# Water and sediment quality in the Bull Creek catchment and City of Melville lakes 2016

**Prepared by the South East Regional Centre for Urban Landcare for the City of Melville**

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The City of Melville put out a request for quotation for a suitably qualified and experienced consultant to undertake the 2016-17 water and sediment quality monitoring in the City of Melville of which SERCUL was successful. The City of Melville provided full funding for SERCUL staff to prepare the sampling and analysis plan, safety plan, conduct the sampling and prepare this final report.

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**Document Control**

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# Executive Summary

This assessment of surface water and sediment quality within the Melville Bull Creek catchments was undertaken in 2016 as part of the annual monitoring program. Initiated in 2007, the purpose of this monitoring program is to determine the water and sediment quality in the western side of the Bull Creek catchment and some of the lakes within the City of Melville to guide management responses within the catchment.

This assessment is based on four sampling events of surface water and one sampling event of sediment collected in 2016. This report also compares the 2016 sample data with datasets from the previous ten years of monitoring (2007 - 2015) where spatial or temporal patterns have been observed.

The following key issues were identified during the 2016 sampling period:

- High lead concentration in sediment at site 5 (John Creaney Park);
- High total zinc concentrations in water at sites 15 and 16 (John Creaney park inlet and downstream Elizabeth Manion park respectively);
- High total nitrogen at the three most downstream Bull Creek main drain sites PSDTBCMD, ROSSTAFE and 2 (Bull Creek Main Drain, Brockman Park inlet and Brockman Park), and high available forms of nitrogen at all Bull Creek main drain sites (particularly nitrogen as ammonia/ammonium at site 2 (Brockman Park));
- High available forms of nitrogen along Brentwood drainage line;
- High sediment metals at site 13 (Brentwood drain);
- Low pH at sites 7 (Booragoon Lake), 12 (Blue Gum Lake), 8 (Piney Lakes outlet) and 9 (Quenda Lake outlet);
- High nutrients at sites 7 (Booragoon Lake) and 12 (Blue Gum Lake);
- High metals at sites 7 (Booragoon Lake) and 12 (Blue Gum lake);
- High pH at site 11 (Marmion Reserve); and
- High metals in sediment at site 10 (Frederick Baldwin).

Generally, the 2016 results were similar to those recorded in previous years and did not indicate any worsening or improvement in water quality or the occurrence of any atypical events impacting water quality within the catchment. The exception to this is the sediment quality at site 13 (Brentwood drain) in 2016, which had significantly higher metal concentrations than in previous years, many exceeding relevant trigger values although this is likely due to the slight change in sampling location that occurred due to restoration work in this portion of Brentwood drain.

Sites 7 and 12 had by far the poorest overall water quality in the catchment, with nutrients significantly exceeding relevant guideline values and multiple metals also exceeding guidelines. Sites along the upper Bull Creek Main drain, as well as sites 8 and 9 (Piney Lakes outlet and Quenda Lake outlet) also had relatively poor water quality, recording various exceedances of guideline values for nutrients and metals. Lower Bull Creek Main Drain and Brentwood drain sites had relatively better water quality, although still had concentrations exceeding guideline values.

It is recommended that the monitoring program be continued in 2017 to detect any changes in the concentrations of nutrients and metals. Further recommendations are focussed on suggested structural and non-structural controls to improve water quality and continued implementation of existing City of Melville management plans (for reserves containing the Bull Creek main drain and for the Melville lakes) and restoration projects (for Brentwood drain and Bull Creek main drain).

# 1. Summary of Results and Recommendations

## 1.1 Summary of 2016 results per parameter

**Table 1.1-1** displays a summary of the results for each parameter analysed in 2016, with the number of samples that exceeded or equalled relevant trigger values (see **Section 4** for further details of guideline values used), number of samples below the limit of reporting (LOR) and the maximum and minimum values for each parameter.

**Table 1.1-1: Summary of water and sediment quality results for 2016**

| WATER | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Group** | **Parameter** | **NUMBER OF SAMPLES EXCEEDING/EQUAL TO WATER QUALITY TRIGGER VALUES** | | | | **RANGE OF RESULTS** | | |
| | | **Lowland rivers/ Wetlands** | **FW protection** | **Rec. value** | **Interim Guideline** | **N° samples < LOR** | **Minimum (Site)** | **Maximum (Site)** |
| **Physical[1]** | pH | 29 | NA | 23 | | NA | 3.55 (Site 7) | 10.02 (Site 11) |
| | Dissolved oxygen | 52 | NA | 43 | | NA | 2.5% (Site 10) | 132.3% (Site 11) |
| | Conductivity | 45 | NA | NA | | NA | 0.0934 mS/cm (Site 10) | 2.449 mS/cm (Site 7) |
| | Total suspended solids | NA | NA | NA | 13 | 13 | <1 mg/L (seven sites) | 62 mg/L (Site 12) |
| | Total water hardness | NA | NA | 3 | | 0 | 20 mg/L (Site 10) | 890 mg/L (Site 7) |
| **Nutrients[1]** | Total nitrogen | 14 | NA | NA | | 0 | 0.26 mg/L (Site 11) | 6.9 mg/L (Site 2) |
| | Total oxidised nitrogen | 28 | NA | NA | | 10 | <0.01 mg/L (five sites) | 2.6 mg/L (Site PSDTBCMD) |
| | Nitrogen as Ammonia/ Ammonium | 29 | 4 | 3 | | 2 | <0.01 mg/L (Sites 10 & 11) | 6.2 mg/L (Site 2) |
| | Total Organic Nitrogen | ND | ND | ND | | 0 | 0.16 mg/L (Site 13) | 2.3 mg/L (Site 7) |
| | Dissolved Organic Nitrogen | ND | ND | ND | | 0 | 0.13 mg/L (Site 13) | 2 mg/L (Sites 7 &12) |
| | Total phosphorus | 9 | NA | NA | | 1 | <0.005 mg/L (Site 9) | 1.2 mg/L (Site 7) |
| | Soluble reactive phosphorus | 4 | NA | NA | | 29 | <0.005 mg/L (thirteen sites) | 0.62 mg/L (Site 12) |

**Key**

| | |
|---|---|
| 1 | Out of 60 samples from all sites |
| 2 | Out of 20 samples from all sites |
| 3 | Out of 8 samples from three sites (15, 16 and ROSSTAFE) |
| 4 | Out of 20 samples from six sites (15, 16, ROSSTAFE, 13, 14 and 6) |
| 5 | Out of 52 samples from 13 sites (all sites except 15 and 16) |
| 6 | Out of 12 samples from 12 sites (all sites except 15, 16 and ROSSTAFE) |
| 7 | Includes samples with pH <6.5 exceeding the low reliability interim value for freshwater protection |
| LOR | Limit of reporting |
| NA | Not applicable |
| ND | No defined trigger value |

**Table 1.1-1 (continued): Summary of water quality and sediment results for 2016**

| WATER | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Group | Parameter | NUMBER OF SAMPLES EXCEEDING/EQUAL TO WATER QUALITY TRIGGER VALUES | | | | RANGE OF RESULTS | | |
| | | Lowland rivers/ Wetlands | FW protection | Rec. value | Interim Guideline | N° samples < LOR | Minimum (Site) | Maximum (Site) |
| Total Metals | Aluminium[2] | NA | 18[7] | 14 | | 0 | 0.03mg/L (Sites 10 &11) | 1 mg/L (Site 7) |
| | Arsenic[3] | NA | 0 | NA | | 8 | <0.001 mg/L (all samples) | NA |
| | Cadmium[3] | NA | 0 | NA | | 8 | <0.0001 mg/L (all samples) | NA |
| | Chromium[2] | NA | 0 | NA | | 15 | <0.001 mg/L (eight sites) | 0.002 mg/L (Sites 15, 13, 6, 7) |
| | Cobalt[3] | NA | 0 | NA | | 8 | <0.001 mg/L (all samples) | NA |
| | Copper[2] | NA | 4 | NA | | 4 | <0.001 mg/L (four sites) | 0.013 mg/L (Site 7) |
| | Iron[2] | NA | NA | NA | 16 | 0 | 0.091 mg/L (Site 11) | 6.3 mg/L (Site 5) |
| | Nickel[3] | NA | 0 | NA | | 6 | <0.001 mg/L (three sites) | 0.002 mg/L (Sites 15 & 16) |
| | Lead[2] | NA | 1 | NA | | 13 | <0.001 mg/L (seven sites) | 0.095 mg/L (Site 12) |
| | Manganese[3] | NA | 0 | NA | | 0 | 0.004 mg/L (Site 16) | 0.021 mg/L (Site 15) |
| | Mercury[4] | NA | 0 | 0 | | 15 | <0.0001 mg/L (six sites) | 0.0003 mg/L (Site 6) |
| | Molybdenum[3] | NA | 0 | NA | | 6 | <0.001 mg/L (three sites) | 0.001 mg/L (Site 15) |
| | Selenium[3] | NA | 0 | NA | | 8 | <0.001 mg/L (all samples) | NA |
| | Zinc[2] | NA | 10 | NA | | 0 | 0.005 mg/L (Site 2) | 0.24 mg/L (Site 12) |
| Soluble Metals | Aluminium[5] | NA | 43[7] | 18 | | 0 | 0.012 mg/L (Site 11) | 0.99 mg/L (Site 9) |
| | Chromium[5] | NA | 0 | NA | | 36 | <0.001 mg/L (12 sites) | 0.003 mg/L (Site 12) |
| | Copper[5] | NA | 4 | NA | | 31 | <0.001 mg/L (ten sites) | 0.013 mg/L (Site 7) |
| | Iron[5] | NA | NA | NA | 42 | 0 | 0.059 mg/L (Site 11) | 5.8 mg/L (Site 5) |
| | Lead[5] | NA | 1 | NA | | 35 | <0.001 mg/L (11 sites) | 0.092 mg/L (Site 12) |
| | Mercury[3] | NA | 0 | NA | | 15 | <0.0001 mg/L (all samples) | NA |
| | Zinc[5] | NA | 17 | NA | | 0 | 0.003 mg/L (Site 11) | 0.24 mg/L (Site 12) |

**Key**

| | |
|---|---|
| 1 | Out of 60 samples from all sites |
| 2 | Out of 20 samples from all sites |
| 3 | Out of 8 samples from three sites (15, 16 and ROSSTAFE) |
| 4 | Out of 20 samples from six sites (15, 16, ROSSTAFE, 13, 14 and 6) |
| 5 | Out of 52 samples from 13 sites (all sites except 15 and 16) |
| 6 | Out of 12 samples from 12 sites (all sites except 15, 16 and ROSSTAFE) |
| 7 | Includes samples with pH <6.5 that exceed the low reliability interim value for freshwater protection |
| LOR | Limit of reporting |
| NA | Not applicable |
| ND | No defined trigger value |

**Table 1.1-1 (continued): Summary of water quality and sediment results for 2016**

| SEDIMENT | | | | | | |
|---|---|---|---|---|---|---|
| Group | Parameter | NUMBER OF SAMPLES EXCEEDING/EQUAL TO SEDIMENT QUALITY TRIGGER VALUES | | RANGE OF RESULTS | | |
| | | Low Trigger Value | High Trigger Value | N° samples < LOR | Minimum | Maximum |
| Total metals[6] | Aluminium | ND | ND | 0 | 510 mg/kg (Site 6) | 30000 mg/kg (Site 13) |
| | Arsenic | 0 | 0 | 4 | <0.5 mg/kg (Sites 2, 6, 9 and 12) | 7.1 mg/kg (Site 7) |
| | Chromium | 1 | 0 | 0 | 1.2 mg/kg (Sites 14 and 6) | 180 mg/kg (Site 13) |
| | Copper | 2 | 0 | 2 | <0.5 mg/kg (Sites 14 and 6) | 95 mg/kg (Site 13) |
| | Iron | ND | ND | 0 | 180 mg/kg (Site 9) | 57000 mg/kg (site PSDTBCMD |
| | Lead | 5 | 0 | 0 | 1.2 mg/kg (Site 6) | 200 mg/kg (Site 10) |
| | Mercury | 1 | 0 | 7 | <0.1 mg/kg (7 sites) | 0.2 mg/kg (Site 7) |
| | Nickel | 1 | 0 | 6 | <1 mg/kg (six sites) | 21 mg/kg (Site 13) |
| | Selenium | ND | NA | 10 | <1 mg/kg (10 sites) | 2.9 mg/kg (Site 7) |
| | Zinc | 2 | 0 | 0 | 1.4 mg/kg (Site 9) | 390 mg/kg (Site 13) |

**Key**

| | |
|---|---|
| 1 | Out of 60 samples from all sites |
| 2 | Out of 20 samples from all sites |
| 3 | Out of 8 samples from three sites (15, 16 and ROSSTAFE) |
| 4 | Out of 20 samples from six sites (15, 16, ROSSTAFE, 13, 14 and 6) |
| 5 | Out of 52 samples from 13 sites (all sites except 15 and 16) |
| 6 | Out of 12 samples from 12 sites (all sites except 15, 16 and ROSSTAFE) |
| 7 | Includes samples with pH <6.5 exceeding the low reliability interim value for freshwater protection |
| LOR | Limit of reporting |
| NA | Not applicable |
| ND | No defined trigger value |

## 1.2 Pertinent results (2016 and long-term) and recommendations per site

### 1. Bull Creek main drain (PSDTBCMD):

#### 1.1 2016 Sampling

During the sampling events held in 2016, this site recorded values outside of trigger values for **water** samples:

1.1.1 **Dissolved oxygen** saturations below the lower acceptable limit for lowland rivers (80%) during all four sampling occasions, from 50% to 64.4%.

1.1.2 **Electrical conductivity** levels above the upper acceptable limit for lowland rivers (0.3 mS/cm) on all four sampling occasions, with values from 0.519 mS/cm to 0.779 mS/cm.

1.1.3 **Total nitrogen** concentrations above the trigger value for lowland rivers (1.2 mg/L) on all four sampling occasions, with concentrations ranging from 2 mg/L to 3.5 mg/L.

1.1.4 **Total oxidised nitrogen** concentrations above the trigger value for lowland rivers (0.15 mg/L) on all four sampling occasions, with concentrations from 1.3 mg/L to 2.6 mg/L. This site recorded the four highest concentrations in the catchment.

1.1.5 **Nitrogen as ammonia/ammonium** concentrations above the trigger value for lowland rivers (0.08 mg/L) on all four sampling occasions, with concentrations from 0.23 mg/L to 0.6 mg/L.

1.1.6 **Total aluminium** concentration above the 95% freshwater protection trigger value (0.055 mg/L) when a sample was collected in July (0.2 mg/L) and **soluble aluminium** concentrations above the trigger value during all four sampling occasions (with concentrations from 0.12 to 0.18 mg/L).

1.1.7 **Total iron** concentration above the interim guideline (0.3 mg/L) in July (0.54 mg/L) and **soluble iron** above the interim guideline on all four sampling occasions with concentrations from 0.3 mg/L to 0.34 mg/L.

1.1.8 **Soluble zinc** concentrations above the 95% freshwater protection hardness modified trigger values on two out of four sampling occasions (September and October) with concentrations ranging from 0.013 mg/L to 0.025 mg/L.

All of the analysed **total metals** in **sediment** had concentrations greater than limits of reporting when tested in October: aluminium, arsenic, chromium, copper, iron (highest in the catchment), lead, nickel, selenium and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were silt (57.58%) and clay (11.36%).

### 1.2 Long term findings

1.2.1 **Dissolved oxygen** has generally recorded saturations below the acceptable range for lowland rivers.

1.2.2 **Electrical conductivity** has always been above the acceptable range for lowland rivers.

1.2.3 **Total nitrogen** has generally concentrations exceeding the trigger value for lowland rivers.

1.2.4 **Total oxidised nitrogen** has generally recorded concentrations exceeding the trigger value for lowland rivers. This site has consistently recorded the highest by far NOx concentrations in the catchment.

1.2.5 **Nitrogen as ammonia/ammonium** has generally recorded concentrations exceeding the trigger value for lowland rivers.

1.2.6 **Total** and **soluble aluminium** has always exceeded the 95% freshwater protection trigger value (or low reliability interim value when pH<6.5).

1.2.7 **Total and soluble iron** concentrations have generally exceeded the interim guideline.

### 1.3 Recommendations for site

1.3.1 Implementation of the current Bull Creek Reserve Management plan (updated 2014) to ensure that the restoration of the foreshore is congruent with the long term stability of the natural waterway's ecological and drainage functions.

1.3.2 Continue and extend the current floodplain restoration works throughout the Bull Creek reserve.

1.3.3 Macroinvertebrate surveys throughout the Bull Creek main drain (starting at site 2 through to PSDTBCMD) are recommended to gauge the impact nitrogen as ammonia/ammonium contamination is having on the ecological health of the system. Further to macroinvertebrate surveys, mosquito dipping coupled with the water quality information should also be conducted as a comparable study on the overall health of the ecosystem.

1.3.4 Consider including a new sampling site at the outfall of Bull Creek to the Canning River to the nitrogen load actually entering the river. As the terminal end of the Bull Creek main drain flows through a wetland, it is possible that some of the nitrogen present at site PSDTBCMD may be filtered from the drain before entering the river. As the vegetation in this area is very dense, the accessibility of such a site will need to be assessed.

## 2. Brockman Park (site 2):

### 2.1 2016 Sampling

During the sampling events held in 2016, this site recorded values outside of trigger values for **water** samples:

2.1.1 **pH** below the lower acceptable limit for lowland rivers (6.5) on all four sampling events, with pH values from 6.16 to 6.26.

2.1.2 **Dissolved oxygen** saturations below the lower acceptable limit for lowland rivers (80%) on all four sampling events, with saturations ranging from 42% to 50.9%.

2.1.3 **Electrical conductivity** levels above the upper acceptable limit for lowland rivers (0.3 mS/cm) on all four sampling events, with values from 0.656 mS/cm to 0.828 mS/cm.

2.1.4 **Total nitrogen** concentrations above the trigger value for lowland rivers (1.2 mg/L) on all four sampling events, with concentrations from 4.8 mg/L to 6.9 mg/L. This site recorded the highest concentrations in the catchment.

2.1.5 **Total oxidised nitrogen** concentrations exceeded the trigger value for lowland rivers (0.15 mg/L) on all four sampling occasions, with concentrations from 0.16 mg/L to 0.22 mg/L.

2.1.6 **Nitrogen as ammonia/ammonium** concentrations above adjusted trigger values for 95% level of protection of the environment and the lowland rivers trigger value (0.08 mg/L) on all four sampling events, with concentrations from 4 mg/L to 6.2 mg/L. This site recorded the highest concentrations of this parameter in the catchment.

2.1.7 **Total aluminium** concentration above the low reliability interim value (0.008 mg/L) when a sample was collected in July (0.29 mg/L) and **soluble aluminium** concentrations above the interim value on all four sampling occasions (with concentrations from 0.21 mg/L to 0.25 mg/L).

2.1.8 **Total iron** concentration above the interim guideline (0.3 mg/L) when sample was collected in July (1.5 mg/L) and **soluble iron** concentrations above the interim guideline on all four sampling occasions with concentrations from 0.99 mg/L to 1.3 mg/L.

2.1.9 **Soluble zinc** concentration above the 95% freshwater protection hardness modified trigger values at one out of four sampling occasions (September) with concentrations ranging from 0.005 mg/L to 0.028 mg/L.

Several of the analysed **total metals** in **sediment** had concentrations greater than limits of reporting when tested in October: aluminium, iron, chromium, copper, lead and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were Medium sand (59.43%) and coarse sand (38%).

## 2.2 Long term findings

2.2.1 **pH** has generally below the lower acceptable limit for lowland rivers.

2.2.2 **Dissolved oxygen** saturations have always been below the lower acceptable limit for lowland rivers.

2.2.3 **Electrical conductivity** levels have always been above the upper acceptable limit for lowland rivers.

2.2.4 **Total nitrogen** concentrations have always been above the trigger value for lowland rivers.

2.2.5 **Nitrogen as ammonia/ammonium** concentrations have always been above the trigger value and have consistently recorded some of the highest concentrations in the catchment.

2.2.6 **Total and soluble aluminium** concentrations have always exceeded the 95% freshwater protection trigger value (or low reliability interim value when pH<6.5).

2.2.7 **Total and soluble iron** concentrations have always exceeded the interim guideline.

## 2.3 Recommendations for site

2.3.1 Implementation of the current Bull Creek Reserve Management plan (updated 2014) to ensure that the restoration of the foreshore is congruent with the long term stability of the natural waterway's ecological and drainage functions.

2.3.2 Continue and extend the current floodplain restoration works throughout the Bull Creek reserve.

2.3.3 Further investigation to determine the source of the very high nitrogen as ammonia/ammonium concentrations at Brockman Park is highly recommended, as this ammonia/ammonium appears to be contributing a significant amount of the total nitrogen into Bull Creek. The water body at Trevor Gribble Park could be sampled to determine whether this is the cause, as could the small local drainage lines feeding into the site.

2.3.4 Primary physical treatment is required prior to the Brockman Park stormwater pipe inlet to prevent gross pollutants, particulate matter and sediment entering Bull Creek Park waterway and its foreshore. Sediment deposition within the park has been observed by SERCUL staff on multiple occasions and a source investigation has been conducted by SERCUL and Water Corporation staff. Sediment was tracked as far upstream as Earnest Wild Park on the Water Corp main drain and appears to be coming from the City of Melville local drainage system. Further investigation into the source is required to develop appropriate management actions.

2.3.5 The existing inlet structure requires regular maintenance to remove gross pollutants and sediment. Maintenance should be conducted once a year at minimum, preferably in autumn.

2.3.6 The implementation of an on-site and desktop drainage mapping investigation identified Trevor Gribble Park as a potential source for the sediment dumping occurring at site 2, as it has a large sandy compensation basin directly connected to the main drainage line upstream of Brockman Park. It is therefore recommended that stabilisation of this area through native revegetation and or structural sediment traps to minimise soil/sand exposure and potential movement down the system in a storm event.

2.3.7 Consider the installation of natural oxygenation features (river restoration technologies e.g. riffles) downstream of site 2 to allow nitrification of the high ammonia concentrations to occur. Rock riffles are also a natural barrier creating sediment traps, or dumping points reducing the amount of sediment moving through the system.

2.3.8 Macroinvertebrate surveys throughout the Bull Creek main drain (starting at site 2 through to PSDTBCMD) are recommended to gauge the impact nitrogen as ammonia/ammonium contamination is having on the ecological health of the system. Further to macroinvertebrate surveys, mosquito dipping coupled with the water quality information should also be conducted as a comparable study on the overall health of the ecosystem.

## 3. Brockman Park inlet (ROSSTAFE):

### 3.1 2016 Sampling

During the sampling events held in 2016, this site recorded values outside of trigger values for **water** samples:

3.1.1 **Dissolved oxygen** saturations below the lower acceptable limit for lowland rivers (80%) on three out of the four sampling occasions (July, August and September), with saturations ranging from 74.5% to 84%.

3.1.2 **Electrical conductivity** levels above the upper acceptable limit for lowland rivers (0.3 mS/cm) during all four sampling occasions, with values from 0.7 mS/cm to 0.78 mS/cm.

3.1.3 **Total nitrogen** concentrations equal to or above the trigger values for lowland rivers (1.2 mg/L) on three of the four sampling events (July, August and September), with concentrations ranging from 1 mg/L to 1.5 mg/L.

3.1.4 **Total oxidised nitrogen** concentrations above the trigger value for lowland rivers (0.15 mg/L) on all four sampling occasions, with concentrations from 0.49 mg/L to 0.9 mg/L.

3.1.5 **Nitrogen as ammonia/ammonium** concentrations above the trigger value for lowland rivers (0.08 mg/L) at one out of four sampling events (July), with concentrations from 0.051 mg/L to 0.096 mg/L.

3.1.6 **Total aluminium** concentration above the 95% freshwater protection trigger value (0.055 mg/L) when a sample was collected in July (0.22 mg/L) and **soluble aluminium** concentrations above the trigger value during all four sampling occasions (with concentrations from 0.15 mg/L to 0.25 mg/L).

### 3.2 Recommendations for site

3.2.1 Continue to include the analysis of Brockman Park inlet site (ROSSTAFE) in the City of Melville Bull Creek monitoring program, which if funded by the City of Canning in the Bull Creek East monitoring program as a part of the implementation of the WQIP. This site was included to enable comparison with the water quality coming upstream from Brockman Park and the effects on the water quality downstream at Bull Creek main drain (PSDTBCMD) located in the bottom of the sub-catchment and the Canning River as the final receiving environment.

## 4. John Creaney Park outlet (site 5):

### 4.1 2016 Sampling

During the sampling events held in 2016, this site recorded values outside of trigger values for **water** samples:

4.1.1 **pH** was below the lower acceptable limit for lowland rivers (6.5) on all four sampling events, with pH values from 6.22 to 6.4.

4.1.2 **Dissolved oxygen** saturations below the lower acceptable limit for lowland rivers (80%) on all four sampling events, with saturations ranging from 10.1% to 45.4%.

4.1.3 **Electrical conductivity** levels above the upper acceptable limit for lowland rivers (0.3 mS/cm) on all four sampling events, from 0.371 mS/cm to 0.81 mS/cm.

4.1.4 **Total suspended solids** concentrations above the interim guideline (6 mg/L) at one of the four sampling occasions (July), with concentrations ranging from 1 mg/L to 8 mg/L.

4.1.5 **Nitrogen as ammonia/ammonium** concentrations above the trigger value for lowland rivers (0.08 mg/L) on three of the four sampling events (July, August and October), with concentrations from 0.048 mg/L to 0.4 mg/L.

4.1.6 **Total phosphorus** concentrations above the trigger value for lowland rivers (0.065 mg/L) on one out of four sampling occasions (July), with concentrations from 0.022 mg/L to 0.098 mg/L.

4.1.7 **Soluble reactive phosphorus** concentrations above the trigger value for lowland rivers (0.04 mg/L) on one out of four sampling occasions (July), with concentrations from <0.005 mg/L to 0.061 mg/L.

4.1.8 **Total aluminium** concentration above the low reliability interim value (0.008 mg/L) when a sample was collected in July (0.16 mg/L) and **soluble aluminium** concentrations above the interim value on all four sampling occasions (with concentrations from 0.06 mg/L to 0.13 mg/L).

4.1.9 **Soluble copper** concentration above the hardness modified trigger value for 95% freshwater protection at one out of four sampling occasions (September), with concentrations from <0.001 mg/L to 0.002 mg/L).

4.1.10 **Total iron** concentration above the interim guideline (0.3 mg/L) when sample was collected in July (1.5 mg/L) and **soluble iron** concentrations above the interim guideline on all four sampling occasions with concentrations from 0.34 mg/L to 5.8 mg/L. This site recorded the highest soluble iron concentration in the catchment of 5.8 mg/L in July.

4.1.11 **Soluble zinc** concentration above the 95% freshwater protection hardness modified trigger values at one out of four sampling occasions (September) with concentrations ranging from 0.016 mg/L to 0.04 mg/L.

Several of the analysed **total metals in sediment** had concentrations greater than limits of reporting when tested in October: aluminium, arsenic, chromium, copper, iron, lead (exceeding the low trigger value), mercury, nickel and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were gravel (31.20%) and silt (28.22%).

### 4.2 Long term findings

4.2.1 **pH values** have often below the acceptable range for lowland rivers.

4.2.2 **Dissolved oxygen** saturations have generally been below the lower acceptable limit for lowland rivers. Generally this site has recorded the lowest dissolved oxygen saturations in the catchment.

4.2.3 **Electrical conductivity** levels have generally been above the acceptable range for lowland rivers.

4.2.4 **Total nitrogen** concentrations have often exceeded the trigger value for lowland rivers.

4.2.5 **Nitrogen as ammonia/ammonium** concentrations have generally been above the lowland rivers trigger value.

4.2.6 **Total phosphorus** concentrations have often exceeded the lowland rivers trigger value.

4.2.7 **Total** and **soluble iron** concentrations have generally been above the interim guideline.

4.2.8 **Total** and **soluble aluminium** concentrations have generally been above the 95% freshwater protection trigger value (or low reliability interim value when pH<6.5).

### 4.3 Recommendations for site

4.3.1 Continued monitoring of the sediment and water at site 5 will allow the potential risk of zinc toxicity to biota within the lake (as indicated by the high total zinc at site 15) to be assessed.

4.3.2 Major basin redesign and restoration is required including the installation of a gross pollutant trapping system to prevent the continued contamination of John Creaney wetland and the downstream receiving environment which includes Bull Creek Park and the Canning River. As part of this restoration, consider dredging and disposing of any silty and/or possibly organic sediment at this site.

4.3.3 In previous years, significant amounts of lawn clippings were observed to be entering the water at John Creaney Park from adjacent park management. Restoration should include creating a buffer between lawn and wetland area to reduce organic load entering the basin.

## 5. John Creaney Park inlet (MELDR 15):

### 5.1 2016 Sampling

During the 2016 sampling events this site recorded values outside of trigger values for the following parameters in **water** samples:

5.1.1 **pH** below the lower acceptable range for lowland rivers (6.5) at one of the four sampling events (September), with pH values from 6.46 to 6.61.

5.1.2 **Dissolved oxygen** saturations below the lower acceptable limit for lowland rivers (80%) on all four sampling events, with saturations ranging from 42.9% to 45.8%.

5.1.3 **Electrical conductivity** exceeded the upper acceptable limit for lowland rivers (0.3 mS/cm) on all four sampling occasions ranging from 0.344 mS/cm to 0.682 mS/cm.

5.1.4 **Total suspended solids** concentrations above the interim guideline (6 mg/L) at one of the four sampling events (August), with concentrations from 1 to 8 mg/L.

5.1.5 **Total oxidised nitrogen** concentrations were above the trigger value for lowland rivers (0.15 mg/L) on two out of four sampling occasions (July and August), with concentrations from 0.14 to 0.37 mg/L.

5.1.6 **Nitrogen as ammonia/ammonium** concentrations above the trigger value for lowland rivers (0.08 mg/L) at one out of four sampling events (October), with concentrations from 0.039 mg/L to 0.091 mg/L.

5.1.7 **Total aluminium** concentrations above relevant trigger values (0.055 mg/L or 0.008 mg/L when pH<6.5) on all four sampling occasions with values from 0.19 mg/L to 0.42 mg/L.

5.1.8 **Total iron** concentrations above the interim guideline (0.3 mg/L) on three out of all four sampling occasions (August, September and October), with concentrations from 0.24 mg/L to 1.6 mg/L.

5.1.9 **Total zinc** concentrations exceeded the 95% freshwater protection hardness modified trigger value on all four sampling occasions, with concentrations from 0.041 mg/L to 0.092 mg/L.

As sampling at this site has only occurred for three years, long term trends cannot yet be determined.

### 5.2 Recommendations for site:

5.2.1 Major basin redesign and restoration is required including the installation of a gross pollutant trapping system to prevent the continued contamination of John Creaney wetland and the downstream receiving environment which includes Bull Creek Park, Bateman Park and the Canning River.

5.2.2 Consider analysing water for soluble zinc as well as total zinc in the future, as the soluble zinc concentration will provide a better estimate of the amount of zinc that could be toxic to biota.

## 6. Downstream Elizabeth Manion Park (MELDR 16):

### 6.1 2016 Sampling

During the 2016 sampling events this site recorded values outside of trigger values for the following parameters in **water** samples:

6.1.1 **Dissolved oxygen** saturations below the lower acceptable limit for lowland rivers (80%) during at one of the three sampling events (July), with saturations ranging from 68.1% to 87.8%.

6.1.2 **Electrical conductivity** exceeded the upper acceptable limit for lowland rivers (0.3 mS/cm) at two of the three sampling occasions (July and August), from 0.219 mS/cm to 0.432 mS/cm.

6.1.3 **Total suspended solids** concentrations above the interim guideline (6 mg/L) at one of the three sampling events (July), with concentrations from 1 to 13 mg/L.

6.1.4 **Total oxidised nitrogen** concentrations above the trigger value for lowland rivers (0.15 mg/L) at all three sampling occasions, with concentrations ranging from 0.15 mg/L to 0.16 mg/L.

6.1.5 **Total iron** concentrations above the interim guideline (0.3 mg/L) at all three sampling occasions, with concentrations from 0.33 mg/L to 1.1 mg/L.

6.1.6 **Total aluminium** concentrations above the 95% freshwater protection trigger value (0.055 mg/L) at all three sampling occasions with concentrations from 0.14 mg/L to 0.51 mg/L.

6.1.7 **Total copper** concentrations above adjusted trigger values on two out of three sampling occasions (July and September), with concentrations from 0.003 to 0.005 mg/L

6.1.8 **Total zinc** concentrations exceeded the 95% freshwater protection hardness modified trigger values on all three sampling occasions, with concentrations from 0.032 mg/L to 0.12 mg/L.

As sampling at this site has only occurred for three years, long term trends cannot yet be determined.

### 6.2 Recommendations:

6.2.1 Consider analysing water for soluble zinc as well as total zinc in the future, as the soluble zinc concentration will provide a better estimate of the amount of zinc that could be toxic to biota.

## 7. Bateman Park (site 6):

### 7.1 2016 Sampling

During the sampling events held in 2016, this site recorded values outside of trigger values for the following parameters in **water** samples:

7.1.1 **Dissolved oxygen** saturations below the lower acceptable limit for lowland rivers (80%) on all four sampling occasions, with saturations from 54.9% to 58.8%.

7.1.2 **Electrical conductivity** levels above the upper acceptable limit for lowland rivers (0.3 mS/cm) on all four sampling events, from 0.56 mS/cm to 0.646 mS/cm.

7.1.3 **Total suspended solids** above the interim guideline (6 mg/L) at two of four sampling events (August and September), with concentrations from 5 to 7 mg/L.

7.1.4 **Total oxidised nitrogen** concentrations above the trigger value for lowland rivers (0.15 mg/L) on all four sampling occasions with concentrations from 0.21 mg/L to 0.34 mg/L.

7.1.5 **Nitrogen as ammonia/ammonium** concentrations exceeded the trigger value for lowland rivers (0.08 mg/L) on all four sampling events, with concentrations from 0.085 mg/L to 0.15 mg/L.

7.1.6 **Total iron** concentration above the interim guideline (0.3 mg/L) when sample was collected in July (2.1 mg/L) and **soluble iron** concentrations above the interim guideline on all four sampling occasions with concentrations from 0.59 mg/L to 1.2 mg/L.

7.1.7 **Total aluminium** concentration above the 95% freshwater protection trigger value (0.055 mg/L) when a sample was collected in July (0.42 mg/L) and **soluble aluminium** concentrations above the trigger value during all four sampling occasions (with concentrations from 0.077 mg/L to 0.11 mg/L).

7.1.8 **Soluble zinc** concentration above the 95% freshwater protection hardness modified trigger value at one out of four sampling occasions (August), with concentrations from 0.008 mg/L to 0.066 mg/L).

Several of the analysed **total metals in sediment** had concentrations greater than limits of reporting when tested in October: aluminium, chromium, iron, lead and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were medium sand (58.82%) and coarse sand (28.40%).

### 7.2 Long term findings

7.2.1 **Dissolved oxygen** saturations have generally been below the lower acceptable limit for lowland rivers.

7.2.2 **Electrical conductivity** levels have generally been above the upper acceptable limit for lowland rivers.

7.2.3 **Total suspended solids** concentrations have generally been above the interim guideline.

7.2.4 **Total oxidised nitrogen** concentrations have often exceeded the lowland rivers trigger value.

7.2.5 **Nitrogen as ammonia/ammonium** concentrations have always been above the lowland rivers trigger value.

7.2.6 **Total** and **soluble aluminium** concentrations have always been above the 95% freshwater protection trigger value (or low reliability interim value when pH<6.5). This site has often recorded the highest total aluminium concentrations.

7.2.7 **Total** and **soluble iron** concentrations have always been above the interim guideline.

### 7.3 Recommendations for site:

7.3.1 Continue supporting the Brentwood living stream restoration project.

7.3.2 Liaise with Main roads regarding the planned upgrade of upstream basin.

## 8. Brentwood drain (site 13):

### 8.1 2016 Sampling

During the sampling events held in 2016, this site recorded values outside of trigger values for:

8.1.1 **Dissolved oxygen** saturations below the lower acceptable limit for lowland rivers (<80%) on all four sampling events, with saturation from 57.3% to 68.5%.

8.1.2 **Electrical conductivity** levels above the upper acceptable limit for lowland rivers (0.3 mS/cm) on all four sampling events, from 0.4632 mS/cm to 0.619 mS/cm.

8.1.3 **Total suspended solids** equal or above the interim guideline (6 mg/L) on three of the four sampling occasions (July, August and September), with concentrations from 1 to 11 mg/L.

8.1.4 **Total oxidised nitrogen** concentrations above the trigger values for lowland rivers (0.15 mg/L) on all four sampling occasions, with concentrations from 0.26 mg/L to 0.34 mg/L.

8.1.5 **Nitrogen as ammonia/ammonium** concentrations above the trigger value for lowland rivers (0.08 mg/L) on all four sampling events, with concentrations from 0.13 mg/L to 0.16 mg/L.

8.1.6 **Total iron** concentration above the interim guideline (0.3 mg/L) when sample was collected in July (2.3 mg/L) and **soluble iron** concentrations above the interim guideline on all four sampling occasions with concentrations from 1.3 mg/L to 2.3 mg/L.

8.1.7 **Total aluminium** concentration above the 95% freshwater protection trigger value (0.055 mg/L) when a sample was collected in July (0.54 mg/L) and **soluble aluminium** concentrations above the trigger value during all four sampling occasions (with concentrations from 0.11 mg/L to 0.19 mg/L).

Several of the analysed **total metals in sediment** had concentrations greater than limits of reporting when tested in October: aluminium (highest in the catchment), arsenic, iron, chromium (exceeding the low trigger value and the highest in the catchment), copper (exceeding the low trigger value and the highest in the catchment), lead (exceeding the low trigger value), nickel (exceeding the low trigger value and the highest in the catchment) and zinc (exceeding the low trigger value and the highest in the catchment). Particle size analysis showed that the dominant fractions of sediment recorded at this site were medium sand (60.26%) and coarse sand (35.80%).

As sampling at this site has only occurred for four years, long term trends cannot yet be determined.

### 8.2 Recommendations for site:

8.2.1 Continue supporting the Brentwood Living Stream restoration project.

8.2.2 The locations of this site may change slightly with the reconstruction of the two drains in the Brentwood Living Stream project, however it is extremely important to continue monitoring this site for changes to the water quality (before, during and after construction) to examine the impact/effectiveness of the restoration works. Furthermore, Water Corporation and Main roads are in the planning stages for the reconstruction of the upstream Cloverleaf compensating basin (located at the off ramp of Leach Highway to Kwinana Freeway South bound) to mitigate the poor water quality issues from the freeway runoff and subsequently reduce negative impacts in the Brentwood drain downstream. Water quality monitoring results at site 13 will allow for the assessment of the impact of these works on the overall outcome of the Brentwood Living Stream project.

8.2.3 The rock riffles installed as part of the Brentwood Living stream project will trap sediment that will require routine removal by the Water Corporation as part of its ongoing maintenance plan agreement.

## 9. RAAF drain (site 14):

### 9.1 2016 Sampling

During the four sampling events held in 2016, this site recorded values outside of trigger values for the following parameters:

9.1.1 **Dissolved oxygen** saturations below the lower acceptable limit for lowland rivers (<80%) at one of the four sampling events (July), with saturations from 78.5% to 87.5%.

9.1.2 **Electrical conductivity** levels above the upper acceptable limit for lowland rivers (0.3 mS/cm) on all four sampling events, from 0.445 mS/cm to 0.665 mS/cm.

9.1.3 **Total oxidised nitrogen** concentrations above the trigger values for lowland rivers (0.15 mg/L) on three out of four sampling occasions (July, August and September), with concentrations from 0.24 mg/L to 0.31 mg/L.

9.1.4 **Total aluminium** concentration above the 95% freshwater protection trigger value (0.055 mg/L) when a sample was collected in July (0.11 mg/L) and **soluble aluminium** concentrations above the trigger value during all four sampling occasions (with concentrations from 0.059 mg/L to 0.078 mg/L).

9.1.5 **Total iron** concentration above the interim guideline (0.3 mg/L) when sample was collected in July (0.45 mg/L) and **soluble iron** concentrations above the interim guideline on three out of four sampling occasions (July, August, and October) with concentrations from 0.26 mg/L to 0.4 mg/L.

9.1.6 **Soluble zinc** concentration above the 95% freshwater protection hardness modified trigger value at one out of four sampling occasions (August), with concentrations from 0.008 mg/L to 0.03 mg/L).

Several of the analysed **total metals in sediment** had concentrations greater than limits of reporting when tested in October: aluminium, arsenic, chromium, iron, lead and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were coarse sand (52%) and medium sand (46.58%).

As sampling at this site has only occurred for four years, long term trends cannot yet be determined.

### 9.2 Recommendations for site:

9.2.1 Continued monitoring of this site to help identify which branch of the drainage line is contributing the greater concentrations of nutrient and non-nutrient pollutants recorded at Bateman Park (site 6).

9.2.2 Although the sources of cat site 14 (RAAF drain) cannot be determined from the results of this monitoring (as there are no sites sampled upstream of site 14), it may of benefit to consider providing education materials to the grounds staff at the RAAF nursing home facility to ensure optimal management of the lake there. This may result in decreased concentrations of total oxidised nitrogen and metals. This may include:

- Information about the implications of excess nutrients in waterways and how to reduce fertiliser application. SERCUL's Phosphorus Awareness Project brochure may be a good starting point (http://sercul.org.au/docs/PAP.pdf).
- Information about the benefits of fringing vegetation around wetlands. Planting fringing vegetation (particularly sedges) around the lake within the facility may help to reduce nutrient and metal concentrations in lake water.

## 10. Booragoon Lake outlet (site 7)

### 10.1 <u>2016 Sampling</u>

During the sampling events held in 2016, this site recorded values outside of trigger values for:

10.1.1 **pH** below the lower acceptable limit for wetlands (<7) on three of the four sampling events (July, August and September), with pH values from 3.55 to 6.55. This site recorded the lowest pH in the catchment (3.55) in September.

10.1.2 **Dissolved oxygen** saturations below the lower acceptable limit for wetlands (<90%) on all four sampling events, with saturations from 8.9% to 56.4%.

10.1.3 **Electrical conductivity** levels above the upper acceptable limit for wetlands (1.5 mS/cm) during all four sampling events, from 1.671 mS/cm to 2.449 mS/cm. This site recorded the highest levels of electrical conductivity in the catchment all of which were classified as marginal (0.965 mS/cm to 1.952 mS/cm) or brackish (>1.953 mS/cm but <8.835 mS/cm).

10.1.4 **Total suspended solids** concentrations above the interim guideline (6 mg/L) at two of the four sampling events (July and September), with concentrations from 1 mg/L to 15 mg/L.

10.1.5 **Total nitrogen** concentrations above the trigger value for wetlands (1.5 mg/L) at one of the four sampling events (October), with concentrations from 0.44 mg/L to 3 mg/L. This site, along with site 12, also had the highest dissolved organic nitrogen and total organic nitrogen concentrations in the catchment.

10.1.6 **Nitrogen as ammonia/ammonium** concentrations above the trigger value for wetlands (0.04 mg/L) on two out of four sampling events (July and October), with concentrations from 0.023 to 0.64 mg/L.

10.1.7 **Total phosphorus** concentrations above the trigger value for wetlands (0.06 mg/L) on all four sampling events, with concentrations from 0.11 mg/L to 1.2 mg/L. This site recorded the highest concentration in the catchment in October.

10.1.8 **Soluble reactive phosphorus** concentrations above the trigger value for wetlands (0.03 mg/L) at one of the four sampling events (October), with concentrations from 0.005 mg/L to 0.61 mg/L. This site recorded the second highest concentration in the catchment in October (after Blue Gum Lake outlet).

10.1.9 **Total iron** concentration above the interim guideline (0.3 mg/L) when a sample was collected in July (5.2 mg/L, the second highest concentration in the catchment after site 5) and **soluble iron** concentrations above the interim guideline on all four sampling occasions with concentrations from 2.7 mg/L to 3.9 mg/L. This site recorded the highest concentration in the catchment of 5.8 mg/L in July.

10.1.10 **Total aluminium** concentrations above the low reliability interim value (0.008 mg/L) when a sample was collected in July (1 mg/L) and **soluble aluminium** concentrations above relevant trigger values (low reliability interim value when pH<6.5, 95% freshwater protection trigger value when pH>6.5) on three out of four sampling occasions (July, August and September) with values from 0.047 mg/L to 0.89 mg/L.

10.1.11 **Total copper** concentration above the hardness modified trigger value for 95% freshwater protection when a sample was collected in July (0.013 mg/L, the highest concentration in the catchment) and a **soluble copper** concentration above the hardness modified trigger value at one out of four sampling occasions (July), with concentrations from <0.001 mg/L to 0.013 mg/L).

10.1.12 **Total zinc** concentration above the hardness modified trigger value for 95% freshwater protection when a sample was collected in July (0.2 mg/L) and **soluble zinc** concentrations above the hardness modified trigger values on three out of four sampling occasions (July, August and September), with concentrations from 0.019 mg/L to 0.2 mg/L).

All of the analysed **total metals in sediment** had concentrations greater than limits of reporting when tested in October: aluminium, arsenic (highest in the catchment), chromium, copper, iron, lead (exceeding the low trigger value), mercury (exceeding the low trigger value and the highest in the catchment), nickel, selenium (highest in the catchment) and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were silt (47.91%) and gravel (28.9%).

## 10.2 Long term findings

10.2.1 **pH** values have generally been below the acceptable range for wetlands. This site has recorded some of the lowest pH in the catchment along with Blue Gum Lake outlet (site 12) and Piney Lakes outlet (site 8).

10.2.2 **Dissolved oxygen** saturations have generally been below the lower acceptable limit for wetlands. This site has recorded some of the lowest dissolved oxygen in the catchment along with John Creaney Park outlet and Blue Gum Lake outlet.

10.2.3 **Electrical conductivity** levels have generally been above the acceptable range for wetlands. This site has consistently recorded some of the highest electrical conductivity levels in the catchment.

10.2.4 **Total suspended solids** concentrations have generally exceeded the interim guideline.

10.2.5 **Total nitrogen concentrations** have generally been above the wetlands trigger value and this site has recorded some of the highest concentrations in the catchment. This site has also often recorded the highest **dissolved organic nitrogen** concentrations and **total organic nitrogen** concentrations in the catchment along with Blue Gum Lake outlet (site 12).

10.2.6 **Total nitrogen as ammonia/ammonium** concentrations have often exceeded the wetlands trigger value.

10.2.7 **Total phosphorus** and **soluble reactive phosphorus** concentrations have generally exceeded the wetlands trigger value. This site has often recorded the highest total and soluble phosphorus concentrations in the catchment.

10.2.8 **Total** and **soluble iron** concentrations have always exceeded the interim guideline. This site often records the highest total and soluble iron concentrations in the catchment.

10.2.9 **Total aluminium** and **soluble aluminium** concentrations have exceeded the 95% freshwater protection trigger value (or low reliability interim value when pH<6.5) in over half of the collected samples.

## 10.3 Recommendations:

10.3.1 The restoration of the ecological function of the foreshore of Booragoon Lake needs to continue to ensure that the surface water entering via the foreshore is naturally treated prior to entering the lake. Continuing with the planting of large and medium trees as well as sedges within the foreshore are critical to both surface and groundwater treatment. Replacement of weeds with slower growing native species (such as *Baumea articulata*) will result in less organic waste production.

10.3.2 A "grass reduction" program has been implemented to prevent grass (from the edge of the lake to the footpath). This should have some benefit in reducing nutrients entering the lake.

10.3.3 The City of Melville is currently in the planning stages of an intervention program involving the redesigning one of the inlets on the North West side of the lake on Aldridge Rd near Gould place in an effort to improve gross pollution management. The design will also include sedge beds for nutrient filtration and is set to be implemented in the 2017-18 financial year.

10.3.4 Potential and existing acid sulfate soils have be shown to be present in Lake sediments in a preliminary acid sulfate soil investigation, and in combination with relatively low and fluctuating water levels are likely to be producing low pH levels in the lake (Oldweather 2012). It may be possible to neutralise acidity in the lake originating from oxidation of acid sulfate soils with materials such as aglime, sodium bicarbonate, hydrated lime or quicklime as described in Department of Environment Regulation (2015a). This may need to be conducted on an ongoing basis (DER 2015a). It is recommended that a more detailed assessment of the practicality and details of this recommendation be evaluated in liaison with DER. This may also reduce mobilisation of metals from sediment, resulting in lower water concentrations of soluble metals.

10.3.5 Consider speciation testing for zinc and copper to determine the labile (and therefore bioavailable) proportion of these metal concentrations, as a proportion of the metals present may be complexed with dissolved organic material.

## 11. Piney Lakes outlet (site 8):

### 11.1 2016 Sampling

During the sampling events held in 2016, this site recorded values outside of trigger values for:

11.1.1 **pH** below the lower acceptable limit for wetlands (<7) on all four sampling events, with pH values from 5.48 to 6.33.

11.1.2 **Dissolved oxygen** saturations below the lower acceptable limit for wetlands (<90%) on all four sampling events, with saturations from 37.4% to 62.2%.

11.1.3 **Total aluminium** concentration above the low reliability interim value (0.008 mg/L) when a sample was collected in July (0.29 mg/L) and **soluble aluminium** concentrations above the interim value on all four sampling occasions (with concentrations from 0.29 mg/L to 0.46 mg/L).

11.1.4 **Total iron** concentration above the interim guideline (0.3 mg/L) when a sample was collected in July (1.3 mg/L) and **soluble iron** concentrations above the interim guideline on all four sampling occasions with concentrations from 0.81 mg/L to 1.4 mg/L.

11.1.5 **Soluble zinc** concentrations above the 95% freshwater protection hardness modified trigger value on two out of four sampling occasions (August and October), with concentrations from 0.034 mg/L to 0.043 mg/L).

Several of the analysed **total metals in sediment** had concentrations greater than limits of reporting when tested in October: aluminium, arsenic, chromium, copper, iron, mercury, nickel, lead and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were silt (40.27%) and coarse sand (26%).

### 11.2 Long term findings

11.2.1 **pH** values have generally been below the lower acceptable limit for wetlands. This site has often recorded the third lowest pH values in the catchment after Blue Gum Lake outlet and Booragoon Lake.

11.2.2 **Dissolved oxygen** saturations have generally been below the acceptable range for wetlands.

11.2.3 **Total iron** concentrations have always exceeded the interim guideline.

11.2.4 **Total aluminium** concentrations have always exceeded the trigger values (or low reliability interim value when pH<6.5).

### 11.3 Recommendations for site:

11.3.1 As previously low water levels have been observed at this lake, consider monitoring of water levels throughout the year.

11.3.2 Consider conducting an acid sulfate soil investigation at Piney Lakes to determine whether this is the cause of low pH levels, and assess possible mitigation strategies.

11.3.3 It is recommended that a groundwater investigation be conducted to assess the cause(s) of the lowering of water levels at Piney Lakes. This could entail measuring groundwater levels on a seasonal basis at bores at existing or newly installed bores at and in the area surrounding Piney Lakes. Some groundwater abstraction does occur at Piney Lakes to facilitate landscaping of the surrounding parkland.

11.3.4 Further to the above, investigation into ecological water requirements (EWRs) for this EPP (WA 073) groundwater dependant wetland is required to determine the possible risk-of-impact of drawdown on the key elements of wetland ecosystem integrity (ecosystem processes, biodiversity, abundance and biomass of biota and quality of water and sediment) and allow for appropriate mitigation strategies to be devised.

11.3.5 Reducing the amount of grass and implementing hydrozoning of vegetation in parklands surrounding Piney Lakes will help to reduce groundwater abstraction. If local abstraction is the cause of low water levels then reducing abstraction may help to increase keep water levels at the Lakes.

## 12. Blue Gum Lake outlet (site 12):

### 12.1 <u>2016 Sampling</u>

During the sampling events held in 2016, this site recorded values outside of trigger values for:

12.1.1 **pH** below the lower acceptable limit for wetlands (<7) on three of the four sampling events (July, August and September), with pH values from 3.74 to 6.98.

12.1.2 **Dissolved** oxygen saturations below the lower acceptable limit for wetlands (<90%) on three out of four sampling events (August, September and October), with saturations from 14.2% to 90%.

12.1.3 **Total suspended solids** concentrations above the interim guideline (6 mg/L) on three of the four sampling events (July, August and September), with concentrations from 4 to 62 mg/L. This site recorded the highest total suspended solids concentration in the catchment.

12.1.4 **Total nitrogen** concentrations above the trigger value for wetlands (1.5 mg/L) at two of the four sampling events (September and October), with concentrations from 0.63 mg/L to 2.6 mg/L. This site, along with site 7, also had the highest dissolved organic nitrogen and total organic nitrogen concentrations in the catchment.

12.1.5 **Nitrogen as ammonia/ammonium** concentrations above the trigger value for wetlands (0.04 mg/L) on three out of four sampling occasions (August, September and October), with concentrations from 0.028 mg/L to 0.34 mg/L.

12.1.6 **Total phosphorus** concentrations above the trigger value for wetlands (0.06 mg/L) on all four sampling events, with concentrations from 0.14 mg/L to 0.91 mg/L. This site recorded the second and third highest concentrations in the catchment (in October and September respectively).

12.1.7 **Soluble reactive phosphorus** concentrations above the trigger value for wetlands (0.03 mg/L) at two of the four sampling occasions (September and October), with concentrations from <0.005 mg/L to 0.62 mg/L. This site recorded the highest concentration in the catchment in October.

12.1.8 **Total aluminium** concentrations above the low reliability interim value (0.008 mg/L) when a sample was collected in July (0.9 mg/L) and **soluble aluminium** concentrations above relevant trigger values (low reliability interim value when pH<6.5, 95% freshwater protection trigger value when pH>6.5) on all four sampling occasions (July, August and September) with values from 0.12 mg/L to 0.86 mg/L.

12.1.9 **Total iron** concentration above the interim guideline (0.3 mg/L) when sample was collected in July (2.4 mg/L) and **soluble iron** concentrations above the interim guideline on all four sampling occasions with concentrations from 1.2 mg/L to 5.1 mg/L. This site recorded the second highest soluble iron concentration in the catchment of 5.1 mg/L in September.

12.1.10 **Total lead** concentration above the 95% freshwater protection hardness modified trigger value when a samples was collected in July (0.095 mg/L) and a **soluble lead** concentration exceeding the hardness modified trigger value at one out of four sampling occasions (July), with concentrations from 0.002 mg/L to 0.092 mg/L.

12.1.11 **Total zinc** concentration above the hardness modified trigger value for 95% freshwater protection when a sample was collected in July (0.24 mg/L, the highest concentration in the catchment) and **soluble zinc** concentrations above the hardness modified trigger values on three out of four sampling occasions (July, August and September), with concentrations from 0.013 mg/L to 0.24 mg/L, the highest concentration in the catchment).

Several of the analysed **total metals in sediment** had concentrations greater than limits of reporting when tested in October: aluminium, chromium, copper, iron, lead (equal to the low trigger value) and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were medium sand (48.52%) and coarse sand (38.80%).

### 12.2 <u>Long term findings</u>

12.2.1 **pH** has generally been below the acceptable range for wetlands. This site (along with Booragoon Lake and Piney Lakes) has often recorded some of the lowest pH in the catchment.

12.2.2 **Dissolved oxygen** saturations have generally been below the acceptable range for wetlands, particularly from 2013 onwards.

12.2.3 **Total suspended solids** concentrations have often exceeded the interim guideline, often with the highest concentrations in the catchment.

12.2.4 **Total nitrogen** concentrations have generally exceeded the trigger value for wetlands, particularly from 2012 onwards. Along with Booragoon Lake, this site has often recorded the highest total and dissolved organic nitrogen concentrations in the catchment.

12.2.5 **Nitrogen as ammonia/ammonium** concentrations have been above the trigger value for wetlands on the majority of sampling occasions.

12.2.6 **Total phosphorus** and **soluble reactive phosphorus** concentrations have generally exceeded the trigger value for wetlands. After Booragoon Lake, this site has generally recorded the second highest total and soluble phosphorus concentrations in the catchment.

12.2.7 **Total** and **soluble iron** concentrations have always been above the interim guideline. Along with Bateman Park and Booragoon Lake, this site has recorded some of the highest total and soluble iron concentrations in the catchment.

12.2.8 **Total aluminium** and **soluble aluminium** concentrations have generally exceeded the trigger value (or low reliability interim value when pH<6.5).

### 12.3 <u>Recommendations for site:</u>

12.3.1 Continue with the current restoration works on the foreshore of the lake with native species particularly with native sedges and wetland plants.

12.3.2 Based on a site meeting between SERCUL and the City of Melville officers held at the end of 2014 to discuss possible treatment of stormwater entering the south west side of the lake from Karoonda Road, it was recommended to redesign the receiving storm water basin to reduce velocity, increase detention time and interaction with native vegetation. This project is currently in the design stages and implementation is set for the 2017-18 financial year.

12.3.3 Considering the excessively high levels of total and soluble phosphorus it is recommended to investigate possible treatment methods for the control/removal of phosphorus in a wetland environment such as an application program for Phoslock.

12.3.4 Continue the removal and control of invasive species that contribute to the large loads of organic material to the lake.

12.3.5 Create a barrier between the foreshore and lawn verge to prevent encroachment of lawn grasses and weeds to facilitate a definite edge for more efficient park management.

12.3.6 The City of Melville has established an MOU with the tennis club in regards to fertiliser use and the storage of fertiliser within the tennis club precinct which involves regular inspections of the premises and annual meeting to discuss the progress and improvements. The City has established a good working relationship with the club and indicated this is an ongoing commitment to reduce the risk of impact to the Blue Gum Lake and its foreshore.

12.3.7 Following previous recommendation the City of Melville has provide guidelines in the form of letterbox drop educating residence about appropriate management of garden and lawn waste to reduce the weed and nutrient load impacting the Blue Gum Lake reserve and the resident macro-invertebrates and turtles. Further plans to conduct drain stencilling (clean drains, river gains) and catchment education with school groups when budget and time allows.

12.3.8 Given the particularly low pH of waters at the site, consider conducting an acid sulfate soil investigation at the lake to determine the extent of acid sulfate soils and consider options for mitigation.

12.3.9 Consider speciation testing for zinc and copper to determine the labile (and therefore bioavailable) proportion of these metal concentrations, as some of the metals present may be complexed with dissolved organic material.

## 13. Quenda Lake outlet (site 9):

### 13.1 <u>2016 Sampling</u>

During the sampling events held in 2016, this site recorded values outside of trigger values for:

13.1.1 **pH** below the acceptable limit for wetlands (7 - 8.5) on three of the four sampling occasions (July, August and September), with pH values from 5.66 to 6.73.

13.1.2 **Dissolved oxygen** saturations below the lower acceptable limit for wetlands (<90%) on all four sampling occasions, with saturations from 22.3% to 40%.

13.1.3 **Total iron** concentration above the interim guideline (0.3 mg/L) when sample was collected in July (0.44 mg/L) and **soluble iron** concentrations above the interim guideline on all four sampling occasions with concentrations from 0.34 mg/L to 0.53 mg/L.

13.1.4 **Total aluminium** concentrations above the low reliability interim value (0.008 mg/L) when a sample was collected in July (0.39 mg/L) and **soluble aluminium** concentrations above relevant trigger values (low reliability interim value when pH<6.5, 95% freshwater protection trigger value when pH>6.5) on all four sampling occasions (July, August and September) with values from 0.32 mg/L to 0.99 mg/L.

Several of the analysed **total metals in sediment** had concentrations greater than limits of reporting when tested in October**:** aluminium, chromium, copper, iron, lead and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were medium sand (48.91%) and coarse sand (21.80%).

### 13.2 Long term findings

13.2.1 **pH values** have often been below the acceptable range for wetlands.

13.2.2 **Dissolved oxygen** saturations have generally been below the lower acceptable limit for wetlands.

13.2.3 **Total iron** concentrations often been below the interim guideline.

13.2.4 **Total aluminium** concentrations have generally exceeded the 95% freshwater protection trigger value (or low reliability interim value when pH<6.5).

### 13.3 Recommendations for site:

13.3.1 Continue monitoring this site is recommended to see the long term impact of the new drainage works from Main Roads, road construction and new building infrastructure upgrades in the surrounding areas. Also, ensure that pH levels at this site do not continue to decrease.

13.3.2 Continue foreshore management to protect the remaining wetland.

13.3.3 It is recommended that investigation of ecological water requirements (EWRs) for this EPP wetland be conducted to assess the potential impacts of climate change to the wetland and allow for appropriate mitigation to be undertaken.

13.3.4 Continue implementing the other objectives included in the Quenda Wetland Reserve Strategic Management Plan (City of Melville 2016).

## 14. Frederick Baldwin (site 10):

### 14.1 2016 Sampling

During the sampling events held in 2016, this site recorded values outside of trigger values for:

14.1.1 **Dissolved oxygen** saturations below the lower acceptable limit for wetlands (<90%) on all four sampling events, with saturations from 2.5% to 73.2%, and recorded the lowest concentrations in the catchment.

14.1.2 **Electrical conductivity** levels below the lower acceptable limit for wetlands (0.3 mS/cm) on three out of four sampling events, from 0.0934 mS/cm to 0.425 mS/cm.

14.1.3 **Nitrogen as ammonia/ammonium** concentrations above the trigger value for wetlands (0.04 mg/L) on two out of four sampling events (July and August), with concentrations from <0.01 mg/L to 0.055 mg/L.

14.1.4 **Soluble iron** concentrations above the interim guideline on two out of four sampling occasions (August and October) with concentrations from 0.17 mg/L to 0.37 mg/L.

14.1.5 **Total copper** concentration above the hardness modified trigger value for 95% freshwater protection when a sample was collected in July (0.002 mg/L) and **soluble copper** concentrations above the hardness modified trigger values on two out of four sampling occasions (August and September), with concentrations from <0.001 mg/L to 0.002 mg/L).

14.1.6 **Total zinc** concentration above the hardness modified trigger value for 95% freshwater protection when a sample was collected in July (0.019 mg/L) and **soluble zinc** concentrations above the hardness modified trigger values on all four sampling occasions, with concentrations from 0.019 mg/L to 0.26 mg/L).

Several of the analysed **total metals in sediment** had concentrations greater than limits of reporting when tested in October**:** aluminium, iron, arsenic, chromium, copper, lead (exceeding the low trigger value and highest in the catchment) mercury, nickel and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were gravel (24.7%) and silt (23.67%).

### 14.2 <u>Long term findings</u>

14.2.1 **pH** values have often been below the acceptable limit for wetlands, particularly since 2013.

14.2.2 **Dissolved oxygen** saturations have generally been below the lower acceptable limit for wetlands.

14.2.3 **Electrical conductivity** levels have often been below the lower acceptable limit for wetlands.

14.2.4 **Total iron** concentrations have generally exceeded the interim guideline but **soluble iron** concentrations have generally been below it.

14.2.5 **Soluble zinc** concentrations have generally recorded concentrations exceeding the 95% freshwater protection hardness modified trigger values.

### 14.3 <u>Recommendations for site:</u>

14.3.1 Remove sediment sludge at the inlet.

14.3.2 Investigate options for the improvement of hydraulic design within the lake.

14.3.3 Implement a progressive weed removal program focusing on the replacement of the *Casuarina cunninghamiana* (Sydney she-oak) with local wetland tree species (*Melaleuca rhaphiophylla, Eucalyptus rudis*) to reduce the weed seeding of downstream wetlands and waterways and increase nutrient uptake. Also removing these trees will remove the needles which prevent the growth of understorey riparian vegetation.

14.3.4 Implement gradual foreshore revegetation program simultaneously with installation of bio-filtration sedge plantings to provide a buffer between the lawn recreational area and the lake foreshore. This will improve the aesthetics as well as improving the filtration of surface water entering the lake.

14.3.5 Develop signage at the lake that increases the community's awareness of where this lake's water comes from and where the lake water flows to. This will increase the local community's awareness of the effect of this lake's water quality on the downstream lakes and the Canning River (this could be a simple sign showing the catchment and the drainage pathway for this lake to the river). The City of Melville have already produced a simple water cycle diagram for public education purposes, this may be utilised on a sign.

## 15. Marmion Reserve (site 11):

### 15.1 <u>2016 Sampling</u>

During the sampling events held in 2016, this site recorded values outside of trigger values for:

15.1.1 **pH** exceeded the upper acceptable limit for wetland (>8.5pH) on one of the four sampling occasions (October), with pH values from 7.4 to 10.02.

15.1.2 **Dissolved oxygen** saturations below the lower acceptable limit for wetlands (<90%) during three of the four sampling occasions (July, August and September) and above during October, with saturations ranging from 65.4% to 132.3%.

15.1.3 **Electrical conductivity** levels were below the lower acceptable limit for wetlands (0.3 mS/cm) on all four sampling events, from 0.1663 mS/cm to 0.286 mS/cm.

15.1.4 **Nitrogen as ammonia/ammonium** concentrations above the trigger value for wetlands (0.04 mg/L) at one out of four sampling events (July), with concentrations from <0.01 mg/L to 0.049 mg/L. Furthermore, the calculated **nitrogen as ammonia** concentration (calculated from the nitrogen as ammonia/ammonia concentration, pH, temperature and conductivity (see **Section 6.1.3**)) was equal to the recreational trigger value of 0.01 mg/L at one out of the four sampling events (in October when the pH was 10.02).

15.1.5 **Soluble iron** concentration above the interim guideline at one out of four sampling occasions (October) with concentrations from 0.059 mg/L to 0.48 mg/L.

15.1.6 **Total zinc** concentration equal to the hardness modified trigger value for 95% freshwater protection when a sample was collected in July (0.008 mg/L) and a **soluble zinc** concentrations above the hardness modified trigger value at one out of four sampling occasions (July), with concentrations from 0.003 mg/L to 0.017 mg/L).

Several of the analysed **total metals in sediment** had concentrations greater than limits of reporting when tested in October**:** aluminium, arsenic, chromium, copper, iron, lead and zinc. Particle size analysis showed that the dominant fractions of sediment recorded at this site were coarse sand (56.2%) and medium sand (33.16%).

**15.2 Long term findings**

15.2.1 **Dissolved oxygen** saturations have been varied but generally outside the acceptable range for wetlands, predominantly below the lower limit.

15.2.2 **Electrical conductivity** levels have often been below the acceptable range for wetlands.

15.2.3 **Total iron** concentrations have generally been above the interim guideline but **soluble iron** has generally been below it.

**15.3 Recommendations:**

15.3.1 It may be of benefit to consider providing educational materials to the grounds staff at the adjacent retirement villages on the west side of Marmion reserve to ensure gardening activities do not result in additional pollution to the lake. This may include information about the implications of nutrient pollution in waterways and how to optimally apply fertiliser to reduce nutrient pollution. SERCUL's Phosphorus Awareness Project brochure may be a good starting point (http://sercul.org.au/docs/PAP.pdf).

15.3.2 Continued control of invasive aquatic weeds, particularly those that grow rapidly on the surface of the water, shading out submerged plant life and impeding oxygen exchange. Submerged plants can take up nutrients present in the water column and therefore impede the growth of algae.

15.3.3 Continued maintenance of the completed City of Melville foreshore restoration project to increase the buffer zone surrounding the lake to increase the bio-filtration of surface water from surrounding parkland. This project included the planting of island and large areas surrounding the lake with sedges and other dryland species and the removal of weeds.

## 1.3 Summary maps for 2016 data

Site maps displaying physicochemical parameters, nutrients and metals outside acceptable ranges/ exceeding relevant trigger values are displayed in **Figure 1.3-1**, **Figure 1.3-2** and **Figure 1.3-3** respectively. Furthermore, to provide a graphical representation of overall water quality in the catchment, **Figure 1.3-4** includes colour-coded symbols for each site displaying "exceedance scores". These "exceedance scores" were calculated by adding together average multiplication factors of a parameter's recorded concentration than its relevant trigger value (where concentrations below trigger values were assigned a zero multiplication factor) for each of the following parameters: TSS, total nitrogen, total phosphorus, soluble aluminium, soluble iron, soluble zinc, soluble copper and soluble lead. Sites 15 and 16 were not given a score as soluble metals were not analysed at these sites. It is apparent from Figure 1-4 that overall, sites 7 and 12 had by far the poorest water quality.

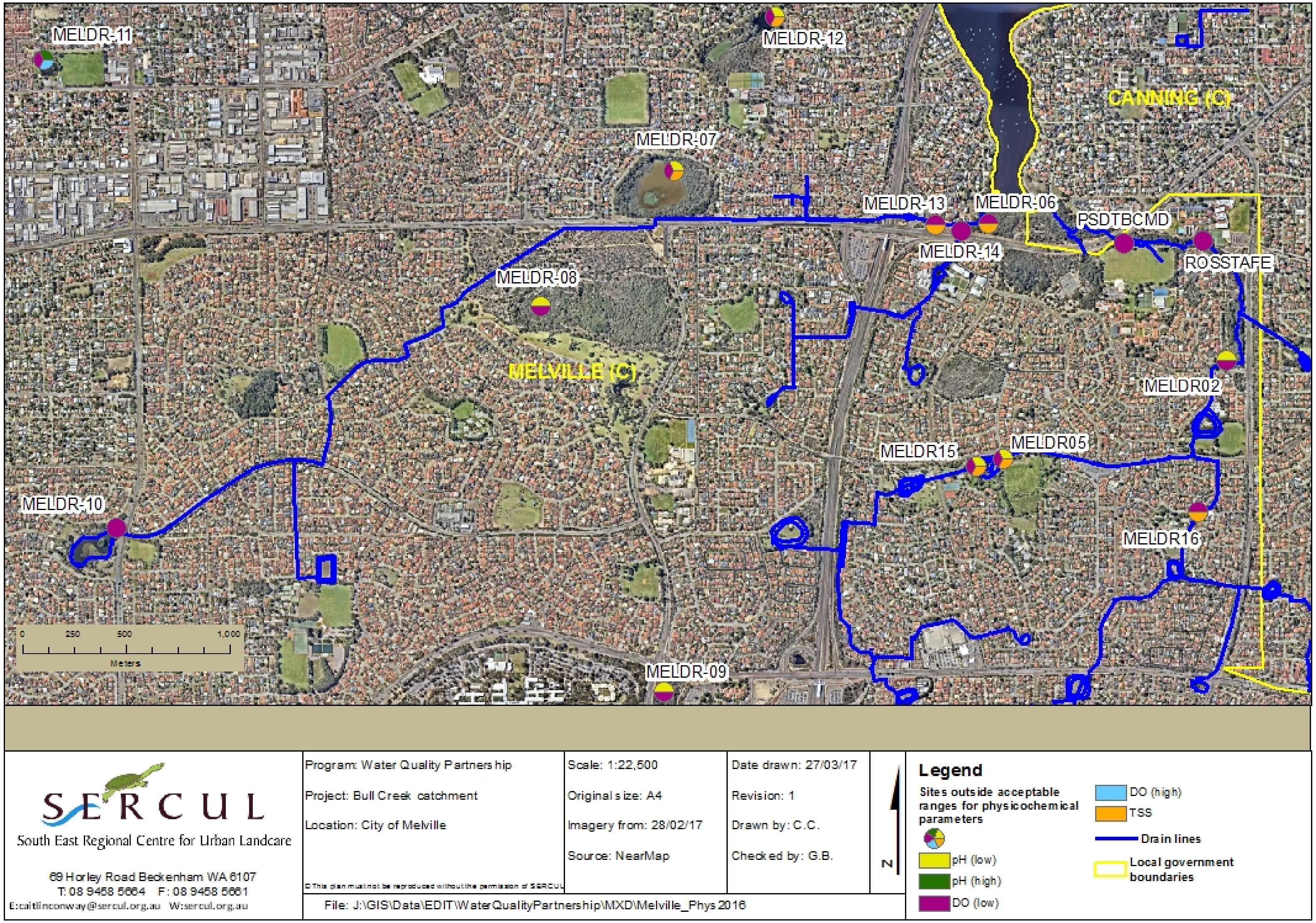


**Figure 1.3-1: Site map showing sites with values outside of ANZECC acceptable ranges for lowland rivers (ANZECC and ARMCANZ 2000) for pH and dissolved oxygen (DO), and exceeding the DoW interim value (DoW n.d.) for total suspended solids (TSS).**

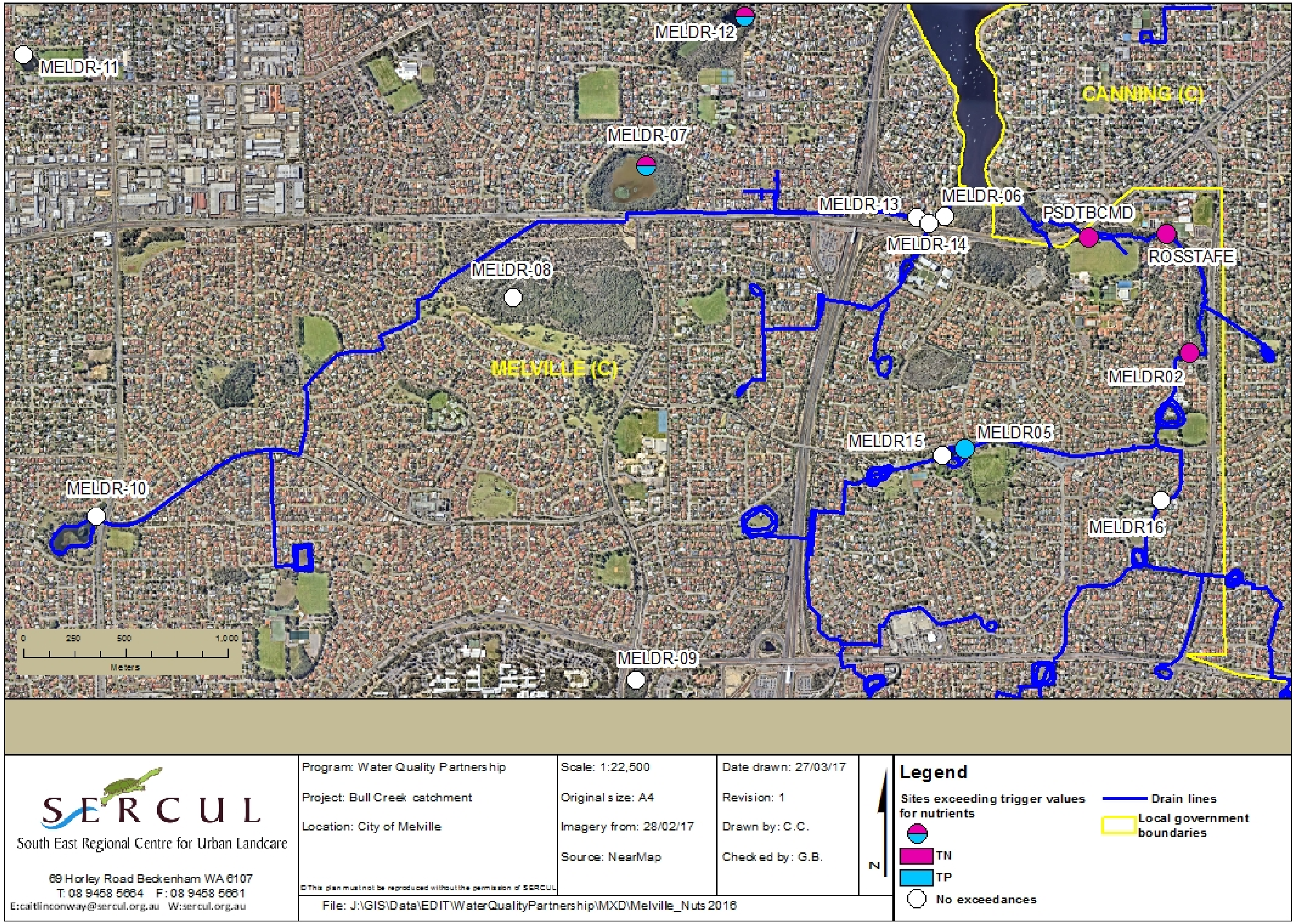


**Figure 1.3-2: Site map showing sites with total nitrogen (TN) and total phosphorus (TP) concentrations exceeding ANZECC trigger values for lowland rivers (ANZECC and ARMCANZ 2000).**

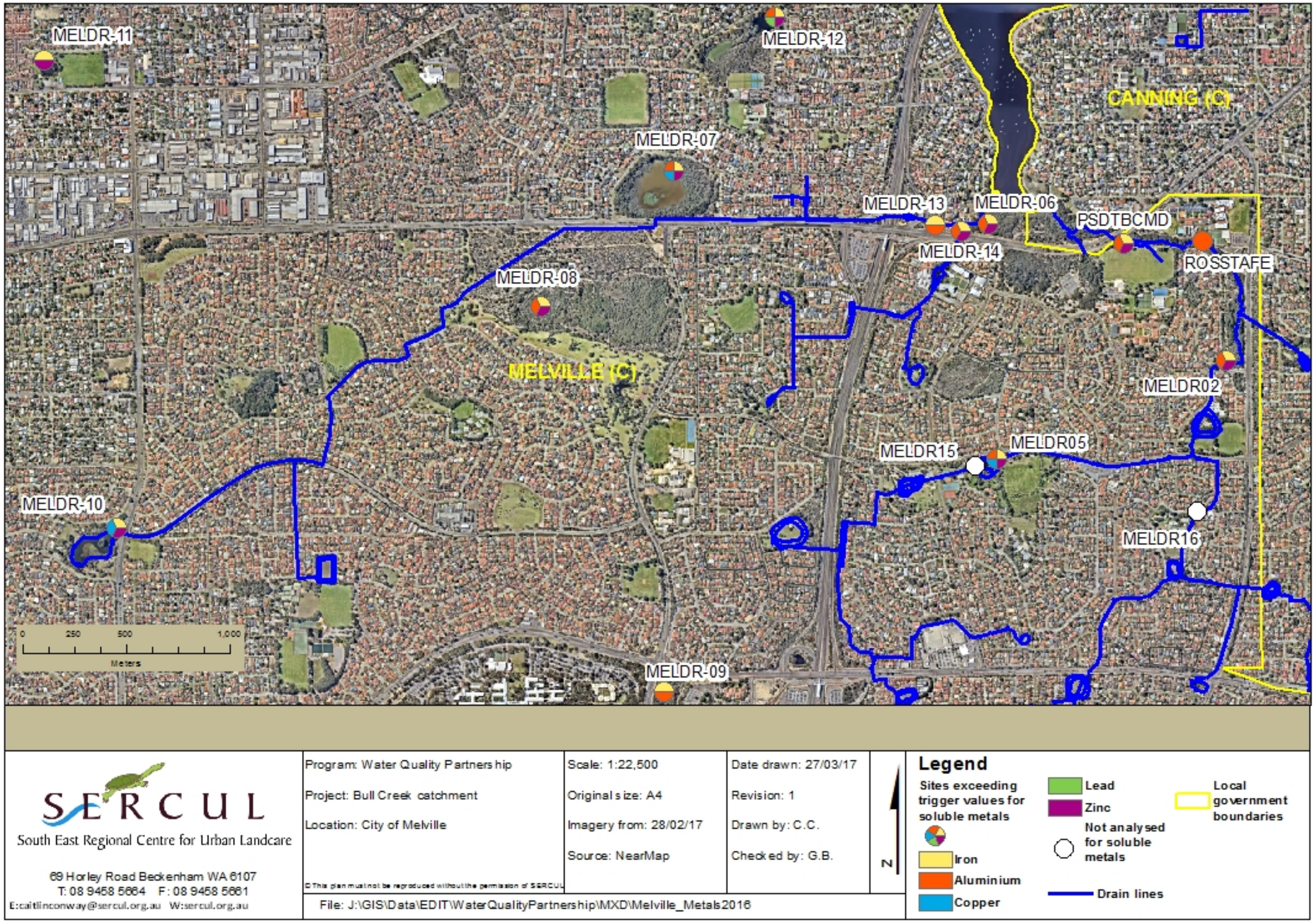


**Figure 1.3-3: Site map showing sites with soluble metal concentrations exceeding ANZECC trigger values for protection of freshwater biota (ANZECC and ARMCANZ 2000)**

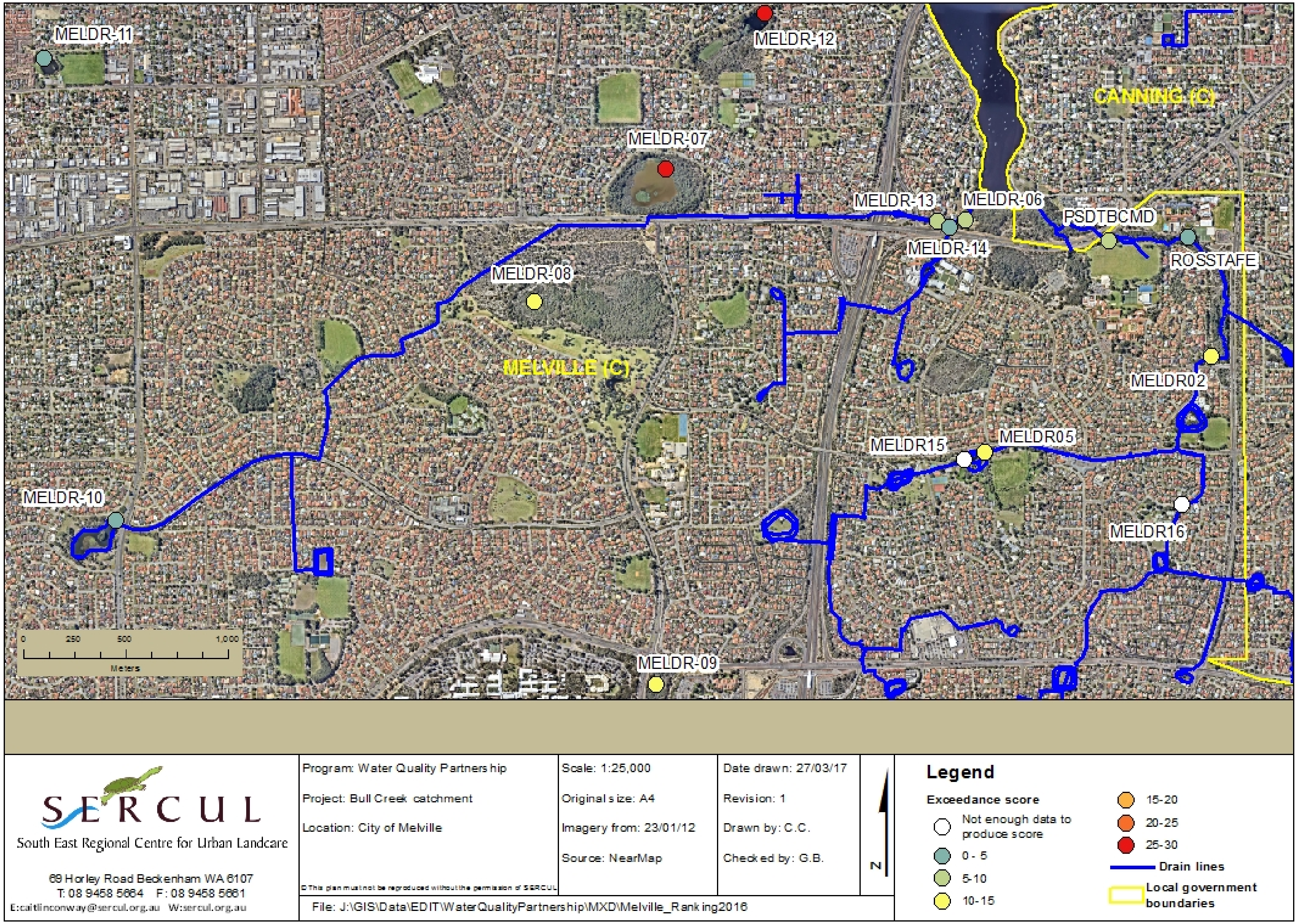


**Figure 1.3-4 Site map showing "exceedance scores" for each site (for an explanation of the derivation of the "exceedance scores" see Section 1.3)**.

