



ANNUAL ENVIRONMENT REPORT 2024



ISO 14001 Certified Environmental Management System



NPL Annual Environment Report 2024

New Porgera Limited

June 2025

NPL ENV 1-25

PO Box 851, Port Morsby 121, NCD

PAPUA NEW GUINEA

Contact: Fiorenzo Guarino – Sustainability Manager

Email: fiorenzo.guarino@npltd.com

Acknowledgements: Aptive Environmental Consulting

CSIRO Land and Water

Hydrobiology

National Measurement Institute

University of Otago

Cover Photo: Strickland River near SG4, 2024

Environment
Building 135, 2-40 Clunies Ross St, Acton,
Black Mountain ACT 2601
Australia
Telephone: (02) 62766851 • ABN 41 687 119 230



Andrew Lomas
Superintendent, Environment
New Porgera Ltd.
P.O Box 484, Mount Hagen WHP
Papua New Guinea

27 June 2025

Dear Andrew,

Re: New Porgera Ltd. Annual Environment Report 2024

Dr Brad Angel and Dr Simon Apte reviewed a draft of the 2024 New Porgera Ltd Annual Environment Report (AER) and provided detailed comments for consideration. Overall, the draft report was found to be technically sound and of good quality. However, as might be expected with a report of this size, a number of minor errors were identified and some general recommendations were made for improvement of various sections. New Porgera Ltd. responded positively to the review team's recommendations and the report was satisfactorily revised in the light of the comments made.

We commend your Department on their considerable efforts in producing this extensive technical report.

Sincerely

A handwritten signature in black ink, appearing to read 'B. Angel', is positioned above the name of Dr Brad Angel.

Dr Brad Angel

Senior Research Scientist (CSIRO)

A handwritten signature in black ink, appearing to read 'S. Apte', is positioned above the name of Dr Simon Apte.

Dr Simon Apte

Principal consultant (Aptive Consulting)

EXECUTIVE SUMMARY

New Porgera Limited (NPL) Gold Mine is located in the Porgera Valley of Enga Province in the Papua New Guinea (PNG) highlands, approximately 630 km NW of Port Moresby.

The mine is owned 49% by Barrick and Zijin Mining, who hold the shares as a 50-50 joint venture in Barrick (Niugini) Limited (BNL). The majority 51% ownership is held by Papua New Guinea stakeholders, with 36% managed by the state through Kumul Minerals Holdings Limited (KMHL) and the remaining 15% shared between the Enga Provincial Government and project area landowners. NPL is managed and operated by Barrick (Niugini) Limited (BNL). The operation consists of an open cut and an underground mine, waste rock dumps, processing facility, gas-fired power station, a water-supply dam, limestone quarry and lime plant and ancillary infrastructure. Production began in 1990 and is expected to continue through to 2043. In April 2020, the mine was placed under care and maintenance following the PNG Government's decision not to renew the Special Mining Lease (SML) upon the expiration of its initial term. In October 2023, SML 13 was granted to NPL, and operations recommenced in December 2023. Key milestones during the ramp-up phase included the restart of both underground and open-pit mining, restoration of the gas-powered station, and the reactivation of the oxygen plant and autoclaves. These efforts resulted in the full restart of process plant operations by August 2024. The site currently employs approximately 3,860 personnel, including local, national, expatriate staff, and contractors. Prior to the 2020 mine shut down; the mine had an average annual gold production of approximately 500,000 ounces.

Porgera Mine has a number of unique economic, social and environmental aspects. The environmental aspects are managed through implementation of an Environmental Management System (EMS). The objectives of the EMS are to ensure methodical, consistent and effective control of the mine's environmental aspects to achieve compliance with legal and other requirements, to mitigate potential environmental risks and to continually improve environmental performance. The EMS has been continuously certified to the ISO14001 international standard since December 2012.

A fundamental element of the NPL EMS is the environmental monitoring and reporting program. The program provides feedback on the effectiveness of the EMS in achieving the stated objectives, it allows the operation to confirm which management techniques are working well and to identify opportunities for improvement.

Since 1995, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia's preeminent scientific organisation, have provided independent oversight of the NPL environmental monitoring program. CSIRO's role includes undertaking a review of NPL's AER, routine quality assurance audits of the NPL environmental monitoring program and environmental laboratory operations, and technical studies to improve the understanding of the behaviour of metals within the receiving environment. CSIRO audits include independent sampling and analysis of water, sediment and fish and prawn tissue to cross-check NPL's results.

The objectives of this Annual Environment Report (AER) are to provide an assessment of the overall environmental performance of the operation throughout the previous calendar year and to assess historical trends in performance. The objectives of this report are aligned with those of the EMS and are to assess:

1. Compliance with legal and other requirements.
2. The level of potential and actual environmental impact; and
3. The environmental performance of the operation.

The first section of the AER describes background environmental conditions by quantifying the natural, non-mine related conditions and changes within the environment. Next, the operation's environmental aspects (activities which interact with the environment) are identified and quantified. Then, assessments are made of compliance, mine-related risk, impact and performance, followed by a discussion of the

findings, and finally, recommendations for improving the environmental management system and the monitoring and reporting program.

Mine Operations and Environmental Aspects

The significant environmental aspects of the operation are riverine tailings disposal, riverine waste rock disposal, on-land waste rock placement, water extraction and discharge, the transport, storage and use of chemicals and waste management.

During care and maintenance period between 2020 and 2023 the tailings discharge, on-land waste rock placement and use of bulk chemicals were suspended. Mudstone and slip material from the open pit were removed and placed in the erodible waste rock dumps.

The physical footprint remained consistent with the previous five years of operation. Ore and gold production were lower in 2024 compared to that period, primarily due to the mine restart and the ramp-up of production following the care and maintenance phase. Water and energy efficiencies were also in line with historical operational performance.

Tailings volumes were consistent with previous operational years and a proportion (1.8% by volume) was diverted from riverine disposal and used for cemented backfill in the underground mine. The volume diverted to paste in 2024 was lower than the previous operational years due to a major landslide at Mulitaka along the highlands highway in Enga Province which had an impact on cement supplies to the mine for paste production.

Total suspended sediment (TSS) concentrations in tailings were comparable to previous operational years. pH, dissolved arsenic and dissolved lead in tailings showed increased trends over the preceding ten-year period (2015-2024), while concentrations of other metals either remained unchanged or decreased.

Contact rainfall runoff from the site was typical of neutral mine drainage and exhibited elevated TSS and concentrations of dissolved cadmium, chromium and zinc. The volumes of mine contact water generated in 2024 were comparable to previous years.

Background Environmental Conditions

The Porgera Valley and upper Lagaip River catchments experienced average annual rainfall during 2024. The middle and lower Strickland River catchments received slightly lower than average rainfall throughout 2024. Due to the care and maintenance phase and mine operational situation, river flow data recovery rates were low for all stations except SG3 and cannot be reported. However, rainfall records for Anawe show that the 2024 total was the fourth highest on record since 1974, suggesting that river flows for the year would likely be above average throughout the upper river within the highlands and the lower river along the Strickland floodplain, and average rates of dilution of mine-related inputs within the receiving aquatic ecosystem.

Background conditions for environmental indicators of water quality, sediment quality, metals in the tissue of fish and prawns (tissue metals) and ecosystem health have been established using data collected from test sites prior to the commencement of mining operations (baseline data), and since operations began from sites (nearby tributaries) that are not influenced by the operation (reference sites).

Although concentrations of physical and chemical parameters at the upper river reference sites were generally lower than the baseline data from the upper river test sites, the reference sites did exhibit moderate TSS concentrations and higher concentrations of dissolved selenium compared to baseline data. This indicates that tributaries to the Lagaip-Strickland system have the potential to contribute non-mine-derived TSS and elevated concentrations of some metals to the system. The trend for pH at upper

and lower river reference sites and dissolved mercury and nickel at upper river reference sites displayed statistically significant increase over the past decade.

Compliance

Legal and other requirements are imposed predominantly by the two environmental permits issued to the mine by the Papua New Guinea Conservation and Environmental Protection Authority (CEPA). The operation complied with 100% of legal and other obligations throughout 2024, including water quality at compliance point at SG3 on the Strickland River.

Environmental Risk, Impact and Performance

Methodology

The methodology for risk and impact assessment developed by NPL is based on international guidelines (ANZG 2018) and advice received during consultation with external technical experts.

The risk and impact assessments are based on the comparison of physical, chemical and biological environmental indicators at sites potentially impacted by the mine (test sites) against a range of trigger values (TVs). TVs are derived from a combination of baseline data, collected from test sites before development of the mine, reference site data, collected from sites within the region that are not potentially influenced by the mine's activities, and international guidelines. The TVs act as benchmarks for determining whether risk or impact has occurred at a test site.

Tests of statistical significance were performed to provide a statistical basis for determining whether risk or impact may exist at a particular test site.

Conclusions

The risk assessment concluded that elevated electrical conductivity (EC), TSS, dissolved cadmium, copper, nickel and zinc in tailings and contact runoff from the competent waste rock dumps, open pit and underground mines, posed a potential risk to aquatic ecosystems in the upper river between the mine and Wankipe on the Lagaip River, 116 km downstream of the mine.

The estimated loads of sediment contributed by tailings and waste rock in 2024 were low compared with historical rates. The proportion of mine-derived sediment at SG3 in 2024 was estimated to be 7.3%, which compares to a long-term median of approximately 22%.

The environmental risk assessment showed that in 2024 there was moderate mine-related environmental impact within the Porgera and Lagaip Rivers between the mine and Wasiba, located on the Lagaip River 96 km downstream. Environmental impact was detected in the form of elevated EC and TSS concentrations in water, elevated weak acid extractable (WAE) concentrations of lead and selenium in benthic sediment, elevated lead and selenium concentrations in prawn abdomen at Wasiba. The impact assessment for prawns and fish at Wasiba and Wankipe sites at upper river showed no impact in 2024. Aside from some elevations of electrical conductivity, the risk assessment and investigation concluded there were no significant mine-related impacts downstream of SG3 and throughout the lower river, ORWBs and Lake Murray regions.

A summary of compliance, human health risk and environmental impact at each test site in 2024 is presented in Table E-1. There was low risk posed to human health by the operation's activities. However, it should be noted people who illegally accessed the tailings stream within the Porgera Special Mining Lease boundary were exposed to concentrations of dissolved cadmium, nickel and zinc which exceeded the ANZG (2018) guidelines for recreational water quality.

It should be noted that the concentrations of metals in fish flesh and prawn abdomen at all sites were below international food standards, indicating that they are safe for human consumption.

Furthermore, the downstream extent of impact, at Wasiba located 96 km downstream from the mine, lies well within the permitted mixing zone, which extends to SG3 on the Strickland River, 164 km downstream of the mine. Additionally, the degree of impact detected is consistent with the predictions

made prior to mining operations commencing in 1990 and compensation for environmental impact is paid to landowners living along the river within the permitted mixing zone, in accordance with the 1996 Ministerial Determination.

Table E-1 Summary of Compliance, Human Health Risk and Environmental Impact at test sites in 2024

Region	Site	Distance From the Mine (km)	Overall Condition			Comments
			Compliance	Human Health Risk	Environmental Impact	
Upper River	SG2	42	Compliant	Low Risk	Moderate Env Impact	Located within the permitted mixing and compensation zone.
	Wasiba	96	Compliant	Low Risk	Moderate Env Impact	
	Wankipe	116	Compliant	Low Risk	Minor Impact	
	SG3	164	Compliant	Low Risk	No Impact	End of the permitted mixing and compensation zone
Lower River	Bebelubi	310	Compliant	Low Risk	No Impact	
	SG4	360	Compliant	Low Risk	No Impact	
	SG5	550	Compliant	Low Risk	No Impact	
ORWBs	Kukufionga	510	Compliant	Low Risk	No Impact	
	Zongamange	560	Compliant	Low Risk	No Impact	
	Avu	575	Compliant	Low Risk	No Impact	
	Levame	600	Compliant	Low Risk	No Impact	
Lake Murray	SG6	570	Compliant	Low Risk	No Impact	
	Miwa	590	Compliant	Low Risk	No Impact	
	Pangoa	600	Compliant	Low Risk	No Impact	

Recommendations for Improvement

The recommendations presented in this section are intended to improve the assessment methodology, communication of the findings to the many stakeholders and to improve the environmental performance of the operation and reduce environmental risk and impact.

Note that a number of the recommendations from the previous AER are still in progress and appear in the list below in addition to new recommendations raised from this year's AER.

Assessment Methodology and Communication of Findings

1. Continue to investigate options for increasing the frequency of TSS sampling in the upper and lower river, Lake Murray and ORWB reference and test sites.
2. Deliver a summary presentation of the report methodology and findings to the Conservation and Environmental Protection Authority to support delivery of the AER.
3. Develop a NPL Environment Report Card to present a summary of the findings of the report and make the report card available in hard copy and via the NPL website.
4. Undertake a study to update the particle size information for the erodible dumps, used in the sediment mass balance calculations.
5. Undertake a study to investigate the major ions present in the system, which contribute to elevated EC, and their impacts on aquatic life. This work should also investigate options for development of site-specific trigger values for specific mine-derived major ions.
6. Review the analytical procedure used for the determination of WAE metals. The CSIRO 2019 ultratrace study reported much lower WAE metal concentrations in benthic sediments from the main river than typically reported by NPL. It may be appropriate to adopt the CSIRO procedure for routine analysis.

Reduce Environmental Risk and Impact and Improve Performance

7. Continue to investigate options for reducing the concentrations of bioavailable metals and mass loads of metals in mine discharges.
8. Investigate the metal uptake pathway by which prawns and fish are accumulating mine derived metals to understand the influence of particulate metals and metals bound to organic matter.
9. Investigate mercury bioaccumulation in Lake Murray food webs: conduct a follow up to the CSIRO/NPL study which was conducted in the mid-1990s.
10. Improve knowledge of the water and sediment exchanges between the ORWBs in the Lower Strickland and the main river channel.

Table of Contents

1	INTRODUCTION	1
1.1	MINE OPERATIONAL HISTORY AND DESCRIPTION	2
1.1.1	Staged development history of the mine	2
1.1.2	Mining operations overview	5
1.1.3	Processing operations overview	5
2	AER METHODOLOGY	9
2.1	RISK ASSESSMENT METHODOLOGY	9
2.2	ESTABLISHING TVS	10
2.2.1	TVs derived from ecological effects data	10
2.2.2	TVs derived from baseline or regional reference site data	10
2.2.3	Adopting TVs provided by guidelines	11
2.2.4	Establishing locally-derived TVs by comparing baseline and reference site data with guidelines and adopting the most relevant	12
2.3	WATER QUALITY TVS AND RISK ASSESSMENT MATRICES	13
2.3.1	Physical, chemical and toxicant indicators (except pH)	13
2.3.2	pH	15
2.4	SEDIMENT QUALITY TVS AND RISK ASSESSMENT MATRIX	16
2.4.1	Tissue metal TVs and risk assessment matrix	18
2.5	DRINKING WATER, AQUATIC RECREATION, FISH AND PRAWN CONSUMPTION, AIR QUALITY	20
2.6	IMPACT ASSESSMENT METHODOLOGY	22
2.6.1	Fish and prawn TVs and impact assessment matrix	23
2.7	TESTING FOR STATISTICAL SIGNIFICANCE	27
3	THE ENVIRONMENTAL MONITORING PROGRAM	29
3.1	ENVIRONMENTAL ASPECTS	29
3.2	BASELINE ENVIRONMENTAL MONITORING	30
3.3	ENVIRONMENTAL CONDITIONS	30
3.3.1	Indicator parameters	30
3.3.2	Monitoring locations	31
3.3.4	Schedule and execution	37
3.3.5	QA & QC	38
4	OPERATIONS AND ENVIRONMENTAL ASPECTS	39
4.1	PRODUCTION	40
4.1.1	Mining and processing operations	40
4.2	WATER USE	41
4.3	LAND DISTURBANCE	42
4.4	WASTE ROCK PRODUCTION	44
4.4.1	Kogai competent dump	45
4.4.2	Anawe North competent dump	46
4.5	INCOMPETENT WASTE ROCK DISPOSAL	46
4.5.1	Anawe erodible dump	47
4.5.1	Anjolek erodible dump	49

4.6	STATUS OF THE ERODIBLE DUMPS IN 2024	51
4.6.1	Anawe erodible dump	51
4.6.2	Anjolek erodible dump	52
4.7	TAILINGS DISPOSAL	54
4.7.1	Riverine tailings disposal	54
4.7.2	Tailings used as underground mine backfill	56
4.8	TAILINGS QUALITY	57
4.9	SEDIMENT CONTRIBUTIONS TO THE RIVER SYSTEM	69
4.10	OTHER DISCHARGES TO WATER	73
4.10.1	Treated sewage effluent	73
4.10.2	Oil/water separator effluent	74
4.10.1	Mine contact runoff	75
4.11	POINT SOURCE EMISSIONS TO AIR	82
4.12	GREENHOUSE GAS AND ENERGY	82
4.13	NON-MINERALISED WASTE	83
5	BACKGROUND ENVIRONMENTAL CONDITIONS AND TRIGGER VALUES	84
5.1	CLIMATE	84
5.1.1	Strickland River catchment rainfall	84
5.1.2	Hydrological context	85
5.1.3	Rainfall summaries	87
5.2	HYDROLOGY	93
5.2.1	Strickland River Catchment	93
5.2.2	SG3	94
5.3	BACKGROUND WATER QUALITY AND TRIGGER VALUES	94
5.3.1	Local reference sites	95
5.3.2	Upper River	107
5.3.1	Lower River & Off-River Water Bodies	110
5.3.2	Lake Murray	112
5.4	BACKGROUND BENTHIC SEDIMENT QUALITY AND TRIGGER VALUES	115
5.4.1	Local reference sites	116
5.4.2	Upper River	116
5.4.3	Lower River and Off-River Water Bodies	119
5.4.4	Lake Murray	121
5.5	BACKGROUND TISSUE METAL CONCENTRATIONS AND TRIGGER VALUES	123
5.5.1	Upper River	124
5.5.2	Lower River	127
5.5.3	Lake Murray	131
5.6	BACKGROUND AQUATIC BIOLOGY AND IMPACT ASSESSMENT CRITERIA	135
6	COMPLIANCE	137
7	RISK ASSESSMENT	138
7.1	HYDROLOGY AND ENVIRONMENTAL FLOWS	138
7.1.1	Waile Creek	138
7.1.2	Kogai Creek	138
7.2	SEDIMENT TRANSPORT AND FATE OF SEDIMENT	139

7.3	SEDIMENT AGGRADATION AND EROSION	144
7.4	WATER QUALITY, SEDIMENT QUALITY AND TISSUE METALS RISK ASSESSMENT	147
7.4.1	Water quality	147
7.4.2	Sediment quality	154
7.4.3	Tissue metals	158
7.4.4	Discussion and Overall Risk Assessment	162
7.4.5	Metals speciation and toxicity	171
7.5	LOCAL WATER SUPPLIES	176
7.6	WATER-BASED ACTIVITIES	180
7.7	FISH AND PRAWN CONSUMPTION	181
7.8	AIR QUALITY	182
8	IMPACT ASSESSMENT	183
8.1	UPPER RIVER	183
8.1.1	Fish	183
8.1.2	Prawns	187
8.2	LOWER RIVER	192
8.2.1	Fish	192
8.3	LAKE MURRAY	197
8.3.1	Fish	197
9	CONCLUSIONS AND OVERALL ASSESSMENT	202
10	RECOMMENDATIONS	205
11	REFERENCES	206
APPENDIX A.	QA & QC – CHEMISTRY AND BIOLOGY	208
APPENDIX B.	BOX PLOTS EXPLAINED	213
APPENDIX C.	BOX PLOTS AND TRENDS OF MINE AREA RUNOFF WATER AND SEDIMENT QUALITY 2015–2024	215
APPENDIX D.	WATER QUALITY – RISK AND PERFORMANCE ASSESSMENT – DETAILS OF STATISTICAL ANALYSIS AND BOX PLOTS	247
APPENDIX E.	SEDIMENT QUALITY – RISK AND PERFORMANCE ASSESSMENT – DETAILS OF STATISTICAL ANALYSIS AND BOX PLOTS	279
APPENDIX F.	TISSUE METAL – RISK AND PERFORMANCE ASSESSMENT – DETAILS OF STATISTICAL ANALYSIS & BOX PLOTS	304

List of Tables

Table 1-1 NPL Project development summary	4
Table 2-1 Adopted Guidelines and Standards	11
Table 2-2 TVs for physical, chemical and toxicant indicators in water	14
Table 2-3 Risk assessment matrix – physical, chemical and toxicant indicators in water	14
Table 2-4 TVs for pH in water	15
Table 2-5 Risk assessment matrix – pH in water	16
Table 2-6 Sediment quality TVs	17
Table 2-7 Risk assessment matrix – Chemical and toxicant indicators in benthic sediment	18
Table 2-8 Tissue metal concentration TVs	19
Table 2-9 Risk assessment matrix – tissue metal concentrations	20
Table 2-10 Drinking water, aquatic recreation, fish and prawn consumption and air quality TVs	21
Table 2-11 Risk assessment matrix – drinking water, air quality and river profiles	21
Table 2-12 Impact assessment trigger values	26
Table 2-13 Impact assessment matrix – Biological indicators for fish and prawn	27
Table 3-1 Environmental aspects and monitoring parameters	29
Table 3-2 Receiving environment monitoring indicator parameters	31
Table 3-3 Test sites, related reference sites and indicator parameters	34
Table 3-4 Assessment of reference site suitability	35
Table 3-5 Monitoring compliance to plan in 2024	37
Table 4-1 Mine production and environmental aspects summary 2024	39
Table 4-2 Areas of cumulative land disturbance and reclamation to December 2024	42
Table 4-3 Total quantities of waste rock placed in each dump 1989 – 2024	44
Table 4-4 Tailings slurry discharge quality 2024 ($\mu\text{g/L}$ except where shown), sample count (n) = 48	58
Table 4-5 Percentage of total metals in tailings in dissolved form in 2024	58
Table 4-6 Tailings solids discharge quality 2024 (mg/kg dry weight, whole fraction), sample count (n) = 48	59
Table 4-7 Trends of tailings quality 2015 – 2024	68
Table 4-8 Summary of incompetent waste rock and tailings disposal tonnages in 2024 and 1989 - 2024	70
Table 4-9 Estimates of particle size distribution of material sampled at erodible dump toe	71
Table 4-10 Summary of long-term dump mass balance from survey data	72
Table 4-11 Estimate of sediment discharge from erodible dumps and tailings during 2024	72
Table 4-12 Estimated volumes of contact runoff from mine lease areas 2024	75
Table 4-13 Mine contact runoff monitoring sites	76
Table 4-14 Contact water quality 2024 median concentrations ($\mu\text{g/L}$ except where shown)	79
Table 4-15 Trends of water quality contact runoff 2015 - 2024 (as tested using Spearman Rank Correlation)	80

Table 4-16 Contact Sediment Quality 2024 median values (mg/kg dry weight, whole fraction)	81
Table 5-1 Summary of meteorological data recorded at Anawe Plant site during 2024	87
Table 5-2 Other Rainfall Site Summary	89
Table 5-3 Summary of flows in m ³ /s for riverine stations in 2024	93
Table 5-4 Local reference site monitoring locations	95
Table 5-5 Local reference site water quality 2024 median values (µg/L except where shown)	97
Table 5-6 Trends of water quality in local creek runoff reference sites 2015-2024 as tested by Spearman Rank Correlation	106
Table 5-7 Summarised water quality for upper river test sites for baseline and reference sites for previous 24 months, presenting 20th%ile, median and 80th%ile of data for each site. ANZG (2018) default TV for 95% species protection provided for comparison (µg/L except where indicated)	108
Table 5-8 Trends for water quality at upper river reference sites 2015-2024 as determined by Spearman Rank correlation against time	109
Table 5-9 Summarised water quality for lower river test sites for baseline and reference sites for previous 24 months, presenting 20th%ile, median and 80th%ile of data for each site. ANZG (2018) default TV for 95% species protection provided for comparison (µg/L except where indicated)	110
Table 5-10 Trends for water quality at lower river reference sites 2015-2024 as determined by Spearman Rank correlation against time	111
Table 5-11 Summarised water quality data for Lake Murray test sites for baseline and reference sites for previous 24 months, presenting 20th%ile, median and 80th%ile of data for each site. ANZG (2018) default TV for 95% species protection provided for comparison (µg/L except where indicated)	114
Table 5-12 Trends for water quality in Lake Murray 2015 - 2024 as determined using Spearman Rank Correlation against time	115
Table 5-13 Local sites sediment quality 2024 (mg/kg dry weight, whole fraction)	116
Table 5-14 Summarised sediment quality data for upper river reference sites for previous 24 months. SDGVs are provided for comparison (mg/kg dry weight, whole fraction)	117
Table 5-15 Trends for sediment quality for upper river reference sites determined by Spearman Rank correlation against time (2015 – 2024)	118
Table 5-16 Summarised sediment quality data for lower river reference sites for previous 24 months. DGVs are provided for comparison (mg/kg dry weight whole fraction)	119
Table 5-17 Trends for sediment quality for lower river reference sites determined by Spearman Rank correlation against time (2015 – 2024)	120
Table 5-18 Summarised sediment quality data for Lake Murray reference sites for previous 24 months, presenting 20th%ile, median and 80th%ile of data for each site. DGVs are provided for comparison (mg/kg dry weight whole fraction)	122
Table 5-19 Trends for sediment quality Lake Murray and ORWBs reference sites determined by Spearman Rank correlation against time (2015 - 2024)	122
Table 5-20 Tissue metal data for upper river reference site Ok Om for previous 24 months (As, Cd, Cr, Cu) (µg/g wet wt.)	125
Table 5-21 Tissue metal data for upper river reference site Ok Om for previous 24 months and applicable US EPA guideline value (Hg, Ni, Pb, Se, Zn) (µg/g wet wt.)	125
Table 5-22 Trends of metals in fish flesh for upper river reference sites 2015 - 2024 determined by Spearman Rank correlation against time	126

NPL Annual Environment Report 2024

Table 5-23 Trends of metals in prawn abdomen for upper river reference sites 2015 - 2024 determined by Spearman Rank correlation against time	126
Table 5-24 Comparison for fish flesh at Lower River reference and test sites 2015 – 2024 ((µg/g wet wt)	127
Table 5-25 Comparison for prawn abdomen at Lower River reference and test sites 2015 - 2024 (µg/g wet wt)	127
Table 5-26 Tissue metal data for lower river reference sites for previous 24 months (As, Cd, Cr, Cu) (µg/g wet wt.)	129
Table 5-27 Tissue metal data for lower river reference sites for previous 24 months and applicable US EPA guideline value (Hg, Pb, Se, Zn) (µg/g wet wt.)	129
Table 5-28 Trends of metals in fish flesh at lower river reference site 2015 - 2024 determined by Spearman Rank correlation against time	130
Table 5-29 Trends of metals in prawn abdomen at lower river reference sites 2015 - 2024 determined by Spearman Rank correlation against time	130
Table 5-30 Summarised tissue metal data for Lake Murray reference sites for previous 24 months (As, Cd, Cr, Cu), presenting median and 80th%ile of data for each site (µg/g wet wt.)	133
Table 5-31 Summarised tissue metal data for Lake Murray reference sites for previous 24 months and applicable US EPA guideline value (Hg, Ni, Pb, Se, Zn), presenting median and 80th%ile of data for each site (µg/g wet wt.)	133
Table 5-32 Trends of metals in fish flesh at Lake Murray and ORWB reference sites 2015-2024 determined by Spearman Rank correlation against time	134
Table 5-33 Trigger Values for Upper River Impact Assessment	135
Table 5-34 Trigger Values for Lower River Impact Assessment	135
Table 5-35 Trigger Values for Lake Murray Impact Assessment	136
Table 6-1 Compliance summary 2024	137
Table 6-2 Median water quality at Upper River Test Sites against SG3 permit criteria 2024 (µg/L except where shown)	137
Table 7-1 Risk assessment – median water quality at upper river test sites in 2024 compared against UpRivs TVs showing which indicators pose low and potential risk (µg/L except where shown)	148
Table 7-2 Risk assessment – Median water quality results at lower river test sites in 2024 compared against LwRiv TVs showing which indicators pose low and potential risk (µg/L) except where shown)	148
Table 7-3 Risk Assessment – Median water quality results at ORWB test sites in 2024 compared against LMY and ORWB TVs showing which indicators pose low and potential risk (µg/L except where shown)	149
Table 7-4 Water quality trends at the upper river test sites 2015-2024	149
Table 7-5 Water quality trends at the lower river test sites 2015- 2024.	150
Table 7-6 Water quality trends at ORWB reference and test sites 2015-2024	150
Table 7-7 Risk Assessment – Median water quality results at Lake Murray test sites in 2024 compared against LMY TVs showing which indicators pose low and potential risk (µg/L except where shown)	153
Table 7-8 Water quality trends at Lake Murray reference and test sites 2015-2024	153

Table 7-9 Risk Assessment – Median sediment quality results at upper river test sites in 2024 compared against UpRivs TVs showing which indicators pose low and potential risk (mg/kg dry weight, whole sediment)	155
Table 7-10 Risk Assessment – Median sediment quality results at lower river test sites in 2024 compared against LwRivs TVs showing which indicators pose low and potential risk (mg/kg dry weight, whole sediment)	155
Table 7-11 Risk assessment – median sediment quality results at ORWB test sites in 2024 compared against LMY and ORWB TVs showing which indicators pose low and potential risk (mg/kg dry weight, whole sediment)	155
Table 7-12 Sediment quality trends at upper river reference and test sites 2015-2024 (mg/kg dry weight, whole sediment)	156
Table 7-13 Comparison of trends of sediment quality at lower river reference and test sites 2015-2024 (mg/kg dry weight, whole sediment)	156
Table 7-14 Sediment quality trends at Lake Murray and ORWB reference and test sites 2015-2024 (mg/kg dry weight, whole sediment)	156
Table 7-15 Risk assessment – median sediment quality results at Lake Murray test sites in 2024 compared against LMY and ORWB TVs showing which indicators pose low and potential risk (mg/kg dry weight, whole sediment)	158
Table 7-16 Sediment quality trends at Lake Murray and ORWB reference and test sites 2015-2024 (mg/kg dry weight, whole sediment)	158
Table 7-17 Risk assessment – median tissue metal results at upper river test sites in 2024 compared against UpRivs TVs showing which indicators pose low and potential risk (µg/g wet wt.)	159
Table 7-18 Risk assessment – median tissue metal results at lower river test sites in 2024 compared against LwRivs TVs showing which indicators pose low and potential risk (µg/g wet wt.)	159
Table 7-19 Tissue metal trends at upper river ref and test sites 2015 - 2024	160
Table 7-20 Tissue metal trends at lower river ref and test sites 2015–2024	160
Table 7-21 Risk assessment – median tissue metal results at Lake Murray test site in 2024 compared against Lake Murray TVs showing which indicators pose low and potential risk (µg/g wet wt.)	162
Table 7-22 Tissue metal trends at Lake Murray test sites 2015–2024	162
Table 7-23 Initial and final risk assessment criteria	163
Table 7-24 TSS Descriptive Statistics 2015 – 2024 at Baia, Tomu, Nth Lake and SG6	164
Table 7-25 EC Descriptive Statistics 2024 TSS at Baia, Tomu, Nth Lake and SG6	165
Table 7-26 Descriptive Statistics WAE Selenium in Sediment Upper River Reference and Test Sites 2024 (whole sediment mg/kg)	170
Table 7-27 Descriptive Statistics WAE Selenium in Sediment Lower River and ORWB Reference and Test Sites 2024 (whole sediment mg/kg)	170
Table 7-28 Descriptive Statistics Selenium in Prawn Abdomen Upper River Reference and Test Sites 2024 (wet mg/kg)	170
Table 7-29 Descriptive Statistics Selenium in Prawn Abdomen Lower River Reference and Test Sites 2024 (wet mg/kg)	170
Table 7-30 Summary of mine discharge water quality compared against respective TVs and receiving environment water quality risk assessment results, showing indicators in discharge and test sites that pose potential risk to the receiving environment in 2024 (µg/L except where indicated)	173

Table 7-31 Summary of mine discharge sediment quality compared against respective TVs and receiving environment sediment quality risk assessment results, showing indicators in discharge and test sites that pose low and potential risk to the receiving environment in 2024 (mg/kg dry weight, whole fraction)	174
Table 7-32 Summary of receiving environment water quality, sediment quality and tissue metals risk assessment results, showing indicators at test sites that pose low and potential risk to the receiving environment in 2024	175
Table 7-33 Sampling sites for local village water supplies	176
Table 7-34 Physiochemical and biological water quality 2024 at drinking water sites against Drinking Water Quality Standards	178
Table 7-35 Metal concentrations of drinking water sites against Drinking Water Quality Standards ($\mu\text{g/L}$)	179
Table 7-36 Comparison of 2024 median receiving water quality concentrations with recreational exposure guideline values ($\mu\text{g/L}$ except where shown)	180
Table 7-37 Risk assessment – median tissue metal results at upper and lower river and Lake Murray test sites in 2024 compared against food standard showing which indicators pose low and potential risk ($\mu\text{g/g}$ wet wt.)	181
Table 7-38 Point source emission metal concentrations (mg/Nm^3)	182
Table 8-1 Fish - Results from one-sample t-tests testing for significant ($p < 0.05$) differences between average values for Wasiba and Wankipe for 2024, and TVs derived from the 2019 assessment for reference Ok Om. NS = not significantly different.	184
Table 8-2 Fish upper river - Spearman correlation coefficients (ρ), linear regression coefficients (R) and associated significance values (p) for species abundance and biomass (g) parameters from hook and line catch for 2015 - 2024. NS = not significant.	185
Table 8-3 Results from one-sample t-tests testing for significant ($p < 0.05$) differences between average values for Wasiba and Wankipe for 2024, and TVs derived from the previous 24 months for reference Ok Om. NS = not significantly different.	188
Table 8-4 Spearman rank correlation coefficients (ρ) and associated significance values (p) for trends over time in total prawn abundance and biomass (g) and in abundance and biomass of the dominant prawn species. Analyses were performed using average of replicate gill net sets averaged within each occasion in each year, 2015 - 2024 (NS = not significant).	189
Table 8-5 Results from one-sample t-tests testing for significant ($p < 0.05$) differences between average values for Bebelubi and SG4 for 2024, and TVs derived from the previous 24 months for respective reference sites Baia and Tomu, and TVs derived from average and percentile values of baseline for Baia (2006-2008), Tomu (1999-2004) and SG4 (1989-1998). NS = not significantly different.	194
Table 8-6 Fish lower rivers - Spearman rank correlation coefficients (ρ), linear regression coefficients (R) and associated significance values (p) for trends in species richness, abundance and biomass (kg) over time from gill net catch for all years. Only data from replicate net #1 were used. NS = not significant.	195
Table 8-7 Results from one-sample t-tests testing for significant ($p < 0.05$) differences between average values for Miwa and Pangoa for 2024 and TVs derived from the 2024 assessment for reference site Maka, and TVs derived 20 th percentile values of baseline for Maka (2001-2006) and Miwa (1989-2000). NS = not significantly different.	198
Table 8-8 Fish Lake Murray - Spearman rank correlation coefficients (ρ), linear regression coefficients (R) and associated significance values (p) for trends in average species richness, abundance and biomass (kg) over time from replicate gill net catch for all years. NS = not significant.	199

Table 9-1 Summary of Compliance, Human Health Risk and Environmental Impact at test sites in 2024
204

List of Figures

Figure 1-1 Location of the Porgera operation	1
Figure 1-2 Process flow chart	8
Figure 2-1 Risk assessment matrix – physical, chemical and toxicant indicators in water	14
Figure 2-2 Risk assessment matrix – pH in water	16
Figure 2-3 Risk assessment matrix – chemical and toxicant indicators in benthic sediment	18
Figure 2-4 Risk assessment matrix – tissue metal concentrations	19
Figure 3-1 Receiving environment monitoring sites	32
Figure 3-2 Lake Murray monitoring locations	33
Figure 4-1 Monthly and cumulative ore processed in 2024	40
Figure 4-2 Yearly and cumulative ore processed 1990 - 2024	40
Figure 4-3 Monthly and cumulative gold production in 2024	41
Figure 4-4 Yearly and cumulative gold production 1990 – 2024	41
Figure 4-5 Water use efficiency 2009 - 2024	42
Figure 4-6 Boundaries of special mining lease and other leases for mining purposes	43
Figure 4-7 Monthly tonnages of competent waste rock placed at Kogai Dump in 2024	45
Figure 4-8 Yearly tonnages of competent waste rock placed at Kogai Dump 1989 – 2024	45
Figure 4-9 Monthly tonnages of competent waste rock placed at Anawe North Dump in 2024	46
Figure 4-10 Yearly tonnages of competent waste rock placed at Anawe North Dump 2001-2024	46
Figure 4-11 Monthly tonnages of incompetent waste rock placed at Anawe Erodible Dump in 2024	47
Figure 4-12 Yearly tonnages of incompetent waste rock placed at Anawe Erodible Dump 1989-2024	48
Figure 4-13 Area, volume of waste placed in the dump (Waste Placement) and volume of Anawe Erodible Dump based on LiDAR survey 2001-2024	48
Figure 4-14 Monthly tonnages of incompetent waste rock placed at Anjolek Erodible Dump in 2024	49
Figure 4-15 Yearly tonnages of incompetent waste rock placed at Anjolek Erodible Dump 1992-2024	50
Figure 4-16 Area, volume of waste placed in the dump (Waste Placement) and volume of Anjolek Erodible Dump based on LiDAR survey 2001-2024	50
Figure 4-17 Upper Tract of Anawe Dump showing eroded surface and ‘upthrust’ zone with vegetation cover	52
Figure 4-18 Anawe erodible dump toe	52
Figure 4-19 Anjolek Dump – lower toe area	53
Figure 4-20 Dumped material ‘rafting’ downslope (view downstream from Aiyoko Ridge area)	54
Figure 4-21 Monthly and cumulative tailings slurry discharge volumes (Mm ³) 2024	55
Figure 4-22 Monthly and cumulative tailings discharge mass (Mt dry solids) 2024	55

NPL Annual Environment Report 2024

Figure 4-23 Annual and cumulative tailings discharge mass (Mt) (dry solids) (1990-2024)	56
Figure 4-24 Tailings diverted to underground backfill in 2024	56
Figure 4-25 Monthly TSS in tailings discharge in 2024	60
Figure 4-26 Annual TSS in tailings discharge 2015-2024	60
Figure 4-27 Monthly pH in tailings discharge in 2024	60
Figure 4-28 Annual pH in tailings discharge 2015-2024	60
Figure 4-29 pH in tailings discharge 1994-2024	61
Figure 4-30 Monthly WAD-CN concentration in tailings discharge in 2024 (mg/L)	61
Figure 4-31 Annual WAD-CN concentration in tailings discharge 2015-2024 (mg/L)	61
Figure 4-32 WAD-CN in tailings discharge 1994-2024	62
Figure 4-33 Monthly dissolved and total silver concentrations in tailings 2024 (µg/L)	62
Figure 4-34 Annual dissolved and total silver concentrations in tailings 2015-2024 (µg/L)	62
Figure 4-35 Monthly dissolved and total arsenic concentrations in tailings 2024 (µg/L)	63
Figure 4-36 Annual dissolved and total arsenic concentrations in tailings 2015-2024 (µg/L)	63
Figure 4-37 Monthly dissolved and total cadmium concentrations in tailings 2024 (µg/L)	63
Figure 4-38 Annual dissolved and total cadmium concentrations in tailings 2015-2024 (µg/L)	63
Figure 4-39 Monthly dissolved and total chromium concentrations in tailings 2024 (µg/L)	64
Figure 4-40 Annual dissolved and total chromium concentrations in tailings 2015-2024 (µg/L)	64
Figure 4-41 Monthly dissolved and total copper concentrations in tailings 2024 (µg/L)	64
Figure 4-42 Annual dissolved and total copper concentrations in tailings 2015-2024 (µg/L)	64
Figure 4-43 Monthly dissolved and total iron concentrations in tailings 2024 (µg/L)	65
Figure 4-44 Annual dissolved and total iron concentrations in tailings 2015-2024 (µg/L)	65
Figure 4-45 Monthly dissolved and total mercury concentrations in tailings 2024 (µg/L)	65
Figure 4-46 Annual dissolved and total mercury concentrations in tailings 2015-2024 (µg/L)	65
Figure 4-47 Monthly dissolved and total nickel concentrations in tailings 2024 (µg/L)	66
Figure 4-48 Annual dissolved and total nickel concentrations in tailings 2015-2024 (µg/L)	66
Figure 4-49 Monthly dissolved and total lead concentrations in tailings 2024 (µg/L)	66
Figure 4-50 Annual dissolved and total lead concentrations in tailings 2015-2024 (µg/L)	66
Figure 4-51 Monthly dissolved and total selenium concentration in tailings 2024 (µg/L)	67
Figure 4-52 Annual dissolved and total selenium concentrations in tailings discharge 2015-2024 (µg/L)	67
Figure 4-53 Monthly dissolved and total zinc concentrations in tailings 2024 (µg/L)	67
Figure 4-54 Annual dissolved and total zinc concentrations in tailings 2015-2024 (µg/L)	67
Figure 4-55 Production of incompetent rock and tailings 1989-2024	70
Figure 4-56 Total annual discharge volumes of treated sewage for 2024	73
Figure 4-57 Average monthly TSS concentration in treated sewage discharge in 2014	73
Figure 4-58 Average monthly BOD ₅ concentration in treated sewage discharge in 2024	74

NPL Annual Environment Report 2024

Figure 4-59 Average monthly faecal coliform count in treated sewage discharge 2024	74
Figure 4-60 Average monthly total hydrocarbon concentrations in oil-water separator discharges in 2024	75
Figure 4-61 Mine contact runoff sampling location	77
Figure 4-62 Energy efficiency 2009 – 2024	82
Figure 4-63 Non-mineralised waste production proportions by volume	83
Figure 5-1 Comparison of annual rainfall (2024 data versus long-term mean) at sites in the Porgera – Lagaip-Strickland Catchment	85
Figure 5-2 Residual mass plots Anawe rainfall station data	86
Figure 5-3 Anawe rainfall, SOI and PDO indices on 10-y moving average	86
Figure 5-4 Monthly rainfall at Anawe Plant site during 2024 compared to long-term monthly means	87
Figure 5-5 Comparison of annual total rainfall at Anawe Plant site with long-term mean (LTM) 1974 - 2024	88
Figure 5-6 Rainfall at the Open Pit during 2024 compared to long-term monthly means	88
Figure 5-7 Comparison of annual total rainfall at Open Pit site with long-term mean (LTM) 1987–2024	89
Figure 5-8 Rainfall at Waile Dam during 2024 compared to long-term monthly means	90
Figure 5-9 Rainfall at Suyan Camp during 2024 compared to long-term monthly means	90
Figure 5-10 Rainfall at SG2 during 2024 compared to long-term monthly means	91
Figure 5-11 Rainfall at Ok Om During 2024 compared to long-term monthly means	91
Figure 5-12 Rainfall at SG3 during 2024 compared to long-term monthly means	92
Figure 5-13 Rainfall at SG4 during 2024 compared to long-term monthly means	92
Figure 5-14 Rainfall at SG5 during 2024 compared to long-term monthly means	93
Figure 5-15 Total daily flow (GL) at SG3 for 2024	94
Figure 5-16 Total monthly flow (cumecs) at SG3 during 2024 compared to long-term monthly means	94
Figure 5-17 Trend analysis Local reference sites (scatter plot of all data from 2015 – 2024 with linear trend line)	97
Figure 5-18 pH in local creek runoff 2024	98
Figure 5-19 pH in local creek runoff 2015-2024	98
Figure 5-20 Sulfate in local creek runoff 2024	98
Figure 5-21 Sulfate in local creek runoff 2015-2024	98
Figure 5-22 Alkalinity in local creek runoff 2024	99
Figure 5-23 Alkalinity in local creek runoff 2015-2024	99
Figure 5-24 TSS in local creek runoff 2024	99
Figure 5-25 TSS in local creek runoff 2015-2024	99
Figure 5-26 Dissolved and total silver in local creek runoff 2024	100
Figure 5-27 Dissolved and total silver in local creek runoff 2015-2024	100
Figure 5-28 Dissolved and total arsenic in local creek runoff 2024	100
Figure 5-29 Dissolved and total arsenic in local creek runoff 2015-2024	100

Figure 5-30 Dissolved and total cadmium in local creek runoff 2024	101
Figure 5-31 Dissolved and total cadmium in local creek runoff 2015-2024	101
Figure 5-32 Dissolved and total chromium in local creek runoff 2024	101
Figure 5-33 Dissolved and total chromium in local creek runoff 2015-2024	101
Figure 5-34 Dissolved and total copper in local creek runoff 2024	102
Figure 5-35 Dissolved and total copper in local creek runoff 2015-2024	102
Figure 5-36 Dissolved and total iron in local creek runoff 2024	102
Figure 5-37 Dissolved and total iron in local creek runoff 2015-2024	102
Figure 5-38 Dissolved and total mercury in local creek runoff 2024	103
Figure 5-39 Dissolved and total mercury in local creek runoff 2015-2024	103
Figure 5-40 Dissolved and total nickel in local creek runoff 2024	103
Figure 5-41 Dissolved and total nickel in local creek runoff 2015-2024	103
Figure 5-42 Dissolved and total lead in local creek runoff 2024	104
Figure 5-43 Dissolved and total lead in local creek runoff 2015-2024	104
Figure 5-44 Dissolved and total selenium in local creek runoff 2024	104
Figure 5-45 Dissolved and total selenium in local creek runoff 2015-2024	104
Figure 5-46 Dissolved and total zinc in local creek runoff 2024	105
Figure 5-47 Dissolved and total zinc in local creek runoff 2015-2024	105
Figure 5-48 Trend analysis Upper River reference sites water quality (scatter plot of all data from 2015 – 2024 with linear trend line)	109
Figure 5-49 Trend analysis Lower River reference sites water quality (scatter plot of all data from 2015 – 2024 with linear trend line)	112
Figure 5-50 Trend analysis upper rivers sediment quality showing elements with statistically significant increasing trends (scatter plot of all data from 2015 – 2024 with linear trend line)	119
Figure 5-51 Trend analysis upper rivers sediment quality showing elements with statistically significant increasing trends (scatter plot of all data from 2015 – 2024 with linear trend line)	121
Figure 5-52 Trend analysis LMY reference sites sediment quality (scatter plot of As-WAE, for all data from 2015 – 2024 with linear trend line)	123
Figure 5-53 Trend analysis of arsenic concentration in fish and lead concentration in prawn ($\mu\text{g/g}$ wet wt.) – Upper River reference sites Ok Om 2015 – 2024. Graph shows weak increasing linear trend.	127
Figure 5-54 Trend analysis of arsenic, nickel and lead concentration ($\mu\text{g/g}$ wet wt.) in fish and lead concentration in prawns – Lower River reference sites combined 2015 – 2024. Graphs show weak increasing linear trend.	131
Figure 5-55 Trend analysis of arsenic concentration ($\mu\text{g/g}$ wet wt.) in fish – Lake Murray reference site (Maka) 2015 – 2024. Graphs show weak increasing linear trend.	134
Figure 7-1 Daily flow duration curve (estimated) for Waile Creek Dam overtopping	138
Figure 7-2 Daily flow duration curves for Kogai Creek	139
Figure 7-3 Mean monthly TSS and flow at SG3 for 2024	140
Figure 7-4 Estimated mean monthly suspended sediment loads for SG3 (Mt).	141

Figure 7-5 Estimated monthly suspended sediment load (black bars) with 3-month moving average at SG3 for full record (red solid line)	141
Figure 7-6 Historical annual average TSS 1990-2024	142
Figure 7-7 Suspended sediment budget at SG3 1991-2024	143
Figure 7-8 Relative contribution of natural and mine-derived suspended sediment at SG3 (%) 1991-2024	143
Figure 7-9 Photo of profile site at Kaiya River downstream of Kogai Creek Confluence	144
Figure 7-10 Photo of profile site at Kaiya River upstream of Yuyan Bridge	144
Figure 7-11 Photo of profile site at the Kaiya River downstream of Yuyan Bridge	145
Figure 7-12 Profile comparison (2016-2024) at SG4 – 360 km downstream	146
Figure 7-13 Profile comparison (2016-2025) at Profile 10 – 400 km downstream	146
Figure 7-14 Profile comparison (2016-2025) at SG5 – 560 km downstream	147
Figure 7-15 Trend analysis upper rivers, lower rivers and ORWB water quality showing elements with statistically significant increasing trends (scatter plot of all data from 2015 – 2024 with linear trend line)	152
Figure 7-16 Trend analysis Lake Murray water quality showing elements with statistically significant increasing trends (scatter plot of all data from 2015 – 2024 with linear trend line)	154
Figure 7-17 Trend analysis upper river, lower river and ORWB test site sediment quality showing statistically significant increasing trends in (mg/kg dry weight, whole sediment) (scatter plot of all data from 2015 – 2024 with linear trend line)	157
Figure 7-18 Trend analysis of statistically significant increasing trends in tissue metal at upper river and lower river test sites 2015 – 2024.	161
Figure 7-19 Trend analysis of statistically significant increasing trends in tissue metal at Pangoa 2015-2024.	162
Figure 7-20 Scatter plot showing pH at Kogai Culvert between 2015 and 2024	163
Figure 7-21 Sampling sites for local village water supplies	177
Figure 8-1 Time series plots of average (\pm 95% CIs) abundance and biomass (g) for combined fish species replicate hook and line catch at test sites Wasiba and Wankipe, and reference site Ok Om, for 2015 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are shown in the plots, yellow dots are first day sampling and blue dots are second day sampling. Only data from the first day sampling (yellow) were used for impact assessment.	186
Figure 8-2 Time series plots of average (\pm 95% CIs) abundance and biomass (g) of <i>Neosilurus equinus</i> in replicate hook and line catch at test sites Wasiba and Wankipe, and reference site Ok Om, for 2015 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are shown in the plots, yellow dots are first day sampling and blue dots are second day sampling. Only data from the first day sampling (yellow) were used for impact assessment.	187
Figure 8-3 Time series plots of average (\pm 95% CIs) abundance and biomass (g) for combined prawn species from replicate electro-seining catch at test sites Wasiba and Wankipe, and reference site Ok Om, for 2015 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are shown in the plots, yellow dots are first day sampling and blue dots are second day sampling. Only data from the first day sampling (yellow) were used for impact assessment.	190
Figure 8-4 Time series plots of average (\pm 95% CIs) abundance and biomass (g) for <i>Macrobrachium handschini</i> in replicate electro-seining catch at test sites Wasiba and Wankipe, and reference site Ok Om, for 2015 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are	

shown in the plots, yellow dots are first day sampling and blue dots are second day sampling. Only data from the first day sampling (yellow) were used for impact assessment. 191

Figure 8-5 Time series plots of average (\pm 95% CIs) abundance and biomass (g) for *Macrobrachium lorentzi* in replicate electro-seining catch at test sites Wasiba and Wankipe, and reference site Ok Om, for 2015 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are shown in the plots, yellow dots are first day sampling and blue dots are second day sampling. Only data from the first day sampling (yellow) were used for impact assessment. 192

Figure 8-6 Time series plots of species richness, abundance and biomass (kg) from replicate net set #1 gill net catch at paired monitoring sites Bebelubi and Baia, 2006 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are included in the plots, but only data from the first day sampling were used for impact assessment. 196

Figure 8-7 Time series plots of species richness, abundance and biomass (kg) from replicate net set #1 gill net catch at paired monitoring sites SG4 and Tomu, 1989 - 2024. Linear trend lines for average values shown in red. Data from consecutive days sampling are included in the plots, but only data from the first day sampling were used for impact assessment. 197

Figure 8-8 Time series plots of average (\pm 95%CIs) species richness, abundance and biomass (kg) from replicate gill net catch at Lake Murray test sites Miwa and Pangoa, 1989 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are included in the plots, but only data from the first day sampling were used for impact assessment. 200

Figure 8-9 Time series plots of average (\pm 95%CIs) species richness, abundance and biomass (kg) from replicate gill net catch at Lake Murray reference site Maka, 1989 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are included in the plots, but only data from the first day sampling were used for impact assessment. 201

List of Abbreviations & Definitions

ADCP: Acoustic Doppler Current Profiler

AEM: Assured Environmental Monitoring

AER: Annual Environment Report.

ANSTO: Australian Nuclear Science and Technology Organisation.

ANZECC/ARMCANZ: Australian and New Zealand Environment and Conservation Council and the Agricultural and Resource Management Council of Australia and New Zealand.

ANZFA: Australia New Zealand Food Authority.

Baseline data: Also called pre-operational data (studies); collected (undertaken) before development begins (ANZG 2018). Note that alluvial and small- scale mining had been conducted in the Porgera Valley prior to collection of PJV baseline data, however, the data were collected prior to beginning construction and operation of the PJV project.

BOD₅: 5-day Biological Oxygen Demand.

CIL: Carbon-in-leach.

CIP: Carbon-in-pulp.

CN: Cyanide.

CO₂-e: Carbon dioxide equivalents.

Competent waste rock: Hard and durable rock with high shear strength, capable of supporting terrestrial waste rock dump construction.

CV-AAS: Cold vapour atomic absorption spectrometry.

Dissolved metals: Operationally defined as passing a very fine (0.45 µm) membrane filter, contains a bioavailable fraction capable of being metabolised by organisms.

EL: Exploration Lease.

EMS: Environmental Management System.

ENSO: El Niño Southern Oscillation.

Environmental aspect: Activities that have the potential to interact with the environment (ISO 14001).

Environmental impact: A statistically significant adverse change in the ecosystem health of the receiving environment as a result of the operation's environmental aspects.

Environmental risk: The potential for adverse effects on living organisms associated with pollution of the environment by effluents, emissions, wastes, or accidental chemical releases, energy use, or the depletion of natural resources. (U.S. Environmental Protection Agency definition).

Erodible/incompetent waste rock: Waste rock with low shear strength, not capable of supporting terrestrial waste rock dump construction.

Erodible waste rock dump: Designed to temporarily store incompetent waste rock in a river valley while allowing the dump to gradually and progressively fail and some material to be eroded and transported downstream by the river system.

FT07: Flow through drain #7, Kogai Waste Rock Dump

GELs: Generally Expected Levels.

ICP-MS: Inductively coupled plasma mass spectrometry.

ISO14001: International Organisation for Standardisation Environmental Standard for Management Systems.

KPI: Key Performance Indicator.

LiDAR: Light Detection and Ranging

LMP: Lease for Mining Purposes.

LOM: Life of Mine.

LOR: Limit of Reporting.

ME: Mining Easement.

NMI: National Measurement Institute.

NPL: New Porgera Limited

NOEC: No Observable Effects Concentration.

NR: Not reported.

ORWBs: Off-river Water Bodies.

PDO: Pacific Decadal Oscillation.

PJV: Porgera Joint Venture

PLOA: Porgera Land Owner Association.

PNG: Papua New Guinea.

QA&QC: Quality Assurance and Quality Control.

Reference site: Sites within an ecosystem that are similar to and in the vicinity of the test site ecosystem but are not influenced by the mine operations.

Risk: A statistical concept defined as the expected likelihood or probability of undesirable effects resulting from a specified exposure to known or potential environmental concentrations of a material. A material is considered safe if the risks associated with its exposure are judged to be acceptable.

Estimates of risk may be expressed in absolute or relative terms. Absolute risk is the excess risk due to exposure. Relative risk is the ratio of the risk in the exposed population to the risk in the unexposed population. (ANZG 2018)

SAG: Semi-autogenous Grinding.

SML: Special Mining Lease.

SOP: Standard Operating Procedure.

DGV: Sediment Quality Guideline Value

TARP: Trigger Action Response Plan.

TD: Total digest

Test site: Those sites at which the influence of the operations environmental aspects may occur.

Total metals: The concentration of metals determined from an unfiltered sample after vigorous digestion, or the sum of the concentrations of metals in the dissolved and suspended fractions. (APHA 2005).

TSM: Test Site Median.

TSS: Total Suspended Solids.

TV: Trigger Value.

UAV: Unmanned Aerial Vehicle

WAD-CN: Weak Acid Dissociable Cyanide.

WAE: Weak Acid Extractable.

WWCB: West Wall Cut-back.

WHO: World Health Organization.

1 INTRODUCTION

The New Porgera Limited (NPL) Gold Mine is located in the Porgera Valley of Enga Province in the Papua New Guinea highlands, approximately 630 km NW of Port Moresby, the location is shown in Figure 1-1.

The mine is owned 49% by Barrick and Zijin Mining, who hold the shares as a 50-50 joint venture in Barrick (Niugini) Limited (BNL). The majority 51% ownership is held by Papua New Guinea stakeholders, with 36% managed by the state through Kumul Minerals Holdings Limited (KMHL) and the remaining 15% shared between the Enga Provincial Government and the Porgera landowner. NPL is managed by Barrick (Niugini) Limited (BNL). The operation consists of an open cut and an underground mine, waste rock dumps, processing facility, gas-fired power station, a water-supply dam, limestone quarry and lime plant and ancillary infrastructure. Production commenced in 1990 and expected to continue until 2043. In 2020 the mine was placed under care and maintenance after the Special Mining Lease (SML) initial term expired. In 2023, SML 13 was granted to NPL and operations resumed. Key milestones during the ramp up phase were commencement of underground and open pit mining, gas-powered station restored, oxygen plant and autoclaves brought online resulting in full process plant operations in August 2024. The site employs 3,860 local, national, expatriate staff and contractors. Prior to 2020, annual production was approximately 500 koz of gold.

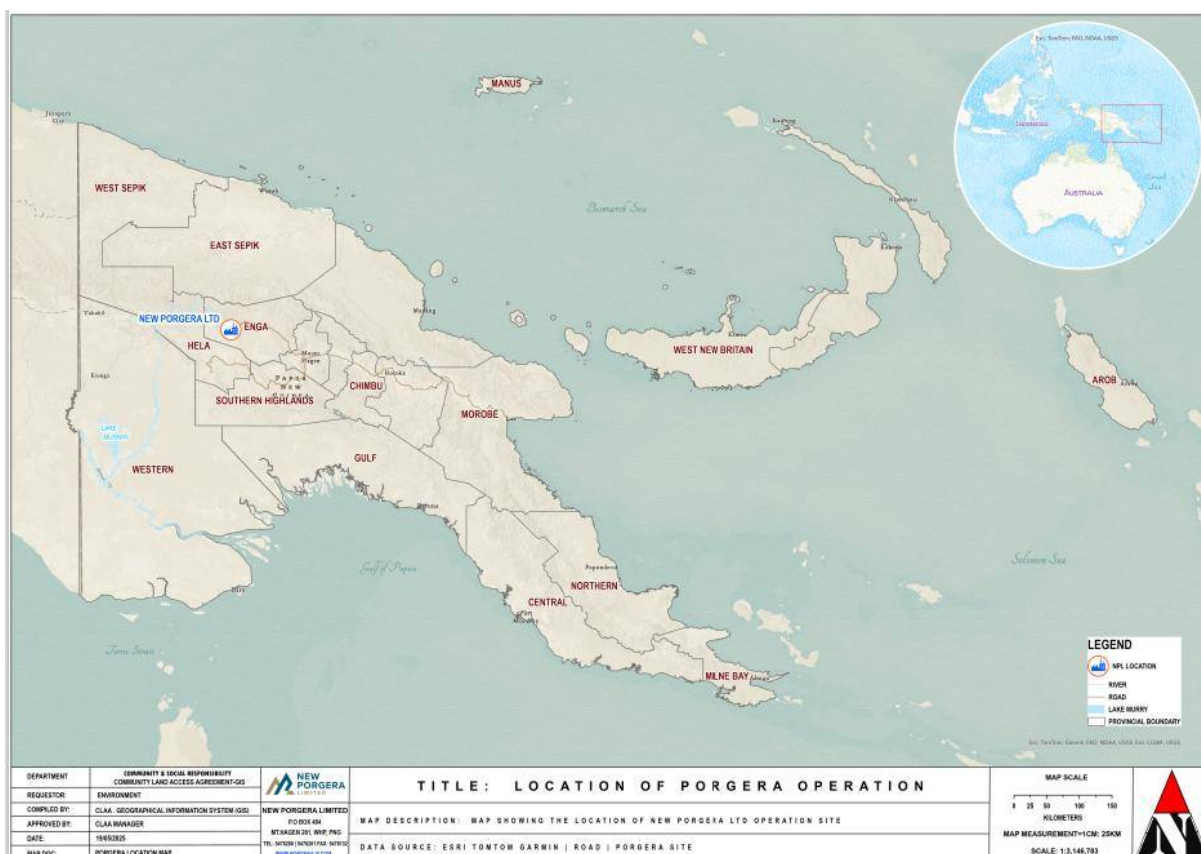


Figure 1-1 Location of the Porgera operation

NPL has number of unique economic, social and environmental aspects. The environmental aspects are managed in accordance with the site’s Environmental Management System (EMS), which is certified to the ISO14001 international standard for EMS. The objectives of the EMS are to ensure methodical, consistent and effective control of the site’s environmental aspects to ensure compliance with legal and

other requirements, to mitigate potential environmental risks and to continually improve environmental performance.

A fundamental element of the EMS is the environmental monitoring and reporting program. The program provides feedback on the effectiveness of the EMS for achieving the stated objectives and therefore allows the operation to confirm which management techniques are working well, and more importantly, identify those which require attention to improve effectiveness.

The objectives of this Annual Environment Report (AER) are to provide an assessment of the overall environmental performance of the operation throughout the previous calendar year (2024), and to assess trends in historical performance. The objectives of this report are aligned with those of the EMS and are to assess:

1. Compliance with legal and other requirements.
2. The level of potential and actual environmental impact; and
3. The environmental performance of the operation.

The first section of the AER describes background environmental conditions by quantifying the natural, non-mine related conditions and changes within the receiving environment. Next, the operation's environmental aspects (activities which interact with the environment) are identified and quantified. Then, assessments are made of compliance, mine-related risk, impact and performance, followed by a discussion of the findings and finally, recommendations for improving the environmental management system and the monitoring and reporting program.

Legal and other requirements are imposed predominantly by the two environmental permits issued to the mine by the Papua New Guinea Conservation and Environmental Protection Authority (CEPA). Compliance assessment is performed by comparing monitoring data against the conditions of the permits.

The methodology for risk and impact assessment has been developed by NPL in accordance with international guidelines (e.g. ANZG 2018) and in consultation with external technical experts.

The risk assessment stage is based on the comparison of physical and chemical environmental indicators at those sites potentially impacted by the mine (test sites) against risk assessment criteria or trigger values (TVs) derived from baseline data, reference sites and/or international guidelines. This step provides an indication of which sites may be potentially impacted as a result of mine aspects.

The impact assessment stage is based on the comparison of biological indicators at test sites against biological indicator trigger values derived from reference sites or baseline data for test sites. When the performance of biological indicator values at the test site is below that of the trigger value, it indicates that environmental impact has occurred (i.e. species abundance at a test site is lower than baseline or reference) and warrants further investigation to determine whether mine-related factors are causing the impact. If the same performance of biological indicators is observed at both the test site and the reference site, then it indicates no impact is detected or there is a system-wide change that is not related to the mine. Additionally, long-term trends of biological indicators were assessed, where a significant declining trend is observed, it indicates that change is occurring over time and warrants further investigation to determine if there are mine-related factors driving the change.

1.1 Mine Operational History and Description

1.1.1 Staged development history of the mine

The Porgera operation was developed in four stages between 1989 and 1996 increasing the nominal processing capacity from 8,500 tonnes per day to 17,500 tonnes per day. The four stages of project development are described below and summarised in Table 1-1.

Stage 1 of construction of the mine commenced in July 1989 and comprised development of an underground mine, ore processing plant and associated infrastructure. The processing plant consisted of a crushing and grinding circuit, a concentrator to recover the gold-bearing sulfide portion of the ore and a cyanidation leach carbon-in-pulp (CIP) circuit. High-grade ore from the underground mine was fed to the mill at a rate of 1,500 tonnes per day (t/day). The sulfide flotation concentrate was direct leached in the CIP circuit, recovering approximately 60% of the contained gold, followed by refining into doré on site. The CIP tailings containing the remaining 40% of the gold were stored in a lined pond for later reclaim and processing through the pressure oxidation circuit. The barren flotation tailings were discharged into the river system. Stage 1 production commenced in September 1990.

Stage 2 of construction consisted of expanding the underground mine production and installation of the pressure oxidation circuit at the processing plant. The underground mine production was increased by addition of an ore crushing and hoisting system to convey the ore to the surface. In September 1991, commissioning was completed for the pressure oxidation autoclaves for processing the sulfide flotation concentrate and recovery of refractory gold. The sulfide flotation concentrate from the ore feed and the previously stockpiled Stage 1 CIP tailings were processed in the pressure oxidation circuit at 2,500 t/day. Gold liberated by pressure oxidation was recovered through the CIP cyanide leach circuit. The tailings neutralisation circuit was commissioned for combining the various processing waste streams (acid wash effluent, cyanidation tailing and flotation tailings) to detoxify and neutralise the tailings before discharge to the river system.

Stage 3 was commissioned in September 1992, with mill throughput increased to 4,500 t/day. The underground ore was supplemented with ore from the open pit mine.

Stage 4A of the project commenced in October 1993 and further expanded open pit mining operations and the mill facilities, increasing mill throughput to 8,500 t/day.

In 1993, a major review of the project recommended expansion to a nominal capacity of 17,500 t/day for optimisation of mining and ore processing rates. Following the granting of project approvals, this additional expansion, known as Stage 4B, was completed in the first quarter of 1996. Stage 4B involved addition of a second semi-autogenous grinding (SAG) mill and a large ball mill, a 350 t/day oxygen plant, a 150 t/day lime kiln and increased flotation and leaching capacity. Process water storage and the Hides power plant generation capacity, together with other infrastructure also were increased to support this expansion.

The open pit mining fleet capacity was expanded in 1997 from 150,000 to 210,000 t/day to provide for the increase in mill feed rates. Four Knelson concentrators were installed in the same year, to recover free gold ahead of the flotation circuit. In 1999, a further flotation expansion was installed to improve recoveries, and additional oxygen plant capacity was added to increase autoclave throughput.

In 2001, an Acacia reactor was commissioned to treat the Knelson gravity concentrate, and modifications were made to the grinding and CIP circuits. During 2003 a contract secondary crusher was installed to optimise the capacity of the crushing plant and allow a better match between milling and oxidation capacity.

In 2009, a cyanide destruction plant was commissioned to reduce the concentration of cyanide in the tailings discharge and achieve compliance with the International Cyanide Management Code. Two years later in 2011, a paste plant was commissioned for placement of the coarse fraction of tailings in the underground mine as cemented paste backfill. The paste plant has a nominal capacity of 8% of the tailings discharged from the processing plant.

In 2016, a sulfide concentrate plant was commissioned for processing a portion of the high sulfur content flotation concentrate for export to a refinery overseas.

Table 1-1 NPL Project development summary

Stage	Period	Ore processing capacity	Comments
1	Jul 1989 – Aug 1991	1,500 t/day	Construction started Jul 1989. First production Sept 1990. CIP tails stored onsite for processing at a later stage. Commenced discharge of flotation tailings to the river system.
2	Sept 1991 – Aug 1992	2,500 t/day	Increased underground mine production. Installation of pressure oxidation circuit. Installation of tailings neutralisation circuit.
3	Sept 1992 – Sept 1993	4,500 t/day	Underground ore supplemented with ore from the open pit.
4A	Oct 1993 – Mar 1996	8,500 t/day	Expansion of open pit mining. Expansion of mill facilities.
4B	Apr 1996 – Apr 2020	17,500 t/day	1996 – Addition of a second semi-autogenous grinding mill, ball mill, 350 t/day oxygen plant, 150 t/day lime kiln, increased flotation and leaching capacity, increased water storage, Hides power station capacity and other infrastructure. 1997 – Increased open pit fleet capacity from 150 to 210 kt/day. 1999 – Further expansion of flotation circuit and additional oxygen plant. 2001 – Acacia reactor. 2003 – Secondary crusher. 2009 – Cyanide destruction plant, reduces WAD-CN in discharge to <0.2mg/L 2011 – Paste plant, diverts approx 8% tailings volume to the underground mine for backfilling. 2016 – Sulfide concentrate filtration and export facility, nominal capacity 100t/day.
5	Apr 2020 – Dec 2023	NA	Porgera operation was shut down due to SML license expiry. The mine was placed under care and maintenance.
6	Dec 2023 – Current	19,500t/day	Porgera operation resumed under SML 13 as New Porgera Limited (NPL). Process plant fully operational in August 2024.

1.1.2 Mining operations overview

NPL mining operations consist of open cut and underground operations. Open pit mining is a hard rock operation developed using drill and blast, load and haul techniques. The design utilises 10 m benches, hydraulic face shovels and haul trucks to achieve a nominal material movement capacity in the order of 50 million tonnes per annum.

A particularly challenging aspect to development of the open pit is the inherent instability of the western wall as a result of the presence of brown mudstone and inflow of water to the pit from surrounding catchments. Although mining continues despite the ingress of mud, the on-going wall failure does pose a risk to workers' safety, equipment and inhibits access to and dilutes ore at the bottom of the open pit. A number of mitigation and stabilisation measures, known collectively as the west wall cutback, are being implemented to stabilise the west wall and prevent the ingress of mud and water to the pit. High grade ore is transported to the crusher and low-grade ore is transported to stockpiles for processing at a later date. Waste rock is classified into three categories, potential acid-forming (PAF), non-acid forming metal leaching (NAF-ML) and non-acid forming (NAF). Waste rock is managed to encapsulate the PAF waste and minimise the generation of metalliferous drainage from the waste rock dumps.

An underground mine was first operated from 1989 to 1997. The underground mining operation was recommenced in 2002 to extract underground reserves in the central and north zones. The original underground workings were subsequently maintained and developed to provide long-term drainage for the open pit, and to provide access for on-going exploration.

The underground mine is accessed by a portal adjacent to the open pit which facilitates mining of ore both from outside and beneath the open pit footprint. The underground mining method used is long-hole bench stoping. Ore is recovered by drilling and blasting while retreating along the strike for the full length of the stope. The broken ore is progressively mucked to trucks on the lower level using a combination of conventional, remote and tele-remote-control loader operations. Longer stopes are filled in stages with a combination of cemented and non-cemented fills to maintain hanging wall spans.

After mining, open stopes in strategic places are filled with unconsolidated waste rock and cement aggregate and a cement-tailings aggregate, produced from the paste plant, to create crown pillars. The underground mine generates approximately 1.2 million tonnes of ore per annum. Ore is transported to the crusher, while the majority of waste rock produced from the underground mine is used as backfill to support underground development, the small quantity of waste rock that is brought to the surface is stored in one of the competent waste rock dumps with waste from the open pit.

1.1.3 Processing operations overview

A flow sheet describing the ore processing operations is shown in Figure 1-2 and begins with run-of-mine ore being delivered by trucks to the crushing and grinding circuit, consisting of a gyratory rock crusher, secondary crusher and two SAG mills.

The SAG mills feed three cyclone packs, a portion of the underflow is sent to four Knelson concentrators to recover free gold, the Knelson concentrate is transferred to an Acacia reactor, an intensive leach reactor located in the gold room at Anawe. The remaining underflow is returned to the ball mills for re-grinding.

Overflow from the cyclone packs contains gold bound to sulfide which is not recoverable by gravity separation. This slurry is transferred via gravity to the Anawe plant site via twin 2 km long pipelines for further processing by flotation concentration, oxidation, Carbon In Pulp / Carbon In Leach (CIP/CIL), electrowinning and smelting.

The flotation circuit consists of rougher, cleaner, and scavenger banks producing a final concentrate of 14% sulfur and tailings. The flotation concentrate is combined with the Acacia reactor tailings and the mixture is reground to 92% passing 38 µm, pumped to a 35m diameter concentrate thickener and then to the concentrate storage tanks that provide approximately six days' worth of production buffer storage between flotation and the oxidation sections. The flotation tailings are sent to the tailings treatment circuit.

The oxidised concentrate is discharged from the autoclaves via a choke valve into a flash vessel that is equipped with a gas scrubber to control acidic emissions. The sulfuric acid produced in the autoclaves is washed from the oxidised concentrate via two wash thickeners, and the washed and thickened solids are pumped to the CIL circuit. The acidic wash water overflow from the thickener is sent to the tailings treatment circuit. In the CIL circuit activated carbon, slaked lime and sodium cyanide are added to facilitate a process known as cyanidation which results in the formation of gold cyanide complexes which are then adsorbed to the activated carbon. The concentrate is then transferred to the CIP circuit where excess activated carbon is added to adsorb any remaining gold cyanide complexes in the solution.

Next the concentrate is transferred to the elution circuit where the precious metals are stripped from the carbon. After stripping, the barren carbon is regenerated in a rotary kiln and then acid-washed prior to being returned to the CIP circuit. Gold and silver contained in the stripped solution are electro-won in three banks of electrowinning cells which produce concentrated, high density sludge. At regular intervals the sludge is washed from the cells, pressure filtered and retorted to remove any mercury. The residue containing gold and silver is mixed with a flux of borax, soda ash, nitre, and silica, and smelted in an induction furnace to produce bars of doré bullion that average about 80% gold. The mercury is condensed and disposed of to a licensed facility overseas. The CIP/CIL tailings are sent to the tailings treatment circuit.

Ore processing generates three effluent streams: flotation tailings from the flotation concentrator, acid wash from the wash thickeners downstream of the autoclaves, and CIP/CIL tailings from the cyanidation leach circuit. Treatment involves cyanide destruction and then neutralisation to reduce metal toxicity.

The CIP/CIL tailing is the only stream that contains cyanide, therefore these tails are sent to the cyanide destruction plant prior to being mixed with the other tailings streams for neutralisation. The cyanide destruction plant employs the International Nickel Companies (INCO) sulfur dioxide/air technology, which requires the addition of sodium metabisulfite, lime and copper sulfate and oxidises the cyanide to form less toxic cyanates. The concentration of cyanide is reduced from 80 – 100mg/L WAD-CN in the feed to <0.2 mg/L WAD-CN in the discharge. The detoxified CIP/CIL tailing is then sent to the tailings neutralisation circuit for further treatment.

Acid wash-water and flotation tailings do not contain cyanide and so are sent directly to the tailings neutralisation circuit. Here they are combined with the CIP/CIL tails and residual naturally occurring carbonates in the flotation tailings neutralise part of the acid and raise the pH of the tailings mixture to approximately 3.5. Slaked lime then is added to raise the pH and precipitate metals as hydroxides prior to discharge to the Porgera River. The target pH range for discharge is pH 6.3 – 9.5.

A portion (nominally 13%) of the treated tailings is diverted to the paste plant where it is filtered in rotary disc filters, mixed with cement and plasticiser then pumped via a steel pipeline into the underground mine to backfill mined stopes.

Lime for neutralisation purposes is produced from limestone quarried from a deposit 15km south of the mine. The limestone is processed in two vertical kilns which use either waste oil or diesel as fuel. Quicklime is stored in a silo and trucked to the Anawe plant site and transferred into one of two lime silos. The quicklime is slaked in a lime mill and stored in an agitated tank.

The pyrite concentrate plant is fed by a small portion of the high sulfur grade flotation concentrate from the first bank of flotation rougher cells and is pumped to the slurry filtration plant. The slurry is passed through a cyclone to remove fines which are returned to the concentrator for re-grinding and processing through the autoclaves. The coarse fraction from the cyclone is dewatered using a filter press and is

then loaded into lined sea containers for export. The sea containers of pyrite concentrate are back-loaded onto trucks and transported by road to Lae Port for export to a refinery overseas.

Most of the water for the process plant is supplied by pipeline from the Waile Creek dam 20km south of the mine site and Aipulungu Creek located upstream of the Lime Plant. Additional water is delivered to the Tawisakale grinding circuit from the nearby Kogai Creek and FT07.

Electrical power is generated at Hides, 73 km south of the mine site using 9 gas turbines having a combined capacity of 72 MW and delivered to site via a 132 kV transmission line. This is supplemented by a 20 MW and 12 MW diesel power stations at the mine site.

2 AER METHODOLOGY

The NPL AER uses a risk-based framework for assessing the environmental compliance, risk, impact and performance of the Porgera mine operations. The report is structured in accordance with the following framework:

1. Identify the environmental aspects of the operation (Section 3.1).
2. Identify appropriate physical, chemical and biological parameters to serve as indicators of natural or mine-related change within the environment (Section 3.3.1).
3. Identify locations within the environment where mine-related environmental impact may occur, these are known as test sites, and identify locations within the environment where mine-related environmental impact will not occur, these are known as reference sites (Section 3.3.2),
4. Quantify the environmental aspects of the mine operation that have the potential to interact with the environment (Section 4).
5. Describe the natural or background environmental condition and establish TVs for each indicator parameter by comparing baseline, background and guideline values (Section 5).
6. Assess compliance against legal requirements (Section 6).
7. Perform a risk assessment to determine whether potential mine-related environmental impact has occurred (Section 7).
8. Perform an impact assessment to determine whether mine-related environmental impact has occurred (Section 8).
9. Discuss findings, draw conclusions and make a determination of the operation's overall environmental performance using multiple lines of evidence (Section 9).
10. Make recommendations for improving environmental performance and the environmental monitoring program (Section 10).

2.1 Risk Assessment Methodology

The purpose of the risk assessment stage is to determine whether potential mine-related environmental impact has occurred within the receiving environment. The risk assessment is based on a comparison of physical and chemical indicators, measured either in discharge from the site or at test sites within the receiving environment, against TVs.

If the levels of physical or chemical indicators in discharge or at test sites exceed the TV, it indicates the potential for impact to have occurred. This exceedance then triggers further and more detailed investigation to determine whether impact has actually occurred. Impact assessment requires a holistic and detailed investigation of ecosystem function based on the relationships between chemical, physical and biological functions within the environment.

Risk assessment based on physical and chemical parameters alone is typically less complicated, less time consuming and less costly than an impact assessment and can therefore be conducted at a higher frequency and over a greater spatial and temporal range. An appropriately designed and executed monitoring program based on physical and chemical indicators provides a robust and economic basis for assessing risk and triggering more detailed impact assessment where required.

2.2 Establishing TVs

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) nominate the following order of preference when establishing guideline TVs for physical and chemical indicators.

2.2.1 TVs derived from ecological effects data

For low-risk TVs, measure the statistical distribution of water quality indicators either at a specific site (preferred), or an appropriate reference system(s), and study the ecological and biological effects of physical and chemical stressors. This is defined the TV as the level of key physical or chemical stressors below which ecologically or biologically meaningful changes do not occur (ANZG 2018).

Developing valid TVs using this method requires identifying a suitable reference site and highly controlled conditions to produce well-correlated physical, chemical and biological data, consequently this method is rarely adopted. NPL has not attempted to develop TVs using this method.

2.2.2 TVs derived from baseline or regional reference site data

Where there is insufficient information on ecological effects to determine an acceptable change from the reference condition, the use of an appropriate percentile of the reference data distribution can be used to derive the trigger value (ANZG 2018). Reference data are gained either from baseline data or regional reference data.

Baseline data are gathered from the test site prior to disturbance and provide the best comparison of pre and post-disturbance conditions. Baseline data are available for Porgera Mine test sites and their use in deriving TVs is discussed further in Section 5. Note that alluvial and small-scale mining had been conducted in the Porgera Valley prior to collection of NPL baseline data, however, the data were collected prior to beginning construction and operation of the current NPL project and are therefore considered an appropriate baseline for the current mine.

Regional reference data are gathered from sites that are similar to and in the vicinity of the respective test sites, but which are not directly affected by the mining operation. Reference sites should be selected from the same biogeographic and climatic region, should have similar geology, soil types and topography, and should contain a range of habitats similar to those at the test site (ANZG 2018).

The suitability of regional reference site data for establishing TVs is influenced by how well the reference sites reflect the pre-disturbance condition of the test site. If the pre-disturbance condition of the regional reference site and test site are different, then TVs based on reference data are unlikely to act as an accurate basis for assessment of mine-related change and therefore risk at the test site. Variation between regional reference site and test site conditions is usually more pronounced in regions where mining projects occur due to naturally elevated mineralisation in the test site catchment. In general, ecosystems in reference sites adjacent to mining projects have evolved with lower levels of natural mineralisation in water and stream sediment than those at the test site prior to disturbance.

Identification of NPL reference sites and an assessment of their suitability are presented in Table 3-3 and Table 3-4 respectively. A comparison of baseline and reference data is presented in Section 5. The assessment shows that the suitability of NPL reference sites as analogues for the test sites is generally fair to poor. When compared to baseline data from the test sites, reference site data exhibit lower TSS, lower pH and lower concentrations of metals in water, sediment, fish flesh and prawn flesh than baseline test site conditions.

For physicochemical stressors (e.g. TSS, pH, turbidity etc), ANZG (2018) recommends that the derivation of TVs from baseline or reference site data should be based on at least two years (24 months) of monthly monitoring data.

The TV is the percentile value (i.e. 80thile or 20thile) derived from the baseline or reference site data that represents the degree of excursion that is permitted at the test site before triggering some action (ANZG 2018). The 80thile and 20thile are deemed to be approximately equivalent to plus or minus

(±) one standard deviation around the median, and it is argued that this level of change is unlikely to result in risk of disturbance to the ecosystem (ANZG 2018). This approach has been adopted widely in Australia for monitoring wetlands and rivers and assessing ecological health (see Fukuda and Townsend 2006, Storey *et al.* 2007).

The preferred protocol is to compare the median of monthly samples from a test site over the previous 1 year (12 months), being the test site median (TSM), with the TV. Statistically, the median represents the most robust descriptor of the test site data.

Inherent in the use of 80thile or 20thile values is the fact that monitoring data may exceed the TV at least 20% of the time. Therefore, a statistical test is required to determine if the exceedance is statistically significant, rather than an artefact of variability within the dataset itself and thus providing a greater level of confidence in the risk assessment result. NPL has adopted Wilcoxon’s test, a non-parametric rank test, to support the comparison of the TSM against the TV and thereby statistically determine if the TSM is significantly higher, lower or not significantly different from the TV. Further description of the statistical test used in the AER is provided in Section 2.7.

2.2.3 Adopting TVs provided by guidelines

For physico-chemical stressors where ecological effects data, baseline data and reference site data are unavailable or unsuitable, and for toxicants, default TVs provided by guidelines and standards can be adopted to support the risk assessment. Default guidelines and standards are typically developed by governments, industry or subject matter experts based on available evidence and a precautionary risk-based approach, and intended to be conservatively protective of the environment. The guidelines are toxicologically-based and therefore link contaminant concentrations to their effects on aquatic organisms, with the inference usually being chronic toxicity. For physical and chemical indicators within the receiving environment, the default values provided by ANZG (2018) are site specific and may not necessarily apply to PNG.

A summary of adopted guidelines and standards for each environmental value is presented in Table 2-1.

Table 2-1 Adopted Guidelines and Standards

Risk	Indicator	Guideline
Aquatic ecosystem health	Water quality	ANZG (2018)
	Benthic sediment quality	ANZG (2018)
	Tissue metal	USEPA (2016) – Selenium only
Drinking water	Water quality	WHO Drinking Water Guidelines (2017)
Aquatic recreation	Water quality	ANZG (2018) Guidelines for recreational water quality and aesthetics
		WHO Drinking Water Guidelines (2017)

Risk	Indicator	Guideline
Fish and prawn consumption	Tissue metal	As – Australia New Zealand Food Standards Code – Standard 1.4.1 – Contaminants and natural toxicants (ANZFS 2016) Cd, Hg, Pb – European Food Safety Authority (EC 2006) Cr – Hong Kong Food Adulteration (Metallic Contamination) Regulations (HK 1997) Cu, Se, Zn – Food Standards Australia New Zealand GEL for Metal Contaminants 90th%ile (ANZFA 2001)
Air quality	Emission quality	NSW Protection of the Environment Operations (Clean Air) Regulation 2010 (NSW 2010) Victoria State Environment Protection Policy (Air Quality Management) 2001 (VIC 2001)

2.2.4 Establishing locally-derived TVs by comparing baseline and reference site data with guidelines and adopting the most relevant

Locally derived TVs are recommended for the situation where biological effects data are not available and where the baseline or reference data consistently exceed the default guideline TV.

The locally derived TV is established by first comparing the TVs derived from baseline data, reference site data and the default guideline or standard TV (i.e. ANZG 2018) and then adopting whichever is highest.

Where the baseline or reference site TV is higher than the ANZG (2018) default GV, it indicates that pre-disturbance levels of those indicators are naturally higher than the dataset from which the default GVs have been derived. Adopting the higher value derived from baseline or reference data accounts for naturally elevated levels of the particular indicator, while still providing a limit to the acceptable level of change at the test site. Adopting the lower guideline value as the TV would be likely to result in frequent exceedance of the TV as a result of natural inputs and would therefore decrease its effectiveness for distinguishing between mine and non-mine related risk.

In cases where the default guideline value is higher than the baseline or reference TV, it indicates that pre-disturbance levels of those indicators are naturally low. Adopting the higher guideline TV provides a prudent basis upon which to allow a level of change at the test site, above that which would be provided by the baseline or reference TV, while still providing confidence that the environmental values are being protected.

The risk assessment is then performed by comparing the TSM derived from monthly data collected at the test site over the previous year (12 months) with the TV using a statistical test.

Based on the lack of biological effects data, elevated concentrations of some indicators in baseline data and the low suitability of the reference sites, NPL has elected to adopt this method for deriving TVs. Further details are provided in Sections 2.3 - 2.7. The comparisons between baseline, reference and guideline data for water quality, sediment quality and tissue metal are shown in Section 5.

2.3 Water Quality TVs and Risk Assessment Matrices

2.3.1 Physical, chemical and toxicant indicators (except pH)

Water quality TVs for physical, chemical and toxicant indicators, except pH, have been established by comparing the 80th percentile value from baseline data, the 80th percentile value from the most recent 24-months regional reference site data and the respective ANZG (2018) default guideline value (GV) for 95% species protection, and then adopting the highest of the three values as the TV.

The ANZG (2018) guidelines are intended to provide government, industry, consultants and community groups with a sound set of tools that will enable the assessment and management of ambient water quality in a wide range of water resource types, and according to designated environmental values. They are the recommended limits to acceptable change in water quality that will continue to protect the associated environmental values. They are not mandatory and have no formal legal status. They also do not signify threshold levels of contamination since there is no certainty that significant impacts will occur above these recommended limits, as might be required for prosecution in a court of law. Instead, the guidelines provide certainty that there will be no significant impact on water resources values if the guidelines are not exceeded. (ANZG 2018)

ANZG (2018) default GVs for physical parameters have been derived from the statistical distribution of reference data collected within five geographical regions across Australia and New Zealand (ANZG 2018).

Most of the ANZG (2018) default GVs for chemical parameters (referred to by ANZG (2018) as toxicants) have been derived from single-species toxicity tests on a range of species, because these formed the bulk of the concentration-response information. High reliability GVs were calculated from chronic 'no observable effect concentration' (NOEC) tests. However, the majority of GVs are described as moderate reliability trigger values, derived from short-term acute toxicity data (from tests ≤ 96 h duration) by applying acute-to-chronic conversion factors (ANZG 2018).

The ANZG (2018) default GVs derived using the statistical species sensitivity distribution method were calculated at four different species protection levels, 99%, 95%, 90% and 80%. Here, protection levels signify the percentage of species expected to be protected at different concentrations of the toxicant (ANZG 2018). The 95% species protection level is most commonly used in monitoring programs.

The GVs were derived primarily according to risk assessment principles, using data from laboratory tests in clean water. They represent the best current estimates of the concentrations of chemicals that should have no significant adverse effects on the aquatic ecosystem (ANZG 2018).

GVs for metals are based on dissolved metal concentrations rather than total metal concentrations as it is the dissolved fraction that is most comparable to the bioavailable fraction and therefore has the potential to cause a toxic effect. Where applicable, the ANZG (2018) default GV for 95% species protection have been hardness-modified prior to comparison with the baseline and reference site data in accordance with ANZG (2018). Hardness modification is done separately for the upper river, lower river, ORWBs and Lake Murray, and conservatively uses the 20th percentile hardness value from all test sites within each of the respective groups. Adoption of the 20th percentile value is considered a conservative approach as it assumes low buffering capacity throughout the entire year, and calculating a specific hardness modified GV for each of the different regions will account for the different hardness within each region.

The comparisons between baseline data, reference site data and the ANZG (2018) default GVs for 95% species protection in the upper river, lower river, ORWBs and Lake Murray are presented in Section 5.

A summary of the TV development method is provided in Table 2-2 and the decision matrix is shown in Figure 2-1 and Table 2-3.

Table 2-2 TVs for physical, chemical and toxicant indicators in water

Indicator Parameter	Trigger Value (TV) Derivation
Water Quality: Physical, chemical and toxicant indicators (except pH)	Adopt whichever is higher: - Baseline 80 th ile (full data set) - Regional reference site 80 th ile (most recent 24-month data set), or - ANZG (2018) default guideline for 95% species protection (hardness-modified where appropriate)

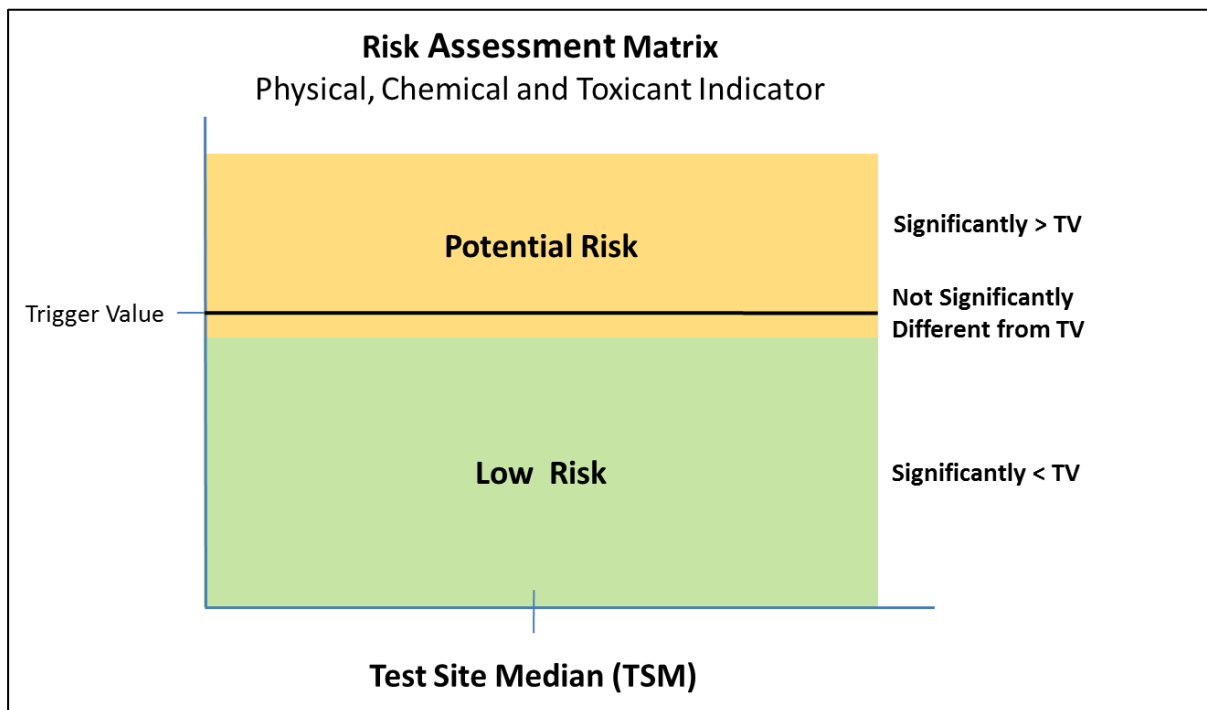


Figure 2-1 Risk assessment matrix – physical, chemical and toxicant indicators in water

Table 2-3 Risk assessment matrix – physical, chemical and toxicant indicators in water

Assessment Result	Risk Rating	Action
TSM significantly > TV	Potential Risk	Confirm whether impact has or is occurring by conducting an impact assessment based on biological indicators.
TSM not significantly different from TV And TV, TSM and TSM data set > LOR.		
TSM not significantly different from TV And TV, TSM and TSM data set all ≤ LOR.	Low Risk	
TSM significantly < TV		

Significance = statistical significance with a probability threshold of p = 0.05

2.3.2 pH

Upper and lower TVs for pH in the upper river were established by comparing the 80th% and 20th%iles of test site baseline data, and the reference site values from the most recent 24-month data with the ANZG (2018) upper and lower limit respectively for pH for upland rivers in tropical Australia.

Upper and lower TVs for pH in the lower river and Lake Murray and ORWBs were established by comparing the 80th% and 20th%iles of Lake Murray baseline data and the North Lake Murray reference site values from the most recent 24-month data with the ANZG (2018) upper and lower limit respectively for pH for lowland rivers in tropical Australia.

Comparisons between upper river baseline data, reference site data and the ANZG (2018) default guidelines for upland rivers in Tropical Australia are presented in Section 5.

Comparisons between test site baseline data, lower river reference site data and the ANZG (2018) default guidelines for lowland rivers in Tropical Australia are presented in Section 5.

A summary of the TV development method is provided in Table 2-4, and the decision matrix is shown in Figure 2-2 and Table 2-5.

Table 2-4 TVs for pH in water

Indicator Parameter	Trigger Value (TV) Derivation
Water: pH – upper	Adopt whichever is higher: - Baseline 80 th %ile (full data set) - Regional reference 80 th %ile (most recent 24 month data set), or - ANZG (2018) upper limit for upland rivers in tropical Australia
Water: pH – lower	Adopt whichever is lower: - Baseline 20 th %ile (full data set) - Regional reference 20 th %ile (most recent 24 months data set), or - ANZG (2018) lower limit for upland rivers in tropical Australia

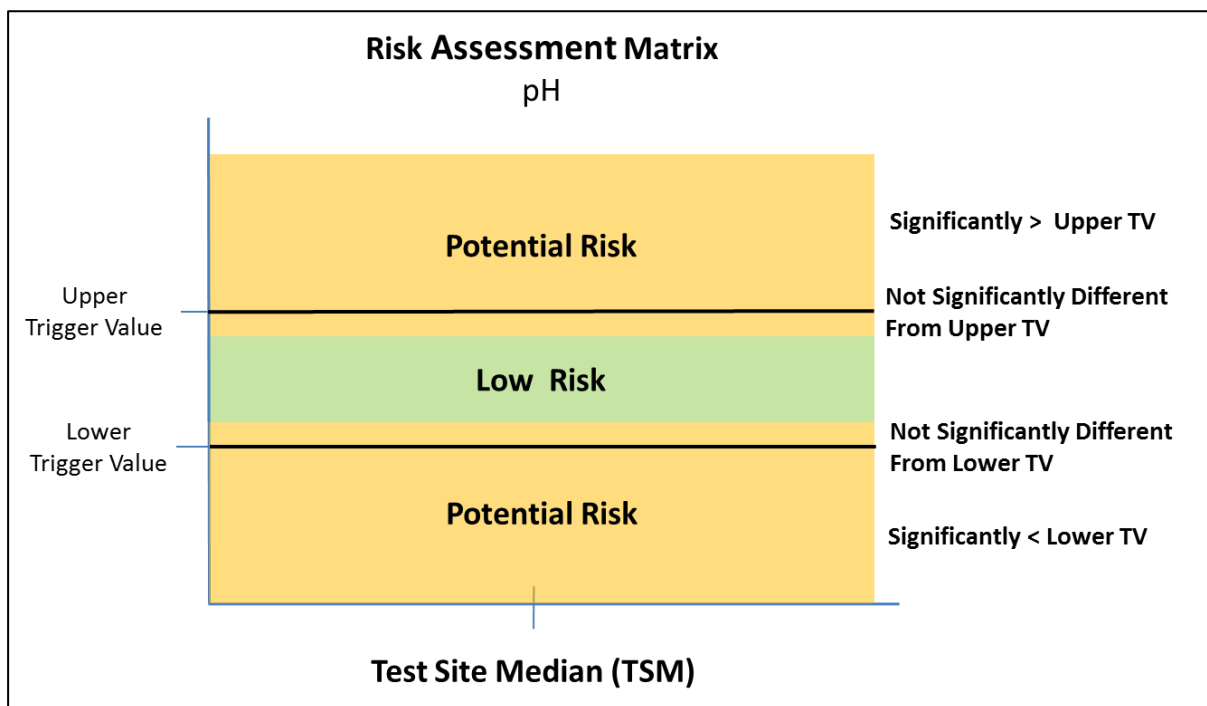


Figure 2-2 Risk assessment matrix – pH in water

Table 2-5 Risk assessment matrix – pH in water

Assessment Result	Risk Rating	Action
TSM significantly > Upper TV	Potential Risk	Confirm whether impact has or is occurring by conducting an impact assessment based on biological indicators.
TSM not significantly different from Upper TV		
TSM significantly < Upper TV	Low Risk	
TSM significantly > Lower TV		
TSM not significantly different from Lower TV	Potential Risk	
TSM significantly < Lower TV		

Significance = statistical significance with a probability threshold of $p = 0.05$

2.4 Sediment Quality TVs and Risk Assessment Matrix

Sediment quality data from the reference sites were compared against the ANZG (2018) Default Guideline Values (DGVs). The guidelines include DGV and GV-High values, which represent the 10th percentile (10thile) and 50th percentile (50thile) values for chemical concentrations associated with acute toxicity effects respectively.

The DGV is the default TV below which the frequency of adverse biological effects is expected to be very low, and if exceeded, should trigger further study. The DGV-High corresponds to the median effect concentration as detailed by Long et al. (1995) and indicates the concentration above which adverse biological effects are expected to occur (ANZG 2018).

The weak acid extractable (WAE) fraction from the whole of sediment sample is used to represent the bioavailable fraction of metals that may cause a toxic effect, and therefore the WAE results for whole sediment are used to derive TVs and to compare against ANZG (2018) DGVs.

Baseline sediment quality conditions were not sampled at river test sites. Baseline conditions were sampled at Lake Murray, but the samples were analysed only for total extractable metals not weak acid extractable metals and are therefore not comparable with reference data or the ANZG (2018) DGV.

TVs for sediment quality for all parameters except selenium (Se) have been established by comparing the WAE whole sediment 80thile from the most recent 24-month reference site data against the ANZG (2018) sediment quality default guideline value (DGV) and adopting whichever is higher.

ANZG (2018) does not provide sediment quality TVs for selenium, therefore the TV for selenium has been established from the most recent 24-month 80thile from the reference data set.

Similar to water quality, the lack of suitable reference sites, particularly due to the presence of natural mineralisation in the test site catchment, means that TVs based on the reference site data alone are likely to be overly conservative. Comparisons between the upper river, the lower river and Lake Murray and ORWB reference site data and the ANZG (2018) DGVs are presented in Section 5.

Also similar to water quality, it should be noted that in cases where the TV, the TSM and the entire test site data set from which the TSM is derived are less than the analytical limit of reporting (LOR), Wilcoxon's test will find the TSM not significantly different from the TV which infers a potential risk of environmental impact. However, in these cases given that the data set from the test site indicates that the concentration of a particular parameter does not have the potential to exceed the TV, and the TV, the TSM and the TSM data set are equal to the LOR, it is considered appropriate to conclude there is low risk of potential impact rather than potential risk of environment impact. This scenario is captured in the risk assessment matrices.

A summary of the TV development method is provided in Table 2-6 and the decision matrix is shown in Figure 2-3 and Table 2-7.

Table 2-6 Sediment quality TVs

Indicator Parameter	Trigger Value (TV) Derivation
Sediment Quality	Adopt whichever is higher: - Reference site 80 th ile WAE in whole sediment (most recent 24months data set), or - ANZG (2018) DGV

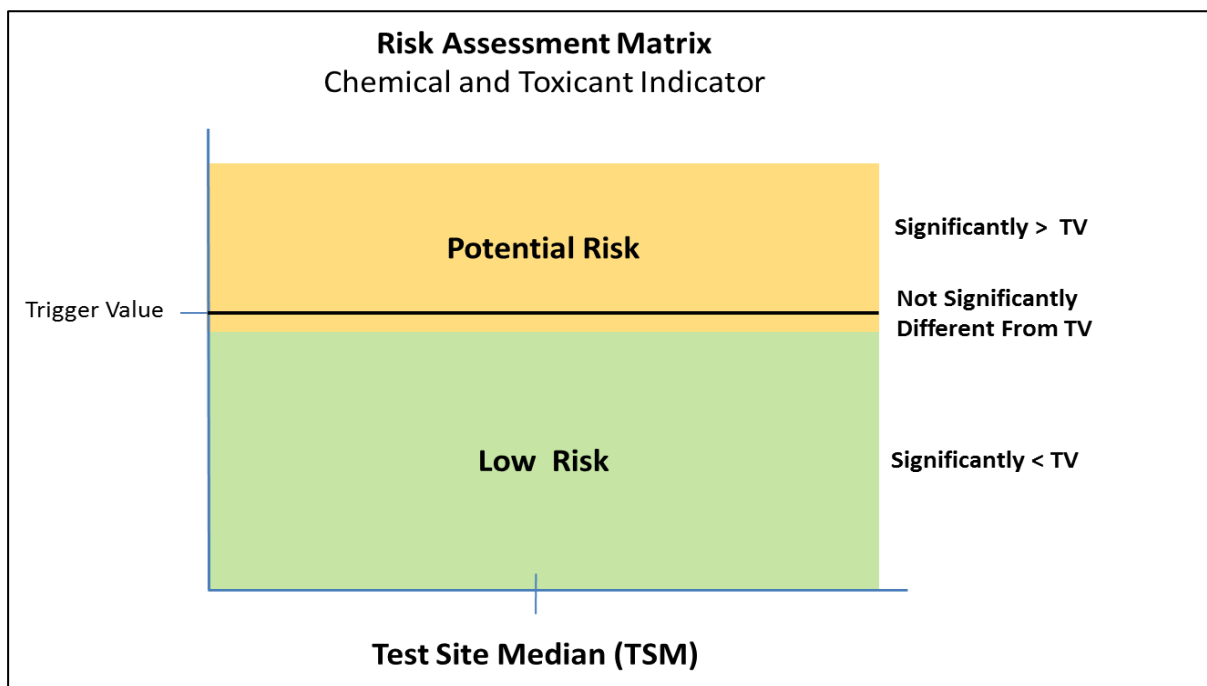


Figure 2-3 Risk assessment matrix – chemical and toxicant indicators in benthic sediment

Table 2-7 Risk assessment matrix – Chemical and toxicant indicators in benthic sediment

Assessment Result	Risk Rating	Action
TSM significantly > TV	Potential Risk	Confirm whether impact has or is occurring by conducting an impact assessment based on biological indicators.
TSM not significantly different from TV And TV, TSM and TSM data set > LOR.		
TSM not significantly different from TV And TV, TSM and TSM data set all ≤ LOR.	Low Risk	
TSM significantly < TV		

Significance = statistical significance with a probability threshold of p = 0.05

2.4.1 Tissue metal TVs and risk assessment matrix

Tissue metal concentrations have been monitored in target species of fish and prawns that were selected on the basis of relative abundance and potential food sources for local villagers. The target species for the upper rivers, lowland and Lake Murray are, respectively:

- Mountain tandan, *Neosilurus equinus* and mountain prawn, *Macrobrachium handschini*;
- Sharp-snouted catfish, *Potamosilurus macrorhyncus* and giant freshwater prawn, *Macrobrachium rosenbergii*; and
- Barramundi, *Lates calcarifer*.

Pre-disturbance baseline data are available for river and Lake Murray test sites, but only for fish flesh tissue samples. TVs for tissue metal concentrations in fish and prawns for all TVs, except selenium in fish flesh, have been established by comparing the reference site 80thile value from the most recent 24-month data against the 80thile of the test site baseline data and adopting the higher value. The

exception to this approach is where the baseline limit of reporting (LOR) is greater than the current limit of reporting and the baseline 80th percentile is equal to the baseline LOR. In these cases, the baseline LOR is not considered representative of actual baseline conditions but rather represents the lowest reportable value at the time of sampling. It is considered prudent in these cases to adopt the reference 80th percentile value as the TV so as not to inadvertently overestimate the TV.

This method has been selected in the absence of any suitable effects-based guidelines for use as a comparison against reference site data and is considered conservative due to the lack of natural mineralisation within the reference site catchments. However, it should be noted that reference site data could be elevated as a result of fish/prawns migrating upstream from test sites and into the reference sites, which tend to be connected tributaries.

The TV for selenium in fish flesh has been established by comparing the reference site 80th percentile value from the most recent 24-month data, the 80th percentile of the test site baseline data and the United States Environmental Protection Agency draft tissue metal criterion for protection of aquatic life (USEPA 2016). Although still in draft form, this is the best available toxic effects-based criterion for fish tissue and is therefore deemed appropriate for use.

A summary of the TV development method is provided in Table 2-8 and the decision matrix is shown in Figure 2-4 and Table 2-9.

Table 2-8 Tissue metal concentration TVs

Indicator Parameter	Trigger Value (TV) Derivation
Tissue metals – fish and prawn flesh	Adopt whichever is highest: <ul style="list-style-type: none"> - Baseline 80th percentile (full data set), not applicable where the baseline 80th percentile is equal to the baseline LOR. - Reference site 80th percentile (most recent 24 months), or - USEPA criterion (available for selenium (Se) only)

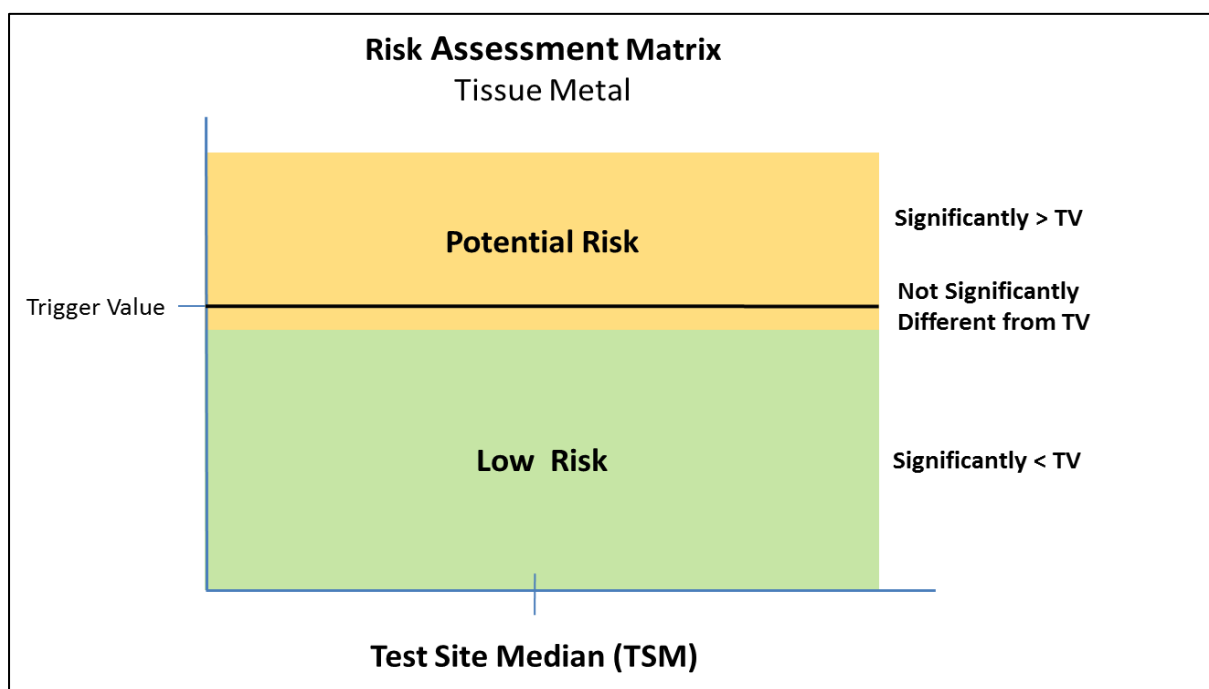


Figure 2-4 Risk assessment matrix – tissue metal concentrations

Table 2-9 Risk assessment matrix – tissue metal concentrations

Assessment Result	Risk Rating	Action
TSM significantly > TV	Potential Risk	Confirm whether impact has or is occurring by conducting an impact assessment based on biological indicators.
TSM not significantly different from TV And TV, TSM and TSM data set > LOR.		
TSM not significantly different from TV And TV, TSM and TSM data set all ≤ LOR.	Low Risk	
TSM significantly < Trigger Value		

Significance = statistical significance with a probability threshold of $p = 0.05$

2.5 Drinking Water, Aquatic Recreation, Fish and Prawn Consumption, Air Quality

NPL has adopted the WHO Drinking Water Guidelines (WHO 2017) as the default risk assessment TVs for drinking water quality. The risk assessment is based on the comparison of guideline values with results of water quality sampling conducted at village water supplies around the special mining lease (SML). The results of the drinking water risk assessment are presented in Section 7.5.

Water-based activities involve contact with water, and in NPL’s context, this includes gold panning, swimming, bathing, washing clothes or fishing by communities downstream of the mine. In general, there are two kinds of exposure pathways associated with these activities: (i) dermal contact with the water body and (ii) ingestion of the water. NPL has adopted the ANZG (2018) recreational water quality guidelines as TVs to support the risk assessment. The ANZG (2018) guidelines are based on the assumption that no more than 100 mL of water is ingested during the recreational activity. An additional assessment against the WHO (2017) is also provided. The results of the risk assessment are presented in Section 7.6.

Human consumption of fish and prawns has the potential to transfer toxicants from the flesh of the animal to humans. The NPL risk assessment is based on a comparison of metal concentrations in the flesh of fish and prawns downstream of the mine against recommended levels from a range of international food standards. Where more than one recommended limit is provided by multiple documents, the lower value has been adopted. The results of the fish and prawn consumption risk assessment are presented in Section 7.7.

PNG has not enacted air quality legislation therefore NPL has adopted the NSW Protection of the Environment Operations (Clean Air) Regulation 2010 (NSW 2010) and the Victoria State Environment Protection Policy (Air Quality Management) 2001 (VIC 2001) as risk assessment TVs for emissions from stationary sources. The results of the air quality risk assessment are presented in Section 7.8.

A summary of guideline trigger values adopted for drinking water, water-based activities, fish and prawn consumption and air emissions are shown in Table 2-10, the risk assessment decision matrix is shown in Table 2-11.

Table 2-10 Drinking water, aquatic recreation, fish and prawn consumption and air quality TVs

Indicator Parameter	Risk Assessment Trigger Value (TV) Derivation
Drinking water: Water quality – village water supplies	WHO Drinking Water Guidelines (2017)
Water-based activities: Water quality – receiving environment TSM	ANZG (2018) Guidelines for recreational water quality and aesthetics (Chapter 5) WHO Drinking Water Guidelines (2017)
Fish and prawn consumption: Tissue metals – fish and prawns TSM	As – Australia New Zealand Food Standards Code – Standard 1.4.1 – Contaminants and natural toxicants (ANZFS 2016) Cd, Hg, Pb – European Food Safety Authority (EC 2006) Cr – Hong Kong Food Adulteration (Metallic Contamination) Regulations (HK 1997) Cu, Se, Zn – Food Standards Australia New Zealand GEL for Metal Contaminants 90th%ile (ANZFA 2001)
Air quality: Emissions at point source	NSW Protection of the Environment Operations (Clean Air) Regulation 2010 (NSW 2010) Victoria State Environment Protection Policy (Air Quality Management) 2001 (VIC 2001)

Table 2-11 Risk assessment matrix – drinking water, air quality and river profiles

Risk	Assessment Result	Risk Rating	Action
Drinking water	TSM > WHO Drinking Water Guidelines	Potential risk	Conduct health risk assessment
	TSM ≤ WHO Drinking Water Guidelines	Low	NIL
Water-based activities	TSM > Recreation TV	Potential risk	Conduct health risk assessment
	TSM ≤ Recreation TV	Low	NIL
Fish and prawn consumption	TSM > Consumption TV	Potential risk	Conduct health risk assessment
	TSM ≤ Consumption TV	Low	NIL
Air quality – at emission point	TSM > Air Quality Guidelines	Potential risk	Monitor ambient air quality at sensitive receptor
	TSM ≤ Air Quality Guidelines	Low	NIL

2.6 Impact Assessment Methodology

The purpose of the impact assessment stage is to confirm whether potential environmental risks have translated to actual environmental impact, and if so, to determine the level or significance and the likely causes of that impact.

It should be noted that although ANZG (2018) recommends further investigation of actual impact in cases where the TV is exceeded, NPL considers it prudent to conduct the impacts assessment regardless of the risk assessment result. This is done to provide confirmation of the risk assessment conclusions, to support ongoing refinement of the TVs, and to provide a direct assessment of impact for ongoing performance monitoring and full transparency of the operation's interactions with the environment.

The aquatic ecosystem impact assessment is based on an assessment of the health of the aquatic ecosystem through the use of biological indicators such as abundance, richness and biomass of aquatic fauna. The NPL monitoring program monitors fish and prawns on an annual basis using quarterly sampling, and macroinvertebrates on a two-yearly campaign basis.

The impact assessment is conducted by comparing biological indicators from the test sites against impact assessment trigger values or benchmarks generated from baseline and reference site data. Where the current biological condition at the test sites is found to have deteriorated compared to the TV, then impact is indicated and further investigation is required to determine the potential causes of those impacts and identify whether the causes are mine related, non-mine related or a combination of both.

Impact assessment based on population monitoring is typically performed by applying statistical analytical methods to a range of population indicators. Methods of statistical analysis range in complexity from parametric tests on univariate parameters, used to assess the difference in mean values of a single indicator between two locations, to parametric tests on multivariate parameters, used to assess the difference in means among multiple parameters and the effect of interacting parameters at multiple locations. Typical population indicators are total number of measurement species (species richness), total number of measurable organisms (abundance), biomass, presence of disease and species assemblage (species presence and absence, and composition).

The most appropriate impact assessment method for any given data set consists of the combination of statistical analysis and indicator type(s), which provide the greatest level of confidence in the assessment results. The ability of different assessment methods to deliver confidence is driven by the available data set, which is ultimately dictated by; the actual condition of the environment being monitored; the sampling method(s) being applied; the duration of the program; and the frequency of sampling.

In previous years' AERs, NPL has applied an alternative method for impact assessment which was based on the comparison of the trend of ecosystem indicators between test and reference sites. This approach was necessary as the application of non-standard sampling methods across different monitoring sites meant that the data being captured were not suitable for direct comparison between reference and test sites.

In 2016, NPL began application of new, improved, standardised methods for monitoring fish and prawn populations in the upper and lower sections of the Lagaip/Strickland system, in an attempt to gain more robust and less variable data. Replicated sampling was performed on a quarterly basis at selected upper and lower river reference and test sites for a range of indicator parameters.

In parallel with implementing improved monitoring methods with the aim of reducing data variance, NPL commissioned Wetland Research & Management (WRM) in 2017 to conduct a review of the biological monitoring data, make recommendations on the most appropriate indicators, TVs and statistical analyses for conducting impact assessment for the AER, and explain how to interpret the statistics correctly. This proposed approach for impact assessment should be as consistent, where possible, with the risk-based approach currently used for water and sediment quality as per ANZG (2018). Where this

was not possible, then the most appropriate alternative approach should be developed. The aim of the review was to enable NPL to reach accurate conclusions on ecological impacts and thereby provide more confidence in the biology impact assessment within the AER. This work was completed, and this new method of impact assessment is used in this AER and is referenced as WRM (2017).

2.6.1 Fish and prawn TVs and impact assessment matrix

Biological indicators such as richness, abundance and biomass can vary between reference and test sites and within reference and test sites over time. Therefore, the impact assessment trigger values and assessment methodology must provide an assessment of both changes between reference and test sites and also within test sites over time.

Ideally, this is performed by comparing current biological conditions at the test sites against current biological condition at the reference sites and also comparing current biological conditions at the test sites against historical, pre-disturbance or baseline biological conditions at the test site. In reality there are many challenges associated with achieving this including: how well the environmental conditions at the reference site match that of the test site; different hydrological, chemical, physical, habitat and anthropogenic factors will influence similarity of the biological conditions at each area; and therefore how appropriate the reference site is as a benchmark for the test site; and additionally, the quality of historical data that have been collected from the test and reference sites. The predominant factor in data quality and comparability is whether the same standardised sampling methods have been applied over time because data from different methods cannot be reliably compared.

In 2017, NPL engaged Wetland Research Management (WRM 2018) to conduct a review of the biological monitoring data, make recommendations on the most appropriate indicators, trigger values (TVs) and statistical analyses for conducting impact assessment for the AER, and explain how to interpret the statistics correctly. This proposed approach for impact assessment was to be as consistent, where possible, with the risk-based approach currently used for water and sediment quality as per the Australia and New Zealand water quality management framework (ANZG 2019). But where this was not possible, then the most appropriate alternative approach was to be developed. The aim of the current review is to enable NPL to reach accurate conclusions on ecological impacts and thereby provide more confidence in the Biology Impact Assessment within the Annual Environmental Report (AER).

WRM (2018) found that the reference sites and test sites used in the NPL monitoring program are not directly comparable due to the inherent difference in channel size, habitat conditions, water quality (*i.e.* TSS) *etc.* between the main channel test sites and reference sites on smaller tributaries. This inherent difference limits direct comparison between test and reference sites. Also, because the test and reference sites are not independent, it is highly likely that an impact at a test site will also affect fish populations at the reference site due to migration, *etc.* Therefore, it is not strictly valid to conduct impact assessment by comparing current communities at test sites to current communities at reference sites. Additionally, there are no suitable pre-mine data or, for some methods, data from early years post-commencement of mining, from which to develop TVs, due to a change to sampling methodology over time.

To overcome these challenges, the TVs recommended by WRM (2018) are based on the best use of available data from reference and test sites to derive a range of impact assessment TVs which together provide a basis for assessing the current biological conditions at the test sites against both the current biological conditions at the reference sites and the historical biological conditions at both the test and reference sites.

The impact assessment TVs recommended by WRM (2018) are presented in Table 2-12. The adopted TVs were determined to provide the most reliable and appropriate benchmark against which the current biological condition at the test sites, represented by the 2024 mean of each indicator, could be compared, and to support a determination of whether impact had occurred. Note that prawns are not used as indicator species within Lake Murray; this is due to prawn sampling not being done there.

The impact assessment decision matrix is presented in Table 2-13. It should be noted that where multiple TVs are applied to each indicator, an assessment of performance against all TVs using a weight of evidence approach is undertaken to reach a final assessment of whether impact is occurring.

2.6.1.1 *Deriving impact assessment TVs for the upper river*

In the upper river, impact assessment was conducted by testing differences in total abundance and biomass of prawn species *M handschini* and *M. lorentzi* and overall prawn abundance and biomass using replicated electroseining, and abundance and biomass of *N equinus* and overall fish abundance and biomass using replicated hook and line fishing. In the upper river, Ok Om was determined to be the most appropriate reference site for test sites Wasiba and Wankipe. Values for reference Ok Om were lower than those for the test sites. The 80thile values for Ok Om were therefore considered more appropriate for use as TVs for total species abundance and total biomass, as using 20thile or even average values would mean the TV would be too low to be protective of existing fish communities at Wasiba and Wankipe. This is in acknowledgment that a TV derived from the 80thile of Ok Om data is likely to be overly-conservative in some years.

For TVs specific to *N. equinus*, the average values for Ok Om were considered more appropriate than the 80thile values, as the latter would have produced an overly conservative TV that would over-estimate the risk of impact at the test sites, while TVs based on the 20thile would not be protective enough.

Values for prawn abundance and biomass at reference Ok Om were lower than those for Wasiba, but slightly higher than those for Wankipe. The average values for Ok Om were therefore considered more appropriate for use as TVs for all parameters, as the numerous low values in the data meant using 20thile values as TVs would be too low to be protective of existing populations at Wasiba, in particular. This is in acknowledgment that a TV derived from the average of baseline data is likely to be overly-conservative in some years. (WRM 2017)

2.6.1.2 *Deriving impact assessment TVs for the lower river*

In the lower river, impact assessment was conducted by testing changes in fish species richness, abundance and biomass derived from quarterly gill netting. In the lower river it was determined that Tomu was the more appropriate reference site for SG4, and Baia the more appropriate reference site for Bebelubi. Therefore, TVs for SG4 and Bebelubi were calculated from data for Tomu and Baia, respectively. To avoid potential confounding effects of 'fishing down' over consecutive sampling days, only data from the first day's catch on each occasion was used.

There also appeared to be a 'fishing-down' effect at SG4 and Tomu due to the combination of higher frequency sampling and increased number of replicates since 2002 and population growth in nearby villages (WRM 2017). Available data suggest that since at least 2007, there have been downward trends in species abundance and biomass at both Tomu and SG4. Because of these trends and the inter-dependence of reference and test site, it was not considered valid to derive TVs for SG4 using recent data from reference Tomu. Nor are there pre-mine data for either site to use as baseline for derivation of TVs. Therefore, the earliest periods post-commencement of mining shown to have a high and stable species composition at both Tomu and SG4 were taken to be 'baseline' for derivation of TVs for univariate parameters. The idea being that although this period may not necessarily represent pre-mine baseline, it provides a benchmark against which future change may be assessed and is sufficiently early in mine life to likely not reflect mine impacts. This stable 'baseline' period was 1999 – 2004. There are few data prior to this period for Tomu, though there are 11 records for SG4 for the period 1989 - 1999. These early records possibly better represent pre-mine conditions at SG4, than do later records for reference Tomu. As such, they were used to develop an alternate set of TVs for SG4.

The same approach used for developing TVs using reference data from Tomu, was used to develop TVs for Bebelubi from reference data from Baia. The period of record is relatively short for both Baia and Bebelubi, though there were no statistically significant trends with time at either site. Data for the

earliest years 2006 - 2008, were therefore used as benchmark or 'baseline' to develop TVs from reference Baia, again acknowledging current condition may not reflect pre-mine condition at either site. In order that TVs allow for a degree of variability, they were developed from three years of 'baseline' data (*i.e.* 2006 to 2008), rather than one or two years.

Values for species richness and abundance at reference Tomu were lower than those for test site SG4, while values for biomass were higher. The average values for baseline (1999 - 2004) data for species richness and abundance at Tomu were therefore considered more appropriate for use as TVs, as the 20th percentile values would be too low to be protective of existing populations at SG4. For biomass however, the 20th percentile value for Tomu was considered more appropriate as the TV, as the average value would have produced an overly conservative TV and therefore an over-estimation of impact at test site SG4.

For alternative TVs for SG4, derived from baseline data for that site (1989 - 1998), the average values for species richness, abundance and biomass were considered more appropriate, as the numerous low values in the baseline data meant using 20th percentile values as TVs would be too low to be protective of existing populations at SG4. This is in acknowledgment that a TV derived from the average of baseline data is likely to be overly-conservative in some years. TV derived from the average of previous 24 months data from Tomu was also used.

For reference Baia, values for all parameters were lower than for test Bebelubi. The 80th percentile values for baseline (2006 - 2008) data for species richness, abundance and biomass at Baia were therefore considered more appropriate for use as TVs than the 20th percentile or even the average values, as the numerous low values in the Baia reference data meant using 20th percentile or average values as TVs would be too low to be protective of existing populations at Bebelubi. The 80th percentile was also less conservative than 90th percentile or 95th percentile values which would have produced overly conservative TVs and therefore an over-estimation of impact at Bebelubi. TV derived from the average of previous 24 months (*i.e.* 2015 – 2024) data from Baia was also used. (WRM 2017)

2.6.1.3 *Deriving impact assessment TVs for Lake Murray*

In Lake Murray, impact assessment was conducted by testing changes in fish species richness, abundance and biomass derived from replicated gill netting on a biannual sampling campaign. In Lake Murray, it is also not possible to validly conduct impact assessment by comparing current communities at test sites to current communities at the reference site. To avoid potential confounding effects of 'fishing down' over consecutive sampling days, only data from the first day's catch on each occasion were used.

Data prior to 2001 (*i.e.* 1989 - 2000) are available for test site Miwa, but there are few data for this period for test site Pangoa or reference Maka. These earlier data show relatively high inter-annual variability but are more likely to represent pre-mine communities at Miwa. Therefore, additional TVs were also calculated for species richness, abundance and biomass at Miwa, based on 1989 - 2000 data.

Values for species richness and abundance at reference Maka were higher than those for test Miwa and Pangoa, while values for species richness were similar. The 20th percentile values for the baseline (2001 - 2006) data for Maka were therefore considered more appropriate for use as TVs for all parameters, as the average values would have produced an overly conservative TV and therefore an over-estimation of impact at test sites.

For alternative TVs for Miwa, derived from baseline data for that site (1989 - 2000), the average values for species richness, abundance and biomass were considered more appropriate, as the numerous low values in this baseline data set meant using 20th percentile values as TVs would be too low to be protective of existing populations at Miwa. This is in acknowledgment that a TV derived from the average of baseline data is likely to be overly-conservative in some years. (WRM 2017). For the most recent assessment, the TV sources used were the same as those applied in the 2019 report.

Table 2-12 Impact assessment trigger values

Region	Test Site	Species	Indicator	Trigger Value Source
Upper River	Wasiba & Wankipe	Fish	Total fish abundance Total fish biomass	Ok Om Reference - 80 th ile of the 24-months from upper river reference site Ok Om used in the 2019 reporting.
			<i>N. equinus</i> abundance <i>N. equinus</i> biomass	Ok Om Reference - Average of the 24-months from upper river reference site Ok Om used in the 2019 reporting.
		Prawns	Total prawn abundance Total prawn biomass <i>M. handschini</i> abundance <i>M. handschini</i> biomass <i>M. lorentzi</i> abundance <i>M. lorentzi</i> biomass	Ok Om Reference - Average of the 24-months from upper river reference site Ok Om used in the 2019 reporting
Lower River	Bebelubi	Fish	Total fish richness Total fish abundance Total fish biomass	Option A1 Baia ‘Baseline’ - 80 th ile 2006-2008 Option A2 Baia Reference - Average previous 24 months
			Fish	Total fish biomass
	SG4	Fish		Total fish richness Total fish abundance
			Lake Murray	Miwa
Pangoa	Fish	Total fish richness Total fish abundance Total fish biomass		

For “TV Source” sites, the time range considered as “reference” was 2018-2019. This means the last 24 months during the last report. For “Test” sites, all tests were run considering 2019 data, as in the last report. When “TV Source” baseline was required, the time ranges were determined as follows:

- Option A1 Baia ‘Baseline’: 80thile 2006-2008

- Option B1 Tomu ‘Baseline’: 20th%ile 1999-2004
- Option B2 SG4 Baseline: 20%ile 1989-1998
- Option B1 Tomu ‘Baseline’: Average 1999-2004
- Option B2 SG4 Baseline: Average 1989-1998
- Option C1 Maka ‘Baseline’: 20th%ile 2001-2006
- Option C2 Miwa ‘Baseline’: Mean 1989-2000
- Option C1 Maka ‘Baseline’: 20th%ile 2001-2006

Table 2-13 Impact assessment matrix – Biological indicators for fish and prawn

Assessment Result	Impact Assessment	Action
Test site mean significantly > TV	No Impact	Investigate cause of impact to determine if the impact is caused by mine related or non-mine related factors.
Test site mean not significantly different from TV.		
Test site mean significantly < TV	Impact	

2.7 Testing for Statistical Significance

Tests of statistical significance are performed as part of the risk and impact assessments to provide a statistical basis for drawing conclusions. Using the statistical tests allows the assessment result to be described as ‘significantly greater than’, ‘significantly less than’ or ‘not significantly different from’ the relevant trigger value, and ultimately to provide confidence that the result is valid and not being influenced by the inherent characteristics of the dataset under consideration.

Because of the size of the dataset and the long period over which it was collected there were some errors in the data. Before any analysis was undertaken a data checking and cleaning process was completed using an automated rules-based protocol in the software R (R Core Development Team 2025). Steps undertaken were as follows:

1. All species names were checked to correct typos, replace synonyms with accepted names, and get full taxonomical hierarchy information using GBIF online dataset as the main information source.
2. Weight outliers were observed, probably due to errors during data entry. To exclude those from further analyses, and considering the whole dataset, the average weight and the interquartile range were estimated for each species. We removed from the dataset all the weights higher than the species average plus five times the interquartile range. This allowed us to exclude clear outliers showing magnitudes many times higher than the species’ weight average.

The three main parameters used to estimate Trigger Values (TVs) and assess environmental impacts were: species abundances, biomass, and species richness.

For species abundance, for each sampling date, the total abundance per observed species was estimated. Then, the species abundance average and its confidence interval were estimated per sampling date.

For biomass and species richness, for each sampling date, the total biomass and species richness per replicate was estimated. Then, we estimated the average and the confidence interval among replicates per sampling date. If one replicate did not observe species (“Zero catch”), that record was kept as zero when estimating the average and confidence intervals.

Confidence intervals were estimated as follows:

$$CI = \bar{x} \pm ct * \frac{\sigma}{\sqrt{n}}$$

Where \bar{x} is the average, σ is the standard deviation, n is the sample size and ct is the critical value. The critical value was adjusted for small sample size. When $n > 30$, ct was estimated traditionally, using z-distribution ($ct = 1.96$). To adjust for uncertainty and larger tails, when $n \leq 30$ we used t-distribution for critical value, adjusting degrees of freedom as $n - 1$ and providing more reliable intervals.

To compare TVs against test site means, we ran a t-test statistical analysis. A parametric test, such as the t-test was considered a more robust statistical approach than non-parametric rank testing, given quarterly sampling will only produce a low number (< 4) of data points for test sites in any given year, and rank tests do not perform well on small data sets. A parametric test is also more justified for classical “impact assessment” as it is testing actual data means and variance against a threshold value, rather than using ranked data.

To evaluate temporal trends, we estimated Spearman and Pearson correlation between the parameters and time (transformed to numerical values). The Spearman Rank Test is used to assess trends over time, with a probability threshold of $p = 0.05$. This test uses ranked data, and so is independent of the absolute values, but is ideal for use on data monotonically related, as it is not dependant on data having a linear relationship (as are linear regression or Pearson Product Moment Correlation).

Where Spearman correlation showed a significant long-term trend, Regression Analysis was used to test if this trend was linear. The trend was considered significant if one of the two p-values was lower than 0.05. For both cases, only “first day” sampling was considered. This means, if two consecutive sampling days were detected, the second was left out of the tests. About temporal range, while t-test was run using temporal ranges adapted to impact assessment requirements, for temporal trends the whole temporal range was considered.

All tests are performed with the software package R 4.5.0 (R Core Development Team, 2025).

The test used for determining statistical significance at the risk assessment stage is 1-Sample Wilcoxon test with a probability threshold of $p = 0.05$. The Wilcoxon test is a non-parametric statistical hypothesis test used to determine if there is a significant difference between the test site median and the trigger value.

Two statistical tests were performed for impact assessment: Spearman rank correlation (ρ) and parametric t-test. Spearman rank correlation (ρ) was used to statistically test for significant long-term trends across sampling dates. Where Spearman correlation showed a significant long-term trend, Regression Analysis was used to test if this trend was linear. One sample t-test was performed to determine if there was a statistically significant difference between the test site average and relevant trigger value. Significance level for both tests is $p = 0.05$.

A parametric test, such as the t-test was considered a more robust statistical approach than non-parametric rank testing, given quarterly sampling will only produce a low number (< 4) of data points for test sites in any given year, and rank tests do not perform well on small data sets. A parametric test is also more justified for classical “impact assessment” as it is testing actual data means and variance against a threshold value, rather than using ranked data.

All tests are performed with the Minitab software package. The procedure for determining significance involves integrating the significance test into the risk and impact assessment matrices. The procedures for testing significance in the risk and impact assessments for water quality, sediment quality, tissue metals and fish and prawn populations are shown as expanded assessment matrices in Appendices.

3 THE ENVIRONMENTAL MONITORING PROGRAM

The environmental monitoring program consists of sampling and measurement of physical, chemical and biological variables to quantify the operations environmental aspects and assess compliance, risk and impact. The monitoring program is detailed in the Porgera Environmental Monitoring, Auditing and Reporting Plan (ENV-SIT-STD-002) and associated Standard Operating Procedures. The spatial scope of the monitoring program is extensive, spanning from the mine site to SG5 on the lower Strickland River, approximately 560 river kilometres downstream from the mine.

Many of the monitoring locations are in remote areas and require the use of helicopters and boats to gain access. While all efforts are taken to conduct the monitoring program to schedule, potential safety issues will sometimes prevent sampling from being undertaken, such as severe flooding, unsafe access, social unrest, or threats against NPL employees.

3.1 Environmental Aspects

The operation has a range of associated environmental aspects, which are defined by ISO 14001 (2015) as activities which have the ability to interact with the environment. Significant environmental aspects of the operation are riverine tailings disposal, waste rock disposal, water extraction and discharge, hazardous substances transport, storage and use, and waste management.

Each aspect is monitored and quantified to determine the risk it poses to the environmental values of the receiving environment, to determine whether the management techniques applied are achieving the desired level of control and to determine whether actions taken to improve performance are effective. Table 3-1 provides an outline of the operation's environmental aspects and the associated physical and chemical parameters that are monitored to quantify each aspect.

Table 3-1 Environmental aspects and monitoring parameters

Environmental Aspect	Physical Parameters	Chemical & Toxicant Parameters	Biological Parameters
Riverine tailings disposal	Volume discharged, TSS concentration	pH, conductivity, metal concentrations, WAD CN	NA – applied only in receiving environment
Waste rock disposal to water	Volume discharged	Metal concentrations	NA – applied only in receiving environment
Other discharges to water: - Mine contact runoff - Treated sewage effluent	Volume discharged, TSS concentration	pH, conductivity, metal concentrations Total hydrocarbons Free chlorine BOD ₅ Total N and P	Faecal coliforms
Waste rock disposal to land	Area disturbed Volume of waste rock disposed	Metal concentrations	NA – applied only in receiving environment
Water extraction	Volume extracted	NA	NA – applied only in receiving environment

Environmental Aspect	Physical Parameters	Chemical & Toxicant Parameters	Biological Parameters
Discharge to air	Emission rate, particulate concentration	Metal concentrations Greenhouse gas volume	NA – applied only in receiving environment
Land disturbance	Area disturbed % rehabilitated	NA	NA
Resource consumption	Volume consumed Consumption efficiency	NA	NA
Waste generation	Volume generated % to landfill %incinerated % recycled	Waste type	NA

3.2 Baseline Environmental Monitoring

Baseline data referenced in this report have been sourced from NSR (1990), NSR Environmental Consultants PTY LTD, *Environmental Baseline Porgera Gold Mine Volume 1 and Volume 2*, April 1990.

3.3 Environmental Conditions

To determine the scope and magnitude of the interactions between the mine operation’s environmental aspects and the receiving environment, it is necessary to identify suitable parameters to act as indicators of the interaction, to identify locations within the receiving environment at which the interaction is likely to take place (test sites) and to identify locations within the environment where no interaction will take place (reference sites). This will ultimately allow a comparison of the same indicators between the test site and reference site and determination of the spatial extent and magnitude of mine-related changes within the receiving environment.

3.3.1 Indicator parameters

The parameters monitored within the receiving environment have been selected based on their suitability for:

- Supporting assessment of compliance against legal and other requirements.
- Assessing the potential impact within the receiving environment as a result of the operation’s environmental aspects.
- Assessing the environmental performance of the operation, linked to environmental Key Performance Indicators (KPIs).

Table 3-2 outlines the physical, chemical and biological parameters that are monitored at both the test sites and reference sites to support compliance, impact and performance assessments.

Table 3-2 Receiving environment monitoring indicator parameters

Environmental Aspect	Physical	Chemical & Toxicant	Biological
Riverine tailings disposal	River profiling: cross-sections. Water quality: TSS concentration	Water quality: pH, conductivity, metal concentration, WAD-CN. Benthic sediment quality: Metal concentration. Fish and prawn tissue:	Species richness, abundance and biomass of fish and prawns. Macroinvertebrate assemblages.
Waste rock disposal to water	River profiling: cross-sections. Water quality: TSS concentration, Sediment grain size	Water quality: pH, conductivity, metal concentration. Benthic sediment quality: Metal concentration. Fish and prawn tissue: Metal concentration.	Species richness, abundance and biomass of fish and prawns. Macroinvertebrate assemblages.
Waste rock disposal to land	Area of disturbance. Volume of waste rock disposed to land. Volume solid waste disposed to land.	Geotechnical characteristics: Competency. Geochemical characteristics: Metal concentrations, acid producing potential.	Terrestrial flora and fauna communities.
Water extraction	Flow downstream of water extraction points.	NA	Macroinvertebrate assemblages.
Discharge to air	Air Quality: particulate concentration.	Air Quality: Metal concentration	NA
Land disturbance	Area of disturbance	NA	Terrestrial flora and fauna communities.
Resource consumption	Consumption volume Consumption efficiency	NA	NA
Waste generation	Area of disturbance.	NA	Terrestrial flora and fauna communities.

NA - Not Applicable

3.3.2 Monitoring locations

Environment monitoring locations are categorised as test sites and reference sites. Test sites are those sites downstream of the mine, receiving discharge from the mine, whereas reference sites are in a similar geographical setting, generally within tributaries adjacent to the test sites that do not receive discharges from the mine. The test and reference sites where environmental monitoring are conducted are listed in Table 3-3. The table also lists which reference sites are used as analogues for each test site. The locations of the monitoring sites are shown in Figure 3-1 and Figure 3-2 shows monitoring locations within Lake Murray. Table 3-4 gives an assessment of reference site suitability.

