Developing ecological response models and determining water requirements for wetlands in the South-East of South Australia

Task 1: Data review and methodological framework

Gehrig, S, Harding, C, Turner, D, Nicol, J, Clarke, K, Clark, M, Deane, D, Aldridge, K, Brookes, J, Ostendorf, B and Lewis, M

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The following Associate organisation contributed to this report:

Enquires should be addressed to: Goyder Institute for Water Research

Level 4, 33 King William Street
Adelaide, SA, 5000
tel: 08-8236 5200
e-mail: enquiries@goyderinstitute.org

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Executive Summary

The South East region of South Australia contains wetlands of high ecological value. Water regime is a principal driver of these wetland communities, where historically water moved from south to north, but the construction of drainage networks in the Lower South East and subsequently the Upper South East severed connectivity and substantially altered regional flow paths. As a result, most wetlands in the South East have suffered from reduced water availability (although, some wetlands that receive drainage water have experienced increased volumes of water) and future management actions are likely to further impact upon the water regimes of these wetlands. Hence it is important to understand the response of wetland communities to altered water regimes that may arise from management (e.g. the distribution of surface water and saline groundwater through the drainage network), land use and/or natural disturbances, such as extended drought.

The aim of the South East Wetlands Project was to build upon existing information to develop ecological response models for wetland plant assemblages in the South East. To undertake this task a classification system for wetlands and vegetation assemblages was developed as a basis for applying conceptual models of different wetland types at the landscape scale (Task 1).

Potentially relevant data and literature pertaining to South East wetlands and vegetation assemblages were sourced. The synthesis of all available data (spatial, hydrological, ecological, and so on) was used to identify data and knowledge gaps that may be required to build appropriate ecological response models for the region. A thorough review of existing data also ensured that any new data collected within this project is comparable to historical data (where appropriate data exists). The synthesis of this information allowed its analysis and application in others tasks (tasks 2 to 5).

Relevant data and literature, including international examples of wetland classifications systems, were also reviewed as part of Task 1 to assist in the development of a regional classification framework. The regional classification framework needed to be as simple as possible (without losing scientific rigour), but also have the ability to predict the possible changes and/or responses of wetland ecosystems within the South East to changes in hydrology (i.e. natural or human-induced) and management actions.

Changes in the salinity and water regime in the South East are believed to be the two primary drivers affecting the floristic composition of the wetlands. By combining hydroperiod and salinity; nine possible types of wetlands potentially exist within the South East. These are: Permanent fresh, Seasonal Fresh, Ephemeral Fresh, Permanent Brackish, Seasonal Brackish, Ephemeral Brackish, Permanent Saline, Seasonal Saline and Ephemeral Saline.

Given the breadth and diversity of wetland types within the South East region, a set of case study sites were selected that best represent the range of hydrological, water quality, and geomorphic settings. These wetlands potentially also encompass the nine potential types of wetlands described by the regional classification framework described above. Case study wetlands selected were: Deadmans Swamp, The Marshes, Trail Waterhole, Toppewein Swamp, Lake Hawdon South, Bool/Hacks Lagoon, Lake Robe, Big Dip Lake, Middlepoint Swamp, Pick Swamp, Lake George and Taratap.

At the selected case study sites, field surveys (Task 2) were undertaken to:

- develop a methodology for assessing the salinity and water regime preferences of plant species/functional groups,
- evaluate regional classification frameworks,
- validate and ground truth remotely sensed data (Tasks 3), and
- guide the development of eco-hydrological conceptual models for wetland types (Task 4).

The classification system, as presented and described in this document, will require further development, testing and refinement because it is only through extensive and long-term implementation that specific problems can be identified and rectified. It is therefore important to stress that the classification system proposed will evolve over time as further information is collected.

1. Background and introduction

The South East of South Australia (herein referred to as the South East) is a highly modified landscape. Prior to the construction of the South East drainage scheme, a series of wetlands occupied the inter-dunal swales and flats and during wet years up to 53% of the region was underwater during winter and early spring (Holmes and Waterhouse 1983). Drainage of wetlands commenced in 1863 with drains cut into the dunes and wetland beds to convert the wetlands to agricultural land and divert the water into the Southern Ocean (Allison and Harvey 1983; Holmes and Waterhouse 1983). Currently approximately 6% of the original wetland area remains (Bachmann 2002; Heneker 2006; Taylor 2006; Harding 2009) with remnant wetlands often highly modified (10% of remnant wetlands are regarded as being intact) (Department for Water, 2010). Nevertheless, the region still contains wetlands of high ecological value (Butcher et al. 2011; Department for Water, 2010). Bool and Hacks Lagoons, Piccaninnie Ponds and the Coorong, Lower Lakes and Murray Mouth are wetlands of international significance under the Ramsar Convention and a further ten are listed in the Directory of Important Wetlands in Australia (Australian Nature Conservation Agency 1996).

With the role that wetlands play in the landscape now being recognised, conservation of remnant wetlands has become a priority (Mitsch and Gosselink 2000; van der Valk 2012). In the South East a conflict exists between wetland conservation and agricultural production. The drainage network was designed to remove water from the land to support agricultural production and despite there often being an excess of water in the landscape (hence the need for the drainage network) wetlands continue to suffer from reduced water availability. This fundamental conflict between removing water from the landscape to allowing farming to proceed but still remaining enough water in appropriate places to maintain some ecological values is a challenge for managers. Nevertheless, there has been a change in water management with water that was historically seen as a nuisance to be disposed of from the landscape is now seen as a valuable resource that can be directed to or away from wetlands via the drainage network to manage water regimes. Water regime (depth, duration, rate, timing, frequency, and predictability of inundation and drawdown (Blanch 1999) is a primary ecological determinant in wetlands (Mitsch and Gosselink 2000; Bunn and Arthington 2002). The changes to the natural water regimes of wetlands brought about by the construction of the drainage network undoubtedly changed the ecology of remnant wetlands. However, hydrological restoration of some wetlands is now viewed as feasible by using drainage water (where possible) and improvements in the ecology will likely follow (Mitsch and Gosselink 2000).

Despite the changes in operation of the drainage networks and construction of new drains to link the lower and upper South East schemes, water scarcity is still a major cause of wetland degradation. Many wetlands are not connected to drainage schemes and are reliant on local surface and groundwater, which is likely to decrease in availability due to climate change and abstraction of groundwater for irrigation. Hence, these wetlands are unable to receive extra water due to their disconnection from the drainage scheme and will not benefit. In addition, water from the drainage network is derived locally and during dry years water availability will be low as there is no other source and even wetlands connected to the drainage network will suffer from low water availability. Other wetlands are impacted by drainage of local catchments where there is now reduced water availability for surface water flow and recharge of groundwater. Finally, the terminus of the Upper South East Drainage Scheme is the South Lagoon of the Coorong (via Salt Creek) and water from the drainage network that currently flows into South East wetlands (e.g. Lake George) may in the future be directed away from these wetlands into the South Lagoon of the Coorong to lower salinity.

To ensure sustainable management of remnant wetlands, it is therefore essential to understand the response of wetland communities to altered water regimes, but the management of SE wetlands is often hindered by the scarcity of information on their ecology. Consequently, it is difficult to predict the response of these habitats to future management actions, such as the distribution of surface water and saline groundwater through the drainage network.

The South East Science Review (Department for Water 2010) identified that further investigations were required in the South East, into the level and type of water dependency of aquatic dependent ecosystems and the water requirements of wetland communities. Improved understanding of the response of ecological communities to changes in water availability would inform the development of more effective policy

The primary aim of this project is to build upon existing information to develop ecological response models for wetland plant assemblages in the South East. As a first step in this process, this report details the results of foundational activities focused on collating and synthesising potentially relevant spatial, hydrological and ecological data and literature pertaining to South East wetlands. These data will then be used to identify data and knowledge gaps that are required to build ecological response models. This information can also be used to help guide the development of an initial wetland classification framework for the region that has the ability to predict the likely responses of wetland ecosystems within the South East region to changes in water quantity (hydroperiod) and quality (salinity). Data obtained from this task and field surveys (Task 2) can then be used to develop eco-hydrological models. This will involve:

- using remote sensing techniques to determine historical trends in wetland plant assemblages in response to hydrological regimes (Task 3),
- identifying thresholds for changes in wetland plant assemblages in response principal drivers of wetland types (e.g. changes in water and salinity regime), and
- the development of eco-hydrological models to conceptualise the response of wetland plant assemblages for selected wetland sites to altered hydrological conditions.

2. Spatial, hydrological and ecological data for South East wetlands

2.1. Existing data

An important aim of the South East Wetlands project was to build upon existing information to develop ecological response models for wetland plant assemblages in the South East. As a first step in this process all available data was sourced, collected or downloaded from Federal and State Governments, industry, private and/or not-for-profit organisations (Appendix 1; Appendix 2).

A range of data formats were included, such as aerial photography, satellite imagery (i.e. Landsat, MODIS), DEM (digital elevation models), other spatial datasets, databases (e.g. South Australia Wetland Inventory Database, Biological Database of South Australia), monitoring data (e.g. Water Connect South Australian groundwater monitoring, Victorian groundwater monitoring data, Australian Water Availability daily climate data), technical reports and other documents. While some datasets were used to identify case study sites and others used to categorise vegetation and wetland types (or for modelling), a few datasets were also included in the analysis for reference purposes only (Appendix 1; Appendix 2).

Spatial data are representative of a wide range of scales, from local, regional, state-wide and/or Australia-wide (Appendix 1). Scale units are understandably variable (i.e. cm to km) depending on the data type; and while there is a range of spatial data for the South East, the continuity of datasets is an issue, with most observations recorded as only a snapshot in time or as a series of snapshots (Appendix 1).

Aerial photograph snapshots exist for the South East at the local scale, at very fine scale units (cm). Most of these are recent (i.e. acquired 2008 - 2013), but one particular dataset provides spatial coverage across 20 case study wetlands (Appendix 1). There is also a data set of aerial photograph snapshots for four focal wetlands from 1969 onwards; providing a temporal framework for site-specific wetlands. Landsat and MODIS (NDVI and NBAR) satellite imagery was downloaded for the entire region. Spatial units are much greater (30m to 500m) than the aerial photographs, but the datasets provide continuous images for the last 42 years (Landsat) or 15 years (MODIS) (Appendix 1). Digital elevation models (DEM), derived from aerial photography or Lidar imagery, were also sourced at regional scales for both the Upper and Lower South East at a range of resolutions (cm to m) from 2008 – 2013 (Appendix 1).

A range of wetland data is found in the South Australian Wetland Inventory Database (SAWID) (Appendix 1). SAWID provides a spatial layer of wetlands for the entire South East region, as well as many tables of attribute data which can be linked to the wetland polygons via wetland id, in particular biological survey data. The state-wide spatial mapping of vegetation communities (pre- and post-European), derived from local vegetation surveys (30 m quadrats) conducted by the South Australian Biological Surveys, is accessible through the Biological Databases of South Australia (BDBSA) data in SAWID, and provides extensive catalogues of species present at site-specific scales. Other site-specific vegetation data from selected research projects, inventories and case studies of selected areas within the South East region are also in SAWID, along with photographs for some locations. Datasets identifying various wetland attributes within the region are also available through the South Australian Aquatic Ecosystems (SAAE) Typology classification (after Scholz and Fee 2008), the Australian National Aquatic Ecosystems (ANAE) classification (Butcher et al. 2011), the National Atlas of Groundwater Dependent Ecosystems (GDE Atlas), the Water-Dependent Ecosystem Risk Assessment Tool (WaterRat) (Harding 2009; Harding and Connor 2012) and Groundwater Dependent Ecosystem monitoring data for 14 case study complexes in the South East (Appendix 1).

Groundwater monitoring data from observation bores (in particular water level and salinity) can be downloaded for the State through the State Government WaterConnect website (www.waterconnect.sa.gov.au) (Appendix 1). Further groundwater monitoring data are available through the Victorian government Department of Environment and Primary Industries (DEPI) Water Measurement Information System (WMIS). Other groundwater data for the South East region can be found through the classification of Likelihood of Groundwater Dependence (SKM 2009), and the National GDE Atlas (SKM 2012). In addition, there is a range of spatial data and layers pertaining to groundwater aquifers, basins, and provinces, drill holes and prescribed wells which can be downloaded from the WaterConnect website for the State.

Surface water basins, waterbodies and watercourses, shallow standing water levels and shallow total dissolved salt can also be obtained through the WaterConnect website for the State. Catchment polygons derived from a national scale 9 second (approximately 250 m) resolution Digital Elevation Model can be downloaded from Geoscience Australia. Spatial data layers and some drain completion dates were sourced for the South East drain network; however no completion dates are available for the myriad of privately constructed drains (Appendix 1). In regards to hydrological data, most of the data is more recent, therefore there is minimal long term data for surface water. The scales at which data are collected are also highly variable and datasets are often patchy (discontinuous) due to difficulties associated with infrastructure, such as instrument failure. A commercial environmental data management package, Hydstra, provides some information on surface water for the Upper South East. A limited amount of water quality data is available from the Environmental Protection Agency for 5 locations (3 drains and 2 creeks), while aquatic ecosystem condition reports and data can be downloaded for 71 sites in the South East from the WaterConnect website (Appendix 1). However, released in late 2014, Geoscience Australia's "Water Observations from Space" (WOfS) is the world's first continent-scale product of the presence of surface water. It consists of two databases; Water Observation Feature Layers (WOFL) derived from Landsat satellite imagery from 1987 to present at 25 metre spatial resolution, and the Water Observations from Space (WOfS) product which combines all water observations from the entire WOFL time series into five summary composite datasets for all of Australia (Appendix 1).

Daily weather observation data is available for the continental weather station network from the Bureau of Meteorology for temperature, rainfall, evaporation, sunshine and wind, but continuity may be patchy depending on the station (Appendix 1). However, gridded interpolated data (daily, monthly and annual) are produced through the Australian Water Availability Project (AWAP) at approximately 5 km x 5 km resolution from 1990 to present (Appendix 1). There are many variables for these datasets including temperature, rainfall, evaporation, soil moisture and surface runoff (Appendix 1).

Spatial data for other layers includes mapping of geology, soils, vegetation, land tenure and land use at State- to Australian-wide scales from a variety of sources such as Geoscience Australia and DEWNR. Base layer geographic information such as built up areas, roads, and waterways is provided by Geodata Topo and is useful for reference purposes (Appendix 1).

Finally, there is an extensive collection of reports which pertain to the South East region (Appendix 1).

2.2. Data synthesis

In regards to this project, many of these datasets required some degree of pre-processing (e.g. conversion to spatial data, re-projection, checking for inconsistencies and/or the removal of outliers for modelling) before they were used in analysis (specific details of which are provided in the following report chapters). Other datasets, could not be used because depending on the investigation undertaken, the scale of study, data collection methods and data continuity (snapshot or series of snapshots) they were understandably varied and inconsistent. In some instances, the metadata available made it difficult to ascertain how the data could be applied to this project.

Furthermore, much of the biological observations were not related to abiotic variables, which is a key objective of this project.

Synthesis of these data was used to identify data gaps that are required to build appropriate ecological response models for the South East and to ensure that new data collected within this project are comparable to historical data (where appropriate data exists and allowed analysis and application in other project tasks). This information was used to help guide the development of an initial wetland classification framework for the region that has the ability to predict the likely responses of wetland ecosystems within the South East to changes in water quantity (hydroperiod) and quality (salinity). Given the breadth and diversity of wetland types within the South East region (Aquatic Ecosystem Task Group 2012) (Table 1), case study sites that best represent the range of hydrological, water quality, and geomorphic settings present needed to be identified.

Table 1. Summary of wetland types and their number in the South-East (SE) region produced by Butcher et al. (2011); using the attributes described in the ANAE (Australian National Aquatic Ecosystems) classification system framework (Aquatic Ecosystem Task Group 2012).

Wetland type	Number in SE region
Coastal Dune lake	31
Freshwater Meadow	1, 270
Grass sedge wetland	10, 043
Inland interdunal wetland	457
Karst	13
Lake Floodplain	7
Permanent Freshwater Lake	14
Permanent Freshwater Swamp	2
Peat Swamp	96
Soaks and Springs	127
Salt Lake	21
Salt Lake Floodplain	1
Saline Swamp	2851
Terminal Lake (riverine)	3
Watercourse	3
Wet Heath	10
Artificial	44

3. Developing a regional South East wetland classification framework

3.1. Existing wetland classification frameworks

Classifications have been widely used in environmental science to order natural systems into meaningful, largely similar and relevant groups. Wetlands are often difficult systems to classify because there is still no universally accepted definition of a wetland (Davis and Brock 2008, Ewart-Smith et al. 2006), although the presence of water, whether it is flowing, standing, salty, fresh, seasonal and/or permanent is a primary factor for forming wetland type habitats (Mucina and Rutherford 2006). There can also be differences in the criteria used to distinguish the range of wetland types. For instance, wetlands may be classified based on vegetation structure (e.g. salt marshes) while others are characterised by their vegetation communities combined with soil/substrate and water types (e.g. peatlands, bogs) and some based on water permanence (e.g. lakes, swamps) (Semeniuk and Semeniuk 1995). Furthermore, small wetlands (<0.2 Ha) need to be included, since they are often part of wetland complexes (which include various wetland types) and because even the loss of small wetlands increases the nearest neighbour distance, which may disrupt or prevent connectivity at the metapopulation level (Semlitsch and Bodie 1998).

One of the earliest classification systems of wetland ecosystems was undertaken in the United States by Cowardin et al. (1979). The classification methodology was developed at the national scale, where the highest level of classification began by identifying the landscape position of a water dependent ecosystem (or hydrosystems), such as tidal, riverine estuarine, lacustrine and palustrine. This particular classification system was intended to describe ecological taxa and then arrange them in a manner that was useful for resource managers, while providing a uniformity of concepts and terms and workable ecological units for mapping purposes. While this approach was useful for developing an extensive inventory of wetland resources at the broad, national scale, it was limited in characterising wetland function at finer regional and landscape scales (Dvorett et al. 2012), but was useful for characterising the broad types of wetland function along a salinity gradient (e.g. saline estuarine to fresh palustrine) (Table 2).

There is also the Convention on Wetlands (Ramsar, Iran, 1971), which is an intergovernmental treaty that provides a framework for national action and international cooperation for the conservation and wise use of wetland ecosystems (Ramsar Convention Secretariat 2013). The Ramsar Convention is a very broad-scale classification framework that identifies 42 types of wetlands at the global scale, classified into three major groups: marine and coastal wetlands, inland wetlands, and human-made wetlands (Frazier 1999).

The two broad, classification systems described above group wetlands based on common attributes, such as salinity (saline to fresh), soil/substrate, dominant vegetation type and water regime; however, Semeniuk and Semeniuk (1995) then developed a classification framework that proposed a geomorphic classification methodology that integrated the physical (landform setting) with degrees of wetness (hydroperiod) in order to encompass both wetland functionality and environmental gradients (Table 2). There are many benefits to this method of classification including providing clarity of decision making, links with landscape processes and potential for remote sensing to differentiate geomorphic based wetland types more easily than simply using water regime and vegetation alone. However, while landform setting may be relatively simple to determine using spatial data, the monitoring of surface water level changes (and hence hydroperiod) is more difficult (Davranche et al. 2013, Munyaneza et al. 2009, Tan et al. 2004).

In Australia the Australian National Aquatic Ecosystem (ANAE) classification framework is also available (Aquatic Ecosystems Task Group, 2012). This framework provides a nationally consistent, yet flexible process to classify aquatic ecosystems and habitat types within regional to landscape scales (Table 2). The ANAE is a classification system based on physical characteristics such as the attributes of geomorphology (shape, substrate), hydrology (wetting and drying regime), chemistry (salinity regime) and vegetation rather than detailed biodiversity and/or ecological functioning. It is a broad-scale, semi-hierarchical, attribute-based, biogeophysical framework. The framework was developed under the presumption that the majority of classification requirements would be undertaken in areas with poor and patchy biological data.

Since then many other classification systems have been developed around the world that often incorporate a little of Cowardin (structure-based) and Semeniuk (functional based) approaches (Table 2) to introduce more flexibility so that the classification systems can work across a range of scales (e.g. broad to fine). For instance Mackenzie and Banner (2001) incorporate a mosaic component into their hydrogeomorphic based classification system in British Columbia in order to capture the fact that wetland ecosystems are generally heterogeneous at moderate scales (Table 2). A more thorough review of wetland classification frameworks that are available, plus their potential advantages and disadvantages are presented in (Table 2).

In regards to the South East region, some classification frameworks have already been used. Three Ramsar listed wetlands are present in the South East: Bool and Hacks Lagoon, the Coorong, Lower Lakes and Murray Mouth (although only the South Lagoon of the Coorong is the only area in this wetland in the South East) (both listed in 1985) and Piccaninnie Ponds (listed in 2012) (see the 'Annotated Ramsar List: Australia at http://ramsar.org.au). Bool and Hacks Lagoon supports five Ramsar wetland types, Piccaninnie Ponds six natural types and one human-made type and the Coorong, Lower Lakes and Murray Mouth 26 types. However, this particular classification is a very broad scale framework which is focused on the protection and conservation of wetlands at a global scale as opposed to being a framework used to direct particular management activities or predict outcomes of management actions.

Similarly, wetland mapping undertaken for the South East region has produced maps that accurately describe both wetland locations and extent (Department for Water, 2010). One of the key sources of wetland information for the South East Region can be obtained from the South Australian Wetland Inventory Database (SAWID). SAWID provides detailed spatial data, as well as associated biological, hydrological, physical, and chemical data for wetland ecosystems collected during various wetland inventories (see Taylor 2006; Harding 2007) and other regional aquatic ecosystem data. SAWID also sources data from other South Australian databases including the Biological Databases of South Australia (BDBSA). A recent review of the SAWID database (Harding and Connor 2012) identified various wetland classification frameworks that have been applied in the South East, identifying wetland typologies and groundwater dependency. These included:

- South Australian Aquatic Ecosystems (SAAE) Typology classification (after Scholz and Fee 2008);
- Classification of Likelihood of Groundwater Dependence (SKM 2009); and
- National GDE Atlas (SKM 2012).
- Australian National Aquatic Ecosystems (ANAE) classification (Butcher et al. 2011);

In particular, Butcher et al. (2011) applied a trial of the national-scale ANAE classification system within the South East. Using this classification system, 17 wetland types were identified in the South East (Table 1). Butcher et al. (2011) highlighted that the adoption of this approach sometimes lacked the sensitivity needed at the regional scale. For instance, a majority of wetlands classified were classified as having periodic inundation because the definitions of that particular attribute are too broad. While at the national scale this may suffice, it is not adequate for management purposes at finer, regional scale (McConville et al. 2013). Furthermore, most of these classification frameworks work well for wetland mapping, in order to understand the extent and distribution of aquatic ecosystems across the region, but they must be tied with ground-truthed, field-based data to be able to truly determine wetland type, condition and/or conservation significance (Department for Water, 2010).

