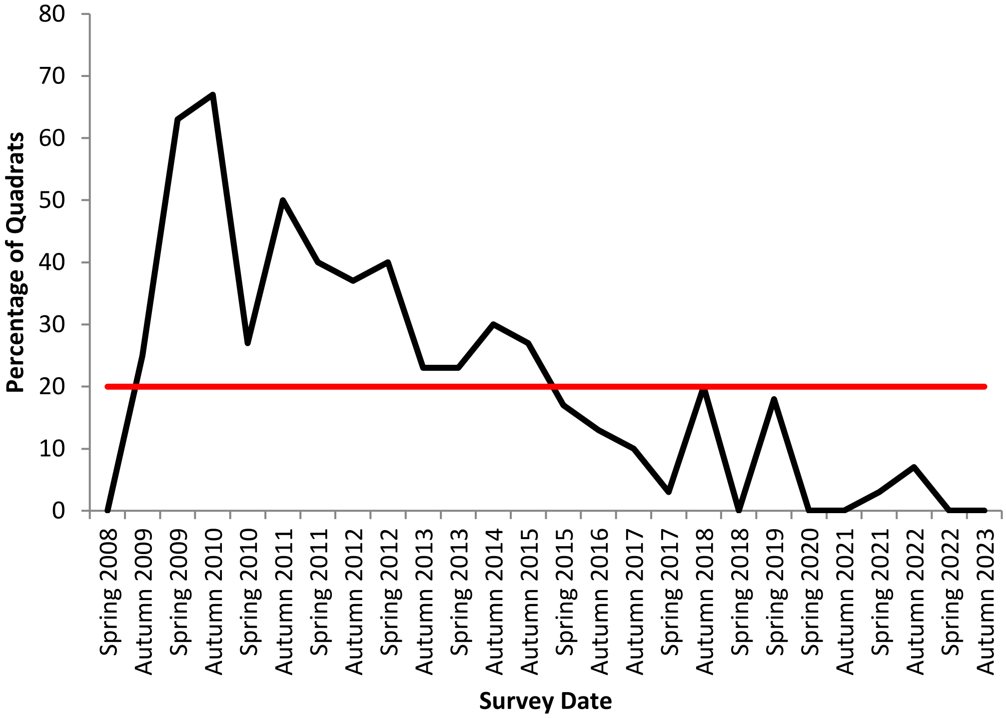



**Figure 20:** Percentage of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone of Lake Albert from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 21 shows the percentage of quadrats containing a cover of native amphibious species ≥5% in the littoral zone from spring 2008 to autumn 2023. The number of quadrats containing these species with a cover of ≥5% has been variable since spring 2008 showing no seasonal patterns or general trends over the condition monitoring program (Figure 21). However, there was an increase from spring 2017 with the target being achieved for the first time in spring 2019. After this there was a decline, followed by an increase which resulted in the target being achieved in spring 2021 and autumn 2022 but not the two most recent surveys (Figure 21).

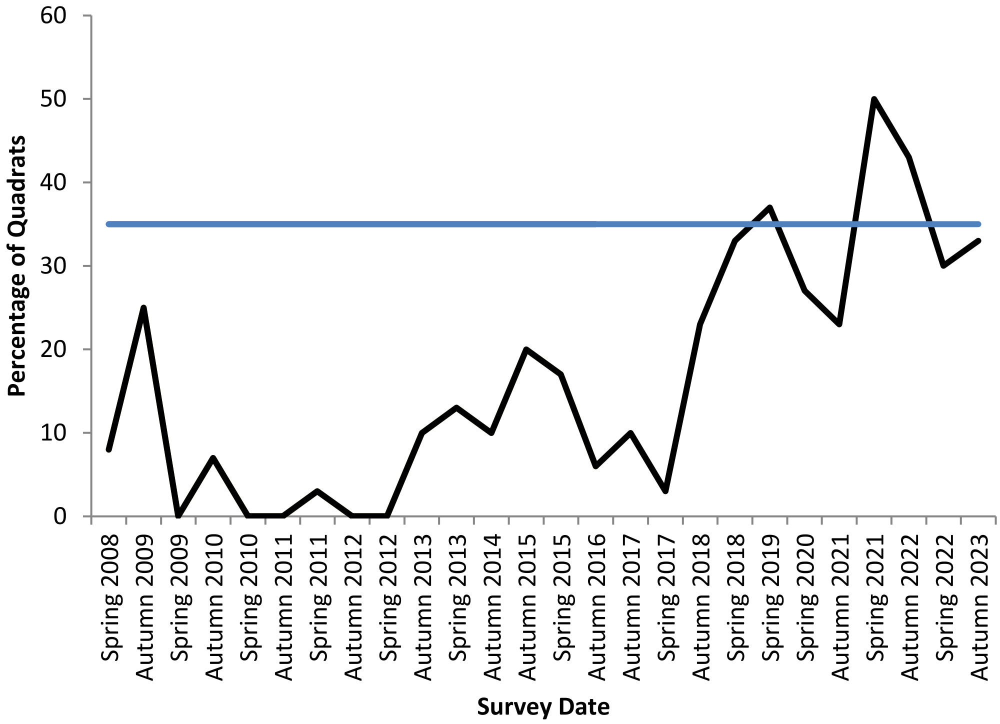



**Figure 21:** Percentage of quadrats containing a cover of native amphibious species greater than 5% in the littoral zone of Lake Albert from spring 2008 to autumn 2023 (the blue line represents the target threshold).

The combined cover of native emergent species other than *Typha domingensis* and *Phragmites australis* has not exceeded 5% in any quadrats in the littoral zone of Lake Albert since spring 2008; therefore, this target has not been achieved (Table 2).

*Aquatic Zone*

Figure 22 shows the percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 50% in the aquatic zone from spring 2008 to autumn 2023. There was a general upward trend of the indicator after water levels were reinstated, except in autumn 2015, spring 2020 and spring 2022 (Figure 22). The proportion of quadrats with a combined cover of *Typha domingensis* and *Phragmites australis* greater than 50% has not exceeded 40% (the largest number of quadrats was 18% in spring 2019) in the aquatic zone of Lake Albert and the target has been achieved since spring 2008 (Figure 22).

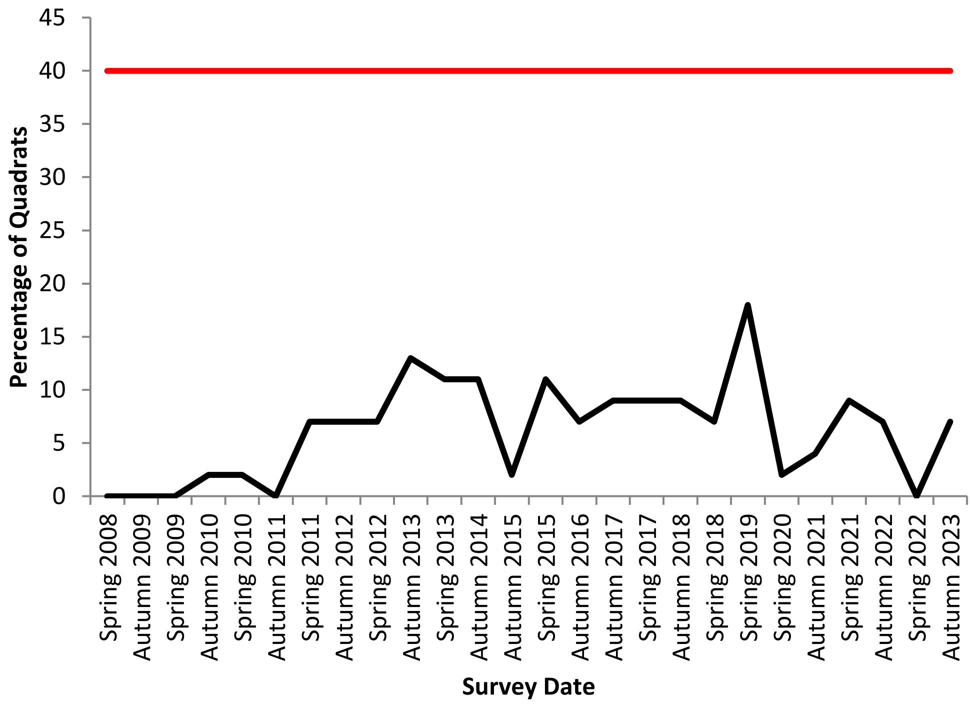



**Figure 22:** Percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 50% in the aquatic zone of Lake Albert from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 23 shows the percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* ≥5% in the aquatic zone from spring 2008 to autumn 2023. These species are uncommon in Lake Albert and quadrats with a combined cover in the aquatic zone ≥5% were recorded on nine occasions; autumn 2013, 2015, 2016, 2017, 2022 and 2023, and spring 2019, 2021 and 2022 (peaking at 13% in spring 2022) (Figure 23). The target has never been achieved over the survey period.

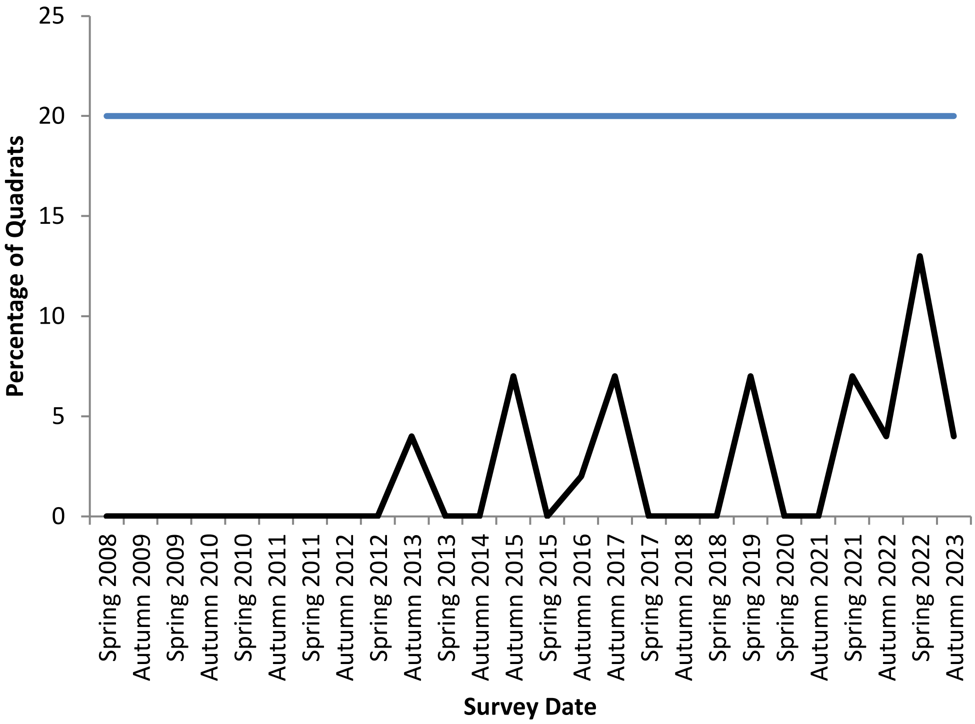



**Figure 23:** Percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* greater than 5% in the aquatic zone of Lake Albert from spring 2008 to autumn 2023 (the blue line represents the target threshold).

Figure 24 shows the percentage of quadrats containing a cover of native submergent species ≥5% in the aquatic zone from spring 2008 to autumn 2023. During the drought the aquatic zone was dry; hence, no submergent species were present. There were two occasions (spring 2011, 6% of quadrats and spring 2022, 3% of quadrats) when native submergent species were present ≥5% cover (Figure 24) in any quadrats. However, neither occasion came close to 20% of quadrats; hence, the target has never been achieved.

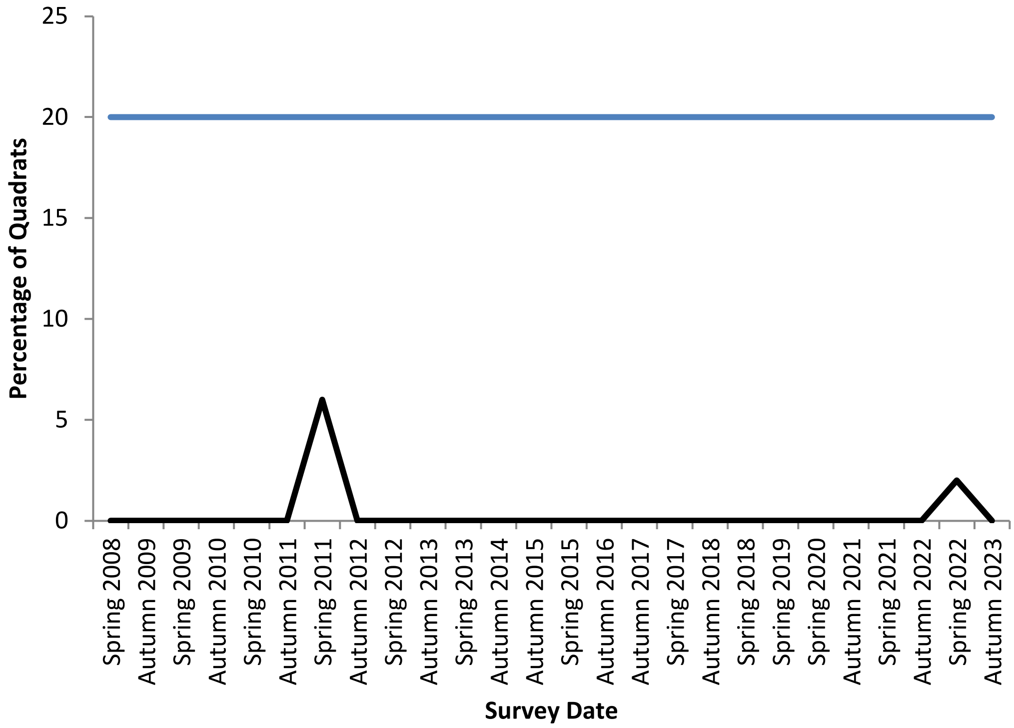



**Figure 24:** Percentage of quadrats containing a cover of native submergent species greater than 5% in the aquatic zone of Lake Albert from spring 2008 to autumn 2023 (the blue line represents the target threshold).

*Whole of habitat condition*

The whole of habitat condition score for Lake Albert is shown in Figure 25. The increase between autumn and spring of 2010 was due to water levels being reinstated and the target for the deep-water zone being achieved (Figure 25). No additional targets were achieved until spring 2015 when the number of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone fell below 20% (Figure 20). However, the proportion of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone increased to 20% in autumn 2018 (Figure 20) and the target was not achieved; hence, the decrease in condition score in autumn 2018 (Figure 25). This target was achieved in spring 2018 (Figure 20), resulting in an increase in habitat condition score between autumn and spring 2018 (Figure 25). There was a further increase between spring 2018 and spring 2019 (Figure 25), which was due to the percentage of quadrats containing cover of native amphibious species ≥5% in the littoral zone exceeded 35% of quadrats, resulting in the target being achieved for the first time (Figure 21). The achievement of this target has varied since then, resulting in a variable condition score in this period (Figure 25) but this target was not achieved in the two most recent surveys (Figure 21).

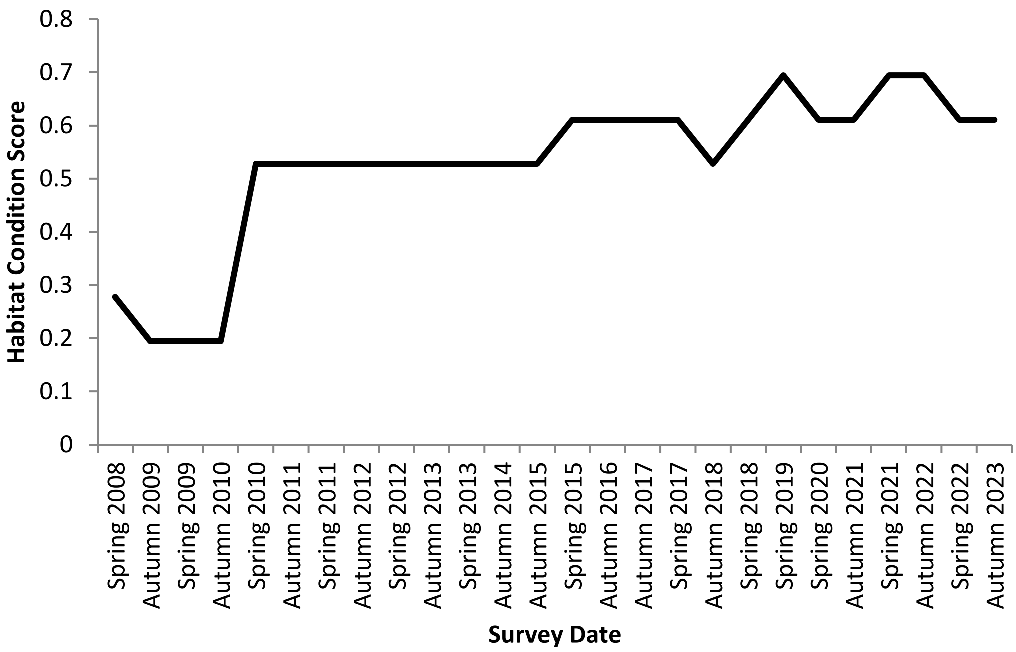



**Figure 25:** Whole of habitat condition score for Lake Albert from spring 2008 to autumn 2023

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## Goolwa Channel

### *Littoral Zone*

Figure 26 shows the percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 75% in the littoral zone from spring 2008 to autumn 2023. There was an upward trend after water levels were reinstated then fluctuation around the target followed by a decline after spring 2015 (Figure 26). The indicator exceeded 50% of quadrats on six occasions (Figure 26). Since spring 2017 it was below 50%, except in spring 2018, resulting in the target being achieved except in spring 2018 (Figure 26).

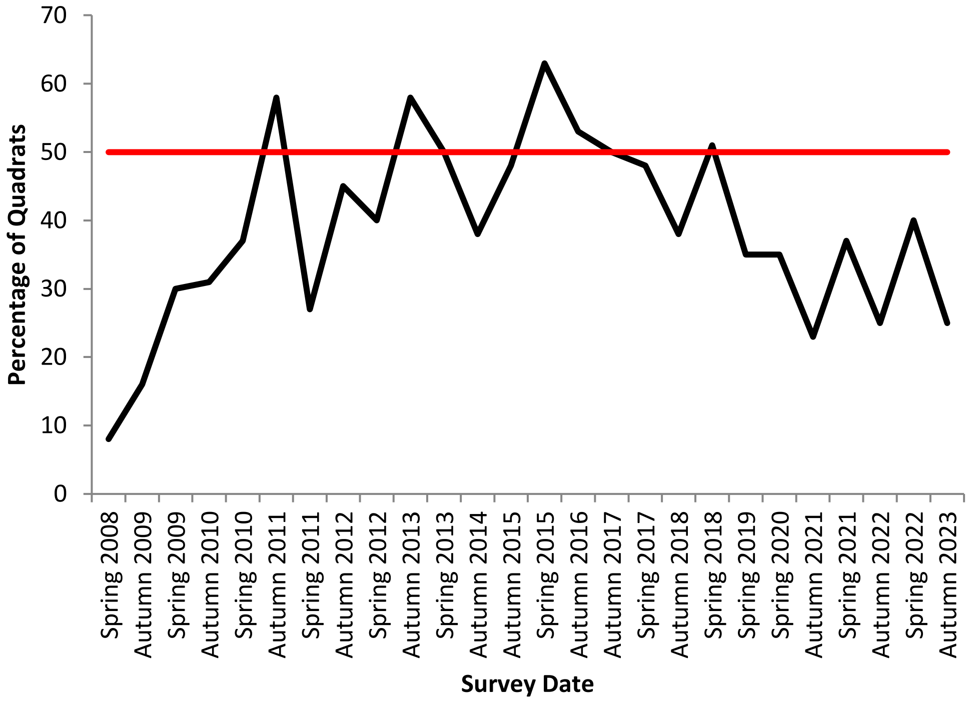


**Figure 26:** Percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 75% in the littoral zone of Goolwa Channel from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 27 shows the percentage of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone from spring 2008 to autumn 2023. The only time this target was not achieved was in autumn 2010, after which there has been a general downward trend (except between autumn 2015 and spring 2017) of the indicator (Figure 27).

