Technical Review Report

Sampling and Analysis Quality Plan and Detailed Site Investigation Reports NZAS Tiwai Point

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Acronyms

ANZECC	Australia and New Zealand Environment Conservation Council
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
BAZ	biologically active zone
CCG	Composite Contractors Group
CLMG	Contaminated Land Management Guideline
COPC	constituents of potential concern
COPEC	constituents of potential ecological concern
CSM	conceptual site model
CTD	conductivity-temperature-depth
DGV	default guideline value
DSI	Detailed Site Investigation
DQO	Data Quality Objectives
ES	Environment Southland
GHD	GHD New Zealand Ltd
HTF	Heat Transfer Fluid
LNAPL	light non-aqueous phase liquid
MfE	Ministry for the Environment
NEPM	National Environmental Protection Measure
NES-CS	National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Huma Health
NZAS	New Zealand Aluminium Smelters Ltd
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
PFAS	per-and polyfluoroalkyl substances
PSI	Preliminary Site Investigation
RPD	relative percent difference
RSL	risk screening level
SCL	Spent Cell Linings
SPL	Spent Pot Linings
SAQP	Sampling and Analysis Quality Plan Summary
SQGV	sediment quality guideline value
SVOC	semi-volatile organic compound
TCE	trichloroethylene
TOC	total organic carbon
TPH	total petroleum hydrocarbons
UPM	under pot material
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
WAD	weak acid dissociable

Units of Measure

Area	
ha	hectare
m^2	square metres
Density	
kg/m^3	kilograms per cubic metre
Electrical Conductance	
µS/cm	microsiemen per centimetre
dS/m	decisiemen per metre
mS/cm	millisiemen per centimetre
mV	millivolt
Length	
µm	micrometres
cm	centimetres
km	kilometres
m	metres
mm	millimetres
Mass	
µg	micrograms
g	grams
kg	kilograms
mg	milligrams
t	metric tonnes
Concentration by Mass	
µg/kg	microgram per kilogram
mg/kg	milligram per kilogram

Pressure	
kPa	kilopascals
Pa	Pascals
Temperature	
°C	degrees Celsius
°F	degrees Fahrenheit
K	kelvin
Velocity	
m/s	metres per second
Volume	
µL	microlitres
cL	centilitres
cm^3	cubic centimetre
GL	gigalitre
L	litres
m^3	cubic metre
mL	millilitres
ML	megalitre
Concentration by Volume	
µg/L	microgram per litre
mg/L	milligram per litre
ppmv	parts per million by volume
ppbv	parts per billion by volume

Elements of the Periodic Table

Element	Symbol
Actinium	Ac
Aluminium	Al
Americium	Am
Antimony	Sb
Argon	Ar
Arsenic	As
Astatine	At
Barium	Ba
Berkelium	Bk
Beryllium	Be
Bismuth	Bi
Bohrium	Bh
Boron	B
Bromine	Br
Cadmium	Cd
Calcium	Ca
Californium	Cf
Carbon	C
Cerium	Ce
Cesium	Cs
Chlorine	Cl
Chromium	Cr
Cobalt	Co
Copernicium	Cn
Copper	Cu
Curium	Cm
Darmstadtium	Ds
Dubnium	Db
Dysprosium	Dy
Einsteinium	Es
Erbium	Er
Europium	Eu
Fermium	Fm
Flerovium	Fl
Fluorine	F
Francium	Fr
Gadolinium	Gd
Gallium	Ga
Germanium	Ge
Gold	Au

Element	Symbol
Hafnium	Hf
Hassium	Hs
Helium	He
Holmium	Ho
Hydrogen	H
Indium	In
Iodine	I
Iridium	Ir
Iron	Fe
Krypton	Kr
Lanthanum	La
Lawrencium	Lr
Lead	Pb
Lithium	Li
Livermorium	Lv
Lutetium	Lu
Magnesium	Mg
Manganese	Mn
Meitnerium	Mt
Mendelevium	Md
Mercury	Hg
Molybdenum	Mo
Neodymium	Nd
Neon	Ne
Neptunium	Np
Nickel	Ni
Niobium	Nb
Nitrogen	N
Nobelium	No
Osmium	Os
Oxygen	O
Palladium	Pd
Phosphorus	P
Platinum	Pt
Plutonium	Pu
Polonium	Po
Potassium	K
Praseodymium	Pr
Promethium	Pm
Protactinium	Pa

Element	Symbol
Radium	Ra
Radon	Rn
Rhenium	Re
Rhodium	Rh
Roentgenium	Rg
Rubidium	Rb
Ruthenium	Ru
Rutherfordium	Rf
Samarium	Sm
Scandium	Sc
Seaborgium	Sg
Selenium	Se
Silicon	Si
Silver	Ag
Sodium	Na
Strontium	Sr
Sulfur	S
Tantalum	Ta
Technetium	Tc
Tellurium	Te
Terbium	Tb
Thallium	Tl
Thorium	Th
Thulium	Tm
Tin	Sn
Titanium	Ti
Tungsten	W
Ununoctium	Uuo
Ununpentium	Uup
Ununseptium	Uus
Ununtrium	Uut
Uranium	U
Vanadium	V
Xenon	Xe
Ytterbium	Yb
Yttrium	Y
Zinc	Zn
Zirconium	Zr

Executive Summary

Introduction and Background

An extensive programme of environmental investigation work has been undertaken by GHD New Zealand Ltd (GHD) at the New Zealand Aluminium Smelters Ltd (NZAS) Tiwai Point manufacturing facility. The scope and results from the investigation work are presented in two GHD reports, listed below:

1. NZAS Closure Preliminary Study – Sampling and Analysis Quality Plan Summary (**SAQP**). GHD. 7 April 2021.
2. New Zealand Aluminium Smelters Ltd. NZAS Closure Preliminary Study. Contaminated Sites Detailed Site Investigation (**DSI**) Report. GHD. August 2021.

Environment Southland (ES) has retained EHS Support New Zealand Ltd (EHS Support) to undertake a review of the above reports, as part of a wider programme of work EHS Support is performing on the NZAS facility for ES.

EHS Support initially prepared a draft review report that was provided to NZAS and GHD for comment. This final review report has been prepared following receipt of these comments. In general, the NZAS/GHD review did not question the technical issues raised in the EHS Support review.

More detailed comments pertaining to the SAQP and DSI are presented in the main body of this report, with many of the comments providing suggestions for the additional work streams to be undertaken by NZAS. Comments are provided in tabular form within **Attachment A** to aid in comment responses.

The NZAS smelter comprises a very large and complex facility and regardless of whether the facility ceases operation in 2024 or not, NZAS has a significant number of environmental challenges to address. This will require NZAS and ES to work in a co-operative manner to agree future environmental work programmes to ensure appropriate environmental management and stewardship of the smelter and the wider environs.

Detail Site Investigation Scope

The DSI as currently drafted has assessed soil, groundwater, and sediment impact within the confines of the smelter domain (the Site) which covers an area of approximately 92 hectares (ha). The wider smelter area, comprising an approximate area of 310 ha (including the NZAS landfill and Spent Cell Lining (SCL) waste pad), was not investigated by GHD. In addition, no receiving environment investigations (groundwater, surface water and sediment outside of the Site) were conducted as part of the DSI.

The principal aims of the investigation were to:

- Support the Preliminary Closure Study (PCS) for the NZAS facility, in particular to inform the assessment of remedial options.
- Assist in understanding the extent and depth of contamination (within the Site) that may require management, further assessment and/or remediation.
- Provide advice to NZAS on compliance with environmental regulations.

The smelter domain investigation has provided critical information to better refine the understanding of contamination conditions at the property.

While a preliminary site investigation (PSI) of the NZAS facility has been prepared by GHD. The DSI review was constrained by NZAS not making the PSI available during the review process. The PSI has since been received by ES and reviewed by EHS Support, but this review is not addressed in this report.

Detailed Site Investigation Report Review Findings

The process of aluminium smelting at the NZAS facility uses the pre-bake method (Hall-Héroult Process) and utilises a number of key inputs (alumina, cryolite, carbon, and pitch) and large amounts of electricity as part of the electrolysis process. A broad range of contaminants are released as part of this process due to handling of materials, air emissions from the facility, production and refurbishment of the pots/cells and anodes, waste management and electrical distribution. Common contaminants associated with aluminium smelting in order of likely mass loadings include aluminium, fluoride, petroleum hydrocarbons (principally polycyclic aromatic hydrocarbons (PAHs)), cyanide, other metals, and historically polychlorinated biphenyls (PCBs).

The DSI comprised an initial independent assessment of contamination at the Site and has highlighted numerous legacy and ongoing sources of contamination to the environment. The management of Spent Pot Lining (SPL) or SCL or other fluoride containing materials (dross, pot bottoms, louvres, cathode bars, bath, dusty materials, including former pot refurbishment areas) have resulted in soil impacts in numerous areas of the Site. Percent level concentrations of fluoride were recorded around the Inalco area where waste materials were observed to be deposited in surface soils during GHD's investigation. Other areas where waste materials and feedstocks were observed to be present at surface were in and around the alumina stores, fume recovery systems, carbon storage and green mill. The presence of these materials at surface suggest levels of poor housekeeping.

Coincident with the soil impacts, contamination (particularly fluoride, cyanide, and aluminium) has also been identified in groundwater, with a large plume(s) of shallow groundwater contamination lying under the smelter domain. Elevated concentrations of contaminants (percent level aluminium for example) were also recorded in the three stormwater drains leading from the facility to the receiving marine environment.

Assessment of groundwater and sediment data for the Site indicates that discharges of contaminants are potentially occurring to the receiving environment with concentrations above generic or default ecological risk-based criteria.

