Mary River Water Quality Catchment Crawl

2019

8 – 9 October 2019

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Executive Summary

The 2019 Catchment Crawl was held on the 8th and 9th of October. 34 sites were sampled along the Mary River and seven of its tributaries, including the Susan River. At each site, we tested for basic physical chemistry, *E. coli*, total suspended solids and nutrients. Overall, most sites complied with Queensland water quality guideline values, indicating that water quality throughout the catchment was in reasonable condition. In some cases, sites did not meet the guideline values due to low flow conditions leading up to the Crawl dates. In other cases, a failure to meet the guideline values was most likely due to nutrients, sediments and/or pathogens entering the catchment from one or more external sources. Annual Catchment crawls have occurred in early October since 2002. However, some new sites have been added over this time. Catchment Crawl data is most useful when comparing results across a number of years. As new sites have no comparable data, data from these sites should be interpreted with caution.

Weather and Stream Flow and Discharge

Leading up to the Catchment Crawl, warmer than average air temperatures were observed and river flow decreased to virtually cease-to-flow conditions during winter-early Spring 2019. Although parts of the Catchment received small localised rainfall just prior to the Catchment Crawl, this made no difference to river heights or discharge rates compared to 2018 and 2017.

Temperature

With air temperatures in the mid to high thirties, most of the 2019 Catchment Crawl sites recorded warmer water temperatures compared to previous years. However, water temperatures nevertheless remained within guideline values for all sites. The hottest water temperature was recorded in the western region at Munna Creek (MUN990) with a temperature of 30°C. The coolest site was recorded near Gympie at the Mary River, Widgee Crossing (MAR510) with 16.85°C. This was the first time that the coolest site was not at the Mary River Headwaters (MAR009), which has the second coolest water temperature for 2019, at 19°C. Due to the high temperatures recorded, only three Mary River sites were assessed as suitable for Mary River cod breeding to occur; Mary River at the Headwaters (MAR009), Widgee Crossing (MAR510) and Bauple Road Bridge (MAR640). Based on the measurements during this 2019 Catchment Crawl, Mary River cod populations would be unlikely to breed in the main trunk of the river and may struggle to survive in the Kenilworth and Goomong reach. Three sites on Six Mile Creek (SIX080, SIX505 and SIX775) were the only tributary sites cool enough for successful Mary River cod spawning at 21°C.

pH

Given the tendency for pH to become more alkaline when water temperature, and therefore algal photosynthesis increases, there was an increase in the number of Catchment Crawl sites that exceeded pH guidelines compared to 2018. These sites were mostly located on the Mary River; at

Conondale (MAR050), Walli Mt (MAR148), Goomong (MAR381), Traveston Crossing (MAR425), Gympie Weir (MAR499), Widgee Xing (MAR510), Miva (MAR605) and Emerys Crossing (MAR660).

Tributary sites generally tend to record lower pH (more acidic). However, 2019 exceptions to this were sites located at Obi Obi Creek (OBI760), Yabba Creek at Imbil (YAB680) and Mary Valley Rd (YAB950), Widgee Creek (WID399) and Munna Creek (MUN990), which all recorded pH levels of 8 or above.

Electrical conductivity (EC)

2019 Catchment Crawl EC recordings had the best compliance rate with the guidelines since 2016, with only one site at the Mary River, Miva (MAR605) exceeding guidelines – unlike previous years where multiple sites below Gympie consistently exceed EC guidelines. Interestingly, the Upper catchment displayed the highest EC trend seen since 2008 which is likely to be directly linked to lower than usual streamflows. There appears to be a trend where the EC levels in the upper catchment are slowly increasing year-on-year. The lower Catchment sites displayed a marked decrease in EC compared to previous Catchment Crawls, unlike previous catchment crawl trends.

Turbidity and Total Suspended Solids

Low turbidity is to be expected at this time of year given it is a low rainfall period, and therefore limited runoff occurs to cause turbidity. Rainfall rates prior to the Catchment Crawl were insufficient to elevate levels above those of previous years.

The guideline for total suspended solids for lowland and upland streams in South-east Queensland is 6 mg/L (Department of Environment and Resource Management, 2009). In 2019 all Mary River sites, except those at Tuchekoi (MAR372), Bauple Rd Bridge (MAR640), Tiaro (MAR743) and River Heads (MAR999) complied with this limit. Six Mile Creek upstream of Lake MacDonald (SIX080), Tinana Creek at Teddington Weir (TIN800), Munna Creek (MUN990) and Susan River (SUS500) also exceeded the guideline in 2019.

Dissolved oxygen (DO)

Most Mary River sites were within DO guidelines, with the exception of Walli Mt (MAR148), Kenilworth (MAR169), Goomong (MAR381), Traveston Crossing (MAR425) and the Gympie Weir (MAR499). Only two tributary sites were within guidelines, both at Yabba Creek located at Imbil (YAB680) and Mary Valley Road (YAB950). All other sites were either below or above DO guidelines. These highly variable figures may have been due to no/slow flows observed or shallow pools that were tested in the afternoon when hotter temperatures occur, resulting in super saturation (above 100% saturation).

Nitrogen & Phosphorus

All Mary River sites were within the nitrogen guidelines. Most tributary sites were also compliant. However, sites at Six Mile Creek, upstream of Lake Macdonald (SIX080) and downstream of Lake Macdonald (SIX160), Munna Creek (MUN990) and Tinana Creek at Teddington Weir (TIN800), exceeded the guidelines. The Six Mile Creek sites (SIX080 and SIX160) may be influenced by stagnant water eg. Waterholes in Six Mile Creek above Lake Macdonald (SIX080) and the Lake Macdonald stilling pool below the spillway (SIX160), as these sites consistently record elevated levels of ammonium. This trend has been observed in previous Catchment Crawls. The Mary River at Widgee Crossing (MAR510) exceeded phosphorus guidelines for the second year in a row. The Mary River at

Kenilworth (MAR170), the next downstream site at Moy Pocket (MAR300) and the Gympie Weir site (MAR499, above Widgee Crossing) were within guidelines, however, elevated similarly to 2018. All tributary sites complied with the Phosphorus guideline.

Like 2018, the highest results for both nitrogen and phosphorus were found at the Susan River site (SUS500). Susan River (SUS500) exceeded the nitrogen guideline, with samples showing this comprised mostly of organic nitrogen, unlike the high elevations of ammonium nitrogen observed in 2018. Like previous years, Susan River (SUS500) also exceeded Phosphorus guidelines and had the highest amount of phosphorus of all sites. With the limited data and information available, we have been unable to determine the reason for the heightened nutrient levels sampled at this site.

E.coli

The highest *E.coli* levels observed on the Mary River during the 2019 Catchment Crawl were at the Gympie Weir (1000MPN/100ml), followed by Kenilworth (770MPN/100ml) (downstream of Obi Obi Creek confluence), then Walli Mountain (650MPN/100ml). Moy Pocket (310MPN/100ml) and Kenilworth (200MPN/100ml) (upstream of the Obi Obi Creek confluence) also exceeded the guideline at the time of the Catchment Crawl.

The Gympie Weir sample was taken above the weir at the dome (stormwater drain). The dome was flowing at the time, despite there being little to no rainfall in the lead up. The high reading could indicate that there is *E. coli* coming from the stormwater inputs. The results on the Mary River at Kenilworth, above and below the confluence of Obi Obi Creek suggest that Obi Obi Creek is also a source for *E. coli*.

1 Introduction and background

The annual Mary River Catchment Crawl, organised by the Mary River Catchment Coordinating Committee (MRCCC), takes place annually in the month of October. The 2019 Catchment Crawl was held on the 8th and 9th of October, and included testing of sites along the Mary River and seven of its tributaries (Obi Obi Creek, Six Mile Creek, Yabba Creek, Widgee Creek, Wide Bay Creek, Munna Creek and Tinana Creek), plus one site on the Susan River. Overall, 34 sites were sampled over the two days. Testing included basic physical chemistry, *E. coli*, total suspended solids and nutrients (N and P).

The aim of MRCCC's annual Catchment Crawl is to provide a snapshot of the state of the water quality in the Mary River Catchment by sampling a large number of sites in a short period of time at the same time of the year. The impact of prevailing weather conditions (temperature, rainfall) is therefore often similar at all testing sites, making it easier to compare sites in one part of the Catchment to another. Whilst several sites tested during the Catchment Crawl have several years' worth of data, there are new sites which have been added to the schedule. For these newer sites, particular care needs to be taken when interpreting the results from one or two data points.

The Catchment Crawl data complements the data in the existing Waterwatch database. The Mary River Waterwatch program has been operating in the Catchment since 2002. It is envisaged that by strategically selecting sites to repeatedly test during the annual Catchment Crawl, longer-term or seasonal trends may become apparent. For example, if a site consistently falls outside guidelines year after year, the data may indicate there is an issue requiring further investigation. Another important use for the Catchment Crawl data is to determine which sites have water temperature that is suitable for Mary River Cod breeding, which occurs during September and October each year, normally during the Catchment Crawl.

Catchment Crawls also provide an opportunity for members of the public to meet with MRCCC representatives and improve their understanding of water quality conditions of the whole catchment, whilst contributing their own localised expertise to build knowledge of the Catchment. Often, Waterwatch volunteers and enthusiastic members of the community join MRCCC representatives for all or part of the Catchment Crawl. This willingness to participate is greatly appreciated. In addition to the regular water testing, wildlife sightings and riparian condition are recorded. These records are often enriched by visiting members of the public who have a keen interest and expertise in wildlife and plant identification. We have also had individuals undertake their own private Catchment Crawls that contribute to the database in their local area.

1.1 History of Mary River Catchment Crawls

The MRCCC has undertaken seventeen Catchment Crawls since 2002. In the first five years of Catchment Crawls it was common for two crawls to occur per year, one in Spring and one in Autumn. There was then a gap of six years between the 2009 crawl and the 2015 crawl. Crawls have occurred annually since 2015 and always in early October. This timing was selected because it coincides with the beginning of the Mary River Cod, Lungfish and Mary River Turtle breeding season and it allows time for data to be collated and presented to the MRCCC AGM in the third week of October.

The standard Waterwatch physical and chemical parameters (pH, temperature, dissolved oxygen, electrical conductivity and turbidity) have been measured during all Catchment Crawls. In some years, additional parameters have been measured. The number of sites sampled has also varied. MRCCC is grateful to the Department of Environment and Science for their support of the nutrient and total suspended solids (TSS) analysis since 2015. Table 1 provides an overview of the Catchment Crawl history in the Mary River Catchment.

In 2018 and 2019 Seqwater has funded the Catchment Crawl which has enabled expansion of the program. Two teams of MRCCC staff and volunteers sampled over the two days of the Catchment Crawl, enabling 34 individual sites to be sampled. The goal with the expanded sampling was to collect data at the up and downstream extents of the three reaches of the Catchment (Kenilworth, Goomong, Lake Macdonald) where Seqwater-MRCCC partnership projects are being undertaken. The selection of the additional sites was based on a detailed analysis of current Waterwatch sites, Catchment Crawl sites and other monitoring sites (e.g. Main Roads monitoring projects). This analysis aimed to identify any suitable sites that had historical data. Although it is difficult to infer a change in water quality from single data points collected in the Catchment Crawl, our aim is to build a long-term record that would enable change to be detected. However, these single data points do serve to flag particular points of interest. Information specific to the Seqwater partnership is reported in the 2019/2020 Performance Report.

Table 1 Overview of all MRCCC-led Catchment Crawls

	Year	Dates	Number of sites	Report completed	Raw data	Interesting aspects
1	2002	22-23 October	14 on Mary River 13 on tributaries	Yes	Yes	
2	2003	1-2 May	16 on Mary River	Yes	Yes	Nitrate and FRP (orthophosphate) tested
3	2003	20-21 October	16 on Mary River	Yes	Yes	Nitrate and FRP (orthophosphate) tested
4	2004	11-12 May	17 on Mary River	Yes	Yes	Riparian condition assessments completed
5	2004	16 and 22 October	22 on Mary River 2 on tributaries	Yes	Yes	Riparian condition assessments completed
6	2005	11-13 October	22 on Mary 2 on tributaries	No	No	
7	2006	14-15 March	19	Yes	Yes	Widgee and Wide Bay Creek sub catchments only
8	2006	16-17 October	17 on Mary River	Yes	Yes	
9	2007	24-25 October	14 on Mary River 7 on tributaries	Yes	No	Pesticide residue tested at six sites
10	2008	April	14	Yes	Yes	Reported with 10/08 data
11	2008	22-23 October	14 on Mary River 8 on tributaries	Yes	Yes	Nutrient tested at six sites
12	2009	19 October	3 on Mary River 2 on tributaries	No	No	Photos of Crawl available – Dickabram Bridge, Emery's Crossing and Coles and Skyring Creeks
13	2015	8-9 October	13 on Mary River 7 on tributaries	Yes	Yes (no e-DNA data)	Nutrients and TSS at all sites (through GBR loads monitoring) Environmental DNA (through Harmony Patricio – Griffith University) Riparian Condition Assessments
14	2016	4-5 October	14 on Mary River 7 on tributaries	Yes	Yes	Nutrients and TSS at all sites (through GBR loads monitoring) *E.coli* at 14 main trunk sites, 2 tributary sites on Six Mile Creek
15	2017	10-11 October	19 on Mary River 13 on tributaries	Yes	Yes	Nutrients and TSS at all sites (through GBR loads monitoring) *E.coli* at 18 main trunk sites, 10 tributary sites
16	2018	8-9 October	20 on Mary River 14 on tributaries	Yes	Yes	Nutrients and TSS at all sites (through GBR loads monitoring) E.coli at 19 main trunk sites, 11 tributary sites
17	2019	8-9 October	20 on Mary River 14 on tributaries	Yes	Yes	Nutrients and TSS at all sites (through GBR loads monitoring) E.coli at 20 main trunk sites, 11 tributary sites

1.2 Weather and river conditions relevant to 2019 crawl

The 2019 Catchment Crawl occurred on Tuesday 8th October and Wednesday 9th October.

The 2019 Winter/Spring season was warmer than average, with average temperatures recorded in June, but warmer temperatures in July (>1.5°C), August (>1°C), September (>2.5°C) and October (>0.5°C). September was 2.5°C warmer than average. There was no Spring break of season in 2019 before the catchment crawl – with average June rainfall, 20% of average for July, 25% of average for August and virtually zero rainfall in September.

Table 2 shows the river heights and flow rates at several gauging stations in the Catchment. This data was sourced from the online 'Water Monitoring Information' Portal, which is provided by the Queensland Government's Department of Natural Resources and Mines. Data sourced represents the mean discharge. Table 2a shows flow rates observed during the Catchment Crawl. At all sites during the Catchment Crawl, river flow was decreasing to virtually cease-to-flow conditions, apart from Home Park which had a stable flow of approximately 30 meg/day for 5 days prior (see Appendix C). River flows were down on 2018 and 2017 conditions.

In the week before the 2019 Catchment Crawl parts of the Catchment received some rainfall. Gympie recorded 2mm on 29/09, Maryborough recorded 6mm on 02/10, Tiaro recorded 14mm on 29/09 and 4mm rainfall on 03/10 and Kenilworth received ~15mm the week prior to the Catchment Crawl. This localised rainfall made no real difference to river flows though.

Table 2 Gauging station locations, river heights and flow rates

Gauging station location	Mean River height (m) 8-9/10/2018	Mean Discharge (ML/day)* 8-9/10/2019 (2018 & 2017)	Notes, see appendix C for riverflow plots
Mary River, above Kenilworth (Bellbird station)	0.452m (<20% flow)	12.42 (20.8 MEG / 20.1)	River flow falling from month prior – virtually cease-to-flow conditions
Mary River, Moy Pocket station	0.684 (<20% flow)	15.22 (59 MEG / 54.2)	River flow falling from month prior – virtually cease-to-flow conditions
Mary River, below Gympie (Fishermans Pkt station)	1.439 (20-50% flow)	31 (155 MEG / 104.7)	River flow decreasing from a peak on 1/10/2019 of 80 meg/day. Considerably lower than 2018/2017
Mary River, Miva station	1.559m (20-50% flow)	31.58 (136 MEG / 196.7)	River flow decreasing from a peak on 4/10/2019. Considerably lower than 2018/2017
Mary River, above Tiaro (Home Park station)	1.074m (20-50% flow)	33.37 (116 MEG / 182.1)	Stable riverflow of approximately 30 meg/day from 4/10/2019

*ML = 1 million Litres

Table 2a Flow observations during Catchment Crawl

Site	Flow
MAR009	Slow
MAR050	No flow
MAR125	No flow
MAR148	Slow
MAR169	Slow
MAR170	Slow
MAR300	Slow
MAR330	Slow
MAR372	Slow
MAR381	Slow
MAR425	Slow
MAR499	Moderate
MAR510	Slow
MAR605	Slow
MAR640	Slow
MAR660	Slow
MAR670	Slow
MAR743	No flow
MAR763	Slow
MAR999	Slow
MUN990	No flow
OBI760	Slow
OBI940	Slow
SIX080	Slow
SIX160	Slow
SIX505	Slow
SIX755	Slow
SUS500	No flow
TIN550	Slow
TIN800	Slow
WIB950	Slow
WID399	No flow
YAB680	Slow
YAB950	Slow

Above: Garth Jacobson looking at flood marker at Tinana Creek, Missings Crossing (TIN800)

Methods

1.3 Sites

In total, 34 sites were sampled. 20 of these sites were on the Mary River itself and the other 14 were collected from the tributaries of Obi Obi, Yabba, Widgee, Wide Bay, Munna, Six Mile and Tinana Creek and the Susan River. All of the sites sampled are shown in Figure 1. Figure 2 and Figure 3 provide more detail of the sites sampled on Day 1 and Day 2 respectively. The Figures also show the Water Types discussed further in section 2.4. The full itinerary is provided in Appendix A.

All samples were analysed for the Waterwatch suite of parameters (pH, Electrical Conductivity, Dissolved Oxygen, Turbidity and temperature) and the Department of Environment and Science (DES) Great Barrier Reef Catchment Loads monitoring suite of parameters (see Table 5). *E.coli* samples were also collected at 19 Mary River sites and 11 tributary sites. Sampling for *E.coli* was limited to 30 sites because of logistical constraints of getting samples to the laboratory within 24 hours of collection.

Table 3 provides the details of all sites tested, their water type, their site code, a brief description of the site and the parameters tested. Duplicate samples were taken at seven sites across the two days for the nutrient and total suspended solids samples. Duplicate samples provide a quality control measure to ensure our sampling methods are consistent and rigorous. The itinerary for all sites is provided in Appendix A.

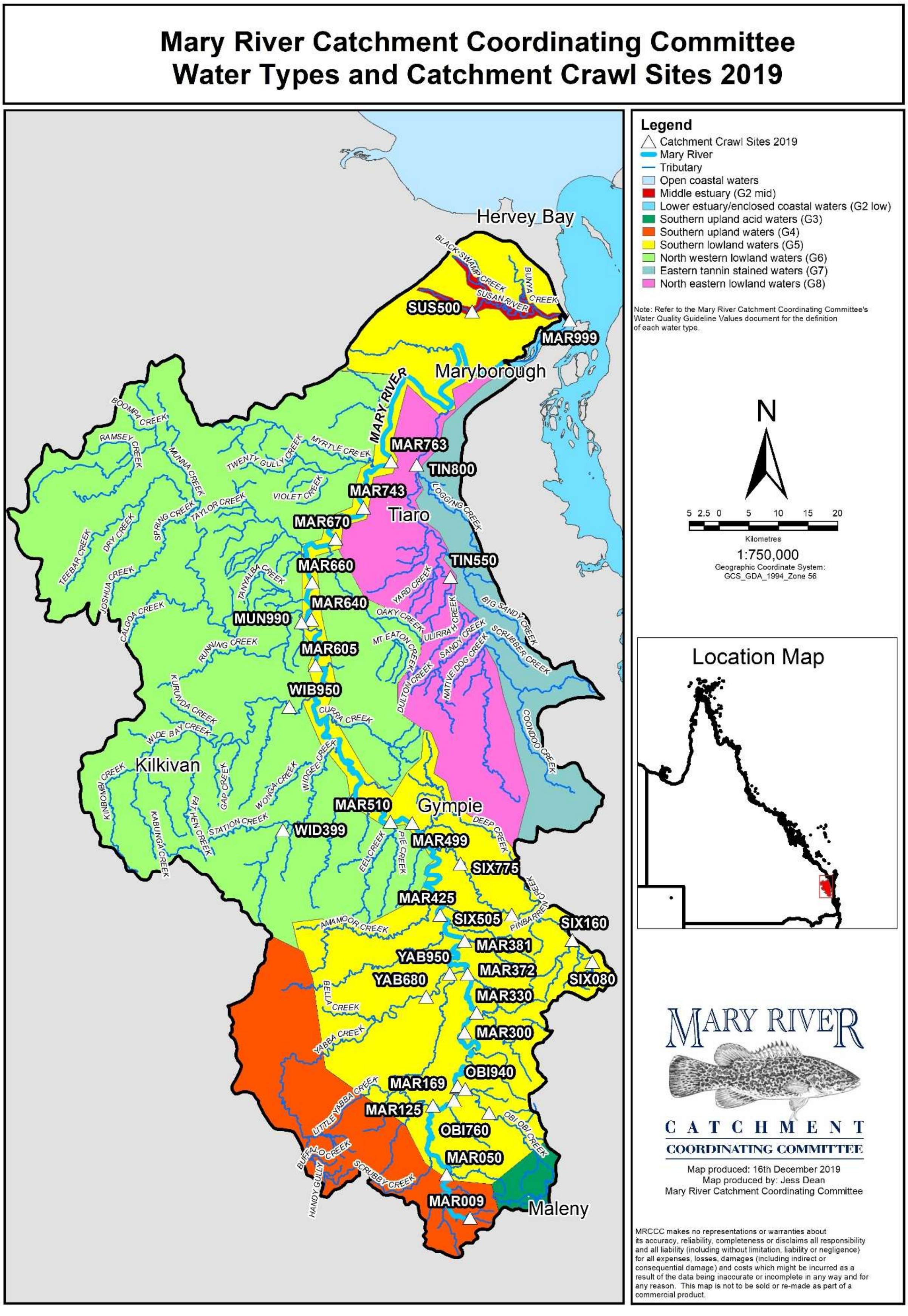

Figure 1 Overview of 2019 Catchment Crawl sites and the water types of the Mary River catchment

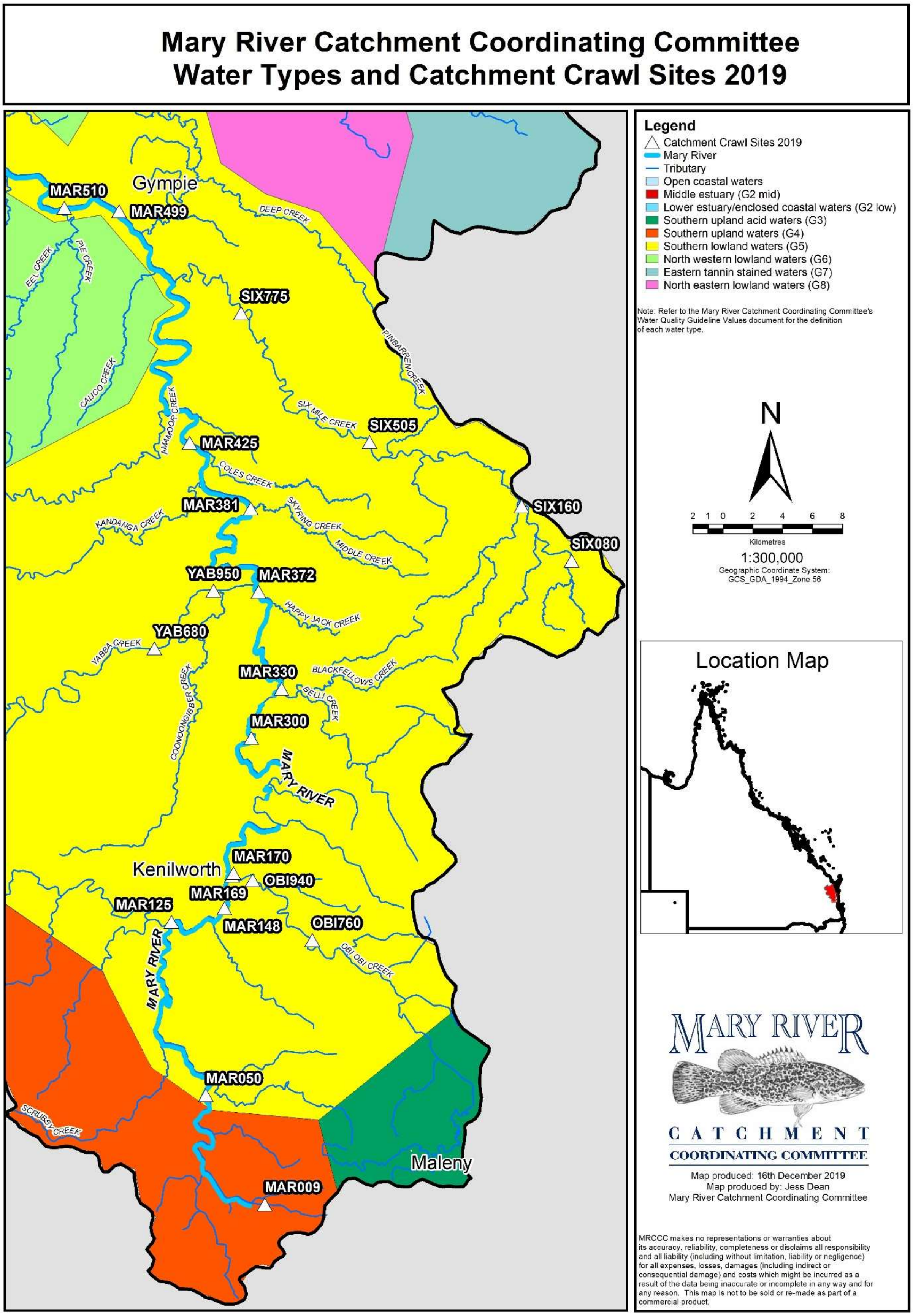

Figure 2 Day 1 Catchment Crawl sites in further detail

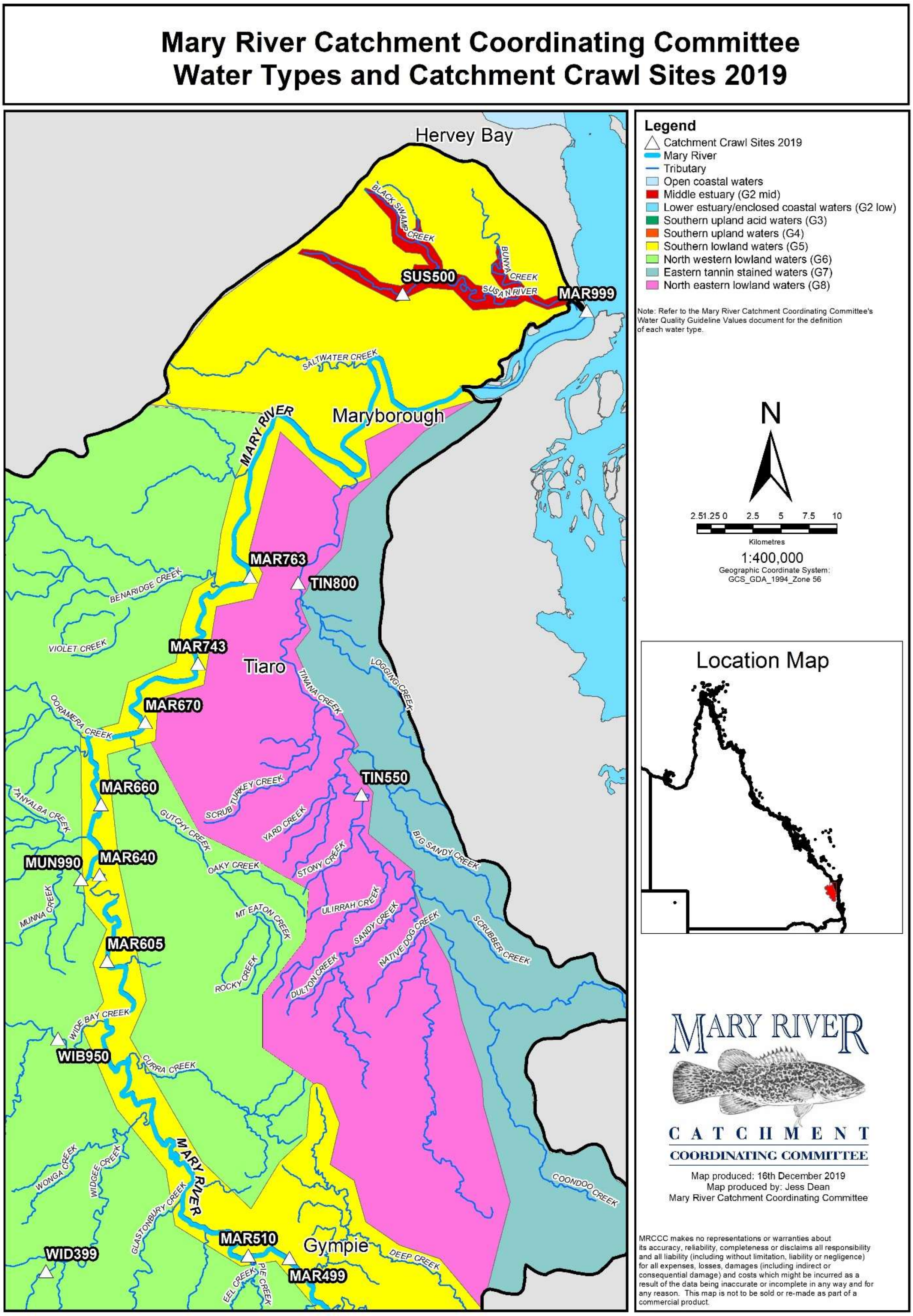

Figure 3 Day 2 Catchment Crawl sites in further detail

Table 3 Details of all sites tested

Water Type	Site Code	Description of Site	Parameters tested*
G4	MAR009	McCrae Lane, Conondale	WW, DES, *E.coli*
G5	MAR050	Grigor Bridge, Conondale	WW, DES, *E.coli*
G5	MAR125	Little Yabba Picnic Area, Cambroon	WW, DES, *E.coli*
G5	MAR148	Eales, Walli Mountain Rd	WW, DES, *E.coli*
G5	MAR169	Charles St River park (u/s of Kenilworth)	WW, DES, *E.coli*
G5	MAR170	Charles St River Park (d/s of Kenilworth)	WW, DES, *E.coli*
G5	MAR300	Walker Rd bridge, Moy Pocket	WW, DES, *E.coli*
G5	MAR330	Belli Creek confluence at Mary River	WW, DES, *E.coli*
G5	MAR372	Olsen's Bridge, Tuchekoi Rd, Tuchekoi	WW, DES, *E.coli*
G5	MAR381	Skyring Ck confluence at Mary River	WW, DES, *E.coli*
G5	MAR425	Mary River Park, Traveston Xing	WW, DES, *E.coli*
G5	MAR499	Gympie weir, Gympie	WW, DES, *E.coli*
G5	MAR510	Eel Ck confluence, Widgee Xing	WW, DES (duplicate), *E.coli*
G5	MAR605	Dickabram Bridge, Miva	WW, DES, *E.coli*
G5	MAR640	Bauple Road Bridge	WW, DES, *E.coli*
G5	MAR660	Emerys Xing , Gundiah	WW, DES, *E.coli*
G5	MAR670	Home Park, Deborah Road, Netherby	WW, DES, *E.coli*
G5	MAR743	Petrie Park, boat ramp, Tiaro	WW, DES, *E.coli*
G5	MAR763	Riverside Park, Grevillea St, Owanyilla	WW, DES (duplicate), *E.coli*
G2	MAR999	River Heads, boat ramp	WW, DES
G2	SUS500	Susan River on Hervey Bay Rd	DES, *E.coli*
G5	OBI760	Obi Crossing #2, Obi Obi	WW, DES, *E.coli*
G5	OBI940	Houston Bridge, Coolabine Road	WW, DES, *E.coli*
G5	SIX080	Six Mile Ck, Worba Lane, Worba Park .	WW, DES, *E.coli*
G5	SIX160	Six Mile Creek, Collwood Drive off Lake Macdonald Drive (spillway pool)	WW, DES, *E.coli*
G5	SIX505	Six Mile Creek, downstream of Victor Giles bridge, Cooran	WW, DES (duplicate), *E.coli*
G5	SIX775	Six Mile Creek, Woondum Rd bridge, Woondum	WW, DES, *E.coli*
G5	YAB680	Yabba Creek, Imbil Town Bridge	WW, DES, *E.coli*
G5	YAB950	Yabba Creek, Mary Valley Road	WW, DES (duplicate), *E.coli*
G6	WID399	Webb Park, Widgee	WW, DES (duplicate)
G6	WIB950	Wilson Bridge, Carmyle Rd, Sexton	WW, DES
G6	MUN990	Birt Rd bridge, Munna Creek	WW, DES
G8	TIN550	Missings Crossing, Bauple	WW, DES, *E.coli*
G8	TIN800	Teddington Weir, Magnolia	WW, DES, *E.coli*

***WW** = pH, Electrical conductivity, Dissolved Oxygen, Temperature, Turbidity; **DES** = Total suspended solids (TSS), Ammonium, Oxidised Nitrogen, Total Kjeldahl Nitrogen, Dissolved Kjeldahl Nitrogen, Phosphate, Total Kjeldahl Phosphorus, Dissolved Kjeldahl Phosphorus; **E.coli** = Escherichia coli

1.4 Equipment

The following equipment was used as part of the Catchment Crawl.

1. FLT 90 multi probe to measure pH, conductivity, salinity, temperature, dissolved oxygen and turbidity (and spare equipment).
2. WP80 and WP81 used to measure pH, conductivity, salinity, temperature, dissolved oxygen.
3. DES sample bottles and sampling equipment (sample pole, gloves, syringes, filters)
4. Esky and portable freezer
5. *E. coli* sample bottles
6. Digital camera
7. Garmin hand held GPS unit
8. Turbidity (clarity) tube
9. 10L bucket
10. Catchment map
11. Hat, sunscreen, first aid kit
12. Folder, data sheets, equipment instructions, itinerary and site hazard analysis assessment sheets

Figure 4 Caitlin Mill recording data from the TPS FLT90 multiprobe

1.5 Parameters

As Table 3 outlined, the same suite of tests is performed at each site during the Catchment Crawl (with some exceptions for *E.coli*). Table 4 shows the different types of tests performed, their units of measurement and the detection limit for laboratory analysis. At each site the team of MRCCC staff and volunteers performed the same tasks to ensure quality control. Where volunteers from the public were part of a team, they were assigned the task of physical chemistry testing. The volunteers were Waterwatchers who had received training in the testing equipment and used it regularly as part of their Waterwatch commitments. A designated and suitably-trained staff member took the *E. coli*, nutrient and TSS samples at each site, as a particular procedure had to be followed to ensure sample integrity (Nutrient and TSS samples follow the Great Barrier Reef Catchments Loads Monitoring program sampling protocol).

Aside from the water quality information collected at each Catchment Crawl site, a riparian zone condition assessment was performed using MRCCC's standardised method.

Table 4 Details of water tests performed at each Catchment Crawl site

Test type	Unit	Detection Limit	Monitoring Suite
Physical chemistry			
Dissolved Oxygen	%sat	-	Waterwatch
Turbidity	NTU	-	Waterwatch
Electrical conductivity	µs/cm	-	Waterwatch
Temperature	°C	-	Waterwatch
pH	-	-	Waterwatch
Total suspended solids	mg/L	1	DES
Microbiological			
Escherichia coli (E.coli)	MPN/100mL	1	WaterOne
Nutrients (directly measured)			
Ammonium nitrogen as N	mg/L	0.002	DES
Oxidised nitrogen as N	mg/L	0.001	DES
Total Kjeldahl nitrogen as N	mg/L	0.04	DES
Dissolved Kjeldahl nitrogen as N	mg/L	0.04	DES
Phosphate phosphorus as P	mg/L	0.001	DES
Total Kjeldahl phosphorus as P	mg/L	0.02	DES
Dissolved Kjeldahl phosphorus as P	mg/L	0.02	DES
Nutrients (calculated from direct measurements)			
Total nitrogen as N	mg/L	0.03	DES
Organic nitrogen (dissolved) as N	mg/L	0.03	DES
Total nitrogen (dissolved) as N	mg/L	0.03	DES
Total nitrogen (suspended) as N	mg/L	0.03	DES
Total phosphorus (suspended) as P	mg/L	0.02	DES
Organic phosphorus (dissolved) as P	mg/L	0.02	DES

1.6 Data interpretation

MRCCC's Water Types (Burgess, 2014) are used in this report to compare the results collected at the Catchment Crawl sites. The Water Types were developed in response to analysis of the long term Waterwatch data which revealed that the EPA's Water Quality objectives (WQOs) were not appropriate for all sites because of the underlying geology and other naturally occurring influences. Seven different water types were identified (see Figure 1). Water quality guidelines have been developed for each Water Type (Burgess, 2014) using Waterwatch data and procedures outlined in the regulations (Department of Environment and Resource Management, 2010). The guidelines values for each Water Type are displayed in Table 5.

The main advantage of the Water Types approach is that Mary River main trunk sites and tributaries can be grouped where they fall in the same water type. Not all water types are sampled as part of the Catchment Crawl. As Figure 1 shows most samples (eighteen on the Mary River, eight on tributaries) fall within the Water Type G5 (Southern Lowland waters), two sites fall within the water type G2, three within water type G6 (North Western Lowland Waters), two within water type G8 (North Eastern Lowland Waters) and one within G4 (Southern upland waters).

Table 5 Mary River Catchment Coordinating Committee water quality guideline values

Quality Guideline Title & Description	Guideline Values
G1 – Artificial Water Bodies e.g. Settling ponds, farm dams, drains, bores and wells	N/A
Mary River lower estuary **(G2low – Estuarine & Marine Waters** **Area GSS1 lower estuary/enclosed coastal waters)** As mapped on the scheduled Mary Basin Water Quality Guidelines. *Upper and lower guideline values need to be developed for electrical conductivity and temperature	Electrical Conductivity N/A* pH 8.1 – 8.4 Dissolved Oxygen saturation 90 – 105 % Turbidity 0 – 4 NTU Temperature N/A*
Mary River middle estuary (incl. Susan River) **(G2mid – Estuarine & Marine Waters Middle Estuary)** As mapped on the scheduled Mary Basin Water Quality Guidelines. *Upper and lower guideline values need to be developed for electrical conductivity and temperature	Electrical Conductivity N/A* pH 8.1 – 8.4 Dissolved Oxygen saturation 90 – 105 % Turbidity 0 – 4 NTU Temperature N/A*
Maleny Plateau **(G3 – Southern Upland Acid Waters)** Upland (>150m) freshwaters draining acid red soils of the Maleny/Mapleton plateau	Electrical Conductivity 0 – 580 µS/cm pH 6.0 – 8.0 Dissolved Oxygen saturation 90 – 110 % Turbidity 0 – 25 NTU Summer Temperature 18 – 28 °C Winter Temperature 13 – 21 °C
Upper Mary River **(G4 – Southern Upland Waters)** Upland (>150m) freshwaters in the main trunk of the Mary River and all tributaries which drain into the Mary River upstream of Deep Creek except for Southern Upland Acid Waters.	Electrical Conductivity 0 – 580 µS/cm pH 6.5 – 8.2 Dissolved Oxygen saturation 90 – 110 % Turbidity 0 – 25 NTU Summer Temperature 18 – 28 °C Winter Temperature 13 – 21 °C
Mary River and southern major tributaries **(G5 – Southern Lowland Waters)** Lowland (<150m) freshwaters in the main trunk of the Mary River and all tributaries which drain into the Mary River upstream of Deep Creek	Electrical Conductivity 0 – 580 µS/cm pH 6.5 – 8.0 Dissolved Oxygen saturation 85 – 110 % Turbidity 0 – 50 NTU Summer Temperature 18 – 28 °C Winter Temperature 13 – 21 °C
Western Tributaries **(G6 – North Western Lowland Waters)** Lowland freshwaters (<150m) in all western tributaries which drain into the Mary River downstream of Six Mile Creek. As well as Gutchy and Curra Creeks and their tributaries.	Electrical Conductivity 0 – 1200 µS/cm pH 6.5 – 8.0 Dissolved Oxygen saturation 85 – 110 % Turbidity 0 – 50 NTU Summer Temperature 22 – 30 °C Winter Temperature 16 – 24 °C

Eastern tributaries of Tinana Creek **(G7 – Eastern Sandplain Tannin Stained Waters)** Tannin stained waters of the eastern tributaries of Tinana Creek **from footnotes in Mary WQO document for water bodies in the natural state	Electrical Conductivity 0 – 580 µS/cm pH 3.6 – 6.0** Dissolved Oxygen saturation 85 – 110 % Turbidity 0 – 50 NTU Summer Temperature 22 – 30 °C Winter Temperature 16 – 24 °C
Tinana Creek **(G8 – North Eastern Lowland Waters)** Lowland freshwater (<150m) eastern tributaries which drain into the Mary River downstream of Deep Creek, except for Eastern Sandplain Tannin Stained Waters.	Electrical Conductivity 0 – 580 µS/cm pH 6.5 – 8.0 Dissolved Oxygen saturation 85 – 110 % Turbidity 0 – 50 NTU Summer Temperature 22 – 30 °C Winter Temperature 16 – 24 °C

Note: Not all water types are presented in this document. Refer to the Environmental Protection (Water) Policy 2009 Mary River environmental values and water quality objectives - Basin No. 138 including all tributaries of the Mary River, July 2010 (https://www.ehp.qld.gov.au/water/policy/pdf/documents/mary-river-ev-2010.pdf). Insufficient data for electrical conductivity and temperature to produce guideline values for estuarine and marine water values.

Compared to the G5 sites which reflect the majority of the catchment, G6 has a higher Electrical conductivity guideline (up to 1200 µS/cm rather than 580 µS/cm), G4 has a lower turbidity guideline (25 NTU rather than 50 NTU) and a more alkaline pH range (6.5-8.2 rather than 6.5-8.0) and G6 and G8 have a higher minimum and maximum temperature (22 -30^{o}C rather than 18-28^{o}C in summer). G2 guidelines are based on the High Environmental Value guidelines for the Great Sandy Strait. There are no scheduled guidelines for temperature, but the MRCCC has developed local guidelines in accordance with the procedures in the legislation to identify extreme summer and winter water temperatures (Dean et al, 2018).

2 Results and discussion

In this section the results are presented and discussed according to each parameter tested (temperature, pH, EC, turbidity, DO, TSS, nitrogen, phosphorus, *E.coli*) and then broken down into sub-sections for each water type. For the Mary River and southern major tributaries (Southern Lowland Waters (G5)), the Mary River and tributary sites are shown in separate graphs due to the large number of sites in this Water Type. The graphs show data from the last four years (2019, 2018, 2017, 2016) and data from 2008 when available. The Mary River at River Heads (MAR999) and Susan River (SUS500) sites fall within the High Environmental value waters area and were sampled for the first time in 2017. If the sampling time of day is significantly different from previous years and may have contributed to a change in water quality that is noted. Otherwise it can be assumed that the time of day is not a factor in the comparison of the data points at a given sample site.

Understanding the site codes on the graphs

The results are plotted according to site code and for sites on the same stream they are ordered from the most upstream site to the most downstream site. The first three letters of the site code indicate which waterway (e.g. MAR - Mary River, OBI – Obi Obi Creek, WIB – Wide Bay Creek etc.) The numbers in the site code indicate how close to the mouth of the creek the site is. For example, sites located at the upper headwaters start from 001 and increase to 999 at the confluence or mouth of the stream. A brief description of the location is also provided with the site code. A more detailed description is given in the Itinerary in Appendix A.

2.1 Temperature & Rainfall

Temperature is an important factor to consider when assessing water quality. In addition to its own effects, temperature can influence several other parameters. It can also alter the physical and chemical properties of water. For example, high water temperatures can increase the solubility and thus toxicity of certain compounds and the solubility of oxygen and other gases will decrease as temperature increases. Water temperature can be affected by many ambient conditions such as sunlight, atmospheric temperature, turbidity, proximity to a stream confluence and releases from impoundments. Shallow water from low flow conditions is more easily influenced by these factors than deep water.

On the first day of the Catchment Crawl (08/10/2019) Gympie maximum temperature was 37.8°C, which is approximately 10°C above average. The day before, the temperature was 38.7°C in Gympie. Nambour (as a representative of the upper catchment) also recorded a hot air temperature of 36.3°C on the 8th of October, 2019. The following day, Gympie dropped to 27.5°C and Maryborough was similar at 27.6°C. The results for each Water Type are discussed in turn below.

Table 6 Summary of rainfall and ambient air temperature during the Crawl

Date	Location	Rainfall (mm)	Daily Minimum Temperature (°C)	Daily Maximum Temperature (°C)
8/10/19	Nambour	0.0	19.8	36.3
8/10/19	Gympie	1.4	18.9	37.8
9/10/19	Gympie	0.0	18.3	27.5
9/10/19	Maryborough	0.0	17.7	27.6

2.1.1 Mary River and southern major tributaries (Southern Lowland Waters (G5))

The Southern Lowland Waters is the main trunk of the Mary River and includes Obi Obi, Six Mile and Yabba creeks. The temperature guideline for this water type is between 18 and 28^{o}C for summer. The guideline range is indicated by horizontal purple lines in Figure 5 which provides the Mary River sites in the G5 (and single G4 site, MAR009 Mary River Headwaters) water type and in Figure 6 which gives the tributary sites. Data points which fall above the upper or below the lower purple line are outside of the guideline range. The black line or bars show the result for 2019.

The Mary River, upstream of Gympie, displayed the second highest temperatures in the last three years. Stream temperature in the Mary Valley is more heavily influenced by air temperature. This is due to stream size (narrower, shallower water bodies). In the lower Mary River, some of the sites were cooler than they had been in the last 11 years (Widgee Crossing, Emery's Crossing). The coolest temperature recorded is Widgee Crossing (16.85°C) this site is sampled first in the morning at the edge of the stream, so temperature fluctuations are expected throughout the course of the day.

In 2019 only three sites, MAR009 at the headwaters of the Mary, MAR510 Widgee Crossing and MAR640 Bauple Road Bridge were cool enough for successful Mary River cod spawning at 21°C. Mary River cod can survive in water temperatures up to 28°C. There are no sites that exceeded the 28^{o}C upper limit for cod. MAR148 Walli Mt is the warmest site (27.98°C) however, still falls within guidelines. This is a significant improvement on 2017 and 2018. This effectively means that at the time of the Catchment Crawl in 2019 there was more of the river with water temperature suitable for cod which means more options for seeking food, travelling to find mates and breeding.

