Environment Protection Authority

Darcy Road drain water quality monitoring

November 2020 to September 2021

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Acknowledgement of Country

The EPA acknowledges the traditional custodians of the land on which we live and work, and we pay our respects to Elders past, present and future.

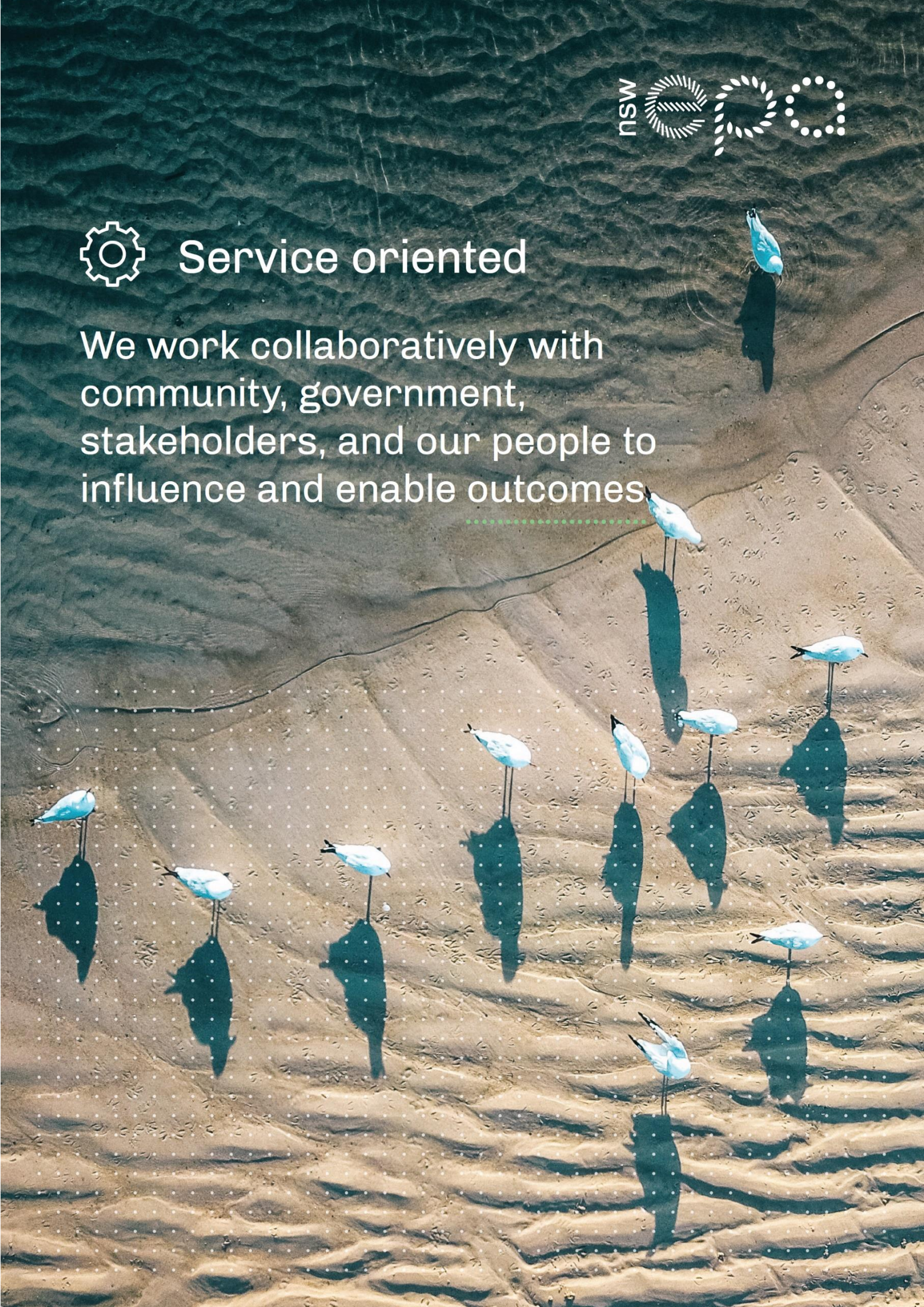
We recognise the connection to their land, their waters and surrounding communities and acknowledge their history here on this land.

We also acknowledge our Aboriginal and Torres Strait Islander employees who are an integral part of our diverse workforce, and recognise the knowledge embedded forever in Aboriginal and Torres Strait Islander custodianship of Country and culture.

Dharawal country, Royal National Park, NSW

In response to local community concerns regarding urban water quality in the Darcy Road drain at Port Kembla, the Environment Protection Authority completed a water sampling program to better understand the water quality discharging to the Port Kembla Outer Harbour.

This report summarises the monitoring data, compares the data to recognised water quality guidelines, and makes recommendations to further improve water quality in the Darcy Road drain.



Service oriented

We work collaboratively with community, government, stakeholders, and our people to influence and enable outcomes.

EPA water quality monitoring program

Background

In late 2020 the local community identified elevated levels of some metals in the urban stormwater in the Darcy Road drain at Port Kembla. The water samples indicated that levels of arsenic, copper, lead, zinc, and other metals were above water quality guidelines for the protection of aquatic ecosystem health.

The EPA carried out some preliminary water sampling in the drain in late 2020 and then began a water sampling program, to better understand the water quality in the drain.

This report summarises the monitoring data, compares the data to water quality guidelines, and makes recommendations to further improve water quality in the Darcy Road drain.

About Darcy Road drain

The Darcy Road drain is a concrete-lined stormwater channel that receives stormwater from both urban and industrial areas and drains to the Port Kembla Outer Harbour.

The lower portion of the Darcy Road drain (near Foreshore Road) is tidally influenced, with high tides flowing up the drain and under Foreshore Road. The upper portion of the drain (near Darcy Road) is not subject to tidal influence.

The presence of contaminants is not unexpected given the long industrial history of the area. The catchment for the Darcy Road drain includes a heavy industrial precinct and part of the Port Kembla township. The catchment has been the subject of extensive studies.

There are diffuse and point sources of heavy metals within the catchment of the Darcy Road drain.

Diffuse sources include stormwater discharges from areas of the Port Kembla township that are known to have legacy soil contamination from the town's industrial past. A literature review examining the legacy of historical heavy metal contamination in the area was released in August 2021. Subsequently the EPA undertook a surface-soil sampling program in public areas. The literature review and the results of surface-soil sampling are available on the EPA's website.[1]

Point sources include, but are not limited to, discharges from two industrial premises regulated through environment protection licences (licences) issued under the *Protection of the Environment Operations Act 1997*. The premises are:

- Port Kembla Copper Pty Ltd (PKC) – Licence No.1753
- IXOM Operations Pty Ltd (IXOM) – Licence No.549.

