APPENDIX 28

ECOTOXICITY ASSESSMENT

Ecological risk assessment of antifouling chemicals for the Northland Shipyard and Drydock Project

Action	Personnel	Version	Date
Preparation of draft for internal review	Mike Stewart	D1	12-06-26
Internal technical review	Ngaire Phillips	D2	12-06-26
Preparation of final draft for client review	Mike Stewart	D3	14-06-26
External review	Phil Mitchell (Mitchell Daysh), Chris Simmons (Chancery Green), Jared Pettersson (Enviser)	D4	22-06-26
Preparation of final report	Mike Stewart	F1	29-07-26
Preparation of final report	Mike Stewart	F2	04-08-26

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Contents

Executive Summary

The Ministry of Business, Innovation and Employment (**MBIE**) is progressing the Northland Shipyard and Drydock Project via the Fast-track Approvals Act 2024 (**FTAA**) pathway as a listed project. MBIE has engaged Streamlined Environmental Ltd (**SEL**) to undertake a high-level aquatic ecological risk assessment on antifouling chemicals in formulations proposed to be used at the facility. The activities that will involve antifouling chemicals will be ship preparation and painting. This assessment has been undertaken on a first principles basis setting out the environmental criteria the detailed design of the facility will need to achieve to ensure that environmental effects will be acceptable.

Critical information provided to undertake the risk assessment included a list of antifouling chemicals, a stormwater assessment, an air discharge assessment with modelled air deposition rates of antifouling chemicals (in gaseous and particulate form), and hydrodynamic modelling of the proposed reclamation and dredging activities.

The purpose of the assessment presented in this report is to:

1. Provide a description of relevant international and New Zealand standards and guidance on potential treatment of discharges that may be required.

2. Identify antifouling chemicals that may be used at the facility.

3. Undertake an ecotoxicological assessment of these chemicals.

4. Undertake a quantitative or semi-quantitative ecological risk assessment from stormwater discharge and spray drift in the coastal marine area (**CMA**) receiving environment[1].

The overarching international standard for antifouling chemicals in paint is the International Convention for the Control of Harmful Anti-fouling Systems on Ships (**AFS Convention**), which has prohibited two classes of antifouling chemicals since its inception in 2001, namely organotin compounds and cybutryne.

In New Zealand, the Environmental Protection Authority (**EPA**) has undertaken multiple assessments and re-assessments of antifouling paints, and in 2013 decided to start the phase out of certain antifouling paints containing thiram, diuron, octhilinone or ziram. We note that none of these chemicals are prohibited by the AFS Convention.

Physico-chemical data were obtained for the antifouling chemicals assessed, where available. These data were used to inform the high-level risk assessment.

Ecotoxicological endpoints were obtained for the antifouling chemicals assessed, where available. These endpoints were used to derive recommendations on appropriate ecological thresholds.

[1] Based on the information available. Where this information is not available this is discussed in the report.

A risk assessment of antifouling chemicals in stormwater is not required as management procedures will ensure that all stormwater generated during high-risk activities (including cleaning and painting of ships) will be conveyed to municipal WWTP as trade waste.

A high-level risk assessment of antifouling chemicals contained in spray drift from unencapsulated painting will lead to extremely low concentrations being deposited to the CMA. High tidal currents will ensure rapid dilution of water soluble antifouling chemicals with the largest residual risk being accumulation of antifouling chemicals in surficial intertidal sediment in proximity to the Shipyard and Drydock facility. A high-level and conservative risk assessment shows that the range of time required for sediment accumulation to reach ecological thresholds is between 101 years and 278,331 years. Therefore, there is negligible ecological risk, and hence a negligible adverse effect, from paint spray drift to inter-tidal sediment.

1. Introduction

The Ministry of Business, Innovation and Employment (**MBIE**) is progressing the Northland Shipyard and Drydock Project via the Fast-track Approvals Act 2024 (**FTAA**) pathway as a listed project. MBIE has engaged Streamlined Environmental Ltd (**SEL**) to undertake a high-level aquatic ecological risk assessment on antifouling chemicals from the proposed shipyard and drydock facility (**Facility**) which will be used to support this application. The activities that will involve antifouling chemicals will be ship preparation and painting.

The location of the proposed Facility and applicable Significant Ecological Areas (**SNAs**) in the Coastal Marine Environment (**CMA**) is shown in **Figure 1**.

Figure 1. Footprint of the proposed Northland Shipyard and Drydock facility and associated dredging (yellow shaded area) along with Significant Ecological Areas (mauve shaded areas) in the Coastal Marine Area (source Northland Regional Council).

This assessment provides a description of the applicable standards and guidance relevant to the ecotoxicity and the potential treatment of discharge of identified antifouling chemicals[2] associated with the proposed Facility, including any relevant New Zealand and international standards.

[2] Chemicals present in antifouling paint formulations such as semi-volatile organics and any others that are not specifically included for antifouling properties are out of scope and not included in this assessment.

The assessment also includes:

- The identification of antifouling chemicals.
- An ecotoxicological assessment of these chemicals.
- A quantitative or semi-quantitative ecological risk assessment from stormwater and spray drift in the coastal marine area (**CMA**) receiving environment[3].

Critical information provided by the wider project team to assess this and undertake the risk assessment was:

- The antifouling chemicals proposed to be used at the facility and estimated air deposition rates, provided by Pattle Delamore Partners (**PDP**)[4].
- Primary exposure pathways:
    - Air deposition of antifouling chemicals (in gaseous and particulate form) from ship preparation and coating to the CMA from the PDP air quality assessment report (Substantive Application Appendix 22: Air Quality Effects Assessment, PDP, 2026).
    - Stormwater discharge of antifouling chemicals from ship preparation and coating to the CMA from stormwater and wastewater the assessment report (Substantive Application Appendix 21: Stormwater, Washwater and Wastewater Assessment, Blackburn, 2026).
- Effects of the proposed reclamation and dredging on hydrodynamic characteristics (channel depths and tidal flows) (Substantive Application Appendix 14: MetOcean Assessment Reports, 2026).

Only a high-level risk assessment could be undertaken at this stage due to the limited information available, and where an assessment couldn't be completed, reasons are provided.

[3] Based on the information available. Where this information is not available this is discussed in the report.
[4] Email from Shanon Lim (PDP) dated 2/6/26.

2. Current international standards

The International Convention for the Control of Harmful Anti-fouling Systems on Ships (**AFS Convention**) is administered by the International Maritime Organization. It was adopted on 5th October 2001 and came into force on 17th September 2008 (AFS Convention, 2001). It applies to ships engaged in international trade.