# 2. Introduction

## 2.1 Purpose of the sampling

The purpose of this sampling program is to:

- ✓ Assess the water quality in the City of Melville portion of the Bull Creek catchments,
- ✓ Assess the quality of the water in the lakes within the City of Melville;
- ✓ Assess trends in water quality over time in the City of Melville lakes and City of Melville portion of the Bull Creek catchments; and
- ✓ Identify any pollutant hotspots throughout the catchment area.

This water quality monitoring program also contributes valid data to the Western Australian water quality database (Water Information Resource - WIR database) which is utilised in the management of the State's water resources.

## 2.2 Background of the monitoring program

In 2006 the Australian Government's Coastal Catchments Initiative identified the Swan Canning river system as a coastal 'hot spot' and funding was provided to the Swan River Trust (now DPaW) to coordinate a Water Quality Improvement Plan for the region. The Swan River Trust developed the Local Water Quality Improvement Plan (WQIP) for the Bull Creek Catchment which was released on November 2012. The Bull Creek Catchment WQIP aims to reduce nutrient loads entering the Canning River through nutrient intervention and changed management practices. By using a treatment train approach, a combined set of management actions are applied along the nutrient pathways to minimise nutrient and non-nutrient contaminant losses to waterways (SRT 2012).

As part of the WQIP implementation the Brentwood Living Stream project was launched in 2012 to mitigate some of the water quality issues identified at Bateman Park (top of the catchment before entrance to the Canning River) coming from two drainage sections of the catchment; Brentwood drain and RAAF Drain. The project includes the reconstruction of the water course where these two drains converge (upstream of Bateman Park) using urban water sensitive nutrient/non-nutrient stripping designs and is driven by a partnership of several agencies including the DPaW Rivers and Estuaries Division, City of Melville, SERCUL, Water Corporation and Main Roads.

The City of Melville has been sampling the lakes and Bull Creek drains twice a year since 1996. In 2007 a partnership between the City, SERCUL and the Department of Water was established in order to standardise all water quality monitoring data collection, management and storage methods. Since 2007 the City has been utilising this data to develop some management programs within the city. The sites and parameters monitored have been modified in response to changes in budget and requirements since the program's introduction in 2007 (see **Appendix B**). No major changes to the program have been made since the 2015 monitoring program. However it should be noted that due to recent upgrades to the Brentwood drain as part of the Brentwood Living stream project, the sampling location for site 13 was changed slightly to being closer to Pulo Road (**see Table 3.1-1**).

## 2.3 Catchment description

The City of Melville is located 8km from the central business district of Perth and has an area of 52.72km$^2$ with 18.1km of foreshore. The City encompasses 18 suburbs connected by over 1,200km of local, arterial and major roads. With a population of approximately 103,767 people within 40,546 dwellings, the City of Melville is the third largest local government in the metropolitan region (City of Melville 2014).

The Myaree Mixed Business precinct is the largest industrial area in the City of Melville (264,000m$^2$ of floor area) and provides a diversity of business, retail and industrial functions. A second industrial area in O'Connor accommodates larger scale manufacturing and traditional industrial uses and includes service commercial and general business uses. These two precincts support over 284 mixed business/commercial properties (City of Melville 2014).

The City residents enjoy 210 parks and reserves comprising 600 hectares of public open space and 300ha of bushland. Booragoon Lake, Blue Gum Lake outlet and Piney Lakes Reserve represent the northern extent of the Beeliar Wetland chain, a system consisting of inter-dunal depressions between the Spearwood and Bassendean dune systems which include a series of lakes running parallel with the coast (Natural Area Consulting 2012a 2012b and 2004d). The chain of wetlands holds significance for the local aboriginal people as they were important camping and ceremonial areas; as well as providing an abundant source of food, offering fish, water fowl, shell fish, vegetable roots and bulbs (City of Melville no date available A).

The Bull Creek Catchment is approximately 43.5km$^2$ and is located mostly within the cities of Melville and Canning. It is highly modified and converted to a largely piped drainage network with some intact natural wetlands and foreshore areas. The wetlands drain into the modified Bull Creek which winds its way through a series of parks in the lower catchment before it discharges directly into the Canning River, the major tributary of the Swan River (SRT 2012).

The stormwater drainage systems that feed into Bull Creek are associated with the suburbs of Bull Creek, Leeming, Willetton, Bateman and Kardinya. There are three main drains: the Bull Creek Main Drain that flows all year round and drains stormwater and local groundwater, the Mandala Crescent Branch Drain that flows in response to rainfall, and the Brentwood Main Drain which flows permanently due to groundwater interception and when flood control pumps at Frederick Baldwin Lake and Kingston Place in Kardinya are in operation. Frederick Baldwin Lake and Kingston Place receive stormwater and groundwater from the suburbs of Kardinya and Murdoch (City of Melville 2004c). In the City of Melville, there are approximately 67 drainage sumps and over 300 km of stormwater drainage pipes (City of Melville 2007). The development of neighbouring urban areas and subsequent management practices has slowly transformed these areas from swamps to semi-permanent lakes.

Blue Gum Lake Reserve is a wetland reserve located approximately 9.5km south of Perth Central Business District (Perth CBD) in the suburb of Mount Pleasant, and occupies an area of approximately 11.09ha. The reserve is bounded by Canning Avenue, Moolyeen Road and Rountree Road and is comprised of wetland areas, upland remnant vegetation and parkland cleared spaces. The Reserve is comprised of four main areas: two wetland basins with an artificial island located between them, two areas of upland Banksia woodland community, a transitional zone characterised by Melaleuca and *Eucalyptus rudis* woodlands, and parkland cleared areas with an over storey of predominantly non-native eucalyptus. The Blue Gum Lake is a surface expression of the unconfined aquifer known as the Jandakot Groundwater Mound, and also receives water from stormwater inflow. Historically Blue Gum Lake would respond to fluctuations of the water table relating to seasonality and climatic variations but following the development of the area the lake has experienced significant changes to its natural cycle (Natural Area Consulting 2012b).

Booragoon Lake Reserve is located approximately 10.5km south of Perth CBD in the suburb of Booragoon, bounded by Leach Highway, Aldridge Road and Lang Street, and occupies an area of approximately 13.5ha. The reserve is comprised of wetland areas, upland remnant vegetation and parkland cleared spaces (Natural area Consulting 2012). Booragoon Lake has always been a lake and there is no record of it being dry over summer, although some locals think that the lake was previously half the size of the existing open water. In the 1940s it was about 1.5m deep in winter. In the late 1960s and early 1970s there was a battle to save the lake from being drained and subdivided (City of Melville 2004a). In the 1970s and 80s the Council drew water from a subterranean bore in the Alfred Cove area and pumped it into Blue Gum and Booragoon Lakes during summer to maintain the water level (City of Melville 2004a). Currently the water levels in Booragoon and Blue Gum Lakes fluctuate dependent on both local and regional factors including: seasonal changes and climatic variation (particularly the amount of rainfall within the lake's catchment area), local and regional bore water extraction, volume of water entering the system during stormwater events, fluctuations in water table height, urban development and drainage, and rate of evaporation and evapotranspiration (Natural Area Consulting 2012a and 2012b).

Piney Lakes Reserve is a bushland and wetland remnant area surrounded by urban development in the suburb of Winthrop in the City of Melville. The Reserve is bounded by Leach Highway to the north and Murdoch Drive to the east and encompasses approximately 67ha (50ha of bushland and wetland environments and about 17ha of developed parklands to the south and west). The Reserve can be divided into four main topographic components: the low-lying areas including the wetland basin, the slopes surrounding the wetland, the east-west ridge across the northern part of the Reserve and the undulating plain to the south-east. Piney Lake and the adjoining damp land are surface expressions of the underlying groundwater level, which fluctuates on a seasonal basis. The local groundwater flow in the area is northward to the Canning River via Booragoon Lake and Blue Gum Lake (City of Melville 2004b).

Quenda Wetland is a unique small reserve in the City of Melville, which is of a high conservation value. The permanent wetland in Quenda Reserve has been artificially deepened, however the adjacent damp land and seasonal wetland area still reflects the natural expression of the water table in this area. Underground water movements are from areas of higher topography surrounding the wetland in the broader catchment. The catchment areas around Quenda Wetland are relatively small and concentrated on land immediately around the lake and damp land. Groundwater also flows from Murdoch University to the west and from the roads surrounding the lake and damp land. The water in the lake is also contributed to by surface water from two GPT (Gross Pollutant Traps) on the corner of South Street and Murdoch Drive, in the north-western corner of the lake. Another drain runs from Murdoch St John of God Hospital from carparks and roads to the south east of the area (City of Melville 2004d).

# 3. Methodology

## 3.1 Site locations

14 sites from the Melville portion of the Bull Creek catchment and Melville Lakes (hereafter collectively referred to as the "Melville Bull Creek catchments") were selected to represent the water quality in different portions of Bull Creek and the Melville lakes, whilst taking into account accessibility and historical sampling sites.

**Table 3.1-1** provides a detailed description and GPS coordinates of each of the sample sites. A map showing the location of the sites is provided in **Figure 3.1-1**. As in 2015 and 2014, the analysis of the Brockman Park inlet (ROSSTAFE) from the 2016-2017 Bull Creek East monitoring program (City of Canning) was also included in this report. Although the drain line itself collects within the City of Canning, it flows directly into the City of Melville main drainage and merges with the Bull Creek Reserve drain which is sampled at Bull Creek MD (PSDTBCMD). **Table 3.1-1** and **Figure 3.1-1** also provide the location details of Brockman Park inlet (ROSSTAFE), containing water from the Rossmoyne drain. The inclusion of the analysis of the Rossmoyne drain is important in the analysis of the water and sediment quality at Bull Creek main drain (PSDTBCMD), as the main drain receives input from both Brockman Park (site 2) and Rossmoyne TAFE drainage lines. This will provide insight into the relative contributions from the individual drainage lines.

**Table 3.1-1: List and description of sampling sites**

| Site No. | WIR site ref. | Drain section/component | Sampling point Location | Easting | Northing |
|---|---|---|---|---|---|
| PSDTBCMD (MELDR-01) | 6162178 | Bull Creek Park Main Drain | Culvert under Leach Hwy | 392965.3 | 6453785.6 |
| MELDR-02 | 6162370 | Brockman Park | Where piped drain opens | 393466.5 | 6453208.5 |
| MELDR-05 | 6162373 | John Creaney Park outlet | Compensation Basin Outlet | 392359 | 6452734.7 |
| MELDR-06 | 6161691 | Bateman Park | Downstream of the confluence of the 2 drains | 392269.8 | 6453880.2 |
| MELDR-07 | 6162375 | Booragoon Lake | In the lake at the end of walkway | 390734.68 | 6454164.09 |
| MELDR-08 | 6162376 | Piney Lakes | At the lake outlet | 390151.59 | 6453473.10 |
| MELDR-09 | 6140831 | Quenda Lake | At the lake outlet | 390749.20 | 6451597.51 |
| MELDR-10 | 6162377 | Frederick Baldwin | At the lake outlet | 387989.87 | 6452295.91 |
| MELDR-11 | 6162378 | Marmion Reserve | At the lake outlet | 387774.89 | 6454629.75 |
| MELDR-12 | 6162379 | Blue Gum Lake | At the lake outlet | 391282.81 | 6454886.75 |
| MELDR-13 | 6165324 | Brentwood drain | Pulo Rd & Leach highway, 10m walking from Pulo Rd. Site moved at beginning of 2015-16 sampling due to construction works reshaping the drain. | 392126.59 | 6453865.28 |
| MELDR-14 | 6165325 | RAAF drain | 10 m down from pipe under Leach highway | 392195 | 6453841 |
| MELDR-15 | 6165331 | John Creaney Park inlet | Approx. 5m upstream of the main inlet into John Creaney Park, access via Water Corp drain man hole (lid lifting and bucket and rope required) | 392256.48 | 6452699.35 |
| MELDR-16 | 6165332 | Closed pipe Downstream Elizabeth Manion Park | On Nicholls Cres close to Hurley Way, in front of pathway, access via Water Corp man hole (lid lifting and bucket and rope required) | 393327.76 | 6452478.47 |

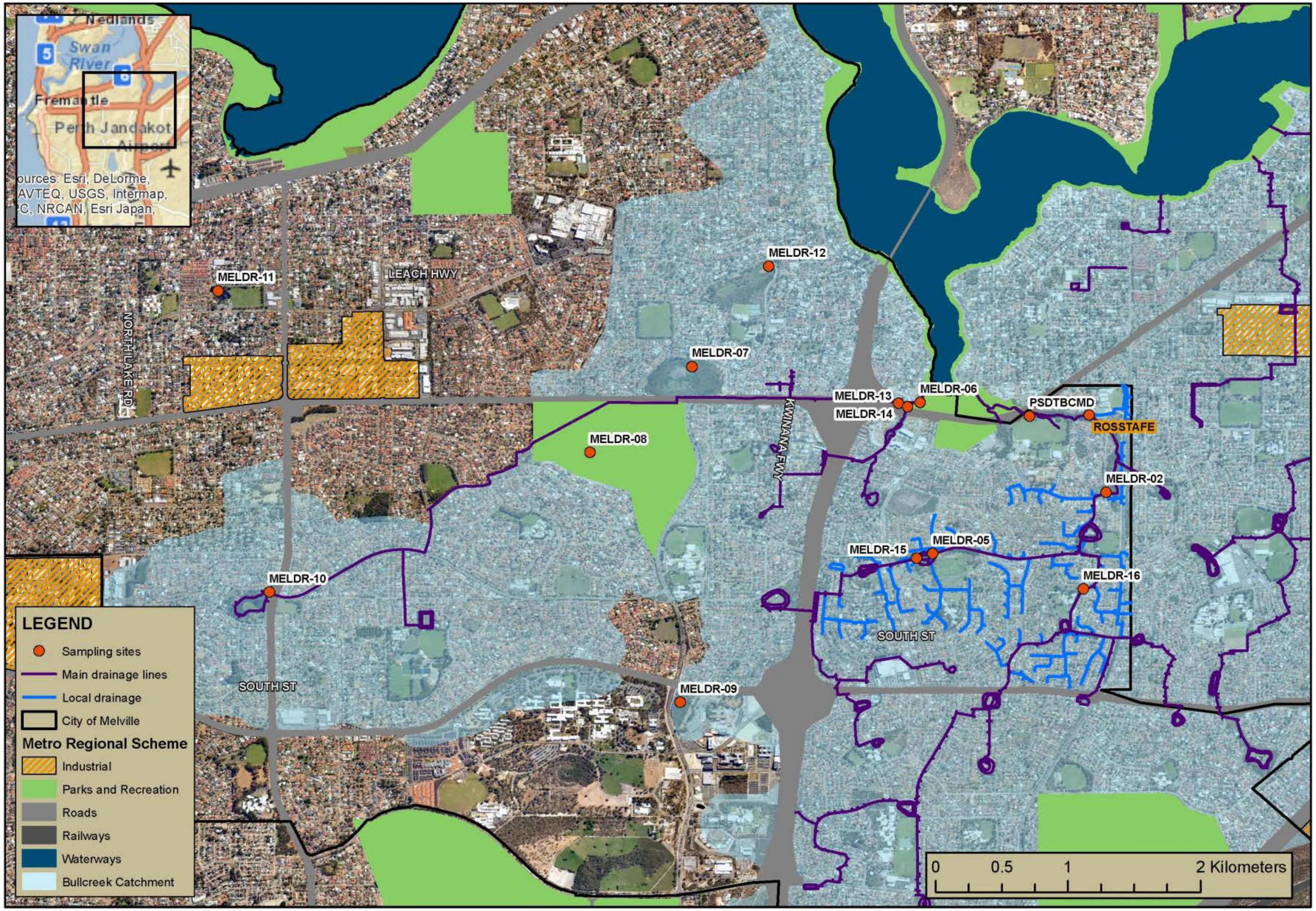


**Figure 3.1-1: Sampling sites within the Melville Bull Creek catchments for 2016 monitoring program.**

## 3.2 Sampling schedule and procedures

Samples were collected in accordance with the City of Melville and Bull Creek Catchment sampling and analysis plan (SAP) 2016 (SERCUL 2016a) and samples for the Brockman Park inlet drain were collected in accordance with the Bull Creek East Catchment (SERCUL 2016b).

Sampling was conducted once a month from July to October 2016 from the 14 Melville sites on the following dates: 20$^{th}$ July, 19$^{th}$ August, 8$^{th}$ September, and 27$^{th}$ October 2016. ROSSTAFE samples were collected one to three days before Melville samples on the four sampling events of the City of Canning Bull Creek East monitoring program (19$^{th}$ July, 16$^{th}$ August, 6$^{th}$ September, and 26$^{th}$ October). All sites were sampled on all sampling occasions except for site 16 which was unable to be sampled in October due to prohibitively low water levels. Temperature and rainfall data for the duration of the sampling is detailed in **Appendix A.**

Field observation forms were filled out for all samples and all of them were transported under "chain of custody" (CoC) to the laboratory and analysed in accordance with the laboratory methods. All water and sediment samples collected were analysed by the National Measurement Institute (NMI), a laboratory accredited by the National Association of Testing Authorities (NATA), and also to CSIRO for particle size analysis.

## 3.3 Parameters measured

Water at each of the 15 sites was measured in situ for physical properties (dissolved oxygen, pH, electrical conductivity and temperature) and samples were collected and analysed for a range of contaminants likely to be present in urban and industrial catchments.

**Water samples** at all Melville Bull Creek sites were analysed for:

- Nutrients - total phosphorus (TP), total nitrogen (TN), total oxidised nitrogen (NOx), total organic nitrogen (TON), dissolved organic nitrogen (DON), soluble reactive phosphorus (SRP) and nitrogen as ammonia/ammonium (N-NH3/N-NH4) tested at all 15 sites on all four sampling occasions.
- Total metals - aluminium (Al), chromium (Cr), copper (Cu), iron (Fe), lead (Pb) and zinc (Zn) tested at 12 sites (PSDTBCMD, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14) on one sampling occasion for surveillance,
- Total metals - aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se) and zinc (Zn) tested at 2 sites (15 and 16) on all four sampling occasions.
- Total mercury (Hg) tested at 5 sites (6, 13, 14, 15 and 16) on all four sampling occasions.
- Soluble metals - aluminium (Al), chromium (Cr), copper (Cu), iron (Fe), lead (Pb) and zinc (Zn) tested at 12 sites (PSDTBCMD, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14) on all four sampling occasions.
- Soluble metals - mercury (Hg) at 3 sites (13, 14 and 6) on all four sampling occasions; and
- Total suspended solids and total water hardness at all 14 sites on all four sampling occasions.

At Brockman Park inlet (ROSSTAFE) water samples were analysed for the following parameters:

- Nutrients: total phosphorus (TP), total nitrogen (TN), total oxidised nitrogen (NOx), dissolved organic nitrogen (DON), soluble reactive phosphorus (SRP) and nitrogen as ammonia/ammonium (N-NH3/N-NH4);
- Total metals: aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se) and zinc (Zn);
- Soluble metals (Al, As, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se and Zn); and
- Total suspended solids and total water hardness.

**Sediment samples** at the west side of the catchment were collected from 12 sites (sites PSDTBCMD, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14) for the analysis of:

- Total metals/metalloids (Al, As, Cr, Cu, Fe, Hg, Ni, Pb, Se and Zn), and
- Moisture
- Particle size analysis

Sediment samples were not collected from sites 15 and 16 (John Creaney Park inlet and Downstream Elizabeth Manion Park) as both sites are closed pipes.

A sediment sample for Rossmoyne Drain was not included in the SAP as this site is where a closed pipe opens onto a hard surface structure before entering the stream below.

## 3.4 Analysis methodology

All water and sediment samples collected were analysed by the National Measurement Institute (NMI), which is a National Association of Testing Authorities (NATA) accredited laboratory independently audited by the Department of Water.

Laboratory results were reported as per the limits of reporting (being the minimum detection level) for each parameter listed in **Table 3.4-1.**

**Table 3.4-1: Analysis method and limit of reporting (LOR) for water and sediment samples**

| Measured parameter | LOR |
|---|---|
| **WATER** | |
| Total phosphorus | 0.005 mg/L |
| Total nitrogen | 0.025 mg/L |
| Total organic nitrogen | 0.025 mg/L |
| Soluble reactive phosphorus | 0.005 mg/L |
| Total oxidised nitrogen | 0.01 mg/L |
| Nitrogen as ammonia | 0.01 mg/L |
| Dissolved organic nitrogen | 0.025 mg/L |
| Total Suspended Solids | 1.0 mg/L |
| Total water hardness | 5.0 mg/L |
| Aluminium – total and soluble | 0.005 mg/L |
| Arsenic – total | 0.001 mg/L |
| Cadmium - total | 0.0001 mg/L |
| Cobalt - total | 0.001 mg/L |
| Chromium - total and soluble | 0.001 mg/L |
| Copper - total and soluble | 0.001 mg/L |
| Iron – total and soluble | 0.005 mg/L |
| Lead - total and soluble | 0.001 mg/L |
| Manganese - total | 0.001 mg/L |
| Mercury – total and soluble | 0.0001 mg/L |
| Molybdenum - total | 0.001 mg/L |
| Nickel - total | 0.001 mg/L |
| Selenium - total | 0.001 mg/L |
| Zinc - total and soluble | 0.001 mg/L |
| **SEDIMENT** | |
| Moisture | 0.1 g/100g |
| Aluminium – total | 1.0 mg/Kg |
| Arsenic – total | 0.5 mg/Kg |
| Chromium - total | 0.5 mg/Kg |
| Copper - total | 0.5 mg/Kg |
| Iron - total | 1.0 mg/Kg |
| Lead - total | 0.5 mg/Kg |
| Mercury | 0.1 mg/kg |
| Nickel - total | 1.0 mg/Kg |
| Selenium | 1.0 mg/kg |
| Zinc - total | 1.0 mg/Kg |

Sediment samples were also analysed by CSIRO laboratory for the particle size distribution. Particles were grouped into the following size classes according to the Wentworth scale (Wentworth 1922) using wet sieving followed by laser diffraction (Mudroch et al. 1997):

| Class | Size |
|---|---|
| Clay | <4 µm |
| Silt | 4-62 µm |
| Fine sand | 62-250 µm |
| Medium sand | 250-500 µm |
| Coarse sand | 500-2,000 µm |
| Gravel | >2,000 µm |

# 4. Guidelines

To provide a frame of reference as to the state of water and sediment quality in Melville Bull Creek catchments, laboratory results have been compared to trigger levels from the ANZECC and ARMCANZ (2000) *Australian and New Zealand Guideline for Fresh and Marine Water Quality* (hereafter referred to as the "ANZECC guidelines"). Exceedance of a trigger value from the ANZECC guidelines indicates that there is the potential for an impact to occur and should therefore trigger a management response (ANZECC & ARMCANZ 2000). The rationale for the trigger values used in the ANZECC guidelines is provided in chapter 8 of the guidelines. **Table A-1, Table A-2 and Table A-3, Appendix A** show the ANZECC trigger values used to compare the results of the analysed parameters.

ANZECC and ARMCANZ (2000) have developed "high reliability" trigger values for toxicants in fresh waters where sufficient "No Observed effect Concentration" (NOEC) data is available, published in chapter 3 of the guidelines. Several trigger values have been derived for each metal depending on the proportion of species for which protection is sought: 99%, 95%, 90% or 80%. Urban and industrial catchments tend to be highly modified and are often artificial ecosystems, where the risk of toxicant contamination is high and current environmental value is low. On that basis, the ANZECC trigger values for 80% protection of freshwater would be applicable to the waterbodies/tributaries within the City of Melville. However, the Bull Creek flows to the Canning River, where environmental values are high and for this reason, the toxicant results, metals and metalloid concentrations of the surface water of the Melville Bull Creek catchments were compared to the trigger values for 95% protection levels (where available), applicable to high conservation value and slightly to moderately disturbed ecosystems. For the metals cobalt and molybdenum, "high reliability" values are not available and therefore ANZECC and ARMCANZ recommend the use of "low reliability" trigger values calculated by different means. For chromium, the "high reliability" trigger value is considered too high and therefore the use of an interim value for freshwater protection is recommended. For iron, ANZECC and ARMCANZ (2000) suggest the use of an interim value based upon the current Canadian guideline level.

ANZECC and ARMCANZ (2000) have also devised trigger values that should not be exceeded for physical and chemical stressors of different ecosystem types. The results of some sites (15, 5, 16, 2, ROSSTAFE, PSDTBMCD, 13, 14 and 6) were compared to the 'lowland rivers' trigger values and others (7, 8, 9, 10, 11 and 12) to 'wetlands' ecosystem trigger values. These are considered to be most applicable for the drains and lakes respectively and their receiving environment, the Canning River. ANZECC and ARMCANZ do not provide a trigger value for total suspended solids, however DoW (n.d.) use an interim assessment value of 6 mg/L, which has been used for comparison purposes in this assessment.

The system being monitored is largely a piped system that ultimately discharges into the Canning River. Much of the monitoring captures data from water running directly off roads and residential areas with no treatment prior to entering the lakes and drains. From a human-use perspective, Bull Creek is not a source of drinking water but may be accessed by the public at several points, on public and privately owned land. Therefore it is reasonable to compare the toxicant results to the National Health and Medical Research Council's (NHMRC) *Guidelines for Managing Risks in Recreational Water* (2008). Trigger values for pH and dissolved oxygen are specified in these guidelines. For toxicant parameters (i.e. metals and ammonia), these guidelines recommend that recreational trigger values be calculated by multiplying the relevant trigger values in the NHMRC (2016) *Australian Drinking Water Guidelines* 6: 2011 (ADWG) by ten. An exceedance of the referenced trigger level does not indicate that 'standards' are not being met, but is an indication that further consideration should be given to the situation.

The ANZECC guidelines also provide both low and high trigger values for metals in sediment in chapter 3 (2000). Where concentrations are between the low and high values background concentrations should be investigated. If the results exceed the high guidelines or are above the background concentrations a further assessment for the bioavailability of the metal is required.

To better graph the site results in accordance with their referenced trigger values they have been ordered with the 'lowland rivers' sites to the left and the 'wetlands' sites to the right. The lowland river sites have been separated into the two main drainage lines (Bull Creek Main Drain and Brentwood Main Drain) and arranged from the top of the catchment to the bottom (entrance to the Canning River) creating a more visual display of the individual segments allowing for better interpretation of flow and spatial patterns and understanding the aquatic conditions upstream and downstream.

# 5. Physicochemical Properties

Refer to **Tables D-1 to D-6 in Appendix D** for all physicochemical parameter data (pH, dissolved oxygen, electrical conductivity, total suspended solids and temperature) collected in the 2016 water quality sampling of the Melville Bull Creek catchments. **Table E-1, Appendix E** outlines the factors that influence changes in these physicochemical parameters, and the impacts that changes to these parameters can have to aquatic ecosystems.

## 5.1 pH

pH is a measure of the acidity or alkalinity of a water body. pH is measured on a logarithmic scale, and as such a pH of 5 is ten times more acidic than a pH of 6 and a pH of 9 is ten times more alkaline than a pH of 8. A pH value of less than 6.5 is considered acidic, between 6.5 and 8.0 is considered neutral and higher than 8.0 is considered high by DoW (n.d.).

In Southwest Australia pH levels between 6.5 and 8.0 are required to sustain aquatic life in freshwater lowland rivers; levels between 7 and 8.5 are required for wetlands and levels between 6.5 and 8.5 are suitable for recreational use (NHMRC 2008).

pH levels in the surface water of the Melville Bull Creek catchments were generally low (acidic). When compared against the appropriate lowland rivers or wetlands acceptable range, just less than half of the samples (28 out of 59) at seven out of the 15 sites (15, 5, 2, 7, 8, 9 and 12) recorded pH values below the acceptable ranges on at least one occasion and one sample (11) exceeded the acceptable range (**Figure 5.1-1** and **Table D-1, Appendix D**). Furthermore, 22 samples recorded pH below the acceptable range for recreational use, and one sample above the acceptable range (**Figure 5.2-2**). The highest pH of 10.02 was recorded during November at Marmion Reserve (site 11) and the lowest of 3.55 during August at Booragoon Lake outlet (site 7).

When comparing results between John Creaney Park (site 5) and downstream Elizabeth Manion Park (site 16) against Brockman Park (site 2), pH values were quite acidic (<6.5) at John Creaney Park on all occasions but within normal limits on all occasions (where samples were able to be collected) at downstream Elizabeth Manion Park, suggesting that the low pH values recorded at Brockman Park may be attributed to contributions from the upstream western branch of the RAAF drain. However, pH levels were once again within acceptable limits further downstream at both Brockman Park Inlet (ROSSTAFE) and Bull Creek MD (PSDTBCMD).

The particularly high pH at site 11 (Marmion Reserve) in October of 10.02, combined with the high dissolved oxygen levels, may partially be a result of high levels of photosynthesis resulting from the large amount of both phytoplankton (indicated by the “greenish water” observed) and filamentous algae observed at the site. This high pH is concerning, as some metals (such as aluminium) become more toxic at high pH, and the proportion of ammonia/ammonium existing as ammonia (the more toxic form) is higher (see Section 9.1.3).

Similarly, the very low pH values at sites 7 and 12 (Booragoon Lake outlet and Blue Gum Lake outlet), and to a lesser degree 8 and 9 (Piney Lakes outlet and Quenda Lake outlet) are concerning as some metals (such as aluminium, manganese, mercury, molybdenum and nickel) can become more soluble or toxic at low pH. Low pH can be caused by the exposure of acid sulfate soils, often present in wetland sediments (DER 2015b), to air which results in their oxidation and a subsequent release of acid. For further discussion regarding low pH levels at these lakes see **Section 11.1.2**,

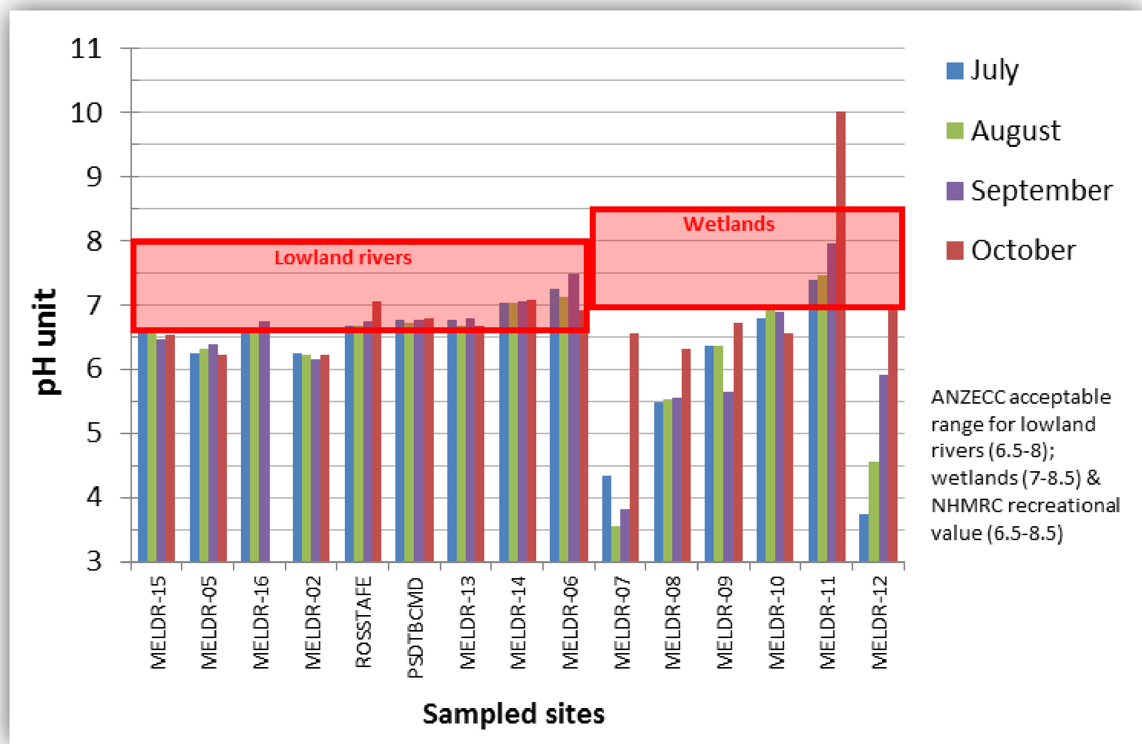


**Figure 5.1-1: pH of the surface water of the Melville Bull Creek catchments in 2016 (as compared to ANZECC lowland rivers and wetlands trigger values)**

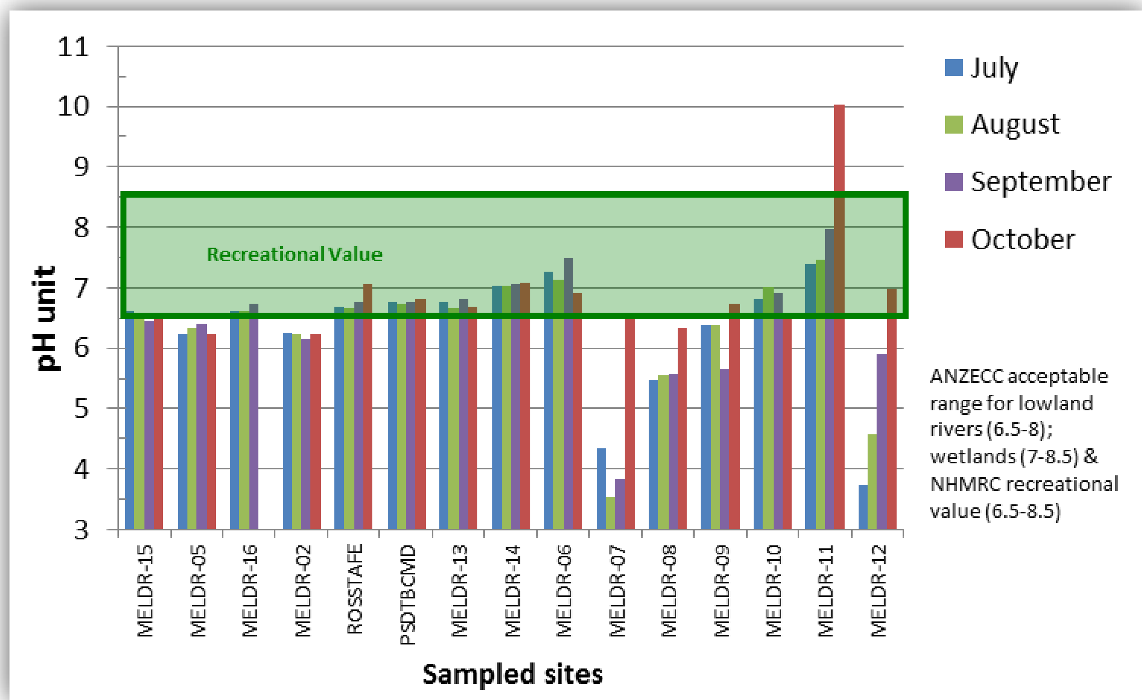


**Figure 5.1-2: pH of the surface water of the Melville Bull Creek catchments in 2016 (as compared to NHMRC recreational trigger value)**

**Table 5.1-1** presents the recorded pH throughout the nine-year monitoring period. Brockman Park, Booragoon Lake outlet, Piney Lakes outlet and Blue Gum Lake outlet (sites 2, 7, 8 and 12) have generally recorded pH below the acceptable range for lowland rivers or wetlands. Bull Creek MD, John Creaney Park outlet, Bateman Park, Frederick Baldwin and Marmion Reserve (sites PSDTBCMD, 5, 6 and 11) have consistently recorded pH within the acceptable ranges. High pH values have been sporadically recorded, often in spring and summer, at site 11 (Marmion Reserve) over the years.

## Table 5.1-1: Record of pH in the Melville Bull Creek catchments 2007 - 2016

pH — Max 10.02 — Min 3.24

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LOWLAND RIVERS (ANZECC acceptable range 6.5 - 8.0) | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | 6.74 | 6.65 | | | 6.45 | 7.18 | 7.35 | | 6.65 | 6.85 | | | 6.93 | 6.91 | 7.1 | 7.31 | 7.22 | 6.33 | 6.29 | 6.45 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | 6.07 | 6.21 | 6.44 | 6.23 | 6.14 | 6.94 | 6.34 | 6.39 | 6.29 | 6.54 | 6.36 | | 6.24 | 6.34 | 6.28 | 6.37 | 6.31 | 6.45 | 6.18 | 6.28 |
| PSDTBCMD | 6.89 | 6.88 | 6.47 | 7.3 | 6.82 | 7.46 | 7.47 | 7.2 | 7.07 | 7.24 | 7.23 | | 6.92 | 7.29 | 7.51 | 7.49 | 6.73 | 7.36 | 6.58 | 7.27 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | 6.17 | 6.51 | 7.6 | 6.35 | 6.35 | 7.27 | 6.58 | 6.68 | 6.74 | 6.52 | 6.67 | | 6.98 | 6.94 | 7.26 | 6.87 | 7.15 | 7.01 | 6.46 | 7.07 |
| Site | WETLANDS (ANZECC acceptable range 7.0 - 8.5) | | | | | | | | | | | | | | | | | | | |
| MELDR-07 | 3.26 | 4.69 | | | 5.71 | 7.17 | 7.19 | | 3.94 | 6.77 | | | 6.23 | 6.55 | 6.88 | 5.6 | | 5.45 | 6.29 | 6.78 |
| MELDR-08 | 4.3 | 5.03 | | | 5.67 | 7.33 | | | 5.87 | | | | | | | | | | 4.19 | 4.73 |
| MELDR-09 | 7.08 | 7.37 | | | 7.11 | 7.69 | 7.52 | 7.51 | 7.04 | 7.14 | 6.96 | | 7.5 | 7.53 | 7.26 | | 5.14 | 6.91 | 6.07 | 6.83 |
| MELDR-10 | 7.21 | 8.4 | | | 9.3 | 8.16 | 7.1 | 7.07 | 9.01 | 9.39 | 6.88 | | 7.55 | 7.51 | 7.32 | 7.55 | 6.96 | 7.95 | 6.99 | 7.62 |
| MELDR-11 | 7.56 | 8.31 | | | 8.38 | 8.17 | 9.08 | 8.16 | 8.67 | 9.3 | 9.7 | 9.21 | 7.34 | 7.52 | 7.87 | 9.08 | 7.22 | 7.8 | 7.51 | 7.59 |
| MELDR-12 | 4.31 | 7.5 | | | 7.05 | 7.92 | 8.49 | | 6.74 | 9.3 | 7.96 | | 7.17 | 7.61 | 9.44 | 8.57 | 3.41 | 3.5 | 6.47 | 7.08 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LOWLAND RIVERS (ANZECC acceptable range 6.5 - 8.0) | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | 6.16 | 6.11 | 6.21 | 6.41 | 6.24 | 6.76 | 6.68 | 6.61 | 6.56 | 6.46 | 6.54 |
| MELDR-05 | 6.23 | 6.62 | 6.52 | 6.67 | 6.51 | 6.57 | 6.96 | 7.1 | 6.13 | 6.25 | 6.17 | 6.43 | 6.33 | 6.15 | 6.55 | 6.55 | 6.24 | 6.33 | 6.4 | 6.22 |
| MELDR-16 | | | | | | | | | | 6.29 | 6.24 | 6.56 | 6.44 | 7.1 | 6.48 | 6.9 | 6.61 | 6.61 | 6.74 | |
| MELDR-02 | 6.22 | 6.18 | 6.33 | 6.38 | 6.27 | 6.32 | 6.54 | 6.71 | 6.1 | 6.21 | 6.17 | 6.22 | 6.11 | 6.04 | 6.16 | 6.16 | 6.26 | 6.22 | 6.16 | 6.23 |
| PSDTBCMD | 6.81 | 6.74 | 7.25 | 7.07 | 6.62 | 7.27 | 6.6 | 6.8 | 6.61 | 6.73 | 6.67 | 6.76 | 6.66 | 6.51 | 6.68 | 6.66 | 6.77 | 6.73 | 6.77 | 6.8 |
| MELDR-13 | | | | | | | 6.67 | 6.72 | 6.59 | 6.69 | 6.66 | 6.74 | 6.5 | 6.31 | 6.57 | 6.41 | 6.77 | 6.67 | 6.81 | 6.69 |
| MELDR-14 | | | | | | | 6.29 | 6.33 | 6.99 | 7.14 | 7.11 | 7.12 | 7.01 | 6.8 | 6.89 | 6.86 | 7.04 | 7.03 | 7.06 | 7.09 |
| MELDR-06 | 6.88 | 6.89 | 7.08 | 7.12 | 6.71 | 7.06 | 6.12 | 6.25 | 6.82 | 6.8 | 6.78 | 6.87 | 6.83 | 6.74 | 6.74 | 6.56 | 7.25 | 7.13 | 7.48 | 6.91 |
| Site | WETLANDS (ANZECC acceptable range 7.0 - 8.5) | | | | | | | | | | | | | | | | | | | |
| MELDR-07 | | | 3.91 | 3.94 | | 3.74 | 6.38 | 6.68 | 4.5 | 6.26 | 6.76 | 6.83 | 3.34 | 3.24 | 6.19 | 6.58 | 4.35 | 3.55 | 3.83 | 6.55 |
| MELDR-08 | | 4.99 | 5.62 | 5.68 | 5.02 | 5.37 | 7.25 | 7.26 | 5.23 | 5.34 | 5.43 | 5.4 | 5.45 | 5.31 | 6.55 | 6.49 | 5.48 | 5.54 | 5.57 | 6.33 |
| MELDR-09 | 7.08 | 6.74 | 7.21 | 7.03 | 6.92 | 6.6 | 8.04 | 9.29 | 6.02 | 6.31 | 6.26 | 6.85 | 6.41 | 6.27 | 6.92 | 6.8 | 6.37 | 6.38 | 5.66 | 6.73 |
| MELDR-10 | 7.31 | 7.4 | 8.42 | 7.1 | 7.14 | 7.31 | 5.62 | 5.72 | 6.98 | 7.37 | 7.61 | 6.73 | 6.77 | 6.94 | 6.63 | 8.31 | 6.8 | 7.01 | 6.9 | 6.56 |
| MELDR-11 | 7.64 | 7.65 | 8.24 | 8.42 | 7.43 | 7.64 | 6.26 | 6.82 | 7.32 | 7.09 | 7.81 | 8.3 | 8.08 | 7.9 | 9.92 | 9.99 | 7.4 | 7.46 | 7.96 | 10.02 |
| MELDR-12 | 3.99 | 4.03 | 5.16 | 6.97 | 4.12 | 6.6 | 6.79 | 7.04 | 6.39 | 6.58 | 6.9 | 7 | 6.48 | 6.43 | 6.95 | 6.97 | 3.74 | 4.57 | 5.91 | 6.98 |

SITES RECORDING pH ALWAYS/GENERALLY OUTSIDE ACCEPTABLE RANGE

SITES RECORDING 40-60% of pH values ABOVE ACCEPTABLE RANGE

SITES RECORDING pH ALWAYS/GENERALLY WITHIN ACCEPTABLE RANGE

Record BELOW acceptable range | Record WITHIN acceptable range

Record ABOVE acceptable range | NO sample taken

## 5.2 Dissolved oxygen

As dissolved oxygen can fluctuate greatly over a diurnal cycle, it is preferable to measure it over a full diurnal cycle for a few days (ANZECC & ARMCANZ 2000). This type of DO monitoring however was not conducted as part of this monitoring program.

Dissolved oxygen saturation between 80-120% is required to sustain aquatic life in freshwater lowland rivers and between 90-120% is required in wetlands (ANZECC and ARMCANZ 2000). For recreational use, dissolved oxygen concentrations greater than 80% saturation are ideal (NHMRC 2008).

Dissolved oxygen saturations in the surface water of the Melville Bull Creek catchments were generally below the acceptable ranges for lowland rivers or wetlands as applicable, with the vast majority of samples (51 out of 59) recorded DO% saturations below the acceptable ranges, and also above the recreational use guideline (**Figure 5.2-1** and **Table D-2, Appendix D**). Only one site recorded saturations above the acceptable range, site 11 (Marmion Reserve) recorded 132.3% saturation in October. Only three sites recorded saturations within the acceptable range on at least one sampling occasion: site 16 (downstream Elizabeth Manion Park) recorded 80.8% and 87.1% in August and September respectively, site 14 (RAAF Drain) recorded 85%, 87.5% and 82.4% in July, August and September respectively and site 12 (Blue Gum Lake outlet) recorded 90% during July. Site 10 (Frederick Baldwin) recorded the lowest saturation in the catchment of 2.5% during October. All samples except seven were below the recreational trigger value.

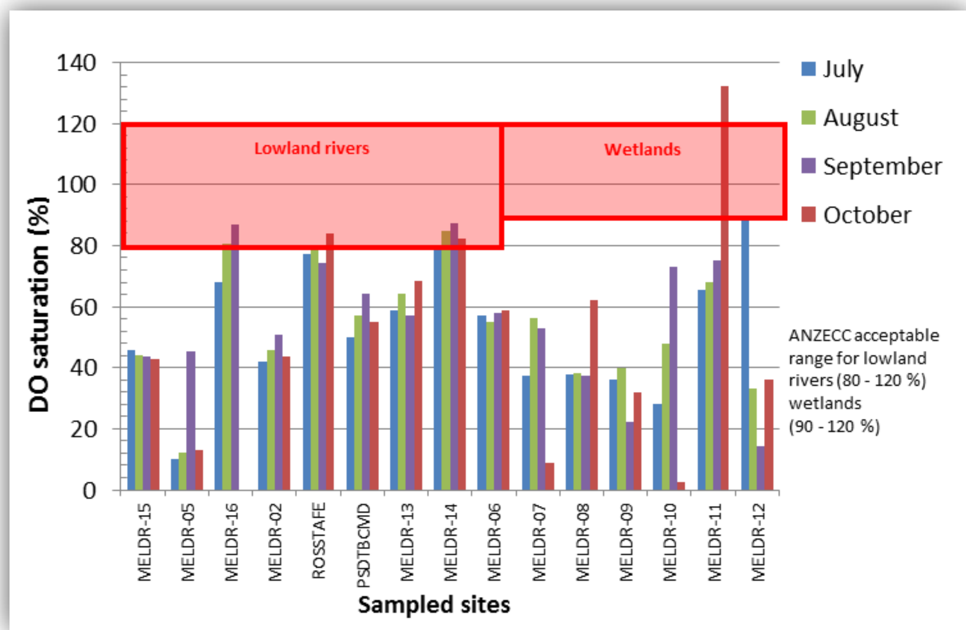


**Figure 5.2-1: Dissolved oxygen (DO %) saturations of the surface water of the Melville Bull Creek catchments in 2016**

When comparing results between sites 13 and 14 (Brentwood Drain and RAAF Drain respectively), DO saturations were always below the acceptable range at site 13 (Brentwood drain), whereas site 14 (RAFF drain) recorded saturations within the acceptable range in August, September and October and close to the acceptable range in July. DO saturations at site 6 (Bateman Park) downstream are similarly low to those at site 13.

Dissolved oxygen saturations were significantly lower at the outlet of John Creaney Park (site 5) than the inlet (site 15) suggesting that the waterway in John Creaney Park is an anoxic oxygen "sink". The particularly low DO saturations at this site are concerning as metals and phosphorus in the sediments could be mobilised under these conditions.

The high dissolved oxygen saturation recorded at site 11 (Marmion Reserve) in October, together with the high pH value, is likely to be a result of high levels of photosynthesis resulting from the large amount of both phytoplankton (indicated by the “greenish water” observed) and filamentous algae observed at the site.

When considering the dissolved oxygen concentrations in mg/L, from a total of 60 samples, 16 recorded very low concentrations (<4 mg/L), 23 recorded low concentrations (4.0 to 6.0 mg/L), 14 recorded moderately oxygenated concentrations (6.0 to 8.0 mg/L), five samples recorded well oxygenated concentrations (8.0 to 10.0 mg/L) and one sample recorded a hyperoxic concentration (>10.0 mg/L) (**Figure 5.2-2** and **Table D-3, Appendix D)**.

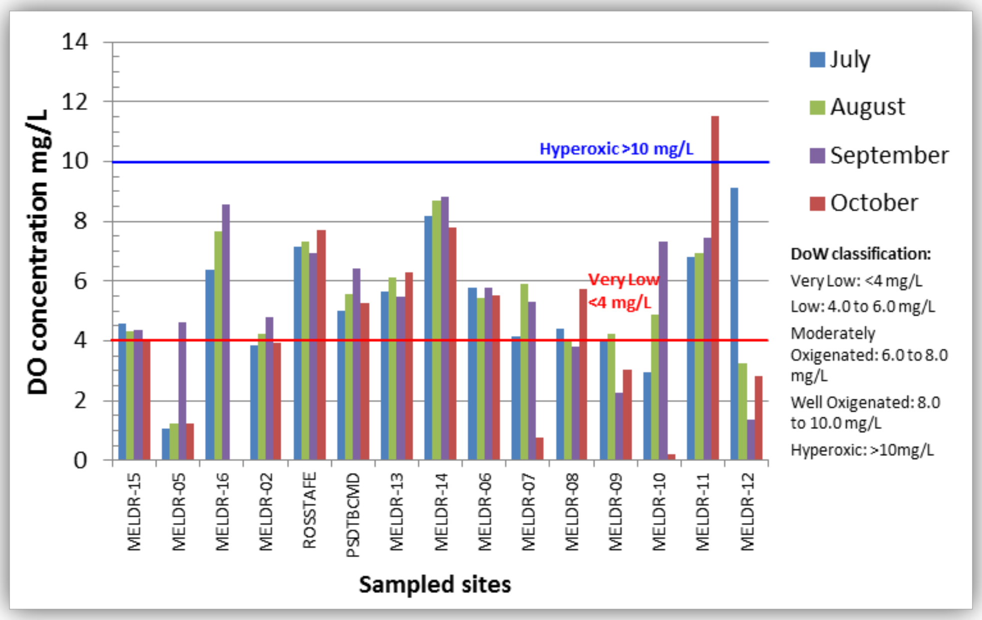


**Figure 5.2-2: Dissolved oxygen concentrations (mg/L) of the surface water of the Melville Bull Creek catchments in 2016**

**Table 5.2-1** shows the DO% throughout the nine-year monitoring period. It is evident that DO saturations have generally been outside the acceptable range for lowland rivers and wetlands, with the majority of saturations below the lower acceptable limit. The low DO saturations within the Melville Bull Creek catchments are of concern, and could lead to several environmental problems (if they are not already present) such as stress to the aquatic community, the facilitation of undesirable chemical reactions, the release of sediment-bound nutrient and toxicants back into the water column, and the increased toxicity of some metals.

**Table 5.2-2** shows the dissolved oxygen concentrations in mg/L and is colour coded to display the oxygen levels in terms of very low (<4 mg/L), low (4-6 mg/L), moderately oxygenated (6-8 mg/L), well oxygenated (8-10 mg/L) and hyper oxygenated (>10 mg/L). Only 31 samples out of 404 samples over the ten-year monitoring period have recorded concentrations for a well oxygenated environment. In the Melville lakes sites (7, 8, 9, 10, 11 and 12), oxygen concentrations have tended to be lower from 2013 onwards compared to the years prior, even though several of these sites (7, 8 and 10) have generally recorded concentrations within the acceptable range when considering the entire ten-year period.

## Table 5.2-1: Record of DO saturation (%) in the Melville Bull Creek catchments 2007 - 2016

DO saturation % — Max 206.5 — Min 0.3

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWLAND RIVERS (ANZECC acceptable range 80-120%) | | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | 13.1 | 21.9 | | | 29.9 | 8.8 | 2.7 | | 42.8 | 65.4 | | | 74.3 | 26.2 | 14.6 | 12.7 | 60.2 | 11.4 | 76.3 | 7.7 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | 51.8 | 53.7 | 46.7 | 44.5 | 53.1 | 50.1 | 46.9 | 44.9 | 53.4 | 49.7 | 41.5 | | 54.8 | 47.2 | 40.2 | 41.1 | 46.1 | 48.2 | 49.7 | 44.1 |
| PSDTBCMD | 65.5 | 70.7 | 83.7 | 66.1 | 66.6 | 61.2 | 68.3 | 62.7 | 61.8 | 67.2 | 69.5 | | 65.3 | 57.9 | 55 | 51.6 | 62.2 | 59.1 | 54.3 | 57.7 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | 76.4 | 84.3 | 63.2 | 76.5 | 76.4 | 82.9 | 86.5 | 80.7 | 76.4 | 84.7 | 84.8 | | 75.7 | 74.9 | 72.3 | 79.8 | 74.5 | 75.7 | 80.2 | 80.5 |
| Site | WETLANDS (ANZECC acceptable range 90-120%) | | | | | | | | | | | | | | | | | | | |
| MELDR-07 | 123.2 | 20.7 | | | 49.5 | 47.2 | 36.6 | | 115.2 | 19 | | | 61.2 | 12.1 | 91.4 | 78.6 | | 115.6 | 32.9 | 22.9 |
| MELDR-08 | 122.8 | 37.5 | | | 65.9 | 43.4 | | | 66.1 | | | | | | | | | | 54.1 | 49.8 |
| MELDR-09 | 62.4 | 92.1 | | | 93.4 | 82.5 | 91 | 75.6 | 84.9 | 100.7 | 74.1 | | 101.2 | 89.9 | 80.4 | | 76.2 | 97.3 | 70 | 78.3 |
| MELDR-10 | 59.2 | 113 | | | 143.8 | 81.9 | 125.6 | 41.8 | 116.5 | 156.1 | 37.5 | | 82.8 | 67.5 | 23.7 | 45.8 | 57.3 | 63 | 57.3 | 82.4 |
| MELDR-11 | 84.8 | 122.8 | | | 110.5 | 80 | 123.8 | | 102 | 206.5 | 188.3 | 186.4 | 48.5 | 54.8 | 103.7 | 134.1 | 61 | 65 | 67.2 | 55 |
| MELDR-12 | 121.9 | 79.7 | | | 48.8 | 88.8 | 123.4 | 83.5 | 41.2 | 134.2 | 88.4 | | 90 | 95.6 | 160.4 | 125.5 | 107.1 | 78.6 | 17.7 | 47.7 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWLAND RIVERS (ANZECC acceptable range 80-120%) | | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | 41.1 | 39.3 | 47.7 | 56.9 | 53 | 48.4 | 56 | 45.8 | 44.1 | 43.7 | 42.9 |
| MELDR-05 | 9.4 | 60.9 | 2.3 | 21.1 | 27.8 | 22.5 | 88.9 | 71.7 | 31.6 | 8.1 | 12.6 | 18.2 | 13.1 | 0.3 | 0.6 | 1.6 | 10.1 | 12 | 45.4 | 12.9 |
| MELDR-16 | | | | | | | | | | 79.4 | 97.9 | 82 | 65.1 | 71.1 | 63.7 | 70.2 | 68.1 | 80.8 | 87.1 | |
| MELDR-02 | 45.6 | 47.1 | 43.2 | 41.1 | 45.1 | 45.9 | 70.5 | 72.9 | 52.3 | 40.8 | 46 | 37 | 41.7 | 37.5 | 32.4 | 35.1 | 42 | 45.8 | 50.9 | 43.5 |
| PSDTBCMD | 48.3 | 56.8 | 51.7 | 48.6 | 57.2 | 55.1 | 75.7 | 73.2 | 63.7 | 53.6 | 53.6 | 52.5 | 56.4 | 53.7 | 45.9 | 51.5 | 50 | 56.9 | 64.4 | 55.1 |
| MELDR-13 | | | | | | | 51.2 | 47.8 | 78.1 | 65.4 | 69.3 | 71.8 | 55.1 | 63.1 | 65.5 | 47.6 | 58.7 | 64.2 | 57.3 | 68.5 |
| MELDR-14 | | | | | | | 8.7 | 13.3 | 88.4 | 77.7 | 82 | 80 | 91.6 | 75.7 | 50.7 | 69.5 | 78.5 | 85 | 87.5 | 82.4 |
| MELDR-06 | 56.9 | 76.8 | 74.8 | 83.1 | 59 | 73.4 | 41.3 | 40 | 72.4 | 71.9 | 73.1 | 75.8 | 77 | 54.2 | 66.2 | 49.4 | 57.3 | 54.9 | 57.9 | 58.8 |
| Site | WETLANDS (ANZECC acceptable range 90-120%) | | | | | | | | | | | | | | | | | | | |
| MELDR-07 | | | 51.9 | 52.5 | | 71.7 | 36.8 | 37.8 | 42.5 | 0.6 | 136.6 | 19.9 | 79.6 | 61.4 | 1.7 | 2.2 | 37.5 | 56.4 | 52.9 | 8.9 |
| MELDR-08 | | 41.5 | 39 | 88.7 | 20.1 | 27.1 | 72.9 | 63.9 | 32.7 | 40.1 | 25.5 | 38.9 | 54.8 | 46.1 | 55.5 | 73.4 | 37.8 | 38.3 | 37.4 | 62.2 |
| MELDR-09 | 72.5 | 85 | 81.3 | 77.8 | 77.8 | 55 | 86.7 | 97.6 | 35 | 3 | 0.8 | 29.6 | 33.4 | 32.4 | 60.2 | 36.8 | 36.2 | 40 | 22.3 | 31.7 |
| MELDR-10 | 55.2 | 71.2 | 84.6 | 27.9 | 52.1 | 72.6 | 32.9 | 30.2 | 54.2 | 61.3 | 70.2 | 59.6 | 32.2 | 52 | 3.7 | 69 | 28.1 | 47.9 | 73.2 | 2.5 |
| MELDR-11 | 65.8 | 68 | 82 | 110.7 | 39.6 | 68.5 | 33.9 | 37.3 | 61.6 | 15 | 64.6 | 67.6 | 76.2 | 80.5 | 121 | 96.1 | 65.4 | 68.1 | 75.1 | 132.3 |
| MELDR-12 | 107.3 | 118.4 | 95.2 | 81.1 | 8.8 | 17.9 | 26.3 | 15.3 | 21.1 | | 30.3 | 21.7 | 31.2 | 41.7 | 48.8 | 35.3 | 90 | 33 | 14.2 | 36.1 |

SITES RECORDING DO SATURATIONS ALWAYS/GENERALLY OUTSIDE ACCEPTABLE RANGE
SITES RECORDING 40-60% of DO saturations ABOVE ACCEPTABLE RANGE
SITES RECORDING DO saturations ALWAYS/GENERALLY WITHIN ACCEPTABLE RANGE

Record BELOW acceptable range | Record WITHIN acceptable range
Record ABOVE acceptable range | NO sample taken

## Table 5.2-2: Record of DO concentrations (mg/L) in the Melville Bull Creek catchments 2007 – 2016

DO concentration (mg/L) — Max 16.35 — Min 0.03

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | 1.4 | 2.03 | | | 2.9 | 0.8 | 0.24 | | 4.11 | 5.42 | | | 7.35 | 2.6 | 1.33 | 1.16 | 6.15 | 1.11 | 7.28 | 0.69 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | 4.77 | 4.91 | 4.12 | 3.92 | 4.87 | 4.52 | 4.16 | 3.95 | 4.93 | 4.46 | 3.65 | | 5.13 | 4.31 | 3.64 | 3.69 | 4.18 | 4.39 | 4.5 | 3.96 |
| PSDTBCMD | 6.59 | 6.66 | 7.32 | 6.14 | 6.44 | 5.79 | 6.33 | 5.84 | 5.96 | 6.04 | 6.37 | | 6.32 | 5.7 | 5.23 | 4.88 | 6.06 | 5.68 | 5.12 | 5.31 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | 7.37 | 7.8 | 5.83 | 6.71 | 7.25 | 7.5 | 7.45 | 7.03 | 7.29 | 7.22 | 7.24 | | 7.25 | 7.27 | 6.66 | 7.32 | 7.01 | 7.1 | 7.43 | 7.21 |
| MELDR-07 | 12.03 | 1.84 | | | 4.67 | 3.65 | 2.78 | | 11.16 | 1.53 | | | 5.72 | 1.17 | 7.83 | 6.36 | | 11.24 | 3.02 | 2.02 |
| MELDR-08 | 11.6 | 3.32 | | | 6.71 | 3.53 | | | 6.49 | | | | | | | | | | 5.17 | 4.5 |
| MELDR-09 | 6.78 | 8.34 | | | 9.41 | 7.18 | 7.38 | 6.83 | 8.27 | 8.3 | 6.21 | | 10.3 | 9 | 7.4 | | 8.04 | 9.85 | 6.75 | 7.04 |
| MELDR-10 | 5.9 | 9.85 | | | 13.46 | 6.9 | 10.16 | 3.76 | 11.03 | 12.36 | 3.1 | | 7.84 | 6.55 | 2.17 | 4.28 | 5.78 | 6.13 | 5.21 | 7.25 |
| MELDR-11 | 8.66 | 10.9 | | | 10.59 | 6.85 | 9.89 | 7.24 | 9.8 | 16.35 | 14.53 | 13.81 | 4.66 | 5.18 | 8.99 | 11.39 | 6.16 | 6.38 | 6.19 | 5.01 |
| MELDR-12 | 11.8 | 6.9 | | | 4.51 | 7.08 | 9.5 | | 3.93 | 10.65 | 6.66 | | 8.12 | 8.81 | 13.57 | 9.79 | 10.27 | 7.34 | 1.61 | 4.05 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | 3.92 | 3.61 | 4.27 | 5.56 | 5.1 | 4.42 | 5.06 | 4.58 | 4.34 | 4.38 | 3.99 |
| MELDR-05 | 1.01 | 6.23 | 0.22 | 1.96 | 2.7 | 2.1 | 8.26 | 6.33 | 3.01 | 0.77 | 1.15 | 1.64 | 1.33 | 0.03 | 0.05 | 0.14 | 1.07 | 1.22 | 4.61 | 1.23 |
| MELDR-16 | | | | | | | | | | 7.52 | 9.06 | 7.39 | 6.05 | 6.58 | 5.78 | 6.36 | 6.39 | 7.67 | 8.57 | |
| MELDR-02 | 4.1 | 4.32 | 3.92 | 3.7 | 4.17 | 4.19 | 6.39 | 6.42 | 4.91 | 3.73 | 4.16 | 3.3 | 3.81 | 3.43 | 2.9 | 3.14 | 3.84 | 4.22 | 4.78 | 3.95 |
| PSDTBCMD | 4.85 | 5.59 | 5.02 | 4.6 | 5.45 | 5.11 | 6.89 | 6.49 | 6.04 | 5.1 | 4.96 | 4.89 | 5.54 | 5.32 | 4.22 | 4.76 | 5.01 | 5.58 | 6.4 | 5.28 |
| MELDR-13 | | | | | | | 4.74 | 4.38 | 7.5 | 6.1 | 6.28 | 6.41 | 5.27 | 5.98 | 5.75 | 4.15 | 5.65 | 6.1 | 5.49 | 6.29 |
| MELDR-14 | | | | | | | 0.79 | 1.18 | 8.5 | 7.45 | 7.52 | 7.28 | 9.33 | 7.62 | 4.57 | 6.21 | 8.18 | 8.71 | 8.83 | 7.78 |
| MELDR-06 | 4.87 | 7.63 | 7.12 | 7.65 | 5.56 | 6.75 | 3.74 | 3.56 | 6.93 | 6.77 | 6.66 | 6.81 | 7.51 | 5.3 | 5.91 | 4.43 | 5.77 | 5.45 | 5.77 | 5.51 |
| MELDR-07 | | | 5.08 | 4.84 | | 6.58 | 3.36 | 3.29 | 4.13 | 0.05 | 11.53 | 1.64 | 8.25 | 6.06 | 0.15 | 0.19 | 4.15 | 5.89 | 5.29 | 0.77 |
| MELDR-08 | | 4.53 | 3.88 | 7.79 | 1.96 | 2.48 | 6.46 | 5.15 | 3.24 | 3.79 | 2.28 | 3.57 | 5.87 | 4.8 | 4.7 | 6.37 | 4.39 | 4.05 | 3.81 | 5.75 |
| MELDR-09 | 8.31 | 9.21 | 7.98 | 7.12 | 7.88 | 5.17 | 7.77 | 7.99 | 3.45 | 0.29 | 0.07 | 2.66 | 3.52 | 3.35 | 5.14 | 3.2 | 3.98 | 4.23 | 2.27 | 3.04 |
| MELDR-10 | 5.94 | 7.26 | 7.77 | 2.61 | 4.97 | 6.71 | 2.93 | 2.54 | 5.19 | 5.53 | 6.1 | 5.24 | 3.21 | 4.95 | 0.33 | 5.67 | 2.94 | 4.88 | 7.32 | 0.23 |
| MELDR-11 | 7.03 | 6.96 | 7.57 | 9.82 | 3.76 | 6.35 | 3.1 | 2.98 | 5.91 | 1.41 | 5.68 | 5.78 | 7.58 | 7.7 | 9.76 | 7.75 | 6.81 | 6.94 | 7.43 | 11.51 |
| MELDR-12 | 11.2 | 11.86 | 8.38 | 6.82 | 0.86 | 1.57 | 2.17 | 1.2 | 1.96 | | 2.39 | 1.76 | 3.03 | 3.71 | 3.68 | 2.65 | 9.14 | 3.25 | 1.35 | 2.84 |

SITES RECORDING DO SATURATIONS ALWAYS/GENERALLY OUTSIDE ACCEPTABLE RANGE
SITES RECORDING 40-60% of DO concentrations ABOVE ACCEPTABLE RANGE
SITES RECORDING DO concentrations ALWAYS/GENERALLY WITHIN ACCEPTABLE RANGE

very low <4 | moderately oxygenated 6-8 | hyperoxic >10
low 4-6 | well oxygenated 8-10

## 5.3 Electrical conductivity

Electrical conductivity (EC) is the ability of water or soil to conduct an electric current. It is commonly used as a measure of salinity or total dissolved salts as solutions with high salt concentrations conduct electricity better than pure water. EC is increased when the total concentration of inorganic ions (particularly sodium, chlorides, carbonates, magnesium, calcium, potassium and sulfates) is increased.

According to the ANZECC (2000) guidelines for electrical conductivity the lower limit of 0.12 mS/cm and upper limit of 0.3 mS/cm for freshwater lowland rivers and for wetlands the lower limit of 0.3 mS/cm and 1.5 mS/cm should not be exceeded.

Electrical conductivity in the surface water of the Melville Bull Creek catchments was varied. 45 out of 59 samples recorded EC levels outside the acceptable ranges for lowland rivers or wetlands. The lowest EC reading (0.0934 mS/cm) was recorded at site 10 (Frederic Baldwin) in July (**Figure 5.3-1** and **Table D-4, Appendix D)**. Site 7 (Booragoon Lake outlet) recorded the highest electrical conductivity in the catchment on all four occasions (2.449, 2.336, 1.919, and 1.671 mS/cm during July, August, September and October respectively).

Sites 15, 5, 2, ROSSTAFE, PSDTBCMD, 13, 14, 6 and 7 (John Creaney Park inlet, John Creaney Park, Brockman Park, Brockman Park inlet, Bull Creek MD, Brentwood drain, RAAF Drain, Bateman Park and Booragoon Lake Outlet respectively) recorded EC levels above the acceptable range on all sampling occasions. Site 16 (Downstream Elizabeth Manion Park) recorded EC above the acceptable range in July and August, site 10 (Frederick Baldwin) recorded EC levels below the acceptable range in July, August and September and site 11 recorded EC levels below the acceptable range on all sampling occasions. Only sites 8, 9 and 12 (Piney Lakes outlet, Quenda Lake outlet and Blue Gum Lake outlet) recorded EC within the acceptable range on all sampling occasions.

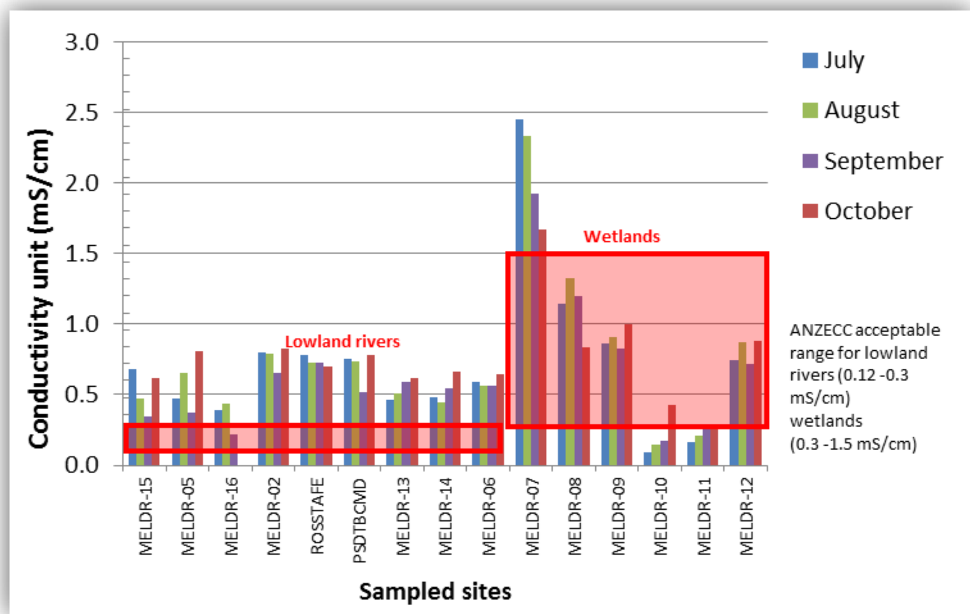


**Figure 5.3-1: Electrical conductivity (mS/cm) of the surface water of the Melville Bull Creek catchments in 2016**

When comparing results between sites 5, 15 and 16 (John Creaney Park inlet, John Creaney Park and downstream Elizabeth Manion Park respectively), EC was above the acceptable range at all sites (except in September at Elizabeth Manion park) however the John Creaney sites recorded the highest readings. These results suggest that the high EC recorded at site 2 can be more attributed to the input coming from John Creaney drain rather than that coming from Elizabeth Manion Park. EC was reasonably similar between sites 2, ROSSTAFE (Brockman Park inlet) and PSDTBCMD (Bull Creek MD) indicating that EC is remaining relatively constant as water flows along that portion of the Bull Creek main drain.

**Table 5.3-1** presents the recorded EC throughout the nine-year monitoring period. Sites 5, 2, PSDTBCMD, 6 and 7 (John Creaney Park outlet, Brockman Park, Bull Creek MD, Bateman Park and Booragoon Lake outlet respectively) have recorded EC outside the acceptable range on all sampling occasions when samples have been collected, with the exception of site 5 during the August 2010 and August 2012, site 6 during the August 2014 sampling event, and site 7 in October and November 2013 sampling events. Sites 8, 9 and 12 (Piney Lakes outlet, Quenda Lake outlet and Blue Gum Lake outlet respectively) have usually recorded EC within the acceptable range when samples have been collected.

## Table 5.3-1: Record of EC (mS/cm) in the Melville Bull Creek catchments 2007- 2016

Conductivity (mS/cm) Max 33.2 Min 0.037

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LOWLAND RIVERS (ANZECC acceptable range 0.12 - 0.3 mS/cm) | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | 0.096 | 0.798 | | | 1.038 | 0.796 | 1.23 | | 0.761 | 0.877 | | | 0.289 | 0.9 | 1.036 | 0.738 | 0.037 | 1.061 | 0.839 | 1.182 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | 0.79 | 0.769 | 0.814 | 0.809 | 0.814 | 0.788 | 0.822 | 0.806 | 0.742 | 0.806 | 0.848 | | 0.568 | 0.79 | 0.805 | 0.809 | 0.762 | 0.754 | 0.832 | 0.773 |
| PSDTBCMD | 0.746 | 0.709 | 0.736 | 0.776 | 0.706 | 0.725 | 0.754 | 0.665 | 0.693 | 0.737 | 0.763 | | 0.415 | 0.72 | 0.738 | 0.726 | 0.687 | 0.712 | 0.758 | 0.694 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | 0.769 | 0.711 | 0.734 | 0.989 | 0.724 | 0.705 | 0.769 | 0.713 | 0.603 | 0.644 | 0.661 | | 0.415 | 0.604 | 0.624 | 0.632 | 0.616 | 0.614 | 0.638 | 0.597 |
| Site | WETLANDS (ANZECC acceptable range 0.3 - 1.5 mS/cm) | | | | | | | | | | | | | | | | | | | |
| MELDR-07 | 3.83 | 1.92 | | | 1.890 | 1.920 | 2.820 | | 1.93 | 2.41 | | | 2.65 | 2.51 | 3.4 | 4.76 | | 2.62 | 2.65 | 2.32 |
| MELDR-08 | 0.951 | 0.79 | | | 0.666 | 0.685 | | | 0.781 | | | | | | | | | | 1.278 | 0.984 |
| MELDR-09 | 0.926 | 0.821 | | | 0.841 | 1.010 | 1.280 | 1.472 | 0.814 | 1.09 | 1.415 | | 0.717 | 0.748 | 0.889 | | 0.922 | 0.827 | 0.853 | 0.919 |
| MELDR-10 | 0.212 | 0.24 | | | 0.342 | 0.328 | 0.590 | 0.558 | 0.351 | 0.418 | 0.7 | | 0.181 | 0.23 | 0.452 | 0.547 | 0.087 | 0.114 | 0.19 | 0.212 |
| MELDR-11 | 0.318 | 0.517 | | | 0.432 | 0.421 | 0.502 | 0.736 | 0.258 | 0.417 | 0.705 | 0.988 | 0.297 | 0.35 | 0.483 | 0.409 | 0.204 | 0.234 | 0.289 | 0.204 |
| MELDR-12 | 1.014 | 0.706 | | | 0.687 | 0.888 | 1.006 | | 0.667 | 0.936 | 1.411 | | 0.714 | 0.809 | 1.003 | 1.196 | 0.834 | 0.732 | 0.652 | 0.832 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | 0.61 | 0.617 | 0.712 | 0.505 | 0.557 | 0.808 | 0.792 | 0.682 | 0.477 | 0.344 | 0.621 |
| MELDR-05 | 0.768 | 0.124 | 1.211 | 1.026 | 0.437 | 0.608 | 0.679 | 0.729 | 0.49 | 0.879 | 0.803 | 1.316 | 0.822 | 0.916 | 1.475 | 1.05 | 0.4718 | 0.651 | 0.371 | 0.81 |
| MELDR-16 | | | | | | | | | | 0.517 | 0.641 | 0.741 | 0.617 | 0.76 | 0.725 | 0.845 | 0.3934 | 0.432 | 0.219 | |
| MELDR-02 | 0.832 | 0.689 | 0.842 | 0.82 | 0.701 | 0.767 | 0.608 | 0.655 | 0.504 | 0.836 | 0.831 | 0.878 | 0.836 | 0.854 | 0.864 | 0.86 | 0.8 | 0.794 | 0.656 | 0.828 |
| PSDTBCMD | 0.78 | 0.598 | 0.761 | 0.744 | 0.48 | 0.741 | 0.606 | 0.655 | 0.551 | 0.782 | 0.766 | 0.802 | 0.769 | 0.773 | 0.77 | 0.779 | 0.75 | 0.734 | 0.519 | 0.779 |
| MELDR-13 | | | | | | | 0.753 | 0.79 | 0.19 | 0.623 | 0.619 | 0.635 | 0.597 | 0.429 | 0.627 | 0.695 | 0.4632 | 0.511 | 0.587 | 0.619 |
| MELDR-14 | | | | | | | 0.828 | 0.86 | 0.49 | 0.459 | 0.634 | 0.736 | 0.502 | 0.539 | 0.701 | 0.607 | 0.4814 | 0.445 | 0.545 | 0.665 |
| MELDR-06 | 33.2 | 0.45 | 0.675 | 0.658 | 0.597 | 0.644 | 1.18 | 0.856 | 0.256 | 0.53 | 0.533 | 0.572 | 0.517 | 0.611 | 0.641 | 0.635 | 0.589 | 0.561 | 0.56 | 0.646 |
| MELDR-07 | | | 3.57 | 3.94 | | 2.17 | 1.166 | 1.333 | 2.038 | 1.874 | 1.75 | 1.811 | 3.06 | 2.989 | 3.134 | 2.767 | 2.449 | 2.336 | 1.919 | 1.671 |
| MELDR-08 | | 1.038 | 1.164 | 1.026 | 1.504 | 1.358 | 0.282 | 0.458 | 0.984 | 1.012 | 0.967 | 0.863 | 1.105 | 1.089 | 0.815 | 0.972 | 1.141 | 1.329 | 1.198 | 0.833 |
| MELDR-09 | 0.814 | 0.806 | 0.828 | 0.855 | 0.782 | 0.739 | 0.289 | 0.267 | 0.877 | 0.788 | 0.672 | 0.935 | 0.706 | 0.727 | 0.852 | 0.749 | 0.864 | 0.909 | 0.825 | 0.997 |
| MELDR-10 | 0.168 | 0.113 | 0.156 | 0.316 | 0.138 | 0.092 | 0.982 | 0.98 | 0.158 | 0.213 | 0.318 | 0.499 | 0.132 | 0.164 | 0.494 | 0.256 | 0.0934 | 0.15 | 0.173 | 0.425 |
| MELDR-11 | 0.34 | 0.346 | 0.317 | 0.391 | 0.297 | 0.211 | 1.746 | 1.981 | 0.187 | 0.235 | 0.248 | 0.242 | 0.24 | 0.287 | 0.281 | 0.234 | 0.1663 | 0.21 | 0.286 | 0.295 |
| MELDR-12 | 1.385 | 1.177 | 0.812 | 1.021 | 0.574 | 0.542 | 0.609 | 0.887 | 0.531 | 0.652 | 0.643 | 0.974 | 0.921 | 1.09 | 1.399 | 1.27 | 0.747 | 0.874 | 0.721 | 0.88 |

SITES RECORDING EC LEVELS ALWAYS/GENERALLY OUTSIDE ACCEPTABLE RANGE
SITES RECORDING 40-60% of EC levels ABOVE ACCEPTABLE RANGE
SITES RECORDING EC levels ALWAYS/GENERALLY WITHIN ACCEPTABLE RANGE

Record BELOW acceptable range | Record WITHIN the acceptable range
Record ABOVE acceptable range | NO sample taken

## 5.4 Total suspended solids

Total Suspended Solids (TSS) in a waterbody is a measure of the concentration of suspended materials in the water that can be removed by filtration. TSS can include a wide variety of material, most often comprising soil particles and organic material (e.g. algae, microorganisms, decaying plant and animal matter).