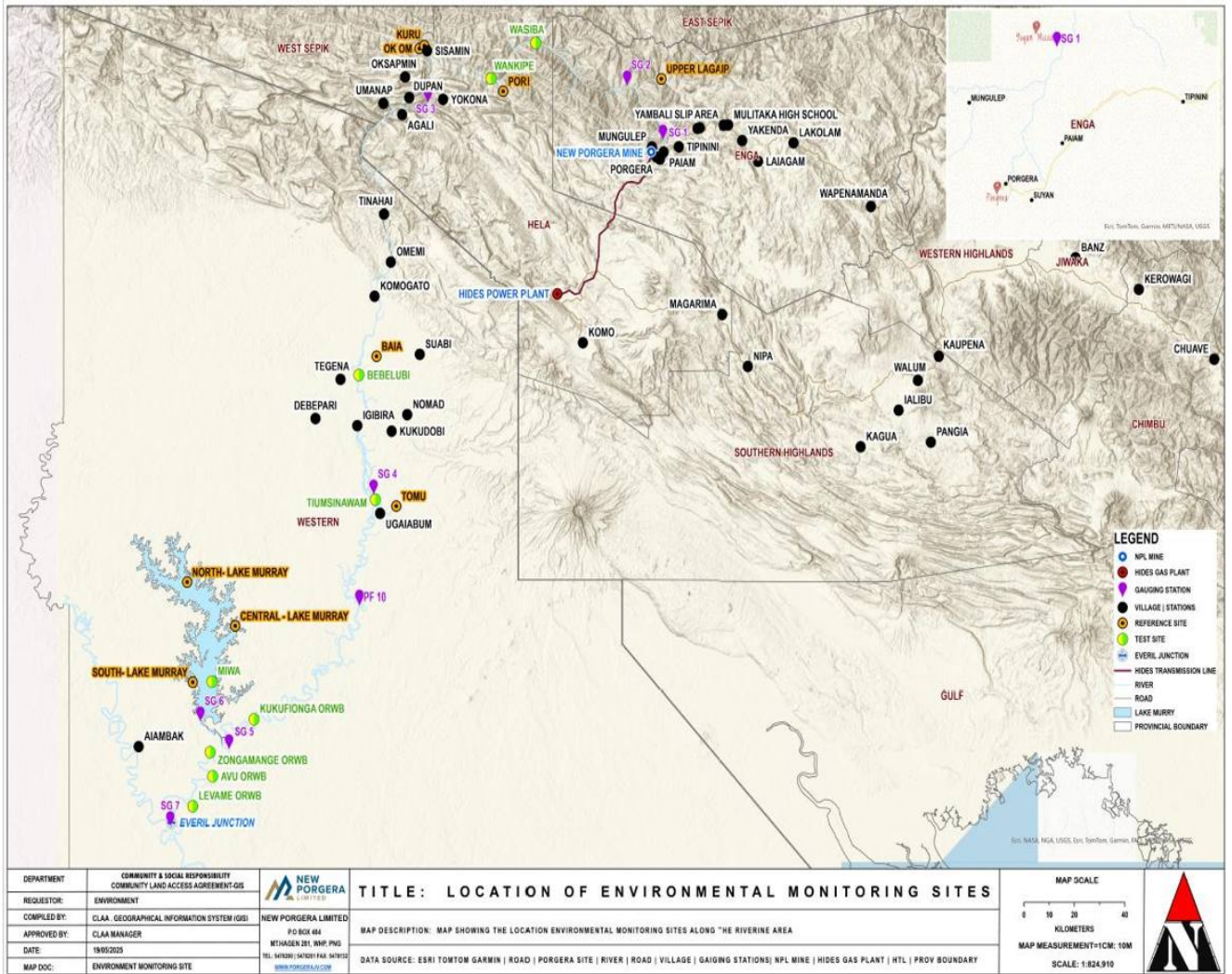


Figure 3-1 Receiving environment monitoring sites

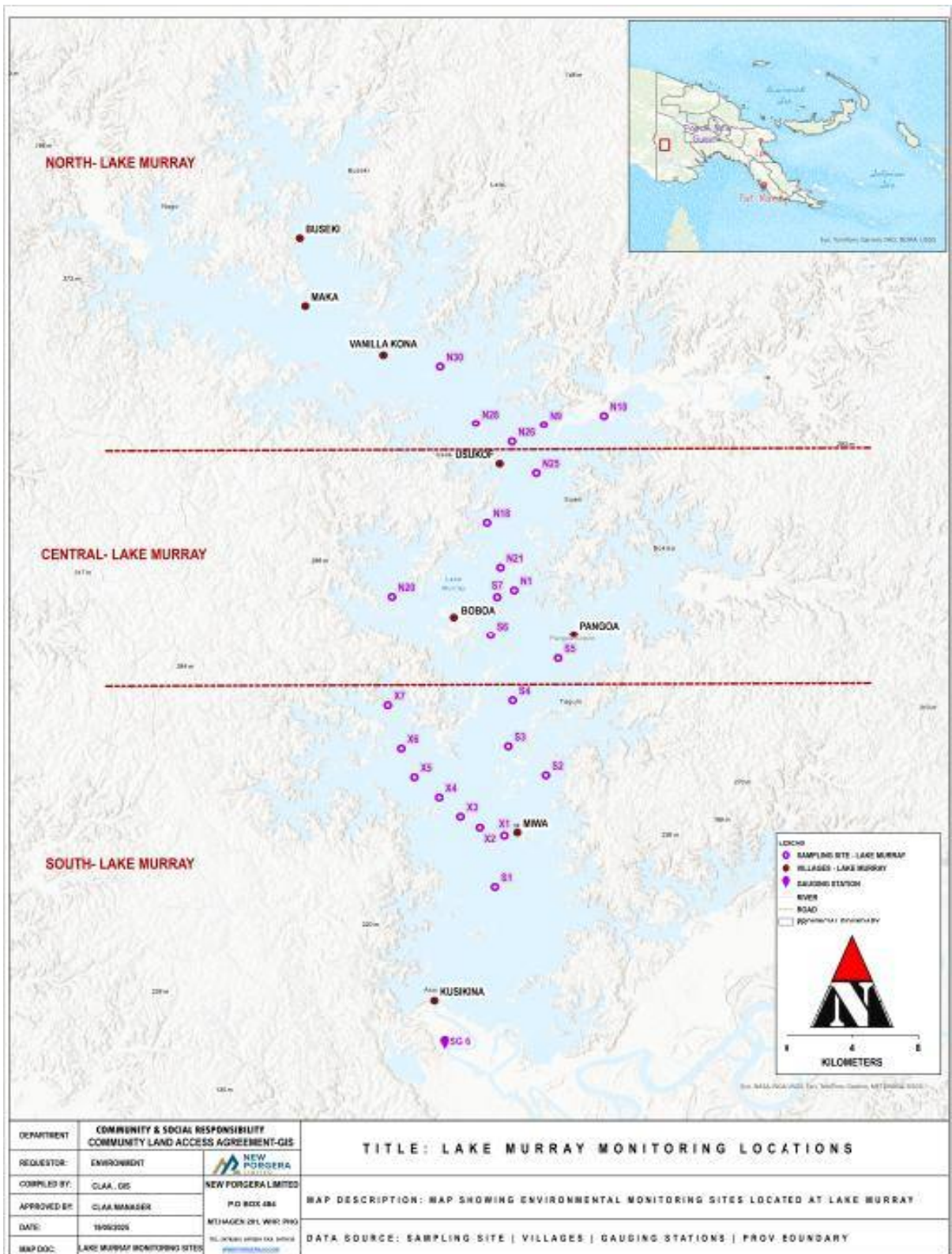


Figure 3-2 Lake Murray monitoring locations

Table 3-3 Test sites, related reference sites and indicator parameters

Receiving Environment Test Site		Reference Sites and Parameters				
		Profile	Water and/or Sediment	Tissue Metal	Fish & Prawn Biology	Macro-invertebrate Biology
Upper River	SG1	NAR	Upper Lagaip Pori Kuru Ok Om	NA ¹	NA ¹	NA ¹
	SG2	NAR	Upper Lagaip Pori Kuru Ok Om	NA ¹	NA ¹	Upper Lagaip Ok Om
	Wasiba	NA ¹	Upper Lagaip Pori Kuru Ok Om	Ok Om	Ok Om	Upper Lagaip Ok Om
	Wankipe	NA ¹	Upper Lagaip Pori Kuru Ok Om	Ok Om	Ok Om	Upper Lagaip Ok Om
	SG3	NA ¹	Upper Lagaip Pori Kuru Ok Om	NA ¹	NA ¹	Upper Lagaip Ok Om
Lower Strickland River	Bebelubi	NA ¹	Baia	Baia	Baia	NA ¹
	SG4	NA ¹	Tomu	Tomu	Tomu	NA ¹
	PF10	NAR	NA ¹	NA ¹	NA ¹	NA ¹
	SG5 Upstream of Everill Junction	NA ¹	Baia Tomu	Baia Tomu	NA ¹	NA ¹
Lake Murray	South Lake Murray Central Lake Murray SG6	NA ¹	North Lake Murray	North Lake Murray	North Lake Murray	NA ¹
Off-River Water Bodies	Kukufionga Zongamange Avu Levame	NA ¹	Baia Tomu	NA ¹	NA ¹	NA ¹
Drinking Water	Villages surrounding Porgera Mine	NA ¹	NA ²	NA ¹	NA ¹	NA ¹
Air Quality	Hides Power Station boundary Villages surrounding Porgera Mine	NA ¹	NA ²	NA ¹	NA ¹	NA ¹

NAR – No appropriate reference site

NA¹ – Indicator not applied at monitoring site

NA² – Indicator at test sites compared against values derived from standards or guidelines not reference sites

Table 3-4 Assessment of reference site suitability

Reference Site	Suitability Assessment for Indicator Parameters				Reference site characteristics affecting suitability
	Physical ¹	Chemicals and Toxicants ²	Fish & Prawn Biology	Macro-invertebrate Biology	
Upper Lagaip	Good	Poor	Poor	Good	Lower natural mineralisation than test site baseline. Naturally depauperate fish and prawn populations. Fish and prawns potentially exposed to test site conditions if migrating between test and reference sites.
Pori	Poor	Poor	Poor	NA	Small tributary compared to main river reference sites. Lower natural mineralisation than test site baseline. Lower flows. Lower suspended sediment. Different habitat types. Reference site biology potentially indirectly impacted (i.e. fish and prawn migration). Fish and prawns potentially exposed to test site conditions if migrating between test and reference sites.
Kuru	Fair	Poor	Poor	NA	Small tributary compared to main river reference sites. Lower natural mineralisation than test site baseline. Lower flows. Lower suspended sediment. Different habitat types. Reference site biology potentially indirectly impacted (i.e. fish and prawn migration). Fish and prawns potentially exposed to test site conditions if migrating between test and reference sites.
Ok Om	Good	Poor	Fair	Fair	Lower natural mineralisation than test site baseline. Fish and prawns potentially exposed to elevated test site conditions if migrating between test and ref sites.

Reference Site	Suitability Assessment for Indicator Parameters				Reference site characteristics affecting suitability
	Physical ¹	Chemicals and Toxicants ²	Fish & Prawn Biology	Macro-invertebrate Biology	
Baia	Fair	Fair	Poor	NA	<p>Medium size tributary compared to main river reference sites.</p> <p>Lower natural mineralisation than test site baseline.</p> <p>Different habitat types.</p> <p>Reference site biology potentially indirectly impacted (i.e. fish and prawn migration).</p> <p>Fish and prawns potentially exposed to test site conditions if migrating between test and ref sites.</p> <p>Ref sites will naturally support lower fish species richness and standing stock biomass than the main river.</p>
Tomu	Fair	Fair	Poor	NA	<p>Medium size tributary compared to main river reference sites.</p> <p>Lower natural mineralisation than test site baseline.</p> <p>Different habitat types.</p> <p>Reference site biology potentially indirectly impacted (i.e. fish and prawn migration).</p> <p>Fish and prawns potentially exposed to test site conditions if migrating between test and ref sites.</p> <p>Ref sites will naturally support lower fish species richness and standing stock biomass than the main river.</p>
North Lake Murray	Good	Fair	Fair	NA	<p>North Lake Murray is physically connected to the central and southern lake and can be theoretically potentially influenced by mine aspects.</p>

1 – For water

2 – For water, benthic sediment and tissue metals

3.3.4 Schedule and execution

Compliance with the monitoring schedule and plan is summarised in Table 3-5. Overall, the monitoring schedule was executed as planned, with a few exceptions due to safety concerns, equipment unavailability and station vandalism. Profile measurements along the Lagaip-Strickland River were conducted only once at each site during the year due to unavailability of measuring equipment, instead of the scheduled twice. Rainfall and flow data collection at SG4 was disrupted due to vandalism, resulting in data loss. Chemistry and biology monitoring activities were completed as scheduled. Compliance was measured by calculating the percentage of actual monitoring conducted against plan.

Table 3-5 Monitoring compliance to plan in 2024

Region	Monitoring Sites	Chemistry		Biology		Hydrology		Comment
		Frequency	% Achieved	Frequency	% Achieved	Frequency	% Achieved	
Contact Sites	Kaiya US Yuyan Bridge	Monthly	0	-	-	Annually	100	Security issue
	Kaiya DS Yuyane Bridge	Monthly	0	-	-	Annually	100	Security issue
	Kaiya @ Yuyane Bridge	Monthly	0	-	-	Annually	100	Security issue
	Kaiya US Kogai Junction	Monthly	0	-	-	Annually	100	Security issue
	DP 3	Monthly	100	-	-	Monthly	100	
	DP 4	Monthly	100	-	-	Monthly	100	
	DP 14	Monthly	100	-	-	Monthly	100	
	DP 16	Monthly	100	-	-	Monthly	100	
	DP 17	Monthly	100	-	-	Monthly	100	
	DP 5	Monthly	100	-	-	Monthly	100	
	DP 6	Monthly	100	-	-	Monthly	100	
	Aipulungu	Monthly	100	-	-	Monthly	100	
	Pongema	Monthly	100	-	-	Monthly	100	
Upper River	SG1	Monthly	0	-	-	6 monthly	0	Security issue
	SG2	Monthly	58	-	-	6 monthly	0	Security issue
	Wasiba	Monthly	100	Quarterly	100	-	-	
	Wankipe	Monthly	100	Quarterly	100	-	-	
	SG3	Monthly	100	-	-	6 monthly	50	
	Upper Lagaip	Monthly	0*	-	-	-	-	Security issue
	Pori	Monthly	100	-	-	-	-	
	Kuru	Monthly	100	-	-	-	-	
Lower Strickland River	Ok Om	Monthly	100	Quarterly	100	6 monthly	100	
	Bebelubi	Quarterly	100	Quarterly	100	-	-	
	SG4/Tiumsinawam	Quarterly	100	Quarterly	100	6 monthly	0	ADCP faulty
	PF10	-	-	-	-	6 monthly	0	ADCP faulty
	SG5	6 monthly	100	-	-	6 monthly	0	ADCP faulty
	Upstream of Everill Junction	Annually	100	-	-	-	-	
	Baia	Quarterly	100	Quarterly	-	-	-	
Tomu	Quarterly	100	Quarterly	100	-	-		
Lake Murray	South Lake Murray	Annually	100	Annually	100	-	-	
	Central Lake Murray	Annually	100	Annually	100	-	-	
	SG6	Annually	100	-	-	-	-	
	North Lake Murray	Annually	100	Annually	100	-	-	
	Kukufionga	Annually	100	-	-	-	-	
	Zongamange	Annually	100	-	-	-	-	

NPL Annual Environment Report 2024

Region	Monitoring Sites	Chemistry		Biology		Hydrology		Comment
		Frequency	% Achieved	Frequency	% Achieved	Frequency	% Achieved	
Off-River Water Bodies	Avu	Annually	100	-	-	-	-	
	Levame	Annually	100	-	-	-	-	
Monitoring Compliance to Plan (%)			99		100		90	

3.3.5 QA & QC

NPL incorporates quality assurance and quality control (QA & QC) into the monitoring and reporting program to ensure the data being reported are accurate and representative.

The QA & QC program consists of operator training and competency assessment, equipment calibration, method validation, field blanks, field duplicates, certified reference material, proficiency testing and inter-laboratory analysis. Analysis of metals in water, benthic sediment, and prawn and fish tissue were performed by National Association of Testing Authorities (NATA)-certified National Measurement Institute (NMI) laboratory in Sydney, Australia.

A full review of QA & QC performance is provided in Appendix A. In summary, the results of the QA & QC program show that sampling and analytical techniques are providing representative and valid results for all water, sediment, tissue metal and biological monitoring results. The performance of QA & QC samples have improved over recent years due to a number of continual improvement initiatives that have been applied to the monitoring program including:

- Updating standard operating procedures and application of staff training and competency assessment;
- Conducting internal lab audits
- WAD CN analysis using picric acid and cyanoprobe methods concurrently.
- Consistent sample tracking and timely data review processes; and
- Engaging CSIRO to perform external audits of the monitoring program and lab operations.

Some of the results from proficiency testing (PTA) samples fell outside the acceptable range, NPL will continue to investigate these deviations and apply corrective actions.

Overall, the data provided by the monitoring and reporting program, and subsequently presented in this report, are deemed representative and valid.

Opportunities to improve the QA & QC program are:

- Continue training and competency system development and implementation for new employees.
- Repeat the two-yearly CSIRO monitoring program and laboratory audit in 2026.

4 OPERATIONS AND ENVIRONMENTAL ASPECTS

This section provides a summary of key operational parameters and environmental aspects for 2024 and throughout the history of the operation. All major milestones for the mine restart from care and maintenance to full production were achieved by NPL, with the processing plant fully operational in August 2024. A summary of results is presented in Table 4-1.

Table 4-1 Mine production and environmental aspects summary 2024

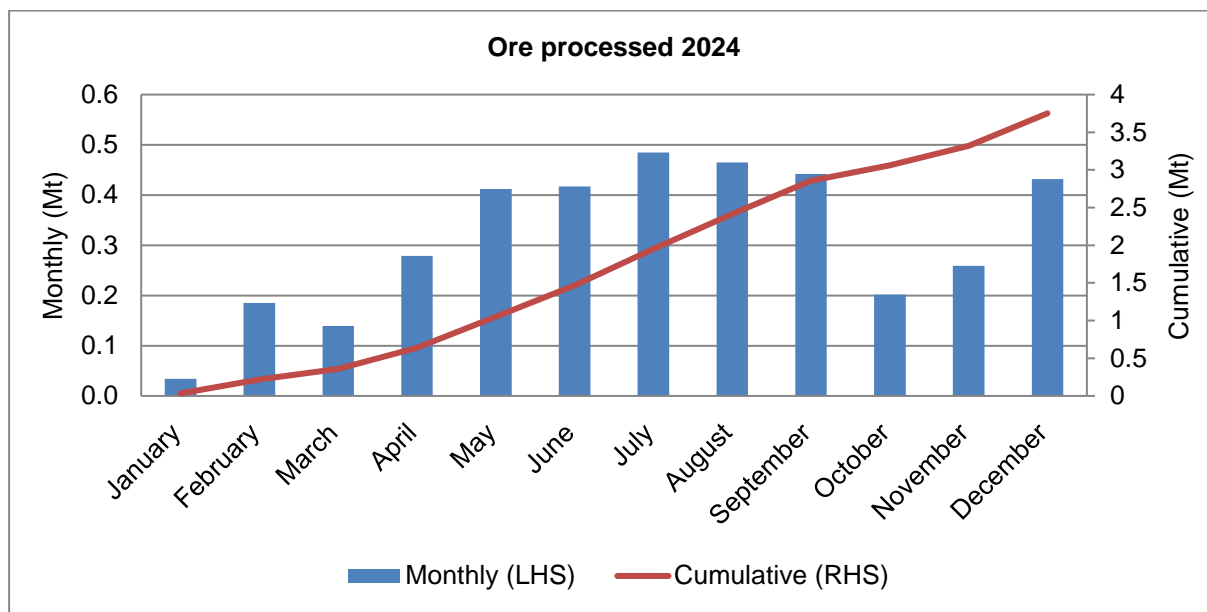
Operational and Environmental Aspects	2024	2024 Target	Life of Mine Total	Comments
Ore processed (Mt)	3.75	3.82	141.07	Below 2024 target.
Gold production (oz)	188,056	264,026	21,223,355	Below 2024 target
Competent waste rock produced (Mt)	3.54	NA	440.88	Lower than previous operational years.
Incompetent waste rock produced – Anawe (Mt)	1.1	15.07	239.86	Lower than previous operational years.
Incompetent waste rock produced – Anjolek (Mt)	6.8	14.23	252.45	Consistent with previous years.
Tailings to underground paste (% total tailings volume)	1.8	10	NA	Below 2024 target.
Tailings discharged (Mt)	1.4	152.15	136.36	Lower than previous years.
Total sediment discharged to river (Mt) (from tailings and erodible dumps)	14	381.45	NA	Consistent with previous years.
Sewage effluent discharge (m ³)	240,536	290,912	NA	Consistent with previous years.
Mine contact rainfall runoff (Mm ³)	40.5	1,745.02	NA	Consistent with previous years.
Greenhouse gas and energy efficiency (kgCO ₂ -e/t processed ore)	68	84	NA	Below 2024 limit
Water use and efficiency (L/t processed ore)	5,072	5,500	NA	Consistent with previous years.
Area land disturbed (ha)	22	NA	2,393	Consistent with previous years.
Area of disturbed land under rehab (ha)	0	NA	240	Rehab target not set for 2024

4.1 Production

4.1.1 Mining and processing operations

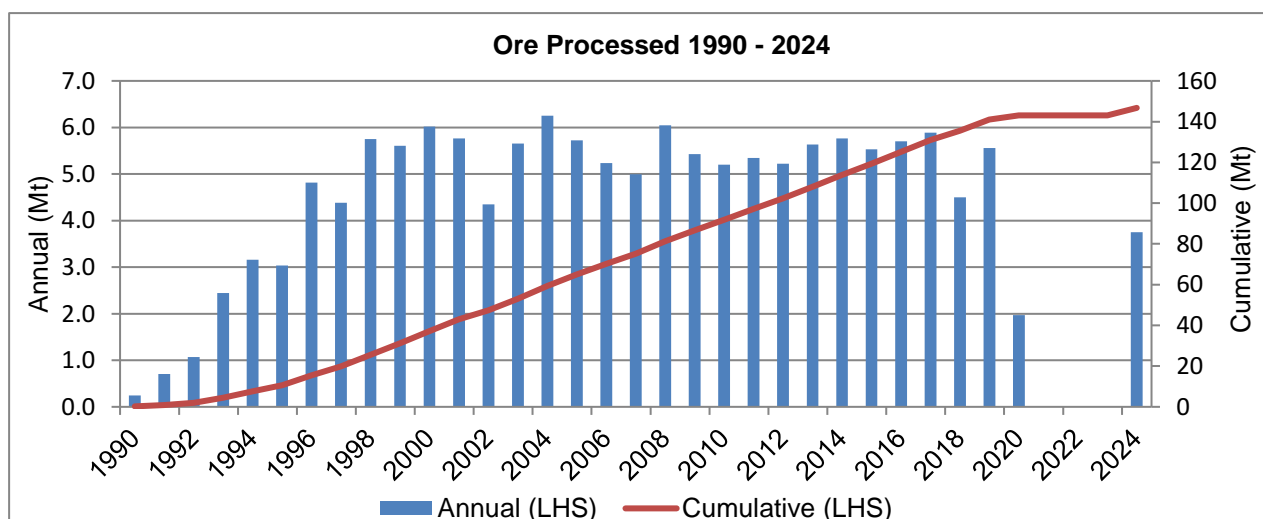
4.1.1.1 Total ore processed

The total quantity of ore processed in 2024 was 3.8 million tonnes (Mt). Figure 4-1 shows the monthly and cumulative quantities of ore processed in 2024. The cumulative quantity of ore processed from 1990 to 2024 was 141Mt and is shown in Figure 4-2. No ore was processed during the care and maintenance period from May 2020 – December 2023.



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-1 Monthly and cumulative ore processed in 2024

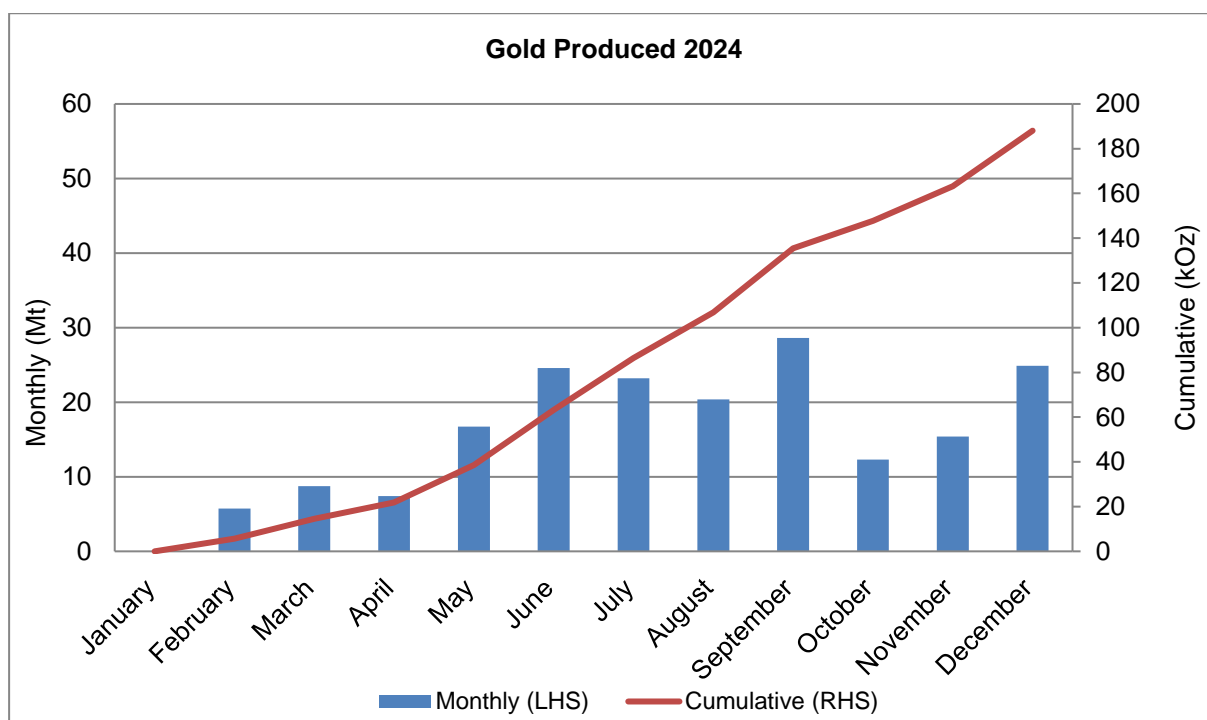


LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-2 Yearly and cumulative ore processed 1990 - 2024

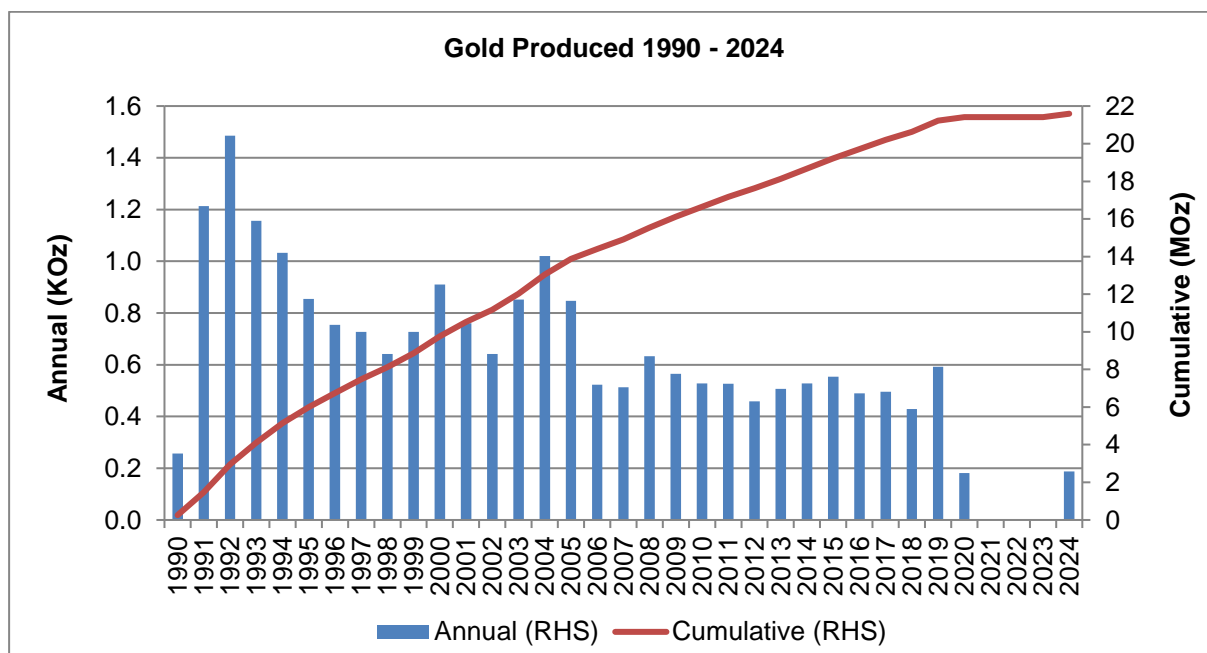
4.1.1.2 Gold production

Total gold production in 2024 was 188 koz. Figure 4-3 shows monthly and cumulative gold production during 2024. Total gold production from 1990 to 2024 was 21.6 million ounces. Figure 4-4 shows annual and cumulative gold production since operations began in 1990.



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-3 Monthly and cumulative gold production in 2024



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-4 Yearly and cumulative gold production 1990 – 2024

4.2 Water Use

Figure 4-5 shows water use intensity between 2009 and 2024. The overall water use efficiency for the year was below the annual target due to lower tonnes of ore processed during the operation ramp-up phase. There was no ore processing during the care and maintenance period from May 2020 to December 2023, therefore no figures available for reporting.

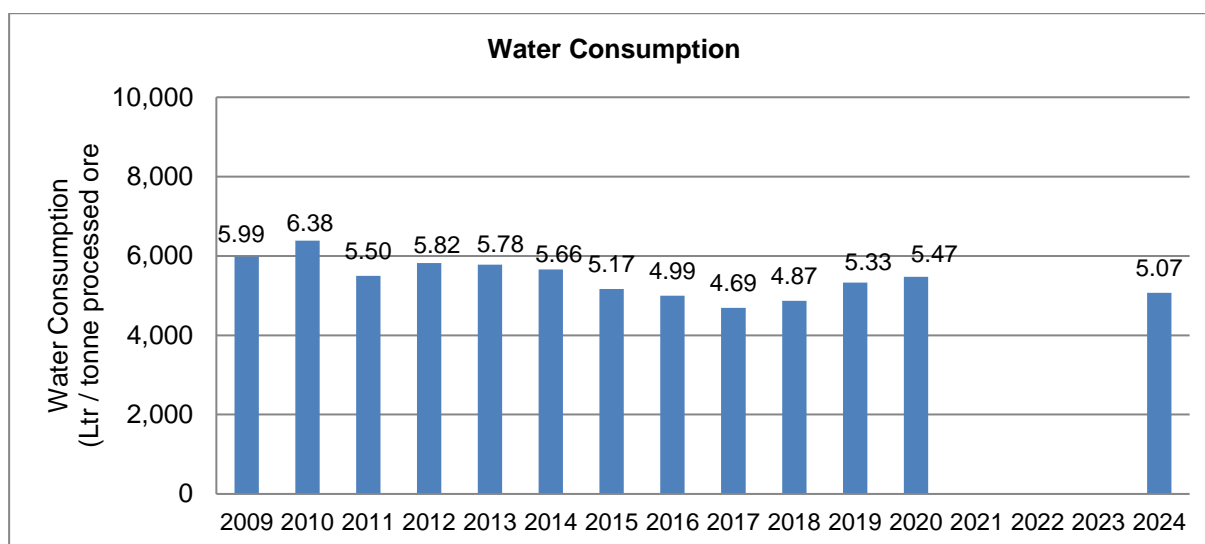


Figure 4-5 Water use efficiency 2009 - 2024

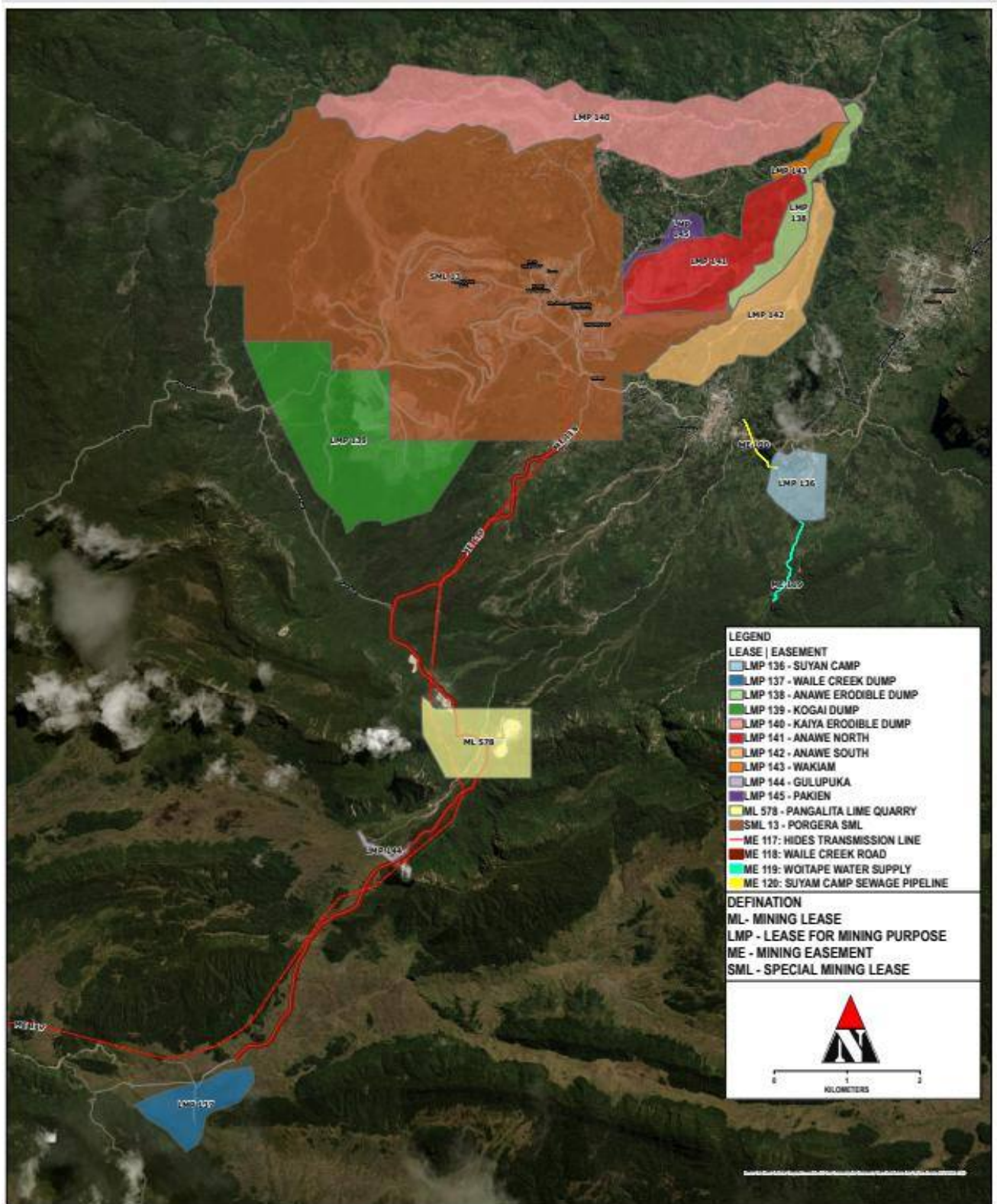
4.3 Land Disturbance

The Porgera mine holds ten leases with a total area of 3,933ha as shown in Table 4-2 and Figure 4-6. The Special Mining Lease (SML) includes the mines, process plant and majority of project infrastructure. The other Leases for Mining Purposes (LMP) are areas associated with the mining operation such as waste rock dumps, Suyan accommodation camp, limestone quarry and water supply. The company also maintains Exploration Leases (EL), which surround the SML and some key LMPs, for on-going exploration. Mining Easements (ME) are held for utilities such as power transmission lines and water supply pipelines. The EL and ME land areas are not included in this report.

The total area disturbed by mining and related activities as of 31 December 2024 was 2,399 ha, equating to 61% of the total leased areas. The total area of disturbance increased by 6.0 ha during 2024, due to construction of a goat track behind Mt.Peruk and Wangima, east of the pit.

Table 4-2 Areas of cumulative land disturbance and reclamation to December 2024

Lease	Total Lease Area (ha)	Total Disturbed Area (ha)	Undisturbed (ha)	Under Progressive Reclamation (ha)
SML	2107	1389	725.2	241
Kogai LMP	424	197	227.3	0
Kaiya LMP	602	345	256.8	0
Anawe North LMP 72	219	122	98.1	0
Anawe South LMP 77	204	133	71.6	0
Anawe LMP3	81	81	0.0	0
Suyan LMP	69	45	24.8	0
Pangalita LMP	135	67	67.7	0
Waile LMP	85	16	69.3	0
Aipulungu Weir LMP	5.8	5.8	0.0	0
TOTAL	3,933	2,399	1,541	241 (10.0% of disturbed)



DEPARTMENT	COMMUNITY & SOCIAL RESPONSIBILITY COMMUNITY LAND ACCESS AGREEMENT-GIS		TITLE: NEW PORGERA LIMITED - NEW TENEMENT LEASES
REQUESTOR:	ENVIRONMENT		
COMPILED BY:	CLAA, GIS	NEW PORGERA LIMITED	MAP DESCRIPTION: MAP SHOWING REVISED TENEMENTS FOR NPL. ALL TENEMENTS ARE LABELLED ACCORDING TO THEIR LEASE AND COLOR CODED TO DIFFERENTIATE THEIR SPATIAL LOCATION.
APPROVED BY:	CLAA MANAGER	P.O BOX 484 MELAKEN 261, WAP, PNG	
DATE:	16/04/2025	TEL: 675200 / 675271 FAX: 675222 www.newporgera.com	DATA SOURCE: IMAGERY: ESRI USGS MAXAR, PROJECTION: AGD 66 AMG ZONE 54, FEATURE: NPL TENEMENTS, HTL
MAP DOC:	NPL TENEMENTS MAP 1		

Figure 4-6 Boundaries of special mining lease and other leases for mining purposes

4.4 Waste Rock Production

The mine generates two types of waste rock which are differentiated by their physical characteristics. Competent or hard rock has high shear strength and is not prone to weathering, and therefore maintains its structural integrity after it has been mined. Incompetent waste rock, comprising colluvium and mudstones has low shear strength and is prone to weathering, breaking down rapidly into sand and silt-sized particles on exposure to air and water after mining. Competent rock is selectively mined and stored in engineered waste rock dumps, which are constructed as a series of terraces into the hillside. Incompetent waste rock is placed in erodible dumps that behave similar to and resemble natural landslides in the area.

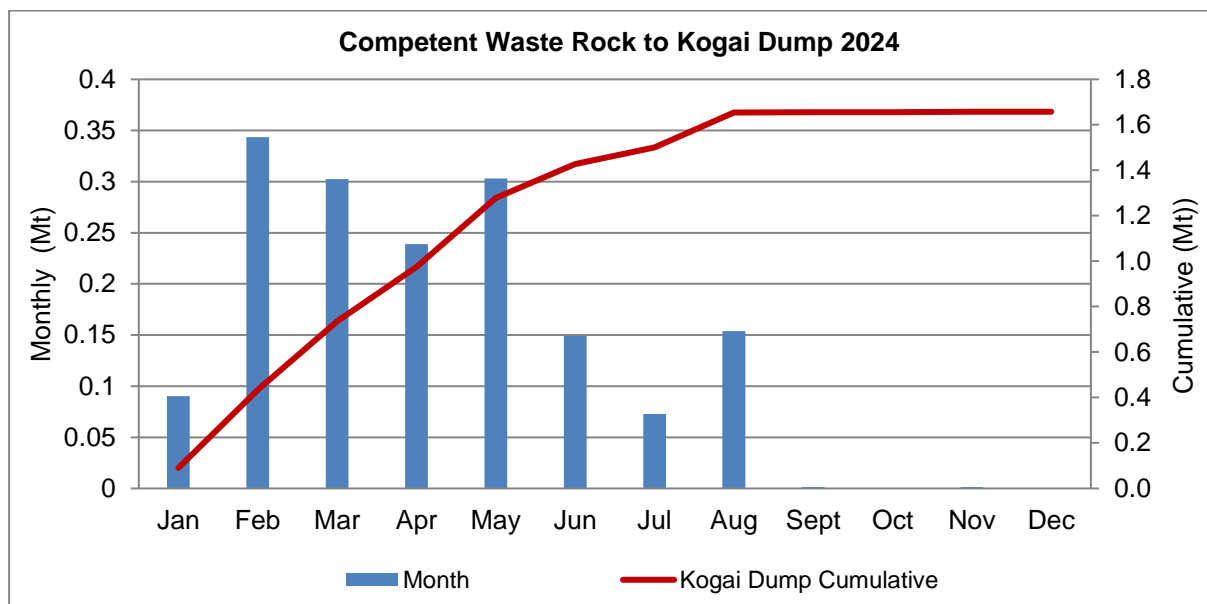
The mass of competent and incompetent waste rock mined between 1989 and 2024 and the corresponding disposal locations are presented in Table 4-3. The data show that to date, the quantity of competent waste rock placed at Kogai dump is approximately twice the total amount placed at Anawe North competent dump since dumping commenced at Anawe in 2001, while similar quantities of incompetent waste rock have been placed in the Anjolek and Anawe erodible dumps.

Table 4-3 Total quantities of waste rock placed in each dump 1989 – 2024

Waste Dump	Total Quantity (Mt)
Anawe North Competent	136.4
Kogai Competent	309.7
Competent Sub-Total	446.1
Anawe Erodible	247.4
Anjolek Erodible	265.1
Erodible Sub-Total	512.5
TOTAL	958.6

4.4.1 Kogai competent dump

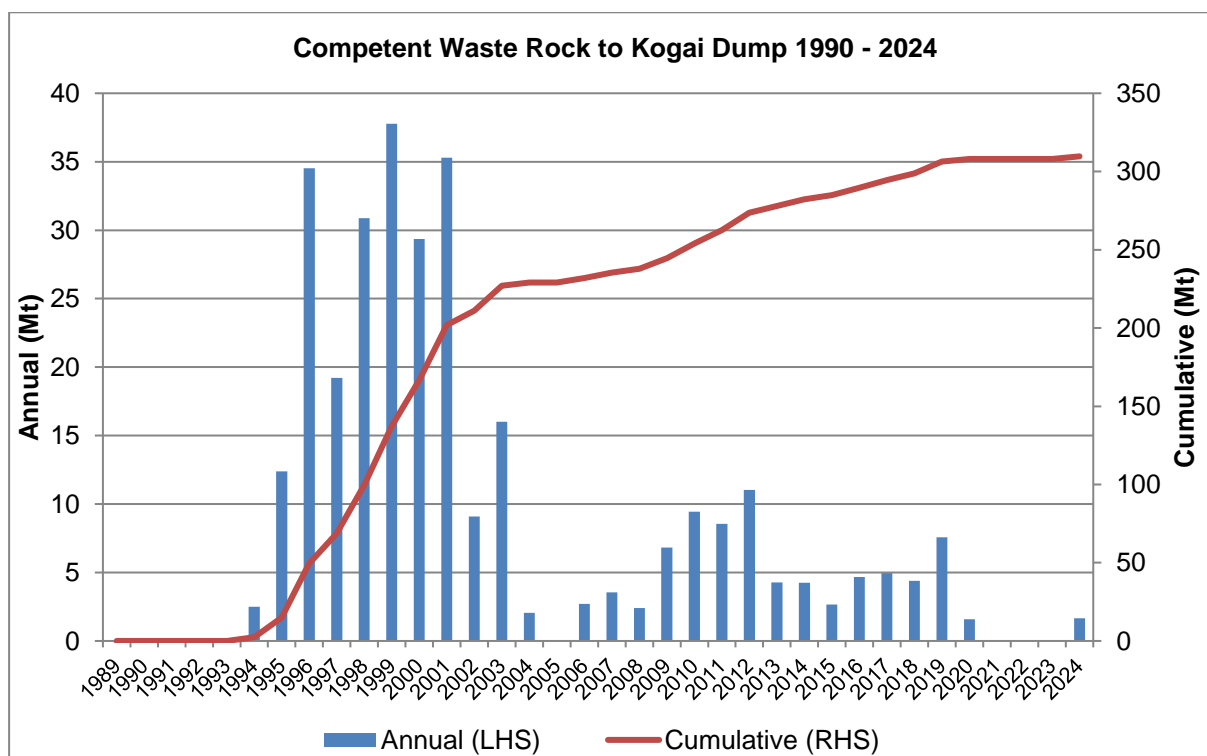
The total quantity of competent waste rock placed at the Kogai competent dump in 2024 was 1.7Mt as shown in Figure 4-7.



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-7 Monthly tonnages of competent waste rock placed at Kogai Dump in 2024

The total quantity of waste rock placed at Kogai competent dump since 1992 was 310Mt. Figure 4-8 shows the annual and cumulative quantities placed at Kogai since construction of the dump began in 1992. As can be seen from the graph, most of the waste was placed between 1995 and 2001 when mining was being carried out at the upper stages of the open pit.

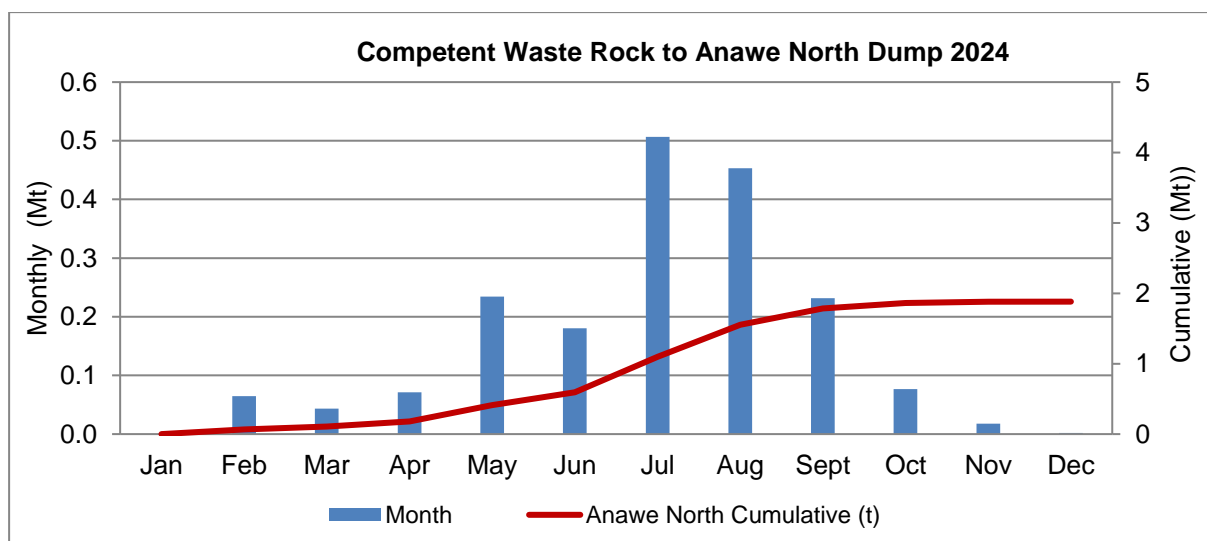


LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-8 Yearly tonnages of competent waste rock placed at Kogai Dump 1989 – 2024

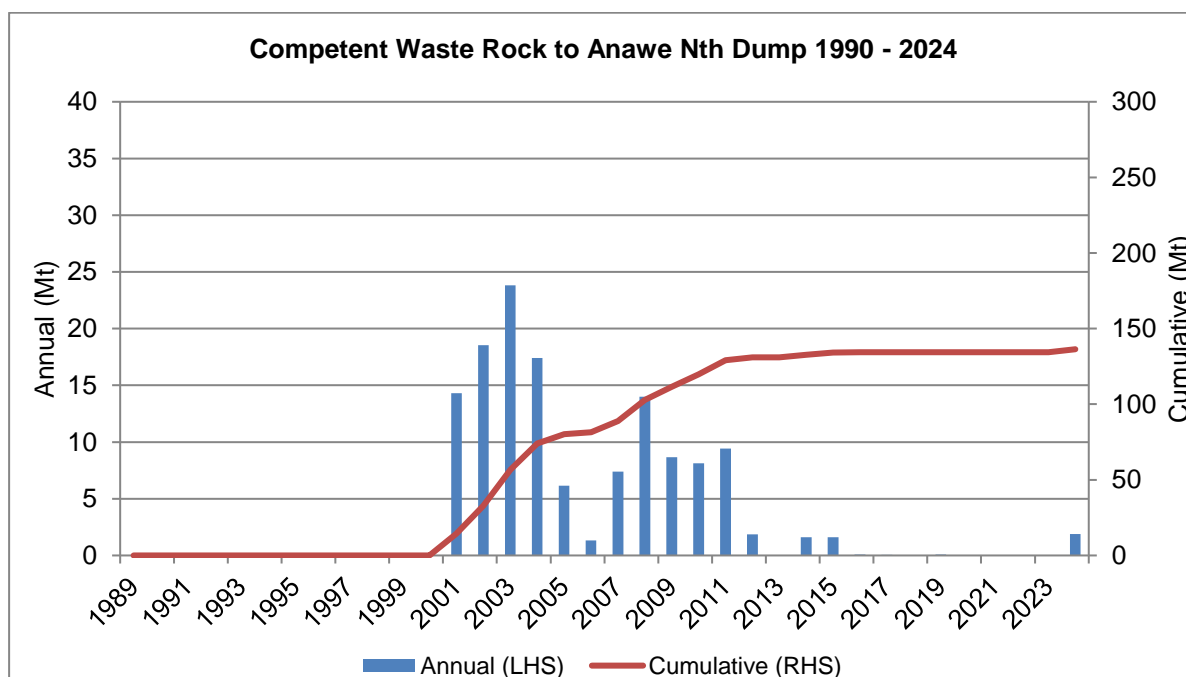
4.4.2 Anawe North competent dump

The Anawe North stable dump received 1.9Mt of competent waste rock in 2024 as shown in Figure 4-9. The total quantity of competent waste rock placed at Anawe North dump since construction began in 2001 was 136.3Mt. Figure 4-10 shows annual and cumulative quantities of competent waste rock placed at Anawe North.



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-9 Monthly tonnages of competent waste rock placed at Anawe North Dump in 2024



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-10 Yearly tonnages of competent waste rock placed at Anawe North Dump 2001-2024

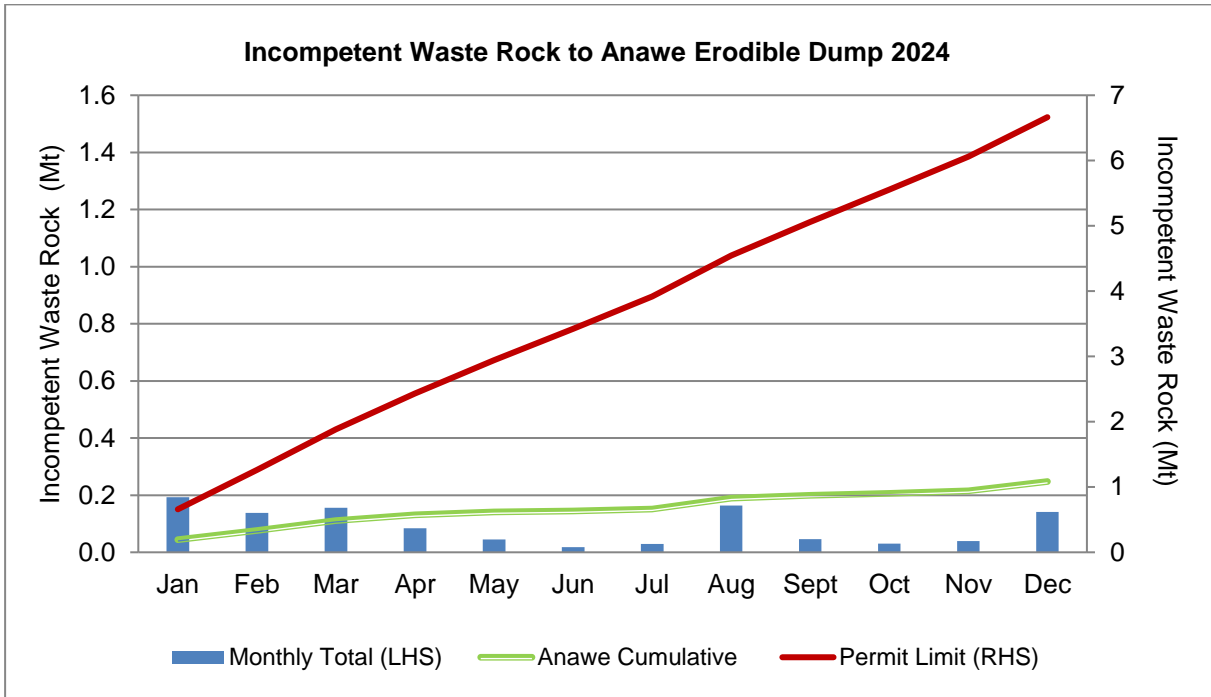
4.5 Incompetent Waste Rock Disposal

Incompetent waste rock is disposed in either the Anawe or Anjolek erodible dumps. Fluvial processes from rainfall runoff gradually erode the unconsolidated waste from within the dumps into the river system. The total quantity of incompetent waste rock placed during 2024 was 7.7 Mt, while a total of 9.5 Mt was

placed between 2020 to 2023 (2019 being the most recent total reported in the Annual Environment Report of that year). Placement rates between 2020 and 2024 were generally low compared with previous years.

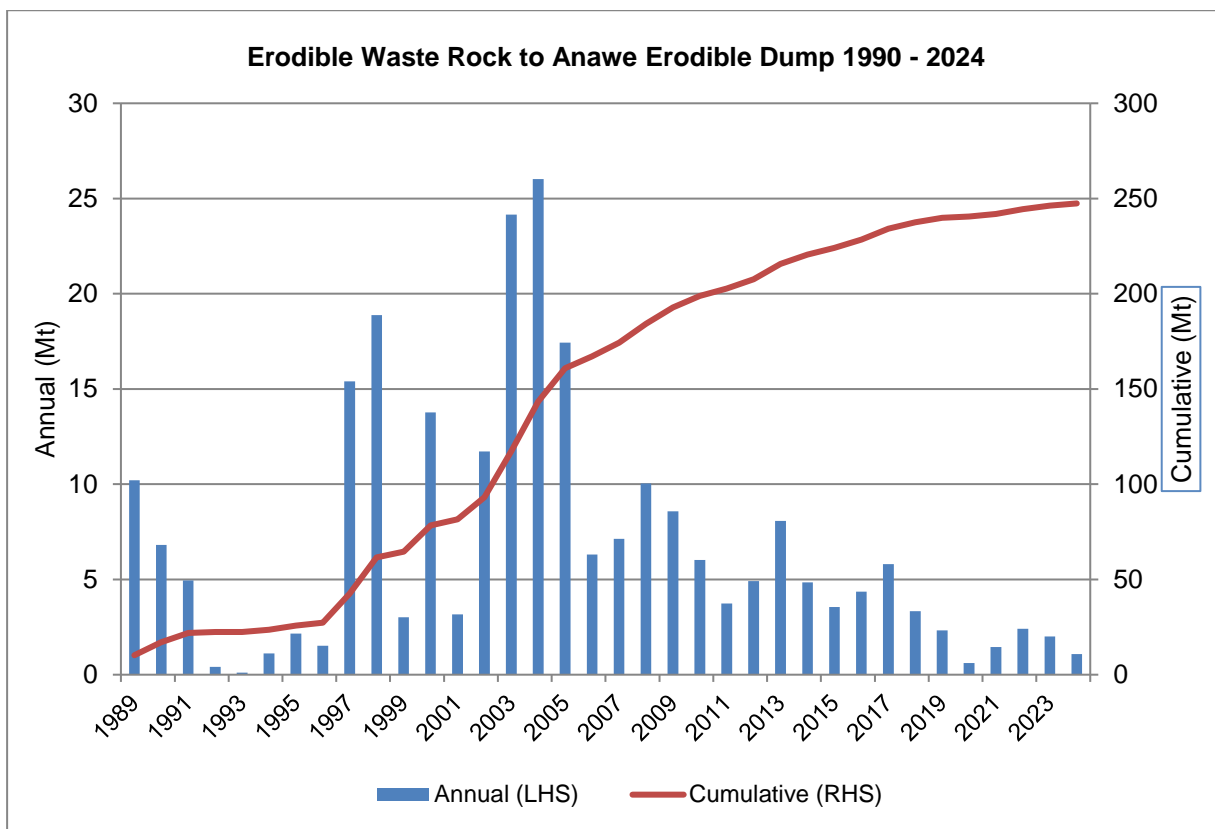
4.5.1 Anawe erodible dump

Monthly tonnages of incompetent waste rock disposed to Anawe erodible dump in 2024 are shown in Figure 4-11. A total of 1.1 Mt of incompetent waste rock was placed in Anawe during the year. The quantity placed was 7.3% of the annual permit limit of 15.1Mt. Figure 4-12 shows the annual tonnages of incompetent waste rock placed in the Anawe dump since dumping began there in 1989. Figure 4-13 shows the cumulative surface area and volume of the dump since 2001.



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-11 Monthly tonnages of incompetent waste rock placed at Anawe Erodible Dump in 2024



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-12 Yearly tonnages of incompetent waste rock placed at Anawe Erodible Dump 1989-2024

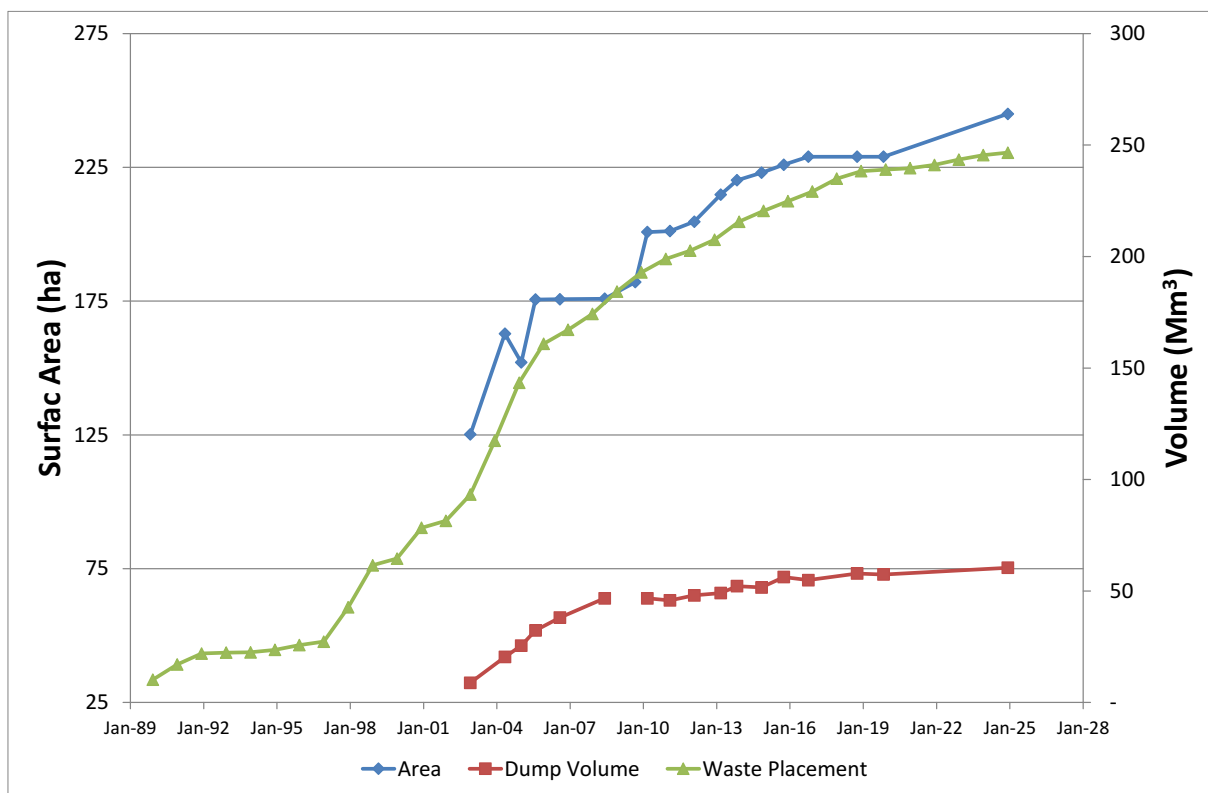
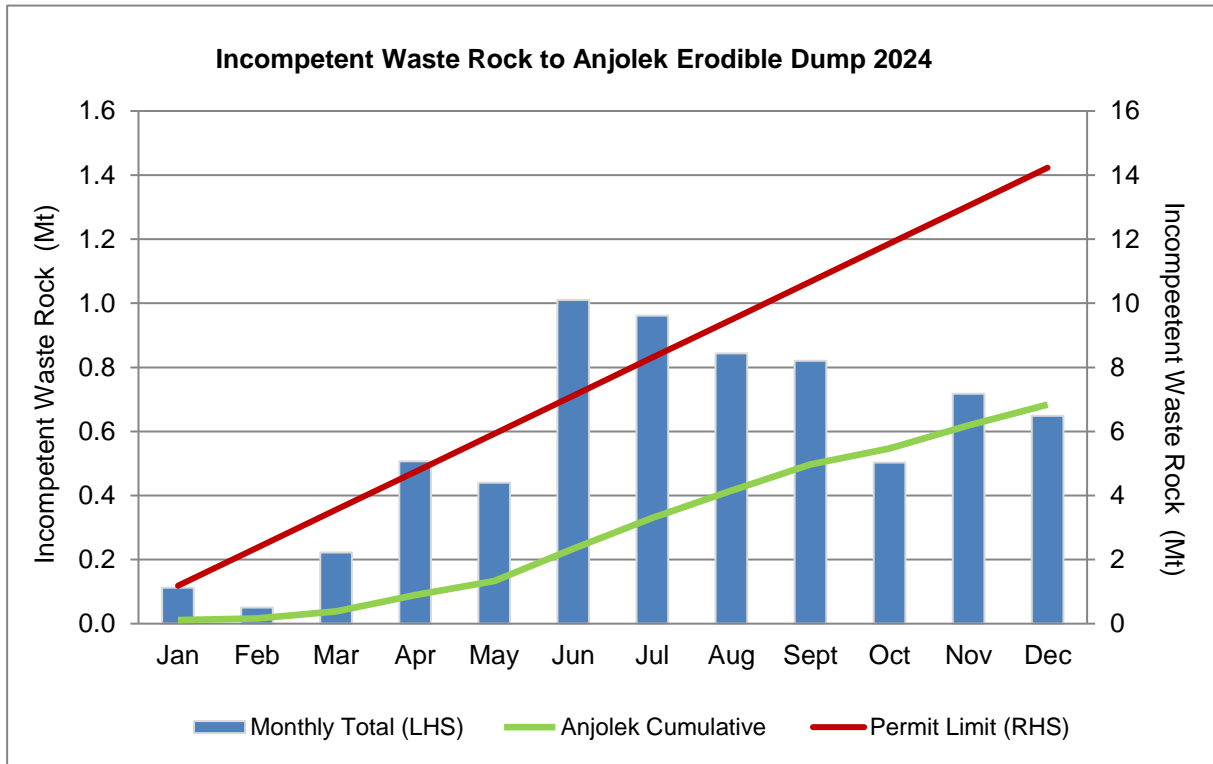


Figure 4-13 Area, volume of waste placed in the dump (Waste Placement) and volume of Anawe Erodible Dump based on LiDAR survey 2001-2024

4.5.1 Anjolek erodible dump

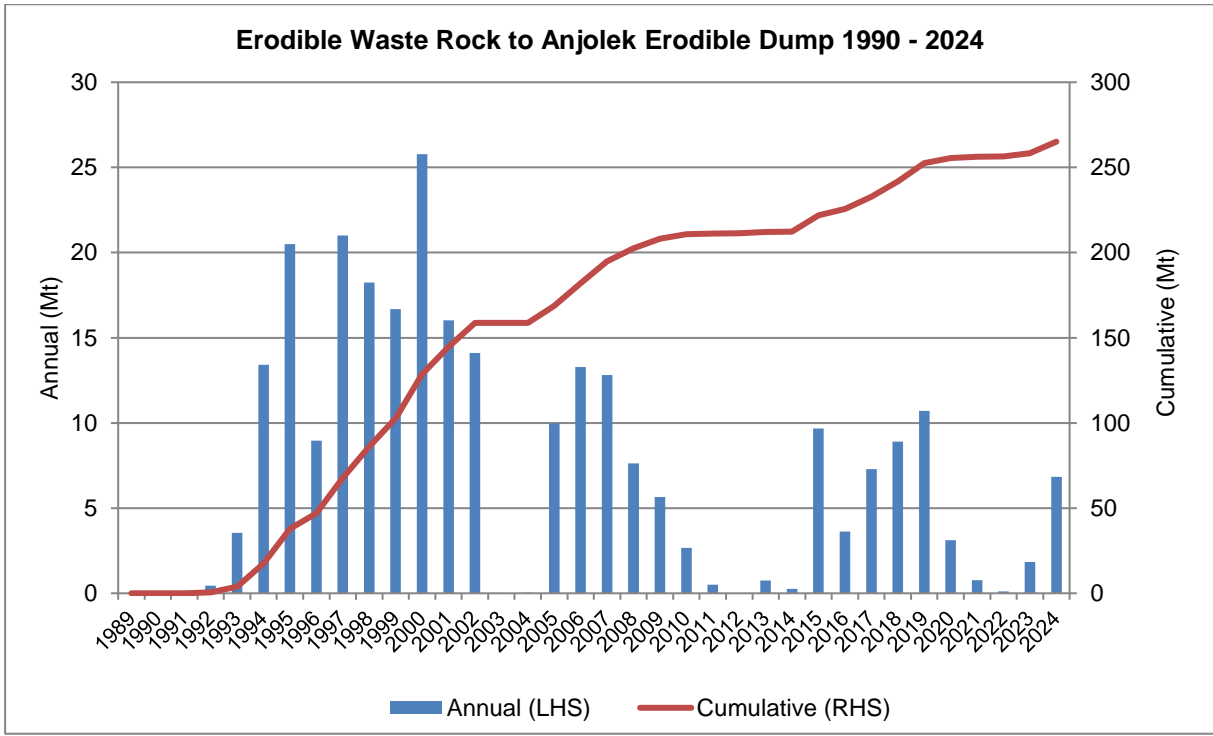
Figure 4-14 shows monthly tonnages of incompetent waste rock disposed to Anjolek erodible dump during 2024. A total of 6.8 Mt was placed during the year. The volume discharged in 2024 was equivalent to 46% of the annual permit limit of 14.2Mt and represents the highest annual total placed to the dump since 2018.

Figure 4-15 shows the tonnage of incompetent waste rock placed in the Anjolek erodible dump since dumping began there in 1992. Figure 4-16 shows the cumulative surface area and volume of the dump since 2001.



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-14 Monthly tonnages of incompetent waste rock placed at Anjolek Erodible Dump in 2024



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-15 Yearly tonnages of incompetent waste rock placed at Anjolek Erodible Dump 1992-2024

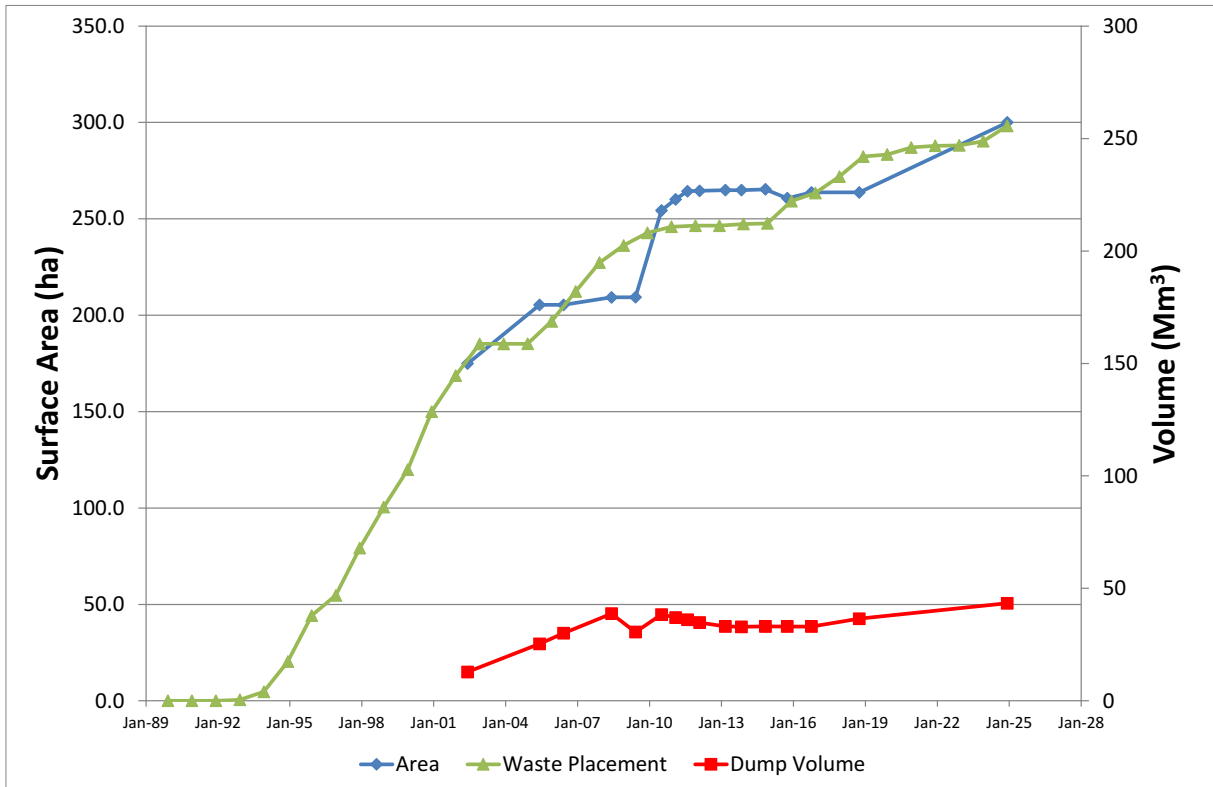


Figure 4-16 Area, volume of waste placed in the dump (Waste Placement) and volume of Anjolek Erodible Dump based on LiDAR survey 2001-2024

4.6 Status of the Erodible Dumps in 2024

A helicopter LiDAR survey of both Anawe and Anjolek erodible dumps was undertaken in November 2024 and was the first survey of Anawe since 2019 and Anjolek in 2018.

Although the rate of waste dumping in 2024 was the highest since 2018, there was very little mining and waste disposal activity between 2019 and 2023, and rates of waste dumping continued to be relatively low in a historical context. The total amount dumped to Anawe was 1.08 Mt and Anjolek received 6.6 Mt which is the highest annual total since 2018 but is still substantially less than peak dumping rates reported in the 2000s, where the combined annual rate peaked at almost 40 Mt in 2000.

4.6.1 Anawe erodible dump

An aerial inspection undertaken in early 2025 showed that there had been relatively little significant change to the overall morphology of Anawe dump since 2019 observations noting that 2024 survey data showed a net gain of dump volume since the previous 2019 survey. Of note, there had been notable erosion of the upper tract of the dump between the tip heads and the Pongema River Fan, but an equally notable accumulation of volume in the lower tract between the Pongema Fan and Toe. It was also noted that while the upper dump tract (above the Pongema River Fan) had little vegetation cover, the lower tract had significantly more. Noting that there had been little waste placement since 2019, this was interpreted to represent dumped waste flowing across the surface of the upper tract and 'thrusting-up' material in the lower tract (Figure 4-17).

- **Tip-heads and upper tract:** Survey data show that the current dump surface is currently some 10-20 m below the level of the original ground topography and has remained at a similar elevation since 2014 (indicating historic scouring). The current dump surface begins to rise above the original ground surface at a location between the Maiapam Area and the Pongema River Fan – opposite to Anawe North Dump and had continued to remain at a similar elevation since 2016. In the Upper Tract, the 2019 surface is close to or just below the level of the 2018 surface, showing a degree of surface erosion in this zone.
- **Maiapam Area to Pongema River Confluence (historical overspill area):** Some degradation is notable in this region with the 2024 surface level of the dump at a lower elevation compared with the previous few years.
- **Confluence with Pongema River (including Pongema Fan).** There has been notable thickening of the dump adjacent to and downstream of the Pongema River Fan since 2019.
- **Between the Pongema River Fan to a location just above the toe,** the dump shows thickening, and an elevated surface level compared with the 2019 survey and up to 50 m above the original ground surface in places. Most of the aggradation occurred on the central and northern parts of the dump, with erosion noted adjacent to the Pongema River on the south flank of the dump. This indicates that fluvial removal of dump material by the Pongema River is occurring.
- **Toe area:** Material is removed from the dump as it flows laterally into the Pongema River on the Southern Flank and by local runoff and tailings flows from the North Flank below Anawe North Dump. Thinning of the toe is evident (of some 10 to 20 m), indicating upstream progressing erosion. (Figure 4-18). It also indicates that the sediment transport capacity of the river at the toe now exceeds the rate of supply of sediment. The most recent (Q2 2024) review of Anawe Erodible Dump by the Mine Geotechnical Department noted that there had been material accumulation and deposition below the toe of Anawe Stable Dump but no signs of progressing further into Pongema-Anawe tributaries. Only finer material was observed to be flowing into the river below.



Figure 4-17 Upper Tract of Anawe Dump showing eroded surface and ‘upthrust’ zone with vegetation cover



Figure 4-18 Anawe erodible dump toe

4.6.2 Anjolek erodible dump

LiDAR and aerial photographic surveys of Anjolek were undertaken in November 2024 and April 2025 respectively. The survey indicated that there had been an increase in the volume of the dump since the 2019 survey. Difference mapping showed areas of fresh waste were present along the length of the dump. Previous observations and analyses suggest that waste material is more likely to ‘raft’ down the surface of Anjolek due to its relatively high longitudinal slope (compared with Anawe). The photographs suggest that:

- In the Upper Tract there has been some build-out of the tip head and in the runout zone immediately below the tip-head, noting this area is scoured relative to the original ground surface. Below the tip-head, the dump surface is at a relatively low elevation consistent with levels since 2016.
- More notable aggradation/waste accumulation is evident between the Aiyoko Ridge area and the Kaiya River Confluence (also noted by the Q4 2024 NPL geotechnical inspection report).
- Between the Kaiya River Confluence and the toe, the dump surface is generally consistent with the 2018 and 2019 surfaces, but areas of aggradation are noted. In late 2016, the Kaiya River reverted to a former course that ran adjacent to the northern slopes, from a position that occupied a central course through the dump. The river appears to be continuing to follow that course and there appears to have been no substantial change to those patterns of erosion. The Q4 2024 Geotechnical Inspection report noted that deposition of coarse alluvial material had shifted the flow of Kaiya River towards the Western Hill side under-cutting the slope and triggering erosion and landslides. This erosion (referring to the Nikelama and Lepelama slopes) is a persistent long-term process where fluvial undercutting causes erosion of historically unstable overlying slopes.
- At the toe area, there has been some aggradation/build-up of waste material (Figure 4-19).
- Fresher dumped material appears to be 'rafting' down on top of the former surface (Figure 4-20)
- From a review of the aerial photographs, there appeared to have been little notable change to the morphology of the Kaiya River between the Anjolek Toe and the Pongema River confluence. However, the Yuyane Bridge has partially collapsed by outflanking of its abutments indicating continued high rates of sediment delivery from the Anjolek Dump and channel widening in certain areas.



Figure 4-19 Anjolek Dump – lower toe area



Figure 4-20 Dumped material 'rafting' downslope (view downstream from Aiyoko Ridge area)

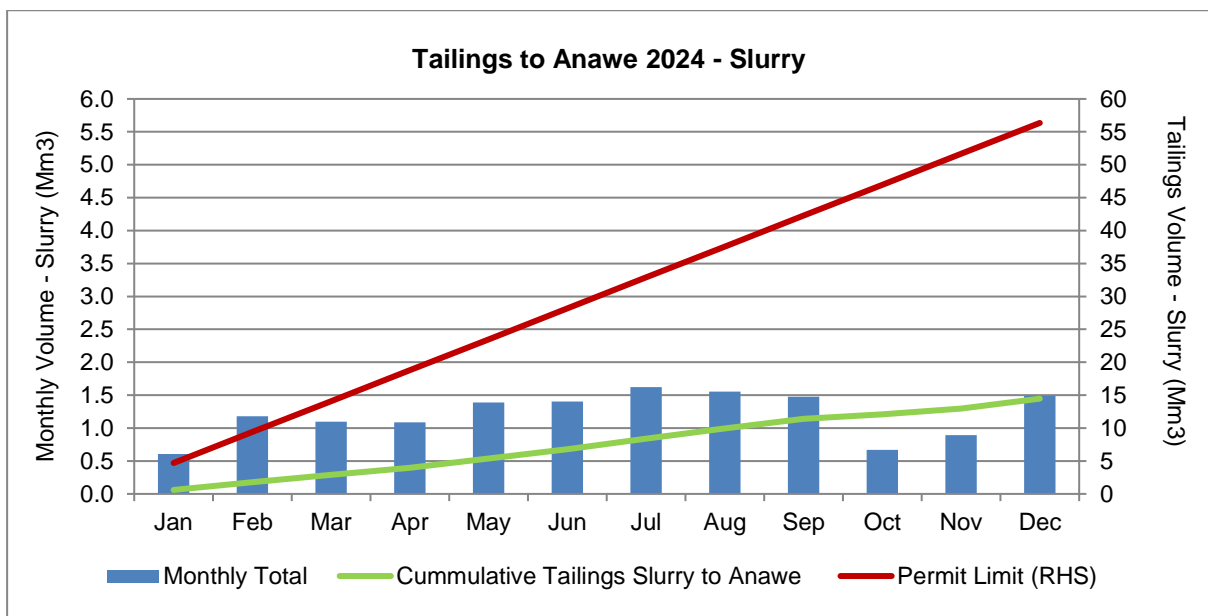
In summary, the most recent survey for both dumps showed that, despite the low rates of dumping since 2019, neither dump had eroded significantly during that period, rather it appears that, in the absence of waste dumping, the dumps revert to relatively stable landforms with sediments gradually removed predominantly by ongoing fluvial erosion by the Pongema River (Anawe) and the Kaiya River (Anjolek). This is analogous to the observed behaviour of the adjacent Maiapam Slide mass which is a useful model to consider for closure purposes.

4.7 Tailings Disposal

4.7.1 Riverine tailings disposal

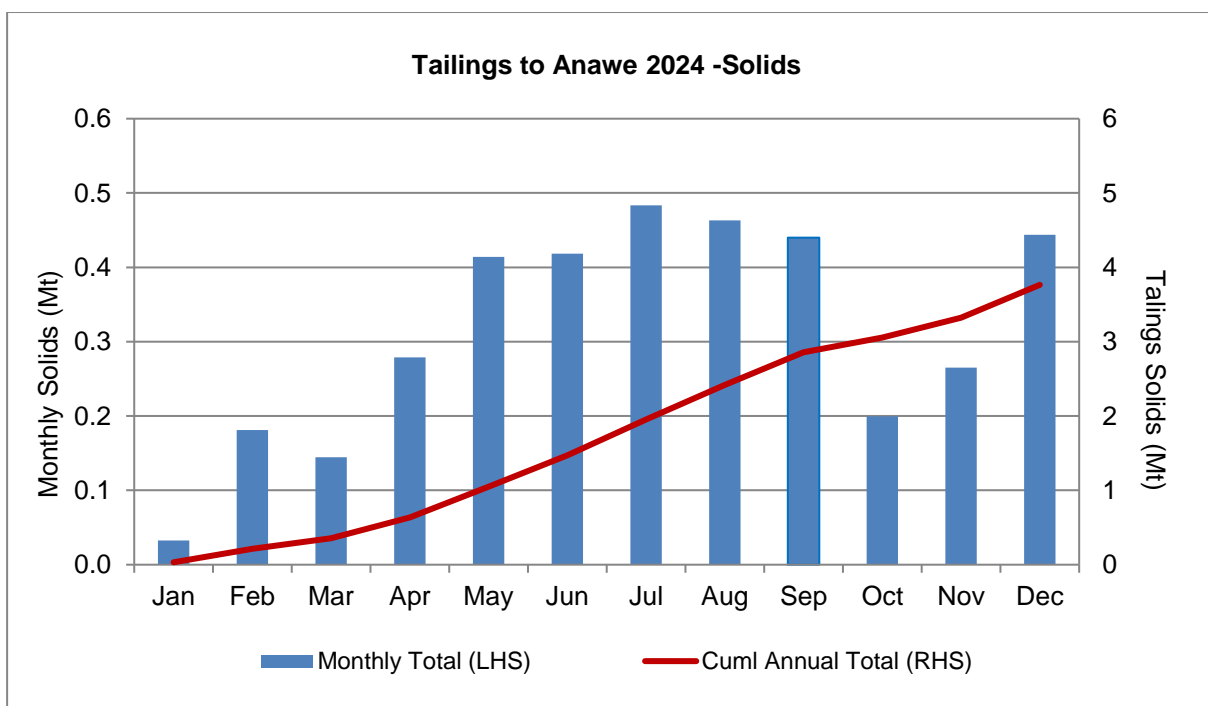
Monthly and cumulative volumes (Mm^3) of tailings slurry, the mixture of solids and water, discharged in 2024 are shown in Figure 4-21 and compared against the permit limits. The total volume of tailings slurry discharged in 2024 was 14.47 Mm^3 and is compliant with the environmental permit limit of 56.35 Mm^3 .

The monthly and yearly mass (t) of tailings solids discharged are shown in Figure 4-22 and Figure 4-23 respectively. The total mass discharged since operations began was 139.4 Mt. The historical mass discharges are reported in tonnes for comparison with the erodible waste rock discharge mass. No tailings has been discharged when the site was in care and maintenance from May 2020 to December 2023.



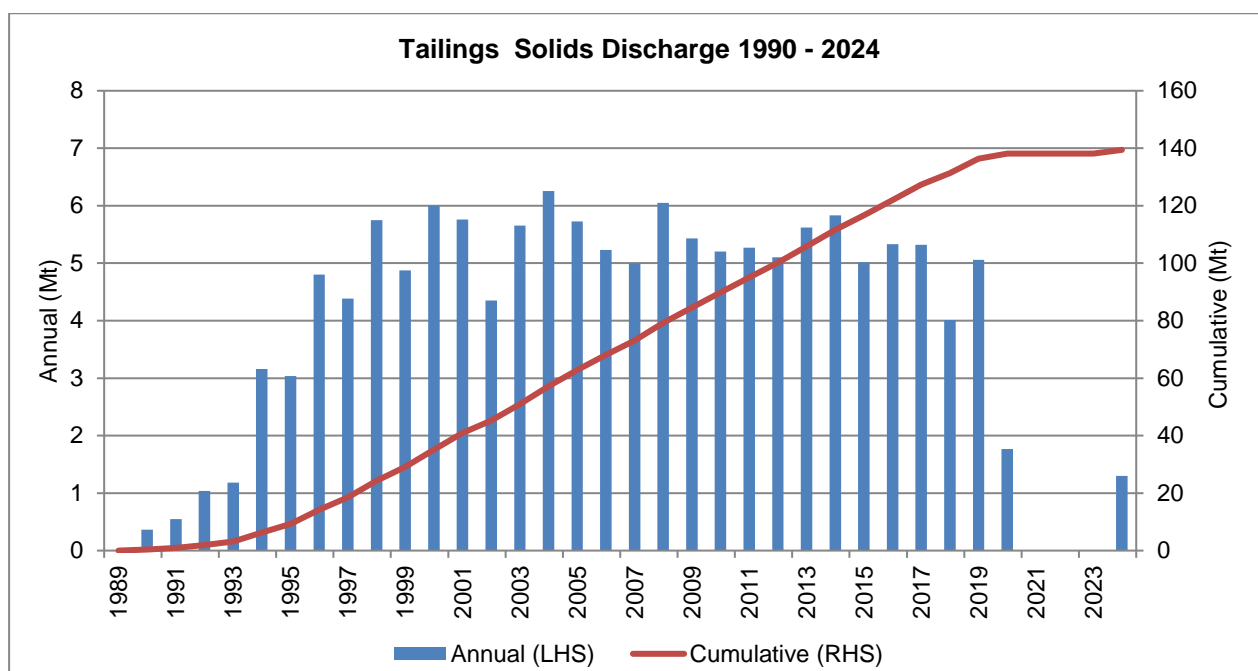
LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-21 Monthly and cumulative tailings slurry discharge volumes (Mm³) 2024



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-22 Monthly and cumulative tailings discharge mass (Mt dry solids) 2024

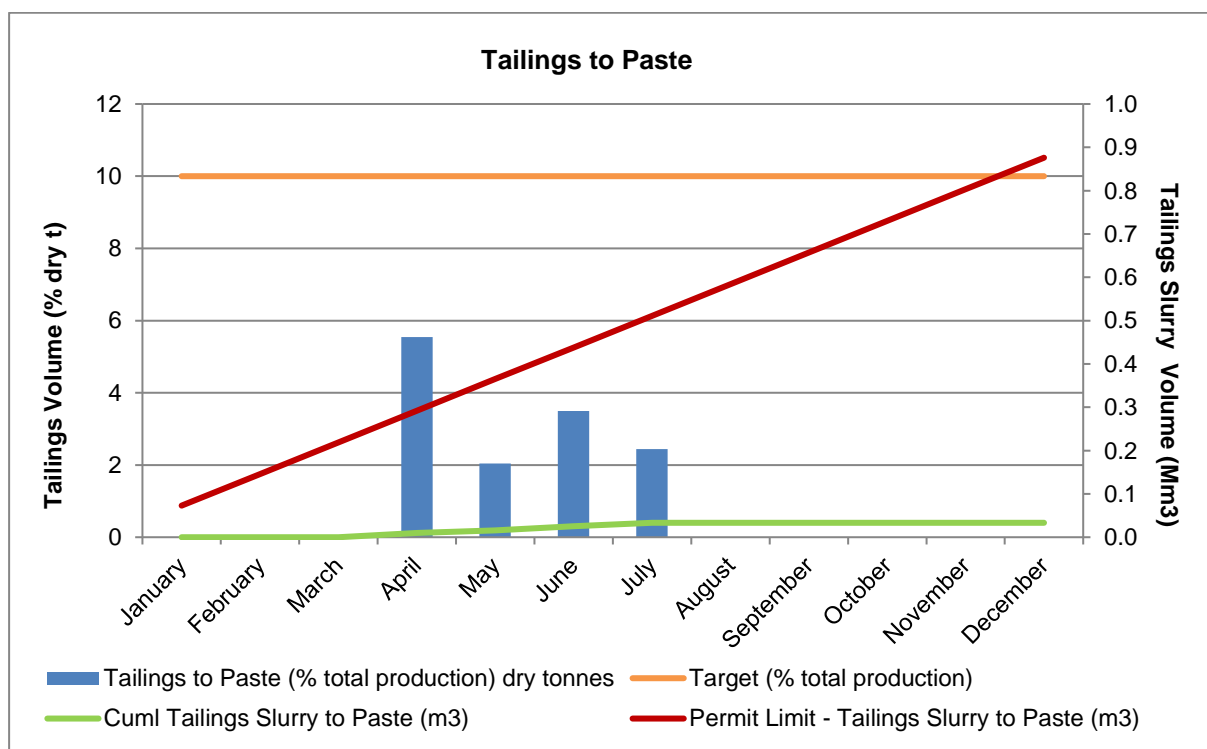


LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-23 Annual and cumulative tailings discharge mass (Mt) (dry solids) (1990-2024)

4.7.2 Tailings used as underground mine backfill

The monthly and cumulative volumes of tailings diverted to the underground mine for use as paste backfill are shown in Figure 4-24 against the environmental permit limit. A total of 33,294 m³ was diverted to paste in 2024, which is 1.8% of the total tailings volume produced. There was no paste production during the month due to the Mulitaka landslip having an impact on cement supplies to the mine.



LHS = Left-hand side y-axis, RHS = Right-hand side y-axis

Figure 4-24 Tailings diverted to underground backfill in 2024

4.8 Tailings Quality

Contaminants of concern within the tailings discharge are cyanide (CN), total suspended solids (TSS) and metals. The quality of the discharge is influenced by the geochemistry of the ore, the gold extraction process and the tailings treatment circuit. Tailings treatment is managed to ensure compliance with internal site-developed requirements for pH and WAD-CN at the discharge point, permit requirements at the SG3 compliance monitoring station and to mitigate the risk of environmental impact within the receiving environment downstream from the point of discharge.

The slurry density, which influences the TSS concentration of the tailings, and the rate of discharge have remained relatively consistent throughout the history of the operation. The median TSS concentration in 2024 was slightly higher than 2019 for the operational period. Monthly and annual TSS concentrations in the tailings discharge are shown in Figure 4-25 and Figure 4-26.

The pH of the tailings discharge is dictated by the geochemistry of the ore, the gold extraction process and by the addition of lime during tailings treatment. Controlling pH is critical for limiting the concentration of dissolved/bioavailable metals in the discharge. A range of metals within the discharge have the potential to impact the downstream environment if the treatment process is not managed appropriately to reduce their bioavailability. The metals are found naturally within the ore body and pass through the process plant with the tailings. A portion of the metals are dissolved during the pressure oxidation stage of the process plant, where pH reaches as low as pH 1. Adding lime raises the pH of the final combined tailings stream and precipitates the metals as solid forms such as hydroxides, which are less bioavailable. In addition, some metals will also adsorb to particulate matter as the pH increases, further reducing the bioavailable concentrations.

The PNG Government has not established compliance targets for tailings quality at the discharge point. NPL has therefore established its own end-of-pipe criterion for pH and WAD-CN, designed to mitigate human health and environmental risks.

Discharge pH for 2024 is shown in Figure 4-27, and the results from 2015 – 2024 are shown in Figure 4-28. The high level of compliance with the targets is attributable to the implementation in 2013 of greater process control in the form of a trigger-action-response plan (TARP) which facilitates proactive control and initiates corrective action in the event of pH excursion outside the target range throughout the process stream. Discharge pH for the period 1994 – 2024 is shown in Figure 4-29.

Cyanide concentrations within the tailings discharge are dictated by the amount of cyanide added to the circuit for gold extraction and the effectiveness of the cyanide destruction plant, which is part of the tailings treatment circuit. Weak Acid Dissociable Cyanide (WAD-CN) concentrations in the tailings discharge during 2024 were low and 100% in compliance with the internal site-developed end of pipe criterion of <0.5 mg/L. The monthly WAD-CN results for 2024 are shown in Figure 4-30. The performance achieved during 2024 has continued the trend of low WAD-CN concentrations demonstrated since the commissioning of the cyanide destruction plant in 2009. Similar to pH, the improved consistency achieved since 2013 is attributable to the implementation of greater process control in the form of a TARP for managing the operation of the treatment circuit.

Monthly concentrations for 2024 and annual concentrations between 2015 and 2024 are shown as box plots in Figure 4-33 to Figure 4-54 for all metals. An explanation of box plots is given in APPENDIX B..

The 20th percentile, median and 80th percentile concentrations of total and dissolved metals in the tailings slurry during 2024 are shown in Table 4-4. A comparison of tailings quality against the upper river risk TVs provides an assessment of which stressors within the tailings discharge posed a potential risk to the downstream environment. The results showed that median EC and median concentrations of TSS, dissolved cadmium, copper, nickel and zinc were elevated in the tailings discharge compared with upper river trigger values and therefore posed a potential risk to the receiving environment. Moderate proportions of cadmium (0.34%), nickel (1.1%) and zinc (0.15%) were present in dissolved forms throughout 2024 as shown in Table 4-5.

Weak-Acid-Extractable (WAE) metals concentrations in tailings solids are presented in Table 4-6. The median concentrations of WAE arsenic, WAE cadmium, WAE copper, WAE lead, WAE selenium and WAE zinc were higher than the upper river TVs and therefore posed a potential risk to the receiving environment.

Table 4-4 Tailings slurry discharge quality 2024 (µg/L except where shown), sample count (n) = 48

Parameter	UpRiv TV	20%ile	Median	80%ile
pH	6.0-8.2	6.5	6.9	7.7
EC	230	907	1,657	2,426
WAD-CN*	NA	0.20	0.20	0.20
Sulfate*	NA	508	795	1,790
ALK-T*	NA	94	131	233
TSS*	2,837	30,000	105,000	140,000
Hardness*	NA	340	1,849	3,513
Ag-D	0.05	0.01	0.01	0.01
Ag-T	NA	222	865	1,800
As-D	24	0.63	2.3	3.1
As-T	NA	9,940	20,500	32,200
Cd-D	0.32	0.24	2.5	21
Cd-T	NA	538	1,105	1,460
Cr-D	1.0	0.10	0.10	0.10
Cr-T	NA	5,840	10,700	16,000
Cu-D	1.4	0.79	2.5	8.7
Cu-T	NA	8,660	13,800	21,800
Fe-D	75	4.3	10	59
Fe-T	NA	3,088,000	5,885,000	7,878,000
Hg-D	0.60	0.050	0.050	0.050
Hg-T	NA	17	43	104
Ni-D	21	1.3	104	392
Ni-T	NA	1,720	4,950	7,600
Pb-D	6.7	0.10	0.35	1.4
Pb-T	NA	33,800	73,000	98,600
Se-D	11	0.20	0.79	2.8
Se-T	NA	100	100	146
Zn-D	20	12	1,035	3,320
Zn-T	NA	67,000	165,000	230,000
	> UpRiv TV = Potential Risk			

^ std units, # µS/cm, * mg/L, **mg CaCO₃/L, D - Dissolved fraction, T – Total, NA – Not Applicable

Table 4-5 Percentage of total metals in tailings in dissolved form in 2024

Parameter	% Total in Dissolved Form 2024		
	20th%ile	Median	80th%ile
Ag-D	0.001	0.002	0.002
As-D	0.006	0.01	0.01
Cd-D	0.11	0.34	1.3
Cr-D	0.001	0.001	0.001
Cu-D	0.013	0.02	0.09
Fe-D	0.01	0.05	0.09
Hg-D	0.10	0.15	0.16
Ni-D	0.58	1.1	3.7

NPL Annual Environment Report 2024

Parameter	% Total in Dissolved Form 2024		
	20th%ile	Median	80th%ile
Pb-D	0.0001	0.001	0.002
Se-D	0.65	0.89	1.3
Zn-D	0.15	0.15	1.5

D – Dissolved fraction

Table 4-6 Tailings solids discharge quality 2024 (mg/kg dry weight, whole fraction), sample count (n) = 48

Parameter	UpRiv TV	20th%ile	Median	80th%ile
Ag-TD	NA	8.7	13	52
Ag-WAE	1.0	0.30	1.6	8.3
As-TD	NA	77	180	216
As-WAE	20	12	42	75
Cd-TD	NA	7.1	9.9	18
Cd-WAE	1.5	3.3	4.4	11
Cr-TD	NA	83	110	126
Cr-WAE	80	18	29	36
Cu-TD	NA	102	145	732
Cu-WAE	65	60	84	794
Fe-TD	NA	39,520	49,450	57,920
Fe-WAE	NA	9,668	13,150	19,260
Hg-TD	NA	0.29	0.41	0.71
Hg-WAE	0.15	0.01	0.04	0.13
Ni-TD	NA	35	48	60
Ni-WAE	21	11	19	28
Pb-TD	NA	434	625	1,054
Pb-WAE	50	55	160	814
Se-TD	NA	0.83	1.0	1.3
Se-WAE	0.22	0.19	0.31	0.56
Zn-TD	NA	1,214	1,515	1,952
Zn-WAE	200	538	635	944
> UpRiv TV = Potential Risk				

WAE – Weak-acid extractable, TD - Total digest, NA – Not Applicable

NPL Annual Environment Report 2024

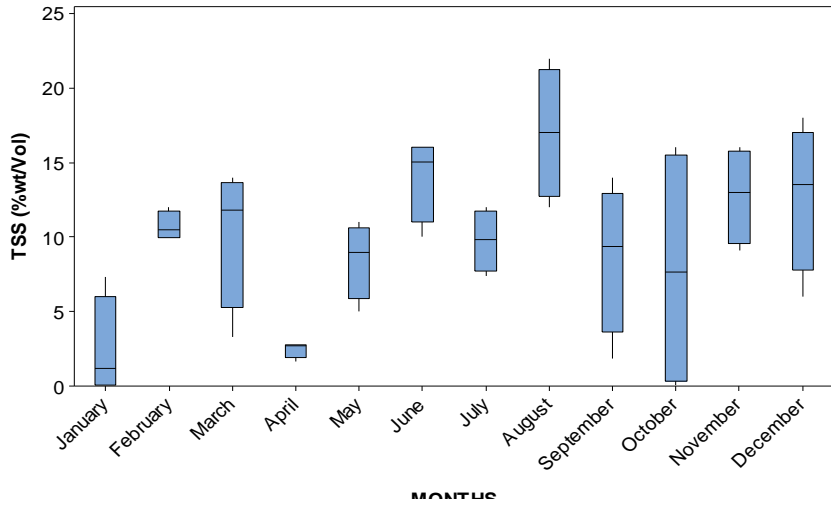


Figure 4-25 Monthly TSS in tailings discharge in 2024

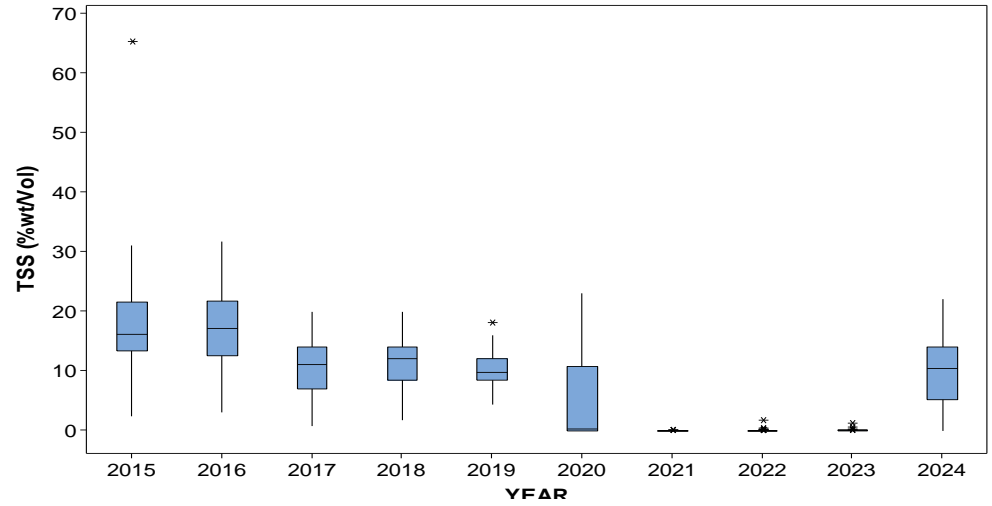


Figure 4-26 Annual TSS in tailings discharge 2015-2024

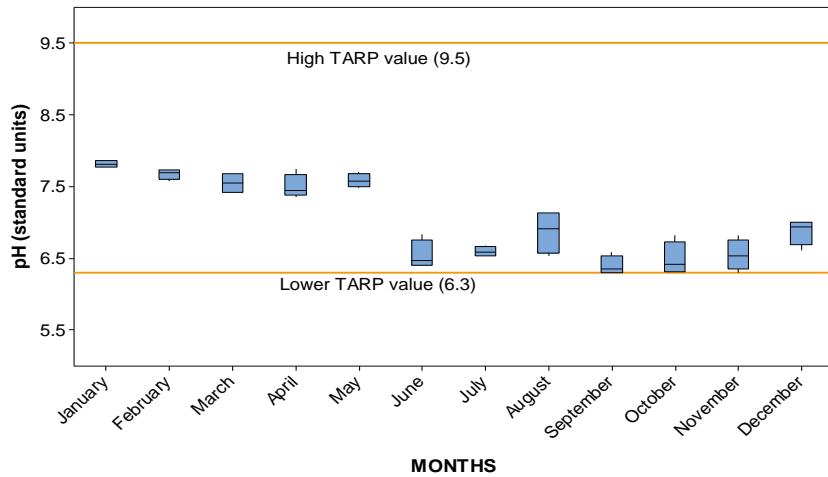


Figure 4-27 Monthly pH in tailings discharge in 2024

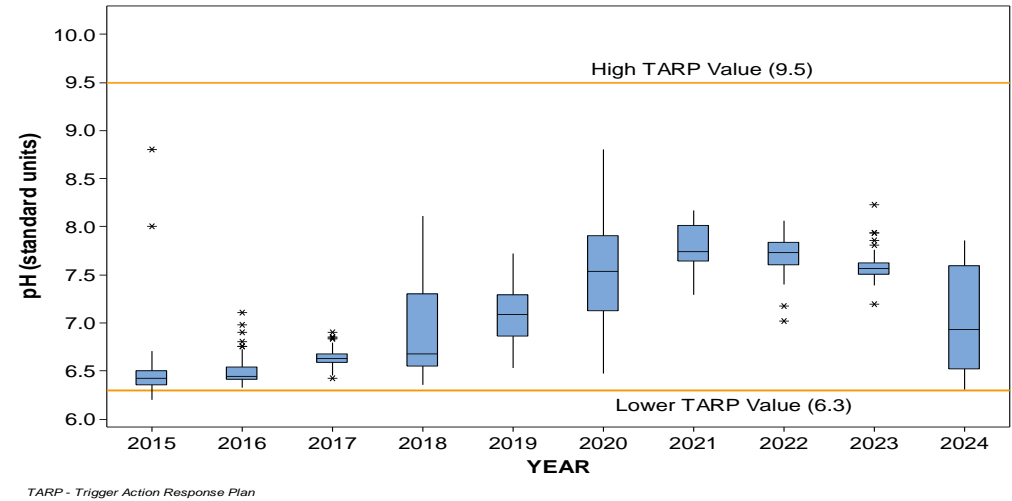
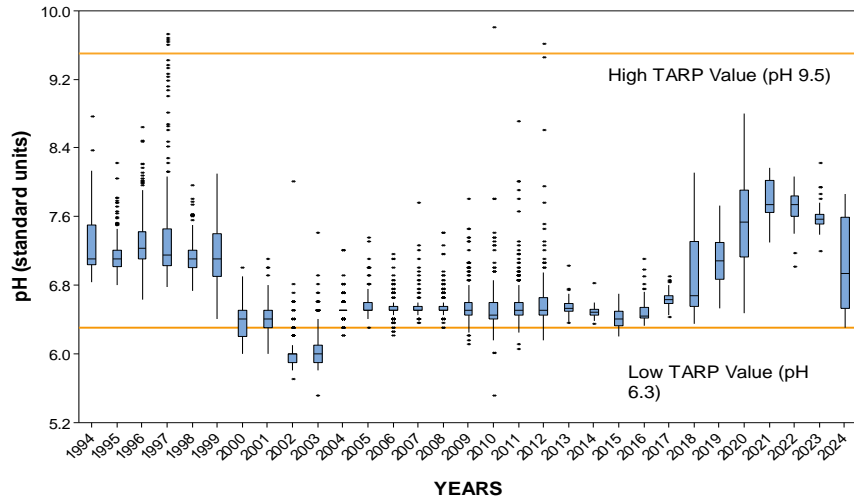


Figure 4-28 Annual pH in tailings discharge 2015-2024

TARP - Trigger Action Response Plan

TARP - Trigger Action Response Plan



Intentionally left blank

Figure 4-29 pH in tailings discharge 1994-2024

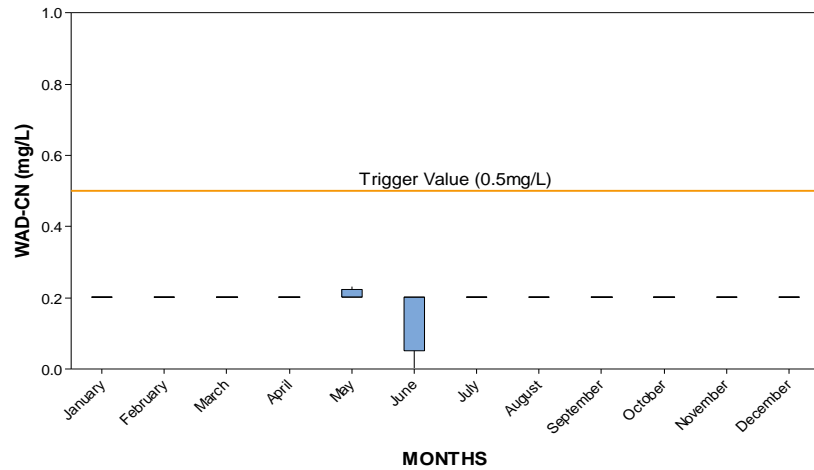


Figure 4-30 Monthly WAD-CN concentration in tailings discharge in 2024 (mg/L)

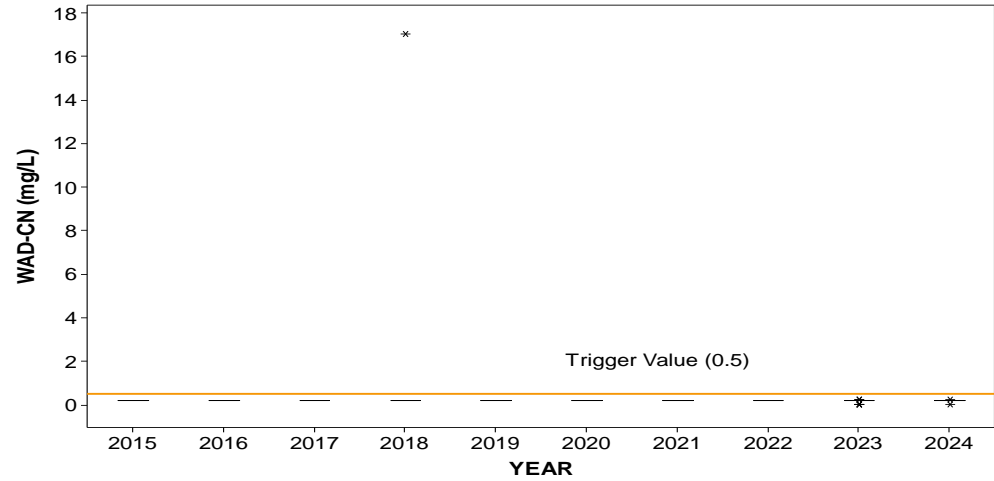
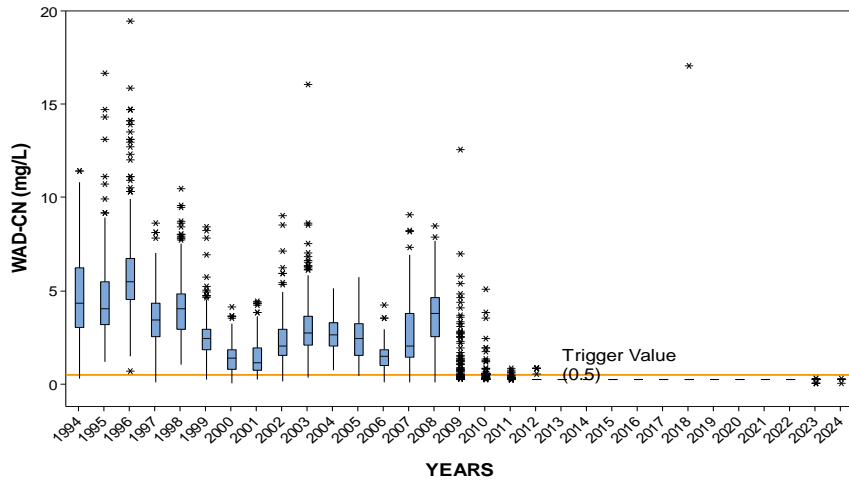


Figure 4-31 Annual WAD-CN concentration in tailings discharge 2015-2024 (mg/L)



Intentionally left blank

Figure 4-32 WAD-CN in tailings discharge 1994-2024

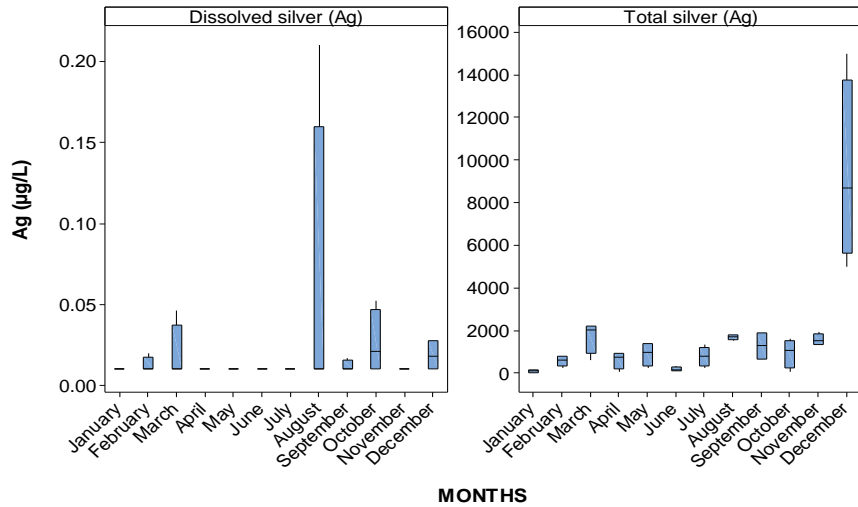


Figure 4-33 Monthly dissolved and total silver concentrations in tailings 2024 (µg/L)

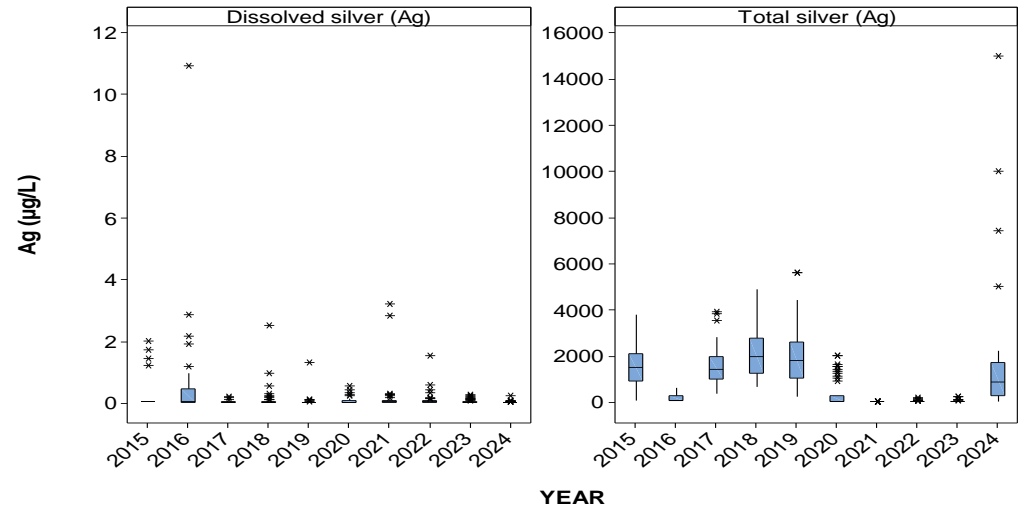


Figure 4-34 Annual dissolved and total silver concentrations in tailings 2015-2024 (µg/L)

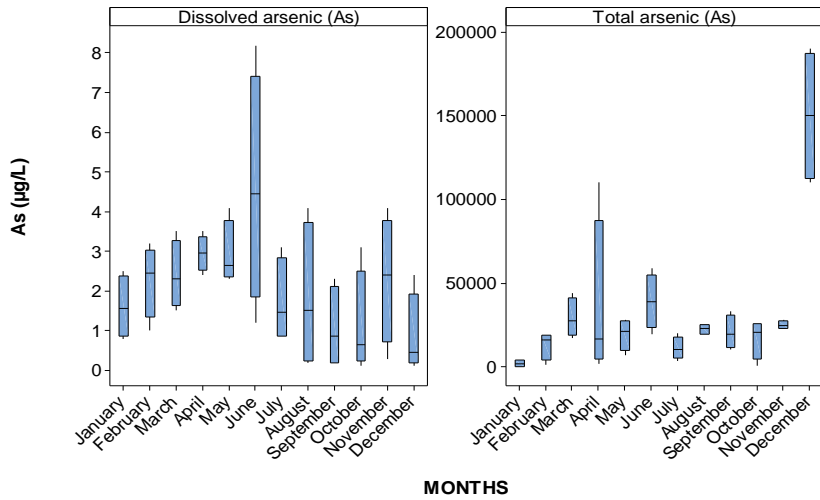


Figure 4-35 Monthly dissolved and total arsenic concentrations in tailings 2024 (µg/L)

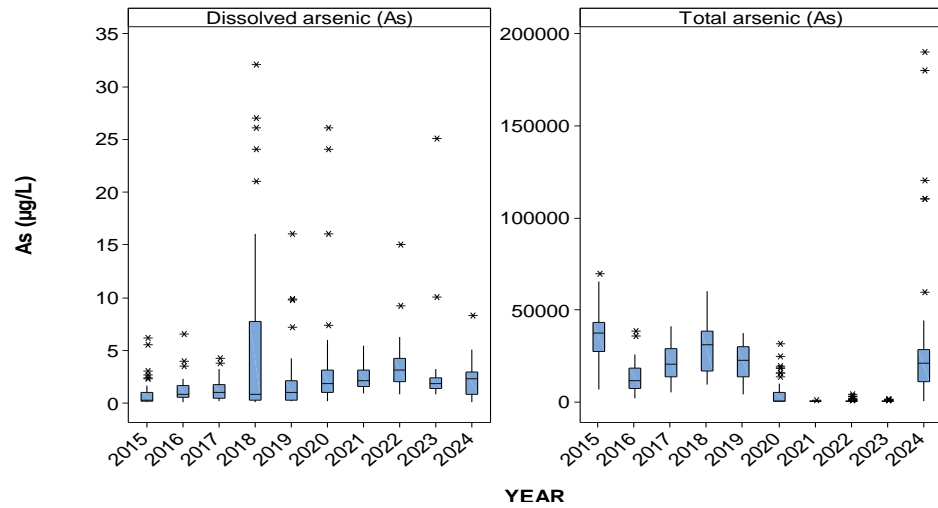


Figure 4-36 Annual dissolved and total arsenic concentrations in tailings 2015-2024 (µg/L)

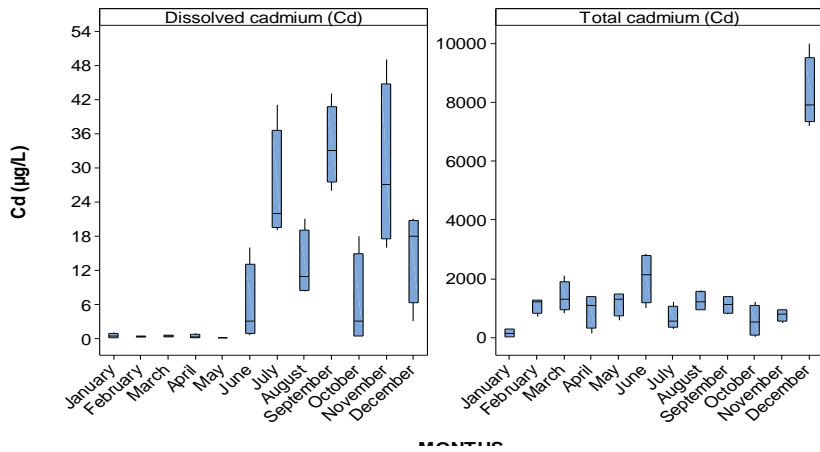


Figure 4-37 Monthly dissolved and total cadmium concentrations in tailings 2024 (µg/L)

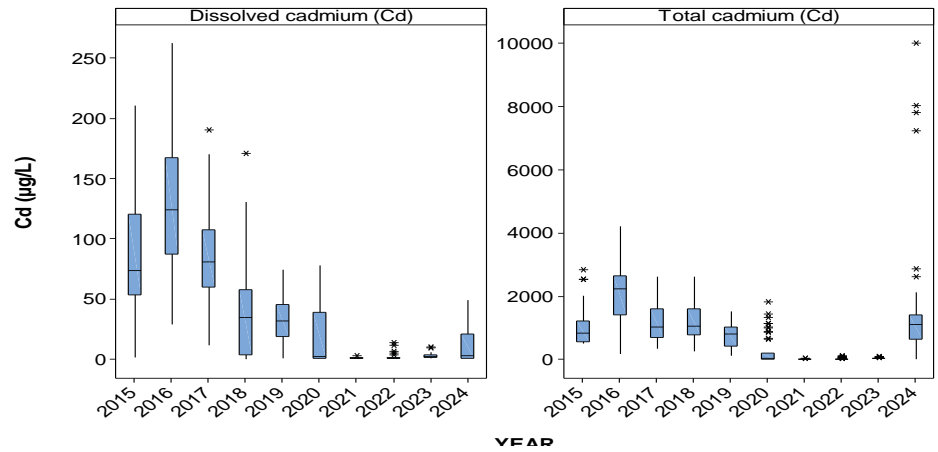


Figure 4-38 Annual dissolved and total cadmium concentrations in tailings 2015-2024 (µg/L)

NPL Annual Environment Report 2024

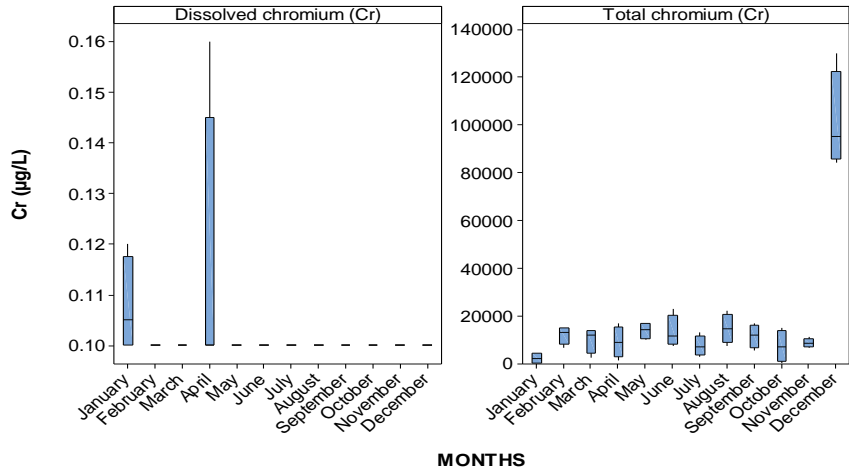


Figure 4-39 Monthly dissolved and total chromium concentrations in tailings 2024 (µg/L)

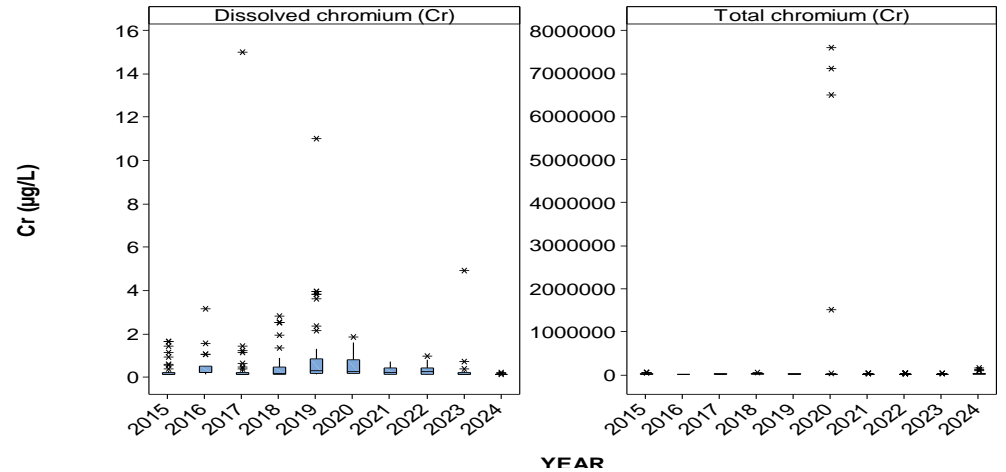


Figure 4-40 Annual dissolved and total chromium concentrations in tailings 2015-2024 (µg/L)

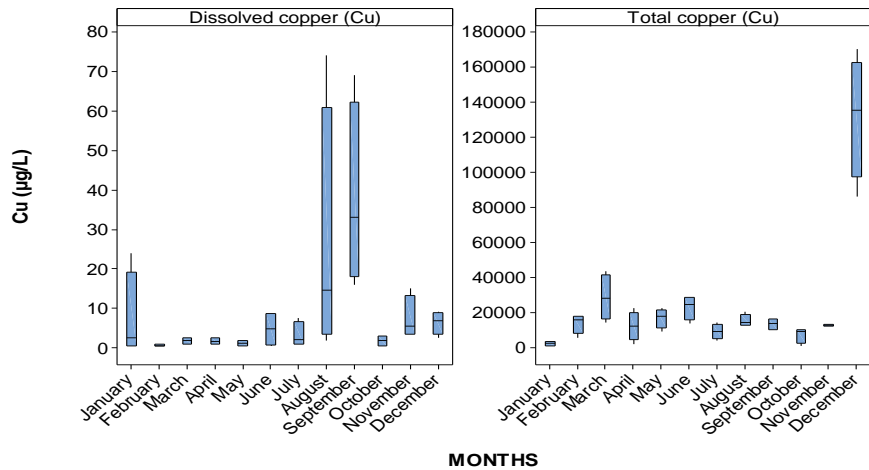


Figure 4-41 Monthly dissolved and total copper concentrations in tailings 2024 (µg/L)

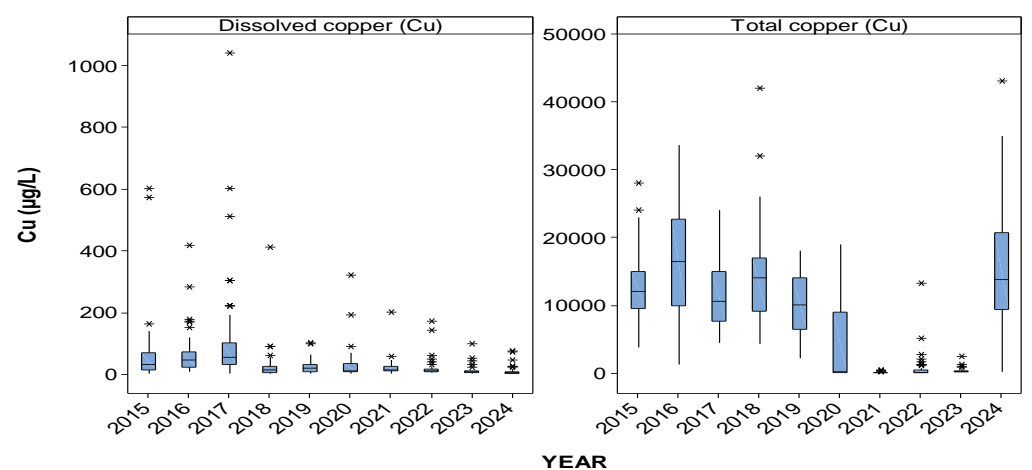


Figure 4-42 Annual dissolved and total copper concentrations in tailings 2015-2024 (µg/L)

NPL Annual Environment Report 2024

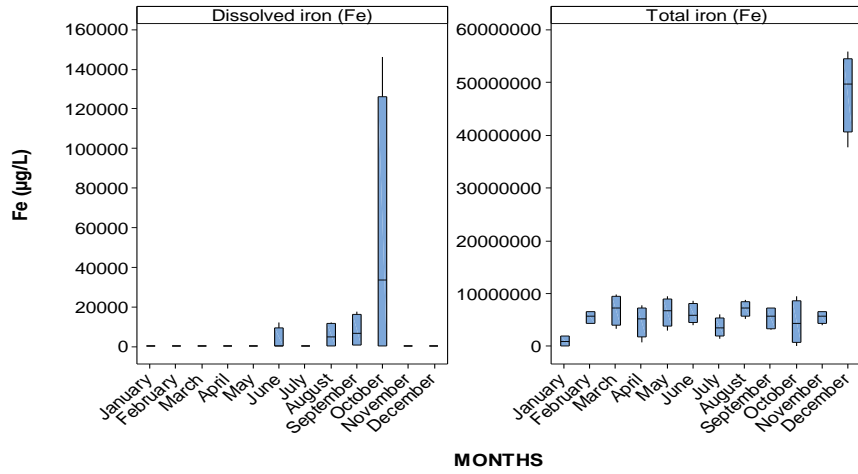


Figure 4-43 Monthly dissolved and total iron concentrations in tailings 2024 (µg/L)

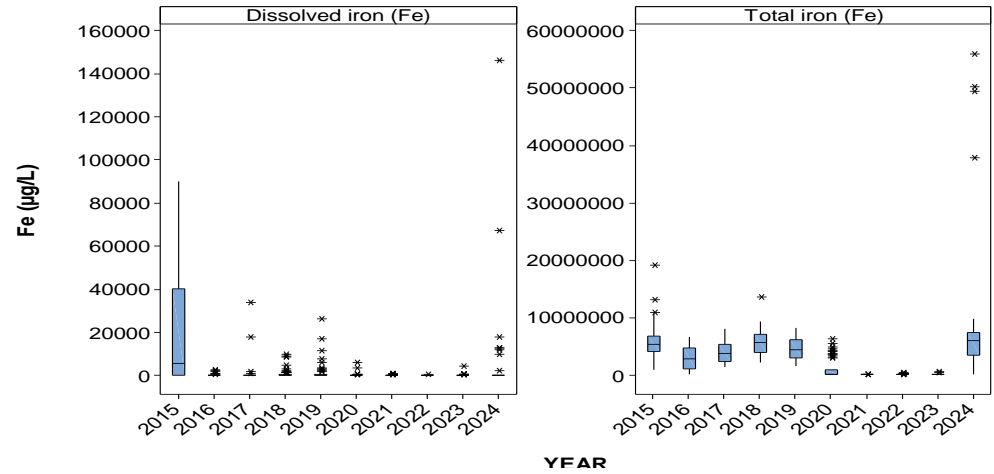


Figure 4-44 Annual dissolved and total iron concentrations in tailings 2015-2024 (µg/L)

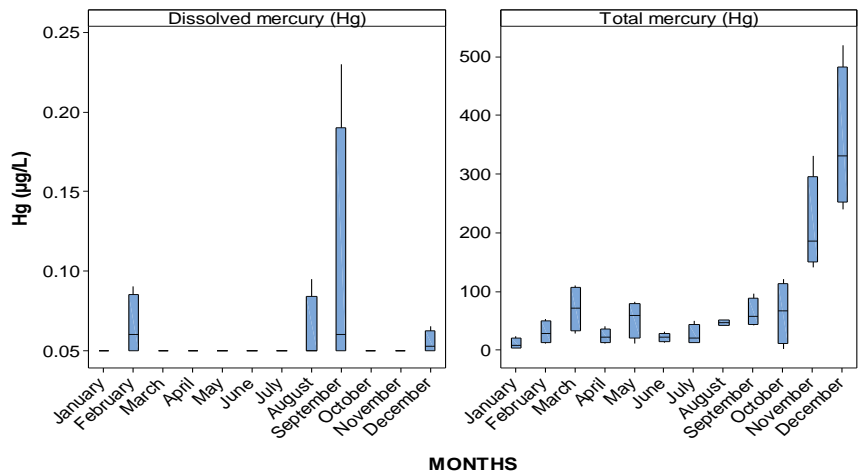


Figure 4-45 Monthly dissolved and total mercury concentrations in tailings 2024 (µg/L)

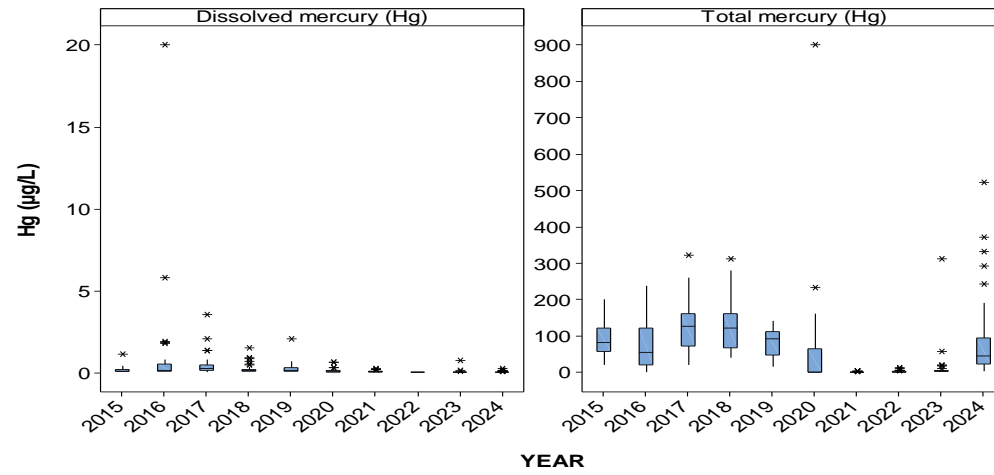


Figure 4-46 Annual dissolved and total mercury concentrations in tailings 2015-2024 (µg/L)

NPL Annual Environment Report 2024

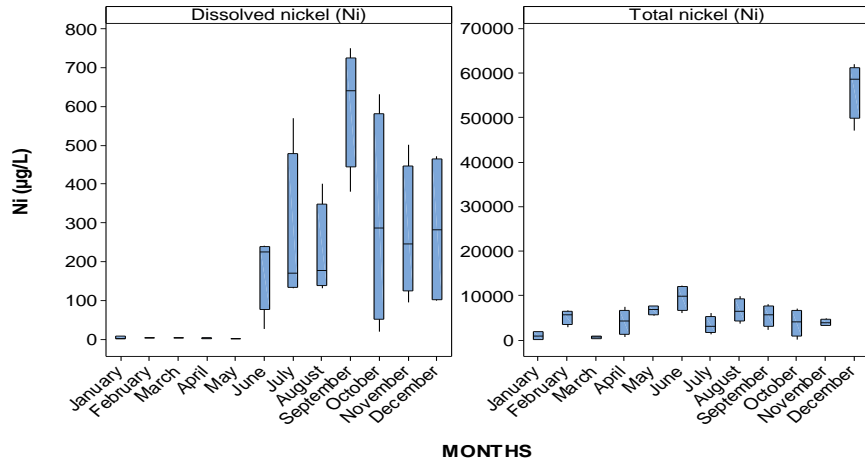


Figure 4-47 Monthly dissolved and total nickel concentrations in tailings 2024 (µg/L)

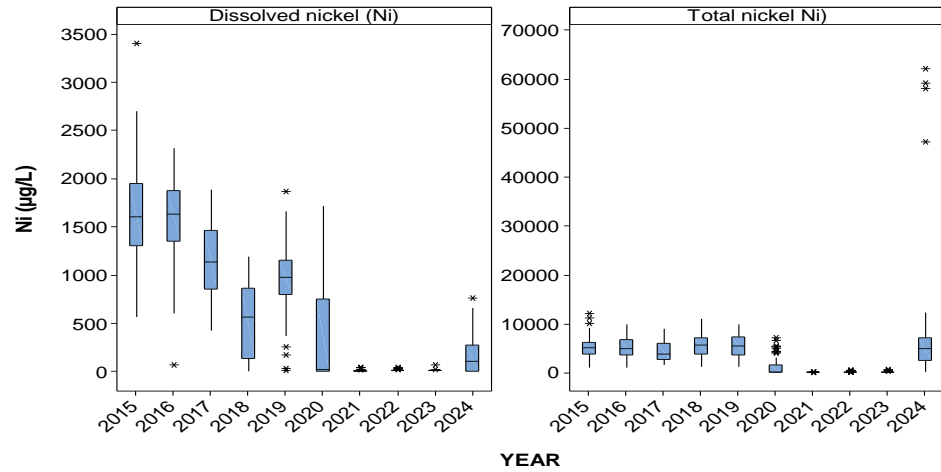


Figure 4-48 Annual dissolved and total nickel concentrations in tailings 2015-2024 (µg/L)

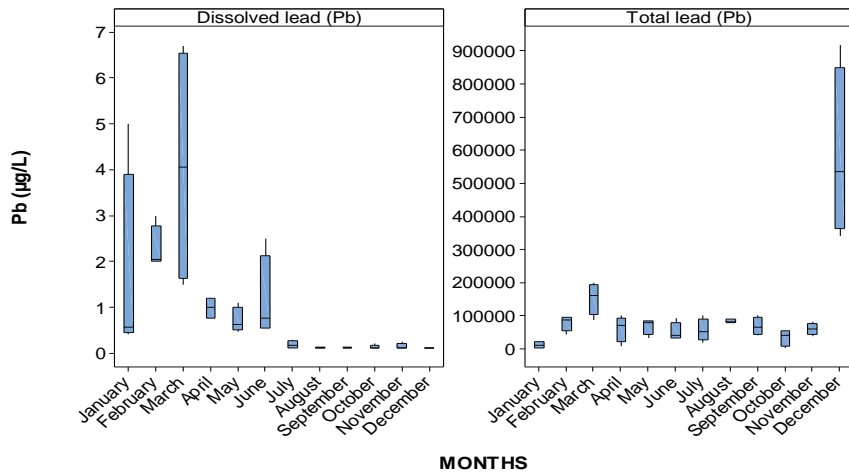


Figure 4-49 Monthly dissolved and total lead concentrations in tailings 2024 (µg/L)

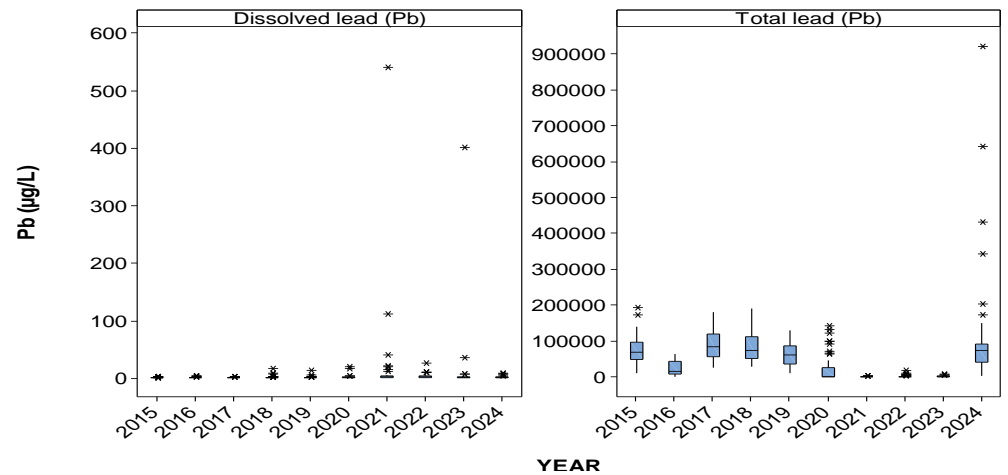


Figure 4-50 Annual dissolved and total lead concentrations in tailings 2015-2024 (µg/L)

NPL Annual Environment Report 2024

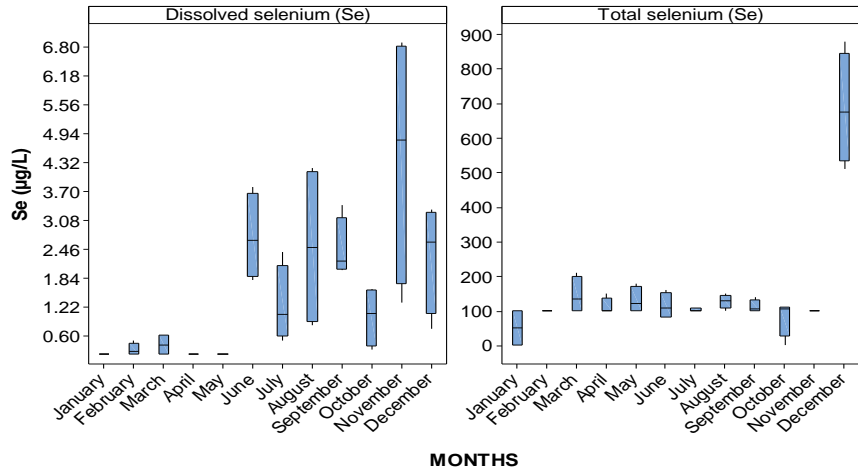


Figure 4-51 Monthly dissolved and total selenium concentration in tailings 2024 (µg/L)

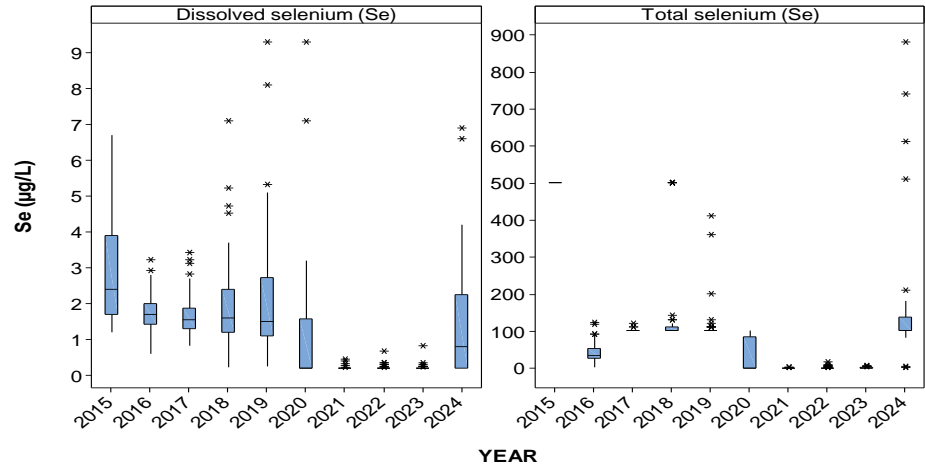


Figure 4-52 Annual dissolved and total selenium concentrations in tailings discharge 2015-2024 (µg/L)

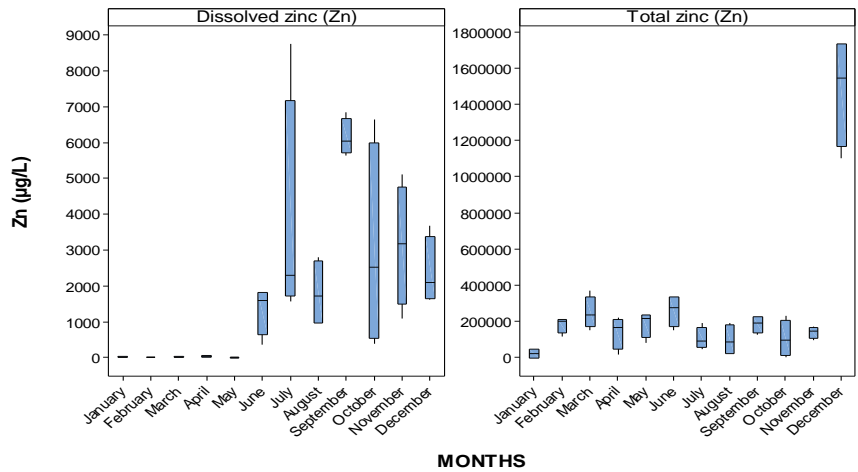


Figure 4-53 Monthly dissolved and total zinc concentrations in tailings 2024 (µg/L)

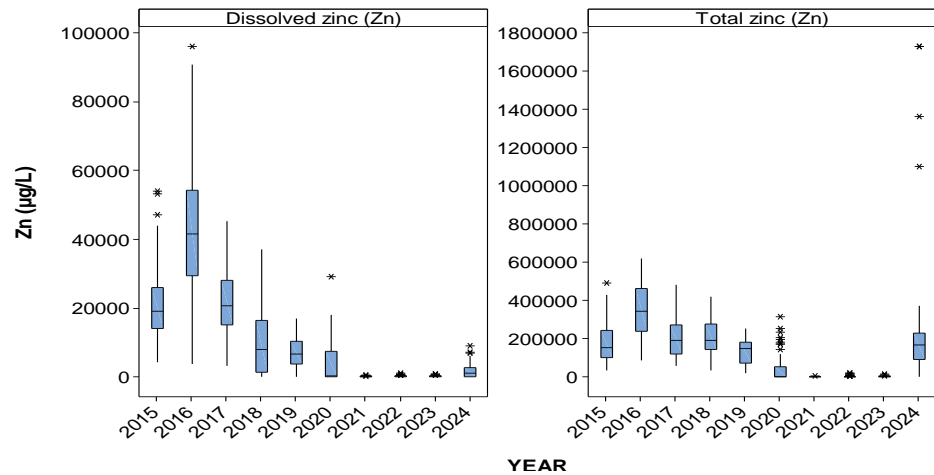


Figure 4-54 Annual dissolved and total zinc concentrations in tailings discharge 2015-2024 (µg/L)

Statistical analysis of tailings quality trends tailings between 2015 and 2024 was performed using the Spearman Rank Test. The results are presented in Table 4-7 and show a statistically significant increase in pH and concentrations of dissolved arsenic and lead. The changes were due to changes in mineralogy and associated metals concentrations in ore being mined from the open pit and underground mines and ore stockpiles. Additionally, no tailings discharged during the care and maintenance period contributed to the reduction in concentrations overtime.

Table 4-7 Trends of tailings quality 2015 – 2024

Indicator	Spearman's rho	p-Value (p=0.05)	Trend (2015 – 2024)
pH	0.602	<0.001	Increased over time
EC	-0.708	<0.001	Reduced over time
WAD-CN	-0.124	0.007	Reduced over time
Sulfate	-0.627	<0.001	Reduced over time
ALK-T	-0.531	<0.001	Reduced over time
TSS	-0.582	<0.001	Reduced over time
Hardness	-0.564	<0.001	Reduced over time
Ag-D	-0.276	<0.001	Reduced over time
Ag-T	-0.411	<0.001	Reduced over time
As-D	0.414	<0.001	Increased over time
As-T	-0.482	<0.001	Reduced over time
Cd-D	-0.712	<0.001	Reduced over time
Cd-T	-0.481	<0.001	Reduced over time
Cr-D	-0.135	0.003	Reduced over time
Cr-T	-0.360	<0.001	Reduced over time
Cu-D	-0.526	<0.001	Reduced over time
Cu-T	-0.445	<0.001	Reduced over time
Fe-D	-0.426	<0.001	Reduced over time
Fe-T	-0.359	<0.001	Reduced over time
Hg-D	-0.580	<0.001	Reduced over time
Hg-T	-0.479	<0.001	Reduced over time
Ni-D	-0.770	<0.001	Reduced over time
Ni-T	-0.454	<0.001	Reduced over time
Pb-D	0.519	<0.001	Increased over time
Pb-T	-0.371	<0.001	Reduced over time
Se-D	-0.608	<0.001	Reduced over time
Se-T	-0.472	<0.001	Reduced over time
Zn-D	-0.758	<0.001	Reduced over time
Zn-T	-0.512	<0.001	Reduced over time

* The trend indicated by Spearman's rho and P of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore, the finding has been corrected to indicate no change over time, which is representative of actual conditions.

D – Dissolved fraction, T – Total, LOR - Limit of Reporting

4.9 Sediment Contributions to the River System

Calculating the annual sediment budget for the Strickland River system and distinguishing between mine-derived and natural inputs is complex because it relies on a large number of factors that vary spatially and temporally across the numerous sub-catchments of the Porgera – Lagaip – Strickland River basins. These include rates of erosion and sediment delivery to the channel network, rainfall and corresponding river flow that influence rates of sediment transport and sediment deposition, and mine-related activity including incompetent waste rock and tailings discharge rates.

Acquiring the datasets required to develop an accurate sediment balance over such a large area on an annual basis is extremely challenging in practice and, ideally, would require simultaneous high-frequency (hourly) sampling throughout the length of the river.

The NPL method for calculating the annual sediment budget is to use a multiple lines-of-evidence approach using the best available datasets for that year, and relevant historical data. In addition, the 30-year documented history of the dynamics of the erodible waste rock dumps and the associated response of the river system are drawn upon to inform the annual assessment. This approach is considered adequate for impact assessment purposes. In summary, the key data elements that inform the annual review of sediment delivery and transport are:

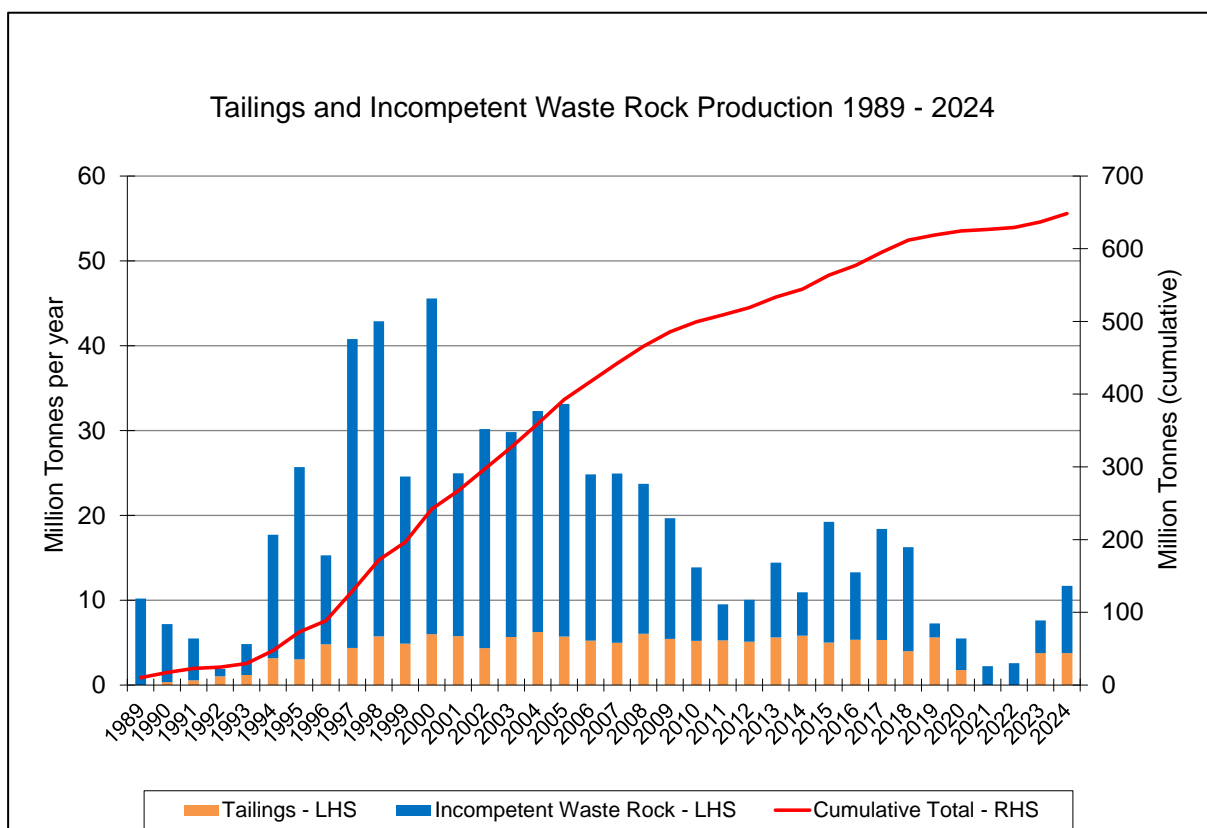
- Discharge of sediment from the toes of the erodible dumps. This is largely controlled by the fluvial action of the Kaiya River (Anjolek erodible waste rock dump) and Pongema River (Anawe erodible waste rock dump), but is also influenced by existing dump morphology, rainfall and flow rates and land sliding activity along valley walls. The loss of sediments from the dumps is best calculated from a mass-balance by using UAV survey which is typically undertaken on an annual basis. A long history of survey data and targeted studies indicate that the export of sediment from the erodible waste rock dumps does not vary greatly on a year to year basis and is limited by the sediment transport capacity of the Pongema and Kaiya Rivers.
- Tailings discharge. This is relatively constant from year to year. A small proportion of tailings are assumed to be retained within the tract of Anawe erodible waste rock dump.
- TSS and flow data. The best available data are derived from the monthly compliance sampling at SG3 and are sufficient to provide a defensible estimate of TSS load at that point in the river.
- Historical datasets including particle size distributions, TSS concentration and flow, observational data on dump behaviour, observations on river impacts and recovery during periods of operational shutdown or low waste placement rates. It should be noted NPL plan to undertake a study to update the data presented in Table 4-9, and this is included in the recommendations of this report.
- Results from targeted studies such as mine sediment tracing which allow independent estimates of the proportion of mine-derived sediment present at specific points in the river.
- Expert review to ensure the results for a particular year are realistic and defensible.