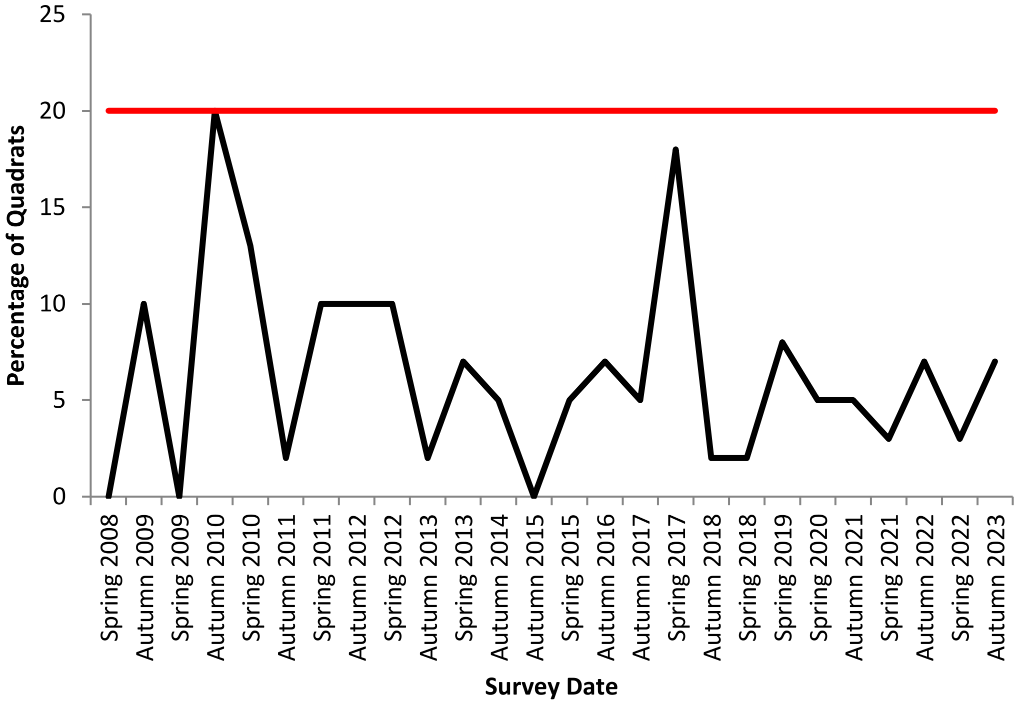


**Figure 27:** Percentage of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone of Goolwa Channel from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 28 shows the percentage of quadrats containing a cover of native amphibious species ≥5% in the littoral zone from spring 2008 to autumn 2023. The indicator has trended upwards since spring 2008; however, there were also strong seasonal patterns from spring 2009 to spring 2013 with higher abundances of these species in spring (Figure 28). After spring 2013 there were no seasonal patterns, and the target has been achieved each subsequent survey (Figure 28).

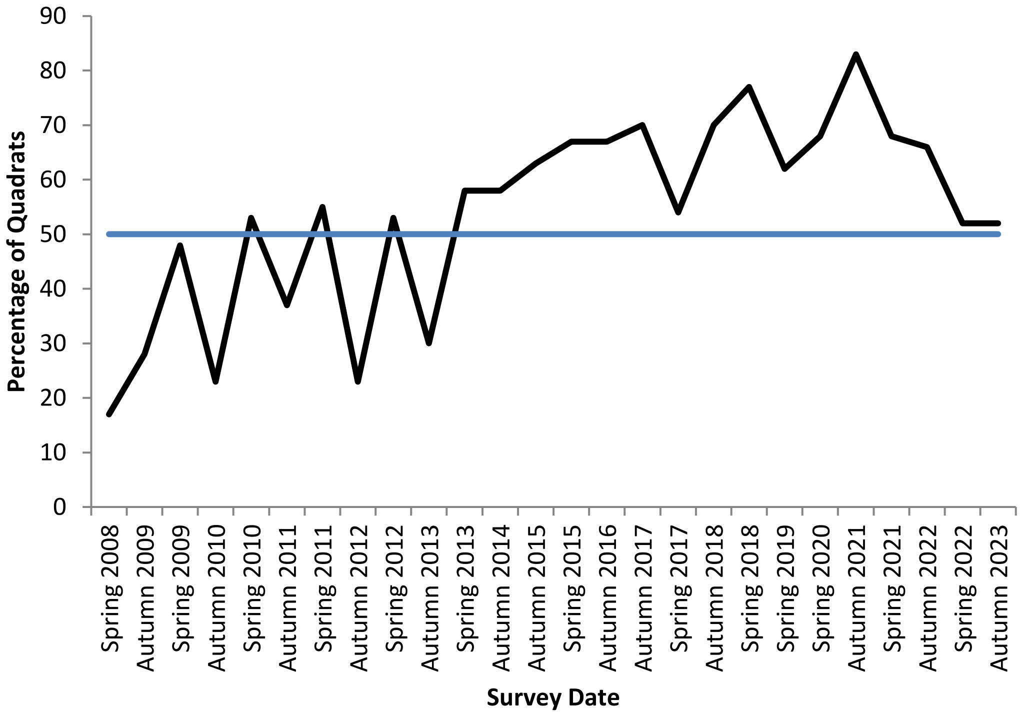


**Figure 28:** Percentage of quadrats containing a cover native amphibious species greater than 5% in the littoral zone of Goolwa Channel from spring 2008 to autumn 2023 (the blue line represents the target threshold).

Figure 29 shows the percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* ≥5% in the littoral zone from spring 2008 to autumn 2023. The indicator has not exceeded 50% of quadrats; therefore, this target has not been achieved during the condition monitoring program (Figure 29). However, there was an increasing trend from spring 2009 to spring 2013 (13% of quadrats) followed by a decrease in autumn 2014 (Figure 29). After autumn 2014 there was another upward trend peaking in spring 2018 followed by a downward trend until autumn 2021 (Figure 29). After then it uncreased until spring 2022 when peaked at 37% of quadrats (Figure 29).

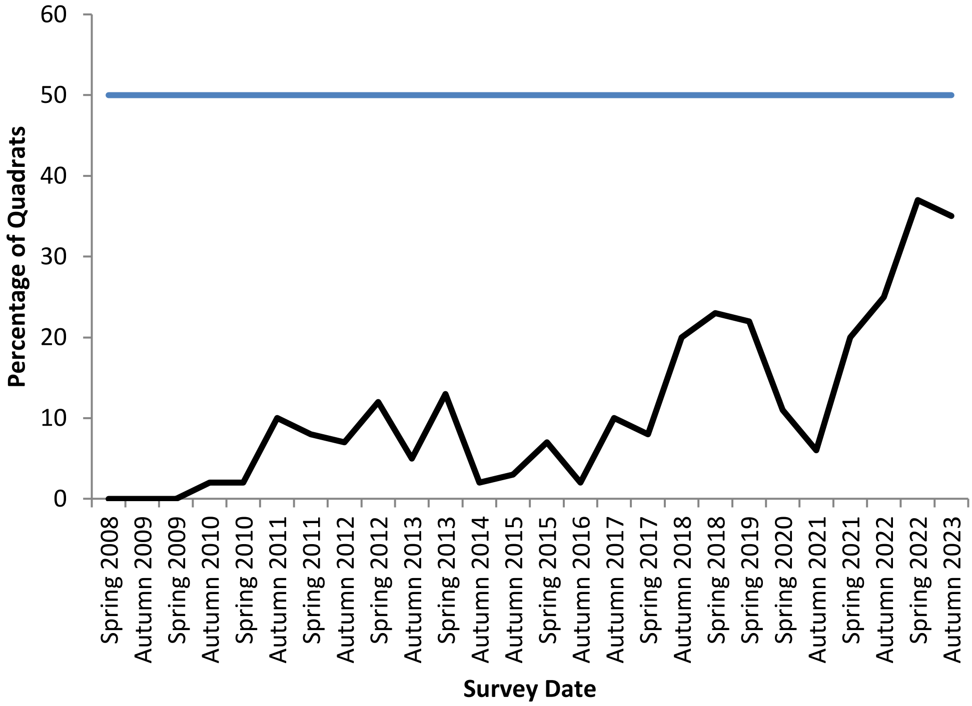


**Figure 29:** Percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* greater than 5% in the littoral zone of Goolwa Channel from spring 2008 to autumn 2023 (the blue line represents the target threshold).

*Aquatic Zone*

Figure 30 shows the percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 50% in the aquatic zone from spring 2008 to autumn 2023. The indicator has exceeded 50% of quadrats on four occasions with the target achieved since autumn 2016 (Figure 30).

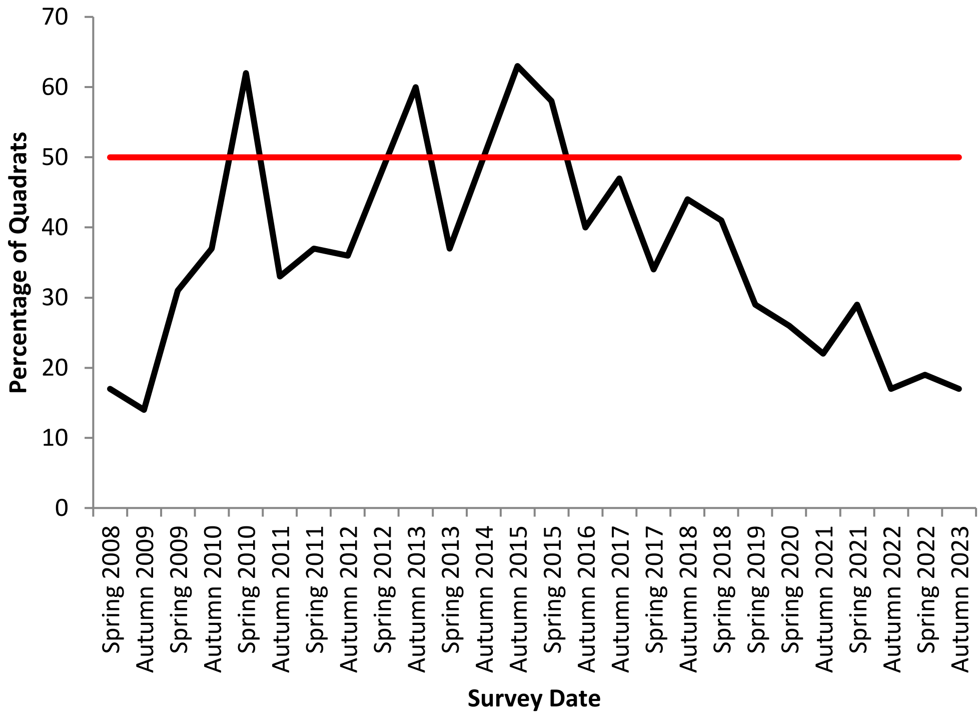


**Figure 30:** Percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 50% in the aquatic zone of Goolwa Channel from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 31 shows the percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* ≥5% in the aquatic zone from spring 2008 to autumn 2023. The indicator exceeded 50% of quadrats (and the target was achieved) for the first time in spring 2018, again in spring 2020 and spring 2021 with a general upwards trend since spring 2009 (Figure 31). However, the target has not been achieved for the three most recent surveys (Figure 31).

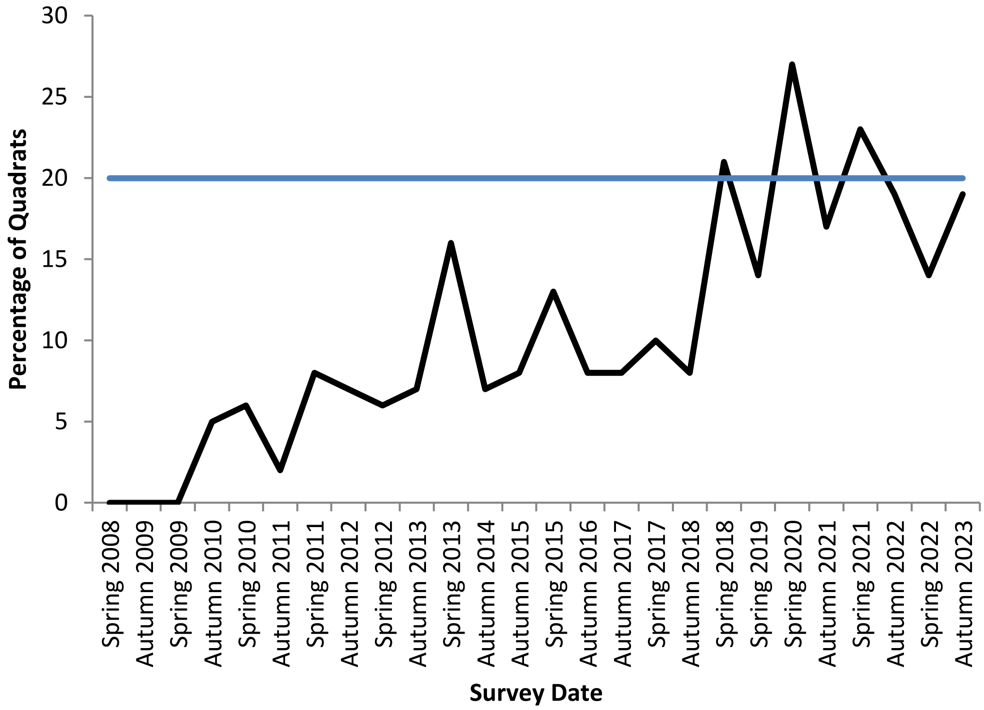


**Figure 31:** Percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* greater than 5% in the aquatic zone of Goolwa Channel from spring 2008 to autumn 2023 (the blue line represents the target threshold).

Figure 32 shows the percentage of quadrats containing a cover of native submergent species ≥5% in the aquatic zone from spring 2008 to autumn 2023. Before spring 2009 the aquatic zone was dry; hence, no submergent species were present but after 2009 there was an increasing trend in the number of quadrats containing native submergent species with a cover of ≥5% peaking in autumn 2016 at 27% of quadrats (Figure 32). From autumn 2016 to spring 2017 there was a downwards trend followed by an upwards trend with the target being achieved for the first time in spring 2020 and again in the four most recent surveys (Figure 32).

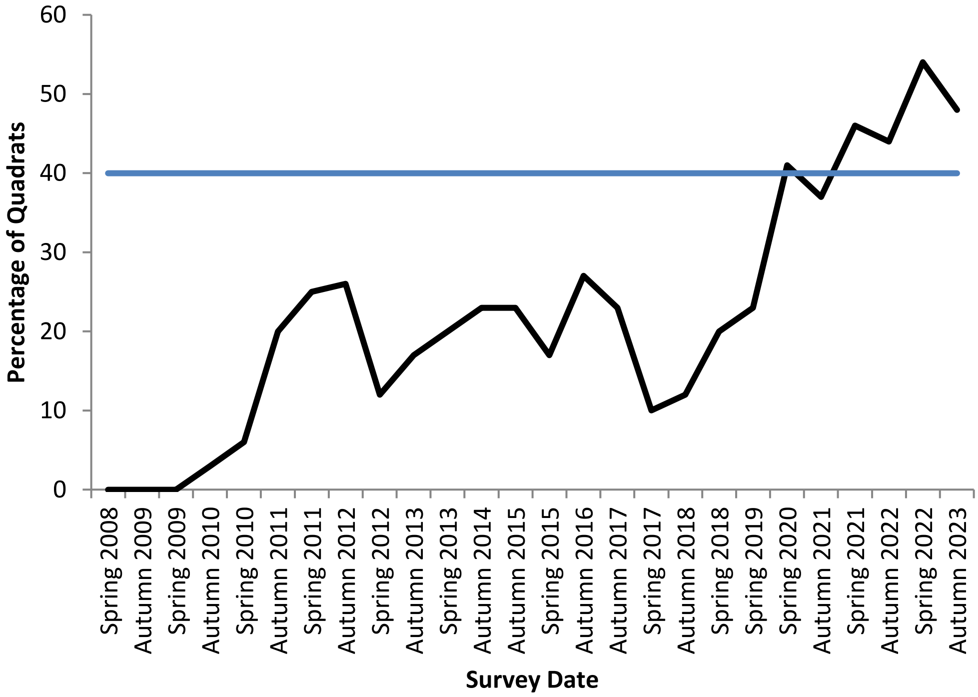


**Figure 32:** Percentage of quadrats containing a cover of native submergent species greater than 5% in the aquatic zone of Goolwa Channel from spring 2008 to autumn 2023 (the blue line represents the target threshold).

*Deep-water zone*

Figure 33 shows the percentage of quadrats containing a cover of native submergent species ≥5% in the deep-water zone from spring 2008 to autumn 2023. Before spring 2009, much of the deep-water zone was dry; hence, no submergent species were present (Figure 33). Between spring 2009 and spring 2010, there was a large increase in the number of quadrats with ≥5% cover of native submergent species (79% in spring 2010) due to the dominance of *Potamogeton pectinatus* after the Clayton Regulator was constructed. After the Clayton Regulator was breached in spring 2010 there was a decrease in the number of quadrats with ≥5% cover of native submergents but the number remained above the target until spring 2015 when it decreased (Figure 33). The target was not achieved again until autumn 2018 and from spring 2020 onwards (Figure 33).

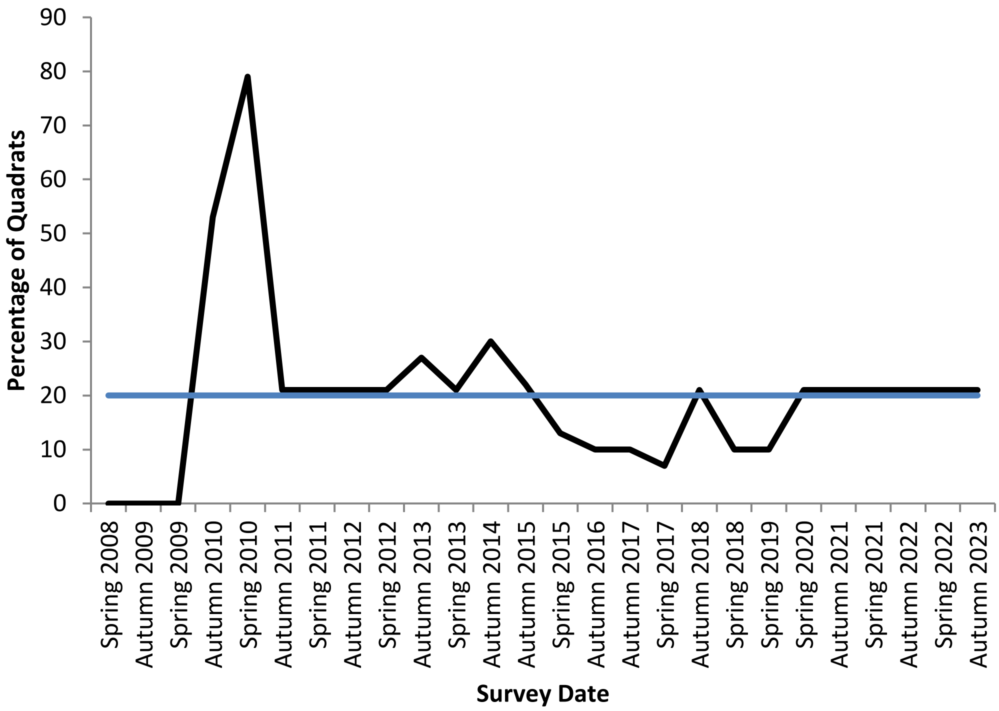


**Figure 33:** Percentage of quadrats containing a cover of native submergent species greater than 5% in the deep water zone of Goolwa Channel from spring 2008 to autumn 2023 (the blue line represents the target threshold).

*Whole of habitat condition*

The whole of habitat condition score for Goolwa Channel is shown in Figure 34. In contrast to lakes Alexandrina (Figure 18) and Albert (Figure 25) there was greater fluctuation in habitat condition score over the condition monitoring program for Goolwa Channel (Figure 34). The generally increasing trend between spring 2008 and autumn 2015 was due to the deep-water target being achieved over this period (Figure 33). The minor fluctuations over this period were due to the *Typha domingensis* and *Phragmites australis* targets in the littoral (Figure 26) and aquatic (Figure 30) zones and the native amphibious species target (Figure 28) in the littoral zone being achieved for some surveys and not others (often due to seasonal patterns in abundance). The decrease in habitat condition score between autumn 2015 and autumn 2016 was because the deep water (Figure 33) and littoral *Typha domingensis* and *Phragmites australis* targets (Figure 26) were not achieved. The increase in condition score between autumn 2017 and autumn 2018 was due to the littoral *Typha domingensis* and *Phragmites australis* target being achieved in spring 2017 and autumn 2018 (Figure 26) and the deep water target being achieved in autumn 2018 (Figure 33). The decline in condition score between autumn 2018 and spring 2019 was due to the littoral zone *Typha domingensis* and *Phragmites australis* (Figure 26) and deep water submergent vegetation (Figure 33) targets not being achieved, despite the emergent species other than *Typha domingensis* and *Phragmites australis* target being achieved in the aquatic zone (Figure 31). The further decline between spring 2018 and 2019 was due to the emergent species other than *Typha domingensis* and *Phragmites australis* target not being achieved in the aquatic zone in spring 2019 (Figure 31). The increase between spring 2019 and spring 2020 was due to the deep water (Figure 33) and the aquatic zone native submergent targets being met (Figure 32). The decline between spring 2020 and autumn 2021 was due to the native submergent target in the aquatic zone not being achieved, the increase in spring 2021 due to this target and the native emergent other than *Typha domingensis* and *Phragmites australis* in the aquatic zone being achieved (Figure 31 and Figure 32). The small decrease in autumn 2022 was due native emergent other than *Typha domingensis* and *Phragmites australis* in the aquatic zone not being achieved (Figure 31). There has been no change in targets achieved or not achieved for the two most recent surveys; hence no change in condition score (Figure 34).