The Department of Water (n.d.) interim guideline for total suspended solids of 6 mg/L should not be exceeded.

A value equal to half the limit of reporting was substituted for occasions where concentrations were recorded as 'below the laboratory limit of reporting', which is a standard technique to allow these 'unknown' values to be represented graphically and to differentiate them from those samples that recorded concentrations equal to the limit of reporting.

Total suspended solids concentrations were generally low across the catchment. Less than a quarter of the samples (13 out of 59) recorded concentrations equal to or above the interim guideline at sites 15, 5, 16, 13, 6, 7 and 12 (John Creaney Park inlet, John Creaney Park, Downstream Elizabeth Manion Park, Brentwood Drain, Bateman Park, Booragoon lake outlet and Blue Gum Lake outlet respectively) on some sampling occasions and (**Figure 5.4-1, Table D-5, Appendix D**). It should be noted that TSS concentrations were all below the interim guideline in October at all sites. The highest concentration of 62 mg/L was recorded at site 12 (Blue Gum Lake outlet) in July. Observations made at sites 6, 7 and 12 of cloudy or turbid water, site 12 of a cloud of algae in the water and at sites 5 and 13 of the presence of iron floc at sampling occasions of higher turbidity may partially explain these increased turbidity levels. 13 samples recorded concentrations below the limit of reporting of 1.0 mg/L at six sites (2, ROSSTAFE, 8, 9, 10 and 11).

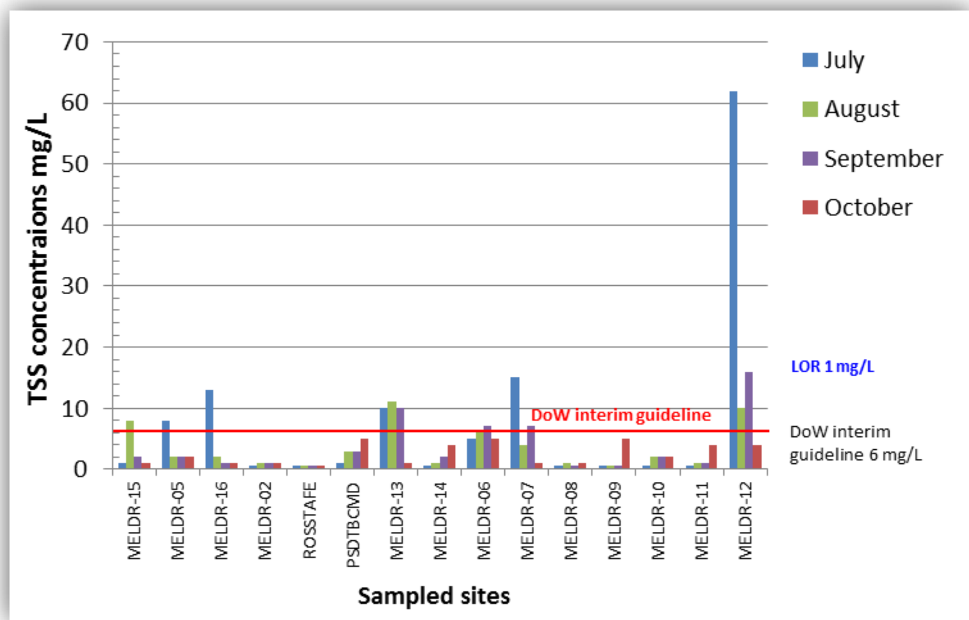


**Figure 5.4-1: Total suspended solids (mg/L) of the surface water in the Melville Bull Creek catchments in 2016**

When comparing results between sites 13 and 14 (Brentwood Drain and RAAF Drain respectively), total suspended solids concentrations were lower at site 14 (samples did not exceed the guideline) than at site 13 except in October, with TSS at site 6 somewhere in between the two sites (except in October), the suggesting the clearer water at site 14 may be diluting the more turbid water at site 13.

**Table 5.4-1** shows the TSS concentrations recorded since 2007 over the ten-year monitoring period. Sites 6 and 7 (Bateman Park and Booragoon lake outlet) have recorded concentrations above the interim guideline on the majority of sampling events; meanwhile sites 5, 2, PSDTBCMD, 8, 9, 10 and 11 (Bull Creek MD, Bateman Park, Piney lakes outlet, Quenda lake outlet, Frederick Baldwin and Marmion Reserve) have generally recorded concentrations below the interim guideline.

## Table 5.4-1: Record of TSS (mg/L) in the Melville Bull Creek catchments 2007 – 2016

Total Suspended Solids (mg/L) DoW interim guideline: 6 mg/L Max 184 Min <1 LOR 1 mg/L

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | |
| MELDR-05 | 11 | 2 | | | 6 | 10 | 12 | | 7 | 4 | | | 8 |
| MELDR-16 | | | | | | | | | | | | | |
| MELDR-02 | 1 | 3 | 2 | 3 | 4 | 1 | 2 | 1 | 2 | 2 | 2 | 54 | 1 |
| PSDTBCMD | 4 | 3 | 29 | 4 | 7 | 1 | 5 | 12 | 6 | 2 | 2 | 7 | 8 |
| MELDR-13 | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | |
| MELDR-06 | 51 | 56 | 4 | 44 | 35 | 27 | 24 | 14 | 13 | 8 | 11 | 8 | 14 |
| MELDR-07 | 17 | 59 | | | 42 | 5 | 58 | | 37 | 11 | | | 32 |
| MELDR-08 | 7 | 27 | | | 23 | 5 | | | 2 | | | | |
| MELDR-09 | 3 | 1 | | | 9 | <1 | 2 | 3 | 1 | 5 | <1 | | 2 |
| MELDR-10 | 1 | 1 | | | 3 | 1 | 6 | 11 | 1 | 1 | 8 | | 1 |
| MELDR-11 | 7 | 3 | | | 5 | 2 | 3 | 12 | 2 | 2 | 14 | 15 | 1 |
| MELDR-12 | 27 | 2 | | | 4 | 1 | 6 | | 2 | <1 | 9 | | 1 |

| Site | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | |
| MELDR-05 | 7 | 12 | 6 | 8 | 10 | 11 | <1 | 9 | 2 | 4 | 3 | 7 | 5 |
| MELDR-16 | | | | | | | | | | | | | |
| MELDR-02 | 2 | 1 | 3 | 2 | 1 | 3 | 1 | 3 | 1 | 1 | <1 | 3 | 2 |
| PSDTBCMD | 3 | 4 | 2 | 2 | <1 | 2 | 4 | 4 | 3 | 5 | 5 | 12 | 4 |
| MELDR-13 | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | |
| MELDR-06 | 9 | 13 | 10 | 12 | 13 | 15 | 9 | 14 | 13 | 8 | 6 | 17 | 10 |
| MELDR-07 | 11 | 11 | 184 | | 19 | 5 | 3 | | | 10 | 2 | | 8 |
| MELDR-08 | | | | | | <1 | <1 | | 1 | 1 | 3 | 3 | <1 |
| MELDR-09 | <1 | 1 | 1 | 3 | 3 | <1 | <1 | 1 | 1 | <1 | <1 | 1 | <1 |
| MELDR-10 | 1 | 4 | 3 | 1 | <1 | <1 | 1 | 1 | 2 | 5 | 3 | 2 | 1 |
| MELDR-11 | 3 | 3 | 50 | 2 | <1 | 2 | 1 | 1 | 3 | 1 | 2 | 3 | 2 |
| MELDR-12 | <1 | <1 | 3 | <1 | 1 | 21 | 4 | 15 | 57 | 63 | 24 | 6 | 15 |

| Site | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | 13 | 4 | 3 | 12 | 13 | 10 | 8 | 1 | 8 | 2 | 1 |
| MELDR-05 | 5 | 5 | 6 | 4 | 3 | 11 | 3 | 4 | 4 | 5 | 8 | 2 | 2 | 2 |
| MELDR-16 | | | | 18 | 10 | 9 | 8 | 13 | 20 | 14 | 13 | 2 | 1 | 1 |
| MELDR-02 | 3 | 1 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 0.5 | 1 | 1 | 1 |
| PSDTBCMD | 6 | 5 | 15 | 5 | 4 | 3 | 2 | 2 | 2 | 1 | 1 | 3 | 3 | 5 |
| MELDR-13 | 21 | 12 | 17 | 13 | 17 | 8 | 7 | 6 | 5 | 5 | 10 | 11 | 10 | 1 |
| MELDR-14 | <1 | 3 | 2 | 2 | 1 | <1 | <1 | <1 | 1 | 1 | 0.5 | 1 | 2 | 4 |
| MELDR-06 | 16 | 7 | 18 | 11 | 11 | 2 | 17 | 5 | 4 | 4 | 5 | 6 | 7 | 5 |
| MELDR-07 | 29 | 2 | 7 | 7 | 17 | 2 | <1 | 1 | 8 | 7 | 15 | 4 | 7 | 1 |
| MELDR-08 | <1 | 1 | <1 | 1 | 4 | <1 | <1 | <1 | 2 | 3 | <1 | 1 | <1 | 1 |
| MELDR-09 | 2 | 1 | <1 | 1 | 1 | <1 | 1 | 2 | 1 | 1 | <1 | <1 | <1 | 5 |
| MELDR-10 | <1 | <1 | 2 | <1 | <1 | <1 | 2 | 1 | 2 | 1 | <1 | 2 | 2 | 2 |
| MELDR-11 | 1 | 3 | 1 | 3 | 2 | 1 | 2 | 3 | 4 | 2 | <1 | 1 | 1 | 4 |
| MELDR-12 | 22 | 20 | 11 | 8 | 24 | 23 | 3 | 5 | 17 | 3 | 62 | 10 | 16 | 4 |

SITES RECORDING TSS CONCENTRATIONS ALWAYS/GENERALLY ABOVE GUIDELINE

SITES RECORDING 40-60% of TSS concentrations ABOVE ACCEPTABLE RANGE

SITES RECORDING TSS concentrations ALWAYS/GENERALLY WITHIN ACCEPTABLE RANGE

| | |
|---|---|
| Concentration ABOVE guideline | Concentration < LOR |
| Concentration BELOW guideline | NO sample taken |

## 5.5 Temperature

It should be noted that water temperature will often increase throughout the day, and hence sampling time can partially influence recorded water temperature. During the 2016 monitoring period, sampling was conducted at varying times between 8 am and 4 pm.

Temperatures in the surface waters of the Melville Bull Creek catchments ranged from 8.7°C in July at site 8 (Piney Lakes) to 27.6°C in October at site 12 (Blue Gum Lake outlet) (**Figure 5.5-1** and **Table D-6, Appendix D**). The highest water temperatures at each site were always recorded in October (except at site 16 where no water was sampled in October). In the "wetland" sites (sites 7, 8, 9, 10, 11 and 12), water temperatures increased as the year progressed, whereas temperatures tended to be similar between months at the drain sites. Temperatures at all sites were considered to lie within a normal seasonal range.


**Figure 5.5-1: Temperature of the surface water in the Melville Bull Creek catchments in 2016**

# 6. Nutrients

The nutrient forms analysed during the 2016 monitoring include total nitrogen, nitrogen in the form of ammonia/ammonium, nitrate and nitrite (oxidised nitrogen), total and dissolved organic nitrogen, total phosphorus and soluble reactive phosphorus.

For all graphs, a value equal to half the limit of reporting was substituted for those occasions where concentrations were recorded as 'below the laboratory limit of reporting' which is a standard technique to allow these 'unknown' values to be represented graphically and to differentiate them from those samples that recorded concentrations equal to the limit of reporting.

Nutrient concentration data for water samples of the Melville Bull Creek catchments are displayed in **Tables D-7 to D-14** in **Appendix D. Table E-1, Appendix E** outlines the sources of nitrogen and phosphorus nutrients and the impacts that changes in these nutrients can have to aquatic ecosystems.

## 6.1 Nitrogen

Nitrogen can exist in many forms in water bodies, including the inorganic forms nitrate ($NO_3^-$), nitrite ($NO_2^-$), ammonium ($NH_4^+$) and ammonia ($NH_3$), and dissolved and particulate organic forms. Nitrogen is converted between these forms, as well as with nitrogen gas ($N_2$) via physical and biological processes known collectively as the nitrogen cycle. When plants and animals die or when animals excrete their wastes, organic nitrogen in the water is converted by bacteria to ammonium/ammonia (mineralisation), then to nitrite and nitrate (nitrification). Ammonium can be converted to ammonia gas (volatilisation) in alkaline conditions and nitrate can be converted to nitrogen gas (denitrification), with the release of these gasses into the atmosphere resulting in a loss of nitrogen from the water. Nitrites, ammonia and ammonium ions are therefore considered intermediate forms of nitrogen in aquatic systems (Northern Territory Government 2003).

### 6.1.1 Total nitrogen

Total nitrogen (TN) in water refers to the sum nitrogen present in oxidised forms (i.e. nitrate and nitrite), in ammonium/ammonia ($NH_3$) and in dissolved and particulate organic forms.

The ANZECC trigger value for total nitrogen is 1.2 mg/L for lowland rivers and 1.5 mg/L for wetlands of southwest Australia.

TN concentrations varied across the Melville Bull Creek catchments. Less than one quarter of the samples (14 out of 59) recorded TN concentrations above the ANZECC trigger value for lowland rivers or wetlands (**Figure 6.1-1** and **Table D-7, Appendix D**). The highest concentrations of 6.9 mg/L, 6.8 mg/L, 5.9 mg/L and 4.8 mg/L were recorded in July, October, August and September respectively at site 2 (Brockman Park), which has also recorded high concentrations in previous years. Exceeding concentrations were also recorded at all sampling occasions at PSDTBCMD (Bull Creek MD), and on at least one sampling occasion at sites ROSSTAFE (Brockman Park inlet), 7 (Booragoon Lake outlet) and 12 (Blue Gum Lake outlet), all of which have consistently recorded exceeding concentrations over the ten year monitoring period. The lowest concentration of 0.26 mg/L was recorded at site 11 (Marmion Reserve) in August.

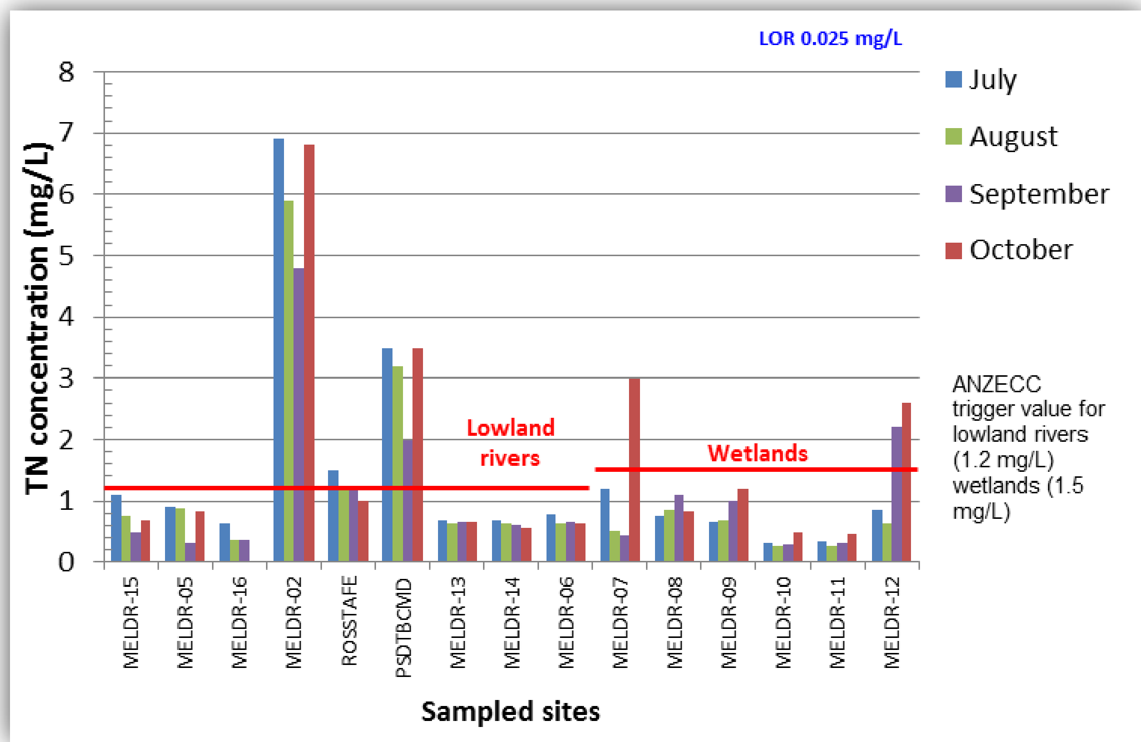


**Figure 6.1-1: Total nitrogen concentration (mg/L) in surface water throughout the Melville Bull Creek catchments in 2016**

**Table 6.1-1** shows the recorded TN concentrations throughout the nine-year sampling period. TN concentrations exceeding the trigger value have been consistently recorded at sites 2, PSDTBCMD, 7 and 12 (Brockman Park, Bull Creek MD, Booragoon Lake outlet and Blue Gum Lake outlet). The continually exceeding TN concentrations at PSDTBCMD are particularly concerning as PSDTBCMD is directly upstream of where the Bull Creek drain discharges into the Canning River.

Frederick Baldwin (site 10) has always recorded TN concentrations below the ANZECC trigger value and sites 6, 8, 9, 10 and 11 (Bateman Park, Piney Lakes outlet, Quenda Lake, Frederick Baldwin and Marmion Reserve) have almost always recorded TN concentrations below the ANZECC trigger values.

It should be noted that sites 5 (John Creaney Park) and 16 (Downstream Elizabeth Manion Park) both recorded exceeding TN concentrations in 2015 but less so in the preceding years (where data is available) and not at all in 2016, suggesting the very high concentrations recorded at these sites in 2015 may be an anomaly. However further downstream, site 2 (Brockman Park) has recorded TN concentrations exceeding the trigger on all sampling occasions for the tenth year running and has regularly produced the highest concentrations in the catchment. Ammonia/ammonium is the predominant form of nitrogen at this site (see Section 9.6). For further discussion of ammonia/ammonium at site 2 refer to **Section 6.1.3.**

When comparing total nitrogen results between upstream sites 2 and ROSSTAFE (Brockman Park and Brockman Park inlet) against downstream site PSDTBCMD (Bull Creek MD), in both 2016 and in previous years, concentrations were always considerably higher at site 2 than those recorded at ROSSTAFE, with concentrations at PSDTBCMD. As water moves from site 2 to PSDTBCMD, TN concentrations may be being diluted by the relatively less nitrogenous input coming from ROSSTAFE, or nitrogen may be being removed from the system by biota or deposited into the sediment. This portion of the Bull Creek main drain is a somewhat remnant natural meandering creek line with substantial aquatic and riparian vegetation and sediment dumping zones all of which could have played a part in the reduction of nitrogen in water.

High TN concentrations at sites 7 and 12 (Booragoon lake outlet and Blue Gum Lake outlet respectively) in spring correspond with increased ammonia/ammonium concentrations in spring. Refer to section 6.1.3 for further discussion regarding ammonia/ammonium concentrations at these sites.

## Table 6.1-1: Records of TN concentrations (mg/L) in the Melville Bull Creek catchments 2007 - 2016

TN (mg/L) Max 20 Min 0.22 LOR 0.025 mg/L

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LOWLAND RIVERS (ANZECC trigger value 1.2 mg/L) | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | 0.89 | 1 | | | 1.5 | 1.9 | 2.4 | | 1.3 | 1.1 | | | 1.4 | 1.3 | 2.1 | 2.5 | 0.45 | 1 | 1.4 | 1.4 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | 5.3 | 3.8 | 5.8 | 6.1 | 4.4 | 5.5 | 7.2 | 6.8 | 4.5 | 5.8 | 6.9 | 6.8 | 3.9 | 6 | 6.8 | 7.8 | 6.5 | 6 | 6.4 | 5.8 |
| PSDTBCMD | 2.7 | 2.4 | 0.63 | 3.5 | 2.6 | 2.9 | 4 | 2.9 | 2.8 | 3.1 | 3.8 | 4.1 | 1.7 | 3 | 3.9 | 3.9 | 3 | 3 | 3.1 | 3 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | 1 | 0.87 | 3.3 | 0.63 | 0.77 | 0.7 | 0.56 | 0.61 | 0.95 | 0.62 | 0.58 | 0.54 | 0.75 | 0.6 | 0.6 | 0.64 | 0.74 | 0.81 | 0.85 | 0.58 |
| Site | WETLANDS (ANZECC trigger value 1.5 mg/L) | | | | | | | | | | | | | | | | | | | |
| MELDR-07 | 1.1 | 10 | | | 6.3 | 11 | 11 | | 3 | 7.6 | | | 2.7 | 6.1 | 16 | 20 | | 2.5 | 6.4 | 10 |
| MELDR-08 | 1.1 | 1.7 | | | 2.3 | 0.62 | | | 0.78 | | | | | | | | | | 0.61 | 0.65 |
| MELDR-09 | 0.81 | 0.81 | | | 0.61 | 0.79 | 1.3 | 1.2 | 0.71 | 0.74 | 0.85 | | 0.49 | 0.54 | 0.6 | 0.95 | 1.1 | 0.73 | 0.85 | 0.75 |
| MELDR-10 | 0.67 | 0.31 | | | 0.37 | 0.46 | 1 | 1.3 | 0.32 | 0.55 | 1.1 | | 0.33 | 0.29 | 0.65 | 0.77 | 0.38 | 0.28 | 0.46 | 0.34 |
| MELDR-11 | 0.8 | 0.56 | | | 0.45 | 0.49 | 0.66 | 1.2 | 0.53 | 0.52 | 1.3 | 1.9 | 1 | 0.6 | 0.63 | 1.2 | 0.55 | 0.44 | 0.61 | 0.39 |
| MELDR-12 | 2.6 | 2 | | | 1.3 | 1.4 | 1.7 | | 1.4 | 1.2 | 2.4 | | 1.3 | 1 | 1.2 | 1.7 | 0.78 | 0.22 | 1.2 | 3.3 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LOWLAND RIVERS (ANZECC trigger value 1.2 mg/L) | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | 0.77 | 0.75 | 0.67 | 1 | 0.82 | 1 | 1.1 | 1.1 | 0.76 | 0.48 | 0.69 |
| MELDR-05 | 1.5 | 0.27 | 1.3 | 1.4 | 0.87 | 0.94 | 0.83 | 1.1 | 0.91 | 1.1 | 0.88 | 1.4 | 1.3 | 1.3 | 1.6 | 1.6 | 0.91 | 0.87 | 0.32 | 0.82 |
| MELDR-16 | | | | | | | | | | 0.7 | 0.63 | 0.81 | 0.82 | 11 | 1.4 | 2.9 | 0.64 | 0.37 | 0.37 | |
| MELDR-02 | 8.3 | 6.5 | 7.2 | 8.2 | 5.2 | 5 | 4.8 | 6.3 | 2.7 | 5.4 | 5.2 | 7 | 6.6 | 7 | 9.1 | 9.6 | 6.9 | 5.9 | 4.8 | 6.8 |
| PSDTBCMD | 4.4 | 2.9 | 4 | 4.4 | 2.1 | 3 | 3.3 | 3.7 | 2.6 | 3.3 | 3.2 | 4.2 | 3.8 | 3.8 | 4.5 | 4.5 | 3.5 | 3.2 | 2 | 3.5 |
| MELDR-13 | | | | | | | 0.64 | 0.6 | 0.47 | 0.66 | 0.62 | 0.53 | 0.51 | 0.51 | 0.55 | 0.52 | 0.69 | 0.63 | 0.66 | 0.67 |
| MELDR-14 | | | | | | | 0.75 | 0.69 | 0.71 | 0.96 | 0.73 | 0.59 | 0.49 | 0.49 | 0.59 | 0.59 | 0.68 | 0.63 | 0.62 | 0.55 |
| MELDR-06 | 0.57 | 0.43 | 0.53 | 0.51 | 0.64 | 0.79 | 0.65 | 0.6 | 0.51 | 0.62 | 0.63 | 0.53 | 0.6 | 0.53 | 0.59 | 0.49 | 0.78 | 0.63 | 0.66 | 0.64 |
| Site | WETLANDS (ANZECC trigger value 1.5 mg/L) | | | | | | | | | | | | | | | | | | | |
| MELDR-07 | | | 0.52 | 0.45 | | 0.55 | 2.8 | 3.3 | 0.76 | 1.6 | 2.2 | 3.5 | 0.37 | 0.31 | 3.5 | 3 | 1.2 | 0.5 | 0.44 | 3 |
| MELDR-08 | | 0.62 | 0.76 | 0.62 | 1.6 | 1.4 | 0.79 | 0.71 | 1.2 | 0.95 | 1.3 | 0.78 | 0.73 | 0.58 | 0.66 | 0.65 | 0.76 | 0.85 | 1.1 | 0.83 |
| MELDR-09 | 0.4 | 0.4 | 0.48 | 0.5 | 0.4 | 0.62 | 1.2 | 1.4 | 1.3 | 1.2 | 1.3 | 1.5 | 0.77 | 0.89 | 0.98 | 1 | 0.67 | 0.68 | 1 | 1.2 |
| MELDR-10 | 0.32 | 0.41 | 0.32 | 0.52 | 0.3 | 0.25 | 0.29 | 0.44 | 0.67 | 0.34 | 0.32 | 0.56 | 0.24 | 0.33 | 0.63 | 0.49 | 0.31 | 0.27 | 0.28 | 0.48 |
| MELDR-11 | 0.4 | 0.42 | 0.34 | 0.46 | 0.65 | 0.38 | 0.31 | 0.44 | 0.43 | 0.43 | 0.42 | 0.44 | 0.32 | 0.35 | 0.73 | 0.72 | 0.35 | 0.26 | 0.32 | 0.47 |
| MELDR-12 | 3.9 | 7.1 | 3.7 | 3 | 1.5 | 2.3 | 2.6 | 3.2 | 2.2 | 2.1 | 2.4 | 5.4 | 3.9 | 3.5 | 2.4 | 3 | 0.86 | 0.63 | 2.2 | 2.6 |

| | | |
|---|---|---|
| SITES RECORDING TN CONCENTRATIONS ALWAYS/GENERALLY ABOVE ANZECC TRIGGER VALUE | Concentration ABOVE trigger value | Concentration < LOR |
| SITES RECORDING 40-60% of TN concentrations ABOVE ACCEPTABLE RANGE | Concentration BELOW trigger value | NO sample taken |
| SITES RECORDING TN CONCENTRATIONS ALWAYS/GENERALLY BELOW ANZECC TRIGGER VALUE | | |

### 6.1.2 Total oxidised nitrogen

Total oxidised nitrogen (NOx-N) is the sum of the oxidised forms of nitrogen: nitrite ($NO_2$) and nitrate ($NO_3$).

The ANZECC trigger value for lowland rivers is 0.15 mg/L and 0.10 mg/L for wetlands (ANZECC and ARMCANZ 2000).

NOx-N concentrations varied across the catchment, with almost half of the samples (28 out of 59) recording concentrations above the ANZECC trigger values for lowland rivers or wetlands (**Figure 6.1-2 and Figure 6.1-3** and **Table D-8, Appendix D**). The four highest concentrations in the catchment were all recorded at site PSDTBCMD (Bull Creek MD): 2.6 mg/L (17 times greater than the trigger value), 2.4 mg/L, 2.1 mg/L and 1.3 mg/L in in October, July, August and September respectively. Sites 16, 2, ROSSTAFE, 13 and 6 (Downstream Elizabeth Manion Park, Brockman Park, Brockman Park inlet, Brentwood drain and Bateman Park) also recorded exceeding NOx-N concentrations at all sampling occasions when samples were collected, and sites 15 and 14 (John Creaney park inlet and RAAF drain) recorded exceeding concentrations at some sampling occasions. Ten samples recorded concentrations below the limit of reporting of 0.01 mg/L.

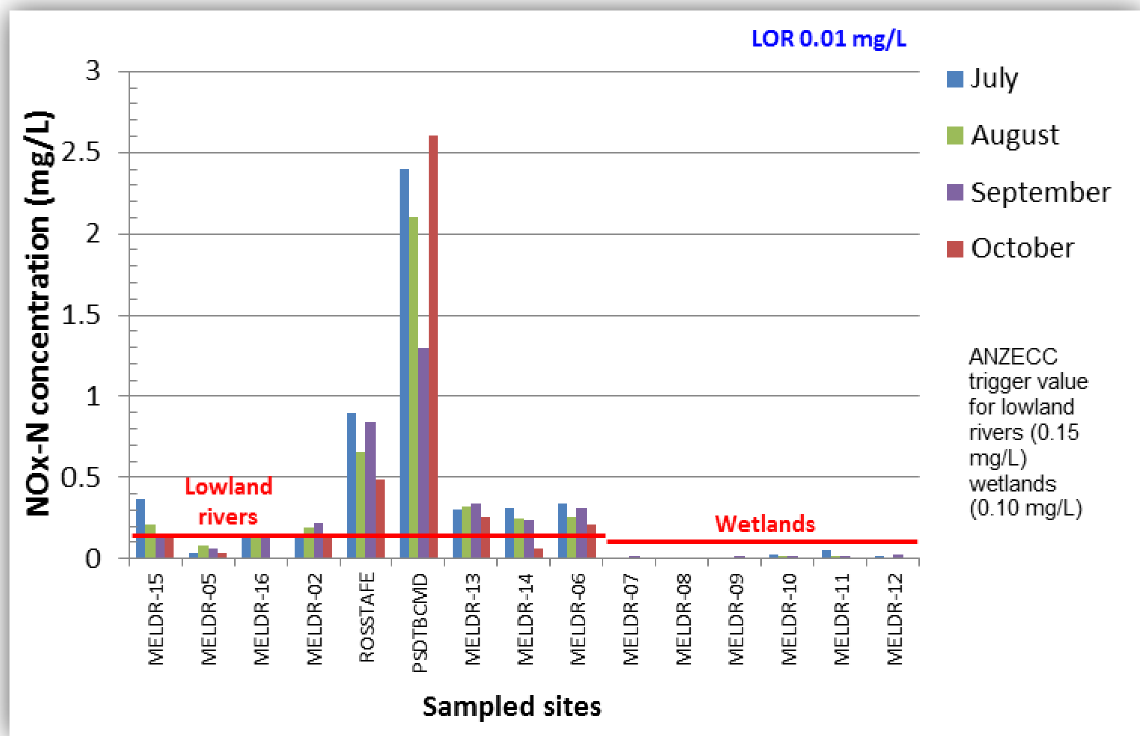

**Figure 6.1-2: Total oxidised nitrogen concentrations (mg/L) in the surface water of Melville Bull Creek catchments in 2016.**

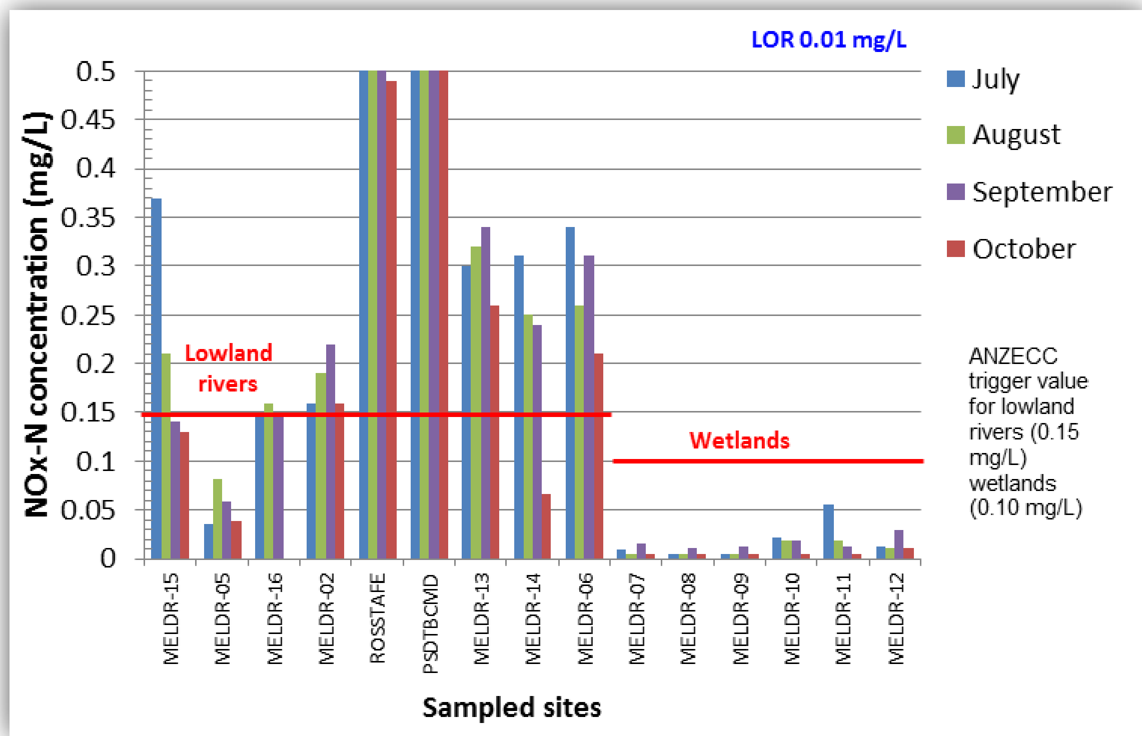


**Figure 6.1-3: Total oxidised nitrogen concentrations (mg/L) in the surface water of Melville Bull Creek catchments in 2016 (zoom in*)**

***Please note this graph scale stops at 0.5 mg/L**

**Table 6.1-2** shows the recorded NOx concentrations throughout the nine-year sampling period. Of particular concern is the consistently high NOx concentrations recorded at PSDTBCMD (Bull Creek MD), which has recorded exceedances of the trigger value on all sampling occasions with the exception of January 2008. Sites 8 and 9 (Piney Lakes outlet and Quenda Lake outlet) have always recorded concentrations below the trigger value.

## Table 6.1-2: Records of NOx concentrations (mg/L) in the Melville Bull Creek catchments 2007 - 2016

NOx (mg/L) Max 3.7 Min <0.01 LOR 0.01 mg/L

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWLAND RIVERS (ANZECC trigger value 0.15 mg/L) | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | | | |
| MELDR-05 | <0.01 | 0.075 | | | 0.056 | 0.019 | <0.01 | | 0.063 | 0.029 | | |
| MELDR-16 | | | | | | | | | | | | |
| MELDR-02 | 0.078 | 0.13 | 0.089 | 0.065 | 0.13 | 0.098 | 0.055 | 0.04 | 0.12 | 0.1 | 0.074 | 0.083 |
| PSDTBCMD | 1.9 | 1.2 | 0.078 | 2.3 | 1.2 | 1.6 | 2.2 | 2 | 1.5 | 2.3 | 3.2 | 3.7 |
| MELDR-13 | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | |
| MELDR-06 | 0.32 | 0.35 | 2.1 | 0.068 | 0.24 | 0.08 | 0.051 | 0.086 | 0.31 | 0.12 | 0.062 | 0.049 |
| WETLANDS (ANZECC trigger value 0.10 mg/L) | | | | | | | | | | | | |
| MELDR-07 | <0.01 | 0.018 | | | 0.022 | 0.51 | 0.3 | | 0.015 | 0.15 | | |
| MELDR-08 | <0.01 | <0.01 | | | <0.01 | <0.01 | | | <0.01 | | | |
| MELDR-09 | <0.01 | 0.011 | | | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | |
| MELDR-10 | 0.036 | 0.011 | | | <0.01 | 0.018 | 0.026 | 0.43 | 0.01 | <0.01 | <0.01 | |
| MELDR-11 | <0.01 | <0.01 | | | 0.01 | <0.01 | <0.01 | 0.14 | 0.011 | 0.01 | 0.013 | 0.01 |
| MELDR-12 | <0.01 | 0.012 | | | 0.01 | <0.01 | <0.01 | | 0.052 | 0.013 | <0.01 | |

| Site | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWLAND RIVERS (ANZECC trigger value 0.15 mg/L) | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | | | | | | |
| MELDR-05 | 0.21 | 0.023 | 0.025 | <0.01 | 0.05 | 0.073 | 0.029 | 0.068 | <0.01 | 0.051 | 0.031 | <0.01 | 0.099 | 0.12 | 0.074 |
| MELDR-16 | | | | | | | | | | | | | | | |
| MELDR-02 | 0.18 | 0.082 | 0.068 | 0.16 | 0.13 | 0.14 | 0.14 | 0.15 | 0.057 | 0.087 | 0.06 | 0.076 | 0.12 | 0.23 | 0.22 |
| PSDTBCMD | 0.95 | 2.3 | 2.8 | 2.7 | 1.8 | 1.8 | 2.2 | 1.9 | 2.5 | 1.6 | 2.1 | 2.4 | 1.2 | 2.1 | 1.8 |
| MELDR-13 | | | | | | | | | | | | | | | 0.2 |
| MELDR-14 | | | | | | | | | | | | | | | 0.23 |
| MELDR-06 | 0.22 | 0.15 | 0.11 | 0.093 | 0.2 | 0.25 | 0.23 | 0.14 | 0.19 | 0.15 | 0.12 | 0.11 | 0.23 | 0.35 | 0.23 |
| WETLANDS (ANZECC trigger value 0.10 mg/L) | | | | | | | | | | | | | | | |
| MELDR-07 | <0.01 | 0.01 | 0.11 | 0.19 | | <0.01 | <0.01 | 0.26 | | | <0.01 | <0.01 | | <0.01 | <0.01 |
| MELDR-08 | | | | | | | <0.01 | <0.01 | | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | <0.01 |
| MELDR-09 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.014 | <0.01 | <0.01 | <0.01 |
| MELDR-10 | 0.016 | <0.01 | <0.01 | 0.019 | 0.037 | <0.01 | 0.011 | <0.01 | 0.018 | 0.11 | <0.01 | <0.01 | 0.021 | <0.01 | 0.021 |
| MELDR-11 | 0.16 | 0.086 | 0.017 | <0.01 | 0.034 | 0.034 | <0.01 | <0.01 | <0.01 | 0.014 | <0.01 | <0.01 | 0.071 | <0.01 | <0.01 |
| MELDR-12 | <0.01 | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | <0.01 | <0.01 | <0.01 | 0.017 | 0.011 | 0.01 | 0.013 | <0.01 | <0.01 |

| Site | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWLAND RIVERS (ANZECC trigger value 0.15 mg/L) | | | | | | | | | | | | | |
| MELDR-15 | | | 0.071 | 0.1 | 0.1 | 0.22 | 0.14 | 0.17 | 0.15 | 0.37 | 0.21 | 0.14 | 0.13 |
| MELDR-05 | 0.051 | 0.079 | 0.057 | 0.077 | 0.019 | 0.062 | 0.015 | 0.005 | 0.01 | 0.036 | 0.082 | 0.059 | 0.038 |
| MELDR-16 | | | 0.17 | 0.16 | 0.14 | 0.2 | 0.67 | 0.8 | 1.7 | 0.15 | 0.16 | 0.15 | |
| MELDR-02 | 0.13 | 0.097 | 0.14 | 0.13 | 0.089 | 0.13 | 0.45 | 0.099 | 0.1 | 0.16 | 0.19 | 0.22 | 0.16 |
| PSDTBCMD | 2.8 | 1.1 | 1.9 | 2.1 | 2.8 | 2.5 | 2.3 | 3.4 | 3.7 | 2.4 | 2.1 | 1.3 | 2.6 |
| MELDR-13 | 0.19 | 0.12 | 0.22 | 0.19 | 0.16 | 0.13 | 0.11 | 0.089 | 0.11 | 0.3 | 0.32 | 0.34 | 0.26 |
| MELDR-14 | 0.077 | 0.23 | 0.43 | 0.21 | 0.06 | 0.12 | 0.071 | 0.038 | 0.029 | 0.31 | 0.25 | 0.24 | 0.066 |
| MELDR-06 | 0.16 | 0.14 | 0.21 | 0.18 | 0.14 | 0.15 | 0.13 | 0.078 | 0.097 | 0.34 | 0.26 | 0.31 | 0.21 |
| WETLANDS (ANZECC trigger value 0.10 mg/L) | | | | | | | | | | | | | |
| MELDR-07 | 0.014 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | 0.01 | 0.08 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 |
| MELDR-08 | 0.011 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| MELDR-09 | <0.01 | <0.01 | 0.01 | <0.01 | <0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| MELDR-10 | <0.01 | 0.036 | 0.014 | <0.01 | 0.15 | 0.017 | <0.01 | <0.01 | <0.01 | 0.022 | 0.019 | 0.018 | 0.005 |
| MELDR-11 | <0.01 | <0.01 | <0.01 | <0.01 | 0.010 | <0.01 | <0.01 | <0.01 | <0.01 | 0.056 | 0.019 | 0.013 | 0.005 |
| MELDR-12 | 0.013 | <0.01 | <0.01 | <0.01 | <0.01 | 0.11 | 0.20 | 0.01 | 0.14 | 0.01 | 0.01 | 0.03 | 0.01 |

SITES RECORDING TP CONCENTRATIONS ALWAYS/GENERALLY ABOVE ANZECC TRIGGER VALUE

SITES RECORDING 40-60% of TP concentrations ABOVE ACCEPTABLE RANGE

SITES RECORDING TP CONCENTRATIONS ALWAYS/GENERALLY BELOW ANZECC TRIGGER VALUE

Concentration ABOVE trigger value

Concentration BELOW trigger value

Concentration < LOR

NO sample taken

### 6.1.3 Nitrogen as ammonia/ammonium

Nitrogen as ammonia/ammonium ($NH_4^+/NH_3$-N) measures the portion of nitrogen present as ammonia ($NH_3$) or ammonium ($NH_4^+$).

The ANZECC trigger value for ammonia/ammonium nitrogen for 95% level of protection is 0.9 mg/L (based on an unionised ammonia ($NH_3$-N) concentration of 0.035 mg/L), for lowland rivers is 0.08 mg/L and for wetlands is 0.04 mg/L (ANZECC and ARMCANZ 2000). The NHMRC (2008) recreational use guideline for ammonia is 5 mg/L – this is based upon the ADWG (NHMRC 2016) trigger value for aesthetic value for recreation only (i.e. not health value). It is important to mention that the trigger value for 95% level of protection is only applicable at pH 8 and 20°C. The trigger value decreases with increasing pH and increases with decreasing pH as per table 8.3.7 in the ANZECC guidelines (ANZECC and ARMCANZ 2000). It is noted that there is no adjusted trigger value for samples with pH values of less than 6 (i.e. for sites 7, 8 and 12 July, August and September and site 9 in September) or greater than 9 (i.e. site 11 in October).

By far the highest NH4+/NH3-N concentrations of 6.2 mg/L, 5.7 mg/L, 5.1 mg/L and 4 mg/L were recorded at site 2 (Brockman Park) in July, October, August and September respectively (**Figure 6.1-4** and **Table D-9, Appendix D**). Two samples from sites 10 and 11 (Frederick Baldwin and Marmion Reserve) recorded concentrations below the limit of reporting of 0.01 mg/L in September.

Four out of 59 samples recorded NH4+/NH3-N concentrations exceeding the adjusted ANZECC trigger value for 95% level of protection, all at site 2 (Brockman Park) (**Figure 6.1-4**). 29 samples exceeded the trigger values for lowland rivers or wetlands (**Figure 6.1-5**). Sites 2, PSDTBCMD, 13 and 6 (Brockman Park, Bull Creek MD, Brentwood drain and Bateman Park) recorded concentrations exceeding the trigger value for lowland rivers and wetlands on all sampling occasions, and sites 15, 5, ROSSTAFE, 7, 10, 11 and 12 (John Creaney Park inlet, John Creaney Park, Brockman Park inlet, Booragoon Lake outlet, Frederick Baldwin, Marmion Reserve and Blue Gum Lake outlet) recorded exceedances on at least one sampling occasion. Only the three highest samples from site 2 exceeded the recreational trigger value.

The highest concentration of 6.2 mg/L at site 2 was almost 2.5 times the pH modified trigger value for 95% level of protection and 77.5 times the trigger value for lowland rivers. This is very concerning particularly considering that site 2 has always recorded exceeding concentrations since November 2008.

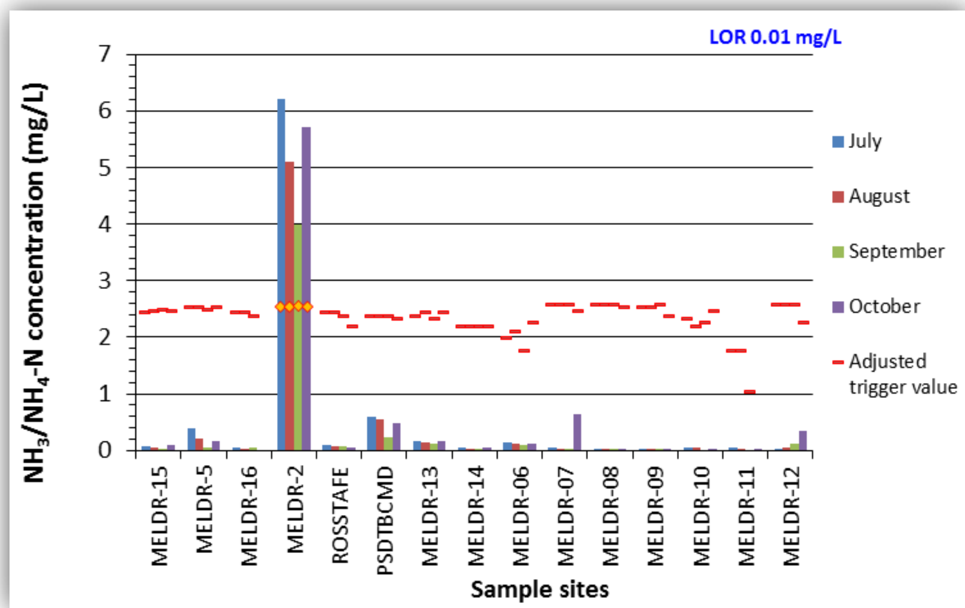


**Figure 6.1-4: Nitrogen as ammonia/ammonium concentrations (mg/L) as compared to pH modified trigger values for 95% level of protection in the surface water of Melville Bull Creek catchments in 2016**

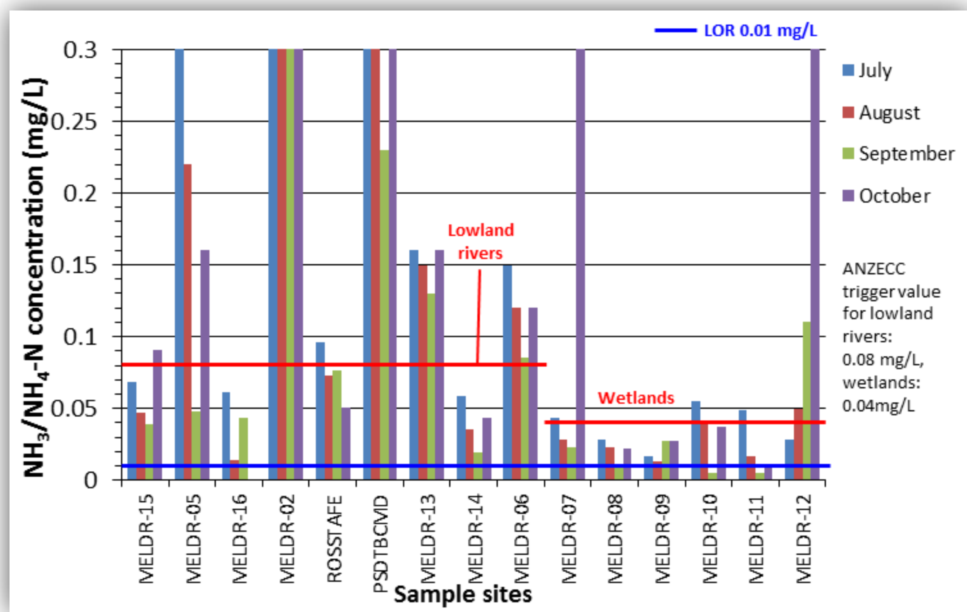


**Figure 6.1-5: Nitrogen as ammonia/ammonium concentrations (mg/L) in the surface water of Melville Bull Creek catchments in 2016 (zoom in*)**

***Please note this graph scale stops at 0.3 mg/L**

When comparing results between sites 5 and 16 (John Creaney Park and downstream Elizabeth Manion Park respectively) and site 2 (Brockman Park), although still often exceeding lowland river trigger values at site 5, nitrogen as ammonia/ammonium was significantly higher at site 2 than sites 5 and 16 at all sampling occasions in 2016, and has also been higher throughout previous years at the site. This suggests a significant consistent source of ammonia/ammonium within the direct vicinity, either from local drainage or groundwater intrusion which is naturally high in peat rich soils. Further investigation to determine this source is highly recommended. It would also appear that the high concentrations recorded at Brockman Park are having a negative impact on the water quality downstream at site PSDTBCMD (Bull Creek MD), as concentrations are also quite high at this site. Exceedances recorded at both sites PSDTBCMD and 6 (Bateman Park) are of concern as they have both recorded concentrations exceeding the trigger value for lowland rivers on all sampling occasions and both are at the bottom of their respective catchments discharging directly into the Canning River.

Nitrogen as ammonia/ammonium concentrations were high at site 13 (Brentwood drain) and only slightly lower downstream site 6 (Bateman Park), with relatively low concentrations at site 14 (RAAF drain) despite similar total nitrogen concentrations at all three sites. This suggests the high ammonia/ammonium concentrations at site 6 are originating from the Brentwood drainage line, with a possible slight dilution from the RAAF drain.

High ammonia/ammonium concentrations in spring at sites 7 and 12 (Booragoon lake outlet and Blue Gum Lake outlet respectively), correspond with high organic nitrogen concentrations (see Sections 9.1.4 and 9.1.5) and high soluble reactive phosphorus concentrations (see Section 9.2.2). Possible explanations for these high nutrient levels could be increased spring bird populations depositing nutrient-rich faecal material in these lakes, or increased local fertiliser application at this time of year. The high ammonia and soluble reactive phosphorus concentrations at these lakes, particularly in spring, is concerning and puts these lakes at risk of harmful algal blooms.

**Table 6.1-3** shows the recorded $NH_3$/N concentrations throughout the nine-year sampling period. Sites 5, 2 PSDTBCMD, 6, 7 and 12 (John Creaney Park, Brockman Park, Bull Creek MD, Bateman Park, Booragoon Lake outlet and Blue Gum lake outlet respectively) have consistently recorded $NH_3$/$NH_4$-N concentrations exceeding the trigger value for lowland rivers or wetlands. Sites 8, 9, 10 and 11 (Piney Lakes outlet, Quenda Lake outlet, Frederick Baldwin and Marmion Reserve respectively) have generally recorded acceptable $NH_3$/$NH_4$-N concentrations.

## Table 6.1-3: Records of $NH_3$/N concentrations (mg/L) in the Melville Bull Creek catchments 2007 – 2016

$NH_3$-N (mg/L) Max 14 Min <0.01 LOR 0.01 mg/L

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWLAND RIVERS (ANZECC trigger value 0.08 mg/L) | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | | | | |
| MELDR-05 | 0.014 | 0.24 | | | 0.53 | 0.73 | 0.049 | | 0.2 | 0.076 | | | 0.15 |
| MELDR-16 | | | | | | | | | | | | | |
| MELDR-02 | 4.8 | 2.9 | 4.9 | 5.4 | 4 | 4.4 | 5.8 | 6.3 | 3.3 | 4.7 | 6.8 | 6.5 | 3.3 |
| PSDTBCMD | 0.5 | 0.39 | 0.27 | 0.1 | 1.2 | 0.47 | 0.7 | 0.12 | 0.25 | 0.13 | 0.21 | 0.039 | 0.27 |
| MELDR-13 | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | |
| MELDR-06 | 0.31 | 0.22 | 0.32 | 0.25 | 0.22 | 0.22 | 0.28 | 0.24 | 0.16 | 0.2 | 0.24 | 0.24 | 0.18 |
| Site | WETLANDS (ANZECC trigger value 0.04 mg/L) | | | | | | | | | | | | |
| MELDR-07 | 0.065 | 7.2 | | | 4.3 | 6.5 | 5 | | 0.044 | 3.6 | | | <0.01 |
| MELDR-08 | <0.01 | 0.038 | | | 0.014 | 0.023 | | | 0.013 | | | | |
| MELDR-09 | 0.017 | 0.015 | | | 0.011 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | | <0.01 |
| MELDR-10 | 0.18 | 0.013 | | | <0.01 | <0.01 | 0.05 | 0.078 | <0.01 | 0.017 | 0.36 | | 0.041 |
| MELDR-11 | 0.024 | <0.01 | | | <0.01 | 0.018 | <0.01 | 0.017 | <0.01 | 0.013 | <0.01 | 0.011 | 0.54 |
| MELDR-12 | 0.37 | 0.31 | | | 0.087 | 0.089 | <0.01 | | 0.18 | 0.021 | 0.023 | | 0.051 |

| Site | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | |
| MELDR-05 | 0.44 | 0.1 | 1.3 | 0.01 | 0.086 | 0.052 | 0.044 | 0.45 | 0.044 | 0.31 | 0.43 | 0.15 | 0.19 | 0.14 |
| MELDR-16 | | | | | | | | | | | | | | |
| MELDR-02 | 5.6 | 6.2 | 7 | 5.6 | 4.9 | 4.9 | 4.9 | 7.6 | 6 | 5.8 | 6.8 | 4 | 4 | 3.8 |
| PSDTBCMD | 0.48 | 0.54 | 0.26 | 0.3 | 0.53 | 0.43 | 0.39 | 1.6 | 0.85 | 1.3 | 1.3 | 0.35 | 0.46 | 0.54 |
| MELDR-13 | | | | | | | | | | | | | | 0.12 |
| MELDR-14 | | | | | | | | | | | | | | 0.023 |
| MELDR-06 | 0.2 | 0.2 | 0.26 | 0.2 | 0.17 | 0.18 | 0.12 | 0.22 | 0.11 | 0.15 | 0.11 | 0.14 | 0.13 | 0.11 |
| MELDR-07 | 3.4 | 12 | 14 | | <0.01 | 3.1 | 6.9 | | | <0.01 | 0.022 | | <0.01 | 0.32 |
| MELDR-08 | | | | | | <0.01 | 0.016 | | <0.01 | <0.01 | 0.013 | 0.027 | 0.013 | 0.016 |
| MELDR-09 | 0.01 | 0.013 | 0.018 | 0.63 | <0.01 | 0.076 | 0.046 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.014 | 0.014 |
| MELDR-10 | 0.013 | 0.21 | 0.26 | 0.05 | <0.01 | 0.05 | 0.03 | 0.068 | 0.07 | 0.015 | 0.023 | 0.05 | <0.01 | <0.01 |
| MELDR-11 | 0.15 | 0.026 | <0.01 | 0.12 | 0.016 | 0.016 | <0.01 | 0.015 | <0.01 | <0.01 | <0.01 | 0.15 | 0.026 | <0.01 |
| MELDR-12 | 0.056 | 0.031 | 0.043 | 0.56 | <0.01 | <0.01 | 1.4 | 1.6 | 1 | 0.021 | 0.026 | 0.85 | 0.083 | <0.01 |

| Site | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | 0.094 | 0.14 | 0.098 | 0.062 | 0.079 | 0.058 | 0.074 | 0.068 | 0.047 | 0.039 | 0.091 |
| MELDR-05 | 0.25 | 0.27 | 0.45 | 0.28 | 0.13 | 0.51 | 0.52 | 0.32 | 0.1 | 0.4 | 0.22 | 0.048 | 0.16 |
| MELDR-16 | | | 0.037 | 0.035 | 0.093 | 0.057 | 9.7 | 0.073 | 0.41 | 0.061 | 0.014 | 0.043 | |
| MELDR-02 | 5.5 | 2 | 4.7 | 4.6 | 5.9 | 6.1 | 6.2 | 7.6 | 7.8 | 6.2 | 5.1 | 4 | 5.7 |
| PSDTBCMD | 0.75 | 0.88 | 0.72 | 0.55 | 1 | 0.63 | 0.76 | 0.37 | 0.34 | 0.6 | 0.55 | 0.23 | 0.48 |
| MELDR-13 | 0.15 | 0.075 | 0.16 | 0.14 | 0.19 | 0.16 | 0.16 | 0.14 | 0.15 | 0.16 | 0.15 | 0.13 | 0.16 |
| MELDR-14 | 0.045 | 0.047 | 0.066 | 0.066 | 0.098 | 0.05 | 0.05 | 0.047 | 0.041 | 0.059 | 0.035 | 0.019 | 0.043 |
| MELDR-06 | 0.13 | 0.089 | 0.16 | 0.14 | 0.17 | 0.14 | 0.14 | 0.12 | 0.13 | 0.15 | 0.12 | 0.085 | 0.12 |
| MELDR-07 | 0.3 | 0.026 | 0.1 | 0.021 | 1.2 | 0.031 | 0.028 | 1.2 | 0.055 | 0.043 | 0.028 | 0.023 | 0.64 |
| MELDR-08 | 0.026 | 0.025 | 0.028 | 0.025 | 0.017 | 0.028 | 0.023 | 0.02 | 0.025 | 0.028 | 0.023 | 0.011 | 0.022 |
| MELDR-09 | <0.01 | <0.01 | 0.033 | 0.024 | 0.027 | 0.019 | 0.02 | <0.01 | <0.01 | 0.017 | 0.013 | 0.027 | 0.027 |
| MELDR-10 | <0.01 | 0.034 | 0.033 | 0.017 | 0.059 | 0.031 | 0.021 | 0.018 | 0.035 | 0.055 | 0.04 | <0.01 | 0.037 |
| MELDR-11 | <0.01 | 0.01 | 0.013 | 0.013 | 0.028 | 0.021 | 0.023 | 0.015 | 0.02 | 0.049 | 0.017 | <0.01 | 0.01 |
| MELDR-12 | 0.027 | 0.027 | 0.043 | 0.07 | 0.034 | 2.1 | 1.4 | 0.021 | 0.9 | 0.028 | 0.05 | 0.11 | 0.34 |

| | | |
|---|---|---|
| Concentration ABOVE trigger value | Concentration < LOR | SITES RECORDING NH3-N CONCENTRATIONS ALWAYS/GENERALLY ABOVE ANZECC TRIGGER VALUE |
| Concentration BELOW trigger value | NO sample taken | SITES RECORDING NH3-N CONCENTRATIONS ALWAYS/GENERALLY BELOW ANZECC TRIGGER VALUE |

### 6.1.4 Organic nitrogen

Total Organic Nitrogen (TON) is a measure of the portion of nitrogen that is bound in organic compounds such as proteins, polypeptides, amino acids, and urea. It can be either dissolved or particulate. Particulate organic nitrogen, such as that found within plant detritus, faeces and dead organisms, is decomposed via a stepwise conversion of complex molecules to more simple molecules, eventually producing dissolved organic nitrogen compounds.

As no guideline currently exists for total organic nitrogen it is difficult to assess this concentration in terms of threats to ecosystem and/or human health. Since some sites have recorded concentrations above the total nitrogen trigger values it is suggested that further monitoring of this parameter is required and also to know more about the nitrogen speciation.

Site 7 (Booragoon Lake) recorded the highest TON concentration in the catchment of 2.3 mg/L in October, followed by site 12 (Blue Gum Lake outlet) with concentrations of 2.2 mg/L and 2.1 mg/L in October and September respectively (**Figure 6.1-6** and **Table D-10, Appendix D**).

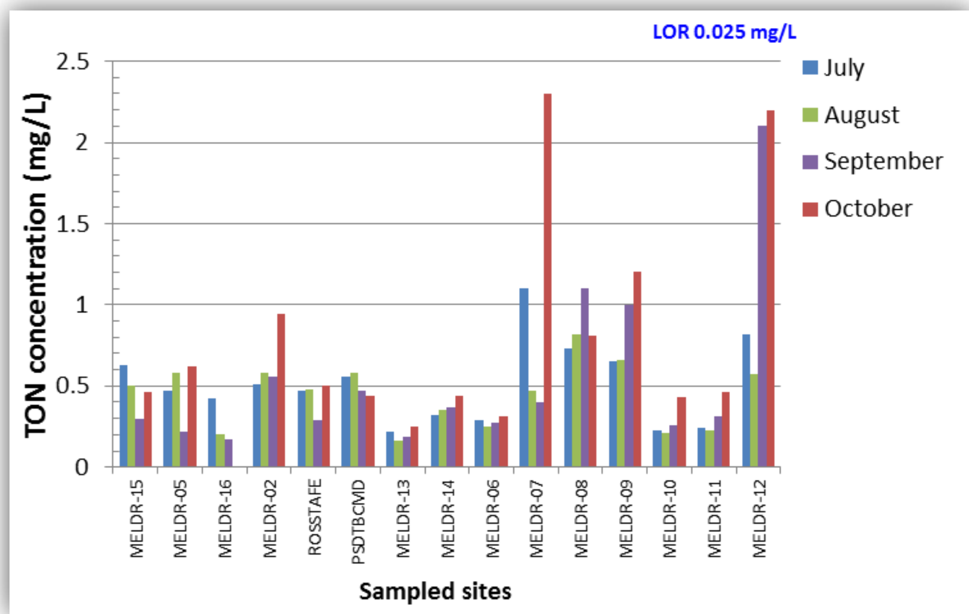


**Figure 6.1-6: Total organic nitrogen concentration (mg/L) in the surface water of the Melville Bull Creek catchments in 2016**

High TON concentrations in spring at sites 7 and 12 (Booragoon lake outlet and Blue Gum Lake outlet respectively), correspond with high ammonia concentrations (see Section 6.1.3) and high soluble reactive phosphorus concentrations (see Section 9.2.2). Possible explanations for these high nutrient levels could be increased spring bird populations depositing nutrient-rich faecal material in these lakes, or increased local fertiliser application at this time of year.

**Table 6.1-4** shows the recorded total organic nitrogen (TON) concentrations since 2011 when this parameter was added to the monitoring program. Sites 7 and 12 (Booragoon Lake outlet and Blue Gum Lake outlet) have continuously recorded the highest TON concentrations in the catchment, often in the spring as opposed to the winter months. Sites 13, 10 and 6 (Brentwood Drain, Frederick Baldwin and Bateman Park) have usually recorded the lowest TON concentrations.

Dissolved organic nitrogen (DON) is a measure of all organically bound nitrogen in the filtrate of a water sample through a 0.45 µm filter (Evans 2009).

As no guideline currently exists for DON it is difficult to assess this concentration in terms of threats to ecosystem and/or human health. Since some sites have recorded concentrations above the total nitrogen trigger value it is suggested that further monitoring of this parameter is required and also to know more about the nitrogen speciation.

DON concentrations were similar to total organic nitrogen concentration, reflecting the large proportion of organic nitrogen that is dissolved (refer to **Section 6.1.5**). Sites 7 and 12 (Booragoon Lake outlet and Blue Gum Lake outlet respectively) both recorded the highest DON concentration of 2.0 mg/L in October, and site 12 also recorded the second highest concentration of 1.6 mg/L in September (**Figure 6.1-7** and **Table D-11 Appendix D**). The lowest concentration of 0.13 mg/L was recorded at site 13 (Brentwood drain) in August.

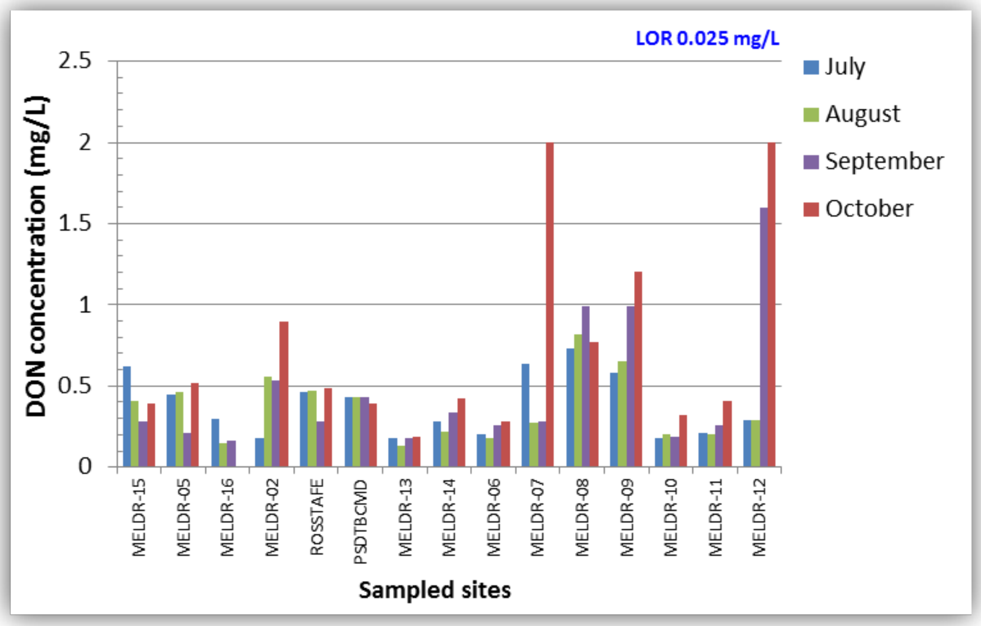


**Figure 6.1-7: Dissolved organic nitrogen concentrations (mg/L) in the surface water of Melville Bull Creek catchments in 2016**

**Table 6.1-5** shows the recorded DON concentrations throughout the nine-year sampling period. Sites 7 and 12 (Booragoon Lake outlet and Blue Gum Lake outlet) have consistently recorded the highest DON concentrations and sites 13, 10 and 6 (Brentwood Drain, Frederick Baldwin and Bateman Park) have usually recorded the lowest ones.

## Table 6.1-4: Records of TON concentrations (mg/L) in the Melville Bull Creek catchments 2011 - 2016

TON — Max 6 — Min 0.15 — LOR 0.025mg/L

| Site | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | 0.61 | 0.51 | 0.47 | 0.73 | 0.61 | 0.81 | 0.89 | 0.63 | 0.5 | 0.3 | 0.46 |
| MELDR-05 | 0.39 | 0.86 | 1.4 | 1.3 | 1 | 0.18 | 0.96 | 1 | 0.62 | 0.62 | 0.61 | 0.77 | 0.56 | 0.59 | 0.52 | 1.3 | 0.74 | 0.8 | 1.3 | 1.5 | 0.47 | 0.58 | 0.22 | 0.62 |
| MELDR-16 | | | | | | | | | | | | | | 0.49 | 0.44 | 0.58 | 0.56 | 0.85 | 0.51 | 0.86 | 0.42 | 0.2 | 0.17 | |
| MELDR-02 | 0.83 | 0.88 | 1.3 | 0.77 | 0.62 | 0.41 | 1.4 | 1.3 | 1 | 0.81 | 0.79 | 0.63 | 0.64 | 0.46 | 0.47 | 0.96 | 0.47 | 0.29 | 1.4 | 1.7 | 0.51 | 0.58 | 0.56 | 0.94 |
| PSDTBCMD | 0.98 | 0.76 | 0.48 | 0.77 | 0.35 | 0.48 | 0.6 | 0.79 | 0.6 | 0.53 | 1 | 0.15 | 0.65 | 0.66 | 0.6 | 0.33 | 0.61 | 0.72 | 0.75 | 0.38 | 0.56 | 0.58 | 0.47 | 0.44 |
| MELDR-13 | | | | | | | | | | | 0.32 | 0.26 | 0.27 | 0.27 | 0.29 | 0.17 | 0.22 | 0.24 | 0.33 | 0.25 | 0.22 | 0.16 | 0.19 | 0.25 |
| MELDR-14 | | | | | | | | | | | 0.5 | 0.57 | 0.43 | 0.46 | 0.46 | 0.44 | 0.32 | 0.37 | 0.51 | 0.52 | 0.32 | 0.35 | 0.37 | 0.44 |
| MELDR-06 | 0.34 | 0.39 | 0.44 | 0.32 | 0.16 | 0.17 | 0.26 | 0.29 | 0.27 | 0.31 | 0.31 | 0.32 | 0.28 | 0.24 | 0.31 | 0.21 | 0.31 | 0.27 | 0.39 | 0.27 | 0.29 | 0.25 | 0.27 | 0.31 |
| MELDR-07 | | 2.5 | 3.3 | 3.2 | | | 0.51 | 0.42 | | 0.55 | 2.5 | 3 | 0.73 | 1.4 | 2.2 | 2.4 | 0.33 | 0.28 | 2.3 | 2.9 | 1.1 | 0.47 | 0.4 | 2.3 |
| MELDR-08 | | | 0.6 | 0.63 | | 0.62 | 0.75 | 0.6 | 1.6 | 1.4 | 0.77 | 0.68 | 1.2 | 0.91 | 1.3 | 0.77 | 0.7 | 0.56 | 0.65 | 0.64 | 0.73 | 0.82 | 1.1 | 0.81 |
| MELDR-09 | 0.42 | 0.72 | 0.77 | 0.7 | 0.39 | 0.39 | 0.47 | 0.48 | 0.4 | 0.61 | 1.1 | 1.4 | 1.3 | 1.1 | 1.3 | 1.4 | 0.75 | 0.87 | 0.97 | 1 | 0.65 | 0.66 | 1 | 1.2 |
| MELDR-10 | 0.29 | 0.28 | 0.4 | 0.3 | 0.24 | 0.24 | 0.31 | 0.49 | 0.23 | 0.24 | 0.26 | 0.43 | 0.6 | 0.29 | 0.29 | 0.34 | 0.19 | 0.32 | 0.61 | 0.45 | 0.23 | 0.21 | 0.26 | 0.43 |
| MELDR-11 | 0.4 | 0.39 | 0.59 | 0.39 | 0.38 | 0.41 | 0.33 | 0.45 | 0.43 | 0.35 | 0.31 | 0.43 | 0.42 | 0.41 | 0.4 | 0.41 | 0.29 | 0.33 | 0.72 | 0.7 | 0.24 | 0.23 | 0.31 | 0.46 |
| MELDR-12 | 0.2 | 0.21 | 1.2 | 1.9 | 2.3 | 6 | 3.6 | 3 | 0.59 | 2.2 | 2.6 | 3.2 | 2.1 | 2.1 | 2.3 | 5.3 | 1.7 | 1.9 | 2.4 | 1.9 | 0.82 | 0.57 | 2.1 | 2.2 |

NO sample taken

Highest concentration of the year

Lowest concentration of the year

## Table 6.1-5: Records of DON concentrations (mg/L) in the Melville Bull Creek catchments 2007 – 2016

DON (mg/L) — Max 5.3 — Min <0.01 — LORs 0.01 & 0.025 mg/L

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | <0.01 | 0.075 | | | 0.76 | 0.81 | 1.4 | | 0.71 | 0.65 | | | 0.42 | 0.57 | 1.1 | 1 | 0.23 | 0.57 | 0.77 | 0.56 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | 0.078 | 0.13 | 0.089 | 0.065 | 0.25 | 1 | 1.1 | 0.3 | 1.1 | 0.93 | 0.44 | 0.23 | <0.025 | <0.025 | <0.025 | 0.43 | 0.5 | 0.71 | 1.1 | 0.57 |
| PSDTBCMD | 1.9 | 1.2 | 0.078 | 2.3 | 0.083 | 0.74 | 0.92 | 0.76 | 0.99 | 0.57 | 0.34 | 0.36 | 0.32 | 0.19 | 0.45 | 0.89 | 0.68 | 0.74 | 0.41 | 0.61 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | 0.32 | 0.35 | 2.1 | 0.068 | 0.3 | 0.28 | 0.15 | 0.18 | 0.45 | 0.26 | 0.2 | 0.24 | 0.24 | 0.22 | 0.22 | 0.28 | 0.29 | 0.32 | 0.4 | 0.28 |
| MELDR-07 | <0.01 | 0.018 | | | 0.92 | 3.5 | 5.3 | | 0.64 | 3.3 | | | 1.5 | 2.7 | 3.5 | 1.2 | | 1.1 | 3.1 | 2.9 |
| MELDR-08 | <0.01 | <0.01 | | | 0.64 | 0.5 | | | 0.69 | | | | | | | | | | 0.6 | 0.6 |
| MELDR-09 | <0.01 | 0.011 | | | 0.54 | 0.66 | 0.92 | 1.1 | 0.69 | 0.66 | 0.74 | | 0.44 | 0.5 | 0.55 | 0.89 | 0.38 | 0.43 | 0.7 | 0.68 |
| MELDR-10 | 0.036 | 0.011 | | | 0.26 | 0.34 | 0.37 | 0.24 | 0.28 | 0.34 | 0.41 | | 0.16 | 0.21 | 0.41 | 0.41 | 0.25 | 0.18 | 0.4 | 0.25 |
| MELDR-11 | <0.01 | <0.01 | | | 0.3 | 0.38 | 0.52 | 0.62 | 0.37 | 0.4 | 0.76 | 0.94 | 0.22 | 0.27 | 0.43 | 0.67 | 0.3 | 0.28 | 0.44 | 0.32 |
| MELDR-12 | <0.01 | 0.012 | | | 1.1 | 1.2 | 1.2 | | 1 | 1.1 | 1.4 | | 0.82 | 0.89 | 1.1 | 1.4 | 0.18 | 0.13 | 0.92 | 1.9 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | 0.4 | 0.39 | 0.46 | 0.59 | 0.6 | 0.65 | 0.79 | 0.62 | 0.41 | 0.28 | 0.39 |
| MELDR-05 | 0.68 | 0.11 | 0.72 | 0.7 | 0.46 | 0.53 | 0.45 | 0.51 | 0.43 | 0.5 | 0.45 | 0.57 | 0.64 | 0.76 | 0.84 | 0.9 | 0.45 | 0.46 | 0.21 | 0.52 |
| MELDR-16 | | | | | | | | | | 0.37 | 0.43 | 0.48 | 0.41 | 0.75 | 0.35 | 0.6 | 0.3 | 0.15 | 0.16 | |
| MELDR-02 | 0.6 | 0.39 | 1.1 | 1.3 | 0.82 | 0.71 | 0.79 | 0.62 | 0.41 | 0.43 | 0.45 | 0.94 | 0.38 | 0.19 | 0.46 | 1.6 | 0.18 | 0.56 | 0.53 | 0.9 |
| PSDTBCMD | 0.34 | 0.48 | 0.59 | 0.76 | 0.5 | 0.53 | 0.76 | 0.099 | 0.39 | 0.57 | 0.57 | 0.26 | 0.53 | 0.7 | 0.64 | 0.35 | 0.43 | 0.43 | 0.43 | 0.39 |
| MELDR-13 | | | | | | | 0.23 | 0.22 | 0.2 | 0.27 | 0.22 | 0.16 | 0.21 | 0.24 | 0.31 | 0.25 | 0.18 | 0.13 | 0.18 | 0.19 |
| MELDR-14 | | | | | | | 0.43 | 0.56 | 0.35 | 0.43 | 0.43 | 0.39 | 0.29 | 0.37 | 0.49 | 0.46 | 0.28 | 0.22 | 0.34 | 0.42 |
| MELDR-06 | 0.16 | 0.17 | 0.23 | 0.26 | 0.21 | 0.28 | 0.23 | 0.28 | 0.19 | 0.24 | 0.25 | 0.18 | 0.24 | 0.24 | 0.37 | 0.26 | 0.2 | 0.18 | 0.26 | 0.28 |
| MELDR-07 | | | 0.32 | 0.29 | | 0.28 | 1.7 | 2.8 | 0.58 | 1 | 1.4 | 2.2 | 0.3 | 0.24 | 1.6 | 2.6 | 0.64 | 0.27 | 0.28 | 2 |
| MELDR-08 | | 0.54 | 0.72 | 0.57 | 1.5 | 1.2 | 0.76 | 0.63 | 1.1 | 0.88 | 1.3 | 0.69 | 0.65 | 0.56 | 0.48 | 0.55 | 0.73 | 0.82 | 0.99 | 0.77 |
| MELDR-09 | 0.39 | 0.35 | 0.44 | 0.48 | 0.35 | 0.54 | 1.1 | 1.3 | 1.2 | 1.1 | 1.1 | 1.4 | 0.71 | 0.84 | 0.71 | 0.91 | 0.58 | 0.65 | 0.99 | 1.2 |
| MELDR-10 | 0.2 | 0.16 | 0.25 | 0.35 | 0.13 | 0.13 | 0.18 | 0.36 | 0.25 | 0.23 | 0.23 | 0.26 | 0.16 | 0.23 | 0.4 | 0.29 | 0.18 | 0.2 | 0.19 | 0.32 |
| MELDR-11 | 0.24 | 0.23 | 0.25 | 0.35 | 0.22 | 0.24 | 0.23 | 0.37 | 0.26 | 0.23 | 0.26 | 0.34 | 0.17 | 0.27 | 0.49 | 0.57 | 0.21 | 0.2 | 0.26 | 0.41 |
| MELDR-12 | 1.2 | 0.69 | 0.75 | 2.1 | 0.35 | 1.4 | 1.9 | 1.9 | 1.6 | 1.6 | 1.6 | 1.5 | 1.4 | 1.5 | 1.6 | 1.9 | 0.29 | 0.29 | 1.6 | 2 |

NO sample taken

Highest concentration of the year

Lowest concentration of the year

### 6.1.5 Nitrogen speciation

Organic nitrogen was the predominant component of total nitrogen (TN) on all sampling occasions at all of the "wetland" sites (sites 7, 8, 9, 10, 11 and12) and at sites 15 and 5 (**Figure 6.1-8**). It also predominated at Bull Creek sites 16 in July and August and site 14 in August, September and October. Most of this organic nitrogen was dissolved, except at sites 7 and 12, where particulate organic nitrogen comprised up to 43% and 69% respectively of total organic nitrogen and often corresponded with high TSS concentrations. It

As in the last few years of sampling, nitrogen as ammonia/ammonium ($NH_3$-N/$NH_4$-N) was the predominant component of total nitrogen at site 2 (Brockman Park) when samples were collected (90%, 87%, 84% and 84% in July, August, September and October 2016 respectively). This site has continuously displayed the same pattern of high total nitrogen with $NH_3$-N/$NH_4$-N as the predominant component during the nine years of monitoring and the continued high levels of ammonia/ammonium at this site are of concern. $NH_3$-N/$NH_4$-N comprised 25% or less of TN in all other samples except at site 5 in July when it comprised 44% of TN.