As discussed previously, the volume of mine-derived waste exported to the downstream river system does not vary greatly from year to year during the period of active mining as the tailings discharge rate is relatively constant, and the removal of waste from the erodible waste rock dump toes is limited by rainfall and the transport capacity of the Kaiya and Pongema Rivers.

The quantity of incompetent waste rock placed in the erodible dumps over the period of mine operation and the quantity of tailings produced by the mine are summarised in Table 4-8. Figure 4-55 presents the yearly and cumulative quantity of incompetent waste rock and tailings produced by the mine.

Table 4-8 Summary of incompetent waste rock and tailings disposal tonnages in 2024 and 1989 - 2024

Discharge Location	Total for 2024 (Mt)	Total 1989 – 2024 (Mt)
Anawe erodible dump	1.08	246
Anjolek erodible dump	6.8	266
Tailings discharge (dry solids)	3.7	146
TOTAL	11.6	648



LHS = Left- hand side y-axis, RHS = Right-hand side y-axis

Figure 4-55 Production of incompetent rock and tailings 1989-2024

These figures, however, do not represent the amount of sediment contributed to the river system each year from the tailings and erodible dumps.

The tailings are discharged across the Anawe erodible dump and as a result a small fraction of the tailings solids settles along the body of the dump and is not transported into the river system.

A minor proportion of sediment contribution from the erodible dumps occurs via surface erosion and failure across the body of dumps driven by the creeks and minor drainage pathways which traverse the body of the dump. The predominant mechanism contributing sediment to the river system from the erodible dumps is erosion and failure of dump material where the toes of the dumps are intersected by higher flowing rivers (specifically the Pongema River and Kaiya River). Sediment eroded in this way is entrained in the river flows and transported downstream. The dominant factors for each of these mechanisms are rainfall, river flow rate and particle size distribution of the dumped material, rather than the volume of material being dumped at the head of the dump.

The volume of sediment contributed to the river system each year is estimated based on the historical estimates of particle size distribution and an annual survey of the erodible dumps which measures changes to dump surface area and volume.

A summary of the various estimates of particle size distribution for the combined Anawe and Anjolek dump toes is presented in Table 4-9 which also shows the adopted size distribution used for the purposes of sediment transport calculations.

It was assumed that 5% of all tailings discharged are trapped and stored in the dump and that, of the tailings leaving the dump, a further 5% is lost to long-term storage (bed and bars) between the dump toe and SG3. While these are arbitrary figures and difficult to verify, they are considered reasonable based on professional judgement.

Table 4-9 Estimates of particle size distribution of material sampled at erodible dump toe

Reference	Silt (%)	Sand (%)	Gravel (%)
1. CSIRO review (1996)	58	27	15
2. NPL 1995 samples (average)	30	30	40
3. Anawe toe 1997 samples (average)	5	35	60
4. Black Sed. Accelerated Weathering Tests	72	20	8
5. Davies et al. (2002)	76	11	13
Mean (1, 2, 4 and 5)	59	22	19

Long-term survey data (2002-2024) and mass-balance calculations for the dumps were used to indicate that approximately 60-80% of erodible waste rock input has been lost downstream as a long-term average. More recent survey data, as of 2024, indicate that the amount of material exported downstream since 2010, expressed as a percentage of the amount of material dumped, was approximately 40% for Anawe and 24% for Anjolek. This partly reflects the lower rates of dumping in recent years, while there has still been consistent erosion of material from the dumps by river flows.

The data analysis described above is based on a simple mass balance which reconciles the year-to-year volume change to each dump, and the amount of waste placed at the tip-heads. This method does not necessarily account for the amount of sediment from landslides that may account for dump volume change, or basal lowering or scouring of colluvium at the base of the dumps. Also, it is possible that some landslide inputs may discharge directly downstream as sediment load and would not be accounted for in the mass balance.

Estimates of the rates of sediment loss from the dumps are summarised in Table 4-10 which also shows that the estimated average annual load of sediment that is transported downstream is 6.1 Mt/y based on survey data since 2010. This appears to be a reasonable estimate and compares well with the estimated suspended load at SG1 of approximately 10 Mt/y, based on historical measured flow and TSS data.

Table 4-10 Summary of long-term dump mass balance from survey data

Dump	Proportion of total dumped material released based on long term survey data since 2002 (%)	Median downstream transport rate since 2002 (Mt/y) (Total mass exported downstream from survey data divided by number of years between survey)	Downstream transport rate since 2010 (Mt/y) and percentage of dumped material released (%)
Anjolek	58	2.7	3.0 (84%)
Anawe	50	2.3	3.1 (67%)
Total	NA	5.0	6.1

Based on the figures above, Table 4-11 presents estimates of suspended sediment discharge from the SML for both tailings and waste rock in 2024, based on the most recent survey data. It should be noted that a level of inherent uncertainty exists within the survey data on a year-to-year basis due to the large area of the dump, difficult terrain in which the survey is conducted and changes to survey equipment and personnel from year to year. Therefore, to account for this uncertainty, the sediment discharge rate from the erodible dumps is based on the average volume change recorded since 2010.

Table 4-11 Estimate of sediment discharge from erodible dumps and tailings during 2024

Source	Total Sediment Discharged from Dumps (Mt/y)	Suspended Sediment Component (Mt/y)	Assumptions
Erodible dumps	6.4	3.6	Assumes 59% (silt fraction) travels as suspended load
Tailings	3.6 (3.8 x 0.95)	3.4 (3.6 x 0.95)	Assumes 95% of tailings is transported to the river system and 5% remains stored in Anawe dump
TOTAL 2024	10	7.0	

4.10 Other Discharges to Water

4.10.1 Treated sewage effluent

The total volume of treated sewage effluent discharged from the five treatment plants that service the mine site and accommodation camps are shown in Figure 4-56 and confirms that discharge volumes from all STPs were within the respective environment permit limits. The Yoko STP discharged 30,423 m³ of effluent, approaching the permitted limit of 30,660 m³. This increase was attributed to stormwater being diverted into the plant. Corrective action was taken to prevent stormwater and to manage effluent discharge volumes more effectively.

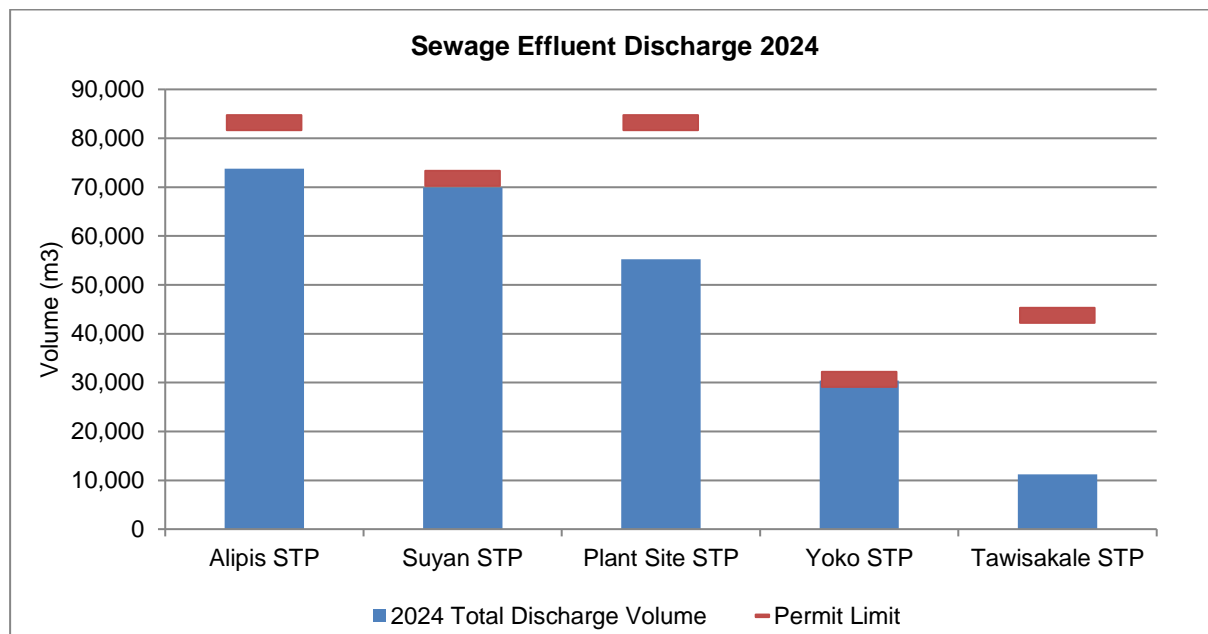


Figure 4-56 Total annual discharge volumes of treated sewage for 2024

The quality of the discharge from each STP is monitored for TSS, BOD₅ and faecal coliforms. The results of monitoring in 2024 are shown in Figure 4-57 to Figure 4-59 respectively. Operation of the sewage treatment plants consistently achieved compliance with the TSS criterion of 30 mg/L throughout the year except for one short-term excursions slightly above the permit limit at Alipis. All plants achieved compliance with the BOD₅ and faecal coliform criteria throughout the year.

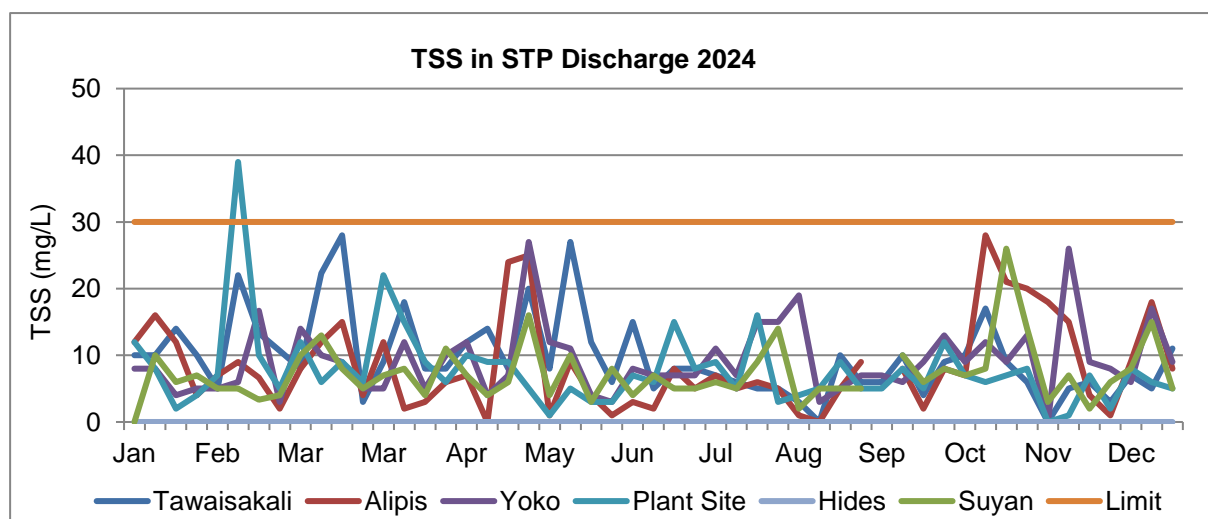


Figure 4-57 Average monthly TSS concentration in treated sewage discharge in 2014

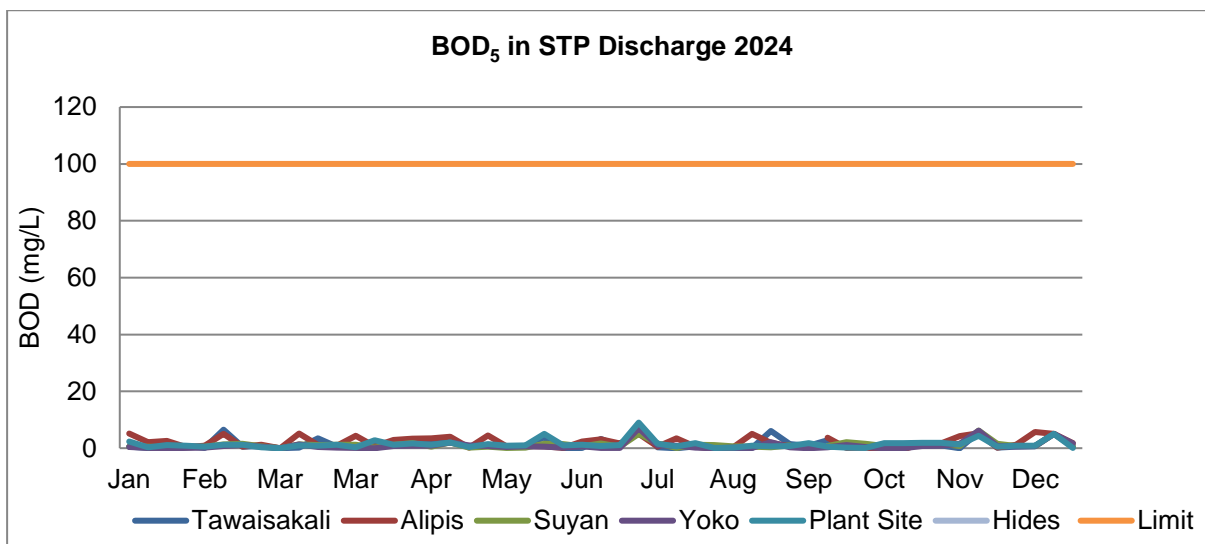


Figure 4-58 Average monthly BOD₅ concentration in treated sewage discharge in 2024

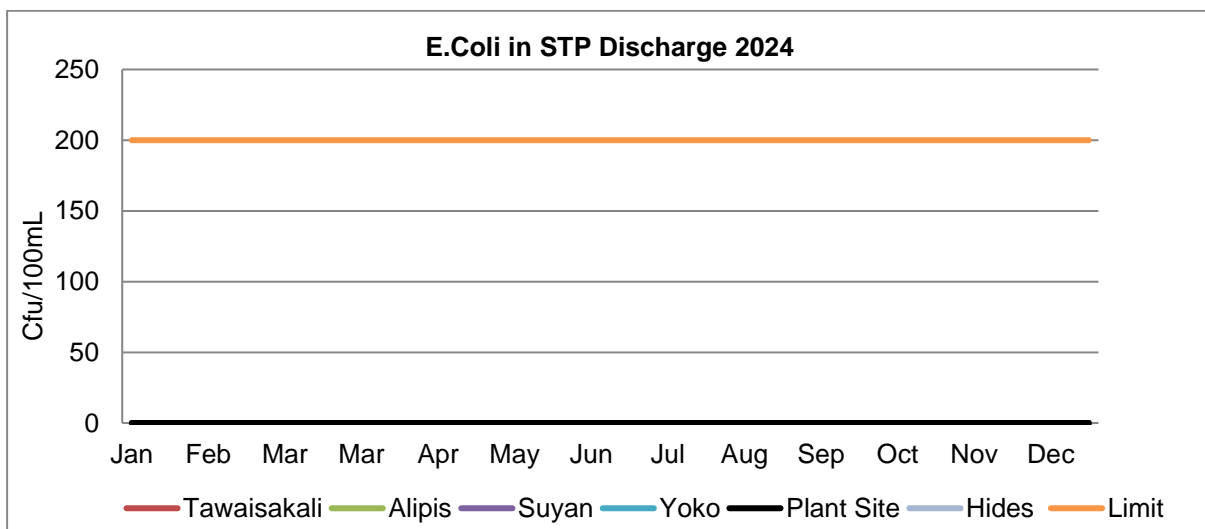


Figure 4-59 Average monthly faecal coliform count in treated sewage discharge 2024

4.10.2 Oil/water separator effluent

The mine operates 21 oil-water separators at maintenance workshops and fuel storage and refuelling installations.

Figure 4-60 shows monthly average hydrocarbon concentrations from oil-water separators and a local creek, compared against the internal site-developed target of 30 mg/L.

Hydrocarbons were detected in low concentrations at oil water separator discharge points and at the receiving creek, however the concentrations were well below the site target and are not considered to pose a risk to the environment or human health.

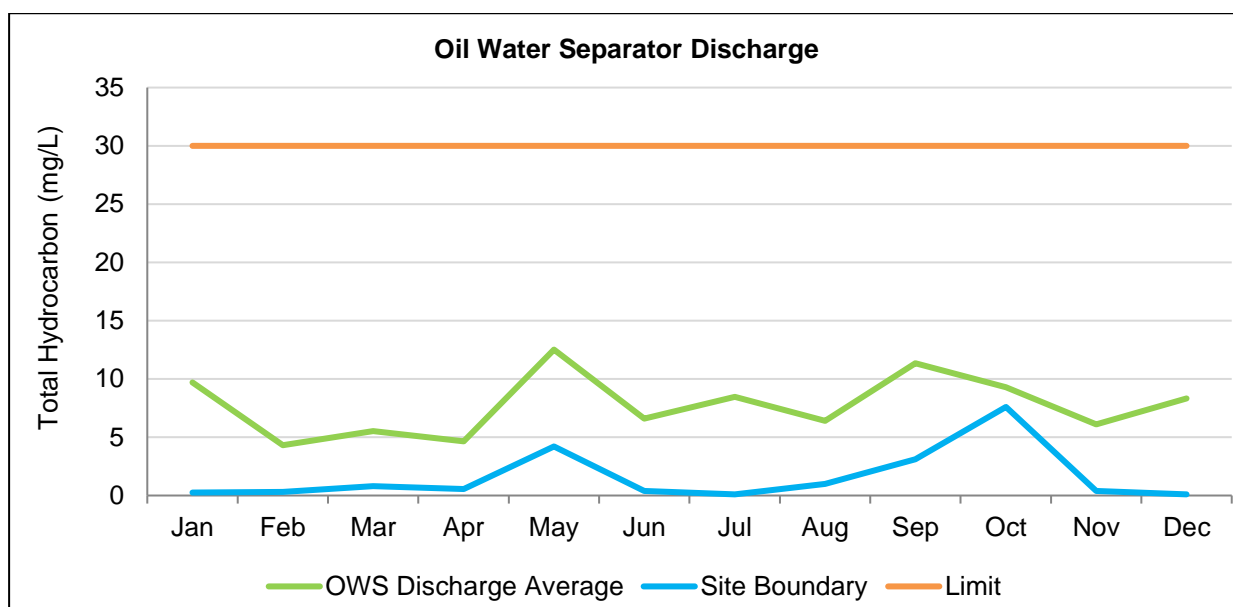


Figure 4-60 Average monthly total hydrocarbon concentrations in oil-water separator discharges in 2024

4.10.1 Mine contact runoff

Mine contact runoff is rainfall runoff from land disturbed by the mining operation and therefore has the potential to contribute contaminants, particularly metals, to the receiving environment. The volume and quality of mine contact runoff are described in the following sections.

4.10.1.1 Contact runoff volumes

Table 4-12 shows the estimated volume of contact runoff from land disturbed by mining operations. It is impractical to measure runoff volumes, and these have been estimated from rainfall and catchment areas. The total volume of contact run-off remained well below the permit limit.

Table 4-12 Estimated volumes of contact runoff from mine lease areas 2024

Location	Total Rainfall runoff 2024 (Mm ³)	Permit Limit (Mm ³ /y)
Starter Dump A (SDA) (DP3)	0.9	1.8
Civil crusher to Kogai Creek (DP4)	0.05	0.1
Kogai waste dump to Kogai Creek (DP5)	21.7	1,680
Open Pit and UG Mine drainage tunnel to Kogai Creek (DP6)	8.0	12.1
Anawe stable dump to Wendoko Creek (DP7)	4.1	4.5
Runoff from Hides to a tributary of the Tagari River (DP16)	0.04	0.1
TOTAL	34.8	1,700

4.10.1.2 Contact runoff water and sediment quality

The quality of water and sediment contained in runoff from within the mining lease is dictated by the land use within the contributing catchment. Table 4-13 identifies the land uses within the contributing catchment for each monitoring site and the locations of the sites are shown in Figure 4-61.

Table 4-13 Mine contact runoff monitoring sites

Monitoring site name	Land Uses
28 Level (underground water discharged at adit)	Underground mine
SDA Toe	Competent waste rock dump
Kaiya River at Yuyan Bridge	Open cut mine Underground mine Erodible waste rock dump
Kaiya River downstream of Anjolek erodible dump	Erodible waste rock dump
Kogai Culvert	Competent waste rock dump Crushing and grinding Workshops Sewage treatment plant Hazardous substance storage
Kogai stable dump toe area	Competent waste rock dump
Lime Plant discharge	Limestone processing
Wendoko Creek downstream of Anawe Nth stable dump	Competent waste rock dump
Yakatabari Creek downstream of 28 Level discharge	Underground mine Workshops Sewage treatment plant Hydrocarbons substance storage
Yunarilama/Yarik portal	Open cut mine Underground mine

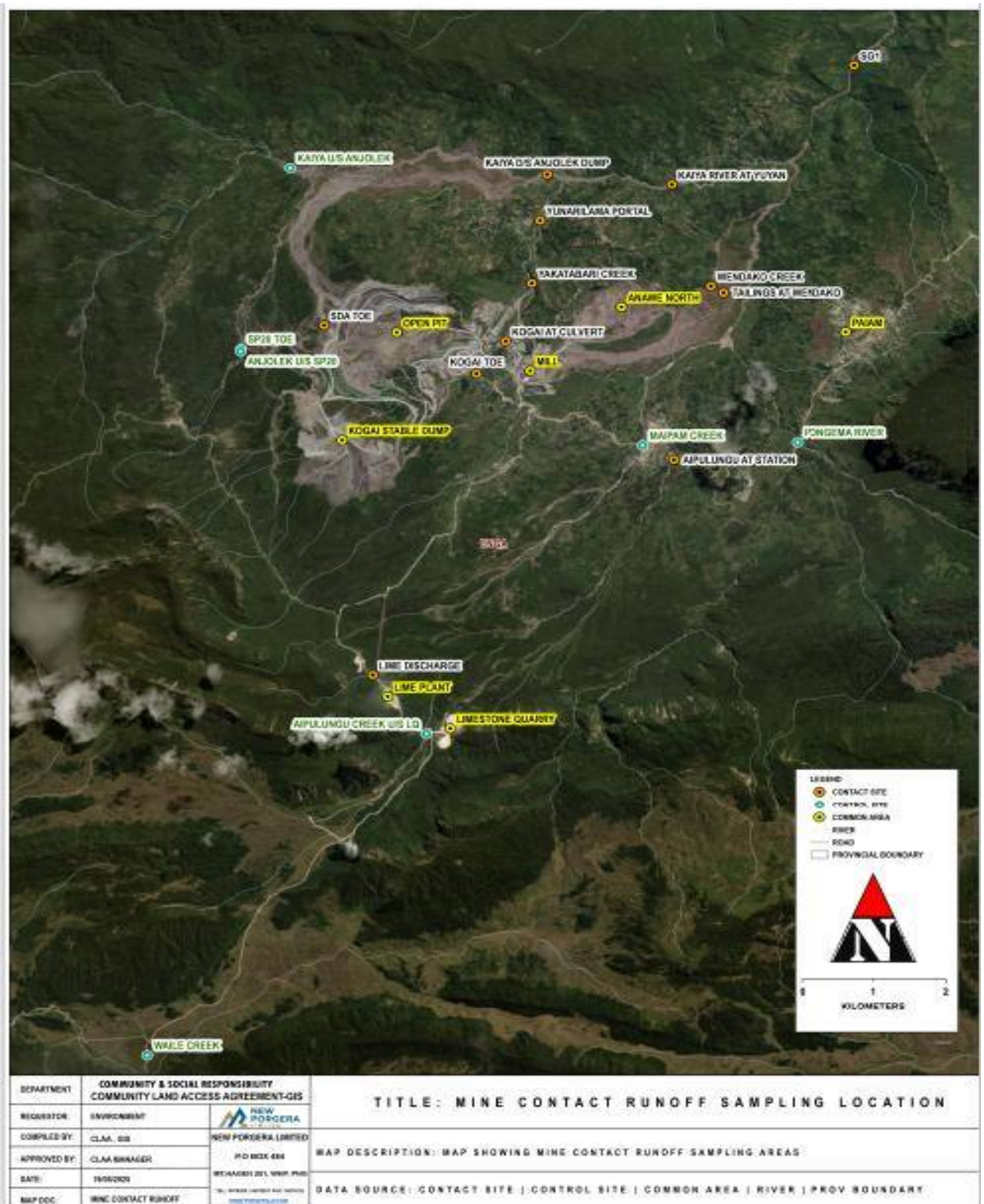


Figure 4-61 Mine contact runoff sampling location

Annual median values from monthly monitoring conducted in 2024 at mine contact runoff sites are shown in Table 4-14, amber highlight indicates values that exceeded or were not significantly different from the upper river TV. Samples were not collected from SDA Toe and Kaiya River D/S Anjolek dump during 2024 due to community and security issues. Electrical conductivity of water discharged from all contact runoff sites exceeded upper river TV. Runoff from Kogai Stable Dump Toe and Wendoko Creek downstream of Anawe Nth, which receives runoff from competent waste rock dumps, exhibited elevated concentrations of dissolved cadmium and zinc. The water quality at these sites is typical of neutral mine drainage and indicates that oxidation/reduction and neutralisation are occurring within the waste rocks dumps due to the presence of sulfides and carbonates. Alkaline pH indicates a net neutralising capacity within the waste rock, which is beneficial for preventing low pH runoff and reducing the concentration of dissolved/bioavailable metals. Discharge from the lime plant exhibited elevated pH and dissolved chromium. 28 Level exhibited elevated dissolved iron and zinc and Yunarilama at Portal, which discharged from underground mine, exhibited elevated TSS.

A summary of trends of water quality parameters between 2015 and 2024 in contact runoff is presented in Table 4-15. Details of the statistical analysis are shown in APPENDIX C. The analysis shows that concentrations of a number of analytes have increased at a number of sites during the period. Trends of increasing concentration of TSS at SDA Toe between 2015 and 2017. SDA toe also showed trends of increasing concentrations of total metals, indicating the presence of mine-derived mineralised sediment. Trends of increasing concentrations of dissolved mercury were observed at 28 level, Kogai dump toe, Wendoko creek D/S Anawe north and Yakatabari D/S 28 level. Dissolved arsenic showed an increasing trend at Lime plant over the last decade.

The median concentrations of WAE metals and total metals in sediment in runoff from the mine areas are shown in Table 4-16. Of note are elevated WAE cadmium, WAE lead and WAE zinc in sediment discharged from Kogai Culvert, Kogai Stable Dump Toe, Wendoko Creek DS Anawe North and Yakatabari Creek DS 28 Level. Elevated lead and zinc in sediment is a reflection of the geology of the Porgera ore body which contains sphalerite, which is a zinc mineral, and galena which is a lead mineral.

NPL Annual Environment Report 2024

Table 4-14 Contact water quality 2024 median concentrations (µg/L except where shown)

Parameter	UpRivs TV	28 Level	SDA Toe	Kaiya Riv D/S Anj dump	Kogai Culvert	Kogai Dump Toe	Lime Plant	Wendoko Crk D/S Anawe Nth	Yakatabari Crk D/S 28 Level	Yunarilama @ Portal
pH	6.0-8.2	7.7	NS	NS	8.0	7.8	10.8	7.8	7.5	7.6
EC	230	633	NS	NS	551	1,370	378	1,805	593	1,907
WAD-CN*	NA	0.2	NS	NS	0.2	0.2	0.2	0.2	0.2	0.2
Sulfate*	NA	130	NS	NS	90	660	3.5	1110	104	520
ALK-T*	NA	143	NS	NS	123	189	129	137	103	162
TSS*	2,837	36	NS	NS	370	67	113	18	6,350	6,750
Hardness*	NA	307	NS	NS	359	769	260	1156	298	408
Ag-D	0.05	0.01	NS	NS	0.01	0.01	0.01	0.01	0.01	0.01
Ag-T	NA	0.08	NS	NS	1.8	0.05	0.01	0.07	78	4.9
As-D	24	1.5	NS	NS	1.0	0.59	0.13	1.1	12	2.5
As-T	NA	4.8	NS	NS	25	4.2	1.1	2.4	640	108
Cd-D	0.32	0.05	NS	NS	0.08	0.71	0.05	1.1	0.05 ¹	0.05
Cd-T	NA	0.12	NS	NS	2.1	1.6	0.092	1.4	40	4.5
Cr-D	1.0	0.10	NS	NS	0.10	0.10	2.8	0.10	0.10	0.10
Cr-T	NA	2.8	NS	NS	16	1.5	8.0	0.46	340	76
Cu-D	1.4	0.25	NS	NS	0.90	0.58	0.81	0.56	1.0 ¹	0.47
Cu-T	NA	2.5	NS	NS	22	4.2	2.4	1.3	500	82
Fe-D	75	32 ¹	NS	NS	6.2	2.9	1.8	2.3	3.3	4.7
Fe-T	NA	2,550	NS	NS	13,950	1,800	1,030	830	329,000	75,150
Hg-D	0.60	0.05	NS	NS	0.05	0.05	0.05	0.05	0.05	0.05
Hg-T	NA	0.05	NS	NS	0.12	0.05	0.05	0.05	3.4	0.5
Ni-D	21	2.5	NS	NS	0.68	1.4	0.50	1.2	1.5	1.9
Ni-T	NA	4.4	NS	NS	15	3.1	1.3	1.5	340	65
Pb-D	6.7	0.12	NS	NS	0.47	0.22	0.10	0.17	0.60	0.21
Pb-T	NA	15	NS	NS	145	29	2.7	6.1	3700	420
Se-D	11	0.2	NS	NS	0.20	0.20	0.20	0.38	0.28	1.0
Se-T	NA	0.2	NS	NS	0.36	0.22	0.20	0.41	5.9	2.0
Zn-D	20	7.6 ¹	NS	NS	6.7	101	1.1	310	5.1	5.0
Zn-T	NA	89	NS	NS	375	250	17	370	7200	1105
	> UpRiv TV = Potential Risk									

¹std units, #µS/cm, * mg/L, **mg CaCO₃/L, D = Dissolved fraction, T = Total, NA – Not applicable, NS - Not sampled in 2024, ¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM is found to be not statistically significantly different from the TV

NPL Annual Environment Report 2024

Table 4-16 Contact Sediment Quality 2024 median values (mg/kg dry weight, whole fraction)

Parameter	UpRiv TV	28 Level	SDA Toe	Kaiya Riv D/S Anj dump	Kogai Culvert	Kogai Dump Toe	Lime Plant	Wendoko Crk D/S Anawe Nth	Yakatabari Crk D/S 28 Level	Yunarilama @ Portal
Ag-WAE	1.0	1.4	NS	NS	0.50	0.67	0.09	0.24	2.1	1.2
Ag-TD	NA	7.5	NS	NS	4.8	4.2	0.11	1.3	6.0	4.0
As-WAE	20	16	NS	NS	7.7	16	1.2	4.9	14	12
As-TD	NA	123	NS	NS	109	170	4.0	35	73	62
Cd-WAE	1.5	0.94	NS	NS	0.76	2.0	0.37	1.5 ¹	1.5 ¹	1.1 ¹
Cd-TD	NA	3.6	NS	NS	3.5	10	0.48	2.9	3.3	2.7
Cr-WAE	80	8.8	NS	NS	3.1	3.2	11	1.4	4.6	5.4
Cr-TD	NA	48	NS	NS	30	44	22	26	94	68
Cu-WAE	65	22	NS	NS	7.5	9.9	4.2	5.1	16	12
Cu-TD	NA	62	NS	NS	37	84	7.8	28	47	40
Hg-WAE	0.15	0.01	NS	NS	0.01	0.01	0.01	0.01	0.01	0.04
Hg-TD	NA	0.53	NS	NS	0.35	0.34	0.03	0.10	0.38	0.31
Ni-WAE	21	11	NS	NS	4.3	4.6	3.1	3.5	8.0	8.6
Ni-TD	NA	42	NS	NS	29	37	6.5	25	58	44
Pb-WAE	50	150	NS	NS	130	200	8.7	59	150	125
Pb-TD	NA	170	NS	NS	205	330	11	69	200	175
Se-WAE	0.22	0.15	NS	NS	0.22 ¹	0.20	0.13	0.23	0.17	0.18
Se-TD	NA	0.91	NS	NS	0.78	0.95	0.14	0.89	0.62	0.72
Zn-WAE	200	400	NS	NS	145	290	43	150	265	178
Zn-TD	NA	1,245	NS	NS	675	1,790	69	550	900	635
	> UpRiv TV = Potential Risk									

WAE – Weak Acid Extractable, TD – Total Digest NA – TV Not applicable NS – Not sampled ¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM is found to be not statistically significantly different from the TV

4.11 Point Source Emissions to Air

NPL monitors emissions from stationary sources at the mine site, the Lime Plant and at Hides Power Station every two years, the most recent sampling was performed in 2024. Papua New Guinea does not have legislation for controlling emissions to air so has voluntarily set a target of complying with the relevant Australian Standards, which are the NSW Protection of the Environment Operations (Clean Air) Regulation 2010 and the Victoria State Environment Protection Policy (Air Quality Management) 2001. A comparison of results against the standards is presented in Section 7.8.

4.12 Greenhouse Gas and Energy

Figure 4-62 presents information on the average annual rate of carbon dioxide equivalents (CO₂-e) emissions per tonne of ore processed. The Porgera annual CO₂-e emission rate is higher than at other gold mining operations because of the high energy requirement for the pressure oxidation processing of ore in autoclaves.

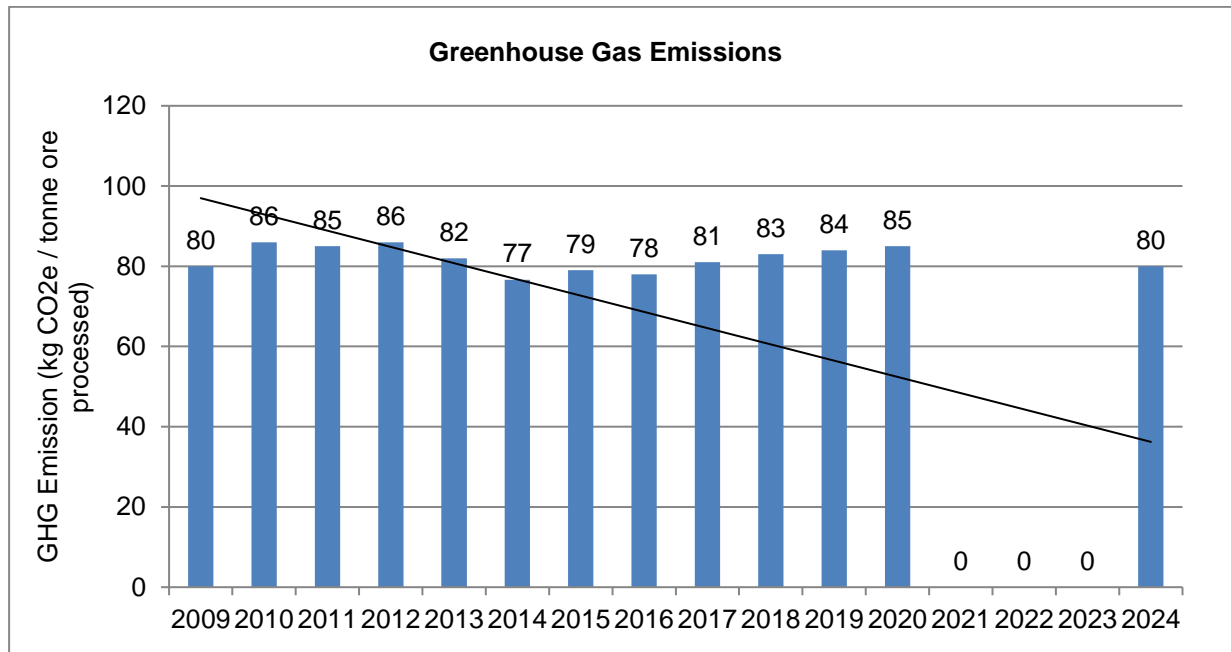


Figure 4-62 Energy efficiency 2009 – 2024

4.13 Non-mineralised Waste

Non-mineralised waste is all wastes produced by the operation other than waste rock and tailings. Porgera has developed a Waste Management Plan that describes the methods for waste segregation, reuse, recycling or treatment for safe disposal. Figure 4-63 shows waste volume by category for non-mineralised waste in 2024. Waste oil is re-used as fuel for heating the lime kiln. Sewage Treatment Plant sludge is disposed of by land application at a reclaimed area of Kogai Waste Rock Dump. Scrap paper is shredded and used as mulch for hydroseeding in land reclamation. Scrap steel is disposed at an industrial landfill on Kogai waste rock dump, while other high value metals and alloys are stored for sale to a recycling contractor. Combustible wastes are disposed by incineration at 1,100°C and remaining materials are disposed to a landfill.

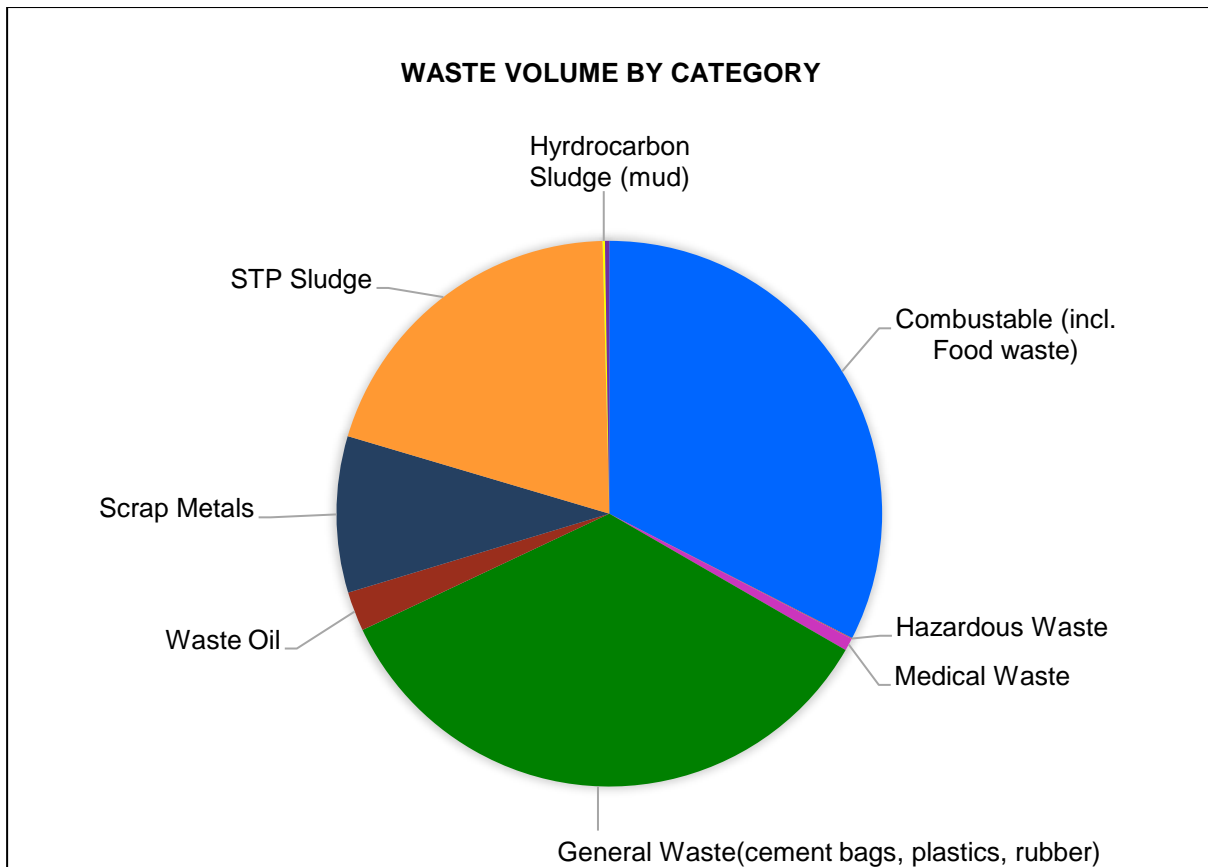


Figure 4-63 Non-mineralised waste production proportions by volume

5 BACKGROUND ENVIRONMENTAL CONDITIONS AND TRIGGER VALUES

The environmental conditions of all natural systems will change throughout time due to natural variations in climate, geography and biology. An objective of the AER is to determine how much change has occurred within the environment at reference sites adjacent to, but not affected by, the mine as opposed to change at sites downstream of the Porgera Mine (test sites). And also then, to determine how much of that change is caused by factors not related to the mining operation, and how much is caused by factors that are related to the mining operation.

Operational activities that have the potential to interact with the environment (the environmental aspects) have been discussed and quantified in Section 4.

The purpose of this section is to quantify the natural, non-mine related changes within the environment adjacent to and downstream of the Porgera mine. This information is then used to determine what degree of change observed at the test sites is attributable to natural change and what degree is attributable to the mine environmental aspects. The objectives of this section are to:

1. Quantify the climatic condition, meteorological and hydrological conditions at the mine site and within the receiving environment during 2024.
2. Describe the background environmental physical, chemical and biological conditions of aquatic ecosystems not influenced by the operation (i.e. reference site condition) and identify and quantify the natural changes at those sites during 2024 and during the past 10 years of operation; and
3. Establish risk assessment and impact assessment TVs and performance criteria for physical, chemical and biological conditions at Upper River, Lower River, ORWBs and Lake Murray to support the compliance, risk, impact and performance assessments.

5.1 Climate

5.1.1 Strickland River catchment rainfall

Annual rainfall at stations in the upper, middle and lower Strickland River catchments is shown in Figure 5-1.

The upper catchment can broadly be described as the reach of river extending from the mine site down to SG2, the middle extends from SG2 down to SG3, and the lower from SG3 past SG5 (near Lake Murray) to the confluence with the Fly River.

In general terms, rainfall in 2024 was approximately 15% above the long-term mean in the upper reach, 1.8% below average in the middle reach (SG2, Ok Om and SG3) and 22% above average in the lower reach (SG5). Data was lost at SG4 in the lower reach due to station vandalism during the care and maintenance period.

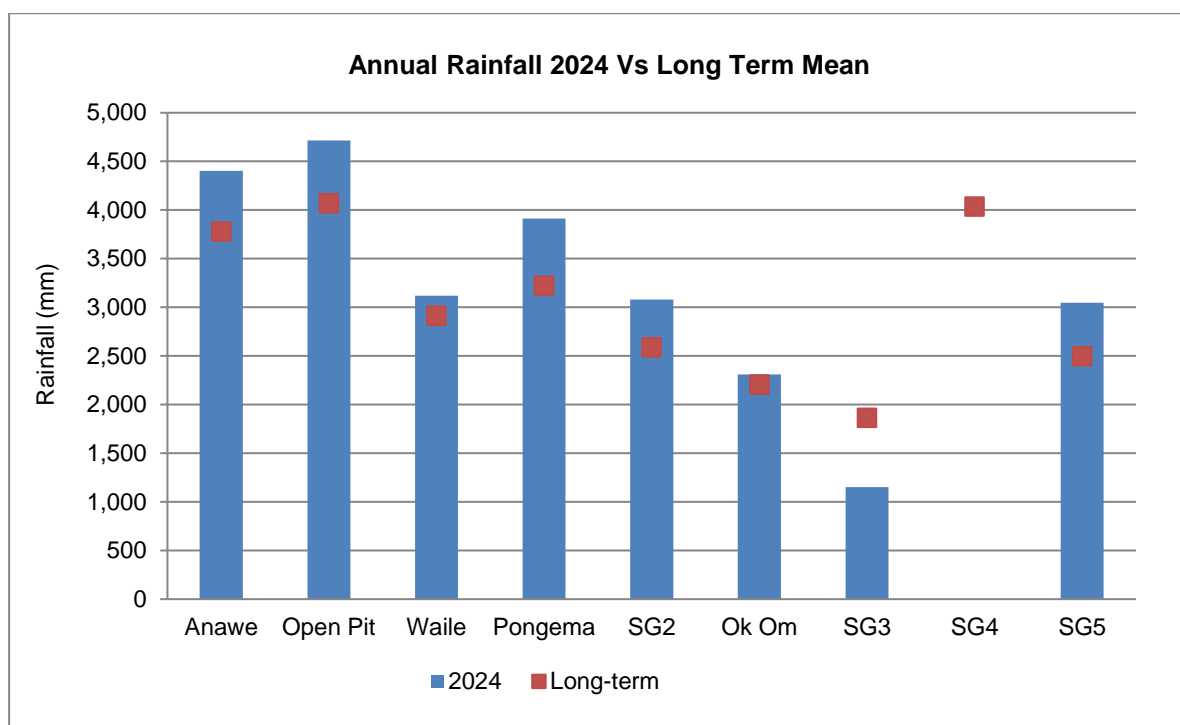


Figure 5-1 Comparison of annual rainfall (2024 data versus long-term mean) at sites in the Porgera – Lagaip-Strickland Catchment

5.1.2 Hydrological context

Rainfall in the PNG Highlands is influenced (in a complex and variable way) by both ENSO (El Niño-Southern Oscillation Index) and the Pacific Decadal Oscillation (PDO). The PDO is a pattern of Pacific climate variability that shifts phases on at least inter-decadal time scale, usually about 20 to 30 years. The PDO influences sea surface temperatures, atmospheric pressure patterns, and large-scale climate variability, including in the western Pacific. The PDO is not the primary influence on rainfall in the Highlands, rather the PDO acts more as a background modulator of ENSO-driven variability. El Niño events generally suppress rainfall in the Highlands, particularly during the main wet season (December to March). In the Western Highlands, there tend to be more pronounced dry anomalies during El Niño.

In the context of longer-term rainfall trends, Figure 5-2 shows the rainfall pattern of recent years at Anawe, the station with the longest period of record, plotted with the. The plotted lines represent the cumulative deviation of each year’s rainfall total and PDO value from the overall mean of the dataset. To interpret the graph, a downward sloping line represents ‘below-average’ years, while an upward sloping line represents ‘above average years’. This demonstrates that since 1997, rainfall was notably higher than the period 1974-1997 suggesting decadal scale variability. Statistically, the Mann-Kendall test run on the series of annual totals showed no significant trend ($p < 0.05$) although a Student’s t-test for pre and post-1999 periods showed that annual rainfall totals for the period 1999-2024 were significantly higher than for the period 1974-1998 ($p < 0.05$).

Figure 5-3 presents the PDO index and Anawe rainfall expressed as a ten-year moving average in order to identify trends more clearly. The PDO is detected as warm or cool surface waters in the Pacific Ocean, north of latitude 20°N. During a ‘warm’ or ‘positive’ phase, the west Pacific becomes cool and part of the eastern ocean warms; during a ‘cool’ or ‘negative’ phase, the opposite pattern occurs. The PDO is strongly related to El Niño Southern Oscillation (ENSO) episodes but operating over much longer timescales. Negative ENSO events generally mean low rainfall for PNG, however, the Porgera rainfall also appears inversely correlated with the PDO on a decadal scale, although both indices are correlated with Anawe rainfall on a 10-year moving average basis. Although detailed analysis of rainfall trends is not the focus of this section, the analysis serves to highlight that rainfall (and, by inference, river flow and sediment transport) varies over both long and short-term timescales. An El Niño event is defined

when the ENSO falls below -8, the average ENSO value in 2024 was 1.12. While 2024 started in a strong El Niño phase there was a transition toward ENSO-neutral conditions by mid to late 2024 and was considered overall a negative year.

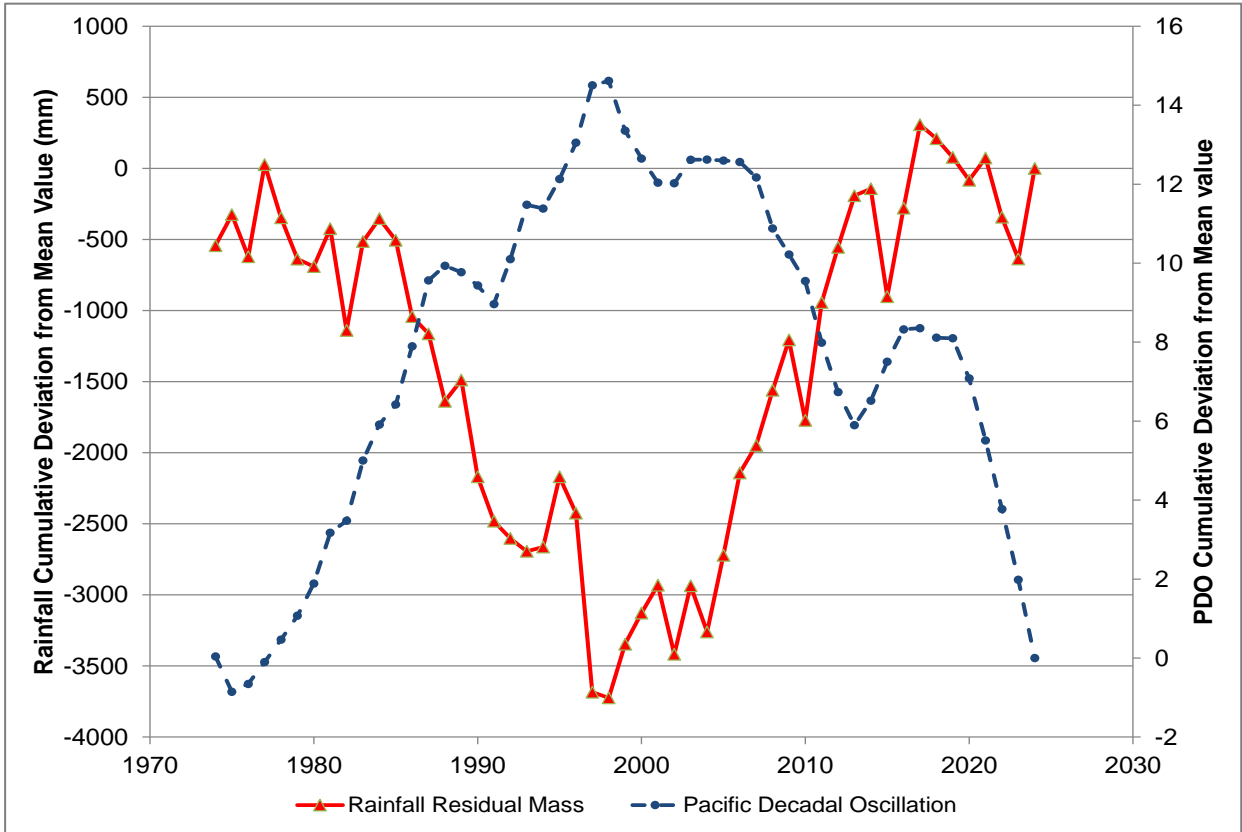


Figure 5-2 Residual mass plots Anawe rainfall station data

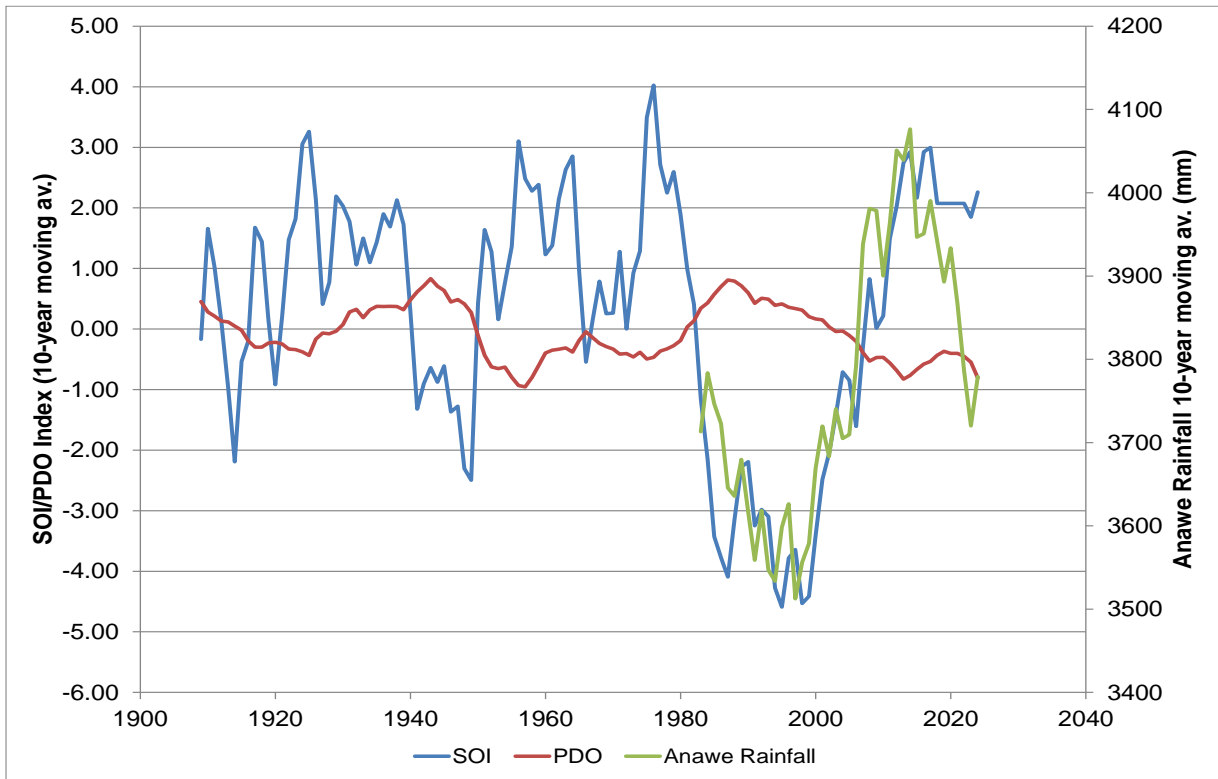


Figure 5-3 Anawe rainfall, SOI and PDO indices on 10-y moving average

5.1.3 Rainfall summaries

5.1.3.1 Anawe plant site

Meteorological data are measured continuously at Anawe Plant site. The parameters monitored are rainfall, temperature, humidity, evaporation, wind vectors, barometric pressure and solar radiation. Due to the influence of the surrounding mountains, there is minimal seasonal variability in climate throughout the year at Porgera. Table 5-1 provides a summary of the meteorological data collected during the year.

Table 5-1 Summary of meteorological data recorded at Anawe Plant site during 2024

Parameter	Yearly total	Daily max	Daily min	Daily mean	Long-term daily mean
Rainfall (mm)	4,402	60	0.0	12	12
Max/Min Temp. (°C)	-	25.6	9.8	-	-
Mean Daily Temp.(°C)	-	25.2	14.1	15.9	16.9
Sunshine (h)	1,122	9.5	0.0	3.3	4.0
Evaporation (mm)	1,031	8.8	0.8	2.9	2.9
Wind run (km)	11,915	95	17	35	46

Figure 5-4 shows monthly total rainfall at Anawe in 2024 against long-term monthly means. Annual rainfall in 2024 was 4,402 mm on 334 wet days against a long-term mean annual total of 3,768 mm. The historical rainfall at Anawe is shown in Figure 5-5. The highest annual rainfall recorded at Anawe was 4,610 mm in 2020.

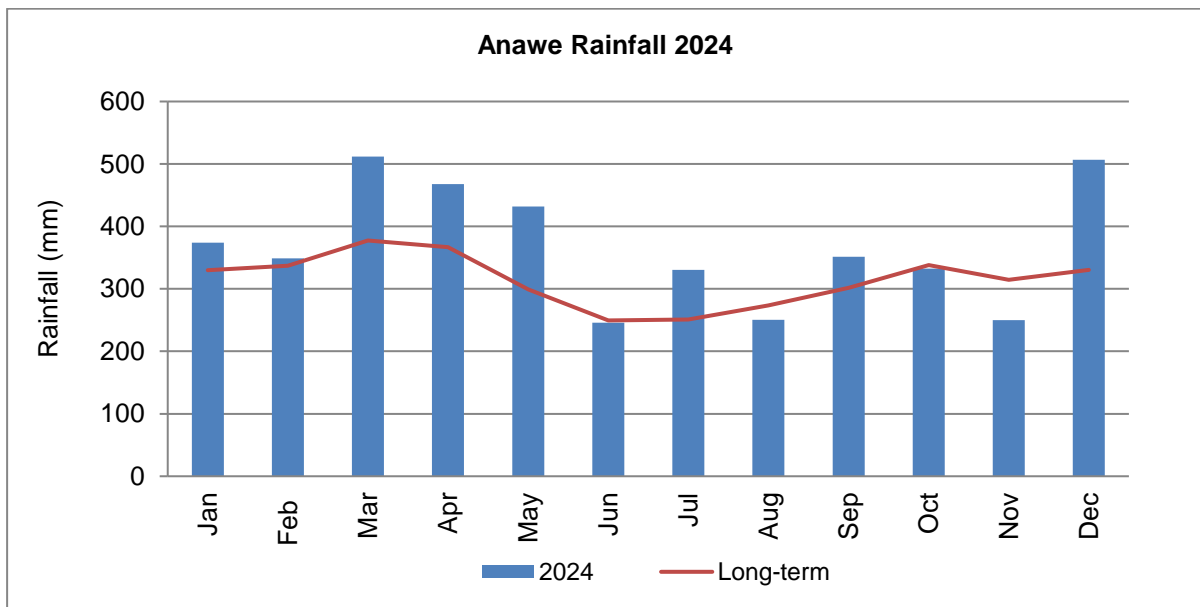


Figure 5-4 Monthly rainfall at Anawe Plant site during 2024 compared to long-term monthly means

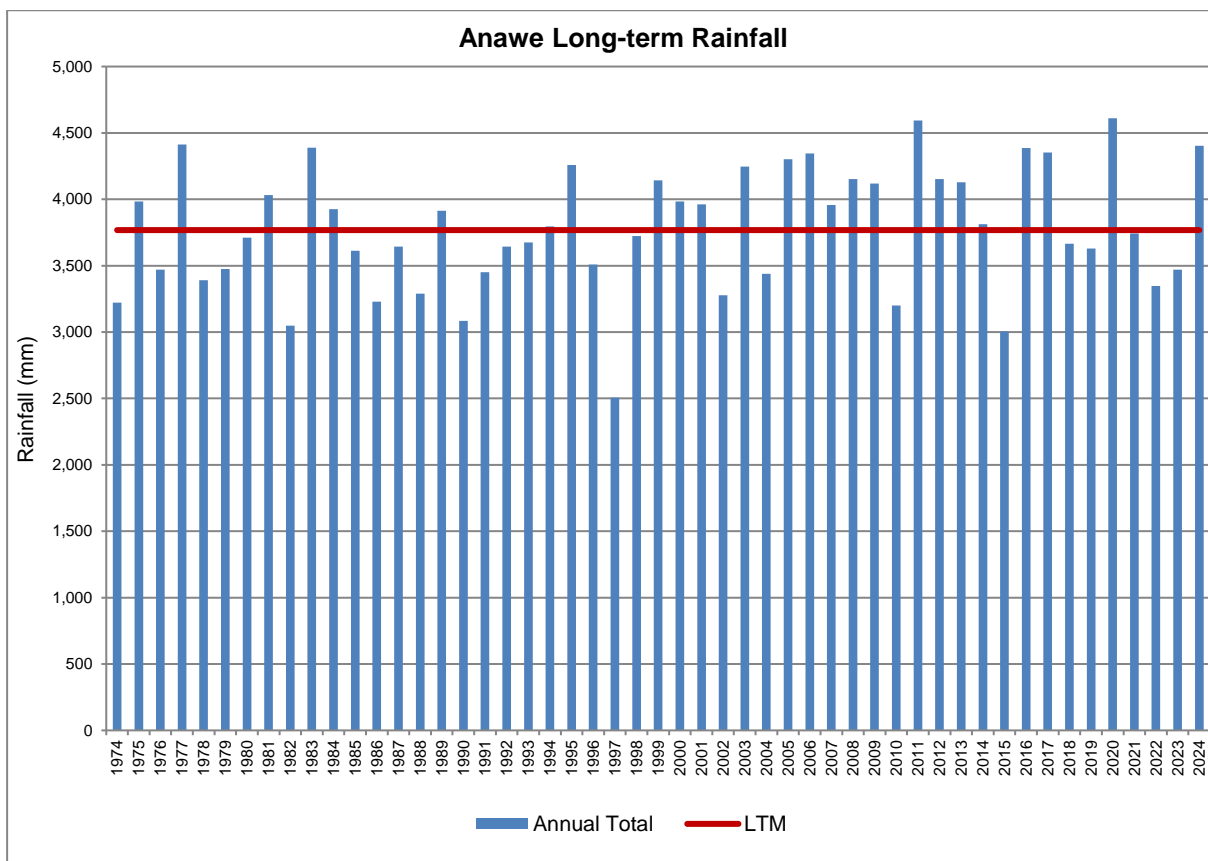


Figure 5-5 Comparison of annual total rainfall at Anawe Plant site with long-term mean (LTM) 1974 - 2024

5.1.3.2 Open pit

Figure 5-6 shows total monthly rainfall at the Open Pit during the year against long-term monthly means. Annual rainfall was 4,716 mm on 334 wet days. The long-term mean annual total was 3,985 mm. Figure 5-7 shows the historical annual totals.

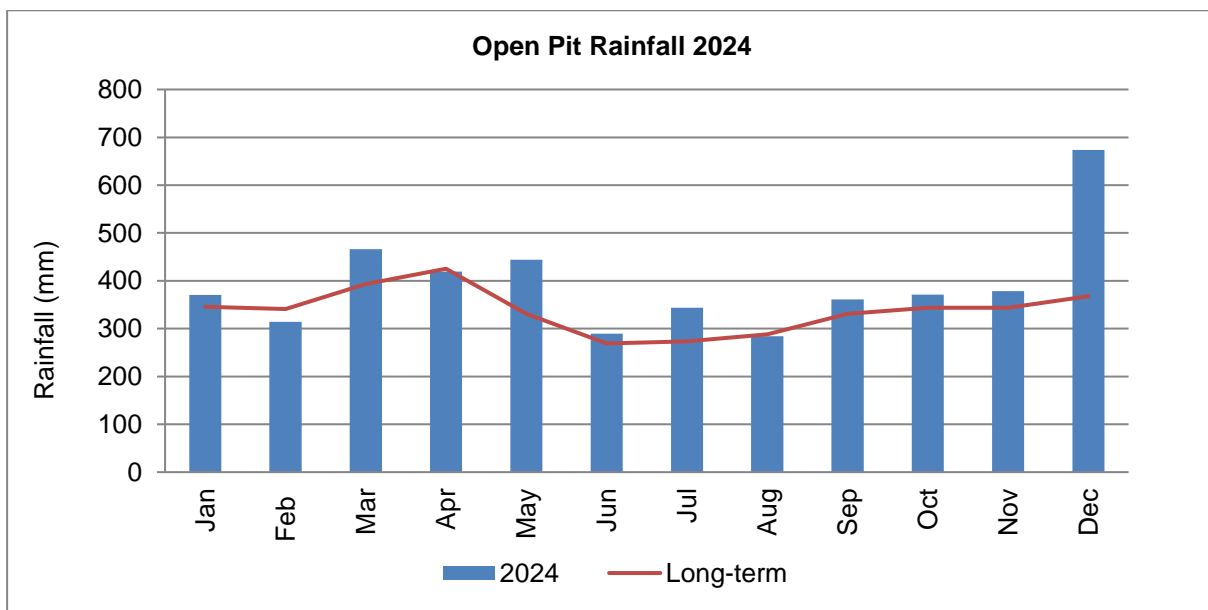


Figure 5-6 Rainfall at the Open Pit during 2024 compared to long-term monthly means

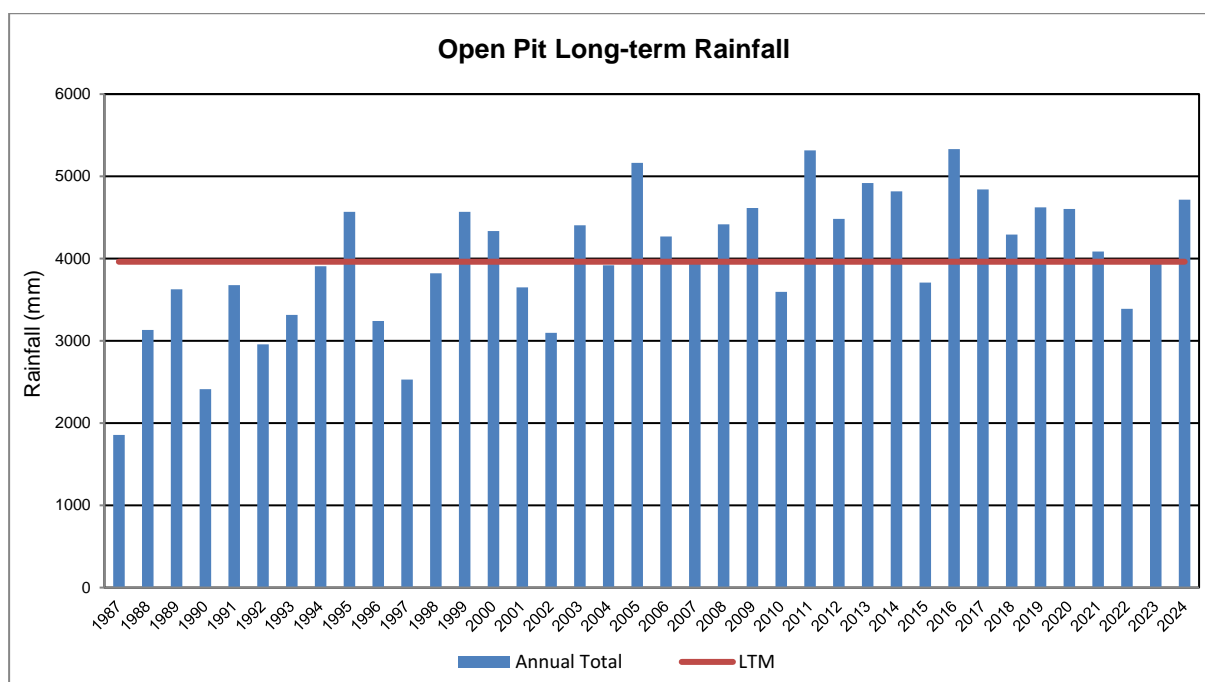


Figure 5-7 Comparison of annual total rainfall at Open Pit site with long-term mean (LTM) 1987–2024

5.1.3.3 Other Sites

Total annual rainfall for 2024, the number of wet days in 2024 and the long-term mean annual total rainfall at Waile Creek, Pongema, SG2, Ok Om, SG3, SG4 and SG5 are shown in Table 5-2 and Figure 5-8 to Figure 5-14. Due to vandalism at SG4 station, the rainfall data from January to September 2024 were lost.

Table 5-2 Other Rainfall Site Summary

Site	2024 Annual Total Rainfall (mm)	Wet Days in 2024	Long-term Mean Total Annual Rainfall (mm)
Waile Creek	3,118	320	2,915
Pongema	3,912	320	3,223
SG2	3,018	313	2,588
Ok Om	2,309	249	2,207
SG3	1,152	199	1,865
SG4*	1,032	-	4,038
SG5	3,046	320	2,497

*Data lost due to station vandalism. Wet days not known.

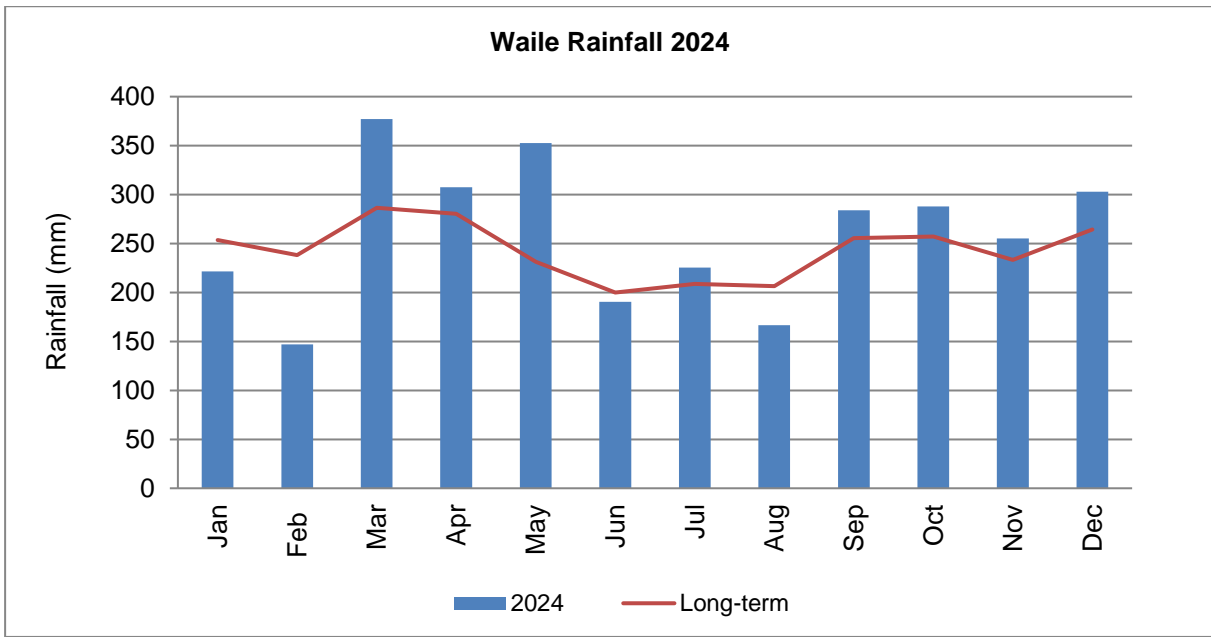


Figure 5-8 Rainfall at Waile Dam during 2024 compared to long-term monthly means

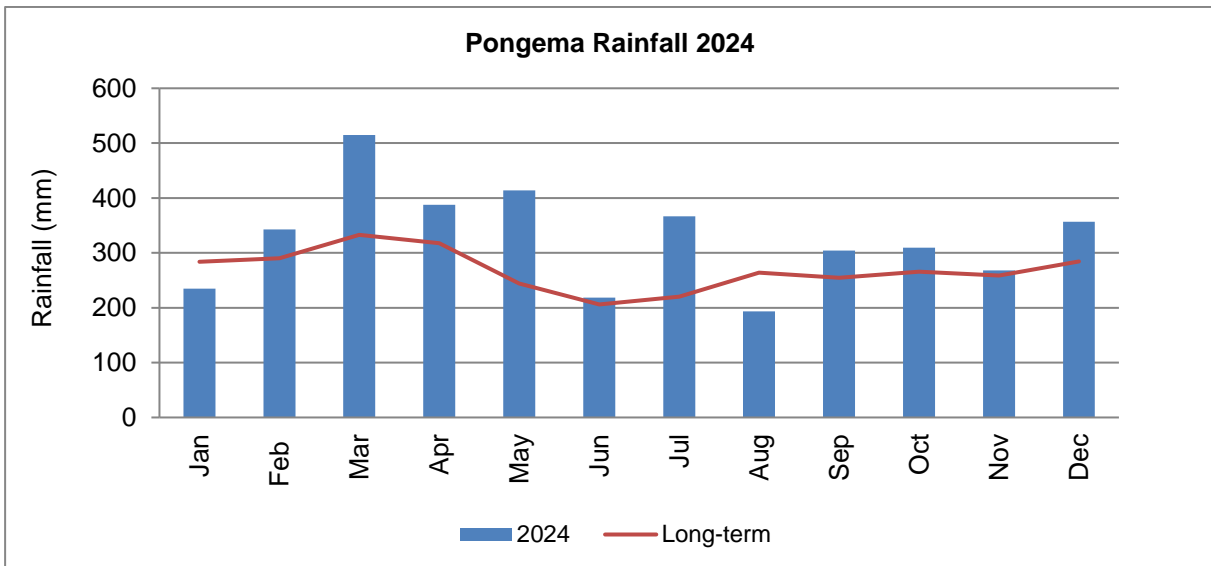


Figure 5-9 Rainfall at Suyan Camp during 2024 compared to long-term monthly means

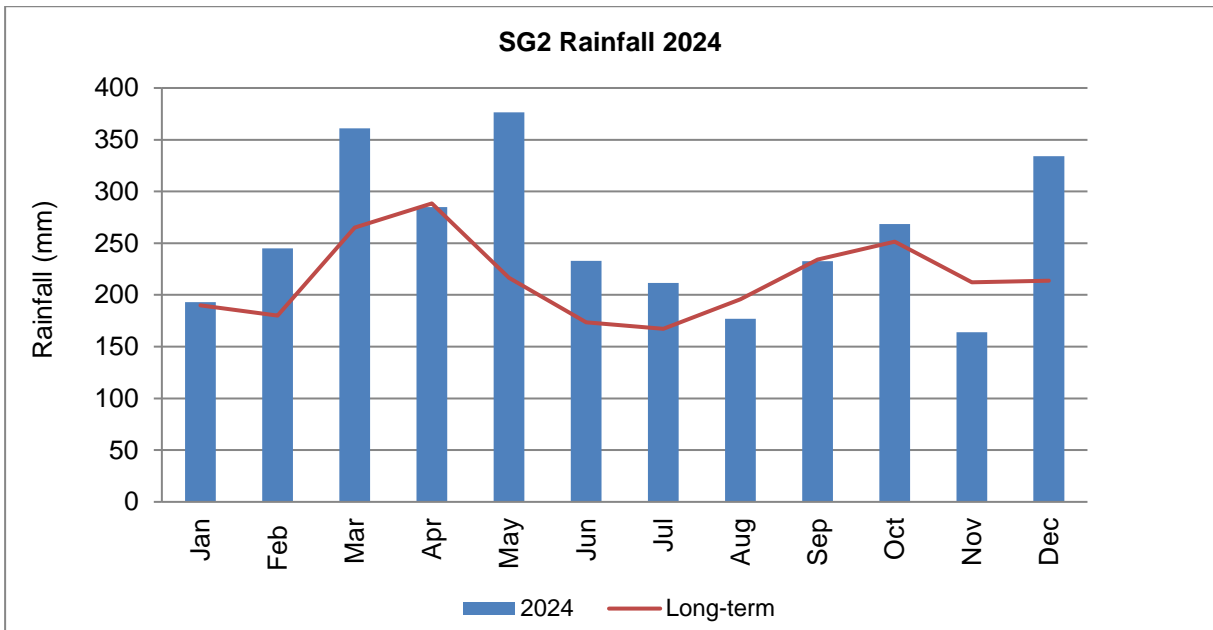


Figure 5-10 Rainfall at SG2 during 2024 compared to long-term monthly means

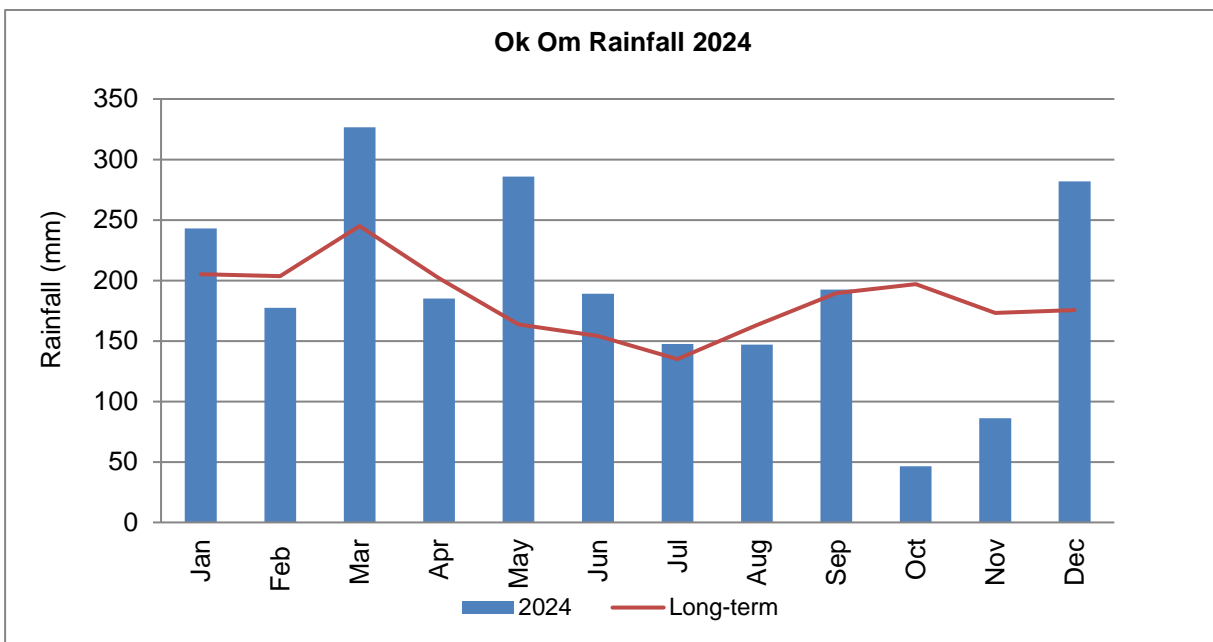


Figure 5-11 Rainfall at Ok Om During 2024 compared to long-term monthly means

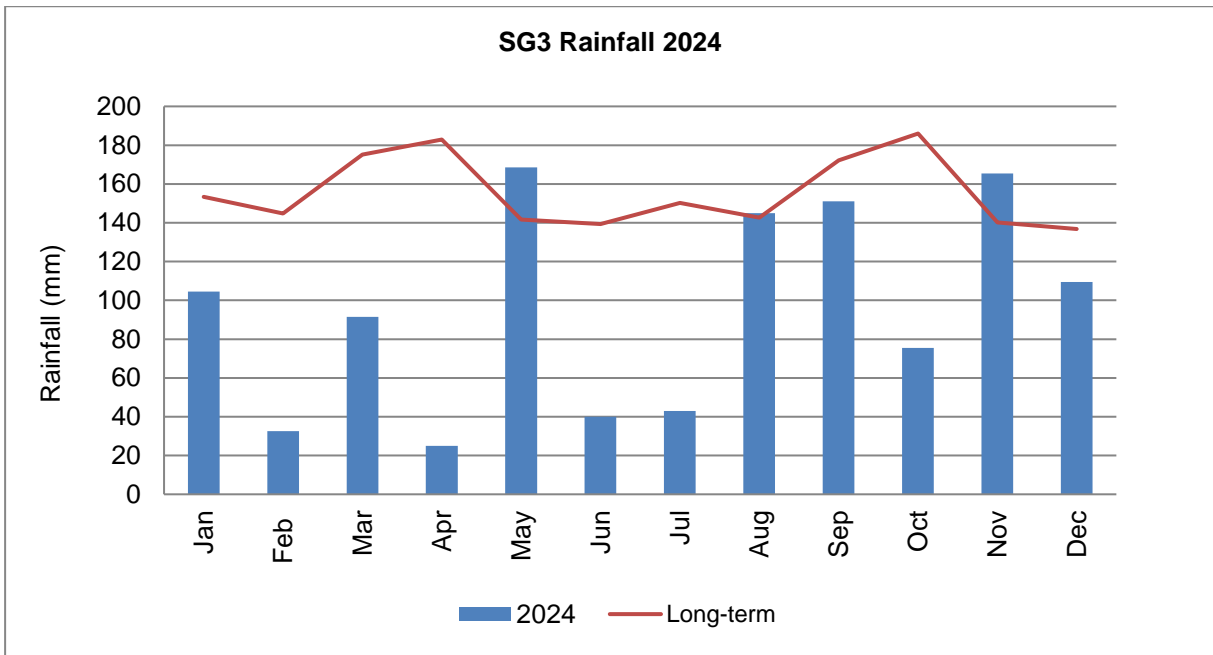


Figure 5-12 Rainfall at SG3 during 2024 compared to long-term monthly means

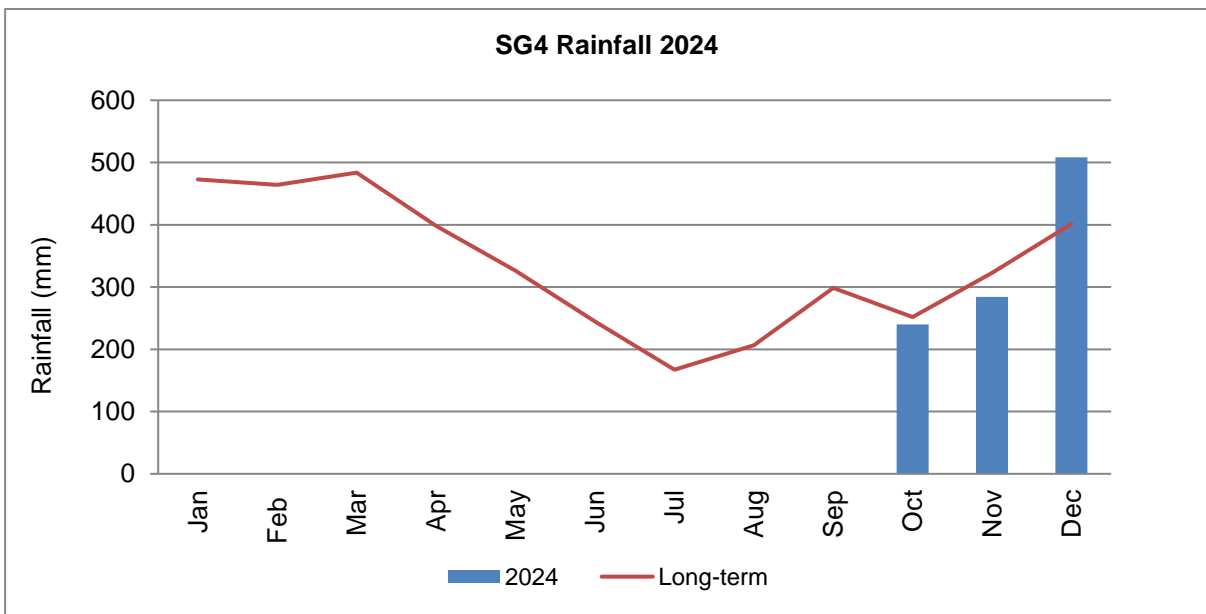


Figure 5-13 Rainfall at SG4 during 2024 compared to long-term monthly means

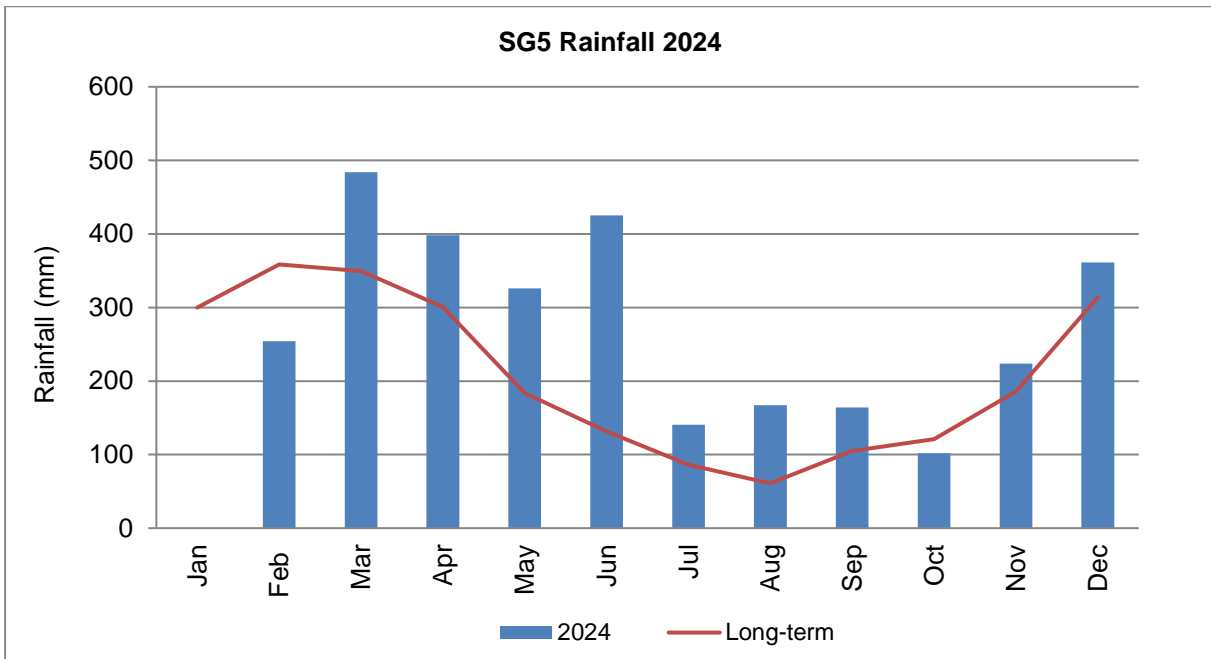


Figure 5-14 Rainfall at SG5 during 2024 compared to long-term monthly means

5.2 Hydrology

5.2.1 Strickland River Catchment

The river systems downstream of, and potentially impacted by, the mine are the Porgera, Lagaip and Strickland Rivers. From a hydrological perspective, these can be broadly grouped into three regions of interest; upper catchment (Porgera Valley), middle catchment (SG2 to SG3) and lower catchment (SG3 to lowlands / floodplain). The Ok Om monitoring site is a reference site and therefore not influenced by the mine.

Due to the care and maintenance phase and mine operational situation in recent years and the difficulties in maintaining the hydrometric network, data recovery rates are particularly low for all stations except SG3 and cannot be reported. However, rainfall records for Anawe show that the 2024 total of 4,402 mm was the fourth highest on record since 1974, suggesting that river flows for the year would likely be well above average.

The complete flow record for SG3 showed that the mean daily flow was 20% above the long-term mean value. A summary of available annual river flow data is shown in Table 5-3.

Table 5-3 Summary of flows in m³/s for riverine stations in 2024

Station	Days lost 2024	Flow (m ³ /s)		
		2024 Mean	2024 Min	Long-term Mean
Lagaip @ SG2	281	NA	NA	220
Ok Om	182	NA	NA	143
Strickland @ SG3	0	920	330	761
Strickland @ SG4	260	NA	NA	2,566
Strickland @ SG5	264	NA	NA	2,889

5.2.2 SG3

Figure 5-15 shows the mean daily flows for the year at SG3 while Figure 5-16 shows total monthly flows compared to long-term monthly averages. The mean daily flow at SG3 of was approximately 20% above the long-term average. Highest flows were recorded in May and the lowest in February.

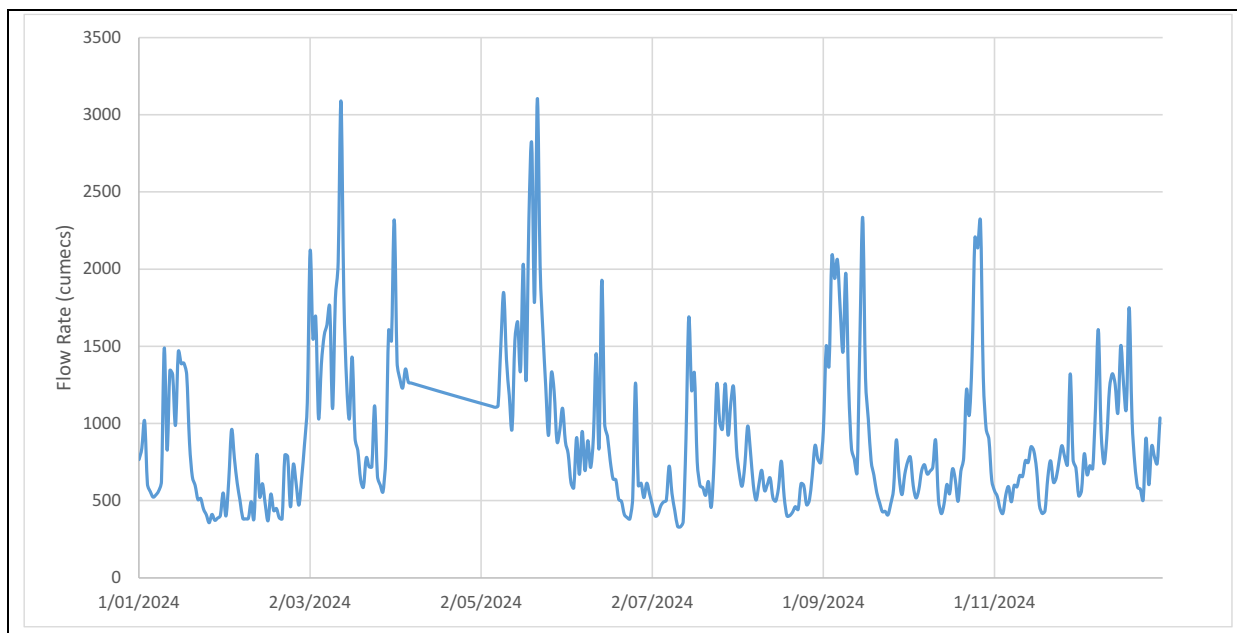


Figure 5-15 Total daily flow (GL) at SG3 for 2024

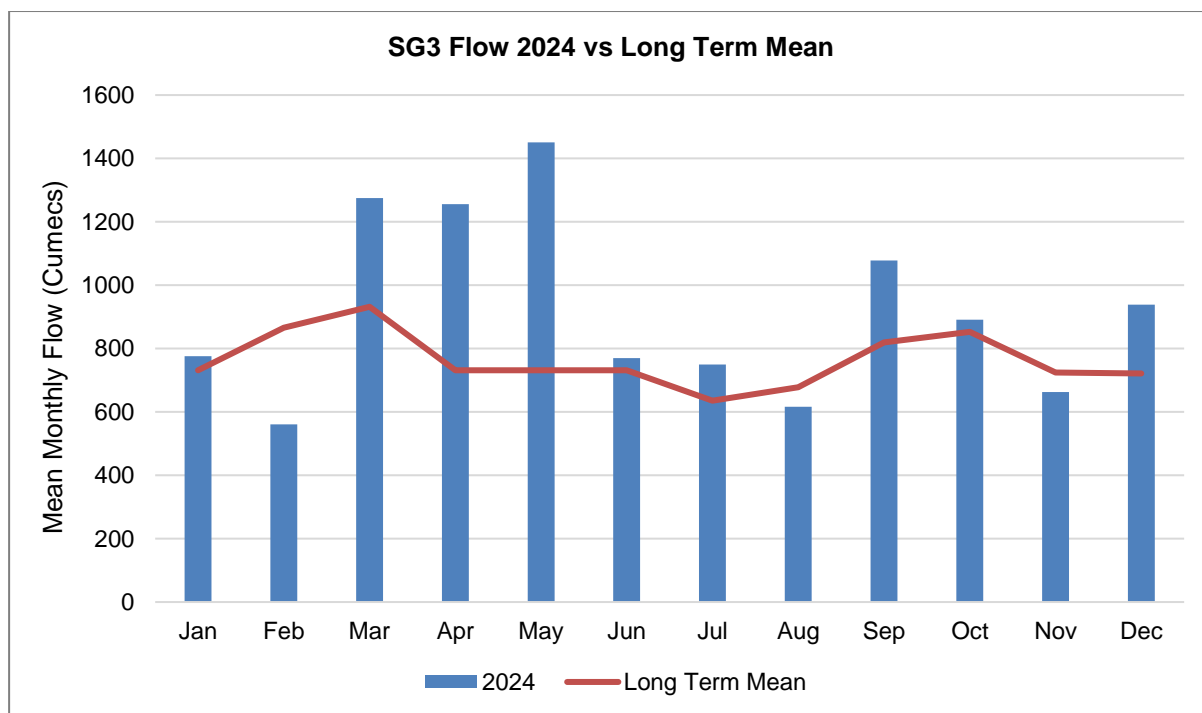


Figure 5-16 Total monthly flow (cumeecs) at SG3 during 2024 compared to long-term monthly means

5.3 Background Water Quality and Trigger Values

This section presents a comparison of water quality data collected at test sites prior to mining operations commencing (baseline data), from reference sites during the previous 24-months and the guideline values for 95% species protection from ANZG (2018).

In accordance with Section 2.3 of this report, the data are compared and the highest value for each parameter is then adopted as the 2024 TV for use in the water quality risk assessment presented in Section 7. The sites are grouped into regions; Local Sites, Upper River, Lower River, ORWBs and Lake Murray.

Data from local reference sites are presented to describe the quality of non-mine-related contributions to the receiving environment and are not used to derive receiving environment TVs.

Water quality TVs for metals were established based on the dissolved concentrations. Dissolved concentrations are a better measure of the concentration of metal that is bioavailable and therefore have the potential to cause toxicity. Total concentrations include bioavailable, non-bioavailable and particle-bound metals and are therefore likely to overestimate potential toxicity.

5.3.1 Local reference sites

Local sites comprise the small highland creeks within the Porgera River catchment that are not affected by the mining operation. Rainfall runoff from these creeks joins with discharge from the mine to form the Porgera River, and so the quality of water in these creeks is important for providing the full context of inputs that influence downstream water quality.

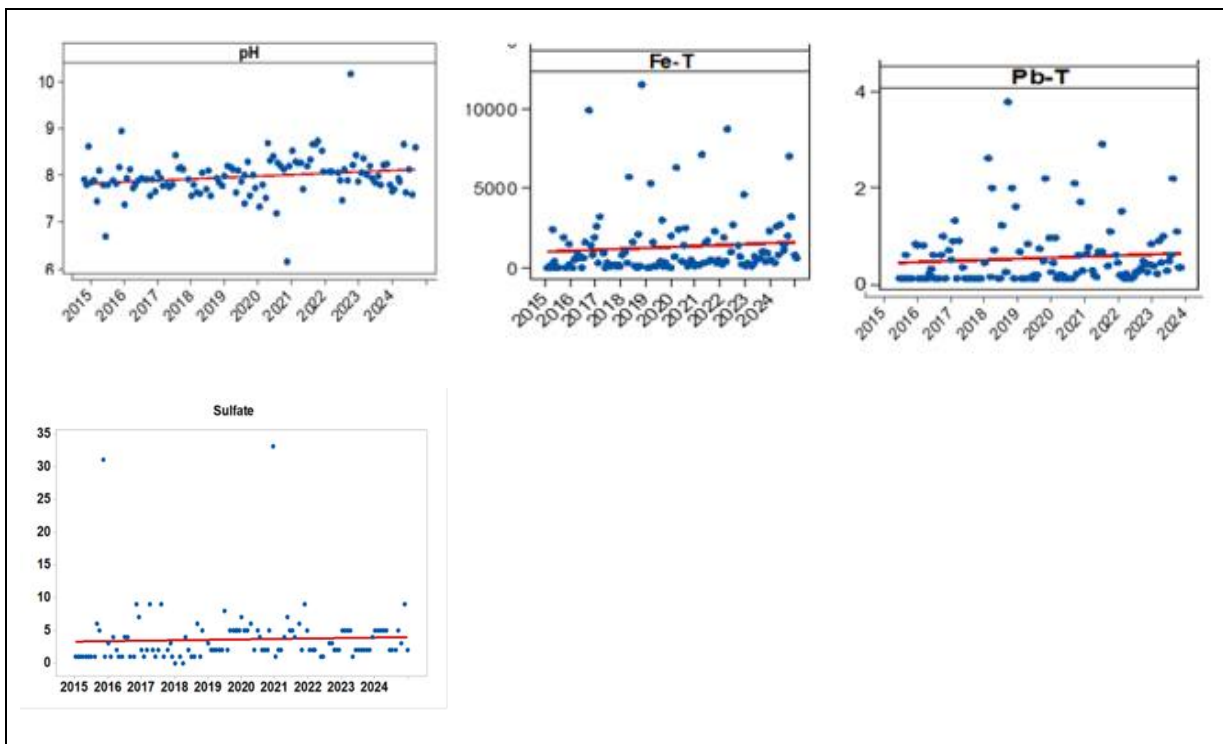
The site names are presented in Table 5-4 and median water quality data for 2024 are presented in Table 5-5 and shown in Figure 5-18 to Figure 5-47. The long-term trends from 2015-2024 are shown in Table 5-6 and as median data in Figure 5-18 to Figure 5-47.

Table 5-4 Local reference site monitoring locations

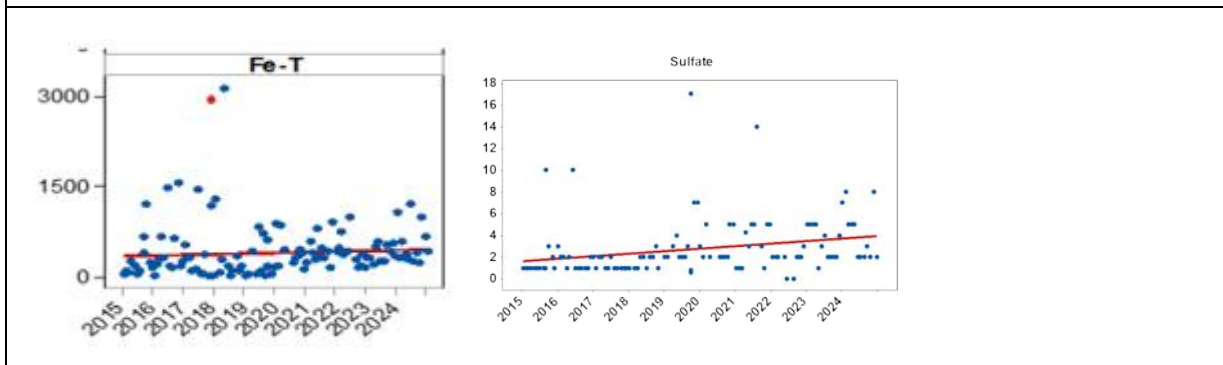
Site Type	Site Name
Local sites	Aipulungu US - Aipulungu River upstream of lime plant and quarry
	Waile Dam
	Kaiya River US – Kaiya River upstream of Anjolek erodible dump
	Pongema River

Water quality in local creeks is dominated by the surrounding limestone geology and relatively low level of development within the catchments. The pH is alkaline and typical of limestone geology, TSS is generally low but has the potential to become elevated during high rainfall periods due to landslides and erosion within the steep valley catchment, and particularly in the Kaiya River US and Aipulungu River US. Concentrations of dissolved metals generally were low; however, background concentrations of chromium, copper, iron, nickel, lead and zinc were at detectable levels throughout the historical record. Electrical conductivity at Pongema exceeded the upper river TV, shown in Table 5-5, elevated concentrations of some total metals were present throughout the record at some sites. The Kaiya River upstream (u/s) Anjolek Dump was not sampled in 2024 due to security concerns.

A summary of the trends between 2015 and 2024 is shown in Table 5-6, and details of the statistical analysis for long-term trends are provided in Appendix C. The analysis showed that dissolved zinc at Kaiya River US have increased over time. This is consistent with a reducing trend in pH at the site. Graphical representation of pH, sulfate, dissolved zinc, total lead and iron from each site showing increasing and trends is presented in Figure 5-17.



Aipulungu U/S Lime Plant – pH, sulfate, total iron and lead 2015 - 2024



Waile Creek – Sulfate and total iron 2015 - 2024



Kaiya U/S Anj Dump - Total zinc 2010- 2018

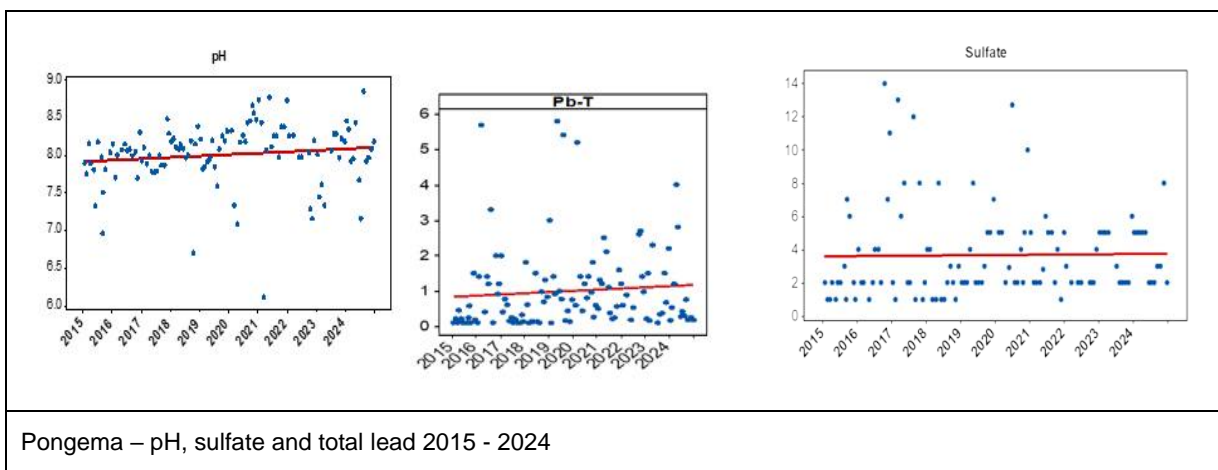


Figure 5-17 Trend analysis Local reference sites (scatter plot of all data from 2015 – 2024 with linear trend line)

Table 5-5 Local reference site water quality 2024 median values (µg/L except where shown)

Parameter	UpRivs TV	Aipulungu U/S Lime Plant	Waile Dam	Kaiya Riv U/S Anj Dump	Pongema
pH [^]	6.0-8.2	7.9	7.8	NS	8.0
EC#	230	185	134	NS	241
WAD-CN*	NA	0.20	0.20	NS	0.20
Sulfate*	NA	5.0	4.0	NS	4.0
ALK-T**	NA	91	71	NS	118
Hardness**	NA	91	67	NS	131
TSS*	2,837	49	11	NS	27
Ag-D	0.05	0.01	0.01	NS	0.01
Ag-T	NA	0.01	0.01	NS	0.01
As-D	24	0.16	0.15	NS	0.19
As-T	NA	0.30	0.22	NS	0.29
Cd-D	0.32	0.05	0.05	NS	0.05
Cd-T	NA	0.05	0.05	NS	0.05
Cr-D	1.0	0.16	0.15	NS	0.17
Cr-T	NA	1.40	0.47	NS	1.0
Cu-D	1.4	0.57	0.53	NS	0.42
Cu-T	NA	1.4	0.82	NS	0.87
Fe-D	75	17	51	NS	7.6
Fe-T	NA	1,270	405	NS	760
Hg-D	0.60	0.05	0.05	NS	0.05
Hg-T	NA	0.05	0.05	NS	0.05
Ni-D	21	0.50	0.50	NS	0.50
Ni-T	NA	1.2	0.62	NS	0.85
Pb-D	6.7	0.10	0.10	NS	0.10
Pb-T	NA	0.44	0.21	NS	0.35
Se-D	11	0.20	0.20	NS	0.20
Se-T	NA	0.20	0.20	NS	0.20
Zn-D	20	0.50	0.63	NS	0.55
Zn-T	NA	2.3	1.1	NS	2.4
	> UpRiv TV				

[^]std units, #µS/cm, * mg/L, **mg CaCO₃/L, D = Dissolved fraction, T = Total, NS – Not sampled

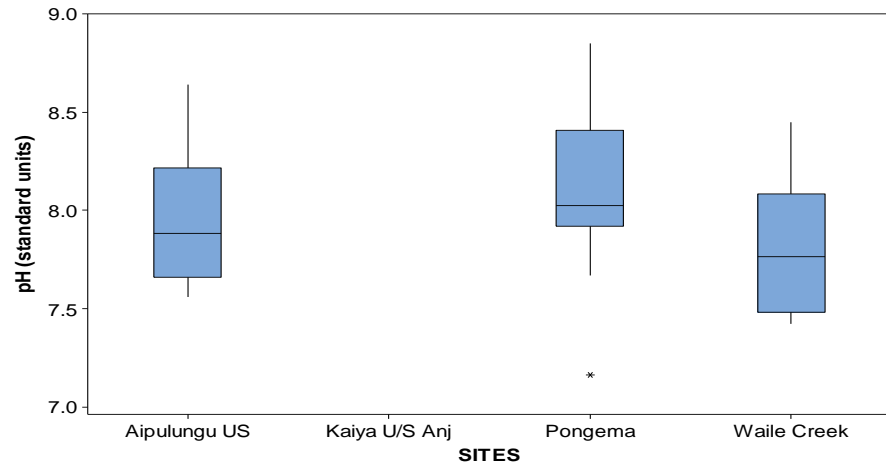


Figure 5-18 pH in local creek runoff 2024

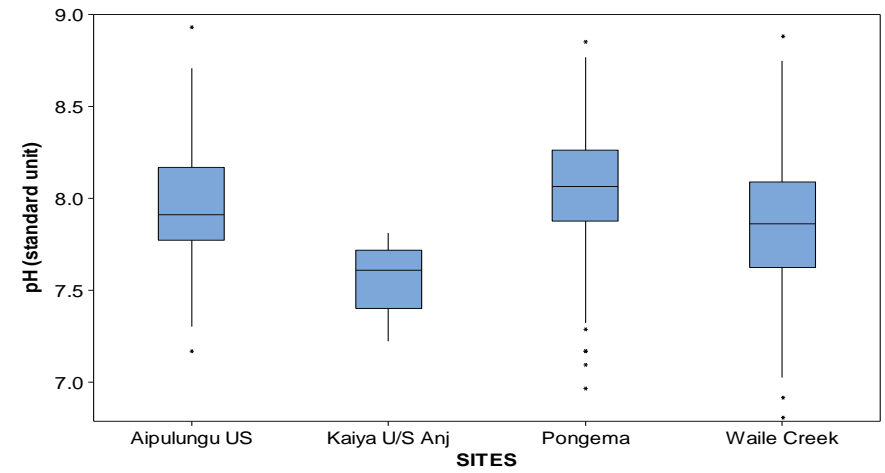


Figure 5-19 pH in local creek runoff 2015-2024

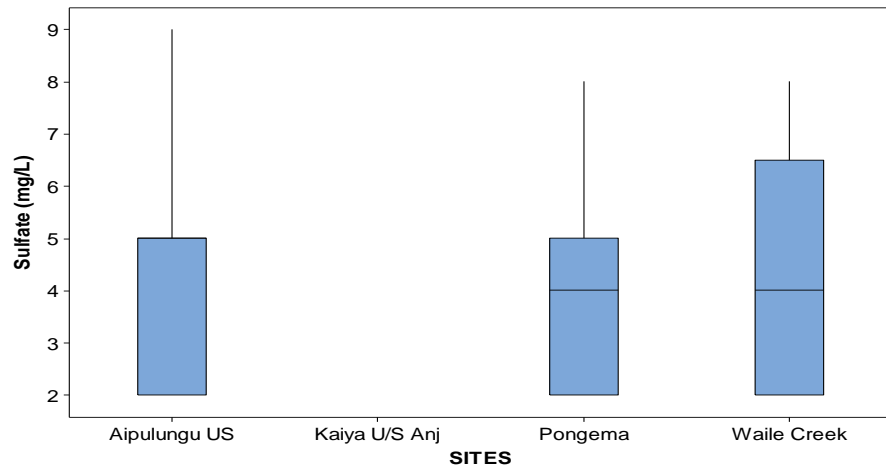


Figure 5-20 Sulfate in local creek runoff 2024

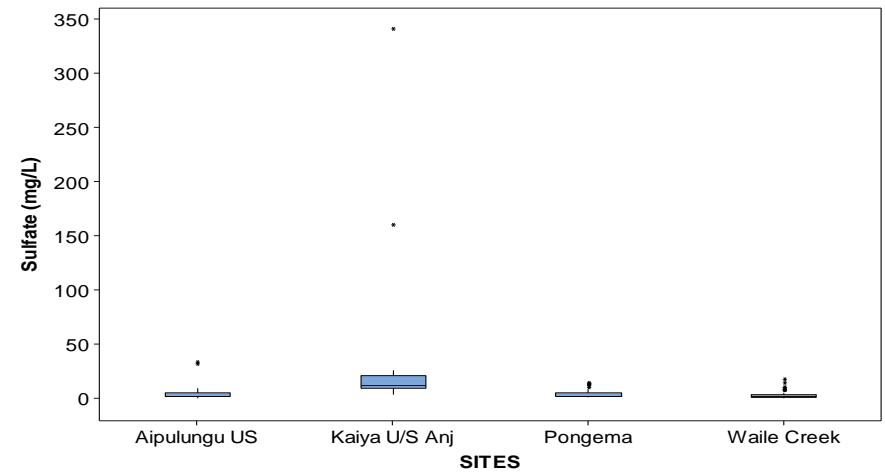


Figure 5-21 Sulfate in local creek runoff 2015-2024

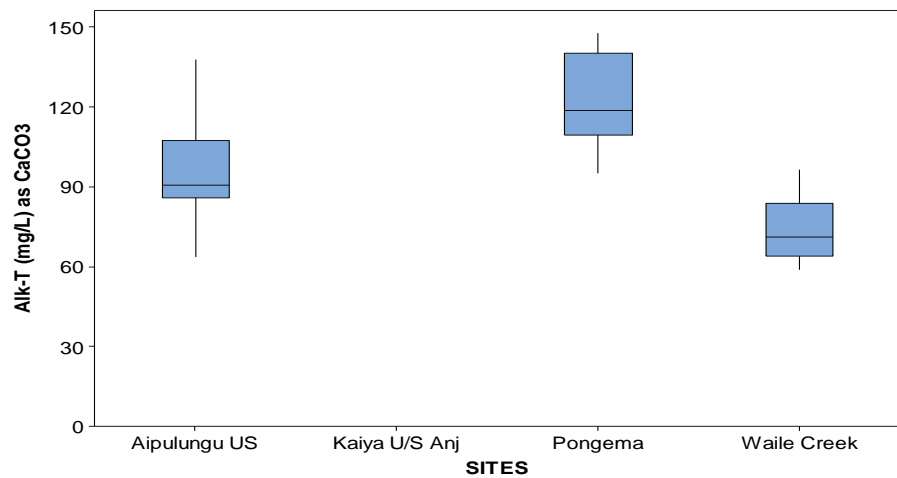


Figure 5-22 Alkalinity in local creek runoff 2024

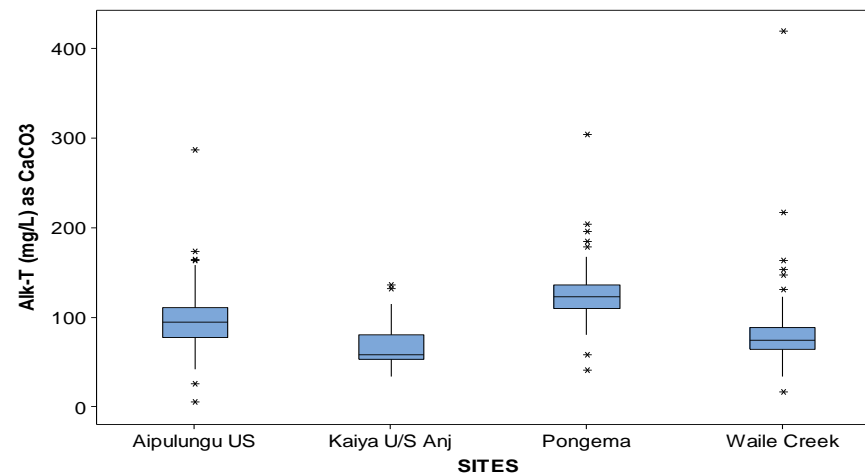


Figure 5-23 Alkalinity in local creek runoff 2015-2024

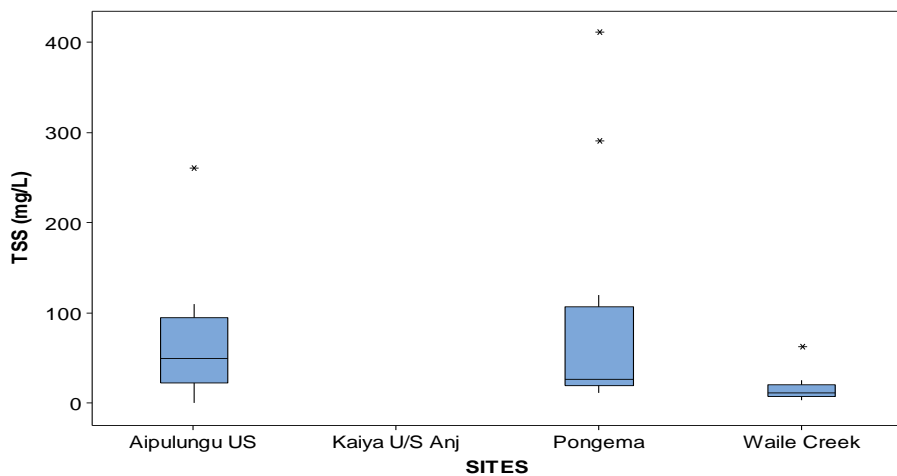


Figure 5-24 TSS in local creek runoff 2024

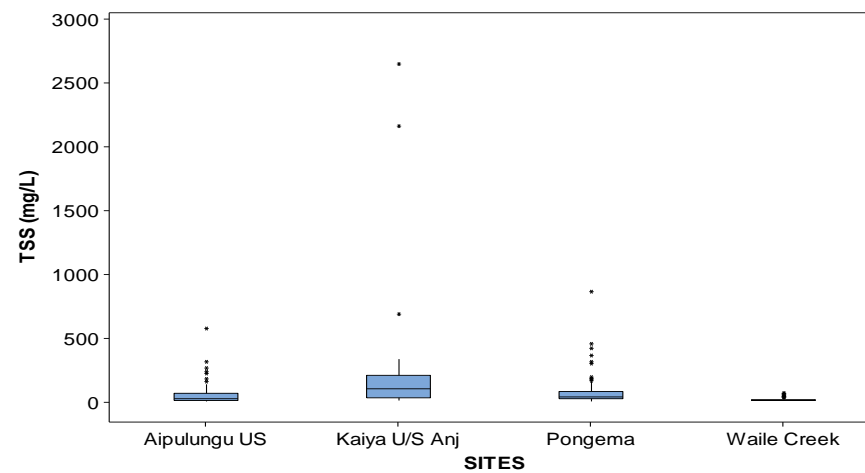


Figure 5-25 TSS in local creek runoff 2015-2024

NPL Annual Environment Report 2024

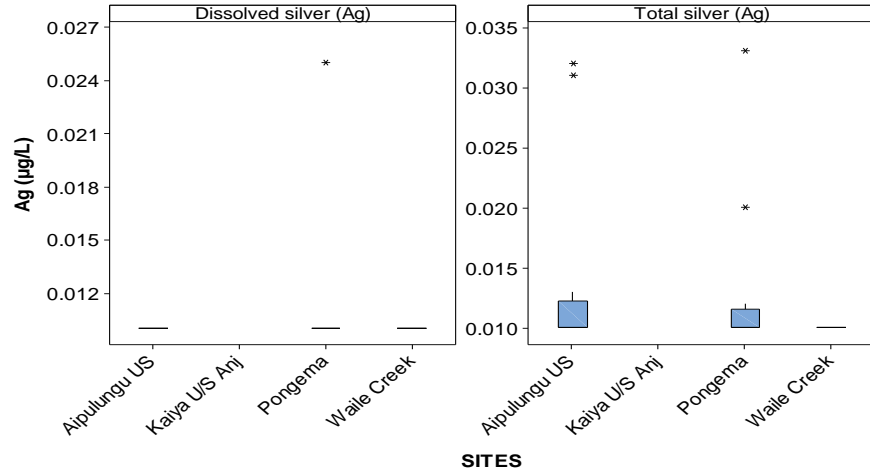


Figure 5-26 Dissolved and total silver in local creek runoff 2024

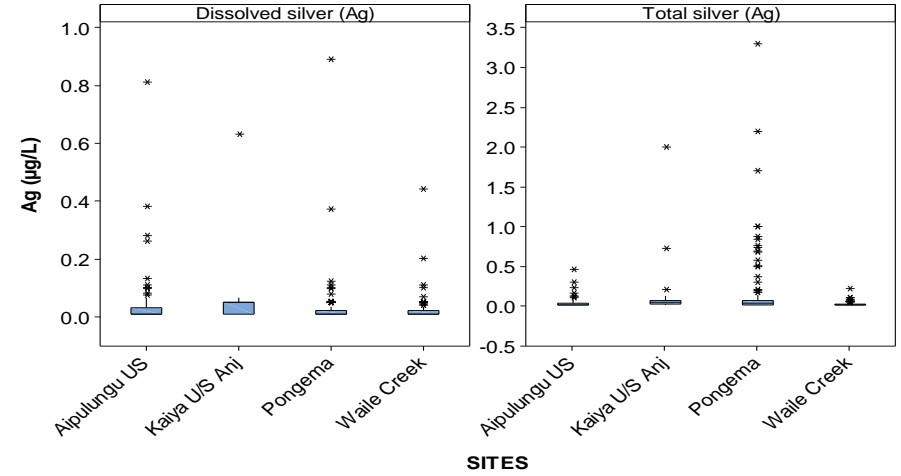


Figure 5-27 Dissolved and total silver in local creek runoff 2015-2024

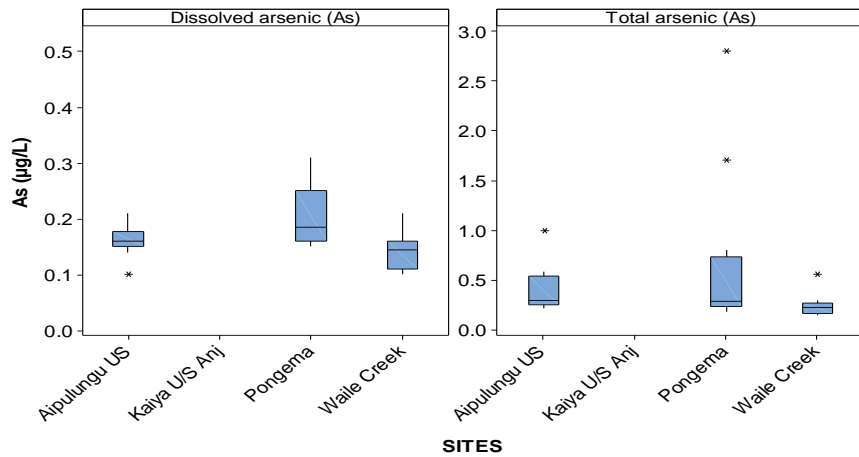


Figure 5-28 Dissolved and total arsenic in local creek runoff 2024

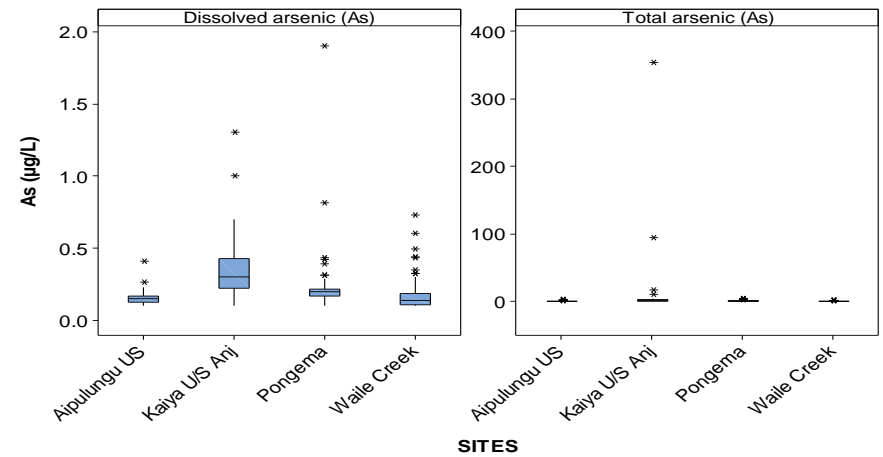


Figure 5-29 Dissolved and total arsenic in local creek runoff 2015-2024

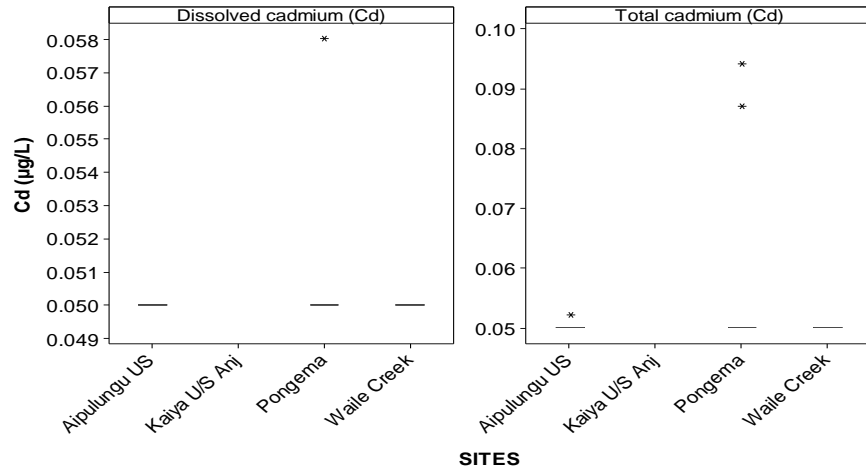


Figure 5-30 Dissolved and total cadmium in local creek runoff 2024

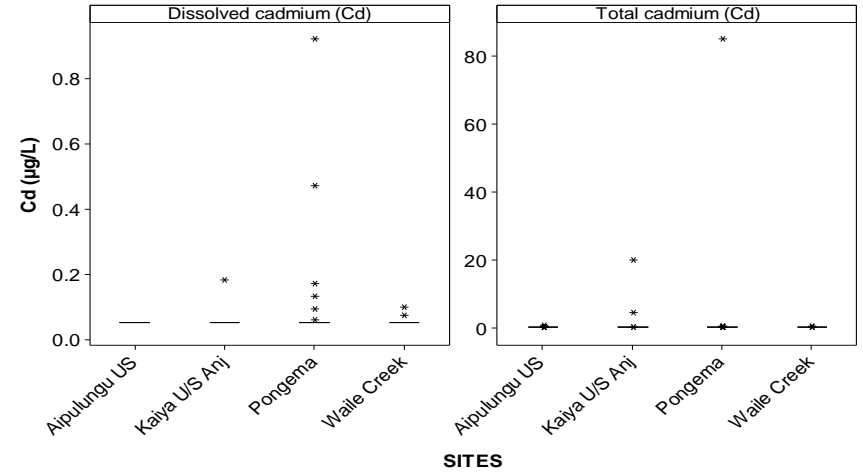


Figure 5-31 Dissolved and total cadmium in local creek runoff 2015-2024

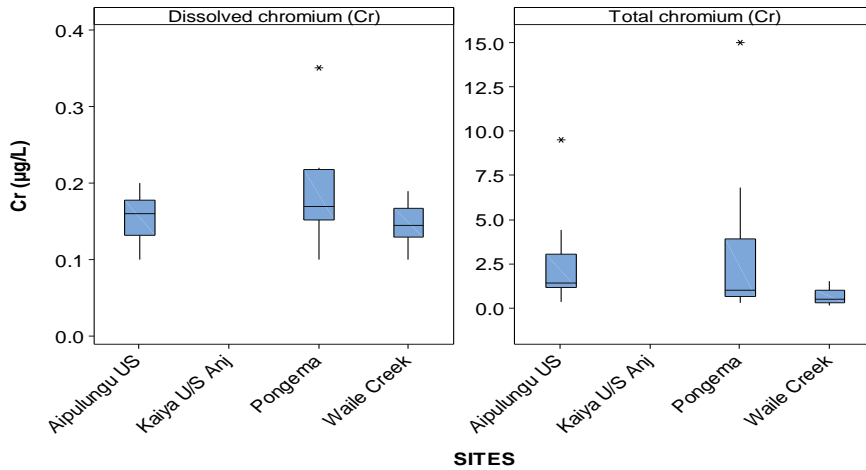


Figure 5-32 Dissolved and total chromium in local creek runoff 2024

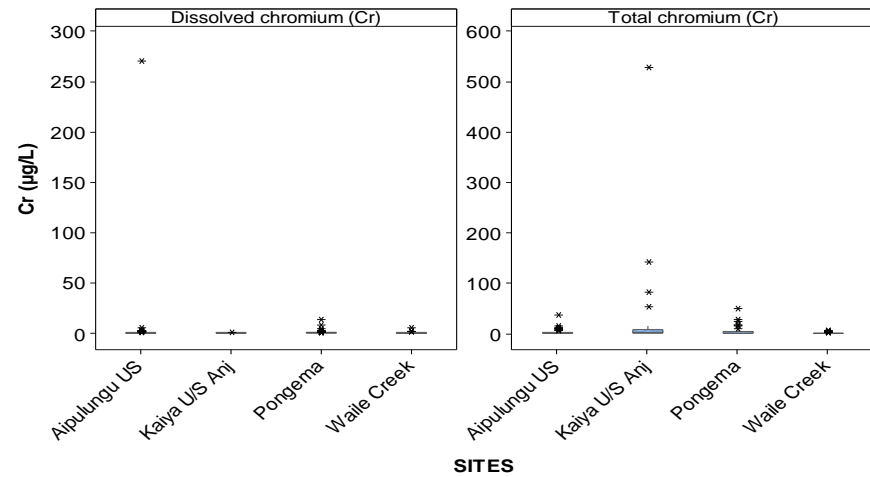


Figure 5-33 Dissolved and total chromium in local creek runoff 2015-2024

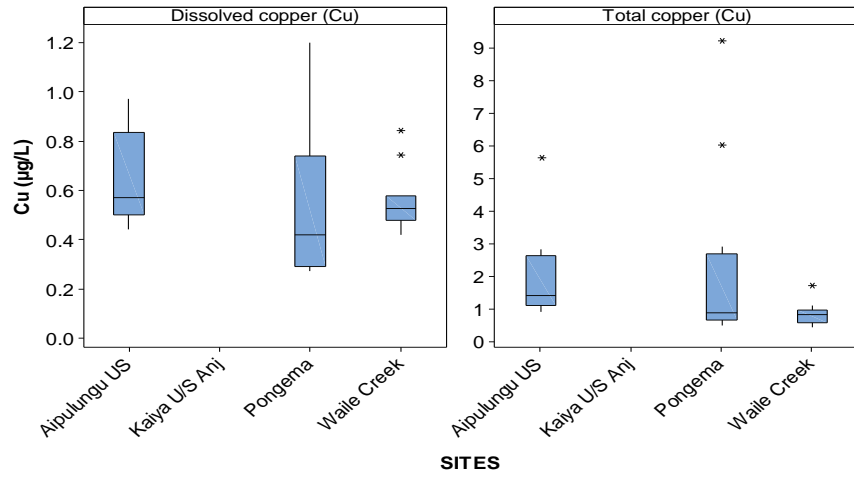


Figure 5-34 Dissolved and total copper in local creek runoff 2024

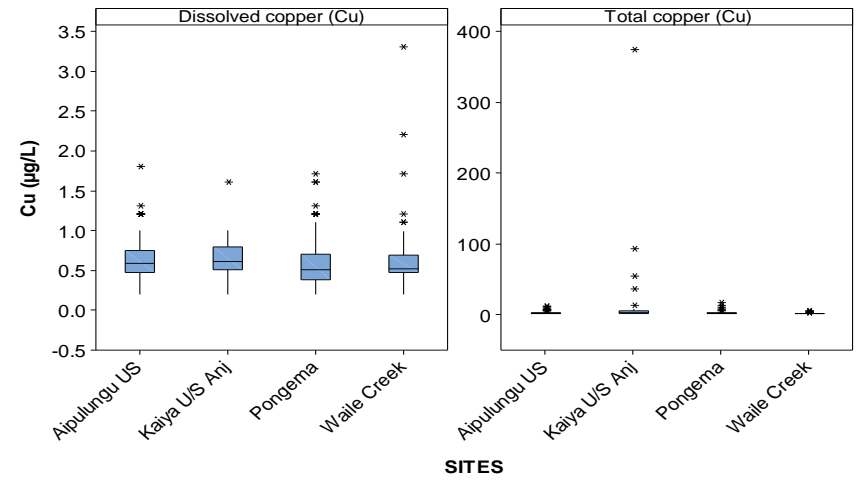


Figure 5-35 Dissolved and total copper in local creek runoff 2015-2024

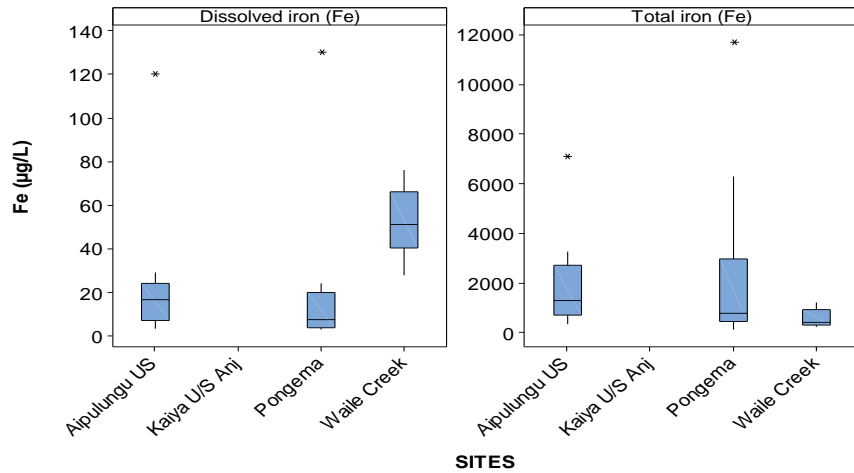


Figure 5-36 Dissolved and total iron in local creek runoff 2024

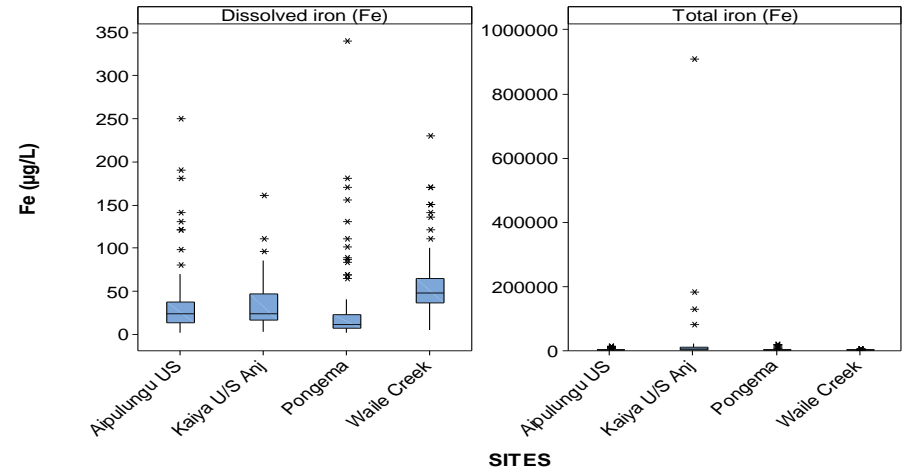


Figure 5-37 Dissolved and total iron in local creek runoff 2015-2024

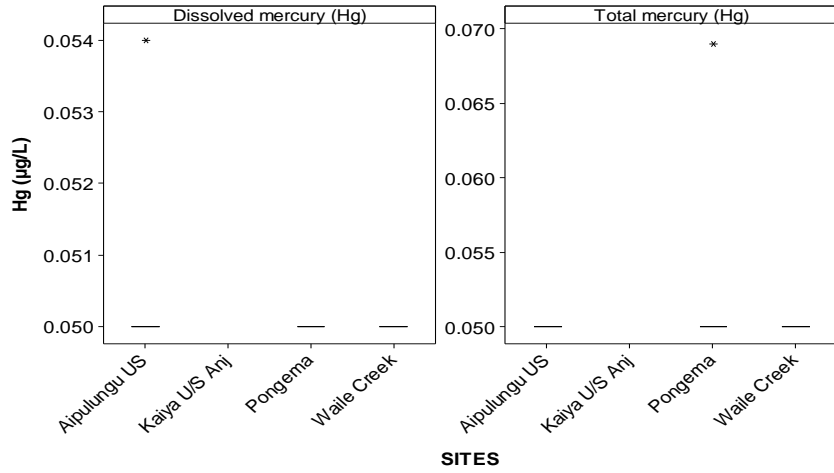


Figure 5-38 Dissolved and total mercury in local creek runoff 2024

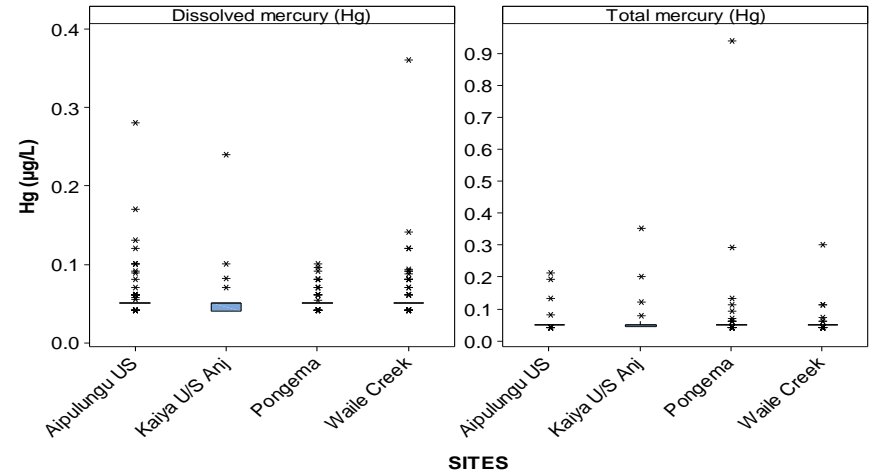


Figure 5-39 Dissolved and total mercury in local creek runoff 2015-2024

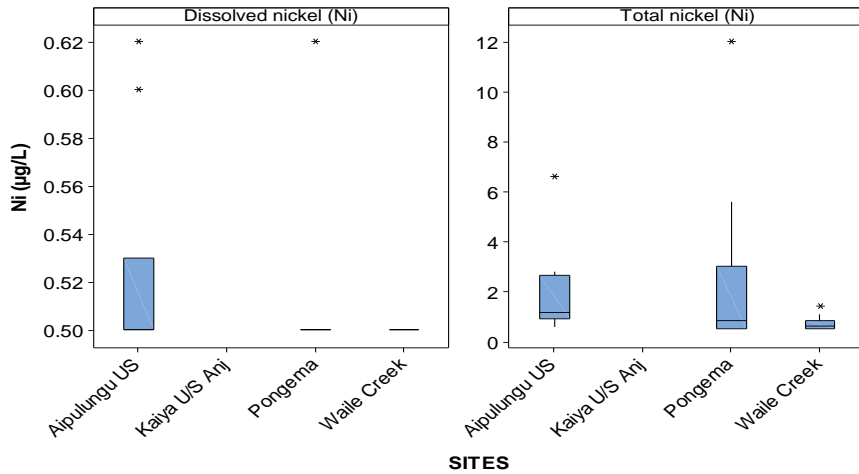


Figure 5-40 Dissolved and total nickel in local creek runoff 2024

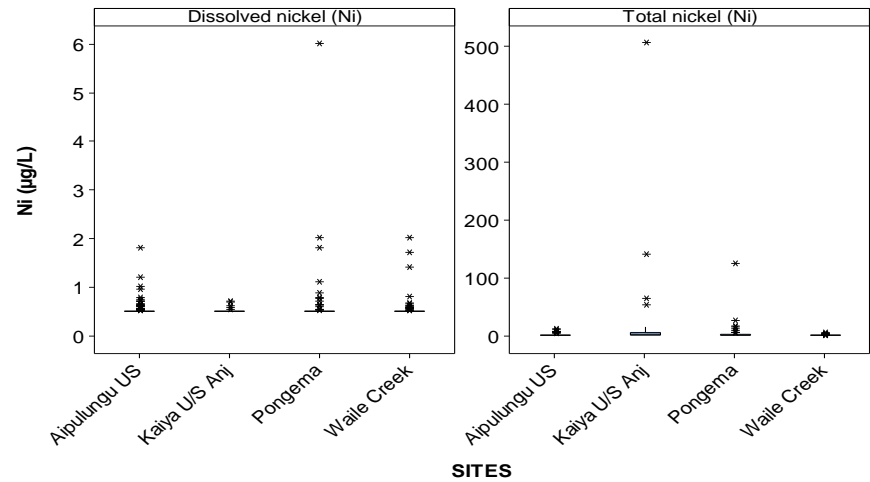


Figure 5-41 Dissolved and total nickel in local creek runoff 2015-2024

NPL Annual Environment Report 2024

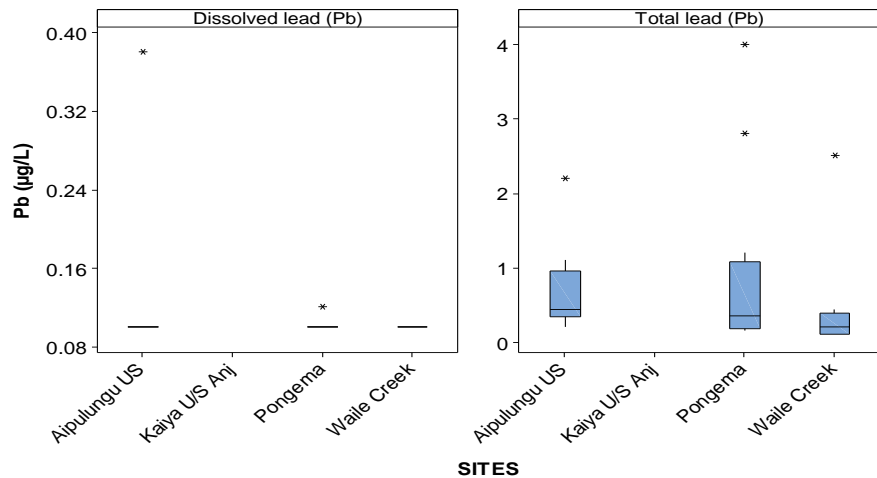


Figure 5-42 Dissolved and total lead in local creek runoff 2024

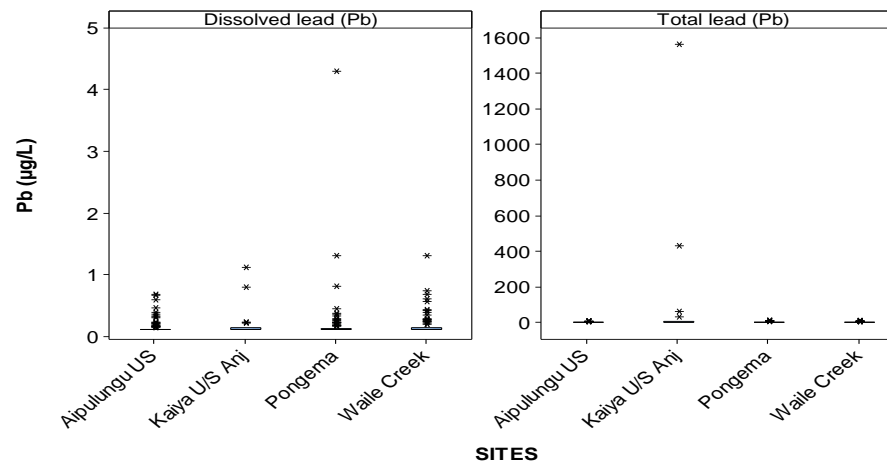


Figure 5-43 Dissolved and total lead in local creek runoff 2015-2024

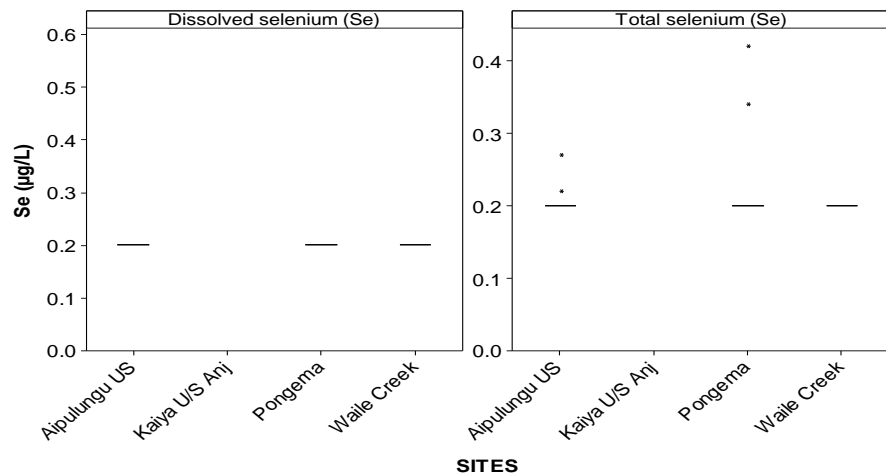


Figure 5-44 Dissolved and total selenium in local creek runoff 2024

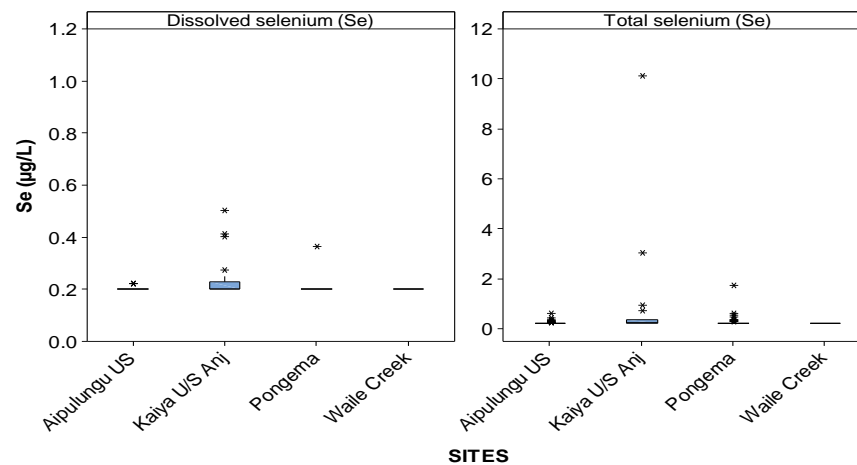


Figure 5-45 Dissolved and total selenium in local creek runoff 2015-2024

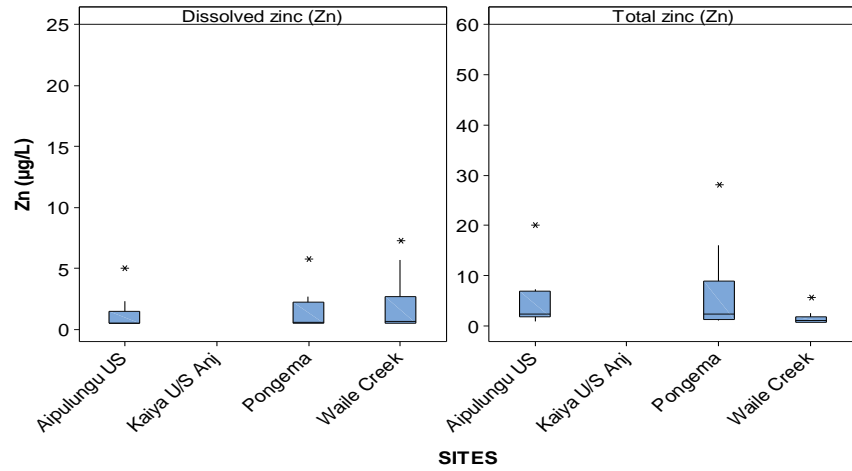


Figure 5-46 Dissolved and total zinc in local creek runoff 2024

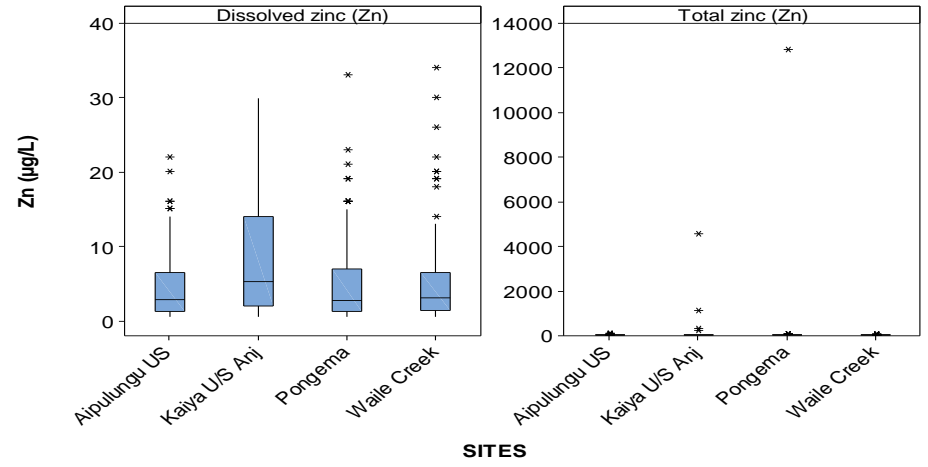


Figure 5-47 Dissolved and total zinc in local creek runoff 2015-2024

Table 5-6 Trends of water quality in local creek runoff reference sites 2015-2024 as tested by Spearman Rank Correlation

Parameter	Aipulungu US	Waile Creek	Kaiya Riv US	Pongema
pH [^]	Increased over time	Decreased or no change over time	Decreased or no change over time	Increased over time
EC [#]	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
WAD-CN [*]	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Sulfate [*]	Increased over time	Increased over time	Decreased or no change over time	Increased over time
ALK-T ^{**}	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
TSS [*]	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Hardness ^{**}	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Ag-D	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Ag-T	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
As-D	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
As-T	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Cd-D	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Cd-T	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Cr-D	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Cr-T	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Cu-D	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Cu-T	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Fe-D	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Fe-T	Increased over time	Increased over time	Decreased or no change over time	Decreased or no change over time
Hg-D	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Hg-T	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Ni-D	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Ni-T	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Pb-D	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Pb-T	Increased over time	Decreased or no change over time	Decreased or no change over time	Increased over time
Se-D	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Se-T	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
Zn-D	Decreased or no change over time	Decreased or no change over time	Increased over time	Decreased or no change over time
Zn-T	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time	Decreased or no change over time
	Decreased or no change over time			
	Increased over time			

[^]std units, [#]µS/cm * mg/L, ^{**}mg CaCO₃/L, D = Dissolved fraction, T = Total

5.3.2 Upper River

This section presents the water quality data for the upper river region collected from test sites prior to mining operations commencing (baseline data), from reference sites during the previous 24 months and from ANZG (2018).

