Assessing the restoration potential of Cunningham Swamp (Point Cook, Victoria)

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September 2021

Nature Glenelg Trust

This project was funded by a grant from the Australian Government, Communities Environment Program

Australian Government

Citation:

Kerr G. D, Farrington L, Tuck J, Bachmann M (2021). *Assessing the restoration potential of Cunningham Swamp (Point Cook, Victoria)*. September 2021. Nature Glenelg Trust, Warrnambool, Victoria.

Acknowledgements:

- The Australian Government Communities Environment Program for providing a small grant that funded the completion of this project
- The Office of Joanne Ryan MP, Federal Member for Lalor, for supporting and recommending the project proposal for Communities Environment Program funding
- Dahua Group Australia for permitting site access to Cunningham Swamp
- Melbourne Water and the Port Phillip and Westernport CMA for provision of aerial photography, elevation data and references

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Cover:

Southern Cane-grass swamp habitat at Cunningham Swamp, April 2021. Photo by J. Tuck.

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EXECUTIVE SUMMARY

Introduction

The Cunningham Swamp wetland complex at Point Cook, comprising Cunningham Swamp and Point Cook Seasonal Herbaceous Wetland, is one of the most important remaining wetland areas in an increasingly urbanised region of Melbourne's western plains, identified as one of 17 'Key Sites of Significance' by the Wyndham City Council (Wyndham City Council 2013) as well as being a registered regional Biosite under the former Department of Sustainability and Environment's (DSE) database which housed spatial information on sites of biological significance.

Despite past agricultural and residential development around and within the wetland complex, and associated modifications to its natural bathymetry in the form of drains, dams and extraction of material, the wetland retains significant natural values that have been documented in a number of prior surveys (Ecology and Heritage Partners 2014, 2020, GHD 2018, 2020). The response of the vegetation at the wetland, as a result of higher rainfall and resultant higher inflows (as observed during a site visit in April 2021) offers a glimpse of potential ecological outcomes under a hydrological restoration scenario that increases future inundation extent and reliability, and improves inundation patterns.

With recent suburban residential developments immediately adjacent to the northern tip of Cunningham Swamp (including associated modification of that portion of the wetland's geomorphology), and proposed further large-scale residential developments in the near future, concerns regarding the long-term future of the wetland have been raised, making it timely for an assessment of the restoration potential of the swamp complex.

Site values

The assessment found that while wetland condition has been significantly affected by past hydrological modifications, as well as agricultural and residential development, the site still retains regionally-important values that can be further enhanced and recovered, including the presence of several threatened Ecological Vegetation Communities (EVCs). The Plains Grassy Wetland/Lignum Swamp Complex (EVC A101), which is very restricted across the Victorian Volcanic Plains, is present across much of the shallow, seasonally inundated areas within Cunningham Swamp. Areas of the bioregionally Vulnerable *Cane Grass Wetland* (EVC 291) occur in the seasonal wetland to its east, and *Tall Marsh* (EVC 821) occurs in and around artificially deepened sections of the swamp.

These vegetation communities provide potential habitat for threatened fauna, including the nationally-threatened Growling Grass Frog, Australasian Bittern and Australian Painted Snipe, as well as a range of waterbirds and other wetland fauna.

The wider area encompasses the traditional lands of the Wathaurong, Woiwurrung and Boonwurrung peoples of the Kulin Nation, whose relationship with this landscape extends back for tens of thousands of years. Wetland features like Cunningham Swamp were significant features in the traditional landscape and provided reliable resources for the custodians of the land.

Modifications

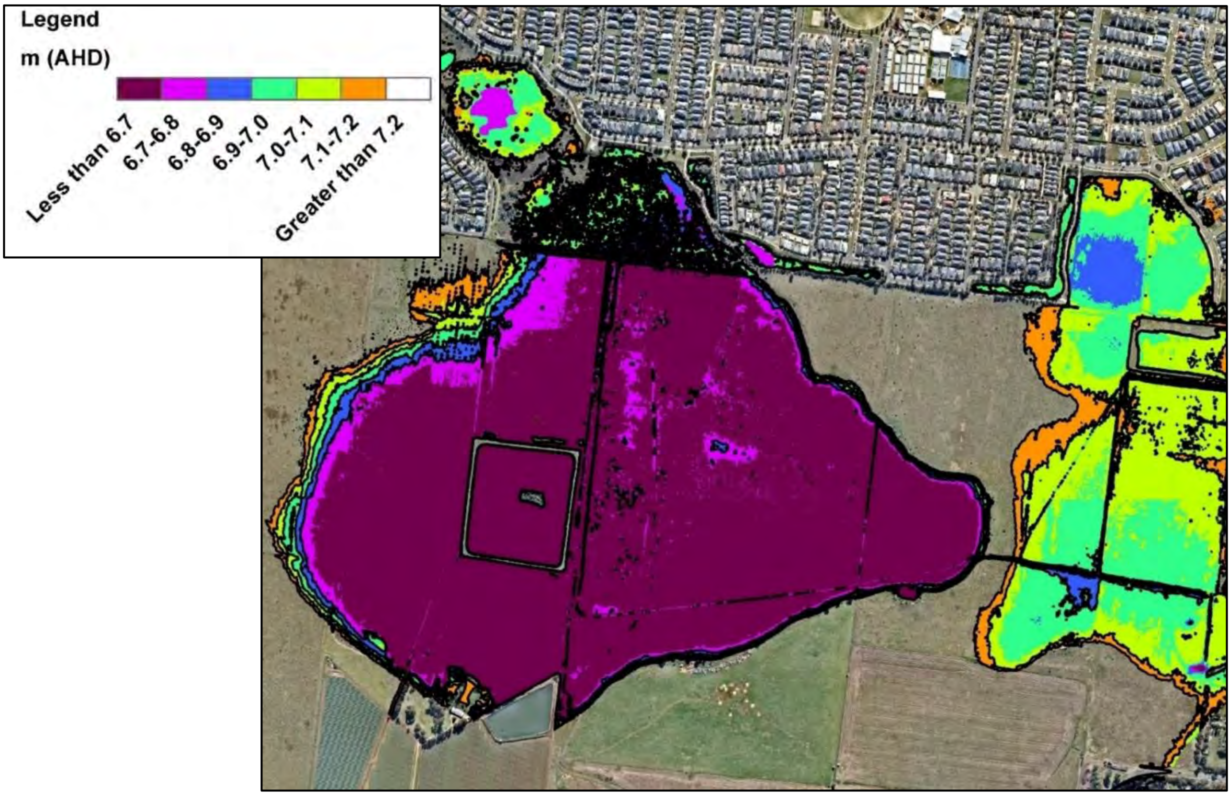
Aerial imagery prior to 1951 shows few changes to Cunningham Swamp with no drains or changes to natural bathymetry, while significant change had been made to the shallower wetland 70594 to its east. Subsequently, Cunningham Swamp underwent gradual modification for the purposes of agricultural development, with drains and a small dam visible in aerial imagery in 1989, before larger excavations took place between 2001 and 2003, removing material and forming a large bunded dam within the swamp.

Restoration potential

The condition of wetland vegetation has been compromised by a combination of factors, including modification of inflows, site drainage, groundwater changes, and agricultural activities such as grazing, ploughing, and track building across much of the wetland basin. However, despite this history of modification, the wetland ecosystem has shown resilience through the persistence and recovery of high value habitats.

High resolution aerial imagery is available from 2009, and combined with recent imagery (to 2021), captures a transition of areas which were essentially bare earth after nearly 10 years of drought in 2009, to now support native wetland vegetation that has naturally regenerated. This is supported by the fact that current partial recovery has occurred after the drought, despite the current drains and other modifications exerting a drying influence, which indicates the further trajectory of recovery that is highly likely under a future restoration scenario if the natural wetland feature is retained, hydrologically restored and adequately protected for that purpose.

Additionally, most (but not all) modifications that exert a hydrological influence on the wetland are reversible and – in most cases – the works to achieve this are relatively straightforward to implement.



Elevation data that illustrates the restoration potential of Cunningham Swamp (left) and the Point Cook Seasonal Herbaceous Wetland (right)

Restoration options

As a result of the assessment of site values, whole-of-wetland hydrological restoration is recommended for the Cunningham Swamp wetland complex, based on natural geomorphic form.

Key proposed restoration actions to achieve this, subject to further investigation, are:

- **Backfilling of internal drains and removal of banks**, allowing flows to re-engage with the full natural wetland extent and floodplain;
- **Setting of a fixed outlet sill level**, thereby setting the depth of inundation across the wider wetland(s); and
- **Potential backfilling of the bunded dam and excavated area** in the north of Cunningham Swamp, which could involve partial retention and optimisation of excavated areas to support Growling Grass Frog habitat, subject to the agreed restoration vision for the site.

Predicted restoration response

Predictions of habitat response to restoration activities indicate that the area and quality of Plains Grassy Wetland/Lignum Swamp would increase across zones where it occurs, but will otherwise continue to decline under a 'do nothing' scenario.

Tall Marsh is likely to continue to expand, encroaching into existing areas of Plains Grassy Wetland / Lignum Swamp where it currently occurs, and into shallower areas of open water. Optimal outcomes would be achieved by a combination of raising the sill and removing banks and drains so that water can spread evenly across the wetland while filling, rather than having to fill and spill across artificial internal barriers, as would be the case if the existing drains and banks were left in place.

For threatened fauna such as Growling Grass Frog, Australasian Bittern and Australian Snipe, the predicted responses in habitat types suggest that most species would benefit from improved habitat quality and extent.

Final Recommendations

On the basis of the findings of this preliminary investigation, it is recommended that further assessment be undertaken to produce a detailed restoration plan for the Cunningham Swamp wetland complex (including the adjacent Point Cook Seasonal Herbaceous Wetland). This work should incorporate hydraulic modelling of various scenarios, including those that include planned urbanisation of the surrounding area, as a precursor to the eventual hydrological restoration of the entire historical footprint of the wetland.

Conclusion

When considering the ever-diminishing opportunities for wetland restoration around Melbourne, the Cunningham Swamp wetland complex offers a compelling case: despite modification, this large natural wetland area still retains an impressive suite of eco-hydrological values and has excellent full restoration potential.

The unique characteristics of the wetland complex, offers the possibility to enhance and recreate wetland habitat on a regionally significant scale, with positive outcomes for threatened vegetation communities, flora and fauna. It will also provide complementary habitat that will likely enhance (and in turn also benefit from its proximity to) the nearby Port Phillip Bay (Western Shoreline) & Bellarine Peninsula Ramsar Site. Finally, Cunningham Swamp presents an opportunity to establish an open, natural public space which provides genuine community, cultural and environmental benefits.

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1.1. Background

Nature Glenelg Trust (NGT) is a non-government, not-for-profit, charitable organisation that works on a wide range of biodiversity related projects across south-eastern Australia. NGT has a particular interest in wetland restoration science, and possesses specialist skills in eco-hydrology. Eco-hydrological assessments involve piecing together the ecological (biodiversity) and hydrological (water management) story of a site to understand its trajectory of change through time, including in response to human interventions and modifications.

NGT has undertaken a large number of these assessments across south-eastern Australia, which in turn has led to the eventual implementation of dozens of wetland restoration projects on both public and private land. Wetlands are especially suitable to restoration, because rapid recovery of degraded, or even lost, biodiversity values is possible at sites with the right attributes in relatively quick time. Over recent years, local communities in the urban growth zones around outer Melbourne have sought NGT's professional advice to help develop an understanding of the restoration potential of wetlands that are situated within areas designated for future urban development.

The Point Cook area is one of Melbourne's fastest growing outer urban areas. Cunningham Swamp was brought to NGT's attention by the community for investigation because it:

- specifically featured in the "Landscape Context Guidelines" produced by Wyndham City Council in 2013 (refer to pages 22 and 23);
- is a key target for habitat protection and enhancement under the Wyndham City Forest and Habitat Strategy (Wyndham City Council, 2017); and,
- is situated in a Precinct Structure Plan (Aviators Field PSP) area where urbanisation plans are imminent.

NGT was awarded a small grant from the Australian Government, Communities Environment Program in 2020, enabling us to undertake an independent assessment of the Point Cook wetlands in 2021. This report provides an overview of our evaluation of the past, present and potential future environmental values of the site, with the concept of wetland restoration in mind.

1.2. Project overview

Urban expansion at Point Cook is bringing new residential development into close proximity with flood prone land (natural wetlands) that was artificially drained in recent decades to facilitate intensification of its use for agriculture. The site is in the vicinity of Aviation Road, Point Cook and lies within the suburban expansion area that is progressing south of Sneydes Road.

The project sought to undertake a basic eco-hydrological assessment, via survey and assessment of the Point Cook wetlands. Our site visit aimed to collect data including inundation extent, flora and fauna species, distribution of vegetation communities, overall vegetation condition and some reference photos, as well as assessing the potential of the site to provide habitat for nationally threatened species.

The information from site visits, combined with remote GIS mapping tasks and a review of historic information, underpins an exploration of options for enhancing the management of the wetland as part of the urbanisation process, which will inevitably occur in this part of outer Melbourne. As well as improving the biodiversity values of the site, this will provide concurrent opportunities to improve future aesthetic and recreational values, offer climate resilience (urban cooling / reduced urban heat effect) and catchment benefits (flood buffering and water quality) – among other potential Integrated Water Management (IWM) benefits.

The Aviators Field PSP, which incorporates Cunningham Swamp, covers a total area of around 414 hectares adjacent to the existing Point Cook urbanised area. The Aviators Field PSP has a focus on sensitive consideration of adjacent agricultural areas but an overarching objective to provide residential land supply in an area with significant demand, in this instance complementing future development in the East Werribee employment precinct. The Wyndham Council's Landscape Context Guidelines notes that, despite modification by soil extraction and agricultural activity, Cunningham Swamp still retains remnant vegetation and faunal habitat (Appendix 2).

Melbourne's Greenfields Guidelines for Precinct Structure Planning (VPA, 2020) place an emphasis on protection and enhancement of areas of significant environmental and biodiversity value, such as native vegetation, waterway corridors and grasslands. With reference to enhancement, the Guidelines (on page 58) also identify "*opportunities to improve the resilience of biodiversity systems and native vegetation against the impacts of climate change through innovative approaches*" as an important consideration in the planning process. In this respect, further investigation is warranted to determine how retained values of wetland features in the PSP footprint can be protected and enhanced. A key element in this process is to understand the on-ground values (both historical and present) across the site and restoration activities which can be implemented to increase overall site resilience; promoting recovery of site values against the background pressures of surrounding development for residential land supply.

An ecological impact assessment (GHD 2020) has determined that, despite past modifications, at the time of investigation Cunningham Swamp retained remnant vegetation communities of Plains Grassy Wetland / Lignum Swamp Complex and Tall Marsh, but did not exhibit vegetation characteristics consistent with the listing for nationally threatened Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains (SHW). Given the modification of the site through drainage channels, there is a potential opportunity to modify inlets and outlets, as well as minimise interruptions to flow caused by banks and levees, to promote inundation regimes to better support, enhance and recover remnant and/or historical native wetland vegetation classes.

This investigation focussed on further documenting site values and used an ecosystem drivers and response framework to investigate hydrological restoration opportunities ultimately aimed at increasing the ecological resilience of biodiversity attributes.

The key objectives of this investigation were to:

- establish a working baseline for the site, in terms of its likely historical hydrological regime and vegetation coverage;
- document changes to hydrology and vegetation contributing to the site's current state;
- formulate a strategic restoration options assessment for the Point Cook wetlands; and
- outline future steps required to bring about on-ground restoration works.

2. SITE DESCRIPTION

2.1. Wetland features

The Cunningham Swamp wetland complex consists of four individual wetlands with overlapping riparian management areas. The Aviators Field PSP site includes two of these wetlands: Wetlands 70405 (Cunningham Swamp) and 70594 (Point Cook Seasonal Herbaceous Wetland) (Figure 1).

Figure 1: Pre-European (Pre 1788) wetland extent in the Point Cook wetland complex

Cunningham Swamp is classified in the Victorian state-wide wetland layer as a deep freshwater marsh with an original extent of around 106 ha. It has been identified as one of 17 'Key Sites of Significance' by the Wyndham City Council (Wyndham City Council 2013), and is a registered regional Biosite (Biosite No. 6536). Wetland 70617 to the north is the last of a chain of wetlands that is linked through what is now the Point Cook urban area and terminated in Cunningham Swamp. It is also classified as a deep freshwater marsh in both pre-European and current wetland mapping, with an original extent of around 5 ha.

Wetland 70594 (Point Cook Seasonal Herbaceous Wetland) lies between Cunningham Swamp and RAAF Lake (70409). It is a shallow freshwater marsh of over 51 ha in area. It has also been identified as a 'Key Site of Significance' by the Wyndham City Council (Wyndham City Council 2013). Part of this wetland is a registered local Biosite (Biosite No. 6537). The nearby semi-permanent saline Wetland 70409 and the northern half of this lies within the Ramsar listed Point Cook Coastal Park. The southern half is in the Point Cook RAAF base.

These wetlands lie within a 1 in 100-year floodway associated with two suburban drainage systems: the first taking water from Hoppers Crossing to the north-west, and the second from the Point Cook area to the north (Figure 2).