Similar to the last six years of sampling, NOx was the predominant component of total nitrogen at all sampling occasions at PDSTBCMD (Bull Creek MD). It was also predominant upstream of PSDTBCMD at ROSSTAFE (Brockman Park inlet) on three occasions (61%, 54% and 70% in July, august and September respectively) and at site 13 (Brentwood drain) on two occasions (51% and 52% in August and September respectively).

Interestingly, while sites 15 and 5 (John Creaney Park Inlet and John Creaney Park) had similar concentrations of total nitrogen, site 15 but not site 5 recorded exceedances of NOx, and site 5 but not 15 recorded exceedances of $NH_3$-N/$NH_4$-N. This is reflected in the differences in nitrogen speciation in the two sites as seen in **Figure 6.1-8**. This may reflect the very low oxygen levels at site 5 resulting in lower rates of conversion of nitrification (conversion of ammonia to nitrate), and/or possible intrusion of groundwater with the compensation basin.

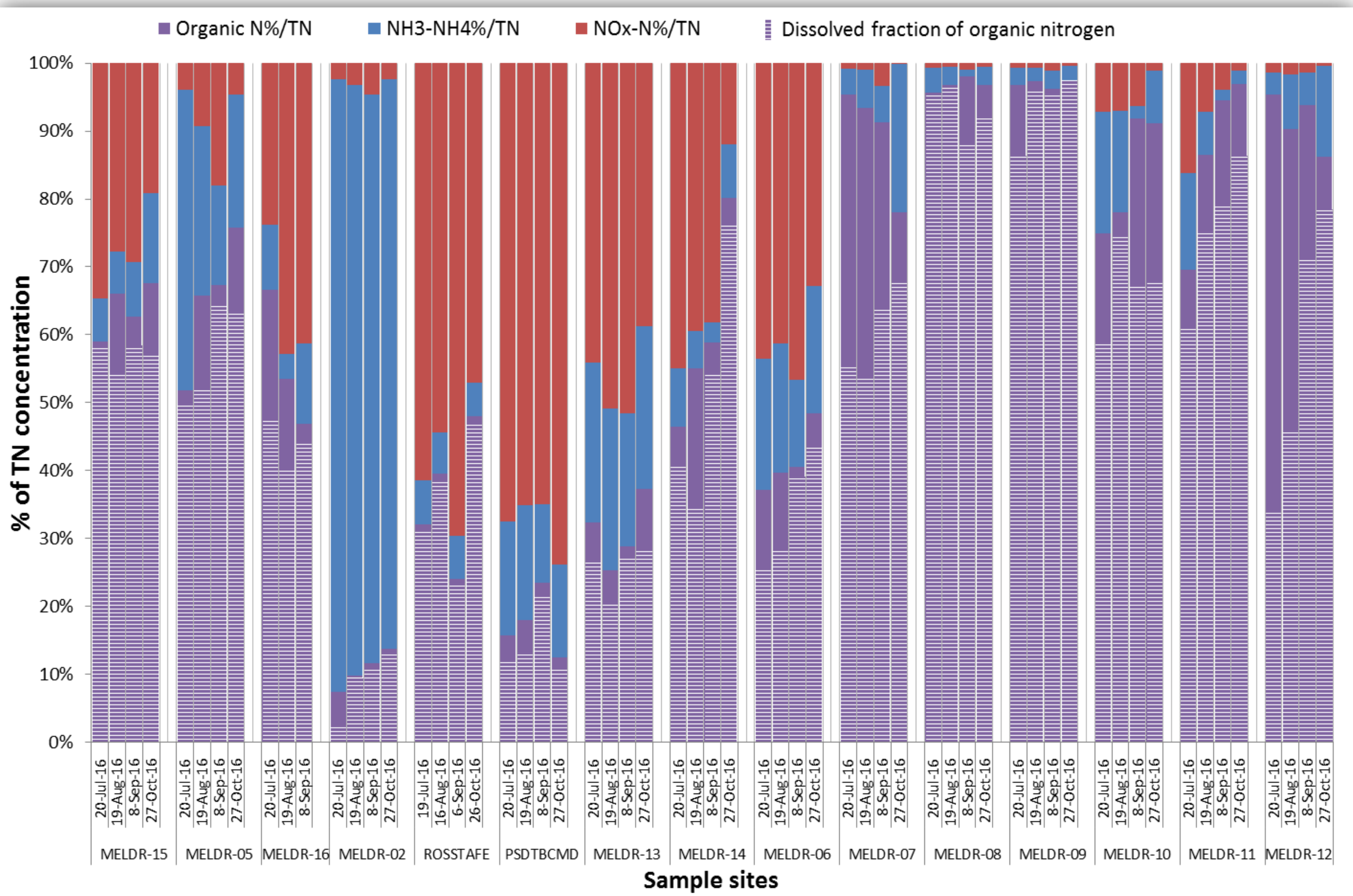


**Figure 6.1-8: Nitrogen speciation in the surface water of Melville Bull Creek catchments in 2016**

## 6.2 Phosphorus

Phosphorus in water can exists in both soluble and particulate forms. Soluble phosphorus is largely comprised of inorganic phosphate ions (PO43-, also known as orthophosphate or soluble reactive phosphorus) but small amounts of condensed phosphate (polyphosphates and metaphosphates) and dissolved organic forms of phosphorus may be present. Particulate phosphorus is comprised of organic material (decaying plant and animal matter), phosphorus adsorbed to particulate material and phosphorus minerals (e.g. apatite).

### 6.2.1 Total phosphorus

Total phosphorus is a measure of all phosphorus present in water, both in dissolved and particulate forms.

The ANZECC trigger value for lowland rivers for TP is 0.065 mg/L and 0.06 mg/L for wetlands (ANZECC and ARMCANZ 2000).

As has been observed in previous years of sampling, TP concentrations in 2016 were generally low and below the ANZECC trigger values (**Figure 6.2-1** and **Table D-12, Appendix D**). Only nine out of 59 samples recorded concentrations above the relevant trigger value at three sites; 5 (John Creaney Park) in July only and 7 and 12 (Booragoon Lake outlet and Blue Gum Lake outlet respectively) at all sampling occasions (**Figure 6.2-2**). Site 7 recorded the highest concentration of 1.2 mg/L in October, which was 20 times the ANZECC trigger value for wetlands (0.06 mg/L). The lowest concentration, below the limit of reporting of 0.005 mg/L, was recorded at site 9 (Quenda Lake outlet) in August.

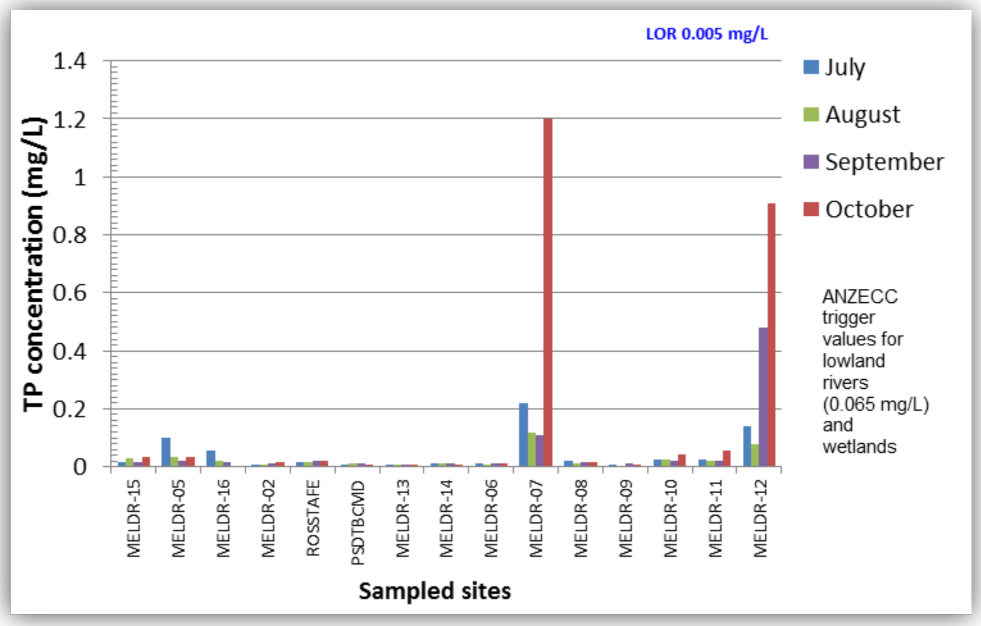


**Figure 6.2-1: Total phosphorus concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016**

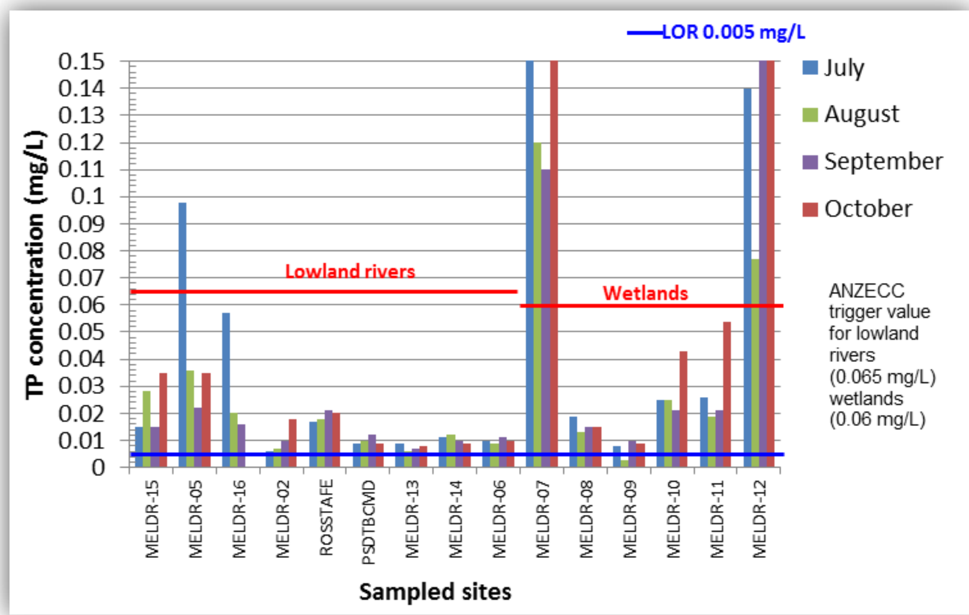


**Figure 6.2-2: Total phosphorus concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016 (zoom in*)**

***Please note this graph scale stops at 0.15 mg/L**

Although total phosphorus appears is high at sampling occasions at sites 7 and 12 (Booragoon Lake outlet and Blue Gum lake outlet) the three highest recorded concentrations at sites 7 (1.2 mg/L in October) and 12 (0.91 mg/L and 0.48 mg/L in October and September respectively) recorded in spring appear to be as a result of increased amounts of soluble reactive phosphorus (see Sections 9.2.2and Section 9.2.3). The exceedance recorded at site 5 (John Creaney Park) in July also seems to be as a result of high soluble reactive phosphorus concentrations (see Sections 9.2.2and Section 9.2.3).

**Table 6.2-1** shows the recorded TP concentrations throughout the nine-year sampling period and a clear pattern has emerged. Some of the sites have consistently recorded concentrations below the trigger values and others have consistently exceeded them. Sites 5, 2, PSDTBCMD, 6, 8, 9, 10 and 11 have consistently recorded TP concentrations below the trigger values and sites 7 and 12 have nearly always exceeded it.

## Table 6.2-1: Records of TP concentration (mg/L) in the Melville Bull Creek catchments 2007 – 2016

TP (mg/L) — Max 8.3 — Min <0.005 — LOR 0.005 mg/L

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWLAND RIVERS (ANZECC trigger value 0.065 mg/L) | | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| **MELDR-05** | 0.14 | 0.025 | | | 0.041 | 0.086 | 0.12 | | 0.059 | 0.049 | | | 0.095 | 0.059 | 0.17 | 0.16 | 0.048 | 0.078 | 0.13 | 0.12 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| **MELDR-02** | 0.01 | 0.009 | 0.008 | 0.014 | 0.01 | 0.01 | 0.008 | 0.014 | 0.015 | 0.013 | 0.013 | 0.072 | 0.028 | 0.01 | 0.011 | 0.017 | 0.007 | 0.012 | 0.016 | 0.016 |
| **PSDTBCMD** | 0.017 | 0.012 | 0.008 | 0.016 | 0.019 | 0.015 | 0.014 | 0.022 | 0.02 | 0.016 | 0.014 | 0.022 | 0.039 | 0.014 | 0.02 | 0.015 | 0.011 | 0.013 | 0.018 | 0.018 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| **MELDR-06** | 0.013 | 0.008 | 0.027 | 0.016 | 0.012 | 0.023 | 0.008 | 0.013 | 0.013 | 0.01 | 0.01 | 0.012 | 0.03 | 0.012 | 0.016 | 0.021 | 0.013 | 0.014 | 0.018 | 0.013 |
| **Site** | WETLANDS (ANZECC trigger value 0.06 mg/L) | | | | | | | | | | | | | | | | | | | |
| **MELDR-07** | 0.12 | 3.2 | | | 1.3 | 2.6 | 8.3 | | 0.66 | 3.2 | | | 1 | 1.5 | 0.95 | 3.9 | | 0.81 | 1.2 | 2.9 |
| **MELDR-08** | 0.077 | 0.11 | | | 0.15 | 0.024 | | | 0.021 | | | | | | | | | | 0.029 | 0.031 |
| **MELDR-09** | 0.02 | 0.018 | | | 0.014 | 0.014 | 0.017 | 0.02 | 0.012 | 0.012 | 0.013 | | 0.012 | 0.015 | 0.02 | 0.028 | 0.025 | 0.03 | 0.025 | 0.017 |
| **MELDR-10** | 0.03 | 0.018 | | | 0.026 | 0.035 | 0.059 | 0.1 | 0.016 | 0.041 | 0.062 | | 0.025 | 0.022 | 0.042 | 0.045 | 0.024 | 0.025 | 0.024 | 0.025 |
| **MELDR-11** | 0.036 | 0.032 | | | 0.03 | 0.039 | 0.042 | 0.077 | 0.033 | 0.038 | 0.11 | 0.16 | 0.042 | 0.034 | 0.049 | 0.089 | 0.039 | 0.033 | 0.044 | 0.027 |
| **MELDR-12** | 0.18 | 0.31 | | | 0.28 | 0.19 | 0.19 | | 0.12 | 0.089 | 0.21 | | 0.12 | 0.076 | 0.073 | 0.14 | 0.008 | 0.017 | 0.26 | 1.1 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWLAND RIVERS (ANZECC trigger value 0.065 mg/L) | | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | 0.048 | 0.044 | 0.014 | 0.047 | 0.041 | 0.025 | 0.027 | 0.015 | 0.028 | 0.015 | 0.035 |
| **MELDR-05** | 0.1 | 0.032 | 0.052 | 0.064 | 0.073 | 0.071 | 0.042 | 0.034 | 0.083 | 0.052 | 0.05 | 0.088 | 0.043 | 0.051 | 0.076 | 0.069 | 0.098 | 0.036 | 0.022 | 0.035 |
| MELDR-16 | | | | | | | | | | 0.059 | 0.043 | 0.037 | 0.042 | 0.051 | 0.063 | 0.12 | 0.057 | 0.02 | 0.016 | |
| **MELDR-02** | <0.005 | <0.005 | <0.005 | <0.005 | 0.023 | 0.018 | 0.03 | 0.012 | 0.051 | 0.019 | 0.019 | 0.011 | 0.006 | 0.008 | <0.005 | 0.006 | 0.006 | 0.007 | 0.01 | 0.018 |
| **PSDTBCMD** | 0.013 | 0.006 | 0.012 | 0.011 | 0.029 | 0.016 | 0.034 | 0.017 | 0.024 | 0.02 | 0.014 | 0.012 | 0.011 | 0.008 | 0.008 | 0.008 | 0.009 | 0.01 | 0.012 | 0.009 |
| MELDR-13 | | | | | | | 0.016 | 0.005 | 0.026 | 0.011 | 0.013 | <0.005 | 0.011 | 0.008 | 0.005 | 0.008 | 0.009 | 0.006 | 0.007 | 0.008 |
| MELDR-14 | | | | | | | 0.009 | 0.017 | 0.013 | 0.014 | 0.012 | 0.011 | 0.014 | 0.012 | 0.016 | 0.02 | 0.011 | 0.012 | 0.01 | 0.009 |
| **MELDR-06** | <0.005 | 0.012 | 0.008 | 0.006 | 0.014 | 0.011 | 0.01 | 0.007 | 0.019 | 0.008 | 0.011 | <0.005 | 0.016 | 0.006 | 0.006 | 0.009 | 0.01 | 0.009 | 0.011 | 0.01 |
| **Site** | WETLANDS (ANZECC trigger value 0.06 mg/L) | | | | | | | | | | | | | | | | | | | |
| **MELDR-07** | | | 0.45 | 0.081 | | 0.21 | 0.91 | 1.5 | 0.33 | 1.1 | 0.77 | 2.3 | 0.02 | 0.025 | 0.73 | 0.64 | 0.22 | 0.12 | 0.11 | 1.2 |
| **MELDR-08** | | 0.034 | 0.034 | 0.025 | 0.12 | 0.069 | 0.013 | 0.016 | 0.016 | 0.014 | 0.015 | 0.01 | 0.01 | 0.008 | 0.01 | 0.017 | 0.019 | 0.013 | 0.015 | 0.015 |
| **MELDR-09** | <0.005 | <0.005 | <0.005 | <0.005 | 0.005 | 0.007 | 0.013 | 0.016 | 0.007 | 0.013 | 0.021 | 0.017 | 0.009 | 0.013 | 0.009 | 0.012 | 0.008 | <0.005 | 0.01 | 0.009 |
| **MELDR-10** | 0.031 | 0.028 | 0.023 | 0.039 | 0.027 | 0.022 | 0.017 | 0.025 | 0.054 | 0.024 | 0.023 | 0.02 | 0.022 | 0.023 | 0.031 | 0.031 | 0.025 | 0.025 | 0.021 | 0.043 |
| **MELDR-11** | 0.035 | 0.03 | 0.027 | 0.029 | 0.066 | 0.025 | 0.024 | 0.033 | 0.039 | 0.04 | 0.04 | 0.03 | 0.027 | 0.025 | 0.048 | 0.094 | 0.026 | 0.019 | 0.021 | 0.054 |
| **MELDR-12** | 0.15 | 0.65 | 0.73 | 0.54 | 0.036 | 0.36 | 0.67 | 0.55 | 0.59 | 0.72 | 0.51 | 0.85 | 0.44 | 0.58 | 0.3 | 0.7 | 0.14 | 0.077 | 0.48 | 0.91 |

SITES RECORDING TP CONCENTRATIONS ALWAYS/GENERALLY ABOVE ANZECC TRIGGER VALUE

SITES RECORDING 40-60% of TP concentrations ABOVE ACCEPTABLE RANGE

SITES RECORDING TP CONCENTRATIONS ALWAYS/GENERALLY BELOW ANZECC TRIGGER VALUE

Concentration ABOVE trigger value

Concentration BELOW trigger value

Concentration < LOR

NO sample taken

### 6.2.2 Soluble reactive phosphorus

Soluble Reactive Phosphorus (SRP) measures only the dissolved phosphorus in water and provides a measure of the immediately available phosphate in the system at the time of sampling. SRP describes the phosphates that pass through a 0.45 µm filter and respond to colorimetric tests without preliminary hydrolysis or oxidative digestions of the sample. SRP is largely a measure of orthophosphate ($PO_4^{3-}$); however a small fraction of any condensed phosphate present, is usually hydrolysed unavoidably in the analytical procedure.

The ANZECC trigger value for soluble reactive phosphorus is 0.04 mg/L for lowland rivers and 0.03 mg/L for wetlands (ANZECC and ARMCANZ 2000b).

As in the last six years of sampling since 2010, soluble reactive phosphorus concentrations in the Melville Bull Creek catchments were generally low (**Figure 6.2-3** and **Table D-13, Appendix D**). Only four out of 59 samples recorded concentrations above the ANZECC trigger value for wetlands: at site 5 in July (0.061 mg/L), site 7 in October (0.61 mg/L) and site 12 in September (0.16 mg/L) and October (0.62 mg/L) when the highest concentration in the catchment was recorded (**Figure 6.2-4**). 29 samples recorded concentrations below the limit of reporting (0.005 mg/L).

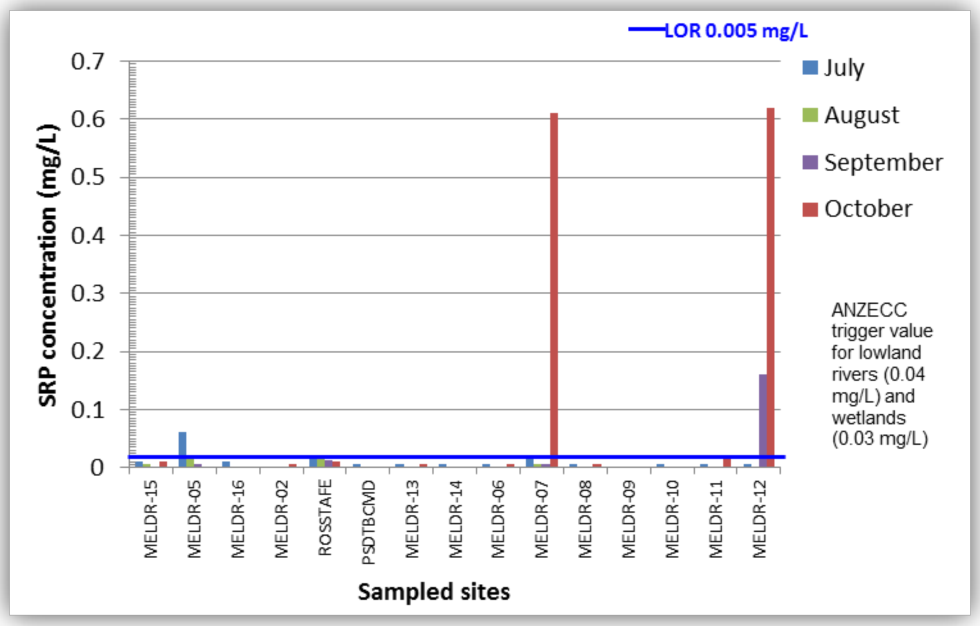


**Figure 6.2-3: Soluble reactive phosphorus concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016**

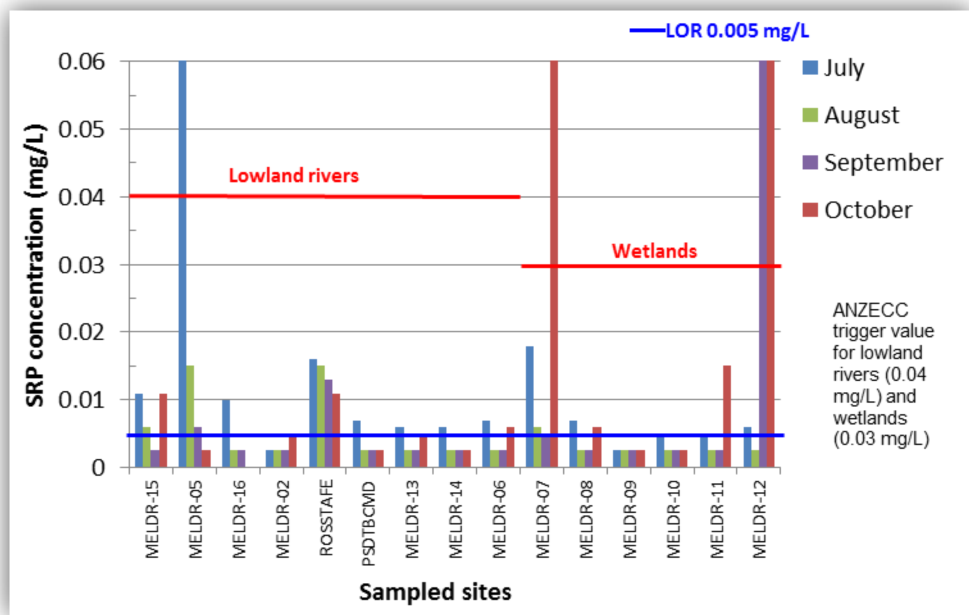


**Figure 6.2-4: Soluble reactive phosphorus concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016 (zoom in*)**

*Please note this graph scale stops at 0.06 mg/L

High SRP concentrations in spring at sites 7 and 12 (Booragoon lake outlet and Blue Gum Lake outlet respectively), correspond with high ammonia concentrations (see **Section 6.1.3**) and organic nitrogen concentrations (see **Section 6.1.4**). Possible explanations for these high nutrient levels could be increased spring bird populations depositing nutrient-rich faecal material in these lakes, or increased local fertiliser application at this time of year**.** The high ammonia and soluble reactive phosphorus concentrations at these lakes, particularly in spring, is concerning and puts these lakes at risk of harmful algal blooms.

Interestingly, concentrations of SRP were significantly lower (and below the trigger value) at site 15 (John Creaney Park inlet) than at site 5 (John Creaney Park) in July. This suggests there was a source of soluble reactive phosphorus within the lake, or entering the lake after the inlet, in July. However SRP concentrations were below trigger values downstream at site 2 (Brockman Park) in July, possibly partially due to the dilution effect of the branch of the Bull Creek Main Drain encompassing site 16 (downstream Elizabeth Manion Park).

**Table 6.2-2** shows the recorded SRP concentrations throughout the nine-year sampling period. Five of the sites (2, PSDTBCMD, 6, 9 and 10) have always recorded SRP concentrations below the trigger value. Sites 7 and 12 (Booragoon Lake outlet and Blue Gum Lake outlet) both recorded concentrations exceeding the trigger value on the majority of occasions when samples were collected, demonstrating that the high concentrations recorded in 2016 are typical of these sites.

## Table 6.2-2: Records of SRP concentration (mg/L) in the Melville Bull Creek catchments 2007 - 2016

SRP (mg/L) Max 1.7 Min <0.005 LOR 0.005 mg/L

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWLAND RIVERS (ANZECC trigger value 0.04 mg/L) | | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | 0.017 | <0.005 | | | <0.005 | <0.005 | <0.005 | | <0.005 | <0.005 | | | 0.021 | <0.005 | <0.005 | 0.066 | 0.006 | 0.015 | <0.005 | 0.01 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | 0.009 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | 0.012 | <0.005 | <0.005 | 0.008 | <0.005 | <0.005 | <0.005 | <0.005 |
| PSDTBCMD | 0.009 | <0.005 | <0.005 | <0.005 | <0.005 | 0.007 | <0.005 | <0.005 | 0.009 | <0.005 | 0.009 | <0.005 | 0.008 | <0.005 | <0.005 | 0.009 | <0.005 | <0.005 | <0.005 | 0.005 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | 0.008 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | 0.007 | <0.005 | <0.005 | 0.009 | <0.005 | <0.005 | <0.005 | <0.005 |
| Site | WETLANDS (ANZECC trigger value 0.03 mg/L) | | | | | | | | | | | | | | | | | | | |
| MELDR-07 | 0.015 | 0.048 | | | 0.13 | 1 | 1.2 | | <0.005 | 0.67 | | | 0.056 | 0.46 | 0.21 | 0.083 | | 0.059 | 0.27 | 1.6 |
| MELDR-08 | 0.008 | <0.005 | | | <0.005 | <0.005 | | | <0.005 | | | | | | | | | | <0.005 | 0.01 |
| MELDR-09 | 0.007 | <0.005 | | | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | | <0.005 | 0.006 | <0.005 | 0.01 | <0.005 | <0.005 | <0.005 | 0.014 |
| MELDR-10 | 0.01 | <0.005 | | | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | | <0.005 | <0.005 | <0.005 | 0.005 | <0.005 | <0.005 | <0.005 | 0.014 |
| MELDR-11 | 0.007 | <0.005 | | | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | 0.01 | <0.005 | <0.005 | 0.01 | 0.009 | 0.005 | <0.005 | 0.016 |
| MELDR-12 | 0.008 | 0.16 | | | 0.18 | 0.078 | 0.048 | | 0.064 | 0.021 | 0.022 | | 0.042 | 0.033 | 0.018 | 0.081 | <0.005 | <0.005 | 0.077 | 0.73 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWLAND RIVERS (ANZECC trigger value 0.04 mg/L) | | | | | | | | | | | | | | | | | | | | |
| MELDR-15 | | | | | | | | | | 0.011 | 0.016 | 0.012 | 0.011 | 0.013 | <0.005 | 0.006 | 0.011 | 0.006 | <0.005 | 0.011 |
| MELDR-05 | 0.081 | 0.01 | <0.005 | <0.005 | 0.026 | 0.03 | <0.005 | <0.005 | 0.032 | 0.005 | 0.016 | <0.005 | 0.019 | 0.009 | <0.005 | 0.005 | 0.061 | 0.015 | 0.006 | <0.005 |
| MELDR-16 | | | | | | | | | | 0.018 | 0.018 | 0.008 | 0.008 | 0.013 | 0.014 | 0.019 | 0.01 | <0.005 | <0.005 | |
| MELDR-02 | <0.005 | <0.005 | <0.005 | <0.005 | 0.01 | 0.007 | 0.014 | <0.005 | 0.019 | <0.005 | 0.006 | <0.005 | 0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | 0.005 |
| PSDTBCMD | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.006 | <0.005 | <0.005 | <0.005 | 0.006 | 0.01 | <0.005 | <0.005 | <0.005 |
| MELDR-13 | | | | | | | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.007 | <0.005 | <0.005 | <0.005 | 0.007 | 0.006 | <0.005 | <0.005 | 0.005 |
| MELDR-14 | | | | | | | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.008 | 0.005 | <0.005 | <0.005 | 0.008 | 0.006 | <0.005 | <0.005 | <0.005 |
| MELDR-06 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | 0.005 | <0.005 | <0.005 | <0.009 | 0.005 | <0.005 | <0.005 | 0.008 | 0.007 | <0.005 | <0.005 | 0.006 |
| Site | WETLANDS (ANZECC trigger value 0.03 mg/L) | | | | | | | | | | | | | | | | | | | |
| MELDR-07 | | | 0.043 | 0.022 | | 0.011 | 0.37 | 1.1 | 0.13 | 0.87 | 0.23 | 1.7 | 0.008 | 0.009 | 0.53 | 0.3 | 0.018 | 0.006 | 0.005 | 0.61 |
| MELDR-08 | | 0.007 | 0.008 | <0.005 | 0.047 | 0.015 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | 0.007 | 0.007 | <0.005 | <0.005 | 0.006 |
| MELDR-09 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| MELDR-10 | 0.008 | 0.006 | <0.005 | <0.005 | 0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | 0.005 | <0.005 | <0.005 | <0.005 |
| MELDR-11 | <0.005 | <0.005 | <0.005 | <0.005 | 0.024 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | 0.01 | 0.039 | 0.005 | <0.005 | <0.005 | 0.015 |
| MELDR-12 | <0.005 | <0.005 | <0.005 | 0.09 | <0.005 | 0.073 | 0.3 | 0.12 | 0.22 | 0.45 | 0.17 | 0.23 | 0.32 | 0.4 | 0.025 | 0.56 | 0.006 | <0.005 | 0.16 | 0.62 |

Concentration ABOVE trigger value
Concentration BELOW trigger value
Concentration < LOR
NO sample taken
SITES RECORDING SRP CONCENTRATIONS ALWAYS/GENERALLY ABOVE ANZECC TRIGGER VALUE
SITES RECORDING SRP CONCENTRATIONS ALWAYS/GENERALLY BELOW ANZECC TRIGGER VALUE

### 6.2.3 Phosphorus speciation

TP was predominantly present in the form of particulate phosphorus (≥50%) at the majority of the samples (44 out of 59) in 2016 (**Figure 6.2-5**). At site ROSSTAFE (Brockman Park inlet) soluble phosphorus comprised the majority of total phosphorus at all sampling occasions and at sites 15, 5, PSDTBCMD, 13, 14, 6, 7 9 and 12 (John Creaney Park Inlet, John Creaney Park, Bull Creek MD, Brentwood Drain, RAAF Drain, Bateman Park, Booragoon Lake outlet, Quenda Lake outlet and Blue Gum Lake outlet) soluble phosphorus comprised the majority of total phosphorus on at least one sampling occasion.

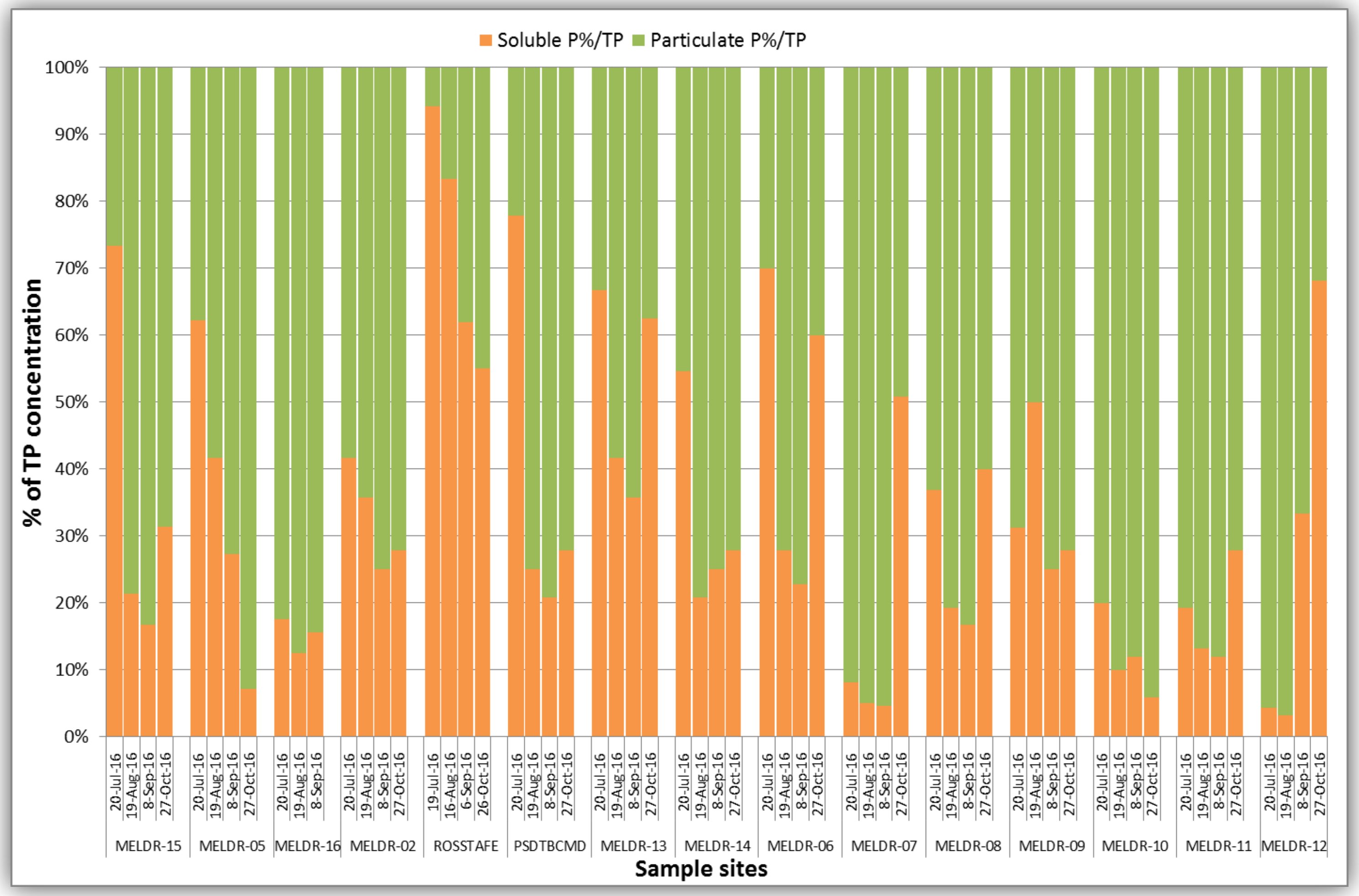


**Figure 6.2-5: Phosphorus speciation in the surface water of Melville Bull Creek catchments in 2016**

# 7. Water Hardness

## 7.1 Hardness

Total hardness, expressed as calcium carbonate ($CaCO_3$), is the combined concentration of earth-alkali metals, predominantly magnesium ($Mg^{2+}$) and calcium ($Ca^{2+}$), and some strontium ($Sr^{2+}$) in the water. Other metal ions (such as aluminium, iron, zinc and manganese) also contribute to water hardness. The source of this hardness is limestone dissolved by water that is rich in carbon dioxide. Increasing calcium and magnesium in water (hardness) is frequently associated with increases in alkalinity (as calcium and/or magnesium carbonate), and thus, pH (ANZECC and ARMCANZ 2000).

For hardness concentrations in water in the Melville Bull Creek catchments see **Table D-14, Appendix D**. **Table E-1, Appendix E** outlines the factors that influence changes in hardness and the impacts that changes in hardness can have on aquatic ecosystems.

The ANZECC guidelines (ANZECC and ARMCANZ 2000) classified the water hardness into five categories: soft (<59 mg/L), moderate (60 to 119 mg/L), hard (120 to 179 mg/L), very hard (180 to 240 mg/L) and extremely hard (>240 mg/L).

In 2016 water hardness in the surface water of the Melville Bull Creek catchments varied from a minimum of 20 mg/L recorded at site 10 (Frederick Baldwin) in July to a maximum of 890 mg/L recorded at site 7 (Booragoon Lake) in July (**Figure 7.1-1** and **Table D-14:, Appendix D**). Six samples recorded soft water hardness (0 to 59 mg/L), 22 samples recorded moderate concentrations (60 to 119 mg/L), 23 samples recorded hard concentrations (120 to 179 mg/L), three samples recorded very hard concentrations (180 to 240 mg/L) and five samples recorded extremely hard concentrations (>240 mg/L).

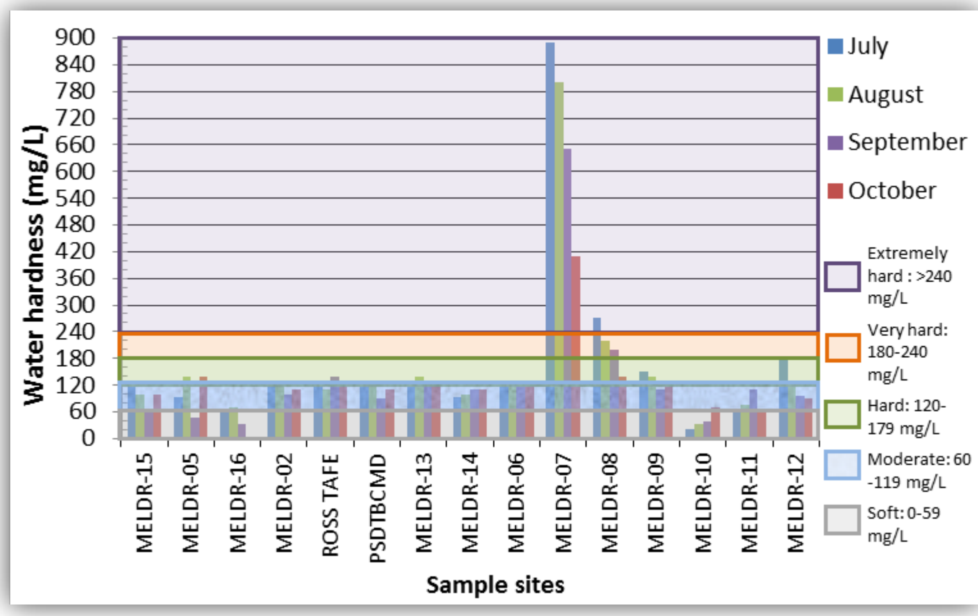


**Figure 7.1-1: Water hardness concentrations (mg/L) in the Melville Bull Creek catchments in 2016**

**Table 7.1-1** shows the total water hardness concentrations in the surface of Melville Bull Creek catchments throughout the nine-year monitoring period. Most sites have usually recorded concentrations classified as moderate or hard and sporadically recording concentrations classified as very hard or extremely hard; with the exception of site 5, samples of which have recorded hardness concentrations that appear to vary throughout each year (with a trend towards softer concentrations in winter and harder in spring and summer), site 7, which has generally recorded “very hard” concentrations and site 10, which has recorded a combination of “soft”, “moderate” and “hard” concentrations.

## Table 7.1-1: Records of water hardness concentration (mg/L) in the Melville Bull Creek catchments 2007 - 2016

**Total Water Hardness** (mg/L)

LOR 5 mg/L

Max 1,500 Min 7

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | |
| MELDR-05 | 20 | 180 | | | 220 | 270 | 290 | | 140 | 200 | | | 63 |
| MELDR-16 | | | | | | | | | | | | | |
| MELDR-02 | 120 | 130 | 130 | 130 | 130 | 1,100 | 120 | 130 | 120 | 120 | 120 | 140 | 92 |
| PSDTBCMD | 130 | 120 | 160 | 130 | 120 | 140 | 110 | 110 | 120 | 120 | 120 | 130 | 75 |
| MELDR-13 | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | |
| MELDR-06 | 170 | 160 | 110 | 200 | 150 | 190 | 150 | 150 | 130 | 140 | 140 | 160 | 87 |
| MELDR-07 | 1,000 | 600 | | | 580 | 180 | 660 | | 620 | 700 | | | 910 |
| MELDR-08 | 170 | 110 | | | 80 | 82 | | | 110 | | | | |
| MELDR-09 | 190 | 130 | | | 120 | 200 | 220 | 270 | 130 | 180 | 260 | | 130 |
| MELDR-10 | 70 | 69 | | | 80 | 120 | 120 | 150 | 76 | 70 | 130 | | 56 |
| MELDR-11 | 120 | 160 | | | 130 | 170 | 93 | 120 | 75 | 83 | 98 | 180 | 130 |
| MELDR-12 | 230 | 98 | | | 100 | 160 | 130 | | 92 | 110 | 210 | | 98 |

| Site | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | |
| MELDR-05 | 74 | 240 | 170 | 7 | 98 | 210 | 100 | 120 | 22 | 220 | 190 | 100 | 130 |
| MELDR-16 | | | | | | | | | | | | | |
| MELDR-02 | 130 | 130 | 75 | 120 | 120 | 140 | 120 | 120 | 100 | 130 | 120 | 110 | 130 |
| PSDTBCMD | 120 | 120 | 110 | 120 | 710 | 130 | 120 | 110 | 95 | 130 | 120 | 78 | 130 |
| MELDR-13 | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | |
| MELDR-06 | 130 | 130 | 140 | 130 | 140 | 130 | 130 | 170 | 100 | 150 | 150 | 130 | 150 |
| MELDR-07 | 850 | 1,100 | 970 | | 1,100 | 870 | 760 | | | 1,400 | 1,500 | | 770 |
| MELDR-08 | | | | | | 220 | 150 | | 150 | 170 | 150 | 230 | 200 |
| MELDR-09 | 140 | 160 | 1,300 | 220 | 180 | 170 | 150 | 150 | 140 | 150 | 170 | 150 | 130 |
| MELDR-10 | 71 | 130 | 160 | 29 | 29 | 51 | 53 | 41 | 20 | 38 | 99 | 32 | 24 |
| MELDR-11 | 150 | 170 | 110 | 91 | 100 | 120 | 84 | 110 | 110 | 110 | 140 | 100 | 86 |
| MELDR-12 | 110 | 120 | 140 | 210 | 140 | 100 | 110 | 280 | 210 | 110 | 130 | 150 | 73 |

| Site | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | 110 | 130 | 140 | 100 | 100 | 150 | 150 | 130 | 98 | 65 | 99 |
| MELDR-05 | 150 | 200 | 100 | 180 | 200 | 220 | 180 | 200 | 220 | 250 | 93 | 140 | 46 | 140 |
| MELDR-16 | | | | 76 | 110 | 120 | 110 | 130 | 130 | 150 | 68 | 69 | 33 | |
| MELDR-02 | 130 | 150 | 94 | 130 | 180 | 150 | 120 | 130 | 110 | 130 | 120 | 130 | 100 | 110 |
| PSDTBCMD | 130 | 140 | 99 | 130 | 170 | 140 | 120 | 130 | 110 | 130 | 130 | 120 | 91 | 110 |
| MELDR-13 | 130 | 160 | 49 | 140 | 180 | 150 | 120 | 130 | 140 | 140 | 130 | 140 | 130 | 120 |
| MELDR-14 | 130 | 160 | 100 | 140 | 170 | 150 | 93 | 100 | 130 | 130 | 94 | 100 | 110 | 110 |
| MELDR-06 | 140 | 160 | 65 | 140 | 180 | 150 | 120 | 130 | 140 | 140 | 130 | 130 | 120 | 120 |
| MELDR-07 | 530 | 620 | 640 | 620 | 650 | 530 | 880 | 900 | 130 | 850 | 890 | 800 | 650 | 410 |
| MELDR-08 | 140 | 140 | 150 | 140 | 180 | 130 | 140 | 140 | 100 | 130 | 270 | 220 | 200 | 140 |
| MELDR-09 | 150 | 180 | 110 | 100 | 120 | 140 | 110 | 120 | 130 | 130 | 150 | 140 | 110 | 130 |
| MELDR-10 | 67 | 130 | 35 | 71 | 110 | 140 | 36 | 39 | 85 | 64 | 20 | 32 | 37 | 71 |
| MELDR-11 | 110 | 98 | 74 | 90 | 130 | 76 | 82 | 91 | 50 | 55 | 58 | 77 | 110 | 66 |
| MELDR-12 | 75 | 120 | 73 | 78 | 110 | 120 | 94 | 110 | 810 | 150 | 180 | 130 | 95 | 91 |

NO sample taken | Moderate 60-119 | Very Hard 180-240

Soft 0-59 mg/L | Hard 120-179 | Extremely Hard > 240

# 8. Metals in water

Refer to **Tables D-15 to D-35 in Appendix D** for all metal concentration data collected in the Melville Bull Creek catchments for the 2016 water quality sampling program. **Table F-1, Appendix F** outlines the sources of these metals, water quality factors affecting their impacts and the impacts of these metals to aquatic biota.

Total metal concentrations for aluminium, chromium, copper, iron, lead and zinc were tested for at all sites during the first sampling event for surveillance purposes. The full suite of 14 total metals, plus total mercury, was tested on all four sampling occasions at sites 15 and 16 (except in October when there was insufficient water at site 16) and in July at ROSSTAFE. Total and soluble mercury was tested at sites 6, 13 and 14 on all four sampling occasions, and soluble mercury was tested at ROSSTAFE on all sampling occasions. Soluble metals concentrations for aluminium, iron, chromium, copper, lead and zinc were tested at 13 sites (all except sites 15 and 16) on all four sampling occasions.

For all graphs, a value equal to half the limit of reporting was substituted for those occasions where concentrations were recorded as ‘below the laboratory limit of reporting’ (<LOR) to allow these ‘unknown’ values to be represented graphically and to differentiate them from those samples that recorded concentrations equal to the limit of reporting.

Metal concentrations in the water of the Melville Bull Creek catchments were varied. All total arsenic, total and soluble chromium, total cadmium, total cobalt, total and soluble lead, total manganese, total and soluble mercury, total molybdenum, total nickel and total selenium samples were below the specific ANZECC trigger values at the sites where these metals were tested. Throughout the nine-year monitoring period the majority of samples have recorded of total and soluble aluminium and total and soluble iron concentrations above the trigger values. Total and soluble copper and zinc samples recorded concentrations above the specific trigger values on some occasions.

## 8.1 Aluminium

The ANZECC trigger value for aluminium in water is 0.055 mg/L for 95% level of protection being applicable when pH is greater than 6.5 (ANZECC and ARMCANZ 2000). When pH is less than 6.5, the ANZECC guidelines (ANZECC and ARMCANZ 2000) have specified a low reliability interim value for freshwater protection of 0.0008 mg/L.

**Total aluminium** was tested at all sites on only one occasion, the July sampling event, however sites 15 and 16 (John Creaney Park inlet and Downstream Elizabeth Manion Park) were tested on all four sampling events (except at site 16 in October when the water level was insufficient) as they are still considered new sites to the catchment. Concentrations were elevated across the catchment during July, with 13 out of 15 samples exceeding the ANZECC trigger value for 95% level of protection (or, for samples with pH <6.5, the low reliability interim value for freshwater protection) (**Figure 8.1-1** and **Table D-15, Appendix D**).

In July the highest concentration of 1 mg/L was recorded at site 7 (Booragoon lake Outlet) however as this site also recorded a pH below 6.5 the trigger value could not be applied. The lowest concentration of 0.03 mg/L was recorded at both sites 10 and 11 (Frederick Baldwin and Marmion Reserve), which incidentally were the only two sites that recorded acceptable total aluminium concentrations.

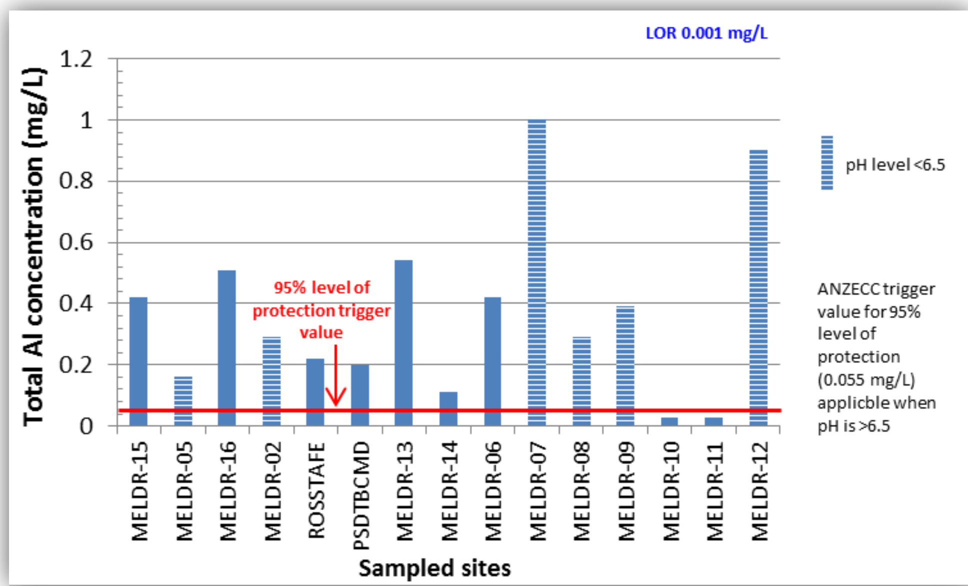


**Figure 8.1-1: Total aluminium concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in July 2016**

At sites 15 and 16 (John Creaney Park inlet and Downstream Elizabeth Manion Park) concentrations exceeded the trigger value for 95% level of protection (or, for the one sample with pH <6.5, the low reliability interim value for freshwater protection) on all sampling occasions (**Figure 8.1-2** and **Table D-15, Appendix D**). The highest (0.51 mg/L) and lowest (0.14 mg/L) concentrations were both recorded at site 16 in July and August respectively.

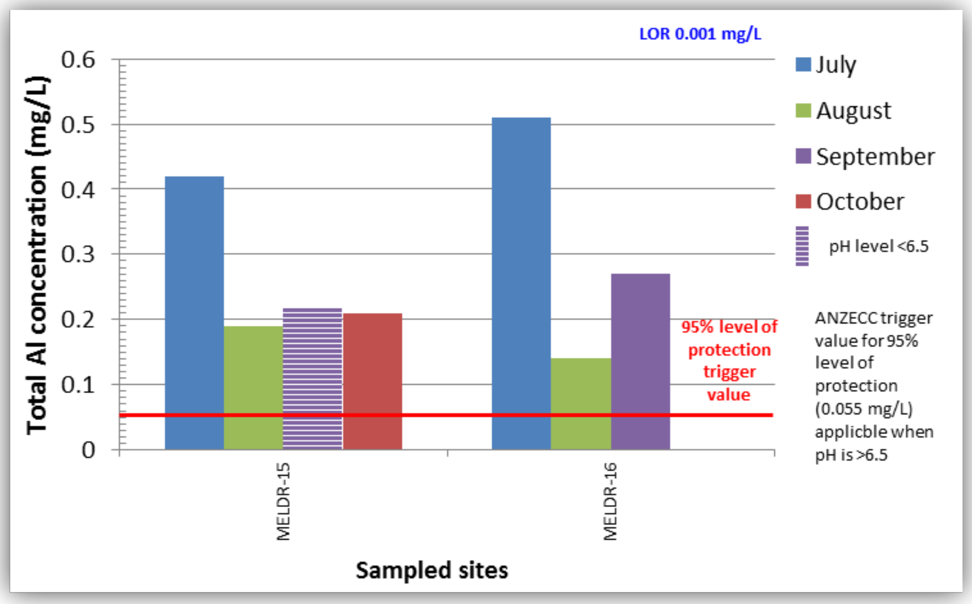


**Figure 8.1-2: Total aluminium concentrations (mg/L) in the surface water of sites 15 and 16 in 2016.**

When comparing results between sites 13 and 14 (Brentwood Drain and RAAF Drain) against site 6 (Bateman Park) in July, the total aluminium concentration was higher at site 13 than at site 14, and in between the two at site 6, indicating the lower concentrations at site 14 are diluting those from site 13.

The concentrations of **soluble aluminium** varied across the Melville Bull Creek catchments (**Figure 8.1-3** and **Table D-16, Appendix D**). 43 out of 52 samples recorded concentrations exceeding the trigger value for 95% level of protection (or, for samples with pH <6.5, the low reliability interim value for freshwater protection). Site 9 (Quenda Lake outlet) recorded the highest concentration of soluble aluminium (0.99 mg/L) during September. Sites 10 and 11 (Frederick Baldwin and Marmion Reserve respectively) were the only sites that recorded concentrations below the trigger value on all sampling occasions, with site 11 recording the lowest aluminium concentration in the catchment of 0.012 mg/L in July.

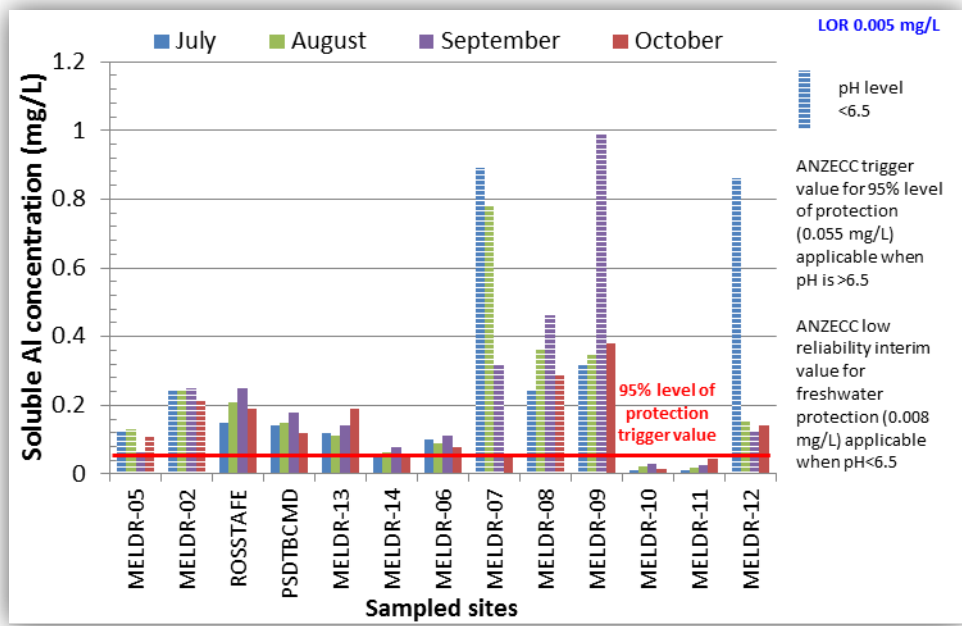


**Figure 8.1-3: Soluble aluminium concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016**

Patterns in soluble aluminium concentrations at sites 13, 14 and 6 (Brentwood Drain, RAAF Drain and Bateman park respectively) mirrored observations of total aluminium concentrations in July at these sites, with soluble aluminium concentrations were always higher at site 13 than 14, and concentrations at site 6 (Bateman Park) between those recorded at the two upstream sites.

Considering that soluble aluminium corresponds to the concentrations available for biological uptake and potential impact on the biota; it is important to highlight that at nine of the 13 sampled sites (sites 5, 2, ROSSTAFE, PSDTBCMD, 14, 7, 8, 9, 10 and 12) the majority of total aluminium was present as soluble aluminium (≥50%) during the July sampling event. As evidenced in **Figure 8.1-4**, the findings of Bache (1986) were corroborated by results obtained in July, when there appeared to be a trend towards a negative relationship between percentage soluble aluminium and pH.

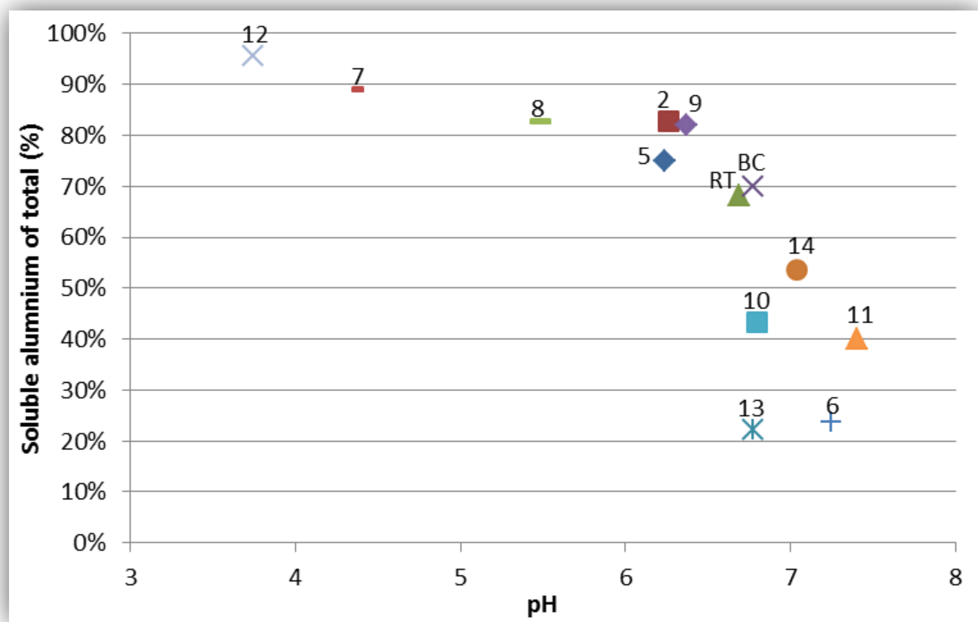


**Figure 8.1-4: Soluble aluminium concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016**

The cause (or causes) of the wide-spread elevated aluminium concentrations (total and soluble) is currently unknown. High aluminium concentrations are common in drainage catchments of the Swan and Canning Rivers (DoW 2009). Groundwater in the Jandakot mound, the source of the groundwater which would communicate with many of the surface water bodies within the Bull Creek and Melville Lake catchments, have been shown to be high in aluminium, with concentrations commonly above 0.2 mg/L (Larsen et al 1998), which is likely to influence aluminium in groundwater dependent surface waters. It is also possible aluminium concentrations in waters could be result of contamination from historical land uses.

**Table 8.1-1** shows the **total aluminium** concentrations in the surface water of the Melville Bull Creek catchments throughout the nine-year monitoring period. Concentrations exceeding the trigger value for 95% level of protection have been recorded on the majority of occasions at sites 5, 2, PSDTBCMD, 6, 7, 8, 9 and 12. Given the toxicity of aluminium to aquatic organisms; this widespread aluminium contamination in the catchment is very concerning and further investigation is warranted, particularly at sites PSDTBCMD and 6 as these two sites are at the bottom of their respective sub catchments and they discharge directly into the Canning River. Sites 10 and 11 have recorded concentrations below the trigger value on the majority of the occasions when samples have been collected.

**Table 8.1-2** shows the **soluble aluminium** concentrations in the surface water of the Melville Bull Creek catchments throughout the seven-year monitoring period. Concentrations exceeding the trigger value for 95% level of protection have generally been recorded at sites 5, PSDTBCMD, 6, 7 and 12. On the other hand, sites 10 and 11 have consistently recorded concentrations below the trigger value.

## Table 8.1-1: Records of total aluminium concentrations (mg/L) in the Melville Bull Creek catchments 2007 – 2016

Total Al (mg/L) | ANZECC trigger value: 0.055 mg/L | (Note: ANZECC trigger value applicable when pH>6.5) | Max 3.9 | Min 0.01 | LOR 0.005 mg/L

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| **MELDR-05** | 0.065 | 0.24 | | | 0.18 | 0.13 | 0.084 | | 0.22 | 0.095 | | | 0.19 | 0.14 | 0.12 | 0.14 | 0.14 | 0.31 | 0.38 | 0.21 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| **MELDR-02** | 0.31 | 0.39 | 0.32 | 0.31 | 0.32 | 0.9 | 0.3 | 0.3 | 0.34 | 0.31 | 0.36 | 2.1 | 0.3 | 0.31 | 0.37 | 0.35 | 0.36 | 0.36 | 0.34 | 0.39 |
| **PSDTBCMD** | 0.21 | 0.3 | 3.2 | 0.16 | 0.29 | 0.17 | 0.2 | 0.22 | 0.29 | 0.17 | 0.19 | 0.21 | 0.3 | 0.19 | 0.23 | 0.17 | 0.2 | 0.19 | 0.23 | 0.22 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| **MELDR-06** | 3.6 | 3.2 | 0.3 | 2.6 | 2.2 | 1.5 | 1.4 | 1.3 | 1.2 | 1.1 | 0.97 | 0.87 | 0.58 | 0.76 | 0.85 | 0.73 | 0.66 | 0.89 | 0.96 | 0.71 |
| **MELDR-07** | 3.9 | 0.058 | | | 0.05 | 0.066 | 0.16 | | 0.072 | 0.05 | | | 0.022 | 0.03 | 0.028 | 0.21 | | 0.17 | 0.029 | 0.037 |
| **MELDR-08** | 0.3 | 0.29 | | | 0.3 | 0.13 | | | 0.25 | | | | | | | | | | 0.37 | 0.24 |
| **MELDR-09** | 0.058 | 0.17 | | | 0.28 | 0.052 | 0.1 | 0.11 | 0.27 | 0.086 | 0.043 | | 0.054 | 0.05 | 0.052 | 0.037 | 0.72 | 0.2 | 0.19 | 0.18 |
| **MELDR-10** | 0.079 | 0.065 | | | 0.053 | 0.029 | 0.031 | 0.056 | 0.055 | 0.051 | 0.053 | | 0.048 | 0.06 | 0.097 | 0.072 | 0.084 | 0.035 | 0.041 | 0.044 |
| **MELDR-11** | 0.067 | 0.032 | | | 0.041 | 0.035 | 0.053 | 0.16 | 0.056 | 0.044 | 0.11 | 0.089 | 0.038 | 0.04 | 0.052 | 0.36 | 0.04 | 0.044 | 0.051 | 0.041 |
| **MELDR-12** | 0.22 | 0.062 | | | 0.058 | 0.039 | 0.036 | | 0.059 | 0.035 | 0.2 | | 0.052 | 0.06 | 0.062 | 0.16 | 1.8 | 0.61 | 0.074 | 0.11 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | 0.047 | 0.31 | 0.21 | 0.53 | 0.48 | 0.23 | 0.6 | 0.42 | 0.19 | 0.22 | 0.21 |
| **MELDR-05** | 0.16 | 0.16 | 0.15 | 0.1 | 0.23 | 0.23 | 0.18 | 0.16 | 0.21 | 0.2 | 0.22 | 0.14 | 0.22 | | | | 0.16 | | | |
| MELDR-16 | | | | | | | | | | 0.11 | 0.75 | 0.34 | 0.94 | 0.33 | 0.14 | 0.49 | 0.51 | 0.14 | 0.27 | |
| **MELDR-02** | 0.37 | 0.31 | 0.28 | 0.3 | 0.31 | 0.36 | 0.26 | 0.3 | 0.15 | 0.29 | 0.34 | 0.27 | 0.3 | | | | 0.29 | | | |
| **PSDTBCMD** | 0.22 | 0.22 | 0.24 | 0.21 | 0.33 | 0.25 | 0.24 | 0.24 | 0.26 | 0.26 | 0.24 | 0.21 | 0.22 | | | | 0.2 | | | |
| MELDR-13 | | | | | | | 1.1 | 0.76 | 0.43 | 0.83 | 0.79 | 0.48 | 0.48 | | | | 0.54 | | | |
| MELDR-14 | | | | | | | 0.13 | 0.22 | 0.13 | 0.18 | 0.13 | 0.08 | 0.12 | | | | 0.11 | | | |
| **MELDR-06** | 0.77 | 0.64 | 0.6 | 0.54 | 0.94 | 0.77 | 0.9 | 0.69 | 0.49 | 0.77 | 0.62 | 0.42 | 0.71 | | | | 0.42 | | | |
| **MELDR-07** | | | 0.55 | 0.24 | | 0.37 | 0.033 | 0.039 | 0.14 | 0.064 | 0.041 | 0.07 | 0.67 | | | | 1 | | | |
| **MELDR-08** | | 0.2 | 0.2 | 0.14 | 0.35 | 0.35 | 0.29 | 0.25 | 0.37 | 0.37 | 0.57 | 0.3 | 0.37 | | | | 0.29 | | | |
| **MELDR-09** | 0.05 | 0.049 | 0.11 | 0.041 | 0.083 | 0.37 | 0.46 | 0.4 | 0.87 | 0.51 | 0.6 | 0.35 | 0.38 | | | | 0.39 | | | |
| **MELDR-10** | 0.039 | 0.17 | 0.079 | 0.053 | 0.049 | 0.032 | 0.035 | 0.032 | 0.045 | 0.036 | 0.03 | 0.018 | 0.03 | | | | 0.03 | | | |
| **MELDR-11** | 0.018 | 0.043 | 0.04 | 0.049 | 0.034 | 0.034 | 0.022 | 0.12 | 0.01 | 0.019 | 0.028 | 0.026 | 0.03 | | | | 0.03 | | | |
| **MELDR-12** | 0.32 | 0.18 | 0.052 | 0.038 | 0.12 | 0.072 | 0.097 | 0.083 | 0.054 | 0.12 | 0.16 | 0.15 | 0.12 | | | | 0.9 | | | |

SITES RECORDING AI CONC. ALWAYS/GENERALLY ABOVE TRIGGER VALUE

SITES RECORDING AI CONC. ALWAYS/GENERALLY BELOW TRIGGER VALUE

Concentration ABOVE trigger value & pH > 6.5

Concentration ABOVE trigger value & pH <6.5

Concentration BELOW trigger value & pH < 6.5 (i.e. potential risk)

Concentration BELOW trigger value and pH > 6.5

NO pH reading

NO sample taken

## Table 8.1-2: Records of soluble aluminium concentrations (mg/L) in the Melville Bull Creek catchments 2009 – 2016

Soluble Al (mg/L) | ANZECC trigger value: 0.055 mg/L | (Note: ANZECC trigger value applicable when pH>6.5) | Max 1.8 | Min <0.005 | LOR 0.005 mg/L

| Site | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MELDR-05** | | | | | | | | | 0.037 | 0.14 | 0.16 | 0.12 | 0.11 | 0.057 | 0.13 | |
| MELDR-02 | | | | | | | | | | | | | | | | |
| **PSDTBCMD** | 0.16 | 0.87 | 0.085 | 0.071 | 0.098 | 0.13 | 0.12 | 0.11 | 0.15 | 0.16 | 0.15 | 0.15 | 0.13 | 0.14 | 0.13 | 0.12 |
| MELDR-13 | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | |
| **MELDR-06** | 0.091 | 0.083 | 0.22 | 0.16 | 0.098 | 0.2 | 0.19 | 0.15 | 0.13 | 0.16 | 0.17 | 0.093 | 0.071 | 0.084 | 0.096 | 0.12 |
| **MELDR-07** | | | | | | | | | | 0.15 | 0.016 | 0.023 | | | 0.56 | 0.23 |
| MELDR-08 | | | | | | | | | | | | | | | | |
| MELDR-09 | | | | | | | | | | | | | | | | |
| **MELDR-10** | | | | | | | | | 0.033 | 0.018 | 0.026 | 0.026 | 0.021 | 0.042 | 0.057 | 0.022 |
| **MELDR-11** | | | | | | | | | 0.013 | 0.018 | 0.012 | 0.022 | <0.005 | 0.0067 | 0.014 | 0.016 |
| **MELDR-12** | | | | | | | | | 1.8 | 0.62 | 0.044 | 0.077 | 0.31 | 0.16 | 0.023 | 0.019 |

| Site | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MELDR-05** | 0.073 | 0.15 | 0.18 | 0.09 | 0.15 | 0.14 | 0.2 | 0.096 | 0.18 | 0.13 | 0.073 | 0.067 | 0.12 | 0.13 | 0.06 | 0.11 |
| MELDR-02 | | | | | | | | | 0.3 | 0.23 | 0.25 | 0.22 | 0.24 | 0.24 | 0.25 | 0.21 |
| **PSDTBCMD** | 0.09 | 0.16 | 0.15 | 0.12 | 0.13 | 0.14 | 0.17 | 0.12 | 0.15 | 0.12 | 0.11 | 0.087 | 0.14 | 0.15 | 0.18 | 0.12 |
| MELDR-13 | | | 0.12 | 0.093 | 0.057 | 0.1 | 0.12 | 0.097 | 0.14 | 0.11 | 0.31 | 0.081 | 0.12 | 0.11 | 0.14 | 0.19 |
| MELDR-14 | | | 0.094 | 0.079 | 0.095 | 0.09 | 0.099 | 0.054 | 0.082 | 0.061 | 0.068 | 0.039 | 0.059 | 0.065 | 0.078 | 0.059 |
| **MELDR-06** | 0.09 | 0.086 | 0.084 | 0.087 | 0.056 | 0.097 | 0.11 | 0.088 | 0.15 | 0.095 | 0.26 | 0.066 | 0.1 | 0.089 | 0.11 | 0.077 |
| **MELDR-07** | | 0.37 | 0.022 | 0.039 | 0.14 | 0.056 | 0.032 | 0.082 | 0.61 | 0.4 | 0.067 | 0.011 | 0.89 | 0.78 | 0.32 | 0.047 |
| MELDR-08 | | | | | | | | | 0.36 | 0.24 | 0.16 | 0.16 | 0.24 | 0.36 | 0.46 | 0.29 |
| MELDR-09 | | | | | | | | | 0.38 | 0.28 | 0.11 | 0.12 | 0.32 | 0.35 | 0.99 | 0.38 |
| **MELDR-10** | 0.014 | 0.012 | 0.017 | 0.014 | 0.045 | 0.022 | 0.022 | 0.011 | 0.019 | 0.019 | 0.054 | 0.029 | 0.013 | 0.021 | 0.029 | 0.016 |
| **MELDR-11** | 0.005 | 0.006 | 0.009 | 0.044 | 0.01 | 0.01 | 0.011 | 0.02 | 0.011 | 0.013 | 0.05 | 0.062 | 0.012 | 0.018 | 0.026 | 0.043 |
| **MELDR-12** | 0.1 | 0.041 | 0.082 | 0.057 | 0.054 | 0.11 | 0.11 | 0.089 | 0.072 | 0.065 | 0.006 | 0.05 | 0.86 | 0.15 | 0.12 | 0.14 |

SITES RECORDING AI CONC. ALWAYS/GENERALLY ABOVE TRIGGER VALUE

SITES RECORDING AI CONC. ALWAYS/GENERALLY BELOW TRIGGER VALUE

Concentration ABOVE trigger value & pH > 6.5

Concentration ABOVE trigger value & pH <6.5

Concentration BELOW trigger value & pH < 6.5 (i.e. potential risk)

Concentration BELOW trigger value and pH > 6.5

NO pH reading

NO sample taken

## 8.2 Arsenic

The trigger value for 95% level of protection of the biota is 0.024 mg/L (ANZECC and ARMCANZ 2000) and the recreational use guideline value for arsenic in water (for health value) is 0.1 mg/L (NHMRC 2008).

This year **total arsenic** was only analysed at sites 15 and 16 (John Creaney inlet and Downstream Elizabeth Manion Park) at all sampling occasions (except at site 16 in October when the water level was insufficient) and at ROSSTAFE in July. Concentrations recorded at these sites were below the LOR (0.001 mg/L) and subsequently below the ANZECC trigger value for 95% level of protection and recreational use on all sampling occasions (**Figure 8.2-1** and **Table D-17, Appendix D**).

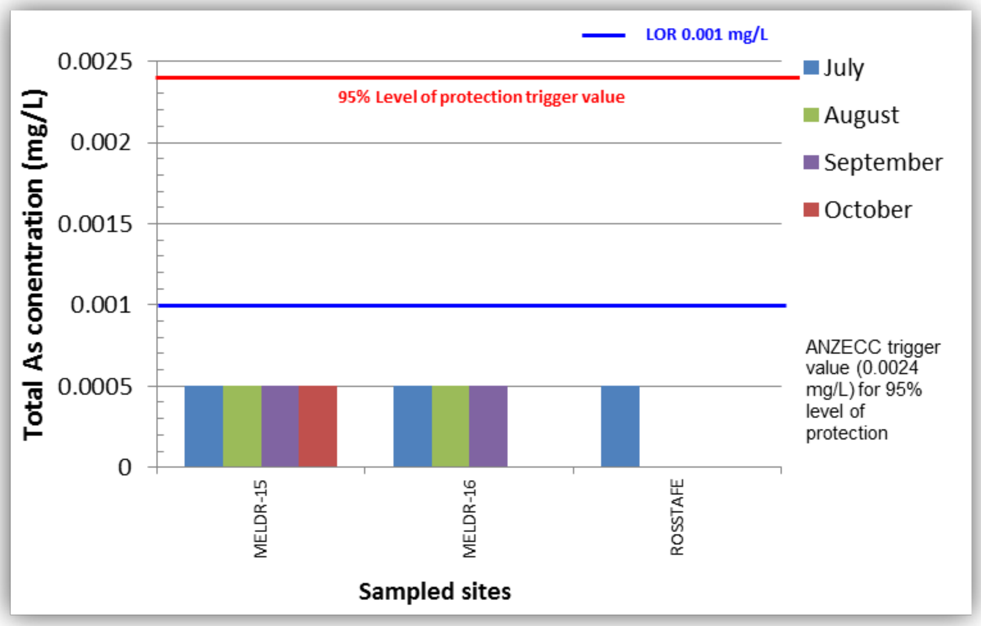


**Figure 8.2-1: Total arsenic concentrations (mg/L) in the surface water of sites 15, 16 and ROSSTAFE in 2016**

## 8.3 Cadmium

The NHMRC (2008) recreational use guideline value for cadmium in water (for health value) is 0.02 mg/L and the unmodified trigger value for 95% level of protection is 0.0002 mg/L (ANZECC and ARMCANZ 2000). As the trigger values are affected by water hardness, the trigger values vary depending on the water hardness recorded at each site. For the details and calculations see **Table D-18, Appendix D**.

**Total cadmium** was only analysed at sites 15 and 16 (John Creaney inlet and Downstream Elizabeth Manion Park) at all sampling occasions (except at site 16 in October when the water level was insufficient) and at ROSSTAFE (Brockman Park inlet) in July (**Figure 8.3-1** and **Table D-18, Appendix D)**. Concentrations were all below the limit of reporting (0.0001 mg/L) and subsequently below the hardness modified ANZECC trigger value for 95% level of protection and NHMRC recreational use.

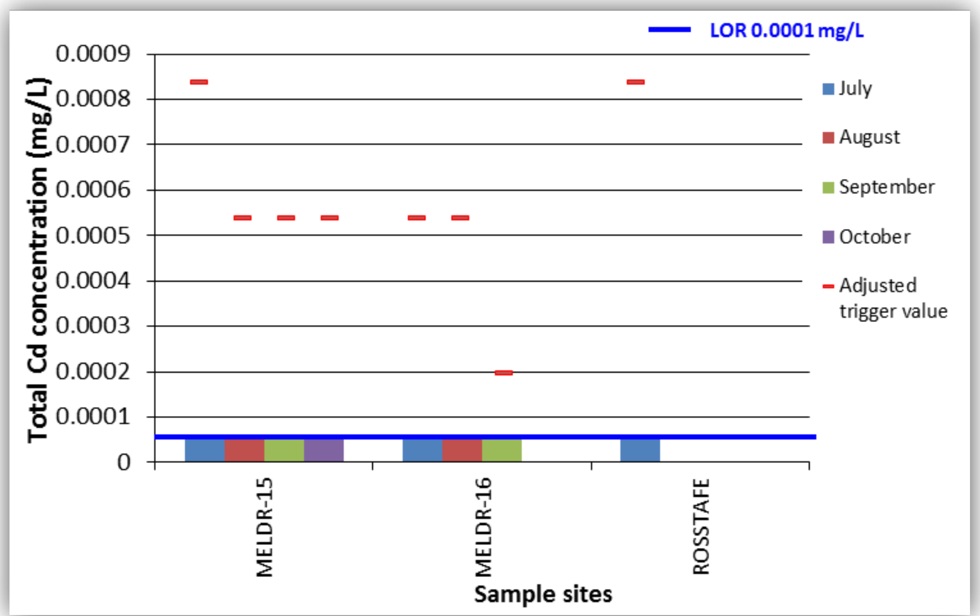


**Figure 8.3-1: Total cadmium concentrations (mg/L) in the surface water of sites 15, 16 and ROSSTAFE in 2016**

## 8.4 Chromium

The ANZECC interim unmodified trigger value for chromium (III) in water for freshwater protection is 0.0033 mg/L (ANZECC and ARMCANZ 2000).[1] The trigger value for Cr III has been selected (and not Cr VI) as in natural water Cr III is the predominant species present due to a range of factors. The trigger value for chromium is affected by water hardness. Therefore, the modified trigger values shown on the graph vary, dependant on the water hardness concentration recorded at each site. For the details and calculations see **Table D-19** and **Table D-21, Appendix D**. The NHMRC (2008) recreational use guideline (for health value) for Cr VI of 0.5 mg/L has been conservatively used.

