Swan Lake Water Quality and Estuary Health Study

Shoalhaven City Council

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311015-00158

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PROJECT 311015-00158 -ENV-REP – 004: Swan Lake Water Quality and Estuary Health Study

Rev	Description	Author	Review	Advisian approval	Revision date	Client approval	Approval date
A	Draft for internal review	M. Priestley	K. Newton		21 Feb 2022		
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E	Final	M. Priestley		C. Adamantidis	12June 2023		

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Executive summary

Advisian has been engaged by Shoalhaven City Council (Council) to undertake a Coastal Management Program (CMP) for the Swan Lake estuary. This CMP is intended to build upon the large body of work that has already been completed in regard to coastal management for this estuary.

The purpose of this Water Quality and Estuary Health Study is to provide an up-to-date assessment of estuarine water quality and health to inform the scope and nature of coastal management actions during the future stages of Council's CMP development and implementation.

The findings of this Water Quality and Estuary Health Study are consistent with previous reports by Council and other relevant agencies (including the Department of Planning and Environment; DP&E) which have identified that the processes that affect water quality in this estuary include entrance management, stormwater discharge, sewage overflows, sediment runoff, tidal exchange and nutrient cycling. In addition, potential impacts on water quality from the recent 2019-20 bushfires are considered.

Overall, the review of existing water quality data from 2010-2021 shows that water quality within Swan Lake within the past decade has generally been good. Water quality was compared to the DP&E Monitoring, Evaluation and Reporting (MER) Guidelines for back dune lagoons. Median levels of Dissolved Oxygen (DO) and pH are within the DP&E MER guideline values for back dune lagoons with occasional elevated values, mainly during summer. Turbidity was regularly elevated above the DP&E MER guideline values for back dune lagoons while chlorophyll–*a* levels were nearly always low and within the guidelines.

Overall, recreational water quality within Swan Lake continues to highly ranked as "Good" (4 stars out of 4) for swimming and other water based activities based on the National Health Medical Research Council (NHMRC) (2008) guidelines. The monitoring site E-37, which is located closest to the inlet from the lake, and near to The Springs Road bridge crossing has enterococci results indicating there could be sources of faecal contamination which may be related to stormwater and urban runoff/natural sources within the inlet (which may include septic systems). However, this has not affected recreational water quality within the lake where recreational activities occur.

NSW DP&E is concurrently preparing an estuary health assessment for the Swan Lake estuary for 2020-2021. Swan Lake had an overall rating of Good (B) (based on the MER Guidelines for Lagoons) and on most occasions there was low algae (chlorophyll-*a*) and clear water clarity (turbidity). This was a slight decrease in estuary health in comparison to the previous estuary health assessments undertaken by DP&E (formerly DPIE) between 2014-2015 and 2008–2009, which received overall ratings of Excellent (A).

The findings of this Water Quality and Estuary Health Study are consistent with previous reports by Council and other relevant agencies (including NSW DP&E). The main issues identified in this study for Swan Lake include limited water quality data availability, impacts on water quality associated with catchment inputs (urban stormwater runoff, sewage overflows and natural events), a possible decline in swans and associated Charophytes as food source (thought to be related to 2019/20 drought). Other threats to estuary health identified include invasive weeds, introduced animals, artificial entrance openings, perceived decline in fish stocks, littering and dumping along foreshore, clearing of foreshore vegetation, foreshore erosion, climate change and sea level rises.

Recommendations were made for an ongoing monitoring program for water quality in terms of sampling sites, frequency, parameters, sampling methodology, limits of reporting (LORs) and applicable trigger values. This is to ensure that the ongoing water quality monitoring program can track improvements towards meeting current water quality objectives.

Acronyms and abbreviations

Acronym/abbreviation	Definition
AFRI	Acute Febrile Respiratory Illness
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines
CMP	Coastal Management Program
CZMP	Coastal Zone Management Plan
DEC	Department of Environment and Conservation
DECCW	Department of Environment, Climate Change and Water
DO	Dissolved oxygen
DPI	Department of Primary Industries
DP&E	Department of Planning and Environment
DPIE	Department of Planning, Infrastructure and Environment
EAC	East Australian Current
FM Act	*Fisheries Management Act 1994*
GI	Gastrointestinal
GIS	Geographic Information System
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
KEFs	Key Ecological Marine Features
LEP	Local Environmental Plan
LGA	Local Government Area
NOAEL	No Observed Effect Level
NSW	New South Wales
NSW EPA	New South Wales Environment Protection Authority
NRMS	National Resource Management Strategy
OEH	Office of Environment and Heritage
SEPP	State Environmental Planning Policy
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids

1 Introduction

The purpose of this Water Quality and Estuary Heath Study is to provide an up-to-date assessment of estuarine water quality and health within Swan Lake to inform the scope and nature of coastal management actions to be included in the future stages of the Shoalhaven City Council (Council) Coastal Management Plan (CMP) development and implementation.

This report presents the following:

- A review of long-term routine estuary water quality monitoring data
- Summary statistics for key water quality parameters across the estuary
- A summary of NSW DP&E's Estuary Health Assessment for the estuary
- A summary of available estuarine macrophyte mapping
- A summary and overall assessment of recreational water quality
- A recommended sampling program for water quality and ecological health.

A desktop review of water quality data was undertaken for Berrara Creek, based on established protocols set out in the:

- NSW Natural Resources Monitoring, Evaluation and Reporting Program (NSW MER program) (DPIE 2016).
- Australian and New Zealand Water Quality Guidelines framework for "Developing a Water Quality Plan" (ANZG 2018),
- National Health and Medical Research Council "Guidelines for Managing Risks in Recreational Waters" (NHMRC 2008).
- Other relevant guidelines as applicable to meet previously identified water quality objectives.

1.1 General Information

Swan Lake is a large brackish coastal lake located south of St Georges Basin and Jervis Bay (Figure 1-1) on the south coast of New South Wales (NSW). Swan Lake has an estuary area of ~4.7 km^2, a catchment area of 26.4 km^2, estuary volume of >10,000 ML and an average depth of 2.4 m (DP&E 2022). *Ruppia* seagrass is the only aquatic vegetation mapped by the NSW Department of Primary Industries (DPI) within this waterway (NSW DPI 2022). Seagrass areas provide important habitat and nursery areas for a variety of marine life. Swan Lake and its foreshore areas are used for a range of recreational activities including passive recreation, fishing, boating, kayaking, cycling, swimming, walking and birdwatching. This region has important cultural and spiritual significance to the local Aboriginal people (NSW NPWS 2012).

Swan Lake is an Intermittently Closed and Open Lake and Lagoon (ICOLL) that is closed to the ocean the majority of the time by a natural sand bar (see images of the closed lake entrance in November 2021 in Figure 1-2). A conceptual model of an ICOLL, including key zones, is provided in Figure 1-3.

The behaviour of the entrance significantly affects the lake's characteristics such as its estuarine ecosystem, water quality and flooding patterns. The Swan Lake Entrance Management Policy (Shoalhaven City Council 2008) outlines the procedure to artificially open the lake entrance to manage flooding of low-lying assets, whilst balancing environmental considerations. A summary of known Swan Lake openings between April 1982 and June 2022 is provided in **Appendix A**.

Swan Lake is classified as a back dune lagoon. Back dune lagoons have been described as simple rounded estuaries that are relatively shallow (below 6 m depth) and have an intermittent entrance (Scanes et al. 2014). Typically, they have a small catchment, and it is expected that groundwater is a large component of the freshwater input. Compared to other lagoons, they have relatively natural high dissolved nitrogen and occasional natural algal blooms. Swan Lake is among only eight estuaries within NSW that is known to support extensive Charophyte beds and thought to be unrelated to the relatively undisturbed nature of the catchment (Roper et al. 2011). However it has been noticed that following the droughts and the subsequent 2019-20 bushfires that these charophyte beds appear to have significantly reduced. As charophytes are also a key food source for the Black Swans, it is thought that the loss of charophytes may also be impacting their numbers within the lake, with community members reporting that they have significantly declined.

The lake is opened an average of once per year via either natural rainfall events or artificially (Shoalhaven City Council 2008). Artificial openings by the Council are undertaken to mitigate flooding in low lying areas around the lake according to the lakes entrance management policy. There is a history of the public prematurely illegally opening the Swan lake entrance when water levels are high enough to allow for manual digging of an entrance channel. This has often occurred below the trigger levels specified within the lakes entrance management policy (Shoalhaven City Council 2008). These reoccurring illegal openings seem to occur due to public perception and preference of where the estuary will open to avoid disturbing surf spots and to improve water clarity within the lake.

However, when the lake has previously been opened, tidal flushing occurs at a slow rate and is insufficient to fully flush the estuary, resulting in mostly brackish waters which are influenced by freshwater inputs (Shoalhaven City Council 2008).

Swan Lake has a small ratio of catchment runoff to estuary volume resulting in high dilution of runoff (which is supported by historical monitoring), and the catchment is moderately pristine (~70% is located within Conjola National Park) (DP&E 2022).

There are specific conditions and consultation processes that need to be satisfied prior to opening of Swan Lake and actions undertaken to mimic natural entrance behaviour to protect ecological health (Shoalhaven City Council 2008). There is an increasing recognition that artificial opening of ICOLL entrances should wherever possible be left to open and close naturally. Continued interference including artificial openings can cause unintended negative impacts on ecological health and there is a need for a catered approach to entrance management accounting for the complexity of the estuary and unique factors of the catchment area, dilution factor, flushing rates and ecology (including aquatic macrophyte habitat area) (DPIE 2021). An illegal artificial opening of Swan Lake was undertaken on the 12th January 2022 (see Figure 1-2) which raised concerns for lake ecology and public safety. Whilst in this instance the lake was close to naturally opening itself, there was concern that this opening led to lower-than normal water levels in the lake due to the location of the channel opening being further to the north than is specified in the entrance management plan, leading to a wider opening and further scouring of the berm. Low water levels may lead to adverse ecological impacts via impacts on water quality (such as reduced DO) as well as odour issues as exposed biological material decays (Shoalhaven City Council 2008 and 2021). High water levels are also vitally important for the inundation of the coastal wetlands areas that are primarily located on the western side of the lake. Without allowing these to occasionally flood, these wetlands could eventually become much drier over the longer term, resulting in altered habitat ecology. These wetlands are also important habitat for numerous threatened species and communities, including being recognised as being potential habitat for Green and Golden Bell Frogs (DECC 2007).

Some images of Swan Lake are provided in Figure 1-2, Figure 1-4 and Figure 1-5.

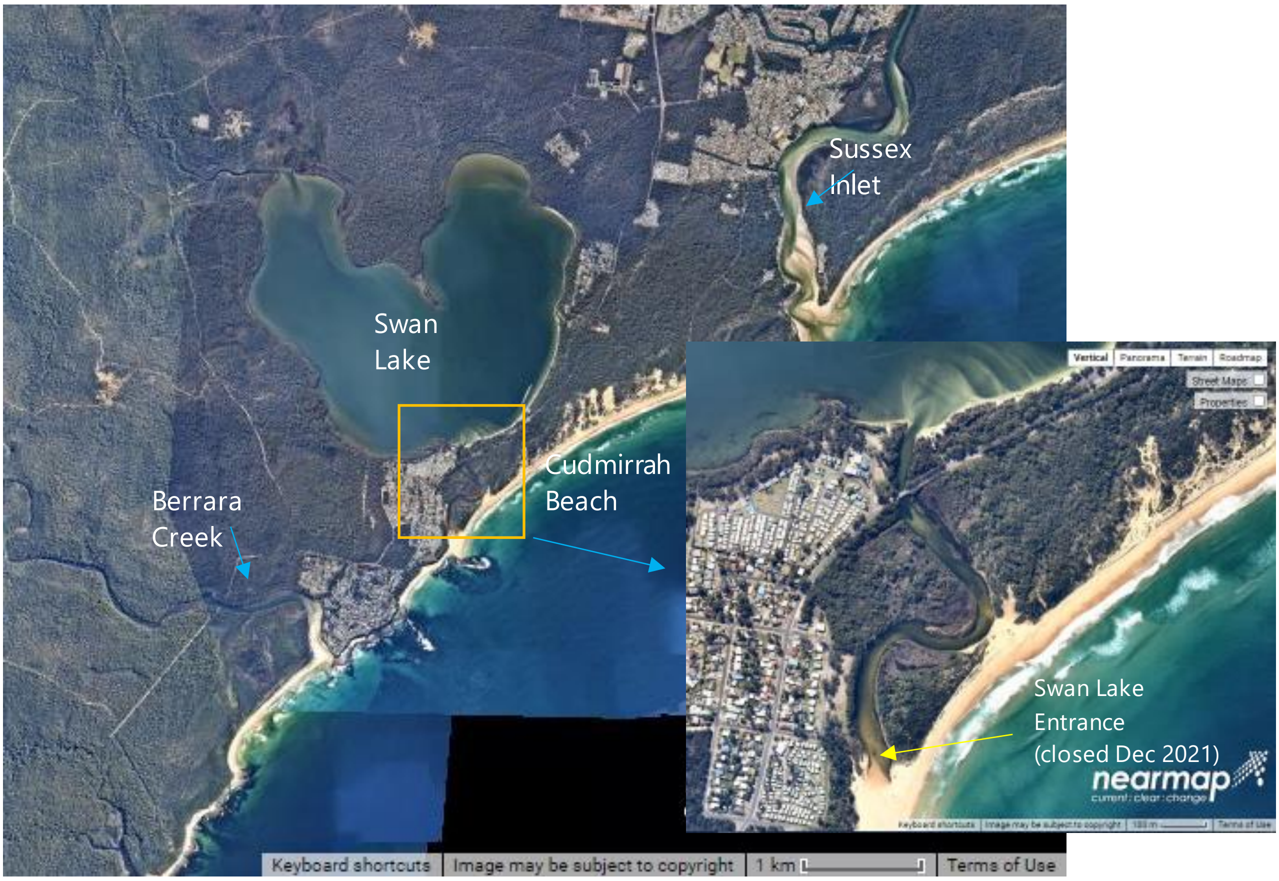


Figure 1-1 Location of Swan Lake and aerial view of closed entrance area – December 2021 (Nearmap 2022).

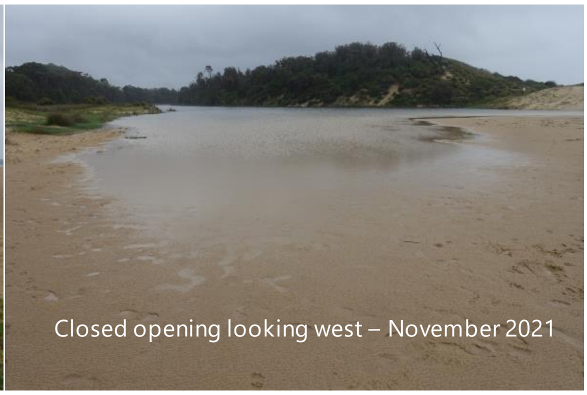


Figure 1-2 Images of the closed Swan Lake entrance in November 2021 (top) (Advisian) and the open entrance on 12 January 2022 (following illegal opening) (bottom) (Shoalhaven City Council).

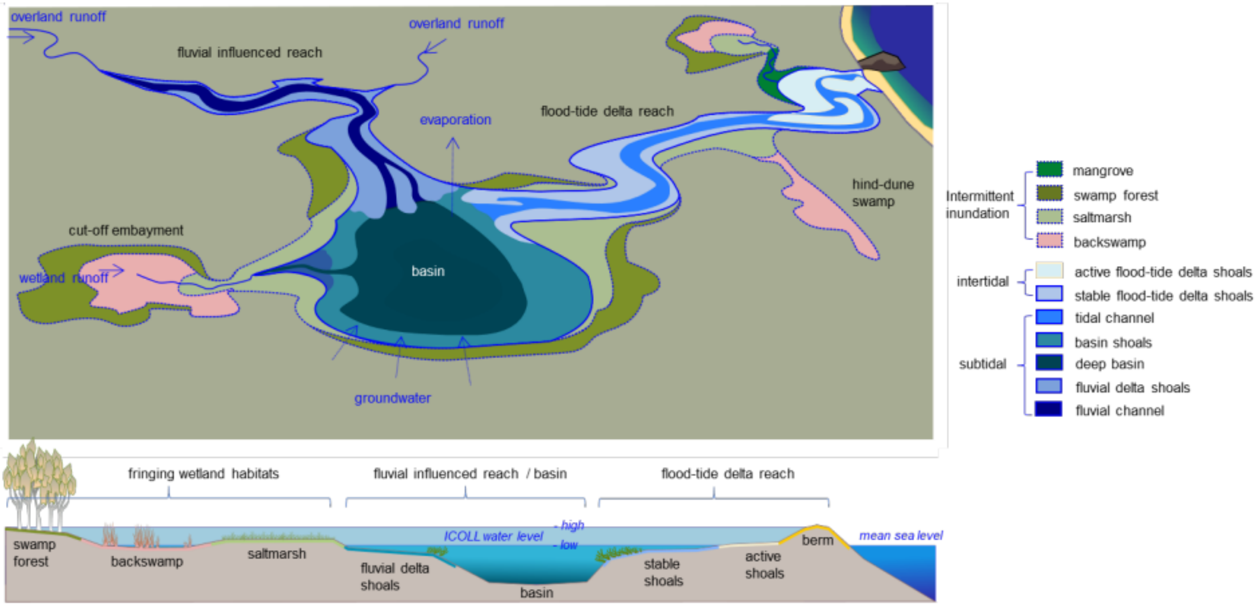


Figure 1-3 Conceptual model of ICOLLs including key zones (from DPIE 2021).

Figure 1-4 Images of Swan Lake (top), Inlet (middle) and south-eastern side of the entrance (bottom) (November 2021) (Advisian).

Figure 1-5 Images of Swan Lake north-eastern side from Conjola National Park (November 2021) (Advisian).

1.2 Waterway and Fish Habitat Classification

Under the *Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management* (NSW DPI 2013) (Table 2 of the Policy), Swan Lake is considered a *CLASS 1 – Major Key Fish Habitat*, i.e. *"a marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g. river or major creek), habitat of a threatened or protected species or 'critical habitat'"*.

Considering the specific attributes of the habitats present within Swan Lake, and in accordance with Table 1 of the Policy, the habitat is considered *TYPE 1 - Highly Sensitive Key Fish Habitat* as it contains Ruppia species of seagrass beds >5 m^2 in area.

1.3 Water Quality Objectives

In 1999, the NSW Government introduced Water Quality Objectives as long-term goals for marine waters, estuaries and rivers to identify and protect identified values and uses of waterways through more sustainable and targeted management The process for setting Water Quality Objectives was previously developed by the Department of Environment and Conservation (DEC 2005) based on the framework outlined in the Australian and New Zealand Guideline for Fresh and Marine Water Quality (ANZECC 2000, now updated to ANZG 2018).

Water Quality Objectives for the estuaries on the NSW South Coast (DEC 2005) include:

- Protection of aquatic ecosystem health.
- Protection of primary and secondary contact recreational activities.

- Protection of visual amenity.
- Protection of aquatic food and commercial shellfish production.

Water Quality Objectives for rivers on the NSW South Coast (DEC 2005) include:

- Maintain wetland and floodplain inundation.
- Manage groundwater for ecosystems.
- Minimise effects of weirs and other structures.
- Maintain or rehabilitate estuarine processes and habitats.

These Water Quality Objectives are currently under review by DP&E to ensure they reflect the current community values and uses of the waterways (DP&E 2022).

1.4 Estuary Health and Water Quality Issues – Swan Lake

The Swan Lake and Berrara Creek Natural Resources Management Strategy (NRMS) (Shoalhaven City Council 2002) has previously guided the management of Swan Lake within six areas including water quality, erosion and sedimentation, entrance management, recreation and visual quality. Strategies that were included for water quality included:

- WQ1 - Minimise sewage contamination of Swan Lake and Berrara Creek from existing sewage management systems.
- WQ2 - Improve system for reuse and disposal of effluent from reticulated sewerage scheme.
- WQ3 - Control other pollutants at source.
- WQ4 - Minimise pollutant transport in stormwater drains.
- WQ5 - Ensure boating is not contaminating lake water.
- WQ6 – Monitor water quality.
- WQ7 - Educate residents and visitors on stormwater issues and solutions.

The key potential issues that are relevant to water quality within Swan Lake that have been identified in previous studies (Advisian 2020, Shoalhaven City Council 2002, Shoalhaven City Council 2008) and community consultation (Advisian 2022b) include:

- Perceived decline in important habitat and associated decline in ecological health as identified by community members during community consultation:
    - There are reports of a decline in abundance of Swans by the community. This is thought to be related to a loss of Charophyte (dense algae) beds, likely a result of the prolonged drought in 2019 – 2020. Similar patterns have been observed in other NSW back dune estuarine lagoons (e.g. Nadgee Lagoon) following decline in water levels or quality (elevated nutrients) associated with drought (Scanes et al. 2014, Scanes et al. 2020). A decline in Charophytes in back dune lagoons is also thought to be related to anthropogenic disturbances. It is believed that all back dune lagoons would have had extensive Charophyte beds prior to European settlement (Scanes et al. 2014).

- o Decline in fish communities that is thought to be associated with recreational and commercial overfishing. However, this community perception has not yet been supported by Department of Fisheries (DPI) data.
- o Decline in endangered wildlife, including birds which is thought to be associated with powered boats, destruction of habitat, competition from introduced animals (foxes, cats, rats and rabbits),decline in food sources (fish stock decline), drought, bushfires and potentially artificial lake water level management.
- o Spread of weeds in native bushland and around the foreshore.

- Poor water quality potentially associated with urban stormwater runoff, sewage overflows and/or natural events, which in affects ecological health.
- Foreshore erosion associated with clearing of vegetation around the foreshore.
- Management of the Swan Lake opening. This includes illegal openings (as occurred in November 2021) which bypass the risk assessment process and may lead to unintended negative consequences. The rising of levels in Swan Lake Lagoon has also been raised as a concern by community members.
- Climate change which is expected to increase the frequency of extreme events (such as bushfires, droughts and sea level rising causing inundation/flooding), which in turn influences water quality and ecological health. Coastal back dune lagoons are highly susceptible to rapid changes (Scanes et al. 2020).

1.5 Previous Water Quality Assessments

Since 2010, Council has routinely collected seasonal water quality data within Swan Lake.

The aim of the monitoring program is to monitor water quality (via comparison to water quality guidelines) and ensure that waters are suitable for both primary and secondary recreational activities as defined by the National Health and Medical Research Council (NHMRC) (2008):

- Primary recreational activities – swimming, paddle boarding and kayaking.
- Secondary recreational activities – boating, fishing, prawning and wading.

Recreational activities can be classified by the degree of water contact, whereby with primary contact activities there is a higher possibility of water being swallowed or inhaled, or coming into contact with the ears, nose or cuts in the skin (NHMRC 2008).

A variety of pressure and stressors indicators are included in Council's routine monitoring program including:

- Physicochemistry – pH, water temperature (°C), salinity (ppt) and turbidity (NTU).
- Dissolved oxygen (DO) (mg/L and % saturation).
- Phytoplankton indicator – chlorophyll-*a* (µg/L).
- Pathogen indicators - faecal coliforms (cfu/100mL) and enterococci (cfu/100mL).
- Nutrients - total nitrogen (TN) (µg/L) and total phosphorous (TP) (µg/L).

Starting in November 2020, the Council has been undertaking more regular monthly sampling to monitor impacts from the 2019 – 2020 bushfires. This includes estuary health parameters (chlorophyll-*a* and turbidity), nutrients (TN and TP) as well as 3-monthly sampling of Total Organic Carbon (TOC) and Dissolved Organic Carbon (2023). This sampling will continue until 2023.

Maintenance of ecological health and maintaining the suitability of Swan Lake for recreational use are objectives of the program which are highly valued by the community (Shoalhaven City Council 2002).

Water quality is influenced primarily by catchment inputs as the periodic (approximately annual) short lived lake entrance openings which are insufficient to fully flush the estuary. Previous studies indicate that the flushing time for Swan Lake would require a prolonged opening of at least 3 to 4 months to allow for a full tidal exchange, which is a relatively long period compared to other estuaries (MHL 2001, Shoalhaven City Council 2008). As a result, catchment inputs of nutrients and pollutants that do occur, can potentially accumulate in the lagoon (Shoalhaven City Council 2008).

It has been suggested that Swan Lake is groundwater fed which is typical of back dune lagoons. This can naturally affect the water quality signature in terms of changing metal concentrations (DPE and NSW DPI pers. Comm). In turn, this may naturally influence the type of fish and invertebrate communities. This is also a potential pathway for migration of pollutants if there are pollutant sources within the upstream groundwater catchment.

Historical water quality monitoring in Swan Lake between 1992 to 2003 was summarised in the Swan Lake Entrance Management Policy (Shoalhaven City Council 2008):

- Concentrations of TN (mg/L) were often above respective guideline values (0.5 mg/L, ANZECC 2000) while concentrations of TP (mg/L) were generally below respective guideline values (0.05 mg/L) (Shoalhaven City Council 2008; MHL 1999). Noting that total nitrogen is often naturally high in back dune lagoons and the ANZECC guideline value is much lower than the more appropriate DP&E MER guideline (refer to Section 2.3.1).
- Chlorophyll-*a* (algae) concentrations were generally low and indicative of a well-functioning system.
- In 2008, based on historical nutrient and chlorophyll-*a* results, the system was classified as "oligotrophic" which is indicative of a closed system that is not nutrient rich and has few algae problems (Shoalhaven City Council 2008).
- Concentrations of faecal coliforms have historically been low, with a median value of 0 cfu/100ml during 1998.
- DO has historically been at levels which are considered healthy and has shown little fluctuation.
- The median salinity (from 1992 to 2003) was 12 ppt and relatively stable, suggesting that freshwater was the dominant input. This is considerably lower in comparison to marine waters, which are typically 35 to 36 ppt.

2 Water Quality Guidelines

2.1 Overview

The following guidelines are applicable to Swan Lake for water quality assessments:

- NSW Department of Environment and Conservation – Marine Water Quality Objectives for NSW Ocean Waters (DEC 2005).
- Assessing Estuary Ecosystem Health: Sampling, Data Analysis and Reporting Protocols. NSW Office of Environment and Heritage, Sydney. P.11. (OEH 2016).
- NSW DP&E Natural Resource Monitoring, Evaluation and Reporting (MER) Program Guideline Values (DP&E in preparation).
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) – Toxicant Default Guideline Values for 95% species protection. http://www.waterquality.gov.au/anz-guidelines.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) – IMCRA mesoscale bioregions Default Guideline Values for Physical and Chemical Stressors, Batemans Shelf. http://www.waterquality.gov.au/anz-guidelines.
- National Health and Medical Research Council Water Quality Guidelines for Recreational Users (NHMRC 2008).

2.2 ANZG (2018) Framework

The Australian and New Zealand Water Quality Guidelines (ANZG 2018, previously ANZECC 2000) provide high-level guidance on the management context, ecological descriptions, biological indicator selection and other advice for five of Australia's six marine planning regions. The Great Barrier Reef Marine Park Authority (GBRMPA) provides separate advice for the Great Barrier Reef Marine Park (which represents the inshore portion of the Coral Sea Marine Region).

The ANZECC (2000) guidelines were revised in 2018 into the ANZG (2018) with key changes to ANZECC (2000): Improvements since 2000 (waterquality.gov.au). Some key changes include:

- Transition to an online based platform for Guidelines to facilitate more regular updates.
- Revision of the Water Quality Management Framework into a ten-step circular framework with improved guidance including applying to seven common applications including the implementation of a broadscale monitoring program.
- Revision of Default Guideline Values (DGVs) for protection of aquatic systems against toxicants including revision of the methodology to derive new DGVs, review and update of some existing DGVs (previously listed under ANZECC 2000) and the addition of DGVs for new toxicants.
- In marine waters, physical and chemical stressor DGVs have been derived on a finer scale, using the Integrated Marine and Coastal Regionalisation of Australia (IMCRA 4.0) mesoscale bioregions and also divided into seasons. The study site is located within the Batemans Shelf IMCRA bioregion. Some of these guidelines are in different units to those reported by laboratories so may require conversion, or may not be applicable.