A copy of each licence is available on EPA's public register.[2]

[1] www.epa.nsw.gov.au/working-together/community-engagement/community-news/legacy-lead-in-wollongong-soil-and-dust

[2] www.epa.nsw.gov.au/prpoeoapp

Licensed premises

Port Kembla Copper Pty Ltd – Military Road, Port Kembla

The former Port Kembla Copper (PKC) smelter is currently regulated by the EPA under Licence No. 1753 for discharge to waters. The licence includes discharge limits, monitoring and reporting requirements.

Smelting and refining operations ceased in 2003 and demolition of the infrastructure on site was completed in 2014. PKC continues to operate a wastewater treatment plant to treat stormwater captured on site during rainfall events. The first 10 mm of rainfall run-off is captured in on-site stormwater detention pits which are then directed to the wastewater treatment plant. Treated water is discharged from the premises to the Darcy Road drain through licence discharge point 1.

PKC is seeking to decommission the wastewater treatment plant and surrender its licence. The EPA has advised PKC that, prior to surrender, PKC will need to demonstrate that any untreated discharges from the premises will not pose a risk of non-trivial harm to human health or the environment.

Since the demolition of the smelter, PKC has engaged an environmental consultant to undertake a range of on-site and off-site investigation work relating to surface water management at the premises. These investigations have focused on assessing any potential risks posed by untreated surface water discharges from the premises to the Darcy Road drain and developing appropriate management strategies for any identified risks. The EPA also required PKC to engage a site auditor accredited by the EPA under the *Contaminated Land Management Act 1997* to provide independent advice on site investigations and proposed management strategies. The EPA will continue to engage with PKC and the accredited site auditor to develop management strategies to address any identified risks to water quality.

IXOM Operations Pty Ltd – Foreshore Road, Port Kembla

The IXOM premises is currently regulated by the EPA under Licence No. 549 for the scheduled activities of chemical storage, resource recovery, shipping in bulk and waste storage. The licence includes discharge limits and monitoring and reporting requirements. Historically, and during this investigation, treated process wastewater and treated stormwater from the premises is discharged to the Darcy Road drain through licence discharge point 4.

The site's operations include the manufacture of sulfuric acid and sulfur-based chemicals for the water treatment industry, sulfuric acid manufacturing, recycling and supply services, and import/export and bulk supply of concentrated sulfuric acid to industrial and power generation customers both locally and overseas.

In late 2020 the EPA required IXOM to engage a consultant to undertake a wastewater characterisation as part of a pollution reduction program (PRP). During this program, IXOM shutdown one of their production processes which significantly reduced wastewater volumes. As an outcome of this closure, IXOM has committed to cease process water discharges to the drain by November 2022.

Broader catchment

In addition to the two EPA licensed premises in the Darcy Road drain catchment, there are several industrial and commercial premises for which Wollongong City Council is the environmental regulator. Some of these sites could be conducting activities that impact on the quality of stormwater, including contributing to elevated metal levels.

Port Kembla Harbour

Water quality assessment

A number of water quality assessments undertaken within Port Kembla Harbour over the last 20 years are publicly available. These assessments have been completed by environmental consultants and as part of development applications, tertiary studies and community programs. In general these studies have reported that, while the marine environment of Port Kembla Harbour was in poor condition in the 1970s, there have been improvements in its water quality, with a reduction in concentrations of metals and other pollutants discharged to the harbour.

A recent study undertaken by Macquarie University (from December 2016 to March 2017) reported that, on average, the quality of the water in Port Kembla is good (Jahan & Strezov 2017*)*. The concentration of some metals (including selenium, mercury, beryllium, bismuth and tin) were all below detection limits, and the mean concentrations of other metals (including silver, aluminium, arsenic, nickel, vanadium, boron) were all within the ANZECC and other international guidelines. Copper concentrations were reported above the ANZECC guidelines at the time.

Public access to the open sections of the Darcy Road drain is generally restricted, with permanent fencing installed around the drain. Port Kembla Outer Harbour is accessed for recreational purposes (launching boats) via the boat ramp at the end of Foreshore Road. Having consideration for the restricted access to the drain as well as dilution and dispersion within the outer harbour, the risk of potential exposure to elevated metal contaminants for recreational users of Port Kembla is considered low.

Swimming is not permitted in Port Kembla Harbour for navigational safety reasons, and so secondary contact recreation (such as boating) is the appropriate recreational water standard. Commercial diving is understood to occur in the harbour on occasion. This is likely to require a specific work health and safety assessment that includes the potential risks from poor water quality. The Port Authority of NSW controls boating and navigation within Port Kembla Harbour.

Fishing

A number of fishing restrictions exist in Port Kembla Harbour. According to the Department of Primary Industries website, all methods of fishing are prohibited in the waters of the Port Kembla Inner Harbour, and any method involving the use of a net or a trap, other than the landing net, is prohibited in the waters of the Outer Harbour.[3] The majority of these restrictions are signposted. They exist for a variety of reasons, from public health and safety to preserving unique aquatic environments.

Sampling methods

The EPA sampled two locations within the Darcy Road drain (**Figure 1** below) on 10 occasions between November 2020 and September 2021. The locations were:

- FS1 – located immediately downstream of Foreshore Road (**Figure 2**). This location is downstream of both the PKC and IXOM premises.
- DAR1 – located immediately downstream of Darcy Road (**Figure 3**). This location is downstream of the PKC premises and upstream of the IXOM premises.

[3] www.dpi.nsw.gov.au/fishing/closures/location-closures/port-kembla

Figure 1 Locations of Darcy Road drain monitoring sites. Image: Nearmap 2020

Figure 2 Monitoring site FS1 – 13 Nov 2020. Photo: C. Patterson/EPA

Figure 3 Monitoring site DAR1 – 13 Nov 2020. Photo: C. Patterson/EPA

Samples were collected under varying conditions, including:

- during low tide events
- on different days of the week
- during rainfall events
- during discharges from PKC and IXOM.

The EPA liaised with interested community members during the sampling program and invited them to attend and observe the sampling. The EPA did not notify PKC or IXOM of the proposed sampling dates prior to sample collection. Sampling and analysis were consistent with the *Approved Methods for the Sampling and Analysis of Water Pollutants in NSW*. A copy of the Approved Methods is available on the EPA's website.[4]

Samples were analysed for total and filtered concentrations of a range of metals. Electrical conductivity and pH were also measured.