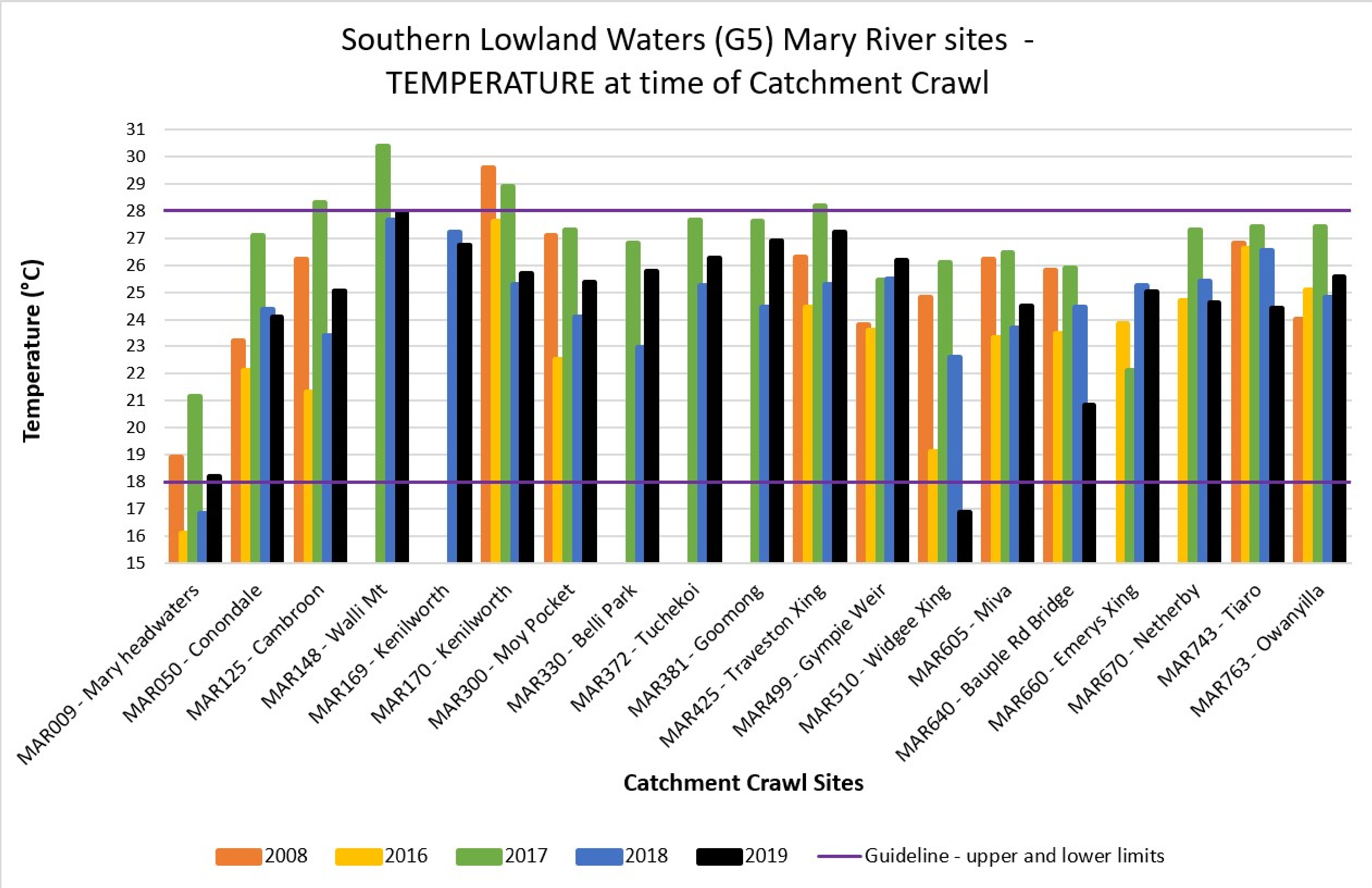

Figure 5 Temperature of Mary River sites in Southern Lowland waters (G5)

Figure 6 provides a comparison of results for 2002-2019 from five sites on the Mary River for which there is long term data and for which the sample was taken at a very similar time of day at every Catchment Crawl. There are eleven data points for Conondale (MAR050) and Kenilworth (MAR170) that fit this criteria, and seven for Widgee Xing (MAR510), Miva (MAR605) and nine for Emerys Xing (MAR660).

The box and whisker plots provide an indication of the spread of data for each site. The median (or middle value) is shown by the line in the middle of the box, the 25th and 75th percentiles by the lower and upper extent of the box and the highest and lowest values by the upper and lower extent of the whiskers.

The Widgee Xing site (MAR510) is measured in early morning (8 am) and the Conondale site (MAR050) during mid-morning (10:00-11:00am). The Kenilworth (MAR170), Miva (MAR605) and Emerys Xing (MAR660) sites have consistently been measured with an hour either side of midday. Despite being taken at the same time of day the Kenilworth site was hotter with a median value of 27.7⁰C compared to a median of 26.3⁰C at Miva and 25.0°C at Emerys Xing respectively, for the period 2002-2017.

The box and whiskers plot confirms that throughout the history of the Catchment Crawls, the Kenilworth site is consistently hotter than the other Mary River sites. The coolest site is Conondale (MAR050) with a median of 23.2°C.

Figure 6 Comparison of temperature at five Mary River sites (based on combined 2002-2019 data)

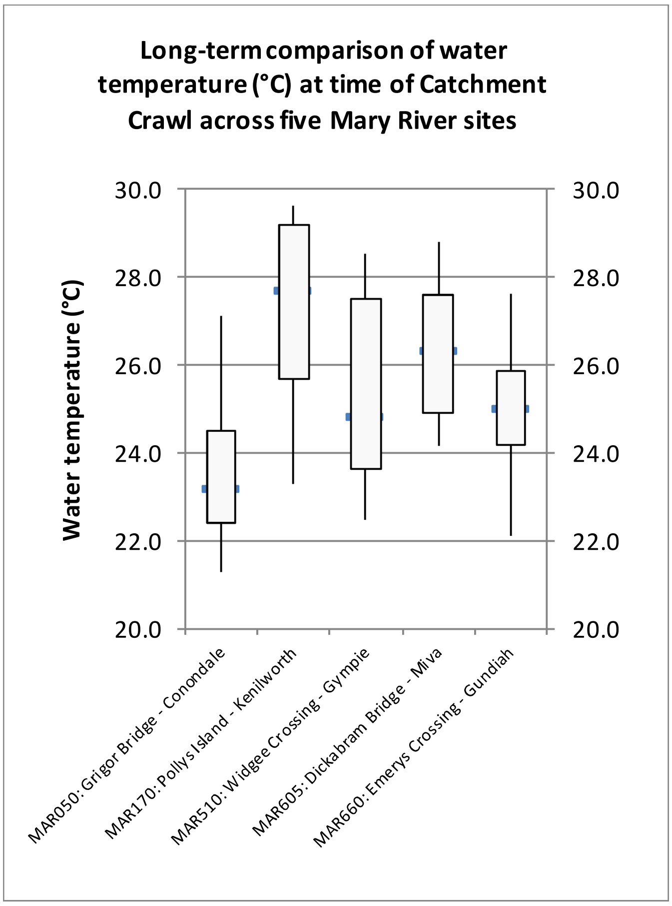

Figure 7 shows the results from tributaries in the G5 water type. The G5 tributaries measured during the catchment crawl are Six Mile (SIX080, SIX160, SIX505 and SIX775), Obi Obi (OBI760 and OBI940) and Yabba Creek (YAB680 and YAB950). In 2019 the tributaries were generally cooler than the main trunk of the river in the G5 water type. Six Mile Creek (particularly the Cooran and Woondum sites which are measured mid-afternoon) is particularly cool, with temperature recordings within the range required to trigger Mary River Cod breeding however, 2019 temperatures are warmer compared to 2018. Temperatures in Obi Obi Creek have increased since 2018 with OBI760 presenting as the warmest G5 tributary site (26.23°C). Obi Obi Creek is also regarded as important cod breeding area and breeding would not occur at higher temperatures. Yabba Creek displays consistently warm temperatures. Six Mile and Obi Obi Creeks have good riparian vegetation providing excellent shading of the waterway. Due to the limited amount of temperature data available for the G5 tributaries detailed comment is not possible.

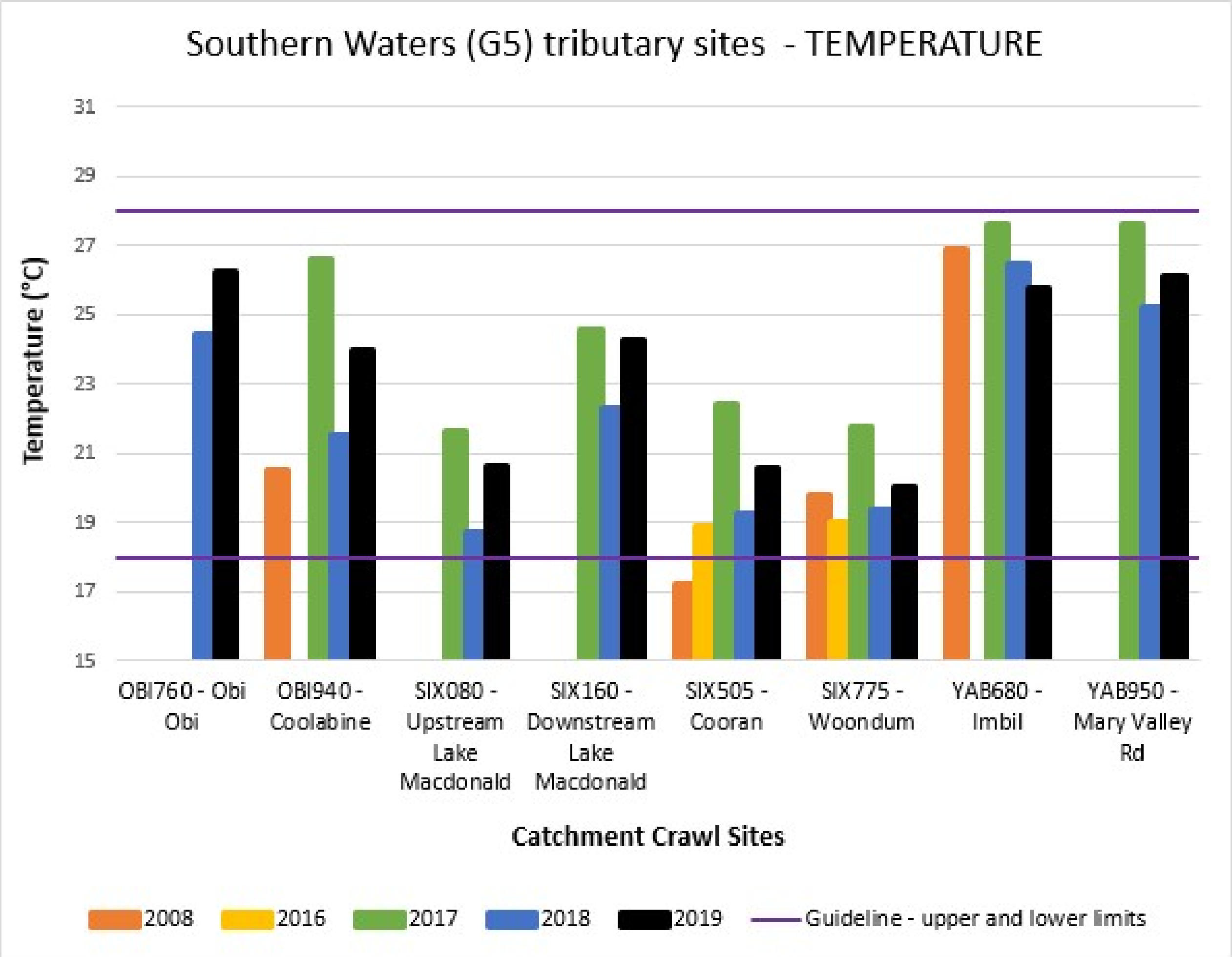

Figure 7 Temperature of Southern Lowland waters (G5) tributaries

2.1.2 Western tributaries (North Western Lowland Waters (G6))

The North Western Lowland Waters tributaries measured during the Catchment Crawl are Munna (MUN990), Wide Bay (WIB950) and Widgee (WID399) Creeks. The temperature guideline for the North western lowland waters is between 22 and 30°C for summer. The horizontal purple lines in Figure 8 show the guideline temperatures. All measurements are within guideline values. Munna Creek (MUN990) fell just below the maximum guideline value and is the warmest G6 site for 2019, at the time of testing it was a stagnant open pool with no flow. Widgee Creek has good temperature compliance and could provide conditions suitable for Mary River Cod spawning. Wide Bay Creek (WIB950) at 22.65 is the coolest record for this site. These temperature records were taken late in the afternoon when high water temperatures are expected, however Widgee Creek appears to have sufficient shading to moderate temperature fluctuations.

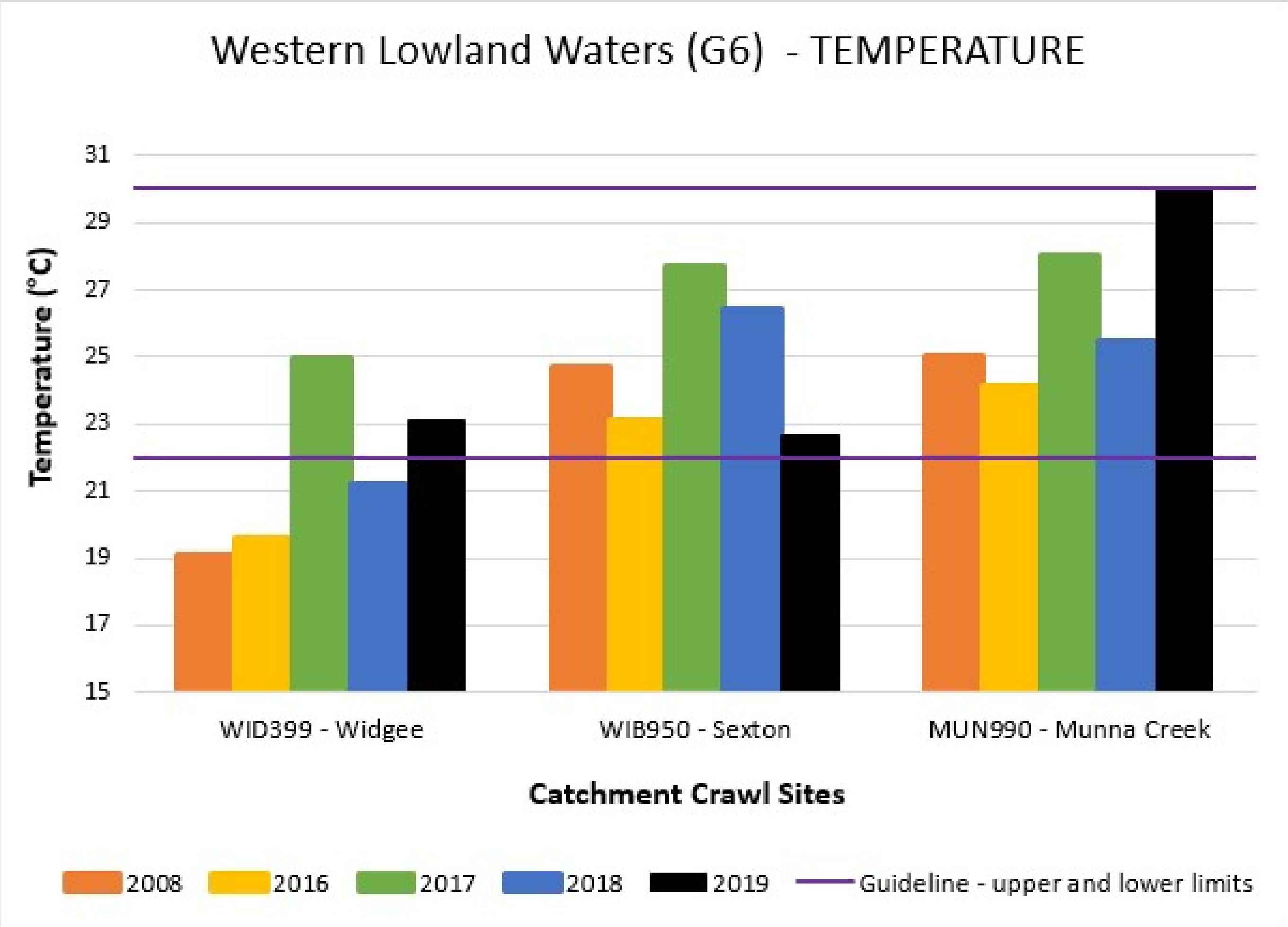

Figure 8 Temperature of tributaries in North Western Lowland Waters (G6)

2.1.3 Tinana Creek (North Eastern Lowland waters (G8))

Tinana Creek is the only tributary measured, at two sites. The temperature guideline for the North eastern lowland water is between 22 and 30°C for summer. The guideline range is indicated in Figure 9 by horizontal purple lines, with data points above the upper line or below the lower line outside of the guideline range. The Tinana Creek site at Bauple (TIN550) has had stable temperature readings over the years. This is most likely due to the healthy riparian ecosystem, providing good shade over the creek. The Teddington Weir site had little flow and was full of Salvinia above the weir. Both Tinana Creek sites have been within guideline values for the last 3 years.

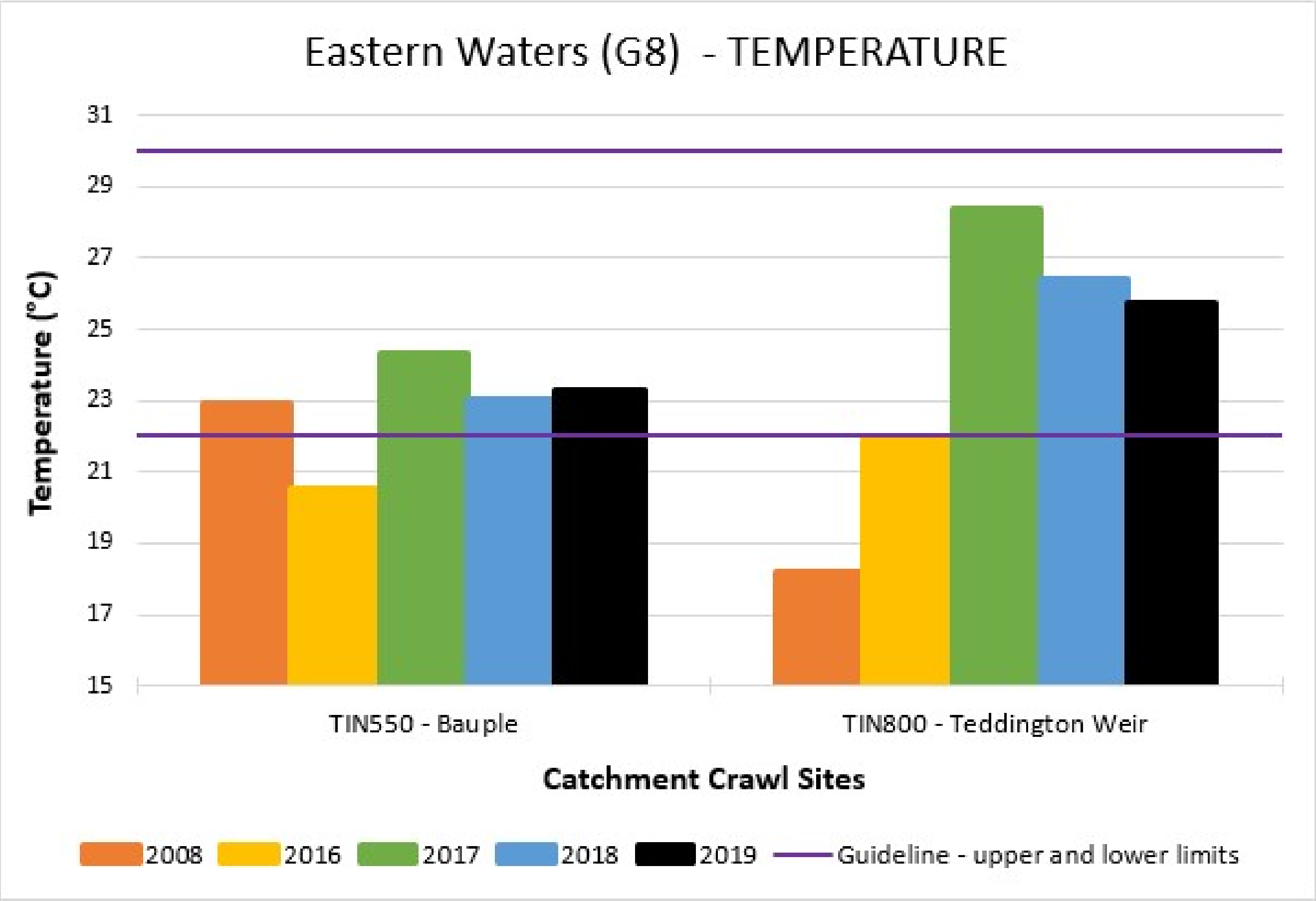

Figure 9 Temperature of tributaries in North Eastern Lowland Waters (G8)

2.1.4 Mary River Estuary – High Environmental Value Waters (G2)

Data collection of the estuary sites only commenced in a comprehensive manner in 2017. There are no guidelines for the High Environmental Value water for temperature, however there is meant to be no change from existing data. Figure 10 shows that 2019 temperatures were lower than 2017 measurements. The MAR999 site at River Heads recorded the coolest temperature for the 3 years of sampling at this site.

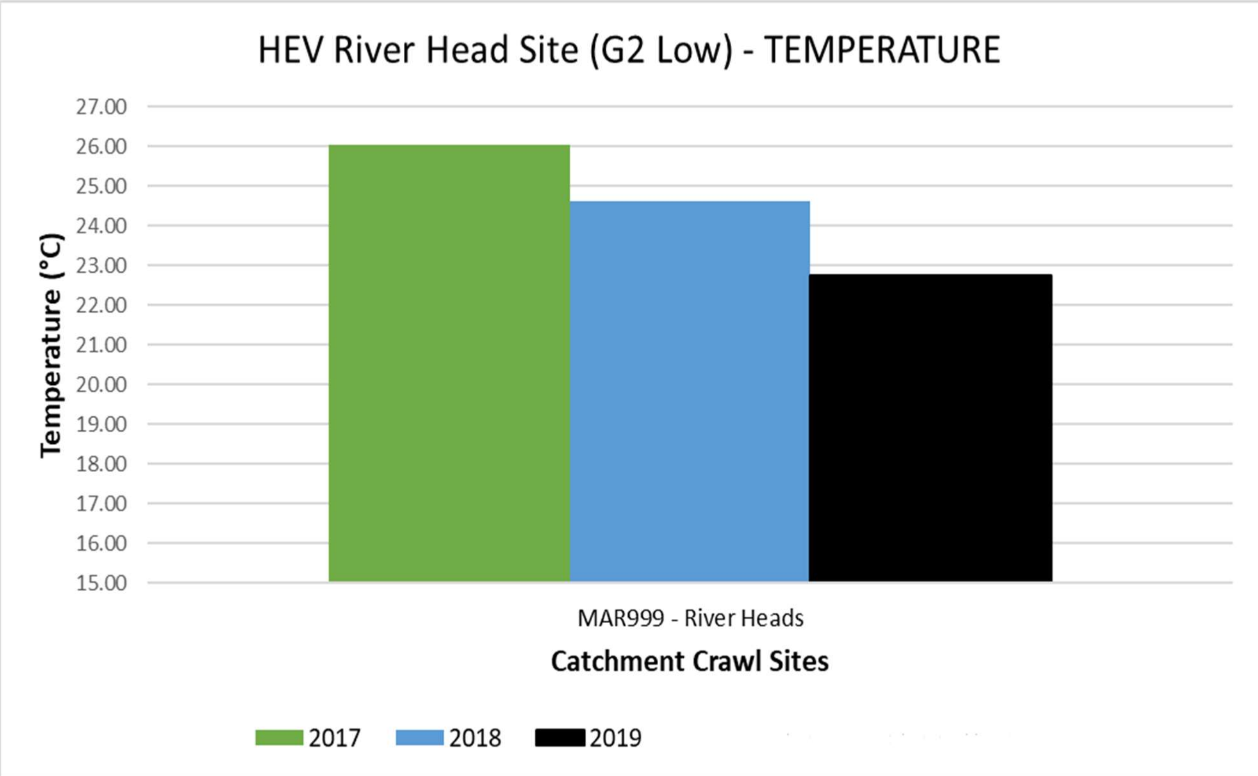

Figure 10 Temperatures at River Heads (G2 low)

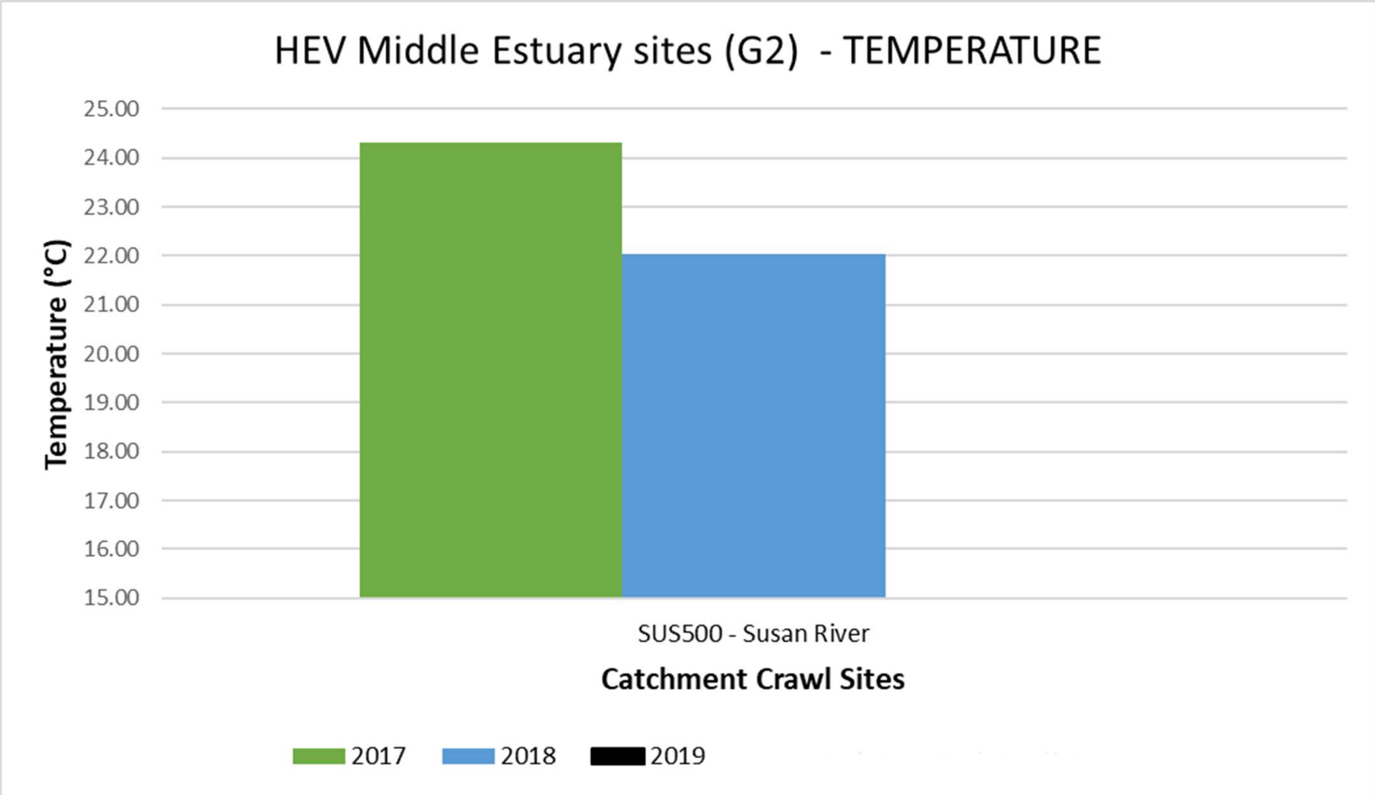

Figure 11 Temperatures at the Susan River (G2 mid)

2.1.5 Comment on long term water temperature trends

Results collected in 2019 raised questions regarding the long term temperature trends and whether or not the water in the catchment may be getting warmer. There are many factors that affect water temperature (e.g. ambient air temperature, river flow, rainfall, dam releases, shade, time of day) and the vulnerability of results to these factors make it difficult to draw conclusions from one off samples collected through the catchment crawl. This is one of the main reasons why sites are always sampled at the same time of day as much as possible.

An increase in temperature would be concerning for numerous reasons. As the guidelines provided in Table 5 show there is a particular range in which aquatic ecosystems are considered healthy. In addition, appropriate water temperature is extremely important for breeding and survival of endangered Mary River Cod, which are likely to be spawning naturally in the wild during Spring which coincides with the Catchment Crawl. The 2018 winter was much colder than the 2017 winter, with significant frosts. In 2019 the late winter/early Spring temperatures were above average (upwards of 2.5°C above average).

An analysis of temperature data collected during Catchment Crawls since 2002 sheds some light on long term temperature trends. Figure 12 below shows a box and whisker plot of all sites sampled in each catchment crawl where sufficient data is available. The line in the centre of each box provides the median (or middle result) result for that year. The lower end of the box is the 25th percentile result, the upper end the 75% percentile and the whiskers extend to include the highest and lowest results recorded. Inclusion of all sites (both Mary and tributaries) in this graph means the plot provides an indication of overall water temperature. Many sites are the same throughout the years, but some are also different. However a warmer winter in 2019 is indicated by the higher median value than 2018. From this data the 2019 Catchment crawl was the 5th warmest since 2002.

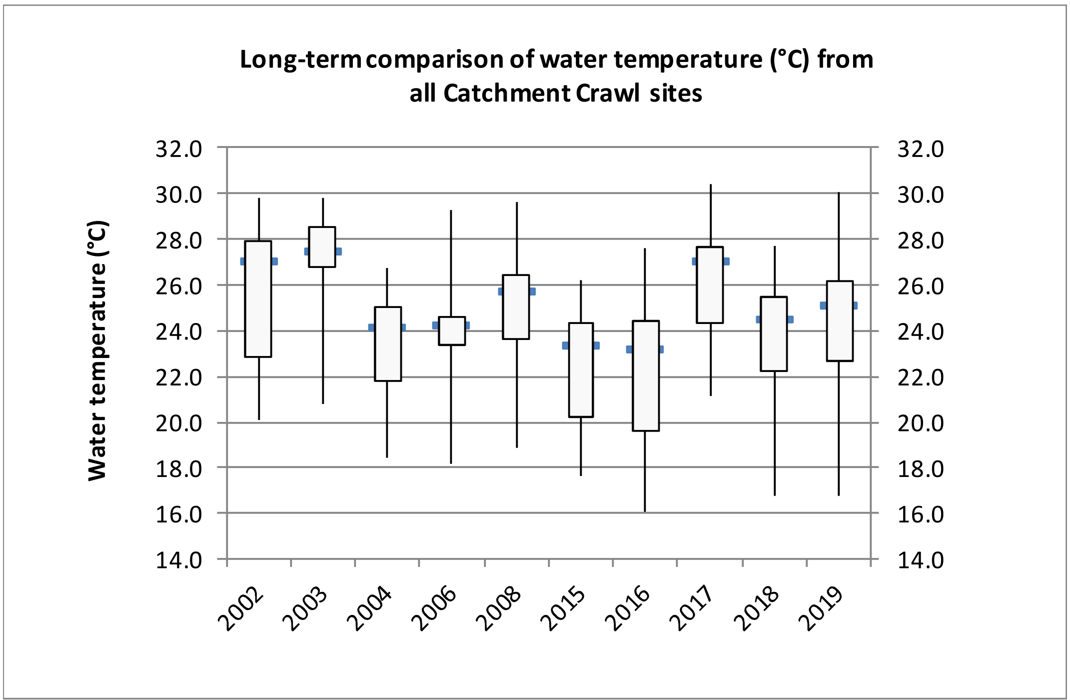

Figure 12 Comparison of temperature data from all sites sampled during catchment crawls 2002-2019

The box and whisker plot shows that 2003 had the hottest median temperature across all Catchment Crawl sites of 27.4°C. 2002 and then 2017 tie for second with a median of 27°C. 2017 had the highest result ever recorded in a Catchment Crawl which was 30.4°C, at the Mary River, Walli Mt (MAR148), approximately 2km upstream of Kenilworth township (this was a new site not previously sampled). 2015 and 2016 had the lowest and second lowest median temperatures of 23.3 and 23.1 respectively. 2016 also has the lowest minimum recorded which was 16.1°C at the Mary headwaters site (MAR009). It is worth noting that this same site was 5°C hotter in 2017. 2019 did not have a record high or low temperature, although it did have the second coldest temperature on record at MAR009, with a temperature of 16.9°C.

In conclusion it is not possible to make comment in depth on trends in water temperature from this data. However, it is apparent that the water during the 2017 was hot compared to most other years since the Catchment Crawl began in 2002 and the water in 2016 and 2015 was the coolest in this timeframe. 2018 temperatures dropped back to lower levels and 2019 slightly increased compared to 2018, although the average 2019 temperature was 24.31°C.

Ambient air temperature is one possible influence on water temperature. To assist with understanding the influence of air temperature, data from the Bureau of Meteorology for the Gympie weather station was downloaded and analysed. Daily maximum and minimums for October were calculated along with the average maximum and minimum for the seven days prior to the Catchment Crawl. The assumption is that the fluctuation in air temperature for several days prior to a sample has an influence on the water temperature. The results of this analysis are presented in Figure 13 which shows the average of the daily maximum and minimum air temperature for seven days prior to the Catchment Crawl together with the median water temperature (from Figure 12).

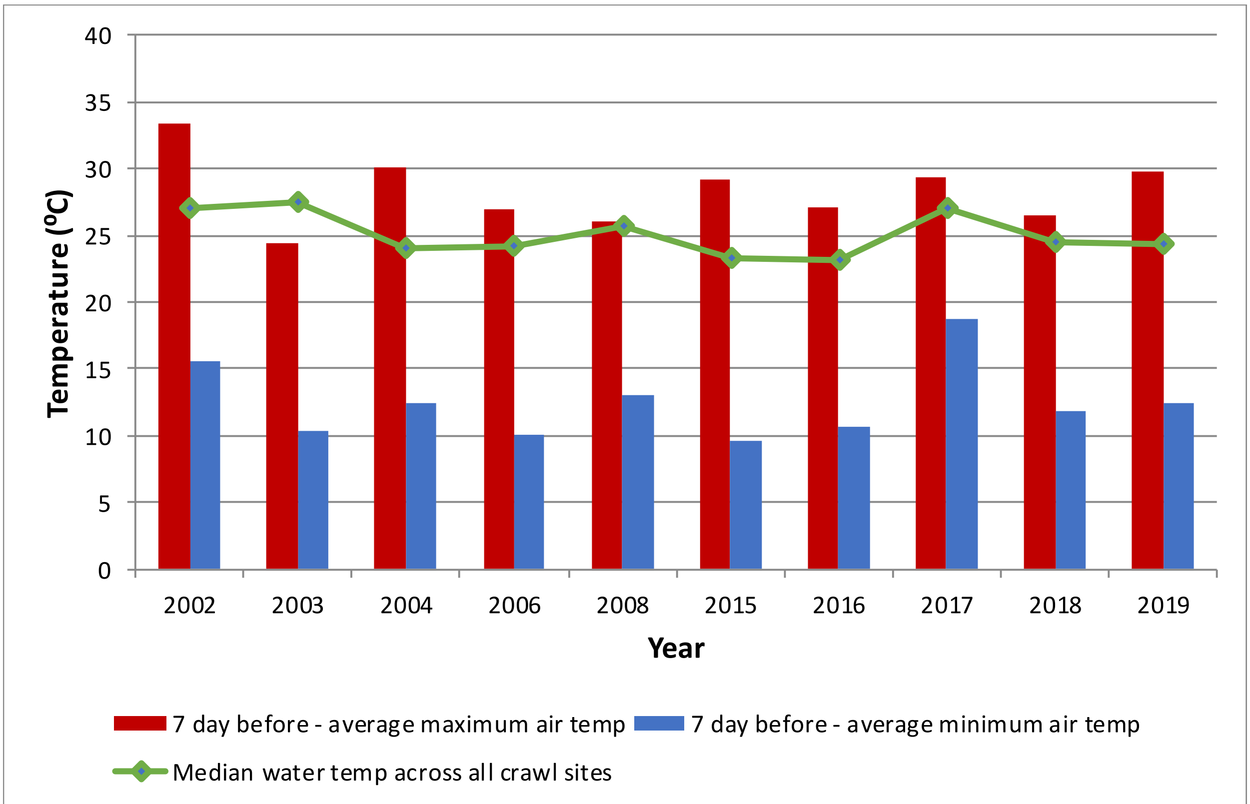

Figure 13 Comparison of average maximum and minimum temperatures for 7 days prior to each catchment crawl

This data would suggest that ambient air temperature is unlikely to fully explain the water temperature results. Even though 2002 and 2003 had very similar median water temperature, they had very different maximum and minimum average air temperature in the seven days prior to the Catchment Crawl. Interestingly the minimum air temperature in the lead up to the 2017 was higher than in any other year suggesting the minimum air temperature could be a driver of hot water temperatures. However, this hypothesis is brought into doubt by the 2003 data. 2003 has the lowest minimum air temperature in the lead up to the Catchment Crawl but was one of the hottest years for water temperature.

Streamflow also significantly influences water temperatures, combined with ambient air temperatures. Streamflow in 2003 was very low, while streamflow in 2017 in the weeks before the Catchment Crawl had ceased to flow across the catchment. Cease to flow conditions in 2018 just prior to the Catchment Crawl are likely to have influenced water temperatures. A full statistical analysis would enable more confident statements about this data.

Figure 14 MUN990 (30°C) – hottest tributary site in 2019 (to the left), MAR148 (27.97°C) – hottest Mary site in 2019 (to right)

3.2 pH

Water pH is influenced by catchment geology, overland flow and air pollution. However, there is also a close link between water temperature and pH. Temperature is directly associated with sunlight intensity. Increased sunlight increases temperature which stimulates photosynthetic activity of aquatic plants and algae in the water column. pH is influenced by the amount of photosynthesis in the water because photosynthesising plants take carbon dioxide from the water which increases alkalinity. Photosynthetic activity is increased with temperature and the associated high levels of incident sunlight (or lack of shade) that is often associated with higher temperatures. The photosynthetic activity can also be increased by nutrients in the water which increase the population of aquatic plants. This process promotes the higher pH readings, particularly in the afternoon when water temperatures are warmest. Plants only photosynthesise in the presence of sunlight. At night they respire, releasing carbon dioxide into the water which increases acidity (lowers the pH). Therefore, the pH at sites with high levels of aquatic plant growth would be expected to fluctuate from more acidic in the morning to more alkaline in the late afternoon. It is important to note that a pH above 7 is considered alkaline and a pH below 7 is considered acidic.

Figure 15 Water testing at site the Mary River, Emery's Crossing (MAR660) in 2019

3.2.1 Mary River and southern major tributaries (Southern Lowland Waters (G5))

The pH guideline for the Southern Lowland Water is 6.5-8. The horizontal purple lines in Figure 16 shows the guideline range. Data points above the upper line or under the lower line are outside of the guideline range. The black bar shows the result for 2019.

A greater number of G5 sites on the Mary River were outside the guideline range in 2019 (8 sites) as compared to previous years. Sites at Conondale (MAR050), Walli Mt (MAR148), Goomong (MAR381), Traveston Xing (MAR425), Gympie Weir (MAR499), Widgee Xing (MAR510), Miva (MAR605) and Emerys Xing (MAR660) were all above the 8.0 upper guideline. The pH value for Bauple Rd Bridge (MAR640) and Netherby (MAR670) were on the upper guideline level (alkaline).

MAR148 at Walli Mt is furthest above guideline level (alkaline) and recorded as the warmest G5 site (27.98°C). In 2018, MAR381 Goomong recorded 7.61pH in 2018 and has markedly increased to 8.48pH in 2019, this may be due to a temperature increase of 2.45°C in 2019.

The comparison between temperature and pH reveals an association at the upper catchment sites from the headwaters to Kenilworth. However, from Kenilworth downstream there does not appear to be a clear association with temperature. It should also be noted that the sites on the Mary River sampled on day 2 are much wider naturally and are more prone to increased sunlight as the shading effect from riparian vegetation is not a strong influencing factor.

Further investigation is required to have a greater understanding of the reasons for the variation in pH levels between 2017, 2018 and 2019 at some sites both in the upper and lower catchment.

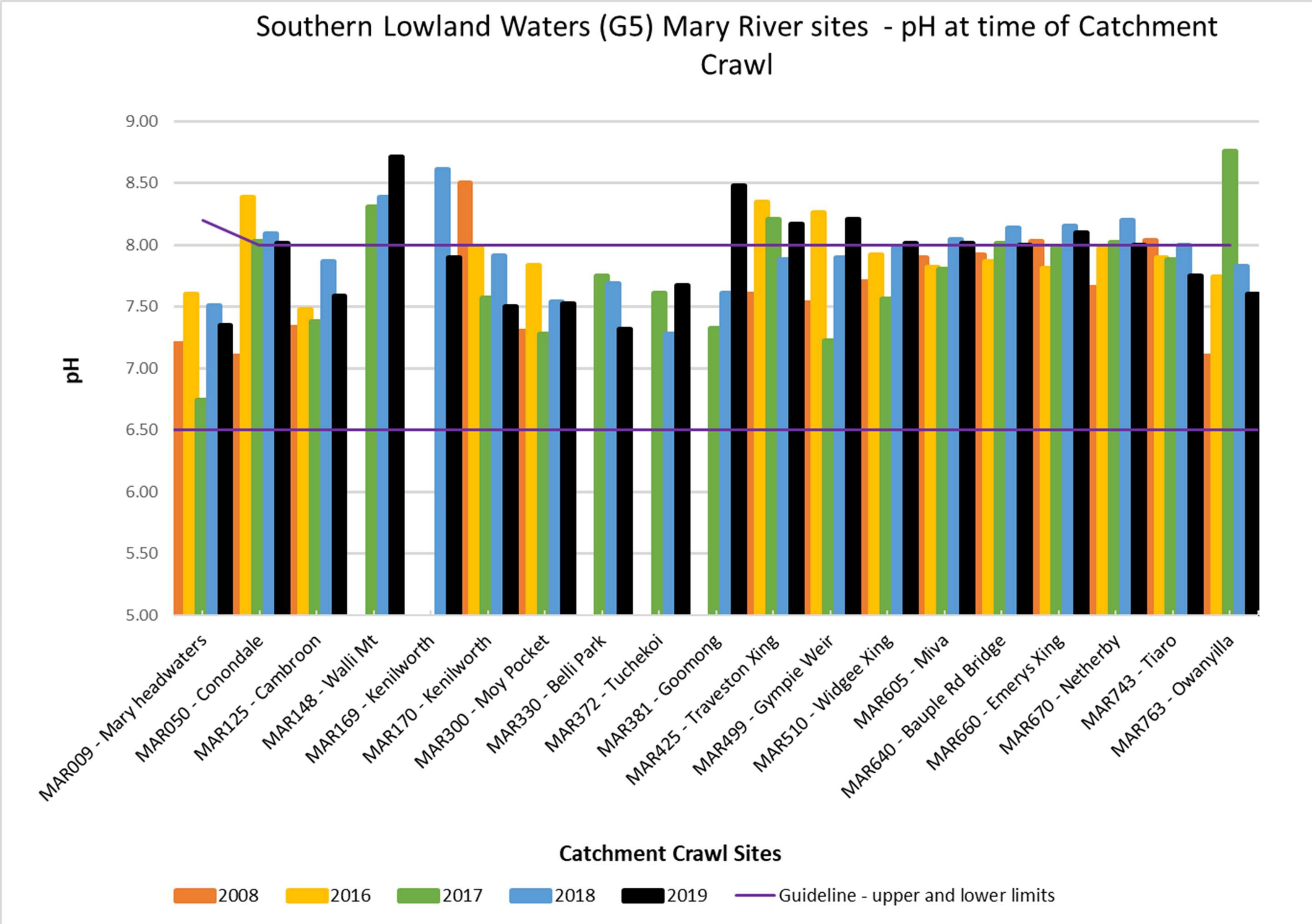

Figure 16 pH of Mary River sites in Southern Lowland waters (G5)

The G5 tributaries (Obi Obi Creek, Six Mile Creek, Yabba Creek) show a different pattern to the main trunk sites with the pH being lower overall (more acidic) (Figure 17). The exception of this is the Yabba Creek site at Imbil (YAB680) where the pH was just above the guideline at 8.15 in 2019. Yabba Creek has consistently recorded higher pH guideline levels at the Imbil township site (which is a weir pool with slow water flows). Obi Obi Creek site OBI760 exceeds the upper guideline limit and has the highest pH out of all G5 tributary sites at 8.19, this site was tested between 1pm – 2pm in 2018 and 2019.

The upstream Lake Macdonald (SIX080) site is the only site to fall below the guideline minimum pH of 6.5 in 2019. Six Mile Creek downstream of Lake Macdonald (SIX160) is just above the minimum guideline value at 6.64. These low pH values of Six Mile creek reflect the natural characteristics of this tributary, and hence the WQO guidelines do not adequately fit Six Mile Creek appropriately.

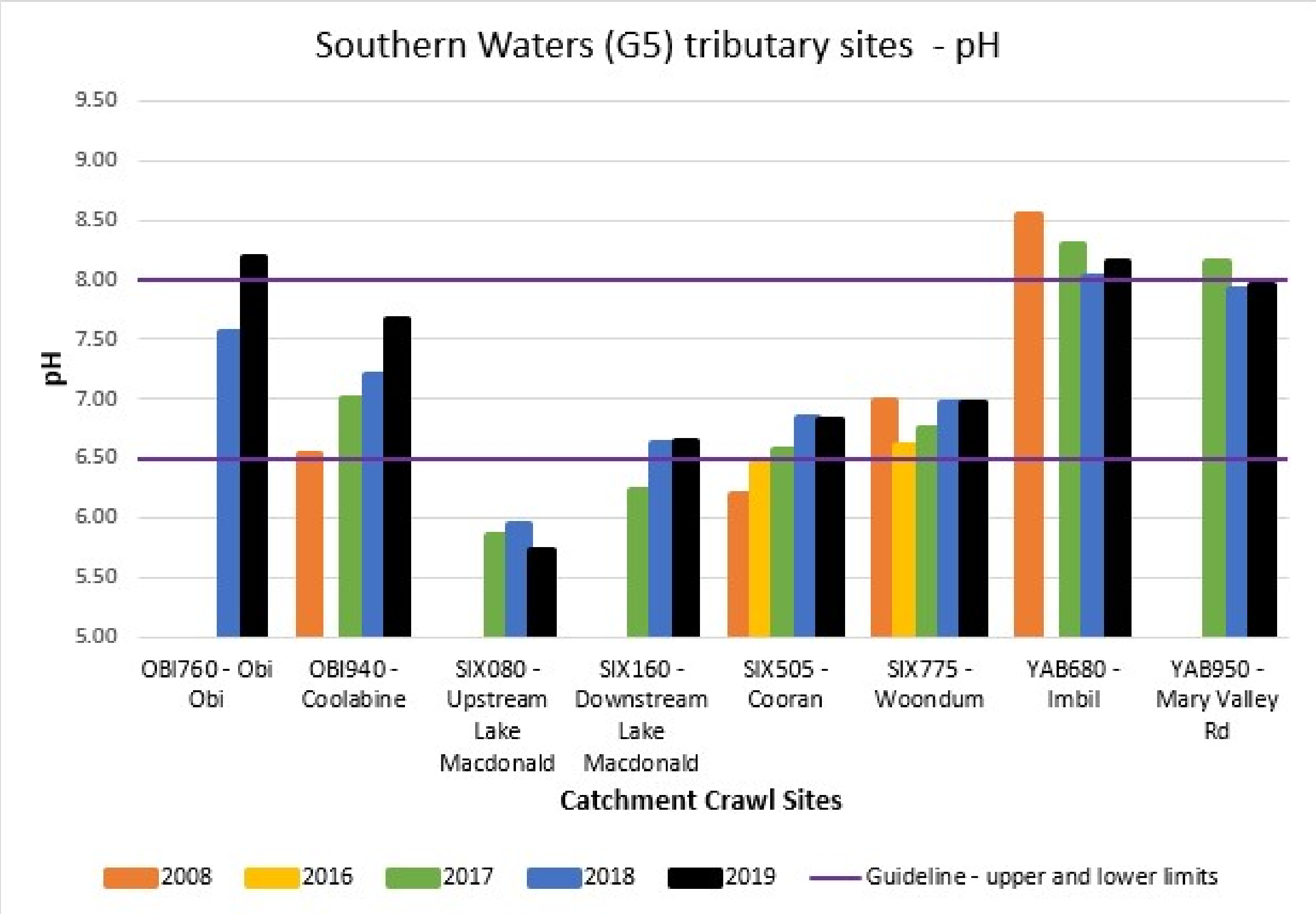

Figure 17 pH of Tributary sites in Southern Lowland waters (G5)

3.2.2 Western tributaries (North Western Lowland Waters (G6))

The pH guideline for the North Western Lowland Water (Munna, Wide Bay, Widgee Creeks) is 6.5 to 8. The horizontal purple lines in Figure 18 show the guideline range. Data points above the upper line or below the lower line are outside of the guideline range.