Contaminant concentrations (including trace elements, PAHs, fluoride) above commercial/industrial and recreational health risk criteria and ecological screening criteria were encountered at surface within the Site. Further assessment is needed to establish whether a combination of groundwater and surface water discharges and air emissions are resulting in impacts to surrounding terrestrial and aquatic ecological communities.

The DSI (as presented) comprises an initial assessment of contamination conditions within the Site, with a number of limitations noted which are described further below. Additional investigation/assessment work is needed to address these limitations and support the PCS process and regulatory compliance. GHD has indicated that a number of additional work streams are either being undertaken or will be undertaken which will potentially address the limitations noted.

In meetings between NZAS and ES and subsequent correspondence, NZAS has indicated that the DSI report should be considered as an Initial Investigation Report, as they are aware that additional work is needed in order to provide a comprehensive DSI report(s). To limit future confusion, it is recommended that the DSI report be re-titled as an Initial Investigation Report. The introduction of the report should note that the report was not designed to be fully compliant with the DSI requirements specified by the Ministry for the Environment's Contaminated Land Management Guidelines No. 1 Reporting on Contaminated Sites in New Zealand (MfE, 2021a) or compliance with the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011.

Supplemental submittals need to be provided to ES describing the nature and scope of GHDs additional work streams and NZAS's proposed programme of works to enable development of a DSI to meet regulatory compliance and potential closure requirements. As part of this submittal or the future DSI submittal, it is recommended that NZAS consider the following:

- A significant amount of historic and recent environmental assessment data exists for the Site and wider smelter complex area (prepared by third parties), this data and the NZAS environmental monitoring data needs to be integrated with the DSI data to build a robust conceptual site model (CSM) for the facility. This CSM will then provide a good foundation on which to plan and implement future environmental investigation work within the Site and wider facility area.
- The DSI report needs to include mapping of historical data and better inclusion of temporal data to demonstrate the progress that has been made in reducing emissions from the facility, fluxes of contaminants to the receiving environmental and remedial success. While much of this data is available in historic reports integration of this information into the DSI is a critical step in defining trends and potential risks.
- The exclusion of the landfill area and the SCL pad from the GHD investigation programme is a critical gap in the contamination assessment. In particular, groundwater flow and contaminant flux from the landfill area and the operational areas need to be assessed together and effects of discharges from all areas (cumulative effects) needs to be considered with respect to the receiving environment.

Consistent with the discussion above on GHD's additional work streams, a more detailed discussion is needed of data gaps and uncertainties and the additional investigation work proposed to address and support delineation of contamination and potential impacts to the receiving environment.

Critical to both this report and future DSI reports, GHD needs to utilise appropriate ecological screening criteria to evaluate the significance of potential contaminant exposure to the receiving environment (terrestrial and aquatic). EHS Support has identified appropriate screening criteria which have been provided as **Attachment B**. The DSI report needs to be updated and revised to incorporate these criteria and based on EHS Support's assessment additional investigations are required to enable completion of an ecological risk assessment for the Site and the receiving environment.

1. Introduction and Background

1.1. Introduction

EHS Support New Zealand Ltd (EHS Support) has been retained by Environment Southland (ES) to undertake a technical review of the following documents relating to the New Zealand Aluminium Smelters Ltd (NZAS) Tiwai Point manufacturing facility:

1. NZAS Closure Preliminary Study – Sampling and Analysis Quality Plan Summary (SAQP). GHD New Zealand Ltd (GHD). 7 April 2021.
2. New Zealand Aluminium Smelters Ltd. NZAS Closure Preliminary Study. Contaminated Sites Detailed Site Investigation (DSI) Report. GHD. August 2021.

The review work has been undertaken in accordance with the Umbrella Contract between ES and EHS Support, dated 2 August 2021.

This report outlines the results from the technical review of the two reports undertaken by EHS Support. The review was initially undertaken between 1 October 2021 and 10 December 2021. NZAS, ES and EHS Support undertook at Site visit on 16 December 2021.

Two key issues noted in the review were the absence of the Preliminary Site Investigation (PSI) report and limited integration of historical environmental data pertaining to the site into the DSI. EHS Support was provided with supplementary data from NZAS (via ES) pertaining to the manufacturing facility in November 2021 and the PSI was provided on 17 February 2022. Review comments pertaining to the PSI and comments on the supplementary data and Site visit have not been included in this review report.

Summaries of the key findings from the review of the two reports are presented in this report and a "by exception reporting" approach has been adopted to address deviations from what would have been expected within the reports. The technical issues raised with respect to the SAQP and the DSI and data gaps are summarised in **Attachment A** and will aid future investigation work.

The EHS Support review is presented in the report sections listed below and follows the chronology and format of the two GHD reports.

- **Section 2** – Sampling and Analysis Quality Plan Review Comments.
- **Section 3** – Contaminated Sites Detailed Site Investigation Report Review Comments.
- **Section 4** – Conclusions.
- **Attachment A** – Tabulated comments on each report (which have also been provided in Excel format) to aid discussions with NZAS/GHD on the DSI and subsequent investigation work.
- **Attachment B** –Assessment of relevant and applicable ecological screening values which is considered pertinent to assessment of the data presented in the DSI.

Section 2 and **Section 3** both contain two sub-sections. First are general comments, followed by specific comments structured around the headings within the SAQP and DSI, respectively.

1.2.1.2 Background and Context

Prior to and since operations commenced at the NZAS Tiwai manufacturing facility in 1970s, NZAS has undertaken a range of environmental monitoring work on and off the site to support resource consent applications, comply with resource consent conditions, and monitor environmental performance and discharges to the environment. It is understood that a majority of the results from this environmental assessment and monitoring work have been supplied to ES and in recent times NZAS has also made some of this information publicly available through their website.

To support closure studies of the NZAS manufacturing facility, ES was verbally informed by NZAS in late 2020 that additional assessment work was being undertaken on the site (augmenting historic contaminated land investigation and environmental monitoring work). The SAQP was provided to ES in April 2021, raw DSI data was supplied on 10 June 2021, and the DSI was supplied on 11 August 2021.

The stated objectives for undertaking the DSI are summarised below:

- Assess the presence and risk from potential contaminant exposure pathways identified in the PSI.
- Understand the spatial extent and depth of contamination that may require management, further assessment and/or remediation.
- Use this information to guide potential remedial options studies and trade off studies that encompass a range of options for rehabilitation of the site.
- To guide and inform implications for future resource consent status under the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NES-CS) and the Proposed Southland Water and Land Plan (PSWLP – ES, 2018).

EHS Support undertook an initial review of the SAQP and DSI in late August 2021, with ES and EHS Support meeting with NZAS on 30 August 2021 to discuss the initial findings of the DSI review and compliance with the PSWLP (notably Rule 46 – passive groundwater contamination discharges). This meeting discussed that a consent under Rule 46 would require a more detailed assessment of site contamination conditions to that presented in the DSI. In late September 2021 EHS Support commenced a formal review of the SAQP and DSI.

The PSI prepared for the NZAS facility, dated January 2021, is referenced in the DSI but was not supplied to ES with the DSI in August 2021. Rather, the PSI was supplied to ES in late February 2022 and so the review of the SAQP/DSI has been undertaken without reference to the PSI. This constraint has been noted in the DSI review. EHS Support has since reviewed the PSI and the findings will be presented in a separate document.

During the course of the SAQP/DSI review, NZAS also supplied a large number of historic contaminated site investigation reports pertaining to the NZAS manufacturing facility, off-site environmental monitoring reports, and reports on waste disposal facilities (notably the landfill and the spent cell lining (SCL) waste pad). A number of these reports are referenced in the DSI. These reports were received by ES in late October 2021 and have since been reviewed by EHS Support.

These historic reports provide invaluable information to support the assessment of site contamination. Unfortunately, it appears most of the data contained in these reports has not been fully integrated into the DSI findings. The SAQP/DSI review has not attempted to integrate this data into the review process.

In mid-December 2021, NZAS, GHD, ES and EHS Support were able to meet and undertake a site inspection which assisted significantly in providing an understanding of site operations. The ability to undertake a site inspection earlier in the year was hindered by Covid restrictions.

EHS Support issued a final draft SAQP/DSI review report to ES on 8 March 2022. This draft report was supplied to NZAS for comment and based on discussion between ES, EHS Support and NZAS on 11 May 2022 and written feedback from GHD (comments received 12 May 2022), this revised DSI/SAQP review report has been prepared.

A key issue to note from discussions with NZAS regarding the DSI, and the subsequent release of the NZAS Preliminary Closure Plan in March 2022, is that the DSI should be considered as an initial contamination assessment of the manufacturing site. The SAQP infers the aim of the DSI was twofold – to support the Preliminary Closure Plan and support regulatory compliance with the NES-CS and PSWLP. While the DSI report states that it aimed to provide an initial "snapshot" of the contamination status of the smelter domain, NZAS has acknowledged that the DSI report (as presented) provides a broad initial assessment of contamination conditions within the manufacturing plant area and that additional investigation work will be required to support remediation of the site and compliance with environmental regulations.

The reviewers are of the opinion there are distinct differences between an investigation that provides an initial snapshot of the contamination status of a site compared with a DSI that has been prepared in accordance with the Ministry for the Environment's (MfE) Contaminated Land Management Guidelines No. 1 Reporting on Contaminated Sites in New Zealand (MfE, 2021), particularly in terms of regulatory compliance (which was a stated aim of the SAQP).

On the basis additional investigation work is proposed for the smelter domain and wider smelter complex, the EHS Support review has also addressed issues that would be expected of a fuller contaminated land assessment of the site, particularly given the range of contaminated land issues that need to be addressed in the future.

