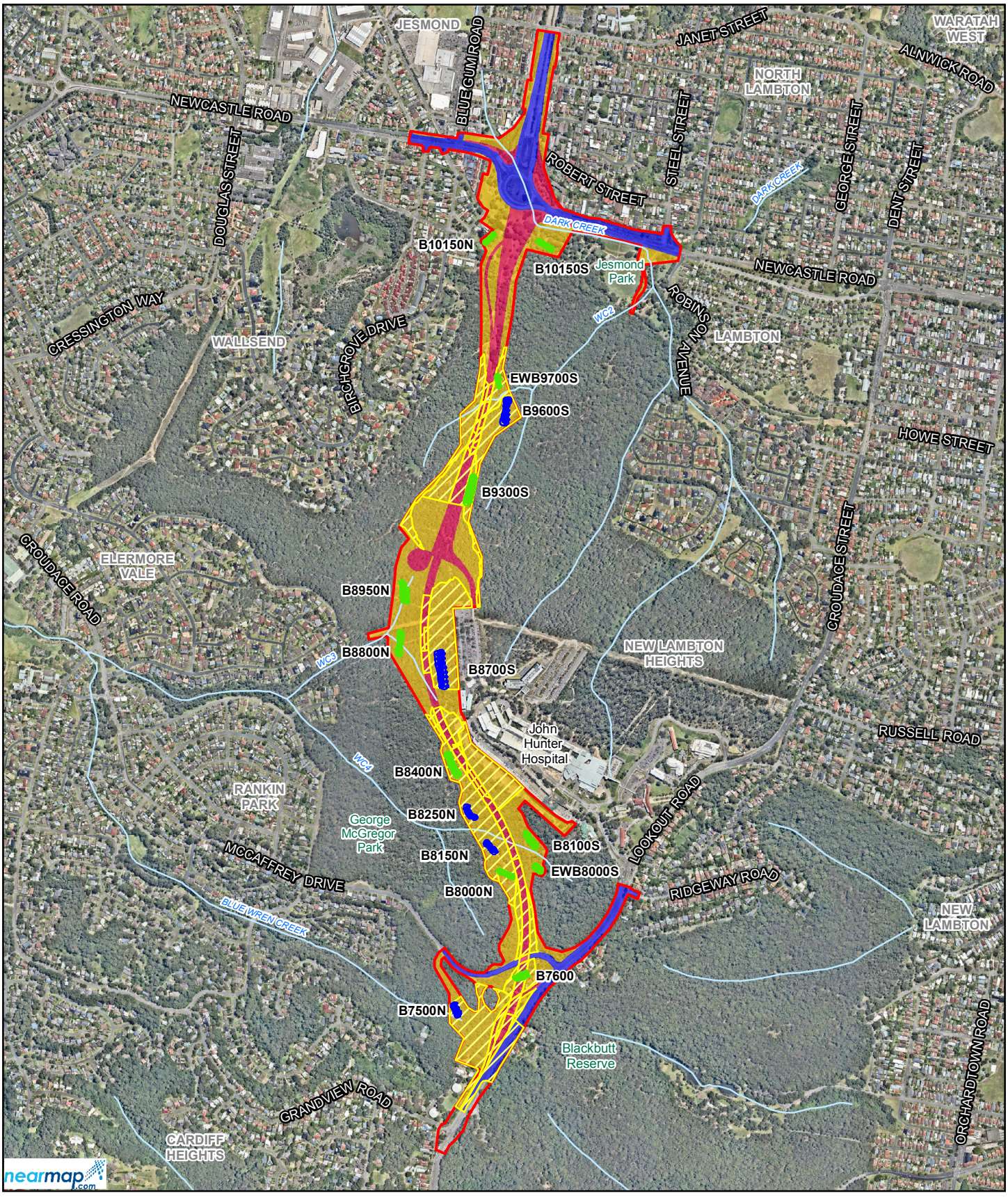


LEGEND

- Construction footprint
- Cleared area
- Existing road
- Proposed pavement area
- Watercourse
- Temporary sedimentation basin
- Operational water quality structure
- Operational water quality treatment structure catchment area

B8100S Temporary sedimentation basin / operational water quality structure name

Paper Size A4

0 62.5 125 250 375 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Rankin Park to Jesmond
Water Quality and Watercourse
Impact Assessment Report

Job Number 22-17656
Revision 0
Date 25 Oct 2016

Construction footprint catchments

Figure 4-1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\17656\GIS\Maps\Deliverables\WaterQuality\2217656_WQ005_ConstructionFootprint_Catchments_0.mxd

Data source: Nearmap: Aerial Imagery, 20160331; Aurecon: Construction footprint, Water quality structures, 2016; LPI: DTDB, 2012. Created by: tmorton, fmackay

It is proposed to modify the retained construction sedimentation basins as follows:

- Lowering of basin walls and filling of basins to provide about 0.5 metres of storage depth.
- Placement of a 100 millimetre layer of topsoil within the base of the basin and planting with a mix of native grasses that are selected to maximise the absorption of TN and TP from the discharge water. This lining should be extended to cover the internal batters and basin walls.
- An open channel is to carry low flows from the stormwater discharge points into the basin. This channel should be, as far as practical, constructed with a longitudinal grade less than 0.5 per cent to minimise inflow velocities. Scour protection, in the form of rock rip-rap, may be required at intervals within the channel and at the entrance to the basin.
- The low-flow bypass should be capable of diverting stormwater discharges generated for design storms up to the three month ARI critical duration design storm event. The low-flow bypass should be self-cleansing to prevent blockage and reduce the requirement for inspection and maintenance.
- An emergency spillway is to be included within the basin to allow excess stormwater to discharge from the basin safely.

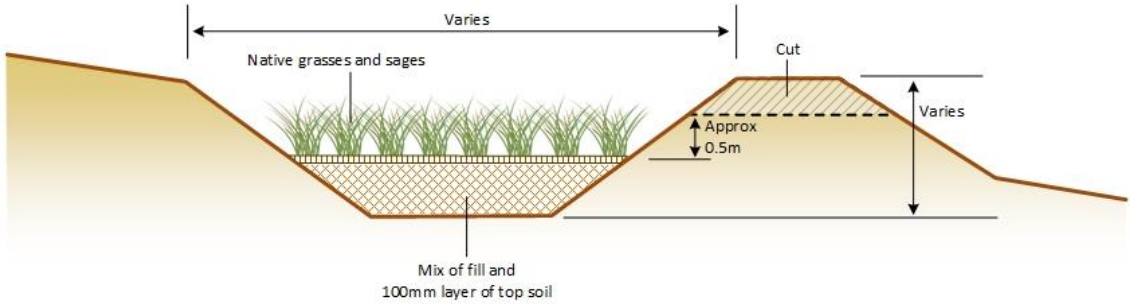


Figure 4-2 Concept design operational water quality treatment structures (operational swales)

5. Mitigation and management measures

5.1 Summary

Management measures will be implemented during the construction and operational phases of the project to minimise the potential for pollutants to be released into the downstream catchment. These mitigation measures have been identified in Table 5-1 and will be included in the project construction environmental management plan.

Table 5-1 Summary of water quality mitigation measures

Impact	Mitigation measures	Responsibility	Timing
Watercourse erosion	Roads and Maritime will investigate the following during detailed design: • Watercourse 2 (northern branch) – additional stabilisation measures near the bridge to minimise the risk of the existing gully head located about 200 metres downstream of the bridge from undermining the bridge or creek reshaping work • Watercourse 2 (southern branch) – additional stabilisation measures near the culvert outlet to minimise the risk of undermining of the outlet structure by the existing gully head (currently located about 100 metres downstream) • Watercourse 3 and 4 - stabilised flow paths, including scour protection measures, to convey the cross drainage outlet flows to existing drainage lines on the western side of the project • Watercourse 4 – measures such as energy dissipaters to minimise erosion risk in the gully system below the multi-storey hospital carpark • Watercourse 4 – measures to minimise erosion and scour risk downstream of the project associated with concentrated flows from drainage outlets.	Roads and Maritime	Detailed design