In 2016 and 2018 none of the G6 tributaries complied with the guideline which is in contrast to 2017 when all sites complied. In 2019 the pH at Widgee and Munna Creek exceeded guidelines values with Widgee at 8.3 and Munna Creek 8.34. The alkaline pH could be attributed to the sampling occurring in the afternoon at both sites. The plant matter including the algae in the creeks photosynthesizes at a greater rate when there is more light. As temperature rises the rate of photosynthesis increases therefore removing carbon dioxide from the water resulting in an increase in alkalinity (pH). Widgee and Munna Creeks are alkaline exceeding the pH guideline of 8. Wide Bay Creek at Sexton is within the pH range for 2019. In summary the pH levels in the western lowland sites seem to fluctuate from year to year between neutral to alkaline.

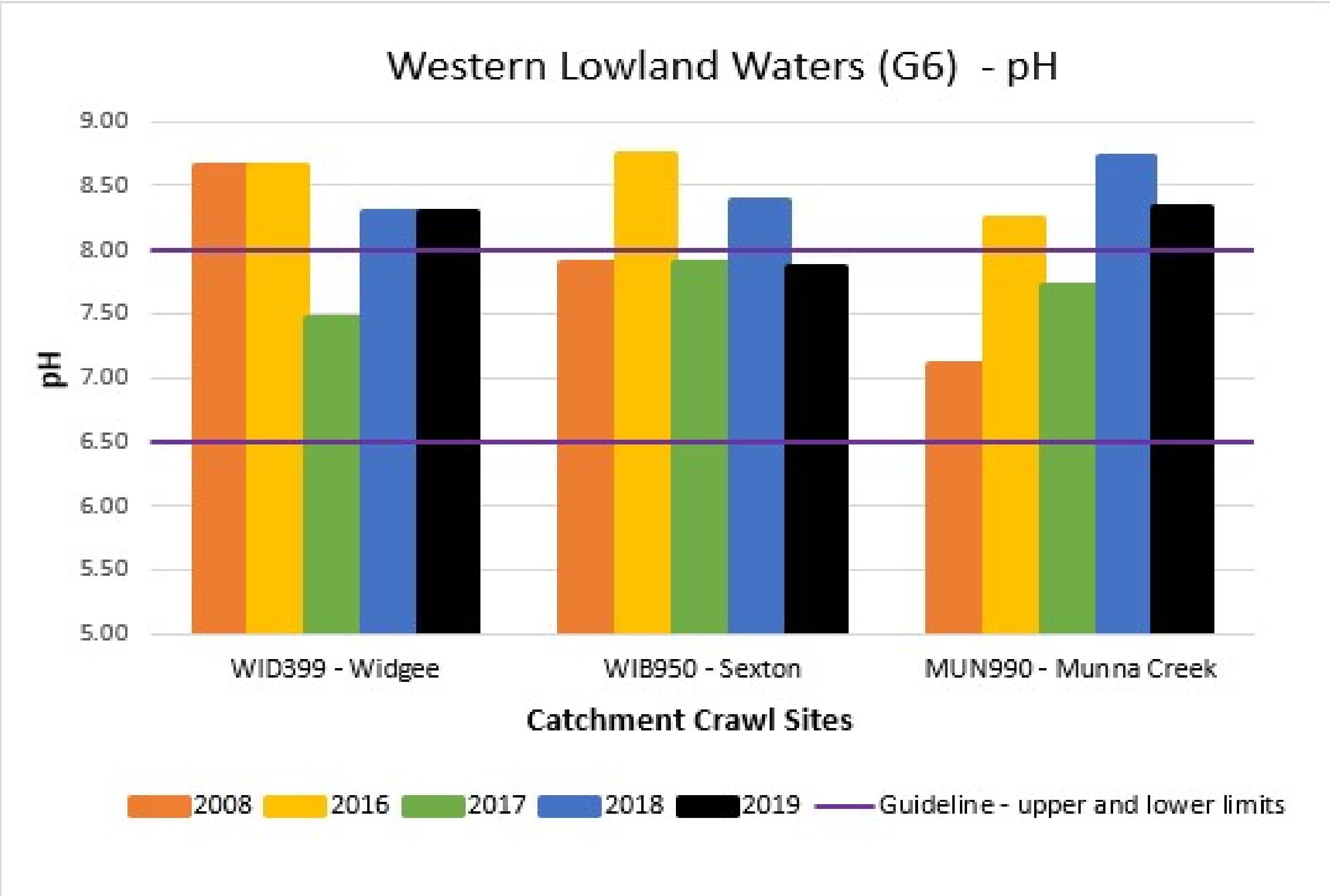

Figure 18 pH of Tributary sites in North Western Lowland waters (G6)

3.2.3 Tinana Creek (North Eastern Lowland waters (G8))

The pH guideline for the Tinana Creek (North Eastern Lowland) water type is 6.5 to 8. The horizontal purple lines in Figure 19 show the guideline range. Data points above the upper line or below the lower line are outside of the guideline range. The pH at Tinana Creek, Teddington Weir has been relatively stable over the past 5 years. The pH for both sites has been within guideline levels for the last four years.

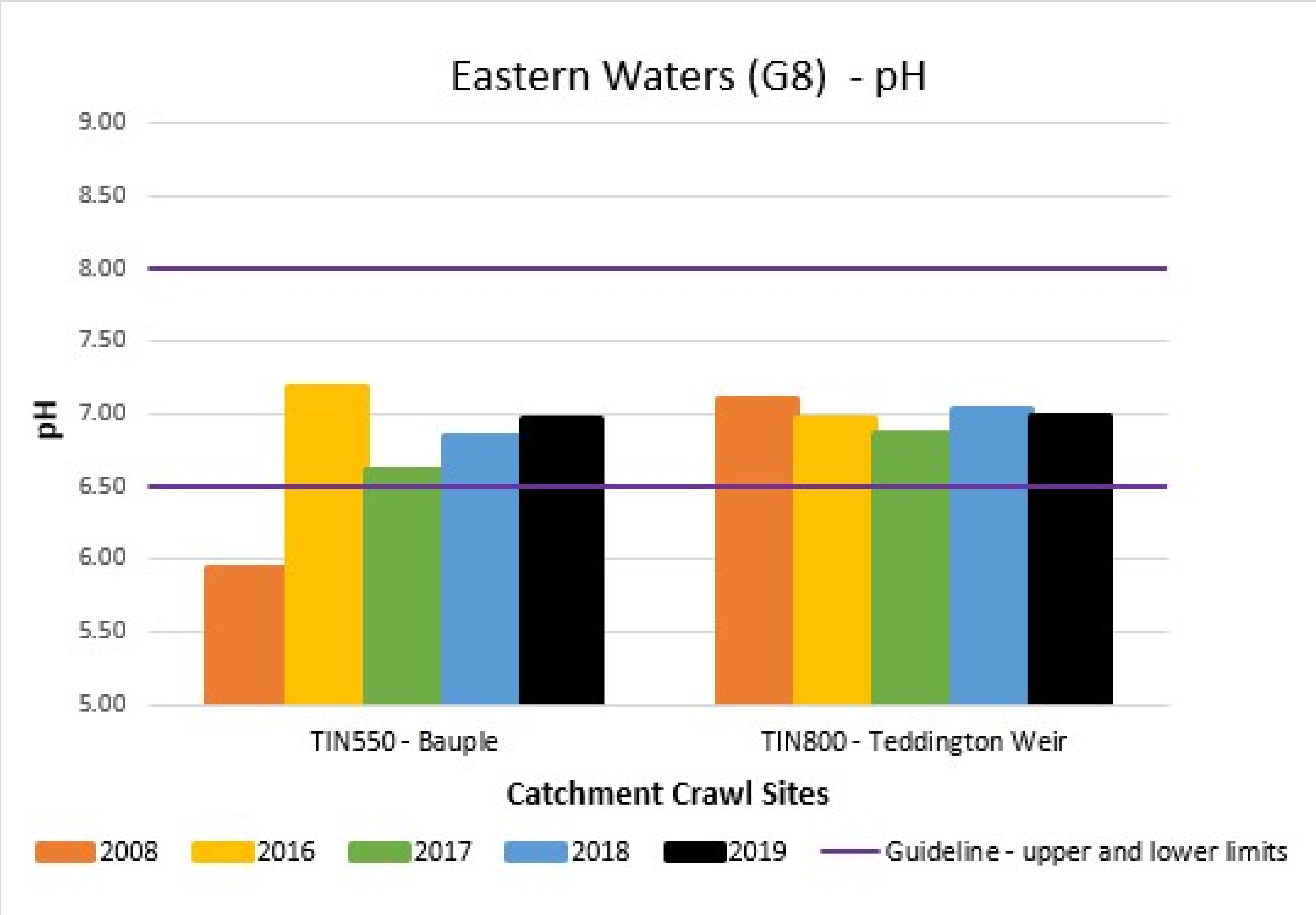

Figure 19 pH of Tinana Creek sites

3.2.4 Mary River Estuary – High Environmental Value Waters (G2)

The guideline for pH for both High Environmental Value Water sites is 8.1 to 8.4 (see Table 5). Two sites are tested in the Mary River estuary, at River Heads (MAR999) (lowest sampling site on the Mary River) and on the Susan River (SUS500) on Hervey Bay Road. The Mary River headwaters site (MAR999) was just above the guideline in 2018 (pH 8.20) and again in 2019 (pH 8.51). In 2017 the pH was just below the guideline lower limit (pH 7.86). Insufficient water was available to perform physical chemistry testing at the Susan River (SUS500) due to low tide during 2019 Catchment Crawl.

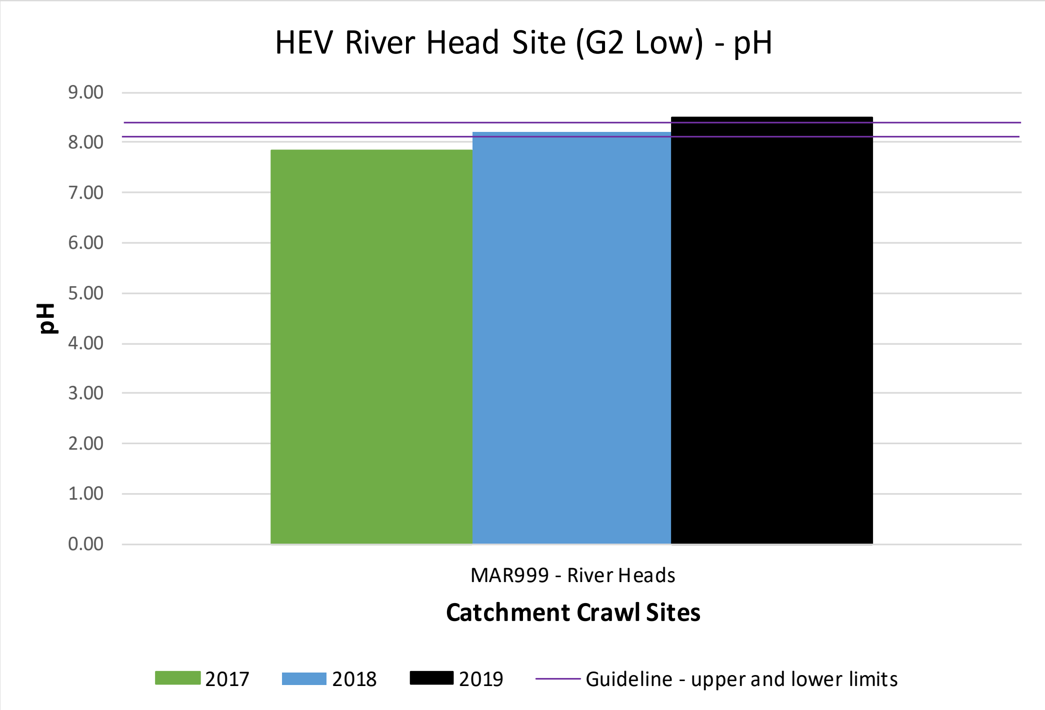

Figure 20 pH of the River Heads site (G2 low)

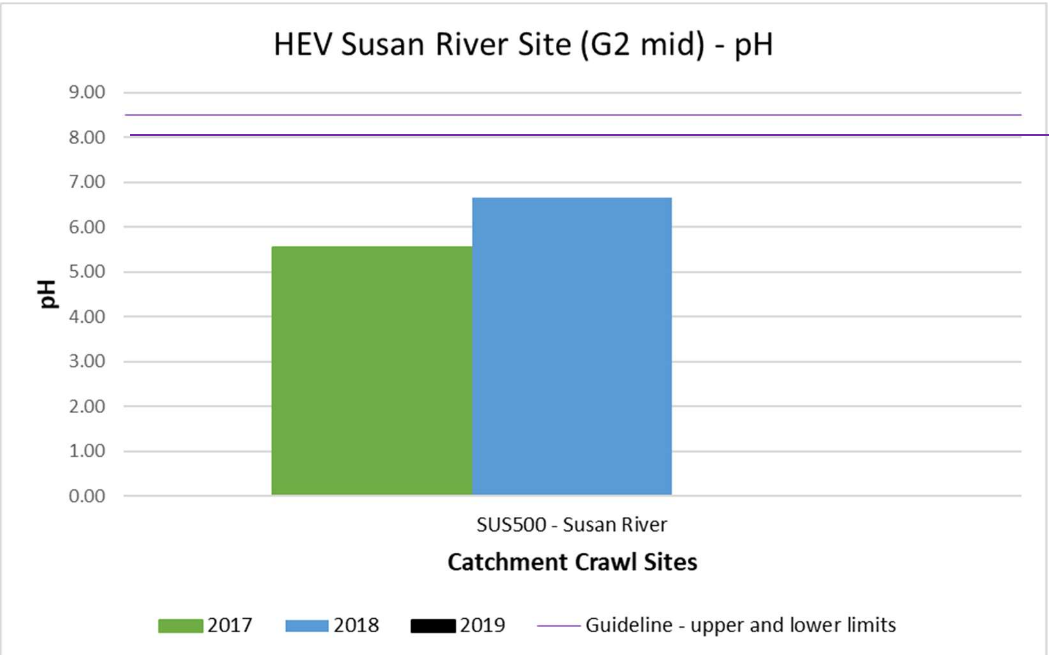

Figure 21 pH of the Susan River site (G2 low)

3.3 Electrical Conductivity (EC)

Electrical Conductivity (EC) is a measure of water's ability to conduct electricity. The EC value is derived from the amount of dissolved salt content in the water. As dissolved salt increases so does the EC. Salt levels also tend to accumulate downstream in a catchment.

Influences include geology of parent rock material, river flow, inflow of groundwater into the stream and rising salt in the water table. The EC levels of the Mary River below Gympie are strongly affected by river flow. At times of higher flow, concentration of dissolved salts in the water decreases therefore lowering salinity and thereby lowering EC.

EC recordings which lie above the upper guideline limit places limitations and jeopardises aquatic flora and fauna health and water used for irrigation and domestic use.

Figure 22 Julian OMara from Seqwater photo-point monitoring on Obi Obi Creek (OBI940).

3.3.1 Mary River and southern major tributaries (Southern Lowland Waters (G5))

The Electrical Conductivity guideline for the Mary River and major tributaries (Southern Lowland Waters) is between 0 – 580 µS/cm. Results for the Mary River (G5) sites and the guideline range is shown in Figure 23. The horizontal purple line shows the upper guideline limit. Data points above the purple line are outside of the guideline range. The black bars show the results for 2019.

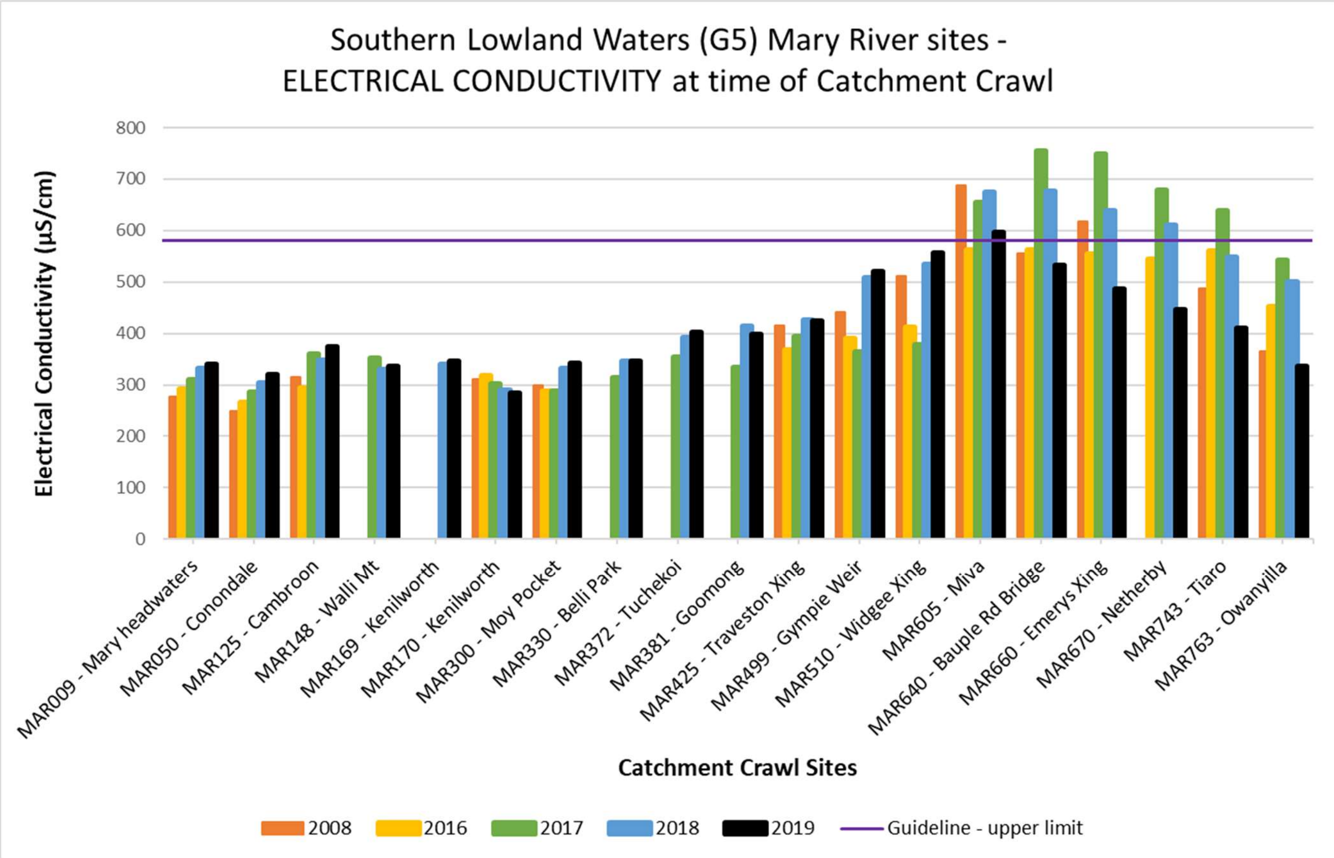

Figure 23 Electrical conductivity of Mary River sites in Southern Lowland waters (G5)

The upper catchment displays the highest EC trend seen since 2008, very similar to 2018. Downstream of Gympie, the Mary River displayed a significant decrease in EC compared to previous years from Miva downstream and was observed to be the lowest since 2008. All Mary River sites, except Miva, comply with the EC guidelines of <580µS/cm. This is the best observed compliance rate since 2016.

Significantly, some sites in the upper catchment and the Mary Valley displayed the highest EC values ever recorded during Catchment Crawls (since 2002). The Conondale sites (MAR009 and MAR050) were the highest recorded. While the Moy Pocket (MAR300), Tuchekoi (MAR372), Gympie Weir (MAR499) and Widgee X'ing (MAR510) sites in the Mary Valley all recorded their highest EC values to date.

Stream flow in the two months prior to the Catchment Crawl was best in 2019 compared to previous years. However, October 2017 and 2018 saw some early rainfall which meant stream flow in the week of the Catchment Crawl was higher than 2019.

The lower catchment displayed the lowest EC levels in the previous ~decade. This is despite having the lowest flow at the time of the Catchment Crawl. It could be attributed to better flow conditions in the previous 2 months, or it could be that there is a lag time for increased EC which we haven't seen yet due to better winter rainfall in 2019.

The tributaries (Obi Obi, Six Mile & Yabba Creeks) in this water type are not affected in the same way with the 2019, 2018 and 2017 values being quite similar (see Figure 24) and well below the guidelines upper limit.

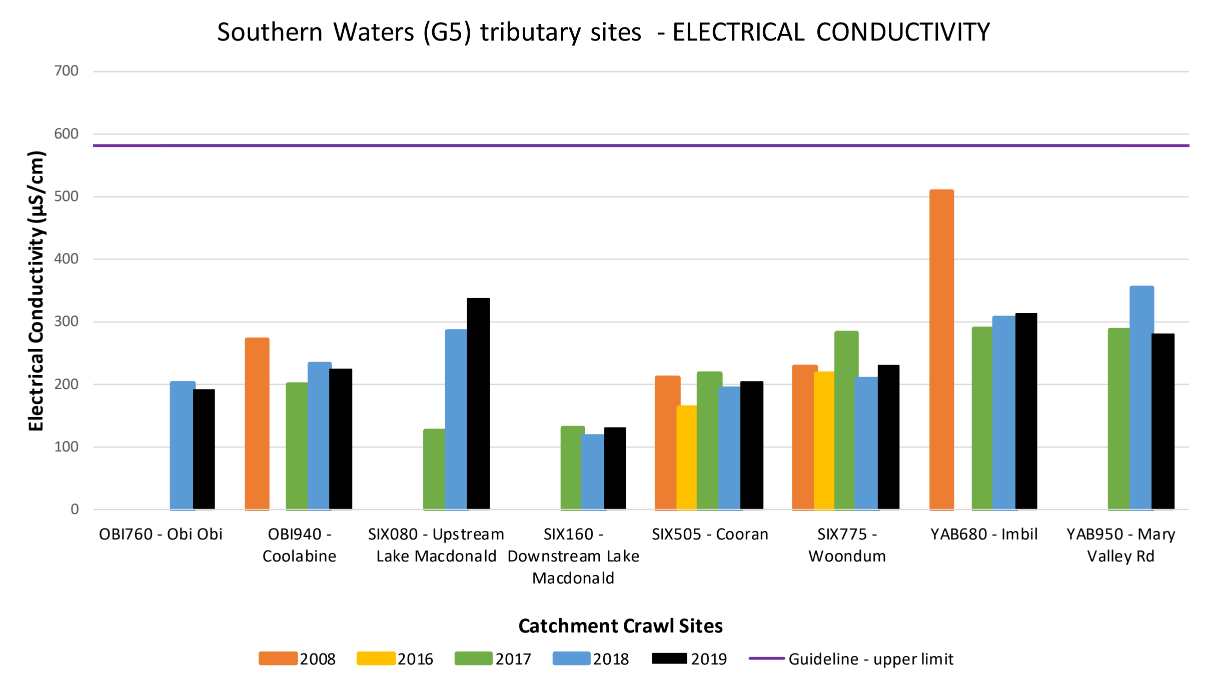

Figure 24 Electrical conductivity of tributary sites in Southern Lowland waters (G5)

3.3.2 Western tributaries (North Western Lowland Waters (G6))

The Electrical Conductivity guideline for the Western tributaries (Southern Lowland Water) (Munna, Wide Bay, Widgee Creeks) is between 0 – 1200µS/cm. The higher upper value reflects the naturally more saline geology in these waters. The Widgee (WID399) and Sexton (WIB950) sites complied with the guidelines between 2019 and previous years. However the Munna Creek site (MUN990) showed a significant increase in 2018, recording 3125 µS/cm (see Figure 25). The high EC value recorded in 2018 could be attributed to high concentrations of salt being flushed through the system with the first rains. Prior to the catchment crawl the Waterwatch sampling for this site recorded EC of 984 µS/cm on the 29th August 2018, well within guideline values. Historic Waterwatch data shows that while the site usually falls within the guideline for EC, periodic spikes do occur.

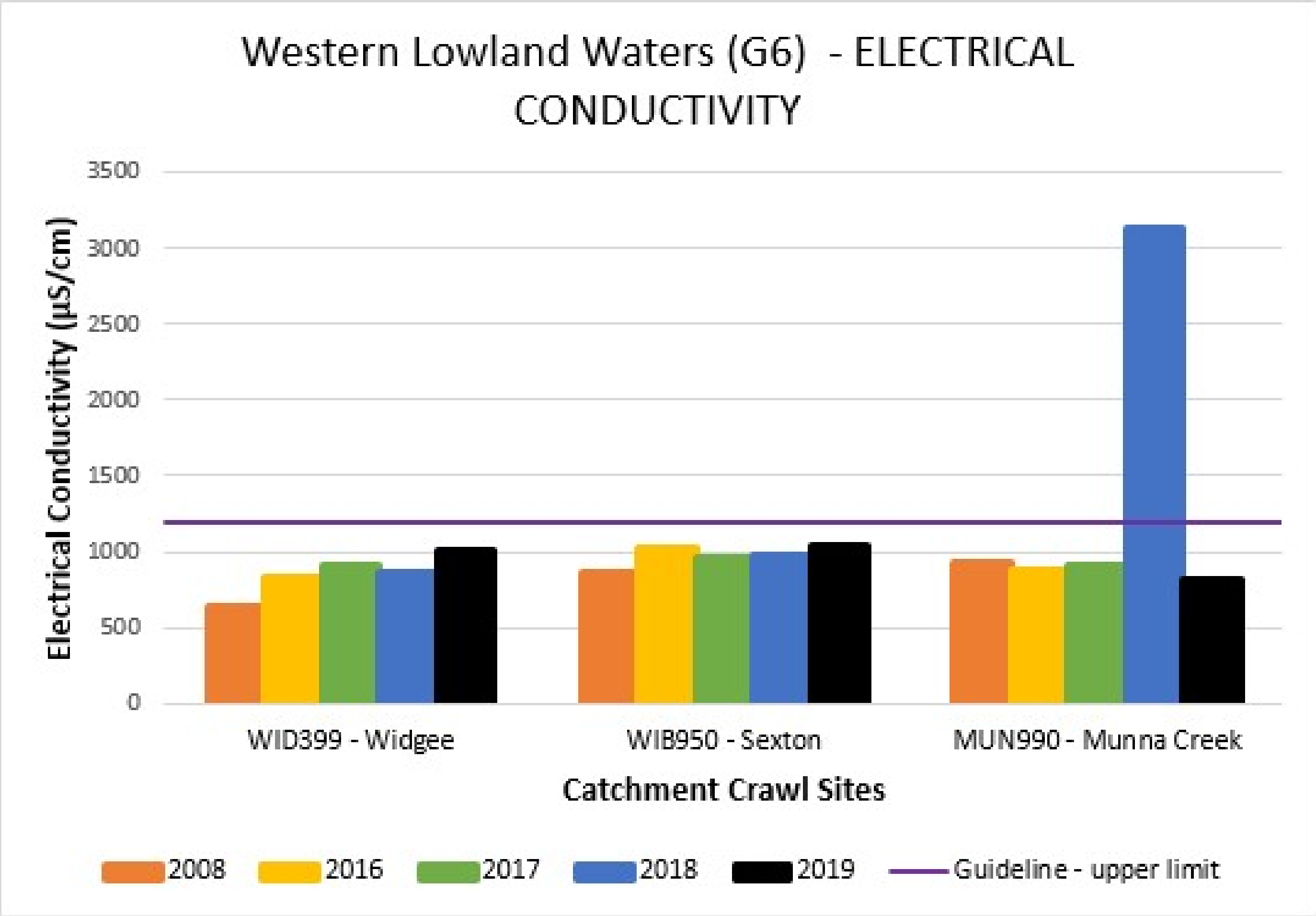

Figure 25 Electrical conductivity of tributary sites in North Western Lowland waters (G6)

3.3.3 Tinana Creek (North Eastern Lowland waters (G8))

The Electrical Conductivity guideline for the Southern Lowland Waters (Tinana Creek only) is between 0 – 580 µS/cm. The horizontal purple line in Figure 26 shows the maximum guideline value. Data points above the line are outside of the guideline range. All sites sampled comply with the guideline. EC at both sites has shown a gradual increase over the last three years. This could be attributed to the lack of rain and therefore a concentration of salt levels.

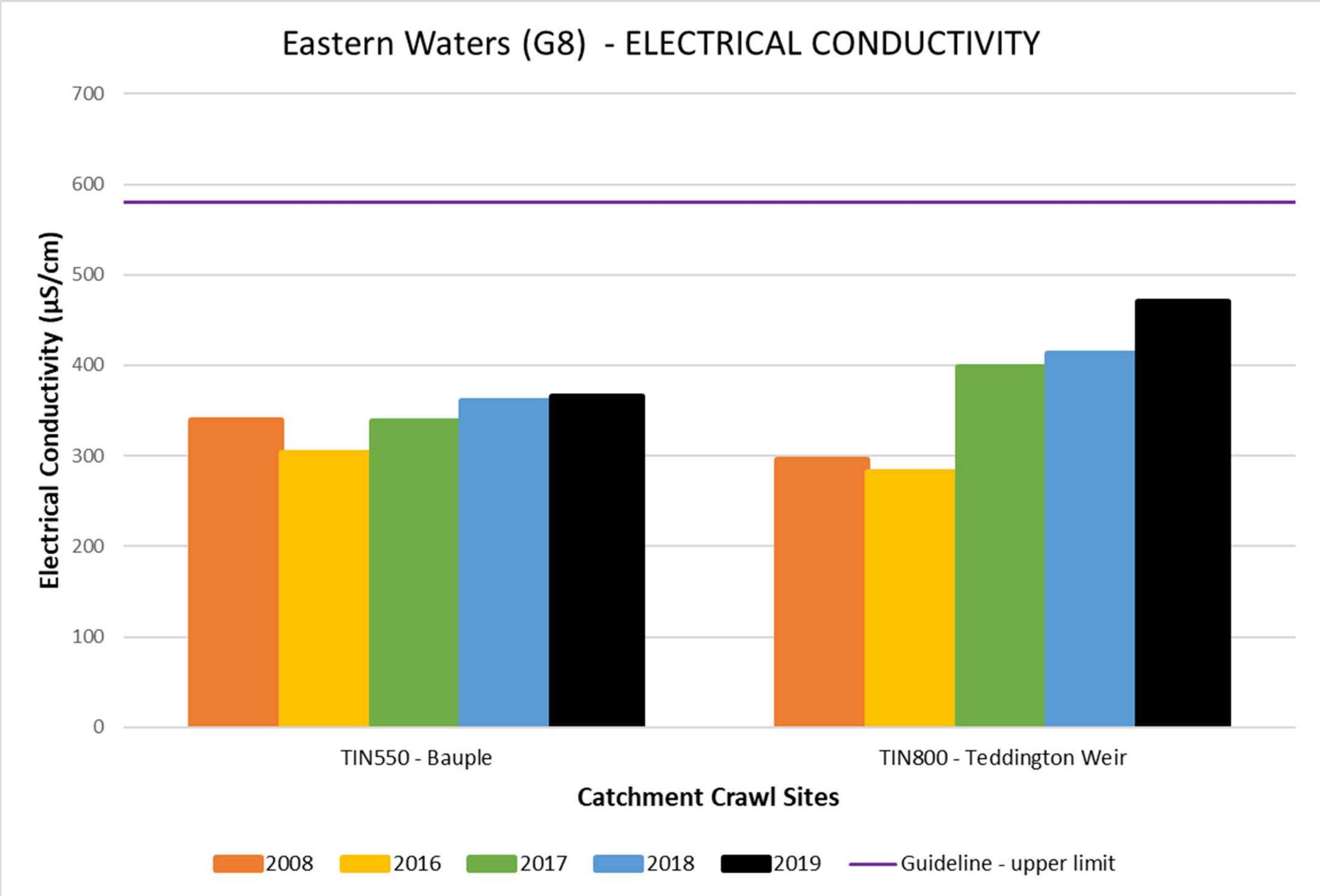

Figure 26 Electrical conductivity of tributary sites in North Eastern Lowland waters (G8)

3.3.4 Mary River Estuary – High Environmental Value Waters (G2)

Data collection of the estuary sites only commenced in a comprehensive manner in 2017. A guideline for EC for estuary waters does not currently exist. Two sites are sampled; Mary River at River Heads (MAR999) and the Susan River at Hervey Bay Road (SUS500).

The 2019 EC value (56900 uS/cm) at River Heads is the highest it has been over the three years of sampling, although similar to previous years. 2018 EC values for the River Heads site (MAR999) are very similar to those recorded in 2017, as shown in Figure 27. However, there is a significant rise in EC at site SUS500 in 2018. As Figure 28 shows, the Susan River site is much more heavily influenced by freshwater than the River Heads site. The Susan River is at the upstream extent of the tidal influence. According to the Queensland Tide Tables for 2018 a low tide of 0.46m occurred at Urangan on 9th October at 2:53pm. The Susan River sample was taken at approximately 2pm so the tide will have had less influence on this sample. However, the highest tides for the month took place on the 7th and 8th of October, with high tides of 3.95 m and 3.94m respectively recorded. This may have caused saline/brackish water to flood into the pools sampled, which would have been left exposed as the tide retreated.

Insufficient water was available to perform physical chemistry testing at the Susan River (SUS500) due to low tide during 2019 Catchment Crawl.

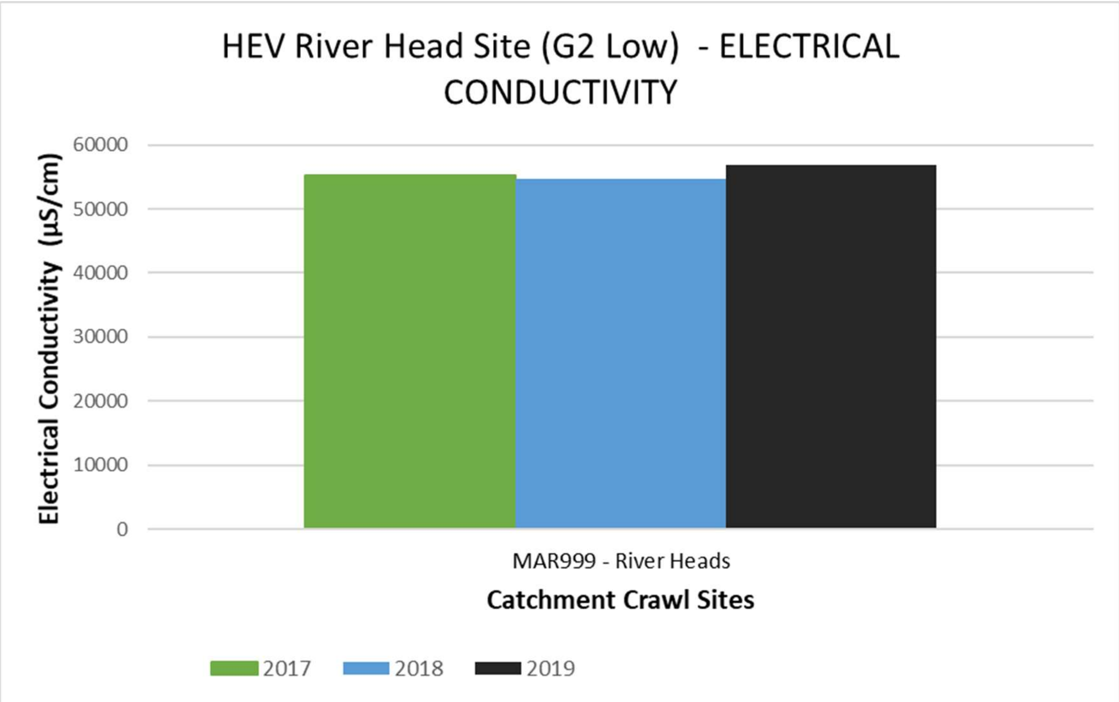

Figure 27 Electrical conductivity of the River Heads and Susan River Sites

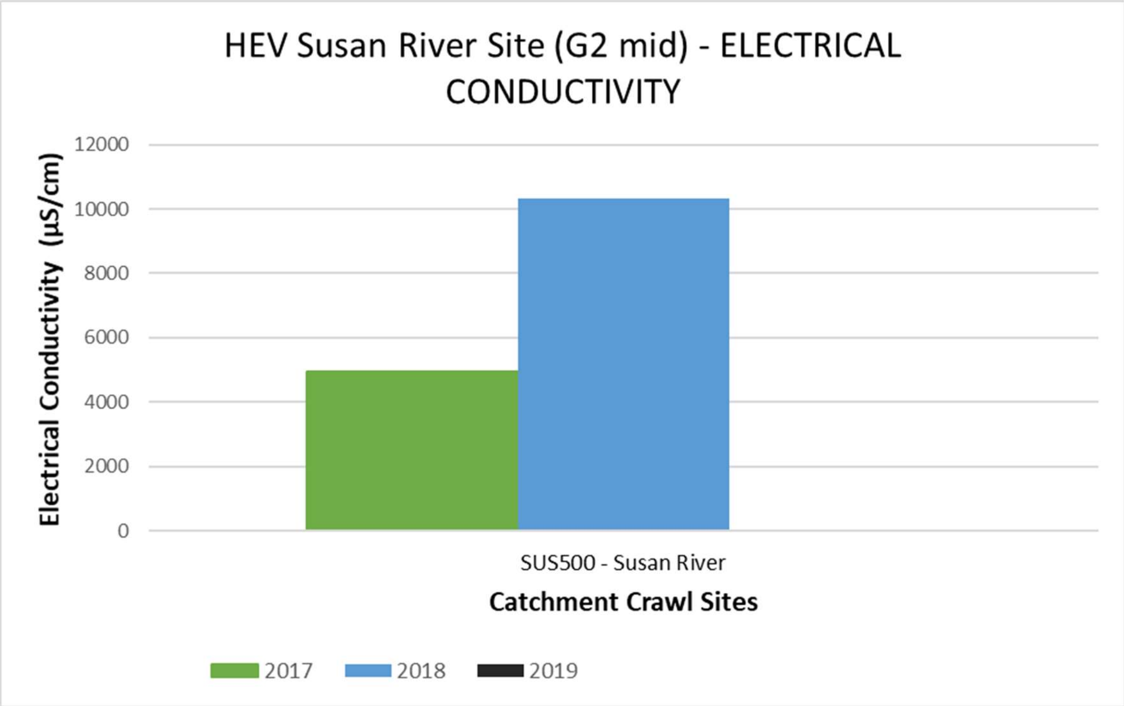

Figure 28 Electrical conductivity of the Susan River Site

3.4 Turbidity and Total Suspended Solids (TSS)

Both turbidity and total suspended solids (TSS) data are discussed in this section.

Turbidity is the measure of suspended sediments within the water. It uses the penetration of light through a liquid to approximate the level of suspended sediments and can be rapidly measured in the field. Total Suspended Solids (TSS) is measured in a laboratory and it provides the concentration of solids in a liquid (mg/L). Turbidity is effectively an approximation of TSS and is a valuable rapid assessment tool. Turbidity can be affected by colour of water and the nature of the sediments and algae in the water (e.g. colloidal sediments make water cloudy and it may therefore appear more turbid) whereas TSS is not affected by these as it is a physical measurement of the weight of solids in a known volume of water. TSS is the more accurate measurement but it requires samples to be analysed in a laboratory and therefore does not provide a rapid result like a turbidity measurement does.

Sediment in water can be from discrete sources for example river and stream bank erosion, runoff from dirt roads or diffuse sources such as sheet flow from land subject to heavy rainfall events.

3.4.1 Mary River and southern major tributaries (Southern Lowland Waters (G5))

The guideline for the Mary River and southern major tributaries (Southern Lowland Waters (G5)) turbidity is 50 NTU and for Southern Upland Waters (G4) is 25 NTU.

In 2019 all (both Mary River and tributary) sites in G5 and the one G4 site at the headwaters complied with their respective guideline for Turbidity. As Figure 29 shows, all results were less than 10NTU. Many of these results are below the detection limit of the methods used (for example a turbidity tube cannot detect less than 7NTU) but the FLT90 can detect lower results. A result of 3.5 indicates that this site was measured with a turbidity tube and was below the detection limit.

Low turbidity is to be expected at this time of year given it follows the driest time year where there has been little potential runoff or rainfall to cause sedimentation and erosion. It is significant that the rainfall the week before this catchment crawl did not elevate levels compared to previous years.

The guideline for total suspended solids (TSS) for lowland and upland streams in the south-east Queensland region is 6 mg/L (Department of Environment and Resource Management, 2009). As Figure 30 shows, in 2019 three sites failed Mary River at Tuchekoi (MAR372 8 mg/L), Bauple Road Bridge (MAR640, 24 mg/L) and Tiaro (MAR743, 8 mg/) to comply with guidelines. In 2018 two sites failed to comply, in 2017 only one site failed to comply, while two sites exceeded the guideline in 2016 and three in 2015. When comparing turbidity levels (NTU) with TSS for each site there is a general correlation between each parameter (see Figure 31).