2. Sampling and Analysis Quality Plan Review Comments

2.1. General comments on the Sampling and Analysis Quality Plan

The SAQP sets out in a logical high-level manner, through the use of figures and tables, the key likely contaminant sources, pathways, and receptors within the smelter domain. The absence of a detailed PSI limited the reviewer's ability to verify the approach/scope proposed in SAQP. However, based on EHS Supports knowledge of aluminium smelters and initial understanding of the aims of the SAQP, the investigation approach suggested would provide an initial independent high-level benchmark on contamination conditions within the smelter domain (acknowledging specific limitations, as listed below). The SAQP states the DSI is to investigate the smelter domain with the key investigation objectives being:

1. Investigation of the Site, assumed to be the smelter domain, and areas to the east (but not the landfill area) using a targeted approach that focusses on areas where historical activities have occurred with the potential to contaminated soils and groundwater.
2. Prepare a DSI report that complies with Regulation 3 of the NES-CS and to be provided to ES with respect to Rule 46A (a) of the PSWLP.

A number of omissions were noted within SAQP (on a by expectation basis) including:

a) A detailed process description including a discussion of the feedstocks, impurities in the feedstocks, recycling of materials, and changes in process that have occurred over time (unless this was to be addressed in the PSI). As part of this process, an example of key items that would need to be discussed for the carbon bakes would include:
    a. How have feedstocks changed over time? For example, pencil pitch was historically used before conversion to a liquid-based pitch. The chemical composition of these feedstocks is different.
    b. What has been the process for recycling of carbon or management of cathodised butts or wastes generated from the rodding process? There is reference in reports to ES of off-spec carbon materials being removed from these waste streams.
    c. How are liquids released from the pressing process managed in the green mill?

b) Integration of all data (including the landfills and data from other groundwater monitoring wells and hydrogeologic studies) into a conceptual hydrogeologic model for the Site. This Site is data rich and integrating all this data is a critical step in the PSI so that study questions can be defined as part of the Data Quality Objectives (DQO) process which will guide DSI activities.

c) There is a need for a better discussion of stormwater catchment areas and drainage lines (off-site runoff of contaminants is a key pathway that must be discussed) and there is no inclusion of historical stormwater and sediment monitoring data (to define the loadings and discharge of contaminants to the receiving environment). Also, a description of management activities (i.e., sweeping of yards, cleaning of catch basins and drains) and associated waste management activities is required.

d) A more robust discussion of current and historical waste storage area is needed. The SAQP Appendix has some notes on storage, etc. but this report and the DSI needs a detailed discussion on the history of SCL storage and treatment, including cathodised butt storage, bath storage, reuse of refractory bricks from the carbon bakes (which would be contaminated).

e) There is no discussion on where ingot casting is conducted, what the process involves and what wastes are generated in this process. As part of this process high temperature oils or hydraulic fluids may have been used and these may have historically contained PCBs.

f) In the switchyard and rectifier yards PCB containing oils would have been used. There are records that indicate that these PCB containing oils were removed and disposed in the on-site landfill. This needs to be confirmed. In addition to the switchyard, it is likely there are transformers located around the Site serving offices and other maintenance/engineering functions. These transformers also would have contained PCB containing oils and leaks would have occurred from these units to ground. A map showing all transformer locations and specifications on transformers (and oils used) is needed.

g) The documents describe the use of background samples in Table 1 but there is no mention of background samples in the text, or any rationale provided for the selection of locations and analytical suites. Key considerations in developing an assessment of background are: (a) the composition and fate of constituents and impurities in coke/carbon/pitch/alumina; and (b) the significance of air emissions (dust and gases) and (c) prevailing wind directions and wind rose assessment.

In this context, the SAQP needs to be amended or use the PSI to present details on processes with supporting maps and additional clarity provided to the document. For example, the words site, Site, plant, and Smelter are used interchangeably within the SAQP with no definitions. It is not clear if this is an intended distinction between operational areas vs. non-operational areas, or some other parcelling. In this context, and to support development of a conceptual exposure model areas of controlled and public access need to be better defined. Is the entire Site (including landfills) fenced to preclude public access? Are any grazing activities conducted on NZAS land or abutting properties?

Section 1.1 states that the SAQP will be used to support the DSI of the NZAS facility and that the DSI is being completed as per the requirements of Regulation 3 of the NES-CS. On this basis, the SAQP should reference and comply with the requirement of CLMG No. 1 and CLMG No. 5 Site Investigation and Analysis of Soils (MfE, 2021b). There is also other standard guidance available in New Zealand and overseas that the SAQP should reference (given the significance and complexity of the investigation and the Site), specifically potentially relevant regulatory criteria which is included in **Attachment B**

2.2.Section Specific comments on the SAQP

The sub-headings within this section refer to the relevant headings with the SAQP.

Section 1.3 Sampling Limitations

The SAQP notes that the electrical switchyard and main potline buildings could not be accessed. For the electrical switchyard, additional information is needed including (a) a discussion of polychlorinated biphenyls (PCB) use, (b) when PCB oils were replaced, and (c) where stormwater drainage from the switchyard goes. In the context of (c), the absence of PCB testing in drainage lines from the switchyard is a critical omission.

While the activities within the pot rooms are unlikely to be sources of contamination, releases outside the pot room (such as via air emissions) can be sources of contamination. There is no discussion on the construction of the pot rooms, if there is under pot material (UPM) which can be deposited below elevated floors of the pot room or contaminants can enter the courtyards between the pot lines. Are there centralised courtyards between the pot lines where this UPM can be accessed and is there drainage in the courtyards? What is being done to prevent UPM and wastes getting into the stormwater system? How is UPM or materials falling out of the pots currently being handled/managed? What are the fume recovery systems and how are these being materials managed/recycled back into the smelting process?

Section 2 Sampling Locations and Rationale

This section does provide a systematic framework for assessment of the Site by dividing the Site up into 13 investigation areas based on an assessment of sources provided in Contaminated Land Register (Appendix B) with locations shown on figures within Appendix A.

Consistent with the comments provided above on the SAQP, it is critical that soil boring and well locations be associated with areas of historical and current interest. Review of historical reports and aerial photographs identified numerous locations of potential interest that should be considered for assessment as part of the DSI. Further, the Contaminated Land Register provided in Appendix B does not reference any historical investigation data or field observations. Requirements for additional soil and groundwater investigations can only be provided once the PSI (as described above) is provided to ES and inherently sample locations should have been biased towards areas of (a) historic impacts (b) areas of known releases (c) stormwater flow lines (d) areas proximal to release areas or waste storage areas and (e) other field base observations that indicate that this is an area of higher potential impacts.

Section 2.3 General Site Contaminant Coverage

In this section of the report, it notes that herbicide application is an exception to a common activity. It is recommended that this sentence be reworded for clarity.

Details of the specific herbicides used, and duration/extent of application is needed. Also, discussion should be provided on whether other pesticides or poisons (rat poisons, etc.) have been used at the Site.

Section 3 Field Methodology

The field methodologies described by GHD generally align with the standard best industry practices.

Section 3.3 Sediment Sampling

The methods to collect sediments seem inadequate and not thoroughly thought out. Further information is needed on:

1. How discrete sediment intervals are sampled without contamination from overlying water if the sample was collected with a hand auger or shovel?
2. Why acrylic core liners and coring methods were not used exclusively?
3. What was the homogenisation procedure?
4. How were volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) sampled versus metals?
5. De-ionised water alone is not sufficient for decontamination between samples. Why alconox (or equivalent) was not used needs to be explained.
6. What sediment lithology information was collected?
7. A detailed sediment sampling program is needed in line with the considerations outlined in Australia and New Zealand Environment Conservation Council (ANZECC, 2000) and the subsequent 2018 revision of this guideline (hereafter referred to as Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) with relevant generic criteria described in **Attachment B**.

Section 3.5 Groundwater Gauging

In the context of the groundwater gauging methodology the following is noted:

1. There is no mention of plans to collect water level and sampling data at a specific point in the tidal range. Based on the potential tidal effects on groundwater levels and flow this is a critical consideration.
2. There is no discussion on salinity and density corrections for groundwater heads at the Site. Saline water has a higher density that fresh water and density corrections may be required based on differences of salinity/electrical conductivity across the Site. Purge records (electrical conductivity measurements) should be reviewed to determine if this is required.
3. There is no mention of methods to correct water levels if light non-aqueous phase liquid (LNAPL) is encountered.

Section 3.6 Groundwater Sampling Methodology

In terms of the groundwater sampling methodologies, it is critical to implement standardised methodologies for sampling. This includes both where within the screened interval samples are collected, and the method(s) used for collection of groundwater samples. Information on the screen intervals for many of the NZAS wells sampled appears not to be known – which brings into question quality and representativeness of the samples collected from these wells. Also, the age and state of the well (including well heads) was not discussed. It is common with old wells that they should be redeveloped/repaired prior to sampling and in some cases may be in such disrepair that sampling is not recommended.

The following is noted in terms of the sampling methodology:

1. There is no discussion on well inspection, repairs, and redevelopment (if required) for old/existing wells.
2. At the periphery of the Site a saltwater wedge may be present. If present groundwater samples should be collected from the upper interval of the well (the freshwater lenses). Discussion is needed to discuss how sampling methodologies will be modified in areas with and without saline intrusion.
3. There is no mention about the need to (or not) for collecting samples at a specific point in the tidal cycle or how this might be verified. For samples at the periphery of the Site
4. There is no discussion on how flow rate was determined during sampling. Was drawdown monitoring a criterion used for establishing sampling flow rate?
5. The SAQP needed detailed procedures to ensure per-and polyfluoroalkyl substances (PFAS) sampling is conducted appropriately, and cross contamination does not occur.