- In inland waters, physical and chemical stressor DGVs will be divided into finer scale, using drainage divisions. There will also be improved guidance around water quality management for temporary waters. Neither are available at the time of reporting, and therefore default to ANZECC (2000) guidelines for southeast Australia.
- Improved guidance and emphasis on the development and application of site-specific guidelines, which are to be used in preference to DGVs where established. Site-specific guidelines can be established if there is sufficient monitoring data at appropriate reference locations or using a combination of methods.
- Removal of guidance on recreational waters and drinking water to avoid duplication with the Australian Drinking Water Guidelines (ADWG) (NHMRC 2011) and the Guidelines for Managing Risk in Recreational Waters (NHMRC 2008).

ANZG (2018) sets out a comprehensive systemic framework and guidance for water quality management, including specifically in relation to the assessment of wastewater discharges. The circular nature of the framework highlights the importance of continual improvement and adaptive management in water quality management. A schematic of the ANZG (2018) framework is shown in Figure 2-1.

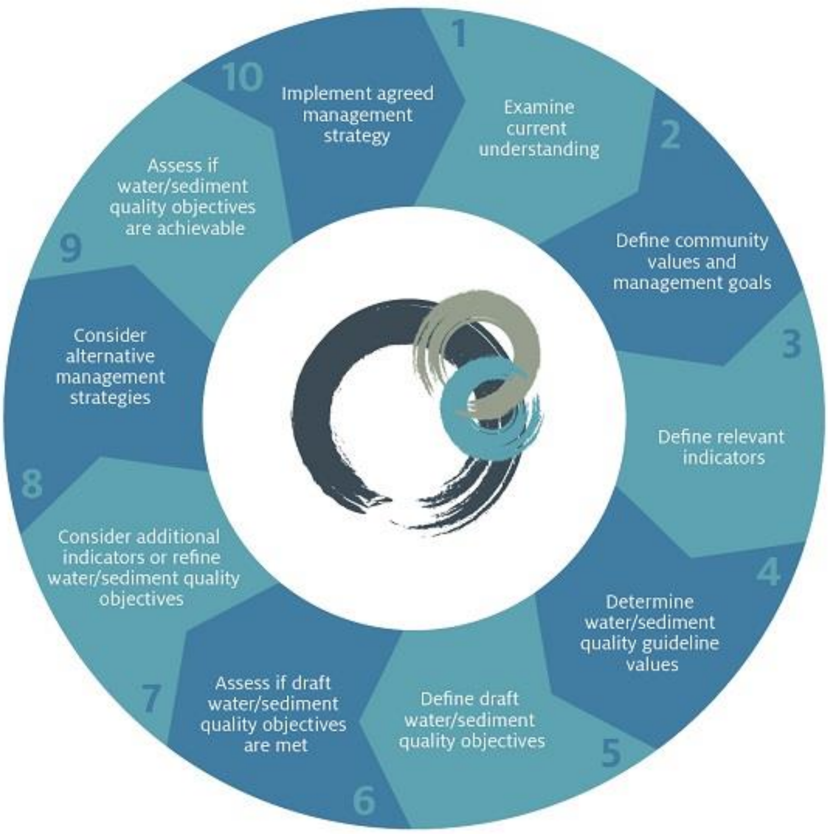


Figure 2-1 ANZG (2018) Water Quality Management Framework.

The ANZG (2018) framework emphasises the importance of a "multiple lines of evidence" approach as shown in Figure 2-2.

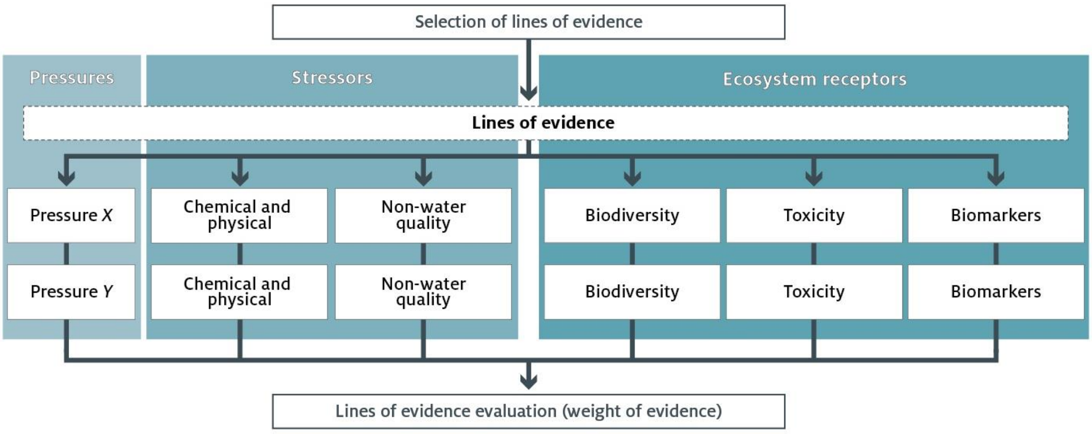


Figure 2-2 Weight of evidence approach across the pressure-stressor-ecosystem pathway (ANZG 2018).

2.3 Monitoring and Evaluation Reporting Program

The NSW Natural Resources Monitoring and Evaluation Program (MER Program) is coordinated by NSW DP&E (formerly OEH) and is generally implemented through Coastal Management Plans (CMPs). This includes standardised protocols for undertaking assessments of estuary ecosystem health including sampling, data analysis and reporting, as outlined in OEH (2016).

Guideline values are used to comparatively assess whether water quality indicators are outside of the expected range and indicate potential for undesirable ecosystem health. As part of the MER program, DP&E has previously determined guideline values for NSW inland waterways including creeks, lakes and rivers using the ANZECC (2000) and ANZG (2018) approach of calculation of the 80th percentile of all data at appropriate reference locations within NSW in various estuary types. Reference estuaries are generally defined as having minimal impacts on chlorophyll-*a* and turbidity. NSW DP&E updates guideline values periodically as additional data is available.

2.3.1 MER Triggers for Protection of Aquatic Ecosystems

The relevant water quality guidelines are based on NSW DP&E MER guideline values, ANZECC (2000) and ANZG (2018) default water quality guidelines, as they apply to protection of aquatic ecosystems (lagoons). Swan Lake is classified as a Back Dune Lagoon, although has also been termed as both a lagoon and a lake in previous assessments (OEH, 2016). The guidelines for Back Dune Lagoons were adopted, given its characteristics (i.e. a coastal water body which is predominantly protected by a sand barrier). Adopted guidelines are shown in Table 2-1. The NSW DP&E MER guideline values were last revised in 2020 (unpublished) and provided by DP&E (DP&E in preparation).

Table 2-1 NSW DP&E MER Values for Back Dune Lagoons

Parameter	Back Dune Lagoons
Ammonia (mg/L)	0.222
Phosphate (mg/L)	0.002
Oxidised Nitrogen (mg/L)	0.023

Parameter	Back Dune Lagoons
Total dissolved P (mg/L)	0.013
Total dissolved N (mg/L)	1.25
TP (mg/L)	0.032
TN (mg/L)	1.38
Chlorophyll-*a*	5.3
Turbidity (NTU)	4.2
pH upper	9.1
pH lower	7.9
DO upper %	120
DO lower %	80

2.4 Recreational Water Quality Guidelines

Recreational water quality is assessed using microbial (enterococci) data as an indicator.

Microbial assessment (of enterococci) measures the impact of pollution sources, enables the effectiveness of stormwater and wastewater management practices to be assessed and highlights areas where further work is needed. Swimming sites are graded as Very Good, Good, Fair, Poor or Very Poor in accordance with the National Health and Medical Research Council (NHMRC) 2008 Guidelines for Managing Risks in Recreational Waters. Grades are determined from the most recent 100 water quality results (two to four years' worth of data) and a risk assessment of potential pollution sources.

There are four Microbial Assessment Categories (A to D) and these are determined from the 95th percentile of an enterococci dataset of at least 100 data points. Each category is associated with a risk of illness determined from epidemiological studies (refer to Table 2-2). The risks of illness are the overall risk of illness associated with the 95th percentile of the enterococci dataset.

Table 2-2 Microbial assessment categories and risk of illness (NHMRC 2008).

Category	95th percentile for enterococci per 100mL	Basis of derivation	Estimation of probability
A	≤40	This value is below the NOEAL in most epidemiological studies.	Gastrointestinal (GI) illness risk: < 1% Acute febrile respiratory illness (AFRI) risk: < 0.3% The 95th%ile of 40/100mL relates to an average probability of less than one case of gastroenteritis

Category	95th percentile for enterococci per 100mL	Basis of derivation	Estimation of probability
			in every 100 exposures. The AFRI would be negligible.
B	41-200	The 200 per 100mL value is above the threshold of illness transmission reported in most epidemiological studies.	GI illness risk: 1-5% AFRI risk: 0.3-1.9% The 95th%ile of 200/100mL relates to an average probability of one case of gastroenteritis in every 20 exposures. The AFRI would be ~ 1 in 50 exposures.
C	201-500	A substantial increase in probability of adverse health outcomes for which dose response data is available.	GI illness risk: 5-10% AFRI risk: 1.9-3.9% The 95th%ile of 200/100mL relates to an average probability of one case of gastroenteritis in every 10-20 exposures. The AFRI would be ~ 1 in 50 to 1 in 25 exposures.
D	>501	Above this level there may be significant risk of high levels of illness transmission.	GI illness risk: >10% AFRI risk: >3.9% The 95th%ile of 200/100mL relates to a greater than 10% change of illness per exposure. The AFRI would be ~ 1 in 25 exposures.

AFRI = acute febrile respiratory illness, GI= gastrointestinal illness, NOEAL = no observed adverse effect level.

Other relevant NHMRC (2008) guidelines for primary contact recreation are shown in Table 2-3.

Table 2-3 NHMRC (2008) Guidelines for Primary Contact Recreation.

Water Quality Guideline	Parameter	Guideline Value	NSW Water Quality Objective
Primary Contact Recreational – biological (NHMRC 2008)	Faecal coliforms	Median over bathing season of less than 150 faecal coliforms/100 mL.	Median over bathing season of less than 150 faecal coliforms/100 mL with 4 out of 5 samples.
Primary Contact Recreational –	Visual clarity	Natural visual clarity should not be reduced by more than 20%. Horizontal sighting of a	A 200 mm diameter black disc should be able to be sighted horizontally from a

Water Quality Guideline	Parameter	Guideline Value	NSW Water Quality Objective
physiochemical (NHMRC 2008)		200 mm black disc should exceed 1.6 m.	distance of more than 1.6 m.
	pH	pH of the water should be within the range of 5.0-9.0 assuming that the buffering capacity of the water is low near the extremes of the pH limits.	--
	Temperature	15-35˚C (for prolonged exposure).	--
	Salinity (TDS)	< 1,000,000 µg/L	--
	Surface films	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour.	--

-- not listed.

At a minimum, microbial monitoring is undertaken as screening to assess suitability of waters for recreational water quality. A detailed assessment would combine microbial monitoring with a sanitary inspection (as undertaken for Beachwatch sites using the DPIE (2020b) template (https://www.environment.nsw.gov.au/research-and-publications/publications-search/protocol-appendix-a-sanitary-inspection-report, see Appendix G) that includes the following:

- Assessment of sewage outfalls and stormwater discharges - present or absent, type of treatment, effectiveness of outfall treatment and location of pumping stations and overflow points.
- Riverine sewage discharges – present or absent, type of treatment, population size and river flow.
- Bathers (i.e. number of bathers and periods of high use).
- Dilution.
- Any additional information that might affect indicators such as rainfall, wind, tides, currents, water releases and flushing rates.

The combination of microbial monitoring and sanitary inspection would then be used to categorise water quality as per Table 2-4.

A sanitary inspection was not possible, as this is site specific and undertaken at the same time as microbial sampling. Instead, a high-level review of faecal contamination sources within the catchment was undertaken, to provide a combined assessment with microbial monitoring data, to provide an assessment of suitability for identified recreational activities.

Table 2-4 NHMRC (2008) classification matrix for faecal pollution of recreational waters.

		Microbial water quality assessment category (95th percentiles — intestinal enterococci/100 mL)				Exceptional circumstances[c]
		A ≤ 40	B 41–200	C 201–500	D > 500	
Sanitary inspection category (Susceptibility to faecal influence)	Very low	Very good	Very good	Follow up[b]	Follow up[b]	ACTION
	Low	Very good	Good	Follow up[b]	Follow up[b]	ACTION
	Moderate	Good[a]	Good	Poor	Poor	ACTION
	High	Good[a]	Fair[a]	Poor	Very poor	ACTION
	Very high	Follow up[a]	Fair[a]	Poor	Very poor	ACTION
	Exceptional circumstances[c]	ACTION				

a Indicates possible discontinuous/sporadic contamination (often driven by results such as rainfall). This is most commonly associated with the presence of sewage – contaminated stormwater. These results should be investigated further, and initial follow-up should include verification of the sanitary inspection category and ensuring that samples recorded include 'event' periods. Confirm analytical results, review possible analytical errors.

b Implies nonsewage sources of faecal indicators (eg livestock), which need to be verified.

c Exceptional circumstances are known periods of higher risk such as during an outbreak involving a human or other pathogen that may be waterborne (eg avian botulism — where outbreaks of avian botulism occur, swimming or other aquatic recreational activities should not be permitted), or the rupture of a sewer in a recreational water catchment area etc. Under such circumstances the classification matrix may not fairly represent risk/safety.

* In certain circumstances there may be a risk of transmission of pathogens associated with more severe health effects through recreational water use. The human health risk depends greatly on specific (often local) circumstances. Public health authorities should be engaged in the identification and interpretation of such conditions.

3 Routine Water Quality Monitoring

3.1 Methodology

Routine water quality monitoring is undertaken by the Council in Swan Lake to assess environmental health. This monitoring data is published online on the Aquadata portal (https://www.esdat.net/Aquadata_Web_Based_Water_Quality_Public_Portal.aspx) and includes raw data and mapping for the Shoalhaven (https://webreports.esdat.net/SCC#results-map).

The frequency of sampling has ranged from one to six times per year and is usually undertaken during summer, spring or autumn. Physicochemistry and enterococci have been measured at most or all sites during all years and chlorophyll-*a* and nutrients measured at E-37 during all years. See **Appendix B** for a summary of sampling frequency.

A review of routine monitoring data from the past decade (2010 to 2021) was undertaken for Swan Lake. This was based on selected monitoring sites (E-35, E-36, E-37, E-38, E-334, E-335, E-779, E-780) (see Figure 3-1) and historical data from January 2010 to October 2021.

The collated raw water quality dataset was provided by Council. An initial quality review of the data was undertaken to identify any anomalous values resulting from instrumentation errors, transcription errors or extreme outliers. Extreme outliers were classified as values which were more than four standard deviations from the median and were also outside the possible range that would be expected for that parameter (including due to pollution events).

Among this review included the removal of:

- pH values below 5.
- DO above 150%.
- Electrical conductivity values below 100 µS/cm.
- Obvious data entry errors.

No laboratory measured results were required to be removed from the dataset. The final collated and reviewed data and more detail on the data review process is provided in **Appendix B**.

For turbidity it is possible there may have been overestimation associated with some of the elevated values which may be due to:

- Calibration - turbidity meters need to be calibrated to low readings (0-20 NTU) or can result in overestimated readings.
- Instrumentation errors.
- Sampling - turbidity readings taken close to the estuary bed or in areas of current can result in elevated readings.

However, turbidity can also be elevated due to high amounts of suspended particulates in the water column which could be associated with plant and animal decay (in land runoff or directly in water) or suspended solids (from terrestrial runoff, high rainfall, storms, erosion or bushfire events). As there was no way of differentiating between actual and overestimated turbidity, values over 100 NTU were kept in the dataset. An acceptable method would be to review the dataset and convert suitable data points (i.e. those which do not correspond to high rainfall and where chlorophyll-*a* is low) using total suspended solids (TSS) data. However, a corresponding TSS dataset is not available for the majority of the data. This approach was used by DP&E for the turbidity dataset used for the 2020-2021 estuary health assessment (Section 4) (DP&E in preparation).

The final collated and reviewed data (and more detail on the data review process) is provided in **Appendix B**.

Boxplot graphs were prepared in Minitab 16.0 (2010) for key water quality parameters and are presented by site and season in **Appendix D**.

3.2 Location of Monitoring sites

The location of monitoring sites for Swan Lake and Swan Lake Inlet included in the review are shown in Figure 3-1.

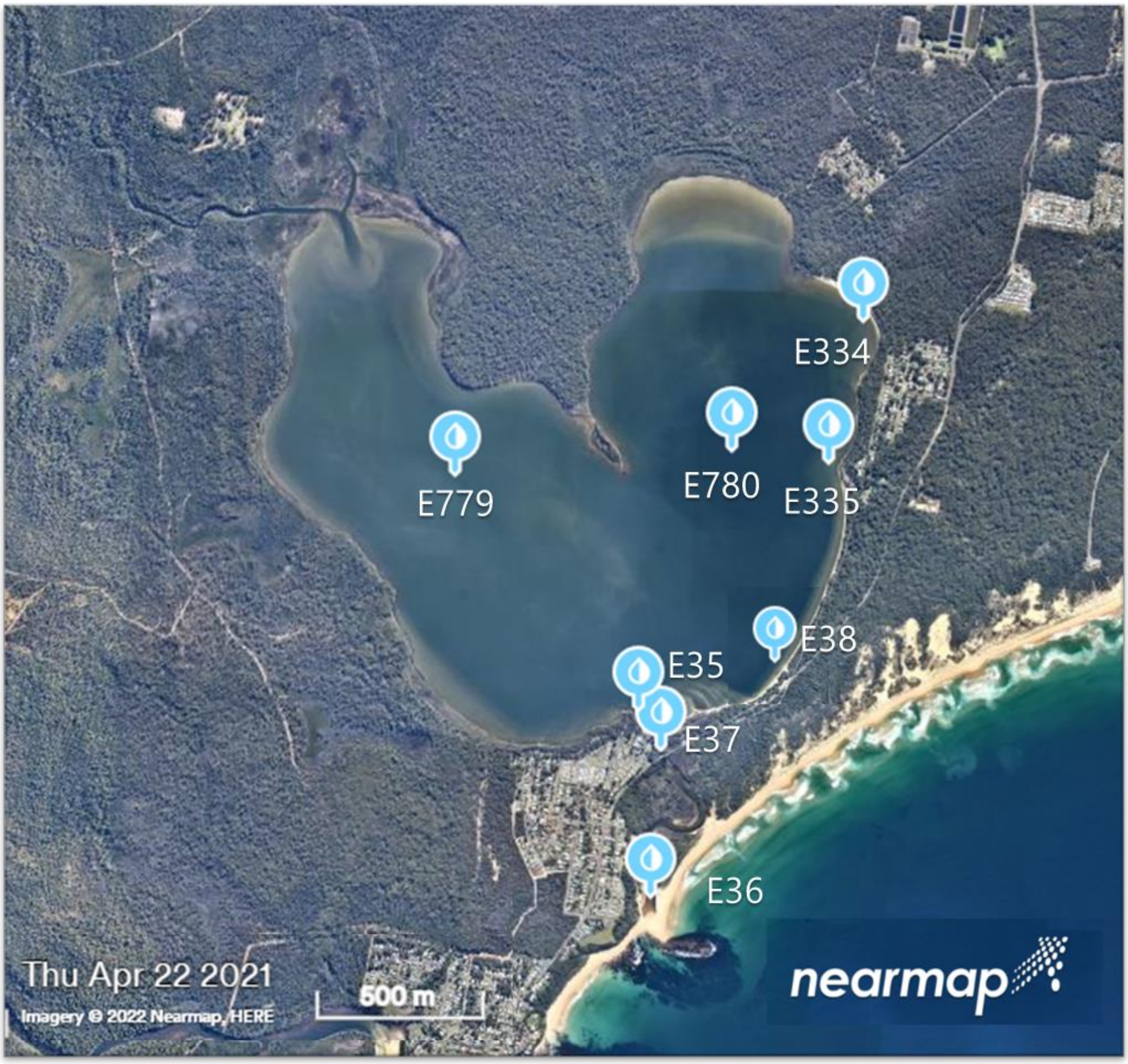


Figure 3-1 Location of selected water quality monitoring sites by Shoalhaven City Council within the project area included in the analysis.

3.3 Frequency of Monitoring

A summary of the water quality monitoring frequency is provided in **Appendix C**.

The frequency of sampling has been variable and has been undertaken between one to six times per year, usually during summer, spring or autumn. Physicochemistry and enterococci have been measured at most or all sites during all years and chlorophyll-*a* and nutrients measured at E-37 during all years.

3.4 Review of Long-Term Water Quality Data

A review of historical water quality data was undertaken for Swan Lake and Swan Lake Inlet. The focus of the review was to identify any broadscale water quality issues or hotspots.

Key water quality statistics (including average, standard deviation, median, minimum, maximum and count of sample replicates) are included in **Appendix C.** Boxplots of the water quality data by area, site, season and with comparison to any available and applicable water quality guidelines for back dune lagoons are shown in **Appendix D**.

The key water quality results are as follows:

- **Temperature (°C)** – All monitoring sites in Swan Lake had low variability in temperature during summer and winter, with more variable levels during autumn and spring (**Appendix D** Figure 8-1). Within seasons there was little variation across monitoring sites.
- **Dissolved Oxygen (DO) (%saturation)** – There were some exceedances of DO above or below the respective DP&E MER guideline upper and lower limits (**Appendix D**). However, all median and the majority of DO values for sites within Swan Lake were within the guideline range.
- **pH** – There were some exceedances above or below the respective DP&E MER guideline upper and lower limits for pH (**Appendix D**). However, all median and the majority of pH values for sites within Swan Lake were within or just below the guideline range.
- **Salinity (ppt)** – Salinity ranged considerably from 3.5 to 31.73 ppt (**Appendix D**). Although overall, salinity within sites was similar, the most variability was within the inlet at site E-36 and the least variability in the middle of the lagoon, at sites E-779 and E780.
- **Turbidity (NTU)** – Turbidity within the inlet was usually elevated with the majority of results above the DP&E MER guideline for lagoons (**Appendix D**). Within Swan Lake there were occasional elevated values, but most median values were below the DP&E MER guideline for back dune lagoons.

  The turbidity results should be viewed with the caveat that the dataset may include overestimated results (either due to calibration, instrumentation errors or sampling methods as outlined in Section 3.1).
- **Chlorophyll-*a* (mg/m^3)** – values at the three sites that are monitored for chlorophyll-*a* (E-37, E-779 and E-780) were below the respective DP&E MER guideline values with the exception of some elevated values at E-37 during summer (**Appendix D**).
- **Total Nitrogen (mg/L)** – The three sites that have been occasionally monitored for TN in Swan Lake had both the median concentration and majority of concentrations below the respective DP&E guideline value for back dune lagoons (**Appendix D**). Within the inlet,

there was high variability in TN values. Within the middle of the lake, there was less variability.

- **Total Phosphorous (mg/L)** – Sites E-37, E-779 and E-780 were occasionally monitored for TP. Median concentrations were below the DP&E MER guideline value in all seasons (**Appendix D**). During spring there were no detections of TP (i.e. all were below the estimated quantification limit i.e. the lowest limit detectable, EQL).
- **Total dissolved phosphorous (mg/L)** – Total dissolved phosphorous has occasionally been monitored within the inlet at site E-37 and in the middle of Swan Lake at sites E-779 and E-780 (**Appendix D**). All values have been below the DP&E MER guideline value and EQL.
- **Total dissolved solids (mg/L) –** Total dissolved solids showed variable values within the inlet in summer and in the middle of the lagoon during autumn and winter (**Appendix D**). However, there were similar median values at all sites.
- **Faecal coliforms and enterococci (CFU/100mL)** – There were some elevated outliers for faecal coliforms (630 cfu/100ml at E-334 and 6,900 cfu/100ml at E-335) and enterococci (2,600 cfu/100ml at E-334 and 3,900 cfu/100ml at E-335) on 29th January 2013 following a heavy rainfall event (>170 mm at Jervis Bay). These two monitoring sites are adjacent to sewage pumping stations. Apart from this event, the majority of samples at all monitoring sites had very low-level detections of faecal coliforms and enterococci, or concentrations were below the estimated quantification limit (EQL).

  Recreational water quality, which uses enterococci as guideline values, is discussed further in Section 6.

Overall, the review shows that water quality within Swan Lake within the past decade has generally been good. Median levels of DO and pH are within the DP&E MER guideline values for back dune lagoons but with occasional elevated values, mainly during summer. Turbidity was regularly elevated above the DP&E MER guideline values for back dune lagoons (noting there are some potential data errors for turbidity) while chlorophyll–*a* levels were nearly always low and within the guidelines.

Based on the available chlorophyll-a (algae) and nutrient monitoring, the majority of samples that levels that were below the respective DP&E MER guidelines values for back dune lagoons. These results are similar to historical monitoring undertaken prior to 2010 within Swan Lake and the previous classification of the lake as "oligotrophic" (Shoalhaven City Council 2008), which is defined as a closed system that is not nutrient rich and has few algae problems.

Historical trends are examined in further detail in Section 3.5.

3.5 Water Quality Analysis

Analysis of physicochemistry data (temperature, turbidity, DO, pH and salinity) and chlorophyll-*a* for Swan Lake is presented in **Appendix D**. This analysis was undertaken to understand the patterns in the dataset and interpret whether there are differences in water quality between sites, years or seasons. This information is useful to understand long term trends but also inform future monitoring requirements (in terms of site replication and frequency of sampling required).

The water quality analysis shows:

- There are no apparent overall differences in physicochemistry or chlorophyll-*a* between Swan Lake and the Swan Lake Inlet when all available water quality parameters are taken into consideration (**Appendix E**). Noting that nutrient data was not able to be included in the multivariate analysis.

- There are no apparent differences in physicochemistry between individual sites within Swan Lake and Swan Lake Inlet (**Appendix E**).
- There is considerable variation in water quality between sampling years, in particular for the parameters temperature, DO and salinity (**Appendix E**). In particular, the sampling years 2010, 2011 and 2012 were different to more recent years with more variable and lower temperatures, DO and salinity. It is known that water quality within Swan Lake is influenced by being opened to the sea. Although this is not shown on the graphs below, it is likely to be an important factor affecting year to year trends in physicochemistry.
- The only seasonal difference seen is related to water temperature, with other physicochemical parameters showing similar median values across all seasons. This can be seen in the review of the data considering separate parameters for each sampling year (**Appendix E**).

4 Estuary Health Assessment 2020 – 2021 (DP&E)

4.1 Water Quality and Estuary Health Assessment Methodology

NSW DP&E is concurrently assisting Council to review Councils (2020 – 2021) data for Shoalhaven Estuaries as part of an assessment of the impacts of Bushfires to water quality and estuary health. This was based on the protocols outlined in the NSW Monitoring, Evaluation and Reporting Strategy (MER) methodology for Assessing Estuary Ecosystem Health: Sampling Data Analysis and Reporting Protocols (OEH) 2016).

The six steps outlined in the NSW MER program include:

1. Calculation of the Non-Compliance Score (NC1) which is the proportion of time that measured values of the indicators are outside the adopted guideline value.
2. Calculation of the Worst Expected Value (WEV) by calculation of the 95^{th}%ile or adoption of those proposed in the MER Program.
3. Calculation of the Distance Score (Dsi) from the guideline value whereby Dsi = (value – guideline value) / (WEV – guideline value).
4. Calculation of an Indicator Score (Isi) for each zone: Isi = $\sqrt{}$(Nci x Dsi).
5. Calculation of the Zone Score (ZS) whereby ZS = (Isc + Ist) / 2.
6. Grading the zone as A (Very Good/Excellent), B (Good), C (Fair), D (Poor) or E (Very Poor) (Figure 4-1).

Score Criteria	Rating
4.3 to 5.0	Very Good
3.5 to 4.2	Good
2.7 to 3.4	Fair
1.9 to 2.6	Poor
< 1.8	Very Poor

Figure 4-1 Scoring classes used to assign overall grades of estuary health (Roper et al. 2011).