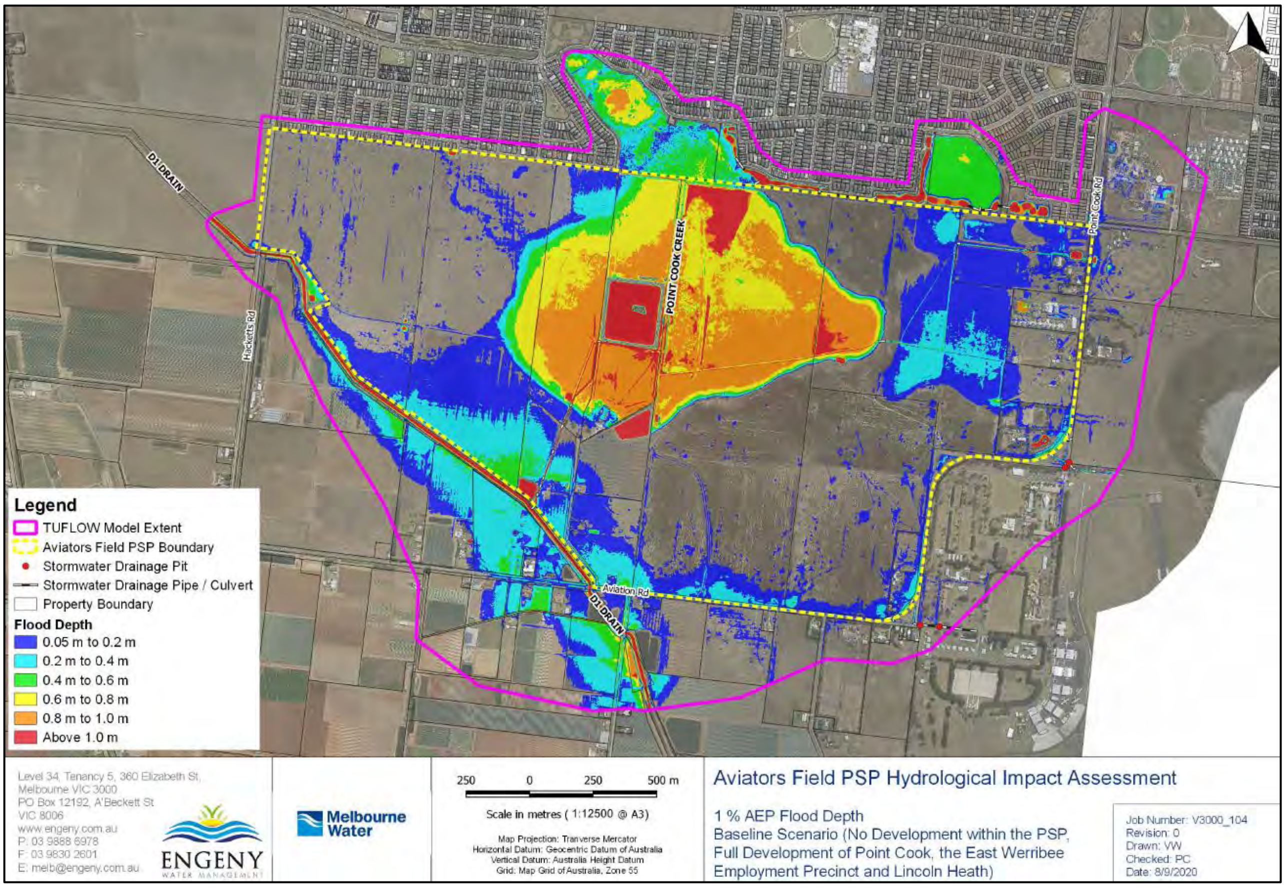


Figure 2: Aviators Field PSP 1 in 100-year flood extent (and depth as per key) under current conditions (Engeny 2020).

2.2. Geology and landforms

The wetland complex lies in a region of low relief with the series of wetlands separated by slight rises. The complex lies on the south-eastern edge of the Victorian Volcanic Plain (SVP01) Interim Biogeographic Regionalisation for Australia (IBRA) subregion and abuts the Otway Plains IBRA subregion to the south-west (SCP02) (Figure 3).

The Cunningham Swamp wetland complex lies above late Pliocene / Pleistocene igneous extrusive flows forming olivine basalt (Figure 4). The area is located within a region of alluvium consisting of transported new volcanics from the outcroppings in the upstream catchment. There is a thin veneer of mid-Pleistocene derived windblown brown silt and clayey silt (loess). In the swamp there is Quaternary lacustrine-paludal dark grey silt and clay.

Just to the south of Cunningham Swamp (bore 59991), soil was recorded to 1.5 metres, then weathered basalt to 17 metres (www.vvg.org.au). Beneath this Upper-Tertiary / Quaternary basalt layer of fractured rock is an upper tertiary fluvial layer of sand, gravel and clay from 20 to 49 metres (Table 1). A lower to mid-Tertiary layer of clay, silt, siltstone (fractured rock), marl (fractured rock) and minor sand is found from 49 to 157 metres. Between this layer and the basement Mesozoic and Palaeozoic sedimentary bedrock at 258 metres is 100 metres of lower Tertiary sand, gravel, clay and silt with some coal.

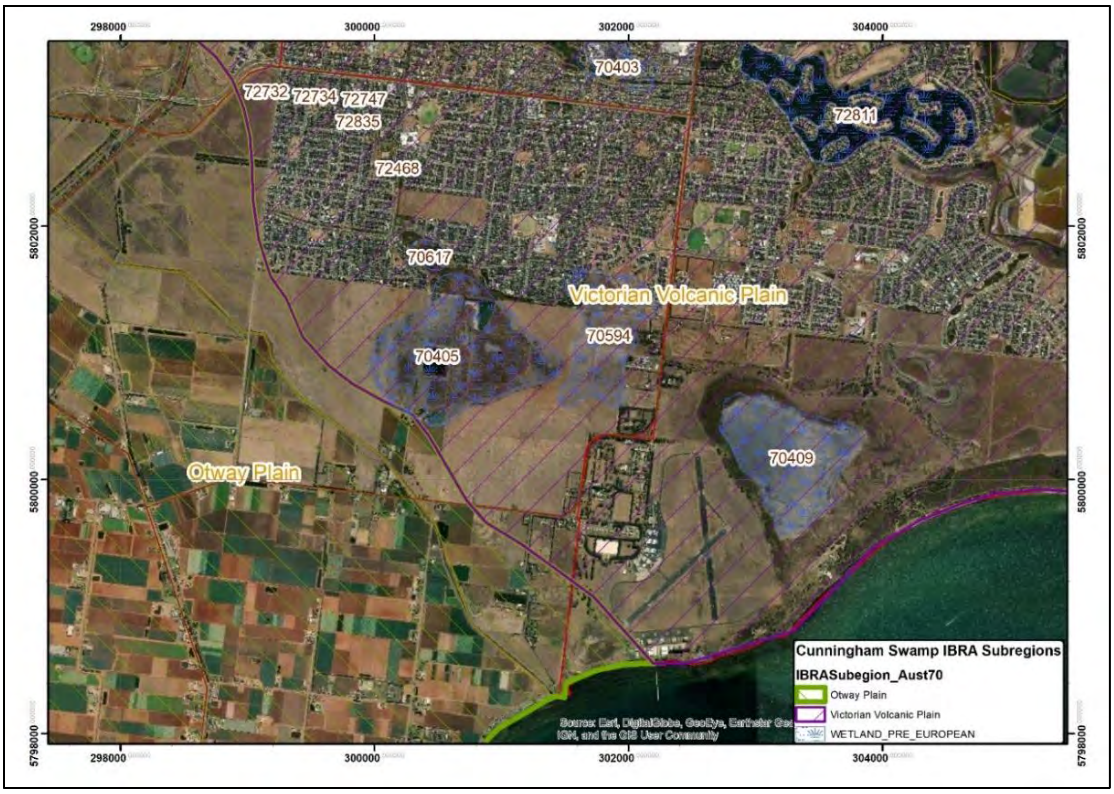


Figure 3: Interim Biogeographic Regionalisation for Australia (IBRA) subregions in association with the Cunningham Swamp wetland complex.

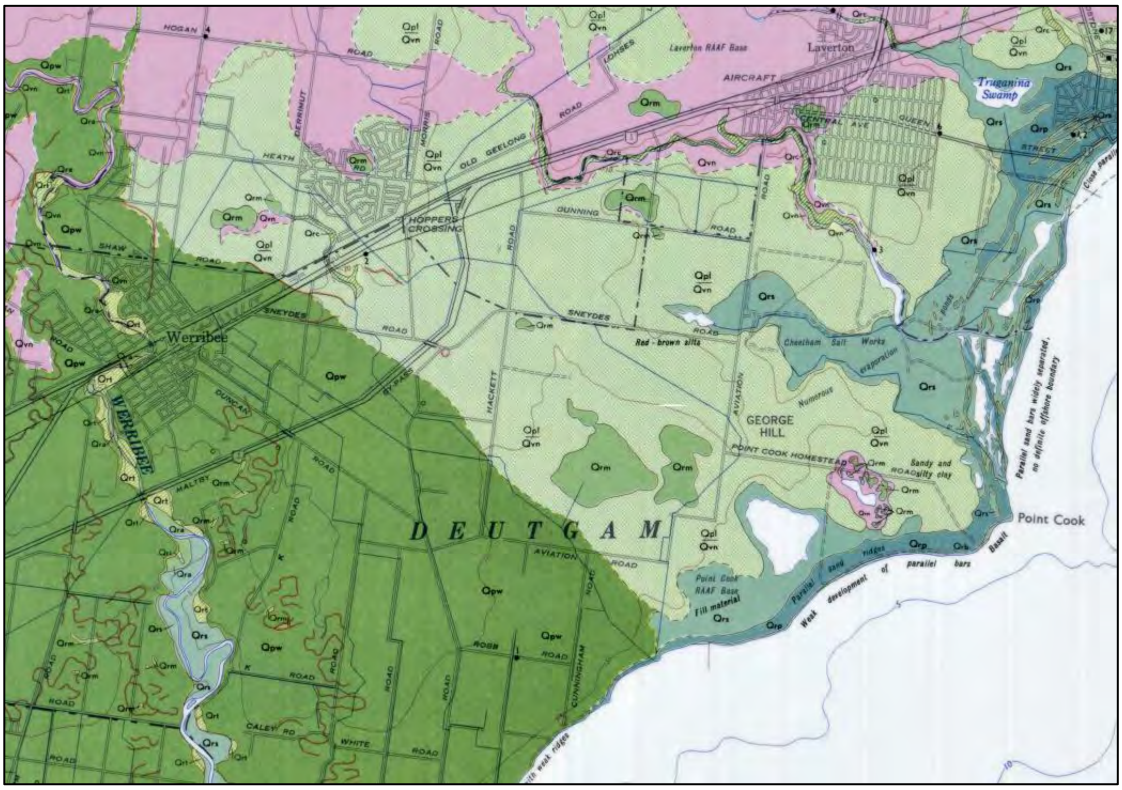


Figure 4: Extract from Melbourne Sheet SJ 55-1 (1974) Geological Survey of Victoria 1:63,000 Part 7822 Zone 55. Qrm = Swamp deposit: dark grey silt and clay, Qvn = Olivine basalt, olivine labradorite basalt, dark to light grey, coarsely vesicular, minor interbedded silty sand and baked soils, Qpl = thin veneer of windblown brown silt and clayey silt (loess).

2.3. Groundwater

The Cunningham Swamp wetland complex is associated with the Port Phillip groundwater basin, with a depth to water table of less than five metres. Groundwater in this area is part of the Deutgam Water Supply Protection Area (WSPA) groundwater management unit.

Six layers, with associated aquifers or aquitards, are known for this site (Table 1). At Cunningham Swamp there is local groundwater flow through the Quaternary sediments. The first three layers (to a depth of 49 m) typically carry water with a salt load between 3,500 and 13,000 mg/L. Two nearby bores (Bore 59991 09/10/1985 – conductivity (EC) 4,800 mg/L; and Bore 60062 29/11/1990 – conductivity (EC) 8,800 mg/L, Hardness 1,163.152 mg/L, TDS 6,048.6 mg/l) show groundwater salinity ranges between 3,500 and 7,000 mg/l. Water in this salinity range is suitable for stock use, industry, ecosystem protection and use in buildings and structures. A fresher (1,000 to 3,500 mg/L) aquifer is found in the Lower Tertiary layer for approximately 100 m below the Mid-Tertiary Aquitard lower boundary at 157 m.

The Permissible Consumptive Volume (PCV) cap for this WSPA is 5,100 ML/yr as set under the *Water Act* (*1989*).

The shallow water table indicates a high likelihood that annual groundwater cycles are important to the duration and extent of wetland inundation across the Cunningham Swamp wetland complex. Fresh surface water may interact with the near surface saline groundwater to form a perched freshwater lens within the wetlands. This wetland is classified as having a moderate potential of groundwater dependence (Groundwater Dependent Ecosystems Atlas, www.bom.gov.au).

Table 1: Cunningham Swamp Groundwater Resource Report. Source: Department of Environment, Land, Water and Planning Groundwater Reporting Tool https://www.water.vic.gov.au/groundwater/groundwater-resource-reports. Printed: 08 July 2020. Date Updated: 11 January 2019.

Groundwater Resource Report

Groundwater catchment: West Port Phillip Bay VICGRID94 Easting: 2476753 Northing: 2398183

Depth to water table: < 5m Water table salinity (mg/L): 3501 - 7000

Groundwater layers (Aquifers and Aquitards)	Depth below surface (m)	Groundwater salinity (mg/L)
QA Quaternary Aquifer sand, gravels, clay, silts	0 - 5	3501 - 13000
UTB Upper Tertiary / Quaternary Basalt basalt (fractured rock)	5 - 20	3501 - 13000
UTAF Upper Tertiary Aquifer (fluvial) sand, gravel and clay	20 - 49	3501 - 13000
UMTD Lower Mid-Tertiary Aquitard clay, silt, siltstone (fractured rock), marl (fractured rock), minor sand	49 - 157	Unknown
LTA Lower Tertiary Aquifer sand, gravel, clay and silt, minor coal	157 - 258	1001 - 3500
BSE Mesozoic and Palaeozoic Bedrock (basement) sedimentary (fractured rock): Sandstone, siltstone, mudstone, shale. Igneous (fractured rock): includes volcanics, granites, granodiorites.	258 - 458	3501 - 13000

Groundwater management unit (GMU)	Depth below surface (m)	PCV (ML/yr)
DEUTGAM WSPA	0-30	5,100

2.4. Climate

As most summer rainfall is lost to evaporation in a temperate Mediterranean climate, winter rainfall (April–October) is a better indicator of the water balance in a catchment than average annual rainfall (Barnett and Rix 2006).

Figure 5 provides an overview of rainfall trends across these months from the closest BOM weather station at the Laverton RAAF base (BOM station 87031). The data suggests that the catchment has experienced a trend of reduced rainfall in the 25 years from 1996, with only four years in that period (2000, 2010, 2016 and 2020) exceeding the long-term April-October mean of 313 mm.

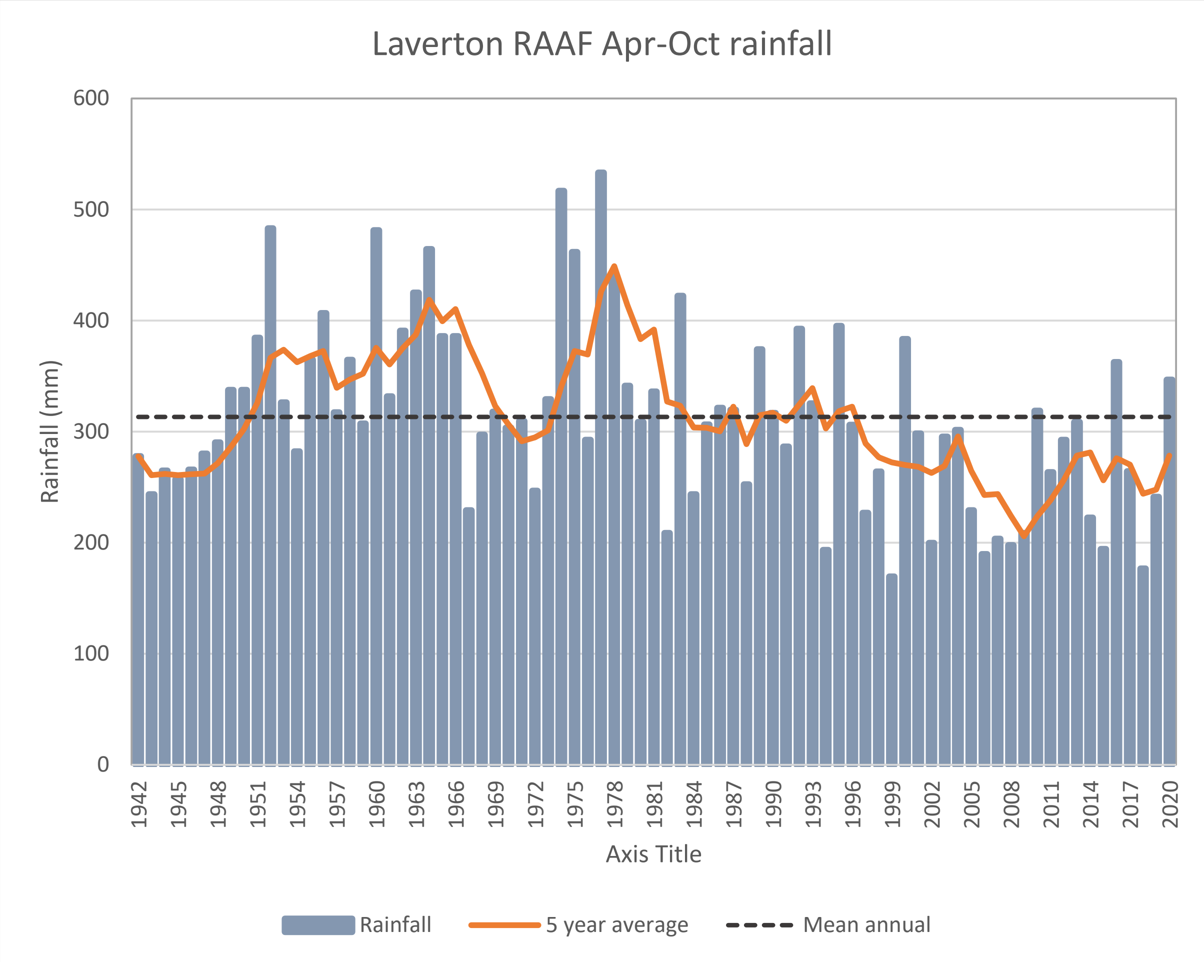


Figure 5: Laverton RAAF April-October rainfall

3. ORIGINAL VEGETATION AND WETLAND EXTENT

In 1841, the surveyor William Wedge Darke, in annotation on his map of the Cunningham Swamp area, described 'fine plains thinly wooded' between the town of Wyndham and the site of the future Werribee Park, as well as 'very rich thinly wooded sheep country' close to the coast between the river and Point Cook (Figure 6).