Section 4 Analytical Suite and Analysis Methods

Detailed justification for the analytical suites is needed. The following constituent groups needs additional explanation:

- Metals – please select a constituent suite that is aligned with known constituents of potential concern (COPC) linked to aluminium feedstocks and/or residual wastes. For example, Ba, Fe, Ti, Li, and other notable metals do not appear to be analysed. There is no discussion on or information pertaining to the source of alumina and associated impurities. This is an important source of metals and the listing of metals included in the analytical suite needs to align with contaminants likely to be present in the alumina.

- Organics – the analytical suites look appropriate; however, it does not appear that total organic carbon (TOC) (or dissolved organic carbon) was analysed across the Site. This is critical for TOC normalising benchmarks when ecological risk assessments of media are conducted.
- Cyanide – the cyanide methods do not align with the reported results in the report. Weak Acid Dissociable (WAD), free and total cyanide measurements are needed because only WAD cyanide is currently reported for groundwater and only free cyanide is reported for soil and sediment.
- Fluoride – what soluble fractions of fluoride were measured in soils and sediments? Please consider analysis of both total and soluble fluoride in these medias.
- PFAS – the sampling program and methodology seems incomplete and inadequate across all matrices. Rationale needs to be provided as to why PFAS compounds were not analysed in areas where PFAS was stored and/or potentially used.
- Cations and anions - It is not clear if cation/anion samples were field filtered and why turbidity was not included in field parameters.

Section 5 QA/QC Control Sampling

In review of the QA/QC control sampling methodology the following comments are provided:

- In Section 5.2.1 why were samples 'selectively' analysed for different parameters? This section needs to explain what criteria and data quality objectives were used to inform the selection process.
- The first sentence of Section 5.2.3 should be re-written as the meaning is not clear.
- Section 5.2.4 should detail the source of the rinsate blank water. Also, 'accompanies" should be "accompanied".

Appendix A Figures

The figures provided are of good quality, however key features of the Site need to be better highlighted including historic operational areas, catch basins, stormwater channels, potential known source areas and other waste management areas of interest.

The aerial photograph on Figure A2 shows a significant amount of phytotoxic stress and/or variability in plant growth. Some of these areas have been sampled and others not. The report needs to discuss these observations and address atmospheric deposition as a source of fluoride impacts to surficial soils.

Appendix B Zone Contamination Register

As noted in the general comments above the Zone Contamination Register is a good summary of activities but lacks important information on historic operations, stormwater management and historical investigations (and associated contamination conditions). This register should be updated as part of the PSI process to include this key information.

Other key comments by area are provided below:

- Zone B – there is no discussion on possible stormwater flow to the south into the abutting natural landscape. Sampling needs to be conducted around the periphery of this area.

- Zone C – there is no discussion on solvent usage in the workshops. Chlorinated solvents (such as tetrachloroethylene [PCE] and trichloroethylene [TCE]) have been detected at other smelters associated with maintenance and repair activities and should be considered as a COPC unless proven otherwise. In addition, the table notes a current firefighting practice area. Were there other similar practice areas? Was the only other former area ID77 in Area E?
- Zone F – the table notes the use of Heat Transfer Fluids (HTFs). What type of HTFs were being used. Many historical HTFs comprise oils containing PCBs.
- There is no reference to a grit blast building for cleaning the pots. Where is/was this located and how is dust and debris managed to mitigate releases to the environment. How does this area correspond to the old processes (including methods using water) and where were these processes undertaken?
- Zone J – there is reference to removal of contaminated sediment in the drains. Are there any reports of these activities and how were these waste materials managed? This suggests that discharges of contaminated sediment were occurring to the receiving environment and the table needs to discuss this as aluminium, cyanide and fluoride are known aquatic toxins and these contaminants as well as polycyclic aromatic hydrocarbons (PAHs) and other metals can result in impacts to benthic communities.

3. Detailed Site Investigation Review

3.1. General Comments on the Detailed Site Investigation

The DSI undertaken by GHD comprised a targeted investigation of the smelter domain which covers a very large area (approximately 92 ha) and comprises the main manufacturing area of the NZAS facility. The media investigated comprised near surface soils (maximum targeted sample depth – 3 m, with some samples collected at 4 m) and groundwater and sediment within the three main smelter stormwater drains. The DSI achieved the investigation aims of providing a "snapshot" of contamination conditions within the smelter domain and serves as an initial benchmark of likely contamination conditions within this study area. The DSI report (as presented) provides a good basis for scoping additional contaminated land work programmes to meet the NZAS Closure Plan objectives and regulatory compliance. The DSI report does not address the requirements of a full DSI of the Site area (as per Regulation 3 of the NES-CS) and additional investigation work will be needed to support a consent application lodged under Rule 46A(a) of the PSLWP.

A summary of the key findings from the DSI are listed below:

- The underlying geology and hydrogeology comprises a shallow unconfined aquifer system, with groundwater described as being potentially present in two discrete systems (sands and gravel unit and medium to fine grained sand unit) which are in hydraulic communication with one another and the marine environment.
- Waste materials and off spec feed stocks stored on-site should be characterised in the context of the Site closure and risk to ecological receptors.
- Significant areas of soil contamination were encountered in select areas of the Site, notably the Inalco area where approximately 8% to 16% concentration fluoride recorded in surface soils.
- Elevated concentrations of fluoride, aluminium, arsenic, and PAHs were recorded in groundwater (along with other elevated trace element concentrations).
- Sediment contamination within the drains should be addressed within the context of ecological receptors in the receiving environment. Elevated concentrations of fluoride, aluminium, PAHs, and heavy metals were recorded in sediment. Additionally, the rationale for sediment analytical suites should be included.
- Ecological screening criteria should be considered for the sampled matrices (groundwater, soil, and sediment). The screening criteria that were considered in the DSI is not appropriate for assessing risk to ecological receptors. Ecological risks and impacts to the receiving environment were not appropriately characterised.
- Not having the PSI available constrained the review of the DSI in that it was not possible to assess the presence of risk from potential contaminant pathways identified in the PSI.
- The absence of an assessment of NZAS temporal groundwater data and review of historic data limited the ability to support our to understanding the hydrogeologic conceptualisation for the Site.

As part of the PSI process, it would be expected that historical investigations and groundwater and stormwater/sediment monitoring data would be collated and summarised and used to develop a preliminary CSM of the wider NZAS manufacturing complex. In preparing the DSI, a chronology of investigations and detailed discussion of the results and findings and the CSM needs to be better leveraged to aid in the assessment of the nature and extent of impacts and identification of data gaps and uncertainties.

It is recognised that numerous data sets and reports are referenced in Appendix E of the DSI. However, this information has not been collated and mapped in the report to aid ES in their review and assessment. Notes in the table make clear reference to historical issues and data collection. It is imperative for the DSI (and future assessments) that areas of historic impacts are re-assessed and an evaluation of changes in contaminant concentration over time (detailed in historical information) be incorporated into future documents

From review of the information contained within the SAQP terrestrial, avian, and aquatic receptors are present on the Site and within the abutting receiving environment. From review of the DSI, ecological risk and impacts to the broader receiving environment were not appropriately characterised or captured in the DSI (as presented). While complete exposure pathways were documented, no effort was made to identify specific terrestrial/avian and aquatic receptors that could be at risk (including fish and shellfish gathering). It is understood that additional studies are being undertaken to address these issues. Detailed assessment of what receptors could be affected by potentially complete exposure (current and future) needs to be conducted to ensure that the soil and sediment sampling depths align with exposure scenario/receptors and the biologically active zone (BAZ). The selected sampling program does not state how it was designed to specifically test exposure conditions that could be potentially complete under current and future scenarios.

Review of the DSI identified several crucial data gaps in GHD's groundwater and surface water assessments. A systematic assessment of mass flux to aquatic receptors (stormwater/groundwater) is needed to demonstrate the presence/absence of unacceptable risk to aquatic/benthic receptors and determine if remedial actions are required (particularly with respect to compliance with Rule 46A(a) of the PSLWP). Additionally, the groundwater analytical suite did not include important parameters that aid in the analysis of data and risk. Discussion of the geochemistry results in the context of the hydrogeological CSM is also warranted. A critical data gap is the configuration of the groundwater divide that must be located between the landfill and main plant. The location of this groundwater divide and how it responds to daily or seasonal variations in groundwater flow is critical for understanding mass flux and contaminant transport mechanisms. The influence of daily (tidal) effects on the groundwater system is presently unknown and constitutes a major data gap in the CSM. This should be addressed in subsequent hydrogeological and contamination assessments.

This data gap is exacerbated by the limited use of historical data to support the hydrogeologic conceptualisation and the absence of any technical assessments that integrated this data with the information obtained from the numerous wells and borings installed by GHD. Without a conceptual hydrogeologic CSM, the spatial distribution and stratigraphic relationships of geologic units cannot be estimated. This data gap precludes effective implementation of future sampling efforts, if required, and development of robust groundwater flux models. In the context of groundwater flow, there is also no mention of precipitation or infiltration, which are essential elements of a hydrogeology discussion. This should be addressed in subsequent assessments that discuss groundwater velocities at the Site, spatial and temporal variations in groundwater gradient and assumptions/data sources for hydraulic conductivity data and effective porosity.