Filtered results are more indicative of the likely bioavailable metals concentrations and, therefore, the risk to aquatic organisms. The filtered results were compared against guideline values recommended by the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) for slightly to moderately disturbed marine ecosystems. For most toxicants this is the guideline value for protection of 95% of species. However, the guideline value for protection of 99% of species is recommended for some toxicants where there is a risk of bioaccumulation. Where relevant, filtered results were also compared to the guideline values for lower levels of protection as an indication of the magnitude of risk. For metals for which ANZG (2018) does not provide moderate or high reliability guideline values, the interim working levels (low reliability guideline values) were adopted where available.

Key results were plotted with rainfall to examine potential relationships with pollutant concentrations. Data from the nearby Port Kembla (BSL Central Lab) Bureau of Meteorology (BOM) weather station were used. As these data were limited, with no data available after March 2021, data from the Berkeley (Northcliffe Drive) BOM weather station were used to fill any gaps in the Port Kembla (BSL Central Lab) data.

Results and discussion

The results indicate relatively poor water quality in the Darcy Road drain, with filtered concentrations of cadmium, cobalt, copper, nickel and zinc above the relevant moderate or high reliability guideline values for slightly to moderately disturbed marine ecosystems at both DAR1 and FS1 at times.

Of these, filtered concentrations of copper and zinc were particularly elevated, with all samples from FS1 and nine of the 10 samples from DAR1 also above the 80% species protection guideline values (**Figure 4** and **Figure 5**). The median copper filtered concentrations were 20 and 15 times the guideline value for slightly to moderately disturbed marine ecosystems at DAR1 and FS1 respectively. The median filtered zinc concentrations were 39 and 53 times the guideline values for slightly to moderately disturbed marine ecosystems at DAR1 and FS1 respectively. The highest filtered copper and zinc concentrations were recorded at FS1 (**Figure 4** and **Figure 5**).

Filtered zinc concentrations at DAR1 and FS1 appeared to be lowest on days when there were discharges from the former Port Kembla Copper site and during the high rainfall event in March 2021 (**Figure 5**). These apparent temporal patterns were less evident in the filtered copper concentrations (**Figure 4**).

Discharges from the former Port Kembla Copper site are monitored for concentrations of total metals (but not for filtered metals) and there were three discharge events during the Darcy Road drain monitoring program. The total copper concentrations of these discharges were in the low to middle range of the filtered copper concentrations observed at the Darcy Road drain sites, and

[4] www.epa.nsw.gov.au/licensing-and-regulation/licensing/environment-protection-licences/licensing-under-poeo-act-1997/licensing-to-regulate-water-pollution/approved-methods-for-sampling-and-analysing-water-pollutants

were lower than those at the drain sites for two of the three discharge sampling events (**Figure 4**). The total zinc concentrations were lower than the filtered zinc concentrations observed at the Darcy Road drain sites during all three discharge sampling events (**Figure 5**). The filtered metals concentrations of these discharges would be lower than the total metals concentrations.

Discharges from IXOM occurred on all sampling days. Discharges were monitored for filtered metals concentrations as part of the required wastewater characterisation on three days during the Darcy Road drain monitoring program. The filtered copper and filtered zinc concentrations of these discharges were lower than those observed at the Darcy Road drain sites during all three discharge sampling events (**Figure 5**). This indicates that these discharges are not the main sources of the elevated metal concentrations in the Darcy Road drain.

Filtered selenium and aluminium concentrations of all samples, from DAR1 and FS1, were above the low reliability guideline values for marine ecosystems. Some samples from both DAR1 and FS1 also contained filtered arsenic, manganese and uranium concentrations above the relevant low reliability guideline values for marine ecosystems. At FS1, filtered molybdenum concentrations of three of the 10 samples were above the low reliability guideline value, while concentrations of all samples were below this guideline value at DAR1. Similarly, five of the 10 samples from FS1 contained filtered iron concentrations above the low reliability guideline value, while concentrations of all samples were below this guideline value at DAR1. Low reliability guideline values should be used with caution as they are not supported by robust effects-based datasets. Further investigation would be required to determine whether the concentrations of these metals pose a risk to aquatic ecosystem health.

Filtered concentrations of antimony, boron, chromium, lead, silver, thallium and vanadium were below the relevant guideline values in all samples from DAR1 and FS1.

The pH was within the guideline range for estuaries (7.0 to 8.5) at DAR1, ranging from 7.3 to 8. The pH was sometimes below the guideline range at FS1, ranging from 6.5 to 7.5. The electrical conductivity at DAR1 ranged from 240 to 1,300 µS/cm, indicating that the site was not influenced by saltwater tidal flows. At FS1, the electrical conductivity ranged from 260 to 18,000 µS/cm indicating that the water was sometimes brackish due to tidal inflows.

The results indicate that concentrations of some metals are often elevated in Darcy Road drain. Elevated metals concentrations appear to occur under a range of rainfall, tidal and discharge conditions. In this context, a range of point and diffuse pollutant sources related to both current and historical activities are likely to be contributing to the poor water quality in the drain. A copy of the monitoring results is available in the Appendix: EPA monitoring results.