The AFS convention, through Annex 1, introduced a worldwide ban on the application of organotin compounds, e.g. tributyl tin (**TBT**), to all ships in January 2003, with a phase out management of organotin compounds on ship hulls so that by January 2008 they were not to be present on the hull, or were covered with a protective coating (**Table 1**).

Table 1. Annex 1 of AFS Convention.

Anti-fouling system	Control measures	Application	Effective date
Organotin compounds which act as biocides in anti-fouling systems	Ships shall not apply or re-apply such compounds	All ships	1 January 2003
Organotin compounds which act as biocides in anti-fouling systems	Ships either: (1) shall not bear such compounds on their hulls or external parts or surfaces; or (2) shall bear a coating that forms a barrier to such compounds leaching from the underlying noncompliant antifouling systems	All ships (except fixed and floating platforms, FSUs[5], and FPSOs that have been constructed prior to 1 January 2003 and that have not been in dry-dock on or after 1 January 2003)	1 January 2008
Cybutryne CASRN 28159-98-0	Ships shall not apply or re-apply anti-fouling systems containing this substance	All ships	1 January 2023
Cybutryne CASRN 28159-98-0	Ships bearing an anti-fouling system that contains this substance in the external coating layer of their hulls or external parts or surfaces on 1 January 2023 shall either: (1) remove the anti-fouling system; or (2) apply a coating that forms a barrier to this substance leaching from the underlying non-compliant anti-fouling system	All ships except: (1) fixed and floating platforms, FSUs, and FPSOs that have been constructed prior to 1 January 2023 and that have not been in dry-dock on or after 1 January 2023; (2) ships not engaged in international voyages; and (3) ships of less than 400 gross tonnage engaged in international voyages, if accepted by the coastal State(s)	At the next scheduled renewal of the anti-fouling system after 1 January 2023, but no later than 60 months following the last application to the ship of an anti-fouling system containing cybutryne

[5] FSUs are Floating Storage Units and FPSOs are Floating Production Storage and Offloading units and are offshore facilities used in the oil and gas industry.

Further, Annex 1 was updated to include a worldwide ban in January 2023 on the application of cybutryne (also known as Irgarol 1051) to all ships. Similar phase out management conditions to organotin compounds are specified to be no later than January 2028 (**Table 1**).

No other antifouling chemicals have been prohibited for use on ships at this time under the AFS Convention.

2.1 New Zealand context

In New Zealand, the Environmental Protection Authority (**EPA**) is responsible for regulating hazardous substances though the Hazardous Substances and New Organisms (**HSNO**) Act 1996. EPA undertakes hazard risk assessments on new chemicals entering the country and periodically undertakes reassessments of chemicals already approved to ensure they are safe to humans and the environment. In 2013, the EPA decided to start the phase out of certain antifouling paints containing thiram, diuron, octhilinone or ziram[6]. We note that none of these chemicals are prohibited by the AFS Convention.

[6] https://www.epa.govt.nz/hazardous-substances/rules-notices-and-how-to-comply/specific-substance-guidance/antifouling-paints/

3. High-level risk assessment

3.1 Methodology

3.1.1 Antifouling chemicals assessed

The antifouling chemicals assessed in this report were provided to SEL[7] and are summarised in **Table 2**.

Table 2. Antifouling chemicals assessed in this report[7].

Compound	Synonym	Chemical Type	CASRN
Titanium dioxide	TiO_2	Inorganic	13463-67-7
Silica crystalline - quartz	Sand	Inorganic	14808-60-7
Zinc oxide	Zinc oxide	Inorganic	1314-13-2
Copper(I) oxide	Cuprous oxide	Inorganic	1317-39-1
Copper(II) oxide	Copper oxide	Inorganic	1317-38-0
Polyamide amine resin	PAR	Polymer	68915-18-4
Epoxy Resin	BADGE-L	Polymer	25036-25-3
Bisphenol A/ diglycidyl ether resin, liquid	BADGE-M	Polymer	25085-99-8
Zineb	Zineb	Organometal	12122-67-7
Pyrithione zinc	Zinc pyrithione	Organometal	13463-41-7
Tris-2,4,6-(dimethylaminomethyl)phenol	TMAP	Small Molecule	90-72-2

3.1.2 Physico-chemical information

For each antifouling chemical, where possible, the following physico-chemical properties were obtained from the European Chemicals Agency (**ECHA**) Chemicals Database[8] or Chemspider database[9], including:

- Synonym.
- Chemical type.
- Chemical formula/structure.
- Molecular weight.
- The partition coefficient for neutral chemicals – logP[10,11].
- The partition coefficient for ionisable chemicals – logD (at pH 7.4)[10,11].

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[7] Email from Shanon Lim (PDP) dated 2/6/26.
[8] https://chem.echa.europa.eu/
[9] https://www.chemspider.com/
[10] LogP, logD, K_{OC} and bioaccumulation concentration factor (BCF) generated by ACD Labs. LogD and BCF and KOC values can be generated at pH 5.5 and 7.4, with pH 7.4 used as this is close to the natural pH of seawater (ca. pH 8).
[11] The partition coefficient, P, is a measure of the differential solubility of a compound in two immiscible solvents. The most commonly used solvent system is octanol/water. The partition coefficient is the descriptor of lipophilicity for neutral compounds, or where the compound exists in a single form. For ionisable solutes, the compound may exist as a variety of different species in each phase at any given pH. D, the distribution coefficient, is the appropriate descriptor for ionizable compounds since it is a measure of the pH-dependent differential solubility of all species in the octanol/water system. P and D are typically used in the logarithmic form, logP and logD (https://www.acdlabs.com/download/app/physchem/logp_vs_logd.pdf)

- Bioaccumulation concentration factor (BCF) (at pH 7.4)[10].
- Water solubility.
- Organic Carbon-Water Partition Coefficient – K_{OC} (at pH 7.4).

3.1.3 Ecotoxicological effects information

Ecotoxicological effects information was not available for all antifouling chemicals assessed.

International ecotoxicology databases were searched, using the unique Chemical Abstracts Registry Number (**CASRN**). This was undertaken on a hierarchical basis in the following order:

1. The ECHA chemicals database, extracting the predicted no-effects concentration (**PNEC**) for marine water and marine sediment.
2. NORMAN ecotoxicity database[12], extracting the lowest PNEC for marine water and marine sediment. These are updated periodically, so the most recent PNECs were used for this assessment[13].
3. Specifically for copper and zinc, the Regional Plan for Northland (**RPN**) Coastal Water Quality Standards (**CWQS**) and Coastal Sediment Quality Standards (**CSQS**) for Estuaries (Northland Regional Council, 2026).
4. Miscellaneous data, such as that provided in Material Safety Data Sheets (**MSDS**).

