Tāmaki Makaurau / Auckland Marine Sediment Contaminant Monitoring: State Report for 2024

Manukau Harbour

Hamish Allen

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Close up of sediment surface showing crab burrows, Taihiki River, Manukau Harbour.
View across a monitoring site in the Taihiki River, Manukau Harbour. Photographs by J De Villiers and H Allen.

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Executive summary 2024

Contaminants such as copper, lead, zinc, arsenic, and mercury can accumulate in the sediments of our harbours, estuaries, and beaches. They originate from a range of different activities and land uses including vehicle tyre and brake wear, industrial discharges, use of agrichemicals, and the breakdown of some building materials. When it rains, these pollutants can wash into stormwater networks and waterways, ending up in the marine environment. The build-up of these contaminants can affect ecological health by reducing the abundance and/or diversity of animals living in the sediment. This results in degraded communities that are dominated by the remaining few species that are tolerant of higher contaminant levels, with flow-on effects for the natural functioning of these ecosystems. Understanding the distribution and level of chemical contaminants in marine sediments provides a useful marker of land use impacts on aquatic receiving environments and ecosystem health.

Auckland Council's Regional Sediment Contaminant Monitoring Programme (RSCMP) monitors chemical contaminant levels in marine sediments at approximately 80 sites across the region's harbours and estuaries. Monitoring follows a temporally nested design, with sites sampled on a rotational basis every three or six years. This report summarises the state of sediment metal contamination and changes over time in state at 14 Manukau Harbour sites sampled in 2024.

Total recoverable metals in the <500µm sediment fraction were analysed for copper, lead, zinc, arsenic (a metalloid), and mercury. One composite sample from each site was also analysed for particle size distribution to characterise sediment grain-size composition. Analysis of quality assurance results indicated that the metals and particle size distribution data collected in 2024 were largely within acceptance criteria and are considered suitable for use in the RSCMP.

Contaminant state is assessed against sediment quality guidelines that indicate potential impacts on marine sediment ecosystems. Sites are classified using a traffic light system: red (elevated concentration with likely ecological effects), amber (moderate concentration with possible effects), and green (low concentration with minimal or no effects).

Results from sampling undertaken in 2024 showed that overall, metal contamination levels in the Manukau Harbour were low. Only one site, Anns Creek, exceeded sediment quality guidelines for zinc, receiving an 'amber' grade; all other sites fell within the green category, indicating minimal impact on animals living on and within the sediment. Comparison with previous monitoring shows that contaminant state has remained stable across most sites, with notable improvements in the Māngere Inlet, where copper, lead, and zinc levels have improved from red or amber to predominantly green.

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1 Introduction

1.1 Overview

Tāmaki Makaurau is a largely marine region, surrounded by numerous sheltered bodies of water and stretches of exposed coastline. These coastal ecosystems play important ecological roles. They help to regulate climate, support rich biodiversity, and maintain essential ecosystem functions. The health of harbours and estuaries is closely linked to land use and human activities in surrounding catchments, which directly influence water quality, biodiversity, and ecological processes.

Chemical contaminants can accumulate in the sediments of estuarine and marine receiving environments. They may be introduced through natural processes, such as the weathering of rocks, and through a range of human-related sources, including industrial activity and the breakdown of certain building materials. They are then transported into the marine environment in numerous ways, including stream and riverine systems and wastewater and stormwater discharges.

The build-up of contaminants in marine sediments is of concern as it can adversely affect ecological health by reducing the abundance and/or diversity of sensitive sediment-dwelling species. At elevated concentrations, contaminants can have a wide range of impacts on organisms, including affecting feeding rates (Townsend et al., 2009), reducing reproductive ability (Mann et al., 2009) and altering population attributes (De Silva et al., 2021). These effects can disrupt local ecosystem functioning, as many of these species perform important roles such as cycling nutrients and stabilising sediments. Their decline can also affect broader food webs, as many serve as essential food sources for higher trophic level animals such as fish and birds.

Sediment contaminant monitoring, in conjunction with ecological and water quality monitoring, contributes information about land use impacts on the health of aquatic environments, and helps us understand the effectiveness of resource management initiatives and remediation efforts aimed at reducing adverse effects.

1.1.1 The Regional Sediment Contaminant Monitoring Programme

Auckland Council's Regional Sediment Contaminant Monitoring Programme (RSCMP) conducts regular monitoring across the region's harbours and estuaries.

The RSCMP aims to achieve the following objectives:

1. Provide assessment of the state of near shore marine sediment contamination using relevant guidelines where applicable.
2. Maintain regionally representative coverage, with an emphasis on areas undergoing change.

3. Provide data which allows the changes (trends) in sediment quality to be assessed over time.
4. Undertake studies to increase understanding and identify new and developing marine sediment contamination issues.

Monitoring began with 26 sites in 1998. Since then, the RSCMP has collected chemical contaminant data from over 120 harbour, estuary, and coastal sites across the region. Approximately 80 sites are monitored regularly with a selection of sites monitored per year. The total number of sites monitored in the RSCMP changes over time as new sites are added to provide more spatial coverage and some existing sites are removed from routine monitoring; for example, sites may be dropped if they become physically compromised by mangrove encroachment or poor access.

Information collected via the RSCMP complements that obtained in Auckland Council coastal and estuarine water quality (Kamke and Gadd, 2025) and benthic ecology (Drylie, 2025a and 2025b) monitoring programmes, which together aim to provide consistent, long-term information on the quality of Auckland's coastal environment.

In addition to data collected as part of the RSCMP, sediment contaminant sampling has also been carried out in conjunction with benthic ecology monitoring in a number of additional estuaries and harbours around the region as part of the 'Harbour Ecology' and 'East Coast Estuaries' monitoring programmes. Monitoring at these locations markedly increases the spatial coverage of our understanding of sediment contaminants across the region, particularly in more rural areas where sites in these programmes are typically located. These sites can provide important baseline information for future assessment, especially in estuaries where urban development is planned or underway within the catchment.

Monitoring data is available for a wide range of end users and stakeholders. Uses of the monitoring data include State of the Environment reporting, stormwater quality management, resource consenting, policy development and public education.

Previous data for sites outside the RSCMP can be found in:

- Hailes et al. (2010) and Allen (2021) for the Kaipara Harbour
- Townsend et al. (2010) and Allen (2023b) for the Whangateau Harbour
- Halliday and Cummings (2012) and Allen (2023b) for the Mahurangi Harbour
- Hewitt and Simpson (2012) for Waiwera, Pūhoi, Mangemangeroa, Waikōpua, Tūranga, and Ōrewa estuaries
- Allen (2023b) for Ōkura Estuary
- Lohrer et al. (2012) and Mills (2021) for the Wairoa embayment.

1.2 Sampling

The sampling protocols used in the RSCMP are outlined in detail in ARC (2004) and described briefly here. Sampling involves the collection of five replicate samples from a plot at each location (plot dimensions are typically 50m x 20m). Each replicate is made up of 10 sub-samples taken from two longitudinal lanes. The sampling depth is 0-2cm, providing a depth-integrated mixture of freshly deposited material and older sediment from slightly deeper in the profile. The sampling is designed to 'smooth out' spatial and short-term temporal variations in contaminant levels to facilitate trend detection. The multiple replicates taken from each site enables robust measures of annual 'average' concentrations to be calculated (medians are generally used for data analyses), as well as providing information on within-year data variability.

Sites are sampled either every three or six years on a rotational basis, with specific areas the focus of each sampling round. Sampling is usually conducted in October-November each year, to align with optimal timing for benthic ecology sampling which is conducted at the same time. Sampling benthic ecology in October-November avoids major recruitment periods for most species, and sampling at regular times within a year increases the ability to detect real change in community composition over time (Hewitt, 2000). The timing of the chemical contaminant sampling is not considered critical, because concentrations are not expected to vary greatly over relatively short time intervals (e.g., weeks-to-months).

At least 100g of freeze dried, <500µm sieved sediment is retained from each sediment sample for archiving. The purpose of the sample archive is to provide sufficient sediment in case future reanalysis is required. For example, sample archives may be used for checking trends or analysis of historical samples for contaminants that have not been routinely monitored.

1.3 Analytes

1.3.1 Metals

The contaminants routinely analysed in the RSCMP are currently limited to total recoverable metals – copper (Cu), lead (Pb), zinc (Zn), arsenic (As; a metalloid species), and mercury (Hg). Copper, lead, and zinc are commonly associated with urban activities, and can be present at elevated concentrations in urban stormwater. Copper and zinc concentrations have generally been predicted to increase in sediments receiving urban stormwater runoff, while lead is anticipated to decrease as its use has declined over time, particularly since the mid-1990s when it was removed from petrol. Arsenic and mercury are toxic contaminants sometimes present at elevated concentrations in Auckland marine sediments. Arsenic can come from natural soils, groundwater, and historical timber or agricultural uses, while mercury mainly originates from urban and industrial activities. Routine analysis of these contaminants was initiated in 2012 to improve our understanding of their concentrations, sources and trends. A recent report assessed state and preliminary trends for arsenic and mercury at over 120 sites across the region (see Allen, 2023c for more detail).

1.3.2 Organic contaminants

Organic contaminants such as polycyclic aromatic hydrocarbons (PAH), organochlorine pesticides (OCPs), and polychlorinated biphenyls (PCBs) have also been analysed at times in the RSCMP. These contaminants are scheduled to be analysed much less frequently than for metals and only at selected 'at risk' sites (see Mills, 2014a and 2014b). This is because ecosystem health is expected to be less sensitive to organic contaminants than metals at most sites (Mills, 2014b), and the analyses are much more expensive to reliably perform than for metals.

A sampling round of organic contaminants at selected sites within the RSCMP network was completed in 2024. Sites were selected based on a range of considerations, including providing spatial coverage across harbours, enabling comparison with previous sampling where available, and capturing areas of potential contamination associated with urban activities, development, or legacy sources. Four sites in the Manukau Harbour were sampled: Anns Creek, Māngere Cemetery, Karaka / Te Hihi Estuary, and Pāhurehure Papakura. These results will be reported separately from the routine metal analysis conducted annually as part of the RSCMP, which is the focus of this report.

1.3.3 Particle size distribution

Particle size distribution (PSD) is presented as percentage composition of gravel/shell hash (>2mm), coarse sand (500-2000µm), medium sand (250-500µm), fine sand (125-250µm), very fine sand (<63-125µm), silt (3.9-63.µm) and clay (<3.9µm).

PSD is determined using the wet sieving/pipette method (see Gatehouse, 1971). This method is also used in Auckland Council's benthic ecology monitoring programmes.

The PSD data are used in the RSCMP primarily to assess whether there have been changes in mud content (i.e., proportion of the sediment in the <63µm range; the sum of silt and clay) that may affect interpretation of the total metals results. Finer grained sediments (i.e., muddier) generally have higher metals' concentrations than coarser (i.e., sandy) material. This is due to several factors: low-energy, muddy zones tend to trap and accumulate contaminants attached to fine particles; the large surface area of numerous very small particles provides more sites for contaminants to adhere; and metals are strongly attracted to ionic exchange sites on the iron and manganese coatings commonly found on clay and silt particles (Ongley, 1996).Trends in metals and PSD (i.e., mud content) therefore need to be considered together to assess the possible contribution of changing sediment composition to trends in metals over time. See Allen (2025) for trends in mud content up to 2023.

1.4 Data and reporting

1.4.1 State report

A state report is produced for each RSCMP monitoring round (the purpose of this report). It includes a summary of the sampling and analyses undertaken (sites, dates, analytes), quality assurance (QA) assessments, an evaluation of current state and changes over time in state, and the monitoring data (metals and PSD) presented in tabular form.

1.4.2 State and trends report

Where sufficient temporal and spatial data have been collected to support more detailed analysis, data have been analysed to assess spatial distribution (state) and trends over time in contamination. State and trends in metals and PAH were reported by Mills et al. (2012), covering monitoring data collected between 1998 and 2010. Mills and Allen (2021) reported state and trends in metals (copper, lead, and zinc) and mud concentrations for the period 2004 to 2019, and Allen (2025) reported state in copper, lead, zinc, arsenic and mercury, and trends in metals (copper, lead and zinc) and mud concentrations for the period 2004 to 2023. Allen (2023c) assessed state and preliminary trends for arsenic and mercury from data collected between 2012 and 2021. Organic contaminants (OCPs, PCBs, and PAHs) and emerging organic contaminants[1] were reviewed in Mills (2014a).

1.4.3 Land, Air, Water Aotearoa (LAWA)

The Land, Air, Water Aotearoa (LAWA) data portal (www.lawa.org.nz) displays sediment contaminant information for sites in the Auckland region under the ‘Estuary Health’ topic. The portal also describes estuary and individual site characteristics, and broadly outlines contaminant impact in estuaries and monitoring methodology. Results can be viewed alongside a range of different sediment quality guidelines including the Auckland specific Environmental Response Criteria (ERC). Site results are updated annually, available for download, and can be viewed dating back to 2010 where data is available.