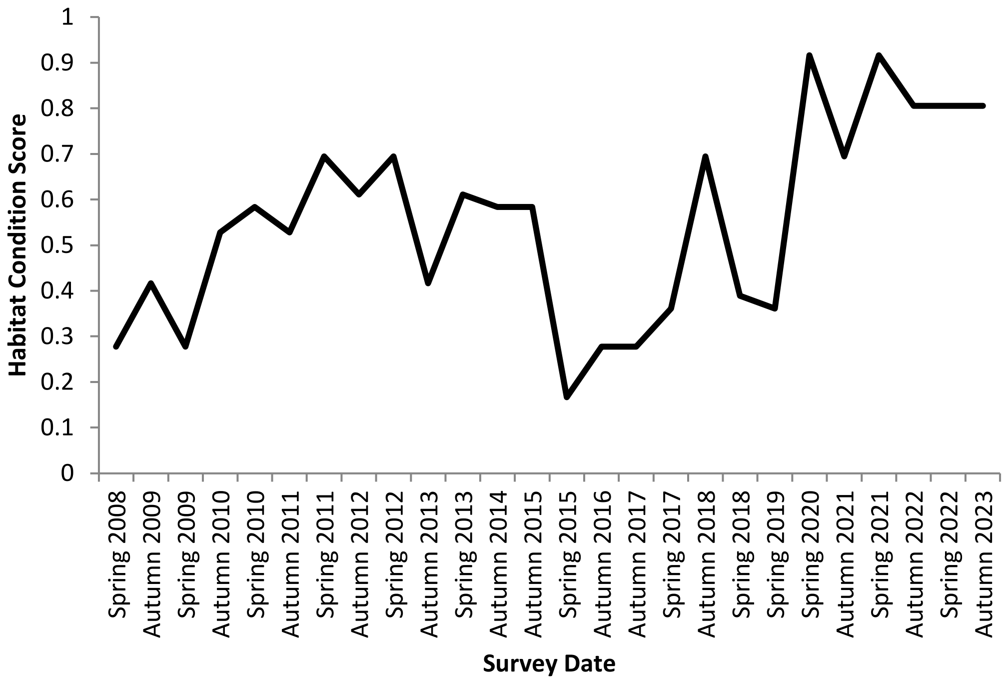


**Figure 34:** Whole of habitat condition score for Goolwa Channel from spring 2008 to autumn 2023.

## Permanent wetlands

### *Littoral zone*

Figure 35 shows the percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 75% in the littoral zone from spring 2008 to autumn 2023. Quadrats in the littoral zone containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 75% were uncommon in permanent wetlands and has never exceeded the target of 35% of quadrats (Figure 35). Therefore, this target has been achieved throughout the condition monitoring program despite there being an upward trend between autumn 2016 and spring 2022 (Figure 35).

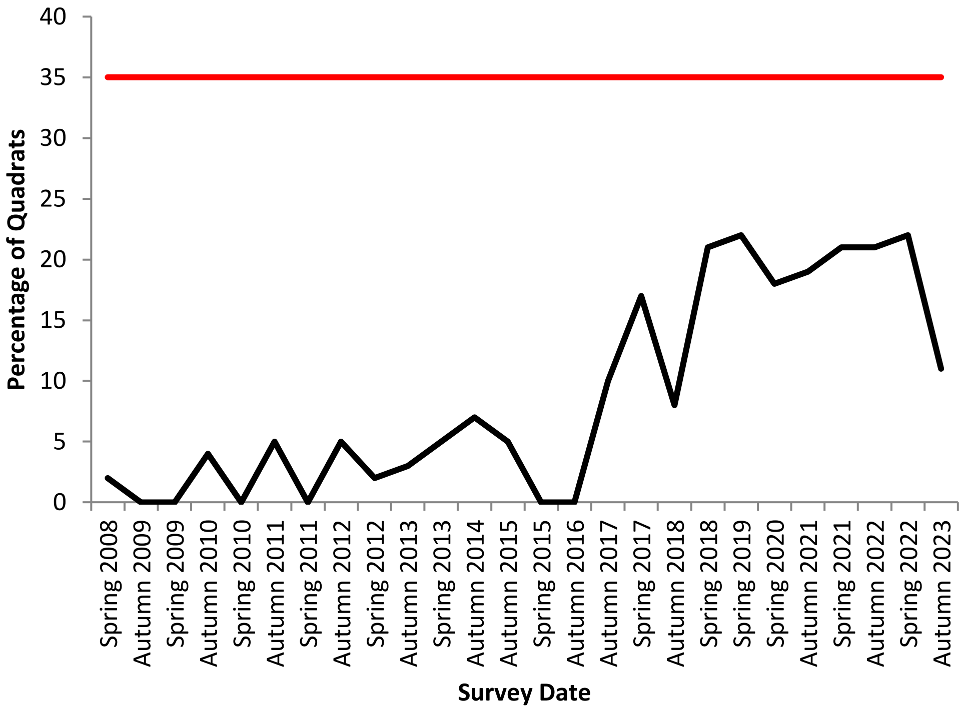


**Figure 35:** Percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 50% in the littoral zone of permanent wetlands from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 36 shows the percentage of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone from spring 2008 to autumn 2023. In contrast to lakes Alexandrina (Figure 12) and Albert (Figure 20) and Goolwa Channel (Figure 27), the reinstatement of water levels did not result in a decrease in the indicator. Between autumn 2010 and autumn 2016 there was a decreasing trend but a large increase between autumn 2016 and autumn 2018 (Figure 36). The highest proportion of quadrats (54%) containing more than 50% cover of these species was in autumn 2018, after which the proportion of quadrats remained between 35 and 55% (Figure 36). The target was only achieved in spring 2008 and spring 2009 (Figure 36).

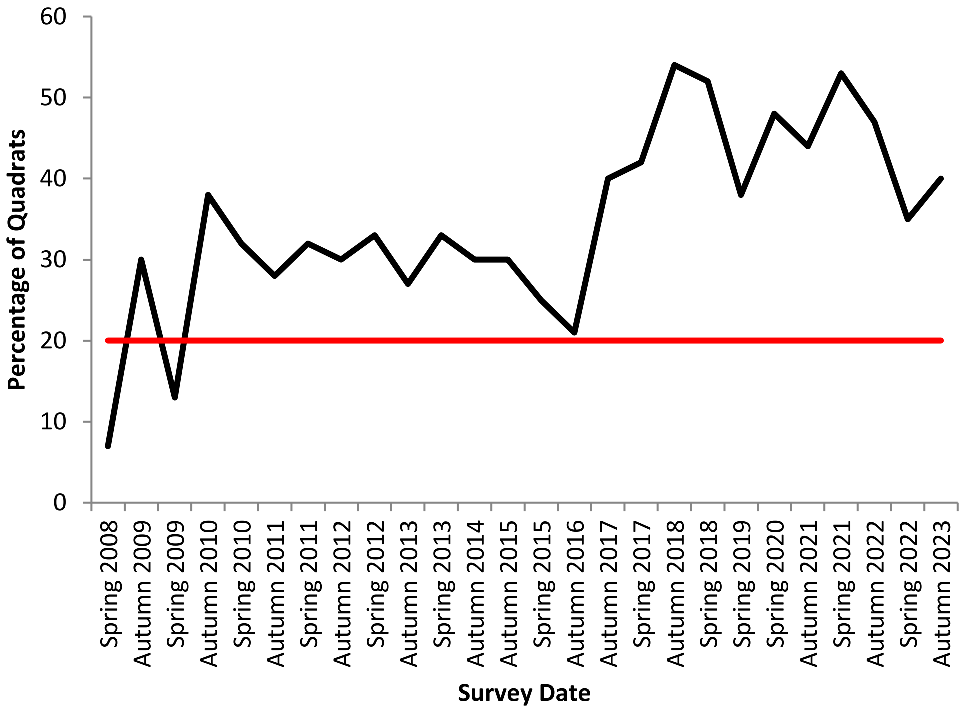


**Figure 36:** Percentage of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% in the littoral zone of permanent wetlands from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 37 shows the percentage of quadrats containing a cover of native amphibious species ≥5% in the littoral zone from spring 2008 to autumn 2023. Percentage cover was highly variable but has generally tended upwards for the duration of the monitoring (Figure 37). The target of 50% of quadrats having a cover of native amphibious species ≥5% was achieved for the first time in spring 2020 and in every following survey (Figure 37).

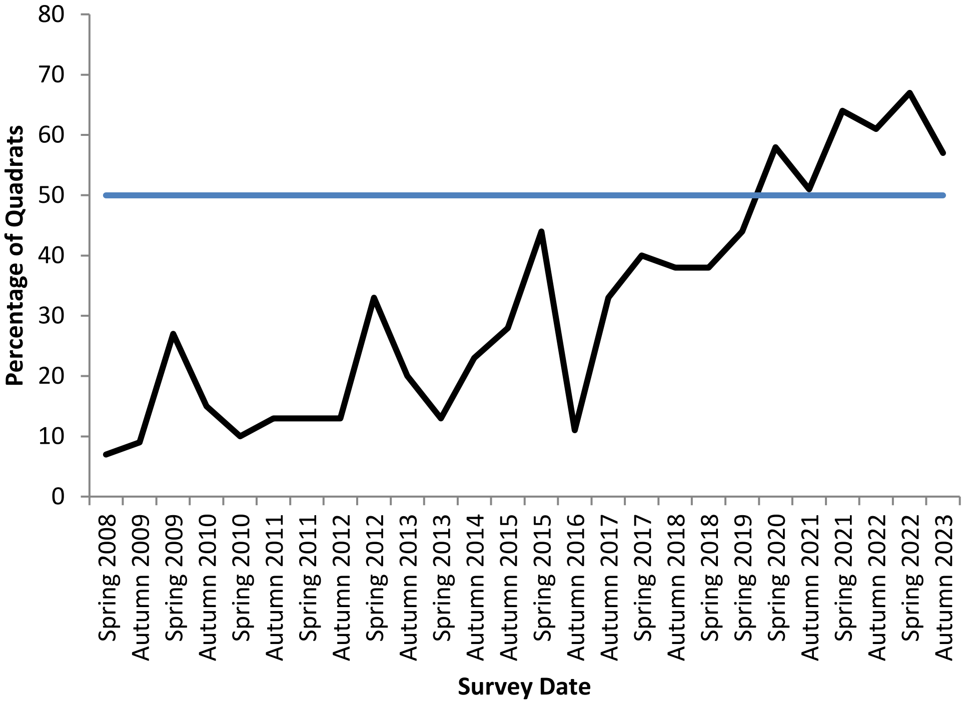


**Figure 37:** Percentage of quadrats containing a cover native amphibious species greater than 5% in the littoral zone of permanent wetlands from spring 2008 to autumn 2023 (the blue line represents the target threshold).

Figure 38 shows the percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* ≥5% in the littoral zone from spring 2008 to autumn 2023. The indicator has not exceeded 50% of quadrats; therefore, this target has not been achieved during the condition monitoring program (Figure 38). There was a general increasing trend of the indicator until autumn 2016, after which it decreased sharply but there has been an increasing trend since autumn 2018 (Figure 38).

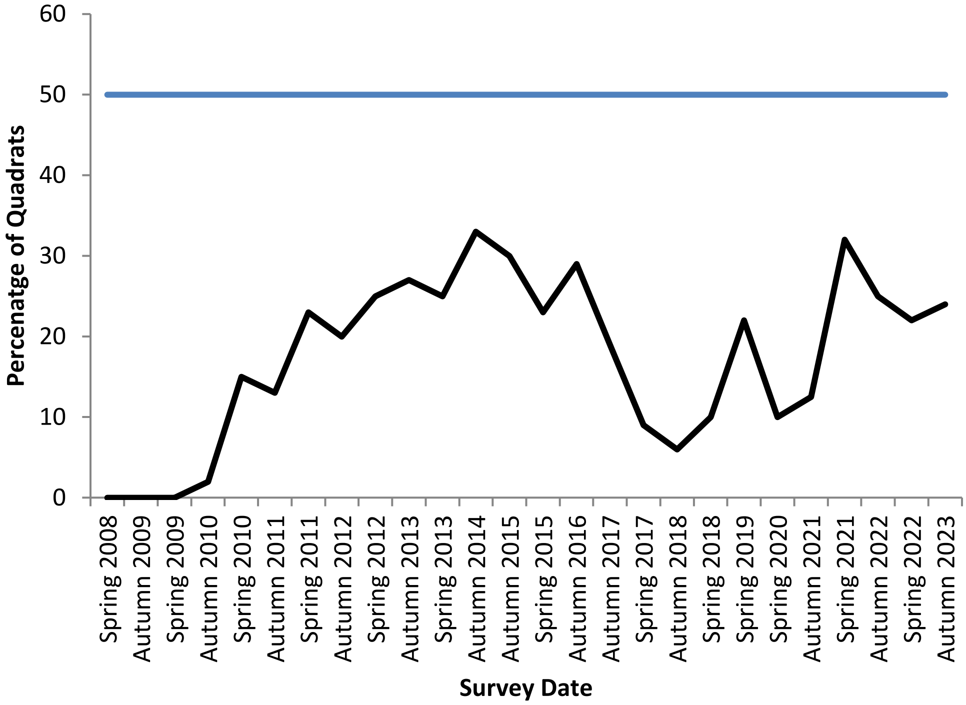


**Figure 38:** Percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* greater than 5% in the littoral zone of permanent wetlands from spring 2008 to autumn 2023 (the blue line represents the target threshold).

*Aquatic zone*

Figure 39 shows the percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 50% in the aquatic zone from spring 2008 to autumn 2023. The indicator showed an increasing trend between autumn 2009 and autumn 2015 after which it levelled and decreased to zero in spring 2019 and has remained there (Figure 39). The number of quadrats has not exceeded 40% and the target was consistently achieved over the monitoring program (Figure 39).

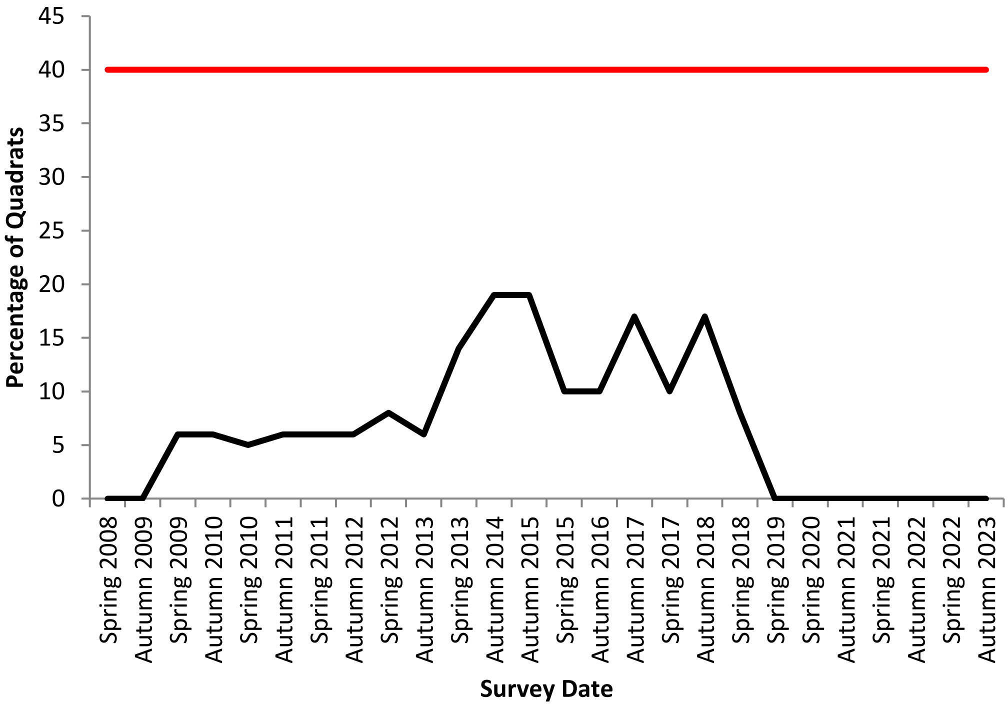


**Figure 39:** Percentage of quadrats containing a combined cover of *Typha domingensis* and *Phragmites australis* greater than 50% in the aquatic zone of permanent wetlands from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 40 shows the percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* ≥5% in the aquatic zone from spring 2008 to autumn 2023. There was an increase in the indicator after water levels were reinstated but that decreased to zero by autumn 2013 (Figure 40). The number of quadrats remained at 5% or lower until spring 2017 then peaked in autumn 2018 when it was 17%, before decreasing to 5% in spring 2018 although it has since shown a generally upward trend (Figure 40). The target has not been achieved during the condition monitoring program (Figure 40).

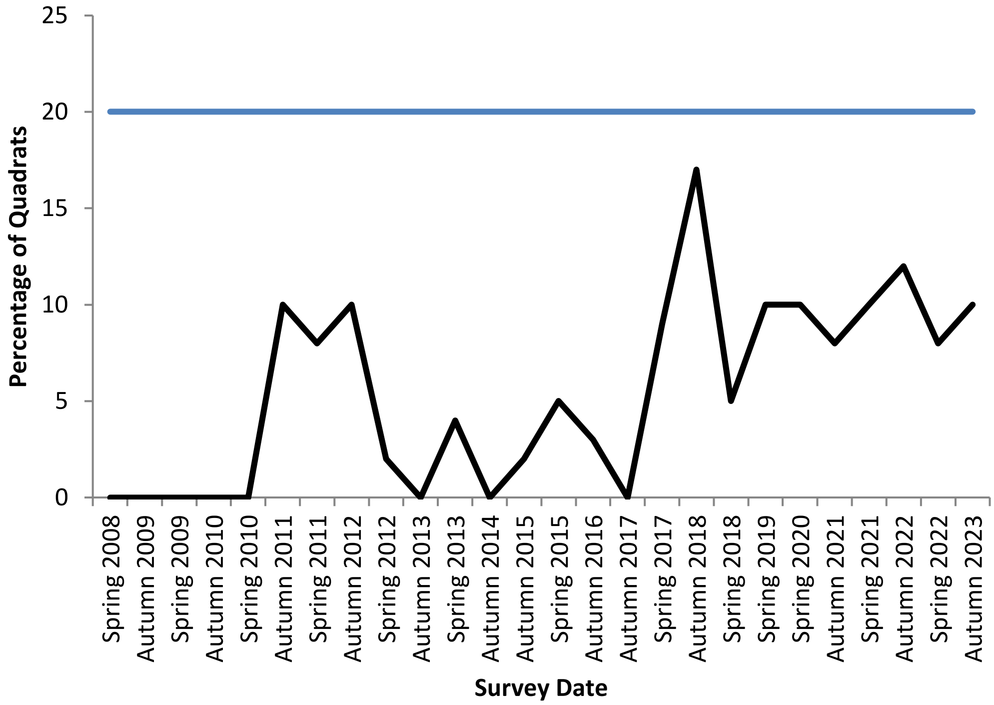


**Figure 40:** Percentage of quadrats containing a cover of native emergent species other than *Typha domingensis* and *Phragmites australis* greater than 5% in the aquatic zone of permanent wetlands from spring 2008 to autumn 2023 (the blue line represents the target threshold).

Figure 41 shows the percentage of quadrats containing a cover of native submergent species between 5 and 50% in the aquatic zone from spring 2008 to autumn 2023. Before spring 2010 the cover of native submergent species was low due to this zone largely being dry (although there were isolated puddles in spring 2008 and 2009 that supported submergent species) (Figure 41). After water levels were reinstated there has been a general increasing trend, with the target being achieved for the first time in spring 2020 and each following survey (Figure 41).

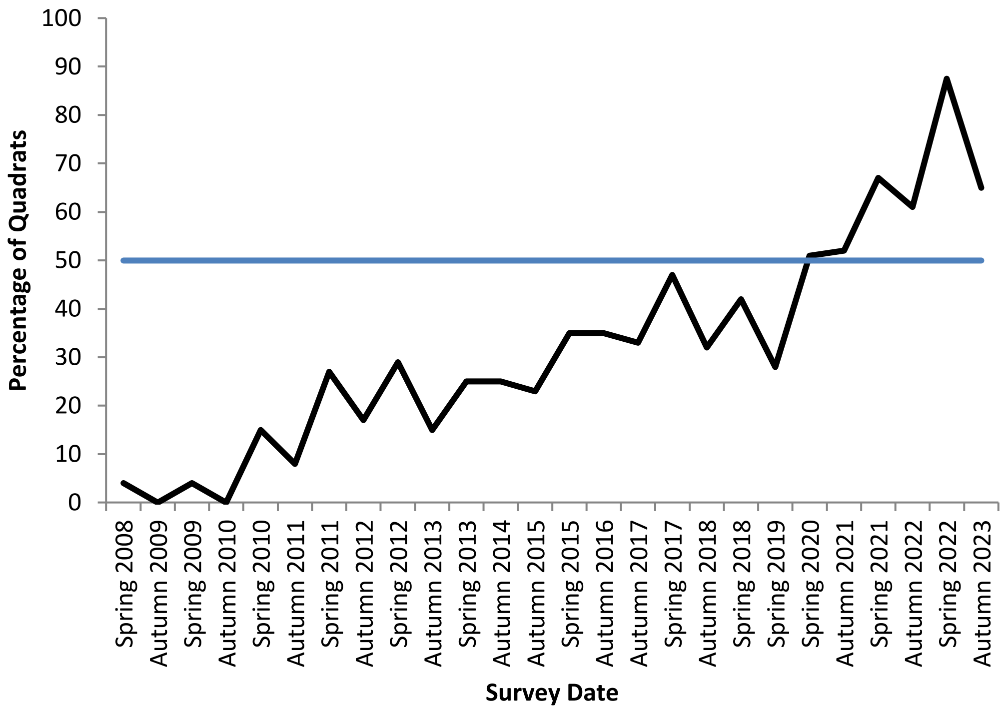


**Figure 41:** Percentage of quadrats containing a cover of native submergent species between 5 and 50% in the aquatic zone of permanent wetlands from spring 2008 to autumn 2023 (the blue line represents the target threshold).