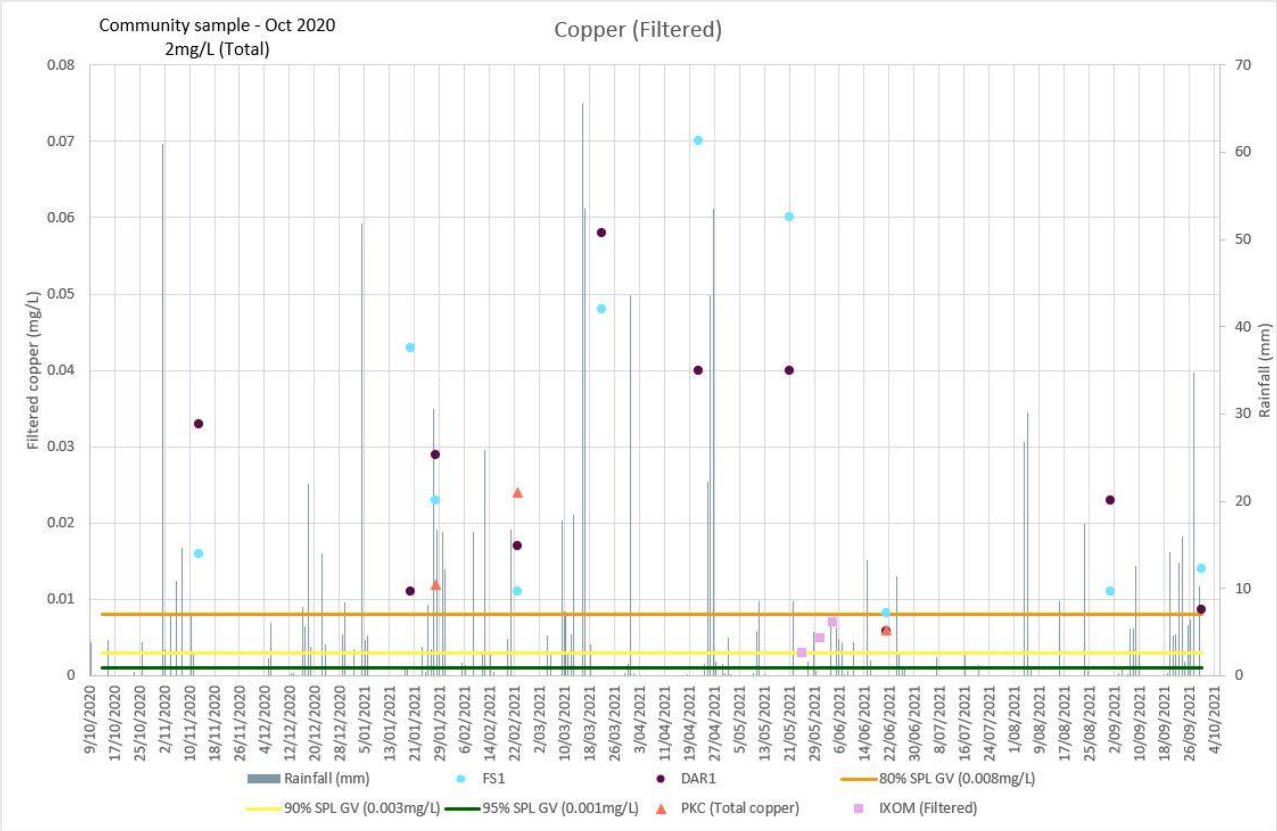


Figure 4 Filtered copper concentrations at DAR1 and FS1

Green, yellow and orange lines indicate marine guideline values (GV) at the 95%, 90% and 80% species protection levels. The IXOM acid recycling plant was discharging on all sampling days. The three IXOM results provided (indicated by the pink squares) are from their wastewater characterisation PRP. The former PKC site was discharging on three of the sampling days (indicated by the orange triangles). These values represent total copper concentrations. Filtered concentrations would be lower.

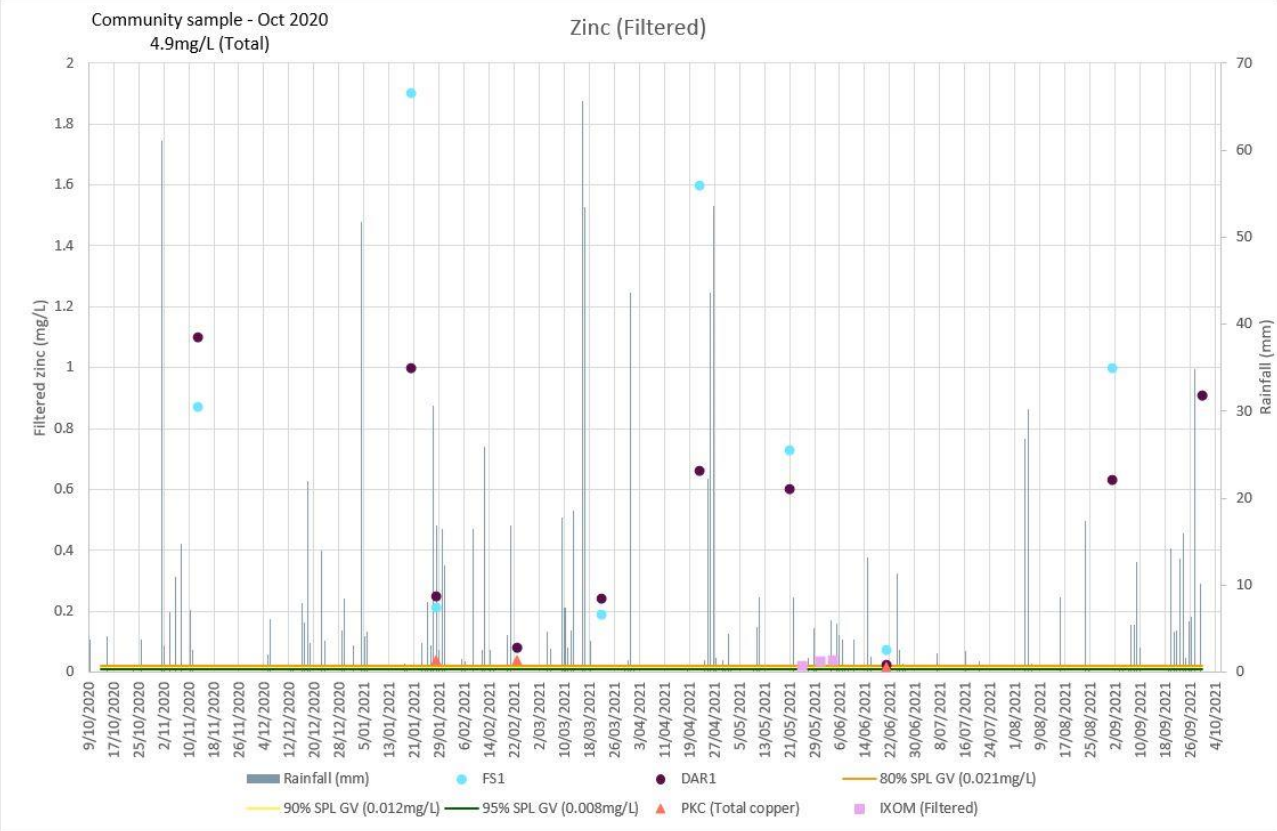


Figure 5 Filtered zinc concentrations at DAR1 and FS1

Green, yellow and orange lines indicate marine guideline values (GV) at the 95%, 90% and 80% species protection levels. The IXOM acid recycling plant was discharging on all sampling days. The 3 IXOM results provided (indicated by the pink squares) are from their wastewater characterisation PRP. The former PKC site was discharging on 3 of the sampling days (indicated by the orange triangles). These values represent total copper concentrations. Filtered concentrations would be lower.

EPA licensed premises

Port Kembla Copper

As part of PKC's site investigations, PKC identified that untreated surface water generated on site contained concentrations of metals above recognised environmental guideline values. As stated above, the EPA has required PKC to continue to operate a wastewater treatment plant to treat stormwater captured on site during rainfall events.