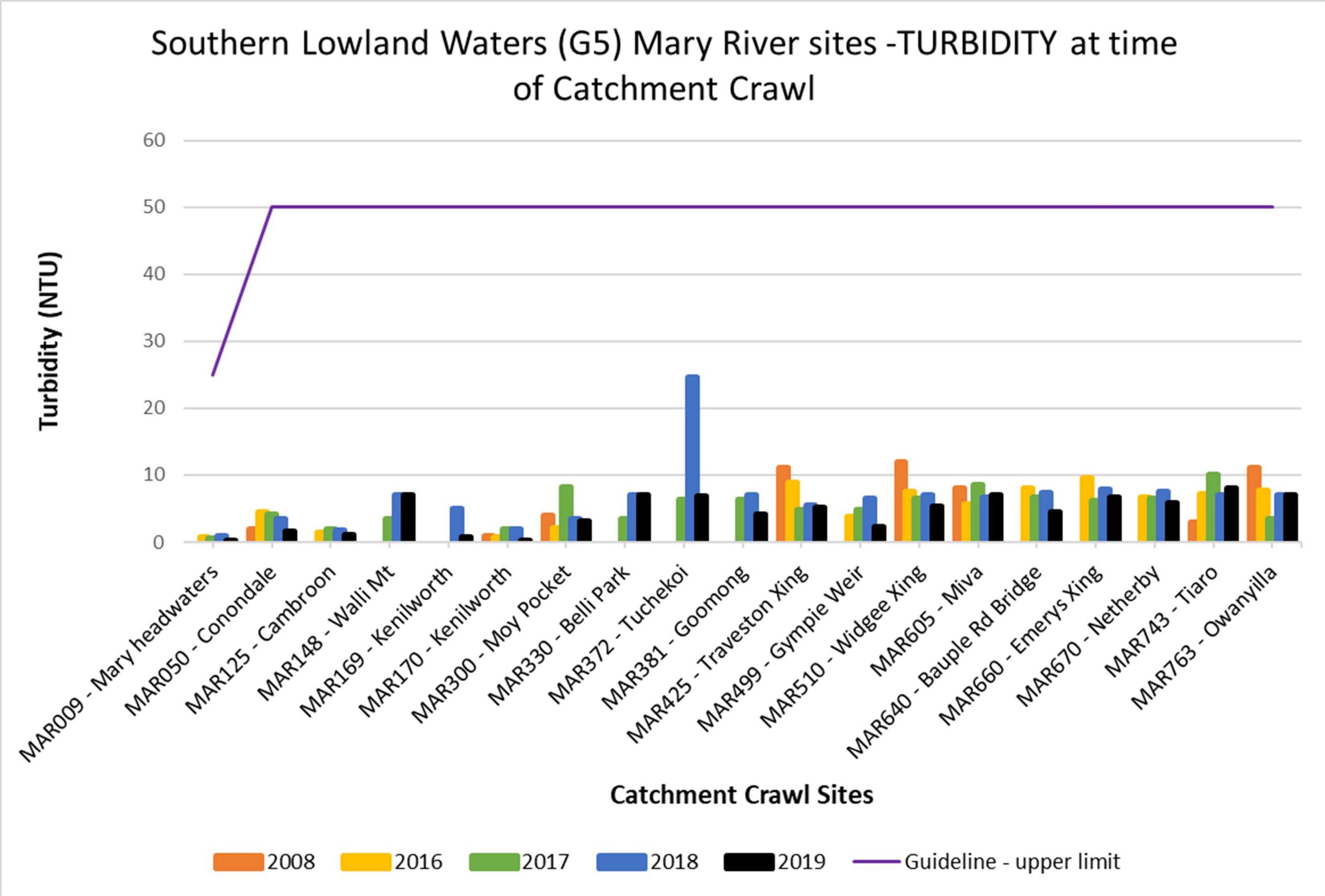

Figure 29 Turbidity of Mary River sites in Southern Lowland waters (G5)

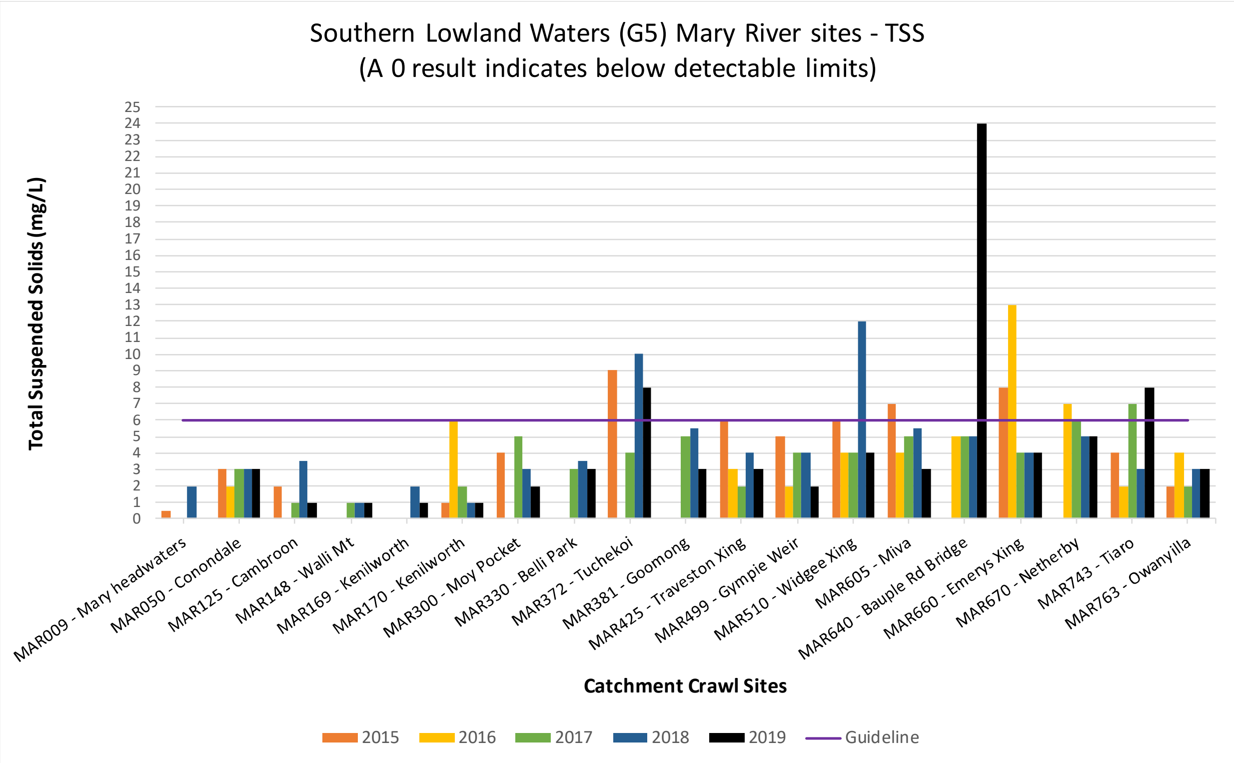

Figure 30 TSS of Mary River sites in Southern Lowland waters (G5)

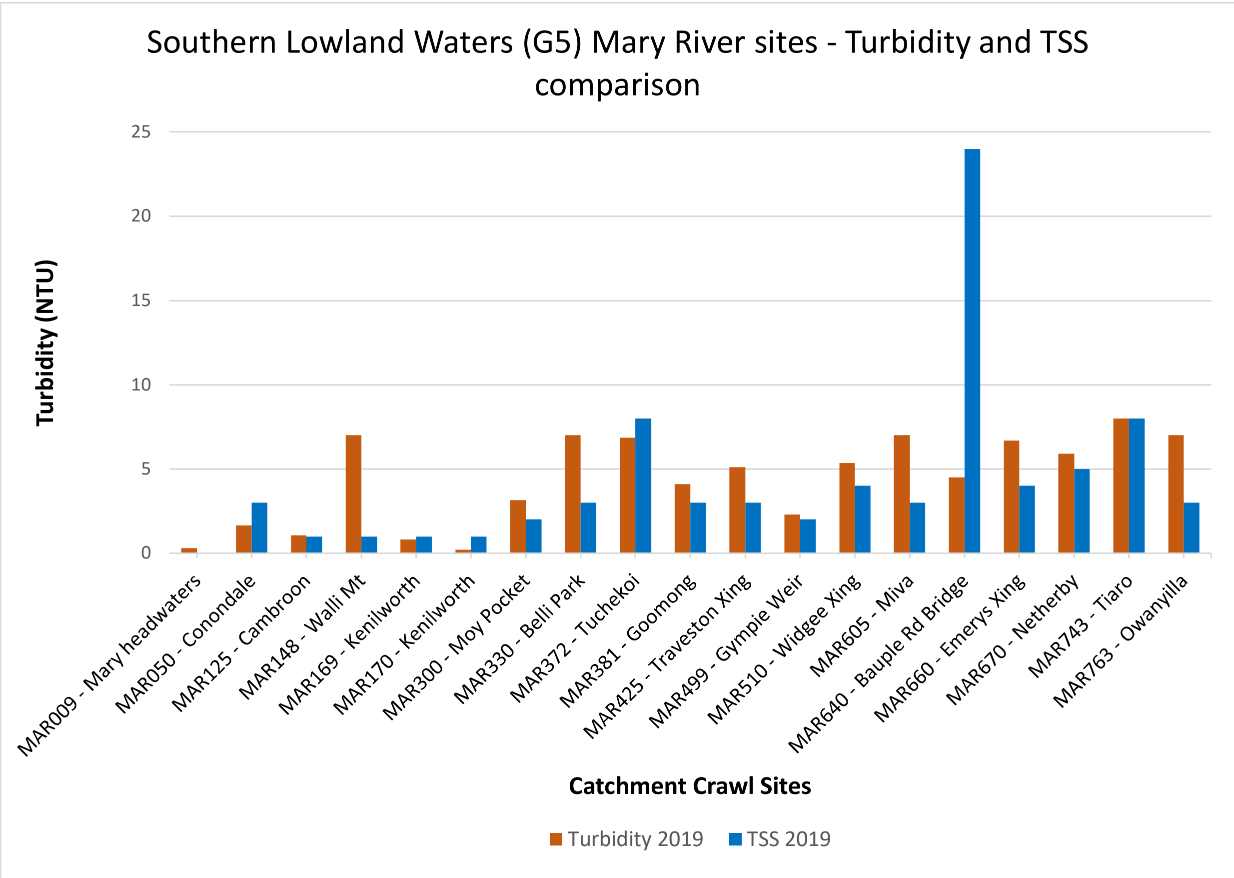

Figure 31 Comparison of TSS and turbidity values in 2019

Like they have in previous years, all tributary sites in the G5 water type (Obi Obi, Six Mile, Yabba Creeks) complied with the Turbidity guideline of 50NTU (see Figure 32). All sites except the Six Mile Creek site upstream of Lake MacDonald (SIX080) complied with the Total Suspended Solid (TSS) guideline (see Figure 33). This site returned a result of 8mg/L. Overall, TSS results are lower this year compared to 2018.

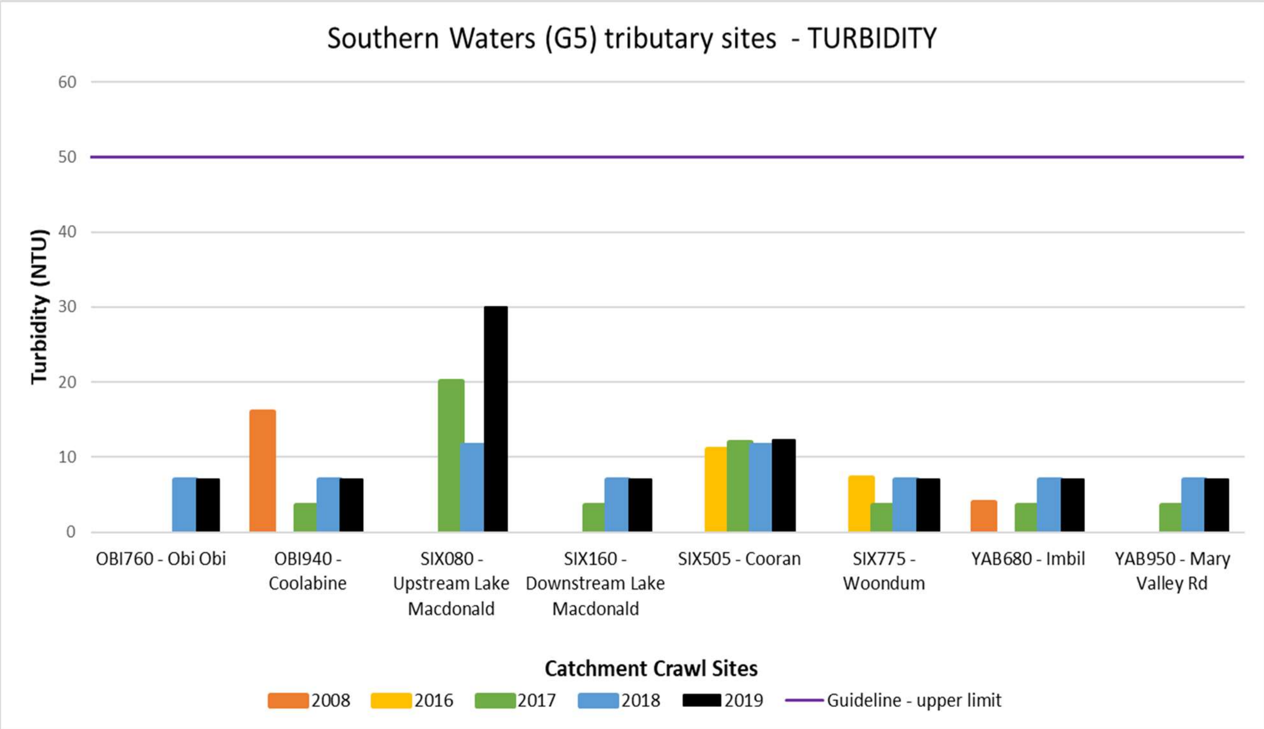

Figure 32 Turbidity of tributary sites in Southern Lowland waters (G5)

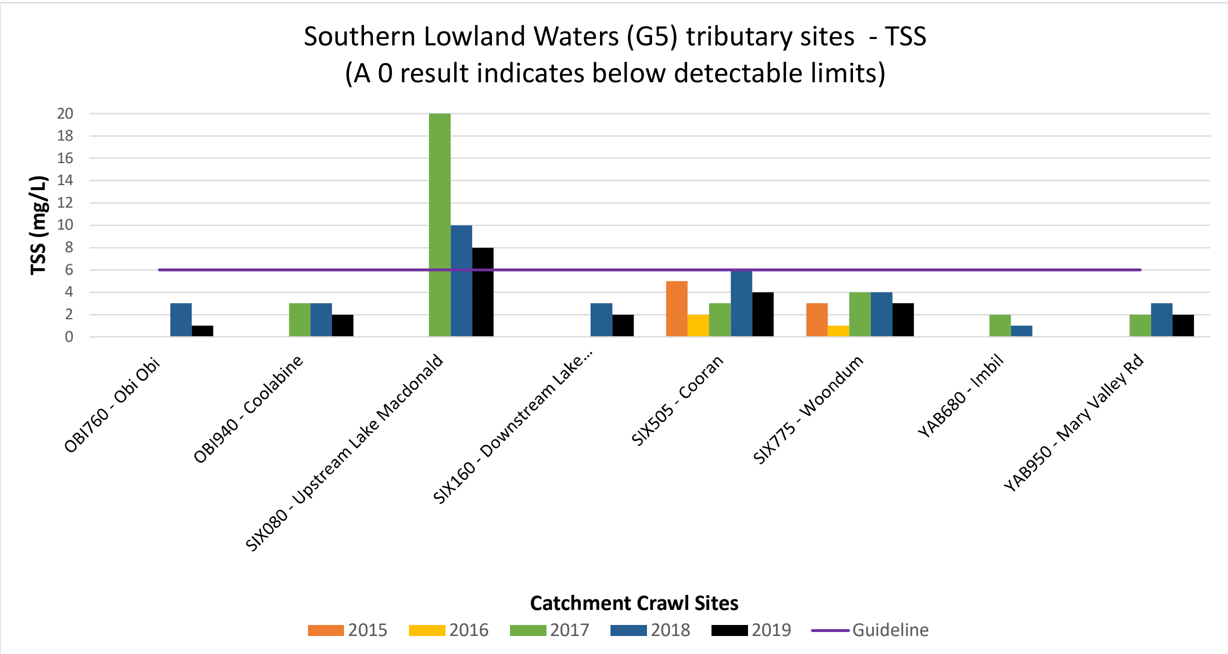

Figure 33 TSS of tributary sites in Southern Lowland waters (G5)

3.4.2 Western tributaries (North Western Lowland Waters (G6))

All sites within the North Western lowland waters (Munna, Wide Bay, Widgee Creeks) were compliant with the turbidity guideline of 50NTU, see Figure 34. Widgee Creek displays a slightly higher TSS result (4 mg/L) compared to 2018 (2 mg/L). Munna Creek (MUN990) exceeds guideline values recording 11 mg/L this year.

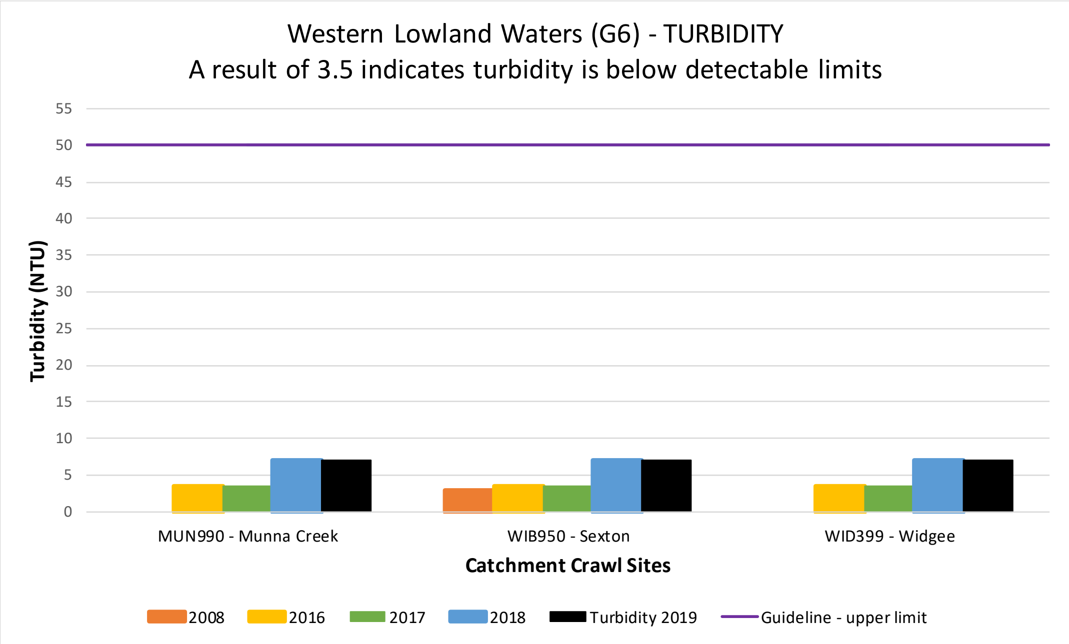

Figure 34 Turbidity of tributary sites in North Western Lowland waters (G6)

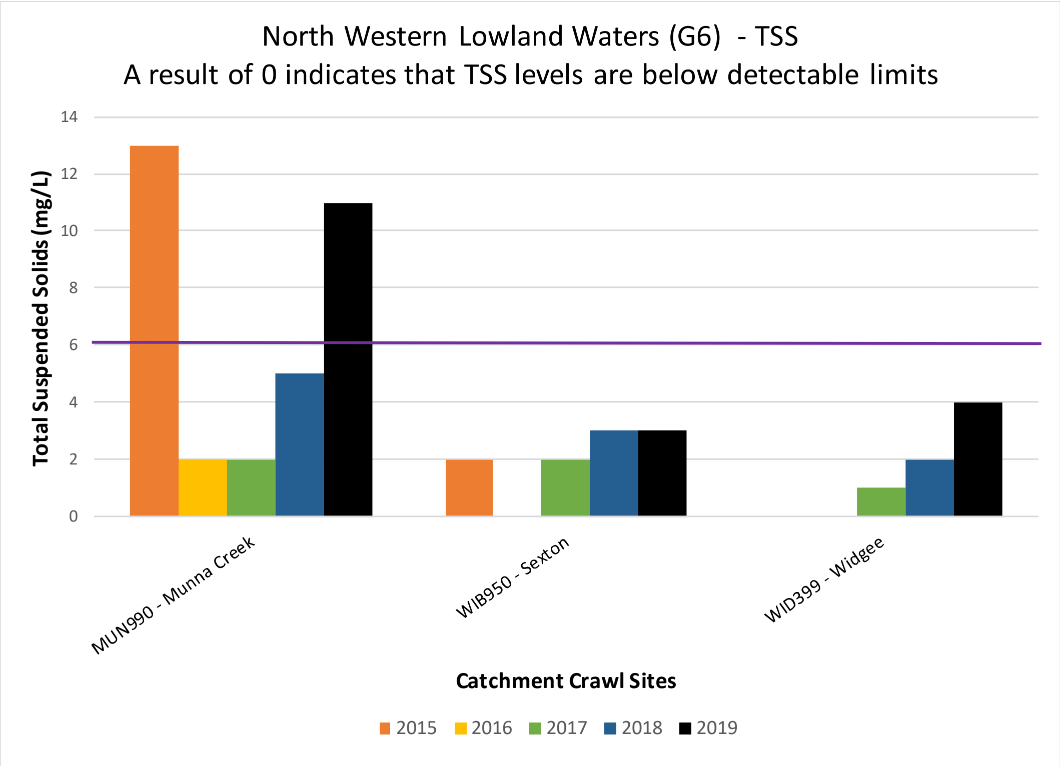

Figure 35 TSS of tributary sites in North Western Lowland waters (G6)

3.4.3 Tinana Creek (North Eastern Lowland waters (G8))

The water clarity (turbidity) at Tinana Creek, Teddington Weir (TIN880) is relatively clear and well within guidelines however, TSS exceeds guidelines indicating a presence of solids suspended in the water column which may be organic material such as decomposing plant matter or algae. Tinana Creek at Bauple (TIN550) has low turbidity and low TSS, both within guidelines.

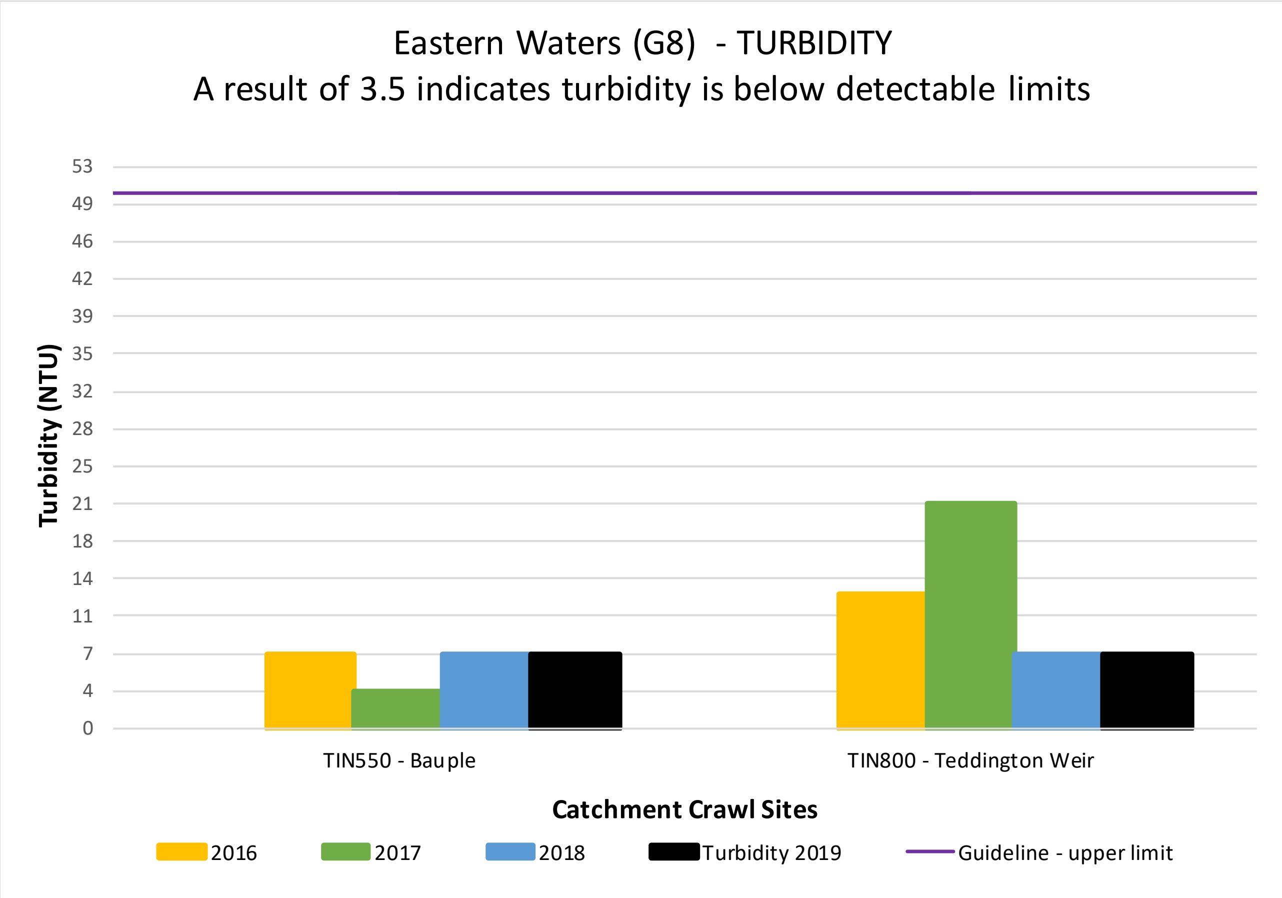

Figure 36 Turbidity of tributary sites in North Eastern Lowland waters (G8)

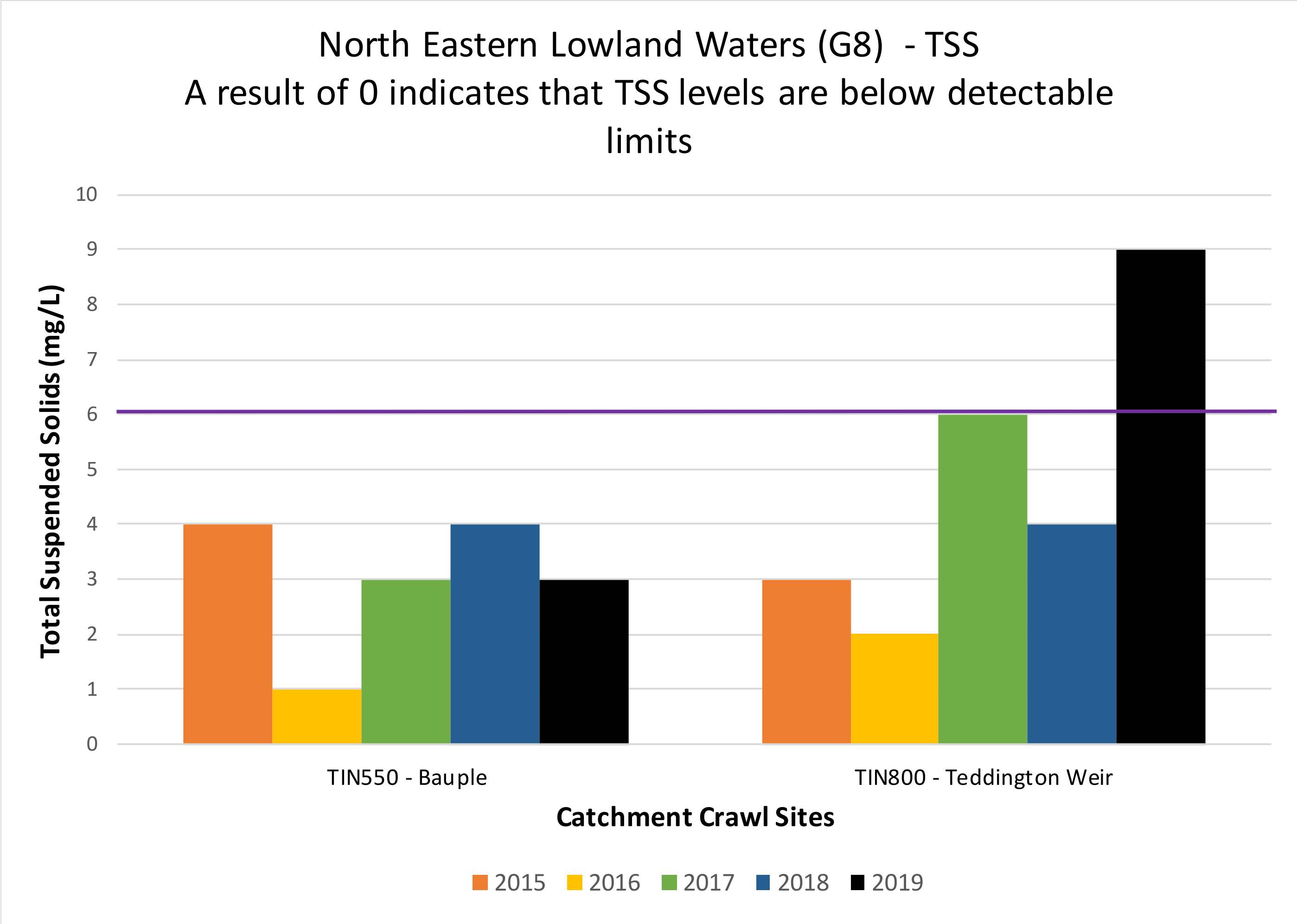

Figure 37 TSS of tributary sites in North Eastern Lowland waters (G8)

3.4.4 Mary River estuary – High Environmental Value Waters (G2)

Data collection of the estuary sites only commenced in a comprehensive manner in 2017.

The guideline for turbidity for High Environmental value waters is 4NTU (see Figure 38) and for suspended solids the 50th percentile value is 9 mg/L (Department of Environment and Resource Management, 2009).

The Mary River at River Heads has very low turbidity compared to previous years however, this year it recorded its highest TSS result of 80mg/L which may be influenced by wave action.

Insufficient water was available to perform physical chemistry testing at the Susan River (SUS500) due to low tide during 2019 Catchment Crawl. However, TSS was tested and the results are significantly higher (69 mg/L) than the guideline limit of 9 mg/L.

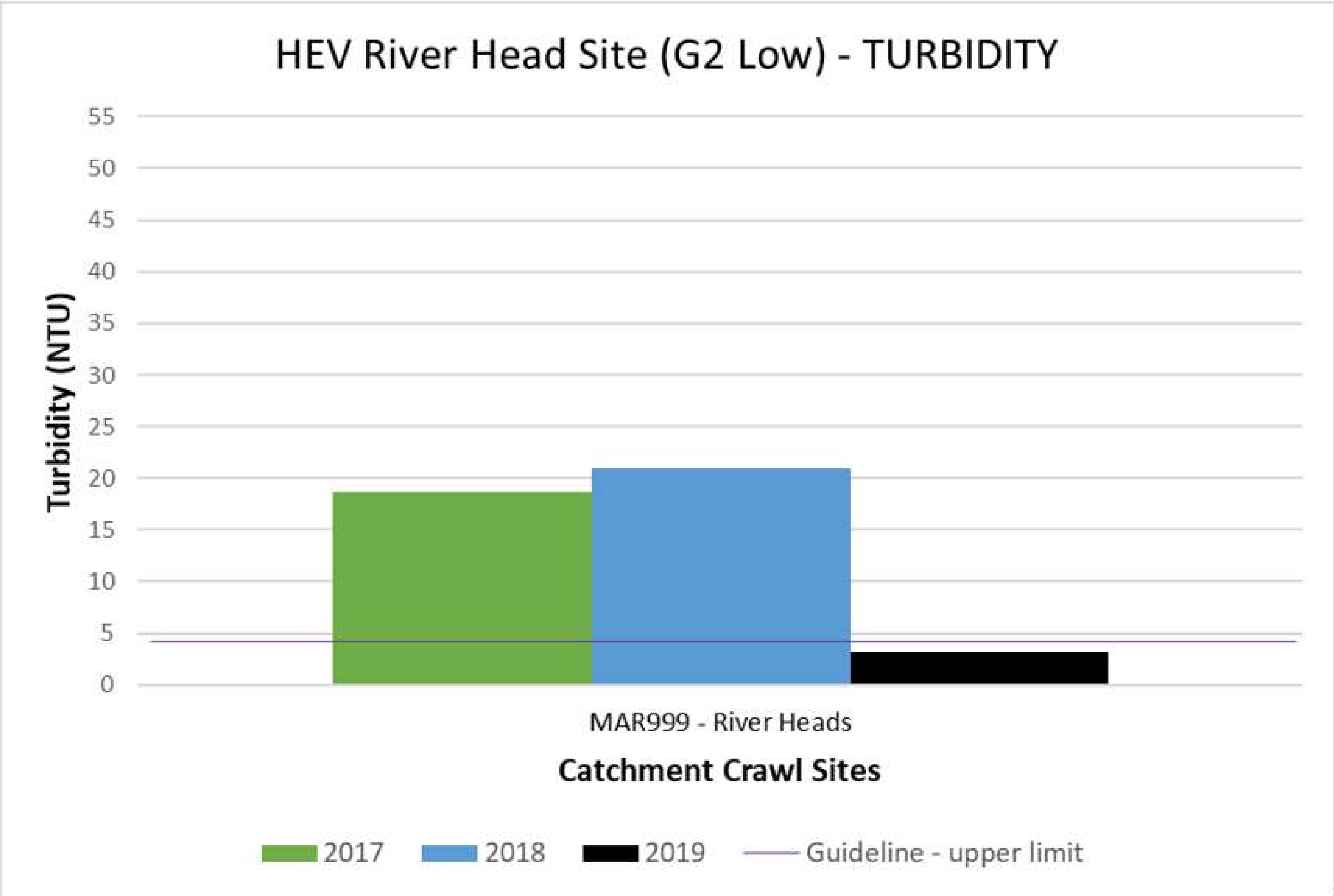

Figure 38 Turbidity of the River Heads site (G2 low)

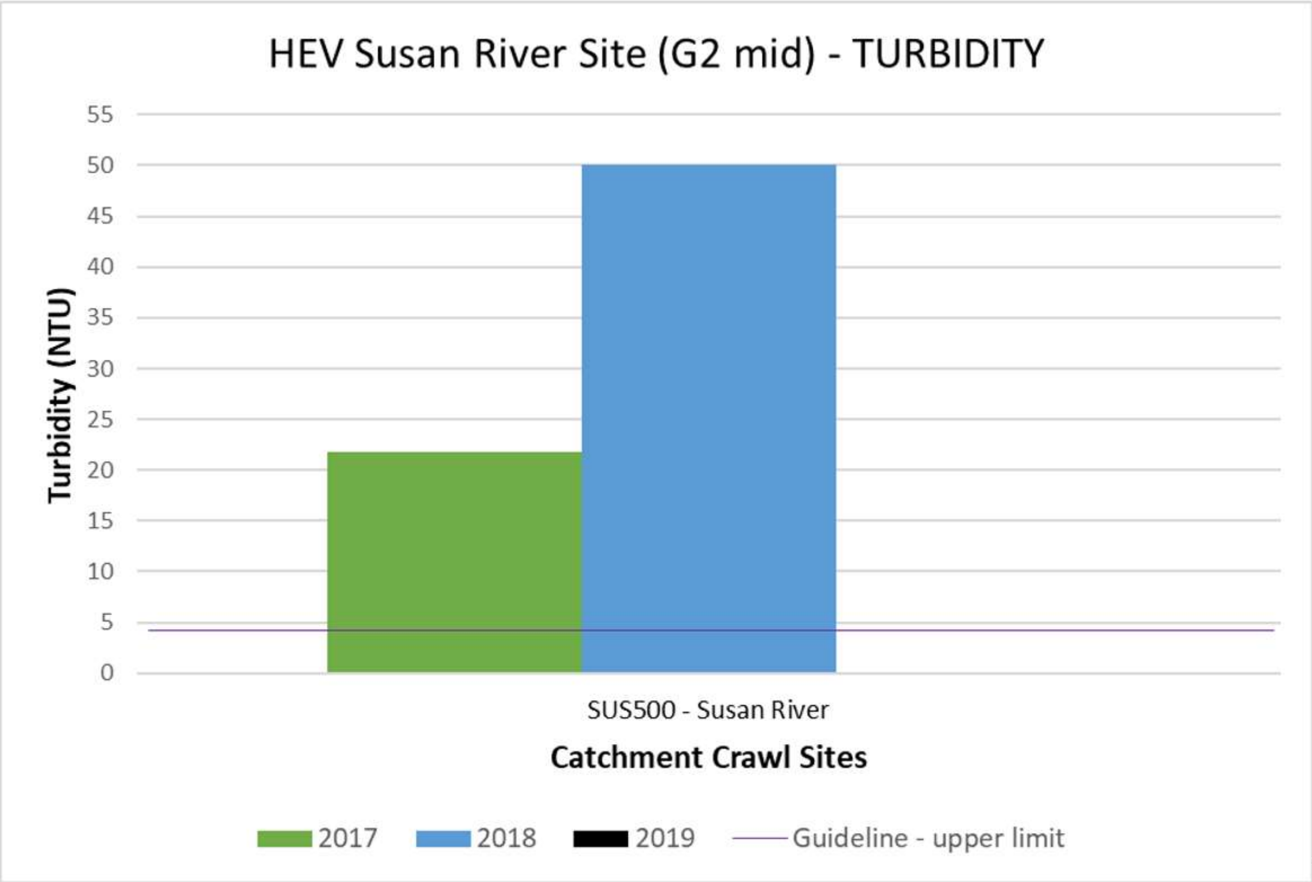

Figure 39 Turbidity of the Susan River site (G2 mid)

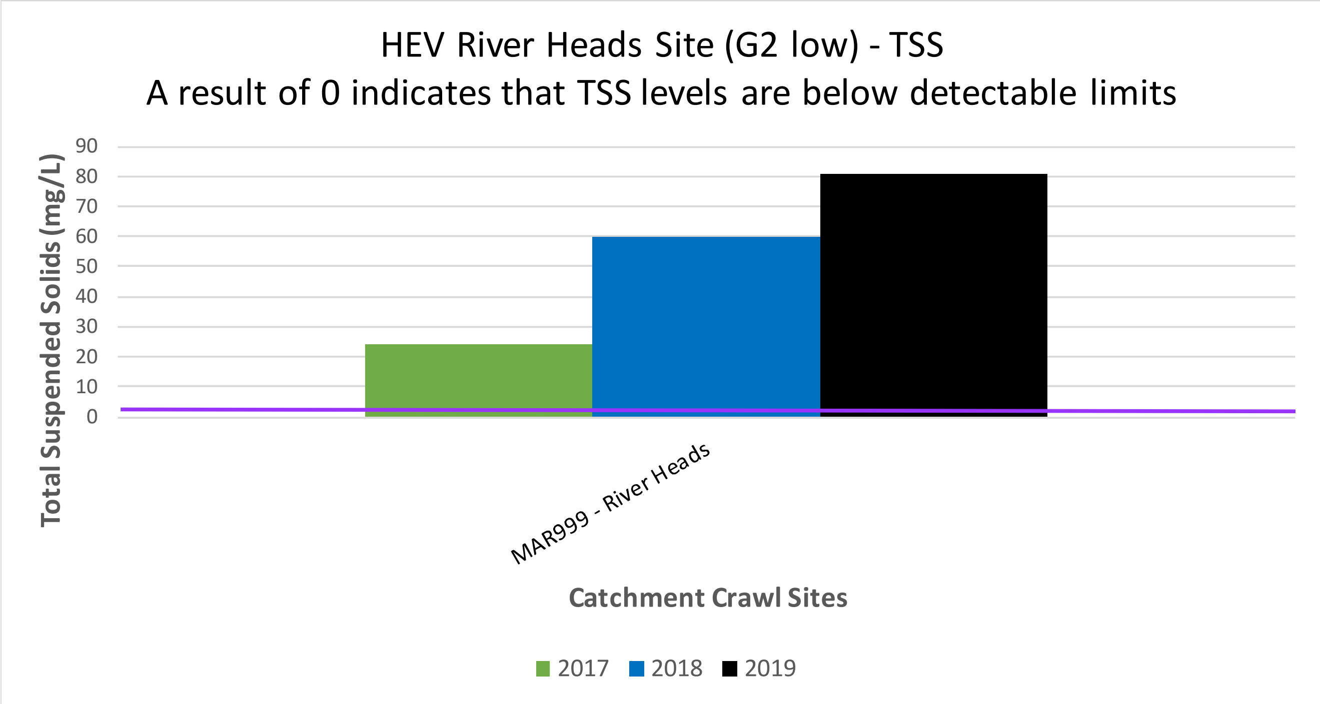

Figure 40 TSS of the River Heads site (G2 low)

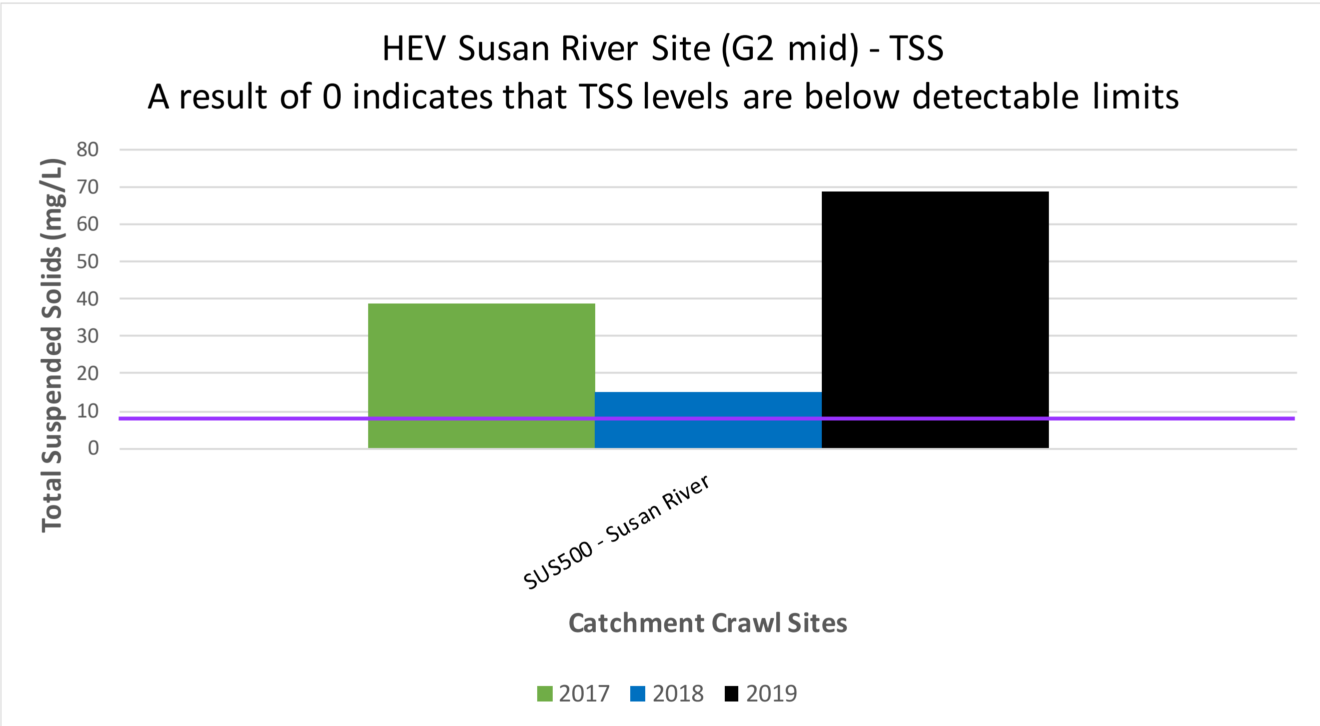

Figure 41 TSS of the Susan River site (G2 mid)

3.5 Dissolved Oxygen (DO)

Dissolved oxygen is a measure of the amount of oxygen dissolved in the water. The results are presented as a % with values above 100% indicating that the water is supersaturated with oxygen. Oxygen is essential for respiration of all living things in the water. It is also produced by photosynthesis of plants and fluctuates throughout the day as a result of the interaction of processes that use oxygen in the water and processes that produce oxygen and how these are affected by temperature and sunlight.

Fish in Australian freshwater ecosystems are adapted to fluctuating oxygen availability given the drought and flood events over the course of evolution. However, it is accepted that where DO% falls below 80%, fish survival is compromised. In waterways that are under stress, DO levels can fluctuate wildly, from very low levels (<10% saturation) early in the morning to super-saturation (>110%) in the late afternoon when air and water temperatures are highest. These wild fluctuations in dissolved oxygen levels are deleterious for fish life making potential habitat e.g. snags, timber debris structures, unusable. Waterways with good riparian vegetation and canopy cover (to moderate water temperatures during the day and overnight), coupled with good streamflows tend to have more stable dissolved oxygen levels, thus creating optimal conditions for fish and aquatic life.

The guideline for dissolved oxygen for the different water types were outlined in Table 5. For the Mary River and southern major tributaries (Southern lowland (G5)), Western tributaries (North western (G6)) and Tinana Creek (north eastern (G8) lowland) water type the guideline range is 85 – 110 % saturation. For the Upper Mary (Southern Upland waters (G4)) the lower limit is slightly higher with a narrower range between 90-100% saturation. When available, data from 2008, 2015, 2016, 2017, 2018 and 2019 has been provided in this section.

Influences causing fluctuating DO% include water temperature (warmer water holds less DO), stream flow and agitation through riffles, timber debris structures, etc. (less agitation leads to lower DO), salinity (more saline water holds less DO) and turbidity (more turbid water holds less oxygen). Readings are taken as percentage saturation of water. For example, where a reading is 100%, would indicate no more oxygen could be dissolved in the water sample and the water is supersaturated with oxygen; a reading <100% would indicate the sample is not fully saturated and more oxygen could be dissolved; a reading > 100% indicates oxygen is being generated more quickly than can escape with water surface tension acting as a barrier resulting in more than 100% oxygen in the water body i.e. from aquatic plant or algae respiration.

3.5.1 Mary River and southern major tributaries (Southern Lowland Waters (G5))

The dissolved oxygen results in the main trunk of the Mary River were very different to the tributary sites (Obi Obi, Six Mile, Yabba Creeks) in the water type. As Figure 42 shows most of the main trunk Mary River sites complied with the guideline of 85-110% saturation (and 90-110% saturation for the upper Mary River) in 2019. The exceptions were MAR009 Mary headwaters, MAR125 Cambroon and MAR372 Tuchekoi which were below the guidelines and MAR148 Walli Mt, MAR169 Kenilworth, MAR381 at Goomong, MAR425 Traveston Crossing and MAR499 Gympie Weir were above the guidelines (super-saturation). In contrast, only two of the tributary sites complied –YAB680 at Imbil and YAB950 at Mary Valley Road (see Figure 43). The lowest value was at Six Mile Creek, upstream of Lake Macdonald (SIX080), at 9.25%sat. This low results may be explained by low flow.

In the week before the Catchment Crawl, Six Mile Creek was flowing at ~3ML/day. On the 8th and 9th of October, 2019 the creek was ~4ML/day streamflow. These are very low flows. Tinana Creek at Bauple (Missings) was also flowing at very low levels eg. 4 – 5ML/day during the week leading up to the 2019 Catchment Crawl.