Normally the temporal scale for the MER Program targets the maximum chlorophyll-*a* period from mid-November to the end of March. A minimum of six samples is recommended from within this period, with more samples providing more statistical confidence.

Rather than only sampling the summer period, Council sampled Swan Lake at two locations approximately monthly between November 2020 and November 2021 for estuary health parameters (turbidity and chlorophyll a) as well as standard physical parameters, nutrients, total organic and total dissolved carbon.

Within Swan Lake, the sampling sites E-779 and E-780 (in the central areas of the lake – see Figure 3-1) were used for the 2020/21 MER assessment.

The turbidity dataset for multiple sites that are included in the assessment, including Swan Lake, showed some elevated readings which were thought to be associated with a faulty probe or incorrect calibration. The results were corrected using TSS data (as there is good correlation between TSS and turbidity) (DP&E in preparation).

4.2 Bushfire Event Monitoring

Bushfires can impact on water quality with key changes including increased sediment and nutrient loads (especially total organic carbon (TOC) and dissolved organic carbon (DOC)) and increased turbidity, which in turn can generate algae blooms where die off can raise pH and reduce DO (NSW EPA 2020).

During the summer of 2019/20 there was an extreme drought and extensive bushfires throughout the City of Shoalhaven LGA (and large parts of NSW). In NSW an estimated 5.5 million hectares (13,600,000 acres) were burnt (NSW Rural Fire Service 2020), and the bushfires are estimated to have affected over 1 million hectares of land, 47 estuaries and coastal catchments in the Shoalhaven LGA (Shoalhaven City Council 2021). Swan Lake was severely impacted by the bushfires with around 85% of its catchment burnt. The fires reached right to the edge of the western foreshore of the lake. The high volumes of rainfall that immediately followed the bushfire period are likely to have caused mobilisation of large volumes of soils, sediments and ash into the estuary, raising concern for the potential of impacts on water quality and estuary health.

Council received grant funding from the NSW Government to develop a South-East Catchment and Waterways Bushfire Recovery Plan including water quality and estuary health monitoring within Shoalhaven. Monitoring of TOC, DOC and nutrients commenced in November 2020 and is being collected at 3-monthly intervals. Monitoring of estuary health, nutrients and physiochemical parameters is being done on a monthly basis (ongoing at time of reporting) (Refer to Section 5.2 below).

As the monitoring did not commence until ~ 9 months after the bushfire period, and missed numerous subsequent large rain events, it is difficult to assess trends yet. A preliminary summary of findings reported that there appears to be raised concentrations of TOC and DOC in comparison to typical concentrations expected for estuarine waters, particularly following large rainfall events, with indications of a decreasing trend over time as less carbon is being washed into the estuary from the surrounding land (DP&E in preparation).

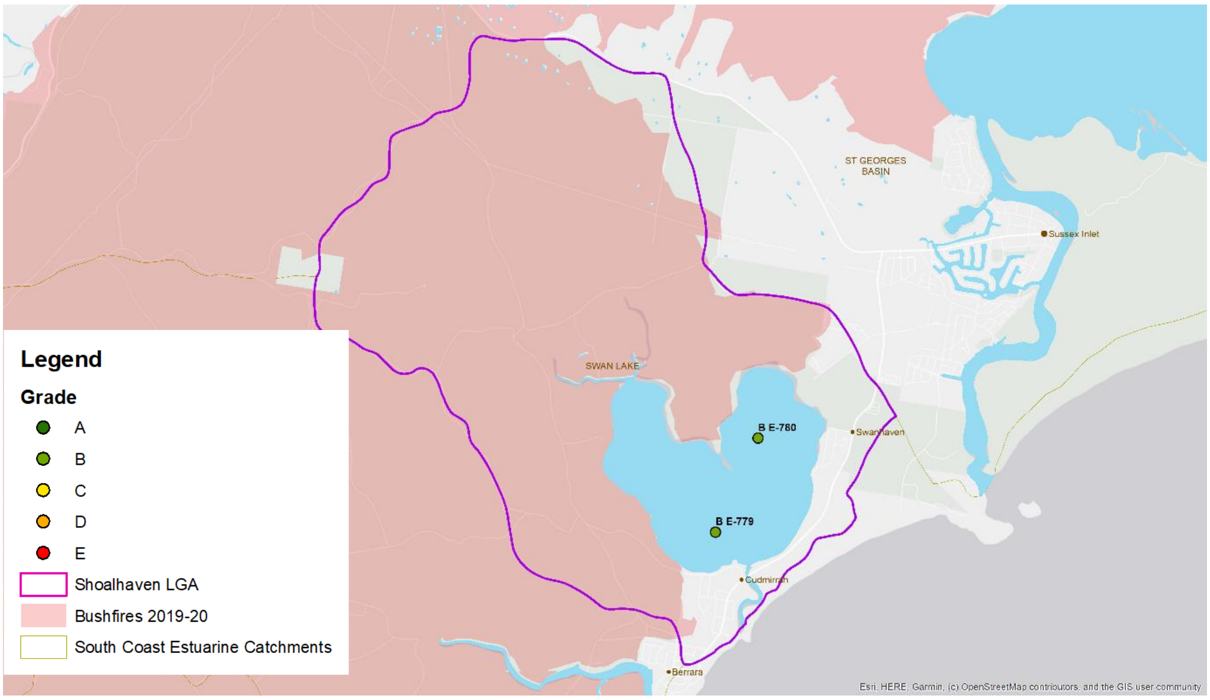
Further analysis of the bushfire monitoring data will be undertaken by NSW DP&E and included in a final report at the end of the grant period in February 2023 (to be prepared by NSW DP&E).

4.2.1 Post Bushfire Water Quality and Estuary Health

The Shoalhaven Estuary Health Assessment for 2020 – 2021 is being undertaken by Council with data analysis assistance from NSW DP&E (in preparation). Water quality data was used to assess ecosystem health using methodology outlined in the NSW Monitoring, Evaluation and Reporting Strategy (MER) Methodology for Assessing Estuary Ecosystem Health: Sampling, Data Analysis and Reporting Protocols (OEH 2016).

The assessment was undertaken for monthly samples collected during 2020/2021 using routine monitoring data collected by Council at two monitoring sites within Swan Lake including E-780 (in the northeast) and E-779 (in the south) (Figure 4-2). This timeframe includes samples taken following the 2019-20 bushfires between November 2020 and December 2021. For 2020 – 2021, the following assessment findings were reported: "Swan Lake received an overall Good (B) estuary health rating. Low algae (chlorophyll-a) and high water clarity (low turbidity) was recorded on most occasions. This is a slight decrease in estuary health from Excellent (A) to Good (B) compared to results collected by DPIE in 2014 – 2015 and 2008 – 2009 (DP&E, in preparation)".

An overview of the Shoalhaven estuary health grades for 2020 – 2021 is provided in Figure 4-2.



Site	Description	Algae (Chlorophyll a)	Water Clarity (Turbidity)	Overall Grade
E-780	Northern Area of Swan Lake	B	B	B
E-779	Southern end of Swan Lake	A	B	B
	Overall Estuary Grades	**B**	**B**	**B**

Figure 4-2 Swan Lake Estuary Health Assessment and monitoring sites.

DP&E's water quality graphs for key health indicators chlorophyll-*a* and turbidity in 2020 – 2021 are shown below in Figure 4-3.

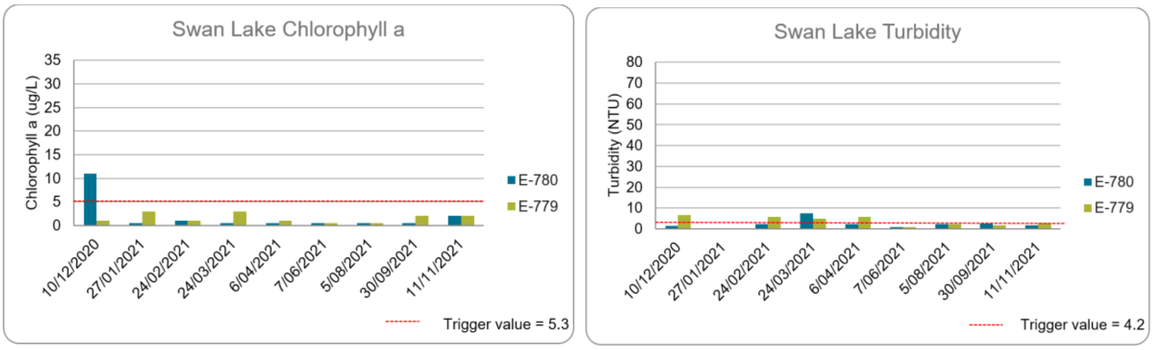


Figure 4-3 DP&E chlorophyll-a and turbidity graphs during 2020-2021 (from DP&E in preparation).

DP&E graphs of other water quality parameters during 2020 – 2021 are provided in **Appendix F**.

DP&E reported that "pH levels were lower than expected, with all readings between 7.2 and 8. This is likely to be related to freshwater inputs and low salinity levels during the sampling period. Total dissolved nitrogen exceeded trigger levels for Back Dune Lagoons on one occasion. Dissolved nitrogen and phosphorus nutrient levels were within expected ranges. DO was within the expected guideline range in all samples".

5 Estuary Macrophyte Mapping (NSW DPI)

5.1 Methodology

NSW DPI undertakes macrophyte mapping of most estuarine habitats within NSW using methods developed over decades (Creese et al. 2019; Sainty 2012; West et al. 1985; West and Glasby 2021). Mapping for Swan Lake was last undertaken in 2004.

Estuarine macrophyte mapping is available via the Estuarine Habitat Dashboard (NSW DPI 2022) which includes the ability to view mapping and undertake a change analysis comparing the percentage mapped macrophyte area between mapping times.

It is noted that due to differences in mapping techniques, mapping from 1980 generally is an overestimation of the large areas of macrophytes.

5.2 1982 and 2004 Mapping

Estuarine macrophyte habitat mapping undertaken by NSW DPI in 1982 is presented in Figure 5-1 and for 2004 in Figure 5-2. Note that there has been a considerable change in mapping methodology since 1982 which is thought to have resulted in a decrease in estimates in 2004.

Habitat mapping is available via https://nsw-dpi.shinyapps.io/NSW_Estuarine_Habitat/.

Only Ruppia has been mapped by NSW DPI in Swan Lake. The 2004 estuarine mapping shows that the inlet of Swan Lake and most of the eastern and northeastern sides of the lake are lined with Ruppia seagrass. The 1982 estuarine mapping shows that considerable beds of Ruppia lined nearly all of the sides of the lake.

Recent observations have reported that Charophytes (dense beds of estuarine algae) have largely disappeared from Swan Lake within the past five years. This is thought to be potentially related to the drought in 2019 – 2020. Charophytes are a major food source for Swans, which have also been observed to have decreased in Swan Lake in recent years. This is a similar pattern to what has been observed in other NSW estuaries due to droughts (eg. at Nadgee Lagoon) where Charophyte abundance declined because of a drop in water levels exposing beds or elevated nutrients (Scanes et al. 2020).

Figure 5-1 NSW DPI estuarine macrophyte mapping of Ruppia in Swan Lake in 1982 (NSW DPI 1982).

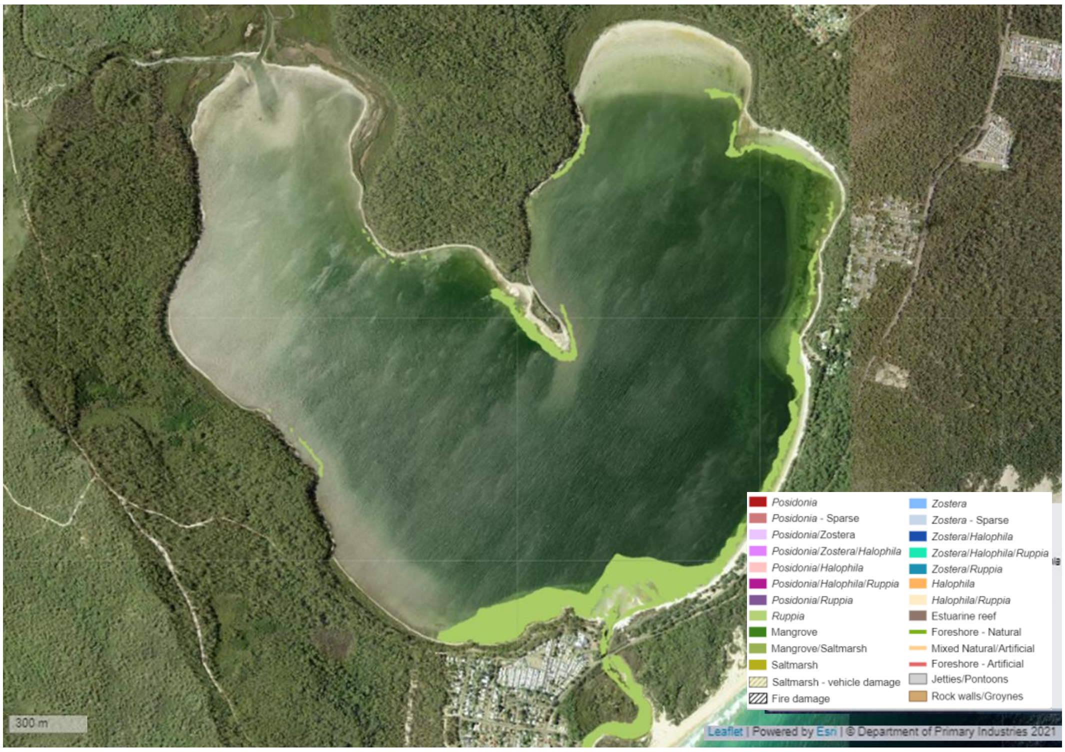


Figure 5-2 NSW DPI estuarine macrophyte mapping of Ruppia in Swan Lake in 2004 (NSW DPI 2004).

5.3 1982 versus 2004

A comparison between the spatial distribution and area of Ruppia is available via the NSW DPI Estuarine Habitat Dashboard (NSW DPI 2022) (Figure 5-3 and Figure 5-4). The mapping shows that there has been a reduction in the area of Ruppia in 2004 compared to 1982. Overall, the area of Ruppia has significantly decreased during 2004 in comparison to 1982. In 1982, there was ~75ha mapped while in 2004 this had decreased to ~28ha. As noted above, there was a difference in mapping techniques between these periods which likely result in an overestimation of the area of Ruppia during 1982, accounting for some of the observed decrease.

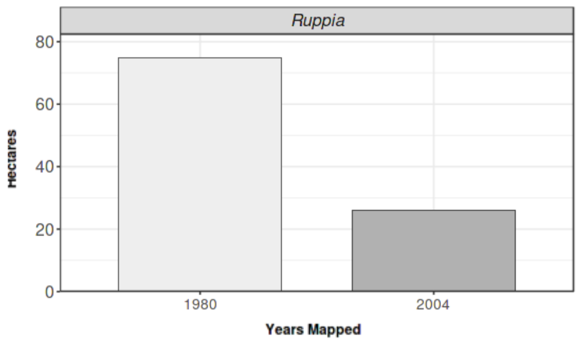


Figure 5-3 NSW DPI estuarine macrophyte mapping – data summary of changes in area (hectares) of Ruppia in Swan Lake between 1982 in comparison to 2004 (NSW DPI 2021).

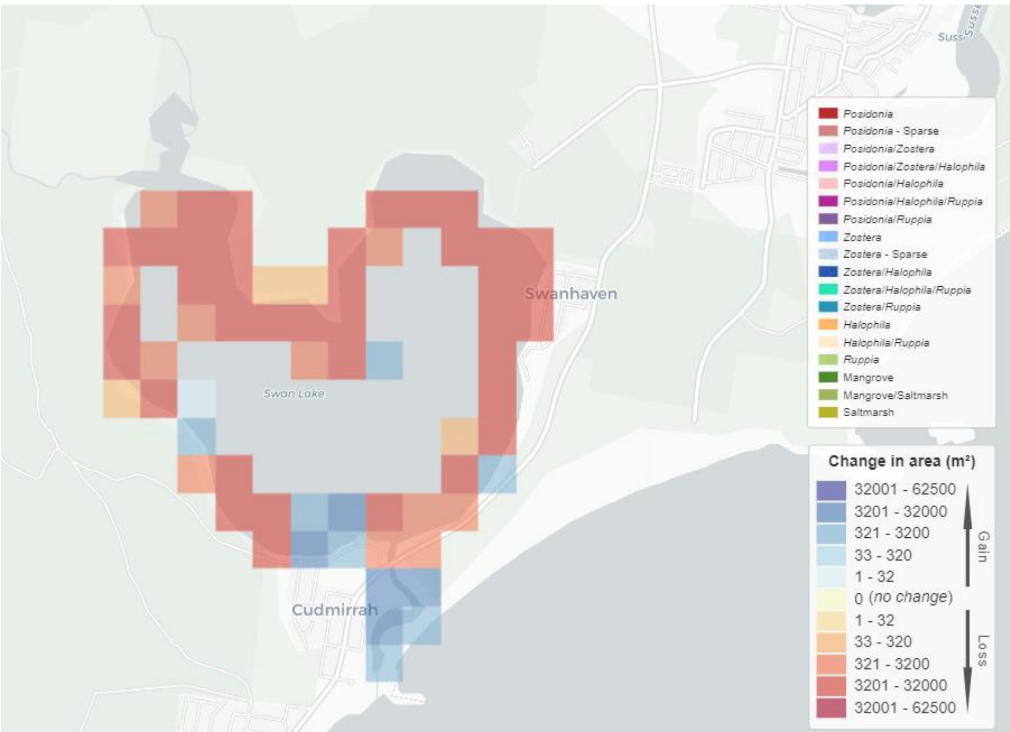


Figure 5-4 NSW DPI estuarine macrophyte mapping change in area (m^2) of Ruppia 1982 in comparison to 2004 (NSW DPI 2021).

6 Recreational Water Quality

6.1 Swan Lake

6.1.1 Microbial Monitoring

A comparison of enterococci data from Swan Lake for the past four years to the NHMRC (2008) recreational guidelines is summarised in Table 6-1.

Table 6-1 Summary of recreational water quality assessment.

Site	95%ile (cfu/100ml)	NHMRC (2008) category	NHMRC (2008) risk of illness
E-334	6	A (≤40 cfu/ 100ml)	GI illness risk: <1% AFRI risk: <0.3%
E-335	5		
E-35	39.6		
E-36	20		
E-38	15.8		
E-37	97	B (41-200 cfu/100ml)	GI illness risk: 1-5% AFRI risk: 0.3-1.9%

AFRI = acute febrile respiratory illness; GI = gastrointestinal, NHMRC = National, Health and Medical Research Council.

6.1.2 Review of Pollution Sources within Catchment

A high-level review of pollution sources within the Swan Lake catchment was undertaken to assess the catchments potential influence from human versus environmental sources of faecal contamination. Refer to Table 6-2.

Table 6-2 Review of faecal pollution sources with Swan Lake.

Site Information	
Catchment land use	Moderately disturbed. Approximately 70% of catchment is located in Conjola National Park and approximately 10% of catchment is urban areas of Sussex Inlet, Cudmirrah and Swan Haven (DPIE 2022).
Type of primary recreational activities	Swimming, paddle boarding and kayaking.
Type of secondary recreational activities	Boating, fishing, prawning and wading.
Groups likely to use the site	All ages (including infants and elderly which are the vulnerable age groups) are likely to use the site for primary recreation.
Flushing	A back-dune lagoon that is intermittently closed to the sea via the Swan Lake Inlet (DPIE 2022) and on average is closed approximately 85% of the time and opens about

	once per year (Shoalhaven City Council 2008). Discharge to the ocean is slow when open and tidal inflows are not sufficient to fully flush the estuary.
Rainfall	The lake is large in relation to its catchment so water level rising during heavy rainfall events is slow (Shoalhaven City Council 2008).
Pollution Sources	
Flooding	A potential source of faecal contamination during extreme flood events related to surrounding low level assets known to be inundated during elevated levels including access tracks, sewage tanks, pump station (Number 13), public toilets and tourist parks. This risk is low and managed via the Swan Lake Entrance Management Policy (Shoalhaven City Council 2008).
Bather shedding (i.e., shed from skin during bathing as source of faecal contamination, sunblock and other chemicals)	The number of bathers can be considered as a source of contamination. This is considered to be a small source in relation to the large size of the basin and inlet. Peak usage is by tourists during school holidays and summer (Dec - Feb).
Toilet facilities	Available near Errol Bond Reserve, Dyball Reserve and at tourist accommodation along the eastern side and inlet.
Wastewater Treatment Plants – routine discharges	Sussex Inlet Sewage Treatment Plant (STP) – a very small plant with annual effluent discharge volume of >219 to 1000 ML and treatment capacity of 8000 persons (NSW EPA EPL 3936). Effluent treatment is tertiary with screening, extended aeration and decanting, ponds, chlorination and sand filtration for inflows between 58 and 319 L/sec. Treatment is sand filtration and chlorination for inflows over 320 L/sec. Effluent is reused via irrigation on local sporting grounds or discharged into Sussex Inlet via sand dunes (close to the mouth of ocean). There are no effluent discharges into Swan Lake from STPs so there is no associated risk with routine discharges.
Designated sewage overflows (including network)	Three pumping stations associated with the network of the Sussex Inlet STP are located around the edges of Swan Lake: 1) western end of Hoffman Drive; 2) reserve at the south end of Yaroma Ave / Lake Drive (pumping station 13) and 3) reserve at the eastern end of Goonawarra Dr (pumping station 1). These wells have very low risk of flooding unless the lake reaches over 3.5 m AHD, under which scenario the lake would be opened prior to reaching this level (Shoalhaven City Council 2008).

	There are multiple controls in place to minimise the possibility of overflows. With the existing management protocols in place the risk associated with network overflows from Sussex Inlet STP is considered low.
Onsite sewage systems	Some onsite sewage systems through urban and lower area of catchment.
Wastewater re-use area	Not known.
Stormwater and urban runoff	Stormwater and urban drainage into the Swan Lake Inlet and along the eastern side.
Tributaries	The tributaries Mondayong Creek and Teatree Creek flow into the north-west of the lake. These tributaries are surrounded by national park and likely to have minor environmental faecal contamination inputs.
Boats	Boating with peak during school holidays and summer.
Animals/Environment	70% of the catchment is within Conjola National Park which is heavily forested to the banks of the creek. Faecal contamination from the tributaries is likely to be predominantly environmental sources such as birds and native animals. Dogs and cats in the lower urban eastern side of catchment and around the inlet (associated with the residential and tourism land uses) are a potential source.
Management Controls in place	
Management controls	Environmental Protection License (EPL) on STPs. Council monitors onsite private sewage management systems on a routine basis to ensure compliance. Ongoing faecal coliform and enterococci monitoring. Risk Assessment, Risk Minimisation and Incident Management Strategy (Shoalhaven City Council). Multi-faceted programs which respond to overflow events. Multiple controls to minimise sewage overflows at pump stations (including storage capacity, standby pumps, telemetry continuous alarms, available portable generator or pump out tankers). CMP management actions (to be developed).
Management response plan for exceptional events (such as sewage overflows)	Pollution Incident Response Management Plan (PIRMP).

6.1.3 Overall Assessment

Overall, recreational water quality within Swan Lake continues to highly ranked as "Good" (4 stars out of 4) for swimming and other water based activities based on the NHMRC (2008) guidelines.

The monitoring site E-37, which is located closest to the inlet from the lake, and near to The Springs Road bridge crossing has enterococci results indicating there could be sources of faecal contamination which may be related to stormwater and urban runoff/natural sources within the inlet (which may include septic systems). However, this has not affected recreational water quality within the lake where recreational activities occur.

The Council is recommended to continue to undertake targeted sampling following significant rainfall or overflow events in recreational seasons to confirm suitability (see Section 7.2). The advice from NHMRC (2011) across all estuaries is that swimming and contact recreational activities should be avoided for 3 days following heavy rainfall or upon inspection that shows water pollution (litter, discoloured waters or odours).

7 Summary

7.1 Estuary Health and Water Quality Issues

A summary of the estuary health and water quality issues relevant to Swan Lake and potential implications is provided in Table 7-1. The next stage of the CMP will include development of an action plan to address identified issues and meet water quality objectives.

Table 7-1 Water quality issues and implications.

Issue	Implication
Water Quality Program – data collection, maintenance and reporting	
Routine water quality has been collected for Swan Lake. There are some inconsistencies with sampling and data entry including: ▪ Inconsistent seasonal sampling replication (e.g. less sampling has occurred in winter months). ▪ Inconsistent approach to reporting values below the estimated limit of reporting (EQL). ▪ Ambigious values that were likely related to data entry and/or instrument errors. ▪ Potential overestimation of turbidity. ▪ The Aquadata portal dataset includes both pollution events and routine monitoring data. However, these cannot be identified or separated (apart from reviewing and aligning historical rainfall data). ▪ Inconsistent sampling of turbidity and chlorophyll-*a* makes it difficult to regularly assess estuary health (i.e. need consistent samples at sites 779 and 780 over time for both parameters). ▪ Increasing the number of sites that are monitored for nutrients could better assist with understanding trends and linking these to ecological risk.	Not having consistent and reliable water quality data affects the ability to assess water quality health, whether water quality objectives are being met and thus ability to make management decisions. A lack of similarity / consistency in data collection and therefore in datasets between years restricts the analysis which can be undertaken, between seasons, for example. Errors in water quality data can carry over into reporting issues if not identified (i.e. such as parameters where values are unusually low or high but within possible range such as elevated turbidity throughout dataset). Inconsistencies with reporting values <EQL makes it difficult to compare at later stages. Reduced ability to discriminate between pollution and routine data can affect interpretation of results.
Elevated turbidity within Swan Lake	
Turbidity within Swan Lake is sometimes above the DP&E MER guideline for lagoons. This presents potential risks to water quality within the lake. This could be related to overestimation of turbidity values based on the low levels of chlorophyll–*a* and TSS. A continuous water quality meter has been temporarily deployed in Swan Lake by DP&E which may help to clarify what are normal turbidity readings for the lake.	Elevated turbidity can result in impacts on ecological functioning which during extreme prolonged events can cause fish kills and loss of habitat.

Issue	Implication
Decline in swans and Charophyte food source	
Community reports on a decline in abundance of Swans thought to be related to loss of Charophyte (a family of dense algae) beds and the prolonged drought in 2019 – 2020. Similar patterns have been observed in other NSW back dune estuarine lagoons including Nadgee Lagoon following decline in water quality (either from dropped water levels exposing beds or elevated nutrients) associated with droughts (Scanes et al. 2020).	Swan Lake is unique and one of only eight back dune lagoons in NSW that is known to support extensive Charophtye beds (Scanes et al. 2020). Long term trends of declines in Swans would result in loss of an important value for this ecosystem.
Reported decline in endangered wildlife, including birds	
There is a reported decline in endangered wildlife including other bird species in addition to Swans. This is thought to be associated with powered boats, destruction of habitat, competition from introduced animals (foxes, cats, rats and rabbits) ordecline in food sources (fish stock decline). There is the possibility that artificial entrance openings could also contribute to altered ecology within the lake over time if the lake is consistently opened below natural levels. In addition, there is observed spread of weeds in native bushland and around the foreshore.	The loss of either abundance or diversity of species corresponds to a decline in overall ecological health. At a broader level reduced biodiversity driven by anthropogenic causes is associated with a lower resilience, lower genetic diversity and overall threatens population decline of species.
Decline in Ruppia from 1980 to 2004	
Ruppia was observed to have significantly declined between 1980 and 2004 based on NSW DPI mapping. Noting, that mapping is likely to have overestimated total area accounting for some of this reduction. Updated macrophyte surveys for Swan Lake would help to better understand the trends and guide management actions if needed. A decline in seagrasses is potentially associated with anthropogenic disturbance but could also be natural variation as seagrasses are very dynamic (Scanes et al. 2020). Ruppia is known to have a good ability to reestablish following disturbance.	Declines in seagrasses are associated with a decreased capacity for sediment stabilisation, nutrient uptake and carbon sequestration as well as reduced fish biodiversity (Jones and West 2005, McCleod et al. 2009, Waycott et al. 2009).
Reported decline in fish communities	
There is a reported decline in fish communities which has been suggested to be related to recreational and commercial overfishing within Swan Lake. This was also noted in community consultation undertaken in 2008 (Shoalhaven City Council). However, these perceptions of declining	A decline in fish stocks has both commercial and recreational implications for Swan Lake. In addition, the loss of either abundance or diversity of fish corresponds to a decline in overall ecological health.