1.4.4 Programme operations

General programme operation including field practices, sample processing and QA and quality control (QC) procedures, are detailed in an internal ‘working’ protocol. Further details of the monitoring programme design and operation are given in a number of reports, including ARC (1999 and 2004), Kelly (2007), Lundquist et al. (2010), Mills and Williamson (2014), Townsend et al. (2015), Mills (2016a), and Mills and Allen (2021).

Several programme reviews have been conducted over the monitoring period of the RSCMP. Most recently, a review in 2022 focussed on site selection, sampling frequency and

[1] Emerging organic contaminants are a very broad range of chemicals that are not yet routinely monitored in the environment but have potential to cause adverse ecological and/or human health effects.

programme structure (Allen, 2022). This included a review of all sites in the RSCMP network, a region wide gap analysis with an emphasis on areas where no/limited monitoring takes place and where urban development is either planned or already underway, and an assessment of the current sampling frequency. As a result of the review several changes were enacted. These included establishing a temporally nested monitoring approach, extending sampling frequency, and annual sampling focussing on specific locations to allow more complete reporting of an area each year to take place (e.g., the focus in 2024 on the Manukau Harbour).

1.4.5 Quality control / quality assurance (QA/QC) reports

In addition to the QA/QC checks conducted for this report Hill Laboratories (Hamilton) performs its own quality control to ensure results meet in-house standards. The laboratory provides a QA/QC report for each batch of RSCMP data. The sample processing laboratory, Earth Sciences New Zealand (formerly NIWA, Hamilton), also assesses the data provided by the analytical laboratory, including their QA/QC results and the variability of the five replicates analysed at each site. These QA/QC reports are available upon request.

Laboratory quality control data – analysis of procedural blanks, Certified Reference Material (CRM; AGAL-12) and 'in-house' reference sediment from Hill Laboratories are available in PDF or excel format upon request.

1.4.6 Data

Once the quality of the analytical results has been verified by the QA protocol, they are imported into Auckland Council's electronic databases (KiECO and KiWQM). Raw data is available on request. Requests can be made via Auckland Council's environmental data portal.

2 Sampling conducted in 2024

2.1 Sites sampled

Sediments from a total of 14 sites were sampled for chemical contaminant analysis. All sampling was undertaken in the Manukau Harbour in the following general areas:

- Five sites in Pāhurehure Inlet
- Three sites in Māngere Inlet
- Two sites in Mauku / Taihiki River
- One site in Te Hihi Estuary
- One site in Puhinui Creek
- One site in Pukaki Creek
- One site in Little Muddy Creek.

Seven sites were sampled by Earth Sciences New Zealand and seven by Auckland Council. Samples were taken between the 7th and 15th November 2024.

The locations of the sites monitored in 2024 (and the remaining RSCMP sites not sampled) are shown in Figure 2-1.

A list of site names, coordinates, sampling dates, the sampling organisation, and analyses conducted are shown in Appendix A: Monitoring site details.

Note: The 14 sites sampled in the Manukau in 2024 represent a subset of the total 26 monitored sites in the harbour. A selection of sites are sampled every three years, while the full complement of sites are sampled every six years (2021 was the most recent 'full' monitoring round in the Manukau; see Allen 2023a for results). This staggered approach helps reduce overall monitoring effort while maintaining consistent long-term data at key locations. This approach also allows some flexibility, enabling sites with unusual or changing results to be shifted to more frequent monitoring, while maintaining a core set of sites for long-term analyses.

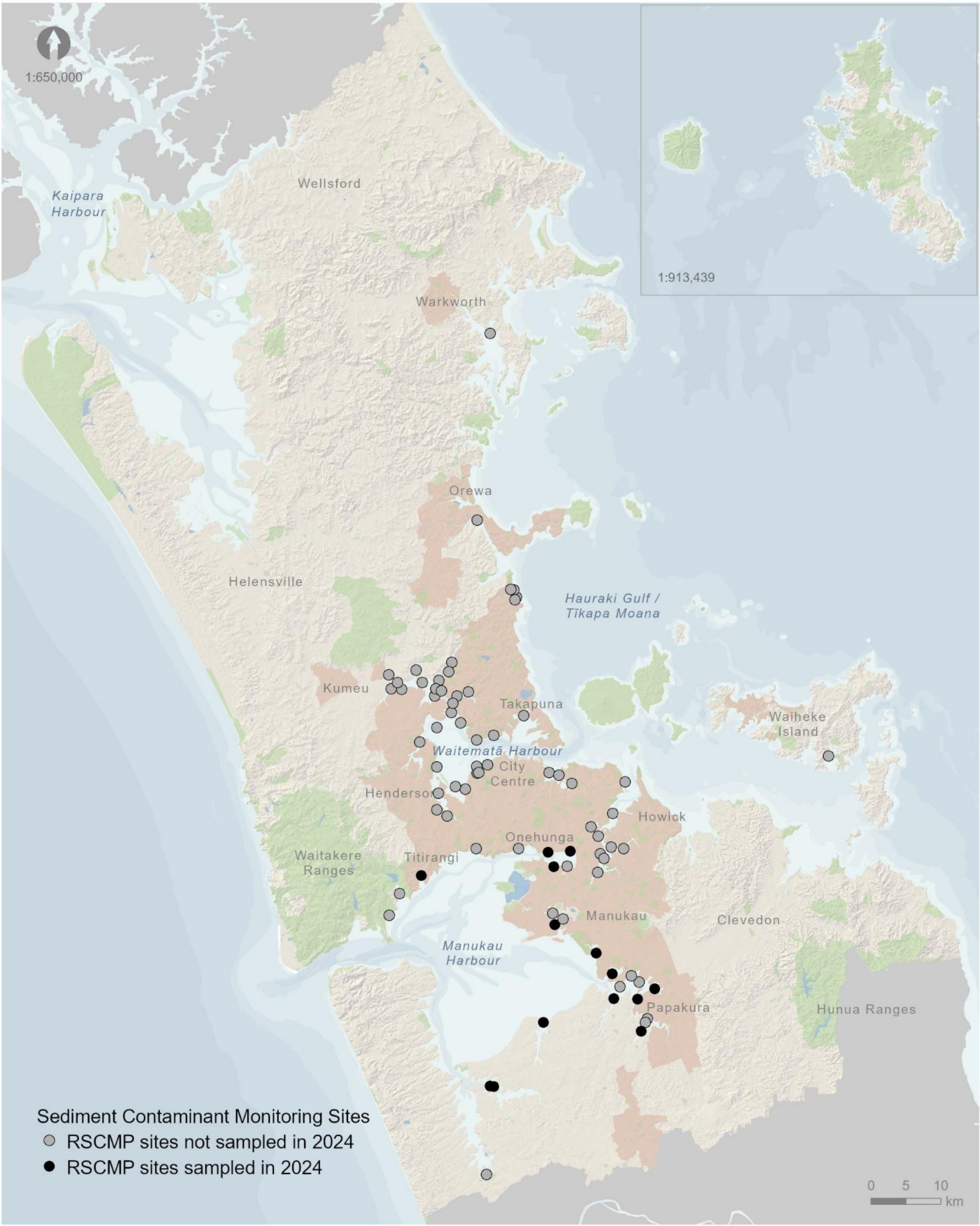

Figure 2-1. Location of the 14 sediment contaminant monitoring sites sampled in 2024, and the remaining sites not sampled.

2.2 Sediment chemistry samples

At each site, five replicate samples (each comprising 10 sub-samples) were collected for sediment chemistry analysis following ARC (2004) protocols. All replicates were homogenised, freeze-dried, and sieved to <500µm at Earth Sciences New Zealand (Hamilton). A sub-sample of each sieved and freeze-dried replicate was then sent to Hill Laboratories (Hamilton) for analysis of total recoverable metals: copper, lead, zinc, arsenic, and mercury. All replicate data is presented in Appendix B: Sediment contaminant data.

Approximately 100g of the remaining freeze-dried <500µm sieved sediment from each replicate was placed in glass jars and archived.

2.3 Particle size distribution samples

A composite sample from each site was used for particle size distribution (PSD) analysis. Each composite sample consisted of 10 sub-samples, each sub-sample being taken from the top 2cm immediately adjacent to a sediment chemistry sample, i.e., the PSD composite was therefore equivalent to a sediment chemistry replicate sample. The PSD samples were analysed by Earth Sciences New Zealand using wet sieving/pipette separation into seven size fractions, followed by oven drying each fraction until all moisture is removed and they have reached a stable weight (all PSD data is presented in Appendix C: Particle size distribution).

2.4 Concentration units for metals

Concentrations for metals are presented in milligrams per kilogram (mg/kg in the <500µm (<0.5mm) fraction). Sediment samples sent to Hill Laboratories for metal analysis were freeze-dried, and no correction for residual moisture was applied. According to Earth Sciences New Zealand (G. Olsen, pers. comm., May 2014), freeze-dried sediments typically retain <2% moisture, and usually <1% for sandy samples. Their analyses have found that the weighing errors for moisture correction are often higher than the mass difference measured between the wet and dry weights. As such, no moisture correction was applied to the 2024 sample data.

2.5 Quality Assurance

For a detailed description and results of the quality assurance (QA) process see Appendix D: Quality assurance analysis.

A robust QA process is conducted to ensure that the data are ‘fit for purpose’ and suitable for use in the RSCMP. Analysis of Certified Reference Material and Bulk Reference Sediments showed that 2024 monitoring data for total recoverable metals and PSD were similar in quality to those obtained in previous years and overall, the metals and mud content data are considered acceptable for use in the RSCMP.

3 Contaminant state at sites sampled in 2024

3.1 State assessment

The contaminant state is a measure of the likelihood of adverse ecological effects occurring, specifically relating to benthic organisms residing in the sediment.

Contaminant concentrations are compared with sediment quality guidelines (SQGs), using the Auckland Council Environmental Response Criteria (ERC; ARC, 2004) for copper, lead and zinc, the Australian and New Zealand Guidelines for fresh and marine water quality (ANZG, 2018) for arsenic, and the Threshold Effects Level / Probable Effects Level (TEL/PEL; MacDonald et al., 1996) for mercury. Specific values used in the SQGs are shown in Table 3-1 and described further below.

3.1.1 Australian and New Zealand Guidelines for fresh and marine water quality (ANZG)

The ANZG values relevant to the monitoring conducted in 2024 are summarised in Table 3-1. Details of the origins of these values, and their relationship to other SQGs is provided in ANZG (2018). The ANZG provides default guideline values (DGV), which indicate the concentrations below which there is a low risk of ecological effects occurring, and in contrast, 'upper' guideline values (GV-high), which indicate concentrations where you might expect to observe adverse toxicity-related effects.

3.1.2 Environmental Response Criteria (ERC)

The ERC are considered conservative thresholds, developed and refined specifically for the Auckland region (ARC, 2004). The ERC are the guidelines predominantly used in assessment of sediment contaminant levels in the RSCMP for copper, lead and zinc. The rationale for selecting lower contaminant thresholds (when compared with the ANZG) is to provide an early warning of environmental degradation, allowing time for further investigations to take place and/or management responses to be properly assessed and implemented before more serious degradation can occur. The ERC values relevant to the monitoring conducted in 2024 are summarised in Table 3-1.

A summary of the meaning of the ERC are as follows (ARC, 2004):

- ERC Green conditions reflect a low level of impact.
- ERC Amber sites have slightly elevated concentrations where adverse effects on benthic ecology may be starting to appear.
- ERC Red sites are higher impact sites where levels are elevated, and impact and degradation are likely to be occurring.

3.1.3 Threshold Effects Level (TEL)/ Probable Effects Level (PEL)

The TEL/PEL were established by McDonald et al. (1996). The TEL is a sediment contamination concentration at which a toxic response has started to be observed in benthic organisms and is intended to estimate the concentration of a chemical below which adverse effects only rarely occur. Conversely, the PEL is intended to provide an estimate of the concentration above which adverse effects frequently occur to a large percentage of the benthic population. The TEL/PEL serve as more conservative guidelines, in line with the ERC. These have been applied to the metal mercury, for which no ERC guidelines exist. The TEL/PEL value for monitoring conducted in 2024 are summarised in Table 3-1.

Table 3-1. Environmental Response Criteria (ERC), Threshold Effects Level /Probable Effects Level (TEL/PEL) and Australian and New Zealand Guidelines (ANZG) for metals. DGV = default guideline value, GV-high = guideline value high.

	ERC (mg/kg)			ANZG (mg/kg)			TEL/PEL (mg/kg)		
Metals	Green	Amber	Red	DGV		GV-high	TEL		PEL
Copper	<19	19 - 34	>34	<65	65 - 270	>270	Not applicable		
Lead	<30	30 - 50	>50	<50	50 - 220	>220	Not applicable		
Zinc	<124	124 - 150	>150	<200	200 - 410	>410	Not applicable		
Arsenic	No ERC values			<20	20 - 70	>70	Not applicable		
Mercury	No ERC values			<0.15	0.15 - 1	>1	<0.13	0.13 - 0.7	>0.7

The ANZG DGV for copper (65 mg/kg) and zinc (200 mg/kg) are higher than the ERC-red values (34 and 150 mg/kg respectively), while for lead the ANZG DGV (50 mg/kg) is the same as the ERC-red threshold. The ANZG DGVs are all higher than the ERC green-amber threshold values for copper, lead and zinc, and the TEL thresholds for mercury. Fewer sites will therefore trigger the ANZG guideline thresholds for adverse ecological effects than the ERC or TEL/PEL.