Furthermore, most of the classification systems discussed do not have the capacity to predict the possible responses of wetlands to management actions, disturbances (natural and/or human-induced) and changes in hydrology. It is possible that a wetland could be classified into a different category after the initial inventory was undertaken due to changes in hydrology, salinity or land use. The Nature Conservation Society of South Australia (2012) on behalf of DEWNR developed a Wetland Condition Assessment method to focus on measuring vegetation changes in relation to possible impacts of changed water regime in the South East. A series of state and transition models were developed to help:

- identify agents of change and stressors possibly operation at different wetland types,
- envision plant communities expected to be present at particular wetland types, and
- identify impacts of various stressors that may be evidenced on ground.

State and transition models are typically built from extensive survey data that can support the definition of 'stable states'; however, for the South East, given the diversity of wetland types (Table 1), it was acknowledged that state and transition models for this system are largely developed from a theoretical understanding of the stressors that contribute to transition, a modest amount of available survey data and input from regional experts. In the absence of an extensive dataset that the states and transitions are based on, these types of models only capture the conceptual understanding of a system and their predictive capacity is limited.

The classification frameworks and models discussed in this section are all potentially useful management tools (especially with respect to regional conservation and prioritisation) but they lack predictive capacity. Due to the diversity of wetlands present in the South East and insufficient biological data available a generalised state and transition wetland model (sensu Lester and Fairweather 2009) would be of little value. State and transition models may be able to be developed for selected sites with extensive datasets; however, they would be site specific and not transferable throughout the region. Whilst a transferrable predictive model or classification framework regarding the whole ecosystem is not available and beyond the scope of this project, the change in vegetation in relation to hydrology and salinity represents an opportunity to develop a predictive model that is transferrable between sites that could be used throughout the region.

Table 2. Review of the available wetland classification systems and their potential advantages and disadvantages for their application and for wetlands within the South-East region.

Description	Reference	Description	Advantages	Disadvantages
Ramsar wetland type classification	Frazier 1999 Also see: http://www.environment.gov.au/water/wetlands/ramsar/wetland-type-classification	Used for identifying different types of wetlands within a Ramsar site boundary (wetland complex). Uses a hierarchical classification with three very board wetland classes (Marine/Coastal, Inland and Human-made). Under each of the three major wetland types there are numerous sub-classes based on hydrology, vegetation, soil/substrate type, geomorphology, salinity, climate, altitude and management regime.	Globally accepted framework for classification of broad wetland types. Useful for mapping wetland types in a wetland complex and for informing management regimes	Classes generally too broad to apply at a regional scale. Has no predictive capacity.
Classification of wetlands and deep water habitats of the United States	Cowardin et al. (1979)	Uses a hierarchical classification system, where 'Hydrosystems' (marine, estuarine, riverine, lacustrine and palustrine) are used to characterise the highest level. There are then subsystems (e.g. marine/estuarine: tidal, lower perennial, upper perennial, intermittent and lacustrine: littoral versus limnetic). Following the subsystems are classes relating to substrate material and flooding regime.	This type of classification system is intended to describe ecological taxa, then arrange them in a manner that is useful for resource managers, provide units for mapping and a uniformity of concepts and terms. Good for mapping wetland types and assisting managers to prioritise wetlands for conservation. This particular type of classification system has been used for some time now. The structure of the classification system allows it to be used at any of the several hierarchical levels.	Data gathering is a prerequisite to classification and development rules need to be constructed by the user for specific map scales. This particular classification system tends to focus on the wetland structure and less on wetland function. Useful system as an inventory tool, but less useful as a management tool to assist in predicting possible response of wetlands to management actions and/or disturbances (natural and/or human-induced).
A geomorphic approach to global classification for inland wetlands	Semeniuk and Semeniuk (1995)	The authors proposed a classification system that used criteria other than vegetation (i.e. geomorphic) to classify inland wetlands. In particular the system used underlying structures, such as landform and their various types of hydroperiod (or inundation time). Landform types included basins, channels, flats, slopes and hills/highlands. Degrees of wetness included:	This classification system can be applied in many settings, regardless of climate and vegetation types. This particular classification system tends to focus on the wetland functionality and less on wetland structure.	Is a system that may harder to use for mapping/inventory purposes, but has a greater predictive for determining the possible responses of wetlands to management actions and/or disturbances (natural and/or human-induced).

Description	Reference	Description	Advantages	Disadvantages
		permanent, seasonal or intermittent and seasonal waterlogging. The combination of landform × hydroperiod produced thirteen common types of wetlands.		
Classification framework for wetlands in British Columbia	Mackenzie, W. and Banner, A. (2001)	Wetland and Riparian Ecosystem Classification (WREC) is a hierarchical 3-component classification. Distinction is made between classification of homogenous sites (Site component, using modified Canadian wetland classification system that describes sites on ecologically homogenous areas based on climate, soils and vegetation climax communities) and classification of whole systems (Hydrogeomorphic classification), based on hydrogeomorphic systems and classification of wetland and deepwater habitats in the US that characterises wetlands based on geomorphic setting, water source and hydrodynamics. These 2 components are then integrated into a Mosaic Component that acknowledges that wetlands typically occur as complexes of associated sites in a landscape across several "functional" scales.	This particular classification system considers both wetland functionality and environmental gradients**.** It integrates physical and biological components and incorporates within a landscape framework (hydrogeomorphic), but the incorporation of a mosaic component captures that wetland ecosystems are generally heterogeneous at moderate scales (use classification of eco-complexes, which describes a spatial arrangement of clusters of ecosystems on predictably heterogeneous environments) and Catenas (a sequence of site associations that occur together alone the environmental gradient of a hydrogeomorphic element).	The concepts for this model are appropriate, but time and resources would be required to develop and define appropriate classifications to fit the Australian, regional or local scales.
Hierarchical spatial organization and prioritization of wetlands (South Africa)	Sieben et al. (2011)	This classification system was developed because of a need for wetland rehabilitation. The framework therefore focuses on the wetland functional unit (hydrogeomorphic HGM unit), which is defined as the section of a wetland with more or less uniform hydrological and geomorphological characteristics. In this instance an individual wetland may	This system considers wetland functionality. Model is also used in a similarly semi-arid region (South Africa) where most wetlands are linked to a fluvial network. For example most out flow from a wetland is connected to a stream or where a wetland dominated by diffuse flow is converted to a strongly channelized system through the excavation of artificial drains, or	This system considers wetland functionality and was designed to help managers prioritise wetlands for conservation and/or rehabilitation purpose; however the predictive capacity to help identify possible responses of wetlands to management actions and/or disturbances (natural and/or human-

Description	Reference	Description	Advantages	Disadvantages
		compromise several HGM units, and a HGM unit itself can be sub-divided into several smaller habitat or vegetation units.	via gully erosion. It also acknowledges 'wetland complexes" as a series of contiguous HGM units. Useful for mangers because incorporates a prioritization process that sits above the HGM classification (tertiary to quaternary catchment scale).	induced) is limited.
Further Development of a proposed national wetland classification system for South Africa	SANBI (2009)	Aim to map and classify the major wetlands and water bodies at the national (coarse) scale in order to distinguish wetlands for management and conservation purposes. Needed to develop a classification system that encompasses the full diversity of wetland types throughout South Africa. A prototype national wetland classification system was develop by Ewart-Smith et al. 2006, which included a 5-teired hierarchical system with Marine, Estuarine and Inland systems at the broadest level (Level 1) through to Habitat Units at the finest level (Level 5). Despite the production of a prototype wetland classification system there was a need to further develop, test and refine the classification system, particularly at the local, finer levels. This particular research therefore focused on testing and application of the classification system.	The proposed, revised wetland classification system has a 6-teired (rather than strictly hierarchical) structure, with 4 spatially-nested primary levels to distinguish between different wetland types, through to hydrogeomorphic (HGM units at the finest spatial scale. Level 1 (highest) describes the system (connectivity to open ocean), Level 2 the regional setting (e.g. eco-region, bioregion, biogeographic zone). A landscape setting was introduced at Level 3 of classification to increase allow the framework to be used by widely. Level 4 (HGM unit: channel, floodplain wetland, flat) and Level 5 (hydrological regime: such as, perennial, seasonal, intermittent or unknown) relate to the functionality of the wetlands. Level 6 (lowest level) describes the structural aspects of a wetland (i.e. what a wetland 'looks like') in terms of terms of geology, naturalness, vegetation cover type, substratum type, salinity and pH. The first 2 levels can be determined through desktop analysis, Levels 3, 4 and 5 via a combination of desktop or ground-truthed data and Level 5 via ground-truthing.	This particular classification system was designed to work at a national scale, not necessarily a regional scale. The proposed classification system is primarily intended for the classification of wetlands in their current functional and structural state. However, for certain applications (such as wetland ‘health’ assessments or rehabilitation planning, where a reference condition is needed as a baseline), the proposed classification system can also be used to classify a wetland according to its assumed natural state. Also important is that the features categorised at Level 6 (lowest level) are dynamic in space and time - therefore it is imperative that the season (dry/wet) in which records are made for particular wetlands are strictly characterised or misclassification can arise.

Description	Reference	Description	Advantages	Disadvantages
A Manual for an Inventory of Asian Wetlands: Version 1.0.	Finlayson et al. (2002)	Has a manual to develop and support a standardized inventory protocol for the assessment, evaluation and monitoring of wetlands in Asia. The key features of this system are that it is hierarchical and map-based with outputs at four levels of detail, where the detail is related to the scale of the maps that are contained within a standardized Geographic Information System (GIS) format.	As an inventory it aims to take investigative steps to build a system that can obtain more information and thereby presents a comprehensive coverage of sites within the scale they are studying (i.e. Asia). Systems such as this allow governments (or managers) to prioritise their conservation and development initiatives.	Is useful for an inventory tool, but less useful as a management tool to assist in predicting possible response of wetlands to management actions and/or disturbances (natural and/or human-induced).
Monitoring changes in Wetland Extent: An environmental performance indicator for wetlands	Lincoln Environmental (1999)	A classification system as a framework to analyse the spatial extent (indicator) of various wetland types in New Zealand was developed and evaluated. The system was standardised and hierarchical where the highest (least detailed) levels consist of Level I: Hydrosystems, Level II: Wetland Class. Within these levels there is a range of wetland types to choose from based on salinity and broad hydrological setting (Level I), flooding regime (Level IA) and substrate, pH, and/or chemistry (Level II). Level III describes the growth form of the vegetation or, in the case of open communities, the leading type of ground surface. Level IV is the species composition of the dominant cover. Only the dominant species are used for classification purposes to avoid the proliferation of terms.	Hydrosystem classification describes the basic type of wetland function through broad categories, essentially along a salinity gradient. For example, Estuarine (alternating saline and fresh water), Palustrine (vegetation emergent over freshwater, not including floating plants), geothermal (> 30 deg C or influence by waters with geothermal chemistry), plutonic (underground water, no photosynthesis), Marine (saline open water), Lacustrine (standing open water, including lake, pond, pool) and Riverine (flowing open freshwater, including river, stream, canal). Sub-systems with the Hydrosystem classification consider the water regime of the wetland, where hydroperiods may be short (ephemeral) through to prolonged (permanent). At the Level II, wetland class considers the characteristic vegetation patterns caused by distinct functional features such as, substrate, pH and/or chemistry. The structural class (Level III) is defined by the structure of the wetland biota (in particular vegetation) using the growth form of dominant canopy species.	Using aerial photography or remote sensing as the only data source may mean that the wetland of interest can only be classified at the higher levels (e.g. Hydrosystem), unless field verification (i.e. ground-truthing) is also incorporated. For instance aerial photography can be used to describe vegetation class, if verified. There are other limitations of this method, in that more detailed method may be required for specific management purposes (e.g. identification of weed infestations).

Description	Reference	Description	Advantages	Disadvantages
			Lastly the Dominant cover (Level 4) id defined by the dominant species of the canopy vegetation.	
Developing a Hydrogeomorphic Wetland Inventory: Reclassifying National Wetland Inventory Polygons in Geographic Information Systems	Dvorett et al. (2012)	The US have developed an extensive inventory of wetland resources (Nationally Wetland Inventory, NWI), but found it was limited in characterising wetland function. Therefore a methodology for reclassifying NWI polygons into Hydrogeomorphic (HGM) classes was developed. The reclassification used spatial and attribute queries in Geographic Information Systems (GIS), which provided a 60% accuracy. Inherent issues with the NWI were a result of attribute accuracy, spatial accuracy and map age contributed to more than 50% of the misclassified wetlands.	Reclassifying NWI polygons into HGM classes can assist in determining the spatial distribution and relative abundance of specific wetland classes, which can help to target restoration and monitoring efforts.	Lack of data and accuracy can increase error rates in classification. Error rates associated with reclassification should be calculated to ensure that incorrect conclusions are not drawn.
Aquatic Ecosystems Toolkit. Module 2. Interim Australian National Aquatic Ecosystem Classification Framework	Aquatic Ecosystems Task Group (2012)	A classification framework that develops a nationally consistent, yet flexible process to classify aquatic ecosystems and habitat types within regional to landscape scales. The ANAE is a classification system based on physical characteristics such as the attributes of geomorphology (shape, substrate), hydrology (wetting and drying regime), chemistry (salinity regime) and vegetation rather than detailed biodiversity and/or ecological functioning. It is a broad-scale, semi-hierarchical, attribute-	Classification systems at the national scale allow for a common language across jurisdictions for comparing information. This system acknowledges a 'top down' approach that can be used where ecological data is patch and/or incomplete. It is advised that it may be more relevant to apply the ANAE classification to the historic (or typical) state of the aquatic ecosystem. This may help explain the change in time or help to track future changes between reporting times.	Data limitations for the SE region were identified for several attributes including dominant vegetation, salinity, pH, and soil cores (Butcher et al. 2011). A trial application of the methodology highlighted that there was a lack of information on the thresholds in the classification system proposed (Butcher et al. 2011). Also, at present the inclusion of artificial or

Description	Reference	Description	Advantages	Disadvantages
		based, biogeophysical framework. Levels 1 and 2 are large scale, national regionalisations for landform, climate, hydrology, topography and water influence (using data sources such as Koppen, IBRA, ASRIS, OzCoasts and Smartline Maps). Level 3 describes the classes of aquatic ecosystems in the Australian landscape (surface water and subterranean) using the Cowardin et al. (1979) approach.		modified water bodies such as sewage treatment ponds, canals and impoundments have not been included, but may be particularly relevant at the South East regional and/or landscape level.

3.2. Wetland vegetation

Wetland plants shape the physical (temperature, light penetration, soil characteristics) and chemical environment (dissolved oxygen, nutrient availability) of wetlands, as well as supporting nearly all wetland related biota (Cronk and Fennessy 2001). Wetland vegetation also provides important habitat and refuge areas (Reid and Brooks 2000) and because of capacity to register long-term change in ecosystem structure and functionality, vegetation communities are often used as an indicator of wetland condition (e.g. Pall and Moser 2009; Cacador et al. 2013). Over time, aquatic plants respond physiologically and phenologically to patterns of water presence, so their continued survival (as extant plants or in the seed bank) can provide an integrated indication of the historical water regime, or the flow and availability of water at the site level during the lifetime of the plants (Casanova 2011). Specific plants may respond to water-regime variables in a predictable manner because they are long-lived (e.g. *Eucalyptus camaldulensis* and *Melaleuca* spp.) and are therefore present for assessment at any time (Ali et al. 1999; Casanova and Brock, 2000) or they can be studied via experimental assays of the seed bank (e.g. Casanova and Brock, 1990). Similarly, in terms of their response to salinity, plants can be broadly divided into two groups; *halophytes,* which are species that are salt tolerant, and glycophytes, which are species that are less tolerant to salinity (Hart et al. 1990). Therefore to maintain certain species requires the water and salinity regimes to which they have adapted, to allow them to successfully complete their life cycles (Casanova 2011; Nielsen et al. 2003).

Plant communities in wetlands typically exhibit strong zonation along water depth gradients (Geoff et al. 2013); although it is likely that zonation in response to salinity regime also occurs (Halse et al. 2004) albeit at a regional scale. Plant Functional Groups (PFGs) have also been developed to compare water plant responses to different depths, durations and frequencies of flooding (Casanova and Brock 1997; Casanova and Brock, 2000; Casanova 2011), overall water regimes (Leck and Brock 2000; Porter et al. 2007) and to compare wetlands (Porter et al. 2007). Casanova (2011) modified the classification system devised by Brock and Casanova (1997) developed for plants growing in wetlands in the New England Tablelands region of northern New South Wales to suit wetlands in the Mount Lofty Ranges. Brock and Casanova (1997) classified plants into three broad categories: terrestrial (intolerant of flooding), amphibious (tolerates or responds to flooding and drying and submergent (intolerant of desiccation). The terrestrial group was split further into terrestrial dry and terrestrial damp depending on desiccation tolerance (Brock and Casanova 1997). The amphibious group was split into five groups based on anatomy and whether a species changes morphologically to wetting and drying: the amphibious fluctuation tolerators-emergent (tolerated flooding and drying but required tissue to remain above the water surface), amphibious fluctuation tolerators-woody (amphibious trees and shrubs), amphibious fluctuation tolerators-low growing (small forbs, sedges and grasses that tolerated inundation and exposure), amphibious fluctuation responders-plastic (changed morphologically to inundation and drying) and amphibious fluctuation responders-floating (entire plants or organs floated on the water surface). Casanova (2011) modified the aforementioned framework by splitting the submergent group into two groups based on Grime's (1979) competitive (k-selected) and ruderal (r-selected) classification: submergent k-selected (species require permanent water) and submergent r-selected (species are adapted to temporary water bodies and are present as extant plants during the inundated phase and present in the propagule bank during the dry phase). Casanova (2011) also added a new category, submerged emergent, which comprises of species adapted to permanent shallow water or saturated soil.

The use of a functional group approach has several advantages compared to a species or community based approach:

- species with similar water regimes preferences are grouped together, which simplifies systems with high species richness (especially where there are large numbers of species with similar water regime preferences),

- predictions about the response of the plant community are made based on processes and does not require prior biological knowledge of the system,
- is transferrable between systems,
- robust and testable models that predict the response of a system to an intervention or natural event can be constructed, which can in turn be used as hypotheses for monitoring programs.

However there are limitations of the approach, which include:

- loss of information on species or communities (especially if there are species or communities of conservation significance or there is a pest plant problem),
- uncertainty regarding which species should be classified into which functional group,
- important factors (e.g. salinity) are often not taken into consideration (additional factors can be included; however, this can often complicate the functional classification and in systems where there is low species richness the number of groups may be greater than the number of species).

The plant functional group approach developed by Casanova (2011) is outlined in Table 3 and the relationship between depth and duration of inundation is presented in Figure 1.

Table 3: Functional classification of plant species based on water regime preferences (modified from Casanova 2011).

Functional Group	Abbreviation	Water Regime Preference	Examples
Terrestrial dry	Tdr	Will not tolerate inundation and tolerates low soil moisture for extended periods.	*Xanthorrhoea semiplana*, *Epacris impressa*
Terrestrial damp	Tda	Will tolerate inundation for short periods (<2 weeks) but require high soil moisture throughout their life cycle.	*Centaurea calcitrapa, Chenopodium album Fumaria bastardii*
Amphibious fluctuation tolerators-emergent	ATe	Fluctuating water levels, plants do not respond morphologically to flooding and drying and will tolerate short-term complete submergence (<2 weeks).	*Baumea juncea, Juncus kraussii, Schoenoplectus pungens*
Amphibious fluctuation tolerators-woody	AFTw	Fluctuating water levels, plants do not respond morphologically to flooding and drying and are large perennial woody species.	*Eucalyptus camaldulensis, Melaleuca halmaturorum,*
Amphibious fluctuation tolerators-low growing	AFTl	Fluctuating water levels, plants do not respond morphologically to flooding and drying and are generally small herbaceous species.	*Crassula helmsii, Lilaeopsis polyantha*
Amphibious fluctuation responders-plastic	AFRp	Fluctuating water levels, plants respond morphologically to flooding and drying (e.g. increasing above to below ground biomass ratios when flooded).	*Persicaria lapathifolia, Villarsia renniformis, Myriophyllum salsugineum*.
Amphibious fluctuation responders-floating	AFRf	Static or fluctuating water levels, responds to fluctuating water levels by having some or all organs floating on the water surface. Most species require permanent water to survive but may persist on mud for short periods.	*Azolla* spp., *Lemna* spp.,
Submergent r-selected	Sr	Temporary wetlands that hold water for longer than 4 months.	*Ruppia tuberosa, Ranunculus trichophyllus*
Submerged-Emergent	SE	Static shallow water <1 m or permanently saturated soil.	*Typha* spp., *Triglochin procera,*
Submergent k-selected	Sk	Permanent water.	*Vallisneria australis, Potamogeton crispus, Potamogeton pectinatus*

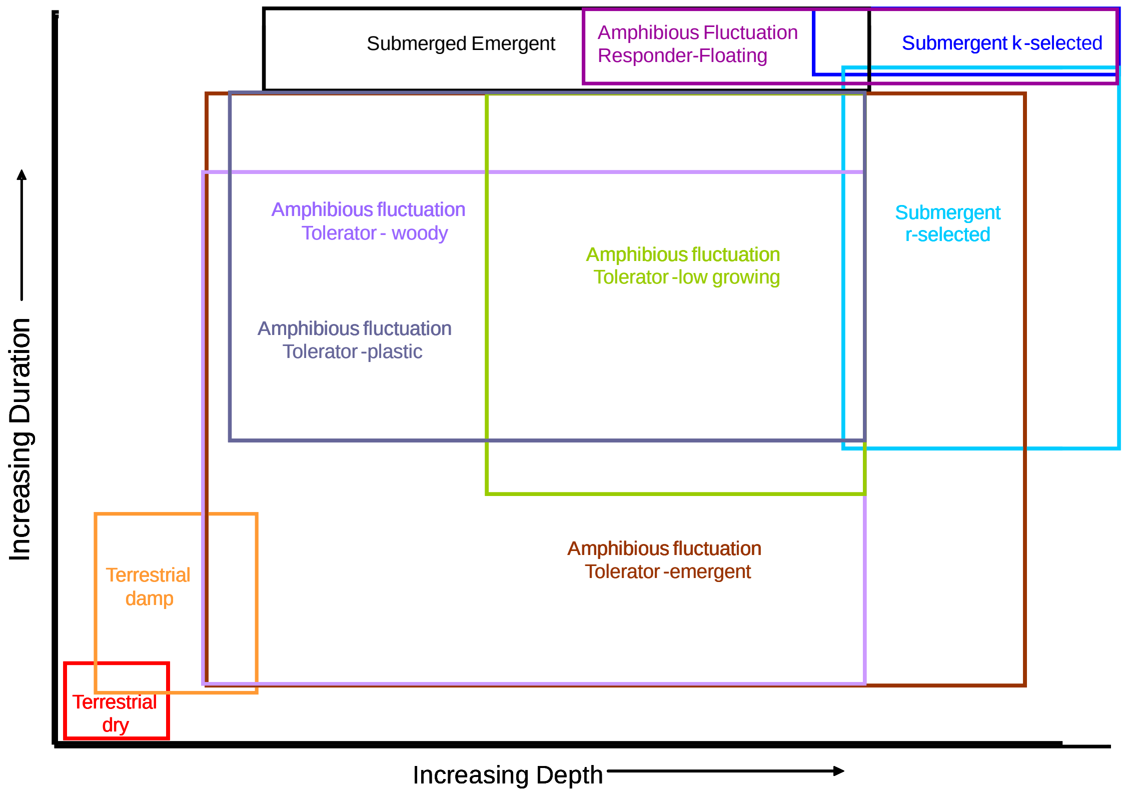

Figure 1. Plant water regime functional groups in relation to depth and duration of flooding.

