

# Recreational Water Quality Program

## Annual Report 2016/17



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Derwent Estuary  
Program

The Derwent Estuary Program (DEP) is a regional partnership between local governments, the Tasmanian State Government, businesses, scientists, and community-based groups to restore and promote our estuary. The DEP was established in 1999 and has been nationally recognised for excellence in coordinating initiatives to reduce water pollution, conserve habitats and species, monitor river health and promote greater use and enjoyment of the foreshore. Our major sponsors include: Brighton, Clarence, Derwent Valley, Glenorchy, Hobart and Kingborough councils, the Tasmanian State Government, TasWater, Tasmanian Ports Corporation, Norske Skog Boyer, Nyrstar Hobart Smelter and Hydro Tasmania.



# 1 EXECUTIVE SUMMARY

This report presents results of the 29<sup>th</sup> year of the Derwent Estuary Recreational Water Quality Program (RWQ), which a joint initiative between six local councils (Council) and the State Government of Tasmania.

Water samples were collected weekly at 39 sites throughout the estuary between 1 December and 31 March, and analysed for the faecal indicator bacteria enterococci. Ten of the 18 Swimming Sites either stayed the same or improved their rating slightly, while 18 of the 21 Environmental Sites saw improvements in rating, mostly within the same rating category. Rainfall during this period was up slightly from the last year's very dry season, but it was still only 67% of the long-term average - with only 1 rainfall event > 10 mm. The low rainfall is probably reflected in the water quality results.

Based on water quality results for the past five years, 13 of the 18 monitored swimming sites are now classified as having good water quality, four are fair and one is poor (western end of Nutgrove beach). Classification improvements were notable at the eastern and western end of Howrah Beach and at Windermere Beach (fair to good), while Blackmans Bay (south) went from a good to a fair rating. Of the 21 bays and other environmental sites monitored, 13 are now classified as having good water quality, three are fair and five are poor. Improvements in classification ratings were noted at Lindisfarne, Geilston and New Town bays, and at the Hobart Regatta Pavilion.

While these results are encouraging, they should be taken in the context of the low rainfall conditions experienced over four of the past five summers; a wet summer could easily reverse any improvements. It is recommended that sanitary investigations continue – particularly at Nutgrove Beach (west), Blackmans Bay (south), Kingston Beach (south) and at Howrah Beach – to identify and correct on-going sources of faecal contamination.

## 2 INTRODUCTION

### 2.1 Pathogens and health risks

Water contaminated by sewage and animal faeces may contain pathogenic micro-organisms (bacteria, viruses, protozoa) which pose a health hazard when the water is used for primary contact recreation, such as swimming. Infection may occur by swallowing, inhaling or by direct contact of contaminated water with ears, nasal passages, mucous membranes and cuts in the skin, which allow the pathogens to enter the body (N.Z. Ministry for the Environment, 2002). The most common health conditions associated with primary contact recreation in contaminated water are gastrointestinal disorders, respiratory illnesses, eye, nose and throat infections and skin disorders.

Direct detection of pathogens is not a feasible option for routine assessments since they occur intermittently and are difficult to recover from water. Thus, water samples are analysed for the concentration of more easily detected microorganisms, which may indicate the presence of pathogens, referred to as faecal indicator bacteria (refer to Coughanowr et al. 2015 for more information).

### 2.2 Recreational water quality guidelines

The Recreational Water Quality Guidelines for Tasmania (Dept of Health & Human Services, 2007) were developed using the National Guidelines for Managing Risks in Recreational Water (NHMRC, 2008). The guidelines are based on aseptic grab sample analysis for the faecal indicator microbial group enterococci, and the Tasmanian

guidelines adopt a three-tiered approach to classifying the long-term quality of a site based on available data. The tiers are:

- *Good*: rolling 5-year 95<sup>th</sup> Hazen percentile value of < 200 enterococci MPN (Most Probably Number) 100 mL<sup>-1</sup>.
- *Moderate*: rolling 5-year 95<sup>th</sup> Hazen percentile value of 200 - 500 enterococci MPN 100 mL<sup>-1</sup>.
- *Poor*: rolling 5-year 95<sup>th</sup> Hazen percentile value of > 500 enterococci MPN 100 mL<sup>-1</sup>. In this case, water at these sites is considered to be a threat to public health in the event of primary contact recreation and the particular local council is required to advise the general public and to erect warning signs to this effect.

In addition to long-term site classification, trigger levels have been set to manage public exposure to episodic or emerging water quality issues. If a sample exceeds 140 MPN 100 mL<sup>-1</sup>, the relevant authority is required to resample, and if two consecutive samples return a result above 280 MPN 100 mL<sup>-1</sup>, the swimming site must be closed and the public notified. The beach may be re-opened for primary contact recreation only following agreement between the Director of Public Health and Council's Authorised Officer.

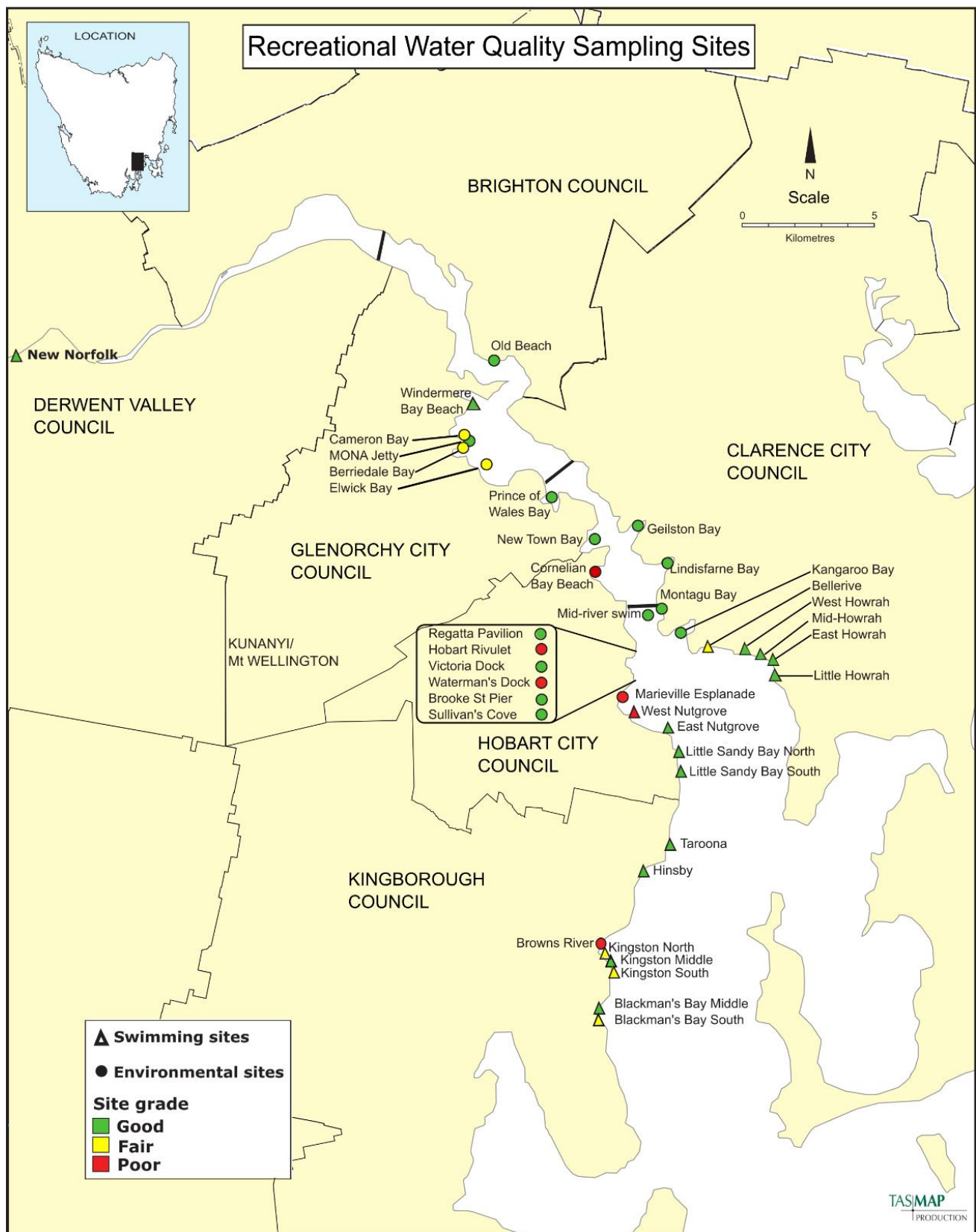
### 3 RECREATIONAL WATER QUALITY PROGRAM

#### 3.1 Swimming and Environmental sites

Aseptic grab samples are collected each Tuesday by Council and the Environmental Protection Authority (EPA) / Derwent Estuary Program (DEP) from 39 sites throughout the Derwent estuary, during summer and early autumn each year (from 1 December to 31 March).

Sites are categorised as either *Swimming Sites* or *Environmental Sites* as described below, and locations are shown in [Figure 1](#).

- The 18 *Swimming Sites* monitored this season are in locations where a significant number of people swim or conduct other primary contact recreation. These sites are sampled by Council to provide a basis for public health information.
- The 21 *Environmental Sites* monitored this season were selected to provide a broader context for interpretation of Swimming Site results and for other purposes. These sites are sampled by either Council or EPA/DEP were selected based on the following rationale:
  - Bays and coves that are frequently used for secondary contact recreation and/or have foreshore parks;
  - Areas with identified potential sources of faecal contamination;
  - Sites with relatively low risk of contamination, sampled to contextualise Swimming Site results;
  - Sites associated with major swimming events, such as the Trans Derwent Swim.