The ECHA is the most preferred database as PNEC data are based for regulatory decision making (in the EU) and calculated using standardised procedures.

NORMAN lowest PNEC data are agreed by NORMAN experts to be used for preliminary prioritisation purposes (i.e. an early warning screening assessment) and do not have a regulatory basis.

Where there is significant uncertainty in the ecotoxicological data assessment factors (**AF**) – also known as safety factors – are used to introduce a level of conservatism that is appropriate for the available data, i.e. put a weighting on the appropriateness of the ecotoxicity data. This may be where there are insufficient data to calculate a robust ecological effects concentration, such as for marine receiving environments where ecotoxicological data on representative species are generally less common than in freshwater. AFs range from 1 – 10,000, with the lower the AF the higher the certainty. Where appropriate, AFs are used in this report, as detailed in Section 4.1.

Using the most conservative approach (representing the worst-case scenario), the lowest marine water ecotoxicological value (PNEC) from any of the databases was used in the assessment.

[12] NORMAN is a network of reference laboratories, research centres and related organisations for monitoring of emerging environmental substances. NORMAN has a membership of more than 70 leading laboratories and authorities across Europe and North America.

[13] https://www.norman-network.com/nds/ecotox/lowestPnecsIndex.php Accessed 08-06-26.

3.2 Exposure pathways

3.2.1 Stormwater

An assessment of stormwater management and discharge of the proposed dry dock extension has been undertaken by Blackburn (Substantive Application Appendix 21: Stormwater, Washwater and Wastewater Assessment, 2026).

Blackburn (2026) stated that there will be mechanisms in place to isolate and safeguard the functional performance of the Northport pond from excessive concentrations or extraordinary contaminants. This will rely on collection and discharge to the Whangārei District Council wastewater network under a trade waste discharge consent. These extraordinary contaminants include antifouling paint residues from cleaning (water blasting) and spray painting of ships. Further, capacity enhancement at Ruakaka WWTP is underway and planned in stages out to 2085. The current stage (to 2030) is likely to align with development timing for the Shipyard and Drydock extension.

With mechanisms in place to divert process wastewater for antifouling chemicals to municipal WWTP via trade waste there is no exposure pathway of these chemicals to the CMA for this activity. Therefore, with no exposure pathway, a risk assessment of antifouling chemicals in stormwater discharge to the CMA is not required.

3.2.2 Air deposition

PDP undertook an assessment of potential effects on air quality at the proposed Facility (Substantive Application Appendix 22: Air Quality Assessment, 2026).

PDP modelled the paint emissions by running two models, one with a gaseous pollutant, and one with a particulate pollutant.

Emission rates were calculated based on conservative assumptions, including:

- All paint will be applied by spray gun with no encapsulation.
- All volatile organics will evaporate off from the product.
- An overspray percentage of 20% has been assumed.
- Spray painting will be undertaken 24 hours per day 7 days per week, even though typical operational hours are 7am to 6pm.

Further, in terms of ship surface preparation, PDP noted that while some particulates (such as spent abrasive media, removed paint and coating materials, corrosion by-products, and marine biofouling) will be discharged during these activities, these are all comparatively large and are expected to deposit in close proximity to the surface being blasted from, even during strong winds, reducing the risk of them reaching the CMA.

PDP stated that an active management approach for paint overspray will be implemented through real-time monitoring of the painting process. This significantly reduces the potential for overspray to occur, however, in the instances that it does occur, there are measures in place to monitor and mitigate.

Therefore, PDP concluded that there are effective management approaches proposed to reduce the risk of paint overspray or ship preparation material reaching the CMA.

PDP provided results of modelling to estimate particle deposition rates to the CMA from spray drift for the antifouling chemicals assessed in this report, including maximum emission rate and maximum off-site deposition rate (see **Table 3** and **Figure 2**). These data were used to complete a high-level risk assessment of antifouling chemicals from spray drift to the CMA (Section 4.2.2).

Table 3. Summary of maximum deposition rates of paint antifouling chemicals from spray painting. (Source: Substantive Application Appendix 22: Air Quality Effects Assessment, 2026).

Compound	Synonym	CASRN	Solid or Volatile	Maximum Emission Rate (g/s)	Maximum Off Site Rate (µg/m²/hr)
Titanium dioxide	TiO2	13463-67-7	Solid	0.1686	32
Polyamide amine resin	PAR	68915-18-4	Solid	0.0507	9
Epoxy Resin	BADGE-L	25036-25-3	Solid	0.3262	61
Tris-2,4,6-(dimethylaminomethyl) phenol	TMAP	90-72-2	Solid	0.0871	16
Bisphenol A/ diglycidyl ether resin, liquid	BADGE-M	25085-99-8	Solid	0.3528	66
Silica crystalline - quartz	Sand	14808-60-7	Solid	0.2067	39
Zinc oxide	Zinc oxide	1314-13-2	Solid	0.2139	40
Copper (I) oxide	Cuprous oxide	1317-39-1	Solid	0.8000	150
Zineb	Zineb	12122-67-7	Solid	0.0535	10
Pyrithione zinc	Zinc pyrithione	13463-41-7	Solid	0.1600	30
copper (II) oxide	Copper oxide	1317-38-0	Solid	0.1600	30

Figure 2. Maximum deposition rates (μg/m²/hr) (orange lines) and footprint of paint antifouling chemicals from spray painting. The orange lines are the worst-case deposition rates for copper (I) oxide (Source: Substantive Application Appendix 22: Air Quality Effects Assessment, 2026).

4. Results and discussion

4.1 Determination of risk assessment thresholds

A summary of physico-chemical, ecotoxicological, and environmental fate data are provided for inorganic antifouling chemicals in **Table 4**, and for organic and organometallic antifouling chemicals in **Table 5**.

Table 4. Summary of physico-chemical, ecotoxicological, and environmental fate properties for inorganic antifouling chemicals assessed.