In accordance with Section 2.3 of this report, the data are compared and the highest is then adopted as the 2024 TV for use in the water quality risk assessment presented in Section 7. Data summaries and presentation of water quality TVs for the upper river reference sites are presented in Table 5-7.

Reference site data used for comparison is generated by combining the data from each of the upper river reference sites; Upper Lagaip, Pori, Kuru and Ok Om. Reference sites within the upper river region exhibited slightly alkaline pH, elevated EC, occasionally elevated TSS and the presence of arsenic, chromium, copper, iron, nickel, lead and zinc.

Analysis of trends between 2015 and 2024 indicate that most parameters remained constant at the reference sites, the exception being pH which showed an increasing trend. Trend analysis results are shown in Table 5-8 and graphical representation of pH at each site showing increasing trends presented in Figure 5-48.

Baseline data in the upper river region exhibited alkaline pH and elevated concentrations of TSS, dissolved arsenic, copper, iron, mercury, lead and zinc compared to the upper river reference sites. This indicates that baseline water quality within the Porgera-Lagaip-Strickland catchment, which hosts the Porgera deposit at its headwaters, was characterised by naturally elevated concentrations of dissolved and total metals prior to mining commencing compared to the regional reference sites.

Upon comparison of reference and baseline data with the ANZG (2018) GVs for 95% species protection, the highest values for each indicator and therefore the value adopted as the 2024 TV were from the following sources:

- Reference site data: EC
- Baseline data: TSS, dissolved iron, nickel and zinc
- ANZG (2018) GVs: Dissolved silver, arsenic, cadmium, chromium, copper, mercury, lead and selenium.

NPL Annual Environment Report 2024

Table 5-7 Summarised water quality for upper river test sites for baseline and reference sites for previous 24 months, presenting 20th%ile, median and 80th%ile of data for each site. ANZG (2018) default TV for 95% species protection provided for comparison (µg/L except where indicated)

Parameter	UpRiv Ref 24 month (n=72)			SG1 Baseline (n=15)			SG2 Baseline (n=24)			SG3 Baseline (n=25)			Baseline SG1,SG2 & SG3 (n=64)			ANZG (2018) 95%	UpRiv TV
	20%ile	Median	80%ile	20%ile	Median	80%ile	20%ile	Median	80%ile	20%ile	Median	80%ile	20%ile	Median	80%ile		
pH^	7.6	7.9	8.0	7.8	8.0	8.1	7.7	7.9	8.2	7.8	7.9	8.1	7.8	7.9	8.1	6.0-8.0	6.0-8.1
EC#	133	189	230	168	180	190	178	185	226	176	188	204	170	185	202	NA	230
Sulfate*	2.0	11	27	10	12	16	18	21	31	28	30	34	15	22	32		
Alk-T**	50	66	114	110	117	122	110	150	263	96	106	124	106	117	169		
TSS*	66	220	682	222	401	2496	258	1462	4874	743	1428	2663	258	1188	2837	NA	2,837
Hardness**	51	72	110	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Ag-D	0.01	0.01	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05	0.05
Ag-T	0.01	0.015	0.06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
As-D	0.39	0.47	0.56	ND	ND	ND	1.7	1.7	1.7	0.50	0.50	1.2	0.50	0.5	1.7	24	24
As-T	1.0	2.5	6.2	1.8	3.5	11	2.0	3.7	10	4.2	9.0	15	2.0	5.5	13		
Cd-D	0.05	0.05	0.05	ND	ND	ND	0.05	0.05	0.05	ND	ND	ND	0.05	0.05	0.05	0.34***	0.34
Cd-T	0.05	0.05	0.057	0.20	0.20	0.40	0.20	0.20	0.40	0.20	0.60	1.0	0.20	0.20	0.8		
Cr-D	0.10	0.23	0.29	ND	ND	ND	133	133	133	ND	ND	ND	0.50	0.50	0.5	1.0	1.0
Cr-T	2.1	6.2	24	ND	ND	ND	0.50	0.50	0.50	ND	ND	ND	133	133	133		
Cu-D	0.33	0.44	0.72	1.1	1.2	1.4	0.56	0.9	7.2	1.0	1.7	4.3	0.98	1.4	4.1	1.4	1.4
Cu-T	1.7	5.3	22	5.2	15	66	8.8	41	146	7.4	36	68	7.0	29	82		
Fe-D	3.8	6.9	15	75	75	75	57	75	75	75	75	75	75	75	75	NA	75
Fe-T*	2.1	9.0	24	14	17	104	13	40	203	23	64	118	13	44	148		
Hg-D	0.05	0.05	0.05	ND	ND	ND	0.20	0.20	0.20	0.05	0.05	0.05	0.08	0.13	0.17	0.60	0.60
Hg-T	0.05	0.05	0.050	0.10	0.10	0.16	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1		
Ni-D	0.50	0.50	0.59	13	15	15	5.7	9.1	15	11	15.7	23	10	15	21	18***	21
Ni-T	2.6	6.6	32	16	16	16	20	20	179	10	12	94	12	20	90		
Pb-D	0.10	0.10	0.10	0.30	0.30	0.64	0.26	0.30	0.38	0.30	0.30	1.3	0.30	0.30	1.0	7.3***	7.3
Pb-T	1.0	3.8	12	4.36	12	160	6.1	18	139	3.6	23	59	4.4	19	82		
Se-D	0.20	0.20	0.20	ND	ND	ND	0.07	0.07	0.07	ND	ND	ND	0.07	0.07	0.07	11	11
Se-T	0.2	0.20	0.40	ND	ND	ND	0.25	0.25	0.25	ND	ND	ND	0.25	0.25	0.25		
Zn-D	0.5	1.0	3.6	0.18	0.2	0.42	0.28	0.40	0.64	0.8	4.3	25	0.48	1.4	20	13***	20
Zn-T	4.5	20	69	25	77	374	30	79	623	45	131	249	26	103	376		

^ std units, #µS/cm, *mg/L, **mg CaCO3/L, ***Hardness modified, D – Dissolved fraction, T – Total fraction, NA – Not applicable, ND – Not determined

Baseline data were collected from the test sites prior to mine operations commencing

Table 5-8 Trends for water quality at upper river reference sites 2015-2024 as determined by Spearman Rank correlation against time

Water Quality Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend (2015 – 2024)
Upper River Ref (Trend of all data from 2015 - 2024)	pH	0.448	<0.001	Increased over time
	EC	-0.075	0.105	No change over time
	TSS	-0.037	0.424	No change over time
	Ag-D*	-0.424	<0.001	No change over time
	Ag-T*	-0.318	<0.001	No change over time
	As-D	-0.004	0.933	No change over time
	As-T	0.001	0.980	No change over time
	Cd-D	-0.027	0.551	No change over time
	Cd-T	-0.093	0.044	Reduced over time
	Cr-D	0.002	0.965	No change over time
	Cr-T	-0.050	0.279	No change over time
	Cu-D*	-0.120	0.009	No change over time
	Cu-T	-0.028	0.549	No change over time
	Fe-D	-0.146	0.001	Reduced over time
	Fe-T	-0.019	0.686	No change over time
	Hg-D*	0.146	0.001	No change over time
	Hg-T	0.081	0.110	No change over time
	Ni-D*	0.273	<0.001	No change over time
	Ni-T	-0.032	0.485	No change over time
	Pb-D	0.000	0.992	No change over time
	Pb-T	0.010	0.828	No change over time
	Se-D	-0.010	0.831	No change over time
	Se-T	-0.042	0.362	No change over time
Zn-D	-0.213	<0.001	Reduced over time	
Zn-T	-0.032	0.481	No change over time	

D - Dissolved fraction, T - Total fraction

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore, the finding has been corrected to indicate no change over time, which is representative of actual conditions.

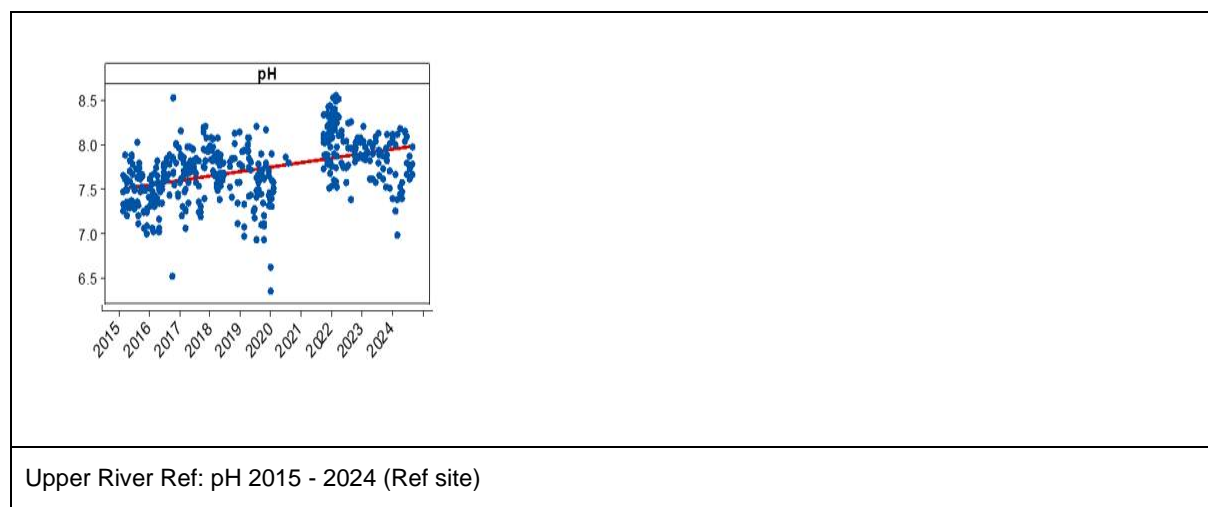


Figure 5-48 Trend analysis Upper River reference sites water quality (scatter plot of all data from 2015 – 2024 with linear trend line)

5.3.1 Lower River & Off-River Water Bodies

This section presents the water quality data for the lower river region collected from test sites prior to mining operations commencing (baseline data), from reference sites during the previous 24-months and from ANZG (2018).

In accordance with Section 2.3 of this report, the data are compared and the highest is then adopted as the 2024 TV for use in the water quality risk assessment for test sites in the lower river region and ORWBs, which is presented in Section 7. Data summaries and presentation of water quality TVs for the lower river and ORWBs are presented Table 5-9.

Reference data were generated by combining the data from each of the lower river reference sites; Baia and Tomu. Reference sites within the lower river region exhibited slightly alkaline pH, elevated EC, occasionally elevated TSS and the presence of arsenic, chromium, copper, iron, nickel, lead and zinc. Analysis of trends between 2015 and 2024 indicated that most parameters remained constant at the reference sites, with the exception of pH, TSS and total chromium, copper and iron, which showed an increasing trend at both sites. Trend analysis results are shown in Table 5-10 and graphical representation of pH, TSS, and total chromium, copper and iron data from each site showing trends is presented in Figure 5-49.

Baseline data in the lower river region exhibited similar conditions to the reference sites in the most recent 24 months with alkaline pH, elevated concentrations of TSS and the presence of arsenic, chromium, copper, iron, nickel, lead and zinc. These results indicate some natural mineralisation in the lower river region although at lower concentrations than the upper river region.

Upon comparison of reference and baseline data with the ANZG (2018) GVs for 95% species protection, the highest values for each indicator and therefore the value adopted as the 2024 TV were from the following sources:

- Baseline data: TSS, dissolved iron and nickel.
- ANZG (2018) GVs: EC, dissolved silver, arsenic, cadmium, chromium, copper, mercury, lead, selenium and zinc.

Table 5-9 Summarised water quality for lower river test sites for baseline and reference sites for previous 24 months, presenting 20th%ile, median and 80th%ile of data for each site. ANZG (2018) default TV for 95% species protection provided for comparison (µg/L except where indicated)

Parameter	LwRiv Ref 24 Month (n=32)			Baseline LwRiv (n=36)			ANZG (2018) 95%	LwRiv & ORWB TV
	20th%ile	Median	80th%ile	20th%ile	Median	80th%ile		
pH [^]	7.3	7.8	8.1	7.8	8.0	8.1	6.0-8.0	6.0-8.1
EC [#]	44	84	156	140	150	170	250	250
Sulfate [*]	2.0	2.0	5.0	10	15	18		
ALK-T ^{**}	26	51	83	83	93	101		
TSS [*]	15	52	214	326	638	983	NA	983
Hardness ^{**}	17	35	77	ND	ND	ND		
Ag-D	0.01	0.01	0.01	ND	ND	ND	0.05	0.05
Ag-T	0.01	0.01	0.01	ND	ND	ND		
As-D	0.10	0.31	0.66	0.60	0.70	0.80	24	24
As-T	0.18	0.61	1.6	3.5	5.5	8.0		
Cd-D	0.05	0.05	0.05	0.07	0.08	0.09	0.20	0.20
Cd-T	0.05	0.05	0.05	0.60	0.90	1.0		
Cr-D	0.10	0.14	0.18	0.50	0.50	0.50	1.0	1.0
Cr-T	0.70	2.0	4.8	18	34	46		
Cu-D	0.41	0.55	0.77	0.50	0.85	1.4	1.4	1.4
Cu-T	1.0	2.3	6.9	8.0	18	26		
Fe-D	5.9	12	30	0.64	75	75	NA	75
Fe-T [*]	0.88	2.0	5.8	17	37	49		

NPL Annual Environment Report 2024

Parameter	LwRiv Ref 24 Month (n=32)			Baseline LwRiv (n=36)			ANZG (2018) 95%	LwRiv & ORWB TV
	20th%ile	Median	80th%ile	20th%ile	Median	80th%ile		
Hg-D	0.05	0.05	0.05	ND	ND	ND	0.60	0.60
Hg-T	0.05	0.05	0.05	0.10	0.10	0.10		
Ni-D	0.50	0.50	0.53	3.6	10	15	11	15
Ni-T	0.76	1.9	6.5	10	23	24		
Pb-D	0.10	0.10	0.10	0.30	0.50	0.70	3.4	3.4
Pb-T	0.31	0.50	1.7	5.6	10	19		
Se-D	0.20	0.20	0.20	0.20	0.25	0.30	11	11
Se-T	0.20	0.20	0.20	0.20	0.20	0.50		
Zn-D	0.57	1.0	2.3	0.50	1.0	2.9	8.0	8.0
Zn-T	1.6	4.0	11	28	68	94		

^ std units, #µS/cm, *mg/L, **mg CaCO3/L, D – Dissolved fraction, T – Total fraction, NA – Not applicable, ND – Not determined

Table 5-10 Trends for water quality at lower river reference sites 2015-2024 as determined by Spearman Rank correlation against time

Water Quality Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend (2015 – 2024)
Lower River Ref (Trend of all data from 2015 - 2024)	pH	0.291	0.001	Increased over time
	EC	-0.218	0.018	Reduced over time
	TSS	0.197	0.035	Increased over time
	Ag-D*	-0.487	<0.001	No change over time
	Ag-T*	-0.585	<0.001	No change over time
	As-D	-0.043	0.642	No change over time
	As-T	0.047	0.617	No change over time
	Cd-D	-0.088	0.346	No change over time
	Cd-T	0.073	0.434	No change over time
	Cr-D	-0.100	0.283	No change over time
	Cr-T	0.197	0.034	Increased over time
	Cu-D	0.015	0.870	No change over time
	Cu-T	0.213	0.021	Increased over time
	Fe-D	-0.257	0.005	Reduced over time
	Fe-T	0.218	0.018	Increased over time
	Hg-D	0.072	0.442	No change over time
	Hg-T	0.053	0.568	No change over time
	Ni-D	0.094	0.315	No change over time
	Ni-T	0.173	0.062	No change over time
	Pb-D	-0.173	0.062	No change over time
Pb-T*	0.205	0.027	No change over time	
Se-D	≤LOR	≤LOR	No change over time	
Se-T	0.131	0.161	No change over time	
Zn-D	-0.366	<0.001	Reduced over time	
Zn-T	0.143	0.125	No change over time	

D – Dissolved fraction, T – Total fraction, LOR – Limit of Reporting

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore, the finding has been corrected to indicate no change over time, which is representative of actual conditions.

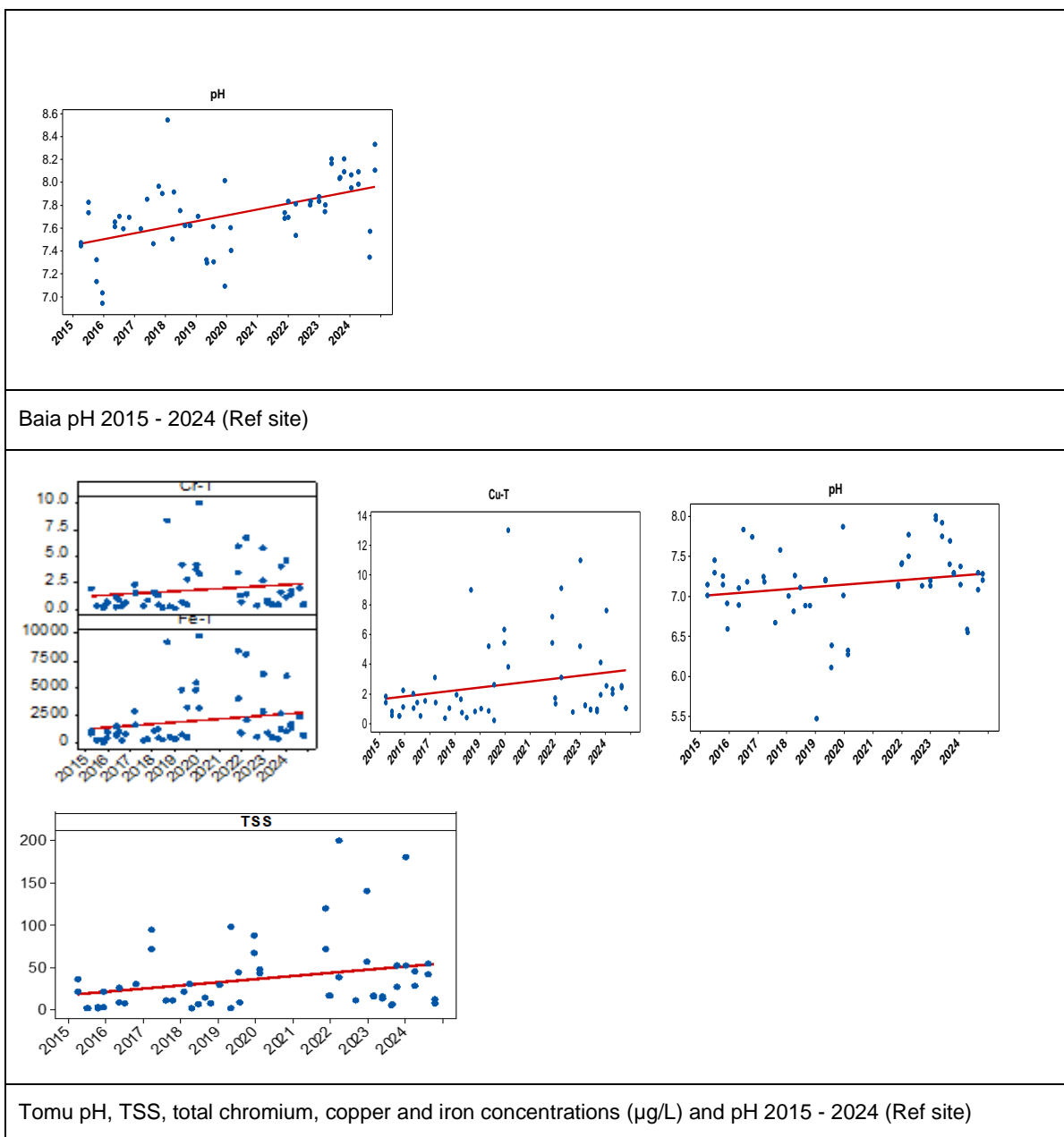


Figure 5-49 Trend analysis Lower River reference sites water quality (scatter plot of all data from 2015 – 2024 with linear trend line)

5.3.2 Lake Murray

This section presents the water quality data for Lake Murray collected from test sites prior to mining operations commencing (baseline data), from reference sites during the previous 24-months and from ANZG (2018).

In accordance with Section 2.3 of this report, the data are compared and the highest is then adopted as the 2024 TV for use in the water quality risk assessment presented in Section 7. Data summaries and presentation of water quality TVs for the lower river are presented Table 5-11.

Reference data were generated from the North Lake Murray region. Reference sites exhibited near neutral pH, low TSS and low concentrations of most metals with the notable presence of detectable concentrations copper, mercury and zinc.

Analysis of trends between 2015 and 2024 indicate that most parameters remained constant at the reference sites. Trend analysis results are shown in Table 5-12.

NPL Annual Environment Report 2024

Baseline data in the Lake Murray regions exhibited similar conditions to the reference sites in the most recent 24 months. These results indicate some natural mineralisation in Lake Murray although at lower concentrations than the upper river region.

Upon comparison of reference and baseline data with the ANZG (2018) GVs for 95% species protection, the highest values for each indicator and therefore the value adopted as the 2024 TV were from the following sources.

- Reference site data: EC
- Baseline data: TSS, dissolved cadmium and iron
- ANZG (2018) GVs: Dissolved silver, arsenic, chromium, copper, mercury, nickel, lead, selenium and zinc.

NPL Annual Environment Report 2024

Table 5-11 Summarised water quality data for Lake Murray test sites for baseline and reference sites for previous 24 months, presenting 20th%ile , median and 80th%ile of data for each site. ANZG (2018) default TV for 95% species protection provided for comparison (µg/L except where indicated)

Parameter	NORTHERN LAKE MURRAY (n=20)			Lake Murray (LM1) Baseline (n=10)			Lake Murray (LM2) Baseline (n=10)			Lake Murray LM1 and LM2 Baseline (n=20)			ANZG (2018) 95%	LMY TV
	20 th %ile	Median	80 th %ile	20 th %ile	Median	80 th %ile	20 th %ile	Median	80 th %ile	20 th %ile	Median	80 th %ile		
pH [^]	6.3	6.5	6.7	6.3	6.4	6.4	6.3	6.4	6.6	6.3	6.4	6.6	6.0-8.0	5.0-8.0
EC [#]	14	16	17	15	15	16	15	15	15.5	15	15	15.5	NA	17
Sulfate [*]	2.0	2.5	4.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
ALK-T ^{**}	4.0	7.2	13	7.7	8.1	8.8	7.9	8.1	8.5	7.8	8.1	8.7		
TSS [*]	2.8	4.5	6.2	6.0	7.0	9.0	4.6	6.0	8.2	5.4	6.5	9.0	NA	9.0
Hardness ^{**}	4.0	5.0	6.0	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Ag-D	0.01	0.01	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05	0.05
Ag-T	0.01	0.01	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND		
As-D	0.12	0.14	0.15	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	24	24
As-T	0.20	0.21	0.23	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50		
Cd-D	0.05	0.05	0.05	0.10	0.20	0.80	0.10	0.10	0.64	0.10	0.10	0.72	0.20	0.72
Cd-T	0.05	0.05	0.05	2.0	4.1	5.1	0.40	1.1	1.3	0.70	1.4	4.8		
Cr-D	0.10	0.11	0.15	0.10	0.10	0.44	0.10	0.10	0.20	0.10	0.10	0.40	1.0	1.0
Cr-T	0.29	0.36	0.43	0.10	0.10	0.40	0.10	0.25	1.3	0.10	0.15	0.60		
Cu-D	0.39	0.43	0.48	0.10	0.10	0.10	0.10	0.10	0.20	0.10	0.10	0.10	1.4	1.4
Cu-T	0.49	0.57	0.66	0.26	0.40	0.80	0.10	0.30	0.52	0.10	0.30	0.70		
Fe-D	91	110	140	138	255	342	166	230	324	148	250	340	NA	340
Fe-T	610	740	882	762	1005	1072	898	945	1024	898	980	1072		
Hg-D	0.05	0.05	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.60	0.60
Hg-T	0.05	0.05	0.05	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30		
Ni-D	0.50	0.50	0.50	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	11	11
Ni-T	0.50	0.50	0.53	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
Pb-D	0.10	0.10	0.10	0.20	0.20	0.70	0.20	0.20	0.62	0.20	0.20	0.7	3.4	3.4
Pb-T	0.11	0.13	0.19	0.50	1.0	1.9	0.40	0.80	1.4	0.38	0.90	1.7		
Se-D	0.20	0.20	0.20	0.70	0.80	0.90	0.70	0.70	0.80	0.70	0.70	0.90	11	11
Se-T	0.20	0.20	0.20	0.90	0.90	0.90	0.70	0.8	1.0	0.70	0.90	1.0		
Zn-D	0.75	1.2	1.4	0.05	0.05	0.14	0.05	0.5	1.0	0.05	0.08	0.80	8.0	8.0
Zn-T	0.62	1.1	1.3	1.2	2.0	2.7	1.3	2.0	2.9	1.3	2.0	2.8		

[^] std units, [#]µS/cm, ^{*}mg/L, ^{**}mg CaCO₃/L, D – Dissolved fraction, T – Total fraction, NA – Not applicable, ND – Not determined

Baseline data were collected from the test sites prior to mine operations commencing

Table 5-12 Trends for water quality in Lake Murray 2015 - 2024 as determined using Spearman Rank Correlation against time

Water Quality Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend (2015 – 2024)
Lake Murray Ref (Trend of all data from 2015 - 2024)	pH	0.034	0.740	No change over time
	EC	-0.198	0.049	Reduced over time
	TSS	-0.229	0.022	Reduced over time
	Ag-D*	-0.417	<0.001	No change over time
	Ag-T	-0.332	0.001	No change over time
	As-D	-0.480	<0.001	Reduced over time
	As-T	-0.072	0.476	No change over time
	Cd-D	≤LOR	≤LOR	No change over time
	Cd-T	≤LOR	≤LOR	No change over time
	Cr-D	-0.194	0.053	No change over time
	Cr-T	-0.116	0.252	No change over time
	Cu-D	-0.292	0.003	Reduced over time
	Cu-T	-0.180	0.072	No change over time
	Fe-D	0.072	0.475	No change over time
	Fe-T	-0.227	0.023	Reduced over time
	Hg-D	0.162	0.107	No change over time
	Hg-T*	0.199	0.048	No change over time
	Ni-D	-0.271	0.006	Reduced over time
	Ni-T	-0.275	0.006	Reduced over time
	Pb-D	-0.012	0.908	No change over time
	Pb-T	-0.254	0.011	Reduced over time
	Se-D	≤LOR	≤LOR	No change over time
	Se-T	≤LOR	≤LOR	No change over time
	Zn-D	-0.299	0.002	Reduced over time
Zn-T	-0.542	<0.001	Reduced over time	

D – Dissolved fraction, T – Total fraction, LOR – Limit of Reporting

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore, the finding has been corrected to indicate no change over time, which is representative of actual conditions.

5.4 Background Benthic Sediment Quality and Trigger Values

This section presents the sediment quality data collected from test sites prior to mining operations commencing (baseline data), from reference sites during the previous 24 months and ANZG (2018) sediment default guideline values (SDGVs). In accordance with Section 2.3, the data are compared and the highest is then adopted as the 2024 TV for use in the sediment quality risk assessment presented in Section 7. The sites are grouped into regions; Local Sites, Upper River, Lower River, ORWBs and Lake Murray.

Data from local reference sites are presented to describe the quality of non-mine-related contributions to the receiving environment and are not used to derive receiving environment TVs.

The weak-acid-extractable (WAE) metal concentrations from the whole sediment fraction have been used to develop the TVs as opposed the total digest (TD). The WAE concentrations best represent the concentration of metals that are bioavailable and therefore have potential to cause toxicity. Concentrations of total digestible metals include weakly and strongly bound sediment metals and over-

estimate the fraction likely to become readily bioavailable, and therefore likely overestimate potential toxicity.

5.4.1 Local reference sites

Local sites comprise the small highland creeks within the Porgera River catchment that are not affected by the mining operation. As is the case for water at these sites, sediment from these creeks mixes with the discharge from the mine to form the Porgera River, and so the quality of sediment within these creeks is important for assessing the full context of inputs that influence downstream environmental conditions. Sediment monitoring began at local sites in 2015, and the results are presented in Table 5-13.

Sediment quality within local creeks is dominated by the surrounding limestone geology and relatively low level of development within the catchments. The WAE and TD concentrations for all metals were comparable to other regional reference sites, indicating that the local creeks do not contribute significant amounts of metals in sediment to the river system downstream of the mine. Sampling was not performed at Kaiya US during 2024 due to security concerns.

Table 5-13 Local sites sediment quality 2024 (mg/kg dry weight, whole fraction)

Parameter	Aipulungu US			Kaiya US			Pongema		
	20 th ile	Median	80 th ile	20 th ile	Median	80 th ile	20 th ile	Median	80 th ile
Ag-WAE	0.06	0.062	0.07	NS	NS	NS	0.05	0.05	0.05
Ag-TD	0.12	0.12	0.12	NS	NS	NS	0.06	0.06	0.07
As-WAE	1.1	1.3	1.3	NS	NS	NS	0.91	0.94	1.1
As-TD	2.7	2.9	2.9	NS	NS	NS	4.0	4.1	4.9
Cd-WAE	0.08	0.08	0.10	NS	NS	NS	0.11	0.12	0.13
Cd-TD	0.10	0.11	0.13	NS	NS	NS	0.12	0.16	0.16
Cr-WAE	2.8	3.6	6.7	NS	NS	NS	2.7	3.4	4.3
Cr-TD	27	28	29	NS	NS	NS	18	19	21
Cu-WAE	6.3	7.4	9.5	NS	NS	NS	1.8	2.0	2.7
Cu-TD	12	13	13	NS	NS	NS	6.2	7.6	8.2
Hg-WAE	0.01	0.01	0.01	NS	NS	NS	0.01	0.01	0.01
Hg-TD	0.02	0.02	0.03	NS	NS	NS	0.02	0.02	0.02
Ni-WAE	4.7	5.8	10	NS	NS	NS	1.8	1.9	2.5
Ni-TD	20	22	23	NS	NS	NS	12	12	14
Pb-WAE	4.0	4.5	5.1	NS	NS	NS	2.7	2.8	2.8
Pb-TD	6.1	6.7	6.9	NS	NS	NS	4.6	4.8	5.0
Se-WAE	0.18	0.25	0.30	NS	NS	NS	0.11	0.16	0.17
Se-TD	0.43	0.53	0.64	NS	NS	NS	0.36	0.38	0.42
Zn-WAE	19	22	37	NS	NS	NS	8.3	9.0	12
Zn-TD	62	66	68	NS	NS	NS	31	36	47

WAE - Weak acid extractable, TD - Total digest, NS – Not sampled

5.4.2 Upper River

This section presents sediment quality data collected from test sites prior to mining operations commencing (baseline data), from reference sites during the previous 24 months and SDGVs ANZG (2018) for the upper river region.

In accordance with Section 2.3 of this report, the data are compared and the highest is then adopted as the 2024 TV for use in the sediment quality risk assessment presented in Section 7. Note that baseline WAE metal concentrations are not available, therefore TD metals on the <63µm fraction are provided for comparison purposes only.

Reference data were generated by combining the data from each of the upper river reference sites; Upper Lagaip, Pori, Kuru and Ok Om. Reference sites within the upper river region exhibited detectable concentrations of arsenic, chromium, copper, nickel, lead and zinc.

Analysis of trends between 2015 and 2024 for WAE metals shows increasing concentrations of mercury TD. Concentrations of all other metals either reduced or did not change over the period. Trend analysis results are shown in Table 5-15 and graphical representation of mercury TD showing increasing trends is presented in Figure 5-50.

Baseline data in the upper river region exhibited detectable concentrations of chromium, copper, nickel, lead and zinc. This indicates that baseline sediment quality within the Porgera-Lagaip-Strickland catchment, which hosts the Porgera deposit at its headwaters, was characterised by naturally elevated concentrations of metals prior to mining commencing.

Upon comparison of reference and baseline data with the ANZG (2018) SDGVs, the highest values for each indicator and therefore the value adopted as the 2024 TV were from the following sources:

- Reference site data: WAE selenium
- SDGVs: WAE silver, arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc.

Table 5-14 Summarised sediment quality data for upper river reference sites for previous 24 months. SDGVs are provided for comparison (mg/kg dry weight, whole fraction)

Parameter	UpRivs Ref 24 month (n = 63)			UpRivs Baseline (<63µm) (n = 2)			ANZG (2018) SDGV	UpRiv TV
	20 th %ile	Median	80 th %ile	20 th %ile	Median	80 th %ile		
Ag-WAE	0.05	0.05	0.05	ND	ND	ND	1.0	1.0
Ag-TD	0.05	0.05	0.09	ND	ND	ND		
As-WAE	1.4	1.7	2.2	ND	ND	ND	20	20
As-TD	7.9	11	14	6.5	10	14		
Cd-WAE	0.050	0.050	0.054	ND	ND	ND	1.5	1.5
Cd-TD	0.05	0.05	0.07	0.06	0.08	0.098		
Cr-WAE	1.0	2.7	5.8	ND	ND	ND	80	80
Cr-TD	19	22	82	28	31	33		
Cu-WAE	3.4	4.9	9.6	ND	ND	ND	65	65
Cu-TD	13	22	38	133	175	217		
Hg-WAE	0.01	0.01	0.01	ND	ND	ND	0.15	0.15
Hg-TD	0.03	0.05	0.06	ND	ND	ND		
Ni-WAE	3.7	6.5	18	ND	ND	ND	21	21
Ni-TD	24	30	94	23	29	34		
Pb-WAE	5.5	6.8	9.3	ND	ND	ND	50	50
Pb-TD	10	16	19	13	17	20		
Se-WAE	0.11	0.14	0.22	ND	ND	ND	NA	0.22
Se-TD	0.39	0.47	0.57	0.46	0.50	0.54		
Zn-WAE	9.0	13	26	ND	ND	ND	200	200

NPL Annual Environment Report 2024

Parameter	UpRivs Ref 24 month (n = 63)			UpRivs Baseline (<63µm) (n = 2)			ANZG (2018) SDGV	UpRiv TV
	20 th ile	Median	80 th ile	20 th ile	Median	80 th ile		
Zn-TD	65	80	98	92	113	133		

WAE = Weak-Acid-Extractable on whole sediment (i.e. the bioavailable fraction); TD = Total Digest on whole sediment; NA = Not applicable; ND = Not determined

Baseline data were data collected from the test sites prior to mine operations commencing

Table 5-15 Trends for sediment quality for upper river reference sites determined by Spearman Rank correlation against time (2015 – 2024)

Sediment Quality Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend (2015 – 2024)
UpRivs Ref (Trend of all data from 2015-2024)	Ag-WAE*	-0.622	<0.001	No change over time
	Ag-TD*	-0.563	<0.001	No change over time
	As-WAE	-0.064	0.181	No change over time
	As-TD	0.020	0.680	No change over time
	Cd-WAE*	-0.471	<0.001	No change over time
	Cd-TD*	-0.633	<0.001	No change over time
	Cr-WAE	0.000	0.998	Reduced over time
	Cr-TD	-0.120	0.013	Reduced over time
	Cu-WAE	-0.059	0.221	No change over time
	Cu-TD	-0.133	0.006	Reduced over time
	Pb-WAE	0.006	0.893	No change over time
	Pb-TD	0.025	0.600	No change over time
	Hg-WAE	-0.088	0.067	No change over time
	Hg-TD	0.105	0.029	Increased over time
	Ni-WAE	0.016	0.741	No change over time
	Ni-TD	-0.074	0.124	No change over time
	Se-WAE*	-0.117	0.015	No change over time
	Se-TD	0.061	0.205	No change over time
Zn-WAE	0.046	0.336	No change over time	
Zn-TD	-0.145	0.002	Reduced over time	

WAE = Weak-Acid-Extractable, TD - Total digest, LOR - Limit of Reporting

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore, the finding has been corrected to indicate no change over time, which is representative of actual conditions.

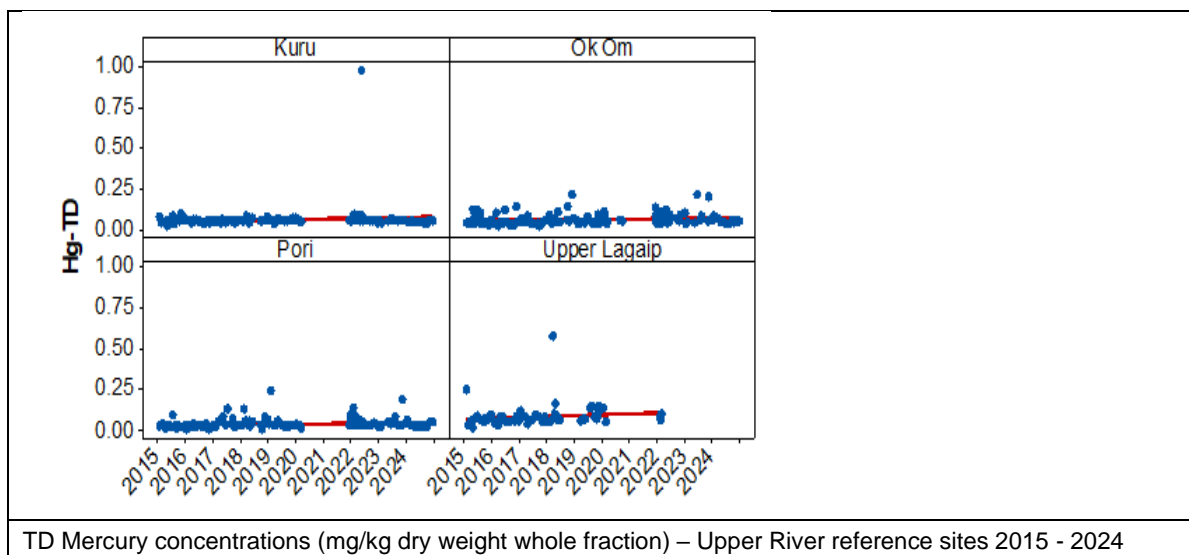


Figure 5-50 Trend analysis upper rivers sediment quality showing elements with statistically significant increasing trends (scatter plot of all data from 2015 – 2024 with linear trend line)

5.4.3 Lower River and Off-River Water Bodies

This section presents sediment quality data collected from test sites prior to mining operations commencing (baseline data), from reference sites during the previous 24 months and ANZG (2018) sediment default guideline values (SDGVs) for the lower river region. In accordance with Section 2.3, the data are compared and the highest is then adopted as the 2024 TV for use in the sediment quality risk assessment presented in Section 7. Note that baseline WAE metal concentrations were not available, therefore TD metals on the <63µm fraction are provided for comparison purposes only. A summary of the analysis and lower river and ORWB sediment TVs are presented in Table 5-16.

Reference data were generated by combining the data from each of the lower river reference sites; Baia and Tomu. Reference sites within the lower river region exhibited detectable concentrations of arsenic, chromium, copper, nickel, lead and zinc. Analysis of trends between 2015 and 2024 show increasing trend for TD chromium and nickel. Concentrations of all other metals either reduced or did not change over the time period. Trend analysis results are shown in Table 5-17 and graphical representation of TD chromium and nickel showing increasing trends is presented in Figure 5-51.

Baseline data in the lower river region exhibited detectable concentrations of arsenic, cadmium, chromium, copper, nickel, lead and zinc. Differences in concentrations of particulate metals between lower and upper river regions likely reflects geological differences between them.

Upon comparison of reference and baseline data with the SDGVs, the highest values for each indicator and therefore the value adopted as the 2024 TV were from the following sources:

- Reference site data: WAE nickel and selenium
- SDGVs: WAE silver, arsenic, cadmium, chromium, copper, mercury, lead, zinc.

Table 5-16 Summarised sediment quality data for lower river reference sites for previous 24 months. DGVs are provided for comparison (mg/kg dry weight whole fraction)

Parameter	LwRiv REF (n=32)			LwRiv Baseline (-63µm)			ANZG (2018) SDGV	LwRiv & ORWBs TV
	20 th ile	Median	80 th ile	20 th ile	Median	80 th ile		
Ag-WAE	0.05	0.05	0.05	ND	ND	ND	1.0	1.0
Ag-TD	0.05	0.05	0.05	ND	ND	ND		
As-WAE	0.43	0.99	1.7	ND	ND	ND	20	20
As-TD	1.6	4.2	5.4	2.8	10	14		

NPL Annual Environment Report 2024

Parameter	LwRiv REF (n=32)			LwRiv Baseline (-63µm)			ANZG (2018) SDGV	LwRiv & ORWBs TV
	20 th ile	Median	80 th ile	20 th ile	Median	80 th ile		
Cd-WAE	0.05	0.06	0.08	ND	ND	ND	1.5	1.5
Cd-TD	0.05	0.07	0.10	2.4	2.4	2.4		
Cr-WAE	2.4	6.4	11.6	ND	ND	ND	80	80
Cr-TD	48	57	67	12	12	12		
Cu-WAE	3.6	4.0	6.3	ND	ND	ND	65	65
Cu-TD	11	14	17	24	24	24		
Hg-WAE	0.01	0.01	0.01	ND	ND	ND	0.15	0.15
Hg-TD	0.01	0.01	0.02	0.34	0.57	0.94		
Ni-WAE	4.4	12	24	ND	ND	ND	21	24
Ni-TD	52	64	81	38	38	38		
Pb-WAE	3.0	3.7	5.2	ND	ND	ND	50	50
Pb-TD	5.3	5.9	7.5	22	22	22		
Se-WAE	0.12	0.16	0.26	ND	ND	ND	NA	0.26
Se-TD	0.19	0.26	0.36	0.20	0.20	0.20		
Zn-WAE	16	20	26	ND	ND	ND	200	200
Zn-TD	67	89	128	105	138	190		

- WAE - Weak acid extractable, TD - Total digest
- Baseline data were data collected from the test sites prior to mine operations commencing

Table 5-17 Trends for sediment quality for lower river reference sites determined by Spearman Rank correlation against time (2015 – 2024)

Sediment Quality Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend (2015 – 2024)
LwRivs Ref (Trend of all data from 2015-2024)	Ag-WAE*	-0.554	<0.001	No change over time
	Ag-TD*	-0.626	<0.001	No change over time
	As-WAE	-0.003	0.978	No change over time
	As-TD	-0.013	0.892	No change over time
	Cd-WAE*	-0.391	<0.001	No change over time
	Cd-TD*	-0.478	<0.001	No change over time
	Cr-WAE	-0.005	0.957	No change over time
	Cr-TD	0.311	0.001	Increased over time
	Cu-WAE	0.089	0.346	No change over time
	Cu-TD	<0.001	0.997	No change over time
	Hg-WAE	-0.063	0.504	No change over time
	Hg-TD	-0.059	0.534	No change over time
	Ni-WAE	0.080	0.399	No change over time
	Ni-TD	0.204	0.03	Increased over time
	Pb-WAE	0.093	0.325	No change over time
	Pb-TD	0.099	0.298	No change over time
	Se-WAE	0.021	0.825	No change over time
	Se-TD	0.027	0.778	No change over time
Zn-WAE	-0.054	0.567	No change over time	

Sediment Quality	Parameter	Spearman's rho	p-Value (p=0.05)	Trend (2015 – 2024)
Site				
	Zn-TD	0.007	0.945	No change over time

WAE - Weak acid extractable, TD - Total digest, LOR - Limit of Reporting

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore, the finding has been corrected to indicate no change over time, which is representative of actual conditions.

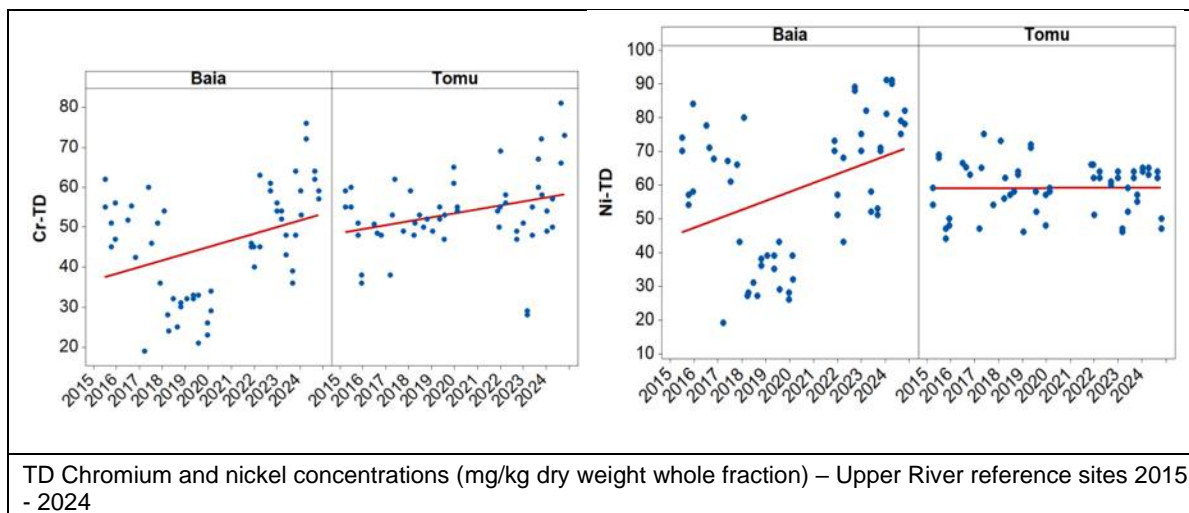


Figure 5-51 Trend analysis upper rivers sediment quality showing elements with statistically significant increasing trends (scatter plot of all data from 2015 – 2024 with linear trend line)

5.4.4 Lake Murray

This section presents sediment quality data collected from test sites prior to mining operations commencing (baseline data), from reference sites during the previous 24-months and ANZG (2018) sediment default guideline values (SDGVs) for the Lake Murray region. In accordance with Section 2.3, the data are compared and the highest is then adopted as the 2024 TV for use in the sediment quality risk assessment presented in Section 7. Note that baseline WAE metal concentrations are not available, therefore TD metals on the <63µm fraction are provided for comparison purposes only. A summary of the analysis and TVs are shown in Table 5-18.

Reference data were generated by combining the data from each of the Lake Murray reference sites at North Lake Murray. Reference sites within the Lake Murray region exhibited detectable concentrations of arsenic, chromium, copper, nickel, lead and zinc. Analysis of trends between 2015 and 2024 shows the increasing concentrations of WAE arsenic, WAE nickel, WAE selenium and TD selenium. Concentrations of all other metals either reduced or did not change over the time period. Trend analysis results are shown in Table 5-19 and Figure 5-52 for WAE arsenic increasing trend.

Baseline data in the lower river region exhibited detectable concentrations of arsenic, chromium, copper, nickel, lead and zinc. These results indicate some natural mineralisation in the Lake Murray region although at lower concentrations than the upper river region.

Upon comparison of reference and baseline data with the SDGVs, the highest values for each indicator and therefore the value adopted as the 2024 TV were from the following sources:

- Reference site data from north Lake Murray: WAE selenium
- SDGVs: WAE silver, arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc.

Table 5-18 Summarised sediment quality data for Lake Murray reference sites for previous 24 months, presenting 20th%ile , median and 80th%ile of data for each site. DGVs are provided for comparison (mg/kg dry weight whole fraction)

Parameter	Northern Lake Murray (n = 20)			LMY Baseline (-63µm)			ANZG (2018) SDGV	LMY TV
	20 th %ile	Median	80 th %ile	20 th %ile	Median	80 th %ile		
Ag-WAE	0.05	0.05	0.05	ND	ND	ND	1.0	1.0
Ag-TD	0.05	0.05	0.05	ND	ND	ND		
As-WAE	1.1	1.3	1.6	ND	ND	ND	20	20
As-TD	4.2	4.7	5.2	2.8	10	14		
Cd-WAE	0.08	0.09	0.10	ND	ND	ND	1.5	1.5
Cd-TD	0.08	0.09	0.10	2.4	2.4	2.4		
Cr-WAE	4.6	5.6	6.0	ND	ND	ND	80	80
Cr-TD	36	38	41	12	12	12		
Cu-WAE	9.8	11	12	ND	ND	ND	65	65
Cu-TD	19	21	23	24	24	24		
Hg-WAE	0.01	0.01	0.01	ND	ND	ND	0.15	0.15
Hg-TD	0.12	0.13	0.15	0.34	0.57	0.94		
Ni-WAE	8.5	9.3	11	ND	ND	ND	21	21
Ni-TD	29	33	35	38	38	38		
Pb-WAE	6.9	7.5	8.3	ND	ND	ND	50	50
Pb-TD	14	14	16	22	22	22		
Se-WAE	0.30	0.32	0.33	ND	ND	ND	NA	0.33
Se-TD	0.77	0.88	0.94	0.20	0.20	0.20		
Zn-WAE	38	43	53	ND	ND	ND	200	200
Zn-TD	88	100	110	105	138	190		

WAE – Weak-Acid-Extractable, TD - Total digest, NA - Not applicable; ND - Not determined

Baseline data were data collected from the test sites prior to mine operations commencing

Table 5-19 Trends for sediment quality Lake Murray and ORWBs reference sites determined by Spearman Rank correlation against time (2015 - 2024)

Sediment Quality	Parameter	Spearman's rho	p-Value (p=0.05)	Trend (2015 – 2024)
Site				
Lake Murray Ref (Trend of all data from 2015 – 2024)	Ag-WAE*	-0.538	<0.001	No change over time
	Ag-TD*	-0.605	<0.001	No change over time
	As-WAE	0.519	<0.001	Increased over time
	As-TD	-0.025	0.813	No change over time
	Cd-WAE	-0.112	0.281	No change over time
	Cd-TD*	-0.450	<0.001	No change over time
	Cr-WAE*	-0.074	0.478	No change over time
	Cr-TD	-0.100	0.336	No change over time
	Cu-WAE	0.017	0.869	No change over time

Sediment Quality	Parameter	Spearman's rho	p-Value (p=0.05)	Trend (2015 – 2024)
Site				
	Cu-TD	-0.032	0.757	No change over time
	Hg-WAE	-0.237	0.021	Reduced over time
	Hg-TD	-0.054	0.606	No change over time
	Ni-WAE	0.210	0.042	Increased over time
	Ni-TD	0.169	0.103	No change over time
	Pb-WAE	-0.040	0.702	No change over time
	Pb-TD	0.010	0.924	No change over time
	Se-WAE	0.605	<0.001	Increased over time
	Se-TD	0.212	0.040	Increased over time
	Zn-WAE	0.163	0.115	No change over time
	Zn-TD	-0.132	0.205	No change over time

WAE – Weak-Acid-Extractable, TD - Total digest, LOR - Limit of Reporting

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore, the finding has been corrected to indicate no change over time, which is representative of actual conditions.

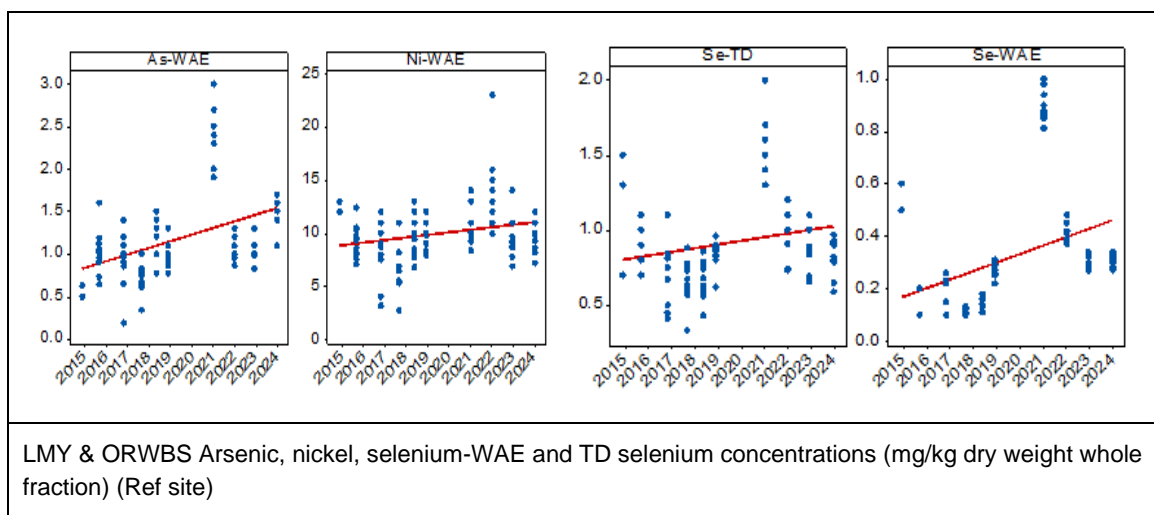


Figure 5-52 Trend analysis LMY reference sites sediment quality (scatter plot of As-WAE, for all data from 2015 – 2024 with linear trend line)

5.5 Background Tissue Metal Concentrations and Trigger Values

This section presents tissue metal data for biota samples collected from test sites prior to mining operations commencing (baseline data), from reference sites during the previous 24 months and comparison of selenium with the applicable US EPA guideline value.

In accordance with Section 2.3 of this report, the data are compared and the highest is then adopted as the 2024 TV for use in the tissue metal risk assessment presented in Section 7. The sites are grouped into regions; Local Sites, Upper River, Lower River and Lake Murray. Tissue metal sampling is not performed in the ORWBs.

5.5.1 Upper River

A summary of tissue metal TVs for the upper river reference sites are presented in Table 5-20 and Table 5-21.

Reference data were generated from the upper river reference site Ok Om, as this is the only upper river reference site where monitoring of fish and prawns is conducted. Fish flesh at the reference site within the upper river region exhibited detectable concentrations of arsenic, cadmium, chromium, copper, mercury, selenium and zinc. Prawn abdomen at the upper river reference site exhibited detectable concentrations of all nine metals analysed. The results indicate a degree of natural mineralisation and bioaccumulation at the upper river reference site. It should be noted that movement of individuals between test sites and reference sites is also possible, but it is very difficult to determine the origin and migration of each individual fish or prawn.

Analysis of trends between 2015 and 2024 indicates that concentrations for metals at the reference site either remained constant or decreased, with the exception of arsenic in fish flesh and lead in prawn abdomen which showed an increasing trend. Trend analysis results are shown in Table 5-22 and Table 5-23, while a graph showing increasing chromium and lead concentrations is shown in Figure 5-53

Baseline data for fish flesh tissue metal in the upper river region exhibited detectable concentrations of arsenic, cadmium, copper, mercury, nickel, lead, selenium and zinc. This indicates that baseline tissue metals in fish within the Porgera-Lagaip-Strickland catchment, which hosts the Porgera deposit at its headwaters, was characterised by elevated concentrations of tissue metals prior to mining commencing, compared to the regional reference sites.

Upon comparison of reference and baseline data with the US EPA guidelines value, the highest values for each indicator and therefore the value adopted as the 2024 TV were from the following sources. It should be noted that where the baseline 80thile is equal to the baseline LOR and the baseline LOR is greater than the 2024 reference site 80thile, the 2024 reference 80thile value is adopted as the TV, this is considered a conservative approach so the TV is not unintentionally inflated due to historical LORs.

- Reference site data:
 - Fish flesh: chromium and nickel
 - Prawn abdomen: arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium and zinc.
- Baseline data:
 - Fish flesh: arsenic, cadmium, copper, mercury, lead, zinc.
 - Prawn abdomen: NA
- US EPA Guidelines:
 - Fish flesh: selenium
 - Prawn abdomen: NA

Table 5-20 Tissue metal data for upper river reference site Ok Om for previous 24 months (As, Cd, Cr, Cu) (µg/g wet wt.)

Site	Sample	n	As		Cd		Cr		Cu	
			Median	80th%ile	Median	80th%ile	Median	80th%ile	Median	80th%ile
Ok Om	Fish Flesh	24	0.013	0.020	0.003	0.003	0.010	0.010	0.20	0.28
	Prawn Ab	24	0.028	0.033	0.003	0.003	0.020	0.026	5.0	6.8
Wankipe baseline	Fish Flesh	28	0.20	0.200	0.010	0.020	ND	ND	0.21	0.48
Trigger Value	Fish Flesh	-	-	0.200	-	0.020	-	0.010	-	0.48
	Prawn Ab	-	-	0.033	-	0.003	-	0.026	-	6.8

n – number of samples, ND - Not Determined, Ab – Abdomen, * Baseline 80th%ile falls below the 2024 LOR, so reference 80th%ile is used as the TV

Table 5-21 Tissue metal data for upper river reference site Ok Om for previous 24 months and applicable US EPA guideline value (Hg, Ni, Pb, Se, Zn) (µg/g wet wt.)

Site	Sample	n	Hg		Ni		Pb		Se		Zn	
			Median	80th%ile	Median	80th%ile	Median	80th%ile	Median	80th%ile	Median	80th%ile
Ok Om	Fish Flesh	24	0.034	0.041	0.010	0.010	0.010	0.010	0.21	0.29	5.2	5.8
	Prawn Ab	24	0.01	0.010	0.010	0.010	0.010	0.010	0.33	0.37	12	16
Wankipe baseline	Fish Flesh	28	0.07	0.08	0.10	0.10	0.07	0.17	0.20	0.20	8.9	10.4
USEPA (2016)	Fish Flesh	NA	NA	NA	NA	NA	NA	NA	2.26 (11.3 dry wt.)		NA	NA
Trigger Value	Fish Flesh	-	-	0.08	-	0.10	-	0.17	-	2.26	-	10.4
	Prawn Ab	-	-	0.01	-	0.01	-	0.01	-	0.37	-	16

n – number of samples, NA - Not Applicable, dry wt. - dry weight, Ab - Abdomen

Table 5-22 Trends of metals in fish flesh for upper river reference sites 2015 - 2024 determined by Spearman Rank correlation against time

Fish Flesh	Parameter	Spearman's rho	p-Value (p=0.05)	Trend (2015–2024)
Site				
UpRivs Ref (Trend of Ok Om data 2015-2024)	As	0.206	0.022	Increased over time
	Cd	-0.269	0.003	Reduced over time
	Cr	-0.1	0.271	No change over time
	Cu	0.114	0.208	No change over time
	Hg	-0.344	<0.001	Reduced over time
	Ni	-0.101	0.264	No change over time
	Pb	0.07	0.44	No change over time
	Se	0.084	0.352	No change over time
	Zn	-0.168	0.062	No change over time

Table 5-23 Trends of metals in prawn abdomen for upper river reference sites 2015 - 2024 determined by Spearman Rank correlation against time

Prawn Abdomen	Parameter	Spearman's rho	p-Value (p=0.05)	Trend (2015–2024)
Site				
UpRivs Ref (Trend of Ok Om data 2015-2024)	As	-0.285	0.002	Reduced over time
	Cd	0.114	0.229	No change over time
	Cr	0.009	0.922	No change over time
	Cu	-0.141	0.136	No change over time
	Hg	0.148	0.118	No change over time
	Ni	-0.096	0.311	No change over time
	Pb	0.236	0.012	Increased over time
	Se	-0.269	0.004	Reduced over time
	Zn	-0.149	0.115	No change over time

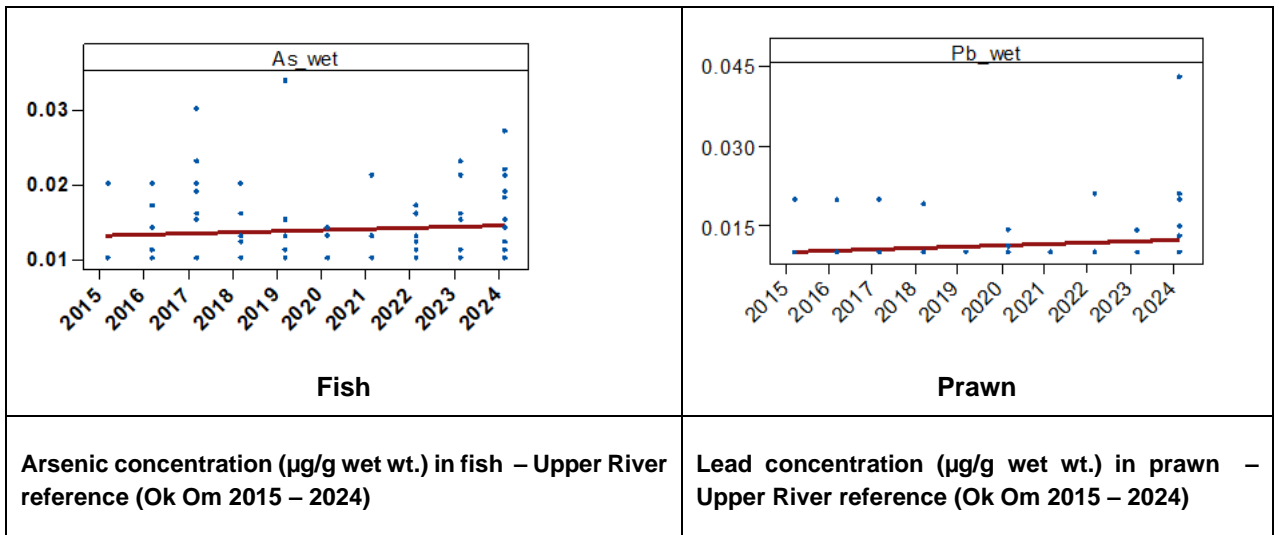


Figure 5-53 Trend analysis of arsenic concentration in fish and lead concentration in prawn (µg/g wet wt.) – Upper River reference sites Ok Om 2015 – 2024. Graph shows weak increasing linear trend.

5.5.2 Lower River

A summary of tissue metal TVs for the lower river reference sites are presented in Table 5-26 and Table 5-27.

Reference site data were generated by combining the data from each of the lower river reference sites; Baia and Tomu. Fish flesh at the lower river reference sites exhibited detectable concentrations of copper, mercury, selenium and zinc and are comparable to the lower river test sites. Comparison of reference and test sites are presented in Table 5-24. Prawn abdomen at the lower river reference site exhibited detectable concentrations of arsenic, chromium, copper, selenium and zinc and are comparable to the lower river reference sites. The results indicate a degree of natural mineralisation at the lower river reference sites. Comparison of reference and test sites are presented in Table 5-25.

Table 5-24 Comparison for fish flesh at Lower River reference and test sites 2015 – 2024 ((µg/g wet wt)

Site	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
LOR	0.010	0.003	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Lower Ref	0.010	0.003	0.010	0.083	0.014	0.010	0.010	0.08	3.1
Bebelubi	0.011	0.003	0.010	0.097	0.10	0.010	0.010	0.16	2.6
SG4	0.010	0.003	0.010	0.094	0.067	0.010	0.010	0.16	4.1

Table 5-25 Comparison for prawn abdomen at Lower River reference and test sites 2015 - 2024 (µg/g wet wt)

Site	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
LOR	0.01	0.003	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Lower Ref	0.052	0.003	0.030	6.3	0.01	0.01	0.01	0.23	11
Bebelubi	0.064	0.003	0.024	6.6	0.01	0.01	0.01	0.23	12
SG4	0.057	0.003	0.020	4.5	0.01	0.01	0.01	0.25	11

Analysis of trends between 2015 and 2024 indicated increasing trends of arsenic and nickel in fish flesh, and lead in prawn abdomen. All other metals either reduced or did not change over the same period.

Trend analysis results are shown in Table 5-28 and Table 5-29, graphical representation of chromium in fish flesh and prawn abdomen data showing weak linear increasing trends is presented in Figure 5-54.

Upon comparison of reference and baseline data with the US EPA guideline value, the highest values for each indicator and therefore the value adopted as the 2024 TV were from the following sources:

- Reference data:
 - Fish flesh: cadmium and chromium
 - Prawn abdomen: arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium and zinc.
- Baseline data:
 - Fish flesh: arsenic, copper, mercury, nickel, lead and zinc.
 - Prawn abdomen: NA
- US EPA Guidelines:
 - Fish flesh: selenium
 - Prawn abdomen: NA

Table 5-26 Tissue metal data for lower river reference sites for previous 24 months (As, Cd, Cr, Cu) (µg/g wet wt.)

Site	Sample	n	As		Cd		Cr		Cu	
			Median	80 th %ile	Median	80 th %ile	Median	80 th %ile	Median	80 th %ile
Baia	Fish	19	0.01	0.015	0.003	0.003	0.012	0.010	0.081	0.12
	Prawn	23	0.077	0.10	0.003	0.003	0.03	0.050	6.8	9.1
Tomu	Fish	18	0.01	0.017	0.003	0.003	0.01	0.010	0.083	0.94
	Prawn	18	0.061	0.068	0.003	0.006	0.0355	0.038	8.9	12
Lower River Ref	Fish Flesh	37	0.010	0.010	0.003	0.003	0.010	0.030	0.08	0.13
	Prawn Ab	41	0.065	0.085	0.003	0.005	0.030	0.050	7.7	10
SG4 baseline	Fish Flesh	19	0.036	0.071	0.003	0.003	0.024	0.026	0.133	0.17
Trigger Value	Fish Flesh	-	-	0.071	-	0.003	-	0.030	-	0.94
	Prawn Ab	-	-	0.085	-	0.006	-	0.050	-	12

n – number of samples, Ab - Abdomen

Table 5-27 Tissue metal data for lower river reference sites for previous 24 months and applicable US EPA guideline value (Hg, Pb, Se, Zn) (µg/g wet wt.)

Site	Sample	n	Hg		Ni		Pb		Se		Zn	
			Median	80 th %ile	Median	80 th %ile	Median	80 th %ile	Median	80 th %ile	Median	80 th %ile
Baia	Fish	19	0.015	0.014	0.010	0.018	0.010	0.010	0.06	0.074	2.8	3.4
	Prawn	23	0.010	0.010	0.010	0.010	0.010	0.010	0.30	0.32	12	14
Tomu	Fish	21	0.045	0.059	0.010	0.024	0.010	0.010	0.13	0.20	2.7	5.4
	Prawn	18	0.010	0.01	0.01	0.01	0.01	0.01	0.255	0.33	12	15
Lower River Ref	Fish Flesh	39	0.036	0.047	0.010	0.010	0.010	0.010	0.08	0.16	2.8	3.9
	Prawn Ab	41	0.010	0.010	0.010	0.010	0.010	0.010	0.27	0.32	12	14
SG4 baseline	Fish Flesh	19	0.060	0.12	0.076	0.165	0.026	0.03	0.128	0.17	3.3	7.5
USEPA (2014)	Fish Flesh	NA	NA	NA	NA	NA	NA	NA	2.26 (11.3 dry wt.)		NA	NA
Trigger Value	Fish Flesh	-	-	0.12	-	0.165	-	0.03	-	2.26	-	7.5
	Prawn Ab	-	-	0.01	-	0.01	-	0.01	-	0.33	-	15

n – number of samples, NA - Not Applicable, Ab - Abdomen

Table 5-28 Trends of metals in fish flesh at lower river reference site 2015 - 2024 determined by Spearman Rank correlation against time

Fish flesh	Element	Spearman's rho	p-Value (p=0.05)	Trend (2015–2024)
Site				
LwRivs Ref (Trend of all data 2015-2024)	As	0.208	0.007	Increased over time
	Cd	-0.058	0.464	No change over time
	Cr	-0.102	0.192	No change over time
	Cu	-0.245	0.002	Reduced over time
	Hg	-0.433	<0.001	Reduced over time
	Ni	0.225	0.004	Increased over time
	Pb	0.040	0.611	No change over time
	Se	-0.193	0.013	Reduced over time
	Zn	-0.259	0.001	Reduced over time

Table 5-29 Trends of metals in prawn abdomen at lower river reference sites 2015 - 2024 determined by Spearman Rank correlation against time

Prawn Abdomen	Element	Spearman's rho	p-Value (p=0.05)	Trend (2015–2024)
Site				
LwRivs Ref (Trend of all data 2015-2024)	As	-0.159	0.029	Reduced over time
	Cd	-0.075	0.307	No change over time
	Cr	-0.039	0.593	No change over time
	Cu	0.098	0.178	No change over time
	Hg	0.080	0.276	No change over time
	Ni	-0.133	0.069	No change over time
	Pb	0.160	0.027	Increased over time
	Se	0.035	0.633	No change over time
	Zn	-0.105	0.151	No change over time

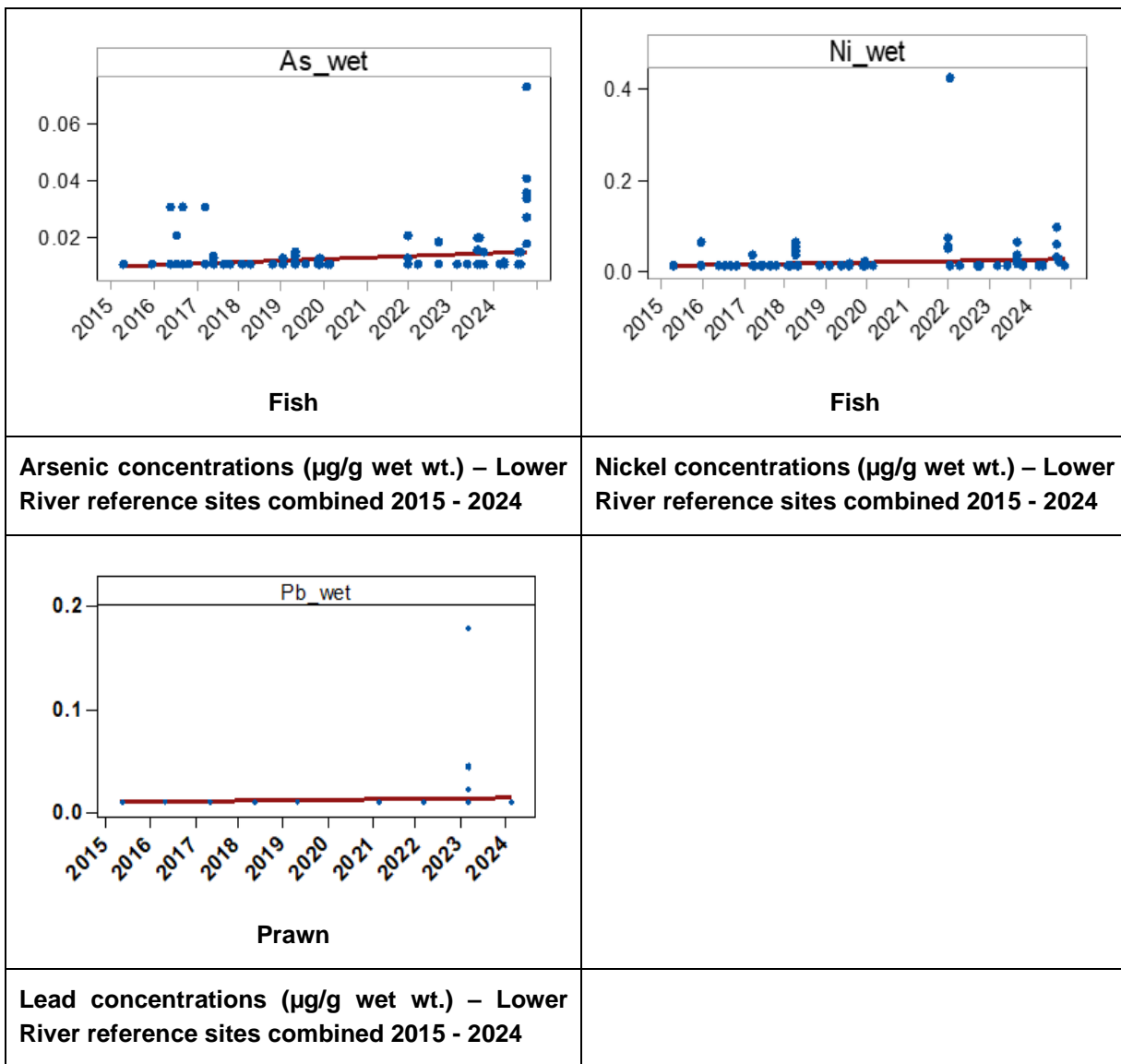


Figure 5-54 Trend analysis of arsenic, nickel and lead concentration ($\mu\text{g/g}$ wet wt.) in fish and lead concentration in prawns – Lower River reference sites combined 2015 – 2024. Graphs show weak increasing linear trend.

5.5.3 Lake Murray

Data summaries and presentation of tissue metal TVs for the Lake Murray reference sites are presented in Table 5-30 and Table 5-31.

Reference data were generated by combining the data from the Lake Murray reference site Maka. Fish flesh at the Lake Murray region reference sites exhibited detectable concentrations of arsenic, copper, mercury, selenium and zinc. Prawns were not sampled in Lake Murray.

Analysis of trends between 2015 and 2024 indicated that the concentration of arsenic in fish flesh increased while concentrations of all other metals either reduced or did not change over the time period. Trend analysis results are shown in Table 5-32 and graphical representation of arsenic in fish flesh showing increasing trend is presented in Figure 5-55.

Baseline data for fish flesh tissue metal in the Lake Murray region exhibited detectable concentrations of arsenic, chromium, copper, mercury, nickel, selenium and zinc, indicating a degree of natural mineralisation at the Lake Murray test sites prior to the commencement of mining.

Upon comparison of reference and baseline data with the US EPA guideline value, the highest values for each indicator and therefore the value adopted as the 2024 TV were from the following sources:

- Reference site data:
 - Fish flesh: cadmium and mercury.
- Baseline data:
 - Fish flesh: arsenic, chromium, copper, nickel, lead and zinc.
- US EPA Guidelines:
 - Fish flesh: selenium

Table 5-30 Summarised tissue metal data for Lake Murray reference sites for previous 24 months (As, Cd, Cr, Cu), presenting median and 80th%ile of data for each site (µg/g wet wt.)

Site	Sample	n	As		Cd		Cr		Cu	
			Median	80 th %ile	Median	80 th %ile	Median	80 th %ile	Median	80 th %ile
Maka	Fish Flesh	6	0.010	0.065	0.003	0.003	0.010	0.028	0.085	0.110
Miwa baseline	Fish Flesh	7	0.04	0.053	0.002	0.002	0.02	0.028	0.16	0.203
Trigger Value	Fish Flesh	-	-	0.065	-	0.003	-	0.028	-	0.203

n – number of samples

Table 5-31 Summarised tissue metal data for Lake Murray reference sites for previous 24 months and applicable US EPA guideline value (Hg, Ni, Pb, Se, Zn), presenting median and 80th%ile of data for each site (µg/g wet wt.)

Site	Sample	n	Hg		Ni		Pb		Se		Zn	
			Median	80 th %ile	Median	80 th %ile	Median	80 th %ile	Median	80 th %ile	Median	80 th %ile
Maka	Fish Flesh	6	0.22	0.19	0.010	0.16	0.010	0.010	0.30	0.36	2.5	2.70
Miwa baseline	Fish Flesh	7	0.11	0.17	0.10	0.19	0.05	0.071	0.13	0.17	2.87	3.12
USEPA (2016)	Fish Flesh	NA	NA	NA	NA	NA	NA	NA	2.26 (11.3 dry wt.)		NA	NA
Trigger Value	Fish Flesh	-	-	0.19	-	0.19	-	0.071	-	2.26	-	3.12

n – number of samples, NA – not applicable

Table 5-32 Trends of metals in fish flesh at Lake Murray and ORWB reference sites 2015-2024 determined by Spearman Rank correlation against time

Fish Flesh Site	Element	Spearman's rho	p-Value (p=0.05)	Trend (2015-2024)
LMY Ref Site (Maka) (Trend of all data 2015-2024)	As	0.518	0.014	Increased over time
	Cd*	-	-	No change over time
	Cr	-0.025	0.911	No change over time
	Cu	0.372	0.089	No change over time
	Hg	-0.244	0.274	No change over time
	Ni	0.344	0.117	No change over time
	Pb*	-	-	No change over time
	Se	-0.226	0.312	No change over time
	Zn	0.289	0.193	No change over time

* The trend indicated by Spearman's rho and P of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore the finding has been corrected to indicate no change over time, which is representative of actual conditions.

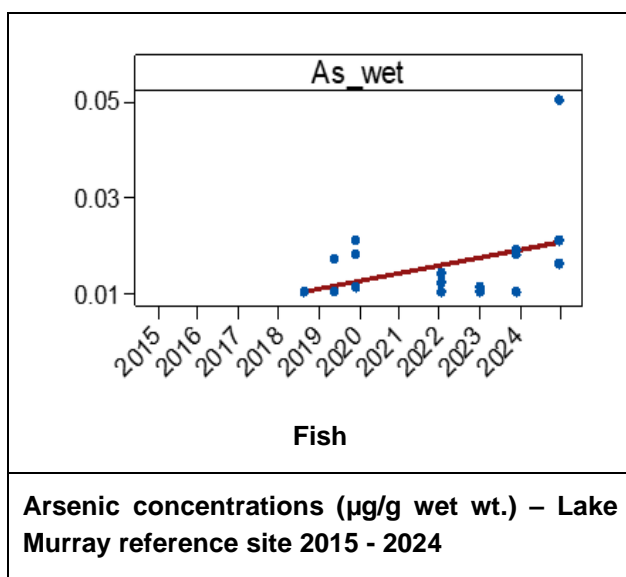


Figure 5-55 Trend analysis of arsenic concentration (µg/g wet wt.) in fish – Lake Murray reference site (Maka) 2015 – 2024. Graphs show weak increasing linear trend.

5.6 Background Aquatic Biology and Impact Assessment Criteria

Impact assessment trigger values for biological indicators in the upper river, lower river and Lake Murray have been developed in accordance with the methodology outlined in Section 2.6 of this report. The TV values used are the same as those applied in the 2019 report and are defined in detail in Section 2.6 and the tables below.

A summary of biological indicator parameters and TVs for the upper river, lower river and Lake Murray are presented in Table 5-33, Table 5-34 and Table 5-35 respectively.

Table 5-33 Trigger Values for Upper River Impact Assessment

Test Site	Indicator Parameter		TV Source	TV
Wasiba & Wankipe	Fish	Total Fish Abundance	Ok Om Reference	3.6
		Total Fish Biomass (g)		174.7
		<i>N. equinus</i> Abundance		2.4
		<i>N. equinus</i> Biomass (g)		129.4
	Prawn	Total Prawn Abundance	Ok Om Reference	6.0
		Total Prawn Biomass		24.6
		<i>M. handschini</i> Abundance		3.2
		<i>M. handschini</i> Biomass		14.1
		<i>M. lorentzi</i> Abundance		2.8
		<i>M. lorentzi</i> Biomass		10.5

Table 5-34 Trigger Values for Lower River Impact Assessment

Test Site	Indicator Parameter		TV Source	TV
Bebelubi	Fish	Total Fish Richness	Option A1 Baia 'Baseline'	3.0
		Total Fish Abundance		15.0
		Total Fish Biomass		8.4
		Total Fish Richness	Option A2 Baia 'Reference'	4.0
		Total Fish Abundance		10.5
		Total Fish Biomass		6.2
SG4	Fish	Total Fish Richness	Option B1 Tomu 'Baseline'	5.2
		Total Fish Abundance		24.8
		Total Fish Biomass		13.5
		Total Fish Richness	Option B2 SG4 Baseline	5.0
		Total Fish Abundance		21.8
		Total Fish Biomass		15.4
		Total Fish Richness	Option B3 Mean of Tomu Reference	5.0
		Total Fish Abundance		17.1
		Total Fish Biomass		12.8

Table 5-35 Trigger Values for Lake Murray Impact Assessment

Test Site	Indicator Parameter		TV Source	TV
Miwa	Fish	Total Fish Richness	20 th percentile of Maka baseline (2001 - 2006)	1.9
		Total Fish Abundance		4.8
		Total Fish Biomass		19.7
		Total Fish Richness	Mean of Miwa baseline (1989 - 2000)	3.8
		Total Fish Abundance		19.4
		Total Fish Biomass		66.7
		Total Fish Richness	Maka Reference	4.8
		Total Fish Abundance		9.9
		Total Fish Biomass		17.5
Pangoa	Fish	Total Fish Richness	20 th percentile of Maka baseline (2001 - 2006)	1.9
		Total Fish Abundance		4.8
		Total Fish Biomass		19.7
		Total Fish Richness	Maka Reference	4.8
		Total Fish Abundance		9.9
		Total Fish Biomass		17.5

6 COMPLIANCE

This Section provides a summary of the operation’s compliance with the conditions of its two environmental permits, issued by the PNG Government. A summary of compliance against the conditions of each permit is shown in Table 6-1. Overall, the site achieved compliance with 100% of the permit conditions.

There was one short duration event at one of the five sewage treatment plants during the year where TSS concentrations in the discharge slightly deviated from the target concentration. The duration of the event was less than 24 hr and TSS in the discharge remained below that of the receiving environment, as a result the environmental impact associated with these events is considered negligible.

River monitoring site SG3 is located at the end of the permitted mixing zone and is the location at which permit water quality criteria apply. Table 6-2 is a summary of water quality results measured at SG3 during 2024 and shows that water quality at SG3 complied with the permit criteria during 2024. Water quality data for river monitoring sites upstream of SG3 are also presented and show that water quality at these sites also complied with the SG3 criteria during 2024. Monitoring was not conducted at SG1 due to security concerns.

Table 6-1 Compliance summary 2024

Permit	% Compliance	Comments
Waste Discharge Permit EP – L3 (923)	100%	Compliant with all forty one (41) conditions.
Water Extraction Permit WE – L3 (923)	100%	Compliant with all eight (8) conditions.
TOTAL	100%	Target is 100% compliance.

Table 6-2 Median water quality at Upper River Test Sites against SG3 permit criteria 2024 (µg/L except where shown)

Site	n	pH	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Ni-D	Pb-D	Zn-D
SG1	0	NS	NS	NS	NS	NS	NS	NS	NS	NS
SG2	6	7.8	0.01	1.2	0.08	0.14	1.3	0.75	0.10	4.8
Wasiba	11	7.8	0.01	0.97	0.05	0.39	0.59	0.56	0.10	0.95
Wankipe	12	7.8	0.01	1.2	0.05	0.15	0.81	0.50	0.10	1.9
SG3	183	7.9	0.01	1.0	0.05	0.15	0.96	0.50	0.10	1.8
SG3 Permit Criteria		6.5 – 9.0	4.0	50	1.0	10	10	50	3.0	50
	Compliant									
	Non-Compliant									

D – Dissolved fraction, ^ standard pH units

Note: There is no permit criterion for mercury (Hg)

NS – Not sampled due to community unrest, which restricted safe access.

7 RISK ASSESSMENT

7.1 Hydrology and Environmental Flows

7.1.1 Waile Creek

Figure 7-1 shows the flow duration curve for Waile Creek Dam in 2024 which has been generated from dam water level measurements and used for estimation of spillway flows to the creek downstream of the extraction point. Overflow was relatively constant for the reporting period but occasional higher peak flows occurred. The frequency and duration of zero-flow periods are important in terms of environmental flows and maintaining downstream ecological values, although it should be noted that some flow continues to occur downstream of the dam wall even when the dam is not overflowing due to leakage from the dam. During 2024, there were 78 occurrences when the dam did not overflow (for one or more days) with the longest period being 8 days.

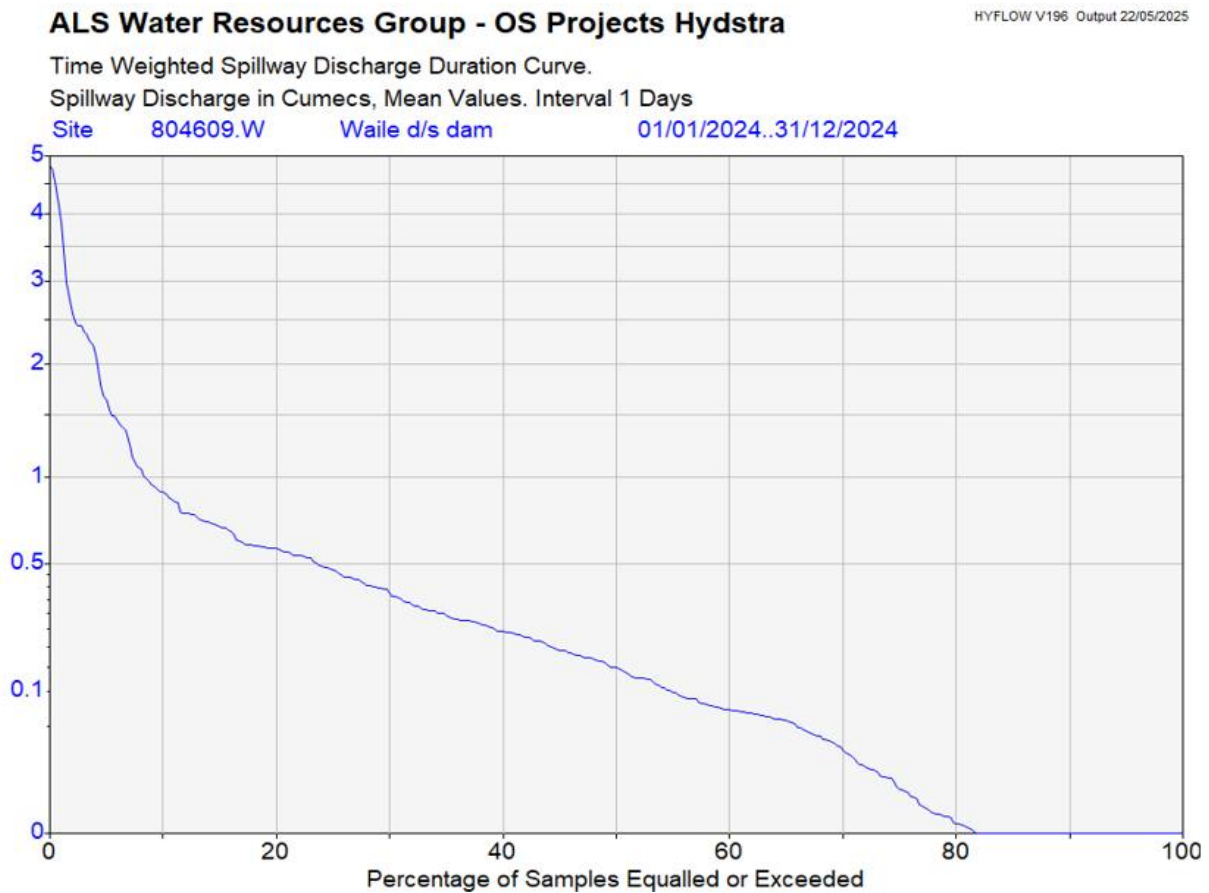


Figure 7-1 Daily flow duration curve (estimated) for Waile Creek Dam overtopping

7.1.2 Kogai Creek

Figure 7-2 shows daily flow duration curve for Kogai Creek downstream of the Mill extraction point (Kogai Culvert). Although there was substantial lost record at Kogai @ SAG Mill (extraction point) the flow duration curve below the extraction point shows there were still variable flows during the year. Flow

variability is typically important for maintenance of downstream ecosystem flow-related values.

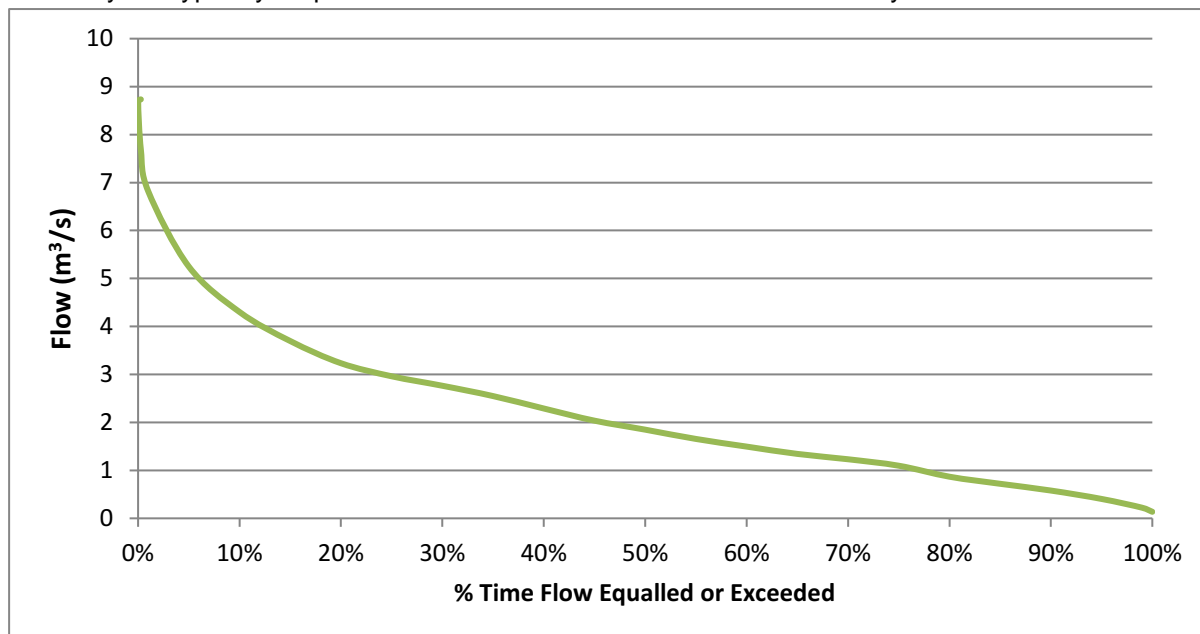


Figure 7-2 Daily flow duration curves for Kogai Creek

7.2 Sediment Transport and Fate of Sediment

Sediments contained in the tailings discharge and in the toe of the erodible dumps, are transported downstream by the river flow. Erodible waste rock is deposited at the head of the Anawe and Anjolek erodible waste rock dumps and discharged in slurry from the Yarik portal, from where it is gradually eroded into the river system. Tailings are discharged at the head of the Anawe erodible dump, and it is estimated that 95% of the sediment contained in the tailings makes its way into the river system, with approximately 5% of the tailings solids being retained by deposition along the Anawe erodible dump surface. These are estimates based on best professional judgement as no tailings mass balance for the dumps has been undertaken.

Estimating the volumes of sediment that actually reach the river system each year, and the relative contributions of natural sediment, waste rock and tailings, were made using a combination of: the measured volumes of waste deposited to the erodible dumps; the volume and density of tailings discharged; the measured change in volume of the erodible dumps from year to year using survey data; the TSS of water from non-mine related catchments downstream of the mine; and river flow rates. This calculation is applied at SG3 as a much higher sampling intensity is performed at this location for compliance purposes, which therefore provides a much larger TSS data set which can be combined with a continuous stream-flow record. Only single monthly TSS samples are taken at the other river monitoring stations, meaning that suspended sediment load estimates at these locations are not as reliable as at SG3.

It should be noted that the river stage at the time of sampling has a significant effect on the TSS concentration, with higher TSS generally measured during high flows, although the relationship between TSS and flow is complex and varies with distance downstream from the mine because mine inputs are relatively constant while natural inputs are more variable. Sampling at SG3 is carried out over 4 successive days each month, so the conditions at the time of sampling may not be representative of flows during the whole of the month. Despite this limitation, the data are considered to provide a reasonable estimate of monthly suspended sediment loads for SG3.

Monthly mean TSS concentrations at SG3 during 2024 are shown in Figure 7-3, 2024 monthly TSS loads are shown in Figure 7-4 and historical (1990-2024) monthly TSS loads are shown in Figure 7-5.

The annual suspended sediment load at SG3 was estimated from the TSS and flow records using a statistical analysis to correct the results for discrepancies arising from irregularly sampled record and continuous record of flow. The statistical analysis is contained in a computer program called *Gumleaf* (Generator for Uncertainty Measures and Load Estimates using Alternative Formulae). The program computes sediment load using 22 different formulae. The program authors are Dr. K. Tan, Professor David Fox (Environmetrics Australia P/L) and Dr. Teri Etchells. Permission for use of Gumleaf was kindly provided by Professor Fox.

The median annual suspended sediment load at SG3 for 2024 was estimated by Gumleaf to be 95.5 Mt.. This compares to the long-term median since 1990 of approximately 45 Mt/a, and an annual load in 2023 of 45.5 Mt/a.

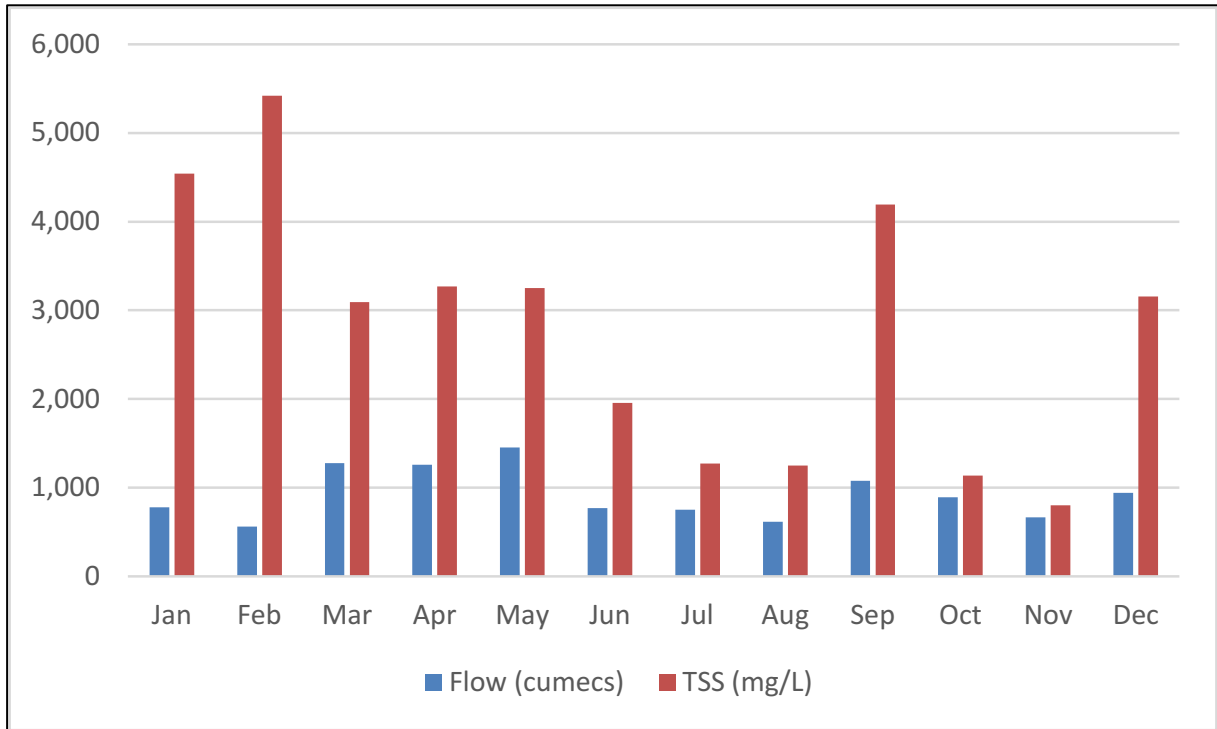


Figure 7-3 Mean monthly TSS and flow at SG3 for 2024

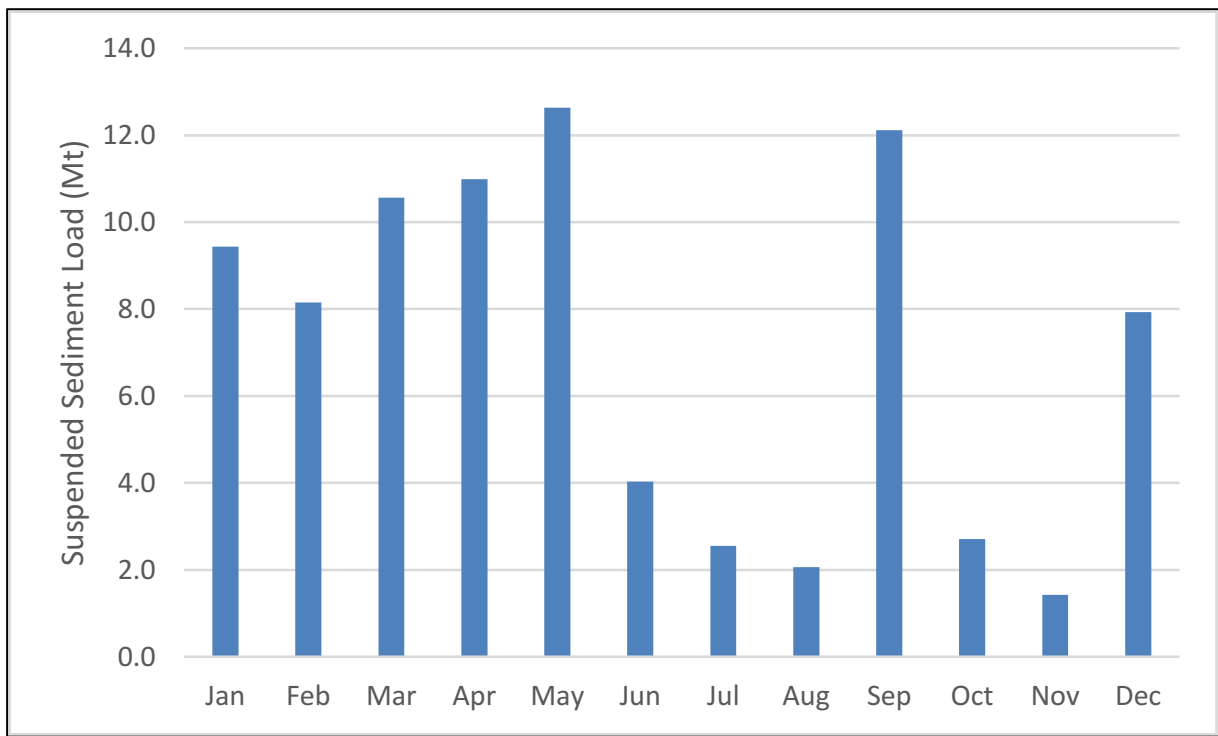


Figure 7-4 Estimated mean monthly suspended sediment loads for SG3 (Mt).

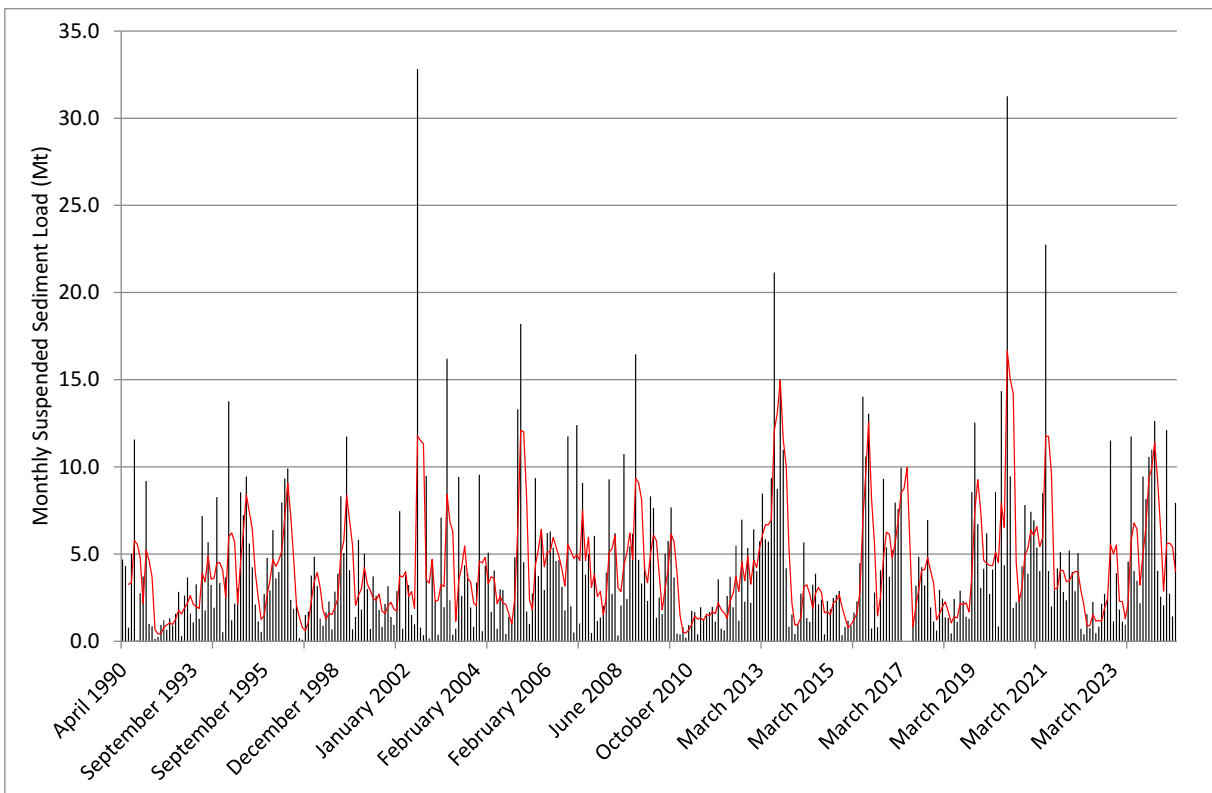
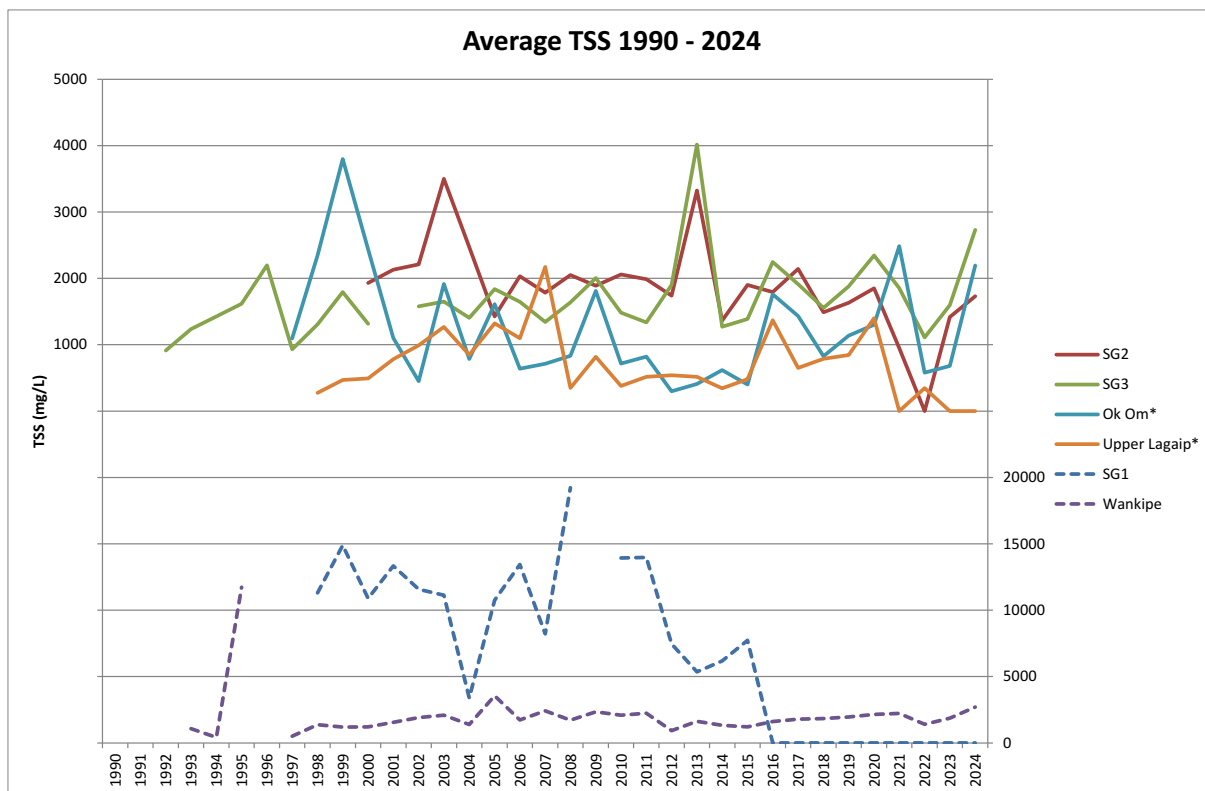


Figure 7-5 Estimated monthly suspended sediment load (black bars) with 3-month moving average at SG3 for full record (red solid line)

To determine the relative contributions of mine-derived and natural sediment to the total sediment load at SG3, the results of the Gumleaf analysis were compared with estimates of mine-derived inputs based on the erodible dump survey analysis and tailings data.

Figure 7-6 shows historical annual average TSS concentrations at river monitoring stations upstream of SG3. In 2024, all reference and test sites showed similar TSS concentrations compared to recent historical values.



* Reference site

Figure 7-6 Historical annual average TSS 1990-2024

Figure 7-7 shows the estimated relative contribution of tailings, waste rock and natural suspended sediment to the total suspended sediment load at SG3 since 1991. Figure 7-8 shows the same dataset presented in terms of the percentage contribution of tailings, waste rock and natural suspended sediment to the overall suspended sediment load.

The analysis shows that the estimated loads contributed by tailings and waste rock in 2024 were low compared with historical rates. However, the background TSS load (computed from SG3 flow and TSS data) was relatively high, and therefore the proportion of that load made up of mine-derived sediment was also relatively low by historic standards.

The percentage of total suspended sediment that was mine-derived during 2024 was calculated to be 7.3%, which compares to a long term median of approximately 22%. By way of comparison, geochemical analyses on sediments conducted as part of the NSF (US National Science Foundation) sponsored Margins Source to Sink Research Program found that, by using silver and lead as tracers, the percentage of mine-derived sediment was 29% for SG3 and 12-13% for SG4 (Swanson et al. 2008).

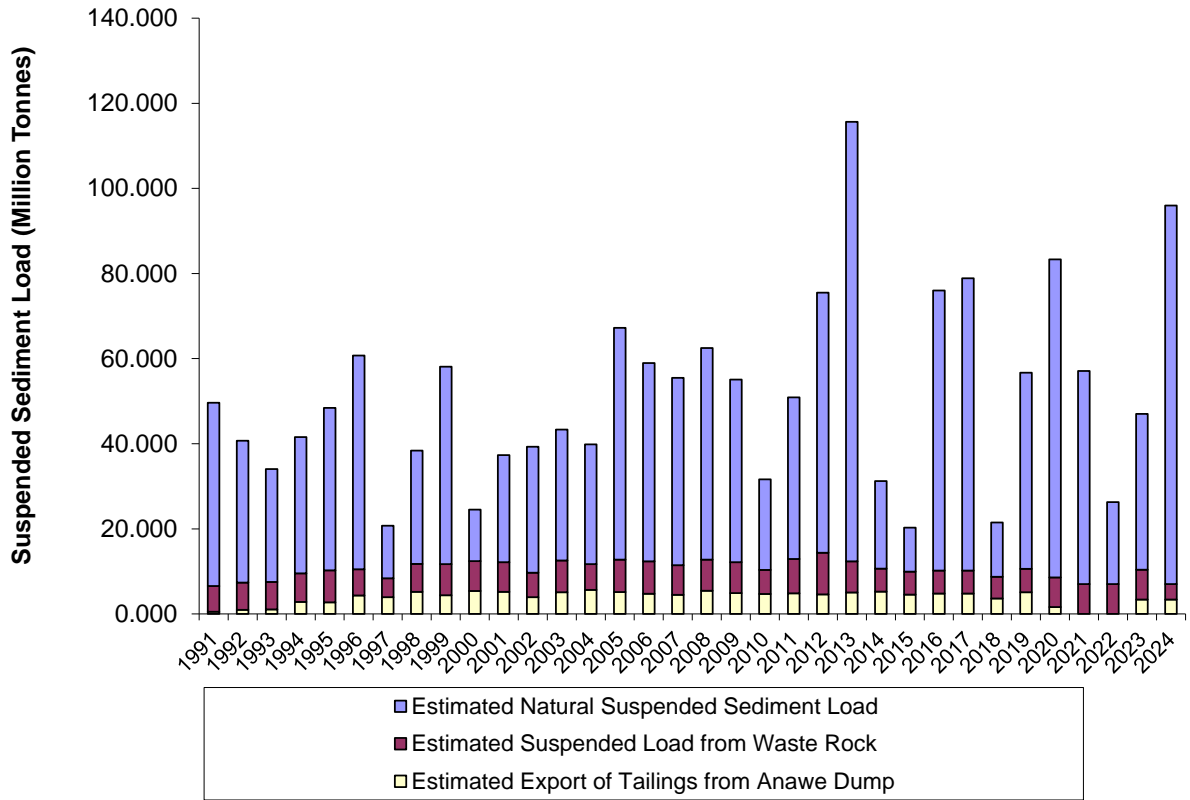


Figure 7-7 Suspended sediment budget at SG3 1991-2024

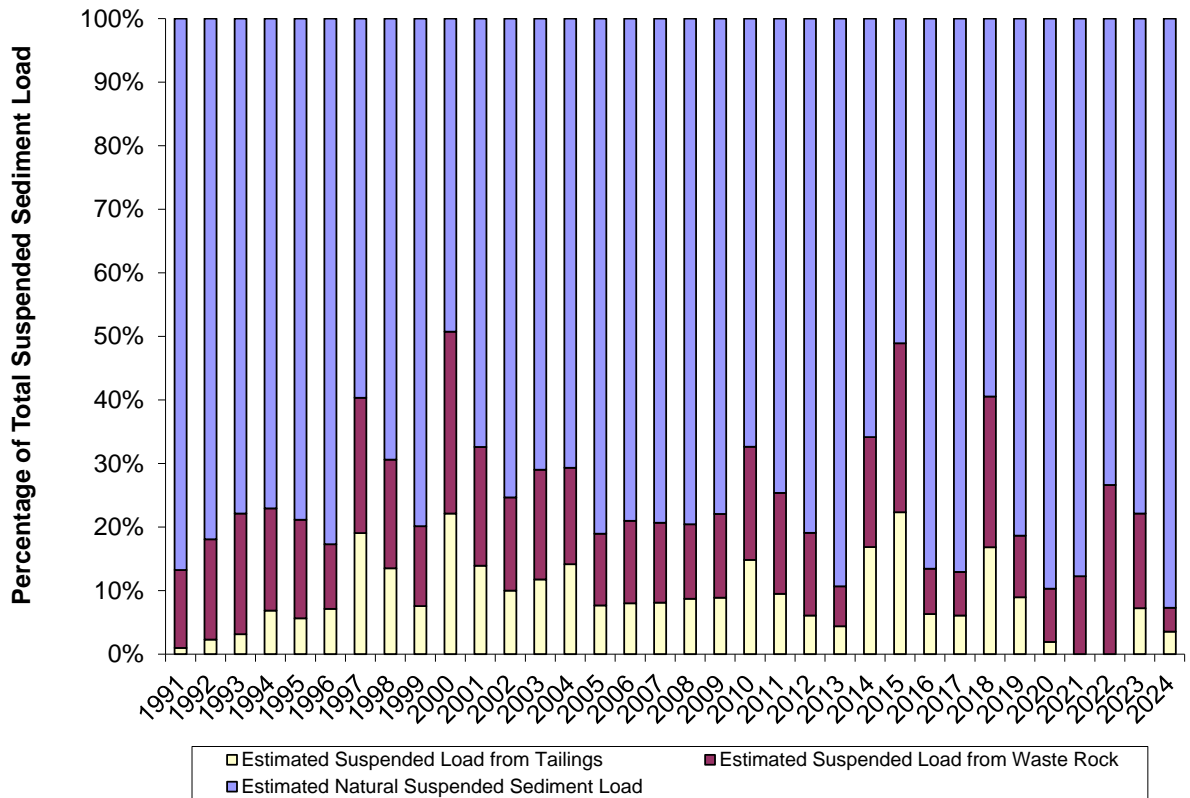


Figure 7-8 Relative contribution of natural and mine-derived suspended sediment at SG3 (%) 1991-2024

7.3 Sediment Aggradation and Erosion

Surveying of river profiles (river-bed cross sections) is typically performed downstream of the mine at designated locations to evaluate changes in bed levels (aggradation or degradation). No recent surveys of either the Kaiya River (between Anjolek Toe) nor the Porgera River have been undertaken in recent years due to operational and security reasons, but visual observations suggest there has been no significant change to river morphology over that time.



Figure 7-9 Photo of profile site at Kaiya River downstream of Kogai Creek Confluence



Figure 7-10 Photo of profile site at Kaiya River upstream of Yuyan Bridge



Figure 7-11 Photo of profile site at the Kaiya River downstream of Yuyan Bridge

As discussed in previous Annual Reports, the bed of the Porgera River at SG1 aggraded (built-up) during mine construction due to the initial disposal of erodible waste rock at Anawe erodible dump between about 1989 and 1991 (see Figure 4-12). Since the initial aggradation, the bed elevation has remained more or less consistent, with only minor variation. Although there have been no flow measurements or cross-section surveys along the Porgera River for some time, due to law and order issues preventing access, there is no evidence from qualitative observations alone that significant aggradation or erosion of valley walls is occurring along the Porgera River.

As the river descends from the upland areas to the lowlands (the Fly Platform), the velocity slows, and temporary sediment deposition starts to occur in the form of transient gravel and sand bars. Further downstream, floodplain connections become better established and the bed material changes to predominantly sands and silts.

Profiles recorded at SG4, 360 km downstream and PF10, 400 km downstream of the mine, are presented in Figure 7-12 and Figure 7-13. SG5 cross-sections are shown in Figure 7-14. At PF10 and SG5 the survey benchmarks (and survey reference) had been lost but were re-established in 2024 as close as could be estimated to the original benchmarks.

Overall, the elevation of the bed and morphology of the cross section at these sites were considered to be within the range of variability shown in the historical survey record.

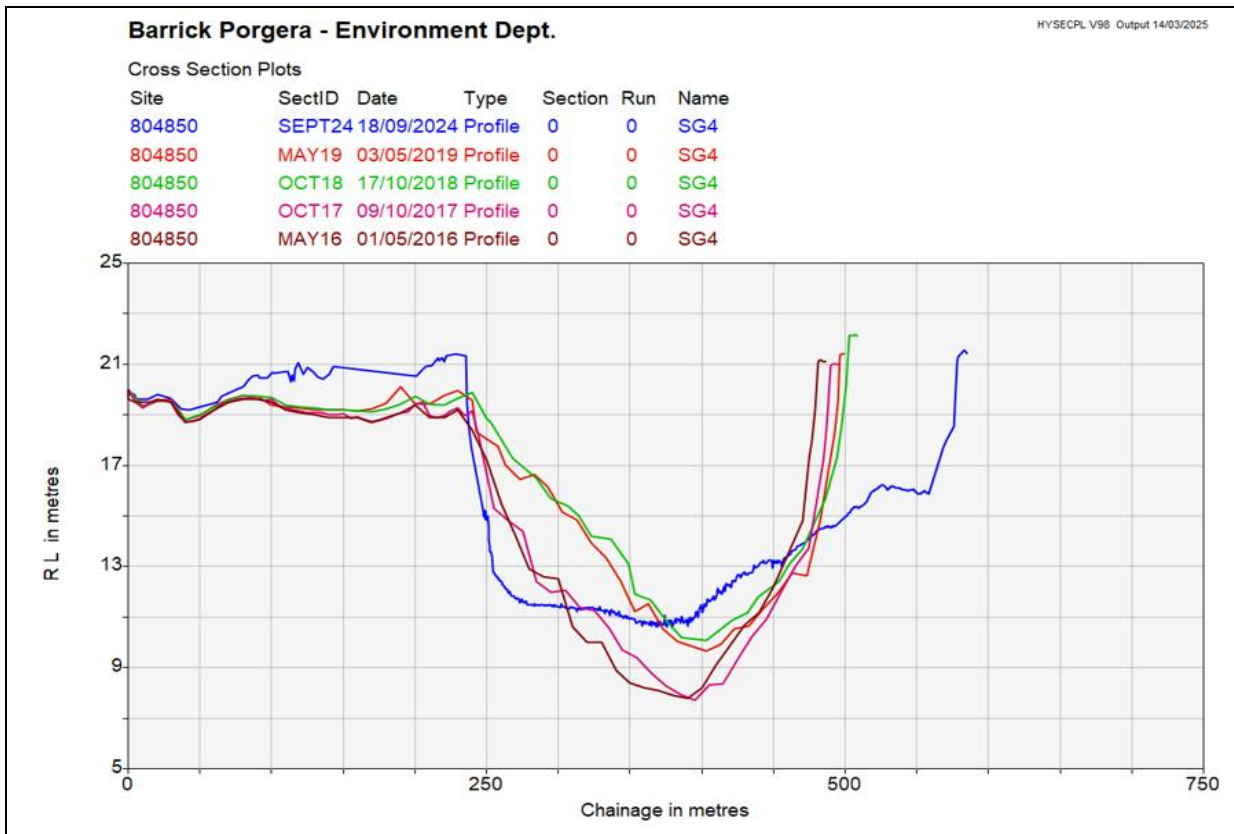


Figure 7-12 Profile comparison (2016-2024) at SG4 – 360 km downstream

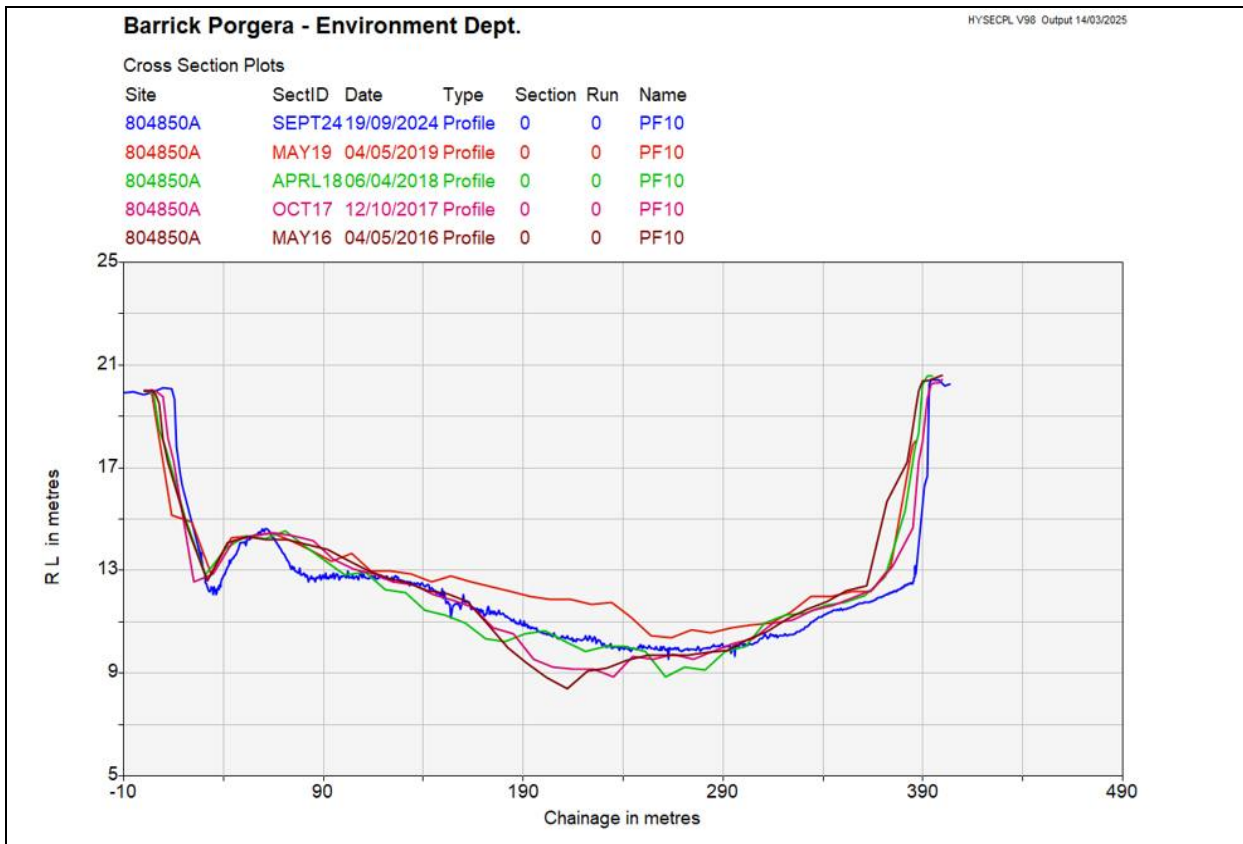


Figure 7-13 Profile comparison (2016-2025) at Profile 10 – 400 km downstream

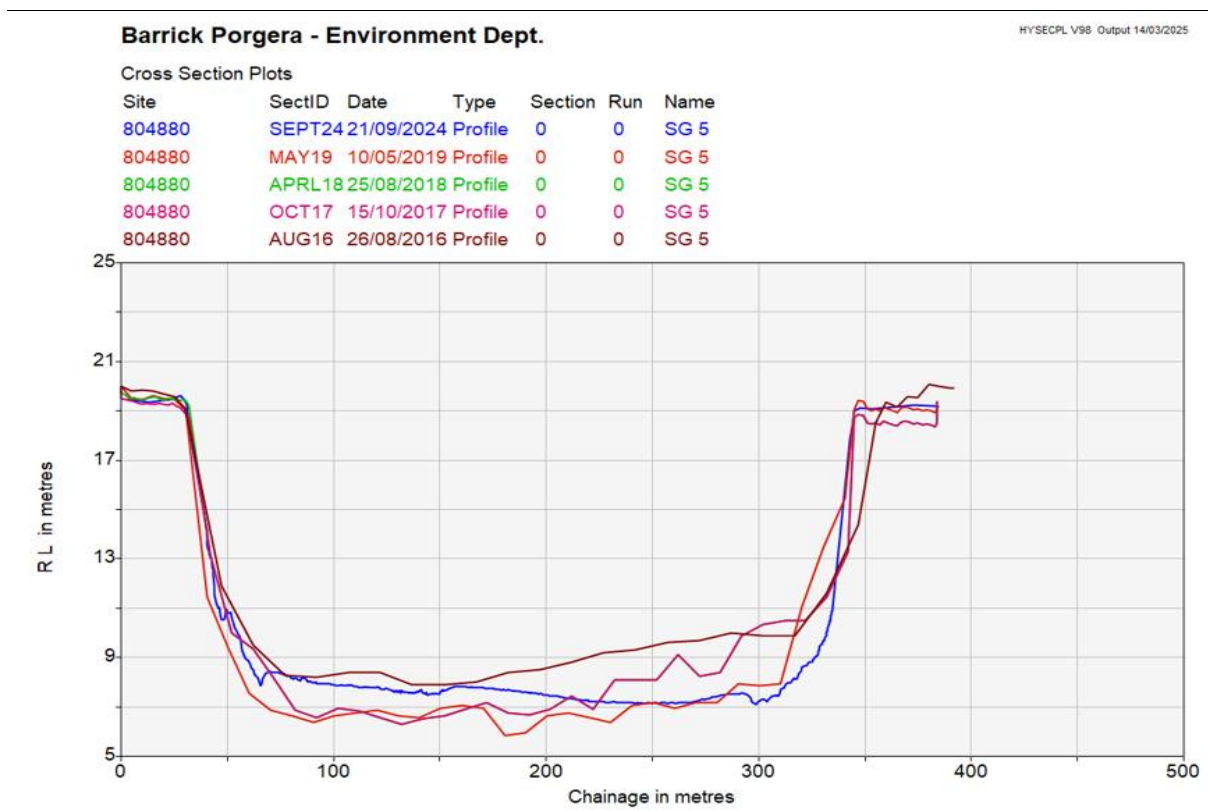


Figure 7-14 Profile comparison (2016-2025) at SG5 – 560 km downstream

7.4 Water Quality, Sediment Quality and Tissue Metals Risk Assessment

This section assesses the risks posed to aquatic ecosystems by physical and chemical stressors and toxicants in water, benthic sediment and fish and prawn tissue. The risk assessment is performed in accordance with the methodology outlined in Section 2.1. The results of each risk assessment are first presented separately for each section of the river system. However, given that a complex relationship exists between physical and chemical toxicants, matrices and other environmental factors such as natural inputs, hydrology and topography, it is also necessary to investigate the potential risks posed by the behaviour of each physical and chemical toxicant throughout the receiving environment. This summary of risks is provided in Section 7.4.

7.4.1 Water quality

7.4.1.1 Upper River, Lower River and ORWBs

The risk assessment for water quality at the upper river, lower river and ORWBs involved comparing the 2024 median value at each test site, the test site median (TSM), against the relevant TV in accordance with the risk assessment procedure described in Section 2. The test site median is derived from the most recent 12-month data set.

The comparison of the TSM against the TV is supported by a statistical analysis using Wilcoxon’s Rank Test to ensure any conclusions are based on sound statistics and are not an artefact of the data set. The results of the risk assessment for the upper and lower river are summarised in Table 7-1, and Table 7-2 respectively. Detailed results of the statistical analysis are shown in Appendix D, Tables D-3 to D-13 and figures showing comparisons of the historical data against the TVs are shown in Appendix D, Figures D-1 to D-46.

Highland and lowland river systems within PNG typically exhibit a naturally high sediment load and are exposed to episodic variations in TSS concentrations. Periods of high TSS result from periods high rainfall with a prevalence of large-scale erosion and landslides, whereas periods of low TSS reflect periods of low rainfall with reduced erosion and sediment transport. Periods of elevated TSS concentration shown in baseline and reference data reflect these processes.

The risk assessment showed that 2024 median pH at all upper river, lower river and ORWB test sites were within the upper and lower pH TVs.

The 2024 median TSS concentration at upper river site at Wankipe was assigned ‘potential risk’ was not statistically different from the TV while 2024 median TSS concentrations at Bebelubi and SG4 for lower river sites were higher than the respective TV, indicating potential risk. TSM for all other upper river, lower river and all of ORWB test sites were significantly less than the respective TVs.

The 2024 median EC at upper river sites at SG2 and Wasiba were higher than the TV indicating potential risk while median EC for Wankipe at upper river and Bebelubi at lower river test sites were not significantly different from the respective TV indicating potential risk. ORWB test sites were less than the TV, indicating low risk.

The risk assessment results for metals indicated that the 2024 TSM for dissolved copper concentrations at SG2, SG3 and Levame were all not significantly different from the TV. Dissolved iron at Zongamange and Avu were significantly higher than the respective TV. All other dissolved metals concentrations at all sites within the upper river, lower river and ORWBs were below their respective TVs.

Table 7-1 Risk assessment – median water quality at upper river test sites in 2024 compared against UpRivs TVs showing which indicators pose low and potential risk (µg/L except where shown)

Site	n	pH [^]	TSS [*]	EC	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Fe-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D
SG1	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SG2	6	7.8	1,450	301	0.01	1.2	0.08	0.14	1.3 ¹	2.6	0.05	0.75	0.10	0.20	4.8
Wasiba	11	7.8	940	256	0.01	0.97	0.05	0.39	0.59	1.7	0.05	0.56	0.10	0.27	0.95
Wankipe	12	7.8	2,300 ¹	228 ¹	0.01	1.2	0.05	0.15	0.81	3.3	0.05	0.50	0.10	0.21	1.9
SG3	183	7.9	2,100	215	0.01	1.0	0.05	0.15	0.96	3.6	0.05	0.50	0.10	0.20	1.8
UpRivs WQ TV		6.0-8.2	2,837	230	0.05	24^{**}	0.32	1.0	1.4	75	0.60	21	6.7	11	20
	Low risk = significantly < TV														
	Potential risk = not significantly different from TV OR significantly > TV														

[^] std units, D - Dissolved fraction, * mg/L, **Arsenic (III)

¹Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM is not statistically significantly different from the TV.

Table 7-2 Risk assessment – Median water quality results at lower river test sites in 2024 compared against LwRiv TVs showing which indicators pose low and potential risk (µg/L) except where shown)

Site	n	pH [^]	TSS [*]	EC	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Fe-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D
Bebelubi	8	7.9	1,450	175 ¹	0.01	0.75	0.05	0.16	0.87	6.8	0.05	0.62	0.10	0.20	1.1
SG4	8	7.9	1,045	159	0.01	0.77	0.05	0.16	0.89	7.4	0.05	0.50	0.10	0.20	1.3
SG5	15	7.9	340	158	0.01	0.75	0.05	0.10	0.95	25	0.05	0.50	0.10	0.20	0.65
LwRivs WQ TV		6.0-8.1	983	250	0.05	24^{**}	0.20	1.0	1.4	75	0.60	15	3.4	11	8.0

NPL Annual Environment Report 2024

	Low risk = significantly < TV
	Potential risk = significantly > TV OR not significantly different from TV

^ std units, * mg/L, D - Dissolved fraction, Arsenic (III)

¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM is not statistically significantly different from the TV.

Table 7-3 Risk Assessment – Median water quality results at ORWB test sites in 2024 compared against LMY and ORWB TVs showing which indicators pose low and potential risk (µg/L except where shown)

Site	n	pH [^]	TSS*	EC	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Fe-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D
Kuku-fionga	6	8.0	24	207	0.01	1.8	0.05	0.10	0.47	1.0	0.05	0.50	0.10	0.20	2.5
Zonga-mange	6	7.2	8.5	131	0.01	0.94	0.05	0.10	0.57	90	0.05	0.50	0.10	0.20	4.1
Avu	6	7.2	9.0	50	0.01	0.81	0.05	0.34	0.32	655	0.05	0.63	0.10	0.20	1.9
Levame	6	7.9	73	178	0.01	0.92	0.05	0.10	1.1	31	0.05	0.50	0.10	0.20	1.1
ORWB WQ TV		6.0-8.1	983	250	0.05	24**	0.20	1.0	1.4	75	0.60	15	3.4	11	8.0
	Low risk = significantly < TV														
	Potential risk = significantly > TV or not significantly different from TV														

^ std units, * mg/L, D - Dissolved fraction, **Arsenic (III)

¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM is found to be not statistically significantly different from the TV.

Trends of water quality in the upper river, lower river and ORWB test sites over the period 2015-2024 are summarised in Table 7-4 to Table 7-6. Detailed results are shown in Appendix D, Tables D-14 to D-16.

The results showed that pH at all upper river sites; TSS, dissolved mercury and dissolved selenium at SG3; dissolved mercury at SG2, dissolved chromium and selenium at Wasiba exhibited a statistically significant increasing trend over the period. In the lower river, pH at all sites exhibited a statistically significant increasing trend over the period. In the ORWBs, EC at Kukufionga, dissolved chromium, dissolved iron and dissolved nickel at Avu and Levame; and dissolved iron at Zongamange exhibited a statistically significant increasing trend over the period.

The trend analysis also showed statistically significant increasing trends for pH, dissolved and total mercury and dissolved nickel at reference sites Upper Lagaip, Pori, Kuru and Ok Om. A. Graphical representation of trends at these sites are shown in Figure 7-15

Table 7-4 Water quality trends at the upper river test sites 2015-2024

Site	pH	TSS	EC	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Fe-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D
SG2														
Wasiba														
Wankipe														
SG3														
	Reduced over time, no change over time or system wide increasing trend													
	Increased over time													

D - Dissolved fraction

Table 7-5 Water quality trends at the lower river test sites 2015- 2024.

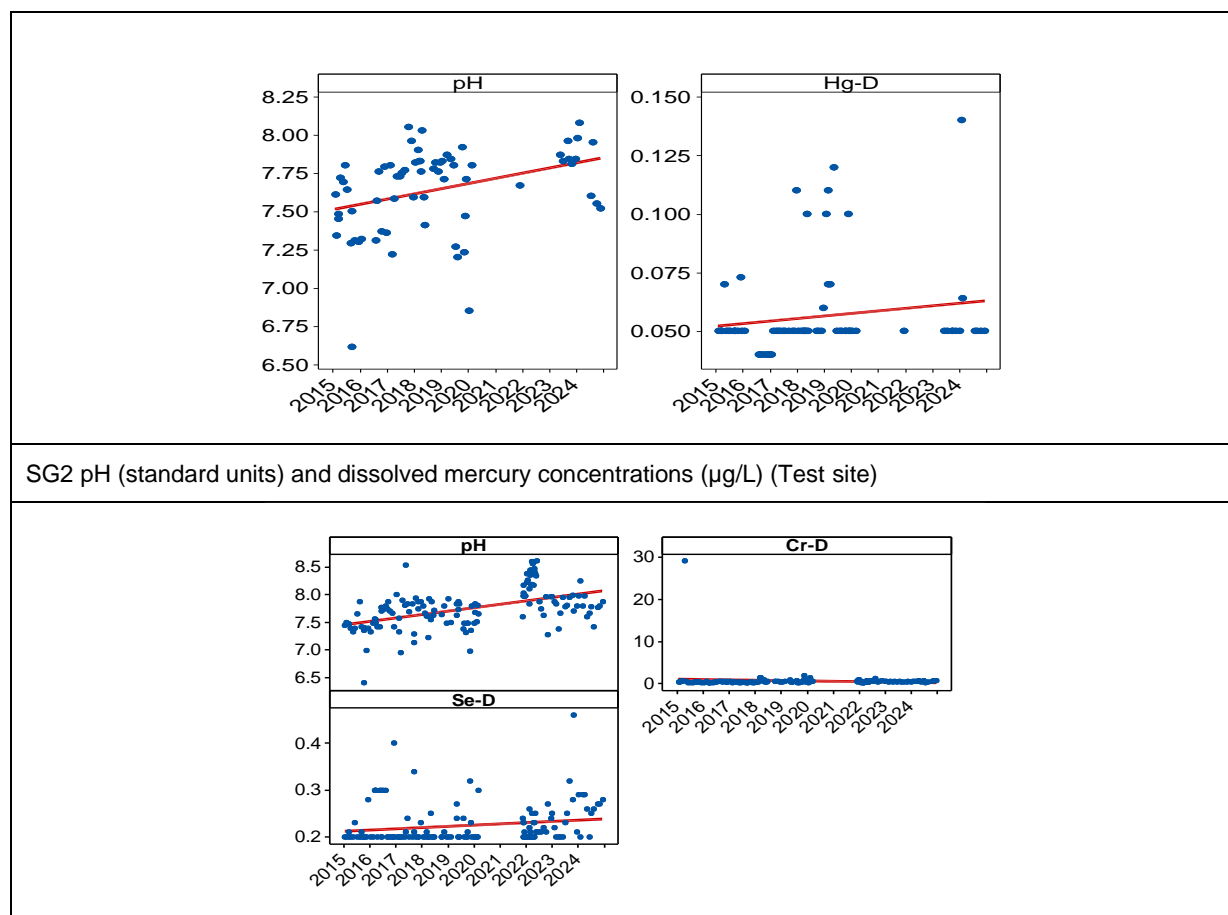
Site	pH	TSS	EC	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Fe-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D
Bebelubi	Increased over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time
SG4	Increased over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time
SG5	Increased over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time
	Reduced or no change over time													
	Increased over time													

D - Dissolved fraction

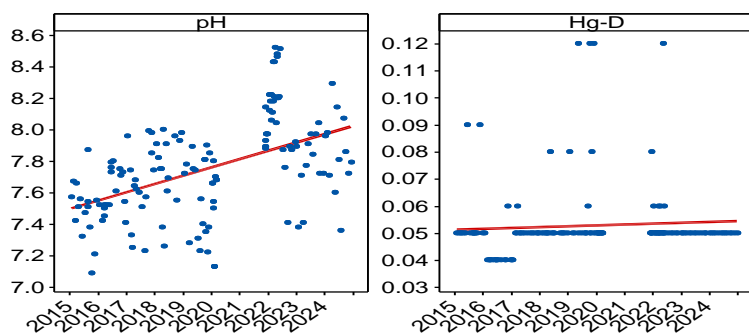
Table 7-6 Water quality trends at ORWB reference and test sites 2015-2024

Site	pH	TSS	EC	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Fe-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D
Kukufionga	Reduced or no change over time	Reduced or no change over time	Increased over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time
Zongamange	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Increased over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time
Avu	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Increased over time	Reduced or no change over time	Increased over time	Reduced or no change over time	Increased over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time
Levame	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time	Increased over time	Reduced or no change over time	Reduced or no change over time	Reduced or no change over time
	Reduced or no change over time													
	Increased over time													

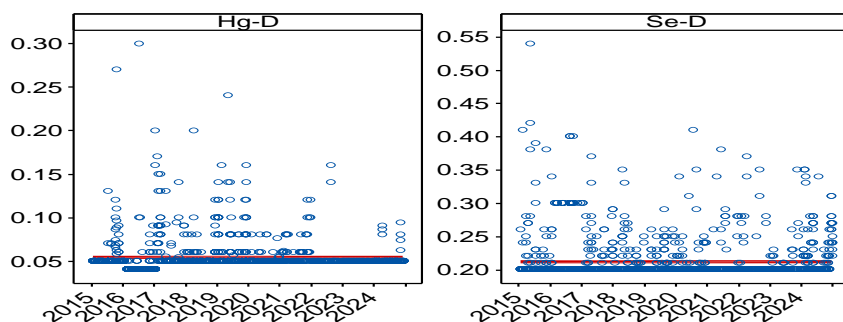
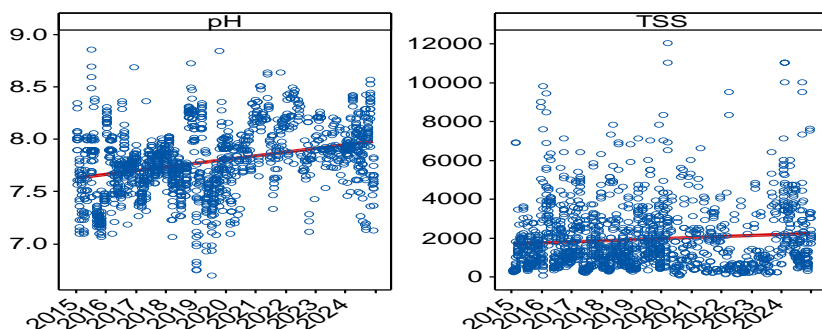
D - Dissolved fraction



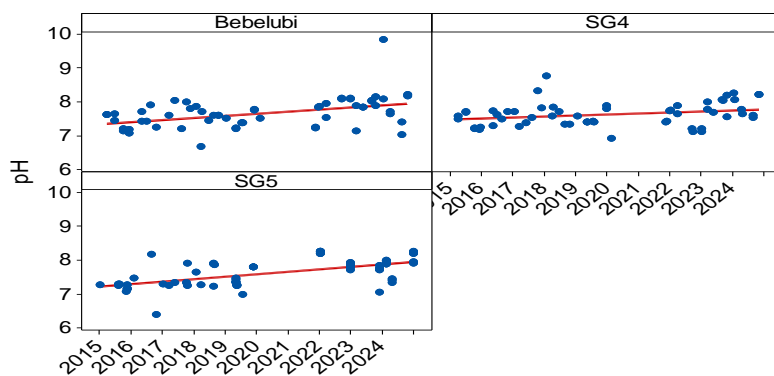
Wasiba pH (standard units), dissolved chromium and dissolved selenium concentrations ($\mu\text{g/L}$) (Test site)



Wankipe pH (standard units) and dissolved mercury concentrations ($\mu\text{g/L}$) (Test site)



SG3 pH (standard units), TSS (mg/L), dissolved mercury and selenium concentrations ($\mu\text{g/L}$) (Test site)



Bebelubi, SG4 and SG5 pH (standard units) (Test site)

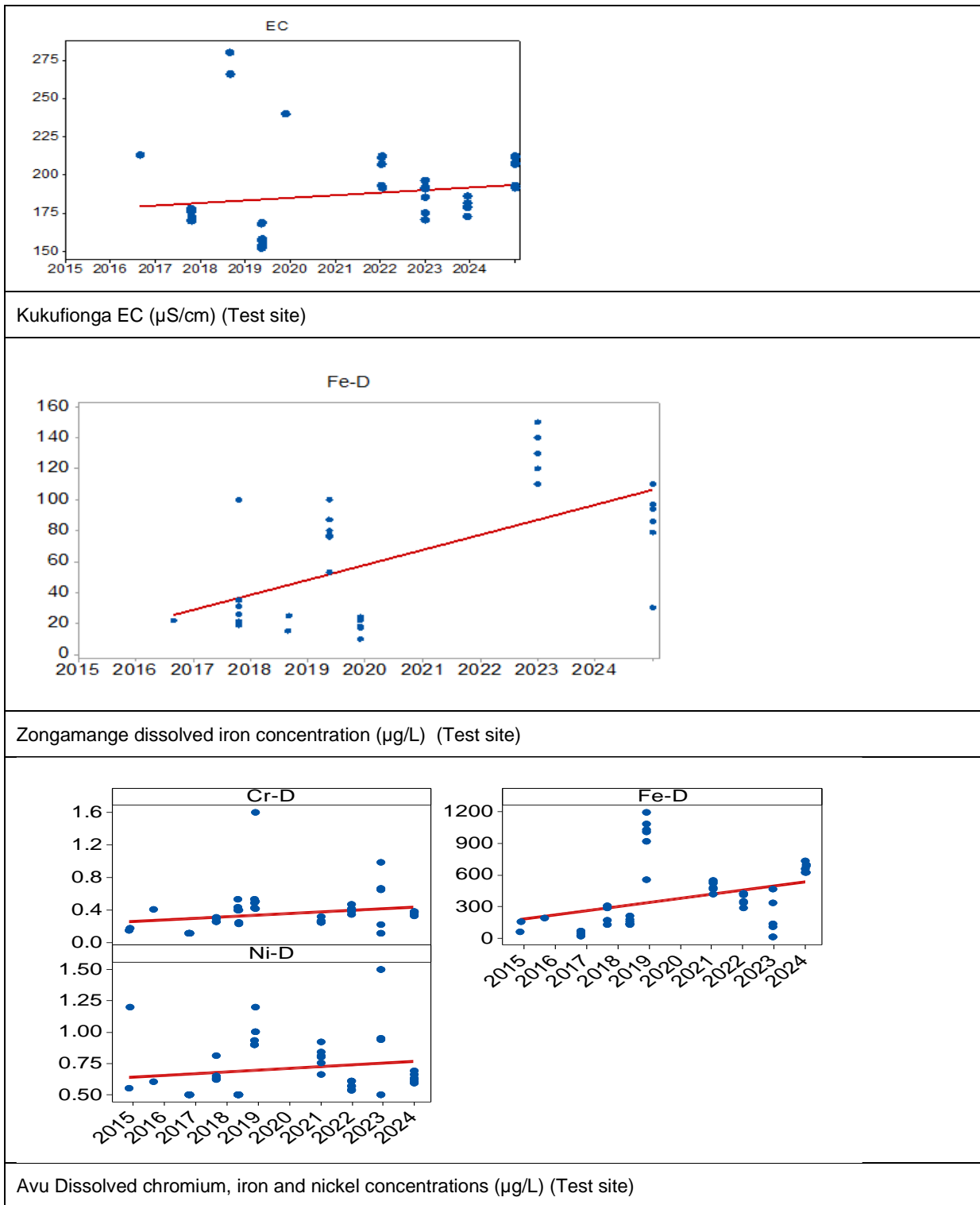


Figure 7-15 Trend analysis upper rivers, lower rivers and ORWB water quality showing elements with statistically significant increasing trends (scatter plot of all data from 2015 – 2024 with linear trend line)

7.4.1.2 Lake Murray

A summary of the water quality risk assessment results for Lake Murray is shown in Table 7-7 and shows that the 2024 TSM for pH at all Lake Murray sites were between the upper and lower pH TVs. The 2024 TSM for TSS is higher than the TV at SG6. The TSM for EC was above the TV at SG6. At Central Lake the EC was determined as ‘potential risk’ but was not statistically significantly different from the TV. The 2024 TSM concentration for all dissolved metals at all sites were below the respective TVs. Trend analysis results presented in Table 7-8 and show a statistically significant increasing trend in

dissolved iron in Central and Southern Lake and dissolved Mercury at Southern Lake. Graphical representation of these trends is shown in Figure 7-16

Details of the statistical analysis are shown in Appendix D, Tables D-17 to D-19, Figures showing comparisons of 2024 data against the TVs are shown in Appendix D, Figures D-47 to D-62 and detailed results of the trend analysis are presented in Table D-20.