This area was designated an open woodland with the presence of *Themeda australis* grasslands, *Casuarina* (*Allocasuarina*) *stricta* (*verticillata*) and *Eucalyptus camaldulensis* (present as a dominant).

Pre-1750 EVC mapping is a model of the assumed pre-European settlement vegetation types of Victoria and provides an understanding of native vegetation, both prior to clearing and as it currently occurs. This layer, in combination with the extant EVC mapping, has been used to identify the level of depletion of EVCs across Victorian bioregions since settlement.

DELWP have assessed the Conservation Status of EVCs in each bioregion using a standard set of criteria. Assessment of the conservation status of vegetation types is based on the broad concepts of inherent rarity, degree of threat (including consideration of historic and on-going impacts) and importance for supporting other significant features (for example, as a drought refuge for native fauna). The combination of EVC and bioregion is used to determine the Bioregional Conservation Significance (BCS) of an EVC, known as BioEVC. This is a measure of the current extent and quality for each EVC, when compared to its original (pre-1750) extent and condition. On this basis, a BioEVC will have a BCS of endangered, vulnerable, depleted, least concern or rare.

Two BCS categories relevant to the Cunningham Swamp wetland complex include:

- Endangered – less than 10% of former range OR less than 10% pre-European extent remains (or a combination of depletion, loss of quality, current threats and rarity that gives a comparable status e.g. 10 to 30% pre-European extent remains and severely degraded); and
- Vulnerable – 10 to 30% pf pre-European extent remains (or a combination of depletion, loss of quality, current threats and rarity that gives a comparable status e.g. greater than 30% and up to 50% to 30% pre-European extent remains and moderately degraded over most of this area).

Based on DELWP mapping, five pre-European EVCs are assumed to have occurred in association with or adjacent to the Cunningham Swamp wetland complex. Two bioregionally endangered EVCs (Plains Sedgy Wetland – EVC 647 and Plains Grassy Wetland – EVC 125) are predicted to have occurred across the wetland area of Cunningham Swamp, while the surrounding area contained another endangered EVC – Plains Grassland (EVC 132) (Figure 7). Additional EVCs across the wider area are provided in Table 2 and shown in Figure 7. It should be noted that historical EVC modelling is quite coarse and its accuracy at the site-specific level should only be inferred as approximate.

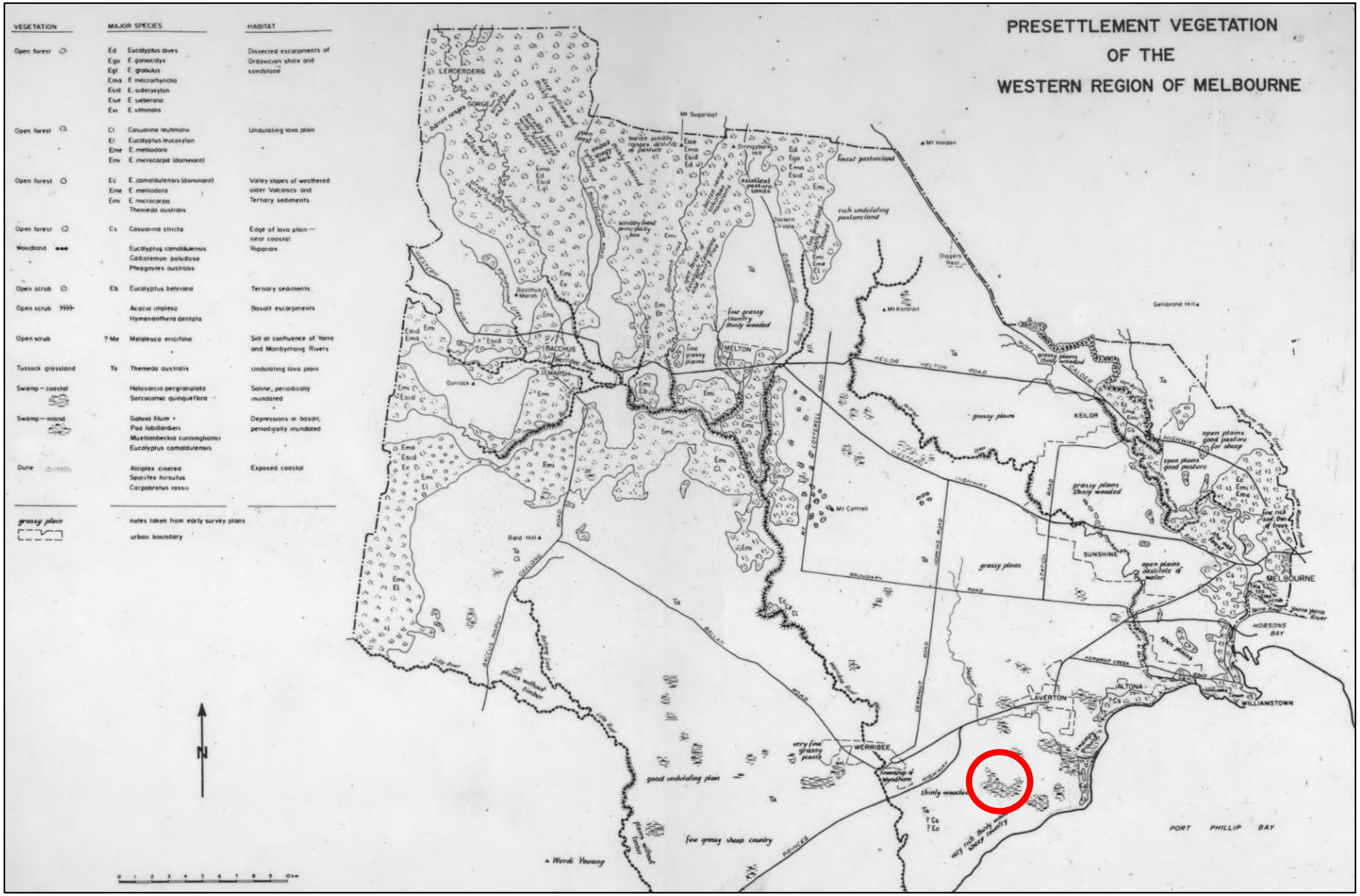


Figure 6: Pre-settlement vegetation of the western region of Melbourne (study area circled in red).

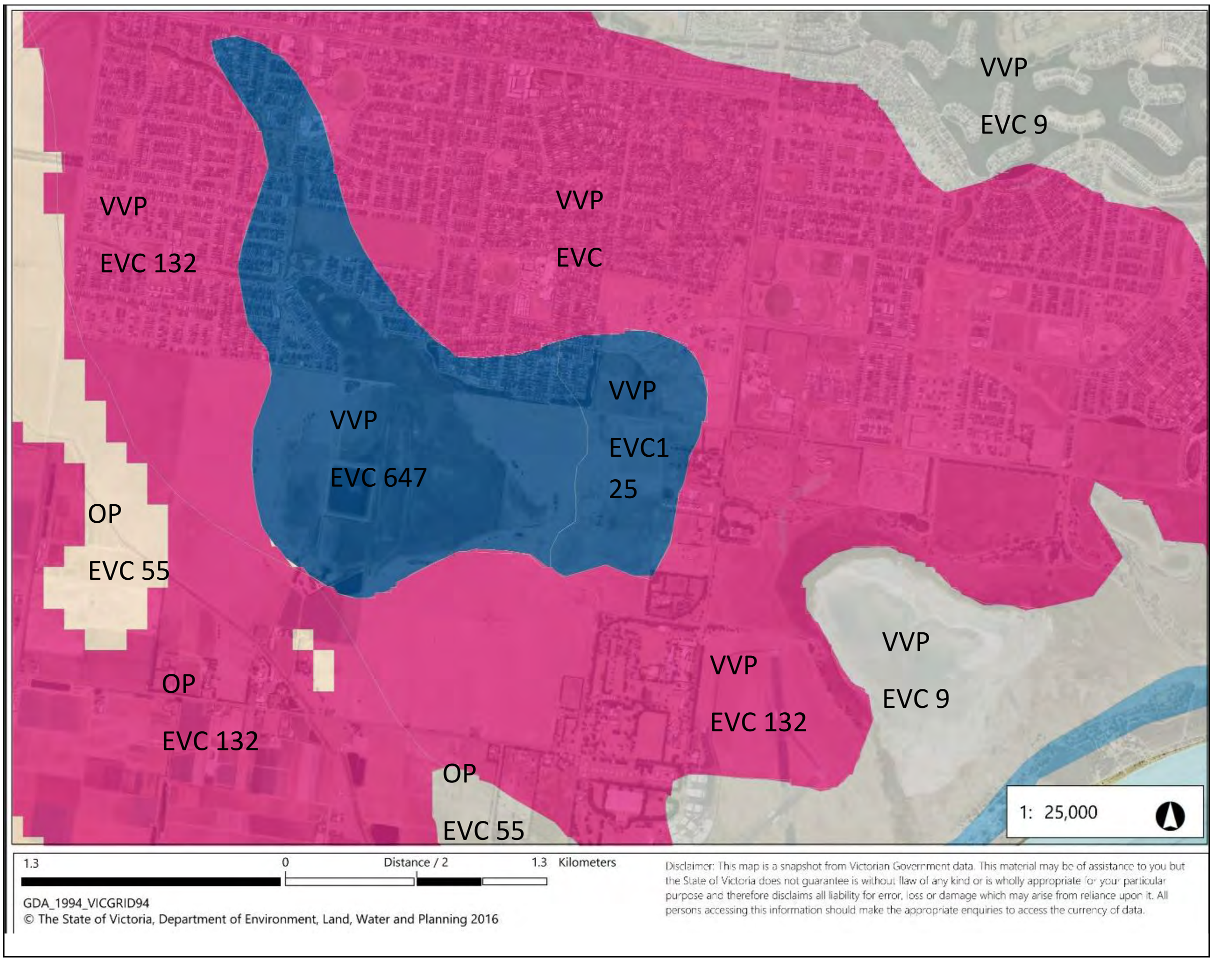


Figure 7: Pre-1750 Ecological Vegetation Classes (EVCs) at Cunningham Swamp. See Table 2 for details. Source: NatureKit www.maps.biodiversity.vic.gov.au

Table 2: Pre-European (Pre-1750) Ecological Vegetation Classes (EVCs) in and around Cunningham Swamp.

Pre-1750 EVC	EVC Number	Bioregion	Group	Subgroup	Geographic Occurrence	Current BCS	Pre-1750 Area (ha)
Plains Sedgy Wetland	647	Victorian Volcanic Plain	Wetlands:	Freshwater	Common	Endangered	230.2
Plains Grassy Wetland	125	Victorian Volcanic Plain	Wetlands:	Freshwater	Common	Endangered	64.5
Plains Grassland	132	Victorian Volcanic Plain	Plains Grasslands and Chenopod Shrublands	Clay soils	Common	Endangered	30856.1
Coastal Saltmarsh	9	Victorian Volcanic Plain	Salt-tolerant and / or succulent Shrublands	Coastal	Naturally restricted	Vulnerable	705.0
Plains Grassland	132	Otway Plain	Plains Grasslands and Chenopod Shrublands	Clay soils	Minor	Endangered	2026.4
Plains Grassy Woodland	55	Otway Plain	Plains Woodlands or Forests	Freely draining	Common	Endangered	2432.8

3.1. Timeline of change to wetland bathymetry and hydrology

A Department of Lands and Survey Map dated 03/06/1887 of Deutgam in the county of Bourke (Figure 8) shows Cunningham Swamp as a salt lake.

It is part of parcel XI (259 Ha) owned by Thomas Chirnside.

Figure 8: Deutgam County of Bourke 1887. (Cunningham Swamp circled in blue)

Aerial photography from 1951 (Figure 9) shows some modification of wetland 70617 and the associated chain of wetlands to its north-west.

A minor drain and small dam (area 1) have been constructed on the flow path into the wetland. At this time there are no drains in or out of Cunningham Swamp and it retains its natural bathymetry and presumably associated vegetation.

There is a ring of River Red Gum (area 2) around the high-water mark of the wetland.

Wetland 70594 (area 3) has been significantly modified, with signs of cropping across its surface, several fence lines across its base and some minor drains to a dam constructed in the south-eastern portion. Prior to artificial drainage, the wetland shows signs of salt scalding, giving clues as to its original underlying character, water regime and salinity.

Figure 9: 1951 Aerial photographs of Cunningham Swamp and surrounds (see text for explanation of shapes and numbers)

Aerial photography from 1989 (Figure 10) shows further modification of Cunningham Swamp with drains through and out of the swamp (4).

A small dam (5) has been constructed in the centre of the swamp and several fence lines have been constructed across its base.

Most of the River Red Gums remain, including a significant patch in the north-western corner (2).

There is evidence of different grazing impacts across the wetland base, with loss of some natural vegetation in areas.

Wetland 70594 (3) shows evidence of inundation in its northern portion, but the coverage of vegetation compared to the previous image also implies a change in water regime which has facilitated shifts in vegetation cover. Despite this change, it is apparent that the wetland still inundated to a degree at this time, at least during wetter years, and still held natural wetland values as late as 1990. This wetland was identified as containing remnant vegetation that qualifies against the Seasonal Herbaceous Wetlands listing and state-significant flora species (Ecology and Heritage Partners, 2014).

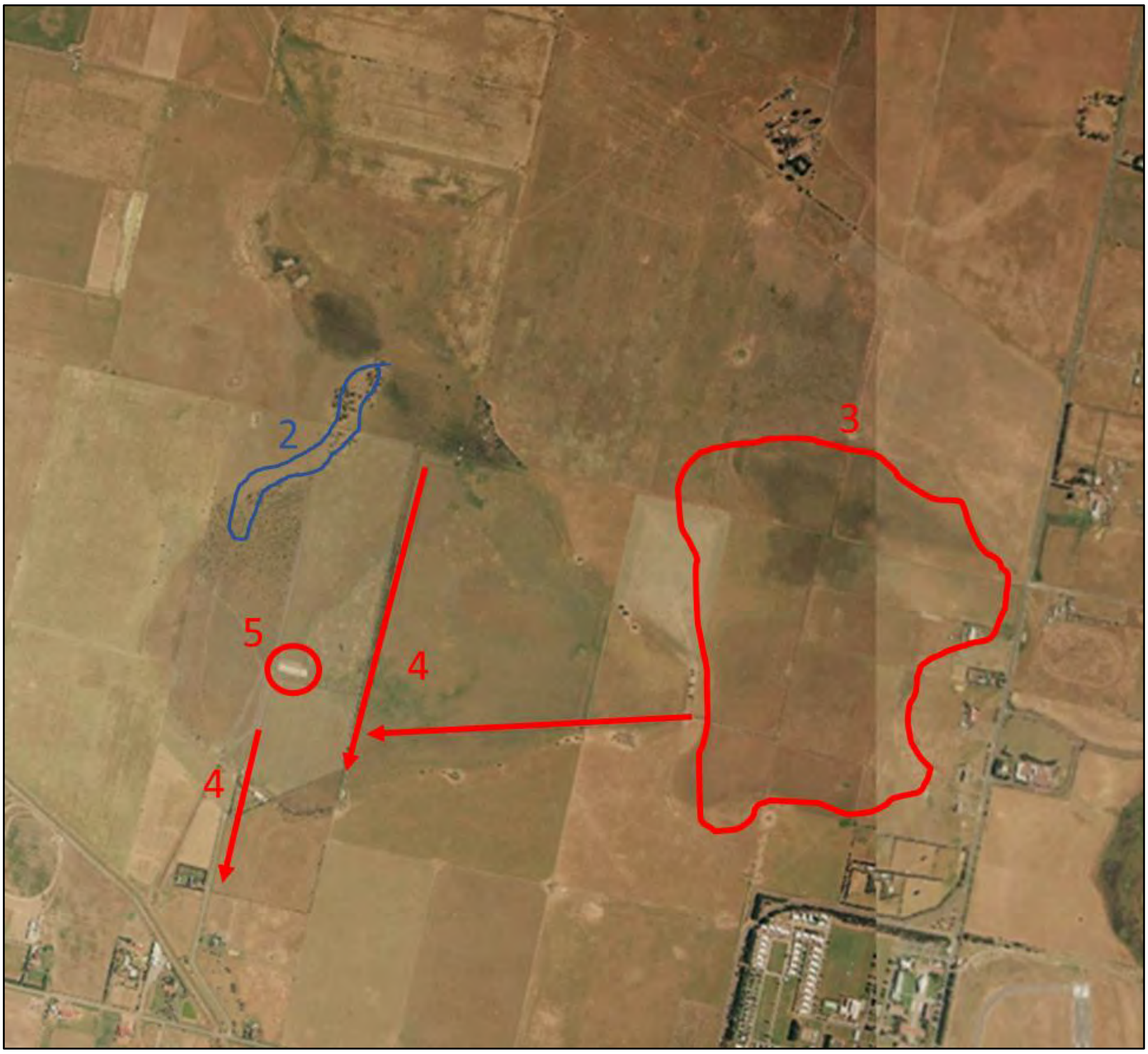
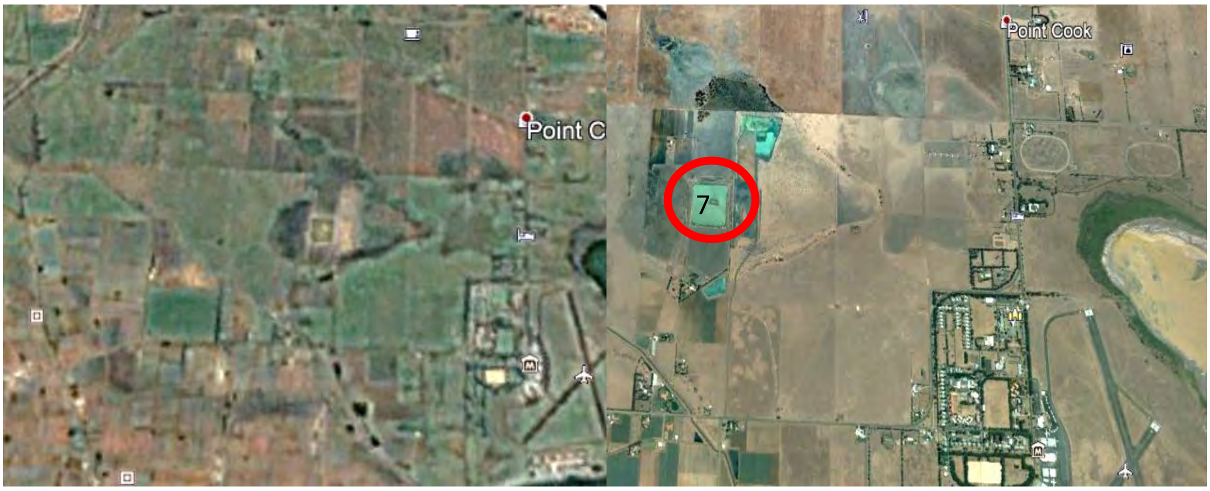


Figure 10: November 1989 aerial photograph montage of Cunningham Swamp and surrounds. Source: 2004 Melbourne 1989 Run 23B frames 93-96 (see text for explanation of shapes and numbers)

In February 2001, evidence of initial on-ground works that resulted in excavation of material to form the large bunded dam in the southern central region (6) of Cunningham Swamp first appear in Landsat imagery (Figure 11).