Chemical information	Antifouling Chemical				
Name	**Titanium dioxide**	**Silica crystalline - quartz**	**Zinc oxide**	**Copper(I) oxide**	**Copper (II) oxide**
Synonym	TiO2	Sand	Zinc oxide	Cuprous oxide	Copper oxide
CASRN	13463-67-7	14808-60-7	1314-13-2	1317-39-1	1317-38-0
Chemical Type	Inorganic	Inorganic	Inorganic	Inorganic	Inorganic
Molecular formula	TiO_2	SiO_2	ZnO	Cu_2O	CuO
Molecular weight	79.9	138.2	81.4	143.1	79.6
Physico-chemical Properties[1,2]					
LogP	NA	NA	NA	NA	NA
Log D (pH 7.4)	NA	NA	NA	NA	NA
BCF (pH 7.4)	NA	NA	NA	NA	NA
Koc (pH 7.4)	NA	NA	NA	NA	NA
Water solubility (µg/L)[2]	<1.51	NA	2,900	600	10
Ecotoxicological information					
ECHA PNEC					
Marine water (µg/L)	No hazard identified	ND	9.6	5.2	5.2
Sediment (marine water) (mg/kg dry weight)	No hazard identified	ND	202	676	676
Other ecotoxicological databases					
NORMAN Lowest PNEC Marine Water (µg/L)	1000	ND	6.1	5.2	5.2
RPN CWQS - Estuaries (µg/L) - metals	NA	NA	15.0	1.3	1.3
NORMAN Lowest PNEC Sediments (mg/kg dry weight)	ND	ND	ND	ND	ND
RPN CSQG - Estuaries (mg/kg dry weight) - metals	NA	NA	124	18.7	18.7

ND = No data available, NA = Not applicable.

[1] Chemspider database (https://www.chemspider.com/).

[2] ECHA.

Table 5. Summary of physico-chemical, ecotoxicological, and environmental fate properties for organic and organometallic antifouling chemicals assessed.

Chemical information	Antifouling Chemical					
Name	**Polyamide amine resin**	**Epoxy Resin**	**Bisphenol A/ diglycidyl ether resin, liquid**	**Zineb**	**Pyrithione zinc**	**TRIS-2,4,6-(Dimethylamino methyl) Phenol**
Synonym	PAR	BADGE-L	BADGE-M	Zineb	Zinc pyrithione	TMAP
CASRN	68915-18-4	25036-25-3	25085-99-8	12122-67-7	13463-41-7	90-72-2
Chemical Type	Polymer	Polymer	Polymer	Organometallic polymer	Organometallic small molecule	Small Molecule
Molecular formula	Polymer	Polymer	Polymer	Polymer	$C_{10}H_8N_2O_2S_2Zn$	$C_{15}H_{27}N_3O$
Molecular weight	Polymer	Polymer	Polymer	Polymer	317.7	265.2
Physico-chemical Properties[1,2]						
LogP	ND	ND	3.95	ND	ND	0.76
Log D (pH 7.4)	ND	ND	3.57	ND	0.90	-2.59
BCF (pH 7.4)	ND	ND	305	ND	ND	1.00
Koc (pH 7.4)	ND	ND	2087	ND	ND	1.00
Water solubility (µg/L)[2]	ND	ND	ND	ND	6,300	8.5×10^8
Ecotoxicological information						
ECHA PNEC						
Marine water (µg/L)	ND	ND	11[4]	ND	ND	5
Sediment (marine water) (mg/kg dry weight)	ND	ND	0.048[4]	ND	ND	0.026
Other ecotoxicological databases						
NORMAN Lowest PNEC Marine Water (µg/L)	ND	ND	ND	0.088	0.090	8.4
RPN WQS - Estuaries (µg/L) - metals	NA	NA	NA	15.0	15.0	NA
NORMAN Lowest PNEC Sediments (mg/kg dry weight)	ND	ND	ND	44.7	ND	0.193
RPN SQG - Estuaries (mg/kg dry weight) - metals	NA	NA	NA	124	124	NA
Miscellaneous PNEC/NOEC (µg/L)			300 (NOEC[3])			

Chemical information	Antifouling Chemical					
Environmental fate[2]						
Biodegradability-water	ND	ND	ND	ND	Not readily biodegradable	Not readily biodegradable

ND = No data available

[1] Chemspider

[2] ECHA

[3] Safety Data Sheet for Loctite 3430 which contains BADGE (25085-99-8) https://www.conro.com/downloads/Manuals/Loctite-EA-3430-SDS.pdf

[4] PNECs not available for BADGE-M so data for an ecotoxicological analogue (CASRN 2425-79-8) of BADGE-M was used from the ECHA database (see text).

4.1.1 Titanium dioxide

Titanium dioxide (TiO_2) is used in antifouling paints as a photocatalytic agent that generates reactive oxygen species (**ROS**) when exposed to UV light. ROS are short-lived and toxic to microorganisms involved in fouling (Liu et al., 2023).

Titanium dioxide is sparingly water soluble, has no potential for bioaccumulation and is considered non-toxic to marine water or sediment dwelling biota (**Table 4**).

Therefore, the risk of adverse effects on marine organisms from TiO2 is very low, and we consider that an ecological threshold value for assessment is not required.

4.1.2 Silica crystalline – quartz (Sand)

Crystalline silica and other silica based chemicals are primarily used in marine antifouling paints as binders and as hardening agents which also increases the durability of the coating.

Crystalline silica (SiO2) is fine sand. Therefore, the risk of adverse effects on marine organisms from SiO2 is negligible and we consider that an ecological threshold value for assessment is not required.

4.1.3 Zinc oxide

Zinc oxide is used in marine paints as an anticorrosive and UV protectant to protect metal hulls and paint integrity. It is also used as a co-biocide to prevent the growth of fouling organisms[14].

Zinc is a ubiquitous toxicant in industrial and residential stormwater and wastewater discharges. Therefore, zinc in antifouling paints has the potential to cause a cumulative increase in zinc concentrations to the CMA.

ECHA provide a marine water PNEC of 9.6 µg/L, while NORMAN provide a lowest PNEC of 6.1 µg/L for zinc oxide. The RPN provides an estuarine CWQS of 15.0 µg/L for zinc (**Table 4**).

Therefore, we recommend that the RPN CWQS for zinc in estuaries of 15.0 µg/L is used as a threshold for effects assessment in marine water.

Zinc is known to associate with sediment, potentially leading to accumulation and increased risk to sediment dwelling biota. For marine sediments ECHA provide a PNEC of 202 mg/kg, dry weight (dw) while the RPN provides a CSQS of 124 mg/kg, dw (**Table 4**).

Therefore, we recommend that the RPN CSWS of 124 mg/kg, dw for zinc is used as a threshold for effects assessment in marine sediment.