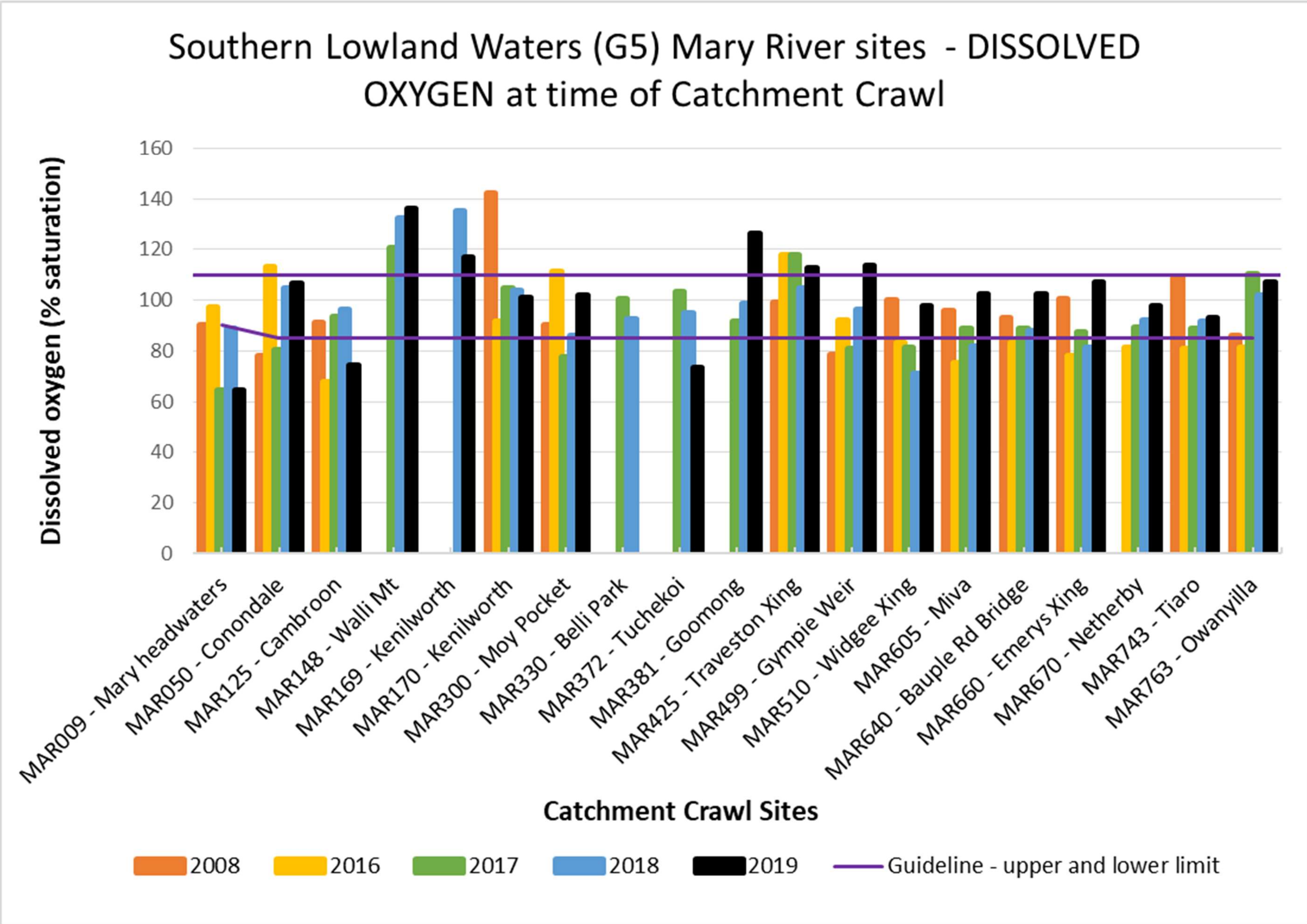

Figure 42 Dissolved Oxygen results for Mary River Southern Lowland Water (G5) sites

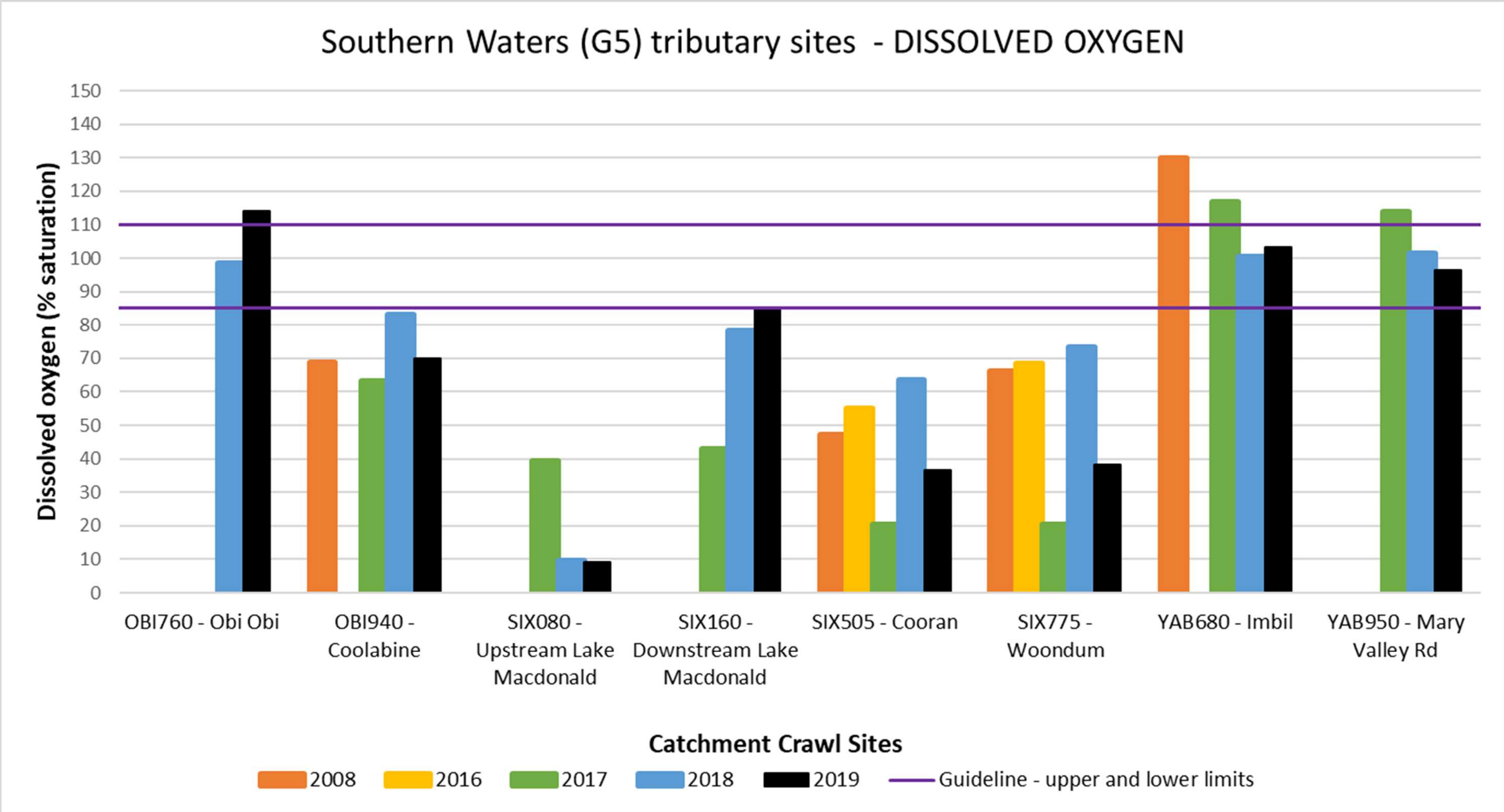

Figure 43 Dissolved Oxygen results for tributary Southern Lowland Water (G5) sites

The Six Mile Creek upstream of Lake Macdonald site (SIX080) has low oxygen levels even though the sample was taken between 9-10am. The high nitrogen and phosphorus level may be contributing to the low oxygen levels at this site because of eutrophic conditions that occur in the presence of high nutrients (eutrophic refers to a situation where microorganisms in the water proliferate to use the nutrients and at the same time draw down the oxygen levels). All tributary sites sampled are located below a dam (apart from SIX080 Six Mile Creek upstream of Lake MacDonald). The releases from the dam will also affect dissolved oxygen levels.

3.5.2 Western Tributaries (North Western Lowland Waters (G6))

Figure 44 shows the dissolved oxygen results for North Western Lowland waters of Munna, Wide Bay and Widgee Creeks (G6). The Wide Bay, Munna and Widgee Creeks all had no flow in the week leading up to the 2019 Catchment Crawl. Widgee Creek Township (WID399) has fallen below guideline values for all sampling years, which may be flow related because the creek has the smallest catchment of the three. The Wide Bay Creek site (WIB950) exceeded the guidelines in 2018 and was below guideline values in 2019. In contrast, the Munna Creek site (MUN990) complied with the guidelines in 2017 but exceeded them in 2018 and 2019.

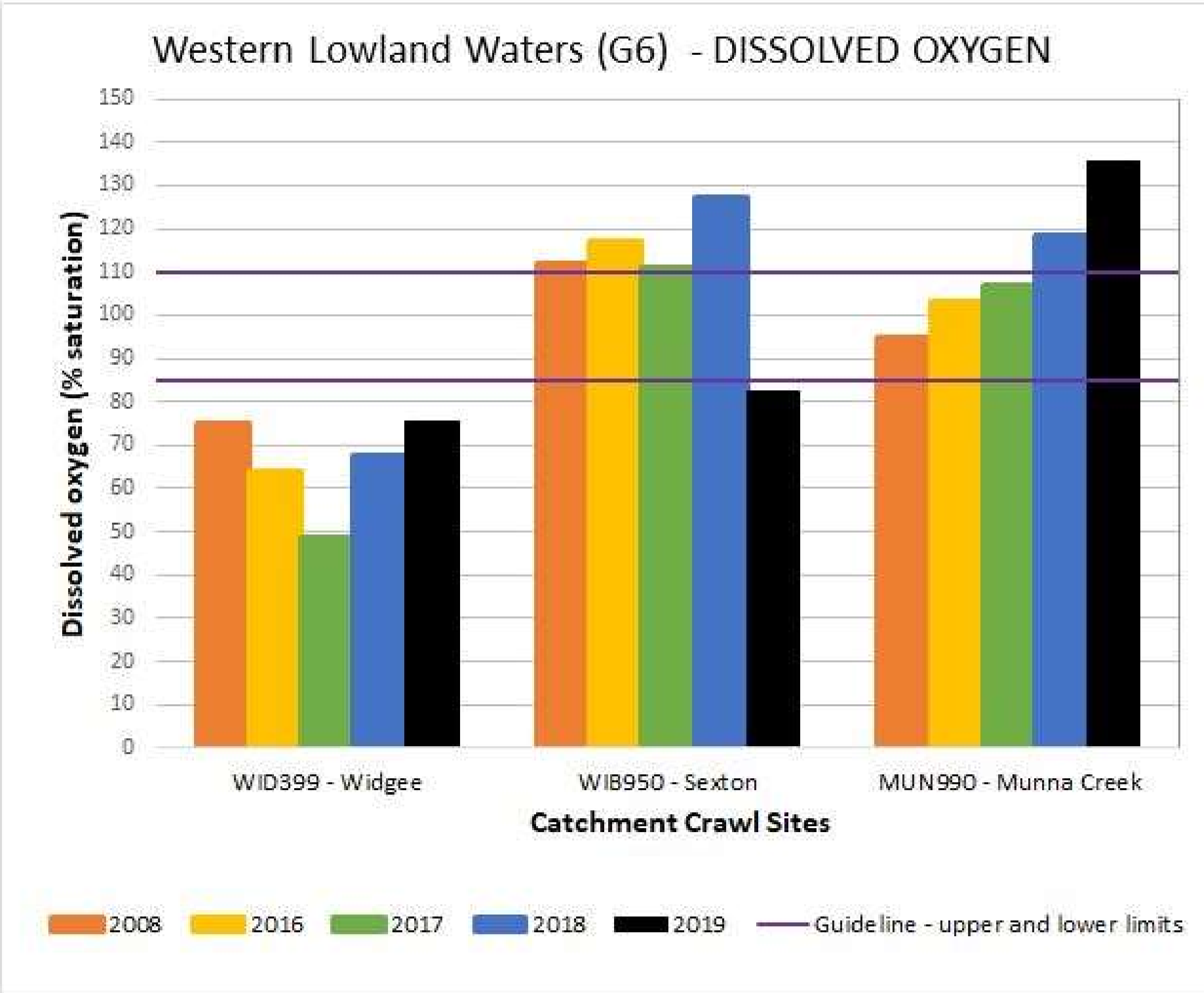

Figure 44 Dissolved oxygen results for North Western Lowland waters (G6)

3.5.3 Tinana Creek (North Eastern Lowland waters (G8))

As Figure 45 shows there is a history of the sites on Tinana Creek not complying with the guideline values. Site TIN800 at Teddington Weir just met the lower guideline in 2018, and fell well below in 2019 with a reading of 56.15%. While TIN550 at Bauple continued to be below guidelines with a slightly higher reading in 2019 of 69% compared to the three previous years. The lower results are in part due to the flat longitudinal profile of Tinana Creek and limited geomorphic features (e.g. riffles) to introduce oxygen into the water, coupled with the Teddington and Tallegalla weir pools also contributing to the low results. Streamflow in Tinana Creek in 2019 was very low, with no flow over Teddington Weir or down the fishway.

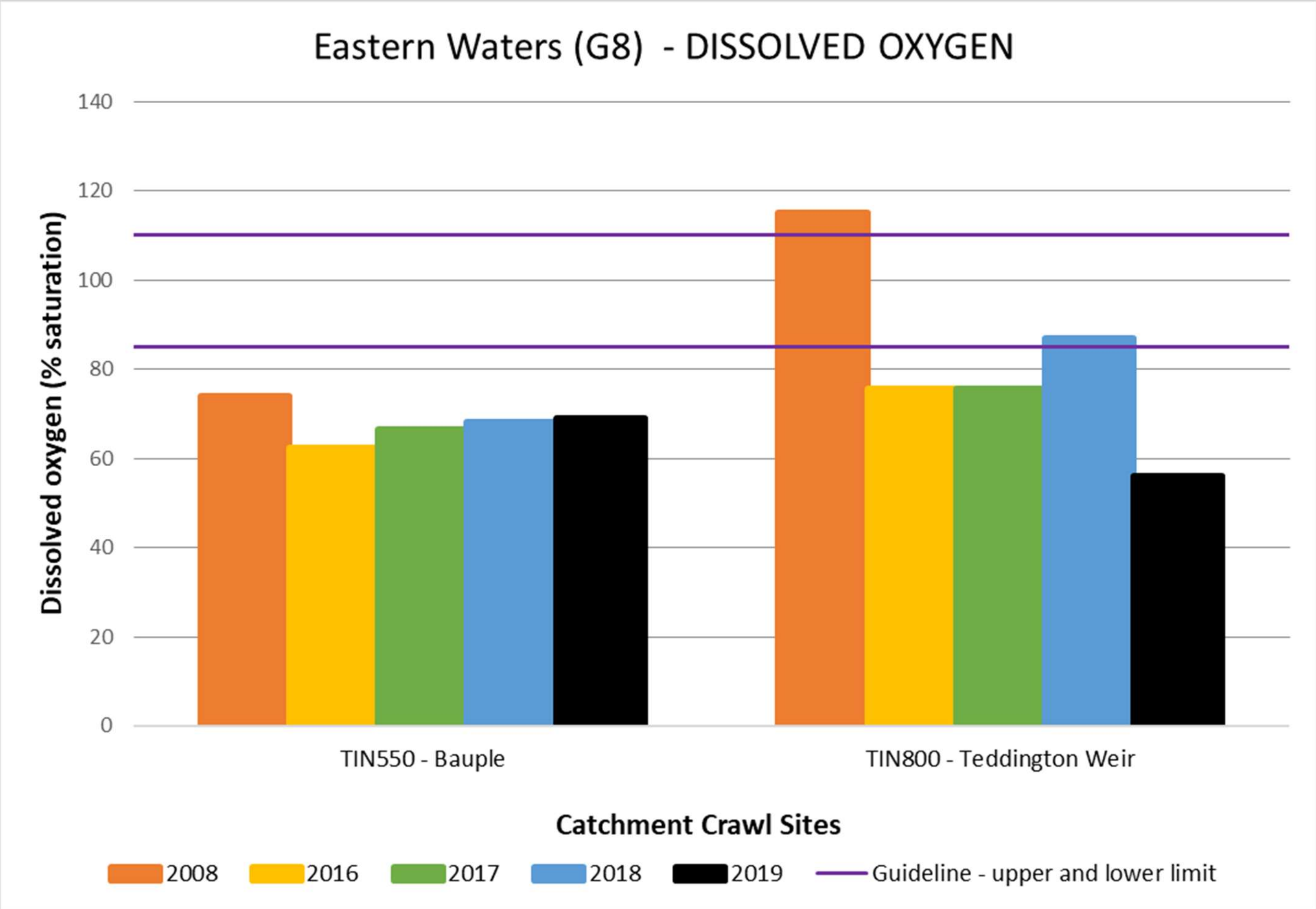

Figure 45 Dissolved oxygen results for North Eastern Lowlands waters (G8)

3.5.4 Middle Estuary – High Environmental Value Waters (G2)

Data collection of the estuary sites only commenced in a comprehensive manner in 2017.

The guideline for dissolved oxygen for High Environmental value waters is 90-105% saturation (see Table 5). Figure 46 shows that in contrast to 2018, River Heads came back within guideline values in 2019.

Insufficient water was available to perform physical chemistry testing at the Susan River (SUS500) due to low tide during 2019 Catchment Crawl.

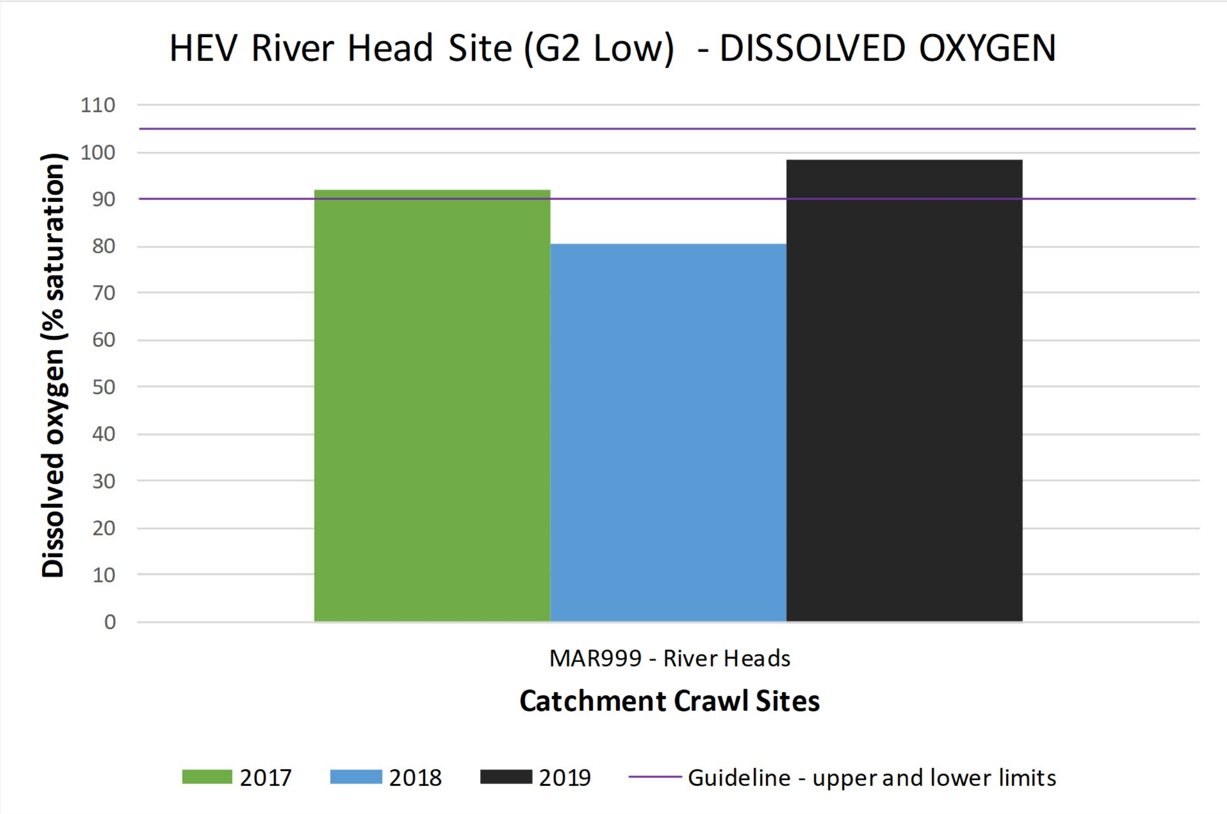

Figure 46 Dissolved oxygen results for the River Heads and Susan River sites (G2 low)

3.6 Nitrogen

The importance of nitrogen in aquatic environments varies according to what forms the nitrogen takes, and the amount of each form. Nitrogen is found in water in organic and inorganic forms and in dissolved and suspended forms. Ammonium and oxidised nitrogen are the main forms of dissolved inorganic nitrogen that can be found in water.

Results for oxidised nitrogen, ammonium, total nitrogen and a comparison of organic nitrogen, oxidised nitrogen and ammonium nitrogen are presented in the graphs in this section.

Total oxidised nitrogen is a measure of the type of nitrogen (nitrite and nitrate) that is available in the water. These are forms of nitrogen that can be readily taken up by plants, and therefore provides a useful indicator of whether a waterbody can produce an algal bloom.

Total kjeldahl nitrogen is a measure of both ammonia, ammonium, and organic forms of nitrogen. Excess ammonia contributes to the eutrophication of water bodies, which results in algal blooms that negatively impact other aquatic life, decrease drinking water quality and affect recreational activities. At high concentrations, ammonia is toxic to aquatic life. Total nitrogen values are calculated from measured results to include all of these forms nitrogen in the result.

The organic nitrogen values are determined from a combination of direct measurement and calculations. The organic nitrogen value includes both suspended and dissolved forms of organic nitrogen. Organic nitrogen cannot be used directly by aquatic life for biological activity, so it does not contribute to plant proliferation until it decomposes into usable forms.

Comparing organic nitrogen, oxidised nitrogen and ammonium nitrogen can provide an indication of the sources of the nitrogen in the water. For example, manure contains organic nitrogen, urine is high in ammonium and synthetic nitrogen fertilisers are high in nitrate. Nitrogen changes form in the environment according to the nitrogen cycle which is depicted in Figure 48.

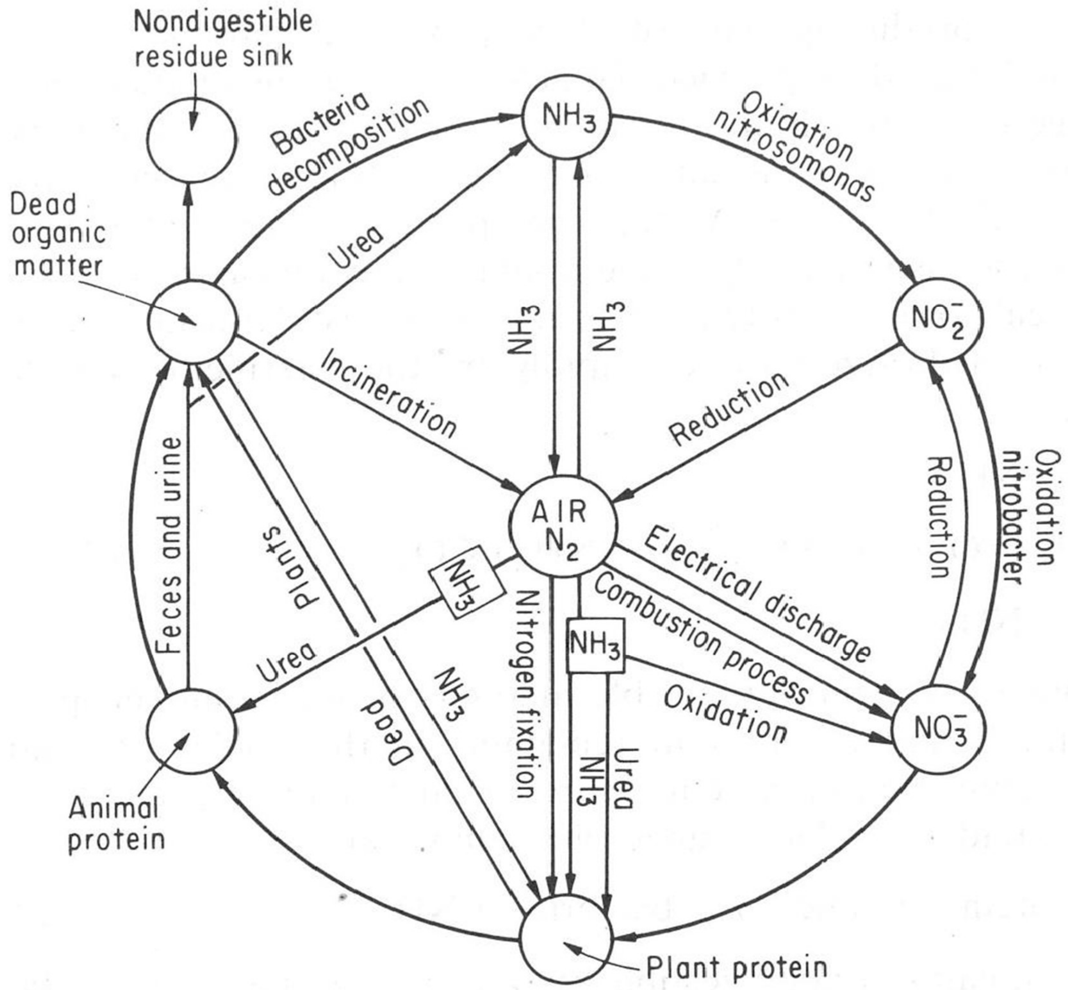

Figure 48 The Nitrogen Cycle (Source: Sawyer et al. 1994, p.553)

For nitrogen the Queensland Water Quality guidelines (Department of Environment and Resource Management, 2009) for the South East Queensland region set the following limits for Aquatic Ecosystem health in the upland (>150m elevation), lowland (<150m elevation) and high environmental value (HEV) water of the Great Sandy Strait and lower Mary and Susan Rivers (see Table 7).

Table 7 South East Queensland region water quality guideline values for nitrogen parameters

Parameter	Lowland streams	Upland streams	HEV water (50^{th} percentile)
Ammonia N (mg/L)	0.02	0.01	0.007
Oxidised N (mg/L)	0.06	0.04	0.002
Organic N (mg/L)	0.42	0.2	0.1
Total N (mg/L)	0.5	0.25	0.115

3.6.1 Mary River and southern major tributaries (Southern Lowland Waters (G5))

Figures 49 – 51 provide the oxidised nitrogen, ammonium and total nitrogen results for the Mary River sites in the Southern Lowland water types. Figure 49 shows that MAR510 at Widgee Xing has exceeded the guideline value of 0.06mg/L for oxidised nitrogen during previous Catchment Crawls. In 2017 the result was particularly high at 3 times the guideline level of 0.06 mg/L. In 2019, the results for this site are below the detectable limit of 0.001mg/L.

The ammonium results show the upper Mary sites from the headwaters to Kenilworth (MAR009, MAR050, MAR125, MAR148 and MAR169) have the highest ammonium results since 2015. The Mary River at Moy Pocket, similar to previous years (2015 and 2017). From Belli Park (MAR330) to Emerys Xing (MAR660) results are relatively similar to previous years. Netherby (MAR670) and Tiaro (MAR743) sites display an increase of ammonium compared to previous years.

As Figure 51 shows, the Moy Pocket site (MAR300) just exceeds the guideline limit for total nitrogen of in 2019. All other sites comply with the guidelines however, there are notable increases of total nitrogen at Walli Mt (MAR148), Traveston Xing (MAR425), Emerys Xing (MAR660) and Tiaro (MAR743) compared to previous years.

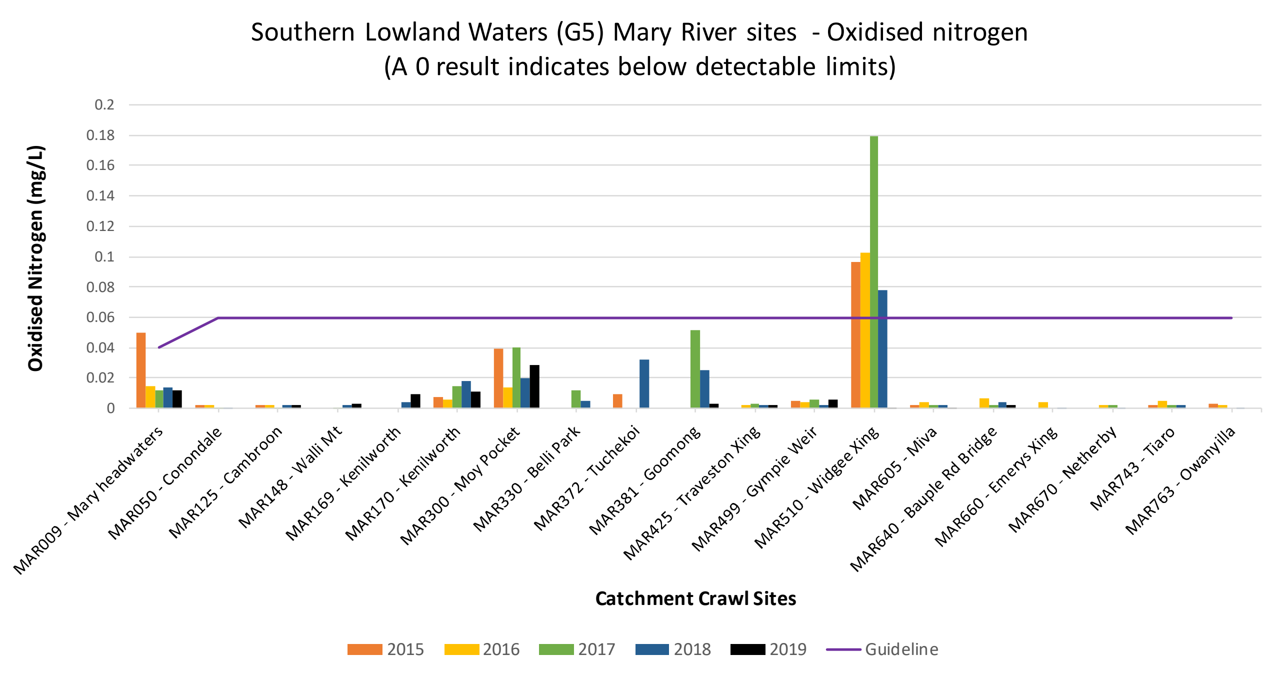

Figure 49 Oxidised nitrogen results for Mary River sites in Southern Lowland Waters (G5)

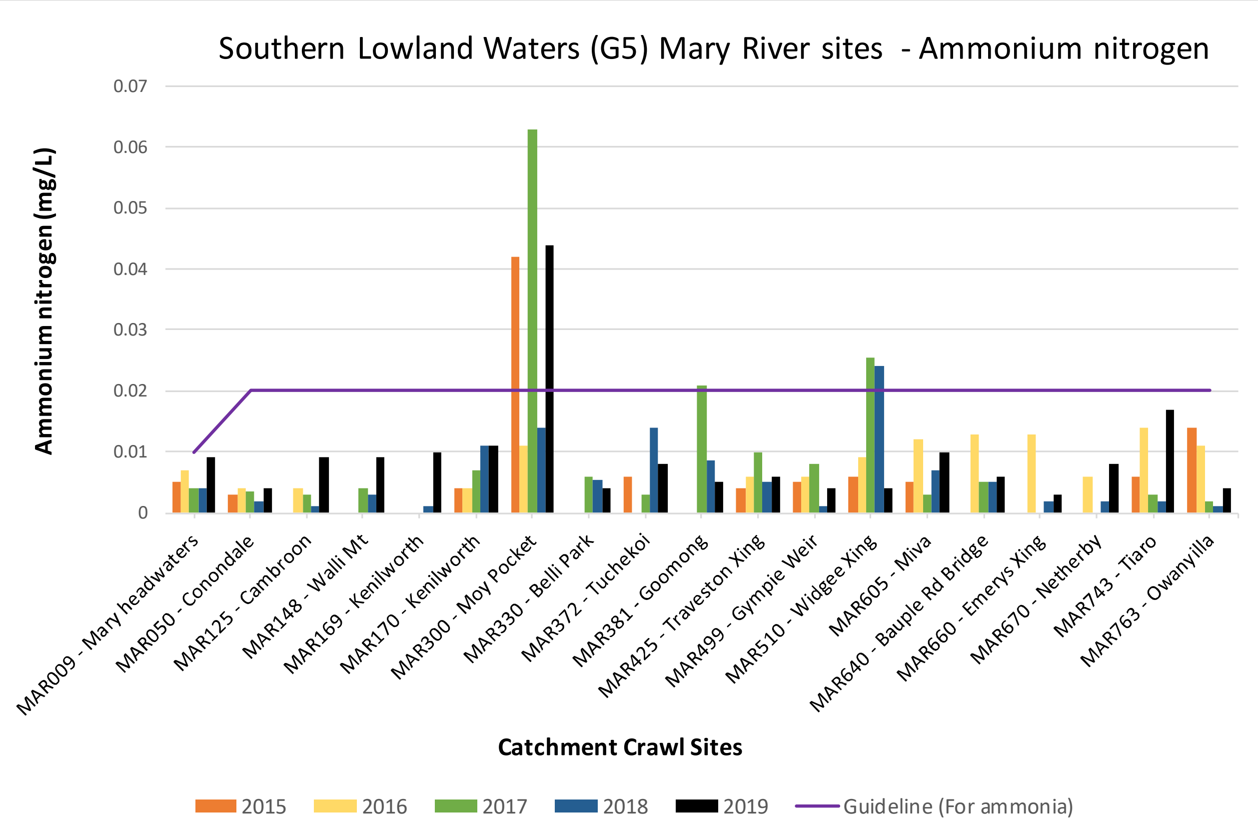

Figure 50 Ammonium nitrogen results for Mary River sites in Southern Lowland Waters (G5)

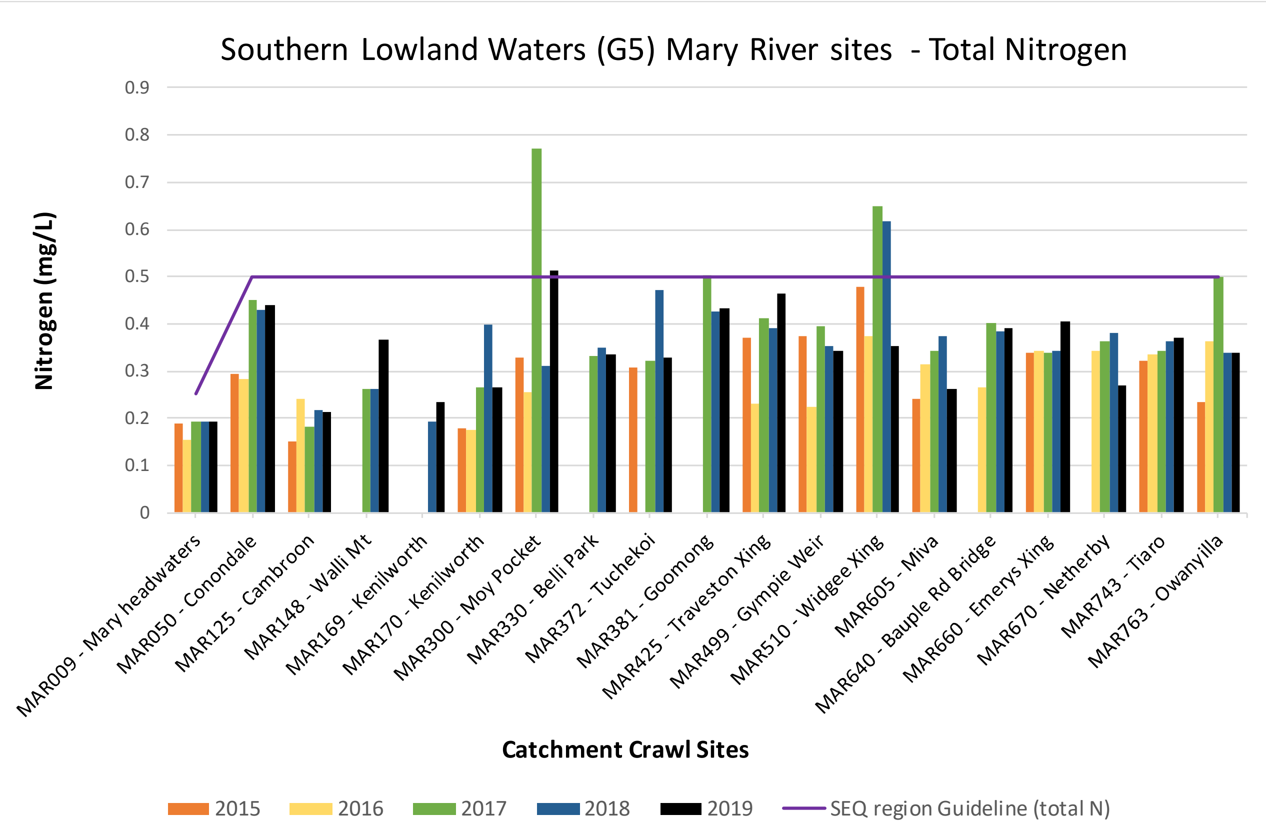

Figure 51 Total nitrogen results for Mary River sites in Southern Lowland Waters (G5)

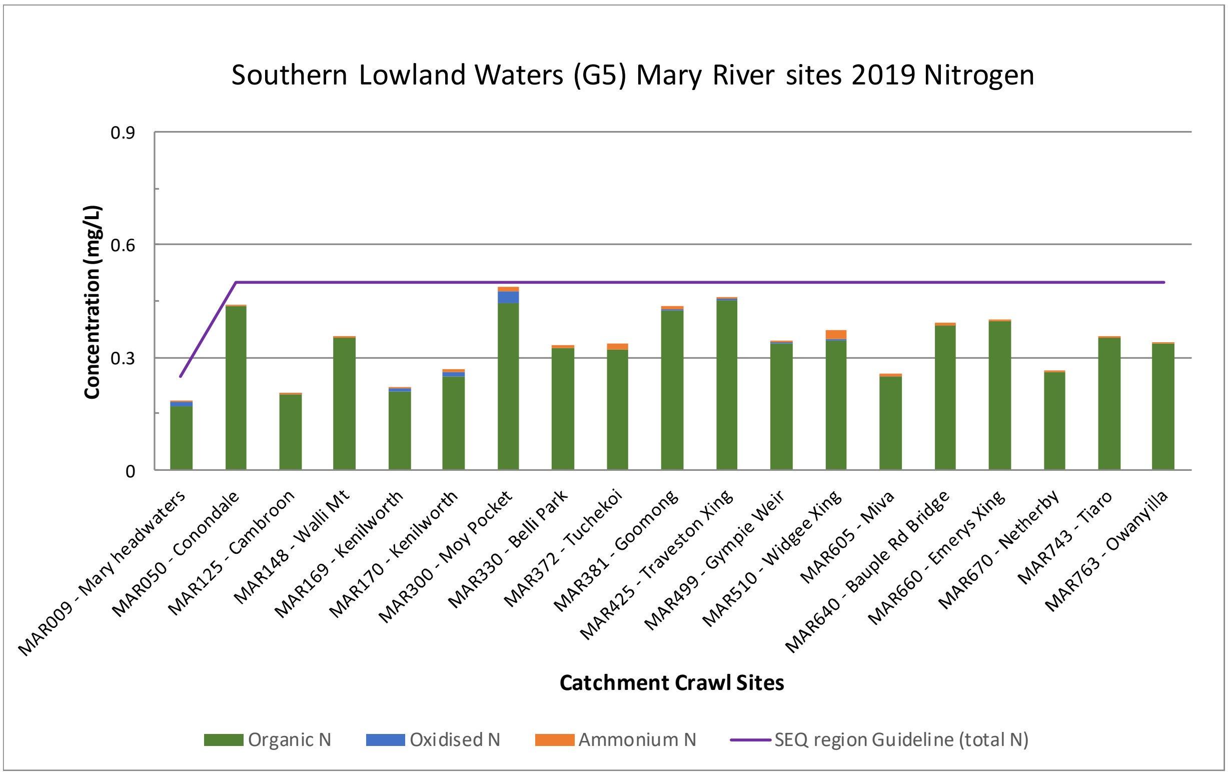

Figure 52 Relative contribution of the different forms of nitrogen in Mary River Southern Lowland waters (G5)

Figure 52 provides a comparison of the different forms of nitrogen across all the sites. The total value of each column is the total nitrogen result which is made up of organic nitrogen, oxidised nitrogen and ammonium. Organic nitrogen (both dissolved and suspended) is the dominant form of nitrogen in all samples. All Mary River sites are below the guideline limit.

The remainder of this section focusses on the tributaries that fall in the Southern Lowland water type (Obi Obi, Six Mile, Yabba Creek). As Figure 53 shows only downstream Lake Macdonald (SIX160) exceeds the guidelines for oxidised nitrogen this year.

In 2019 Six Mile Creek upstream of Lake MacDonald (SIX080), downstream of Lake MacDonald (SIX160) exceed both the guidelines for Ammonium (see Figure 54) and total nitrogen (see Figure 55). Six Mile Creek at Cooran (SIX505) just exceeds the ammonium nitrogen guideline limit and Six Mile Creek at Woondum (SIX775) also marginally exceeds the guideline for total nitrogen. Most tributary sites sit below the total nitrogen guideline in 2019.

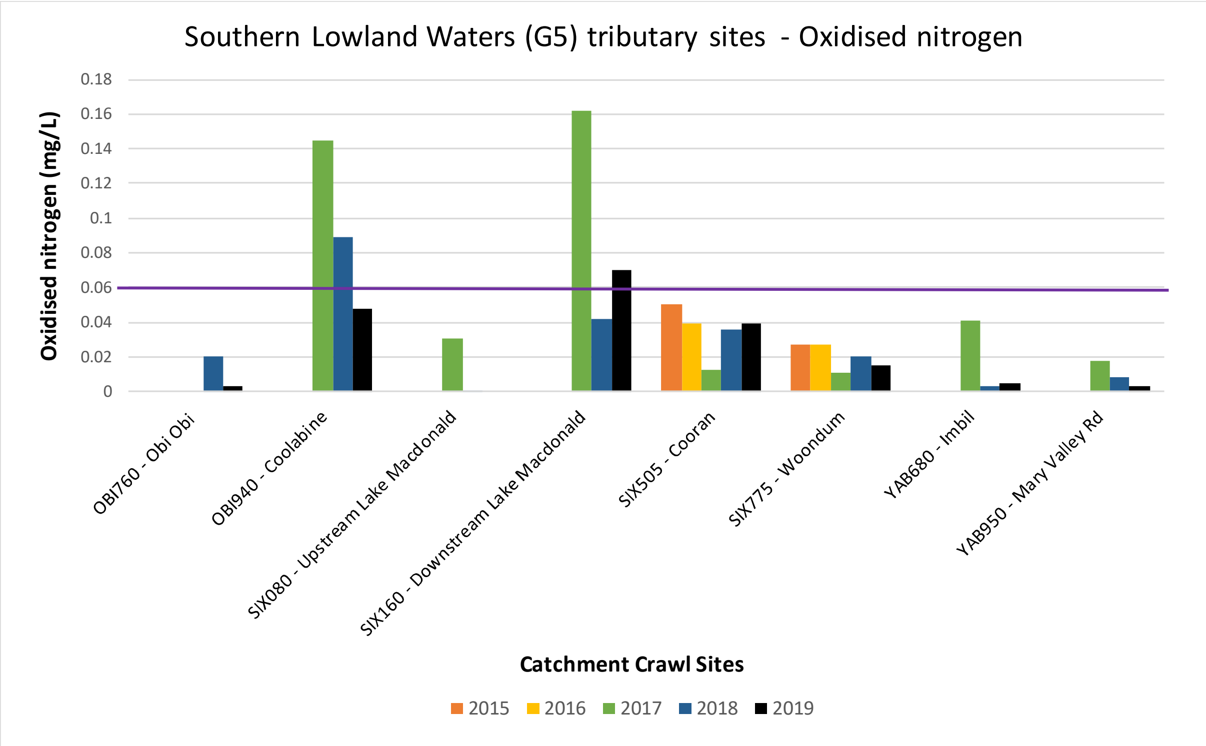

Figure 53 Oxidised nitrogen results for tributary sites in Southern Lowland Waters (G5)

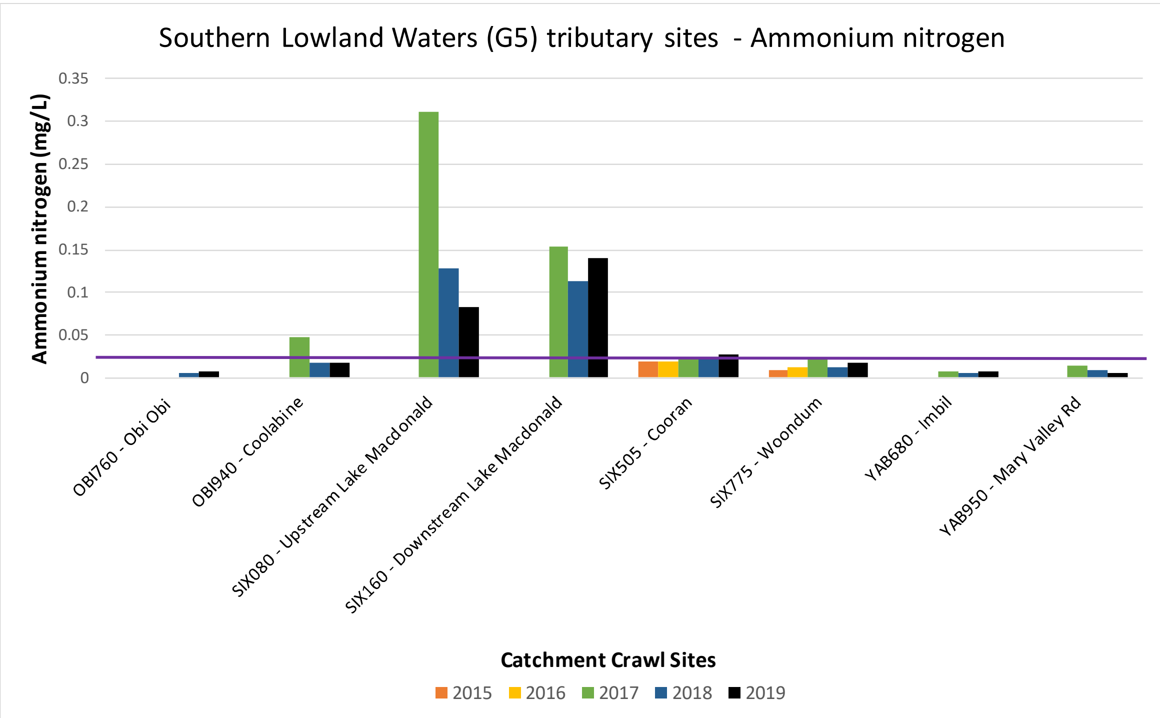

Figure 54 Ammonium results for tributary sites in Southern Lowland Waters (G5)

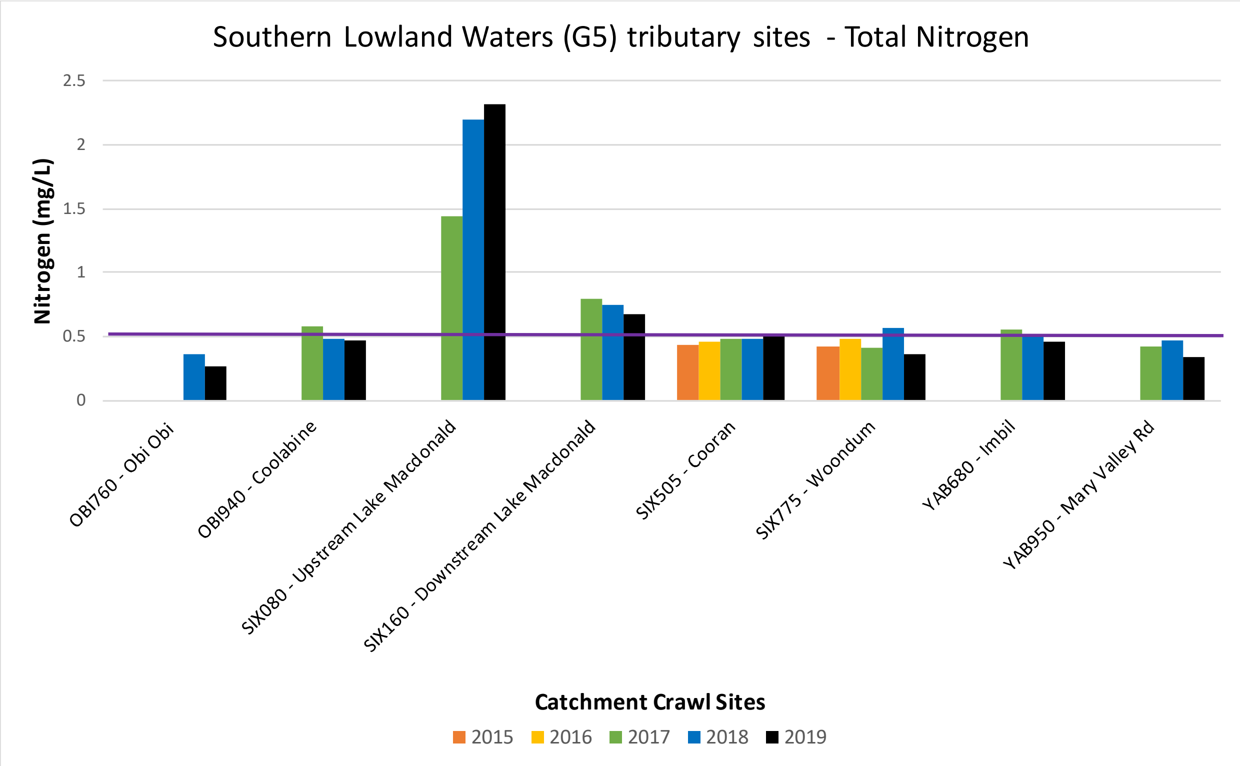

Figure 55 Total nitrogen results for tributary sites in Southern Lowland Waters (G5)

Figure 56 shows the comparison of the organic nitrogen, oxidised nitrogen and ammonium for the Southern Lowland waters tributary sites. It shows that Six Mile Creek upstream of Lake Macdonald (SIX080) has very high levels of organic nitrogen compared to the other sites, as well as high levels of ammonium. The high levels of organic nitrogen may be explained by decomposing organic matter found near this wetland type site above Lake MacDonald. The presence of the high levels of ammonium at Six Mile Creek upstream (SIX080) and downstream (SIX160) of Lake Macdonald indicate there is a possible source of dissolved nitrogen, such as effluent, also entering Six Mile creek further upstream of SIX080.