Impact	Mitigation measures	Responsibility	Timing
Managing impacts to water quality	A soil and water management plan will be prepared in accordance with: • Roads and Maritime Code of Practice for Water Management • Roads and Maritime Erosion and Sedimentation Procedure • *Managing Urban Stormwater, Soils and Construction, Volume 1 4th Edition, March 2004* (Landcom 2004) and *Managing Urban Stormwater, Volume 2D – Main road construction* (DECC 2008) • Roads and Maritime Technical Guideline: Temporary Stormwater Drainage for Road Construction • Roads and Maritime Stockpile Management Guideline • Roads and Maritime Technical Guideline: Environmental Management of Construction Site Dewatering. • Management of Tannins from Vegetation Mulch (Roads and Maritime 2012) • Guideline for Batter Surface Stabilisation using vegetation (Roads and Maritime 2015).	Construction contractor	Pre-construction
Managing impacts to water quality	The soil and water management plan will address the following: • Consideration of soil erodibility • Management strategies to be used to minimise surface water impacts, including identification of water treatment measures, discharge points and erosion and sediment control measures • Minimising stormwater (volume and velocity) from running onto downstream work by appropriate staging of the work and, where necessary, utilising erosion control measures • Maximising diversion of clean water around or through disturbed portions of the site • Sedimentation basin construction and management • Measures to monitor and manage spoil, fill and materials • Protection of waterways • Management of tannins that may be generated from stockpiled vegetation. • Monitoring of discharge waters. • Measures for the management of tannins from stockpiled vegetative materials • Management of stockpiles.	Construction contractor	Pre-construction
Managing impacts to water quality	A soil conservation specialist will be engaged during construction to advise on the planning and implementation of erosion and sedimentation controls.	Construction contractor	Construction

Impact	Mitigation measures	Responsibility	Timing
Managing impacts to water quality	Sediment laden water will be directed through the construction phase water management system. All construction sedimentation basins and associated temporary drainage shall be designed and constructed as detailed in this report to manage flows generated by the 80th percentile five day rainfall event.	Construction contractor	Construction
Managing impacts to water quality	Water quality monitoring will be carried out at key discharge points from the construction phase water management system. The monitoring requirements will be defined in the soil and water management plan and will include collection of samples for analysis from sedimentation basin discharge points and visual monitoring of other points of release of construction waters.	Construction contractor	Construction
Managing impacts to water quality	Where practical stormwater, including road runoff and intercepted groundwater, will be directed towards operational water quality treatment structures that will assist in the removal of pollutants from discharge water.	RMS	Operation
Construction accidental spills	An emergency spill response procedure will be prepared to minimise the impact of spills including details on the requirements for managing, cleaning up and reporting.	Construction contractor	Construction
	Spill kits and adequate quantities of suitable material to counteract spillage will be kept readily available.	Construction contractor	Construction
	The refuelling of plant and maintenance of machinery will be carried out in designated refuelling areas. Refuelling would be attended at all times.	Construction contractor	Construction
	Vehicle wash-downs and/or concrete truck washouts will be located within a designated bunded area or located off-site.	Construction contractor	Construction
	Machinery will be checked daily to ensure that there are no oil, fuel, or other liquid leaks.	Construction contractor	Construction
Mine remediation – grouting	A mine remediation management plan will be prepared to manage potential risks associated with grouting operations. The plan will be prepared with reference to groundwater monitoring data to determine the risk of grouting impacting on groundwater. The plan will detail measures to manage the risk of escape of grout, including into surface watercourses or groundwater, through natural fractures including: • Consultation • Monitoring • Emergency spill response procedure.	Construction contractor	Construction

Impact	Mitigation measures	Responsibility	Timing
Potential contamination	Measures to manage potential contamination associated with the project will be addressed through preparation of a contaminated soil management plan. The plan will specify measures to ensure the contaminated soil is managed so that it does not pose a risk to water quality. Measures to be implemented include ensuring contaminated soils are deep buried and blended where further testing confirms on-site reuse is acceptable, or off-site disposal to a licensed facility where required.	Construction contractor	Construction
Building demolition impacts	During demolition the following controls will be implemented: • Scheduling of work to avoid strong winds and rainfall • Mandatory coverage of trucks carrying debris • Temporary barriers or dust screens, as appropriate, to suppress the effect of dust movement to uncontrolled sites • Dust suppress ion such as wetting measures • Fencing of temporary stockpiles on hardstands.	Construction contractor	Construction
Revegetation	Proposed re-vegetation of cleared areas will be carried out with consideration of minimising erosion and in accordance with the Guideline for Batter Surface Stabilisation using vegetation (Roads and Maritime 2015).	Construction contractor	Post-construction
Managing impacts to water quality	Roads and Maritime will implement the operational water quality controls detailed in this report (subject to further refinement during detailed design) to provide ongoing water quality improvements during operation of the project. As part of an operational environmental management plan visual inspection of stormwater management system, including the operational water quality structures, will be carried out for a minimum period of 12 months to ensure the stormwater management system is operating as designed.	Roads and Maritime	Operation

6. Conclusion

The project lies primarily within the Ironbark Creek catchment. The construction of the project would require clearing, earthworks, construction of temporary access roads, watercourse crossings, pavement, and revegetation work.

The construction of watercourse crossings and stormwater discharges have the potential to alter flow characteristics within the watercourses near the project. A geomorphological inspection of the watercourse determined that many of the watercourses near the project are currently undergoing active erosion and scouring, by way of an active head cut. The active head cuts are likely to continue until a natural bed control point is reached. In most cases this would consist of native bed rock. The proposed project is not likely to increase the extent of the current erosion and scouring, however may result in an increased rate of erosion (ie the watercourses would reach the natural bed control points sooner). Where the natural erosion and scouring has the potential to interact with the project, additional scour protection at watercourse crossings may be required.

There are a number of potential pollutants associated with the construction of the project, including naturally occurring hydrocarbons in intercepted groundwater, contaminated soils, fuels from machinery, tannins from cleared and mulched vegetation and sediment laden runoff. Each of these pollutants has the potential to impact on the water quality of the downstream environment, including the SEPP 14 and Ramsar wetlands. The risks associated with each of these potential sources of pollution have been considered and with management procedures can be adequately managed. This includes the risks associated with the eutrophication of the local ephemeral drainage lines, which are unlikely to retain discharges within pools and ponds for eutrophication to occur.

With suitable erosion and sediment controls, construction of the project is unlikely to have an appreciable impact on downstream water qualities.

Potential water quality impacts to the local catchments and wider catchments of the SEPP 14 and Ramsar wetlands during the operation phase of the project have been assessed using MUSIC modelling, with consideration of the operational water management system. The analysis indicates that the project is unlikely to have an appreciable impact on the water quality reporting to the SEPP 14 and Ramsar wetlands located downstream. The retention of operational water quality treatment structures (swales) assist in removing TSS, TN and TP from the stormwater runoff, thereby reducing the potential impacts of the project on water quality.

Much of Ironbark Creek downstream of the project passes through residential, commercial and industrial areas, and has been concrete lined. The catchment area of the SEPP 14 and Ramsar wetlands is therefore highly developed, with estimated impervious areas of about 57 per cent and 45 percent respectively. The highly developed nature of the Ironbark Creek catchment results in flows into the wetlands that have relatively high pollutant concentrations. The project is estimated to result in a small increase in the impervious area of the SEPP 14 and Ramsar wetland catchments (about one per cent and 0.6 per cent respectively).

The MUSIC modelling indicates that such a minor increase in impervious area does not result in an appreciable change in pollutant concentrations reporting to the SEPP 14 and Ramsar wetlands. As a result, it is considered unlikely that the project would result in an appreciable impact on the quality of water flowing into the SEPP 14 and Ramsar wetlands, and is therefore considered to be consistent with *Significant impacts guidelines 1.1: Matters of National Environmental Significance* (DotE 2013). Overall it is considered that the project is likely to result in no appreciable impacts to the water quality of the local catchments and the SEPP 14 and Ramsar wetlands.

7. References

ANZECC and ARMCANZ 2000a, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

ANZECC and ARMCANZ 2000b, *Australian Guidelines for Water Quality Monitoring and Reporting. National Water Quality Management Strategy*. Australian and New Zealand Environment and Conservation Council Agriculture and Resource Management Council of Australia and New Zealand, October 2000.

Aurecon 2015, Newcastle Inner City Bypass - Rankin Park to Jesmond. Concept Design and Environmental Assessment. Geotechnical and Mining Investigations Factual Report. Ref: 245321. 26 August 2015

Aurecon 2015, *Newcastle Inner City Bypass Rankin Park to Jesmond. Concept Design and Environmental Assessment. Geotechnical Investigations Factual Report*. Revision 1, 23 October 2015.