**Figure 1:** Recreational Water Quality sampling sites (Swimming and Environmental sites) with their current water quality classification based on data collected in the summer months between Dec 2012 and March 2017.

### **3.2 Inter-calibration exercise**

An inter-calibration exercise is organised by the DEP at the start of each season to ensure that all sampling officers are using the same protocols, thus minimising sampler bias. The sampling method is demonstrated, associated protocols are reviewed and participants simultaneously sample from a designated location. Results are compared to identify any sampler bias, and are also useful to better understand the degree of variability between water samples collected from a given site and/or between sites.

### **3.3 Rainfall**

The water quality of urban beaches and bays can be strongly influenced by stormwater run-off (NHMRC, 2008), with poorer water quality in wet years compared with dry years. Rainfall data collected and reported by the Bureau of Meteorology (BOM) at a number of weather stations throughout the Derwent estuary catchment are used to compare rainfall throughout each RWQ season (December to March), against the long-term average rainfall for that period. Observations of daily rainfall are nominally made at 9 am and record the total for the previous 24 hours.

### **3.4 Sample analysis**

All samples are analysed at the Public Health Laboratory (St Johns Ave. New Town) using the Enterolert method, which provides confirmed results within 24 hours of analysis. For designated Swimming Sites, if the original sample exceeds the relevant trigger level (NHMRC, 2008), laboratory staff notify Council so retesting can occur. Results are typically reported between 24 and 48 hours after sample submission to the laboratory.

For the next RWQ season we could re-consider which Environmental Sites to test using the larger lab testing trays. At the moment the following sites use the larger trays: Watermans Dock, Lindisfarne Bay, Browns River, Geilston Bay, Nutgrove Beach (west), Marieville Esplanade, Cornelian Beach Bay, Elwick Bay, MONA jetty, Berriedale Bay. Using the larger trays provide results up to 20,000, as opposed to giving the result of “> 2,000”, without loss of accuracy. To be discussed at a future Monitoring Taskforce meeting.

## **4 2016/17 RWQ SEASON RESULTS**

### **4.1 Inter-calibration exercise**

On 28 November 2016, environmental health officers from five local council partners and the DEP simultaneously collected a single sample each at two sites on Howrah Beach. The aseptic sampling technique adopted by samplers was assessed as good, and the enterococci concentration results were also consistent between samplers. Results also suggested that the nearby stormwater drain may be influencing water quality.

Further discussion of the inter-calibration exercise results is available in the *RWQ Inter-calibration report 2016/17* (Visby and Coughanowr, 2016) – see [Appendix A](#). The next inter-calibration exercise will be conducted in November 2017.

### **4.2 Rainfall**

The 2016/17 RWQ season, as measured at the Ellerslie Road, Hobart Bureau of Meteorology (BOM) weather station, was slightly wetter than the previous season, but still only recording 68% of the average summer rainfall for this site. The majority of rain fell in December and January, with the driest Feb on record in 14 years (Table 1).



**Table 1:** Rainfall recorded (in mm.) at Ellerslie Road Weather Station (BOM), across the summer months between December 2008 and March 2017.

Season	Dec	Jan	Feb	Mar	Total summer rainfall	% of long-term average
2008/9	39.2	10	59.2	70	178.4	94.9%
2009/10	58.6	14.4	34.8	30.4	138.2	73.5%
2010/11	31	59.8	54.4	45.4	190.6	101.4%
2011/12	52.4	56	22.6	30.8	161.8	86.1%
2012/13	22	11.4	23.4	48.6	105.4	56.1%
2013/14	28.2	16.2	27.6	23.4	95.4	50.7%
2014/15	78	121.6	21.6	51	272.2	144.8%
2015/16	35	40.2	21.8	17	114	60.6%
2016/17	56.6	60	10.4	37	127	67.6%
<b>Long-term monthly average</b>	56.2	47.6	39.5	44.7	188	NA

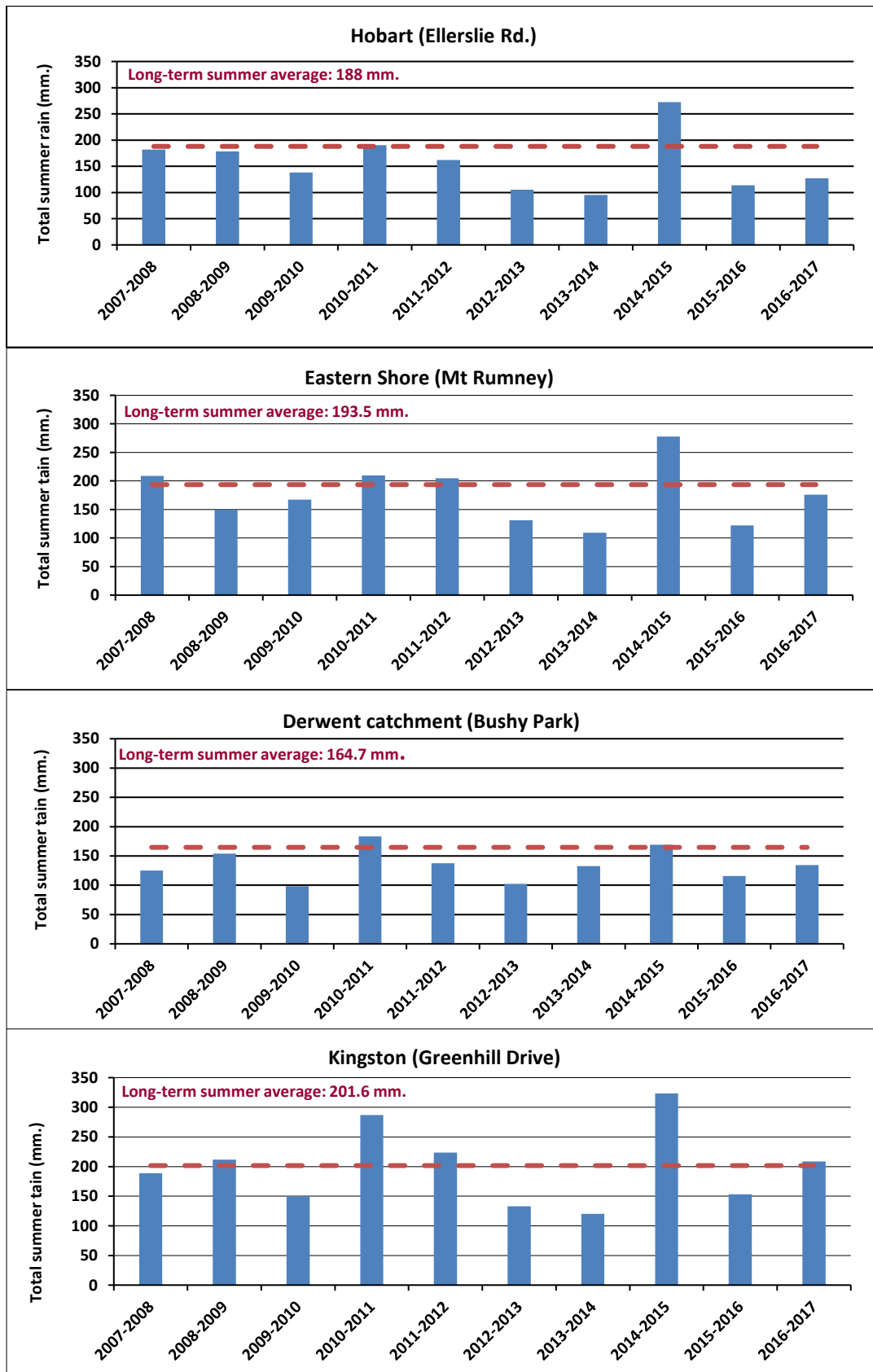
Rainfall varies across the estuary, with long-term averages for the summer months ranging between 164.7 mm. at Bushy Park to 201.6 mm. at Greenhill Drive in Kingston. There is also a significant rainfall gradient across the estuary, with higher rainfall on the western vs eastern shore. During the 2016-2017 season, summer rainfall was again lower than the long-term average in most locations: Hobart (Ellerslie Road) recorded 61 mm. less than average, New Norfolk (Bushy Park) 30.1 mm. less, and Eastern Shore (Mt Rumney) 17.5 mm. less, whereas in Kingston it rained slightly more than the long-term average ([Figure 2](#)).

Rainfall on the Eastern Shore has previously been recorded at Rokeby, but this BOM station has recently been closed down. The closest station to our Eastern Shore beaches is now the station at Mt Rumney, which records a 25.4 mm. higher long-term summer rain average than Rokeby.

There were four rainfall events in the 2016-17 RWQ season where > 10 mm. of rain was recorded, and only one event, which occurred within a day of a Tuesday sampling event (Monday 2 January), as recorded by the Ellerslie Road BOM weather station:

- Thursday 29 December                      12.6 mm.
- Friday 30 December                        20.8 mm.
- **Monday 2 January                            34.8 mm.**
- Wednesday 22 March                        10.2 mm.

Over the Christmas period, sampling took place during a rainfall event on Wed 28 Dec (7.2 mm. of rain to 9 am on the 28<sup>th</sup>, plus 12.6 mm on the 29<sup>th</sup>), resulting in very high enterococci results at a majority of Swimming sites and the few Environmental sites (see Appendix [B](#) + [C](#) for detailed results).