The "terrestrial dry" functional group is intolerant of flooding and taxa will persist in environments with low soil moisture (Table 3) (Brock and Casanova 1997). Taxa from this functional group often invade wetlands that have been drawn down for an extended period but are often restricted to highlands that never flood (Brock and Casanova 1997).

Taxa in the "terrestrial damp" group will tolerate inundation for short periods and require high soil moisture to complete their life cycle (Table 3) (Brock and Casanova 1997). Taxa from this functional group are often winter annuals, perennial species that grow around the edges of permanent water bodies where there is high soil moisture or species that colonise wetlands shortly after they are drawn down and riparian zones (Brock and Casanova 1997).

The "amphibious fluctuation tolerator-emergent" group consists mainly of emergent sedges and rushes that prefer high soil moisture or shallow water but require their photosynthetic parts to be emergent, although many will often tolerate short-term submergence (Table 3) (Brock and Casanova 1997). Taxa from this group are often found on the edges of permanent water bodies, in seasonal and temporary wetlands and areas that frequently wet and dry.

Species in the "amphibious fluctuation tolerator-woody" group have similar water regime preferences to the amphibious fluctuation tolerator-emergent group (Figure 1) and consist of woody perennial species (Table 3) (Brock and Casanova 1997). Plants generally require high soil moisture in the root zone but there are several species that are tolerant of desiccation for extended periods. Species in this functional group are generally found on the edges of permanent water bodies, in seasonal and temporary wetlands and areas that frequently wet and dry.

The "amphibious fluctuation tolerator-low growing" group have similar water regime preferences to the amphibious fluctuation tolerator-emergent and amphibious fluctuation tolerator-woody group (Figure 1); however, some species can grow totally submerged except during flowering (when there is a requirement for a dry phase) (Table 3) (Brock and Casanova 1997). Species in the this functional group are generally found on the edges of permanent water bodies, in seasonal and temporary wetlands, in riparian zones and areas that frequently wet and dry but species are usually less desiccation tolerant than species in the other amphibious tolerator groups (Figure 1).

The "amphibious fluctuation responder-plastic" group occupies a similar zone to the amphibious fluctuation tolerator-low growing group; except that they have a physical response to water level changes such as rapid shoot elongation or a change in leaf type (Brock and Casanova 1997). They can persist on damp and drying ground because of their morphological flexibility but can flower even if the site does not dry out. They occupy a slightly deeper/wet for longer area than the amphibious fluctuation tolerator-low growing group (Figure 1).

Species in the "amphibious fluctuation responder-floating" functional group float on the top of the water (often unattached to the sediment) with the majority of species requiring the presence of free water of some depth year round; although, some species can survive and complete their life cycle stranded on mud (Table 3) (Brock and Casanova 1997). Taxa in this group are usually found in permanent wetlands, often forming large floating mats upstream of barriers (e.g. weirs).

"Submergent r-selected" species colonise recently flooded areas (Table 3) and show many of the attributes of Grime's (1979) r-selected (ruderal) species, which are adapted to periodic disturbances. Many require drying to stimulate germination on rewetting; they frequently complete their life cycle quickly and die off naturally. They persist via a dormant, long-lived bank of seeds, spores or asexual propagules (e.g. *Ruppia tuberosa* and *Ruppia polycarpa* turions in the soil) (Brock 1982). They prefer habitats that are annually flooded to a depth of more than 10 cm but can persist as dormant propagules for a number of years in temporary and ephemeral wetlands.

The "submerged emergent" group consists of taxa that require permanent shallow water or a permanently saturated root zone, but require emergent leaves or stems (Table 3). They are often found on the edges of permanent waterbodies and in permanent water up to 2 m deep (depending on species) or in areas where there are very shallow water tables that result in soil saturation at the surface or in the root zone (Roberts and Marston 2011).

"Submergent k-selected" species require permanent water greater than 10 cm deep for more than a year to either germinate or reach sufficient biomass to start reproducing (Table 3) (Roberts and Marston 2011). Species in this group show many of the attributes of Grime's (1979) k-selected (competitor) species that are adapted to stable environments and are only found in permanent water bodies. The depth of colonisation of submergent k-selected species is dependent on photosynthetic efficiency and water clarity (*sensu* Spence 1982).

For wetlands in the SE region, Taylor (2006) and Ecological Associates (2009) investigated the use of Wetland Vegetation Components (WVC) to determine and characterise the required hydrology and salinity regimes for particular vegetation community types. The aforementioned researchers grouped species according to similarities in responses to water regime and produced 20 common WVC types present in the South East (Table 4). Using the best available information, the authors then produced WVC models to describe the floristic composition and structure of all WVCs, their associated water and salinity requirements and their potential role as habitat. They then modelled which elevation band from 30 cm below the terrestrial/wetland boundary a particular WVC may occupy and later tested their hypotheses to illustrate their arrangement across the elevation gradient in wetlands throughout the South East (Figure 2). The WVCs present in a wetland reflect the antecedent hydrology of the system and changes to hydrology will result in changes to WVCs present, the position of WVCs on the elevation gradient or the extent of WVCs (*sensu* Taylor et al. 2014).

Likewise Goodman (2012) investigated the salinity preferences of many wetland plant species in the South East region and found that some species may be grouped as least salt tolerant (e.g. *Lemna minor*, *Lileaopsis polyantha*) with a probability of occurrence of <10% in wetlands with surface water electrical conductivity greater than 600-1000 $\mu S\ cm^{-1}$, while others are moderately salt tolerant

(*Triglochin procerum, Myriophyllum verrucosum)* through to the most salt tolerant (*Lepilaena cylindrocarpa, Ruppia megacarpa, R. polycarpa, Sarcocornia quinqueflora*). The salinity range within which these species have been recorded is therefore indicative of the salinity tolerances of their respective WVCs (Ecological Associates 2009).

A combination of WVCs, plant functional groups and salinity preferences linked to a classification framework could form the basis of a predictive model. The likelihood of a species, WVC or functional group being present at a point in a wetland at a point in time can be estimated through their water regime and salinity preferences. The natural water availability gradient (elevation) within wetlands and regional water availability and salinity gradients present in the South East can be used as proxies to predict changes in the plant community at a site as a result of changes in salinity and hydrology.

Table 4. List of the 20 WVCs (Wetland Vegetation Components) for the South-East wetlands and a summary of their water regime, salinity targets and tolerance ranges (reproduced from Ecological Associates 2009).

	HYDROLOGY							SURFACE WATER SALINITY (μS cm^{-1})	
	Target Hydrology			*Tolerance Range*					
	Depth (m)	*Duration (months)* *Annual*	*Duration (months)* *1 year in 3*	*Max. Depth (m)*	*Dry Phase required?*	*Maximum continuous inundation*	*Maximum continuous dry phase*	*Target*	*Tolerance Range*
1.1 *Eucalyptus camaldulensis* woodland	Dry Waterlogged 0.1	12 n/a n/a	10 1 1	>2	Yes	48 months	36 months	<5000	
1.2 Seasonal brackish aquatic bed	Dry Waterlogged 0.2 0.4 0.6	4 2 2 2 2		2	No	Several years	2 years	3000 to 6000	
1.3 *Melaleuca brevifolia* low shrubland	Dry Waterlogged 0.2	10 2 n/a	8 2 2	0.5	Yes	6 months	2 years	<4000	0 to 6500
1.4 *Melaleuca halmaturorum* tall shrubland	Dry Waterlogged 0.2	10 2 n/a	8 2 2	0.5	Yes	24 months	4 years	6000	5000 to 30000
1.5 *Leptospermum continentale* shrubland	Dry Waterlogged 0.2	10 2 n/a	8 2 2	0.5	Yes	6 months	2 years	<3000	
1.6 *Leptospermum lanigerum* shrubland	Dry Waterlogged 0.1	4 4 4		0.3	No	Indefinite (waterlogged)	8 months	<3000	0 to 10000
1.7 *Callistemon rugulosus* shrubland	Dry Waterlogged	6 6		0.2	Yes	9 months	?	<2000	
1.8 *Gahnia filum* tussock sedgeland	Dry Waterlogged 0.2 0.4	8 2 2 n/a	6 2 2 2	0.5	Yes	9 months	Several years	8000	3000 to 16600
1.9 *Gahnia trifida* tussock sedgeland	Dry Waterlogged 0.2 0.4	8 2 2 n/a	6 2 2 2	0.5	Yes	Indefinite (waterlogged)	Several years	< 5000	

1.10 Drier emergent macrophytes mixed sedgeland	Dry Waterlogged 0.3	8 2 2		0.5	Yes	12 months	4 years	<6500	
1.11 Seasonal freshwater emergent sedgeland	Dry Waterlogged 0.2 0.4 0.6	6 2 2 2 n/a	4 2 2 2 2	1	No	Indefinite (waterlogged)	4 years	<5000	0 to 15000
1.12 Samphire low herbland	Dry Waterlogged 0.3	8 2 2		0.5	Yes	Indefinite (waterlogged)	5 years	<60000	
1.13 Semi-permanent deep/open water	Dry Deeply inundated	0 12		No upper limit	No	Indefinite	Several years	<10000	
1.14 Hypersaline wetlands	Dry 1.5 approx.	0 12		2.5	No	Indefinite	Several years	>58300	
2.15 Seasonal saline low aquatic bed	Dry Waterlogged 0.2 0.4	6 2 2 1		0.8	Yes	9 months	3 years	16600 to 58300	
2.16 *Melaleuca squarrosa* mid shrubland	Dry Waterlogged 0.2 0.4	8 2 2 n/a	6 2 2 2	0.3	Yes	12 months	2 years	<5000	
2.17 *Typha* sp., *Phragmites australis* grassland	Dry Waterlogged 0.2 0.5	6 2 2 2		2	No	Indefinite	4 years	<8000	
2.18 Karstic spring pool with deeply submerged aquatics	Dry Deeply inundated	0 12		No upper limit	No	Indefinite	Intolerant of drying	<3000	
2.19 Permanent coastal lake	Dry 3.5 approx.	0 12		4.5	No	Indefinite	Intolerant of drying	30000	2500 to 75000
2.20 Seasonal freshwater aquatic bed	Dry Waterlogged 0.2 0.4 0.7	3 3 2 2 2		2	No	Indefinite	4 years	<3000	0 to 15000

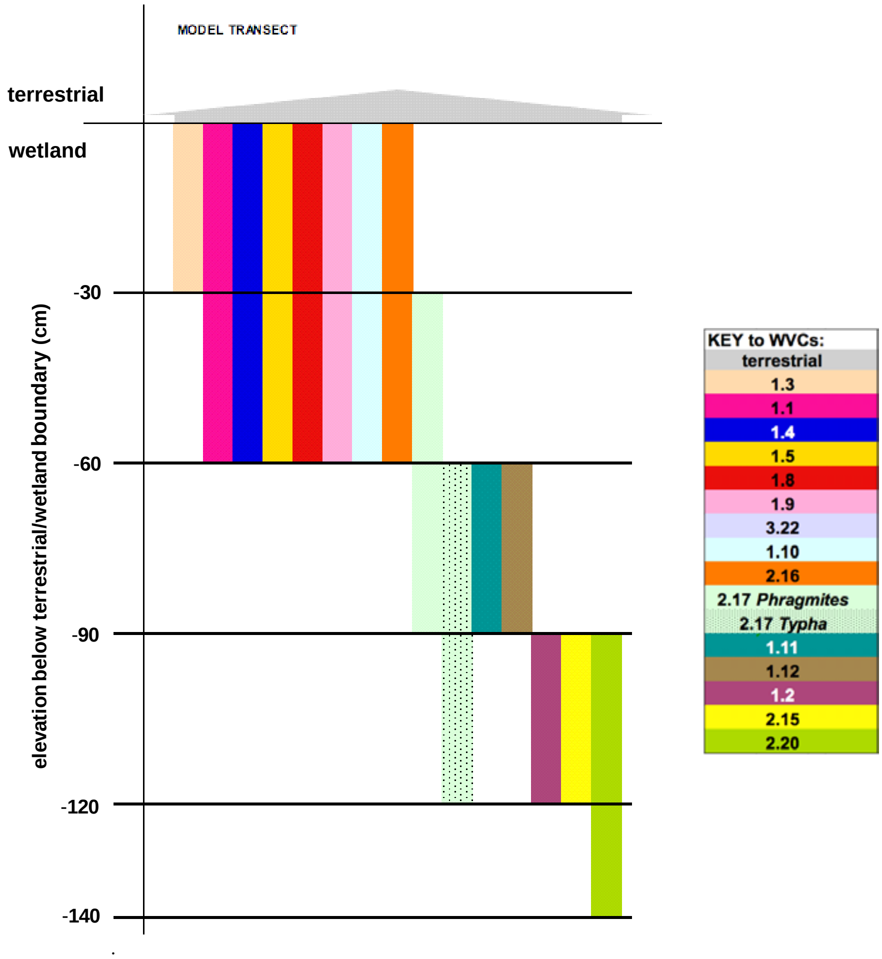

Figure 2. Model transect, illustrating the hypothetical arrangement of WVCs across the elevation gradient, based upon elevation data from 16 transects in wetlands throughout the South-East (from Ecological Associates 2009). Descriptions of WVCs (Wetland Vegetation Components) are in described in further detail in Table 4.

3.3. Framework development

The classification systems currently being used and applied within Australia (Aquatic Ecosystems Task Group, 2010) and South Australia (Butcher et al. 2011) are useful for providing an 'inventory' of wetlands for the region and also help managers to identify and prioritise wetland conservation and management. What the current classification systems do not do particularly well is predict the possible changes and/or responses of wetland composition and/or condition to changes in hydrology (natural or human –induced) and specific management actions.

Harding (2007) linked the key agents of change, stressors and ecosystem responses in South East wetland systems. *Agents of change* are mechanisms, such as natural processes and events or human manipulations, which can operate within a natural variability and/or within the limits of acceptable change for a given wetland, but *stressors* are associated problems and products of human activities or natural events that diminish the quality of the ecosystem. Lastly, the ecosystem responses are measureable and detectable changes or trends in wetland ecosystem structure, function or process that are considered indicative of ecosystem quality. For instance, specific stressors that may be particularly relevant to vegetation communities in South East wetlands are listed in Table 5.

Table 5. List of stressors that can diminish ecosystem quality of wetlands in the South East region (Harding 2007).

Type	Stressor description
Water regime	• Reduced depth and duration of inundation
	• Increased depth and duration of inundation
	• Reduced frequency of inundation events
	• Increased frequency of inundation events
	• Rising Groundwater level
	• Falling groundwater
Salinity	• Rising groundwater salinity
	• Increased surface water salinity,
Other	• Agricultural pollutants (nutrients, sediments, pesticides, herbicides)
	• Grazing by domestic stock

Changes in the salinity and water regime in the region are already affecting the floristic composition of the wetland complexes in the South East. Comparisons between survey data collected pre-2000 and survey data collected post-2000 indicate that a) salt sensitive glycophyte species have disappeared from some areas while salt tolerant halophyte species that were not present before are now recorded and b) some species requiring standing surface water have also been lost, while species that prefer waterlogged to drained conditions now favoured (Department for Water 2010; Taylor et al. 2014). Indeed, salinity is such a key stressor (Cocks 2003) that there is potential for wetlands to shift from an aquatic plant dominated system to one dominated by phytoplankton and microbial mats (Davis et al. 2003).

Hence, the evidence of stressors on the systems may be detected by changes in the vegetation community composition (e.g. weed and/or terrestrial species invasion, changes in the abundance of salt sensitive species, changes in aquatic macrophyte communities), change in plant community spatial distribution (e.g. increase in *Leptospermum* spp. distribution) or changes to vegetation health (e.g. river red gum and/or *Melaleuca* spp. health) (Harding 2007).

In many wetland systems; both hydroperiod and salinity are often closely tied to human activities (Aznar et al. 2003) and indeed, water regime is one of the major historical changes contributing to the decline in the South East wetlands. Paradoxically it is also one of the major tools at the disposal of wetland managers to possibly alter wetland condition (Nature Conservation Society of South Australia, 2012).

Hence, if the two primary drivers of wetland structure in the South East are hydroperiod and salinity, a straightforward approach would be to classify the wetlands based on these attributes (after Semeniuk and Semeniuk 1995). Here the hydroperiod encapsulates the degree of inundation that a particular wetland type may experience (Semeniuk and Semeniuk 1995), ranging from permanently inundated to never inundated (Table 6). Likewise, salinity may be subdivided into categories of fresh, brackish or saline (Cowardin et al. 1979) where wetlands that are seasonally (or ephemerally) variable in salinity are characterised by the salinity in which the wetland exists for the major part of the year (or inundation period). The boundaries/thresholds in this report are adapted from Cowardin et al. 1979 and Semeniuk and Semenuik 1995 for hydroperiod (Table 6) and Butcher et al. (2011) for salinity (Table 7).

Therefore, by combining the hydroperiod and salinity (hydroperiod × salinity), nine primary types of common wetlands are recognised: Permanent Fresh (e.g. Pick Swamp), Seasonal Fresh (e.g. Trail Waterhole, Topperwein, The Marshes, Bool and Hacks Lagoon), Ephemeral Fresh (e.g. Deadmans Swamp), Permanent Brackish, Seasonal Brackish (e.g. Taratap, Lake Hawdon South, Middlepoint Swamp), Ephemeral Brackish, Permanent Saline (e.g. Big and Middle lakes (Lake George), Robe Lake, Big Dip Lake), Seasonal Saline (e.g. Small Lake (Lake George) and Ephemeral Saline.

Case study sites where vegetation data can be collected in Task 2 and historical vegetation and inundation patterns can be investigated (Task 3) needed to be selected. These sites need to encompass as many of the proposed wetland types as possible (Figure 3) and have surface and groundwater monitoring infrastructure installed. The rationale behind the site selection process is outlined in Section 4.

Table 6. Characterisation of Hydroperiod (number of days of inundation per year) for the South East region based on approaches by Cowardin et al. (1979) and Semeniuk and Semeniuk (1995).

Hydroperiod	Description
Permanent	Surface water present throughout the year (Cowardin et al. 1979), except in years of extreme drought (Semeniuk and Semeniuk 1995).
Seasonal	Surface water present persist throughout growing season (or for extended periods of usually > 3 – 4 months duration) in most years (Cowardin et al. 1979), but drying up annually either to complete dryness or to point of saturation during the dry season (Semeniuk and Semeniuk 1995).
Ephemeral	Holding surface water irregularly for changeable periods of time of <1 season duration (e.g. <3-4 weeks duration) (Cowardin et al. 1995) at intervals varying from less than a year to several years (Semeniuk and Semeniuk 1995).
Unknown	Where inundation periodicity is unknown, but saturation periodicity is known and has been recorded.

Table 7. Salinity categories for wetlands in the South East region, based on Butcher et al. 2011, Department for Water, 2010).

Salinity	Description
Fresh	Salinity = < 3000 mg L^{-1} (or <1600 mg L^{-1} Goodman 2012)
Brackish	Salinity = 3000 – 5000 mg L^{-1}
Saline	Salinity = >5000 mg L^{-1}

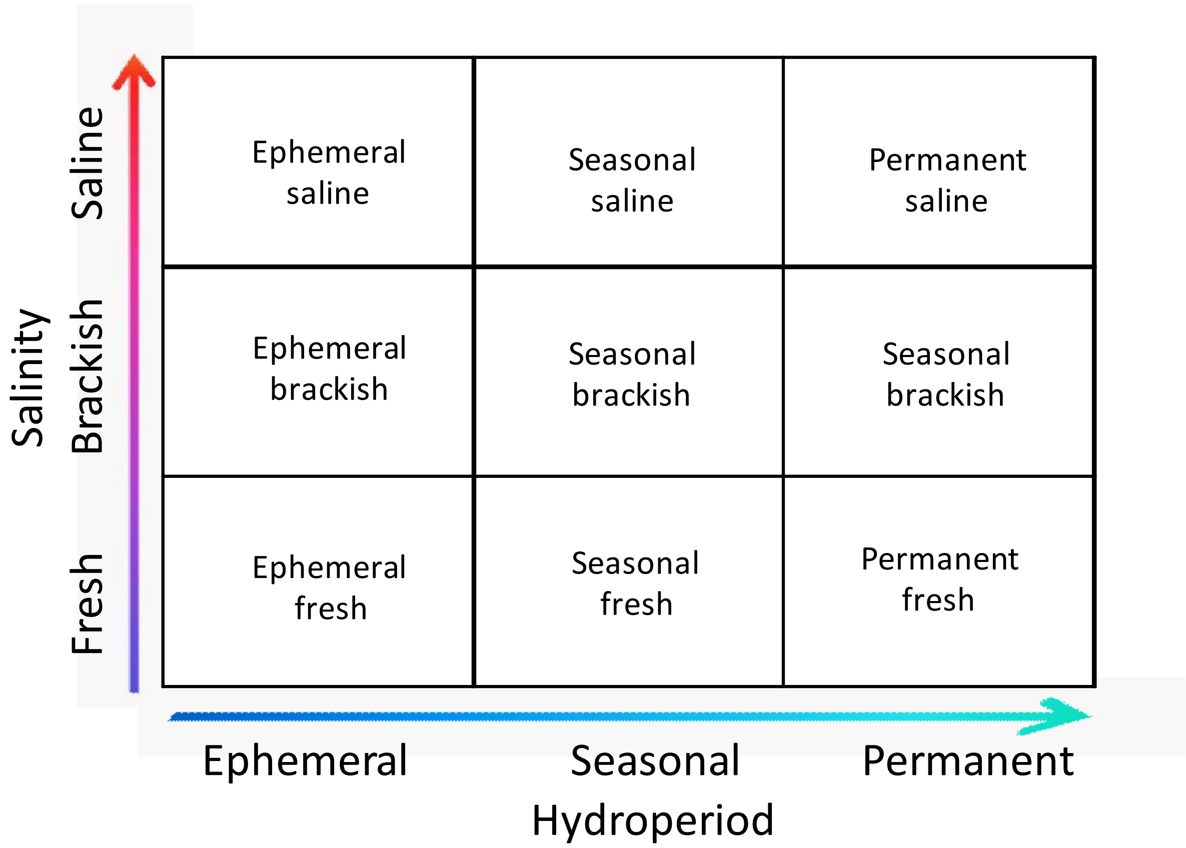

Figure 3. Classification framework for South East wetland types combining hydroperiod and salinity.

4. Case study site selection

A set of case study sites were selected to assist the development of eco-hydrological models for South East wetlands. The models are intended to inform wetland water requirements and vegetation response at a landscape scale; hence, the case study sites needed to include minimum monitoring infrastructure for inferring groundwater and surface water interactions (as suggested by Cook et al. (2008), and ideally possess historic or existing vegetation monitoring data. Given the requirement for some existing hydrological monitoring, case study sites were selected from a short-list of wetlands already monitored by DEWNR as part of the GDE (Groundwater Dependent Ecosystems) Monitoring or Upper South East Program (Sinclair Knight Merz 2010, M. de Jong and C. Harding, pers. comm.) (Appendix 3).