Aurecon 2016a, *Newcastle Inner City Bypass – Rankin Park to Jesmond Concept Design and Environmental Assessment: Geotechnical Interpretive Report*. Revision 2, 29 March 2016.

Aurecon 2016b, *Newcastle Inner City Bypass Rankin Park to Jesmond, Flooding and Drainage Assessment*.

BMT WBM 2010, *Draft NSW MUSIC Modelling Guidelines,* prepared for Sydney Metropolitan Catchment Management Authority, BMT WBM Pty Ltd.

DotE 2012, *Significant impact guidelines 1.1: Maters of National Environmental Significance*, Australia Government Department of the Environment (DotE).

DEC 2004, *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales*, Department of Environment and Conservation.

DECC 2008, *Managing Urban Stormwater: Main road construction, Volume 2D,* Department of Environment and Climate Change, NSW.

EPA 1998, *Managing Urban Stormwater: Source Control,* NSW Environment Protection Authority.

GHD 2016a, *Newcastle Inner City Bypass – Rankin Park to Jesmond Contamination Assessment*

GHD 2016b, *Newcastle Inner City Bypass – Rankin Park to Jesmond Groundwater Assessment*

Landcom 2004, *Managing Urban Stormwater: Soils and Construction – Volume 1, 4th Edition*, Landcom NSW.

NCC 2004, *Stormwater Management Plan,* Newcastle City Council.

NCC 2012, *Local Environmental Plan*, Newcastle City Council.

NSW Department of Land and Water Conservation (DLWC) 1995, 1:100,000 Soil Landscape Sheet of the Newcastle Region

OEH 2006, *NSW Water Quality and River Flow Objectives,* NSW Office of Environment and Heritage, retrieved from http://www.environment.nsw.gov.au/ieo/Hunter/index.htm.

OEH 2012, *Hunter Estuary Wetlands Ramsar Site,* retrieved from: http://www.environment.nsw.gov.au/wetlands/HunterEstuaryWetlands.htm.

Roads and Maritime 2012, *Management of Tannins from Vegetation Mulch.*

Wong, T.H.F, Breen, P.F. & Lloyd, S.D. 2000, *Water Sensitive Road Design – Design Options for Improving Stormwater Quality of Road Runoff,* Cooperative Research Centre for Catchment Hydrology.

Appendices

Appendix A – Watercourse photographs

Photograph	Description
Watercourse 2 - Northern Branch	
	Upstream view of fill deposit within narrow valley.
	Upstream view of scour hole in fill deposit.
	Upstream view of gully head.
	Downstream view of incised channel below gully head.

Photograph	Description
Watercourse 2 – Southern Branch	
	Upstream view of upper steep gradient reach.
	Upstream view of bedrock bound reach.
	Upstream view of lower reach with fill deposit in narrow valley.
	Upstream view of gully head at downstream extent of the southern branch.

Photograph	Description
Watercourse 3 – Northern Branch	
	Downstream view of upper steep reach.
	Upstream view in channelised section downstream of gully head.
Watercourse 3 – Southern Branch	
	Downslope view to upper steep reach.
	Upstream view displaying well vegetated fill deposit in valley floor.

Photograph	Description
Watercourse 4	
	Downstream view of Watercourse 4 displaying continuous channel.
	Upstream view of Watercourse 4 displaying debris/root step.
	Existing drainage outlets downslope of carpark at John Hunter Hospital.
	Across channel view of gully tributary with fill deposit in narrow valley.

Photograph	Description
Watercourse 5	
	Upstream view of gully erosion on hillslope downstream of existing drainage outlet from Lookout Road.
	Upstream view of debris deposit from scour along the upper steep gradient reach.
	Downstream view of defined channel in lower reach.

Appendix B – Water quality data

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Dark Creek tributary – behind Heaton Public School	Dark Creek	26/7/2014	14.9	6.82	115	20	8.6	–	0.7	0.45	0.7
Dark Creek tributary – behind Heaton Public School	Dark Creek	9/9/2014	17.8	7.19	680	12	7.3	–	0.06	0.02	0.06
Dark Creek tributary – upstream of Sunset Boulevard	Dark Creek	19/2/2014	23.2	6.53	175	12	1.62	–	0.83	0.61	0.83
Blue Wren Creek Hasluck Drive	Ironbark Creek	2/11/2004	18.4	7.67	1530	50	4.05	–	–	0.62	0.15
Blue Wren Creek Hasluck Drive	Ironbark Creek	26/03/2006	19.7	7.26	227	2	12.1	–	–	0.3	0.032
Blue Wren Creek Hasluck Drive	Ironbark Creek	22/10/2005	19	7.36	252	0	9.09	–	–	0.14	0.018
Blue Wren Creek Hasluck Drive	Ironbark Creek	12/10/2006	19	8	220	0	8.5	–	–	0.48	0.036
Blue Wren Creek Hasluck Drive	Ironbark Creek	19/11/2011	22.23	7.45	614	5	6	–	–	0.03	0.072
Blue Wren Creek Hasluck Drive	Ironbark Creek	26/09/2012	16.21	6.12	910	5.6	10.39	–	–	3.35	0.076
Blue Wren Creek Hasluck Drive	Ironbark Creek	22/10/2014	15.98	7.11	598	0.3	6.72	–	–	–	–
McCaffrey Drive – Rankin Park	Ironbark Creek	24/10/2004	20.9	7.21	678	6	9.82	–	–	0.34	0.24

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
McCaffrey Drive – Rankin Park	Ironbark Creek	15/04/2005	20.2	7.48	1780	0	2.58	–	–	0.21	0.072
McCaffrey Drive – Rankin Park	Ironbark Creek	22/10/2005	20.4	7.48	1310	0	3.5	–	–	0.48	0.04
McCaffrey Drive – Rankin Park	Ironbark Creek	1/04/2006	19.1	7.46	715	10	7.33	–	–	0.84	0.028
McCaffrey Drive – Rankin Park	Ironbark Creek	12/10/2006	17	8.1	400	0	8.6	–	–	1.26	0.06
McCaffrey Drive – Rankin Park	Ironbark Creek	19/10/2011	20.7	7.98	424	7	9.52	–	–	0.05	0.105
McCaffrey Drive – Rankin Park	Ironbark Creek	15/10/2012	16.53	6.63	1730	47.7	5.18	–	–	0.18	0.059
McCaffrey Drive – Rankin Park	Ironbark Creek	8/10/2013	20	7.35	2110	1.9	9.43	–	–	0.04	0.01
Blue Wren Creek Rosedale Cres Reserve	Ironbark Creek	26/03/2006	19	7	222	3	9.4	–	–	0.4	0.13
Blue Wren Creek Rosedale Cres Reserve	Ironbark Creek	19/11/2011	28.86	7.35	580	1.1	4.38	–	–	0.66	0.085
George McGregor Park – Sygna Cl Rankin Park	Ironbark Creek	24/10/2004	19.1	6.4	276	39	9	–	–	0.31	0.012
George McGregor Park – Sygna Cl Rankin Park	Ironbark Creek	15/04/2005	19.9	7.02	381	9	0.9	–	–	0.25	0.089
George McGregor Park – Sygna Cl Rankin Park	Ironbark Creek	22/10/2005	18.5	6.67	363	13	3.45	–	–	0.24	0.08
George McGregor Park – Sygna Cl Rankin Park	Ironbark Creek	1/04/2006	19.1	6.71	178	208	7.22	–	–	0.7	0.68

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
George McGregor Park – Sygna Close Rankin Park	Ironbark Creek	12/10/2006	22	7.2	4100	0	2.2	–	–	0.81	0.11
George McGregor Park – Sygna Close Rankin Park	Ironbark Creek	19/11/2011	19.5	6.5	350	8	6.4	–	–	0.55	0.11
George McGregor Park – Sygna Close Rankin Park	Ironbark Creek	29/09/2012	19.38	6.54	310	8.6	3.05	–	–	0.7	0.1
George McGregor Park – Sygna Close Rankin Park	Ironbark Creek	19/10/2014	15.52	6.96	308	286	13.2	–	–	–	–
Ironbark Creek – Wallsend Pk off Cowper St	Ironbark Creek	9/11/2005	23.3	6.83	219	3	2.37	–	–	0.98	0.08
Ironbark Creek – Wallsend Park off Cowper Street	Ironbark Creek	13/11/2006	20.6	6.9	351	6	0.94	–	–	0.78	0.36
Ironbark Creek – Wallsend Park off Cowper Street	Ironbark Creek	20/04/2007	21	6.9	490	1	6.8	–	–	0.05	0.001
Ironbark Creek – Wallsend Park off Cowper Street	Ironbark Creek	19/10/2011	19.7	7.4	1300	23	11.5	–	–	0.09	0.33
Ironbark Creek – Wallsend Park off Cowper Street	Ironbark Creek	15/10/2012	16.27	6.21	376	6	3.43	–	–	0.15	0.16
Ironbark Creek – Wallsend Park off Cowper Street	Ironbark Creek	20/10/2013	23.63	4.44	330	3.1	10.21	–	–	0.02	0.01
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	12/10/2004	18.7	6.54	608	10	6.55	–	–	3.35	0.085
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	5/04/2006	21.3	6.92	203	186	3.31	–	–	0.22	0.055