A note on arsenic: The application of more conservative guidelines (such as the TEL/PEL) for the metalloid arsenic are not deemed suitable for Auckland, as guideline values can sit below what is found to occur naturally or as ‘background’ concentrations in the region. As such, arsenic is compared with ANZG guidelines only. See Allen (2023c) for more detail on the interpretation of arsenic concentrations under different sediment quality guidelines.

3.2 State of sites sampled in 2024

3.2.1 Overall summary

The contaminant state of sites sampled in 2024 was assessed from median concentrations (from five replicates) of total recoverable metals in the <500µm fraction.

Levels of contamination from the analysed metals are generally low in the Manukau Harbour. Only one site (Anns Creek in the Māngere Inlet) exceeded the ERC sediment quality guidelines for zinc, resulting in an 'amber' grade. Metal concentrations at all other sites fall within the green category, indicating a low level of impact on benthic fauna.

Figure 3-1 shows the most recent contaminant state for all sites sampled in the RSCMP. Figure 3-2 and Table 3-2 show the contaminant concentration (the median from five replicates) at all sites sampled in 2024. The associated state is based on suitable sediment quality guidelines for each metal (i.e., the ERC for copper, lead, and zinc, the TEL/PEL for mercury, and the ANZG for arsenic).

The ERC state history (for copper, lead and zinc) of sites sampled in 2024 is shown in Table 3-3. Where applicable, the metal determining the highest ERC category is indicated. Table 3-4 shows state history for metals copper lead and zinc for sites in the Māngere Inlet. For completeness, this table includes state history for site Harania which was not sampled in 2024. Changes in state refer to changes in ERC sediment quality guideline grades (i.e., green, amber, red categories) only. For a more detailed analysis of changes in concentrations over time (i.e., trends), see Allen, 2025.

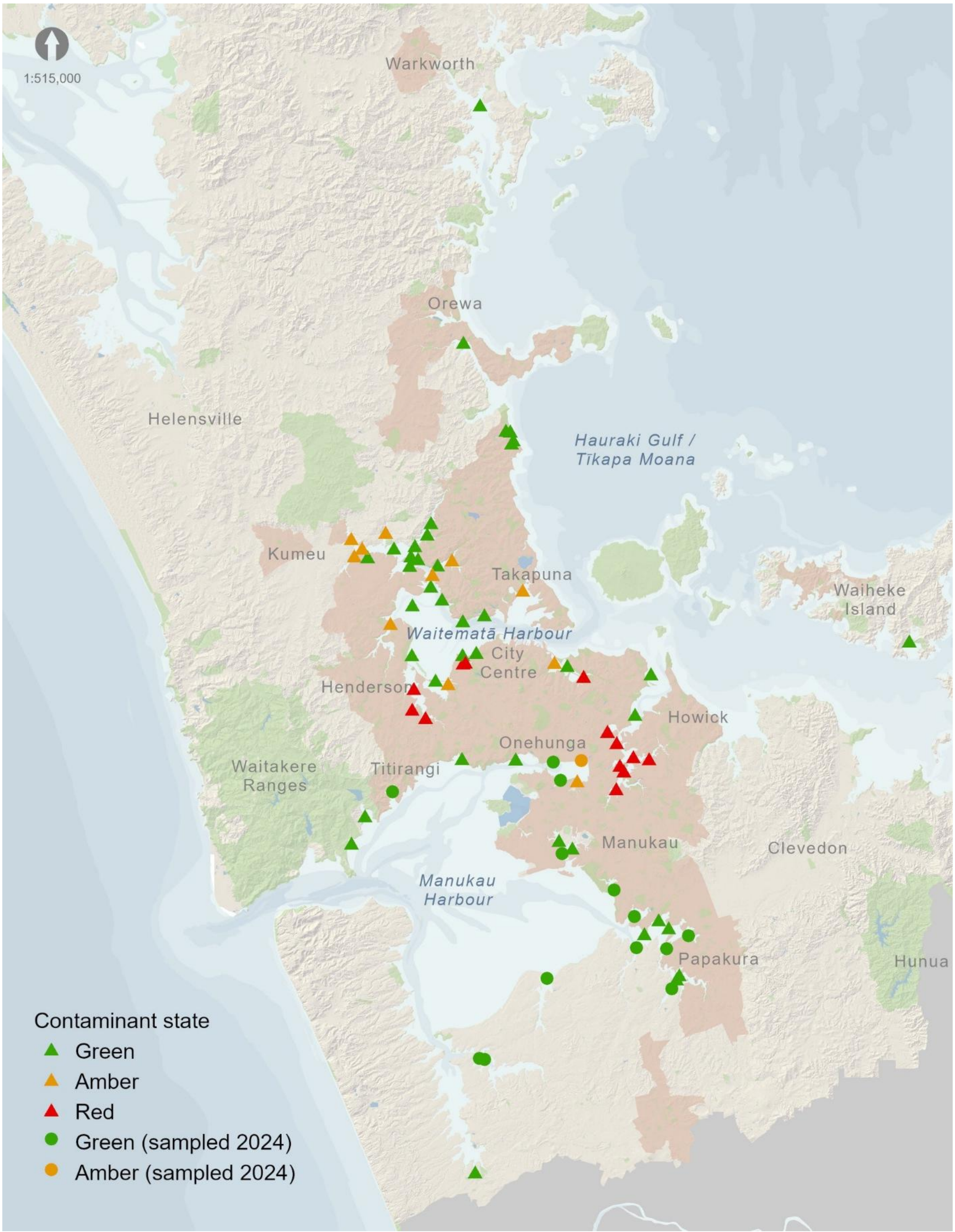

Figure 3-1. Contaminant state for metals copper, lead, zinc, arsenic and mercury at all sites sampled in the Regional Sediment Contaminant Monitoring Programme. Sites sampled in 2024 are shown with a circle (●), sites sampled in previous years are shown with a triangle (▲).

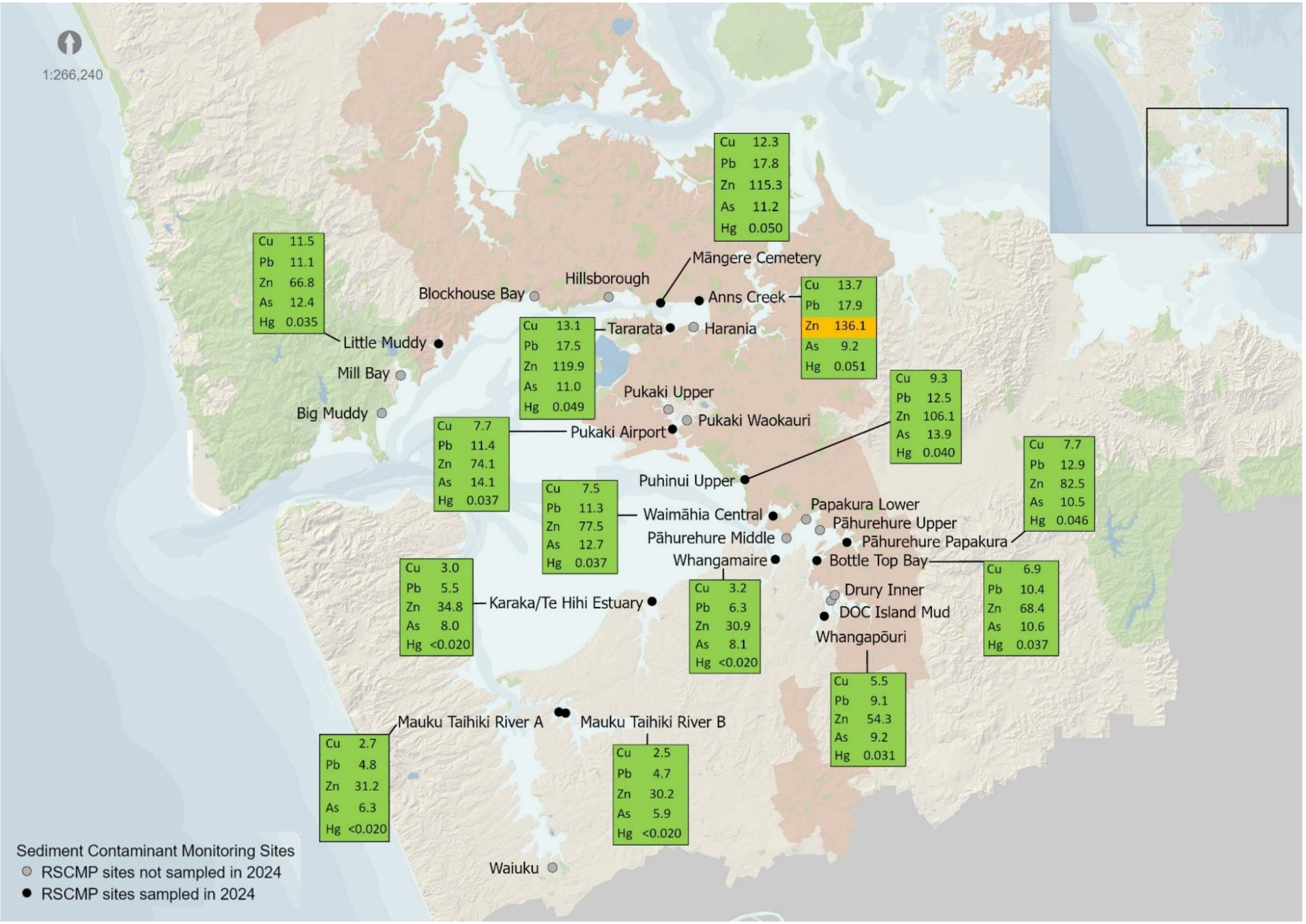

Figure 3-2. Sampling sites and metal concentrations (mg/kg, <500 μm fraction) measured in 2024 as part of the Regional Sediment Contaminant Monitoring Programme. Metals are copper (Cu), lead (Pb), zinc (Zn), arsenic (As), and mercury (Hg). The colour band represents the green, amber, or red category based on sediment quality guidelines (the ERC for Cu, Pb, and Zn, the TEL/PEL for Hg, and the ANZG for As). Concentrations are medians of five replicates. Inset map shows regional location.

Table 3-2. Contaminant state for total recoverable metals at Regional Sediment Contaminant Monitoring Programme sites sampled in 2024. Sediment quality guidelines used to denote potential ecological impact are the ERC for copper (Cu), lead (Pb), and zinc (Zn), the ANZG for arsenic (As), and the TEL/PEL for mercury (Hg). Concentrations are medians of five replicates.

Site	Location	Mud Content % <63 µm	Total Recoverable metals, mg/kg <500 µm				
			ERC			ANZG	TEL
			Cu	Pb	Zn	As	Hg
Anns Creek	Māngere Inlet	92.9	13.7	17.9	136.1	9.2	0.051
Māngere Cemetery	Māngere Inlet	91.7	12.3	17.8	115.3	11.2	0.050
Tararata	Māngere Inlet	87.4	13.1	17.5	119.9	11.0	0.049
Mauku/Taihiki River A	Taihiki River	39.1	2.7	4.8	31.2	6.3	<0.020
Mauku/Taihiki River B	Taihiki River	21.4	2.5	4.7	30.2	5.9	<0.020
Little Muddy	Northern Coast	30.8	11.5	11.1	66.8	12.4	0.035
Bottle Top Bay	Pāhurehure Inlet	89.5	6.9	10.4	68.4	10.6	0.037
Pāhurehure Papakura	Pāhurehure Inlet	69.7	7.7	12.9	82.5	10.5	0.046
Waimāhia Central	Pāhurehure Inlet	87.5	7.5	11.3	77.5	12.7	0.037
Whangamaire	Pāhurehure Inlet	38.7	3.2	6.3	30.9	8.1	<0.020
Whangapōuri	Pāhurehure Inlet	38.2	5.5	9.1	54.3	9.2	0.031
Puhinui Upper	Puhinui Creek	91.6	9.3	12.5	106.1	13.9	0.040
Pukaki Airport	Pukaki Creek	88.9	7.7	11.4	74.1	14.1	0.037
Karaka/ Te Hihi Estuary	Te Hihi Estuary	31.1	3.0	5.5	34.8	8.0	<0.020

Table 3-3. History of Environmental Response Criteria (ERC) state for the metals copper (Cu), lead (Pb), and zinc (Zn) at sites sampled in 2024.