*Whole of habitat condition*

The whole of habitat condition score for permanent wetlands is shown in Figure 42. There has been little change in the habitat condition score for permanent wetlands between spring 2008 and spring 2019 (Figure 42). The variability in condition score between spring 2008 and autumn 2010 was due to the littoral zone *Paspalum distichum* and *Cenchrus clandestinus* being achieved in spring 2008 and spring 2009 (Figure 36). From autumn 2010 there was no change in condition score until spring 2020 with the only targets that were achieved consistently over this period being the *Typha domingensis* and *Phragmites australis* targets in the littoral (Figure 35) and aquatic (Figure 39) zones. In spring 2020 and each subsequent survey the littoral zone amphibious (Figure 46) and aquatic zone submergent (Figure 48) targets were achieved resulting in an increase in habitat condition score.

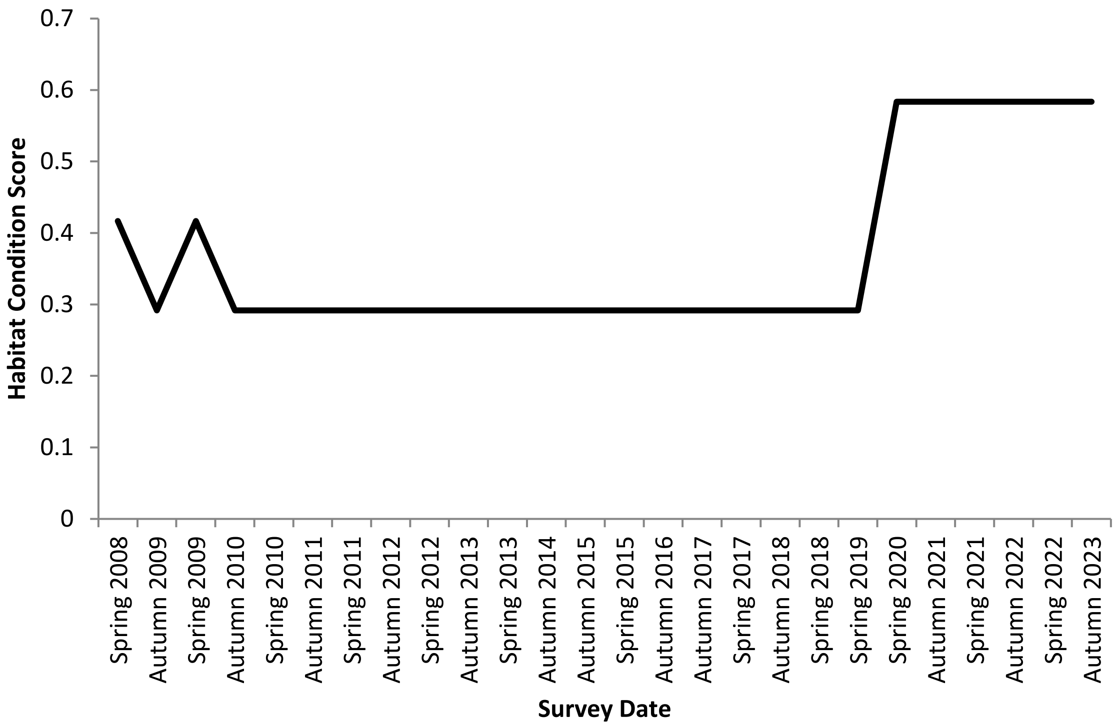


**Figure 42:** Whole of habitat condition score for permanent wetlands from spring 2008 to autumn 2023.

## Seasonal wetlands

### *Wetland edge*

Figure 43 shows the percentage of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% around the edges of seasonal wetlands from spring 2008 to autumn 2023. There has been a generally increasing trend in the indicator around the edges of seasonal wetlands over the duration of the condition monitoring program (Figure 43). In addition, there was a seasonal pattern with higher abundances usually in autumn when water levels are low (Figure 43). The target of a maximum of 20% of quadrats was exceeded (target not achieved) in autumn 2012, autumn 2013 and from autumn 2014 onwards (Figure 43).

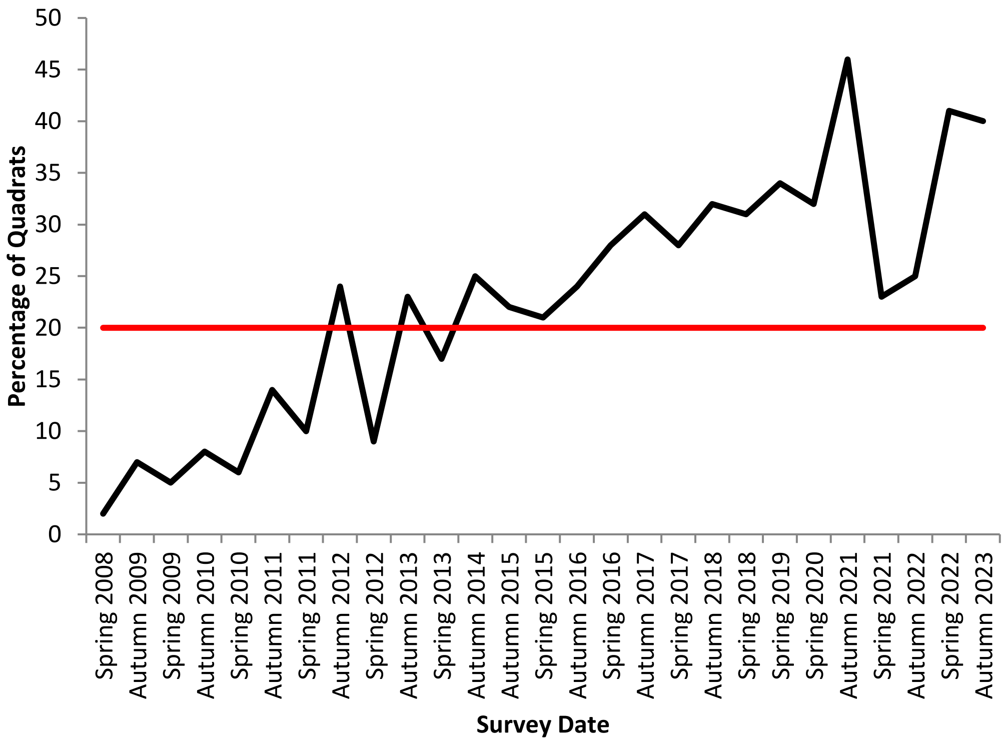


**Figure 43:** Percentage of quadrats containing a combined cover of *Paspalum distichum* and *Cenchrus clandestinus* greater than 50% around the edge of seasonal wetlands from spring 2008 to autumn 2023 (the red line represents the target threshold).

Figure 44 shows the percentage of quadrats containing a cover of native amphibious species ≥5% around the edges of seasonal wetlands from spring 2008 to autumn 2023. Native amphibious species were common around the edges of seasonal wetlands and the number of quadrats with a cover of ≥5% was higher than the 50% target throughout the survey period despite the downward trend from autumn 2016 to spring 2021 (Figure 44). Therefore, this target was consistently achieved over the condition monitoring program (Figure 44).

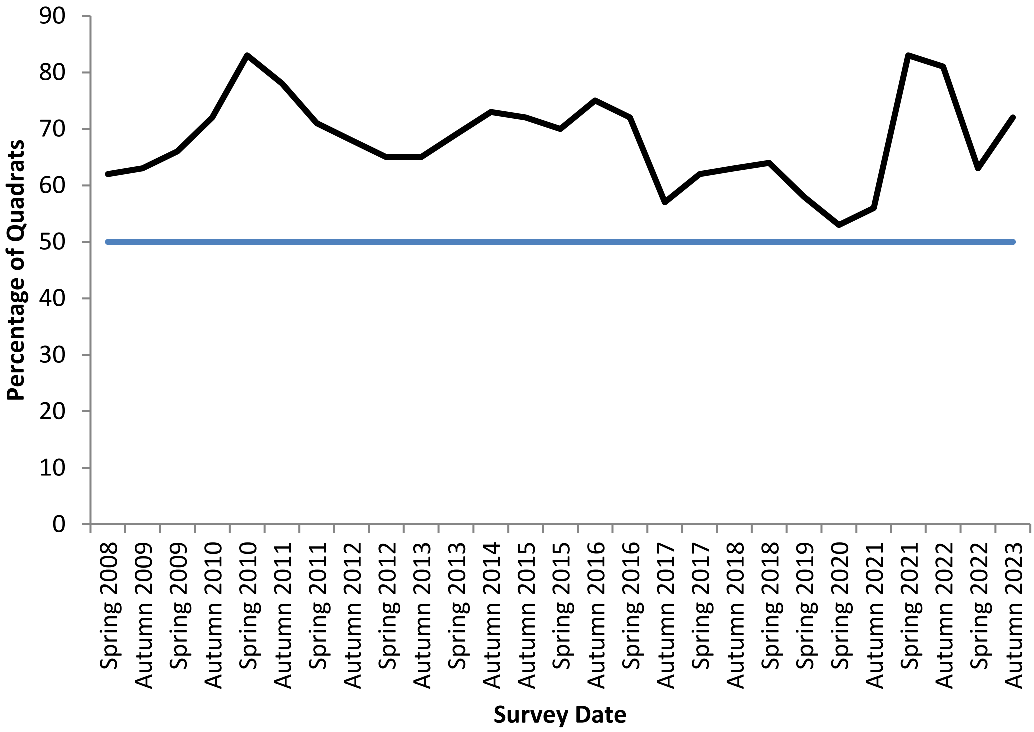


**Figure 44:** Percentage of quadrats containing a cover native amphibious species greater than 5% around the edge of seasonal wetlands from spring 2008 to autumn 2023 (the blue line represents the target threshold).

Figure 45 shows the percentage of quadrats containing a cover of native emergent species ≥5% around the edges of seasonal wetlands from spring 2008 to autumn 2023. The percentage of quadrats with a cover of native emergent species ≥5% has not exceeded 50% of quadrats; therefore, this target has not been achieved during the condition monitoring program (Figure 45). However, there was a general increasing trend from over the condition monitoring program, with a sharp increase between autumn 2021, peaking in spring 2021 with 45% of quadrats containing native emergent species with a cover of ≥5% (Figure 45).

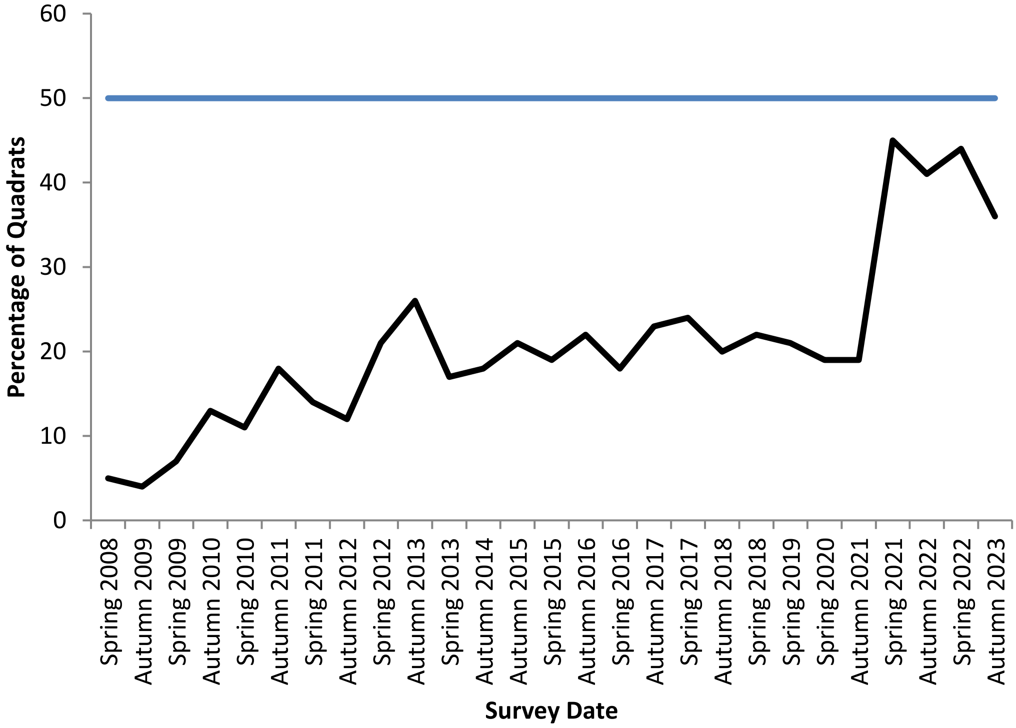


**Figure 45:** Percentage of quadrats containing a cover of native emergent species greater than 5% around the edge of seasonal wetlands from spring 2008 to autumn 2023 (the blue line represents the target threshold).

*Wetland bed*

Figure 46 shows the percentage of quadrats containing a cover of native amphibious species ≥5% on the beds of seasonal wetlands from spring 2008 to autumn 2023. Native amphibious species were less common on the beds of seasonal wetlands compared to the edges (Figure 44). The number of quadrats with a combined cover of these species ≥5% peaked in spring 2010 (59%), after which it fell to 26% and fluctuated between 15% and 32% until spring 2016 when it rose to 50% but fell to 18% in autumn 2017 (Figure 46). The target was achieved 16 times over the condition monitoring program (including the three most recent surveys), with spring 2020 having the lowest percentage (13%) of quadrats containing native amphibious species with a cover of ≥5% (Figure 46).

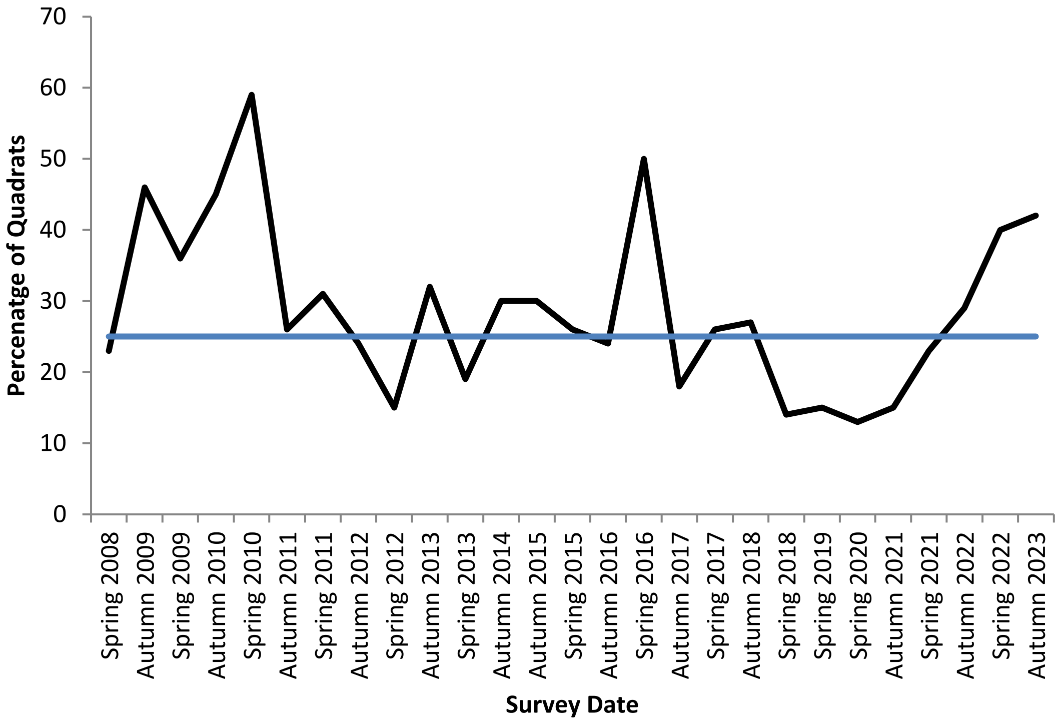


**Figure 46:** Percentage of quadrats containing a cover of native amphibious species greater than 5% on the bed of seasonal wetlands from spring 2008 to autumn 2023 (the blue line represents the target threshold).

Figure 47 shows the percentage of quadrats containing a cover of native emergent species ≥5% on the beds of seasonal wetlands from spring 2008 to autumn 2023. Between spring 2008 and spring 2009 there was a decrease of the indicator (Figure 47). However, the number of quadrats increased between spring 2009 and autumn 2011, after which there was a seasonal pattern with higher abundances in autumn compared to spring (Figure 47). The target of 20% of quadrats was first achieved in autumn 2011 and was achieved each subsequent survey, except in spring 2013 and spring 2018 (Figure 47).

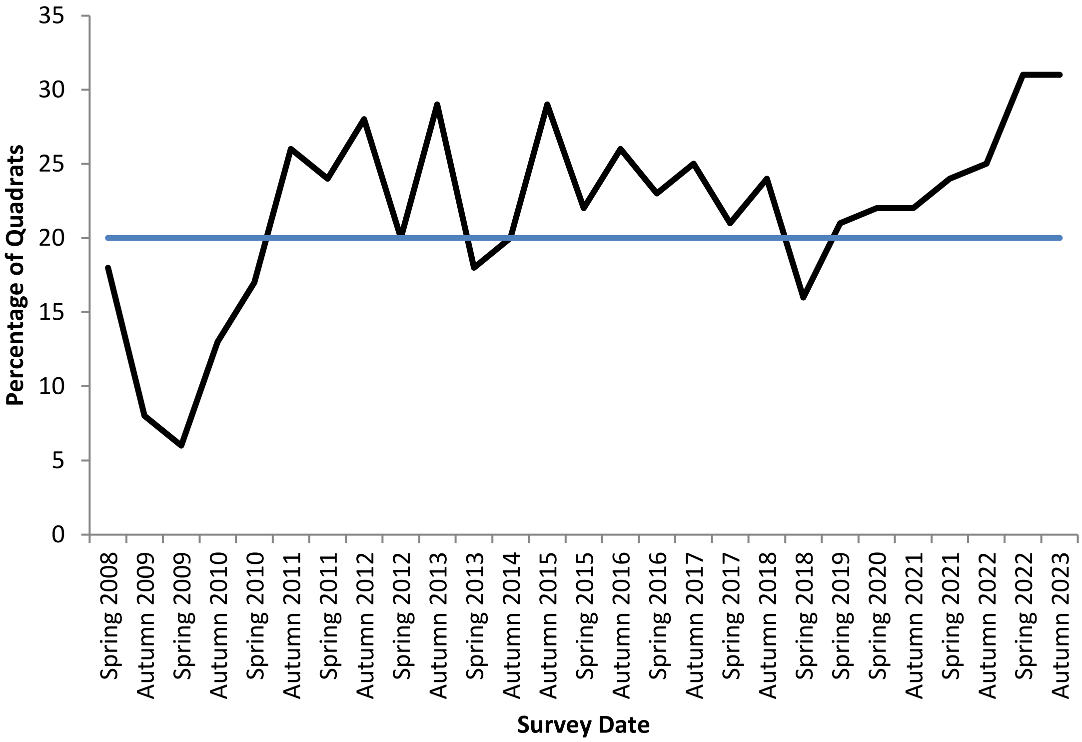


**Figure 47:** Percentage of quadrats containing a cover of native emergent species greater than 5% on the beds of seasonal wetlands from spring 2008 to autumn 2023 (the blue line represents the target threshold).

Figure 48 shows the percentage of quadrats containing a cover of native submergent species ≥25% on the beds of seasonal wetlands in spring from 2008 to spring 2022. Before spring 2011 the cover of native emergent species was low due to seasonal wetland beds largely being dry (although there were isolated puddles in spring 2008 and 2009 that supported submergent species) (Figure 41). After water levels were reinstated in spring 2010, there has been an increasing trend in the indicator, with the highest percentage of quadrats with submergent species greater than 25% cover (49%) in spring 2021 (Figure 41). However, the target of 50% of quadrats has not been achieved over the duration of the condition monitoring program (Figure 41).

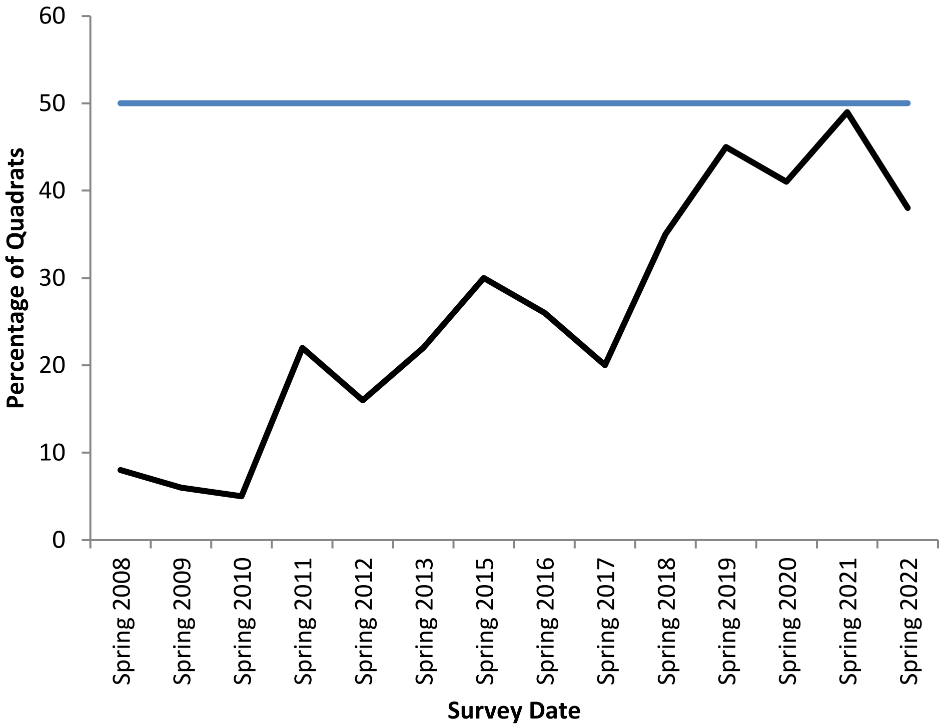


**Figure 48:** Percentage of quadrats containing a cover of native submergent species greater than 25% in spring on the beds of seasonal wetlands from spring 2008 to spring 2022 (the blue line represents the target threshold).