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	19/04/2007	17	7.9	270	90	0.4	–	–	0.14	0.036
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	17/10/2011	17.7	6.2	610	4.7	11.1	–	–	0.03	0.063
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	15/10/2012	20.67	6.47	464	13.7	3.54	–	–	0.76	0.32
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	8/10/2013	19.49	6.85	341	21.3	9.7	–	–	0.01	0.01
Ironbark Creek – Croudace and Cardiff Road Elermore Vale	Ironbark Creek	28/10/2014	22.59	7.26	366	9.6	10.09	–	–	–	–
Ironbark Creek – Canoe Trail Wetlands Centre	Ironbark Creek	25/11/2004	21.8	7.22	16200	20	8.51	–	–	0.44	0.076
Ironbark Creek – Canoe Trail Wetlands Centre	Ironbark Creek	20/04/2006	23.1	7.21	22500	13	6.41	–	–	0.18	0.08
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	23/10/2004	19.4	5.57	–	18	5.8	–	–	0.33	0.58
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	15/04/2005	20	7.4	250	19	2.3	–	–	0.1	0.043
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	15/10/2005	19.5	6.94	293	3	0.94	–	–	0.22	0.086
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	14/10/2006	21	6.7	360	5	2.1	–	–	0.61	0.15

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	18/10/2011	17.8	6.33	1520	5.6	12.8	–	–	0.04	0.13
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	20/10/2012	20.19	6.03	628	11.3	5.63	–	–	0.26	0.38
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	16/10/2013	16.24	6.11	342	10.4	2.56	–	–	0.03	0.19
Ironbark Creek – Upper Reserve Barney Street	Ironbark Creek	25/10/2014	21.13	7.2	314	2	5.29	–	–	–	–
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	3/11/2004	23.6	7.29	552	40	9.32	–	–	0.39	0.009
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	25/11/2004	23.8	9.56	601	120	18.22	–	–	1.03	–
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	9/11/2005	27.7	7.05	478	70	10.17	–	–	0.18	0.07
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	29/03/2006	22.2	7.33	1030	12	6.74	–	–	0.89	0.063
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	30/10/2011	20.4	6.33	2260	106	4.1	–	–	0.95	0.12
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	17/10/2012	19.19	6.92	20800	28.3	8.41	–	–	0.055	0.43
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	23/10/2013	22.22	7.11	22700	115	7.39	–	–	0.01	0.01
Ironbark Creek Main Channel Minmi Road	Ironbark Creek	29/10/2014	19.81	7.19	477	5.1	2.52	–	–	–	–

Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	24/10/2004	19.3	6.2	870	20	7.5	–	–	0.41	0.38
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	22/10/2005	–	7.72	270	0	3.3	–	–	0.66	0.24
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	12/10/2006	16	7.2	400	2	0.9	–	–	1.46	0.009
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	19/11/2011	19.7	7	330	7.3	6.6	–	–	0.19	0.03
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	29/09/2012	17.51	7.35	312	5.2	10.33	–	–	3.35	0.055
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	20/10/2013	17.21	6.23	470	11.1	6.33	–	–	0.3	0.01
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	8/10/2013	17.53	6.9	579	16.3	5.24	–	–	0.01	0.02
Sygna Close Reserve – Dangerfield Drive Silver Stream	Ironbark Creek	25/10/2014	21	7.23	484	9.9	4.06	–	–	–	–
Elermore Vale Reserve	Ironbark Creek	28/02/2014	22.7	7.07	154	28	8.21	20	0.13	–	0.46
Elermore Vale Reserve	Ironbark Creek	27/01/2015	22.1	6.8	140	15	8.77	10	0.11	–	1.03

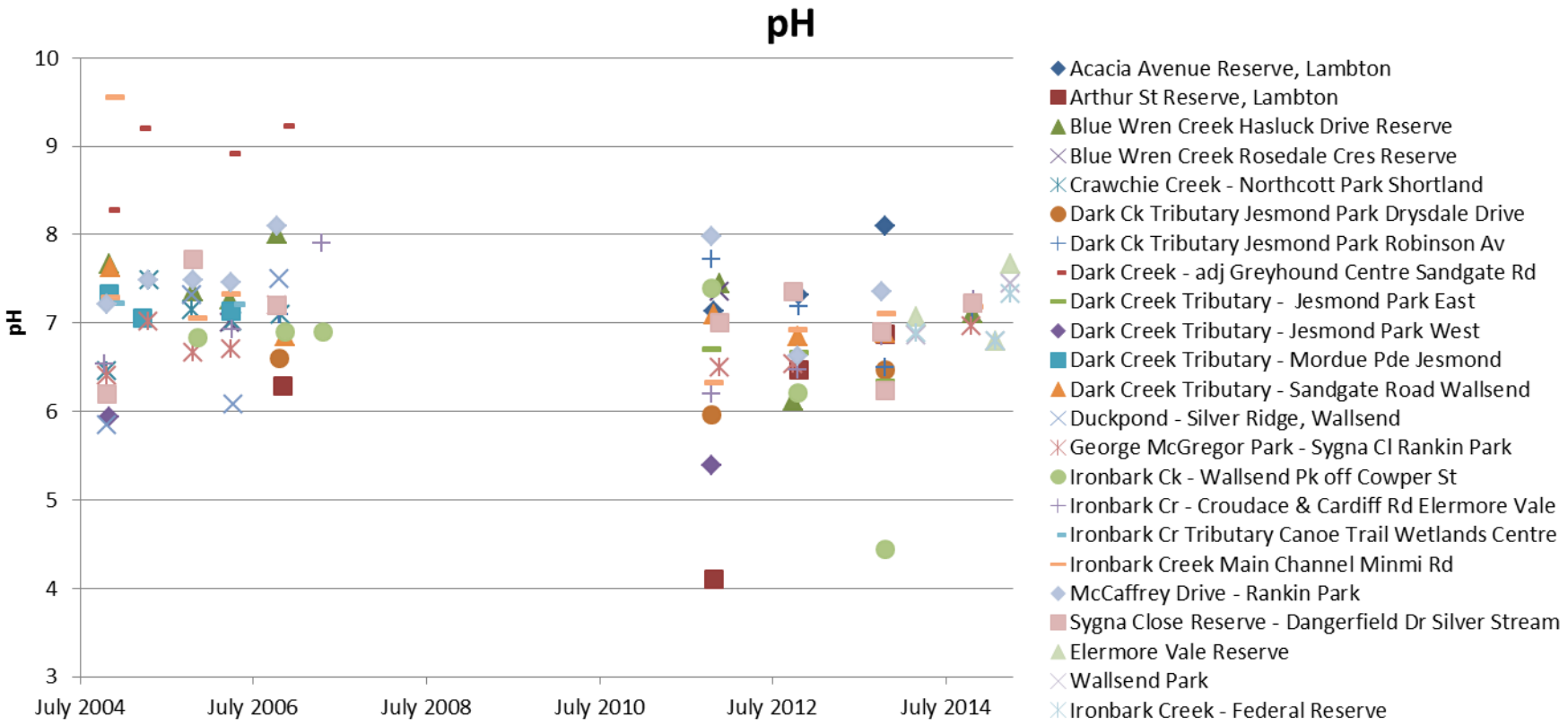
Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Elermore Vale Reserve	Ironbark Creek	4/04/2015	20	7.67	250	35	7.57	20	0.12	–	0.78
Wallsend Park	Ironbark Creek	28/02/2014	23.4	6.86	111	85	7.98	91	0.2	–	0.28
Wallsend Park	Ironbark Creek	27/01/2015	22.3	6.8	155	20	8.51	15	0.09	–	7.19
Wallsend Park	Ironbark Creek	4/04/2015	19.8	7.44	100	250	7.41	220	0.07	–	4.35
Ironbark Creek – Federal Reserve	Ironbark Creek	28/02/2014	23.2	6.88	100	100	8.01	112	0.18	–	0.19
Ironbark Creek – Federal Reserve	Ironbark Creek	27/01/2015	21.9	6.8	155	20	8.9	15	0.08	–	7.79
Ironbark Creek – Federal Reserve	Ironbark Creek	4/04/2015	19.9	7.33	150	260	7.81	230	0.06	–	5.26
Crawchie Creek – Northcott Park Shortland	Ironbark Creek	23/10/2004	22.4	6.46	1160	25	7.75	–	–	–	–
Crawchie Creek – Northcott Park Shortland	Ironbark Creek	20/04/2005	19.8	7.48	1800	7	2.35	–	–	–	–
Crawchie Creek – Northcott Park Shortland	Ironbark Creek	15/10/2005	17.6	7.15	1150	18	1.71	–	–	–	–
Crawchie Creek – Northcott Park Shortland	Ironbark Creek	5/04/2006	18.9	7.01	2690	12	3.86	–	–	–	–
Crawchie Creek – Northcott Park Shortland	Ironbark Creek	26/10/2006	19	7.1	1600	40	1.5	–	–	–	–
Acacia Avenue Reserve, Lambton	Dark Creek	26/10/2011	16.6	7.13	1660	30	5.73	–	–	0.1	0.33