**Total chromium** was tested at all sites on only one occasion, the July sampling event, however sites 15 and 16 (John Creaney Park inlet and Downstream Elizabeth Manion Park) were tested on all four sampling events (except at site 16 in October when the water level was insufficient) as they are still considered new sites to the catchment. All samples recorded concentrations below the hardness modified trigger values and recreational use (**Figure 8.4-1** and **Table D-19, Appendix D**). The highest concentration of 0.002 mg/L was recorded at sites 15, 13, 6, 7 (John Creaney Park inlet, Brentwood drain, Bateman Park and Booragoon Lake outlet) in July and at site 15 in October. Eight samples recorded concentrations below the LOR (0.001 mg/L).

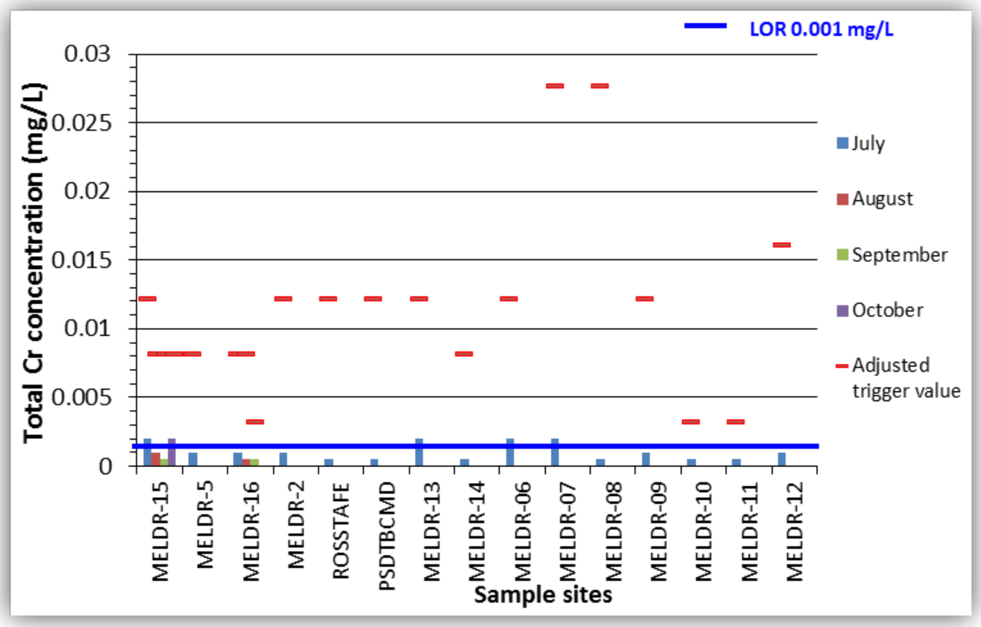


**Figure 8.4-1: Total chromium concentrations (mg/L) in the surface waters of the Melville Bull Creek catchments in 2016**

**Soluble chromium** was analysed at 13 sites (all except sites 15 and 16) on four sampling occasions. All sites recorded acceptable concentrations and 36 out of 52 samples recorded concentrations below the limit of reporting of 0.001 mg/L (**Figure 8.4-2** and **Table D-21, Appendix D**). The highest concentration of 0.003 mg/L was recorded at site 12 (Blue Gum Lake outlet) in October.

[1] The value provided is the low reliability trigger value, derived by applying an AF (assessment factor) of 20 to the lowest chromic toxicity figure (for *Oncorhynchus mykiss*, from a limited set of chronic data) (ANZECC and ARMCANZ 2000). This applies to low hardness water at 30 mg/L as CaCO3. This figure should only be used as an indicative interim working level.

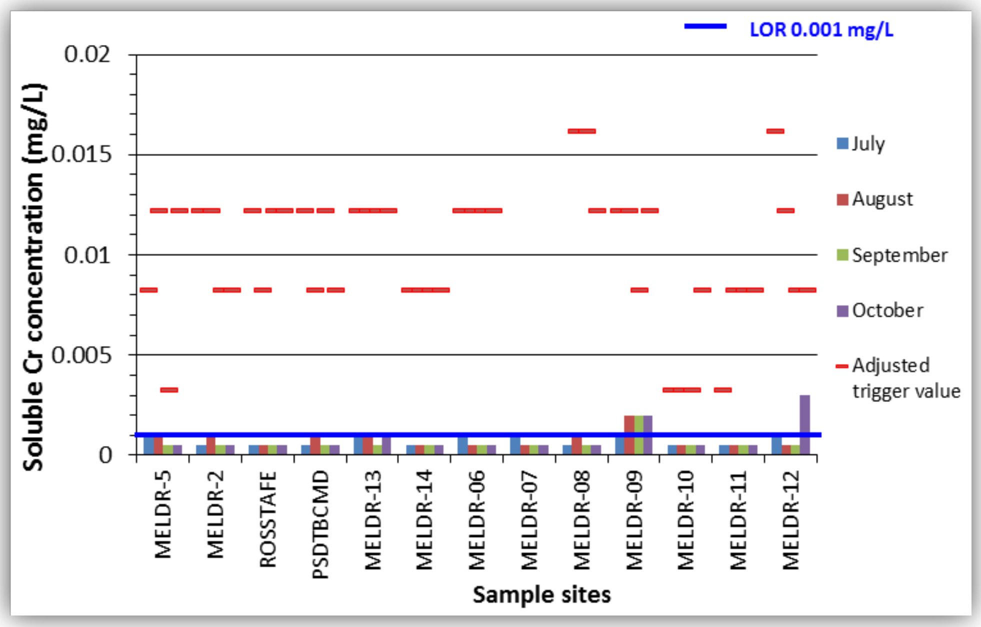


**Figure 8.4-2: Soluble chromium concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016.**

**Table 8.4-1** shows the recorded **total chromium** concentrations throughout the nine-year sampling period. Total Cr samples have always been below the trigger value for Cr III at all sites with the exception of sites PSDTBCMD, 6 and 12 (Bull Creek main drain, Bateman Park and Blue Gum Lake outlet) in 2007 and site 6 in 2008.

**Table 8.4-2** shows the recorded **soluble chromium** concentrations throughout the seven-year monitoring period. Soluble Cr samples have always recorded concentrations below the trigger value for Cr III. All sites except for 11 have recorded at least one concentration greater than the limit of reporting (0.001 mg/L).

## Table 8.4-1: Records of total Cr concentrations (mg/L) in the Melville Bull Creek catchments 2007 – 2016

**Total Chromium (Cr)** (mg/L) LOR 0.001 mg/L

Unmodified trigger value Cr III for 95% Level of Protection 0.0033 mg/L Max 0.006 Min <0.001

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | <0.001 | 0.002 | | | 0.002 | 0.002 | 0.0018 | | 0.002 | 0.001 | | | <0.001 | 0.002 | 0.002 | <0.001 | <0.001 | 0.001 | 0.0022 | 0.001 | <0.001 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | <0.001 | 0.001 | <0.001 | <0.001 | 0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 | <0.001 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | 0.0014 | 0.001 | <0.001 |
| PSDTBCMD | <0.001 | 0.001 | 0.004 | <0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.001 | <0.001 | <0.001 | <0.001 | 0.0014 | 0.001 | <0.001 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | 0.006 | 0.005 | <0.001 | 0.003 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 | <0.001 | 0.002 | 0.003 | 0.001 | <0.001 | 0.002 | 0.0028 | 0.002 | 0.0015 |
| MELDR-07 | 0.001 | 0.001 | | | <0.001 | 0.001 | 0.002 | | <0.001 | <0.001 | | | <0.001 | <0.001 | <0.001 | 0.002 | | <0.001 | <0.001 | <0.001 | |
| MELDR-08 | <0.001 | 0.002 | | | 0.002 | 0.001 | | | <0.001 | | | | | | | | | | <0.001 | <0.001 | |
| MELDR-09 | <0.001 | <0.001 | | | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 |
| MELDR-10 | <0.001 | <0.001 | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-11 | <0.001 | 0.002 | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-12 | 0.001 | 0.003 | | | 0.002 | 0.002 | 0.001 | | 0.002 | <0.001 | 0.001 | | 0.002 | 0.002 | 0.002 | <0.001 | <0.001 | <0.001 | 0.0019 | 0.004 | <0.001 |

| Site | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | <0.001 | Jan-00 | Jan-00 | 0.003 | 0.002 | 0.002 | 0.003 | 0.002 | 0.001 | <0.001 | 0.002 |
| MELDR-05 | <0.001 | 0.0014 | 0.0014 | 0.002 | 0.001 | 0.001 | 0.001 | <0.001 | 0.002 | 0.001 | 0.002 | 0.002 | | | | 0.001 | | | |
| MELDR-16 | | | | | | | | | <0.001 | 0.001 | 0.001 | 0.003 | 0.001 | <0.001 | 0.002 | 0.001 | <0.001 | <0.001 | |
| MELDR-02 | 0.0016 | 0.0011 | 0.0012 | <0.001 | 0.001 | 0.001 | 0.001 | <0.001 | 0.002 | 0.001 | 0.002 | 0.002 | | | | 0.001 | | | |
| PSDTBCMD | 0.0013 | 0.0013 | 0.0013 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | <0.001 | 0.001 | 0.001 | 0.002 | | | | <0.001 | | | |
| MELDR-13 | | | | | | 0.004 | 0.002 | 0.003 | 0.003 | 0.003 | 0.002 | 0.002 | | | | 0.002 | | | |
| MELDR-14 | | | | | | 0.001 | 0.002 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001 | | | | <0.001 | | | |
| MELDR-06 | 0.0027 | 0.002 | 0.002 | 0.003 | 0.002 | 0.003 | 0.002 | 0.003 | 0.003 | 0.002 | 0.002 | 0.003 | | | | 0.002 | | | |
| MELDR-07 | | <0.001 | <0.001 | | <0.001 | 0.001 | 0.002 | <0.001 | <0.001 | 0.001 | 0.002 | 0.002 | | | | 0.002 | | | |
| MELDR-08 | 0.0011 | <0.001 | <0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 | 0.002 | | | | <0.001 | | | |
| MELDR-09 | 0.0011 | <0.001 | <0.001 | <0.001 | 0.001 | 0.002 | 0.002 | 0.003 | 0.004 | 0.003 | 0.003 | 0.003 | | | | 0.001 | | | |
| MELDR-10 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | | | | <0.001 | | | |
| MELDR-11 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | | | | <0.001 | | | |
| MELDR-12 | 0.0011 | <0.001 | <0.001 | <0.001 | 0.004 | 0.006 | 0.005 | 0.003 | 0.004 | 0.004 | 0.004 | 0.003 | | | | 0.001 | | | |

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ADJUSTED TRIGGER VALUE

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value

Concentration BELOW ADJUSTED trigger value

Highest concentration of the year

Concentration < LOR

NO sample taken

## Table 8.4-2: Records of soluble Cr concentrations (mg/L) in the Melville Bull Creek catchments 2009 – 2016

**Soluble Chromium (Cr)** (mg/L) LOR 0.001 mg/L

Unmodified trigger value Cr III for 95% Level of Protection 0.0033 mg/L Max 0.007 Min <0.001

| Site | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-05 | | | | | | | | | <0.001 | <0.001 | 0.0014 | 0.001 | <0.001 | <0.001 | 0.0012 | 0.0011 | <0.001 | 0.001 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | <0.001 | <0.001 |
| MELDR-02 | | | | | | | | | | | | | | | | | | | | | | | | | 0.001 | 0.001 | <0.001 | 0.007 | <0.001 | 0.001 | <0.001 | <0.001 |
| PSDTBCMD | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.003 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | 0.0013 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | 0.001 | 0.001 | <0.001 | <0.001 | 0.001 | 0.0015 | 0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | 0.001 | 0.001 | 0.001 | <0.001 | <0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001 | <0.001 | 0.001 |
| MELDR-14 | | | | | | | | | | | | | | | | | | | 0.001 | 0.001 | 0.001 | 0.002 | <0.001 | 0.001 | <0.001 | <0.001 | 0.001 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-06 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | 0.001 | 0.001 | 0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | 0.0011 | <0.001 | <0.001 | 0.001 | 0.001 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-07 | | | | | | | | | | <0.001 | <0.001 | <0.001 | | | <0.001 | <0.001 | | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.002 | <0.001 | 0.002 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-08 | | | | | | | | | | | | | | | | | | | | | | | | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 |
| MELDR-09 | | | | | | | | | | | | | | | | | | | | | | | | | 0.002 | 0.002 | 0.001 | 0.004 | 0.001 | 0.002 | 0.002 | 0.002 |
| MELDR-10 | | | | | | | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.003 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-11 | | | | | | | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-12 | | | | | | | | | <0.001 | <0.001 | <0.001 | 0.003 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.003 | 0.004 | 0.004 | 0.003 | 0.004 | 0.003 | 0.003 | 0.002 | 0.003 | <0.001 | 0.002 | 0.001 | <0.001 | <0.001 | 0.003 |

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ADJUSTED TRIGGER VALUE

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value

Concentration BELOW ADJUSTED trigger value

Highest concentration of the year

Concentration < LOR

NO sample taken

## 8.5 Cobalt

The ANZECC low reliability trigger value for cobalt in water for freshwater protection of 0.0028 mg/L (ANZECC & ARMCANZ 2000) should not be exceeded.[2]

**Total cobalt** was only analysed at sites 15 and 16 (John Creaney inlet and Downstream Elizabeth Manion Park) at all sampling occasions (except at site 16 in October when the water level was insufficient) and at ROSSTAFE (Brockman Park inlet) in July. Concentrations were all below the limit of reporting (0.001 mg/L) and subsequently below the ANZECC trigger value for freshwater protection (**Figure 8.5-1** and **Table D-20, Appendix D**).

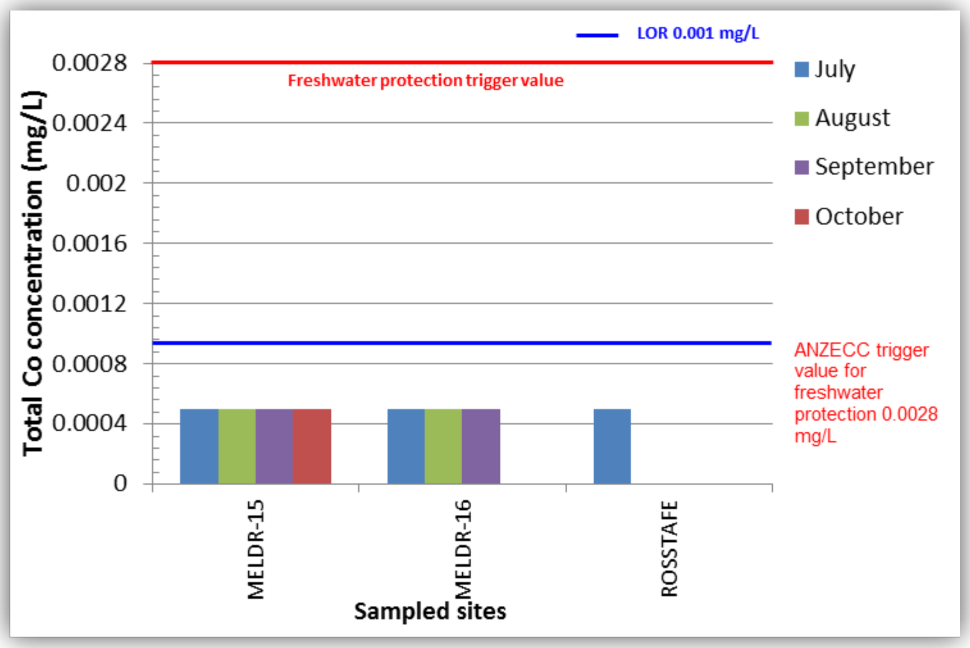


**Figure 8.5-1: Total cobalt concentrations (mg/L) in the surface water of sites 15, 16 and ROSSTAFE in 2016.**

[2] The value provided is the low reliability trigger value, derived by dividing the lowest chronic toxicity figure (2.8 µg/L for *Daphnia magna*) by an AF (assessment factor) of 2 (ANZECC and ARMCANZ 2000). Although a freshwater moderate reliability trigger value could be derived for cobalt (90 µg/L with 95% protection), both the 95% and 99% (30 µg/L) figures were well above some experimental chronic figures, particularly for D. magna (between NOEC of 2.8 µg/L and LC50 of 27 µg/L).

## 8.6 Copper

The ANZECC (2000) unmodified trigger value for copper in water for 95% level of protection is 0.0014 mg/L and the NHMRC (2008) value for recreational use guideline (for aesthetic value) is 10 mg/L. The 95% protection trigger value for copper is affected by water hardness. Therefore, the modified trigger values shown on the graph vary, dependant on the water hardness concentration recorded at each site. For the details and calculations see **Table D-22** and **Table D-23, Appendix D**.

**Total copper** was tested at all 15 sites on only one occasion, the August sampling event; however sites 15 and 16 (John Creaney Park inlet and Downstream Elizabeth Manion Park) were tested on all four sampling events (except at site 16 in October when the water level was insufficient) as they are still considered new sites to the catchment. Concentrations in July were varied; three samples recorded concentrations above the hardness modified trigger value at sites 16, 7 and 10 (Downstream Elizabeth Manion Park, Booragoon Lake outlet and Frederick Baldwin respectively) (**Figure 8.6-1** and **Table D-22, Appendix D**). The highest total copper concentration of 0.013 mg/L was recorded at site 7 (Booragoon Lake outlet). Site 16 also recorded a total copper concentration exceeding the hardness modified trigger value in September (**Figure 8.6-2**). No samples recorded concentrations exceeding the recreational trigger value. Three sites in July (2, 13 and 6), as well as site 15 in October, recorded concentrations below the limit of reporting (0.001 mg/L).

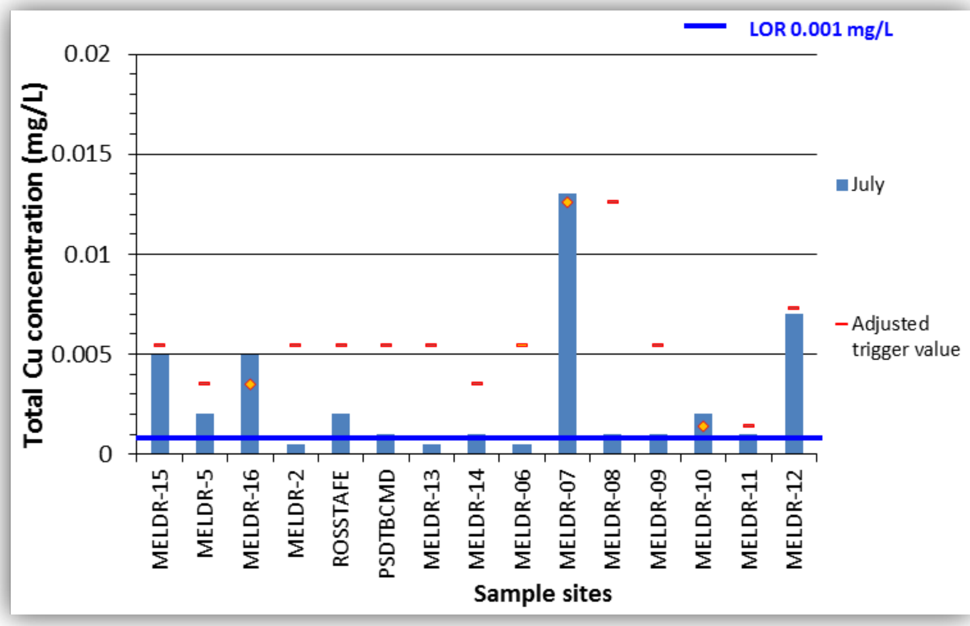


**Figure 8.6-1: Total copper concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in July 2016**

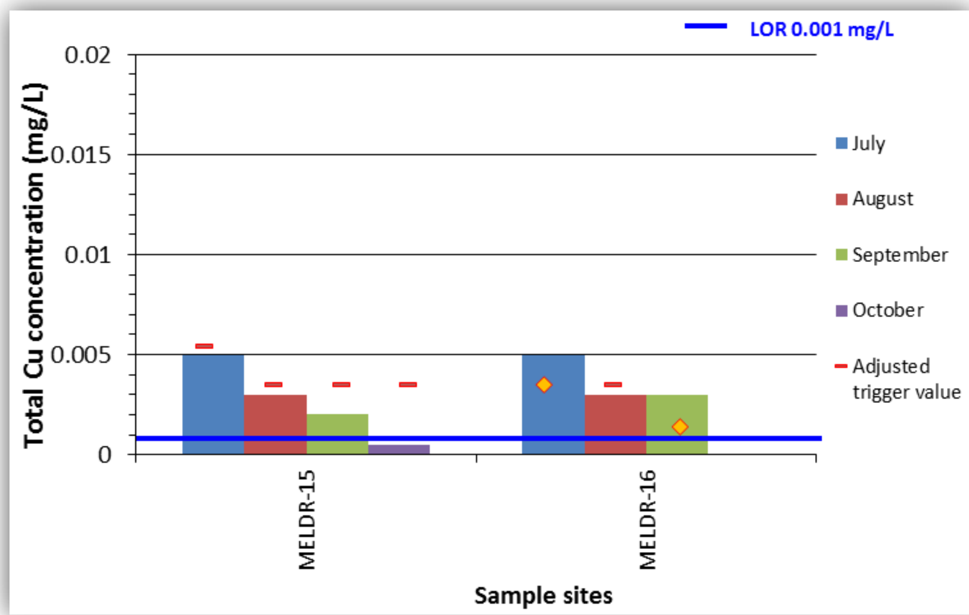


**Figure 8.6-2: Total copper concentrations (mg/L) in the surface water of sites 15 and 16 in 2016.**

The relatively high (although at site 15 not exceeding the adjusted trigger value) total Cu concentrations on the Bull Creek main drainage line at sites 16 and 15 in July (John Creaney Park inlet and downstream Elizabeth Manion Park) do not appear to be having an impact at downstream sites 2, ROSSTAFE and PSDTBCMD, where concentrations were low.

**Soluble copper** concentrations were predominantly low, with 31 of 52 samples recording concentrations equal to the limit of reporting of 0.001 mg/L (**Figure 8.6-3** and **Table D-23, Appendix D**). Only four samples at sites 7 (in July), 10 (in August and September) and 5 (in September) (Booragoon Lake outlet, Frederick Baldwin and John Creaney Park) recorded concentrations exceeding the hardness modified trigger value. Site 7 recorded the highest concentrations of 0.013 mg/L in July (exceeding the trigger value) and 0.009 mg/L in August (acceptable). Site 7 also recorded the two highest concentrations in 2015.

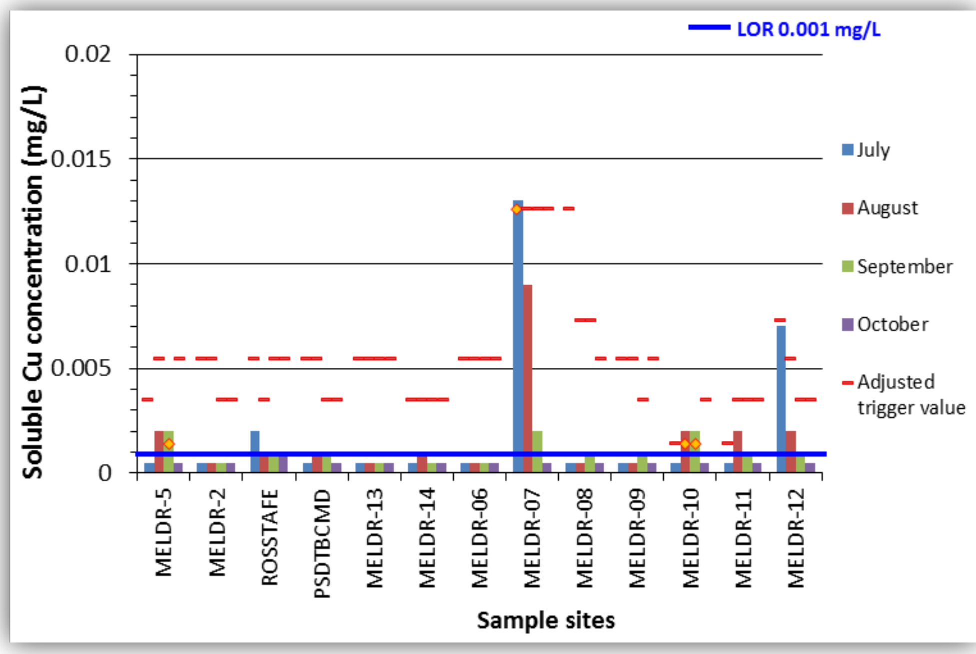


**Figure 8.6-3: Soluble copper concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016**

**Table 8.6-1** shows the recorded **total copper** concentrations throughout the ten-year sampling period. Sites 15, 5, 16, PSDTBCMD, 13, 6, 7, 8, 10 and 12 have occasionally recorded concentrations exceeding the modified trigger value. Site 10 has recorded the greatest number of exceedances (eleven) of any site, which is a consequence of the relatively soft water found at the site rather than particularly high copper concentrations compared to other sites.

**Table 8.6-2** shows the recorded **soluble copper** concentrations throughout the eight-year sampling period. Sites 5, 13, 7, 10, and 12 have recorded concentrations exceeding the modified trigger value on at least one sampling occasion. Site 10 has recorded the greatest number of exceedances (nine) of any site, which is a consequence of the relatively soft water found at the site rather than particularly high copper concentrations compared to other sites.

## Table 8.6-1: Records of total Cu concentrations (mg/L) in the Melville Bull Creek catchments 2007 - 2016

**Total Copper (Cu)** (mg/L) LOR 0.001 mg/L

Unmodified ANZECC trigger value for 95% Level of Protection 0.0014 mg/L Max 0.025 Min <0.001

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | 0.003 | <0.001 | | | <0.001 | 0.001 | 0.002 | | 0.003 | <0.001 | | | 0.008 | 0.002 | 0.002 | 0.002 | 0.004 | 0.002 | 0.0015 | 0.002 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.003 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| PSDTBCMD | <0.001 | 0.002 | <0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.002 | 0.002 | 0.001 | <0.001 | <0.001 | 0.004 | 0.001 | 0.001 | 0.001 | 0.0015 | 0.001 | 0.0011 | 0.001 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | <0.001 | <0.001 | <0.001 | 0.003 | <0.001 | <0.001 | <0.001 | 0.0011 | <0.001 | <0.001 | <0.001 |
| MELDR-07 | 0.006 | 0.001 | | | 0.002 | 0.002 | <0.001 | | <0.001 | <0.001 | | | <0.001 | <0.001 | <0.001 | 0.003 | | <0.001 | 0.0027 | 0.001 |
| MELDR-08 | 0.003 | 0.001 | | | 0.001 | <0.001 | | | <0.001 | | | | | | | | | | 0.0018 | 0.002 |
| MELDR-09 | <0.001 | <0.001 | | | <0.001 | <0.001 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | | <0.001 | <0.001 | <0.001 | <0.001 | 0.0011 | <0.001 | 0.0011 | <0.001 |
| MELDR-10 | 0.001 | 0.001 | | | 0.001 | 0.001 | <0.001 | 0.004 | 0.001 | <0.001 | <0.001 | | 0.002 | 0.001 | <0.001 | 0.001 | 0.003 | 0.002 | 0.001 | 0.002 |
| MELDR-11 | <0.001 | <0.001 | | | <0.001 | <0.001 | <0.001 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | 0.003 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-12 | 0.002 | <0.001 | | | <0.001 | <0.001 | <0.001 | | <0.001 | <0.001 | <0.001 | | 0.001 | <0.001 | <0.001 | <0.001 | 0.01 | 0.004 | <0.001 | 0.002 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | <0.001 | <0.001 | 0.002 | 0.007 | 0.005 | 0.001 | 0.003 | 0.005 | 0.003 | 0.002 | <0.001 |
| MELDR-05 | 0.0031 | 0.0035 | <0.001 | 0.0028 | 0.004 | 0.002 | <0.001 | 0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.003 | | | | 0.002 | | | |
| MELDR-16 | | | | | | | | | | <0.001 | 0.001 | 0.003 | 0.007 | 0.003 | 0.004 | 0.013 | 0.005 | 0.003 | 0.003 | |
| MELDR-02 | <0.001 | 0.0018 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | 0.002 | 0.001 | <0.001 | <0.001 | <0.001 | | | | <0.001 | | | |
| PSDTBCMD | <0.001 | 0.0021 | 0.001 | 0.001 | 0.003 | 0.002 | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 | 0.001 | 0.001 | | | | 0.001 | | | |
| MELDR-13 | | | | | | | 0.001 | <0.001 | 0.005 | <0.001 | <0.001 | <0.001 | 0.001 | | | | <0.001 | | | |
| MELDR-14 | | | | | | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | <0.001 | <0.001 | | | | 0.001 | | | |
| MELDR-06 | <0.001 | 0.0025 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | 0.005 | <0.001 | <0.001 | <0.001 | 0.001 | | | | <0.001 | | | |
| MELDR-07 | | | 0.0034 | 0.0014 | | 0.003 | <0.001 | 0.001 | <0.001 | 0.0015 | 0.002 | 0.002 | 0.025 | | | | 0.013 | | | |
| MELDR-08 | | 0.0015 | <0.001 | <0.001 | 0.001 | <0.001 | 0.002 | <0.001 | <0.001 | 0.002 | 0.002 | 0.001 | 0.002 | | | | 0.001 | | | |
| MELDR-09 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 | <0.001 | 0.001 | | | | 0.001 | | | |
| MELDR-10 | 0.0017 | 0.0045 | 0.0029 | 0.0024 | 0.001 | 0.002 | <0.001 | 0.001 | 0.002 | 0.001 | 0.001 | <0.001 | 0.002 | | | | 0.002 | | | |
| MELDR-11 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | | | | 0.001 | | | |
| MELDR-12 | 0.004 | 0.0032 | 0.0015 | 0.001 | <0.001 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | <0.001 | | | | 0.007 | | | |

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ADJUSTED TRIGGER VALUE

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value

Concentration BELOW ADJUSTED trigger value

Highest concentration of the year

Concentration < LOR

NO sample taken

## Table 8.6-2: Records of soluble Cu concentrations (mg/L) in the Melville Bull Creek catchments 2009 - 2016

**Soluble Copper (Cu)** (mg/L) LOR 0.001 mg/L

Unmodified ANZECC trigger value for 95% Level of Protection 0.0014 mg/L Max 0.021 Min <0.001

| Site | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-05 | | | | | | | | | 0.003 | 0.002 | <0.001 | 0.002 | 0.002 | 0.0025 | <0.001 | 0.0018 | 0.002 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.002 | <0.001 |
| MELDR-02 | | | | | | | | | | | | | | | | | | | | | | | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| PSDTBCMD | 0.001 | <0.001 | <0.001 | <0.001 | 0.003 | 0.001 | 0.001 | 0.002 | 0.0013 | 0.001 | <0.001 | 0.001 | <0.001 | 0.0018 | 0.001 | 0.001 | 0.001 | <0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.0005 | 0.001 | 0.001 | <0.001 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | <0.001 | <0.001 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-14 | | | | | | | | | | | | | | | | | | | 0.001 | 0.001 | 0.001 | 0.001 | <0.001 | <0.000 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 |
| MELDR-06 | 0.002 | <0.001 | 0.002 | <0.001 | 0.002 | 0.001 | 0.002 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-07 | | | | | | | | | | <0.001 | 0.0022 | 0.001 | | | 0.0034 | 0.0014 | | <0.001 | <0.001 | <0.001 | <0.001 | 0.0015 | <0.001 | 0.002 | 0.021 | 0.009 | <0.001 | <0.001 | 0.013 | 0.009 | 0.002 | <0.001 |
| MELDR-08 | | | | | | | | | | | | | | | | | | | | | | | | | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 |
| MELDR-09 | | | | | | | | | | | | | | | | | | | | | | | | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 |
| MELDR-10 | | | | | | | | | 0.003 | 0.001 | 0.0013 | 0.002 | 0.0016 | 0.0033 | 0.0024 | 0.0012 | 0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.001 | 0.001 | <0.001 | 0.002 | 0.001 | 0.001 | 0.001 | <0.001 | 0.002 | 0.002 | <0.001 |
| MELDR-11 | | | | | | | | | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | 0.001 | 0.001 | <0.001 | 0.002 | 0.001 | <0.001 |
| MELDR-12 | | | | | | | | | 0.011 | 0.004 | <0.001 | 0.001 | 0.0023 | 0.0029 | 0.0015 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.007 | 0.002 | 0.001 | <0.001 |

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ADJUSTED TRIGGER VALUE

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value

Concentration BELOW ADJUSTED trigger value

Highest concentration of the year

Concentration < LOR

NO sample taken

## 8.7 Iron

There has been insufficient data to derive a reliable trigger value for iron (ANZECC and ARMCANZ 2000). ANZECC and ARMCANZ (2000) suggests that the current Canadian guideline level of 0.3 mg/L could be used as an interim indicative working level, however further data is required to establish a figure appropriate for Australian and New Zealand waters. The NHMRC (2008) recreational trigger value for aesthetic value only (i.e. not for health value) is 3 mg/L.

**Total iron** was tested at all 15 sites on only one occasion, the July sampling event; however sites 15 and 16 (John Creaney Park inlet and Downstream Elizabeth Manion Park) were tested on all four sampling events (except at site 16 in October when the water level was insufficient) as they are still considered new sites to the catchment. Concentrations were elevated across the Melville Bull Creek catchments in July, with 11 out of 15 samples (from sites 5, 16, 2, PSDTBCMD, 13, 14, 6, 7, 8, 9 and 12) exceeding the interim guideline value (**Figure 8.7-1** and **Table D-24, Appendix D)**. The two highest concentrations of 6.3 mg/L (recorded at site 5 (John Creaney Park)) and 5.2 mg/L (recorded at site 7 (Booragoon Lake outlet)) also exceeded the recreational trigger value. The lowest concentration of 0.091 mg/L was recorded at site 11 (Marmion Reserve). All samples collected from sites 15 and 16 in August, September and October also exceeded the interim guideline value) **(Figure 8.7-2)**.

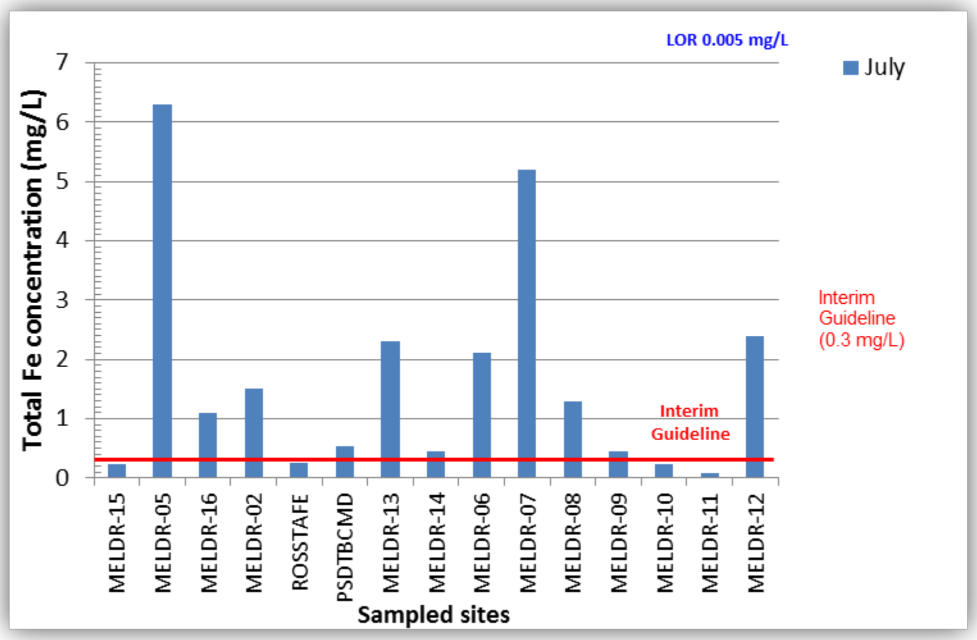


**Figure 8.7-1: Total iron concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in July 2016.**

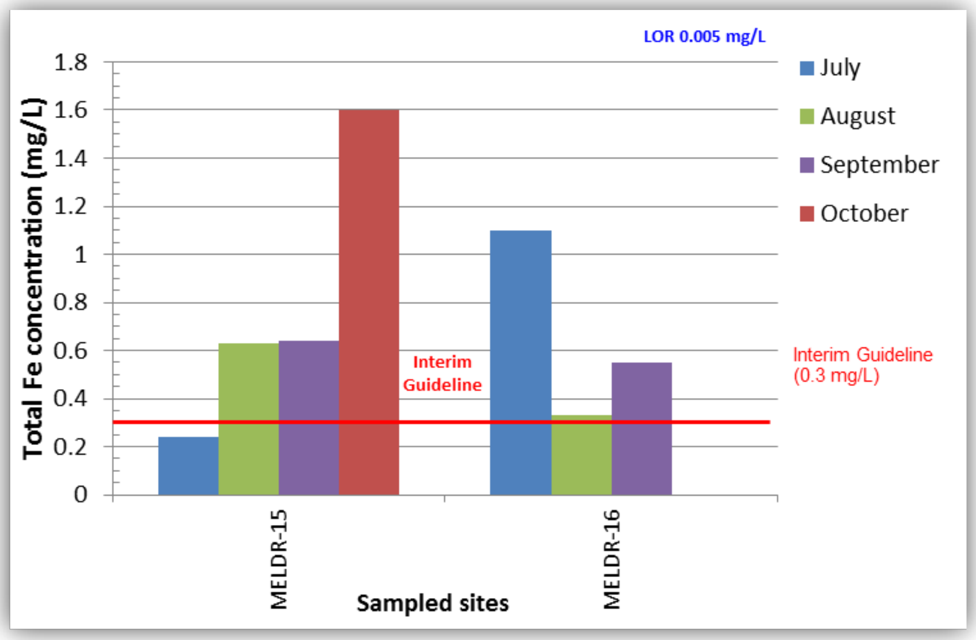


**Figure 8.7-2: Total iron concentrations (mg/L) in the surface water of sites 15 and 16 in 2016.**

When comparing results between sites 13 and 14 (Brentwood Drain and RAAF Drain respectively) in July, total iron concentrations were much higher at site 13 than at 14 and the concentration recorded downstream at site 6 (Bateman Park) was between the values recorded at both upstream sites. Concentrations are still relatively high at the outlet of the Brentwood drain to the Canning River (site 6 – Bateman Park).

Total iron was much higher at site 5 than site 15 in July (John Creaney Park and John Creaney Park inlet respectively) which may reflect possible intrusion of groundwater with the compensation basin. Concentrations then fluctuated along the length of the Bull Creek main drain, with exceeding concentrations found at the outlet to the Canning River at PSDTBCMD.

**Soluble iron** concentrations were also elevated; 42 out of 52 samples exceeded the interim guideline and six exceeded the recreational guideline value (**Figure 8.7-3** and **Table D-25, Appendix D**). The highest concentration of 5.8 mg/L was recorded at site 7 (Booragoon Lake) in July, followed by site 12 in September (5.1 mg/L) and site 7 in July and August (3.8 mg/L and 3.7 mg/L respectively). The lowest concentration of 0.059 mg/L was recorded at site 11 (Marmion Reserve) in July. Soluble iron comprised more than 50% of total iron at all 13 sites in July.

Similarly to total iron concentrations in July, soluble iron concentrations were always higher at 13 than at 14 (Brentwood Drain and RAAF Drain respectively), and concentrations recorded at site 6 (Bateman Park) were between the values recorded at both sites upstream.

High iron concentrations are common in drainage catchments of the Swan and Canning Rivers (DoW 2009), likely due to the iron rich nature of Perth groundwater and the relatively shallow groundwater table resulting in the connection of groundwater and many waterbodies.

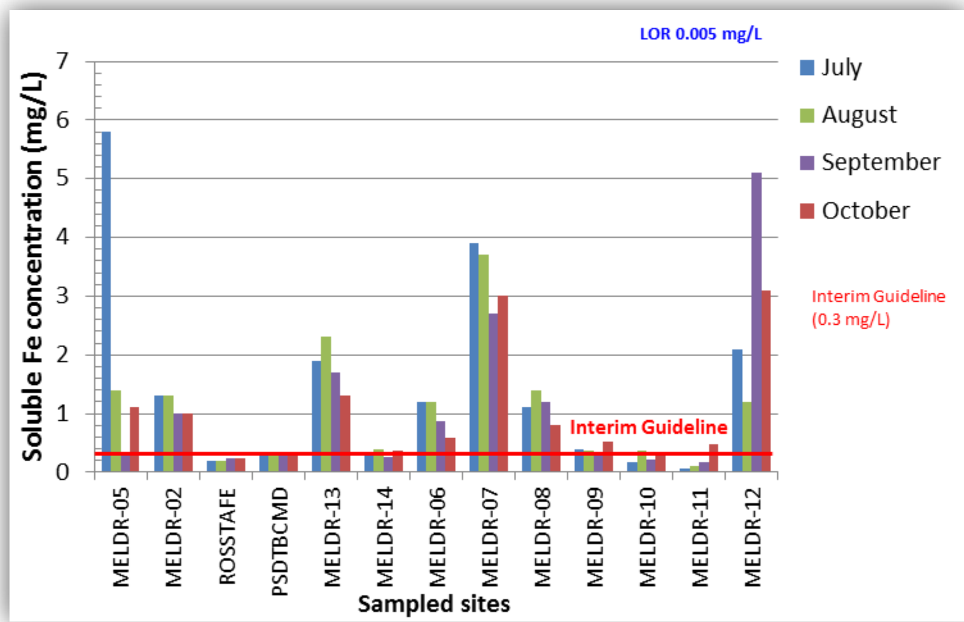


**Figure 8.7-3: Soluble iron concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016**

**Table 8.7-1** shows the recorded **total iron** concentrations throughout the ten-year sampling period. All sites (including sites 15, 16, 13 and 14 that have only been analysed for total iron since 2013 or 2014) have recorded total iron concentrations exceeding the guideline on the majority of sampling occasions where samples have been collected except site 9 (48%). Site 7 has recorded the highest concentration in the catchment in five out of ten years.

**Table 8.7-2** shows the recorded **soluble iron** concentrations throughout the seven-year sampling period. Sites 5, PSDTBCMD, 6, 7 and 12 (as well as 2, 13, 14, 8 and 9 which have only been analysed for soluble iron since 2015) have generally recorded soluble iron concentrations exceeding the guideline value. Only sites 10 and 11 have generally recorded soluble iron concentrations below the guideline value. Site 7 (Booragoon Lake outlet) has recorded the highest soluble iron concentrations in the catchment in every year since 2013 except for this year, when it recorded the second highest concentration.

## Table 8.7-1: Record of total Fe concentrations (mg/L) in the Melville Bull Creek catchments 2007 - 2016

Total Fe (mg/L) Interim guideline 0.3 mg/L Max 19.0 Min 0.1 LOR 0.005 mg/L

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | 1.2 | 2.7 | | | 1.9 | 1.3 | 0.51 | | 1.8 | 0.93 | | | 0.71 | 2.0 | 1.0 | 1.1 | 0.25 | 4.3 | 2.2 | 1.5 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | 1.1 | 2.0 | 1.2 | 1.1 | 1.6 | 1.2 | 1.2 | 1.2 | 1.4 | 1.2 | 1.5 | 15.0 | 1.1 | 1.3 | 1.1 | 1.3 | 1.2 | 1.5 | 1.4 | 1.4 |
| PSDTBCMD | 0.76 | 1.0 | 13.0 | 0.68 | 1.6 | 0.6 | 0.88 | 0.97 | 0.79 | 0.64 | 0.85 | 0.88 | 1.2 | 0.68 | 0.78 | 0.58 | 0.58 | 0.82 | 0.88 | 0.65 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | 16.0 | 12.0 | 1.4 | 12.0 | 8.3 | 6.6 | 7.0 | 6.4 | 4.3 | 4.9 | 6.2 | 5.6 | 2.8 | 4.5 | 4.5 | 5.1 | 4.1 | 4.6 | 4.6 | 3.4 |
| MELDR-07 | 3.9 | 15.0 | | | 9.5 | 7.3 | 16.0 | | 5.4 | 6.9 | | | 4.8 | 6.3 | 4.5 | 19.0 | | 3.3 | 4.5 | 3.3 |
| MELDR-08 | 0.95 | 5.6 | | | 0.99 | 0.41 | | | 0.63 | | | | | | | | | | 0.91 | 1.3 |
| MELDR-09 | 0.82 | 0.61 | | | 0.45 | 0.11 | 0.13 | 0.08 | 0.26 | 0.06 | 0.12 | | 0.07 | 0.05 | 0.06 | 0.1 | 0.7 | 1.0 | 1.6 | 1.9 |
| MELDR-10 | 0.39 | 0.34 | | | 0.7 | 0.31 | 1.1 | 1.8 | 0.14 | 0.34 | 2.7 | | 0.22 | 0.29 | 0.9 | 1.1 | 0.24 | 0.19 | 0.49 | 0.41 |
| MELDR-11 | 0.39 | 0.59 | | | 0.53 | 0.7 | 0.91 | 1.6 | 0.32 | 0.99 | 1.7 | 1.8 | 0.43 | 0.37 | 0.4 | 2.0 | 0.26 | 0.33 | 0.36 | 0.32 |
| MELDR-12 | 1.4 | 3.7 | | | 2.5 | 1.1 | 0.61 | | 1.6 | 0.58 | 0.68 | | 1.4 | 1.2 | 0.69 | 0.55 | 1.6 | 2.2 | 7.6 | 6.0 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | 5.1 | 3.8 | 2.3 | 2.5 | 5.7 | 0.46 | 2.4 | 0.24 | 0.63 | 0.64 | 1.6 |
| MELDR-05 | 4.3 | 0.33 | 1.2 | 0.92 | 1.2 | 2.3 | 2.5 | 2.1 | 2.8 | 2.4 | 2.1 | 1.6 | 1.3 | | | | 6.3 | | | |
| MELDR-16 | | | | | | | | | | 6.5 | 7.5 | 3.3 | 1.4 | 1.5 | 0.68 | 2.7 | 1.1 | 0.33 | 0.55 | |
| MELDR-02 | 1.9 | 1.2 | 1.0 | 1.2 | 1.3 | 1.5 | 1.7 | 1.4 | 1.5 | 1.7 | 1.6 | 1.3 | 1.1 | | | | 1.5 | | | |
| PSDTBCMD | 0.9 | 0.59 | 0.78 | 0.75 | 1.2 | 0.9 | 1.2 | 1.1 | 1.1 | 1.2 | 0.8 | 0.86 | 0.53 | | | | 0.54 | | | |
| MELDR-13 | | | | | | | 4.4 | 4.1 | 1.9 | 4.1 | 4.3 | 3.2 | 3.2 | | | | 2.3 | | | |
| MELDR-14 | | | | | | | 0.9 | 1.5 | 0.6 | 0.9 | 0.9 | 0.86 | 0.56 | | | | 0.45 | | | |
| MELDR-06 | 7.0 | 3.7 | 4.0 | 3.1 | 4.7 | 3.9 | 3.8 | 3.4 | 2.2 | 3.6 | 3.3 | 2.8 | 2.7 | | | | 2.1 | | | |
| MELDR-07 | | | 5.4 | 1.3 | | 4.7 | 5.8 | 2.8 | 2.0 | 5.9 | 5.0 | 2.8 | 6.9 | | | | 5.2 | | | |
| MELDR-08 | | 0.59 | 1.2 | 0.63 | 3.5 | 2.6 | 0.91 | 0.91 | 1.3 | 1.0 | 1.30 | 0.68 | 0.68 | | | | 1.3 | | | |
| MELDR-09 | 0.15 | 0.13 | 0.22 | 0.14 | 0.1 | 0.22 | 0.93 | 0.72 | 0.9 | 1.00 | 0.59 | 0.58 | 0.58 | | | | 0.44 | | | |
| MELDR-10 | 0.46 | 0.41 | 0.7 | 0.53 | 0.32 | 0.23 | 0.5 | 0.70 | 0.35 | 0.52 | 0.3 | 0.34 | 0.37 | | | | 0.23 | | | |
| MELDR-11 | 0.53 | 0.62 | 0.47 | 0.69 | 0.34 | 0.13 | 0.18 | 0.4 | 0.12 | 0.13 | 0.09 | 0.23 | 0.082 | | | | 0.091 | | | |
| MELDR-12 | 1.9 | 4.8 | 4.3 | 5.6 | 1.4 | 3.6 | 5.3 | 3.2 | 2.7 | 4.0 | 1.9 | 1.7 | 5.3 | | | | 2.4 | | | |

SITES RECORDING Fe CONCENTRATIONS ALWAYS/GENERALLY ABOVE GUIDELINE
**SITES RECORDING 40-60% of Fe concentrations ABOVE ACCEPTABLE RANGE**
SITES RECORDING Fe CONCENTRATIONS ALWAYS/GENERALLY BELOW GUIDELINE

Concentration ABOVE guideline
Highest concentration of the year
Concentration BELOW guideline

Concentration < LOR
NO sample taken

## Table 8.7-2: Record of soluble Fe concentrations (mg/L) in the Melville Bull Creek catchments 2009 - 2016

Soluble Fe (mg/L) Interim guideline 0.3 mg/L Max 5.80 Min 0.026 LOR 0.005 mg/L

| Site | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-05 | | | | | | | | | 0.1 | 2.9 | 1 | 0.73 | | 0.22 | 0.77 | 0.57 |
| MELDR-02 | | | | | | | | | | | | | | | | |
| PSDTBCMD | 0.35 | 0.25 | 0.24 | 0.2 | 0.3 | 0.29 | 0.25 | 0.25 | 0.35 | 0.48 | 0.36 | 0.3 | 0.34 | 0.27 | 0.31 | 0.32 |
| MELDR-13 | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | |
| MELDR-06 | 3.4 | 2.8 | 3.7 | 2.6 | 1.3 | 3.1 | 2.6 | 3.1 | 2.7 | 2.7 | 3.1 | 1.8 | 5.2 | 2.2 | 2.7 | 1.7 |
| MELDR-07 | | | | | | | | | | 0.99 | 1.3 | 1.1 | | | 3.9 | 1.2 |
| MELDR-08 | | | | | | | | | | | | | | | | |
| MELDR-09 | | | | | | | | | | | | | | | | |
| MELDR-10 | | | | | | | | | 0.21 | 0.16 | 0.37 | 0.26 | 0.37 | 0.19 | 0.51 | 0.24 |
| MELDR-11 | | | | | | | | | 0.19 | 0.2 | 0.081 | 0.081 | 0.21 | 0.11 | 0.085 | 0.11 |
| MELDR-12 | | | | | | | | | 1.6 | 1.9 | 5.3 | 4.1 | 0.81 | 1.8 | 0.34 | 1.9 |

| Site | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-05 | 0.66 | 1.6 | 1.2 | 0.64 | 2.7 | 1.2 | 1.8 | 0.7 | 1 | 0.96 | 0.44 | 0.35 | 6 | 1.40 | 0.34 | 1.10 |
| MELDR-02 | | | | | | | | | 1 | 1.1 | 0.93 | 0.88 | 1 | 1.3 | 1.00 | 0.99 |
| PSDTBCMD | 0.24 | 0.42 | 0.5 | 0.37 | 0.3 | 0.46 | 0.37 | 0.33 | 0.26 | 0.34 | 0.34 | 0.14 | 0.30 | 0.34 | 0.32 | 0.33 |
| MELDR-13 | | | 2.7 | 2.3 | 0.6 | 2.0 | 1.7 | 1.1 | 1.7 | 1.3 | 2.6 | 0.87 | 1.9 | 2.3 | 1.7 | 1.30 |
| MELDR-14 | | | 0.68 | 0.56 | 0.4 | 0.6 | 0.57 | 0.5 | 0.42 | 0.55 | 0.77 | 0.39 | 0.30 | 0.40 | 0.26 | 0.36 |
| MELDR-06 | 2.6 | 2.9 | 2.6 | 1.8 | 0.55 | 1.7 | 1.4 | 0.96 | 1.2 | 1.4 | 2 | 0.47 | 1.2 | 1.2 | 1 | 0.59 |
| MELDR-07 | | 4.1 | 2.5 | 2.2 | 1.7 | 5.6 | 2.3 | 2.1 | 5.7 | 2.4 | 2.3 | 1.7 | 3.9 | 3.7 | 2.7 | 3.0 |
| MELDR-08 | | | | | | | | | 0.66 | 0.44 | 0.49 | 0.59 | 1.10 | 1.40 | 1.20 | 0.81 |
| MELDR-09 | | | | | | | | | 0.41 | 0.45 | 0.37 | 0.3 | 0.38 | 0.36 | 0.34 | 0.5 |
| MELDR-10 | 0.19 | 0.14 | 0.32 | 0.28 | 0.24 | 0.38 | 0.19 | 0.077 | 0.24 | 0.12 | 0.41 | 0.11 | 0.17 | 0.37 | 0.21 | 0.33 |
| MELDR-11 | 0.16 | 0.05 | 0.066 | 0.14 | 0.12 | 0.037 | 0.026 | 0.096 | 0.04 | 0.03 | 0.19 | 0.22 | 0.06 | 0.11 | 0.18 | 0.48 |
| MELDR-12 | 0.72 | 1.3 | 3.2 | 1.3 | 1.8 | 3.4 | 1.1 | 1.1 | 3.9 | 2.9 | 1.6 | 1.7 | 2.1 | 1.2 | 5.1 | 3.1 |

SITES RECORDING Fe CONCENTRATIONS ALWAYS/GENERALLY ABOVE GUIDELINE
SITES RECORDING Fe CONCENTRATIONS ALWAYS/GENERALLY BELOW GUIDELINE

Concentration ABOVE guideline
Highest concentration of the year
Concentration BELOW guideline

Concentration < LOR
NO sample taken

## 8.8 Lead

The ANZECC hardness unmodified trigger value for lead in water is 0.0034 mg/L for 95% level of freshwater protection (ANZECC and ARMCANZ 2000) and the NHMRC (2008) recreational use guideline (for health value) is 0.1 mg/L. Since the freshwater protection trigger value for lead is affected by water hardness, modified trigger values vary dependant on the water hardness concentration recorded at each site. For the details and calculations see **Table D-26** and **Table D-27, Appendix D.**

**Total lead** was tested at all 15 sites on the July sampling occasion only; however sites 15 and 16 (John Creaney Park inlet and Downstream Elizabeth Manion Park) were tested on all four sampling events as they are still considered new sites to the catchment. Concentrations in the Melville Bull Creek catchments were all below the hardness modified trigger value except for the sample with the highest concentration in the catchment (0.095 mg/L) collected at site 12 in July (**Figure 8.8-1** and **Table D-26, Appendix D**). Seven of the 15 samples collected in July recorded concentrations below the limit of reporting (0.001 mg/L), as did the samples collected at site 16 in August and September and at site 15 in October. All sites recorded total lead concentrations below the recreational trigger value.

**Soluble lead** was tested at 13 sites (all except sites 15 and 16) on all four sampling occasions. Concentrations were all below the hardness modified trigger value except for the sample with the highest concentration in the catchment (0.092 mg/L), also collected at site 12 in July (**Figure 8.8-2** and **Table D-27, Appendix D**). 35 out of the 52 samples also recorded concentrations below the limit of reporting (0.001 mg/L). All sites recorded soluble lead concentrations below the recreational trigger value.

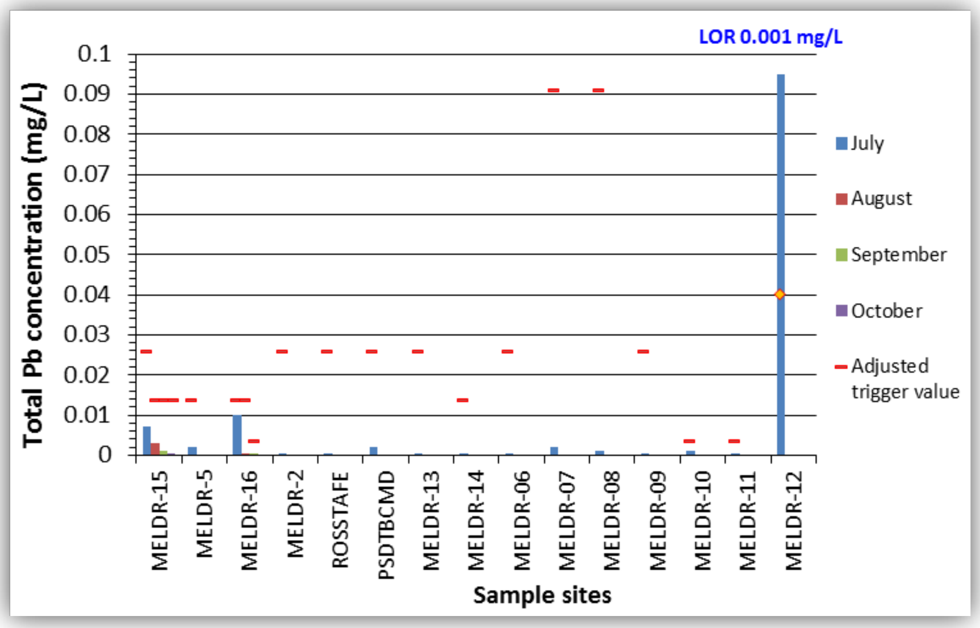


**Figure 8.8-1: Total lead (Pb) concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016**

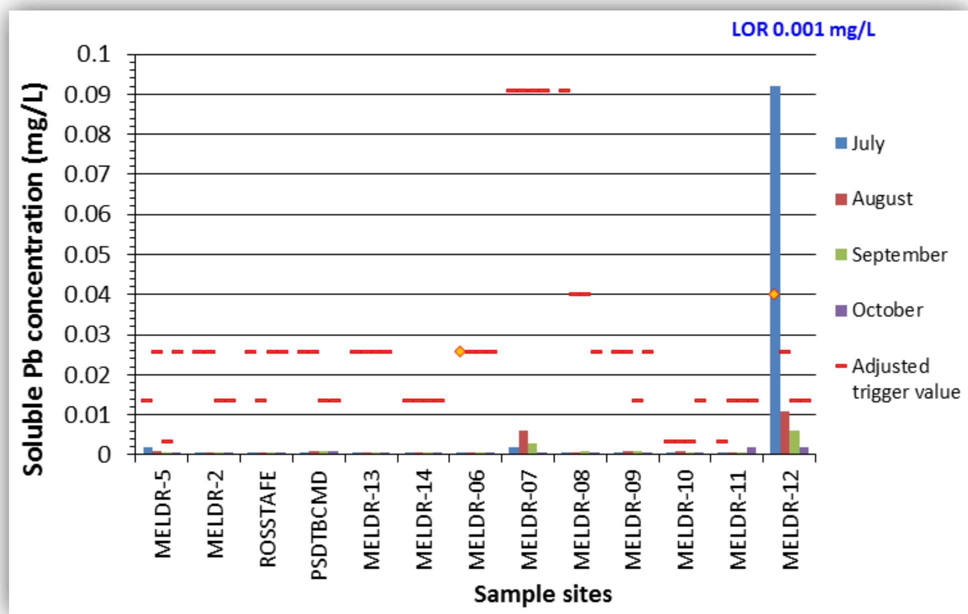


**Figure 8.8-2: Soluble lead concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016**

**Table 8.8-1** shows the recorded **total lead** concentrations throughout the nine-year sampling period. Concentrations exceeding the hardness modified trigger values have sporadically been recorded at sites 5, 10, 11 and 12 (John Creaney Park, Frederick Baldwin, Marmion Reserve and Blue Gum Lake outlet respectively). The concentration recorded at site 12 in 2016 (0.095 mg/L) is the highest recorded over the ten years of monitoring.

**Table 8.8-2** shows the recorded **soluble lead** concentrations throughout the seven-year sampling period. Concentrations exceeding the hardness modified trigger values have only been recorded on three sampling events, at site 12 (Blue Gum Lake outlet) in July 2011 and July 2016 and at site 10 (Frederick Baldwin) in September 2012.

## Table 8.8-1: Record of total Pb concentrations (mg/L) in the Melville Bull Creek catchments 2007 – 2016

**Total Lead (Pb)** (mg/L)

LOR 0.001 mg/L

Unmodified trigger value for 95% Level of Protection 0.0034 mg/L

Max 0.095 Min <0.001

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | |
| **MELDR-05** | 0.004 | 0.003 | | | 0.002 | 0.002 | 0.003 | | 0.003 | 0.002 | | |
| MELDR-16 | | | | | | | | | | | | |
| **MELDR-02** | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.005 |
| **PSDTBCMD** | 0.002 | 0.004 | 0.003 | 0.003 | 0.004 | 0.001 | 0.003 | 0.004 | 0.002 | 0.003 | 0.003 | 0.004 |
| MELDR-13 | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | |
| **MELDR-06** | 0.003 | 0.004 | 0.006 | 0.002 | 0.002 | <0.001 | 0.001 | 0.001 | 0.002 | 0.002 | 0.001 | <0.001 |
| **MELDR-07** | 0.032 | 0.001 | | | 0.001 | 0.001 | 0.008 | | <0.001 | 0.002 | | |
| **MELDR-08** | 0.002 | 0.003 | | | 0.002 | <0.001 | | | <0.001 | | | |
| **MELDR-09** | <0.001 | 0.001 | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | |
| **MELDR-10** | 0.002 | 0.003 | | | 0.002 | <0.001 | 0.001 | 0.009 | <0.001 | 0.001 | 0.003 | |
| **MELDR-11** | 0.004 | 0.003 | | | 0.001 | 0.001 | 0.002 | 0.008 | 0.0013 | 0.002 | 0.005 | 0.003 |
| **MELDR-12** | 0.029 | 0.009 | | | 0.003 | 0.005 | 0.003 | | 0.0056 | 0.005 | 0.019 | |

| Site | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | | |
| **MELDR-05** | 0.005 | 0.002 | 0.005 | 0.006 | 0.003 | 0.005 | 0.002 | 0.002 | 0.0068 | 0.0022 | <0.001 | <0.001 | 0.003 | 0.002 | <0.001 |
| MELDR-16 | | | | | | | | | | | | | | | |
| **MELDR-02** | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 |
| **PSDTBCMD** | 0.006 | 0.002 | 0.003 | 0.002 | 0.002 | 0.001 | 0.0022 | 0.002 | 0.0034 | 0.0028 | 0.0027 | 0.0029 | 0.006 | 0.003 | 0.004 |
| MELDR-13 | | | | | | | | | | | | | | | 0.002 |
| MELDR-14 | | | | | | | | | | | | | | | 0.001 |
| **MELDR-06** | 0.003 | 0.001 | 0.002 | 0.001 | 0.0015 | 0.001 | 0.0014 | <0.001 | 0.0025 | 0.0028 | 0.0012 | <0.001 | 0.002 | 0.001 | 0.002 |
| **MELDR-07** | 0.002 | <0.001 | <0.001 | 0.012 | | 0.002 | <0.001 | <0.001 | | | 0.004 | 0.003 | | 0.002 | <0.001 |
| **MELDR-08** | | | | | | | 0.0014 | 0.001 | | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 |
| **MELDR-09** | <0.001 | <0.001 | <0.001 | <0.001 | 0.0014 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| **MELDR-10** | 0.002 | 0.002 | 0.005 | <0.001 | 0.003 | 0.001 | 0.0024 | 0.002 | 0.0023 | 0.0039 | 0.006 | 0.0028 | 0.002 | 0.001 | 0.002 |
| **MELDR-11** | 0.001 | 0.002 | 0.003 | 0.014 | 0.002 | 0.002 | 0.0025 | 0.001 | <0.001 | 0.0015 | 0.0021 | 0.0021 | 0.001 | 0.001 | 0.001 |
| **MELDR-12** | 0.011 | 0.01 | 0.011 | 0.014 | 0.065 | 0.026 | 0.0012 | 0.003 | 0.051 | 0.036 | 0.0065 | 0.008 | 0.019 | 0.003 | 0.001 |

| Site | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | <0.001 | <0.001 | <0.001 | 0.009 | 0.006 | 0.001 | 0.009 | 0.007 | 0.003 | 0.001 | <0.001 |
| **MELDR-05** | 0.001 | 0.002 | 0.001 | <0.001 | 0.001 | 0.002 | | | | 0.002 | | | |
| MELDR-16 | | | <0.001 | 0.002 | <0.001 | 0.011 | 0.003 | <0.001 | 0.01 | 0.01 | <0.001 | <0.001 | |
| **MELDR-02** | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | <0.001 | | | |
| **PSDTBCMD** | 0.004 | 0.007 | <0.001 | 0.003 | 0.003 | 0.002 | | | | 0.002 | | | |
| MELDR-13 | 0.001 | 0.003 | <0.001 | 0.001 | <0.001 | <0.001 | | | | <0.001 | | | |
| MELDR-14 | 0.002 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | | | | <0.001 | | | |
| **MELDR-06** | 0.001 | 0.003 | <0.001 | <0.001 | <0.001 | 0.002 | | | | <0.001 | | | |
| **MELDR-07** | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.005 | | | | 0.002 | | | |
| **MELDR-08** | <0.001 | 0.001 | 0.001 | 0.002 | <0.001 | 0.001 | | | | 0.001 | | | |
| **MELDR-09** | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | <0.001 | | | |
| **MELDR-10** | 0.002 | 0.002 | 0.001 | <0.001 | <0.001 | <0.001 | | | | 0.001 | | | |
| **MELDR-11** | 0.005 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | <0.001 | | | |
| **MELDR-12** | <0.001 | 0.003 | 0.001 | 0.002 | 0.003 | 0.008 | | | | 0.095 | | | |

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ADJUSTED TRIGGER VALUE

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value

Concentration BELOW ADJUSTED trigger value

Highest concentration of the year

Concentration < LOR

NO sample taken

## Table 8.8-2: Record of soluble Pb concentrations (mg/L) in the Melville Bull Creek catchments 2009 – 2016

**Soluble Lead (Pb)** (mg/L)

LOR 0.001 mg/L

Unmodified trigger value for 95% Level of Protection 0.0034 mg/L

Max 0.092 Min <0.001

| Site | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MELDR-05** | | | | | | | | | <0.001 | 0.002 | <0.001 | <0.001 | 0.0015 | 0.0011 | <0.001 | <0.001 |
| **MELDR-02** | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.0016 | 0.0011 | 0.001 | <0.001 |
| PSDTBCMD | | | | | | | | | | | | | | | | |
| MELDR-13 | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | |
| **MELDR-06** | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| **MELDR-07** | | | | | | | | | | <0.001 | <0.001 | <0.001 | | | 0.004 | 0.003 |
| MELDR-08 | | | | | | | | | | | | | | | | |
| MELDR-09 | | | | | | | | | | | | | | | | |
| **MELDR-10** | | | | | | | | | 0.002 | <0.001 | 0.0016 | <0.001 | 0.002 | 0.0019 | 0.0038 | <0.001 |
| **MELDR-11** | | | | | | | | | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| **MELDR-12** | | | | | | | | | 0.066 | 0.024 | <0.001 | 0.002 | 0.046 | 0.026 | <0.001 | 0.0031 |

| Site | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MELDR-05** | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.001 | <0.001 | <0.001 |
| **MELDR-02** | 0.001 | <0.001 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| PSDTBCMD | | | | | | | | | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | 0.001 |
| MELDR-13 | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-14 | | | <0.001 | 0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| **MELDR-06** | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| **MELDR-07** | | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.005 | 0.005 | 0.008 | <0.001 | 0.002 | 0.006 | 0.003 | <0.001 |
| MELDR-08 | | | | | | | | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 |
| MELDR-09 | | | | | | | | | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | 0.001 | 0.001 | <0.001 |
| **MELDR-10** | 0.001 | <0.001 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 |
| **MELDR-11** | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | <0.001 | <0.001 | <0.001 | 0.002 |
| **MELDR-12** | 0.018 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | <0.001 | <0.001 | 0.006 | 0.006 | <0.001 | 0.006 | 0.092 | 0.011 | 0.006 | 0.002 |

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ADJUSTED TRIGGER VALUE

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value

Concentration BELOW ADJUSTED trigger value

Highest concentration of the year

Concentration < LOR

NO sample taken

## 8.9 Manganese

The ANZECC trigger value for manganese for 95% level of protection of freshwaters is 1.9 mg/L (ANZECC and ARMCANZ 2000) and the NHMRC (2008) recreational use guidelines are 5 mg/L (for health value) and 1 mg/L (for aesthetic value).

**Total manganese** was only tested at sites 15 and 16 (John Creaney inlet and Downstream Elizabeth Manion Park) on all four sampling occasions and ROSSTAFE (Brockman Park inlet) in July. Concentrations were all below the trigger values for 95% level of protection and recreational use guideline (**Figure 8.9-1** and **Table D-28, Appendix D**). The highest concentration of 0.021 mg/L was recorded at site 15 in October. The lowest concentration of 0.004 mg/L was recorded at site 16 in September.

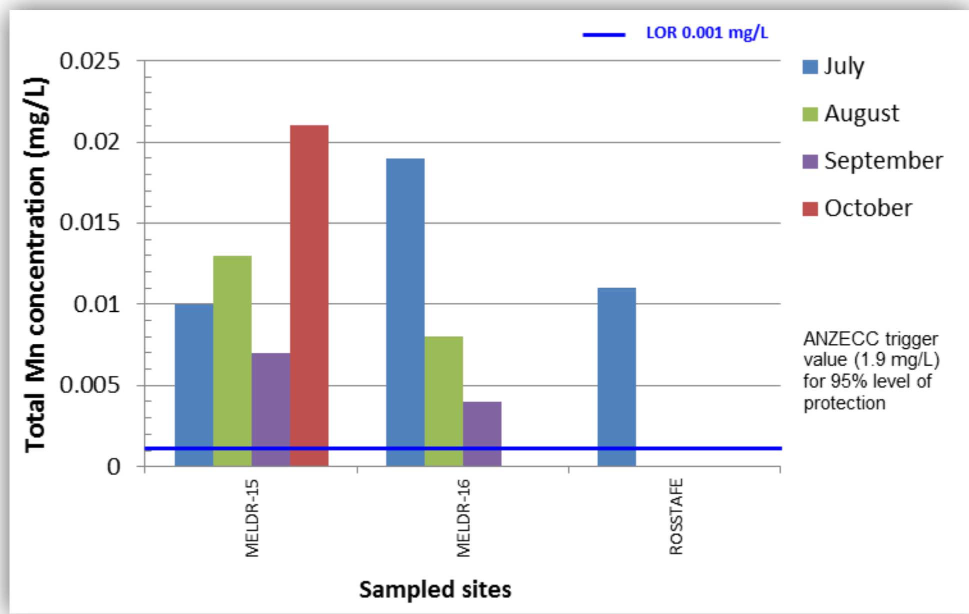


**Figure 8.9-1: Total manganese (Mn) concentrations (mg/L) in the surface water of sites 15, 16 and ROSSTAFE in 2016.**

## 8.10 Mercury

The ANZECC trigger value for mercury in water is 0.0006 mg/L for 95% protection of freshwaters (ANZECC and ARMCANZ 2000) and the NHMRC (2008) recreational use guideline (for health) is 0.01 mg/L.

**Total mercury** was tested at six sites - 15, 16, ROSSTAFE, 13, 14 and 6 (John Creaney Park inlet, downstream Elizabeth Manion Park, Brockman Park inlet, Brentwood drain, RAAF Drain and Bateman Park respectively) - on all four sampling occasions except ROSSTAFE which was only tested in July and site 16 which was not tested in October as the water level was insufficient. Concentrations were all below the ANZECC trigger value for 95% level of protection and NHMRC guideline for recreational use (**Figure 8.10-1** and **Table D-29, Appendix D**). All samples from July, August and October recorded concentrations below the limit of reporting (0.0001 mg/L); however samples in September were all greater than the limit of reporting, with the highest concentration of 0.0003 mg/L recorded at Bateman Park. This is the first time since analysis of total mercury began in 2014 that concentrations have exceeded the LOR.

**Soluble mercury** was tested at four sites: sites ROSSTAFE 6, 13, 14 and ROSSTAFE (Brockman Park inlet, Brentwood Drain, RAAF Drain and Bateman Park respectively) on all four sampling occasions. Concentrations were all below the trigger values for 95% level of protection and recreational use, and also below the limit of reporting of 0.0001 mg/L (**Figure 8.10-2** and **Table D-30, Appendix D**).

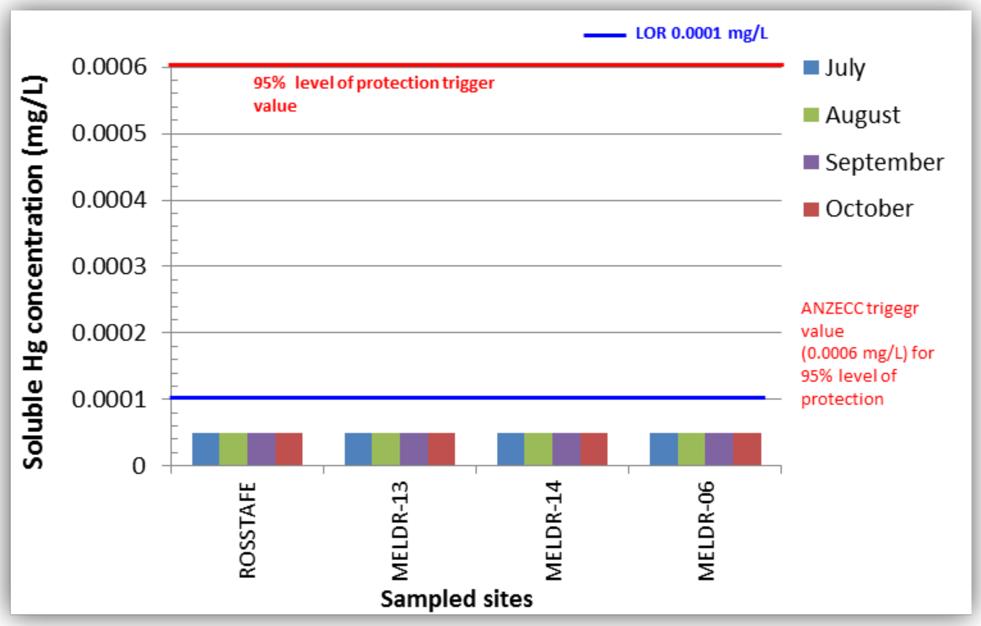


**Figure 8.10-1: Total mercury (Hg) concentrations (mg/L) in the surface water at sites 15, 16, ROSSTAFE, 13, 14 and 6 in 2016.**

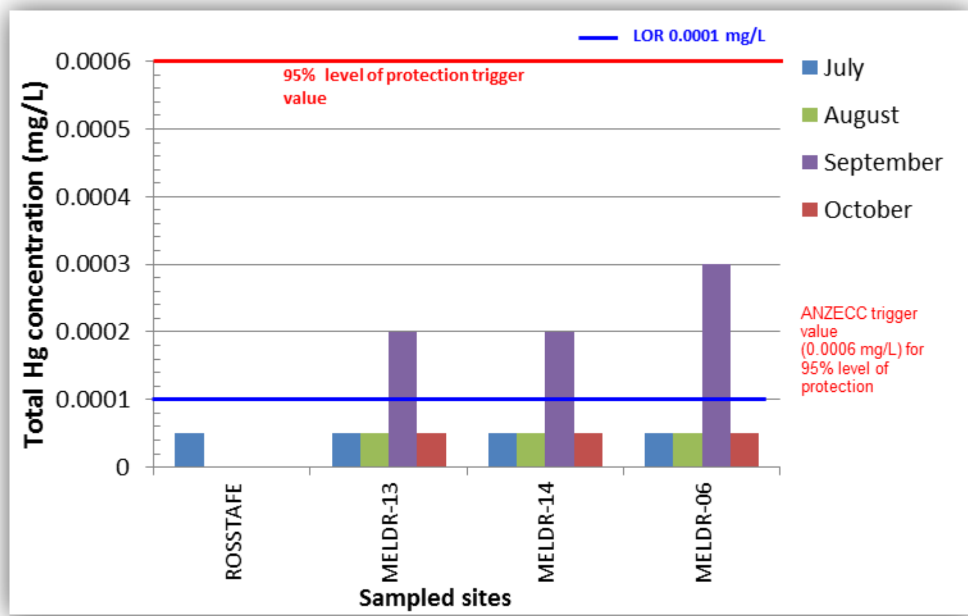


**Figure 8.10-2: Soluble mercury (Hg) concentrations (mg/L) in the surface water of site ROSSTAFE, 13, 14 and 6 in 2016.**

## 8.11 Molybdenum

The ANZECC low reliability trigger value for freshwater protection for molybdenum in water is 0.034 mg/L[3] (ANZECC and ARMCANZ 2000) and the recreational trigger value (for health) is 0.5 mg/L (NHMRC 2008).

**Total molybdenum** was only tested at sites 15 and 16 (John Creaney inlet and Downstream Elizabeth Manion Park) on all four sampling occasions and at ROSSTAFE (Brockman Park inlet) in July. Total molybdenum concentrations were all below the limit of reporting of 0.001 mg/L except at site 15 in July and August, when a concentration of 0.001 mg/L was recorded, and therefore no trigger values were exceeded (**Figure 8.11-1** and **Table D-31, Appendix D**).

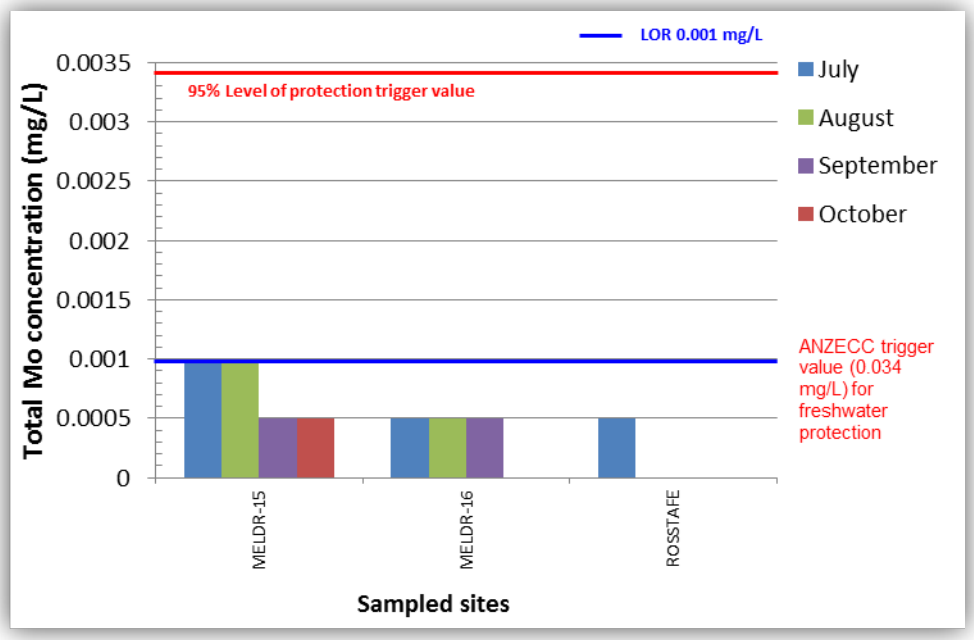


**Figure 8.11-1: Total molybdenum (Mo) concentrations (mg/L) in the surface water of sites 15, 16 and ROSSTAFE in 2016.**

## 8.12 Nickel

The ANZECC (2000) hardness unmodified trigger values for nickel is 0.011 mg/L for 95% level of freshwater protection and the NHMRC (2008) recreational use guideline (for health) is 0.2 mg/L. Since the trigger values for nickel are affected by water hardness, the trigger values are variable, dependent on the water hardness concentration recorded at each site. For the details and calculations see **Table D-32, Appendix D**.