PKC identified that seepage waters generated from the former blending shed area was a primary source of surface water contamination (metals) on the site. PKC has implemented actions to manage this source separately to help improve the water quality being discharged from the premises. This has included installing a new water treatment plant to capture, isolate and treat this water. The treated water is proposed to be discharged to sewer via a trade waste agreement with Sydney Water Corporation.

PKC has also proposed to develop and implement a surface water management plan, focusing on additional source controls and targeted sampling to further assess the site discharge water quality, with the aim of improving the water quality generated on site. This work is ongoing, and the EPA will continue to engage with PKC and the site auditor in relation to surface water management at the site and ongoing investigations.

IXOM Operations

The wastewater characterisation assessment undertaken by IXOM identified that the treated wastewater discharged from the premises contained metal concentrations that on occasion were above recognised environmental guideline values: see **Figure 4** and **Figure 5** above.

IXOM advised the EPA that the majority of the process water discharge will cease with the pending closure of the spent acid regeneration plant (SARP).

Based on the outcome of the assessment, and in consideration of the plant closure, IXOM has agreed to implement a non-discharge management option that diverts process discharges from the Darcy Road drain by November 2022.

The EPA has also required IXOM to undertake further site investigations into groundwater seepage at the site as a condition of the licence, to assess any diffuse water discharges from the site that may require remediation. The EPA will continue to engage with IXOM in relation to surface water management at the site and ongoing investigations.

Recommendations

To further improve water quality in the Darcy Road drain, the EPA will:

1. require PKC to continue to implement its surface water management plan in consultation with the site auditor, to develop appropriate management strategies to improve the water quality discharged from the premises
2. require IXOM to eliminate, its discharges to the drain
3. engage collaboratively with Wollongong City Council in relation to non-licensed premises in the drain's catchment where opportunities exist to reduce stormwater pollution
4. liaise with NSW Ports and DPI (Fisheries) about the EPA's findings, implications for its functions, and options for public notification.

References

1. ANZG 2018, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Governments and Australian State and Territory Governments, Canberra ACT, Australia, www.waterquality.gov.au/anz-guidelines
2. Jahan S & Strezov V 2017, Water quality assessment of Australian ports using water quality evaluation indices, *PLoS ONE* 12 (12): e0189284

Appendix: EPA monitoring results

Table 1 EPA Sample Results – Foreshore Road (FS1) – Filtered

	Water quality criteria					FS1	FS1-Dup	FS1	FS1	FS1	FS1-Dup	FS1	FS1	FS1-Dup	FS1	FS1	FS1-Dup	FS1	FS1-Dup	FS1
Metals (Filtered)	**ANZG 2018 (Note 1)**					**13/11/2020**	**13/11/2020**	**20/01/2021**	**28/01/2021**	**23/02/2021**	**23/02/2021**	**22/03/2021**	**22/04/2021**	**22/04/2021**	**21/05/2021**	**21/06/2021**	**21/06/2021**	**1/09/2021**	**1/09/2021**	**30/09/2021**
	Low reliability trigger value (Indicative interim working level)	**80% Marine**	**90% Marine**	**95% Marine**	**99% Marine**															
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Aluminium	0.0005					0.05	0.07	0.14	0.08	0.17	0.19	0.32	0.42	0.41	0.14	0.08	0.07	0.05	0.08	0.05
Antimony	0.27					0.006	0.0062	0.0043	0.0005	0.0007	0.0007	0.0029	0.004	0.004	0.002	0.0005	<0.0005	0.005	0.005	0.002
Arsenic (Note 2)	0.0023					0.006	0.006	0.003	0.001	0.002	0.002	0.008	<0.003	<0.003	<0.003	0.002	0.001	<0.003	<0.003	<0.003
Barium						0.035	0.035	0.05	0.0092	0.01	0.011	0.02	0.034	0.033	0.024	0.0093	0.0093	0.032	0.034	0.04
Beryllium						<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0002	<0.0002	<0.0002	<0.0001	<0.0001	<0.0002	<0.0002	<0.0002
Boron	5.1					0.3	0.3	0.3	<0.1	<0.1	<0.1	<0.1	0.3	0.3	<0.1	<0.1	<0.1	0.2	0.2	0.1
Cadmium		0.036	0.014	0.0055	0.0007	0.016	0.016	0.03	0.014	0.0024	0.0025	0.0054	0.012	0.011	0.011	0.0017	0.0016	0.011	0.012	0.0082
Calcium						110	120	110	32	37	36	21	110	110	50	31	30	120	110	61
Chromium (Note 3)		0.085	0.02	0.0044	0.00014	<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
Cobalt		0.15	0.014	0.001	0.000005	0.018	0.018	0.026	0.0031	0.001	0.001	0.0023	0.021	0.021	0.009	0.0007	0.0007	0.02	0.02	0.013
Copper		0.008	0.003	0.0013	0.0003	0.016	0.017	0.043	0.023	0.011	0.011	0.048	0.07	0.07	0.06	0.0082	0.0084	0.011	0.015	0.014
Iron						<0.04	0.05	1.6	0.09	0.08	0.07	0.32	0.81	0.82	0.61	0.12	0.1	0.05	0.07	0.78
Lead		0.012	0.0066	0.0044	0.0022	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.0013	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001
Lithium						0.031	0.032	0.04	0.005	0.0044	0.0044	0.0042	0.026	0.025	0.01	0.0046	0.0046	0.034	0.034	0.015
Magnesium						33	35	37	2.9	2.7	2.6	4.5	37	36	12	2.7	2.6	41	42	26
Manganese	0.08					1.1	1.1	1.5	0.04	0.04	0.04	0.094	1.3	1.3	0.57	0.032	0.034	1.1	1.2	0.9
Molybdenum	0.023					0.02	0.02	0.02	0.0025	0.0052	0.0052	0.0022	0.06	0.058	0.02	0.0036	0.004	0.025	0.036	0.062
Nickel		0.56	0.2	0.07	0.007	0.19	0.19	0.23	0.029	0.01	0.0099	0.011	0.22	0.23	0.06	0.01	0.011	0.23	0.24	0.18
Phosphorus						<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.09	0.07	0.12	0.08	<0.04	<0.04	0.21	0.15	0.02
Potassium						14	15	14	2.4	2.1	2.1	2.9	13	13	6.5	2.9	2.8	16	20	21
Selenium	0.003					0.09	0.1	0.05	0.017	0.019	0.018	0.022	0.038	0.037	0.011	0.016	0.013	0.064	0.067	0.022
Silver		0.0026	0.0018	0.0014	0.0008	<0.0002	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium						250	260	530	17	22	22	18	4600	4600	1200	19	18	1200	2500	6400
Strontium						0.5	0.55	0.49	0.07	0.09	0.09	0.1	0.49	0.48	0.19	0.072	0.074	0.52	0.51	0.3
Sulfur						250	250	470	24	28	27	15	3200	3100	880	21	21	980	1900	4700
Thallium	0.017					0.001	0.001	0.0009	0.0002	<0.0001	<0.0001	<0.0001	0.0012	0.0011	0.0005	0.0001	0.0001	0.0009	0.001	0.0008
Tin						<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.001	<0.001	<0.001	<0.0002	<0.0002	<0.001	<0.001	<0.001
Titanium						<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	<0.01	<0.01
Uranium						0.0008	0.0009			<0.0001	<0.0001	0.0002	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001
Vanadium		0.28	0.16	0.1	0.05	0.0003	0.0002	<0.0002	0.0003	0.0003	0.0003	0.0084	<0.0005	<0.0005	<0.0005	0.0004	0.0004	<0.0005	<0.0005	<0.0005
Zinc		0.043	0.023	0.015	0.007	0.87	0.89	1.9	0.21	0.08	0.08	0.19	1.6	1.7	0.73	0.072	0.064	1	1.1	0.91