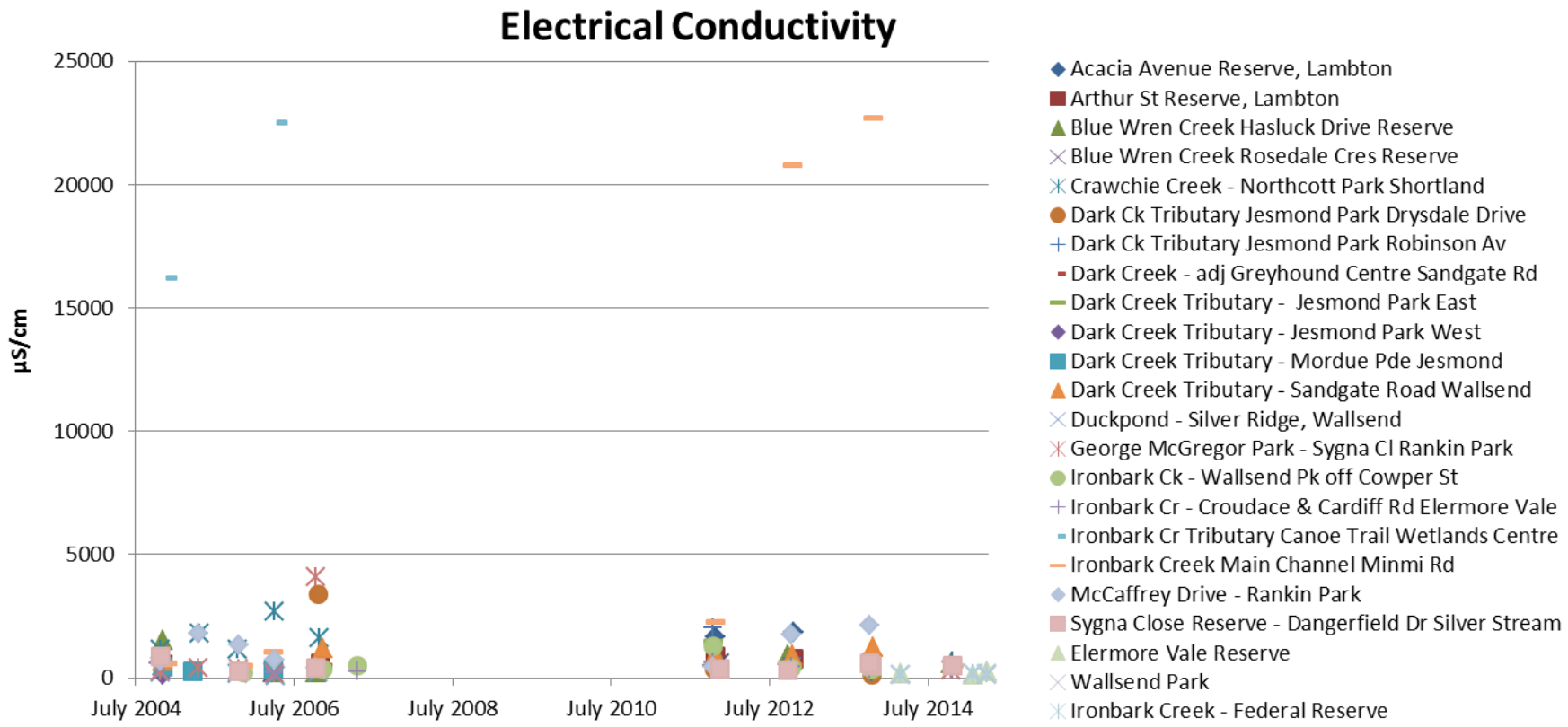
Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Acacia Avenue Reserve, Lambton	Dark Creek	21/10/2012	17.68	7.32	1840	17.1	3.52	–	–	0.2	0.085
Acacia Avenue Reserve, Lambton	Dark Creek	21/10/2013	21.58	8.1	681	262	10.05	–	–	0.01	0.11
Arthur Street Reserve, Lambton	Dark Creek	2/11/2004	17.3	7.32	532	10	6.55	–	–	0.42	0.003
Arthur Street Reserve, Lambton	Dark Creek	2/11/2006	18.5	6.29	572	239	7.2	–	–	0.86	1.2
Arthur Street Reserve, Lambton	Dark Creek	27/10/2011	16.7	4.1	880	16	10.7	–	–	0.08	0.077
Arthur Street Reserve, Lambton	Dark Creek	21/10/2012	17.35	6.47	788	28.3	1.82	–	–	0.66	0.3
Arthur Street Reserve, Lambton	Dark Creek	21/10/2013	19.87	6.87	628	7.2	6.12	–	–	0.03	0.01
Dark Creek Tributary Jesmond Park Drysdale Drive	Dark Creek	19/10/2006	17	6.6	3400	7	0.1	–	–	0.58	0.24
Dark Creek Tributary Jesmond Park Drysdale Drive	Dark Creek	20/10/2011	20.6	5.96	374	35	4.3	–	–	0.11	0.085
Dark Creek Tributary Jesmond Park Drysdale Drive	Dark Creek	21/10/2013	19.09	6.47	98	22.5	10.17	–	–	0.01	0.01
Dark Creek Tributary Jesmond Park Robinson Avenue	Dark Creek	19/10/2006	20	7.1	610	10	5.2	–	–	0.23	–