**Figure 2:** Total rainfall (in mm.) at four weather stations in the Derwent estuary catchment during the last 10 RWQ program seasons (between December and March), as recorded by the Bureau of Meteorology. The long-term average rainfall is indicated in red text and by dotted line.



### 4.3 Site results

**Table 2:** RWQ program 2016/17 season results, with data collected in the summer months between Dec. 2012 and Mar. 2017. Colour refers to Australian Government's *Recreational Water Quality Guidelines* using rolling 5-year Hazen percentile for enterococci where green denotes 'good' (< 200 MPN 100 mL<sup>-1</sup>), yellow denotes 'fair' (200 - 500 MPN 100 mL<sup>-1</sup>), red denotes 'poor' (> 500 MPN 100 mL<sup>-1</sup>). Number of samples with enterococci readings between 140 and 280, > 280 MPN 100 mL<sup>-1</sup>, and total number of samples per sites are shown.

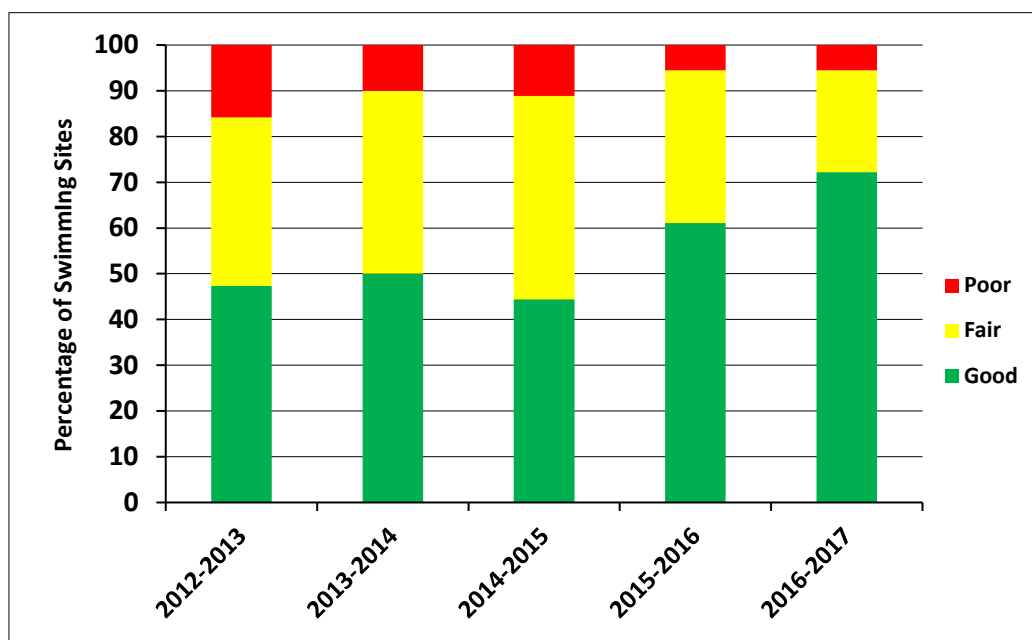
		5-year Hazen percentile enterococci	Samples between 140 and 280	Number of samples > 280	Total number of samples
Swimming Sites	Bellerive Beach	214	1	4	85
	Blackmans Bay Beach (mid)	87	1	3	85
	Blackmans Bay Beach (south)	201	4	3	85
	*Fitzgerald Park, New Norfolk	65	0	0	47
	Hinsby Beach	31	0	0	85
	Howrah Beach (east)	194	5	2	85
	Howrah Beach (mid)	67	0	2	85
	Howrah Beach (west)	78	0	2	85
	Kingston Beach (mid)	81	1	0	85
	Kingston Beach (north)	275	2	4	85
	Kingston Beach (south)	243	3	4	85
	Little Howrah Beach	90	0	2	85
	Little Sandy Bay Beach (south)	78	2	0	85
	Little Sandy Bay Beach (north)	161	5	0	85
	Nutgrove Beach (east)	182	5	1	85
	Nutgrove Beach (west)	578	3	8	85
	Taroona Beach	55	0	0	85
	Windermere Bay Beach	172	3	2	78
Environmental Sites	* Brooke St Pier	54	0	1	43
	Brown's River	2027	17	25	84
	* Cornelian Bay Beach	2684	2	4	33
	Elwick Bay	393	4	7	75
	Geilston Bay	112	1	1	74
	Hobart Regatta Pavilion	162	2	3	73
	Hobart Rivulet	3900	12	27	74
	Kangaroo Bay	31	0	0	73
	Lindisfarne Bay	94	0	2	74
	Marievilla Esplanade	869	12	18	84
	Mid-river Derwent Swim	18	0	0	74
	*MONA Berriedale	297	2	4	43
	*MONA Cameron Bay	470	1	1	16
	* MONA Jetty	166	1	2	49
	Montagu Bay	20	0	0	73
	New Town Bay	161	4	2	74
	Old Beach, Jetty Road	53	0	1	75
	Prince of Wales Bay Marina	94	2	1	74
	Sullivans Cove	19	0	0	73
	Victoria Dock	31	0	0	74
	Waterman's Dock	520	2	8	74

\* Indicates < 5 years of data available. Cornelian Bay is monitored intermittently, when conditions allow.

### 4.3.1 Swimming Sites

The water quality conditions at the Swimming Sites were largely similar to the previous RWQ season. This was expected with the mostly dry conditions experienced throughout this sampling period.

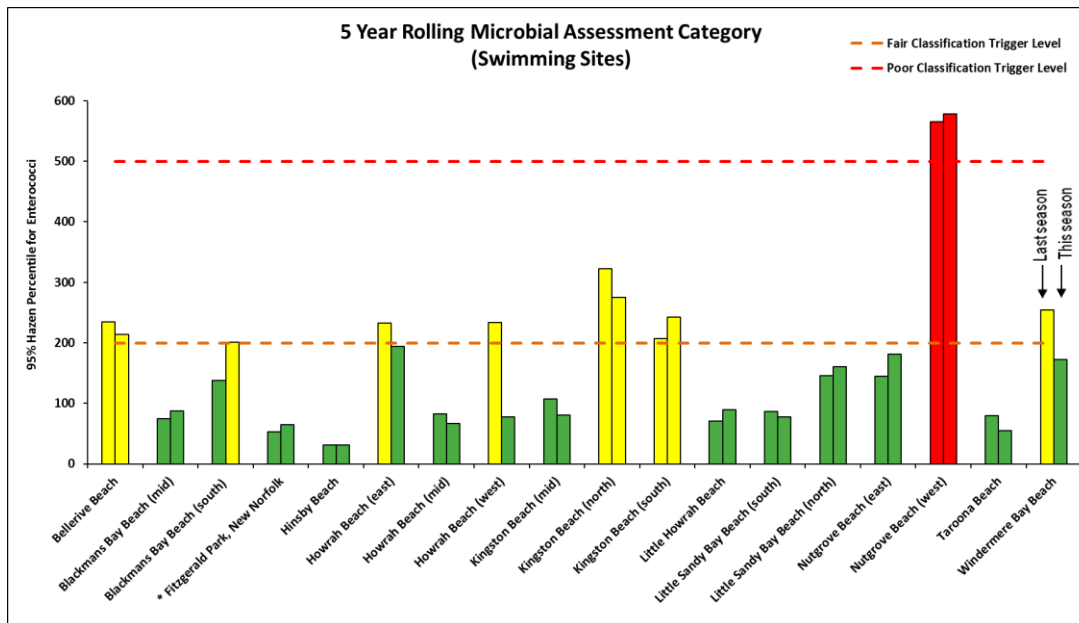
At the end of the 2016/17 RWQ season, 13 of the 18 Swimming Sites are ranked as having 'good' water quality. Four sites are classified as 'fair', while one is 'poor' (Nutgrove Beach (west), with primary recreation not recommended at this site. Based on their 5-year Hazen percentile calculations, the three best performing sites were Hinsby Beach, Fitzgerald Park in New Norfolk (site only monitored for three RWQ seasons), and Taroona. [Table 2](#) shows the 2016-17 RWQ season's updated 5-year Hazen percentile calculations for each site, as well as how many times each site measured between 140 and 280, and above 280 MPN 100 mL<sup>-1</sup> for enterococci during the last five seasons. The sites with the greatest number of exceedance > 280 MPN 100 mL<sup>-1</sup> were Nutgrove Beach (west; eight times), followed by Bellerive, Kingston Beach south and north (all with four times). A gradual overall improvement in water quality has occurred over time, as can be seen in [Figure 3](#).



**Figure 3.** Proportion of Swimming Sites graded as 'Good', 'Fair', and 'Poor' in the last five RWQ seasons.

Changes in classification from the last RWQ season occurred at four sites. At Howrah Beach east and west, and at Windermere Bay Beach the 5-year rolling 95<sup>th</sup> Hazen percentile ratings improved from 'fair' to 'good', and at Blackmans Bay the rating declined from 'good' to 'fair'. The water quality rating remained 'poor' at Nutgrove Beach (west). Bellerive Beach and Kingston Beach (north, south), remain in the 'fair' category ([Figure 4](#)). See the full enterococci results for all Swimming sites in Appendix B, and read more details about Howrah, Nutgrove and Blackmans Bay in [section 5](#) on Specific Investigations.

The rainfall event on 27/28 December had a strong influence on water quality, with 11 of 16 sites sampled exceeding the guidelines (some by a significant amount), and advice was subsequently issued to avoid swimming in the Derwent for several days thereafter.



