# LOWLANDS LAGOONS (ANEMBO LAKES) WATERBODY MANAGEMENT PLAN

DesignFlow

Prepared for Fraser Coast Regional Council

February 2021

## Document Control Sheet

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|---|---|
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## Disclaimer

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## SUMMARY

Lowlands Lagoons, commonly referred to as Anembo Lakes, is a very high profile and amenity waterbodies located within the suburbs of Torquay and Urangan. The system comprises five interconnected waterbodies. The waterbodies receive stormwater runoff from a 136 ha catchment comprising of residential and parkland/natural land uses. Local residents living adjacent to the Lowlands Lagoons value the amenity provided by the large open waterbodies. The waterbodies are regularly accessed by residents for passive recreation.

The priority management issues identified for the Lowlands Lagoons system include:

- Public Safety
- Edge stability
- Water quality
- Water birds and faecal contamination
- Aquatic weeds
- Waterbody residence times (poorly flushed)

As outlined in DesignFlow (2021) the risk associated with the 'business as usual' management approach may results in high reactive management costs and/or further decline in water quality due to untreated catchment inputs and associated increase in algal and floating weed issues. A proactive approach has to be adopted.

**Recommended Actions:** The key management actions that have been identified as part of the *Lowlands Lagoon (Anembo Lakes) Waterbody Management Plan* (this report) include:

- Immediate actions:
  - Development of Waterbody Edge - Public Safety Risk Assessment to reduce/remove high risk waterbody edges to manage public safety risk.
  - Development of Waterbird Management Plan to assist in reducing public health risk associated with waterbird faecal contamination.
  - Development of Weed Management Plan (in particular to target Broad Leaf Pepper Tree)
- Short term actions (1-2 years):
  - Implement works to 'high risk' unsafe edges.
  - Signage to discourage bird feeding.
  - Implement works recommended in the Weed Management Plan (Phase 1).
  - Targeted removal of declared weeds around waterbody margins (i.e. Broad Leaf Pepper Tree).
  - Terrestrial buffer planting.
  - Management of other declared weeds (e.g. Singapore Daisy and *Salvinia molesta* as required).
- Medium term actions (3-5 years):
  - Stabilise eroding edges.
  - Landscaping works in key locations to discourage bird feeding and loafing.
  - Other items identified in the Waterbird Management Plan.
  - Implement works recommended in the Weed Management Plan (Phase 2).
  - Wetland planting to waterbody edges.
  - Management of non-declared weeds (e.g. *Nymphaea mexicana*).
  - Review and update catchment stormwater management strategy.
- Long term opportunities (5-10 years):
  - Wetland planting (across the base of Waterbody A, B and C).
  - Continue to implement catchment based stormwater treatment initiatives.
- Future / Aspirational:
  - Removal small islands from Waterbody E.
  - Install waterbody recirculation system between waterbodies A and E.
  - Modify Waterbody B and a section of Waterbody C to function as treatment wetlands.
  - Investigate regrading Anembo Dr inlet to be a free draining revegetated swale.

# 1 INTRODUCTION

## 1.1 BACKGROUND

The Lowlands Lagoons (also commonly referred to as Anembo Lakes) is a 28 ha waterbody system located within the suburbs of Torquay and Urangan. The Lowlands Lagoons system comprises five large waterbodies surrounded by parkland and local residential properties. The waterbodies are highly valued by the local community, particularly residents living adjacent to the system.

The focus of management to date has been on maintaining drainage conveyance (i.e. the passage of stormwater through the waterbodies to the downstream waterways), desilting around drainage structures (i.e. inlets/outlets), aquatic plant and water quality management, and where possible, preserving the open water aesthetic of the waterbodies.

The management of aquatic plants has primarily involved the mechanical removal declared and pest species (via Council's *Aquatic Plant Management Policy*). Water quality management has involved: a) construction of stormwater treatment infrastructure (bioretention system) near Robert Street, b) installation of a GPT within the Robert Street drain, and c) establishment and maintenance of buffer vegetation (via Council's *Urban Lakeside Vegetation Policy)*.

This report presents the Lowlands Lagoons (Anembo Lakes) Waterbody Management Plan (WMP). The Lowlands Lagoons system was identified to be a 'Very High' management priority system as part of the *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report* (DesignFlow, 2021). It was therefore selected as one of the initial waterbodies to have a specific plan developed to inform its future management.

## 1.2 PREVIOUS STUDIES

In 2013, Council commissioned GHD Pty Ltd to undertake an environmental assessment for the Lowlands Lagoons system. The environmental assessment involved:

- Assessment of flora and fauna likely to be associated with the lagoon system,
- Water quality monitoring
- Catchment modelling to determine stormwater and pollutant loads discharged to the lagoon system

The environmental assessment report provided a range of opportunities/strategies for improving the water quality and overall condition of the waterbodies including community involvement, hydraulic improvements, weed management and stormwater treatment.

The Lowlands Lagoons WMP seeks to build upon the *Lowlands Lagoon Environmental Assessment Report* (GHD, 2013), and provide Council with a strategic plan to manage and improve the overall condition of the waterbodies.

## 1.3 APPROACH

This WMP has been developed using the waterbody management framework outlined in *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report* (DesignFlow, 2021). The framework provides a step-wise assessment and prioritisation approach to identify and manage FCRC waterbodies (Figure 1-1).

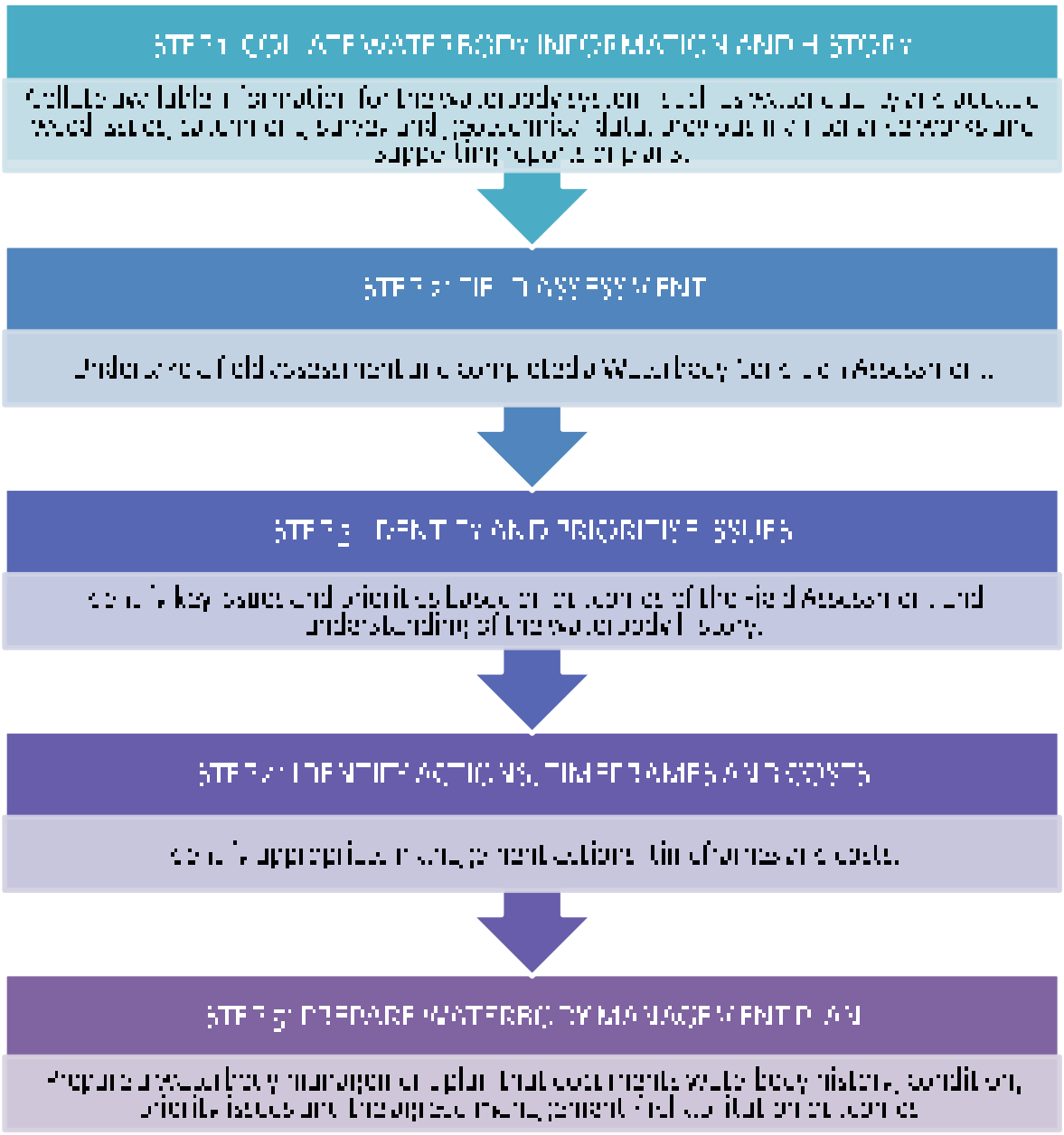


**Figure 1-1. Overview of the Waterbody Management Framework.**

### 1.4 REPORT STRUCTURE

**Sections 2-5** of this report provides details associated with each 'step' taken through the framework. **Section 6** summarises the proposed management plan for the Lowlands Lagoons system based on the outcomes of these steps.

# 2 WATERBODY INFORMATION AND HISTORY

Waterbody information and history was collated via discussions with Council officers, correspondence and a review of existing reports. The following information relevant to the management plan was collated:

- GIS information for the waterbodies and catchment.
- Topographical survey including pipes, pits, pathways, services and vegetation.
- Bathymetric survey.
- Water quality information.
- Aquatic weed management approach.

## 2.1 HISTORIC DRAINAGE

The Lowlands Lagoons system originally drained into the Tooan Tooan Creek catchment (Figure 2-1). The construction of the surrounding roads and embankments has resulted in the historic flow path diverting flows towards the main Margaret Street outlet.

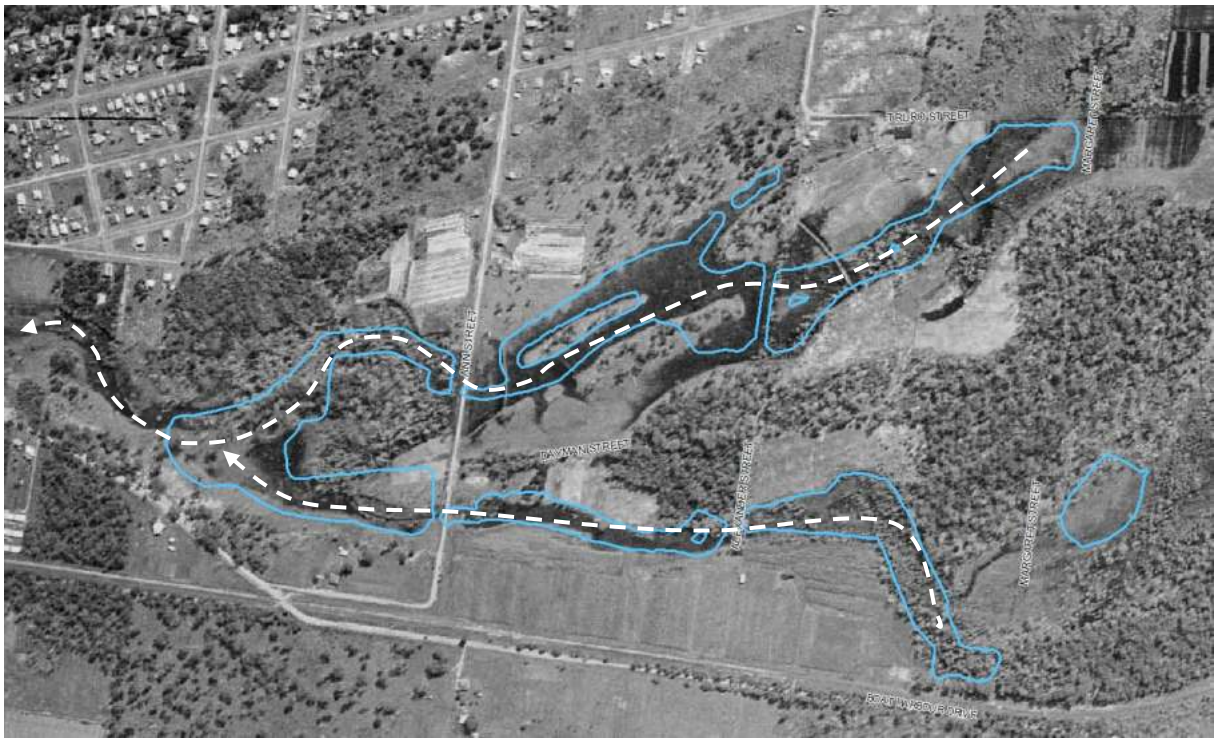
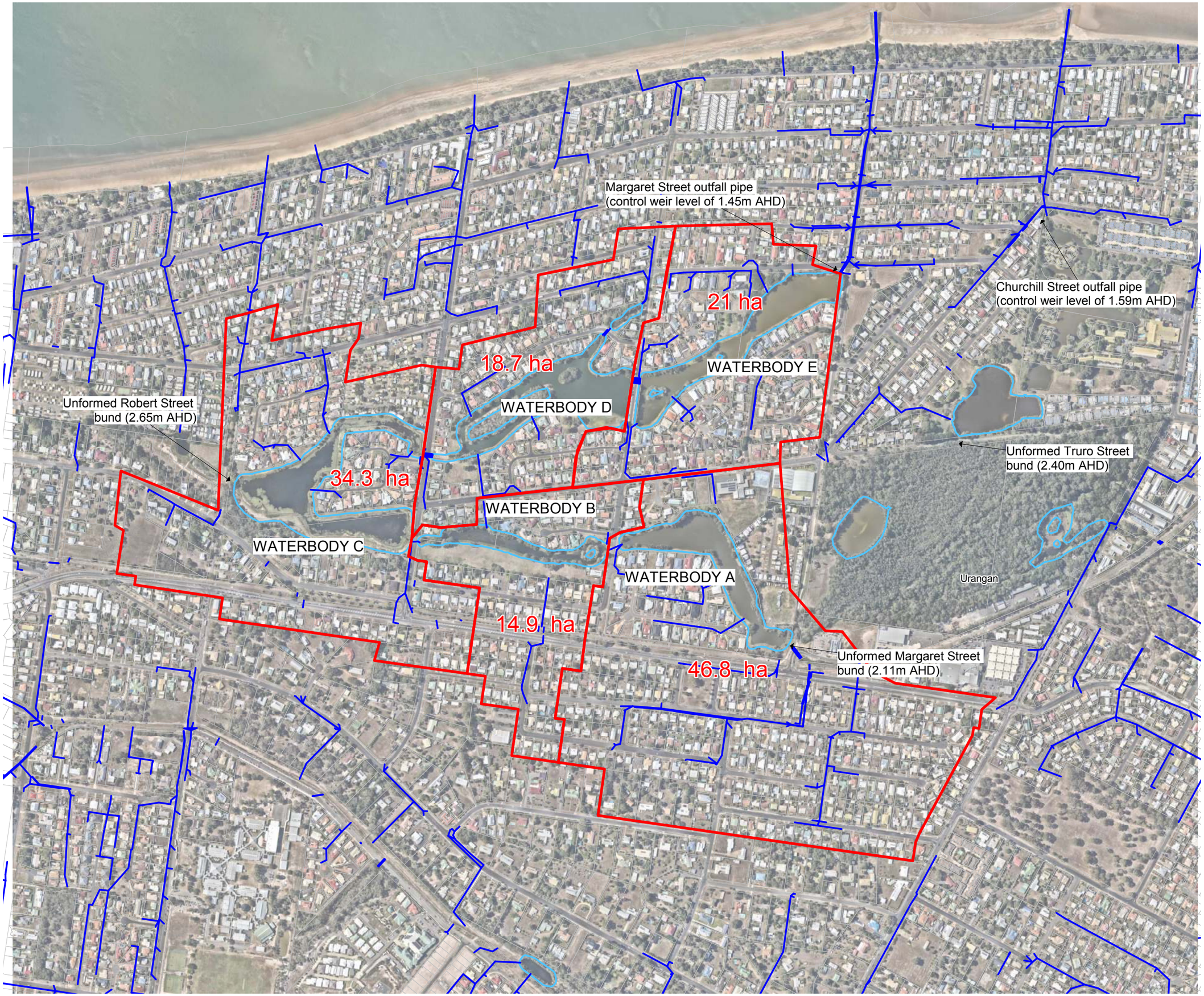



**Figure 2-1. Aerial image from 1958 showing the pre-development flow path.**

## 2.2 EXISTING CATCHMENTS

The Lowlands Lagoons system comprises of five large waterbodies and is configured with northern and southern branches (Figure 2-2). For the purpose of this Waterbody Management Plan, the waterbodies have been identified as Waterbodies A to E. The Lowlands Lagoons catchment area is approximately 135 ha and comprises of residential (75%) and park/natural (25%) areas. Stormwater runoff from the surrounding sub-catchments enters the Lowlands Lagoons via stormwater inlets throughout the system.




DesignFlow

EGEND

- Waterbody outline
- Property boundary
- Catchment boundary
- Existing stormwater pipe

0 75 150 300 m

**Figure 2-2. Stormwater drainage and catchment plan**

Lowlands Lagoons (Anembo Lakes) Waterbody Management Plan

SCALE: 1:7,500

DATE: 19 February 2021

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## 2.3 WATERBODY BATHYMETRY

A bathymetric survey was commissioned in December 2012 as part of the Lowlands Lagoons Environmental Assessment (GHD, 2013). The waterbodies are all typically in the range of 1-3m deep. Waterbodies A and B are the shallowest and vary in depth up to 1.5 m. Waterbodies C, D and E are the deepest and have depths of up to 3m.

The depth distributions and operating water levels for each waterbody are summarised in Table 2-1 and presented in Figure 2-3.

**Table 2-1 Waterbody depth distributions and operating water levels.**

| Waterbody ID | Standing Water Level (m AHD) | Average depth (m) | Outlet | High flow outlet |
|---|---|---|---|---|
| **A** | 1.65 | 1.00-1.50 | Submerged culvert to Waterbody B @ Alexander Street | Earthen channel @ Margaret Street |
| **B** | 1.65 | 0.75-1.25 | Submerged culvert to Waterbody C @ Ann Street | N/A |
| **C** | 1.65 | 1.00-1.75 | Culvert to Waterbody D @ Ann Street | N/A |
| **D** | 1.45 | 1.25-1.75 | Submerged culvert to Waterbody E @ Alexander Street | N/A |
| **E** | 1.45 | 1.50-2.00 | Overflow weir @ Cnr Truro and Margaret Streets | Overflow weir @ Cnr Truro and Margaret Streets |

## 2.4 EXISTING DRAINAGE

Figure 2-2 shows the existing stormwater pipe connections within and around the Lowlands Lagoons. Waterbodies A, B and C are interconnected by large submerged culverts and share a common water level (~RL 1.65m AHD). Waterbodies D and E are interconnected by culverts under Alexander St, and share a common water level (1.45m AHD).

When the system is full (i.e. at normal water level), water flows from Waterbody C into Waterbody D, and spills from Waterbody E via a large overflow weir (RL 1.59 AHD) into two 1800 mm pipes and is conveyed along the Margaret St drain before being discharged to the sea.

In high rainfall events, the water levels within all of the waterbodies rise to share a common level. When the water level exceeds 2.11m AHD, water flows from Waterbody A through a secondary outlet, over the unformed sections of Margaret Street (2.11m AHD) and then Truro Street (2.40m AHD) and towards the Churchill Street outlet. When the water level exceeds 2.65m AHD, water also flows over the earthen bund at Robert St into the Tooan Tooan Creek drainage line. Thus, the water level within the Lowlands Lagoons must increase by approximately 1.5 m before water is discharged into the Tooan Tooan Creek drainage line. FCRC flood modelling assessment confirms that the system maintains a clockwise flow regardless of flood break-over to east (unformed Margaret Street) or west (unformed Robert Street).

DesignFlow

LEGEND

- Waterbody outline
- Property boundary
- Catchment boundary
- Existing stormwater pipe

**LEGEND**

Lake Depth (m)

- 0.0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- >2.0

0 40 80 160 m

**Figure 2-3. Waterbody depth and drainage plan**

Lowlands Lagoons (Anembo Lakes) Waterbody Management Plan

| | |
|---|---|
| SCALE: 1:4,000 | DATE: 19 February 2021 |

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## 2.5 INFORMAL STAKEHOLDER FEEDBACK

The following issues were identified through discussion with relevant Council officers and onsite maintenance staff having knowledge of the local system and exposure of previous community feedback and requests:

- Council developed the *Management of Urban Lakeside Vegetation Policy* (FCRC 2017) in 2016 and are implementing the policy across the region including Lowlands Lagoons. This policy established an objective to establish a 1.0-1.5m unmown vegetated buffer around waterbody edges (except for strategic locations such as viewing platforms). Council may adopt wider buffer than 1.5m where appropriate.
- Council developed the *Aquatic Plant Management Policy (FCRC 2017)* in 2012 and are implementing the policy across the region, including Lowlands Lagoons. The policy set criteria for the management of aquatic plants (both native and weed species).
- The lagoon system is highly valued by the community, particularly the residents who live around the perimeter of the waterbodies.
- Some local residents expect Council to provide a high level of service for the system, with a keen desire for unobstructed water views (i.e. no macrophytes (aquatic plants)).
- Management of waterbody edges adjacent to residential properties is difficult. Despite Council's waterbody edge buffer policy, some residents take it upon themselves to mow the batters to the water line (including buffers established by Council).
- The waterbodies have a long residence time due the relatively large waterbody volume compared to the contributing catchment area ratio (i.e. the water is not regularly turned over).
- The growth of aquatic plants, particularly *Nymphaea mexicana* (Mexican Water-lily), upon the surface of Waterbody C is a primary aesthetic concern for some adjacent residents.
- *Nymphaea mexicana* is difficult to control and is an ongoing management issue for Council staff.
- The floating native plant, *Azolla pinnata*, is considered by some residents as a visual amenity problem in Waterbody C. Despite being a naturally occurring native plant, there is an expectation by some residents that the Azolla be removed when present in the waterbody. This floating plant comes and goes naturally, and is only actively managed in extreme cases by FCRC (via mechanical removal).
- The declared floating weed, *Salvinia molesta* has occurred within the Lowlands Lagoons, but is not considered a current management issue.
- Some residents raise concerns about submerged weeds in the Lowlands Lagoons, which they often assume to be a Cabomba but is actually *Ceratophyllum demersum*, which is a native species.
- Council officers expressed a desire to achieve healthy and robust waterbodies through the establishment and maintenance of native aquatic and riparian vegetation.
- The Ibis rookery present at the western end of Anembo Island contributes a high nutrient load to the lagoon system, and the associated odours from the faeces is an ongoing issue for the local residents.
- The presence of Broad-leaved Pepper trees around the waterbody margins on Anembo Island and other islands within the waterbodies encourages waterbird roosting and nesting (particularly Ibis).
- The feeding of waterbirds is considered to be an ongoing source of nutrient inputs to the waterbodies.
- Similar concerns were also expressed in regards to the feeding of turtles, but this is not considered to be a major issue.
- Access for Council's weed harvester is not considered to be an issue, and all waterbodies are readily accessible.

- Fish kills may occur seasonally, usually with sudden changes in temperature (more prevalent in deeper water) or after prolonged dry periods followed by heavy rainfall. Some residents link fish kills with poor water quality or need for dredging to uniform and deeper depths.
- The removal of accumulated sediment from the base of the waterbodies has been raised by residents as an option to improve water quality and the overall health of the lagoon system. This approach has generally not been supported to date due to being unviable (i.e. high cost) and potentially detrimental to waterbody health, but is expected to be further informed by the *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report* (DesignFlow, 2021) and this Plan.
- The management of floating debris/litter within the waterbodies is difficult. Floating litter, particularly plant matter, often blocks the culverts between Waterbodies C and D, and Waterbodies D and E. The blockage of the culverts impedes flow and may increase waterbody water levels.
- Some local residents living adjacent to the Lowlands Lagoons value the amenity provided by the large open waterbodies. Many areas around the waterbodies (behind the residential properties) are accessed by residents for passive recreation.
- Some residents expect Council to provide a high level of service in regards to waterbody management, including: water quality, aquatic plants, litter and waterbody edges.
- Generally, the community expects Council to maintain open water views, particularly Waterbody C, which is subject to extensive water lily and occasional *Azolla pinnata* growth.
- Requests from residents to address steep bank erosion, including recent feedback to fill in some areas as a possible solution.
- Many local residents keenly observe and display great interest in the health of the waterbodies.

# 3 FIELD ASSESSMENT

A field assessment of the Lowlands Lagoons was conducted by DesignFlow, between the 3rd - 7th of December 2018. A summary of the field assessments findings and scores for each waterbody are provided in the following tables. Photographs from the site inspections are provided in Figure 3-1 through Figure 3-5.