Site	Location	Year																										
		2024	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Anns Creek	Māngere Inlet	Zn			Zn			Zn		Zn			Zn		Zn		Cu Zn		Cu Zn		Zn		Cu Zn		Cu Zn		Cu Zn	Cu Zn
Māngere Cemetery	Māngere Inlet														Cu Zn				Cu Zn		Cu Zn		Cu Pb Zn		Cu Zn		Cu Pb Zn	Cu Pb Zn
Tararata	Māngere Inlet								Zn							Zn					Cu Zn							
Mauku/Taihiki River A	Taihiki River																											
Mauku/Taihiki River B	Taihiki River																											
Little Muddy	Northern Coast																											
Bottle Top Bay	Pāhurehure Inlet																											
Pāhurehure Papakura	Pāhurehure Inlet																											
Waimāhia Central	Pāhurehure Inlet						Zn																					
Whangamaire	Pāhurehure Inlet																											
Whangapōuri	Pāhurehure Inlet																											
Puhinui Upper	Puhinui Creek																											
Pukaki Airport	Pukaki Creek																											
Karaka/ Te Hihi Estuary	Te Hihi Estuary																											

Table 3-4. History of Environmental Response Criteria (ERC) state for sites in the Māngere Inlet. Each set of dots (● ● ●) represents sediment metal state for a given year – copper (left), lead (middle), and zinc (right). Note that site Harania is included here for completeness but was not sampled in 2024.

Site	Location	Year																										
		2024	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Anns Creek	Māngere Inlet	🟢🟢🟡			🟢🟢🟡			🟢🟢🔴		🟢🟢🟡			🟢🟢🟡		🟡🟢🔴		🟡🟢🟡		🟡🟢🟡		🟡🟡🔴		🔴🟡🔴		🔴🟡🔴		🔴🟡🔴	🔴🟡🔴
Māngere Cemetery	Māngere Inlet	🟢🟢🟢			🟢🟢🟢			🟢🟢🟢		🟢🟢🟢			🟢🟢🟢		🟡🟢🟡		🟡🟢🟢		🟡🟢🟡		🟡🟢🟡		🟡🟡🟡		🔴🟡🔴		🟡🟡🟡	🟡🟡🟡
Tararata	Māngere Inlet	🟢🟢🟢			🟢🟢🟢		🟢🟢🟢		🟢🟢🟡		🟢🟢🟢					🟢🟢🟡					🟡🟢🟡							
Harania	Māngere Inlet				🟢🟢🟡		🟢🟢🟡		🟢🟢🟡		🟢🟢🟡					🟢🟢🟡					🟡🟢🟢							

3.3 Discussion

The Manukau Harbour is a large, relatively shallow estuary on the west coast of Tāmaki Makaurau, encompassing a range of coastal habitats, including intertidal sand and mud flats, fringing mangroves, and seagrass meadows. These habitats support a diverse array of plants and animals, and the harbour provides significant cultural, recreational, and environmental values for the region (Auckland Council, 2021).

In 2024, sediment samples were collected from 14 Manukau Harbour sites to assess concentrations of metal contaminants: copper, lead, zinc, arsenic, and mercury. Results indicated generally low levels of metal contamination, with all but one site falling within the 'green' sediment quality guideline range, suggesting a low likelihood of adverse impacts on benthic ecology at most sites.

Aside from arsenic, contaminant levels were generally higher in the Māngere Inlet (a shallow tidal arm in the upper northeast reaches of the harbour) compared to other sites. This reflects both the influence of human activities in the surrounding highly urbanised catchment and the Inlet's physical characteristics – a low energy, muddy environment that limits dispersal and facilitates contaminant retention.

The sole exceedance of sediment quality guidelines occurred at Anns Creek, where moderately elevated **zinc** levels placed this Māngere Inlet site in the amber category. As has been noted previously (see Mills and Allen, 2021 and Allen, 2025), zinc is the metal most regularly exceeding red level sediment quality guidelines across the region. This is typically in catchments with intensive industrial and urban areas, particularly where there is a long history of this type of land use.

Copper levels were mostly very low, with only a handful of sites exceeding 10 mg/kg (the ERC amber threshold is 19 mg/kg). This is encouraging, considering the numerous potential sources of contamination from urban runoff, including brake linings, building materials, and industrial areas.

As with copper, **lead** levels were relatively low at most sites. The sites in Māngere Inlet, however, were close to exceeding the 19 mg/kg ERC amber threshold (values at the three sites sampled were ~18 mg/kg). Levels of lead are now largely historic (e.g., the removal of lead from petrol in the mid 1990's) and there is a general improving trend in concentration levels at sites in the RSCMP. This is expected to continue and highlights both good progress, and the slow recovery of contaminated sediment.

Mercury levels were consistently low across the Manukau sites sampled in 2024. Four sites were below the lab detection limit (<0.02 mg/kg), and no sites were close to triggering the conservative TEL/PEL level of 0.13 mg/kg (the highest value recorded was 0.051 mg/kg at Anns Creek). Although mercury levels in other parts of the Manukau harbour have not shown high levels previously, it is the metal most commonly exceeding moderate (amber) grades in the wider Auckland region (see Allen, 2025) and is often elevated in conjunction with other metals.

Arsenic concentrations were also below guideline thresholds (ANZG amber threshold: 20 mg/kg), ranging from 5.6 mg/kg at Mauku / Taihiki River B, to 15.0 mg/kg at Puhinui Upper. The average across all sites was 10.2 mg/kg, in line with what would be expected to occur naturally (regional reference concentrations are estimated to be ~12 mg/kg). These results indicate that arsenic is not currently a concern at any of the sampled sites.

When compared to the Waitematā Harbour, the Manukau shows considerably lower levels of metal concentrations. This is presumably due to the much lower percentage of urban land use in its surrounding catchment (just ~20% land cover) and the high volume of tidal flushing, which helps remove and dilute contaminants with each cycle.

In general, ERC contaminant state (i.e., whether a site is categorised as red, amber or green) for metals copper, lead, and zinc has remained relatively stable over time at most sites sampled in 2024 (see Table 3-3). The exception is in the Māngere Inlet, where all four monitored sites (including Harania, which was not sampled in 2024) have shown improvements over time, shifting from red and/or amber categories to mostly green (see Table 3-4). Although not presented in this annual report, recent state and trend reporting (Allen, 2025) indicates that these improvements have occurred gradually over time rather than abruptly. The exact cause or causes of these ongoing decreases is not certain, but may be due to improved industrial site, stormwater, and waste management in the surrounding heavily urbanised catchment.

While current contaminant levels at most sites in the Manukau are relatively low, ongoing monitoring remains important. Several areas adjacent to the harbour are either zoned for future, or are undergoing, urban development. This has the potential to increase contaminant loads if not carefully and proactively managed. Additionally, a predicted increase in climate-related extreme weather events may increase erosion, potentially releasing older buried contaminants, or mobilise pollutants previously contained on land, transporting them into the marine environment. For these reasons, maintaining broad spatial monitoring will allow tracking of any changes in contaminant distribution over time and help assess both the effects of newly developed areas and the effectiveness of management actions aimed at reducing contaminant levels.

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5 Appendix A: Monitoring site details

Regional Sediment Contaminant Monitoring Programme sites sampled in Manukau Harbour, 2024. Table shows site name and location, site coordinates in New Zealand Transverse Mercator (NZTM 2000), sampling date, sampling organisation and analyses conducted.

Site name	Location	NZTM X	NZTM Y	Sampling Date	Sampled by	<500 µm fraction	Benthic Ecology	Particle Size
						Total Cu Pb Zn As Hg		
Anns Creek	Māngere Inlet	1762280	5911361	14/11/2024	NIWA	✓	✓	✓
Māngere Cemetery	Māngere Inlet	1759928	5911221	14/11/2024	NIWA	✓	✓	✓
Tararata	Māngere Inlet	1760526	5909707	14/11/2024	NIWA	✓	✓	✓
Mauku/Taihiki River A	Taihiki River	1753754	5886376	8/11/2024	AC	✓	✓	✓
Mauku/Taihiki River B	Taihiki River	1754164	5886311	8/11/2024	AC	✓	✓	✓
Little Muddy	Northern Coast	1746459	5908737	12/11/2024	AC	✓	✓	✓
Bottle Top Bay	Pāhurehure Inlet	1769435	5895583	15/11/2024	NIWA	✓	✓	✓
Pāhurehure Papakura	Pāhurehure Inlet	1771260	5896689	7/11/2024	AC	✓	✓	✓
Waimāhia Central	Pāhurehure Inlet	1766761	5898287	15/11/2024	NIWA	✓	✓	✓
Whangamaire	Pāhurehure Inlet	1766906	5895649	15/11/2024	NIWA	✓	✓	✓
Whangapōuri	Pāhurehure Inlet	1769867	5892204	15/11/2024	NIWA	✓	✓	✓
Puhinui Upper	Puhinui Creek	1765048	5900492	11/11/2024	AC	✓	✓	✓
Pukaki Airport	Pukaki Creek	1760665	5903547	11/11/2024	AC	✓	✓	✓
Karaka/ Te Hihi Estuary	Te Hihi Estuary	1759424	5893094	8/11/2024	AC	✓	✓	✓

6 Appendix B: Sediment contaminant data

Metals' data for 2024 monitoring. Concentrations are in mg/kg freeze-dry weight (<500µm fraction). QA sample data are included for Certified Reference Material (CRMB = AGAL-12) and Bulk Reference Sediments (MeOZ FD = Meola; Mid FD = Middlemore).

			Total Recoverable metals, mg/kg <500 µm				
Site name	**Location**	**Replicate**	**Cu**	**Pb**	**Zn**	**As**	**Hg**
Anns Creek	Māngere Inlet	1	13.7	18.0	136.1	9.3	0.051
Anns Creek	Māngere Inlet	2	14.0	17.9	137.9	9.2	0.048
Anns Creek	Māngere Inlet	3	13.9	18.0	137.8	9.7	0.046
Anns Creek	Māngere Inlet	4	12.9	17.2	132.1	8.5	0.051
Anns Creek	Māngere Inlet	5	13.2	16.7	133.2	8.9	0.059
Māngere Cemetery	Māngere Inlet	1	12.3	17.8	115.3	11.2	0.062
Māngere Cemetery	Māngere Inlet	2	13.5	18.8	125.6	12.1	0.050
Māngere Cemetery	Māngere Inlet	3	13.5	19.7	126.7	12.4	0.053
Māngere Cemetery	Māngere Inlet	4	12.1	17.5	112.2	11.1	0.049
Māngere Cemetery	Māngere Inlet	5	11.7	16.3	109.5	10.5	0.050
Tararata	Māngere Inlet	1	13.4	17.4	118.8	11.0	0.045
Tararata	Māngere Inlet	2	13.1	17.4	119.9	10.7	0.049
Tararata	Māngere Inlet	3	12.6	18.0	115.9	10.7	0.049
Tararata	Māngere Inlet	4	13.2	17.5	121.8	11.2	0.047
Tararata	Māngere Inlet	5	13.1	17.5	120.5	11.1	0.049
Mauku/Taihiki River A	Taihiki River	1	2.6	4.8	30.5	6.3	<0.02
Mauku/Taihiki River A	Taihiki River	2	2.7	4.8	32.3	6.3	<0.02
Mauku/Taihiki River A	Taihiki River	3	2.8	4.9	32.4	6.4	<0.02
Mauku/Taihiki River A	Taihiki River	4	2.7	4.8	31.1	6.1	<0.02
Mauku/Taihiki River A	Taihiki River	5	2.7	5.0	31.2	6.3	<0.02
Mauku/Taihiki River B	Taihiki River	1	2.6	4.7	30.2	6.4	<0.02
Mauku/Taihiki River B	Taihiki River	2	2.3	4.5	28.2	5.8	<0.02
Mauku/Taihiki River B	Taihiki River	3	2.7	5.1	30.9	6.6	<0.02
Mauku/Taihiki River B	Taihiki River	4	2.3	4.4	27.2	5.6	<0.02
Mauku/Taihiki River B	Taihiki River	5	2.5	5.0	30.4	5.9	<0.02
Little Muddy	Northern Coast	1	11.2	10.9	65.8	11.7	0.035
Little Muddy	Northern Coast	2	11.9	11.2	69.8	12.4	0.031
Little Muddy	Northern Coast	3	11.2	10.8	65.4	12.5	0.037
Little Muddy	Northern Coast	4	12.0	11.1	68.8	12.4	0.032
Little Muddy	Northern Coast	5	11.5	11.1	66.8	12.4	0.036
Bottle Top Bay	Pāhurehure Inlet	1	7.1	10.5	70.0	10.6	0.037
Bottle Top Bay	Pāhurehure Inlet	2	6.9	10.4	68.4	10.8	0.041
Bottle Top Bay	Pāhurehure Inlet	3	6.9	10.4	67.7	10.3	0.040
Bottle Top Bay	Pāhurehure Inlet	4	6.9	10.4	68.7	10.3	0.037
Bottle Top Bay	Pāhurehure Inlet	5	6.9	10.5	67.5	10.6	0.036
Pāhurehure Papakura	Pāhurehure Inlet	1	7.5	12.9	80.9	10.5	0.045
Pāhurehure Papakura	Pāhurehure Inlet	2	7.7	13.1	82.7	10.8	0.046
Pāhurehure Papakura	Pāhurehure Inlet	3	7.7	13.2	82.5	10.7	0.046
Pāhurehure Papakura	Pāhurehure Inlet	4	7.8	12.8	81.1	10.4	0.050
Pāhurehure Papakura	Pāhurehure Inlet	5	7.8	12.7	84.8	10.4	0.047
Waimāhia Central	Pāhurehure Inlet	1	7.5	11.3	77.5	12.4	0.037
Waimāhia Central	Pāhurehure Inlet	2	7.6	11.6	78.6	12.7	0.040
Waimāhia Central	Pāhurehure Inlet	3	7.8	11.6	79.4	13.1	0.032
Waimāhia Central	Pāhurehure Inlet	4	7.4	11.1	77.0	12.7	0.037
Waimāhia Central	Pāhurehure Inlet	5	7.2	11.1	76.9	12.4	0.037
Whangamaire	Pāhurehure Inlet	1	3.1	6.0	29.4	7.7	<0.02
Whangamaire	Pāhurehure Inlet	2	3.4	6.4	31.7	8.2	<0.02
Whangamaire	Pāhurehure Inlet	3	3.2	6.4	30.9	8.1	<0.02
Whangamaire	Pāhurehure Inlet	4	2.9	5.8	28.6	7.4	<0.02
Whangamaire	Pāhurehure Inlet	5	3.3	6.3	31.8	8.1	<0.02