By April 2002 these works (7) show the footprint of the structure which is present today. At this time, the northern section is still natural, but the full extent of excavation had occurred by January 2003. Hence, despite its altered state, the timeline of major changes to the bathymetry are relatively recent.

Landsat 15/11/2000 Landsat 03/02/2001



Landsat 11/10/2002 Landsat 1/1/2003

Figure 11: Major bathymetric modifications to the Cunningham Swamp wetland complex over the last 20 years. Landsat Imagery November 2000 to January 2003 (see text for explanation of shapes and numbers).

Water Observations from Space (WOfS), viewed via the National Maps website (www.ga.gov.au/scientific-topics/community-safety/flood/wofs), provide information on the spatial and temporal extent of surface water on the Australian landscape, derived from satellite imagery from 1986 to the present. Over the 34-year period there are 1544 observations of Cunningham Swamp.

These data suggest that most of the wetland footprint is infrequently inundated (Figure 12) but that the deeper, excavated areas are semi-permanent to permanently inundated. The neighbouring RAAF Lake (70409) appears to be a near permanent deep marsh.

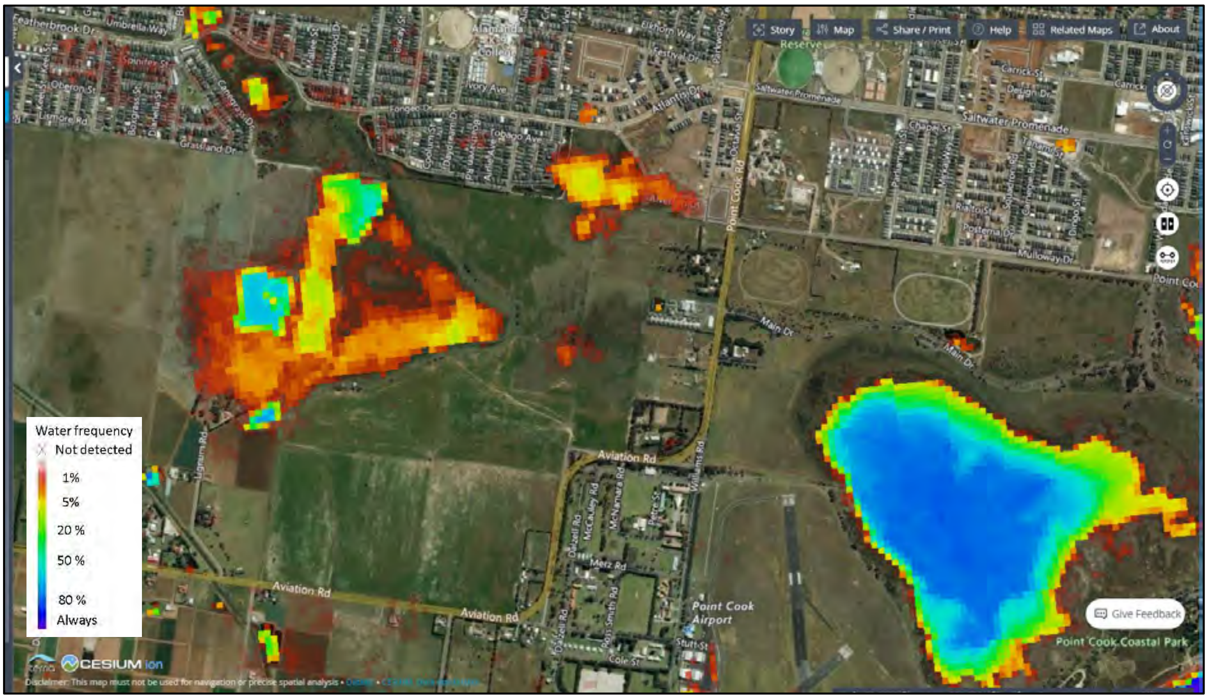


Figure 12: Unfiltered summary of all water observations - WOfS Statistics are calculated from the full depth time series (1986 – 2018). The water detected for each location is summed through time and then compared to the number of clear observations of that location. The result is a percentage value of the number of times water was observed at the location.

Inundation (water detection) is likely to be underrepresented in densely vegetated wetland areas and this does need to be considered as relevant context in interpreting this information. Brackish to saline systems don't typically contain dense perennial vegetation (in comparison to fresher wetlands) and the water signatures are much more reliable as a result.

Hence based on the constraints described above, and inundation signatures for adjacent wetlands, these data suggest that under the present modified (artificially drained) water regime the wider footprint of Cunningham Swamp is currently experiences ephemeral to seasonal inundation patterns, depending on climatic conditions, whereas it once would have been truly seasonal in nature.

A more detailed investigation of temporal change (Figure 13) reveals that the frequency of inundation in one part of Cunningham Swamp has increased, with a distinct transition to permanence from 2010 onwards.

This transition reflects:

- extensive works to modify and constrain flows across the wetland basin and in adjacent paddocks, resulting in the concentration of water in discrete areas of the wetland (the dams), as opposed to inundation across the wider wetland area; and,
- a corresponding likely increase in runoff from the rapidly urbanising (Point Cook Creek) catchment to the north.

Figure 13: Wet surface areas (top) and time series for frequency of wetting (bottom). Based on water classification (https://www.ga.gov.au/dea/products/wofs) for every available Landsat satellite image and wet frequency of greater than 10% of the time and are larger than 3125 m^2 i.e. 5 Landsat pixels.

Wetting frequency in discrete areas of the wetland indicate that wider inundation potential remains high and therefore the modification or "undoing" of some of the bathymetric changes and flow diversions has potential to help restore something approaching a pre-modification hydrological regime to wider areas of the wetland.

Past modifications impacting on site hydrology are clearly identifiable in a digital terrain model (Figure 14) and an annotated view of drainage and flow modifying features (Figure 15).

In summary, there are currently over 11 km of drains and 12.5 km of spoil banks or levees that have been constructed across the area.

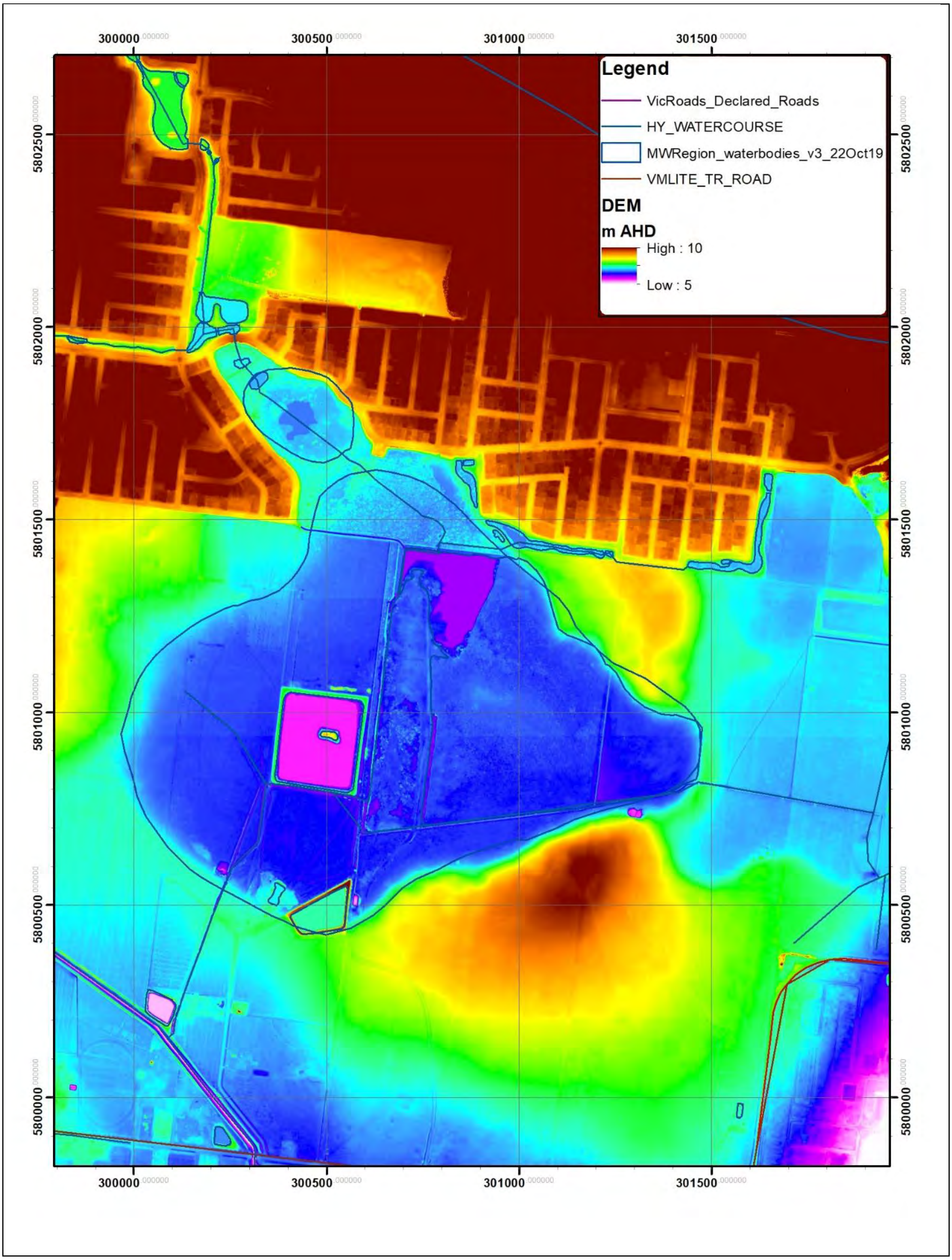


Figure 14: Cunningham Swamp Digital Elevation Model (DEM). DEM colour enhance constrained to 5 to 10 m AHD.

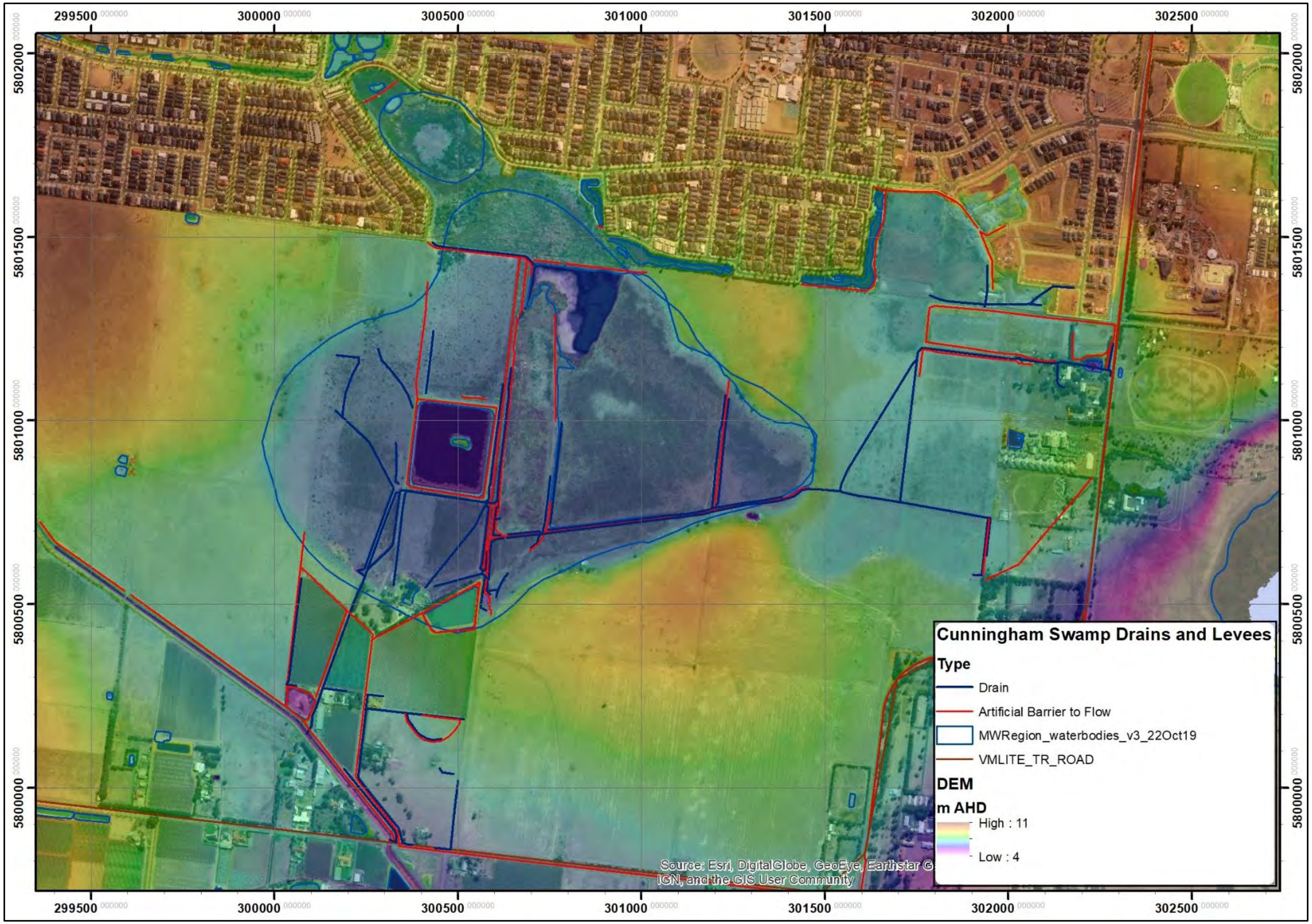


Figure 15: Drains and artificial constraints to flow across Cunningham Swamp locality. Aerial Photograph overlain with 70% transparent Digital Elevation Model (DEM). DEM colour enhance

3.2. Function of primary drains

The primary drains in the Aviators Field PSP have been summarised by GHD (2020), referred to as Channels North, East, South and Southwest (Figure 16). These can be described as follows:

Channel North drains Cunningham Swamp internally and functions as the primary drainage for the wetland system. It runs from the northern boundary of the PSP area to the centre of Cunningham Swamp, where it meets Channel East.

Channel East begins on the eastern extent of the PSP and drains the floodplain including Wetland 70594 (Point Cook Seasonal Herbaceous Wetland) and the eastern half of Cunningham Swamp. The drain moves water west to its confluence with Channel North in the centre of Cunningham Swamp.

Channel South is the outlet arm for the Aviator's Field drainage system and extends from the confluence of Channel North and Channel East to the constructed D1 Drain, where it is hydraulically controlled by a reinforced concrete pipe culvert.

Channel Northwest drains the residential development to the northwest of the study site, providing primary treatment of stormwater through a sedimentation system and vegetated drain, before depositing flows into the wetland.

Figure 16: Aviators Field PSP waterway channels (derived from GHD 2020)

3.3. Contemporary vegetation

An overview of vegetation communities has been superimposed through a combination of consolidating past reports, contemporary mapping based on high-resolution aerial imagery, and ground-truthing. This information informs our understanding of current and potential future inundation regimes and likely vegetation response.

Ground-truthing of existing values occurred during a site visit in April 2021 and entailed vegetation transect surveys through representative locations across the swamp encompassing:

- description of wetland/terrestrial vegetation type and condition;
- representative photopoints;
- inundation levels;
- location and depth of any drains; and
- weed species present.

As previously described by GHD (2020), the main vegetation communities providing wetland habitat of value are Plains Grassy Wetland / Lignum Swamp Complex (EVC A101) and Tall Marsh (EVC 821). Artificial dams also provide permanent water and support fringing Tall Marsh. The wider pattern of vegetation across the site matches elevation profile and resulting inundation frequency as follows:

- **Higher ground** with exotic grasses, and agricultural weeds including Artichoke Thistle (*Cynara cardunculus*) and Serrated Tussock (*Nassella trichotoma*) along with some native grassland remnants.
- **Seasonally damp** areas with Tangled Lignum (*Duma florulenta*), River Red Gum (*Eucalyptus camaldulensis* ssp. *camaldulensis*), African Boxthorn (**Lycium ferocissimum*), around the fringe, with Lignum and weedy grasses including Toowoomba Canary-grass (**Phalaris aquatica*) and Tall Wheat-grass (**Thinopyrum ponticum*) extending downslope and into the wetland proper in some areas.
- **Edge of inundated zone** including *Juncus* species, Nardoo (*Marsilea drummondii*), Milfoil (*Myriophyllum* spp.), Raspwort (*Haloragis* spp.), and scattered Southern Cane-grass (*Eragrostis infecunda*).
- **Inundated zone** including dense Southern Cane-grass, Milfoil, and Common Duckweed (*Lemna minor*) in open water.
- **Deep** artificial dams are fringed by Cumbungi (*Typha domingensis*) and Common Reed (*Phragmites australis*) with open water in the deeper sections.
- **Drains** contain Common Spike-rush (*Eleocharis acuta*) and Water Milfoil.