**Table 3-1 Waterbody A - Field condition assessment summary.**

| | Performance Indicator | Rating Score | Comments |
|---|---|---|---|
| Public Health & Safety | Risk of injury or drowning | 3 | • Many areas of the waterbody are obscured and do not have adjacent open space areas.<br>• The majority of the waterbody edges have steep drop-offs into the water, often with undercutting.<br>• Mown edges often with greater than 1:3 batter slope.<br>• No fencing present around the waterbody.<br>• Unrestricted access to open water areas. |
| | Batter slopes | 3 | |
| | Fencing/barriers | 3 | |
| | Contaminated Water | 2 | |
| | Mosquitoes | 2 | |
| | **Overall condition score** | **2.6** | |
| | **Overall condition rating** | **Poor** | |
| Hydraulic Function | Inlet condition | 2 | • Submerged inlet pipes.<br>• Major inlet area – accumulated sediment with weed cover.<br>• Submerged connection to Waterbody B.<br>• Outlet channel stable<br>• Waterbody residence time expected to be long (large volume compared to catchment areas).<br>• Batter slopes extremely steep tending to vertical in some areas.<br>• Waterbody edges well vegetated and stable. |
| | Outlet condition | 1 | |
| | Other structures | 1 | |
| | Flushing/Residence Time | 2 | |
| | Water Levels | 1 | |
| | Stability of batters and bunds | 1 | |
| | Sediment accumulation | 3 | |
| | **Overall condition score** | **1.6** | |
| | **Overall condition rating** | **Adequate** | |
| Water Quality | Odours | 1 | • Moderate turbidity.<br>• Planktonic algal biomass low.<br>• Floating litter observed within the waterbody. |
| | Algae/Cyanobacteria | 1 | |
| | Turbidity | 2 | |
| | Litter/debris | 2 | |
| | **Overall condition score** | **1.5** | |
| | **Overall condition rating** | **Good** | |
| Aquatic habitat | Aquatic vegetation - emergent | 1 | • Extensive emergent macrophyte cover around the edges of the waterbody. Generally confined to low profile species growing out from edges including: *Alternanthera denticulata, Persicaria attenuata, Leersia hexandra* and *Typha orientalis*.<br>• No submerged macrophytes observed.<br>• Minor floating macrophyte cover present – Spirodela sp.<br>• No declared or non-declared aquatic weeds observed. |
| | Aquatic vegetation - submerged | 3 | |
| | Aquatic vegetation - floating | 1 | |
| | Aquatic weeds - declared | 1 | |
| | Aquatic weeds – non-declared | 1 | |
| | Aquatic fauna and pests | 1 | |
| | Filamentous algae | 1 | |
| | **Overall condition score** | **1.2** | |
| | **Overall condition rating** | **Good** | |
| Terrestrial habitat | Edge vegetation condition | 2 | • Edge vegetation highly variable, ranging from grass cover to overhanging trees. South-east waterbody edges dominated by Sporobolus *virginicus*. Southern edge mix of mown turf and native species including: *Bacopa monnieri, Fimbristylis* sp. and *Restio* sp. Northern edge vegetation dominated by overhanging trees including Broadleaved pepper tree. North-west corner of waterbody with extensive grass cover extending into the water, comprising of *Leersia hexandra* and *Paspalum vaginatum*.<br>• Waterbody edges dominated by Broad-leaved pepper tree and Cassia in several locations.<br>• Introduced grasses and broad-leaved weeds present along edges. |
| | Terrestrial weeds – declared | 3 | |
| | Terrestrial weeds – non-declared | 3 | |
| | **Overall condition score** | **2.7** | |
| | **Overall condition rating** | **Poor** | |

| | | | |
|---|---|---|---|
| Maintenance Access | Access to reserve | 2 | • Access to the waterbody mainly foot access, some areas along northern edge accessible by vehicle.<br>• Majority of the waterbody edges accessible, access to north-east corner (mainly overhanging vegetation) limited.<br>• Access to water edge available at waterbody inlet (SE corner) or via Margaret Street. |
| | Access to waterbody margin | 1 | |
| | Access to water surface | 1 | |
| | **Overall condition score** | **1.3** | |
| | **Overall condition rating** | **Good** | |

*Overall condition rating based on: Good <1.5, Adequate 1.5-2.5, Poor 2.5-3.5, Very Poor >3.5.*

**Table 3-2 Waterbody B - Field condition assessment summary.**

| | Performance Indicator | Rating Score | Comments |
|---|---|---|---|
| Public Health & Safety | Risk of injury or drowning | 3 | • Areas of the waterbody with extremely steep batters, public risk moderated as many of the batters inaccessible to the public.<br>• Steep batters (<1:3 slope) present along the northern waterbody edge and in the south-east corner of the waterbody.<br>• No fencing present along south-eastern edge.<br>• Private fencing and retaining walls along the northern edge dilapidated. |
| | Batter slopes | 3 | |
| | Fencing/barriers | 3 | |
| | Contaminated Water | 2 | |
| | Mosquitoes | 2 | |
| | **Overall condition score** | **2.6** | |
| | **Overall condition rating** | **Poor** | |
| Hydraulic Function | Inlet condition | 1 | • Waterbody inlet and outlet stable<br>• Waterbody residence time expected to be long (large volume compared to catchment areas).<br>• Island at eastern end with poorly flushed backwater along southern edge.<br>• Open drain below inlet along southern waterbody edge eroded.<br>• Northern waterbody edge very steep, minor erosion (minor instability), located directly adjacent to residential properties. North-west edge comprising of vertical sleeper wall.<br>• Southern edge with low batter slope, vegetated and stable.<br>• South-east corner of waterbody, stable batters comprising almost vertical edge (700-900 mm deep).<br>• Area to the south of pipe under Alexander Street, without vegetative cover and steep. |
| | Outlet condition | 1 | |
| | Other structures | 3 | |
| | Flushing/Residence Time | 3 | |
| | Water Levels | 1 | |
| | Stability of batters and bunds | 2 | |
| | Sediment accumulation | 1 | |
| | **Overall condition score** | **1.7** | |
| | **Overall condition rating** | **Adequate** | |
| Water Quality | Odours | 1 | • Clear water due to extensive macrophyte and filamentous algal cover. |
| | Algae/Cyanobacteria | 1 | |
| | Turbidity | 1 | |
| | Litter/debris | 1 | |
| | **Overall condition score** | **1** | |
| | **Overall condition rating** | **Good** | |
| Aquatic habitat | Aquatic vegetation - emergent | 1 | • Extensive patches of Alternanthera denticulata and Persicaria attenuata growing out from the batters along the southern edge.<br>• Over 90% of the waterbody covered by submerged macrophyte *Ceratophyllum demersum*.<br>• Low floating macrophyte cover – *Azolla* sp. and *Spirodella* sp. present in backwater areas.<br>• No declared or non-declared aquatic weeds observed.<br>• Extensive areas of filamentous algae. |
| | Aquatic vegetation - submerged | 3 | |
| | Aquatic vegetation - floating | 1 | |
| | Aquatic weeds - declared | 1 | |
| | Aquatic weeds – non-declared | 1 | |
| | Aquatic fauna and pests | 1 | |
| | Filamentous algae | **3** | |
| | **Overall condition score** | **1.6** | |
| | **Overall condition rating** | **Adequate** | |

| | | | |
|---|---|---|---|
| **Terrestrial habitat** | **Edge vegetation condition** | **2** | • **Northern high canopy cover, dominated by Broad-leaved Pepper tree.**<br>• **Southern edge low canopy cover, dominated by introduced grasses and Singapore daisy.**<br>• **Broad-leaved Pepper Tree and Singapore Daisy present on waterbody edges.**<br>• **Southern edges dominated by introduced grasses and broad leaved weeds.**<br>• **Extensive growth of filamentous algae throughout the waterbody. The algae was observed to be growing on the submerged macrophyte.**<br>• **Minor damage to waterbody edges by waterbirds.** |
| | Terrestrial weeds – declared | 3 | |
| | Terrestrial weeds – non-declared | 3 | |
| | **Overall condition score** | **2.7** | |
| | **Overall condition rating** | **Poor** | |
| Maintenance Access | Access to reserve | 2 | • No formal maintenance access to northern edge of the waterbody – majority of residential boundaries extending to top of batter.<br>• Waterbody readily accessible along southern edge by foot and vehicle.<br>• Access to water surface from southern edge via Ann Street. |
| | Access to waterbody margin | 3 | |
| | Access to water surface | 1 | |
| | **Overall condition score** | **2.0** | |
| | **Overall condition rating** | **Adequate** | |

*Overall condition rating based on: Good <1.5, Adequate 1.5-2.5, Poor 2.5-3.5, Very Poor >3.5.*

**Table 3-3 Waterbody C - Field condition assessment summary.**

| | Performance Indicator | Rating Score | Comments |
|---|---|---|---|
| Public Health & Safety | Risk of injury or drowning | 1 | • Waterbody edges generally with low batter slopes, combined with shallow profile – presents low risk of injury or drowning.<br>• Majority of the batter slopes >1:6, some areas with steep to vertical batter slopes.<br>• No formal fencing present. |
| | Batter slopes | 1 | |
| | Fencing/barriers | 2 | |
| | Contaminated Water | 2 | |
| | Mosquitoes | 2 | |
| | **Overall condition score** | **1.6** | |
| | **Overall condition rating** | **Adequate** | |
| Hydraulic Function | Inlet condition | 2 | • Macrophyte cover present in front of inlet/outlets (Ann Street crossings).<br>• Waterbody residence time expected to be long (large volume compared to catchment areas).<br>• Batters well vegetated (mostly grass cover) and stable.<br>• Waterbody extremely shallow, appears to be accumulated sediment in some areas. |
| | Outlet condition | 1 | |
| | Other structures | - | |
| | Flushing/Residence Time | 2 | |
| | Water Levels | 1 | |
| | Stability of batters and bunds | 2 | |
| | Sediment accumulation | 3 | |
| | **Overall condition score** | **1.8** | |
| | **Overall condition rating** | **Adequate** | |
| Water Quality | Odours | 1 | • Excellent water quality – low turbidity and planktonic algal biomass.<br>• Water quality most likely related to shallow waterbody profile and high macrophyte cover. |
| | Algae/Cyanobacteria | 1 | |
| | Turbidity | 1 | |
| | Litter/debris | 1 | |
| | **Overall condition score** | **1** | |
| | **Overall condition rating** | **Good** | |

| | | | |
|---|---|---|---|
| Aquatic habitat | Aquatic vegetation - emergent<br>Aquatic vegetation - submerged<br>Aquatic vegetation - floating<br>Aquatic weeds - declared<br>Aquatic weeds – non-declared<br>Aquatic fauna and pests<br>Filamentous algae<br>**Overall condition score**<br>**Overall condition rating** | 1<br>2<br>3<br>1<br>3<br>3<br>2<br>**2.1**<br>**Adequate** | • Excellent emergent plant cover around the margins of the waterbody, dominated by *Alternanthera denticulata*, sub-dominants including: *Bolboschoenus caldwellii, Eleocharis sp., Persicaria attenuata, Phragmites australis*.<br>• Submerged aquatic plant, *Ceratophyllum demersum* observed throughout the waterbody.<br>• Floating aquatic vegetation dominated by *Nymphaea mexicana and N. indica*. Floating plant cover occupying over 60% of the waterbody surface area.<br>• No declared weeds observed.<br>• Waterbody surface dominated by *Nymphaea Mexicana*.<br>• Lower waterbody edges densely vegetated, mostly with introduced grasses and native sedges: *Fimbristylis sp., Restio sp., Bacopa monnieri, Imperata cylindrica.* |
| Terrestrial habitat | Edge vegetation condition<br>Terrestrial weeds – declared<br>Terrestrial weeds – non-declared<br>**Overall condition score**<br>**Overall condition rating** | 2<br>3<br>3<br>**2.75**<br>**Poor** | • Class 3 declared weed species, Singapore Daisy, growing extensively along the northern waterbody edge.<br>• High cover of introduced grass and broad leaved weed species including Johnson grass and *Dalrymple vigna*.<br>• Minor filamentous algal cover throughout the waterbody. Mainly due to shallow waterbody profile and presence of submerged and floating aquatic vegetation, upon which the filamentous algae uses as a substrate to grow upon.<br>• Large population of Tilapia present within the waterbody. Large areas of the waterbody bed have disturbed by the fish constructing nesting areas. |
| Maintenance Access | Access to waterbody reserve<br>Access to waterbody margin<br>Access to water surface<br>**Overall condition score**<br>**Overall condition rating** | 1<br>1<br>2<br>**1.3**<br>**Good** | • Access to the waterbody via Ann Street and southern edge of waterbody.<br>• Maintenance access to the majority of the waterbody edges.<br>• No formal access to the water surface (i.e. boat ramp) however access to water at either of the Ann Street connections or via Robert Street. |

*Overall condition rating based on: Good <1.5, Adequate 1.5-2.5, Poor 2.5-3.5, Very Poor >3.5.*

**Table 3-4 Waterbody D - Field condition assessment summary.**

| | Performance Indicator | Rating Score | Comments |
|---|---|---|---|
| Public Health & Safety | Risk of injury or drowning<br>Batter slopes<br>Fencing/barriers<br>Contaminated Water<br>Mosquitoes<br>**Overall condition score**<br>**Overall condition rating** | 3<br>3<br>2<br>3<br>2<br>**2.6**<br>**Poor** | • High risk of drowning along the northern edges of waterbody where the batter slopes vary between very steep to vertical. In particular, the batter slopes to the east of the Anembo Drive inlet are severely undercut and vertical. The bathymetric survey data for this area indicates the water is shallow (<0.75m), however visual inspection of this area indicated that the water depth is likely to be substantially deeper.<br>• The batter slopes along the southern waterbody edge are less steep and do not represent a potential public hazard.<br>• Majority of the residential properties along the northern waterbody edge with fences to the waterbody (i.e. no public access).<br>• Fencing present to prevent public access from the Anembo Drive inlet and along the northern boundary at Alexander Street. |

| | | | |
|---|---|---|---|
| **Hydraulic Function** | **Inlet condition** | **3** | • **Minor scour present near the inlet headwall.**<br>• **Waterbody residence time expected to be long (large volume compared to catchment areas). Channel area to the north of Anembo Island appears to have longer residence time compared to south side (more stagnant).**<br>• **Stormwater inlets to the northern channel provide some flushing of stagnant water.**<br>• **Batters generally steep with some vertical drops into the water.**<br>• **Undercutting of batters adjacent to Anembo Drive inlet causing major instability and waterbody edges to slump. Undercutting and slumping posing risk to private property at 37 and 43 Anembo Drive.** |
| | Outlet condition | 1 | |
| | Other structures | - | |
| | Flushing/Residence Time | 3 | |
| | Water Levels | 1 | |
| | Stability of batters and bunds | 3 | |
| | Sediment accumulation | 1 | |
| | **Overall condition score** | **2.0** | |
| | **Overall condition rating** | **Adequate** | |
| Water Quality | Odours | 3 | • Notable odours present adjacent to Anembo Island due to bird nesting areas. Uncertain whether odours related to water quality or deposition of faeces onto terrestrial areas.<br>• Notable planktonic algal biomass present within the waterbody.<br>• Moderate turbidity, mostly related to algal biomass. |
| | Algae/Cyanobacteria | 3 | |
| | Turbidity | 3 | |
| | Litter/debris | 1 | |
| | **Overall condition score** | **2.5** | |
| | **Overall condition rating** | **Poor** | |
| Aquatic habitat | Aquatic vegetation - emergent | 3 | • Very little emergent aquatic vegetation present within the waterbody.<br>• No submerged aquatic vegetation observed.<br>• No floating aquatic vegetation observed.<br>• No aquatic weeds observed.<br>• Large Ibis colony nesting on Anembo Island. Nesting associated with Broad-leaved Pepper Trees. Contributing to poor water quality and major odour issue for local residents. |
| | Aquatic vegetation - submerged | 3 | |
| | Aquatic vegetation - floating | 2 | |
| | Aquatic weeds - declared | 1 | |
| | Aquatic weeds – non-declared | 1 | |
| | Aquatic fauna and pests | 3 | |
| | Filamentous algae | 2 | |
| | **Overall condition score** | **2.1** | |
| | **Overall condition rating** | **Adequate** | |
| Terrestrial habitat | Edge vegetation condition | 3 | • Waterbody edges generally stable, except as noted above, and well vegetated with *Bacopa monnieri* and *Cynodon dactylon.*<br>• Edge of Anembo Island generally devoid of groundcover. High overstorey cover, dominated by Broad-leaved Pepper Tree.<br>• Broad-leaved Pepper Tree present around the waterbody margin including Anembo Island.<br>• Edges highly shaded. |
| | Terrestrial weeds – declared | 3 | |
| | Terrestrial weeds – non-declared | 3 | |
| | **Overall condition score** | **3** | |
| | **Overall condition rating** | **Poor** | |
| Maintenance Access | Access to waterbody reserve | 3 | • Majority of the waterbody accessible from the water but limited access around the waterbody margins.<br>• Maintenance access particularly poor along the northern edge of the waterbody.<br>• No dedicated access to the water surface, although the waterbody edge can be easily accessed via the parkland area off Ann Street. |
| | Access to waterbody margin | 2 | |
| | Access to water surface | 2 | |
| | **Overall condition score** | **2.3** | |
| | **Overall condition rating** | **Adequate** | |

*Overall condition rating based on: Good <1.5, Adequate 1.5-2.5, Poor 2.5-3.5, Very Poor >3.5.*

**Table 3-5 Waterbody E - Field condition assessment summary.**

| Performance Indicator | | Rating Score | Comments |
|---|---|---|---|
| Public Health & Safety | Risk of injury or drowning | 3 | • Steep batters present around edges of waterbody, greater than 1:3 slope in many areas.<br>• Batters with vertical drop present along western edge of waterbody.<br>• No fencing present to prevent public access to waterbody edges in areas with steep batter slopes.<br>• Visible green algal discoloration of the water column.<br>• No mosquitos observed. |
| | Batter slopes | 3 | |
| | Fencing/barriers | 3 | |
| | Contaminated Water | 3 | |
| | Mosquitoes | 2 | |
| | **Overall condition score** | **2.8** | |
| | **Overall condition rating** | **Poor** | |
| Hydraulic Function | Inlet condition | 1 | • Inlet pipes below Alexander Street submerged.<br>• Minor stormwater inlets functioning well with no sediment accumulation or blockage.<br>• Outlet functioning well without blockage or scour.<br>• Water level in the waterbody is set by overflow weir. |
| | Outlet condition | 1 | |
| | Other structures | - | |
| | Flushing/Residence Time | 2 | |
| | Water Levels | 1 | |

| | | | |
|---|---|---|---|
| | Stability of batters and bunds<br>Sediment accumulation<br>**Overall condition score**<br>**Overall condition rating** | 3<br>1<br>**1.4**<br>**Good** | • Waterbody residence time expected to be long (large volume compared to catchment areas).<br>• Batters along southern edge of waterbody comprising of mown turf with steep drop off into water. Some edges locally undermined. |
| Water Quality | Odours<br>Algae/Cyanobacteria<br>Turbidity<br>Litter/debris<br>**Overall condition score**<br>**Overall condition rating** | 3<br>3<br>3<br>2<br>**2.75**<br>**Poor** | • Notable odours present at outlet, most likely associated with tidal backwatering in downstream drainage system.<br>• Visible green discoloration of water indicating high planktonic algal biomass.<br>• Turbidity high due to algal biomass.<br>• Minor litter present near the waterbody outlet. |
| Aquatic habitat | Aquatic vegetation - emergent<br>Aquatic vegetation - submerged<br>Aquatic vegetation - floating<br>Aquatic weeds - declared<br>Aquatic weeds – non-declared<br>Aquatic fauna and pests<br>Filamentous algae<br>**Overall condition score**<br>**Overall condition rating** | 3<br>1<br>1<br>1<br>1<br>2<br>1<br>**1.4**<br>**Good** | • Edges of waterbody with very little emergent macrophyte cover except for waterbody outlet with large patches of Phragmites australis and *Cladium procerum*.<br>• No submerged macrophytes observed.<br>• No floating macrophytes observed.<br>• No aquatic weeds observed.<br>• No filamentous algae observed.<br>• Established waterbird feeding point present within the park adjacent to Truro Street. This is resulting in the aggregation of large waterbird numbers within the waterbody.<br>• A large turtle population is present within the waterbody. The behaviour of the turtles suggests that they are being fed by local residents. |
| Terrestrial habitat | Edge vegetation condition<br>Terrestrial weeds – declared<br>Terrestrial weeds – non-declared<br>**Overall condition score**<br>**Overall condition rating** | 2<br>3<br>1<br>**2**<br>**Adequate** | • Edge vegetation comprising of mown turf along the south-eastern edge, and combination of turf and dense native/introduced overstorey vegetation overhanging the edges along the north-western edge.<br>• Broadleaved pepper trees widespread along the north-western edge and the two islands.<br>• Noted that majority of residents are mowing waterbody batters to the water's edge (including notably steep areas).<br>• Edge vegetation has been removed in some areas. Herbicide treatment of the edge vegetation observed in the south-east corner of the waterbody (adjacent to Margaret Street). |
| Maintenance Access | Access to waterbody reserve<br>Access to waterbody margin<br>Access to water surface<br>**Overall condition score**<br>**Overall condition rating** | 2<br>2<br>2<br>**2**<br>**Adequate** | • Access to the waterbody via Truro Street, Margaret Street and Alexander Street.<br>• Waterbody edges accessible by foot. Limited access to maintenance vehicles.<br>• No formal maintenance access to the water surface. Vehicular access available at Margaret Street. |

*Overall condition rating based on: Good <1.5, Adequate 1.5-2.5, Poor 2.5-3.5, Very Poor >3.5.*

**Figure 3-1 Waterbody A – a) Eastern end, and b) Edge buffer zone established by Council.**

**Figure 3-2 Waterbody B – a) Shallow water with dense growth of Ceratophyllum demersum, and b) Deeper water at eastern end of waterbody.**

**Figure 3-3 Waterbody C – a) Dense cover of *Nymphaea mexicana* near outlet to Waterbody D, and b) Main waterbody.**

**Figure 3-4 Waterbody D – a) Anembo Island – Ibis rookery, and b) Steep batters along the southern edge with steep drop-off at the water's edge.**

**Figure 3-5 Waterbody E – a) Main waterbody (turtles waiting to be fed in foreground), and b) Example of residents mowing batters to the water's edge.**

# 4 ISSUES IDENTIFICATION AND PRIORITISATION

Following the condition assessment, the range of waterbody management issues were identified and prioritised.

## 4.1 IDENTIFY ISSUES

The following sub-sections provide a summary of the management issues associated with each waterbody.

### 4.1.1 Public safety (Batter slopes)

As part of the field condition assessment a rapid batter profile safety assessment was completed. This assessment involved mapping the various batter profiles in relation to public safety risk. Typically batters steeper than 1V:3H which allow unrestricted access to open water present a safety risk to the public. Shallow batters, or with physical barriers and/or shallow water profiles present a lower risk.

It was found that the majority of the waterbody batter slopes were generally flatter than a 1:3 grade and/or transitioned into relatively shallow water, which renders these edges relatively safe. However a number locations were noted to have grades steeper than 1:3 or which had open, unrestricted access to deeper water. These locations were considered a potential safety risk because of the following factors:

- There is a high risk of unintentional water entry
- Exiting the water can be difficult due to the batter slope
- The presence of drop offs/vertical edges at the base of the batter slope makes exiting more difficult
- The presence of deep water and steep batter slope increases drowning risk substantially

Several of the waterbodies have constructed vertical batters where concrete or timber sleeper revetment walls have been constructed. Many of these walls are >1m tall and adjoin deep water, and therefore were considered to pose a potentially high risk in need of further assessment.

High risk batter slopes were identified in all of the Lowlands Lagoons. A summary of the common batter slope/waterbody edge profiles and associated safety risks are presented in Table 4-1.

**Table 4-1 Waterbody edge profiles.**

| Edge Type | Comments/notes | Photo |
|---|---|---|
| Gentle batter +/- sharp drop off into shallow water | Generally >1:3 batter slope, mown grassed edge +/- sharp drop off into shallow (<0.3m) water. Moderate risk but shallow depth of water means exiting is fine.<br>Safe |  |
| Gentle batter +/- sharp drop off into deep water | Generally >1:3 batter slope, mown grassed edge +/- sharp drop off into deep (>0.3m) water. High risk as deep depth of water means exiting may be difficult.<br>Potentially Hazardous. |  |
| Steep batter +/- sharp drop off shallow water | Generally <1:3 batter slope, +/- sharp drop off into shallow (<0.3m) depth water. Moderate risk but steep batter slope may make it very difficult to exit waterbody (and easy to fall back in). High drowning risk<br>Potentially Hazardous |  |
| Steep batter +/- sharp drop off deep water | Generally <1:3 batter slope, +/- sharp drop off into deep (>0.3m) water. High risk as steep batter slope and deep depth of water means exiting is extremely difficult (and easy to fall back in). High drowning risk<br>Hazardous |  |
| Vertical/highly eroded edge | Vertical waterbody edge with drop off into +/- deep water. Extremely difficult to exit waterbody. Presence of deep water means high drowning risk.<br>Extremely Hazardous |  |

### 4.1.2 Waterbody edge stability

The majority of the lower batters/edges have good vegetation cover and are stable. Many of the waterbody edges comprise of mown grass, and have shallow vertical edges where wave action or waterbird activity has resulted in minor scour (Figure 4-1). These edges are relatively stable but are highly susceptible to further scour due the presence of the bare soils.

Notable scour of the lower batters observed in several locations:

- Waterbody B – northern waterbody edge
- Waterbody C – northern waterbody edge (one location)
- Waterbody D – northern waterbody edge and Anembo Drive inlet

Active erosion and undermining of the waterbody edges along the northern margin of Waterbody D and within the Anembo Drive inlet are of most concern, as the batters are steep to vertical, adjoining deep water and represent a risk to both public safety and the adjoining residential properties.

Of particular concern and requiring urgent attention, the waterbody edge adjacent to the residential property to the east of Anembo Drive inlet is severely undermined, is actively eroding and is retreating towards the property boundary. Intervention will be required to arrest the erosion and protect the residential property boundary. A similar scenario is occurring along the waterbody edges adjacent to this area, but the batters are moderately stable and not endangering the adjacent properties.