From the 21 sites already monitored by DEWNR (GDE Monitoring or Upper South East Program; Table 8) a selection of sites representing the range of the most common wetland types in the South East region were chosen based on the following criteria (Table 8):

- existing groundwater and surface water monitoring, including minimum of 1 gaugeboard and 1 suitable groundwater observation well,
- a good representative of a wetland type in the South East (hydrology, salinity, geomorphology, groundwater dependence),
- wetland vegetation in relatively undisturbed condition (e.g. not overly impacted by grazing or other non-hydrological impacts), and
- existing vegetation monitoring and/or mapping data available.

From the short-listed case-study sites (Table 8), selections of priority sites were required in order to assess temporal mapping of inundation and vegetation response via remote sensing. The criteria considered for ranking of priority sites included:

- a known historical change in hydrological or hydrogeological conditions that was likely to have influenced the wetland vegetation community, and
- the timing of the known change in hydrology to be within a time period which would allow for a discernable change in vegetation community within imagery and remote sensing limitations and capabilities (ideally around the late 1980s or early 1990s).

When assessing the 21 sites regularly monitored by DEWNR (Appendix 3), hydrological changes were expected to result from a number of causes, including:

- nearby or upstream increase in water use,
- increase in ground water extraction (for irrigation),
- direct or upstream diversions or drainage impacts, or
- reduced rainfall and consequent impact on recharge and runoff.

Likely impacts on wetland hydrology from groundwater extraction and reduced rainfall were able to be analysed using long-term groundwater monitoring to establish periods in which groundwater levels changed significantly, and whether levels recovered or continued to decline. Appendix 3 provides details of groundwater level trends for each of the short-listed monitored sites.

Drainage history was also reviewed, however most major impacts from drainage would have occurred in a time-period where remote sensing data and aerial photos are not available for analysis (pre 1950), or too recent (post 2007) to be able to determine vegetation response (Appendix 3).

Table 8. Selection criteria for the 11 shortlisted wetlands representative of range of wetland types in the South-East region.

Wetland Name **GDE Monitoring Site**	**Wetland Type**	• **Ecohydrological Conceptualisation Case Study Sites**	**Priority Sites: Mapping temporal changes in inundation and vegetation response**
Deadmans Swamp	**Grass Sedge Wetland (non-interdunal):** Seasonal – Intermittent, Fresh, <1m depth, high likelihood of permanent groundwater dependency	• Representative of wetland type • Potentially demonstrates implications of drying • Identified as a priority site for mapping vegetation response • Existing vegetation monitoring data available • Existing groundwater and surface water monitoring	Priority 1 • Recent (past 50 years) change in hydrology – significant groundwater level decline in the 1990s • Landuse change: Forestry and irrigation expansion • Dry since 2006, and likely to have been very dependent on the regional unconfined aquifer.
The Marshes	**Grass Sedge Wetland (perched):** Seasonal, Very Fresh, <1m depth, perched aquifer groundwater dependency	• Representative of wetland type • Example of perched system • Identified as a priority site for mapping vegetation response • Existing groundwater and surface water monitoring	Priority 2 • Recent (past 50 years) change in hydrology – significant groundwater level decline in the 1990s • Landuse change: Forestry expansion • Perched aquifer potentially more vulnerable to climatic influences
Trail Waterhole	**Grass Sedge Wetland (non-interdunal):** Seasonal, Fresh, >1m depth, moderate (or historic) groundwater dependency	• Representative of a common wetland type • Identified as a priority site for mapping vegetation response • Existing vegetation monitoring data available • Existing groundwater and surface water monitoring	Priority 3 • Recent (past 50 years) change in hydrology – significant groundwater level decline in the 1990s • Landuse change: Forestry expansion • Observed vegetation response to drying
Topperwein	**Grass Sedge Wetland (non-interdunal):** Seasonal, Very Fresh, <1m depth, moderate (or historic) seasonal groundwater dependency	• Representative of wetland type • Identified as a priority site for mapping vegetation response • Existing vegetation monitoring data available • Existing groundwater and surface water monitoring	Priority 4 • Recent (past 50 years) change in hydrology – significant groundwater level decline in the 1990s • Landuse change: Forestry expansion • Observed vegetation response to drying
Lake Hawdon South	**Inland Interdunal Wetland:** Seasonal, Fresh-Brackish, <1m depth, very high likelihood of permanent groundwater dependency	• Representative of a common wetland type • Range of depth and water regime gradients present in large wetland system • Existing vegetation monitoring data available • Existing groundwater and surface water monitoring • Reference site for Inland Interdunal systems	• Temporal inundation and vegetation response mapping exists for this site
Bool/Hacks Lagoon	**Grass Sedge Wetland (interdunal)**: Seasonal/Semi-permanent, Fresh-Brackish, >1m depth, very high likelihood of permanent groundwater dependency	• Representative of a common wetland type • Range of depth and water regime gradients present in large wetland system • Existing vegetation monitoring data available • Existing groundwater and surface water monitoring	
Lake Robe and Big Dip Lake	**Coastal Saline Lake:** Permanent, Saline - Hypersaline, >1m depth, very high likelihood of permanent groundwater dependency	• Representative of a hypersaline coastal lakes • Existing vegetation monitoring data available • Existing groundwater and surface water monitoring	

Middlepoint Swamp	**Coastal Peat Swamp:** Seasonal, Brackish, <1m depth, very high likelihood of permanent groundwater dependency	• Representative of a brackish coastal wetland type • Existing vegetation monitoring data available • Existing groundwater and surface water monitoring	
Pick Swamp	**Karst Rising Spring / Peat Swamp:** Seasonal/Permanent, Fresh, >1m / <1m depth, very high likelihood of permanent groundwater dependency	• Representative of wetland type • Example of response from re-wetting post wetland restoration work. • Range of depth and water regime gradients present in large wetland system • Existing vegetation monitoring data available • Existing groundwater and surface water monitoring	
Lake George	**Coastal Saline Lake:** Permanent, Saline, >1m depth, very high likelihood of permanent groundwater dependency	• Representative of permanent Saline Lakes • Existing vegetation monitoring data available • Existing surface water monitoring	
Englands Swamp - Taratap	**Inland Interdunal Wetland:** Seasonal, Brackish, <1m depth, high likelihood of seasonal groundwater dependency	• Representative of Inland Interdunal wetland and floodplain • Existing vegetation monitoring data available • Existing groundwater and surface water monitoring	
Refer to Appendix 3 for site selection criteria of all GDE monitoring sites.			

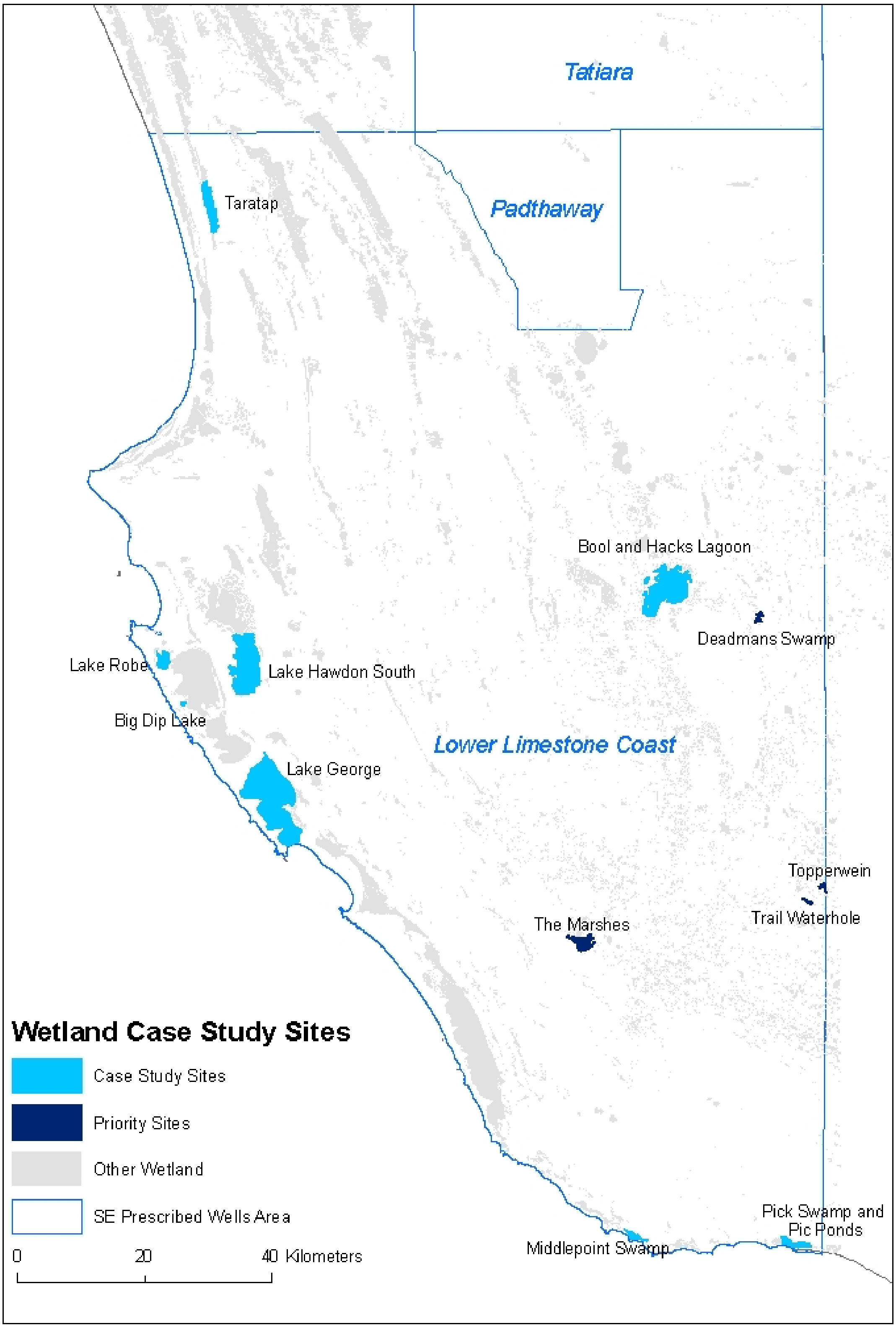

Figure 4. Map showing location of the 11 shortlisted wetland case study sites representative of wetlands types in the South-East region

From the 11 short-listed sites (Table 8; Figure 4); four were chosen as priority sites, namely Deadmans Swamp, Topperwein, Trail Waterhole and The Marshes. All four sites exhibited groundwater level declines in the period 1990 – 2000 of greater than 0.15 m year^{-1} (i.e. up to 0.28 m year^{-1}) with sustained groundwater level drawdown continuing to 2012. All sites were thought to have undergone significant hydrological and vegetative change in recent history, which may be able to be demonstrated through temporal remote sensing imagery and aerial photographs.

Figure 5 represents the salinity and water regimes (hydroperiod) experienced in the case study wetlands. Water level changes in a wetland interact with elevation to determine the water regime a plant may experience in its habitat (e.g. permanently aquatic, intermittent floodplain or dry terrestrial), with wetter habitats occurring further down the elevation gradient and vice versa. Other drivers such as turbidity and nutrient levels also strongly affect plant dynamics (Blanch et al. 1999a, 1999b, Nicol and Ganf 2000; Nicol et al. 2003; Rea and Ganf 1994a; Deegan et al. 2007). Assigning boundaries for water regime and salinity categories is useful for classification purposes; however, it does not accurately reflect what occurs in nature. The water regime and salinity gradients experienced in wetlands are continua and variable in time and space. For example, Trail Waterhole, Topperwein and The Marshes are seasonal freshwater wetlands; however, the hydroperiod at higher elevations is shorter and less predictable and would be considered ephemeral (Figure 5). Similarly, Small Lake in Lake George is classed as a saline seasonal wetland; however, salinity is highly variable and can range from brackish to hypersaline depending on drain M inflow (Department for Environment, Water and Natural Resources 2014; Figure 5). With the exception of permanent brackish (which are probably only represented by drains in the South East), the case study wetlands (or points in the case study wetlands) represent all of the proposed wetland types.

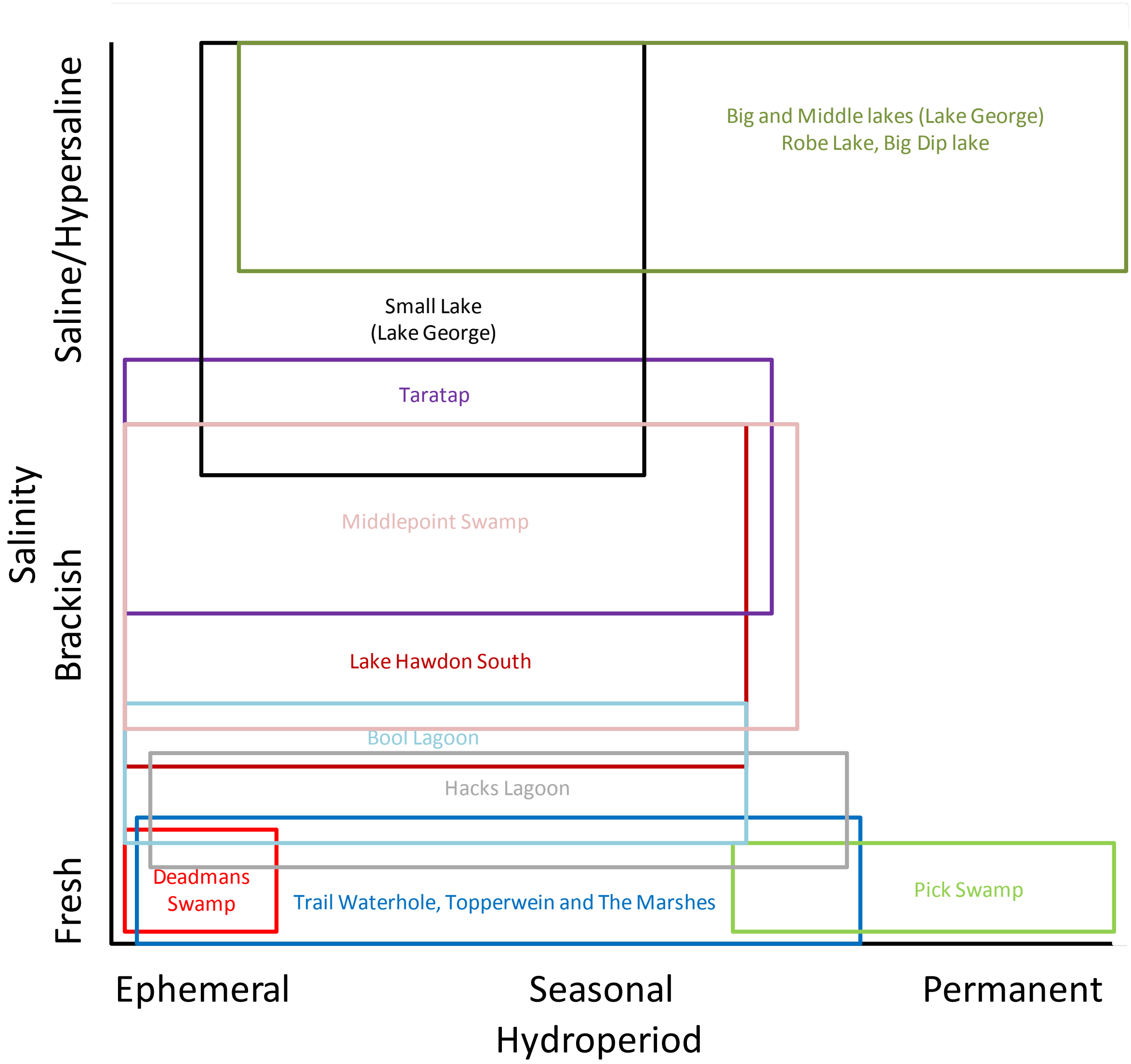

Figure 5. Salinity and hydroperiod regimes for the case study sites.

Figure 6 pictorially represents probable hydroperiod and salinity preferences of selected common wetland plant species present in the South East. It is unlikely that the shape of the hydroperiod and salinity envelop for species will be rectangular (they will probably be ovoid); however, they were drawn rectangular for illustrative purposes. Based on information collected in Task 2 of this project and from other sources, probability relationships for occurrence of functional groups based on salinity and hydroperiod can be developed that can form the basis of the predictive model.

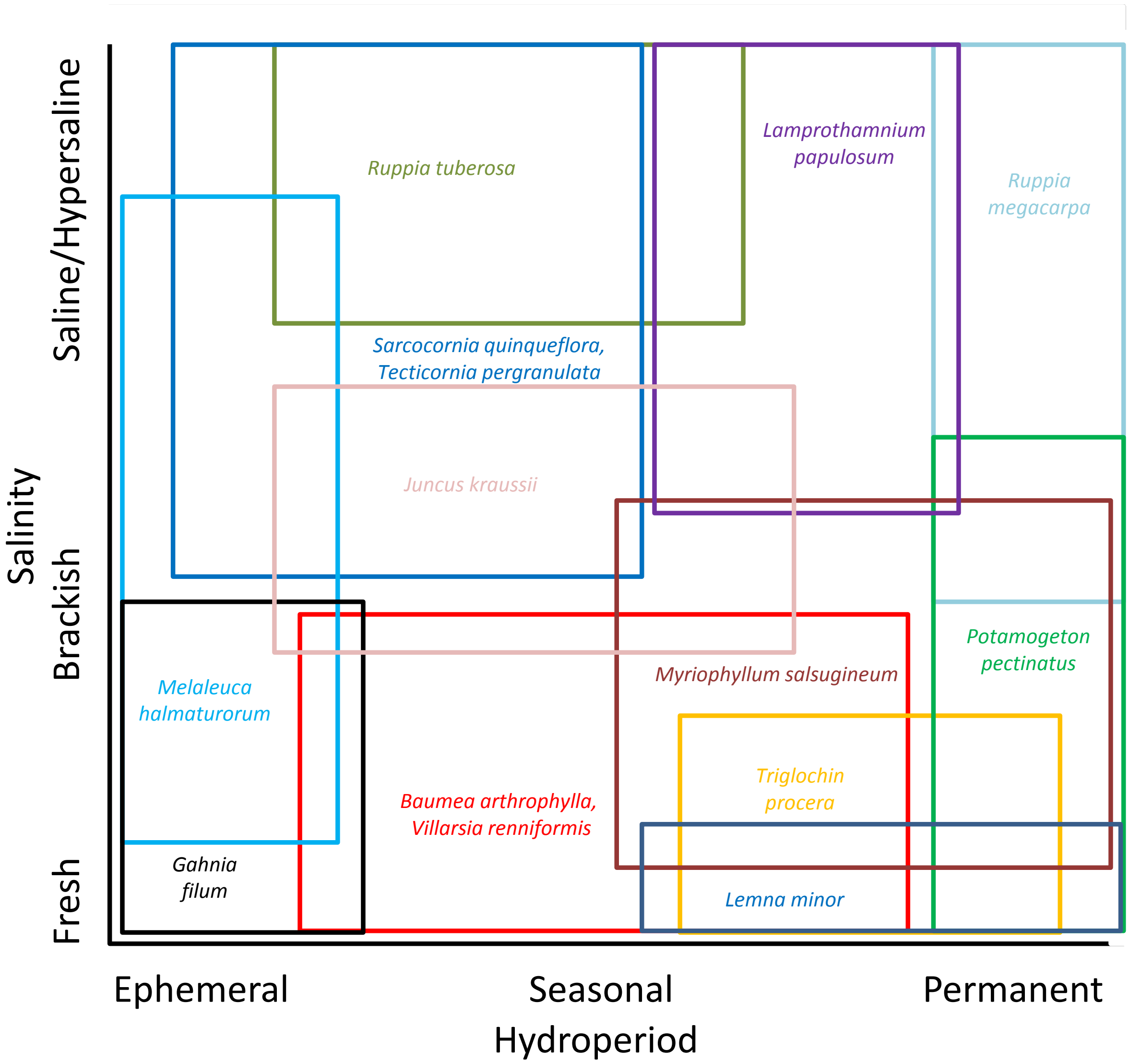

Figure 6. Probable hydroperiod and salinity preferences of selected common species present in South East wetlands.

5. Vegetation surveying protocol for Task 2

The vegetation surveying protocol was designed to capture a large number of observations over a wide range of hydroperiods and salinities to enable probability functions to be developed for species and/or functional groups. This entailed a large number of small quadrats be established (Appendix 4) to enable statistically significant relationships between hydrology and salinity and the presence of a species or functional group. Undertaking inventories of the species present was not an aim of the project; therefore, the species list presented in Appendix 5 is by no means a comprehensive plant species list of wetlands in the South East.

Vegetation surveys were undertaken in the case study wetlands in spring 2013, autumn 2014 and spring 2014. In spring 2013, a series of 1 x 1 m quadrats were established in the case study wetlands (40 to 130 in each wetland depending on size and plant diversity); with 817 quadrats in total across the case study wetlands (Appendix 4). Quadrats were positioned at different points along the elevation gradient from the spring/winter high water level (usually wet heath) to a maximum depth of approximately 1 m (depths greater than 1 m are difficult and often dangerous to survey without the use of a vessel). The location of each quadrat was recorded by GPS (Appendix 4) and the elevation determined using the digital elevation model (DEM). Where the DEM elevation was inaccurate the elevation was determined using water depth for inundated quadrats (comparisons of nearby quadrats) or a laser level in the case of Deadmans Swamp where no quadrats were inundated. The species present in each quadrat were recorded along with water depth. Electrical conductivity (EC), pH and turbidity were measured for each wetland (or each basin if the wetland was comprised of more than one basin or there are likely water quality gradients present e.g. Hacks/Bool Lagoon or Lake George).

Plants were identified using keys in Sainty and Jacobs (1981), Jessop and Tolken (1986), Prescott (1988), 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 (2014) Species identified during vegetation surveys were allocated to a WPFG (sensu Brock and Casanova 1997; Casanova 2011) on the basis of information obtained about germination behaviour from seed bank studies and ecological information obtained from literature and overall morphology. A list of species recorded during the vegetation surveys and functional groups is presented in Appendix 5.

The data collected in the vegetation surveys undertaken in Task 2 were used to assist in ground-truthing remotely sensed data (Task 3) and develop probability functions (*sensu* Goodman 2010; Hood 2013) used for the predictive modelling. The predictive model predicts the probability of occurrence of a plant functional group in relation to hydrology and salinity and development and scenario testing are presented in two draft journal papers.

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Appendices

Appendix 1. Summary of available spatial and/or hydrological data sources pertaining to wetlands in the South-East region.