**Figure 4:** Comparison of rolling 5-year Hazen percentile enterococci result for Swimming Sites. Each site is presented as a pair of results, where the left bar represents 2015/16 RWQ season results, while the right bar represents 2016/17 season results. Green denotes 'good' (< 200 MPN 100 mL<sup>-1</sup>), yellow denotes 'fair' (200 - 500 MPN 100 mL<sup>-1</sup>), red denotes 'poor' (> 500 MPN 100 mL<sup>-1</sup>), and the classification trigger lines are indicated with dotted lines.

\* indicates that less than five years of data is available, thus those results are less robust.

#### 4.3.2 Environmental Sites

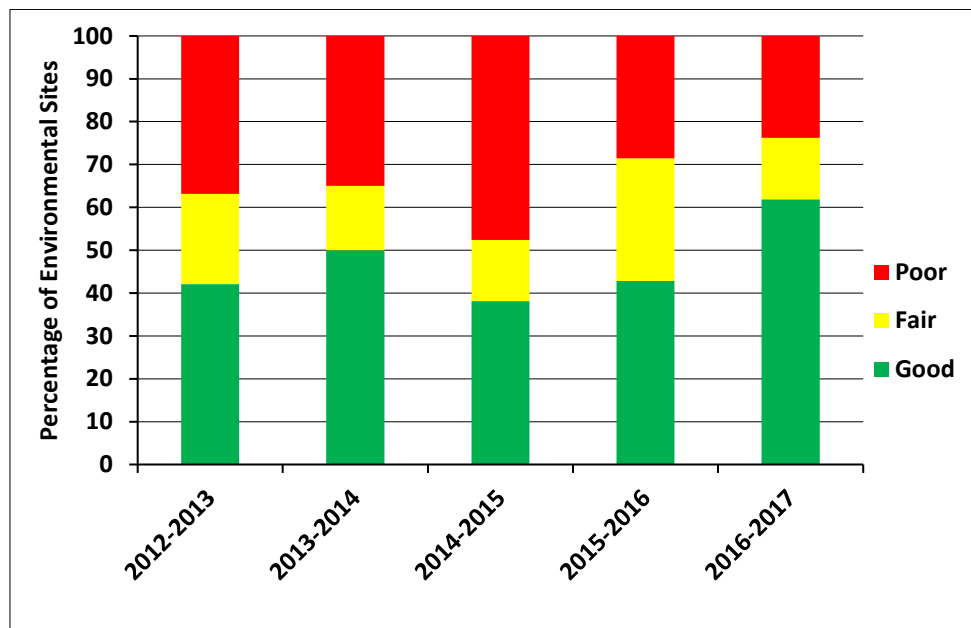
The water quality conditions at the Environmental Sites have predominantly improved from the previous RWQ season. Similarly to the Swimming Sites, this was expected with the mostly dry conditions experienced throughout this sampling season.

As of the end of the 2016/17 RWQ season, 13 of the 21 Environment Sites ranked as 'good', three as 'fair', and five as 'poor' water quality, based on the 5-year 95<sup>th</sup> Hazen Percentile for enterococci. The three best performing sites are Sullivans Cove, the Mid-River Derwent location, and Montagu Bay, and the worst sites are at the mouth of the Hobart Rivulet, at Cornelian Bay Beach, at the mouth of Browns River and at Marieville Esplanade. [Table 2](#) shows the updated 5-year Hazen percentile calculations for each Environmental Site, as well as how many times each site measured between 140 and 280, and above 280 MPN 100 mL<sup>-1</sup> for enterococci during the last five years. The sites with the greatest number of exceedance > 280 MPN 100 mL<sup>-1</sup> were the mouth of Hobart Rivulet (27 times), Browns River (24 times), and Marieville Esplanade (18 times). A gradual improvement in water quality, with additional 'good' sites, has occurred over time, as can be visualised in [Figure 5](#).

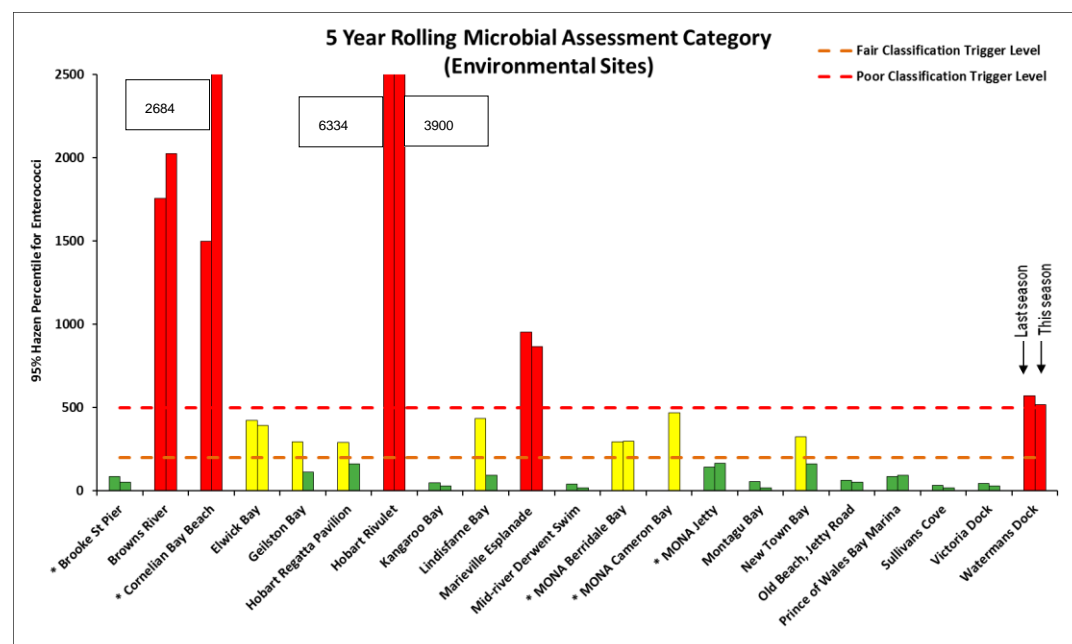
Changes in the classification from the last RWQ season occurred at four sites, Geilston Bay, Hobart Regatta Pavilion, New Town Bay, and Lindisfarne Bay all improved their 5-year rolling 95<sup>th</sup> Hazen percentile rating from 'fair' to 'good'. No sites saw a decline in their rating category, though Cornelian Bay Beach appears to have deteriorated within its 'poor' rating ([Figure 6](#)); however this site is not routinely monitored due to difficult access, so the statistics may not be robust. See the full enterococci results for all Environmental sites in Appendix C.

It is encouraging to note that water quality remains good at most sites around Sullivans Cove, and has improved over the past few years at a number of bays, (e.g. Newtown,

Kangaroo, Lindisfarne and Geilston). Poor water quality in Hobart Rivulet and Browns River is probably related to upstream catchment and infrastructure issues.



**Figure 5.** Proportion of Environmental Sites graded as 'Good', 'Fair', and 'Poor' in the last five RWQ seasons.



**Figure 6:** Comparison of rolling 5-year Hazen percentile enterococci result for Environmental Sites. Each site is presented as a pair of results, where the left bar represents 2015/16 RWQ season results, while the right bar represents 2016/17 season result. Green denotes 'good' (< 200 MPN 100 mL<sup>-1</sup>), yellow denotes 'fair' (200 - 500 MPN 100 mL<sup>-1</sup>), red denotes 'poor' (> 500 MPN 100 mL<sup>-1</sup>), and the classification trigger lines are indicated with dotted lines. \* indicates that less than five years of data is available, thus those results are less robust.

## 5 SPECIFIC INVESTIGATIONS

While water quality at most beaches is currently classified as good to fair, previous monitoring has identified longer-term issues at several sites that merit further investigation. A number of water quality investigations are in progress at various sites,

including at Nutgrove Beach, west (City of Hobart and TasWater), Windermere Bay Beach (Glenorchy City Council), Howrah Beach (Clarence City Council), and at the southern end of Blackmans Bay and Kingston beaches (Kingborough Council) as discussed below.

### **5.1 Nutgrove Beach (west)**

The stormwater outfall of Lipscombe Rivulet has previously been identified as the likely discharge point for faecal contaminated stormwater that has contributed to a poor recreational water quality rating at the western end of Nutgrove Beach. Over the past few summers, there has been a concerted collaboration between TasWater, Hobart City Council and the DEP to improve the situation.

This summer has seen various highly coordinated investigations take place:

- Additional sampling at end-of-pipe and in targeted streets, assisted by the University of Queensland, tracking for anthropogenic tracers.
- Hydraulic sewer modelling / pipe pressurisation in lower end of catchment.
- Dye-testing of houses in the upper catchment for connection of sewer to stormwater.
- Investigations using CCTV cameras.

Results started with confirmation of a sewerage signal in the stormwater from Lipscombe Rivulet. The modelling, followed by CCTV investigations, then discovered a crack in a sewer pipe and ingress to gravel surround, causing sewer to enter gravel surrounding the stormwater pipe at the crossover point; as well as possible sagging/compromised sewer pipe joints. This led to TasWater undertaking repairs and sewer pipe relining. In addition, council conducted dye-testing of a series of house, with 'successful' results – that is, the discovery of a direct sewage to stormwater connection at one property, which is in the process of being fixed.

All this excellent work will now be finalised with a series of sampling by council to hopefully gather evidence that an improvement is taken place in the beach water quality as a result of the combined effort. There are real glimmers of hope for substantial improvement to the water quality at this long-suffering beach – stay tuned for the next RWQ season!