**Figure 4-1 Minor scour present below grassed edges creating shallow vertical edge.**

**Figure 4-2 Eroded areas within Waterbody C: a) northern edge, and b) near Anembo Drive inlet.**

### 4.1.3 Water quality

An understanding of water quality within the Lowlands Lagoons have been established based on field inspections (completed by DesignFlow in 2018) and the results of an 8 week water quality monitoring program documented in GHD (2013). The following observations were made:

- **Electrical conductivity** - the waterbodies are fresh with slightly elevated electrical conductivity at the eastern inlet to Waterbody A. Salinity at the eastern end of Waterbody A (Site 6) was ranged between 1.47-1.61 mS/cm (compared to generally less than 1.0 mS/Cm at other locations).
- **pH** – relatively high, generally greater than pH 8. This may reflect the time of water quality sampling and the presence of algal and waterplant productivity within the waterbody.
- **Turbidity** – generally low, less than 20 NTU.
- **Total suspended solids** – exceeded the QWQG trigger value of 2 mg/L at all sites. Additional sampling undertaken by Council in February 2018 found that TSS concentrations exceeded 15 mg/L at all sampling sites except for Waterbody C where TSS concentrations at sampling sites 4 and 5 were below the limit of reporting (3.6 mg/L). It is likely that the low TSS concentrations observed in Waterbody C were associated with low chlorophyll-a (algal) concentrations.
- **Dissolved oxygen** – generally high saturation levels were present across the waterbodies.
- **Phosphorus** – varied throughout the waterbodies with total phosphorous concentrations sites in Waterbodies A and D regularly exceeding the QWQG trigger value of 0.01 mg/L. Additional sampling undertaken by Council in February 2018 found notably high total phosphorous concentrations (> 1.3 mg/L) in Waterbodies A, D and E. High dissolved phosphorus concentrations were also found within Waterbodies A and D, suggesting the faeces deposition by the waterbirds (primarily Ibis) is directly impacting water quality within the waterbody.
- **Nitrogen** – total nitrogen concentrations within the waterbodies exceeded the QWQG trigger value of 0.35 mg/L at sites. The same trend was also observed in February 2018 with total nitrogen exceeding 2 mg/L at all sampling sites. Extremely low concentrations were observed for Ammonia and Nitrate/Nitrite indicating the majority of nitrogen present within the waterbodies comprised of organic nitrogen (dissolved organic and particulate organic). The presence of high concentrations of chlorophyll-a within the waterbodies suggests that the majority of nitrogen comprises of algal biomass or decomposing organic matter in the water column.
- **Biochemical oxygen demand** - exceeded the QWQG trigger range of 0.5-1.3 mg/L at all sampling sites (BOD concentrations >5 mg/L). BOD concentrations exceeded the QWQG trigger range at all sampling sites in February 2018.
- **E. coli** – refer to Section 4.1.5.
- **Chlorophyll-a** - exceeded the QWQG trigger range of 5 ug/L at all sampling sites. Chlorophyll-a concentrations exceeded 44 ug/L at all sampling sites in February 2018, except in Waterbody C where chlorophyll-a concentrations were 7 and <0.1 ug/L (low). The high chlorophyll-a concentrations observed in the waterbodies in both 2013 and 2018 are most likely associated with planktonic algal biomass (algae present in the water column).
- **Algal biomass -** Planktonic algal biomass was visible in Waterbodies A, D and E during the 2018 waterbody condition assessment, with little to no algal biomass visible in Waterbodies B and C. Filamentous algal biomass was observed in Waterbody B, where filamentous algae were observed growing upon the submerged waterplants. The presence of algal biomass, both in the water column and upon the submerged macrophytes indicates that there are high nutrient concentrations present throughout the waterbodies.

GHD (2013) assessed catchment inputs into the waterbodies using the conceptual urban pollution modelling program MUSIC. The Lowlands Lagoons ~135 ha contributing catchment includes ~100ha of urban run-off. Stormwater runoff from these urban areas will convey pollutants into the waterbodies in

the form of nutrients, sediments and other contaminants (i.e. associated with roads etc). These catchment pollutants will accumulate in the water column and bed sediments, leading to a gradual decline in condition over time.

Algal growth within waterbodies is stimulated by nutrients, water temperature and light. Healthy, robust, shallow waterbodies generally have high submerged and emergent waterplant cover. Waterplants, and in particular submerged species, aggressively compete with algae for nutrient resources, such as phosphorus, and help to maintain low turbidity in shallow waterbodies. Waterbodies with high waterplant cover are generally able to withstand moderate increases in nutrient levels and turbidity, however, a threshold exists whereby the submerged waterplants are unable to access sufficient light resources to survive the plant population crashes. This may be due to excessive turbidity (i.e. via stormwater runoff) or the excessive growth of floating waterplants (i.e. Azolla or Salvinia). The loss of submerged plants is rapid and catastrophic, and results in a transition from a clear water waterplant dominated state to either an algal or floating waterplant state. This is referred to as the 'alternative states model' and is a scientific model often used to interpret and understand shallow waterbody ecosystem function (Figure 4-3).

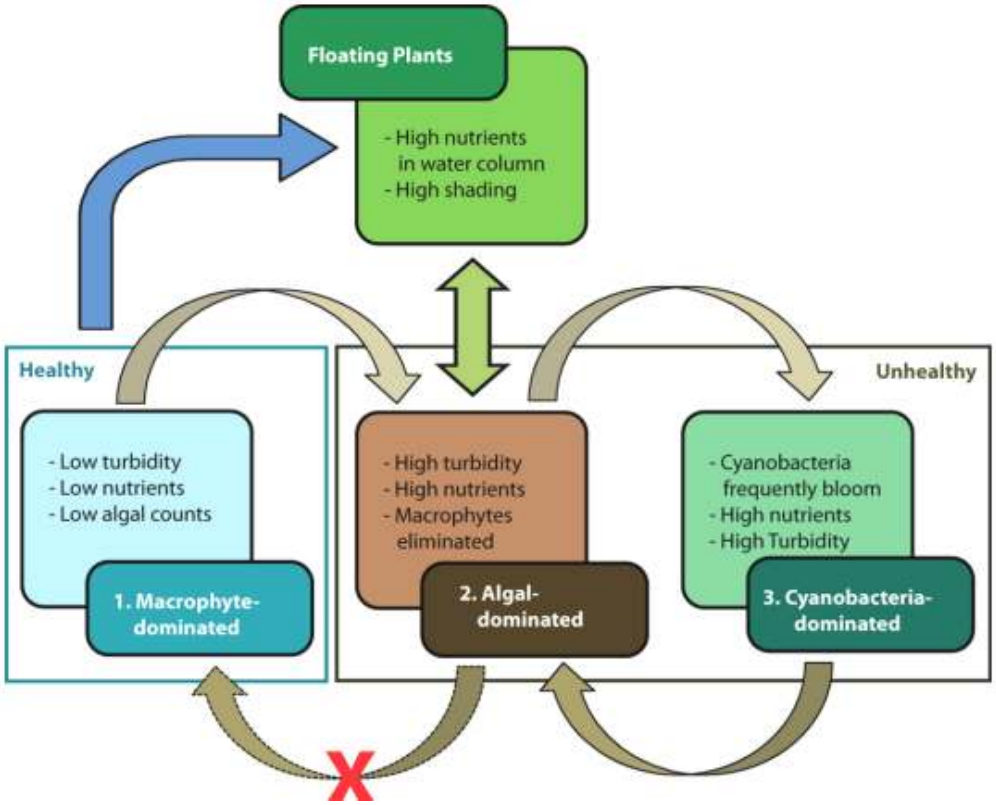


**Figure 4-3 Alternative states model used to interpret shallow waterbody ecosystem function.**

### 4.1.4 Waterbirds (Faecal contamination)

The Lowlands Lagoons is home to a variety of native waterbirds including: Black ducks, Chestnut teal, Hardhead ducks, Pelicans, Australian wood ducks, Black swans, Purple swamp hens, Dusky moorhens and Australian white ibis.

Notable congregations of birds were observed in both Waterbodies D and E. The large number of waterbirds observed in Waterbody E was thought to be associated with an informal public bird feeding area within the parkland on Truro Street (Figure 4-4). Observations during the site inspection (December 2018) indicated that several hundred waterbirds are fed on a daily basis within the park.

Australian white ibis rookeries were present at the western end of Anembo Island (Waterbody D) and the small island at the western end of Waterbody E (Figure 4-5). Both of these locations are also within close vicinity to the bird feeding area in the parkland near Truro St.

The size of the waterbird population, in particular Australian white ibis, throughout the waterbodies reflects the quantity of food being fed to the birds on a regular basis, and not necessarily the quantity and quality of habitat and food resources present in the waterbodies. The regular supply of food sustains higher numbers of waterbirds than would naturally be present within the waterbodies, and is impacting waterbody health via bird faeces and organic material (e.g. egg shells, feathers, food scraps etc.) entering the water.

The presence of the large waterbird population within the waterbody environment potentially impacts upon:

- **Public safety** – The large volume of bird faeces present around the waterbody represents a potential public health risk from direct exposure to excreta or indirect exposure to waters contaminated by faeces or associated algal blooms.
- **Public amenity** – Many of the grassed areas around the waterbodies are used by the birds for loafing and are generally covered by excreta resulting in smell and reduced amenity.

### 4.1.5 Faecal contamination

Human contact with waterbird faecal matter presents a public health hazard. This risk was considered highest in areas with high bird populations, such as areas adjacent to bird rookeries or bird feeding areas.

Previous water quality monitoring (GHD, 2013) indicated that high E. coli levels were present throughout waterbodies, with the highest concentrations present at the western end of Anembo Island, adjacent to the Ibis rookery. The presence of high E. coli levels is almost certainly associated with the large resident waterbird population, primarily ducks and ibis, living in the lagoon system.

Areas within the waterbodies where waterbirds congregate are considered to be associated with a potentially higher risk, as there is generally higher deposition of bird faeces in these areas. This includes the areas (both the water and waterbody edges) adjacent to the Ibis rookeries (Waterbody D - Anembo Island and small island, Waterbody E - island). The waterbody edges behind the residential properties and adjacent to the Ibis rookery on Anembo Island were notably contaminated and notably odorous during the waterbody inspection (Figure 4-5).

Daily feeding of the waterbirds occurs within the park between Truro Street and Waterbody E, resulting in a major aggregation of the waterbirds every morning and high loads of faecal matter present within the park (Figure 4-4).

**Figure 4-4 Bird feeding area within the parkland on Truro St.**

**Figure 4-5 Ibis rookery on Anembo Island.**

### 4.1.6 Aquatic plant management

**Declared weeds -** No declared aquatic weeds were observed during the waterbody condition audit. Discussion with Council staff and a review of historical aerial imagery indicates that excessive growth of *Salvinia molest*a has occurred within the waterbodies in the past, however Salvinia outbreaks have not occurred in recent times.

**Submerged aquatic plants -** Some concern was expressed about the potential presence of the declared submerged aquatic weed *Cabomba caroliana* growing in both Waterbodies B and C. However, plant samples collected from both waterbodies were consistent with *Ceratophyllum demersum*, a native submerged waterplant species. *Ceratophyllum demersum* is considered a beneficial submerged waterplant that assists with the uptake of nutrients and reduction of suspended solids (turbidity).

**Mexican Water Lily -** A large population of *Nymphaea mexicana* (Mexican Water Lily) is present throughout Waterbody C, and is particularly dominant in the northern arm leading to Waterbody D (Figure 4-6). The presence of *N. mexicana* potentially reduces hydraulic conveyance through the waterbody, and reduces aquatic biodiversity and habitat. The presence of *N. mexicana* reduces open water views across the waterbody and is perceived by some local residents as detrimental to both waterbody amenity and health (Figure 4-7).

The management of *N. mexicana* is an ongoing management issue for Council, as Council receives regular requests to remove *N. mexicana* from the waterbody. The removal of *N. mexicana* from the Lowlands Lagoons is undertaken in accordance with Council's *Aquatic Plant Management Policy.* The policy aims to balance the expectations of the community with appropriate intervention levels and maintenance practices.

*N. mexicana* is mechanically removed from the waterbody using Council's aquatic weed harvester. Removal of the *N. mexicana* is difficult as it is generally concentrated in the shallow waterbody areas. Whilst the weed harvester is effective at removing the floating foliage (leaves), it is extremely difficult to remove the extensive root systems (rhizomes) that are present on the bed of the waterbody.

It is understood that Council conducted a trial in late 2018 to reduce the distribution of *N. mexicana* within Waterbody C. This involved repeated harvesting over a short period of time. Discussions with Council staff indicated that the trial appears to have been ineffective at reducing the distribution of *N. mexicana* within Waterbody C, and may have increased overall cover.

**Red Azolla -** Occasional occurrence of the native floating waterplant, *Azolla pinnata*, within Waterbody C is also an ongoing management issue for Council. The presence of Azolla on the surface of the waterbody is perceived by some local residents as detrimental to waterbody amenity and health, and it is understood that Council is regularly requested to remove the Azolla from the waterbody when present. The removal of Azolla is extremely difficult to achieve given the small size of the plant and distribution of Azolla around the shallow margins of the waterbody within the emergent waterplants  Excessive growth can in extreme cases cause impacts to submerged aquatic plant health.. However, in most occurrences Azolla has beneficial qualities (including as a natural food source for aquatic fauna, such as ducks and turtles) and generally doesn't require management intervention.

**Figure 4-6.** ***N. mexicana*** **(light green areas) around margins of Waterbody C.**

**Figure 4-7.** ***N. mexicana*** **– a) Northern arm of Waterbody C, and b) Extensive population along the southern edge of the waterbody.**

### 4.1.7 Aquatic vegetation

Waterplant communities throughout the waterbodies comprised of isolated patches of emergent waterplants along the waterbody edges, and widespread cover of submerged waterplants within Waterbodies B and C. No submerged waterplants were observed in Waterbodies A, D and E.

The presence of dense waterplant communities, particularly submerged waterplants, provides competition for bio-available nutrients and assists with the removal of suspended solids. In the case of Waterbodies B and C, the presence of dense submerged waterplant cover results in low algal biomass and the persistence of clear water conditions. The dominant submerged waterplant present in Waterbodies B and C was *Ceratophyllum demersum*, a common native species often observed growing in shallow waterbodies and wetlands.

A review of historical aerial images indicates that the bed of Waterbody D was dominated by submerged waterplants in 2010. However by 2014, following multiple Salvinia blooms, the waterbody had transitioned to a turbid, floating waterplant/algal dominated system, and it appears that submerged waterplants have been permanently lost from the waterbody (Figure 4-8). A similar loss of submerged waterplants also occurred in both Waterbodies A and E during the same period.

Emergent waterplants are also important as the biofilms growing on the plant stems and the plants themselves aggressively compete for nutrients within the water column. Emergent water plants are also important for stabilising the waterbody edges, preventing erosion and the introduction of suspended solids to the waterbodies.

Native emergent waterplants were observed growing along the waterbody edges included:

- *Alternanthera denticulata*
- *Bolboschoenus caldwellii*
- *Cladium procerum*
- *Cyperus spp.*
- *Eleocharis acuta*
- *Leersia hexandra*
- *Persicaria attenuata*
- *Phragmites australis*
- *Typha orientalis*

The distribution of emergent waterplants throughout the waterbodies is extremely patchy. The reasons for limited emergent waterplant cover are not clear but may be due to:

- waterbird grazing
- active erosion
- root disturbance by fish
- lack of waterplant recruitment
- steep to vertical batters
- deep water at the waterbody edges
- excessive mowing/slashing to the waterbody edge
- deliberate removal of the emergent waterplants by residents


**Figure 4-8 Waterbody D – comparison of submerged waterplant cover between 2010 and 2014.**

**Figure 4-9 Examples of emergent waterplants: a) *Alternanthera denticulata*, and b) *Bolboschoenus caldwellii*.**

### 4.1.8 Hydraulic retention times and mixing

The Lowlands Lagoons systems has a large waterbody area (27.8 ha total) compared to the contributing catchment (135.7 ha). This equates to a waterbody to catchment area ratio of approximately 20%, as a result the waterbodies will be prone to longer residence times (i.e. it takes significant rainfall to displace the stored water within the system). Long retention times generally results in poor water quality due to lack of flushing and associated algal and weed issues. Typically waterbodies >5-10% of the catchment area may experience obvious water level variations and potentially dry out from time-to-time. However it is suspect that the base of the Lowlands Lagoons interact with the local groundwater table, which assist in regulating water levels.

The waterbodies area also deep in places, with a number of locations in Waterbodies A, C and D with depths of up to 2.75-3m (Figure 2-3). Open water areas deeper than 1.5-2m are more susceptible to stratification (due to poor light penetration and mixing). Stratification of the water column can lead to the development of an anoxic hypolimnion (bottom layer of water) and the subsequent release of nutrients from the waterbody sediments (via bacterial decomposition). The release of nutrients due to stratification is often associated with the development of algal biomass and the excessive growth of aquatic weeds. The presence of stratified conditions followed by mixing of the waterbody can also lead to fish kills due to low

oxygen concentrations within the water column. Council officers have noted that Lowlands Lagoons is known to experience seasonal fish kills.

A number of 'backwater' areas were noted in Lowlands Lagoons. Backwater areas within the waterbodies can often have longer residence times as they are poorly flushed. Backwater areas often appear stagnant and are associated with the accumulation and decomposition of organic material. Poorly flushed waterbody water combined with nutrient release (e.g. from anoxic sediments or bird faecal matter) often results in ideal conditions for incubating algal and floating water weed growth (Figure 4-10).

**Figure 4-10 Backwatered areas such as Anembo Drive inlet can act as incubators for algal and floating waterplant growth.**

### 4.2 PRIORITISE ISSUES

The waterbody management issues identified above have been mapped and prioritised for each waterbody (refer Figure 4-11 to Figure 4-15). Issues have been prioritised based on the rating system developed in the *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report* (DesignFlow, 2021). Each waterbody issue has been prioritised as either:

- High – Issue is currently management risk to Council, health and safety or environment that requires addressing.
- Medium - Issue is a minor management risk to Council, health and safety or environment but has the potential to become a High priority in future if not managed.
- Low – Not currently a management risk to Council and unlikely to become issue in near future.

DesignFlow

LEGEND

- Property boundary
- Existing stormwater pipe

EDGE CONDITION

- Edge dominated by over hanging Broadleaf Pepper Tree
- Edge dominated by Singapore Daisy
- Overhanging vegetation (native & introduced)
- Grassed edge, steep batter, sharp drop-off
- Grassed edge, mown
- Edge dominated by emergent water plants

- High priority issue
- Medium priority issue

0 15 30 60 m

**Figure 4-11**
**Lake A - Issues Plan**

Lowlands Lagoons (Anembo Lakes)
Waterbody Management Plan

SCALE: 1:1,500

DATE: 19 February 2021

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For:
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Edge dominated by *Persicaria sp. Paspalum vaginatus, Alternanthera denticulata*

**C2, C3** Algal biomass in water column, Elevated turbidity

WATERBODY A

**D1** Submerged water plants absent. No visible submerged water plants

ALEXANDER STREET

Submerged outlet

MARGARET STREET

**D1** Previous Salvinia infestation

**A4** Nutrient inputs via stormwater inlets

**A1** Public safety due to steep vertical edges

**C5** Potential ingress of saline groundwater

Edge dominated by *Persicaria sp., Alternanthera denticulata*

Secondary overflow outlet (~2.45 mAHD)

Edge dominated by *Typha sp., Alternanthera denticulata*

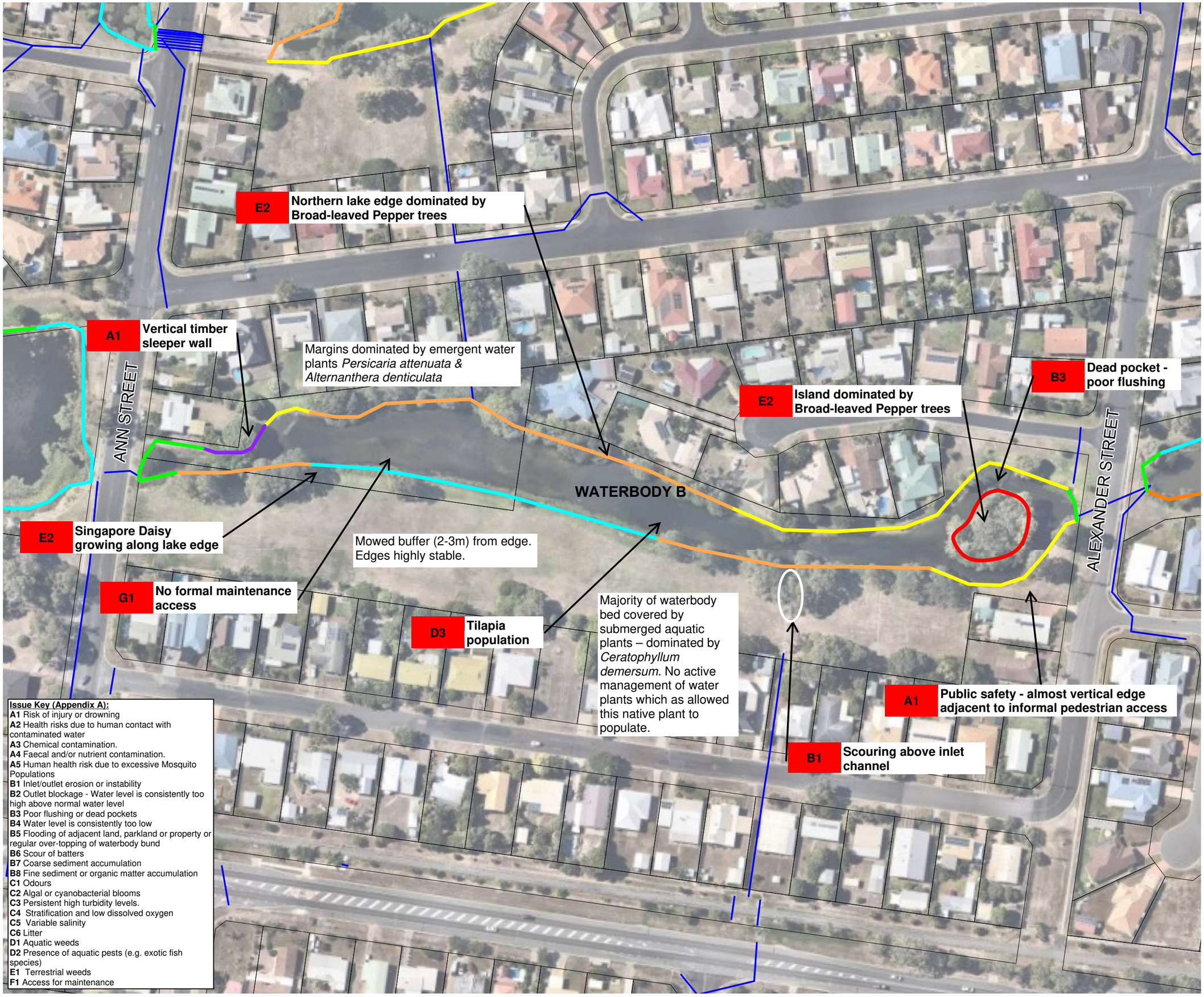
Edge dominated by *Sporobolus*

BOAT HARBOUR D

**B1** Eroded inlet channel

Primary inlet

**Issue Key (Appendix A):**
**A1** Risk of injury or drowning
**A2** Health risks due to human contact with contaminated water
**A3** Chemical contamination.
**A4** Faecal and/or nutrient contamination.
**A5** Human health risk due to excessive Mosquito Populations
**B1** Inlet/outlet erosion or instability
**B2** Outlet blockage - Water level is consistently too high above normal water level
**B3** Poor flushing or dead pockets
**B4** Water level is consistently too low
**B5** Flooding of adjacent land, parkland or property or regular over-topping of waterbody bund
**B6** Scour of batters
**B7** Coarse sediment accumulation
**B8** Fine sediment or organic matter accumulation
**C1** Odours
**C2** Algal or cyanobacterial blooms
**C3** Persistent high turbidity levels.
**C4** Stratification and low dissolved oxygen
**C5** Variable salinity
**C6** Litter
**D1** Aquatic weeds
**D2** Presence of aquatic pests (e.g. exotic fish species)
**E1** Terrestrial weeds
**F1** Access for maintenance




DesignFlow

LEGEND

- Property boundary
- Existing stormwater pipe

EDGE CONDITION

- Edge dominated by over hanging Broadleaf Pepper Tree
- Edge dominated by Singapore Daisy
- Overhanging vegetation (native & introduced)
- Grassed edge, steep batter, sharp drop-off
- Grassed edge, mown
- Edge dominated by emergent water plants
- Retaining wall
- High priority issue
- Medium priority issue

0 15 30 60 m

**Figure 4-12**
**Waterbody B - Issues Plan**

Lowlands Lagoons Waterbody Management Plan

SCALE: 1:1,500

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For:
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**Issue Key (Appendix A):**
**A1** Risk of injury or drowning
**A2** Health risks due to human contact with contaminated water
**A3** Chemical contamination.
**A4** Faecal and/or nutrient contamination.
**A5** Human health risk due to excessive Mosquito Populations
**B1** Inlet/outlet erosion or instability
**B2** Outlet blockage - Water level is consistently too high above normal water level
**B3** Poor flushing or dead pockets
**B4** Water level is consistently too low
**B5** Flooding of adjacent land, parkland or property or regular over-topping of waterbody bund
**B6** Scour of batters
**B7** Coarse sediment accumulation
**B8** Fine sediment or organic matter accumulation
**C1** Odours
**C2** Algal or cyanobacterial blooms
**C3** Persistent high turbidity levels.
**C4** Stratification and low dissolved oxygen
**C5** Variable salinity
**C6** Litter
**D1** Aquatic weeds
**D2** Presence of aquatic pests (e.g. exotic fish species)
**E1** Terrestrial weeds
**F1** Access for maintenance

**B6** **Steep eroding batter**

**E1** **Singapore daisy infestation**

**D3** **Nesting Tilapia throughout, particularly in shallow areas.**

High level of service expected by local residents. Main issues include *Nymphaea mexicana* cover over waterbody surface

Garden waste dumped into waterbody

N STREET

Edge dominated by *Fimbristylis sp., Bacopa monnerii* and *Restio sp.*

**D1** **Limited emergent water plant cover to lake margins**

Occasional blockage at culverts

Floating filamentous algae

Turf mowed to water edge by residents

Overflow to Tooan Tooan drainage line (>~2.80mAHD)

High frequency harvesting of *Nymphaea Mexicana* trialled in waterbody

**E1** **Turf mowed to water edge - no buffer**

**A4** **Nutrient inputs via stormwater inlets**

**D2** ***N. mexicana* infestations. Historic Azolla blooms**

**WATERBODY C**

Good water quality with low turbidity

Edges stable but highly weedy

Edge dominated by, *Alternanthera denticulata, Bolboshoenus caldwellii*

Constriction shallow

Shallow area dominated by *Nymphaea Mexicana* and *N. indica* along edges, *Ceratophyllum demersum* in deeper areas. Also subject to Azolla sp. growth across surface.