The condition of vegetation communities is also influenced by disturbance history, the majority of which has occurred relatively recently and is ongoing through periodic grazing and associated impacts (e.g. pugging). High resolution aerial imagery is available from 2009 and this captures a transition of areas which were essentially bare earth, to what has now regenerated to the present day. This transition corresponds both with the end of the millennium drought and may, in part, be due to the wetland being less accessible for agricultural activities. Irrespective of the drivers, this recent and rapid transition, even in the absence of full hydrological restoration, illustrates the inherent recovery potential and dynamic nature of wetlands.

A map of contemporary vegetation communities is provided in Figure 17.

These are areas which have elements consistent with EVC descriptions, but which vary in condition according to level of weed infestation and the degree of disturbance. An overview of areas which have been subject to disturbance in recent history (since 2009) highlights those areas which have regenerated relatively recently but are likely to exhibit higher weed loads and/or poorer or transitioned floristic diversity (Figure 17).

Figure 17: Area with identifiable Ecological Vegetation Class remnants across Cunningham Swamp (recent modification dates indicated)

4. RESTORATION SCENARIOS AND RESPONSE MODELLING

Artificial wetlands are being constructed around the world to provide 'environmental services' that have been removed by dredging, draining, and filling natural wetlands. The services that natural wetlands provide were often not recognised and valued before they were lost, and the urban environment is being retrofitted with artificial wetlands in an attempt to recreate their function (Giblett 2020).

In many scenarios, the temptation early in the planning process (from an urban engineering perspective) is to design constructed wetlands to provide these services, sometimes superimposed within the footprint of natural wetlands, to maximise developable area. This can mean that in many locations the range of services which could and ideally would be provided by restoring natural wetlands and their functionality is overlooked – ultimately leading to permanent loss via complete or partial infilling, or modification of their original geomorphic form.

Previously modified natural wetlands in urban growth areas are therefore often viewed as a problematic, flood-prone part of the landscape, that need to be further altered through major engineering to service and facilitate development of the surrounding area.

However, a more integrated, culturally appropriate (for Traditional Owners) and biodiversity-sensitive approach, capable of working with the natural form of the landscape, is to assess the wetland by considering its pre-disturbance state and determining which disturbances can be rectified (soft disturbances) versus those which cannot be rectified (hard disturbances). These can be physical (e.g. changes to bathymetry), chemical (e.g. destruction of seed banks through application of fertiliser or salinisation) or biological (e.g. vegetation responses, weed invasion and grazing).

Given the underlying resilience of wetland plants and their propagules to minor physical disturbance, a useful foundation for understanding likelihood or response is the assignment of Inundation Likelihood Zones (ILZs). Within a wetland feature, these are areas which are subject to the same hydrological drivers e.g. water source and depth of inundation.

For Cunningham Swamp, we have identified three zones based on elevation, using 10 cm contours derived from LiDAR and a visual assessment of contours which encapsulated broad areas fringing and across the pre-European wetland footprint. Where bathymetric changes were apparent (i.e. dams and drainage channels), a boundary was approximated according to natural surface elevations adjacent to the modified area. These three units are as follows:

- Bank (mostly dry - 7.3 to 7 m AHD);
- Fringe (damp - 7.0 to 6.7 m AHD); and
- Inundation zone (ephemeral inundation - below 6.7 m AHD).

A visual overlay of the extent of these zones is provided in Figure 18. This assignment assumes that groundwater contributions and surface water influences are uniform across the wetland. There are likely to be some discrepancies around major points of inflow, particularly at the northern end, where urbanisation in the northern part of the catchment means that inflows and inundation of the area fringing the inflow area are now flashier in comparison to the wider wetland area. Drains, dams, and levee banks now provide additional areas where the modified inundation profile, and its interaction with flows, is likely to be inconsistent with the general elevation pattern.

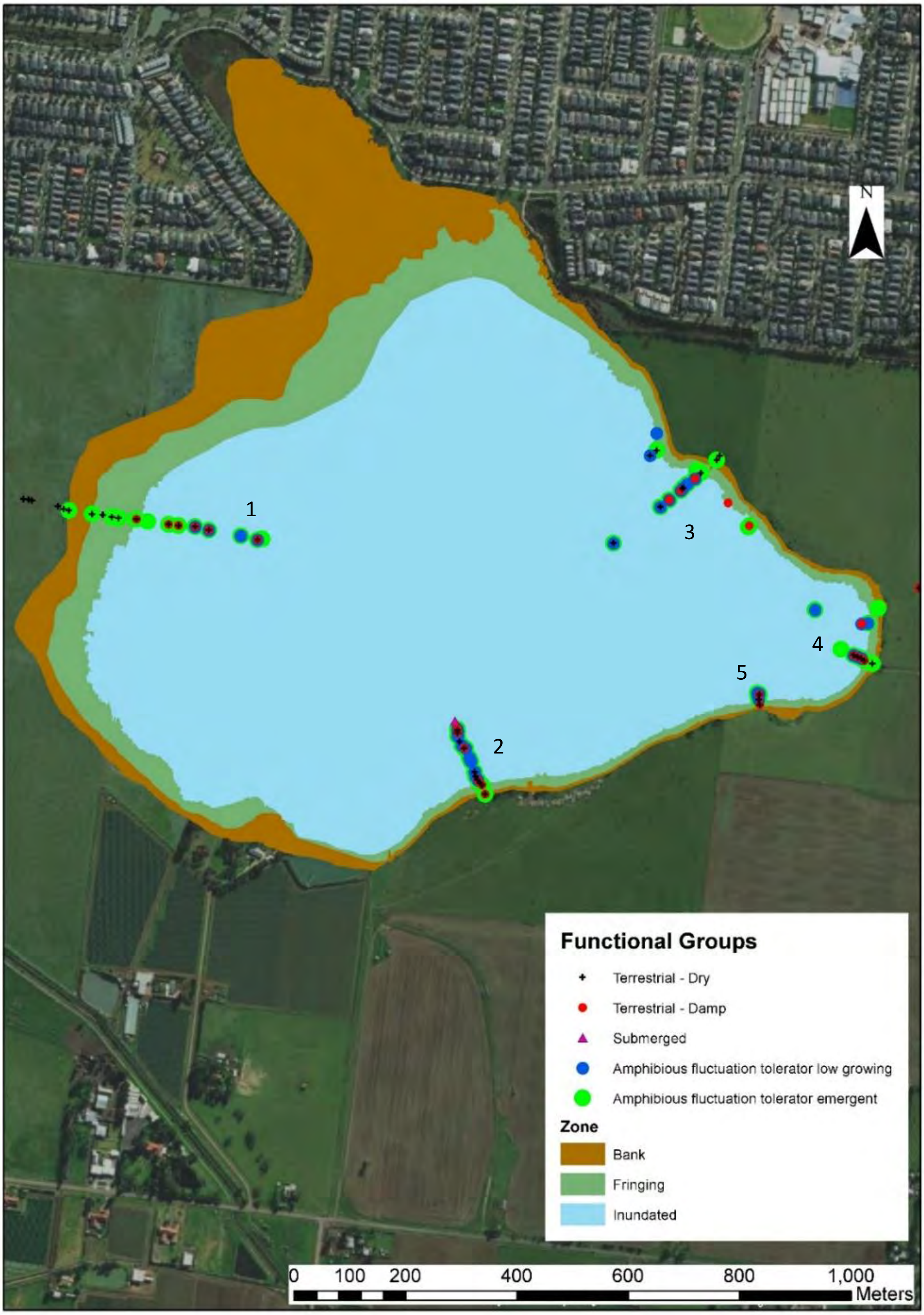


Figure 18: Hydro-geomorphic zones based on an assumed pre-European bathymetry across Cunningham Swamp showing cross-sections (numbered) and functional groups identified.

4.1. Contemporary indicators

In terms of ILZs we have estimated the extent of different functional groups (FGs) of plants (Table 3).

Table 3: Plant functional group descriptions and acronyms as described by Leck and Brock (2000).

Type	Constraints			Group
Terrestrial	**Do not tolerate flooding**			
	Dry	Germination, growth, and reproduction in the absence of surface water and where the water table is below the soil surface		Tdr
	Damp	Germination, growth, and reproduction on saturated soil		Tdamp
Amphibious Tolerate flooding and drying	**Tolerate flooding and drying**			
	Fluctuation tolerator	Germination under damp or flooded conditions		
		Emergent	Basal portions under water and reproduction out of water	Afte
		Low growing	Low growing and tolerate complete submersion	Aftl
		Vines	Vines	Aftv
		Trees and shrubs	Woody plants	Aftw
	Fluctuation responder	Germination under flooded conditions, growth in flooded and damp conditions and reproductions out of water		
		Morphologically plastic	Heterophylly in response to water level variation	Afrp
		Floating leaves	Floating leaves when inundated	Afrf
Submerged	**Do not tolerate drying**			S

For the "bank zone" we would anticipate a grading from terrestrial dry (**Tdry**) to terrestrial damp (**Tdamp**), the "fringe zone" transitioning from **Tdamp** to amphibious fluctuation tolerators (**Aft**) and the "inundation zone" containing a mix of **Aft**, amphibious fluctuation responder (**Afr**) and submerged (**S**) species (Figure 19).

The bathymetric shape and overall shallowness (aside from artificial dams and channels) suggest that submergent species were likely not a feature in a pre-European Cunningham Swamp. An overview of species currently found across the wetland and their respective functional grouping is provided in Figure 20 (See Appendix 1 for species recorded and functional grouping). This overview indicates that contemporary vegetation zonation is still broadly consistent with elevation, but that the contemporary wetter area vegetation assemblage is composed of amphibious fluctuation tolerator emergent (**Afte)** species (*Eragrostis infecunda*, *Juncus* species, *Eleocharis acuta*) which are more resilient under drying conditions (Deane et al. 2018) and have persisted following agricultural disturbance. Of note is the general absence of amphibious fluctuation tolerator low-growing (**Aftl)** species, none of which have been recorded in previous studies or during ground-truthing components in this study.

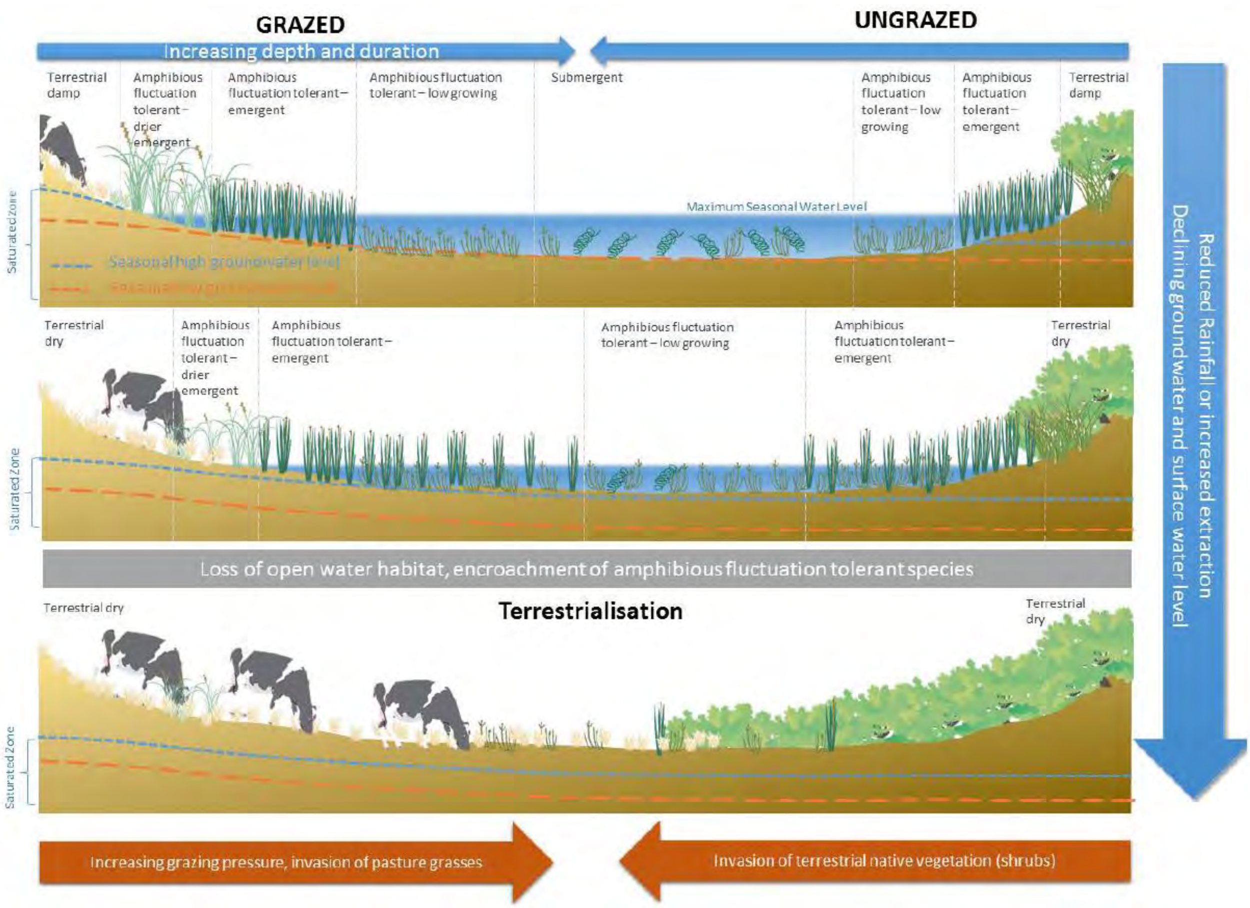


Figure 19: Conceptual model of changes in wetland plant functional group zonation because of declining water availability (Deane et al. 2015).

Previous reports have suggested that the wetland potentially contains assemblages consistent with "Seasonal Herbaceous Wetland" vegetation (Melbourne Water 2018) although more recent and detailed investigations did not find characteristic vegetation present which met with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) criteria for this community (GHD, 2020). The apparent lack of floristic diversity is potentially a consequence of grazing, cropping and drainage (GHD 2009, Ecology and Heritage Partners 2014, GHD 2018), which would result in some of the less tolerant **Afr** species dropping out. It should also be noted that additional surveys targeted at wetter periods (and following sustained inactivity of grazing) are required to fully determine this but the overall abundance of more tolerant species like *E. infecunda* is indicative of an overall modification of state.

The **Afte** functional group is primarily composed of grasses and sedges, but the higher coverage of smaller herb species (**Aftl**) provides an interesting point of focus for determining likely response under restoration scenarios. Raspwort (*Haloragis* species), Nardoo (*Marsilea* species) and Milfoil (*Myriophyllum* species) were only observed across areas of the wetland below approximately 6.7 m AHD (Figure 20) (see Figure 21 for example photo of community).

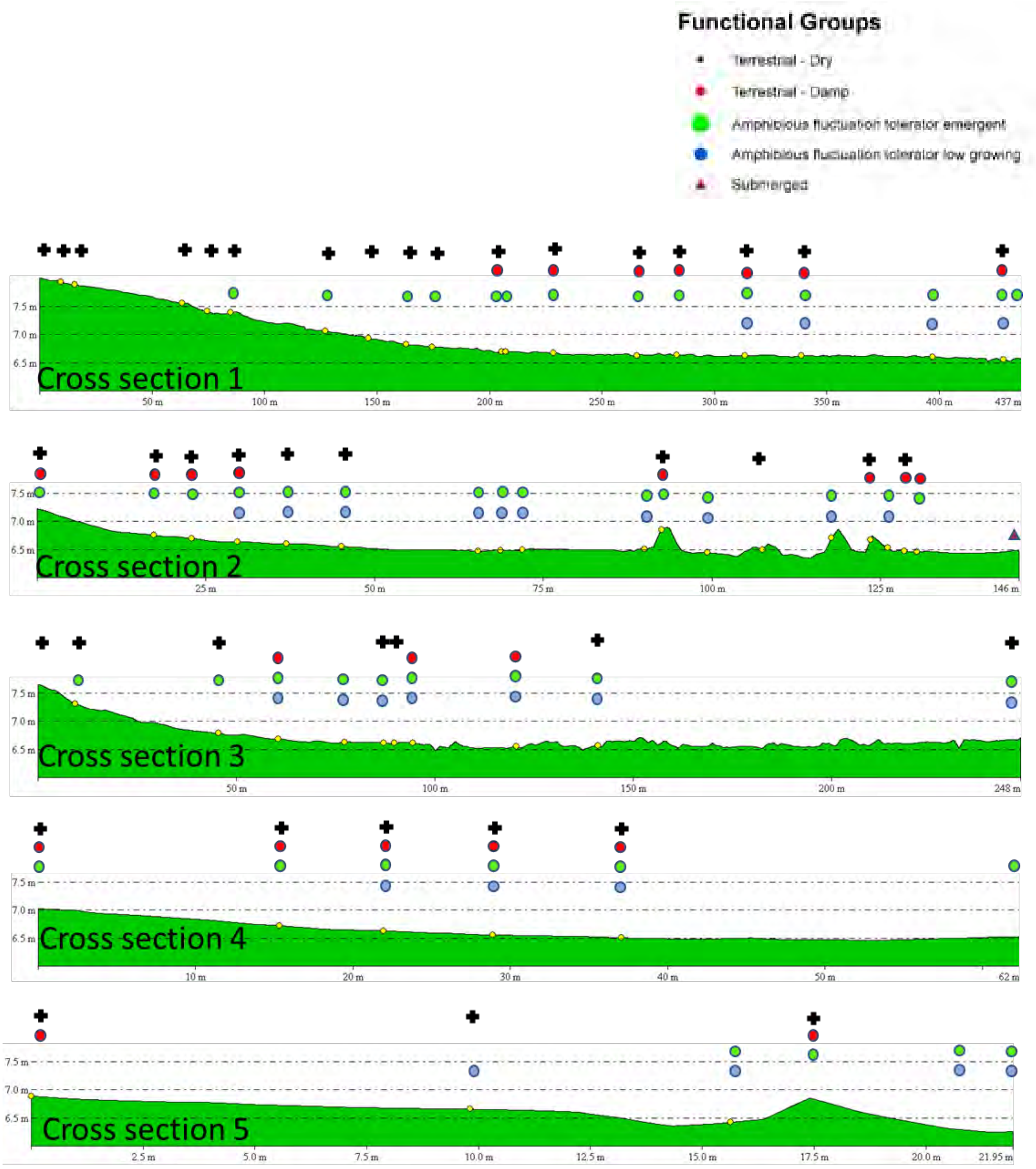


Figure 20: Occurrence of functional groups in relation to cross-sectional elevation (LiDAR-derived) for five transects at Cunningham Swamp (See Figure 18 for cross-sections).