**Total nickel** was only tested at sites 15 and 16 (John Creaney inlet and Downstream Elizabeth Manion Park) on all four sampling occasions (except at site 16 in October when the water level was insufficient) and at ROSSTAFE in July. Concentrations were all below the hardness modified trigger values and the recreational trigger value and six out of nine samples recorded concentrations below or equal to the limit of reporting (**Figure 8.12-1** and **Table D-32, Appendix D**). The highest concentration of 0.002 mg/L was recorded at both sites 15 in July and 16 in October.

For previous total nickel concentrations in the surface water of the Melville Bull Creek catchments between 2007 and 2016 please refer to **Table 8.12-1**. Exceedances of the 95% protection trigger value have not been recorded at any site in the catchment throughout the ten years of monitoring.

3 The value provided is the low reliability trigger value, derived by applying an AF (assessment factor) of 20 to the lowest chronic toxicity figure (670 µg/L for *Daphnia magna*) (ANZECC and ARMCANZ 2000).

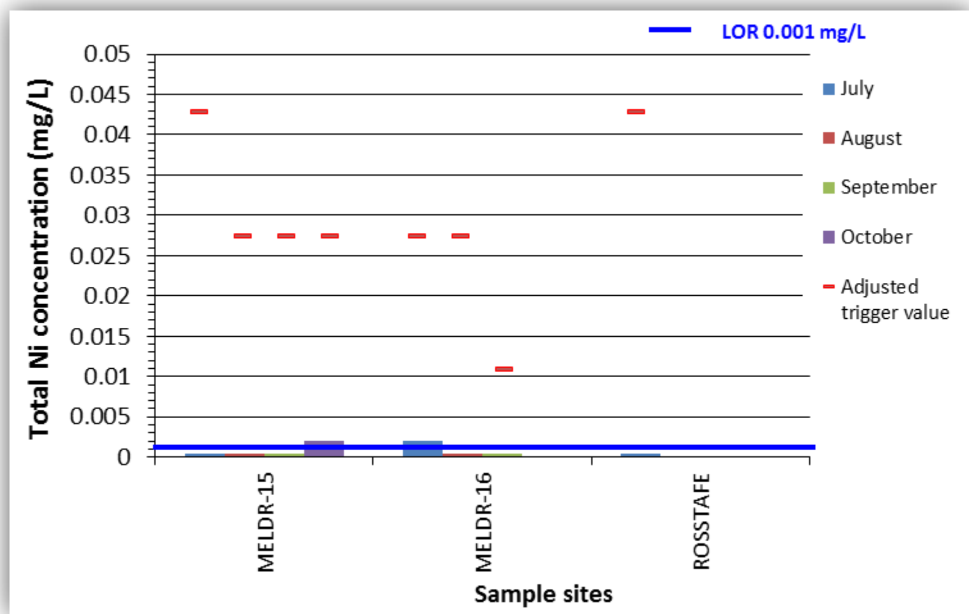


**Figure 8.12-1: Total nickel concentrations (mg/L) in the surface waters of sites 15, 16 and ROSSTAFE in 2016.**

## Table 8.12-1: Records of total nickel concentrations (mg/L) in the Melville Bull Creek catchments 2007 - 2016

**Total Nickel (Ni)** (mg/L) LOR 0.001 mg/L

Unmodified trigger value for 95% level of protection 0.011 mg/L Max 0.021 Min <0.001

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | |
| MELDR-05 | 0.001 | 0.001 | | | <0.001 | <0.001 | 0.002 | | 0.002 | <0.001 | | |
| MELDR-16 | | | | | | | | | | | | |
| MELDR-02 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| PSDTBCMD | <0.001 | <0.001 | 0.006 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-13 | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | |
| MELDR-06 | 0.008 | 0.007 | <0.001 | 0.006 | 0.004 | 0.004 | 0.004 | 0.003 | 0.004 | 0.003 | 0.002 | 0.002 |
| MELDR-07 | 0.021 | 0.003 | | | 0.002 | 0.002 | 0.002 | | 0.002 | 0.002 | | |
| MELDR-08 | 0.004 | 0.002 | | | <0.001 | <0.001 | | | 0.003 | | | |
| MELDR-09 | 0.001 | <0.001 | | | <0.001 | 0.001 | 0.002 | <0.001 | 0.002 | <0.001 | <0.001 | |
| MELDR-10 | <0.001 | <0.001 | | | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | <0.001 | <0.001 | |
| MELDR-11 | <0.001 | 0.001 | | | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-12 | 0.003 | <0.001 | | | <0.001 | 0.005 | 0.001 | | 0.001 | <0.001 | <0.001 | |

| Site | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | | |
| MELDR-05 | <0.001 | 0.001 | 0.002 | <0.001 | 0.001 | 0.004 | 0.0018 | 0.001 | 0.0015 | <0.001 | <0.001 | 0.0012 | 0.001 | 0.002 | 0.001 |
| MELDR-16 | | | | | | | | | | | | | | | |
| MELDR-02 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | <0.001 |
| PSDTBCMD | <0.001 | 0.002 | <0.001 | <0.001 | 0.001 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | <0.001 |
| MELDR-13 | | | | | | | | | | | | | | | 0.002 |
| MELDR-14 | | | | | | | | | | | | | | | <0.001 |
| MELDR-06 | 0.001 | 0.002 | 0.002 | 0.002 | 0.0015 | 0.003 | 0.002 | 0.002 | 0.0035 | 0.0022 | 0.0014 | 0.0017 | 0.002 | 0.002 | 0.002 |
| MELDR-07 | 0.001 | 0.001 | 0.001 | 0.001 | | 0.01 | 0.0021 | 0.002 | | | 0.0031 | 0.002 | | 0.003 | <0.001 |
| MELDR-08 | | | | | | | 0.003 | 0.002 | | 0.0014 | <0.001 | <0.001 | 0.003 | 0.002 | 0.001 |
| MELDR-09 | <0.001 | <0.001 | <0.001 | <0.001 | 0.009 | 0.011 | 0.0022 | 0.002 | 0.0017 | 0.0014 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 |
| MELDR-10 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-11 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| MELDR-12 | <0.001 | <0.001 | <0.001 | <0.001 | 0.011 | 0.008 | <0.001 | 0.002 | 0.0033 | 0.003 | <0.001 | <0.001 | 0.002 | <0.001 | <0.001 |

| Site | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | <0.001 | 0.002 | 0.001 | 0.002 | 0.002 | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | 0.002 |
| MELDR-05 | 0.001 | <0.001 | 0.001 | 0.002 | <0.001 | | | | | | | | |
| MELDR-16 | | | <0.001 | 0.003 | 0.003 | 0.003 | 0.002 | 0.001 | 0.002 | 0.002 | <0.001 | <0.001 | |
| MELDR-02 | 0.001 | <0.001 | 0.001 | 0.001 | <0.001 | | | | | | | | |
| PSDTBCMD | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | |
| MELDR-13 | 0.002 | <0.001 | 0.002 | 0.002 | 0.001 | | | | | | | | |
| MELDR-14 | 0.001 | <0.001 | 0.001 | <0.001 | <0.001 | | | | | | | | |
| MELDR-06 | 0.002 | 0.001 | 0.002 | 0.002 | 0.001 | | | | | | | | |
| MELDR-07 | 0.001 | 0.001 | 0.002 | 0.001 | 0.002 | | | | | | | | |
| MELDR-08 | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 | | | | | | | | |
| MELDR-09 | 0.001 | <0.001 | 0.001 | 0.001 | 0.001 | | | | | | | | |
| MELDR-10 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | |
| MELDR-11 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | |
| MELDR-12 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | | | | | | | | |

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ADJUSTED TRIGGER VALUE

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value

Concentration BELOW ADJUSTED trigger value

Highest concentration of the year

Concentration < LOR

NO sample taken

## 8.13 Selenium

The ANZECC trigger value for selenium in water is 0.005 mg/L for 95% level of protection of freshwater (ANZECC and ARMCANZ 2000), and the NHMRC (2008) trigger value for recreational use (health value) is 0.1 mg/L.

**Total selenium** was only tested at sites 15 and 16 (John Creaney inlet and Downstream Elizabeth Manion Park) on all four sampling occasions (except at site 16 in October when the water level was insufficient) and at ROSSTAFE in July. Total selenium concentrations were all below the limit of reporting of 0.001 mg/L, and thus freshwater protection and recreational trigger values (**Figure 9.9-1** and **Table D-44, Appendix D**).

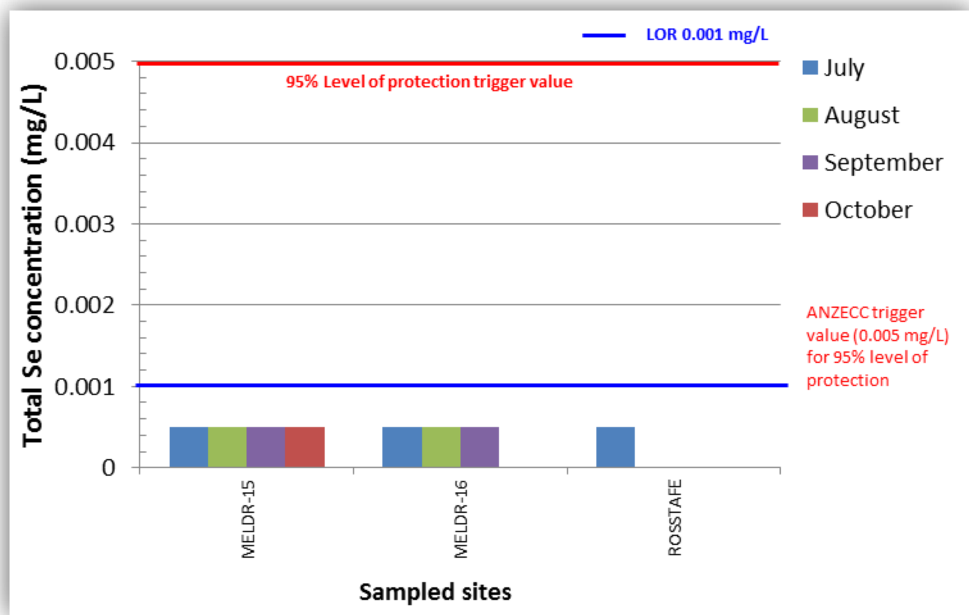


**Figure 8.13-1: Total Selenium (Se) concentrations (mg/L) in the surface water of sites 15, 16 and ROSSTAFE in 2016.**

## 8.14 Zinc

The ANZECC hardness unmodified trigger value for zinc in water for 95% level of protection is 0.008 mg/L (ANZECC and ARMCANZ 2000). Since the trigger values for zinc are affected by water hardness, the trigger values are variable, dependent on the water hardness concentration recorded at each site. For the details and calculations see (**Table D-34 and Table D-35, Appendix D**). The NHMRC (2008) trigger value for recreational use (aesthetic value) is 30 mg/L.

**Total zinc** was tested at all 15 sites on only one occasion, the July sampling event; however sites 15 and 16 (John Creaney Park inlet and Downstream Elizabeth Manion Park) were tested on all four sampling events as they are still considered new sites to the catchment. Concentrations in July were varied. Six out of 15 sites, sites 15, 16, 7, 10, 11 and 12 (John Creaney Park inlet, downstream Elizabeth Manion Park, Booragoon Lake outlet, Frederick Baldwin, Marmion Reserve and Blue Gum Lake outlet) recorded concentrations equal to or exceeding hardness modified trigger values for 95% level of protection (**Figure 8.14-1** and **Table D-34, Appendix D)**. The highest August concentration of 0.24 mg/L was recorded at site 12, which substantially exceeded the hardness modified trigger value (0.0416 mg/L). The lowest August concentration of 0.005 mg/L was recorded at site 2 (Brockman Park). In addition to recording total zinc concentrations exceeding adjusted trigger values in July, both sites 15 and 16 recorded concentrations exceeding the respective hardness modified trigger values in August, September and October when samples were collected. All total zinc concentrations were below the recreational use guideline.

Although sites 15 and 16 both recorded high exceeding concentrations in August it would appear that neither had an impact on the sites downstream, which had relatively low zinc concentrations (site 5 is downstream of 15, and site 2 is downstream of sites 5 and 16).

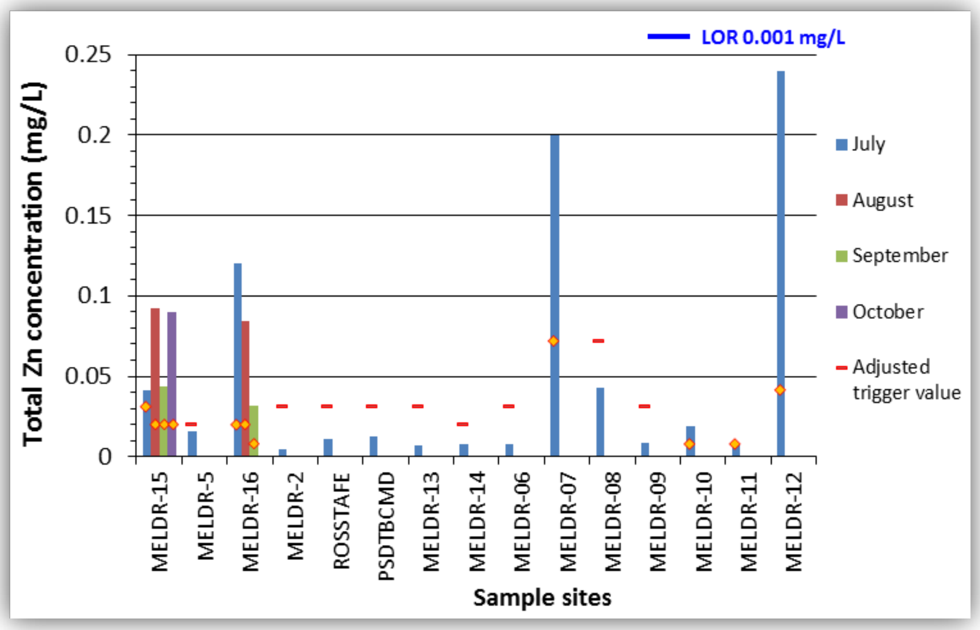


**Figure 8.14-1: Total zinc (Zn) concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in August 2016.**

**Soluble zinc** was tested at 13 sites (all except sites 15 and 16) on all four sampling occasions. Concentrations in the surface water of the Melville Bull Creek catchments were varied; 19 out of 52 samples (at sites 5, 2, PSDTBCMD, 14, 6, 7, 8, 10, 11 and 12) recorded concentrations exceeding the hardness modified trigger value for 95% level of protection on at least one sampling occasion (**Figure 8.14-2** and **Table D-35, Appendix D**). The two highest concentrations were recorded in July at sites 12 (Blue Gum Lake outlet) (0.24 mg/L) and 7 (0.2 mg/L), which both exceeded the modified trigger values. The lowest concentration of 0.003 mg/L was recorded at site 11 (Marmion Reserve) in October. All soluble zinc concentrations were below the recreational use guideline.

At the sites with the highest concentrations, 7 and 12 (Booragoon Lake outlet and Blue Gum Lake outlet), soluble zinc concentrations declined from July to October.

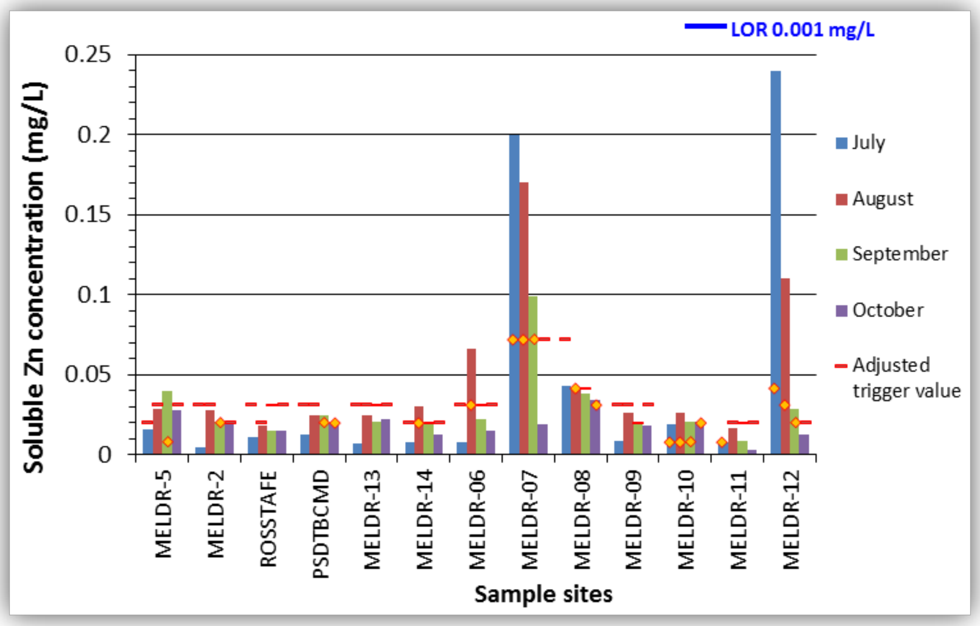


**Figure 8.14-2: Soluble zinc concentrations (mg/L) in the surface water of the Melville Bull Creek catchments in 2016.**

**Table 8.14-1** shows the recorded **total zinc** concentrations throughout the ten-year sampling period. Concentrations exceeding the hardness modified triggers value were only recorded on a few occasions between 2007 and 2010, and since then more widespread high concentrations, exceeding the hardness modified trigger value, have been recorded at the majority of the sites. All sites have recorded concentrations greater than the hardness modified trigger value on at least one sampling occasion.

**Table 8.14-2** shows the recorded **soluble zinc** concentrations throughout the eight-year sampling period. All sites where soluble zinc was tested, recorded concentrations above or equal to the hardness modified trigger value on at least one occasion. Site 10 (Frederick Baldwin) has consistently recorded soluble zinc concentrations above the modified trigger values.

## Table 8.14-1: Records of total zinc concentrations (mg/L) in the Melville Bull Creek catchments 2007 - 2016

**Total Zinc (Zn)** (mg/L) LOR 0.001 mg/L

Unmodified trigger value for 95% level of protection 0.008 mg/L Max 1.2 Min <0.001

| Site | Jul-07 | Oct-07 | Jan-08 | Apr-08 | Sep-08 | Nov-08 | Jan-09 | Mar-09 | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | | | | | | | | | | | |
| MELDR-05 | 0.006 | 0.011 | | | 0.005 | 0.006 | 0.003 | | 0.021 | 0.008 | | | 0.054 | 0.004 | 0.005 | 0.008 | 0.024 | 0.05 | 0.018 | 0.017 |
| MELDR-16 | | | | | | | | | | | | | | | | | | | | |
| MELDR-02 | 0.002 | 0.003 | <0.001 | <0.001 | 0.003 | 0.004 | 0.004 | 0.004 | 0.01 | 0.004 | 0.003 | 0.009 | 0.015 | 0.002 | 0.005 | 0.004 | 0.008 | 0.012 | 0.007 | 0.009 |
| PSDTBCMD | 0.006 | 0.007 | 0.011 | 0.012 | 0.006 | 0.009 | 0.005 | 0.009 | 0.015 | 0.008 | 0.002 | 0.005 | 0.02 | 0.006 | 0.008 | 0.006 | 0.017 | 0.014 | 0.011 | 0.01 |
| MELDR-13 | | | | | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | | | | | |
| MELDR-06 | 0.01 | 0.01 | 0.009 | 0.011 | 0.007 | 0.006 | 0.004 | 0.008 | 0.011 | 0.008 | 0.002 | 0.004 | 0.021 | 0.005 | 0.006 | 0.006 | 0.02 | 0.014 | 0.011 | 0.008 |
| MELDR-07 | 1.2 | 0.02 | | | 0.016 | 0.002 | <0.001 | | 0.058 | 0.002 | | | 0.009 | 0.002 | <0.001 | 0.018 | | 0.092 | 0.005 | 0.002 |
| MELDR-08 | 0.13 | 0.026 | | | 0.024 | 0.009 | | | 0.031 | | | | | | | | | | 0.07 | 0.026 |
| MELDR-09 | 0.004 | 0.003 | | | 0.006 | 0.004 | 0.003 | 0.002 | 0.007 | 0.001 | <0.001 | | <0.001 | <0.001 | 0.002 | 0.002 | 0.22 | 0.091 | 0.033 | 0.01 |
| MELDR-10 | 0.006 | 0.004 | | | 0.003 | 0.003 | 0.003 | 0.012 | 0.003 | 0.003 | <0.001 | | 0.004 | 0.002 | 0.004 | 0.007 | 0.02 | 0.041 | 0.009 | 0.007 |
| MELDR-11 | 0.007 | 0.003 | | | 0.001 | 0.001 | <0.001 | 0.008 | 0.0023 | 0.002 | 0.001 | 0.002 | 0.004 | 0.003 | 0.002 | 0.017 | 0.006 | 0.003 | 0.005 | 0.002 |
| MELDR-12 | 0.19 | 0.001 | | | 0.001 | 0.002 | <0.001 | | 0.003 | <0.001 | 0.004 | | 0.003 | 0.002 | 0.003 | 0.002 | 0.65 | 0.22 | 0.013 | 0.003 |

| Site | Jul-12 | Aug-12 | Sep-12 | Oct-12 | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-15 | | | | | | | | | | 0.029 | 0.041 | 0.041 | 0.09 | 0.094 | 0.057 | 0.055 | 0.041 | 0.092 | 0.044 | 0.09 |
| MELDR-05 | 0.014 | 0.027 | 0.0084 | 0.012 | 0.03 | 0.03 | 0.028 | 0.014 | 0.031 | 0.021 | 0.018 | 0.007 | 0.023 | | | | 0.016 | | | |
| MELDR-16 | | | | | | | | | | 0.024 | 0.039 | 0.023 | 0.18 | 0.074 | 0.051 | 0.072 | 0.12 | 0.084 | 0.032 | |
| MELDR-02 | <0.001 | 0.011 | 0.0037 | 0.0019 | 0.021 | 0.019 | 0.03 | 0.035 | 0.021 | 0.012 | 0.01 | 0.005 | 0.009 | | | | 0.005 | | | |
| PSDTBCMD | 0.0092 | 0.016 | 0.01 | 0.009 | 0.02 | 0.02 | 0.012 | 0.011 | 0.021 | 0.012 | 0.01 | 0.008 | 0.014 | | | | 0.013 | | | |
| MELDR-13 | | | | | | | 0.019 | 0.008 | 0.033 | 0.011 | 0.012 | 0.008 | 0.01 | | | | 0.007 | | | |
| MELDR-14 | | | | | | | 0.008 | 0.005 | 0.046 | 0.01 | 0.005 | 0.004 | 0.008 | | | | 0.008 | | | |
| MELDR-06 | 0.009 | 0.017 | 0.01 | 0.0053 | 0.02 | 0.01 | 0.015 | 0.0081 | 0.032 | 0.011 | 0.01 | 0.008 | 0.011 | | | | 0.008 | | | |
| MELDR-07 | | | 0.14 | 0.05 | | 0.12 | 0.002 | 0.001 | 0.048 | 0.013 | 0.004 | 0.003 | 0.21 | | | | 0.2 | | | |
| MELDR-08 | | 0.05 | 0.011 | 0.0031 | 0.1 | 0.023 | 0.02 | 0.012 | 0.024 | 0.031 | 0.037 | 0.021 | 0.041 | | | | 0.043 | | | |
| MELDR-09 | 0.014 | 0.014 | 0.012 | 0.0044 | 0.007 | 0.013 | 0.011 | 0.004 | 0.006 | 0.008 | 0.005 | 0.003 | 0.011 | | | | 0.009 | | | |
| MELDR-10 | 0.011 | 0.023 | 0.014 | 0.0058 | 0.02 | 0.013 | 0.007 | 0.003 | 0.03 | 0.009 | 0.006 | 0.007 | 0.016 | | | | 0.019 | | | |
| MELDR-11 | 0.002 | 0.0058 | 0.0024 | 0.002 | 0.003 | 0.004 | 0.001 | 0.003 | 0.003 | 0.003 | 0.003 | 0.002 | 0.004 | | | | 0.008 | | | |
| MELDR-12 | 0.16 | 0.11 | 0.016 | <0.001 | 0.1 | 0.002 | 0.003 | 0.002 | 0.002 | 0.003 | 0.005 | 0.008 | 0.003 | | | | 0.24 | | | |

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ADJUSTED TRIGGER VALUE

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value

Concentration BELOW ADJUSTED trigger value

Highest concentration of the year

Concentration < LOR

NO sample taken

9

## Table 8.14-2: Records of soluble zinc concentrations (mg/L) in the Melville Bull Creek catchments 2009 – 2016

**Soluble Zinc (Zn)** (mg/L) LOR 0.001 mg/L

Unmodified trigger value for 95% level of protection 0.008 mg/L Max 0.58 Min <0.001

| Site | Sep-09 | Nov-09 | Jan-10 | Mar-10 | Aug-10 | Sep-10 | Oct-10 | Nov-10 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Jul-12 | Aug-12 | Sep-12 | Oct-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-05 | | | | | | | | | 0.025 | 0.05 | 0.016 | 0.026 | 0.0064 | 0.027 | 0.011 | 0.012 |
| MELDR-02 | 0.015 | 0.01 | 0.011 | 0.009 | 0.02 | 0.015 | 0.01 | 0.013 | 0.019 | 0.014 | 0.01 | 0.017 | 0.007 | 0.016 | 0.01 | 0.009 |
| PSDTBCMD | | | | | | | | | | | | | | | | |
| MELDR-13 | | | | | | | | | | | | | | | | |
| MELDR-14 | | | | | | | | | | | | | | | | |
| MELDR-06 | 0.015 | 0.015 | 0.015 | 0.012 | 0.02 | 0.016 | 0.018 | 0.02 | 0.02 | 0.014 | 0.013 | 0.022 | 0.009 | 0.017 | 0.01 | 0.0053 |
| MELDR-07 | | | | | | | | | | 0.092 | 0.006 | 0.012 | | | 0.14 | 0.05 |
| MELDR-08 | | | | | | | | | | | | | | | | |
| MELDR-09 | | | | | | | | | | | | | | | | |
| MELDR-10 | | | | | | | | | 0.022 | 0.039 | 0.012 | 0.01 | 0.011 | 0.021 | 0.015 | 0.0055 |
| MELDR-11 | | | | | | | | | 0.006 | 0.003 | 0.005 | 0.002 | 0.002 | 0.0055 | 0.0024 | 0.002 |
| MELDR-12 | | | | | | | | | 0.58 | 0.0024 | 0.018 | 0.013 | 0.16 | 0.11 | 0.016 | <0.001 |

| Site | Aug-13 | Sep-13 | Oct-13 | Nov-13 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Jul-16 | Aug-16 | Sep-16 | Oct-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELDR-05 | 0.03 | 0.02 | 0.028 | 0.014 | 0.028 | 0.021 | 0.018 | 0.03 | 0.02 | 0.015 | 0.01 | 0.011 | 0.016 | 0.029 | 0.04 | 0.028 |
| MELDR-02 | 0.02 | 0.02 | 0.012 | 0.011 | 0.021 | 0.012 | 0.01 | 0.008 | 0.009 | 0.016 | 0.012 | 0.015 | 0.005 | 0.028 | 0.021 | 0.019 |
| PSDTBCMD | | | | | | | | | 0.014 | 0.019 | 0.015 | 0.013 | 0.013 | 0.025 | 0.025 | 0.02 |
| MELDR-13 | | | 0.019 | 0.008 | 0.028 | 0.011 | 0.012 | 0.008 | 0.01 | 0.017 | 0.007 | 0.015 | 0.007 | 0.025 | 0.021 | 0.022 |
| MELDR-14 | | | 0.008 | 0.005 | 0.02 | 0.01 | 0.005 | 0.004 | 0.008 | 0.014 | 0.005 | 0.014 | 0.008 | 0.03 | 0.019 | 0.013 |
| MELDR-06 | 0.02 | 0.01 | 0.015 | 0.0081 | 0.032 | 0.011 | 0.01 | 0.008 | 0.011 | 0.015 | 0.006 | 0.014 | 0.008 | 0.066 | 0.022 | 0.015 |
| MELDR-07 | | 0.12 | 0.002 | 0.001 | 0.048 | 0.013 | 0.004 | 0.003 | 0.18 | 0.13 | 0.01 | 0.014 | 0.2 | 0.17 | 0.099 | 0.019 |
| MELDR-08 | | | | | | | | | 0.038 | 0.029 | 0.023 | 0.021 | 0.043 | 0.042 | 0.038 | 0.034 |
| MELDR-09 | | | | | | | | | 0.011 | 0.015 | 0.012 | 0.011 | 0.009 | 0.026 | 0.019 | 0.018 |
| MELDR-10 | 0.02 | 0.013 | 0.007 | 0.003 | 0.03 | 0.009 | 0.006 | 0.007 | 0.016 | 0.02 | 0.006 | 0.008 | 0.019 | 0.026 | 0.021 | 0.021 |
| MELDR-11 | 0.003 | 0.004 | 0.001 | 0.001 | 0.003 | 0.003 | 0.003 | 0.002 | 0.004 | 0.008 | 0.002 | 0.003 | 0.008 | 0.017 | 0.009 | 0.003 |
| MELDR-12 | 0.1 | 0.002 | 0.003 | 0.002 | 0.002 | 0.003 | 0.005 | 0.008 | 0.003 | 0.011 | 0.018 | 0.009 | 0.24 | 0.11 | 0.029 | 0.013 |

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ADJUSTED TRIGGER VALUE

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value

Concentration BELOW ADJUSTED trigger value

Highest concentration of the year

Concentration < LOR

NO sample taken

# 9. Metals in sediment

Refer to **Tables D-36 to D-45 in Appendix D** for all sediment metal concentration data collected in the Melville Bull Creek catchments in the 2016. **Table F-1, Appendix F** outlines potential sources of these metals.

It is difficult to analyse and compare the results found over the duration of sampling because of the variation in flows from one year to the next, meaning that sites frequently could not be sampled due to a lack of water flowing or disconnection between pools. In other cases, the nature of the substrate (rock, gravel) prevented the collection of sediment samples at some sites.

For all graphs, a value equal to half the limit of reporting was substituted for those occasions where concentrations were recorded as 'below the laboratory limit of reporting' which is a standard technique to allow these 'unknown' values to be represented graphically and to differentiate them from concentrations equal to the limit of reporting.

Concentrations of metals varied spatially however sites 5, PSDTCBMD, 13, 7 and 10 (John Creaney Park, Bull Creek MD, Brentwood drain, Booragoon Lake outlet and Frederick Baldwin respectively) recorded some of the highest concentrations of some of the tested metals, some even exceeding the ANZECC low trigger values (TV). In particular site 13 (Brentwood drain) recorded the highest concentrations in the catchment of total chromium (exceeding the low TV), total copper (exceeding the low TV), total nickel (exceeding the low TV) and total zinc (exceeding the low TV). Site 13 also exceeded the low TV for total lead along with sites 5, 7, 8 and 10.

It is important to note that the sample location of site 13 was changed in 2016 due to recent upgrades to the drain as part of the Brentwood Living stream project. The on ground works resulted in a change to the water flow path, leading to new deposition of material near the newly established drain outfall of Brentwood Main Drain. The opportunity was taken to move site 13 to this position to sample this deposited material. This newly deposited material was observed to be mottled and reddish brown in colour.

## 9.1 Aluminium

No guideline currently exists for aluminium concentrations in sediment; therefore, it is difficult to gauge the severity of any potential impact arising from the concentrations recorded in the sediment of the Bull Creek catchment, in terms of human and ecosystem health. Aluminium concentrations in sediment were varied across the catchment (**Figure 9.1-1** and **Table D-36, Appendix D**). The highest concentration of 57,000 mg/kg was recorded at PSDTBCMD (Bull Creek main drain) followed by site 13 (Brentwood Drain) which recorded 54,000 mg/kg. The lowest concentration of 730 mg/kg was recorded at site 16 (Bateman Park).

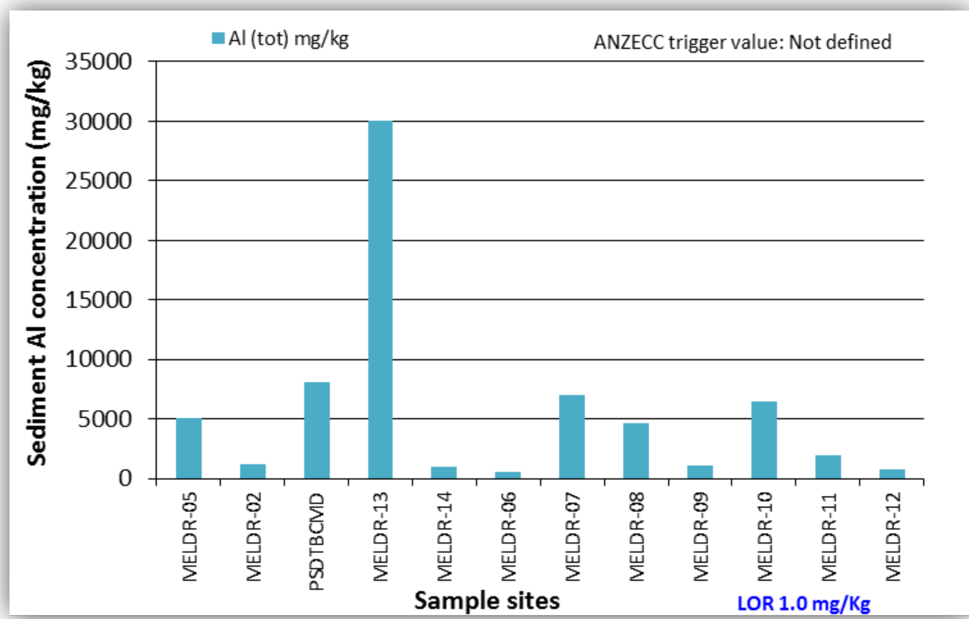


**Figure 9.1-1: Total aluminium concentrations (mg/kg) in the sediment of the Melville Bull Creek catchments in 2016.**

**Table 9.1-1** shows the total aluminium concentrations in sediment recorded in the last four years of monitoring of the Melville Bull Creek catchments. Site 13 (Brentwood drain) interestingly recorded the highest sediment total aluminium concentration in the catchment for the whole four year monitoring period in 2016, whereas in other years this site has recorded relatively low concentrations, and the lowest concentration in the catchment in 2013. This may possibly be due to the change in site location in 2016. However, while total and soluble aluminium concentrations (both exceeding the freshwater protection trigger value) in water at the site were reasonably high in 2016, 2016 concentrations are similar to those recorded in 2015, indicating the higher sediment concentrations do not appear to be impacting the water column.

Total aluminium concentrations in sediment at PSDTBCMD (Bull Creek main drain) are similar to 2015 (when it recorded the highest concentration in the catchment) following a three year period of increasing concentrations, indicating the possible accumulation of aluminium at this site may have stabilised.

**Table 9.1-1: Records of total aluminium concentrations (mg/kg) in the Melville Bull Creek catchments 2013 - 2016**

| Aluminium (Al) (total sediment) (mg/kg) | | | | |
|---|---|---|---|---|
| ANZECC trigger value: ND | | | | LOR 1.0 mg/Kg |
| Max (red) 8,200 | | Min (blue) 360 | | |
| Site name | Nov-13 | Sep-14 | Oct-15 | Oct-16 |
| MELDR-05 | 2,300 | 1,300 | 630 | 5100 |
| MELDR-02 | 1,400 | 1,500 | 2,100 | 1200 |
| PSDTBCMD | 500 | 1,300 | 8,200 | 8100 |
| MELDR-13 | 360 | 470 | 760 | 30000 |
| MELDR-14 | 560 | 460 | 470 | 1000 |
| MELDR-06 | 620 | 500 | 640 | 510 |
| MELDR-07 | 6,500 | | 2,300 | 7000 |
| MELDR-08 | 3,200 | 2,900 | 5,000 | 4600 |
| MELDR-09 | 1,000 | 1,000 | 720 | 1100 |
| MELDR-10 | 1,100 | 1,500 | 2,200 | 6500 |
| MELDR-11 | 1,100 | | 2,900 | 1900 |
| MELDR-12 | 2,200 | 820 | 1,000 | 720 |
| Highest concentration of the year | | | | |
| Lowest concentration of the year | | | | |

## 9.2 Arsenic

The ANZECC low and high trigger values for arsenic in sediment are 20 and 70 mg/kg respectively (ANZECC and ARMCANZ 2000). Arsenic concentrations in sediments in 2016 were all below the low trigger value (**Figure 9.2-1** and **Table D-37, Appendix D**). The highest concentration of 7.1 mg/kg was recorded at site 7 (Booragoon Lake outlet), which also recorded the highest concentration in 2015 of 20 mg/kg (equal to the low trigger value). Four samples recorded concentrations below the limit of reporting of 0.5 mg/kg at sites 2, 6, 9 and 12 (Brockman Park, Bateman Park and Blue Gum Lake outlet respectively).

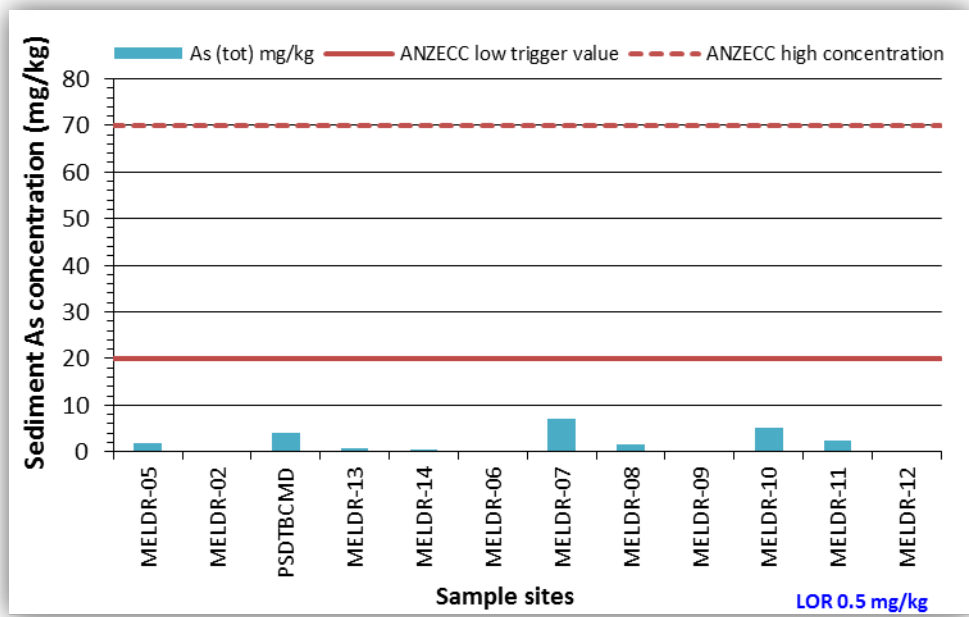


**Figure 9.2-1: Total arsenic concentrations (mg/kg) in the sediment of the Bull Creek catchment in 2016**

**Table 9.2-1** shows the total arsenic concentrations in sediment recorded in the last four years of monitoring of the Melville Bull Creek catchments. Site 7 (Booragoon Lake outlet) has recorded the highest concentrations in the catchment each year that sediment was collected from this site and was the only site to exceed the low trigger value (20 mg/kg in 2015), however concentrations are lower this year than in previous years.

**Table 9.2-1: Records of total arsenic concentrations (mg/kg) in the Melville Bull Creek catchments 2013 - 2016**

Arsenic (As) (total sediment) (mg/kg)

All data in blue were <0.5 (LOR)

ANZECC low TV: 20 mg/kg, high TV: 70 mg/Kg

Max (red) 20 Min (blue) <0.5

| Site name | Nov-13 | Sep-14 | Oct-15 | Oct-16 |
|---|---|---|---|---|
| MELDR-05 | 0.8 | <0.5 | <0.5 | 1.9 |
| MELDR-02 | <0.5 | <0.5 | 0.6 | <0.5 |
| PSDTBCMD | <0.5 | 0.8 | 2.6 | 4.1 |
| MELDR-13 | 0.7 | 0.8 | <0.5 | 0.7 |
| MELDR-14 | <0.5 | <0.5 | <0.5 | 0.6 |
| MELDR-06 | 1.4 | 0.7 | <0.5 | <0.5 |
| MELDR-07 | 18 | | 20 | 7.1 |
| MELDR-08 | 1.4 | 0.8 | 1.4 | 1.5 |
| MELDR-09 | <0.5 | <0.5 | <0.5 | <0.5 |
| MELDR-10 | 1.1 | 1.3 | 1.4 | 5.1 |
| MELDR-11 | 1 | | 2.8 | 2.5 |
| MELDR-12 | 1.4 | <0.5 | 0.7 | <0.5 |

| | |
|---|---|
| Record >LOW Trigger Talue | Concentration < LOR |
| Record >HIGH Trigger Value | NO sample taken |
| Record <LOW Trigger Value | |

## 9.3 Chromium

The ANZECC low and high trigger values for chromium in sediment are 80 and 370 mg/kg respectively (ANZECC and ARMCANZ 2000). Chromium concentrations at all sites in the Melville Bull Creek catchments exceeded all were greater than the limit of reporting value of 0.5 mg/kg (**Figure 8.3-1** and **Table D-38 Appendix D**). The highest concentration in the catchment of 180 mg/kg, recorded at site 13 (Brentwood drain), was the only to exceed the low trigger value. The lowest concentration of 1.2 mg/kg was recorded at sites 14 and 6 (RAAF drain and Bateman Park respectively); site 14 also recorded the lowest concentration in both 2015 and 2014.

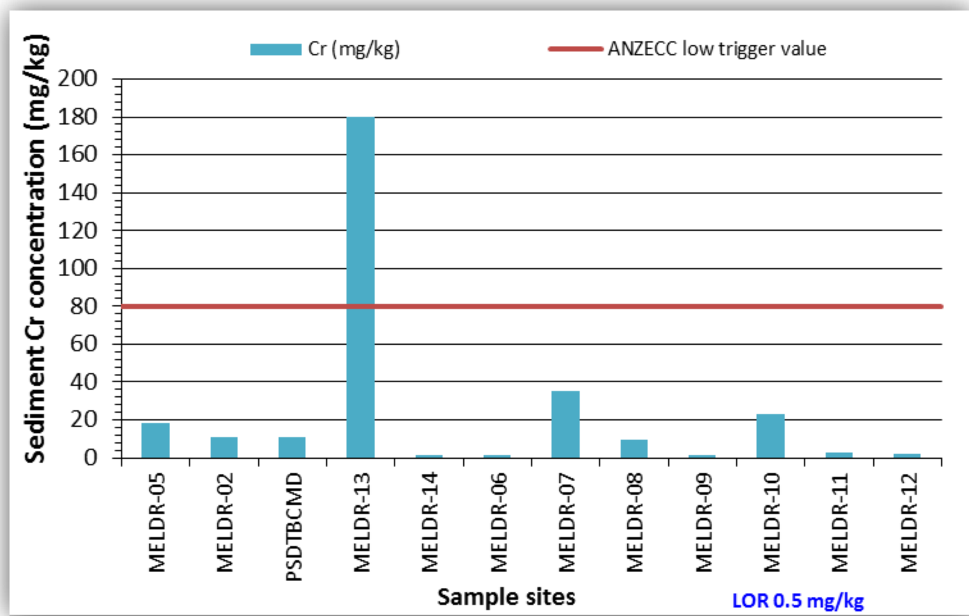


**Figure 9.3-1: Total chromium concentrations (mg/kg) in the sediment of the Melville Bull Creek catchments in 2016**

**Table 9.3-1** shows the total chromium concentrations in sediment recorded in the last four years of monitoring of the Melville Bull Creek catchments. The concentration of 180 mg/kg recorded at site 13 (Brentwood drain) in 2016 is by far the highest concentration recorded in catchment over the four year period. This site has not previously recorded such high concentrations in the past. This may possibly be due to the change in site location in 2016.

However, concentrations of total and soluble chromium in the water at this site in 2016 have remained similarly low to those in 2015 (below adjusted ANZECC freshwater protection trigger values), indicating the higher sediment concentrations do not appear to be impacting the water column.

**Table 9.3-1: Records of total chromium concentrations (mg/kg) in the Melville Bull Creek catchments 2013 - 2016**

**Chromium (Cr) (total sediment) (mg/kg)**
All data in blue w ere <0.5 (LOR)
**ANZECC lower TV: 80 mg/kg, higher TV: 370 mg/kg**
Max (red) 72 Min (blue) 0.9

| Site name | Nov-13 | Sep-14 | Oct-15 | Oct-16 |
|---|---|---|---|---|
| MELDR-05 | 12 | 4.3 | 2 | 18 |
| MELDR-02 | 3.3 | 3.4 | 4.2 | 11.0 |
| PSDTBCMD | 0.9 | 3.1 | 12 | 11 |
| MELDR-13 | 1 | 1.5 | 1.7 | 180.0 |
| MELDR-14 | 1.7 | 1.3 | 1.3 | 1.2 |
| MELDR-06 | 2.1 | 2.5 | 1.6 | 1.2 |
| MELDR-07 | 64 | | 72 | 35 |
| MELDR-08 | 9.4 | 6.5 | 12 | 10 |
| MELDR-09 | 2.8 | 1.7 | 1.5 | 1.6 |
| MELDR-10 | 3.6 | 3.9 | 4.6 | 23.0 |
| MELDR-11 | 4.4 | | 5 | 3 |
| MELDR-12 | 11 | 2.1 | 4.7 | 2.0 |

| | |
|---|---|
| Record >LOW Trigger Talue | Concentration < LOR |
| Record >HIGH Trigger Value | NO sample taken |
| Record <LOW Trigger Value | |

## 9.4 Copper

The ANZECC low and high trigger values for copper in sediment are 65 and 270 mg/kg respectively (ANZECC and ARMCANZ 2000). Copper concentrations in sediment were below the ANZECC low trigger value except at all sites except 13 (Brentwood drain), which recorded the highest concentration in the catchment (95 mg/kg), and site 10 (Frederick Baldwin), which recorded 72 mg/kg (**Figure 9.3-1** and **Table D-39, Appendix D**). Sites 14 and 6 (RAAF drain and Bateman Park respectively) recorded concentrations below the limit of reporting (0.5 mg/kg).

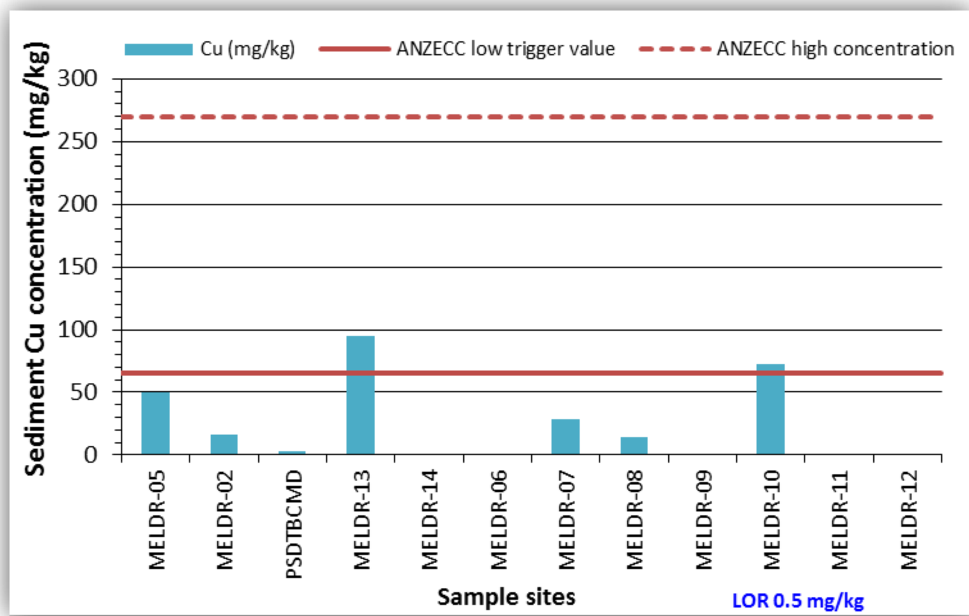


**Figure 9.4-1: Total copper concentrations (mg/kg) in the sediment of the Bull Creek catchment in 2016**

**Table 9.4-1** shows the total copper concentrations in sediment recorded in the last four years of monitoring of the Melville Bull Creek catchments. The 2016 concentration at site 13 (Brentwood drain) is significantly greater than that in 2015. This may possibly be due to the change in site location in 2016.

Similarly, the 2016 concentration of total copper in sediment at site 10 is significantly higher than that in previous years, exceeding the ANZECC low trigger value. For site 10, this may be possibly be accounted for by the greater proportion of fine material in sediment collected in 2016 (23.67% silt, 3.41% clay and described as “fine organic-rich”) to 2015 (coarse/medium sand). Although exceedances of adjusted freshwater trigger value for both total and soluble copper concentrations in water were recorded at site 10 in 2016, concentrations are similar to those in 2015 (when exceedances were also recorded), indicating the higher sediment concentrations do not appear to be impacting the water column.

**Table 9.4-1: Records of total copper concentrations (mg/kg) in the Bull Creek catchment 2013 – 2016**

**Copper (Cu) (total sediment) (mg/kg)**
All data in blue were <0.5 (LOR)
**ANZECC lower TV: 65 mg/kg, higher TV: 270 mg/kg**
Max (red) 250 Min (blue) <0.5

| Site name | Nov-13 | Sep-14 | Oct-15 | Oct-16 |
|---|---|---|---|---|
| MELDR-05 | 20 | 11 | 4.3 | 50.0 |
| MELDR-02 | 7.9 | 3.6 | 7.0 | 16.0 |
| PSDTBCMD | <0.5 | 4.2 | 1.3 | 2.4 |
| MELDR-13 | <0.5 | 0.7 | <0.5 | 95.0 |
| MELDR-14 | <0.5 | 0.8 | 0.8 | <0.5 |
| MELDR-06 | 0.9 | 2.1 | 0.5 | <0.5 |
| MELDR-07 | 38 | | 250.0 | 28.0 |
| MELDR-08 | 13 | 10 | 16.0 | 14.0 |
| MELDR-09 | <0.5 | 0.7 | 1.2 | 1.2 |
| MELDR-10 | 4.9 | 8 | 7.3 | 72.0 |
| MELDR-11 | 2.6 | | 1.3 | 1.0 |
| MELDR-12 | 11 | 3.2 | 4.2 | 1.2 |

| | |
|---|---|
| Record >LOW Trigger Talue | Concentration < LOR |
| Record >HIGH Trigger Value | NO sample taken |
| Record <LOW Trigger Value | |

## 9.5 Iron

No guideline currently exists for iron concentrations in sediment; therefore, it is difficult to gauge the severity of any potential impact arising from the concentrations recorded in the sediment of the Melville Bull Creek catchments, in terms of human and ecosystem health. In 2016 iron concentrations in sediment were varied (**Figure 9.5-1** and **Table D-40, Appendix D**). The highest concentration of 57,000 mg/kg was recorded at PSDTBCMD (Bull Creek MD) (which also recorded the highest concentration in 2015) followed by 54,000 mg/L at site 13 (Brentwood drain) and the lowest concentration of 180 mg/kg was at site 9 (Quenda Lake outlet) (which also recorded the lowest concentration in 2015).

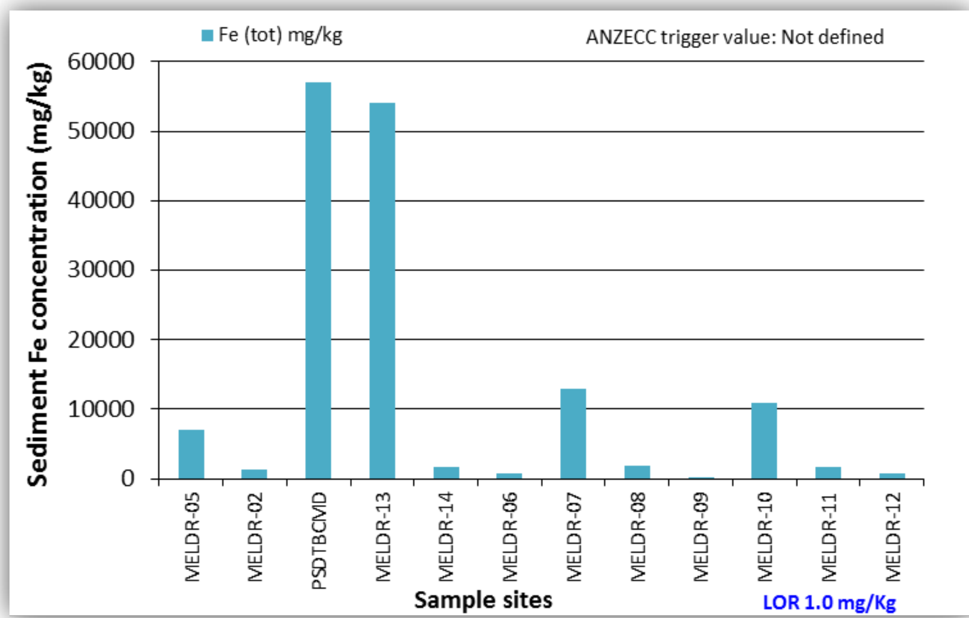


**Figure 9.5-1: Total iron concentrations (mg/kg) in the sediment of the Melville Bull Creek catchments in 2016**

**Table 9.5-1** shows the total iron concentrations in sediment recorded in the last four years of monitoring of the Melville Bull Creek catchments. The concentration at PSDTBCMD (Bull Creek main drain) in 2016, while still the highest in the catchment, was similar to 2015 following a three year period of increasing concentrations, indicating the possible accumulation of iron at this site may have stabilised.

Site 13 (Brentwood drain) recorded a significantly higher concentration of total iron in sediment in 2016 than in previous years. This may possibly be due to the change in site location in 2016. However, while total and soluble iron concentrations in water at the site were reasonably high in 2016 (both exceeding the interim trigger value), 2016 concentrations were similar to those recorded in 2015, indicating the higher sediment concentrations do not appear to be impacting the water column.

**Table 9.5-1: Records of total iron concentrations (mg/kg) in the Bull Creek catchment 2013 - 2016**

**Iron (Fe) (total sediment) (mg/kg)**

**ANZECC trigger value: ND** LOR 1.0 mg/Kg

Max (red) 56,000 Min (blue) 85

| Site name | Nov-13 | Sep-14 | Oct-15 | Oct-16 |
|---|---|---|---|---|
| MELDR-05 | 6,200 | 3,400 | 1,700 | 7000 |
| MELDR-02 | 3,000 | 3,500 | 4,000 | 1400 |
| PSDTBCMD | 810 | 3,700 | 56,000 | 57000 |
| MELDR-13 | 1,800 | 2,700 | 760 | 54000 |
| MELDR-14 | 650 | 560 | 620 | 1700 |
| MELDR-06 | 3,400 | 2,500 | 1,200 | 730 |
| MELDR-07 | 17,000 | | 17,000 | 13000 |
| MELDR-08 | 2,100 | 1,500 | 2,100 | 1800 |
| MELDR-09 | 85 | 170 | 350 | 180 |
| MELDR-10 | 3,300 | 3,900 | 3,600 | 11000 |
| MELDR-11 | 1,100 | | 3,000 | 1700 |
| MELDR-12 | 3,700 | 880 | 1,400 | 850 |

Highest concentration of the year

Lowest concentration of the year

## 9.6 Lead

The ANZECC low and high trigger values for lead in sediment are 50 and 220 mg/kg respectively (ANZECC and ARMCANZ 2000). Lead concentrations in sediment were varied with four sites, 5, 13, 7, 8 and 10 (John Creaney Park, Brentwood drain, Booragoon Lake outlet, Piney Lakes outlet and Frederick Baldwin respectively) recording concentrations exceeding or equal to the low trigger value (**Figure 9.6-1** and **Table D-41, Appendix D**). Site 10 (Frederick Baldwin) recorded the highest concentration of 200 mg/kg, followed by site 13 (Brentwood drain) which recorded a concentration of 170 mg/kg. The lowest concentration of 1.2 mg/kg was recorded at site 6 (Bateman Park).

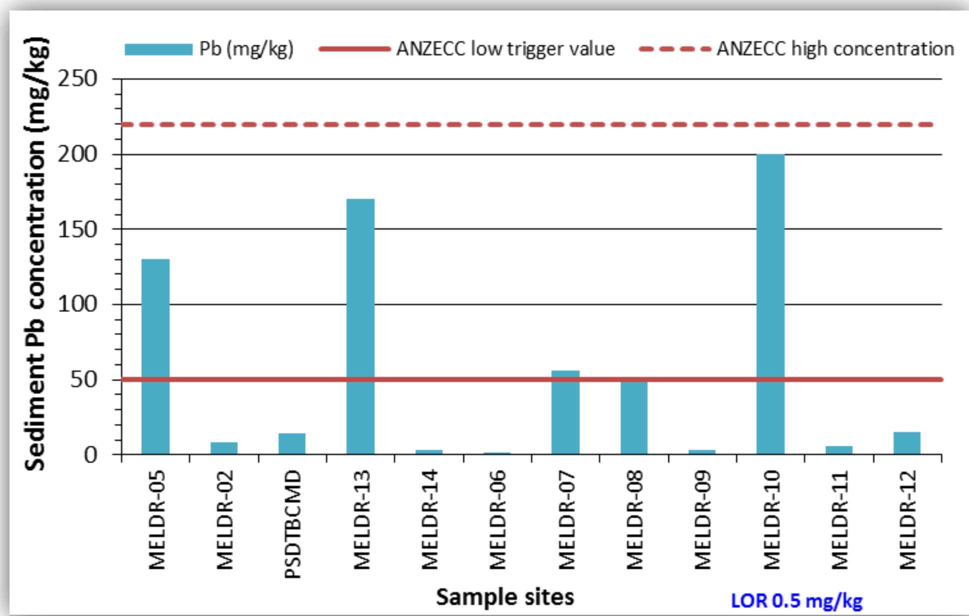


**Figure 9.6-1: Total lead concentrations (mg/kg) in the sediment of the Melville Bull Creek catchments in 2016**

**Table 9.6-1** shows the total lead concentrations in sediment recorded in the last four years of monitoring of the Melville Bull Creek catchments. While also recording concentrations exceeding the low trigger value in both 2014 and 2015, site 10 (Frederick Baldwin) recorded a concentration almost four times higher in 2016. Similarly, site 5 recorded a concentration of almost ten times higher in 2016 than in 2015 (when the concentration was below the trigger value). At both sites, this may be possibly be accounted for by the greater proportion of fine material in sediment collected in 2016 (23.67% silt, 3.41% clay and 28.22% silt, 4.48% clay at sites 10 and 5 respectively) to 2015 (coarse/medium sand and medium/coarse sand at sites 10 and 5 respectively). Both sediments were also described as “organic” in 2016.

Also, the 2016 concentration of total lead in sediment at site 13 (Brentwood drain), exceeding the ANZECC low trigger value, is significantly higher than that in previous years when no exceedances were recorded. This may possibly be due to the change in site location in 2016. However, concentrations of total and soluble lead in the water in 2016 have remained similarly low to those in 2015 (below the ANZECC freshwater protection trigger value) at both sites 10 and 13, indicating the higher sediment concentrations do not appear to be impacting the water column.

**Table 9.6-1: Records of total lead concentrations (mg/kg) in the Bull Creek catchment 2013 - 2015**

**Lead (Pb)(total sediment) (mg/kg)**
All data in blue w ere <0.5 (LOR)
**ANZECC low TV: 50 mg/kg, high TV: 220 mg/kg**
Max (red) 220 Min (blue) 1.7

| Site number | Nov-13 | Sep-14 | Oct-15 | Oct-16 |
|---|---|---|---|---|
| MELDR-05 | 220 | 80 | 14 | 130 |
| MELDR-02 | 8.6 | 4.5 | 20 | 8.5 |
| PSDTBCMD | 4.2 | 29 | 9.6 | 14 |
| MELDR-13 | 2.3 | 21 | 2.1 | 170 |
| MELDR-14 | 7.4 | 8.3 | 9.2 | 3.5 |
| MELDR-06 | 6.5 | 5.5 | 2.2 | 1.2 |
| MELDR-07 | 120 | | 50 | 56 |
| MELDR-08 | 44 | 36 | 66 | 50 |
| MELDR-09 | 1.7 | 2.9 | 7.7 | 3.5 |
| MELDR-10 | 48 | 54 | 54 | 200 |
| MELDR-11 | 19 | | 8.6 | 5.7 |
| MELDR-12 | 150 | 12 | 59 | 15 |

| | |
|---|---|
| Record >LOW Trigger Talue | Concentration < LOR |
| Record >HIGH Trigger Value | NO sample taken |
| Record <LOW Trigger Value | |

## 9.7 Mercury

The ANZECC low and high trigger values for mercury in sediment are 0.15 and 1.0 mg/kg respectively (ANZECC and ARMCANZ 2000). Mercury concentrations in sediment were all below the ANZECC low trigger value except at site 7 where a concentration of 0.2 mg/kg (equal to the low trigger value) was recorded (**Figure 9.7-1** and **Table D-42, Appendix D**). Seven sites recorded concentrations below or equal to the limit of reporting of 0.1 mg/kg.

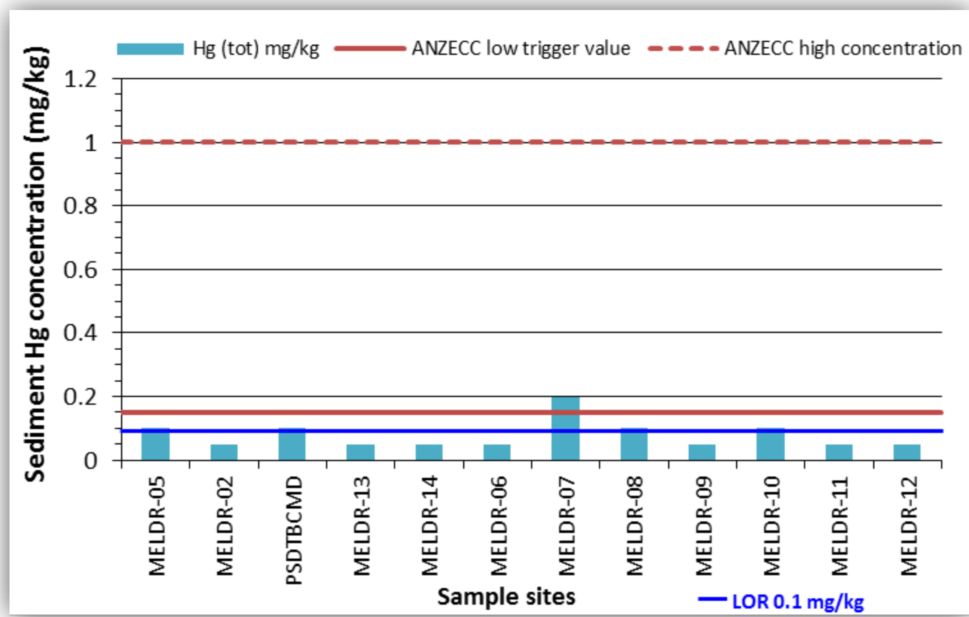


**Figure 9.7-1: Total mercury concentrations (mg/kg) in the sediment of the Melville Bull Creek catchments in 2016**

**Table 9.7-1** shows the total mercury concentrations in sediment recorded in the last four years of monitoring of the Melville Bull Creek catchments. It is noteworthy that in 2016 sites 5, PSDTBCMD and 10 (John Creaney Park, Bull Creek main drain and Frederick Baldwin respectively) recorded concentrations exceeding the LOR when they had not previously. Furthermore, site 7 recorded the only concentration exceeding the low trigger value throughout the four year period in in 2016.

**Table 9.7-1: Records of total mercury concentrations (mg/kg) in the Melville Bull Creek catchments 2013 - 2016**

**Mercury (Hg) (total sediment) (mg/kg)**

All data in blue were <0.1 (LOR)

**ANZECC low TV: 0.15 mg/kg, high TV: 1.0 mg/kg**

Max (red) 0.1 Min (blue) <0.1

| Site name | Nov-13 | Sep-14 | Oct-15 | Oct-16 |
|---|---|---|---|---|
| MELDR-05 | <0.1 | <0.1 | <0.1 | 0.1 |
| MELDR-02 | <0.1 | <0.1 | <0.1 | <0.1 |
| PSDTBCMD | <0.1 | <0.1 | <0.1 | 0.1 |
| MELDR-13 | <0.1 | <0.1 | <0.1 | <0.1 |
| MELDR-14 | <0.1 | <0.1 | <0.1 | <0.1 |
| MELDR-06 | <0.1 | <0.1 | <0.1 | <0.1 |
| MELDR-07 | <0.1 | | 0.1 | 0.2 |
| MELDR-08 | <0.1 | <0.1 | 0.1 | 0.1 |
| MELDR-09 | <0.1 | <0.1 | <0.1 | <0.1 |
| MELDR-10 | <0.1 | <0.1 | <0.1 | 0.1 |
| MELDR-11 | <0.1 | | <0.1 | <0.1 |
| MELDR-12 | <0.1 | <0.1 | <0.1 | <0.1 |

| | |
|---|---|
| Record >LOW Trigger Talue | Concentration < LOR |
| Record >HIGH Trigger Value | NO sample taken |
| Record <LOW Trigger Value | |

## 9.8 Nickel

The ANZECC low and high trigger values for nickel in sediment are 21 and 52 mg/kg respectively (ANZECC and ARMCANZ 2000). Nickel concentrations in sediment were varied, with only site 13 (Brentwood drain) recording a concentration equal to the low trigger value (21 mg/kg) (**Figure 9.8-1** and **Table D-43, Appendix D**). Six samples recorded concentrations below the limit of reporting of 1.0 mg/kg.

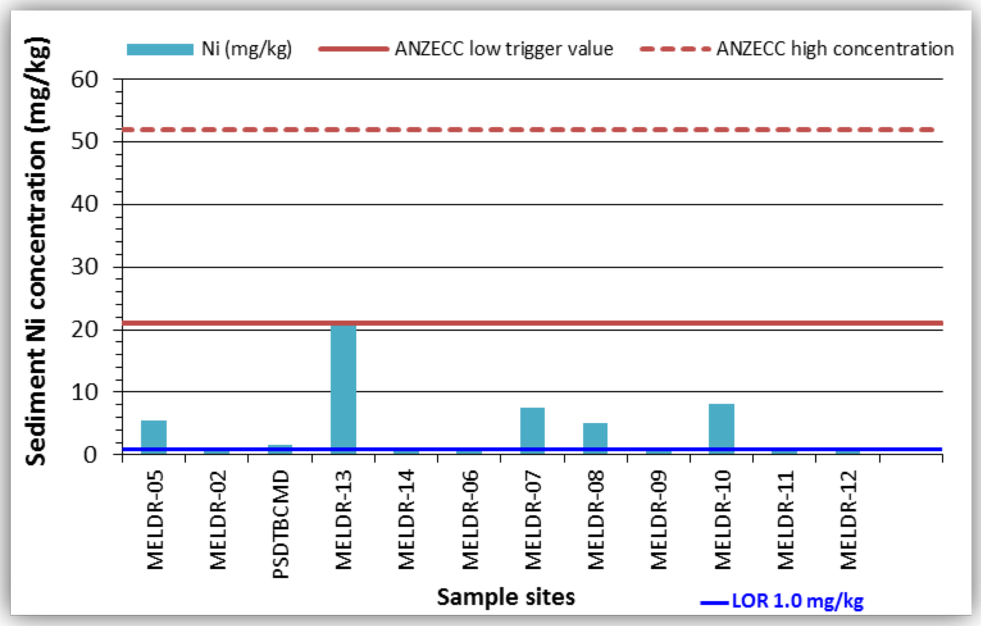


**Figure 9.8-1: Total nickel concentrations (mg/kg) in the sediment of the Melville Bull Creek catchments in 2016**

**Table 9.8-1** shows the total nickel concentrations in sediment recorded in the last four years of monitoring of the Melville Bull Creek catchments. The 2016 concentration at site 13 (Brentwood drain) is significantly greater than that in previous years, when concentrations were all below the LOR. This may possibly be due to the change in site location in 2016. Nickel concentrations were not recorded at site 13 in 2016 or in previous years and as such the effect of this sediment on the water quality at the site cannot be assessed.

**Table 9.8-1: Records of total nickel concentrations (mg/kg) in the Melville Bull Creek catchments 2013 - 2016**

**Nickel (Ni) (total sediment) (mg/kg)**
All data in blue were <1.0 (LOR)
**ANZECC low TV:21 mg/kg, high TV: 52 mg/kg**
Max (red) 31.0 Min (blue) <1.0

| Site number | Nov-13 | Sep-14 | Oct-15 | Oct-16 |
|---|---|---|---|---|
| MELDR-05 | 2.9 | 1.4 | <1.0 | 5.5 |
| MELDR-02 | 1.2 | 1.8 | 2.1 | <1.0 |
| PSDTBCMD | <1.0 | 1.3 | 1.8 | 1.6 |
| MELDR-13 | <1.0 | <1.0 | <1.0 | 21 |
| MELDR-14 | <1.0 | <1.0 | <1.0 | <1.0 |
| MELDR-06 | <1.0 | <1.0 | <1.0 | <1.0 |
| MELDR-07 | 8.2 | | 31 | 7.6 |
| MELDR-08 | 4.8 | 2.7 | 5.5 | 5.1 |
| MELDR-09 | <1.0 | <1.0 | <1.0 | <1.0 |
| MELDR-10 | 1.6 | 1.8 | 2.2 | 8.2 |
| MELDR-11 | 1.3 | | 1.2 | <1.0 |
| MELDR-12 | 2.3 | <1.0 | <1.0 | <1.0 |

| | |
|---|---|
| Record >LOW Trigger Talue | Concentration < LOR |
| Record >HIGH Trigger Value | NO sample taken |
| Record <LOW Trigger Value | |

## 9.9 Selenium

No guideline currently exists for selenium concentrations in sediment; therefore it is difficult to gauge the severity of any potential impact arising from the concentrations recorded in the sediment of the Bull Creek catchment. Selenium concentrations in sediment were all below the limit of reporting of 1.0 mg/kg except at sites 7 (Booragoon Lake outlet) which recorded a concentration of 2.9 mg/kg and site PSDTBCMD (Bull Creek main drain) which recorded a concentration of 1.1 mg/kg (**Figure 9.9-1** and **Table D-44, Appendix D**).

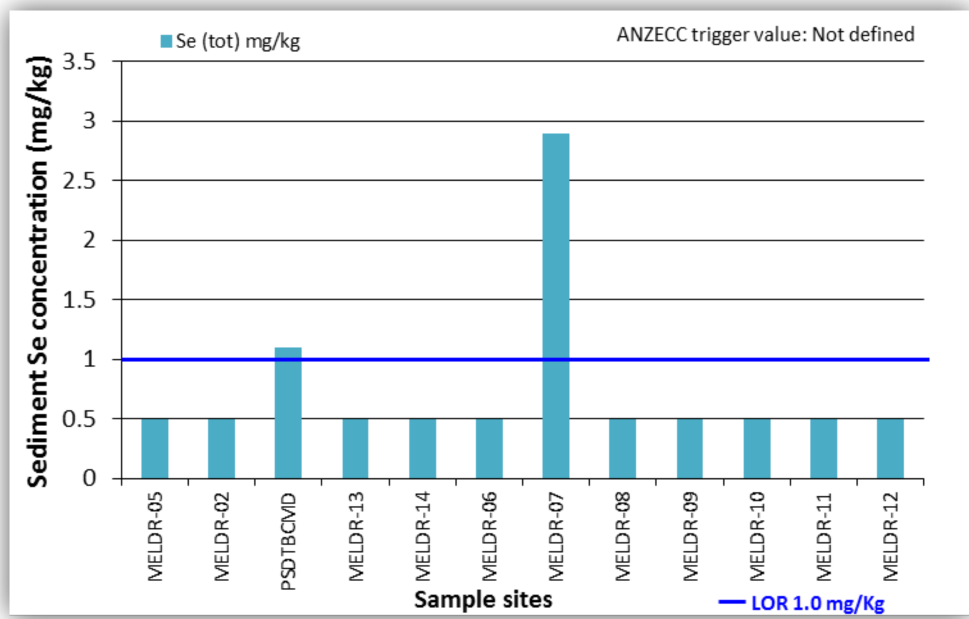


**Figure 9.9-1: Total selenium concentrations (mg/kg) in the sediment of the Melville Bull Creek catchments in 2016.**

**Table 9.9-1** shows the total selenium concentrations in sediment recorded in the last four years of monitoring of the Melville Bull Creek catchments. Similar results have been recorded in each year, with site 7 (Booragoon Lake outlet) recording concentration exceeding the LOR. 2016 was the first year that site PSDTBCMD (Bull Creek main drain) has recorded a concentration exceeding the LOR.

**Table 9.9-1: Records of total selenium concentrations (mg/kg) in the Melville Bull Creek catchments 2013 - 2016**

Selenium (Se) (total sediment) (mg/kg)

ANZECC trigger value: ND LOR 1.0 mg/Kg

Max (red) 2.8 Min (blue) <1.0

| Site name | Nov-13 | Sep-14 | Oct-15 | Oct-16 |
|---|---|---|---|---|
| MELDR-05 | <1.0 | <1.0 | <1.0 | <1.0 |
| MELDR-02 | <1.0 | <1.0 | <1.0 | <1.0 |
| PSDTBCMD | <1.0 | <1.0 | <1.0 | 1.1 |
| MELDR-13 | <1.0 | <1.0 | <1.0 | <1.0 |
| MELDR-14 | <1.0 | <1.0 | <1.0 | <1.0 |
| MELDR-06 | <1.0 | <1.0 | <1.0 | <1.0 |
| MELDR-07 | 2.8 | | 1.3 | 2.9 |
| MELDR-08 | <1.0 | <1.0 | <1.0 | <1.0 |
| MELDR-09 | <1.0 | <1.0 | <1.0 | <1.0 |
| MELDR-10 | <1.0 | <1.0 | <1.0 | <1.0 |
| MELDR-11 | <1.0 | | <1.0 | <1.0 |
| MELDR-12 | <1.0 | <1.0 | <1.0 | <1.0 |

Highest concentration of the year

Lowest concentration of the year

## 9.10 Zinc

The ANZECC low and high trigger values for zinc in sediment are 200 and 410 mg/kg respectively (ANZECC and ARMCANZ 2000). Zinc concentrations in sediment were varied (**Figure 9.10-1** and **Table D-45, Appendix D**). Concentrations of 390 mg/kg and 320 mg/kg recorded at sites 13 and 10 respectively (Brentwood drain and Frederick Baldwin) exceeded the low trigger value. The lowest concentration of 1.4 mg/kg was recorded at Quenda Lake outlet (site 9).

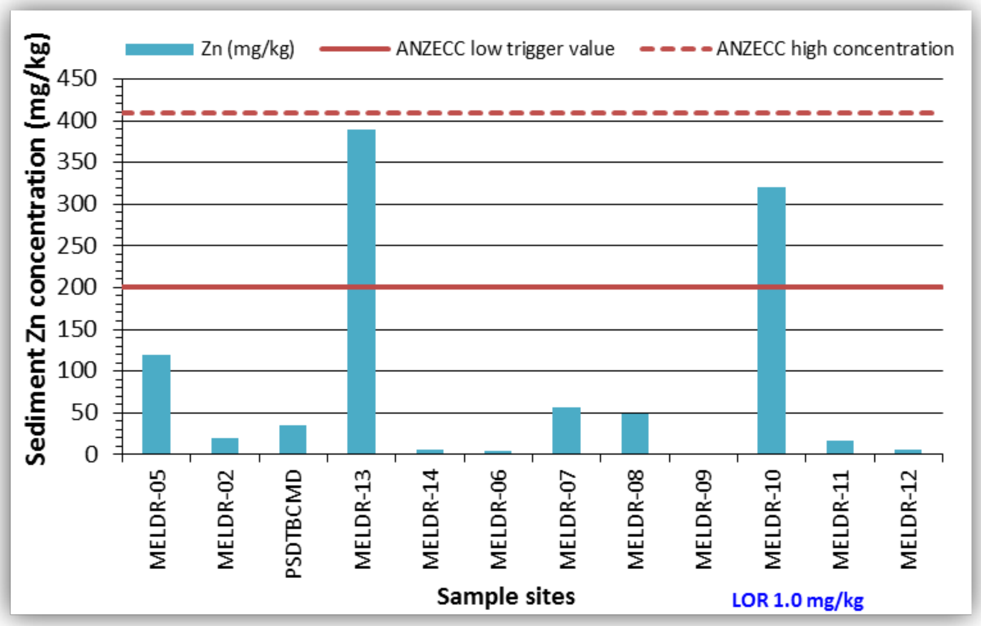


**Figure 9.10-1: Total zinc concentrations (mg/kg) in the sediment of the Melville Bull Creek catchments in 2016**

**Table 9.10-1** shows the three year results for total zinc concentrations (mg/kg) in sediment for Bull Creek catchment. Sites 13 and 10 (Brentwood drain and Booragoon Lake outlet respectively) were the first sites to exceed the low trigger value in the four year sampling period, with concentrations significantly higher than those recorded in previous years at the sites. For site 13, this may possibly be due to the change in site location in 2016. For site 10, this may be possibly be accounted for by the greater proportion of fine material in sediment collected in 2016 (23.67% silt, 3.41% clay and described as "fine organic-rich") to 2015 (coarse/medium sand, described as "fine organic-rich"). Concentrations of total and soluble zinc in the water in 2016 have remained similarly low to those in 2015 (below the ANZECC freshwater protection trigger value) at sites 13, indicating the higher sediment concentrations do not appear to be impacting the water column at this site. Exceedances of total and soluble zinc in water were recorded in 2016 as well as in previous years at site 10, possibly indicating the mobilisation of zinc from the zinc-contaminated sediments present at this site.

**Table 9.10-1: Records of total zinc concentrations (mg/kg) in the Melville Bull Creek catchments 2013 - 2016**

**Zinc (Zn) (total sediment) (mg/kg)**
LOR 1.0 mg/Kg
**ANZECC low TV:200 mg/kg, high TV: 410 mg/kg**
Max (red) 120 Min (blue) <1.0

| Site number | Nov-13 | Sep-14 | Oct-15 | Oct-16 |
|---|---|---|---|---|
| MELDR-05 | 49 | 24 | 20 | 120 |
| MELDR-02 | 26 | 15 | 49 | 19 |
| PSDTBCMD | 3.7 | 22 | 18 | 35 |
| MELDR-13 | 13 | 27 | 6.8 | 390 |
| MELDR-14 | 6.1 | 6.4 | 9.4 | 5.5 |
| MELDR-06 | 14 | 22 | 4.4 | 4.2 |
| MELDR-07 | 95 | | 120 | 57 |
| MELDR-08 | 34 | 25 | 39 | 49 |
| MELDR-09 | 1.0 | <1.0 | 3.7 | 1.4 |
| MELDR-10 | 30 | 39 | 48 | 320 |
| MELDR-11 | 17 | | 13 | 16 |
| MELDR-12 | 37 | 9.9 | 13 | 5.6 |

| | |
|---|---|
| Record >LOW Trigger Talue | Concentration < LOR |
| Record >HIGH Trigger Value | NO sample taken |
| Record <LOW Trigger Value | |

# 10. Particle size analysis

## 10.1 Particle size analysis

Particle size distribution of sediment was grouped into the following size classes according to the Wentworth scale (Wentworth 1992):

- Clay <4 µm
- Silt 4-62 µm
- Fine sand 62-250 µm
- Medium sand 250-500 µm
- Coarse sand 500-2,000 µm
- Gravel >2,000 µm

All sediment samples consisted of particles from the different size categories (see **Table 10.1-1** and **Figure 10.1-1** for details). The dominant fractions for seven of the 12 sites, sites 2, 13, 14, 6, 9, 11 and 12 (Brockman Park, Brentwood drain, RAAF drain, Bateman Park, Quenda Lake outlet, Marmion Reserve and Blue Gum lake outlet respectively) were medium sand and coarse sand. Sediment at sites 5 and 10 (John Creaney Park and Frederick Baldwin respectively) was comprised of silty gravel with some sand, and at sites PSDTBCMD, 7 and 8 (Bull Creek main drain, Booragoon Lake outlet and Piney Lakes outlet respectively) sediment was predominantly comprised of silt with varying fractions of clay, sand and gravel.