Dataset Type	Time Period	Data Format	Scale Units	Data Provided by / Available from	Custodian	Notes	Spatial (Y/N)	Scale	File Size (subset)	Data Continuity (Snapshot/continuous)
Aerial Photography	2008	Raster	90 cm	Claire Harding	DEWNR: Department of Environment, Water and Natural Resources	Flown by Aerometrix. 3 band CIR (false colour infra-red) and 3 band RGB (true colour). Compressed ECW format and Uncompressed ECW format. SE NRM.	Y	Local	21.4 GB	Snapshot
Aerial Photography	2013	Raster	90 cm	James Cameron	DEWNR	Flown by Aerometrix. Mosaic in compressed ECW format (after colour balancing). 3 bands (RGB). SE NRM.	Y	Local	103 GB	Snapshot
Aerial Photography	2013	Raster	90 cm	James Cameron	DEWNR	Flown by Aerometrix. Ortho tiles uncompressed (before colour balancing). 4 bands. For 20 case study wetlands.	Y	Local	54.8 GB	Snapshot
Aerial Photography	1969 1982 1992 1999 2005 2008	Raster	Various scales	James Cameron	DEWNR	1 or 3 bands (black and white, True colour or false colour infra-red). For vegetation community mapping for 4 focal wetlands.	Y	Various (Regional – local)	15.7 GB	Series of snapshots
DEM	2013	Raster	30 m	James Cameron	DEWNR	Digital Elevation Model derived from Aerometrix aerial photography (which included infra-red). SE NRM.	Y	Regional	2.18 GB	Snapshot
DEM	2008	Raster	10 m	Claire Harding	DEWNR	Digital Elevation Model (derived from Lidar or Aerometrix aerial photography?). SE NRM + adjoining 30 km into Victoria.	Y	Regional	1.52 GB	Snapshot
DEM	2010	Raster	2 m	Claire Harding	DEWNR	Digital Elevation Model derived from Lidar. Separate files for: • Upper SE • Lower SE • Areas 2 - 10	Y	Regional	80 GB	Snapshot
DEM	2013	Raster	90 cm	James Cameron	DEWNR	Digital Elevation Model (derived from Aerometrix aerial photography, which included infra-red). SE NRM.	Y	Regional	1 TB	Snapshot
Landsat satellite imagery	1972 to present	Raster	30 m	Download from USGS GloVis site: http://glovis.usgs.gov/	USGS: United States Geological Survey	Downloaded 1 wet and 1 dry (cloud free) image per year 1991 to 2012 - 43 images. Landsat Band 5 density slice. To map temporal inundation extent for the 20 case study wetlands in SE NRM.	Y	Regional subset of Global dataset	38.9 GB	Series of snapshots from a continuous record
MODIS satellite imagery - NDVI	2000 to present	Raster	250 m	Download from USGS GloVis site: http://glovis.usgs.gov/	USGS: United States Geological Survey	Downloaded 2000 to 2013 MODIS MOD13Q1 NDVI Product. 16-day composites of NDVI (veg index). Created an isoclass unsupervised clustering of the MODIS NDVI to map general wetland greenness. SE NRM.	Y	Regional subset of Global dataset		Continuous

Dataset Type	Time Period	Data Format	Scale Units	Data Provided by / Available from	Custodian	Notes	Spatial (Y/N)	Scale	File Size (subset)	Data Continuity (Snapshot/continuous)
MODIS satellite imagery - NBAR	2000 to present	Raster	500 m	Download from USGS GloVis site: http://glovis.usgs.gov/	USGS: United States Geological Survey	Downloaded 2000 to 2013 MODIS MCD43A4 Product. 16-day composites of Nadir BRDF-Adjusted Reflectance (NBAR). SE NRM.	Y	Regional subset of Global dataset		Continuous
SAWID - GIS Database	As of May 2014	Polygon shapefile	N/A	Claire Harding	DEWNR	South Australian Wetland Inventory Database: SAWID Version 4 (Harding 2014) 17,231 Polygons in Region S01 within SE NRM.	Y	Regional	147 MB	N/A
SAWID - Access Database	As of May 2014	Access database	N/A	Claire Harding	DEWNR	South Australian Wetland Inventory Database. 154 tables. Can be joined to SAWID wetland polygons. Region S01 within SE NRM.	Y (via join)	Regional	36.6 MB	Mix of snapshots and continuous
SAWID - Photos	As of May 2014	Photos and Access table	N/A	Claire Harding	DEWNR	Approx 2,000 photos. Can be linked to SAWID wetland polygons.	Y (via join)	Regional - Site specific		Snapshots
SAWID - Case study sites	Aug 2013	Polygon shapefile	N/A	Claire Harding	DEWNR	20 case study sites from SAWID wetlands. Region S01within SE NRM.	Y	Local within region	1 MB	N/A
BDBSA (via SAWID)	1874 to present. As of May 2014	Access tables	N/A	Claire Harding	DEWNR	Biological Database of South Australia. Survey data from 1874 to present. Synchronised with SAWID in June 2013. Region S01 within SE NRM.	Y (via join)	Regional subset of State dataset. Site specific		Mix of snapshots and continuous
ANAE (via SAWID)	As of May 2014	Access table	1:250,000	Claire Harding	DEWNR	Australian National Aquatic Ecosystems. Wetlands Classification Layer. Now available in SAWID [SE_ANAECLASS]. Region S01 within SE NRM. (Butcher et al. 2011)	Y (via join)	Regional subset of Australian dataset		N/A
SAAE (via SAWID)	As of May 2014	Access table	1:250,000 or better	Claire Harding	DEWNR	South Australian Aquatic Ecosystems. About 50 attributes. Now available in SAWID [SE_ANAECLASS]. Region S01 within SE NRM.	Y (via join)	Regional subset of State dataset		N/A
GDE Atlas (via SAWID)	As of May 2014	Access table	N/A	Claire Harding	DEWNR	The National Atlas of Groundwater Dependent Ecosystems. (SKM 2012). Data now available in SAWID [SE_GDEAtlas]. Region S01 within SE NRM.	Y (via join)	Regional subset of Australian dataset		N/A
Likelihood of Groundwater Dependence (via SAWID)	As of May 2014	Access table	N/A	Claire Harding	DEWNR	Likelihood of Groundwater Dependence. Based on zonal statistics of seasonal water depths etc. (SKM 2009). Data now available in SAWID [SE_GDE]. Region S01 within SE NRM.	Y (via join)	Regional		N/A
WaterRAT - Wetland Risk Assessment Tool	2009	GIS tool		Claire Harding	DEWNR	WaterRAT: Water Dependent Ecosystems Risk Assessment Tool A GIS tool designed to provide critical information in order to identify ecologically significant water dependent ecosystem assets and processes. (Harding 2009, Harding and Connor 2012).	Y	Regional, State		

Dataset Type	Time Period	Data Format	Scale Units	Data Provided by / Available from	Custodian	Notes	Spatial (Y/N)	Scale	File Size (subset)	Data Continuity (Snapshot/continuous)
GDE Monitoring Database South Australia			N/A	Claire Harding	DEWNR	Groundwater Dependent Ecosystems (GDE) Monitoring Database. 14 case study wetland complexes. SE NRM	Y	Local within region		Mix of snapshots and continuous?
GDE Atlas of Australia	2012	Polygon shapefiles	N/A	Download from BOM site: www.bom.gov.au/water/grpindwater/gde/map.shtml	BOM	The National Atlas of Groundwater Dependent Ecosystems. 3 layers can be downloaded: • Potential GDEs reliant on subsurface presence of groundwater • Potential GDEs reliant of surface expression of groundwater • Subterranean GDEs (cave and aquifer) Australia	Y	Regional subset of Australian dataset		N/A
Water Connect – SA Groundwater data	1939 to present. As of Dec 2013	CSV tables (converted to Point shapefiles)	N/A	Download from Water Connect site: https://www.waterconnect.sa.gov.au/Systems/GD/Pages/default.aspx	DEWNR	South Australian groundwater monitoring data. Observation bore data - Periodic sampling. Extracted: • Observation well (Obswell) data only • Region S01 within SE NRM • Unconfined Aquifers only Tables (.csv) extracted: • Construction Details (×4 files) • Construction Summary • Drillers Log • Elevation • Hydrostatigraphic Log • Lithological Logs • Salinity • Statigraphic Log • Water Chemistry • Water Level • Well Summary Converted to Spatial Data from Lat. and Long.	Y (convert)	Regional subset of State dataset. Site specific	16 MB	Mix of snapshots and continuous
Victoria DEPI's – Water Measurement Information System Groundwater Data	1958 to present. As of Dec 2013	CSV tables converted to Point shapefiles	N/A	Download from DEPI's Water Monitoring Data site: http://data.water.vic.gov.au/monitoring.htm	DEPI: Department of Environment and Primary Industries	Victorian groundwater monitoring data from the Water Measurement Information System (WMIS). Extracted: • Groundwater Data, • For Monitoring and Observation, • Clipped to SE NRM Catchments Tables (.csv) extracted: • Site (Location and Depth) • Water Level • Water Quality Field • Water Quality Laboratory • Driller Logs • Geology Logs • Lithology Logs Converted to Spatial Data from Lat. and Long. Victorian Catchments in SE NRM.	Y (convert)	Regional subset of State dataset Site specific	744 MB	Mix of snapshots and continuous

Dataset Type	Time Period	Data Format	Scale Units	Data Provided by / Available from	Custodian	Notes	Spatial (Y/N)	Scale	File Size (subset)	Data Continuity (Snapshot/continuous)
Water Connect – Spatial Data	As of Sep 2013	Shapefiles	N/A	Download from Water Connect site: https://www.waterconnect.sa.gov.au/Systems/SitePages/Spatial%20Data.aspx	DEWNR	Layers Downloaded for SE NRM: • Drillholes • Groundwater Aquifers • Groundwater Basins • Groundwater Border Agreement Zones • Groundwater Provinces • Levee Banks • NRM Regions South Australia • Prescribed Surface Water Areas • Prescribed Watercourses • Prescribed Well Areas • Shallow Standing Water Level • Shallow Total Dissolved Salt • Shallow Yield • Surface Water Basin • Waterbodies • Watercourses	Y	Regional subset of State dataset	1.4 GB	N/A
NGSA Catchments	2011	Polygon shapefile	9 second (~ 250 m)	Download from Geoscience Australia site: http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_b1d20bbb-cab7-6e7d-e044-00144fdd4fa6/Catchment+Polygons%2C+National+Geochemical+Survey+of+Australia%2C+2011	Geoscience Australia	National Geochemical Survey of Australia 2011. Catchments derived from a national scale 9 second (approximately 250 m) resolution Digital Elevation Model. Australia.	Y	Regional subset of Australian dataset	24 MB	N/A
Surface Water	2015?	Shapefiles		David Tonkin	DEWNR	Recently updated by Chris Malem.	Y	Regional subset of State dataset		N/A
SE Drains	Jun 2013	Geodatabase of shapefiles	N/A	Mark de Jong	DEWNR	Drain Network. SE NRM.	Y	Regional	12 MB	N/A
Drains Completion	Jun 2013	Polyline shapefile and Table	N/A	Mark de Jong	DEWNR	Shapefile of Lower South East drains operated by the SEWCDB including completion dates. Also a table of drain completion dates for the Upper South East Program. No completion dates for the myriad of privately constructed drains provided.	Y (convert some)	Regional	200 KB	N/A
Hydstra	1970s to present	Data management package	N/A	Peta Hansen	DEWNR	Disparate hydrological data sets for the Upper SE area were amalgamated into a single data system, Hydstra TS (hydrometric time series data) Commercial Environmental data management package: • Surface water data • Daily data logger data or flow meter readings • Water quality data • Periodic groundwater data	Y (convert)	Regional		Mix of snapshots and continuous

Dataset Type	Time Period	Data Format	Scale Units	Data Provided by / Available from	Custodian	Notes	Spatial (Y/N)	Scale	File Size (subset)	Data Continuity (Snapshot/continuous)
Creeks, Rivera and Lakes Water Quality Data	1971 - 2008	Spreadsheets	N/A	Download from EPA site: https://maps.google.com.au/maps/ms?msid=216383563782058666930.0004be62e36508f46faa8&msa=0	EPA	5 locations: • Blackford Drain • Drain L • Drain M • Eight Mile Creek • Mosquito Creek Convert to Spatial Data from Lat. and Long.	Y (convert)	Local within region		A series of snapshots
Aquatic Ecosystem Condition Reports and Data	2009	Spreadsheets Report	N/A	Download from Water Connect site: https://www.waterconnect.sa.gov.au/Systems/EPAWQ/Pages/Map.aspx	EPA	71 sites in SE NRM. Fauna, habitat and water quality data. Convert to Spatial Data from Lat. and Long.	Y (convert)	Local within region		A series of snapshots
WOfS: WOFL Inundation per date	1987 to present	Raster	25 m	Norman Mueller (Not currently available to the public)	Geoscience Australia	Water Observations from Space (WOfS) product from Landsat imagery. Water Observation Feature Layers (WOFL) A file per Landsat tile – generally1one every 16 days. Each WOFL file contains one byte per pixel: • 0: No water in pixel • 1: No data (one or more bands) in source NBAR tile • 2: No contiguity • 4: Sea water • 8: Terrain shadow • 16: High slope • 32: Cloud shadow • 64: Cloud • 128: Water in pixel SE NRM	Y	Regional subset of Australian dataset	10 GB	Continuous
WOfS Inundation Summaries	1987 to present	Raster	25 m	Geoscience Australia WOfS site: http://www.ga.gov.au/scientific-topics/hazards/flood/wofs	Geoscience Australia	A summary of the WOFL layers. 5 WOfS summary datasets: • Clear Observations • Water Observations • Water Summary • Confidence • Filtered Summary SE NRM	Y	Regional subset of Australian dataset	227 MB	N/A
Daily Weather Station Data	1900 to present	Spreadsheets	N/A	Download from BOM site: http://www.bom.gov.au/climate/data/?ref=ftr	BOM: Bureau of Meteorology	Including: • Temperature (Max/Min) • Rainfall • Evaporation • Sunshine Hours • Max Wind Gust (Direction/ Speed) Convert to Spatial Data from Lat. and Long.	Y (convert)	Regional subset of Australian dataset		Continuous (with some gaps)

Dataset Type	Time Period	Data Format	Scale Units	Data Provided by / Available from	Custodian	Notes	Spatial (Y/N)	Scale	File Size (subset)	Data Continuity (Snapshot/continuous)
AWAP Monthly and Annual Climate Data	1900 - present	Raster	0.05° (~ 5 km)	Download from AWAP site: http://www.eoc.csiro.au/awap/	CSIRO: Commonwealth Scientific and Industrial Research Organisation	Australian Water Availability Project (AWAP) Downloaded Run 26h (July 2012)1960 -2011. Monthly and Annual means Australia-wide: • Incident Solar Radiation • Daily Maximum Temperature • Daily Minimum Temperature • Precipitation • Relative Soil Moisture (Upper Layer) • Relative Soil Moisture (Upper Layer) at end of aggregation period • Relative Soil Moisture (Lower Layer) at end of aggregation period • Total Evaporation (Soil + Vegetation) • Total Transpiration • Soil Evaporation • Potential Evaporation • Local Discharge (Runoff + Drainage) • Surface Runoff • Open Water Evaporation ('pan' equiv) • Deep Drainage • Daily Sensible Heat Flux • Daily Latent Heat Flux SE NRM.	Y	Regional subset of Australian dataset	24.8 B	Continuous
AWAP Daily Climate Data	1900 - present	Raster	0.05° (~ 5 km)	Lynette Bettio	BOM	Australian Water Availability Project. Downloaded 1960 to 2014. Daily climate data (Australia wide): • Solar irradiance • Maximum Temperature • Minimum Temperature • Rainfall • Soil Moisture (Upper) • Soil Moisture (Lower) • Total Evaporation • Transpiration • Soil Evaporation • Potential Evaporation • Local Discharge • Surface Runoff • Deep Drainage • Sensible Heat • Latent Heat SE NRM.	Y	Regional subset of Australian dataset		Continuous
Surface Geology Australia	2012	Geodatabase	1: 1 million	Download from Geoscience Australia Site: http://www.ga.gov.au/ausgeonews/ausgeonews200903/geological.jsp	Geoscience Australia	5, 900 described geological units. Based on 1:250,000 State maps. Seamless across borders. Australia-wide.	Y	Regional subset of Australia dataset	395 MB	N/A
Geology South Australia		Geodatabase of shapefiles	1:100,000 Geodatabase	Adelaide University	DEWNR	206,113 described geological units. South Australia.	Y	Regional subset of State dataset	567 MB	N/A

Dataset Type	Time Period	Data Format	Scale Units	Data Provided by / Available from	Custodian	Notes	Spatial (Y/N)	Scale	File Size (subset)	Data Continuity (Snapshot/continuous)
Geology - Various products South Australia	Various	Various	Various scales	Download from DMITRE site: http://www.pir.sa.gov.au/minerals/publications_and_information/maps and http://www.pir.sa.gov.au/minerals/geological_survey_of_sa/geology	DMITRE: Department for Manufacturing, Innovation, Trade, Resources and Energy	Many products available for download. South Australia.	Y	Regional subset of State dataset	Various	N/A
Soil Landscapes - Site Data		Point shapefile	N/A	Craig Liddicoat	DEWNR	Over 1,000 pits. 42 attributes. South Australia.	Y	Regional subset of State dataset		N/A
Soil Landscapes - Spatial Database	2007	Polygon shapefile	1:100,000	David Tonkin	DEWNR	SA State Land and Soil Mapping Program. 42 Land and Soil attributes and derivatives.	Y	Regional subset of State dataset	419 MB	N/A
Vegetation – Site Data		Point shapefile	N/A	Claire Harding	DEWNR	Across the whole state. Derived from Biological Survey sites.	Y	Regional subset of State dataset		Snapshots
Vegetation - Polygons		Polygon shapefile	Various	David Tonkin	DEWNR	EGIS Data Layer: • Veg.SAVegetation +table(s) Veg mapping from across the whole state. Polygons ranging in scale of aerial photography and age. Derived from Biological Survey Sites (30 m quadrats) and aerial photography (pattern analysis of plant associations).	Y	Regional subset of State dataset		N/A
Pre-European Vegetation	Pre European	Polygon shapefile	1:10,000 – 1:250,000	David Tonkin	DEWNR	Native vegetation. EGIS Data Layer: • Veg.SthEast_pe. South Australia.	Y	Regional subset of State dataset		Snapshot
Land Use of Australia (Version 3 and Version 4)	1992 - 1993 1993 - 1994 1996 - 1997 1998 - 1999 2000 - 2001 2001 - 2002 2005 - 2006	Raster	0.01° (~ 1 km)	Download from ABARES site: http://www.agriculture.gov.au/abares/aclump/land-use/data-download	ABARE: Australian Bureau of Agricultural and Resource Economics	Derived and compiled by Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences (ABARE – BRS). Version 3 (1992 to 2002) uses Version 4 of the Australian Land Use Management Classification (ALUMC). Version 4 (2005 - 2006) uses ALUMC V5.	Y	Regional subset of Australian dataset	35 MB	Series of snapshots
South Australian Land Use	2003 2008	Polygon shapefiles	1:100,000 / 1:250,000	David Tonkin	DEWNR	EGIS Data Layers: • LANDSCAPE.LandUse2008 • LANDSCAPE.LandUse2003 Based on ALLUM Version 6 classification. Positional accuracy is 1:100,000 for the Agricultural Regions and 1:250,000 for the Pastoral Regions.	Y	Regional subset of State dataset	389 MB	Series of snapshots
Geodata Topo 10m 2002	2002	Shapefiles	1:250,000 - 1:10,000,000	Download from Geoscience Australia site: http://www.ga.gov.au/metadata-gateway/metadata/record/60803/	Geoscience Australia	Fundamental base layers of geographic info. Built up areas, roads, drainage, waterbodies, etc. For reference purposes only. Australian States.	Y	Regional subset of Australian dataset	6 MB	N/A

Dataset Type	Time Period	Data Format	Scale Units	Data Provided by / Available from	Custodian	Notes	Spatial (Y/N)	Scale	File Size (subset)	Data Continuity (Snapshot/continuous)
TOPOmap SA Version2 - South East	2001	ECW	1:50,000	Adelaide University	DEWNR	50k Topo map - seamless maps. For reference purposes only. South East.	Y	Regional	385 MB	N/A
Drawdown Contours	1999 - 2029				Aquaterra	Water table drawdown contours for modelled scenarios.		Regional		
Student project				David Tonkin	DEWNR	Hydrological monitoring data.				
SE Science Review - Spatial Data	Jul 2010	Polygon shapefiles	N/A	David Tonkin	DEWNR	Landsat veg indices etc.	Y	Regional		
South East Science Review - Report	2010	PDF files	N/A	Download from Water Connect site: https://www.waterconnect.sa.gov.au/	DEWNR	Downloaded full Report from Waterconnect website.	N	Regional	50 MB	N/A
NGT report and spreadsheets		Report Spreadsheets	N/A	Claire Harding	DEWNR	Nature Glenelg Trust. A report. Collated data in spreadsheets.	Y	Regional		N/A
Abby Goodman PhD thesis		Data, PDF file	N/A	Download thesis from Adelaide University Library site: https://digital.library.adelaide.edu.au/dspace/handle/2440/79815	Adelaide University	Thesis. Data from Megan Lewis / Claire Harding / Kane Aldridge.	Y	Regional		N/A
WETCAT report(s)		PDF files	N/A	Claire Harding	DEWNR	Wetland Condition Assessment Tool SE NRM	N	Regional		N/A
Wetland water requirements		PDF files	N/A	Claire Harding	Ecological Associates Pty Ltd	The Adaptive Flows Management (AFM). Decision Support System. Ben's Wetland Water Requirements. Upper SE NRM		Regional		N/A
ANAE report /documents and Case Studies		PDF files	N/A	Claire Harding	DEWNR		N	Australia, State		N/A

Dataset Type	Time Period	Data Format	Scale Units	Data Provided by / Available from	Custodian	Notes	Spatial (Y/N)	Scale	File Size (subset)	Data Continuity (Snapshot/continuous)
Water Connect Reports	Various: 2000 - present	PDF files DOC files	N/A	Download from Water Connect site: https://www.waterconnect.sa.gov.au/	DEWNR	• Groundwater Model Briefs • Groundwater Technical Notes • Groundwater Technical Reports • Groundwater Model Reports • Groundwater Resource Assessments • Surface Water Technical Notes • Surface Water Technical Reports • Surface Water Model Reports • Surface Water Consultation Reports	N	State, Regional	27.5 MB	N/A
Goyder Institute Technical Reports	2011 - present	PDF	N/A	Download from Goyder Institute site: http://goyderinstitute.org/index.php?id=20	Goyder Institute	Various reports	N	Local, Regional, State	N/A	N/A
Other Written Reports Various authors	1972 - present	Documents	N/A	Various sources	Various	• Jones (1978) - wetlands of the Lower South East. • Jolly et al. (1985) - described wetlands/wetland complexes within the Lower South East area. • Lloyd and Balla (1986) - summarised the wetland resources of South Australia to highlight environmentally important area. • Howe et al. (2005) - quantified conservation value of 786 mapped wetlands of the SE. • Kingsford et al. (2006) – used criteria such as species richness, rarity and naturalness (condition), representativeness and special features to prioritise wetlands. • Margules and Pressey (2000) – comprehensive biophysical data. • Sinclair Knight Mertz (2010) – developed conceptual models for groundwater dependent ecosystems for 13 wetland sites in the SE region. Also developed a database based on using the AcrHydro data model.	N	Various	N/A	N/A

Appendix 2. Summary of available ecological data sources pertaining to wetlands in the South-East region.