The western section of the wetland (cross-section 1) shows that, despite falling within this depth range, representation of these species is limited to the middle section of the wetland. Hence, FG representation in this zone suggests additional disturbance agents to those occurring across the other areas surveyed. It should also be noted that **Tdry** species also occur across the middle sections of the wetland, however these are predominantly associated with exotic species growing opportunistically on higher points (mounds, levee banks etc.) across the wetland. Nevertheless, the extent of **Tdry** species across the cross-sections is most pronounced in the western section (cross-section 1), indicating that this section is undergoing a hydrological regime which varies from (i.e. is artificially even drier than) the other areas surveyed.

Figure 21: A wetter section of Cunningham Swamp showing a mix of Amphibious fluctuation tolerant (Aft) and responder (Afr) species.

While there have been obvious changes to the way water enters the wetland and finds its way across the wetland / floodplain, there have also been occurrences of grazing, ploughing and surface scalping, the latter two of which have been identified in more recent aerial imagery (Figure 17).

It is particularly interesting to note that areas of Tall Marsh (S), which do not tolerate long-term drying, have colonised areas which have been deeply excavated and where inundation is now more reliable (see Figure 22).

*Figure 22: Tall marsh (*Typha domingensis *– right),*
establishing in an artificially deep excavation alongside a dam bank.

This community is an associated habitat for several bird species, including the nationally endangered Australasian Bittern and, despite it being an unlikely component of the wetland's original character, it does now add an extra element of habitat complexity. It is an EVC which has responded favourably to hydrologically disruptive works in wetlands across the globe. Its capacity to rapidly colonise areas subject to flashy inflows, increased nutrient inputs and silt deposition, have made it a problematic responder in the context of conventional waterway management. However, the underlying drivers creating optimal habitat for Tall Marsh species are difficult to counteract in the face of ongoing urban expansion and agricultural intensification, so a more holistic approach can entail working with the EVC, recognising its habitat value and facilitating drivers and disturbance regimes in an attempt to limit the species to areas fringing deeper sections; with lower growing grasses, sedges, herbs and more extensive open areas for waterbird foraging (i.e. more sustained and extensive seasonal wetting and drying rather than pulse flows and concentrated inundation areas).

Tall Marsh habitat in Cunningham Swamp is dominated by Narrow-leaf Cumbungi (*Typha domingensis*) with Common Reed (*Phragmites australis*) being almost or entirely absent (GHD, 2020) which bodes well for follow-up action as Common Reed is a much more aggressive (and often ecologically unwanted) coloniser. The species is very effective at permanently altering site conditions and vegetation communities through positive feedback loops that affect the morphology of the wetland bed (through accumulation of root mass) and site hydrology (Wilson and Agnew 1992, Packer et al. 2017).

For the "bank zone" we would anticipate a grading from terrestrial dry (**Tdry**) to terrestrial damp (**Tdamp**) FGs, the "fringe zone" transitioning from **Tdamp** to amphibious fluctuation tolerators (**Aft**) and the inundation zone containing a mix of **Aft**, amphibious fluctuation responder (**Afr**) and submerged (**S**) species. This pattern does occur across the wetland, in its modified state, but with greater representation of bank and fringe zone species over a majority of the historical inundation zone.

Representative photos of contemporary vegetation across these zones are provided below (Figure 23 through to Figure 30).

Figure 23: Bank zone vegetation: typical lower quality area with Galenia, Artichoke Thistle and Phalaris.

Figure 24: Bank zone vegetation: higher quality area dominated by Wallaby Grass with scattered rushes.

Figure 25: Fringe zone vegetation: Tangled Lignum with River Red Gum overstorey and weedy ground layer, impacted by clearance and grazing.

Figure 26: Fringe zone vegetation: Lignum Swamp EVC (open woodland form) to the north-west of the wetland, excluded from grazing and in higher condition with native Wallaby and Spear Grass understorey.

Figure 27: Fringe zone vegetation: Southern Cane-grass and Tangled Lignum with Phalaris and interspersed native grasses.

Figure 28: Inundation zone vegetation: emergent rushes (Juncus), with lower-growing Spike-sedge, Nardoo, Milfoil and small aquatic herbs and sedges.

Figure 29: Inundation zone vegetation: large areas of Southern Cane-grass with interspersed Juncus (darker) and emergent Lignum, looking south from the southern spoil bank of the bunded dam.

Figure 30: Inundation zone vegetation: closer view of Southern Cane-grass with Nardoo, Milfoil and Juncus.

4.2. Management zones

The nature of disturbance across Cunningham Swamp means that different areas of the wetland are acting independently from one another and can currently be considered as distinct management zones under present, hydrologically modified, conditions.

Recent management has seen a cessation of intensive agriculture, however the disruption to surface flow has resulted in different parts of the wetland becoming hydrologically disconnected and water is typically confined to drains. Spoil banks formed alongside the drains and around dams also mean that water which does make it on to the wider floodplain becomes trapped, resulting in localised and prolonged inundation of some areas of the wetland, while other areas remain artificially dry.

The effect of this can be seen on the far eastern edge of the wetland where bare ground stands out from the surrounding areas where vegetation has re-established or persisted (Figure 31).

Figure 31: Example of bare ground adjacent to drain bank, indicative of impounding of flows and prolonged inundation.

A key consideration for restoring Cunningham Swamp therefore lies in how the network of drains and banks can be remediated, allowing the surrounding bathymetry to accommodate stormwater pulses, while also supporting the natural and potential future habitat values that will positively respond if the entire wetland feature is allowed to regain functionality. Hydraulic modelling to reflect restoration scenarios that accommodate the remediated terrain within the wetland, and projected catchment changes as a result of adjacent urbanisation, would be a necessary first-step process in this instance.

The wetland can be broken down into 12 units which reflect whether inundation has been increased or decreased because of drains and banks (Figure 32).

Both northern zones are now wetter because of urban development and stormwater runoff. Because of the proximity of housing, facilitation of flows through this area is required. An additional drain also enters from the west. Banks on the southern side of this drain prevent inflow entering the Central 2 Zone and, in combination with the northern drains from North 1 and North 2, deliver water to an excavated area at the top of Central 3.

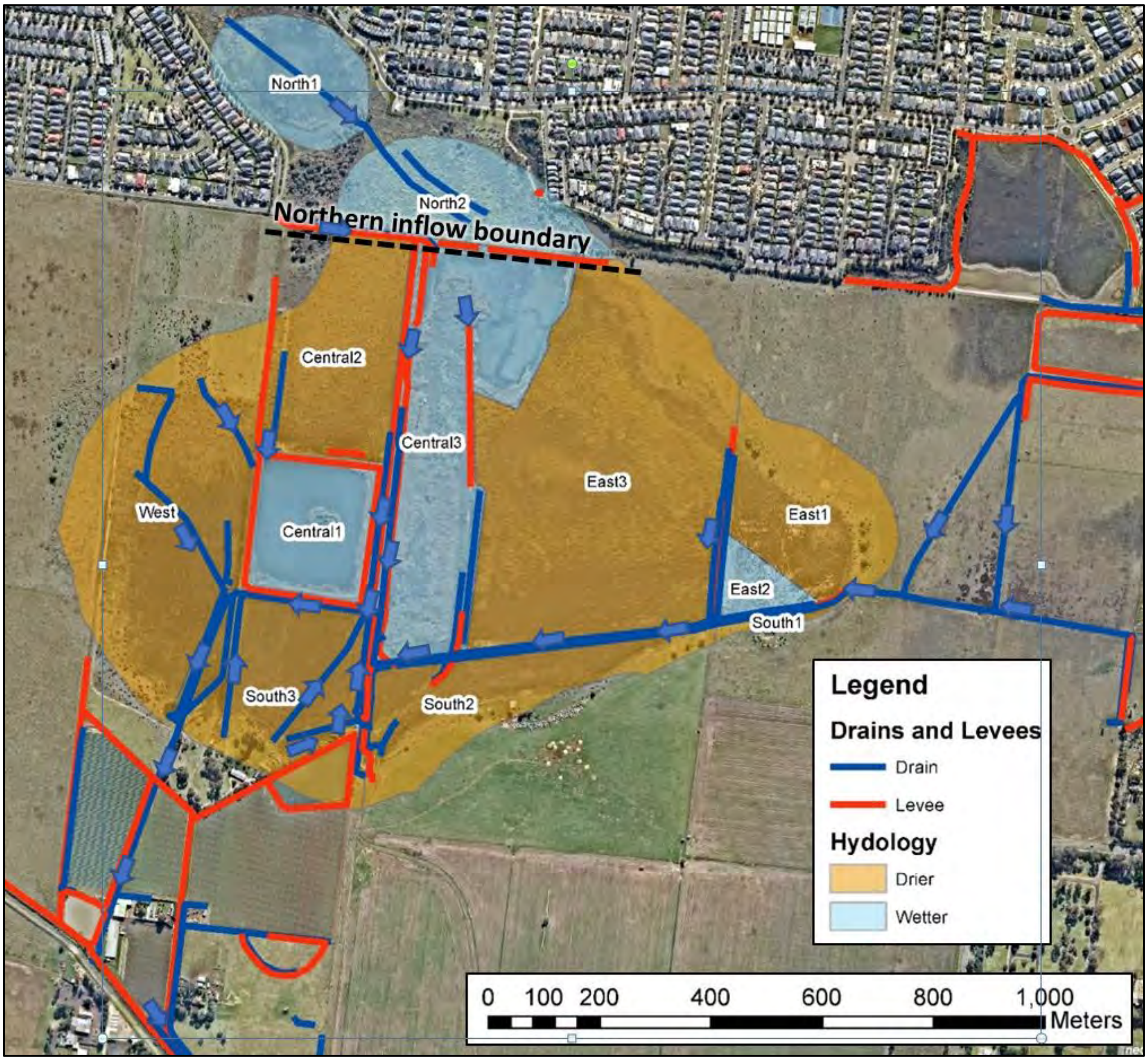


Figure 32: Hydrological management zones of Cunningham Swamp. (Arrows indicated direction of flow).

Banks and drains facilitate movement of water through Central 3 and into the outflow drain which passes through South 3. The central 3 zone is much wetter as a result and has seen the establishment of Tall Marsh. The Central 1 zone is a bunded and excavated agricultural dam. Closer inspection is required to determine if flows enter this dam (via culverts or pumping), and thereby its influence on the hydrology of the wider wetland area. It is currently assumed that groundwater contributions likely underpin water permanence.

Additional inflows enter the wetland from the east, acting to increase inflows into the wetlands but conveying water toward the southern outlet drain. Banks and excavations alongside this drain result in localised water accumulation on the floodplain side of the drain, particularly in zone East 2 and, to a lesser extent, zone East 3.

Aside from the Northern zones and Central 1 and Central 3 Zones, drains across all other zones act to draw water from the wetland and floodplain, resulting in them being drier than their natural state. This drying trend is evident in the vegetation present, including an increasing coverage of *E. infecunda* and also weeds (GHD, 2020).

5. RESTORATION OPTIONS

To restore Cunningham Swamp, the primary action that would be recommended is to backfill drains and levees to restore the natural bathymetry of the wetland. Visual inspection confirmed that most of the drains have an overburden bank which could be pushed back in with machinery during dry conditions. This would be a relatively inexpensive activity and allow inflows to re-engage with the natural wetland surface / floodplain. This would also remove artificially elevated areas where exotic species preferentially establish and grow, reducing the opportunity for weed invasion across the wetland. With respect to the northern urban area, removal of drain banks would also facilitate flows of stormwater to dissipate over a larger area, effectively increasing the cross-sectional profile at the northern end of the wetland (Figure 33).

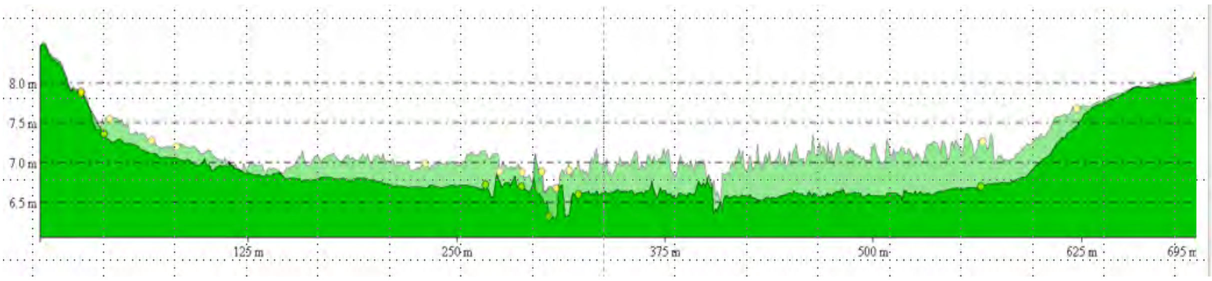


Figure 33: Comparison of current (lighter green) and rectified (darker green) cross-sections at the northern inflow boundary of Cunningham Swamp if the boundary embankment were removed (See Figure 32 for cross-section location – black dashed line)

Consideration also needs to be given to setting an appropriate outlet sill to manage inundation depth and passing flows. This relates to the depth of the drain at the outflow point, and ultimately sets the depth of inundation across the wider wetland area. Upstream of this point, the artificial drain would be backfilled across and within the wetland itself, while downstream of this point, flows would be permitted to re-enter, and confine flows to, existing artificial drainage infrastructure.

Bearing in mind that Cunningham Swamp was never a permanent lake (a deep, static waterbody), ideally the sill would be a spillway, set at a level that is not manipulated and designed to:

- allow outflows and capable of offsetting temporary water level rises across the wetland (so that flows do not back up and compromise stormwater infrastructure).
- enable natural seasonal variation in water extent and depth in response to periods of inflows and drying.
- facilitate inundation depths capable of supporting maximum wetland habitat diversity that, if possible, broadly approximates its original condition.

Initial inundation extent modelling derived from LiDAR based digital terrain modelling indicates that a fixed sill level above 6.9 m AHD would see water backing up drains into the wetland system to the east, the Point Cook Seasonal Herbaceous Wetland (Figure 34). Based on the defined outlet of the Point Cook Seasonal Herbaceous Wetland, and overall bathymetry in relation to adjacent urban infrastructure, this wetland also offers high potential for hydrological restoration.

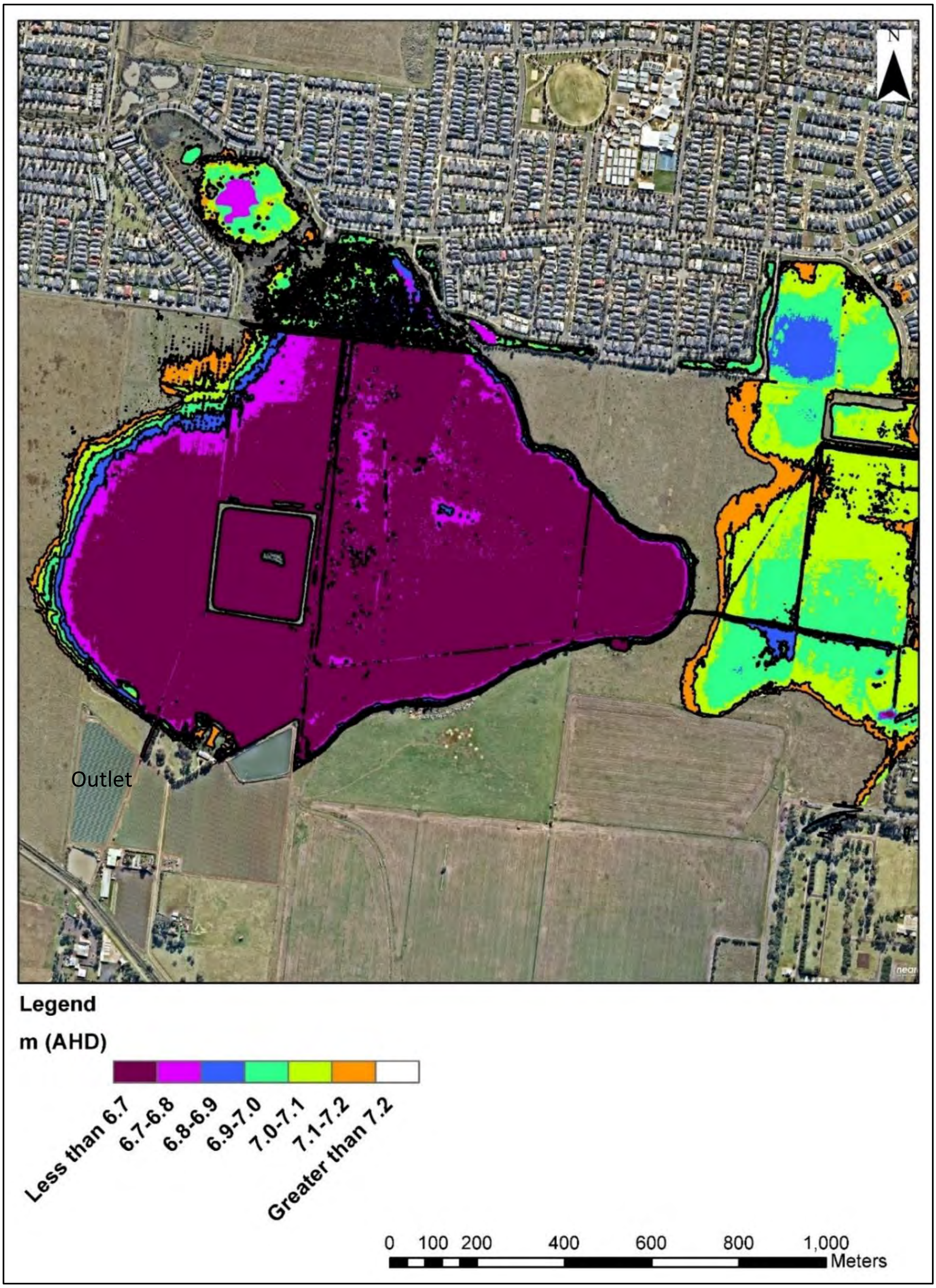


Figure 34: Inundation extents based on 10 cm increments across Cunningham Swamp and adjacent areas (including Point Cook Seasonal Herbaceous Wetland to the east) connected by drainage.