Notes

1. ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines
2. The ANZG 2018 As(III) indicative interim working level has been adopted
3. The ANZG 2018 Cr(VI) indicative interim working level has been adopted
4. Dup = duplicate sample

Table 2 EPA Sample Results – Darcy Road (DAR1) – Filtered

	Water quality criteria					DAR1	DAR1-Dup	DAR1	DAR1-Dup	DAR1	DAR1	DAR1	DAR1-Dup	DAR1	DAR1	DAR1-Dup	DAR1	DAR1-Dup	DAR1	DAR1	DAR1-Dup
Metals (Filtered)	ANZG 2018 (Note 1)					13/11/2020	13/11/2020	20/01/2021	20/01/2021	28/01/2021	23/02/2021	22/03/2021	22/03/2021	22/04/2021	21/05/2021	21/05/2021	21/06/2021	21/06/2021	1/09/2021	30/09/2021	30/09/2021
	Low reliability trigger value (Indicative interim working level)	80% Marine	90% Marine	95% Marine	99% Marine																
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Aluminium	0.0005					<0.04	<0.04	0.09	<0.04	<0.04	0.05	0.08	0.09	0.11	0.06	0.05	<0.04	<0.04	0.08	<0.04	0.06
Antimony	0.27					0.0085	0.0088	0.007	0.007	<0.0005	0.0006	0.0032	0.0037	0.006	0.0043	0.0044	<0.0005	<0.0005	0.0059	0.0049	0.0049
Arsenic (Note 2)	0.0023					0.054	0.054	0.057	0.06	0.001	0.003	0.009	0.014	0.071	0.05	0.05	0.002	0.002	0.064	0.067	0.06
Barium						0.036	0.036	0.04	0.04	0.0095	0.0094	0.033	0.03	0.038	0.032	0.032	0.0086	0.0086	0.041	0.04	0.04
Beryllium						<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Boron	5.1					0.3	0.3	0.3	0.3	<0.1	<0.1	<0.1	<0.1	0.3	0.2	0.2	<0.1	<0.1	0.2	0.2	0.2
Cadmium		0.036	0.014	0.0055	0.0007	0.032	0.033	0.04	0.04	0.018	0.0048	0.011	0.0091	0.02	0.017	0.017	0.0012	0.0012	0.016	0.011	0.013
Calcium						100	100	100	92	32	32	22	23	94	62	60	28	28	140	86	100
Chromium (Note 3)		0.085	0.02	0.0044	0.00014	<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
Cobalt		0.15	0.014	0.001	0.000005	0.007	0.0073	0.0084	0.0083	0.0032	0.0007	0.0016	0.0014	0.0074	0.0045	0.0042	0.0002	0.0002	0.0087	0.0055	0.0063
Copper		0.008	0.003	0.0013	0.0003	0.033	0.038	0.011	0.0094	0.029	0.017	0.058	0.049	0.04	0.04	0.042	0.0058	0.0064	0.023	0.0087	0.0099
Iron						<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.07	0.06	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Lead		0.012	0.0066	0.0044	0.0022	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0008	0.0008	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Lithium						0.033	0.033	0.05	0.05	0.0051	0.0043	0.0031	0.0037	0.034	0.019	0.02	0.0042	0.0041	0.03	0.026	0.028
Magnesium						15	15	18	16	2.5	1.9	5.3	4.9	17	11	11	1.8	1.9	27	19	21
Manganese	0.08					0.16	0.16	0.25	0.19	0.013	0.006	0.012	0.011	0.28	0.14	0.13	0.004	0.004	0.36	0.22	0.27
Molybdenum	0.023					0.023	0.024	0.02	0.02	0.0025	0.0042	0.0019	0.0025	0.013	0.011	0.011	0.0043	0.0042	0.018	0.013	0.016
Nickel		0.56	0.2	0.07	0.007	0.41	0.42	0.36	0.32	0.031	0.013	0.013	0.015	0.21	0.17	0.18	0.0081	0.0079	0.23	0.22	0.26
Phosphorus						<0.04	<0.04	0.06	0.05	<0.04	<0.04	0.24	0.2	0.14	0.17	0.14	<0.04	<0.04	0.12	0.14	0.14
Potassium						17	17	16	14	2.4	2	3.5	3.8	13	9	9	2.7	2.7	16	13	15
Selenium	0.003					0.13	0.13	0.08	0.07	0.016	0.018	0.008	0.027	0.063	0.041	0.042	0.013	0.013	0.068	0.035	0.04
Silver		0.0026	0.0018	0.0014	0.0008	<0.0002	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium						110	110	110	110	15	19	21	21	110	69	71	14	14	140	110	120
Strontium						0.46	0.47	0.5	0.47	0.06	0.07	0.13	0.13	0.48	0.29	0.3	0.051	0.052	0.6	0.44	0.5
Sulfur						110	110	110	87	23	22	8.1	9.1	83	55	54	17	18	140	84	100
Thallium	0.017					0.0015	0.0015	0.0017	0.0018	0.0002	<0.0001	0.0001	0.0001	0.0021	0.0011	0.0011	0.0001	0.0001	0.0011	0.0014	0.0013
Tin						<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Titanium						<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	<0.01	<0.01	<0.01
Uranium						0.0006	0.0006				<0.0001	0.0002	0.0002	0.0006	0.0004	0.0004	<0.0001	<0.0001	0.0008	0.0007	0.0007
Vanadium		0.28	0.16	0.1	0.05	0.0037	0.0034	0.0041	0.0043	<0.0002	<0.0002	0.0084	0.0088	0.0028	0.008	0.0074	0.0003	0.0003	0.0042	0.0057	0.0049
Zinc		0.043	0.023	0.015	0.007	1.1	1.1	1	1	0.25	0.08	0.24	0.16	0.66	0.6	0.62	0.026	0.027	0.63	0.56	0.56