The sediment particle size distribution results may explain metal concentrations in some instances. Site PSDTBCMD, which similarly had the finest sediment (57.58% silt and 11.36% clay) also had the highest sediment iron concentrations, although this site had fairly low concentrations of other metals in sediment. Increased concentrations of various metals at site 10 in 2016 as compared to 2015 may be a result of the greater proportion of fine material in sediment collected in 2016 (23.67% silt, 3.41% clay, described as “fine organic-rich”) than 2015 (coarse/medium sand with no silt or clay), or to the possible greater amount of organic material in the sediment, which can strongly bind to some metals. This difference in sediment composition could be due to natural variation in sediments at the site (i.e. sediments were collected from a slightly different place in 2016 than in 2015) or due to changing sediment conditions at the site. The silty sediments recorded at site 7 in both 2016 and 2015 may also explain high selenium concentrations and exceedances of the low trigger value for lead (in both years) and mercury (in 2016). However site 13, which recorded exceedances of low trigger values for chromium, copper, nickel, zinc and lead and significantly higher concentrations of these metals as well as aluminium and iron than in previous years, recorded a very similar sediment particle size distribution in 2016 (60.26% medium sand, 35.80% coarse sand) to 2015.

These results highlight the importance of including particle size analysis to gain a better understanding of the nature of the contamination and potentially help ‘explain’ the high concentrations of these metals both in water and in sediment.

**Table 10.1-1: Particle size analysis results from 2016**

| Site Name | Site Ref No. | Date Collected | Clay % (<4 µm) | Silt % (4-62 µm) | Fine sand % (62-250 µm) | Medium sand % (250-500 µm) | Coarse sand % (500-2,000 µm) | Gravel % (>2,000 µm) | Total % |
|---|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 4.48 | 28.22 | 11.67 | 7.63 | 16.80 | 31.20 | 100.0 |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.00 | 0.00 | 0.87 | 59.43 | 38.00 | 1.70 | 100.0 |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 11.36 | 57.58 | 7.59 | 3.36 | 10.50 | 9.60 | 100.0 |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.00 | 0.00 | 0.94 | 60.26 | 35.80 | 3.00 | 100.0 |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.00 | 0.00 | 1.32 | 46.58 | 52.00 | 0.10 | 100.0 |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.00 | 0.00 | 12.68 | 58.82 | 28.40 | 0.10 | 100.0 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 7.72 | 47.91 | 7.71 | 1.45 | 6.30 | 28.90 | 100.0 |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 5.74 | 40.27 | 11.01 | 8.99 | 26.00 | 8.00 | 100.0 |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 1.77 | 11.78 | 13.64 | 48.91 | 21.80 | 2.10 | 100.0 |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 3.41 | 23.67 | 20.97 | 17.76 | 9.50 | 24.70 | 100.0 |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 1.65 | 4.48 | 4.01 | 33.16 | 56.20 | 0.50 | 100.0 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.95 | 4.32 | 3.70 | 48.52 | 38.80 | 3.70 | 100.0 |

| |
|---|
| Highest particle size % |
| Second highest particle size % |
| Lowest particle size % |

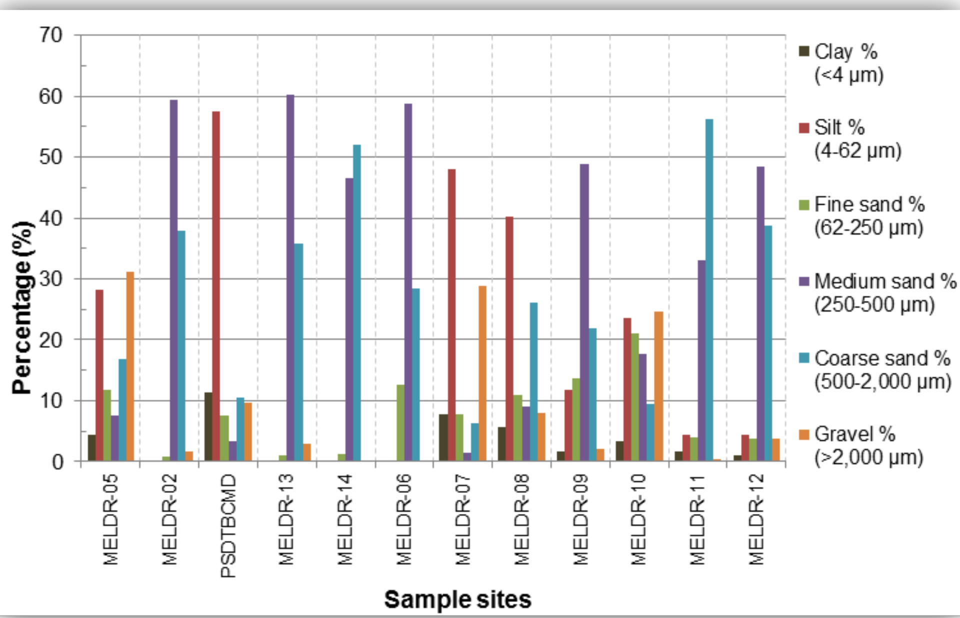


**Figure 10.1-1: Particle size distribution (%) by site in sediment of the Melville Bull Creek catchments in 2016.**

# 11. Discussion and recommendations

This water quality monitoring program is continuing to contribute valid data to the Western Australian water quality database (Water Information Resource - WIR database) which is utilised in the management of the State's water resources and also provides supporting evidence for the City of Melville to prioritise investment in water quality improvement technologies and management practices across the landscape.

The discussion and recommendation section is divided into two segments. The first is a discussion of the key water quality issues in the Melville Bull Creek catchments. The second is recommendations and management actions based on the key findings within the catchment.

## 11.1 Discussion of key issues

### 11.1.1 Drainage branches

The sediment at site 5 recorded lead concentrations exceeding the low ANZECC guideline, as it has done in previous years (but not in 2015). This may be due to the amount of fine material present in the sediment at this site. Although lead concentrations in water did not exceed 95% freshwater protection hardness modified trigger values, under certain conditions (e.g. low pH) it could be released from the sediments and into the water column and have toxic effects on biota within the lake.

High total zinc is present in water at sites 15 and 16 as compared to other sites within the drainage lines. The source of this zinc is unknown.

Also concerning are the very high nitrogen as ammonia/ammonium concentrations in water at site 2 (Brockman Park), both in 2016 and in previous years, which exceed freshwater protection trigger values. Over the last ten years of monitoring this site has recorded excessively high exceeding concentrations of nitrogen as ammonia/ammonium, fluctuating between 40 to 100 times greater than the trigger value for lowland rivers. While concentrations were above lowland rivers trigger values at upstream site 5 (John Creaney Park), the significantly higher concentrations at site 2 suggest that there is a source of nitrogen between sites 5 and 16 (downstream Elizabeth Manion Park), and site 2. One possible source of this nitrogen could be the portion of the Bull Creek main drainage line running through the compensation basin at Trevor Gribble Park. This water has been anecdotally noted to have an anoxic smell, and it is possible that this water may intersect with groundwater (often a source of ammonia). The sandy banks of the compensation basin may also contribute sediment to the drainage line, which may be a source of nutrients. As Bull Creek downstream of site 2 has undergone significant rehabilitation within previous years, this high ammonia could potentially have negative effects on biota living within the creek. As the odour threshold of ammonia is 1.5 mg/L (NHMRC 2016), these ammonia levels may be causing an odour that could be unpleasant for users of Brockman Park.

This high nitrogen as ammonia/ammonium at site 2 may be contributing to the high total nitrogen at the three sites closest to the river along Bull Creek main drain (2 (Brockman Park), ROSSTAFE (Brockman Park inlet) and PSDTBCMD (Bull Creek main drain)). Again these high concentrations have been recorded in water both in 2016 and in previous years. These high nitrogen concentrations are of concern, as this nitrogen will eventually enter the Canning River and could potentially contribute to eutrophication there. The low oxygen in the downstream portion of the Bull Creek main drain sites could be reducing denitrification of the high ammonia concentrations, therefore nitrogen cycling and eventual loss of nitrogen from the water.

The sediment at site 13 (Brentwood drain) recorded exceedances of low trigger values for five metals in the 2016 sampling (chromium, copper, lead, nickel and zinc) and had relatively high concentrations of aluminium and iron, in contrast in 2015 where metal concentrations were relatively low. This may be due to the change in sample location of site 13 due to recent upgrades to the drain as part of the Brentwood Living stream project. Sediment near the newly established drain outfall of Brentwood Main Drain was sampled, which was observed to be mottled and reddish brown in colour. Concentrations of metals in water at this site were not particularly high except for total and soluble iron and aluminium, however if water quality were to decline at this site (for example if dissolved oxygen concentrations or pH values decreased) these metals may be released into the water column and could potentially enter the Canning River.

Available forms of total nitrogen ($NO_x$-N and $NH_3/NH_4^+$-N) in water were also high in 2016 at all sites along the Brentwood drainage line (13 (Brentwood drain), 14 (RAAF drain) and 6 (Bateman Park)). Total nitrogen and $NO_x$ concentrations were higher in these sites in 2016 than in 2015.

### 11.1.2 Melville lakes

pH values at sites 7, and 12 (Booragoon Lake outlet and Blue Gum Lake outlet) and to a lesser degree site 8 (Piney Lakes outlet) in July to September were very low, and have also been low in previous years. pH was also slightly low at site 9 (Quenda Lake outlet), and has been consistently low in the last three years. These low pH levels are of concern as low pH can increase the toxicity of some metals, and can also have a direct negative effect on biota. The cause of the low pH in these winter to early spring months may be due to oxidation of acid sulfate soils present at the lakes and acidification of the overlying lake waters due to generally lowered lake levels and seasonally fluctuating water levels. Acid sulfate soils are often associated with wetland sediments (DER 2015b), and lowered lake levels are likely to be as a result of both reduced stormwater flow and lower groundwater levels in the Jandakot Mound resulting from lower rainfall in recent years (Natural Area Consulting 2012).

For example, depth to groundwater at Booragoon Lake in 1997 was between 0 - 1 m (Waters and Rivers Commission 1997) and in 2004 was 1 – 2 m (Department of Environment 2004b), and low lake water levels relative to other sampling years were observed at Piney Lakes in 2015. Both existing and potential acid sulfate soils were found to be present in the sediments at Booragoon Lake when sampled in 2012 (Oldweather 2012), whereas in 2015 groundwater in bores surrounding the Lake, which were mainly installed in (relatively alkaline) Tamala limestone, was found to be slightly low (5.4 – 6.3) but not suggestive of acid sulfate soil oxidation (Geo and Hydro Environmental Management Pty Ltd 2015), indicating Lake acidity is likely to be originating from within the lake and not surrounding groundwater.

Low pH can also be caused by the presence of high concentration of tannins in the water. Tannins are organic compounds derived from plant materials that give water a brown (often described as "tea coloured") hue, and break down into humic and fulvic acids. The presence of excess plant material in the water is likely to result in the production of high concentrations of tannins. Tannin staining was noted at various sampling months at sites 8, 9 and 12. The pH increases in middle to late spring at these sites may be partially due to increased algal growth and therefore increased photosynthesis.

Particularly high concentrations of soluble and total metals (aluminium, copper, iron, zinc (both sites) and lead (site 12 only)) in water were recorded at sites 7 and 12 (Booragoon Lake and Blue Gum Lake), especially in July, and have occurred in previous years. These metals may be entering the lakes via stormwater, or from surrounding groundwater. For example, Geo and Hydro Environmental Management Pty Ltd (2015) found that groundwater in some bores surrounding Booragoon Lake contained very high concentrations of total iron (up to 62 mg/L) and a couple of wells containing high total aluminium (up to 0.6 mg/L). Regardless of origin, the low pH values at these sites would promote release of these metals stored in sediment into the water column, and it may even be the case that the acidic lakes may even be a source of metals contributing to groundwater contamination (Oldweather 2012).The high concentrations of these metals could be toxic to the biota within these lakes. However, copper, lead and zinc all complex with dissolved organic material in water, which significantly reduces (copper and zinc) or is likely to reduce (lead) the toxicity of these metals (ANZECC and ARMCANZ 2000). There appears to be relatively high concentrations of dissolved organic nitrogen (an indicator of dissolved organic material) in waters at these sites (see **Section 6.1.4**), and thus these high metal concentrations recorded may not actually be pose a risk to biota. Metal speciation testing could determine the proportion of labile (not complexed) metals complexed to organic material, and thus their actual potential for toxicity (CSIRO n.d.); however this speciation testing is relatively costly. High concentrations of lead and mercury were also found in sediments at site 7, which could potentially be released into the water column in certain conditions.

Sites 7 and 12 (Booragoon Lake and Blue Gum Lake) also recorded high concentrations of total nitrogen (mainly ammonia/ammonium and organic nitrogen) in spring. Furthermore, although total phosphorus concentrations were high on all four sampling occasions, particularly high concentrations in spring were due to large spring increases in soluble reactive phosphorus. These high nutrient concentrations in spring have also occurred in previous years and are likely to be a result of the large numbers of waterbirds (and therefore faecal material) in these lakes in spring. The combination of high soluble phosphorus and nitrogen is likely to be the cause of the algae observed in these lakes.

The pH at site 11 (Marmion Reserve) was very high in October (10.02) and has often be high in late spring and summer months. In October 2016 this may be due to the high amount of algae (both macroalgae and phytoplankton) observed at the site at this time photosynthesising, which would also explain the very high dissolved oxygen concentration observed. This prolific algal growth has occurred despite total nitrogen and phosphorus concentrations being below ANZECC wetland guideline values, although nitrogen as ammonia/ammonium was also high in July.

The sediment at site 10 (Frederick Baldwin) recorded significantly higher concentrations of all analysed metals except for selenium than in previous years, and recorded exceedances of the ANZECC low trigger value for copper, lead and zinc. This may be a result of the greater proportion of fine material in sediment collected in 2016 (23.67% silt, 3.41% clay, described as "fine organic-rich") than 2015 (coarse/medium sand with no silt or clay), or to the possible greater amount of organic material in the sediment, which can strongly bind to some metals. This difference in sediment composition could be due to natural variation in sediments at the site (i.e. sediments were collected from a slightly different place in 2016 than in 2015), due to changing sediment conditions at the site or possibly due to the oxidation of acid sulfate soils in sediments. As waters at this site are relatively soft, therefore increasing the toxicity of lead, copper and zinc in water, these exceeding sediment concentrations are concerning. It is noted that while iron and aluminium water concentrations were low, this site also recorded concentrations of zinc and copper in water exceeding 95% freshwater protection due to its relatively soft water.

## 11.2 Recommendations

These recommendations represent a collective of general and specific site based recommendation for the improvement of the water quality in the catchment and also general actions for integrated catchment management.

### 11.2.1 General recommendations

1. Continue monitoring the water and sediment quality at all sites in the catchment to generate more interpretable data about the condition of the catchment, to determine patterns and changes that may be happening over time and to detect anomalies in the concentrations of parameters that may occurring in response to events.
2. Exceedance of a trigger value, for any parameter, indicates that there is the potential for an impact to occur, management responses should be oriented to minimise or alleviate those impacts before water flows to the Canning River.
3. The high concentrations of metals and nutrients recorded at some sites are of concern and should warrant further investigation along with some focus on Light Industry Audits in the catchment area by local government and or Department of Environment Regulation (DER) Pollution Response to address the ongoing problems.
4. It is understood that City of Melville parks and gardens staff have undertaken SERCUL's Fertilise Wise training. The best management practices taught as part of this training should be implemented when managing parks, including optimal timing of fertiliser application and calculation of optimal rates of fertiliser application.
5. Continue with the implementation of Water Quality Improvement Plan (WQIP) including the water and sediment quality monitoring on the East side of the catchment located within the City of Canning to have a better understanding of the catchment as a whole and its patterns.
6. Prepare an analysis of the findings for the ten-year water quality monitoring program to gain a more comprehensive understanding of the results, rank sites, identify 'hot spots' and align them to specific management actions aimed at improving the water quality in the catchment.
7. Low oxygen saturations within the wetlands, lakes and waterways of this catchment are common. This is a consistent finding with heavily piped catchments and/or wetlands with excessively high organic loads (either from animal waste or vegetation decomposition). It is recommended that wherever possible open water inlets and if possible outlets should flow over loosely arrange rocky substrate that provides some oxygenation during medium to high flow events. This, along with open water areas that allow wind driven oxygen transfer and appropriate wetland designs which allow for seasonal wetting/drying processes to assist microbial activity (breaking down organic matter) may provide a collective improvement in oxygenation over time.
8. Continue with particle size analysis (to be reported on Wentworth scale) to enable better interpretation of metals concentrations in sediment samples by gaining a better understanding about the available surface area to which metals can bind. A smaller particle size equates to a relatively greater surface area available to metals to bind to, which can 'explain' higher concentrations in some cases. A sediment that is more coarse (sand and

gravel) has a relatively smaller surface area and is more likely to release toxicants more readily than finer materials (silts and clays) which have a relatively greater surface area and therefore binding capacity to metals.

### 11.2.2 Integrated catchment management actions:

1. Support the implementation of the 2015-2017 Light Industry Audit Program of DPAW RED, DER and local governments. Audit businesses in the industrial area and analyse the results as well as conduct a desk top study to identify old landfill sites and or other contaminated sites that may now be leaching contaminants. The City's health department is currently involved in the program with a focus on the Myaree commercial/light industrial area.
2. As proposed in the WQIP for Bull Creek Catchment, review historical and current land use data, in particular contaminated and old tip sites, to identify potential sources of nun-nutrient contaminants, prioritise areas requiring further investigation and identify management options;
3. Implement nutrient stripping strategies to improve the water quality of the Bull Creek catchment and the quality of the water which is discharged to the Canning River.
4. As recommended in the Stormwater Management Manual for Western Australia (2004) to coordinate road sweeping with maintenance activities (i.e. road or construction works) and specific events (i.e. storm events or public major events). Best results can be achieved by focusing on 'hot spots' rather than routinely sweeping all streets;
5. Continue to regularly remove accumulated pollutants (e.g. sediment and gross pollutants) from nodes in the stormwater network, such as pits and infiltration sumps;
6. Incorporate water sensitive urban design techniques into management practices when upgrading the catchment (e.g. permeable paving, bio-retention swales, pipe-less streets and rain gardens);
7. Continue to ensure the use of herbicides and insecticides on roadsides in undertaken as per manufacturer's recommendations, and ensure maintenance staff use appropriate handling and application procedures for these materials;
8. Continue to regularly conduct soil test and leaf tissue analysis on turf areas before applying fertilisers;
9. Continue to use native vegetation along roadsides, paths and in swales.
10. Continue to revegetate natural areas and remove weeds to increase biodiversity.
11. The following issues should be considered when formulating ASS environmental management strategies:
    a) The sensitivity and environmental values of the receiving environment. This includes the conservation, protected or other relevant status of the receiving environment (e.g. wetlands, Marine Parks, etc.).
    b) Whether groundwater and/or surface water are likely to be directly or indirectly affected.
    c) The heterogeneity, geochemical and textural properties of soils on site.
    d) The management and planning strategies of local government and/or state government.

The following examples of structural best management practices to be incorporated into management plans where appropriate:

- Onsite detention;
- Stormwater infiltration systems;
- Buffer strips;
- Pollutant traps;
- Grass or reed swale drains;
- Broken or flush kerbing;
- Pervious paving materials;
- Nutrient intervention installation
- Native landscaping; and
- Ponds and wetlands including implementation of living streams with the involvement of the community to provide multiple positive effects by increasing public awareness and further improving water quality.

The following examples of non-structural best management practices (BMP) to be continued:

- Park and gardens officers attend fertilise wise fertiliser training to learn current fertilise BMP;
- Education of residents on appropriate plant species, fertiliser and water use (Piney programs, brochures, mail outs and work with community groups);
- Review the ongoing street sweeping regimes to reduce the impact of road run off on the water quality of the stormwater system.
- Improve waste and stormwater management for industrial premises by working with relevant regulatory authorities to ensure minimum standards are met; and
- Reduce waste and stormwater contamination by implementing the unauthorised discharge regulations (UDR's) and Local Government Light Industry Management Program using industrial environmental trained compliance officers.

### 11.2.3 Recommendations to address key issues

**High lead concentration in sediment at site 5 (John Creaney Park)**

a. Major basin redesign and restoration is required including the installation of a gross pollutant trapping system to prevent the continued contamination of John Creaney wetland and the downstream receiving environment which includes Bull Creek Park and the Canning River. As part of this restoration, consider dredging and disposing of any silty and/or possibly organic sediment at this site.

**High total zinc concentrations in water at sites 15 (John Creaney Park inlet) and 16 (downstream Elizabeth Manion park)**

a. Major basin redesign and restoration is required including the installation of a gross pollutant trapping system to prevent the continued contamination of John Creaney wetland and the downstream receiving environment which includes Bull Creek Park and the Canning River. As part of this restoration, consider dredging and disposing of any silty and/or possibly organic sediment at this site.
b. Continued monitoring of the sediment and water at site 5 will allow the potential risk of zinc toxicity to biota within the lake to be assessed.
c. Also consider analysing water at sites 15 and 16 for soluble zinc in the future to determine the proportion of this zinc that could be toxic to biota.

**High total nitrogen at the three most downstream Bull Creek main drain sites, and high available forms of nitrogen at all Bull Creek main drain sites (particularly nitrogen as ammonia/ammonium at site 2 (Brockman Park))**

a. In previous years, significant amounts of lawn clippings were observed to be entering the water at John Creaney Park from adjacent park management. Restoration should include creating a buffer between lawn and wetland area to reduce organic load entering the basin.
b. Major basin redesign and restoration is required including the installation of a gross pollutant trapping system to prevent the continued contamination of John Creaney wetland and the downstream receiving environment which includes Bull Creek Park and the Canning River. As part of this restoration, consider dredging and disposing of any silty and/or possibly organic sediment at this site.
c. The existing inlet structure requires regular maintenance to remove gross pollutants and sediment. Maintenance should be undertaken at a minimum of once a year in autumn.
d. Further investigation to determine the source of the very high nitrogen as ammonia/ammonium concentrations at Brockman Park is highly recommended, as this ammonia/ammonium appears to be contributing a significant amount of the total nitrogen into Bull Creek. The water body at Trevor Gribble Park could be sampled to determine whether this is the cause, as could the small local drainage lines feeding into the site.
e. Primary physical treatment is required prior to the Brockman Park stormwater pipe inlet to prevent gross pollutants, particulate matter and sediment entering Bull Creek Park waterway and its foreshore. Sediment deposition within the park has been observed by SERCUL staff on multiple occasions and a source investigation has been conducted by SERCUL and Water Corporation staff. Sediment was tracked as far

upstream as Earnest Wild Park on the Water Corp main drain and appears to be coming from the City of Melville local drainage system. Further investigation into the source is required to develop appropriate management actions.

- The implementation of an on-site and desktop drainage mapping investigation identified Trevor Gribble Park as a potential source for the sediment dumping occurring at site 2, as it has a large sandy compensation basin directly connected to the main drainage line upstream of Brockman Park. It is therefore recommended that stabilisation of this area through native revegetation and or structural sediment traps to minimise soil/sand exposure and potential movement down the system in a storm event.

f. Consider the installation of natural oxygenation features (river restoration technologies e.g. riffles) downstream of site 2 to allow nitrification of the high ammonia concentrations to occur. Rock riffles are also a natural barrier creating sediment traps, or dumping points reducing the amount of sediment moving through the system.

g. Macroinvertebrate surveys throughout the Bull Creek main drain (starting at site 2 through to PSDTBCMD) are recommended to gauge the impact nitrogen as ammonia/ammonium contamination is having on the ecological health of the system. Further to macroinvertebrate surveys, mosquito dipping coupled with the water quality information should also be conducted as a comparable study on the overall health of the ecosystem.

h. Continue and extend the current floodplain restoration works throughout the Bull Creek reserve.

i. Continue to include the analysis of Brockman Park inlet site (ROSSTAFE) in the City of Melville Bull Creek monitoring program, if funded by the City of Canning in the Bull Creek East monitoring program as a part of the implementation of the WQIP. This site was included to enable comparison with the water quality coming upstream from Brockman Park and the effects on the water quality downstream at Bull Creek main drain (PSDTBCMD) located in the bottom of the sub-catchment and the Canning River as the final receiving environment.

j. Consider including a new site at the outfall of Bull Creek to the Canning River to the nitrogen load actually entering the river. As the terminal end of the Bull Creek main drain flows through a wetland, it is possible that some of the nitrogen present at site PSDTBCMD may be filtered from the drain before entering the river. As the vegetation in this area is very dense, the accessibility of such a site will need to be assessed.

k. Considering the high concentrations of total nitrogen, nitrogen as ammonia/ammonium and total oxidised nitrogen, the development and implementation of a community education program for stormwater protection is recommended. The City of Melville have already produced a simple water cycle diagram for public education purposes, this may be utilised on a sign.

**High sediment metals at site 13 (Brentwood drain)**

a. The locations of this site may change slightly with the reconstruction of the two drains in the Brentwood Living Stream project, however it is extremely important to continue monitoring this site for changes to the water quality (before, during and after construction) to examine the impact/effectiveness of the restoration works. Furthermore, Water Corporation and Main roads are in the planning stages for the reconstruction of the upstream Cloverleaf compensating basin (located at the off ramp of Leach Highway to Kwinana Freeway South bound)to mitigate the poor water quality issues from the freeway runoff and subsequently reduce negative impacts in the Brentwood drain downstream. Water quality monitoring results at site 13 will allow for the assessment of the impact of these works on the overall outcome of the Brentwood Living Stream project.

b. The rock riffles installed as part of the Brentwood Living stream project will trap sediment that will require routine removal by the Water Corporation as part of its ongoing maintenance plan agreement.

**High available forms of nitrogen along Brentwood drainage line**

a. Continue supporting the Brentwood living stream restoration project.

b. Considering the high concentrations of total nitrogen, nitrogen as ammonia/ammonium and total oxidised nitrogen, the development and implementation of a community education program for stormwater protection is recommended. The City of Melville have already produced a simple water cycle diagram for public education purposes, this may be utilised on a sign.

c. Although the sources of pollutants at site 14 (RAAF drain) cannot be determined from the results of this monitoring (as there are no sites sampled upstream of site 14), it may of benefit to consider providing education materials to the grounds staff at the RAAF nursing home facility to ensure optimal management of the lake there. This may include:
   - Information about the implications of excess nutrients in waterways and how to reduce fertiliser application. SERCUL's Phosphorus Awareness Project brochure may be a good starting point (http://sercul.org.au/docs/PAP.pdf):
   - Information about the benefits of fringing vegetation around wetlands. Planting fringing vegetation (particularly sedges) around the lake within the facility may help to reduce nutrient and metal concentrations in lake water.

d. Liaise with Main roads regarding the planned upgrade of the Cloverleaf basin.

**Low pH sites 7 (Booragoon Lake), 12 (Blue Gum Lake), 8 (Piney Lakes outlet) and 9 (Quenda Lake outlet)**

- **Booragoon Lake:**
  a. It may be possible to neutralise acidity in the lake originating from oxidation of acid sulfate soils with materials such as aglime, sodium bicarbonate, hydrated lime or quicklime as described in DER (2015a). This may need to be conducted on an ongoing basis (DER 2015a). It is recommended that a more detailed assessment of the practicality of this recommendation be conducted in liaison with DER.
- **Blue Gum Lake:**
  a. Given the particularly low pH of waters at the site, consider conducting an acid sulfate soil investigation at the lake to determine the extent of acid sulfate soils and consider options for mitigation.
- **Piney Lakes:**
  b. As previously low water levels have been observed at this lake, consider monitoring of water levels throughout the year.
  c. Consider conducting an acid sulfate soil investigation at Piney Lakes to determine whether this is the cause of low pH levels, and assess possible mitigation strategies.
  d. It is recommended that a groundwater investigation be conducted to assess the cause(s) of the lowering of water levels at Piney Lakes. This could entail measuring groundwater levels on a seasonal basis at bores at existing or newly installed bores at and in the area surrounding Piney Lakes. Some groundwater abstraction does occur at Piney Lakes to facilitate landscaping of the surrounding parkland.
  e. Further to the above, investigation into ecological water requirements (EWRs) for this EPP (WA 073) groundwater dependant wetland is required to determine the possible risk-of-impact of drawdown on the key elements of wetland ecosystem integrity (ecosystem processes, biodiversity, abundance and biomass of biota and quality of water and sediment) and allow for appropriate mitigation strategies to be devised.
  f. Reducing the amount of grass and implementing hydrozoning of vegetation in parklands surrounding Piney Lakes will help to reduce groundwater abstraction. If local abstraction is the cause of low water levels then reducing abstraction may help to increase keep water levels at the Lakes.
- **Quenda Lake:**
  a. It is recommended that investigation of ecological water requirements (EWRs) for this EPP wetland is conducted to assess the impacts of climate change to the wetland and allow for appropriate mitigation to be undertaken.
  b. Continue implementing the other objectives included in the Quenda Wetland Reserve Strategic Management Plan (City of Melville 2016).

**High nutrients at sites 7 (Booragoon Lake) and 12 (Blue Gum Lake)**

- **Booragoon Lake:**
  a. The restoration of the ecological function of the foreshore of Booragoon Lake needs to continue to ensure that the surface water entering via the foreshore is naturally treated prior to entering the lake. Continuing with the planting of large and medium trees as well as sedges within the foreshore are critical to both surface and groundwater treatment. Replacement of weeds with slower growing native species (such as *Baumea articulata*) will result in less organic waste production.
  b. A "grass reduction" program has been implemented to prevent grass (from the edge of the lake to the footpath). This should have some benefit in reducing nutrients entering the lake.

c. The City of Melville is currently in the planning stages of an intervention program involving the redesigning one of the inlets to Booragoon Lake on the North West side of the lake on Aldridge Rd near Gould place in an effort to improve gross pollution management. The design will also include sedge beds for nutrient filtration and is set to be implemented in the 2017-18 financial year.

- **Blue Gum Lake:**

a. Continue with the current restoration works on the foreshore of the lake with native species particularly with native sedges and wetland plants.

b. Based on a site meeting between SERCUL and the City of Melville officers held at the end of 2014 to discuss possible treatment of stormwater entering the south west side of the lake from Karoonda Road, it was recommended to redesign the receiving storm water basin to reduce velocity, increase detention time and interaction with native vegetation. This project is currently in the design stages and implementation is set for the 2017-18 financial year.

c. Considering the excessively high levels of total and soluble phosphorus it is recommended to investigate possible treatment methods for the control/removal of phosphorus in a wetland environment such as an application program for Phoslock.

d. Continue the removal and control of invasive species that contribute to the large loads of organic material to the lake.

e. Create a barrier between the foreshore and lawn verge to prevent encroachment of lawn grasses and weeds to facilitate a definite edge for more efficient park management.

f. The City of Melville has established an MOU with the club in regards to fertiliser use and the storage of fertiliser within the tennis club precinct which involves regular inspections of the premises and annual meeting to discuss the progress and improvements. The City has established a good working relationship with the club and indicated this is an ongoing commitment to reduce the risk of impact to the Blue Gum Lake and its foreshore.

g. Following previous recommendation the City of Melville has provide guidelines in the form of letterbox drop educating residence about appropriate management of garden and lawn waste to reduce the weed and nutrient load impacting the Blue Gum Lake reserve and the resident macro-invertebrates and turtles. Further plans to conduct drain stencilling (“Clean Drains, River Gains”) and catchment education with school groups when budget and time allows.

- **Quenda Lake:**

h. Continued monitoring at this site is recommended to assess the long term impact of the new drainage works from Main Roads, road construction and new building infrastructure upgrades in the surrounding areas.

i. Continue foreshore management to protect the remaining wetland.

**High metals sites 7 and 12**

- **Booragoon Lake:**

a. The restoration of the ecological function of the foreshore of Booragoon Lake needs to continue to ensure that the surface water entering via the foreshore is naturally treated prior to entering the lake. Continuing with the planting of large and medium trees as well as sedges within the foreshore are critical to both surface and groundwater treatment.

b. Neutralisation of acidity at the lake (see above) may reduce mobilisation of metals from sediments, and therefore soluble metal concentrations, in the lake.

c. Consider speciation testing for zinc and copper to determine the labile (and therefore bioavailable) proportion of these metal concentrations, as a proportion of the metals present may be complexed with dissolved organic material.

- **Blue Gum Lake:**

a. Continue with the current restoration works on the foreshore of the lake with native species particularly with native sedges and wetland plants.

b. Based on a site meeting between SERCUL and the City of Melville officers held at the end of 2014 to discuss possible treatment of stormwater entering the south west side of the lake from Karoonda Road, it was recommended to redesign the receiving storm water basin to reduce velocity, increase detention time and interaction with native vegetation. This project is currently in the design stages and implementation is set for the 2017-18 financial year.

c. Consider conducting an acid sulfate soil investigation to allow for mitigation strategies for low pH levels to be implemented– reducing acidity in Lake water may reduce mobilisation of metals.

d. Consider speciation testing for zinc and copper to determine the labile (and therefore bioavailable) proportion of these metal concentrations, as a proportion of the metals present may be complexed with dissolved organic material.

**High pH (and presence of aquatic weeds and algae) at site 11 (Marmion Reserve)**

a. It may be of benefit to consider providing educational materials to the grounds staff at the adjacent retirement villages on the west side of Marmion reserve to ensure gardening activities do not result in additional pollution to the lake. This may include information about the implications of nutrient pollution in waterways and how to optimally apply fertiliser to reduce nutrient pollution. SERCUL's Phosphorus Awareness Project brochure may be a good starting point (http://sercul.org.au/docs/PAP.pdf).and surrounding parkland.
b. Continued control of invasive aquatic weeds, particularly those that grow rapidly on the surface of the water.
c. Continued maintenance of the completed City of Melville foreshore restoration project to increase the buffer zone surrounding the lake to increase the bio-filtration of surface water from surrounding parkland. This project included the planting of island and large areas surrounding the lake with sedges and other dryland species and the removal of weeds.

**High metals in sediment at site 10 (Frederick Baldwin)**

a. Remove sediment sludge at the inlet.
b. Investigate options for the improvement of hydraulic design within the lake.
c. Implement a progressive weed removal program focusing on the replacement of the *Casuarina cunninghamiana* (Sydney she-oak) with local wetland tree species (*Melaleuca rhaphiophylla, Eucalyptus rudis*) to reduce the weed seeding of downstream wetlands and waterways and increase nutrient uptake. Also removing these trees will remove the needles which prevent the growth of understorey riparian vegetation.
d. Implement gradual foreshore revegetation program simultaneously with installation of bio-filtration sedge plantings to provide a buffer between the lawn recreational area and the lake foreshore. This will improve the aesthetics as well as improving the filtration of surface water entering the lake.
e. Develop signage at the lake that increases the community's awareness of where this lake's water comes from and where the lake water flows to. This will increase the local community's awareness of the effect of this lake's water quality on the downstream lakes and the Canning River (this could be a simple sign showing the catchment and the drainage pathway for this lake to the river). The City of Melville have already produced a simple water cycle diagram for public education purposes, this may be utilised on a sign.

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# Appendix A ANZECC Trigger Values and Guidelines

### Table A-1: Trigger values for physicochemical parameters and nutrients

| Guideline | pH | DO % Sat | EC (mS/cm) | TSS (mg/L) | TN (mg/L) | $NO_X$-N (mg/L) | $NH_3$-N/$NH_4$-N (mg/L) | TP (mg/L) | SRP (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| Guideline values for recreational use (NHMRC 2008) | 6.5-8.5 | >80 | - | - | - | 30 (for $NO_2^-$)<br>500 (for $NO_3^-$)<br>(health) | 5<br>(aesthetic) | - | - |
| ANZECC Water Quality Trigger Values - lowland river (2000) | 6.5-8.0 | 80-120 | 0.12-0.3 | - | 1.2 | 0.15 | 0.08 | 0.065 | 0.04 |
| ANZECC Water Quality Trigger Values wetland (2000) | 7-8.5 | 90-120<br>(>6mg/L) | 0.3-1.5 | - | 1.5 | 0.10 | 0.04 | 0.06 | 0.03 |
| ANZECC Water Quality Trigger Values - freshwater protection (2000) | - | - | - | - | - | - | 0.9 | - | - |
| DoW (n.d.) interim guideline | - | - | - | 6 | - | - | - | - | |
| NMI Limit of Reporting | - | - | - | 1 | 0.025 | 0.01 | 0.01 | 0.005 | 0.005 |

**[1]Trigger value not adjusted for pH and temperature**

### Table A-2: Trigger values for metals in water

| Guideline | Al (mg/L) | As (mg/L) | Cd (mg/L) | Cr (mg/L) | Co (mg/L) | Cu (mg/L) | Fe (mg/L) | Pb (mg/L) | Hg (mg/L) | Mn (mg/L) | Mo (mg/L) | Ni (mg/L) | Se (mg/L) | Zn (mg/L) | Hardness (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recreational use guideline values (NHMRC 2008, NHMRC 2016) | - | 0.1<br>(health) | 0.01<br>(health) | 0.5[5]<br>(health) | - | 10<br>(aesthetic)<br>20 (health) | 3<br>(aesthetic) | 0.1<br>(health) | 0.01<br>(health) | 1<br>(aesthetic)<br>5 (health) | 0.5<br>(health) | 0.2<br>(health) | 0.1<br>(health) | 30<br>(aesthetic) | - |
| ANZECC Water quality trigger value – Freshwater 95% (2000) | 0.055[1] | 0.024 | 0.0002[2] | 0.0033[2,3] | 0.0028[3] | 0.0014[2] | 0.3[4] | 0.0034[2] | 0.0006 | 1.9 | 0.034[3] | 0.011[2] | 0.011 | 0.008[2] | - |
| NMI Limit of Reporting (required) | 0.005 | 0.001 | 0.0001 | 0.001 | 0.001 | 0.001 | 0.005 | 0.001 | 0.0001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 5 |

**[1]Applicable only when pH>6.5, when pH<6.5 a low reliability interim value of 0.0008 mg/L is applicable**
**[2]Trigger values not adjusted for water hardness.**
**[3]Low reliability interim value**
**[4]Interim guideline**
**[5] Value for Cr VI used**

### Table A-3: ANZECC trigger values for metals in sediment

| Guideline | Al (mg/kg) | As (mg/kg) | Cr (mg/kg) | Cu (mg/kg) | Fe (mg/kg) | Hg (mg/kg) | Pb (mg/kg) | Ni (mg/kg) | Zn (mg/kg) | Se (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| ANZECC Low Trigger Value (2000) | N.D. | 20 | 80 | 65 | N.D. | 0.15 | 50 | 21 | 200 | N.D. |
| ANZECC High trigger value (2000) | N.D. | 70 | 370 | 270 | N.D. | 1.0 | 220 | 52 | 410 | N.D. |
| NMI Limit of Reporting | 1.0 | 0.5 | 0.5 | 0.5 | 1.0 | 0.1 | 0.5 | 1.0 | 1.0 | 1.0 |

# Appendix B Changes to the monitoring program since 2007

In 2008 the following changes were made:

- Sites MELDR-03, MELDR-04 and MELDR-05 were dropped from the project as they were always dry in 2007 and are only overflow points from the drains rather than being representatives of the drainage network itself.
- The collection of organic carbon samples was discontinued due to insufficient funds.
- Analysis for polycyclic aromatic hydrocarbons, benzene, ethyl benzene, toluene and xylene (BTEX) and total petroleum hydrocarbons in water samples was discontinued from all sites, as they were rarely detected above laboratory limits of reporting in 2007 and due to reduced budget.
- Sampling frequency was altered from quarterly in 2007 to once every two months for 4 events in total in 2008. This is due to the very late start for the project in 2008 due to funding uncertainty.
- Sampling for sediment was discontinued as the City of Melville could not provide sufficient funds to continue this component of the sampling program.

The project started very late in 2008 (September) due to funding uncertainty from the major stakeholder and as a result all winter rains and flows have been missed for the 2008 sampling project. It is possible that this may have an effect on the water quality of the collected samples and the number of samples that can be collected.

In 2009 the following change was made:

- Soluble metals analysis (for soluble aluminium, chromium, copper, iron, lead and zinc) was added at two sites (MELDR-01 and MELDR -06) based on the recommendations from the previous year's results.

In 2010 the following change was made:

- Sampling frequency was altered from every two months to monthly during the winter for four events in total during 2010. This is due to the dry conditions at most of the sites throughout the year.

In 2011 the following changes were made:

- Sampling for metals that have recorded concentrations below the limit of report during the four-year sampling period was discontinued. Therefore, only eight total metals were included in the 2011 sampling program (aluminium, arsenic, chromium, copper, iron, nickel, lead and zinc) and cadmium and mercury were dropped. Surveillance monitoring of arsenic and nickel will be continued as these metals have consistently been detected above the LORs at some sites (particularly arsenic at Bateman Park, Booragoon lake, Frederick Baldwin, Marmion Reserve and Blue Gum Lake and nickel at John Creaney, Bateman Park and Booragoon Lake), despite having not been detected above trigger values.
- Considering the consistent, sometimes widespread, contamination of some metals in the catchment, soluble metals were included to provide data about the concentrations of these metals that may be available for biological uptake and therefore potentially impact on the biota. Soluble metals analysis for aluminium, chromium, copper, iron, lead and zinc was added at four more sites (MELDR-05, MELDR-10, MELDR-11 and MELDR-12). These four sites have consistently recorded concentrations above the trigger value.
- The City of Melville included soluble metals analysis for a fifth site; Booragoon Lake (MELDR-07) due to the works that the City has undertaken there.

There were additional changes to those included in the 2011 SAP due to some very low pH values (<4.5) recorded in Booragoon and Blue Gum Lakes and turtle deaths at Blue Gum lake.

- Addition of six new sites, one at Booragoon Lake (MELDR-BL1) and five at Blue Gum Lake (MELDR-BGL1, MELDR-BGL2, MELDR-BGL3, MELDR-BGL4 and MELDR-BGL5).
- Sampling for total acidity and total alkalinity in water at two existing sites (MELDR-07 and MELDR-12) and the new six sites (listed above).
- Sampling for titratable actual acidity (TAA) in sediment at these two lakes at two existing sites (MELDR-07 and MELDR-12) and the new six sites.

In 2012 the following change was made:

- Sampling at the six new sites (included in 2011) at Booragoon Lake (MELDR-BL1) and Blue Gum Lake (MELDR-BGL1, MELDR-BGL2, MELDR-BGL3, MELDR-BGL4 and MELDR-BGL5) was discontinued. However, if Blue Gum Lake pH falls rapidly again after a period of drying and rewetting, these sites would be sampled for the same parameters than in 2011.

In 2013 the following change were made:

- Due to proposed restoration works upstream Bateman Park site (site 6) two new sites were added upstream this site to collect baseline data from the two drains (Brentwood drain and RAAF drain) before they merge. These two new sites (sites 13 and 14) were sampled during October and November 2013 sampling events and were continued in the 2014 sampling monitoring program. These sites were sampled for the same parameters included at Bateman Park site (site 6).

In 2014 the following changes were made:

- Total metal analysis for mercury (Hg) (originally discontinued in 2011) was added to Bateman Park, Brentwood Drain and RAAF Drain (sites 6, 13 and 14) for suspicions of elevated levels where the proposed earth works may occur in the pending Brentwood MD restoration project. Earlier sediment testing conducted by SRT indicated Hg contamination at the site but subsequent testing was not consistent.
- In an effort to isolate the pollution source/s that were contributing with the poor water quality entering at Brockman Park site (site 2) two new sites were added to the last three sampling events. John Creaney Park inlet and Down Stream Elizabeth Manion Park (site 15 and 16) were tested for the same nutrients and physical parameters included in Brockman Park: dissolved oxygen, pH, temperature and electrical conductivity, total and soluble nutrients and total suspended solids. Additionally, these two sites were tested for the 14 total metals suite recommended by the Department of Water for new sites: aluminium, cadmium, arsenic, chromium, cobalt, copper, iron, mercury, nickel, lead, manganese, molybdenum, selenium, and zinc. Since soluble metals were not included in Brockman Park, they were also no included at the two new sites.
- The eastern side of the catchment (within the City of Canning) was monitored for the first time in 2014 including the Brockman Park inlet (ROSSTAFE) which enters the Bull Creek main drain downstream Brockman Park (site 2) and before Bull Creek MD (PSDTBCMD). The inclusion of the analysis of Brockman Park inlet in this report will provide insight into the relative contributions from the individual segments (Brockman Park in the City of Melville and Rossmoyne Drain in the City of Canning) and their impact downstream on Bull Creek MD (site1).

In 2015 the following changes were made:

- Total arsenic and total nickel in water were discontinued at the 12 original sites (1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14) as they have always recorded concentrations below the trigger values and on many occasions they have been equal to the limits of reporting at all sites. At the above mentioned 12 sites, six total metals (aluminium, chromium, copper, iron, lead and zinc) were included on one sampling occasion for surveillance, and six soluble metals (aluminium, chromium, copper, iron, lead and zinc) were included on all four sampling occasions.
- The addition of particle size analysis in sediment samples to enable better interpretation of metals concentrations in these samples. Particle size analysis was performed on the same sampling event when sediment samples were taken at 12 of the 15 sites included in the SAP.

# Appendix C Temperature and rainfall data

The greatest flow in Bull Creek generally occurs as a result of winter rainfall between June and September. There is a delay between the onset of winter rain and the commencement of consistent flow in the catchment. Samples from the 14 Melville sites were collected during four sampling events (20th July, 19th August, 8th September, and 27th October). ROSSTAFE samples were collected one to three days before Melville samples on the four sampling events of the City of Canning Bull Creek East monitoring program (19th July, 16th August, 6th September, and 26th October).

On the September Melville sampling date (8th of September) there was 5.4 mm of rainfall and on the August ROSSTAFE sampling date (16th of August) there was 4 mm of rainfall (**Figure C-1**). Furthermore, rain fell several days prior to the Melville July sampling dates (32.8 mm and 6.8 mm on the 17th and 18th of July respectively), August sampling dates (0.2 mm, 4 mm, 1.6 mm and 17.4 mm on the 15th, 16th, 17th and 18th of August) and September sampling dates (6.2 mm on the 7th of September). There was an adequate amount of flow at the majority of the sites for sampling. The air maximum temperatures recorded for the four Melville sampling days were 19.0°C on July 20th, 15.9°C on August 19th, 17.9°C on September 8th and 21.9°C on October 27th. The air maximum temperatures recorded for the four ROSSTAFE sampling days were 18.0°C on July 19th, 19.9°C on August 16th, 19.6°C on September 6th and 22.3°C on October 26th. These observations are based on a combination of both Mount Lawley and Perth Airport daily weather observations (Australian Government Bureau of Meteorology (BOM) 2016a).

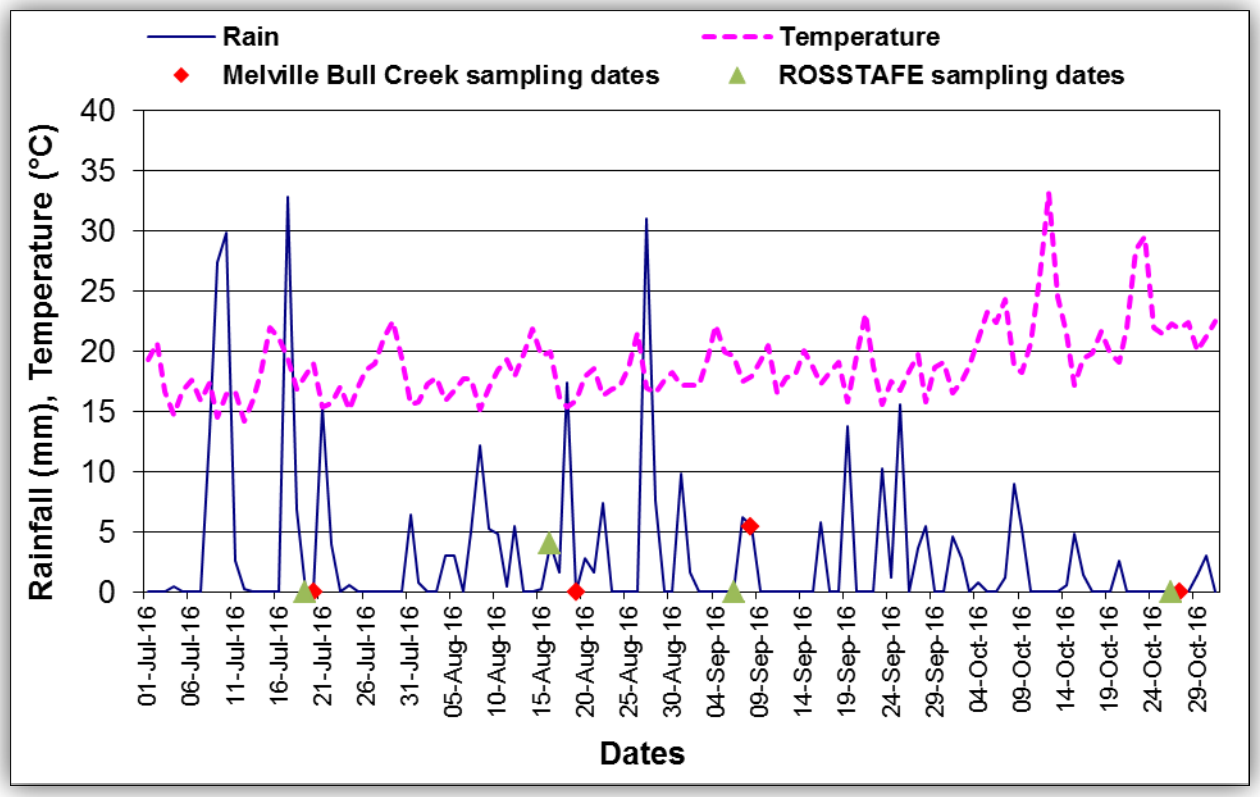


**Figure C-1: Daily rainfall (mm) and temperature (°C) in Perth (a combination of observations from Mount Lawley and Perth Airport Metropolitan region) from July to October 2016**

**Source: Australian Government Bureau of Meteorology (BOM) 2016a**

Winter 2016 was Perth's wettest winter in five years, although many sites still experienced below average rainfall. Most Perth sites experienced close to the average number of rain days (BOM 2016b).

Rainfall in spring 2016 in the Perth area was near to below average, with totals ranging from 100 mm to 150 mm on coastal plain sites, and 180 to 230 mm in the hills. Perth Metro recorded a total of 120.6 mm (over 30 mm below the long-time spring average) over 24 rain days, below the long term average of 30 rain days (however this was largely due to a dry November) (BOM 2016c).

Mean maximum temperatures and overnight temperatures in winter 2016 were below average across Perth. Many Perth sites experienced their coldest winter days in over 20 years, and many had between ten and thirteen days with a maximum temperature of 20°C or higher, the least number of such days for at least 20 years (BOM 2016b).

Mean maximum temperatures in spring 2016 were close to 1°C cooler than normal for many Perth sites. Perth Metro recorded the coolest mean maximum (of 22.7°C) in eight years. Spring mean minimum temperatures were also 1°C to 5°C below average at most Perth sites, with several sites recording the lowest spring mean minimum temperature in at least 30 years (BOM 2016c).

Commonly, categories of rain are defined by their intensity: light, moderate and heavy rain which are characterised by the amount of mm of water/hour (respectively 2.5, 2.5 to 7.5, >7.5). According to the duration of a given rainfall event, the same intensity can be observed during a short period (shower) or a longer one (storm). Consequences of these precipitations can result in, so called, extreme rain or flood respectively at local or regional scale. Increases of frequency and intensity of heavy precipitation events may have a strong impact on the water quality at that time. Resulting changes in flow regimes will influence the chemistry, hydro morphology and ecology of water bodies as well. In urban areas the wastewater quality, the sewage treatment efficiency, and the corresponding pollutant load can also have an impact on the water quality (Roig et al 2011).

The effect of the runoff on water quality of waterbodies after a rainfall event depends on the land use, slope, soil type, amount of impervious surfaces, and the duration and intensity of the rainfall event. During storm events, large amounts of urban debris are flushed from the catchment into the stormwater drainage system. This debris is often referred to as gross pollutant and includes all forms of solids such as urban-derived litter, vegetation and coarse sediment. Gross pollution is generally the most noticeable indicator of water pollution to the community. Gross pollution (primarily sediment) can also contribute to a reduction in the drainage capacity and efficiency of stormwater conveyance systems and also has a negative visual impact. Gross pollution is also a threat to the aquatic ecosystem when deposited into the receiving water bodies, through a combination of physical impacts on habitats and biota. Finally, gross pollution can also reduce the oxygen availability in the receiving water body and offer a surface for hydrocarbons and metals to bind to (Wong et al 2000).

# Appendix D Water quality results tables

## Physicochemical parameters in water

### Table D-1: pH in the Melville Bull Creek catchments in 2016

pH Max (red) 10.02 Min (blue) 3.55

ANZECC trigger value for lowland rivers of SW Australia 6.5 - 8.0; for wetlands 7.0 - 8.5; for recreational value 6.5 - 8.5

| Site Name | Site Number | Collect Date | pH (no units) | pH lower limit 6.5 Lowland Rivers/ 7 Wetlands | pH upper limit 8 Lowland Rivers/ 8.5 Wetlands | pH lower limit 6.5 Recreational | pH upper limit 8.5 Recreational |
|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 6.61 | Acceptable | Acceptable | Acceptable | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 6.24 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 6.61 | Acceptable | Acceptable | Acceptable | Acceptable |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 6.26 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 6.69 | Acceptable | Acceptable | Acceptable | Acceptable |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 6.77 | Acceptable | Acceptable | Acceptable | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 6.77 | Acceptable | Acceptable | Acceptable | Acceptable |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 7.04 | Acceptable | Acceptable | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 7.25 | Acceptable | Acceptable | Acceptable | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 4.35 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 5.48 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 6.37 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 6.8 | Does not meet guidelines | Acceptable | Acceptable | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 7.4 | Acceptable | Acceptable | Acceptable | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 3.74 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 6.56 | Acceptable | Acceptable | Acceptable | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 6.33 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 6.61 | Acceptable | Acceptable | Acceptable | Acceptable |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 6.22 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 6.67 | Acceptable | Acceptable | Acceptable | Acceptable |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 6.73 | Acceptable | Acceptable | Acceptable | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 6.67 | Acceptable | Acceptable | Acceptable | Acceptable |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 7.03 | Acceptable | Acceptable | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 7.13 | Acceptable | Acceptable | Acceptable | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 3.55 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 5.54 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 6.38 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 7.01 | Acceptable | Acceptable | Acceptable | Acceptable |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 7.46 | Acceptable | Acceptable | Acceptable | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 4.57 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 6.46 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 6.4 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 6.74 | Acceptable | Acceptable | Acceptable | Acceptable |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 6.16 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 6.76 | Acceptable | Acceptable | Acceptable | Acceptable |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 6.77 | Acceptable | Acceptable | Acceptable | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 6.81 | Acceptable | Acceptable | Acceptable | Acceptable |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 7.06 | Acceptable | Acceptable | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 7.48 | Acceptable | Acceptable | Acceptable | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 3.83 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 5.57 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 5.66 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 6.9 | Does not meet guidelines | Acceptable | Acceptable | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 7.96 | Acceptable | Acceptable | Acceptable | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 5.91 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 6.54 | Acceptable | Acceptable | Acceptable | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 6.22 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 6.23 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 7.06 | Acceptable | Acceptable | Acceptable | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 6.8 | Acceptable | Acceptable | Acceptable | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 6.69 | Acceptable | Acceptable | Acceptable | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 7.09 | Acceptable | Acceptable | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 6.91 | Acceptable | Acceptable | Acceptable | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 6.55 | Does not meet guidelines | Acceptable | Acceptable | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 6.33 | Does not meet guidelines | Acceptable | Does not meet guidelines | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 6.73 | Does not meet guidelines | Acceptable | Acceptable | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 6.56 | Does not meet guidelines | Acceptable | Acceptable | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 10.02 | Acceptable | Does not meet guidelines | Acceptable | Does not meet guidelines |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 6.98 | Does not meet guidelines | Acceptable | Acceptable | Acceptable |

## Table D-2: Dissolved oxygen saturation in the Melville Bull Creek catchments in 2016

**Dissolved oxygen (DO%)** Max (red) 132.3 Min (blue) 2.5

**ANZECC acceptable range for lowland rivers: 80-120%, wetlands: 90-120%; NHMRC recreational value: >80%**

| Site Name | Site Number | Collect Date | DO (%) | DO lower limit 80/90 % | DO upper limit 120 % |
|---|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 45.8 | Does not meet guidelines | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 10.1 | Does not meet guidelines | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 68.1 | Does not meet guidelines | Acceptable |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 42 | Does not meet guidelines | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 77.3 | Does not meet guidelines | Acceptable |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 50 | Does not meet guidelines | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 58.7 | Does not meet guidelines | Acceptable |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 78.5 | Does not meet guidelines | Acceptable |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 57.3 | Does not meet guidelines | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 37.5 | Does not meet guidelines | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 37.8 | Does not meet guidelines | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 36.2 | Does not meet guidelines | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 28.1 | Does not meet guidelines | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 65.4 | Does not meet guidelines | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 90 | Acceptable | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 44.1 | Does not meet guidelines | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 12 | Does not meet guidelines | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 80.8 | Acceptable | Acceptable |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 45.8 | Does not meet guidelines | Acceptable |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 79.1 | Does not meet guidelines | Acceptable |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 56.9 | Does not meet guidelines | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 64.2 | Does not meet guidelines | Acceptable |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 85 | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 54.9 | Does not meet guidelines | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 56.4 | Does not meet guidelines | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 38.3 | Does not meet guidelines | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 40 | Does not meet guidelines | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 47.9 | Does not meet guidelines | Acceptable |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 68.1 | Does not meet guidelines | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 33 | Does not meet guidelines | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 43.7 | Does not meet guidelines | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 45.4 | Does not meet guidelines | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 87.1 | Acceptable | Acceptable |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 50.9 | Does not meet guidelines | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 74.5 | Does not meet guidelines | Acceptable |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 64.4 | Does not meet guidelines | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 57.3 | Does not meet guidelines | Acceptable |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 87.5 | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 57.9 | Does not meet guidelines | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 52.9 | Does not meet guidelines | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 37.4 | Does not meet guidelines | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 22.3 | Does not meet guidelines | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 73.2 | Does not meet guidelines | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 75.1 | Does not meet guidelines | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 14.2 | Does not meet guidelines | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 42.9 | Does not meet guidelines | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 12.9 | Does not meet guidelines | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 43.5 | Does not meet guidelines | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 84 | Acceptable | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 55.1 | Does not meet guidelines | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 68.5 | Does not meet guidelines | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 82.4 | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 58.8 | Does not meet guidelines | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 8.9 | Does not meet guidelines | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 62.2 | Does not meet guidelines | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 31.7 | Does not meet guidelines | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 2.5 | Does not meet guidelines | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 132.3 | Acceptable | Does not meet guidelines |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 36.1 | Does not meet guidelines | Acceptable |

## Table D-3: Dissolved oxygen concentration (mg/L) in the Melville Bull Creek catchments 2016

**Dissolved oxygen (DO mg/L)**

Max (red) 11.51 Min (blue) 0.23

| Site Name | Site Number | Collect Date | O - DO (mg/L) |
|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 4.58 |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 1.07 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 6.39 |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 3.84 |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 7.15 |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 5.01 |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 5.65 |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 8.18 |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 5.77 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 4.15 |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 4.39 |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 3.98 |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 2.94 |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 6.81 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 9.14 |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 4.34 |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 1.22 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 7.67 |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 4.22 |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 7.34 |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 5.58 |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 6.1 |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 8.71 |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 5.45 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 5.89 |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 4.05 |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 4.23 |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 4.88 |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 6.94 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 3.25 |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 4.38 |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 4.61 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 8.57 |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 4.78 |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 6.94 |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 6.4 |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 5.49 |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 8.83 |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 5.77 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 5.29 |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 3.81 |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 2.27 |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 7.32 |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 7.43 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 1.35 |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 3.99 |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 1.23 |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 3.95 |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 7.71 |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 5.28 |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 6.29 |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 7.78 |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 5.51 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 0.77 |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 5.75 |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 3.04 |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.23 |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 11.51 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 2.84 |

## Table D-4: Electrical conductivity (mS/cm) in the Melville Bull Creek catchments in 2016

Electrical Conductivity (EC) Max (red) 2.449 Min (blue) 0.0934

ANZECC trigger value 0.12-0.3 mS/cm for lowland rivers; 0.3 - 1.5 mS/cm for wetlands

| Site Name | Site Number | Collect Date | EC (mS/cm) | lower limit 0.12/0.3 | upper limit 0.3/1.5 |
|---|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.682 | Acceptable | Does not meet guidelines |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 0.4718 | Acceptable | Does not meet guidelines |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.3934 | Acceptable | Does not meet guidelines |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 0.8 | Acceptable | Does not meet guidelines |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.78 | Acceptable | Does not meet guidelines |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.75 | Acceptable | Does not meet guidelines |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.4632 | Acceptable | Does not meet guidelines |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.4814 | Acceptable | Does not meet guidelines |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.589 | Acceptable | Does not meet guidelines |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 2.449 | Acceptable | Does not meet guidelines |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 1.141 | Acceptable | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.864 | Acceptable | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.0934 | Does not meet guidelines | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.1663 | Does not meet guidelines | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.747 | Acceptable | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.477 | Acceptable | Does not meet guidelines |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 0.651 | Acceptable | Does not meet guidelines |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.432 | Acceptable | Does not meet guidelines |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 0.794 | Acceptable | Does not meet guidelines |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.723 | Acceptable | Does not meet guidelines |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.734 | Acceptable | Does not meet guidelines |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.511 | Acceptable | Does not meet guidelines |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.445 | Acceptable | Does not meet guidelines |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.561 | Acceptable | Does not meet guidelines |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 2.336 | Acceptable | Does not meet guidelines |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 1.329 | Acceptable | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.909 | Acceptable | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.15 | Does not meet guidelines | Acceptable |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.21 | Does not meet guidelines | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.874 | Acceptable | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.344 | Acceptable | Does not meet guidelines |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 0.371 | Acceptable | Does not meet guidelines |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.219 | Acceptable | Acceptable |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 0.656 | Acceptable | Does not meet guidelines |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.722 | Acceptable | Does not meet guidelines |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.519 | Acceptable | Does not meet guidelines |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.587 | Acceptable | Does not meet guidelines |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.545 | Acceptable | Does not meet guidelines |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.56 | Acceptable | Does not meet guidelines |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 1.919 | Acceptable | Does not meet guidelines |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 1.198 | Acceptable | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.825 | Acceptable | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.173 | Does not meet guidelines | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.286 | Does not meet guidelines | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 0.721 | Acceptable | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.621 | Acceptable | Does not meet guidelines |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.81 | Acceptable | Does not meet guidelines |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.828 | Acceptable | Does not meet guidelines |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.7 | Acceptable | Does not meet guidelines |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.779 | Acceptable | Does not meet guidelines |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.619 | Acceptable | Does not meet guidelines |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.665 | Acceptable | Does not meet guidelines |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.646 | Acceptable | Does not meet guidelines |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 1.671 | Acceptable | Does not meet guidelines |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.833 | Acceptable | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.997 | Acceptable | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.425 | Acceptable | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.295 | Does not meet guidelines | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.88 | Acceptable | Acceptable |

**Table D-5: Total suspended solids (mg/L) in the Melville Bull Creek catchments in 2016**

**Total Suspendid Solids (TSS)** | All data in blue were <1 (LOR)

**DoW interim guideline 6 mg/L** | Max (red) 62 | Min (blue) <1

| Site Name | Site Number | Collect Date | TSS (mg/L) | DoW interim guideline |
|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 1 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 8 | Does not meet guidelines |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 13 | Does not meet guidelines |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 0.5 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.5 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 1 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 10 | Does not meet guidelines |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.5 | Acceptable |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 5 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 15 | Does not meet guidelines |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.5 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.5 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.5 | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.5 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 62 | Does not meet guidelines |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 8 | Does not meet guidelines |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 2 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 2 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 1 | Acceptable |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.5 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 3 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 11 | Does not meet guidelines |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 1 | Acceptable |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 6 | Does not meet guidelines |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 4 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 1 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.5 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 2 | Acceptable |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 1 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 10 | Does not meet guidelines |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 2 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 2 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 1 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 1 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.5 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 3 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 10 | Does not meet guidelines |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 2 | Acceptable |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 7 | Does not meet guidelines |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 7 | Does not meet guidelines |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.5 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.5 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 2 | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 1 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 16 | Does not meet guidelines |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 1 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 2 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 1 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.5 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 1 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 5 | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 1 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 4 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 5 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 1 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 1 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 5 | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 2 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 4 | Acceptable |

## Table D-6: Water temperature (°C) in the Melville Bull Creek catchments in 2016

**Temperature (°C)**

Max (red) 27.6 Min (blue) 8.7

| Site Name | Site Number | Collect Date | Temp (°C) |
|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 15.2 |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 12.4 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 18.4 |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 19.6 |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 19.1 |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 15.2 |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 17.1 |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 13.4 |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 15 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 10.5 |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 8.7 |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 11 |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 13.3 |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 13.5 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 14.6 |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 16 |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 14.8 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 17.8 |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 19.3 |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 18.9 |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 16.2 |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 17.7 |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 14.2 |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 15.7 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 13.1 |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 12.7 |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 12.7 |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 14.6 |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 14.5 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 16 |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 15.2 |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 14.6 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 16.1 |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 18.3 |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 18.7 |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 15.6 |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 17.3 |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 14.9 |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 15.5 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 15.1 |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 14.4 |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 14.5 |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 15.4 |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 15.8 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 18 |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 18.7 |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 17.6 |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 19.9 |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 19.4 |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 17.3 |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 19.5 |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 18 |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 18.4 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 21.9 |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 19.1 |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 17.2 |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 19.6 |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 22.2 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 27.6 |

## Nutrients in water

### Table D-7: Total nitrogen concentrations (mg/L) in the Melville Bull Creek catchments in 2016

**Total Nitrogen (TN) (mg/L)** N (tot) {TN, pTN} (mg/L) LOR <0.025

ANZECC trigger value for lowland rivers (1.2 mg/L); for wetlands (1.5 mg/L)

Max (red) 6.9 Min (blue) 0.26

| Site Name | Site Number | Collect Date | TN | Comparison to ANZECC trigger value |
|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 1.1 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 0.91 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.64 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 6.9 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 1.5 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 3.5 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.69 | Acceptable |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.68 | Acceptable |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.78 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 1.2 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.76 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.67 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.31 | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.35 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.86 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.76 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 0.87 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.37 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 5.9 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 1.2 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 3.2 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.63 | Acceptable |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.63 | Acceptable |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.63 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.5 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.85 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.68 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.27 | Acceptable |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.26 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.63 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.48 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 0.32 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.37 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 4.8 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 1.2 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 2 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.66 | Acceptable |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.62 | Acceptable |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.66 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.44 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 1.1 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 1 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.28 | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.32 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 2.2 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.69 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.82 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 6.8 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 1 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 3.5 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.67 | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.55 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.64 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 3 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.83 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 1.2 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.48 | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.47 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 2.6 | Guideline exceeded |

## Table D-8: Total oxidised nitrogen concentrations (mg/L) in the Melville Bull Creek catchments in 2016

**Total Oxidised Nitrogen (NOx)** N (sum sol ox) {NOx-N, TON} (mg/L)
**ANZECC trigger value: 0.15 mg/L for lowland rivers; 0.10 mg/L for wetlands**
All data in blue were <0.01 (LOR) Max (red) 2.6 Min (blue) <0.01

| Site Name | Site Number | Collect Date | NOx | Comparison to ANZECC trigger value |
|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.37 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 0.036 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.15 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 0.16 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.9 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 2.4 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.3 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.31 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.34 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.01 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.005 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.005 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.022 | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.056 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.012 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.21 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 0.082 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.16 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 0.19 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.66 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 2.1 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.32 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.25 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.26 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.005 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.005 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.005 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.019 | Acceptable |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.019 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.011 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.14 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 0.059 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.15 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 0.22 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.84 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 1.3 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.34 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.24 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.31 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.015 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.011 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.012 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.018 | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.013 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 0.03 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.13 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.038 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.16 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.49 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 2.6 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.26 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.066 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.21 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 0.005 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.005 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.005 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.005 | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.005 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.011 | Acceptable |

## Table D-9: Nitrogen as ammonia/ammonium concentrations (mg/L) in the Melville Bull Creek catchments in 2016

**Nitrogen as ammonia/ammonium (sol mg/L)** NH3-N/NH4-N (sol) (mg/L) All data in blue were <0.01 (LOR)

**ANZECC trigger value for lowland rivers: 0.08 mg/L, wetlands: 0.04 mg/L; NHMRC guideline for recreational value: 5 mg/L**

Max (red) 6.20 Min (blue) <0.01

| Site name | Site number | Date | NH3-N/NH4-N (sol) (mg/L) | pH | Adjusted ANZECC freshwater protection trigger value (mg/L) | Comparison to ANZECC freshwater protection trigger value | Comparison to ANZECC lowland rivers/wetlands trigger value | Comparison to NHMRC trigger value for recreation |
|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.068 | 6.61 | 2.43 | Acceptable | Acceptable | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 0.4 | 6.24 | 2.54 | Acceptable | Guideline exceeded | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.061 | 6.61 | 2.43 | Acceptable | Acceptable | Acceptable |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 6.2 | 6.26 | 2.54 | Guideline exceeded | Guideline exceeded | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.096 | 6.69 | 2.43 | Acceptable | Guideline exceeded | Acceptable |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.6 | 6.77 | 2.38 | Acceptable | Guideline exceeded | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.16 | 6.77 | 2.38 | Acceptable | Guideline exceeded | Acceptable |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.059 | 7.04 | 2.18 | Acceptable | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.15 | 7.25 | 1.99 | Acceptable | Guideline exceeded | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.043 | 4.35 | outside range (2.57) | Acceptable | Guideline exceeded | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.028 | 5.48 | outside range (2.57) | Acceptable | Acceptable | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.017 | 6.37 | 2.52 | Acceptable | Acceptable | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.055 | 6.8 | 2.33 | Acceptable | Guideline exceeded | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.049 | 7.4 | 1.75 | Acceptable | Guideline exceeded | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.028 | 3.74 | outside range (2.57) | Acceptable | Acceptable | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.047 | 6.56 | 2.46 | Acceptable | Acceptable | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 0.22 | 6.33 | 2.52 | Acceptable | Guideline exceeded | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.014 | 6.61 | 2.43 | Acceptable | Acceptable | Acceptable |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 5.1 | 6.22 | 2.54 | Guideline exceeded | Guideline exceeded | Guideline exceeded |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.073 | 6.67 | 2.43 | Acceptable | Acceptable | Acceptable |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.55 | 6.73 | 2.38 | Acceptable | Guideline exceeded | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.15 | 6.67 | 2.43 | Acceptable | Guideline exceeded | Acceptable |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.035 | 7.03 | 2.18 | Acceptable | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.12 | 7.13 | 2.09 | Acceptable | Guideline exceeded | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.028 | 3.55 | outside range (2.57) | Acceptable | Acceptable | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.023 | 5.54 | outside range (2.57) | Acceptable | Acceptable | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.013 | 6.38 | 2.52 | Acceptable | Acceptable | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.04 | 7.01 | 2.18 | Acceptable | Guideline exceeded | Acceptable |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.017 | 7.46 | 1.75 | Acceptable | Acceptable | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.05 | 4.57 | outside range (2.57) | Acceptable | Guideline exceeded | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.039 | 6.46 | 2.49 | Acceptable | Acceptable | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 0.048 | 6.4 | 2.49 | Acceptable | Acceptable | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.043 | 6.74 | 2.38 | Acceptable | Acceptable | Acceptable |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 4 | 6.16 | 2.555 | Guideline exceeded | Guideline exceeded | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.076 | 6.76 | 2.38 | Acceptable | Acceptable | Acceptable |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.23 | 6.77 | 2.38 | Acceptable | Guideline exceeded | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.13 | 6.81 | 2.33 | Acceptable | Guideline exceeded | Acceptable |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.019 | 7.06 | 2.18 | Acceptable | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.085 | 7.48 | 1.75 | Acceptable | Guideline exceeded | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.023 | 3.83 | outside range (2.57) | Acceptable | Acceptable | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.011 | 5.57 | outside range (2.57) | Acceptable | Acceptable | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.027 | 5.66 | outside range (2.57) | Acceptable | Acceptable | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.005 | 6.9 | 2.26 | Acceptable | Acceptable | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.005 | 7.96 | 1.03 | Acceptable | Acceptable | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 0.11 | 5.91 | outside range (2.57) | Acceptable | Guideline exceeded | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.091 | 6.54 | 2.46 | Acceptable | Guideline exceeded | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.16 | 6.22 | 2.54 | Acceptable | Guideline exceeded | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 5.7 | 6.23 | 2.54 | Guideline exceeded | Guideline exceeded | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.051 | 7.06 | 2.18 | Acceptable | Acceptable | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.48 | 6.8 | 2.33 | Acceptable | Guideline exceeded | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.16 | 6.69 | 2.43 | Acceptable | Guideline exceeded | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.043 | 7.09 | 2.18 | Acceptable | Acceptable | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.12 | 6.91 | 2.26 | Acceptable | Guideline exceeded | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 0.64 | 6.55 | 2.46 | Acceptable | Guideline exceeded | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.022 | 6.33 | 2.52 | Acceptable | Acceptable | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.027 | 6.73 | 2.38 | Acceptable | Acceptable | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.037 | 6.56 | 2.46 | Acceptable | Acceptable | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.01 | 10 | outside range | Acceptable | Acceptable | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.34 | 6.98 | 2.26 | Acceptable | Guideline exceeded | Acceptable |

**Table D-10: Total organic nitrogen concentrations (mg/L) in the Melville Bull Creek catchments in 2016**

**Total Organic Nitrogen (TON)** N (sum org) {TON} (mg/L)

**ANZECC trigger value: ID**

Max (red) 2.3 Min (blue) 0.16

| Site Name | Site Number | Collect Date | TON |
|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.63 |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 0.47 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.42 |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 0.51 |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.47 |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.56 |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.22 |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.32 |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.29 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 1.1 |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.73 |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.65 |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.23 |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.24 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.82 |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.5 |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 0.58 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.2 |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 0.58 |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.48 |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.58 |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.16 |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.35 |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.25 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.47 |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.82 |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.66 |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.21 |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.23 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.57 |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.3 |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 0.22 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.17 |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 0.56 |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.29 |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.47 |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.19 |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.37 |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.27 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.4 |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 1.1 |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 1 |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.26 |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.31 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 2.1 |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.46 |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.62 |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.94 |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.5 |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.44 |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.25 |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.44 |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.31 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 2.3 |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.81 |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 1.2 |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.43 |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.46 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 2.2 |

**Table D-11: Dissolved organic nitrogen concentrations (mg/L) in the Melville Bull Creek catchments in 2016**

**Dissolved Organic Nitrogen (DON) (mg/L)** N (sum sol org) {DON} (mg/L)
**ANZECC trigger value: ID**
Max (red) 2 Min (blue) 0.13

| Site Name | Site Number | Collect Date | DON |
|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.62 |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 0.45 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.3 |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 0.18 |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.46 |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.43 |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.18 |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.28 |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.2 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.64 |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.73 |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.58 |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.18 |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.21 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.29 |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.41 |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 0.46 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.15 |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 0.56 |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.47 |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.43 |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.13 |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.22 |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.18 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.27 |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.82 |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.65 |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.2 |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.2 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.29 |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.28 |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 0.21 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.16 |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 0.53 |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.28 |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.43 |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.18 |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.34 |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.26 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.28 |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.99 |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.99 |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.19 |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.26 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 1.6 |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.39 |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.52 |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.9 |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.49 |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.39 |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.19 |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.42 |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.28 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 2 |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.77 |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 1.2 |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.32 |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.41 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 2 |

## Table D-12: Total phosphorus concentrations (mg/L) in the Melville Bull Creek catchments in 2016

Total Phosphorus (TP) (mg/L) P (tot) {TP, pTP} (mg/L)

ANZECC trigger value: 0.065mg/L for lowland rivers; 0.06 mg/L for wetlands

All data in blue were <0.005 (LOR) Max (red) 1.2 Min (blue) <0.005

| Site Name | Site Number | Collect Date | TP | Comparison to ANZECC trigger value |
|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.015 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 0.098 | Guideline exceeded |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.057 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 0.006 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.017 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.009 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.009 | Acceptable |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.011 | Acceptable |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.01 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.22 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.019 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.008 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.025 | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.026 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.14 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.028 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 0.036 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.02 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 0.007 | Acceptable |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.018 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.01 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.006 | Acceptable |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.012 | Acceptable |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.009 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.12 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.013 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.0025 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.025 | Acceptable |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.019 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.077 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.015 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 0.022 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.016 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 0.01 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.021 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.012 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.007 | Acceptable |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.01 | Acceptable |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.011 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.11 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.015 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.01 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.021 | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.021 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 0.48 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.035 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.035 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.018 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.02 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.009 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.008 | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.009 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.01 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 1.2 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.015 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.009 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.043 | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.054 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.91 | Guideline exceeded |

**Table D-13: Soluble reactive phosphorus concentrations (mg/L) in the Melville Bull Creek catchments in 2016**

| **Soluble Reactive Phosphorus (SRP) (mg/L)** | | PO4-P (sol react) {SRP, FRP} (mg/L) | | |
|---|---|---|---|---|
| **ANZECC trigger value: 0.04 mg/L for lowland rivers and 0.03 mg/L for wetlands** | | | | |
| All data in blue were <0.005 (LOR) | Max (red) 0.62 | | Min (blue) <0.005 | |
| **Site Name** | **Site** | **Collect Date** | **SRP** | **Comparison to** |
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.011 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 0.061 | Guideline exceeded |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.01 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 0.0025 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.016 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.007 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.006 | Acceptable |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.006 | Acceptable |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.007 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.018 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.007 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.0025 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.005 | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.005 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.006 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.006 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 0.015 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.0025 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 0.0025 | Acceptable |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.015 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.0025 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.0025 | Acceptable |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.0025 | Acceptable |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.0025 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.006 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.0025 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.0025 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.0025 | Acceptable |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.0025 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.0025 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.0025 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 0.006 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.0025 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 0.0025 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.013 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.0025 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.0025 | Acceptable |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.0025 | Acceptable |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.0025 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.005 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.0025 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.0025 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.0025 | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.0025 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 0.16 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.011 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.0025 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.005 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.011 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.0025 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.005 | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.0025 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.006 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 0.61 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.006 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.0025 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.0025 | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.015 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.62 | Guideline exceeded |

## Water hardness

### Table D-14: Water hardness (mg/L) in the Melville Bull Creek catchments in 2016

Water Hardness (CaCO3) {Ca+Mg} (mg/L)