### **5.2 Windermere Bay Beach**

Despite Windermere Bay Beach having now moved into the 'good' category, there are still unresolved issues in the Faulkners Rivulet. Council had continued its sampling within this catchment, up to and including April this year, but due to continuing dry weather and insufficient flow throughout the rivulet, the sampling has been discontinued. It is not expected to recommence until the next RWQ season, however, an assessment of flows will be undertaken before any further decisions are made.

### **5.3 Howrah Beach**

Previous investigations have confirmed that recreational water quality at Howrah Beach is highly susceptible to stormwater contamination. In 2015 TasWater commenced an investigation into the capacity and potential risk sites in their network to help assess whether sewerage is contributing to faecal contamination at the beach. The Clarence City Council have since conducted targeted stormwater sampling, but have so far been unable to pinpoint any specific hotspots that may be the cause of the poor water quality. New catchment management plans are currently being prepared, and it is hoped that they will incorporate a water quality improvement aspect, including some 'end of pipe' WSUD (Water Sensitive Urban Design) options.

## 5.4 Blackmans Bay (south)

After years of good water quality, at the end of this RWQ season, Blackmans Bay south changed its rating from 'good' to 'fair'. This summer saw five results over 120 (MPN of enterococci per 100 mL), including one > 2000, see [Appendix B](#) for all results. The exact cause is still unknown, and Kingborough Council is currently investigating whether the issue is stormwater related and trying to pinpoint the exact problem.

## 5.5 Kingston Beach (south)

The water quality rating at the southern end of Kingston Beach declining after this season from 207 to 243, still within the 'fair' rating. This is due to a few very high results over the last two seasons. The 2015/16 RWQ season saw three results above 140 enterococci (MPN per 100 mL), one being > 2005, and this RWQ season saw one result > 2005, the latter possibly connected with a heavy rain event.

Kingborough Council suspect a re-occurrence of a previous faecal contamination issue, that had been addressed by diverting contaminated baseflow within the stormwater pipe to sewer. This temporary fix (a diversion) had been in place for about a decade, but it appears to have been inadvertently removed after recent (last two years) stormwater and sewer upgrades in the area in connection with urban development.

With a new swimming pontoon deployed and increased swimming occurring at the southern end of the beach, there is increased pressure to improve this situation. The matter is being discussed with TasWater.

# 6 OTHER INVESTIGATIONS

## 6.1 Upper Estuary

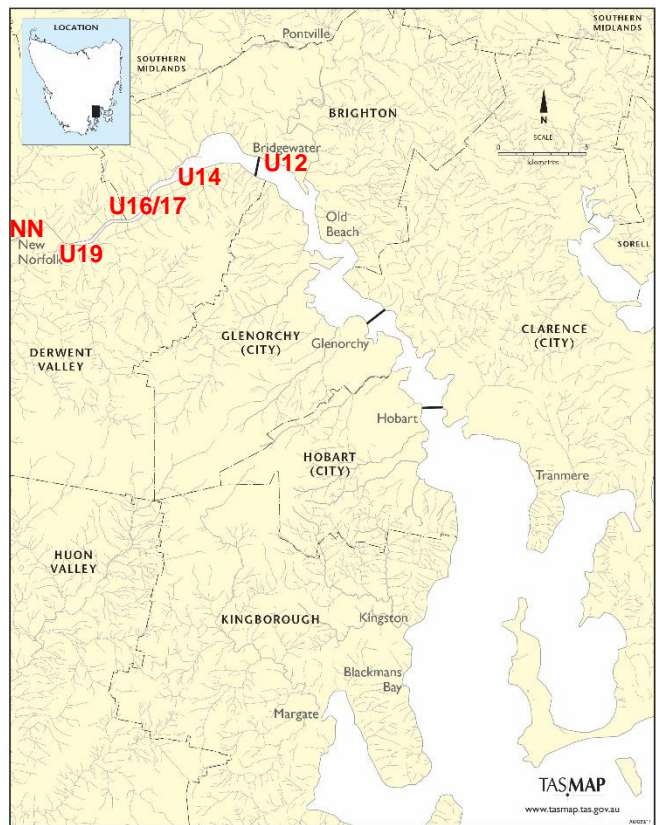
This study followed up on previous work on faecal indicator bacteria in the upper estuary (see RWQ Annual Review 2015/16). While enterococci values at New Norfolk have been consistently low, several surveys in 2013/14 had suggested that enterococci values have been occasionally elevated in the vicinity of the Turriff Lodge sewage treatment plant (and associated wetlands), and Sorell Creek. Another survey in 2015/16 found that high *Escherichia coli* and thermotolerant coliforms counts could co-occur with low enterococci, raising questions about the suitability of enterococci as an indicator in this section of the estuary, which typically experiences fresh-to-brackish conditions.

Water samples were collected at five sites between New Norfolk and the Bridgewater Causeway ([Figure 7](#)) with support from Norske Skog, as part of their monthly Ambient Water Quality monitoring program, between December 2016 and April 2017. This area contains the lowest salinity levels in the estuary, with long-term average at New Norfolk at 0.06 ppt and 5.61 ppt at the Bridgewater end. Each water sample was analysed for three faecal indicators: enterococci, *E. coli* and thermotolerant coliforms. See all results in [Appendix D](#), including the regular New Norfolk RWQ results for same dates + salinity levels across the five sites.

Enterococci counts were consistently low throughout the upper estuary, with no sample over 20 counts/100 mL. *E. coli* and thermotolerant coliform counts were occasionally elevated, with some relatively high values in February 2017 (and possibly January). For the upper estuary sites NN and U19, and site U14, the mean value of the *E. coli* results over the 4 months sampling period was well below 126 cfu/100 mL (USA EPA 30-day mean guidelines, however the mean value at U16/17 and U12 were 293 and 262



cfu/100 mL, respectively, suggesting bacterial sources (potentially non-faecal) within these sections of the estuary.



**Figure 7:** Map of the Derwent estuary, with upper estuary sampling sites indicated in red.

There were no apparent trends between salinity levels and bacterial results across the sites. Results should be considered as indicative, given the small samples sizes, and some variability in analytical methods/detection limits.

A review of current guidelines, recent literature and expert advice was also undertaken, with respect to the suitability of various faecal indicators in freshwater, estuarine and marine conditions. This review showed consistent support for the use of enterococci as the preferred indicator in marine and coastal waters, as it is more robust in salt water and there is strong epidemiological evidence to support its use (N.Z. Ministry for the Environment, 2002; Wade *et al.*, 2003; WHO, 2003; Jin *et al.*, 2004; NHMRC, 2008).

However, there is still considerable debate about the best freshwater indicator, and the epidemiological

evidence available to date for these waters are not satisfying everybody (N.Z. Ministry for the Environment, 2002; WHO, 2003). Some guidelines support the use of enterococci in freshwater as the more conservative approach (WHO, 2003; NHMRC, 2008), while others note that enterococci can grow naturally in freshwater systems, and maintain that the use of *E. coli* is well supported, and a more reliable and consistent predictor in fresh conditions where they can survive up to six weeks (N.Z. Ministry for the Environment, 2002; Wade *et al.*, 2003) (Table 3).

Thermotolerant coliforms are now largely discounted as a faecal bacteria indicator, as they show a poor relationship between densities and illness, and some species have non-faecal or environmental origins (ANZECC, 2000; Hachich *et al.*, 2012; USEPA, 2012). Furthermore, thermotolerant coliforms can be particularly prevalent in wastewater from pulp and paper mills (Health Canada, 2012), as has previously been documented in effluent from the Boyer mill.

**Table 3:** Summary of preferred faecal bacteria indicators, national and international guidelines.

Guidelines	Marine	Estuarine	Freshwater
Tasmania (2007)	Enterococci	Enterococci	Enterococci
Australia/NH&MRC (2008)	Enterococci	Enterococci	Enterococci
New Zealand (2002)	Enterococci	Enterococci or <i>E. Coli</i>	<i>E. Coli</i>
US EPA (2012)	Enterococci		Enterococci or <i>E. Coli</i>
WHO (2003)	Enterococci	Enterococci	Enterococci
Vic EPA/Yarra (2015) – recommendation only	Enterococci	Enterococci or <i>E. Coli</i>	<i>E. Coli</i> or Enterococci
Canada (2012)	Enterococci		<i>E. Coli</i>
EU (2006)	Enterococci		<i>E. Coli</i> or Enterococci

The consistently low enterococci values observed at New Norfolk over many years suggest that either the catchment is not a significant source of faecal bacteria and associated pathogens, or that enterococci is not a sensitive indicator in this freshwater area of the estuary. To further test this, it is recommended that a dual testing trial be undertaken at New Norfolk next RWQ season for both enterococci and *E. coli*, using the Enterolert and Colilert methods, and using a 100 mL sample size. It may also be of interest to extend this dual testing downstream, to assess the apparent spikes in *E. coli* at U16/17 and U12. Furthermore, consultation with TasWater is recommended regarding their faecal indicator monitoring program at Bryn Estyn (they measure *E. coli* and Thermotolerant coliforms), as well as a comparative analysis of relevant data and a review of potential pathogen risks associated with catchment activities.

*This report and results will be submitted to the current review of the national Guidelines for Managing Risks in Recreational Water (NHMRC, 2008).*

## 7 COMMUNICATIONS

### 7.1 Information sharing

At the beginning of the RWQ season, general information about the monitoring program, including current water quality classifications for all sites, were sent to local council newsletters, local papers, and managers of events planned in the River Derwent over the summer.

### 7.2 Website

Weekly RWQ results were reported via the DEP website (<http://www.derwentestuary.org.au/beach-watch/>) throughout the summer, which was seen by almost 2,500 people. Swimming and Environmental sites were reported under the labels *Beach Watch* (Figure 8) and *Bay Watch* respectively (Figure 9).