4.1.4 Copper (I) oxide and Copper (II) oxide

Copper(I) oxide is the most commonly used biocide in antifouling paints (Lagerström et al., 2020).

[14] https://www.indolysaght.com/zinc-oxide-for-marine-paint

As for zinc, copper is ubiquitous in stormwater and wastewater so leaching from paints or dry docks has the potential to result in a cumulative increase in copper concentrations to the CMA.

ECHA provide a marine water PNEC of 5.2 µg/L, while NORMAN provide a lowest marine water PNEC of 5.2 µg/L for copper and cuprous oxides. The RPN provides an estuarine CWQS of 1.3 µg/L for copper (**Table 4**).

Therefore, following conservative principles, we recommend that the CSWS of 1.3 µg/L for copper is used as a threshold for effects assessment in marine water.

Copper is known to associate with sediment, potentially leading to accumulation and increased risk to sediment dwelling biota. For marine sediments ECHA provide a PNEC of 676 mg/kg, dry weight (dw) while the RPN provides a CSQS of 18.7 mg/kg, dw (**Table 4**).

Therefore, following conservative principles, we recommend that the CSWS of 18.7 mg/kg dw for copper is used as a threshold for effects assessment in marine sediment.

4.1.5 Polyamide amine resin (PAR)

Polyamide amine resin (**PAR**) is a complex polymer and is used as an epoxy curing agent/hardener. No physico-chemical information could be obtained for this resin, including its chemical stability (**Table 5**). It appears in multiple SDS as a component[15,16,17] and the EPA state that it may be used as a component in a product covered by a group standard but that it is not approved for use as a chemical in its own right[18].

Further, no ecotoxicological information could be obtained from any of the databases searched.

Therefore, ecological risk from PAR could not be assessed and we cannot recommend a threshold for assessment.

4.1.6 Epoxy resin (BADGE-L) and Bisphenol A/diglycidyl ether resin (BADGE-M)

O-alkylation of bisphenol A (**Figure 3**) with epichlorohydrin forms the monomer bisphenol A diglycidyl ether (**BADGE**), which undergoes further reaction with bisphenol A to form a range of polymer epoxy resins, including both antifouling chemicals being considered in this assessment, BADGE-L and BADGE-M (**Figure 3**) (Environment Canada, 2019).

The average degree of polymerisation of these resins, n, varies from 0.1 up to 25. The two antifouling chemicals assessed in this report are higher molecular weight polymers. We have classed these based on polymer chain lengths with n ≈ 0.2 as BADGE-M (medium) (CASRN 25085-99-8) and with n > 0.2 as BADGE-L (large) (CASRN 25036-25-3). Importantly, no residual reactants

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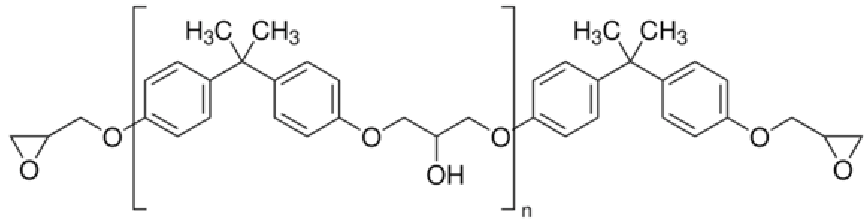
[15] https://smitsgroup.co.nz/Content/SiteResources/PRODUCT/60861/29302%20lechsys%20epobuild%20primer%20hardener%20sds%20nz%202022.pdf?srsltid=AfmBOor281oaYN7OyO8NSdda1Uw2goe87_kIAzvRmi4UJCevguHBM5Sn

[16] https://www.versatileproducts.co.nz/downloadhandler.axd?type=2&id=100290&ins=1

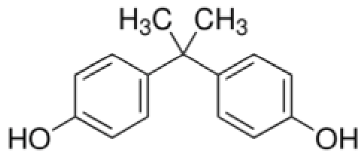
[17] https://www.paintdocs.com/docs/webPDF.jsp?SITEID=BOLTON_EX&prodno=L574A&doctype=SDS&lang=en_GB

[18] https://www.epa.govt.nz/database-search/new-zealand-inventory-of-chemicals-nzioc/view/4206AA64-4B2A-4A57-AEA0-FEFBD15CFB78/

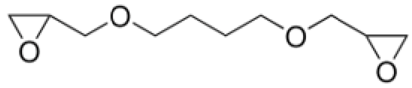
(i.e. the BADGE monomer, bisphenol A, and epichlorohydrin) are expected to remain as these processes involve several purification stages to remove all impurities (Environment Canada, 2019).



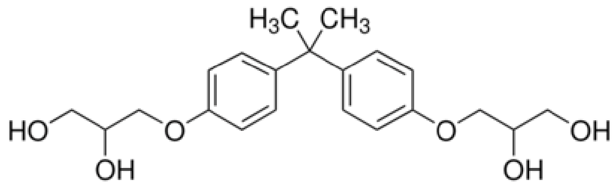
BADGE polymers



bisphenol A



Ecotoxicological analogue of BADGE resins



BADGE.2H_2O

Figure 3. Chemical structures of polymers of BADGE (top), bisphenol A (second from top), ecotoxicological analogue of BADGE-M (second from bottom) and BADGE hydrolysis product (BADGE.2H_2O, bottom).

Finding information on ecotoxicological effects of these two polymers is complex due to sparsity of information, and due to potential differences in their reactivity, transformation products and stability. However, some conclusions can be made.

The epoxide functional group may be associated with adverse effects on fish, invertebrates, and algae. In terms of these two polymers, Structure Activity Relationship (**SAR**) analysis indicated that the larger polymers (BADGE-L) are not expected to pose a hazard under any conditions, while the smaller polymer (BADGE-M) may be hazardous to aquatic organisms (Environment Canada, 2019).

The ECHA and NORMAN databases do not provide any PNEC data for either BADGE-M or BADGE-L. However, 1,4-bis(2,3-epoxypropoxy)butane (CASRN 2425-79-8) (**Figure 3**) is a close structural analogue of BADGE epoxy resins (Environment Canada, 2019). The ECHA database provide marine water and sediment PNEC of 11 µg/L and 0.048 mg/kg, dw, respectively (**Table 5**). This suggests moderate to high ecotoxicity of structurally similar epoxide analogues of BADGE-M.