Dataset	Dates	From	Custodian	Scale	Comments	Size	Spatial
Atlas of Living Australia	1850 - present		http://www.ala.org.au/	National State Regional Local	• Herbarium specimens • Distribution of samples • Presence only data • Opportunistic acquisition • Provides a species profile/description		Y
Aquatic Plant Communities	? - present	Peter Canty, Manager	State Herbarium, South Australia	State Regional Local			N
Land Evaluations			Land Titles Office		The major economic activity on the Parcel		
Goyder Project E.2.3 SE "SE Regional Water Balance" Report data	2010 - 2011	Kane Aldridge	University of Adelaide	Regional	"SE Regional Water Balance"		N
Any salinity data		Mark de Jong	DEWNR				
Landuse		Graham Green and Chris Li?			From SE Regional Water Balance project		
Wetland assessment and vegetation associations		Troy Horn	Forestry SA				
Non-BOM Rain gauge data		Mark De Jong	DEWNR		(Mentioned at SE Wetlands Working Group meeting 15/5/2013) The Adaptive Flows Management (AFM) Decision Support System The is data from some extra non-BOM rain gauges		
Management Action Database		Mary Kosiou					
Drain reports		Mark de Jong, Matt Gibbs Ben Taylor	DEWNR		A record of when the drains went in: • Ben Taylor – Drain L • Mark de Jong – Drain M		
A record of management change etc.		Claire Harding	DEWNR		Drains, forestry, inlet, outlets		
Written reports	1972 - present	Various	N/A		Jones 1978 wetlands of the Lower South East Jolly et al. 1985 described wetlands/wetland complexes within the Lower South East area Lloyd and Balla (1986) summarised the wetland resources of South Australia to highlight environmentally important area. Howe et al. (2005) quantified conservation value of 786 mapped wetlands of the SE.		

Appendix 3. Case study site selection summary of selection criteria attributes.

				Existing Monitoring					Land Management		Groundwater level trend (m/year)					Hydro parameters		
GDE Monitoring sites	**GDE Classification (TLA)**	**ANAE Type**	**Size**	**Surface water**	**Groundwater**	**Veg monitoring**	**Veg mapping**	**other existing monitoring**	**Drainage**	**Other landuse**	**1970-1980**	**1980 - 1990**	**1990-2000**	**2000-2012**	**1970-2012**	**Salinity Range (EC)**	**Depth (approx max)**	**Permanency**
Bool / Hacks Lagoon	Very High Likelihood - Permanent Dep)	Grass Sedge Wetland	~2500 ha	4 gaugeboards (SEWCDB)	13 obswells (most with loggers)	Yes (various)	Yes	Birds / Frogs / Fish	Historic Drainage pre 1970.	Increased irrigation adjacent and in Mosq Creek Catchment	0.03	-0.01	-0.08	-0.02	-0.01			
Trail Waterhole	Moderate Likelihood - Unlikely (potentially perched / historically connected to TLA)	Grass Sedge Wetland	~50 ha	1 gaugeboard (DEWNR)	2 obswells (both with loggers)	Yes	Yes		no	Irrigation (apple orchard) established in 2000's	no data	0.16	-0.28	-0.1	-0.16	Fresh: 267 - ~1000	1m	Seasonal
Topperwein	Moderate Likelihood - Unlikely (potentially perched / historically connected to TLA)	Grass Sedge Wetland	73 ha	1 gaugeboard (DEWNR)	1 obswell (with logger)	Yes	Yes		no	Some recent increased irrigation (vineyards - Nangwarry Station)	-0.03	0.02	-0.15	-0.14	-0.11	Fresh: ~1137	0.9m	Seasonal
Lake Frome	Very High Likelihood - Permanent Dependency	Inland Interdunal Wetland	~900 ha	3 gaugeboards (DEWNR)	6 obswells (with loggers)	Yes	Yes		Historic Drainage pre 1960	Increased irrigation adjacent and up-gradient.	0.02	0	-0.06	-0.02	-0.01	Fresh-Brackish: 1630-3460 (mean 2746)	1.5m	Seasonal
The Marshes	Low Likelihood - Unlikely (perched aquifer)	Grass Sedge Wetlands	~170+ ha	2 gaugeboards (DEWNR)	4 obswells (with loggers)	Yes	No		Not directly, but private drains and Mt Burr Heath Drain are close by.	Irrigation to the south	-0.04	0.03	-0.27	-0.13	-0.09	Fresh: 135 - 269	0.6m	Seasonal
Honans	Low Likelihood - Unlikely (perched)	Grass Sedge Wetlands	~100+ ha	2 gaugeboards	2 obswells (with loggers) + wells installed by Flinders Uni	YEs	Yes		no	no	no data	0.05	0.11	-0.14	0.08	Fresh: 160-1389 (mean 992)	0.6m	Seasonal
Lake Robe	Very High Likelihood - Permanent Dep	Saline Lake	365 ha	1 gaugeboard (DEWNR)	2 obswells (with loggers)	Yes	Yes		no	limited irrigation	0.04	0.01	-0.02	-0.02	-0.01	Brackish - Saline: 3720 - 127500 (mean 13500)	1-2m	Permanent
Freshwater Lake	Very High Likelihood - Permanent Dep	Coastal Dune Lake	~7 ha	1 gaugeboard (DEWNR)	1 obswell (with logger)	Yes	No		no	no	0.04	0.01	-0.02	-0.02	-0.01	Saline: 15330	1.2m	Permanent
Big Dip Lake	Very High Likelihood - Permanent Dep	Coastal Dune Lake	~46 ha	1 gaugeboard (DEWNR)	2 obswells (with loggers)	Yes	Yes		no	no	0.04	0.01	-0.02	-0.02	-0.01	Saline: 141500	0.8m	Permanent
Middlepoint Swamp	Very High Likelihood - Permanent Dep	Coastal Peat Swamp	~172 ha	1 gaugeboard (DEWNR)	2 obswells (with loggers)	Yes	Yes		Historic outlet pre 1950. Recent: weir (mid-2000's)		0.01	-0.08	-0.01	-0.09	-0.02	Brackish: (mean 3421)	0.6m	Seasonal
Ewens Ponds	Very High Likelihood - Permanent Dep	Karst	~10 ha	1 gaugeboard (DEWNR)	2 obswells (with loggers)	No	No	Historic aquatic veg photo monitoring	Historic: Eight Mile Creek: pre 1900's. Further drain construction in the 1950's.	Significant up-gradient irrigation development	0	0.09	-0.07	-0.03	0.01	Fresh: 640-936	11-12m	Permanent

Deadmans Swamp	High Likelihood - Permanent Dep	Grass Sedge Wetland	~ 114 ha	1 gaugeboard (DEWNR)	1 obswell (with logger)	Yes	No		no	Irrigation to the west and east. Forestry surrounding.	0.03	0	-0.22	-0.06	-0.04	Fresh: 1475-1612	0.9m	Seasonal - now intermittent
Cress Creek	High Likelihood - Permanent Dep	Peat Swamp ~11ha	~ 11 ha	1 gaugeboard in spring/creek (DEWNR)	1 obswell (with logger)	No	No	Access issues	Historic drainage pre 1950	Irrigation up-gradient	-0.08	-0.01	-0.15	-0.05	-0.03	Fresh: 738 - 880	0.5m	Permanent
Butchers Lake	Very High Likelihood - Permanent Dep	Saline Swamp ~60ha	~ 60 ha	1 gaugeboard (DEWNR)	1 obswell (with logger)	Yes	Yes		Historic drainage pre 1912	Some irrigation up-gradient	0.07	-0.01	-0.05	-0.09	-0.01	Saline: 16660 - 38400	1m	Seasonal
Lake Hawdon South	Very High Likelihood - Permanent Dep	Inland interdunal wetland	~3290 ha	3 gaugeboards (DEWNR)	7 obswells (with loggers)	Yes	Yes	Bray drain flow data	Historic drainage pre 1960. Recent 2011? Small weir in outlet	limited irrigation to east	0.05	0.01	0.01	0	0	Fresh - Brackish: 2752-4550	0.8m	Seasonal
Pick Swamp / Pic Ponds complex	Very High Likelihood - Permanent Dep	Soaks and Springs (?) Peat Swamp / Karst	322 ha	2 gaugeboards in pick swamp; 1 gaugeboard pic ponds. Loggers at depths to ~90m within Pic Ponds.	At least 7 or 8. 3 through dunes (DEH); Feasts property on western boundary (2?); IWR wells to the north (2); 1 obswell (DEWNR) near pic ponds; CAR011	Yes	Yes	Hydro model / Current PhD – modelling Climate station / Some gauging of outflow / flow between pick swamp and pic ponds	Historic: outlets and private drains (early 1900's or before), most 1970's - 1990's including unauthorised drains near Crescent Pond. Mid-late 2000's - recent: weir in Pick Swamp and Pick Ponds outlets and drain rehabilitation/removal.	Irrigation up-gradient	-0.07	-0.01	-0.07	-0.02	-0.03	Fresh: 750 - 2100	>1m	Permanent / Seasonal
Rocky Swamp / West Avenue Complex	High Likelihood - Permanent Dep	Inland Interdunal Wetland and Floodplain	~2000+ ha	Telemetered surfacewater monitoring in Rocky Swamp	1 obswell (Rocky Swamp) and 3 in floodplain	Yes	Yes	Fish / Frogs / Birds	Historic: private drains Robertson Rd Drain etc. (1980s). Recent: West Avenue Drain + Floodway 2010	no	0.05	0.05	-0.07	-0.02	0	Fresh - Brackish: 778 - 14058	0.8m	Seasonal
Bimbimbi Swamp / Willalooka wetlands	Very High Likelihood - Permanent Dep	Permanent Freshwater Lake / Inland Interdunal Wetlands	~100+ ha	? SEWCDB / USE Program	Transect	Yes (USE Program)	No		Historic: private drains between wetland on marcollat watercourse (~1950's -1980's); Recent: Didicoolum drain 2007	no		0.04	-0.06	-0.09	-0.01	Fresh - Brackish: 1820 - 10650	0.5 - 2m	Seasonal / Permanent
Kangaroo Flat	Moderate Likelihood - Unlikely (potentially perched)	Grass Sedge Wetland	~8 ha	1 gaugeboard (DEWNR)	2 obswells (with loggers) DEWNR	Transect (EA) WetCAT trial		Maybe perched.	no	no	no data	0.05	0.11	-0.14	0.08	Fresh: 183-1378	0.6m	Seasonal
Mosquito Creek (permanent pools Naracoorte Caves and Badmans)	Very High Likelihood - Permanent Dep	Watercourse / Permanent Pools	<1 ha	1 gaugeboard	4 obswells (with loggers)	No	No	Fish monitoring	no	Nearby irrigation (potatoes / dairy)						Fresh - Brackish: ~ <3000	1.5m	Permanent (pools); Seasonal (creek)
Lake George	Very High Likelihood - Permanent Dep	Saline Lake	~6400 ha	gaugeboard / telemetered level readings	no specific equip - reliant on regional monitoring network	Yes	No	Fish monitoring								Saline: mean 26800	>1m	Permanent

Appendix 4. GPS coordinates (WGS 84) for vegetation surveying sites in the case study wetlands.

Wetland	Site identifier	Latitude	Longitude
Deadmans Swamp	Ddm_001	-37.16547297	140.8472679
Deadmans Swamp	Ddm_002	-37.16508568	140.8475165
Deadmans Swamp	Ddm_003	-37.16477043	140.8477086
Deadmans Swamp	Ddm_004	-37.16445535	140.8480359
Deadmans Swamp	Ddm_005	-37.16422143	140.8483855
Deadmans Swamp	Ddm_006	-37.16424871	140.8485656
Deadmans Swamp	Ddm_007	-37.16436618	140.8487907
Deadmans Swamp	Ddm_008	-37.16437554	140.849061
Deadmans Swamp	Ddm_009	-37.16481757	140.8493304
Deadmans Swamp	Ddm_010	-37.16137473	140.8497765
Deadmans Swamp	Ddm_011	-37.16159145	140.8500802
Deadmans Swamp	Ddm_012	-37.16178096	140.8502487
Deadmans Swamp	Ddm_013	-37.16200667	140.8505299
Deadmans Swamp	Ddm_014	-37.16231346	140.850777
Deadmans Swamp	Ddm_015	-37.16255663	140.8506076
Deadmans Swamp	Ddm_016	-37.16253801	140.8501346
Deadmans Swamp	Ddm_017	-37.16246564	140.849932
Deadmans Swamp	Ddm_018	-37.16214034	140.8493132
Deadmans Swamp	Ddm_019	-37.16230288	140.8495381
Deadmans Swamp	Ddm_020	-37.15226406	140.8519004
Deadmans Swamp	Ddm_021	-37.15246243	140.8519451
Deadmans Swamp	Ddm_022	-37.15266084	140.8520235
Deadmans Swamp	Ddm_023	-37.15294919	140.8519441
Deadmans Swamp	Ddm_024	-37.15326472	140.851966
Deadmans Swamp	Ddm_025	-37.15321022	140.8516396
Deadmans Swamp	Ddm_026	-37.15304728	140.8510881
Deadmans Swamp	Ddm_027	-37.15306488	140.8507502
Deadmans Swamp	Ddm_028	-37.15310018	140.8501532
Deadmans Swamp	Ddm_029	-37.15321696	140.8498264
Deadmans Swamp	Ddm_030	-37.15871564	140.8571474
Deadmans Swamp	Ddm_031	-37.15881473	140.8570909
Deadmans Swamp	Ddm_032	-37.15885975	140.8570458
Deadmans Swamp	Ddm_033	-37.15889624	140.8574061
Deadmans Swamp	Ddm_034	-37.16355934	140.8523064
Deadmans Swamp	Ddm_035	-37.16325257	140.8520817
Deadmans Swamp	Ddm_036	-37.16295487	140.8518908
Deadmans Swamp	Ddm_037	-37.16272923	140.851666
Deadmans Swamp	Ddm_038	-37.16248561	140.851475
Deadmans Swamp	Ddm_039	-37.16257531	140.8511257
Deadmans Swamp	Ddm_040	-37.16285433	140.8507872
Deadmans Swamp	Ddm_041	-37.16302547	140.8506855
Deadmans Swamp	Ddm_042	-37.16318768	140.8506514
Deadmans Swamp	Ddm_043	-37.16345788	140.8504707
Deadmans Swamp	Ddm_044	-37.16411667	140.8466833
Deadmans Swamp	Ddm_045	-37.16395	140.847
Deadmans Swamp	Ddm_046	-37.16383333	140.8474833
Deadmans Swamp	Ddm_047	-37.16375	140.8478
Deadmans Swamp	Ddm_048	-37.16358333	140.8481167
Deadmans Swamp	Ddm_049	-37.16343333	140.8481833
Deadmans Swamp	Ddm_050	-37.16325	140.8481
Deadmans Swamp	Ddm_051	-37.16318768	140.8506514
Deadmans Swamp	Ddm_052	-37.16286667	140.8477
Deadmans Swamp	Ddm_053	-37.16268333	140.84755
Deadmans Swamp	Ddm_054	-37.16115	140.8499
Deadmans Swamp	Ddm_055	-37.16111667	140.8501167
Deadmans Swamp	Ddm_056	-37.16083333	140.8507333
Deadmans Swamp	Ddm_057	-37.1605	140.8514333
Deadmans Swamp	Ddm_058	-37.16028333	140.852
Deadmans Swamp	Ddm_059	-37.16015	140.8524333
Deadmans Swamp	Ddm_060	-37.15976667	140.8523
Deadmans Swamp	Ddm_061	-37.15956667	140.8518
Deadmans Swamp	Ddm_062	-37.15926667	140.8511833

Wetland	Site identifier	Latitude	Longitude
Deadmans Swamp	Ddm_063	-37.15881667	140.8504333
Deadmans Swamp	Ddm_064	-37.15218333	140.8522
Deadmans Swamp	Ddm_065	-37.15248333	140.8526833
Deadmans Swamp	Ddm_066	-37.15241667	140.8533167
Deadmans Swamp	Ddm_067	-37.15263333	140.8537333
Deadmans Swamp	Ddm_068	-37.15266667	140.85405
Deadmans Swamp	Ddm_069	-37.1525	140.8543167
Deadmans Swamp	Ddm_070	-37.15223333	140.8544333
Deadmans Swamp	Ddm_071	-37.15206667	140.8544
Deadmans Swamp	Ddm_072	-37.15176667	140.8545333
Deadmans Swamp	Ddm_073	-37.15143333	140.8545
Deadmans Swamp	Ddm_074	-37.1586	140.8568833
Deadmans Swamp	Ddm_075	-37.15863333	140.85675
Deadmans Swamp	Ddm_076	-37.15876667	140.8563333
Deadmans Swamp	Ddm_077	-37.15856667	140.8563667
Deadmans Swamp	Ddm_078	-37.16358333	140.8524167
Deadmans Swamp	Ddm_079	-37.16321667	140.8526833
Deadmans Swamp	Ddm_080	-37.16286667	140.8527667
Deadmans Swamp	Ddm_081	-37.16236667	140.85285
Deadmans Swamp	Ddm_082	-37.16201667	140.85275
Deadmans Swamp	Ddm_083	-37.16168333	140.8527667
Deadmans Swamp	Ddm_084	-37.16166667	140.8526667
Deadmans Swamp	Ddm_085	-37.16188333	140.8521667
Deadmans Swamp	Ddm_086	-37.16166667	140.8519333
Deadmans Swamp	Ddm_087	-37.1616	140.85155
The Marshes	Mar_001	-37.620312	140.53533
The Marshes	Mar_002	-37.619674	140.536563
The Marshes	Mar_003	-37.61962	140.537039
The Marshes	Mar_004	-37.619544	140.537236
The Marshes	Mar_005	-37.619472	140.53755
The Marshes	Mar_006	-37.619421	140.537804
The Marshes	Mar_007	-37.619422	140.538166
The Marshes	Mar_008	-37.619392	140.538263
The Marshes	Mar_009	-37.619312	140.538485
The Marshes	Mar_010	-37.61918	140.5387
The Marshes	Mar_011	-37.619078	140.53885
The Marshes	Mar_012	-37.61901	140.538859
The Marshes	Mar_013	-37.618975	140.538996
The Marshes	Mar_014	-37.618908	140.53907
The Marshes	Mar_015	-37.61875	140.539402
The Marshes	Mar_016	-37.618725	140.539602
The Marshes	Mar_017	-37.619429	140.537381
The Marshes	Mar_018	-37.619624	140.536987
The Marshes	Mar_019	-37.625408	140.551887
The Marshes	Mar_020	-37.625546	140.551593
The Marshes	Mar_021	-37.625709	140.5516
The Marshes	Mar_022	-37.626071	140.551382
The Marshes	Mar_023	-37.626094	140.55088
The Marshes	Mar_024	-37.626116	140.550632
The Marshes	Mar_025	-37.625957	140.550464
The Marshes	Mar_026	-37.626003	140.550278
The Marshes	Mar_027	-37.625956	140.550024
The Marshes	Mar_028	-37.626005	140.550029
The Marshes	Mar_029	-37.625886	140.549891
The Marshes	Mar_030	-37.625914	140.54976
The Marshes	Mar_031	-37.627213	140.543702
The Marshes	Mar_032	-37.627078	140.54373
The Marshes	Mar_033	-37.626977	140.543769
The Marshes	Mar_034	-37.626867	140.543969
The Marshes	Mar_035	-37.626745	140.544326
The Marshes	Mar_036	-37.626735	140.544265
The Marshes	Mar_037	-37.626621	140.544441
The Marshes	Mar_038	-37.626536	140.544475
The Marshes	Mar_039	-37.626466	140.544708

Wetland	Site identifier	Latitude	Longitude
The Marshes	Mar_040	-37.63098333	140.5391
The Marshes	Mar_041	-37.63101667	140.5391333
The Marshes	Mar_042	-37.63126667	140.5398833
The Marshes	Mar_043	-37.62131667	140.5335667
The Marshes	Mar_044	-37.62108333	140.5339333
The Marshes	Mar_045	-37.62076667	140.53415
The Marshes	Mar_046	-37.62075	140.5342833
The Marshes	Mar_047	-37.62053333	140.5349167
The Marshes	Mar_048	-37.61983333	140.53625
The Marshes	Mar_049	-37.61968333	140.53735
The Marshes	Mar_050	-37.61973333	140.5377333
The Marshes	Mar_051	-37.61981667	140.5385
The Marshes	Mar_052	-37.6198	140.5388833
The Marshes	Mar_053	-37.6199	140.5394333
The Marshes	Mar_054	-37.61981667	140.5396667
The Marshes	Mar_055	-37.61981667	140.5403333
The Marshes	Mar_056	-37.61998333	140.5407333
The Marshes	Mar_057	-37.62011667	140.54115
The Marshes	Mar_058	-37.62028333	140.5415833
The Marshes	Mar_059	-37.62031667	140.5419667
The Marshes	Mar_060	-37.62026667	140.5424333
The Marshes	Mar_061	-37.62011667	140.54285
The Marshes	Mar_062	-37.61995	140.5431833
The Marshes	Mar_063	-37.61981667	140.5428667
The Marshes	Mar_064	-37.6197	140.5421
The Marshes	Mar_065	-37.61975	140.5412333
The Marshes	Mar_066	-37.62545	140.5517833
The Marshes	Mar_067	-37.62536667	140.5514
The Marshes	Mar_068	-37.62508333	140.5516333
The Marshes	Mar_069	-37.62468333	140.5517
The Marshes	Mar_070	-37.62458333	140.5512833
The Marshes	Mar_071	-37.62458333	140.5508
The Marshes	Mar_072	-37.62465	140.5500667
The Marshes	Mar_073	-37.62495	140.5498167
The Marshes	Mar_074	-37.62488333	140.5494833
The Marshes	Mar_075	-37.6251	140.5492667
The Marshes	Mar_076	-37.62516667	140.5488333
The Marshes	Mar_077	-37.62526667	140.5487667
The Marshes	Mar_078	-37.62553333	140.54915
The Marshes	Mar_079	-37.62571667	140.54955
The Marshes	Mar_080	-37.6273	140.5438333
The Marshes	Mar_081	-37.62746667	140.54405
The Marshes	Mar_082	-37.6276	140.5443
The Marshes	Mar_083	-37.62748333	140.5444833
The Marshes	Mar_084	-37.62778333	140.5444667
The Marshes	Mar_085	-37.62796667	140.5448167
The Marshes	Mar_086	-37.62781667	140.5449333
The Marshes	Mar_087	-37.62808333	140.5450333
The Marshes	Mar_088	-37.62823333	140.5456
The Marshes	Mar_089	-37.62826667	140.5459833
The Marshes	Mar_090	-37.6283	140.5464333
The Marshes	Mar_091	-37.62803333	140.5464
Topperwein	Top_001	-37.5445	140.97225
Topperwein	Top_002	-37.5445	140.9722
Topperwein	Top_003	-37.54436667	140.9719167
Topperwein	Top_004	-37.54415	140.9721167
Topperwein	Top_005	-37.5441	140.9721667
Topperwein	Top_006	-37.54378333	140.97205
Topperwein	Top_007	-37.54348333	140.9716667
Topperwein	Top_008	-37.54331667	140.9716833
Topperwein	Top_009	-37.54291667	140.9718333
Topperwein	Top_010	-37.5426	140.97175
Topperwein	Top_011	-37.54215	140.9719
Topperwein	Top_012	-37.54165	140.9720333