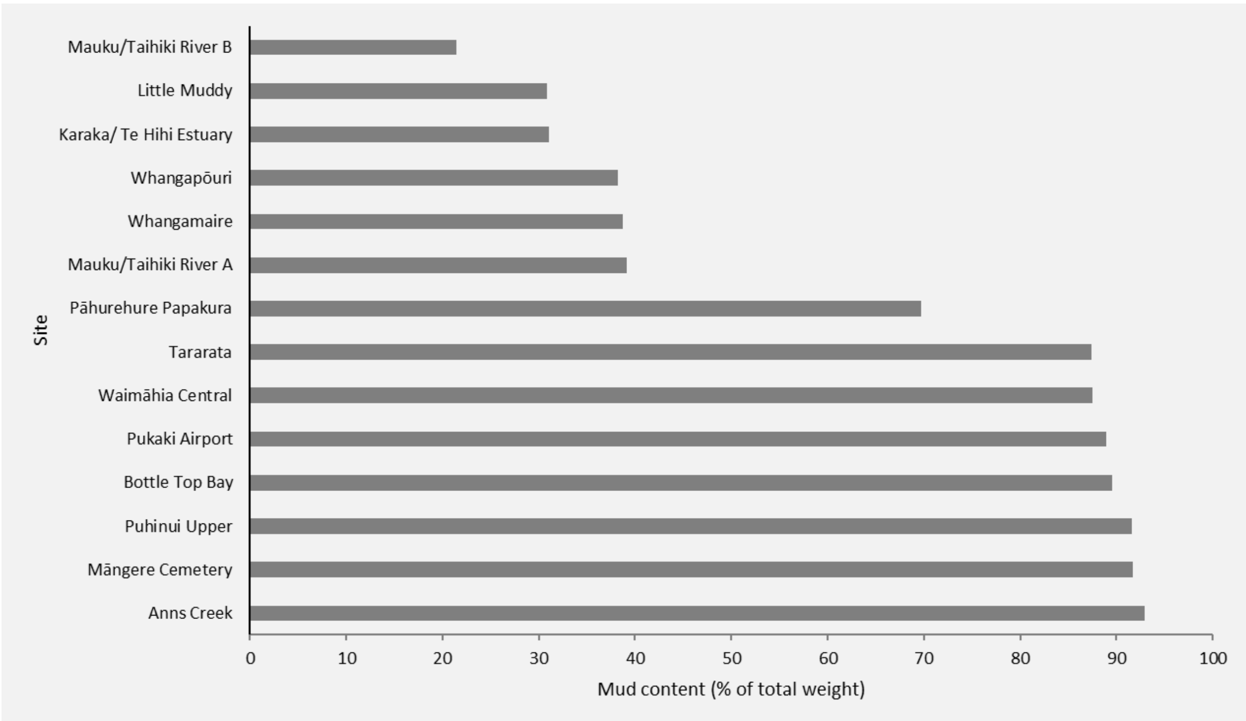
Metals' data for 2024 monitoring cont.

Site name	Location	Replicate	Total Recoverable metals, mg/kg <500 µm				
			Cu	Pb	Zn	As	Hg
Whangapōuri	Pāhurehure Inlet	1	5.5	9.5	55.3	9.2	0.031
Whangapōuri	Pāhurehure Inlet	2	5.5	9.1	54.3	9.0	0.034
Whangapōuri	Pāhurehure Inlet	3	5.7	9.2	57.0	9.2	0.031
Whangapōuri	Pāhurehure Inlet	4	4.5	8.0	47.6	7.8	0.032
Whangapōuri	Pāhurehure Inlet	5	5.4	8.8	53.9	9.3	0.029
Puhinui Upper	Puhinui Creek	1	9.6	12.8	108.0	15.0	0.039
Puhinui Upper	Puhinui Creek	2	9.3	13.1	106.7	14.8	0.041
Puhinui Upper	Puhinui Creek	3	9.4	12.5	106.1	13.7	0.042
Puhinui Upper	Puhinui Creek	4	9.2	12.5	104.7	13.9	0.034
Puhinui Upper	Puhinui Creek	5	8.9	12.5	104.7	13.9	0.040
Pukaki Airport	Pukaki Creek	1	7.5	11.1	72.0	13.4	0.034
Pukaki Airport	Pukaki Creek	2	7.6	11.0	71.0	13.9	0.034
Pukaki Airport	Pukaki Creek	3	7.9	11.4	74.6	14.1	0.037
Pukaki Airport	Pukaki Creek	4	8.3	12.0	77.8	14.5	0.037
Pukaki Airport	Pukaki Creek	5	7.7	11.4	74.1	14.1	0.037
Karaka/Te Hihi Estuary	Te Hihi Estuary	1	2.9	5.2	33.9	7.7	<0.02
Karaka/Te Hihi Estuary	Te Hihi Estuary	2	3.0	5.3	34.4	7.7	<0.02
Karaka/Te Hihi Estuary	Te Hihi Estuary	3	3.3	5.7	36.6	8.1	<0.02
Karaka/Te Hihi Estuary	Te Hihi Estuary	4	3.0	5.5	34.8	8.0	<0.02
Karaka/Te Hihi Estuary	Te Hihi Estuary	5	3.3	5.6	36.2	8.7	<0.02
MeOZ FD	Bulk Reference Sediment	1	3.1	9.4	43.2	2.9	0.031
MeOZ FD	Bulk Reference Sediment	2	3.0	9.8	42.2	2.8	0.029
MeOZ FD	Bulk Reference Sediment	3	2.8	9.7	40.0	2.6	0.028
MeOZ FD	Bulk Reference Sediment	4	2.9	9.1	42.4	2.9	0.028
MeOZ FD	Bulk Reference Sediment	5	3.1	9.8	43.7	2.8	0.033
MID FD	Bulk Reference Sediment	1	30.0	35.0	237.0	8.6	0.178
MID FD	Bulk Reference Sediment	2	28.5	34.2	231.4	8.4	0.171
MID FD	Bulk Reference Sediment	3	27.5	32.5	222.8	8.1	0.163
MID FD	Bulk Reference Sediment	4	29.3	34.8	242.9	8.6	0.177
MID FD	Bulk Reference Sediment	5	29.3	33.7	234.6	8.6	0.166
CRMB	Certified Reference Material	1	142.7	30.3	171.0	3.1	0.440
CRMB	Certified Reference Material	2	140.9	29.0	169.2	3.1	0.452
CRMB	Certified Reference Material	3	150.0	33.1	180.4	3.6	0.466
CRMB	Certified Reference Material	4	160.9	34.7	192.0	3.9	0.483
CRMB	Certified Reference Material	5	151.4	30.4	179.6	3.4	0.477

7 Appendix C: Particle size distribution data

Sediment particle size distribution (PSD) data obtained from a single composite surface (<2cm) sample per site in 2024. Samples were analysed by Earth Sciences New Zealand (formerly NIWA; Hamilton) by wet sieving/pipette analysis. The data are per cent of the total sediment (by weight) in each fraction.

Site name	Location	Organic Content	Gravel >2mm	Coarse Sand 500-2000um	Medium Sand 250-500um	Fine Sand 62.5-250um	Very Fine Sand 63-124um	Total Sand	Silt 3.9-62.5um	Clay 0-3.9um	Mud (Silt + Clay)
Anns Creek	Māngere Inlet	3.9	0.0	0.1	0.1	1.2	5.7	7.1	73.9	19.0	92.9
Māngere Cemetery	Māngere Inlet	5.0	0.0	0.0	0.3	2.7	5.3	8.3	67.4	24.3	91.7
Tararata	Māngere Inlet	4.9	0.0	0.2	0.4	6.4	5.6	12.6	69.9	17.5	87.4
Mauku/Taihiki River A	Taihiki River	2.1	0.3	1.2	1.5	36.6	21.2	60.5	34.7	4.4	39.1
Mauku/Taihiki River B	Taihiki River	1.7	0.4	0.5	1.3	62.9	13.4	78.2	15.5	5.9	21.4
Little Muddy	Northern Coast	3.5	1.7	9.6	11.0	24.5	22.3	67.5	21.4	9.4	30.8
Bottle Top Bay	Pāhurehure Inlet	4.4	0.0	0.0	0.3	2.1	8.1	10.5	70.9	18.6	89.5
Pāhurehure Papakura	Pāhurehure Inlet	4.7	0.0	1.4	1.7	12.1	15.1	30.3	51.8	17.9	69.7
Waimāhia Central	Pāhurehure Inlet	4.6	0.0	0.1	0.7	3.0	8.7	12.5	64.9	22.6	87.5
Whangamaire	Pāhurehure Inlet	2.1	0.1	2.8	3.1	40.9	14.4	61.2	31.9	6.8	38.7
Whangapōuri	Pāhurehure Inlet	2.7	0.1	0.8	2.9	46.2	11.7	61.7	25.8	12.4	38.2
Puhinui Upper	Puhinui Creek	5.8	0.0	0.2	0.2	1.7	6.3	8.4	74.7	16.8	91.6
Pukaki Airport	Pukaki Creek	5.4	0.2	0.4	0.3	1.5	8.7	10.9	67.6	21.3	88.9
Karaka/ Te Hihi Estuary	Te Hihi Estuary	1.7	1.1	0.5	0.5	20.5	46.4	67.9	24.2	6.9	31.1
Meola Outer Zone BRS - MO PS16	QA Reference Material	0.7	2.3	0.3	0.9	52.4	41.2	94.8	1.7	1.1	2.8
Meola Outer Zone BRS - MO PS48	QA Reference Material	0.8	0.7	0.4	1.1	49.7	45.4	96.6	1.3	1.5	2.7
Meola Outer Zone BRS - MO PS75	QA Reference Material	0.8	0.2	0.3	1.0	51.7	43.2	96.2	1.2	2.4	3.6
Middlemore BRS - MID PS20	QA Reference Material	5.3	0.0	0.2	0.6	16.2	15.0	31.9	49.5	18.6	68.1
Middlemore BRS - MID PS29	QA Reference Material	5.3	0.0	0.1	0.6	14.9	15.2	30.8	46.2	23.1	69.2
Middlemore BRS - MID PS55	QA Reference Material	5.1	0.0	0.0	0.5	15.5	14.3	30.2	49.1	20.7	69.8



Mud content (sediment <63µm; the sum of silt and clay particles) data obtained from a single composite surface (<2cm) sample per site in 2024. Mud content is presented as per cent of the total sediment weight.

8 Appendix D: Quality assurance analysis

8.1 Introduction

Quality assurance (QA) is conducted to check that the RSCMP data are 'fit for purpose', i.e., suitable for reliably assessing state and temporal trends which require low variability. The QA data are assessed for acceptability using a set of 'acceptance guidelines'. Considerable emphasis is placed on intercepting clearly outlying results (and verifying or correcting these) and evaluating the year-to-year consistency of the results.

The QA system has evolved over time since the programme first began in 1998. The approach currently used, including the use of Bulk Reference Sediment (BRS[2]) to track data consistency, has been operating since 2011. Certified Reference Material (CRM) results have been acquired each year since 2002. Details of the QA approaches used for the period 1998-2011 are given in Mills and Williamson (2014). The information from this review have been developed into a set of QA guidelines, as described in Mills (2016a).

QA currently used in the RSCMP follows a '3-tiered' approach as follows:

1. Quality control checks conducted by the analytical laboratory (Hill Laboratories, Hamilton) to ensure that the results have met the laboratory's in-house quality standards. The laboratory is required to provide a quality assurance/control (QA/QC) report for each batch of RSCMP data. This report is available on request.
2. The sample processing laboratory (Earth Sciences New Zealand, Hamilton) undertakes an assessment of the data provided by the analytical laboratory, including their QA/QC results and the variability of the results reported for the five replicates analysed at each site. In addition, the results from QA samples added to each RSCMP sample batch are assessed. Currently, the protocol is to analyse a minimum of five CRM QA samples and five BRS QA samples (from each of two BRS sites) with each batch of RSCMP samples. Any results that appear unusual or outside the variability range considered acceptable by the processing laboratory are checked with the analytical laboratory, and repeat analyses conducted if required. The results are collated, and an overall assessment provided in a 'data quality assessment' report. This report is available on request via Auckland Council's environmental data portal.