Issue	Implication
fish number have not yet been supported by data from NSW Fisheries. The corresponding observed decline in Ruppia also suggests a loss of habitat and food sources.	
Sea level rise & climate change	
Potential impacts on water quality through changes to the hydrodynamics of the estuary and more frequent extreme weather events (e.g., drought and heavy rainfall).	Impacts on hydrodynamic and ecological processes within the estuary affecting water quality. Sea level rises will likely increase shoreline erosion resulting in increased organic matter, suspended sediments and debris. Potential implications for ecological health via inundation of infrastructure and endangered ecological communities are loss of macrophytes and/or landward migration of saltmarsh, mangroves and changes to seagrass distribution. More frequent disturbances affect the resilience of ecosystems and may result in longer term trends of continued decline of estuarine biodiversity. This could potentially result in the loss of macrophytes completely with Swan Lake and other NSW estuaries.
Management of Swan Lake opening – Illegal openings	
There are specific conditions and consultation processes that need to be satisfied prior to opening of Swan Lake and specific actions required to mimic natural entrance behaviour to protect ecological health (Shoalhaven City Council 2008). Continued openings by the public by-pass these risk assessments and may lead to unintended consequences	Impacts on hydrodynamics, ecological processes, water quality within the estuary. Lower water levels within the lake that can lead to adverse ecological impacts via water quality (for example fish kills or altered vegetation).
Impacts on water quality following bushfires (2019-2020)	
Increased catchment runoff and associated sediment and nutrients from burnt areas after the bushfires.	Bushfires can impact on water quality with key changes including increased sediment and nutrient loads (especially total organic carbon and dissolved carbon) and increased turbidity, which in turn can generate algae blooms where die off can raise pH and reduce DO (NSW EPA 2020). Increases in suspended solids and turbidity can smother seagrasses resulting in a decline in available habitat for species (i.e. fish).

7.2 Recommended Sampling Program

7.2.1 Water Quality

Recommended monitoring sites for inclusion in future sampling is shown in Figure 7-1 and a summary of the recommended program is provided in Table 7-2.

Improvements to ongoing monitoring will ensure that the program can track improvements towards meeting current water quality objectives.

Estuary health monitoring should be coordinated with the existing DP&E three-year rotational schedule for estuaries across the state. This would consist of approximately 3 weekly sampling between the identified chlorophyll-*a* maximum period of mid-November to end of March at the monitoring sites E-779 and E-780. This equates to a minimum of 6 sampling occasions which is recommended within the DP&E guidelines (OEH, 2016) for statistical analysis. At a minimum this would include turbidity and chlorophyll-*a,* although it is recommended that all parameters listed in the table are included in the estuary health assessment.

These recommendations are based on:

- Recommended monitoring sites as indicators of estuary health.
- Continuing to monitor faecal coliforms and enterococci as indicators of recreational quality for primary and secondary recreational activities.
- Reducing the number of monitoring sites. Monitoring sites around the shoreline have been recommended for exclusion as these may not be representative of the estuary and picking up localised issues (i.e., elevated enterococci associated with diffuse runoff and nutrients associated with sediment resuspension). However, it may still be appropriate to sample sites close to shore for enterococci in popular swimming areas that are being used for primary contact recreation (e.g. E335, E38). These sites are also not used in the estuary health program.
- Increasing sampling frequency to get more value from the monitoring program.
    - Physicochemistry and chlorophyll-*a* – This is recommended to be undertaken monthly for physicochemistry and once every 3 weeks for chlorophyll-*a* and turbidity.
    - Pathogens – recommended to be sampled monthly during recreational seasons (spring, summer and autumn).
    - Suspended sediments and nutrients – once during each season.
- Continuing to monitor physicochemistry, chlorophyll-*a* and nutrients across all.
- Recommendation to undertake water quality sampling following high rainfall or pollution events (such as sewage overflows into tributaries or groundwater migration pathways (if known)). This is particularly important for enterococci. It is recommended that an appropriate trigger for wet weather sampling is developed (for example, >75mm combined rainfall in three days). It's important that this information is stored alongside the monitoring data.
- It is recommended that enterococci sampling is paired with a sanitary inspection as undertaken for Beachwatch sites using the DPIE (2020b) template (see Appendix G).

DP&E water quality guidelines for back dune lagoons outlined in Section 2.3 are recommended for comparison to ongoing water quality monitoring.

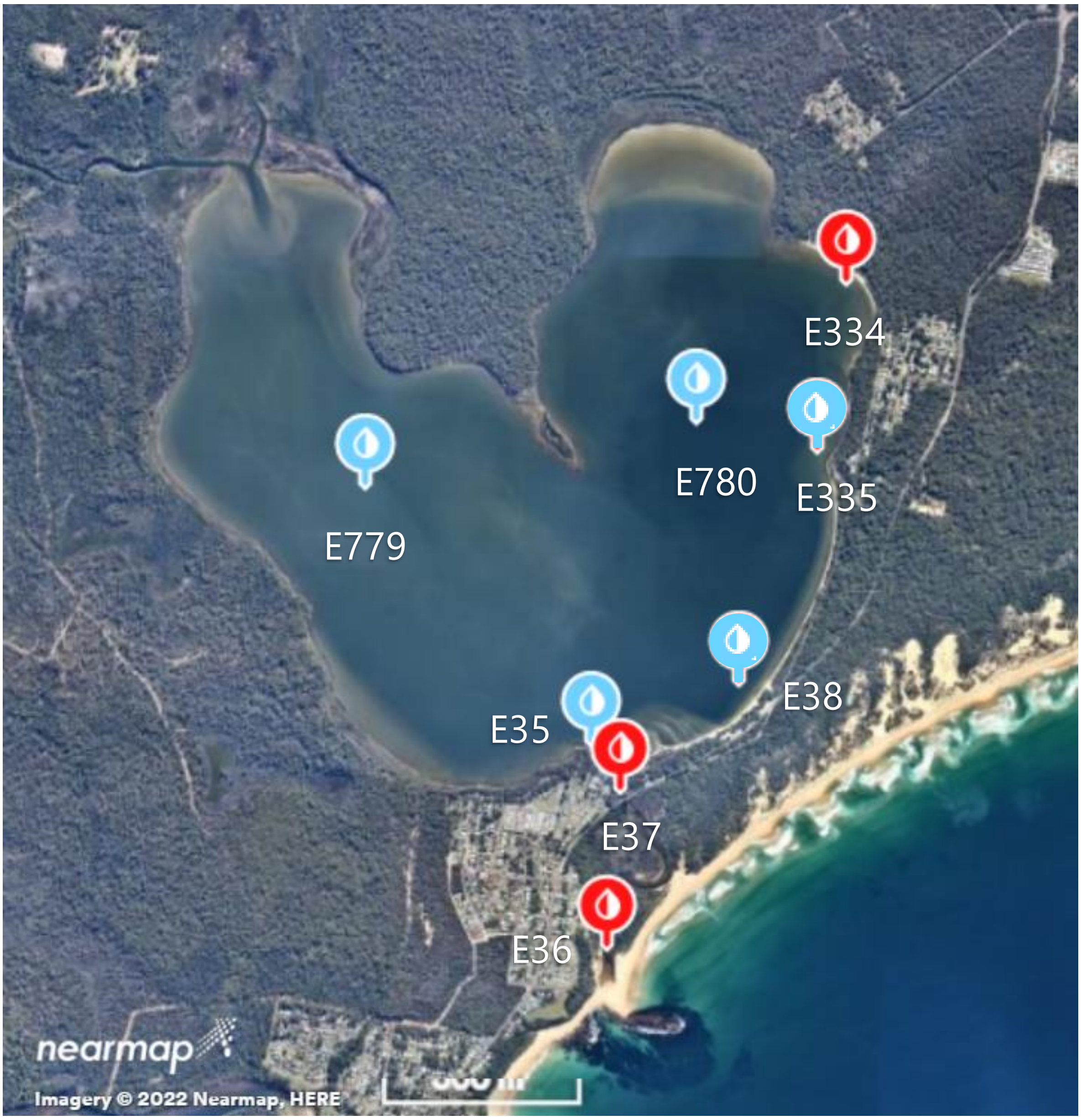


Figure 7-1 Recommended monitoring sites for ongoing water quality sampling. Blue = recommended for inclusion; red = recommended for exclusion.

Table 7-2 Summary of proposed water quality program

<table>
<tr><th>Parameter</th><th>LOR</th><th>Frequency</th><th>Sites</th><th>Rationale</th></tr>
<tr><td colspan="5">Physicochemistry</td></tr>
<tr><td>pH</td><td>--</td><td rowspan="6">Council monitoring, monthly during summer.
Council monitoring once each during other seasons winter, autumn and spring (i.e 3 sampling occasions) with boat based transect sampling.
DPE Estuary Health Assessment[2] Every 3 years, measure every 3 weeks during November to March (i.e. 6 sampling occasions) with boat based transect sampling.
Event sampling[1] as required</td><td rowspan="6">E-35, E-779 and E-780</td><td rowspan="6">Estuary health within basin.</td></tr>
<tr><td>Temperature</td><td>0.1 °C</td></tr>
<tr><td>Salinity</td><td>ppt</td></tr>
<tr><td>Electrical conductivity</td><td>µS/cm</td></tr>
<tr><td>Turbidity</td><td>0.1 ntu</td></tr>
<tr><td>DO</td><td>0.1 mg/L</td></tr>
<tr><td colspan="5">Algae</td></tr>
<tr><td>Chlorophyll-a</td><td>0.5 mg/m^3</td><td>Council monitoring every three weeks during summer (minimum 6 samples between November to March).
Once each during other seasons winter, autumn and spring (i.e. 3 sampling occasions).
Event sampling[1]
Estuary Health Assessment[2] Every 3 years, measure every 3 weeks during November to March (i.e. 6 sampling occasions).</td><td>E-35, E-779 and E-780</td><td>Estuary health within basin.</td></tr>
<tr><td colspan="5">Nutrients</td></tr>
<tr><td>TN</td><td>0.025 mg/L</td><td rowspan="2">Council monitoring once during each season.
Event sampling[1]</td><td rowspan="2">E-35, E-779 and E-780</td><td rowspan="2">Estuary health within basin.
As key indicators to measure erosion improvements works.</td></tr>
<tr><td>TP</td><td>0.005 mg/L</td></tr>
</table>

Parameter	LOR	Frequency	Sites	Rationale
Pathogens				
Enterococci	1 CFU/100ml	Council monitoring monthly during swimming seasons (spring, summer and autumn). Event sampling[1]	E-35, E-38 and E-335	Recreational water quality within basin.
Faecal coliforms	1 CFU/100ml			
Suspended sediments				
TDS	0. 1 mg/L	Council monitoring once during each season. Event sampling[1]	E-35, E-779 and E-780	As key indicators to measure erosion improvement works.
TSS	0.1 mg/L			

LOR = limit of reporting. 1= to investigate potential impacts on water quality during events where elevated enterococci or other water quality parameter readings are recorded,, 2= For the estuary health assessment every 3 years, undertake 3 weekly monitoring of parameters (turbidity and chlorophyll-*a* as minimum) during November to March.

7.2.2 Ecological Health

Updated estuarine health surveys are recommended to be undertaken to assist in the causes and management of issues of potential decline in habitat and estuarine species within Swan Lake.

In particular, the following ecological surveys are recommended:

- Updated macrophyte/Ruppia surveys for inclusion in NSW DPI mapping and to enable comparison of temporal trends to 1982 and 2004.
- Baseline surveys of charophyte beds and swans to be able to monitor ongoing abundance and response following the 2019 drought.
- Targeted fish surveys to identify species, abundance and diversity as baseline to measure over long term.

Estuary health monitoring should be coordinated with DP&E and NSW DPI and existing monitoring and mapping programs.

It is also recommended that records are maintained of the estuary openings as this information will assist with interpretation of the water quality and macrophyte mapping information.

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Appendix A
Summary of Swan Lake Openings

Table 8-1 Summary of Swan Lake Openings (to July 2022)

Opening Date	Closure Date	Natural/artificial	Duration	Opening Level	Notes	Reference
Apr-82 [confirm]	?	A	?	?		Illawarra Mercury, p24, 31/3/82; 1909264 (Estuaries).
7/11/1983	7/03/1984	N	121 days	?	Flood: other sources suggest opening date of 17th Nov. with a duration of ~150 days.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
23/04/1984	30/04/1984	Unknown	7 days	?		Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
28/07/1984	18/08/1984	N	21 days	?	Flood: other sources suggest opening date of 4th Aug. with a duration of 11 days.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
15/10/1985	12/03/1986	N	148 days	?	Flood.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
20/10/1987	2/12/1987	A	43 days	?	Council: Other sources suggest a duration of 36 days.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
1/04/1989	1/06/1989	A	61 days	?	How Opened: 'hand'	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
3/06/1989	15/07/1989	Unknown	42 days	?		Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
12/2/1990 - 14/2/1990	15/05/1990	Unknown	90-92 days	?	How Opened: 'hand' [Artificial] or 'flood' [Natural] (depending on source).	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.

Opening Date	Closure Date	Natural/artificial	Duration	Opening Level	Notes	Reference
1/08/1990	27/08/1990	N	26 days	?	Flood.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
15/09/1990	11/10/1990	Unknown	26 days	?	Other sources suggest opening date of 4th Oct. with a duration of 19 days.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
10/06/1991	12/07/1991	Unknown	32 days	?		Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
10/02/1992	21/03/1992	N	40 days	?	Flood.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
16/05/1993	3/06/1993	A	18 days	1.48	Council.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
14/11/1995	14/02/1996	Unknown	92 days	~2.00	How Opened: 'hand' [Artificial] or 'flood' [Natural] (depending on source).	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
6/7/1997 - 7/7/1997	3/8/97 - 4/8/97	A	28 days	~2.50	How Opened: 'hand'	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
19/08/1998	22/10/1998	N	64 days	2.47	Possible assistance from 'public'.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
3/10/1999	n/a	Unsuccessful Artificial attempt	n/a	?	Unsuccessful attempted opening by 'public'.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13.
15/04/2002	29/05/2002	A	44 days	2.12	How Opened: 'public'.	Swan Lake & Berrara Creek Natural Resources Management Strategy, SCC, Dec. 2002. p. 13; MHL: N.S.W. estuary & River Water Levels Annual Summary 2001-2002.

Opening Date	Closure Date	Natural/artificial	Duration	Opening Level	Notes	Reference
21/08/2011	13/09/2011	N	23	~1.58 (note MHL reports 1.88m)	Council discussed with community reps who confirmed it was a natural breach.	Email Notification Ray Massie (Shoalhaven Council), 23/08/2011
23/06/2013	21/09/2013	N	90	2.2	Beach berm completed Jan 2013 confirming 1.9m crest.	SCC
27/06/2015	18/07/2015	?	21	2.084		MHL website
25/08/2015	24/09/2015	?	30	2.013		MHL website
8/07/2016	5/09/2016	?	59	2.177		MHL website
28/07/2020	26/08/2020	Suspected Artificial	29	2.1	Swan Lake is reported to have been opened (not by Council) rather than naturally breaching and doesn't appear to be dropping as quickly as it would with inflow to boost the scour.	SCC
12/01/2022	4/02/2022	Assisted by public	23	2.132	Assisted by children digging channel. Entrance berm was not high so may have potentially opened naturally without this interference.	Youtube video posted online and MHL data https://www.youtube.com/watch?v=_gXgX9ehHZg
6/03/2022	1/04/2022	N	26	2.08		MHL website and Council staff

Opening Date	Closure Date	Natural/artificial	Duration	Opening Level	Notes	Reference
20/07/2022	Still open at 24/08/22	Suspected artificial	Unknown	2.33	Members of the public dug a channel a few days prior to the lake entrance opening. This channel may have contributed to its opening a few days later following some additional rainfall and increased lake levels	MHL website, DPE and Council staff reports

Appendix B
Water Quality Data from 2010- 2021

					Field							Biological		Algae indicator	Nutrients			Other
					Temperature	Dissolved Oxygen (% Saturation)	Dissolved Oxygen	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorus	Total Dissolved Phosphorus as P	TDS
EQL					0.1	0.1	0.1	0.1		100	0.1	1	1	0.5	0.025	0.005	0.005	
NSW DPIE MER Triggers - Back dune lagoons						80-120		7.9-9.1			4.2			5.3	1.38	0.032	0.013	
NHRMC (2008) Primary contact recreational					15-35							median 150	median < 35					
Area	**Field ID**	**Date**	**Year**	**Season**	**°C**	**%**	**mg/L**	**-**	**ppt**	**µS/cm**	**ntu**	**CFU/100mL**	**cfu/100mL**	**mg/m3**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Swan Lake	E-334	23/02/2010	2010	Summer	25.82	116.4	8.77	8.5	13.61	22600	0.3	0		0.7				14000
Swan Lake	E-334	22/06/2010	2010	Winter	12.75	110.8	10.9	8.73	12.21	21470	0.8	1	0					13000
Swan Lake	E-334	5/10/2010	2010	Spring	21.96	83.9	6.91	10.33	10.55	17900	14.5	0	1					11000
Swan Lake	E-334	17/01/2011	2011	Summer	25.76	124.4	9.5	9.11	11.29		0.1		1					12000
Swan Lake	E-334	4/04/2011	2011	Autumn	22.33	118	9.6	8.49	11.09	18700	0.1	200	100					
Swan Lake	E-334	1/11/2011	2011	Spring	23.95	52.8	4.2	9.35	9.97	1700	0.9		0					
Swan Lake	E-334	14/11/2011	2011	Spring	27.53	141	10.54	9.59	9.57	16360		40	0					10000
Swan Lake	E-334	17/01/2012	2012	Summer	27.3	66.1	4.9	7.76	10.53	17900	6	0	0					
Swan Lake	E-334	28/05/2012	2012	Autumn	13.77			7.43	7.08	12400	12.1	3	3					
Swan Lake	E-334	29/01/2013	2013	Summer	25.6			7.78	7.72	13410		630	2600					
Swan Lake	E-334	21/01/2014	2014	Summer	26.39	102	7.46	9.35	17.09	27820	5.8	0	0					
Swan Lake	E-334	30/04/2014	2014	Autumn	19.98	101.2	8.5	7.87	14.53	24000	19.1	510	78					
Swan Lake	E-334	12/11/2014	2014	Spring	22.61	84.6	6.8	8.09	11.61	19500	2.7							
Swan Lake	E-334	12/11/2014	2014	Spring								2	5					
Swan Lake	E-334	18/05/2015	2015	Autumn								7	1					
Swan Lake	E-334	24/11/2015	2015	Spring	27.96	89	6.5	8.32	13.44	22300								
Swan Lake	E-334	24/11/2015	2015	Spring								1	1					
Swan Lake	E-334	5/04/2016	2016	Autumn	25.26	66	5.1	7.92	11.64	19600								
Swan Lake	E-334	6/04/2016	2016	Autumn								2	1					
Swan Lake	E-334	21/11/2016	2016	Spring	27.33	105.9	7.55	6.25	18.78	30320	2.4							
Swan Lake	E-334	21/11/2016	2016	Spring								1	1					
Swan Lake	E-334	4/05/2017	2017	Autumn								13	7					
Swan Lake	E-334	21/11/2017	2017	Spring	26.29	79.1	5.85	9.27	15.37		10.9							
Swan Lake	E-334	21/11/2017	2017	Spring								1	1					
Swan Lake	E-334	17/09/2018	2018	Spring	18.89	121.6	10.64		10.4	17660								
Swan Lake	E-334	17/09/2018	2018	Spring								1	1					
Swan Lake	E-334	19/09/2018	2018	Spring	17.99	114.6	9.7	7.63	18.77	30290	1.7							
Swan Lake	E-334	3/12/2018	2018	Summer	23.11	108.5	8.33	7.32	18.95	30560	17.2							
Swan Lake	E-334	3/12/2018	2018	Summer								3	1					
Swan Lake	E-334	11/04/2019	2019	Autumn	19.95	121.5	9.66	8.07	22.94	36350	47.9							
Swan Lake	E-334	11/04/2019	2019	Autumn								1	1					
Swan Lake	E-334	14/11/2019	2019	Spring								1	2					
Swan Lake	E-334	15/04/2020	2020	Autumn								4	4					
Swan Lake	E-334	23/11/2020	2020	Spring	24.46	84.8		7.36	16.15		30.4	1	1					
Swan Lake	E-334	15/04/2021	2021	Autumn								1	1					
Swan Lake	E-335	23/02/2010	2010	Summer	26.29	124.3	9.29	8.58	13.66	22680	0.2	0		0.62				14000
Swan Lake	E-335	22/06/2010	2010	Winter	12.65	110.9	10.93	8.76	12.13	20340	0	1	6					13000
Swan Lake	E-335	5/10/2010	2010	Spring	21.83	77.7	6.41	10.33	10.63	18.02	13.3	0	4					11000
Swan Lake	E-335	17/01/2011	2011	Summer	26.04	131.6	10	9.14	11.29	19040	0.2		0					12000
Swan Lake	E-335	4/04/2011	2011	Autumn	21.76	88.6	7.3	8.5	11.11	18800	0.1	0	8					
Swan Lake	E-335	1/11/2011	2011	Spring	23.42	47.4	3.8	8.54	10.02	17100	1.5		0					
Swan Lake	E-335	14/11/2011	2011	Spring	26.88	125.8	9.5	9.57	9.73	16620	91.4	37	5					10000
Swan Lake	E-335	17/01/2012	2012	Summer	27.65	82.5	6.1	7.69	10.75	18200	2.2	0	0					
Swan Lake	E-335	28/05/2012	2012	Autumn	13.73			6.46	7.09	12400	8.9	12	7					
Swan Lake	E-335	29/01/2013	2013	Summer	26.2	141.3	10.87	8.37	8.84	15210		6900	3900					
Swan Lake	E-335	21/01/2014	2014	Summer	26.32	100.7	7.37	9.35	17.08	27.81	9.6	0	1					
Swan Lake	E-335	30/04/2014	2014	Autumn	20.34	100.3	8	7.02	13.72	22800		29	16					

					Field							Biological		Algae indicator	Nutrients			Other
					Temperature	Dissolved Oxygen (% Saturation)	Dissolved Oxygen	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorus	Total Dissolved Phosphorus as P	TDS
		EQL			0.1	0.1	0.1	0.1		100	0.1	1	1	0.5	0.025	0.005	0.005	
		NSW DPIE MER Triggers - Back dune lagoons				80-120		7.9-9.1			4.2			5.3	1.38	0.032	0.013	
		NHRMC (2008) Primary contact recreational			15-35							median 150	median < 35					
Swan Lake	**E-335**	**12/11/2014**	**2014**	**Spring**	23.55	90.3	7.2	8.01	11.49	19400	2.7							
Swan Lake	**E-335**	**12/11/2014**	**2014**	**Spring**								1	5					
Swan Lake	**E-335**	**18/05/2015**	**2015**	**Autumn**								1	11					
Swan Lake	**E-335**	**24/11/2015**	**2015**	**Spring**	27.52		8.07	8.07	12.69									
Swan Lake	**E-335**	**24/11/2015**	**2015**	**Spring**								1	2					
Swan Lake	**E-335**	**5/04/2016**	**2016**	**Autumn**	25.54	68.2	5.2	7.89	11.64	19600								
Swan Lake	**E-335**	**6/04/2016**	**2016**	**Autumn**	25.45	68.2	5.2	7.89	11.64	19600								
Swan Lake	**E-335**	**6/04/2016**	**2016**	**Autumn**								1	1					
Swan Lake	**E-335**	**21/11/2016**	**2016**	**Spring**	27.28	93.3	6.65	6.25	18.89	30470								
Swan Lake	**E-335**	**21/11/2016**	**2016**	**Spring**								1	1					
Swan Lake	**E-335**	**21/11/2017**	**2017**	**Spring**	25.33	73.9	5.56	9.51	15.3		5.8							
Swan Lake	**E-335**	**21/11/2017**	**2017**	**Spring**								1	2					
Swan Lake	**E-335**	**17/09/2018**	**2018**	**Spring**								2	1					
Swan Lake	**E-335**	**19/09/2018**	**2018**	**Spring**	17.74	113.3	9.64	7.63	18.73	30250	3							
Swan Lake	**E-335**	**3/12/2018**	**2018**	**Summer**	23.25	109	8.34	7.47	18.89	30480								
Swan Lake	**E-335**	**3/12/2018**	**2018**	**Summer**								5	4					
Swan Lake	**E-335**	**11/04/2019**	**2019**	**Autumn**	20.07	119.9	9.54	8	22.39	35560	9.2							
Swan Lake	**E-335**	**11/04/2019**	**2019**	**Autumn**								1	1					
Swan Lake	**E-335**	**14/11/2019**	**2019**	**Spring**								1	1					
Swan Lake	**E-335**	**15/04/2020**	**2020**	**Autumn**								2	5					
Swan Lake	**E-335**	**23/11/2020**	**2020**	**Spring**	24.58	113.3		8.07	16.47		47.5	2	3					
Swan Lake	**E-335**	**15/04/2021**	**2021**	**Autumn**								1	1					
Swan Lake	**E-35**	**23/02/2010**	**2010**	**Summer**	26.63	124	9.21	8.54	13.64	22650	1.8	5		0.5				14000
Swan Lake	**E-35**	**22/06/2010**	**2010**	**Winter**	12.67	111.3	10.97	8.8	12.16	20380	0	2	0					13000
Swan Lake	**E-35**	**5/10/2010**	**2010**	**Spring**	21.51	82.1	6.82	10.22	10.62	18000	14.4	20	3					11000
Swan Lake	**E-35**	**17/01/2011**	**2011**	**Summer**	26.42	138.6	10.48	9.15	11.18	18870	0.1		9					12000
Swan Lake	**E-35**	**4/04/2011**	**2011**	**Autumn**	21.45	134.1	11.1	8.71	11.12	18800	0.2	0	0					
Swan Lake	**E-35**	**1/11/2011**	**2011**	**Spring**	23.45	48.7	3.9	8.88	10.25	17400	0.5		2					
Swan Lake	**E-35**	**14/11/2011**	**2011**	**Spring**	27.19	139.4	10.47	9.42	9.84	16790	4.1	49	5					10000
Swan Lake	**E-35**	**17/01/2012**	**2012**	**Summer**	25.66	68.6	5.2	7.23	12.1	20300	3	0	0					
Swan Lake	**E-35**	**28/05/2012**	**2012**	**Autumn**	13.49			7.23	7.7	13400	2.4	0	0					
Swan Lake	**E-35**	**29/01/2013**	**2013**	**Summer**	26.83	20.6	1.57	8.51	7.69	13370		200	260					
Swan Lake	**E-35**	**21/01/2014**	**2014**	**Summer**	25.33	91.8	6.72	8.41	20.23	32430	232	0	9					
Swan Lake	**E-35**	**30/04/2014**	**2014**	**Autumn**	20.5	95.4	7.9	8.54	14.81	24400	5.7	17	4					
Swan Lake	**E-35**	**12/11/2014**	**2014**	**Spring**	21.77	82.2	6.8	8.02	11.46	19300	0.4							
Swan Lake	**E-35**	**12/11/2014**	**2014**	**Spring**								46	12					
Swan Lake	**E-35**	**18/05/2015**	**2015**	**Autumn**								1	1					
Swan Lake	**E-35**	**24/11/2015**	**2015**	**Spring**	27.2	77.9	5.8	8.3	12.78									
Swan Lake	**E-35**	**24/11/2015**	**2015**	**Spring**								11	5					
Swan Lake	**E-35**	**5/04/2016**	**2016**	**Autumn**	24.2	72.1	5.7	8.3	11.77	19800								
Swan Lake	**E-35**	**6/04/2016**	**2016**	**Autumn**	24.2	72.1	5.7	8.3	11.77	19800								
Swan Lake	**E-35**	**6/04/2016**	**2016**	**Autumn**								45	36					
Swan Lake	**E-35**	**21/06/2016**	**2016**	**Winter**	12.73	58.5	6.2	6.89										
Swan Lake	**E-35**	**21/11/2016**	**2016**	**Spring**	25.86	101.6	7.43	6.28	18.73	30240	2.8							
Swan Lake	**E-35**	**21/11/2016**	**2016**	**Spring**								1	1					
Swan Lake	**E-35**	**4/05/2017**	**2017**	**Autumn**								20	60					
Swan Lake	**E-35**	**21/11/2017**	**2017**	**Spring**	25.85	77.5	5.78	9.4	15.39	25290	27							
Swan Lake	**E-35**	**21/11/2017**	**2017**	**Spring**								9	3					