In the context of impacts within the receiving environment, sediment should be considered as a separate media and presented in a separate sub-section within the report. As part of this section a detailed rationale for the sediment analytical suite needs to be provided for each drain feature. We note significant omissions of important constituents as well as critical co-factors (e.g., grain size, total organic carbon (TOC), etc.) that would permit appropriate sediment assessment and evaluation of potential risk to ecological receptors. Rationale for exclusion of contemporaneous surface water sampling with the sediment investigation is needed. Moreover, any available aqueous data that exists for the drain features should be included within DSI or PSI. Additionally, the methods to collect

sediments seem inadequate and not thoroughly thought out (acknowledging it was an initial investigation). A detailed sediment sampling program is needed in line with the considerations outlined in Australia and New Zealand Environment Conservation Council (ANZECC) Australian and New Zealand Guidelines for Freshwater and Marine Water Quality (ANZECC, 2000) and the subsequently revised guidelines Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018).

As part of the assessment of data, relevant and applicable ecological criteria need to be identified and used for screening. The omission of these criteria makes the analysis contained within the report flawed. **Attachment B** provides a preliminary assessment of relevant and applicable generic criteria. Rather than use other internationally accepted sediment guidelines, the document uses Australian National Environmental Protection Measure (NEPM) and the United States Environmental Protection Agency (USEPA) soil human health guidelines which are not designed to be protective of aquatic or terrestrial receptors. The groundwater criteria currently being applied does not consider discharge of groundwater to surface water and the maintenance of aquatic ecosystems. ANZECC 2000 and ANZG 2018 aquatic ecosystem and other international criteria are needed to assess the potential for unacceptable risk to the aquatic environment from this discharge as well as other community values, such as cultural and spiritual values, drinking water, industrial water, primary industries, recreational water, and aesthetics.

Lastly, atmospheric deposition from the smelter is a contaminant transport pathway and the assessment of background conditions as described in the DSI needs further work and should be addressed in future studies. The predominance of westerly winds means that the peninsula will be subject to atmospheric deposition from the plant. No systematic assessment or reference to historic atmospheric deposition studies was provided in the DSI and as such the impacts of atmospheric deposition on soils within the Site and abutting sites could not be completed. The background locations included in the DSI appear to be located downwind (to the east) of the plant and therefore are likely unsuitable as background sites. Assessment of atmospheric deposition from the Site using soil data will require more extensive near surface sampling, the sampling on longitudinal transects and the use robust statistical assessment methods to define impacts relative to background.

3.2. Specific Comments on the DSI

The subheadings within this section refer to the relevant headings with the DSI.

Section 3.1 Introduction

The document references a CSM that was developed as part of the PSI. From our review of the SAQP this document only discusses possible sources by area. It is anticipated that the PSI may address this comment and this comment should also be considered prior to finalisation of the DSI.

A CSM must discuss sources, pathways, and targets (receptors) and through this process identify relevant and applicable screening criteria, define investigation locations downgradient of sources and consider historical data that will inform collection of data on the fate and transport of contaminants. This was not adequately completed in the SAQP, and inherently major uncertainties and data gaps remain (most notably in the characterisation of groundwater conditions and impacts).

Sections 3.3, 3.4 and 3.5 Landfill, Smelter, Peninsula and SCL PAD Preliminary CSMs

The CSM provided in the text and the documents in Appendix K and L appropriately separate terrestrial/avian and aquatic receptors. A fuller DSI (or other ecological assessment) needs a detailed summary of what terrestrial receptors could be affected by the potentially complete exposure pathways under current and future conditions.

For the terrestrial environment, the potential receptors need to be defined and better assessed in terms of current and future exposure conditions. For example, at other smelters the majority of impacts on herbivores were associated with atmospheric deposition and fluoride accumulation on foliage. One important consideration is that the soil depth needs to be aligned with exposure scenario/receptors (the biologically active zone [BAZ] is likely limited to the top 100 mm -150 mm at this Site). The BAZ in the environment should be defined as a part of future scopes of work.

In addition, a systematic assessment of mass flux to aquatic receptors (stormwater/groundwater) is needed to demonstrate the presence/absence of unacceptable risk to aquatic receptors and determine if remedial actions are required and/or address regulatory compliance.

Section 4 Scope of Work

As a general comment, sediment sampling should be a separate sub-section and provide detailed rationale to the analytical suite selected for analysis in each drain feature. We note significant omissions of important constituents as well as critical co-factors (e.g., grain size, TOC, etc.) that would permit appropriate sediment assessment.

Section 4.1 Soil Investigation

The shallow soil sampling depth of up to 0.2 m is not a surface sample and therefore may not be appropriate for assessment of atmospheric deposition and impacts to terrestrial receptors from incidental contact and ingestion. For livestock the majority of fluoride uptake is associated with ingestion of foliage and atmospheric deposition of materials onto the leaf surfaces. In future assessments a description of how the selected sampling program was designed to specifically test exposure conditions that could be potentially complete under current and future scenarios is warranted and necessary.

Significant areas of the Site were not evaluated such as the eastern portion of the Zone J – Composite Contractors Group (CCG) Yard. Details of the historical use of this area are needed as aerials from the 1980s indicate significant industrial operations in the portion of the zone that is currently grass.

Section 4.2 Groundwater Investigation

The use of low flow groundwater sampling methodologies is an excellent approach to limit total suspended solids (TSS) and turbidity in samples. Despite this it does appear that some solids impacted on aluminium results with aluminium concentrations above solubility limits in groundwater. These poor-quality results may be a function of well construction and/or age and as noted in the comments to the SAQP a detailed assessment of well construction/integrity etc. should have been conducted prior to sampling to determine the suitability of the well and if well redevelopment was required.

In addition, the groundwater analytical suite did not include important parameters that would aid in the analysis of data and risk. This includes and requires consideration of:

a) TSS – a number of the aluminum values are above the solubility limits. This could be a function of fine colloids (post filtering) in the samples.
b) The analytical suite did not consider incorporate key ameliorating factors (Toxicity Modifying Factors) such as hardness and alkalinity which will be important for metals and fluoride toxicity evaluations in the groundwater to surface water exposure pathway.
c) The testing did not include all forms of cyanide (free/total and WAD).

Detailed justification for all analytical suites selected and how the selected constituents align with known operations (e.g., why does the metal suite does not contain metals known to occur as impurities in alumina or core constituents in dross, spent cell liners (SCL), or other residual wastes?) needs to be provided.

Section 5 Field Programme

Numerous descriptions of visual observations of windblown coke, alumina and cryolite were noted within the DSI. These observations are consistent with typical operations at aluminium smelters. These materials lying at surface across the Site area when combined with stormwater runoff are a major source of mass discharge to the receiving environment. It is important in the assessment to note the locations where these waste/process materials are present and sample the materials to confirm known migration pathways.

While a downwind transect was completed for the Site (and considered background locations in the DSI) no detailed assessment of constituent fate and transport along that gradient was considered. A rigorous assessment and analysis of known downwind transport pathways is needed to adequately consider atmospheric deposition and fugitive dust transport pathways on and off-site soils and foliage. NZAS has indicated in subsequent discussion that atmospheric deposition studies have historically been completed but this information was not provided with the report. The inclusion of historical data and assessments combined with more recent data would considerably improve the understanding of atmospheric deposition at this site.

In addition, the text and reports need to be better linked with the visual observations from the field team and the analytical results. Sometimes, affirmative language is provided telling the reader an area was sampled for a particular reason but in other areas the language is vague. Later in the report there is a need to associate/cross reference the analytical results with the areas of “worst” visual evidence of potential contamination to emphasize the source, transport, receptor model. Further, in Zone D, the presence of significant coke and alumina in the drains (in combination with sediment sampling data) indicates that discharge of materials in stormwater is a very important pathway which may impact on the receiving environment. The absence of appropriate sediment screening values for aquatic and benthic organisms is therefore a critical omission from the report with Al, F, CN, PAHs, and PCBs all important constituents that may pose risks in the receiving environment.

To facilitate assessment of data, it is generally recommended that paired analysis of sediment and surface water samples are completed within the stormwater drainage systems and receiving environment. GHD did not conduct the assessment in this manner, and it is recommended that future aqueous assessments align with the sediment parameters. In addition, NZAS/GHD should include an assessment of historical stormwater monitoring data that may exist for the drain features to support an assessment of ecological risks.

Section 6 Geology, Hydrogeology and Hydrology

As noted above, the exclusion of select areas from the assessment and the limited use of historical data is considered a critical omission in the preparation of the DSI and should be addressed in future studies. Much of the report references historical work completed by Woodward Clyde New Zealand Ltd in 1994 (Woodward Clyde, 1994) but does not effectively integrate findings of the historical reports with the new Site data into a comprehensive assessment. This information is needed in order to build out a robust hydrogeological CSM.

As part of NZAS on-going assessments, a more robust geochemical evaluation needs to be completed. It is noted that five groundwater samples were tested for a comprehensive suite of inorganic geochemical parameters, and several samples for a more limited suite of geochemical parameters. However, no analysis or discussion of this data is included within the report and should be addressed in future studies.

Other key comments include:

- The testing did not attempt to align aqueous sample with their relevant fractions (suspended solids/dissolved constituents) for risk screening. It is recommended that future studies design an analytical program that includes both total and dissolved fractions when relevant for the purpose of better understanding dynamics between fractions. The United States Environmental Protection Agency (USEPA) risk screening levels (RSLs) should be screened against total fractions, not dissolved/filtered.
- No verification or documentation of instrument calibration is provided. Field parameter measurements cannot be considered representative without calibration verification.
- A comprehensive well construction table with (at minimum) coordinates, elevations, screen intervals, screen units and well integrity is absent from the report. This table should include all existing and new well details. This information is imperative, particularly for the older NZAS wells, to provide confidence in the quality of the samples being collected (in particular sample depth and well screened interval).