Notes

1. ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines
2. The ANZG 2018 As(III) indicative interim working level has been adopted
3. The ANZG 2018 Cr(VI) indicative interim working level has been adopted
4. Dup = duplicate sample

Table 3 EPA Sample Results – Foreshore Road (FS1) – Total

	FS1	FS1-Dup	FS1	FS1	FS1	FS1-Dup	FS1	FS1-Dup	FS1	FS1	FS1	FS1-Dup	FS1	FS1-Dup	FS1
Metals (Total)	**13/11/2020**	**13/11/2020**	**20/01/2021**	**28/01/2021**	**23/02/2021**	**23/02/2021**	**22/03/2021**	**22/04/2021**	**22/04/2021**	**21/05/2021**	**21/06/2021**	**21/06/2021**	**1/09/2021**	**1/09/2021**	**30/09/2021**
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Aluminium	1.6	1.6	2.7	0.11	0.22	0.26	1.1	5.8	5.4	2.4	0.17	0.17	2	5.4	1.2
Antimony	0.0065	0.0065	0.0048	0.0005	0.0007	0.0007	0.003	0.004	0.004	0.002	0.0005	0.0007	0.006	0.006	0.003
Arsenic	0.018	0.018	0.011	0.003	0.004	0.004	0.013	0.047	0.046	0.02	0.004	0.005	0.024	0.065	0.009
Barium	0.037	0.037	0.05	0.0092	0.0097	0.01	0.024	0.034	0.033	0.025	0.0098	0.0099	0.035	0.038	0.04
Beryllium	0.0002	0.0001	0.0003	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	0.0003	<0.0002	<0.0001	<0.0001	<0.0002	0.0003	<0.0002
Boron	0.3	0.3	0.3	<0.1	<0.1	<0.1	<0.1	0.3	0.3	<0.1	<0.1	<0.1	0.2	0.2	0.2
Cadmium	0.02	0.019	0.03	0.015	0.0025	0.0027	0.0066	0.013	0.013	0.011	0.0021	0.002	0.014	0.017	0.0088
Calcium	110	120	120	32	35	36	23	120	110	51	31	31	110	110	63
Chromium	0.002	0.002	0.004	0.002	0.002	0.002	0.002	0.006	0.006	0.006	0.001	<0.001	0.002	0.018	0.002
Cobalt	0.018	0.02	0.026	0.003	0.0009	0.0011	0.0027	0.02	0.02	0.009	0.0009	0.0009	0.02	0.021	0.014
Copper	0.11	0.12	0.18	0.046	0.021	0.026	0.1	0.31	0.29	0.17	0.026	0.024	0.12	0.25	0.07
Iron	4.4	4.5	5.6	0.41	0.33	0.35	1	10	9.6	5	0.48	0.49	8.2	16	6.3
Lead	0.0018	0.0019	0.0011	0.0005	<0.0001	0.0002	0.0059	0.007	0.007	0.006	0.0007	0.0005	0.002	0.019	0.003
Lithium	0.031	0.032	0.05	0.005	0.0044	0.0046	0.0045	0.026	0.027	0.01	0.0047	0.0047	0.036	0.036	0.017
Magnesium	33	35	35	3	2.5	2.6	4.6	38	36	12	2.7	2.8	41	42	27
Manganese	1.1	1.2	1.3	0.041	0.041	0.046	0.11	1.3	1.3	0.56	0.037	0.036	1.1	1.2	0.94
Mercury					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.19	<0.05
Molybdenum	0.019	0.02	0.01	0.0025	0.0061	0.0065	0.0024	0.066	0.066	0.02	0.0045	0.0044	0.028	0.044	0.065
Nickel	0.19	0.2	0.21	0.029	0.0098	0.011	0.014	0.24	0.23	0.06	0.012	0.012	0.24	0.27	0.19
Phosphorus	<0.04	<0.04	0.05	<0.04	<0.04	<0.04	0.2	0.22	0.12	0.2	<0.04	<0.04	0.21	0.15	0.02
Potassium	14	15	14	2.5	2	2.1	2.9	14	13	7.4	2.9	2.9	16	20	22
Selenium	0.1	0.1	0.06	0.02	0.016	0.016	0.021	0.05	0.05	0.015	0.013	0.014	0.06	0.072	0.029
Silver	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	250	260	480	17	22	22	18	4700	4800	1200	18	18	1300	2600	6600
Strontium	0.5	0.55	0.52	0.07	0.09	0.12	0.11	0.5	0.48	0.19	0.076	0.077	0.52	0.52	0.31
Sulfur	250	250	420	26	26	27	17	3200	3100	860	21	22	1000	1900	4800
Thallium	0.001	0.001	0.0009	0.0002	<0.0001	<0.0001	<0.0001	0.0012	0.0012	0.0006	0.0001	0.0001	0.0009	0.001	0.0008
Tin	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.001	<0.001	<0.001	<0.0002	<0.0002	<0.001	<0.001	<0.001
Titanium	<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	<0.01	<0.01
Uranium	0.001	0.001			<0.0005	<0.0005	<0.0005	0.001	0.001	<0.001	<0.0001	<0.0001	0.001	0.001	<0.001
Vanadium	0.0027	0.003	0.0025	0.0006	0.0005	0.0007	0.013	0.0039	0.0038	0.0098	0.0011	0.001	0.002	0.0048	0.002
Zinc	1.2	1.2	2	0.25	0.085	0.088	0.28	1.9	1.8	0.78	0.08	0.079	1.3	1.6	0.99