					Field							Biological		Algae indicator	Nutrients			Other
					Temperature	Dissolved Oxygen (% Saturation)	Dissolved Oxygen	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorus	Total Dissolved Phosphorus as P	TDS
		EQL			0.1	0.1	0.1	0.1		100	0.1	1	1	0.5	0.025	0.005	0.005	
NSW DPIE MER Triggers - Back dune lagoons						80-120		7.9-9.1			4.2			5.3	1.38	0.032	0.013	
NHRMC (2008) Primary contact recreational					15-35							median 150	median < 35					
Swan Lake	E-35	17/09/2018	2018	Spring								10	1					
Swan Lake	E-35	19/09/2018	2018	Spring	17.69	127.9	10.9	7.84	18.8	30330	9.3							
Swan Lake	E-35	3/12/2018	2018	Summer	23.62	118.5	9.01	7.65	18.96		12.2							
Swan Lake	E-35	3/12/2018	2018	Summer								31	1					
Swan Lake	E-35	11/04/2019	2019	Autumn	21.6	123.8	9.52	8.18	23.33	36900	5.7							
Swan Lake	E-35	11/04/2019	2019	Autumn								2	21					
Swan Lake	E-35	14/11/2019	2019	Spring								1	1					
Swan Lake	E-35	15/04/2020	2020	Autumn								9	2					
Swan Lake	E-35	23/11/2020	2020	Spring	24.54	102.5		8.09	16.51		32.3	1	1					
Swan Lake	E-35	15/04/2021	2021	Autumn								1	1					
Swan Lake	E-38	23/02/2010	2010	Summer	26.7	117.5	8.71	8.56	13.68	22710	0.3	1		5.95				14000
Swan Lake	E-38	22/06/2010	2010	Winter	12.63	110.1	10.89	8.79	11.84	19890	0	5	9					12000
Swan Lake	E-38	5/10/2010	2010	Spring	21.65	91.4	7.57	10.35	10.52	17840	15.2	4	1					11000
Swan Lake	E-38	17/01/2011	2011	Summer	26.07	129.6	9.85	9.13	11.22	18930	0.1		0					12000
Swan Lake	E-38	4/04/2011	2011	Autumn	21.31	132.1	11	8.62	11.08	18700	0.6	0	0					
Swan Lake	E-38	1/11/2011	2011	Spring	21.69	52.6	4.4	9.01	10.18	17300	1		0					
Swan Lake	E-38	14/11/2011	2011	Spring	25.91	100	7.69	9.38	9.7	16560	16.5	3	0					10000
Swan Lake	E-38	17/01/2012	2012	Summer	27.4	73.7	5.5	7.6	10.74	18200	4.4	0	0					
Swan Lake	E-38	28/05/2012	2012	Autumn	13.79			6.62	7.16	12500	1.5	3	8					
Swan Lake	E-38	29/01/2013	2013	Summer	25.03	117.1	9.67	8.54				92	190					
Swan Lake	E-38	21/01/2014	2014	Summer	27.1	99	7.14	9.28	17.29	28.12	17	0	5					
Swan Lake	E-38	30/04/2014	2014	Autumn	20.37	102.4	8.5	8.41	14.88	24500	7.1	14	3					
Swan Lake	E-38	12/11/2014	2014	Spring	22.66	90.6	7.3	8.12	11.43	19300	3.9							
Swan Lake	E-38	12/11/2014	2014	Spring								1	3					
Swan Lake	E-38	18/05/2015	2015	Autumn								1	1					
Swan Lake	E-38	24/11/2015	2015	Spring	27.83	66.7	4.9	8.13	11.9	20000								
Swan Lake	E-38	24/11/2015	2015	Spring								15	4					
Swan Lake	E-38	5/04/2016	2016	Autumn	25.29	68	5.2	8.18	11.13	18800								
Swan Lake	E-38	6/04/2016	2016	Autumn	25.29	68	5.2	8.18	11.13	18800								
Swan Lake	E-38	6/04/2016	2016	Autumn								420	99					
Swan Lake	E-38	21/11/2016	2016	Spring	26.27	101.5	7.4	6.28	18	29170	3.1							
Swan Lake	E-38	21/11/2016	2016	Spring								1	1					
Swan Lake	E-38	4/05/2017	2017	Autumn								1	1					
Swan Lake	E-38	21/11/2017	2017	Spring	25.02	69.5	5.25	9.42	15.38	25280	85.2							
Swan Lake	E-38	21/11/2017	2017	Spring								1	1					
Swan Lake	E-38	17/09/2018	2018	Spring								4	1					
Swan Lake	E-38	19/09/2018	2018	Spring	17.53	94.3	8.09	7.58	18.24	29520	19.3							
Swan Lake	E-38	3/12/2018	2018	Summer	23.54	109.4	8.33	7.42	18.8	30340	293.5							
Swan Lake	E-38	3/12/2018	2018	Summer								5	20					
Swan Lake	E-38	11/04/2019	2019	Autumn	20.59	105.7	8.28	8.09	23.24	36770	4							
Swan Lake	E-38	11/04/2019	2019	Autumn								1	2					
Swan Lake	E-38	14/11/2019	2019	Spring								1	1					
Swan Lake	E-38	15/04/2020	2020	Autumn								2	5					
Swan Lake	E-38	23/11/2020	2020	Spring	24.14	103.5		7.91	15.93		30.5	1	11					
Swan Lake	E-38	15/04/2021	2021	Autumn								6	1					
Swan Lake	E-779	12/01/2010	2010	Summer	26.81	77.3	5.7	8.26	14.13	23380	0.5		0	0				15000
Swan Lake	E-779	12/01/2010	2010	Summer										0				
Swan Lake	E-779	12/01/2010	2010	Summer										0				

					Field							Biological		Algae indicator	Nutrients			Other
					Temperature	Dissolved Oxygen (% Saturation)	Dissolved Oxygen	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorus	Total Dissolved Phosphorus as P	TDS
		EQL			0.1	0.1	0.1	0.1		100	0.1	1	1	0.5	0.025	0.005	0.005	
NSW DPIE MER Triggers - Back dune lagoons						80-120		7.9-9.1			4.2			5.3	1.38	0.032	0.013	
NHRMC (2008) Primary contact recreational					15-35							median 150	median < 35					
Swan Lake	E-779	9/02/2010	2010	Summer	25.26	148.8	11.32	8.4	13.75	22820	0.7		0	0				14000
Swan Lake	E-779	9/02/2010	2010	Summer										0				
Swan Lake	E-779	9/02/2010	2010	Summer										0				
Swan Lake	E-779	23/02/2010	2010	Summer	25.77	112.2	8.46	8.62	13.54	22490	7.8		1	0				14000
Swan Lake	E-779	23/02/2010	2010	Summer										0				
Swan Lake	E-779	23/02/2010	2010	Summer										0				
Swan Lake	E-779	9/03/2010	2010	Autumn										0				
Swan Lake	E-779	9/03/2010	2010	Autumn	24.62	115	8.84	9.01	13.77	22850	27.2		1	1				14000
Swan Lake	E-779	9/03/2010	2010	Autumn										1				
Swan Lake	E-779	22/03/2010	2010	Autumn	24.02	127.8	9.93	8.81	13.92	23070	0.2		0	0				14000
Swan Lake	E-779	22/03/2010	2010	Autumn										0				
Swan Lake	E-779	22/03/2010	2010	Autumn										0				
Swan Lake	E-779	6/04/2010	2010	Autumn									0	0				
Swan Lake	E-779	6/04/2010	2010	Autumn										0				
Swan Lake	E-779	6/04/2010	2010	Autumn										0				
Swan Lake	E-779	13/04/2010	2010	Autumn									0	0				
Swan Lake	E-779	13/04/2010	2010	Autumn										0				
Swan Lake	E-779	13/04/2010	2010	Autumn										0				
Swan Lake	E-779	25/05/2010	2010	Autumn										1				
Swan Lake	E-779	25/05/2010	2010	Autumn	15.04	156.4	14.46	8.79	14.15	23420	2.2		0	2				
Swan Lake	E-779	25/05/2010	2010	Autumn										2				
Swan Lake	E-779	22/06/2010	2010	Winter										0				
Swan Lake	E-779	22/06/2010	2010	Winter										0				
Swan Lake	E-779	22/06/2010	2010	Winter	12.61	125.5	12.37	8.7	12.34	20660	0.2		0	2				13000
Swan Lake	E-779	1/11/2010	2010	Spring	20.42	96.7	7.24	7.65	31.73	48650	0.4		0	0				
Swan Lake	E-779	1/11/2010	2010	Spring										0				
Swan Lake	E-779	1/11/2010	2010	Spring										1				
Swan Lake	E-779	1/12/2010	2010	Summer	20.92	68	5.69	8.82	11.35	19140	0		14	0				
Swan Lake	E-779	1/12/2010	2010	Summer										0				
Swan Lake	E-779	1/12/2010	2010	Summer										0				
Swan Lake	E-779	10/01/2011	2011	Summer	25.57	100.3	7.7	8.69	11.09	18740	0.6		660	0				12000
Swan Lake	E-779	10/01/2011	2011	Summer										0				
Swan Lake	E-779	10/01/2011	2011	Summer										1				
Swan Lake	E-779	17/01/2011	2011	Summer	27.17	136.5	10.19	9.01	10.92	18.47	0.2		1	0				12000
Swan Lake	E-779	17/01/2011	2011	Summer										0				
Swan Lake	E-779	17/01/2011	2011	Summer										0				
Swan Lake	E-779	8/02/2011	2011	Summer	24.18	48.9	3.84	7.69	11.52	19400	0.2		0	0				12000
Swan Lake	E-779	8/02/2011	2011	Summer										0				
Swan Lake	E-779	8/02/2011	2011	Summer										0				
Swan Lake	E-779	22/02/2011	2011	Summer	22.29	101.7	8.27	7.57	11.6	19520	0.2		8	0				
Swan Lake	E-779	22/02/2011	2011	Summer										0				
Swan Lake	E-779	22/02/2011	2011	Summer										0				
Swan Lake	E-779	6/09/2011	2011	Spring	16.94	117.9	10.84	9.24	8.75	15070	8.3		0	0				9000
Swan Lake	E-779	6/09/2011	2011	Spring										0				
Swan Lake	E-779	6/09/2011	2011	Spring										0				
Swan Lake	E-779	4/10/2011	2011	Spring	16.67	55.2	5.1	8.02	9.04	15500	0.7		0	0				
Swan Lake	E-779	4/10/2011	2011	Spring										0				
Swan Lake	E-779	4/10/2011	2011	Spring										0				

					Field							Biological		Algae indicator	Nutrients			Other
					Temperature	Dissolved Oxygen (% Saturation)	Dissolved Oxygen	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorus	Total Dissolved Phosphorus as P	TDS
		EQL			0.1	0.1	0.1	0.1		100	0.1	1	1	0.5	0.025	0.005	0.005	
		NSW DPIE MER Triggers - Back dune lagoons				80-120		7.9-9.1			4.2			5.3	1.38	0.032	0.013	
		NHRMC (2008) Primary contact recreational			15-35							median 150	median < 35					
Swan Lake	E-779	8/11/2011	2011	Spring	24.57	113.9	8.98	9.85	9.47	16200	0.2		0	0				10000
Swan Lake	E-779	8/11/2011	2011	Spring										0				
Swan Lake	E-779	8/11/2011	2011	Spring										0				
Swan Lake	E-779	22/11/2011	2011	Spring	23.59	41.7	3.34	9.24	9.61	16430	0.2		0	0				10000
Swan Lake	E-779	22/11/2011	2011	Spring										0				
Swan Lake	E-779	22/11/2011	2011	Spring										0				
Swan Lake	E-779	6/12/2011	2011	Summer										0				
Swan Lake	E-779	6/12/2011	2011	Summer										0				
Swan Lake	E-779	6/12/2011	2011	Summer	18.6	34.9	3.09	8.45	9.4	16090	75.2		1	3				10000
Swan Lake	E-779	4/01/2012	2012	Summer	27.36	103.4	7.73	8.93	10.19	17330	0.2		1	0				11000
Swan Lake	E-779	4/01/2012	2012	Summer										0				
Swan Lake	E-779	4/01/2012	2012	Summer										0				
Swan Lake	E-779	17/01/2012	2012	Summer	23.67		0.43	7.27	10.47	17770	2		0	0				11000
Swan Lake	E-779	17/01/2012	2012	Summer										0				
Swan Lake	E-779	17/01/2012	2012	Summer										0				
Swan Lake	E-779	14/02/2012	2012	Summer										0				
Swan Lake	E-779	14/02/2012	2012	Summer										0				
Swan Lake	E-779	14/02/2012	2012	Summer	23.42	117.9	9.45	8.43	10.34	17570	1.3		0	1				11000
Swan Lake	E-779	28/02/2012	2012	Summer	26.19	96.5	7.35	8.821	10.47	17780	0.1		0	0				11000
Swan Lake	E-779	28/02/2012	2012	Summer										0				
Swan Lake	E-779	28/02/2012	2012	Summer										1				
Swan Lake	E-779	30/04/2012	2012	Autumn	17.67	35.5	3.24	7.19	6.91	12200	0.2	0	0	0				7000
Swan Lake	E-779	30/04/2012	2012	Autumn										0				
Swan Lake	E-779	30/04/2012	2012	Autumn										0				
Swan Lake	E-779	16/05/2012	2012	Autumn										0				
Swan Lake	E-779	16/05/2012	2012	Autumn										0				
Swan Lake	E-779	16/05/2012	2012	Autumn	16.95	84.5	7.77	9.23	8.5	14660	44.5		0	4				9000
Swan Lake	E-779	23/07/2012	2012	Winter										0				
Swan Lake	E-779	23/07/2012	2012	Winter										1				
Swan Lake	E-779	23/07/2012	2012	Winter	12.38	23.2	2.38	7.97	7.07	12370	0.2		0	2				8000
Swan Lake	E-779	27/08/2012	2012	Winter	13.55	105.8	10.55	8.42	7.24	12640	1.7		0	0				8000
Swan Lake	E-779	27/08/2012	2012	Winter										0				
Swan Lake	E-779	27/08/2012	2012	Winter										0				
Swan Lake	E-779	11/09/2012	2012	Spring	15.77	115.5	10.97		7.3	12750	0.1		0	0				8000
Swan Lake	E-779	11/09/2012	2012	Spring										0				
Swan Lake	E-779	11/09/2012	2012	Spring										0				
Swan Lake	E-779	10/12/2020	2020	Summer	22.73	84.8	6.6	7.87	17.67	28680	32.9	1	1	1	0.732		0.0025	
Swan Lake	E-779	27/01/2021	2021	Summer	25.59	84.8		7.87	17.67		72.2	1	1	3	0.834		0.009	
Swan Lake	E-779	24/02/2021	2021	Summer	22.33	81.9		7.97	18.19		34.2			1	1.22		0.0025	
Swan Lake	E-779	24/03/2021	2021	Autumn	21.8	88.2		7.54	15.86		28.9			3	1.3		0.0025	
Swan Lake	E-779	6/04/2021	2021	Autumn	23.43	86.4		7.69	16.11		30.7			1	1.29		0.0025	
Swan Lake	E-779	7/06/2021	2021	Winter	7.51	94.3		7.7	15.49	8000	3.7			1	1.27		0.0025	
Swan Lake	E-779	5/08/2021	2021	Winter	11.95	85.9			15.56		21.8			1	0.979		0.0025	
Swan Lake	E-780	12/01/2010	2010	Summer	26.36	78.8	5.86	8.17	14.07	23300	4.3		0	0				15000
Swan Lake	E-780	12/01/2010	2010	Summer										0				
Swan Lake	E-780	12/01/2010	2010	Summer										0				
Swan Lake	E-780	9/02/2010	2010	Summer	25.18	109.3	8.31	8.49	13.95	23120	0.7		0	0				15000
Swan Lake	E-780	9/02/2010	2010	Summer										0				

					Field							Biological		Algae indicator Nutrients				Other
					Temperature	Dissolved Oxygen (% Saturation)	Dissolved Oxygen	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorus	Total Dissolved Phosphorus as P	TDS
		EQL			0.1	0.1	0.1	0.1		100	0.1	1	1	0.5	0.025	0.005	0.005	
NSW DPIE MER Triggers - Back dune lagoons						80-120		7.9-9.1			4.2			5.3	1.38	0.032	0.013	
NHRMC (2008) Primary contact recreational					15-35							median 150	median < 35					
Swan Lake	E-780	9/02/2010	2010	Summer										0				
Swan Lake	E-780	23/02/2010	2010	Summer	25.46	133.6	10.13	8.62	13.63	22630	10.1		0	0				14000
Swan Lake	E-780	23/02/2010	2010	Summer										0				
Swan Lake	E-780	9/03/2010	2010	Autumn	24.71	144.8	11.12	9.09	13.68	22710	37.7		0	0				14000
Swan Lake	E-780	9/03/2010	2010	Autumn										0				
Swan Lake	E-780	9/03/2010	2010	Autumn										0				
Swan Lake	E-780	22/03/2010	2010	Autumn	23.93	69.3	5.39	8.9	14.01	23210	0.5		0	0				15000
Swan Lake	E-780	22/03/2010	2010	Autumn										0				
Swan Lake	E-780	22/03/2010	2010	Autumn										0				
Swan Lake	E-780	6/04/2010	2010	Autumn									0	0				
Swan Lake	E-780	6/04/2010	2010	Autumn										0				
Swan Lake	E-780	6/04/2010	2010	Autumn										0				
Swan Lake	E-780	13/04/2010	2010	Autumn									1	0				
Swan Lake	E-780	13/04/2010	2010	Autumn										0				
Swan Lake	E-780	13/04/2010	2010	Autumn										0				
Swan Lake	E-780	25/05/2010	2010	Autumn	15.11	122.8	11.34	8.93	14.15		1.4		0	1				
Swan Lake	E-780	25/05/2010	2010	Autumn										1				
Swan Lake	E-780	25/05/2010	2010	Autumn										2				
Swan Lake	E-780	22/06/2010	2010	Winter	12.56	112.8	11.14	8.7	12.25	20520	0		1	0				13000
Swan Lake	E-780	22/06/2010	2010	Winter										0				
Swan Lake	E-780	22/06/2010	2010	Winter										1				
Swan Lake	E-780	1/11/2010	2010	Spring	20.97	98	7.27	7.64	31.64	48510	1		7	0				
Swan Lake	E-780	1/11/2010	2010	Spring										0				
Swan Lake	E-780	1/11/2010	2010	Spring										0				
Swan Lake	E-780	1/12/2010	2010	Summer	20.79	72.7	6.08	9.02	11.6	19520	0		0	0				12000
Swan Lake	E-780	1/12/2010	2010	Summer										0				
Swan Lake	E-780	1/12/2010	2010	Summer										0				
Swan Lake	E-780	10/01/2011	2011	Summer										0				
Swan Lake	E-780	10/01/2011	2011	Summer	24.98	139.5	10.8	8.83	11.4	19220	0.2		0	2				12000
Swan Lake	E-780	10/01/2011	2011	Summer										2				
Swan Lake	E-780	17/01/2011	2011	Summer	26.1	131.3	9.97	9.11	11.32	19.08	0.2		0	0				12000
Swan Lake	E-780	17/01/2011	2011	Summer										0				
Swan Lake	E-780	17/01/2011	2011	Summer										0				
Swan Lake	E-780	8/02/2011	2011	Summer	25.01	10.8	0.84	7.98	11.56	19470	0.2		0	0				12000
Swan Lake	E-780	8/02/2011	2011	Summer										0				
Swan Lake	E-780	8/02/2011	2011	Summer										0				
Swan Lake	E-780	22/02/2011	2011	Summer	22.78	40.4	3.25	7.73	11.67	19630	0.2		24	0				
Swan Lake	E-780	22/02/2011	2011	Summer										0				
Swan Lake	E-780	22/02/2011	2011	Summer										0				
Swan Lake	E-780	6/09/2011	2011	Spring	16.95	122.1	11.22	9.24	8.68	14950	13.4		0	0				9000
Swan Lake	E-780	6/09/2011	2011	Spring										0				
Swan Lake	E-780	6/09/2011	2011	Spring										0				
Swan Lake	E-780	4/10/2011	2011	Spring	15.59	46.6	4.4	8.8	9.92	16900	0.5		0	0				
Swan Lake	E-780	4/10/2011	2011	Spring										0				
Swan Lake	E-780	4/10/2011	2011	Spring										0				
Swan Lake	E-780	8/11/2011	2011	Spring	23.76	104.4	8.35	9.66	9.76	16660	4.2		0	0				10000
Swan Lake	E-780	8/11/2011	2011	Spring										0				
Swan Lake	E-780	8/11/2011	2011	Spring										0				

					Field							Biological		Algae indicator	Nutrients			Other
					Temperature	Dissolved Oxygen (% Saturation)	Dissolved Oxygen	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorus	Total Dissolved Phosphorus as P	TDS
		EQL			0.1	0.1	0.1	0.1		100	0.1	1	1	0.5	0.025	0.005	0.005	
	NSW DPIE MER Triggers - Back dune lagoons					80-120		7.9-9.1			4.2			5.3	1.38	0.032	0.013	
	NHRMC (2008) Primary contact recreational				15-35							median 150	median < 35					
Swan Lake	E-780	22/11/2011	2011	Spring	23.24	57	4.6	9.13	9.78	16690	0.2		5	0				10000
Swan Lake	E-780	22/11/2011	2011	Spring										0				
Swan Lake	E-780	22/11/2011	2011	Spring										0				
Swan Lake	E-780	6/12/2011	2011	Summer	17.94	54.5	4.88	8.51	9.8		10.4		0	0				10000
Swan Lake	E-780	6/12/2011	2011	Summer										0				
Swan Lake	E-780	6/12/2011	2011	Summer										0				
Swan Lake	E-780	4/01/2012	2012	Summer	26.49	103.3	7.84	8.96	10.2	17350	0.2		0	0				11000
Swan Lake	E-780	4/01/2012	2012	Summer										0				
Swan Lake	E-780	4/01/2012	2012	Summer										0				
Swan Lake	E-780	17/01/2012	2012	Summer	23.61	74.4	5.94	8.26	10.48	17790	59.8		0	0				11000
Swan Lake	E-780	17/01/2012	2012	Summer										0				
Swan Lake	E-780	17/01/2012	2012	Summer										0				
Swan Lake	E-780	14/02/2012	2012	Summer	22.94	107.7	8.7	8.22	10.55	17890	3.8		6	0				11000
Swan Lake	E-780	14/02/2012	2012	Summer									0					
Swan Lake	E-780	14/02/2012	2012	Summer									2					
Swan Lake	E-780	28/02/2012	2012	Summer	25.82	90.6	6.94	8.73	10.53	17860	6.1		0	0				11000
Swan Lake	E-780	28/02/2012	2012	Summer										0				
Swan Lake	E-780	28/02/2012	2012	Summer										1				
Swan Lake	E-780	30/04/2012	2012	Autumn	17.7	30.1	2.86	7.19	3.52	889			0	0				4000
Swan Lake	E-780	30/04/2012	2012	Autumn										0				
Swan Lake	E-780	30/04/2012	2012	Autumn										0				
Swan Lake	E-780	16/05/2012	2012	Autumn	17.84	60.1	5.43	8.56	8.56	14760	61.2		0	0				9000
Swan Lake	E-780	16/05/2012	2012	Autumn										0				
Swan Lake	E-780	16/05/2012	2012	Autumn										0				
Swan Lake	E-780	23/07/2012	2012	Winter	12.27	27.9	2.87	7.99	7.09	12410	0		0	0				8000
Swan Lake	E-780	23/07/2012	2012	Winter										1				
Swan Lake	E-780	23/07/2012	2012	Winter										3				
Swan Lake	E-780	27/08/2012	2012	Winter	13.51	104	10.37	8.37	7.24	12650	0		0	0				8000
Swan Lake	E-780	27/08/2012	2012	Winter										0				
Swan Lake	E-780	27/08/2012	2012	Winter										2				
Swan Lake	E-780	11/09/2012	2012	Spring	15.36	105.5	10.11		7.31	12750	0		0	0				8000
Swan Lake	E-780	11/09/2012	2012	Spring										0				
Swan Lake	E-780	11/09/2012	2012	Spring										0				
Swan Lake	E-780	10/12/2020	2020	Summer	22.56	101	7.89	7.89	17.65	28650	33.6	1	1	11	0.751		0.006	
Swan Lake	E-780	27/01/2021	2021	Summer	25.53	101		7.89	17.65		74			1	0.834		0.009	
Swan Lake	E-780	24/02/2021	2021	Summer	22.1	82.2		7.91	18.18		33.8			1	1.23		0.0025	
Swan Lake	E-780	24/03/2021	2021	Autumn	21.29	92.8		7.28	13.5		25.1			1	1.16		0.01	
Swan Lake	E-780	6/04/2021	2021	Autumn	23.38	86.1		7.72	16.2		30.6			1	1.35		0.0025	
Swan Lake	E-780	7/06/2021	2021	Winter	7.65	101.6		7.83	15.47	8000	6.3			1	1.34		0.0025	
Swan Lake	E-780	5/08/2021	2021	Winter	11.87	94.8			15.53		21.4			1	1.09		0.0025	
Swan Lake Inlet	E-36	23/02/2010	2010	Summer	26.47	108.2	8.16	7.96	11.53	19420	29.5	3		7.13				12000
Swan Lake Inlet	E-36	22/06/2010	2010	Winter	14.19	82.9	7.77		14.93	24590		10	36					
Swan Lake Inlet	E-36	5/10/2010	2010	Spring	21.62	76.8	6.35	9.02	10.99	18580	58.1	12	45					12000
Swan Lake Inlet	E-36	17/01/2011	2011	Summer	25.96	102.1	7.87	8.55	8.97	15410	68.6		8					10000
Swan Lake Inlet	E-36	4/04/2011	2011	Autumn	21.25	100.2	8.4	8.37	9.72	16600	0.2	60	85					
Swan Lake Inlet	E-36	1/11/2011	2011	Spring	22.06	47.8	3.8	8.14	16.06	26300	0.8		6					
Swan Lake Inlet	E-36	14/11/2011	2011	Spring	26.72	103.8	7.69	8.35	13.71	22750	63.5	81	1					14000
Swan Lake Inlet	E-36	17/01/2012	2012	Summer	27.01	66.8	4.9	7.91	16.45	26900	1.2	0	0					