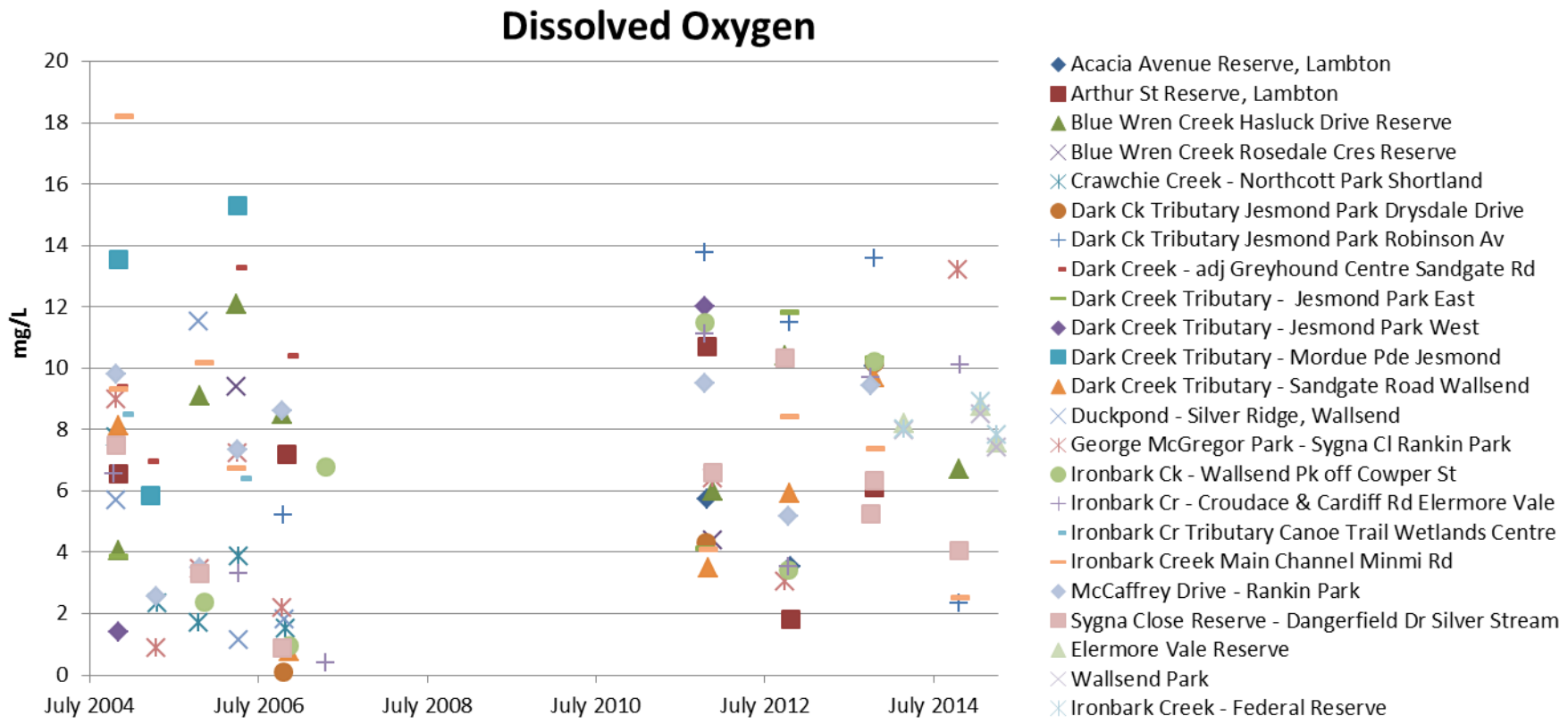
Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Dark Creek Tributary Jesmond Park Robinson Avenue	Dark Creek	19/10/2011	18.2	7.72	2010	12	13.76	–	–	0.03	0.33
Dark Creek Tributary Jesmond Park Robinson Avenue	Dark Creek	20/10/2012	22.8	7.18	787	14.3	11.49	–	–	0.76	0.24
Dark Creek Tributary Jesmond Park Robinson Avenue	Dark Creek	21/10/2013	20.93	6.5	223	69.4	13.57	–	–	0.1	0.1
Dark Creek Tributary Jesmond Park Robinson Avenue	Dark Creek	25/10/2014	18.96	7.15	700	2.7	2.33	–	–	–	–
Dark Creek – adjacent Greyhound Centre Sandgate Road	Dark Creek	3/11/2004	22	8.28	466	15	9.41	–	–	0.35	0.15
Dark Creek – adjacent Greyhound Centre Sandgate Road	Dark Creek	15/03/2005	32.7	9.2	388	7	6.97	–	–	0.69	0.068
Dark Creek – adjacent Greyhound Centre Sandgate Road	Dark Creek	31/03/2006	27.6	8.92	312	10	13.28	–	–	0.3	0.051
Dark Creek – adjacent Greyhound Centre Sandgate Road	Dark Creek	13/11/2006	25.4	9.23	489	48	10.41	–	–	0.76	0.38
Dark Creek Tributary – Jesmond Park East	Dark Creek	2/11/2004	18.1	7.24	477	2	3.87	–	–	0.35	0.003
Dark Creek Tributary – Jesmond Park East	Dark Creek	18/10/2011	15.8	6.7	1450	10	4.14	–	–	0.06	0.13

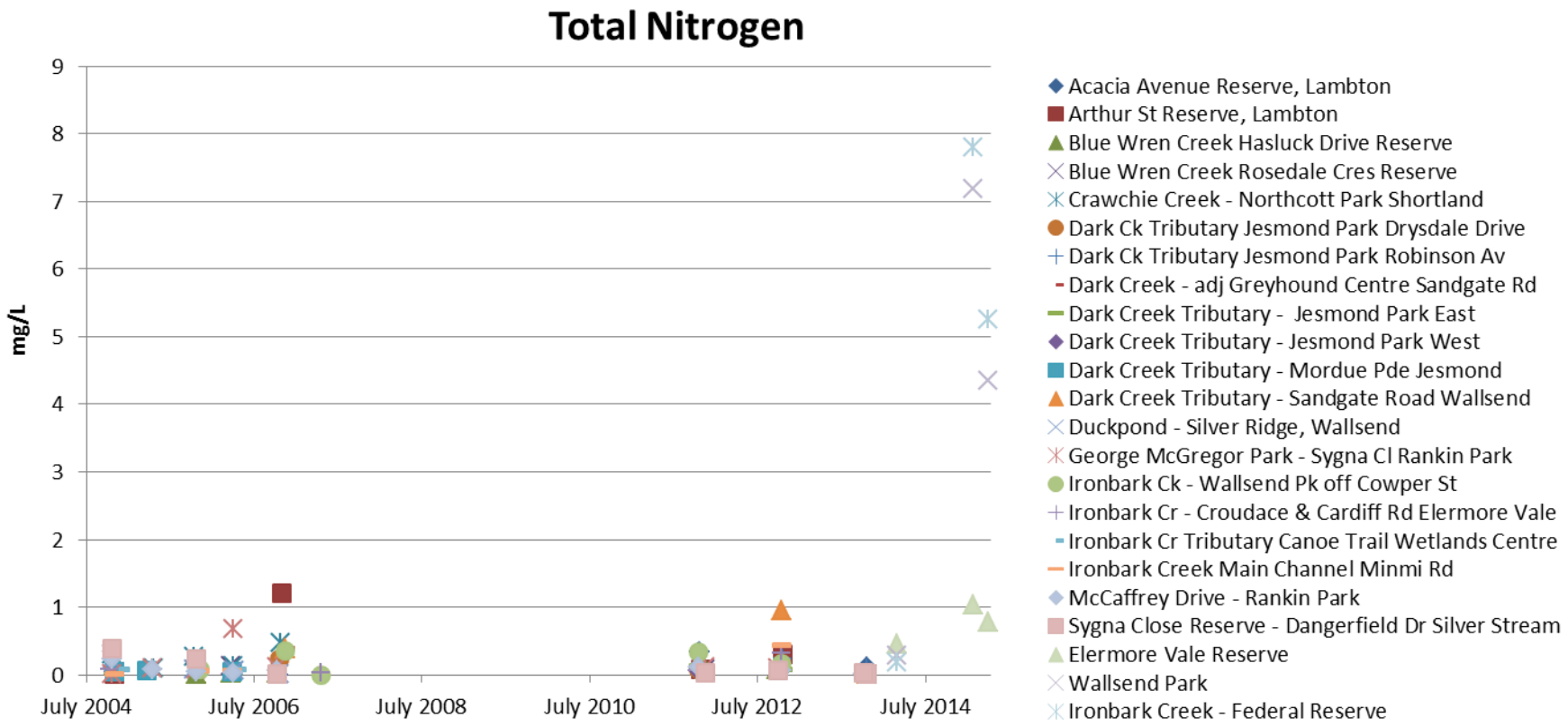
Location	Catchment	Date	Temperature (°C)	pH	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	TSS (mg/L)	Phosphorus (Total) (mg/L)	Phosphate (Dissolved) (mg/L)	Total Nitrogen (mg/L)
Dark Creek Tributary – Jesmond Park East	Dark Creek	20/10/2012	21.26	6.67	445	126	11.81	–	–	0.27	0.085
Dark Creek Tributary – Jesmond Park East	Dark Creek	21/10/2013	22.01	6.34	151	40.4	10.34	–	–	0.02	0.01
Dark Creek Tributary – Jesmond Park West	Dark Creek	2/11/2004	19	5.94	97	27	1.42	–	–	0.33	0.04
Dark Creek Tributary – Jesmond Park West	Dark Creek	18/10/2011	17.74	5.39	488	17.2	12.01	–	–	0.16	0.059
Dark Creek Tributary – Mordue Parade Jesmond	Dark Creek	2/11/2004	24.8	7.33	438	2	13.54	–	–	0.2	0.04
Dark Creek Tributary – Mordue Parade Jesmond	Dark Creek	22/03/2005	20.1	7.05	249	15	5.83	–	–	0.18	0.059
Dark Creek Tributary – Mordue Parade Jesmond	Dark Creek	31/03/2006	27	7.13	353	149	15.3	–	–	2	0.043
Dark Creek Tributary – Sandgate Road Wallsend	Dark Creek	3/11/2004	18.8	7.63	699	8	8.14	–	–	–	–
Dark Creek Tributary – Sandgate Road Wallsend	Dark Creek	13/11/2006	20	6.85	1210	36	0.77	–	–	0.76	0.38
Dark Creek Tributary – Sandgate Road Wallsend	Dark Creek	30/10/2011	19.49	7.09	941	280	3.5	–	–	–	–
Dark Creek Tributary – Sandgate Road Wallsend	Dark Creek	17/10/2012	16.51	6.85	912	25.1	5.94	–	–	1.66	0.95
Dark Creek Tributary – Sandgate Road Wallsend	Dark Creek	22/10/2013	22.52	6.88	1220	79.6	9.69	–	–	0.01	0.01