Table 4 EPA Sample Results – Darcy Road (DAR1) – Total

	DAR1	DAR1-Dup	DAR1	DAR1-Dup	DAR1	DAR1	DAR1	DAR1-Dup	DAR1	DAR1	DAR1-Dup	DAR1	DAR1-Dup	DAR1	DAR1	DAR1-Dup
Metals (Total)	**13/11/2020**	**13/11/2020**	**20/01/2021**	**20/01/2021**	**28/01/2021**	**23/02/2021**	**22/03/2021**	**22/03/2021**	**22/04/2021**	**21/05/2021**	**21/05/2021**	**21/06/2021**	**21/06/2021**	**1/09/2021**	**30/09/2021**	**30/09/2021**
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Aluminium	0.06	0.06	0.07	0.07	<0.04	0.08	0.63	0.53	0.14	0.11	0.1	0.05	0.05	0.1	0.07	0.09
Antimony	0.0091	0.0093	0.0078	0.0078	0.0005	0.0006	0.0033	0.0039	0.0057	0.0043	0.0044	<0.0005	<0.0005	0.0058	0.0048	0.005
Arsenic	0.076	0.08	0.095	0.096	0.003	0.004	0.009	0.015	0.089	0.065	0.066	0.004	0.004	0.076	0.082	0.075
Barium	0.038	0.038	0.04	0.04	0.0098	0.0095	0.038	0.035	0.039	0.033	0.033	0.0091	0.0091	0.042	0.04	0.04
Beryllium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Boron	0.3	0.3	0.3	0.3	<0.1	<0.1	<0.1	<0.1	0.3	0.2	0.2	<0.1	<0.1	0.2	0.2	0.2
Cadmium	0.041	0.04	0.05	0.05	0.02	0.0049	0.013	0.012	0.021	0.019	0.019	0.0018	0.0018	0.017	0.017	0.016
Calcium	100	100	97	95	32	32	23	24	95	61	59	29	29	140	88	110
Chromium	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.001	0.001	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	0.0069	0.0072	0.0085	0.0087	0.0033	0.0007	0.002	0.0016	0.0071	0.0045	0.0043	0.0004	0.0004	0.009	0.0056	0.0064
Copper	0.32	0.33	0.27	0.26	0.058	0.026	0.093	0.093	0.2	0.17	0.18	0.018	0.017	0.18	0.15	0.17
Iron	1.5	1.5	1.1	1.1	0.25	0.06	0.5	0.45	1.1	0.79	0.82	0.19	0.18	0.85	0.99	1
Lead	0.0018	0.0018	0.002	0.0021	0.0005	<0.0001	0.0056	0.0052	0.0018	0.0022	0.0023	0.0003	0.0003	0.001	0.0017	0.0014
Lithium	0.034	0.034	0.05	0.05	0.0052	0.0043	0.0037	0.0041	0.034	0.02	0.02	0.0044	0.0043	0.029	0.026	0.027
Magnesium	15	15	16	16	2.5	1.8	5.5	5	17	11	10	1.9	1.9	27	19	22
Manganese	0.16	0.16	0.18	0.19	0.022	0.008	0.02	0.018	0.29	0.14	0.13	0.007	0.008	0.36	0.23	0.29
Mercury						<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	0.022	0.023	0.02	0.02	0.0025	0.0051	0.0021	0.0028	0.016	0.011	0.011	0.0045	0.0045	0.02	0.014	0.017
Nickel	0.42	0.43	0.37	0.36	0.033	0.013	0.015	0.018	0.22	0.17	0.18	0.01	0.01	0.23	0.24	0.27
Phosphorus	<0.04	<0.04	0.13	0.13	<0.04	<0.04	0.3	0.25	0.14	0.14	0.15	<0.04	<0.04	0.12	0.14	0.14
Potassium	17	17	16	16	2.4	2	3.6	3.7	13	9.7	9.6	2.8	2.7	16	13	15
Selenium	0.14	0.14	0.09	0.09	0.019	0.015	0.009	0.027	0.053	0.044	0.044	0.013	0.013	0.061	0.033	0.038
Silver	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	110	110	120	120	15	18	21	21	110	66	67	14	14	130	120	120
Strontium	0.46	0.47	0.48	0.47	0.06	0.062	0.13	0.13	0.48	0.3	0.3	0.053	0.055	0.6	0.45	0.52
Sulfur	110	110	96	95	24	21	8.9	10	90	56	54	18	17	140	87	100
Thallium	0.0015	0.0015	0.0019	0.002	0.0002	<0.0001	0.0002	0.0001	0.002	0.0011	0.0011	0.0001	0.0001	0.0012	0.0015	0.0014
Tin	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Titanium	<0.01	<0.01	0.05	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	0.0006	0.0006				<0.0005	<0.0005	<0.0005	0.0006	0.0004	0.0004	<0.0001	<0.0001	0.0009	0.0007	0.0007
Vanadium	0.0041	0.0041	0.0049	0.0052	0.0003	0.0003	0.0099	0.011	0.0032	0.0091	0.009	0.0005	0.0006	0.0048	0.0062	0.006
Zinc	1.3	1.4	1.3	1.3	0.29	0.086	0.3	0.26	0.81	0.68	0.69	0.041	0.042	0.72	0.76	0.73

Table 5 **EPA Sample Results – Foreshore Road (FS1) – pH and conductivity**

	FS1	FS1-Dup	FS1	FS1	FS1	FS1-Dup	FS1	FS1-Dup	FS1	FS1	FS1	FS1-Dup	FS1	FS1-Dup	FS1
	13/11/2020	13/11/2020	20/01/2021	28/01/2021	23/02/2021	23/02/2021	22/03/2021	22/04/2021	22/04/2021	21/05/2021	21/06/2021	21/06/2021	1/09/2021	1/09/2021	30/09/2021
pH	7.4	7.4	6.9	7.4	7.5	7.4	7.4	6.5	6.5	6.6	7.5	7.4	7.2	7.2	6.9
Conductivity (µS/cm)	2000	2000	2900	310	330	320	270	18000	18000	5700	280	260	6100	12000	24000

Table 6 **EPA Sample Results – Darcy Road (DAR1) – pH and conductivity**

	DAR1	DAR1-Dup	DAR1	DAR1-Dup	DAR1	DAR1	DAR1	DAR1-Dup	DAR1	DAR1	DAR1-Dup	DAR1	DAR1-Dup	DAR1	DAR1	DAR1-Dup
	13/11/2020	13/11/2020	20/01/2021	20/01/2021	28/01/2021	23/02/2021	22/03/2021	22/03/2021	22/04/2021	21/05/2021	21/05/2021	21/06/2021	21/06/2021	1/09/2021	30/09/2021	30/09/2021
pH	7.9	7.9	7.8	7.8	7.3	7.6	7.9	7.9	7.9	7.8	7.9	7.6	7.6	8	7.8	7.7
Conductivity (µS/cm)	1200	1200	1200	1200	290	280	290	290	1100	770	760	240	250	1300	1200	1400