					Field							Biological		Algae indicator	Nutrients			Other
					Temperature	Dissolved Oxygen (% Saturation)	Dissolved Oxygen	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorus	Total Dissolved Phosphorus as P	TDS
		EQL			0.1	0.1	0.1	0.1		100	0.1	1	1	0.5	0.025	0.005	0.005	
NSW DPIE MER Triggers - Back dune lagoons						80-120		7.9-9.1			4.2			5.3	1.38	0.032	0.013	
NHRMC (2008) Primary contact recreational					15-35							median 150	median < 35					
Swan Lake Inlet	E-36	28/05/2012	2012	Autumn	13.51			7.69	6.82	12000	1.4	6	6					
Swan Lake Inlet	E-36	29/01/2013	2013	Summer	26.49	19.1	1.46	9.63	8.73	15030	44.1	320	1500					
Swan Lake Inlet	E-36	21/01/2014	2014	Summer	26.05	88.6	6.4	8.11	20.17	323400		1	6					
Swan Lake Inlet	E-36	30/04/2014	2014	Autumn	20.35	104	8.6	8.3	15.82	25900	4.5	81	15					
Swan Lake Inlet	E-36	12/11/2014	2014	Spring	21.97	103.1	8.4	8.52	11.48	19300	4.3							
Swan Lake Inlet	E-36	12/11/2014	2014	Spring								1	1					
Swan Lake Inlet	E-36	18/05/2015	2015	Autumn								3	3					
Swan Lake Inlet	E-36	24/11/2015	2015	Spring	25.81	95.4	7.1	8.79	15.5	25500								
Swan Lake Inlet	E-36	24/11/2015	2015	Spring								13	18					
Swan Lake Inlet	E-36	6/04/2016	2016	Autumn								1	1					
Swan Lake Inlet	E-36	21/11/2016	2016	Spring	26.5	113.9	8.14	6.26	20.87	33360	8.1							
Swan Lake Inlet	E-36	21/11/2016	2016	Spring								8	12					
Swan Lake Inlet	E-36	4/05/2017	2017	Autumn								13	1					
Swan Lake Inlet	E-36	21/11/2017	2017	Spring	25.54	64.6	4.85	9.16	15.37	25260	19							
Swan Lake Inlet	E-36	21/11/2017	2017	Spring								4	3					
Swan Lake Inlet	E-36	17/09/2018	2018	Spring								1	1					
Swan Lake Inlet	E-36	19/09/2018	2018	Spring	17.52	127.5	10.79	8.63	20.49	32800	11.4							
Swan Lake Inlet	E-36	3/12/2018	2018	Summer	23.99	124.8	9.47	8.6	18.13		1.3							
Swan Lake Inlet	E-36	3/12/2018	2018	Summer								1	1					
Swan Lake Inlet	E-36	11/04/2019	2019	Autumn	18.68	122.8	10	8.56	23.07	36520	5.1							
Swan Lake Inlet	E-36	11/04/2019	2019	Autumn								1	1					
Swan Lake Inlet	E-36	14/11/2019	2019	Spring								1	1					
Swan Lake Inlet	E-36	15/04/2020	2020	Autumn								11	19					
Swan Lake Inlet	E-36	23/11/2020	2020	Spring	24.86	117.6		8.35	16.86		60.7	34	26					
Swan Lake Inlet	E-36	15/04/2021	2021	Autumn								4	10					
Swan Lake Inlet	E-37	23/02/2010	2010	Summer	27.01	67.5	4.96	7.71	14.4	23790		60		49.98				15000
Swan Lake Inlet	E-37	22/06/2010	2010	Winter	13.56	84.2	8.13		12.41	20770	11.9	120	99	2	1.5	0		13000
Swan Lake Inlet	E-37	5/10/2010	2010	Spring	21.76	112.7	9.31	10.05	10.62	18010	14.5	28	2	2	1.1	0		11000
Swan Lake Inlet	E-37	17/01/2011	2011	Summer	26.43	98.6	7.5	8.73	10	17030	1.5		22	0	1.2	0		11000
Swan Lake Inlet	E-37	4/04/2011	2011	Autumn	21.08	104.7	8.7	8.56	10.99	18600	0.7	100	20	3	0.8	0.02		
Swan Lake Inlet	E-37	1/11/2011	2011	Spring	21.99	47.3	3.9	8.18	11.98	20100	2.3		0	0	0.6	0		
Swan Lake Inlet	E-37	14/11/2011	2011	Spring	26.52	139.2	10.55	8.92	10.49	17800		67	47	0	0.5	0		11000
Swan Lake Inlet	E-37	17/01/2012	2012	Summer	25.53	40.8	3.1	7.21	12.14	20400	5.3	4	5	2	1.1	0.05		
Swan Lake Inlet	E-37	28/05/2012	2012	Autumn	13.67			7.3	7.1	12400	1	10	5	0	1.4	0.65		
Swan Lake Inlet	E-37	29/01/2013	2013	Summer	25.7	95	7.45	9.11	6.92	12120		500	5800	2	0.9	0.03		
Swan Lake Inlet	E-37	21/01/2014	2014	Summer	27.22	99.8	7.19	9.28	17.31	28150	71.2	5	14	6	0.7	0.01		
Swan Lake Inlet	E-37	30/04/2014	2014	Autumn	20.11	95.3	7.9	8.16	15.02	24700	1.8	290	13	6	0.1	0		
Swan Lake Inlet	E-37	12/11/2014	2014	Spring								5	1	1	2.4		0.05	
Swan Lake Inlet	E-37	12/11/2014	2014	Spring	22.47	88.2	7.2	8.02	11.48	19300	3.1							
Swan Lake Inlet	E-37	18/05/2015	2015	Autumn								15	4	1	1.5		0.01	
Swan Lake Inlet	E-37	24/11/2015	2015	Spring								8	3	2	0.7		0.02	
Swan Lake Inlet	E-37	24/11/2015	2015	Spring	25.47	74.3	5.6	8.29	13.71	22700								
Swan Lake Inlet	E-37	5/04/2016	2016	Autumn	23.68	72.2	5.7	8.09	12.08	20300								
Swan Lake Inlet	E-37	6/04/2016	2016	Autumn								99	33	2	0.25		0.01	
Swan Lake Inlet	E-37	6/04/2016	2016	Autumn	23.68	72.2	5.7	8.09	12.08	20300								
Swan Lake Inlet	E-37	21/11/2016	2016	Spring								27	19	2	0.1		0.01	
Swan Lake Inlet	E-37	21/11/2016	2016	Spring	24.74	88.5	6.61	6.29	18.43	29800	28.5							
Swan Lake Inlet	E-37	4/05/2017	2017	Autumn								30	1	1	0.8		0.01	

					Field							Biological		Algae indicator	Nutrients			Other
					Temperature	Dissolved Oxygen (% Saturation)	Dissolved Oxygen	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorus	Total Dissolved Phosphorus as P	TDS
				EQL	0.1	0.1	0.1	0.1		100	0.1	1	1	0.5	0.025	0.005	0.005	
				NSW DPIE MER Triggers - Back dune lagoons		80-120		7.9-9.1			4.2			5.3	1.38	0.032	0.013	
				NHRMC (2008) Primary contact recreational	15-35							median 150	median < 35					
Swan Lake Inlet	**E-37**	**21/11/2017**	**2017**	**Spring**								2	1	1	0.4		0.06	
Swan Lake Inlet	**E-37**	**21/11/2017**	**2017**	**Spring**	23.74	61.6	4.77	9.29	15.39	25290	10.5							
Swan Lake Inlet	**E-37**	**17/09/2018**	**2018**	**Spring**								8	1	3	0.767		0.021	
Swan Lake Inlet	**E-37**	**19/09/2018**	**2018**	**Spring**	17.93	142.2	12.05	8.51	19.16	30880	1.5							
Swan Lake Inlet	**E-37**	**3/12/2018**	**2018**	**Summer**								1	1	1	0.953		0.017	
Swan Lake Inlet	**E-37**	**3/12/2018**	**2018**	**Summer**	23.64	110.5	8.4	7.4	18.73	30240	1.5							
Swan Lake Inlet	**E-37**	**11/04/2019**	**2019**	**Autumn**								11	140	1	1.15		0.012	
Swan Lake Inlet	**E-37**	**11/04/2019**	**2019**	**Autumn**	19.31	98.7	7.93	7.98	23.13	36620	4.1							
Swan Lake Inlet	**E-37**	**14/11/2019**	**2019**	**Spring**								1	6	67	1.5		0.0025	
Swan Lake Inlet	**E-37**	**15/04/2020**	**2020**	**Autumn**								3	58	2	2.33		0.0025	
Swan Lake Inlet	**E-37**	**23/11/2020**	**2020**	**Spring**	24.37	84		7.84	17		32.6	13	22	2	0.678		0.0025	
Swan Lake Inlet	**E-37**	**15/04/2021**	**2021**	**Autumn**								3	34	2	0.884		0.0025	

WQ Triggers

NSW DPIE MER Triggers - Back dune lagoons
NHRMC (2008) Primary contact recreational

91.3

Data Review Notes

Data range was restricted to 2010-current.

Only parameters with a min sample size of 10 were selected.

Data that were clearly erroneous due to instrument error or data entry were removed

Where errorenous results were seen in field data, the rest of that sampling period was reviewed to identify other errors as a result of incorrect calibration.

For micro values -1 were assumed to be <EQL and converted to EQL of 1.

Microbiology values <EQL were replaced with EQL.

For turbidity negative values were assumed as 0. This is common with water quality meters and can be calibrated within the sampling period by setting the lowest negative result as 0 and adding the difference to the rest of dataset.

Chemistry values that were reported as <EQL were converted by * 0.5, which is the recommended approach by ANZG.

It is likely that there has been some inconsistency in reporting <EQL with some values converted as negative or zero. Negative or zero values were converted to the next lowest EQL for purposes of calculating statistics.

For chemistry and field data, values over 4 standard deviations from the median were review and removed from dataset if obviously errors due to being outside the possible range for that parameter. Most of these were likely related to a calibration issue with field instrument, as consistent outliers were reported within the same month/sampling period. Other outliers were related to data entry (an extra 0 added).

turbidity values >100 were removed.

Dissolved oxygen % above 150 were removed.

EC below 100 at all sites during April 2018 were removed.

Appendix C
Water Quality Summary Statistics

Table 8-2 Summary of water quality sampling replication during 2010 – October 2021

Parameter/s	Frequency	Sampling Events	Sites
pH, temperature, salinity, turbidity, DO, enterococci	2010, 2011 & 2014	3 – 4 (x 1 sample)	E-334, E-335, E-35, E36, E-37, E-38
	2012, 2013, 2015, 2017, 2019	1 (x 1 sample)	
	2020 and 2021	2 (x 1 sample)	
	2010, 2011 and 2012	9 (x 1 sample)	E-779, E-780
	2020	1 (x 1 sample)	
	2021	6 (x 1 sample)	
TP and TN	All years	1 – 2 (x 1 sample)	E-37
Chlorophyll-*a*	2010, 2011 and 2012	5 - 6 (x 3 samples)	E-779, E-780
	2020	1 (x 1 sample)	
	2021	6 (x 1 sample)	
	All years	1 – 2	E-37
Enterococci	2010	2 (x 1 sample)	E-334, E-335, E-35, E36, E-37, E-38
		9 (x 3 samples)	E-779, E-780
	2011	4 (x 1 sample)	E-334, E-335, E-35, E36, E-37, E-38
		9 (x 3 samples)	E-779, E-780
	2012 – 2021	1 to 2	E-334, E-335, E-35, E36, E-37, E-38, E-779, E-780

One sample was collected at each specified site during each event, with exception of some events where 3 replicates were collected of chlorophyll-*a* or enterococci.

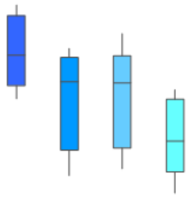
			Temperature	DO	DO	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorous	Total Organic Phosphorous	TDS
Estimated Quantification Limit			0.1	0.1		0.1		100	0.1	1	1	0.5	0.025	0.005		
NSW DPIE MER Triggers - Lagoons				76-107	5.7-7.9	7.5-8.9		4.4			3.9	0.625	0.025	0.01		
NHRMC (2008) Primary contact recreational			15-35							median <150	median < 35					
Area	**Site**	**Stats**	**°C**	**%**	**mg/L**	**-**	**ppt**	**µS/cm**	**ntu**	**CFU/100mL**	**cfu/100 mL**	**mg/m3**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Swan Lake	E-334	Mean	23.05	100	8	8	13	21097	10	59	112	1	--	--	--	12000
Swan Lake	E-334	StDeV	4.30	23.01	2.05	0.95	4.07	7907	12.95	163.45	518.82	--	--	--	--	1581
Swan Lake	E-334	Median	24.21	103.95	8.33	8.09	11.93	19600	5.80	1.00	1.00	0.70	--	--	--	12000
Swan Lake	E-334	Min	12.75	52.80	4.20	6.25	7.08	1700	0.10	0.00	0.00	0.70	--	--	--	10000
Swan Lake	E-334	Max	27.96	141.00	10.90	10.33	22.94	36350	47.90	630.00	2600.00	0.70	--	--	--	14000
Swan Lake	E-334	N	22	20	19	21	22	19	17	24	25	1	--	--	--	5
Swan Lake	E-335	Mean	23.34	99.03	7.75	8.23	13.37	21679	13.04	304.30	166.04	0.62	--	--	--	12000
Swan Lake	E-335	StDeV	4.22	24.53	2.02	0.99	3.89	6328	24.71	1437.84	795.34	--	--	--	--	1581
Swan Lake	E-335	Median	24.96	100.50	7.69	8.07	11.89	19600	3.00	1.00	2.50	0.62	--	--	--	12000
Swan Lake	E-335	Min	12.65	47.40	3.80	6.25	7.09	12400	0.00	0	0	0.62	--	--	--	10000
Swan Lake	E-335	Max	27.65	141.30	10.93	10.33	22.39	35560	91.40	6900	3900	0.62	--	--	--	14000
Swan Lake	E-335	N	22	20	20	22	22	17	15	23	24	1	--	--	--	5
Swan Lake	E-35	Mean	22.63	94.05	7.48	8.30	13.67	22024	19.66	20	18	0.50	--	--	--	12000
Swan Lake	E-35	StDeV	4.53	31.43	2.58	0.88	4.17	6413	53.79	41	52	--	--	--	--	1581
Swan Lake	E-35	Median	24.20	93.60	6.82	8.30	12.13	19800	3.55	7	2	0.50	--	--	--	12000
Swan Lake	E-35	Min	12.67	20.60	1.57	6.28	7.69	13370	0.00	0	0	0.50	--	--	--	10000
Swan Lake	E-35	Max	27.20	139.40	11.10	10.22	23.33	36900	232.00	200	260	0.50	--	--	--	14000
Swan Lake	E-35	N	23	22	21	23	22	19	18	24	25	1	--	--	--	5
Swan Lake	E-38	Mean	23.08	95.37	7.54	8.35	13.50	21848	27.96	24	15	5.95	--	--	--	11800
Swan Lake	E-38	StDeV	4.16	21.82	1.98	0.93	3.91	5977	69.26	86	41	--	--	--	--	1483
Swan Lake	E-38	Median	24.58	100.00	7.63	8.30	11.84	19300	4.20	2	1	5.95	--	--	--	12000
Swan Lake	E-38	Min	12.63	52.60	4.40	6.28	7.16	12500	0.00	0	0	5.95	--	--	--	10000
Swan Lake	E-38	Max	27.83	132.10	11.00	10.35	23.24	36770	293.50	420	190	5.95	--	--	--	14000
Swan Lake	E-38	N	22	21	20	22	21	19	18	24	25	1	--	--	--	5
Swan Lake	E-779	Mean	20.80	90.97	7.57	8.37	12.50	19114	11.76	1	22	0.36	1.09	--	0.00	11045

			Temperature	DO	DO	pH	Salinity	Electrical Conductivity	Turbidity	Faecal Coliforms	Enterococci	Chlorophyll a	Nitrogen	Total Phosphorous	Total Organic Phosphorous	TDS
Estimated Quantification Limit			0.1	0.1		0.1		100	0.1	1	1	0.5	0.025	0.005		
NSW DPIE MER Triggers - Lagoons				76-107	5.7-7.9	7.5-8.9		4.4			3.9	0.625	0.025	0.01		
NHRMC (2008) Primary contact recreational			15-35							median <150	median < 35					
Area	**Site**	**Stats**	**°C**	**%**	**mg/L**	**-**	**ppt**	**µS/cm**	**ntu**	**CFU/100mL**	**cfu/100 mL**	**mg/m3**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Swan Lake	E-779	StDeV	5.21	30.84	3.33	0.66	4.67	7305	20.27	1	118	0.80	0.24	--	0.00	2319
Swan Lake	E-779	Median	22.53	95.40	7.75	8.43	11.44	17775	0.70	1	0	0.00	1.22	--	0.00	11000
Swan Lake	E-779	Min	7.51	23.20	0.43	7.19	6.91	8000	0.00	0	0	0.00	0.73	--	0.00	7000
Swan Lake	E-779	Max	27.36	148.80	14.46	9.85	31.73	48650	75.20	1	660	4.00	1.30	--	0.01	15000
Swan Lake	E-779	N	34	32	28	32	34	28	34	3	31	94	7	--	7	22
Swan Lake	E-780	Mean	20.63	88.58	7.28	8.42	12.43	18771	13.37	1	1	0.36	1.11	--	0.01	11043
Swan Lake	E-780	StDeV	5.10	33.06	2.99	0.61	4.74	8183	20.26	--	4	1.27	0.24	--	0.00	2705
Swan Lake	E-780	Median	22.67	96.40	7.56	8.50	11.58	17875	3.80	1	0	0.00	1.16	--	0.00	11000
Swan Lake	E-780	Min	7.65	10.80	0.84	7.19	3.52	889	0.00	1	0	0.00	0.75	--	0.00	4000
Swan Lake	E-780	Max	26.49	144.80	11.34	9.66	31.64	48510	74.00	1	24	11.00	1.35	--	0.01	15000
Swan Lake	E-780	N	34	34	28	32	34	26	33	1	32	91	7	--	7	23
Swan Lake Inlet	E-36	Mean	22.83	93.16	7.23	8.36	14.78	39979	22.46	28	72	7.13	--	--	--	12000
Swan Lake Inlet	E-36	StDeV	4.19	28.11	2.30	0.68	4.51	71049	25.82	67	298	--	--	--	--	1633
Swan Lake Inlet	E-36	Median	24.43	102.10	7.82	8.37	15.44	24925	8.10	5	6	7.13	--	--	--	12000
Swan Lake Inlet	E-36	Min	13.51	19.10	1.46	6.26	6.82	12000	0.20	0	0	7.13	--	--	--	10000
Swan Lake Inlet	E-36	Max	27.01	127.50	10.79	9.63	23.07	323400	68.60	320	1500	7.13	--	--	--	14000
Swan Lake Inlet	E-36	N	20	19	18	19	20	18	17	24	25	1	--	--	--	4
Swan Lake Inlet	E-37	Mean	22.71	89.40	7.13	8.24	13.66	22348	12.00	59	254	6.19	0.97	0.07	0.02	12200
Swan Lake Inlet	E-37	StDeV	3.86	25.59	2.19	0.84	4.04	6159	18.57	114	1156	15.65	0.58	0.19	0.02	1789
Swan Lake Inlet	E-37	Median	23.68	88.50	7.33	8.16	12.28	20400	3.60	12	13	2.00	0.88	0.00	0.01	11000
Swan Lake Inlet	E-37	Min	13.56	40.80	3.10	6.29	6.92	12120	0.70	1	0	0.00	0.10	0.00	0.00	11000
Swan Lake Inlet	E-37	Max	27.22	142.20	12.05	10.05	23.13	36620	71.20	500	5800	67.00	2.40	0.65	0.06	15000
Swan Lake Inlet	E-37	N	22	21	20	21	22	21	16	24	25	26	25	11	14	5

Appendix D
Water Quality Graphs – 2010 to 2021

Boxplot graphs were prepared in Minitab 16.0 (2010) for key water quality parameters and are presented by site and season in **Appendix D**. The relevant water quality guidelines (listed in Section 2) were included as reference lines on graphs, with the colour of the reference line matching the relevant sites area (for example, Swan Lake sites were coloured green, with respective DP&E MER guidelines for lagoons also coloured green).

In boxplots, the following information is shown:



End of upper whisker = maximum value excluding outliers
Upper end of box = 75th percentile value
Middle line = median value
Lower end of box = 25th percentile value
End of lower whisker = minimum value excluding outliers

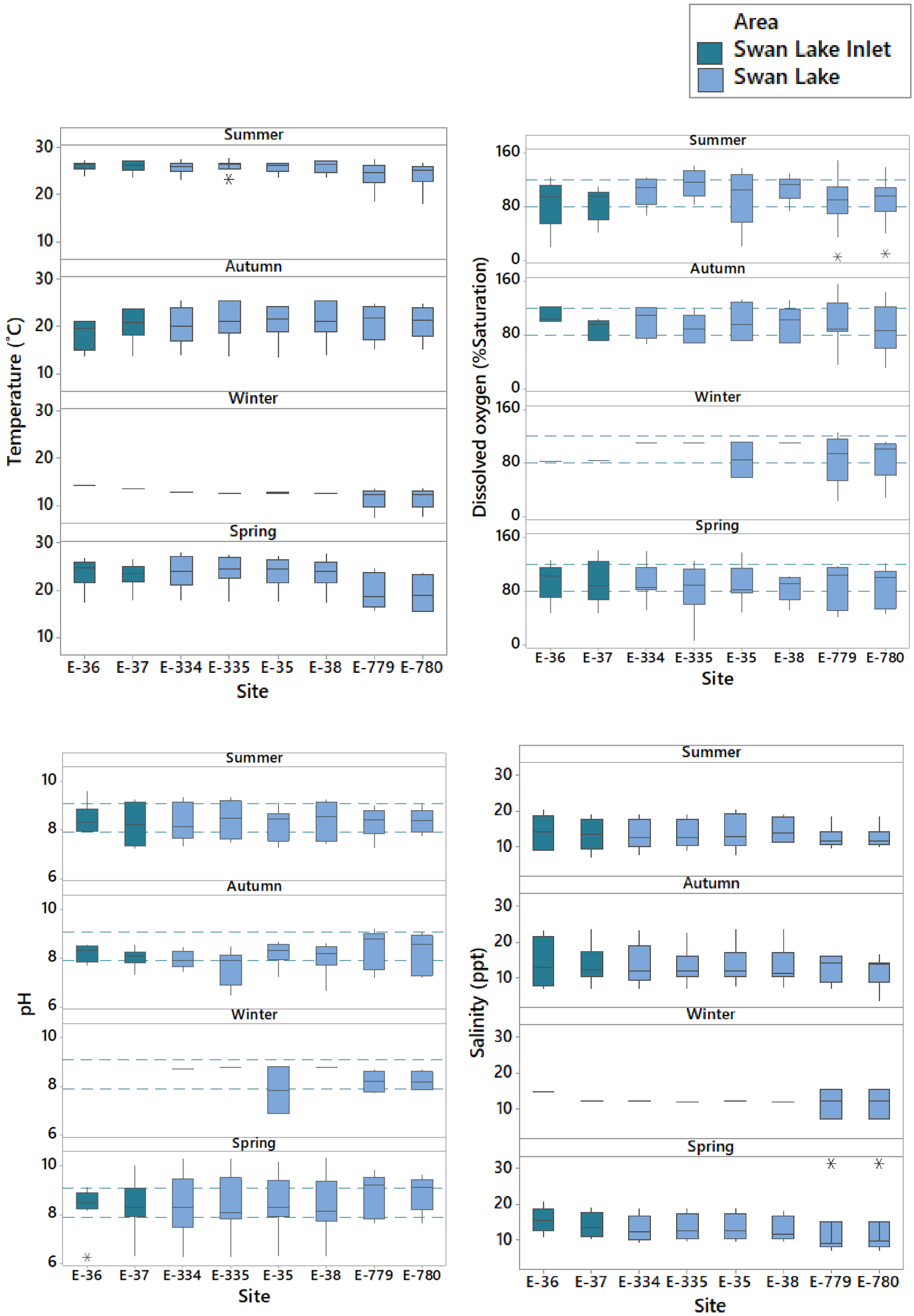


Figure 8-1 Temperature (°C), dissolved oxygen (%), pH and salinity (ppt) by season in Swan Lake from January 2010 - October 2021.

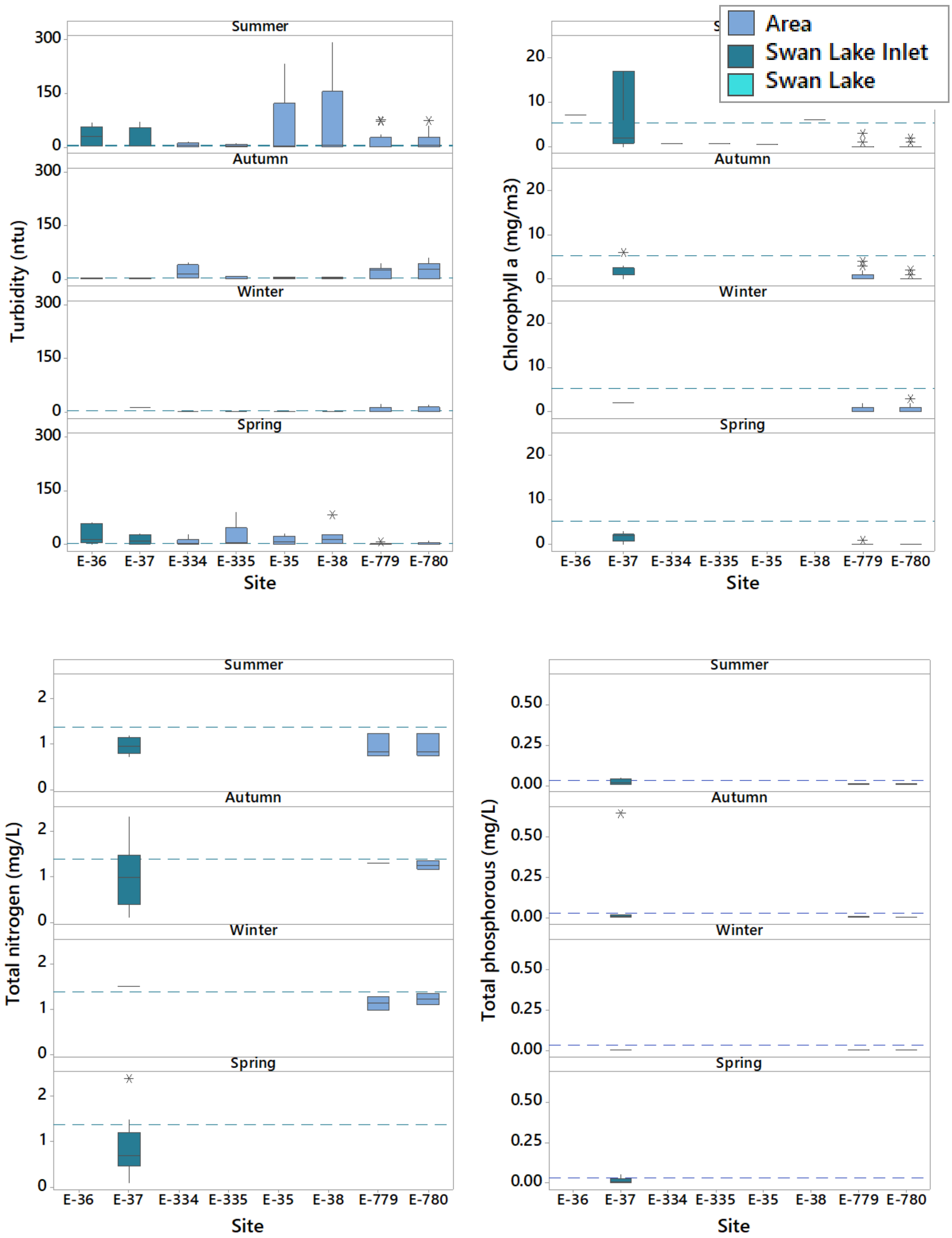


Figure 8-2 Turbidity (NTU), chlorophyll – a (mg/m^3), total nitrogen as N (mg/L) and total phosphorous as P (mg/L) by season in Swan Lake from January 2010 - October 2021. Dotted lines show DPIE MER guideline for Lagoons. Note elevated value of 0.65 mg/L of total phosphorous at E-37 during autumn is excluded from graph.