ANN STREET

Mowed buffer (2-3m) from water edge. Edges highly stable but highly weedy

Infiltration basin

Edge vegetation dominated by *Imperata cylindrical, Restio sp., Bolboschoenus caldwellii, Fimbrystylis sp., Bacopa monnieri & Persicaria attenuata*

Maintenance access to water at multiple locations along the southern boundary.

DesignFlow

LEGEND

Property boundary

Existing stormwater pipe

EDGE CONDITION

Edge dominated by over hanging Broadleaf Pepper Tree

Edge dominated by Singapore Daisy

Overhanging vegetation (native & introduced)

Grassed edge, steep batter, sharp drop-off

Grassed edge, mown

Edge dominated by emergent water plants

High priority issue

Medium priority issue

0 15 30 60 m

**Figure 4-13**
**Waterbody C - Issues Plan**

Lowlands Lagoons (Anembo Lakes) Waterbody Management Plan

SCALE: 1:1,500

DATE: 19 February 2021

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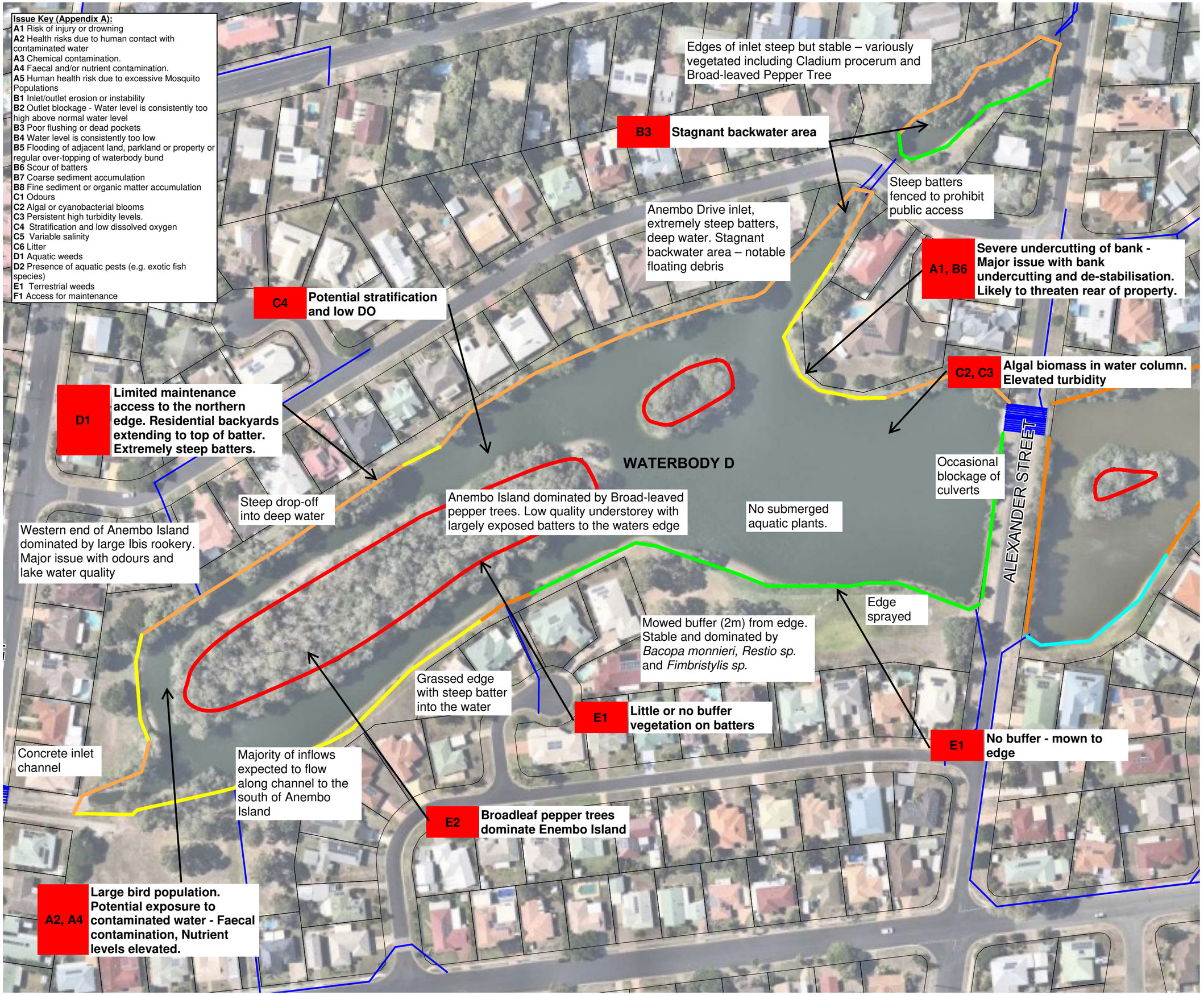


DesignFlow

LEGEND

Property boundary

Existing stormwater pipe

EDGE CONDITION

Edge dominated by over hanging Broadleaf Pepper Tree

Edge dominated by Singapore Daisy

Overhanging vegetation (native & introduced)

Grassed edge, steep batter, sharp drop-off

Grassed edge, mown

Edge dominated by emergent water plants

High priority issue

Medium priority issue

0 15 30 60 m

**Figure 4-14**
**Waterbody D - Issues Plan**

Lowlands Lagoons (Anembo Lakes) Waterbody Management Plan

SCALE: 1:1,500

DATE: 19 February 2021

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For:
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**Issue Key (Appendix A):**
**A1** Risk of injury or drowning
**A2** Health risks due to human contact with contaminated water
**A3** Chemical contamination.
**A4** Faecal and/or nutrient contamination.
**A5** Human health risk due to excessive Mosquito Populations
**B1** Inlet/outlet erosion or instability
**B2** Outlet blockage - Water level is consistently too high above normal water level
**B3** Poor flushing or dead pockets
**B4** Water level is consistently too low
**B5** Flooding of adjacent land, parkland or property or regular over-topping of waterbody bund
**B6** Scour of batters
**B7** Coarse sediment accumulation
**B8** Fine sediment or organic matter accumulation
**C1** Odours
**C2** Algal or cyanobacterial blooms
**C3** Persistent high turbidity levels.
**C4** Stratification and low dissolved oxygen
**C5** Variable salinity
**C6** Litter
**D1** Aquatic weeds
**D2** Presence of aquatic pests (e.g. exotic fish species)
**E1** Terrestrial weeds
**F1** Access for maintenance

**A4** **Bird & turtle feeding introduce higher nutrient load into lake**

TRURO STREET

Primary lake outlet (~1.29 mAHD).

Major bird feeding area

Turtle feeding area

MARGARET STREET

Water access point

**E2** **Broadleaf pepper trees**

Herbicide treatment of edge vegetation

**E1** **Turf mowed to water edge - no buffer. Steep batters with drop-off**

Mowed steep batters, often under-cut

**G1** **Limited maintenance access along northern boundary**

WATERBODY E

**D1** **No submerged water plants. Limited emergent water plants**

ALEXANDER STREET

**C2, C3** **Algal biomass in water column. Elevated turbidity**

Islands dominated by Broadleaf pepper tree. Ibis and egret rookery

**A2, A4, C4** **Large bird population. Potential exposure to contaminated water - Faecal contamination, Nutrient levels elevated. Potential stratification**

DesignFlow

LEGEND

Property boundary

Existing stormwater pipe

EDGE CONDITION

Edge dominated by over hanging Broadleaf Pepper Tree

Edge dominated by Singapore Daisy

Overhanging vegetation (native & introduced)

Grassed edge, steep batter, sharp drop-off

Grassed edge, mown

Edge dominated by emergent water plants

High priority issue

Medium priority issue

0 15 30 60 m

**Figure 4-15**
**Waterbody E - Issues Plan**

Lowlands Lagoons (Anembo Lakes) Waterbody Management Plan

SCALE: 1:1,500

DATE: 19 February 2021

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For:
FCRC

# 5 IDENTIFY MANAGEMENT ACTIONS

## 5.1 IDENTIFYING MANAGEMENT ACTIONS

The following section provides discussion of the range of management actions proposed to address the identified issues in **Section 4**.

### 5.1.1 Public Safety (Batter slopes)

Undertake detailed batter safety risk assessment: A detailed batter safety risk assessment should be conducted to review safety around waterbodies to both the public and for Council workers. A detailed audit is required to investigate all of the waterbody edges and to determine high risk locations where intervention is required to manage public safety risk. The waterbody condition assessment identified many areas around the waterbodies where steep batters connect directly into deep water (i.e. high drowning risk is present).

It was noted that the field observations do not necessarily agree with the waterbody bathymetric survey data around the shallow margins. The survey data generally indicates shallow edges for the entire margins but this did not correlate with field observations. Therefore the risk assessment process should include an assessment of edges above and below the water line and not rely on the underwater survey for this assessment (which had a focus on water depth in the base of the systems).

It is expected that an outcome of the safety risk assessment will be a stage plan for rectifying high risk waterbody edges. Actions may include:

- Specific waterbody edge depth mapping to identify steep drop-offs and high risk locations.
- Identify design responses to high risk locations, such as:
    - Establishing vegetated buffers (e.g. in key locations to create physical barriers to open water)
    - Fencing high risk areas (e.g. where vegetation buffers are not practical)
    - Re-profiling and stabilising batter slopes (e.g. where erosion/bank undercutting may make the use of physical barriers difficult).

### 5.1.2 Waterbody edge stability

Edge stability assessment: Scoured batter areas need to be assessed to determine whether they are stable or require rectification. The rectification of scoured batters will require:

- Re-enforcing and stabilising eroded areas (e.g. rock protection and benching)
- Replacing topsoil and re-establishing vegetation cover.

Establish vegetated buffer around waterbodies: Stabilise the waterbody edges by establishing a minimum 1.5m vegetated buffer strip around the margins of the waterbodies. This will involve:

- Educating residents on Council's *Urban Lakeside Vegetation Management Policy* and the importance of retaining vegetation cover along the waterbody margins to maintain edge stability
- Establishing vegetated buffer strips in mowed areas
- On unstable batters or areas with poor or no batter vegetation cover:
    - Remove terrestrial weeds
    - Re-establish native vegetation cover (including the use of *Bacopa monnieri* and *Leersia hexandra* to stabilise the waterbody/batter interface)
    - Establish groundcover vegetation along the batters on Anembo Island. This may require soil assessment and amelioration, and strategic weed control prior to planting.

### 5.1.3 Water quality

The following actions should be considered to improve the water quality within the Lowlands Lagoon system:

- Improving stormwater runoff quality from urban areas via catchment based initiatives (see below).
- Re-establishing native emergent and submerged waterplants throughout Lowlands Lagoons. Refer to Section 5.1.6
- Managing waterbird populations. Refer to Section 5.1.4.
- Converting parts of Lowlands Lagoons into water quality treatment wetland combined with a waterbody recirculation system. Refer to Section 5.1.7.

Formal water quality monitoring of the Lowlands Lagoons system is not currently undertaken and at this stage is not considered essential or of cost-benefit value. Regular, long-term monitoring of biophysical parameters (nutrients, dissolved oxygen etc) can provide some insight about system condition and changes over time (noting that identifying trends in this type of data can be difficult) but can be prohibitively expensive. Monitoring of faecal coliforms would be useful in monitoring public health risk and also in tracking the effectiveness of management actions (such as removing roosting sites).

General Waterbody Condition Monitoring: To assist in gauging the general condition of the waterbodies over time it is suggested that a regular condition assessments are undertaken for the Lowlands Lagoons system. A suggested monitoring frequency is bi-annually (or in response to a specific issue) using the Field Condition Assessment Form in Appendix A. Ideally this would involve an assessment late-spring and late-summer where waterbody condition may be in decline and management responses may be required.

Decline in performance indicators from visual inspections, or other triggers may prompt water quality testing, where warranted, for example in response to a fish kill (refer Appendix C for discussion of triggers for monitoring).

Review and implement catchment based stormwater management initiatives: Council should continue to implement catchment based stormwater quality treatment initiatives to reduce nutrient loads discharged to the waterbodies. GHD (2013) proposed a range of stormwater treatment initiatives to reduce pollutant loads entering the Lowlands Lagoons including:

- Gross pollutant traps (GPTs)
- Grass buffers and bio-retention swales
- Constructed wetlands
- Floating wetlands

The stormwater treatment model and the proposed treatment strategy in GHD (2013) were not comprehensively reviewed as part of this waterbody management plan. The general approach proposed in the GHD report is supported but the treatment strategy requires updating based on the following points:

- The strategy relies heavily upon GPT's to remove total suspended solids. GPT's are not typically used for TSS management, and the widespread use of GPT's within the Lowlands Lagoons catchments may not deliver the expected TSS reductions. It is also noted that the stormwater strategy also relies upon less conventional stormwater treatment assets such as floating wetland systems.
- Floating wetlands cannot be currently modelled in MUSIC as there is insufficient data to determine appropriate modelling parameters (i.e. decay rates). The use of floating wetlands to manage both stormwater runoff and waterbody water quality is currently subject to ongoing investigation and research.

- The strategy targets TSS and nutrient concentrations within the waterbodies. The use of MUSIC to model waterbody nutrient concentrations for such a complex system is considered unreliable and expected to be associated with a high margin of error. The stormwater treatment strategy should focus upon the treatment of stormwater runoff quality to meet objectives outlined in the *State Planning Policy* (DSDIP, 2017).
- Many of the stormwater outfalls into the waterbodies are submerged. This will make intercepting and treating stormwater in vegetated systems (such as bioretention or constructed wetlands) level constrained and difficult to implement.

It is recommended that the GHD (2013) stormwater management opportunities be reviewed and updated.

### 5.1.4 Waterbird management (Faecal contamination)

Development of a bird management plan: Management of the waterbird population within Lowlands Lagoons is crucial to managing public health risks and the long term health of the waterbodies. It is recommended that a Bird Management Plan be developed to detail how the bird population will be managed. The focus of the Bird Management Plan should focus on two objectives: a) managing bird roosting habitat, and b) restricting bird feeding.

The following recommendations for managing water bird populations at the Lowlands Lagoons are proposed, which should be incorporated into the Bird Management Plan. These actions focus on managing the bird population around the waterbodies, which will force the birds to seek alternative food and habitat resources, eventually reducing the number of birds permanently inhabiting the waterbodies. Potential actions include:

- Remove Broad-leaved Pepper Trees: Implementing phased removal of Broad-leaved Pepper trees from the margins of the waterbodies and islands will effectively remove roosting habitat for Australian White Ibis. Where practical, Broad-leaved Pepper trees should be replaced with native tree species with low roosting habitat potential such as Melaleucas and Eucalypts.
- Public education and signage: to discourage bird feeding in the primary bird feeding areas. Examples of signage that could be erected in these areas is illustrated in Figure 5-1. Signage should generally aim to communicate through an emotion and not in a regulatory or authoritarian manner.
- Create physic barrier at main feeding areas: Installing dense planted garden beds along the waterbody edge will reduce locations where waterbirds can exit the waterbody. This should be considered in location where signed is proposed (e.g. parkland adjacent to the Waterbody E outlet at the corner of Truro and Margaret Streets.
- Breeding restriction of Australian White Ibis. This may be through egg and nest removal, egg oiling, vegetation management or a combination of these. Breeding restriction of this native species requires a Damage Mitigation Permit from the Department of Environment and Heritage Protection. Approvals for removal of native vegetation may also be required.


**Figure 5-1 Example of direct-education message approach.**

### 5.1.5 Aquatic weed management

Trial alternative approach to the control of *N. mexicana:* *Nymphaea mexicana* can be effectively controlled (but not necessarily eradicated) using glyphosate and diquat at relatively low application rates. *N. mexicana* cover can be reduced for extended periods of time (up to 12 months) using herbicides, but regrowth will ultimately occur if the root systems (rhizomes) are left intact. Other studies have shown that follow-up spot spraying (annually) of the seedling and rhizome regrowth can result in the effective eradication of water lilies (Hofstra et al, 2013).

It is recommended that a phased trial program using herbicide be implemented to remove *N. mexicana* from the Waterbody C. One of the potential drawbacks from using herbicides to control *N. mexicana* is that rapid plant die-back and decay can result in very low dissolved oxygen levels in the waterbody. Removal of the dead rhizomes and floating plant material is essential following herbicide treatment to preserve water quality in the waterbodies.

It is expected that the exposed waterbody bed areas following Nymphaea removal within Waterbody C will be rapidly colonised by *Ceratophyllum demersum* which is currently growing in the waterbody.

Undertake public education on the management of *Azolla pinnata* growth within the waterbodies.. The excessive growth of Azolla within the waterbodies is a response to in-situ nutrient concentrations, and occurs in both natural and constructed waterways. The removal of *Azolla pinnata* is extremely difficult, and mechanical removal should only be required when a thick surface layer across the entire waterbody is present. In these circumstances, removal of the organic biomass will help to remove nutrient load from the waterbody and to prevent nutrient release back into the water column during decomposition of the dead Azolla biomass. It is recommended that actions to reduce Azolla growth should focus upon reducing nutrient concentrations within the waterbodies.

### 5.1.6 Aquatic vegetation

Re-establish macrophytes: It is recommended that emergent and submerged waterplants are re-established throughout the waterbodies to manage nutrient concentrations and turbidity. This will be achieved by:

- Planting emergent waterplants along the waterbody edges between Normal Water Level (NWL) - 0.25m depth. It is recommended that larger format tubestock (i.e. 600cm$^3$) are planted as the:
    - plant foliage extends well above the water and enables the seedlings to cope with minor water level fluctuations (i.e. minor floods)
    - larger format tubestock grow more vigorously and quickly establish
    - large root system enables the plants to be bedded into the sediments, thereby preventing waterbirds from plucking the seedlings from the sediments
    - well-developed root biomass enables the seedlings to withstand waterbird grazing
    - lower planting density 1-2 plants per m$^2$ means that the overall planting cost is comparable to using conventional tubestock (200cm$^3$ tubes).
- Planting submerged waterplants (*Ceratophyllum demersum, Vallisneria australis*) along the waterbody edges. The re-establishment of submerged waterplants within turbid waterbodies is extremely difficult due to limited light penetration to the base of the waterbody. The presence of a large waterbird population will also make re-establishing submerged waterplants a challenge, as some graze on submerged waterplants. Ideally, submerged waterplants need to be established across the base of the waterbodies to establish sufficient aquatic waterplant coverage to manage waterbody nutrients and reduce algal growth. Ideally, submerged waterplants grow in less than 2m water depth. Average depths across the waterbodies are generally less than 2m, and historical aerial imagery clearly shows that submerged macrophytes were previously growing throughout

the waterbodies. It is recommended that submerged plants be established along the shallow edges (0.25 - 0.6m water depth) so that the plants can access adequate light to survive. If successful, the submerged plants will migrate into the deeper zones of the waterbodies, but this may take a long time, and other measures to manage waterbody nutrients and turbidity will be required to achieve this outcome.

### 5.1.7 Hydraulic retention times and mixing

Reducing hydraulic residence times will lead to improved waterbody mixing and water quality. A strategy often utilised to reduce waterbody residence times is to introduce artificial recirculation system (e.g. via pumping). Typically recirculation systems pump recirculated water through constructed wetlands to improve water quality. To be effective these systems are typically designed to achieve relatively high turnover rates (10-20 days), which involves high pumping rates and significant investment in infrastructure (pumps and pipelines).

Actions to improve mixing include physical modifications to waterbody bathymetry and configuration to optimise flow paths and reduce stratification. This may include reducing waterbody depth, improving wind force mixing and removing backwatered areas offline to the main flow path (i.e. behind islands). The management of hydraulic residence times and poor mixing within the Lowlands Lagoons can be achieved via a number of actions, including:

- Removal small islands from Waterbodies B, D and E: The small islands located in these waterbodies are resulting in areas of poor mixing and backwater areas (creating ideal condition for algal incubation). These islands also provide ideal bird roosting habitat. Removing these islands will improve mixing of these zones and help improve water quality. Removal of islands should be considered an aspirational opportunity and should be re-assessed following implementation other short and medium term actions (such as removing bird roosting sites from islands).
- Converting waterbodies (or parts of) to treatment wetlands: Treatment wetlands are designed to remove sediments and nutrients from stormwater via allowing water levels to rise following rainfall and then slow release flows to maximise treatment benefit. The creation of treatment wetlands within the waterbodies would require new water level control outlets, either to Waterbody E (sets water levels in D and E) and/or Waterbody C (sets water levels in A, B and C). New outlet controls would allow standing water levels to reduced and provide extended detention to provide enhance treatment function. In additional, infilling and re-profiling of bed levels in proposed wetland areas would be required to support the treatment wetland function (i.e. create planting zones with depths <0.5m). Creation of constructed wetlands has high costs and would require further community consultation. Therefore it is recommend as a future or aspirational item that should be re-assessed pending implementation of short and medium term actions.
- Improving mixing via re-circulating system: Implementing a waterbody re-circulation system to decrease waterbody retention times, including converting areas of the waterbodies into constructed wetlands to improve waterbody water quality. This would involve a pumping system and recirculation pipeline. This option would be considered low priority option due to the potentially high cost to construct and operate.
- Infill channel beside Anembo Island: This would involve importing fill material and placing between Anembo Island and residential houses to create shallow wetland planting areas to the northern side of Anembo Island. This location has high nutrient loads due to high bird numbers in this location and due to poor flushing (offline to the main flow path from Waterbody C towards the outlet). This action would improve water quality via the wetland plants and remove a stagnant open water area. The works should be considered low priority due to the cost of construction and impact on adjacent residents and as such should be re-assessed following implementation of other actions.

### 5.1.8 Excluded actions

A number of management actions were considered through the assessment process but ultimately excluded as unviable for either social, environmental or economic reasons. A summary of these are provided in Table 5-1.

**Table 5-1 Excluded management actions.**

| Excluded action | Potential benefits | Reason action excluded |
|---|---|---|
| Dredging sediments and /or increasing depths | • Creates more open water zones. | • Significant construction cost associated with dewatering and earthworks.<br>• Increased waterbody volume results in longer hydraulic residence times (which reduces flushing rates).<br>• Deepening waterbody increases likelihood of stratification (and associated fish kills).<br>• Loss of aquatic habitat and fauna.<br>• Environmental impacts with disposed sediments.<br>• Physical disturbance of bed sediments and associated impacts on water quality and potential increased algal growth during works.<br>• Difficult to establish wetland plants which play an important role in maintaining water quality. |
| Infilling deep areas of the waterbody to reduce depths (modify bathymetry)<br>*This may be supported when undertake in targeted locations or in conjunction with other actions (e.g. edge re-profiling and minor filling to create treatment wetland areas).* | • Reduce deep areas that are prone to stratification issues (release of nutrients from sediments).<br>• Reduces waterbody volume, reduces residence times and improves flushing (marginal subject to extent of filling undertaken).<br>• May allow for additional macrophyte growth which improves water quality | • Significant construction cost associated with dewatering and earthworks.<br>• Physical disturbance of bed sediments and associated impacts on water quality and potential increased algal growth during works. |

### 5.1.9 Discussion of Dredging / Deepening

One of the re-occurring feedback suggestions arising from community and stakeholder engagement (refer 2.5) was to 'dredge' or 'deepen' the waterbodies. These suggested actions were based on a number of perceived benefits associated with dredging, including improving water quality, reducing fish kills and reducing aquatic weeds. Removing organic matter and nutrient loads may improve water quality in the short term, but ultimately the same issues will re-occur unless catchment inputs can be treated prior to entering the system.

The process of dredging/deepening would result in a number of negative impacts including significant disturbance and impacts on water quality (re-suspension of sediments and fine particulate), potential to expose acid sulfate soils and groundwater and associated impacts fauna within the system. There would also be a significant financial cost associated with dredging / deepening on a large scale.

There are also a range of potential negative impacts in the long term associated with dredging or deepening waterbodies , including increased hydraulic residence times (i.e. reduced flushing) and risk of stratification (refer 4.1.8). Deeper water can also make it more difficult to establish wetland plants (required for a healthy waterbody).