Table 7-7 Risk Assessment – Median water quality results at Lake Murray test sites in 2024 compared against LMY TVs showing which indicators pose low and potential risk (µg/L except where shown)

Site	n	pH [^]	TSS [*]	EC	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Fe-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D
Central Lake	10	6.8	5.5	16 ¹	0.01	0.14	0.05	0.12	0.38	125	0.05	0.50	0.10	0.20	2.6
Southern Lake	14	6.9	2.5	14	0.01	0.21	0.05	0.10	0.40	135	0.05	0.50	0.10	0.20	0.66
SG6	6	7.3	72	38	0.01	0.52	0.05	0.10	0.86	81	0.05	0.50	0.10	0.20	0.70
LMY WQ TV		5.0-8.0	9.0	17	0.05	24^{**}	0.72	1.0	1.4	340	0.60	11	3.4	11	8.0
	Low risk = significantly < TV														
	Potential risk = significantly > TV or not significantly different from TV														

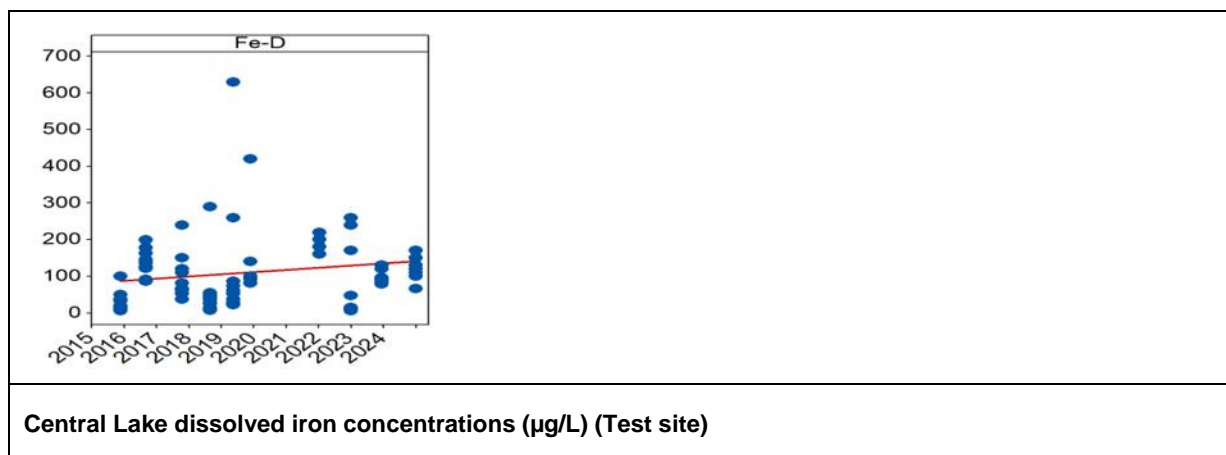
[^] std units, ^{*} mg/L, D - Dissolved fraction, ^{**}Arsenic (III)

¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM is found to be not statistically significantly different from the TV.

Table 7-8 Water quality trends at Lake Murray reference and test sites 2015-2024

Site	pH	TSS	EC	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Fe-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D
Central Lake														
Southern Lake														
SG6														
	Reduced or no change over time													
	Increased over time													

D - Dissolved fraction



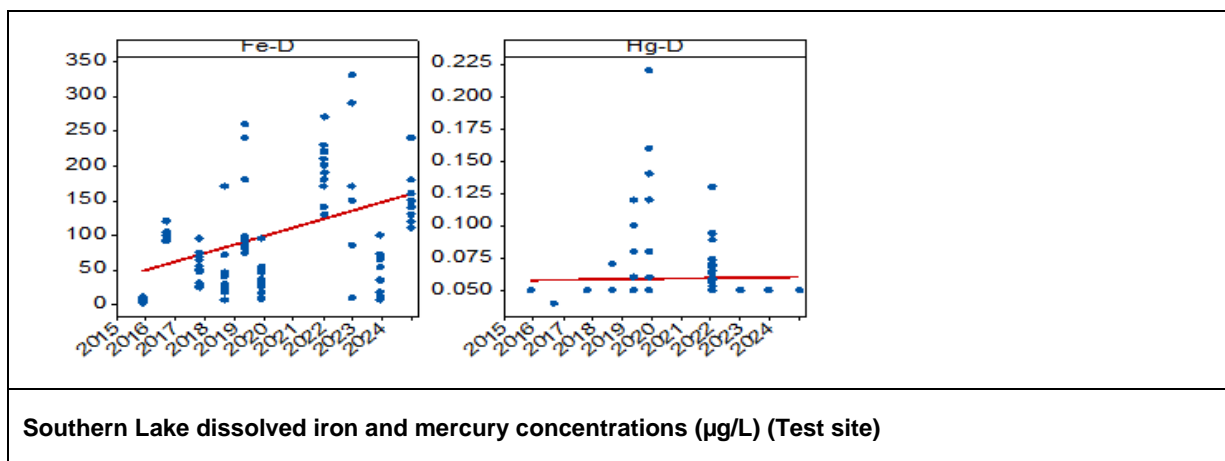


Figure 7-16 Trend analysis Lake Murray water quality showing elements with statistically significant increasing trends (scatter plot of all data from 2015 – 2024 with linear trend line)

7.4.2 Sediment quality

7.4.2.1 Upper River, Lower River and ORWBs

Similar to water quality, elevated concentrations of WAE metals in sediment have the potential to cause chronic and/or acute toxic effects to organisms within the receiving environment, including humans, and as a result can potentially affect aquatic ecosystem health and ecosystem biodiversity.

The results of the risk assessment for sediment quality in the upper river are presented in Table 7-9 and show that at SG2, the 2024 TSM for WAE lead and WAE selenium were assigned as 'potential risk' but were not significantly different from the respective TVs.

Results for the lower river are presented in Table 7-10 and show that WAE selenium was assigned as 'potential risk' at Bebelubi and SG4, but the TSMs were not significantly different from the TV.

Results for the ORWBs are presented in Table 7-11 and show that the 2024 TSM data for WAE selenium at Avu and WAE nickel at Levame were assigned as 'potential risk' but were not significantly different from the TV.

The results of trend analysis of sediment quality in the upper river are shown in Table 7-12 and showed a statistically significant increasing trend for WAE nickel at SG3.

The results of trend analysis of sediment quality in the lower river are shown in Table 7-13 and show no increased concentrations over time. Results for trend analysis of sediment in the ORWBs are shown in Table 7-14 and show a statistically significant increasing trend for WAE selenium for all sites. WAE chromium, WAE copper and WAE nickel at Levame show a statistically significant increasing trend during the period. Graphical representation of the statistically significant increasing trends are shown in Figure 7-17

Detailed results of the statistical analysis are shown in Appendix E, Tables E-2 to E-12 and figures showing comparisons of the historical data against the TVs are shown in Appendix E, Figures E-1 to E-32, and detailed results of the trend analysis are presented in Appendix E, Table E-13 to E-15.

Table 7-9 Risk Assessment – Median sediment quality results at upper river test sites in 2024 compared against UpRivs TVs showing which indicators pose low and potential risk (mg/kg dry weight, whole sediment)

Site	n	Ag - WAE	As - WAE	Cd - WAE	Cr - WAE	Cu - WAE	Hg - WAE	Ni - WAE	Pb - WAE	Se - WAE	Zn - WAE
SG2	7	0.07	5.0	0.45	2.1	9.8	0.01	4.4	48 ¹	0.19 ¹	72
Wasiba	10	0.05	3.4	0.22	1.7	8.2	0.01	8.3	28	0.16	39
Wankipe	12	0.05	3.4	0.21	1.6	6.9	0.01	7.5	24	0.16	37
SG3	10	0.05	2.7	0.10	1.9	6.9	0.01	11	13	0.15	22
UpRivs Sed TV		1.0	20	1.5	80	65	0.15	21	50	0.22	200
	Low risk = significantly < TV										
	Potential risk = significantly > TV OR not significantly different from TV										

WAE – Weak-Acid-Extractable

¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM is found to be not statistically significantly different from the TV.

Table 7-10 Risk Assessment – Median sediment quality results at lower river test sites in 2024 compared against LwRivs TVs showing which indicators pose low and potential risk (mg/kg dry weight, whole sediment)

Site	n	Ag - WAE	As - WAE	Cd - WAE	Cr - WAE	Cu - WAE	Hg - WAE	Ni - WAE	Pb - WAE	Se - WAE	Zn - WAE
Bebelubi	8	0.05	2.7	0.13	3.1	5.7	0.01	12	12	0.22 ¹	26
SG4	8	0.05	2.6	0.15	2.8	5.9	0.01	9.2	11	0.22 ¹	24
SG5	14	0.05	2.9	0.19	3.1	11	0.01	10	15	0.19	37
LwRivs Sed TV		1.0	20	1.5	80	65	0.15	24	50	0.26	200
	Low risk = significantly < TV										
	Potential risk = significantly > TV OR not significantly different from TV										

WAE – Weak-Acid-Extractable;

¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM is found to be not statistically significantly different from the TV.

Table 7-11 Risk assessment – median sediment quality results at ORWB test sites in 2024 compared against LMY and ORWB TVs showing which indicators pose low and potential risk (mg/kg dry weight, whole sediment)

Site	n	Ag - WAE	As - WAE	Cd - WAE	Cr - WAE	Cu - WAE	Hg - WAE	Ni - WAE	Pb - WAE	Se - WAE	Zn - WAE
Kukufionga	6	0.05	4.7	0.26	2.4	16	0.01	7.6	19	0.23	48
Zongamange	6	0.06	4.7	0.23	2.3	16	0.01	6.9	21	0.23	46
Avu	6	0.25	5.5	0.26	3.0	19	0.01	7.9	33	0.25 ¹	55
Levame	6	0.06	5.5	0.29	8.6	21	0.01	15 ¹	33	0.23	88
ORWBs Sed TV		1.0	20	1.5	80	65	0.15	24	50	0.26	200
	Low risk = significantly < TV										
	Potential risk = significantly > TV OR not significantly different from TV										

WAE – Weak-Acid-Extractable

Table 7-12 Sediment quality trends at upper river reference and test sites 2015-2024 (mg/kg dry weight, whole sediment)

Site	Ag - WAE	As - WAE	Cd - WAE	Cr - WAE	Cu - WAE	Hg - WAE	Ni - WAE	Pb - WAE	Se - WAE	Zn - WAE
SG2										
Wasiba										
Wankipe										
SG3										
	No change or reduced over time									
	Increased over time									

WAE – Weak-Acid-Extractable

Table 7-13 Comparison of trends of sediment quality at lower river reference and test sites 2015-2024 (mg/kg dry weight, whole sediment)

Site	Ag - WAE	As - WAE	Cd - WAE	Cr - WAE	Cu - WAE	Hg - WAE	Ni - WAE	Pb - WAE	Se - WAE	Zn - WAE
Bebelubi										
SG4										
SG5										
	No change or reduced over time									
	Increased over time									

WAE – Weak-Acid-Extractable

Table 7-14 Sediment quality trends at Lake Murray and ORWB reference and test sites 2015-2024 (mg/kg dry weight, whole sediment)

Site	Ag - WAE	As - WAE	Cd - WAE	Cr - WAE	Cu - WAE	Hg - WAE	Ni - WAE	Pb - WAE	Se - WAE	Zn - WAE
Kukufionga										
Zongamange										
Avu										
Levame										
	No change or reduced over time									
	Increased over time									

WAE - Weak-Acid-Extractable

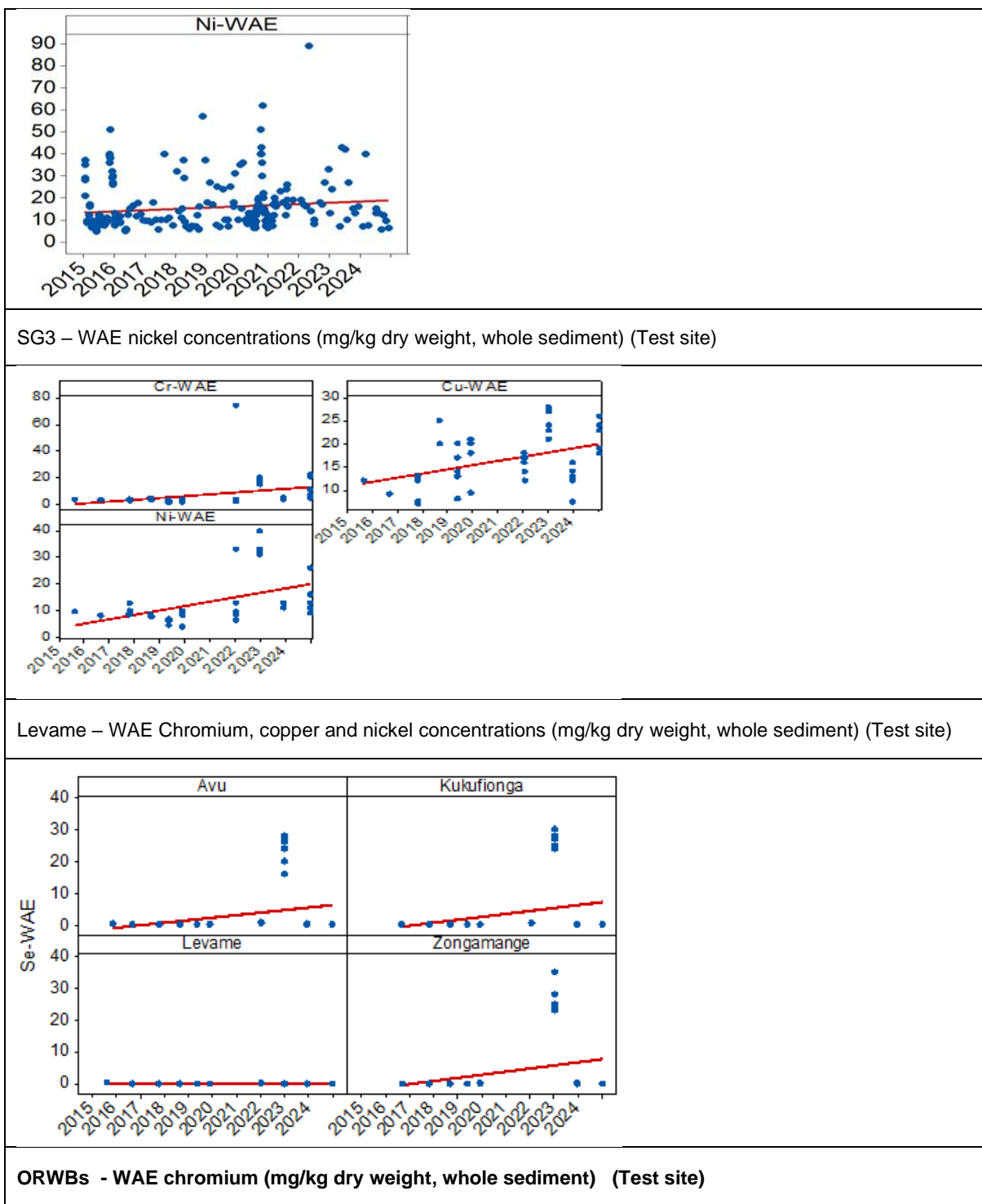


Figure 7-17 Trend analysis upper river, lower river and ORWB test site sediment quality showing statistically significant increasing trends in (mg/kg dry weight, whole sediment) (scatter plot of all data from 2015 – 2024 with linear trend line)

7.4.2.2 Lake Murray

The results of the risk assessment for WAE metals concentrations in sediment at Lake Murray test sites are presented in Table 7-15. The risk assessment shows that the 2024 TSM for all other metals at all sites were below their respective TVs except WAE selenium at Central where the TSM was not statistically significantly different from the TV.

Analysis of trends of benthic sediment quality at Lake Murray test sites is presented in Table 7-16 and showed that for all sites WAE selenium and for Southern Lake WAE silver, WAE nickel displayed statistically significant increasing trends between 2015 and 2024.

Detailed results of the statistical analysis are shown in Appendix E, Tables E-16 to E-18 and figures showing comparisons of the historical data against the TVs are shown in Appendix E, Figures E-33 to E-42. Details of the statistical analysis are shown in Appendix E, Table E-19.

Table 7-15 Risk assessment – median sediment quality results at Lake Murray test sites in 2024 compared against LMY and ORWB TVs showing which indicators pose low and potential risk (mg/kg dry weight, whole sediment)

Site	n	Ag - WAE	As - WAE	Cd - WAE	Cr - WAE	Cu - WAE	Hg - WAE	Ni - WAE	Pb - WAE	Se - WAE	Zn - WAE
Central Lake	10	0.06	2.7	0.11	5.1	14	0.01	11	14	0.32 ¹	48
Southern Lake	11	0.22	4.2	0.19	3.7	15	0.01	10	29	0.27	56
SG6	6	0.06	5.2	0.15	3.2	18	0.01	8.5	19	0.24	33
Lake Murray Sed TV		1.0	20	1.5	80	65	0.15	21	50	0.33	200
	Low risk = significantly < TV										
	Potential risk = significantly > TV OR not significantly different from TV										

WAE – Weak-Acid-Extractable

¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM is found to be not statistically significantly different from the TV.

Table 7-16 Sediment quality trends at Lake Murray and ORWB reference and test sites 2015-2024 (mg/kg dry weight, whole sediment)

Site	Ag - WAE	As - WAE	Cd - WAE	Cr - WAE	Cu - WAE	Hg - WAE	Ni - WAE	Pb - WAE	Se - WAE	Zn - WAE
Central Lake										
Southern Lake										
SG6										
	No change or reduced over time									
	Increased over time									

WAE - Weak-Acid-Extractable

7.4.3 Tissue metals

7.4.3.1 Upper and Lower Rivers

The results of the tissue metal risk assessment for the upper and lower rivers are shown in Table 7-17 and Table 7-18 respectively.

The assessment showed that at Wasiba in the upper river the 2024 TSMs for lead and selenium in prawn abdomen were greater than the TVs and the 2024 TSMs for chromium and zinc assigned as ‘potential risk’ but were not significantly different from the TVs. At Wankipe, the 2024 TSMs for chromium in prawn abdomen were greater than the respective TVs while the 2024 TSMs for arsenic, lead and selenium were assigned as ‘potential risk’ but were not significantly different from the TVs. The 2024 TSMs for all metals in fish tissue were less than the respective TVs Upper Rivers.

The 2024 TSMs for all metals in prawn abdomens and fish tissues at Lower Rivers were less than the respective TVs.

A summary of results from trend analysis performed for the upper and lower rivers is presented in Table 7-19 and Table 7-20. The results showed that in the upper river, concentrations of mercury in prawn abdomen at Wasiba showed a statistically significant increasing trend between 2015 and 2024. At

Wankipe copper in fish tissue, chromium and mercury in prawn abdomen showed a statistically significant increasing trend between 2015 and 2024.

In the lower river, concentrations of arsenic and nickel in fish tissue and chromium in prawn abdomen at Bebelubi showed a statistically significant increasing trend between 2015 and 2024. Scatter plots with linear trend lines for metals with statistically significant increasing trends are shown in Figure 7-18.

Detailed results of the statistical analysis are shown in Appendix F, Tables F-2 to F-5, comparisons of the historical data against the TVs are shown in Appendix F, Figures F-1 to F-36, and detailed results of the statistical analysis are shown in Appendix F, Tables F-7 to F-10.

Table 7-17 Risk assessment – median tissue metal results at upper river test sites in 2024 compared against UpRivs TVs showing which indicators pose low and potential risk (µg/g wet wt.)

Site	Sample	n	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Wasiba	Fish Flesh	12	0.022	0.003	0.01	0.21	0.046	0.01	0.01	0.31	4.0
	Prawn Ab	12	0.031	0.003	0.017 ¹	4.7	0.01	0.01	0.012	0.47	15 ¹
Wankipe	Fish Flesh	12	0.015	0.003	0.01	0.25	0.037	0.01	0.01	0.23	4.5
	Prawn Ab	12	0.030 ¹	0.003	0.029	4.1	0.01	0.01	0.010 ¹	0.36 ¹	13
UpRivs TV	Fish Flesh		0.200	0.020	0.010	0.48	0.08	0.10	0.17	2.26	10.4
	Prawn Ab		0.033	0.003	0.026	6.8	0.01	0.01	0.01	0.37	16
	Low risk = significantly < TV										
	Potential risk = significantly > TV OR not significantly different from TV										

¹ Although TSM is equal to or less than the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM was found to be not statistically significantly different from the TV.

Ab – Abdomen

Table 7-18 Risk assessment – median tissue metal results at lower river test sites in 2024 compared against LwRivs TVs showing which indicators pose low and potential risk (µg/g wet wt.)

Site	Sample	n	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Bebelubi	Fish Flesh	12	0.011	0.003	0.01	0.097	0.10	0.01	0.01	0.16	2.6
	Prawn Ab	12	0.064	0.003	0.024	6.6	0.01	0.01	0.01	0.23	12
SG4	Fish Flesh	12	0.01	0.003	0.01	0.094	0.067	0.01	0.01	0.16	4.1
	Prawn Ab	12	0.057	0.003	0.020	4.5	0.01	0.010	0.010	0.25	11
LwRivs TV	Fish Flesh		0.071	0.003	0.03	0.17	0.12	0.165	0.03	2.26	7.5
	Prawn Abdo		0.085	0.005	0.05	12	0.01	0.01	0.01	0.32	14
	Low risk = significantly < TV										
	Potential risk = significantly > TV OR not significantly different from TV										

¹ Although TSM is equal to or less than the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM was found to be not statistically significantly different from the TV.

Ab – Abdomen

Table 7-19 Tissue metal trends at upper river ref and test sites 2015 - 2024

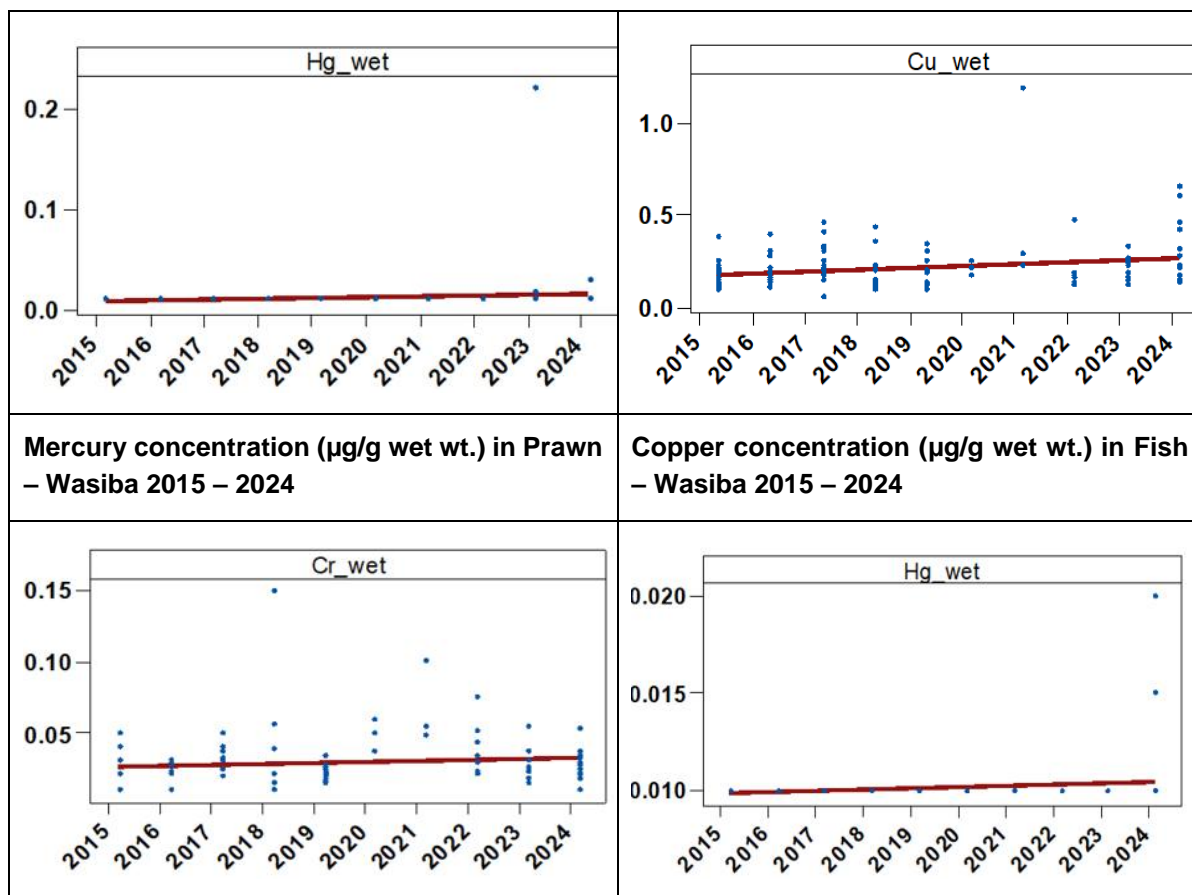
Site	Sample	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Wasiba	Fish Flesh									
	Prawn Ab									
Wankipe	Fish Flesh									
	Prawn Ab									
		No change or reduced over time								
		Increased over time								

Ab – Abdomen

Table 7-20 Tissue metal trends at lower river ref and test sites 2015–2024

Site	Sample	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Bebelubi	Fish Flesh									
	Prawn Ab									
SG4	Fish Flesh									
	Prawn Ab									
		No change or reduced over time								
		Increased over time								

Ab – Abdomen



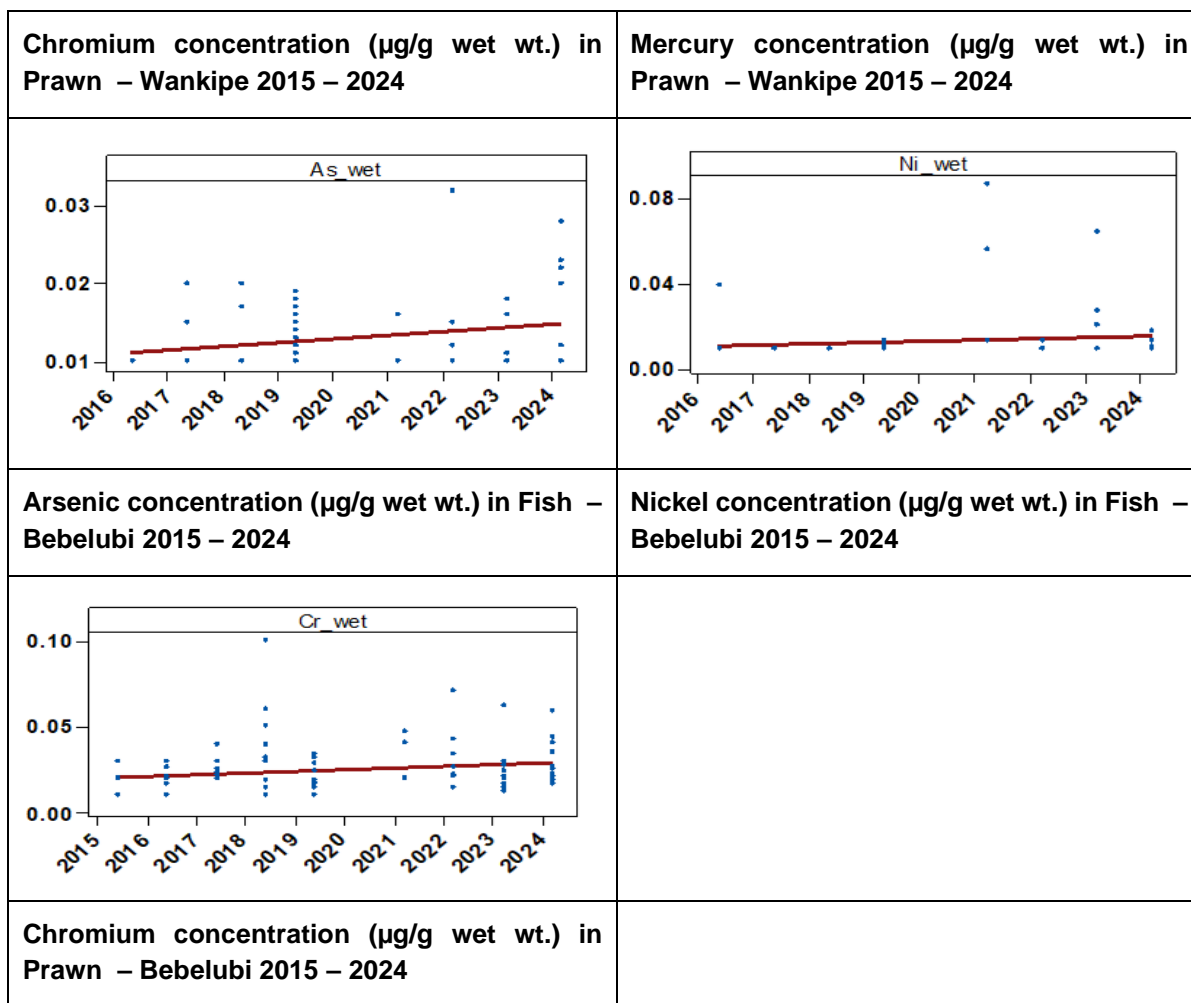


Figure 7-18 Trend analysis of statistically significant increasing trends in tissue metal at upper river and lower river test sites 2015 – 2024.

7.4.3.2 Lake Murray

The results of the tissue metal risk assessment for Lake Murray are shown in Table 7-21. The assessment showed that the 2024 TSM for mercury in fish flesh at Pangoa was assigned as ‘potential risk’ but was not significantly different from the TV. At Miwa 2024 TSM for mercury and zinc in fish flesh were greater than the respective TVs. The 2024 TSM for all other metals in fish flesh were below the TVs.

A summary of results from trend analysis performed for Lake Murray sites is presented in Table 7-22. The results showed that the concentration of arsenic in fish flesh at Pangoa displayed a statistically significant increasing trend between 2015 and 2024. Scatter plots with linear trend lines for metals with statistically significant increasing trends are shown in Figure 7-19.

Detailed results of the direct comparison are shown in Appendix F, Table F-6 and graphical comparisons of the data against the TVs are shown in Appendix F, Figures F-37 to F-45. and detailed results of the statistical analysis are shown in Appendix F, Table F-11.

Table 7-21 Risk assessment – median tissue metal results at Lake Murray test site in 2024 compared against Lake Murray TVs showing which indicators pose low and potential risk (µg/g wet wt.)

Site	Sample	n	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
C. Lake - Pangoa	Fish Flesh	3	0.064	0.003	0.01	0.09	0.19 ¹	0.01	0.01	0.36	2.5
S. Lake - Miwa	Fish Flesh	3	0.021	0.003	0.01	0.09	0.32	0.01	0.01	0.28	3.2
Lake Murray TV	Fish Flesh		0.065	0.003	0.028	0.203	0.19	0.19	0.071	2.26	3.12
	Low risk = significantly < TV										
	Potential risk = significantly > TV OR not significantly different from TV										

¹ Although TSM is equal to or less than the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM was found to be not statistically significantly different from the TV.

Table 7-22 Tissue metal trends at Lake Murray test sites 2015–2024

Site	Sample	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	
Pangoa	Fish Flesh										
Miwa	Fish Flesh										
	No change or reduced over time										
	Increased over time										

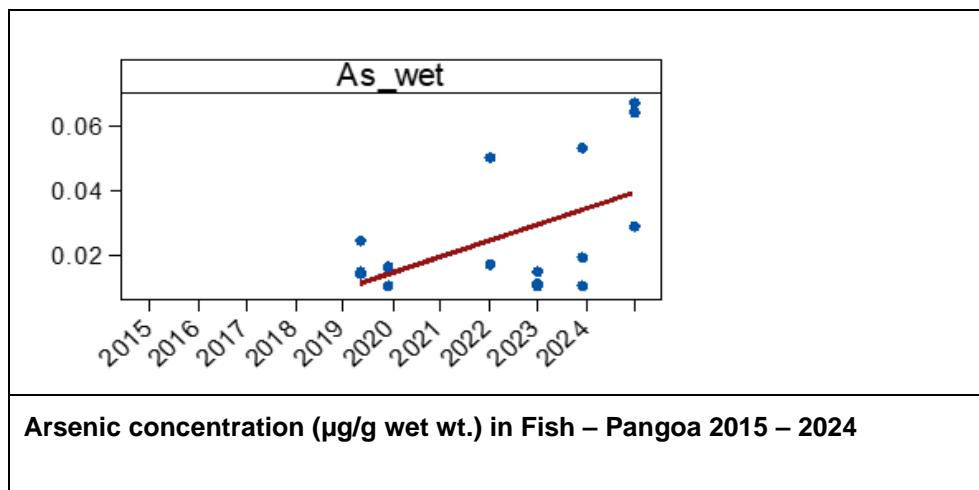


Figure 7-19 Trend analysis of statistically significant increasing trends in tissue metal at Pangoa 2015-2024.

7.4.4 Discussion and Overall Risk Assessment

This section presents a discussion of the individual risk assessments carried out based on water quality, sediment quality and tissue metal concentrations in fish and prawns at test sites downstream of the mine. The discussion is based on a weight of evidence approach which considers the concentration of contaminants of concern in the discharge from the mine, the level of risk posed by each individual element in water, sediment and tissue at each site and concludes with an overall assessment of risk. This process is intended to identify those contaminants of concern which are deemed to pose a material potential risk to the receiving environment.

Where further assessment supports the result of the initial risk assessment, that result is maintained, however, in some cases, this process has resulted in a change of the initial risk assessment result from potential risk to low risk. The final risk assessment results have been categorised in accordance with the criteria outlined in Table 7-23.

Table 7-30 to Table 7-32 provide a compilation of final risk assessment results for each physical and chemical toxicant in water, sediment, fish tissue and prawn abdomen, for the purposes of comparison throughout the receiving environment and between matrices.

Table 7-23 Initial and final risk assessment criteria

Key	Initial Risk Assessment Result	Final risk assessment result
	Low risk	Low risk
	Potential risk	Low risk
	Potential risk	Potential risk

As a general finding, it should be noted that the concentrations of all metals and metalloids within prawn and fish tissues at all sites within the upper and lower rivers were below applicable food standards and therefore do not pose a risk to human health from these contaminants if consumed. A comparison against food standards is provided in Section 7.7.

7.4.4.1 pH

Lime Plant was flagged as a potential risk for pH, (median pH; 10.8). The pH of all other discharges from the mine was within the upper and lower bounds of the TV for the upper rivers and posed low risk or impact to the receiving environment.

Rainfall runoff discharged from the lime plant exhibited elevated pH as a result of contact with limestone. The discharge flow rate is relatively low compared to flows within the receiving environment, which also exhibit alkaline conditions due to the naturally occurring limestone geology in the contributing catchment.

The risk posed by elevated pH in discharge from the lime plant is localised, being restricted to the area immediately downstream of the discharge point.

Within the receiving environment downstream of the Porgera River at all sites, the pH was within upper and lower bounds of the respective TVs, indicating low risk to the condition of the receiving environment.

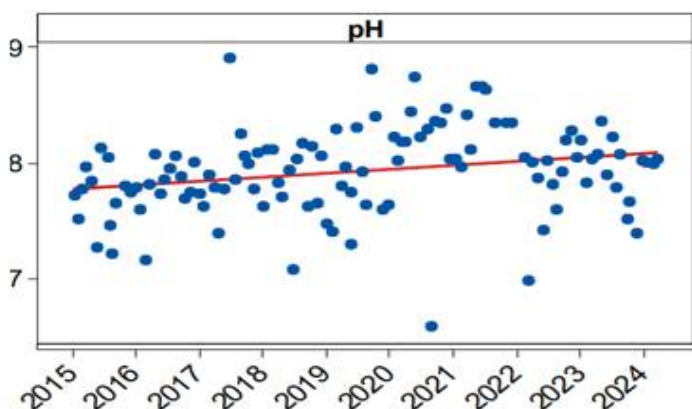


Figure 7-20 Scatter plot showing pH at Kogai Culvert between 2015 and 2024

7.4.4.2 Total Suspended Solids

Tailings ex-pipe and water discharged from Yakatabari creek D/S 28 level and Yunarilama/Yarik at Portal exhibited median TSS concentrations in 2024 which exceeded the upper river TV and therefore posed a potential risk to the receiving environment.

Within the receiving environment, the concentrations of TSS at all sites within the upper river downstream of the Porgera River were below the respective TVs except the TSM for Wankipe was not statistically significantly different from the TV, indicating potential risk.

In the lower river, the 2024 median TSS concentration at Bebelubi and SG4 were above the respective TV, and at SG6, the 2024 median was also above the respective TV indicating potential risk and warranting further investigation. A comparative analysis shows that TSS concentrations at upper river test sites were consistently lower than the respective TV while the TSS concentrations at lower river test sites were higher than the respective TV. The only upstream median concentration that was lower than at Bebelubi was at Wasiba. The river condition at the time of sampling has a significant effect on the TSS concentration, with higher TSS generally measured during high flows. The natural sediment inputs were high during the year due to above average rainfall recorded in the upper catchment sites. It was concluded that the elevated TSS concentrations observed at Bebelubi and SG4 were associated with increased natural sediment loads and not an increase in mine-derived sediment inputs. Potential risk was therefore downgraded to low risk at these sites.

At SG6, the results from the initial risk assessment show that the 2024 median for TSS exceeded the Lake Murray TV, indicating potential risk. The SG6 site is located on the Herbert River which connects the lower Strickland River to Lake Murray, and as a result, water quality at this site is influenced by water flowing from Lake Murray into the Strickland River, as well as by water flowing from the Strickland River into Lake Murray during reverse flow events. Reverse flow events are known to occur when the water level in the Strickland River is higher than in Lake Murray, causing water to flow from the river into the lake via the Herbert River and the Mamboi breakthrough.

TSS and EC results at SG6 in 2024 are indicative of water quality at SG6 being influenced by inflow from the Strickland River. SG6, being located on the Herbert River is also not considered completely analogous with the Lake Murray reference sites, located in the northern section of the lake. The hydrological characteristics of the Herbert River, where it is subjected to higher flow velocities than a lake environment, mean it is subject to higher turbulence and higher TSS concentrations than a large lake. When comparing TSS data at the Northern Lake and with Baia and Tomu lower river reference sites, it can be seen that TSS at SG6 in 2024 was comparable to TSS at Tomu and lower than TSS at Baia. Table 7-24 shows the descriptive statistics for TSS at lower river reference sites Baia and Tomu, Lake Murray reference site Nth Lake and test site SG6 for 2024.

As a result, it is concluded that TSS at SG6 in 2024 was influenced by inflow from the Strickland River during a flow reversal event, that the Northern Lake is not an entirely appropriate reference for SG6 located on the Herbert River, and that TSS at SG6 in 2024 was comparable to TSS at the lower river reference sites Baia and Tomu. Therefore, the initial risk assessment for TSS at SG6 has been adjusted from potential risk to low risk. The change is reflected in Table 7-30.

Table 7-24 TSS Descriptive Statistics 2015 – 2024 at Baia, Tomu, Nth Lake and SG6

Parameter	Site	N	Mean	StDev	Min	Q1	Median	Q3	Max
TSS	Baia	8	331	278	38	87	285	610	780
	Tomu	8	53	54	7.0	16	44	54	180
	Nth Lake	10	5.8	1.8	3.0	4.0	6.0	7.3	8.0
	SG6	6	179	225	13	15	72	395	560

7.4.4.3 *Electrical Conductivity (EC)*

Electrical conductivity (EC) is a measure of waters capability to pass electrical flow, which in turn is directly related to the concentration of ions in the water. Conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfates and carbonate compounds.

EC was elevated (median>TV) at all discharge points from the operation and is driven by elevated concentrations of total dissolved salts primarily; sulfates, calcium, magnesium, sodium and potassium. These ions are present in the natural geology of the Porgera deposit but are concentrated in certain streams due to the mining and processing activities. In the tailings, EC is also driven by high concentrations of calcium sulfate which is formed when sulfate in the tailings steam is combined with calcium hydroxide (slaked lime), which is added to the tailings stream to raise the pH prior to discharge.

Elevated EC in the discharge from the competent waste rock dumps (Wendoko Creek downstream of Anawe Nth and Yakatabari Creek D/S 28 level) is driven by high concentrations of sulfate, generated from the redox reaction occurring within the competent waste rock dumps.

At test sites within the upper river, the 2024 median EC was greater than the TV at SG2 and Wasiba and not significantly different from the TV at Wankipe indicating potential risk. In the lower river the 2024 median EC was not significantly different from the TV at Bebelubi indicating potential risk. In 2024 EC median for all sites at the ORWBs were below the TV, indicating low risk.

In Lake Murray, the 2024 median EC at the Central Lake – Pangoa was initially found to be close to, but not significantly above the TV, indicating a potential risk. However, further analysis shows that the mean EC in the Southern Lake – Miwa, where inflows from the Strickland River (via the Mamboi Breakthrough or Hubert River) first enter the lake system, is lower than the median EC recorded at Central Lake – Pangoa, which lies further into the lake's interior. This indicated natural variation in EC levels within the lake and suggests that the slightly elevated EC at Central Lake – Pangoa is not due to mine contribution. Therefore, the result of the initial risk assessment for EC at Central Lake - Pangoa has been adjusted from potential risk to low risk. The change is reflected in Table 7-30

At SG6, the 2024 median EC was higher than the TV, indicating potential risk. At SG6 however, similar to TSS at SG6, as discussed above in 7.4.4.2, it is concluded that EC at SG6 in 2024 was influenced by inflow from the Strickland River during a flow reversal event, that the Northern Lake is not an entirely appropriate reference for SG6 located on the Herbert River, and that EC at SG6 in 2024 was comparable to EC at the lower river reference sites Baia and Tomu. Table 7-25 shows the descriptive statistics for EC at lower river reference sites Baia and Tomu, Lake Murray reference site Nth Lake and test sites Sth Lake and SG6 for 2024. Therefore, the result of the initial risk assessment for EC at SG6 has been adjusted from potential risk to low risk. The change is reflected in Table 7-30.

Table 7-25 EC Descriptive Statistics 2024 TSS at Baia, Tomu, Nth Lake and SG6

Parameter	Site	N	Mean	StDev	Min	Q1	Median	Q3	Max
EC	Baia	8	125	18	102	113	118	145	154
	Tomu	8	45	16	20	37	42	62	67
	Nth Lake	10	16	2.5	13	14	16	17	22
	SG6	6	38	3.0	35	36	38	41	42

7.4.4.4 *Silver (Ag)*

The median concentrations of dissolved silver in water discharged from all discharge points during 2024 were below the upper river TV, indicating low risk (Table 7-30). Throughout the receiving environment the 2024 median silver concentrations at all test sites indicated low risk.

Median concentrations of WAE silver in tailings and sediments sampled at 28 Level, Yakatabari Creek D/S 28 level and Yunarilama/Yarik at Portal exceeded the upper river TV, indicating potential risk within the mining area. Within the receiving environment downstream of the Porgera River, 2024 median WAE silver concentrations in benthic sediments were below the TVs, indicating low risk (Table 7-31).

Overall, given the low concentrations of silver in water and sediment throughout the receiving environment downstream of the Porgera River, the risk posed by silver to the condition of the receiving environment downstream of the Porgera River in 2024 was designated as low.

7.4.4.5 Arsenic (As)

The 2024 median concentrations of dissolved arsenic in tailings and all contact waters discharged from the mine were below the upper river TV and therefore posed a low risk to the receiving environment. Throughout the receiving environment, the 2024 median concentrations of dissolved arsenic in water were below the TVs and therefore posed a low risk.

In sediment discharged from the operation, the 2024 median concentration of WAE arsenic in tailings exceeded the upper river TV, indicating potential risk. Throughout the receiving environment, the 2024 median WAE arsenic concentrations in sediment were below the TVs and therefore posed a low risk.

The 2024 median concentrations of arsenic in prawn abdomen at Wankipe were not significantly different from the TVs, indicating potential risk. The trends of arsenic in prawn abdomen at each site did not change between 2015 and 2024.

Overall, there is a low risk posed by arsenic in water and sediment throughout the receiving environment while arsenic in prawn abdomen at each site did not change between 2015 and 2024. As a result, the overall risk posed by arsenic in 2024 to the condition of the receiving environment downstream of the Porgera River in 2024 was considered low. Therefore, the results of the initial risk assessment for arsenic in prawn abdomen at Wankipe adjusted from potential risk to low risk, the change is reflected in Table 7-32.

7.4.4.6 Cadmium (Cd)

The 2024 median concentrations of dissolved cadmium in water discharged in tailings and at Wendoko Creek D/S Anawe Nth, Kogai stable dump toe and Yakatabari creek D/S 28 level exceeded the upper river TV, indicating potential risk. The 2024 median concentrations of dissolved cadmium in waters discharged from all other discharge points were below the upper river TV, indicating low risk. In the receiving environment downstream of the Porgera River, dissolved cadmium in water was below the TVs at all test sites, indicating low risk.

The 2024 median concentrations of WAE cadmium in sediment discharged from the operation in tailings and Kogai Stable Dump Toe exceeded the upper river TV, indicating potential risk. The 2024 median concentrations of WAE cadmium at Wendoko creek D/S Anawe Nth, Yakatabari creek D/S 28 level and Yunarilama/Yarik at Portal was not significantly different from the TV. All other sites were below the upper river TV, indicating low risk. In the receiving environment downstream of the Porgera River, WAE cadmium in sediment was below the TVs at all test sites, indicating low risk.

The 2024 median concentration of cadmium in fish flesh and prawn abdomen at all upper river, Lower River and Lake Murray test sites were below the respective TVs, indicating low risk.

Trends for cadmium in water, sediment, fish flesh and prawn abdomen at all test sites and reference sites within the upper river, lower river, ORWBs and Lake Murray either did not change or decreased between 2015 and 2024.

7.4.4.7 Chromium (Cr)

The 2024 median concentration of dissolved chromium in water discharged from the Lime Plant exceeded the upper river TV, indicating potential risk. The 2024 median concentrations of dissolved

chromium in water from all other discharge points were below the upper river TV, indicating low risk. In the receiving environment, the 2024 median concentrations of dissolved chromium in water at all test sites were below the respective TVs, indicating low risk.

The 2024 median concentrations of WAE chromium in sediment discharged from the site were below the upper river TV, indicating low risk. In the receiving environment, the 2024 median concentrations of WAE chromium in sediment at all test sites were below the respective TVs, indicating low risk.

The 2024 median concentrations of chromium in prawn abdomen at upper river test site Wasiba was marginally lower but not significantly different from the TV. Chromium in prawn abdomen at upper test site Wankipe exceeded the TV, indicating risk. The 2024 median concentrations of chromium in fish flesh for all sites and prawn abdomen at all other test sites were below the respective TVs.

Overall, given the low concentrations of chromium in discharge from the site, the low risk indicated by concentrations of dissolved chromium in water and WAE chromium in sediment throughout the receiving environment and that the concentrations of chromium in prawn abdomen at Bebelubi and SG4 sites are below the TV, the risk of chromium to the condition of the receiving environment downstream of the Porgera River in 2024 was considered to be low. As a result, the initial risk assessments for chromium in prawn abdomen at Wasiba and Wankipe have been adjusted from potential risk to low risk, the change is reflected in Table 7-32.

7.4.4.8 Copper (Cu)

The 2024 median concentration of dissolved copper in water discharged in tailings and Yakatabari creek were higher than, or not significantly different from the upper river TV, while at 28 level, Kogai Culvert, Kogai stable dump toe, Lime Plant, Wendoko creek D/S Anawe Nth, Yunarilama/Yarik portal the median concentrations of dissolved copper were below the upper river TV, indicating low risk (Table 7-33).

In the receiving environment, the 2024 median concentrations of dissolved copper in water at upper river test site SG2 was not significantly different from the TV, indicating potential risk. It should be noted that Angel et al (2019, 2017) showed that a significant portion of dissolved copper is not Chelex labile indicating low bioavailability/toxicity. Therefore, while the result of the initial risk assessment is maintained, it should be considered conservative and is likely to overestimate the actual risk posed by copper in water.

The 2024 median concentration of WAE copper in discharged tailings exceeded the upper river TV, indicating potential risk. Within the receiving environment, the 2024 median concentrations of WAE copper in sediment at all test sites within the upper river, lower river, ORWBs and Lake Murray were below the respective TVs, indicating low risk.

The risk assessment for tissue metal indicated that the 2024 median concentration in fish flesh and prawn abdomen at all test sites within the upper river, lower river and Lake Murray were below the TVs, indicating low risk.

Given that 2024 median dissolved copper for SG2 was less than, but not significantly different from the TV, and there is low risk posed by copper at the other river sites, and in sediment, fish flesh and prawn abdomen, the overall risk posed by copper is low. As a result, the initial risk assessments for dissolved copper in water at SG2 has been revised from potential risk to low risk, the change is reflected in Table 7-30.

7.4.4.9 Mercury (Hg)

The 2024 median concentrations of mercury in water discharged from all sites were below the upper river TV, indicating low risk. Similarly, at all test sites within the upper river, lower river, ORWBs and Lake Murray, the 2024 median concentrations of dissolved mercury in water were below the respective TVs, indicating low risk.

The 2024 median concentrations of WAE mercury in sediments from all discharge sites were below the respective TVs, indicating low risk. Within the receiving environment, the 2024 median concentrations of WAE mercury in sediment at all test sites within the upper river, lower river, ORWBs and Lake Murray were below the respective TVs, indicating low risk.

The median concentration of mercury in fish tissue at Central Lake was equal to the TV while median concentration of mercury in fish tissue at Southern Lake (0.32 µg/g) exceeded the respective TV of (0.19 µg/g), indicating potential risk. It should be noted that mercury bioaccumulation in Lake Murray is a historical issue which pre-dates the development of the Porgera mine. Monitoring data does not indicate an increase in mercury concentrations in fish tissues over the last 5 years which could be associated with mine-related activities. The 2024 median concentrations of mercury in prawn abdomen and fish tissue at all other test sites within the upper river, lower river, ORWBs and Lake Murray were below the respective TVs, indicating low risk.

Overall, given the low risk posed by mercury in water, sediment, fish flesh and prawn abdomen at all test sites, the risk posed by mercury is low. Therefore, the mercury in fish tissue at lake Murray is downgraded to low.

7.4.4.10 Nickel (Ni)

The 2024 median concentration of dissolved nickel in water discharged in tailings exceeded upper river TV, indicating potential risk. In the receiving environment, the 2024 median concentrations of dissolved nickel in water at all test sites within the upper river, lower river, ORWBs and Lake Murray, were below the respective TVs, indicating low risk.

The 2024 median concentrations of WAE nickel in sediments from all discharge sites were below the respective TVs, indicating low risk. Within the receiving environment, WAE nickel concentrations in sediment at all test sites except for Levame were below the respective TVs, indicating low risk. At Levame, the median WAE nickel concentration was below the TV but not significantly different from the respective TVs indicating potential risk.

The 2024 median concentrations of nickel in fish flesh and prawn abdomen at all test sites within the upper river, lower river and Lake Murray were below the TVs, indicating low risk.

Overall, given the only indicator of potential risk from nickel in WAE sediment Levame was less than, but not significantly different from the TVs, the overall risk posed by nickel in the receiving environment is considered to be low. Therefore, the results of the initial risk assessment for WAE nickel in sediment at Levame have been revised from potential risk to low risk, the change is reflected in Table 7-32.

7.4.4.11 Lead (Pb)

The 2024 median concentrations of dissolved lead in water from all discharge sites were below the upper river TV, indicating low risk. Similarly in the receiving environment, at all test sites within the upper river, lower river, ORWBs and Lake Murray, the 2024 median concentrations of dissolved lead in water were below the respective TVs, indicating low risk.

Sediment from all discharge points except the lime plant, exhibited median concentrations of WAE lead in 2024 that exceeded the upper river TV, indicating potential risk. Within the receiving environment in the upper rivers the 2024 median concentration of WAE lead in sediment at SG2 was lower than but not significantly different from the TV, indicating potential risk. The 2024 median concentrations of WAE lead in sediment at all other test sites within the upper river, lower river, ORWBs and Lake Murray were below the respective TVs, indicating low risk.

The results of the risk assessment performed on prawn abdomen showed that the 2024 median concentrations of lead in prawn abdomen at Wasiba was higher than the TV and at Wankipe equal to the TV, indicating potential risk at both sites. All other results showed the 2024 median concentrations of lead in prawn abdomen and fish flesh in the upper river, lower river and Lake Murray were below the TVs, indicating low risk.

Overall, given that the concentrations of lead in sediment at SG2 were lower but not significantly different from the TV, and for prawn abdomen were equal to the TV at Wankipe and higher than the TV at Wasiba, lead is considered to pose a potential risk to the environmental condition within the upper river between the mine and Wankipe. Downstream of Wankipe in the upper river and in the lower river, ORWBs and Lake Murray, lead in water, sediment, prawn abdomen and fish flesh, was considered to be low.

7.4.4.12 Selenium (Se)

The 2024 median concentrations of dissolved selenium in water from all discharge sites were below the upper river TV, indicating low risk. Similarly in the receiving environment, at all test sites within the upper river, lower river, ORWBs and Lake Murray, the 2024 median concentrations of dissolved selenium in water were below the respective TVs, indicating low risk.

In sediment discharged in tailings and from Kogai Culvert and Wendoko Creek D/S Anawe Nth, median concentrations of WAE selenium either exceeded the upper rivers TV or the median was not significantly different from the TV, indicating potential risk. The 2024 median WAE selenium values for sediments within the receiving environment at SG2, Bebelubi, SG4, Avu and Central Lake were not significantly different from the TV, indicating potential risk.

The 2024 median concentration of selenium in prawn abdomen at upper river test site Wasiba was higher than the TV and prawn abdomen at Wankipe were not significantly different from the TV, indicating potential risk. In fish flesh at Wasiba and Wankipe, the 2024 median concentrations of selenium were below the TVs, indicating low risk. In the lower river and lake Murray, the selenium concentration for prawn abdomen and fish flesh were lower than the TV, indicating low risk.

Further review of WAE selenium in sediment shows that the range of WAE selenium concentrations in sediment at the upper river test sites are comparable to those at the reference sites. The maximum concentration at the reference sites in 2024 was 0.28 mg/kg, compared to a maximum at SG2 of 0.26 mg/kg, Wasiba 0.27 mg/kg, Wankipe 0.27 mg/kg and SG3 0.26 mg/kg. Descriptive statistics for WAE selenium in sediment at the upper river reference and test sites are shown in

Table 7-26. These results indicate while discharge from the mine does contribute low concentrations of WAE selenium in sediment to the system, there are also natural contributions of low concentrations of WAE selenium in sediment from the reference sites.

In the lower river, the ranges of concentrations of WAE selenium in sediment at the test sites are comparable to those at the lower river reference sites. Most of the WAE selenium concentration of the test sites are lower than the maximum concentration at the reference site. It is likely that selenium from the lower river reference sites is contributing to the selenium signature at the lower river test sites, along with low concentrations in discharge from the mine. Descriptive statistics for WAE selenium in sediment at the lower river reference and test sites are shown in Table 7-27.

Similarly for selenium in prawn abdomen, the concentrations observed at the upper and lower river test and reference sites are comparable, indicating bioaccumulation from a low natural selenium source throughout the system. Descriptive statistics for selenium in prawn abdomen at the upper and lower river reference and test sites are shown in Table 7-28 and Table 7-29 respectively.

Overall, given the generally low concentrations of selenium in discharge from the mine and the presence of low natural selenium contributions from the reference sites; the risk posed by selenium to the environmental condition within the upper river, lower river, ORWBs and Lake Murray is considered to be low. Therefore, the result of the initial risk assessment for selenium in sediment and prawn abdomen except Wasiba have been revised from potential risk to low risk, the change is reflected in Table 7-30, Table 7-31 and Table 7-32.

Table 7-26 Descriptive Statistics WAE Selenium in Sediment Upper River Reference and Test Sites 2024 (whole sediment mg/kg)

Parameter	Site	N	Mean	StDev	Min	Q1	Median	Q3	Max
Se-WAE Sediment	UpRiv Ref	35	0.16	0.054	0.10	0.11	0.14	0.21	0.28
	SG2	7	0.20	0.047	0.13	0.16	0.19	0.24	0.26
	Wasiba	10	0.18	0.052	0.12	0.13	0.16	0.23	0.27
	Wankipe	12	0.18	0.051	0.12	0.14	0.16	0.22	0.27
	SG3	10	0.16	0.042	0.11	0.14	0.15	0.18	0.26

Table 7-27 Descriptive Statistics WAE Selenium in Sediment Lower River and ORWB Reference and Test Sites 2024 (whole sediment mg/kg)

Parameter	Site	N	Mean	StDev	Min	Q1	Median	Q3	Max
Se-WAE Sediment	LwRiv Ref	8	0.26	0.14	0.12	0.15	0.23	0.40	0.50
	Bebelubi	8	0.26	0.13	0.13	0.15	0.22	0.39	0.47
	SG4	8	0.26	0.15	0.12	0.15	0.22	0.40	0.54
	SG5	14	0.20	0.064	0.13	0.14	0.19	0.25	0.31
	Kukufionga	6	0.23	0.0075	0.22	0.23	0.23	0.24	0.24
	Zongamange	6	0.23	0.019	0.20	0.22	0.23	0.25	0.25
	Avu	6	0.25	0.024	0.23	0.23	0.25	0.27	0.28
	Levame	6	0.23	0.014	0.21	0.21	0.23	0.24	0.24

Table 7-28 Descriptive Statistics Selenium in Prawn Abdomen Upper River Reference and Test Sites 2024 (wet mg/kg)

Parameter	Site	N	Mean	StDev	Min	Q1	Median	Q3	Max
Se Prawn Abdomen	UpRiv Ref	12	0.33	0.058	0.21	0.31	0.33	0.39	0.42
	Wasiba	12	0.49	0.18	0.13	0.40	0.47	0.61	0.81
	Wankipe	12	0.36	0.10	0.13	0.33	0.36	0.43	0.52

Table 7-29 Descriptive Statistics Selenium in Prawn Abdomen Lower River Reference and Test Sites 2024 (wet mg/kg)

Parameter	Site	N	Mean	StDev	Min	Q1	Median	Q3	Max
Se Prawn Abdomen	LwRiv Ref	24	0.22	0.058	0.14	0.17	0.23	0.27	0.32
	Bebelubi	12	0.25	0.074	0.15	0.20	0.23	0.31	0.38
	SG4	12	0.26	0.060	0.14	0.22	0.25	0.31	0.36

7.4.4.13 Zinc (Zn)

The 2024 median concentrations of dissolved zinc in water discharged in tailings and Wendoko Crk D/S Anawe Nth were greater than the upper river TV, and in water from Kogai stable dump toe and 28 Level the 2024 median concentration of dissolved zinc was not significantly different from the upper river TV, indicating potential risk. In the receiving environment, all the test sites within the upper river, lower river, ORWBs and Lake Murray, the 2024 median concentration of dissolved zinc in water was below the respective TVs, indicating low risk.

In sediment discharged in tailings and from 28 Level, Kogai Stable Dump Toe and Yakatabari Crk D/S 28 Level, the 2024 median concentrations of WAE zinc were greater than the upper river TV, indicating potential risk. At all test sites in the upper river, lower river, ORWBs and Lake Murray, the 2024 median concentrations of WAE zinc were below the respective TVs, indicating low risk.

Zinc concentrations in prawn abdomen at upper river test site Wasiba was not significantly different from the respective TV, indicating potential risk. Zinc concentration in fish tissue at Lake Murray test site Southern Lake (Miwa) were higher than the TV, indicating potential risk.

The 2024 median concentrations of zinc in prawn abdomen were not significantly different from the TV at Wasiba. Additionally, the concentrations of zinc in fish and prawns did not change between 2015 and 2024 and in the absence of potential risk for water, sediment or fish tissue at these sites, the overall risk posed by zinc in 2024 is considered low. Therefore, the results of the initial risk assessment for zinc in prawn abdomen at Wasiba have been revised from potential risk to low risk, the change is reflected in Table 7-32.

All fish tissue and Prawn abdomen for Zinc at lower river test sites were below the respective TV, indicating low risk.

In Lake Murray at test site Miwa, the 2024 median concentration of zinc in fish flesh was higher than the TV, indicating potential risk. All indicators, water, sediment and fish flesh at Pangoa indicated low risk for zinc. Given that the median concentration of zinc in fish flesh at Miwa was calculated from 3 fish tissues (n=3), the result from 2 of the samples were lower than the TV while one had a high spike of 4.8 mg/kg which exceeded the TV of 3.12 mg/kg. The result was driven by the single high value and there were no other indications of risk associated with zinc in Lake Murray, the overall risk posed by zinc to the environmental condition of Lake Murray is considered to be low. Therefore, the result of the initial risk assessment for zinc in fish tissue at Miwa has been revised from potential risk to low risk, the change is reflected in Table 7-32 respectively.

7.4.5 Metals speciation and toxicity

Elevated concentrations of copper, lead and zinc in tailings and in drainage from the waste rock dumps resulted in concentrations of these metals that exceeded the TVs and presented potential risk to the aquatic ecosystem in the Porgera River and in the upper reaches of the Lagaip River. The risk assessment is based on dissolved metal concentrations in water, which best reflect the bioavailable metal concentrations that pose a risk of toxicity to aquatic organisms.

However, it is well known that dissolved metals as a direct exposure medium over-estimate bioavailability and potential toxicity. In order to understand the potential toxicity of the metals and risk to the ecosystem, in 2017 NPL commissioned CSIRO to undertake a study (Angel et al. 2018) to determine metal bioavailability by measuring the speciation of dissolved metals and applying highly sensitive bioassays which respond only to the bioavailable forms of metals. The study was repeated in 2019 (Angel et al. 2020) to again determine metal bioavailability by measuring the speciation of dissolved metals, the 2019 study did not include the use of sensitive bioassays.

The 2017 and 2019 study determined the concentrations of Chelex-labile Cd, Cu, Ni, Pb and Zn as a measure of the bioavailable form of these metals available for uptake by organisms from the dissolved phase, and the 2017 study also assessed metal toxicity to sensitive bacteria and algal species using bioassay techniques developed by CSIRO. The study design in 2017 and 2019 was based on the

environmental monitoring sites of NPL. Water samples were collected from thirteen sites comprising mine site tailings, mine drainage waters, test sites and reference sites of the upper and lower sections of the Lagaip/Strickland River system.

The key findings of the 2017 and 2019 studies were:

- The concentrations of dissolved metals in mine site waters and the river system generally were in the same range as those measured previously (Angel et al., 2015; 2017 and 2020) and in the NPL monitoring program, where concentrations decrease rapidly downstream of the mine.
- In the mine waters, cadmium, copper, nickel and zinc were generally mostly present in Chelex-labile (bioavailable) forms.
- For the Lagaip and Strickland River sites in 2019, there were no metal concentrations that exceeded ANZGV (2018) default guideline values for 95% species protection.
- In the river water samples, a significant component of dissolved cadmium, nickel and copper was present as non-labile species (non-bioavailable), however, dissolved zinc was present mainly in a Chelex-labile (bioavailable) form. It may be possible that some complexation of zinc by natural organic matter occurs but this is not detected by the Chelex column method, and requires investigation using other less-aggressive speciation methods.
- Metal-related inhibition of bacterial respiration was observed only at SG2 and Wasiba. (Angel et al., 2017)
- Significant stimulation of bacterial respiration was observed in samples from SG3 and SG4. The cause of the observed respiratory stimulation is yet to be identified. (Angel et al., 2017)
- The only samples showing small (10% or lower) but significant algal growth bioassay inhibition were from Upper Lagaip, Baia, and Ok Om, which are reference sites that do not receive mine-related inputs. Further work is required to identify the causes of growth inhibition in these samples. (Angel et al., 2017)

Table 7-30 Summary of mine discharge water quality compared against respective TVs and receiving environment water quality risk assessment results, showing indicators in discharge and test sites that pose potential risk to the receiving environment in 2024 (µg/L except where indicated)

Region	Site	WATER												
		pH [^]	TSS [*]	EC [#]	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D
Discharge	Tailings	6.9	105,000	1,657	0.01	2.3	2.5	0.10	2.5	0.05	104	0.35	0.79	1,035
	28 Level	7.7	36	633	0.01	1.5	0.05	0.10	0.25	0.05	2.5	0.12	0.20	7.6 ¹
	SDA Toe	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Kaiya Riv D/S Anj Dump	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Kogai Culvert	8.0	370	551	0.01	1.0	0.08	0.10	0.90	0.05	0.68	0.47	0.20	6.7
	Kogai Stable Dump Toe	7.8	67	1,370	0.01	0.59	0.71	0.10	0.58	0.05	1.4	0.22	0.20	101
	Lime Plant	10.8	113	378	0.01	0.13	0.05	2.8	0.81	0.05	0.50	0.10	0.20	1.1
	Wendoko Creek D/S Anawe Nth	7.8	18	1,805	0.01	1.1	1.1	0.10	0.56	0.05	1.2	0.17	0.38	310
	Yakatabari Creek D/S 28 Level	7.5	6,350	593	0.01	12	0.05 ¹	0.10	1.0 ¹	0.05	1.5	0.60	0.28	5.1
	Yunarilama/Yarik @ Portal	7.6	6,750	1,907	0.01	2.5	0.05	0.10	0.47	0.05	1.9	0.21	1.0	5.0
Upper River	SG1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	SG2	7.8	1450	301	0.01	1.2	0.08	0.14	1.3 ¹	0.05	0.75	0.10	0.20	4.8
	Wasiba	7.8	940	256	0.01	0.97	0.05	0.39	0.59	0.05	0.56	0.10	0.27	0.95
	Wankipe	7.8	2,300 ¹	228 ¹	0.01	1.2	0.05	0.15	0.81	0.05	0.50	0.10	0.21	1.9
	SG3	7.9	2,100	215	0.01	1.0	0.05	0.15	0.96	0.05	0.50	0.10	0.20	1.8
Lower River	Bebelubi	7.9	1,450	175 ¹	0.01	0.75	0.05	0.16	0.86	0.05	0.62	0.10	0.20	1.1
	SG4	7.9	1,045	159	0.01	0.77	0.05	0.16	0.89	0.05	0.50	0.10	0.20	1.3
	SG5	7.9	340	158	0.01	0.75	0.05	0.10	0.95	0.05	0.50	0.10	0.20	0.65
ORWBs	Kukufionga	8.0	24	207	0.01	1.8	0.05	0.10	0.47	0.05	0.50	0.10	0.20	2.5
	Zongamange	7.2	8.5	131	0.01	0.94	0.05	0.10	0.57	0.05	0.50	0.10	0.20	4.1
	Avu	7.2	9.0	49	0.01	0.81	0.05	0.34	0.32	0.05	0.63	0.10	0.20	1.9
	Levame	7.9	73	178	0.01	0.92	0.05	0.10	1.2	0.05	0.50	0.10	0.20	1.1
Lake Murray	Central Lake - Pangoa	6.8	5.5	16 ¹	0.01	0.14	0.05	0.12	0.38	0.05	0.50	0.10	0.20	2.6
	Southern Lake - Miwa	6.9	2.5	14	0.01	0.21	0.05	0.10	0.40	0.05	0.50	0.10	0.20	0.66
	SG6	7.3	72	38	0.01	0.52	0.05	0.10	0.86	0.05	0.50	0.10	0.20	0.70
	Low Risk		Low Risk - Initial assessment showed potential risk – downgraded to low risk after further investigation										Potential Risk	

[^] std units, ^{*} mg/L, [#] µS/cm, D = Dissolved fraction, ¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM was not statistically significantly different from the TV.

Table 7-31 Summary of mine discharge sediment quality compared against respective TVs and receiving environment sediment quality risk assessment results, showing indicators in discharge and test sites that pose low and potential risk to the receiving environment in 2024 (mg/kg dry weight, whole fraction)

Region	Site	SEDIMENT										
		Ag - WAE	As - WAE	Cd - WAE	Cr - WAE	Cu - WAE	Hg - WAE	Ni - WAE	Pb - WAE	Se - WAE	Zn - WAE	
Discharge	Tailings	1.6	42	4.4	29	84	0.04	19	160	0.31	635	
	28 Level	1.4	16	0.94	8.8	22	0.01	11	150	0.15	400	
	SDA Toe	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
	Kaiya Riv D/S Anj Dump	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
	Kogai Culvert	0.50	7.7	0.76	3.1	7.5	0.01	4.3	130	0.22 ¹	145	
	Kogai Stable Dump Toe	0.67	16	2.0	3.2	9.9	0.01	4.6	200	0.20	290	
	Lime Plant	0.09	1.2	0.37	11	4.2	0.01	3.1	8.7	0.13	43	
	Wendoko Creek D/S Anawe Nth	0.24	4.9	1.5 ¹	1.4	5.1	0.01	3.5	59	0.23	150	
	Yakatabari Creek D/S 28 Level	2.1	14	1.5 ¹	4.6	16	0.01	8.0	150	0.17	265	
	Yunartilama/Yarik @ Portal	1.2	12	1.1 ¹	5.4	12	0.04	8.6	125	0.18	178	
Upper River	SG1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
	SG2	0.07	5.0	0.45	2.1	9.8	0.01	4.4	48 ¹	0.19 ¹	72	
	Wasiba	0.05	3.4	0.22	1.7	8.2	0.01	8.3	28	0.16	39	
	Wankipe	0.05	3.4	0.21	1.6	6.9	0.01	7.5	24	0.16	37	
	SG3	0.05	2.7	0.10	1.9	6.9	0.01	11	13	0.15	22	
Lower River	Bebelubi	0.05	2.7	0.13	3.1	5.7	0.01	12	12	0.22 ¹	26	
	SG4	0.05	2.6	0.15	2.8	5.9	0.01	9.2	11	0.22 ¹	24	
	SG5	0.05	2.9	0.19	3.1	11	0.01	10	15	0.19	37	
ORWBs	Kukufionga	0.05	4.7	0.26	2.4	16	0.01	7.6	19	0.23	48	
	Zongamange	0.06	4.7	0.23	2.3	16	0.01	6.9	21	0.23	46	
	Avu	0.25	5.5	0.26	3.0	19	0.01	7.9	33	0.25 ¹	55	
	Levame	0.06	5.5	0.29	8.6	21	0.01	15 ¹	33	0.23	88	
Lake Murray	Central Lake	0.06	2.7	0.11	5.1	14	0.01	11	14	0.32 ¹	48	
	Southern Lake	0.22	4.2	0.19	3.7	15	0.01	10	29	0.27	56	
	SG6	0.06	5.2	0.15	3.2	18	0.01	8.5	19	0.24	33	
	Low Risk		Low Risk - Initial assessment showed potential risk – downgraded to low risk after further investigation								Potential Risk	

WAE – Weak acid extraction, ¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM was not statistically significantly different from the TV.

NPL Annual Environment Report 2024

Table 7-32 Summary of receiving environment water quality, sediment quality and tissue metals risk assessment results, showing indicators at test sites that pose low and potential risk to the receiving environment in 2024

Region	Site	Indicator	Unit	WATER, SEDIMENT, TISSUE METAL COMBINED												
				pH [^]	TSS [*]	EC	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Upper River	Wasiba	Water-D	µg/L	7.8	940	256	0.01	0.97	0.05	0.39	0.59	0.05	0.56	0.10	0.27	0.95
		Sed-WAE	mg/kg	-	-	-	0.05	3.4	0.22	1.7	8.2	0.01	8.3	28	0.16	39
		Fish Flesh	µg/g	-	-	-	-	0.022	0.003	0.01	0.21	0.046	0.01	0.01	0.31	4.0
		Prawn Abdo	µg/g	-	-	-	-	0.031	0.003	0.017 ¹	4.7	0.01	0.01	0.012	0.47	15 ¹
	Wankipe	Water-D	µg/L	7.8	2,300 ¹	228 ¹	0.01	1.2	0.05	0.15	0.81	0.05	0.50	0.10	0.21	1.9
		Sed-WAE	mg/kg	-	-	-	0.05	3.4	0.21	1.6	6.9	0.01	7.5	24	0.16	37
		Fish Flesh	µg/g	-	-	-	-	0.015	0.003	0.01	0.25	0.037	0.01	0.01	0.23	4.5
		Prawn Abdo	µg/g	-	-	-	-	0.030 ¹	0.003	0.029	4.1	0.01	0.01	0.010 ¹	0.36 ¹	13
Lower River	Bebelubi	Water-D	µg/L	7.9	1,450	175	0.01	0.75	0.05	0.16	0.86	0.05	0.62	0.10	0.20	1.1
		Sed-WAE	mg/kg	-	-	-	0.05	2.7	0.13	3.1	5.7	0.01	12	12	0.22 ¹	26
		Fish Flesh	µg/g	-	-	-	-	0.011	0.003	0.01	0.097	0.10	0.01	0.01	0.16	2.6
		Prawn Abdo	µg/g	-	-	-	-	0.064	0.003	0.024	6.6	0.01	0.01	0.01	0.23	12
	SG4	Water-D	µg/L	7.9	1,045	159	0.01	0.77	0.05	0.16	0.89	0.05	0.50	0.10	0.20	1.3
		Sed-WAE	mg/kg	-	-	-	0.05	2.6	0.15	2.8	5.9	0.01	9.2	11	0.22 ¹	24
		Fish Flesh	µg/g	-	-	-	-	0.01	0.003	0.01	0.094	0.067	0.01	0.01	0.16	4.1
		Prawn Abdo	µg/g	-	-	-	-	0.057	0.003	0.020	4.5	0.01	0.010	0.010	0.25	11
Lake Murray	C. Lake - Pangoa	Water-D	µg/L	6.8	5.5	16 ¹	0.01	0.14	0.05	0.12	0.38	0.05	0.50	0.10	0.20	2.6
		Sed-WAE	mg/kg	-	-	-	0.06	2.7	0.11	5.1	14	0.01	11	14	0.32 ¹	48
		Fish Flesh	µg/g	-	-	-	-	0.064	0.003	0.01	0.09	0.19 ¹	0.01	0.01	0.36	2.5
	S. Lake – Miwa	Water-D	µg/L	6.9	2.5	14	0.01	0.21	0.05	0.10	0.40	0.05	0.50	0.10	0.20	0.66
		Sed-WAE	mg/kg	-	-	-	0.22	4.2	0.19	3.7	15	0.01	10	29	0.27	56
		Fish Flesh	µg/g	-	-	-	-	0.021	0.003	0.01	0.09	0.32	0.01	0.01	0.28	3.2
	Low Risk		Low Risk - Initial assessment showed potential risk – downgraded to low risk after further investigation											Potential Risk		

¹ Although TSM falls below the TV, the 2024 dataset contains some values that do exceed the TV, this increases the standard deviation of the dataset and as a result, the TSM was not statistically significantly different from the TV.

7.5 Local Water Supplies

Participatory sampling of local village water supplies was carried out in July 2024 at Special Mining Lease (SML) and Lease for Mining Purposes (LMP) villages (Yarik, Timorope, Panadaka, Alipis, Pakien Camp, Mungalep and Kulapi). Ongoing security issues and grievances within the Porgera Valley during 2024 prevented the NPL team from safely access villages for sampling. The purpose of the program is to assess the suitability of water from known drinking water sources for domestic use. Apalaka and Yarik villages were not sampled in 2024 due to community issues that prevented the NPL team from sampling.

The sampling was arranged in consultation with the Porgera Landowners Association (PLOA), who assisted to identify the sampling sites and participated in the sample collection. Sampling sites and details are listed in Table 7-33 and locations are shown in Figure 7-21.

Table 7-33 Sampling sites for local village water supplies

Village	Site	Name on map	Easting	Northing
Yarik	Porep Pulawa (Tank)	YR_PP	732651	9397387
	Akope Mare (Tank)	YR-AM	732936	9397395
	Jenny Bolo (Tank)	YR_JB	732922	9397591
	Kapio Kendo (Spring)	YR_KS	732678	9397507
Panadaka	Panadaka 1 Bilip Aile Tank	PA_V1H6	733671	9395507
	Panadaka 2 Timothy Kerene Tank	PA_V2H4	733845	9395780
Alipis	Alipis Village Tank 3	AL_T3	733346	9395775
Kulapi	Kulapi V4 H1 tank	KL_V4H1	732772	9394700
Timorope	Iso Kulina Tank	TI_H2	733221	9397580
	Wari Ekali	TI_H1	733234	9397568
Pakien	Pakien United Church	PA_UC	734407	9397184
Mungalep	Catholic Mission	MG_CC	734407	9397184
	Tawano Pos	MG_TP	735429	9397430

The water quality results are presented in Table 7-34 and Table 7-35 and are compared against the PNG Raw Drinking Water Standard (PNG 1984) and the World Health Organisation (WHO) Guidelines for Drinking Water Quality (WHO 2017).

The pH was below the WHO and PNG drinking water quality guideline lower value at seven sites. It is suspected that the low pH was due to the presence of organic matter in the tanks, such as leaves and sticks, which enter the tanks from the rooftop catchments that feed the tanks. Organic matter breaks down and generates natural tannins (humic and fulvic acid) that will reduce pH in water. All other parameters were within the respective quality guidelines.

Concentrations of dissolved and total metals were below, and therefore compliant with, both the PNG and WHO guidelines.

NPL has implemented a supplementary water project involving the installation of rainwater tanks in villages within the special mining lease (SML) to improve the availability and reliability of safe drinking water for local communities.

Since 2011, 114 water tanks have been installed in more than 85 separate locations, throughout the seven main communities on the SML.

The water is captured from existing catchment structures and piped to a central location which is accessible to the broader community. The water is considered a communal resource and is managed by the Village Water Committee.

The total capacity of all water tanks installed under this program to date is 550,000 litres. NPL will continue to work with relevant communities on an ongoing basis to determine where the installation of further supplemental water supplies may be required.

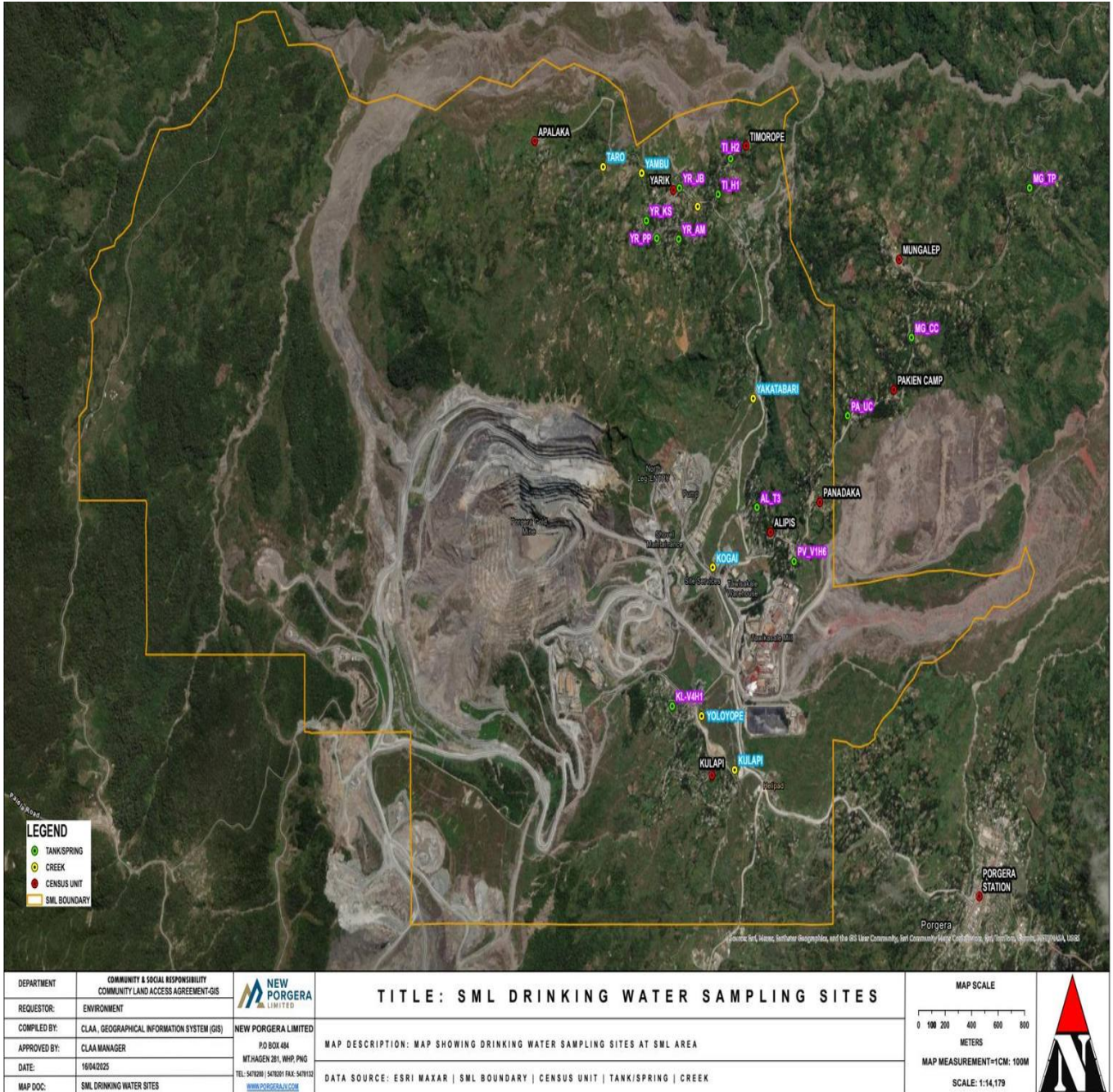


Figure 7-21 Sampling sites for local village water supplies

Table 7-34 Physiochemical and biological water quality 2024 at drinking water sites against Drinking Water Quality Standards

Site / Parameter	pH	EC	Total Solids	Colour	Turbidity	Total Hardness	Faecal Coliforms	Total Coliforms
Unit	SU	µS/cm	mg/L	HU	NTU	mg/L	cfu/100 mL	cfu/100 mL
Porep Pulawa (Tank)	NS	NS	NS	NS	NS	NS	NS	NS
Akope Mare (Tank)	NS	NS	NS	NS	NS	NS	NS	NS
Jenny Bolo (Tank)	NS	NS	NS	NS	NS	NS	NS	NS
Kapio Kendo (Spring)	NS	NS	NS	NS	NS	NS	NS	NS
Wari Ekali	6.9	16	20	4.0	0.99	1.3	None	None
Iso Kulina (Tank)	7.4	5.6	<5.0	4.0	0.90	0.69	None	None
Alipis Village (Tank 3)	4.2	12	<5.0	6.0	1.3	1.4	None	None
Bilip Aile (Tank)	5.6	6.6	<5.0	3.0	0.76	0.98	None	None
Timothy Kerene (Tank)	4.6	10	10	5.0	1.8	2.1	None	None
Kulapi V4 H1 (Tank)	5.3	4.7	<5.0	5.0	1.0	1.3	None	None
Pakien United Church	4.7	2.5	20	4.0	0.67	0.83	None	None
Mungalep Catholic Mission	5.3	3.1	<5.0	8.0	3.2	0.18	None	None
Tawano Pos	5.5	6.2	<5.0	5.0	0.93	0.21	None	None
PNG (1984)	6.5 - 9.2	NA	500	15	<5	200	None	<10
WHO (2017)	6.5 – 8.5	NA	NA	15	<4	200	None	None
	Compliant							
	Non-compliant							



PNG (1984), PNG Public Health (Drinking Water) Regulation 1984. Schedule 1 Standard for Raw Water.

WHO (2017), WHO Guidelines for drinking-water quality: fourth edition incorporating the first addendum

NA - Not Applicable; Cfu – Colony forming units; SU - Standard Units

NS – Apalaka and Yarik villages were not sampled due to ongoing security and community issues that prevented the NPL team from sampling

Table 7-35 Metal concentrations of drinking water sites against Drinking Water Quality Standards (µg/L)

Site / Parameter	As		Cd		Cu		Pb		Hg		Ni		Se		Zn	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Porep Pulawa (Tank)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Akope Mare (Tank)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Jenny Bolo (Tank)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Kapio Kendo (Spring)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Wari Ekali	0.10	0.10	0.05	0.05	1.8	0.96	0.10	0.10	0.05	0.05	0.50	0.50	0.20	0.20	89	81
Iso Kulina (Tank)	0.10	0.10	0.05	0.05	5.6	5.0	0.56	0.68	0.05	0.05	0.50	0.50	0.20	0.20	65	63
Alipis Village (Tank 3)	0.10	0.13	0.05	0.05	1.9	1.3	0.19	0.24	0.05	0.05	0.50	0.50	0.20	0.20	210	110
Bilip Aile (Tank)	0.10	0.10	0.053	0.054	1.6	1.8	0.27	0.39	0.05	0.05	0.50	0.50	0.20	0.20	86	88
Timothy Kerene (Tank)	0.10	0.12	0.05	0.05	0.59	0.68	0.11	0.22	0.05	0.05	0.50	0.50	0.20	0.20	57	57
Kulapi V4 H1 (Tank)	0.10	0.11	0.05	0.081	1.7	1.5	0.27	0.55	0.05	0.05	0.50	0.50	0.20	0.20	170	150
Pakien United Church	0.10	0.10	0.05	0.05	0.20	0.20	0.10	0.10	0.05	0.05	0.50	0.50	0.20	0.20	65	62
Mungalep Catholic Mission	0.10	0.10	0.05	0.05	0.23	0.20	0.10	0.10	0.05	0.05	0.50	0.50	0.20	0.20	490	480
Tawano Pos	0.10	0.10	0.05	0.05	0.40	0.33	0.10	0.10	0.05	0.05	0.50	0.50	0.20	0.20	50	46
PNG (1984)	7.0		2.0		1,000		10		1.0		20		10		3,000	
WHO (2017)	10		3.0		2,000		10		6.0		70		40		NA	
 Compliant																
 Non-compliant																

PNG (1984), PNG Public Health (Drinking Water) Regulation 1984. Schedule 1 Standard for Raw Water.

WHO (2017), WHO Guidelines for drinking-water quality: fourth edition incorporating the first addendum.

D – Dissolved, T – Total, NA – Not Applicable

NS – Apalaka and Yarik villages were not sampled due to ongoing security and community issues that prevented the NPL team from sampling

7.6 Water-based Activities

Various water-based activities are undertaken by local communities downstream of the mine: gold panning, bathing, laundry, fishing and swimming. To assess the potential health risks to people contacting this water, the median pH and concentration of dissolved metals in tailings and at test sites downstream of the mine in the upper river were compared against the ANZG (2018) recreational water quality guideline values and the WHO Drinking Water Quality Guidelines (2017).

The results are presented in Table 7-36 and showed that concentrations of dissolved nickel in undiluted tailings exceeded the guideline values, which therefore indicated potential risk to persons directly exposed to undiluted tailings. The only mechanism for exposure to undiluted tailings is for individuals to illegally enter the mining lease and enter the undiluted tailings stream at the discharge point to pan for gold.

At all test sites downstream of the Porgera River, pH was within the upper and lower guideline values, and dissolved metal concentrations were below, and therefore compliant with, the respective guideline values indicating low risk to human health.

Exposure patterns differ greatly along the Porgera, Lagaip and Strickland rivers downstream of the mine. River use in the mountain section above the Strickland Gorge is primarily for gold panning, with little use for subsistence fishing. Occasional exposure occurs when people cross the river and when children play on the exposed sandbars, or other activities. Along the Lower Strickland and at Lake Murray, people regularly use the waterways as a transportation corridor, for subsistence fishing and harvesting of sago crops, washing of clothes and bathing. Although lowland communities have significantly greater exposure, the very low concentrations of metals mean that the overall risk of adverse health effects is low.

Table 7-36 Comparison of 2024 median receiving water quality concentrations with recreational exposure guideline values (µg/L except where shown)

Site	n	pH [^]	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Fe-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D
Tailings	48	6.9	0.01	2.3	2.5	0.10	2.5	10	0.05	104	1.0	0.79	1,035
SG1	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SG2	6	7.8	0.01	1.2	0.08	0.14	1.3	2.6	0.05	0.75	0.10	0.20	4.8
Wasiba	11	7.8	0.01	0.97	0.05	0.39	0.59	1.7	0.05	0.56	0.10	0.27	6.5
Wankipe	12	7.8	0.01	1.2	0.05	0.15	0.81	3.3	0.05	0.5	0.10	0.21	1.5
SG3	183	7.9	0.01	1.0	0.05	0.15	0.96	3.6	0.05	0.5	0.10	0.20	1.8
ANZG (2018) Recreational WQG		6.5 – 8.5	50	50	5.0	50	1,000	300	1.0	100	50	10	5,000
WHO (2017) Drinking WQG		6.5 – 8.5	NA	10	3.0	NA	2,000	NA	6.0	70	10	40	NA
	< Guideline = Low risk												
	≥ Guideline = Potential risk												

[^] standard units; NA = Not Applicable; NS = Not Sampled

7.7 Fish and Prawn Consumption

Median tissue metal concentrations in fish flesh and prawn abdomen are compared against relevant food standards in Table 7-37. The results show that all tissue metals at all locations were below the relevant food standard. Although dietary intake of fish and prawns differs greatly between the mountain and lowland sections of the river, the results show that tissue metals in fish flesh and prawn abdomen pose a low risk to human health.

Table 7-37 Risk assessment – median tissue metal results at upper and lower river and Lake Murray test sites in 2024 compared against food standard showing which indicators pose low and potential risk (µg/g wet wt.)

Site	Sample	n	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Wasiba	Fish Flesh	12	0.022	0.003	0.01	0.21	0.05	0.01	0.01	0.31	4.0
	Prawn Ab	12	0.031	0.003	0.017	4.7	0.01	0.01	0.012	0.47	15
Wankipe	Fish Flesh	12	0.015	0.003	0.01	0.25	0.04	0.01	0.01	0.23	4.5
	Prawn Ab	12	0.030	0.003	0.029	4.1	0.01	0.01	0.01	0.36	13
Bebelubi	Fish Flesh	12	0.011	0.003	0.10	0.097	0.10	0.01	0.01	0.16	2.6
	Prawn Ab	12	0.064	0.003	0.024	6.6	0.01	0.01	0.01	0.23	11
SG4	Fish Flesh	12	0.01	0.003	0.01	0.094	0.067	0.01	0.01	0.16	4.1
	Prawn Ab	12	0.057	0.003	0.020	4.5	0.01	0.01	0.01	0.25	11
Pangoa	Fish Flesh	3	0.064	0.003	0.01	0.089	0.19	0.01	0.01	0.36	2.5
Miwa	Fish flesh	3	0.021	0.003	0.010	0.094	0.32	0.01	0.01	0.28	3.2
Food Std	Fish		2.0	0.050	1.0	2.0	0.5	NA	0.30	2.0	15
	Prawn		2.0	0.50	1.0	20	0.5	NA	0.50	1.0	40
	Compliant										
	Non-compliant										

As – Food Standard Australia New Zealand 1.4.1 (ANZFS 2016),

Cd, Hg, Pb – European Food Safety Authority (EC 2006)

Cr – Hong Kong Food Adulteration (Metallic Contamination) Regulations (HK 1997)

Cu, Se, Zn – Food Standards Australia New Zealand GEL 90th%ile (FSANZ 2001)

NS – Not sampled, Ab - Abdomen

7.8 Air Quality

Monitoring of point source emissions to air is conducted by NPL every two years, the most recent having been performed in 2024. Papua New Guinea has not enacted legislation for controlling emissions to air, therefore NPL has voluntarily set a target of reporting against the relevant Australian Standards, which are the NSW Protection of the Environment Operations (Clean Air) Regulation 2010 and the Victoria State Environment Protection Policy (Air Quality Management) 2001. A comparison of results from 2024 against the standards is presented in Table 7-38. The results showed that oxides of nitrogen (NO_x) in emissions from the Aggreko Diesel Generator and 789 Haul Truck 60 and Hg from the Carbon Regen Kiln exceeded the targets. NPL is continuing to assess options for improving emissions controls to achieve the targets at each discharge point.

Table 7-38 Point source emission metal concentrations (mg/Nm³)

Source	PM	NO _x	As	Cd	Pb	Ni	Hg	SO ₃
Anawe Diesel Generator	23	257	0.006	0.0013	0.021	0.008	0.002	0.77
Aggreko Diesel Generator	1.9	2,670	0.005	0.002	0.023	0.001	0.001	0.74
Assay Laboratory	3.5	3.6	0.004	<0.001	0.4	0.001	<0.001	NA
Anawe Autoclaves	76	13	0.12	0.006	0.2	0.21	0.039	26
Carbon Regeneration Kiln	17	75	0.006	0.013	0.018	0.018	7.5	NA
Gold Room Retort	NS	NS	NS	NS	NS	NS	NS	NS
Lime Kiln No 2	NS	NS	NS	NS	NS	NS	NS	NS
Primary Crusher	5.6	2.1	0.004	<0.001	0.003	<0.001	<0.001	NA
Hides Gas Turbine	5.1	107	0.004	<0.001	0.005	0.004	<0.001	0.51
789 Haul Truck 60	2.4	1,070	0.007	0.002	0.038	0.001	0.001	1.4
Criterion	500	1,000	10	3.0	10	20	3.0	200
	Compliant							
	Non-Compliant							
As, Cd, Pb, Ni SO ₃ , PM, NO _x – Victoria State Environment Protection Policy (Air Quality Management) 2001 Schedule D Hg – New South Wales Protection of the Environment Operations (Clean Air) Regulation 2010 NS – Not sampled due to power outage and safety reasons.								

PM = Particulate Matter

< = Less than Limit of Reporting

8 IMPACT ASSESSMENT

The impact assessment was performed by firstly comparing the 2024 mean value for biological indicators at each test site against their respective TVs using a one-sample t-test to test statistical significance. Where the test site mean is significantly greater than or not significantly different from the TV, this indicates no impact has occurred. Where the test site mean is significantly less than the TV, this indicates impact has occurred.

Secondly, the trend over time (2015 - 2024) was investigated for each indicator at both the test and reference site. Where significant downward (negative) trends are observed at the test sites and not at the reference sites, this indicates the potential for further reduction over time and serves as an early indication of where continued change may lead to future impact.

8.1 Upper River

8.1.1 Fish

The impact assessment for fish in the upper river is based on the following indicators: total fish species abundance; total fish biomass; abundance of *N. equinus* and biomass of *N. equinus*. Data were collected using a standardised, replicated hook and line fishing method.

8.1.1.1 Comparison against fish impact assessment TVs

Results from the comparison of 2024 test site means for fish impact indicators in the upper river against their respective TVs are provided in Results for total species abundance of the upper river test site at Wasiba showed no significant difference from the TV in the 2024 sampling. Total fish biomass was significantly higher in 2024 than the TV. Test site means for *N. equinus* (mountain tandan) abundance were significantly higher than the relevant TVs, but biomass was significantly lower. This is suggestive of more but smaller fish present and could indicate adverse impacts on larger individuals or recruitment of juveniles into the population of this species in the upper river at this site. Total fish species abundance and total fish species biomass showed no impact at Wasiba during 2024.

Results for total species abundance at the upper river test site at Wankipe showed no significant difference from the TV in the 2024 sampling. Total fish biomass was higher in 2024 than the TV although this was not statistically significant. Test site means for *N. equinus* (mountain tandan) abundance and biomass were higher than the relevant TVs, but these differences were not statistically significant. At Wankipe, total abundance and biomass of all fish species and of the indicator species *N. equinus* (mountain tandan) showed no impact.

Table 8-1 and include the t-statistic and significance value (p) for each test. Results for total species abundance of the upper river test site at Wasiba showed no significant difference from the TV in the 2024 sampling. Total fish biomass was significantly higher in 2024 than the TV. Test site means for *N. equinus* (mountain tandan) abundance were significantly higher than the relevant TVs, but biomass was significantly lower. This is suggestive of more but smaller fish present and could indicate adverse impacts on larger individuals or recruitment of juveniles into the population of this species in the upper river at this site. Total fish species abundance and total fish species biomass showed no impact at Wasiba during 2024.

Results for total species abundance at the upper river test site at Wankipe showed no significant difference from the TV in the 2024 sampling. Total fish biomass was higher in 2024 than the TV although this was not statistically significant. Test site means for *N. equinus* (mountain tandan) abundance and biomass were higher than the relevant TVs, but these differences were not statistically significant. At Wankipe, total abundance and biomass of all fish species and of the indicator species *N. equinus* (mountain tandan) showed no impact.

Table 8-1 Fish - Results from one-sample t-tests testing for significant ($p < 0.05$) differences between average values for Wasiba and Wankipe for 2024, and TVs derived from the 2019 assessment for reference Ok Om. NS = not significantly different.

Test Site	Indicator Parameter	2024 Test Mean	TV SOURCE	TV	t-Test			Level of Impact
					df	t-stat	P	
Wasiba	Total Fish Abundance	20.2	Ok Om Reference	3.6	6	0.85	0.42	NS.
	Total Fish Biomass (g)	275.9		174.7	6	2.92	0.03	Signif. > TV
	<i>N. equinus</i> Abundance	4.6		2.4	10	3.57	<0.01	Signif. > TV
	<i>N. equinus</i> Biomass (g)	47.4		129.4	10	3.47	<0.01	Signif. < TV

Test Site	Indicator Parameter	2024 Test Mean	TV SOURCE	TV	t-Test			Level of Impact
					df	t-stat	p	
Wankipe	Total Fish Abundance	16.6	Ok Om Reference	3.6	11	0.33	0.74	NS.
	Total Fish Biomass (g)	311.7		174.7	5	2.23	0.08	NS.
	<i>N. equinus</i> Abundance	26.4		2.4	8	0.49	0.63	NS.
	<i>N. equinus</i> Biomass (g)	202.4		129.4	5	1.02	0.35	NS.

8.1.1.2 Trends for fish impact indicators

The results of Spearman rank correlation and linear regression analyses for fish indicators in the upper river are provided in Table 8-2, and time series plots for each site for all fish species combined, and for the indicator species *N. equinus*, are shown in Table 8-2 and Figure 8-2. Note that the catch from consecutive days is shown in the plots but only the first day's catch was used for impact assessment due to the potential to 'fish-down' a site by sampling on consecutive dates (WRM 2018).

The analyses show no statistically significant evidence for negative (i.e. decreasing) trends in total fish abundance and biomass or *N. equinus* abundance and biomass at the Wasiba test site. The only significant trend was towards increased abundance in total fish.

The Wankipe site showed no trends in abundance for total fish number or for *N. equinus* alone. However, there were statistically significant declines in total fish biomass and *N. equinus* biomass between 2015 and 2024. These decreasing trends may indicate adverse impacts on fish populations, including those of *N. equinus* at Wankipe. The lack of a significant result for abundance coupled with significantly lower biomass is suggestive of the loss of larger individuals. At Wankipe, where no impact was detected for *N. equinus* in 2019, the declining trend indicates the potential for impact to occur in the future, should the declining trend continue.

No significant upward or downward trends were detected for any other indicators at the upper river test sites and reference site over the same period.

Table 8-2 Fish upper river - Spearman correlation coefficients (rho), linear regression coefficients (R) and associated significance values (p) for species abundance and biomass (g) parameters from hook and line catch for 2015 - 2024. NS = not significant.

Site	Parameter	n	Spearman Corr.		Linear Regress.		Trend	
			Rho	p	R	p		
Test	Wasiba 2015-2024	Total Fish Abundance	30	0.523	0.003	0.536	0.002	Sig. +ve
		Total Fish Biomass (g)	30	0.167	0.377	0.129	0.496	NS.
		<i>N. equinus</i> Abundance	30	0.048	0.799	-0.015	0.938	NS.
		<i>N. equinus</i> Biomass (g)	30	-0.008	0.966	-0.060	0.752	NS.
	Wankipe 2015-2024	Total Fish Abundance	31	0.091	0.626	-0.032	0.866	NS.
		Total Fish Biomass (g)	31	-0.592	<0.001	-0.621	<0.001	Sig. -ve
		<i>N. equinus</i> Abundance	31	-0.113	0.544	-0.211	0.179	NS.
		<i>N. equinus</i> Biomass (g)	30	-0.617	<0.001	-0.562	0.001	Sig. -ve
Ref	Ok Om 2015-2024	Total Fish Abundance	31	0.077	0.680	0.073	0.695	NS.
		Total Fish Biomass (g)	31	-0.033	0.856	0.014	0.938	NS.
		<i>N. equinus</i> Abundance	31	0.086	0.646	0.115	0.536	NS.
		<i>N. equinus</i> Biomass	31	-0.036	0.848	0.108	0.564	NS.

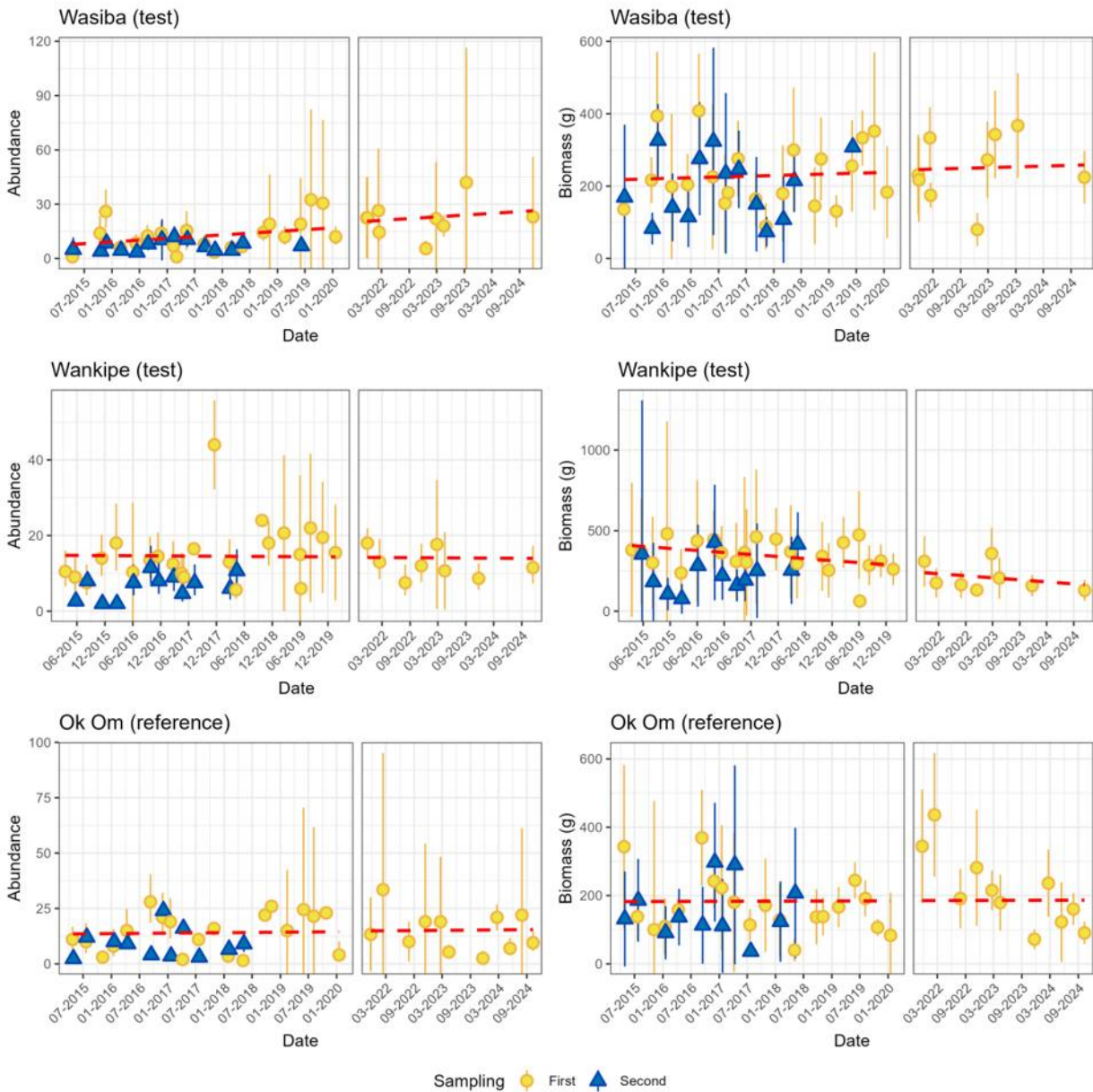


Figure 8-1 Time series plots of average (\pm 95% CIs) abundance and biomass (g) for combined fish species replicate hook and line catch at test sites Wasiba and Wankipe, and reference site Ok Om, for 2015 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are shown in the plots, yellow dots are first day sampling and blue dots are second day sampling. Only data from the first day sampling (yellow) were used for impact assessment.

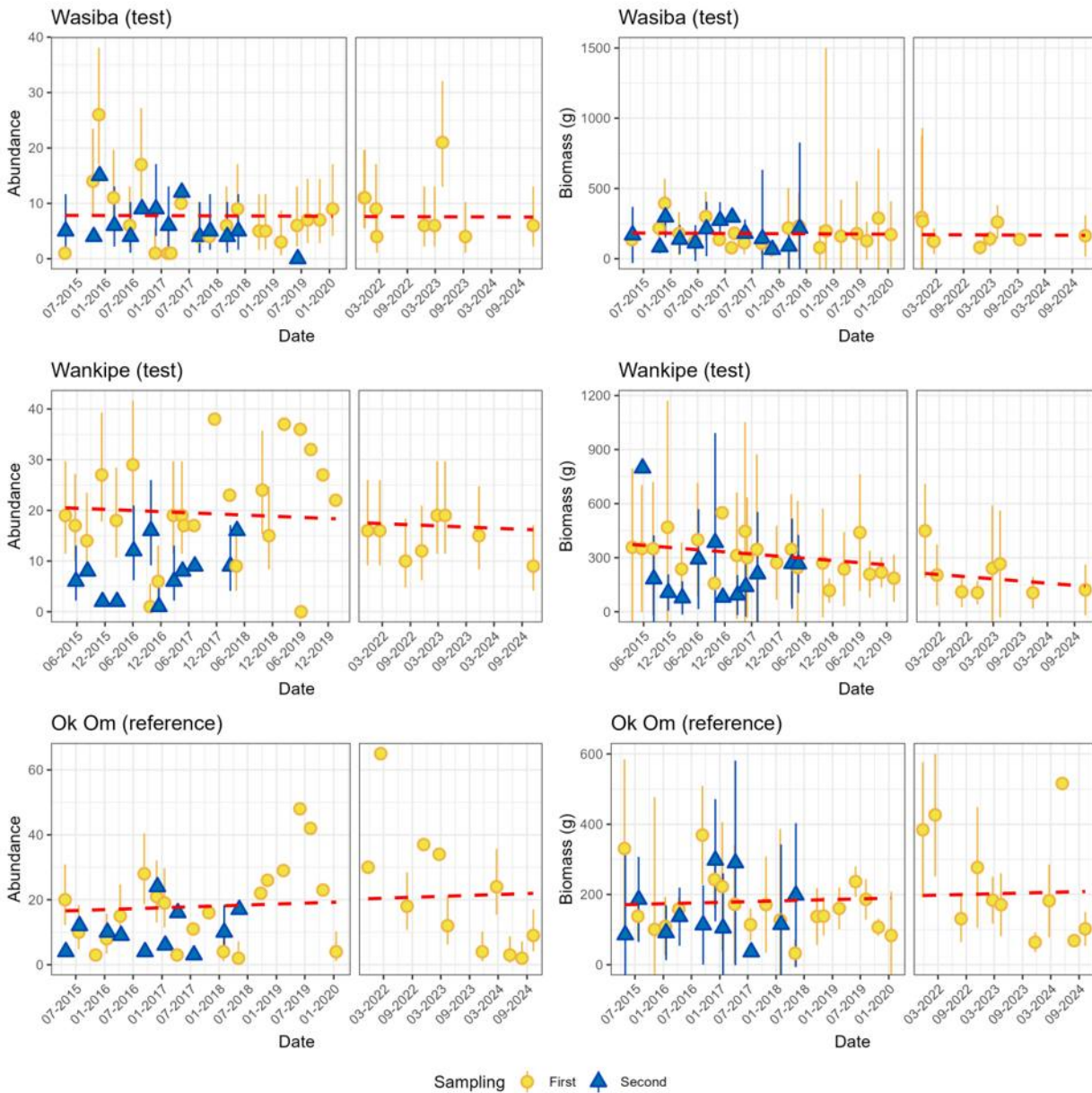


Figure 8-2 Time series plots of average ($\pm 95\%$ CIs) abundance and biomass (g) of *Neosilurus equinus* in replicate hook and line catch at test sites Wasiba and Wankipe, and reference site Ok Om, for 2015 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are shown in the plots, yellow dots are first day sampling and blue dots are second day sampling. Only data from the first day sampling (yellow) were used for impact assessment.

8.1.2 Prawns

The impact assessment for prawns in the upper river is based on the following indicators: total prawn species abundance, total prawn biomass, abundance of *M. handschini*, biomass of *M. handschini*, abundance of *M. lorentzi* and biomass of *M. lorentzi*. Data were collected using a standardised, replicated electro-seining method.

8.1.2.1 Comparisons against prawn impact TVs

Results from the comparison of 2024 test site means for prawn impact indicators in the upper river against their respective TVs are provided in Figure 8-3, and include the t-statistic and significance value (p) for each test.

Results for upper river test sites Wasiba and Wankipe showed that the 2024 test site means for all indicator parameters were either not significantly different from their respective TVs, or significantly higher than their respective TVs, indicating no impact on prawns in the upper rivers during 2024.

Table 8-3 Results from one-sample t-tests testing for significant ($p < 0.05$) differences between average values for Wasiba and Wankipe for 2024, and TVs derived from the previous 24 months for reference Ok Om. NS = not significantly different.

Test Site	Indicator Parameter	2024 Test Mean	TV SOURCE	TV	t-Test			Level of Impact
					df	t-stat	P	
Wasiba	Total Prawn Abundance	26.7	Ok Om Ref	15.1	3	1.69	0.171	NS.
	Total Prawn Biomass	55.3		24.9	3	2.66	0.065	NS.
	<i>M. handschini</i> Abundance	32.5		15.4	3	1.63	0.190	NS.
	<i>M. handschini</i> Biomass	39.0		13.9	3	2.67	0.068	NS.
	<i>M. lorentzi</i> Abundance	21.0		14.8	3	1.35	0.223	NS.
	<i>M. lorentzi</i> Biomass	16.3		11.1	3	2.70	0.058	NS.
Wankipe	Total Prawn Abundance	35.0	Ok Om Ref	15.1	3	3.67	0.019	Signif. > TV.
	Total Prawn Biomass	51.2		24.9	3	3.76	0.016	Signif. > TV.
	<i>M. handschini</i> Abundance	36.0		15.4	3	2.64	0.062	NS.
	<i>M. handschini</i> Biomass	31.1		13.9	3	2.70	0.058	NS.
	<i>M. lorentzi</i> Abundance	34.0		14.8	3	4.18	0.004	Signif. > TV.
	<i>M. lorentzi</i> Biomass	19.0		11.1	3	3.28	0.009	Signif. > TV.

8.1.2.2 Trends for prawn impact indicators

The results of Spearman rank correlation and linear regression analyses for prawn indicators in the upper river are provided in Table 8-4, and time series plots are shown in Figure 8-3, Figure 8-4 and Figure 8-5.

The analyses showed a statistically significant negative (i.e. decreasing) trend in total abundance of prawns, only for abundance of *M. lorentzi* at test site Wasiba between 2015 and 2024. All other indicators at upper river test sites and reference site showed either significant positive (i.e. increasing) trends or no significant change over the same period. It should be noted that the impact assessment presented in Section 0 showed no impact to *M. lorentzi* abundance and biomass at Wasiba in 2024 relative to the TV. However, the decreasing trend is justification for continued vigilance of this species at this site.

Table 8-4 Spearman rank correlation coefficients (ρ) and associated significance values (p) for trends over time in total prawn abundance and biomass (g) and in abundance and biomass of the dominant prawn species. Analyses were performed using average of replicate gill net sets averaged within each occasion in each year, 2015 - 2024 (NS = not significant).

Site		Parameter	n	Spearman Corr.		Linear Regress.		Trend
				Rho	p	R	p	
Test	Wasiba 2015-2024	Total Prawn Abundance	31	-0.161	0.386	-0.090	0.630	NS
		Total Prawn Biomass	31	0.015	0.937	0.111	0.553	NS
		<i>M. handschini</i> Abundance	31	0.321	0.078	0.205	0.269	NS
		<i>M. handschini</i> Biomass	29	0.339	0.073	0.284	0.136	NS
		<i>M. lorentzi</i> Abundance	31	-0.380	0.035	-0.191	0.304	Sig. -ve
		<i>M. lorentzi</i> Biomass	31	-0.313	0.087	-0.056	0.767	NS
Test	Wankipe 2015-2024	Total Prawn Abundance	30	0.544	0.002	0.448	0.013	Sig. +ve
		Total Prawn Biomass	28	0.311	0.107	0.211	0.280	NS
		<i>M. handschini</i> Abundance	30	0.373	0.042	0.387	0.034	Sig. +ve
		<i>M. handschini</i> Biomass	30	0.275	0.142	0.345	0.062	NS
		<i>M. lorentzi</i> Abundance	30	0.109	0.566	0.255	0.174	NS
		<i>M. lorentzi</i> Biomass	30	0.046	0.809	0.223	0.236	NS
Ref	Ok Om 2015-2024	Total Prawn Abundance	31	0.507	0.004	0.537	0.002	Sig. +ve
		Total Prawn Biomass	31	0.485	0.006	0.515	0.003	Sig. +ve
		<i>M. handschini</i> Abundance	31	0.570	0.001	0.588	0.001	Sig. +ve
		<i>M. handschini</i> Biomass	30	0.524	0.003	0.556	0.001	Sig. +ve
		<i>M. lorentzi</i> Abundance	31	0.470	0.008	0.348	0.055	Sig. +ve
		<i>M. lorentzi</i> Biomass	31	0.404	0.025	0.346	0.057	Sig. +ve

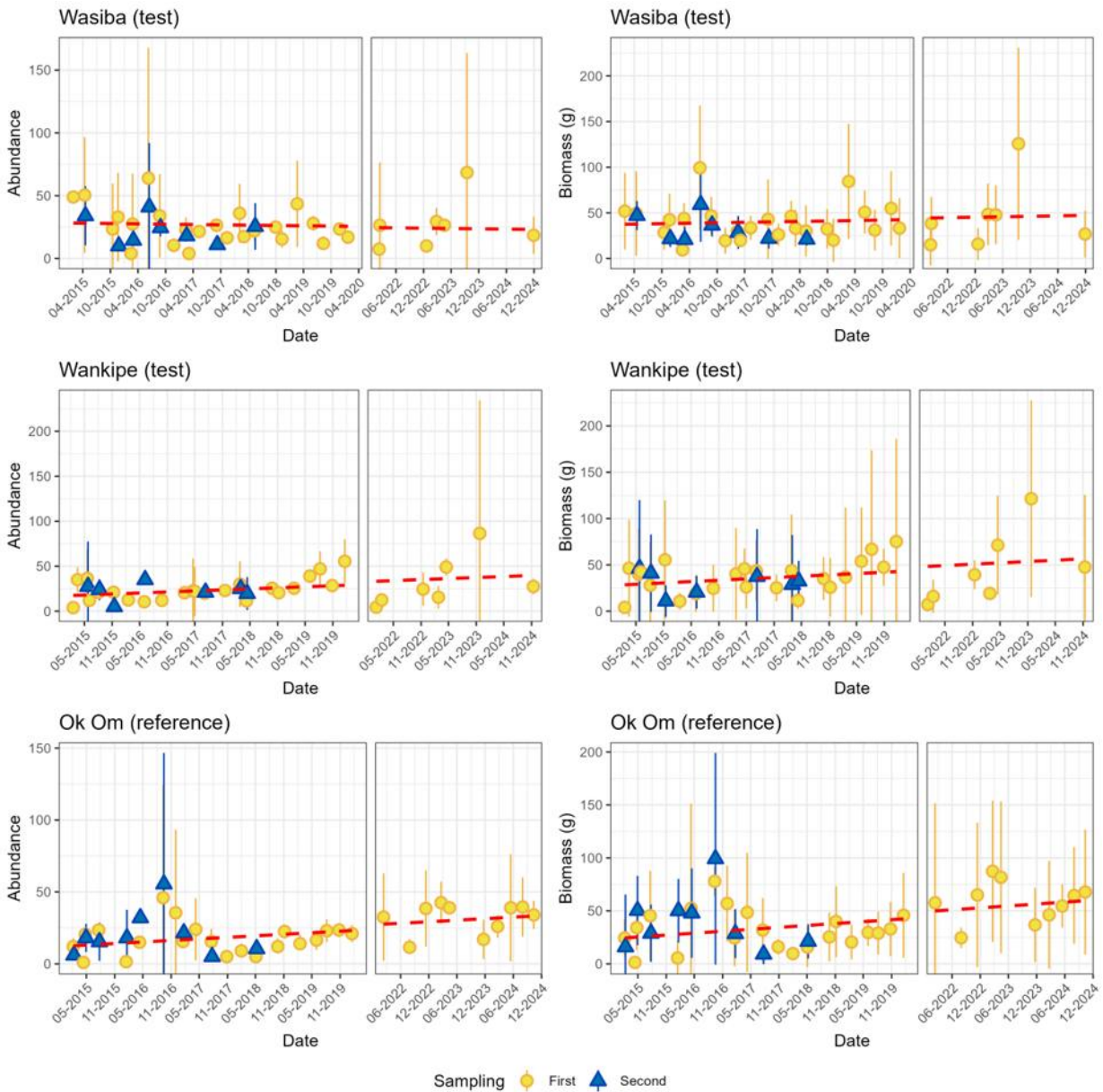


Figure 8-3 Time series plots of average (\pm 95% CIs) abundance and biomass (g) for combined prawn species from replicate electro-seining catch at test sites Wasiba and Wankipe, and reference site Ok Om, for 2015 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are shown in the plots, yellow dots are first day sampling and blue dots are second day sampling. Only data from the first day sampling (yellow) were used for impact assessment.

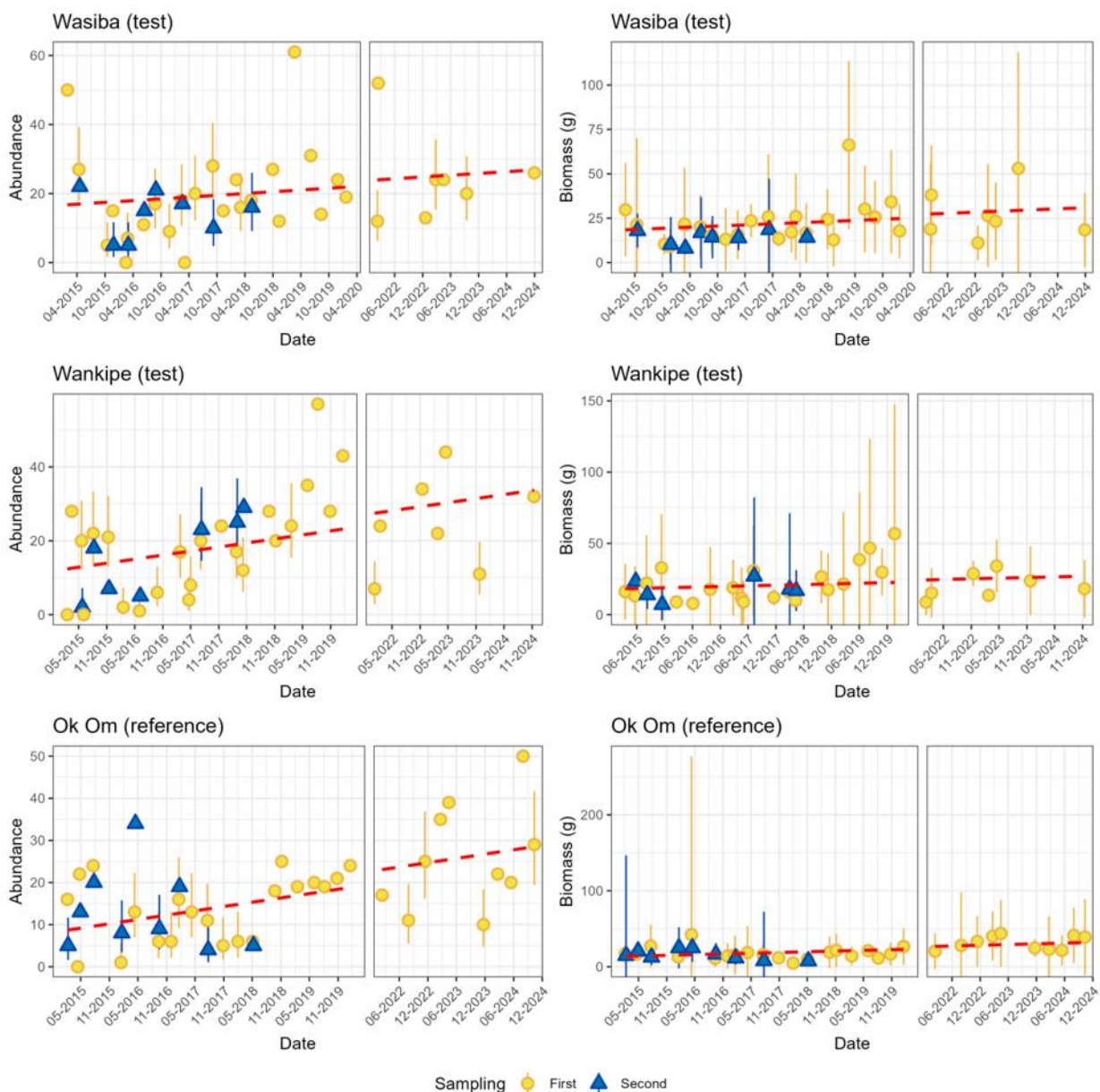


Figure 8-4 Time series plots of average (\pm 95% CIs) abundance and biomass (g) for *Macrobrachium handschini* in replicate electro-seining catch at test sites Wasiba and Wankipe, and reference site Ok Om, for 2015 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are shown in the plots, yellow dots are first day sampling and blue dots are second day sampling. Only data from the first day sampling (yellow) were used for impact assessment.

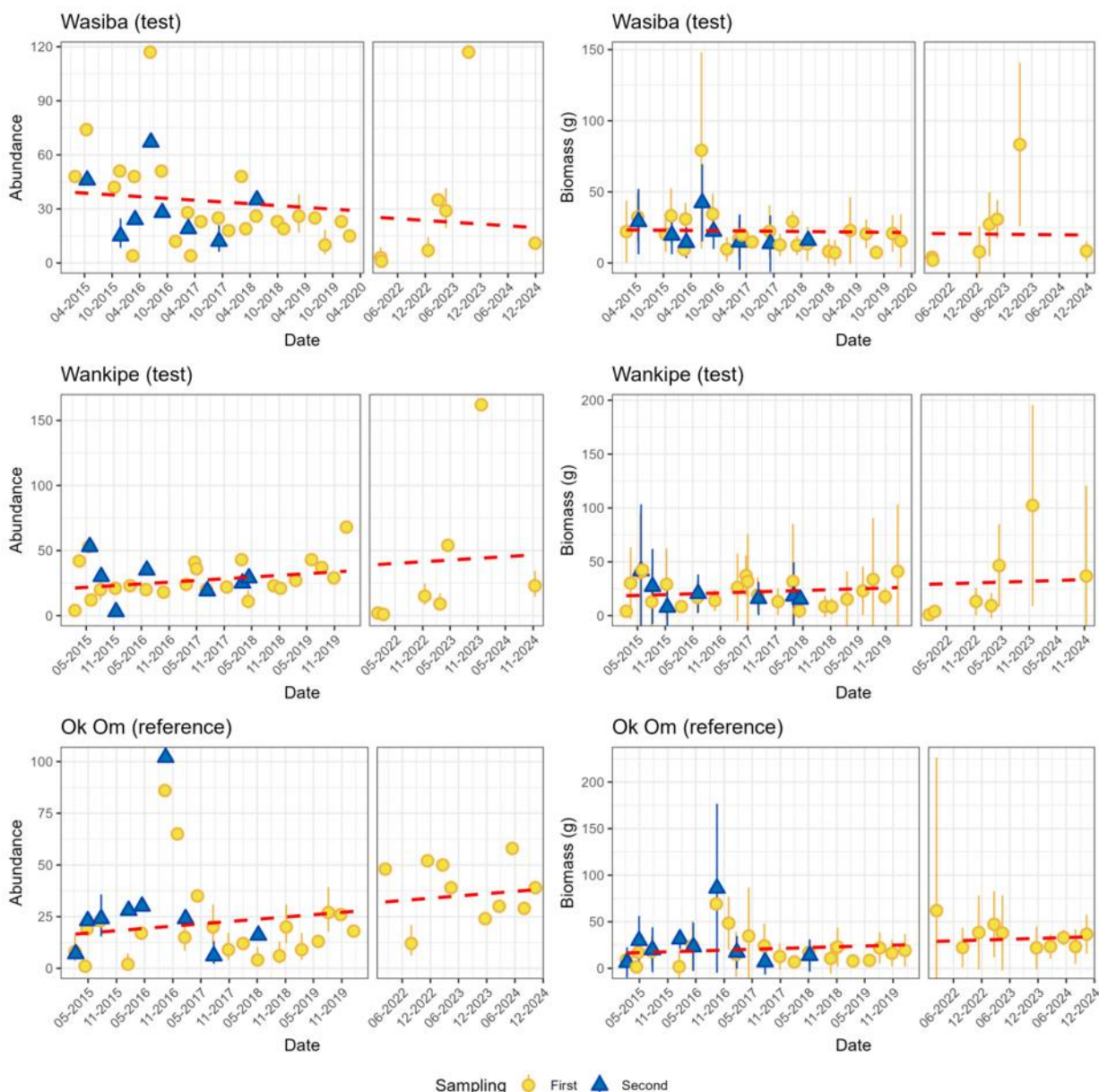


Figure 8-5 Time series plots of average (\pm 95% CIs) abundance and biomass (g) for *Macrobrachium lorentzi* in replicate electro-seining catch at test sites Wasiba and Wankipe, and reference site Ok Om, for 2015 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are shown in the plots, yellow dots are first day sampling and blue dots are second day sampling. Only data from the first day sampling (yellow) were used for impact assessment.

8.2 Lower River

8.2.1 Fish

The impact assessment for fish in the lower river is based on the following indicators: total fish species richness, total fish species abundance and total fish biomass. Data were collected using a standardised, replicated gill net fishing method.

8.2.1.1 Comparison against fish impact TVs

Results from the comparison of 2024 test site means for fish impact indicators in the lower river against their respective TVs are provided in Table 8-5 and include the t-statistic and significance value (p) for each test.

Results for lower river test site Bebelubi showed that the 2024 test site means for all indicators were not significantly different to, or were significantly greater than the respective TVs, indicating no impact on fish populations at Bebelubi during 2024.

Results for lower river test site SG4 showed the 2024 test site mean for species richness was either not significantly different to, or significantly greater than the TVs for species richness, indicating no impact to fish species richness at SG4 during 2024. Abundance was significantly greater than the TV based on the average of Tomu baseline data (i.e. 1999-2004), and was either not significantly different to, or significantly greater than the other TVs for SG4. On a weight of evidence approach, it was concluded there was no impact to fish abundance at SG4.

The mean biomass at SG4 was significantly greater than all three TVs. Further analysis of the trends for each indicator showed statistically significant negative (i.e. decreasing) trends in abundance at test site SG4 and test site Bebelubi, and statistically significant negative trends in biomass at SG4. However, there were also significant negative trends in biomass and abundance at both reference sites Baia and Tomu. The fact that declines in biomass were recorded at both reference sites, as well as test sites, and in the absence of risk caused by water quality, sediment quality and tissue metal, indicates that the low biomass recorded at SG4 in 2024 is not related to the operation of the Porgera Mine. This conclusion is further supported by WRM (2018) which performed an analysis of fishery yield versus artisanal fish consumptions by the local village populations. The results showed a significant increase in artisanal fish consumption since 2011 as a result of population growth, and based on census data, likely even greater increase in consumption since 2000 (and even more so since commencement of mining). Such increases in consumption could account for the observed declines in fish catch, especially at locations subjected to high fishing pressure as a result of localised population growth (WRM 2018).

Table 8-5 Results from one-sample t-tests testing for significant ($p < 0.05$) differences between average values for Bebelubi and SG4 for 2024, and TVs derived from the previous 24 months for respective reference sites Baia and Tomu, and TVs derived from average and percentile values of baseline for Baia (2006-2008), Tomu (1999-2004) and SG4 (1989-1998). NS = not significantly different.

Test Site	Indicator Parameter	2024 Test Site Mean	TV Source	TV	t-Test			Level of Impact
					df	t-stat	p	
Bebelubi	Total Fish Richness	6.00	Baia Reference As per 2019 assessment	3.0	8	2.40	0.042	Signif > TV.
	Total Fish Abundance	2.51		10.5	10	0.93	0.371	NS.
	Total Fish Biomass (kg)	6.78		6.2	8	0.58	0.575	NS.
	Total Fish Richness	6.00	Baia Baseline 80 th ile	5.0	1	1.41	0.252	NS.
	Total Fish Abundance	2.51		7.0	3	2.23	0.262	NS.
	Total Fish Biomass (kg)	6.78		10.1	5	1.64	0.167	NS.

Test Site	Indicator Parameter	2024 Test Site Mean	TV Source	TV	t-Test			Level of Impact
					df	t-stat	p	
SG4	Total Fish Richness	4.83	Tomu Reference Most recent 24mo	5.0	6	0.171	0.870	NS.
	Total Fish Abundance	4.28		3.2	13	1.788	0.097	NS.
	Total Fish Biomass (kg)	13.83		6.3	14	2.469	0.027	Signif. > TV.
	Total Fish Richness	5.88	Tomu Baseline Mean	5.0	3	0.980	0.377	NS.
	Total Fish Abundance	8.76		3.2	3	5.800	<0.001	Signif. > TV.
	Total Fish Biomass (kg)	30.26		6.2	3	4.941	<0.001	Signif. > TV.
	Total Fish Richness	6.36	SG4 Baseline Mean	5.0	4	1.53	0.197	NS.
	Total Fish Abundance	6.76		3.2	24	3.83	<0.001	Signif. > TV.
	Total Fish Biomass (kg)	30.33		6.2	24	3.18	0.004	Signif. > TV.

8.2.1.2 Trends for fish impact indicators

The results of Spearman correlation and linear regression analyses for fish indicators in the lower river are provided in Table 8-6, and time series plots for each site are shown in Figure 8-6 and Figure 8-7.

Analysis of the trends for each indicator showed statistically significant negative (i.e. decreasing) trends in abundance at test site SG4 and test site Bebelubi, and statistically significant negative trends in biomass at SG4. However, there were also significant negative trends in biomass and abundance at both reference sites Baia and Tomu.

The fact that declines in biomass were recorded at both reference sites, as well as test sites, suggests the cause is not mine related. The absence of a strong mine-related signal in sediment and water metal concentrations and TSS levels in surface water at these sites (see Risk Assessment Section 7) provides further weight to the argument that the mine is not the sole factor influencing fish populations. As discussed above, it is possible the declines observed reflect the combined indirect effects of NPL's presence in the region, which may aid communities to have access to more effective fishing methods (through access to income, nets and boats), as well as local fishing pressure and population pressure, rather than direct mine impacts. Analysis of fishery yield versus artisanal consumptions (WRM 2018) shows a significant increase in artisanal consumption since 2011 as a result of population growth, and based on census data, likely even greater increase in consumption since 2000 (and even more so since commencement of mining). Such increases in consumption could account for the observed declines in fish catch, especially at locations subjected to high fishing pressure as a result of localised population growth (WRM 2018).

Table 8-6 Fish lower rivers - Spearman rank correlation coefficients (ρ), linear regression coefficients (R) and associated significance values (p) for trends in species richness, abundance and biomass (kg) over time from gill net catch for all years. Only data from replicate net #1 were used. NS = not significant.

Site	Indicator Parameter	n	Spearman Corr.		Linear Regress.		Trend	
			Rho	p	R	P		
Test	Bebelubi 2006-2024	Total Fish Richness	51	0.133	0.353	0.043	0.767	NS
		Total Fish Abundance	51	-0.456	0.001	-0.469	0.001	Sig. -ve
		Total Fish Biomass (kg)	51	-0.261	0.064	-0.245	0.083	NS
	SG4 1989-2024	Total Fish Richness	110	-0.176	0.066	-0.187	0.050	NS
		Total Fish Abundance	110	-0.199	0.037	-0.154	0.108	Sig. -ve
		Total Fish Biomass (kg)	110	-0.441	0.000	-0.419	<0.001	Sig. -ve
Ref	Baia 2006-2024	Total Fish Richness	56	-0.129	0.342	-0.088	0.521	NS
		Total Fish Abundance	56	-0.276	0.039	-0.338	0.011	Sig. -ve
		Total Fish Biomass (kg)	56	-0.294	0.028	-0.282	0.035	Sig. -ve
	Tomu 1996-2024	Total Fish Richness	100	-0.168	0.095	-0.180	0.073	NS
		Total Fish Abundance	100	-0.311	0.002	-0.294	0.003	Sig. -ve
		Total Fish Biomass (kg)	100	-0.392	0.000	-0.463	<0.001	Sig. -ve

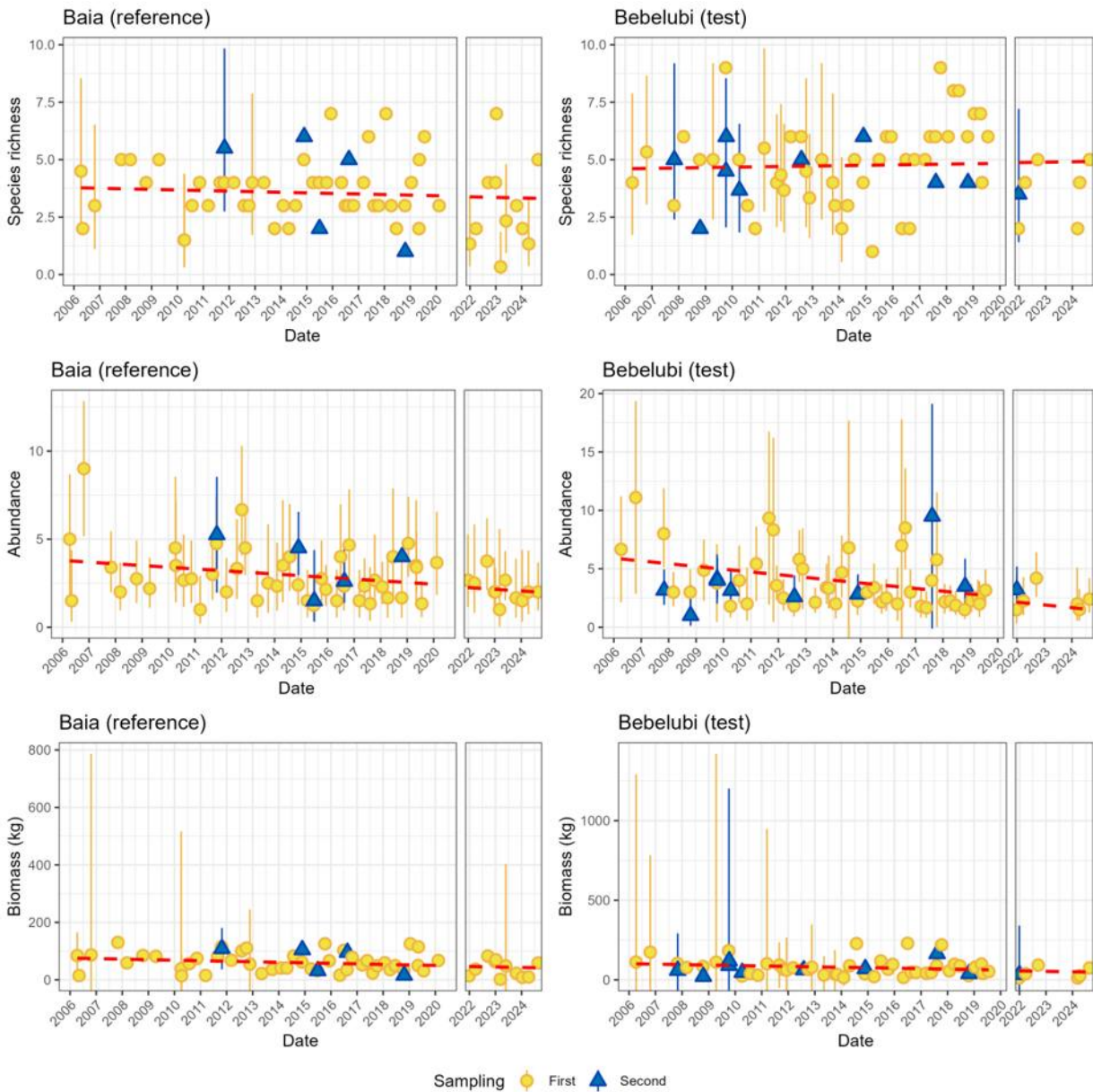


Figure 8-6 Time series plots of species richness, abundance and biomass (kg) from replicate net set #1 gill net catch at paired monitoring sites Bebelubi and Baia, 2006 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are included in the plots, but only data from the first day sampling were used for impact assessment.