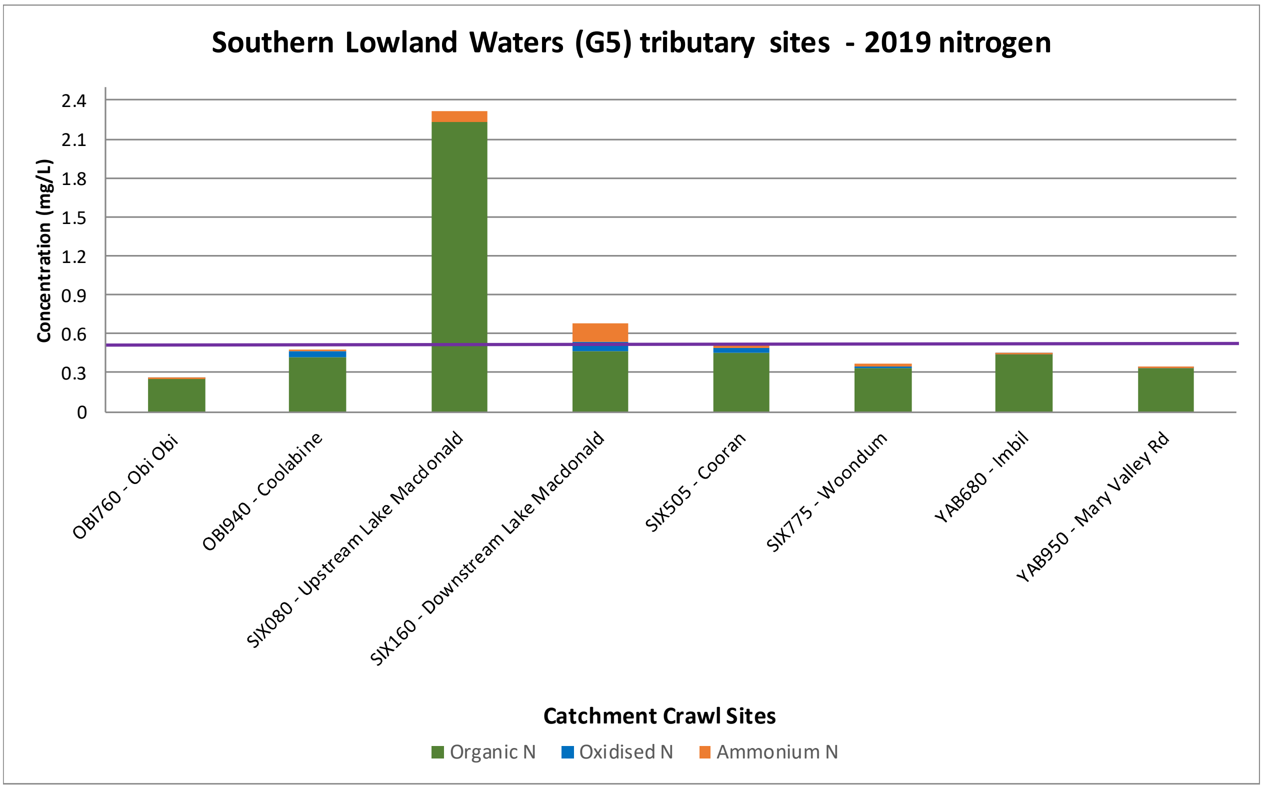

Figure 56 Relative contribution of the different forms of nitrogen in tributaries of Southern Lowland waters (G5)

It is of significance to note that these nitrogen values in Six Mile Creek are the highest of all samples collected in freshwater during the Catchment Crawl. As will be discussed in section 3.6.4 the Susan River site gave the highest result of all sites.

3.6.2 Western tributaries (North Western Lowland Waters (G6))

Figures 57-59 show that all three sites (Munna, Wide Bay, Widgee Creeks) in this water type complied with all of the guidelines for the different forms of nitrogen, except for total nitrogen which was marginally exceeded by the Wide Bay site (WIB950) and Munna Creek (MUN990). At the Munna Creek site (MUN990) cattle were observed within the vicinity of the stagnant waterhole and seemed to had formed a cattle camp next to the waterhole.

Over the five years compared, the nitrate levels have been well below the guideline of 0.06mg/L (all less than 0.01 mg/L) across all sites and all years (see Figure 57). Munna Creek and Widgee Creek oxidised nitrogen levels were below the detectable limit (see Figure 57). All sites are below the guideline of 0.02mg/L for Ammonium N (see Figure 58), the Wide Bay Creek site (WIB950) has increased Ammonium N compared to 2018. Total nitrogen for all three sites has been relatively within guidelines throughout the Catchment Crawl years. However, in 2019 it was exceeded at the Munna Creek (MUN990) site, almost double the guideline limit with 0.98mg/L (See Figure 59). Widgee Creek (WID399) site just exceeds the guidelines recording 0.537mg/L.

Figure 60 shows the relative contribution of the different forms of nitrogen to the total nitrogen. It shows that all sites are dominated by organic N with small amounts of Oxidised N and Ammonium N.

Above: Cow crossing Birt Rd Bridge, Munna Creek (MUN990)

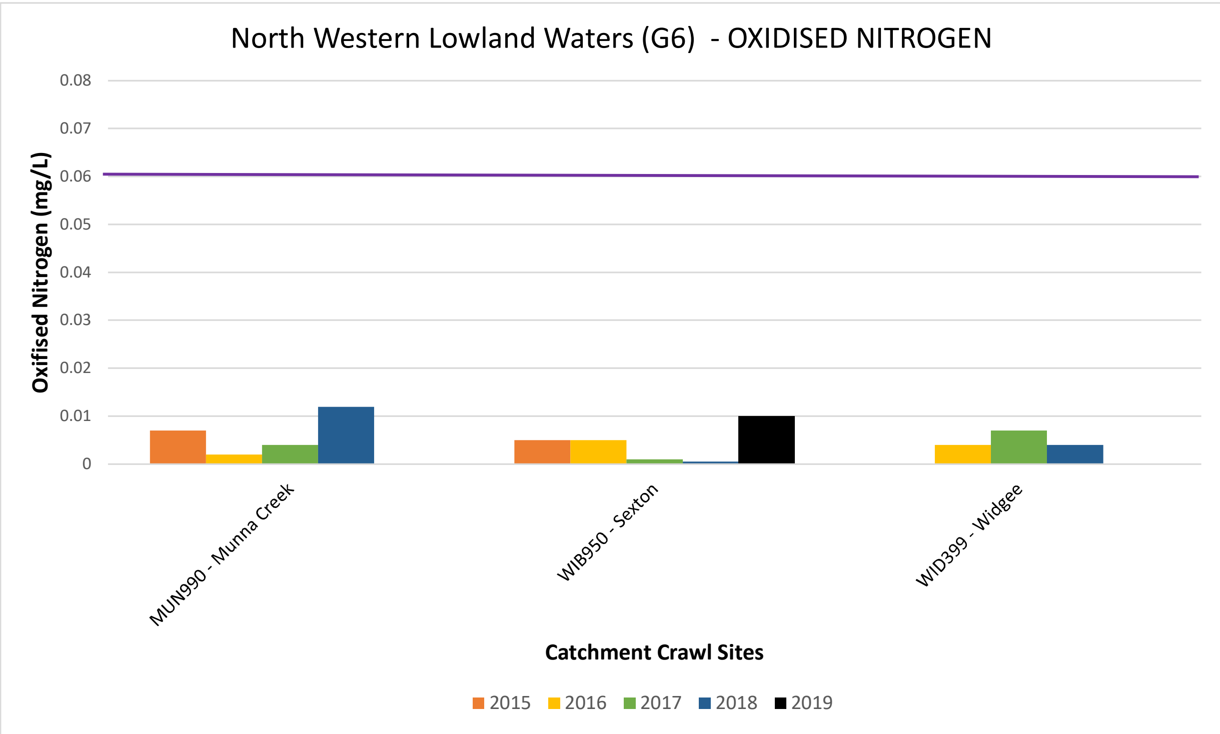

Figure 57 North Western Lowland waters (G6) oxidised nitrogen

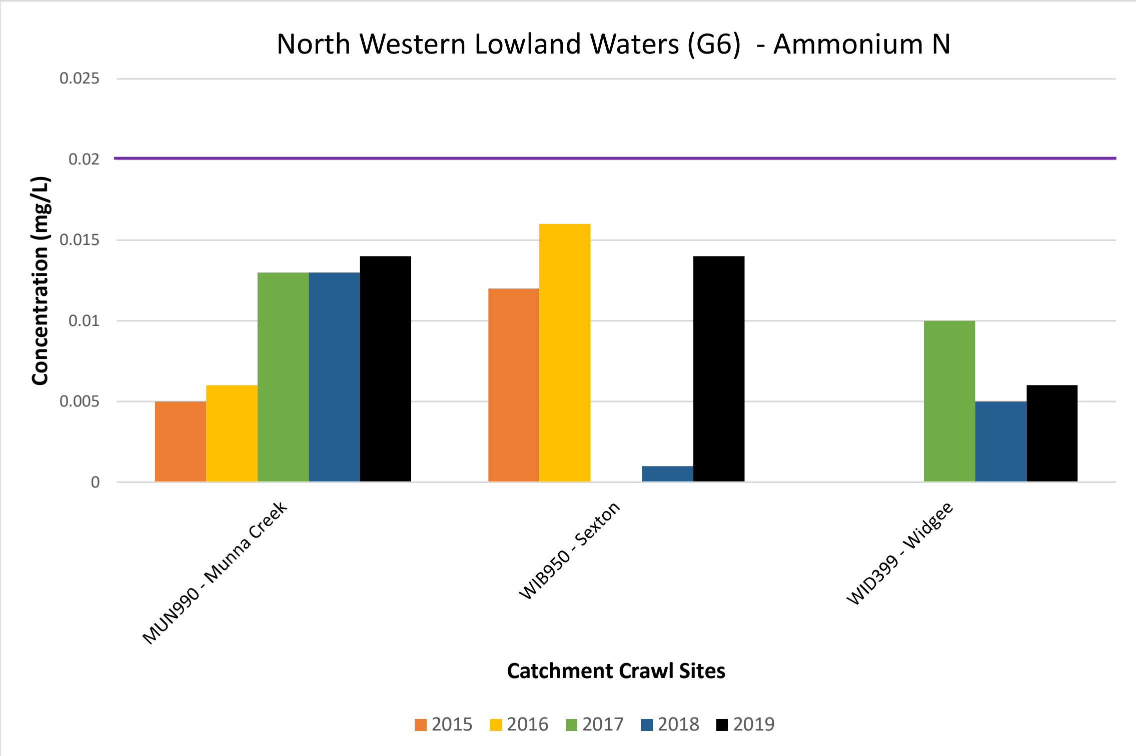

Figure 58 North Western Lowland waters (G6) Ammonium

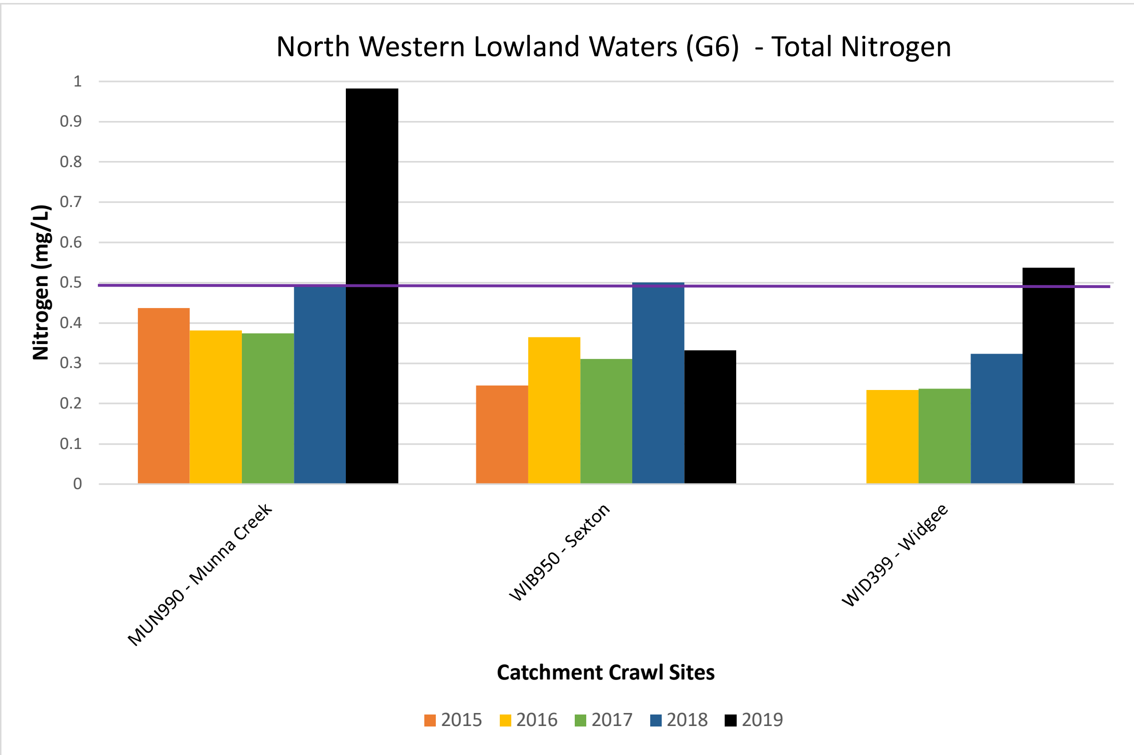

Figure 59 Total nitrogen results for North Western Lowland waters (G6)

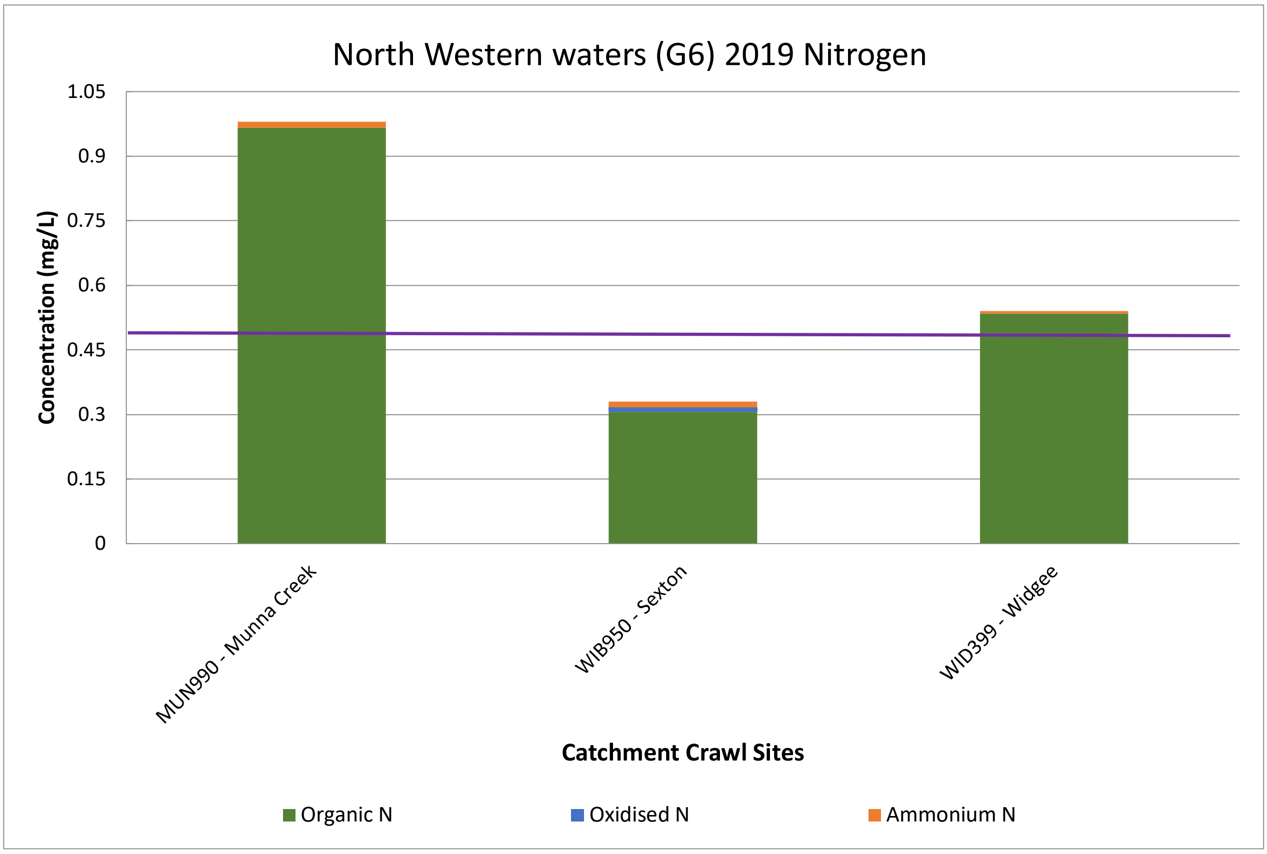

Figure 60 Relative contribution of the different forms of nitrogen to the North Western waters (G6).

3.6.3 Tinana Creek (North Eastern Lowland waters (G8))

Tinana Creek at Bauple (TIN550) and Teddington Weir (TIN800) consistently comply with oxidised nitrogen guidelines across years (Figure 61). Teddington Weir also followed its trend of higher total nitrogen levels than recommended (Figure 63), recording the highest record yet at 0.73 mg/L. Tinana Creek at Bauple (TIN550) is below the total nitrogen guideline (see Figure 63). Tinana Creek at Teddington Weir (TIN800), ammonium N levels exceeded guidelines in 2019 recording 0.039 mg/L (Figure 62). This may be toxic to aquatic life. The cause of the spike is unknown as ammonium can be generated through many sources such as fertilisers, manure, and organic material.

Organic nitrogen is the main contributor to total nitrogen for, and concentrations of this form alone exceed the total nitrogen upper limit guideline at Teddington Weir (see Figure 64). Lower Tinana Creek is dominated by weir pools formed largely by Teddington Weir, and further upstream, Tallegalla Weir, which results in low flowing or even stagnant water bodies, coupled with high leaf litter inputs from excellent riparian vegetation. Teddington Weir (TIN800) can have high levels of floating aquatic weeds (hyacinth, salvinia) which decompose and provide organic nitrogen sources to the waterway. Other potential sources include sediment, organic matter in soil, and effluent.

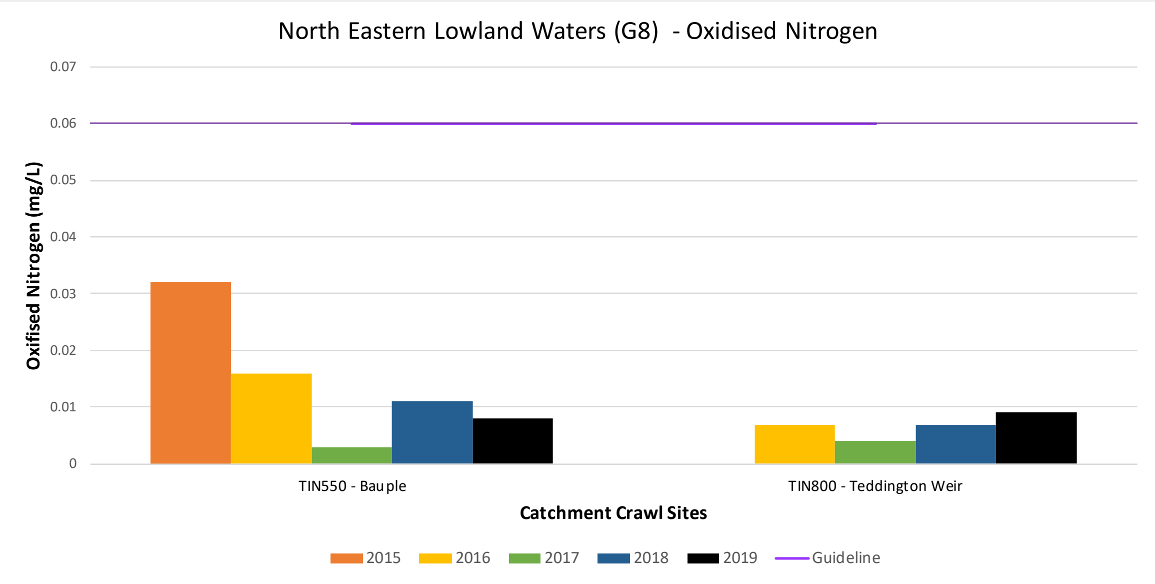

Figure 61 Oxidised nitrogen results for the North Eastern lowland waters (G8)

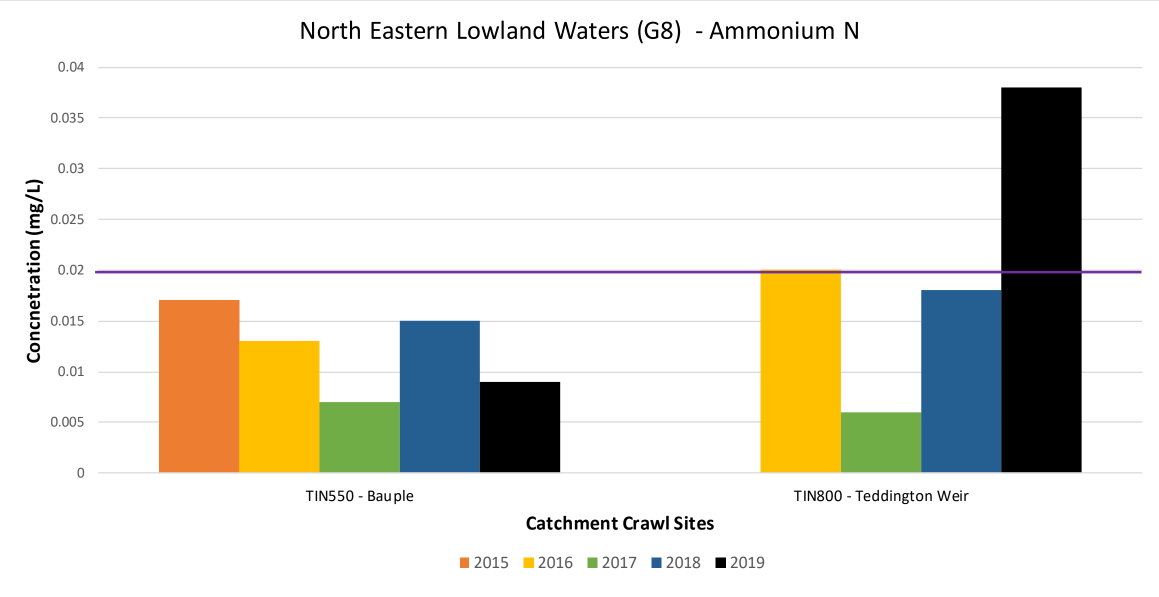

Figure 62 Ammonium N results for the North Eastern Lowland Waters (G8)

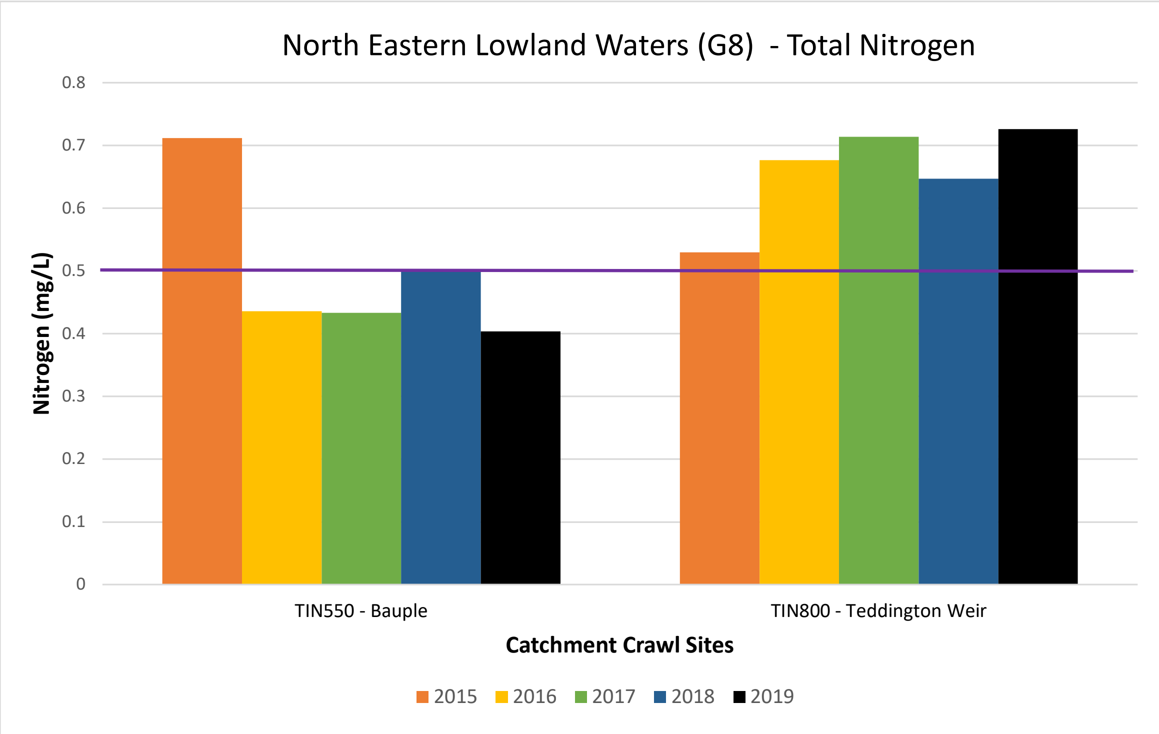

Figure 63 Total nitrogen Results for the North Eastern Waters (G8)

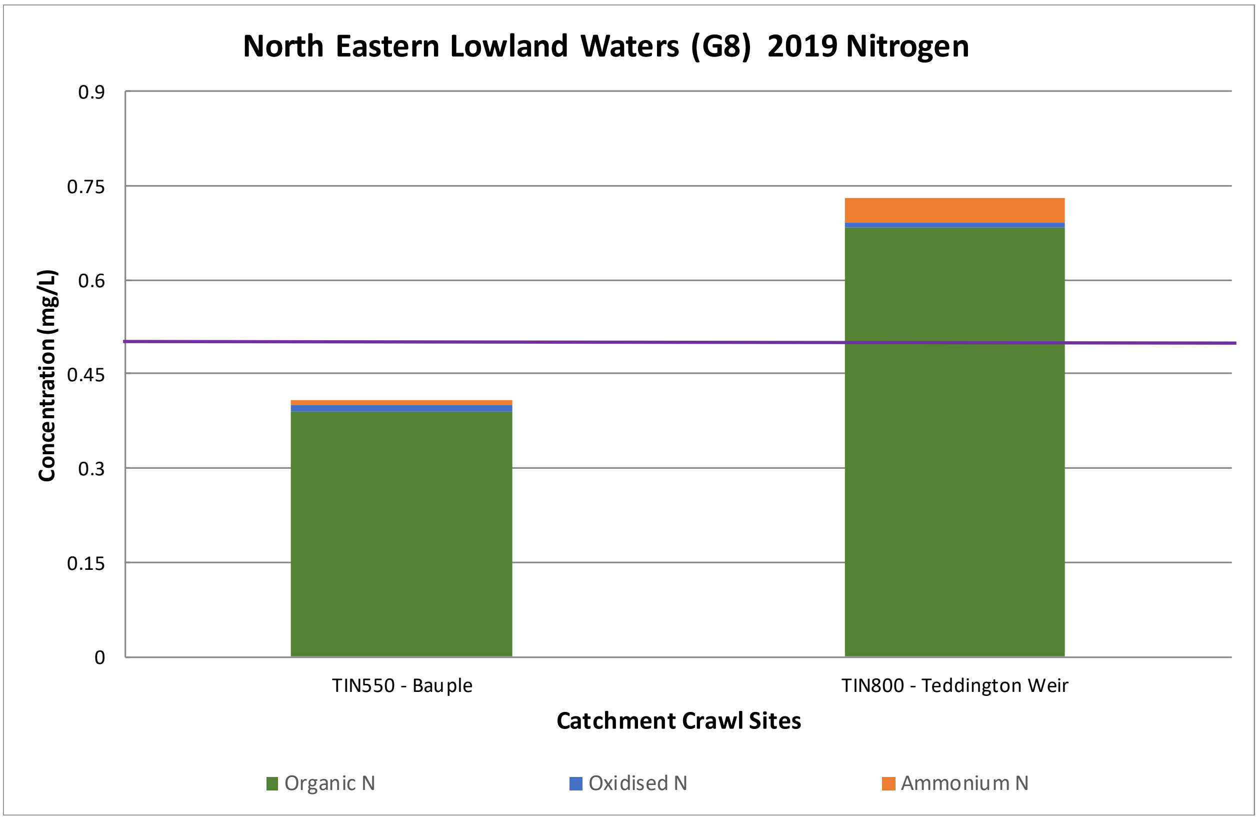

Figure 64 Relative contribution of the different forms of nitrogen to the North Eastern Lowland waters (G8)

3.6.4 Mary River Estuary – High Environmental Value Waters (G2)

Figures 65 and 67 provide the results for different forms of nitrogen at each site. They show that the River Heads site exceeds the guideline for oxidised nitrogen, organic nitrogen and total nitrogen. Ammonium nitrogen is below the guideline limit. The Susan River (SUS500) site had an elevated organic nitrogen and total nitrogen level compared to previous years. This result is the highest for all sites tested in the Catchment Crawl. At the time of sampling, the Susan River site (SUS500) was a shallow pool with visible detritus, including a decaying feline carcass. Figures 66 and 68 show the relative contribution of different forms of nitrogen at each site.

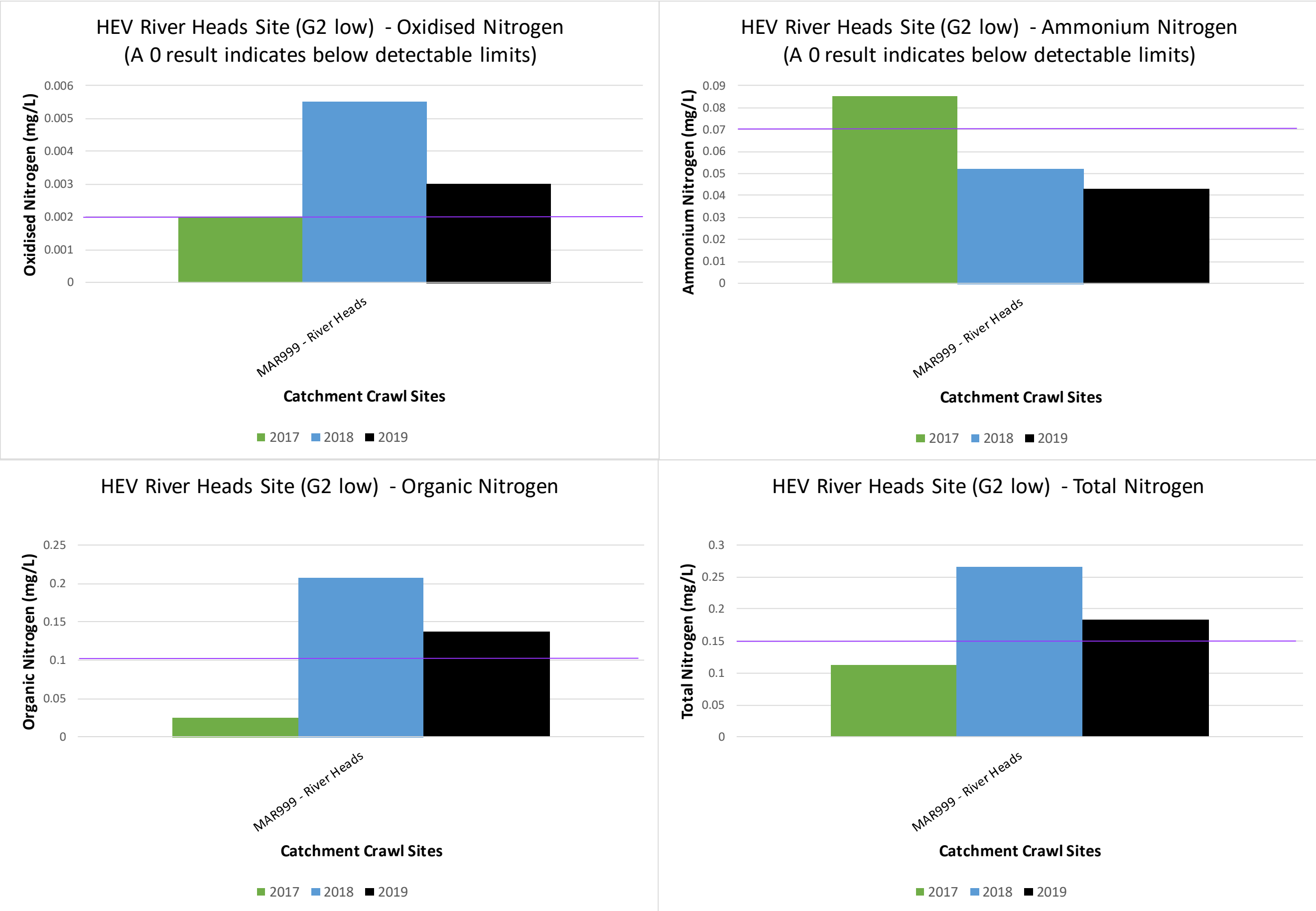

Figure 65 Results for River Heads site (G2 low): Oxidised nitrogen (upper left), ammonium nitrogen (upper right), organic nitrogen (lower left) and total nitrogen (lower right)

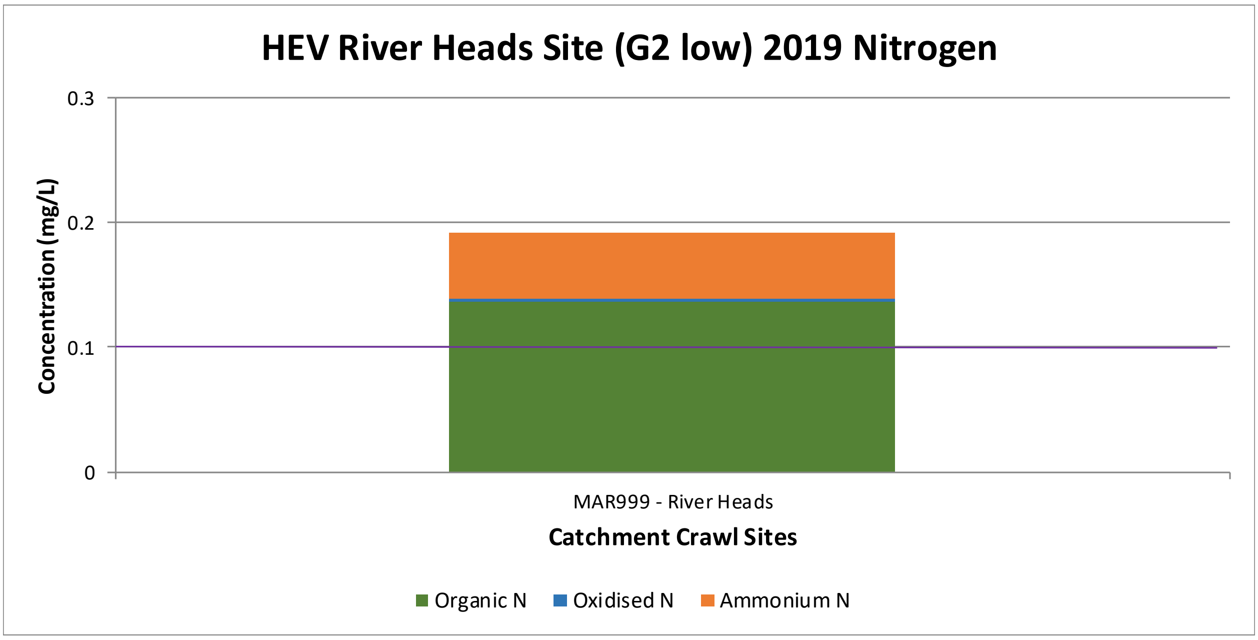

Figure 66 Relative contribution of different forms of nitrogen to the River Heads site (G2 low)

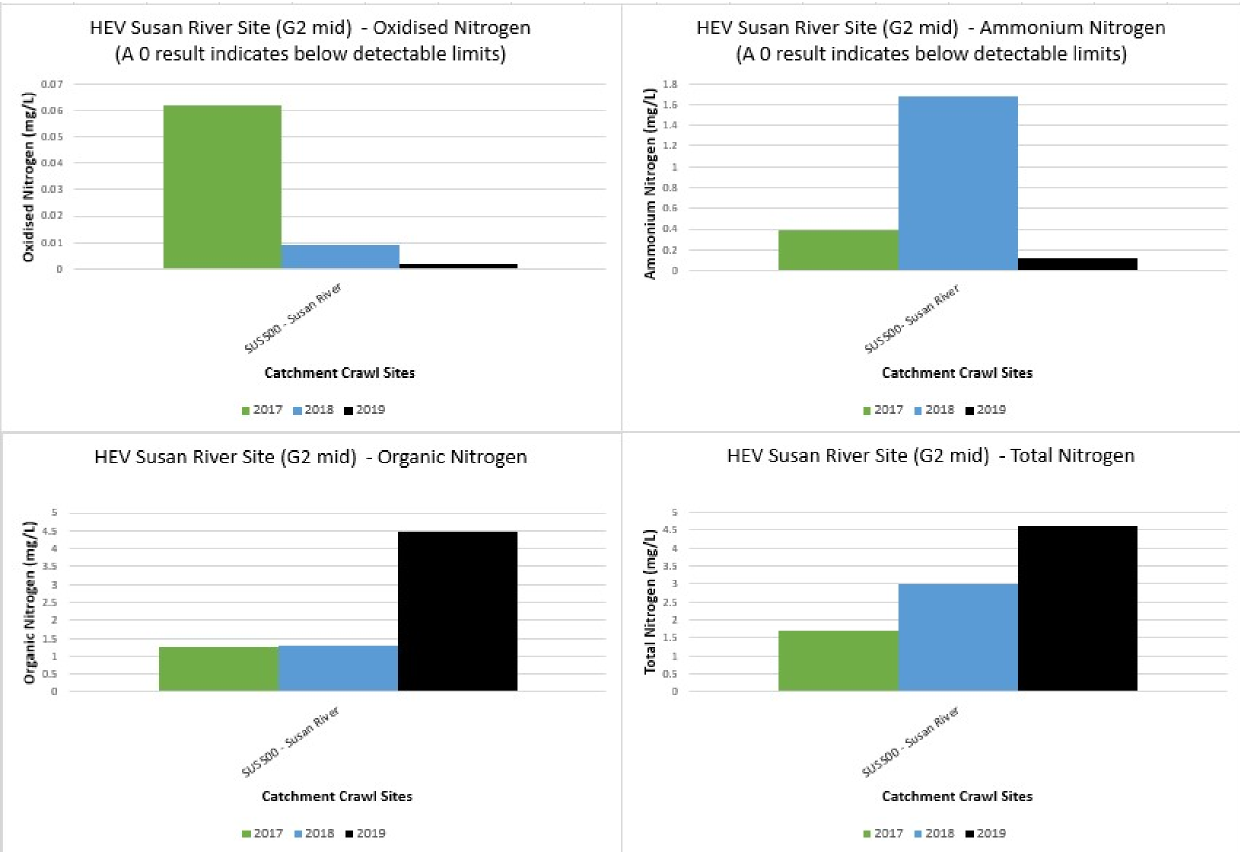

Figure 67 Results for the Susan River site (G2 mid): Oxidised nitrogen (upper left), ammonium nitrogen (upper right), organic nitrogen (lower left) and total nitrogen (lower right)

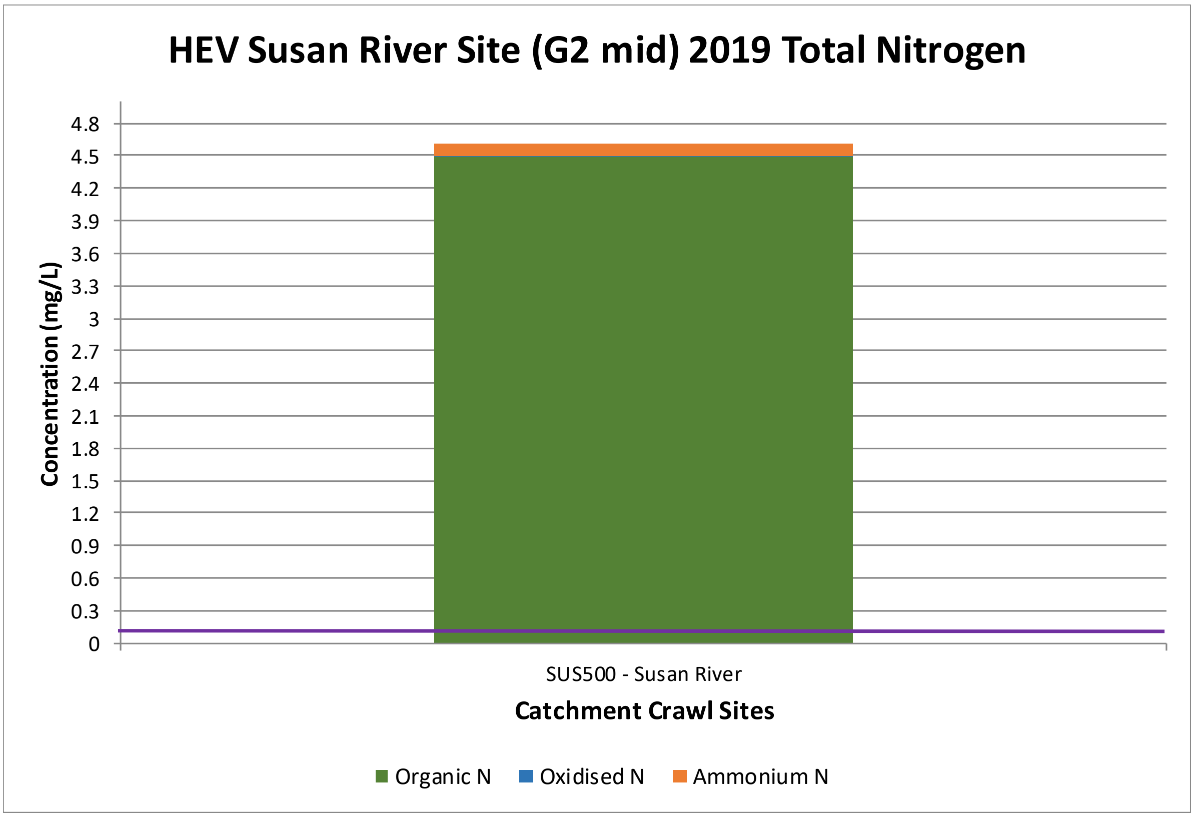

Figure 68 Relative contribution of different forms of nitrogen to the Susan River site (G2 mid)

3.7 Phosphorus

Total phosphorus is a measure of both the organic and inorganic forms of phosphorus. Phosphorus can be present in water as dissolved or particulate matter. It is an essential plant nutrient which is often the most limiting nutrient to plant growth in freshwater. It is uncommon to find it in significant concentrations in surface waters. Therefore, if significant concentrations of phosphorus do enter a freshwater system, extreme algal blooms can occur. Phosphorus inputs are the main contributing factor in the eutrophication of freshwater systems.

For phosphorus the Queensland Water Quality guidelines (Department of Environment and Resource Management, 2009) for the South East Queensland region set the limits listed in Table 8 for Aquatic Ecosystem health in the upland (>150m elevation), lowland (<150m elevation) and high environmental value (HEV) water of the Great Sandy Strait and lower Mary and Susan Rivers.

Table 8 South East Queensland region water quality guideline values for phosphorus parameters

Parameter	Lowland streams	Upland streams	Upper estuarine	HEV water (50th percentile)
Filterable reactive P (mg/L)*	0.02	0.015	0.01	0.002
Total P (mg/L)	0.05	0.03	0.03	0.01

*primarily phosphate (PO_4^-)

3.7.1 Mary River and southern major tributaries (Southern Lowland Waters (G5))

The guideline value for Southern Lowland waters (G5) is 0.02 mg/L for Filterable reactive phosphorus and 0.05 mg/L for total phosphorus.

As Figure 69 shows, all sites complied with the phosphate guideline. The Mary River, Widgee Crossing site (MAR510) site has exceeded the guideline for previous Catchment Crawls. The upland waters have a stricter guideline of 0.015 mg/L which the only upland site at the Mary River headwaters (MAR009) fell just below guidelines in 2019 with a result of 0.014 mg/L.

The Mary River at Moy Pocket (MAR300) and Widgee Xing (MAR510) exceed the guideline limit for total phosphorus (see Figure 70). Figure 71 shows the contribution of both phosphate and organic phosphate to the results in 2019. It shows that the Widgee Xing (MAR510) site exceeds the phosphorus guideline limit and has the highest organic phosphorus level.