*Whole of habitat condition*

The whole of habitat condition score for seasonal wetlands is shown in Figure 49. There has not been a sustained increase in habitat condition score over the condition monitoring program for temporary wetlands (Figure 49). There is a seasonal pattern in wetland condition score with scores usually higher in autumn compared to spring, which is due to the higher abundance of native amphibious (Figure 44; Figure 46) and emergent (Figure 45; Figure 47) species and there being no submergent species target in autumn (which has never been achieved in spring) (Figure 48). There was no change in score between autumn 2017 and autumn 2018 after which there was a decrease resulting in the lowest habitat condition score over the condition monitoring program (Figure 49). The decrease between autumn and spring 2018 was due to the native amphibious (Figure 46) and emergent species (Figure 47) targets for the wetland beds not being achieved in spring 2018. However, there has been a general upward trend since spring 2018 due to multiple targets being achieved, with a sharp increase between spring 2021 and autumn 2022 due to the amphibious target being achieved on the wetlands bed and there being no submergent target (Figure 47). The change in the two most recent surveys (Figure 49) was also due to the submergent target (Figure 47).

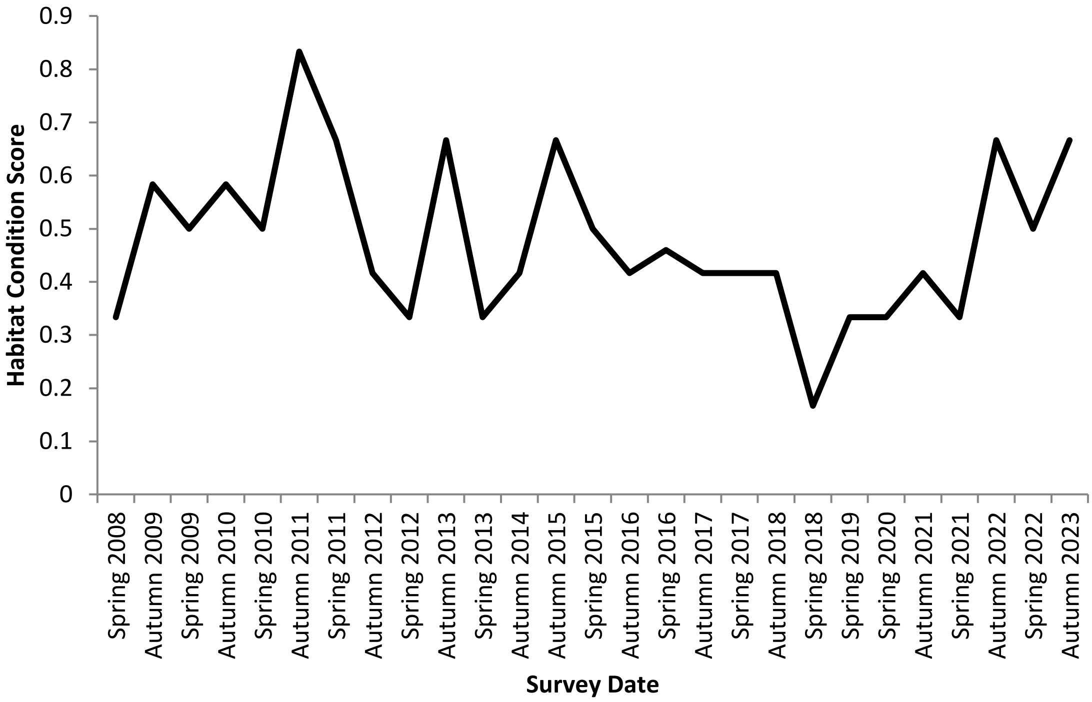


**Figure 49:** Whole of habitat condition score for seasonal wetlands from spring 2008 to autumn 2023.

## Whole of lakes condition

The Whole of Icon Site Score (WOISS) for aquatic and littoral vegetation represents the proportion of targets achieved throughout the five different habitats and using the Matter 8 condition rating. Based on this score, objective V3 has been achieved because a ‘good’ rating (defined by Matter 8 criteria) has been reached in the six most recent surveys (Table 9).

During the period of low water levels (surveys prior to spring 2010) the WOISS was low and fluctuated between 0.32 and 0.34 (poor condition rating (Figure 50, Table 9)). There was an increase between spring 2009 and spring 2011, after which it fluctuated between 0.43 and 0.55 (‘fair’ condition) until spring 2018 after which there was upwards trend and a ‘good’ rating was achieved in the six latest surveys (Figure 50, Table 9).

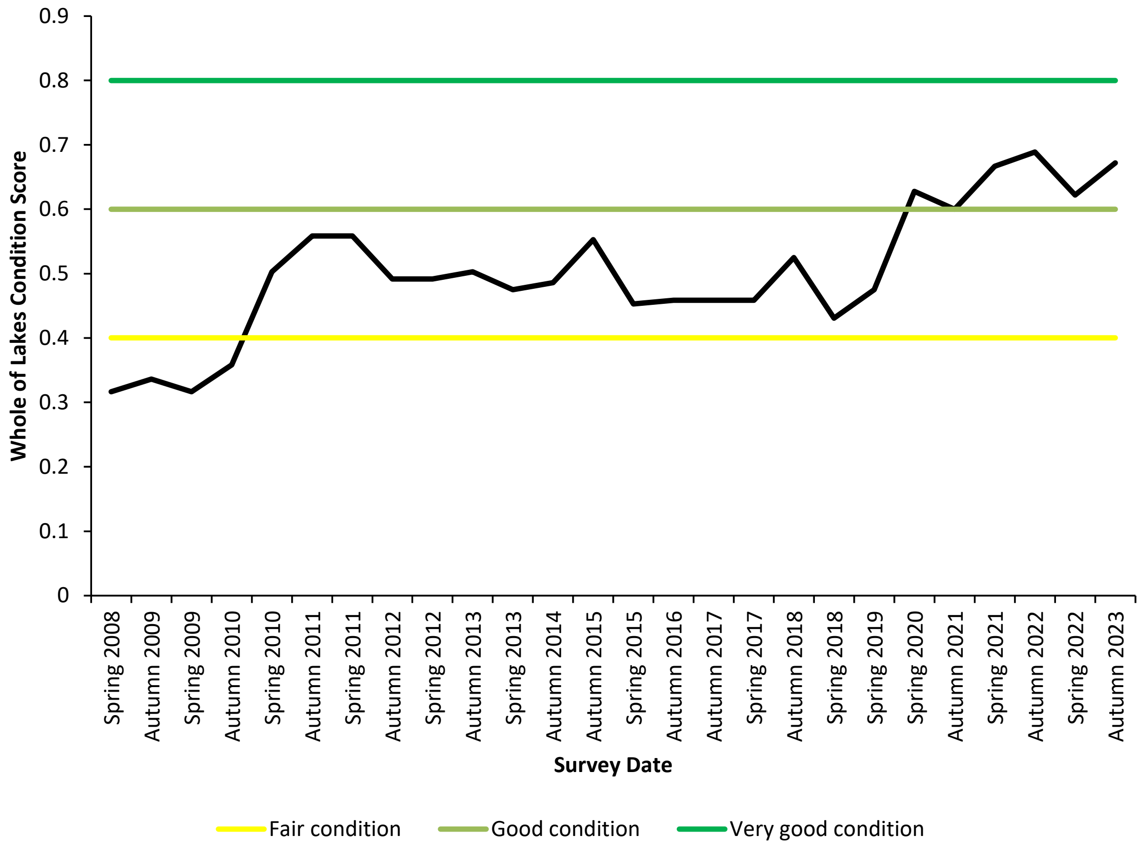


**Figure 50:** Whole of lakes condition score from spring 2008 to autumn 2023.

**Table 9:** Whole of lakes condition score and Matter 8 condition rating (Department for Environment and Water 2019) from spring 2008 to autumn 2023.

| Survey Date | Whole of lakes condition score | Condition rating |
|---|---|---|
| Spring 2008 | 0.32 | Poor |
| Autumn 2009 | 0.34 | Poor |
| Spring 2009 | 0.32 | Poor |
| Autumn 2010 | 0.36 | Poor |
| Spring 2010 | 0.50 | Fair |
| Autumn 2011 | 0.56 | Fair |
| Spring 2011 | 0.56 | Fair |
| Autumn 2012 | 0.49 | Fair |
| Spring 2012 | 0.49 | Fair |
| Autumn 2013 | 0.50 | Fair |
| Spring 2013 | 0.48 | Fair |
| Autumn 2014 | 0.49 | Fair |
| Autumn 2015 | 0.55 | Fair |
| Spring 2015 | 0.45 | Fair |
| Autumn 2016 | 0.46 | Fair |
| Autumn 2017 | 0.46 | Fair |
| Spring 2017 | 0.46 | Fair |
| Autumn 2018 | 0.53 | Fair |
| Spring 2018 | 0.43 | Fair |
| Spring 2019 | 0.48 | Fair |
| Spring 2020 | 0.63 | Good |
| Autumn 2021 | 0.60 | Good |
| Spring 2021 | 0.67 | Good |
| Autumn 2022 | 0.69 | Good |
| Spring 2022 | 0.62 | Good |
| Autumn 2023 | 0.67 | Good |

# 4. DISCUSSION AND MANAGEMENT IMPLICATIONS

## 4.1. Impacts of water level and salinity

During the most recent survey period (spring 2022 to autumn 2023), salinity (Figure 3) in Lake Alexandrina and the Goolwa Channel remained similar to values recorded since spring 2010. Electrical conductivity also remained stable in Lake Albert but was higher than Lake Alexandrina, although the higher salinity in Lake Albert is probably not biologically significant for the plant species present. Water levels in summer/autumn 2022-23 were the highest recorded during the condition monitoring program (1.29 m AHD) due to the large flood; and no managed lake drawn down compared to previous lower flow years with minimum water level +0.6 m AHD.

During the drought-induced draw-down (2007 to 2010), plant assemblages had shifted towards terrestrial taxa. However, following restoration of water levels in the Lower Lakes in late August 2010 (and the subsequent reconnection of most wetlands) there has been a general increasing trend in the abundance and diversity of aquatic dependent taxa (e.g. submergent, amphibious and emergent), suggesting the vegetation of the system is still recovering.

During 2012/13, water level management in the Lower Lakes involved two draw-down and refilling cycles (between +0.4 and +0.8 m AHD) with the aim to reduce salinity in Lake Albert (Figure 2). There have been no deliberate lake level cycles since then; however, the typical seasonal cycle of high-water levels in spring and early summer and low water levels in autumn has occurred each year (Figure 2). Stable water levels have been identified as detrimental to aquatic plant communities, with a greater diversity of aquatic plants generally in systems with fluctuating water levels (e.g. Nielsen and Chick 1997). Increases in water levels between autumn 2016 and autumn 2017 periodically inundated areas at higher elevations (above +0.9 m AHD) in spring 2016, which may have resulted in the increase in abundance of *Cenchrus clandestinus* and *Paspalum distichum* in permanent and temporary wetland habitats. The lower water levels in autumn 2017, 2018 and 2019 exposed the fringes of lakeshores and wetlands, which provided opportunities for species requiring exposure to germinate (e.g., *Persicaria lapathifolia, Berula erecta, Calystegia sepium, Ludwigia peploides, Juncus* spp., *Cyperus gymnocaulos*) (Nicol 2004). There may be limited opportunity for recruitment of species that require exposure to germinate due to fringing areas being densely vegetated with emergent species such as *Typha domingensis* or *Phragmites australis*. However, native amphibious plant species richness at +0.6 m AHD at the site scale was higher in the autumn 2017 and 2018 surveys compared to spring 2017 in all habitats indicating that the draw-down provided opportunities for species to recruit. Furthermore, native amphibious species richness in spring 2018 and 2019 (despite decreasing during this period in Lake Albert and Goolwa Channel) was higher than spring 2017 across all habitats (Figure 10) indicating an increase that persisted for several years, most likely due to seasonal lake level cycling. However, there was a decrease in native amphibious species richness at +0.6 m AHD in the six most recent surveys across all habitats that may be due to the higher lake levels throughout the 2020-21, 2021-22 and 2022-23 water years. Despite the decrease in native amphibious species richness at +0.6 m AHD, it was maintained at +0.8 m AHD and increased for the two most recent surveys (probably due to the high-water levels) indicating that species from the amphibious functional have not been lost from the littoral zone and should recruit in the future at lower elevations when lake levels are drawn down below +0.6 m AHD. Often shorelines that are not densely vegetated are subjected to wave action, which can prevent seedlings from establishing (e.g. Foote and Kadlec 1988). Nevertheless, seasonal water level fluctuations between >+0.8 and +0.5 m AHD are recommended because areas of submergent vegetation are maintained and the establishment of amphibious taxa in areas protected from wave action is facilitated. The main downside to these water level fluctuations is the increase in abundance of *Paspalum distichum* and (to a lesser extent) *Cenchrus clandestinus* in recent years.

### 4.2. Change in plant community, spring 2008 to autumn 2023

The change in floristic composition observed over the duration of the condition monitoring program (spring 2008 to autumn 2023) has provided information regarding the recovery of the aquatic and littoral plant community after the Millennium Drought, which resulted in complete loss of the submergent plant community and a decrease in the abundance of amphibious and emergent species. Pooling data from each habitat, although at the cost of losing information regarding the response of individual wetlands or sites, has enabled the change in floristic composition to be analysed at a broader spatial scale. There were similarities in the patterns of change among habitats, such as the expected large changes observed when water levels were reinstated in spring 2010, the decrease in change between surveys through time and the seasonal patterns evident in some habitats.

The smaller change in floristic composition in recent surveys for all habitats except seasonal wetlands (even in a year when the highest lake levels over the condition monitoring program were recorded) may indicate that the current plant community may persist into the future with only minor changes, providing recent salinity and water level regimes are maintained. However, multiple, minor, non-seasonal changes through time can result in large (albeit gradual) changes in the plant community. There is evidence this may have occurred in recent years in all habitats (Figure 6 to Figure 8). The points on this ordination from the latest surveys, whilst showing less change in floristic composition among surveys compared to those prior to autumn 2011, exhibited a temporal directional change. Furthermore, many of the TLM targets have shown decreasing or increasing trends in the abundances of species or functional groups in recent years that suggests there may be gradual changes in floristic composition that will continue to occur.

The patterns observed in the temporary wetlands (Figure 9) were expected due to the patterns in seasonal inundation and spring surveys that occurred when submergent species were present. Whilst the spring plant community in seasonal wetlands was variable, the autumn plant community was similar among surveys post 2010. The variability among the spring surveys was due to the increasing abundance of submergent species over time. In comparison, the plant community in autumn was dominated by *Phragmites australis, Sarcocornia quinqueflora* and *Paspalum distichum* and has not changed to the same degree through time as the plant community in spring (Figure 9).

It is unknown whether the plant community present in recent years is comparable to the community prior to 2007 because direct quantitative comparisons between the condition monitoring data and the small amount of data collected prior to 2007 cannot be made. However, for sites where data do exist (Teringie, Narrung, Clayton Bay, Dunn's Lagoon, Milang, Loveday Bay, Point Sturt and Hunters Creek), the diversity and abundance of submergent species were higher before 2007 compared to recent surveys (Holt *et al.* 2005; Nicol *et al.* 2006). For example, Holt *et al.* (2005) reported extensive beds of *Vallisneria australis* and *Myriophyllum salsugineum* throughout Dunns Lagoon almost completely covering the permanently inundated areas in spring 2004. In addition, Nicol *et al.* (2006) reported a bed of dense *Ruppia polycarpa* covering the entire inundated area of Point Sturt wetland. In the most recent surveys, *Myriophyllum salsugineum* and *Vallisneria australis* were present in Dunns Lagoon and abundant in places, but overall vegetation cover across the lagoon was patchy. In addition, *Ruppia polycarpa* has not been recorded in Point Sturt Wetland during the condition monitoring program but in the six most recent spring surveys, the low elevations were dominated by *Ruppia tuberosa. Althenia cylindrocarpa* (formerly *Lepilaena cylindrocarpa*) was observed for the first time in the condition monitoring program in Loveday Bay wetland in spring 2021. This species was recorded at the same site in the 2005 River Murray Wetlands Baseline Surveys (Nicol *et al.* 2006).

## 4.3. The Living Murray targets and condition scores

The original vegetation target (now an objective) (V3): *maintain or improve aquatic and littoral vegetation in the Lower Lakes*, whilst an appropriate management aim and ecological objective for the system, cannot (in the strictest sense) be assessed because there is no quantitative baseline. Furthermore, baseline data would need to be collected over a minimum of 5–10 years (or even longer) to determine the natural (acceptable) variability of the system. Davis and Brock (2008) identified this as a problem when determining limits of acceptable change for wetlands of international importance under the Ramsar Convention. These authors proposed that conceptual models be developed to determine limits of acceptable change and to design a monitoring program to assess and refine the proposed limits of acceptable change (Davis and Brock 2008). Nicol (2016) proposed limits of acceptable change (and management triggers) for aquatic and littoral vegetation in the Coorong and Lakes Alexandrina and Albert Ramsar Wetland using conceptual models (*sensu* Davis and Brock 2008), and TLM aquatic and littoral vegetation targets were based on proposed limits of acceptable change management triggers. In addition, the Whole of Icon Site Scores (WOISS) have been used for the South Australian Basin Plan environmental outcome reporting (Matter 8) and is used to report on the achievement of Objective V3.

The refined targets (Department for Environment, Water and Natural Resources 2017) were based largely on expert opinion; however, data from the 2005 (Holt *et al.* 2005) and 2006 (Nicol *et al.* 2006) baseline surveys, habitat mapping (Seaman 2003), biological surveys of conservation reserves adjacent to the Murray Mouth (Brandle *et al.* 2002), a survey of the aquatic vegetation of Hindmarsh Island (Renfrey *et al.* 1989) and condition monitoring data were also used to develop the targets. The achievement of targets in recent years across habitats suggests that they are realistic and reflect condition of the vegetation. However, the native emergent species other than *Typha* and *Phragmites* targets in the littoral zones of Lakes Alexandrina (Figure 14) and Albert (Figure 23) and temporary wetlands (Figure 38) are not close to the percentage of quadrats required to meet the target. The threshold to attain these targets may be too ambitious; however, these species are indicative of diverse reed bed habitats that support a higher diversity of plant species, and an aspirational target may be appropriate. Continued repeated surveys will support further refinement of the targets.

The habitats with the highest proportion of targets achieved in the most recent surveys and therefore, having the highest condition scores were lakes Alexandrina and Albert and Goolwa Channel. The condition scores for lakes Alexandrina and Albert have generally been stable or increasing since water levels were reinstated. In contrast, the condition score for Goolwa Channel was highly variable but has been trending upwards since spring 2018.

In Lake Alexandrina, there have generally been upward trends for targets for desirable taxa in recent surveys. There was also a downward trend in the number of quadrats that were dominated by *Paspalum distichum* and *Cenchrus clandestinus* after spring 2010. However, there was an increase in the number of quadrats dominated by *Typha domingensis* and *Phragmites australis*. These trends suggest that the condition score in Lake Alexandrina will continue to improve through time as more targets are achieved providing the abundances of *Typha domingensis* and *Phragmites australis* remain at current levels and there is not an increase in *Paspalum distichum* and *Cenchrus clandestinus* abundance as observed in permanent and temporary wetlands.

The habitat condition score for Lake Albert has also been generally stable or increasing since water levels were reinstated. There has been a general downward trend in quadrats dominated by *Paspalum distichum* and *Cenchrus clandestinus* after spring 2010 except between spring 2017 and autumn 2018 and the target was not achieved for this survey; hence, the decline in habitat condition score over this period. Between autumn 2018 and autumn 2021 there was a general decrease in quadrats dominated by *Paspalum distichum* and *Cenchrus clandestinus* and the target was achieved resulting in an increase in habitat score. Like the trend for Lake Alexandrina, there has been an increase in the number of quadrats dominated by *Typha domingensis* and *Phragmites australis* but not to a level close to the target. The progress towards achievement of targets that require an increase in the abundance of desirable species observed in Lake Alexandrina has generally not occurred in Lake Albert. The exception is the native amphibious species in the littoral zone target, which has generally increased since water levels were reinstated and was achieved in spring 2021 and autumn 2022 but not the two most recent surveys (Figure 21) hence the recent decline in condition.

In contrast to condition scores in lakes Alexandrina and Albert, the condition score in Goolwa Channel was highly variable. This was primarily due to an increase in the number of quadrats dominated by *Typha domingensis* and *Phragmites australis* in the littoral zone and a decrease in the abundance of submergent species in the deep-water zone. However, since spring 2010 the number of quadrats dominated by *Typha domingensis* and *Phragmites australis* in the littoral and aquatic zones has been relatively stable and has fluctuated around the target level (Figure 26 and Figure 30). However, the target was met in recent surveys in both zones and shows a downward trend in the aquatic zone and is stable in the littoral zone

(Figure 26 and Figure 30). The deep-water zone target was achieved in autumn 2018 for the first time since autumn 2015 and again for the six most recent surveys. In spring 2020 and spring 2021 all targets, except the emergent species other than *Typha domingensis* and *Phragmites australis* in the littoral zone (Figure 29), were achieved resulting in the highest habitat condition scores for the condition monitoring program (Figure 34). The emergent species other than *Typha domingensis* and *Phragmites australis* target in the aquatic zone (Figure 31) was not met in the two most recent surveys resulting in a decrease in habitat condition score but still the second highest score over the monitoring program. Similar to the trend for Lake Alexandrina, there has generally been progress towards achieving the targets that require an increase in the abundance of desirable species and if these trends continue, the condition score for Goolwa Channel will increase again and be maintained at a high level.