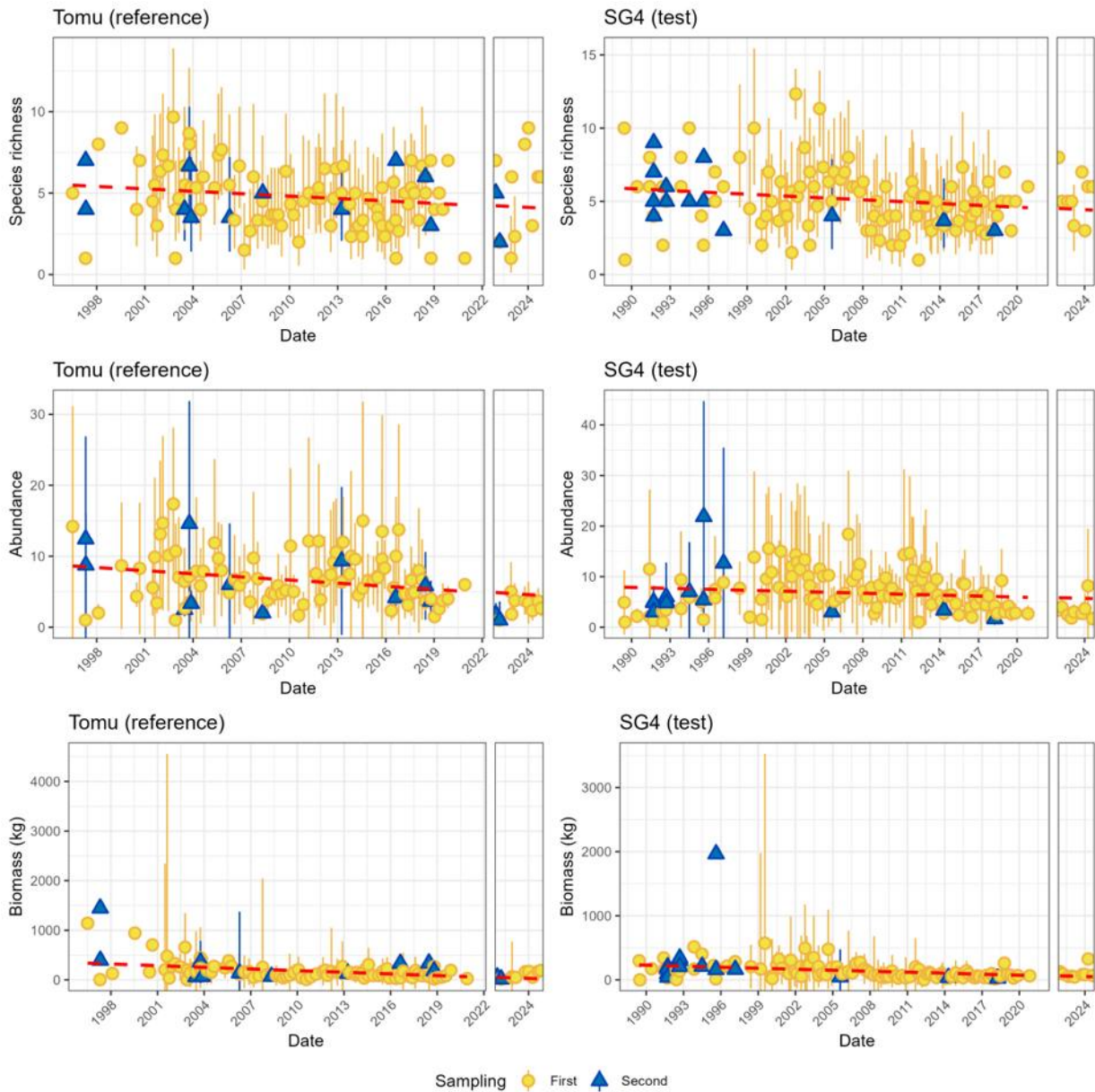


Figure 8-7 Time series plots of species richness, abundance and biomass (kg) from replicate net set #1 gill net catch at paired monitoring sites SG4 and Tomu, 1989 - 2024. Linear trend lines for average values shown in red. Data from consecutive days sampling are included in the plots, but only data from the first day sampling were used for impact assessment.

8.3 Lake Murray

The impact assessment for fish in Lake Murray is based on the following indicators: total fish species richness, total fish abundance and total fish biomass. Data were collected using a standardised, replicated gill net fishing method.

8.3.1 Fish

8.3.1.1 Comparison against fish impact TVs

Results from the comparison of 2024 test site means for fish impact indicators in Lake Murray against their respective TVs are provided in Table 8-7 and include the t-statistic and significance value (p) for each test.

Results for lower lake test site Miwa showed the 2024 test site mean for species richness and abundance was not significantly different to the relevant TVs, indicating no impact on fish species richness or abundance at Miwa during 2024. Biomass was significantly less than the TV based on the average of Miwa baseline data (i.e. 1989-2006) and the 20thile, which is suggestive of a reduction in average fish size. This could be due to removal of large individuals or recruitment of small juvenile fish. On a weight of evidence approach, it was therefore concluded that there was no impact to fish abundance and biomass at Miwa. Over the past decade, the population around Lake Murray has grown significantly, leading to increased pressure on the lake’s natural resources. Community members have set fishing nets in all parts of the lake almost daily to meet rising demand for fish consumption. As a result of this consistent and intensive fishing activity, a noticeable decline in fish biomass has been observed, indicating the impacts of overfishing in the Lake Murray region. Results for mid-lake test site Pangoa showed that the 2024 test site means for all indicators were not significantly different to the respective TVs for the most recent time period, but that total fish abundance and biomass were significantly lower than the long-term baseline. This may indicate some impact to fish at Pangoa during 2024.

Table 8-7 Results from one-sample t-tests testing for significant ($p < 0.05$) differences between average values for Miwa and Pangoa for 2024 and TVs derived from the 2024 assessment for reference site Maka, and TVs derived 20th percentile values of baseline for Maka (2001-2006) and Miwa (1989-2000). NS = not significantly different.

Test Site	Indicator Parameter	2024 Test Site Mean	TV Source	TV	t-Test			Level of Impact
					df	t-stat	p	
Miwa	Total Fish Richness	3.8	Maka Reference Previous 24mo	5.9	2	1.01	0.410	NS.
	Total Fish Abundance	9.3		4.2	2	0.85	0.480	NS.
	Total Fish Biomass (kg)	10.8		7.1	3	3.23	0.053	NS.
	Total Fish Richness	3.8	Maka Baseline 20%ile	4.1	2	0.16	0.883	NS.
	Total Fish Abundance	9.3		9.5	2	0.04	0.972	NS.
	Total Fish Biomass (kg)	10.8		66.5	2	3.95	<0.001	Signif. < TV
	Total Fish Richness	3.8	Miwa Baseline Mean	4.3	2	0.24	0.829	NS.
	Total Fish Abundance	9.3		12.1	3	0.42	0.698	NS.
	Total Fish Biomass (kg)	10.8		70.1	42	4.33	<0.001	Signif. < TV.

Test Site	Indicator Parameter	2024 Test Site Mean	TV Source	TV	t-Test			Level of Impact
					df	t-stat	p	
Pangoa	Total Fish Richness	4.0	Maka Reference As per 2019 assessment	5.9	2	4.25	0.051	NS.
	Total Fish Abundance	2.4		4.2	3	1.80	0.169	NS.
	Total Fish Biomass (kg)	16.9		30.2	2	2.84	0.118	NS.
	Total Fish Richness	4.0	Maka Baseline 20 th ile	4.1	15	0.24	0.812	NS.
	Total Fish Abundance	2.4		9.5	16	4.32	<0.001	Signif. < TV
	Total Fish Biomass (kg)	16.9		66.5	17	3.65	0.002	Signif. < TV

8.3.1.2 Trends for fish impact indicators

The results of Spearman correlation and linear regression analyses for fish indicators in Lake Murray are provided in Table 8-8 and time series plots for each site are shown in Figure 8-8 and Figure 8-9.

The analyses showed statistically significant weak negative (i.e. decreasing) trends in species richness, abundance and biomass at test site Miwa (lower lake), and in biomass at test site Pangoa (mid lake). There was also significant decrease in biomass at the reference site Maka. The fact that declines were recorded in biomass at all sites suggests that there is some other driver than the mine which is affecting fish biomass. Reductions in richness and abundance at one test site (Miwa) but not the other (Pangoa) also suggest that these trends are not related to the mine.

Table 8-8 Fish Lake Murray - Spearman rank correlation coefficients (rho), linear regression coefficients (R) and associated significance values (p) for trends in average species richness, abundance and biomass (kg) over time from replicate gill net catch for all years. NS = not significant.

Site	Indicator Parameter	n	Spearman Corr.		Linear Regress.		Trend	
			Rho	p	R	p		
Test	Miwa 1989-2024	Total Fish Richness	72	-0.217	0.067	-0.310	0.008	Sig. -ve
		Total Fish Abundance	72	0.114	0.340	-0.261	0.027	Sig. -ve
		Total Fish Biomass (kg)	72	-0.403	0.000	-0.335	0.004	Sig. -ve
	Pangoa 1992-2024	Total Fish Richness	40	-0.076	0.642	-0.139	0.392	NS
		Total Fish Abundance	40	0.124	0.446	0.165	0.308	NS
		Total Fish Biomass (kg)	40	-0.420	0.007	-0.256	0.111	Sig. -ve
Ref	Maka 1993-2024	Total Fish Richness	38	0.099	0.552	0.001	0.998	NS
		Total Fish Abundance	38	-0.153	0.360	-0.178	0.286	NS
		Total Fish Biomass (kg)	38	-0.266	0.107	-0.382	0.018	Sig. -ve

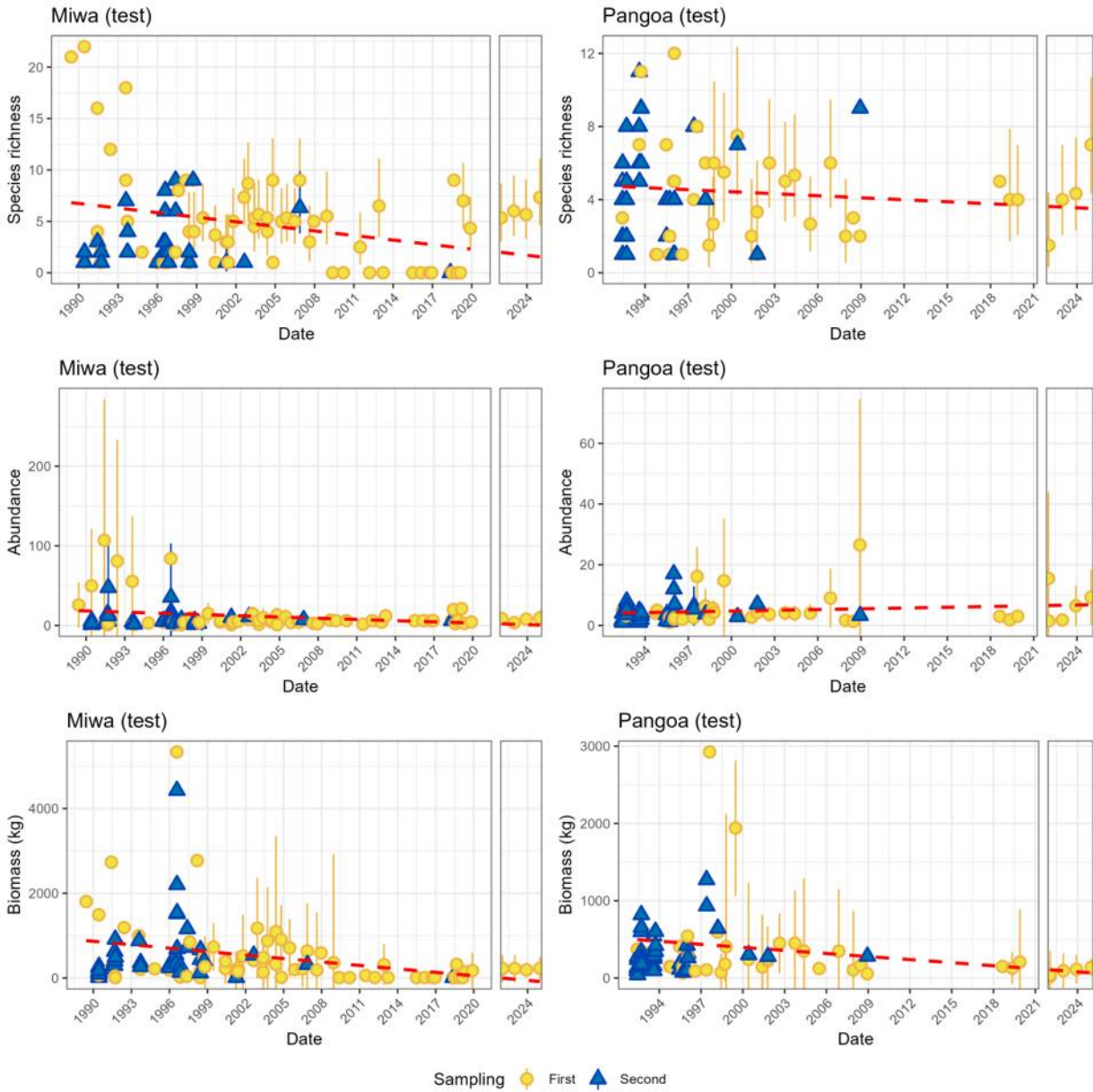


Figure 8-8 Time series plots of average ($\pm 95\%$ CIs) species richness, abundance and biomass (kg) from replicate gill net catch at Lake Murray test sites Miwa and Pangoa, 1989 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are included in the plots, but only data from the first day sampling were used for impact assessment.

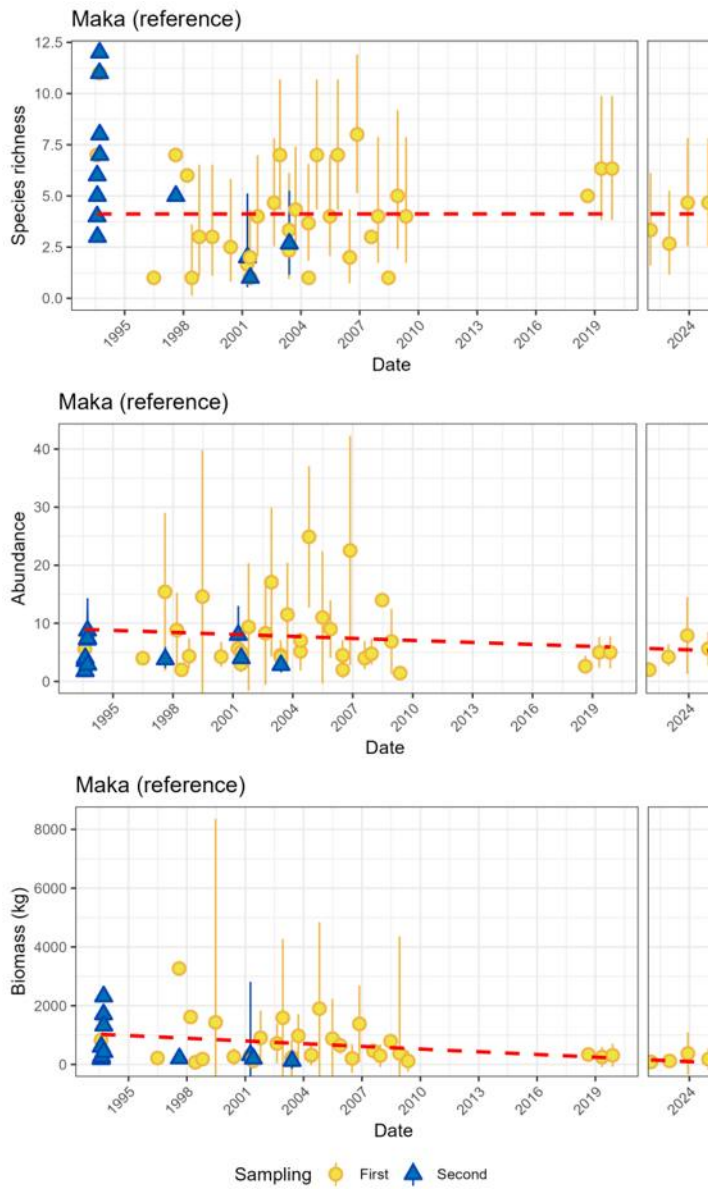


Figure 8-9 Time series plots of average ($\pm 95\%$ CIs) species richness, abundance and biomass (kg) from replicate gill net catch at Lake Murray reference site Maka, 1989 - 2024. Linear trend lines are shown in red. Data from consecutive days sampling are included in the plots, but only data from the first day sampling were used for impact assessment.

9 CONCLUSIONS AND OVERALL ASSESSMENT

NPL is a large-scale open cut and underground gold mine that has been operating since 1990. The environmental aspects of the operation are managed through the implementation of the NPL EMS, which has been certified to the ISO 14001 standard since 2012. The objectives of the EMS are to consistently achieve compliance with legal obligations, mitigate risk and continually improve performance. The NPL environmental monitoring program provides data and information upon which to measure the ability of the EMS to achieve its objectives.

The monitoring program has continually evolved, benefiting from improvements to scientific knowledge, sampling and data analysis techniques and environmental management practices. The 2024 Annual Environment Report continues this tradition by incorporating historical and newly acquired data, information and knowledge within the AER framework.

Since 1995, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia's preeminent scientific organisation, have provided independent oversight of the NPL environmental monitoring program. CSIRO's role includes undertaking review of NPL's AER, routine quality assurance audits of the NPL environmental monitoring program and environmental laboratory operations and technical studies to improve the understanding of contaminant behaviour within the receiving environment. CSIRO audits include independent sampling and analysis of water, sediment and fish and prawn tissue to cross-check NPL's results.

Consistent with the EMS, the purpose of the AER is to assess compliance, risk, impact and performance of the operation. The assessment is based on the use of environmental indicators at discharge points and potentially impacted (test) sites within the receiving environment downstream of the mine. The data at the test sites are assessed against compliance limits dictated by the site's environmental permits; trigger values that act as benchmarks of risk and historical data to assess performance trends. Where possible, the comparison is supported by statistical analysis to provide added confidence in the results.

For the purposes of this AER, the receiving environment is divided into four (4) regions. The upper river section of the receiving environment extends from the mine to SG3 on the Strickland River, 164 km downstream of the mine. This zone also constitutes the permitted mixing zone as defined by the PNG Government environmental permits and is also the zone in which compensation for environmental impact is paid to communities living along the river.

The lower river extends from SG3 on the Strickland River, to the junction of the Strickland and Fly Rivers, approximately 600 km downstream of the mine. The off-river water bodies (ORWBs) are a number of ox-bow lakes that lie adjacent to the lower section of the Strickland River, between 510 km and 600 km from the mine. And finally, Lake Murray, a large freshwater lake which is connected to the lower section of the Strickland River via the Mamboi breakthrough and Herbert River, approximately 550 km downstream of the mine. Typically, water flows from Lake Murray into the Strickland River, however when the water level within the river is higher than that of the lake, the direction of flow will reverse and water will flow from the Strickland River into the southern and central regions of Lake Murray.

The 2024 NPL AER assessment was performed by assessing compliance against the conditions of the operation's environmental permits and by applying a weight of evidence approach to assessing human health risk and environmental impact based on a range of environmental indicators. It should be noted that the 2024 assessment applies to sites downstream of SG1 on the Porgera River, monitoring was not conducted at SG1 during 2024 due to security concerns, therefore the assessment could not be performed at this location.

The operational footprint and the quality and quantity of inputs from the site to the receiving environment in 2024 were consistent with recent operational years prior to the care and maintenance period between 2020 and 2023. Natural environmental conditions in 2024 were characterised by approximately average rainfall totals at the mine site and at all other monitoring sites within the receiving environment.

Given that inputs from the mine are relatively consistent from year to year, particularly in recent history, the behaviour of mine inputs within the receiving aquatic ecosystem are largely dictated by the natural flow rates and sediment loadings of rivers, which in turn are related to rainfall. Average rainfall results in moderate natural flows and sediment loads to the system.

Moderate rainfall resulted in consistent water supply from Waile Creek Dam, Aipulungu Creek, FTO7 and Kogai Creek to support mine production throughout the year. Water extraction for the mine supply is considered to present low environmental risk because environmental flows were maintained in Waile Creek, Aipulungu Creek, FT07 and Kogai Creeks downstream of the extraction points.

In 2024, the site achieved full (100%) compliance with the conditions of the environmental permits issued by the PNG Government.

The risk assessment concluded that elevated electrical conductivity (EC), TSS, dissolved cadmium, copper, nickel and zinc in tailings and contact runoff from the competent waste rock dumps, open pit and underground mines, posed a potential risk to aquatic ecosystems in the upper river between the mine and Wankipe on the Lagaip River, 116 km downstream of the mine.

The environmental risk assessment showed that in 2024 there was moderate mine-related environmental impact within the Porgera and Lagaip Rivers between the mine and Wasiba, located on the Lagaip River 96 km downstream of the mine. Impacts were detected in the form of elevated EC and TSS concentrations in water, elevated weak acid extractable (WAE) concentrations of lead and selenium in benthic sediment, elevated lead and selenium concentrations in prawn abdomen at Wasiba. The assessment for prawns and fish at Wasiba and Wankipe at upper river showed no impact in 2024. Aside from some elevations of electrical conductivity, the risk assessment and investigation concluded that there were no significant mine-related impacts downstream of SG3 and throughout the lower river, ORWBs and Lake Murray regions.

Biological impact assessment involved measurement of fish and prawn biomass at selected sites in the river system and Lake Murray. The collected data was compared to trigger values derived from background data. In addition, trends in annual fish and prawn catch data collected over the last 10 years were analysed statistically.

In the upper river there were no impacts on fish biomass and abundance at Wasiba and Wankipe. However, a statistically significant decline in total fish biomass and *N. equinus* biomass at Wankipe was observed between 2015 and 2024. Compared to trigger values, there were no impacts on prawn biomass and abundance at Wasiba and Wankipe. However, a statistically significant negative (i.e. decreasing) trend in abundance of the prawn species *M. lorentzi* was observed at Wasiba between 2015 and 2024.

In the lower river, there were no impacts on fish abundance and biomass. However statistically significant negative (i.e. decreasing) trends in abundance at test site SG4 and test site Bebelubi, and statistically significant negative trends in biomass at SG4. It is likely these trends were associated with increasing fishing pressures in this part of the river system.

In Lake Murray a general decline in fish biomass was observed at both test and reference sites. The fact that declines were recorded at all sites suggests that some other driver than the mine, such as over-fishing, is responsible for this trend.

A summary of compliance, human health risk and environmental impact at each test site in 2024 is presented in Table 9-1. There was low risk posed to human health by the operation's activities. However, it should be noted people who illegally accessed the tailings stream within the Porgera Special Mining Lease boundary were exposed to concentrations of dissolved cadmium, nickel and zinc which exceed the ANZG (2018) guideline for recreational water quality. The concentrations of metals in fish flesh and prawn abdomen at all monitoring sites were below international food standards, indicating that they are safe for human consumption.

Furthermore, the downstream extent of impact, at Wasiba located 96 km downstream from the mine, lies well within the permitted mixing zone, which extends to SG3 on the Strickland River, 164 km downstream

of the mine. Additionally, the degree of impact detected is consistent with the predictions made prior to mining operations commencing in 1990 and compensation for environmental impact is paid to landowners living along the river within the permitted mixing zone, in accordance with the 1996 Ministerial Determination.

Table 9-1 Summary of Compliance, Human Health Risk and Environmental Impact at test sites in 2024

Region	Site	Distance From the Mine (km)	Overall Condition			Comments
			Compliance	Human Health Risk	Environmental Impact	
Upper River	SG2	42	Compliant	Low Risk	Moderate Env Impact	Within the permitted mixing and compensation zone.
	Wasiba	96	Compliant	Low Risk	Moderate Env Impact	
	Wankipe	116	Compliant	Low Risk	Minor Impact	
	SG3	164	Compliant	Low Risk	No Impact	End of the permitted mixing and compensation zone
Lower River	Bebelubi	310	Compliant	Low Risk	No Impact	
	SG4	360	Compliant	Low Risk	No Impact	
	SG5	550	Compliant	Low Risk	No Impact	
ORWBs	Kukufionga	510	Compliant	Low Risk	No Impact	
	Zongamange	560	Compliant	Low Risk	No Impact	
	Avu	575	Compliant	Low Risk	No Impact	
	Levame	600	Compliant	Low Risk	No Impact	
Lake Murray	SG6	570	Compliant	Low Risk	No Impact	
	Miwa	590	Compliant	Low Risk	No Impact	
	Pangoa	600	Compliant	Low Risk	No Impact	

10 RECOMMENDATIONS

The recommendations presented in this section are intended to improve the assessment methodology, communication of the findings to the many stakeholders and to improve the environmental performance of the operation and reduce environmental risk and impact.

Note that a number of the recommendations from the previous AER are still in progress and appear in the list below in addition to new recommendations raised from this year's AER.

Assessment Methodology and Communication of Findings

1. Continue to investigate options for increasing the frequency of TSS sampling in the upper and lower river, Lake Murray and ORWB reference and test sites.
2. Deliver a summary presentation of the report methodology and findings to the Conservation and Environmental Protection Authority to support delivery of the AER.
3. Develop a NPL Environment Report Card to present a summary of the findings of the report and make the report card available in hard copy and via the NPL website.
4. Undertake a study to update the particle size information for the erodible dumps, used in the sediment mass balance calculations.
5. Undertake a study to investigate the major ions present in the system, which contribute to elevated EC, and their impacts on aquatic life. This work should also investigate options for development of site-specific trigger values for specific mine-derived major ions.
6. Review the analytical procedure used for the determination of WAE metals. The CSIRO 2019 ultratrace study reported much lower WAE metal concentrations in benthic sediments from the main river than typically reported by NPL. It may be appropriate to adopt the CSIRO procedure for routine analysis.

Reduce Environmental Risk and Impact and Improve Performance

7. Continue to investigate options for reducing the concentrations of bioavailable metals and mass loads of metals in mine discharges.
8. Investigate the metal uptake pathway by which prawns and fish are accumulating mine derived metals to understand the influence of particulate metals and metals bound to organic matter.
9. Investigate mercury bioaccumulation in Lake Murray food webs: conduct a follow up to the CSIRO/NPL study which was conducted in the mid-1990s.
10. Improve knowledge of the water and sediment exchanges between the ORWBs in the Lower Strickland and the main river channel.

11 REFERENCES

- ANZFA (2001). Australia New Zealand Food Authority – Generally Expected Levels (GELs) for Metal Contaminants.
- Angel BM, Adams M, Spadaro DA, Jarolimek CV, Apte SC. (2018). Metal speciation and toxicity of Lagaip / Strickland River and PJV mine waters. CSIRO Land and Water Report, Australia, EP18430.
- Angel BM, Apte SC, Simpson SL, Jarolimek CV, King JJ, Jung RJ. (2015). A survey of metal concentrations in the Strickland River and tributaries, Papua New Guinea, Minerals Resources Flagship Report. CSIRO, Australia.
- Angel BM, Jarolimek CV, King JJ, Apte SC. (2017). Porgera Joint Venture 2017 ultratrace water and sediment quality survey. CSIRO Mineral Resources Report, Australia.
- Angel BM, Jarolimek CV, King JJ, Apte SC. (2020). Porgera Joint Venture 2019 ultratrace water and sediment quality survey. CSIRO Mineral Resources Report, Australia.
- ANZFS (2016). Australia New Zealand Food Standards Code – Standard 1.4.1 – Contaminants and natural toxicants.
- 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
- APHA (2005). *Standard Methods for the Examination of Water and Wastewater*, American Public Health Association, Washington DC, United States of America.
- Apte SC. (1995). Factors affecting the release of metals from discharged mine tailings in the Porgera/Strickland River system. CSIRO Investigation Report CETLH/IR394 prepared for the Porgera Joint Venture.
- CSIRO (1996). *Porgera Joint Venture Review of Riverine Impacts*. CSIRO Environmental Projects Office.
- Davies M, Parker G and Savigny W (2002). *Porgera Mine Erodible Dumps Panel Review Final Report*. AMEC Consultants.
- EC (2006). *Commission of the European Communities, Commission Regulation (EC) No 1881/2006 of 19 December 2006, setting maximum levels for certain contaminants in foodstuffs*.
- Fukuda Y, Townsend S. (2006). *Water Quality Objectives for the Darwin Harbour*. Region Aquatic Health Unit, Department of Natural Resources, Environment, the Arts and Sport, Darwin, NT.
- HK (1997). *Hong Kong Food Adulteration (Metallic Contamination) Regulations*. Centre for Food Safety, the Government of the Hong Kong Special Administrative Region. <https://www.gld.gov.hk/egazette/pdf/20182223/es220182223113.pdf>
- ISO 14001 (2015). International Organisation for Standardisation, AS/NZSISO 14001:2015, Environmental management systems – Requirements with guidance for use.
- Long ER, MacDonald DD, Smith SL, Calder ED. (1995). *Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments*. Environment Management 19, 81-97.
- NSR (1990), NSR Environmental Consultants PTY LTD, *Environmental Baseline Porgera Gold Mine Volume 1 and Volume 2*, April 1990.
- NSW (2010), *NSW Protection of the Environment Operations (Clean Air) Regulation 2010*.
- PNG (1984), *PNG Public Health (Drinking Water) Regulation 1984*. Schedule 1 Standards for Raw Water.

Storey AW, Andersen LE, Lynas J, Melville F. (2007). Port Curtis Ecosystem Health Report Card. Port Curtis Integrated Monitoring Program, Centre for Environmental Management, Central Queensland University. Gladstone, Queensland.

USEPA (2016). *External Peer Review Draft Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater*. United States Environmental Protection Agency Office of Water, Office of Science and Technology, Washington D.C.

VIC (2001), *Victoria State Environment Protection Policy (Air Quality Management) 2001*.

WHO (2017), WHO Guidelines for drinking-water quality: fourth edition incorporating the first addendum.

WRM (2017). Aquatic Macroinvertebrate Monitoring Program - 2016 Baseline Surveys. Unpublished report to Barrick (Niugini) Limited, Papua New Guinea, by Wetland Research & Management. Draft report v1.

WRM (2018). Biology data Review and Statistical Analysis: Recommended Indicators and Analytical Methods for Fish and Prawn Impact Assessments. Unpublished report to Porgera Joint Venture, Papua New Guinea, by Wetland Research & Management. Final Report 12 March 2019.

APPENDIX A. QA & QC – CHEMISTRY AND BIOLOGY

Collection of environmental monitoring data is performed by the NPL Environment Department. The team consists of 24 staff and includes trained environmental scientists, chemists, engineers, biologists, hydrologists and technicians.

Water samples are analysed for alkalinity, pH, conductivity, total suspended solids, sulfate, chloride, WAD-CN, total hydrocarbons and coliforms by NPL staff at the onsite environmental chemistry laboratory. All other analysis of water, sediment and fish and prawn tissue in 2024 are performed by the National Measurement Institute (NMI) in Sydney which is a NATA-accredited laboratory.

Quality assurance and quality control (QA & QC) measures for water, sediment and tissue metals are performed to ensure the results of the monitoring program are accurate, representative and defensible. The QA & QC measures associated with the Porgera Environmental Monitoring and Reporting program are discussed in the following sections.

Training and Competency

The training and competency system is aimed at achieving consistent application of techniques for sampling, analysis, data management and reporting that are consistent with industry best practice.

Each task associated with the monitoring and reporting program is outlined in a Standard Operating Procedure (SOP). Each staff member is then trained to conduct the task in accordance with the SOP and then assessed to confirm competence.

QA & QC Sampling and Laboratory Results

The sampling schedule includes the collection of QA & QC samples for the purpose of validating that the monitoring results are accurate and representative. The QA & QC samples, their purpose, collection frequency and performance criteria are shown in Table A-1.

Upon receiving the results from the laboratory, the results are screened to ensure the QA & QC results are within acceptable limits prior to being transferred to the database.

Water and Sediment

The QA & QC samples for water and sediment, their purpose, collection frequency and performance criteria are shown in Table A-1. It should be noted that the acceptance criteria applied to field duplicate samples of $\pm 44\%$ aligns with the criteria applied by NMI to the internal laboratory samples, and when combined with the acceptance criteria applied to the field blanks, is considered acceptable for supporting a robust QA program.

Table A-1 QA & QC Samples – Water and Sediment Quality

QA & QC Sample	Purpose	Sample rate	Acceptance Criteria
Combined field, method and transport blank (water only)	Test for contamination during field work, sample preparation and transport. Test for accuracy of laboratory analytical method.	1 blank per sample batch	≤2 x LOR for each analyte
Field duplicate	Test repeatability of laboratory analytical method.	1 duplicate for every 8 samples (minimum 1 per batch)	±44% of primary sample
NMI lab duplicate	Test repeatability of laboratory analytical method.	1 blank per sample batch	±44% of primary sample
NMI lab control sample	Test influence of sample preparation and analysis on recovery.	1 blank per sample batch	75% – 120% recovery
NMI matrix spike	Test influence of sample preparation and analysis on recovery.	1 blank per sample batch	75% – 120% recovery

The results of QA & QC samples from water quality sampling at SG3 in 2024 as shown in Table A-2 indicated good performance for all of QA & QC samples across all parameters.

Table A-2 2024 Water quality QA & QC sample results SG3

Sample Type	% Within Acceptable Criteria												
	Ag-D	As-D	Cd-D	Cr-D	Cu-D	Hg-D	Ni-D	Pb-D	Se-D	Zn-D	pH	EC	WAD-CN
Combined Blank	100	92	100	100	100	100	90	92	100	100	NA	92	100
CRM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	100	100	NA
Field Duplicate	100	90	100	92	90	100	100	90	96	96	92	100	100
NMI Duplicate	100	100	100	100	100	100	100	100	100	100	NA	NA	NA
NMI Lab Control Sample	100	100	100	100	100	100	100	100	100	100	NA	NA	NA
NMI Matrix Spike	100	100	100	100	100	100	100	100	100	100	NA	NA	NA

D = Dissolved fraction

The results of QA & QC samples from sediment quality sampling at SG3 in 2024 shown in Table A-3 indicated good performance of all samples for all parameters.

Table A-3 2024 Sediment quality QA & QC sample results SG3

Sample Type	% Within Acceptable Criteria									
	Ag - WAE	As - WAE	Cd - WAE	Cr - WAE	Cu - WAE	Hg - WAE	Ni - WAE	Pb - WAE	Se - WAE	Zn - WAE
Field Duplicate	95	95	97	98	97	96	93	96	100	93
NMI Duplicate	100	100	100	92	100	91	100	100	100	100
NMI Matrix Spike	100	95	100	100	100	100	100	100	95	100
NMI Blank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NMI LCS	100	100	100	100	100	100	100	100	100	96

WAE = Weak-Acid Extractable

In addition to the routine QA & QC samples, NPL also participated in five proficiency test rounds in 2024 run by Proficiency Testing Australia. The inter-laboratory testing program provides an independent assessment of the analytical methods used within the NPL Environmental Chemistry Laboratory.

The proficiency testing results are summarised in Table A-4. The results show that a number of PTA results obtained by the NPL environment laboratory did not fall within the acceptable range of the test. Each time a parameter falls outside the acceptable range, an internal investigation is commenced to identify the cause and establish corrective and preventative actions. Actions are ongoing to address these results.

Table A-4 Proficiency testing results 2024

Date	Round	Analyte	Units	Lab result	MU	Median	NORM IQR	CV (%)	n	z-score
Feb-24	320	Chloride	mg/L	78.9	NA	74.7	2.67	3.6	17	1.57
		Chloride	mg/L	156	NA	149	6.7	4.5	17	1.05
May-24	324	Sulfate	mg/L	26.5	NA	20.45	1.52	7.4	22	3.98
		Sulfate	mg/L	33.5	NA	35.05	2.11	6	22	-0.78
		Conductivity	µS/cm	370	NA	383.5	6.30	1.6	36	-1.41
		Conductivity	µS/cm	1295	NA	1361	19.80	1.5	36	-2.42
		pH - potable	SU	7.03	NA	7.505	0.09	1.2	38	-5.45
		pH - potable	SU	6.53	NA	6.81	0.06	0.8	38	-4.79
		pH - standard	SU	7.83	NA	7.73	0.04	0.6	37	2.25
		Turbidity	NTU	3.14	NA	2.87	0.39	13.4	25	0.7
		Turbidity	NTU	4.34	NA	3.63	0.49	13.5	25	1.45
		Turbidity standard	NTU	4.49	NA	4.0	0.04	3.3	25	3.67
		Colour standard	Pt/Co	14	NA	12.0	1.50	12.4	14	1.35
Jul-24	326	Total Recoverable Oil and Grease	mg/L	23.3	1.2	74.3	14.16	19.1	23	-3.69
		Total Recoverable Oil and Grease	mg/L	36.1	2.6	55.25	17.83	32.3	23	-1.86
Sep-24	328	Total Solids	mg/L	182	3	219	17.4	8	22	-2.12
		Total Solids	mg/L	315	12	334.5	21.5	6.4	22	0.91
		Total Suspended Solids	mg/L	24.5	3.7	26.6	2.48	9.3	39	-0.85

Date	Round	Analyte	Units	Lab result	MU	Median	NORM IQR	CV (%)	n	z-score
		Total Suspended Solids	mg/L	38.3	2.6	37.75	4.60	12.2	38	0.23
Oct-24	332	Sulfate	mg/L	38.7	NA	32.65	1.7	5.1	14	3.63
		Sulfate	mg/L	17.7	NA	17.95	0.87	4.9	14	-0.29
		Conductivity	µS/cm	1186	NA	1226	20.0	1.6	25	-1.63
		Conductivity	µS/cm	411	NA	410	10.4	2.5	25	0.10
		pH - potable	SU	7.15	NA	7.22	0.690	0.9	28	-1.02
		pH - potable	SU	7.05	NA	7.01	0.076	1.1	28	0.53
		pH - standard	SU	7.6	NA	7.48	0.052	0.7	28	2.31
		Turbidity - potable	NTU	9.42	NA	4.505	0.93	20.7	16	5.28
		Turbidity - potable	NTU	7.63	NA	3.775	0.67	17.6	16	5.79
		Turbidity standard	NTU	3.87	NA	3.85	0.27	7.0	15	0.07
		Colour standard	Pt/Co		NA					
		Within acceptable range of results								
		Outlier – value lies outside acceptable range of results.								

MU - Measurement Uncertainty, NORM IQR - Normalized Interquartile Range, CV - Coefficient of Variation, Z - score - statistical measurement of a score's relationship to the mean.

Tissue Metals

The QA & QC samples for tissue metal, their purpose, collection frequency and performance criteria are shown in Table A-5. It should be noted that the acceptance criteria applied to field duplicate samples of ±44% aligns with the criteria applied by NMI to the internal lab samples, and when combined with the acceptance criteria applied to the field blanks, is considered acceptable for supporting a robust QA program.

Table A-5 QA & QC samples – tissue metals

QA&QC Sample	Purpose	Sample rate	Acceptance Criteria
Field reference sample (Fish flesh of known concentration)	Test for contamination during field work, sample preparation and transport. Test for accuracy of laboratory analytical method.	1 blank per sample batch (as per sampling monitoring schedule)	±44% of known concentration.
Field duplicate	Test repeatability of laboratory analytical method.	1 duplicate for every 8 samples (minimum 1 per batch)	±44% of primary sample
NMI blank	Test for contamination during sample analysis. Test for accuracy of laboratory analytical method.	1 blank per sample batch	≤LOR for each analyte

QA&QC Sample	Purpose	Sample rate	Acceptance Criteria
NMI duplicate	Test repeatability of laboratory analytical method.	Minimum 1 blank per sample batch	±44% of primary sample
NMI lab control sample	Test influence of sample preparation and analysis on recovery.	Minimum 1 blank per sample batch	75 – 120% recovery
NMI matrix spike	Test influence of sample preparation and analysis on recovery.	Minimum 1 blank per sample batch	75 – 120% recovery

The results of QA & QC samples from tissue metal sampling in 2024 are shown in Table A-6 and indicate good performance for the majority of QA & QC samples across most parameters. The exceptions are the performance of Arsenic, chromium, Nickel, mercury and selenium in the field duplicate samples and chromium and zinc in the field reference sample. An increased focus of compliance to SOPs and training and competency is expected to improve accuracy and will facilitate a more timely investigation of non-compliant QA & QC results.

Table A-6 2024 Tissue metal QA & QC sample results

	% Within Acceptable Criteria									
	n	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Field Duplicate	14	93	100	90	100	90	93	100	95	100
Field Reference Sample	14	100	100	93	100	100	100	100	100	95
NMI Duplicate	10	100	100	100	100	100	100	100	100	100
NMI Lab Control Sample	10	100	100	100	100	100	100	100	100	100
NMI Matrix Spike	10	100	100	100	100	100	100	100	100	100

Discussion

The QA & QC program is designed to provide accurate, representative and defensible results. It includes a training and competency program to ensure the correct procedures are defined and complied with, and it includes a sampling program to provide evidence to validate that the results are accurate and representative.

The results show that overall, the QA & QC program provides a good level of confidence that the results as reported are accurate and representative. A number of opportunities for improvement have been identified from a CSIRO lab audit conducted in December 2024, and the review of SOPs, training and competency and timely investigation of poor QA & QC performance will be ongoing throughout 2025.

APPENDIX B. BOX PLOTS EXPLAINED

Box plots are used throughout the AER to visually present a range of statistical information for a given dataset and to allow visual comparison of statistical information between a number of datasets.

The features of a boxplot are defined below and shown in Figure B-1.

Median: The median (middle quartile) marks the mid-point of the data and is shown by the line that divides the box into two parts. Half the values are greater than or equal to this value and half are less.

Inter-quartile range (IQR): The middle “box” represents the middle 50% of values for the dataset. The range of values from lower to upper quartile is referred to as the inter-quartile range. The middle 50% of values fall within the inter-quartile range.

Upper quartile: Seventy-five percent of the values within the dataset are lower than the upper quartile.

Lower quartile: Twenty-five percent of the values within the dataset are lower than the lower quartile.

Whiskers: The upper and lower whiskers represent scores outside the middle 50%. Whiskers often (but not always) stretch over a wider range of scores than the middle quartile groups.

Outlier: Values within the dataset that statistically do not fall within the IQR, outliers can be treated as a high or low value that is significantly different from the IQR of values within the dataset.

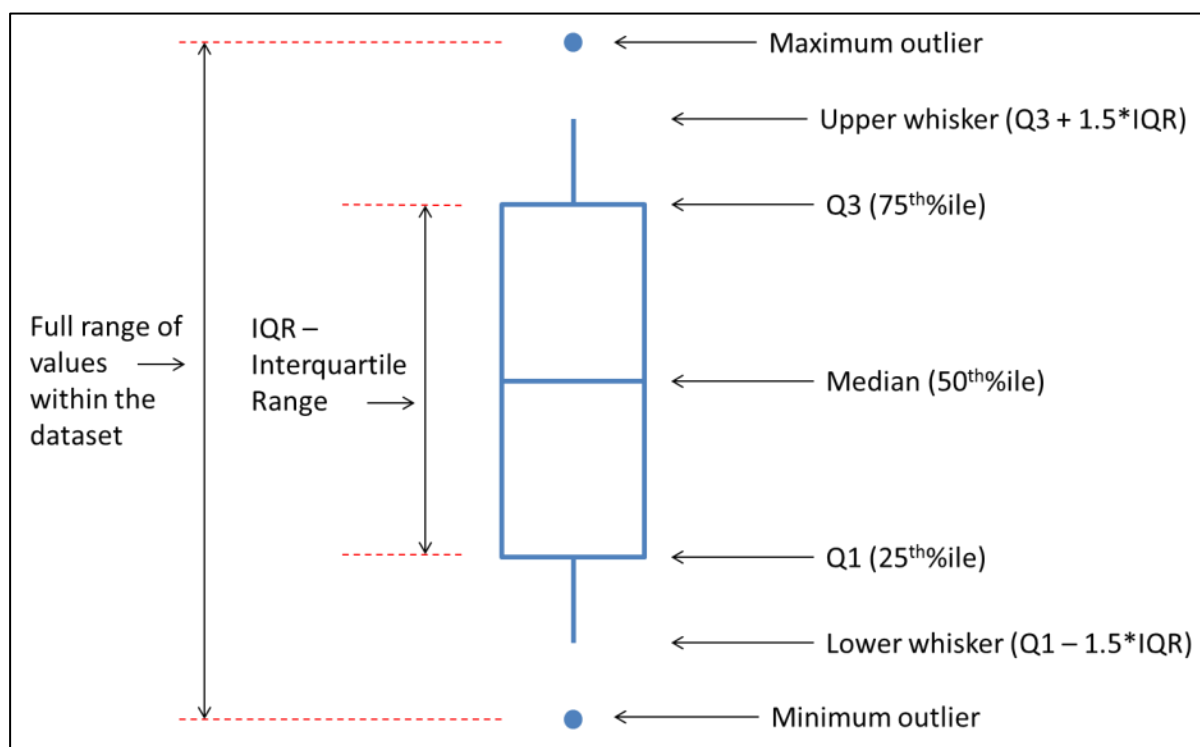


Figure B-1 Box Plot Explained

Interpreting box plots between two datasets and against a trigger value is shown in Figure B-2 and described below.

SITE A:

The median value for the indicator at Site A falls below the trigger value, as do all of the values, with the exception of an outlier. This indicates that the median is likely to be statistically significantly less than the trigger value, to be confirmed by Wilcoxon’s test, and indicating low risk. The distance between the

median and Q3 is the same as the distance between the median and Q1, indicating the data are normally distributed and therefore there are as many values between the median and Q3 as there are between the median and Q1.

SITE B:

The median value for the indicator at Site B falls below the trigger value, as do all of the values. This indicates that the median is likely to be statistically significantly less than the trigger value, to be confirmed by Wilcoxon’s test, and indicating low risk. The distance between the median and Q3 is larger than that between the median and Q1, indicating the data are not normally distributed and skewed towards Q3, meaning more values were recorded between the median and Q3, than between the median and Q1.

COMPARING BETWEEN SITES:

The median and IQR at Site A are higher than Site B, indicating that values for the indicator are higher at Site A than at Site B for the particular dataset.

The IQR for Site A is larger than for Site B, indicating a wider range of values were recorded at Site A than at Site B for the particular dataset.

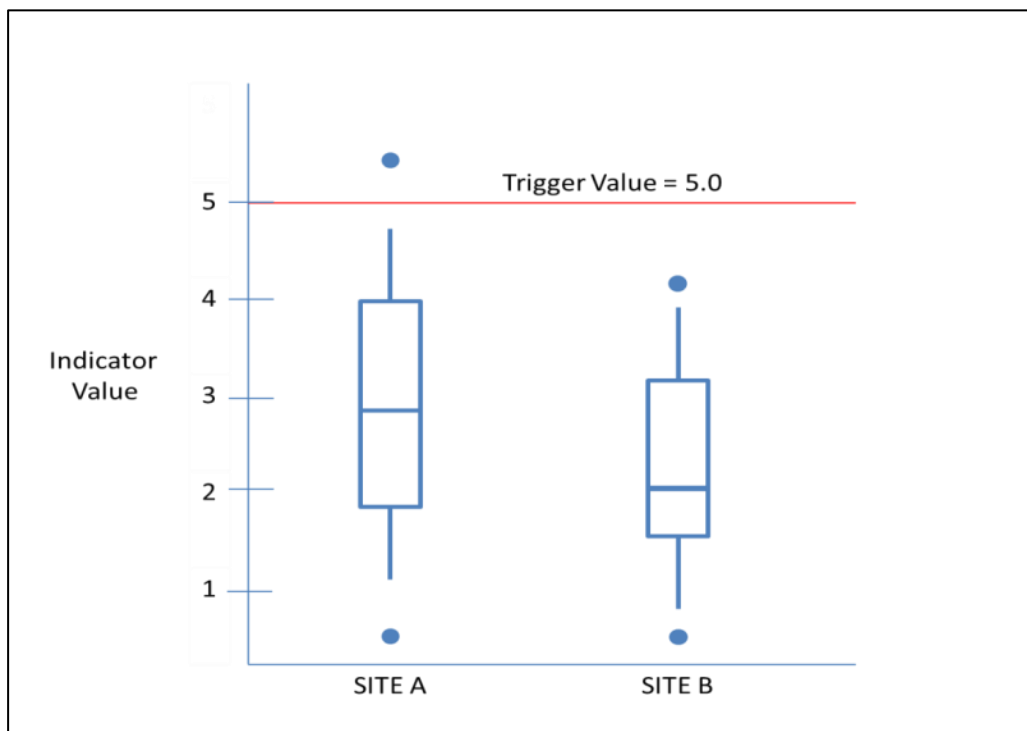


Figure B-1 Comparing box plots between sites and against trigger values

**APPENDIX C. BOX PLOTS AND TRENDS OF MINE AREA RUNOFF WATER
AND SEDIMENT QUALITY 2015–2024**

Table C-1 28 Level 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
28 Level	N	N(Test)	Median	Result	Go to			
pH	12	12	7.7	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.001 / 0.002	LOW
EC	12	12	633	TSM ≥ TV	Step 2	230	0.999	POTENTIAL
TSS	12	12	36	TSM < TV	Step 1	2,837	0.001	LOW
Ag-D	12	12	0.01	TSM < TV	Step 1	0.05	0.001	LOW
As-D	12	12	1.5	TSM < TV	Step 1	24	0.001	LOW
Cd-D	12	12	0.05	TSM < TV	Step 1	0.34	0.001	LOW
Cr-D	12	12	0.10	TSM < TV	Step 1	1.0	0.001	LOW
Cu-D	12	12	0.25	TSM < TV	Step 1	1.4	0.001	LOW
Fe-D	12	12	32	TSM < TV	Step 1	75	0.362	POTENTIAL
Hg-D	12	12	0.05	TSM < TV	Step 1	0.60	0.001	LOW
Ni-D	12	12	2.5	TSM < TV	Step 1	21	0.001	LOW
Pb-D	12	12	0.12	TSM < TV	Step 1	7.3	0.001	LOW
Se-D	12	12	0.20	TSM < TV	Step 1	11	0.001	LOW
Zn-D	12	12	7.6	TSM < TV	Step 1	20	0.112	POTENTIAL

Table C-2 Anjolek SDA 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Anjolek	N	N(Test)	Median	Result	Go to			
pH	0	0	NR	NR	NR	NR	NR	NR
EC	0	0	NR	NR	NR	NR	NR	NR
TSS	0	0	NR	NR	NR	NR	NR	NR
Ag-D	0	0	NR	NR	NR	NR	NR	NR
As-D	0	0	NR	NR	NR	NR	NR	NR
Cd-D	0	0	NR	NR	NR	NR	NR	NR
Cr-D	0	0	NR	NR	NR	NR	NR	NR
Cu-D	0	0	NR	NR	NR	NR	NR	NR
Fe-D	0	0	NR	NR	NR	NR	NR	NR
Hg-D	0	0	NR	NR	NR	NR	NR	NR
Ni-D	0	0	NR	NR	NR	NR	NR	NR
Pb-D	0	0	NR	NR	NR	NR	NR	NR
Se-D	0	0	NR	NR	NR	NR	NR	NR
Zn-D	0	0	NR	NR	NR	NR	NR	NR

NR – Not recorded – sampling not performed at this site during 2024 due to security issues preventing safe access.

Table C-3 Kaiya at Yuyan Bridge 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Kaiya	N	N(Test)	Median	Result	Go to			
pH	1	1	7.6	Lower TV<TSM<Upper	Step 1 / 2	6.0-8.1	0.500 / 0.500	LOW*
EC	1	1	374	TSM ≥ TV	Step 2	230	0.997	POTENTIAL*
TSS	1	1	2,400	TSM < TV	Step 1	2,837	0.500	LOW*
Ag-D	1	1	0.01	TSM < TV	Step 1	0.05	0.500	LOW*
As-D	1	1	2.3	TSM < TV	Step 1	24	0.500	LOW*
Cd-D	1	1	0.05	TSM < TV	Step 1	0.34	0.500	LOW*
Cr-D	1	1	0.1	TSM < TV	Step 1	1.0	0.500	LOW*
Cu-D	1	1	0.65	TSM < TV	Step 1	1.4	0.500	LOW*
Fe-D	1	1	2.2	TSM < TV	Step 1	75	0.500	LOW*
Hg-D	1	1	0.05	TSM < TV	Step 1	0.60	0.500	LOW*
Ni-D	1	1	0.5	TSM < TV	Step 1	21	0.500	LOW*
Pb-D	1	1	0.34	TSM < TV	Step 1	7.3	0.500	LOW*
Se-D	1	1	0.29	TSM < TV	Step 1	11	0.500	LOW*
Zn-D	1	1	3.5	TSM < TV	Step 1	20	0.500	LOW*

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison.

Table C-4 Kaiya River downstream Anjolek erodible dump 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Kaiya	N	N(Test)	Median	Result	Go to			
pH	0	0	NR	NR	NR	NR	NR	NR
EC	0	0	NR	NR	NR	NR	NR	NR
TSS	0	0	NR	NR	NR	NR	NR	NR
Ag-D	0	0	NR	NR	NR	NR	NR	NR
As-D	0	0	NR	NR	NR	NR	NR	NR
Cd-D	0	0	NR	NR	NR	NR	NR	NR
Cr-D	0	0	NR	NR	NR	NR	NR	NR
Cu-D	0	0	NR	NR	NR	NR	NR	NR
Fe-D	0	0	NR	NR	NR	NR	NR	NR
Hg-D	0	0	NR	NR	NR	NR	NR	NR
Ni-D	0	0	NR	NR	NR	NR	NR	NR
Pb-D	0	0	NR	NR	NR	NR	NR	NR

NPL Annual Environment Report 2024

Discharge Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Kaiya	N	N(Test)	Median	Result			
Se-D	0	0	NR	NR	NR	NR	NR
Zn-D	0	0	NR	NR	NR	NR	NR

NR – Not recorded – sampling not performed at this site during 2024 due to security issues preventing safe access.

Table C-5 Kogai Culvert 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment	
Kogai	N	N(Test)	Median	Result				Go to
pH	12	12	8.0	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.001 / 0.023	LOW
EC	12	12	551	TSM ≥ TV	Step 2	230	0.999	POTENTIAL
TSS	12	12	370	TSM < TV	Step 1	2,837	0.001	LOW
Ag-D	12	12	0.01	TSM < TV	Step 1	0.05	0.001	LOW
As-D	12	12	1.0	TSM < TV	Step 1	24	0.001	LOW
Cd-D	12	12	0.083	TSM < TV	Step 1	0.34	0.002	LOW
Cr-D	12	12	0.10	TSM < TV	Step 1	1.0	0.001	LOW
Cu-D	12	10	0.90	TSM < TV	Step 1	1.4	0.010	LOW
Fe-D	12	12	6.2	TSM < TV	Step 1	75	0.001	LOW
Hg-D	12	12	0.05	TSM < TV	Step 1	0.60	0.001	LOW
Ni-D	12	12	0.68	TSM < TV	Step 1	21	0.001	LOW
Pb-D	12	12	0.47	TSM < TV	Step 1	7.3	0.001	LOW
Se-D	12	12	0.20	TSM < TV	Step 1	11	0.001	LOW
Zn-D	12	12	6.7	TSM < TV	Step 1	20	0.027	LOW

Table C-6 Kogai Stable dump toe area 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment	
Kogai	N	N(Test)	Median	Result				Go to
pH	12	12	8.0	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.001 / 0.001	LOW
EC	12	12	1,370	TSM ≥ TV	Step 2	230	0.999	POTENTIAL
TSS	12	12	67	TSM < TV	Step 1	2,837	0.001	LOW
Ag-D	12	12	0.01	TSM < TV	Step 1	0.05	0.001	LOW
As-D	12	12	0.56	TSM < TV	Step 1	24	0.001	LOW
Cd-D	12	12	0.71	TSM ≥TV	Step 2	0.34	0.985	POTENTIAL
Cr-D	12	12	0.10	TSM < TV	Step 1	1.0	0.001	LOW
Cu-D	12	12	0.58	TSM < TV	Step 1	1.4	0.001	LOW

NPL Annual Environment Report 2024

Fe-D	12	12	2.9	TSM < TV	Step 1	75	0.001	LOW
Hg-D	12	12	0.05	TSM < TV	Step 1	0.60	0.001	LOW
Ni-D	12	12	1.4	TSM < TV	Step 1	21	0.001	LOW
Pb-D	12	12	0.22	TSM < TV	Step 1	7.3	0.001	LOW
Se-D	12	12	0.20	TSM < TV	Step 1	11	0.001	LOW
Zn-D	12	12	101	TSM ≥ TV	Step 2	20	0.998	POTENTIAL

Table C-7 Lime Plant discharge 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment	
L Plant	N	N(Test)	Median	Result				Go to
pH	12	12	10.7	TSM ≥TV	Step 3	6.0-8.1	0.001 / 0.998	POTENTIAL
EC	12	12	378	TSM ≥TV	Step 2	230	0.967	POTENTIAL
TSS	12	12	113	TSM < TV	Step 1	2,837	0.023	LOW
Ag-D	12	12	0.01	TSM < TV	Step 1	0.05	0.001	LOW
As-D	12	12	0.13	TSM < TV	Step 1	24	0.001	LOW
Cd-D	12	12	0.05	TSM < TV	Step 1	0.34	0.001	LOW
Cr-D	12	11	2.8	TSM ≥TV	Step 2	1.0	0.988	POTENTIAL
Cu-D	12	12	0.81	TSM < TV	Step 1	1.4	0.033	LOW
Fe-D	12	12	1.8	TSM < TV	Step 1	75	0.001	LOW
Hg-D	12	12	0.05	TSM < TV	Step 1	0.60	0.001	LOW
Ni-D	12	12	0.50	TSM < TV	Step 1	21	0.001	LOW
Pb-D	12	12	0.10	TSM < TV	Step 1	7.3	0.001	LOW
Se-D	12	12	0.20	TSM < TV	Step 1	11	0.001	LOW
Zn-D	12	12	1.1	TSM < TV	Step 1	20	0.001	LOW

Table C-8 Wendoko Creek D/S Anawe Nth 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment	
Wend	N	N(Test)	Median	Result				Go to
pH	12	12	7.8	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.001 / 0.001	LOW
EC	12	12	1,805	TSM ≥ TV	Step 2	230	0.999	POTENTIAL
TSS	12	12	18	TSM < TV	Step 1	2,837	0.001	LOW
Ag-D	11	11	0.01	TSM < TV	Step 1	0.05	0.002	LOW
As-D	12	12	1.1	TSM < TV	Step 1	24	0.001	LOW
Cd-D	12	12	1.1	TSM ≥TV	Step 2	0.34	0.999	POTENTIAL
Cr-D	12	12	0.10	TSM < TV	Step 1	1.0	0.001	LOW
Cu-D	12	11	0.56	TSM < TV	Step 1	1.4	0.002	LOW
Fe-D	12	12	2.3	TSM < TV	Step 1	75	0.001	LOW
Hg-D	12	12	0.05	TSM < TV	Step 1	0.60	0.001	LOW
Ni-D	12	12	1.2	TSM < TV	Step 1	21	0.001	LOW
Pb-D	12	12	0.20	TSM < TV	Step 1	7.3	0.001	LOW
Se-D	12	12	0.38	TSM < TV	Step 1	11	0.001	LOW
Zn-D	12	12	310	TSM ≥TV	Step 2	20	0.999	POTENTIAL

Table C-9Yakatabari Creek D/S 28 level 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment	
Yakatabari	N	N(Test)	Median	Result				Go to
pH	12	12	7.5	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.001 / 0.001	LOW
EC	12	12	593	TSM ≥ TV	Step 2	230	0.999	POTENTIAL
TSS	12	12	6,350	TSM ≥ TV	Step 2	2,837	0.990	POTENTIAL
Ag-D	12	12	0.01	TSM < TV	Step 1	0.05	0.001	LOW
As-D	12	12	12	TSM < TV	Step 1	24	0.001	LOW
Cd-D	12	12	0.05	TSM < TV	Step 1	0.34	0.112	POTENTIAL
Cr-D	12	12	0.10	TSM < TV	Step 1	1.0	0.001	LOW
Cu-D	12	12	1.0	TSM < TV	Step 1	1.4	0.003	LOW
Fe-D	12	12	3.3	TSM < TV	Step 1	75	0.001	LOW
Hg-D	12	12	0.05	TSM < TV	Step 1	0.60	0.001	LOW
Ni-D	12	12	1.5	TSM < TV	Step 1	21	0.001	LOW
Pb-D	12	12	0.60	TSM < TV	Step 1	7.3	0.001	LOW
Se-D	12	12	0.28	TSM < TV	Step 1	11	0.001	LOW
Zn-D	12	12	5.1	TSM < TV	Step 1	20	0.112	POTENTIAL

Table C-10 Yunarilama at Portal 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment	
Yunarilama	N	N(Test)	Median	Result				Go to
pH	12	12	7.6	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.001 / 0.001	LOW
EC	12	12	1,907	TSM ≥ TV	Step 2	230	0.999	POTENTIAL
TSS	12	12	6,750	TSM ≥ TV	Step 2	2,837	0.927	POTENTIAL
Ag-D	12	12	0.01	TSM < TV	Step 1	0.05	0.001	LOW
As-D	12	12	2.5	TSM < TV	Step 1	24	0.001	LOW
Cd-D	12	12	0.05	TSM < TV	Step 1	0.34	0.001	LOW
Cr-D	12	12	0.10	TSM < TV	Step 1	1.0	0.002	LOW
Cu-D	12	12	0.47	TSM < TV	Step 1	1.4	0.001	LOW
Fe-D	12	12	4.7	TSM < TV	Step 1	75	0.002	LOW
Hg-D	12	12	0.05	TSM < TV	Step 1	0.60	0.001	LOW
Ni-D	12	12	1.9	TSM < TV	Step 1	21	0.001	LOW
Pb-D	12	12	0.21	TSM < TV	Step 1	7.3	0.001	LOW
Se-D	12	12	1.0	TSM < TV	Step 1	11	0.001	LOW
Zn-D	12	11	5.0	TSM < TV	Step 1	20	0.002	LOW

Table C-11 Tailings slurry 2024 median against upper river TV (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Tails W	N	N(Test)	Median	Result	Go to			
pH	48	48	6.9	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	<0.001 / <0.001	LOW
EC	48	48	1,657	TSM ≥TV	Step 2	230	1.0	POTENTIAL
TSS	48	48	105,000	TSM ≥ TV	Step 2	2,837	1.0	POTENTIAL
Ag-D	48	48	0.01	TSM < TV	Step 1	0.05	<0.001	LOW
As-D	48	48	2.3	TSM < TV	Step 1	24	<0.001	LOW
Cd-D	48	48	2.5	TSM ≥ TV	Step 2	0.34	1.0	POTENTIAL
Cr-D	48	48	0.1	TSM < TV	Step 1	1.0	<0.001	LOW
Cu-D	48	47	2.5	TSM >TV	Step 2	1.4	1.0	POTENTIAL
Fe-D	48	48	10	TSM < TV	Step 1	75	0.009	LOW
Hg-D	48	47	0.05	TSM < TV	Step 1	0.60	<0.001	LOW
Ni-D	48	48	104	TSM ≥TV	Step 2	21	1.0	POTENTIAL
Pb-D	48	48	0.35	TSM < TV	Step 1	7.3	<0.001	LOW
Se-D	48	48	0.79	TSM < TV	Step 1	11	<0.001	LOW
Zn-D	48	47	1,035	TSM ≥TV	Step 2	20	1.0	POTENTIAL

Table C-12 Tailings solids 2024 median against upper river sediment TV (mg/kg)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Tails S	N	N(Test)	Median	Result	Go to			
Ag-WAE	48	48	1.6	TSM ≥TV	Step 2	1.0	0.995	POTENTIAL
As- WAE	48	46	42	TSM ≥TV	Step 2	20	1.0	POTENTIAL
Cd- WAE	48	48	4.4	TSM ≥TV	Step 2	1.5	1.0	POTENTIAL
Cr- WAE	48	48	29	TSM < TV	Step 1	80	<0.001	LOW
Cu- WAE	48	46	84	TSM ≥TV	Step 2	65	1.0	POTENTIAL
Hg- WAE	48	47	0.04	TSM < TV	Step 1	0.15	<0.001	LOW
Ni- WAE	48	48	19	TSM < TV	Step 1	21	0.23	POTENTIAL
Pb- WAE	48	48	160	TSM ≥TV	Step 2	50	1.0	POTENTIAL
Se- WAE	48	46	0.31	TSM ≥TV	Step 2	0.22	1.0	POTENTIAL
Zn- WAE	48	48	635	TSM ≥TV	Step 2	200	1.0	POTENTIAL

Table C-13 28 Level 2024 median against upper river TV- sediment whole sediment WAE (mg/kg)

Discharge Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment	
28 Level	N	N(Test)	Median	Result				Go to
Ag-WAE	4	4	1.4	TSM ≥ Upper TV	Step 2	1.0	0.819	POTENTIAL*
As- WAE	4	4	16	TSM < Upper TV	Step 1	20	0.292	LOW*
Cd- WAE	4	3	0.93	TSM < Upper TV	Step 1	1.5	0.091	LOW*
Cr- WAE	4	4	8.8	TSM < Upper TV	Step 1	80	0.050	LOW*
Cu- WAE	4	4	22	TSM < Upper TV	Step 1	65	0.050	LOW*
Hg- WAE	4	4	0.01	TSM < Upper TV	Step 1	0.15	0.050	LOW*
Ni- WAE	4	4	11	TSM < Upper TV	Step 1	21	0.050	LOW*
Pb- WAE	4	4	150	TSM ≥ Upper TV	Step 2	50	0.978	POTENTIAL*
Se- WAE	4	4	0.15	TSM < Upper TV	Step 1	0.22	0.050	LOW*
Zn- WAE	4	4	400	TSM ≥ Upper TV	Step 2	200	0.978	POTENTIAL*

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison.

Table C-14 Anjolek SDA 2024 median against upper river TV- sediment whole sediment WAE (mg/kg)

Discharge Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment	
Anjolek	N	N(Test)	Median	Result				Go to
Ag-WAE	NR	NR	NR	NR	NR	1.0	NR	NR
As- WAE	NR	NR	NR	NR	NR	20	NR	NR
Cd- WAE	NR	NR	NR	NR	NR	1.5	NR	NR
Cr- WAE	NR	NR	NR	NR	NR	80	NR	NR
Cu- WAE	NR	NR	NR	NR	NR	65	NR	NR
Hg- WAE	NR	NR	NR	NR	NR	0.15	NR	NR
Ni- WAE	NR	NR	NR	NR	NR	22	NR	NR
Pb- WAE	NR	NR	NR	NR	NR	50	NR	NR
Se- WAE	NR	NR	NR	NR	NR	0.15	NR	NR
Zn- WAE	NR	NR	NR	NR	NR	200	NR	NR

NR – Not recorded – sampling not performed at this site during 2024 due to security issues preventing safe access.

Table C-15 Kaiya at Yuyan Bridge 2024 median against upper river TV- sediment whole sediment WAE (mg/kg)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Kaiya	N	N(Test)	Median	Result	Go to			
Ag-WAE	NR	NR	NR	NR	NR	1.0	NR	NR
As- WAE	NR	NR	NR	NR	NR	20	NR	NR
Cd- WAE	NR	NR	NR	NR	NR	1.5	NR	NR
Cr- WAE	NR	NR	NR	NR	NR	80	NR	NR
Cu- WAE	NR	NR	NR	NR	NR	65	NR	NR
Hg- WAE	NR	NR	NR	NR	NR	0.15	NR	NR
Ni- WAE	NR	NR	NR	NR	NR	21	NR	NR
Pb- WAE	NR	NR	NR	NR	NR	50	NR	NR
Se- WAE	NR	NR	NR	NR	NR	0.22	NR	NR
Zn- WAE	NR	NR	NR	NR	NR	200	NR	NR

NR – Not recorded – sampling not performed at this site during 2024 due to security issues preventing safe access.

Table C-16 Kaiya River downstream Anjolek erodible dump 2019 median against upper river TV- sediment whole sediment WAE (mg/kg)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Kaiya	N	N(Test)	Median	Result	Go to			
Ag-WAE	NR	NR	NR	NR	NR	1.0	NR	NR
As- WAE	NR	NR	NR	NR	NR	20	NR	NR
Cd- WAE	NR	NR	NR	NR	NR	1.5	NR	NR
Cr- WAE	NR	NR	NR	NR	NR	80	NR	NR
Cu- WAE	NR	NR	NR	NR	NR	65	NR	NR
Hg- WAE	NR	NR	NR	NR	NR	0.15	NR	NR
Ni- WAE	NR	NR	NR	NR	NR	21	NR	NR
Pb- WAE	NR	NR	NR	NR	NR	50	NR	NR
Se- WAE	NR	NR	NR	NR	NR	0.22	NR	NR
Zn- WAE	NR	NR	NR	NR	NR	200	NR	NR

NR – Not recorded – sampling not performed at this site during 2024 due to security issues preventing safe access.

Table C-17 Kogai Culvert 2024 median against upper river TV- sediment whole sediment WAE (mg/kg)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Kogai C	N	N(Test)	Median	Result	Go to			
Ag-WAE	4	4	0.51	TSM ≥ TV	Step 2	1.0	0.050	POTENTIAL*
As- WAE	4	4	7.7	TSM < Upper TV	Step 1	20	0.050	LOW*
Cd- WAE	4	4	0.76	TSM < Upper TV	Step 1	1.5	0.050	LOW*
Cr- WAE	4	4	3.1	TSM < Upper TV	Step 1	80	0.050	LOW*
Cu- WAE	4	4	7.5	TSM < Upper TV	Step 1	65	0.050	LOW*
Hg- WAE	4	4	0.01	TSM < Upper TV	Step 2	0.15	0.050	LOW*
Ni- WAE	4	4	4.3	TSM < Upper TV	Step 1	21	0.050	LOW*
Pb- WAE	4	4	130	TSM ≥ TV	Step 2	50	0.978	POTENTIAL*
Se- WAE	4	4	0.22	TSM = Upper TV	Step 1	0.22	0.428	POTENTIAL*
Zn- WAE	4	4	145	TSM ≥ TV	Step 2	200	0.101	POTENTIAL*

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison.

Table C-18 Kogai Stable dump toe area 2024 median against upper river TV- sediment whole sediment WAE (mg/kg)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Kogai S	N	N(Test)	Median	Result	Go to			
Ag-WAE	5	5	0.67	TSM < Upper TV	Step 1	1.0	0.295	LOW*
As- WAE	5	5	16	TSM < Upper TV	Step 1	20	0.069	LOW*
Cd- WAE	5	5	2.0	TSM ≥ TV	Step 2	1.5	0.985	POTENTIAL*
Cr- WAE	5	5	3.2	TSM < Upper TV	Step 1	80	0.030	LOW*
Cu- WAE	5	5	9.9	TSM < Upper TV	Step 1	65	0.030	LOW*
Hg- WAE	5	5	0.01	TSM < Upper TV	Step 1	0.15	0.030	LOW*
Ni- WAE	5	5	4.6	TSM < Upper TV	Step 1	21	0.030	LOW*
Pb- WAE	5	5	200	TSM ≥ TV	Step 2	50	0.985	POTENTIAL*
Se- WAE	5	5	0.20	TSM < Upper TV	Step 1	0.22	0.181	LOW*
Zn- WAE	5	5	290	TSM ≥ TV	Step 2	200	0.985	POTENTIAL*

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison.

Table C-19 Lime Plant discharge 2024 median against upper river TV- sediment whole sediment WAE (mg/kg)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
L Plant	N	N(Test)	Median	Result	Go to			
Ag-WAE	4	4	0.09	TSM < Upper TV	Step 1	1.0	0.050	LOW*
As- WAE	4	4	1.2	TSM < Upper TV	Step 1	20	0.050	LOW*
Cd- WAE	4	4	0.37	TSM < Upper TV	Step 1	1.5	0.050	LOW*
Cr- WAE	4	4	11	TSM < Upper TV	Step 1	80	0.050	LOW*
Cu- WAE	4	4	4.2	TSM < Upper TV	Step 1	65	0.050	LOW*
Hg- WAE	4	4	0.01	TSM < Upper TV	Step 1	0.15	0.050	LOW*
Ni- WAE	4	4	3.1	TSM < Upper TV	Step 1	21	0.050	LOW*
Pb- WAE	4	4	8.7	TSM < Upper TV	Step 1	50	0.050	LOW*
Se- WAE	4	4	0.13	TSM < Upper TV	Step 1	0.22	0.101	LOW*
Zn- WAE	4	4	43	TSM < Upper TV	Step 1	200	0.050	LOW*

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison.

Table C-20 Wendoko Creek D/S Anawe Nth 2024 median against upper river TV- sediment whole sediment WAE (mg/kg)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Wend	N	N(Test)	Median	Result	Go to			
Ag-WAE	3	3	0.24	TSM < Upper TV	Step 1	1.0	0.091	LOW*
As- WAE	3	3	4.9	TSM < Upper TV	Step 1	20	0.091	LOW*
Cd- WAE	3	1	1.5	TSM < Upper TV	Step 1	1.5	0.500	LOW*
Cr- WAE	3	3	1.4	TSM < Upper TV	Step 1	80	0.091	LOW*
Cu- WAE	3	3	5.1	TSM < Upper TV	Step 1	65	0.091	LOW*
Hg- WAE	3	3	0.01	TSM < Upper TV	Step 1	0.15	0.091	LOW*
Ni- WAE	3	3	3.5	TSM < Upper TV	Step 1	21	0.091	LOW*
Pb- WAE	3	3	5.9	TSM ≥ TV	Step 2	50	0.789	POTENTIAL*
Se- WAE	3	3	0.23	TSM > Upper TV	Step 2	0.22	0.605	POTENTIAL*
Zn- WAE	3	3	150	TSM < Upper TV	Step 1	200	0.091	LOW*

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison.

Table C-21 Yakatabari Creek D/S 28 level 2024 median against upper river TV- sediment whole sediment WAE (mg/kg)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Yakatabari	N	N(Test)	Median	Result	Go to			
Ag-WAE	4	4	2.1	TSM ≥ TV	Step 2	1.0	0.899	POTENTIAL*
As- WAE	4	4	14	TSM < Upper TV	Step 1	20	0.101	LOW*
Cd- WAE	4	4	1.5	TSM = Upper TV	Step 2	1.5	0.428	POTENTIAL*
Cr- WAE	4	4	4.6	TSM < Upper TV	Step 1	80	0.050	LOW*
Cu- WAE	4	4	16	TSM < Upper TV	Step 1	65	0.050	LOW*
Hg- WAE	4	4	0.01	TSM < Upper TV	Step 1	0.15	0.050	LOW*
Ni- WAE	4	4	8.0	TSM < Upper TV	Step 1	21	0.050	LOW*
Pb- WAE	4	4	150	TSM ≥ TV	Step 2	50	0.950	POTENTIAL*
Se- WAE	4	4	0.17	TSM < Upper TV	Step 1	0.22	0.428	LOW*
Zn- WAE	4	4	265	TSM ≥ TV	Step 2	200	0.819	POTENTIAL*

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison.

Table C-22 Yunarilama at Portal 2024 median against upper river TV- sediment whole sediment WAE (mg/kg)

Discharge Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Yunarilama	N	N(Test)	Median	Result	Go to			
Ag-WAE	4	4	1.2	TSM > Upper TV	Step 2	1.0	0.819	POTENTIAL*
As- WAE	4	4	12	TSM < Upper TV	Step 1	20	0.137	LOW*
Cd- WAE	4	4	1.1	TSM < Upper TV	Step 1	1.5	0.292	LOW*
Cr- WAE	4	4	5.4	TSM < Upper TV	Step 1	80	0.050	LOW*
Cu- WAE	4	4	12	TSM < Upper TV	Step 1	65	0.050	LOW*
Hg- WAE	4	4	0.04	TSM < TV	Step 1	0.15	0.101	LOW*
Ni- WAE	4	4	8.6	TSM < Upper TV	Step 1	21	0.050	LOW*
Pb- WAE	4	4	125	TSM > Upper TV	Step 2	50	0.978	POTENTIAL*
Se- WAE	4	4	0.18	TSM < TV	Step 1	0.22	0.428	LOW*
Zn- WAE	4	4	178	TSM < TV	Step 2	200	0.572	LOW

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison

NPL Annual Environment Report 2024

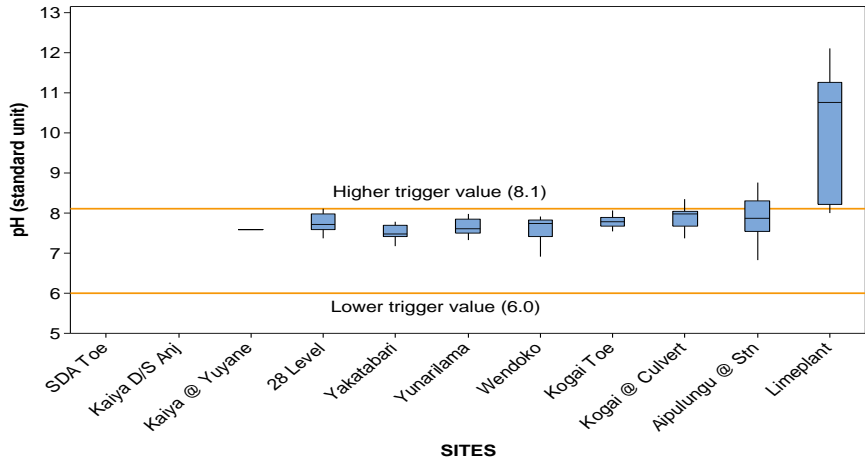


Figure C-1 pH in mine contact runoff 2024

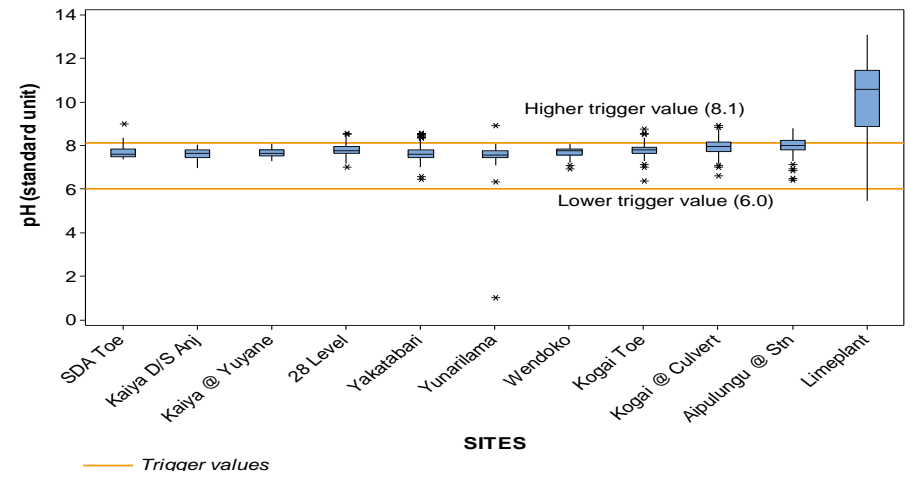


Figure C-2 pH in mine contact runoff 2015-2024

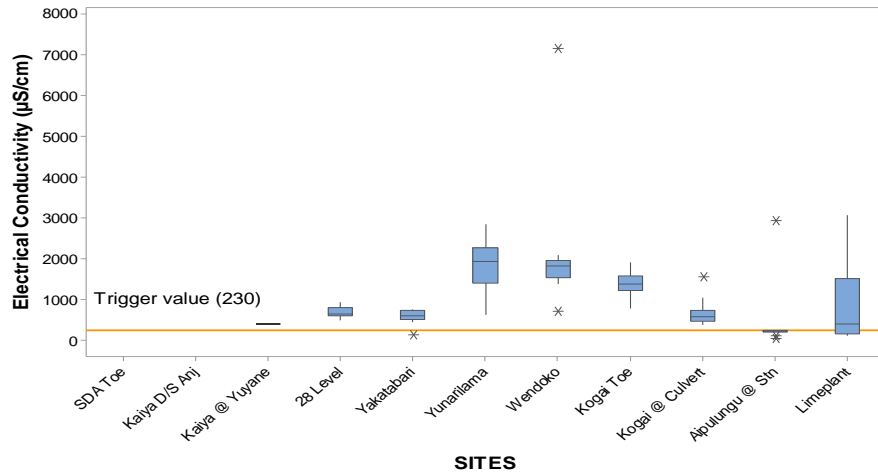


Figure C-3 Electrical conductivity in mine contact runoff 2024

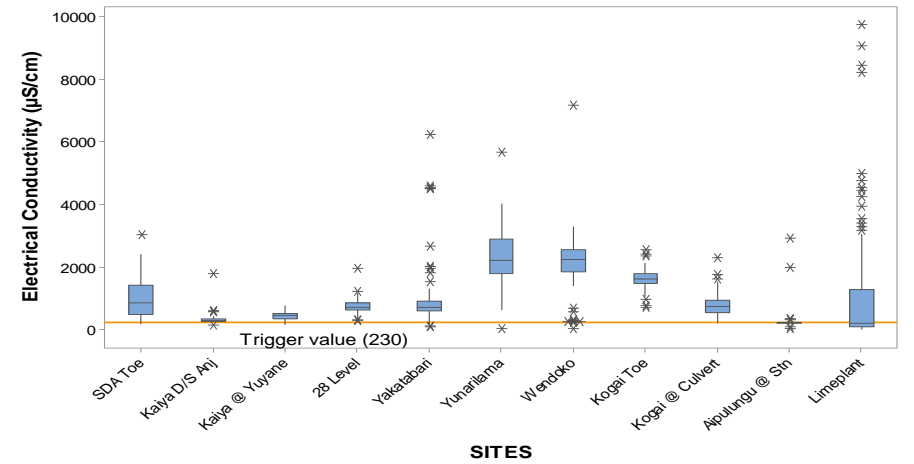


Figure C-4 Electrical conductivity in mine contact runoff 2015-2024

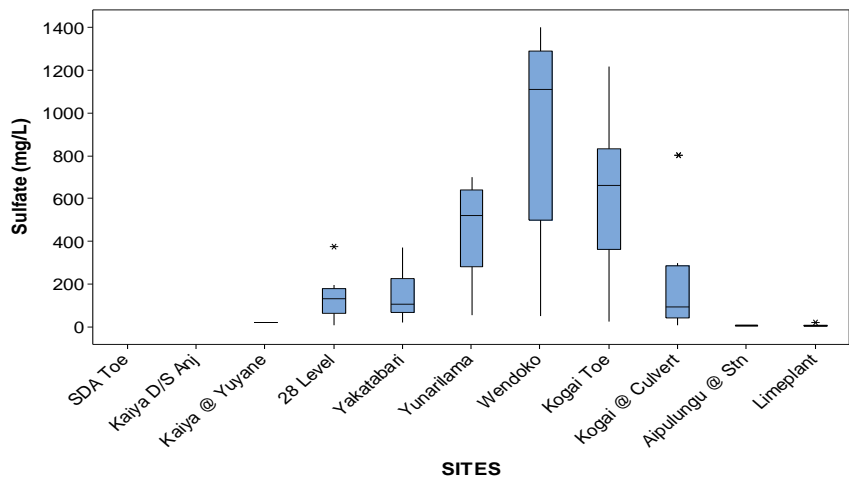


Figure C-5 Sulfate in mine contact runoff 2024

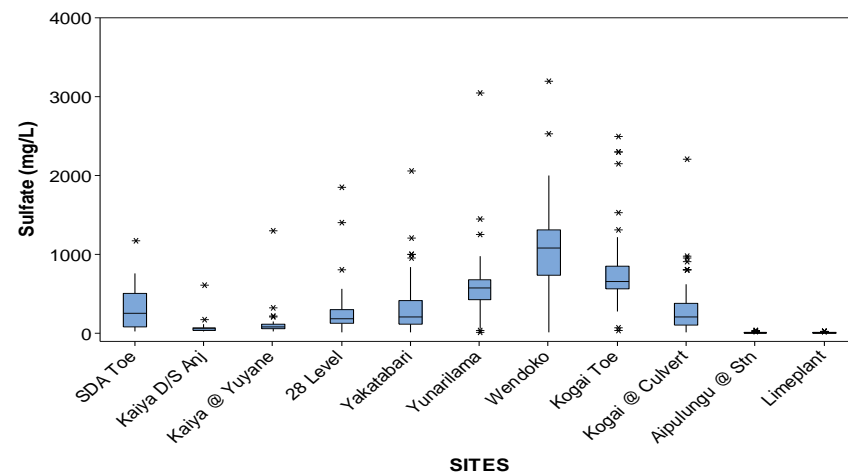


Figure C-6 Sulfate in mine contact runoff 2015-2024

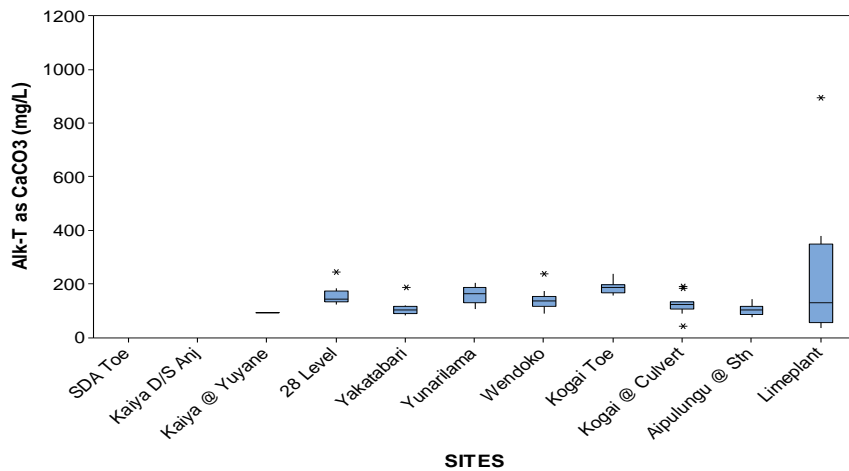


Figure C-7 Alkalinity of contact runoff 2024

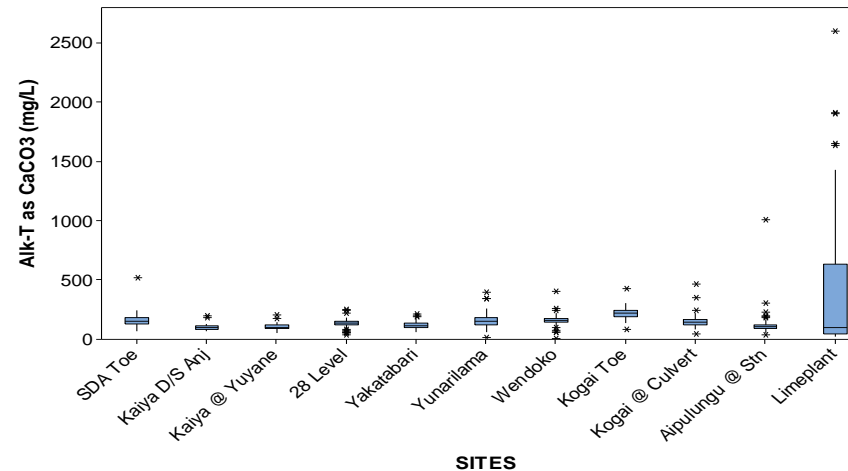


Figure C-8 Alkalinity of contact runoff 2015-2024

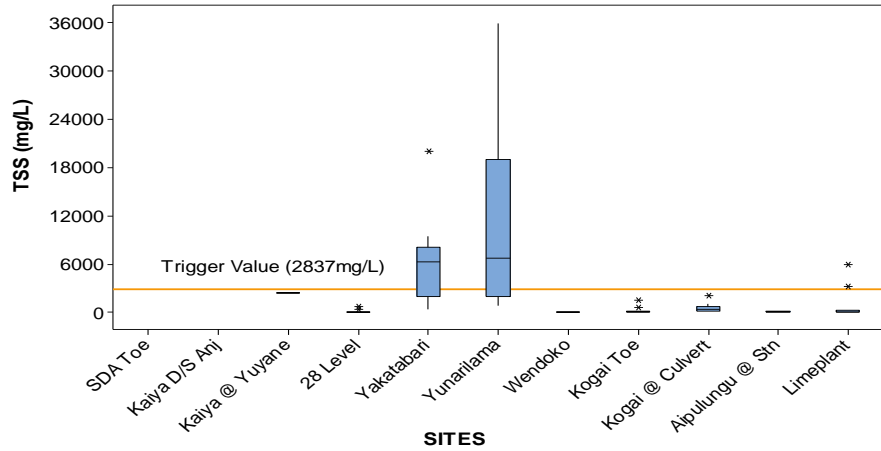


Figure C-9 TSS in contact runoff 2024

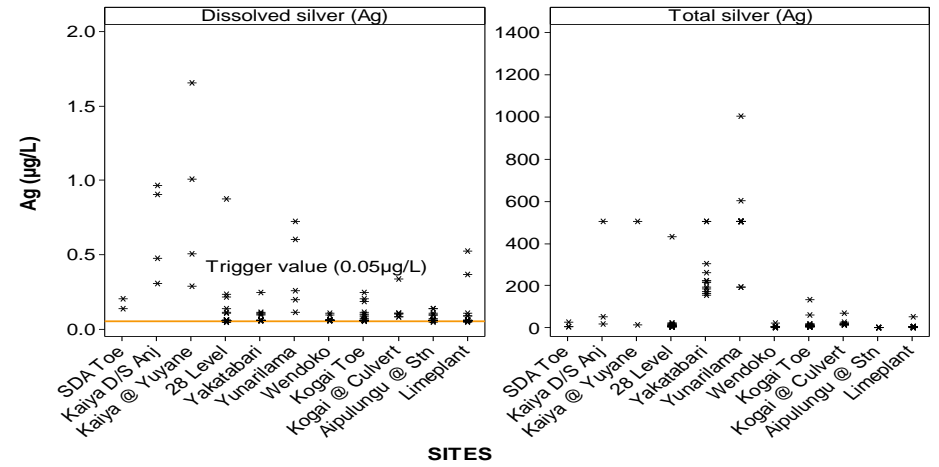


Figure-10 TSS in contact runoff 2015-2024

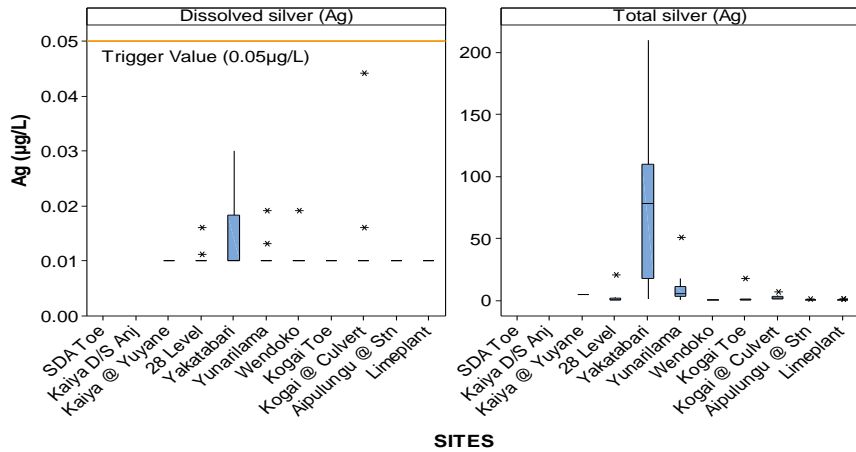


Figure C-11 Dissolved and total silver in contact runoff 2024

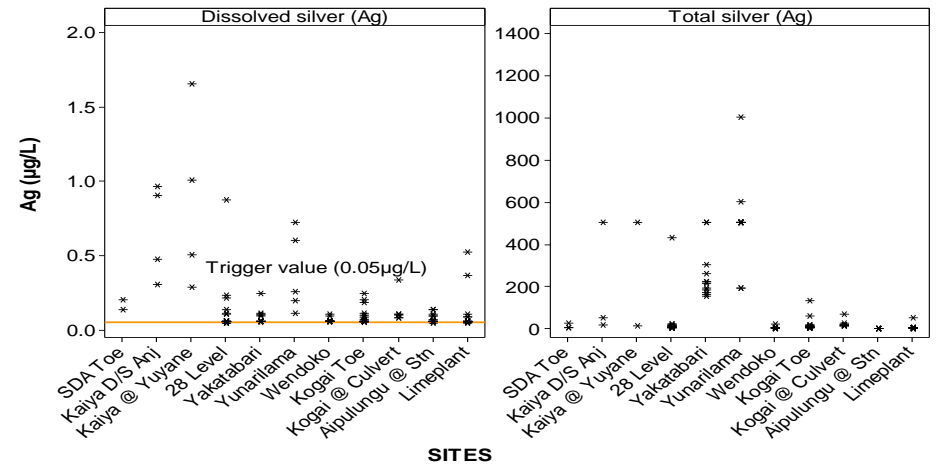


Figure C-12 Dissolved and total silver in contact runoff 2015-2024

NPL Annual Environment Report 2024

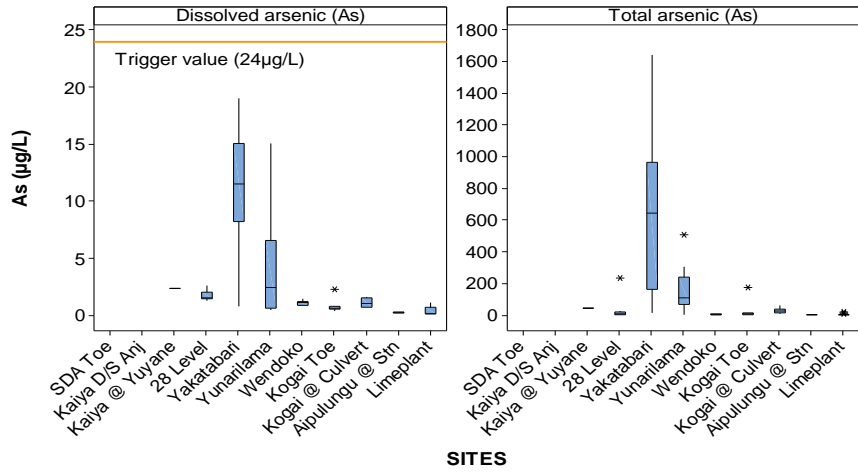


Figure C-13 Dissolved and total arsenic in contact runoff 2024

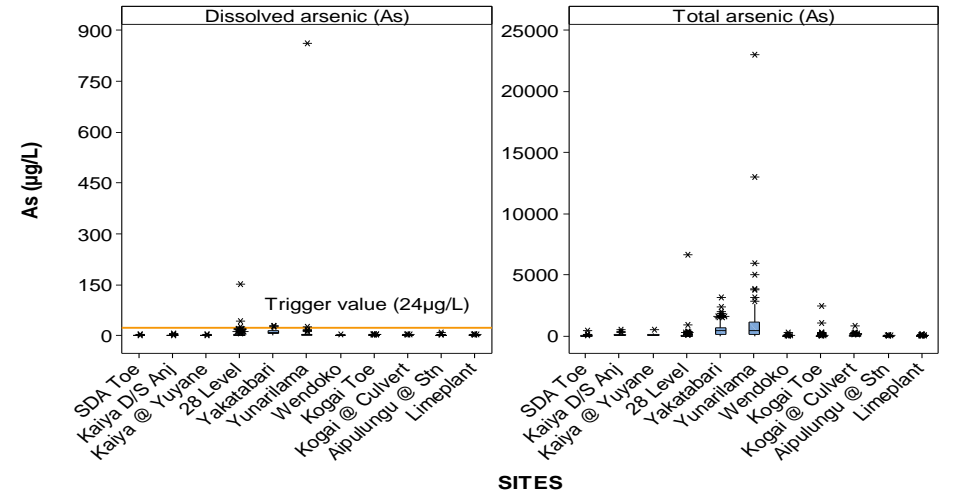


Figure C-14 Dissolved and total arsenic in contact runoff 2015-2024

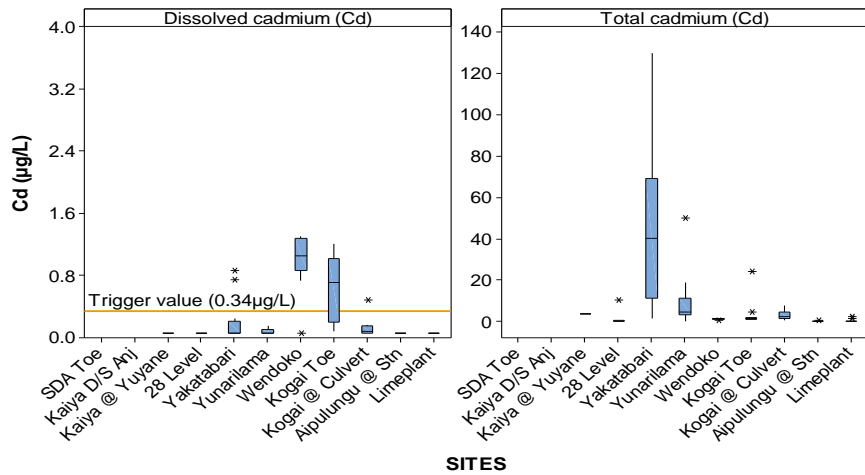


Figure C-15 Dissolved and total cadmium in contact runoff 2024

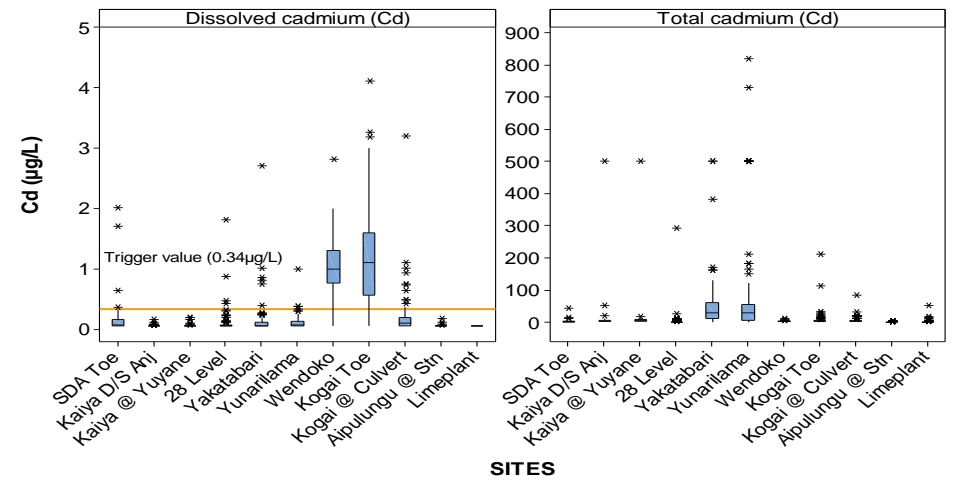


Figure C-16 Dissolved and total cadmium contact runoff 2015-2024

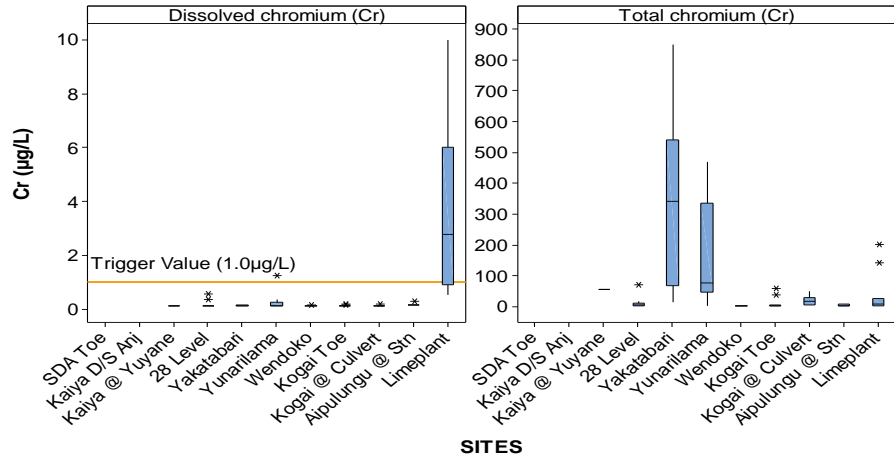


Figure C-17 Dissolved and total chromium in contact runoff 2024

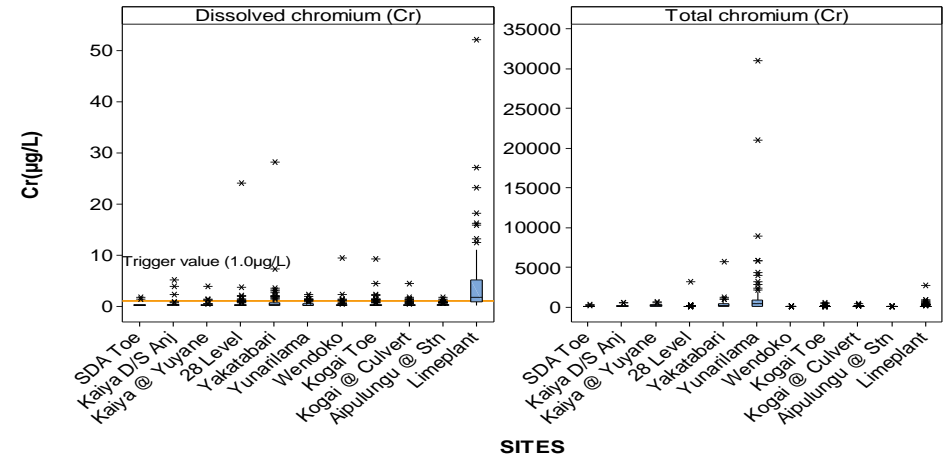


Figure C-18 Dissolved and total chromium in contact runoff 2015-2024

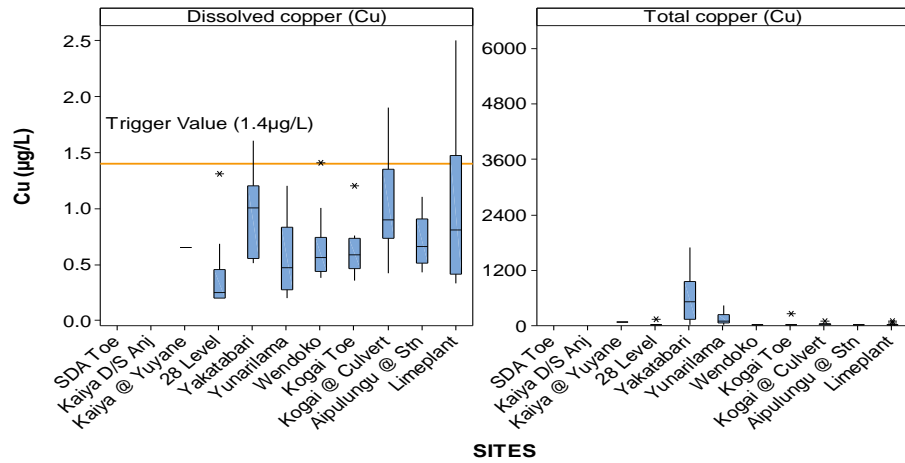


Figure C-19 Dissolved and total copper in contact runoff 2024

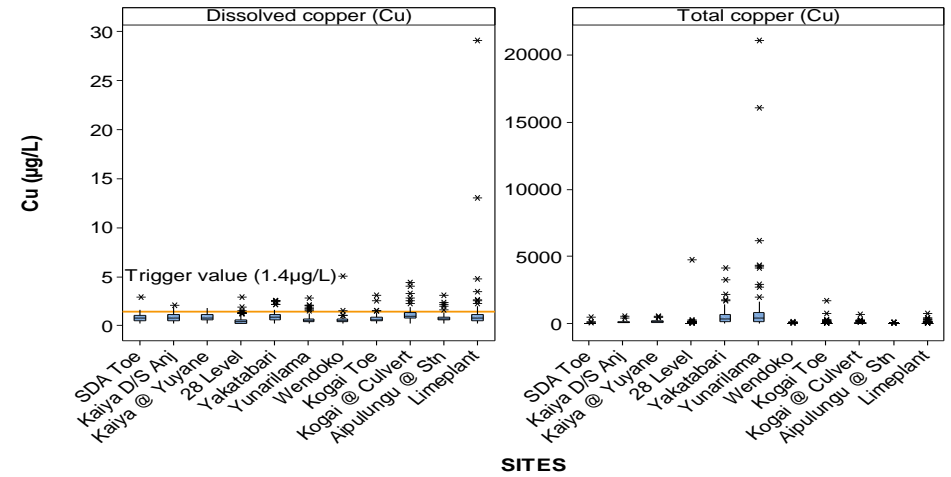


Figure C-20 Dissolved and total copper contact runoff 2015-2024

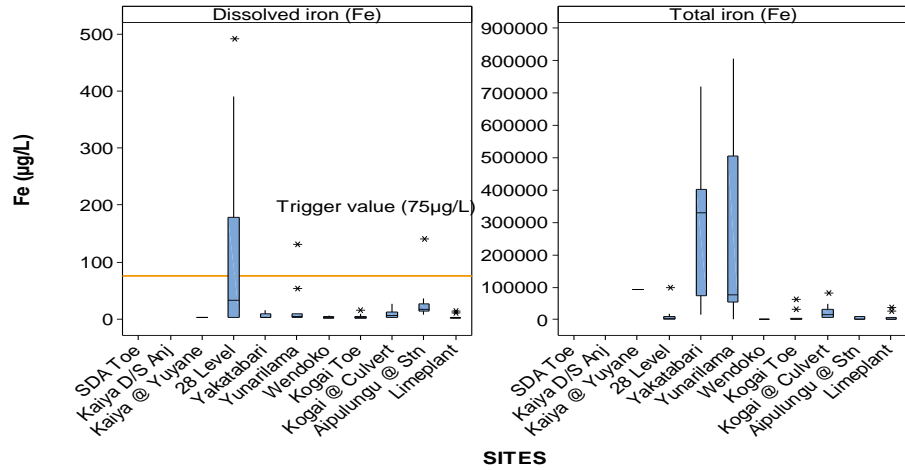


Figure C-21 Dissolved and total iron in contact runoff 2024

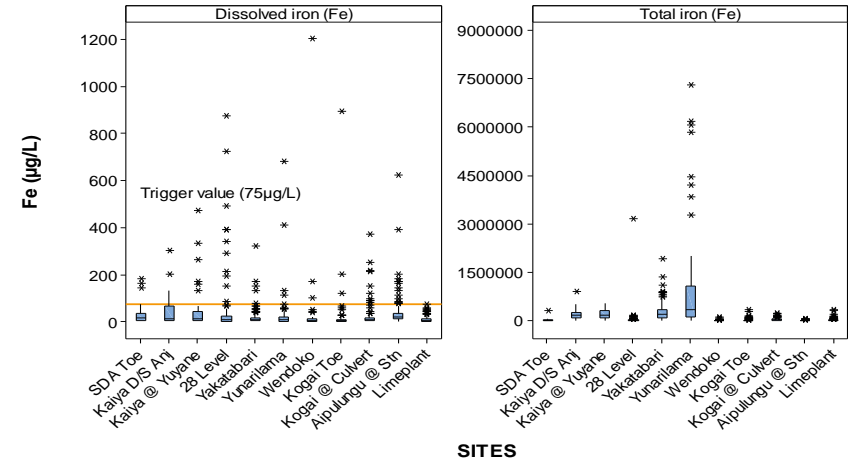


Figure C-22 Dissolved and total iron in contact runoff 2015-2024

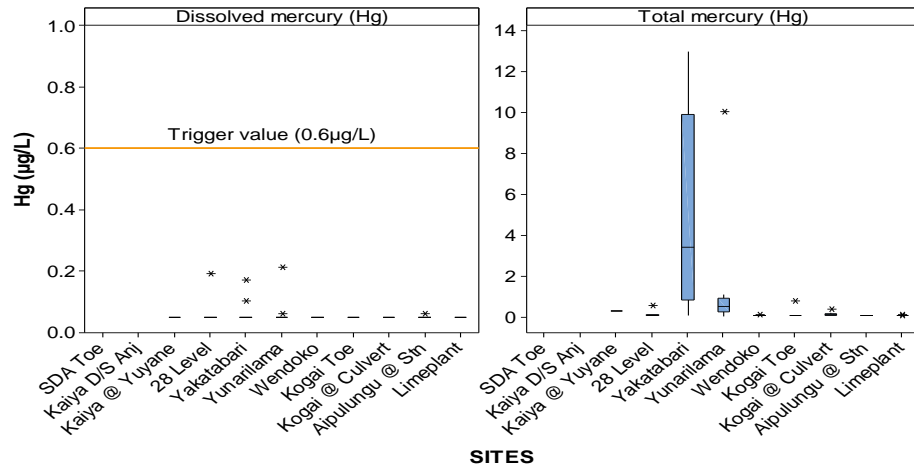


Figure C-23 Dissolved and total mercury in contact runoff 2024

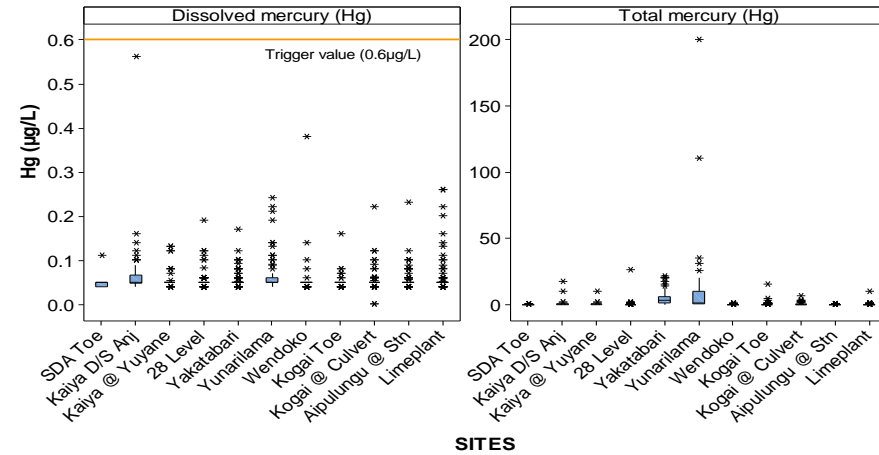


Figure C-24 Dissolved and total mercury in contact runoff 2015-2024

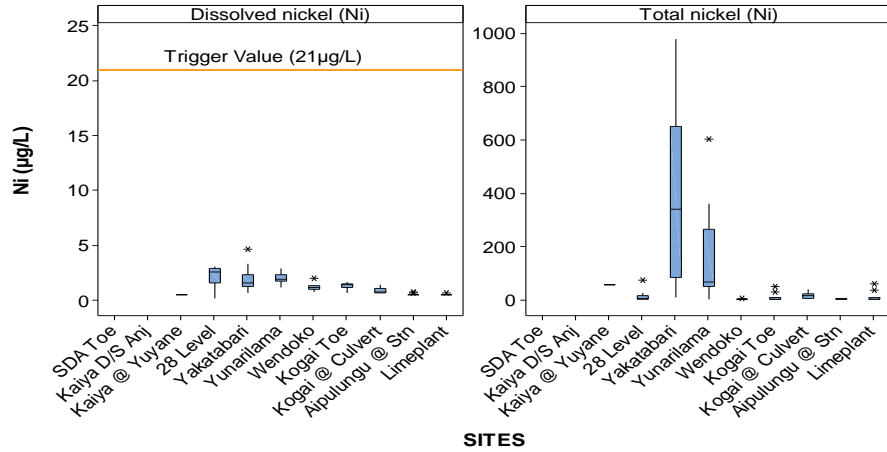


Figure C-25 Dissolved and total nickel in contact runoff 2024

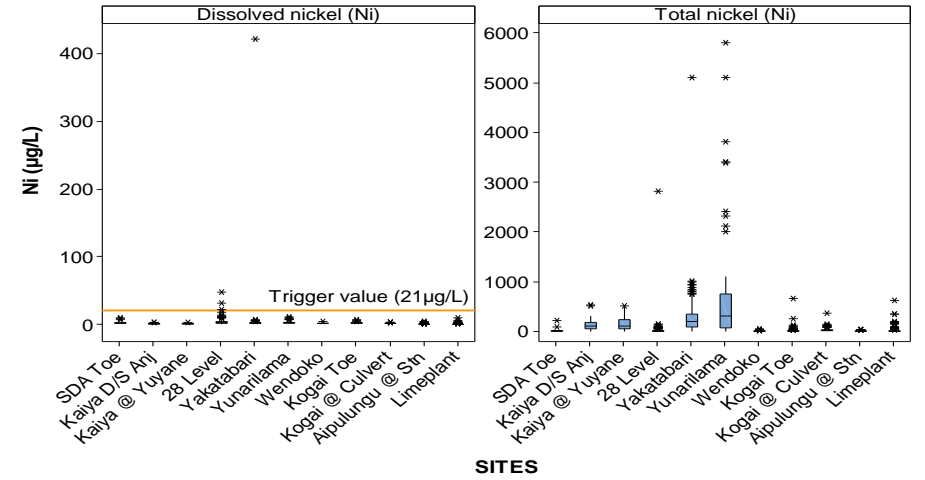


Figure C-26 Dissolved and total nickel in contact runoff 2015-2024

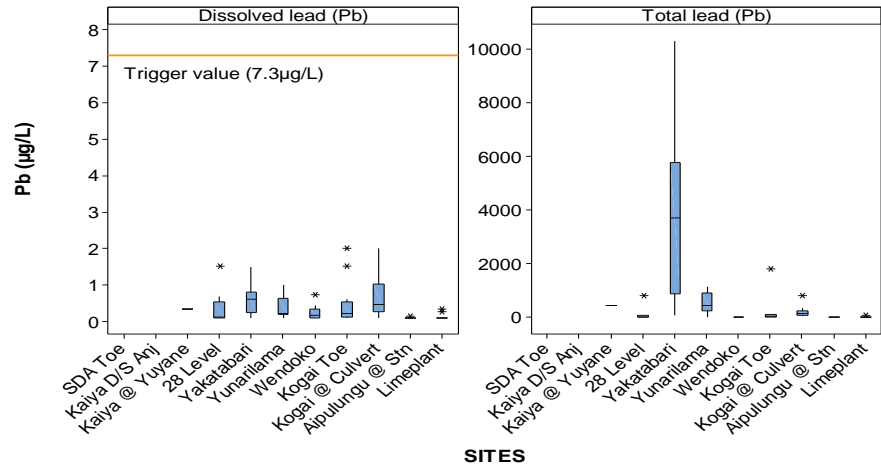


Figure C-27 Dissolved and total lead in contact runoff 2024

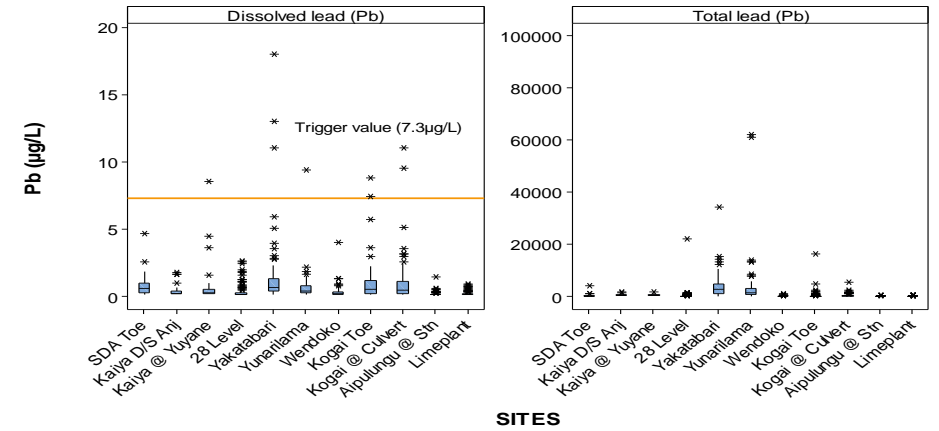


Figure C-28 Dissolved and total lead contact runoff 2015-2024

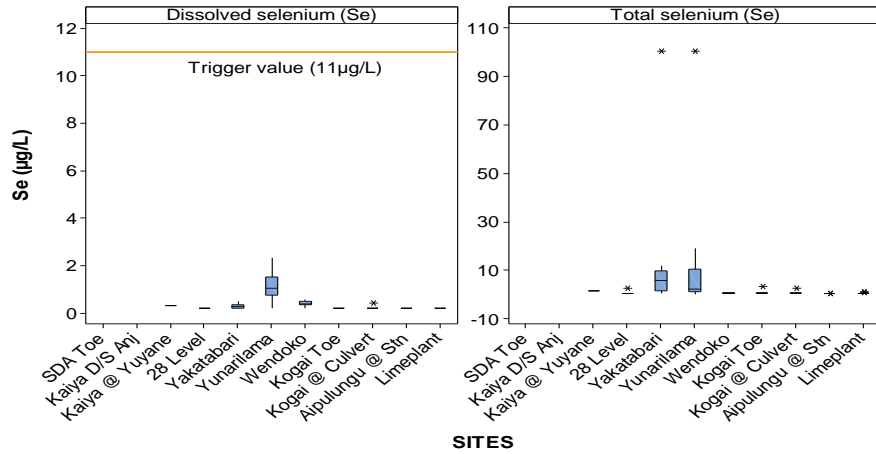


Figure C-29 Dissolved and total selenium in contact runoff 2024

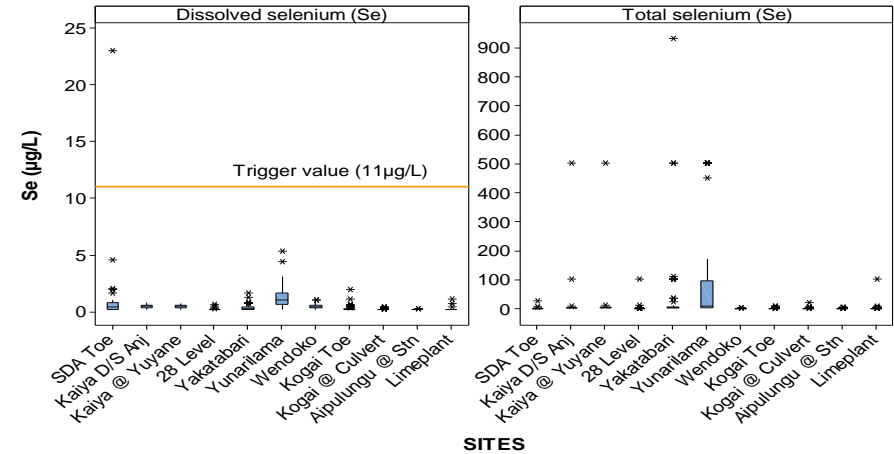


Figure C-30 Dissolved and total selenium in contact runoff 2015-2024

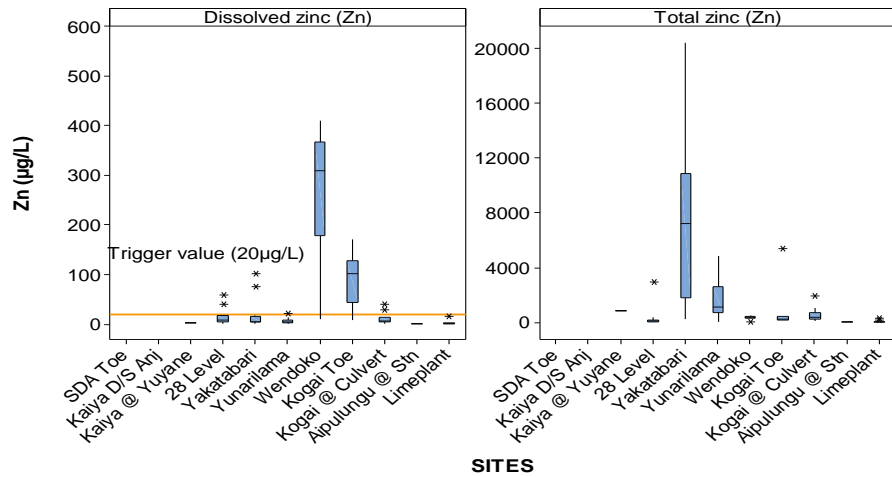


Figure C-31 Dissolved and total zinc in contact runoff 2024

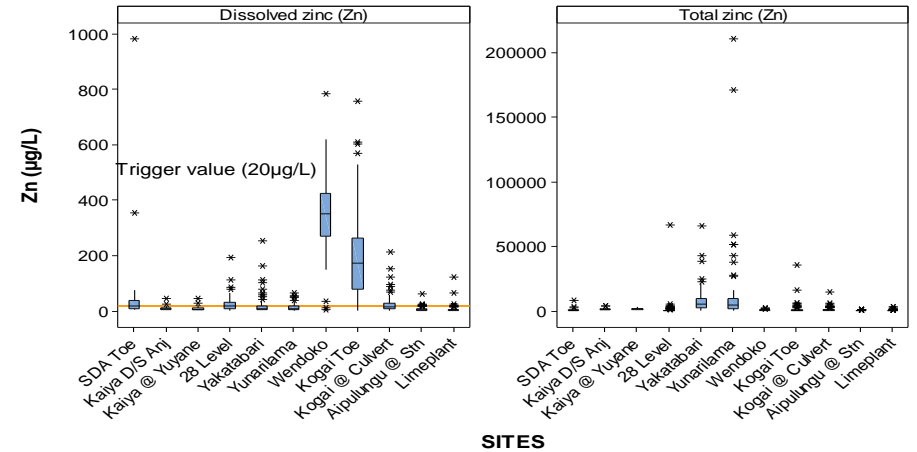


Figure C-32 Dissolved and total zinc in contact runoff 2015-2024

Table C-23 SDA Toe 2015 - 2017 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	-0.429	<0.001	Reduced over time
EC	0.167	0.164	No change over time
Sulfate	-0.090	0.422	No change over time
Alk-T	0.058	0.603	No change over time
TSS	0.404	<0.001	Increased over time
Hardness	0.733	<0.001	Increased over time
Ag-D	-0.794	<0.001	Reduced over time
Ag-T	0.049	0.668	No change over time
As-D	-0.181	0.101	No change over time
As-T	0.322	0.003	Increased over time
Cd-D	-0.385	<0.001	Reduced over time
Cd-T	0.197	0.074	No change over time
Cr-D	-0.744	<0.001	Reduced over time
Cr-T	0.360	0.001	Increased over time
Cu-D	-0.597	<0.001	Reduced over time
Cu-T	0.255	0.002	Increased over time
Fe-D	0.150	0.175	No change over time
Fe-T	0.312	0.004	Increased over time
Hg-D	-0.828	<0.001	Reduced over time
Hg-T	-0.539	<0.001	Reduced over time
Ni-D	-0.128	0.248	No change over time
Ni-T	0.291	0.008	Increased over time
Pb-D	-0.085	0.444	No change over time
Pb-T	0.272	0.013	Increased over time
Se-D	-0.173	0.239	No change over time
Se-T	-0.046	0.754	No change over time
Zn-D	0.106	0.342	No change over time
Zn-T	0.238	0.029	Increased over time

Table C-24 Kaiya D/S Anjolek Dump 2015 - 2019 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.528	0.001	Increased over time
EC	0.036	0.832	No change over time
SO4-D	-0.109	0.511	No change over time
Alk-T	0.012	0.941	No change over time
TSS	-0.123	0.457	No change over time
Hardness	0.322	0.052	No change over time
Ag-D	-0.466	0.005	Reduced over time
Ag-T	-0.142	0.417	No change over time
As-D	0.169	0.312	No change over time
As-T	-0.245	0.139	No change over time
Cd-D	0.475	0.003	Increased over time
Cd-T	-0.301	0.066	No change over time
Cr-D	0.424	0.008	Increased over time
Cr-T	-0.125	0.455	No change over time
Cu-D	0.306	0.062	No change over time
Cu-T	-0.073	0.663	No change over time
Fe-D	0.269	0.102	No change over time
Fe-T	-0.220	0.190	No change over time
Hg-D	0.233	0.159	No change over time
Hg-T	-0.192	0.248	No change over time
Ni-D	0.328	0.044	Increased over time
Ni-T	-0.151	0.364	No change over time
Pb-D	0.445	0.005	Increased over time
Pb-T	-0.280	0.088	No change over time
Se-D	0.108	0.519	No change over time
Se-T	-0.092	0.582	No change over time
Zn-D	0.233	0.164	No change over time
Zn-T	-0.246	0.136	No change over time

Table C-25 Kaiya at Yuyan 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.306	0.049	Increased over time
EC	-0.016	0.922	No change over time
SO4-D	0.273	0.077	No change over time
Alk-T	-0.228	0.142	No change over time
TSS	-0.064	0.686	No change over time
Hardness	0.386	0.013	Increased over time
Ag-D	-0.616	<0.001	Reduced over time
Ag-T	-0.066	0.691	No change over time
As-D	0.252	0.107	No change over time
As-T	-0.185	0.24	No change over time
Cd-D	-0.012	0.938	No change over time
Cd-T	-0.122	0.443	No change over time
Cr-D	0.498	0.001	Increased over time
Cr-T	-0.130	0.412	No change over time
Cu-D	0.282	0.07	No change over time
Cu-T	0.002	0.989	No change over time
Fe-D	0.167	0.292	No change over time
Fe-T	-0.249	0.116	No change over time
Hg-D	0.206	0.191	No change over time
Hg-T	-0.059	0.712	No change over time
Ni-D	0.157	0.322	No change over time
Ni-T	-0.240	0.126	No change over time
Pb-D	0.390	0.011	Increased over time
Pb-T	-0.082	0.605	No change over time
Se-D	0.031	0.847	No change over time
Se-T	-0.078	0.622	No change over time
Zn-D	0.051	0.751	No change over time
Zn-T	-0.143	0.367	No change over time

Table C-26 28 Level 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.312	0.001	Increased over time
EC	0.012	0.899	No change over time
SO4-D	0.038	0.684	No change over time
Alk-T	0.619	<0.001	Increased over time
TSS	-0.476	<0.001	Reduced over time
Hardness	0.044	0.635	No change over time
Ag-D	-0.250	0.007	Reduced over time
Ag-T	-0.187	0.045	Reduced over time
As-D	-0.189	0.041	Reduced over time
As-T	-0.424	<0.001	Reduced over time
Cd-D	-0.574	<0.001	Reduced over time
Cd-T	-0.477	<0.001	Reduced over time
Cr-D	-0.261	0.004	Reduced over time
Cr-T	-0.348	<0.001	Reduced over time
Cu-D	-0.504	<0.001	Reduced over time
Cu-T	-0.328	<0.001	Reduced over time
Fe-D	-0.165	0.075	No change over time
Fe-T	-0.185	0.046	Reduced over time
Hg-D	0.181	0.05	Increased over time
Hg-T	-0.066	0.476	No change over time
Ni-D	-0.243	0.008	Reduced over time
Ni-T	-0.353	<0.001	Reduced over time
Pb-D	-0.201	0.029	Reduced over time
Pb-T	-0.325	<0.001	Reduced over time
Se-D	-0.094	0.311	No change over time
Se-T	-0.243	0.008	Reduced over time
Zn-D	-0.420	<0.001	Reduced over time
Zn-T	-0.339	<0.001	Reduced over time

Table C-27 Yakatabari Creek D/S 28 Level 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.176	0.063	No change over time
EC	-0.510	<0.001	Reduced over time
SO4-D	-0.471	<0.001	Reduced over time
Alk-T	-0.287	0.002	Reduced over time
TSS	-0.040	0.674	No change over time
Hardness	-0.328	<0.001	Reduced over time
Ag-D	-0.270	0.004	Reduced over time
Ag-T	0.268	0.005	Increased over time
As-D	0.001	0.993	No change over time
As-T	0.095	0.318	No change over time
Cd-D	-0.047	0.619	No change over time
Cd-T	0.099	0.297	No change over time
Cr-D	-0.542	<0.001	Reduced over time
Cr-T	0.154	0.105	No change over time
Cu-D	-0.082	0.388	No change over time
Cu-T	0.139	0.143	No change over time
Fe-D	-0.366	<0.001	Reduced over time
Fe-T	0.132	0.168	No change over time
Hg-D	0.187	0.048	Increased over time
Hg-T	0.184	0.052	No change over time
Ni-D	0.046	0.631	No change over time
Ni-T	0.225	0.017	Increased over time
Pb-D	-0.492	<0.001	Reduced over time
Pb-T	0.124	0.191	No change over time
Se-D	-0.350	<0.001	Reduced over time
Se-T	0.141	0.140	No change over time
Zn-D	-0.070	0.463	No change over time
Zn-T	0.065	0.496	No change over time

Table C-28 Yunarilama / Yarik @ Portal 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.364	0.001	Increased over time
EC	-0.191	0.092	No change over time
SO4-D	0.018	0.876	No change over time
Alk-T	0.034	0.762	No change over time
TSS	-0.048	0.673	No change over time
Hardness	-0.185	0.102	No change over time
Ag-D	-0.604	<0.001	Reduced over time
Ag-T	-0.360	0.001	Reduced over time
As-D	-0.079	0.484	No change over time
As-T	-0.394	<0.001	Reduced over time
Cd-D	-0.357	0.001	Reduced over time
Cd-T	-0.337	0.002	Reduced over time
Cr-D	-0.093	0.414	No change over time
Cr-T	-0.339	0.002	Reduced over time
Cu-D	-0.312	0.005	Reduced over time
Cu-T	-0.369	0.001	Reduced over time
Fe-D	-0.285	0.01	Reduced over time
Fe-T	-0.296	0.008	Reduced over time
Hg-D	-0.203	0.07	No change over time
Hg-T	-0.190	0.091	No change over time
Ni-D	-0.340	0.002	Reduced over time
Ni-T	-0.358	0.001	Reduced over time
Pb-D	-0.219	0.051	No change over time
Pb-T	-0.365	0.001	Reduced over time
Se-D	-0.115	0.311	No change over time
Se-T	-0.300	0.007	Reduced over time
Zn-D	-0.263	0.019	Reduced over time
Zn-T	-0.367	0.001	Reduced over time

Table C-29 Wendoko Creek D/S Anawe Nth 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.281	0.017	Increased over time
EC	-0.586	<0.001	Reduced over time
SO4-D	-0.126	0.289	No change over time
Alk-T	-0.282	0.016	Reduced over time
TSS	-0.448	<0.001	Reduced over time
Hardness	-0.314	0.007	Reduced over time
Ag-D	-0.581	<0.001	Reduced over time
Ag-T	-0.166	0.170	No change over time
As-D	-0.052	0.660	No change over time
As-T	-0.419	<0.001	Reduced over time
Cd-D	0.165	0.164	No change over time
Cd-T	-0.135	0.254	No change over time
Cr-D	-0.206	0.081	No change over time
Cr-T	-0.463	<0.001	Reduced over time
Cu-D	-0.229	0.052	No change over time
Cu-T	-0.327	0.005	Reduced over time
Fe-D	-0.339	0.003	Reduced over time
Fe-T	-0.393	0.001	Reduced over time
Hg-D	0.244	0.037	Increased over time
Hg-T	0.124	0.294	No change over time
Ni-D	-0.699	<0.001	Reduced over time
Ni-T	-0.671	<0.001	Reduced over time
Pb-D	-0.374	0.001	Reduced over time
Pb-T	-0.333	0.004	Reduced over time
Se-D	-0.471	<0.001	Reduced over time
Se-T	-0.461	<0.001	Reduced over time
Zn-D	-0.238	0.044	Reduced over time
Zn-T	-0.299	0.010	Reduced over time

Table C-30 Kogai Dump Toe 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.447	<0.001	Increased over time
EC	-0.419	<0.001	Reduced over time
SO4-D	0.120	0.193	No change over time
Alk-T	-0.341	<0.001	Reduced over time
TSS	-0.461	<0.001	Reduced over time
Hardness	-0.254	0.006	Reduced over time
Ag-D	-0.286	0.002	Reduced over time
Ag-T	-0.408	<0.001	Reduced over time
As-D	-0.384	<0.001	Reduced over time
As-T	-0.333	<0.001	Reduced over time
Cd-D	-0.560	<0.001	Reduced over time
Cd-T	-0.526	<0.001	Reduced over time
Cr-D	-0.168	0.068	No change over time
Cr-T	-0.420	<0.001	Reduced over time
Cu-D	-0.046	0.621	No change over time
Cu-T	-0.318	<0.001	Reduced over time
Fe-D	-0.351	<0.001	Reduced over time
Fe-T	-0.372	<0.001	Reduced over time
Hg-D	0.213	0.020	Increased over time
Hg-T	-0.269	0.003	Reduced over time
Ni-D	-0.716	<0.001	Reduced over time
Ni-T	-0.473	<0.001	Reduced over time
Pb-D	-0.558	<0.001	Reduced over time
Pb-T	-0.301	0.001	Reduced over time
Se-D	-0.288	0.002	Reduced over time
Se-T	-0.329	<0.001	Reduced over time
Zn-D	-0.652	<0.001	Reduced over time
Zn-T	-0.545	<0.001	Reduced over time

Table C-31 Kogai at Culvert 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.313	0.001	Increased over time
EC	0.180	0.052	No change over time
SO4-D	0.225	0.014	Increased over time
Alk-T	-0.034	0.717	No change over time
TSS	0.013	0.893	No change over time
Hardness	0.323	<0.001	Increased over time
Ag-D	-0.280	0.002	Reduced over time
Ag-T	-0.013	0.891	No change over time
As-D	0.022	0.815	No change over time
As-T	-0.018	0.845	No change over time
Cd-D	-0.178	0.054	No change over time
Cd-T	-0.185	0.045	Reduced over time
Cr-D	-0.230	0.012	Reduced over time
Cr-T	0.013	0.892	No change over time
Cu-D	-0.217	0.018	Reduced over time
Cu-T	-0.014	0.88	No change over time
Fe-D	-0.326	<0.001	Reduced over time
Fe-T	0.066	0.479	No change over time
Hg-D	0.146	0.114	No change over time
Hg-T	-0.100	0.28	No change over time
Ni-D	-0.054	0.564	No change over time
Ni-T	-0.028	0.761	No change over time
Pb-D	-0.281	0.002	Reduced over time
Pb-T	-0.081	0.38	No change over time
Se-D	-0.018	0.848	No change over time
Se-T	0.013	0.888	No change over time
Zn-D	-0.322	<0.001	Reduced over time
Zn-T	-0.215	0.019	Reduced over time

Table C-32 Aipulungu at Station 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.267	0.004	Increased over time
EC	-0.065	0.488	No change over time
SO4-D	0.167	0.073	No change over time
Alk-T	-0.034	0.719	No change over time
TSS	-0.184	0.049	Reduced over time
Hardness	-0.026	0.783	No change over time
Ag-D	-0.381	<0.001	Reduced over time
Ag-T	-0.329	<0.001	Reduced over time
As-D	-0.398	<0.001	Reduced over time
As-T	-0.181	0.052	No change over time
Cd-D	-0.058	0.537	No change over time
Cd-T	-0.152	0.102	No change over time
Cr-D	-0.193	0.037	Reduced over time
Cr-T	-0.161	0.085	No change over time
Cu-D	-0.033	0.726	No change over time
Cu-T	-0.134	0.152	No change over time
Fe-D	-0.162	0.082	No change over time
Fe-T	-0.132	0.16	No change over time
Hg-D	0.126	0.178	No change over time
Hg-T	0.229	0.014	Increased over time
Ni-D	-0.047	0.619	No change over time
Ni-T	-0.143	0.125	No change over time
Pb-D	-0.099	0.29	No change over time
Pb-T	-0.064	0.493	No change over time
Se-D	-0.034	0.72	No change over time
Se-T	-0.267	0.004	Reduced over time
Zn-D	-0.471	<0.001	Reduced over time
Zn-T	-0.184	0.048	Reduced over time

Table C-33 Lime Plant 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	-0.363	<0.001	Reduced over time
EC	-0.309	0.001	Reduced over time
SO4-D	0.230	0.015	Increased over time
Alk-T	-0.421	<0.001	Reduced over time
TSS	-0.495	<0.001	Reduced over time
Hardness	-0.291	0.002	Reduced over time
Ag-D	-0.337	<0.001	Reduced over time
Ag-T	-0.558	<0.001	Reduced over time
As-D	0.337	<0.001	Increased over time
As-T	-0.293	0.002	Reduced over time
Cd-D	*	*	No change over time
Cd-T	-0.420	<0.001	Reduced over time
Cr-D	-0.385	<0.001	Reduced over time
Cr-T	-0.547	<0.001	Reduced over time
Cu-D	0.121	0.200	No change over time
Cu-T	-0.466	<0.001	Reduced over time
Fe-D	-0.007	0.938	No change over time
Fe-T	-0.491	<0.001	Reduced over time
Hg-D	-0.015	0.876	No change over time
Hg-T	-0.167	0.077	No change over time
Ni-D	-0.071	0.457	No change over time
Ni-T	-0.531	<0.001	Reduced over time
Pb-D	-0.129	0.174	No change over time
Pb-T	-0.274	0.003	Reduced over time
Se-D	-0.192	0.041	Reduced over time
Se-T	-0.439	<0.001	Reduced over time
Zn-D	-0.076	0.426	No change over time
Zn-T	-0.355	<0.001	Reduced over time

Table C-34 Aipulungu U/S Lime plant 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.238	0.010	Increased over time
EC	-0.005	0.955	No change over time
SO4-D	0.288	0.002	Increased over time
Alk-T	-0.126	0.176	No change over time
TSS	-0.045	0.629	No change over time
Hardness	-0.064	0.497	No change over time
Ag-D	-0.280	0.003	Reduced over time
Ag-T	-0.330	<0.001	Reduced over time
As-D	-0.225	0.015	Reduced over time
As-T	0.075	0.419	No change over time
Cd-D	*	*	No change over time
Cd-T	-0.066	0.483	No change over time
Cr-D	-0.090	0.332	No change over time
Cr-T	0.139	0.135	No change over time
Cu-D	-0.010	0.914	No change over time
Cu-T	0.147	0.115	No change over time
Fe-D	-0.162	0.082	No change over time
Fe-T	0.273	0.003	Increased over time
Hg-D	0.071	0.446	No change over time
Hg-T	0.280	0.002	Increased over time
Ni-D	0.166	0.074	No change over time
Ni-T	0.112	0.228	No change over time
Pb-D	-0.036	0.699	No change over time
Pb-T	0.241	0.009	Increased over time
Se-D	-0.026	0.784	No change over time
Se-T	-0.019	0.835	No change over time
Zn-D	-0.413	<0.001	Reduced over time
Zn-T	-0.028	0.766	No change over time

Table C-35 Waile Creek 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	-0.002	0.981	No change over time
EC	-0.140	0.136	No change over time
SO4-D	0.454	<0.001	Increased over time
Alk-T	-0.124	0.184	No change over time
TSS	-0.052	0.579	No change over time
Hardness	-0.185	0.047	Reduced over time
Ag-D	-0.320	0.001	Reduced over time
Ag-T	-0.447	<0.001	Reduced over time
As-D	-0.254	0.006	Reduced over time
As-T	-0.156	0.095	No change over time
Cd-D	-0.019	0.843	No change over time
Cd-T	-0.126	0.177	No change over time
Cr-D	-0.095	0.310	No change over time
Cr-T	0.132	0.158	No change over time
Cu-D	0.128	0.172	No change over time
Cu-T	0.160	0.086	No change over time
Fe-D	-0.125	0.181	No change over time
Fe-T	0.290	0.002	Increased over time
Hg-D	0.072	0.440	No change over time
Hg-T	0.286	0.002	Increased over time
Ni-D	0.109	0.246	No change over time
Ni-T	0.076	0.417	No change over time
Pb-D	-0.153	0.101	No change over time
Pb-T	0.131	0.162	No change over time
Se-D	*	*	No change over time
Se-T	*	*	No change over time
Zn-D	-0.436	<0.001	Reduced over time
Zn-T	-0.154	0.099	No change over time

Table C-36 Kaiya U/S Anjolek 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.248	0.202	No change over time
EC	0.102	0.605	No change over time
SO4-D	0.139	0.474	No change over time
Alk-T	-0.008	0.966	No change over time
TSS	0.117	0.546	No change over time
Hardness	-0.087	0.668	No change over time
Ag-D	-0.657	0.000	Reduced over time
Ag-T	-0.531	0.006	Reduced over time
As-D	0.311	0.107	No change over time
As-T	0.258	0.185	No change over time
Cd-D	0.274	0.158	No change over time
Cd-T	0.025	0.901	No change over time
Cr-D	0.192	0.329	No change over time
Cr-T	0.176	0.370	No change over time
Cu-D	-0.013	0.948	No change over time
Cu-T	0.203	0.300	No change over time
Fe-D	0.229	0.241	No change over time
Fe-T	0.155	0.440	No change over time
Hg-D	-0.248	0.203	No change over time
Hg-T	-0.483	0.009	Reduced over time
Ni-D	0.316	0.101	No change over time
Ni-T	0.192	0.327	No change over time
Pb-D	0.253	0.194	No change over time
Pb-T	0.068	0.732	No change over time
Se-D	0.127	0.518	No change over time
Se-T	-0.028	0.886	No change over time
Zn-D	0.624	0.001	Increased over time
Zn-T	0.179	0.363	No change over time

Table C-37 Pongema 2015 - 2024 (trend of all data)

Parameter	Spearman's rho	P-Value (P=0.05)	Trend
pH	0.234	0.013	Increased over time
EC	-0.057	0.553	No change over time
SO4-D	0.234	0.013	Increased over time
Alk-T	-0.058	0.544	No change over time
TSS	-0.039	0.683	No change over time
Hardness	-0.078	0.414	No change over time
Ag-D	-0.296	0.002	Reduced over time
Ag-T	-0.131	0.169	No change over time
As-D	0.005	0.960	No change over time
As-T	0.127	0.179	No change over time
Cd-D	-0.080	0.399	No change over time
Cd-T	-0.120	0.205	No change over time
Cr-D	0.039	0.683	No change over time
Cr-T	0.073	0.442	No change over time
Cu-D	-0.117	0.218	No change over time
Cu-T	0.123	0.193	No change over time
Fe-D	-0.213	0.023	Reduced over time
Fe-T	0.101	0.292	No change over time
Hg-D	0.023	0.809	No change over time
Hg-T	0.315	0.001	Increased over time
Ni-D	-0.043	0.650	No change over time
Ni-T	0.065	0.493	No change over time
Pb-D	-0.106	0.263	No change over time
Pb-T	0.223	0.018	Increased over time
Se-D	-0.035	0.715	No change over time
Se-T	-0.105	0.267	No change over time
Zn-D	-0.368	<0.001	Reduced over time
Zn-T	0.020	0.836	No change over time

Table C-38 Trend for sediment quality from mine contact sites 2015 - 2024

Sediment Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend
28 Level (Trend of all data 2015 - 2024)	Ag-WAE	-0.169	0.304	No change over time
	As-WAE	0.158	0.336	No change over time
	Cd-WAE	-0.041	0.806	No change over time
	Cr-WAE	-0.341	0.034	Reduced over time
	Cu-WAE	0.043	0.793	No change over time
	Fe-WAE	-0.048	0.771	No change over time
	Pb-WAE	-0.408	0.01	Reduced over time
	Hg-WAE	-0.131	0.427	No change over time
	Ni-WAE	-0.107	0.518	No change over time
	Se-WAE	-0.176	0.284	No change over time
	Zn-WAE	0.028	0.866	No change over time
Anjolek SDA (Trend of all data 2015 - 2017)	Ag-WAE	-0.711	0.01	Reduced over time
	As-WAE	-0.091	0.779	No change over time
	Cd-WAE	0.084	0.795	No change over time
	Cr-WAE	-0.259	0.417	No change over time
	Cu-WAE	-0.168	0.602	No change over time
	Fe-WAE	-0.329	0.297	No change over time
	Pb-WAE	0.077	0.812	No change over time
	Hg-WAE	-0.083	0.799	No change over time
	Ni-WAE	0.011	0.974	No change over time
	Se-WAE	-0.719	0.008	Reduced over time
	Zn-WAE	0.27	0.397	No change over time
Kaiya @ Yuyan Bridge (Trend of all data 2015 - 2020)	Ag-WAE	-0.548	0.034	Reduced over time
	As-WAE	-0.318	0.248	No change over time
	Cd-WAE	-0.045	0.874	No change over time
	Cr-WAE	0.211	0.451	No change over time
	Cu-WAE	0.59	0.021	Increased over time
	Fe-WAE	0.182	0.516	No change over time
	Pb-WAE	0.471	0.076	No change over time
	Hg-WAE	-0.417	0.122	No change over time
	Ni-WAE	0.400	0.14	No change over time
	Se-WAE	-0.642	0.01	Reduced over time
	Zn-WAE	0.27	0.331	No change over time
Kaiya River downstream Anjolek erodible dump (Trend of all data 2015 - 2020)	Ag-WAE	-0.577	0.024	Reduced over time
	As-WAE	-0.157	0.576	No change over time
	Cd-WAE	-0.204	0.465	No change over time
	Cr-WAE	0.236	0.398	No change over time
	Cu-WAE	0.517	0.048	Increased over time
	Fe-WAE	0.100	0.723	No change over time
	Pb-WAE	0.265	0.339	No change over time
	Hg-WAE	-0.319	0.246	No change over time
	Ni-WAE	0.436	0.104	No change over time
	Se-WAE	-0.658	0.008	Reduced over time
	Zn-WAE	0.281	0.311	No change over time
Kogai culvert	Ag-WAE	0.149	0.336	No change over time
	As-WAE	0.034	0.828	No change over time