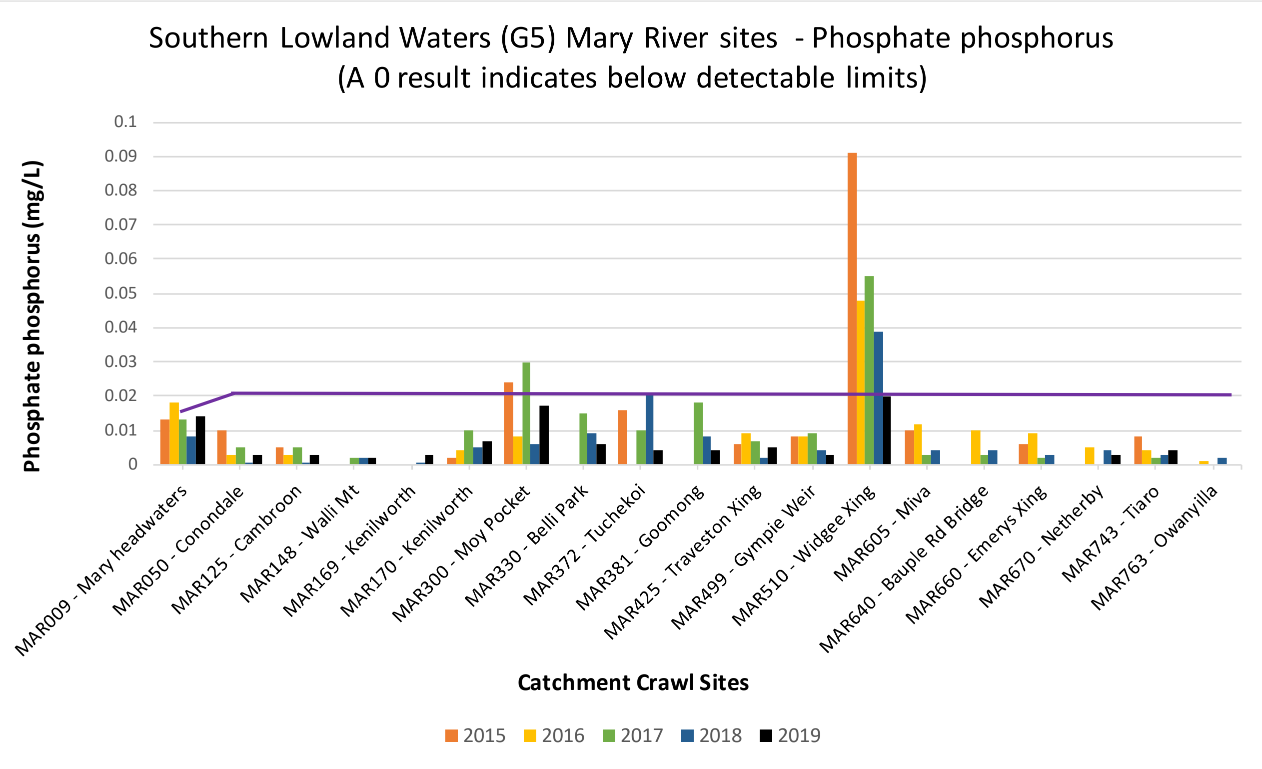

Figure 69 Phosphate results for the Mary River Southern Lowland waters (G5)

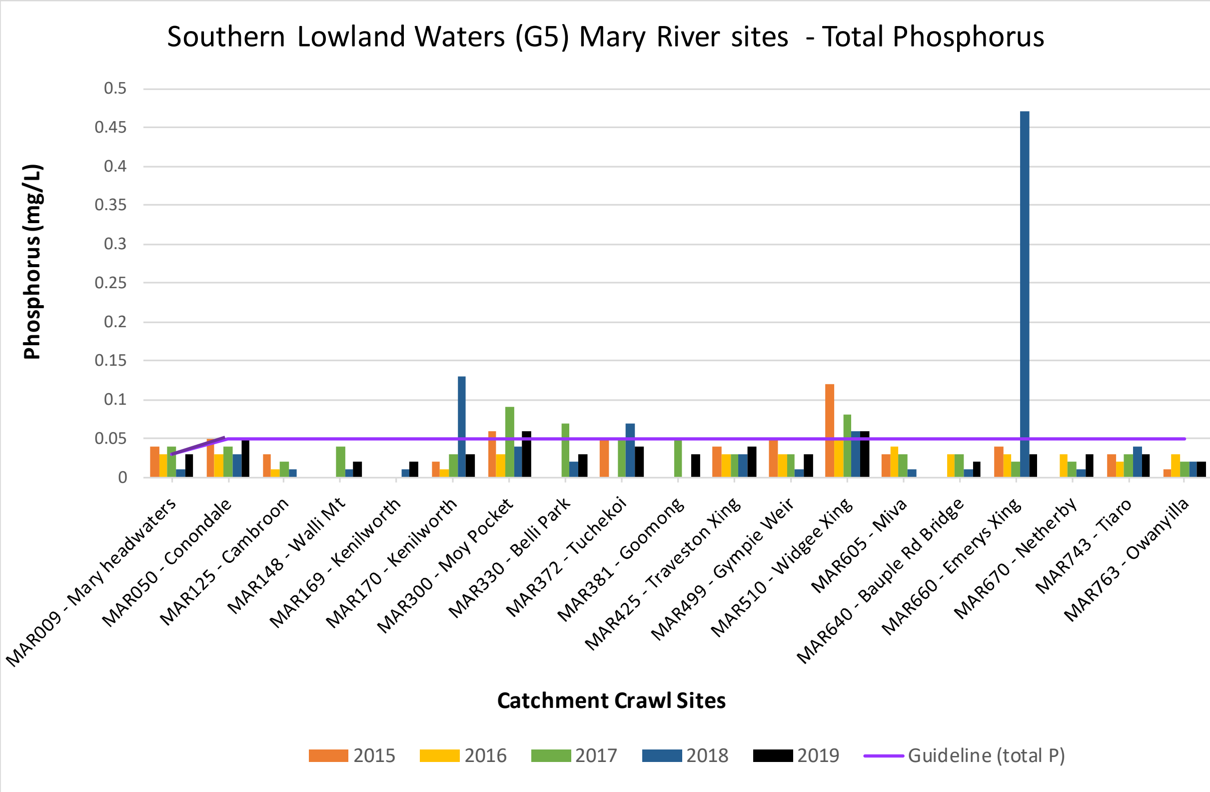

Figure 70 Total Phosphorus results for the Mary River Southern Lowland waters (G5)

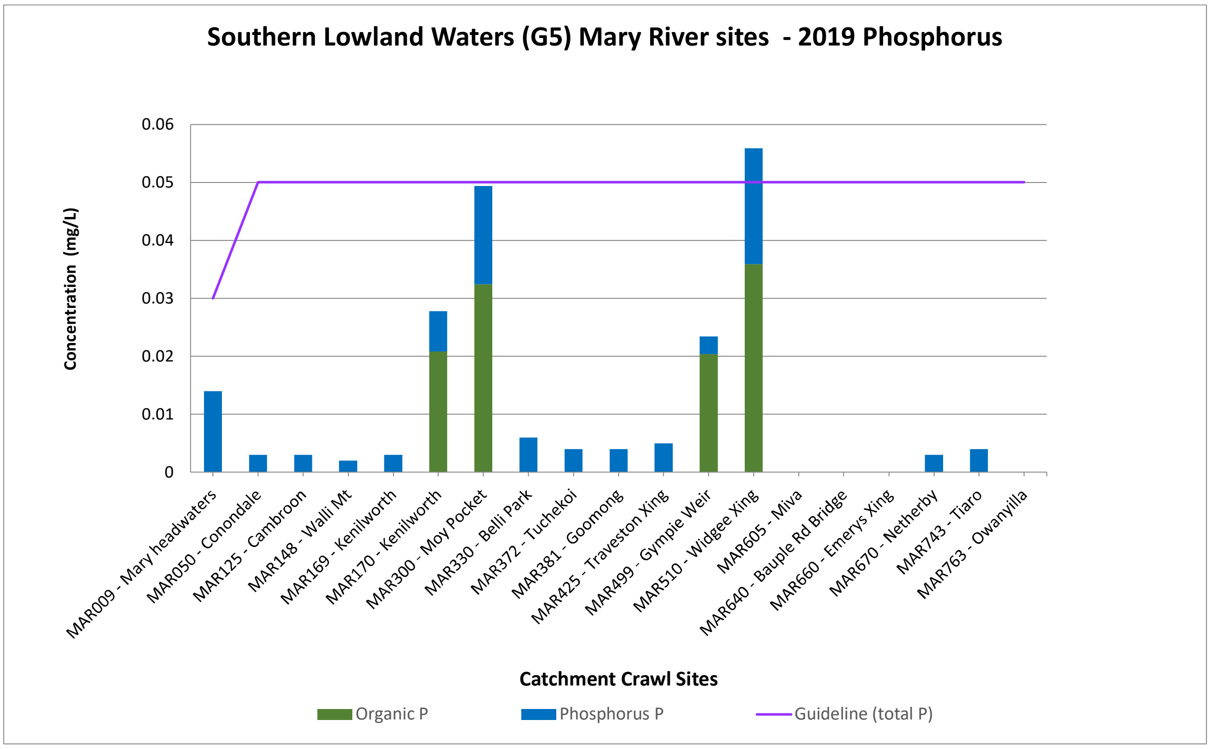

Figure 71 Relative contribution of the different forms of Phosphorus in Mary River Southern Lowland waters (G5)

Of the seven tributaries tested in this water type the only site to exceed the phosphate guideline of 0.02 mg/L is Obi Obi (OBI760) (see Figure 72) but two sites equal or exceed the 0.05mg/L guideline for total phosphorus (see Figure 73). The Obi Obi site at Houston Bridge (OBI940) equalled the guideline limit of 0.05 mg/L and the Six Mile Creek upstream of Lake Macdonald (SIX080) exceed the guideline limit with a record of 0.13 mg/L. Figure 74 shows the relative contribution of organic and phosphate phosphorus to this total phosphorus result. It shows that Six Mile Creek site is almost entirely organic phosphorus.

The Obi Obi Creek (OBI760) site had many campers present during the 2019 Catchment Crawl. Some campers were virtually camped in the creek, and it was also a very hot day during Catchment Crawl sampling.

Above: Campers in the background at Obi Obi Creek (OBI760)

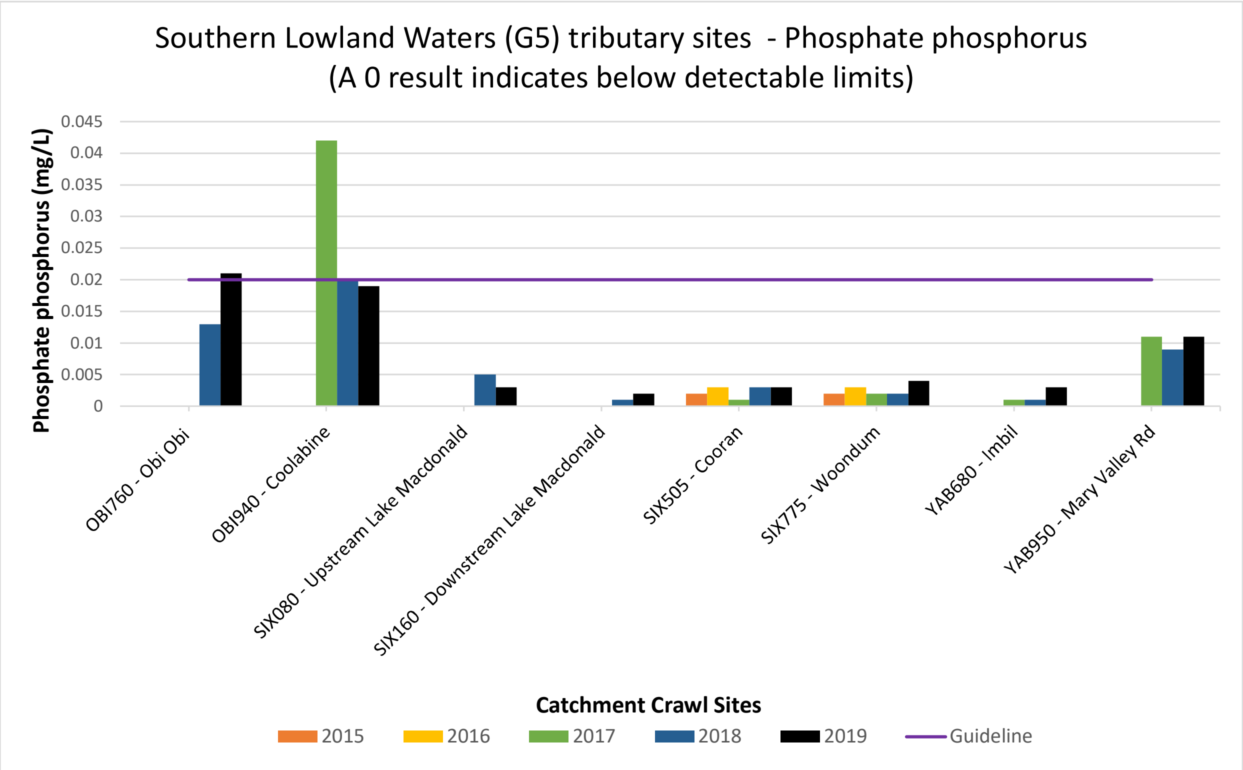

Figure 72 Phosphate results for the Southern Lowland water (G5) tributaries

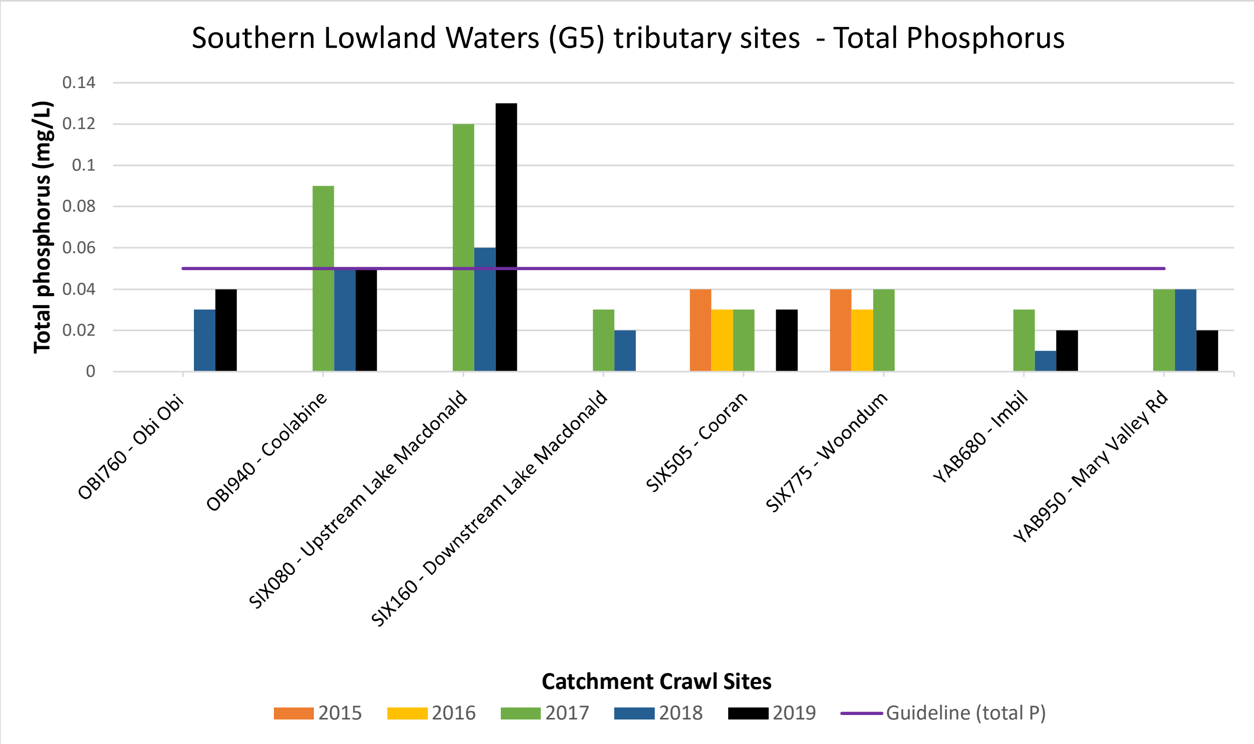

Figure 73 Total Phosphorus results for the Southern Lowland water (G5) tributaries

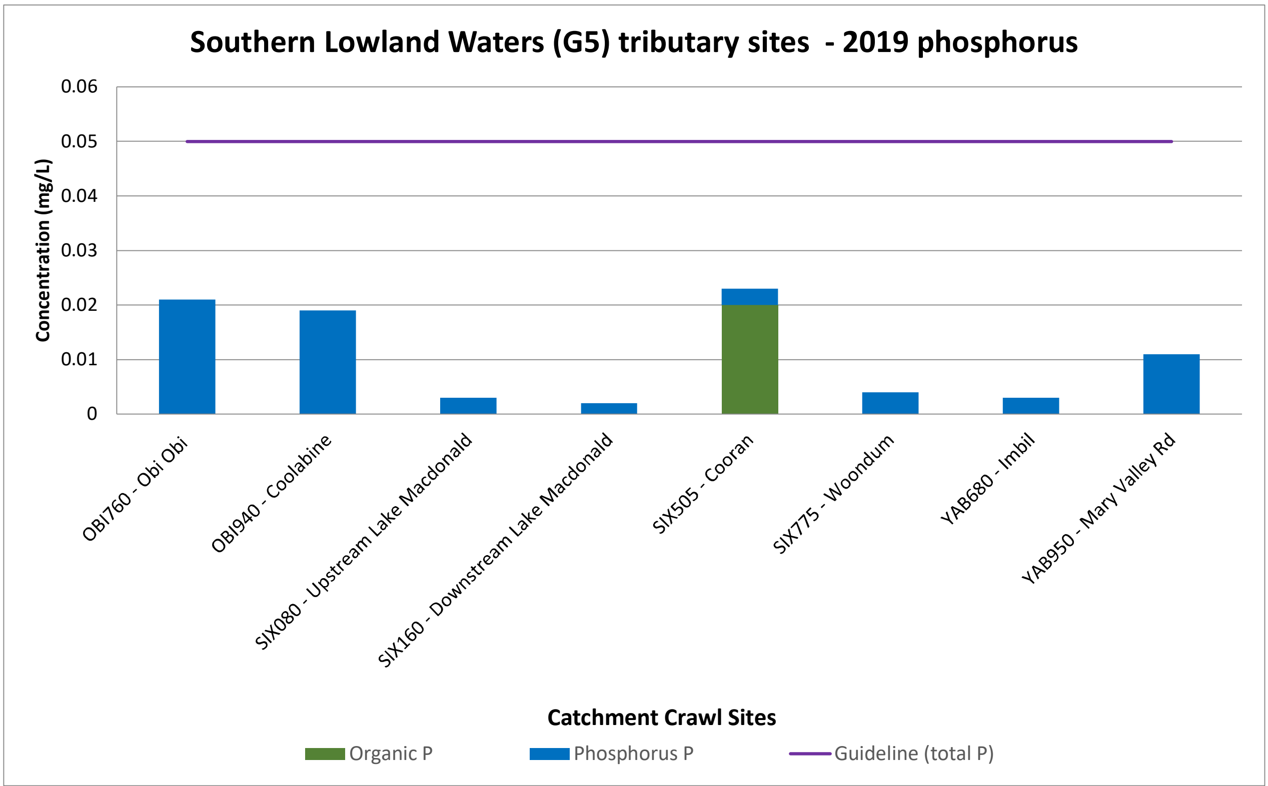

Figure 74 Relative contribution of the different forms of Phosphorus in tributary Southern Lowland waters (G5)

3.7.2 Western tributaries (North Western Lowland Waters (G6))

The north western lowland waters (Munna, Wide Bay, Widgee Creeks) comply with phosphate phosphorus guideline at all sites in this water type (see Figure 75). Munna Creek (MUN990) site has the highest record for total phosphorus and the Widgee Creek (WID399) site is just at the guideline limit of 0.05 mg/L (see Figure 76). All three sites have the highest results out of all years for total phosphorus. Figure 76.a displays that both Munna Creek (MUN990) and Wide Bay Creek (WIB950) sites almost entirely consist of organic phosphorus. These results suggest that there is a source of organic material which contains a significant phosphorus component.

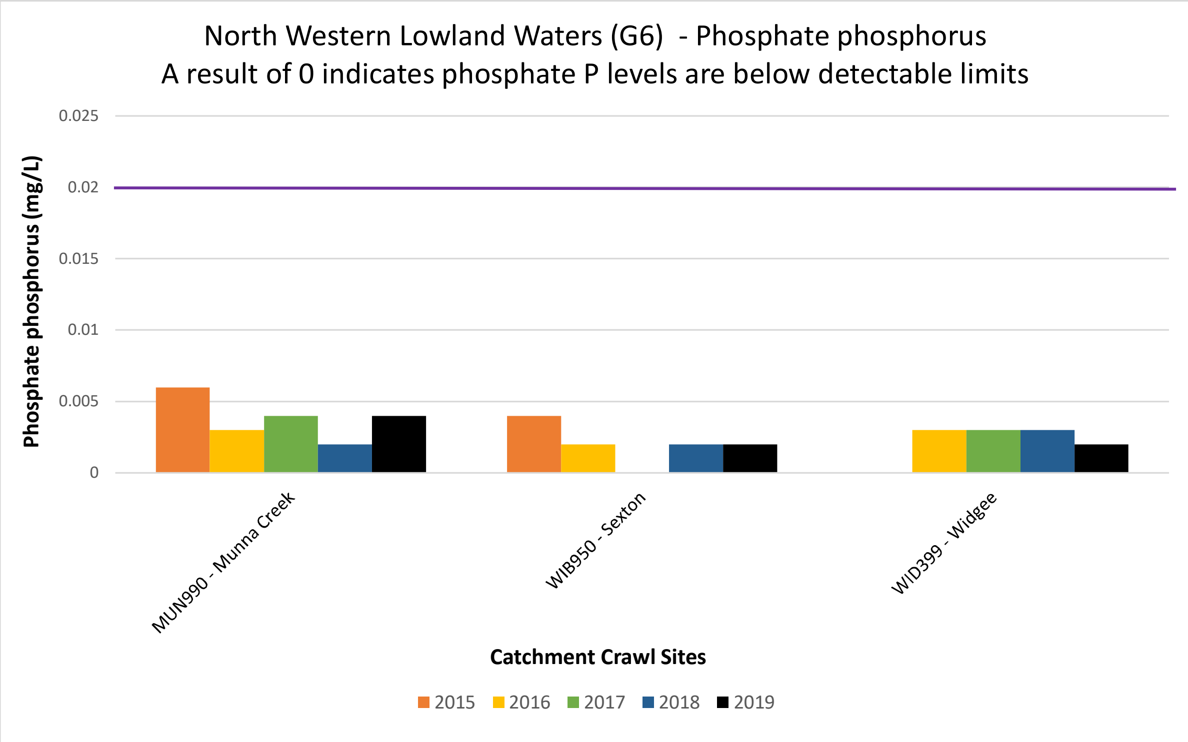

Figure 75 Phosphate results for North Western Lowland waters (G6)

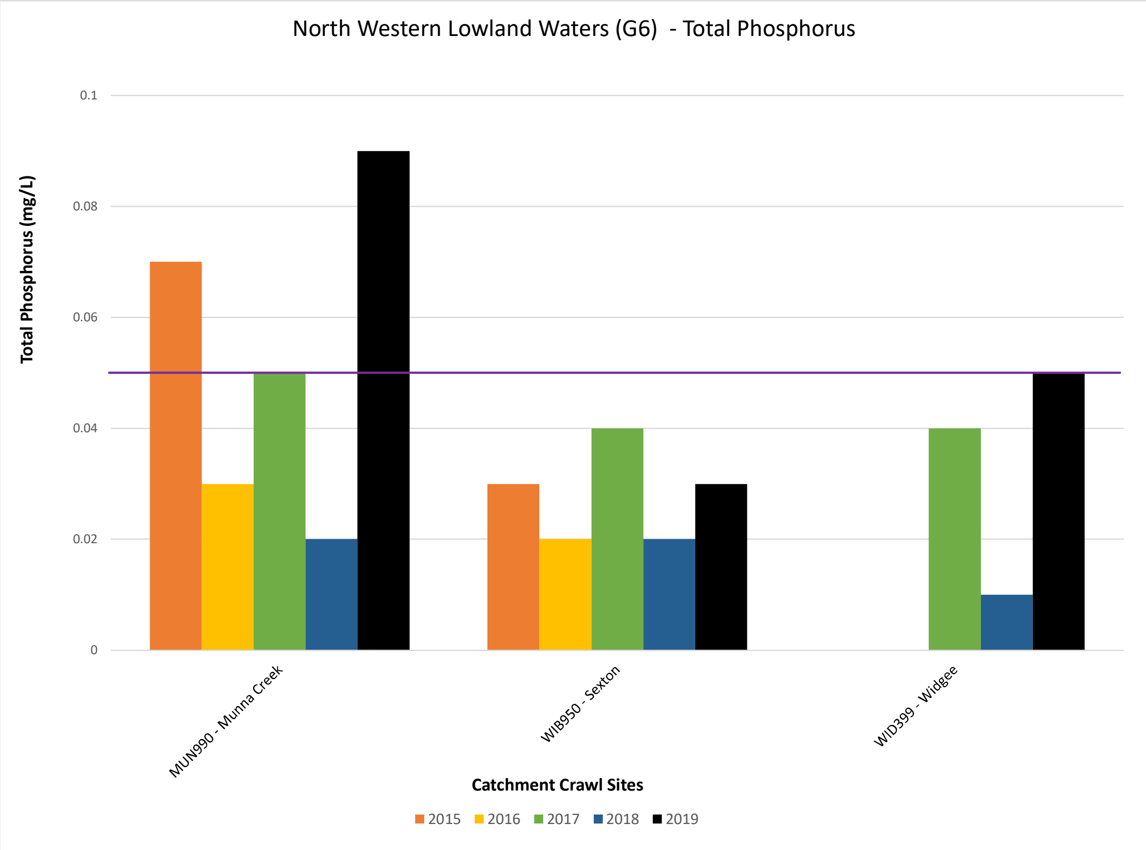

Figure 76 Total Phosphorus results for North Western Lowland waters (G6)

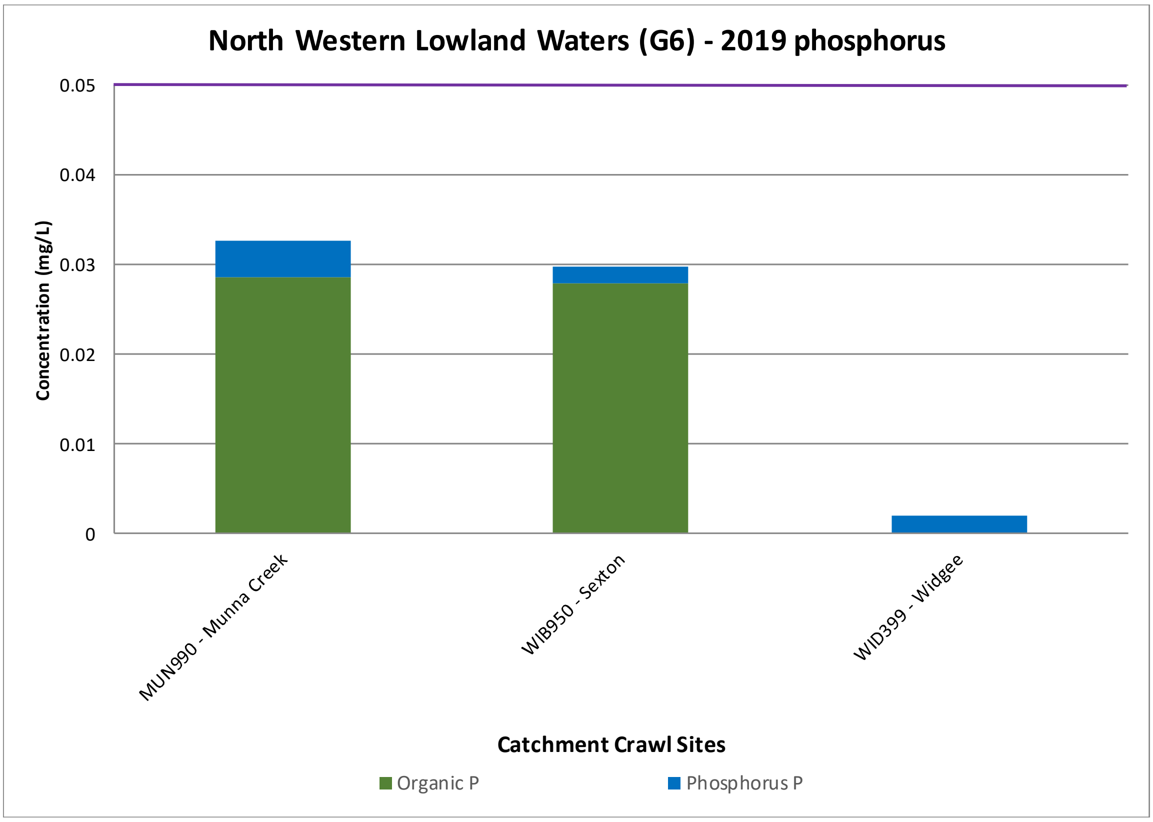

Figure 76.a Relative contribution of the different forms of Phosphorus results for North Western Lowland waters (G6)

3.7 Tinana Creek (North Eastern Lowland waters (G8))

The North Eastern Lowland waters sites at Tinana Creek at Bauple (TIN550) and Tinana Creek at Teddington Weir (TIN800) results are below the detectable limit of <0.001 mg/L for phosphate phosphorus (Figure 77, no results due to being below detectable limit) and below the <0.02 mg/L detectable limit for organic phosphorus (Figure 79, no results due to being below detectable limit). Bauple and Teddington Weir are both under the upper guideline for total phosphorus, although Teddington Weir is close to exceeding it. The majority of phosphorus present is particulate phosphorus (Total Phosphorus Suspended (TPS) = 0.03mg/L) with a small amount present as dissolved organic phosphate (~0.006mg/L). There is less than 0.001mg/L present as inorganic phosphate. For total particulate phosphorus it can't be determined if it is present as inorganic or organic phosphate because both can be present.

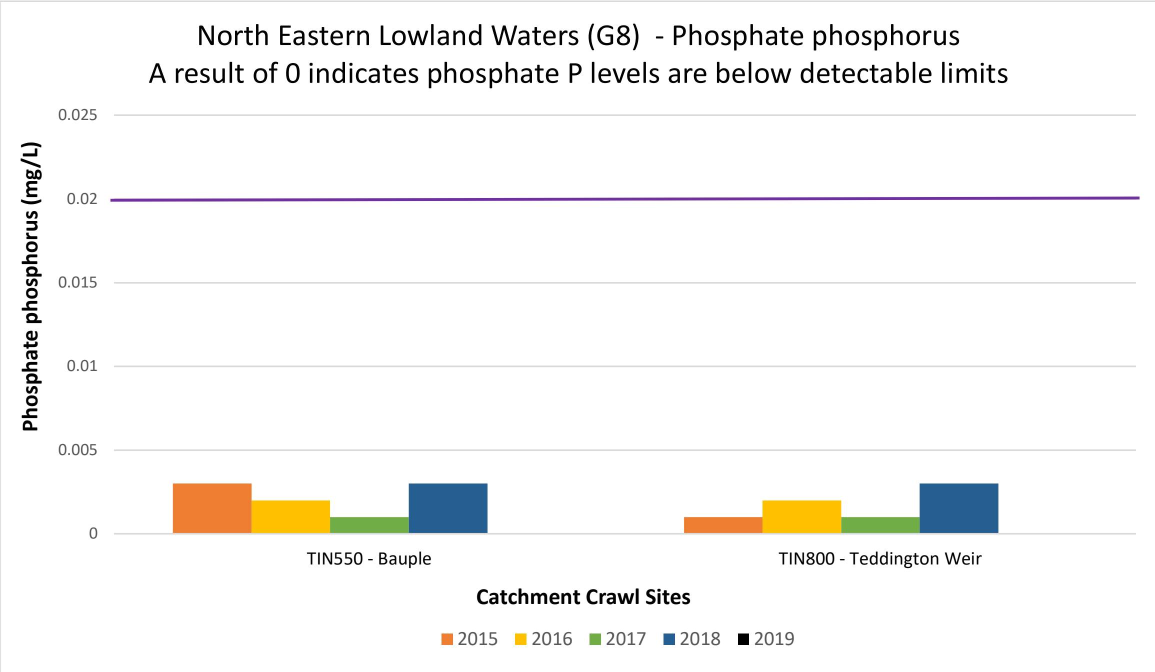

Figure 77 Phosphate results for North Eastern Lowland waters (G8)

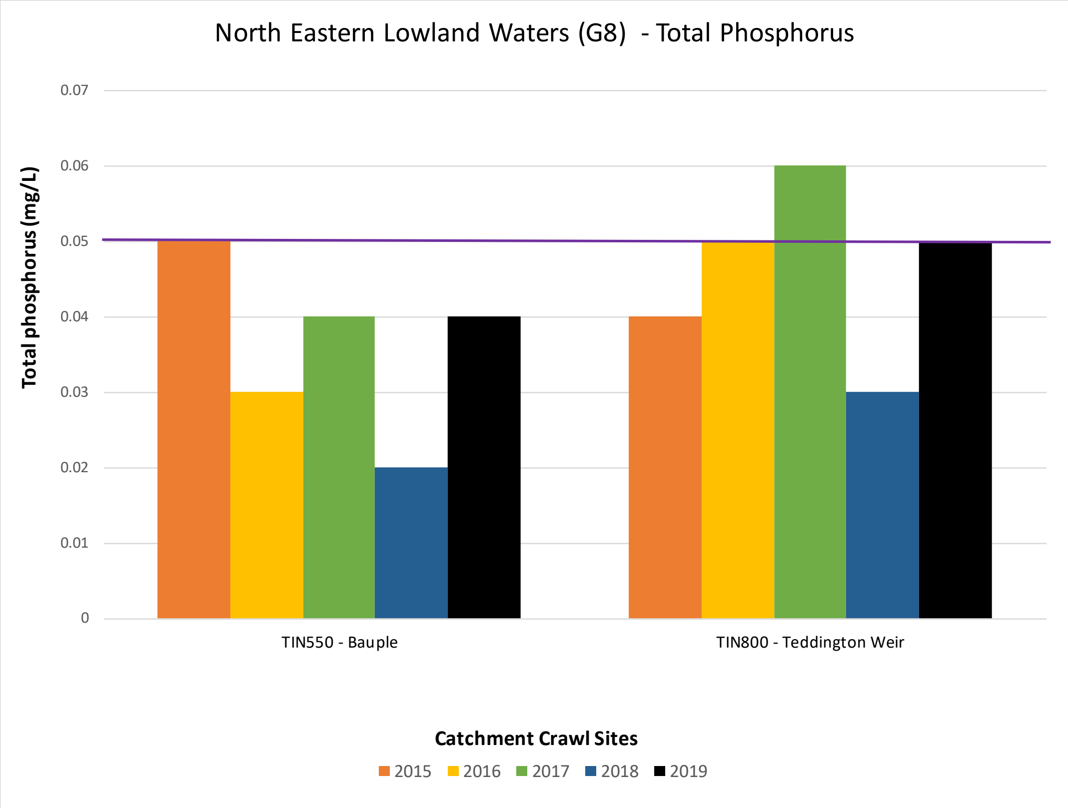

Figure 78 Total phosphorus results for North Eastern Lowland waters (G8)

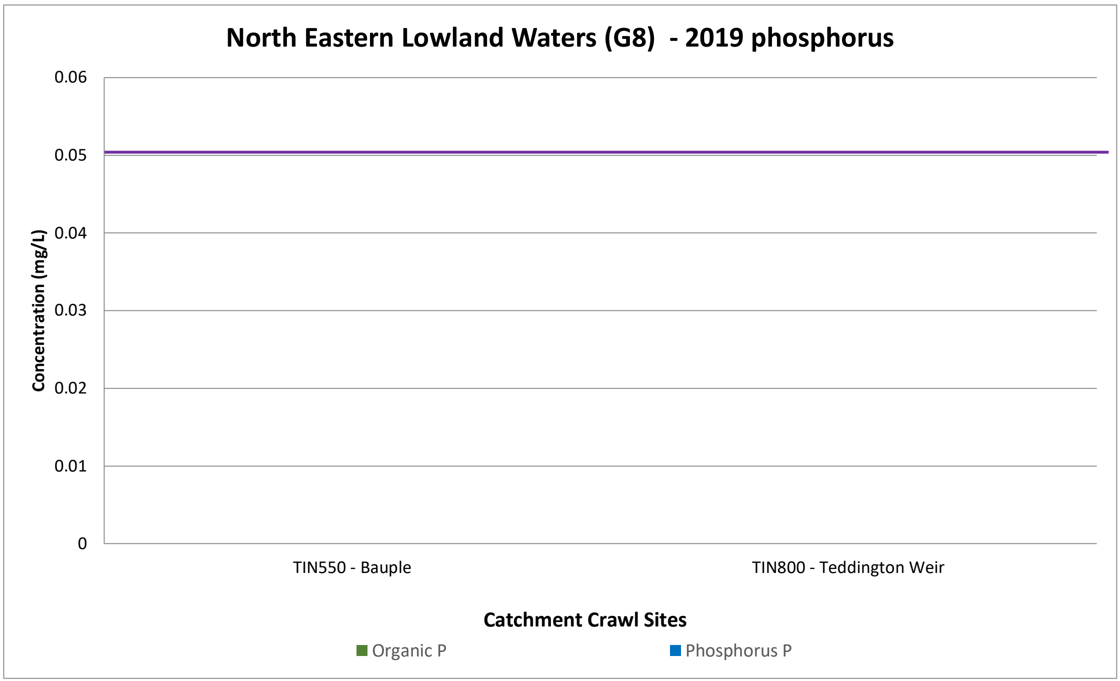

Figure 79 Relative contribution of the different forms of phosphorus to the North Eastern Lowland waters (G8)

3.7.3 Mary River Estuary – High Environmental Value Waters (G2)

Data collection of the estuary sites only commenced in a comprehensive manner in 2017.

All phosphorus results were below the detectable limit for the River Heads site (MAR999) (see Figures 80 and 81). Figure 82 shows that the total phosphorus significantly increased at the Susan River site (SUS500) compared to previous years. The limit is 0.01mg/L and SUS500 recorded a maximum of 0.3 mg/L. SUS500 has a high amount of organic phosphorus and exceeds phosphorus guideline limit (see Figure 83).

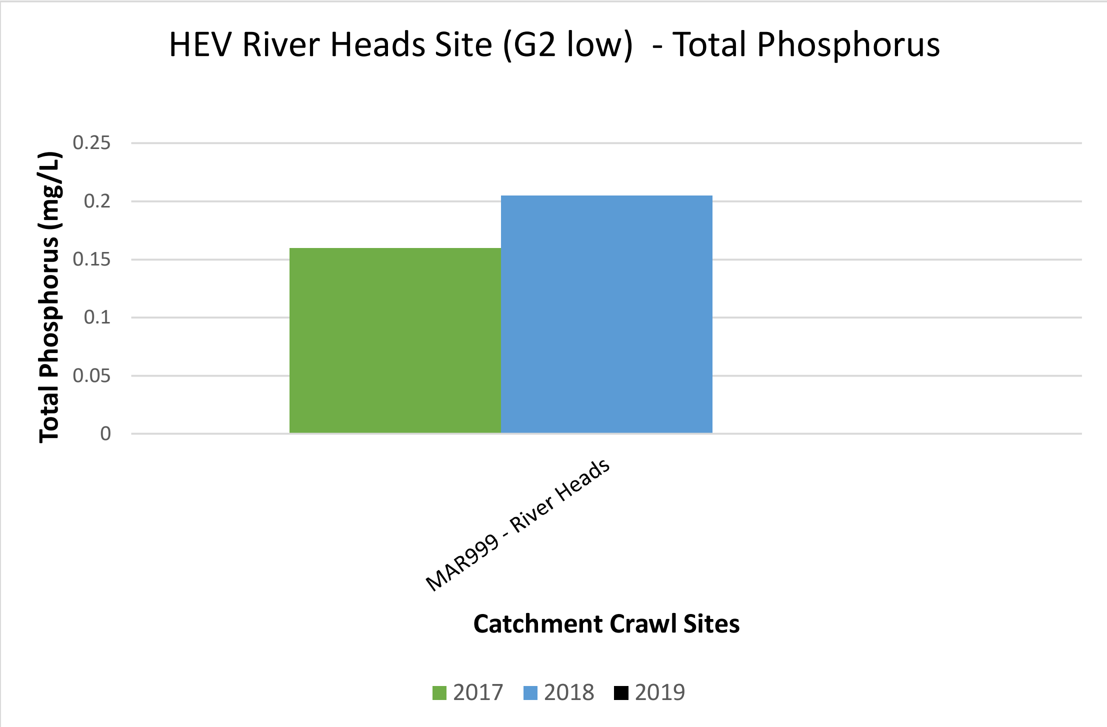

Figure 80 Total phosphorus results for the River Heads site (G2 low)

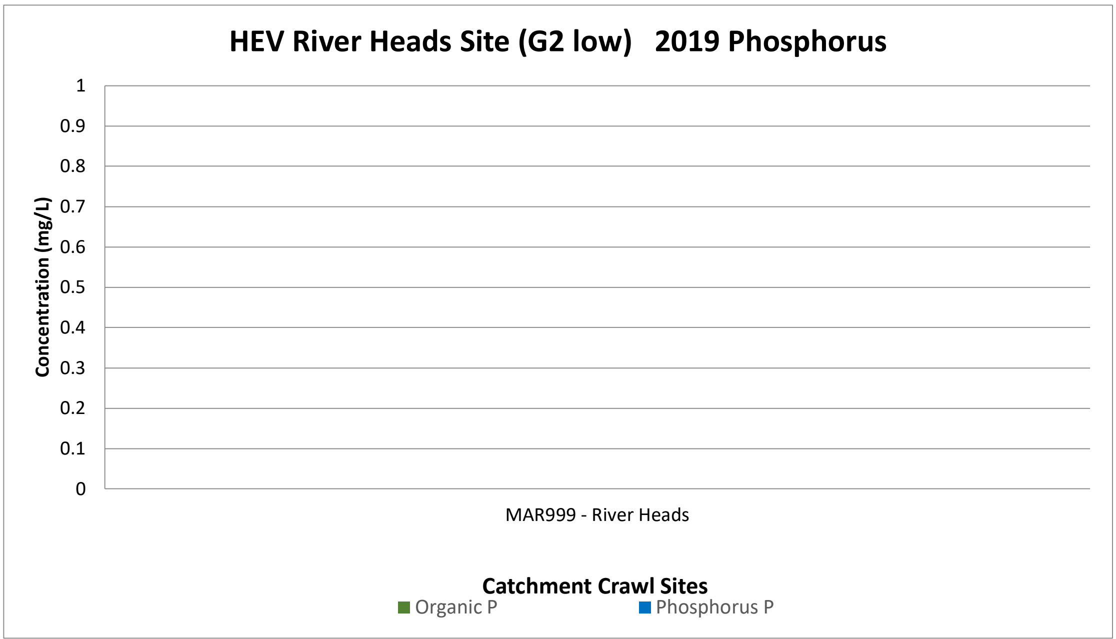

Figure 81 Relative contributions of different forms of phosphorus to the River Heads site (G2 low)

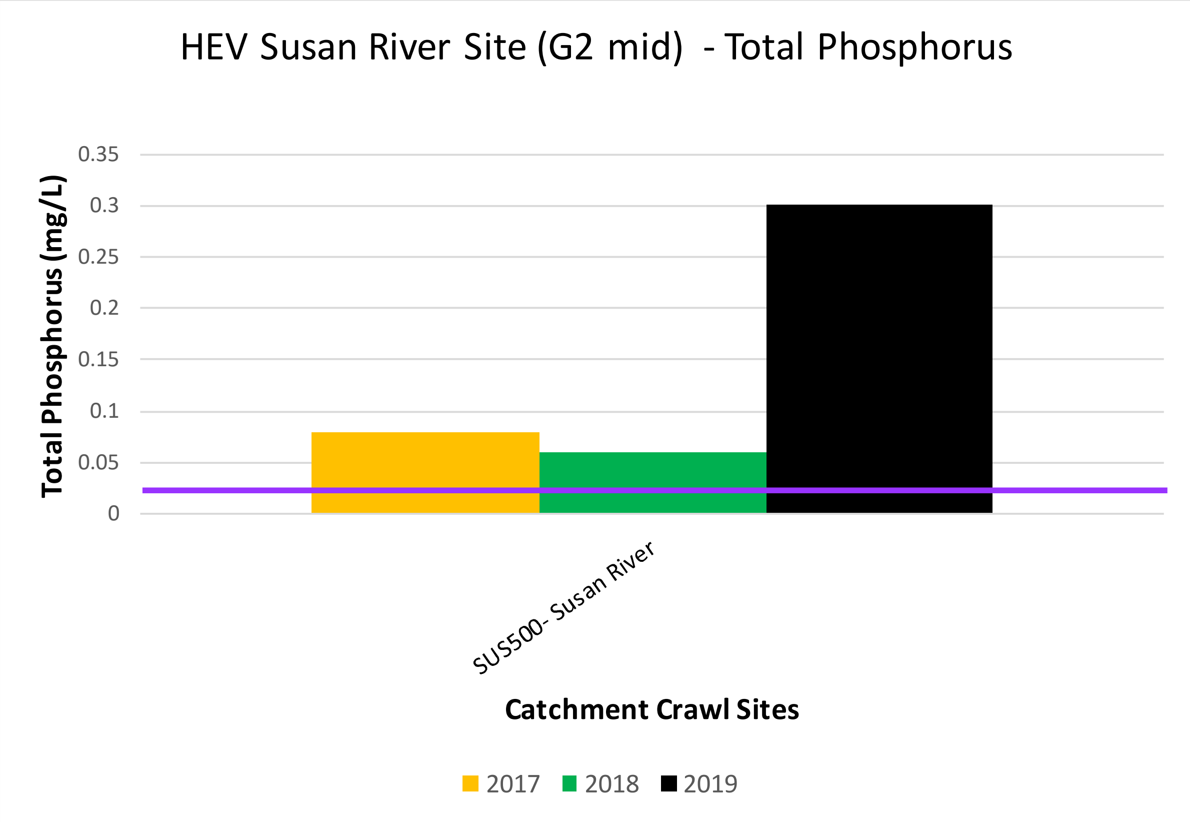

Figure 82 Total phosphorus results for the Susan River site (G2 mid)

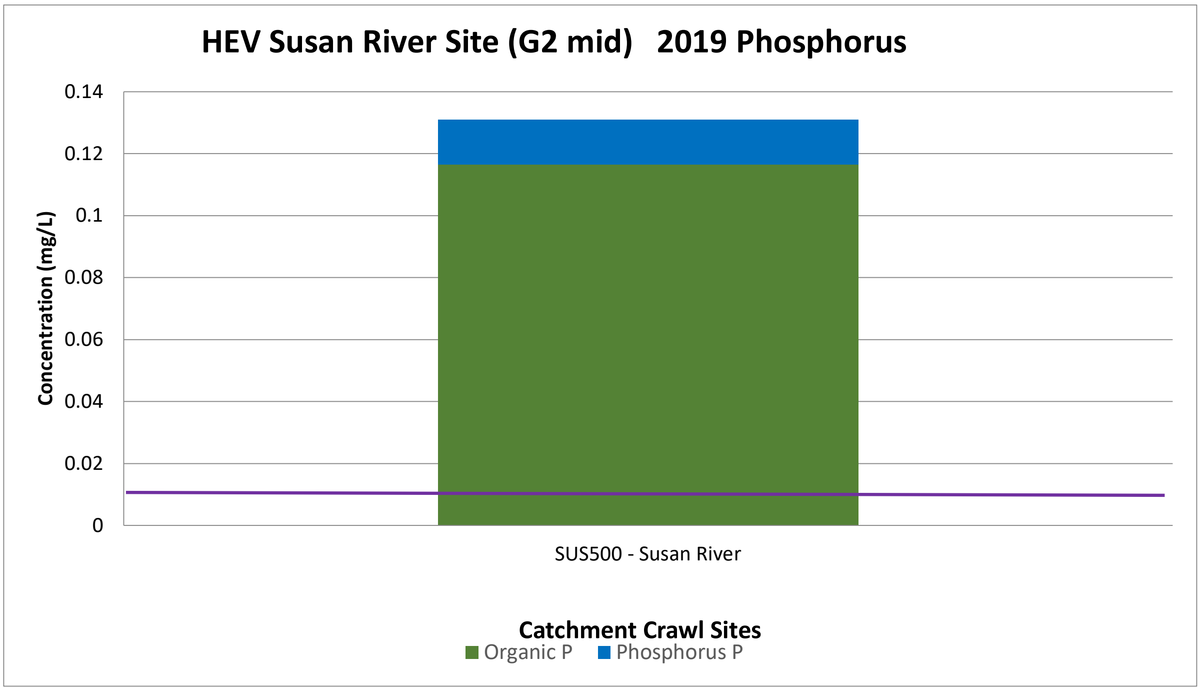

Figure 83 Relative contributions of the different forms of phosphorus to the Susan River site (G2 mid)

3.8 E. coli

Escherichia coli (*E. coli*) is a bacterium that is commonly found in the gut of humans and warm-blooded animals. *E. coli* levels are used as indicators of the presence of faecal material in drinking and recreational waters. Both indicate the possible presence of disease-causing bacteria, viruses, and protozoans. Sources of bacteria include improperly functioning wastewater treatment plants, leaking septic systems, storm water runoff, animal carcasses, and runoff from animal manure and manure storage areas of intensive animal industries e.g. feedlots, piggeries etc.