[2] BRS are sediments from two sites (a sandy sediment from Meola Outer Zone, and a muddy sediment from Middlemore), which have been archived in frozen and freeze-dried forms for repeated analysis with each year's monitoring samples. Analysis of the BRS each year provides an on-going record of within-year and between-year analytical variability and changes over time (drift or trend). Details of the BRS production and use are provided in Mills (2016a).

3. Lastly, the results from the QA assessments, in particular the CRM and BRS results, are checked against acceptance guidelines for the RSCMP programme, to ensure the variability and consistency over time are acceptable. An overall QA summary is produced (Table 8-1), which highlights any aspects that may require attention in future – e.g., any data that do not meet RSCMP data quality targets and might therefore be higher or lower than expected in the overall trend record, or are more variable than expected compared to previous results.

The likelihood of trends in the reference material being greater than or less than zero was assessed from the Sen Slope probability, as provided in 'Time Trends' software (Version 11.1). Note that for contaminants, an increasing trend reflects a degrading or worsening state, while a decreasing trend indicates improving conditions. Likelihood was categorised into five groups, as described by LAWA (2019):

- 'very likely' increasing or decreasing trends, where the Sen Slope probability is 90-100%.
- 'likely' increasing or decreasing trends (Sen Slope probability 67-90%). The lower certainty reflects the fact that while there is an indication of a trend, there is less statistical support for it.
- 'indeterminate' trends, where the Sen Slope probability is lower (<67%), reflecting insufficient evidence to confidently determine if there is an improving or degrading trend.

Because of the detailed checking of the analytical results conducted in tiers 1 and 2, it is unlikely that a significant number of 'fail' data will be encountered in tier 3. It is anticipated that some data each year may 'fail' and be flagged, but the numbers of these should decrease as a better understanding of analyte variability over time is gained, particularly from on-going BRS analyses.

At present the QA approach is rather involved. This is currently considered necessary because trends in contaminant concentrations at RSCMP sites measured to date have been relatively small, and assessment of their reliability has been hampered by a lack of long-term QA information for verifying year-to-year data consistency over the trend monitoring period. As more QA data are acquired, guidelines/criteria can be more robustly defined, and it is hoped that in future years the QA approach can be refined and, where possible, simplified.

8.2 Assessments undertaken

8.2.1 Metals

For metals' analysis, quality assurance (QA) comprised the following:

- Laboratory quality control samples – analysis of procedural blanks, blind duplicate samples, Certified Reference Material (CRM; AGAL-12) and 'in-house' reference sediment.
- Analysis of Auckland Council 'Bulk Reference Sediments' (BRS). Five replicates of each of the Meola Outer (sandy) and Middlemore (muddy) BRS in freeze-dried form were analysed.

Note on CRM: In 2020, Hill Laboratories advised Auckland Council that they are running short of the Hawkesbury River sediment reference material AGAL-10. The laboratory has transitioned to AGAL-12 (a dried powder mixture of sewage sludge and loam). Both AGAL-10 and AGAL-12 are produced and verified by the Australian National Measurement Institute. The AGAL-12 CRM does have very high levels of copper, but concentrations of other metals are in a similar range to those expected for sediments assessed in this programme. Hill Laboratories ran between five and seven replicates of AGAL-12 (called 'CRMB') alongside the AGAL-10 CRM from 2020 to 2023 to enable comparison between the reference materials and consistency in the QA/QC process. In 2023, the remaining supply of AGAL-10 was fully consumed, and in 2024, AGAL-12 was the only certified reference material used in the RSCMP.

8.2.2 Particle size distribution

For particle size distribution (PSD), quality assurance was conducted by analysing three replicates of each of the BRS sediments (Meola Outer and Middlemore). BRS used for PSD analysis are stored in frozen form, as drying (probably including freeze drying) is likely to affect the aggregation of particles within the sediments. The frozen BRS samples are thawed and homogenised before PSD analysis, exactly as for the RSCMP field samples.

8.3 Acceptance guidelines

The acceptance guidelines are based on a combination of analytical performance characteristics as measured in the RSCMP to date, and trend measurement thresholds currently considered relevant for the RSCMP (Mills, 2016a).

Current acceptance guidelines include measures for:

- Potential sample contamination, as assessed from procedural blanks;
- Data accuracy, from comparison of results with certified concentrations (i.e., CRM);
- Year-to-year data consistency, and within-year variability, as assessed principally from analysis of CRM and BRS samples. Within-site replicate results are also used to check within-year variability;
- Agreement between results from within the analytical sample batch, as assessed from blind duplicate analyses.

Each quality assurance measure is categorised as a '**pass**', '**note**' or '**fail**', depending on how the data compare with the guidelines. If the data meet the guidelines, they 'pass', if they are clearly outside then they 'fail', and if some values are slightly outside the 'pass' guidelines (or there are other considerations to be noted), they are flagged as 'note'.

Data that are classified as either a 'note' or 'fail' in the QA process are not omitted from reporting. Rather, the main purpose of this classification is to highlight data which are outside of the acceptance criteria (the 'fails') so that they can be checked and (if necessary) corrected. Results in the 'note' category may require further follow up checks in future – for example when trend assessments are done, are the values measured in some years slightly higher or lower than usual, and hence is the trend being affected by these values.

If the QA results for an analyte show continued 'note' or 'fail' grades in successive monitoring rounds, further work will be required to find out why and to take corrective action. Reanalysis of archived samples may be required[3].

These acceptance guidelines are still in development and are not strict quantitative criteria – some professional judgement may be required (e.g., comparing variability with historical results from the same site) when assessing whether the data are acceptable or not.

8.4 Data quality assessment results for 2024 sites

Table 8-1 summarises the QA information obtained for the 2024 RSCMP sampling round analyses, highlighting whether or not the data quality acceptance guidelines were met. These analyses indicated that the total recoverable metals data were generally of good quality.

The CRM data gave results that were acceptable but rated overall as a '**note**', due to a 'very likely' trend probability for lead and arsenic. The per cent annual change was below the 1% acceptance criteria for lead (0.55%), but slightly above for arsenic (-1.07%). This is not of immediate concern, as the new CRM data set has just five samples to date, the sample size is still too small to be considered robust, and further analyses are required to have a more definitive understanding of trend direction and magnitude over time. The CRM results generally indicated good accuracy and were largely within the upper and lower limits of the certified values.

The BRS samples gave results that were acceptable but also prompted a '**note**' with respect to temporal stability. These were for a 'very likely' trend probabilities for arsenic and lead (Meola) and zinc and copper (Middlemore). These results will require continued scrutiny in the coming years. However, as with the CRM analysis, they are not considered an urgent concern at this stage: although trend probabilities were high (exceeding 90%), the annual percentage change remains low and within acceptable guidelines (all below 1%). In addition, for BRS samples with successive 'very likely' probabilities in both 2023 and 2024 (currently this is occurring for arsenic at Meola and copper and zinc at Middlemore), per cent annual change was decreasing.

PSD data was generally within control limits and overall show good results for both within year variability and temporal stability.

Following the summary table, sections 8.5 and 8.6 will provide more detail and present concentration values from CRM and BRS analysis.

[3] This approach has been used for extractable metals, which showed unexpectedly high concentrations in 2003-2007 at some sites. Further testing involving archived samples and BRS samples resulted in this analysis being dropped from routine RSCMP monitoring from 2015 onwards. It has also been used to test increasing trends in zinc observed in BRS samples in 2017, 2018 and 2019. This resulted in further testing of archived samples and adjustments of analytical methods to rectify the issue.

Table 8-1. Summary of analytical quality assurance results for 2024 monitoring. CVs = coefficient of variation; RPDs = relative percentage difference; CLs = confidence limit; SD = standard deviation.

QA Measure	Acceptance guidelines	Pass Note Fail	Comments
Blanks	All values less than detection limits, or <10% of metal concentrations	Pass	Concentrations in procedural blanks were low for all analytes. No background contamination introduced in the laboratory would contribute significantly to metals' concentrations.
Within site variability	CVs <20%	Pass	Overall variability within sites is very good for all analytes. No sites exceed 20% and only one site exceeds 10% (for Hg).
Certified Reference Material	Accuracy: Results within lab control limits (+/- 3s, or 99% CLs)	Pass	Five CRMB (AGAL-12) samples analysed as unknowns for total recoverable metals. Means <10% of certified values for As, Cu, Pb, and Zn. Hg was slightly outside this at 87.5%. Four individual samples were outside the lab in-house control limit: Pb - 34.7 mg/kg just above the higher control limit of 34.2 mg/kg; As - 3.93 mg/kg, above the higher control limit of 3.91 mg/kg; and two Hg samples - 0.44 and 0.45 mg/kg, below the lower limit of 0.46 mg/kg.
	Variability: Within-batch CV <10%	Pass	Variability <10%. CVs between 3.9 - 9.7% for all metals.
	Temporal stability: Means of new data within 10% of previous data means	Pass	Good temporal stability. Difference in means (RPDs) between new and previous means were between -5.5% (Hg) and +2.0% (Pb).
	Temporal stability: No trends over time >1% of median concentration per year (and "very likely" likelihood; Sen Slope P>90%).	**Note** Pb and As with "very likely " trend probability	Trends over time to Nov 2024 were between -1.07 and 0.21% per year. Cu and Zn had indeterminate trends, while Pb and As had very likely, and Hg likely. Overall, temporal stability is a 'Note'. Arsenic is of most concern, with a very likely probability and annual change >1%. As the data set for the CRMB is still relatively small (five sets of data) this is not of immediate concern but should be watched closely as the data set builds.
Lab In-House Reference Material (optional)	Accuracy: Results within lab control limits	Pass	Eight samples of Hill Laboratories in house reference material ('SETOC-705') were included through the analytical run. There were no exceedances of the laboratory in-house control limits for any metals. Very good precision was evident with low CV's (1.3 - 4.4%). Recoveries for all metals were within 6% of reference values.
Bulk Reference Sediments:			
Total Recoverable Metals	Accuracy: Results within lab control limits (+/- 3sd)	Pass	All metals' results within control limits.
	Within-year variability: CVs <10%.	Pass	Within-year variability met targets for all metals (CVs 2.7 - 7.1%). Highest variability seen in Hg at Meola OZ.
	Temporal stability: Means of new data within 10% of previous data means	Pass	Results for all metals within 10% of the previous data means (RDP between -3.8 - 6.03%).
	Temporal stability: No trends over time >2% of median concentration per year (and "very likely" likelihood; Sen Slope P>90%).	**Note** - Overall good results and generally meet acceptance criteria. Watch increasing trend for As and Pb (Meola), and Zn and Cu (Middlemore).	BRS trends over time for Nov 2011 to Nov 2024 were all <2% per year annual change. 'Very likely' increasing trends for As and Pb (Meola) and Zn and Cu (Middlemore) need to be watched but are all currently showing low percent annual change (<1%).
Mud content	Accuracy: Results within lab control limits (+/- 3sd)	Pass	All mud content values within control limits
	Within-year variability: CVs <10%.	**Note**	CVs <10% for Middlemore (1.3%). CV of 14.4 % for Meola due to one slightly high result.
	Temporal stability: Means of new data within 10% of previous data means	Pass	2024 mean mud content within 4% of the previous data mean for Meola and within 3% of the previous data mean for Middlemore.
	Temporal stability: No trends over time >2% of median concentration per year (and "very likely" likelihood; Sen Slope P>90%).	Pass	Overall good temporal stability results. Both Middlemore and Meola showing 'likely' trends but very low percent annual change (-0.33% and +0.10% rrespectively).
OVERALL ASSESSMENT		**Total metals** **Note**: increasing Zn and Cu trend in Middlemore BRS. Increasing trend for As and Pb in MeOZ BRS.	Metals' results for 2024 sampling are acceptable for use in the RSCMP. The most notable exceptions are in BRS analysis with 'very likely' trend probability As and Pb (Meola) and Zn and Cu (Middlemore). However, these results are within acceptance criteria as all are showing percent annual change <1%. The high Zn continues to improve from those reported in 2019. CRMB results need to be watched closely (particularly for As) as data builds.
		PSD **Pass**	All QA targets for particle size distribution met in 2024 except for a slightly high CV at Meola.

8.5 Certified Reference Material

Two types of reference materials were used by Hill Laboratories as a quality control check for metal analysis:

- Certified Reference Material (CRM) 'AGAL-12', a dried powder mixture of sewage sludge and loam prepared by the Australian Government Analytical Laboratories. This reference material replaces 'AGAL-10' which had been used in the RSCMP and preceding monitoring programmes since 2002 to check data accuracy and consistency over time; and
- an 'in-house' laboratory reference material, 'SETOC-705', a sediment sample prepared by Hill Laboratories for use in their QA/QC programme. The results from these QA/QC analyses are provided in Earth Sciences New Zealand's assessment report. This report is available upon request.

The CRM analyses involve extraction/digestion and ICP-MS analysis only, and do not include the homogenising/sub-sampling/sieving/drying steps undertaken for analysis of field samples. Variability may be higher when sediment processing steps such as sieving and drying are included.