However, the epoxide functional group is expected to undergo rapid hydrolysis in water to a stable diol product (**Figure 3**). The BADGE monomer and its hydrolysis product – BADGE.2H_2O – are known endocrine disrupting chemicals (**EDCs**) (Marqueño et al., 2019). However, these EDC effects were established for the monomers and we could find no EDC information on hydrolysis products from polymeric BADGE-M.

Therefore, in summary BADGE-L polymers are not expected to pose an ecological hazard under any conditions. Environment Canada (2019) concluded that, on the basis of empirical, analogue and model data, that BADGE-M is expected to show moderate to low toxicity to aquatic organisms, and low toxicity to sediment dwelling species in natural environments. However, there are no clear ecological thresholds for BADGE-M in marine water and therefore we cannot recommend a threshold for assessment.

4.1.7 Zineb

Zineb is primarily used as a co-biocide in marine antifouling paints to increase the efficacy of the primary biocide[19]. In a reassessment by the EPA in 2013 zineb was approved for use in marine paints, with controls[20]. EPA have approvals for zineb as a co-biocide with copper-based chemicals[21,22].

No physico-chemical data could be obtained from either ECHA or Chemspider databases (**Table 5**).

There were no marine water or sediment PNECs for zineb available on the ECHA database. A lowest marine water and sediment PNEC of 0.088 µg/L, and 44.7 mg/kg, dw were obtained from the NORMAN database (**Table 5**). An AF of 1000 was applied to create both PNECs, indicating a high degree of uncertainty. Notwithstanding that NORMAN PNEC are "early warning" values, the water PNEC shows the potential for moderate to high ecotoxicity effects from zineb in marine water.

There is evidence that degradation products of zineb may be the cause of the ecotoxicity. A 1990 study showed that (1) there was a delay in efficacy of the antifouling effect of zineb and (2) two breakdown products – 5,6-dihydro-3H-imidazo (2,1-c)-1,2,4-dithiazole-3-thione (**DIDT**) and

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19 https://agria-zenithcropsciences.com/en/product/perozine-marine/

20 https://www.epa.govt.nz/assets/FileAPI/hsno-ar/APP201051/720402e41b/APP201051-APP201051-Decision-Final.pdf

21 https://www.epa.govt.nz/assets/RecordsAPI/Antifouling_paint_containing_copper_thiocyanate_zinc_oxide_and_zineb_HSR000918.pdf

22 https://www.epa.govt.nz/assets/RecordsAPI/Antifouling_paint_containing_648_glitre_cuprous_oxide_and_70_glitre_zineb_HSR000933.pdf

ethylene diisothiocyanate (**EDI**) – were more toxic against the persistent ship-fouling diatom *Amphora coffeaeformis* (Hunter and Evans, 1990) when compared with zineb.

Therefore, with controls in place for its use in New Zealand, and evidence that there is high ecotoxicity of (likely) its breakdown products, we consider that zineb in marine paints is potentially a high ecological risk to the CMA and recommend ecological thresholds for assessment of 0.088 µg/L for marine water and 44.7 mg/kg, dw for sediment.

4.1.8 Pyrithione zinc (Zinc Pyrithione)

Zinc pyrithione is a small molecule organometallic chemical that was introduced as a substitute for TBT and used primarily with copper in antifouling paints (Bao et al., 2008).

Zinc pyrithione is highly water soluble and is not readily biodegradable (**Table 5**). The high solubility in water suggests partitioning to sediment may be relatively low, however there are no data (K_{OC}) to support this.

There were no marine water or sediment PNECs for zinc pyrithione available on the ECHA database. A lowest marine water PNEC of 0.090 µg/L was obtained from the NORMAN database but there were no data for marine sediment PNEC (**Table 5**). An AF of 5 was applied for the marine water PNEC, indicating a low degree of uncertainty. Although zinc pyrithione contains zinc, the parent molecule is more ecotoxic than zinc alone, so RPN CWQS is not an appropriate threshold in this case.

Notwithstanding that NORMAN PNEC are "early warning" values, the water PNEC shows the potential for moderate to high ecotoxicity effects from zinc pyrithione in marine water. Therefore, we recommend an ecological threshold for assessment of 0.090 µg/L in marine water. However, although partitioning to sediment is not known, high water solubility suggests that zinc pyrithione may be rapidly diluted in the CMA due to high tidal currents, thus reducing ecological risk.

4.1.9 Tris-2,4,6-(dimethylaminomethyl)phenol (TMAP)

TMAP is used as a curing agent in epoxy resins including antifouling paints[23].

TMAP is extremely water soluble (850 g/L), has low potential to adsorb to sediment (K_{OC} = 1), has no potential for accumulation and is not readily biodegradable (**Table 5**).

The ECHA database provides marine water and sediment PNECs of 5.0 µg/L and 0.026 mg/kg, dw, respectively. The NORMAN database provides marine water and sediment PNECs of 8.4 µg/L and 0.193 mg/kg, dw, respectively (**Table 5**). An AF of 10,000 was applied to both the ECHA and NORMAN marine water PNEC data and 1,000 was applied to the NORMAN sediment PNEC data[24], indicating a high degree of uncertainty in all cases.

[23] https://www.chemicalbook.com/CASEN_90-72-2.htm

[24] The ECHA used a different technique – the equilibrium partitioning method and the use of uses mechanistic partitioning coefficients – for establishing their sediment PNEC which does not include an explicit AF.

Using the most conservative data, we recommend the use of the ECHA PNECs of 5.0 µg/L and 0.026 mg/kg, dw as ecological thresholds for assessment of marine water and sediment ecotoxicity, respectively. These data suggest that TMAP has the potential for moderate ecotoxicity effects in marine water. Despite the low propensity to adsorb to sediment there is the potential for moderate to high ecotoxicity effects in marine sediment from TMAP.

4.2 Risk assessment

4.2.1 Stormwater

With mechanisms in place to divert process wastewater for antifouling chemicals to municipal WWTP via trade waste there is no exposure pathway of these chemicals to the CMA for this activity. Therefore, with no exposure pathway, a risk assessment of antifouling chemicals in stormwater discharge to the CMA is not required.

4.2.2 Air Deposition

While there are various proposed measures to manage and control paint discharges, unencapsulated spray painting will lead to spray drift into the CMA. The maximum deposition rate and deposition footprint is shown as orange contours in **Figure 2**. We note the deposition rates are provided for copper (I) oxide and hence are worst-case.

Due to high tidal currents around the Facility, rapid dilution will occur for antifouling chemicals in spray drift and reduce the chance for settling and accumulation in surface sediments.

Settling of particles containing antifouling paint to the inter-tidal sediments (bottom left of **Figure 2**) are the highest risk for long-term accumulation.