E.coli was not sampled at all sites due to constraints with delivery of samples to the laboratory within 24 hours of sample collection. Samples were collected for the Southern Lowland waters, North Eastern Lowland waters and one site in the High Environmental Value waters. These results are discussed below.

The guideline for *E. coli* level used is the Primary Contact guideline (ANZECC and ARMCANZ, 2000) and the value is 150 MPN/100ml. The most probable number (MPN) is the number of organisms that are most likely to have produced laboratory results in a particular test.

Observations

The highest *E. coli* levels observed on the Mary River during the 2019 Catchment Crawl were at the Gympie Weir (1000 MPN), followed by Kenilworth (770 MPN) (downstream of Obi Obi Creek confluence), then Walli Mountain (650 MPN). Moy Pocket (310 MPN) and Kenilworth (200 MPN) (upstream of Obi Obi Creek confluence) also exceeded the guideline at the time of the Catchment Crawl.

The Gympie Weir sample was taken above the weir at the stormwater drain. The drain was flowing at the time, despite there being little to no rainfall in the lead up. The high reading could indicate that there is *E. coli* coming from the stormwater inputs. The results on the Mary River at Kenilworth above and below the confluence of Obi Obi Creek suggest that Obi Obi Creek is also a source for *E. coli*.

Overall, more *E. coli* data is required over several years to identify trends.

3.7.5 Mary River and southern major tributaries (Southern Lowland Waters (G5))

The highest *E. coli* levels observed on the Mary River during the 2019 Catchment Crawl were at the Gympie Weir (1000 MPN), followed by Kenilworth (770 MPN) (downstream of Obi Obi Creek confluence), then Walli Mountain (650 MPN). Moy Pocket (310 MPN) and Kenilworth (200 MPN) (upstream of Obi Obi Creek confluence) also exceeded the guideline at the time of the Catchment Crawl.

The Gympie Weir sample was taken above the weir at the dome (stormwater drain). The dome was flowing at the time, despite there being little to no rainfall in the lead up. The high reading could indicate that there is *E. coli* coming from the stormwater inputs. The results on the Mary River at Kenilworth above and below the confluence of Obi Obi Creek suggest that Obi Obi Creek is also a source for *E. coli*.

Above: Stormwater drain above Gympie Weir (MAR499)

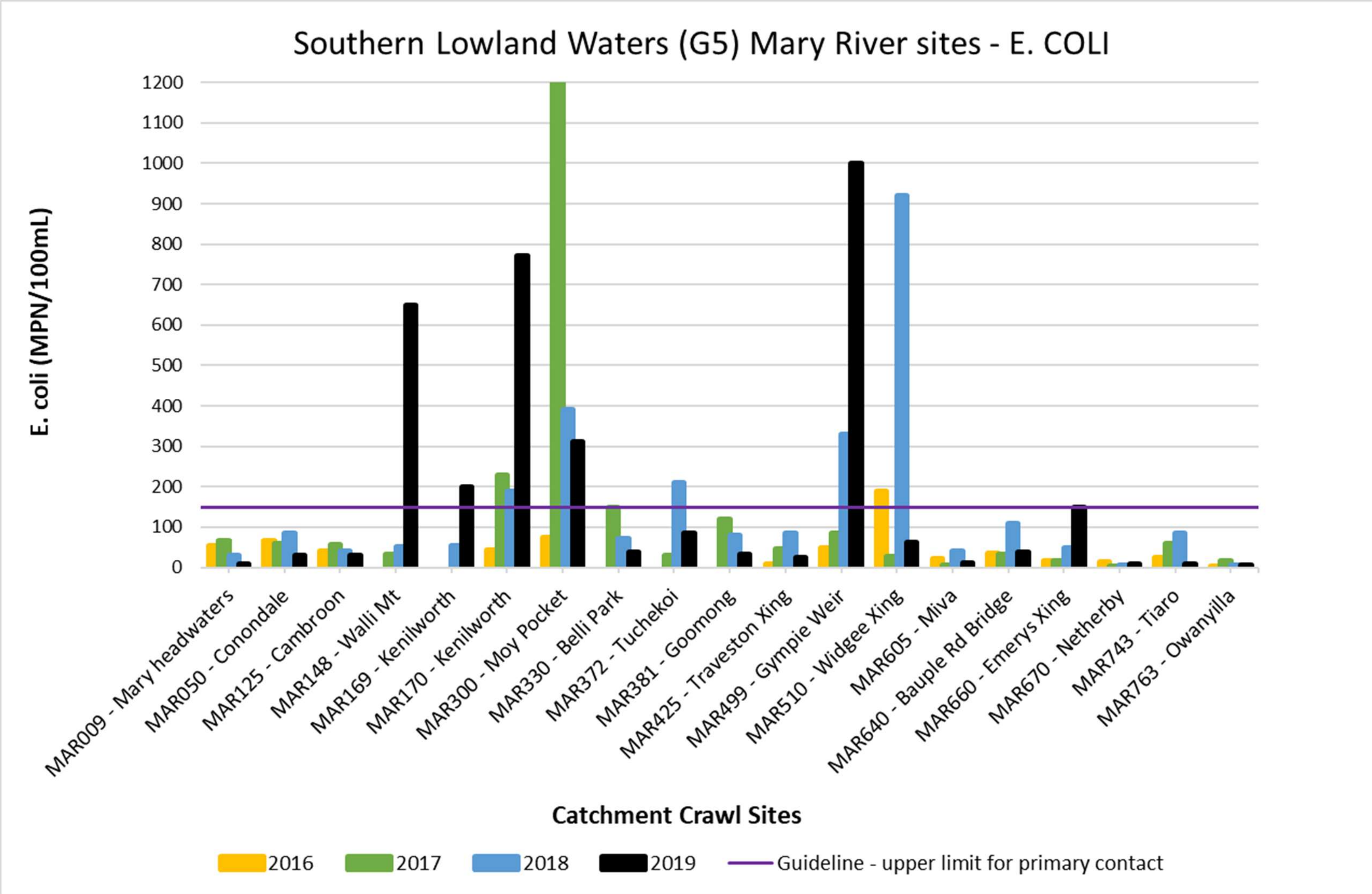

Figure 84 E.coli results for Mary River Southern Lowland waters (G5)

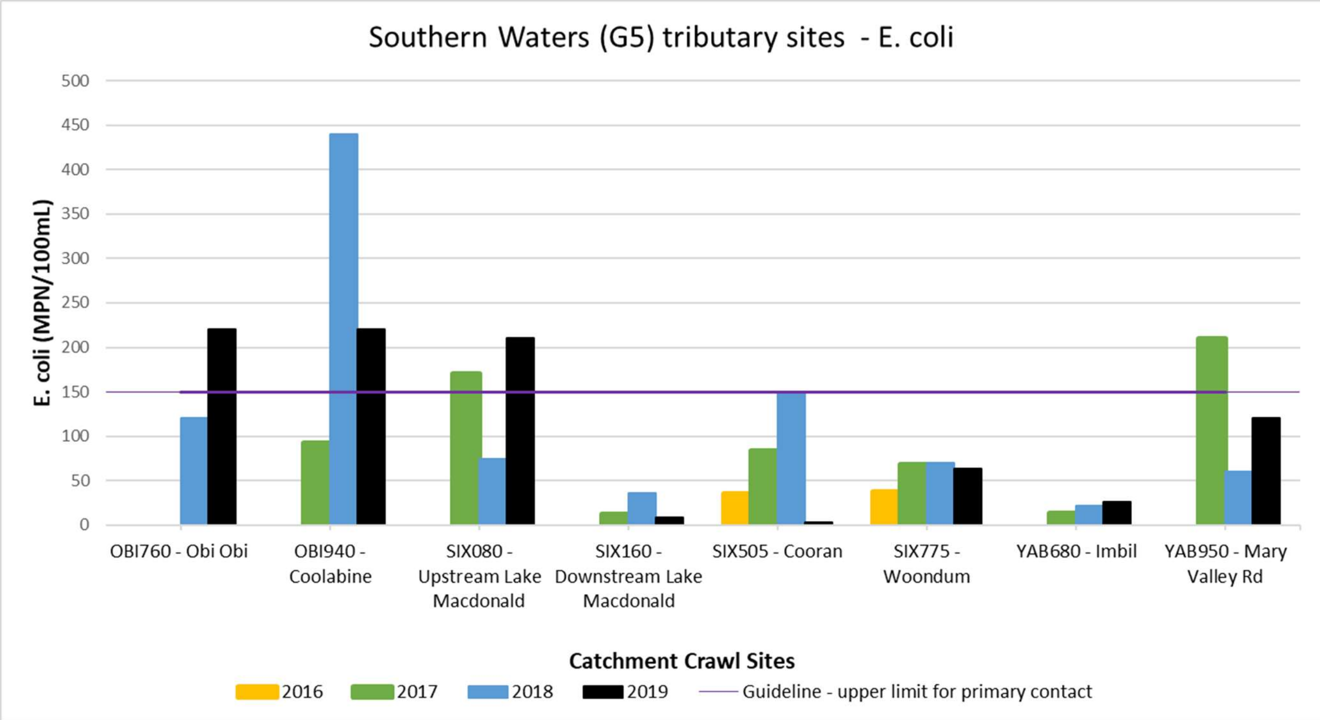

Figure 85 E.coli results for tributaries in the Southern Lowland waters (G5)

3.7.6 Tinana Creek (North Eastern Lowland waters (G8))

Figure 86 shows that the sites tested in the north eastern lowland waters (G8) of Tinana Creek both complied with *E.coli* guidelines in the three years of testing 2016 – 2019.

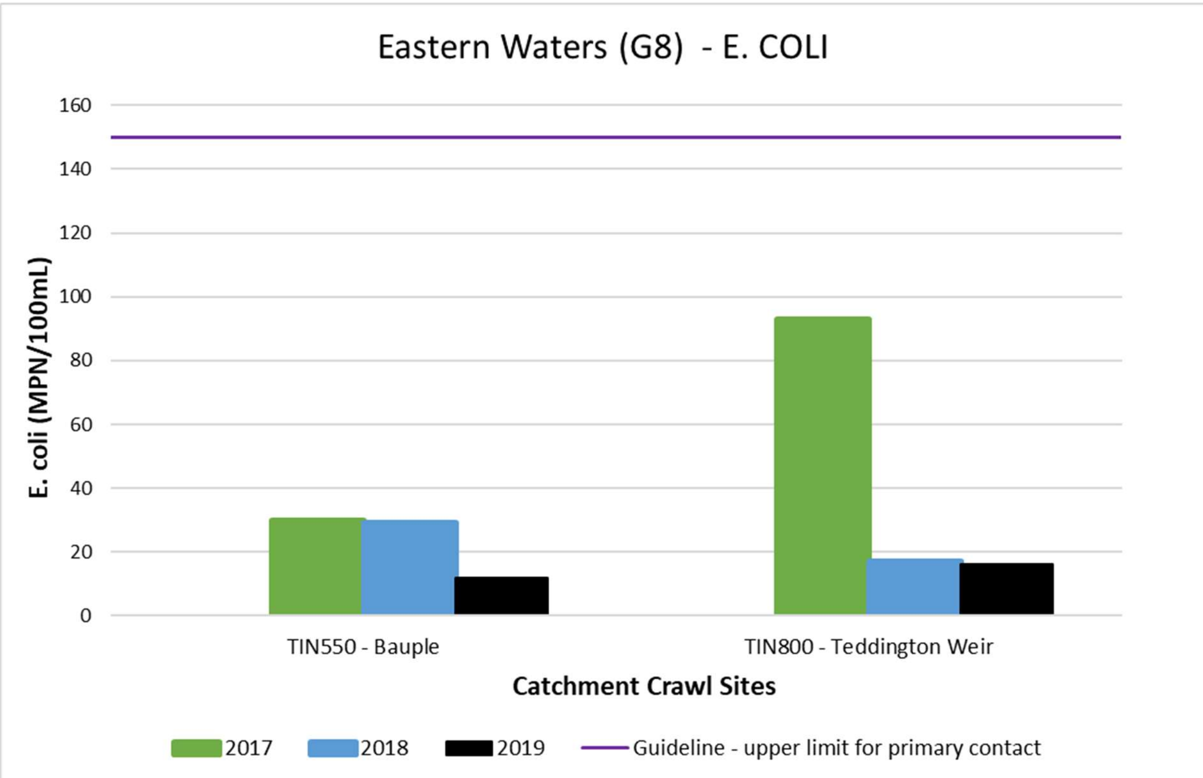

Figure 86 E.coli results for North Eastern Lowland waters (G8)

3.7.7 Mary River Estuary – High Environmental Value Waters (G2)

The result for *E.coli* in 2019 is below the detectable limit (see Figure 87). In 2018 the high E.coli result was attributed to the accumulation of animal faeces in the stagnant pool in 2018.

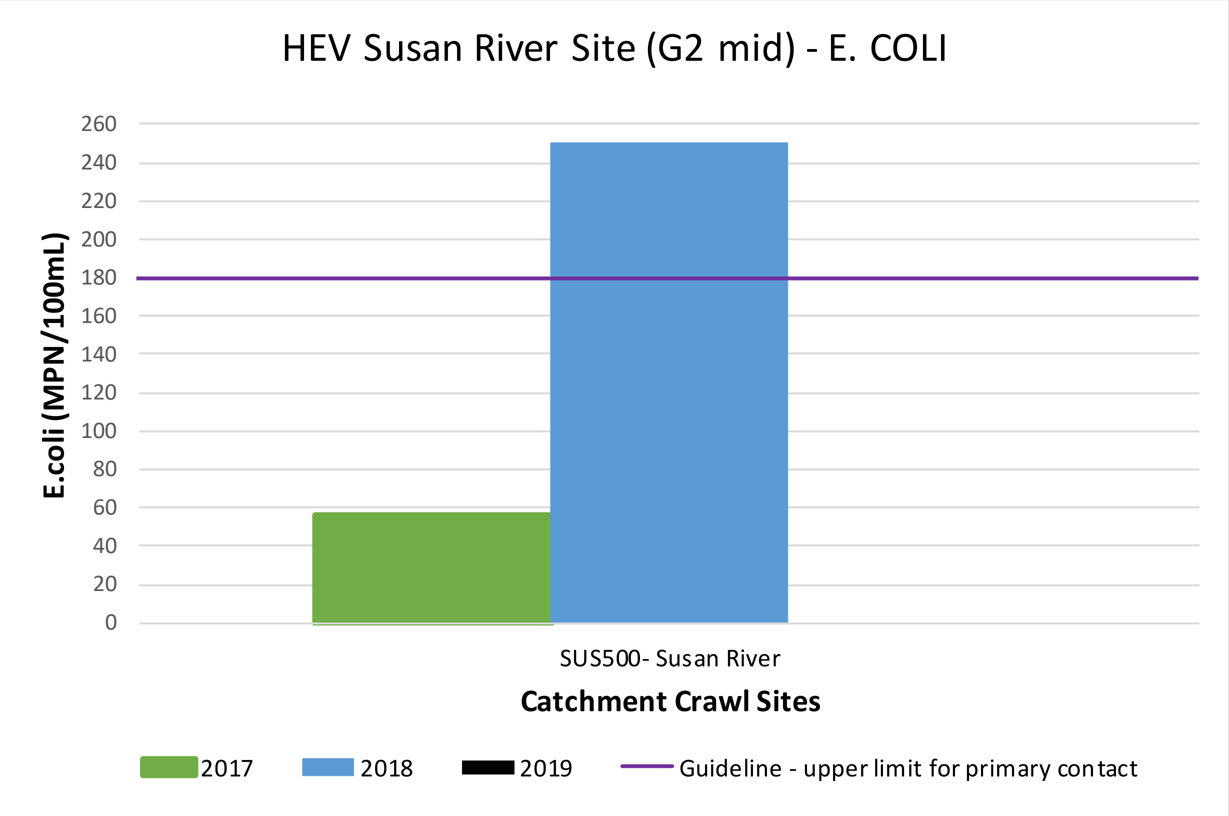

Figure 87 E.coli results for North Eastern Lowland waters (G8)

3.8 Aquatic weeds

Table 9 Approximate coverage of water weeds observed during the 2019 catchment crawl

Site	Location	Salvinia	Water Hyacinth	Dense Water Weed	Cambomba	Filamentous Algae	Other
MAR009	McCrae Lane, Conondale						None seen
MAR050	Grigor Bridge, Conondale						None seen
MAR125	Little Yabba Picnic Area, Cambroon					<20%	
MAR148	Eales, Walli Mountain Rd					<20%	Azolla 20-80%
MAR169	Charles St River park (u/s of Kenilworth)					<20%	Azolla <20%
MAR170	Charles St River Park (d/s of Kenilworth)	<20%				<20%	Water Lettuce <20%
MAR300	Walker Rd bridge, Moy Pocket					<20%	Duckweed <20%
MAR330	Belli Creek confluence at Mary River					<20%	
MAR372	Olsen's Bridge, Tuchekoi Rd, Tuchekoi	<20%					
MAR381	Skyring Ck confluence at Mary River					<20%	
MAR425	Mary River Park, Traveston Xing						None seen
MAR499	Gympie weir, Gympie					20-80%	
MAR510	Eel Ck confluence, Widgee Xing		<20%				
MAR605	Dickabram Bridge, Miva						Azolla <20%
MAR640	Bauple Road Bridge						None seen
MAR660	Emerys Xing , Gundiah						None seen
MAR670	Home Park, Deborah Road, Netherby						None seen
MAR743	Petrie Park, boat ramp, Tiaro						None seen
MAR763	Riverside Park, Grevillea St, Owanyilla						None seen
MAR999	River Heads, boat						None seen

	ramp						
MUN990	Susan River on Hervey Bay Rd						None seen
OBI760	Obi Crossing #2, Obi Obi			<20%		<20%	Water Lettuce <20%
OBI940	Houston Bridge, Coolabine Road			<20%		<20%	Water Lettuce <20%
SIX080	Six Mile Ck, Worba Lane, Worba Park .						None seen
SIX160	Six Mile Creek, Collwood Drive off Lake Macdonald Drive (spillway pool)						None seen
SIX505	Six Mile Creek, downstream of Victor Giles bridge, Cooran						None seen
SIX755	Six Mile Creek, Woondum Rd bridge, Woondum						None seen
SUS500	Yabba Creek, Imbil Town Bridge						None seen
TIN550	Yabba Creek, Mary Valley Road						None seen
TIN800	Webb Park, Widgee	<20%	<20%				
WIB950	Wilson Bridge, Carmyle Rd, Sexton						None seen
WID399	Birt Rd bridge, Munna Creek						None seen
YAB680	Missings Crossing, Bauple					<20%	
YAB950	Teddington Weir, Magnolia	<20%					Smartweed (native) Persicaria <20%

Aquatic weeds sighted on the 2019 catchment crawl and their approximate coverage is displayed in Table 9. Less than 20% coverage of filamentous algae was present at a number of sites. Teddington Weir (TIN800) had large amounts of Salvinia trapped by the road crossing with some Water Hyacinth present. Dense water weed was observed at Obi Obi Creek at OBI760 and OBI940.

3.9 Riparian Zone Condition Assessment

Riparian zone condition assessments were conducted for all sites in 2019. An analysis of the Mary River sites was conducted to assess whether changes to riparian condition occur along the length of the waterway. Sites were given a rating of between A+ and D-, with A+ representing sites in the best condition and D- representing those in the worst condition. Each site was assessed in four categories:

- Vegetation layers present

- Shading over the waterway

- Bank stability

- Aquatic and terrestrial weeds

Each category was given a score and then the site was given an overall score to represent overall riparian zone condition. As Figure 88 shows, Site MAR009 at the Mary River headwaters is in excellent condition but thereafter sites show a score in the C or lower B range until around 200km from the headwaters where most scores increase to the higher B range. At the Mary River Heads, the riparian zone was in the best condition of all sites assessed, largely because the site is intact and undisturbed apart from a number of boat ramps and jetties.

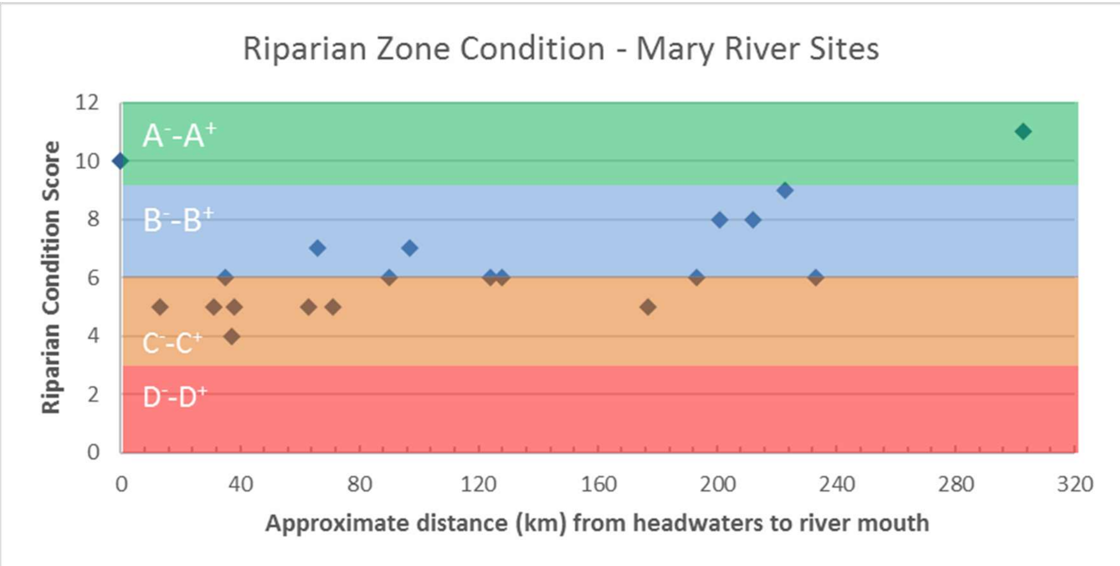

Figure 88 Riparian Zone Condition scores for Mary River sites ranked A+ to D- showing change from the headwaters to the mouth along the course of the rive

4 Photographic evidence of historical change at Catchment Crawl sites

Figures 89 to 95 below show images from the 2019 Catchment Crawl compared with those taken during past Catchments Crawls. This provides photographic evidence of historical change within the stream and riparian zone. The sites chosen represent the Mary River along its course, starting at the Mary headwaters site (MAR009) and ending at the River Heads site (MAR999), and including the five sites for which long term temperature records exist – Conondale (MAR050), Kenilworth (MAR170), Gympie (MAR510), Miva (MAR605) and Emerys Crossing (MAR660).

Figure 2 Mary River, McCrae Lane (MAR009)

Figure 3 Mary River, Conondale (MAR050)

Figure 4 Mary River, Kenilworth (MAR170)

Figure 3 Mary River, Widgee Crossing (MAR510)

Figure 5 Mary River, Miva (MAR605)

Figure 6 Mary River, Emerys Crossing (MAR660)

Figure 7 Mary River, River Heads (MAR999)

4 References

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Appendix A Catchment Crawl Itinerary

Itinerary for Day 1

Mary River Catchment Crawl 2019

Team Mary - Upper Mary River Tuesday 8th October 2019

Team: Kath, Caitlin, Belinda, Katie, Ian Mackay **Car:** Triton

Depart MRCCC at 7:00am (1hr 18mins to MAR009), pick Ian up from Charles St at 7.45am.

Tributary	Site	Site code	Arrival Time	Departure Time	Transport time to next site	Who's coming/Notes
Mary	End of Policemans Spur Rd, Conondale	MAR009	8:20 AM	9:00 AM	15 mins	Ian M - 0455 031 952 Policeman's Spur to Walker Rd. Meet at Charles St. 7.45am
Mary	Fritz Park, Grigor Bridge, Conondale U/S of bridge RHB	MAR050	9:15 AM	9:45AM	12 mins	Marg Thompson 5494 4420 - Deb has given her Caitlin's number
Mary	Little Yabba Picnic Area, Cambroon 150m U/S of Confluence	MAR125	10:00 AM	10:30 AM	9 mins	
Mary	Charles St River Park Kenilworth (downstream of Obi Obi mouth) (Lunch)	MAR170	10:40 AM	11:10 AM		
Mary	Charles St River Park Kenilworth (upstream of Obi Obi mouth) (Lunch)	MAR169	11:10 AM	11:40 AM		
	Lunch		11:40 AM	12:30 PM	19 mins	
Mary	Walker Rd bridge, Moy Pocket D/S	MAR300	12:50 PM	1:15 PM	15 mins via Lowe Rd	
Mary	Olsen's Bridge, Tuchekoi U/S	MAR372	1:30 PM	2:00 PM	16 mins via MV Rd	
Mary	Kevindale (D/S of Skyring Ck confluence, u/s of offtake)	MAR381	2:15 PM	3:00PM	10 mins	**NOT PUBLIC**
Mary	Traveston Crossing, Traveston U/S of bridge	MAR425	3:15 PM	3:45 PM	15 mins via MV Rd	
Mary	Gympie Weir U/S	MAR499	4:00 PM	4:45 PM	15 mins fuel up on way home	

Arrive MRCCC at 5:15pm

Team tribs - Upper Mary catchment tributaries Tuesday 8th October 2019

Team: Sarah, Jess, Eva, Brad, Becky **Car:** D-Max and Barina

Depart MRCCC at 7:00am (17 mins to SIX775)

Tributary	Site	Site code	Arrival Time	Departure Time	Transport time to next site	Who's coming/Notes
Six Mile	Woondum Rd Bridge, Woondum u/s rhb	SIX775	7:20 AM	7:45 AM	20 mins	
Six Mile	Victor Giles Bridge, Cooran D/S of bridge lhb	SIX505	8:05 AM	8:30 AM	19 mins	200m D/S of bridge accessed from rec club
Six Mile	u/s of Collwood Rd (spillway pool), off Lake Macdonald Drive	SIX160	8:50 AM	9:15 AM	9 mins	
Six Mile	Worba Ln – Worba Pk (off Dath Henderson lane) D/S and under culvert	SIX080	9:25 AM	9:50 AM	34 mins via Ridgewood	
Mary	Mimburi – Newpaper Hill D/S of Belli mouth	MAR330	10:30 AM	11:15 AM	23 mins	Stan 0417 196 646 (NDSHS) - sign in at house first.
Mary	Charles St River Park Kenilworth (Lunch)		11:40 AM	12:30 PM	11 mins	No sampling at Charles St
Mary	Eales/Jones boundary	MAR148/150	12:45 PM	1:15 PM	10 mins	
Obi Obi	Houston Bridge (D/S right bank)	OBI940	1:25 PM	2:00 PM	5 mins	
Obi Obi	Xing #2 (D/S of LWD, lhb)	OBI760	2:05 PM	2:30 PM	25 mins	
Yabba	Imbil Town U/S of Bridge	YAB680	3:00 PM	3:30 PM	6 mins	
Yabba	Mary Valley HWY (after barn) u/s of bridge rhb	YAB950	3:40 PM	4:15 PM	45 min fuel up on way home	

Arrive MRCCC at 5:00pm

Itinerary for Day 2

Mary River Catchment Crawl 2019

Team Mary - Lower Mary River Wednesday 9th October 2019 - Gympie North

Team: Caitlin, Sarah, Belinda, Katie, Jess **Car:** Triton

Depart Gympie at 7:30am (12 mins to MAR510)

Tributary	Site	Site code	Arrival Time	Departure Time	Transport time to next site	
					36 mins (if bridge open)	**Bridge is CLOSED**. Call Darren as we leave the office.
Mary	Widgee Crossing @ Eel Ck Junction	MAR510	7:45 AM	8:30 AM	**53 mins (if bridge closed)**	**Everyone must wear HiVis**
Mary	Dickabram Bridge, Miva Road, Miva (U/S under bridge, lhb)	MAR605	9:30 AM	10:00AM	14 mins	2019 Site supervisor: Darren Manderson (ph 0417752047)
Mary	Bauple Woolooga Road Bridge (under bridge)	MAR640	10:15 AM	10:45 AM	13 mins	
Mary	Emerys Bridge Road, Gundiah (between bridges, rhb)	MAR660	11:00 AM	11:30 AM	13 mins (to gate on Deborah Rd)	
Mary	Home Park, Deborah Road, Netherby (Garth's crossing, D/S)	MAR670	11:45 AM	12:15 PM	10 mins (from Home Park gate)	**NOT PUBLIC**
Mary	Petrie Park, boat ramp, Tiaro (Lunch)	MAR743	12:30 PM	1:30 PM	35 mins	
Susan	Susan River - bridge on Maryborough-Hervey Bay Road, rhb under bridge	SUS500	2:05 PM	2:35 PM	16 mins	**NOT PUBLIC**
	Day 2 samples - Water One (31 Ellengowan St, Urangan) to deliver E.coli samples by 3.30pm. Ask for esky back		2:50 PM	3:00 PM	14 mins	
Mary	River Heads - most northern non-ferry boat Ramp	MAR999	3:15 PM	3:45 PM	1 hour 45 mins	

Arrive MRCCC at 5:30pm

Team Tribs - Lower Mary catchment tributaries Tuesday 9th October

Team: Kath, Brad, Becky, Garth, Bob and Lorraine **Car:** D-Max, Barina

Depart Gympie at 7.30am (1 hr 35 mins to Water One)

Tributary	Site	Site code	Arrival Time	Departure Time	Transport time to next site
	Staff to courier Day 1E.coli samples to 29-31Ellangowan St Urangan. Contact Neisha at lab if doors locked at reception 0417124144		9:00 AM	9:15 AM	46 mins
Mary	Grevillea St, Riverside Park, Owanyilla (off wooden platform)	MAR763	10:00 AM	10:30 AM	11 mins
Tinana	Teddington Weir, Magnolia (D/S of crossing, lhb)	TIN800	10:40 AM	11:05 AM	35 mins (via Forestry Rd)
Tinana	Missings crossing, Bauple (D/S of bridge on lhb)	TIN550	11:40 AM	12:05 PM	25 mins (via Bauple)
Mary	Petrie Park, boat ramp, Tiaro (Lunch)		12:30 PM	1:30 PM	27 mins
Munna	Birt Rd Bridge, Munna Creek (D/S)	MUN990	2:00 PM	2:30 PM	26 mins
Wide Bay	Wilson Bridge, Carmyle Rd, Sexton (D/S, lhb)	WIB950	3:00 PM	3:30 PM	35 mins
Widgee	Webb Park, Widgee (D/S of pedestrian x-ing)	WID399	4:05 PM	4:30 PM	24 mins

Arrive MRCCC at 5:00pm

Appendix B Results

Type	Site Code eg LAT001	Site Description	temp 2019	pH 2019	EC 2019	turb 2019	DO 2019	E.coli 2019	Oxidised N 2019	Ammonium N 2019	Kjeldahl N 2019	Total N 2019	Organic N 2019	Phosphate P 2019	Kjeldahl P 2019	Organic P 2019	TSS 2019
G2	MAR999 - River Heads	River Heads, boat ramp	22.75	8.51	56900	3.15	98.30	N/A	0.003	0.043	0.18	0.183	0.137	<0.001	<0.02	<0.02	81
G2	SUS500 - Susan River	Susan River on Bruce Highway	N/A	N/A	N/A	N/A	N/A	<1	0.002	0.118	4.61	4.61	4.492	0.014	0.3	0.117	69
G4	MAR009 - Mary headwaters	Causeway on McCrea Lane, Conondale	18.20	7.35	340	0.30	64.65	8	0.012	0.009	0.18	0.191	0.171	0.014	0.03	<0.02	<1
G5	MAR050 - Conondale	Grigor Bridge, Conondale	24.10	8.02	321	1.65	106.60	29	<0.001	0.004	0.44	0.439	0.436	0.003	0.05	<0.02	3
G5	MAR125 - Cambroon	Little Yabba Picnic Area, Cambroon	25.05	7.59	375	1.05	74.05	29	0.002	0.009	0.21	0.213	0.201	0.003	<0.02	<0.02	1
G5	MAR148 - Walli Mt	Eales, Walli Mountain Rd	27.98	8.71	336	7.00	136.00	650	0.003	0.009	0.36	0.366	0.351	0.002	0.02	<0.02	1
G5	MAR169 - Kenilworth	Charles St Park Upstream of Obi Obi Mouth	26.75	7.90	347	0.80	116.95	200	0.009	0.01	0.22	0.234	0.21	0.003	0.02	<0.02	1
G5	MAR170 - Kenilworth	Charles St River Park, Downstream of Obi Obi Mouth, Kenilworth	25.70	7.50	285	0.20	100.95	770	0.011	0.011	0.26	0.266	0.249	0.007	0.03	0.0208	1
G5	MAR300 - Moy Pocket	Walker Rd bridge, Moy Pocket	25.35	7.53	342	3.15	101.95	310	0.029	0.044	0.49	0.514	0.446	0.017	0.06	0.0324	2
G5	MAR330 - Belli Park	Mimburi at Belli/Mary confluence	25.75	7.32	346	7.00		38	<0.001	0.004	0.33	0.335	0.326	0.006	0.03	<0.02	3
G5	MAR372 - Tuchekoi	Olsen's Bridge, Tuchekoi Rd, Tuchekoi	26.25	7.67	402	6.85	73.20	86	<0.001	0.008	0.33	0.329	0.322	0.004	0.04	<0.02	8
G5	MAR381 - Goomong	Skyring Ck confluence with Mary	26.90	8.48	398	4.10	126.30	31	0.003	0.005	0.43	0.433	0.425	0.004	0.03	<0.02	3
G5	MAR425 - Traveston Xing	Mary River Park, Traveston Crossing	27.20	8.17	425	5.10	112.50	23	0.002	0.006	0.46	0.464	0.454	0.005	0.04	<0.02	3
G5	MAR499 - Gympie Weir	Gympie weir, Gympie	26.15	8.21	522	2.30	113.40	1000	0.006	0.004	0.34	0.343	0.336	0.003	0.03	0.0204	2
G5	MAR510 - Widgee Xing	Widgee Crossing @ Eel Ck junction	16.85	8.02	558	5.35	97.75	62	0.001	0.004	0.35	0.352	0.346	0.02	0.06	0.0359	4
G5	MAR605 - Miva	Dickabram Bridge, Miva	24.50	8.01	598	7.00	102.15	10	0.001	0.01	0.26	0.262	0.25	<0.001	<0.02	<0.02	3
G5	MAR640 - Bauple Rd Bridge	Bauple Woolooga Road Bridge	20.85	8.00	533	4.50	102.15	37	0.002	0.006	0.39	0.39	0.384	<0.001	0.02	<0.02	24

Type	Site Code eg LAT001	Site Description	temp 2019	pH 2019	EC 2019	turb 2019	DO 2019	E.coli 2019	Oxidised N 2019	Ammonium N 2019	Kjeldahl N 2019	Total N 2019	Organic N 2019	Phosphate P 2019	Kjeldahl P 2019	Organic P 2019	TSS 2019
G5	MAR660 - Emerys Xing	Emerys Bridge Road, Gundiah (at John William's waterwatch site)	25.00	8.10	486	6.70	107.05	150	<0.001	0.003	0.4	0.406	0.397	<0.001	0.03	<0.02	4
G5	MAR670 - Netherby	Home Park, Deborah Road, Netherby	24.60	8.00	446	5.90	97.75	7	<0.001	0.008	0.27	0.27	0.262	0.003	0.03	<0.02	5
G5	MAR743 - Tiaro	Petrie Park, boat ramp, Tiaro	24.40	7.75	410	8.00	93.07	7	<0.001	0.017	0.37	0.37	0.353	0.004	0.03	<0.02	8
G5	MAR763 - Owanyilla	Grevillea St, Riverside Park, Owanyilla (off wooden platform)	25.55	7.61	337	7.00	107.00	5	<0.001	0.004	0.34	0.338	0.336	<0.001	0.02	<0.02	3
G5	OBI760 - Obi Obi	Obi obi crossing No #2	26.23	8.19	191	7.00	113.95	220	0.003	0.007	0.26	0.262	0.253	0.021	0.04	<0.02	1
G5	OBI940 - Coolabine	Houston Bridge, Coolabine Road	24.00	7.67	224	7.00	69.90	220	0.048	0.018	0.43	0.475	0.412	0.019	0.05	<0.02	2
G5	SIX080 - Upstream Lake Macdonald	Six Mile Ck, Worba Lane, Worba Park	20.60	5.74	336	30.00	9.25	210	<0.001	0.083	2.32	2.32	2.237	0.003	0.13	<0.02	8
G5	SIX160 - Downstream Lake Macdonald	Six Mile Creek, Lake Macdonald Drive (d/s Lake)	24.25	6.64	131	7.00	85.45	9	0.07	0.14	0.61	0.679	0.47	0.002	<0.02	<0.02	2
G5	SIX505 - Cooran	Six Mile Creek, Victor Giles bridge, Cooran	20.58	6.82	205	12.25	36.55	3	0.039	0.028	0.48	0.514	0.452	0.003	0.03	0.02	4
G5	SIX775 - Woondum	Six Mile Creek, Woondum Rd bridge, Woondum	20.05	6.97	231	7.00	38.40	63	0.015	0.018	0.35	0.361	0.332	0.004	<0.02	<0.02	3
G5	YAB680 - Imbil	Yabba Creek, Imbil Town Bridge	25.78	8.15	312	7.00	103.20	26	0.005	0.008	0.45	0.454	0.442	0.003	0.02	<0.02	<1
G5	YAB950 - Mary Valley Rd	Yabba Creek, Mary Valley Road	26.12	7.95	279	7.00	96.55	120	0.003	0.006	0.34	0.343	0.334	0.011	0.02	<0.02	2
G6	WID399 - Widgee	Webb Park, Widgee	30.00	8.34	810	7.00	135.30	N/A	<0.001	0.014	0.98	0.982	0.966	0.004	0.09	0.0286	11
G6	WIB950 - Sexton	Wilson Bridge, Carmyle Rd, Sexton	22.65	7.86	1039	7.00	82.30	N/A	0.01	0.014	0.32	0.332	0.306	0.002	0.03	0.0278	3
G6	MUN990 - Munna Creek	Birt Rd bridge, Munna Creek	23.10	8.30	1010	7.00	75.30	N/A	<0.001	0.006	0.54	0.537	0.534	0.002	0.05	<0.02	4
G8	TIN550 - Bauple	Missings crossing, Bauple (D/S of bridge on lhb)	23.28	6.96	366	7.00	69.00	12	0.008	0.009	0.4	0.404	0.391	<0.001	0.04	<0.02	3
G8	TIN800 - Teddington Weir	Teddington Weir, Magnolia (D/S of crossing, lhb)	25.75	6.99	471	7.00	56.15	16	0.009	0.038	0.72	0.726	0.682	<0.001	0.05	<0.02	9

Appendix C – River Flow Plots

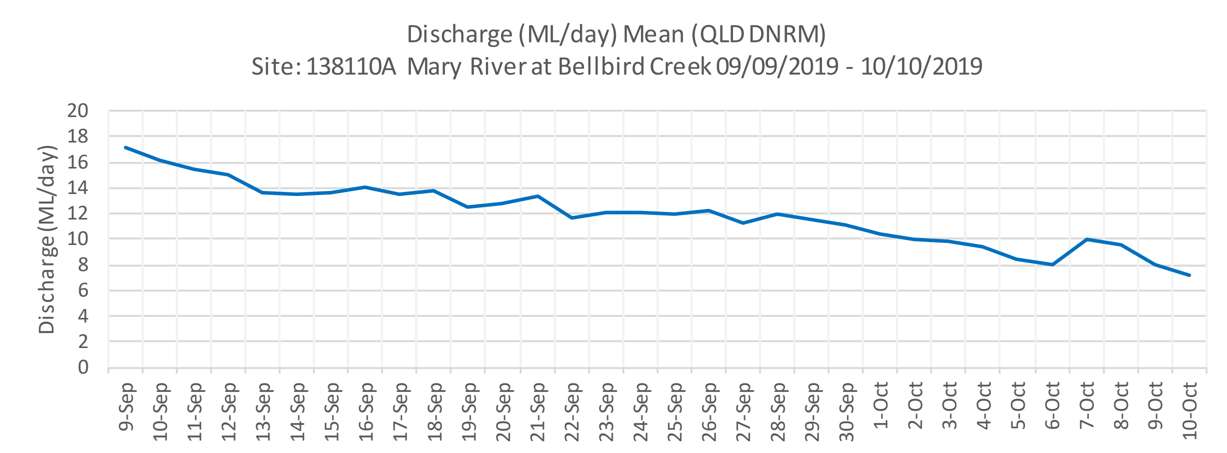

Figure 96 Discharge and volume plot for the Mary River at Bellbird Creek. Source: QLD DNRME (n.d.)

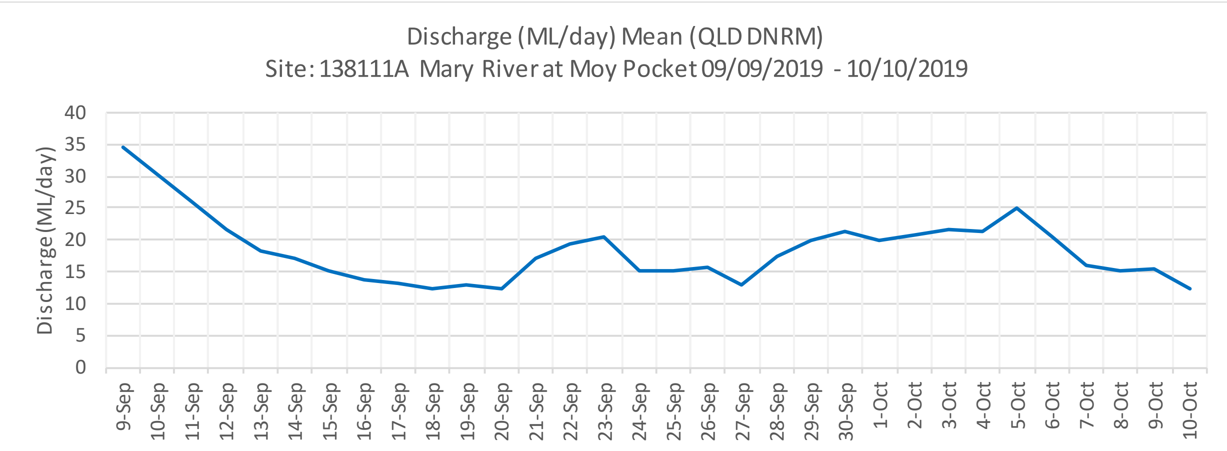

Figure 97 Discharge and volume plot for the Mary River at Moy Pocket. Source: QLD DNRME (n.d.)

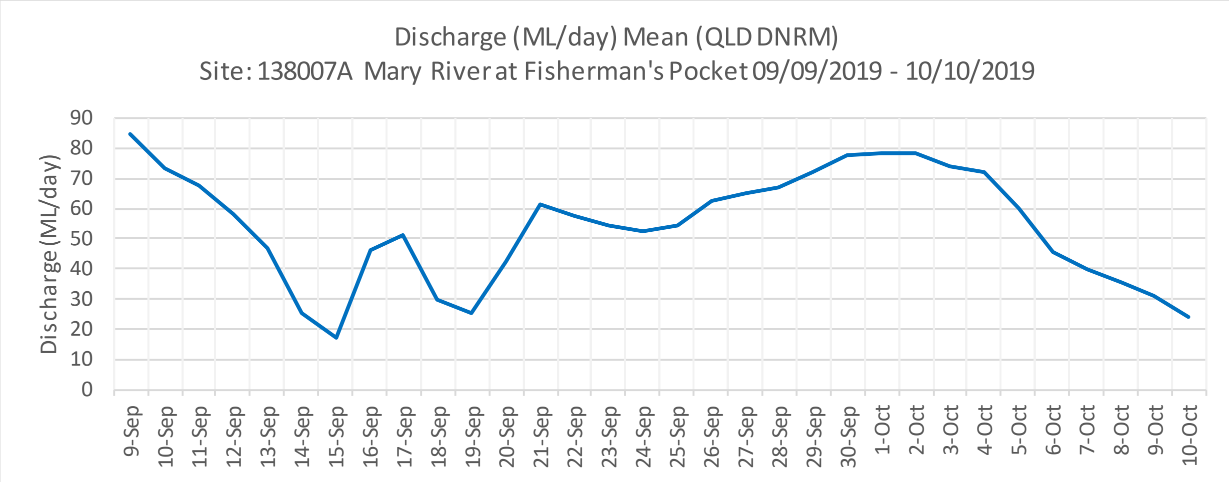

Figure 98 Discharge and volume plot for the Mary River at Fishermans Pocket. Source: QLD DNRME (n.d.)

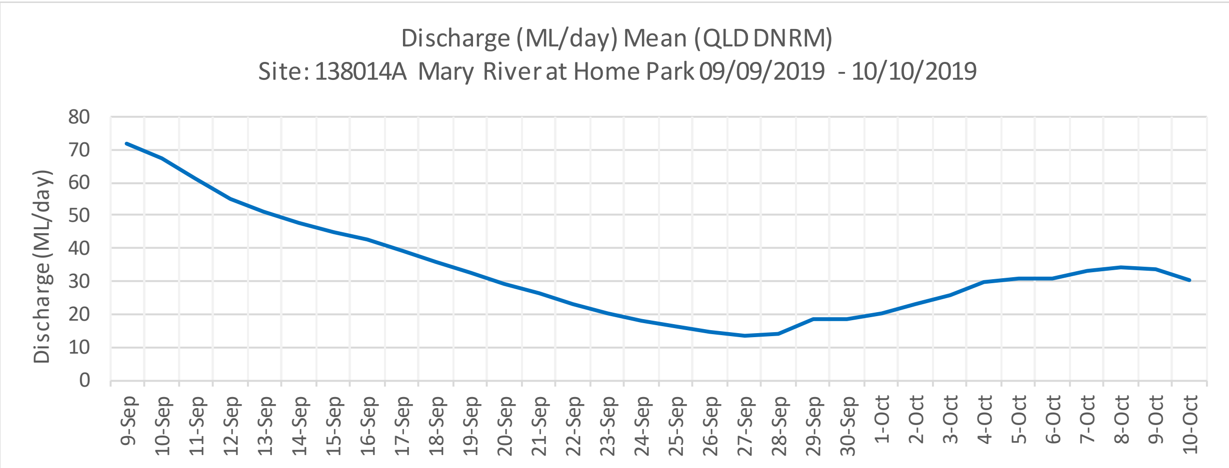

Figure 99 Discharge and volume plot for the Mary River at Home Park. Source: QLD DNRME (n.d.)