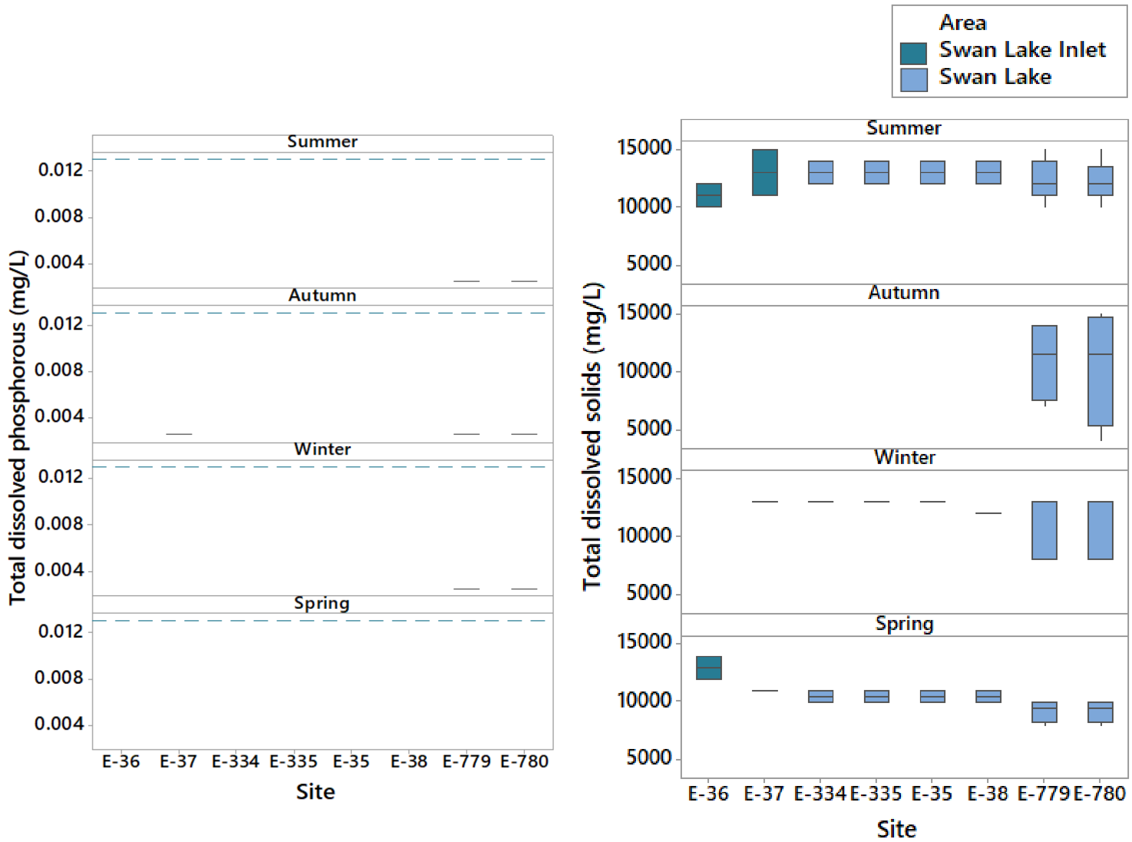


Figure 8-3 Total organic phosphorous as P (mg/L) and total dissolved solids (mg/L) by season in Swan Lake from January 2010 - October 2021. Dotted line shows DPIE MER guideline for Lagoons.

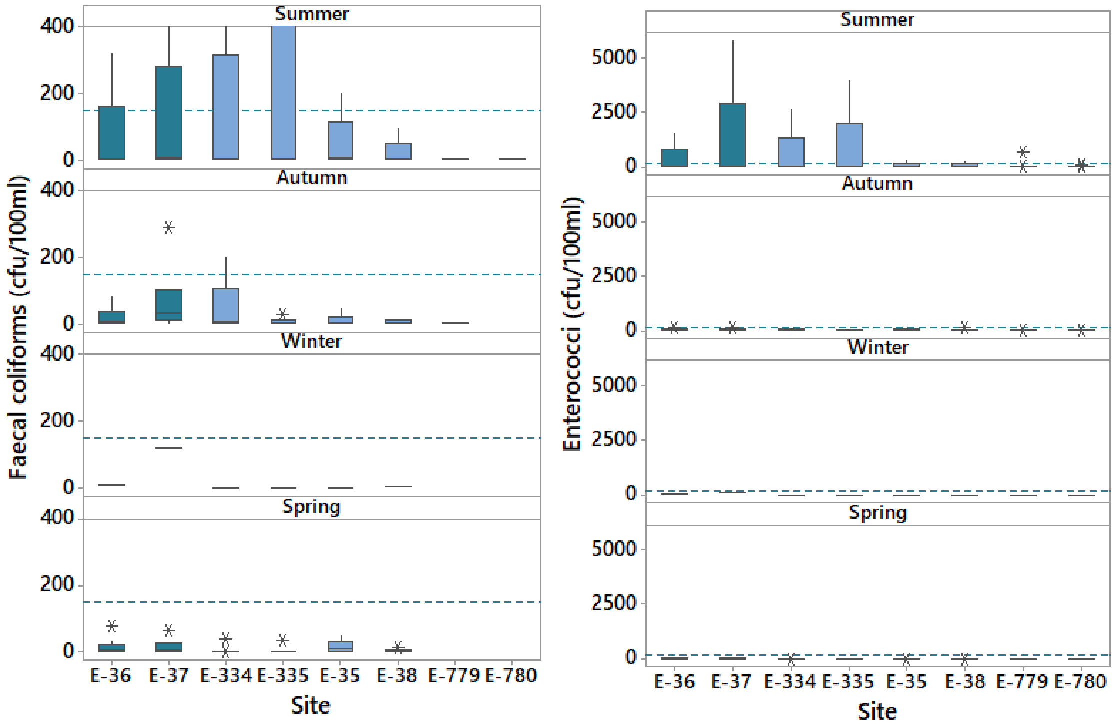


Figure 8-4 Faecal coliforms (cfu/100ml) and enterococci (cfu/100ml) by season in Swan Lake from January 2010 - October 2021. Dotted line shows NHMRC (2008) Primary Recreational Guidelines for comparison to 95%ile values at primary recreational sites. An elevated value of 6,900 cfu/100ml for faecal coliforms at E-335 is not shown.

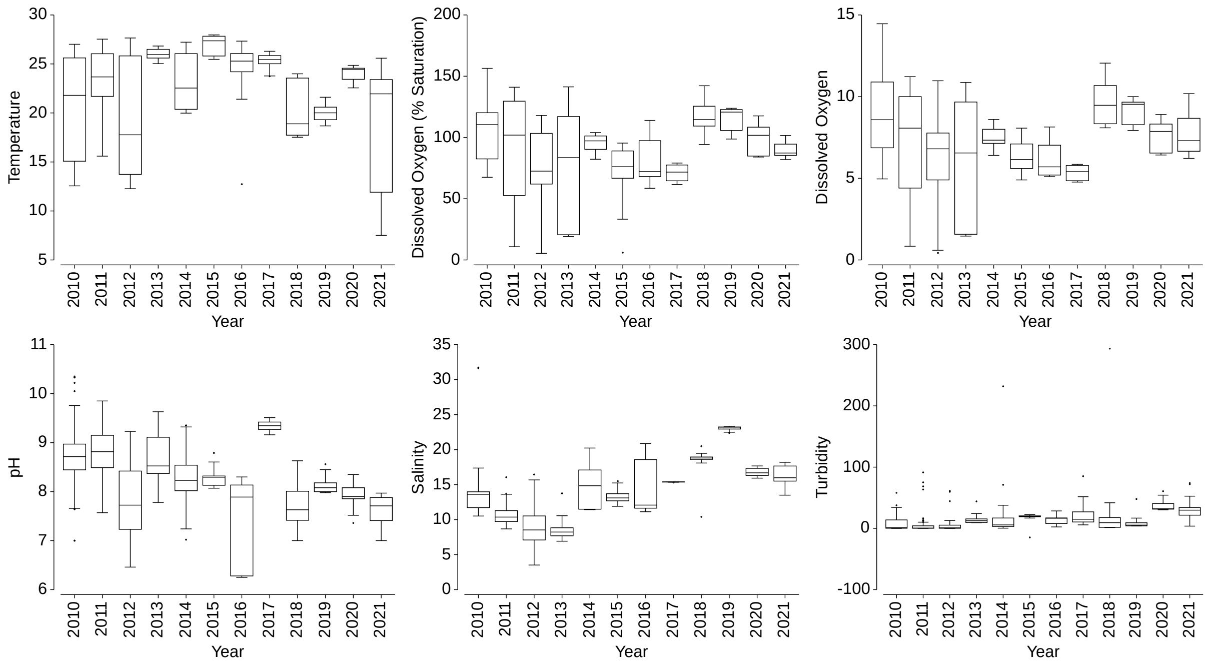


Figure 8-5 Summary of physicochemistry parameters in Swan Lake and Swan Lake Inlet during all sampling years (all sampling sites pooled).

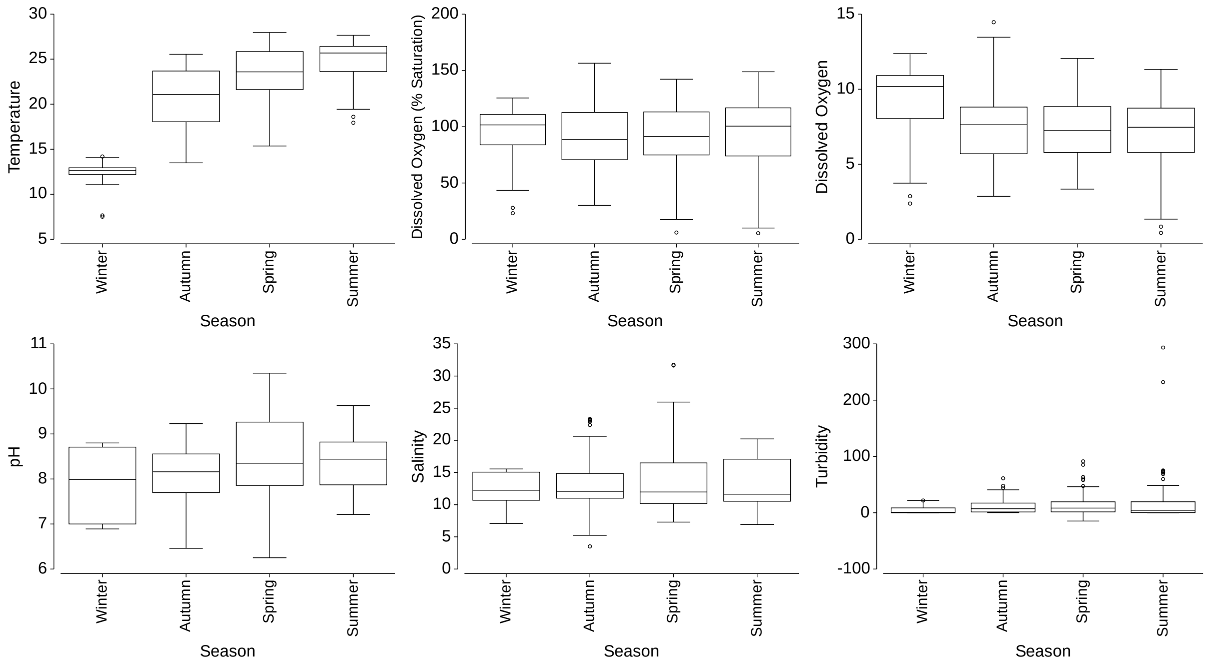


Figure 8-6 Summary of physicochemistry parameters in Swan Lake and Swan Lake Inlet during all sampling seasons (all sampling sites pooled).

Appendix E
Water Quality Analysis

Multivariate Analysis Methodology

Summary statistics for key water quality indicators were prepared in Minitab 16.0 and included mean, median, minimum, maximum and standard deviation.

Multivariate analyses were undertaken in PRIMER 7 with the PERMANOVA add on (Anderson et al. 2008; Clarke et al. 2014a) to determine differences in physicochemical water quality data between sites, areas, seasons or years. Due to the nature of multivariate analysis, there needs to be a matched dataset available for all parameters included in the analysis, so this restricted the data that could be included. The selected dataset used for analysis included sites within Swan Lake and Swan Lake Inlet during 2010 - 2021, where data was available for all the physiochemical parameters temperature (°C), pH, salinity (PSU), dissolved oxygen (DO) (%), turbidity (NTU) and chlorophyll-*a* (mg/m^3).

For multivariate analysis, the data needs to be transformed to achieve similar distribution among the variables. The water quality dataset was transformed using log + 1 transformation which is typical for this type of environmental data. The transformed dataset was then used to make a resemblance matrix using the Euclidean similarity metric, which is robust to environmental data measured on different scales. A resemblance matrix is a matrix of scores which represents the pairwise similarity between each pairwise combination of data points. This matrix was then used to generate multi-dimensional scaling (MDS) plots which were then overlaid with various factors of interest (e.g. area, site, season and year). Goodness of fit (stress) was assessed using Kruskal's stress formula and compared to maximum values (stress should be less than 0.2) as recommended by Sturrock and Rocha (2000).

Water Quality Analysis

The below graphs show the combined physicochemistry and chlorophyll-*a* data, where points that are closer together have more similar water quality and points further apart are more different. In each plot below, the points are in the same position but are shaded by the different factors of site, year and season. This allows a visualisation of whether there are differences between sites, years or seasons. Vectors were overlaid on the graphs of all physiochemical parameters and chlorophyll-*a*. The direction of the vector indicates sample points most influenced by that parameter and the length correlates to the strength of the relationship.

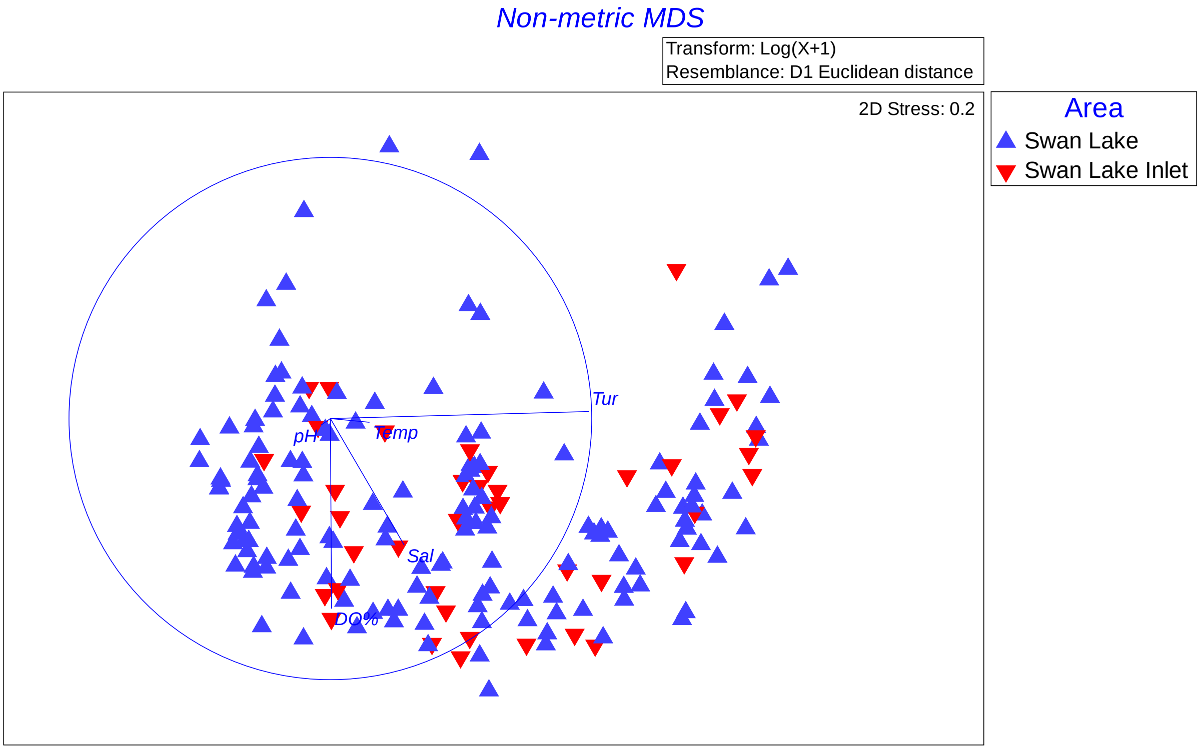


Figure 8-7 nMDS plot of water quality in Swan Lake grouped by area (Swan Lake v Swan Lake Inlet).

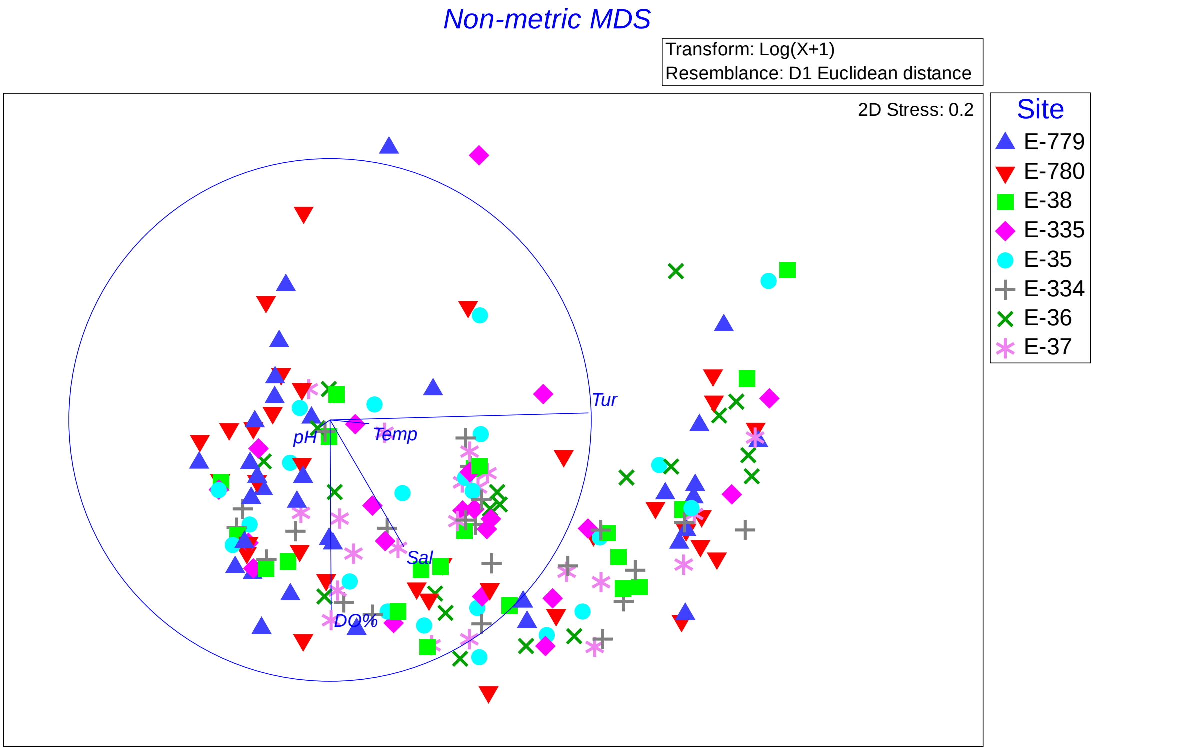


Figure 8-8 nMDS plot of water quality within Swan Lake and Swan Lake Inlet grouped by site.

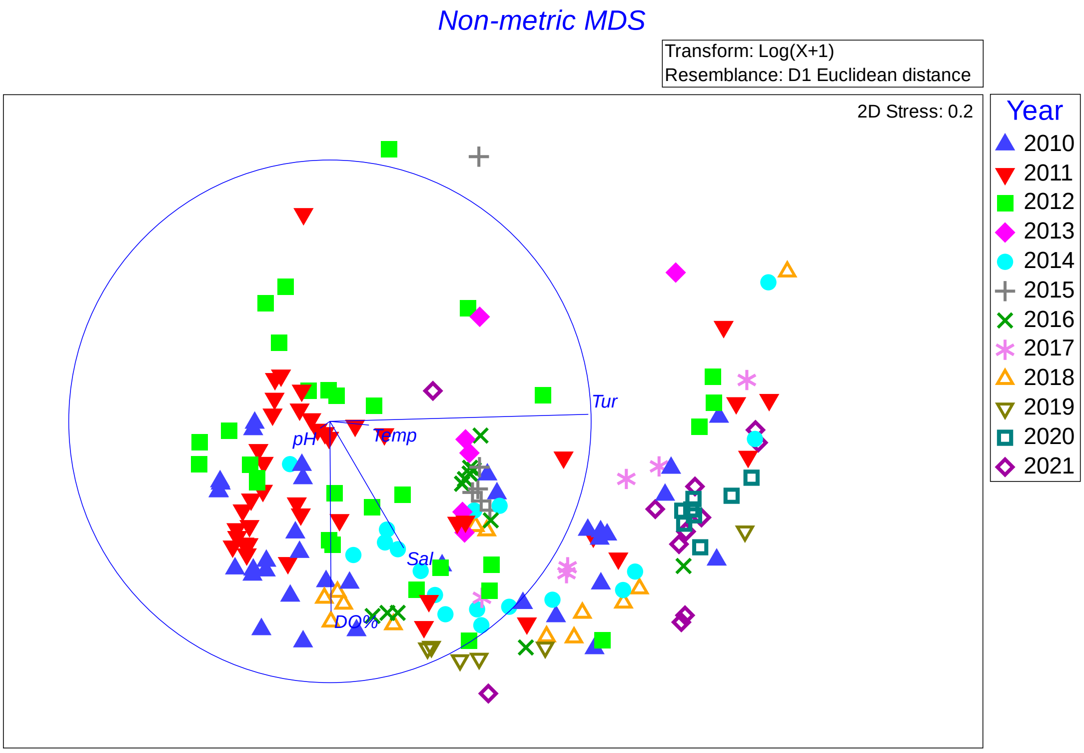


Figure 8-9 nMDS plot of water quality in Swan Lake and Swan Lake Inlet grouped by year.

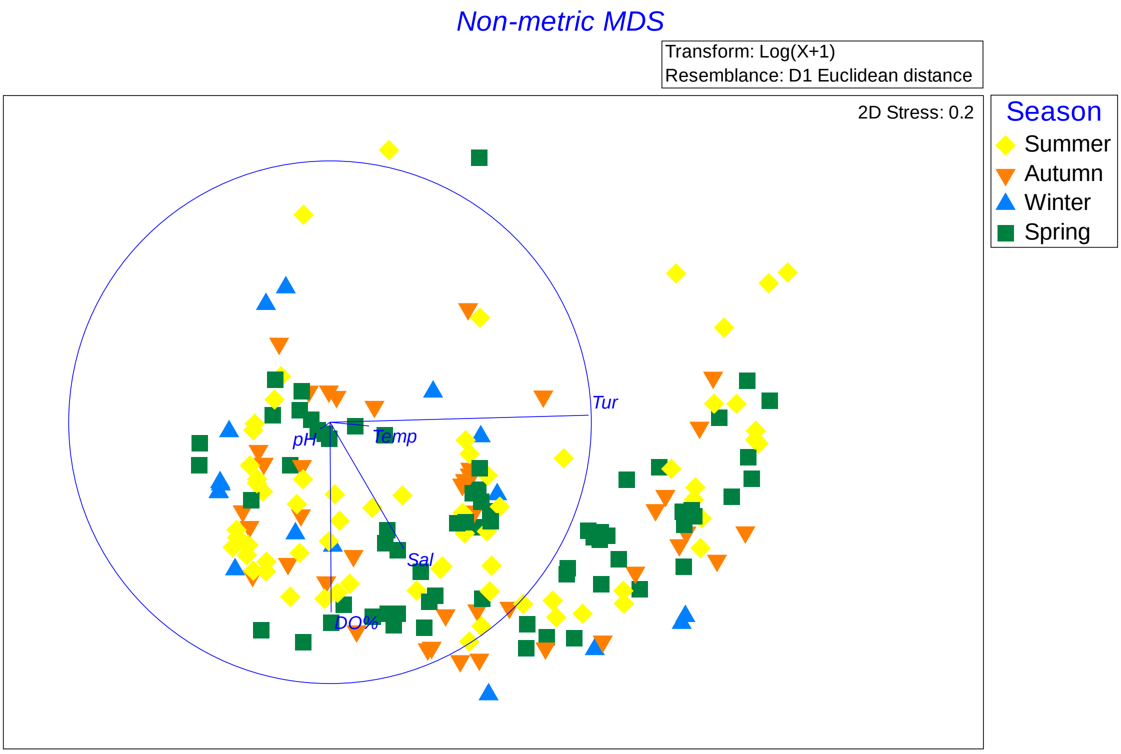
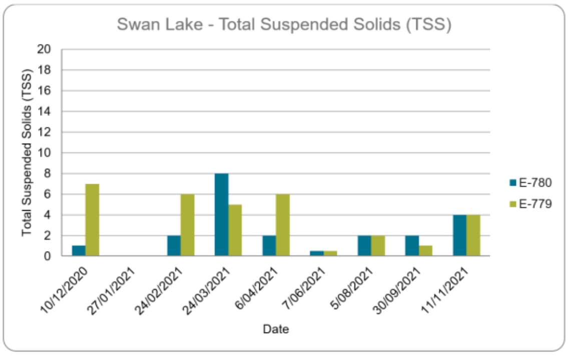
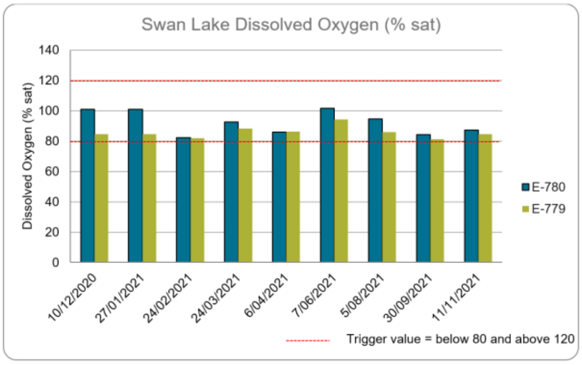
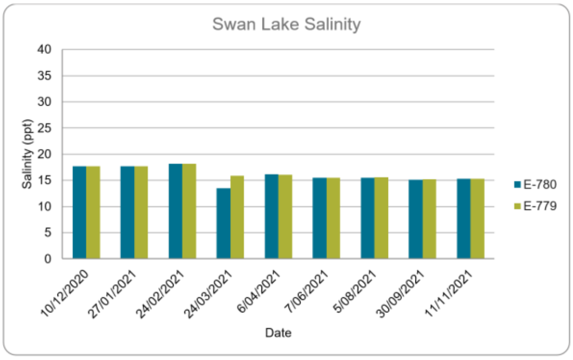


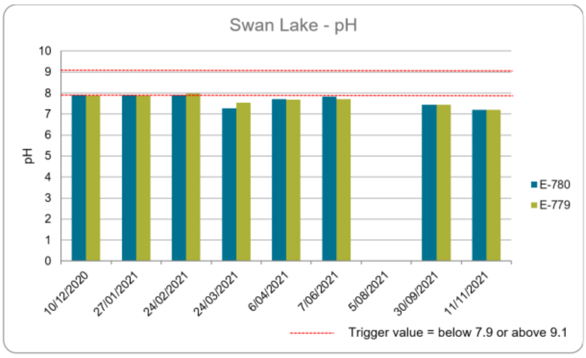
Figure 8-10 nMDS plot of water quality in Swan Lake and Swan Lake Inlet grouped by season.