Wetland	Site identifier	Latitude	Longitude
Topperwein	Top_013	-37.54113333	140.9720833
Topperwein	Top_014	-37.54096667	140.972
Topperwein	Top_015	-37.54076667	140.9720333
Topperwein	Top_016	-37.54055	140.9721333
Topperwein	Top_017	-37.54036667	140.9724
Topperwein	Top_018	-37.54083333	140.9727333
Topperwein	Top_019	-37.53891667	140.9666
Topperwein	Top_020	-37.5381	140.9674667
Topperwein	Top_021	-37.53786667	140.9676
Topperwein	Top_022	-37.53758333	140.96795
Topperwein	Top_023	-37.53733333	140.9682833
Topperwein	Top_024	-37.53705	140.9685667
Topperwein	Top_025	-37.5368	140.96905
Topperwein	Top_026	-37.53656667	140.9690167
Topperwein	Top_027	-37.53616667	140.96915
Topperwein	Top_028	-37.53591667	140.9691
Topperwein	Top_029	-37.53568333	140.9692833
Topperwein	Top_030	-37.53576667	140.9695
Topperwein	Top_031	-37.53646667	140.96985
Topperwein	Top_032	-37.53696667	140.9701667
Topperwein	Top_033	-37.5374	140.9698167
Topperwein	Top_034	-37.53753333	140.9695667
Topperwein	Top_035	-37.53811667	140.9692667
Topperwein	Top_036	-37.53893333	140.96935
Topperwein	Top_037	-37.53928333	140.9692833
Topperwein	Top_038	-37.544697	140.972556
Topperwein	Top_039	-37.544593	140.972476
Topperwein	Top_040	-37.544519	140.972443
Topperwein	Top_041	-37.544452	140.972434
Topperwein	Top_042	-37.544312	140.972371
Topperwein	Top_043	-37.544162	140.972325
Topperwein	Top_044	-37.544022	140.972325
Topperwein	Top_045	-37.543818	140.972357
Topperwein	Top_046	-37.543569	140.972368
Topperwein	Top_047	-37.543475	140.972339
Topperwein	Top_048	-37.543103	140.97225
Topperwein	Top_049	-37.542913	140.972322
Topperwein	Top_050	-37.542597	140.972528
Topperwein	Top_051	-37.542428	140.972738
Topperwein	Top_052	-37.542406	140.972784
Topperwein	Top_053	-37.542324	140.972919
Topperwein	Top_054	-37.542243	140.97309
Topperwein	Top_055	-37.54215	140.973237
Topperwein	Top_056	-37.542022	140.9734
Topperwein	Top_057	-37.539207	140.966188
Topperwein	Top_058	-37.538878	140.966399
Topperwein	Top_059	-37.538659	140.966388
Topperwein	Top_060	-37.53841	140.96618
Topperwein	Top_061	-37.538394	140.966723
Topperwein	Top_062	-37.538089	140.966602
Topperwein	Top_063	-37.537737	140.966861
Topperwein	Top_064	-37.537595	140.967054
Topperwein	Top_065	-37.537404	140.96697
Topperwein	Top_066	-37.537208	140.96684
Topperwein	Top_067	-37.537151	140.966191
Topperwein	Top_068	-37.537198	140.965918
Topperwein	Top_069	-37.537447	140.965199
Topperwein	Top_070	-37.5377	140.964535
Topperwein	Top_071	-37.538334	140.964039
Topperwein	Top_072	-37.538694	140.963781
Topperwein	Top_073	-37.538963	140.963536
Topperwein	Top_074	-37.539187	140.963309
Topperwein	Top_075	-37.540126	140.962405
Trail Waterhole	Tra_001	-37.55955	140.9474

Wetland	Site identifier	Latitude	Longitude
Trail Waterhole	Tra_002	-37.55958333	140.9472
Trail Waterhole	Tra_003	-37.55968333	140.9470667
Trail Waterhole	Tra_004	-37.55976667	140.94675
Trail Waterhole	Tra_005	-37.55981667	140.9465
Trail Waterhole	Tra_006	-37.55985	140.9465333
Trail Waterhole	Tra_007	-37.55988333	140.9464
Trail Waterhole	Tra_008	-37.55991667	140.9456667
Trail Waterhole	Tra_009	-37.56013333	140.9454333
Trail Waterhole	Tra_010	-37.55988333	140.9449
Trail Waterhole	Tra_011	-37.56038333	140.9442667
Trail Waterhole	Tra_012	-37.55996667	140.9439167
Trail Waterhole	Tra_013	-37.55986667	140.9432167
Trail Waterhole	Tra_014	-37.55976667	140.9429167
Trail Waterhole	Tra_015	-37.56025	140.9423833
Trail Waterhole	Tra_016	-37.56046667	140.9418833
Trail Waterhole	Tra_017	-37.56016667	140.9411333
Trail Waterhole	Tra_018	-37.55988333	140.9407667
Trail Waterhole	Tra_019	-37.55998333	140.9401833
Trail Waterhole	Tra_020	-37.55975	140.9395333
Trail Waterhole	Tra_021	-37.55961667	140.9394167
Trail Waterhole	Tra_022	-37.55916667	140.93955
Trail Waterhole	Tra_023	-37.5592	140.94005
Trail Waterhole	Tra_024	-37.55895	140.9411167
Trail Waterhole	Tra_025	-37.55876667	140.9411
Trail Waterhole	Tra_026	-37.55586667	140.93365
Trail Waterhole	Tra_027	-37.55615	140.9340167
Trail Waterhole	Tra_028	-37.5561	140.9342167
Trail Waterhole	Tra_029	-37.55603333	140.9344667
Trail Waterhole	Tra_030	-37.55566667	140.9352333
Trail Waterhole	Tra_031	-37.5559	140.9354333
Trail Waterhole	Tra_032	-37.55638333	140.9356667
Trail Waterhole	Tra_033	-37.55676667	140.9358167
Trail Waterhole	Tra_034	-37.55706667	140.93585
Trail Waterhole	Tra_035	-37.55736667	140.9363167
Trail Waterhole	Tra_036	-37.55773333	140.9364667
Trail Waterhole	Tra_037	-37.55778333	140.9374167
Trail Waterhole	Tra_038	-37.5578	140.93785
Trail Waterhole	Tra_039	-37.55761667	140.9384
Trail Waterhole	Tra_040	-37.55761667	140.9388
Trail Waterhole	Tra_041	-37.55696667	140.93955
Pick Swamp	Pic_001	-38.04411667	140.8939833
Pick Swamp	Pic_002	-38.0441	140.89405
Pick Swamp	Pic_003	-38.04463333	140.894
Pick Swamp	Pic_004	-38.04516667	140.8939833
Pick Swamp	Pic_005	-38.04525	140.89395
Pick Swamp	Pic_006	-38.04605	140.8943667
Pick Swamp	Pic_007	-38.04613333	140.8948
Pick Swamp	Pic_008	-38.046	140.8948667
Pick Swamp	Pic_009	-38.04625	140.8958333
Pick Swamp	Pic_010	-38.04606667	140.8957833
Pick Swamp	Pic_011	-38.04605	140.8960167
Pick Swamp	Pic_012	-38.04606667	140.8962
Pick Swamp	Pic_013	-38.04613333	140.8974333
Pick Swamp	Pic_014	-38.0461	140.8977333
Pick Swamp	Pic_015	-38.04615	140.8980167
Pick Swamp	Pic_016	-38.04618333	140.8982333
Pick Swamp	Pic_017	-38.04583333	140.9021333
Pick Swamp	Pic_018	-38.04508333	140.9022167
Pick Swamp	Pic_019	-38.0445	140.9023167
Pick Swamp	Pic_020	-38.04393333	140.9024333
Pick Swamp	Pic_021	-38.04485	140.9023333
Pick Swamp	Pic_022	-38.04411667	140.9024667
Pick Swamp	Pic_023	-38.04753333	140.9069333
Pick Swamp	Pic_024	-38.04795	140.9087

Wetland	Site identifier	Latitude	Longitude
Pick Swamp	Pic_025	-38.04745	140.9066333
Pick Swamp	Pic_026	-38.04793333	140.9089833
Pick Swamp	Pic_027	-38.0479	140.9097667
Pick Swamp	Pic_028	-38.04741667	140.913
Pick Swamp	Pic_029	-38.04621667	140.9021
Pick Swamp	Pic_030	-38.04553333	140.9022167
Pick Swamp	Pic_031	-38.04796667	140.9094333
Pick Swamp	Pic_032	-38.04743333	140.91325
Pick Swamp	Pic_033	-38.04715	140.9125167
Pick Swamp	Pic_034	-38.04413333	140.9108167
Pick Swamp	Pic_035	-38.04425	140.9104833
Pick Swamp	Pic_036	-38.04218333	140.90995
Pick Swamp	Pic_037	-38.04728333	140.91275
Pick Swamp	Pic_038	-38.04401667	140.9110333
Pick Swamp	Pic_039	-38.04418333	140.9105333
Pick Swamp	Pic_040	-38.0423	140.9104
Pick Swamp	Pic_041	-38.04255	140.9091167
Pick Swamp	Pic_042	-38.04263333	140.9090833
Middlepoint Swamp	Mid_001	-38.029367	140.627619
Middlepoint Swamp	Mid_002	-38.029543	140.627379
Middlepoint Swamp	Mid_003	-38.029579	140.627224
Middlepoint Swamp	Mid_004	-38.029927	140.626835
Middlepoint Swamp	Mid_005	-38.030104	140.626637
Middlepoint Swamp	Mid_006	-38.030577	140.625997
Middlepoint Swamp	Mid_007	-38.030782	140.625513
Middlepoint Swamp	Mid_008	-38.031609	140.624431
Middlepoint Swamp	Mid_009	-38.031679	140.624305
Middlepoint Swamp	Mid_010	-38.031833	140.624108
Middlepoint Swamp	Mid_011	-38.032078	140.623864
Middlepoint Swamp	Mid_012	-38.031329	140.623086
Middlepoint Swamp	Mid_013	-38.031174	140.623244
Middlepoint Swamp	Mid_014	-38.030875	140.623385
Middlepoint Swamp	Mid_015	-38.030639	140.623647
Middlepoint Swamp	Mid_016	-38.030452	140.623683
Middlepoint Swamp	Mid_017	-38.030283	140.623818
Middlepoint Swamp	Mid_018	-38.030101	140.623845
Middlepoint Swamp	Mid_019	-38.030042	140.623856
Middlepoint Swamp	Mid_020	-38.029516	140.624148
Middlepoint Swamp	Mid_021	-38.028796	140.624711
Middlepoint Swamp	Mid_022	-38.028277	140.625799
Middlepoint Swamp	Mid_023	-38.028606	140.627188
Middlepoint Swamp	Mid_024	-38.02343333	140.6113333
Middlepoint Swamp	Mid_025	-38.02348333	140.6114167
Middlepoint Swamp	Mid_026	-38.024	140.6114167
Middlepoint Swamp	Mid_027	-38.02443333	140.61205
Middlepoint Swamp	Mid_028	-38.0237	140.6113667
Middlepoint Swamp	Mid_029	-38.0243	140.61135
Middlepoint Swamp	Mid_030	-38.02418333	140.6118833
Middlepoint Swamp	Mid_031	-38.02375	140.6118667
Middlepoint Swamp	Mid_032	-38.02395	140.612
Middlepoint Swamp	Mid_033	-38.0235	140.6118833
Middlepoint Swamp	Mid_034	-38.02363333	140.6129
Middlepoint Swamp	Mid_035	-38.02441667	140.6125333
Middlepoint Swamp	Mid_036	-38.02383333	140.6128167
Middlepoint Swamp	Mid_037	-38.02411667	140.6127667
Middlepoint Swamp	Mid_038	-38.02476667	140.61335
Middlepoint Swamp	Mid_039	-38.02423333	140.61385
Middlepoint Swamp	Mid_040	-38.02451667	140.6135333
Middlepoint Swamp	Mid_041	-38.02393333	140.6139167
Middlepoint Swamp	Mid_042	-38.02988333	140.6280833
Middlepoint Swamp	Mid_043	-38.03013333	140.62795
Middlepoint Swamp	Mid_044	-38.03041667	140.6275333
Middlepoint Swamp	Mid_045	-38.03075	140.6272
Middlepoint Swamp	Mid_046	-38.0311	140.6268833

Wetland	Site identifier	Latitude	Longitude
Middlepoint Swamp	Mid_047	-38.03155	140.6265333
Middlepoint Swamp	Mid_048	-38.03183333	140.6262833
Middlepoint Swamp	Mid_049	-38.03201667	140.6260833
Middlepoint Swamp	Mid_050	-38.03233333	140.6258167
Middlepoint Swamp	Mid_051	-38.03248333	140.6256333
Middlepoint Swamp	Mid_052	-38.0328	140.62545
Middlepoint Swamp	Mid_053	-38.03328333	140.6255833
Middlepoint Swamp	Mid_054	-38.03385	140.6262
Middlepoint Swamp	Mid_055	-38.03361667	140.6266
Middlepoint Swamp	Mid_056	-38.03331667	140.6269667
Middlepoint Swamp	Mid_057	-38.03308333	140.6271667
Middlepoint Swamp	Mid_058	-38.03278333	140.6274833
Middlepoint Swamp	Mid_059	-38.03255	140.6277333
Middlepoint Swamp	Mid_060	-38.03235	140.6279
Middlepoint Swamp	Mid_061	-38.03201667	140.6282
Middlepoint Swamp	Mid_062	-38.03173333	140.6284667
Middlepoint Swamp	Mid_063	-38.03151667	140.6286833
Middlepoint Swamp	Mid_064	-38.03125	140.6289667
Middlepoint Swamp	Mid_065	-38.03061667	140.6291333
Middlepoint Swamp	Mid_066	-38.0304	140.62905
Middlepoint Swamp	Mid_067	-38.03028333	140.6288333
Taratap	Tar_001	-36.5764	139.89615
Taratap	Tar_002	-36.57663333	139.8958167
Taratap	Tar_003	-36.57691667	139.8953833
Taratap	Tar_004	-36.57721667	139.8948667
Taratap	Tar_005	-36.57761667	139.8942167
Taratap	Tar_006	-36.57798333	139.8937333
Taratap	Tar_007	-36.57825	139.8933333
Taratap	Tar_008	-36.57858333	139.8929167
Taratap	Tar_009	-36.57878333	139.89265
Taratap	Tar_010	-36.5791	139.8922
Taratap	Tar_011	-36.57946667	139.8915833
Taratap	Tar_012	-36.58743333	139.9014
Taratap	Tar_013	-36.58735	139.90085
Taratap	Tar_014	-36.58733333	139.9001167
Taratap	Tar_015	-36.5873	139.8995667
Taratap	Tar_016	-36.58733333	139.8990333
Taratap	Tar_017	-36.58733333	139.8985333
Taratap	Tar_018	-36.58743333	139.8981167
Taratap	Tar_019	-36.58761667	139.8974667
Taratap	Tar_020	-36.58788333	139.8969333
Taratap	Tar_021	-36.58798333	139.8964667
Taratap	Tar_022	-36.58801667	139.8959167
Taratap	Tar_023	-36.58805	139.8950833
Taratap	Tar_024	-36.574526	139.894998
Taratap	Tar_025	-36.574737	139.894573
Taratap	Tar_026	-36.575038	139.894048
Taratap	Tar_027	-36.575452	139.893412
Taratap	Tar_028	-36.575643	139.893163
Taratap	Tar_029	-36.576091	139.892686
Taratap	Tar_030	-36.57668	139.891495
Taratap	Tar_031	-36.577022	139.89078
Taratap	Tar_032	-36.577134	139.890539
Taratap	Tar_033	-36.58786	139.902275
Taratap	Tar_034	-36.588022	139.901499
Taratap	Tar_035	-36.588274	139.900215
Taratap	Tar_036	-36.588331	139.899817
Taratap	Tar_037	-36.588546	139.899128
Taratap	Tar_038	-36.588688	139.898425
Taratap	Tar_039	-36.588927	139.897429
Taratap	Tar_040	-36.588926	139.897357
Taratap	Tar_041	-36.588828	139.896766
Taratap	Tar_042	-36.588903	139.896364
Taratap	Tar_043	-36.588797	139.896983

Wetland	Site identifier	Latitude	Longitude
Big Dip	Big_001	-37.270868	139.83792
Big Dip	Big_002	-37.271026	139.837937
Big Dip	Big_003	-37.271206	139.838068
Big Dip	Big_004	-37.27095	139.838266
Big Dip	Big_005	-37.271612	139.838747
Big Dip	Big_006	-37.27103333	139.8370833
Big Dip	Big_007	-37.2712	139.8370667
Big Dip	Big_008	-37.27138333	139.8372
Big Dip	Big_009	-37.27093333	139.8375333
Big Dip	Big_010	-37.27118333	139.8386
Big Dip	Big_011	-37.27208333	139.8388167
Robe Lake	Rob_001	-37.223993	139.80088
Robe Lake	Rob_002	-37.224004	139.800896
Robe Lake	Rob_003	-37.223933	139.800933
Robe Lake	Rob_004	-37.223951	139.801012
Robe Lake	Rob_005	-37.223877	139.801114
Robe Lake	Rob_006	-37.223996	139.801657
Robe Lake	Rob_007	-37.223926	139.802041
Robe Lake	Rob_008	-37.223984	139.802487
Robe Lake	Rob_009	-37.22403	139.802792
Robe Lake	Rob_010	-37.224073	139.802883
Robe Lake	Rob_011	-37.224043	139.803724
Robe Lake	Rob_012	-37.224043	139.803724
Robe Lake	Rob_013	-37.223993	139.803994
Robe Lake	Rob_014	-37.223994	139.804141
Robe Lake	Rob_015	-37.223904	139.803318
Robe Lake	Rob_016	-37.219569	139.806585
Robe Lake	Rob_017	-37.21975	139.806461
Robe Lake	Rob_018	-37.220048	139.806377
Robe Lake	Rob_019	-37.220172	139.806566
Robe Lake	Rob_020	-37.220461	139.806536
Robe Lake	Rob_021	-37.22063	139.806457
Robe Lake	Rob_022	-37.220865	139.80664
Robe Lake	Rob_023	-37.221181	139.806598
Robe Lake	Rob_024	-37.221362	139.806732
Robe Lake	Rob_025	-37.22147	139.806633
Robe Lake	Rob_026	-37.221662	139.806736
Robe Lake	Rob_027	-37.221679	139.806542
Robe Lake	Rob_028	-37.22395	139.8004833
Robe Lake	Rob_029	-37.22385	139.8001333
Robe Lake	Rob_030	-37.22351667	139.79995
Robe Lake	Rob_031	-37.22328333	139.7998167
Robe Lake	Rob_032	-37.2231	139.7992833
Robe Lake	Rob_033	-37.22301667	139.7993667
Robe Lake	Rob_034	-37.22291667	139.7994
Robe Lake	Rob_035	-37.22303333	139.799
Robe Lake	Rob_036	-37.22306667	139.7986833
Robe Lake	Rob_037	-37.22301667	139.7982333
Robe Lake	Rob_038	-37.2233	139.7978167
Robe Lake	Rob_039	-37.22328333	139.7971
Robe Lake	Rob_040	-37.21925	139.8064333
Robe Lake	Rob_041	-37.21921667	139.8062167
Robe Lake	Rob_042	-37.21841667	139.8061833
Robe Lake	Rob_043	-37.21835	139.80585
Robe Lake	Rob_044	-37.21776667	139.8060667
Robe Lake	Rob_045	-37.2172	139.8060167
Robe Lake	Rob_046	-37.21678333	139.8055333
Robe Lake	Rob_047	-37.21621667	139.8060167
Robe Lake	Rob_048	-37.21581667	139.80605
Robe Lake	Rob_049	-37.21526667	139.8058833
Robe Lake	Rob_050	-37.21478333	139.8064667
Robe Lake	Rob_051	-37.2153	139.8069333
Lake George	Lak_001	-37.392933	140.023778
Lake George	Lak_002	-37.393018	140.023646

Wetland	Site identifier	Latitude	Longitude
Lake George	Lak_003	-37.393279	140.022627
Lake George	Lak_004	-37.393713	140.022004
Lake George	Lak_005	-37.394246	140.021648
Lake George	Lak_006	-37.393517	140.023645
Lake George	Lak_007	-37.393396	140.024029
Lake George	Lak_008	-37.393202	140.024082
Lake George	Lak_009	-37.45654	140.034328
Lake George	Lak_010	-37.456605	140.034148
Lake George	Lak_011	-37.456901	140.032952
Lake George	Lak_012	-37.457102	140.032332
Lake George	Lak_013	-37.457667	140.030661
Lake George	Lak_014	-37.447862	140.018212
Lake George	Lak_015	-37.448071	140.017603
Lake George	Lak_016	-37.448422	140.016707
Lake George	Lak_017	-37.448513	140.016249
Lake George	Lak_018	-37.448553	140.016061
Lake George	Lak_019	-37.430615	139.966813
Lake George	Lak_020	-37.430565	139.966867
Lake George	Lak_021	-37.430522	139.966919
Lake George	Lak_022	-37.439006	139.975498
Lake George	Lak_023	-37.439001	139.975512
Lake George	Lak_024	-37.438994	139.975534
Lake George	Lak_025	-37.438871	139.975454
Lake George	Lak_026	-37.442199	139.979682
Lake George	Lak_027	-37.442157	139.979692
Lake George	Lak_028	-37.442129	139.97973
Lake George	Lak_029	-37.442103	139.979701
Lake George	Lak_030	-37.453097	139.987921
Lake George	Lak_031	-37.453042	139.987918
Lake George	Lak_032	-37.452962	139.98793
Lake George	Lak_033	-37.450298	139.995934
Lake George	Lak_034	-37.450267	139.995842
Lake George	Lak_035	-37.450088	139.995637
Lake George	Lak_036	-37.450348	139.99568
Lake George	Lak_037	-37.45039	139.997979
Lake George	Lak_038	-37.450277	139.998091
Lake George	Lak_039	-37.469875	140.004508
Lake George	Lak_040	-37.46961	140.004729
Lake George	Lak_041	-37.469399	140.004959
Lake George	Lak_042	-37.469085	140.005158
Lake George	Lak_043	-37.39	140.0219
Lake George	Lak_044	-37.39	140.0217333
Lake George	Lak_045	-37.39018333	140.02125
Lake George	Lak_046	-37.39028333	140.0208
Lake George	Lak_047	-37.39045	140.0203333
Lake George	Lak_048	-37.39045	140.01985
Lake George	Lak_049	-37.38881667	140.0206833
Lake George	Lak_050	-37.39081667	140.0224
Lake George	Lak_051	-37.45555	140.0332167
Lake George	Lak_052	-37.45568333	140.0321
Lake George	Lak_053	-37.45586667	140.0316
Lake George	Lak_054	-37.45663333	140.0301833
Lake George	Lak_055	-37.44681667	140.0167333
Lake George	Lak_056	-37.44676667	140.0161833
Lake George	Lak_057	-37.44658333	140.0155
Lake George	Lak_058	-37.44645	140.0150833
Lake George	Lak_059	-37.44633333	140.0145833
Lake George	Lak_060	-37.44616667	140.0141333
Lake George	Lak_061	-37.43025	139.9666833
Lake George	Lak_062	-37.43023333	139.9668167
Lake George	Lak_063	-37.43023333	139.9668833
Lake George	Lak_064	-37.43765	139.975
Lake George	Lak_065	-37.43753333	139.97505
Lake George	Lak_066	-37.43753333	139.9751