## DERWENT BEACH WATCH

**Don't swim for several days after heavy rain, or at any time near stormwater pipes and rivulets.**

	Long-term grade	Weekly result
New Norfolk (Fitzgerald Park)	Good	Pass 10
Windermere Bay Beach	Fair	Pass 20
Nutgrove Beach (east)	Good	Pass <10
Nutgrove Beach (west)	Poor	Don't swim
Little Sandy Bay (south)	Good	Pass 10
Little Sandy Bay (north)	Good	Pass 31
Hinsby Beach	Good	Pass <10
Taroona Beach	Good	Pass 10
Kingston Beach (north)	Fair	Pass 10
Kingston Beach (mid)	Good	Pass 31
Kingston Beach (south)	Fair	Pass <10
Blackman's Bay (mid)	Good	Pass 10
Blackman's Bay (south)	N/A	Pass 10
Bellerive Beach	Fair	Pass <10
Howrah Beach (east)	Fair	Pass <10
Howrah Beach (mid)	Good	Pass <10
Howrah Beach (west)	Fair	Pass <10
Little Howrah Beach	Good	Pass <10

N/A = Insufficient data. N/S = Not sampled. Don't swim = DHRW recommends not swimming at this site. Retest = First sample exceeded guidelines, so a second sample is required for verification.

## BACKGROUND INFORMATION

### THE DERWENT BEACH WATCH MONITORING PROGRAM

Derwent Beach Watch is a collaborative monitoring program between councils and state government that tests water quality at swimming sites around the estuary during summer, click [here](#) for a map. Water samples are collected each Tuesday from the start of December to the end of March and analysed for the faecal indicator bacteria Enterococci using the Enterolert method at the Public Health Laboratories. Because the samples must be cultured, it takes several days to publish the results.

### HOW TO READ THE BEACH WATCH SNAPSHOT

Check the long-term grade

Each beach has been classified as GOOD, FAIR or POOR based on the last 5 years monitoring data.

- GOOD = water quality is usually good for swimming and rarely requires retesting.
- FAIR = water quality is usually fair for swimming, but occasionally requires retesting.
- POOR = Swimming is not advised.
- NA = The site has not been sampled for 5 years so a long term grade has not been assigned.

### Check the weekly test result

Periodic POOR water quality can occur at GOOD and FAIR water quality sites. Regular weekly monitoring assists in detecting such events.

- PASS = OK for swimming - test result was less than the set action level (140 bacteria colonies counted per 100 ml).
- RETEST = Caution - test result exceeded action level (140), requiring a second sample to be collected but results are not yet available.
- FAIL = Swimming is not advised - two consecutive samples exceeded action level (280 bacteria colonies counted per 100ml).

Has there been heavy rain in the past few days?

If so, avoid swimming in the Derwent River for several days as beaches are likely to be polluted by storm water.

### Signage and further information

This monitoring program has been used to develop the Beach Watch signage that has been installed at all Derwent River swimming sites. For further details see our latest Recreational Water Quality Report.

### FOR SWIMMING EVENT ORGANISERS AND PARTICIPANTS

- Avoid using sites with poor water quality classifications
- Develop water quality contingency plans in the event of heavy rain or poor test results
- Inform swimming event participants about water quality so that they can decide whether to swim.

For more specific information or health advice contact the Department of Health and Human Services (Scott Burton) at (08) 6222-7707 or your local council Environmental Health Officer.

**Results of samples collected on 7 February 2017**

**Figure 8.** Swimming Sites reported on the DEP website under the label *Beach Watch*, from the 7<sup>th</sup> February during the 2016 - 17 RWQ season.

DERWENT BAY WATCH			BACKGROUND INFORMATION	
<p><b>Don't swim for several days after heavy rain, or at any time near stormwater pipes and rivulets</b></p>			<p><b>THE DERWENT BAY WATCH MONITORING PROGRAM</b></p> <p>Derwent Bay Watch is a collaborative monitoring program between councils and state government that tests water quality at bays, coves and other sites around the estuary during summer, click <a href="#">here</a> for a map. Water samples are collected each Tuesday from the start of December to the end of March and analysed for the faecal indicator bacteria Enterococci (Enterolert method) at the Public Health Laboratory. Because the samples must be cultured, it takes several days to publish the results.</p> <p>Bay Watch sites are not designated swimming sites, and many are located in areas that are subject to stormwater pollution. Sampling is carried out weekly so that sites can be assigned a long-term using the last 5 years monitoring data.</p> <p><b>HOW TO READ THE BEACH WATCH SNAPSHOT</b></p> <p>Check the long-term grade</p> <p>Each beach has been classified as GOOD, FAIR or POOR based on the last 5 years monitoring data</p> <ul style="list-style-type: none"> <li>GOOD = water quality is usually good for swimming and rarely requires retesting</li> <li>FAIR = water quality is usually fair for swimming, but occasionally requires retesting</li> <li>POOR = Swimming is not advised</li> <li>NA = The site has not been sampled for 5 years, so a long term grade has not been assigned</li> </ul> <p>Check the weekly test result</p> <p>Periodic POOR water quality can occur at GOOD &amp; FAIR water quality sites - regular weekly monitoring assists in detecting such events. Weekly test results provide an additional level of information, particularly for event organizers and participants, but should be interpreted with caution. Swimming is not recommended at sites with a long-term grade of Poor, even if the weekly test result is occasionally good. A weekly test result in excess of 140 (bacteria colonies counted/100 ml) is an indication of potential health risks.</p> <p>Has there been heavy rain in the past few days?</p> <p>If so, avoid swimming in the Derwent for several days as beaches are likely to be polluted by stormwater.</p> <p><b>FOR SWIMMING EVENT ORGANISERS AND PARTICIPANTS</b></p> <ul style="list-style-type: none"> <li>Avoid using sites with poor water quality classifications</li> <li>Develop water quality contingency plans in the event of heavy rain or poor test results</li> <li>Inform swimming event participants about water quality conditions so that they can make an informed decision.</li> </ul> <p>For more specific information or health advice contact the Department of Health and Human Services (Scott Burton) at (03) 6166 0682 or your local council Environmental Health Officer.</p>	
	Long-term grade	Weekly result		
Old Beach Jetty	Good	10		
Elwick Bay Yacht Club	Fair	30		
New Town Bay	Fair	<10		
Prince of Wales Bay	Good	<10		
Geilston Bay	Fair	74		
Lindisfarne Bay	Fair	<10		
Montagu Bay	Good	<10		
Mid-River Swim	Good	<10		
Hobart Rivulet (mouth)	Poor	Don't swim		
Regatta Pavilion	Fair	20		
Victoria Dock	Good	<10		
Waterman's Dock	Poor	Don't swim		
Brooke Street Pier	Good	<10		
Sullivan's Cove	Good	<10		
Marievale Esplanade	Poor	Don't swim		
Kangaroo Bay	Good	31		
Brown's River	Poor	Don't swim		

Don't swim = Swimming not recommended due to long-term poor grade.  
NS = Not sampled, NA = Insufficient data.  
Based on samples collected on 7 February 2017

**Figure 9.** Environmental Sites reported on the DEP website under the label *Bay Watch*, from the 7 February during the 2016 - 17 RWQ season.

### 7.3 Facebook

For the first time, we this season also shared our weekly RWQ results on the DEP Facebook page [www.facebook.com/derwentestuary](http://www.facebook.com/derwentestuary). We had hoped to have exciting and pretty photos from around the estuary to go with these posts, but were not too successful on that front ([Figure 10](#)).

The number of Facebook views varied quite a bit. The best result was 816 views early in the season, with a post that included a view from the EPA boat, but typically RWQ results post was viewed by an average of 50 people. View numbers were highest when councils forwarded the posts.

We will continue to improve our Facebook postings, with new photos and for example have a weekly focus on individual beaches or regions, and by encouraging councils and other stakeholders to share our posts. All EHO's are warmly invited to share photos from their sampling days for this purpose, and hopefully we will reach more people next season through this popular social medium.



**Figure 10.** DEP Facebook posting from 23 December, referring to the weekly RWQ results on the website.



## 7.4 Weekend advisory

The most important message that we need to convey to the swimming public, is to not swim after heavy rains, due to the water quality of urban beaches and bays being often strongly influenced by stormwater run-off (NHMRC, 2008). We keep an eye on the weekend forecasts, and can put out an advisory on the DEP website and Facebook page when necessary, e.g. when recent or predicted rainfall is greater than 10 mm (Figure 11). This was done after the high rainfall event over the Christmas period.



**Figure 11.** A weekend advisory from 20 January, advising caution over the weekend as the water quality can be significantly affected by stormwater run-off.

## 7.5 Signage

The RWQ signage installed at Derwent swimming beaches is a useful source of information for beach users. The DEP recommends that local councils conduct an annual review of signage in their municipality to ensure that all signs are located in the most appropriate locations (i.e. visible to most visitors), are in good condition (e.g. free of graffiti), and that they are replaced with new signs as required (e.g. when the water quality category changes).

At the end of the 2015/16 RWQ season the DEP conducted a review of all the RWQ beach signs. New/updated/moved signs were subsequently installed at:

- Windermere Bay Beach
- Little Sandy Bay
- Nutgrove Beach (west + east)
- Kingston Beach (south)
- Blackmans Bay (south)
- Howrah Beach (mid)

In light of this season's rating changes, it is suggested that the following signage updates take place before next summer:

- Howrah Beaches east and west (both from 'fair' to 'good')
- Blackmans Bay south (from 'good' to 'fair')

## 7.6 Boat sewage

Prompted by an unusually high enterococci result at Watermans Dock at the end of the last RWQ season, the DEP has assisted the EPA with upgrading information on the their website with regards to sewage from boats: <http://epa.tas.gov.au/epa/water/boat->

[sewage-management](#). This information is a much more readable version of the **Directive on The Discharge of Sewage from Certain Vessels into State Waters**.