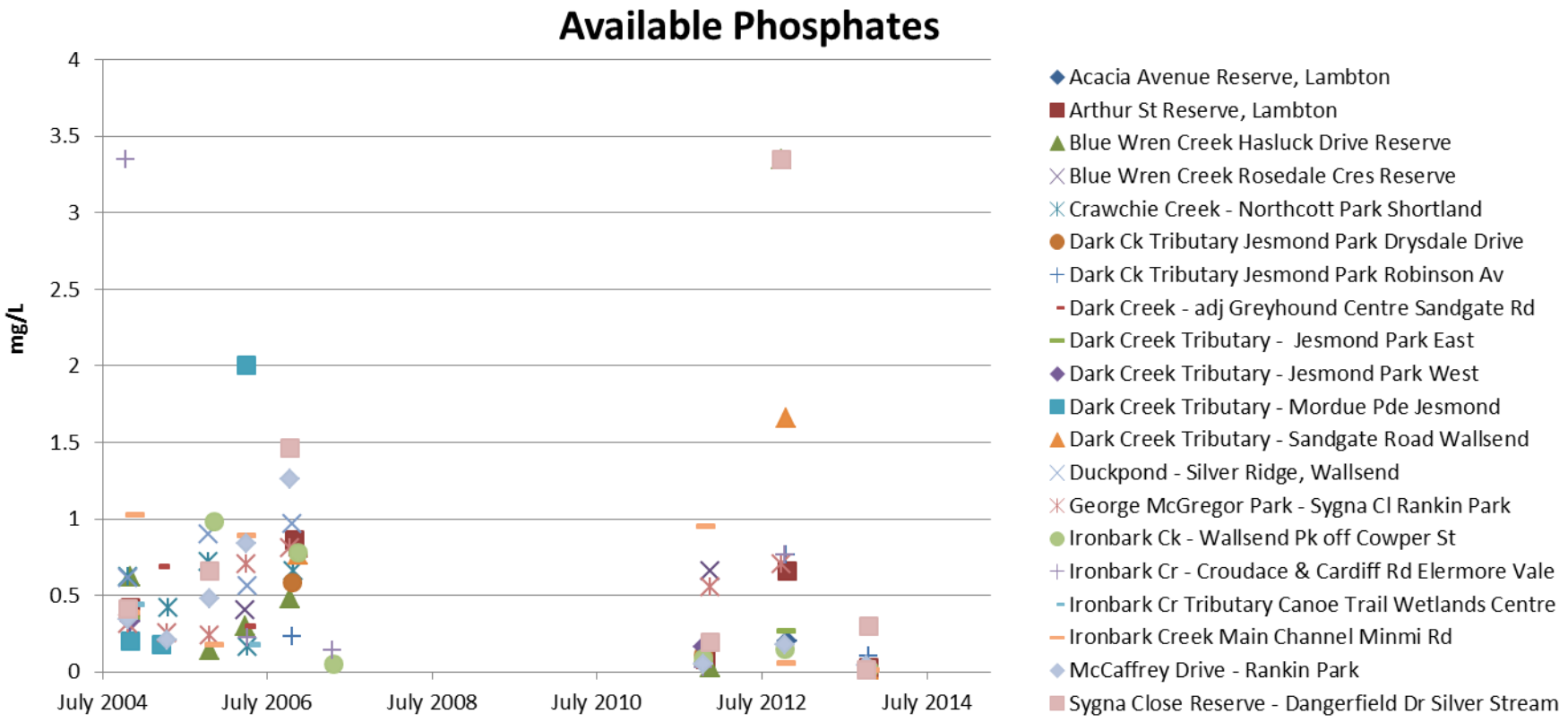
Appendix C – Water quality plots

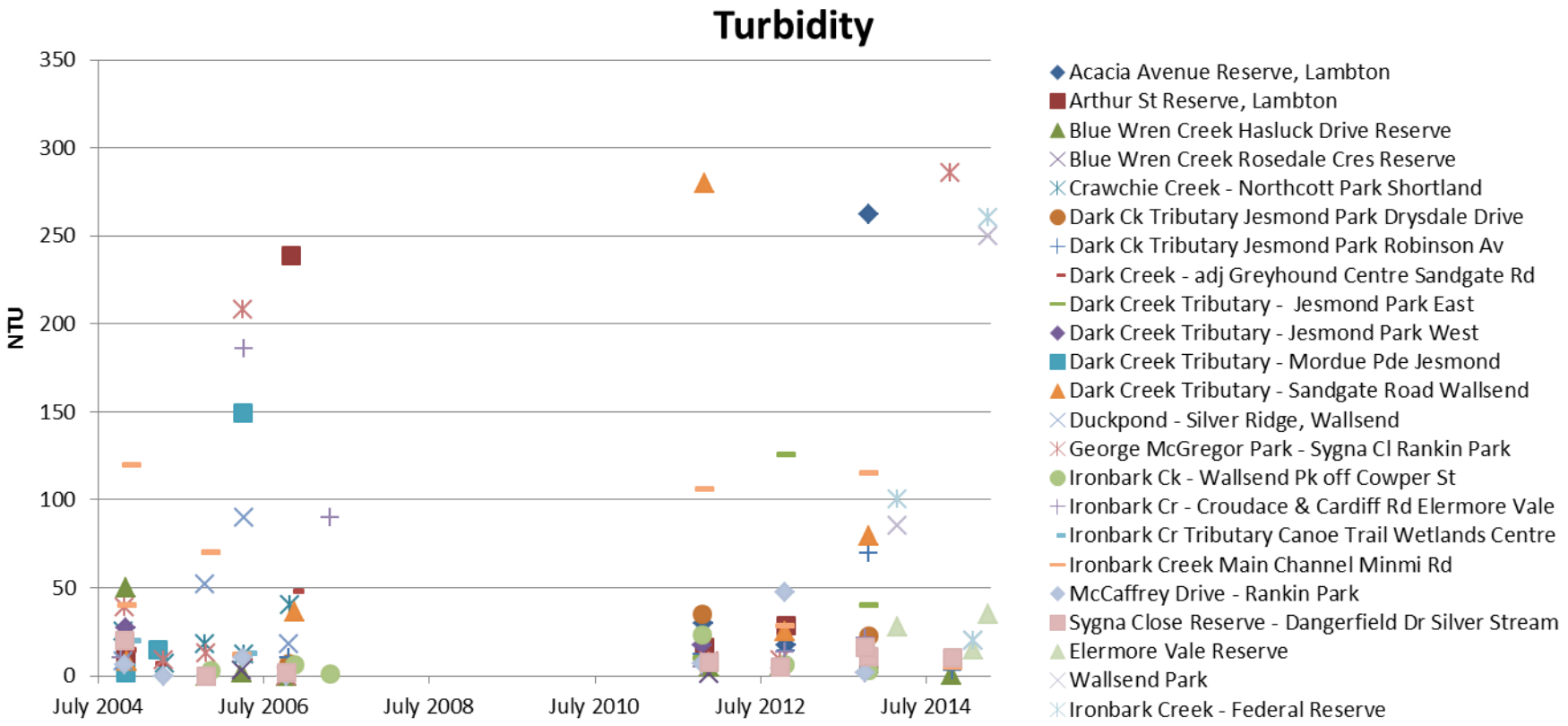

pH
10
9
8
7
6
5
4
3
pH
July 2004
July 2006
July 2008
July 2010
July 2012
July 2014
Acacia Avenue Reserve, Lambton
Arthur St Reserve, Lambton
Blue Wren Creek Hasluck Drive Reserve
Blue Wren Creek Rosedale Cres Reserve
Crawchie Creek - Northcott Park Shortland
Dark Ck Tributary Jesmond Park Drysdale Drive
Dark Ck Tributary Jesmond Park Robinson Av
Dark Creek - adj Greyhound Centre Sandgate Rd
Dark Creek Tributary - Jesmond Park East
Dark Creek Tributary - Jesmond Park West
Dark Creek Tributary - Mordue Pde Jesmond
Dark Creek Tributary - Sandgate Road Wallsend
Duckpond - Silver Ridge, Wallsend
George McGregor Park - Sygna Cl Rankin Park
Ironbark Ck - Wallsend Pk off Cowper St
Ironbark Cr - Croudace & Cardiff Rd Elermore Vale
Ironbark Cr Tributary Canoe Trail Wetlands Centre
Ironbark Creek Main Channel Minmi Rd
McCaffrey Drive - Rankin Park
Sygna Close Reserve - Dangerfield Dr Silver Stream
Elermore Vale Reserve
Wallsend Park
Ironbark Creek - Federal Reserve


Electrical Conductivity
µS/cm
25000
20000
15000
10000
5000
0
July 2004
July 2006
July 2008
July 2010
July 2012
July 2014
Acacia Avenue Reserve, Lambton
Arthur St Reserve, Lambton
Blue Wren Creek Hasluck Drive Reserve
Blue Wren Creek Rosedale Cres Reserve
Crawchie Creek - Northcott Park Shortland
Dark Ck Tributary Jesmond Park Drysdale Drive
Dark Ck Tributary Jesmond Park Robinson Av
Dark Creek - adj Greyhound Centre Sandgate Rd
Dark Creek Tributary - Jesmond Park East
Dark Creek Tributary - Jesmond Park West
Dark Creek Tributary - Mordue Pde Jesmond
Dark Creek Tributary - Sandgate Road Wallsend
Duckpond - Silver Ridge, Wallsend
George McGregor Park - Sygna Cl Rankin Park
Ironbark Ck - Wallsend Pk off Cowper St
Ironbark Cr - Croudace & Cardiff Rd Elermore Vale
Ironbark Cr Tributary Canoe Trail Wetlands Centre
Ironbark Creek Main Channel Minmi Rd
McCaffrey Drive - Rankin Park
Sygna Close Reserve - Dangerfield Dr Silver Stream
Elermore Vale Reserve
Wallsend Park
Ironbark Creek - Federal Reserve


Dissolved Oxygen
mg/L
20
18
16
14
12
10
8
6
4
2
0
July 2004
July 2006
July 2008
July 2010
July 2012
July 2014
Acacia Avenue Reserve, Lambton
Arthur St Reserve, Lambton
Blue Wren Creek Hasluck Drive Reserve
Blue Wren Creek Rosedale Cres Reserve
Crawchie Creek - Northcott Park Shortland
Dark Ck Tributary Jesmond Park Drysdale Drive
Dark Ck Tributary Jesmond Park Robinson Av
Dark Creek - adj Greyhound Centre Sandgate Rd
Dark Creek Tributary - Jesmond Park East
Dark Creek Tributary - Jesmond Park West
Dark Creek Tributary - Mordue Pde Jesmond
Dark Creek Tributary - Sandgate Road Wallsend
Duckpond - Silver Ridge, Wallsend
George McGregor Park - Sygna Cl Rankin Park
Ironbark Ck - Wallsend Pk off Cowper St
Ironbark Cr - Croudace & Cardiff Rd Elermore Vale
Ironbark Cr Tributary Canoe Trail Wetlands Centre
Ironbark Creek Main Channel Minmi Rd
McCaffrey Drive - Rankin Park
Sygna Close Reserve - Dangerfield Dr Silver Stream
Elermore Vale Reserve
Wallsend Park
Ironbark Creek - Federal Reserve


Total Nitrogen
mg/L
9
8
7
6
5
4
3
2
1
0
July 2004
July 2006
July 2008