Wetland	Site identifier	Latitude	Longitude
Lake George	Lak_067	-37.44273333	139.9803
Lake George	Lak_068	-37.44266667	139.9803667
Lake George	Lak_069	-37.44261667	139.9805333
Lake George	Lak_070	-37.44248333	139.98095
Lake George	Lak_071	-37.45293333	139.9888833
Lake George	Lak_072	-37.45286667	139.9888167
Lake George	Lak_073	-37.45271667	139.9888333
Lake George	Lak_074	-37.45256667	139.9889333
Lake George	Lak_075	-37.4493	139.9962333
Lake George	Lak_076	-37.4492	139.9960333
Lake George	Lak_077	-37.45045	139.9988833
Lake George	Lak_078	-37.4501	139.9990167
Lake George	Lak_079	-37.47011667	140.0044667
Lake George	Lak_080	-37.47023333	140.0052333
Lake George	Lak_081	-37.47023333	140.0058833
Lake George	Lak_082	-37.47018333	140.00665
Lake Hawdon South	Haw_001	-37.181518	139.937545
Lake Hawdon South	Haw_002	-37.181729	139.937838
Lake Hawdon South	Haw_003	-37.182046	139.937763
Lake Hawdon South	Haw_004	-37.182758	139.937648
Lake Hawdon South	Haw_005	-37.179676	139.935068
Lake Hawdon South	Haw_006	-37.180909	139.934716
Lake Hawdon South	Haw_007	-37.179581	139.933663
Lake Hawdon South	Haw_008	-37.180386	139.933357
Lake Hawdon South	Haw_009	-37.18096	139.933249
Lake Hawdon South	Haw_010	-37.181794	139.932605
Lake Hawdon South	Haw_011	-37.182185	139.932138
Lake Hawdon South	Haw_012	-37.18215	139.931117
Lake Hawdon South	Haw_013	-37.178437	139.93
Lake Hawdon South	Haw_014	-37.178818	139.930204
Lake Hawdon South	Haw_015	-37.179413	139.930295
Lake Hawdon South	Haw_016	-37.179939	139.930391
Lake Hawdon South	Haw_017	-37.180266	139.930362
Lake Hawdon South	Haw_018	-37.18027	139.929745
Lake Hawdon South	Haw_019	-37.17984	139.929566
Lake Hawdon South	Haw_020	-37.243408	139.962709
Lake Hawdon South	Haw_021	-37.243193	139.962466
Lake Hawdon South	Haw_022	-37.243138	139.962374
Lake Hawdon South	Haw_023	-37.242809	139.961936
Lake Hawdon South	Haw_024	-37.24233	139.961658
Lake Hawdon South	Haw_025	-37.241995	139.961316
Lake Hawdon South	Haw_026	-37.24181	139.961727
Lake Hawdon South	Haw_027	-37.241646	139.962321
Lake Hawdon South	Haw_028	-37.24162	139.962372
Lake Hawdon South	Haw_029	-37.241689	139.96323
Lake Hawdon South	Haw_030	-37.24168	139.963427
Lake Hawdon South	Haw_031	-37.241708	139.964089
Lake Hawdon South	Haw_032	-37.246368	139.961678
Lake Hawdon South	Haw_033	-37.246425	139.9612
Lake Hawdon South	Haw_034	-37.246406	139.960758
Lake Hawdon South	Haw_035	-37.246361	139.960568
Lake Hawdon South	Haw_036	-37.246215	139.960311
Lake Hawdon South	Haw_037	-37.245912	139.959716
Lake Hawdon South	Haw_038	-37.18105	139.9382
Lake Hawdon South	Haw_039	-37.18128333	139.9379833
Lake Hawdon South	Haw_040	-37.18145	139.9381833
Lake Hawdon South	Haw_041	-37.18181667	139.9382
Lake Hawdon South	Haw_042	-37.18226667	139.9384667
Lake Hawdon South	Haw_043	-37.18271667	139.9386167
Lake Hawdon South	Haw_044	-37.18335	139.93855
Lake Hawdon South	Haw_045	-37.18396667	139.9384667
Lake Hawdon South	Haw_046	-37.1798	139.9369667
Lake Hawdon South	Haw_047	-37.18053333	139.9370333
Lake Hawdon South	Haw_048	-37.18091667	139.9362333

Wetland	Site identifier	Latitude	Longitude
Lake Hawdon South	Haw_049	-37.18106667	139.9360667
Lake Hawdon South	Haw_050	-37.18128333	139.9357167
Lake Hawdon South	Haw_051	-37.1814	139.9354
Lake Hawdon South	Haw_052	-37.18141667	139.9352667
Lake Hawdon South	Haw_053	-37.18143333	139.9344167
Lake Hawdon South	Haw_054	-37.17943333	139.9346667
Lake Hawdon South	Haw_055	-37.18048333	139.9343
Lake Hawdon South	Haw_056	-37.18143333	139.9339333
Lake Hawdon South	Haw_057	-37.1816	139.9337167
Lake Hawdon South	Haw_058	-37.1819	139.9335833
Lake Hawdon South	Haw_059	-37.18243333	139.9334333
Lake Hawdon South	Haw_060	-37.18258333	139.93325
Lake Hawdon South	Haw_061	-37.18278333	139.9327333
Lake Hawdon South	Haw_062	-37.18308333	139.9324333
Lake Hawdon South	Haw_063	-37.18323333	139.9321667
Lake Hawdon South	Haw_064	-37.18323333	139.9318
Lake Hawdon South	Haw_065	-37.18323333	139.9315167
Lake Hawdon South	Haw_066	-37.17731667	139.9297167
Lake Hawdon South	Haw_067	-37.17778333	139.9291667
Lake Hawdon South	Haw_068	-37.17836667	139.9285
Lake Hawdon South	Haw_069	-37.1788	139.92795
Lake Hawdon South	Haw_070	-37.17918333	139.92745
Lake Hawdon South	Haw_071	-37.17981667	139.92685
Lake Hawdon South	Haw_072	-37.18013333	139.9264833
Lake Hawdon South	Haw_073	-37.18038333	139.9261833
Lake Hawdon South	Haw_074	-37.24358333	139.96245
Lake Hawdon South	Haw_075	-37.24363333	139.9622
Lake Hawdon South	Haw_076	-37.24373333	139.9618
Lake Hawdon South	Haw_077	-37.24378333	139.9615333
Lake Hawdon South	Haw_078	-37.24381667	139.9610333
Lake Hawdon South	Haw_079	-37.24405	139.9601667
Lake Hawdon South	Haw_080	-37.24411667	139.9597167
Lake Hawdon South	Haw_081	-37.24425	139.9590167
Lake Hawdon South	Haw_082	-37.24431667	139.9584833
Lake Hawdon South	Haw_083	-37.24441667	139.9581167
Lake Hawdon South	Haw_084	-37.24458333	139.9582
Lake Hawdon South	Haw_085	-37.24515	139.9585833
Lake Hawdon South	Haw_086	-37.24541667	139.9591333
Lake Hawdon South	Haw_087	-37.24558333	139.9596
Lake Hawdon South	Haw_088	-37.24563333	139.96075
Lake Hawdon South	Haw_089	-37.24568333	139.9610667
Lake Hawdon South	Haw_090	-37.24571667	139.9613667
Lake Hawdon South	Haw_091	-37.24565	139.9615167
Lake Hawdon South	Haw_092	-37.24721667	139.96115
Lake Hawdon South	Haw_093	-37.24756667	139.961
Lake Hawdon South	Haw_094	-37.2476	139.9602667
Lake Hawdon South	Haw_095	-37.2476	139.9595833
Lake Hawdon South	Haw_096	-37.24756667	139.9590667
Lake Hawdon South	Haw_097	-37.24738333	139.9587
Lake Hawdon South	Haw_098	-37.2473	139.9580167
Lake Hawdon South	Haw_099	-37.2473	139.9574667
Hacks/Bool Lagoon	Boo_001	-37.1029	140.7185333
Hacks/Bool Lagoon	Boo_002	-37.10406667	140.7193667
Hacks/Bool Lagoon	Boo_003	-37.10398333	140.7194833
Hacks/Bool Lagoon	Boo_004	-37.1039	140.7196
Hacks/Bool Lagoon	Boo_005	-37.10375	140.7197833
Hacks/Bool Lagoon	Boo_006	-37.10366667	140.72005
Hacks/Bool Lagoon	Boo_007	-37.10356667	140.7202333
Hacks/Bool Lagoon	Boo_008	-37.10358333	140.7208167
Hacks/Bool Lagoon	Boo_009	-37.1036	140.72085
Hacks/Bool Lagoon	Boo_010	-37.1036	140.7209833
Hacks/Bool Lagoon	Boo_011	-37.1037	140.7212333
Hacks/Bool Lagoon	Boo_012	-37.10381667	140.72165
Hacks/Bool Lagoon	Boo_013	-37.1041	140.7223833

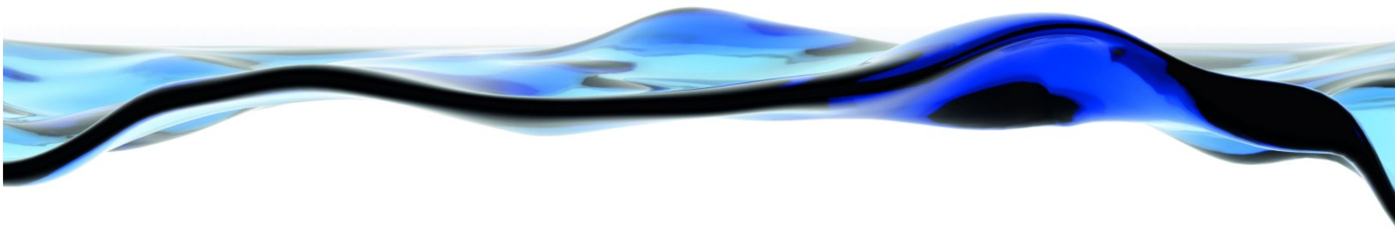
Wetland	Site identifier	Latitude	Longitude
Hacks/Bool Lagoon	Boo_014	-37.10428333	140.7227
Hacks/Bool Lagoon	Boo_015	-37.10445	140.7224833
Hacks/Bool Lagoon	Boo_016	-37.10456667	140.7224833
Hacks/Bool Lagoon	Boo_017	-37.1048	140.7225167
Hacks/Bool Lagoon	Boo_018	-37.105	140.7224667
Hacks/Bool Lagoon	Boo_019	-37.10515	140.7225167
Hacks/Bool Lagoon	Boo_020	-37.10525	140.7221833
Hacks/Bool Lagoon	Boo_021	-37.10491667	140.7209
Hacks/Bool Lagoon	Boo_022	-37.10476667	140.7203833
Hacks/Bool Lagoon	Boo_023	-37.14856667	140.6568667
Hacks/Bool Lagoon	Boo_024	-37.14861667	140.6569833
Hacks/Bool Lagoon	Boo_025	-37.14863333	140.6572167
Hacks/Bool Lagoon	Boo_026	-37.14866667	140.6575667
Hacks/Bool Lagoon	Boo_027	-37.1487	140.6580167
Hacks/Bool Lagoon	Boo_028	-37.14883333	140.6584
Hacks/Bool Lagoon	Boo_029	-37.14886667	140.6587
Hacks/Bool Lagoon	Boo_030	-37.14903333	140.6594333
Hacks/Bool Lagoon	Boo_031	-37.14918333	140.6603167
Hacks/Bool Lagoon	Boo_032	-37.1494	140.6606167
Hacks/Bool Lagoon	Boo_033	-37.14968333	140.66095
Hacks/Bool Lagoon	Boo_034	-37.14971667	140.6607833
Hacks/Bool Lagoon	Boo_035	-37.12351667	140.6979333
Hacks/Bool Lagoon	Boo_036	-37.12346667	140.6978167
Hacks/Bool Lagoon	Boo_037	-37.12333333	140.6976167
Hacks/Bool Lagoon	Boo_038	-37.1233	140.6972667
Hacks/Bool Lagoon	Boo_039	-37.1232	140.6967
Hacks/Bool Lagoon	Boo_040	-37.12311667	140.6965833
Hacks/Bool Lagoon	Boo_041	-37.12301667	140.69635
Hacks/Bool Lagoon	Boo_042	-37.12403333	140.6972167
Hacks/Bool Lagoon	Boo_043	-37.12375	140.6976667
Hacks/Bool Lagoon	Boo_044	-37.12363333	140.6977
Hacks/Bool Lagoon	Boo_045	-37.12445	140.6991333
Hacks/Bool Lagoon	Boo_046	-37.1246	140.69935
Hacks/Bool Lagoon	Boo_047	-37.12498333	140.6994833
Hacks/Bool Lagoon	Boo_048	-37.12515	140.6997333
Hacks/Bool Lagoon	Boo_049	-37.1253	140.6999667
Hacks/Bool Lagoon	Boo_050	-37.1255	140.7000833
Hacks/Bool Lagoon	Boo_051	-37.1255	140.7000833
Hacks/Bool Lagoon	Boo_052	-37.12571667	140.70065
Hacks/Bool Lagoon	Boo_053	-37.12561667	140.7012667
Hacks/Bool Lagoon	Boo_054	-37.12526667	140.7009333
Hacks/Bool Lagoon	Boo_055	-37.10468333	140.7186333
Hacks/Bool Lagoon	Boo_056	-37.10468333	140.71845
Hacks/Bool Lagoon	Boo_057	-37.10476667	140.7182
Hacks/Bool Lagoon	Boo_058	-37.10496667	140.7179833
Hacks/Bool Lagoon	Boo_059	-37.10518333	140.71785
Hacks/Bool Lagoon	Boo_060	-37.10505	140.7175833
Hacks/Bool Lagoon	Boo_061	-37.10333333	140.7297167
Hacks/Bool Lagoon	Boo_062	-37.10328333	140.7295667
Hacks/Bool Lagoon	Boo_063	-37.10311667	140.7292167
Hacks/Bool Lagoon	Boo_064	-37.10291667	140.729
Hacks/Bool Lagoon	Boo_065	-37.10245	140.7291
Hacks/Bool Lagoon	Boo_066	-37.10223333	140.7293
Hacks/Bool Lagoon	Boo_067	-37.10218333	140.7296667
Hacks/Bool Lagoon	Boo_068	-37.10216667	140.7195
Hacks/Bool Lagoon	Boo_069	-37.10198333	140.7202333
Hacks/Bool Lagoon	Boo_070	-37.10083333	140.7223667
Hacks/Bool Lagoon	Boo_071	-37.12433917	140.6999024
Hacks/Bool Lagoon	Boo_072	-37.12451044	140.6999017
Hacks/Bool Lagoon	Boo_073	-37.12483466	140.6997878
Hacks/Bool Lagoon	Boo_074	-37.12502341	140.6995732
Hacks/Bool Lagoon	Boo_075	-37.12509521	140.6994491
Hacks/Bool Lagoon	Boo_076	-37.12487862	140.6993486
Hacks/Bool Lagoon	Boo_077	-37.12450037	140.6994852

Wetland	Site identifier	Latitude	Longitude
Hacks/Bool Lagoon	Boo_078	-37.10517719	140.7192231
Hacks/Bool Lagoon	Boo_079	-37.10536611	140.7190648
Hacks/Bool Lagoon	Boo_080	-37.1056451	140.7188725
Hacks/Bool Lagoon	Boo_081	-37.10581597	140.718703
Hacks/Bool Lagoon	Boo_082	-37.10598683	140.7185336
Hacks/Bool Lagoon	Boo_083	-37.104435	140.728204
Hacks/Bool Lagoon	Boo_084	-37.104398	140.727965
Hacks/Bool Lagoon	Boo_085	-37.104383	140.727919
Hacks/Bool Lagoon	Boo_086	-37.104319	140.727767
Hacks/Bool Lagoon	Boo_087	-37.104274	140.727626
Hacks/Bool Lagoon	Boo_088	-37.10423	140.727532
Hacks/Bool Lagoon	Boo_089	-37.103704	140.727359
Hacks/Bool Lagoon	Boo_090	-37.103534	140.727523
Hacks/Bool Lagoon	Boo_091	-37.10329	140.727435
Hacks/Bool Lagoon	Boo_092	-37.103586	140.72771
Hacks/Bool Lagoon	Boo_093	-37.1235904	140.6996689
Hacks/Bool Lagoon	Boo_094	-37.12341023	140.6997147
Hacks/Bool Lagoon	Boo_095	-37.12317592	140.6997381
Hacks/Bool Lagoon	Boo_096	-37.12291482	140.699863
Hacks/Bool Lagoon	Boo_097	-37.12266308	140.7001229
Hacks/Bool Lagoon	Boo_098	-37.12254439	140.6995267
Hacks/Bool Lagoon	Boo_099	-37.12245607	140.7002475
Hacks/Bool Lagoon	Boo_100	-37.1223117	140.7001918
Hacks/Bool Lagoon	Boo_101	-37.12258056	140.6995716
Hacks/Bool Lagoon	Boo_102	-37.12285024	140.6992778
Hacks/Bool Lagoon	Boo_103	-37.12296748	140.6992999
Hacks/Bool Lagoon	Boo_104	-37.12329265	140.6995575
Hacks/Bool Lagoon	Boo_105	-37.15018933	140.6558594
Hacks/Bool Lagoon	Boo_106	-37.1500554	140.6562992
Hacks/Bool Lagoon	Boo_107	-37.15001973	140.6564344
Hacks/Bool Lagoon	Boo_108	-37.14991281	140.6568629
Hacks/Bool Lagoon	Boo_109	-37.14985944	140.6571108
Hacks/Bool Lagoon	Boo_110	-37.14983295	140.6573024
Hacks/Bool Lagoon	Boo_111	-37.14972667	140.657956
Hacks/Bool Lagoon	Boo_112	-37.14969129	140.6581927
Hacks/Bool Lagoon	Boo_113	-37.14966571	140.6586995
Hacks/Bool Lagoon	Boo_114	-37.14962204	140.6591839
Hacks/Bool Lagoon	Boo_115	-37.10295	140.71855
Hacks/Bool Lagoon	Boo_116	-37.10285	140.7186167
Hacks/Bool Lagoon	Boo_117	-37.10285	140.7187667
Hacks/Bool Lagoon	Boo_118	-37.1028	140.7190167
Hacks/Bool Lagoon	Boo_119	-37.10256667	140.71915
Hacks/Bool Lagoon	Boo_120	-37.10235	140.7194
Hacks/Bool Lagoon	Boo_121	-37.10216667	140.7195
Hacks/Bool Lagoon	Boo_122	-37.10218333	140.71985
Hacks/Bool Lagoon	Boo_123	-37.10198333	140.7202333
Hacks/Bool Lagoon	Boo_124	-37.1019	140.7207
Hacks/Bool Lagoon	Boo_125	-37.10178333	140.72135
Hacks/Bool Lagoon	Boo_126	-37.10163333	140.72155
Hacks/Bool Lagoon	Boo_127	-37.10128333	140.722
Hacks/Bool Lagoon	Boo_128	-37.10083333	140.7223667

Appendix 5. Taxa recorded in case study wetlands (*denotes exotic species, **denotes proclaimed pest plant in South Australia, * denotes weed of national significance, # denotes listed as rare in South Australia, ## denotes listed as vulnerable in South Australia, ### denotes listed as endangered in South Australia) and functional groups (Casanova 2011).**

Taxon	Functional Group
Apium sp.	Tdamp
*Aster subulatus**	Afte
*Avena barbata**	Tdry
Azolla filiculoides	Afrf
Baloskian tetraphyllum##	Afte
Baumea arthrophylla	Afte
Baumea articulata	Afte
Baumea juncea	Afte
Berula erecta	Afte
Brassica spp.*	Tdry
*Briza minima**	Tdry
Bromus spp.*	Tdry
Carex apressa	Afte
Carex fasicularis	Afte
*Centaurea calcitrapa**	Tdamp
Chara spp.	Sr
Chorizandra australis###	Afte
*Conyza bonariensis**	Tdamp
Crassula helmsii	Aftl
Daucus glochidiatus	Tdamp
Distichlis distichophylla	Tdamp
Drosera whittakeri	Tdamp
Eleocharis acuta	Afte
Eleocharis sphacelata	Se
Epacris impressa	Tdry
*Eragrostis curvula***	Tdamp
Eucalyptus camaldulensis	Aftw
Ficinia nodosa	Afte
Gahnia clarkei#	Afte
Gahnia filum	Afte
Gahnia triffida	Afte
Geranium solanderi	Tdamp
Glyceria australis	Afte
Gonocarpus tetragynus	Tdamp
Hibbertia riparia	Tdry
*Holcus lanatus**	Tdamp
Hypolaena fastigiata	Tdamp
*Hypochoeris glabra**	Tdry
*Hypochoeris radicata**	Tdry
Isolepis fluitans	Sr
Isolepis platycarpa	Aftl
Juncus holoschoenus	Afte
Juncus kraussii	Afte
Juncus pallidus	Afte
Lachnagrostis filiformis	Tdamp
*Lactuca serriola**	Tdry
Lamprothamnium papulosum	Sr
Lamprothamnium succinctum	Sr
Lemna minor	Afrf
Lepilaena cylindrocarpa	Sr
Leptospermum longitudinale	Aftw
Leptospermum myrsinoides	Aftw
Lilaeopsis polyantha	Aftl
Limosella australis	Afrp
Lythrum salicaria	Afte
*Malva parviflora**	Tdry
Medicago spp.*	Tdry
Melaleuca halmaturorum	Aftw
Melaleuca squamea	Aftw
Melaleuca squarrosa	Aftw
Mimulus repens	Aftl
Myriophyllum meullerii	Afrp
Myriophyllum salsugineum	Afrp
Myriophyllum simulans	Afrp
Myriophyllum verrucosum	Afrp

Taxon	Functional Group
Nitella spp.*	Sr
Phragmites australis	Se
*Plantago coronopus**	Tdry
*Polypogon monspeliensis**	Afte
Potamogeton pectinatus	Sk
Potamogeton tricarinatus	Afrp
Ranunculus amphitrichus	Afrp
Ranunculus rivularis	Afrp
*Rorippa nasturtium-aquaticum**	Afrp
Rubus fruticosus agg.***	Afte
Rumex bidens	Afrp
Ruppia polycarpa	Sr
Ruppia tuberosa	Sr
Samolus repens	Tdamp
Sarcocornia quinqueflora	Afte
Schoenus nitens	Afte
Schoenoplectus pungens	Afte
Selliera radicans	Afrp
*Senecio pterophorus**	Tdry
*Sonchus asper**	Tdamp
*Sonchus oleraceus**	Tdry
Sporobolus virginicus	Tdamp
Suaeda australis	Afte
Tecticornia pergranulata	Afte
Triglochin procera	Se
Triglochin striatum	Aftl
Trifolium spp.*	Tdry
Typha domingensis	Se
*Urtica urens**	Tdamp
Villarsia renniformis	Afrp
Wolffia sp.	Afrf
Xanthorrhoea semiplana	Tdry



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