The full version is here:

<http://epa.tas.gov.au/Documents/Final%20Signed%20Sewage%20Management%20Directive%20-%202018%20December.pdf>

As a general rule, the DEP and EPA encourage boat owners in the Derwent to treat wastewater on board until it can be disposed of properly on land, and to use TasPort's wastewater pump-out station at Kings Pier Marina by the Franklin Wharf:

[http://www.tasports.com.au/port\\_services/sewage.html](http://www.tasports.com.au/port_services/sewage.html)

## **7.7 Predictive modelling**

As we only test the water quality of our beaches and bays on Tuesdays, it is not possible to predict what the quality will be like on the weekends, which is when most people swim. We partly remedy this by providing more generic advice on the classification of beaches based on the long-term monitoring, along with the standing advice to avoid swimming in the Derwent for several days after heavy rain

Numerous beaches interstate and overseas are now, in addition to their regular water sampling and testing, providing the swimming public with a predicted forecast of the water quality for each day during their summer season. This includes the Sydney beaches, the Yarra River and beaches around Port Phillip Bay, and around Auckland. Forecasts are generally produced using a combination of historical water quality data, past and predicted rainfall, and cloud cover conditions, but may also include simulations of tidal and wind-driven currents.

During the coming winter the DEP will investigate the possibility of conducting a limited forecasting trial at some of our popular swimming beaches during the 2017-18 RWQ season. This will be discussed at the spring Monitoring Taskforce meeting.

## **8 CONCLUSION AND RECOMMENDATIONS**

Generally good water quality was reported this season for most Swimming Sites and for many of the Environmental Sites, and some sites had an improved result from last season. This is likely due principally to overall low rainfall this summer.

Therefore, although the long term grade at many sites has recently improved, and given this is likely due to the low rainfall or timing of rainfall over the previous five summers, it is possible that sites historically graded as poor or fair will again return to their prior status during summers with rainfall closer to the longer term average, unless the sources of faecal contamination have been identified and rectified.

## **9 ACKNOWLEDGEMENTS**

The DEP would like to sincerely thank all Council environmental health officers and other Council staff who have contributed to this RWQ season, as well as EPA staff who have assisted with boating requirements. Many thanks also go to the staff at the Public Health Laboratory for their ongoing participation and friendly support, and our industry partners, including Norske Skog and TasWater.

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## 11 APPENDIX

### 11.1 Appendix A – RWQ Intercalibration report 2016-17 by I. Visby, C. Coughanowr.

#### Executive Summary

Recreational Water Quality (RWQ) monitoring in the Derwent estuary is conducted and reported in accordance with the Recreational Water Quality Guidelines 2007 (*Public Health Act 1997*). In order to ensure consistency of sampling methods and to assess the degree of variability between samples and samplers, the Derwent Estuary Program (DEP) coordinates an annual inter-calibration exercise. On 28 November 2016, environmental health officers from five council partners and the DEP simultaneously collected a single sample each at two sites on Howrah Beach. Results were consistent between samplers and sites, with low results reported at both sites.

#### Introduction

The RWQ monitoring is conducted and reported in accordance with the Recreational Water Quality Guidelines 2007 (*Public Health Act 1997*). The guidelines recommend classifying primary contact recreation beaches according using a 95<sup>th</sup> Hazen percentile values for the faecal indicator bacteria enterococci. Long-term water classification codes are based on a 5-year 95<sup>th</sup> Hazen percentile for the faecal indicator bacteria enterococci:

- Good (surveillance mode) = < 200 MPN/100 mL.
- Fair (alert mode) = 200 - 500 MPN/100 mL.
- Poor (action mode) = > 500 MPN/100 mL.

The long-term beach classification guidelines do not take into account the possible influence of variability in the data due to differences in sampling techniques between samplers, or possible heterogeneity of the sampled water body. The DEP RWQ program uses data provided by a number of different council Environmental Health Officers, which increases the risk of variability due to sampling technique. Thus, the primary objective of the annual inter-calibration exercise is to review and practice sampling methods at the start of the season in order to improve consistency of results. A secondary objective is to gain a better understanding of water quality at a particular site.

#### Methodology

##### Participants

The DEP (Inger Visby) coordinated the participation of the following council partners:

- Hobart City Council (Jess MacRae, Elizabeth Phillips)
- Clarence City Council (Andrew Forshaw)
- Glenorchy City Council (Tracy Tavaszi)
- Kingborough Council (Rachel Tenni)
- Brighton Council (Brent Basstian)

##### Location

Site 1 was off the beach near the stormwater outfall at the eastern end of Howrah Beach, and Site 2 was approx. 100 m. further west along the beach. An additional sample was also taken by DEP only, directly by the stormwater outfall on the beach to assess this as a potential source of contamination (Figure 1).

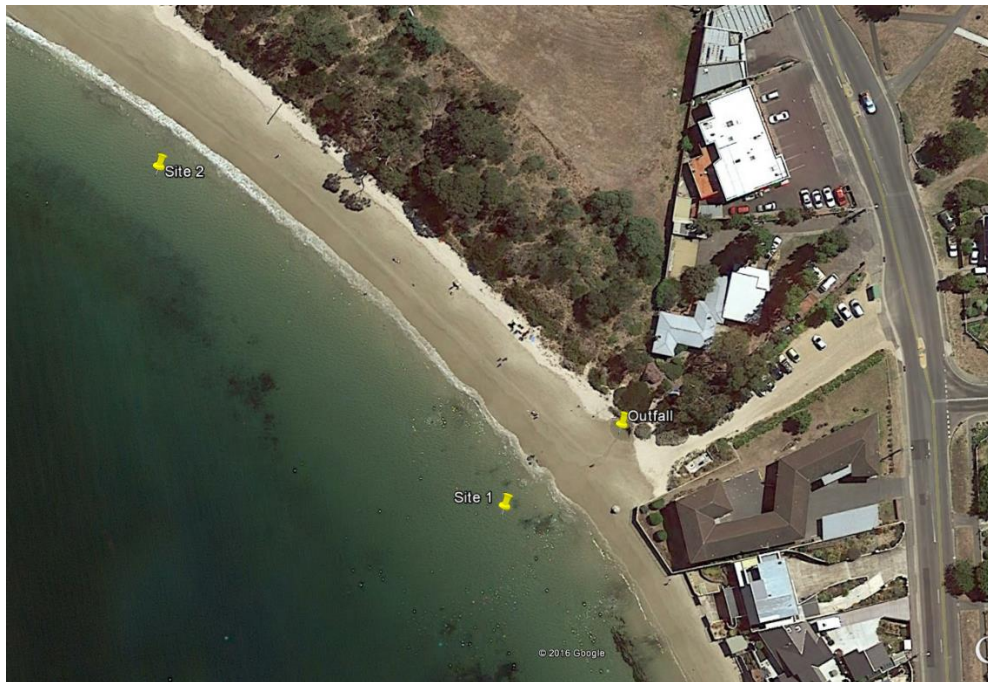


Figure 1. Position of the three locations sampled for the RWQ inter-calibration exercise on 28 Nov. 2016.

### Method

Field sheets were completed by entering wind speed, wind direction, preceding rainfall, date and time of sampling. Any general observations were also noted, such as discolouration, odour, construction activity, boat presence, density of wildlife, evidence of faeces, proximity to stormwater outfalls or any other matters which might influence results. Bottles were labelled with the site, time, sample identification code and the sampler's name.

All samplers concurrently collected a single sample at each site from an approximate water depth of 0.3 m. Bottles were only opened immediately prior to collecting the sample. Once the bottle cap had been removed, care was taken to ensure that this was not contaminated by fingers or by contact with surfaces. The bottle was quickly plunged to the required sampling depth, then it was tilted upward with the mouth pointed upward. The sample was brought to the surface and a portion of the sample tipped out so that the level in the sample container was at the bottle collar. The sample lid was screwed tightly shut before removing it from the sample pole and the sample was placed upright in a chilled esky ready for transport to the laboratory.

Samples were delivered to the laboratory immediately upon completion of the inter-calibration event.

In addition to enterococci sampling, Clarence City Council and the Derwent Estuary Program used *in-situ* physical and chemical water quality multi-probes, using a Horiba Water Quality Checker U-10 and Hydrolab Quanta respectively. The calibrated multi-probes were deployed to the same depth of water from which an extra enterococci sample was collected (on Bellerive Beach) and left in the water until data readings stabilised prior to comparing temperature (°C), pH and salinity (ppt).

### **Results**

The enterococci results from Site 1 varied between <10 and 63 (mean 27.3) MPN/100 mL. At Site 2 all results were 10 or below MPN/100 mL. At the stormwater outlet the result was 282 MPN/100 mL. (Table 1).

The of results from the multi-probes compared almost identically (Table 2).

Table 1: Summary of enterococci concentration results (MPN/100 mL) sampled on 28 Nov 2016

<b>Sampler</b>	<b>Site 1: Near outfall</b>	<b>Site 2: Howrah East</b>
Glenorchy	< 10	< 10
Brighton	10	< 10
Hobart	63	10
Clarence	41	< 10
Kingborough	20	< 10
DEP	20	< 10
<b>Mean</b>	<b>27.3</b>	<b>10</b>

<b>Sampler</b>	<b>Directly by outfall</b>
DEP	282

Table 2: Summary of the multi-probe comparison exercise with Clarence City Council (CCC) and Derwent Estuary Program (DEP) from 28 Nov 2016.