July 2010
July 2012
July 2014
Acacia Avenue Reserve, Lambton
Arthur St Reserve, Lambton
Blue Wren Creek Hasluck Drive Reserve
Blue Wren Creek Rosedale Cres Reserve
Crawchie Creek - Northcott Park Shortland
Dark Ck Tributary Jesmond Park Drysdale Drive
Dark Ck Tributary Jesmond Park Robinson Av
Dark Creek - adj Greyhound Centre Sandgate Rd
Dark Creek Tributary - Jesmond Park East
Dark Creek Tributary - Jesmond Park West
Dark Creek Tributary - Mordue Pde Jesmond
Dark Creek Tributary - Sandgate Road Wallsend
Duckpond - Silver Ridge, Wallsend
George McGregor Park - Sygna Cl Rankin Park
Ironbark Ck - Wallsend Pk off Cowper St
Ironbark Cr - Croudace & Cardiff Rd Elermore Vale
Ironbark Cr Tributary Canoe Trail Wetlands Centre
Ironbark Creek Main Channel Minmi Rd
McCaffrey Drive - Rankin Park
Sygna Close Reserve - Dangerfield Dr Silver Stream
Elermore Vale Reserve
Wallsend Park
Ironbark Creek - Federal Reserve


Available Phosphates
mg/L
4
3.5
3
2.5
2
1.5
1
0.5
0
July 2004
July 2006
July 2008
July 2010
July 2012
July 2014
Acacia Avenue Reserve, Lambton
Arthur St Reserve, Lambton
Blue Wren Creek Hasluck Drive Reserve
Blue Wren Creek Rosedale Cres Reserve
Crawchie Creek - Northcott Park Shortland
Dark Ck Tributary Jesmond Park Drysdale Drive
Dark Ck Tributary Jesmond Park Robinson Av
Dark Creek - adj Greyhound Centre Sandgate Rd
Dark Creek Tributary - Jesmond Park East
Dark Creek Tributary - Jesmond Park West
Dark Creek Tributary - Mordue Pde Jesmond
Dark Creek Tributary - Sandgate Road Wallsend
Duckpond - Silver Ridge, Wallsend
George McGregor Park - Sygna Cl Rankin Park
Ironbark Ck - Wallsend Pk off Cowper St
Ironbark Cr - Croudace & Cardiff Rd Elermore Vale
Ironbark Cr Tributary Canoe Trail Wetlands Centre
Ironbark Creek Main Channel Minmi Rd
McCaffrey Drive - Rankin Park
Sygna Close Reserve - Dangerfield Dr Silver Stream

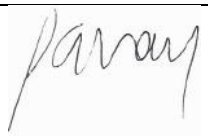

Turbidity
NTU
350
300
250
200
150
100
50
0
July 2004
July 2006
July 2008
July 2010
July 2012
July 2014
Acacia Avenue Reserve, Lambton
Arthur St Reserve, Lambton
Blue Wren Creek Hasluck Drive Reserve
Blue Wren Creek Rosedale Cres Reserve
Crawchie Creek - Northcott Park Shortland
Dark Ck Tributary Jesmond Park Drysdale Drive
Dark Ck Tributary Jesmond Park Robinson Av
Dark Creek - adj Greyhound Centre Sandgate Rd
Dark Creek Tributary - Jesmond Park East
Dark Creek Tributary - Jesmond Park West
Dark Creek Tributary - Mordue Pde Jesmond
Dark Creek Tributary - Sandgate Road Wallsend
Duckpond - Silver Ridge, Wallsend
George McGregor Park - Sygna Cl Rankin Park
Ironbark Ck - Wallsend Pk off Cowper St
Ironbark Cr - Croudace & Cardiff Rd Elermore Vale
Ironbark Cr Tributary Canoe Trail Wetlands Centre
Ironbark Creek Main Channel Minmi Rd
McCaffrey Drive - Rankin Park
Sygna Close Reserve - Dangerfield Dr Silver Stream
Elermore Vale Reserve
Wallsend Park
Ironbark Creek - Federal Reserve

GHD

Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO Box 5403 Hunter Region Mail Centre NSW 2310
T: (02) 4979 9999 F: (02) 4979 9988 E: ntlmail@ghd.com

G:\22\17656\WP\110065.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	A Wyatt	S Gray		S Pearce		3/11/2016

www.ghd.com