A high-level, but conservative, risk assessment of antifouling chemicals to inter-tidal sediments was undertaken with results summarised in **Table 6**. Assumptions used were:

1. Based on inter-tidal sediments, the highest deposition rate is 90 µg/m^3/hr. Therefore, all maximum deposition rates were reduced by a factor of 0.6 (90/150).
2. A 1cm (0.01m) accumulation depth in the sediment was assumed to convert the maximum off-site deposition rate from an aerial rate to a volumetric rate – µg/m^3/hr = µg/m^2/hr/100.
3. Based on a bulk density of sandy sediment of 1500 kg/m^3 (Hicks et al., 2019) the volumetric rate from (2) was converted to µg/kg/hr, and from this to mg/kg/hr.
4. The time (hours, days, and years) for sediment accumulation to reach the recommended sediment threshold was calculated. This assumed an 11 hour day of application with no refresh of sediment between applications. We note that this is conservative as it assumes:
    - No sediment transport/turnover. MetOcean data suggests that for some wave classes there will be a relatively high potential for sediment transport, hence refreshing the surficial sediment layer (Substantive Application Appendix 14: MetOcean Assessment Reports, 2026).
    - No biodegradation of the antifouling chemical.

Results (**Table 6**) show that the time required to reach a sediment threshold ranges from 101 years (TMAP) to 278,331 years (Zineb). Three antifouling chemicals – titanium dioxide, crystalline silica, and BADGE-L – had no accumulation limit. Further, three other antifouling chemicals – PAR, BADGE-M, and zinc pyrithione – could not be assessed as we could not derive a sediment threshold. We note that, as the low sediment PNEC for TMAP (0.024 mg/kg) results in a time to reach this threshold of 101 years, it is likely that these three antifouling chemicals will, at worst, be in a similar range.

Therefore, spray drift from unencapsulated painting will result in negligible ecological risk, and hence negligible adverse ecological effects on intertidal sediments near the Facility.

Table 6. Summary of maximum deposition rates to the CMA intertidal zone and accumulation time required to reach sediment threshold for antifouling chemicals from spray painting.

Name	Recommended Threshold Sediment (mg/kg, dw)	Maximum Off Site Rate (Table 3)	Maximum Off Site Rate to CMA intertidal zone				Time to reach sediment threshold (4,5)		
		µg/m²/hr	µg/m²/hr (1)	µg/m³/hr (2)	µg/kg/hr (3)	mg/kg/hr	Hours	Days	Years
Zinc oxide	124	40	24	0.240	0.00016	1.6×10^{-7}	7.8×10^{8}	7.0×10^{7}	193,026
Copper(I) oxide	18.7	150	90	0.900	0.00060	6.0×10^{-7}	3.1×10^{7}	2.8×10^{6}	7,763
Copper(II) oxide	18.7	30	18	0.180	0.00012	1.2×10^{-7}	1.6×10^{8}	1.4×10^{7}	38,813
Zineb	44.7	10	6	0.060	0.00004	4.0×10^{-8}	1.1×10^{9}	1.0×10^{8}	278,331
TMAP	0.026	16	10	0.096	0.00006	6.4×10^{-8}	406,250	36,932	101
Titanium dioxide	No hazard identified	32	19	0.192	0.00013	1.3×10^{-7}	No limit	No limit	No limit
Silica crystalline	No hazard identified	39	23	0.234	0.00016	1.6×10^{-7}	No limit	No limit	No limit
BADGE-L	No hazard identified	61	37	0.366	0.00024	2.4×10^{-7}	No limit	No limit	No limit
PAR	No data available	9	5	0.054	0.00004	3.6×10^{-8}	Not assessed	Not assessed	Not assessed
BADGE-M	No data available	66	40	0.396	0.00026	2.6×10^{-7}	Not assessed	Not assessed	Not assessed
Pyrithione zinc	No data available	30	18	0.180	0.00012	1.2×10^{-7}	Not assessed	Not assessed	Not assessed

Assumptions

(1) Used factor of 90/150 = 0.6 as highest concentration to reach CMA intertidal zone, based on PDP contour map (**Figure 2**).

(2) Volume calculated based on 1cm depth (0.01m). Conversion to µg/m³/hr by µg/m²/hr/100

(3) Based on bulk density of sandy sediment 1500 kg/m³ as per Hicks et al. (2019). Conversion to µg/kg/hr by m³/hr/1500.

(4) Assumes no sediment transport. This is conservative as MetOcean data suggests for some wave classes there will be relatively high potential for sediment transport (Substantive Application Appendix 14: MetOcean Assessment Reports, 2026)

(5) Assumes an 11 hour day of application with no refresh between applications.

4.3 Summary

4.3.1 Standards

The overarching international standard for antifouling chemicals in paint is the AFS Convention, which has prohibited two classes of antifouling chemicals since its inception in 2001, organotin compounds and cybutryne.

In New Zealand, EPA have undertaken multiple assessments and re-assessments of antifouling paints, and in 2013 decided to start the phase out of certain antifouling paints containing thiram, diuron, octhilinone or ziram. We note that none of these chemicals are prohibited by the AFS Convention.

4.3.2 Antifouling chemicals

Physico-chemical data were obtained for the antifouling chemicals assessed, where available. These data provided information on lipophilicity/water solubility (logP and logD, and measured water solubility), propensity to partition to sediment (K_{OC}) and potential to bioaccumulate (BCF) and were used to inform the high-level risk assessment.

4.3.3 Ecological thresholds

Ecotoxicological endpoints (PNECs) were obtained for the antifouling chemicals assessed, where available. A discussion on these endpoints was undertaken (Section 4.1) and recommendations made on appropriate ecological thresholds for assessment of ecotoxicological effects.

A summary of ecological thresholds for the antifouling chemicals assessed in this report is provided in **Table 7**.

In marine water, thresholds available are generally lower for organic biocides ranging from around 0.09 µg/L (zineb and zinc pyrithione) to 5.0 µg/L for TMAP. In marine sediments, thresholds for organic biocides ranged from 0.026 (TMAP) to 44.7 (Zineb). In both water and sediment no hazard was identified for BADGE-L and no data were available for PAR or BADGE-M.

In both marine water and sediment, inorganic antifouling chemical thresholds were set based on copper and zinc RPN CWQS and CSQS, respectively.

Table 7. Summary of recommended ecological thresholds of antifouling chemicals assessed in marine water and sediment.