<b>Multi-probe</b>	<b>Temperature (°C)</b>	<b>Salinity (ppt)</b>	<b>pH</b>
Hydrolab Quanta (DEP)	17.8	23.22	8.09
Horiba Water Quality Checker U-10 (CCC)	17.4	23.70	8.02

## Conclusions

Water quality was good at both sites. The monitoring results demonstrated fairly homogeneous water quality conditions at both locations, with results demonstrating the expected variability.

Given that urban stormwater drains are a known source of faecal contamination, the higher enterococci result from samples collected at Site 1 were expected, but results were still low compared with the sample collected directly by the pipe, indicating significant dilution over a relatively short distance. The variability between < 10 and 63 at Site 1 suggests some variability in the flow path and dilution rates. The result directly by the outfall may have been slightly diluted, as the pipe was half emerged in bay water, reducing enterococci concentration; the tide was still going out. The results from Site 2 suggests that at 100 m. distance from the stormwater outfall the flow from the drain has been completely diluted.

Samplers adopted good aseptic grab sampling technique, removing bottle lids at the last moment before collecting a sample, protecting the bottle and lid from contamination, labelling bottles correctly and storing samples in a chilled esky for subsequent transport to the laboratory. Samplers were aware of potential sources of faecal contamination.

## References

*Public Health Act 1997*

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## 11.2 Appendix B – Swimming Sites results

2016-17 RWQ season Swimming Site results - enterococci MPN per 100 mL.

	Bellerive Beach	Blackmans Bay Beach (mid)	Blackmans Bay Beach (south)	Fitzgerald Park, New Norfolk	Hinsby Beach	Howrah Beach (east)	Howrah Beach (mid)	Howrah Beach (west)	Kingston Beach (mid)	Kingston Beach (north)	Kingston Beach (south)	Little Howrah Beach	Little Sandy Bay Beach (south)	Little Sandy Bay Beach (north)	Nutgrove Beach (east)	Nutgrove Beach (west)	Taroona Beach	Windermere Bay Beach
06-Dec-16	<10	<10	10		<10	<10	<10	10	<10	10	64	10	<10	<10	<10	10	<10	<10
13-Dec-16	<10	42	31	10	<10	<10	<10	10	20	64	453	10	64	<10	64	573	10	164
20-Dec-16	<10	<10	<10	<10	10	<10	<10	<10	<10	10	<10	99	<10	10	10	63	<10	<10
28-Dec-16	1091	324	>2005		42	531	2247	1013	<10	288	>2005	>2005	10	207	238	74	20	
03-Jan-17	31	20	<10	20	<10	10	10	52	63	41	52	41	20	<10	<10	41	52	53
10-Jan-17	10	10	<10	<10	20	<10	<10	10	<10	137	<10	10	<10	20	<10	10	<10	20
17-Jan-17	20	10	<10	<10	<10	31	<10	20	31	10	10	<10	20	<10	<10	41	<10	<10
24-Jan-17	10	10	87	10	<10	185	<10	<10	<10	10	178	42	20	<10	<10	<10	<10	<10
31-Jan-17	<10	10	64	20	10	148	20	20	<10	10	53	87	<10	<10	<10	10	10	20
07-Feb-17	<10	10	10	<10	<10	<10	<10	<10	31	10	<10	<10	10	31	<10	10	10	
14-Feb-17	<10	<10	31	42	<10	<10	10	<10	20	<10	111	<10	10	<10	<10	<10	<10	<10
21-Feb-17	20	10	31	<10	<10	10	31	<10	10	<10	20	10	<10	<10	<10	<10	<10	<10
28-Feb-17	<10	10	659	64	20	63	<10	42	20	10	99	<10	<10	192	178	20	<10	<10
07-Mar-17	<10	20	453	20	<10	<10	<10	<10	<10	192	111	<10	10	10	10	<10	20	10
14-Mar-17	<10	<10	124	<10	<10	<10	10	<10	<10	10	10	<10	20	<10	<10	10	<10	<10
21-Mar-17	31	<10	178	<10	<10	10	<10	<10	42	53	10	10	<10	31	<10	<10	<10	53
28-Mar-17	<10	<10	31	288	<10	10	10	10	31	10	<10	111	<10	<10	20	52	10	53

### 11.3 Appendix C – Environmental Sites results

2016-17 RWQ season Environmental Site results - enterococci MPN per 100 mL.

	Brooke St Pier	Browns River	Cornelian Bay Beach	Elwick Bay	Geilston Bay	Hobart Regatta Pavilion	Hobart Rivulet	Kangaroo Bay	Lindisframe Bay	Marieville Esplanade	Mid-river Derwent Swim	MONA Berridale Bay	MONA Cameron Bay	MONA Jetty	Montagu Bay	New Town Bay	Old Beach, Jetty Road	Prince of Wales Bay Marina	Sullivans Cove	Victoria Dock	Watermans Dock
06-Dec-16	<10	281		20	<10	10	<10	<10	10	158	<10	20	<10	<10	10	10	10	<10	<10	<10	10
13-Dec-16	<10	317		318	10	<10	75	20	<10	771	<10	41	64	<10	<10	10	<10	10	<10	10	10
20-Dec-16	10	145		10	<10	<10	<10	<10	10	<10	<10	63	10	<10	<10	10	<10	10	<10	<10	<10
28-Dec-16		52	3076							1785											
03-Jan-17	10	1918	201	31	<10	556	959	41	<10	148	20		20	20	10	20	20	10	<10	<10	31
10-Jan-17	<10	2909		213	31	<10	805	10	<10	262	10	108	64	63	<10	<10	<10	<10	<10	<10	<10
17-Jan-17	<10	10	10	<10	52		41	<10	<10	30	<10	10	<10	<10	<10	<10	10	<10	<10	<10	<10
24-Jan-17	10	933		41	30	<10	203	31	10	41	<10	301	254	63	<10	20	10	<10	10	10	41
31-Jan-17	<10	275	97	30	<10	10	86	<10	<10	481	<10	30	10	<10	<10	10	10	10	<10	<10	<10
07-Feb-17	<10	96			74	20	538	31	<10	<10	<10		10		<10	<10	10	<10	<10	<10	20
14-Feb-17	<10	1184	42	20	<10	<10	20	<10	<10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	10
21-Feb-17	<10	373		<10	<10	<10	341	<10	20	10	10	109	<10	<10		<10	<10	<10	<10	<10	<10
28-Feb-17		41	10	10						<10		134	563	<10			20				
07-Mar-17	20	471		10	<10	<10	663	<10	20	96	10		10	<10	20	20	<10	<10	<10	<10	10
14-Mar-17		481	<10	<10						<10		63	30	10			<10				
21-Mar-17	<10	156		75	<10	20	4106	<10	63	<10	<10	52	<10	20	<10	53	<10	20	10	10	41
28-Mar-17	31	1287	31	309	42	10	146	<10	75	108	<10	288	42	309	42	164	<10	150	75	20	20

## 11.4 Appendix D – Upper estuary study

### 11.4.1 Long-term average salinity levels + levels recorded on sample days, at surface depths (ppt), as measured by the Ambient Water Quality Program

	Long-term average	20-Dec	17-Jan	21-Feb	21-Mar
<b>NN</b>	<b>0.06</b>	0.02	0.09	0.41	0.24
<b>U19</b>	<b>0.63</b>		1.46	1.32	0.54
<b>U16/17</b>	<b>1.62</b>	1.98	2.37	2.95	0.98
<b>U14</b>	<b>3.38</b>	4.29	5.66	4.18	2.36
<b>U12</b>	<b>5.61</b>	4.29	9.8	6.37	6.98

### 11.4.2 Results from upper estuary faecal bacterial indicator study. The last column is results from the regular RWQ program sampling at New Norfolk on the same days

Date sampled	Time	Sample size analysed	Site locations	Sample depth	Thermotolerant coliforms (cfu/100mL)	<i>E. coli</i> (cfu/100mL)	Enterococci (MPN/100mL)	New Norfolk RWQ enterococci (MPN/100mL)
<b>20/12/2016</b>	8:40	10mL	U12	0.1m	20	20	<10	< 10
	9:05		U14		20	20	<10	
	9:25		U16/17		10	10	10	
	9:45		U19 S1		10	<10	<10	
	9:45		U19 S2		40	40	<10	
	10:15		NN		20	20	<10	
<b>17/01/2017</b>		100mL	U12	0.1m	90	18	5.1	< 10
			U14		>100	>50	6.3	
			U16/17		>100	>90	5.2	
			U19		53	44	1	
			NN		41	41	<1	
<b>21/02/2017</b>	8:45	10mL	U12	0.1m	1800	<b>900</b>	20	< 10
	9:00		U14		900	<10	<10	
	9:20		U16/17		1800	<b>900</b>	<10	
	9:30		U19 S1		170	<b>170</b>	<10	
	9:30		U19 S2		170	<b>170</b>	10	
	10:00		NN		100	100	10	
<b>21/03/2017</b>	8:50	100mL	U12	0.1m	160	110	16.1	< 10
	9:10		U14		28	28	13.2	
	9:30		U16/17		230	<b>170</b>	2	
	9:50		U19		56	56	<1	
	10:10		NN S1		59	49	<1	
	10:10		NN S2		58	58	<1	