At this level, the inundation level would still fall below the height of the northwest drain bank and allow 2.4 m freeboard for roads surrounding the northern urban area. The wetland could quite safely contain inundation up to 7.2 m AHD in flood events, which would equate to approximately 300 ML of storage volume based on a volume-depth relationship (Figure 35).

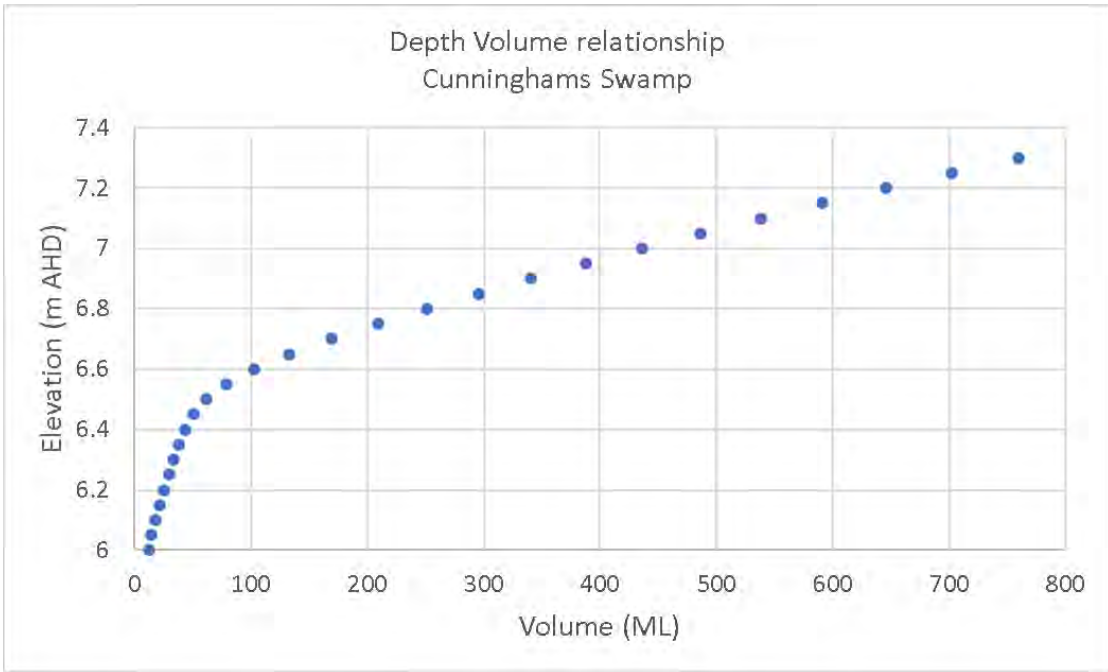


Figure 35: Relationship between depth and volume up to maximum full supply level of Cunningham Swamp

Two-dimensional hydraulic flow modelling, using a terrain model modified to reflect the system without internal drains and banks, and augmented with calibrated flow data, would be required to inform whether the overall wetland volume and outlet capacity could accommodate significant rainfall events.

An adjustable outlet structure – via removable gauge boards fitted to the existing outlet structure – could be installed but should only be considered if absolutely necessary considering modelled risk and/or future management flexibility. Alternatively a static spillway outlet sill level is not only ecologically preferable, but it reduces risk because it removes potential for tampering and eliminates the need for agreed ongoing operating procedures and resource-intensive management responsibilities. Either way, outlet infrastructure could be designed to tie into the reinforced concrete pipe culvert currently in place at the outlet.

Additional restoration scenarios can be considered around different zones of the wetlands, retaining isolation from the northern and eastern inflows. However, any of these would compromise the overall restoration outcomes and flood mitigation capacity hence a detailed exploration of each of these scenarios is not recommended.

A final consideration is the removal or backfilling of excavations, namely the bunded dam and the excavated area in the northern part of Central Zone 3. These excavated areas do have some impact in terms of increasing the amount of water required to achieve increases in depth of inundation across the wider wetland, but they likely offer some value in the form of additional habitat complexity – albeit artificial, including deeper drought-refuge habitat – across the wetland. Of note, the ongoing ecological value of these excavations is not likely to be as critical under a restoration scenario with increased frequency, depth and duration of inundation across the full extent of the natural wetland basin.

5.1. Predicted vegetation response

Predictions of how each habitat type will respond in each of the different zones to different restoration activities indicate that the area and quality of Plains Grassy Wetland / Lignum Swamp would increase across zones where it occurs under the raised sill and bank / drain removal scenarios but will continue to decline under a 'do nothing' scenario (Table 4).

Tall Marsh is likely to continue to expand, encroaching into existing areas of Plains Grassy Wetland / Lignum Swamp around where it currently occurs, and into shallower areas of open water (in the northern sections and banks of dams), although it will probably decline where drains are filled, particularly in the central 3 zone. Dam-filling in this zone would also result in a localised decline of Tall Marsh. Optimal outcomes would be achieved by a combination of raising the sill and removing banks and drains so that water can spread evenly across the wetland while filling, rather than having to fill and spill across barriers, as would be the case if drains and banks were left in place.

Note that these initial, coarse predictions of vegetation response to restoration impacts are subject to amendment, depending on the outcomes of future modelling exercises to determine the likely frequency and volume of inflows after increased urbanisation of the surrounding catchment.

5.2. Wetland Fauna

Based on the biota so far recorded across the project site, and in line with existing literature, the restoration of a more natural hydrological regime across the Cunningham Swamp wetland will likely result in an increased area of inundation and an extended period of inundation, without removing the important wet / dry cycles that underpin wetland productivity. The increased extent of inundation incorporates a large area of wetland bed with a very shallow and gentle bank gradient. These inundated mud flat and sand flat areas increase both the productivity and carrying capacity of the wetlands to a diversity of fauna and can be anticipated to increase faunal populations and diversity in Cunningham Swamp. The increased likelihood of some wetland elements holding water through summer into early autumn in some years, because of greater water depth, provides an important summer (and potentially drought) refuge for a range of water dependent species.

The following section outlines some more specific considerations for determining the likely response of faunal components.

Table 4: Predicted habitat change under different restoration scenarios

Zone	Action															
	Do nothing				Raised sill (6.9 m AHD)				Bank and drain removal				Dam backfilling			
	LS	PGW/LS	TM	OW	LS	PGW/LS	TM	OW	LS	PGW/LS	TM	OW	LS	PGW/LS	TM	OW
Central1			**+**	**0**			**+**	**0**			**+**	**0**			**-**	**-**
Central2		**-**				**+**				**+**				**+**		
Central3		**-**	**+**	**0**		**+**	**0**			**+**	**-**			**+**	**-**	
East1		**-**				**+**				**+**				**0**		
East2		**-**				**0**				**+**				**0**		
East3		**0**				**+**				**+**				**0**		
North1		**-**	**+**	**-**	**0**	**0**	**+**	**-**	**0**	**0**	**+**	**-**	**0**	**0**	**+**	**-**
North2	**0**		**+**	**-**										**0**		
South1					**-**	**+**			**-**	**+**			**0**	**0**		
South2					**-**	**+**			**-**	**+**				**0**		
South3		**-**				**+**				**+**				**+**		
West		**-**				**+**				**+**				**0**		

Habitat type (LS = Lignum Swamp (EVC 104), PGW/LS = Plains Grassy Wetland/Lignum Swamp Complex (EVC A101), TM = Tall Marsh (EVC 821), OW = Open Water;
+ = increase under action, - = decline under action, 0 = no change under restoration.
See Figure 32 for zones

5.2.1 Waterbirds

The habitat composition and complexity at Cunningham Swamp is severely constrained under existing (highly modified) inundation scenarios, although wetland dependent species do currently contribute to the sites overall biodiversity value (e.g. Figure 36), and have been noted in above average rainfall years or wetter climatic phases (which counteract the impacts of artificial drainage).

Under a restored scenario, waterbird foraging habitat would increase in complexity and extent with important implications for wetland productivity and food web complexity. Important waterbird habitats include:

- **Shallow water** (0-30cm) for wader foraging noting that world-wide the greatest diversity and abundance of foraging waterbirds is found in depths of between 10 and 20 cm (Isola et al. 2000, Taft et al. 2002)
- **Flood, wind surge and seiche zones**: inundation and exposure of these zones provides important foraging habitat for many waterbird species, particularly those with very flat profiles where water movement can inundate and expose large areas. Wind also concentrates food sources on the leeward side of a waterbody.
- **Mud and sand flats**: the western side of Cunningham Swamp is very flat and increased water levels across this area would result in the establishment of invertebrate macrofauna and a complex and productive food web, capable of sustaining wader population.
- **Flood zones**: Seasonal inundation and exposure stimulates a cycle of growth and decay which in turn increases nutrient availability in the water column (Baldwin and Mitchell, 2000) and underpins complex food webs required for breeding in fish and waterbirds (Crome 1988, Junk et al. 1989, Scott, 1987).
- **Emergent and fringing vegetation**: Healthy macrophyte communities provide direct and indirect sources of food as well as shelter and roosting sites. Total and breeding waterbird species correlates positively with macrophyte abundance and diversity (Hargeby et al. 1994, VanRees-Siewert and Dinsmore 1996, Safran et al. 2000, Fairbairn and Dinsmore 2011)
- **Deep water**: A range of waterbird feeding guilds (diving waterbirds, deep diving ducks and piscivores) use deep, open water but most larger birds prefer shallow water when food is available (Gawlik 2002).
- **Drought and summer refuge**: The more permanent wetland elements provide important areas capable of sustaining individual birds that are dependent on aquatic environments for feeding during periods when surface water is otherwise scarce.

In addition to habitats for foraging and refuge, **breeding habitat** is an important consideration with respect to wetland function and overall condition. Waterbirds breed either as pairs (in trees or tree hollows, aquatic vegetation or on the ground) or as colonial nesting species (in ground nests on islands, in trees or on platforms built on reeds, lignum of bushes). The relatively simple current vegetation structure across Cunningham Swamp means that few waterbird species have the necessary microhabitats required for breeding in or around the wetland. In addition to suitable habitat, waterbird breeding is also stimulated by environmental factors (flooding, rainfall and seasonal cues) (Briggs 1990).

For most Australian waterbirds, breeding occurs when food resources are approaching, or are at, a maximum (Kingsford and Norman 2002). Given the lag between flooding and the time required for large and complex food webs to establish, waterbird breeding requires floodwaters to persist, usually through to the warmer months. Waterbirds that feed on animals lower in the food chain (e.g. Ibis feeding on invertebrates) can usually initiate breeding earlier than piscivores (Crome 1988), but the minimum lag from flooding to breeding onset in most waterbirds species is in the order of two to three months (Scott 1997).

Colonial nesting waterbirds are even more constrained because of longer lag times between flooding and breeding onset (e.g. Scott 1997, Kingsford and Auld 2005) as well as vulnerability to sudden drops in water levels (Kingsford 1988, Kingsford and Norman 2002), as is prone to occur in artificially regulated wetlands and reservoirs. This information clearly supports the installation of a fixed outlet sill wherever possible at restored wetlands.

Figure 36: Australian Reed Warbler in Lignum (left) and Yellow-billed Spoonbill and Australian White Ibis foraging (right) at Cunningham Swamp under current modified conditions.

The deeper drains and fringes of permanent water bodies contain dense, reedy vegetation, which is important for the nationally endangered Australasian Bittern. Australian Painted Snipe, which are another cryptic species, have not been formally recorded although their preference for shallowly inundated areas adjacent to emergent grass tussocks, sedges and rushes is consistent with habitat which currently occurs, and would be actively supplemented through restoration activities.

5.2.2 Amphibians

Frog species recorded at the site include common froglet (*Crinia* signifera), spotted marsh frog (*Limnondynastes tasmaniensis*), striped marsh frog (*Limnodnynastes peronii*) and growling grass frogs *(Litoria raniformis*)*,* although the latter has not been detected in recent surveys (Ecology and Heritage Partners, 2020).

Elements of favourable habitat features *L. raniformis* – e.g. abundant aquatic vegetation, minimal tree canopy cover, moderate to low salinity, and water for at least six months of the year over the breeding season (DELWP, 2017) – occur across the wetland, and would be significantly enhanced by restoration works.

The drivers of localised extinction of the species which have seen it disappear across many wetlands throughout its range (a combination of inability to persist within or around a given wetland, pool or pond and due to limited wetland size, permanence and cover of aquatic vegetation - Heard et al. 2010) don't appear to have played out at Cunningham Swamp, even with recent modifications and disturbance. Given recent records, it should still be considered a key species likely to benefit from improvements in hydrology through restoration works.

The adult phase of the species is relatively mobile, being able to move up to one kilometre in 24 hours. Breeding begins in August when calling males begin being able to attract females, although females usually don't begin to lay eggs until October or November. Eggs are laid in spring, so the frogs need water to last over the summer for their tadpoles to develop (DELWP, 2017). The age at first breeding is about 1 year and the generation length is estimated to be three to six years (Heard et al. 2012). So while permanent water does currently occur within Cunningham Swamp, it is the nature of adjacent vegetation which may be limiting for the species. Restoration activities to increase the duration of inundation of shallower, vegetated areas would increase overall habitat value for the species and – given the overall size of the wetland – would greatly increase the likelihood of persistence if the species does still occur here, is colonised from transient adults from any nearby wetlands, or (if absent) were reintroduced.

5.2.3 Overview of Fauna Response

Increased depth of water in wetlands extends the duration of inundation across the period from late winter into early summer and increases the diversity (and usually also extent) of vegetation communities present, providing habitat for a wider diversity of wetland dependant faunal species. This change to the temporal nature of inundation also increases the likelihood that a greater number of faunal species, including colonial nesting waterbirds, may be attracted to the site and start to breed.

The preceding sections indicate that increased depth and therefore extent of inundation across the main wetland will provide an increase in available feeding and breeding habitat for fauna. This would help to negate the wider trend of habitat decline across the south-eastern Australian landscape which has been occurring since systematic wetland drainage commenced in many areas to facilitate agriculture from the late 1800s.

This informs restoration objectives Cunningham Swamp, which ideally would focus on maximising the extent of the wetland fringe that is subject to seasonal wetting and drying.

The wetland area of Cunningham Swamp currently provides tall and dense habitat which serves as an important refuge for wetland fauna, along with areas of lower-growing wetland plants and areas which are seasonally inundated. Whilst the more common, wetland dependent species are regularly observed across the site, several nationally and state listed threatened species have been recorded or are considered likely to occur at the site (Table 5).

Predicted responses in habitat types, relative to these species suggest that most would benefit from improved habitat quality and extent (Table 5). Further investigations of buffers/setbacks around urban design (road interfaces and vegetation setbacks) are required, particularly in relation to potential impacts from light, noise and domestic animals (e.g. cats and dogs).

Table 5: Fauna species of conservation significance confirmed or likely to be present at Cunningham Swamp (GHD, 2020)

Species	Conservation Status				Likelihood	Habitat type			
BIRDS	EPBC	FFG	DELWP	Migratory		LS	PGS/LS	TM	OW
Australasian Bittern (*Botaurus poiciloptilus*)	en	L	en		Present	+	+	0	
Australasian Shoveler (*Anas rhynchotis*)			vu		Possible		+		
Black Falcon (*Falco subniger*)		L	vu		Possible				
Blue-billed Duck (*Oxyura australis*)		L	en		Possible				*0
Brolga (*Grus rubicunda*)		L	vu		Present		+		
Eastern Great Egret (*Ardea modesta*)		L	vu		Present	+	+		
Hardhead (Aythya australis)			vu		Present		+		*0
Intermediate Egret (*Ardea intermedia*)		L	en		Present	+	+		
Latham's Snipe (*Gallinago hardwickii*)			nt	mi	Present	+	+		
Lewin's Rail (*Rallus pectoralis*)		L	vu		Present	+	+	0	
Musk Duck (*Biziura lobata*)			vu		Possible				*0
Painted Snipe (*Rostratula australis*)	en	L	cr		Possible		+		
Royal Spoonbill (*Platalea regia*)			nt		Present	+	+		
Sharp-tailed Sandpiper (*Calidris acuminata*)				mi	Present		+		
Spotted Harrier (*Circus assimilis*)			nt		Present	+	+	0	
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)		L	vu		Possible	+	+	0	*0
Whiskered Tern (*Chlidonias hybridus*)			nt		Present		+		
White-throated Needletail (*Hirundapus caudacutus*)		L	vu		Possible		+		
AMPHIBIANS									
Growling Grass Frog (*Litoria raniformis*)	vu	L	en		#Present	+	+	0	*0
REPTILES									
Eastern Snake-necked Turtle (*Chelodina longicollis*)			dd		Present	0	+	0	*0

Conservation status (EPBC - Environment Protection and Biodiversity Conservation Act 1999, FFG - Victorian Flora and Fauna Guarantee Act 1988, DELWP - DELWP Advisory List of Threatened Vertebrate Fauna in Victoria (2013) or Threatened Invertebrate Fauna in Victoria (2009), Migratory - EPBC Act-listed migratory fauna;
en =endangered, vu = vulnerable, l = listed under FFG, nt = near threatened, dd = data deficient.
Habitat type (LS = Lignum Swamp EVC 104, PGW/LS = Plains Grassy Wetland / Lignum Swamp Complex EVC A101, TM = Tall Marsh EVC 821, OW = Open Water; + = increase under restoration, 0 = no change under restoration) *Deep open water habitat would likely decline if dams were backfilled.
#see GHD (2020) for *L. raniformis* detection notes

6. RECOMMENDATIONS

As a result of the assessment of site values and restoration potential in this study, future planning controls and a sophisticated landholder negotiation, to ensure ongoing protection and a whole-of-wetland hydrological restoration approach, is strongly recommended for Cunningham Swamp. Additionally, although not investigated in detail in this report, the inundation modelling undertaken as part of this project highlights the potential for restoration of the Point Cook Seasonal Herbaceous Wetland, to the east of Cunningham Swamp.