Therefore dredging on large scale within waterbodies is generally not supported by Council. Dredging activities at smaller scales, where costs and risks can be appropriately managed may be considered. For example, dredging for the purposes of maintaining drainage structures (e.g. removing built up sediments blocking flows through an outlet structure).

## 5.2 MANAGEMENT PRIORITY

Each management action discussed above has been prioritised as either High, Medium or Low priority based on the following considerations:

- The scale of the risk to Council and ongoing cost to Council if proactive management is not implemented.
- The community desires for the waterbody
- The environmental/conservation values of the waterbody and surrounds
- The ability to manage a number of risks through a single actions (e.g. converting a waterbody to a wetland will improve water quality, aquatic weeds and hydraulic issues).

Appendix B presents a recommended schedule of works with broad implementation times for all High and Medium priority actions. The timeframes established are suggestions only and based on immediate, short (1-2 years), medium (3-5 years) and long (5-10 years) term implementation periods. Future or aspirational actions are subject to further consideration and may only be feasible based on the success of earlier actions. The order is subject to review based on Council priorities and available budgets.

It is recommended that management works associated with public safety and health issues are implemented as priority issues. We note that some management actions could be implemented over several years (such as the re-establishment of waterplants throughout the waterbodies) and other actions may be contingent on the successful implementation of previous management works (e.g. management of the local waterbird population prior to planting to improve plant survival).

## 5.3 COMMUNITY CONSULTATION

A community consultation process was undertaken to inform the development of the Lowlands Lagoons (Anembo Lakes) Management Plan. The aim of the consultation program was to ensure that community feedback on the draft actions (as shown in Figure 5-2) were incorporated in the final WMP (as documented in Section 6). The community consultation process presented the potential management actions for Lowlands Lagoons to the community in a range of formats including:

- A letter drop to all residents within 1km of the Lowlands Lagoons
- An online survey
- A drop-in session and walking tour of the Lowlands Lagoons with Council and DesignFlow personnel.

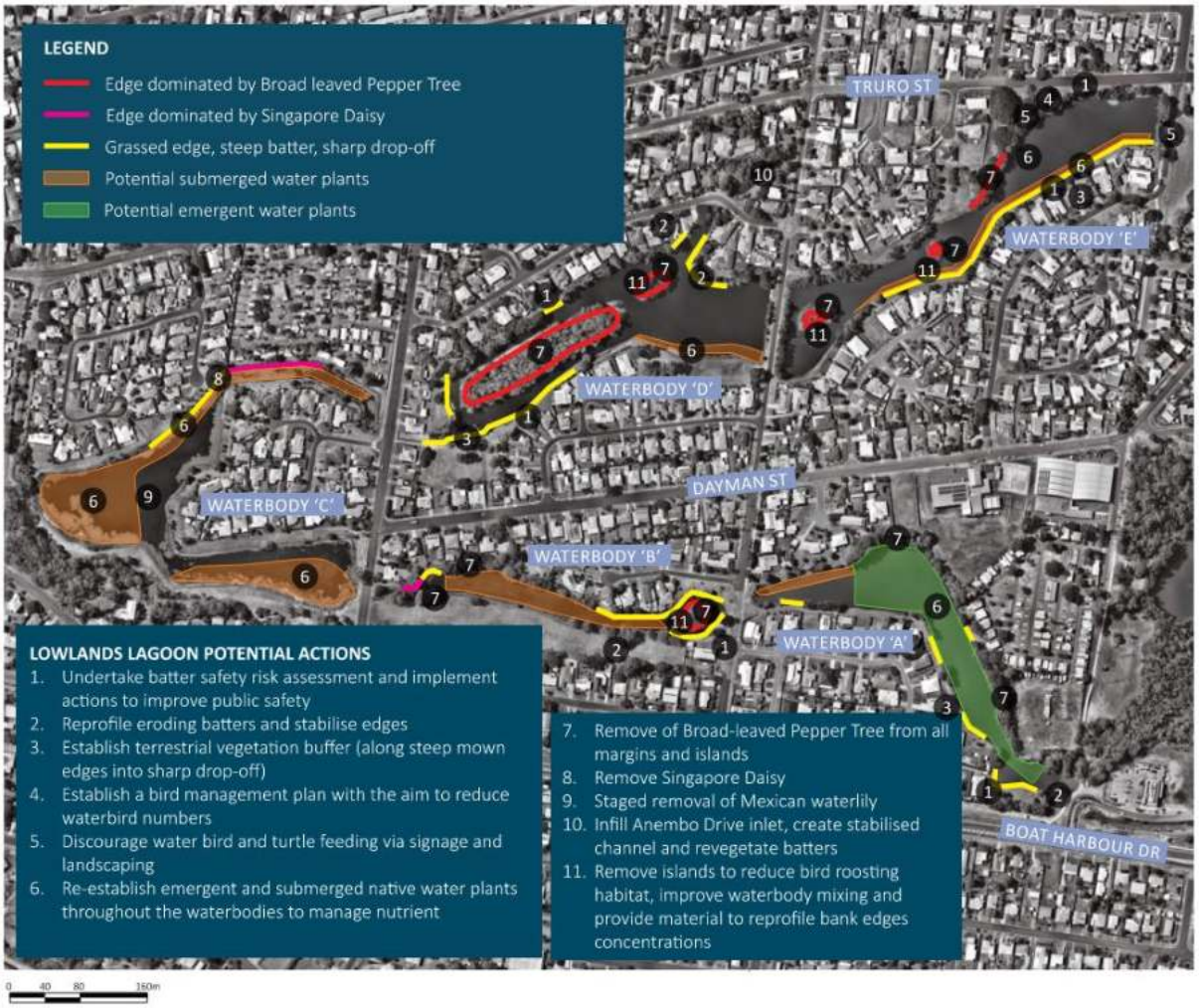



**Figure 5-2. Summary of potential actions for the community consultation process.**

Key findings of the community consultation process included:

- Respondents were typically regular visitors and lived within walking distance of the waterbody. There were a range of concerns but the key issues related to fish kills and nuisance water bird populations.
- Respondents generally supportive of the draft plan and potential management approaches
- Actions with HIGH community support:
    - Re-establish emergent and submerged native water plants throughout the waterbodies to manage nutrient content;
    - Removal of broad leaf pepper tree and Singapore daisy;
    - Establish vegetation buffers, especially along steep mown edges;
    - Discourage water bird and turtle feeding; and
    - Establish a bird management plan to reduce waterbird numbers.
- Actions with MODERATE community support:
    - Implement actions to improve public safety;
    - Re-profile eroded batters and stabilise edges; and
    - Stabilise channel and revegetate batters.
- Actions with LOW community support included:
    - Infill Anembo Drive inlet; and
    - Remove islands to reduce bird roosting habitat and improve water mixing.

The feedback obtained from the community consultation process has been incorporated into the Management Plan (refer Section 6).

# 6 MANAGEMENT PLAN

This section outlines the Lowlands Lagoons Waterbody Management Plan. The plan is presented in two sections:

- Section 6.1 provides an overview of the Lowlands Lagoons system.
- Section 6.2 details all the waterbody issues identified and provides a range of recommended management actions.

Further detail of the proposed actions, including high level costs, timeframes, delivery mode and scope of works are provided in Appendix B - Lowlands Lagoons (Anembo Lakes) Actions Table.

## 6.1 WATERBODY CHARACTERISTICS, ISSUES AND CONSTRAINTS

A summary of the key characteristics, issues and constraints associated with the Lowlands Lagoons system is provided in Table 6-1.

**Table 6-1 Summary of key characteristics of Lowlands Lagoons.**

| | | | |
|---|---|---|---|
| **Name:** | Lowlands Lagoons | | |
| **Description:** | Lowlands Lagoons is a very high profile and amenity waterbodies located within the suburbs of Torquay and Urangan. The system comprises five interconnected waterbodies. The Lowlands Lagoons are located within the Tooan Tooan Creek catchment, however the waterbody configuration results in waterbody overflows being piped directly to the ocean rather than to Tooan Tooan Creek. The waterbodies receives untreated stormwater runoff from a 136 ha catchment comprising of residential and parkland/natural land uses.<br>The waterbodies are valued by the local community and provide a high level of amenity. The waterbodies is surrounded by residential housing and most of the waterbodies are inaccessible to the public. An open parkland is present between Truro St and Waterbody E. Informal open public spaces are also present adjacent to Waterbodies B, C and D.<br>The waterbodies have a history of water quality and aquatic weed problems. Regular aquatic weed harvesting is undertaken to manage aquatic weeds, particularly *Nymphaea Mexicana*.<br>The batter slopes along the margins of the waterbodies vary from shallow slopes to vertical drop offs in some areas. The waterbody edges are variously covered with groundcovers (grasses, sedges, rushes and herbs), shrubs and trees. The waterbody edges are generally stable however areas of active erosion exist along the steeper batter areas. Steep mown batters with vertical drops into open water also present safety concerns in numerous locations. | | |
| **Waterbody Priority:** | Very High – Waterbody D;<br>High – Waterbodies A, B & E;<br>Medium – Waterbody C | | |
| **Management Goal:** | Maintain and enhance public safety, long term water quality and aesthetic values through:<br>Improving public safety<br>maintaining native aquatic vegetation<br>managing aquatic weeds<br>minimising maintenance (and allowing easier maintenance)<br>improving hydraulic function, particularly by increasing flushing rates and/or removing dead water pockets<br>improving waterbody water quality by:<br>○ reducing bird numbers and feeding<br>○ treating stormwater inflows<br>○ enhancing and re-establishing emergent and submerged aquatic plants | | |
| **Council ID:** | STDS00008A to STDS00008E | **Surface Area:** | 280, 478 $m^2$ (combined) |
| **Catchment:** | Tooan Tooan Creek | | |
| **Function / Purpose** | The waterbodies was constructed as part of large residential development. The waterbodies provides flood retardation, and high visual and passive recreational amenity to the local residents. | | |

| | |
|---|---|
| **Issues / Values** | **Public safety**<br>Steep/vertical batters present along some of the waterbodies present very high safety risk<br>Batters are actively eroding in some areas with severe bank undermining present<br>**Water quality**<br>Local stormwater inputs treated by a bioretention system and GPT located adjacent to Waterbody C. No other formal treatment of stormwater entering the Lowlands Lagoons system.<br>Poor water quality conditions indicated by algal and aquatic weed growth.<br>Large waterbird population present at the waterbody results in faecal contamination and contributes a significant nutrient load to the waterbodies.<br>**Aquatic vegetation/weeds**<br>Lack of emergent and submerged aquatic waterplants throughout the waterbodies, particularly along the waterbody margins.<br>Aquatic weeds which require ongoing management (e.g. *Nymphaea mexicana*)<br>**Waterbody edge stability**<br>Many of the waterbody batters are steep and have vertical drop-offs to the waterbody water.<br>Active erosion is undermining the stability of some waterbody batters.<br>Lack of an adequate riparian buffer increases the risk of batter instability and increases the pollutant load discharged to the waterbodies.<br>**Profile / Amenity**<br>The waterbodies have a high profile with high amenity and aesthetic values.<br>Local residents expect that Council provide a high level of service to maintain the waterbodies in good condition.<br>Diminished aesthetic values associated with the presence of aquatic plants such as *Nymphaea Mexicana* and *Azolla pinnata* are a major concern from a residential amenity perspective.<br>**Hydraulic function**<br>Excessively long water residence times in waterbodies.<br>Poor flushing resulting in dead water pockets, particularly in waterbody D |
| **Constraints** | Shallow waterbody profile provide maintenance problems for weed harvester in Waterbody B and parts of C<br>Local Councillor / local community has strong desire to maintain open water area as much as possible<br>Presence of steep/vertical batters<br>View lines from residential areas to be maintained where possible. |
| **Conservation designations** | None identified |
| **Existing management and rectification** | Council currently maintains the Lowlands Lagoons to a moderate standard. The waterbody edges are regularly maintained as part of Council's open space program, and involves mowing and removal of high priority weeds (e.g. Singapore Daisy). Removal of aquatic weeds occurs on an 'ad hoc' basis, generally in response to residential complaints or aquatic weed growth outbreaks. Management of aquatic weeds is undertaken by Council maintenance staff using equipment (e.g. mechanical weed harvester, vehicles and spray kits, mowing equipment etc). |
| **Supporting information** | Topographic survey, including water levels, pipes, pits, pathways, services and vegetation<br>Bathymetric survey including water levels and waterbody bottom profile<br>GIS information for waterbody and catchment<br>Water quality data<br>Aquatic weed maintenance schedules<br>Lowlands Lagoons Environmental Assessment report<br>Council Management Policies<br>Fraser Coast Regional Council Water Monitoring Strategy<br>Tooan Tooan Creek including Lowlands Lagoon Catchment Analysis – Flood Risk Study |

## 6.2 WATERBODY ISSUES AND MANAGEMENT ACTIONS

A summary of the waterbody issues and draft recommended management actions for the Lowlands Lagoons system is provided in Table 6-2. The table identifies the primary and supporting Council departments that are proposed to be responsible for managing each management issue. Figure 6-1 shows the location of potential management actions across each of the waterbodies for consultation.

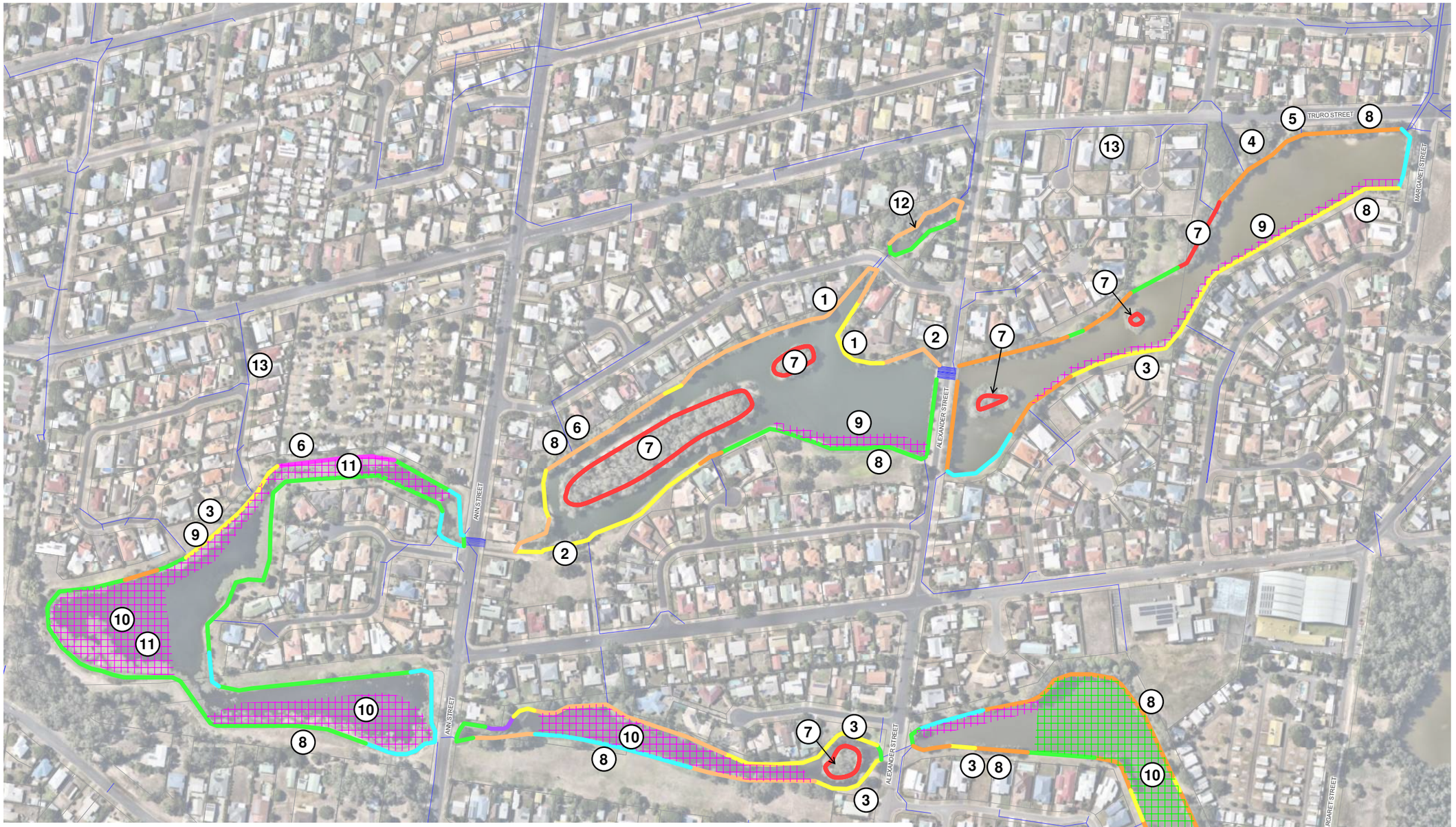
**Table 6-2. Waterbody issues and potential management actions for the Lowlands Lagoons system.**

| Management Issue (refer Appendix C) | Issue | Description of issue | Condition Rating | Management Priority (H,M,L) | Potential Management Actions | Likely rating following management | Responsible Departments | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Primary | Supporting |
| **A1/B6** | Risk of injury of drowning | Batter slopes vary around the waterbodies. Waterbodies A, B, D and E have a heightened risk of drowning associated with steep batter slopes/revetment walls adjacent to deep water (>0.5m) areas. | Poor | High | A detailed batter safety risk assessment should be conducted to review public safety around waterbodies. Initiate management of high risk waterbody edges. This may include:<br>• Establishing vegetated buffers<br>• Fencing high risk areas<br>• Re-profiling and stabilising batter slopes. Refer B6<br><br>Ongoing: Continue to monitor public safety risks associated with the waterbody edges. Create a log book for onsite staff to report incidents that may involve public safety issues. | Adequate | C&CIS | E&NAM |
| **A2** | Health risks due to human contact with contaminated water | A potential health risk exists associated with human contact with waterbird faecal matter present within the waterbody water, and edges of the waterbodies adjacent to the Ibis rookeries or bird feeding area.<br><br>Water quality monitoring (GHD, 2013) indicated that high E. coli levels were present at all monitoring sites (entire waterbodies), with the highest concentrations present at the western end of Anembo Island, adjacent to the Ibis rookery. | Poor | Medium | Reduce waterbird numbers to more sustainable levels and discourage bird feeding, via:<br>• Develop and implement a bird management plan to inform the management of bird populations to sustainable levels.<br>• Provide public education and signage to discourage bird feeding and health risks associated with bird faeces<br>• Removal of Broad-leaved Pepper trees overhanging water and replacement with native vegetation (to discourage overhanging water roosting sites).<br><br>Ongoing: Manage algal blooms in accordance with *The Guidelines For Managing Risks In Recreational Water* (NHMRC, 2008). Refer to C2 | Adequate | - | - |
| **A3** | Chemical contamination | No chemical contamination observed in waterbodies. | Good | Low | No Action Required | Low | - | - |
| **A4** | Faecal and/or nutrient contamination | Nutrient levels in the waterbodies are elevated as illustrated by the visible presence of algal biomass in the water column. The primary sources of nutrients within the system includes: untreated stormwater runoff, high water bird population and organic sediments.<br><br>The high number of birds present within the waterbodies, particularly near the Ibis rookeries, means that the waterbodies will be permanently subject to high in faecal contamination. Given the high interaction between the local residents and the waterbodies, the faecal contamination represents a health risk. | Poor | Medium | The following initiatives should be implemented to mitigate the health risks associated with waterbody water:<br>• Continue to implement catchment based stormwater quality treatment initiatives to reduce nutrient loads discharged to the waterbodies (GHD, 2013)<br>• Establish waterplants throughout the waterbodies. Refer C2.<br>• Reduce unsustainable bird population. Refer A2.<br><br>Ongoing: Monitor waterbody water quality on a monthly basis (the scope of monitoring should be reviewed to ensure that it provides useful information and is cost effective) | Adequate | E&NAM | EH |
| **B1** | Inlet/Outlet erosion or instability | Erosion of stormwater inlet channels to Waterbodies A and B observed.<br><br>Minor scour observed near inlet headwall in Waterbody D. | Poor | Medium | • Stabilise and re-inforce eroded channel areas using rock protection.<br>• Replace topsoil in scoured zones and re-establish vegetation cover. | Good | C&CIS | - |
| **B2** | Outlet blockage – water level is consistently too high above normal water level. | Partial blockage of culverts between Waterbodies C and D, and D and E due to waterplant accumulation. | Good | Low | If blockage of the culverts persists, install floating booms upstream of the culverts to trap floating plant debris.<br><br>Ongoing: Monitoring culverts following rainfall events and remove accumulated debris. | Good | C&CIS | Following rainfall events |
| **B3** | Poor flushing or dead pockets | Waterbody retention times expected to be high, particularly during the dry season. High waterbody retention times in urban waterbodies are often associated excessive algal growth.<br><br>Dead pockets/backwater areas are present adjacent to islands in Waterbodies B, D and E, and within the Anembo Drive inlet. | Poor | Medium | Rectify dead pockets/backwater areas by:<br>• Removing islands from Waterbodies B, D and E to remove back water areas and to encourage wind forced mixing (subject to further consultation with residents).<br>• Infill Anembo Drive inlet, create stabilised channel and revegetate batters. This will remove the steep-vertical edges, ameliorate erosion and remove the backwater area (which at present accumulates floating organic debris and is mildly stagnant).<br><br>Future Opportunity: Rectify waterbody retention times by installing a waterbody recirculation system. This will involve installing a pump and pipeline between Waterbodies A and E to recirculate water through the waterbodies. For a waterbody recirculation system to the effective, the waterbody water must be passed through a wetland system where algal biomass is removed. The installation of a recirculation system would therefore involve converting one or more of the waterbodies into treatment wetlands. This management action is not considered feasible given the adjacent residential areas. | Adequate | C&CIS | LPN |

| Management Issue (refer Appendix C) | Issue | Description of issue | Condition Rating | Management Priority (H,M,L) | Potential Management Actions | Likely rating following management | Responsible Departments | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Primary | Supporting |
| **B4** | Water level is consistently low | Water levels in the waterbodies appear to be stable. Reduction in waterbody water levels expected following extended dry periods | Good | Low | No Action Required | Good | - | - |
| **B5** | Flooding of adjacent land, parkland or property or regular overtopping of waterbody bund | No issues with flooding of adjacent land | Good | Low | No Action Required | Good | - | - |
| **B6** | Scour of batters | Scour of the batters observed in the following waterbodies:<br>• Waterbody B – northern waterbody edge<br>• Waterbody C – northern waterbody edge (one location)<br>• Waterbody D – northern waterbody edge and Anembo Drive inlet | Poor | Medium | Investigate scoured batter areas to assess whether they are stable or require management. Management of scoured batters areas along the northern edge of Waterbody C and Anembo Drive:<br>• Re-enforce and stabilise eroded areas with rock protection and benching<br>• Replace topsoil in scoured zone and re-establish vegetation cover<br>Ongoing: Monitor stability of the scoured batter areas, particularly following large rainfall events. | Adequate | C&CIS | E&NAM |
| **B7** | Coarse sediment accumulation | No coarse sediment accumulation observed below stormwater inlets or culvert connections.<br>Note: no testing of accumulated sediment depth in the base of the systems were undertaken as part of the waterbody assessment. | Good | Low | No Action Required | Good | - | - |
| **B8** | Fine sediment or organic matter accumulation | No fine sediment or organic matter accumulation observed in waterbodies.<br>It was observed during the waterbody condition assessment that many local residents are either mowing close the waterbody edge, thereby 'flicking' lawn clippings into the waterbody or manually depositing lawn clippings and woody debris into the waterbody.<br>*Note*: Sediment testing was not conducted as part of the waterbody condition assessment. | Good | Low | Implement education program for local residents to highlight the need to keep organic debris from the waterbodies. This might include: information signage, flyers or personal visits to properties who are clearly depositing organic matter into the waterbodies. | Good | C&CIS | OWC |
| **C1** | Odour | No odours were detected during the waterbody condition assessment | Good | Low | No Action Required | Good | - | - |
| **C2** | Algal or cyanobacterial blooms | Planktonic algal biomass is visible in Waterbodies A, D and E.<br>Algal growth within the waterbodies system is stimulated by:<br>• nutrients<br>• water temperature<br>• light<br>Filamentous algal biomass was also observed in Waterbody B, where the algae were observed growing upon the submerged waterplants. The presence of algal biomass, both in the water column and upon the submerged macrophytes indicates that there are high nutrient concentrations present within the waterbodies. | Poor | Medium | Algal growth within the waterbodies should be managed by reducing the concentration of available nutrients within the water column. Refer to A2.<br>Re-establish emergent and submerged waterplants throughout the waterbodies to manage nutrient concentrations and to limit algal growth. Refer to D1.<br>Ongoing:<br>• Monitor planktonic algal biomass (chl-a) in the waterbodies.<br>• Create a formal process for reporting and recording algal issues.<br>• Manage algal blooms in accordance with the *Guidelines for managing risks in recreational water* (NHMRC, 2008) | Adequate | - | - |
| **C3** | Persistent high turbidity levels. | Turbidity levels vary throughout the waterbodies depending on algal concentrations and suspended solids.<br>Low turbidity was observed in Waterbodies B and C which have high emergent and submerged waterplant cover.<br>High turbidity was observed in Waterbodies D and E and was associated with high waterbird numbers and the locations of Ibis rookeries.<br>Turbidity in Waterbodies A, D and E was primarily related to algal biomass within the water column. It is likely that algal turbidity in these waterbodies is related to the loss/lack of submerged macrophytes growing in the waterbodies. | Poor | Medium | Waterbody turbidity should be managed by<br>• Managing stormwater runoff quality. Refer A2.<br>• Reducing waterbird numbers. Refer A2.<br>• Establishing waterplants throughout the waterbodies. Refer C2.<br>Ongoing: Continue to monitor waterbody water quality. Refer to A4. | Adequate | - | - |
| **C4** | Stratification and low dissolved oxygen | The waterbody residence times during the year is likely to facilitate the development of stratification in parts of the waterbodies. Stratification of the waterbody water column can lead to the development of an anoxic hypolimnion (bottom layer of water) and the subsequent release of nutrients from the waterbody sediments into the water column. | Poor | Medium | Reduce the risk of stratification in Waterbodies A, D and E by either:<br>• Removing islands to encourage wind forced mixing. Refer B3.<br>• Installing a waterbody mixing systems (e.g. aeration system).<br>Note: The use of convection type mixers such as SolarBee units have proven to be ineffective in large shallow waterbodies (option not considered further),<br>• Modifying waterbody bathymetry to reduce waterbody depth (max. 2m) and encourage wind forced mixing, or | Poor | EH | BPW |