NPL Annual Environment Report 2024

Sediment Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend
(Trend of all data 2015 - 2024)	Cd-WAE	-0.162	0.293	No change over time
	Cr-WAE	-0.093	0.547	No change over time
	Cu-WAE	0.287	0.059	No change over time
	Fe-WAE	-0.033	0.831	No change over time
	Pb-WAE	-0.140	0.366	No change over time
	Hg-WAE	0.675	<0.001	Increased over time
	Ni-WAE	-0.655	<0.001	Reduced over time
	Se-WAE	-0.118	0.446	No change over time
	Zn-WAE	-0.055	0.725	No change over time
Kogai stable dump toe (Trend of all data 2015 - 2024)	Ag-WAE	0.245	0.118	No change over time
	As-WAE	0.279	0.073	No change over time
	Cd-WAE	0.278	0.074	No change over time
	Cr-WAE	-0.093	0.558	No change over time
	Cu-WAE	0.417	0.006	Increased over time
	Fe-WAE	-0.156	0.324	No change over time
	Pb-WAE	-0.001	0.993	No change over time
	Hg-WAE	0.170	0.281	No change over time
	Ni-WAE	0.168	0.288	No change over time
	Se-WAE	-0.018	0.91	No change over time
	Zn-WAE	0.335	0.03	Increased over time
Lime Plant discharge (Trend of all data 2015 - 2024)	Ag-WAE	-0.244	0.134	No change over time
	As-WAE	0.395	0.013	Increased over time
	Cd-WAE	-0.080	0.629	No change over time
	Cr-WAE	0.108	0.513	No change over time
	Cu-WAE	0.206	0.208	No change over time
	Fe-WAE	0.15	0.361	No change over time
	Pb-WAE	0.224	0.17	No change over time
	Hg-WAE	-0.313	0.052	No change over time
	Ni-WAE	0.083	0.615	No change over time
	Se-WAE	-0.341	0.034	Reduced over time
	Zn-WAE	0.409	0.01	Increased over time
Wendoko Creek downstream Anawe North (Trend of all data 2015 - 2024)	Ag-WAE	-0.159	0.47	No change over time
	As-WAE	-0.120	0.586	No change over time
	Cd-WAE	0.225	0.303	No change over time
	Cr-WAE	-0.194	0.376	No change over time
	Cu-WAE	0.066	0.764	No change over time
	Fe-WAE	-0.168	0.444	No change over time
	Pb-WAE	-0.173	0.43	No change over time
	Hg-WAE	-0.227	0.297	No change over time
	Ni-WAE	0.018	0.936	No change over time
	Se-WAE	-0.391	0.065	No change over time
	Zn-WAE	0.021	0.925	No change over time
Yakatabari Creek D/S 28 level (Trend of all data 2015 - 2024)	Ag-WAE	0.413	0.010	Increased over time
	As-WAE	0.295	0.073	No change over time
	Cd-WAE	0.330	0.043	Increased over time
	Cr-WAE	0.166	0.320	No change over time
	Cu-WAE	0.448	0.005	Increased over time

NPL Annual Environment Report 2024

Sediment Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend
	Fe-WAE	0.074	0.659	No change over time
	Pb-WAE	-0.193	0.245	No change over time
	Hg-WAE	-0.085	0.613	No change over time
	Ni-WAE	0.356	0.028	Increased over time
	Se-WAE	-0.216	0.192	No change over time
	Zn-WAE	0.38	0.019	Increased over time
Yunarilama at Portal (Trend of all data 2015 - 2024)	Ag-WAE	-0.018	0.926	No change over time
	As-WAE	0.022	0.91	No change over time
	Cd-WAE	0.112	0.571	No change over time
	Cr-WAE	0.126	0.523	No change over time
	Cu-WAE	0.054	0.784	No change over time
	Fe-WAE	0.096	0.628	No change over time
	Pb-WAE	-0.642	<0.001	No change over time
	Hg-WAE	0.574	0.001	Reduced over time
	Ni-WAE	-0.525	0.004	No change over time
	Se-WAE	-0.193	0.324	No change over time
	Zn-WAE	0.221	0.259	No change over time

**APPENDIX D. WATER QUALITY – RISK AND PERFORMANCE ASSESSMENT –
DETAILS OF STATISTICAL ANALYSIS AND BOX PLOTS**

Table D-1 Expanded risk matrix – water quality – metals and TSS

Initial Assessment Result					Go To
TSM < TV					Step 1
TSM ≥ TV and TV, TSM and full TSM data set are > LOR					Step 2
TSM = TV and TV, TSM and full TSM data set ≤ LOR					Step 3
Step	Alt Hypothesis	Null Hypothesis	Sig Test Result		Risk Assessment
1	TSM < TV	TSM = TV	p < 0.05	Accept Alt	LOW
			p > 0.05	Accept Null	POTENTIAL
			Error	Accept Neither	ND
2	TSM ≥ TV and TV, TSM and full TSM data set are > LOR				POTENTIAL
3	TSM = TV and TV, TSM and full TSM data set are ≤ LOR				LOW

TSM = Test Site Median

ND = No determination

Table D-2 Expanded risk matrix – water quality – pH

Initial Assessment Result					Go To
Lower TV < TSM < Upper TV					Step 1
TSM ≤ Lower TV OR TSM ≥ Upper TV					Step 3
Step	Alt Hypothesis	Null Hypothesis	Sig Test Result		Risk Assessment
1	TSM < Upper TV	TSM = Upper TV	p < 0.05	Accept Alt	STEP 2
			p > 0.05	Accept Null	POTENTIAL
2	TSM > Lower TV	TSM = Upper TV	p < 0.05	Accept Alt	LOW
			p > 0.05	Accept Null	POTENTIAL
			Error	Accept Neither	ND
3	TSM ≤ Lower TV OR TSM ≥ Upper TV				POTENTIAL

TSM = Test Site Median

ND = No determination

Table D-3 Water quality upper river test sites - SG2 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
SG2	N	N(Test)	Median	Result	Go to			
pH	6	6	7.8	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.018 / 0.018	LOW
EC	6	6	301	TSM ≥TV	Step 2	230	0.953	POTENTIAL
TSS	6	6	1,450	TSM < TV	Step 1	2,837	0.030	LOW
Ag-D	6	6	0.01	TSM < TV	Step 1	0.05	0.018	LOW
As-D	6	6	1.2	TSM < TV	Step 1	24	0.018	LOW
Cd-D	6	6	0.08	TSM < TV	Step 1	0.34	0.018	LOW
Cr-D	6	6	0.14	TSM < TV	Step 1	1.0	0.018	LOW
Cu-D	6	6	1.3	TSM = TV	Step 2	1.4	0.663	POTENTIAL
Fe-D	6	6	2.6	TSM < TV	Step 1	75	0.201	LOW
Hg-D	6	6	0.05	TSM < TV	Step 1	0.60	0.018	LOW
Ni-D	6	6	0.75	TSM < TV	Step 1	21	0.018	LOW
Pb-D	6	6	0.10	TSM < TV	Step 1	7.3	0.018	LOW
Se-D	6	6	0.20	TSM < TV	Step 1	11	0.018	LOW
Zn-D	6	6	4.8	TSM < TV	Step 1	20	0.018	LOW

Table D-4 Water quality upper river test sites - Wasiba 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Wasiba	N	N(Test)	Median	Result	Go to			
pH	11	11	7.8	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.002 / 0.004	LOW
EC	11	11	256	TSM ≥TV	Step 2	230	0.993	POTENTIAL
TSS	11	11	940	TSM < TV	Step 1	2,837	0.023	LOW
Ag-D	11	11	0.01	TSM < TV	Step 1	0.05	0.002	LOW
As-D	11	11	0.97	TSM < TV	Step 1	24	0.002	LOW
Cd-D	11	11	0.05	TSM < TV	Step 1	0.34	0.002	LOW
Cr-D	11	11	0.39	TSM < TV	Step 1	1.0	0.002	LOW
Cu-D	11	11	0.59	TSM < TV	Step 1	1.4	0.002	LOW
Fe-D	11	11	1.7	TSM < TV	Step 1	75	0.002	LOW
Hg-D	11	11	0.05	TSM < TV	Step 1	0.60	0.002	LOW
Ni-D	11	11	0.56	TSM < TV	Step 1	21	0.002	LOW
Pb-D	11	11	0.10	TSM < TV	Step 1	7.3	0.002	LOW
Se-D	11	11	0.27	TSM < TV	Step 1	11	0.002	LOW
Zn-D	11	11	0.95	TSM < TV	Step 1	20	0.003	LOW

NPL Annual Environment Report 2024

Table D-5 Water quality upper river test sites - Wankipe 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment	
Wankipe	N	N(Test)	Median	Result				Go to
pH	12	12	7.8	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.001 / 0.007	LOW
EC	12	12	228	TSM < TV	Step 1	230	0.377	POTENTIAL
TSS	12	12	2,300	TSM < TV	Step 1	2837	0.305	POTENTIAL
Ag-D	12	12	0.01	TSM < TV	Step 1	0.05	0.019	LOW
As-D	12	12	1.2	TSM < TV	Step 1	24	0.001	LOW
Cd-D	12	12	0.05	TSM < TV	Step 1	0.34	0.001	LOW
Cr-D	12	12	0.15	TSM < TV	Step 1	1.0	0.001	LOW
Cu-D	12	12	0.81	TSM < TV	Step 1	1.4	0.001	LOW
Fe-D	12	12	3.3	TSM < TV	Step 1	75	0.001	LOW
Hg-D	12	12	0.05	TSM < TV	Step 1	0.60	0.001	LOW
Ni-D	12	12	0.50	TSM < TV	Step 1	21	0.001	LOW
Pb-D	12	12	0.10	TSM < TV	Step 1	7.3	0.001	LOW
Se-D	12	12	0.21	TSM < TV	Step 1	11	0.001	LOW
Zn-D	12	12	1.9	TSM < TV	Step 1	20	0.001	LOW

Table D-6 Water quality upper river test sites - SG3 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site			Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment	
SG3	N	N(Test)	Median	Result				Go to
pH	183	180	7.9	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	<0.001 / <0.001	LOW
EC	183	183	215	TSM < TV	Step 2	230	<0.001	LOW
TSS	183	183	2,100	TSM < TV	Step 1	2837	0.003	LOW
Ag-D	183	183	0.01	TSM < TV	Step 1	0.05	<0.001	LOW
As-D	183	183	1.0	TSM < TV	Step 1	24	<0.001	LOW
Cd-D	183	183	0.05	TSM < TV	Step 1	0.34	<0.001	LOW
Cr-D	183	183	0.15	TSM < TV	Step 1	1.0	<0.001	LOW
Cu-D	183	183	0.96	TSM < TV	Step 1	1.4	<0.001	LOW
Fe-D	183	183	3.6	TSM < TV	Step 1	75	<0.001	LOW
Hg-D	183	183	0.05	TSM < TV	Step 1	0.60	<0.001	LOW
Ni-D	183	183	0.50	TSM < TV	Step 1	21	<0.001	LOW
Pb-D	183	183	0.10	TSM < TV	Step 1	7.3	<0.001	LOW
Se-D	183	183	0.20	TSM < TV	Step 1	11	<0.001	LOW
Zn-D	183	183	1.8	TSM < TV	Step 1	20	<0.001	LOW

NPL Annual Environment Report 2024

Table D-7 Water quality lower river test sites - Bebelubi 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
Bebelubi	N	N (Test)	Median	Result	Go to			
pH	8	8	7.9	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.007 / 0.030	LOW
EC	8	8	175	TSM < TV	Step 2	250	0.092	POTENTIAL
TSS	8	8	1,450	TSM > TV	Step 2	983	0.995	POTENTIAL
Ag-D	8	8	0.01	TSM < TV	Step 1	0.05	0.007	LOW
As-D	8	8	0.75	TSM < TV	Step 1	24	0.007	LOW
Cd-D	8	8	0.05	TSM < TV	Step 1	0.20	0.007	LOW
Cr-D	8	8	0.16	TSM < TV	Step 1	1.0	0.007	LOW
Cu-D	8	8	0.87	TSM < TV	Step 1	1.4	0.007	LOW
Fe-D	8	8	6.8	TSM < TV	Step 1	75	0.007	LOW
Hg-D	8	8	0.05	TSM < TV	Step 1	0.60	0.007	LOW
Ni-D	8	8	0.62	TSM < TV	Step 1	15	0.007	LOW
Pb-D	8	8	0.10	TSM < TV	Step 1	3.4	0.007	LOW
Se-D	8	8	0.20	TSM < TV	Step 1	11	0.007	LOW
Zn-D	8	8	1.1	TSM < TV	Step 1	8.0	0.007	LOW

Table D-8 Water quality lower river test sites - SG4 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical test Result (p=0.05)	Risk Assessment
SG4	N	N (Test)	Median	Result	Go to			
pH	8	8	7.9	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	0.007 / 0.030	LOW
EC	8	8	159	TSM < TV	Step 2	250	0.007	LOW
TSS	8	8	1,045	TSM > TV	Step 1	983	0.688	POTENTIAL
Ag-D	8	8	0.01	TSM < TV	Step 1	0.05	0.007	LOW
As-D	8	8	0.77	TSM < TV	Step 1	24	0.007	LOW
Cd-D	8	8	0.05	TSM < TV	Step 1	0.20	0.007	LOW
Cr-D	8	8	0.16	TSM < TV	Step 1	1.0	0.007	LOW
Cu-D	8	8	0.89	TSM < TV	Step 1	1.4	0.007	LOW
Fe-D	8	8	7.4	TSM < TV	Step 1	75	0.007	LOW
Hg-D	8	8	0.05	TSM < TV	Step 1	0.60	0.007	LOW
Ni-D	8	8	0.50	TSM < TV	Step 1	15	0.007	LOW
Pb-D	8	8	0.10	TSM < TV	Step 1	3.4	0.007	LOW
Se-D	8	8	0.20	TSM < TV	Step 1	11	0.007	LOW
Zn-D	8	8	1.3	TSM < TV	Step 1	8.0	0.007	LOW

NPL Annual Environment Report 2024

Table D-9 Water quality lower river test sites - SG5 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
SG5	N	N (Test)	Median	Result	Go to			
pH	15	15	7.9	Lower TV<TSM<Upper TV	Step 1 / 2	6.0-8.1	<0.001 / 0.001	LOW
EC	15	15	158	TSM < TV	Step 1	250	<0.001	LOW
TSS	15	15	340	TSM < TV	Step 1	983	<0.001	LOW
Ag-D	15	15	0.01	TSM < TV	Step 1	0.05	<0.001	LOW
As-D	15	15	0.75	TSM < TV	Step 1	24	<0.001	LOW
Cd-D	15	15	0.05	TSM < TV	Step 1	0.20	<0.001	LOW
Cr-D	15	15	0.10	TSM < TV	Step 1	1.0	<0.001	LOW
Cu-D	15	15	0.95	TSM < TV	Step 1	1.4	<0.001	LOW
Fe-D	15	15	25	TSM < TV	Step 1	75	<0.001	LOW
Hg-D	15	15	0.05	TSM < TV	Step 1	0.60	<0.001	LOW
Ni-D	15	15	0.50	TSM < TV	Step 1	15	<0.001	LOW
Pb-D	15	15	0.10	TSM < TV	Step 1	3.4	<0.001	LOW
Se-D	15	15	0.20	TSM < TV	Step 1	11	<0.001	LOW
Zn-D	15	15	0.65	TSM < TV	Step 1	8.0	<0.001	LOW

Table D-10 Water quality ORWB test sites - Kukufionga 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Kukufionga	N	N (Test)	Median	Result	Go to			
pH	6	6	8.0	Lower TV < TSM < Upper TV	Step 1/2	6.0-8.1	0.018 / 0.018	LOW
EC	6	6	207	TSM < Upper TV	Step 2	250	0.018	LOW
TSS	6	6	24	TSM < Upper TV	Step 1	983	0.018	LOW
Ag-D	6	6	0.01	TSM < Upper TV	Step 1	0.05	0.018	LOW
As-D	6	6	1.8	TSM < Upper TV	Step 1	24	0.018	LOW
Cd-D	6	6	0.05	TSM < Upper TV	Step 1	0.20	0.018	LOW
Cr-D	6	6	0.10	TSM < Upper TV	Step 1	1.0	0.018	LOW
Cu-D	6	6	0.47	TSM < Upper TV	Step 1	1.4	0.018	LOW
Fe-D	6	6	1.0	TSM < Upper TV	Step 1	75	0.018	LOW
Hg-D	6	6	0.05	TSM < Upper TV	Step 1	0.60	0.018	LOW
Ni-D	6	6	0.50	TSM < Upper TV	Step 1	15	0.018	LOW
Pb-D	6	6	0.10	TSM < Upper TV	Step 1	3.4	0.018	LOW
Se-D	6	6	0.20	TSM < Upper TV	Step 1	11	0.018	LOW
Zn-D	6	6	2.5	TSM < Upper TV	Step 1	8.0	0.030	LOW

NPL Annual Environment Report 2024

Table D-11 Water quality ORWB test sites - Zongamange 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Zongamange	N	N (Test)	Median	Result	Go to			
pH	6	6	7.2	Lower TV < TSM < Upper TV	Step 1 / 2	6.0-8.1	0.018 / 0.018	LOW
EC	6	6	131	TSM < Upper TV	Step 1	250	0.018	LOW
TSS	6	6	8.5	TSM < Upper TV	Step 1	983	0.018	LOW
Ag-D	6	6	0.01	TSM < Upper TV	Step 1	0.05	0.018	LOW
As-D	6	6	0.94	TSM < Upper TV	Step 1	24	0.018	LOW
Cd-D	6	6	0.05	TSM < Upper TV	Step 1	0.20	0.018	LOW
Cr-D	6	6	0.10	TSM < Upper TV	Step 1	1.0	0.018	LOW
Cu-D	6	6	0.57	TSM < Upper TV	Step 1	1.4	0.018	LOW
Fe-D	6	6	90	TSM ≥ Upper TV	Step 2	75	0.853	POTENTIAL
Hg-D	6	6	0.05	TSM < Upper TV	Step 1	0.60	0.018	LOW
Ni-D	6	6	0.50	TSM < Upper TV	Step 1	15	0.018	LOW
Pb-D	6	6	0.10	TSM < Upper TV	Step 1	3.4	0.018	LOW
Se-D	6	6	0.20	TSM < Upper TV	Step 1	11	0.018	LOW
Zn-D	6	6	4.1	TSM < Upper TV	Step 1	8.0	0.018	LOW

Table D-12 Water quality ORWB test sites - Avu 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Avu	N	N (Test)	Median	Result	Go to			
pH	6	6	7.2	Lower TV < TSM < Upper TV	Step 1 / 2	6.0-8.1	0.018 / 0.018	LOW
EC	6	6	50	TSM < Upper TV	Step 1	250	0.018	LOW
TSS	6	6	9.0	TSM < Upper TV	Step 1	983	0.018	LOW
Ag-D	6	6	0.01	TSM < Upper TV	Step 1	0.05	0.018	LOW
As-D	6	6	0.81	TSM < Upper TV	Step 1	24	0.018	LOW
Cd-D	6	6	0.05	TSM < Upper TV	Step 1	0.20	0.018	LOW
Cr-D	6	6	0.36	TSM < Upper TV	Step 1	1.0	0.018	LOW
Cu-D	6	6	0.32	TSM < Upper TV	Step 1	1.4	0.018	LOW
Fe-D	6	6	665	TSM ≥ Upper TV	Step 1	75	0.989	POTENTIAL
Hg-D	6	6	0.05	TSM < Upper TV	Step 1	0.60	0.018	LOW
Ni-D	6	6	0.63	TSM < Upper TV	Step 1	15	0.018	LOW
Pb-D	6	6	0.10	TSM < Upper TV	Step 1	3.4	0.018	LOW
Se-D	6	6	0.20	TSM < Upper TV	Step 1	11	0.018	LOW
Zn-D	6	6	1.9	TSM < Upper TV	Step 1	8.0	0.030	LOW

NPL Annual Environment Report 2024

Table D-13 Water quality ORWB test sites - Levame 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Levame	N	N (Test)	Median	Result	Go to			
pH	6	6	7.9	Lower TV < TSM < Upper TV	Step 1 / 2	6.0-8.1	0.018 / 0.018	LOW
EC	6	6	178	TSM < Upper TV	Step 2	250	0.018	LOW
TSS	6	6	73	TSM < Upper TV	Step 1	983	0.018	LOW
Ag-D	6	6	0.01	TSM < Upper TV	Step 1	0.05	0.018	LOW
As-D	6	6	0.92	TSM < Upper TV	Step 1	24	0.018	LOW
Cd-D	6	6	0.05	TSM < Upper TV	Step 1	0.20	0.018	LOW
Cr-D	6	6	0.10	TSM < Upper TV	Step 1	1.0	0.018	LOW
Cu-D	6	6	1.2	TSM < Upper TV	Step 1	1.4	0.018	LOW
Fe-D	6	6	31	TSM < Upper TV	Step 1	75	0.018	LOW
Hg-D	6	6	0.05	TSM < Upper TV	Step 1	0.60	0.018	LOW
Ni-D	6	6	0.50	TSM < Upper TV	Step 1	15	0.018	LOW
Pb-D	6	6	0.10	TSM < Upper TV	Step 1	3.4	0.018	LOW
Se-D	6	6	0.20	TSM < Upper TV	Step 1	11	0.018	LOW
Zn-D	6	6	1.1	TSM < Upper TV	Step 1	8.0	0.018	LOW

NPL Annual Environment Report 2024

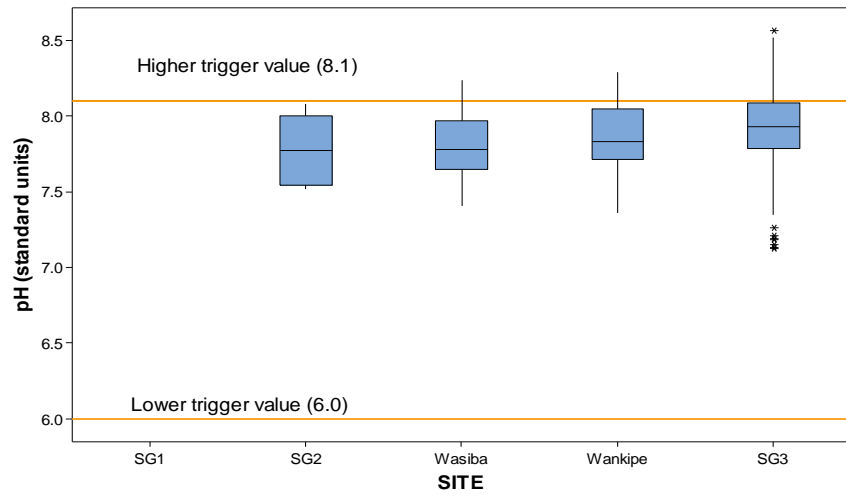


Figure D-1 pH in water upper river test sites 2024

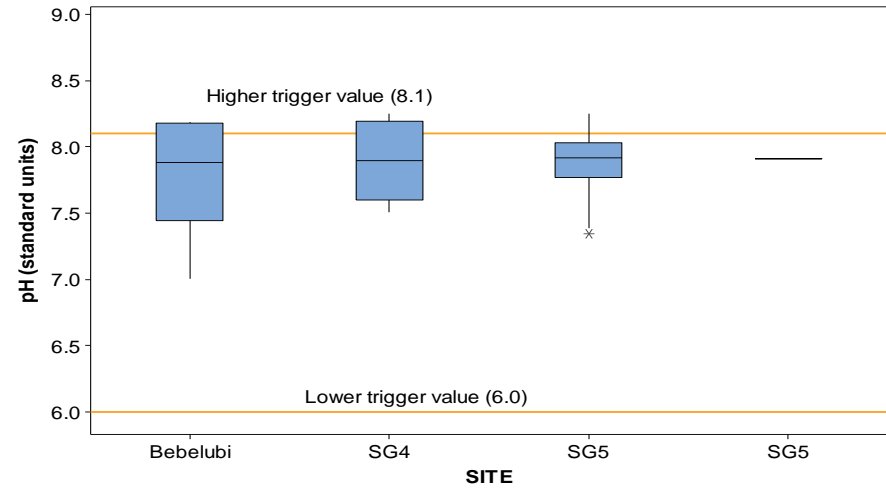


Figure D-2 pH in water at lower river test sites 2024

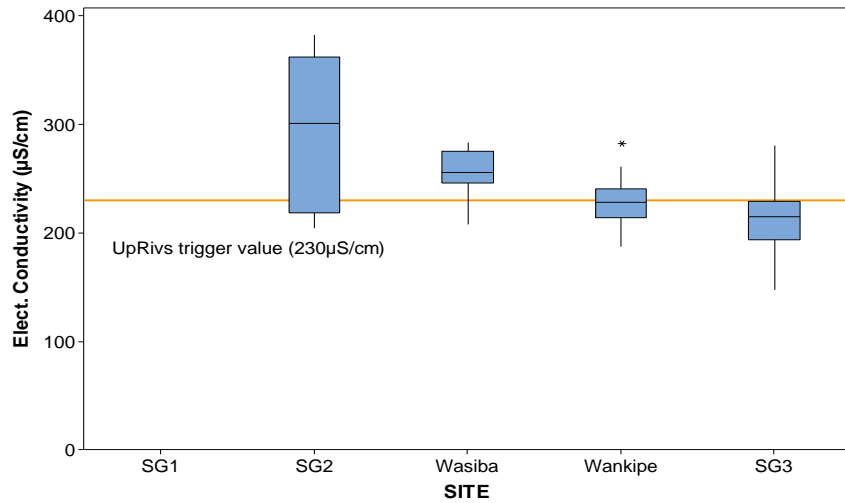


Figure D-3 Electrical conductivity in water upper river test sites 2024

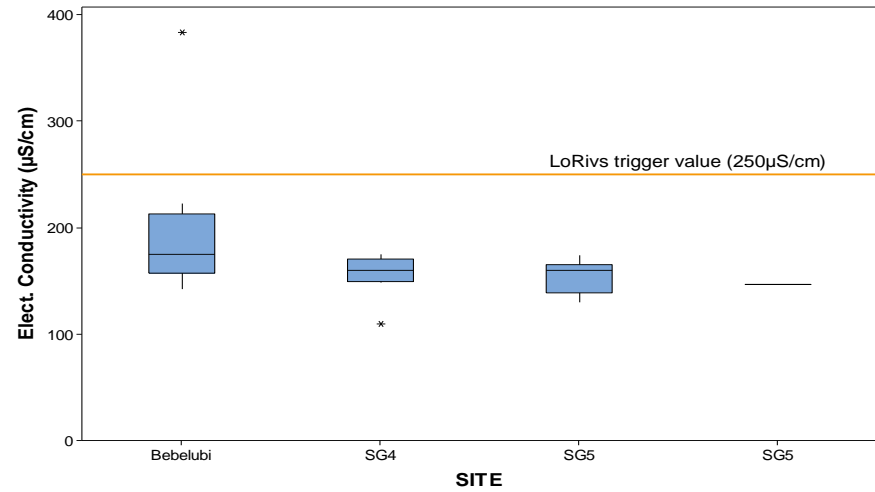


Figure D-4 Electrical conductivity in water at lower river test sites 2024

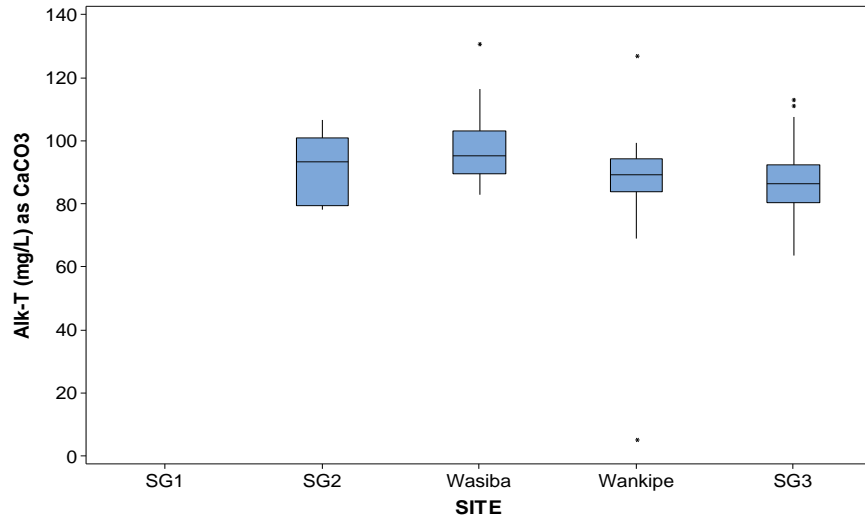


Figure D-5 Alkalinity in water upper river test sites 2024

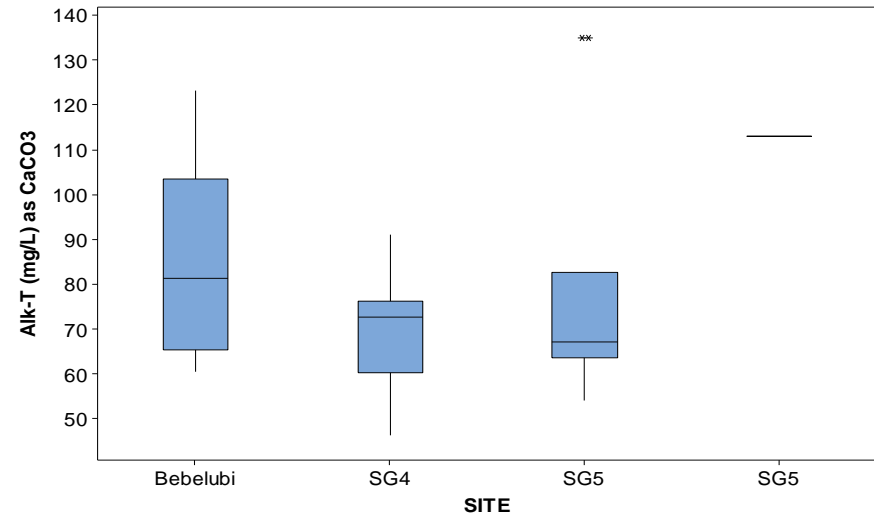


Figure D-6 Alkalinity in water lower river test sites 2024

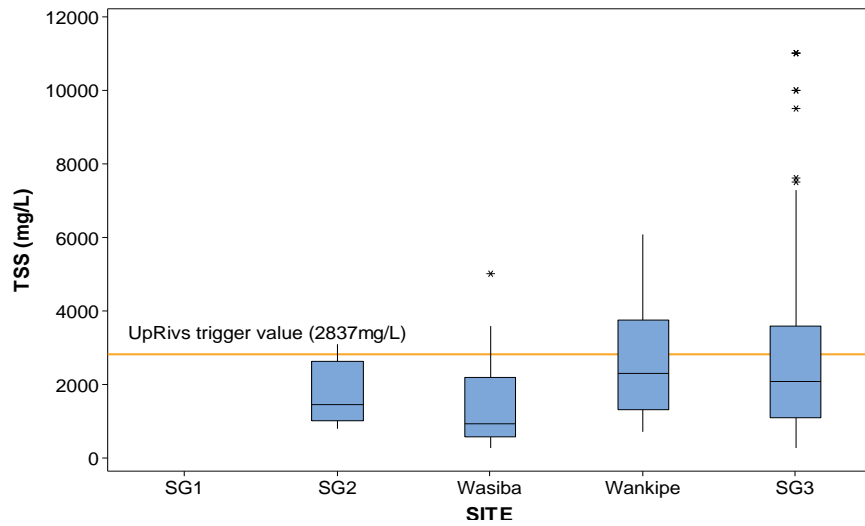


Figure D-7 TSS in water upper river test sites 2024

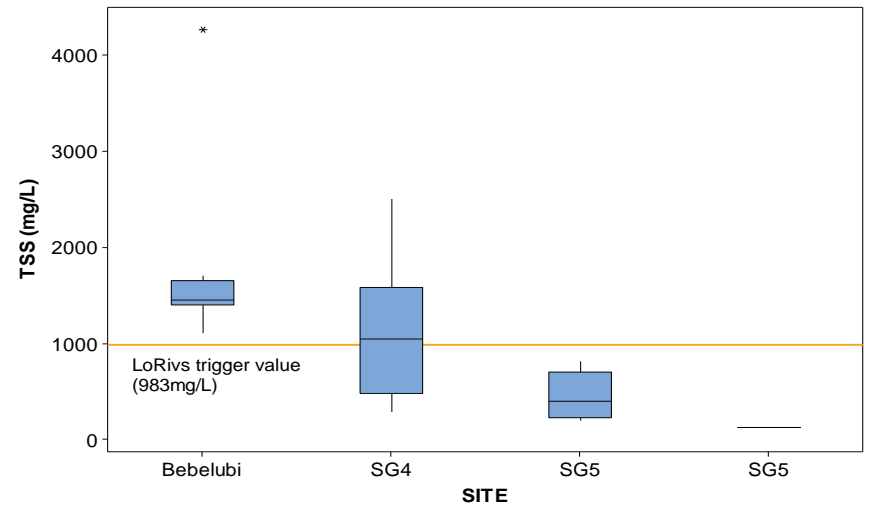


Figure D-8 TSS in water lower river test sites 2024

NPL Annual Environment Report 2024

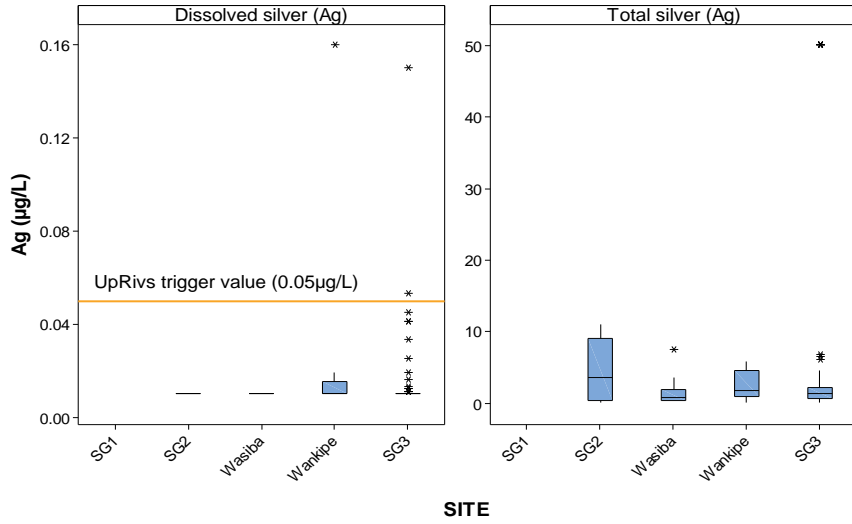


Figure D-9 Silver in water upper river test sites 2024

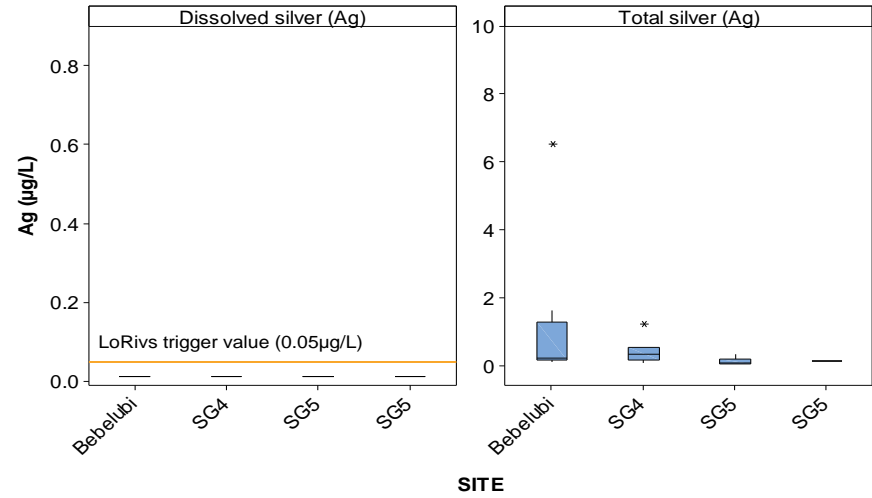


Figure D-10 Silver in water lower river test sites 2024

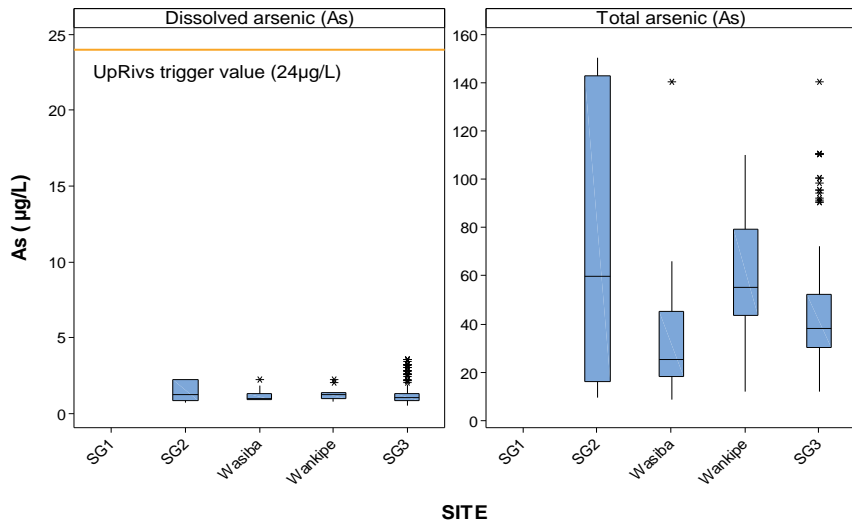


Figure D-11 Arsenic in water upper river test sites 2024

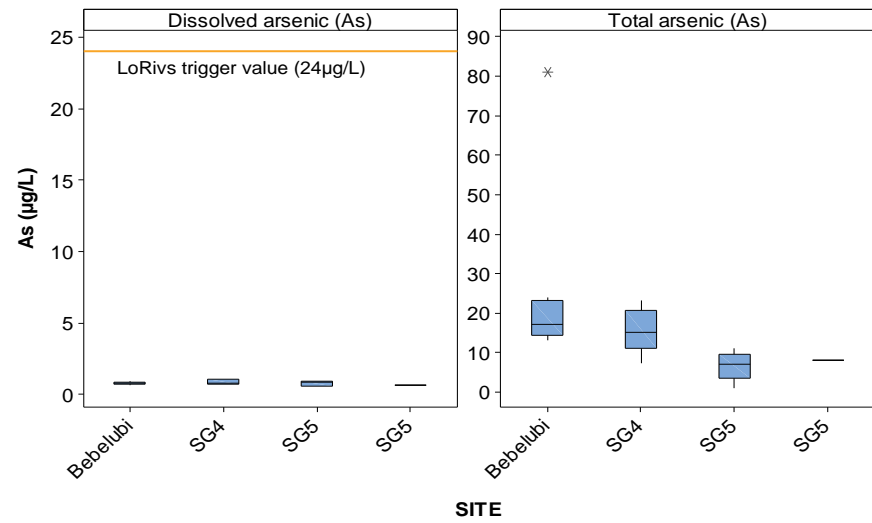


Figure D-12 Arsenic in water lower river test sites 2024

NPL Annual Environment Report 2024

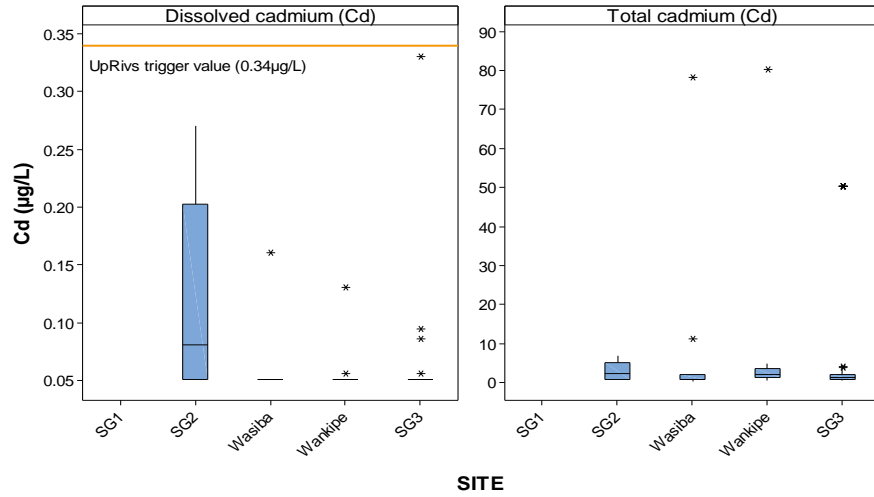


Figure D-13 Cadmium in water upper river test sites 2024

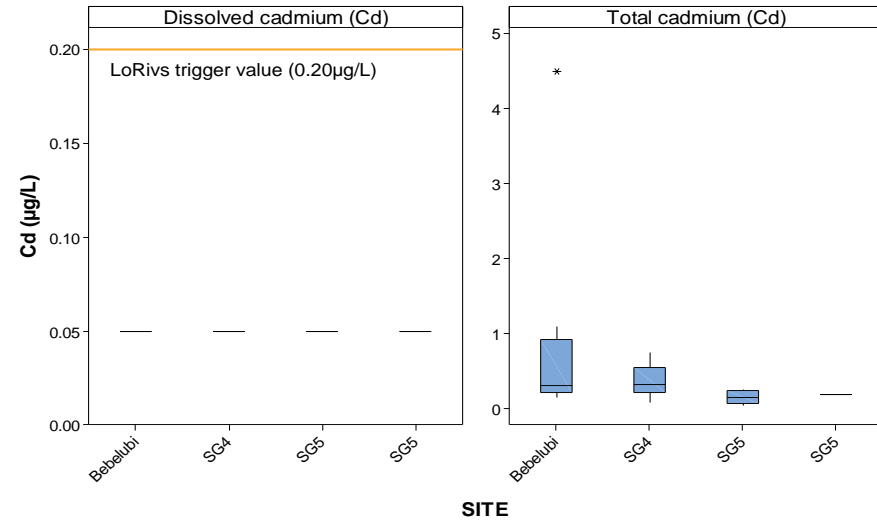


Figure D-14 Cadmium in water lower river test sites 2024

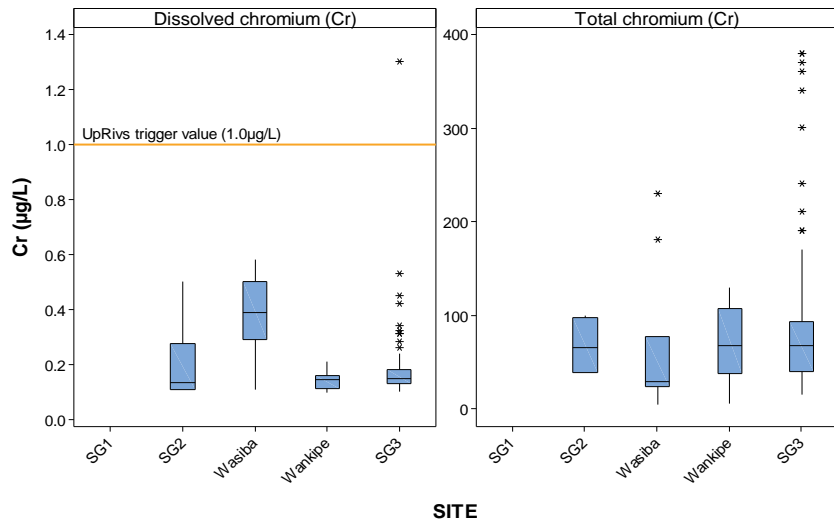


Figure D-15 Chromium in water upper river test sites 2024

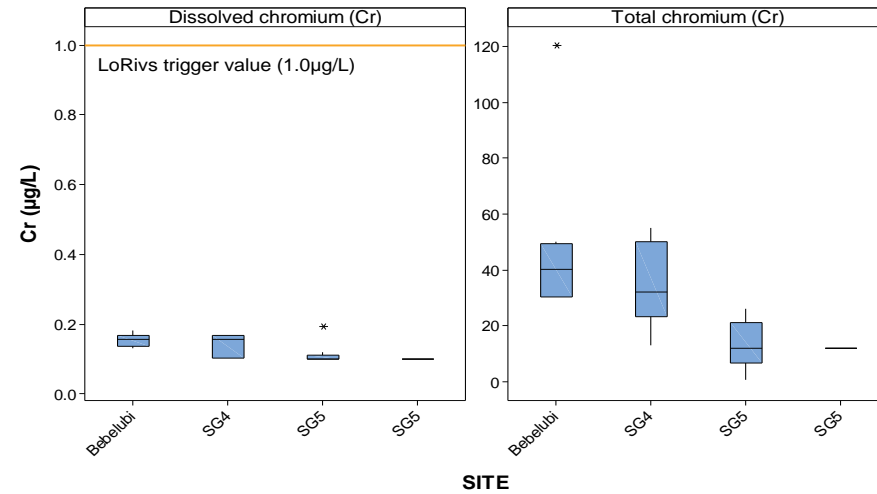


Figure D-16 Chromium in water lower river test sites 2024

NPL Annual Environment Report 2024

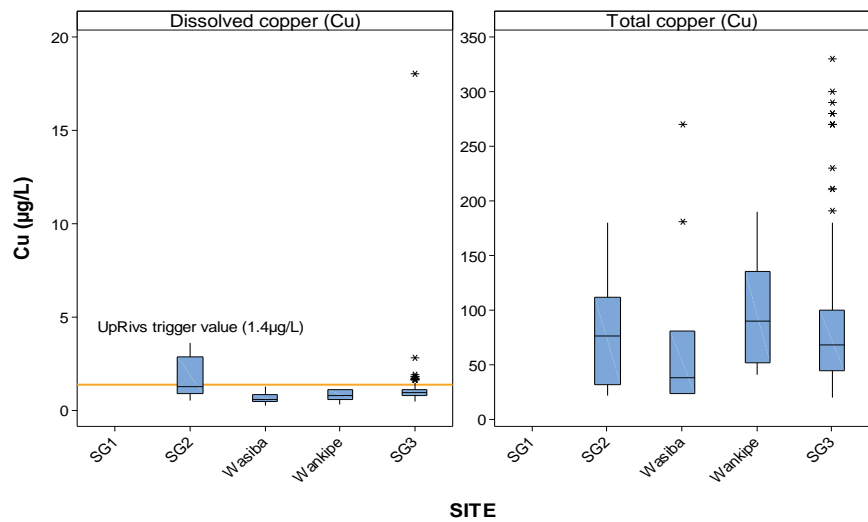


Figure D-17 Copper in water upper river test sites 2024

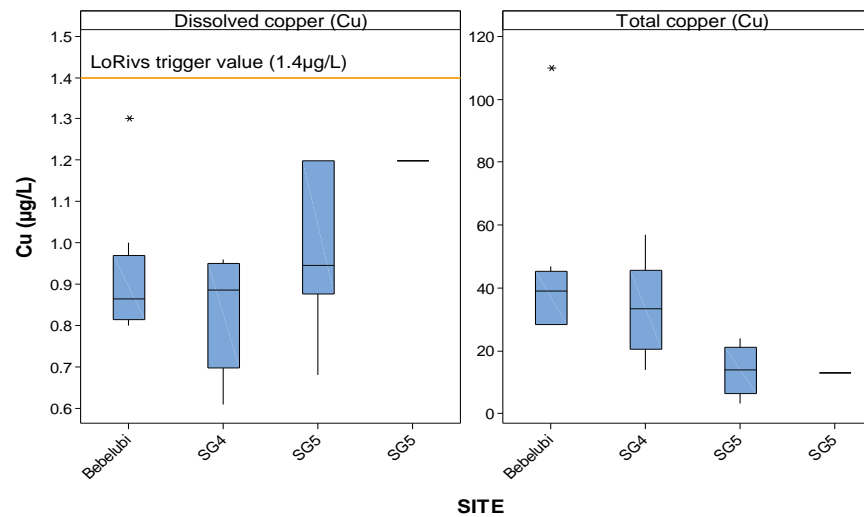


Figure D-18 Copper in water lower river test sites 2024

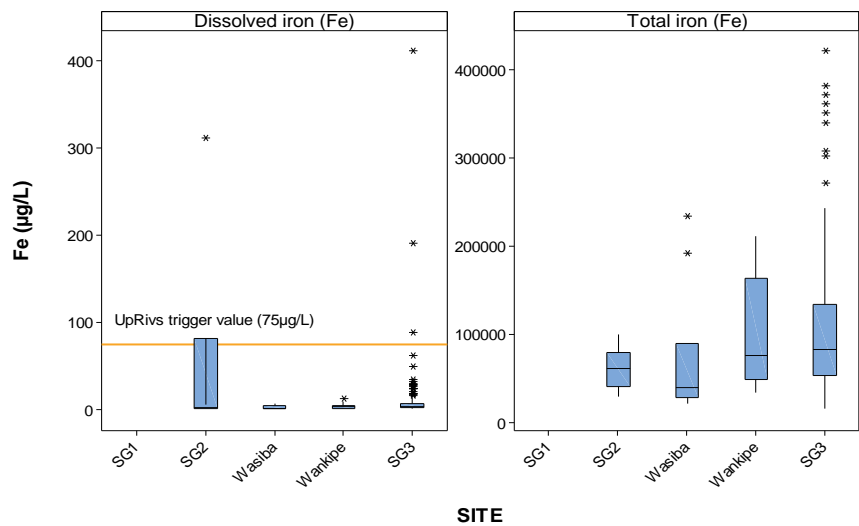


Figure D-19 Iron in water upper river test sites 2024

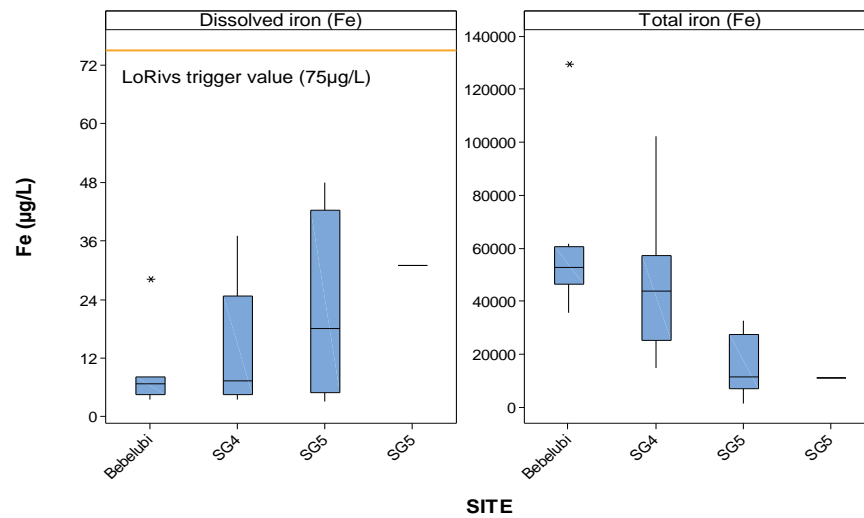


Figure D-20 Iron in water lower river test sites 2024

NPL Annual Environment Report 2024

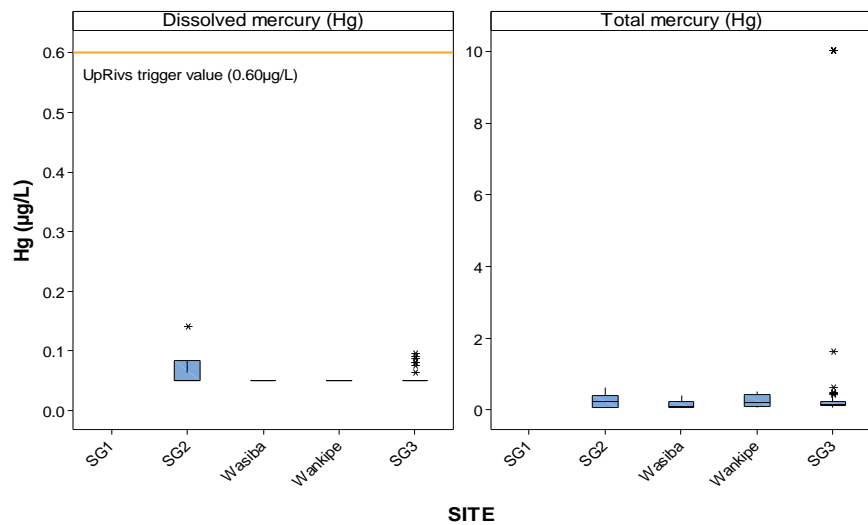


Figure D-21 Mercury in water upper river test sites 2024

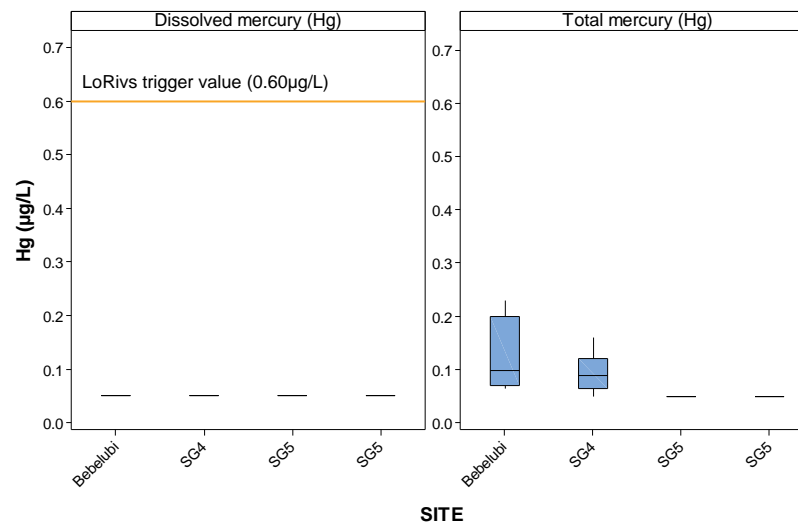


Figure D-22 Mercury in water lower river test sites 2024

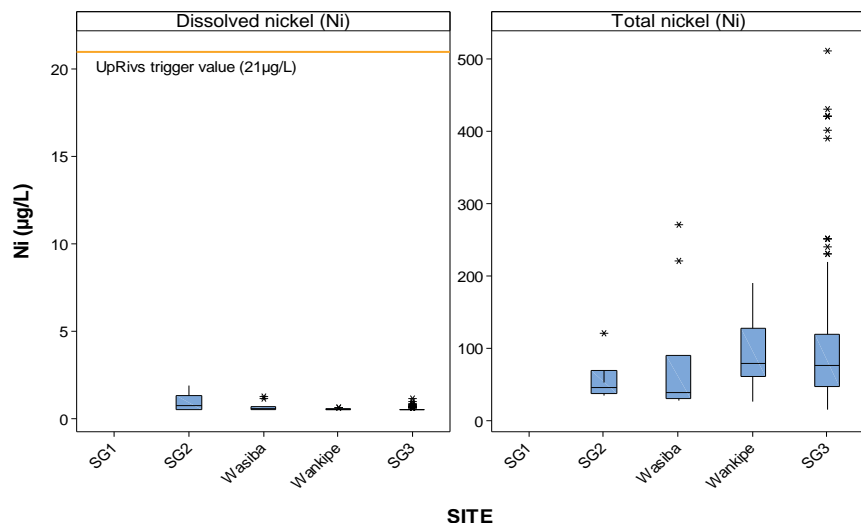


Figure D-23 Nickel in water upper river test sites 2024

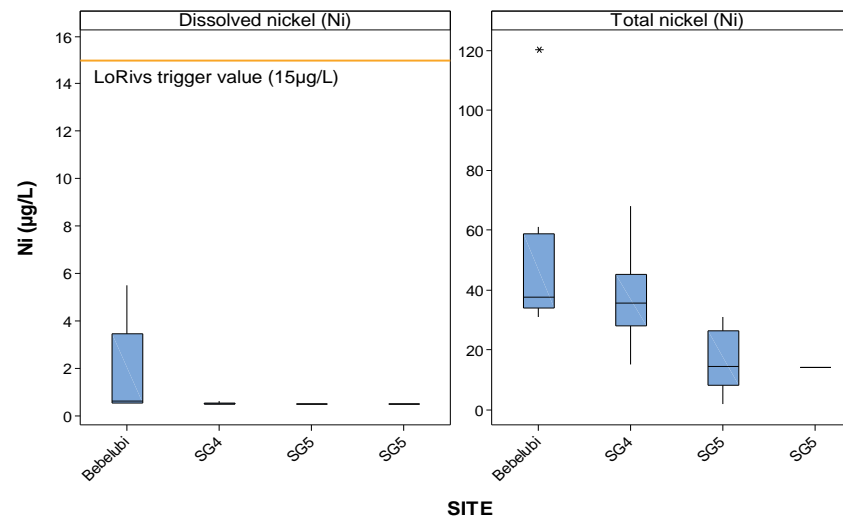


Figure D-24 Nickel in water lower river test sites 2024

NPL Annual Environment Report 2024

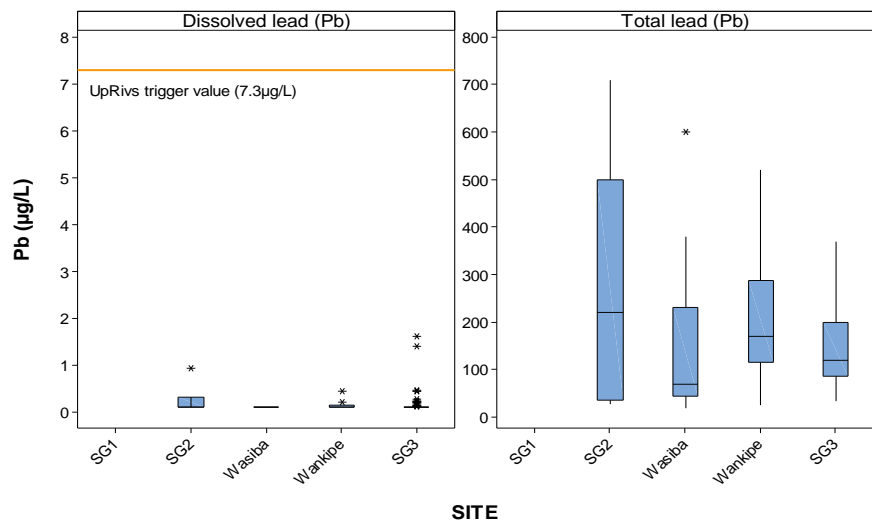


Figure D-25 Lead in water upper river test sites 2024

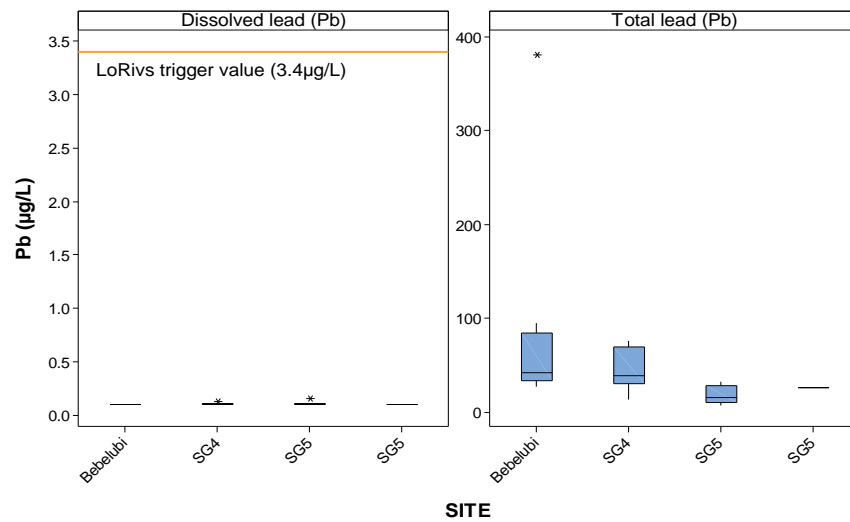


Figure D-26 Lead in water lower river test sites 2024

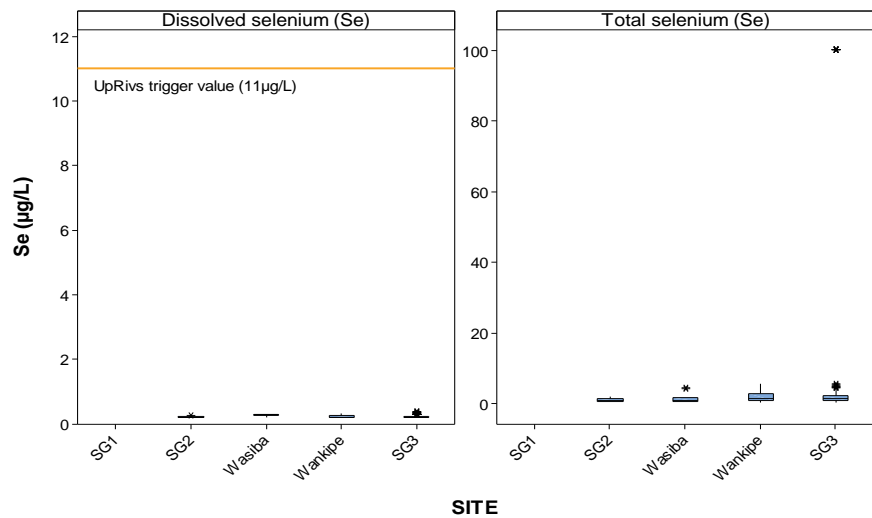


Figure D-27 Selenium in water upper river test sites 2024

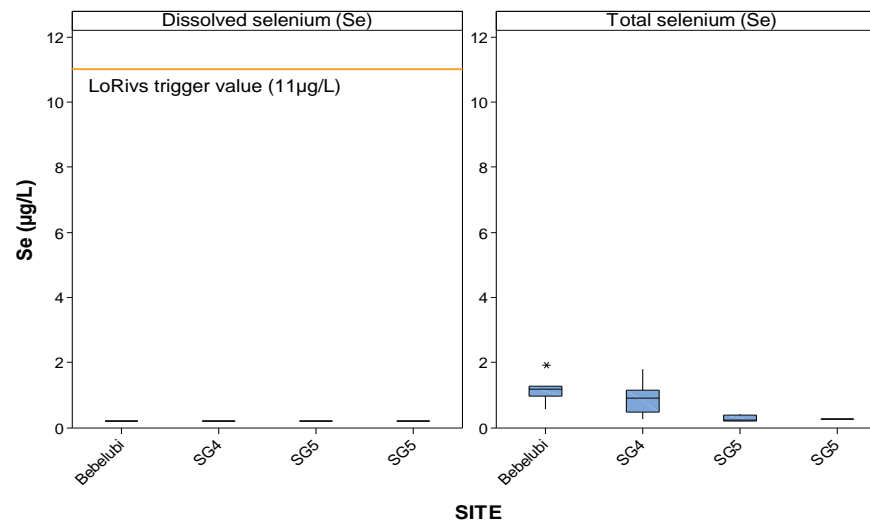


Figure D-28 Selenium in water lower river test sites 2024

NPL Annual Environment Report 2024

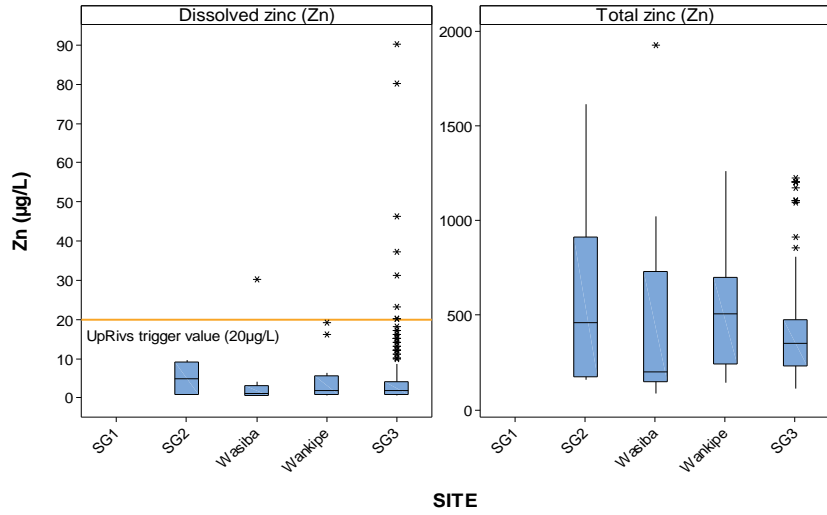


Figure D-29 Zinc in water upper river test sites 2024

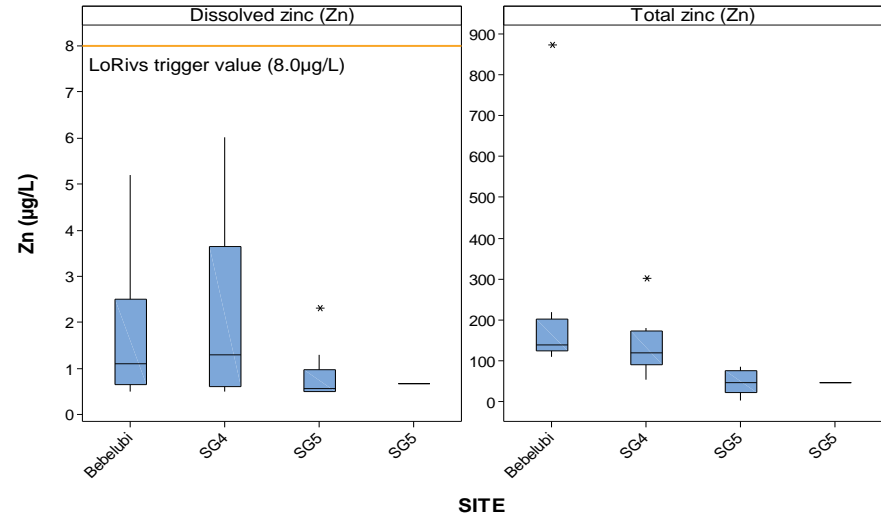


Figure D-30 Zinc in water lower river test sites 2024

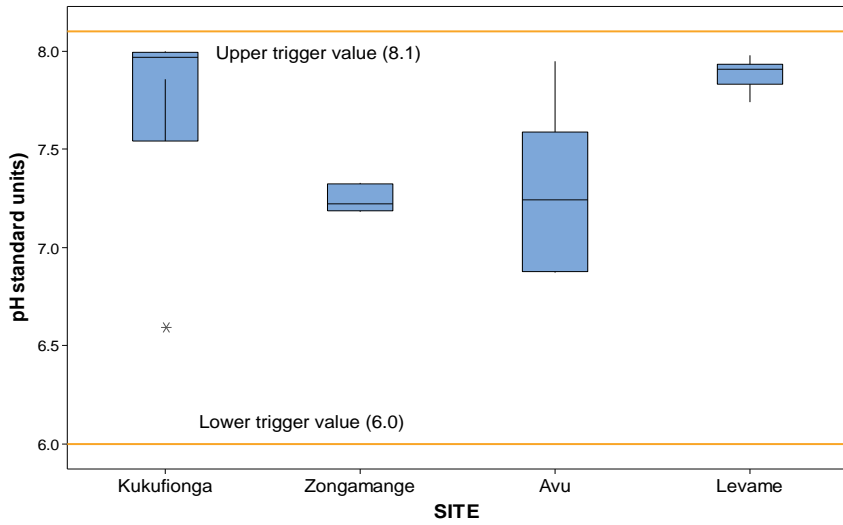


Figure D-31 pH in water ORWB test sites 2024

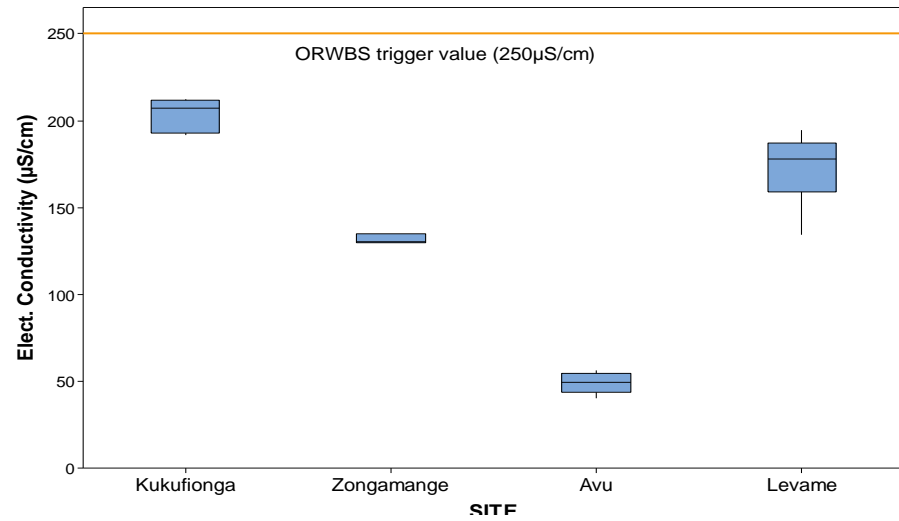


Figure D-32 Electrical conductivity in water ORWB test sites 2024

NPL Annual Environment Report 2024

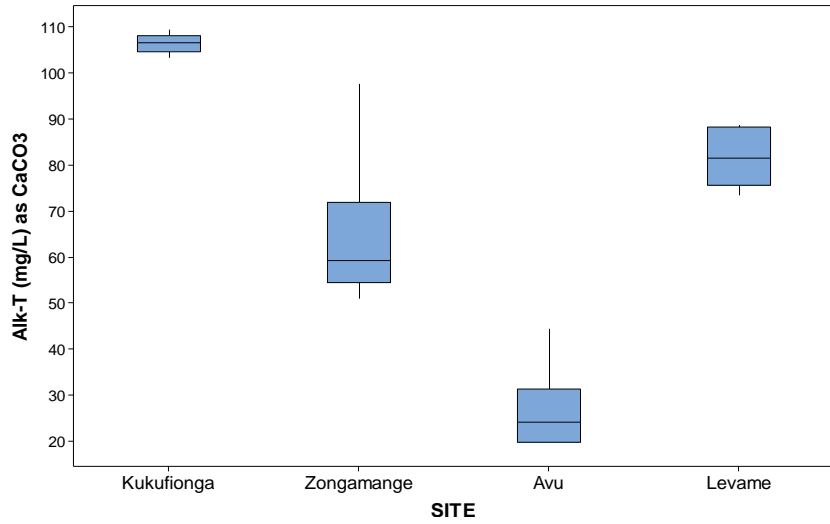


Figure D-33 Alkalinity in water ORWB test sites 2024

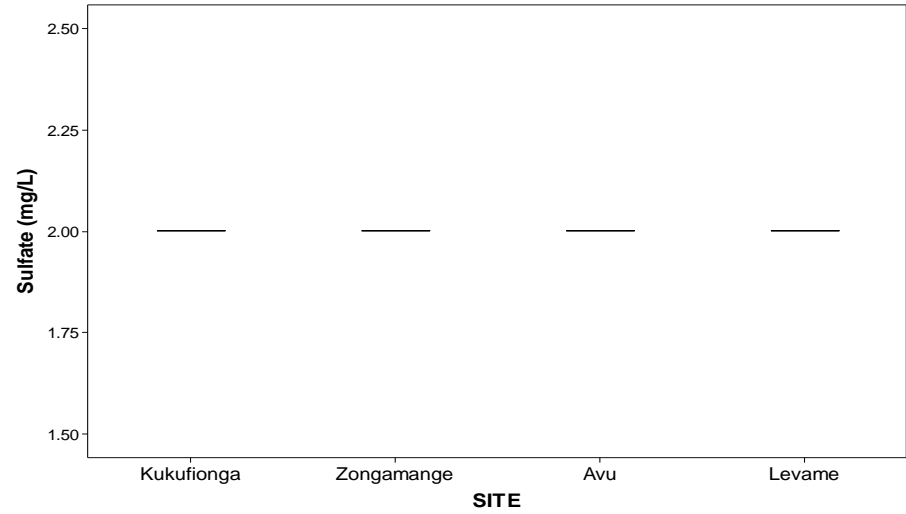


Figure D-34 Sulfate in water ORWB test sites 2024

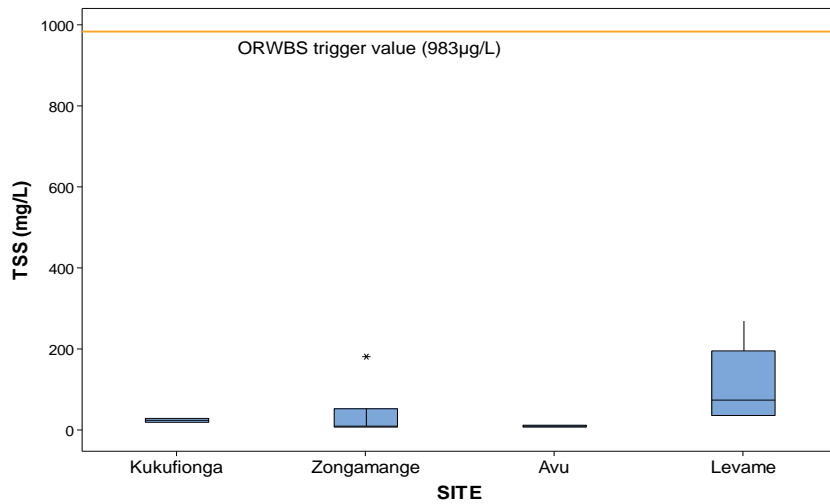


Figure D-35 TSS in water ORWB test sites 2024

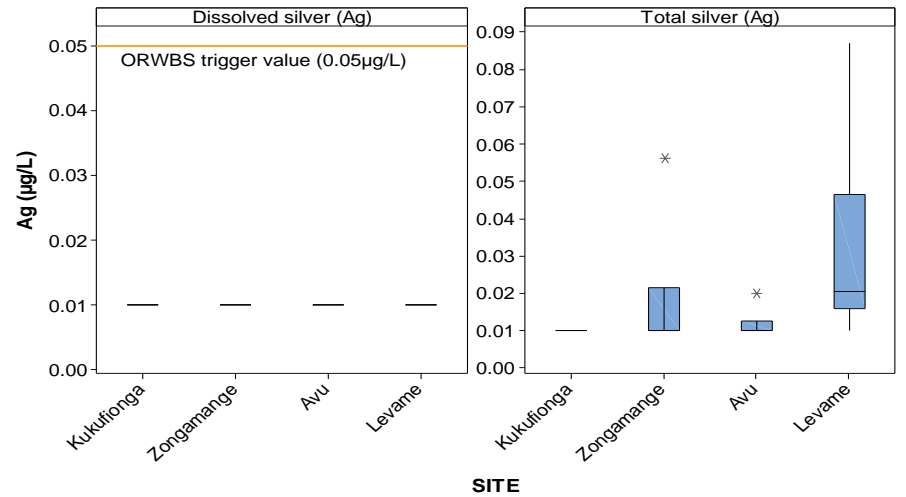


Figure D-36 Silver in water ORWB test sites 2024

NPL Annual Environment Report 2024

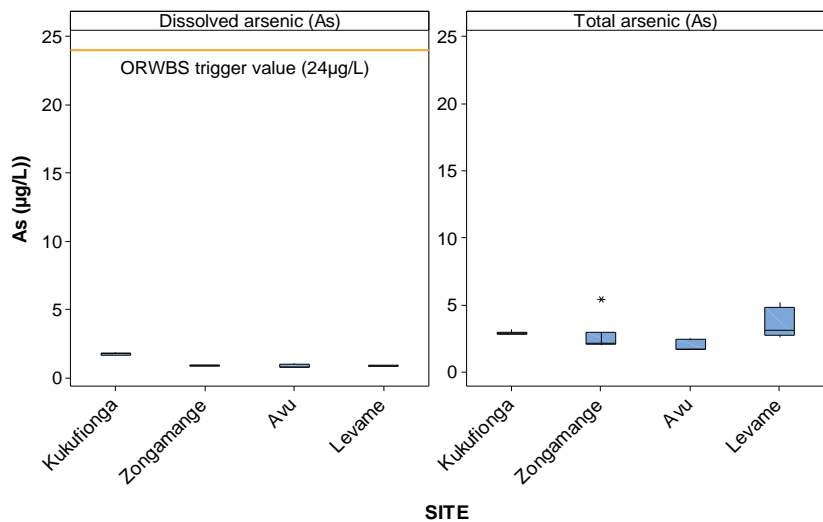


Figure D-37 As in water ORWB test sites 2024

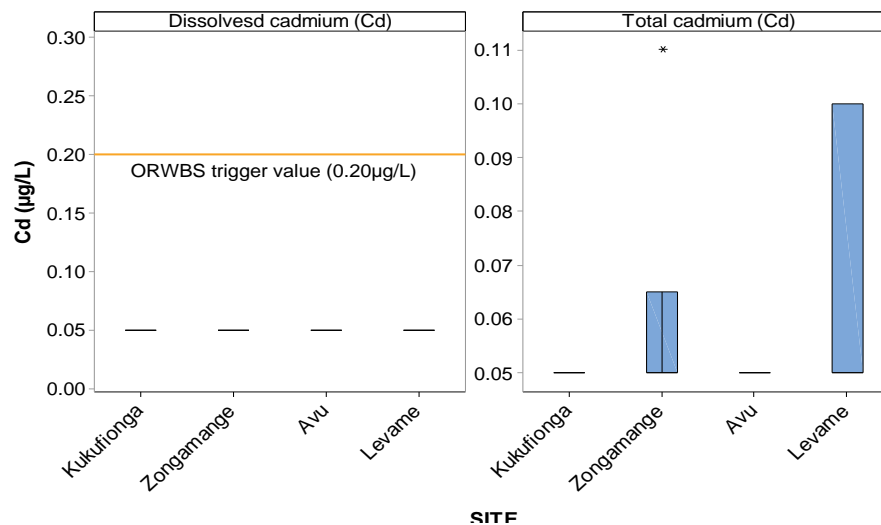


Figure D-38 Cadmium in water ORWB test sites 2024

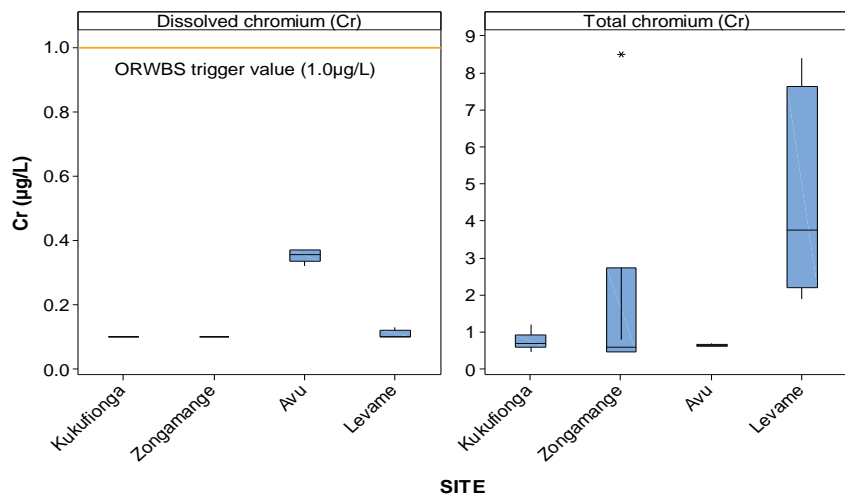


Figure D-39 Cr in water ORWB test sites 2024

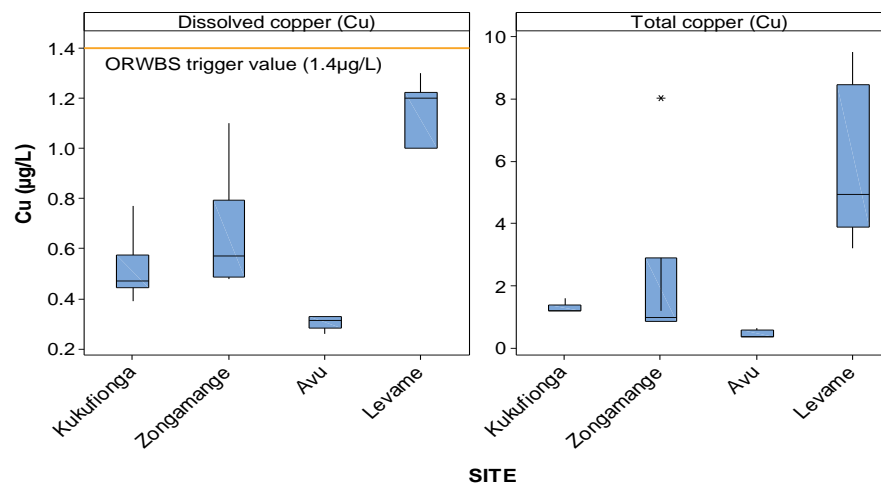


Figure D-40 Copper in water ORWB test sites 2024

NPL Annual Environment Report 2024

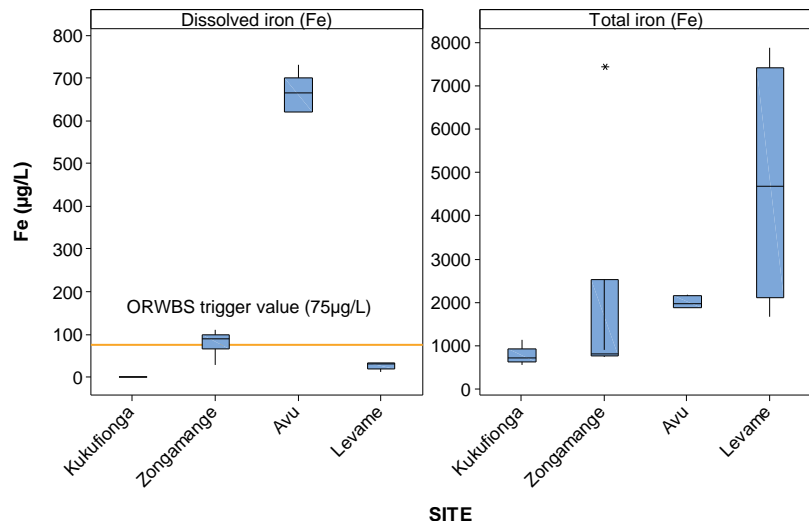


Figure D-41 Iron in water ORWB test sites 2024

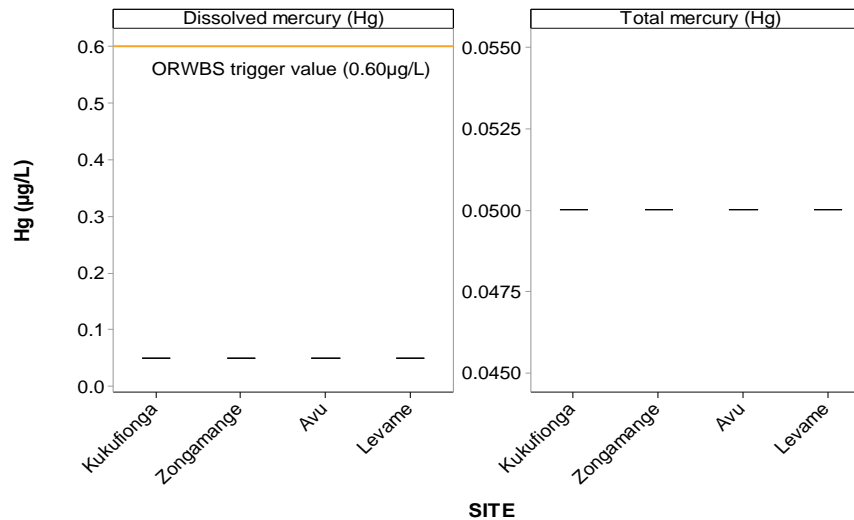


Figure D-42 Mercury in water ORWB test sites 2024

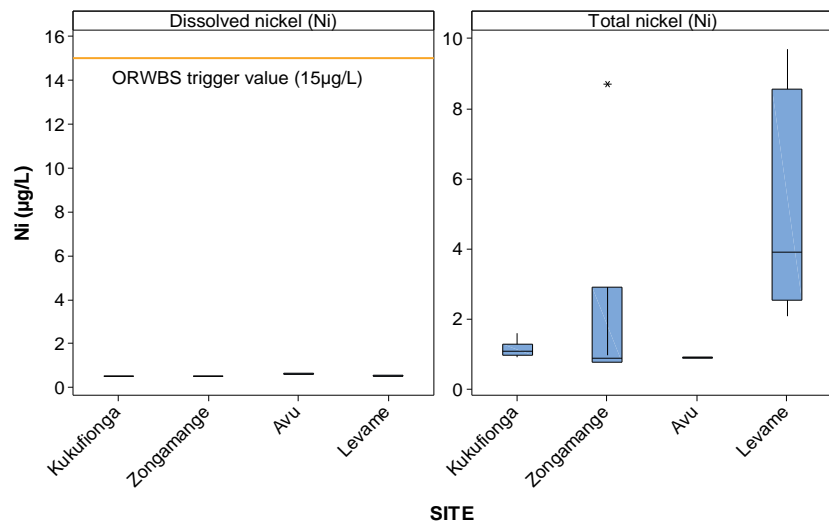


Figure D-43 Nickel in water ORWB test sites 2024

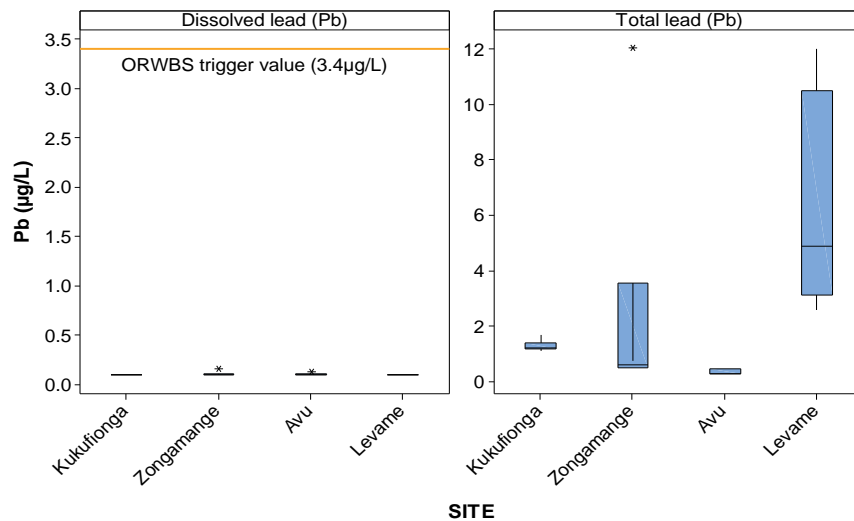


Figure D-44 Lead in water ORWB test sites 2024

NPL Annual Environment Report 2024

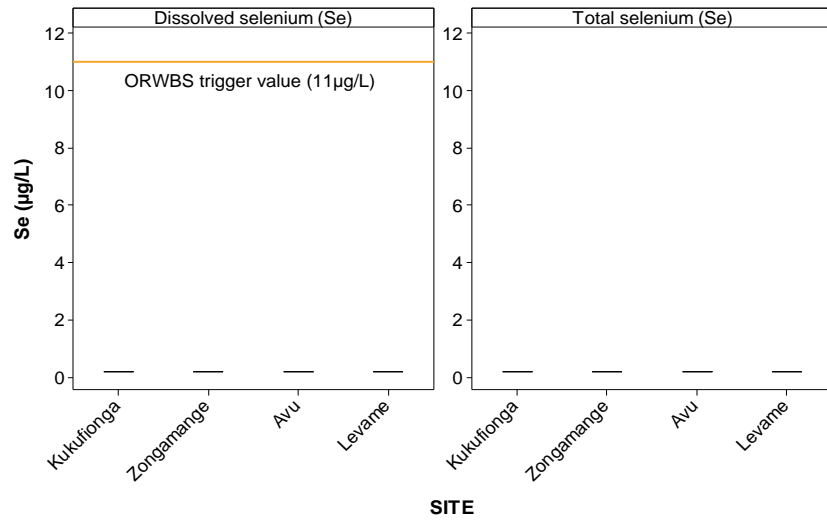


Figure D-45 Selenium in water ORWB test sites 2024

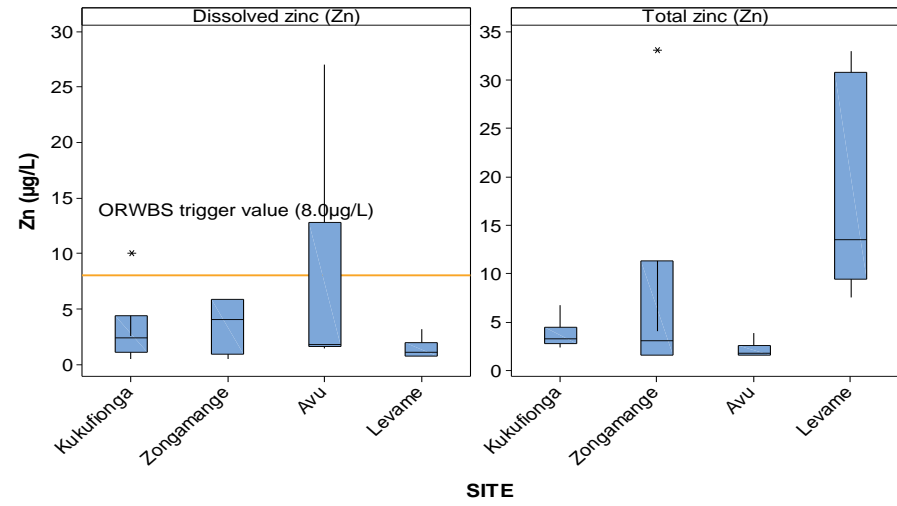


Figure D-46 Zinc in water ORWB test sites 2024

Table D-14 Performance assessment – Based on the trend of water quality indicators (all data) at upper river test sites between 2015 and 2024 using Spearman Rank Test.

Water Quality Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend 2015 - 2024
SG1 (Trend of all data 2010 - 2015) Monitoring not conducted since 2015	pH	-0.066	0.578	No change over time
	EC	-0.601	<0.001	Reduced over time
	TSS	-0.426	<0.001	Reduced over time
	Ag-D*	-0.362	0.002	No change over time
	As-D	-0.579	<0.001	Reduced over time
	Cd-D	-0.089	0.455	No change over time
	Cr-D*	-0.714	<0.001	No change over time
	Cu-D	-0.123	0.300	No change over time
	Fe-D	0.058	0.626	No change over time
	Hg-D*	-0.520	<0.001	No change over time
	Ni-D	-0.138	0.246	No change over time
	Pb-D*	-0.254	0.030	No change over time
	Se-D*	-0.663	0.001	No change over time
	Zn-D	-0.088	0.457	No change over time
SG2 (Trend of all data 2015 - 2024)	pH	0.400	0.001	Increased over time
	EC	-0.402	0.001	Reduced over time
	TSS	-0.260	0.028	Reduced over time
	Ag-D*	-0.540	<0.001	No change over time
	As-D	-0.227	0.054	No change over time
	Cd-D	-0.359	0.002	Reduced over time
	Cr-D	0.045	0.705	No change over time
	Cu-D	-0.311	0.007	Reduced over time
	Fe-D	-0.049	0.683	No change over time
	Hg-D	0.257	0.028	Increased over time
	Ni-D	-0.251	0.032	Reduced over time
	Pb-D	0.099	0.404	No change over time
	Se-D	0.057	0.635	No change over time
	Zn-D	-0.304	0.01	Reduced over time
Wasiba (Trend of all data 2015 - 2024)	pH	0.501	<0.001	Increased over time
	EC	-0.377	<0.001	Reduced over time
	TSS	-0.211	0.012	Reduced over time
	Ag-D*	-0.429	<0.001	No change over time
	As-D	-0.552	<0.001	Reduced over time
	Cd-D	-0.580	<0.001	Reduced over time
	Cr-D	0.345	<0.001	Increased over time
	Cu-D	-0.611	<0.001	Reduced over time
	Fe-D	-0.248	0.003	Reduced over time
	Hg-D	0.125	0.14	No change over time
	Ni-D	-0.175	0.038	Reduced over time
	Pb-D	-0.233	0.005	Reduced over time
	Se-D	0.288	0.001	Increased over time
	Zn-D	-0.513	<0.001	Reduced over time

NPL Annual Environment Report 2024

Water Quality Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend 2015 - 2024
Wankipe (Trend of all data 2015 - 2024)	pH	0.491	<0.001	Increased over time
	EC	-0.446	<0.001	Reduced over time
	TSS	0.120	0.151	No change over time
	Ag-D*	-0.289	0.001	No change over time
	As-D	-0.516	<0.001	Reduced over time
	Cd-D	-0.508	<0.001	Reduced over time
	Cr-D	-0.138	0.098	No change over time
	Cu-D	-0.482	<0.001	Reduced over time
	Fe-D	-0.159	0.057	No change over time
	Hg-D	0.245	0.003	Increased over time
	Ni-D	-0.243	0.003	Reduced over time
	Pb-D	-0.037	0.66	No change over time
	Se-D	0.011	0.894	No change over time
	Zn-D	-0.373	<0.001	Reduced over time
SG3 (Trend of all data 2015 - 2024)	pH	0.341	<0.001	Increased over time
	EC	-0.574	<0.001	Reduced over time
	TSS	0.075	0.004	Increased over time
	Ag-D*	-0.298	<0.001	No change over time
	As-D	-0.464	<0.001	Reduced over time
	Cd-D	-0.433	<0.001	Reduced over time
	Cr-D	-0.035	0.174	No change over time
	Cu-D	-0.434	<0.001	Reduced over time
	Fe-D	-0.080	0.002	Reduced over time
	Hg-D	0.217	<0.001	Increased over time
	Ni-D	-0.101	<0.001	Reduced over time
	Pb-D	-0.002	0.951	No change over time
	Se-D	0.071	0.005	Increased over time
	Zn-D	-0.365	<0.001	Reduced over time

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore, the finding has been corrected to indicate no change over time, which is representative of actual conditions.

Table D-15 Performance assessment – Based on the trend of water quality indicators (all data) at lower river test sites between 2015 and 2024 using Spearman Rank Test.

Water Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend 2015 - 2024
Bebelubi (Trend of all data 2015 - 2024)	pH	0.462	<0.001	Increased over time
	EC	-0.148	0.265	No change over time
	TSS	0.212	0.110	No change over time
	Ag-D*	-0.491	<0.001	No change over time
	As-D	-0.620	<0.001	Reduced over time
	Cd-D	-0.479	<0.001	Reduced over time
	Cr-D	-0.200	0.129	No change over time
	Cu-D	-0.500	<0.001	Reduced over time
	Fe-D	-0.302	0.020	Reduced over time
	Hg-D	0.131	0.323	No change over time
	Ni-D	0.211	0.109	No change over time
	Pb-D	-0.249	0.058	No change over time
	Se-D	≤LOR	≤LOR	No change over time
Zn-D	-0.452	<0.001	Reduced over time	
SG4 (Trend of all data 2015 - 2024)	pH	0.329	0.012	Increased over time
	EC	-0.397	0.002	Reduced over time
	TSS	0.145	0.278	No change over time
	Ag-D*	-0.479	<0.001	No change over time
	As-D	-0.507	<0.001	Reduced over time
	Cd-D	-0.390	0.002	Reduced over time
	Cr-D	-0.200	0.128	No change over time
	Cu-D	-0.670	<0.001	Reduced over time
	Fe-D	-0.329	0.011	Reduced over time
	Hg-D	0.050	0.706	No change over time
	Ni-D	-0.042	0.752	No change over time
	Pb-D	-0.327	0.011	Reduced over time
	Se-D	≤LOR	≤LOR	No change over time
Zn-D	-0.492	<0.001	Reduced over time	
SG5 (Trend of all data 2015 - 2024)	pH	0.602	<0.001	Increased over time
	EC	-0.215	0.074	No change over time
	TSS	-0.024	0.842	No change over time
	Ag-D	-0.565	<0.001	Reduced over time
	As-D	-0.441	<0.001	Reduced over time
	Cd-D	≤LOR	≤LOR	No change over time
	Cr-D	-0.350	0.003	Reduced over time
	Cu-D	-0.126	0.297	No change over time
	Fe-D	0.001	0.995	No change over time
	Hg-D	0.129	0.287	No change over time
	Ni-D	-0.018	0.88	No change over time
	Pb-D	-0.094	0.44	No change over time
	Se-D	≤LOR	≤LOR	No change over time
Zn-D	-0.670	<0.001	Reduced over time	

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore, the finding has been corrected to indicate no change over time, which is representative of actual conditions.

Table D-16 Performance assessment – Based on the trend of water quality indicators (all data) at ORWB test sites between 2015 and 2024 using Spearman Rank Test.

Water Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend 2015 - 2024
Kukufionga (Trend of all data 2015 - 2024)	pH	0.050	0.742	No change over time
	EC	0.353	0.018	Increased over time
	TSS	-0.258	0.088	No change over time
	Ag-D	-0.120	0.431	No change over time
	As-D	0.035	0.819	No change over time
	Cd-D	≤LOR	≤LOR	No change over time
	Cr-D	-0.270	0.073	No change over time
	Cu-D	-0.412	0.005	Reduced over time
	Fe-D	-0.557	<0.001	Reduced over time
	Hg-D*	-0.266	0.077	No change over time
	Ni-D	0.055	0.720	No change over time
	Pb-D	-0.195	0.199	No change over time
	Se-D	≤LOR	≤LOR	No change over time
Zn-D	-0.359	0.016	Reduced over time	
Zongamange (Trend of all data 2015 - 2024)	pH	-0.352	0.045	Reduced over time
	EC	-0.140	0.436	No change over time
	TSS	-0.446	0.009	Reduced over time
	Ag-D	≤LOR	≤LOR	No change over time
	As-D	-0.264	0.138	No change over time
	Cd-D	≤LOR	≤LOR	No change over time
	Cr-D	-0.451	0.008	Reduced over time
	Cu-D	-0.573	<0.001	Reduced over time
	Fe-D	0.477	0.005	Increased over time
	Hg-D	-0.048	0.792	No change over time
	Ni-D	-0.371	0.033	Reduced over time
	Pb-D	-0.235	0.189	No change over time
	Se-D	≤LOR	≤LOR	No change over time
Zn-D	-0.278	0.117	No change over time	
Avu (Trend of all data 2015 - 2024)	pH	0.163	0.263	No change over time
	EC	-0.311	0.03	Reduced over time
	TSS	0.204	0.16	No change over time
	Ag-D*	-0.361	0.011	No change over time
	As-D	-0.089	0.542	No change over time
	Cd-D	≤LOR	≤LOR	No change over time
	Cr-D	0.347	0.014	Increased over time
	Cu-D	0.159	0.275	No change over time
	Fe-D	0.493	<0.001	Increased over time
	Hg-D	-0.244	0.091	No change over time
	Ni-D	0.300	0.036	Increased over time
	Pb-D	-0.292	0.042	Reduced over time
	Se-D	≤LOR	≤LOR	No change over time
Zn-D	-0.205	0.158	No change over time	

NPL Annual Environment Report 2024

Water Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend 2015 - 2024
Levame (Trend of all data 2015 - 2024)	pH	0.074	0.636	No change over time
	EC	0.047	0.765	No change over time
	TSS	-0.191	0.219	No change over time
	Ag-D*	-0.349	0.022	No change over time
	As-D	-0.166	0.286	No change over time
	Cd-D	≤LOR	≤LOR	No change over time
	Cr-D	-0.497	0.001	Reduced over time
	Cu-D	-0.013	0.933	No change over time
	Fe-D	-0.237	0.126	No change over time
	Hg-D	0.249	0.107	No change over time
	Ni-D	0.357	0.019	Increased over time
	Pb-D	-0.194	0.212	No change over time
	Se-D	≤LOR	≤LOR	No change over time
	Zn-D	-0.492	0.001	Reduced over time

Insufficient data – Insufficient number of data points within the historical data set to support trend analysis.

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore the finding has been corrected to indicate no change over time, which is representative of actual conditions.

Table D-17 Water quality Lake Murray test sites - Central Lake Murray 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Central Lake	N	N (Test)	Median	Result	Go to			
pH	10	10	6.8	Lower TV < TSM < Upper TV	Step 1 / 2	5.0-8.0	0.003 / 0.003	LOW
EC	10	10	16	TSM < Upper TV	Step 1	17	0.203	POTENTIAL
TSS	10	10	5.5	TSM < Upper TV	Step 1	9.0	0.003	LOW
Ag-D	10	10	0.01	TSM < Upper TV	Step 1	0.05	0.003	LOW
As-D	10	10	0.14	TSM < Upper TV	Step 1	24	0.003	LOW
Cd-D	10	10	0.05	TSM < Upper TV	Step 1	0.72	0.003	LOW
Cr-D	10	10	0.12	TSM < Upper TV	Step 1	1.0	0.003	LOW
Cu-D	10	10	0.38	TSM < Upper TV	Step 1	1.4	0.003	LOW
Fe-D	10	10	125	TSM < Upper TV	Step 1	340	0.003	LOW
Hg-D	10	10	0.05	TSM < Upper TV	Step 1	0.60	0.003	LOW
Ni-D	10	10	0.50	TSM < Upper TV	Step 1	11	0.003	LOW
Pb-D	10	10	0.10	TSM < Upper TV	Step 1	3.4	0.003	LOW
Se-D	10	10	0.20	TSM < Upper TV	Step 1	11	0.003	LOW
Zn-D	10	10	2.6	TSM < Upper TV	Step 1	8.0	0.003	LOW

Table D-18 Water quality Lake Murray test sites - South Lake Murray 2024 median (µg/L for metals, std pH units for pH, µS/cm for EC and mg/L for TSS)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Southern Lake	N	N (Test)	Median	Result	Go to			
pH	14	14	6.9	Lower TV < TSM < Upper TV	Step 1 / 2	5.0-8.0	0.001 / 0.001	LOW
EC	14	14	14	TSM ≥ Upper TV	Step 2	17	0.001	LOW
TSS	14	14	2.5	TSM < Upper TV	Step 1	9.0	0.022	LOW
Ag-D	14	14	0.01	TSM < Upper TV	Step 1	0.05	0.001	LOW
As-D	14	14	0.21	TSM < Upper TV	Step 1	24	0.001	LOW
Cd-D	14	14	0.05	TSM < Upper TV	Step 1	0.72	0.001	LOW
Cr-D	14	14	0.10	TSM < Upper TV	Step 1	1.0	0.001	LOW
Cu-D	14	14	0.40	TSM < Upper TV	Step 1	1.4	0.001	LOW
Fe-D	14	14	135	TSM < Upper TV	Step 1	340	0.001	LOW
Hg-D	14	14	0.05	TSM < Upper TV	Step 1	0.60	0.001	LOW
Ni-D	14	14	0.50	TSM < Upper TV	Step 1	11	0.001	LOW
Pb-D	14	14	0.10	TSM < Upper TV	Step 1	3.4	0.001	LOW
Se-D	14	14	0.20	TSM < Upper TV	Step 1	11	0.001	LOW
Zn-D	14	14	0.66	TSM < Upper TV	Step 1	8.0	0.001	LOW

Table D-19 Water quality Lake Murray test sites - SG6 2024 median ($\mu\text{g/L}$ for metals, std pH units for pH, $\mu\text{S/cm}$ for EC and mg/L for TSS)

Test Site			Initial Assessment		TV	Statistical Test Result ($p=0.05$)	Risk Assessment	
SG6	N	N (Test)	Median	Result				Go to
pH	6	6	7.3	Lower TV < TSM < Upper TV	Step 1 / 2	5.0-8.0	0.018 / 0.018	LOW
EC	6	6	38	TSM \geq Upper TV	Step 2	17	0.989	POTENTIAL
TSS	6	6	72	TSM \geq Upper TV	Step 2	9.0	0.989	POTENTIAL
Ag-D	6	6	0.01	TSM < Upper TV	Step 1	0.05	0.018	LOW
As-D	6	6	0.52	TSM < Upper TV	Step 1	24	0.018	LOW
Cd-D	6	6	0.05	TSM < Upper TV	Step 1	0.72	0.018	LOW
Cr-D	6	6	0.10	TSM < Upper TV	Step 1	1.0	0.018	LOW
Cu-D	6	6	0.86	TSM < Upper TV	Step 1	1.4	0.018	LOW
Fe-D	6	6	81	TSM < Upper TV	Step 1	340	0.018	LOW
Hg-D	6	6	0.05	TSM < Upper TV	Step 1	0.60	0.018	LOW
Ni-D	6	6	0.50	TSM < Upper TV	Step 1	11	0.018	LOW
Pb-D	6	6	0.10	TSM < Upper TV	Step 1	3.4	0.018	LOW
Se-D	6	6	0.20	TSM < Upper TV	Step 1	11	0.018	LOW
Zn-D	6	6	0.70	TSM < Upper TV	Step 1	8.0	0.018	LOW

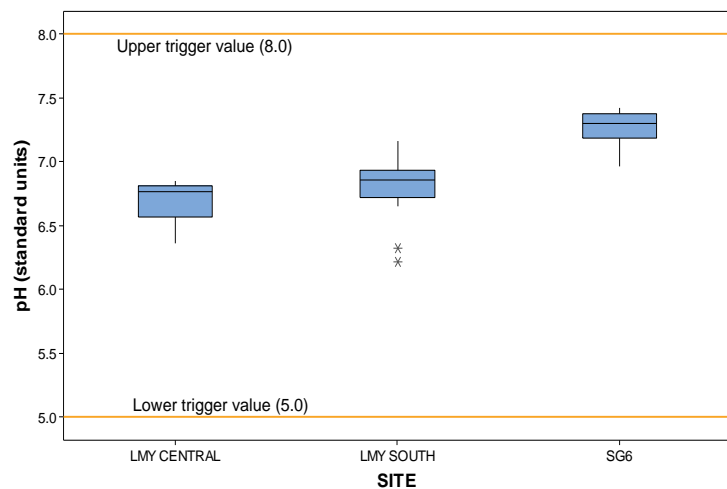


Figure D-47 pH in water Lake Murray test sites 2024

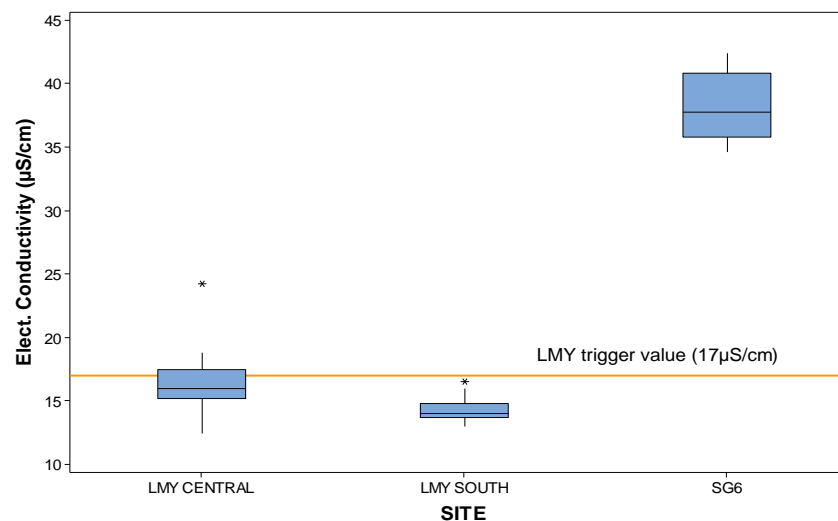


Figure D-48 Electrical conductivity in water Lake Murray test sites 2024

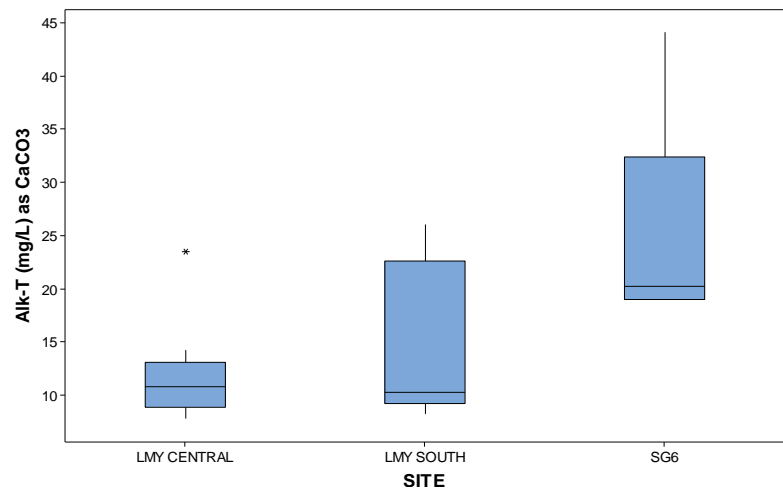


Figure D-49 Alkalinity in water Lake Murray test sites 2025

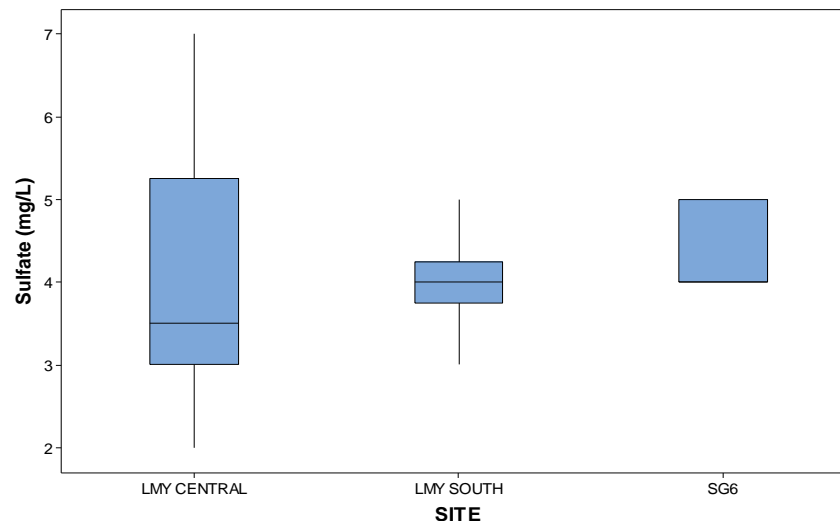


Figure D-50 Sulfate in water Lake Murray test sites 2025

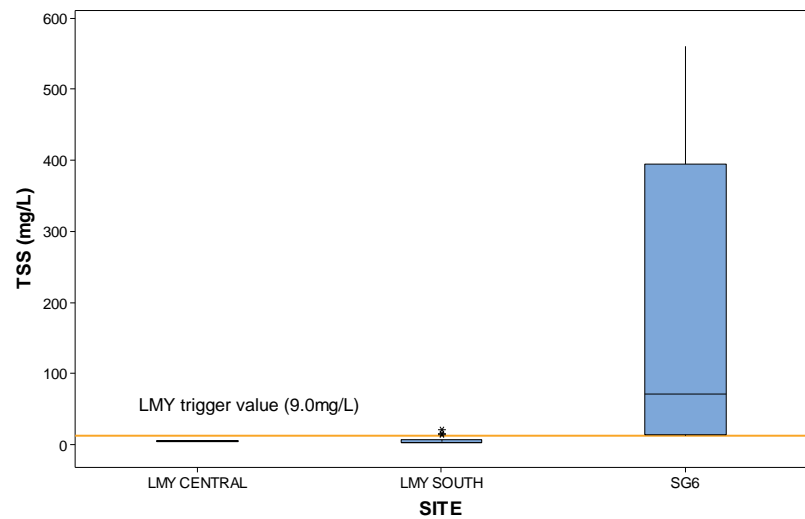


Figure D-51 TSS in water Lake Murray test sites 2025

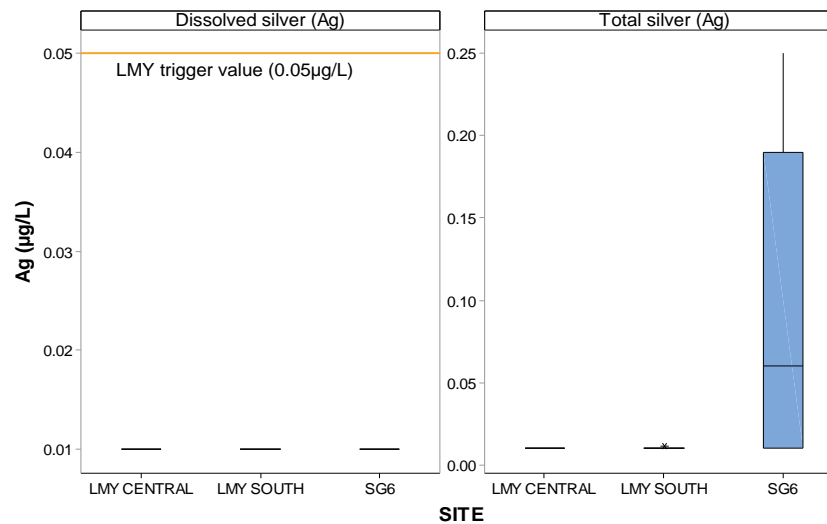


Figure D-52 Silver in water Lake Murray test sites 2025

NPL Annual Environment Report 2024

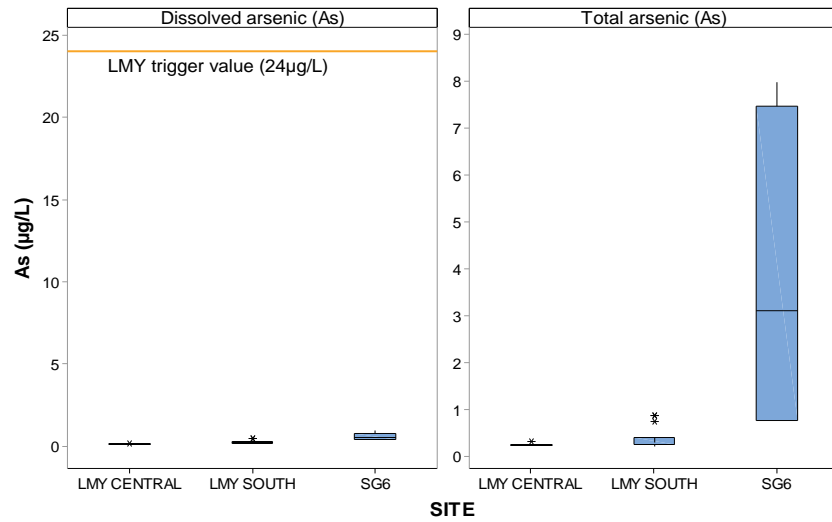


Figure D-53 As in water Lake Murray test sites 2024

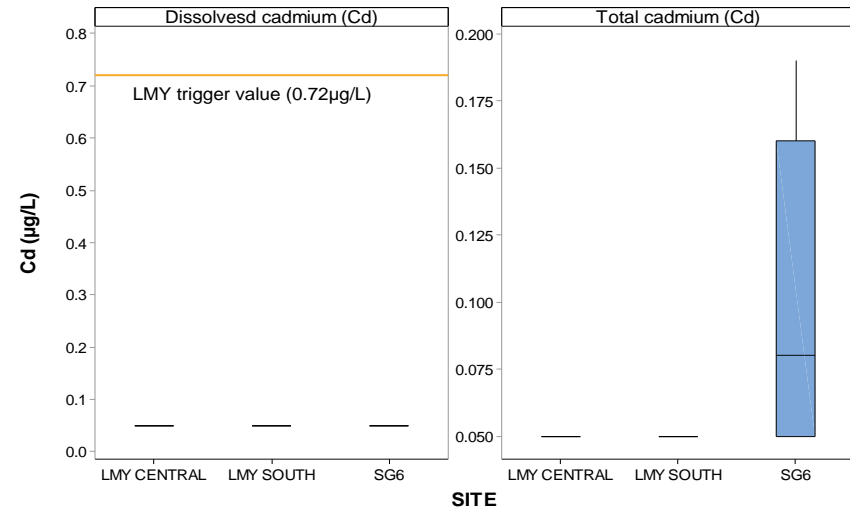


Figure D-54 Cadmium in water Lake Murray test sites 2024

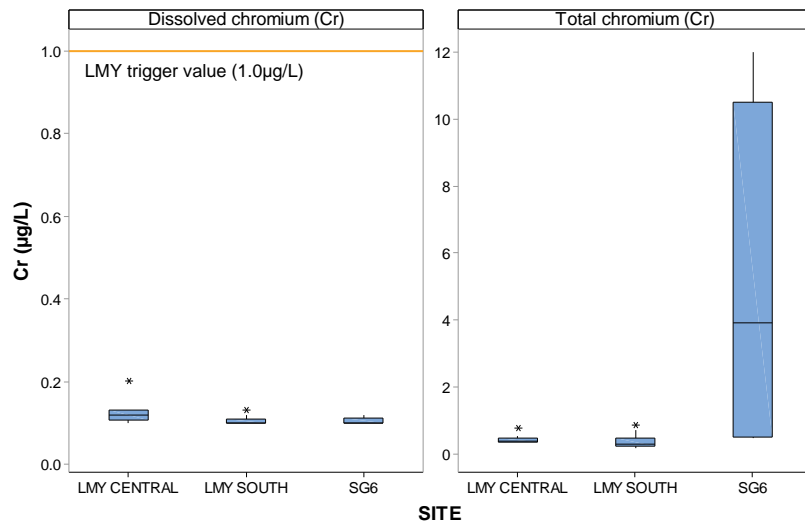


Figure D-55 Cr in water Lake Murray test sites 2024

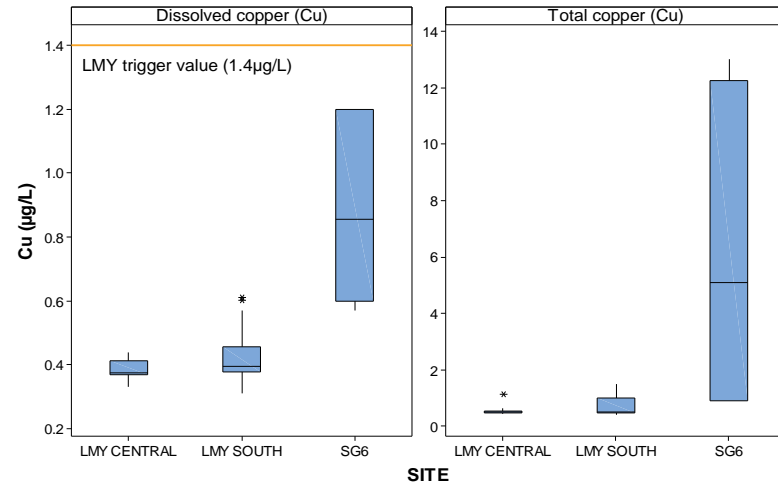


Figure D-56 Copper in water Lake Murray test sites 2024

NPL Annual Environment Report 2024

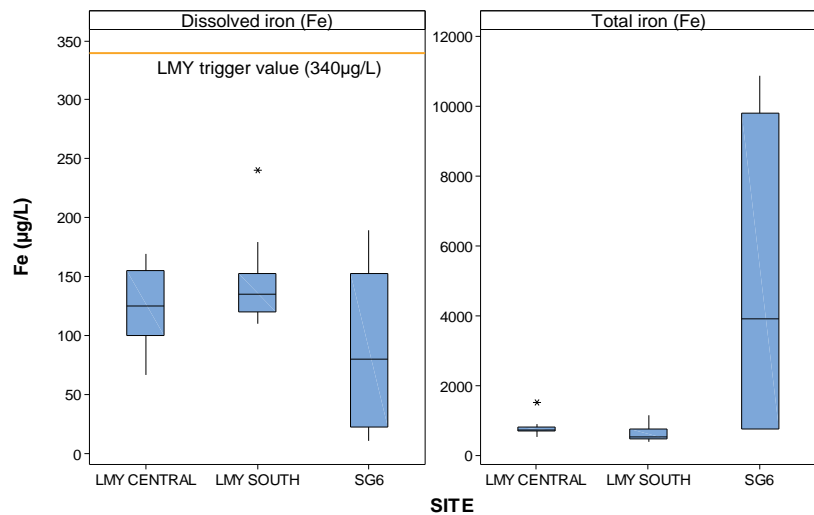


Figure D-57 Iron in water Lake Murray test sites 2024

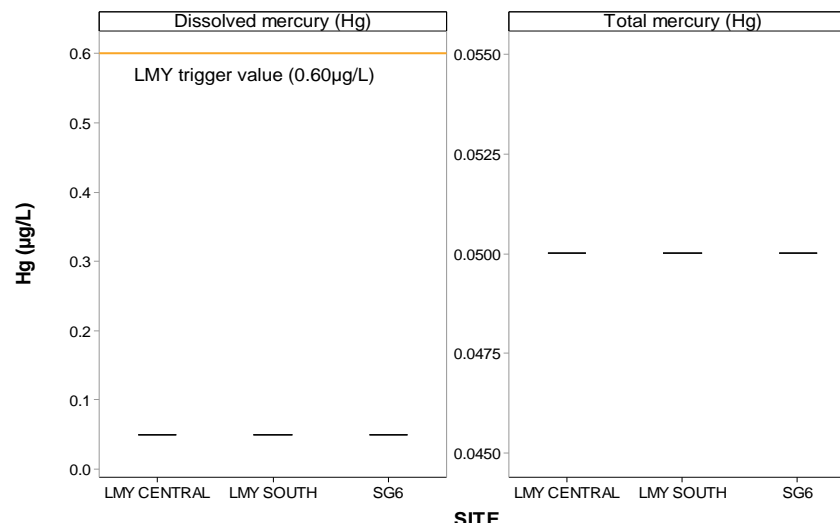


Figure D-58 Mercury in water Lake Murray test sites 2024

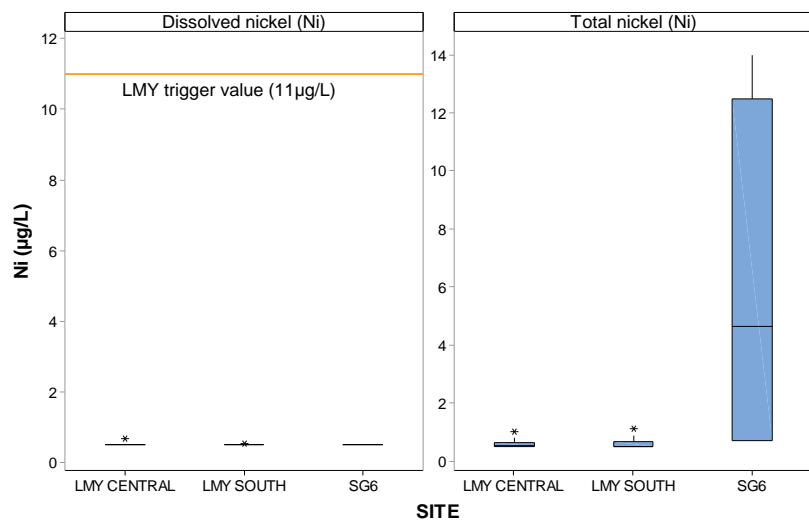


Figure D-59 Nickel in water Lake Murray test sites 2024

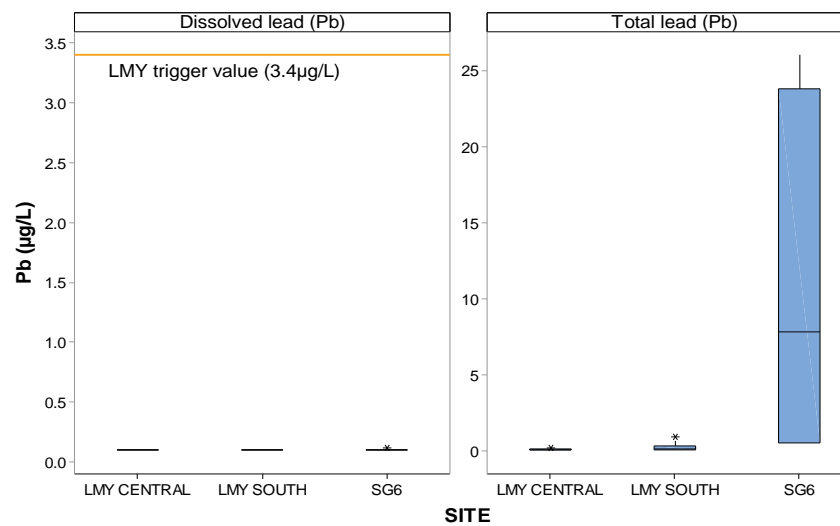


Figure D-60 Lead in water Lake Murray test sites 2024

NPL Annual Environment Report 2024

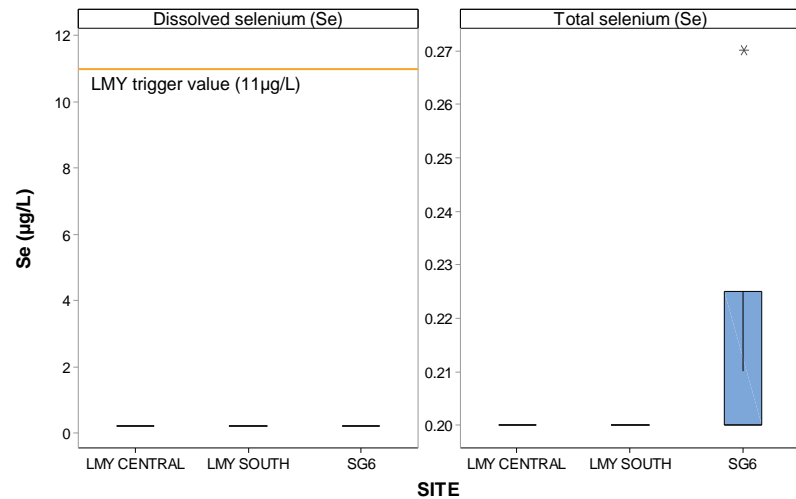


Figure D-61 Selenium in water Lake Murray test sites 2024

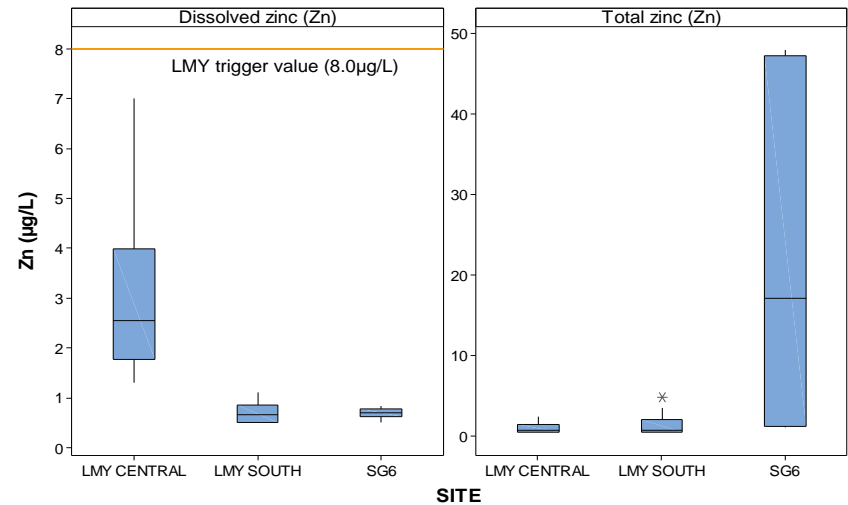


Figure D-62 Zinc in water Lake Murray test sites 2024

Table D-20 Performance assessment – Based on the trend of water quality indicators (all data) at Lake Murray test sites between 2015 and 2024 using Spearman Rank Test.

Water Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend 2015 – 2024
Central (Trend of all data 2015 – 2024)	pH	0.198	0.053	No change over time
	EC	-0.237	0.020	Reduced over time
	TSS	0.037	0.718	No change over time
	Ag-D*	-0.437	<0.001	No change over time
	As-D	-0.558	<0.001	Reduced over time
	Cd-D	≤LOR	≤LOR	No change over time
	Cr-D	0.050	0.628	No change over time
	Cu-D	-0.327	0.001	Reduced over time
	Fe-D	0.281	0.006	Increased over time
	Hg-D	0.129	0.211	No change over time
	Ni-D	0.013	0.898	No change over time
	Pb-D	-0.046	0.656	No change over time
	Se-D	≤LOR	≤LOR	No change over time
	Zn-D	-0.129	0.211	No change over time
Southern (Trend of all data 2015 – 2024)	pH	-0.044	0.637	No change over time
	EC	-0.594	<0.001	Reduced over time
	TSS	-0.251	0.006	Reduced over time
	Ag-D*	-0.444	<0.001	No change over time
	As-D	-0.021	0.826	No change over time
	Cd-D	-0.131	0.158	No change over time
	Cr-D	-0.217	0.019	Reduced over time
	Cu-D	-0.301	0.001	Reduced over time
	Fe-D	0.432	<0.001	Increased over time
	Hg-D	0.193	0.037	Increased over time
	Ni-D	0.136	0.144	No change over time
	Pb-D	-0.171	0.065	No change over time
	Se-D	≤LOR	≤LOR	No change over time
Zn-D	-0.494	<0.001	Reduced over time	
SG6 (Trend of all data 2015 – 2024)	pH	0.261	0.061	No change over time
	EC	-0.621	<0.001	Reduced over time
	TSS	0.230	0.100	No change over time
	Ag-D*	-0.474	<0.001	No change over time
	As-D	-0.218	0.117	No change over time
	Cd-D	≤LOR	≤LOR	No change over time
	Cr-D	-0.358	0.008	Reduced over time
	Cu-D	-0.033	0.815	No change over time
	Fe-D	0.207	0.138	No change over time
	Hg-D	-0.142	0.311	No change over time
	Ni-D	0.120	0.392	No change over time
	Pb-D	-0.214	0.124	No change over time
Se-D	≤LOR	≤LOR	No change over time	
Zn-D	-0.590	<0.001	Reduced over time	

**APPENDIX E. SEDIMENT QUALITY – RISK AND PERFORMANCE
ASSESSMENT – DETAILS OF STATISTICAL ANALYSIS AND BOX PLOTS**

Table E-1 Expanded risk matrix – sediment quality

Initial Assessment Result				Go To	
TSM < TV				Step 1	
TSM ≥ TV and TV, TSM and full TSM data set are > LOR				Step 2	
TSM = TV and TV, TSM and full TSM data set ≤ LOR				Step 3	
Step	Alt Hypothesis	Null Hypothesis	Sig Test Result		Risk Assessment
1	TSM < TV	TSM = TV	p < 0.05	Accept Alt	LOW
			p > 0.05	Accept Null	POTENTIAL
			Error	Accept Neither	ND
2	TSM ≥ TV and TV, TSM and full TSM data set are > LOR				POTENTIAL
3	TSM = TV and TV, TSM and full TSM data set are ≤ LOR				LOW

TSM = Test Site Median

ND = No determination

Table E-2 Sediment quality upper river test sites - SG2 2024 median (mg/kg dry weight, whole fraction)

Test Site			Initial Assessment			TV	Statistical Test Result (p=0.05)	Risk Assessment
SG2	N	N (Test)	Median	Result	Go to			
Ag-WAE	7	7	0.07	TSM < Upper TV	Step 1	1.0	0.011	LOW
As-WAE	7	7	5.0	TSM < Upper TV	Step 1	20	0.011	LOW
Cd-WAE	7	7	0.45	TSM < Upper TV	Step 1	1.5	0.026	LOW
Cr-WAE	7	7	2.1	TSM < Upper TV	Step 1	80	0.011	LOW
Cu-WAE	7	7	9.8	TSM < Upper TV	Step 1	65	0.011	LOW
Hg-WAE	7	7	0.01	TSM < Upper TV	Step 1	0.15	0.011	LOW
Ni-WAE	7	7	4.4	TSM < Upper TV	Step 1	21	0.011	LOW
Pb-WAE	7	7	48	TSM = Upper TV	Step 1	50	0.534	POTENTIAL
Se-WAE	7	7	0.19	TSM < Upper TV	Step 1	0.22	0.155	POTENTIAL
Zn-WAE	7	7	72	TSM < Upper TV	Step 1	200	0.038	LOW

Table E-3 Sediment quality upper river test sites - Wasiba 2024 median (mg/kg dry weight, whole fraction)

Test Site			Initial Assessment			TV	Statistical Test Result (p=0.05)	Risk Assessment
Wasiba	N	N (Test)	Median	Result	Go to			
Ag-WAE	10	10	0.05	TSM < Upper TV	Step 1	1.0	0.003	LOW
As-WAE	10	10	3.4	TSM < Upper TV	Step 1	20	0.003	LOW
Cd-WAE	10	10	0.22	TSM < Upper TV	Step 1	1.5	0.003	LOW
Cr-WAE	10	10	1.7	TSM < Upper TV	Step 1	80	0.003	LOW
Cu-WAE	10	10	8.2	TSM < Upper TV	Step 1	65	0.003	LOW
Hg-WAE	10	10	0.01	TSM < Upper TV	Step 1	0.15	0.003	LOW
Ni-WAE	10	10	8.3	TSM < Upper TV	Step 1	21	0.042	LOW
Pb-WAE	10	10	28	TSM < Upper TV	Step 1	50	0.003	LOW
Se-WAE	10	10	0.16	TSM < Upper TV	Step 1	0.22	0.019	LOW
Zn-WAE	10	10	39	TSM < Upper TV	Step 1	200	0.003	LOW

NPL Annual Environment Report 2024

Table E-4 Sediment quality upper river test sites - Wankipe 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Wankipe	N	N (Test)	Median	Result	Go to			
Ag-WAE	12	12	0.05	TSM < Upper TV	Step 1	1.0	0.001	LOW
As-WAE	12	12	3.4	TSM < Upper TV	Step 1	20	0.001	LOW
Cd-WAE	12	12	0.21	TSM < Upper TV	Step 1	1.5	0.001	LOW
Cr-WAE	12	12	1.6	TSM < Upper TV	Step 1	80	0.001	LOW
Cu-WAE	12	12	6.9	TSM < Upper TV	Step 1	65	0.001	LOW
Hg-WAE	12	12	0.01	TSM < Upper TV	Step 1	0.15	0.001	LOW
Ni-WAE	12	12	7.5	TSM < Upper TV	Step 1	21	0.002	LOW
Pb-WAE	12	12	24	TSM < Upper TV	Step 1	50	0.001	LOW
Se-WAE	12	12	0.16	TSM < Upper TV	Step 1	0.22	0.008	LOW
Zn-WAE	12	12	37	TSM < Upper TV	Step 1	200	0.001	LOW

Table E-5 Sediment quality upper river test sites - SG3 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
SG3	N	N (Test)	Median	Result	Go to			
Ag-WAE	10	10	0.05	TSM < Upper TV	Step 1	1.0	0.003	LOW
As-WAE	10	10	2.7	TSM < Upper TV	Step 1	20	0.003	LOW
Cd-WAE	10	10	0.10	TSM < Upper TV	Step 1	1.5	0.003	LOW
Cr-WAE	10	10	1.9	TSM < Upper TV	Step 1	80	0.003	LOW
Cu-WAE	10	10	6.9	TSM < Upper TV	Step 1	65	0.003	LOW
Hg-WAE	10	10	0.01	TSM < Upper TV	Step 1	0.15	0.003	LOW
Ni-WAE	10	10	11	TSM < Upper TV	Step 1	21	0.042	LOW
Pb-WAE	10	10	13	TSM < Upper TV	Step 1	50	0.003	LOW
Se-WAE	10	10	0.15	TSM < Upper TV	Step 1	0.22	0.006	LOW
Zn-WAE	10	10	22	TSM < Upper TV	Step 1	200	0.003	LOW

NPL Annual Environment Report 2024

Table E-6 Sediment quality lower river test sites - Bebelubi 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Bebelubi	N	N (Test)	Median	Result	Go to			
Ag-WAE	8	8	0.05	TSM < Upper TV	Step 1	1.0	0.007	LOW
As-WAE	8	8	2.7	TSM < Upper TV	Step 1	20	0.007	LOW
Cd-WAE	8	8	0.13	TSM < Upper TV	Step 1	1.5	0.007	LOW
Cr-WAE	8	8	3.1	TSM < Upper TV	Step 1	80	0.007	LOW
Cu-WAE	8	8	5.7	TSM < Upper TV	Step 1	65	0.007	LOW
Hg-WAE	8	8	0.01	TSM < Upper TV	Step 1	0.15	0.007	LOW
Ni-WAE	8	8	12	TSM < Upper TV	Step 1	24	0.013	LOW
Pb-WAE	8	8	12	TSM < Upper TV	Step 1	50	0.007	LOW
Se-WAE	8	8	0.22	TSM < Upper TV	Step 1	0.26	0.363	POTENTIAL
Zn-WAE	8	8	26	TSM < Upper TV	Step 1	200	0.007	LOW

Table E-7 Sediment quality lower river test sites - SG4 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Tium/SG4	N	N (Test)	Median	Result	Go to			
Ag-WAE	8	8	0.05	TSM < Upper TV	Step 1	1.0	0.007	LOW
As-WAE	8	8	2.6	TSM < Upper TV	Step 1	20	0.007	LOW
Cd-WAE	8	8	0.15	TSM < Upper TV	Step 1	1.5	0.007	LOW
Cr-WAE	8	8	2.8	TSM < Upper TV	Step 1	80	0.007	LOW
Cu-WAE	8	8	5.9	TSM < Upper TV	Step 1	65	0.007	LOW
Hg-WAE	8	8	0.01	TSM < Upper TV	Step 1	0.15	0.007	LOW
Ni-WAE	8	8	9.2	TSM < Upper TV	Step 1	24	0.007	LOW
Pb-WAE	8	8	11	TSM < Upper TV	Step 1	50	0.007	LOW
Se-WAE	8	8	0.22	TSM < Upper TV	Step 2	0.26	0.363	POTENTIAL
Zn-WAE	8	8	24	TSM < Upper TV	Step 1	200	0.007	LOW

NPL Annual Environment Report 2024

Table E-8 Sediment quality lower river test sites - SG5 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
SG5	N	N (Test)	Median	Result	Go to			
Ag-WAE	14	14	0.05	TSM < Upper TV	Step 1	1.0	0.001	LOW
As-WAE	14	14	2.9	TSM < Upper TV	Step 1	20	0.001	LOW
Cd-WAE	14	14	0.19	TSM < Upper TV	Step 1	1.5	0.001	LOW
Cr-WAE	14	14	3.1	TSM < Upper TV	Step 1	80	0.001	LOW
Cu-WAE	14	14	11	TSM < Upper TV	Step 1	65	0.001	LOW
Hg-WAE	14	14	0.01	TSM < Upper TV	Step 1	0.15	0.001	LOW
Ni-WAE	14	14	10	TSM < Upper TV	Step 1	24	0.001	LOW
Pb-WAE	14	14	15	TSM < Upper TV	Step 1	50	0.001	LOW
Se-WAE	14	14	0.19	TSM < Upper TV	Step 1	0.26	0.006	LOW
Zn-WAE	14	14	37	TSM < Upper TV	Step 1	200	0.001	LOW

Table E-9 Sediment quality ORWB test site Kukufionga 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Kukufionga	N	N (Test)	Median	Result	Go to			
Ag-WAE	6	6	0.05	TSM < TV	Step 1	1.0	0.018	LOW
As-WAE	6	6	4.7	TSM < TV	Step 1	20	0.018	LOW
Cd-WAE	6	6	0.26	TSM < TV	Step 1	1.5	0.018	LOW
Cr-WAE	6	6	2.4	TSM < TV	Step 1	80	0.018	LOW
Cu-WAE	6	6	16	TSM < TV	Step 1	65	0.018	LOW
Hg-WAE	6	6	0.01	TSM < TV	Step 1	0.15	0.018	LOW
Ni-WAE	6	6	7.6	TSM < TV	Step 1	24	0.018	LOW
Pb-WAE	6	6	19	TSM < TV	Step 1	50	0.018	LOW
Se-WAE	6	6	0.23	TSM < TV	Step 1	0.26	0.018	LOW
Zn-WAE	6	6	48	TSM < TV	Step 1	200	0.018	LOW

NPL Annual Environment Report 2024

Table E-10 Sediment quality ORWB test site Zongamange 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Zongamange	N	N (Test)	Median	Result	Go to			
Ag-WAE	6	6	0.06	TSM < TV	Step 1	1.0	0.018	LOW
As-WAE	6	6	4.7	TSM < TV	Step 1	20	0.018	LOW
Cd-WAE	6	6	0.23	TSM < TV	Step 1	1.5	0.018	LOW
Cr-WAE	6	6	2.3	TSM < TV	Step 1	80	0.018	LOW
Cu-WAE	6	6	16	TSM < TV	Step 1	65	0.018	LOW
Hg-WAE	6	6	0.01	TSM < TV	Step 1	0.15	0.018	LOW
Ni-WAE	6	6	6.9	TSM < TV	Step 1	24	0.018	LOW
Pb-WAE	6	6	21	TSM < TV	Step 1	50	0.018	LOW
Se-WAE	6	6	0.23	TSM < TV	Step 1	0.26	0.018	LOW
Zn-WAE	6	6	46	TSM < TV	Step 1	200	0.018	LOW

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison.