Five CRM samples (AGAL-12) were included in the analytical run as 'unknowns'. Results for these have been assessed according to the following 'acceptance guidelines':

- Accuracy: Results are within control limits (+/- 1 Standard Deviations (SD), or 99% confidence limits)
- Variability: within-batch Coefficient Variation (CV) <10%
- Temporal stability:
  - Means of new data are within 10% of previous data means; and
  - trends over time are <1% of the median concentration per year (Sen slope) and with less than a 'very likely' trend probability (Sen Slope P<0.90, as per LAWA likelihood categorisation (LAWA, 2019)). Trends were analysed by the Mann Kendall trend test, on median data using 'Time Trends' software (Version 11.1).

The results summarised in Table 8-2 show that the CRM results generally met all the QA acceptance guidelines, despite two '**fails**'. These were due to a 'very likely' trend probability (>90%) for arsenic and lead, however the per cent annual change was low (-1.07% for arsenic and -0.55% for lead). A 'Likely' increasing trend was observed for mercury, again with a low rate of annual change (-0.53%). When the mean of each metal is compared with the certified value, only mercury was outside the 10% acceptance criteria (87.5%) while all others showed values close to 100% (between 98.1% - 101.2%). Most results are within upper and lower limits of the certified reference value except for four values (one for lead, one for arsenic, and two for mercury), which were just outside the ± 1 SD limit. Overall, the CRM results recorded a '**note**' and are deemed to be satisfactory and generally consistent with previous years' results.

The CRM trend results obtained for total recoverable metals since 2020 are shown in Figure 8-1, and depict very weak increasing trends for copper and zinc, and stronger decreasing trends for lead, arsenic, and mercury. Although the data set is still small, the graphical presentation shows reasonably good consistency across the five years of analysis.

Table 8-2. Quality assurance results for five Certified Reference Material (CRMB; AGAL-12) samples analysed as unknowns in the 2024 sediment sample batch.

	QA Acceptance	Total Recoverable Metals (<500 mm)				
Sample ID and QA measures	Pass Note Fail	Cu	Pb	Zn	As	Hg
CRMB - Agal 12 - 1	Pass	142.7	30.3	171.0	3.12	0.44
CRMB - Agal 12 - 2	Pass	140.9	29.0	169.2	3.14	0.45
CRMB - Agal 12 - 3	Pass	150.0	33.1	180.4	3.55	0.47
CRMB - Agal 12 - 4	Pass	160.9	34.7	192.0	3.93	0.48
CRMB - Agal 12 - 5	Pass	151.4	30.4	179.6	3.41	0.48
New mean	n/a	149.2	31.5	178.5	3.4	0.46
Variability in new mean (CV, %)	Pass	5.3	7.4	5.1	9.7	3.9
Mean of all previous CRM data	n/a	150.8	30.9	177.3	3.6	0.49
Difference between new and previous data means (RPD, %)	Pass	-1.1	2.0	0.6	-4.8	-5.5
New mean, as % of certified value	Pass	99.4	100.4	98.1	101.2	87.5
Trends (% annual change, Sen Slope)	Pass	0.09	-0.55	0.21	-1.07	-0.53
Trends (probabilities, Sen Slope p values)	Note Hg. Fail As & Pb.	0.50	0.98	0.67	0.90	0.87
Trends (likelihood based on Sen Slope p values)	Note Hg. Fail As & Pb.	indeterminate	very likely	indeterminate	very likely	likely
Certified Reference Value (mg/kg)	n/a	150	31.4	182	3.39	0.53
Lab in-house lower limit (mg/kg; mean - 1 s.d)	n/a	138	28.6	169	2.87	0.46
Lab in-house upper limit (mg/kg; mean + 1 s.d)	n/a	162	34.2	195	3.91	0.60
Overall assessment	**Note**	**Pass**	**Note**	**Pass**	**Note**	**Note**
Comments	Small (<2%/year) but very likely trends for Pb and As. Small (<1%/year) likely trend for Hg. All new means close to previous (RDP % < -5.5) values. With only 5 samples, trend analysis is preliminary. Monitor closely as CRMB data set builds.		Very likely decreasing trend but <1% per year		Very likely decreasing trend - 1.07% per year	Likely decreasing trend but <1% per year

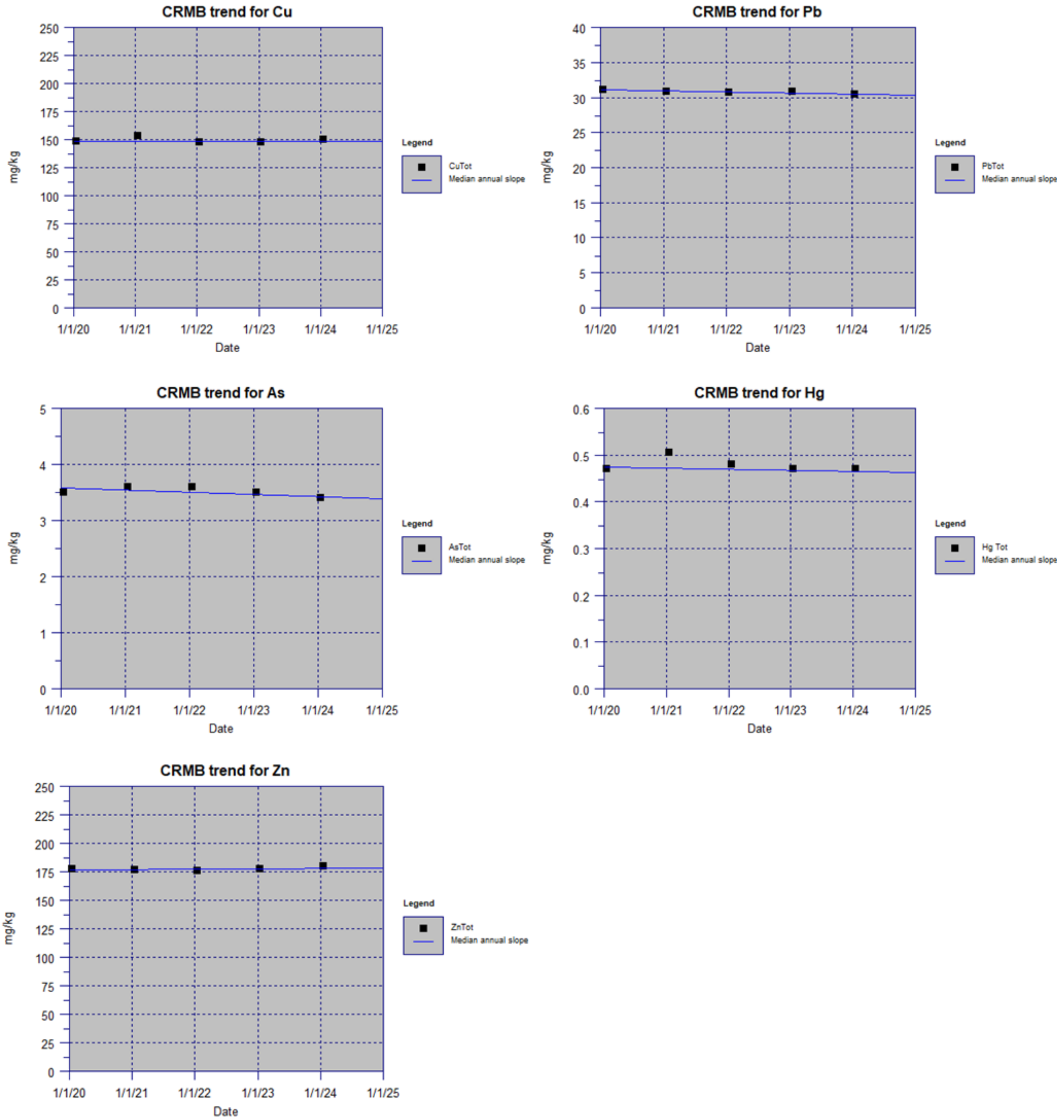


Figure 8-1. Certified Reference Material (CRM) results for total recoverable metals in CRMB AGAL-12, analysed with RSCMP samples from 2020 to 2024. The plots show annual medians. The line is a linear regression.

8.6 Bulk Reference Sediments

Five samples (stored in freeze-dried form) from each of the sandy Meola Outer Zone and muddy Middlemore BRS sites were analysed for metals. Three replicates of each of the BRS sediments (stored in frozen form) were analysed for particle size distribution (PSD). Results are summarised in sections 8.6.1 and 8.6.2.

The BRS results for metals have been assessed according to the same 'acceptance guidelines' as those used for the CRM, with the exception of the temporal stability trend measure, for which a trend acceptance guideline of ±2% per year (rather than the ±1% per year for the CRM) has been used. This broader guideline range for an acceptable trend in the BRS accommodates the slightly increased variability that may be introduced by sample processing steps such as homogenisation, sub-sampling, sieving, and drying. In future, with a larger BRS trend dataset, and a better understanding of temporal variability in the BRS results, tighter trend guidelines may be able to be justified. The BRS also currently has a slightly more lenient upper and lower control limit (3 SD compared with 1 SD used for the CRM). As with the trend acceptance guidelines, it is envisioned that these limits may be able to be tightened as the data set grows.

The BRS data acceptance guidelines used for the 2024 data are:

- Accuracy: results are within lab control limits (+/- 3 standard deviations, or 99% confidence limits)
- Variability: within-batch coefficient variation <10%
- Temporal stability:
    - means of new data are within 10% of previous data means; and
    - trends over time are <2% of the median concentration per year (Sen slope) and with less than a 'highly likely' trend probability (Sen Slope P<0.90, as per LAWA likelihood categorisation (LAWA, 2019)). Trends were analysed by the Mann Kendall trend test, on median data using 'Time Trends' software (Version 11.1).

BRS samples for chemistry analysis were initially prepared in both freeze dried and frozen forms. RSCMP samples may be analysed in either of these forms – field monitoring samples are generally frozen while they await chemistry analysis, but archived samples are stored freeze dried. Both frozen and freeze dried BRS were analysed with RSCMP monitoring rounds from November 2011 to June 2015, and the results compared in annual RSCMP reports (see Mills, 2016b for the last time they were compared). For total recoverable metals, the results from both freeze dried and frozen BRS were essentially the same. For RSCMP monitoring from November 2015 onwards, only analysis of the freeze dried BRS for total recoverable metals is considered necessary. Frozen samples are still used for PSD analysis because drying, including freeze-drying, may alter particle aggregation in sediments. The frozen BRS samples are thawed and homogenised prior to PSD analysis, following the same procedure as the RSCMP field samples.

8.6.1 Meola Outer Zone BRS

The total recoverable metals' results from the 2024 sample batch for the sandy Meola Outer Zone BRS are summarised in Table 8-3. Median values of BRS data acquired with RSCMP monitoring from November 2011 to 2024 are shown in Figure 8-2. The results for the Meola Outer Zone BRS obtained in 2024 were generally consistent with previous years.

The metals' results for the Meola Outer Zone BRS in 2024 are a '**note**', having failed two acceptance criteria ('very likely' increasing trends for arsenic and lead). Per cent annual change for arsenic has lowered slightly from 2023 (down to 0.90% from 1.14%), however lead per cent annual change increased slightly, from 0.37% to 0.52%, and the probability increased from 0.88 to 0.96. This will need to be watched closely in the coming years. In addition, several 'notes' were made for 'likely' (probability 67-90%) trends occurring for mud, copper, zinc, and mercury, however the per cent annual change for these are all low (<1%). The Meola Outer Zone BRS trend plots obtained for total recoverable metals, and mud content since 2011 depict slightly increasing trends for lead, zinc and copper, a stronger increasing trend for arsenic, and weak decreasing trends for mercury and mud content (see Figure 8-2).

All results are within upper and lower limits (± 3 SD) of the certified reference value. Variability in the data was generally low (CVs <10%), aside from mud content where one slightly higher result saw the CV increase to 14.4%. The difference between the new means and the previous data means was low for all analytes (RPD <6.03%).

Table 8-3. Quality assurance results for Bulk Reference Sediment (BRS) samples from Meola Outer Zone analysed with the 2024 RSCMP sample batch.