| Management Issue (refer Appendix C) | Issue | Description of issue | Condition Rating | Management Priority (H,M,L) | Potential Management Actions | Likely rating following management | Responsible Departments | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Primary | Supporting |
| | | Water quality monitoring (GHD, 2013) indicated that most sites were characterised by high dissolved oxygen saturation levels, indicating that they were relatively well mixed. | | | • Installing waterbody recirculation system. Refer to B3.<br><br>No management actions required for dissolved oxygen<br>Ongoing: Monitor stratification in Waterbodies A, D and E to confirm spatial and temporal occurrence. | | | |
| **C5** | Variable salinity | Lagoon system is fresh as are all inflows.<br><br>Water quality monitoring (GHD, 2013) indicated that salinity at the eastern end of Waterbody A (Site 6) was higher than the other waterbodies and ranged between 1.47-1.61 mS/cm (compared to generally less than 1.0 mS/Cm for all other locations.<br><br>The presence of *Sporobolus virginicus* (Salt grass) at the eastern end of Waterbody A supports the WQ observation and may be indicative of saline soils and/or potentially saline groundwater intrusion at this location. | Good | Low | No Action Required | Good | - | - |
| **C6** | Litter | No litter issues were observed during the waterbody condition assessment. | Good | Low | No Action Required. | Good | - | - |
| **D1** | Aquatic vegetation | Aquatic plant communities throughout the lagoon system comprise predominantly of isolated patches of emergent waterplants along the edges, and submerged waterplants within Waterbodies B and C.<br><br>The presence of dense waterplant populations, particularly submerged waterplants, provides competition for bio-available nutrients. Shallow waterbodies with high submerged waterplant cover are generally characterised by low turbidity due low algal biomass. The presence of waterplants also assists with the removal of suspended solids. It can be seen in Waterbodies B and C, that the presence of dense submerged waterplant cover results in low algal biomass and the persistence of clear water conditions.<br><br>Emergent waterplants are also important as the biofilms growing on the plant stems, and the plants themselves aggressively compete for nutrients within the water column. Emergent water plants are also important for stabilising the waterbody edges, preventing erosion and the introduction of suspended solids to the waterbodies. | Poor | High | Re-establish emergent and submerged waterplants within Waterbodies A, D and E to manage nutrient concentrations and turbidity:<br>• Plant emergent waterplants along the waterbody margins (depth range NWL to -0.25m). It is recommended that 600cm$^3$ tubestock are used as the plants foliage extends well above the water, the large root biomass enables the plants to be embedded into the sediments (thereby preventing waterbirds from plucking the seedlings from the sediments). The well-developed root biomass also enables the seedlings to withstand waterbird grazing. Recommended planting density 2 plants per m$^2$.<br>• Plant submerged waterplants (Ceratophyllum demersum, Vallisneria australis) along the waterbody edges (depth range -0.25m to -0.6m). Recommended 600cm$^3$ tubestock at 1 plant per m$^2$. The re-establishment of submerged waterplants within turbid waterbodies is extremely difficult due to limited light penetration to the base of the waterbody. Ideally, submerged waterplants should be planted across the base of the waterbodies to establish sufficient aquatic waterplant coverage to manage nutrients and reduce algal growth.<br><br>Ongoing: Continue to manage aquatic plants in accordance with Council's Aquatic Plant Management Policy. | Adequate | E&NAM | CEP |
| **D2** | Aquatic weeds | No declared aquatic weeds were observed during the waterbody condition audit.<br><br>A large population of Nymphaea Mexicana (Mexican Water Lily) is present throughout Waterbody C, and is particularly dominant in the northern arm leading to Waterbody D.<br><br>Occasional excessive growth of the native floating waterplant, Azolla pinnata, within Waterbody C is also an ongoing management issue for Council. | Poor | High | Implement staged removal of *N. mexicana* from Waterbody C:<br>• Cease intensive harvesting. This stimulates rhizome expansion and development of additional foliage<br>• Apply glyphosate aerially to dense patches, i.e. patches greater than 20m$^2$ where there is 100% water surface coverage.<br>• Recommended application timing:<br>  ○ Oct-Nov<br>  ○ Feb-Mar<br>• Monitor for 2-3 weeks to track plant mortality<br>• Remove floating and loosely attached rhizomatous biomass with mechanical harvester. Note: it is critical that all biomass is removed from the waterbody to prevent decomposition and poor water quality.<br>Re-establish emergent and submerged waterplants throughout the waterbodies to manage nutrient concentrations and to limit Azolla growth. Refer to D1.<br><br>Ongoing: Continue to manage aquatic weeds in accordance with Council's Aquatic Plant Management Policy.<br><br>Manage aquatic weeds in accordance with the following hierarchy:<br>• Biological control<br>• Mechanical control<br>• Chemical control | Good | BPW | C&CISS |
| **D3** | Presence of exotic fish species | Tilapia observed | Adequate | Medium | Monitor Tilapia populations within the waterbodies. Whilst individuals were observed only in Waterbodies B and C, Tilapia will be present in all of the waterbodies. Establishing and | Adequate | - | - |

| Management Issue (refer Appendix C) | Issue | Description of issue | Condition Rating | Management Priority (H,M,L) | Potential Management Actions | Likely rating following management | Responsible Departments | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Primary | Supporting |
| | | | | | maintaining emergent and submerged plants may indirectly help with exotic fish management through promoting native fish habitat.<br><br><u>Future Opportunity</u>: If population levels become unacceptable or require a formal intervention undertake Tilapia control to manage population levels using a combination of:<br>• Electrofishing<br>• Gill and seine netting<br>N.B. Chemical control is deemed unfeasible in the Lowlands Lagoons system. The introduction of native predatory fish species in combination with the methods recommended above may aid in managing the Tilapia population size. | | | |
| **E1** | Batter/edge vegetation | Batter vegetation composition and cover varies throughout the waterbodies. Common batter profiles include:<br>• Grassed edge mown<br>• Grassed edge with steep batter +/- sharp drop-off<br>• Overhanging canopy vegetation (native and introduced)<br>• Edge dominated by Broad-leaved Pepper tree<br>• Edge dominated by Singapore daisy<br><br>The width of the vegetated buffer strip around the margins of the waterbodies varies from mown turf to the waterbody edge to dense native vegetation. Council maintained batters are generally mowed to leave a 1.0-1.5m buffer along the waterbody edge (in accordance with Council's Management of Urban Lakeside Vegetation management policy), however it is apparent that many local residents are mowing the buffer strip to the waterbody edge.<br><br>Low groundcover vegetation cover was observed on the batters on Anembo Island which is dominated by canopy vegetation. It is understood that the soils on Anembo Island are characterised by low organic content, are compacted and have been subject to erosion. | Adequate | Low | Rectify batter/edge vegetation cover in accordance with the following tasks:<br>• Re-establish vegetation on unstable batters. Refer to B6<br>• Remove terrestrial weeds and replace with native species. Refer to E2.<br>• Educate local residents on Council's Urban Lakeside Vegetation management policy and the importance of establishing a filter buffer strip around the waterbodies<br><br>Anembo Island:<br>• Establish groundcover vegetation along the batters on Anembo Island. This may require soil assessment and amelioration, and strategic weed control. Refer to E2<br><br>Ongoing: Establish and maintain 1.0-1.5 m filter buffer strip around the waterbody edge in accordance with Council's Management of Urban Lakeside Vegetation management policy. | Adequate | E&NAM | C&CIS |
| **E2** | Terrestrial weeds | Class 3 declared weeds observed within the waterbody riparian zones include:<br>• Singapore Daisy – Waterbodies B and C<br>• Broad-leaved Pepper Tree – all waterbodies<br><br>Lower batters along waterbody edges with high weed cover comprising introduced grasses and introduced broad leaved species.<br><br>Discussions with Council staff indicated that weeds present on Anembo Island have severely impacted native plant communities present on the island. | Poor | Medium | Phased removal of Broad-leaved Pepper trees from all waterbody and island riparian zones is recommended. Broad-leaved Pepper trees provide ideal roosting and nesting habitat for Ibis and compete with native species for space along the waterbody riparian zones.<br>• Trees growing on all islands to be targeted first to remove Ibis nesting habitat.<br>• Cut and paint stems with herbicide (e.g. glyphosate 360 mg/L or similar)<br>• Replant with native shrub and tree species that are less favoured as Ibis nesting habitat.<br>• Re-establish batter groundcover vegetation. Refer to E1<br><br>Rectify batter/edge vegetation cover in accordance with the following tasks:<br>• Re-establish vegetation on unstable batters. Refer to B6<br>• Remove terrestrial weeds and replace with native species.<br><br>Anembo Island:<br>• Undertake strategic staged weed removal on Anembo Island<br>• Revegetate cleared areas with a mix of indigenous species to enhance habitat quality and visual amenity. Refer to E1<br><br>Ongoing: Replant with native shrub and tree species that are less favoured as Ibis nesting habitat. | Good | E&NAM | C&CIS |
| **F1** | Access for maintenance | No formal maintenance access for weed harvester equipment.<br><br>It is noted that the waterbodies can be readily accessed (via the batters) by Council's mechanical harvester at multiple locations within each waterbody. | Adequate | Low | No Action Required | Good | - | - |




## MANAGEMENT ACTIONS

Waterbody edge / public safety:
Undertake of waterbody edge public safety risk assessment:

1. Implement works to 'high risk' unsafe edges
2. Stabilise eroding edges
3. Establish terrestrial vegetation buffer (along steep mown edges into sharp drop-off)

Waterbird management:
Development of waterbird management plan

4. Signage to discourage bird feeding
5. Landscaping works in key locations to discourage bird feeding and loafing

Terrestrial weeds:
Development of weed management plan:

6. Removal of declared weeds around waterbody margins (Singapore daisy)
7. Removal of broad leaf pepper tree from all lake margins and islands
8. Terrestrial buffer planting

Waterbody planting:
Establish emergent and submerged native water plants throughout the waterbodies to manage nutrient concentrations:

9. Planting water plants along shallow edge
10. Long term action – install wetland plants (across the base of Waterbody A, B and C)

Aquatic weeds:

11. Staged removal of *Nymphaea mexicana*

Waterbody mixing / turnover

12. Investigate regrading Anembo Drive inlet to be a free draining revegetated swale.

Catchment management

13. Review and update catchment stormwater management strategy. Continue to implement catchment based stormwater treatment initiatives

DesignFlow

LEGEND

- Property boundary
- Existing stormwater pipe

WATERBODY EDGE CONDITION

- Edge dominated by over hanging Broadleaf Pepper Tree
- Edge dominated by Singapore Daisy
- Overhanging vegetation (native & introduced)
- Grassed edge, steep batter, sharp drop-off
- Grassed edge, mown
- Edge dominated by emergent macrophytes
- Potential emergent wetland planting areas
- Potential submerged wetland planting areas

0 40 80 160 m

**Figure 6-1**
**Management Actions Plan**

Lowlands Lagoons (Anembo Lakes)
Waterbody Management Plan

SCALE: 1:4,000

DATE: 23 February 2021

DesignFlow
PO Box 1250, Southport BC
7 Bauer St, Southport QLD 4215

For:
FCRC

# 7 REFERENCES


Department of State Development, Infrastructure and Planning (DSDIP, 2017) *State Planning Policy*.

DesignFlow (2021) *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report*.

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Hofstra, D. E., Champion, P. D., Dugdale, T. M., Fridman, M., Baker, R and Finlay, M. (2013) *Comparison of use rates and treatment timing with glyphosate to control Mexican water lily*. Journal of Aquatic Plant Management 51: 69-76.

## APPENDIX A. WATERBODY FIELD CONDITION ASSESSMENT FORM

| Asset Name: | Asset ID: | Location: | Date: |
|---|---|---|---|

**Condition Scoring: 1 = Good (PI exceeded), 2 = Adequate (PI met), 3 = Poor (PI not met), 4 = Very Poor (PI failed)**

| Cate-gory | Item | Component | Performance indicator (PI) | Condition Score | Comment |
|---|---|---|---|---|---|
| Public Health & Safety | 1.1 | Risk of injury or drowning | Open space areas adjacent to water minimise risk of drowning | | |
| | 1.2 | Batter slopes | Slope ideally 1:6 or flatter adjacent to open water zones. Batter slope above and below water level is no steeper than 1 in 4. | | |
| | 1.3 | Fencing/ barriers | Fencing / barriers present in unsafe areas (walls greater than 1m high anywhere or walls/steep batters of any height into permanent water). Appropriate fencing or vegetation barriers in place where batter slope is steep or adjacent to deep water | | |
| | 1.4 | Contaminated Water | No obvious contamination of water. E.g. due to chemical contamination, faecal matter (e.g. large bird population, sewer leaks etc.) | | |
| | 1.5 | Mosquitoes | Low mosquito populations, no isolated depressions creating mosquito habitat, no larvae observed. | | |
| Hydraulic Condition | 2.1 | Inlet Condition - e.g. pipes, channels | No blockage, erosion or structural damage | | |
| | 2.2 | Outlet Condition - Including bund, pipes, pits, grates, outlet weirs, scour protection | No blockage or damage. No erosion, scour tunnelling or structural damage. The waterbody bund is not overtopped regularly | | |
| | 2.3 | Other structures | No erosion and damage to other structures, e.g. pits, pipes, ramps and walls. | | |
| | 2.4 | Flushing/ Residence Time | The system is well flushed with no dead pockets/backwatered areas | | |
| | 2.5 | Water levels | Water level close to normal operating level. | | |
| | 2.6 | Stability of Batters and bunds | Minor and localised erosion only. No scour or exposed earth on batters. | | |
| | 2.7 | Sedimentation accumulation | No visible coarse sediment accumulation within waterbody. | | |
| Water Quality | 3.1 | Odours | No odours detected | | |
| | 3.2 | Algae / Cyano-bacteria | No obvious sign of planktonic algae in water column or floating scums. | | |
| | 3.3 | Turbidity | Water column clear and visibility >1m. Turbidity ranges between 1-20 NTU | | |
| | 3.4 | Litter/ Debris | No grass clippings. No floating litter. Bins are provided and are adequately maintained and routinely empty. | | |
| Aquatic habitat | 4.1 | Aquatic vegetation - emergent | Native emergent macrophytes present around the shallow margins (<0.35m depth) of the waterbody. Plants healthy and free from disease (includes native water lilies). | | |
| | 4.2 | Aquatic vegetation - submerged | Native submerged macrophytes present (0.35-1.5 m depth). Includes all submerged genera (Ceratophyllum, Potamogeton, Myriophyllum) | | |
| | 4.3 | Aquatic vegetation – free-floating | Less than 5% of the waterbody surface covered by native floating macrophytes (i.e. Azolla, Water lilies). | | |
| | 4.4 | Aquatic weeds – declared | Declared weeds controlled. | | |
| | 4.5 | Aquatic weeds – non-declared | Less than 20% of the waterbody surface area covered in non-declared weeds | | |
| | 4.6 | Aquatic fauna pests | No damage by pests (e.g. Tilapia digging). No pests present (e.g. no Tilapia observed, no large bird populations) | | |
| | 4.7 | Filamentous algae | Less than 10% of the water surface covered with filamentous algae. | | |
| Terrestrial Habitat | 5.1 | Edge vegetation condition | A minimum vegetation width of 1.5m along the lower waterbody batter. Greater than 90% vegetation cover. Plants healthy and free from disease. | | |
| | 5.2 | Terrestrial weeds - declared | Declared weeds controlled. | | |
| | 5.3 | Terrestrial weeds – non-declared | Less than 10% of the batters covered in non-declared weeds | | |
| Access for Maintenance | 6.1 | Access to waterbody reserve | Formal access provided into the waterbody reserve. | | |
| | 6.2 | Access to waterbodies margin | Adequate access to waterbody edge provided for weed management | | |
| | 6.3 | Access to water surface | An appropriate access is available for harvesting aquatic weeds (weed harvester or boat) | | |

## APPENDIX B. LOWLANDS LAGOONS (ANEMBO LAKES) ACTIONS TABLE

| Action Category | Proposed Action | Timeframe | Indicative Budget period (planning purposes only) | Cost Level | Indicative Cost estimate | Indicative Scope of Works | Indicative Lead Department | Indicative Delivery Mode | Pros | Cons | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WATERBODY EDGE - PUBLIC SAFETY RISK ASSESSMENT (AND DESIGN) | Development of Waterbody Edge - Public Safety Risk Assessment<br><br>+<br><br>Design | Immediate | 2021 - 2022 | Low | $15k-$30k (+ Design Cost) | Inspect waterbody margins to map and rate risk areas that may present risk of falling or drowning as a result of steep batters into open water. Assessment should take a risk management approach where 'consequence' and 'likelihood' are rated for each bank profile. Where risks are rated as 'high' then cost effective 'risk control measures' should be recommended and the residual risks rated. This could range from temporary or permanent physical barriers, landscaping, re-profiling, signage or combination of above works. Scope to include actions to manage eroding edges and dispersive soil management. As part of this scope a review of the option to infill narrow inlets to | Infrastructure Planning | External consultants (Risk assessment Inspector, Landscape Architect + Environmental or Geotechnical Engineer) to resolve design responses. | Identifies approach to managing public safety risk. | Cost to complete<br>Requires actioning of recommended works to manage FCRC liability. | Action applicable across all FCRC waterbodies. Implement works to address identified high risk locations as a priority. |
| | Implement works to 'high risk' unsafe edges | Short | 2022 - 2023 | Medium | $100k-$300k | Subject to outcomes of the 'Waterbody Edge Risk Assessment and Design' action. Assumes majority of works are simple or low cost interventions to manage safety. Excludes major bank reprofiling works. | Capital Delivery | Design Team for detailed design; External Contractors for construction. | Improved public safety associated with accessible waterbody edges. | May create an expectation that Council willl stabilise and repair all eroding waterbody edges. | Combine action with other edge planting works (e.g. planting bird loafing areas and terrestrial buffers). |
| | Stabilise eroding edges | Medium | 2023 - 2025 | Medium - High | $100k-$500k | Implement actions to manage eroding edges identified as part of the edge assessment action. Works will need to be itemised and prioritised based on return on investment approach due to the extent of waterbody edges that could potentially require works. May require rectification of incised vertical batters located on the south side of the Anembo Drive inlet area. | Open Space & Environment | Design Team for detailed design; External Contractors for construction. | Stabilises edges. | Some actively eroding edges may cost significant amount to address to avoid impacts to private land holders (but may not currently create a safety risk). | Dispersive soils are a re-occurring issue across a number of FCRC waterbodies. Such soil types are prone to slaking and erosion resulting in vertical and undercut edges. Particularly evident when water levels are lower during dry periods. |
| WATERBIRD MANAGEMENT | Development of Waterbird Management Plan | Immediate | 2021 - 2022 | Low | $25k-35k | Focus of waterbird management plan would be to characterise nuisance water bird species and locations were they are congregating and developing appropriate management responses to reduce numbers to more sustainable numbers (e.g. reducing bird feeding via signage and community education, limit loafing via landscaping, removing roosting sites associated with Broad leave pepper trees). Plan should inform associated actions including removal of BLP trees, public signage, etc. | Open Space & Environment | Specialist ecological consultants | Provides transparent approach to inform future decisions around waterbird management. Allows for reductions in: bird population, public health risk, odours, nutrient loads and algal/cyanobacterial growth. Improvements to: waterbird health, water quality, batter/edge stability and increased amenity. | Minor loss of resident experience (waterbird feeding). | Action applicable across all FCRC waterbodies. |
| | Signage to discourage bird feeding | Short | 2022 - 2023 | Low | $10k | Development of educational signage | Open Space & Environment | External contractors for design and manufacturing. Internal resources for installation. | Improved community education of waterbirds | Visual amenity impacts | Potential for signage to be informative (rather than prescriptive). Could be completed in partnership with bird watchers / community groups. Signage should be generic and suitable to use across all lakes systems |
| | Landscaping works in key locations to discourage bird feeding and loafing | Medium | 2023 - 2025 | Low | $30k | Design and installed landscaping to bare waterbody margins associated with bird feeding e.g. Truro park | Open Space & Environment | External landscape architect | Improve landscape outcome in areas impacted by birds in high use area. | Cost to complete | |
| | Other items identified in the Waterbird Management Plan | Medium | 2023 - 2025 | Low | $20k-50k | TBA - e.g. actions to support lowing bird numbers such as breeding restrictions | Open Space & Environment | TBA | *TBA* | *TBA* | *TBA* |

| Action Category | Proposed Action | Timeframe | Indicative Budget period (planning purposes only) | Cost Level | Indicative Cost estimate | Indicative Scope of Works | Indicative Lead Department | Indicative Delivery Mode | Pros | Cons | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TERRESTRIAL WEEDS | Development of Weed Management Plan (e.g. Broad Leaf Pepper Tree) | Immediate | 2021 - 2022 | Low | $15k | Development of basic strategy/plan to remove weeds and Broad Leaf Pepper (BLP) trees including replacement planting to align with the waterbird management objectives and follow-up maintenance to limit re-occurrence. Plan should identify the existing extent of BLP around the lakes and determine costs to implement. | Open Space & Environment | External ecological consultants | Provides transparent approach to inform future decisions around weed management informed by the outcomes of the Waterbird Management Plan | Cost to complete. | Action applicable across all FCRC waterbodies. FCRC may be able to review and adapt existing policies to support this action. |
| | Implement works recommended in the Weed Management Plan (Phase 1) | Short | 2022 - 2023 | Low | $50k | Implement removal of terrestrial weeds in accordance with the Weed Management Plan. Priority initially to remove Ibis rookery habitat areas associated with Broad-leaved Pepper trees overhanding water) and replace with more appropriate native vegetation (e.g. groundcovers and shrubs). | Open Space & Environment | Design Team for detailed design; External Contractors for construction. | Reductions in: bird population, public health risk, odours, nutrient loads and algal/cyanobacterial growth. Improvements to: waterbird health, water quality, batter/edge stability and increased amenity. | Cost to complete. | Ongoing monitoring and removal of new BLP trees will be required |
| | Implement works recommended in the Weed Management Plan (Phase 2) | Medium | 2023 - 2025 | Medium | $150k | Implement removal of terrestrial weeds in accordance with the Weed Management Plan. Priority initially to remove Ibis rookery habitat areas associated with Broad-leaved Pepper trees overhanding water) and replace with more appropriate native vegetation (e.g. groundcovers and shrubs). | Open Space & Environment | Design Team for detailed design; External Contractors for construction. | Reductions in: bird population, public health risk, odours, nutrient loads and algal/cyanobacterial growth. Improvements to: waterbird health, water quality, batter/edge stability and increased amenity. | Cost to complete. | Ongoing monitoring and removal of new BLP trees will be required |
| | Targeted removal of declared weeds around waterbody margins | Short | 2022 - 2023 | Low | $15k | Remove Singapore Daisy from margins or Waterbody C (and any other locations) | Open Space & Environment | Internal works team to action | Replace weeds with native vegetation | Cost to complete. | Ongoing monitoring and maintenance will be required to prevent further re-occurrences |
| WATERBODY PLANTING | Terrestrial buffer planting | Short | 2022 - 2023 | Medium | $150k-250k | Works involve planting waterbody margins to reduce areas to create native vegetation buffers to waterbody margins. Existing weedy 'no mow buffers' to be infill planted with natives. Existing mown edges to be planted with native species (min 1.5m wide). | Open Space & Environment | Design Team for detailed design; External Contractors for installation. | Stabilise edges, limit bird egress locations, improve water quality, improve edge safety | Potential for loss of views to adjacent residents. | May be a combination of groundcovers, shrubs and trees subject to site lines and CPTED requirements. |
| | Wetland planting to waterbody edges | Medium | 2023 - 2025 | Medium | 150k | Works involve planting shallow waterbody margins with native emergent water plants | Open Space & Environment | Design Team for detailed design; External Contractors for construction. | Stabilise edges, limit bird egress locations, improve water quality, provide aquatic habitat | Cost to complete. Poor water clarity and steep drop-offs will limit planting success. | These works may also be required as part of edge stabilisation or removal of BLP actions |
| | Wetland planting (across the base of Waterbody A, B and C) | Long | 2025 - 2030 | Medium | $150k-250k | Works involve planting floor waterbody (away from shallow margins) with native emergent and submerged macrophytes (subject to depth and water clarity) | Open Space & Environment | Design Team for detailed design; External Contractors for construction. | Improved water quality treatment benefit. | Difficult to establish wetland plants into deeper zones if water clarity is poor. | Works contingent on improved water quality and clarity. If water clarity improves it is anticipated that existing water plants species will establish across the wetlands. |
| AQUATIC WEEDS | Management of declared weeds | Short | 2022 - 2023 | Low | $15k p.a. | Monitor for and remove as required declared weeds occurring within Waterbodies | Biosecurity | Internal works team to action | Required under Biosecurity Act. | | Ongoing monitoring and maintenance but none present in the system currently |
| | Management of non-declared weeds | Medium | 2023 - 2025 | Low | $15k p.a. | Implement trial staged removal of *Nymphaea mexicana* from Waterbody C. | Open Space & Environment | Internal works team to action | Potential to remove and replace *N. mexicana* with native *C. demersum* or *N. indica.* Reduced long term maintenance. | Potential for large scale dieback and decomposition of *N. mexicana*. Undertake as small scale trial initially | Works to be trialled in small areas to manage risk associated with herbicides. Ongoing monitoring and maintenance once completed. |
| CATCHMENT MANAGEMENT | Review and update catchment stormwater management strategy | Medium | 2023 - 2025 | Low | $15k | Review the current GHD report and resolve if these opportunities are viable in terms of level constraints/space and costs. Identify if other new options are possible. | Infrastructure Planning | External stormwater consultant | Improved stormwater runoff quality. Reduced sediment and nutrient load being discharged to the Lowland Lagoons system. Improved water quality. Long term waterbody stability. Reduced algal/cyanobacterial growth. Increased amenity within the waterbodies. | Retrofitting stormwater treatment infrastructure into developed catchments can be difficult and expensive. | Works contingent on improved water quality and clarity. |
| | Continue to implement catchment based stormwater treatment initiatives | Long | 2025 - 2030 | High | >$500k | Subject to outcomes of updated Catchment Management Strategies | Infrastructure Planning | External stormwater/civil consultant for detailed design; External Contractors for construction. | | | Works contingent on improved water quality and clarity. |