The condition habitat score for permanent wetlands has remained constant between spring 2009 and spring 2019 and was lower than that for lakes Alexandrina and Albert over the same period. There was a downward trend in the number of quadrats dominated by *Paspalum distichum* and *Cenchrus clandestinus* between spring 2010 and autumn 2016 but since then there has been a general increase (probably due to water level fluctuations) and the target has not been achieved since spring 2009. There has been progress towards achieving the targets that require an increase in abundance of desirable species since water levels were reinstated (except emergent species other than *Typha domingensis* and *Phragmites australis* in the littoral and aquatic zones) with the targets for amphibious taxa in the littoral zone (Figure 37) and submergents in the aquatic zone (Figure 41) being achieved in the six most recent surveys. This resulted in an increase in the habitat condition score similar to the values in Lakes Alexandrina (Figure 18) and Albert (Figure 25).

The condition score for seasonal wetlands over the duration of the condition monitoring program was variable until autumn 2015, after which it has trended downwards with the lowest score in spring 2018. The peaks in autumn were due to the absence of a submergent vegetation target for this season. The downward trend since autumn 2015 and autumn 2017 was due to an increase in the number of quadrats dominated by *Paspalum distichum* and *Cenchrus clandestinus* (which has shown an increasing trend from spring 2008). Furthermore, the percentage of quadrats containing native amphibious and emergent species with a cover of greater than 5% on the wetland bed have fluctuated around the target with both targets not being met in spring 2018 but the emergent target achieved in spring 2019 onwards and the amphibious target being achieved in the three most recent surveys. This resulted in an increasing trend in the habitat score from spring 2018 onwards. The number of quadrats containing submergent species with a cover ≥25% on the wetland bed in spring (the spring 2021 survey had the highest percentage recorded at 49%) and quadrats with a cover of native emergent species around the edge of ≥5% have generally increased since spring 2010, peaking in spring 2021. These trends, if they continue, suggest that the condition score for seasonal wetlands will increase in the future.

The WOISS has fluctuated between 0.56 and 0.43 between autumn 2011 and spring 2019, which is classed as being in fair condition but not achieving objective V3. Many of the individual indicators have fluctuated around their target values, which has resulted in small to moderate variations in the habitat condition scores and hence the WOISS. However, in the six most recent surveys, several of the increasing trends for targets that require an increase in the abundance of desirable taxa exceeded the threshold for targets being achieved, resulting in increases in habitat scores and the whole of lakes condition score. Each survey between spring 2020 and autumn 2023 the whole of lakes condition score was higher than 0.6, which resulted in the condition rating improving from fair to good and meeting the ecological objective. Furthermore, most of the targets not achieved in recent surveys are trending towards being met, suggesting that under the current hydrological and salinity regime the plant community is improving through time. Therefore, it is important that the current salinity and water level regimes are maintained to provide conditions for the continual improvement of vegetation condition. Whilst water and salinity are two key drivers of the littoral and aquatic vegetation of the Lower Lakes, complementary land management practices (e.g., weed control, grazing management) may result in further improvement in vegetation condition.

## 4.4. Further studies

Suggested further studies (in priority order) to improve the understanding of the vegetation dynamics of the Lower Lakes and the impacts of changes in water levels and salinity include:

1. continuation of the condition monitoring program (with both spring and autumn surveys and *Melaleuca halmaturorum* demographics) to continue to improve understanding of the medium to long-term vegetation dynamics of the system, monitor the recovery trajectory post hydrological restoration (e.g., do current trends persist or is there an equilibrium state?) and to refine indicators;
2. mapping of large-scale plant communities in the Goolwa Channel (*sensu* Gehrig *et al.* 2011a), expanding to key wetlands and lakeshore areas to complement the condition monitoring program and gain a better understanding of vegetation dynamics at the landscape scale;

3. integration of existing data sets for plant and other biotic groups such as fish, birds and invertebrates to better understand relationships among components of the wider aquatic ecosystem to inform (a) development of broader ecological indicators and (b) future research directions;
4. investigation of different control methods for *Paspalum distichum* and *Cenchrus clandestinus* such as controlled summer grazing, herbicides and mowing and monitor to determine effectivenss and native species recovery;
5. investigation of the salinity tolerances of potential local ecotypes of key species (e.g., *Typha domingensis, Phragmites australis, Schoenoplectus tabernaemontani, Vallisneria australis, Myriophyllum salsugineum*);
6. investigation of the effects of elevated but sub-lethal salinities on key species;
7. determine propagule longevity under different conditions (e.g., salinity, pH, soil moisture);
8. investigation of the the current submergent plant propagule bank in key wetlands and the Goolwa Channel;
9. trial emergent vegetation control at *Melaleuca halmaturorum* stands and monitor to determine whether competition is restricting recruitment.

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# APPENDICES

**Appendix 1:** Species list, functional classification (Gehrig and Nicol 2010b), life history strategy and conservation status (state conservation status from listings in Barker *et al.* (2005) and regional conservation status from listings in Lang and Kaeheneuhl (2001) from all sites and survey dates (*denotes exotic taxon, **denotes proclaimed pest plant in South Australia, ***denotes weed of national significance # denotes listed as rare in South Australia).

| Taxon | Functional Group | Life history strategy | Status and Comments |
|---|---|---|---|
| *Acacia myrtifolia* | Terrestrial dry | Perennial | Native |
| *Althenia cylindrocarpa* | Submergent (r-selected) | Annual | Native |
| *Anagallis arvensis** | Terrestrial damp | Annual | Exotic |
| *Apium graveolens** | Terrestrial damp | Annual | Exotic |
| *Arctotheca calendula** | Terrestrial dry | Annual | Exotic |
| *Asparagus asparagoides**** | Terrestrial dry | Perennial | Exotic |
| *Asparagus officinalis** | Terrestrial dry | Perennial | Exotic |
| *Atriplex prostrata** | Terrestrial damp | Perennial | Exotic |
| *Atriplex* spp. | Terrestrial dry | Perennial | Native |
| *Atriplex suberecta* | Floodplain | Perennial | Native |
| *Avena* spp.* | Terrestrial dry | Annual | Exotic-*Avena* spp. is comprised of *Avena barbata* and *Avena fatua* |
| *Azolla filiculoides* | Floating | Perennial | Native |
| *Baumea juncea* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Berula erecta** | Emergent | Perennial | Exotic |
| *Bolboschoenus caldwellii* | Emergent | Perennial | Native |
| *Brassica rapa** | Terrestrial dry | Annual | Exotic |
| *Brassica tournifortii** | Terrestrial dry | Annual | Exotic |
| *Briza minor** | Terrestrial dry | Annual | Exotic |
| *Bromus catharticus** | Terrestrial dry | Annual | Exotic |
| *Bromus diandrus** | Terrestrial dry | Annual | Exotic |
| *Bromus hordeaceus* ssp. *hordeaceus** | Terrestrial dry | Annual | Exotic |
| *Bromus rubens** | Terrestrial dry | Annual | Exotic |
| *Calystegia sepium* | Amphibious fluctuation tolerator-emergent | Perennial | Native-Listed as Uncommon in the Murray and Southern Lofty Regions |
| *Carex apressa* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Carex fasicularis* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Cenchrus clandestinus* | Terrestrial dry | Perennial | Exotic |
| *Centaurea calcitrapa** | Terrestrial damp | Annual | Exotic |
| *Centaurium tenuiflorum** | Terrestrial damp | Annual | Exotic |
| *Centella asiatica* | Amphibious fluctuation responder-plastic | Perennial | Native |
| *Ceratophyllum demersum#* | Submergent (k-selected) | Perennial | Native-Listed as Rare in South Australia |
| *Chara* spp. | Submergent (r-selected) | Annual | Native |
| *Chenopodium album** | Terrestrial damp | Annual | Exotic |
| *Chenopodium glaucum** | Terrestrial damp | Annual | Exotic |
| *Chenopodium nitrariaceum* | Terrestrial dry | Perennial | Native |
| *Conyza bonariensis** | Terrestrial damp | Annual | Exotic |
| *Cotula coronopifolia** | Amphibious fluctuation responder-plastic | Perennial | Exotic |
| *Crassula helmsii* | Amphibious fluctuation tolerator-low growing | Perennial | Native |
| *Cycnogeton procera* | Emergent | Perennial | Native-Listed as Uncommon in the Southern Lofty Region |
| *Cyperus exaltatus* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Cyperus gymnocaulos* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Dianella revoluta* | Terrestrial dry | Perennial | Native |

| Taxon | Functional Group | Life history strategy | Status and Comments |
|---|---|---|---|
| *Disphyma crassifolium* | Terrestrial dry | Perennial | Native |
| *Distichlis distichophylla* | Terrestrial damp | Perennial | Native-Listed as Uncommon in the Murray Region |
| *Duma florulenta* | Amphibious fluctuation tolerator-woody | Perennial | Native |
| *Echinochloa crus-galli** | Terrestrial damp | Annual | Exotic |
| *Ehrharta longiflora** | Terrestrial damp | Annual | Exotic |
| *Einadia nutans* | Terrestrial dry | Perennial | Native |
| *Eleocharis acuta* | Emergent | Perennial | Native |
| *Enchylaena tomentosa* | Terrestrial dry | Perennial | Native |
| *Epilobium pallidiflorum* | Terrestrial damp | Perennial | Native-Listed as Uncertain in the Murray Region and uncommon in the Southern Lofty Region |
| *Eragrostis australasica* | Floodplain | Perennial | Native |
| *Eragrostis curvula*** | Terrestrial damp | Annual | Exotic-Proclaimed pest plant in SA |
| *Eragrostis* sp. | Terrestrial damp | Annual | Native-could not identify to species |
| *Erodium cicutarium** | Terrestrial dry | Annual | Exotic |
| *Euphorbia terracina*** | Terrestrial dry | Annual | Exotic-Proclaimed pest plant in SA |
| *Ficinia nodosa* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Foeniculum vulgare** | Terrestrial damp | Annual | Exotic |
| *Frankenia pauciflora* | Terrestrial dry | Perennial | Native |
| *Fumaria bastardii** | Terrestrial damp | Annual | Exotic |
| *Gahnia clarkii* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Gahnia filum* | Amphibious fluctuation tolerator-emergent | Perennial | Native-Listed as Rare in the Murray and Southern Lofty Regions |
| *Galenia secunda** | Terrestrial dry | Perennial | Exotic |
| *Glyceria australis* | Emergent | Perennial | Native |
| *Heliotropium europaeum** | Floodplain | Annual | Exotic |
| *Holcus lanatus** | Terrestrial damp | Annual | Exotic |
| *Hordeum vulgare** | Terrestrial dry | Annual | Exotic |
| *Hypochoeris glabra** | Terrestrial dry | Annual | Exotic |
| *Hypochoeris radicata** | Terrestrial dry | Annual | Exotic |
| *Iris* spp.* | Terrestrial dry | Perennial | Exotic |
| *Isolepis producta* | Amphibious fluctuation tolerator-low growing | Perennial | Native |
| *Juncus acutus*** | Amphibious fluctuation tolerator-emergent | Perennial | Exotic |
| *Juncus holoschoenus* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Juncus kraussii* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Juncus pallidus* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Juncus subsecundus* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Juncus usitatus* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Lachnagrostis filiformis* | Floodplain | Annual | Native |
| *Lactuca saligna** | Terrestrial dry | Annual | Exotic |
| *Lactuca serriola** | Terrestrial dry | Annual | Exotic |
| *Lagurus ovatus** | Terrestrial dry | Annual | Exotic |
| *Lamprothamnium macropogon* | Submergent r-selected | Annual | Native |
| *Lemna* spp. | Floating | Perennial | Native |
| *Limosella australis* | Amphibious fluctuation responder-plastic | Perennial | Native |
| *Lobelia anceps* | Terrestrial damp | Perennial | Native |

| Taxon | Functional Group | Life history strategy | Status and Comments |
|---|---|---|---|
| *Lolium* spp.* | Terrestrial dry | Annual | Exotic-*Lolium* spp. comprises of *Lolium perenne* and *Lolium rigidum* |
| *Ludwigia peploides* ssp. *montevidensis* | Amphibious fluctuation responder-plastic | Perennial | Native |
| *Lupinus cosentinii** | Terrestrial dry | Annual | Exotic |
| *Lycium ferocissimum**** | Terrestrial dry | Perennial | Exotic-Proclaimed pest plant in SA |
| *Lycopus australis* | Amphibious fluctuation tolerator-emergent | Perennial | Native-Listed as Rare in the Murray Region |
| *Lythrum hyssopifolia* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Lythrum salicaria* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Malva parviflora** | Terrestrial dry | Annual | Exotic |
| *Marrubium vulgare*** | Terrestrial dry | Annual | Exotic |
| *Medicago* spp.* | Terrestrial dry | Annual | Exotic-*Medicago* spp. comprises of *Medicago polymorpha, Medicago truncatula* and *Medicago minima* |
| *Melaleuca halmaturorum* | Amphibious fluctuation tolerator-woody | Perennial | Native |
| *Melilotus albus** | Terrestrial dry | Annual | Exotic |
| *Melilotus indicus** | Terrestrial dry | Annual | Exotic |
| *Mentha australis* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Mentha* spp.* | Amphibious fluctuation tolerator-emergent | Perennial | Exotic-*Mentha* spp. comprises of *Mentha piperita, Mentha pulegium* and *Mentha spicata* |
| *Myoporum insulare* | Terrestrial dry | Perennial | Native |
| *Myriophyllum caput-medusae* | Submergent k-selected | Perennial | Native |
| *Myriophyllum muelleri* | Amphibious fluctuation responder-plastic | Perennial | Native |
| *Myriophyllum salsugineum* | Submergent k-selected | Perennial | Native-Listed as Uncertain in the Southern Lofty Region |
| *Myriophyllum verrucosum* | Amphibious fluctuation responder-plastic | Perennial | Native |
| *Onopordum acanthium** | Terrestrial damp | Annual | Exotic |
| *Paspalum distichum** | Terrestrial damp | Perennial | Exotic |
| *Persicaria lapathifolia* | Amphibious fluctuation responder-plastic | Perennial | Native |
| *Phragmites australis* | Emergent | Perennial | Native |
| *Phyla canescens** | Amphibious fluctuation tolerator-low growing | Perennial | Exotic |
| *Picris angustifolia* ssp. *angustifolia* | Terrestrial dry | Annual | Native |
| *Plantago coronopus** | Terrestrial dry | Annual | Exotic |
| *Plantago lanceolata** | Terrestrial dry | Annual | Exotic |
| *Polygonum aviculare** | Terrestrial dry | Perennial | Exotic |
| *Polypogon monspeliensis** | Amphibious fluctuation tolerator-emergent | Annual | Exotic |
| *Potamogeton crispus* | Submergent k-selected | Perennial | Native |
| *Potamogeton pectinatus* | Submergent k-selected | Perennial | Native |
| *Pseudognaphalium luteoalbum* | Floodplain | Annual | Native |
| *Puccinellia* sp.* | Terrestrial damp | Annual | Exotic-could not be identified to species but was not *Puccinellia stricta* or *Puccinellia perlaxa* |
| *Ranunculus trichophyllus** | Submergent (r-selected) | Annual | Exotic |
| *Ranunculus trilobus** | Amphibious fluctuation tolerator-emergent | Annual | Exotic |
| *Reichardia tingitana** | Terrestrial dry | Annual | Exotic |
| *Rorippa nasturtium-aquaticum** | Amphibious fluctuation responder-plastic | Annual | Exotic |
| *Rorippa palustris** | Floodplain | Annual | Exotic |

| Taxon | Functional Group | Life history strategy | Status and Comments |
|---|---|---|---|
| *Rumex bidens* | Amphibious fluctuation responder-plastic | Perennial | Native |
| *Ruppia megacarpa* | Submergent k-selected | Perennial | Native |
| *Ruppia polycarpa* | Submergent r-selected | Annual | Native |
| *Ruppia tuberosa* | Submergent r-selected | Annual | Native |
| *Salix babylonica** | Emergent | Perennial | Exotic |
| *Salsola australis* | Terrestrial dry | Perennial | Native |
| *Samolus repens* | Terrestrial damp | Perennial | Native- Listed as Rare in the Murray Region and Uncommon the Southern Lofty Region |
| *Sarcocornia quinqueflora* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Scabiosa atropurpurea** | Terrestrial dry | Annual | Exotic |
| *Scaevola calendulacea* | Terrestrial dry | Perennial | Native |
| *Schoenoplectus pungens* | Amphibious fluctuation tolerator-emergent | Perennial | Native-Listed as Rare in the Southern Lofty Region |
| *Schoenoplectus tabernaemontani* | Emergent | Perennial | Native |
| *Sclerolaena blackiana* | Terrestrial dry | Perennial | Native-Listed as Rare in SA |
| *Senecio cunninghamii* | Floodplain | Perennial | Native |
| *Senecio pterophorus** | Terrestrial dry | Annual | Exotic |
| *Senecio runcinifolius* | Floodplain | Perennial | Native-Listed as Uncommon in the Murray Region |
| *Silybum marianum*** | Terrestrial damp | Annual | Exotic-Proclaimed pest plant in SA |
| *Solanum lycopersicum** | Terrestrial dry | Annual | Exotic |
| *Solanum nigrum** | Terrestrial damp | Annual | Exotic |
| *Sonchus asper** | Terrestrial damp | Annual | Exotic |
| *Sonchus oleraceus** | Terrestrial damp | Annual | Exotic |
| *Spergularia brevifolia** | Terrestrial damp | Annual | Exotic |
| *Stenotaphrum secundatum** | Terrestrial dry | Perennial | Exotic |
| *Suaeda australis* | Amphibious fluctuation tolerator-emergent | Perennial | Native |
| *Symphyotrichum subulatum* * | Terrestrial damp | Annual | Exotic |
| *Thyridia repens* | Amphibious fluctuation tolerator-low growing | Perennial | Native |
| *Trifolium* spp.* | Terrestrial dry | Annual | Exotic-*Trifolium* spp. comprises of *Trifolium angustifolium, Trifolium arvense, Trifolium repens* and *Trifolium subterraneum* |
| *Triglochin striata* | Amphibious fluctuation tolerator-low growing | Perennial | Native |
| *Triticum* sp.* | Terrestrial dry | Annual | Exotic-could not be identified to species |
| *Typha domingensis* | Emergent | Perennial | Native |
| *Urtica urens** | Terrestrial damp | Annual | Exotic |
| *Vallisneria australis* | Submergent k-selected | Perennial | Native-Listed as Uncommon in the Murray Region and Threatened in the Southern Lofty Region |
| *Vicia sativa** | Terrestrial dry | Annual | Exotic |
| *Wilsonia rotundifolia* | Terrestrial damp | Perennial | Native |

**Appendix 2:** GPS coordinates (UTM format, map datum WGS84) for lakeshore and wetland understorey vegetation monitoring sites (site numbers correspond with site numbers in Figure 1).

| Site # | Site | Easting | Northing | Site type |
|---|---|---|---|---|
| 1 | Bremer Mouth Lakeshore | 323061 | 6081991 | lakeshore |
| 2 | Brown Beach 1 | 350172 | 6052777 | lakeshore |
| 3 | Brown Beach 2 | 350287 | 6053158 | lakeshore |
| 4 | Clayton Bay | 311301 | 6070626 | lakeshore |
| 5 | Currency Creek 3 | 296772 | 6074222 | lakeshore |
| 6 | Currency Creek 4 | 301013 | 6071800 | lakeshore |
| 7 | Goolwa North | 303330 | 6070156 | lakeshore |
| 8 | Goolwa South | 300490 | 6066366 | lakeshore |
| 9 | Hindmarsh Island Bridge 01 | 299670 | 6068521 | lakeshore |
| 10 | Hindmarsh Island Bridge 02 | 299695 | 6068616 | lakeshore |
| 11 | Lake Reserve Rd | 339298 | 6089987 | lakeshore |
| 12 | Loveday Bay | 329431 | 6058407 | lakeshore |
| 13 | Loveday Bay Lakeshore | 326621 | 6061647 | lakeshore |
| 14 | Lower Finniss 02 | 305131 | 6076401 | lakeshore |
| 15 | Milang | 315964 | 6079870 | lakeshore |
| 16 | Milang Lakeshore | 316081 | 6079746 | lakeshore |
| 17 | Pt Sturt Lakeshore | 322811 | 6069643 | lakeshore |
| 18 | Pt Sturt Water Reserve | 317673 | 6070784 | lakeshore |
| )19 | Teringie Lakeshore | 327461 | 6066887 | lakeshore |
| 20 | Upstream of Clayton Regulator | 312281 | 6069151 | lakeshore |
| 21 | Wally’s Landing | 303066 | 6079631 | lakeshore |
| 22 | Warrengie 1 | 347722 | 6049163 | lakeshore |
| 23 | Lower Finniss 03 | 305131 | 6072406 | lakeshore |
| 24 | Narrung Lakeshore | 333762 | 6069807 | lakeshore |
| 25 | Nurra Nurra | 341786 | 6063837 | lakeshore |
| 26 | Warrengie 2 | 348487 | 6049133 | lakeshore |
| 27 | Angas Mouth | 318391 | 6081206 | wetland |
| 28 | Bremer Mouth | 323056 | 6082019 | wetland |
| 29 | Dunns Lagoon | 312417 | 6070300 | wetland |
| 30 | Goolwa Channel Drive | 307024 | 6064437 | wetland |
| 31 | Hunters Creek | 308219 | 6065526 | wetland |
| 32 | Poltalloch | 343248 | 6071554 | wetland |
| 33 | Pt Sturt | 322778 | 6069794 | wetland |
| 34 | Teringie | 327334 | 6065286 | wetland |
| 35 | Waltowa | 353908 | 6057756 | wetland |
| 36 | Narrung | 334542 | 6068744 | wetland |