ANZECC trigger value for recreational value 500 mg/L

Max (red) 890 Min (blue) 20

| Site Name | Site Number | Collect Date | Total Water Hardness |
|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 130 |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 93 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 68 |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 120 |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 130 |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 130 |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 130 |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 94 |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 130 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 890 |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 270 |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 150 |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 20 |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 58 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 180 |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 98 |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 140 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 69 |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 130 |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 110 |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 120 |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 140 |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 100 |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 130 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 800 |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 220 |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 140 |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 32 |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 77 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 130 |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 65 |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 46 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 33 |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 100 |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 140 |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 91 |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 130 |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 110 |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 120 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 650 |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 200 |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 110 |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 37 |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 110 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 95 |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 99 |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 140 |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 110 |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 120 |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 110 |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 120 |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 110 |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 120 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 410 |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 140 |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 130 |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 71 |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 66 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 91 |

## Metals in water

### Table D-15 : Total aluminium concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

| Total Aluminium (Al) | (mg/L) | | | LOR 0.005 mg/L |
|---|---|---|---|---|
| ANZECC trigger value: 0.055mg/L for 95% Level of protection | | | | |
| (Note: only applicable if pH>6.5) | Max (red) 1 | | Min (blue) | 0.03 |
| **Site Name** | **Site Number** | **Collect Date** | **Al (tot) (mg/L)** | **Comparison to ANZECC trigger value 95% Level of Protection** |
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.42 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 0.16 | Guideline exceeded |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.51 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 0.29 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.22 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.2 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.54 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.11 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.42 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 1 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.29 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.39 | Guideline exceeded |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.03 | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.03 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.9 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.19 | Guideline exceeded |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.14 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 08-Sep-16 | 0.22 | Guideline exceeded |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 08-Sep-16 | 0.27 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.21 | Guideline exceeded |

Table D-16: Soluble aluminium concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

| Soluble Aluminium (Al) | (mg/L) | | LOR 0.005 mg/L | |
|---|---|---|---|---|
| ANZECC trigger value: 0.055mg/L for 95% Level of protection | | | | |
| (Note: only applicable if pH>6.5) | Max (red) 0.99 | | Min (blue) 0.012 | |
| **Site Name** | **Site Number** | **Collect Date** | **Al (sol) (mg/L)** | **Comparison to ANZECC 95% trigger value** |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 0.12 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 0.24 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.15 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.14 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.12 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.059 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.1 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.89 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.24 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.32 | Guideline exceeded |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.013 | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.012 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.86 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 0.13 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 0.24 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.21 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.15 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.11 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.065 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.089 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.78 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.36 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.35 | Guideline exceeded |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.021 | Acceptable |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.018 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.15 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 0.06 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 0.25 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.25 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.18 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.14 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.078 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.11 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.32 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.46 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.99 | Guideline exceeded |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.029 | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.026 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 0.12 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.11 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.21 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.19 | Guideline exceeded |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.12 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.19 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.059 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.077 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 0.047 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.29 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.38 | Guideline exceeded |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.016 | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.043 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.14 | Guideline exceeded |

## Table D-17: Total arsenic concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

**Total Arsenic (As)** (mg/L) All data in blue were <0.001 (LOR)

**ANZECC trigger for 95% protection: 0.024mg/L, NHMRC guideline recreational value (health): 0.1 mg/L**

Max <0.001 Min (blue) <0.001

| Site Name | Site Number | Collect Date | As | Comparison to ANZECC freshwater protection trigger value |
|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.0005 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.0005 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.0005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.0005 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.0005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 08-Sep-16 | 0.0005 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 08-Sep-16 | 0.0005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.0005 | Acceptable |

## Table D-18: Total cadmium concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

**Cadmium (Cd) (total mg/L)** Max <0.0001 Min (blue) <0.0001 LOR <0.0001 mg/L

**ANZECC unmodified freshwater 95% trigger value: 0.0002 mg/L, NHMRC recreational guideline (health value): 0.2 mg/L**

| Site name | Site number | Date | Cd (tot) (mg/L) | Hardness (mg/) | Adjust factor | Adjusted trigger value | Comparison to ANZECC trigger ADJUSTED value | Hardness range (mg/L) | Adjust factor | Unmodified ANZECC trigger value* |
|---|---|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.00005 | 130 | 4.2 | 0.000840 | Acceptable | 0-59 | 1 | 0.0002 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.00005 | 68 | 2.7 | 0.000540 | Acceptable | 60-119 | 2.7 | |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.00005 | 130 | 4.2 | 0.000840 | Acceptable | 120-179 | 4.2 | |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.00005 | 98 | 2.7 | 0.000540 | Acceptable | 180-240 | 5.7 | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.00005 | 69 | 2.7 | 0.000540 | Acceptable | 400 | 10 | |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.00005 | 65 | 2.7 | 0.000540 | Acceptable | | | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.00005 | 33 | 1 | 0.000200 | Acceptable | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.00005 | 99 | 2.7 | 0.000540 | Acceptable | | | |

## Table D-19: Total chromium concentrations (mg/L) in the Melville Bull Creek catchments in 2016

**Chromium (Cr III) (total mg/L)** Max (red) 0.002 Min (blue) <0.001 All data in blue were <0.001 mg/L (LOR)

**ANZECC unmodified trigger value for protection of biota: 0.0033 mg/L, NHMRC guideline for recreational use (health value): 0.5 mg/L**

| Site name | Site number | Date | Cr (tot) (mg/L) | Hardness (mg/) | Adjust factor | Adjusted trigger value | Comparison to ANZECC trigger ADJUSTED value | Hardness range (mg/L) | Adjust factor | Unmodified ANZECC trigger value* |
|---|---|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.002 | 130 | 3.7 | 0.01221 | Acceptable | 0-59 | 1 | 0.0033 |
| JOHN CREANEY PARK | MELDR-5 | 20-Jul-16 | 0.001 | 93 | 2.5 | 0.00825 | Acceptable | 60-119 | 2.5 | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.001 | 68 | 2.5 | 0.00825 | Acceptable | 120-179 | 3.7 | |
| BROCKMAN PARK | MELDR-2 | 20-Jul-16 | 0.001 | 120 | 3.7 | 0.01221 | Acceptable | 180-240 | 4.9 | |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.0005 | 130 | 3.7 | 0.01221 | Acceptable | 400 | 8.4 | |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.0005 | 130 | 3.7 | 0.01221 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.002 | 130 | 3.7 | 0.01221 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.0005 | 94 | 2.5 | 0.00825 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.002 | 130 | 3.7 | 0.01221 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.002 | 890 | 8.4 | 0.02772 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.0005 | 270 | 8.4 | 0.02772 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.001 | 150 | 3.7 | 0.01221 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.0005 | 20 | 1 | 0.0033 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.0005 | 58 | 1 | 0.0033 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.001 | 180 | 4.9 | 0.01617 | Acceptable | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.001 | 98 | 2.5 | 0.00825 | Acceptable | | | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.0005 | 69 | 2.5 | 0.00825 | Acceptable | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.0005 | 65 | 2.5 | 0.00825 | Acceptable | | | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.0005 | 33 | 1 | 0.0033 | Acceptable | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.002 | 99 | 2.5 | 0.00825 | Acceptable | | | |

## Table D-20: Total cobalt concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

**Total Cobalt (Co)** (mg/L) All data in blue were <0.001 (LOR)

**ANZECC trigger value: 0.0028mg/L for freshwater protection**

Max (red) <0.001 Min (blue) <0.001

| Site Name | Site Code | Collect Date | Co | Comparison to ANZECC trigger value |
|---|---|---|---|---|
| Brockman Park inlet | ROSS TAFE | 19-Jul-16 | 0.0005 | Acceptable |
| Upstream of Willetton Reserve outlet | WILL RES US | 19-Jul-16 | 0.0005 | Acceptable |
| Downstream of Willetton Reserve inlet | WILL RES DS | 19-Jul-16 | 0.0005 | Acceptable |
| Roxby Lane comp basin outlet | ROXBY CB | 19-Jul-16 | 0.0005 | Acceptable |
| Kalangedy Drive outlet east end Nurdi Park | BAMDKD | 19-Jul-16 | 0.0005 | Acceptable |
| Burrendah Park outlet | BURNDAH Pk | 19-Jul-16 | 0.0005 | Acceptable |
| Prendwick Park outlet | PRENDWICK | 19-Jul-16 | 0.0005 | Acceptable |
| Holmes Rd outlet | SCCIS2 | 19-Jul-16 | 0.0005 | Acceptable |
| Corinthian Road east inlet | CORINTH RD | 19-Jul-16 | 0.0005 | Acceptable |
| Riverton Drive east main drain outlet | MAMDO | 19-Jul-16 | 0.0005 | Acceptable |
| Drain outfall at Adenia Park | RRMDOUT | 19-Jul-16 | 0.0005 | Acceptable |

## Table D-21: Soluble chromium concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

**Chromium (Cr III) (soluble mg/L)** Max (red) 0.003 Min (blue) <0.001 All data in blue were <0.001 mg/L (LOR)

**ANZECC unmodified trigger value for protection of biota: 0.0033 mg/L, NHMRC guideline for recreational use (health value): 0.5 mg/L**

| Site name | Site number | Date | Cr (sol) (mg/L) | Hardness (mg/) | Adjust factor | Adjusted trigger value | Comparison to ANZECC trigger ADJUSTED value | Hardness range (mg/L) | Adjust factor | Unmodified ANZECC trigger value* |
|---|---|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK | MELDR-5 | 20-Jul-16 | 0.001 | 93 | 2.5 | 0.00825 | Acceptable | 0-59 | 1 | 0.0033 |
| BROCKMAN PARK | MELDR-2 | 20-Jul-16 | 0.0005 | 120 | 3.7 | 0.01221 | Acceptable | 60-119 | 2.5 | |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.0005 | 130 | 3.7 | 0.01221 | Acceptable | 120-179 | 3.7 | |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.0005 | 130 | 3.7 | 0.01221 | Acceptable | 180-240 | 4.9 | |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.001 | 130 | 3.7 | 0.01221 | Acceptable | 400 | 8.4 | |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.0005 | 94 | 2.5 | 0.00825 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.001 | 130 | 3.7 | 0.01221 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.001 | 890 | 8.4 | 0.02772 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.0005 | 270 | 8.4 | 0.02772 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.001 | 150 | 3.7 | 0.01221 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.0005 | 20 | 1 | 0.0033 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.0005 | 58 | 1 | 0.0033 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.001 | 180 | 4.9 | 0.01617 | Acceptable | | | |
| JOHN CREANEY PARK | MELDR-5 | 19-Aug-16 | 0.001 | 140 | 3.7 | 0.01221 | Acceptable | | | |
| BROCKMAN PARK | MELDR-2 | 19-Aug-16 | 0.001 | 130 | 3.7 | 0.01221 | Acceptable | | | |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.0005 | 110 | 2.5 | 0.00825 | Acceptable | | | |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.001 | 120 | 3.7 | 0.01221 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.001 | 140 | 3.7 | 0.01221 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.0005 | 100 | 2.5 | 0.00825 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.0005 | 130 | 3.7 | 0.01221 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.0005 | 800 | 8.4 | 0.02772 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.001 | 220 | 4.9 | 0.01617 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.002 | 140 | 3.7 | 0.01221 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.0005 | 32 | 1 | 0.0033 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.0005 | 77 | 2.5 | 0.00825 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.0005 | 130 | 3.7 | 0.01221 | Acceptable | | | |
| JOHN CREANEY PARK | MELDR-5 | 8-Sep-16 | 0.0005 | 46 | 1 | 0.0033 | Acceptable | | | |
| BROCKMAN PARK | MELDR-2 | 8-Sep-16 | 0.0005 | 100 | 2.5 | 0.00825 | Acceptable | | | |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.0005 | 140 | 3.7 | 0.01221 | Acceptable | | | |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.0005 | 91 | 2.5 | 0.00825 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.0005 | 130 | 3.7 | 0.01221 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.0005 | 110 | 2.5 | 0.00825 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.0005 | 120 | 3.7 | 0.01221 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.0005 | 650 | 8.4 | 0.02772 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.0005 | 200 | 4.9 | 0.01617 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.002 | 110 | 2.5 | 0.00825 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.0005 | 37 | 1 | 0.0033 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.0005 | 110 | 2.5 | 0.00825 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 0.0005 | 95 | 2.5 | 0.00825 | Acceptable | | | |
| JOHN CREANEY PARK | MELDR-5 | 27-Oct-16 | 0.0005 | 140 | 3.7 | 0.01221 | Acceptable | | | |
| BROCKMAN PARK | MELDR-2 | 27-Oct-16 | 0.0005 | 110 | 2.5 | 0.00825 | Acceptable | | | |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.0005 | 120 | 3.7 | 0.01221 | Acceptable | | | |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.0005 | 110 | 2.5 | 0.00825 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.001 | 120 | 3.7 | 0.01221 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.0005 | 110 | 2.5 | 0.00825 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.0005 | 120 | 3.7 | 0.01221 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 0.0005 | 410 | 8.4 | 0.02772 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.0005 | 140 | 3.7 | 0.01221 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.002 | 130 | 3.7 | 0.01221 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.0005 | 71 | 2.5 | 0.00825 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.0005 | 66 | 2.5 | 0.00825 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.003 | 91 | 2.5 | 0.00825 | Acceptable | | | |

## Table D-22: Total copper concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

**Copper (Cu) (total mg/L)** Max (red) 0.013 Min (blue) <0.001 All data in blue were <0.001 mg/L (LOR)

ANZECC unmodified freshwater 95% trigger value: 0.0014 mg/L, NHMRC guideline for recreational use (aesthetic value): 10 mg/L

| Site name | Site number | Date | Cu (tot) (mg/L) | Hardness (mg/) | Adjust factor | Adjusted trigger value | Comparison to ANZECC trigger ADJUSTED value | Hardness range (mg/L) | Adjust factor | Unmodified ANZECC trigger value* |
|---|---|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.005 | 130 | 3.9 | 0.00546 | Acceptable | 0-59 | 1 | 0.0014 |
| JOHN CREANEY PARK | MELDR-5 | 20-Jul-16 | 0.002 | 93 | 2.5 | 0.0035 | Acceptable | 60-119 | 2.5 | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.005 | 68 | 2.5 | 0.0035 | Guideline exceeded | 120-179 | 3.9 | |
| BROCKMAN PARK | MELDR-2 | 20-Jul-16 | 0.0005 | 120 | 3.9 | 0.00546 | Acceptable | 180-240 | 5.2 | |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.002 | 130 | 3.9 | 0.00546 | Acceptable | 400 | 9 | |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.001 | 130 | 3.9 | 0.00546 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.0005 | 130 | 3.9 | 0.00546 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.001 | 94 | 2.5 | 0.0035 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.0005 | 130 | 3.9 | 0.00546 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.013 | 890 | 9 | 0.0126 | Guideline exceeded | | | |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.001 | 270 | 9 | 0.0126 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.001 | 150 | 3.9 | 0.00546 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.002 | 20 | 1 | 0.0014 | Guideline exceeded | | | |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.001 | 58 | 1 | 0.0014 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.007 | 180 | 5.2 | 0.00728 | Acceptable | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.003 | 98 | 2.5 | 0.0035 | Acceptable | | | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.003 | 69 | 2.5 | 0.0035 | Acceptable | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.002 | 65 | 2.5 | 0.0035 | Acceptable | | | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.003 | 33 | 1 | 0.0014 | Guideline exceeded | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.0005 | 99 | 2.5 | 0.0035 | Acceptable | | | |

## Table D-23: Soluble copper concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

**Copper (Cu) (soluble mg/L)** Max (red) 0.013 Min (blue) <0.001 All data in blue were <0.001 mg/L (LOR)

ANZECC unmodified freshwater 95% trigger value: 0.0014 mg/L, NHMRC guideline for recreational use (aesthetic value): 10 mg/L

| Site name | Site number | Date | Cu (sol) (mg/L) | Hardness (mg/) | Adjust factor | Adjusted trigger value | Comparison to ANZECC trigger ADJUSTED value | Hardness range (mg/L) | Adjust factor | Unmodified ANZECC trigger value* |
|---|---|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK | MELDR-5 | 20-Jul-16 | 0.0005 | 93 | 2.5 | 0.0035 | Acceptable | 0-59 | 1 | 0.0014 |
| BROCKMAN PARK | MELDR-2 | 20-Jul-16 | 0.0005 | 120 | 3.9 | 0.00546 | Acceptable | 60-119 | 2.5 | |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.002 | 130 | 3.9 | 0.00546 | Acceptable | 120-179 | 3.9 | |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.0005 | 130 | 3.9 | 0.00546 | Acceptable | 180-240 | 5.2 | |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.0005 | 130 | 3.9 | 0.00546 | Acceptable | 400 | 9 | |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.0005 | 94 | 2.5 | 0.0035 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.0005 | 130 | 3.9 | 0.00546 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.013 | 890 | 9 | 0.0126 | Guideline exceeded | | | |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.0005 | 270 | 9 | 0.0126 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.0005 | 150 | 3.9 | 0.00546 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.0005 | 20 | 1 | 0.0014 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.0005 | 58 | 1 | 0.0014 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.007 | 180 | 5.2 | 0.00728 | Acceptable | | | |
| JOHN CREANEY PARK | MELDR-5 | 19-Aug-16 | 0.002 | 140 | 3.9 | 0.00546 | Acceptable | | | |
| BROCKMAN PARK | MELDR-2 | 19-Aug-16 | 0.0005 | 130 | 3.9 | 0.00546 | Acceptable | | | |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.001 | 110 | 2.5 | 0.0035 | Acceptable | | | |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.001 | 120 | 3.9 | 0.00546 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.0005 | 140 | 3.9 | 0.00546 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.001 | 100 | 2.5 | 0.0035 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.0005 | 130 | 3.9 | 0.00546 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.009 | 800 | 9 | 0.0126 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.0005 | 220 | 5.2 | 0.00728 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.0005 | 140 | 3.9 | 0.00546 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.002 | 32 | 1 | 0.0014 | Guideline exceeded | | | |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.002 | 77 | 2.5 | 0.0035 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.002 | 130 | 3.9 | 0.00546 | Acceptable | | | |
| JOHN CREANEY PARK | MELDR-5 | 8-Sep-16 | 0.002 | 46 | 1 | 0.0014 | Guideline exceeded | | | |
| BROCKMAN PARK | MELDR-2 | 8-Sep-16 | 0.0005 | 100 | 2.5 | 0.0035 | Acceptable | | | |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.001 | 140 | 3.9 | 0.00546 | Acceptable | | | |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.001 | 91 | 2.5 | 0.0035 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.0005 | 130 | 3.9 | 0.00546 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.0005 | 110 | 2.5 | 0.0035 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.0005 | 120 | 3.9 | 0.00546 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.002 | 650 | 9 | 0.0126 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.001 | 200 | 5.2 | 0.00728 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.001 | 110 | 2.5 | 0.0035 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.002 | 37 | 1 | 0.0014 | Guideline exceeded | | | |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.001 | 110 | 2.5 | 0.0035 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 0.001 | 95 | 2.5 | 0.0035 | Acceptable | | | |
| JOHN CREANEY PARK | MELDR-5 | 27-Oct-16 | 0.0005 | 140 | 3.9 | 0.00546 | Acceptable | | | |
| BROCKMAN PARK | MELDR-2 | 27-Oct-16 | 0.0005 | 110 | 2.5 | 0.0035 | Acceptable | | | |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.001 | 120 | 3.9 | 0.00546 | Acceptable | | | |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.0005 | 110 | 2.5 | 0.0035 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.0005 | 120 | 3.9 | 0.00546 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.0005 | 110 | 2.5 | 0.0035 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.0005 | 120 | 3.9 | 0.00546 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 0.0005 | 410 | 9 | 0.0126 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.0005 | 140 | 3.9 | 0.00546 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.0005 | 130 | 3.9 | 0.00546 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.0005 | 71 | 2.5 | 0.0035 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.0005 | 66 | 2.5 | 0.0035 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.0005 | 91 | 2.5 | 0.0035 | Acceptable | | | |

## Table D-24: Total iron concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

Total Iron (Fe) (mg/L) LOR 0.005 mg/L

Interim guideline for biota protection: 0.3 mg/L, NHMRC guideline for recreation (aesthetic): 3 mg/L

Max (red) 6.3 Min (blue) 0.091

| Site Name | Site | Collect Date | Fe (mg/L) | Comparison to interim |
|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.24 | Acceptable |
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 6.3 | Guideline exceeded |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 1.1 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 1.5 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.26 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.54 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 2.3 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.45 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 2.1 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 5.2 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 1.3 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.44 | Guideline exceeded |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.23 | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.091 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 2.4 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.63 | Guideline exceeded |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.33 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 08-Sep-16 | 0.64 | Guideline exceeded |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 08-Sep-16 | 0.55 | Guideline exceeded |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 1.6 | Guideline exceeded |

## Table D-25: Soluble iron concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

Soluble Iron (Fe) (mg/L) LOR 0.005 mg/L

Interim guideline for biota protection: 0.3 mg/L, NHMRC guideline for recreation (aesthetic): 3 mg/L

Max (red) 5.8 Min (blue) 0.059

| Site Name | Site Number | Collect Date | Fe (mg/L) | Comparison to interim guideline |
|---|---|---|---|---|
| JOHN CREANEY PARK | MELDR-05 | 20-Jul-16 | 5.8 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 20-Jul-16 | 1.3 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.2 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.3 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 1.9 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.3 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 1.2 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 3.9 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 1.1 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.38 | Guideline exceeded |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.17 | Acceptable |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.059 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 2.1 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-05 | 19-Aug-16 | 1.4 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 19-Aug-16 | 1.3 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.2 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.34 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 2.3 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.4 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 1.2 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 3.7 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 1.4 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.36 | Guideline exceeded |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.37 | Guideline exceeded |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.11 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 1.2 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-05 | 8-Sep-16 | 0.34 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 8-Sep-16 | 1 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.23 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.32 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 1.7 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.26 | Acceptable |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.86 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 2.7 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 1.2 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.34 | Guideline exceeded |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.21 | Acceptable |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.18 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 5.1 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 1.1 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.99 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.24 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.33 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 1.3 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.36 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.59 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 3 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.81 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.53 | Guideline exceeded |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.33 | Guideline exceeded |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.48 | Guideline exceeded |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 3.1 | Guideline exceeded |

## Table D-26: Total lead concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

**Lead (Pb) (total mg/L)** Max (red) 0.095 Min (blue) <0.001 All data in blue were <0.001 mg/L (LOR)

ANZECC unmodified freshwater 95% trigger value: 0.0034 mg/L, NHMRC recreational guideline value (health value): 0.1 mg/L

| Site name | Site number | Date | Pb (tot) (mg/L) | Hardness (mg/) | Adjust factor | Adjusted trigger value | Comparison to ANZECC trigger ADJUSTED value | Hardness range (mg/L) | Adjust factor | Unmodified ANZECC trigger value* |
|---|---|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.007 | 130 | 7.6 | 0.02584 | Acceptable | 0-59 | 1 | 0.0034 |
| JOHN CREANEY PARK | MELDR-5 | 20-Jul-16 | 0.002 | 93 | 4 | 0.0136 | Acceptable | 60-119 | 4 | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.01 | 68 | 4 | 0.0136 | Acceptable | 120-179 | 7.6 | |
| BROCKMAN PARK | MELDR-2 | 20-Jul-16 | 0.0005 | 120 | 7.6 | 0.02584 | Acceptable | 180-240 | 11.8 | |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | 400 | 26.7 | |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.002 | 130 | 7.6 | 0.02584 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.0005 | 94 | 4 | 0.0136 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.002 | 890 | 26.7 | 0.09078 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.001 | 270 | 26.7 | 0.09078 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.0005 | 150 | 7.6 | 0.02584 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.001 | 20 | 1 | 0.0034 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.0005 | 58 | 1 | 0.0034 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.095 | 180 | 11.8 | 0.04012 | Guideline exceeded | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.003 | 98 | 4 | 0.0136 | Acceptable | | | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.0005 | 69 | 4 | 0.0136 | Acceptable | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.001 | 65 | 4 | 0.0136 | Acceptable | | | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.0005 | 33 | 1 | 0.0034 | Acceptable | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.0005 | 99 | 4 | 0.0136 | Acceptable | | | |

## Table D-27: Soluble lead concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

**Lead (Pb) (soluble mg/L)** Max (red) 0.092 Min (blue) <0.001 All data in blue were <0.001 mg/L (LOR)

ANZECC unmodified freshwater 95% trigger value: 0.0034 mg/L, NHMRC recreational guideline value (health value): 0.1 mg/L

| Site name | Site number | Date | Pb (sol) (mg/L) | Hardness (mg/) | Adjust factor | Adjusted trigger value | Comparison to ANZECC trigger ADJUSTED value | Hardness range (mg/L) | Adjust factor | Unmodified ANZECC trigger value* |
|---|---|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK | MELDR-5 | 20-Jul-16 | 0.002 | 93 | 4 | 0.0136 | Acceptable | 0-59 | 1 | 0.0034 |
| BROCKMAN PARK | MELDR-2 | 20-Jul-16 | 0.0005 | 120 | 7.6 | 0.02584 | Acceptable | 60-119 | 4 | |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | 120-179 | 7.6 | |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | 180-240 | 11.8 | |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | 400 | 26.7 | |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.0005 | 94 | 4 | 0.0136 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.002 | 890 | 26.7 | 0.09078 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.0005 | 270 | 26.7 | 0.09078 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.0005 | 150 | 7.6 | 0.02584 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.0005 | 20 | 1 | 0.0034 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.0005 | 58 | 1 | 0.0034 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.092 | 180 | 11.8 | 0.04012 | Guideline exceeded | | | |
| JOHN CREANEY PARK | MELDR-5 | 19-Aug-16 | 0.001 | 140 | 7.6 | 0.02584 | Acceptable | | | |
| BROCKMAN PARK | MELDR-2 | 19-Aug-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | | | |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.0005 | 110 | 4 | 0.0136 | Acceptable | | | |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.001 | 120 | 7.6 | 0.02584 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.0005 | 140 | 7.6 | 0.02584 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.0005 | 100 | 4 | 0.0136 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.006 | 800 | 26.7 | 0.09078 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.0005 | 220 | 11.8 | 0.04012 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.001 | 140 | 7.6 | 0.02584 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.001 | 32 | 1 | 0.0034 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.0005 | 77 | 4 | 0.0136 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.011 | 130 | 7.6 | 0.02584 | Acceptable | | | |
| JOHN CREANEY PARK | MELDR-5 | 8-Sep-16 | 0.0005 | 46 | 1 | 0.0034 | Acceptable | | | |
| BROCKMAN PARK | MELDR-2 | 8-Sep-16 | 0.0005 | 100 | 4 | 0.0136 | Acceptable | | | |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.0005 | 140 | 7.6 | 0.02584 | Acceptable | | | |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.001 | 91 | 4 | 0.0136 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.0005 | 110 | 4 | 0.0136 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.0005 | 120 | 7.6 | 0.02584 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.003 | 650 | 26.7 | 0.09078 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.001 | 200 | 11.8 | 0.04012 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.001 | 110 | 4 | 0.0136 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.0005 | 37 | 1 | 0.0034 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.0005 | 110 | 4 | 0.0136 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 0.006 | 95 | 4 | 0.0136 | Acceptable | | | |
| JOHN CREANEY PARK | MELDR-5 | 27-Oct-16 | 0.0005 | 140 | 7.6 | 0.02584 | Acceptable | | | |
| BROCKMAN PARK | MELDR-2 | 27-Oct-16 | 0.0005 | 110 | 4 | 0.0136 | Acceptable | | | |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.0005 | 120 | 7.6 | 0.02584 | Acceptable | | | |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.001 | 110 | 4 | 0.0136 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.0005 | 120 | 7.6 | 0.02584 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.0005 | 110 | 4 | 0.0136 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.0005 | 120 | 7.6 | 0.02584 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 0.0005 | 410 | 26.7 | 0.09078 | Acceptable | | | |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.0005 | 140 | 7.6 | 0.02584 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.0005 | 130 | 7.6 | 0.02584 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.0005 | 71 | 4 | 0.0136 | Acceptable | | | |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.002 | 66 | 4 | 0.0136 | Acceptable | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.002 | 91 | 4 | 0.0136 | Acceptable | | | |

### Table D-28: Total manganese concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

Total Manganese (Mn) (mg/L) All data in blue were <0.001 (LOR)

ANZECC trigger value for 95% protection: 1.9 mg/L, NHMRC recreational guidline (health): 1 mg/L

Max (red) 0.021 Min (blue) 0.004

| Site Name | Site Ref No. | Date Collected | Manganese Total | Comparison to ANZECC trigger value 95% Level of Protection |
|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.01 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.019 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.011 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.013 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.008 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 08-Sep-16 | 0.007 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 08-Sep-16 | 0.004 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.021 | Acceptable |

### Table D-29: Total mercury concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

Total Mercury (Hg) (mg/L) All data in blue were <0.0001 (LOR)

ANZECC trigger for 95% protection: 0.0006 mg/L, NHMRC guideline for recreation (health): 0.01 mg/L

Max <0.0001 Min (blue) <0.0001

| Site Name | Site Number | Collect Date | Hg (mg/L) | Comparison to interim guideline |
|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.00005 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.00005 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.00005 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.00005 | Acceptable |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.00005 | Acceptable |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.00005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.00005 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.00005 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.00005 | Acceptable |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.00005 | Acceptable |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.00005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 08-Sep-16 | 0.0001 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 08-Sep-16 | 0.0002 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 08-Sep-16 | 0.0002 | Acceptable |
| RAAF DRAIN | MELDR-14 | 08-Sep-16 | 0.0002 | Acceptable |
| BATEMAN PARK | MELDR-06 | 08-Sep-16 | 0.0003 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.00005 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.00005 | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.00005 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.00005 | Acceptable |

### Table D-30: Soluble mercury concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

Soluble Mercury (Hg) (mg/L) — All data in blue w ere <0.0001 (LOR)

ANZECC trigger for 95% protection: 0.0006 mg/L, NHMRC guideline for recreation (health): 0.01 mg/L

Max <0.0001 Min (blue) <0.0001

| Site Name | Site Number | Collect Date | Hg (mg/L) | Comparison to ANZECC trigger value 95% Level of Protection |
|---|---|---|---|---|
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.00005 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.00005 | Acceptable |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.00005 | Acceptable |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.00005 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 16-Aug-16 | 0.00005 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.00005 | Acceptable |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.00005 | Acceptable |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.00005 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.00005 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.00005 | Acceptable |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.00005 | Acceptable |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.00005 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.00005 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.00005 | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.00005 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.00005 | Acceptable |

### Table D-31: Total molybdenum concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

Total Molybdenum (Mo) (mg/L) — All data in blue w ere <0.001 (LOR)

ANZECC trigger value for 95% protection: 0.034 mg/L, NHMRC recreational guidline (health): 0.5 mg/L

Max (red) 0.001 Min (blue) <0.001

| Site Name | Site Ref No. | Date Collected | Molybdenum Total | Comparison to ANZECC trigger value 95% Level of Protection |
|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.001 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.0005 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.0005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.001 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.0005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 08-Sep-16 | 0.0005 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 08-Sep-16 | 0.0005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.0005 | Acceptable |

### Table D-32: Total nickel concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

Nickel (Ni) (total mg/L) — Max (red) 0.002 Min (blue) <0.001 LOR <0.001 mg/L

ANZECC unmodified trigger value for 95% protection: 0.011 mg/L, NHMRC recreational guidline (health): 0.2 mg/L

| Site name | Site number | Date | Ni (tot) (mg/L) | Hardness (mg/) | Adjust factor | Adjusted trigger value | Comparison to ANZECC trigger ADJUSTED value | Hardness range (mg/L) | Adjust factor | Unmodified ANZECC trigger value* |
|---|---|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.0005 | 130 | 3.9 | 0.042900 | Acceptable | 0-59 | 1 | 0.011 |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.002 | 68 | 2.5 | 0.027500 | Acceptable | 60-119 | 2.5 | |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.0005 | 130 | 3.9 | 0.042900 | Acceptable | 120-179 | 3.9 | |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.0005 | 98 | 2.5 | 0.027500 | Acceptable | 180-240 | 5.2 | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.0005 | 69 | 2.5 | 0.027500 | Acceptable | 400 | 9 | |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.0005 | 65 | 2.5 | 0.027500 | Acceptable | | | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.0005 | 33 | 1 | 0.011000 | Acceptable | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.002 | 99 | 2.5 | 0.027500 | Acceptable | | | |

**Table D-33: Total selenium concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016**

**Total Selenium (Se)** **(mg/L)** All data in blue were <0.001 (LOR)

**ANZECC trigger value for 95% protection: 0.005 mg/L, NHMRC recreational guideline (health): 0.1 mg/L**

Max <0.001 Min (blue) <0.001

| Site Name | Site Ref No. | Date Collected | Selenium Total | Comparison to ANZECC trigger value 95% Level of Protection |
|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.0005 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.0005 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.0005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.0005 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.0005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 08-Sep-16 | 0.0005 | Acceptable |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 08-Sep-16 | 0.0005 | Acceptable |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.0005 | Acceptable |

**Table D-34: Total zinc concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016**

**Zinc (Zn) (total mg/L)** Max (red) 0.24 Min (blue) 0.005 All data in blue were <0.001 mg/L (LOR)

**ANZECC freshwater 95% trigger value: 0.008 mg/L, NHMRC recreational use guildeine (aesthetic value): 30 mg/L**

| Site name | Site number | Date | Zn (tot) (mg/L) | Hardness (mg/) | Adjust factor | Adjusted trigger value | Comparison to ANZECC trigger ADJUSTED value | Hardness range (mg/L) | Adjust factor | Unmodified ANZECC trigger value* |
|---|---|---|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK INLET | MELDR-15 | 20-Jul-16 | 0.041 | 130 | 3.9 | 0.0312 | Guideline exceeded | 0-59 | 1 | 0.008 |
| JOHN CREANEY PARK | MELDR-5 | 20-Jul-16 | 0.016 | 93 | 2.5 | 0.02 | Acceptable | 60-119 | 2.5 | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 20-Jul-16 | 0.12 | 68 | 2.5 | 0.02 | Guideline exceeded | 120-179 | 3.9 | |
| BROCKMAN PARK | MELDR-2 | 20-Jul-16 | 0.005 | 120 | 3.9 | 0.0312 | Acceptable | 180-240 | 5.2 | |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.011 | 130 | 3.9 | 0.0312 | Acceptable | 400 | 9 | |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.013 | 130 | 3.9 | 0.0312 | Acceptable | | | |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.007 | 130 | 3.9 | 0.0312 | Acceptable | | | |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.008 | 94 | 2.5 | 0.02 | Acceptable | | | |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.008 | 130 | 3.9 | 0.0312 | Acceptable | | | |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.2 | 890 | 9 | 0.072 | Guideline exceeded | | | |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.043 | 270 | 9 | 0.072 | Acceptable | | | |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.009 | 150 | 3.9 | 0.0312 | Acceptable | | | |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.019 | 20 | 1 | 0.008 | Guideline exceeded | | | |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.008 | 58 | 1 | 0.008 | Guideline exceeded | | | |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.24 | 180 | 5.2 | 0.0416 | Guideline exceeded | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 19-Aug-16 | 0.092 | 98 | 2.5 | 0.02 | Guideline exceeded | | | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 19-Aug-16 | 0.084 | 69 | 2.5 | 0.02 | Guideline exceeded | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 8-Sep-16 | 0.044 | 65 | 2.5 | 0.02 | Guideline exceeded | | | |
| DOWNSTREAM ELIZABETH MANION PARK | MELDR-16 | 8-Sep-16 | 0.032 | 33 | 1 | 0.008 | Guideline exceeded | | | |
| JOHN CREANEY PARK INLET | MELDR-15 | 27-Oct-16 | 0.09 | 99 | 2.5 | 0.02 | Guideline exceeded | | | |

## Table D-35: Soluble zinc concentrations (mg/L) in water in the Melville Bull Creek catchments in 2016

**Zinc (Zn) (soluble mg/L)** Max (red) 0.24 Min (blue) 0.003 All data in blue were <0.001 mg/L (LOR)

**ANZECC freshwater 95% trigger value: 0.008 mg/L, NHMRC recreational use guidleine (aesthetic value): 30 mg/L**

| Site name | Site number | Date | Zn (sol) (mg/L) | Hardness (mg/) | Adjust factor | Adjusted trigger value | Comparison to ANZECC trigger ADJUSTED value |
|---|---|---|---|---|---|---|---|
| JOHN CREANEY PARK | MELDR-5 | 20-Jul-16 | 0.016 | 93 | 2.5 | 0.02 | Acceptable |
| BROCKMAN PARK | MELDR-2 | 20-Jul-16 | 0.005 | 120 | 3.9 | 0.0312 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 19-Jul-16 | 0.011 | 130 | 3.9 | 0.0312 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 20-Jul-16 | 0.013 | 130 | 3.9 | 0.0312 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 20-Jul-16 | 0.007 | 130 | 3.9 | 0.0312 | Acceptable |
| RAAF DRAIN | MELDR-14 | 20-Jul-16 | 0.008 | 94 | 2.5 | 0.02 | Acceptable |
| BATEMAN PARK | MELDR-06 | 20-Jul-16 | 0.008 | 130 | 3.9 | 0.0312 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 20-Jul-16 | 0.2 | 890 | 9 | 0.072 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 20-Jul-16 | 0.043 | 270 | 9 | 0.072 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 20-Jul-16 | 0.009 | 150 | 3.9 | 0.0312 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 20-Jul-16 | 0.019 | 20 | 1 | 0.008 | Guideline exceeded |
| MARMION RESERVE | MELDR-11 | 20-Jul-16 | 0.008 | 58 | 1 | 0.008 | Guideline exceeded |
| BLUE GUM LAKE OUTLET | MELDR-12 | 20-Jul-16 | 0.24 | 180 | 5.2 | 0.0416 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-5 | 19-Aug-16 | 0.029 | 140 | 3.9 | 0.0312 | Acceptable |
| BROCKMAN PARK | MELDR-2 | 19-Aug-16 | 0.028 | 130 | 3.9 | 0.0312 | Acceptable |
| BROCKMAN PARK INLET | ROSS TAFE | 16-Aug-16 | 0.018 | 110 | 2.5 | 0.02 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 19-Aug-16 | 0.025 | 120 | 3.9 | 0.0312 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 19-Aug-16 | 0.025 | 140 | 3.9 | 0.0312 | Acceptable |
| RAAF DRAIN | MELDR-14 | 19-Aug-16 | 0.03 | 100 | 2.5 | 0.02 | Guideline exceeded |
| BATEMAN PARK | MELDR-06 | 19-Aug-16 | 0.066 | 130 | 3.9 | 0.0312 | Guideline exceeded |
| BOORAGOON LAKE OUTLET | MELDR-07 | 19-Aug-16 | 0.17 | 800 | 9 | 0.072 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 19-Aug-16 | 0.042 | 220 | 5.2 | 0.0416 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 19-Aug-16 | 0.026 | 140 | 3.9 | 0.0312 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 19-Aug-16 | 0.026 | 32 | 1 | 0.008 | Guideline exceeded |
| MARMION RESERVE | MELDR-11 | 19-Aug-16 | 0.017 | 77 | 2.5 | 0.02 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 19-Aug-16 | 0.11 | 130 | 3.9 | 0.0312 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-5 | 8-Sep-16 | 0.04 | 46 | 1 | 0.008 | Guideline exceeded |
| BROCKMAN PARK | MELDR-2 | 8-Sep-16 | 0.021 | 100 | 2.5 | 0.02 | Guideline exceeded |
| BROCKMAN PARK INLET | ROSSTAFE | 6-Sep-16 | 0.015 | 140 | 3.9 | 0.0312 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 8-Sep-16 | 0.025 | 91 | 2.5 | 0.02 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 8-Sep-16 | 0.021 | 130 | 3.9 | 0.0312 | Acceptable |
| RAAF DRAIN | MELDR-14 | 8-Sep-16 | 0.019 | 110 | 2.5 | 0.02 | Acceptable |
| BATEMAN PARK | MELDR-06 | 8-Sep-16 | 0.022 | 120 | 3.9 | 0.0312 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 8-Sep-16 | 0.099 | 650 | 9 | 0.072 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 8-Sep-16 | 0.038 | 200 | 5.2 | 0.0416 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 8-Sep-16 | 0.019 | 110 | 2.5 | 0.02 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 8-Sep-16 | 0.021 | 37 | 1 | 0.008 | Guideline exceeded |
| MARMION RESERVE | MELDR-11 | 8-Sep-16 | 0.009 | 110 | 2.5 | 0.02 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 8-Sep-16 | 0.029 | 95 | 2.5 | 0.02 | Guideline exceeded |
| JOHN CREANEY PARK | MELDR-5 | 27-Oct-16 | 0.028 | 140 | 3.9 | 0.0312 | Acceptable |
| BROCKMAN PARK | MELDR-2 | 27-Oct-16 | 0.019 | 110 | 2.5 | 0.02 | Acceptable |
| BROCKMAN PARK INLET | ROSSTAFE | 26-Oct-16 | 0.015 | 120 | 3.9 | 0.0312 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.02 | 110 | 2.5 | 0.02 | Guideline exceeded |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.022 | 120 | 3.9 | 0.0312 | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.013 | 110 | 2.5 | 0.02 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.015 | 120 | 3.9 | 0.0312 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 0.019 | 410 | 9 | 0.072 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.034 | 140 | 3.9 | 0.0312 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.018 | 130 | 3.9 | 0.0312 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.021 | 71 | 2.5 | 0.02 | Guideline exceeded |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.003 | 66 | 2.5 | 0.02 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.013 | 91 | 2.5 | 0.02 | Acceptable |

| Hardness range (mg/L) | Adjust factor | Unmodified ANZECC trigger value* |
|---|---|---|
| 0-59 | 1 | 0.008 |
| 60-119 | 2.5 | |
| 120-179 | 3.9 | |
| 180-240 | 5.2 | |
| 400 | 9 | |

## Total metals in sediment

**Table D-36: Total aluminium concentration (mg/kg) in sediment in the Melville Bull Creek catchments in 2016**

**Aluminium (Al) (total)** **(mg/kg)** LOR 1.0 mg/Kg

**ANZECC trigger value: ND**

Max (red) 30,000 Min (blue) 510

| Site name | Site number | Date | Al (tot) mg/kg |
|---|---|---|---|
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 5100 |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 1200 |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 8100 |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 30000 |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 1000 |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 510 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 7000 |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 4600 |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 1100 |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 6500 |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 1900 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 720 |

**Table D-37: Total arsenic concentration (mg/kg) in sediment in the Melville Bull Creek catchments in 2016**

**Arsenic (As) (total sediment)** (mg/kg) All data in blue were <0.5 (LOR)

**ANZECC trigger value: low 20 mg/kg and high 70 mg/Kg**

Max (red) 7.1 Min (blue) <0.5

| Site name | Site number | Date | As (tot) mg/kg | Comparison to ANZECC lower trigger value 20 mg/kg |
|---|---|---|---|---|
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 1.9 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.25 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 4.1 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.7 | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.6 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.25 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 7.1 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 1.5 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.25 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 5.1 | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 2.5 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.25 | Acceptable |

**Table D-38: Total chromium concentration (mg/kg) in sediment in the Melville Bull Creek catchments in 2016**

| Chromium (Cr) (total) | | (mg/kg) | All data in blue w ere <0.5 (LOR) | |
|---|---|---|---|---|
| ANZECC lower trigger value: 80 mg/kg and higher 370 mg/kg | | | | |
| | Max (red) | 180 | Min (blue) | 1.2 |
| **Site name** | **Site number** | **Date** | **Cr (mg/kg)** | **Comparison to ANZECC lower trigger value 80 mg/kg** |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 18 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 11 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 11 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 180 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 1.2 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 1.2 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 35 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 9.7 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 1.6 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 23 | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 3 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 2 | Acceptable |

**Table D-39: Total copper concentration (mg/kg) in sediment in the Melville Bull Creek catchments in 2016**

| Copper (Cu) (total) | | (mg/kg) | All data in blue w ere <0.5 (LOR) | |
|---|---|---|---|---|
| ANZECC lower trigger value: 65 mg/kg & higher 270 mg/kg | | | | |
| | Max (red) | 95 | Min (blue) | <0.5 |
| **Site name** | **Site number** | **Date** | **Cu (mg/kg)** | **Comparison to ANZECC lower trigger value 65mg/kg** |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 50 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 16 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 2.4 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 95 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.25 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.25 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 28 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 14 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 1.2 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 72 | Guideline exceeded |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 1 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 1.2 | Acceptable |

Table D-40: Total iron concentration (mg/kg) in sediment in the Melville Bull Creek catchments in 2016

| Iron (Fe) (total) (mg/kg) LOR 1.0 mg/Kg | | | |
|---|---|---|---|
| ANZECC trigger value: ND | | | |
| Max (red) 57,000 | | Min (blue) 180 | |
| **Site name** | **Site number** | **Date** | **Fe (tot) mg/kg** |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 7000 |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 1400 |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 57000 |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 54000 |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 1700 |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 730 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 13000 |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 1800 |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 180 |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 11000 |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 1700 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 850 |

Table D-41: Total lead concentration (mg/kg) in sediment in the Melville Bull Creek catchments in 2016

| Lead (Pb) (total) (mg/kg) All data in blue were <0.5 (LOR) | | | | |
|---|---|---|---|---|
| ANZECC lower trigger value: 50 mg/kg & higher 220 mg/kg | | | | |
| Max (red) 200 | | Min (blue) 1.2 | | |
| **Site name** | **Site number** | **Date** | **Pb (mg/kg)** | **Comparison to ANZECC lower trigger value 50 mg/kg** |
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 130 | Guideline exceeded |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 8.5 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 14 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 170 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 3.5 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 1.2 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 56 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 50 | Guideline exceeded |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 3.5 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 200 | Guideline exceeded |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 5.7 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 15 | Acceptable |

**Table D-42: Total mercury concentration (mg/kg) in sediment in the Melville Bull Creek catchments in 2016**

**Mercury (Hg) (total)** (mg/kg) All data in blue were <0.1 (LOR)

**ANZECC lower trigger value: 0.15 mg/kg and higher 1.0 mg/kg**

Max (red) 0.2 Min (blue) <0.1

| Site name | Site number | Date | Hg (tot) mg/kg | Comparison to ANZECC lower trigger value 0.15 mg/kg |
|---|---|---|---|---|
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.1 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.05 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 0.1 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.05 | Acceptable |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.05 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.05 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 0.2 | Guideline exceeded |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.1 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.05 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.1 | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.05 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.05 | Acceptable |

**Table D-43: Total nickel concentration (mg/kg) in sediment in the Melville Bull Creek catchments in 2016**

**Nickel (Ni) (total)** (mg/kg) All data in blue were <1.0 mg/Kg(LOR)

**ANZECC lower trigger value: 21 mg/kg & higher 52 mg/kg**

Max (red) 21 Min (blue) <1.0

| Site name | Site number | Date | Ni (mg/kg) | Comparison to ANZECC lower trigger value 21 mg/kg |
|---|---|---|---|---|
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 5.5 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.5 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 1.6 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 21 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.5 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.5 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 7.6 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 5.1 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.5 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 8.2 | Acceptable |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.5 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.5 | Acceptable |

Table D-44: Total selenium concentration (mg/kg) in sediment in the Melville Bull Creek catchments in 2016

**Selenium (Se) (total)** (mg/kg) LOR 1.0 mg/Kg

**ANZECC trigger value: ND**

Max (red) 2.9 Min (blue) <1.0

| Site name | Site number | Date | Se (tot) mg/kg |
|---|---|---|---|
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 0.5 |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 0.5 |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 1.1 |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 0.5 |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 0.5 |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 0.5 |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 2.9 |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 0.5 |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 0.5 |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 0.5 |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 0.5 |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 0.5 |

Table D-45: Total zinc concentration (mg/kg) in sediment in the Melville Bull Creek catchments in 2016

**Zinc (Zn) (total)** (mg/kg) LOR 1.0 mg/Kg

**ANZECC lower trigger value: 200 mg/kg & higher 410 mg/kg**

Max (red) 390 Min (blue) 1.4

| Site name | Site number | Date | Zn (mg/kg) | Comparison to ANZECC lower trigger value 200 mg/kg |
|---|---|---|---|---|
| JOHN CREANEY PARK | MELDR-05 | 27-Oct-16 | 120 | Acceptable |
| BROCKMAN PARK | MELDR-02 | 27-Oct-16 | 19 | Acceptable |
| BULL CREEK MD | PSDTBCMD | 27-Oct-16 | 35 | Acceptable |
| BRENTWOOD DRAIN | MELDR-13 | 27-Oct-16 | 390 | Guideline exceeded |
| RAAF DRAIN | MELDR-14 | 27-Oct-16 | 5.5 | Acceptable |
| BATEMAN PARK | MELDR-06 | 27-Oct-16 | 4.2 | Acceptable |
| BOORAGOON LAKE OUTLET | MELDR-07 | 27-Oct-16 | 57 | Acceptable |
| PINEY LAKES OUTLET | MELDR-08 | 27-Oct-16 | 49 | Acceptable |
| QUENDA LAKE OUTLET | MELDR-09 | 27-Oct-16 | 1.4 | Acceptable |
| FREDERICK BALDWIN | MELDR-10 | 27-Oct-16 | 320 | Guideline exceeded |
| MARMION RESERVE | MELDR-11 | 27-Oct-16 | 16 | Acceptable |
| BLUE GUM LAKE OUTLET | MELDR-12 | 27-Oct-16 | 5.6 | Acceptable |

# Appendix E Potential effects of stressors on aquatic environments

In the context of water quality, stressors can be described as chemical compounds or indicators that are naturally occurring in waterways, for which values outside of certain ranges can have multiple negative effects. Stressors often reach undesirable levels in waterways as a result of human intervention. Stressors analysed in this monitoring program included physicochemical parameters (pH, dissolved oxygen, electrical conductivity, total suspended solids and temperature), nutrients (nitrogen and phosphorus in their various forms) and hardness. **Table E-1** describes the undesirable effects that these stressors can have on surface water bodies.

**Table E-1: Effects of stressors on aquatic environments**

| Parameter | Factors/sources impacting stressor levels | Ecosystem impacts |
|---|---|---|
| **pH** | • **Natural**<br>  • Rainfall - ($CO_2$) in atmosphere decreases pH of precipitation<br>  • Algal or plant growth (photosynthesis increases pH, respiration decreases pH)<br>    o pH often higher during the day (more photosynthesis) and lower at night (more respiration)<br>  • Salinity<br>  • Underlying soil type (e.g. Bassendean sands – acidic, limestone – alkaline)<br>  • Influence of groundwater<br>  • Presence of acidic tannins from vegetation – decreases pH<br>• **Anthropogenic**<br>  • Oxidation of acid sulfate soils due to manual disturbance or anthropogenic change in water levels – decreases pH<br>  • Acidic or alkaline discharges from industry<br>  • Acidic mining runoff or exposure of acidic rocks from mining<br>  • Acid rain resulting from certain industrial processes | • High or low pH can result in increased toxicity of certain metals (ANZECC and ARMCANZ 2000)<br>  • High – e.g. aluminium (pH>9)<br>  • Low –e.g. chromium (VI), nickel<br>• High or low levels can be directly toxic to biota – different species tolerate different ranges<br>  • → changes can result in altered compositions and/or reduced biodiversity of plants and animals<br>• Mosquitoes can tolerate low pH waters and can therefore become a nuisance in acidic wetlands where other macroinvertebrate predators may not survive<br>• Alkaline conditions can result in conversion of ammonium (generally non-toxic) to ammonia (toxic)<br>• Low pH can weaken shells and exoskeletons and kill macroinvertebrates |

**Table E-1 (continued): Effects of stressors on aquatic environments**

| Parameter | Factors/sources impacting stressor levels | Ecosystem impacts |
|---|---|---|
| **Dissolved Oxygen (DO)** | • **Natural**<br>• Depth of waterbody (deeper waters more likely to have low oxygen levels)<br>• Depth of measurement - surface waters often higher, bottom often lower<br>o Stratification (e.g. different layers of salinity) can enhance this effect<br>• Algal or plant growth (photosynthesis increases pH, respiration decreases pH)<br>o DO often higher during the day (more photosynthesis) and lower at night (more respiration)<br>• Decomposition of organic material – process consumes DO<br>• Temperature<br>• Rain and wind can introduce oxygen into water<br>• Influence of groundwater<br>• **Anthropogenic**<br>• Microbial breakdown of excess organic material (e.g. from grass clippings, sewage, industrial wastes or as a result of eutrophication) – decreases DO<br>• Oxidation of hydrocarbons, reduction of metals, microbial (bacterial and archaea) activity and nitrification – decreases DO.<br>• Excess plant/macroalgal growth on the water surface from eutrophication can smother water – decreasing DO<br>• Excess algal growth can also increase DO (high levels of photosynthesis)<br>• Aeration through fountains and subsurface aeration - increases DO | • Low DO - directly toxic to biota<br>• Especially fish and molluscs<br>• High DO saturations can also be harmful<br>• Oxygen bubbles can block blood vessels in fish resulting in death<br>• Changes in DO result in altered redox conditions which can facilitate certain chemical reactions<br>• Low DO results in phosphorus release from sediments – can lead to eutrophication (Correll 1998)<br>• Low DO results in formation of reduced compounds, such as hydrogen sulphide, resulting in toxic effects on aquatic animals (Camargo & Alonso 2006)<br>• Low DO can increase toxicity of certain metals (e.g. copper) and ammonia (ANZECC and ARMCANZ 2000)<br>• Low DO levels also halt nitrogen loss from water by preventing nitrification of ammonia (Geoscience Australia 2015a) |

**Table E-1 (continued): Effects of stressors on aquatic environments**

| Parameter | Factors/sources impacting stressor levels | Ecosystem impacts |
|---|---|---|
| **Electrical Conductivity (EC)** | • **Natural**<br>  • Communication with the ocean will increase EC<br>  • Proximity to ocean – fine sea spray or atmospheric salt can eventuate in waterbodies<br>  • Depth of measurement - salt water heavier than freshwater so will sink<br>    o Stratification (e.g. different layers of salinity) can enhance this effect<br>  • Underlying geology<br>  • Temperature<br>  • Influence of groundwater<br>  • Seasonal water level changes –increased rainfall and runoff can dilute water (decreasing EC) and evaporation concentrates ions (increasing EC)<br>• **Anthropogenic**<br>  • Discharges from industry<br>    o E.g. sewage contamination can increase EC<br>    o Oil spills can decrease EC | • High or low levels can be directly toxic to biota – different species tolerate different ranges (Hart et al 1991)<br>  • → changes can result in altered compositions and/or reduced biodiversity of plants and animals<br>  • In this catchment water is naturally reasonably fresh, therefore high EC will result in loss of many endemic plant and animal species<br>    o Particularly leeches, flatworms and macroinvertebrates without impermeable skeletons (pulmonate gastropods) (Dunlop et al 2005). |
| **Total Suspended Solids (TSS)** | • **Natural**<br>  • Sources include soil particles and organic material (e.g. algae, microorganisms, decaying plant and animal matter)<br>  • Windy conditions can result in increased resuspension of bottom sediments and introduction of soil particles<br>  • Heavy rainfall will result in increased erosion of surrounding soils and increased introduction of particles through runoff<br>• **Anthropogenic**<br>  • Discharges from industry from runoff and dust<br>  • Products of vehicle wear from road run-off<br>  • Increased amounts of soil particulate material entering waterbodies as a result of construction and demolition operations. | • Deposition of suspended solids can block pipes, change flow conditions in open channels (IEA 2006), alter streambed properties and aquatic habitat for fish, smother benthic organisms, and reduce the food supply and refuge for bottom feeding organisms, macrophytes, and benthic organisms (Chetia 2014)<br>• High concentrations can reduce water clarity and light available to support photosynthesis → loss of submerged macrophytes (i.e. seagrasses)<br>• High concentrations can impair the function of fish gills (ANZECC and ARMCANZ 2000)<br>• Suspended solids can alter predator-prey relationships (e.g. could make it difficult for fish to see prey)<br>• Suspended solids can also provide surface area for the sorption and transport of nutrients and other pollutants (e.g. metals and bacteria)<br>  • → often used as an "indicator" of nutrients or other pollutants |

**Table E-1 (continued): Effects of stressors on aquatic environments**

| Parameter | Factors/sources impacting stressor levels | Ecosystem impacts |
|---|---|---|
| **Temperature** | • **Natural**<br>• Air temperature and sun exposure<br>o Therefore time of day<br>• Turbidity – increases temperature through scattering of solar radiation<br>• Waterbody depth and depth of measurement<br>• Vegetation - temperatures in unvegetated water bodies will vary more than those with vegetation due to greater exposure to weather conditions, but will generally be higher due to lack of shade<br>• **Anthropogenic**<br>• Industrial discharges – can increase or decrease temperature<br>• Stormwater runoff from hot surfaces (e.g. roads and carparks) could increase the temperature of receiving water bodies<br>• Reservoirs could discharge cooler water to waterbodies. | • Higher rates of plant and algae growth<br>• As soon as the temperature cools or other supporting processes cease, growth declines and biological decay commences → increased oxygen demand<br>• Influences sediment redox reactions<br>• E.g. increased temperatures result in increased sediment phosphorus release (Lehtoranta 1995).<br>• Increased temperatures increase metabolic rate of bacteria and therefore mineralisation of organic matter → release of bioavailable phosphorus and nitrogen species into the water (Lehtoranta 1995).<br>• High temperatures reduce oxygen solubility<br>• High temperatures increase solubility of salts<br>• Many chemicals exhibit between a two and four fold increase or decrease in toxicity for each 10°C rise in temperature (ANZECC and ARMCANZ 2000).<br>• Some organisms become more vulnerable to toxic wastes, parasites and diseases at low water temperatures<br>• Increased metabolic rate of organisms with increasing temperature → increased oxygen demand (compounded by decreased oxygen solubility)<br>• Different species tolerant to different ranges → changes can result in differing biotic communities<br>• Fish and macro-invertebrates are ectotherms as their body temperature is controlled by the temperature of the surrounding environment (Marsh et al 2005) – as such they particularly sensitive to temperature changes<br>• Low temperatures - loss of spawning trigger for fish |

**Table E-1 (continued): Effects of stressors on aquatic environments**

| Parameter | Factors/sources impacting stressor levels | Ecosystem impacts |
|---|---|---|
| **Nitrogen** | • **Natural**<br>  • Soil type – e.g. highly mineral soils will store less nitrogen available to be mobilised into the water<br>  • Fringing and emergent vegetation type and volume<br>  • Seasonal conditions<br>  • Hydrology – loss of nitrogen as $N_2$ gas may occur more readily in certain wetland hydrology<br>  • Sources include plant and animal decomposition, faecal material, lightning and volcanic activity<br>• **Anthropogenic**<br>  • Fertilisers<br>  • Sewerage<br>  • Feed lots<br>  • Pet droppings<br>  • Combustion of fossil fuels<br>  • Plant debris (e.g. from glass clippings)<br>  • Industrial and household cleaning products (e.g. runoff from car washing)<br>  • Ammonia/ammonium specific:<br>    o Industrial processes including the preparation of synthetic fibres (e.g. nylons), plastics and explosives, resins, human and veterinary medicines, fuel cells, rocket fuel, dyes, metal treating operations, refrigeration, and petroleum (DoE 2016).<br>    o Proportion of ammonia/ammonium in water varies with pH & temperature (ammonium is predominant at pH 5 to 8) and as such levels can vary throughout the day | • Some nitrogen is required for life - wetlands with very low concentrations of nitrogen and phosphorus will support little life (oligotrophic)<br>• High concentrations (particularly of bioavailable forms) in conjunction with high phosphorus result in nuisance growth of aquatic plants/algae/cyanobacteria (blue green algae) known as eutrophication, which can have flow-on negative effects:<br>  • Toxic effects of cyanobacterial toxins (particularly due to cyanobacteria in fresh and brackish waters) to humans, birds and aquatic biota<br>  • Decreased dissolved oxygen from surface growth acting as physical barrier and decomposition of excessive growth → harm to fish, macroinvertebrates and desirable macrophyte species<br>  • Decreased light available to desirable macrophyte species<br>  • Reduction in recreational amenity (phytoplankton blooms and macrophytes in wetlands and lakes) from cyanobacterial toxins and odours produced from decomposing material<br>  • Physical blocking of waterways<br>  • Reduction in biodiversity or change in species composition<br>    o E.g. mosquitoes (tolerant to poor water quality) can become predominant in eutrophic waterways<br>• Nitrogenous fertilisers and car emissions can lead to acidification of waterbodies<br>• High levels of ammonia are directly toxic to fish & aquatic organisms |

**Table E-1 (continued): Effects of stressors on aquatic environments**

| Parameter | Factors/sources impacting stressor levels | Ecosystem impacts |
|---|---|---|
| **Phosphorus** | • **Natural**<br>  • Decomposition of organic matter<br>  • Weathering of rocks<br>• **Anthropogenic**<br>  • Motor vehicle exhaust, fuels, lubricants, fertilisers, detergents, car wash products, eroded soils, and industrial wastes (IEA 2006)<br>  • Runoff from impervious surfaces such as roads, parking lots and rooftops (especially in commercial, industrial and high-density residential areas) can potentially contribute a large portion of phosphorus to the water bodies as this water is not filtered (Department of Environment (Western Australia) 2004a) | • Some phosphorus is required for life - wetlands with very low concentrations of phosphorus and nitrogen will support little life (oligotrophic)<br>• Excessive concentrations (particularly bioavailable forms (i.e. SRP)) in conjunction with high nitrogen concentrations, can result in eutrophication (see ecosystem impacts of nitrogen for more information) |
| **Hardness** | • **Natural**<br>  • Underlying geology – e.g. wetlands over limestone generally have hard water<br>• **Anthropogenic**<br>  • Discharges from operating and disused rock quarries<br>  • Inorganic chemical industry | • Generally, hard waters are more alkaline, and waters with greater hardness are generally less susceptible to acidification<br>• Increasing water hardness and alkalinity specifically reduces the uptake and toxicity to freshwater organisms of several metals (such as cadmium, chromium III, copper, lead, nickel and zinc) |

# Appendix F Potential sources, factors affecting toxicity and impacts of metals found in urban stormwater

The metals analysed as part of this monitoring program can be derived from a wide variety of sources, some natural and some anthropogenic. Understanding the sources of these metals can provide potential avenues for investigation if high concentrations are detected. Furthermore, if high metal concentrations are encountered, other water quality indicators and local factors may provide an indication of the severity of the impact of these concentrations. The impact of hardness on concentrations is has been quantified for some metals (see tables in **Appendix D**), but also, for example, for metals that adsorb to suspended particles, the presence of these particles may reduce the bioavailability of some (but not all) of these metals to biota, thus effectively reducing their toxicity. As metals are generally more bioavailable in soluble form, factors that increase solubility will increase their toxicity. Different functional groups of biota may also differ in their sensitivity to metals. The main impact of metals to surface waters is generally toxicity to biota, but some metals (such as iron) can have other negative environmental impacts.

**Table F-1** describes the potential sources, factors affecting impacts and toxic and other impacts of metals. Information regarding sources of metals is taken from The National Pollutant Inventory (Australian Government Department of Environment (DoE) 2016) and information regarding factors affecting toxicity and impacts to biota are derived from ANZECC and ARMCANZ (2000) unless otherwise stated.

**Table F-1: Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater**

| METAL | SOURCES/USES | FACTORS AFFECTING IMPACTS | IMPACTS |
|---|---|---|---|
| Aluminium (Al) | • Natural leaching from soil and rock<br>• Increased in soluble groundwater concentrations under acidic conditions, therefore strongly linked to the presence of Acid Sulfate Soils (ASS) (DER 2015b)<br>• Anthropogenic sources include industrial discharges and corrosion of products containing aluminium<br>    • used in frames, door knobs, car bodies, plane parts, engines, cables, cans, solar mirrors & heat reflecting blankets (Lenntech n.d.-a) | • Toxicity to fish and invertebrates increased at pH<5.5 and >9, with a maximum toxicity around pH 5.0-5.2<br>• Toxicity reduced by complexing with humic (organic) substances<br>• Toxicity reduced at high water hardness<br>• Toxicity possibly increased with increased temperature | • Toxic to biota at high concentrations<br>• Among aquatic plants, single celled plants most susceptible<br>• Fish more susceptible than aquatic macroinvertebrates<br>• Accumulates on fish gills and clogs them with a slimy layer, limiting breathing (Lenntech n.d.-a) |

**Table F-1 (continued): Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater**

| METAL | SOURCES/USES | FACTORS AFFECTING IMPACTS | IMPACTS |
|---|---|---|---|
| Arsenic (As) | • Naturally present in the earth's crust<br>• Can enter waterways through wind-blown dust and water run-off<br>• Naturally released into the environment through weathering of rocks and volcanic activity<br>• High arsenic concentrations in groundwater (and communicating surface waters) linked to the presence of Acid Sulfate Soils (ASS) (DER 2015b)<br>• Mining and metal manufacturing main anthropogenic source of arsenic in Australia<br>  ◦ Other uses of arsenic in industry include manufacturing of food, paper products, glass products, petroleum and coal products and chemicals<br>• Also released from combustion of fuels and other incineration activities | • Several valencies exist in water – most common are As (III) and As (V)<br>  ◦ both bond with carbon to form numerous organo-arsenic compounds, some of which are very toxic (e.g. methylarsine)<br>• Valency state main factor affecting toxicity – As (III) most toxic form<br>• Toxicity of As (V) increases with increasing temperature<br>• As (III) removed by sulfides, As (V) by clays | • Toxic to biota<br>• Can bio-accumulate in some animals<br>• Phytoplankton is among the most sensitive organisms to both forms of arsenic<br>• Higher trophic levels are less sensitive to arsenic because they generally accumulate the element from food rather than the water column.<br>• Adult freshwater fish are generally less sensitive to arsenic |
| Cadmium (Cd) | • Can be found naturally in the earth's crust in various ores with other metals and compounds<br>• Enters waterways through settling of particles, rain, and polluted waters<br>• Short life in expectancy in atmosphere - not expected to travel far from source<br>• Produced as by-product of zinc, lead and copper extraction, and can be released into the environment from such extraction<br>• Often found in manures and pesticides (Lenntech n.d.-b)<br>• It can be found in fairly high concentrations in wastewater and sewage sludge (Lenntech n.d.-b)<br>  ◦ Can be transported over great distances when it is absorbed by sludge; cadmium-rich sludge can pollute surface waters and soils<br>• Cadmium metal and compounds are used in the following products: metal plating, batteries, polyvinyl chloride (PVC) products, automobile radiators, dying and printing of fabrics, electronics components, photography, electroplating, semiconductors, glass, ceramic glazes, tires, petrol, diesel fuel and lubricating oils<br>• Other sources of cadmium include combustion, wear of tyres and brake pads, possible combustion of lubricating oils, industrial emissions, corrosion of galvanised metals and landfill leachate (IEA 2006) | • Toxicity decreases as water hardness increases<br>• Toxicity is lower in lower pH, and at pH>8<br>• Dissolved organic material reduces toxicity<br>• Strongly adsorbed by suspended material – as such in natural waters, cadmium is found mainly in bottom sediments and suspended particles (WHO 2004)<br>• Complexes with chloride and therefore is less toxic in high salinity | • Non-essential to life<br>• Is highly toxic and accumulates in the liver and kidneys of animals and is a known carcinogen (WHO 2004)<br>• In aquatic ecosystems can bio-accumulate in mussels, oysters, shrimps, lobsters and fish<br>• Susceptibility to cadmium can vary greatly between aquatic organisms<br>• Salt-water organisms are known to be more resistant to cadmium poisoning than freshwater organisms |

**Table F-1 (continued): Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater**

| METAL | SOURCES/USES | FACTORS AFFECTING IMPACTS | IMPACTS |
|---|---|---|---|
| Chromium (Cr) | • Exists naturally in low concentrations (rocks, soil, plants, animals, volcanic dust, gasses)<br>• Enters waterways through settling of atmospheric particles and rainfall and contaminated water and soil<br>• Chromium in stormwater is mostly associated with suspended solids (IEA 2006)<br>• Two forms: The trivalent form (Cr III) is mainly discharged from the metal industry where it is used for chrome plating, and the hexavalent form (Cr VI) is mainly discharged from tanning & painting (IEA 2006)<br>• Predominant form of chromium in the environment is Cr III<br>• It is also used in industry to produce the following: electrical products, engine parts, fungicides, wood treatment products, ceramics, clay, paper, glass, porcelain, pharmaceuticals/medicines/medical treatment, steam & air conditioning supplies and cement products Other sources include combustion of fossil fuels, incineration of waste and sewerage sludge | • Toxicity of both forms decreases with increasing water hardness and/or alkalinity<br>• Cr VI toxicity increases in freshwater at lower pH<br>• Cr VI not affected by presence of suspended material, whereas Cr III is readily removed from the water column with both dissolved organic matter and suspended material<br>• Toxicity decreases with increasing salinity and sulfate<br>• More toxic at high temperatures | • Chromium VI is toxic to aquatic organisms, and a carcinogen for animals & humans<br>• Chromium III is far less toxic than Cr VI<br>• Chromium VI may bio-accumulate to some degree<br>• Freshwater algae & invertebrates are more sensitive to Cr VI than fish, with crustaceans particularly sensitive |
| Cobalt (Co) | • Found naturally in soil, dust, seawater, volcanic emissions, smoke from bush fires<br>• Short life in expectancy in atmosphere - not expected to travel far from source<br>• Automotive repair shops significant emitters of cobalt in air<br>• Other sources include mining/refining of nickel, copper, silver, lead and iron, and the manufacturing, use or disposal of paints, varnishes, ceramic, ink and enamels | • Adsorbs to suspended particles and sediment<br>• Solubility (and therefore bioavailability/toxicity) increased by complexing with organic matter | • An essential element for life but toxic at certain concentrations<br>• May bioaccumulate in some organisms |
| Copper (Cu) | • Copper compounds naturally occur in rocks, soil, water, plants, animals and humans<br>• Enters water from settling of atmospheric particles or dissolved in waters<br>• Natural sources include decaying vegetation, forest fires and sea spray<br>• Mining and metal manufacturing largest sources of copper emissions in Australia<br>• Other industrial sources include electricity supply and manufacturing of chemicals, cement, lime, plaster and concrete products, transport equipment, petroleum, coal, beverages, paper products, glass products, motor vehicles and parts, wood products, ceramic products, food and beverage products, and textiles (DoE 2016)<br>• Found to be related to the flow of vehicles and road network characteristics (Beasley & Kneale 2002).<br>• Also possible release from solid and liquid fuel combustion, lawn mowing, leaching from antifouling paint on ships and boats | • Toxicity increases when hardness, alkalinity & dissolved oxygen decrease<br>• Strongly attaches to organic matter and suspended material<br>    • Levels of dissolved organic matter in freshwaters usually remove copper toxicity (except in very soft waters)<br>• Its toxicity in algae, invertebrates & fish generally increases as salinity decreases<br>• Copper and lead toxicity appear to interact in synergism | • It is a micro-nutrient and essential to life at low concentrations, toxic at higher concentrations to freshwater fish, invertebrates and plants<br>• Some species of algae particularly sensitive<br>• Negatively affects fish and macro-invertebrates in various body systems across multiple life stages<br>• Can bio-accumulate in aquatic organisms |

**Table F-1 (continued): Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater**

| METAL | SOURCES/USES | FACTORS AFFECTING IMPACTS | IMPACTS |
|---|---|---|---|
| Iron (Fe) | • Fourth most abundant metal in earth's crust<br>• Naturally present in water in varying quantities depending upon local geology and other chemical factors<br>• Insoluble ferric state ($Fe^{3+}$) usually more prevalent in surface waters (ANZECC and ARMCANZ 2000)<br>• Soluble ferrous state ($Fe^{2+}$) present in reducing (anaerobic) waters and usually originates from groundwater (ANZECC and ARMCANZ 2000)<br>• Manufacturing uses of iron compounds that may contribute anthropogenic iron pollution could include production of containers, cars, laundry machines, bridges, buildings, springs, pigments in glass, pharmaceutics, chemicals, iron fertilisers, pesticides, wood impregnation and photography (Lenntech n.d.-c) | • Solubility increases in acidic water<br>• Solubility higher in anaerobic waters | • Essential for both plants and animals<br>• Has been shown to be toxic to some macroinvertebrate species<br>• In aerobic waters, ferric iron can form colloidal suspensions which can either form suspended flocs or settle and harden<br>    • may cause problems with turbidity, decreased light penetration and smothering of benthic organisms |
| Lead (Pb) | • Rare in nature, anthropogenic sources outweigh natural sources (ANZECC and ARMCANZ 2000)<br>• Lead reaches aquatic environment through rainfall, lead dust , street runoff and industrial discharges (ANZECC and ARMCANZ 2000)<br>• Also fires and fuel combustion<br>• Lead used to be used in water pipes, stained glass windows, paint and fuel and as such these products may be partially responsible for the legacy of lead in waterways<br>• Mining and metal manufacturing greatest industrial emitters<br>• Also used in production of cement, plaster, concrete, iron, steel, petroleum, coal products, paper products, glass products, metal products, motor vehicles and parts, wood products, yarn and fabric | • Toxicity increases when water hardness decreases<br>• Low solubility in water reduces toxicity<br>• Strongly adsorbed by suspended clay, humic substances and other suspended material<br>• Strongly complexed by dissolved organic material<br>• Toxicity possibly increased at low pH | • Non-essential, highly poisonous element<br>• Shellfish particularly sensitive (Lenntech n.d.-d)<br>• Affects chlorophyll synthesis in plants and phytoplankton (Lenntech n.d.-d)<br>• Can potentially bioaccumulate but not generally present in great enough concentrations that bioaccumulation has much effect |
| Manganese (Mn) | • Compounds widely distributed in earth's crust, mainly as $MnO_2$ (ANZECC and ARMCANZ 2000)<br>• Commonly associated with dissolved ferrous iron and a naturally occurring constituent of groundwater (Department of Environment (WA) 2004)<br>• Can enter waterways from settling of atmospheric particles or dissolved compounds in waters<br>• Common constituent of mining and smelting discharges (ANZECC and ARMCANZ 2000)<br>• Used in steel alloys, dry cell batteries, paints, inks, glass, ceramics, fireworks and fertilisers (ANZECC and ARMCANZ 2000) | • Generally present in suspended form, but soluble at low pH and low DO<br>• Toxicity in brown trout shown to decrease with increasing hardness | • Vital micro-nutrient for plants and animals<br>• Low toxicity compared to other metals<br>• Not much data available regarding toxicity, chronic data only available for three taxonomic groups |

**Table F-1 (continued): Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater**

| METAL | SOURCES/USES | FACTORS AFFECTING IMPACTS | IMPACTS |
|---|---|---|---|
| Mercury (Hg) | • Naturally occurring element found in rocks and ores<br>• Can enter waterways from atmospheric particles settling or deposited by rain, or through emissions in water and soil<br>• Natural sources of mercury in waterways include emissions from volcanoes and evaporation of water from soil<br>• Largest source of mercury emissions in Australia from manufacturing, mining and alumina production of non-ferrous metals<br>• Also can be released from burning of fossil fuels, precious metal mining, cement manufacturing, chemical manufacturing and sewerage<br>• Landfills and disposal of batteries, thermometers and other mercury containing products can emit mercury to land, which can eventually end up in water | • Present as inorganic Hg (II) and organomercurial compounds (such as methyl mercury) - microorganisms can convert Hg (II) to methyl mercury<br>• Increased toxicity with decreased hardness<br>• Strongly adsorbed by particles, often associated with sediments<br>• Strong affinity for chloride – toxicity of inorganic mercury reduced in saline waters | • Inorganic mercury relatively low toxicity and low ability to bioaccumulate<br>• Methyl mercury particularly toxic - can be absorbed quickly<br>  • can bioaccumulate in fish and their food chains<br>  • is known to cause nerve damage (Lenntech n.d.-e)<br>• In mercury polluted areas, larger and older fish tend to have higher levels |
| Molybdenum (Mo) | • Occurs naturally in igneous or sedimentary rocks as molybdenite ($MoS_2$) and molybdates ($MoO_4$) (ANZECC and ARMCANZ 2000)<br>• Molybdenum and its compounds are used in the manufacture of specialty steel products, electrical apparatus, glass, ceramics, fertilisers and pigments (ANZECC and ARMCANZ 2000) | • Mo can adsorb to clay surfaces, but generally occurs in the dissolved form at natural pH | • Essential to life but toxic in excess quantities<br>• Can cause foetal deformities in animals (Lenntech n.d.-f) |
| Nickel (Ni) | • Exists naturally in soils and rocks often with arsenic, antimony and sulfur<br>• Found at background concentrations in natural waters (ANZECC and ARMCANZ 2000)<br>• Can enter waterways from settling of atmospheric particles or dissolved compounds in waters<br>• Natural sources include weathering of rocks (ANZECC and ARMCANZ 2000) and volcanoes<br>• Anthropogenic sources of atmospheric nickel include combustion of fossil fuels, mining and refining operations, steel production, nickel alloy production, electroplating, municipal waste incineration and nickel refineries<br>• Can enter water in wastewater from municipal sewage treatment plants, stormwater runoff and from groundwater near landfill sites | • Toxicity increases with decreased hardness<br>• Toxicity usually increases with decreased pH<br>• Complexed by dissolved organic material<br>• Less bioavailable when adsorbed to suspended material<br>• Toxicity increases with decreasing salinity | • Essential to life<br>• Moderately toxic to freshwater organisms<br>• Reduces growth of freshwater algae at relatively low concentrations<br>• Fish less sensitive to nickel, but it differs between species<br>• Teratogenic in some forms (Lenntech n.d.-g) |

**Table F-1 (continued): Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater**

| METAL | SOURCES/USES | FACTORS AFFECTING TOXICTY AND IMPACTS | IMPACTS |
|---|---|---|---|
| Selenium (Se) | • Occurs naturally in the environment at varying concentrations, usually combined with other compounds (such as sulphide ores of other metals)<br>• Commonly found in sedimentary rock formations<br>• Can enter waterways from settling of atmospheric particles or dissolved compounds in waters<br>• Exists in water as oxyions selenate (selenium (VI)) and selenite (selenium (IV))<br>• Natural sources in water include weathering of rocks<br>• Released into the air and water from combustion of fossil fuels, smelting and refining of metals, glass and ceramics manufacturing and refuse incinerators<br>• Can also enter waterways from anti dandruff shampoos and application as fungicides and insecticides | • Toxicity of selenate increases with decreasing sulfate and phosphate concentrations<br>• Selenite uptake increases at low pH<br>• Toxicity ameliorated by mercury and copper<br>• Binding of selenium to particles does not reduce bioavailability | • Toxicity dependent on valency state – Se (IV) more toxic than Se (VI)<br>• Selenites readily removed form water column, but selenates can bioaccumulate in aquatic ecosystems<br>• Food chain uptake more significant than water uptake<br>• At high concentrations, can cause reproductive failure and birth defects in animals (Lenntech n.d.-h) |
| Zinc (Zn) | • Exists naturally in rocks, soil, air, waters, plants and humans<br>• Can enter waterways from settling of atmospheric particles or dissolved compounds in waters<br>• Natural sources in water include weathering of rocks<br>• Anthropogenic sources include mining, steel production, waste incineration, chemical waste dumps & landfills, sewage treatment plants, corrosion of galvanised structures, fertilisers and herbicides<br>• Urban runoff also potential source from wear of car tyres or fuel combustion | • Toxicity increases with decreasing hardness and alkalinity<br>• Levels of organic matter present in freshwater generally sufficient to remove zinc toxicity<br>    • pH determines stability of these compounds<br>• Adsorbed by suspended material<br>• Toxicity generally decreases with decreasing pH when pH <8<br>• Uptake and toxicity decrease with increasing salinity | • Essential for life<br>• Labile $Zn^{+2}$ most toxic form<br>• Bioaccumulates in freshwater animal tissues but not a major problem |