Table E-11 Sediment quality ORWB test site Avu 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Avu	N	N (Test)	Median	Result	Go to			
Ag-WAE	6	6	0.25	TSM < TV	Step 1	1.0	0.018	LOW
As-WAE	6	6	5.5	TSM < TV	Step 1	20	0.018	LOW
Cd-WAE	6	6	0.26	TSM < TV	Step 1	1.5	0.018	LOW
Cr-WAE	6	6	3.0	TSM < TV	Step 1	80	0.018	LOW
Cu-WAE	6	6	19	TSM < TV	Step 1	65	0.018	LOW
Hg-WAE	6	6	0.01	TSM < TV	Step 1	0.15	0.018	LOW
Ni-WAE	6	6	7.9	TSM < TV	Step 1	24	0.018	LOW
Pb-WAE	6	6	33	TSM < TV	Step 1	50	0.018	LOW
Se-WAE	6	6	0.25	TSM < TV	Step 1	0.26	0.201	POTENTIAL
Zn-WAE	6	6	55	TSM < TV	Step 1	200	0.018	LOW

Table E-12 Sediment quality ORWB test site Levame 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Levame	N	N (Test)	Median	Result	Go to			
Ag-WAE	6	6	0.06	TSM < TV	Step 1	1.0	0.018	LOW
As-WAE	6	6	5.5	TSM < TV	Step 1	20	0.018	LOW
Cd-WAE	6	6	0.29	TSM < TV	Step 1	1.5	0.018	LOW
Cr-WAE	6	6	8.6	TSM < TV	Step 1	80	0.018	LOW
Cu-WAE	6	6	21	TSM < TV	Step 1	65	0.018	LOW
Hg-WAE	6	6	0.01	TSM < TV	Step 1	0.15	0.018	LOW
Ni-WAE	6	6	15	TSM < TV	Step 1	24	0.071	POTENTIAL
Pb-WAE	6	6	33	TSM < TV	Step 1	50	0.018	LOW
Se-WAE	6	6	0.23	TSM < TV	Step 1	0.26	0.018	LOW
Zn-WAE	6	6	88	TSM < TV	Step 1	200	0.018	LOW

NPL Annual Environment Report 2024

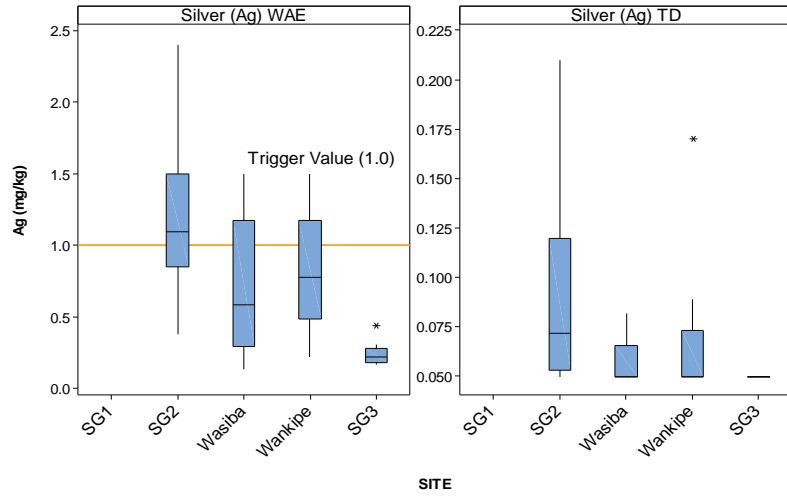


Figure E-1 Silver in sediment upper river test sites 2024

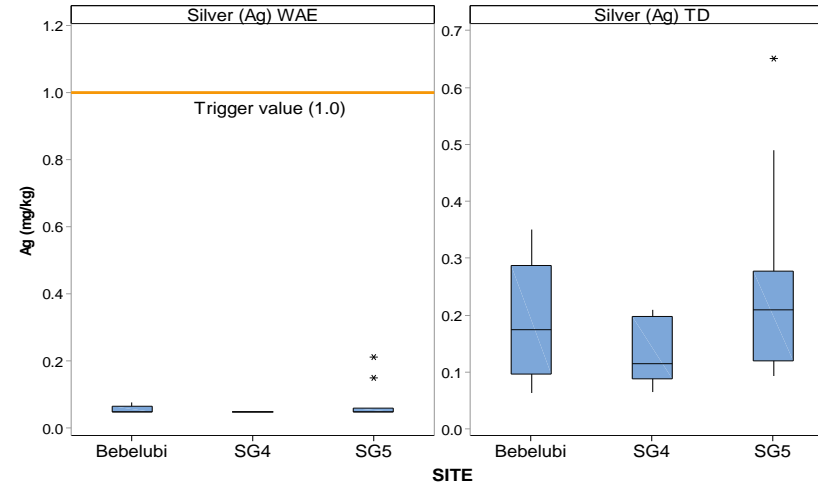


Figure E-2 Silver in sediment lower river test sites 2024

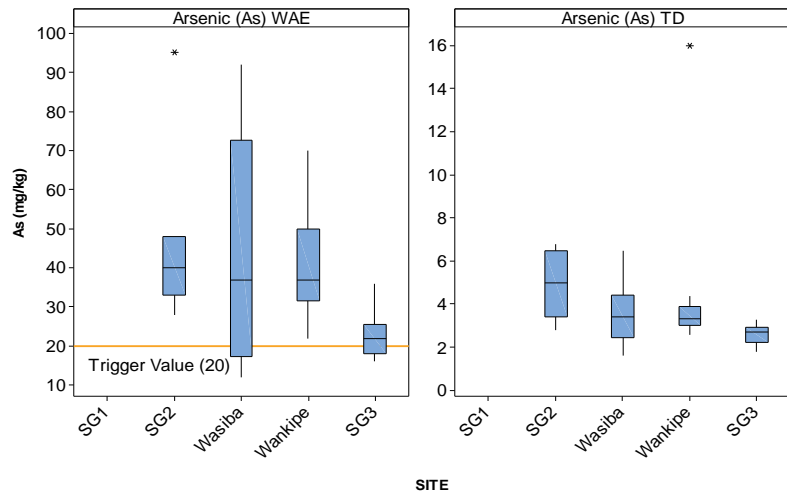


Figure E-3 Arsenic in sediment upper river test sites 2024

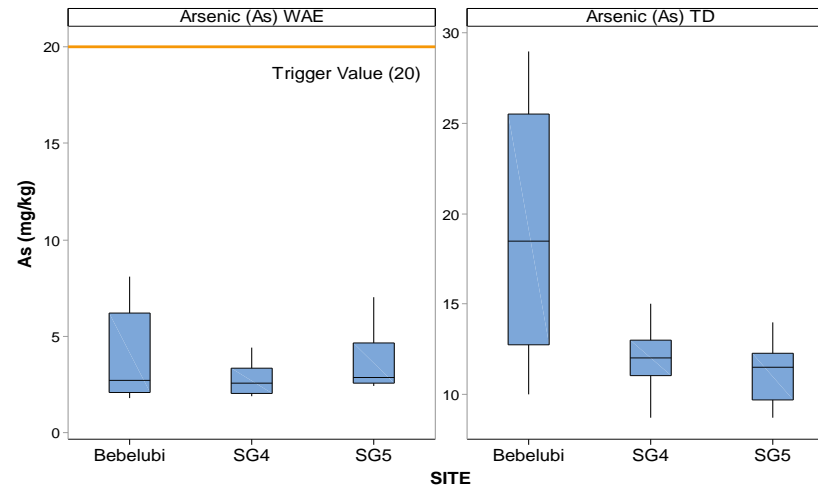


Figure E-4 Arsenic in sediment lower river test sites 2024

NPL Annual Environment Report 2024

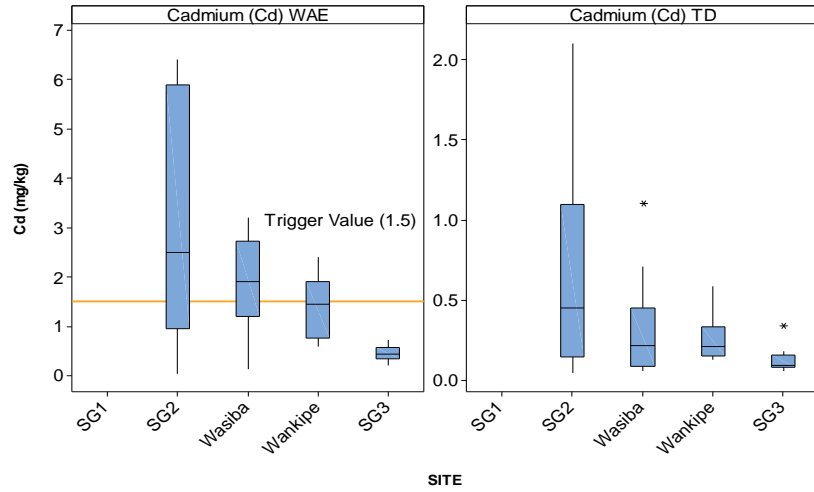


Figure E-5 Cadmium in sediment upper river test sites 2024

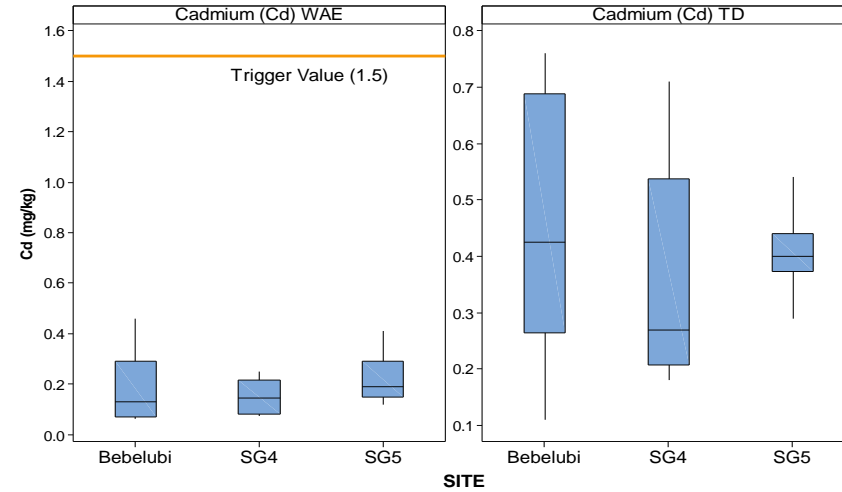


Figure E-6 Cadmium in sediment lower river test sites 2024

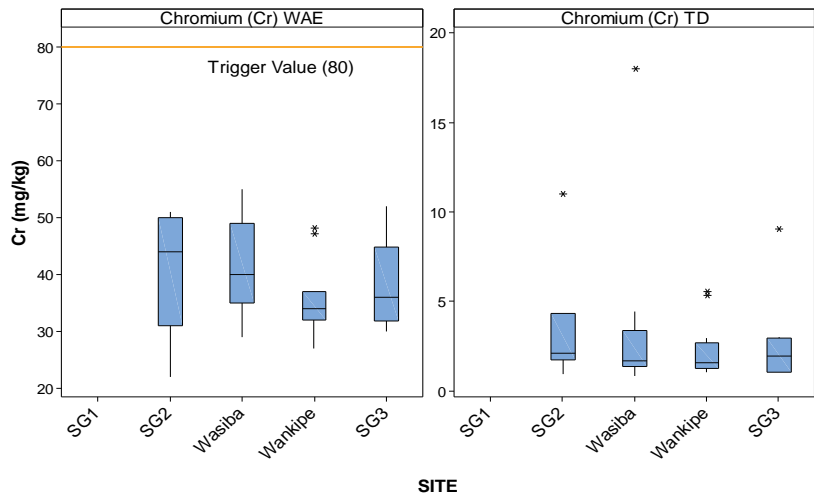


Figure E-7 Chromium in sediment upper river test sites 2024

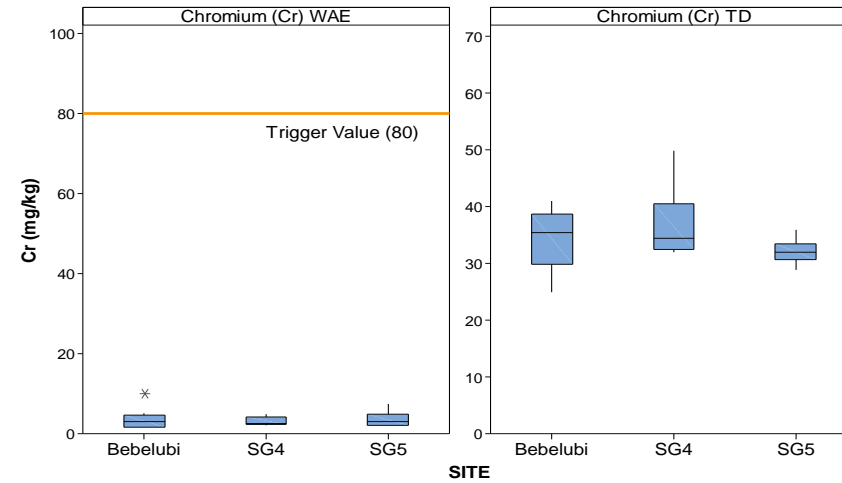


Figure E-8 Chromium in sediment lower river test sites 2024

NPL Annual Environment Report 2024

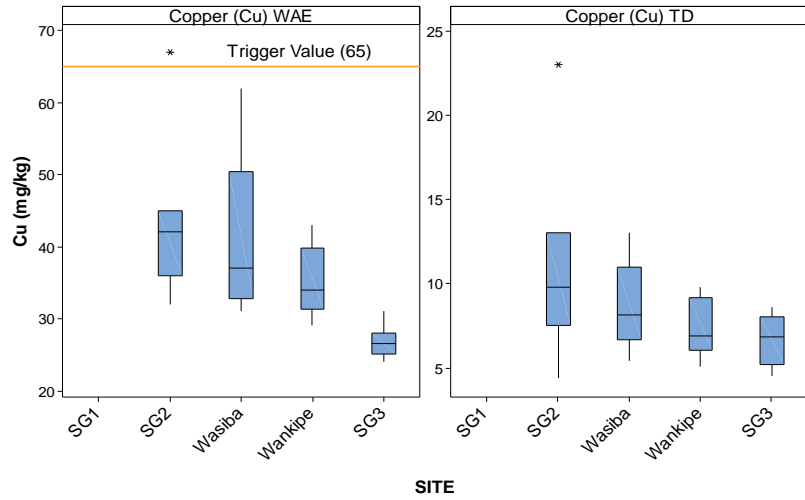


Figure E-9 Copper in sediment upper river test sites 2024

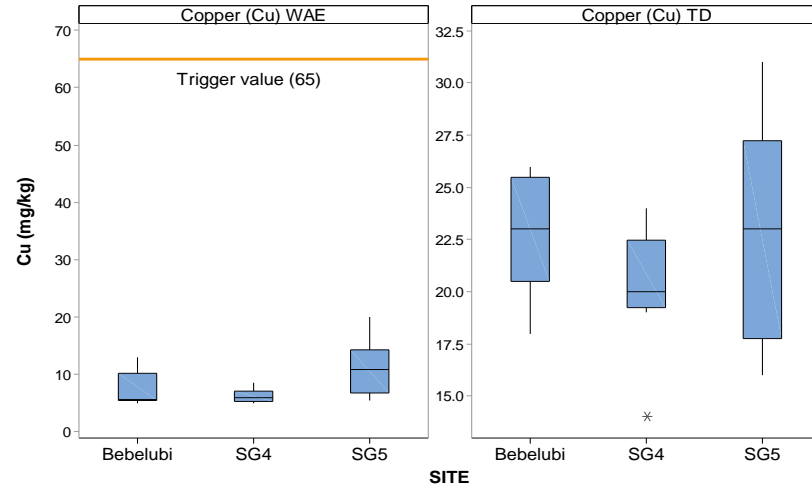


Figure E-10 Copper in sediment lower river test sites 2024

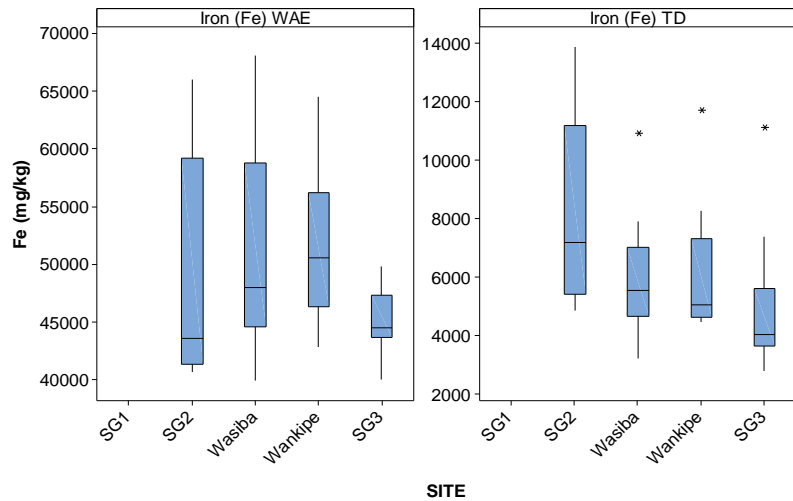


Figure E-11 Iron in sediment upper river test sites 2024

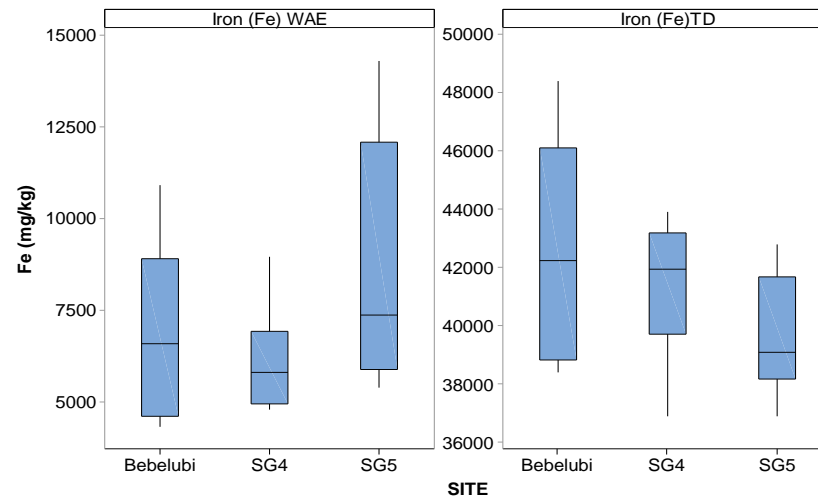


Figure E-12 Iron in sediment lower river test sites 2024

NPL Annual Environment Report 2024

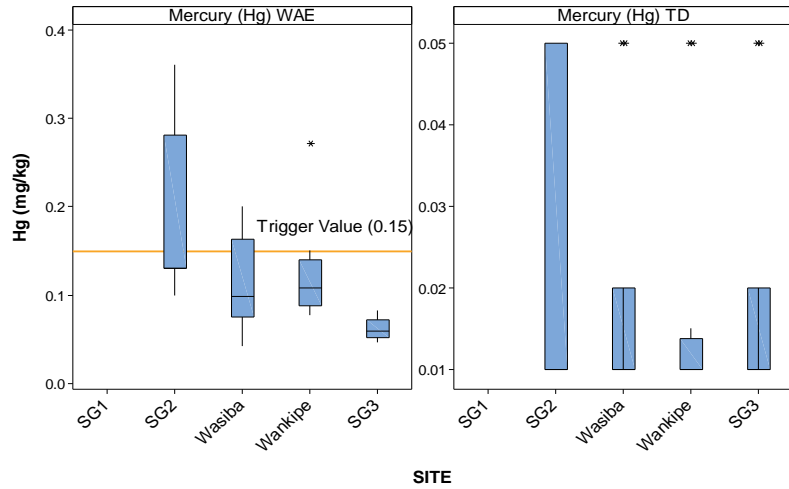


Figure E-13 Mercury in sediment upper river test sites 2024

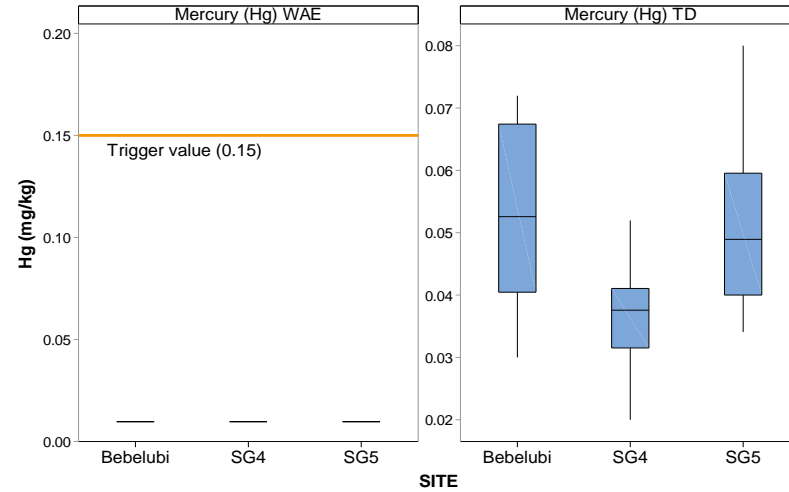


Figure E-14 Mercury in sediment lower river test sites 2024

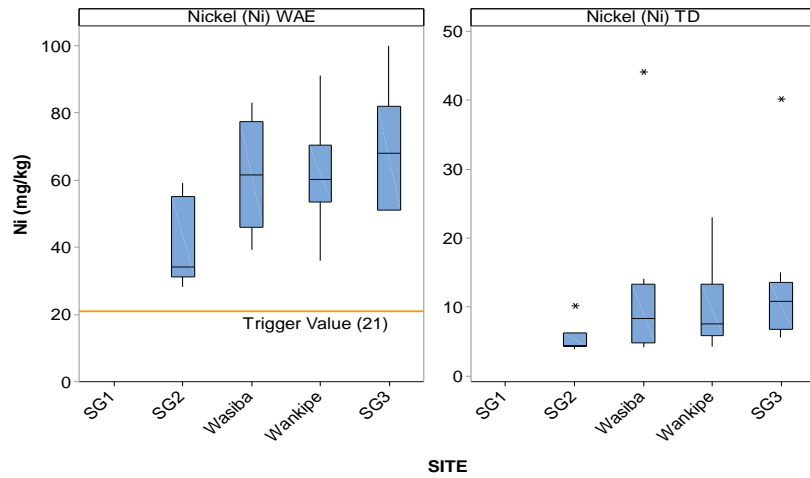


Figure E-15 Nickel in sediment upper river test sites 2024

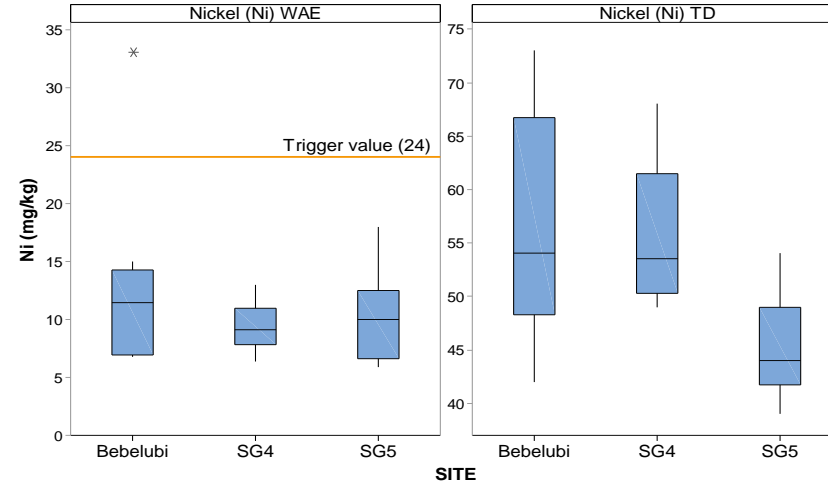


Figure E-16 Nickel in sediment lower river test sites 2024

NPL Annual Environment Report 2024

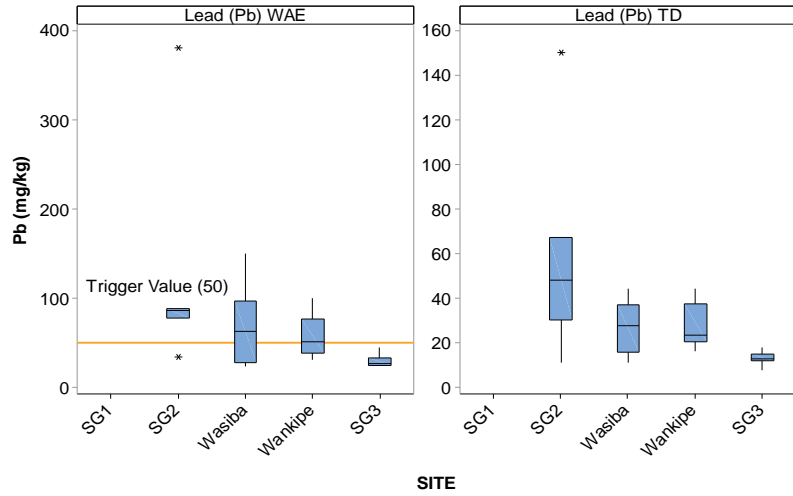


Figure E-17 Lead in sediment upper river test sites 2024

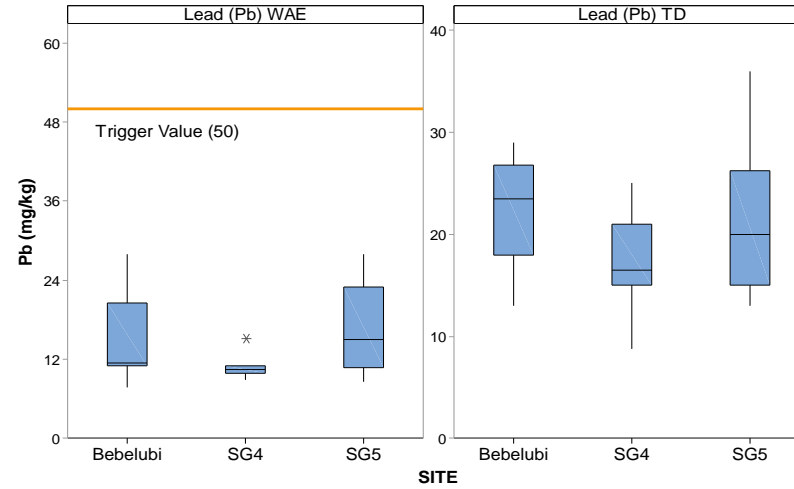


Figure E-18 Lead in sediment lower river test sites 2024

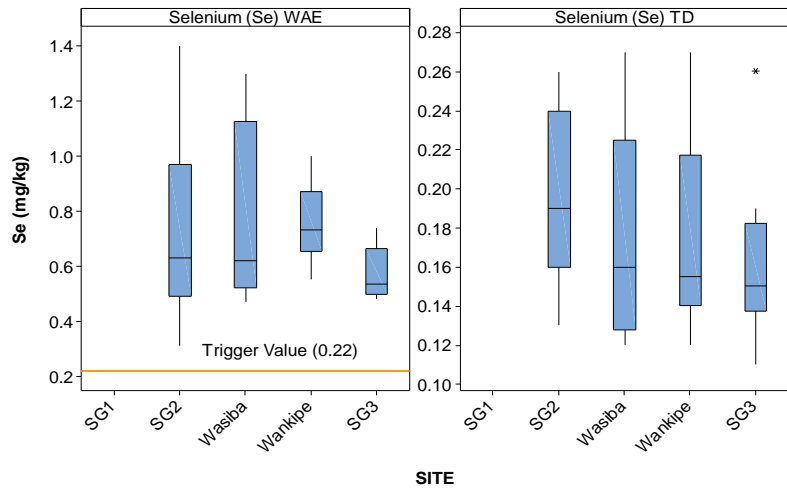


Figure E-19 Selenium in sediment upper river test sites 2024

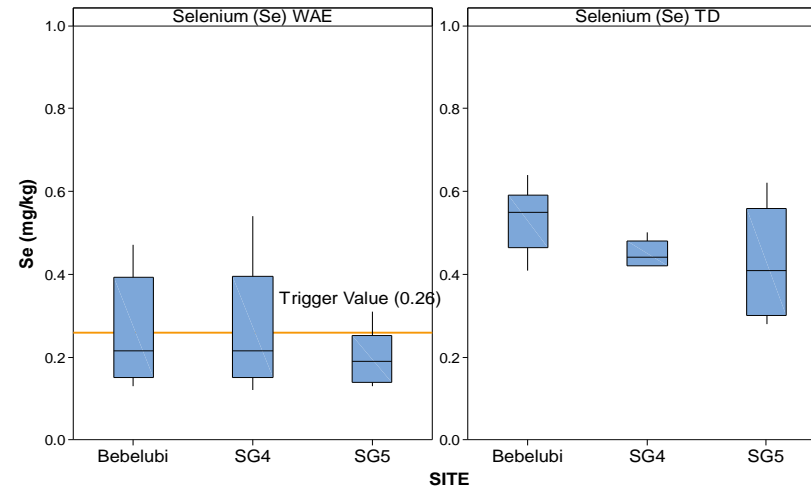


Figure E-20 Selenium in sediment lower river test sites 2024

NPL Annual Environment Report 2024

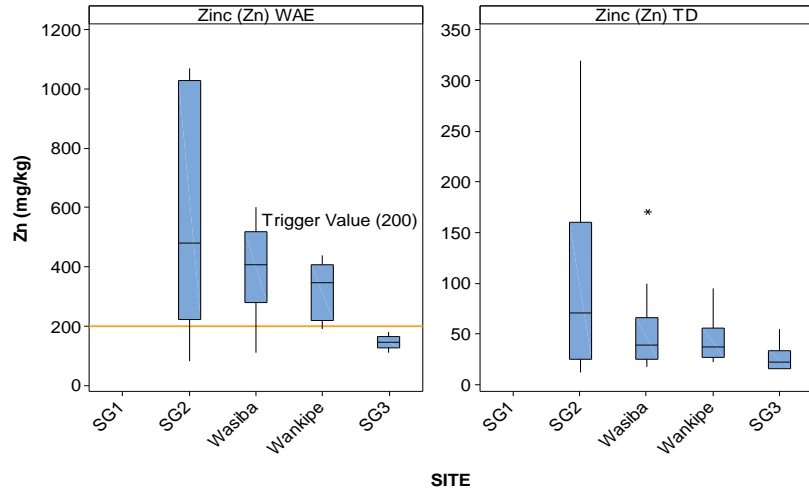


Figure E-21 Zinc in sediment upper river test sites 2024

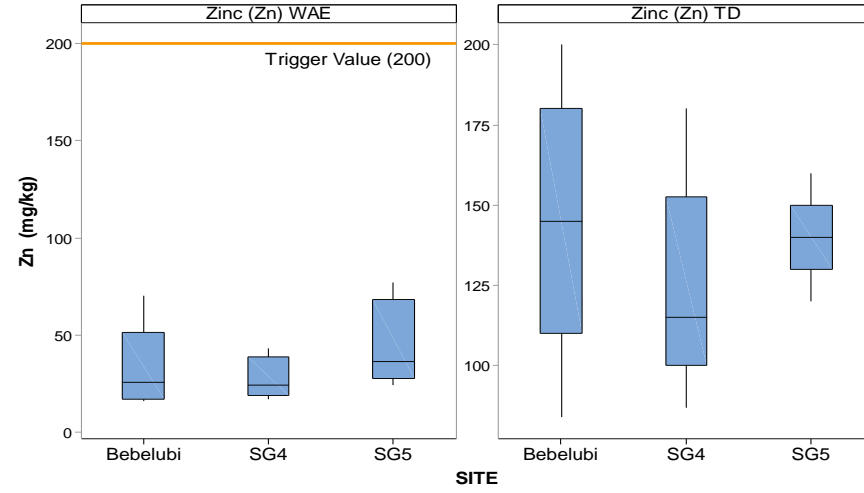


Figure E-22 Zinc in sediment lower river test sites 2024

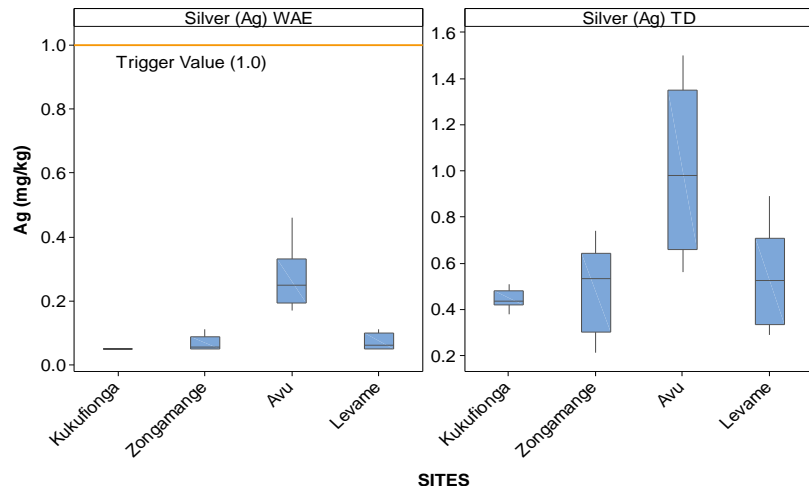


Figure E-23 Silver in sediment ORWB test sites 2024

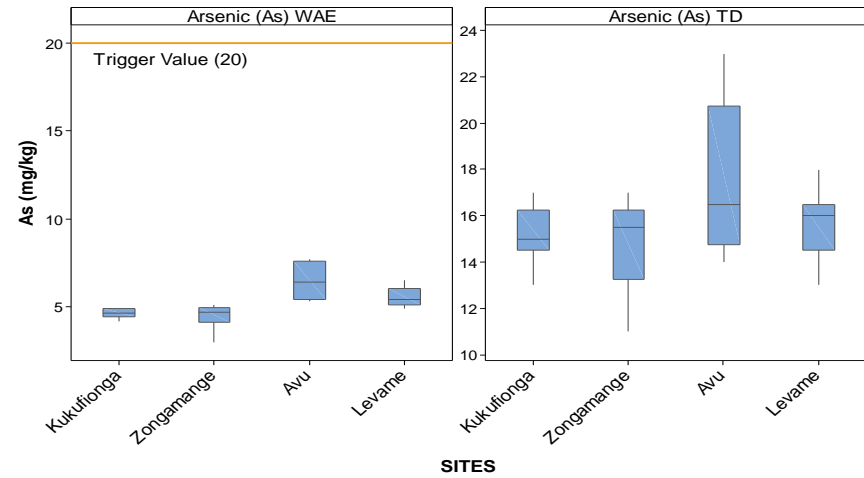


Figure E-24 Arsenic in sediment ORWB test sites 2024

NPL Annual Environment Report 2024

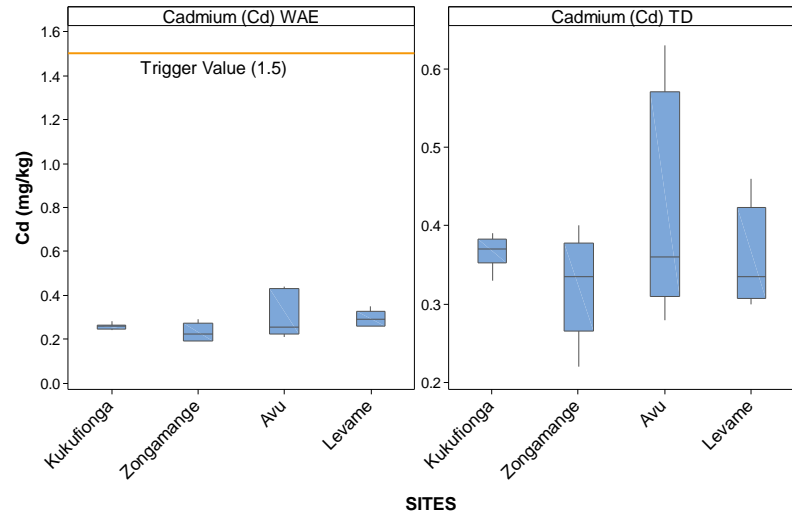


Figure E-25 Cadmium in sediment ORWB test sites 2024

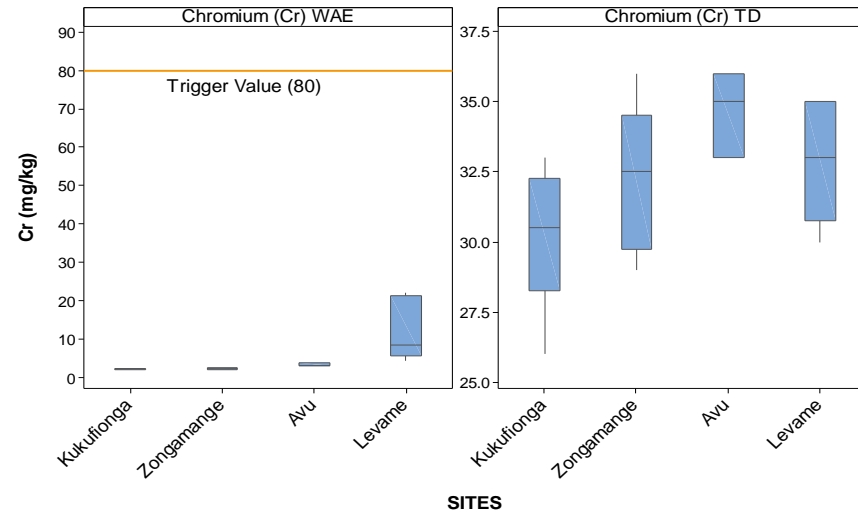


Figure E-26 Chromium in sediment ORWB test sites 2024

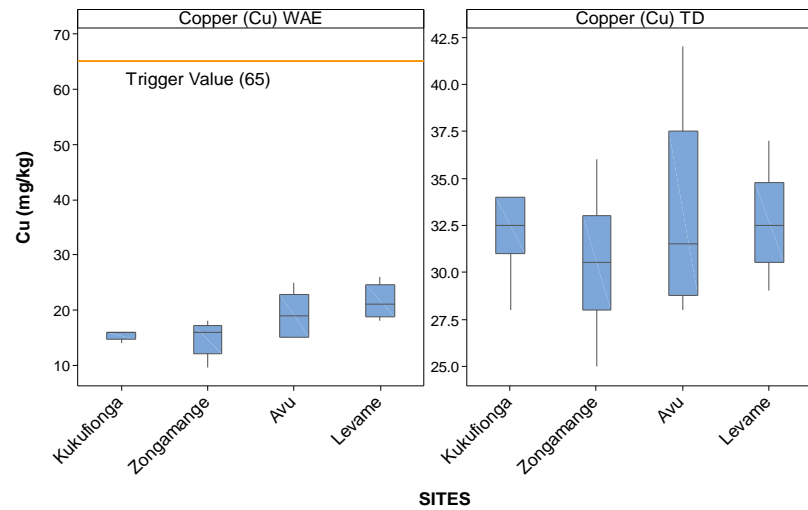


Figure E-27 Copper in sediment ORWB test sites 2024

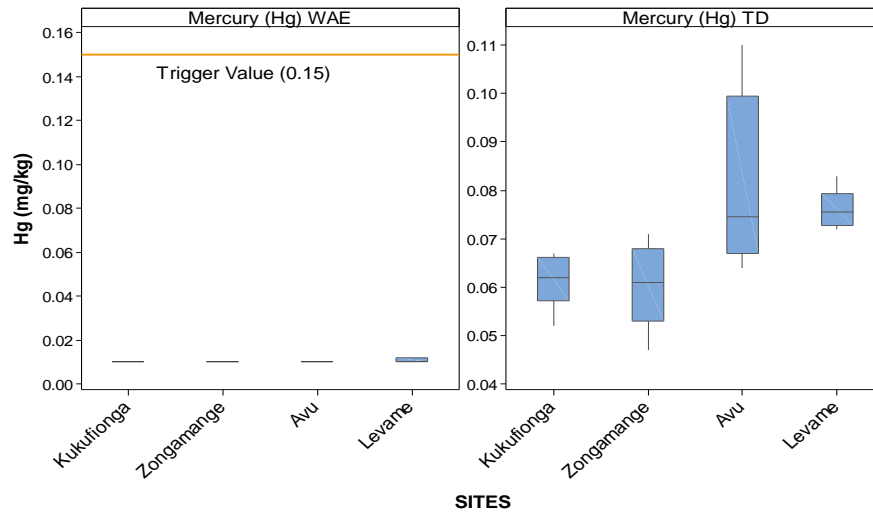


Figure E-28 Mercury in sediment ORWB test sites 2024

NPL Annual Environment Report 2024

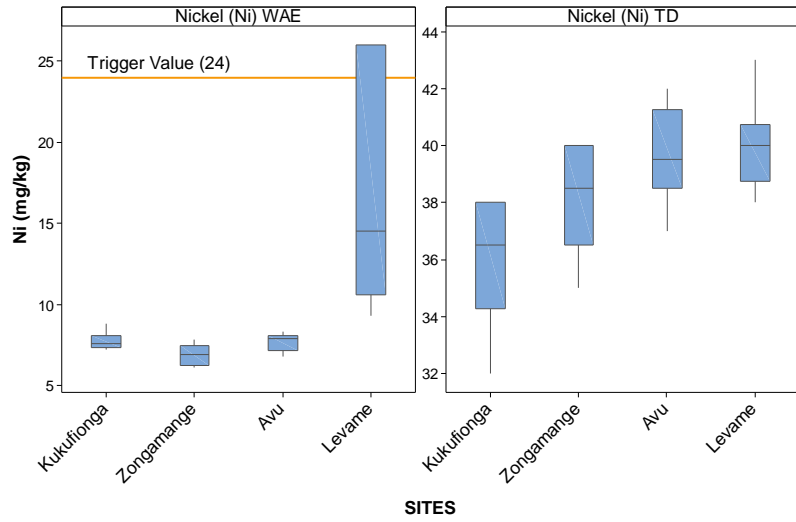


Figure E-29 Nickel in sediment ORWB test sites 2024

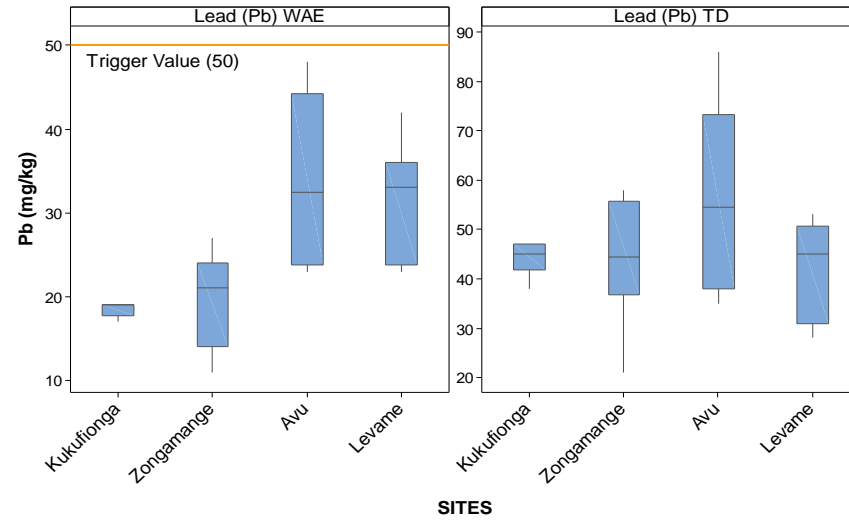


Figure E-30 Lead in sediment ORWB test sites 2024

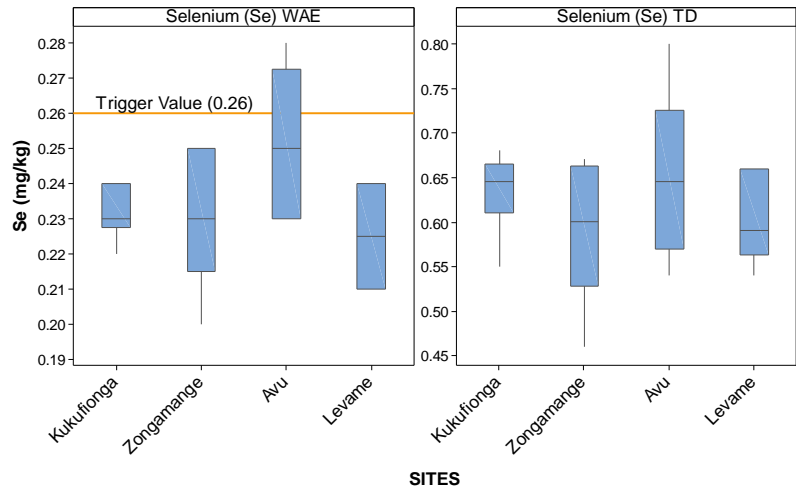


Figure E-31 Selenium in sediment ORWB test sites 2024

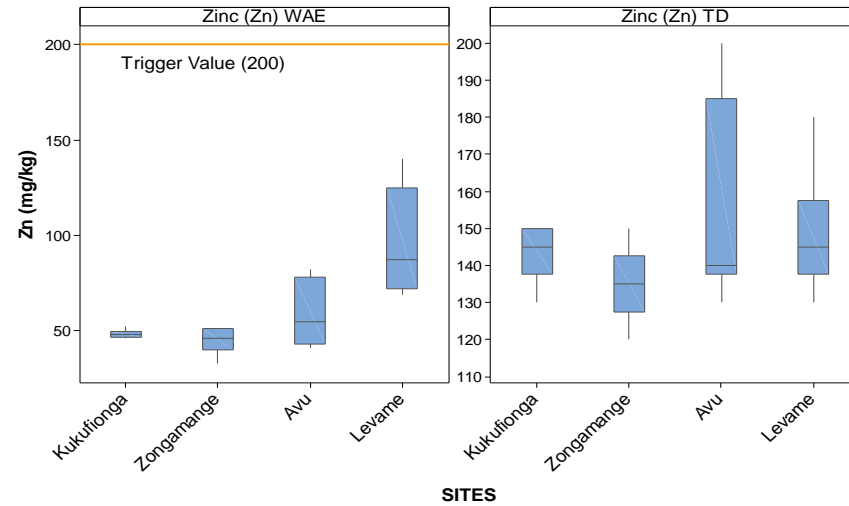


Figure E-32 Zinc in sediment ORWB test sites 2024

Table E-13 Performance assessment – Based on the trend of sediment quality indicators (all data) at upper river test sites between 2015 and 2024 using Spearman Rank Test (mg/kg dry weight, whole fraction)

Sediment Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend
SG1 (Trend of all data 2013 - 2015)	Ag-WAE	0.258	0.246	No change over time
	As-WAE	0.336	0.127	No change over time
	Cd-WAE	0.13	0.563	No change over time
	Cr-WAE	0.56	0.007	Increased over time
	Cu-WAE	0.27	0.224	No change over time
	Fe-WAE	0.682	<0.001	Increased over time
	Pb-WAE	0.196	0.381	No change over time
	Hg-WAE	-0.649	0.001	Reduced over time
	Ni-WAE	0.514	0.014	Increased over time
	Se-WAE	<LOR	<LOR	No change over time
	Zn-WAE	0.178	0.428	No change over time
SG2 (Trend of all data 2015 - 2024)	Ag-WAE*	-0.506	<0.001	No change over time
	As-WAE	-0.492	<0.001	Reduced over time
	Cd-WAE	-0.341	0.003	Reduced over time
	Cr-WAE	-0.181	0.126	No change over time
	Cu-WAE	-0.206	0.08	No change over time
	Fe-WAE	-0.162	0.17	No change over time
	Pb-WAE	-0.099	0.403	No change over time
	Hg-WAE	-0.276	0.018	Reduced over time
	Ni-WAE	-0.012	0.922	No change over time
	Se-WAE*	-0.219	0.063	No change over time
	Zn-WAE	-0.222	0.059	No change over time
Wasiba (Trend of all data 2015 - 2024)	Ag-WAE*	-0.362	<0.001	No change over time
	As-WAE	-0.386	<0.001	Reduced over time
	Cd-WAE	-0.53	<0.001	Reduced over time
	Cr-WAE	-0.198	0.022	Reduced over time
	Cu-WAE	-0.213	0.014	Reduced over time
	Fe-WAE	-0.264	0.002	Reduced over time
	Pb-WAE	-0.321	<0.001	Reduced over time
	Hg-WAE	-0.265	0.002	Reduced over time
	Ni-WAE	0.16	0.065	No change over time
	Se-WAE	0.044	0.616	No change over time
	Zn-WAE	-0.369	<0.001	Reduced over time
Wankipe (Trend of all data 2015 - 2024)	Ag-WAE*	-0.344	<0.001	No change over time
	As-WAE	-0.206	0.017	Reduced over time
	Cd-WAE	-0.528	<0.001	Reduced over time
	Cr-WAE	-0.246	0.004	Reduced over time
	Cu-WAE	-0.263	0.002	Reduced over time
	Fe-WAE	-0.216	0.013	Reduced over time
	Pb-WAE	-0.189	0.03	Reduced over time
	Hg-WAE	-0.213	0.014	Reduced over time
	Ni-WAE	0.128	0.142	No change over time
	Se-WAE	0.052	0.552	No change over time
	Zn-WAE	-0.371	<0.001	Reduced over time
SG3 (Trend of all data 2015 - 2024)	Ag-WAE*	-0.681	<0.001	No change over time
	As-WAE	-0.586	<0.001	Reduced over time
	Cd-WAE	-0.748	<0.001	Reduced over time
	Cr-WAE	-0.339	<0.001	Reduced over time
	Cu-WAE	-0.399	<0.001	Reduced over time
	Fe-WAE	-0.434	<0.001	Reduced over time
	Pb-WAE	-0.606	<0.001	Reduced over time
	Hg-WAE	-0.321	<0.001	Reduced over time
	Ni-WAE	0.220	0.001	Increased over time
	Se-WAE*	-0.373	<0.001	No change over time

NPL Annual Environment Report 2024

Sediment Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend
	Zn-WAE	-0.604	<0.001	Reduced over time

LOR – Limit of Reporting

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore the finding has been corrected to indicate no change over time, which is representative of actual conditions.

Table E-14 Performance assessment – Based on the trend of sediment quality indicators (all data) at lower river test sites between 2015 and 2024 using Spearman Rank Test (mg/kg dry weight, whole fraction)

Sediment Quality Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend
Bebelubi (Trend of all data 2015 - 2024)	Ag-WAE*	-0.431	0.001	No change over time
	As-WAE	-0.207	0.129	No change over time
	Cd-WAE	-0.64	<0.001	Reduced over time
	Cr-WAE	-0.195	0.154	No change over time
	Cu-WAE	-0.058	0.675	No change over time
	Fe-WAE	-0.052	0.703	No change over time
	Hg-WAE	≤LOR	≤LOR	No change over time
	Ni-WAE	-0.041	0.764	No change over time
	Pb-WAE	-0.068	0.623	No change over time
	Se-WAE	0.093	0.499	No change over time
	Zn-WAE	-0.286	0.035	Reduced over time
SG4 (Trend of all data 2015 - 2024)	Ag-WAE*	-0.619	<0.001	No change over time
	As-WAE	-0.169	0.206	No change over time
	Cd-WAE*	-0.743	<0.001	No change over time
	Cr-WAE	-0.141	0.291	No change over time
	Cu-WAE	-0.104	0.437	No change over time
	Fe-WAE	-0.046	0.733	No change over time
	Hg-WAE	≤LOR	≤LOR	No change over time
	Ni-WAE	0.049	0.717	No change over time
	Pb-WAE	-0.157	0.239	No change over time
	Se-WAE	-0.004	0.976	No change over time
	Zn-WAE	-0.322	0.014	Reduced over time
SG5 (Trend of all data 2015 - 2024)	Ag-WAE*	-0.334	0.005	No change over time
	As-WAE	-0.242	0.047	Reduced over time
	Cd-WAE	-0.655	<0.001	Reduced over time
	Cr-WAE	-0.204	0.096	No change over time
	Cu-WAE	0.062	0.614	No change over time
	Fe-WAE	-0.083	0.503	No change over time
	Hg-WAE	-0.353	0.003	Reduced over time
	Ni-WAE	-0.039	0.752	No change over time
	Pb-WAE	-0.303	0.012	Reduced over time
	Se-WAE	0.071	0.566	No change over time
	Zn-WAE	-0.381	0.001	Reduced over time

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore the finding has been corrected to indicate no change over time, which is representative of actual conditions.

Table E-15 Performance assessment – Based on the trend of the annual median of sediment quality indicators at ORWB test sites throughout the history of the operation using Spearman Rank Test. (mg/kg dry weight, whole fraction)

Sediment Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend
Kukufionga (Trend of all data 2015 - 2024)	Ag-WAE	-0.233	0.120	No change over time
	As-WAE	-0.084	0.579	No change over time
	Cd-WAE	-0.747	<0.001	Reduced over time
	Cr-WAE	-0.263	0.078	No change over time
	Cu-WAE	-0.115	0.447	No change over time
	Fe-WAE	-0.124	0.412	No change over time
	Pb-WAE	-0.344	0.019	Reduced over time
	Hg-WAE	-0.070	0.642	No change over time
	Ni-WAE	-0.255	0.087	No change over time
	Se-WAE	0.632	<0.001	Increased over time
	Zn-WAE	-0.645	<0.001	Reduced over time
Zongamange (Trend of all data 2015 - 2024)	Ag-WAE	-0.198	0.227	No change over time
	As-WAE	-0.071	0.669	No change over time
	Cd-WAE	-0.706	<0.001	Reduced over time
	Cr-WAE	-0.157	0.340	No change over time
	Cu-WAE	0.115	0.485	No change over time
	Fe-WAE	0.020	0.902	No change over time
	Pb-WAE	-0.336	0.036	Reduced over time
	Hg-WAE	0.095	0.566	No change over time
	Ni-WAE	-0.361	0.024	Reduced over time
	Se-WAE	0.604	<0.001	Increased over time
	Zn-WAE	-0.611	<0.001	Reduced over time
Avu (Trend of all data 2015 - 2024)	Ag-WAE	0.059	0.686	No change over time
	As-WAE	0.051	0.726	No change over time
	Cd-WAE	-0.361	0.011	Reduced over time
	Cr-WAE	0.054	0.715	No change over time
	Cu-WAE	0.036	0.806	No change over time
	Fe-WAE	0.196	0.177	No change over time
	Pb-WAE	-0.093	0.525	No change over time
	Hg-WAE	-0.321	0.025	Reduced over time
	Ni-WAE	-0.344	0.016	Reduced over time
	Se-WAE	0.467	0.001	Increased over time
	Zn-WAE	-0.476	0.001	Reduced over time
Levame (Trend of all data 2015 - 2024)	Ag-WAE	-0.194	0.196	No change over time
	As-WAE	0.254	0.089	No change over time
	Cd-WAE	-0.435	0.003	Reduced over time
	Cr-WAE	0.656	<0.001	Increased over time
	Cu-WAE	0.447	0.002	Increased over time
	Fe-WAE	0.692	<0.001	Increased over time
	Pb-WAE	-0.013	0.933	No change over time
	Hg-WAE	-0.127	0.400	No change over time
	Ni-WAE	0.580	<0.001	Increased over time
	Se-WAE	0.400	0.006	Increased over time
	Zn-WAE	0.200	0.182	No change over time

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore the finding has been corrected to indicate no change over time, which is representative of actual conditions.

Table E-16 Sediment quality Lake Murray test sites Central Lake 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Central	N	N (Test)	Median	Result	Go to			
Ag-WAE	10	10	0.06	TSM < TV	Step 1	1.0	0.003	LOW
As-WAE	10	10	2.7	TSM < TV	Step 1	20	0.003	LOW
Cd-WAE	10	10	0.11	TSM < TV	Step 1	1.5	0.003	LOW
Cr-WAE	10	10	5.1	TSM < TV	Step 1	80	0.003	LOW
Cu-WAE	10	10	14	TSM < TV	Step 1	65	0.003	LOW
Hg-WAE	10	10	0.01	TSM < TV	Step 1	0.15	0.003	LOW
Ni-WAE	10	10	11	TSM < TV	Step 1	21	0.004	LOW
Pb-WAE	10	10	14	TSM < TV	Step 1	50	0.003	LOW
Se-WAE	10	10	0.32	TSM < TV	Step 1	0.33	0.142	POTENTIAL
Zn-WAE	10	10	48	TSM < TV	Step 1	200	0.003	LOW

Table E-17 Sediment quality Lake Murray test sites South Lake 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Southern	N	N (Test)	Median	Result	Go to			
Ag-WAE	11	11	0.22	TSM < TV	Step 1	1.0	0.002	LOW
As-WAE	11	11	4.2	TSM < TV	Step 1	20	0.002	LOW
Cd-WAE	11	11	0.19	TSM < TV	Step 1	1.5	0.002	LOW
Cr-WAE	11	11	3.7	TSM < TV	Step 1	80	0.002	LOW
Cu-WAE	11	11	15	TSM < TV	Step 1	65	0.002	LOW
Hg-WAE	11	11	0.01	TSM < TV	Step 1	0.15	0.002	LOW
Ni-WAE	11	11	10	TSM < TV	Step 1	21	0.015	LOW
Pb-WAE	11	11	29	TSM < TV	Step 1	50	0.002	LOW
Se-WAE	11	11	0.27	TSM < TV	Step 1	0.33	0.003	LOW
Zn-WAE	11	11	56	TSM < TV	Step 1	200	0.002	LOW

Table E-18 Sediment quality Lake Murray test site SG6 2024 median (mg/kg dry weight, whole fraction)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
SG6	N	N (Test)	Median	Result	Go to			
Ag-WAE	6	6	0.06	TSM < TV	Step 1	1.0	0.018	LOW
As-WAE	6	6	5.2	TSM < TV	Step 1	20	0.018	LOW
Cd-WAE	6	6	0.15	TSM < TV	Step 1	1.5	0.018	LOW
Cr-WAE	6	6	3.2	TSM < TV	Step 1	80	0.018	LOW
Cu-WAE	6	6	18	TSM < TV	Step 1	65	0.018	LOW
Hg-WAE	6	6	0.01	TSM < TV	Step 1	0.15	0.018	LOW
Ni-WAE	6	6	8.5	TSM < TV	Step 1	21	0.018	LOW
Pb-WAE	6	6	19	TSM < TV	Step 1	50	0.018	LOW
Se-WAE	6	6	0.24	TSM < TV	Step 1	0.33	0.018	LOW
Zn-WAE	6	6	33	TSM < TV	Step 1	200	0.018	LOW

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison.

NPL Annual Environment Report 2024

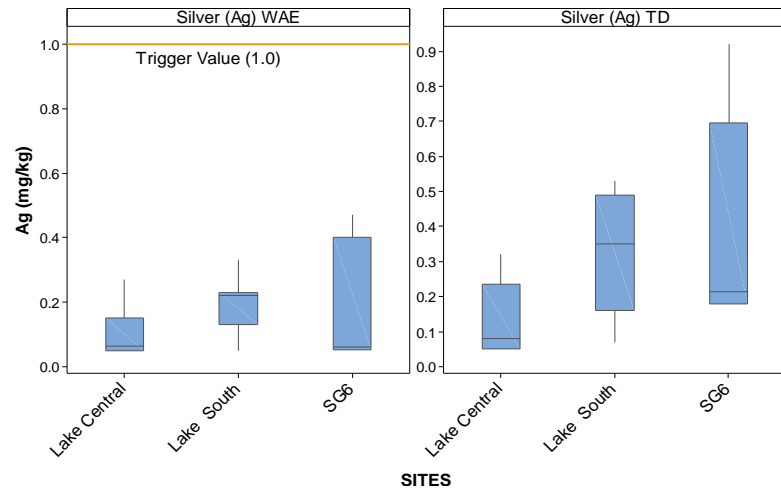


Figure E-33 Silver in sediment LMY test sites 2024

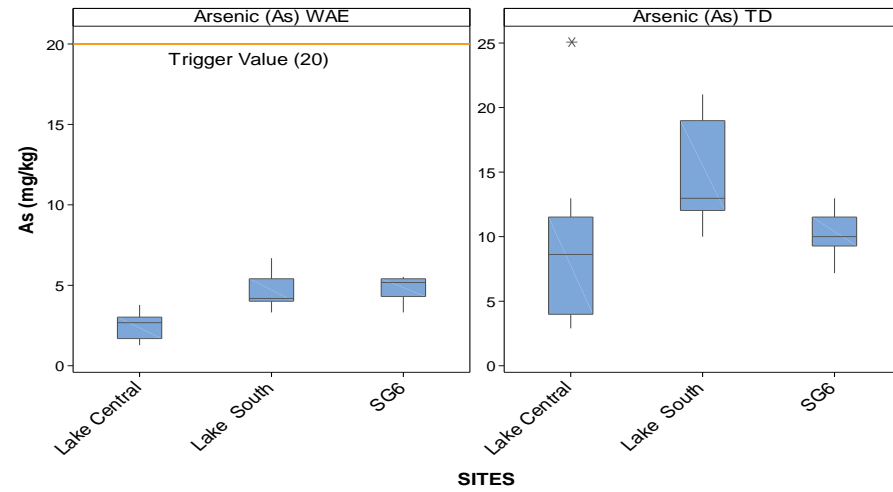


Figure E-34 Arsenic in sediment LMY test sites 2024

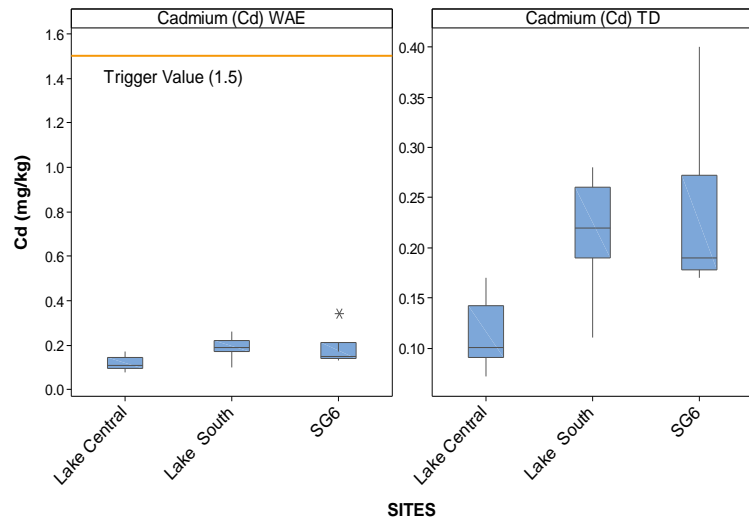


Figure E-35 Cadmium in sediment LMY test sites 2024

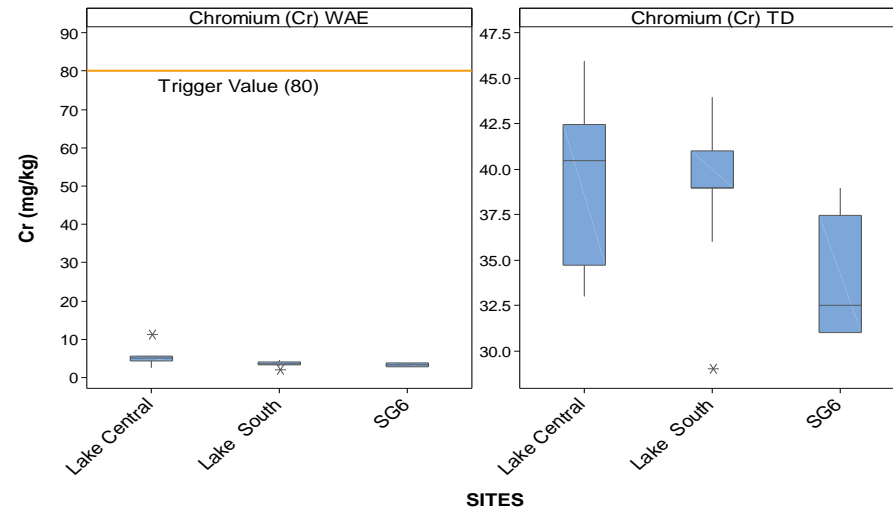


Figure E-36 Chromium in sediment LMY test sites 2024

NPL Annual Environment Report 2024

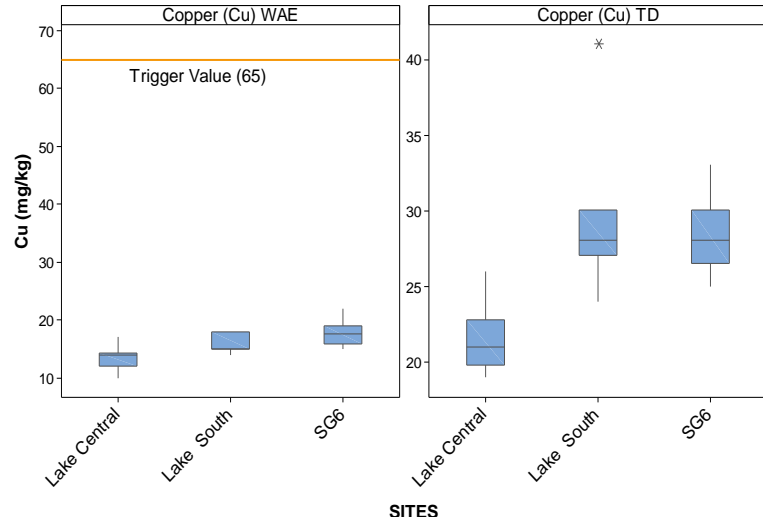


Figure E-37 Copper in sediment LMY test sites 2024

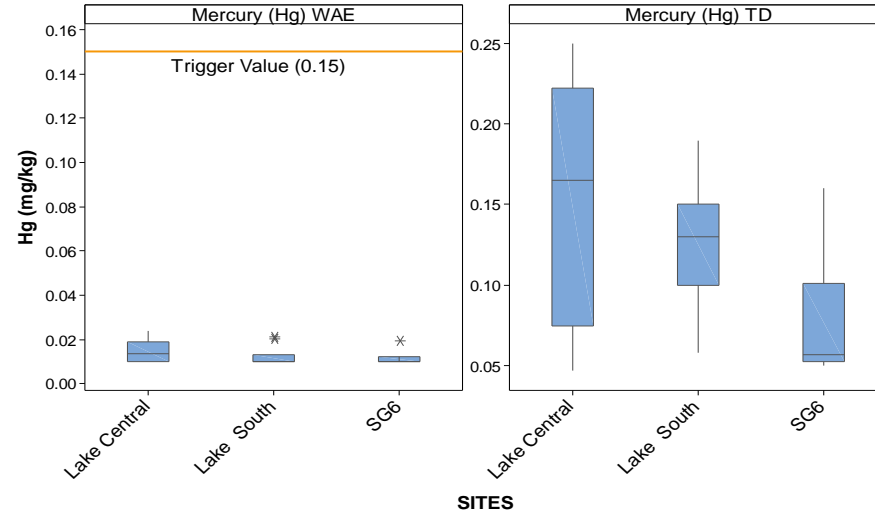


Figure E-38 Mercury in sediment LMY test sites 2024

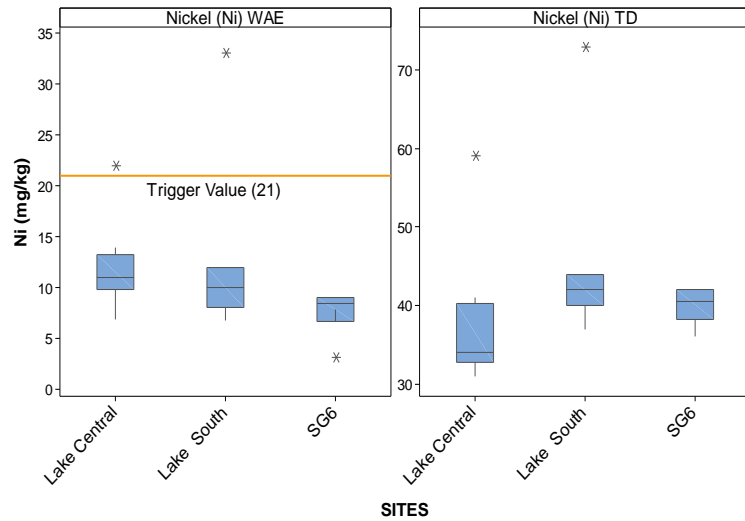


Figure E-39 Nickel in sediment LMY test sites 2024

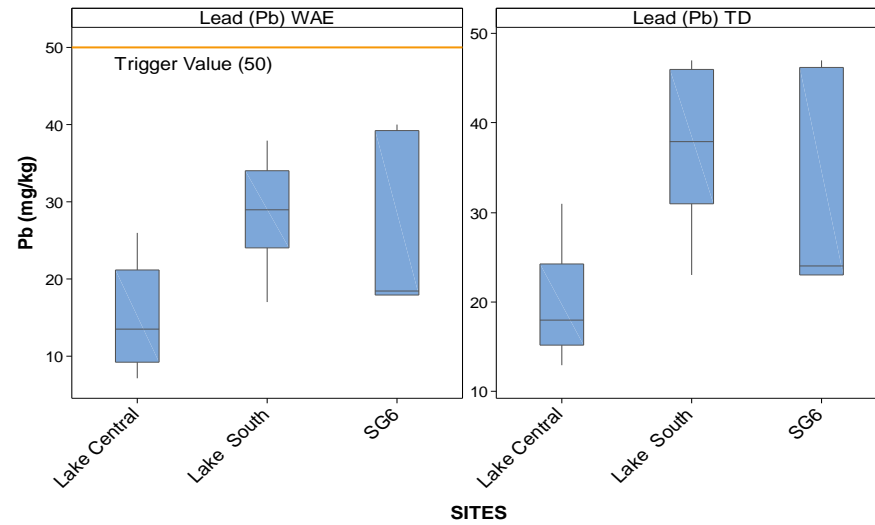


Figure E-40 Lead in sediment LMY test sites 2024

NPL Annual Environment Report 2024

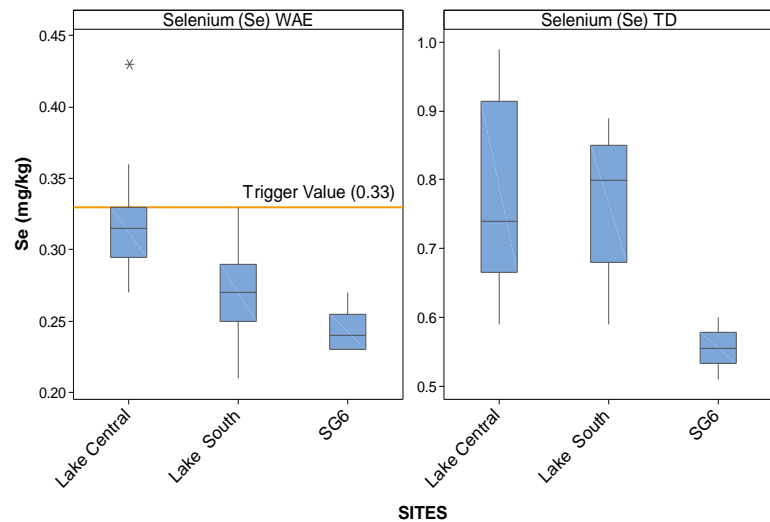


Figure E-41 Selenium in sediment LMY test sites 2024

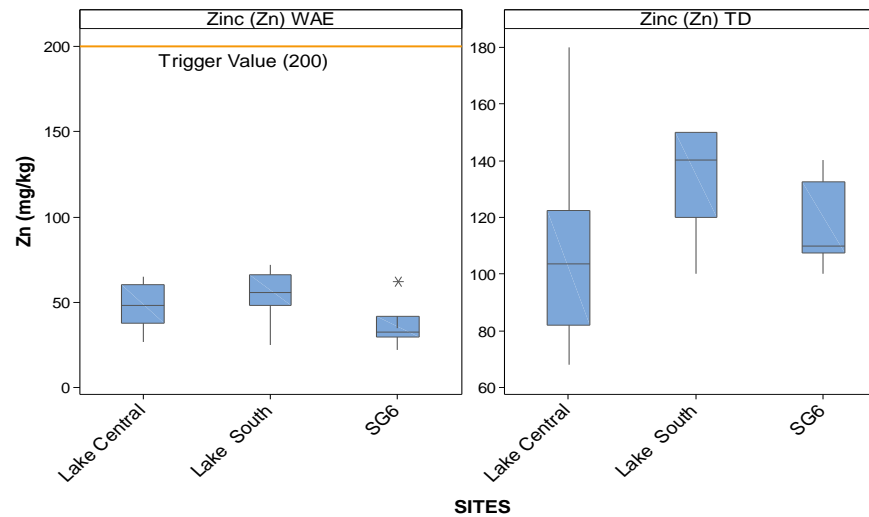


Figure E-42 Zinc in sediment LMY test sites 2024

Table E-19 Performance assessment – Based on the trend of the annual median of sediment quality indicators at Lake Murray test sites throughout the history of the operation using Spearman Rank Test. (mg/kg dry weight, whole fraction)

Sediment Quality Site	Parameter	Spearman's rho	P-Value (P=0.05)	Trend
Central (Trend of all data 2015 - 2024)	Ag-WAE	-0.220	0.037	Reduced over time
	As-WAE	0.050	0.638	No change over time
	Cd-WAE	-0.211	0.045	Reduced over time
	Cr-WAE	-0.028	0.793	No change over time
	Cu-WAE	0.109	0.302	No change over time
	Fe-WAE	0.042	0.694	No change over time
	Pb-WAE	-0.171	0.105	No change over time
	Hg-WAE	-0.167	0.113	No change over time
	Ni-WAE	0.085	0.425	No change over time
	Se-WAE	0.623	<0.001	Increased over time
	Zn-WAE	-0.084	0.426	No change over time
South (Trend of all data 2015 - 2024)	Ag-WAE	0.183	0.024	Increased over time
	As-WAE	0.088	0.279	No change over time
	Cd-WAE	-0.181	0.026	Reduced over time
	Cr-WAE	0.119	0.146	No change over time
	Cu-WAE	0.083	0.312	No change over time
	Fe-WAE	0.165	0.042	Increased over time
	Pb-WAE	-0.136	0.095	No change over time
	Hg-WAE	-0.072	0.380	No change over time
	Ni-WAE	0.250	0.002	Increased over time
	Se-WAE	0.474	<0.001	Increased over time
	Zn-WAE	0.043	0.596	No change over time
SG6 (Trend of all data 2015 - 2024)	Ag-WAE	-0.175	0.202	No change over time
	As-WAE	0.053	0.703	No change over time
	Cd-WAE	-0.368	0.006	Reduced over time
	Cr-WAE	-0.191	0.162	No change over time
	Cu-WAE	0.141	0.305	No change over time
	Fe-WAE	-0.057	0.680	No change over time
	Pb-WAE	-0.175	0.201	No change over time
	Hg-WAE	-0.492	<0.001	Reduced over time
	Ni-WAE	-0.093	0.502	No change over time
	Se-WAE	0.283	0.036	Increased over time
Zn-WAE	-0.295	0.029	Reduced over time	

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore the finding has been corrected to indicate no change over time, which is representative of actual conditions.

**APPENDIX F. TISSUE METAL – RISK AND PERFORMANCE ASSESSMENT
– DETAILS OF STATISTICAL ANALYSIS & BOX PLOTS**

Table F-1 Expanded risk matrix – tissue metals

Initial Assessment Result					Go To
TSM < TV					Step 1
TSM ≥ TV and TV, TSM and full TSM data set are > LOR					Step 2
TSM = TV and TV, TSM and full TSM data set ≤ LOR					Step 3
Step	Alt Hypothesis	Null Hypothesis	Sig Test Result		Risk Assessment
1	TSM < TV	TSM = TV	p < 0.05	Accept Alt	LOW
			p > 0.05	Accept Null	POTENTIAL
			Error	Accept Neither	ND
2	TSM ≥ TV and TV, TSM and full TSM data set are > LOR				POTENTIAL
3	TSM = TV and TV, TSM and full TSM data set are ≤ LOR				LOW

TSM = Test Site Median

ND = No determination

Table F-2 Tissue metals - fish flesh upper river test sites 2024 median (µg/g)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Wasiba	N	N (Test)	Median	Result	Go to			
As	12	12	0.022	<	Step 1	0.20	0.001	LOW
Cd	12	12	0.003	<	Step 1	0.020	0.001	LOW
Cr*	12	-	0.010	=	Step 3	0.010	-	LOW
Cu	12	12	0.21	<	Step 1	0.48	0.001	LOW
Hg	12	12	0.046	<	Step 1	0.080	0.001	LOW
Ni	12	12	0.01	<	Step 1	0.10	0.001	LOW
Pb	12	12	0.01	<	Step 1	0.17	0.001	LOW
Se	12	12	0.31	<	Step 1	2.26	0.001	LOW
Zn	12	12	4.0	<	Step 1	10.4	0.002	LOW
Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Wankipe	N	N (Test)	Median	Result	Go to			
As	12	12	0.015	<	Step 1	0.20	0.001	LOW
Cd	12	11	0.003	<	Step 1	0.020	0.001	LOW
Cr*	12	-	0.010	=	Step 1	0.010	-	LOW
Cu	12	12	0.25	<	Step 1	0.48	0.008	LOW
Hg	12	12	0.037	<	Step 1	0.080	0.001	LOW
Ni	12	12	0.010	<	Step 1	0.10	0.001	LOW
Pb	12	12	0.010	<	Step 2	0.17	0.001	LOW
Se	12	12	0.23	<	Step 1	2.26	0.001	LOW
Zn	12	12	4.5	<	Step 1	10.4	0.001	LOW

* Wilcoxon's test returns an error when all test and reference data are equal, which usually occurs when all results are < the analytical limit of reporting. Although the result is not statistically significant the TSM is considered = TV.

Table F-3 Tissue metals - prawn abdomens from upper river test sites 2024 median (µg/g)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Wasiba	N	N (Test)	Median	Result	Go to			
As	12	12	0.031	<	Step 1	0.033	0.001	LOW
Cd*	12	-	0.003	=	Step 2	0.003	-	LOW
Cr	12	12	0.017	<	Step 1	0.026	0.063	POTENTIAL
Cu	12	12	4.7	<	Step 1	6.8	0.019	LOW
Hg*	12	-	0.010	=	Step 2	0.010	-	LOW
Ni*	12	-	0.010	=	Step 2	0.010	-	LOW
Pb	12	6	0.012	>	Step 2	0.010	0.989	POTENTIAL
Se	12	12	0.47	>	Step 2	0.37	0.992	POTENTIAL
Zn	12	12	15	<	Step 1	16	0.265	POTENTIAL
Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Wankipe	N	N (Test)	Median	Result	Go to			
As	12	12	0.030	<	Step 1	0.033	0.068	POTENTIAL
Cd*	12	-	0.003	=	Step 2	0.003	-	LOW
Cr	12	12	0.029	>	Step 1	0.026	0.837	POTENTIAL
Cu	12	12	4.1	<	Step 2	6.8	0.002	LOW
Hg*	12	-	0.010	=	Step 3	0.010	-	LOW
Ni*	12	-	0.010	=	Step 3	0.010	-	LOW
Pb	12	5	0.010	=	Step 2	0.010	0.985	POTENTIAL
Se	12	12	0.36	<	Step 1	0.37	0.469	POTENTIAL
Zn	12	12	13	<	Step 2	16	0.023	LOW

* Wilcoxon's test returns an error when all test and reference data are equal, which usually occurs when all results are < the analytical limit of reporting. Although the result is not statistically significant the TSM is considered = TV.

Table F-4 Tissue metals - fish flesh lower river test sites 2024 median (µg/g)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Bebelubi	N	N (Test)	Median	Result	Go to			
As	12	12	0.011	<	Step 1	0.071	0.001	LOW
Cd*	12	-	0.003	=	Step 3	0.003	-	LOW
Cr	12	12	0.010	<	Step 1	0.030	0.001	LOW
Cu	12	12	0.097	<	Step 1	0.94	0.001	LOW
Hg	12	11	0.10	<	Step 1	0.12	0.023	LOW
Ni	12	12	0.010	<	Step 1	0.165	0.001	LOW
Pb	12	12	0.010	<	Step 1	0.03	0.001	LOW
Se	12	12	0.16	<	Step 1	2.26	0.001	LOW
Zn	12	12	2.6	<	Step 1	7.5	0.001	LOW
Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
SG4	N	N (Test)	Median	Result	Go to			
As	12	11	0.010	<	Step 1	0.071	0.001	LOW
Cd*	12	-	0.0030	=	Step 2	0.003	-	LOW
Cr	12	12	0.010	<	Step 1	0.030	0.001	LOW
Cu	12	12	0.094	<	Step 1	0.94	0.001	LOW
Hg	12	12	0.067	<	Step 1	0.12	0.003	LOW
Ni	12	12	0.010	<	Step 1	0.165	0.002	LOW
Pb	12	12	0.010	<	Step 1	0.03	0.001	LOW
Se	12	12	0.16	<	Step 1	2.26	0.001	LOW
Zn	12	12	4.1	<	Step 1	7.5	0.001	LOW

* Wilcoxon's test returns error when all test and reference data are equal, which occurs when all results are < the analytical limit of reporting. Although the result is not statistically significant the TSM is considered = TV.

Table F-5 Tissue metals - prawn abdomens lower river test sites 2024 median (µg/g)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Bebelubi	N	N (Test)	Median	Result	Go to			
As	12	12	0.064	<	Step 1	0.085	0.008	LOW
Cd	12	12	0.003	<	Step 1	0.006	0.002	LOW
Cr	12	12	0.024	<	Step 1	0.050	0.002	LOW
Cu	12	12	6.6	<	Step 1	12	0.001	LOW
Hg*	12	-	0.010	=	Step 3	0.010	-	LOW
Ni*	12	-	0.010	=	Step 2	0.010	-	LOW
Pb*	12	-	0.010	=	Step 3	0.010	-	LOW
Se	12	12	0.23	<	Step 1	0.33	0.007	LOW
Zn	12	10	12	<	Step 1	15	0.031	LOW
Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
SG4	N	N (Test)	Median	Result	Go to			
As	12	11	0.057	<	Step 1	0.085	0.003	LOW
Cd	12	12	0.003	<	Step 2	0.006	0.003	LOW
Cr	12	12	0.020	<	Step 1	0.050	0.001	LOW
Cu	12	10	4.5	<	Step 1	12	0.003	LOW
Hg*	12	-	0.010	=	Step 3	0.010	-	LOW
Ni	12	-	0.010	=	Step 2	0.010	-	LOW
Pb	12	-	0.010	=	Step 2	0.010	-	LOW
Se	12	11	0.25	<	Step 2	0.33	0.004	LOW
Zn	12	11	11	<	Step 1	15	0.003	LOW

* Wilcoxon's test returns an error when all test and reference data are equal, which usually occurs when all results are < the analytical limit of reporting. Although the result is not statistically significant the TSM is considered = TV.

Table F-6 Tissue metals - fish flesh from Lake Murray test sites 2024 median (µg/g)

Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Miwa	N	N (Test)	Median	Result	Go to			
As	3	-	0.021	<	Step 1	0.065	Direct Comparison	LOW*
Cd	3	-	0.003	=	Step 2	0.003	Direct Comparison	LOW*
Cr	3	-	0.010	<	Step 1	0.028	Direct Comparison	LOW*
Cu	3	-	0.094	<	Step 1	0.203	Direct Comparison	LOW*
Hg	3	-	0.32	>	Step 1	0.19	Direct Comparison	POTENTIAL*
Ni	3	-	0.010	<	Step 1	0.19	Direct Comparison	LOW*
Pb	3	-	0.010	<	Step 1	0.071	Direct Comparison	LOW*
Se	3	-	0.28	<	Step 1	2.26	Direct Comparison	LOW*
Zn	3	-	3.20	>	Step 1	3.12	Direct Comparison	POTENTIAL*
Test Site				Initial Assessment		TV	Statistical Test Result (p=0.05)	Risk Assessment
Pangoa	N	N (Test)	Median	Result	Go to			
As	3	-	0.064	<	Step 1	0.065	Direct Comparison	LOW*
Cd	3	-	0.003	=	Step 2	0.003	Direct Comparison	LOW*
Cr	3	-	0.01	<	Step 1	0.028	Direct Comparison	LOW*
Cu	3	-	0.089	<	Step 1	0.203	Direct Comparison	LOW*
Hg	3	-	0.19	=	Step 1	0.19	Direct Comparison	POTENTIAL*
Ni	3	-	0.01	<	Step 1	0.19	Direct Comparison	LOW*
Pb	3	-	0.01	<	Step 1	0.071	Direct Comparison	LOW*
Se	3	-	0.36	<	Step 1	2.26	Direct Comparison	LOW*
Zn	3	-	2.5	<	Step 1	3.12	Direct Comparison	LOW*

*Small sample size (n) therefore Wilcoxon (signed rank) does not have sufficient power to detect significance difference between medians. Risk assessment is based on direct comparison

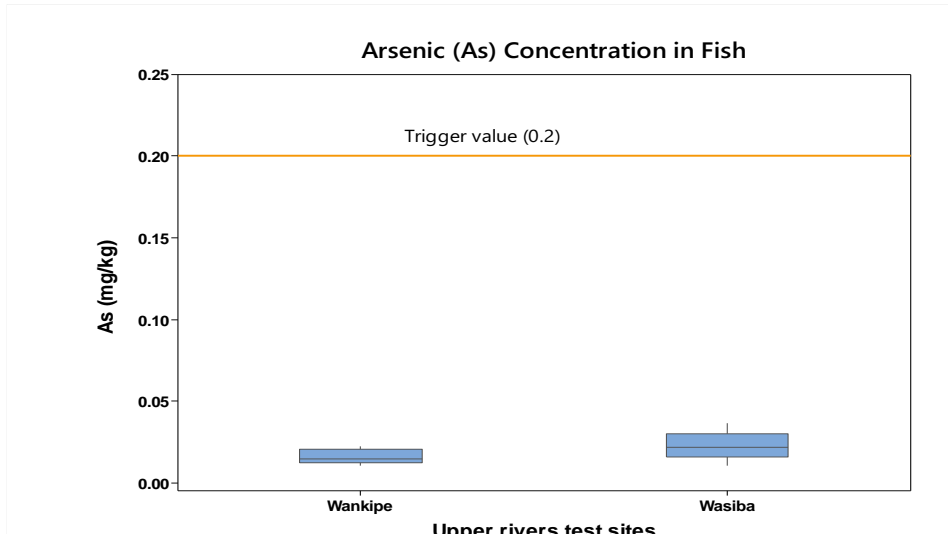


Figure F-1 Arsenic in fish flesh upper rivers test sites 2024

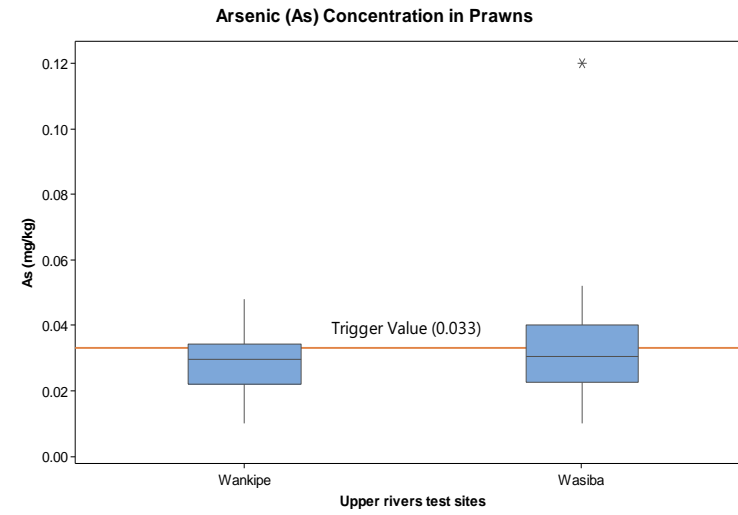


Figure F-2 Arsenic in prawn abdomen upper rivers test sites 2024

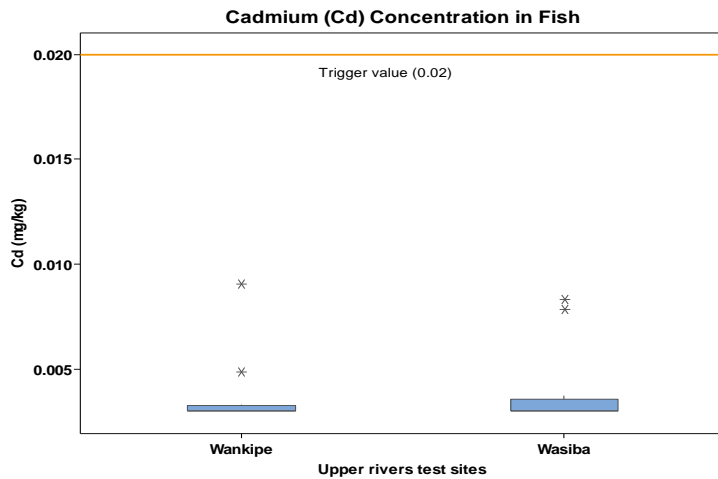


Figure F-3 Cadmium in fish flesh upper rivers test sites 2024

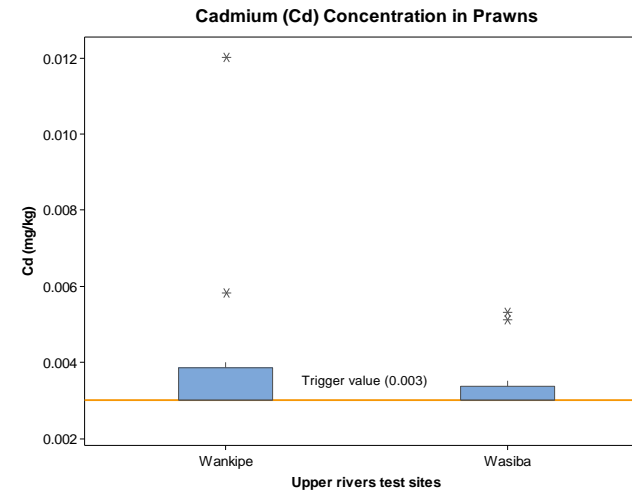


Figure F-4 Cadmium in prawn abdomen upper rivers test sites 2024

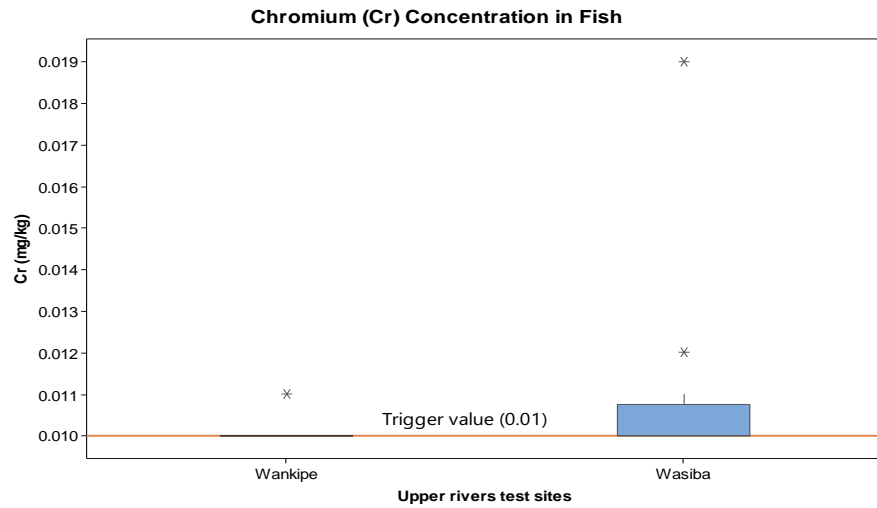


Figure F-5 Chromium in fish flesh upper rivers test sites 2024

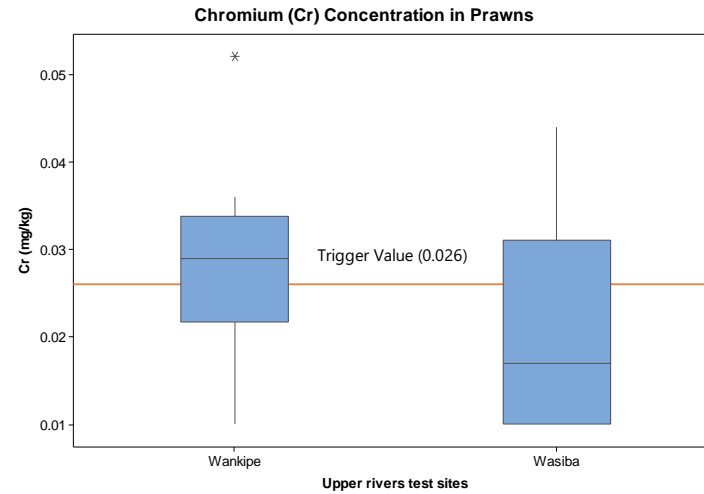


Figure F-6 Chromium in prawn abdomen upper rivers test sites 2024

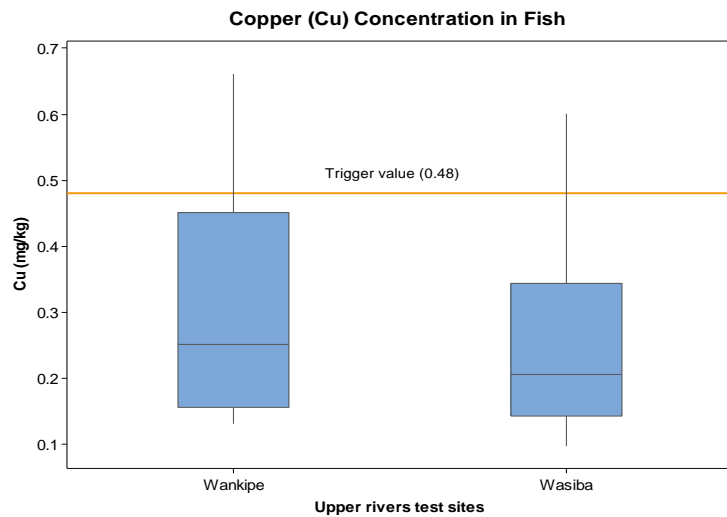


Figure F-7 Copper in fish flesh upper rivers test sites 2024

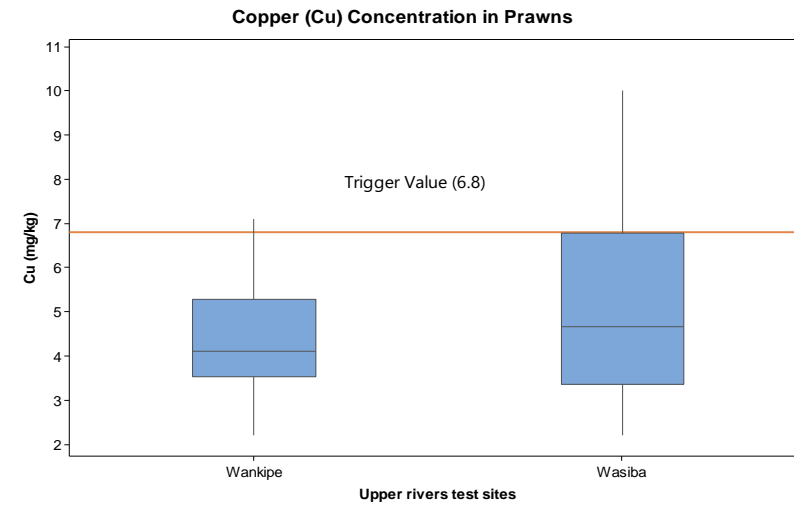


Figure F-8 Copper in prawn abdomen upper rivers test sites 2024

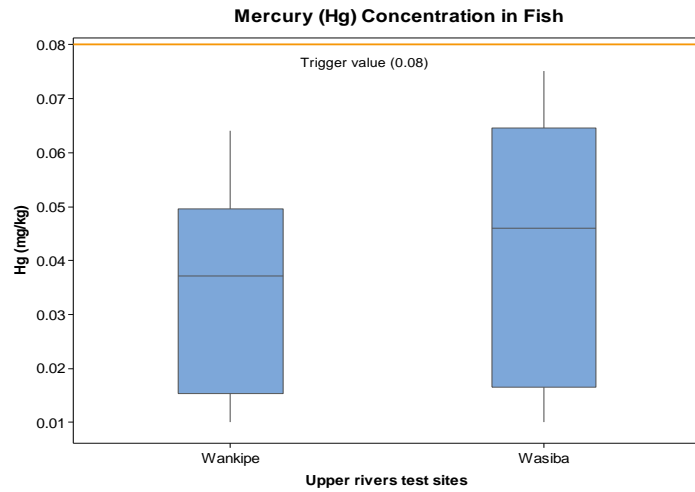


Figure F-9 Mercury in fish flesh upper rivers test sites 2024

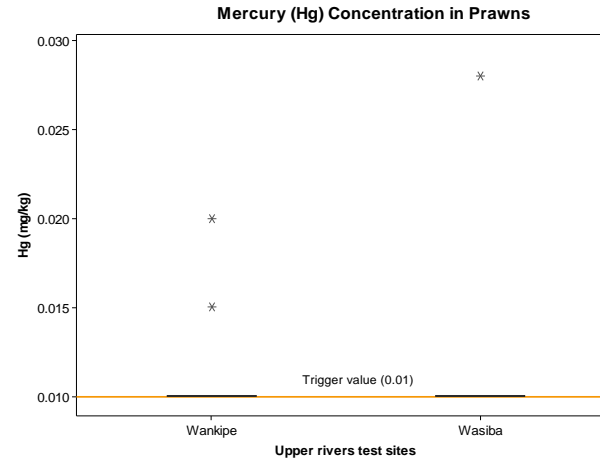


Figure F-10 Mercury in prawn abdomen upper rivers test sites 2024

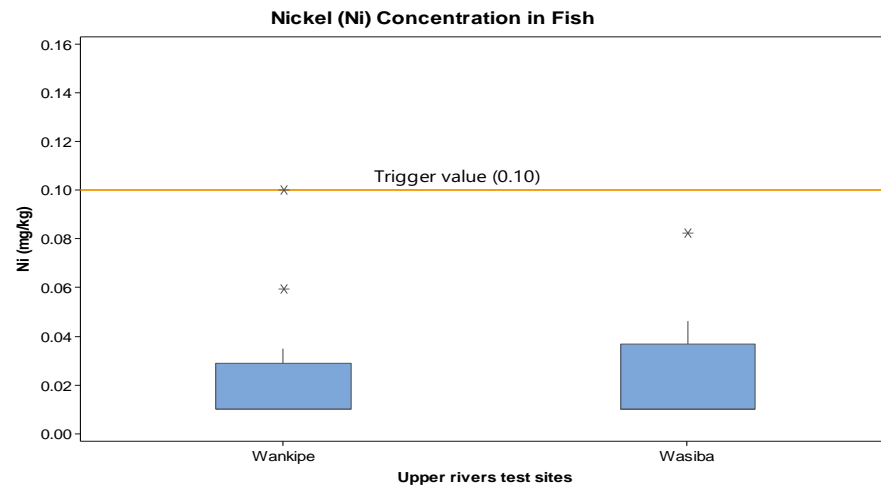


Figure F-11 Nickel in fish flesh upper rivers test sites 2024

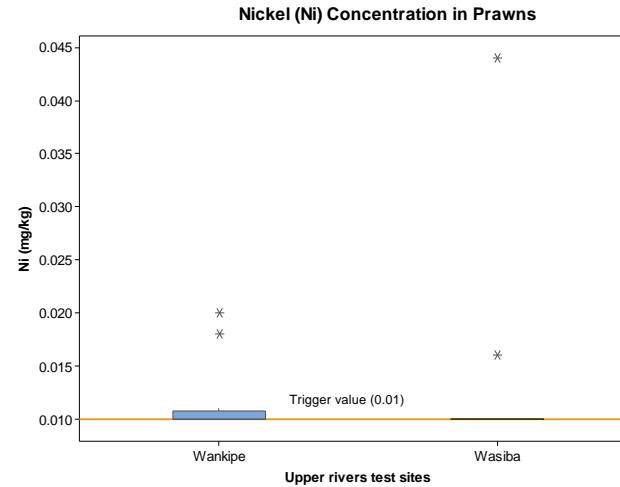


Figure F-12 Nickel in prawn abdomen upper rivers test sites 2024

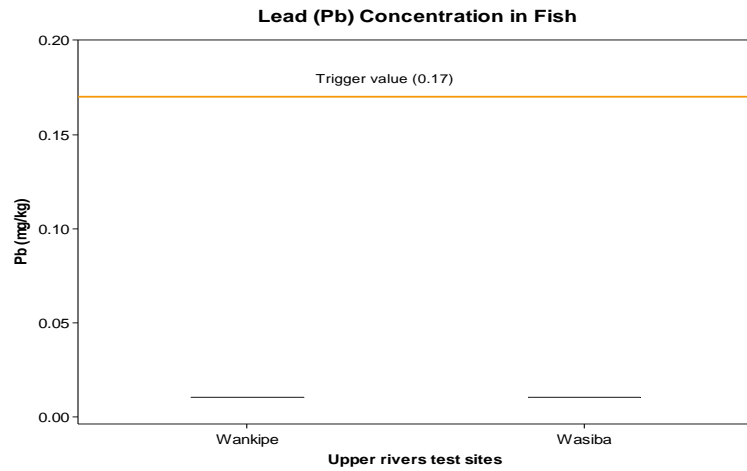


Figure F-13 Lead in fish flesh upper rivers test sites 2024

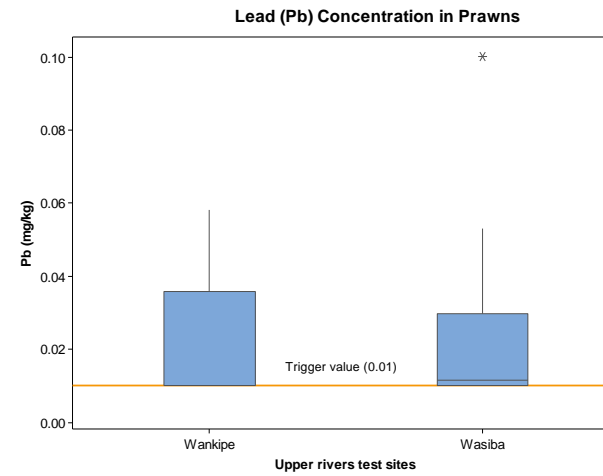


Figure F-14 Lead in prawn abdomen upper rivers test sites 2024

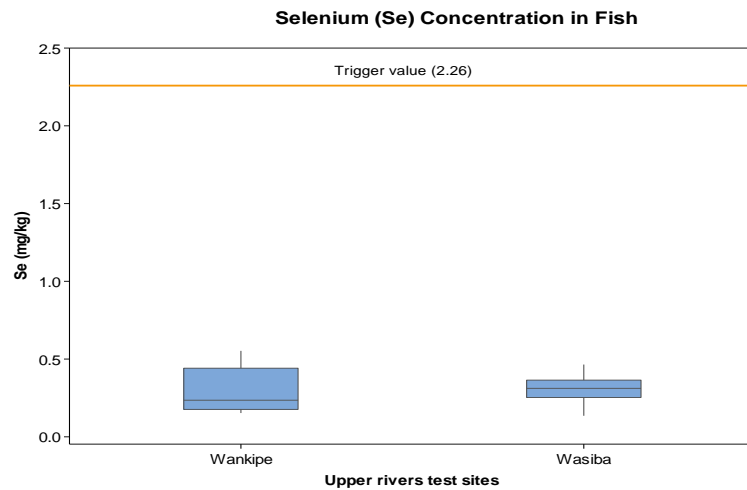


Figure F-15 Selenium in fish flesh upper rivers test sites 2024

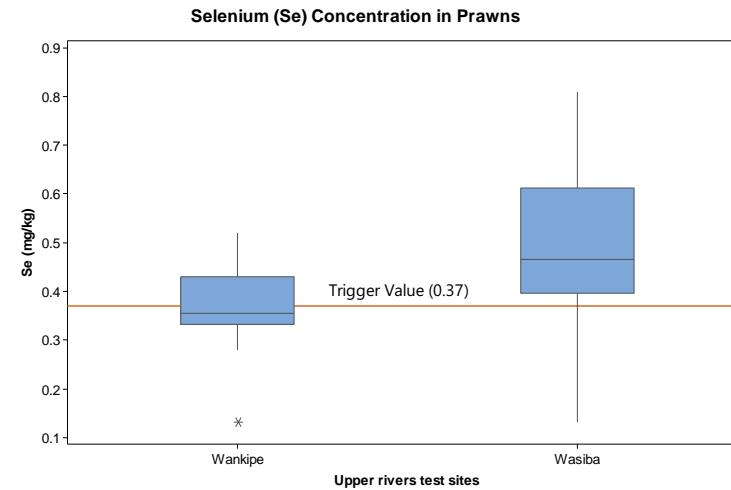


Figure F-16 Selenium in prawn abdomen upper rivers test sites 2024

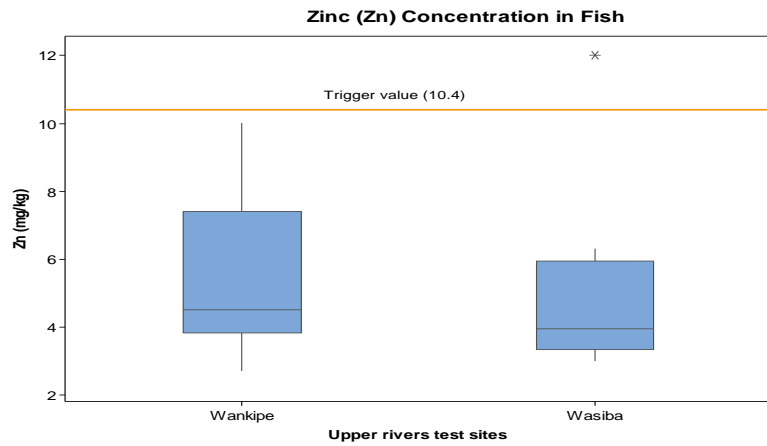


Figure F-17 Zinc in fish flesh upper rivers test sites 2024

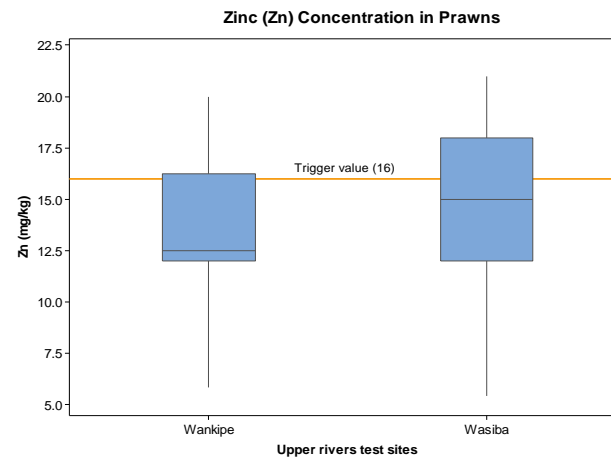


Figure F-18 Zinc in prawn abdomen upper rivers test sites 2024

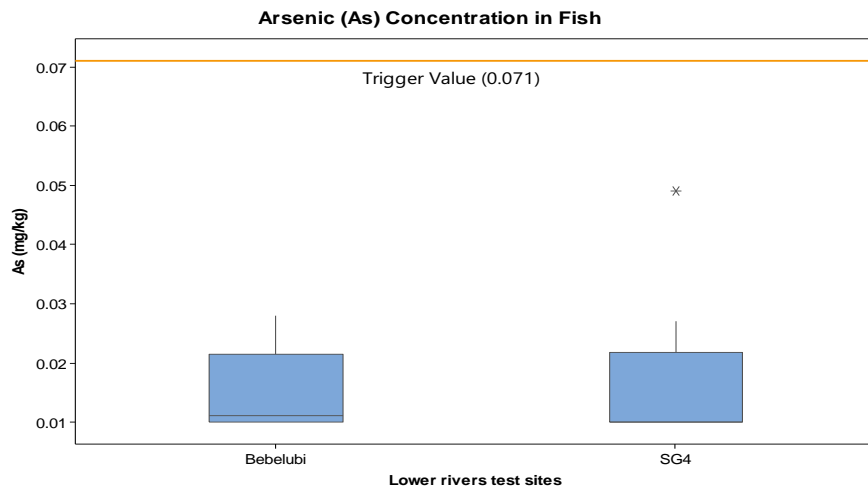


Figure F-19 Arsenic in fish flesh lower rivers test sites 2024

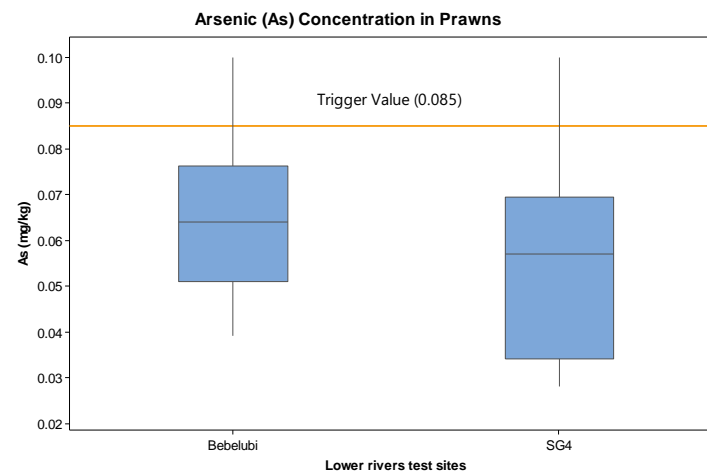


Figure F-20 Arsenic in prawn abdomen lower rivers test sites 2024

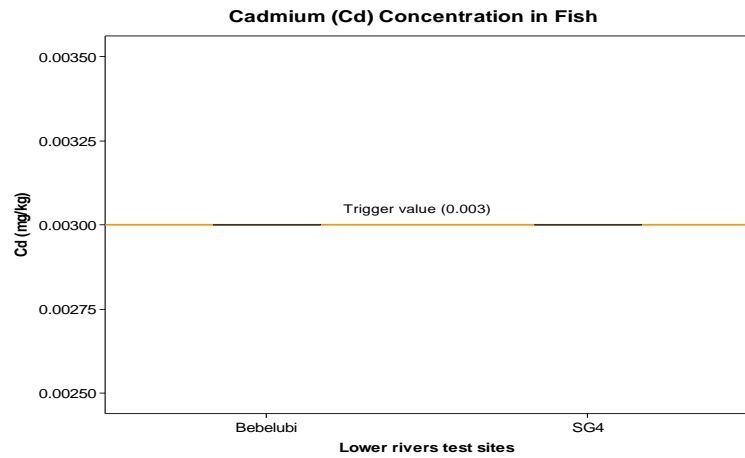


Figure F-21 Cadmium in fish flesh lower rivers test sites 2024

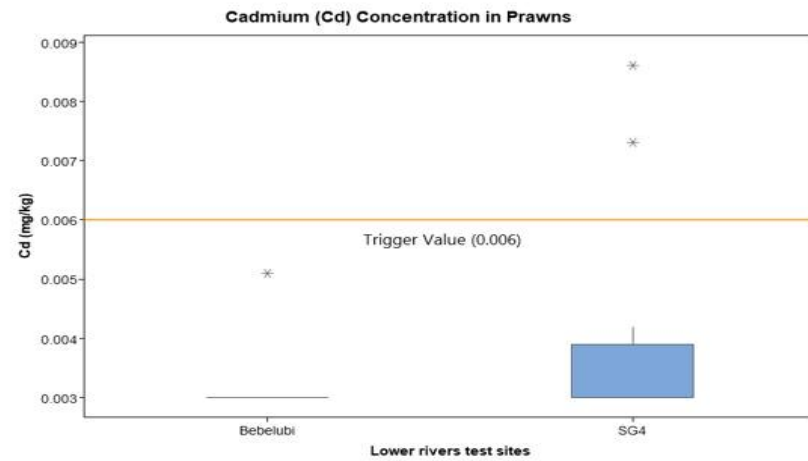


Figure F-22 Cadmium in prawn abdomen lower rivers test sites 2024

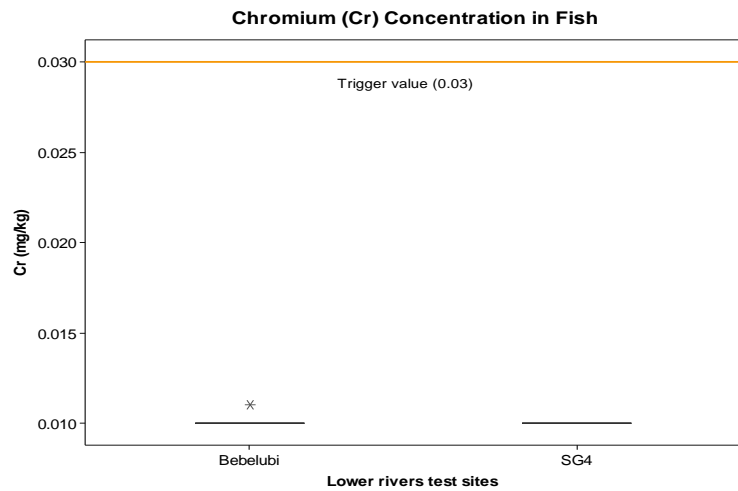


Figure F-23 Chromium in fish flesh lower rivers test sites 2024

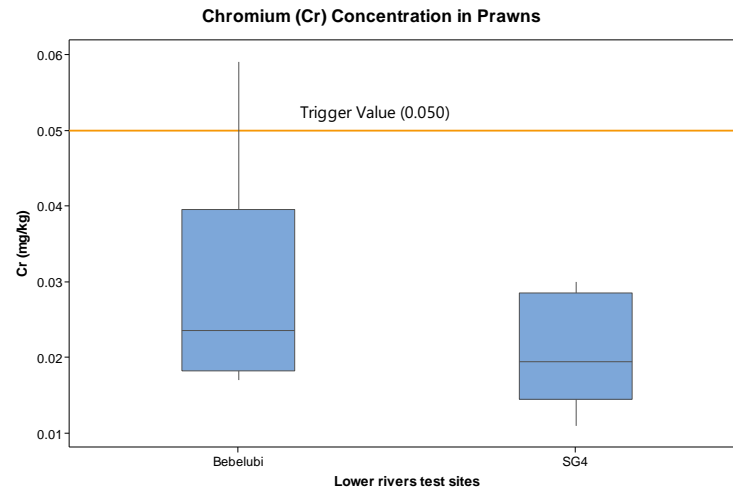


Figure F-24 Chromium in prawn abdomen lower rivers test sites 2024

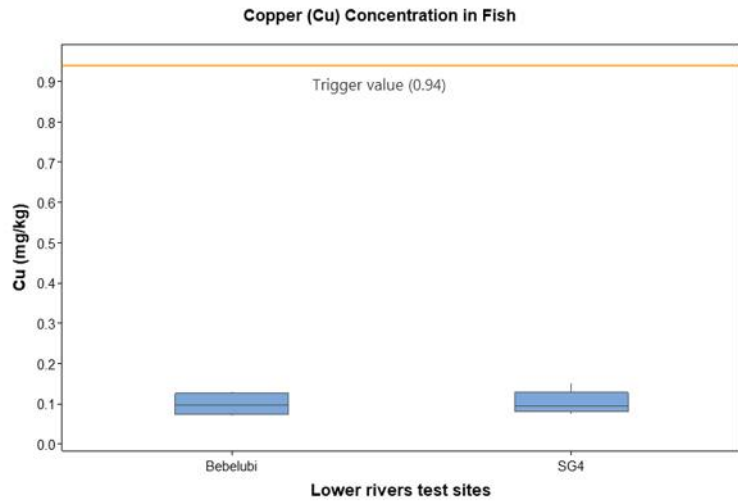


Figure F-25 Copper in fish flesh lower rivers test sites 2024

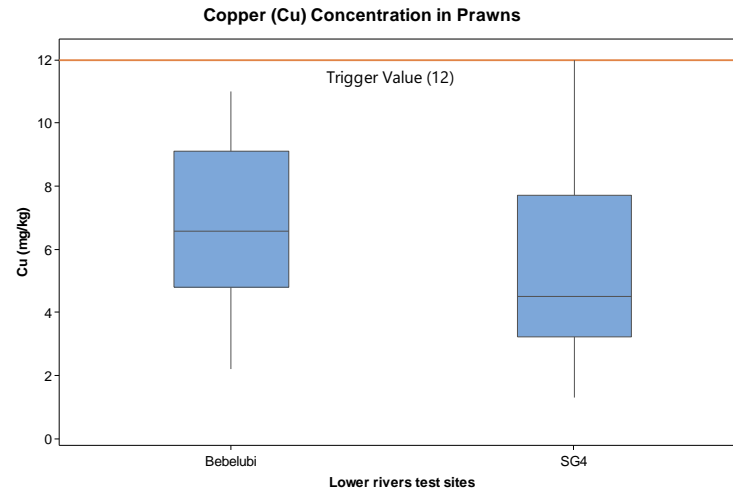


Figure F-26 Copper in prawn abdomen lower rivers test sites 2024

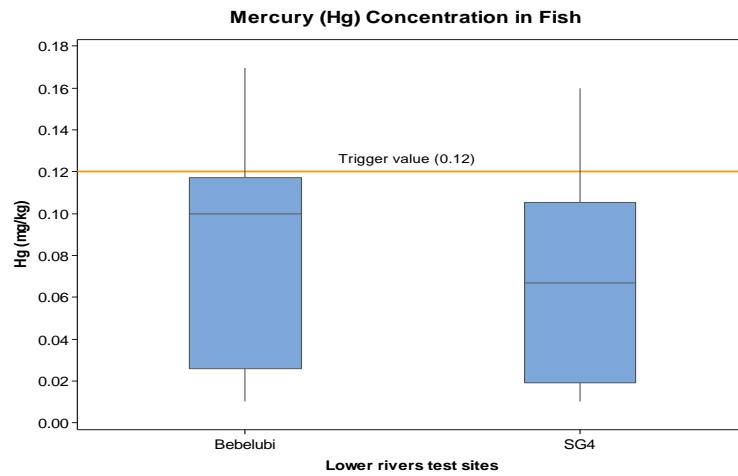


Figure F-27 Mercury in fish flesh lower rivers test sites 2024

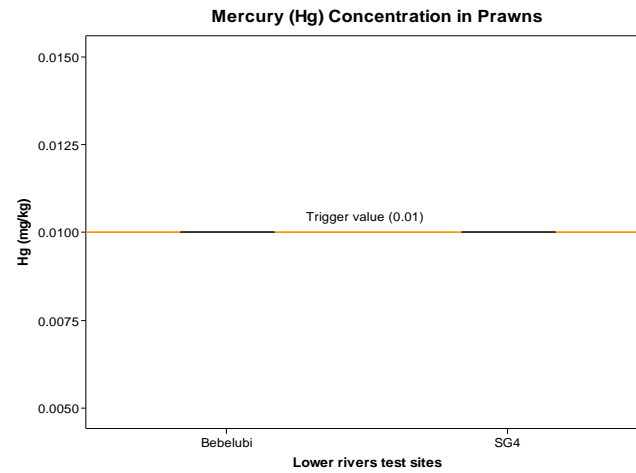


Figure F-28 Mercury in prawn abdomen lower rivers test sites 2024

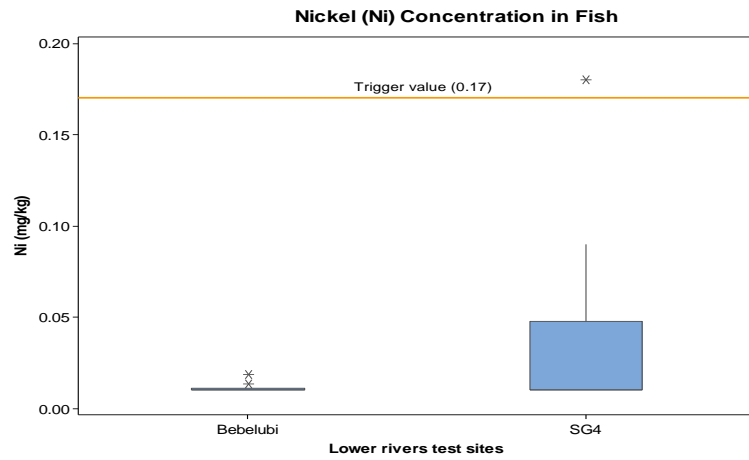


Figure F-29 Nickel in fish flesh lower rivers test sites 2024

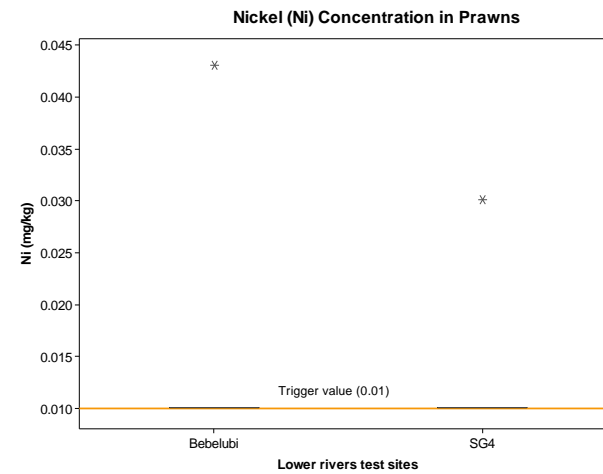


Figure F-30 Nickel in prawn abdomen lower rivers test sites 2024

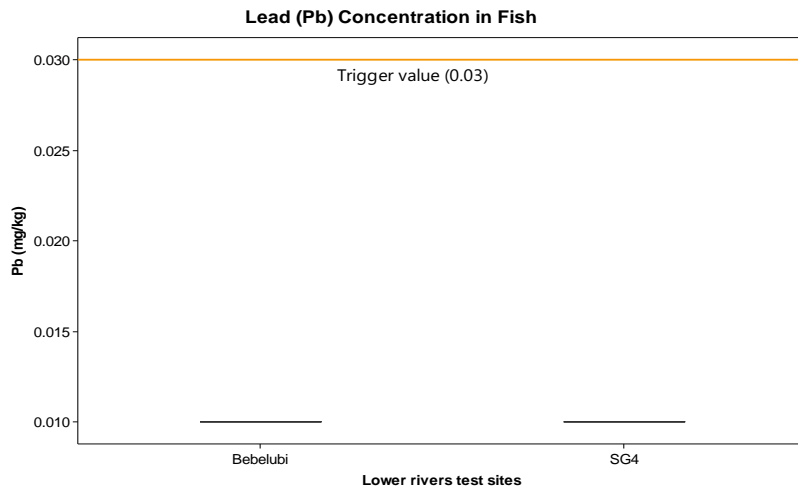


Figure F-31 Lead in fish flesh lower rivers test sites 2024

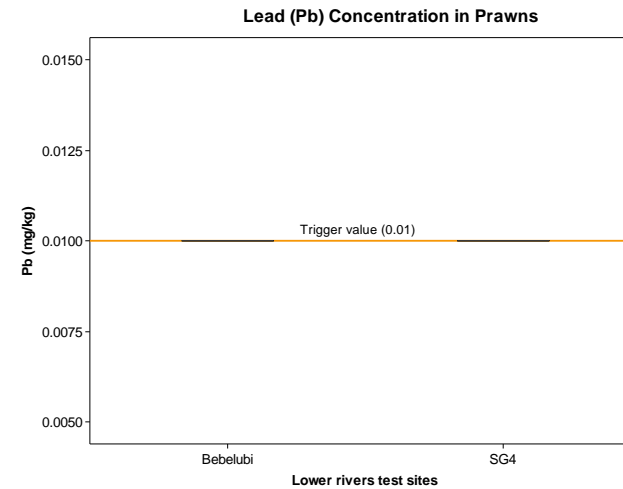


Figure F-32 Lead in prawn abdomen lower rivers test sites 2024

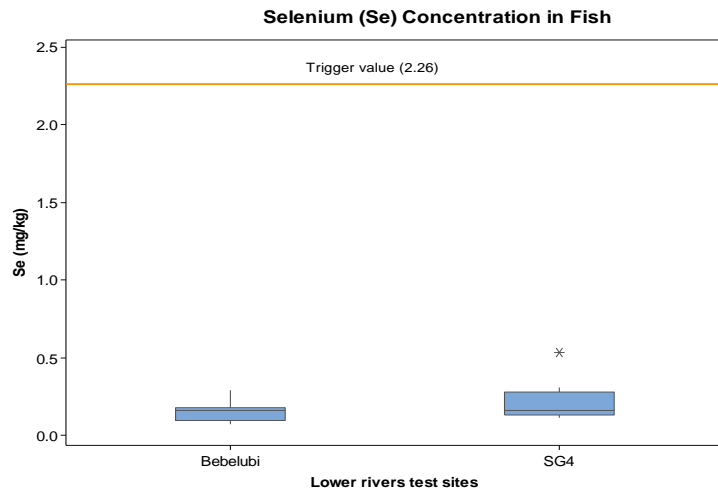


Figure F-33 Selenium in fish flesh lower rivers test sites 2024

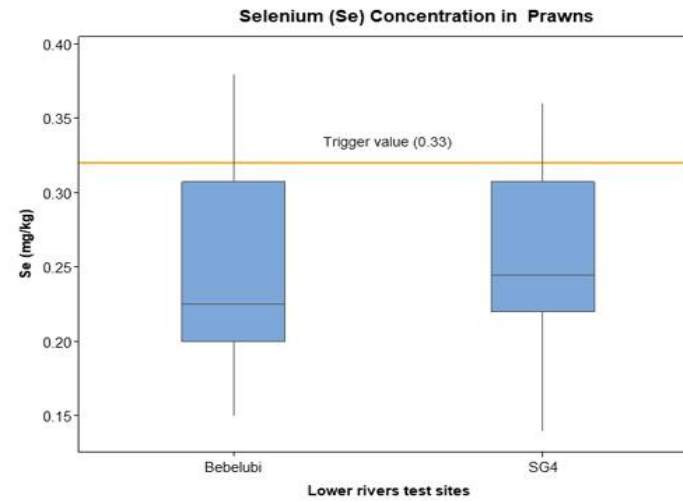


Figure F-34 Selenium in prawn abdomen lower rivers test sites 2024

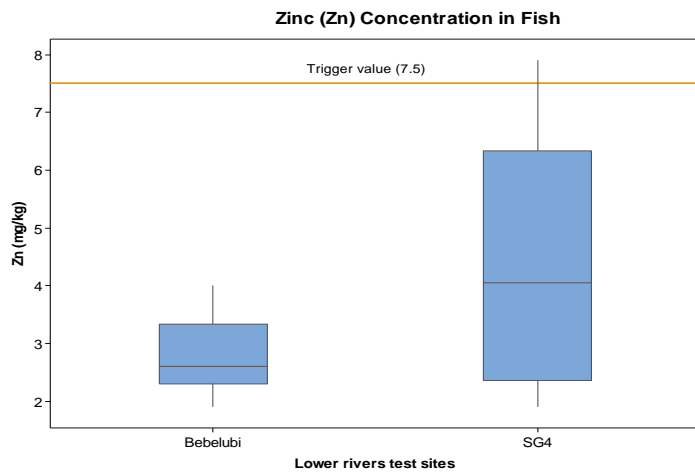


Figure F-35 Zinc in fish flesh at lower rivers test sites 2024

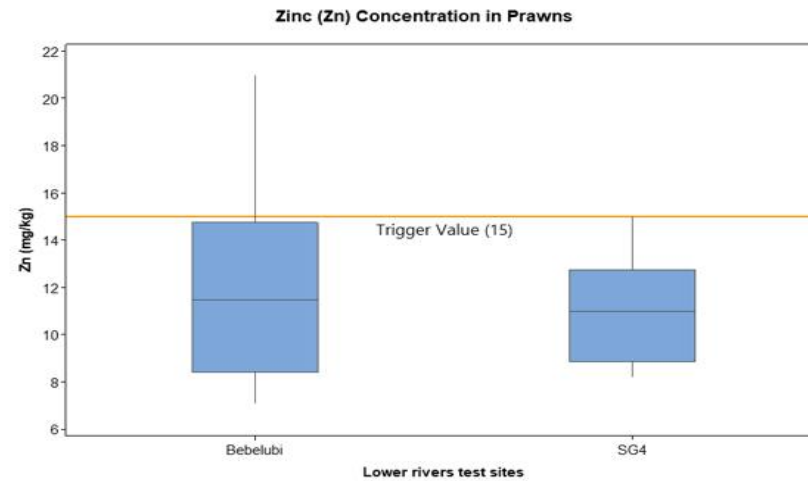


Figure F-36 Zinc in prawn abdomen lower rivers test sites 2024

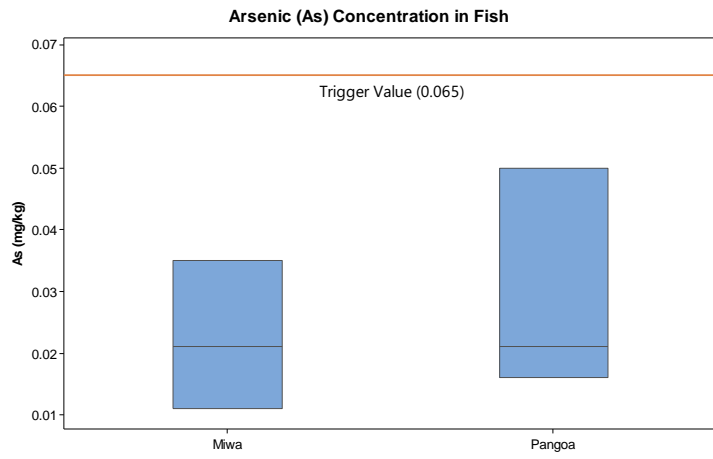


Figure F-37 Arsenic in fish flesh Lake Murray test sites 2024

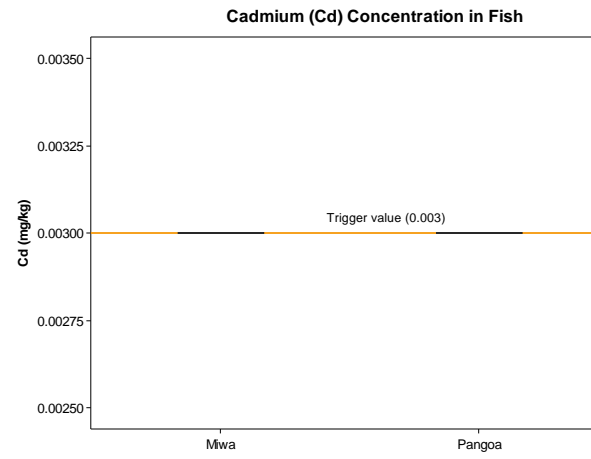


Figure F-38 Cadmium in fish flesh Lake Murray test sites 2024

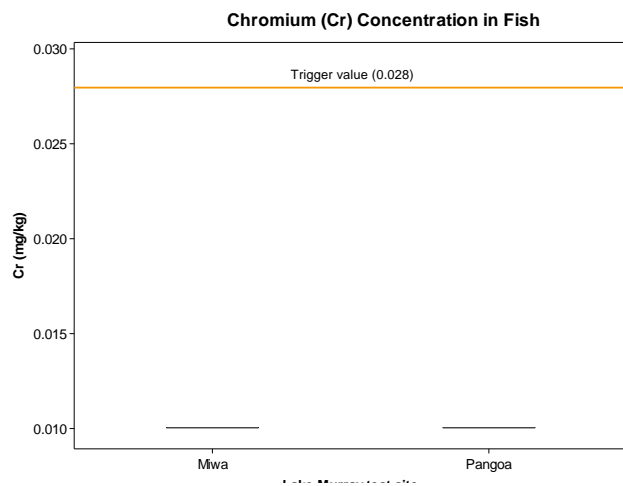


Figure F-39 Chromium in fish flesh Lake Murray test sites 2024

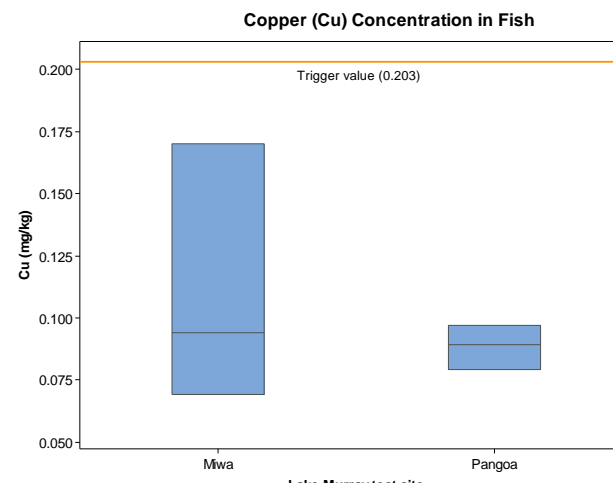


Figure F-40 Copper in fish flesh Lake Murray test sites 2024

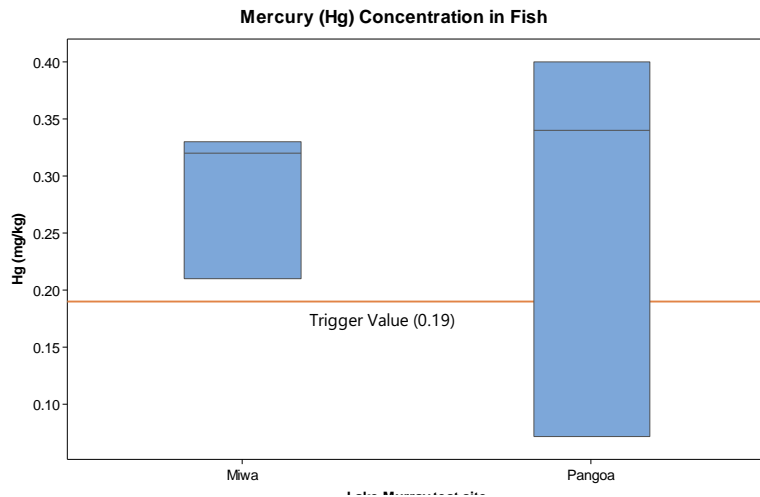


Figure F-41 Mercury in fish flesh Lake Murray test sites 2024

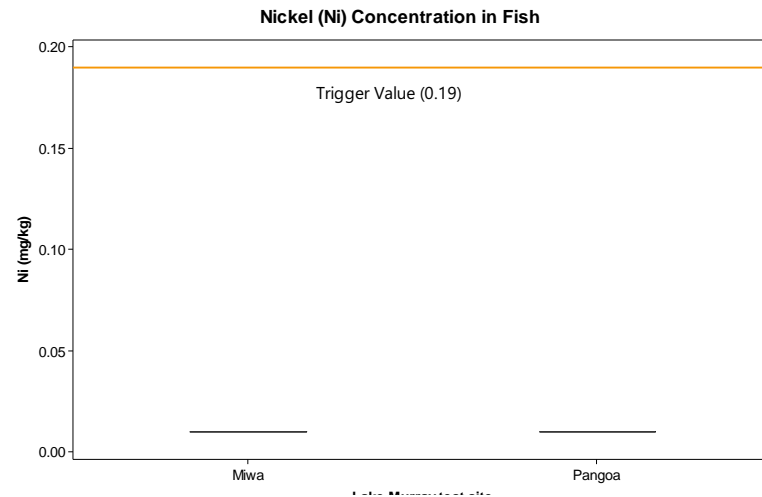


Figure F-42 Nickel in fish flesh Lake Murray test sites 2024

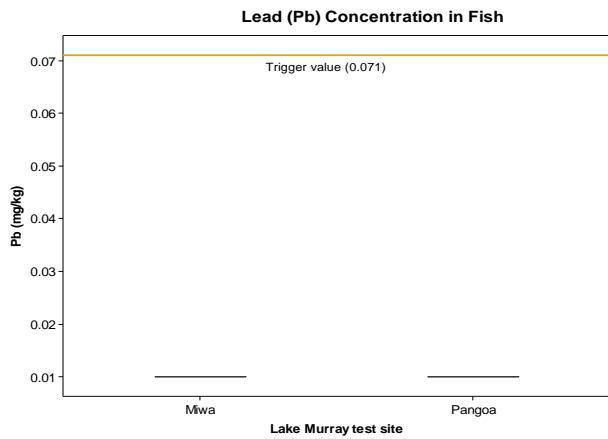


Figure F-43 Lead in fish flesh Lake Murray test sites 2024

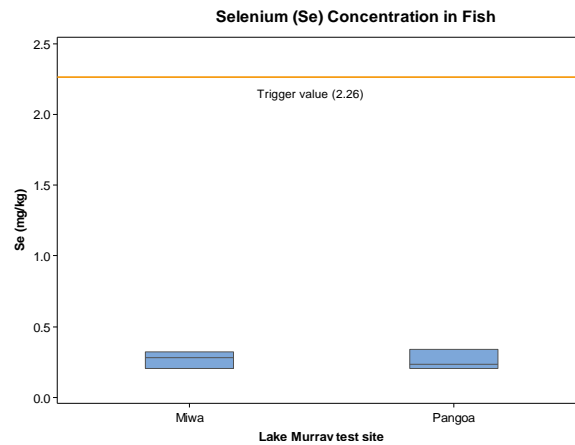


Figure F-44 Selenium in fish flesh Lake Murray test sites 2024

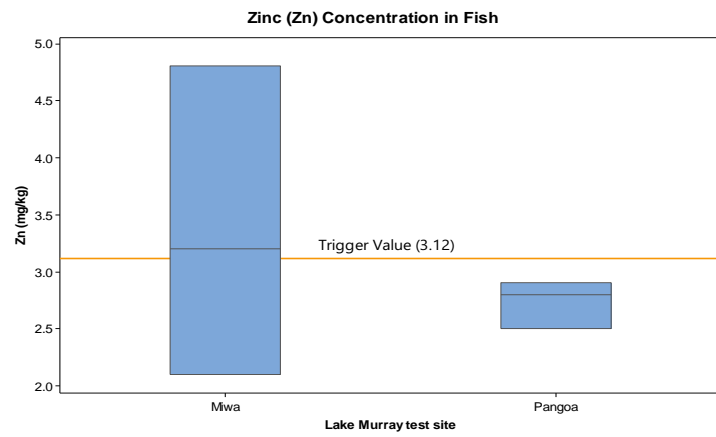


Figure F-45 Zinc in fish flesh Lake Murray test sites 2024

Table F-7 Performance assessment – Based on the trend of tissue metals in fish flesh at upper river test sites from 2015-2024 using Spearman Rank Test.

Fish Flesh Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend 2015 - 2024
Wasiba (Trend of Annual Median 2015 - 2024)	As	-0.216	0.015	Reduced over time
	Cd	-0.145	0.106	No change over time
	Cr	-0.042	0.645	No change over time
	Cu	0.082	0.363	No change over time
	Hg	-0.465	<0.001	Reduced over time
	Ni	0.048	0.592	No change over time
	Pb	0.009	0.922	No change over time
	Se	0.152	0.09	No change over time
	Zn	-0.17	0.059	No change over time
Wankipe (Trend of Annual Median 2015 - 2024)	As	-0.059	0.518	No change over time
	Cd	-0.166	0.067	No change over time
	Cr	-0.008	0.934	No change over time
	Cu	0.192	0.034	Increased over time
	Hg	-0.451	<0.001	Reduced over time
	Ni	0.008	0.93	No change over time
	Pb	0.047	0.609	No change over time
	Se	0.138	0.13	No change over time
	Zn	0.019	0.833	No change over time

Table F-8 Performance assessment – Based on the trend of tissue metals in prawn abdomen at upper river test sites from 2015-2024 using Spearman Rank Test.

Prawn Abdomen Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend 2015 - 2024
Wasiba (Trend of Annual Median 2015 - 2024)	As	-0.319	0.001	Reduced over time
	Cd	-0.7	<0.001	Reduced over time
	Cr	0.088	0.356	No change over time
	Cu	-0.334	<0.001	Reduced over time
	Hg	0.218	0.021	Increased over time
	Ni	-0.107	0.266	No change over time
	Pb	-0.205	0.031	Reduced over time
	Se	-0.135	0.157	No change over time
	Zn	-0.249	0.008	Reduced over time
Wankipe (Trend of Annual Median 2015 - 2024)	As	-0.433	<0.001	Reduced over time
	Cd	-0.552	<0.001	Reduced over time
	Cr	0.232	0.013	Increased over time
	Cu	-0.071	0.457	No change over time
	Hg	0.21	0.026	Increased over time
	Ni	-0.244	0.009	Reduced over time
	Pb	-0.041	0.668	No change over time
	Se	0.103	0.278	No change over time
	Zn	0.104	0.275	No change over time

Table F-9 Performance assessment – Based on the trend of tissue metals in fish flesh at lower river test sites from 2015-2024 using Spearman Rank Test.

Fish flesh Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend 2015 - 2024
Bebelubi (Trend of Annual Median 2015 - 2024)	As	0.313	0.008	Increased over time
	Cd	-0.157	0.194	No change over time
	Cr	0.119	0.328	No change over time
	Cu	0.084	0.488	No change over time
	Hg	-0.024	0.842	No change over time
	Ni	0.242	0.044	Increased over time
	Pb*	-	-	No change over time
	Se	-0.577	<0.001	Reduced over time
	Zn	-0.333	0.003	Reduced over time
SG4 (Trend of Annual Median 2015 - 2024)	As	-0.02	0.832	No change over time
	Cd	-0.04	0.664	No change over time
	Cr	-0.211	0.021	Reduced over time
	Cu	-0.085	0.358	No change over time
	Hg	-0.281	0.002	Reduced over time
	Ni	0.067	0.467	No change over time
	Pb	-0.04	0.664	No change over time
	Se	0.093	0.31	No change over time
	Zn	-0.199	0.029	Reduced over time

Table F-10 Performance assessment – Based on the trend of tissue metals in prawn abdomen at lower river test sites from 2015-2024 using Spearman Rank Test.

Prawn Abdomen Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend 2015 - 2024
Bebelubi (Trend of Annual Median 2015 - 2024)	As	-0.407	<0.001	Reduced over time
	Cd	-0.543	<0.001	Reduced over time
	Cr	0.249	0.013	Increased over time
	Cu	-0.044	0.667	No change over time
	Hg*	-	-	No change over time
	Ni	-0.194	0.055	No change over time
	Pb	0.118	0.244	No change over time
	Se	-0.224	0.026	Reduced over time
	Zn	-0.326	0.001	Reduced over time
SG4 (Trend of Annual Median 2015 - 2024)	As	-0.044	0.644	No change over time
	Cd	-0.499	<0.001	Reduced over time
	Cr	0.04	0.678	No change over time
	Cu	-0.005	0.955	No change over time
	Hg*	-	-	No change over time
	Ni	-0.278	0.003	Reduced over time
	Pb	-0.132	0.162	No change over time
	Se	0.162	0.087	No change over time
	Zn	-0.043	0.65	No change over time

Table F-11 Performance assessment – Based on the trend of tissue metals in fish flesh at Lake Murray test sites from 2015-2024 using Spearman Rank Test.

Fish Flesh Site	Parameter	Spearman's rho	p-Value (p=0.05)	Trend 2015 - 2024
Miwa (Trend of Annual Median 2015 - 2024)	As	0.063	0.793	No change over time
	Cd*	-	-	No change over time
	Cr	-0.191	0.419	No change over time
	Cu	0.359	0.12	No change over time
	Hg	-0.289	0.216	No change over time
	Ni	0.329	0.156	No change over time
	Pb	-0.205	0.386	No change over time
	Se	-0.487	0.03	Reduced over time
	Zn	0.329	0.157	No change over time
Pangoa (Trend of Annual Median 2015 - 2024)	As	0.562	0.019	Increased over time
	Cd*	-	-	No change over time
	Cr	0.001	0.997	No change over time
	Cu	0.222	0.391	No change over time
	Hg	-0.057	0.827	No change over time
	Ni	0.112	0.669	No change over time
	Pb*	-	-	No change over time
	Se	0.045	0.865	No change over time
	Zn	0.253	0.328	No change over time

* The trend indicated by Spearman's rho and p of these tests are artefacts of a change (either upwards or downwards) of the analytical limit of reporting throughout the historical record and are not representative of an actual positive or negative trend. Therefore the finding has been corrected to indicate no change over time, which is representative of actual conditions.