| Action Category | Proposed Action | Timeframe | Indicative Budget period (planning purposes only) | Cost Level | Indicative Cost estimate | Indicative Scope of Works | Indicative Lead Department | Indicative Delivery Mode | Pros | Cons | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WATERBODY MIXING / TURN-OVER | Removal small islands from Waterbody E | Future / Aspirational | 2025 - 2030 | High | >$250k | This will involve earthmoving machinery to spread the existing islands out of the base of the waterbodies. | Open Space & Environment | Internal works team to action | Removes habitat for nuisance bird species. Some reduction in waterbody volume. | High cost to implement. No community support. Disturbance during construction. | Long term option |
| | Install waterbody recirculation system between waterbodies A and E | Future / Aspirational | 2025 - 2030 | High | >$500k | Supply, install and operate pump (located within) Wetland E and new pump line to Waterbody A (or B). Aiming for a turnover rate of 20 days for combined volume of system. | Infrastructure Planning | External stormwater/civil consultant for detailed design; External Contractors for construction. | Improved turnover of stagnant water areas. | Cost to implement, operate and maintained high. Potential impact on waterbodies in better condition (e.g. Waterbody C). | Long term option. |
| | Modify waterbody depths to enable parts of Waterbody A-E to be converted to treatment wetlands | Future / Aspirational | 2025 - 2030 | High | >$500k | This will involve installation of new water level outlet controls (likely required for Waterbody C and E) and potentially minor infill to the base of waterbodies to create depths suitable for emergent wetland plants | Infrastructure Planning | External stormwater/civil consultant for detailed design; External Contractors for construction. | Improved water quality treatment benefit. Reduced waterbody volume to turnover. | Potentially high cost to implement if de-watering and filling of the waterbody floor is required. Modification to water levels would require investigation of impact to adjacent residents. | Long term option in conjunction with re-circulation system. |
| | Investigate regrading Anembo Dr inlet to be a free draining revegetated swale. | Future / Aspirational | 2025 - 2030 | Medium | $150k-250k | Re-profile the inlet area between Anembo Drive and Alexander Road to reduce or remove backwatering and stagnant water. Works subject to further design development, community consultation and feature survey. | Infrastructure Planning | External stormwater/civil consultant for detailed design; External Contractors for construction. | Removes stagnant section of Waterbody D. | Loss of visual amenity and open water zones for adjacent residents. | Long term option |
| | Infill between Anembo Island residential houses to create shallow wetland planting areas | Future / Aspirational | 2025 - 2030 | High | >$500k | This will involve infill of the waterbody body between Anembo Island and the mainland to create depth suitable for emergent macrophytes. | Infrastructure Planning | External stormwater/civil consultant for detailed design; External Contractors for construction. | Improve water quality from wetland plants. Removes stagnant section of Waterbody D. Reduce waterbody volume. | High cost to import fill. Difficult location to gain access for construction. Loss of visual amenity and open water zones associated with islands | Long term option |

## APPENDIX C. WMS FRAMEWORK: ISSUES AND MANAGEMENT TABLE

The following table is an extract from the *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report* (DesignFlow, 2021).

| Issue | Description | Investigations / monitoring | Minor or Immediate Response Management Actions[1] | Proactive Management Actions[2] | Relevant policy, legislation and supporting information |
|---|---|---|---|---|---|
| **A. Public Health and Safety** | | | | | |
| **A1**<br><br>**Risk of injury or drowning** | Potential safety issues (i.e. drowning) may be due to:<br>• Steep batters<br>• Lack of access control<br>• Lack of perimeter vegetation | Discuss with asset owner to identify and document any issues. Undertake desk-top review and initial site inspection. | If risk is deemed unacceptable the following actions should be considered:<br>• Install temporary protection (temporary fencing) to exclude public entry; and/or<br>• Erect signage to highlight risk to public and that a response is being identified. | Proactive management actions will depend on the scale, type and degree of risk. Actions may include:<br>• Planting waterbody batters with dense vegetation to restrict access.<br>• Installing access control using barriers such as permanent fencing where risk of access is high.<br>• Modifying the waterbody edge to provide safe batters above and below the water level (a maximum slope of 1:4 is recommended as a minimum).<br>• Reducing the depth of the waterbody, particularly around the edges.<br>• Where the waterbody is located near high children use area (i.e. children's playground), consider moving the use to another part of the parkland.<br>Refer to *Rectifying WSUD Assets* – Appendix B (Water by Design) for additional guidance. | Water by Design (2011) *Rectifying WSUD Assets.* |
| **A2**<br>**Health risks due to human contact with contaminated water** | Potential health risks may exist where public have direct access to water contaminated with chemicals, faecal matter or cyanobacteria<br>Certain types of cyanobacteria (blue–green algae) can release toxins that affect the liver or nervous system when they die, which can be a major public health issue. In addition, all Cyanobacteria contain toxins within their cell walls that can cause skin irritations and allergic responses in human skin tissue from direct contact with the cells. | Discuss waterbody contamination history with asset owner, engineering and environmental health departments to identify and document any issues.<br>Undertake desk-top review and site inspection.<br>Detailed investigations will depend on the nature of the contamination. Refer to issue A-3 for chemical contamination, A-4 for faecal contamination and C-2 for algal and cyanobacterial blooms | Where contamination is reported, the relevant state government department (environmental health) should be notified and monitoring/management completed in accordance with DERM (2009), ANZECC (2018) and NH&MRC (2008). Management actions will be guided by monitoring outcomes but may include:<br>• Installation of temporary protection (temporary fencing) to exclude public entry;<br>• Erecting signage to highlight risk to public and that a response is being identified.<br>• Community consultation<br>• clean-up/treatment or adaptive management as required<br>For ongoing management actions refer to issue A-3 for chemical contamination, A-4 for faecal contamination and C-2 for algal and cyanobacterial blooms | Refer to issue A-3 for chemical contamination, A-4 for faecal contamination and C-2 for algal and cyanobacterial blooms | DSDIP (2017) *State Planning Policy.*<br>ANZECC (2018) *The Australian and New Zealand Guidelines for Fresh and Marine Water Quality – 2018 edition.*<br>NH&MRC (2008) *Guidelines for managing risk in recreational waters.*<br>DERM (2010a) *Environmental Protection (Water) Policy 2009 Burrum, Gregory, Isis, Cherwell and Elliott Rivers environmental values and water quality objectives Basin No. 137 (July 2010)*<br>DERM (2010b) *Environmental Protection (Water) Policy 2009 - Mary River environmental values and water quality objectives. Basin No. 138, including all tributaries of the Mary River (July 2010)*<br>Chorus and Bartram (1999). *Toxic cyanobacteria in water: A guide to their public health consequences, monitoring and management.* |

[1] Actions that can be completed immediately, rapidly or cost effectively in response to the issue. The focus of management actions is investigation and easily implemented responses. May require ongoing management/investigations.

[2] Actions that require planning, design and budgeting to implement. Generally involves responses/actions which are more onerous and take time to consider.

| Issue | Description | Investigations / monitoring | Minor or Immediate Response Management Actions[1] | Proactive Management Actions[2] | Relevant policy, legislation and supporting information |
|---|---|---|---|---|---|
| **A3**<br><br>**Chemical contamination.** | The presence of chemical contamination may be indicated by:<br>• Obvious discoloration of the waterbody water (i.e., orange, red, grey).<br>• Chemical residues floating on the surface of the waterbody (e.g. oily scums).<br>• Fish kills | Discuss with asset owner, engineering and environmental health departments to identify and document any historical issues.<br><br>Undertake desk-top review of potential contamination sources (e.g. proximity to ERAs) and site inspection. | Suspected contamination by toxic chemicals should be reported immediately to DERM.<br><br>If toxic chemicals are found at levels which exceed the relevant WQOs (DERM 2010a, DERM 2010b) an adaptive management program should be implemented in accordance with the risk assessment framework set out in NH&MRC (2008).<br>Management actions may include:<br>• Installation of temporary protection (temporary fencing) to exclude public entry;<br>• Erecting signage to highlight risk to public and that a response is being identified.<br>• Community consultation<br>• treatment or adaptive management as required | Clean-up of spills should be conducted with advice from DERM and an appropriate specialist as required, in accordance with the NH&MRC (2008) risk assessment framework.<br><br>Management actions will be resolved as part of the waterbody investigations. Potential management responses to may include :<br>• Installation of stormwater treatment systems in the upstream catchment to remove pollutants prior to entering the waterbody.<br>• Resetting the waterbody system as a wetland. | NH&MRC (2008) *Guidelines for managing risk in recreational waters.*<br><br>DERM (2010a) *Environmental Protection (Water) Policy 2009 Burrum, Gregory, Isis, Cherwell and Elliott Rivers environmental values and water quality objectives Basin No. 137 (July 2010)*<br><br>DERM (2010b) *Environmental Protection (Water) Policy 2009 - Mary River environmental values and water quality objectives. Basin No. 138, including all tributaries of the Mary River (July 2010)* |
| **A4**<br><br>**Faecal and/or nutrient contamination.** | Contamination of the waterbody by faecal bacteria and nutrients may be due to:<br>• Large bird populations on or adjacent to the waterbody.<br>• Untreated sewage entering waterbody via stormwater inflows.<br>• Leakage of septic systems into ground, surface or stormwater.<br>• Diffuse runoff from surrounding land uses, particularly areas with high concentrations of domestic animals (e.g. dogs, cats, cattle, sheep, pigs, poultry etc.).<br>• Internal (nutrient) loading from the sediments)<br>The presence of faecal contamination is often difficult to detect, however may be indicated by:<br>• Obvious discolouration of the waterbody water (e.g. grey, blue-grey).<br>• Unusual foaming on the surface of the waterbody, especially at inflow sites<br>• Unusual water odours (e.g. effluent). | Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues.<br><br>Undertake desk-top review and initial site inspection.<br><br>Depending on the outcomes of the risk assessment, the asset owner may wish to undertake additional site surveys and /or Implement a water quality monitoring program in accordance with NH&MRC (2008). | If faecal contamination is found at levels which exceed the relevant WQOs (DERM 2010a, DERM 2010b) an adaptive management program should be implemented in accordance with the risk assessment framework set out in NH&MRC (2008).<br>Management actions may include:<br>• Installation of temporary protection (temporary fencing) to exclude public entry;<br>• Erecting signage to highlight risk to public and that a response is being identified.<br>• Community consultation<br>• Routine inspections and maintenance of existing dog waste bins<br>• treatment or adaptive management as required | If the risk is deemed unacceptable, management actions may include::<br>• Removing or culling waterfowl from the waterbody system.<br>• Treating contamination sources from the catchment, including illegal sewer connections to drainage system, STP overflows, stormwater etc.<br>• Treatment or containment of drainage from intensive agriculture / industry<br>• Signage and public education programs.<br>• Installation of dog/domestic animal waste bins | NH&MRC (2008) *Guidelines for managing risk in recreational waters.*<br><br>DERM (2010a) *Environmental Protection (Water) Policy 2009 Burrum, Gregory, Isis, Cherwell and Elliott Rivers environmental values and water quality objectives Basin No. 137 (July 2010)*<br><br>DERM (2010b) *Environmental Protection (Water) Policy 2009 - Mary River environmental values and water quality objectives. Basin No. 138, including all tributaries of the Mary River (July 2010)* |

| Issue | Description | Investigations / monitoring | Minor or Immediate Response Management Actions[1] | Proactive Management Actions[2] | Relevant policy, legislation and supporting information |
|---|---|---|---|---|---|
| **A5**<br><br>**Human health risk due to excessive Mosquito Populations** | The presence of large mosquito populations represents both a potential human health risk (as mosquitoes are vectors for many pathogens including protozoa, nematodes and viruses) and a nuisance to local residents. | Discuss safety with asset owner and environmental health stakeholders to identify and document any issues.<br>Undertake site inspection to check for evidence of mosquito breeding sites around the margins of the waterbody and also in any isolated shallow pools in the near vicinity. Check for evidence of litter which may support mosquito breeding.<br>Record whether or not:<br>• The mosquito problem is associated with the waterbody (or the surrounding ecosystems).<br>• Simple management actions can be implemented to reduce populations.<br>• A mosquito control plan should be prepared and management actions implemented.<br>Where a mosquito control plan is required then an audit of the mosquito species and population density both within the waterbody and adjacent habitats is required. | Simple management actions may include:<br>• Implementing a regular litter removal program<br>• Regular Spraying with larvicides (seek advice from environmental health experts within Council if the use of chemical control agents are deemed necessary.) | Where further management is required, a mosquito control plan should be prepared in accordance with the *Mosquito Management Code of Practice for Queensland* (Local Government Association of Queensland Inc. 2002).<br>Rectification options may include:<br>• Draining isolated pockets of pooled water.<br>• Filling in uneven areas where stagnant water accumulates<br>• Increasing depth in open water areas to >60cm to limit mosquito breeding<br>• Improving waterbody circulation and flushing<br>• Introducing mosquito predators (native fish). | Local Government Association of Queensland (2002) *Mosquito Management Code of Practice.*<br>Diseases Control Services, Communicable Diseases Unit, Queensland Health (2002) *Guidelines to minimise mosquito and midge biting problems in new development areas.*<br>Water by Design (2011) *Rectifying WSUD Assets.*<br>Water by Design (2011) *Maintaining WSUD Assets.* |
| **B. Hydraulic condition** | | | | | |
| **B1**<br><br>**Inlet/outlet erosion or instability** | Instability or erosion of inlet or outlet structures may be hazardous due to structural failure of hydraulic controls, blockages, creation of deep pools/unsafe batters, etc.<br>Instability of the inlet/outlet may result from:<br>• High discharges due to storm inflows.<br>• Lateral surface flows entering the waterbody via drainage lines.<br>• Localised high velocities (e.g. shape of waterbody, around inlet).<br>• Failure of aging infrastructure | Inlet/outlet scour/instability issues with inlets and outlets with asset owners to identify and document any issues.<br>Complete a site inspection to check for evidence of failure of hydraulic controls at inlets/outlets and assess the scale of the problem and reason for erosion/instability.<br>Following the investigation tasks listed above a decision needs to be made regarding the following whether the issues require management or not. This decision will be dictated by the amount of erosion/instability, risk of further failure and the public safety risk (**A1**). Where management is required, in most cases this will not require detailed assessment but rather will involve design of a replacement structure / scour protection measures. | Where erosion/instability exists and has stabilized or is not considered a risk to Council, then no management action required. Monitor the issue zones via regular visual inspection. | Management of significant erosion/instability will be dictated by the investigations and may require specialist input from a soil scientist and /or stormwater engineer.<br>Management responses may include:<br>• Re-enforcing the eroded areas with rock protection.<br>• Directing inflows to rock-lined channels that feed down the batters to the waterbody.<br>• Replacing topsoil in scoured zones and re-establishing the vegetation.<br>• Modifying hydraulic control structures (i.e. inlet and outlet pipes and weirs).<br>If the soil is problematic, seek advice from the soil laboratory for management options to meet the specifications. In some cases, in-situ management may be possible. However, if not, remove and replace the soil. | |
| **B2**<br><br>**Outlet blockage - Water level is consistently too high above normal water level** | Persistent high water levels (minor flood conditions) within the waterbody causing issues adjacent to waterbody (e.g. death of vegetation, waterlogging of parkland area, tidal backwatering etc.). | Discuss elevated water levels issue with asset owner and engineering services to identify and document any issues.<br>• Complete site inspection following rainfall and during dry conditions to assess elevated water levels and identify potential causes: This will include checking for blockage of the outlet pipe or weir.<br>• Incorrect design or construction of the outlet pipe or weir.<br>• Blockage or siltation of downstream drainage system causing backwatering up the pipe.<br>• Increased catchment inflows due to changes in catchment land use or drainage.<br>Where the risk of elevated water levels is high or very high and the solution is not straight forward then further technical assessment may be required. Seek advice from an engineer if the outlet is regularly blocked or undersized. Review catchment land use to determine if there has been a significant increase in catchment imperviousness. Catchment modelling may be required to determine waterbody inflows. Assess the capacity of the waterbody outlet to cope with increased flows. Installation of a water level gauge may assist with technical assessment. | Management options for elevated water level may include:<br>• Undertaking regular inspection and maintenance of waterbody outlet.<br>• Cleanout of downstream waterways to ensure free drainage of waterbody<br>• Erecting signs to inform the community about the water level issue in the waterbody. | If the risk is deemed unacceptable, management actions may include:<br>• Decrease future risk of blockage (i.e. submerged outlets, inclined grates, large conveyance opening to allow for accumulation of litter)<br>• Provide increased capacity (i.e. new pit or pipes).<br>• Provide easy inspection and maintenance access (4.8)<br>• Allow adaptive management of the waterbody water levels (e.g. install valve or stage outlet to allow water levels to be lowered or raised easily). | Healthy Waterways (2010) *WSUD Technical Design Guidelines.* |

| Issue | Description | Investigations / monitoring | Minor or Immediate Response Management Actions[1] | Proactive Management Actions[2] | Relevant policy, legislation and supporting information |
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| **B3**<br><br>**Poor flushing or dead pockets** | Poor flushing or dead pockets are demonstrated by patches of still, stagnant water, sometimes accompanied by an odour and / or algal growth. This is caused locally by areas of open water that are rarely flushed (isolated 'dead pockets') or more broadly waterbodies that have relatively small or infrequent inflows. | Discuss coarse poor flushing and dead pockets with asset owner and engineering services to identify and document any issues. Complete site inspection around the full perimeter of the waterbody to identify potential to dead pockets indicated by:<br>• Small backwaters which do not receive flowing water.<br>• Poor water quality and algae | Where poor flushing exists but it is not leading to poor water quality, then no management action required. Monitor the poorly flushed zones via regular visual inspection. | Where poor flushing is resulting in poor water quality outcomes (i.e. algae blooms), then management should occur. Options include:<br>• Recirculation<br>• Removal of islands<br>• Retrofitting of inlets/outlets to maximize flushing<br>• Redirecting flows through the waterbody to ensure flow pass through dead pockets.<br>• Re-shaping base of the waterbody to remove or fill in dead pockets.<br>• Converting dead pockets to wetland zones. | |
| **B4**<br><br>**Water level is consistently too low** | The waterbody water level drops following rainfall to expose the bed of the waterbody system. | Discuss low water levels with asset owner and engineering services to identify and document any issues.<br>Complete site inspection following rainfall and during dry conditions to assess elevated water levels and identify potential causes. This will include checking for:<br>• Incorrect outlet structure.<br>• Leaking outlet structure.<br>• The waterbody catchment is small (i.e. not enough inflow to sustain water level)<br>• The base or bund of the waterbody is not properly sealed.<br>• Depth of waterbody has reduced due to siltation.<br>• Inflows are bypassing the waterbody.<br>Where the risk of low water levels is high or very high and the solution is not straight forward then further technical assessment may be required. Seek advice from an waterbody specialist (internal or external to Council) to confirm the reason for the water level reduction:<br>• Obtain design information for the waterbody in particular catchment area, inflow points, earthworks/bathymetry and outlet structure.<br>• Obtain certification and construction information for the waterbody.<br>• Where required collect survey data to confirm the design levels are achieved.<br>• Review the catchment area to ensure the catchment is suitably large enough to sustain water in the waterbody (i.e. waterbodies which are greater than 5% of the catchment in the Fraser Coast region may experience significant water level variation).<br>• Review the depth of the system to confirm whether siltation has occurred (may require survey).<br>• Complete boreholes in the base of the waterbody to confirm the presence of a clay liner (or otherwise). | Management options for low water levels may include:<br>• Erecting signs to inform the community about the water level issue in the waterbody. | If the risk is deemed unacceptable, management actions may include:<br>• Installing a new outlet structure.<br>• Fixing any leaks in the outlet structure.<br>• For a waterbody with a small catchment, reduce the size of the waterbody or decommission.<br>• Diverting more catchment into the waterbody.<br>• Use proprietary product which flocculates fine sediment to the base of the waterbody to create a thick impermeable liner. Apply following a number of rainfall events where suspended solids are elevated to maximize sediment capture on base.<br>• Draining and sealing the base or bund of the waterbody properly<br>• Converting a waterbody which has a 'leaky' base to an ephemeral wetland.<br>Where the waterbody has been constructed recently and certified by geotechnical engineer or civil engineer, consider taking action for compensation to cover costs of management works. | |
| **B5**<br><br>**Flooding of adjacent land, parkland or property or regular overtopping of waterbody bund** | Drainage into or out of the waterbody has the potential to flood adjacent land, park or property due to poor hydraulic controls (i.e. uncontrolled flow out of waterbody). | Discuss flooding issues with asset owner and engineering services to identify and document any issues.<br>Complete site inspection following rainfall to assess flow behaviour through the waterbody system with a focus on inflows and outflows from the waterbody and any recorded flood prone areas.<br>Further assessment may be required if risk is identified as high. This may include undertaking a detailed desktop catchment investigation (areas, land use incl. changes, flood/stormwater management reports, flow calculations and/or modelling, complaints register) | Management actions may include::<br>• Undertaking regular inspection and maintenance of waterbody outlet.<br>• Regular cleanout of downstream waterways to ensure free drainage of waterbody. | If the risk is deemed unacceptable, management actions may include:<br>• Modifying outlet structures to control flooding (i.e. lower water levels, increase capacity, staged outlet)<br>• Installing or increasing the size of the high flow weir outlet from the waterbody.<br>• Increasing the capacity of downstream waterways<br>• Stabilising flood inflow and outflow locations.<br>• Diverting upstream catchment into or around waterbody. | Department of Natural Resources and Water (2016) *Queensland Urban Drainage Manual Fourth Edition.* |