Section 6.1.1 Smelter Geology

Figure 6-1 within the geology section highlights the use of fill in a depression at the Site. Future assessments needs to consider the following issues associated with the depression and associated fill materials:

1. What is the importance/significance of this feature in terms of contaminant migration?
2. Where were these fill materials noted/observed during the investigation and what did the observations comprise?
3. When were fills deposited?
4. Inclusion of this feature on the investigation maps and a discussion of the physical nature of fill and analytical results within and outside this feature should be considered.
5. Figure 6-1 shows seeps W1 and W2 but these are not discussed in the document. The presence of seeps and historical monitoring data is very important as this is a direct pathway to environmental receptors. Sampling of these areas is recommended and discussion on the continued presence or absence of these seeps should be included in the document.

Section 6.1.2 Smelter Hydrology

The figure provided in the Appendices to support this discussion does not show the catchment and surface topography. Future studies will need to define surface water catchments as well as

stormwater infrastructure and services to assist in developing the hydrogeological CSM as well as supporting the identification of sources/processes contributing to the detection of contaminants in surface water and sediment discharges from the facility.

Based on atmospheric deposition from the plant and other ancillary activities (bath management, etc.) and the observations of alumina, coke and debris on the ground surface, runoff of contaminants from the Site is a critical mode of transport. Not all stormwater will enter drains and sheet flow will go to soakage in select areas of the Site resulting in impacts to soil and groundwater. A Digital Elevation Model or similar with flow paths and flow accumulation lines would aid the reader.

Further, as noted in the general comments given the importance of this mechanism for contaminant discharge to the environment, stormwater data for the outfalls needs to be incorporated into the future reports. Interpretation of sediment data would be aided with paired surface water sampling data.

Section 6.1.3 Smelter Hydrogeology

Key comments concerning the smelter hydrogeology which should be considered and addressed in future reports (including the final DSI report after additional data is collected) includes:

- The report states that "Woodward-Clyde concluded that a number of different interpretations could be made based on the scattered water level data…". The same comment is true of the 2021 water level contours produced by GHD, and this should be acknowledged and assessed in future studies.
- The Figure 6.2 images are of low quality and well names are not possible to read. A discussion is missing on which wells Woodward-Clyde used in their assessment and whether all of these wells still exist on-site or were abandoned.
- Figure D1 Piezometric Contour Map is a key map referenced in this section however there are a number of inconsistencies that need to be addressed including:
  - The depiction of a groundwater 'sink' at C_MW-_B14 is unlikely unless there is knowledge of infrastructure or other geologic features to support the observed pattern at this location.
  - Most groundwater contours are drawn perpendicular to the coastline. This suggests the groundwater system is isolated from the surrounding estuary and ocean. This has not been verified and is not supported by the Site geology. Contours should be parallel to the coastline.
  - A critical data gap is the configuration of the groundwater divide that must be located between the landfill and main plant. The location of this groundwater divide and how it responds to daily or seasonal variations in the groundwater system is critical for understanding mass flux and contaminant transport mechanisms.
  - There is no discussion on why it is appropriate to include water levels from Well No. 15 (total depth >30 m) in contouring of the remainder of wells that have total depths generally around 5 to 8 m. A co-located well here would provide the means to establish vertical groundwater gradients. Lack of vertical groundwater gradient data at several locations is a data gap.
  - It should be verified that monitoring well locations listed in the table on page 136 align with the locations plotted on this figure.
  - It appears data from some of the 13 historical wells are missing from the figure.
- The influence of daily (tidal) effects on the groundwater system is presently unknown and constitutes a major data gap in the CSM. The tidal range immediately adjacent to the Site

encompasses the range of groundwater elevations reported by Woodward Clyde for 1992 and by GHD in this report. Mention of marine influences on the groundwater system is restricted to a couple of very minor comments on pages 43 and 88 and should be addressed in future studies. Additionally, seasonal variations in the groundwater system are not captured by a single monitoring event from the expanded well network and temporal data is needed. At minimum, a conductivity-temperature-depth (CTD) transducer study should be implemented to define temporal shifts in the groundwater system and marine mixing contributions.

- Water levels were only measured on a falling tide, and this has implications for all subsequent groundwater flow and hydrogeochemical conclusions, which should be acknowledged and addressed in future studies. Specifically, if there is a tidal influence:
  - Groundwater gradients (Table 6-1) would be approaching a daily extreme, and all subsequent mass flux and contaminant travel time estimates would be exaggerated and should be flagged with high bias.
  - If samples were also collected on a falling tide and there is marine influence, groundwater chemical character may reflect regional groundwater, and contaminant loading would represent an extreme that is undiluted by any infiltrating marine water. Thus, contaminant flux estimates based on samples collected during a falling tide should be flagged with 'high bias', if there is appreciable marine mixing.
- In paragraph 6 it is noted that the "Contours show a much flatter gradient across the centre of the smelter which coincides with areas of sealed surfaces where infiltration is reduced." No doubt infiltration is reduced in paved areas. However, not everywhere are gradients flatter beneath paved areas, indicating that there are elements of the groundwater flow system that are not presently understood. This should be addressed in future studies.
- With respect to Table 6.1 the groundwater gradients reported here should be considered meaningless until diurnal/tidal effects are assessed. In addition, it is not clear how calculated groundwater gradients (or the piezometric surface map) relate to the screened intervals of wells. No discussion or assessment is provided on the similarity (or differences) in groundwater elevations in wells with different screened intervals/depth ranges.
- A number of Grammatical or syntax errors were identified in section 6.1.3 including:
  - Under the 4th bullet, 'mapped' should be 'maps'.
  - In paragraph 2, "Dips' should be replaced with 'depths'.

Section 6.1.4 Smelter Discharges

This section would benefit from a figure to conceptualise the discharge and infiltration locations discussed. The word ‘infiltration’ should be considered for inclusion in the title. There is no mention of the implications of infiltration for groundwater elevations and groundwater constituent concentrations, which constitutes a data gap in the context of the DSI report.

Section 6.2.1 Peninsula Geology

This section on peninsula geology lacks discussion of the geological processes that formed the peninsula. There is no integration of information obtained from the numerous wells and borings installed by GHD and the historic investigations. Without a conceptual geologic CSM, the spatial distribution and stratigraphic relationships of geologic units cannot be estimated. This data gap precludes effective implementation of future sampling efforts, if required, and development of robust groundwater flux models.

Section 6.2.2 Peninsula Hydrology

There is no mention of precipitation or infiltration, which are essential elements of a hydrology discussion.

Section 6.2.3 Peninsula Hydrogeology

This section should consider how the results for the groundwater flow velocities, etc. from the GHD groundwater assessment compared to the former Woodward Clyde data. There is no integration of data from the GHD work effort.

A critical data gap in the groundwater velocities that are presented are possible variations in the groundwater gradient, and assumptions/data sources for hydraulic conductivity data and effective porosity.

Section 6.3.1 Landfill Geology

As a general comment, there is published literature on the structure, geochemistry, and nature of bedrock at Bluff and Tiwai Point that could be incorporated to strengthen the landfill CSM. This information should be considered in the assessment of the landfills when undertaken. Other comments include:

- In paragraph 2 there are several grammatical errors that require attention.
- Paragraph 3 comments on the structural characteristics of the bedrock underlying this area should be documented and verified beyond the statement 'poorly fractured'. The structural nature of bedrock is a key element of the landfill hydrogeological CSM and constitutes a data gap.
- Paragraph 4 comments on the elevation of bedrock beneath the landfill and this should be verified through review of historical Site reports and data, or by direct investigation. The elevation/configuration of bedrock beneath the landfill relative to sea level is a key data gap.

Section 6.3.2 Landfill Hydrology

As a general comment, a watershed map of the landfill area, and Site in general, is lacking in the hydrology assessment. This data gap should be addressed in future studies to better understand the locations of infiltration divides and planning for future infrastructure design, if needed.

As noted in routine monitoring reports for the Site there are areas of the Site where waste materials (off-spec carbon and old refractory bricks) are present at surface. These waste materials will contain leachable constituents and infiltration, ponding and stormwater flow from these areas will be important contributors to impacts in the area. In this context the outfall and configuration of the drainage/peripheral ditches should be clarified.

Section 6.3.3 Landfill Hydrogeology

Paragraph 2 states that groundwater recharge to the north of the landfill is inconsistent with 2001 groundwater contours. Some comparison or assessment of this statement by Woodward-Clyde is warranted in light of the GHD data. As part of this process more recent groundwater monitoring data for the landfill areas and temporal changes in groundwater levels should be evaluated and included in the discussion.

Section 6.3.4 DSI Findings

Consistent with the comments above, the inclusion of groundwater elevation data from the landfill piezometer/groundwater monitoring well network and use of geochemistry data would greatly strengthen the hydrogeological conceptual model. This also could include assessment of differences in groundwater electrical conductivity (and associated density), tidal effects (possibly with the use of pressure transducers) and other tools to aid in the conceptualisation of groundwater flow over the domain that comprises the peninsula.

In terms of geochemistry data, Section 9.4.1 of the DSI states that "the chemical results can be assessed to determine the hydrochemical facies of the water". Plotting of the results from the five samples show they cluster closely within the area known as 'Sodium Chloride Type'. This is typical of a regime with rapid recharge and coastal saline groundwater influence." This information (marine contributions) is critical for consideration in the hydrogeological CSM and will require further assessment in subsequent studies. Note, other samples are provided for which chloride and sulphate were analysed. There is an opportunity to use these analytical results to strengthen the hydrogeological CSM.

Please note as part of the geochemistry assessment that Well 15 is technically a mixed or Ca-Cl water type, although plots close to a NaCl type.

Section 7 Regulatory Overview and Screening Criteria

Section 7.2 Guideline Selection Summary

Consistent with the comments provided in the overview above, limited to no consideration of ecological receptors was provided in the DSI in terms of selection and use of appropriate screening criteria. **Attachment B** provides our assessment of relevant and applicable criteria for soil, groundwater, and sediment.