It is recommended that further detailed assessment be undertaken to produce a detailed restoration plan that covers both wetlands, as a precursor to future full hydrological restoration.

Additional areas to be explored by further detailed investigations include establishment of a hydrological baseline by monitoring of flows and water levels, and determining whether the large bunded dam in Cunningham Swamp receives flows via culverts or pumping, and if so, its influence on the larger wetland area.

In terms of future on-ground restoration works, the following key cost-effective actions are proposed, subject to further investigation:

- **Backfilling of internal drains and removal of banks**, allowing flows to re-engage with the full natural wetland extent and floodplain;
- **Setting of a fixed outlet sill level**, thereby setting the depth of inundation across the wider wetland(s); and
- **Potential backfilling of the bunded dam and excavated area** in the north of Cunningham Swamp, which could involve partial retention and optimisation of excavated areas to support Growling Grass Frog habitat, subject to the agreed restoration vision for the site.

When considering the ever-diminishing opportunities for wetland restoration around Melbourne, Cunningham Swamp and adjacent wetlands in the Point Cook area offer a compelling case. Despite modification, this large natural wetland complex still retains an impressive suite of eco-hydrological values and has excellent restoration potential. This is because existing residual values can be harnessed, via works (as outlined above) that reverse past changes to wetland hydrology, which in turn will trigger an ongoing and self-sustaining ecological response across the entire geomorphic footprint of the natural wetland feature.

The unique characteristics of the wetland complex offers the possibility to enhance and recreate wetland habitat on a regionally significant scale, with positive outcomes for threatened vegetation communities, flora and fauna, and providing complementary habitat that will likely enhance (and in turn also benefit from its proximity to) the nearby Port Phillip Bay (Western Shoreline) & Bellarine Peninsula Ramsar Site.

Finally, Cunningham Swamp presents an opportunity to establish an open, natural public space which provides community, cultural and environmental benefits – as a vital catchment management asset that is accessible to (and improves liveability for) the surrounding urban population. In this way it would further contribute to a network of important areas of open public space for all metropolitan residents.

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APPENDIX 1: FLORA LIST

Scientific Name	Common Name	Functional Group	Records This study	Records VBA
Acetosella vulgaris	Sheep Sorrel	Tdry	x	x
Agrostis capillaris	Brown-top Bent	Tdry	x	
Amphibromus neesii	Southern Swamp Wallaby-grass	Tdamp	x	
**Arctotheca calendula*	Cape Weed	Tdamp	x	
Asperula conferta	Common Woodruff	Tdry	x	x
Asperula spp.	Woodruff	Tdry	x	
Atriplex semibaccata	Berry Saltbush	Tdamp	x	x
Atriplex prostrata		Tdamp		
Austrostipa spp.	Spear Grass	Tdry	x	x
**Avena spp.*	Oat	Tdry	x	x
Azolla rubra	Pacific Azolla	Afrf	x	
Brachyscome paludicola	Woodland Swamp-daisy	Tdry	x	
**Brassica fruticulosa*	Twiggy Turnip	Tdry	x	
**Brassica spp.*	Turnip	Tdry	x	x
**Bromus arenarius*	Sand Brome	Tdry	x	
**Bromus catharticus*	Prairie Grass	Tdry	x	
**Bromus hordeaceus*	Soft Brome	Tdry	x	x
Carex appressa	Tall Sedge	Afte	x	
Carex tereticaulis	Poong'ort	Tdamp	x	
**Cenchrus clandestinus*	Kikuyu	Tdry	x	x
Centipeda cunninghamii	Common Sneezeweed	Tdamp	x	x
**Chenopodium album*	Fat Hen	Tdamp	x	
Chenopodium desertorum subsp. microphyllum	Small-leaf Goosefoot	Tdamp	x	
Chenopodium glaucum	Glaucous Goosefoot	Tdamp	x	x
**Chenopodium murale*	Sowbane	Tdamp	x	
Chloris truncata	Windmill Grass	Tdry	x	x
**Cirsium vulgare*	Spear Thistle	Tdry	x	x
Cotula coronopifolia	Water Buttons	Afrp	x	
**Cucumis myriocarpus subsp. myriocarpus*	Paddy Melon	Tdamp	x	
**Cynara cardunculus subsp. flavescens*	Artichoke Thistle	Tdamp	x	x
**Cynodon dactylon*	Couch	Tdamp	x	x
**Cyperus eragrostis*	Drain Flat-sedge	Afte	x	
**Dactylis glomerata*	Cocksfoot	Tdry	x	x
**Deyeuxia quadriseta*	Reed Bent-grass	Afte	x	
Dichondra repens	Kidney-weed	Tdry	x	
Distichlis distichophylla	Australian Salt-grass	Tdamp	x	
**Dittrichia graveolens*	Stinkwort	Tdry	x	
Duma florulenta	Tangled Lignum	Aftw	x	x
**Ecballium elaterium*	Squirting Cucumber	Tdry	x	
**Ehrharta erecta*	Panic Veldt-grass	Tdamp	x	
**Ehrharta longiflora*	Annual Veldt-grass	Tdamp	x	
Einadia nutans	Nodding Saltbush	Tdry	x	x

Scientific Name	Common Name	Functional Group	Records This study	Records VBA
Einadia nutans subsp. nutans (s.s.)	Nodding Saltbush	Tdry	x	
Eleocharis acuta	Common Spike-sedge	Afte	x	x
Enchylaena tomentosa var. tomentosa	Ruby Saltbush	Tdry	x	
Epilobium billardiereanum	Variable Willow-herb	Tdamp	x	x
Epilobium billardiereanum subsp. billardiereanum	Smooth Willow-herb	Tdamp	x	x
Epilobium hirtigerum	Hairy Willow-herb	Tdamp	x	
Eragrostis infecunda	Southern Cane-grass	Afte	x	x
**Erigeron sumatrensis*	Tall Fleabane	Tdamp	x	
Eryngium vesciculosum	Prickfoot	Aftl		x
Eucalyptus camaldulensis	River Red-gum	Aftw	x	x
Euchiton sphaericus	Annual Cudweed	Tdamp	x	
Gahnia filum	Chaffy Saw-sedge	Afte	x	
**Galenia pubescens var. pubescens*	Galenia	Tdry	x	x
Glyceria australis	Australian Sweet-grass	Afte	x	x
Haloragis heterophylla	Varied Raspwort	Afrp	x	x
Haloragis spp.	Raspwort	Afrp	x	
**Helminthotheca echioides*	Ox-tongue	Tdry	x	
**Hookerochloa spp.*	Fescue	Tdry	x	
**Hordeum leporinum*	Barley-grass	Tdamp	x	
**Hordeum marinum*		Tdamp	x	
**Hordeum spp.*	Barley Grass	Tdamp	x	x
**Hypochaeris radicata*	Flatweed	Tdry	x	x
Juncus australis	Austral Rush	Tdamp	x	
**Juncus bulbosus*	Bulbous Rush	Afte	x	
Juncus flavidus	Gold Rush	Afte	x	x
Juncus holoschoenus	Joint-leaf Rush	Afte	x	x
Juncus pallidus	Pale Rush	Afte	x	x
Juncus procerus	Tall Rush	Afte	x	
Juncus spp.	Rush	Afte	x	x
Juncus subsecundus	Finger Rush	Tdamp	x	
Lachnagrostis filiformis s.l.	Common Blown-grass	Afte	x	x
Lachnagrostis filiformis s.s.	Common Blown-grass	Afte	x	
**Lactuca serriola*	Prickly Lettuce	Tdry	x	x
Lemna disperma	Common Duckweed	Afrf	x	x
**Leontodon saxatilis subsp. saxatilis*	Hairy Hawkbit	Tdry	x	x
Lobelia anceps	Angled Lobelia	Tdamp	x	
Lobelia pratioides	Poison Lobelia	Afte	x	x
**Lolium perenne*	Perennial Rye-grass	Tdry	x	x
**Lolium rigidum*	Wimmera Rye-grass	Tdry	x	
**Lophopyrum ponticum*	Tall Wheat-grass	Tdamp	x	x
**Lycium ferocissimum*	African Box-thorn	Tdry	x	x
**Lysimachia arvensis*	Pimpernel	Tdry	x	
Lythrum hyssopifolia	Small Loosestrife	Afte	x	x
Malva spp.	Mallow	Tdry	x	
Marsilea drummondii	Common Nardoo	Afrp	x	x

Scientific Name	Common Name	Functional Group	Records	
			This study	VBA
Marsilea spp.	Nardoo	Afrp	x	
**Medicago spp.*	Medic	Tdry	x	x
Melaleuca armillaris subsp. armillaris	Giant Honey-myrtle	Aftw	x	
**Melilotus indicus*	Sweet Melilot	Tdry	x	
**Modiola caroliniana*	Red-flower Mallow	Tdry	x	
Muellerina spp.	Mistletoe	Tdry	x	
Myriophyllum crispatum	Upright Water-milfoil	Afrp	x	x
Myriophyllum spp.	Water Milfoil	Afrp	x	x
**Nassella neesiana*	Chilean Needle-grass	Tdry	x	
**Nassella trichotoma*	Serrated Tussock	Tdry	x	x
Oxalis corniculata s.l.	Yellow Wood-sorrel	Tdry	x	
Oxalis perennans	Grassland Wood-sorrel	Tdry	x	x
Oxalis pes-caprae	Soursob	Tdry	x	
**Paspalum dilatatum*	Paspalum	Tdamp	x	x
**Pauridia glabella var. glabella*	Tiny Star	Tdry	x	
Persicaria decipiens	Slender Knotweed	Afrp	x	
**Phalaris aquatica*	Toowoomba Canary-grass	Tdry	x	x
**Phalaris spp.*	Canary Grass	Tdry	x	x
Plantago coronopus	Buck's-horn Plantain	Tdamp	x	x
**Plantago lanceolata*	Ribwort	Tdamp	x	x
Poa labillardierei var. (Volcanic Plains)	Basalt Tussock-grass	Tdamp	x	x
**Polygonum arenastrum*	Wireweed	Tdry	x	
**Polygonum aviculare s.l.*	Prostrate Knotweed	Tdry	x	x
Potamogeton tricarinatus s.l.	Floating Pondweed	Afrp	x	
**Rapistrum rugosum*	Turnip weed	Tdry		x
Rhagodia candolleana subsp. candolleana	Seaberry Saltbush	Tdry	x	x
Rorippa dictyosperma	Forest Bitter-cress	Tdamp	x	
Rumex brownii	Slender Dock	Tdamp	x	
**Rumex crispus*	Curled Dock	Tdamp	x	x
Rytidosperma duttonianum	Brown-back Wallaby-grass	Tdamp	x	x
Rytidosperma racemosum		Tdry		x
Rytidosperma spp.	Wallaby Grass	Tdry	x	x
Selliera radicans	Shiny Swamp-mat	Tdry	x	
Senecio runcinifolius	Tall Fireweed	Tdamp	x	
Solanum laciniatum	Large Kangaroo Apple	Tdamp	x	
**Solanum linnaeanum*	Apple of Sodom	Tdamp	x	
**Solanum nigrum s.l.*	Black Nightshade	Tdamp	x	
**Solanum nigrum s.s.*	Black Nightshade	Tdamp	x	x
**Sonchus asper s.l.*	Rough Sow-thistle	Tdamp	x	
**Sonchus oleraceus*	Common Sow-thistle	Tdry	x	x
**Sonchus spp.*	Sow Thistle	Tdry	x	
**Symphyotrichum subulatum*	Aster-weed	Tdry	x	
**Trifolium angustifolium var. angustifolium*	Narrow-leaf Clover	Tdry	x	x
Typha domingensis	Narrow-leaf Cumbungi	SE	x	x
Typha spp.	Bulrush	SE	x	

Scientific Name	Common Name	Functional Group	Records	
			This study	VBA
Urtica urens	Small Nettle	Tdamp	x	
Viola hederacea sensu	Ivy-leaf Violet	Tdamp	x	
****Vulpia bromoides***	Squirrel-tail Fescue	Tdry	x	x
****Vulpia myuros***	Rat's-tail Fescue	Tdry	x	
Wilsonia rotundifolia	Round-leaf Wilsonia	Tdamp	x	
****Xanthium spinosum***	Bathurst Burr	Tdry	x	x

APPENDIX 2: WYNDHAM CITY COUNCIL LANDSCAPE CONTEXT GUIDELINES

wyndhamcity

Landscape Context Guidelines

Key Site No.:	**3**
Site:	**Remnant Cane Grass Lignum Swamp (locally known as Cunninghams Swamp)**
Location:	Directly adjoining south side of Featherbrook and Alamanda Estate
PSP:	Approved Point Cook South logical inclusion area

Cunninghams Swamp within the Point Cook logical inclusions area has been modified by soil extraction and agricultural activity. Despite this, remnant vegetation and faunal habitat remain. River Red Gums and Tangled Lignum are scattered around the perimeter of the Swamp. This Swamp may satisfy the recent EPBC Act listed critically endangered vegetation community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains.

The Swamp extends north into the Featherbrook and Alamanda Estates where it is dominated by the endangered EVC655 Lignum Cane Grass Swamp and supports the regionally significant Volcanic Plains form of *Poa labillardieri*. Cunninghams Swamp is also a registered regional Biosite (Biosite No. 6536).

In the event that the urban growth boundary is extended to include the Point Cook logical inclusion area, opportunities exist to connect the Swamp via conservation areas and/or open space to:

a. the D1 drain and Port Phillip Bay.
b. the adjoining natural wetlands
c. Point Cook Coastal Park
d. Point Cook RAAF Base
e. Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Wetland Site
f. Point Cook Marine Sanctuary
g. Council's recreation reserve on the northeast corner of Point Cook and Point Cook Homestead Roads.

The *Wyndham Biodiversity Study 2006* recommends that this Swamp/wetland be protected under an Environmental Significance Overlay.

Figure 26: Remnant Cane Grass Lignum Swamp (locally known as Cunninghams Swamp) within Featherbrook Estate, Point Cook.
Photograph by Jill Orr-Young

Figure 27: Aerial view of the Remnant Cane Grass Lignum Swamp (Cunninghams Swamp)
Source: nearmap 2012

Key Site 3 – Remnant Cane grass Lignum Swamp (Cunningham's Swamp) Recommendations

R.3.1 Rehabilitate Cunningham's Swamp as a flora and fauna sanctuary/conservation reserve.

R.3.2 In the event that the urban growth boundary is extended to include the approved Point Cook logical inclusion area opportunities exist to connect Cunningham's Swamp via conservation areas and/or open space to the adjoining Point Cook Seasonal Herbaceous Wetland (Key Site 4), Point Cook Coastal Park and the D1 Drain in the East Werribee Employment Precinct and approved Point Cook logical inclusion area (Key Site 1).

R.3.3 Use of Cunningham's Swamp as a storm water retarding basin should not be at the expense of the natural contours and flora and fauna values.

R.3.4 Roads must not encroach on Cunningham's Swamp.

R.3.5 Protect Cunningham's Swamp under an Environmental Significance Overlay.

Please also refer to General Recommendations in Section 8

Key Site No.: **4**
Site: **Point Cook Seasonal Herbaceous Wetland**
Location: East of Cunninghams Swamp (Key Site 3), west of Point Cook Road and southeast of Alamanda Estate in Point Cook.
PSP: Approved Point Cook South logical inclusion area

This wetland may satisfy the recent EPBC Act listed critically endangered vegetation community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. Part of this wetland is a registered local Biosite[14] (Biosite No. 6537).

The exact boundary of this wetland is subject to further environmental assessment at the Precinct Structure Plan and/or Development Plan phases.

Figure 28: Aerial View of the Point Cook Seasonal Herbaceous Wetland
Source: Nearmap 2012

Key Site 4 – Point Cook Seasonal Herbaceous Wetland Recommendations

R.4.1 Rehabilitate the Point Cook Seasonal Herbaceous Wetland as a flora and fauna conservation reserve.

R.4.2 In the event the urban growth boundary is extended to include the approved Point Cook logical inclusion area opportunities exist to connect the Point Cook Seasonal Herbaceous Wetland via conservation areas and/or open space to Cunninghams Swamp (Key Site 3), Point Cook Coastal Park and the Point Cook RAAF Base.

R.4.3 Use of the Point Cook Seasonal Herbaceous Wetland as a storm water retarding basin should not be at the expense of natural contours and flora and fauna values.

R.4.4 Roads must not encroach on Point Cook Seasonal Herbaceous Wetland.

R.4.5 Protect Point Cook Seasonal Herbaceous Wetland under an Environmental Significance Overlay

Please also refer to General Recommendations in Section 8