**Appendix 3:** Taxa present (green shading) in Lake Alexandrina spring 2008 to autumn 2023 (Sp denotes spring, Au denotes autumn, *denotes exotic taxon; **denotes proclaimed pest plant in South Australia; ***denotes weed of national significance; #denotes listed as rare in South Australia).

| | Survey Date | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxon** | **Sp 2008** | **Au 2009** | **Sp 2009** | **Au 2010** | **Sp 2010** | **Au 2011** | **Sp 2011** | **Au 2012** | **Sp 2012** | **Au 2013** | **Sp 2013** | **Au 2014** | **Au 2015** | **Sp 2015** | **Au 2016** | **Au 2017** | **Sp 2017** | **Au 2018** | **Sp 2018** | **Sp 2019** | **Sp 2020** | **Au 2021** | **Sp 2021** | **Au 2022** | **Sp 2022** | **Au 2023** |
| *Apium graveolens** | | * | * | | | | * | * | * | | * | | * | * | * | | * | * | | | | | | | | |
| *Arctotheca calendula** | * | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Atriplex prostrata** | * | * | | * | * | | | | | | | | | | | | | | | | | | | | | |
| *Atriplex* spp. | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Atriplex suberecta* | | * | * | | | | | | | | | | | | | | * | | | | | | | | | |
| *Avena* spp.* | * | | * | | * | | | | * | | | | | | | | | | | | | | | | | |
| *Azolla filiculoides* | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * |
| *Berula erecta** | * | | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Bolboschoenus caldwellii* | | * | | * | * | * | * | | * | * | * | * | * | * | | * | * | * | | | * | * | * | * | * | * |
| *Brassica rapa** | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Brassica tournifortii** | | | | * | | | | | | | | * | | | | | | | | | | | | | | |
| *Briza minor** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Bromus diandrus** | * | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Bromus hordeaceus* ssp. *hordeaceus** | | | * | | | | | | * | | | | | | | | | | | | | | | | | |
| *Bromus rubens** | | | | | | | | | * | | | | | | | | | | | | | | | | | |
| *Calystegia sepium* | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Carex apressa* | | | | | | | | | | | | | | | * | | | | | * | | | * | | * | |
| *Carex fasicularis* | | | | | | | | | * | | | | * | | | | * | * | | * | | | | | | |
| *Cenchrus clandestinus** | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Centaurea calcitrapa** | * | * | * | * | | | | | * | | | | * | * | | | | | | | | * | * | | * | |
| *Centaurium tenuiflorum** | * | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Centella asiatica* | * | | | | | | | * | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Ceratophyllum demersum#* | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | | | | | |
| *Chara* spp. | | | | | | | | | | * | | | * | | | | | | | | | | | | | |
| *Chenopodium glaucum** | | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Chenopodium nitrariaceum* | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Conyza bonariensis** | * | * | * | * | | | | | | | | | * | * | | | | | | | | | | | | |
| *Cotula coronopifolia** | * | * | * | | * | * | * | * | * | | | | | * | * | | | * | * | * | * | | | * | * | * |
| *Crassula helmsii* | | | | | | | | | | | | | | | | * | | * | * | * | * | * | * | * | * | * |
| *Cycnogeton procera* | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | |
| *Cyperus gymnocaulos* | * | * | * | * | * | * | * | * | * | * | | * | | * | | | * | | | | * | | | | | |
| *Distichlis distichophylla* | * | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Duma florulenta* | * | | | | * | | | | | | | | | | | | | | | | | | | | | |
| *Ehrharta longiflora** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Einadia nutans* | | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Eleocharis acuta* | | | | | | | * | | * | * | * | * | | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Enchylaena tomentosa* | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Epilobium pallidiflorum* | | | | | | | | | | | | * | | * | | * | | * | | | * | * | * | * | * | * |
| *Eragrostis curvula*** | * | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Eragrostis* sp. | * | * | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Ficinia nodosa* | | * | * | * | * | | | | | | | * | * | | | | * | | | | | | | * | * | * |
| *Foeniculum vulgare** | * | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Frankenia pauciflora* | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| *Fumaria bastardii** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Galenia secunda** | | | | | | | | | | | | | * | | | | | | | | | | | | | |
| *Glyceria australis* | | | | | | | * | | | | | | | | | | | | | | | | | | | |

| | Survey Date | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxon** | **Sp 2008** | **Au 2009** | **Sp 2009** | **Au 2010** | **Sp 2010** | **Au 2011** | **Sp 2011** | **Au 2012** | **Sp 2012** | **Au 2013** | **Sp 2013** | **Au 2014** | **Au 2015** | **Sp 2015** | **Au 2016** | **Au 2017** | **Sp 2017** | **Au 2018** | **Sp 2018** | **Sp 2019** | **Sp 2020** | **Au 2021** | **Sp 2021** | **Au 2022** | **Sp 2022** | **Au 2023** |
| *Holcus lanatus** | * | | | | | | * | | | | | | | | | | * | | | | | | | | | |
| *Hordeum vulgare** | * | | * | | * | | | | | | | | | | | | | | | | | | | | | |
| *Hypochoeris glabra** | * | | * | | * | | | | | | | | | | | | | | | | | | | | | |
| *Hypochoeris radicata** | * | * | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Isolepis producta* | * | * | * | | | | | | * | | | | | | | | | | | | | * | | | | |
| *Juncus acutus*** | * | * | * | * | | | | | | | | | | | | | | | | | | | * | | * | |
| *Juncus holoschoenus* | | | | | | | | | | | | * | | * | * | * | | | | | | | | | | |
| *Juncus kraussii* | * | * | * | * | * | * | * | * | * | * | * | | | | * | * | | | | | | | | * | | * |
| *Juncus pallidus* | | | | | | | | | | | | | | | | | | | | | | | * | | * | |
| *Juncus usitatus* | | * | * | * | * | * | | | * | | | | | * | | | * | * | * | * | * | | * | | * | |
| *Lachnagrostis filiformis* | * | * | * | * | | * | * | * | | | * | | * | | | * | | | | | | | | | | |
| *Lactuca saligna** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Lactuca serriola** | | * | * | * | * | | | | | | * | * | * | | | | | | | | | | | | | |
| *Lagurus ovatus** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Lemna* spp. | | | | | | * | * | | | | * | * | | * | * | * | * | * | | | | | | * | * | * |
| *Limosella australis* | | | | | | | | * | | * | | | | | | | | | | | | | | * | | * |
| *Lobelia anceps* | | | * | | | | | | | | | | * | | | | | * | | | | | | | | |
| *Lolium* spp.* | * | | * | | * | | * | | * | | * | | | * | | | * | | | | * | * | | | | |
| *Ludwigia peploides* ssp. *montevidensis* | | | | | | * | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Lycopus australis* | | * | * | * | | | * | | | * | | * | * | * | | * | * | * | * | * | * | * | * | * | * | * |
| *Lythrum hyssopifolia* | | | | | | | | | | | * | | | | | | | | | | | * | | | | |
| *Medicago* spp.* | * | | * | | | | * | * | | * | | | | | | | | | | | * | * | | | | |
| *Melilotus indicus** | * | | * | | | | | | | | | | * | | | | | | | * | | | | | | |
| *Mentha australis* | * | | | | | | | * | | | | | | | | | | * | * | * | | | * | * | * | * |
| *Mentha* spp.* | | * | * | * | * | * | | | | * | * | * | * | * | * | * | * | | | | | | | | | |
| *Myriophyllum muelleri* | | | | | | | | | | | | | | | | * | | * | | | | | | | | |
| *Myriophyllum salsugineum* | | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Onopordum acanthium** | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Paspalum distichum** | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Persicaria lapathifolia* | * | | * | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Phragmites australis* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Picris angustifolia* ssp. *angustifolia* | * | * | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Plantago coronopus** | * | * | * | * | * | | | | | | | | | | | | | | | | | | | | | |
| *Plantago lanceolata** | | | | | | | | | * | | | | | | | | | | | | | | | | | |
| *Polygonum aviculare** | | * | * | | | * | | | | | | | | | | | | | | | | | | | | |
| *Polypogon monspeliensis** | * | * | * | * | | * | * | | * | * | * | | | * | | | | | * | | | | | | | |
| *Potamogeton crispus* | | | | | | | | | | | * | | | * | | | * | | * | * | | * | * | | * | |
| *Potamogeton pectinatus* | | | | | | | | | * | | * | * | * | | * | | | | | * | * | * | * | | * | |
| *Pseudognaphalium luteoalbum* | * | | * | * | | | | | | | * | | | | | | | | | | | | | | | |
| *Puccinellia* sp.* | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Ranunculus* sp. | | | | | | | | | | | | | | | | | | | | | | | * | * | * | * |
| *Ranunculus trichophyllus** | | | | | | | | | * | | | * | * | * | * | * | * | * | * | * | * | | | | | |
| *Reichardia tingitana** | * | | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Rorippa nasturtium-aquaticum** | | | | | | | | | | * | * | | | | * | | | * | | | | | | | | |
| *Rorippa palustris** | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rumex bidens* | * | | | | | | * | * | * | * | * | | * | * | * | * | * | | * | * | * | * | * | * | * | * |
| *Ruppia tuberosa* | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Salix babylonica** | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Sarcocornia quinqueflora* | * | * | * | * | | | | | | | | | | | | | | | | | | | | | | |

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| *Schoenoplectus pungens* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | | * | | * | * | * |
| *Schoenoplectus tabernaemontani* | * | | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Sclerolaena blackiana* | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Senecio cunninghamii* | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Senecio pterophorus** | * | * | * | * | | | | * | * | * | * | * | | * | * | | * | * | | | | | | | | |
| *Senecio runcinifolius* | | * | | | | | | | | | | | * | | | | | | | | | | | | | |
| *Silybum marianum*** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Solanum lycopersicum** | | | | | | | | | | | | | | | * | | | | | | | | | | | |
| *Solanum nigrum** | | * | * | | | * | | * | | * | | | | | * | | | | | | | | | | | |
| *Sonchus asper** | | | * | * | | * | * | * | | | | | | | | | | | | | | | | | | |
| *Sonchus oleraceus** | * | * | * | * | * | | * | | * | * | | | * | | * | | * | | | | | | | | | |
| *Spergularia brevifolia** | * | | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Suaeda australis* | * | * | * | * | | | | | | | | | * | | | | | | | | | | | | | |
| *Symphyotrichum subulatum** | * | * | * | * | | * | * | * | * | * | | * | * | | * | * | | * | * | * | | * | | | | |
| *Thyridia repens* | | * | | | | | | | | | | * | | | | | | | | | | | | | | |
| *Trifolium* spp.* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | | | | | |
| *Triglochin striata* | | | * | * | | * | | | | | | | | | | | | | | * | | | | | | |
| *Triticum* sp.* | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Typha domingensis* | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Urtica urens** | | | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Vallisneria australis* | | | | | | | | | | | * | * | | | * | | * | | | * | * | * | * | * | * | * |
| *Vicia sativa** | * | | * | | | | * | | | | | | | | | | * | * | | | | | | | | |
| *Wilsonia rotundifolia* | | * | | | | | | | | | | | | | | | | | | | | | | | | |

**Appendix 4:** Taxa present (green shading) in Lake Albert spring 2008 to autumn 2023 (Sp denotes spring, Au denotes autumn, *denotes exotic taxon; **denotes proclaimed pest plant in South Australia; ***denotes weed of national significance; #denotes listed as rare in South Australia).

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| *Acacia myrtifolia* | | * | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Anagallis arvensis** | | | | | | | | | | * | | | | | | | | | | | | | | | | |
| *Arctotheca calendula** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Avena* spp.* | * | | * | | | | | | * | | | | | | | | | | | | | | | | | |
| *Bolboschoenus caldwellii* | | | | | | | | | * | | | | | | | | | | | | | | | | | |
| *Bromus catharticus** | | | | | | | | | * | | | | | | | | | | | | | | | | | |
| *Bromus diandrus** | * | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Bromus hordeaceus* ssp. *hordeaceus** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Calystegia sepium* | | | | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Cenchrus clandestinus** | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Centaurea calcitrapa** | * | | * | | | | | | * | | | | | | | | | | | | | | | | | |
| *Chenopodium album** | | | | * | | | | | | | | | * | | | | | | | | | | | | | |
| *Chenopodium glaucum** | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Conyza bonariensis** | * | | | | | | | * | | | | | | | | | | | | | | | | | | |
| *Cotula coronopifolia** | * | | * | * | | | * | * | | | | | | | | | | | | | | | | | | |
| *Cyperus gymnocaulos* | * | * | * | * | * | | * | | * | * | | * | * | | | | * | * | * | | | | | * | * | * |
| *Distichlis distichophylla* | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Duma florulenta* | | | | | | | * | | | | | | * | | | * | | * | * | * | * | * | * | * | * | * |
| *Ehrharta longiflora** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Enchylaena tomentosa* | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Eragrostis australasica* | | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Eragrostis curvula*** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Euphorbia terracina*** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Ficinia nodosa* | | * | * | * | * | | | | | | | | | | | | | | | | | | | | | |
| *Hordeum vulgare** | * | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Hypochoeris glabra** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Hypochoeris radicata** | | | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Isolepis producta* | * | | | * | | | | | | | | | * | | | | | | | | | | | | | |
| *Lachnagrostis filiformis* | * | * | | | | | | | | | | * | * | | | | | | | | | | | | | |
| *Lactuca serriola** | | | | | | | | | * | | | | | | | | | | | | | | | | | |
| *Lagurus ovatus** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Lolium* spp.* | * | | * | | | | | | * | | | | | | | | | | | | | | | | | |
| *Lythrum hyssopifolia* | | | | | | | | | * | | | * | | | * | | | | | | | | | | | |
| *Lythrum salicaria* | | | | | | | | | | | | | * | | | | | | | | | | | | | |
| *Medicago* spp.* | * | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Melaleuca halmaturorum* | | | * | * | | | | | | | | | * | | | | | | | | | | | | | |
| *Melilotus indicus** | * | | * | * | | | | | | | | | | | | | | * | | | | | | | | |
| *Myriophyllum salsugineum* | | | | | | | | | | | | | | | | | | | * | | | * | | | | |
| *Paspalum distichum** | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Phragmites australis* | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |

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| *Plantago coronopus** | | | * | * | | | | | * | | * | | | | | | | | | | | | | | | |
| *Polypogon monspeliensis** | * | * | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Potamogeton pectinatus* | | | | | | | * | | | | | | | | | | * | | | | | | | | | |
| *Puccinellia* sp.* | | | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Reichardia tingitana** | * | * | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Rumex bidens* | | | | | | | | | * | | | | | | | * | | | | | * | | * | * | * | * |
| *Sarcocornia quinqueflora* | | * | * | * | | * | | | | | | | | | | | | | | | | | | | | |
| *Scaevola calendulacea* | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Schoenoplectus pungens* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | | | * | * | * | | * | | | | |
| *Schoenoplectus tabernaemontani* | * | | | | * | * | | | * | * | | | * | | * | * | | * | * | * | | | * | * | * | * |
| *Senecio pterophorus** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Sonchus oleraceus** | * | | * | * | | | | * | * | | | * | | | | | | | | | | | | | | |
| *Spergularia brevifolia** | | | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Suaeda australis* | | | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Symphyotrichum subulatum** | * | | * | * | | | | * | | | | * | * | | | | | * | | * | | * | * | * | * | * |
| *Thyridia repens* | * | | | * | | | | * | | * | | | | | | | | | | | | * | * | * | * | * |
| *Trifolium* spp.* | * | | * | * | | | | | * | | | | * | | | | | | * | | | | | | | |
| *Triglochin striata* | | | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Typha domingensis* | | | | | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Vicia sativa** | * | | * | | | | | | * | | | | | | | | | | | | | | | | | |

**Appendix 5:** Taxa present (green shading) in Goolwa Channel spring 2008 to autumn 2023 (Sp denotes spring, Au denotes autumn, *denotes exotic taxon; **denotes proclaimed pest plant in South Australia; ***denotes weed of national significance; #denotes listed as rare in South Australia).

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| *Acacia myrtifolia* | | | | | | | | | | | | * | * | * | * | | | * | | * | * | * | | | | |
| *Asparagus asparagoides**** | | | | | | | | | | | | | | | | | | | | * | | | | | | |
| *Asparagus officinalis** | | * | | | | | | | * | | | | | | | | | | | | | | | | | |
| *Atriplex prostrata** | | * | | * | | | | | | | | * | | | | | | | | | | | | | | |
| *Atriplex* spp. | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| *Azolla filiculoides* | | | * | | | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * |
| *Berula erecta** | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Bolboschoenus caldwellii* | | | * | * | * | * | * | * | | * | * | | | | | | | * | * | * | * | * | * | * | * | * |
| *Bouteloua dactyloides** | | | | | | | | | | | | | | * | | | * | | | | * | * | * | * | * | * |
| *Brassica tournifortii** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Bromus diandrus** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Bromus hordeaceus* ssp. *hordeaceus** | | | * | | | | * | | | | | | | | | | | | | | | | | | | |
| *Calystegia sepium* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Carex fasicularis* | | | | | | | | | | | | | | | | | | | | | | | * | | | |
| *Cenchrus clandestinus** | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Centaurea calcitrapa** | * | | | | | | | | | | | | | | | | | | | | | * | * | | | |
| *Centella asiatica* | | | | | | | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * |
| *Ceratophyllum demersum#* | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Chenopodium glaucum** | * | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Conyza bonariensis** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Cotula coronopifolia** | * | | * | * | * | | * | | | | * | | | | | | | | | | | | | | | |
| *Crassula helmsii* | | | | | | | | | | | | | | | | | | | | * | * | * | | | | |
| *Cycnogeton procera* | | | * | * | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Cyperus exaltatus* | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Cyperus gymnocaulos* | * | | * | | * | | | | | | | | | | | | | | | | | | | | | |
| *Duma florulenta* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Eleocharis acuta* | | | | | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Enchylaena tomentosa* | | | * | | | | | | | | | | * | | | | | | | | | | | | | |
| *Epilobium pallidiflorum* | | * | | | | | | | | | | | | | | | | | | | | | * | | | |
| *Eragrostis* sp. | | | | | | | | | * | | | | | | | | | | | | | | | | | |
| *Ficinia nodosa* | | | * | | * | | * | | | | * | | | | * | | * | * | * | * | | | * | * | * | * |
| *Gahnia clarkii* | | | | | | | | | | | | | | | | | | | | | | * | | | | |
| *Juncus kraussii* | * | * | | | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Juncus usitatus* | | | * | * | | * | * | | | | | | | | | | | | | | | | | | | |
| *Lachnagrostis filiformis* | * | * | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Lactuca saligna** | | | | | | | * | | * | | | | | | | | | | | | | | | | | |
| *Lemna* spp. | | | | | * | | * | | | | * | * | | * | * | | * | | | | | | | | | |
| *Lobelia anceps* | | | | | | | | | | | | | * | | | | | | | | | | | | | |
| *Lolium* spp.* | | | * | | | | * | | | | | | | | | | | | | | | | | | | |
| *Lupinus cosentinii** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Lycopus australis* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |

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| *Lythrum hyssopifolia* | | | | | | | | | * | | | | | | | | | | | | | | | | | |
| *Lythrum salicaria* | * | | | | | | | | | | | | | | | | * | | | | | | | | | |
| *Medicago* spp.* | | | | | | | * | | | | * | | | | | | | | | | | | | | | |
| *Melilotus indicus** | | | * | | | | * | | | | | | | | | | | | | | | | | | | |
| *Mentha australis* | | | | | | | | * | | | | | | | | | | * | * | * | * | * | * | * | * | * |
| *Mentha* spp.* | | | * | | | | * | | * | * | * | * | * | * | * | * | * | | | | | | | | | |
| *Myriophyllum caput-medusae* | | | | | | | | | * | | | | | | * | | | | | | | | | | | |
| *Myriophyllum muelleri* | | | | | | | | | | | | | | | | | | * | | | | | | | | |
| *Myriophyllum salsugineum* | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Paspalum distichum** | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Persicaria lapathifolia* | | | | | | | | | | | * | * | | * | | * | * | * | * | * | * | * | * | * | * | * |
| *Phragmites australis* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Picris angustifolia* ssp. *angustifolia* | | * | | * | | * | | * | | | | * | | | | | | | | | | | | | | |
| *Plantago coronopus** | | | * | | * | | | | | | | | | | | | | | | | | | | | | |
| *Plantago lanceolata** | | | * | | * | | | * | * | * | | | | | | | | | | | | | | | | |
| *Polygonum aviculare** | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Polypogon monspeliensis** | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Potamogeton crispus* | | | | | * | * | | | | | | | | * | | | | * | | | * | * | | * | | * |
| *Potamogeton pectinatus* | | | | * | * | | | | * | | | | * | | | | | | | | * | | * | * | * | * |
| *Ranunculus trilobus** | | | | | | | * | | * | | * | * | * | * | * | | | | | | | | | | | |
| *Rumex bidens* | | | | | * | | * | * | * | | * | * | | * | | | * | | * | * | | | * | * | * | * |
| *Salix babylonica** | | | | * | * | * | | * | * | * | | | | | | | | | | | | | | | | |
| *Samolus repens* | | | | | | | | | * | * | * | | | * | | | * | | | | * | * | * | | | |
| *Scabiosa atropurpurea** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Schoenoplectus pungens* | | | * | * | * | | * | | * | | * | * | | | | | | | | | | | | | | |
| *Schoenoplectus tabernaemontani* | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Silybum marianum*** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Solanum nigrum** | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Sonchus oleraceus** | * | | * | | | | * | * | * | | * | | | | | | | | | | | | | | | |
| *Suaeda australis* | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Symphyotrichum subulatum** | * | * | * | * | | | | * | * | * | * | | * | * | | * | * | * | | | | * | | | | |
| *Thyridia repens* | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Trifolium* spp.* | | | | | | | | | | | | * | | | | | | | | | | | | | | |
| *Triglochin striata* | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| *Typha domingensis* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Vallisneria australis* | | | | | | | * | * | | * | * | * | | | | | * | * | * | | * | * | * | * | * | * |

**Appendix 6:** Taxa present (green shading) in permanent wetlands spring 2008 to autumn 2023 (Sp denotes spring, Au denotes autumn, *denotes exotic taxon; **denotes proclaimed pest plant in South Australia; ***denotes weed of national significance; #denotes listed as rare in South Australia).

| | Survey Date | | | | | | | | | | | | | | | | | | | | | | | | | |
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| **Taxon** | **Sp 2008** | **Au 2009** | **Sp 2009** | **Au 2010** | **Sp 2010** | **Au 2011** | **Sp 2011** | **Au 2012** | **Sp 2012** | **Au 2013** | **Sp 2013** | **Au 2014** | **Au 2015** | **Sp 2015** | **Au 2016** | **Au 2017** | **Sp 2017** | **Au 2018** | **Sp 2018** | **Sp 2019** | **Sp 2020** | **Au 2021** | **Sp 2021** | **Au 2022** | **Sp 2022** | **Au 2023** |
| *Atriplex prostrata** | * | * | * | * | * | | | | | * | | | | | | * | | | * | | | | | | | |
| *Avena* spp.* | | | * | | * | | | | | | | | | | | | * | | | | | | | | | |
| *Azolla filiculoides* | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Baumea juncea* | | | | | | | | | | | | | | | | | | | * | * | * | * | * | * | * | * |
| *Berula erecta** | * | | | | | | | | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Bolboschoenus caldwellii* | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Brassica rapa** | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Brassica tournifortii** | | | | | | | * | | | | | | | | | | | | | | | | | | | |
| *Bromus diandrus** | * | | * | | * | | * | | | | | | | | | | * | | | | | | | | | |
| *Bromus hordeaceus ssp. hordeaceus** | * | | * | | | | | | | | | | | | | | * | | | | | | | | | |
| *Bromus rubens** | | | | | | | | | | | | | | | | | | | | * | | | | | | |
| *Calystegia sepium* | | | | * | | | | | | | | * | | | | * | | | | * | * | * | * | * | * | * |
| *Cenchrus clandestinus** | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Centaurea calcitrapa** | * | * | | | * | * | | | | | | | | | | | | | | * | | | * | | | |
| *Centella asiatica* | * | | * | | | | | | | | | * | | | * | * | | * | * | | | | | * | * | * |
| *Ceratophyllum demersum#* | | | | | * | * | * | * | * | * | | * | * | | * | * | * | * | * | * | * | * | * | * | * | * |
| *Chenopodium album** | * | | * | * | | * | | | | | | | | | | | | | | | | | | | | |
| *Chenopodium glaucum** | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| *Conyza bonariensis** | * | | | | * | | | | | | | | | | | | | | | | | | * | * | * | * |
| *Cotula coronopifolia** | * | | * | | * | * | * | * | * | | * | * | | | | | | | | | | | | | | |
| *Crassula helmsii* | | | | | | | | | | | * | | * | * | | | | * | * | * | | * | * | * | * | * |
| *Cycnogeton procera* | * | | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Cyperus exaltatus* | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Cyperus gymnocaulos* | | | | * | * | | * | | * | | | * | | | | | | | | | | | | | | |
| *Dianella revoluta* | | | | | | | | | * | | | | | | | | | | | | | | | | | |
| *Disphyma crassifolium* | | | | | | | | | | | | | | | | * | * | * | | | | | | | | |
| *Distichlis distichophylla* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Duma florulenta* | | | | | * | | * | | | | | | | | | | | | | | | | | | | |
| *Echinochloa crus-galli** | | | | | | | | | * | | | | | | | | | | | | | | | | | |
| *Eleocharis acuta* | | | | | * | * | * | * | * | * | * | * | | * | | | | * | * | * | * | * | * | * | * | * |
| *Enchylaena tomentosa* | | | * | | | | | | | | | | | | | | | | | | * | * | * | * | * | * |
| *Eragrostis curvula*** | * | | * | | * | | * | | * | | | | | | | | * | | | | | | | | | |
| *Eragrostis* sp. | * | | * | | | | * | | * | | | | | | | | | | | | | | | | | |
| *Ficinia nodosa* | | * | | * | | * | | | | | | | | | | | | | | | | | | | | |
| *Gahnia filum* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Hordeum vulgare** | * | | * | | * | * | * | * | * | | | | | | | | * | | | | | | | | | |
| *Hypochoeris glabra** | | | * | | | * | | * | | | | | | | | | | | | | | | | | | |
| *Hypochoeris radicata** | | | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Iris* spp.* | | | | | * | | | | | | | | | | | | | | | | | | | | | |
| *Isolepis producta* | | | * | | | * | | | | | | | | | | | | | | | | | | | | |
| *Juncus acutus*** | | | * | | | | | | * | | | | | | | | | | | | | | | | | |
| *Juncus kraussii* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |

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| *Juncus subsecundus* | | | | | | | * | | | | | | | | | | | | | | | | | | | |
| *Lachnagrostis filiformis* | * | * | * | * | | * | * | * | | | | * | | | | | | | | | | | | | | |
| *Lactuca saligna** | * | | | | | | | | | | | | | | | | | | | | | | | * | | * |
| *Lactuca serriola** | * | | | | * | * | * | * | * | | | * | | * | | * | * | * | | | | | | | | |
| *Lemna* spp. | | | | | * | | * | | | * | * | * | * | * | * | | * | | * | * | * | * | * | * | * | * |
| *Lobelia anceps* | | | | | | | | | | | | | | | | | | | | | | * | * | * | * | * |
| *Lolium* spp.* | * | | * | | * | * | * | | * | | | | | | | | * | | * | * | * | | * | | | |
| *Ludwigia peploides* ssp. *montevidensis* | | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Lycium ferocissimum**** | | | | | | | | | | | | | | | | | | * | | | | | | | | |
| *Lycopus australis* | | | | | | | | | | * | | | | | * | | * | | | | | | * | * | * | * |
| *Medicago* spp.* | | | * | | * | | | | | | | | | | * | | | | | * | | | | | | |
| *Melaleuca halmaturorum* | * | * | * | * | | * | * | | | | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Melilotus indicus** | * | | * | | | | | | | | | | | | | | * | | * | | | | | | | |
| *Mentha australis* | | | | | | | | | | | | | | | | | | * | | | * | * | * | * | | |
| *Mentha* spp.* | * | | | | | | | | | | | * | * | * | | * | * | | | | | | | | | |
| *Myoporum insulare* | | | | | | | | | | | | | | | | | * | | | * | * | * | * | * | | |
| *Myriophyllum caput-medusae* | | | | | | | | | * | * | | * | * | | | | | | | | | | | | | |
| *Myriophyllum muelleri* | | | | | | | | | | | | | | | | | | * | | | | | | | | |
| *Myriophyllum salsugineum* | | | | | * | * | * | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Paspalum distichum** | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Persicaria lapathifolia* | * | * | * | * | * | | | * | * | | * | | * | * | | * | * | | | | | | | * | | * |
| *Phragmites australis* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Picris angustifolia* ssp. *angustifolia* | | | | * | * | | | | | | | | | | | | | | | | | | | | | |
| *Plantago coronopus** | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Polypogon monspeliensis** | * | | | | * | | * | | * | | * | | | * | | | | | | | | | | | | |
| *Potamogeton crispus* | | | | | * | | * | | * | | * | * | * | * | | | | | * | | * | * | | | | |
| *Potamogeton pectinatus* | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * |
| *Pseudognaphalium luteoalbum* | | | * | * | | | * | | | | | | | | | | | | | | | | | | | |
| *Reichardia tingitana** | * | | * | * | | * | * | * | | | | | | | | | | | | | | | | | | |
| *Rorippa nasturtium-aquaticum** | * | | | | | | | | | | | | | | | | | | * | | | | | | | |
| *Rumex bidens* | * | * | | | * | | * | * | * | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Ruppia megacarpa* | | | | | * | * | * | | | | | | | | | | | | | | | | | | | |
| *Ruppia polycarpa* | | | | | * | | | | | | | | | | | | | | | | | | | | | |
| *Ruppia tuberosa* | * | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Samolus repens* | * | | * | | * | | | | | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * |
| *Sarcocornia quinqueflora* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Scabiosa atropurpurea** | | | | | | * | | | | | | | | | | | | | | | | | * | * | * | * |
| *Schoenoplectus pungens* | * | | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | * | * |
| *Schoenoplectus tabernaemontani* | | | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |

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| *Senecio pterophorus** | * | * | * | * | | * | | | * | * | * | * | | | | | | | | | | | | | | |
| *Senecio runcinifolius* | | | * | | | | | | | | | | | | | | | | | | | | | | | |
| *Sonchus asper** | | | * | * | * | | | | | | | | | | | | | | | | | | | | | |
| *Sonchus oleraceus** | * | * | * | * | * | | * | | * | | * | * | | * | * | * | * | * | * | * | * | | * | | * | |
| *Spergularia brevifolia** | * | * | * | * | | | | | | | | | | | | | | | | | | | | | | |
| *Suaeda australis* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Symphyotrichum subulatum** | * | * | * | * | * | * | * | * | * | * | | * | | * | | * | | * | * | * | | * | * | * | * | * |
| *Thyridia repens* | * | | * | | | * | * | | | | * | | | | | | | | | | | | | | | |
| *Trifolium* spp.* | | | * | | | | | | | | | | | | | | * | | | | | | | | | |
| *Triglochin striata* | * | * | * | | * | * | | | * | | * | | | | | | | | | | | * | | | | |
| *Typha domingensis* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Urtica urens** | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Vallisneria australis* | * | | * | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | | | | |
| *Wilsonia rotundifolia* | * | * | | | * | * | | | | | | | * | * | * | | * | * | | | | | | | | |

**Appendix 7:** Taxa present (green shading) in temporary wetlands spring 2008 to autumn 2023 (Sp denotes spring, Au denotes autumn,*denotes exotic taxon; **denotes proclaimed pest plant in South Australia; ***denotes weed of national significance; #denotes listed as rare in South Australia).

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| *Althenia cylindrocarpa* | | | | | | | | | | | | | | | | | | | | | | | | * | | * | |
| *Atriplex prostrata** | * | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Atriplex* spp. | * | * | | * | | * | * | | | | * | | | | | | | | | | | | | | | | |
| *Atriplex suberecta* | | * | * | * | * | | | | | | | | * | | * | | | * | | | | | | | | | |
| *Avena* spp.* | * | | * | | | | * | | | | | | | * | | | | * | | * | * | * | | * | | | |
| *Azolla filiculoides* | | | | | | | * | | * | | | | | * | * | | | * | | | * | * | | * | | | |
| *Berula erecta** | | | | | | | | | | | | | | | | | | * | | | | | | | | | |
| *Bolboschoenus caldwellii* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Brassica tournifortii** | * | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Bromus diandrus** | * | | * | | * | | * | | * | | | | | | | | | | | | | | | | | | |
| *Bromus hordeaceus* ssp. *hordeaceus** | | | * | | | | * | | * | | | | | | | | | | | | | | | | | | |
| *Bromus rubens** | | | | | | | | | | | | | | | | | | | | | * | | | | | | |
| *Cenchrus clandestinus** | | | | | | | | | | | | | * | | | | | | | | | | | | | | |
| *Centaurea calcitrapa** | | | * | | * | * | * | * | * | | | * | | | | | | | | | * | * | | | | | |
| *Centaurium tenuiflorum** | | | | | | | | | | | | | | | | | | | | | * | | | | | | |
| *Chara* spp. | | | | | | * | * | * | * | | | | | * | | | | * | | | | | | | | | |
| *Chenopodium album** | | | | | | * | | | | | | | | | | | | | | | | | | | | | |
| *Chenopodium glaucum** | * | | | | * | | | * | | * | | | * | | * | | * | | * | | | | * | | * | | * |
| *Conyza bonariensis** | * | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Cotula coronopifolia** | * | | * | | * | * | * | * | * | * | * | | | * | | * | | * | | | | * | | * | | | |
| *Cycnogeton procera* | | | | | | | | | | | | | | | | | | | | | | * | | * | | | |
| *Cyperus gymnocaulos* | * | * | | * | | * | | * | * | | * | | | | | | | | | | | | | | | | |
| *Disphyma crassifolium* | | | | | * | * | * | * | * | * | * | | * | * | | * | * | * | | * | * | * | * | * | * | * | * |
| *Distichlis distichophylla* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Duma florulenta* | | | | | | * | * | | | * | | | | * | * | * | * | * | | * | | | | | | | |
| *Einadia nutans* | | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Eleocharis acuta* | | | | | * | | * | | * | | * | | | * | | | | | | * | * | * | * | * | | | |
| *Epilobium paladiflorum* | | | | | | | | | | | | | | | | | | | | | | | * | * | * | * | * |
| *Enchylaena tomentosa* | * | * | * | * | * | * | | * | * | | | * | * | | * | | | * | | | | | | | | | |
| *Eragrostis curvula*** | * | | * | | * | | * | | * | | | | | * | | | | * | | | * | | | | | | |
| *Eragrostis* sp. | * | | * | | | | * | | | | | | | | | | | | | | | | | | | | |
| *Erodium cicutarium** | | | | | | | | * | | | | | | | * | | | | | | | | | | | | |
| *Ficinia nodosa* | * | | * | | | | | | | | | * | * | | | | * | | | | | | | | | | |
| *Frankenia pauciflora* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * |
| *Glyceria australis* | | | | | * | | * | | | | | | | | | | | | | | | | | | | | |
| *Heliotropium europaeum** | | | | * | | * | | | | | | | | | | | | | | | | | | | | | |
| *Hordeum vulgare** | * | | * | | * | * | * | * | * | | * | | | | | | * | * | | * | * | | | | | | |
| *Hypochoeris glabra** | | | | | | * | | | | | | | | | | | | | | | | | | | | | |
| *Isolepis producta* | | | | | | | | | * | | | * | | * | | * | | | | * | * | | * | | | | |
| *Juncus acutus*** | | | | | | | | | | | | | * | | | | | | | | | | | | | | |
| *Juncus kraussii* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | | | | |
| *Juncus subsecundus* | | | | | | | | * | | | | | | | | | | | | | | | * | | | | |
| *Lachnagrostis filiformis* | * | | * | | * | | | * | * | * | * | | | | * | | | * | * | | | * | | | | | |
| *Lactuca saligna** | * | | * | | | | * | | | | | | | | | | | | | | | | | | | | |
| *Lactuca serriola** | * | | * | | * | * | * | * | * | | | * | | | | | * | * | | * | | | * | * | * | * | * |
| *Lagurus ovatus** | * | | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Lamprothamnium macropogon* | * | | * | | * | * | * | | * | | * | | | * | | * | | * | | * | * | * | * | * | | * | |
| *Lemna* spp. | | | | | | * | | | * | | | | | | | * | | * | | * | * | * | | * | | * | |
| *Limosella australis* | | | | | | | | | | | | | | | | | | | | | | * | | | | | |

| | Survey Date | | | | | | | | | | | | | | | | | | | | | | | | | |
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| **Taxon** | **Sp 2008** | **Au 2009** | **Sp 2009** | **Au 2010** | **Sp 2010** | **Au 2011** | **Sp 2011** | **Au 2012** | **Sp 2012** | **Au 2013** | **Sp 2013** | **Au 2014** | **Au 2015** | **Sp 2015** | **Au 2016** | **Sp 2016** | **Au 2017** | **Sp 2017** | **Au 2018** | **Sp 2018** | **Sp 2019** | **Sp 2020** | **Au 2021** | **Sp 2021** | **Au 2022** | **Sp 2022** | **Au 2023** |
| *Lobelia anceps* | | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Lolium* spp.* | * | | * | * | * | * | * | * | * | | * | | * | * | | * | | * | | * | * | * | | * | | | |
| *Ludwigia peploides* ssp. *montevidensis* | | | | | | | | | | | | | * | | * | | | | | * | | | | | * | * | * |
| *Lycium ferocissimum**** | * | | * | * | * | * | | * | | | | | | | | | | | | * | | | | | | | |
| *Lythrum hyssopifolia* | | | | | | | | | | | | | | | | | | | | | | * | | | | | |
| *Lythrum salicaria* | | | | | | | | | | | | | | | | | | * | | | | | | | | | |
| *Malva parviflora** | | | | | | * | | | | | | | | | | | | | | | | | | | | | |
| *Marrubium vulgare*** | | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Medicago* spp.* | * | | * | | * | * | * | * | | * | | | | | * | | | | | | | | | | | | |
| *Melaleuca halmaturorum* | | | | | | | * | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Melilotus albus** | | | | | | | | | * | | | | | | | | | | | | | | | | | | |
| *Melilotus indicus** | * | | * | | * | | * | | | | * | | | * | | | | | | | | | | | | | |
| *Myoporum insulare* | | | | | | | | | | | | | | * | * | | * | * | * | | * | * | * | | | | |
| *Myriophyllum salsugineum* | | | | | * | | | | | | | | | * | | | * | | | | | | | | | | |
| *Myriophyllum verrucosum* | | | | | | | | | | | | | * | | | | | | | | | | | | | | |
| *Paspalum distichum** | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Phragmites australis* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Phyla canescens** | * | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Picris angustifolia* ssp. *angustifolia* | | | | | * | * | | | | | | | | | | | | | | | | | | | | | |
| *Plantago coronopus** | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Polygonum aviculare** | * | * | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Polypogon monspeliensis** | * | | * | | * | | * | | * | | * | | | * | | * | | * | * | * | * | * | | * | * | * | * |
| *Potamogeton pectinatus* | | | | | | * | * | * | * | * | | | | | | | | | | | | | | | | | |
| *Pseudognaphalium luteoalbum* | | | | | * | | * | | | | | | | | | | | | | | | | | | | | |
| *Puccinellia* sp.* | | | * | | | | * | | | | | | | | | | | | | | | | | | | | |
| *Ranunculus trichophyllus* | | | | | * | | * | | * | * | * | * | | | | | | | | * | * | * | | | | | |
| *Reichardia tingitana** | * | | * | | | * | * | | * | | | | | | | | | | | | | | | | | | |
| *Rorippa nasturtium-aquaticum** | | | | | | | | | | | | | | | | | | | | * | | | | | | | |
| *Rorippa palustris** | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rumex bidens* | * | | * | | | * | | | | | * | * | | * | | * | | * | | * | * | * | * | * | | | |
| *Ruppia polycarpa* | | | | | * | * | * | | * | | | | | | | | | | | | | * | | | | | |
| *Ruppia tuberosa* | * | | * | | * | * | | * | * | | * | | | * | | * | | * | | * | * | * | * | * | * | * | * |
| *Salsola australis* | | | | * | | * | | | | | | | | * | * | | | * | | | | | | | | | |
| *Samolus repens* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Sarcocornia quinqueflora* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Schoenoplectus pungens* | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Schoenoplectus tabernaemontani* | | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Senecio pterophorus** | * | | * | * | | | | | | * | | | | | | | | * | * | * | | | * | * | * | * | * |
| *Silybum marianum*** | | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| *Sonchus asper** | | | | | | | | | | | | | | | * | | | | | | * | * | | | | | |
| *Sonchus oleraceus** | * | | * | * | * | * | * | * | * | * | * | * | | * | | * | | | | * | * | * | | | | | |
| *Spergularia brevifolia** | * | * | * | * | * | * | * | | * | | | | | | | | | | | | | | | | | | |
| *Suaeda australis* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Symphyotrichum subulatum** | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Thyridia repens* | * | | * | | * | * | * | * | * | * | * | * | * | * | | | * | | * | | | * | | * | | | |
| *Trifolium* spp.* | * | | * | | * | * | * | | * | | * | * | | * | | * | | * | | * | * | * | * | | | | |
| *Triglochin striata* | * | | | | * | * | * | * | * | * | * | | * | * | | * | * | * | * | * | * | * | * | * | * | * | * |

| | Survey Date | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| *Typha domingensis* | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Wilsonia rotundifolia* | * | | | | * | * | * | * | * | | | * | * | | * | * | | | * | | * | | * | * | * | * | * |