The absence of a thorough assessment of relevant and applicable criteria and specifically identification of appropriate criteria to assess ecological risks invalidates much of the assessment and discussion provided in Section 9 of the report.

Section 7.2.1 Soil

This section and Table 7-1 have an anthropogenic focus. Few ecological criteria have been selected and used in the screening process. This is despite the CSM (included in Appendix L and K) clearly identifying terrestrial and marine fauna and flora as being potentially exposed and the pathways being determined to be complete.

In the context of current conditions, there is natural habitat around the periphery of the Site and in a future recreational development scenario additional habitat would be present on-site.
Relevant and applicable ecological criteria need to be identified and used for screening. The omission of these criteria makes the analysis contained within the report flawed. Additional comments are provided below that outline potential relevant and applicable criteria for ecological receptors. Presented in **Attachment B** are examples of relevant and applicable ecological criteria that were identified through a hierarchical approach.

In terms of Table 7.1, the hierarchy of screening criteria does not include relevant ecological screening criteria. Guidelines are predominately selected for human health criteria except for PFAS

criteria which includes ecological screening values, which is inconsistent with the rest of the approach. There is also no rationale listed as to why the analytical suite listed was selected (no reference to the CSM), in particular the following issues are noted:

- USEPA guidelines adopted are not suitable to evaluate ecological risks.
- Inclusion of "background" as a guideline is not appropriate as the locations analysed as background are likely influenced by the downwind positioning of the Site. Failure to thoroughly assess this is discussed above and requires further consideration in future studies. Further, "trace elements" needs to be specified – what constituents/analytes were compared to background?
- Hydrocarbon screening does not match what is listed in guidance table and it is recommended that direct contact/ingestion criteria be compared to vapor inhalation criteria.
- There is a misalignment between what is listed in the table as a guideline and what is presented in the appendix screening tables notes (wrong tables are cited).
- No rationale for using USEPA RSLs is provided, and no indication of Total Hazard Quotient (THQ) used to derive criteria and why. We recommend screening soil samples against human health and ecological criteria. A suggested criteria hierarchy is presented in **Attachment B**.

Consistent with aluminium smelting activities the primary contaminants of concern are aluminium and fluoride across the Site with some more focused areas of PAH, total petroleum hydrocarbons (TPH), cyanide, trace metals and potentially PCBs. Key observations from review of the existing soil data are as follows:

- The absence of PCB detections in the investigation is likely attributable to the key PCB sources (switchyard and other smaller transformer locations) not being investigated thoroughly. Documentation of PCB handling and use needs to be provided in the PSI and linked to the SAQP and DSI to inform sampling strategy, etc.
- The absence of cyanide detections is of interest and is an artifact of the sampling program and the analytical methods employed (tested for free cyanide only and did not assess total or weak acid dissociable (WAD) cyanide).
- Review of the size of the Site and identification of impacts (as shown on the figures) supports the need for additional sampling to support delineation of soil impacts.

Section 7.2.1 Sediment

This section and Table 7.2 outline sediment criteria. Only select ANZG sediment default guideline values were considered in the investigation and (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn and TPH). These sediment quality guideline values (SQGVs) are suitable to assess risk to ecological receptors. Total organic carbon normalised SQGVs and SQG-High values from ANZG (2018) were ignored for organic constituents and need to be considered for SVOCs analysed but not screened, such as PAHs.

Soil values from National Environmental Protection Measure (NEPM) and USEPA are not appropriate or conservative to screen sediment in the absence of relevant ecological screening levels. This comparison is directly counter to NEPM, which calls for careful consideration and evaluation of sediments which require special expertise. Rather than use other internationally accepted sediment guidelines, GHD has used NEPM and USEPA soil human health guidelines which are not designed to be protective of aquatic or benthic receptors. This is a significant omission and additional comments on relevant and applicable sediment criteria are provided. The tables presented in **Attachment B** provide example relevant and applicable ecological criteria.

Section 7.2.2 Groundwater

Similar to soil and sediment discussion, the groundwater criteria do not consider discharge of groundwater to surface water, the maintenance of aquatic ecosystems, and other community values of water specified in ANZG (2018). To assess ecological exposure conditions associated with groundwater discharges to surface water, a comparison of groundwater concentrations to the ANZG (2018) aquatic ecosystem default guideline values (DGVs) is needed and should be addressed in future studies. For constituents lacking criteria, a hierarchical approach to identifying relevant and applicable guidelines should be used (see **Attachment B**). All potential current or future beneficial uses of water need to be evaluated for groundwater in the DSI, which include aquatic ecosystems, cultural and spiritual values, drinking water, industrial water, primary industries (i.e., water is suitable for irrigation, livestock drinking water, aquaculture, and human consumers of aquatic foods) and recreational water and aesthetics.

The use of the Environment Southland Rule 46 criteria is not appropriate for assessment of ecological risk, the criteria are triggers for resource consent consenting.

No explanation is given for the suite of analytes include in Table 7.3. Ecological criteria are considered for PFAS screening but not for any other analyte group. There is no mention of background values. It is not clear which USEPA RSL criteria is used and there is no rationale given to identify the source of these guidelines.

As a general comment, NZAS background values are cited as the average of four surface samples collected on the peninsula (Section 7.4.5). NZAS background soil concentrations in all soil concentration tables indicates that background values were developed from 95th percentile of 12 site-specific samples. It is unclear how background sample set was derived and to what value on-site samples were screened against. More clarification on the background assessment and the effect of atmospheric or fugitive dust is needed in future studies.

For consistency, the waste management screening criteria included in Appendix F should be discussed in Section 7.2. The basis and relevance of this criteria needs to be specifically discussed in this section.

Section 8 Smelter Domain – Soil Analytical Results

Soil impacts have been identified across the smelter site primarily associated with the management of feedstocks and waste products. As noted above a number of analytical testing deficiencies have been noted around testing for cyanide and the absence of PCB testing in soils proximal to the switch yard and transformers and key drainage features at the Site. Further, other trace elements will be present in the petroleum coke and alumina and the analytical testing suites need to be evaluated further to determine whether they are appropriate.

A range of impacts have been identified in sediment at the Site however no PCB testing was conducted in the south, north and west drain sediments. At other smelter sites PCBs have commonly been detected in sediment with large scale remediation required. As noted in other comments, the presence of PCBs is associated with the switchyard, Site transformers and potentially heat transfer and high temperature hydraulic fluids. This in combination with the absence of soil investigations in the switchyard and other transformer sites means PCB contamination at this Site is effectively unassessed.

As noted above, the absence of relevant and applicable ecological criteria is a major impediment to assessment of the data, evaluation of potential risks and determination of whether the extent of impacts has been defined (see **Attachment B**).

The SAQP and DSI makes no reference to how sample locations were identified/chosen and compliance with CLMG No. 5 – acknowledging that the DSI is described as an initial "snapshot" assessment. Was a grid-based approach or random sampling plan employed? What is the sample density (samples per hectare) in each zone and does GHD feel this is sufficient/adequate to characterise exposure conditions?

No soil sampling was conducted on the eastern portion of Zone J – CCG Yards. Review of historical aerials indicate this area was used for stockpiling of materials and has extensive land modifications. A detailed summary of what activities were conducted in the eastern portion of the CCG Yards is needed and will have to be addressed in future studies..

No soil sampling was conducted on the western portion of Zone L – East Gate. Review of historical aerials indicate that this area had several historical drainage flow paths and land disturbance adjacent to the switchyard was present. Moreover, the foreshore area directly south of the Inalco exposure area is unevaluated. This area will need to be addressed in future assessments.

General comments by area are provided below and it is anticipated that with inclusion of appropriate criteria the data presented in this section will be re-evaluated in future assessments

Section 8.2- Zone B Inalco

The concentrations of fluoride in the Inalco area are indicative of waste materials deposited at surface. The presence of fluoride concentrations of 8.3% and 16% by weight is a concern and aeolian transport and surface runoff of these materials will have a major impact on the receiving environment.

Having observed and noted very high contaminant concentrations (waste) at surface, mitigation measures should be implemented to address housekeeping and prevent impacts in the receiving environment.

Section 8.4- Zone D Solid Storage

Exceedances of Commercial/Industrial and Recreational criteria were noted in the drain for Al, TPH, PAHs with sediment contamination highest in the east and declining downstream. This clearly indicates that runoff is transporting alumina, carbon, and other waste products into the stormwater system. Comparisons to relevant and applicable ecological criteria are needed.

Based on the years of operation of the facility, significant flux of alumina, cryolite, carbon and PAHs would be anticipated to have occurred into the receiving environment. No PCBs analyses were conducted in sediment and should be undertaken as part of additional investigation work.

As noted above the absence of ecological criteria has not allowed proper assessment of ecological risks. More detailed comments will be provided once data has been appropriate screened against ecological criteria.

Section 8.5 - Zone E Liquid Storage Sampling Locations

In section 3 of the report, it is noted that firefighting foam was used in this area. Why does this section state that firefighting foam had potentially been discharged in Section 8.5.1? This requires assessment in subsequent studies undertaken at the site.

Section 9 Smelter Domain – Groundwater Analytical Results

As noted above the assessment in this section is limited by the use of criteria that do not adequately consider ecological exposures. This section will be subject to a major revision when relevant and applicable ecological criteria are used to support the assessment (refer to **Attachment B**)

Further, a number of issues were identified in the analytical suites including:

- The absence of testing for total cyanide and free cyanide (only WAD cyanide was tested). It is anticipated that significantly larger areas of cyanide impacts will be detected with use of the appropriate test methods.
- TSS was not analysed for in groundwater. As noted earlier suspended solids less than 0.45 µm may explain the elevated aluminium (above solubility limits).