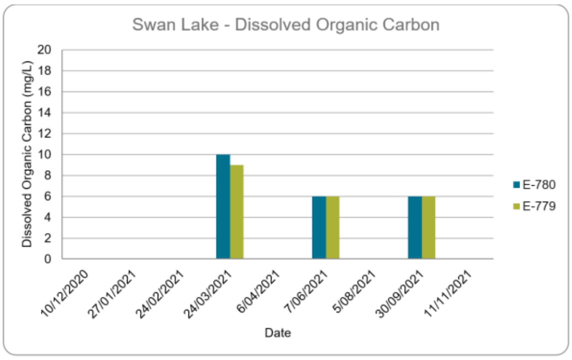
Appendix F
DP&E Water Quality Graphs 2020 - 2021

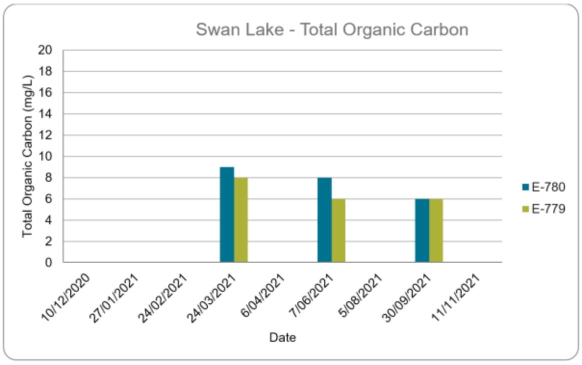

Swan Lake - Total Suspended Solids (TSS)
Total Suspended Solids (TSS)
Date
10/12/2020 27/01/2021 24/02/2021 24/03/2021 6/04/2021 7/06/2021 5/08/2021 30/09/2021 11/11/2021
E-780
E-779

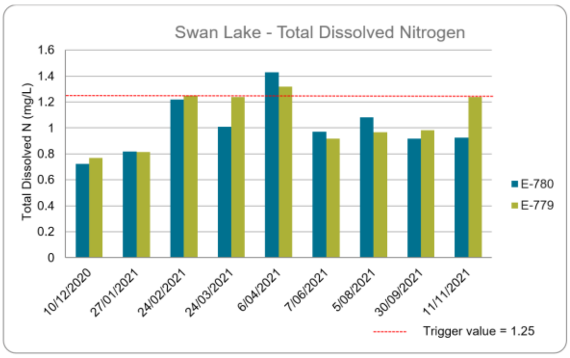

Swan Lake Dissolved Oxygen (% sat)
Dissolved Oxygen (% sat)
10/12/2020 27/01/2021 24/02/2021 24/03/2021 6/04/2021 7/06/2021 5/08/2021 30/09/2021 11/11/2021
E-780
E-779
Trigger value = below 80 and above 120

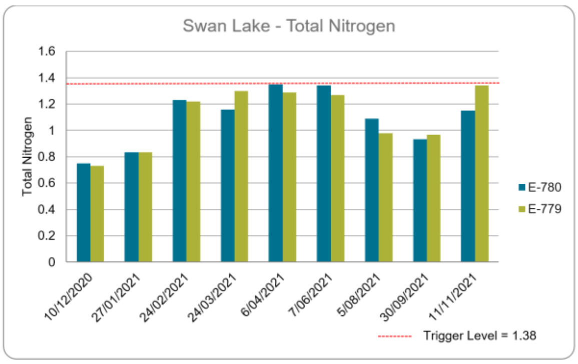

Swan Lake Salinity
Salinity (ppt)
Date
10/12/2020 27/01/2021 24/02/2021 24/03/2021 6/04/2021 7/06/2021 5/08/2021 30/09/2021 11/11/2021
E-780
E-779


Swan Lake - pH
pH
10/12/2020 27/01/2021 24/02/2021 24/03/2021 6/04/2021 7/06/2021 5/08/2021 30/09/2021 11/11/2021
E-780
E-779
Trigger value = below 7.9 or above 9.1


Swan Lake - Dissolved Organic Carbon
Dissolved Organic Carbon (mg/L)
Date
10/12/2020 27/01/2021 24/02/2021 24/03/2021 6/04/2021 7/06/2021 5/08/2021 30/09/2021 11/11/2021
E-780
E-779


Swan Lake - Total Organic Carbon
Total Organic Carbon (mg/L)
Date
10/12/2020 27/01/2021 24/02/2021 24/03/2021 6/04/2021 7/06/2021 5/08/2021 30/09/2021 11/11/2021
E-780
E-779


Swan Lake - Total Dissolved Nitrogen
Total Dissolved N (mg/L)
10/12/2020 27/01/2021 24/02/2021 24/03/2021 6/04/2021 7/06/2021 5/08/2021 30/09/2021 11/11/2021
E-780
E-779
Trigger value = 1.25


Swan Lake - Total Nitrogen
Total Nitrogen
10/12/2020 27/01/2021 24/02/2021 24/03/2021 6/04/2021 7/06/2021 5/08/2021 30/09/2021 11/11/2021
E-780
E-779
Trigger Level = 1.38

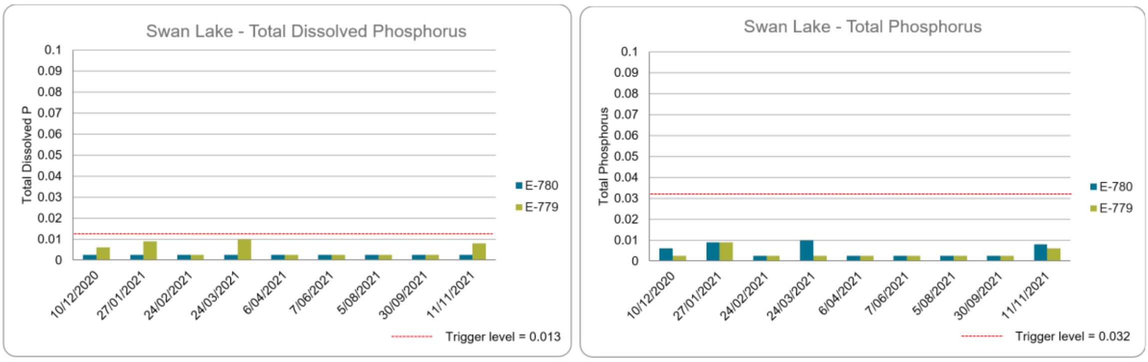
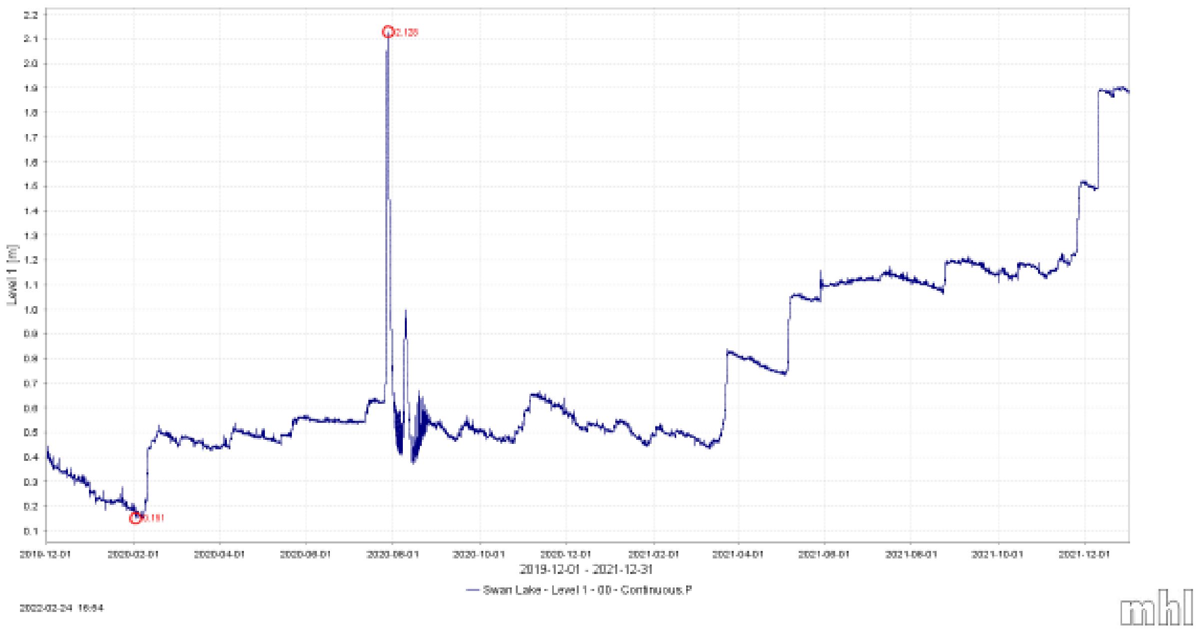


Figure 8-11 DP&E nutrient water quality graphs during 2020-2021 from (DP&E in preparation).

Note: Details of all raw water quality data for all sites is available via the Aqua Data web-site https://www.shoalhaven.nsw.gov.au/Environment/Aqua-Data. *Note: Aqua data shows the raw data which has not been adjusted for outliers or errors in measurement as per the results presented in this report*



Swan Lake Water Levels 2019 to 2021

Note: The estuary entrance was opened once at the end of July 2020 when water levels quickly peaked with rainfall but closed again soon after. Water levels increased again gradually with more rain over the remainder of 2021.

Figure 8-12 Water Levels in Swan Lake during 2019-2021 (MHL 2021) (from DP&E in preparation).

Appendix G
DPIE Sanitary Inspection Template

Appendix A: Sanitary inspection report

Sanitary inspection report

+ Determination of Beach Suitability Grade

Version 11

Summary of findings

Site name: ________________________________ Site reference number: __________

Site visit date:______________ Council meeting date:______________

Sanitary Inspection Category (SIC): ______________ Determined on: ______________

Microbial Assessment Category (MAC): ___________ Calculated on: _______________

Matrix for determining the Beach Suitability Grade

Sanitary Inspection Category (SIC)	Microbial Assessment Category (MAC) (95th percentiles – enterococci cfu/100 mL)			
	A ≤40	**B 41–200**	**C 201–500**	**D >500**
Very Low	Very Good	Very Good	Follow up	Follow up
Low	Very Good	Good	Follow up	Follow up
Moderate	Good	Good	Poor	Poor
High	Good	Fair	Poor	Very Poor
Very High	Follow up	Fair	Poor	Very Poor

Beach Suitability Grade: _______________ for the year: __________

Entered into database on: _______________

This template can be used as a field sheet for the Beachwatch Sanitary Inspection Database or on its own as a sanitary inspection report. The template is available as a fillable form on the Beachwatch website.

For further guidance in determining the likelihood of pollution from each pollution source contact Beachwatch – beachwatch@environment.nsw.gov.au

Contents of the sanitary inspection report

1. Site information

Site name: ______________________________ Site reference number: __________

Type of site: ☐ Ocean ☐ Estuarine ☐ Freshwater

☐ Other ____________________________

Sandy beach? ☐ Yes ☐ No

Swimming dimensions: Length (m): ________ Width (m): _______ = Area (m^2): ________

Catchment area: __________ square kilometres

Catchment land use: Bushland: ________% Rural: ________% Urban: ________%

Contact details

Responsible authority: ____________________________

Name: ____________________________ Position: ____________________________

Landline: _______________ Mobile: ________________ Fax: _________________

Email: ____________________________

Site location

Address: ____

Latitude: __________________________ Longitude: __________________________

Site description: ____

____

Diagram of site

1. Site information, cont.

Level of flushing:
- ☐ High (e.g. coastal beach)
- ☐ Medium (e.g. estuarine)
- ☐ Low (e.g. lagoon)

Elevated enterococci (>40 cfu/100mL):
- ☐ After light rain (5 mm in 24hrs)
- ☐ After moderate rain (10 mm in 24hrs)
- ☐ After heavy rain (20 mm in 24hrs)
- ☐ After very heavy rain (50 mm in 24hrs)

2A. Site use

Activities at site: ☐ Swimming ☐ Surfing ☐ Jet skiing ☐ Canoeing/kayaking

☐ Fishing ☐ Sailing ☐ Boating ☐ Diving

☐ Other ________________________________

Groups using site: ☐ Young children (<7yrs) ☐ Elderly (>60yrs)

☐ Adults & older children ☐ Tourists

Number of users: ________ to ________ people per day on weekends

________ to ________ people per weekday (non-holiday period)

________ to ________ people per weekday (holiday period)

Off-street parking? ☐ No ☐ Yes, number of bays: __________

Lifeguards: ☐ Unpatrolled ☐ Weekends ☐ Weekdays (non-holiday)

☐ Summer/School holidays

Do conditions deter people from entering?

☐ No ☐ Yes, details: ____

Any complaint of illness recorded?

☐ No ☐ Yes, details: ____

Consequence

☐ Minor

- Rarely used on weekdays
- Occasionally used on weekends or holidays
- Few people enter the water
- Location not popular with children or the elderly
- Location of minimal importance to the local economy

☐ Moderate

- Occasionally used on weekdays (e.g. <100 people per day for non-holiday period)
- Frequently used on weekends or holidays
- Most people enter the water
- Location very popular with children or the elderly
- Location of some importance to the local economy

☐ Major

- Frequently used on weekdays, weekends and holidays
- Most people enter the water
- Location very popular with children or the elderly
- Location of great importance to the local economy

2B. Pollution sources

Pollution source inventory

Pollution sources that could affect the water quality at the swimming site:

- ☐ Do **bathers** use the site?
- ☐ Are **toilet facilities** located within close proximity to the site?
- ☐ Are **wastewater treatment plants (including outfalls)** located within 2 km of the site?
- ☐ Do **designated sewage overflows** occur in the catchment (or within approximately 1 km radius of the site)?
- ☐ Do **sewer chokes or leakages** occur in the catchment (or within approximately 1 km radius of the site)?
- ☐ Do surrounding properties use **onsite sewage disposal systems**?
- ☐ Does **wastewater re-use** occur within 100 m radius of the site?
- ☐ Does **stormwater** discharge within 500 m of the site?
- ☐ Do **rivers** discharge within 1 km of the site?
- ☐ Do **lagoons** discharge within 500 m of the site?
- ☐ Are **boats** located in the vicinity of the site?
- ☐ Are **animals** (wildlife or domestic animals) present at the site?

Bather shedding

☐ Applicable ☐ Not applicable, details:____________________________________

Number of bathers at busy times: ________

Toilets available? ☐ No ☐ Yes, location: ________________________________

Bather density calculation

Use **area** as defined on the *Site details* sheet.

Use **number at busy times** as defined above.

Number at busy times: _________ *divided by* site area: ________ = _________ (people/m^2)

☐ Low (bather density <0.2)

☐ High (bather density ≥0.2)

Likelihood of pollution from bathers (select from the following matrix)

		Toilets available = YES		Toilets available = NO	
		Low bather density	**High bather density**	**Low bather density**	**High bather density**
Flushing	**Low**	Low	Moderate	Low	Moderate
	Medium	Very Low	Low	Low	Moderate
	High	Very Low	Low	Low	Moderate

Likelihood of pollution from bathers is: _______________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** ________________

Comments/Justification: ____

____

____

Toilet facilities

☐ Applicable ☐ Not applicable, details:________________________________

Distance from toilets to site (m): __________

Total number of toilets: _________

Total number of showers: ________

Type of sewerage system: ☐ Sewered

☐ Onsite system, how often serviced?____________________

Discharges/odours recorded? ☐ No, details: ______________________________

☐ Yes, details: ______________________________

____

Likelihood of pollution from toilet facilities (select from the following matrix)

		Distant proximity		Close proximity	
		Low use/flow	**High use/flow**	**Low use/flow**	**High use/flow**
Facility condition	**Poor**	Low	Moderate	Moderate	High
	Good	Very Low	Low	Low	Moderate

Likelihood of pollution from toilet facilities is: ________________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** ________________

Comments/Justification: ____

____

____

Wastewater treatment plant (within 2 km)

☐ Applicable ☐ Not applicable, details:____

Name of outfall: _________________________________

Distance from site (m):__________

a. Discharges from wastewater treatment plants

Outfall type: ☐ Direct ☐ Short ☐ Long (offshore)

Treatment level: ☐ None ☐ Preliminary ☐ Primary ☐ Secondary + disinfection

☐ Tertiary ☐ Tertiary + disinfection ☐ Lagoon

Likelihood of pollution for discharges from wastewater treatment plants (select from the following matrix)

		Outfall type		
		Direct	**Short**	**Long (offshore)**
Treatment level	**None**	Very High	High	Low
	Preliminary	Very High	High	Low
	Primary	Very High	High	Low
	Secondary	High	High	Low
	Secondary + disinfection	Moderate	Moderate	Very Low
	Tertiary	Moderate	Moderate	Very Low
	Tertiary + disinfection	Low	Low	Very Low
	Lagoons	High	High	Low

b. Wastewater treatment plant bypasses

Average discharge volume per bypass event (mL):___________

Dilution of bypass effluent: ☐ High ☐ Low

Minimum treatment level of bypassed effluent:

☐ None ☐ Primary ☐ Secondary ☐ Tertiary/lagoon

Bypassed effluent disinfected: ☐ Never ☐ Sometimes ☐ Always

Bypass discharge location: ☐ Direct ☐ Short ☐ Long (offshore)

Wastewater treatment plant (within 2 km), cont.

Likelihood of pollution for wastewater treatment plant bypasses (select from the following matrix)

		Wastewater treatment plant bypass frequency (assuming effluent is not disinfected)				
		May occur in exceptional circumstances (1 in 10 years)	**Unlikely to occur but could occur at least once in a 5-year period**	**Might occur at least once or twice per bathing season**	**Will probably occur at least 3–4 times per bathing season**	**Will occur on a regular basis (once a week)**
Dilution (from discharge location)	**High**	Very Low	Very Low	Low	Moderate	High
	Low	Very Low	Low	Moderate	High	Very High

If there is no history of bypasses the likelihood of contamination for wastewater treatment plants is determined using the likelihood of pollution from wastewater treatment plant discharge matrix (a); however, if there is a history of treatment bypasses at the wastewater treatment plant the likelihood is determined by using likelihood of pollution for wastewater treatment plant bypasses matrix (b).

Likelihood of pollution from the wastewater treatment plant is:________________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** ________________

Comments/Justification: ____

____

____

Designated sewage overflows

☐ Applicable ☐ Not applicable, details:____

For each overflow in the catchment (or 1 km radius), list:

Name	Address	Frequency/10yrs	Volume

Dilution: ☐ High ☐ Low

Likelihood of pollution from designated sewage overflows (select from the following matrix)

		Frequency				
		May occur in exceptional circumstances (1 in 10 years)	**Unlikely to occur but could occur at least once in a 5-year period**	**Might occur at least once or twice per bathing season**	**Will probably occur at least 3–4 times per bathing season**	**Will occur on a regular basis (once a week)**
Dilution	**High**	Very Low	Very Low	Low	Moderate	High
	Low	Very Low	Low	Moderate	High	Very High

Likelihood of pollution from designated sewage overflows is:__________________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** __________________

Comments/Justification: ____

____

____

Sewer chokes and leakages

☐ Applicable ☐ Not applicable, details:________________________________

For each overflow in the catchment (or 1 km radius), list:

Date	**Address**
____________________	____
____________________	____
____________________	____
____________________	____
____________________	____
____________________	____
____________________	____

Dilution: ☐ High ☐ Low

Likelihood of pollution from sewer chokes and leakages (select from the following matrix)

		Frequency				
		May occur in exceptional circumstances (1 in 10 years)	**Unlikely to occur but could occur at least once in a 5-year period**	**Might occur at least once or twice per bathing season**	**Will probably occur at least 3–4 times per bathing season**	**Will occur on a regular basis (once a week)**
Dilution	**High**	Very Low	Very Low	Low	Moderate	High
	Low	Very Low	Low	Moderate	High	Very High

Likelihood of pollution from sewer chokes and leakages is: ________________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** ________________

Comments/Justification: ____

____

____

Onsite sewage disposal systems

☐ Applicable ☐ Not applicable, details: ________________________________

Approximate number of systems in catchment: __________

Distance to site from nearest system (m): _________ (not including onsite toilet facilities identified under 'Toilets facilities')

Discharges/odours recorded? ☐ No, details: ________________________________

☐ Yes, details: ________________________________

____

Likelihood of pollution from onsite sewage disposal systems (select from the following matrix)

		Distant proximity		Close proximity	
		<50 systems	**≥50 systems**	**<50 systems**	**≥50 systems**
Condition	**Good – no complaints**	Very Low	Very Low	Low	Low
	Poor – history of odours and discharges	Low	Moderate	Moderate	High

Likelihood of pollution from onsite sewage disposal systems is: _______________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** _______________

Comments/Justification: ________________________________

____

____

Wastewater re-use

☐ Applicable ☐ Not applicable, details: ______________________

Location of wastewater re-use area: ______________________

Distance from site to re-use area: ____________

Wastewater treated prior to use? ☐ No ☐ Yes, details: ______________________

____

Likelihood of pollution from wastewater re-use (select from the following matrix)

		Distant proximity		Close proximity	
		Low volume	**High volume**	**Low volume**	**High volume**
Treatment level	**High – disinfected**	Very Low	Very Low	Low	Low
	Low – not disinfected	Low	Moderate	Moderate	High

Likelihood of pollution from wastewater re-use is: ______________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** ______________

Comments/Justification: ______________________

____

____

Stormwater

☐ Applicable ☐ Not applicable, details:________________________________

Total number of drains at swimming site: _________

Pick the **two drains** that have the most influence on your sampling site (or if there is only one drain, enter its details).

Drain 1

Location: ____________________________ Authority: ____________________________

____________________________ ____________________________

Distance from site (m):_________________

Type of drain: ☐ Box culvert ☐ Creek ☐ Pipe

Discharge area: ☐ Dune ☐ Beach ☐ Offshore ☐ Direct <50m ☐ Direct ≥50m

Drain 2

Location: ____________________________ Authority: ____________________________

____________________________ ____________________________

Distance from site (m):_________________

Type of drain: ☐ Box culvert ☐ Creek ☐ Pipe

Discharge area: ☐ Dune ☐ Beach ☐ Offshore ☐ Direct <50m ☐ Direct ≥50m

Primary land use: ☐ High density urban ☐ Low density urban ☐ Rural – grazing

☐ Rural – cropping ☐ Bushland/reserve

Likelihood of pollution from stormwater (select from the following matrix – choose the highest likelihood if you have two different drains)

		Discharge area		
		Dune	**Beach, offshore or direct ≥50 m**	**Direct <50 m**
Land use	**High density urban**	Low	Moderate	High
	Low density urban	Very Low	Low	Moderate
	Rural – grazing	Very Low	Low	Moderate
	Rural – cropping	Very Low	Low	Low
	Bushland/reserve	Very Low	Low	Low

Stormwater, cont.

Likelihood of pollution from stormwater drains is: ________________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** ________________

Comments/Justification: ____

____

____

River discharge

☐ Applicable ☐ Not applicable, details:______________________________________

Name of river: _________________________________

Distance from discharge point to site (m): __________

Pollution sources in river discharge:

☐ Urban stormwater

☐ Leachate from onsite wastewater systems

☐ Agricultural runoff

☐ Intensive livestock production

☐ Other, details: ____________________________

____

Likelihood of pollution from river discharge (select from the following matrix)

		Distant proximity		Close proximity	
		Low discharge volume	**High discharge volume**	**Low discharge volume**	**High discharge volume**
River water quality	**Good**	Very Low	Very Low	Low	Low
	Poor	Low	Moderate	Moderate	High

Likelihood of pollution from river discharge is: _________________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** _________________

Comments/Justification: ____

____

____

Lagoons

☐ Applicable ☐ Not applicable, details:_______________________________________

Name of lagoon:________________________________

Distance from site (m):__________

Area of lagoon (sq. km):__________

Catchment area (sq. km): __________

Sources of pollution to lagoon: ☐ Urban stormwater ☐ Agricultural runoff

☐ Other, details:________________________________

____

% time open to ocean (recent average): ________

Entrance managed or modified?

☐ No ☐ Yes, details:____

Likelihood of pollution from lagoons (select from the following matrix)

Likelihood of pollution from lagoons				
Very Low	**Low**	**Moderate**	**High**	**Very High**
May occur only in exceptional circumstances, e.g. 1 in 10 years	Unlikely to occur but could occur at least once within a 5-year period	Might occur at least once or twice per bathing season	Will probably occur at least 3–4 times per bathing season	Will occur on a regular basis, e.g. once a week

Likelihood of pollution from lagoons is: _______________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** ________________

Comments/Justification: ____

____

____

Boats

☐ Applicable ☐ Not applicable, details:________________________________

What is located near the site?

☐ Marina ☐ Permanent moorings

☐ Harbour ☐ Temporary moorings

☐ Anchorage ☐ Jetty

☐ Boat ramp ☐ Ferry berth

Distance from site to nearest boat (m): __________

Number of boats near site:___________

Pump-out facilities provided?

☐ No ☐ Yes, details:________________________________

Complaints of boat discharges?

☐ No ☐ Yes, details:________________________________

Onshore toilets provided?

☐ No ☐ Yes, details:________________________________

Likelihood of pollution from boats (select from the following matrix)

		Number of boats		
		<20 boats	**20–50 boats**	**50–100 boats**
Waste management	**Good (holding-tanks required)**	Very Low	Very Low	Low
	Poor (holding-tanks not required)	Low	Moderate	Moderate

Likelihood of pollution from boats is: ________________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** ________________

Comments/Justification: ________________________________

____

____

Animals

☐ Applicable ☐ Not applicable, details:______________________________

Aquatic birds? ☐ Yes ☐ No

Density: ☐ Low ☐ Medium ☐ High

Roosting structures present? ☐ Yes ☐ No

Native animals? ☐ Yes ☐ No

Density: ☐ Low ☐ Medium ☐ High

Domestic animal exercise area? ☐ Yes ☐ No

Type: ☐ Dogs ☐ Horses ☐ Other, details: ______________________

Dog waste bags available? ☐ Yes ☐ No

Animals directly access water? ☐ Yes ☐ No

Area regularly cleaned? ☐ Yes ☐ No

Likelihood of pollution from animals (select from the following matrix)

Likelihood of pollution from animals				
Very Low	**Low**	**Moderate**	**High**	**Very High**
May occur only in exceptional circumstances, e.g. 1 in 10 years	Unlikely to occur but could occur at least once within a 5-year period	Might occur at least once or twice per bathing season	Will probably occur at least 3–4 times per bathing season	Will occur on a regular basis, e.g. once a week

Likelihood of pollution from animals is: _____________

Is this likelihood appropriate? ☐ Yes ☐ **No, revised likelihood:** _____________

Comments/Justification: ____

____

____

2C. Management

Which management controls are in place to warn people of periods of increased risk?

☐ None ☐ Permanent onsite signage ☐ Temporary onsite signage

☐ Media releases ☐ Beach closures ☐ Website

☐ Other, details: ____

Provide details of advisories: ______________________________________

____

____

Do management controls effectively prevent people from entering the water during these periods?

☐ No ☐ Yes, details: ______________________________________

____

____

Is there a management response plan in place to deal with exceptional events such as sewage overflows and bypasses?

☐ No ☐ Yes, details: ______________________________________

____

____

3. Calculating the Sanitary Inspection Category

On the **form on the next page** complete the following steps:

STEP 1: Fill out the likelihood for each of the pollution sources in the top part of the form (leave blank if pollution source is not applicable).

STEP 2: By referring to the table below, fill out the numerical likelihood values for these pollution sources.

Likelihood	Numerical likelihood
Very Low	0.1
Low	0.2
Moderate	1
High	3
Very High	12

STEP 3: Sum the numerical likelihoods.

STEP 4: By referring to the table below, fill out the numerical likelihood for animal pollution source (if applicable) in the second part of the form and sum the total numerical likelihood.

Likelihood	Numerical likelihood
Very Low	0.1
Low	0.1
Moderate	0.2
High	1
Very High	1

STEP 5: Using the total numerical likelihood, identify the Sanitary Inspection Category using the table below.

Total numerical likelihood	Sanitary Inspection Category
0–0.19	Very Low
0.2–0.99	Low
1–2.99	Moderate
3–11.99	High
>12	Very High

Pollution source	Likelihood		Numerical likelihood
Bathers	____________________	....	= _______
Toilet facilities	____________________	....	= _______
Wastewater treatment plant	____________________	....	= _______
Designated sewage overflows	____________________	....	= _______
Sewer chokes and leakages	____________________	....	= _______
Onsite sewage disposal systems	____________________	....	= _______
Wastewater re-use	____________________	....	= _______
Stormwater	____________________	....	= _______
River discharge	____________________	....	= _______
Lagoons	____________________	....	= _______
Boats	____________________	....	= _______
	Sum of numerical likelihoods		= _______

Pollution source	Likelihood		Numerical likelihood
Animals	____________________	....	= _______
	Sum of numerical likelihoods from previous table		= _______
	Total numerical likelihood		= _______

The **Sanitary Inspection Category** for this site is: ________________________