Name	Synonym	Recommended Thresholds	
		Marine water (μg/L)	Sediment (marine water) (mg/kg dw)
Titanium dioxide	TiO2	No hazard identified	No hazard identified
Silica crystalline - quartz	Disilicic acid	No hazard identified	No hazard identified
Zinc oxide	Zinc oxide	15.0	124
Copper(I) oxide	Cuprous oxide	1.3	18.7
Copper (II) oxide	Copper oxide	1.3	18.7
Polyamide amine resin	PAR	No data available	No data available
Epoxy Resin	BADGE-L	No hazard identified	No hazard identified
Bisphenol A/ diglycidyl ether resin, liquid	BADGE-M	No data available	No data available
Zineb	Zineb	0.088	44.7
Pyrithione zinc	Zinc pyrithione	0.090	No data available
TRIS-2,4,6-(Dimethylaminomethyl) Phenol	TMAP	5.0	0.026

4.3.4 Risk assessment

Due to proposed mechanisms to divert stormwater that will contain antifouling chemicals to municipal WWTP via trade waste there is no exposure pathway from stormwater to the CMA during activities that include cleaning and painting of ships. No risk assessment was required for antifouling chemicals in stormwater.

Noting the various management controls proposed to maintain air quality, a high-level risk assessment of antifouling chemicals contained in spray drift from unencapsulated painting will lead to extremely low concentrations being deposited to the CMA. High tidal currents will ensure rapid dilution of water-soluble antifouling chemicals with the largest residual risk being accumulation of antifouling chemicals in surficial intertidal sediment in proximity to the Facility. A high-level and conservative risk assessment shows that the range of time required for sediment accumulation to reach ecological thresholds is between 101 years and 278,331 years. Therefore, there is negligible ecological risk, and hence a negligible adverse effect, from paint spray drift to inter-tidal sediment.

5. References

AFS Convention, 2001. International Convention On the Control of Harmful Anti-Fouling Systems on Ships, 2001 London, 5 October 2001.

Bao, V.W.W., Leung, K.M.Y., Kwok, K.W.H., Zhang, A.Q., Lui, G.C.S., 2008. Synergistic toxic effects of zinc pyrithione and copper to three marine species: Implications on setting appropriate water quality criteria. 5th Int. Conf. Mar. Pollut. Ecotoxicol. 57, 616–623. https://doi.org/10.1016/j.marpolbul.2008.03.041

Blackburn, J., 2026. Appendix 21: Stormwater, Washwater and Wastewater Assessment.

Environment Canada, 2019. Screening assessment Epoxy Resins Group Chemical Abstracts Service Registry Numbers 25036-25-3 25068-38-6 25085-99-8 28064-14-4 Environment and Climate Change Canada Health Canada.

Hicks, M., Semadeni-Davies, A., Haddadchi, A., Shankar, U., Plew, D., 2019. Updated sediment load estimator for New Zealand. Prepared for Ministry for the Environment, March 2019, 190pp.

Hunter, J.E., Evans, L.V., 1990. The toxicity of the biocides zineb, nabam and their derivatives to the ship-fouling diatom Amphora coffeaeformis. Biofouling 2, 267–287. https://doi.org/10.1080/08927019009378150

Lagerström, M., Ytreberg, E., Wiklund, A.-K.E., Granhag, L., 2020. Antifouling paints leach copper in excess – study of metal release rates and efficacy along a salinity gradient. Water Res. 186, 116383. https://doi.org/10.1016/j.watres.2020.116383

Liu, T., Liang, R., Qin, W., 2023. Anti-fouling TiO2-Coated Polymeric Membrane Ion-Selective Electrodes with Photocatalytic Self-Cleaning Properties. Anal. Chem. 95, 6577–6585. https://doi.org/10.1021/acs.analchem.2c05514

Marqueño, A., Pérez-Albaladejo, E., Flores, C., Moyano, E., Porte, C., 2019. Toxic effects of bisphenol A diglycidyl ether and derivatives in human placental cells. Environ. Pollut. 244, 513–521. https://doi.org/10.1016/j.envpol.2018.10.045

MetOcean Assessment Reports, 2026. Appendix 14A: Hydrodynamic Assessment.

Northland Regional Council, 2026. Regional Plan for Northland, March 2026, 366 pp.

PDP, 2026. Appendix 22: Air Quality Effects Assessment.

6. Qualifications and Environment Court Statement

6.1 Qualifications and experience

Dr Mike Stewart is an environmental chemistry specialist and has been a Director at Streamlined Environmental Ltd since 2015. Prior to this he was an environmental chemistry scientist at NIWA (2006-2014) and prior to that worked primarily in drug discovery research in the United Kingdom (pharmaceutical/biotech sector) and Australia (academia).

Dr Stewart's relevant professional experience spans 29 years and he holds a PhD in Chemistry from the University of Canterbury, New Zealand (awarded in 1997).

Dr Stewart is a certified Resource Management Act (RMA) Independent Hearing Commissioner, having initially completed the Making Good Decisions Programme in 2017, and recertified in 2021 and 2025.

Dr Stewart's relevant expertise and experience includes:

a) Ecological and human health risk assessment of process chemicals in industrial aquatic discharges for RMA consenting purposes (Refining NZ, Ravensdown, Graymont, Contact Energy).
b) Reviews and technical studies of water and sediment quality and/or emerging organic contaminants provided in support of applications for discharge consent by Watercare Services Limited, Refining NZ, Port of Tauranga, and private developers at Te Kauwhata, Whitford and Kingseat.
c) The design and implementation of monitoring programmes on legacy and/or emerging organic contaminants for research, State of the Environment Monitoring and for discharge consents on behalf of MBIE, Auckland Council, the Bay of Plenty Regional Council, the Waikato Regional Council and Meridian Energy Limited.
d) Critical reviews of state of the environment monitoring programmes for Auckland and Waikato Regional Councils.
e) Key researcher in a Ministry for Business Innovation and Employment (MBIE) funded programme (2017-2022) assessing environmental and economic risks to New Zealand from emerging organic contaminants.

Dr Stewart has co-authored 26 peer-reviewed scientific publications, 12 as lead author and 24 in international journals. He is actively engaged in research, especially around the environmental fate and effects of emerging contaminants in New Zealand and the development of methods to measure bioavailable concentrations of chemical toxicants.

6.2 Code of conduct

Dr Stewart has confirmed that he has read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023 and has complied with it in preparing this report. He confirms that the issues addressed in this report are within his area of expertise and he has not omitted material facts known to him that might alter or detract from his findings.