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| **B6**<br><br>**Scour of batters** | Scoured batters may be hazardous due to the instability of the waterbody edges and presence of under-cut edges.<br>Scour of the batters may result from:<br>• High discharges due to storm inflows.<br>• Lateral surface flows entering the waterbody via drainage lines.<br>• Localised high velocities (e.g. shape of waterbody, around inlet).<br>• Lapping of water against exposed turf edges.<br>• Use of inappropriate soils around the edge of the waterbody (dispersive soils and the associated tunnel erosion). | Discuss scour of waterbody batters with asset owner and environmental health stakeholders to identify and document any issues.<br>Complete a site inspection to check for evidence of scour around the margins of the waterbody and assess the scale of the problem and reason for scour.<br>Following the investigation tasks listed above a decision needs to be made regarding the following whether the scour issues require management or not. This decision will be dictated by the amount of scour, risk of further scour and the public safety risk (1.1). Where management is required, in most cases this will not require detailed assessment but rather will involve design of a new waterbody batter which stable. | Where scour exists and has stabilized or is not considered a risk to Council, then no management action required. Monitor the scour zones via regular visual inspection. | Management of significant scour will be dictated by the investigations and may require specialist input from a soil scientist and /or stormwater engineer.<br>Management responses may include:<br>• Re-enforcing the eroded areas with rock protection and benching.<br>• Directing inflows to rock-lined channels that feed down the batters to the waterbody.<br>• Replacing topsoil in scoured zones and re-establishing the vegetation.<br>• Modifying hydraulic control structures (i.e. inlet and outlet pipes and weirs).<br>If the soil is problematic, seek advice from the soil laboratory for management options to meet the specifications. In some cases, in-situ management may be possible. However, if not, remove and replace the soil. | |
| **B7**<br><br>**Coarse sediment accumulation** | Coarse sediment is the largest component of urban stormwater pollutants in term of quantity. Therefore, coarse sediment deposition in the inlet zones to waterbodies will eventually be an issue for management.<br>Excessive sediment accumulation within the waterbody may result in the blockage of preferred flow path and the development of multiple flow paths.<br>The growth of emergent macrophyte vegetation upon silted areas may also influence the hydraulic behaviour of a waterbody system | Discuss coarse sediment accumulation with asset owner and engineering services to identify and document any issues.<br>Complete site inspection to each of the inflow points into the waterbody to assess coarse sediment accumulation:<br>• Visible sediment accumulation above or below the normal water level. Sediment accumulation is often most evident near the waterbody inlet zone/s.<br>• Growth of emergent macrophytes within the waterbody.<br>• Collection of sediment cores using a simple grab sampler/corer.<br>Where coarse sediment has accumulated the cause should be identified e.g.:<br>• Untreated catchment runoff<br>• Catchment land use or activities<br>• Failure of WSUD systems (GPTs or sediment basins) within the catchment to adequately capture coarse sediments<br>• Erosion of upstream waterways. | Management actions for coarse sediment manage can be undertaken provided access to the inlet zone is possible and include:<br>• Desilting the inlet area with machinery or dredges<br>• Desilting sediment basins of GPTs located upstream of the waterbody. | If the risk is deemed unacceptable and cannot be treated by management actions alone, management actions may include:<br>• De-watering the waterbody and mechanically removing the sediments.<br>• Managing the coarse sediment at its source (e.g. stabilizing upstream waterway).<br>• Installing GPT or sediment basins at the inflow point to the waterbody<br>• Creating maintenance access to the inflow zones or sediment capture systems.<br>• Creating dewatering areas<br>Note: An analysis of the sediment quality should be undertaken prior to removing sediments in order to determine the contamination level. | |
| **B8**<br><br>**Fine sediment or organic matter accumulation** | Fine or organic sediment accumulation on the bed of the waterbody system has a significant influence on waterbody function. Fine or organic sediment carries a large quantity of particulate nutrients. At the bed of the waterbody the sediment becomes anaerobic and these nutrients may be released in soluble form into the waterbody water column. Therefore, the fine organic sediment that accumulates on the base of waterbody can become a limitless source of nutrients to support algae blooms and weed growth. | It can be generally assumed that most waterbodies will have fine sediment accumulation. The question is how much accumulation. Discuss fine sediment accumulation with asset owner and engineering services to identify and document any issues.<br>Complete site inspection to the waterbody to assess fine sediment accumulation. This will require collection of sediment cores using a simple grab sampler/corer and visual inspection. Sample testing may be considered but in most cases the accumulation of fine sediment will be obvious. The sediment assessment should be combined with water quality profiling for dissolved oxygen and redox to assess the state of the sediment (i.e. anoxic).<br>Where fine sediment has accumulated the cause should be identified e.g.:<br>• Untreated catchment runoff<br>• Catchment land use or activities<br>• Failure of WSUD systems within the catchment to adequately fine coarse sediments<br>• Erosion of upstream waterways. | Where fine sediment accumulation is minor (say < 5cm) and the waterbody water quality is in relatively good condition, monitor waterbody water quality and health. No need to remove sediment. | Where fine sediment accumulation is significant (say > 5cm), anoxic and is the likely cause of poor water quality in the waterbody the management is required. Management options include:<br>• Converting the waterbody to a wetland (if shallow enough)<br>• Filling in the waterbody<br>• Dewatering the waterbody, allowing to dry out and removing sediment.<br>• Dredging or desilting the waterbody in wet conditions.<br>• Sealing the fine sediments under a layer of flocculated layer of sediment (i.e. flocculent added to waterbody) | |

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| **C. Water Quality** | | | | | |
| **C1**<br><br>**Odours** | Odours that detract from public open space or are a nuisance for local residents. There are a number of reasons why odours may develop in waterbody systems (also refer to Issues A2 - A4 and C2 - C5 in this table). | Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues.<br>Undertake desk-top review and initial site inspection.<br>Site inspections should be undertaken during early morning or low wind conditions to confirm presence of odour. Check the waterbody for possible sources of odour. This will include checking for:<br>• Decomposing organic matter<br>• Evidence of algal blooms (e.g. surface scums).<br>• Anoxic sediments (surface bubbling, sulphur-based odours when the sediment is disturbed).<br>• Chemical residues upon the water surface<br>• Large populations of water birds<br>• Chemical spillage (via the stormwater drainage system).<br>• Cross-connections from the sewerage system, or cross-contamination from septic systems in rural areas.<br>As indicated by the possible causes above, the presence of odour is almost always associated with other waterbody management issues. In most cases the presence of odour will be temporary and not a significant issue. | Where the odour issue is believed to be temporary or low-medium risk then no action is required.<br><br>Where odour is believed to be permanent and high to very high risk then management will be required. In the interim the odour issues could be managed by:<br>• Notifying residents of the issue<br>• Erecting signage notifying people of the issue. | If the risk is deemed unacceptable, management actions may include:<br>• Installation of mixers or aerators into the waterbody to increase dissolved oxygen levels (C7 and B3)<br>• Removing organic matter and fine sediment (B8)<br>• Removal or treatment of chemical contamination (A3)<br>• Managing bird populations (A4)<br>• Identifying and sealing sewerage cross connection (A4)<br>• Rectifying the source of algal blooms (C2) | |
| **C2**<br><br>**Algal or cyanobacterial blooms** | Algal and / or Cyanobacterial blooms are indicators of poor water quality and aquatic health within a waterbody system. While most species of algae (e.g. green algae, flagellates and diatoms) are not dangerous to humans or animals, some may reduce aesthetic values through changes in water colour, odours and surface scums.<br>The presence of persistent cyanobacterial / algal biomass may be due to a range of factors, including:<br>• Untreated stormwater inflows.<br>• Nutrient released from the sediments.<br>• Excessive waterbody residence times<br>• High internal carbon (organic) loading (i.e. resulting from decay of aquatic weeds such as Salvinia).<br>• Low submerged or emergent macrophyte cover.<br>• Excessive waterbird population.<br>• Rapid variations in salinity | Discuss algal and cyanobacterial issues with asset owner, engineering and environmental health departments to identify and document any historical issues.<br>Undertake desk-top review and site inspection.<br>Further assessment is only required if persistent blooms are recorded and if the asset owner considers it necessary to obtain a more detailed understanding of waterbody processes to inform rectification. This may include:<br>Monitoring for the following parameters::<br>• Chlorophyll-a, total phosphorous, soluble phosphorous, total nitrogen and nitrate-N.<br>• Temperature, redox, salinity and DO depth profiles at a number of locations<br>• Cyanobacterial identification and counts<br>• Cyanobacterial toxin concentrations (i.e. where counts exceed the Red Alert level). | If cyanobacteria / algal risks are deemed unacceptable, a specialist should be consulted to develop a monitoring program and implement an adaptive management framework in accordance with DERM (2009), ANZECC (2018) and NH&MRC (2008). Management actions will be guided by monitoring outcomes but may include:<br>• Installation of temporary protection (temporary fencing) to exclude public entry;<br>• Erecting signage to highlight risk to public and that a response is being identified.<br>• Community consultation<br>• Treatment or adaptive management as required<br>Immediate actions are not generally required for managing harmless algal blooms. However, long term management actions may be necessary to improve aesthetic values and aquatic habitat condition (refer to management actions). | The management actions will be resolved as part of the waterbody investigations. Potential management responses<br>• the waterbody system as a wetland.<br>• Installing recirculation systems for waterbody waters (wetland, sand filter, UV) to deplete algal biomass and nutrient loading within the waterbody.<br>If cyanobacterial toxin concentrations exceed the primary contact recreation WQOs Powdered activated carbon (PAC) dosing may be required (note that specialist advice should be sought before this action is undertaken). | DERM (2009) *Queensland Water Quality Guidelines.*<br>ANZECC (2018) *The Australian and New Zealand Guidelines for Fresh and Marine Water Quality – 2018 edition.*<br>NH&MRC (2008) *Guidelines for managing risk in recreational waters.*<br>DERM (2010a) *Environmental Protection (Water) Policy 2009 Burrum, Gregory, Isis, Cherwell and Elliott Rivers environmental values and water quality objectives Basin No. 137 (July 2010)*<br>DERM (2010b) *Environmental Protection (Water) Policy 2009 - Mary River environmental values and water quality objectives. Basin No. 138, including all tributaries of the Mary River (July 2010)*<br>Chorus and Bartram (1999). *Toxic cyanobacteria in water: A guide to their public health consequences, monitoring and management.* |

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| **C3**<br><br>**Persistent high turbidity levels.** | Excessive turbidity, total suspended solids (TSS) or total dissolved solids (TDS) can smother aquatic habitats and reduce sunlight infiltration, which may provide conditions favourable to increased algal production and invasive species (e.g. carp, tilapia etc) that are more tolerant to a range of water quality conditions. | Discuss with asset owner and engineering department to identify and document any current or historical issues.<br><br>Undertake desk-top review and site inspection. Record turbidity levels in-situ using a water quality probe. Further monitoring during both wet and dry weather may be required if potential sediment sources are identified.<br><br>If turbidity levels within the waterbody consistently exceed the relevant WQOs (1-20 NTU), for the protection of moderately disturbed freshwaters) in DERM 2010a or b, then further investigation may be required to determine the source/s of the high turbidity (e.g. development sites, stormwater inflows, sediment re-suspension etc) and to consider other catchment management solutions. | Treatment of persistent high turbidity levels will not normally require any ongoing management actions – refer to rectification | Management actions will be dictated by the field investigations and whether or not the risk is identified by the asset owner as acceptable. Management actions may include:<br>• Establish and maintain healthy submerged and emergent macrophytes within the waterbody.<br>• Establish and maintain healthy riparian vegetation on waterbody margins.<br>• Repair areas of bank erosion (e.g. lining with geofabric) and revegetating using endemic species<br>• Stormwater treatment within the upstream catchment. (e.g. providing additional sediment capture upstream of waterbody such as sediment basins).<br>• Managing runoff from construction sites in accordance with State Planning Policy for Healthy Waters (DERM 2010c) and IECA Australasia (2008).<br>• Replacing topsoil used within the waterbody (refer AS4419 2003).<br>• Repairing areas of the waterbody where the clay liner has been exposed. | DERM (2010a) *Environmental Protection (Water) Policy 2009 Burrum, Gregory, Isis, Cherwell and Elliott Rivers environmental values and water quality objectives Basin No. 137 (July 2010)*<br><br>DERM (2010b) *Environmental Protection (Water) Policy 2009 - Mary River environmental values and water quality objectives. Basin No. 138, including all tributaries of the Mary River (July 2010)*<br><br>AS4419 (2003). *Soils for landscaping and garden use*<br><br>DSDIP (2017) *State Planning Policy.*<br><br>IECA Australasia (2008). *Best Practice Erosion and Sediment Control. November 2008.* |
| **C4**<br><br>**Stratification and low dissolved oxygen** | Water column stratification may be present due to a range of factors, including:<br>• Excessive water depth (>2.5 m) – although stratification can occur in highly eutrophic waterbodies less than 1m deep.<br>• High surface water temperatures.<br>• Elevated salinity in freshwater waterbody systems.<br>• Fresh water inflows to saline waterbodies.<br>• Elevated organic carbon, nutrient and sediment loading.<br>• Long detention times or lack of wind mixing.<br>• Low or absent cover of submerged or emergent aquatic macrophytes.<br>• Unsuitable waterbody configuration / orientation<br>• The presence of inappropriate or multiple flow paths<br>One of the major concerns associated with stratification is dissolved oxygen depletion. This may result in the release of dissolved (bioavailable) nutrients from the waterbody sediment which encourages algae and floating weed growth. Low dissolved oxygen concentrations are also a major cause of fish kills and sediment odour problems. | Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues.<br>Undertake desk-top review and initial site inspection.<br>The asset owner may wish to undertake additional monitoring to determine the spatial extent and duration of stratification. This will involve regularly monitoring electrical conductivity, water temperature dissolved oxygen and Redox potential through the full water column at several locations throughout the waterbody system.<br>(Note: as dissolved oxygen concentrations vary considerably throughout the day due to the processes of respiration and photosynthesis it is recommended that monitoring is undertaken at different times during the day.) | Persistent stratification will not normally require any ongoing management actions – refer to rectification | If the risk of persistent stratification is deemed unacceptable, management actions may include:<br>• Installation of mixing systems (including aerators and water pumps).<br>• Modification of waterbody bathymetry to increase hydraulic efficiency and wind forced mixing (e.g. infilling backwaters, moving inlet/outlet structures, targeting planting, removal of clumped vegetation to promote longer flow paths, removal of islands, dredging etc).<br>• Installation of waterbody re-circulation systems to improve internal waterbody mixing.<br>• Establishment and maintenance of healthy submerged and emergent macrophytes within the waterbody to facilitate nutrient uptake, reduce turbidity levels and reduce sediment oxygen consumption.<br>• Establishment and management of healthy riparian vegetation on waterbody margins to improve shading and reduce sources of diffuse runoff.<br>• Removal and / or treatment (e.g. Phoslock®) of the waterbody sediments (refer to 'Siltation' in this table).<br>• Installation of stormwater treatment systems in the upstream catchment to remove pollutants before they enter the waterbody. | |

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| **C5**<br><br>**Variable salinity** | Brackish waterbodies and waterbodies which experience large variations in salinity should be avoided.<br><br>For freshwater and saline waterbody systems, large fluctuations in salinity levels may provide conditions that are unfavourable for submerged macrophytes and favour undesirable vegetation (riparian or aquatic) and algae (particularly blue-green algae).<br><br>Increased salinity within freshwater waterbodies may be due to:<br>• Tidal intrusion of saline water into waterbody.<br>• Ingress of saline groundwater to the waterbody.<br>• Contamination from upstream land uses (e.g. industrial, agricultural etc.) via stormwater inflows or diffuse runoff<br><br>For saline waterbodies (tidally flushed), decreased salinity may be due to:<br>• Stormwater inflows or diffuse runoff to the waterbody.<br>• Ingress of freshwater groundwater to the waterbody.<br>• Often the inflow of freshwater into saline waterbodies is accompanied by increased nutrient loads. | Discuss with asset owner and engineering department to identify and document any current or historical issues.<br><br>Undertake desk-top review and initial site inspection.<br><br>Refer to Appendix G of the *Queensland Water Quality Guidelines* (DERM 2009) to determine acceptable variations in salinity.<br><br>The asset owner may wish to undertake additional site surveys and /or Implement a monitoring program including monitoring electrical conductivity both after rain and during long dry periods to observe changes in salinity. For freshwater waterbodies, electrical conductivity levels of >1500 µS/cm pose an immediate risk to aquatic plants. For saline waterbodies, the risk of cyanobacterial blooms increases where electrical conductivity is <10 000 µS/cm. Refer to DesignFlow 2010 for guidance on additional investigations to determine the source of the saline / freshwater intrusion. | Variable salinity will not normally require any ongoing management actions – refer to rectification | If the risk of variable salinity levels is deemed unacceptable, management actions may include:<br><br><u>Freshwater waterbodies</u><br><br>If observations during large tide events and salinity monitoring confirm tidal backwatering into the waterbody, consider:<br>• Raising the water level within the waterbody so that saline water cannot enter through the waterbody outlet. This will require modifying the configuration of the outlet structure.<br>• Installing a flap gate on the outlet pipe to the downstream saline environment.<br>• Raising bund levels to prevent tidal backwatering<br><br>If saline groundwater intrusion is evident within the waterbody and impacts on vegetation health are obvious, it may be necessary to replace or repair the waterbody liner. Alternative options include<br>• Trenching along the waterbody batter and placing a clay or bentonite barrier across the groundwater intrusion site.<br>• Replanting the waterbody with saline or brackish tolerant plant species. (Note: there is an increased risk of mosquitoes in saline / brackish waters which will need to be monitored). Refer to mosquitoes in this table.<br><br>If other catchment sources are suspected, contact DERM to investigate potential sources of contamination.<br><br><u>Saline (tidal) waterbodies</u><br><br>If observations during rainfall events and salinity monitoring confirm freshwater inflows and lack of tidal flushing is occurring, consider:<br>• Diverting stormwater flows around waterbody<br>• Converting to a freshwater waterbody<br>• Increasing tidal flushing or removing any blockages<br>• Groundwater management as per above | DERM (2009). *Queensland Water Quality Guidelines: Appendix G: Salinity guidelines (expressed in conductivity units) for Queensland freshwaters.*<br><br>ANZECC (2018) *The Australian and New Zealand Guidelines for Fresh and Marine Water Quality – 2018 edition.*<br><br>DesignFlow (2010). *Townsville Constructed Lakes Guideline.* |
| **C6**<br><br>**Litter** | The presence of excessive amounts of litter reduces the amenity of the waterbody and can increase public health risk by harbouring mosquitoes. | Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues.<br><br>Undertake desk-top review and initial site inspection.<br><br>Check for possible sources of litter. This will include checking for:<br>• Catchment runoff from commercial or industrial zones<br>• Failure of a gross pollutant traps<br>• Direct dumping of litter in adjacent parkland areas<br>• Overflowing or un-managed bins | Where risk is medium then litter removal should occur on a scheduled or reactive basis. If gross pollutant traps or trash racks exists then commence maintenance on this system as required. | If the risk is deemed unacceptable management actions may include:<br>• Retrofitting the upstream drainage system with litter controls, e.g. a gross pollutant trap or a trash rack<br>• Incorporating a trash rack with easy access to the inlet zone of the waterbody<br>• Providing litter disposal bins in the adjacent public open space<br>• Creating access to the zones in the waterbody where litter tends to accumulate for litter collection. This will typically be at the downwind of the waterbody along the line of prevailing winds.<br>• Undertaking an education campaign within the catchment on litter and its impact on downstream ecosystems. | |

| Issue | Description | Investigations / monitoring | Minor or Immediate Response Management Actions[1] | Proactive Management Actions[2] | Relevant policy, legislation and supporting information |
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| **D. Aquatic Habitat** | | | | | |
| **D1**<br><br>**Aquatic weeds** | The persistence of aquatic weeds within the waterbody may be due to:<br>• Uncontrolled weed infestations in the upstream catchment.<br>• Excess sediment accumulation within waterbody.<br>• High nutrient concentrations present within the waterbody<br>• Vegetation failure allowing weeds to colonise.<br>• Accidental or illegal introduction (e.g. ornamental pond or aquarium species, such as Salvinia)<br>• Presence of vectors, e.g. birds.<br>• Lack of maintenance. | Discuss aquatic weed issues with asset owner, engineering and environmental health departments to identify and document any issues.<br>Complete a site inspection to determine presence of / proportion, species etc.<br>Seek advice from a weed specialist for long term weed removal or control strategies. This will require:<br>• Confirming the weed species present<br>• Identifying the cause/s of the weed infestation<br>• Considering the biological characteristics of the weed species<br>• Determining long term weed management options | The control of declared weeds is mandated under the *Biosecurity Act 2014*. Therefore, these weeds must be dealt with as part of the regular maintenance schedule.<br><br>Refer to *Maintaining WSUD Assets* for general advice about managing weeds. Management actions may include<br>• Regular harvesting using aquatic weed harvester<br>• Chemical control (Note: Seek advice from weed specialist if chemical control is being considered. The potential impacts of chemical herbicides on the waterbody ecosystem should be considered.<br>• Biological control agents, such as the Salvinia weevil (*Cyrtobagous salviniae*) and water hyacinth weevil (*Necochetina eichorniae*) (Note: specialist advice should be sought *from the CSIRO divisio*n of entomology). | If the risk is deemed unacceptable and the aquatic weed infestation cannot be controlled by management alone, management actions include:<br>• Completely removing the weed species using control methods listed in *Maintaining WSUD Assets*.<br>• Draining and drying out the waterbody in order to desiccate the weed species. Obtain specialist advice about the required drying out period.<br>• Preventing the future ingress of weeds by planting the edges of the waterbody with plant species that provide dense cover and shade.<br>• Establishment and maintenance of healthy submerged and emergent macrophytes within the waterbody.<br>• Establishment and management of healthy riparian vegetation on waterbody margins to improve shading and reduce sources of diffuse runoff.<br>Generally a combination of the above actions is required to manage and / or eradicate infestations. | *Biosecurity Act 2014*.<br>Water by Design (2011) *Maintaining WSUD Assets.*<br>Refer to Biosecurity Queensland: DPI website (http://www.dpi.qld.gov.au), including:<br>• *Guideline for the management of Salvinia*<br>• *Guideline for the management of water lettuce*<br>• *Guideline for the management of water hyacinth*<br>Refer to weeds of national significance (WONS) http://www.weeds.gov.au/weeds/lists/wons.html<br>FCRC (2017) *Fraser Coast Regional Council Biosecurity Surveillance Program for Prohibited and Restricted matter 2017 - 2021* |
| **D2**<br><br>**Presence of aquatic pests (e.g. exotic fish species)** | Exotic fish species (e.g. European carp, tilapia, mosquitofish, goldfish etc.) are generally able to tolerate a wide range of water quality and environmental conditions, and so have a competitive advantage over native fish species.<br>Exotic fish can also contribute to the further deterioration of water quality through sediment re-suspension (bottom feeders), habitat destruction/fragmentation and increased internal loading of nutrients. | Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues.<br>Undertake desk-top review and initial site inspection.<br>The asset owner may wish to undertake a fish survey to determine the proportion of native and exotic fish species, biomass and size distribution present.<br>(Note: The capture, removal or destruction of fish is governed by strict ethical considerations and should only be undertaken by qualified staff, in accordance NH&MRC (2004) and with relevant permits obtained from the Queensland Department of Primary Industries and Fisheries). | The presence of exotic fish species will not normally require any ongoing management actions – refer to rectification | If the risk is deemed unacceptable management actions to reduce/eliminate the invasion of exotic fish species may include:<br>• Trapping and removal of pest species in accordance with NH&MRC (2004).<br>• Improving aquatic habitat conditions to encourage recruitment and breeding of native species. This may include the establishment and maintenance of healthy submerged and emergent macrophytes, installation of artificial habitat structures, introducing large woody debris (LWD/re-snagging) etc.<br>• Establishing and maintaining healthy riparian vegetation.<br>• Implementing a native fish stocking program.<br>• Improving hydraulic connectivity of on-river waterbodies (where possible) by modifying/replacing existing inlet/outlet structures to provide for suitable upstream passage of native fish and other aquatic organisms.<br>• Improving water quality conditions. | Refer to DAF Website: https://www.daf.qld.gov.au/business-priorities/fisheries/habitats<br>FCRC (2017) *Fraser Coast Regional Council Biosecurity Surveillance Program for Prohibited and Restricted matter 2017 - 2021* |
| **E. Terrestrial Habitat** | | | | | |
| **E1**<br><br>**Terrestrial weeds** | The persistence of terrestrial along waterbody edges or adjacent to the waterbody may be due to:<br>• Uncontrolled weed infestations in the upstream catchment.<br>• Discontinuous or fragmented perimeter vegetation<br>• Vegetation failure allowing weeds to colonise.<br>• Accidental or illegal introduction<br>• Presence of vectors, e.g. birds.<br>• Lack of maintenance.<br>• Contaminated fill and mulch (on batters) | Discuss terrestrial weed issues with asset owner, engineering and environmental health departments to identify and document any issues.<br>Complete a site inspection to determine presence of / proportion, species etc.<br>Seek advice from a weed specialist for long term weed removal or control strategies. This will require:<br>• Confirming the weed species present<br>• Identifying the cause/s of the weed infestation<br>• Considering the biological characteristics of the weed species<br>• Determining long term weed management options | The control of declared weeds is mandated under the *Biosecurity Act 2014*. These weeds must be dealt with as part of the regular maintenance schedule.<br>Refer to *Maintaining WSUD Assets* for general advice about managing weeds.<br>Management actions include:<br>• Chemical control (Note: Seek advice from weed specialist if chemical control is being considered. The potential impacts of chemical herbicides on the waterbody ecosystem should be considered).<br>• Regular inspection and application of clean mulch around waterbody perimeters | If the risk is deemed unacceptable and the aquatic weed infestation cannot be controlled by management alone, management actions include:<br>• Completely removing the weed species using control methods listed in *Maintaining WSUD Assets*.<br>• Establishment and management of healthy riparian vegetation on waterbody margins<br>Generally a combination of the above actions is required to manage and / or eradicate infestations | *Biosecurity Act 2014.*<br>Water by Design (2011) *Maintaining WSUD Assets.*<br>Refer to weeds of national significance (WONS) http://www.weeds.gov.au/weeds/lists/wons.html<br>FCRC (2017) *Fraser Coast Regional Council Biosecurity Surveillance Program for Prohibited and Restricted matter 2017 - 2021* |

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| **F. Maintenance** | | | | | |
| **F1**<br><br>**Access for maintenance** | Poor access for maintenance of hydraulic structures, removal of sediment from inlet areas and pump infrastructure can result in deterioration of the system<br>Ideally maintenance access should be following locations:<br>• Stormwater inflows to waterbody for sediment desilting.<br>• Edge of waterbody for weed harvesting or to launch boat.<br>• Hydraulic controls<br>• Around the broad perimeter of the waterbody of riparian weed management. | Discuss maintenance access allowance with asset owner, maintenance and engineering services to identify and document any issues. Complete site inspection to identify existing maintenance allowance and obvious access problems. | Provided the maintenance access is constructed from suitable materials (i.e. gravel, concrete or reinforced vegetation), then maintenance will be minimal and based on inspections. Maintenance may involve weeding and filling of wheel ruts. | Where maintenance access is deficient installation of access will be required. The nature of access for different maintenance activities should be discussed with the asset owner. Management actions may include:<br>• Provision of maintenance access for vehicles, boats and weed harvesters (e.g. ramps for sediment removal, tracks for access to structures etc)<br>• Provision of work areas for sediment drying, maintenance of hydraulic structures and erosion/scour<br>• Installation of access tracks<br>• Provision of Sediment drying area/s | *Maintaining WSUD Assets* (Water by Design, 2012) |