Sample ID and QA measures	QA Guidelines Pass Note Fail	Mud Content % <63 mm	Total Recoverable Metals (mg/kg, <500 mm) Cu	Pb	Zn	As	Hg
Meola OZ BRS 1	Pass	2.85	3.11	9.38	43.23	2.94	0.031
Meola OZ BRS 2	Pass	2.75	3.02	9.83	42.15	2.79	0.029
Meola OZ BRS 3	Pass	3.56	2.84	9.73	40.01	2.64	0.028
Meola OZ BRS 4	Pass		2.94	9.14	42.40	2.92	0.028
Meola OZ BRS 5	Pass		3.07	9.78	43.73	2.80	0.033
New mean	Pass	3.05	3.00	9.57	42.30	2.82	0.030
Variability in new data (CV, %)	Pass	14.4	3.5	3.1	3.4	4.2	7.1
Difference between new and previous data means (RPD, %)	Pass	3.69	0.62	6.03	2.80	3.35	-2.42
Trends (% annual change, Sen Slope)	Pass	-0.33	0.34	0.52	0.59	0.90	-0.62
Trends (probabilities, Sen Slope p values)	Fail As and Pb. Note others.	0.89	0.79	0.96	0.86	0.93	0.85
Trends (likelihood based on Sen Slope p values)	Fail As and Pb. Note others.	likely	likely	very likely	likely	very likely	likely
Overall mean of previous data	n/a	2.94	2.98	9.01	41.14	2.72	0.030
Lower control limit (mean - 3sd)	n/a	2.65	2.48	7.64	32.87	2.02	0.019
Upper control limit (mean + 3sd)	n/a	3.23	3.48	10.39	49.41	3.43	0.041
Overall assessment	Note	Pass	Pass	Note	Pass	Note	Pass
Comments	Overall satisfactory results. Increasing trend <1% per year for Zn. Continual improvement since 2020. Watch Pb as a slight increase on 2023 results. Watch As, very likely trend but low % annual change and a slight improvement on 2023 results.	Likely decreasing trend, <1% per year.	Likely increasing trend, <1% per year.	Very likely increasing trend, <2% per year	Likely increasing trend, <1% per year	Very likely increasing trend, <2% per year	Likely decreasing trend, < 1% per year

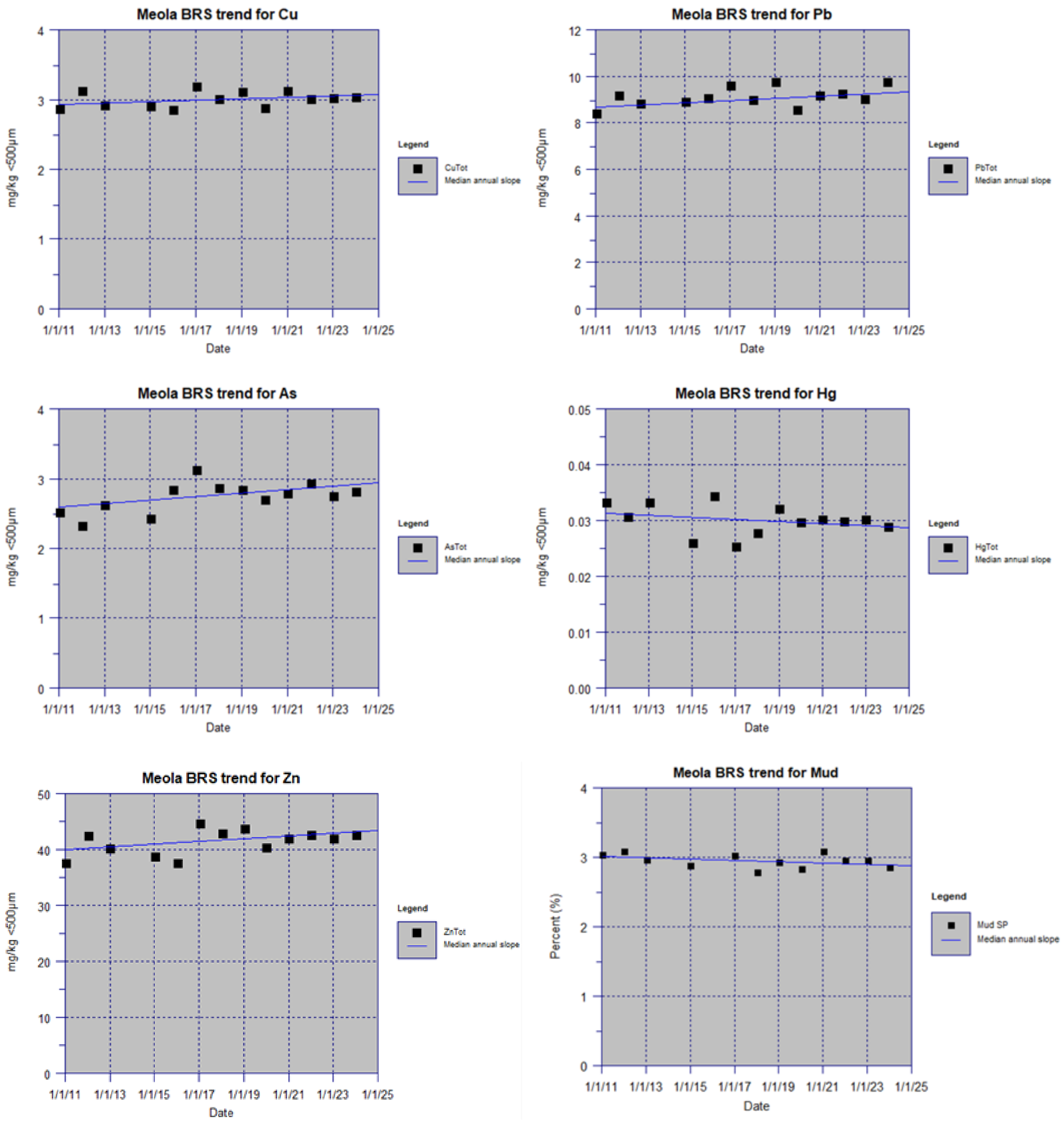


Figure 8-2. Plots of median data for Meola Outer Zone BRS metals and mud samples, November 2011 to November 2024. Metals are in mg/kg <500µm fraction, mud is silt + clay <63µm fraction.

8.6.2 Middlemore BRS

The total recoverable metals' results from the 2024 sample batch for the muddy Middlemore BRS samples are summarised in Table 8-4. Median values from data acquired with RSCMP monitoring from November 2011 to 2024 are shown in Figure 8-3. The results for the Middlemore BRS obtained in 2024 were generally consistent with previous years and mostly met acceptance guidelines.

Two acceptance guideline '**fails**' were observed due to a 'very likely' increasing trend observed in zinc and copper, however the per cent annual change was below the 2% criteria for both metals. In addition, a 'note' was made for a 'likely' increasing trend for mud content (probability 72%), however this showed a very low per cent annual change (0.10%) and is not currently of concern. Trends observed for lead, arsenic and mercury passed acceptance criteria, with a trend probability of 'indeterminate' (probability <67%).

All results are within upper and lower limits (± 3 SD) of the certified reference value.

The overall assessment for the Middlemore BRS is a '**note**', based on the 'very likely' trend observed for zinc and copper. The continuing reduction in the rate of increase observed in zinc trends in 2024 compared to that of previous years (down from 1.13% in 2023 to 0.94%) is encouraging. It is anticipated that the trend probability and per cent annual change for zinc will continue to decrease following the improvements made in analytical methods in 2019. Copper needs to be watched closely in coming years. The trend probability has moved from 'likely' (86%) to 'very likely' (0.93%), however the per cent annual change remains low (0.36%), and is a slight improvement on 2023 results (0.50%).

Table 8-4. Quality assurance results for Bulk Reference Sediment (BRS) samples from Middlemore analysed with the 2024 RSCMP sample batch.

Sample ID and QA measures	QA Guidelines Pass Note Fail	Mud Content % <63 mm	Total Recoverable Metals (mg/kg, <500 mm) Cu	Pb	Zn	As	Hg
Middlemore BRS 1	Pass	68.06	30.0	35.0	237.0	8.60	0.178
Middlemore BRS 2	Pass	69.25	28.5	34.2	231.4	8.36	0.171
Middlemore BRS 3	Pass	69.78	27.5	32.5	222.8	8.08	0.163
Middlemore BRS 4	Pass		29.3	34.8	242.9	8.62	0.177
Middlemore BRS 5	Pass		29.3	33.7	234.6	8.58	0.166
New mean	Pass	69.0	28.9	34.1	233.7	8.45	0.171
Variability in new data (CV, %)	Pass	1.3	3.3	2.9	3.2	2.7	3.8
Difference between new and previous data means (RPD, %	Pass	2.9	-1.5	-2.7	-0.6	-3.8	2.0
Trends (% annual change, Sen Slope)	Note Zn	0.10	0.36	0.06	0.82	-0.10	-0.14
Trends (probabilities, Sen Slope p values)	Fail Zn and Cu. Note Hg.	0.72	0.93	0.55	0.94	0.57	0.62
Trends (likelihood based on Sen Slope p values)	Fail Zn and Cu. Note Hg.	likely	very likely	indeterminate	very likely	indeterminate	indeterminate
Overall mean of previous data	n/a	67.08	29.33	34.99	235.04	8.78	0.167
Lower control limit (mean - 3sd)	n/a	60.34	24.22	29.35	179.87	6.92	0.128
Upper control limit (mean + 3sd)	n/a	73.82	34.43	40.64	290.22	10.63	0.207
Overall assessment	Note	Pass	Note	Pass	Note	Pass	Pass
Comments	Overall good results and generally meet acceptance criteria. Increasing trend <1% per year for Zn. Continual improvement since 2020. Watch trends for Cu, 'very likely' likelihood but currently low % annual change.	Likely trend, <1% per year.	Very likely increasing trend, <1% per year.	Indeterminate trend, <1% per year.	Very likely increasing trend < 2% per year. Results continuing to improve from 2023.	Indeterminate trend , <1% per year	Indeterminate trend, < 1% per year

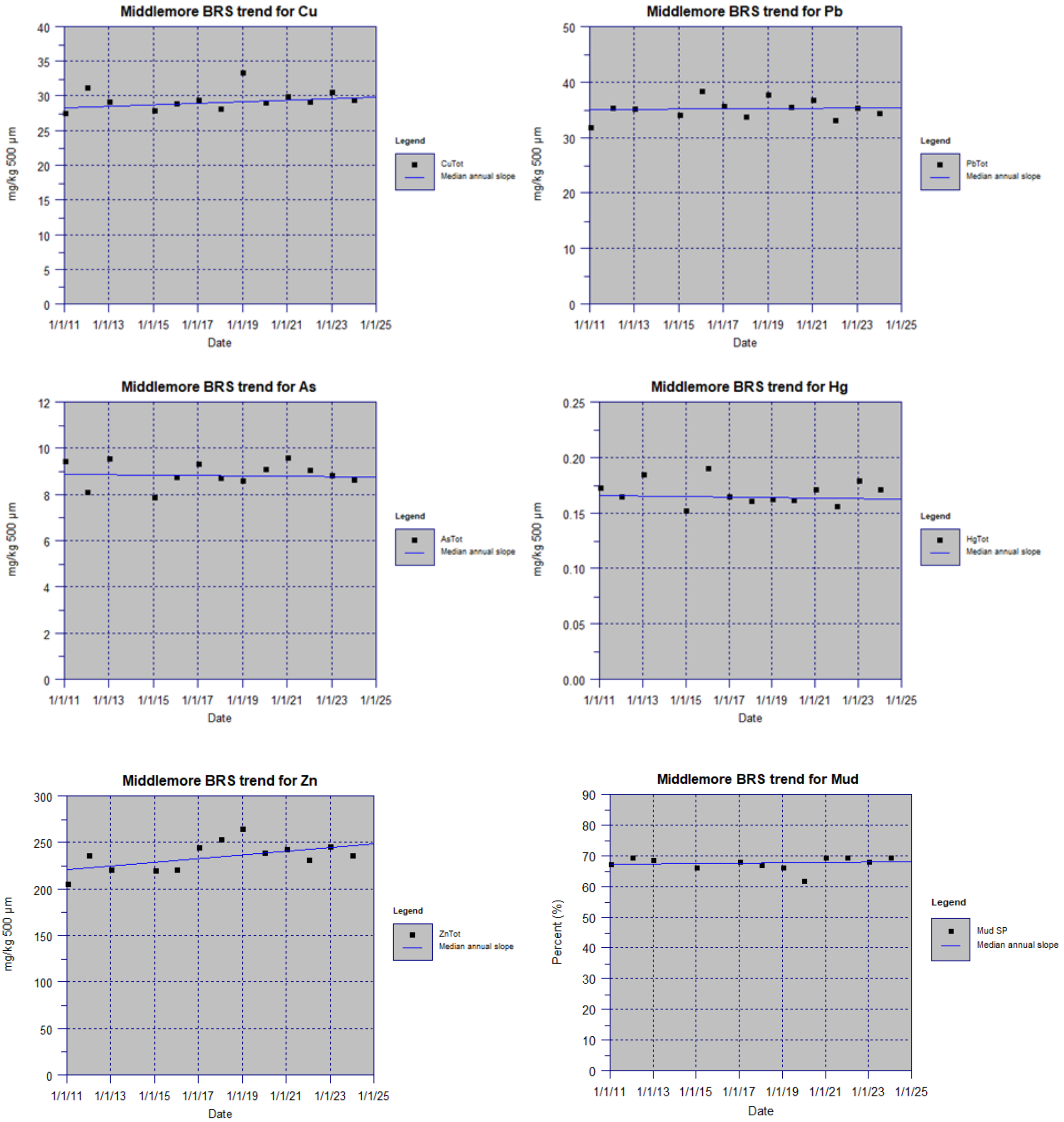


Figure 8-3. Plots of median data for Middlemore BRS metals and mud samples, November 2011 to November 2024. Metals are in mg/kg <500µm fraction, mud is silt + clay <63µm fraction.

Find out more:
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