In addition, statements of attenuation for aluminium are not necessarily supported by data and no additional analysis was conducted by GHD to show lateral attenuation. The concentration gradients in many areas of the Site would in many cases not support a concentration drop below the 0.15 mg/L aluminium criteria.

Section 9.2 Light Non-Aqueous Phase Liquids

LNAPL was noted to be present in one well. No work has been undertaken to assess the source of LNAPL and the extent of LNAPL impacts. This is a data gap that needs to be addressed.

Section 9.3 Spatial Distribution of Impacts

Key comments concerning fluoride spatial distribution include:

- The fluoride discussion references the landfill or leakage from the south drain as a possible source of fluoride (at well D_MW_B13). It also notes this is an exceedance of ES Rule 46. This statement supports the need for integration of all wells (including the landfills) into a comprehensive Site wide groundwater sampling event.
- Additionally, the contour plan of fluoride in groundwater shows high concentrations north of the reduction plant (well MC11126c). This area requires additional delineation during future studies.

Section 9.4.2 Trace Elements and Nutrients

Background trace metal concentrations, particularly in bedrock, should at a minimum be assessed from a literature review perspective. Given the geological setting in which bedrock was formed, elevated background copper and arsenic might be expected.

Section 11 Landfill Domain Analytical Results

The historical soil, waste, surface water, and groundwater monitoring data needs to be assessed for the landfill sites before an assessment of these areas can be completed and presented in a PSI (or similar report). This section provides no detailed hydrogeologic discussion of the area, information on the nature of landfill closure, and data that can aid in an understanding of waste in place and migration of constituents into and within groundwater.

As it is anticipated that NZAS will be potentially seeking to manage these landfills in place (as part of the consent renewal or surrender for the landfills) a more comprehensive assessment of data is required (including supplemental investigations) before an understanding of risk and closure requirements can be provided. Further survey data is required for this area as a primary concern is the permanency of these landfills in the context of anticipated future sea level rise (and associated issues).

Section 12 Quality Control and Quality Assurance

The key issues noted with respect to the QA/QC associated with the DSI are noted below and should be addressed in future studies

- It is noted that the majority of soil duplicate results are outside of acceptance criteria. The relative percent difference (RPD) discussion is inadequate.
- Based on the major differences in analytical results more discussion is needed to determine the impact that variability in results could have on data interpretation. No mention is made of how sample concentration values are displayed on maps/figures - were maximum, minimum, or average values used?
- The adopted analytical test methods for some constituents are not aligned with international standards supports the potential need for triplicate samples being tested at another lab to ensure the method is accurate.
- The limited cyanide detections in key areas of the Site and absence of high concentrations in soil samples in waste processing areas is an issue when compared to other smelter sites.
- The QA/QC section has no significant discussion of field and trip blanks and laboratory QA/QC reviews. This is important especially if the data is going to be used for risk-based decision making. A more detailed QA/QC review is needed.

Section 14 – Risk Assessment and CSM Update

Based on the comments provided above, significant revisions to this assessment are anticipated in future studies. Use of the generic screening criteria provided in **Attachment B** and addressing comments associated with the analytical suites will result in a significant update of the CSM in future studies.

Further in terms of impacts to the receiving environment it is recommended that a more holistic assessment is provided. This should include development of a hydrogeologic CSM that includes all monitoring wells and data and consideration of the flux of constituents from all sources via groundwater and stormwater flows.

Figures, Tables and Appendices

Key comments concerning figures and appendices are stated below:

Figure A3

The rationale for the development of the investigation zones is unclear as several of the zones have not been investigated. Additionally, no zone is situated west of the Zone E where historical seeps were identified. How do the drawn zones relate to the titled boundaries of the Site versus leased lands or Crown lands?

Figure A19

Aluminium concentrations in select wells are above the solubility limits inferring solids entrainment. This is most evident in wells MC11126C, MC346076 and C_MW_B12 this needs consideration and annotating on the figure.

Figure A20

The fluoride criteria being applied as screening criteria is not appropriate. The primary exposure route is via impacts to aquatic receptors and criteria should have been proposed or developed for fluoride which, along with aluminium, is likely to have the greatest mass flux and potential impact on aquatic receptors.

Appendix F Table K3/K4 and 15/16

Data does not match between Tables 15 and 16. It appears as if values were ordered differently between tables, but constituent names were not reordered to match.

Appendix K

The risk assessment tables rightly identify terrestrial and aquatic receptors as being in complete or potentially complete exposure pathways. However, the report had no relevant criteria to complete the assessment.

Additional detailed assessment of direct contact vs. dietary exposure routes are warranted. Please describe why direct contact ecological exposure was not considered.

4. Conclusions

EHS Support has undertaken a review of the GHD SAQP and DSI. The DSI as currently drafted has assessed soil, groundwater, and sediment impact within the confines of the smelter domain which covers an area of approximately 92 ha.

The wider smelter area, comprising an approximate area of 310 ha (including the NZAS landfill and SCL waste pad), was not investigated by GHD. In addition, no receiving environment investigations (groundwater, surface water and sediment outside of the Site) were conducted as part of the DSI. The exclusion of the landfill, SCL pad and wider receiving environment is a critical gap in the contamination assessment of the wider facility.

While a PSI of the NZAS facility has been prepared by GHD. The DSI review was constrained by NZAS not making the PSI available during the review process.

A preliminary draft of the EHS Support review of the SAQP and DSI was provided to NZAS for their review. In response to the EHS Support review a number of clarifications have been provided by both GHD and NZAS which have been incorporated into this document. The most important of these clarifications was that NZAS considers the DSI report to be an Initial Investigation Report and that supplemental scopes of work will be implemented to address data gaps and uncertainties. In general, the NZAS/GHD review did not question the technical issues raised in the EHS Support review. The comments provided in this document should be considered for incorporation into the SAQP and DSI (which should be renamed Initial Assessment Report), supplemental scopes of works and associated reports, and the final comprehensive DSI which will be prepared for the site.

The SAQP and DSI review highlighted various issues that need to be addressed by NZAS/GHD in the next phase(s) of the investigation work undertaken on the Site (operational area of the smelter) and surrounding areas. Addressing these issues will aid NZAS's understanding of the nature and extent of contamination within the wider smelter complex, assist in scoping contamination remedial and mitigation efforts, and support environmental compliance. A detail description of the findings from EHS Support's review of the SAQP and DSI has been provided in the previous sections of the report with comments provided in tabular form within Attachment A to aid in comment responses. Further revisions to the DSI are anticipated in order to align with the PSI and current and historical areas of interest.

Based on the long history of site operations and ongoing NZAS compliance monitoring programmes (stormwater and groundwater monitoring data) an extensive historical data set exists for the site. This data set needs to be better leveraged to develop a facility wide geo-hydrogeologic CSM, define areas of historical impacts, and assessment of the persistence/attenuation of soil and groundwater impacts. As part of the PSI/DSI process it is expected that a chronology of historical investigations and compilation of data (figures/tables) and temporal assessment of trends would be conducted.

As part of future applications for consents, and inherently the assessment of ecological risk to the receiving environment (as part of the final DSI), an assessment of both discrete (point source) and passive discharges from the site will be required to determine mass loadings and potential risks. The human health and ecological risk assessments need to consider all sources, pathways, and exposure scenarios in order to provide a determination on the acceptable level of human and ecological risks.

The DSI has highlighted numerous legacy and ongoing sources of contamination to the environment. The management of SPL/SCL/Bath and other waste products have resulted in significant soil impacts in numerous areas of the Site. Percent level concentrations of fluoride were recorded around the

Inalco area where waste materials were observed to be deposited in surface soils during GHD's investigation. Other areas where waste materials and feedstocks were observed to be present at surface were in and around the alumina stores, fume recovery systems, carbon storage and green mill. The presence of this contamination at surface suggests a level of poor house-keeping practice.

Materials were also observed to be deposited in stormwater drains leading from the facility to the receiving environment (with percent level aluminium concentrations recorded in the drain sediments for example). Coincident with the soil impacts within the Site, fluoride impacts have also been identified in groundwater along with other contaminants of concern. This contamination has created a shallow groundwater contamination plume(s) over a large part of the smelter domain.

Based on the nature of Site operations and proximity to the coast, discharges of contaminants are occurring to the receiving environment with concentrations above generic or default risk-based criteria. Contaminant concentrations (including trace elements, PAHs, and fluoride) above commercial/industrial and recreational health risk criteria and ecological screening criteria were encountered at surface within the Site. Further assessment is needed to establish whether a combination of groundwater and surface water discharges and air emissions are resulting in impacts to surrounding terrestrial and marine ecological communities. The GHD assessment of ecological impacts was compromised by the application of incorrect screening criteria.

Despite limitations of the DSI, the investigations have provided critical information to better refine the understanding of contamination conditions at the property. In this context the report has been successful in providing an initial assessment of site conditions. Additional investigation/assessment work is needed to address these limitations and support the PCS process and regulatory compliance. GHD has indicated that a number of additional work streams are either being undertaken or will be undertaken which will potentially address the limitations noted. The nature and scope of this work needs to be shared with ES. The additional investigations and assessment are needed to:

- Address key data gaps and uncertainties.
- Support the development of a human health and ecological risk assessment (including assessment of key areas of the Site and wider NZAS complex which have not been investigated).
- Assess all constituents of potential concern (COPC) or constituents of potential ecological concern (COPEC) associated with Site activities.
- Delineate the extent of impacts including conditions in the receiving environment.

EHS Support has identified appropriate ecological screening criteria which have been provided as **Attachment B**. The DSI report needs to be updated and revised to incorporate these criteria and based on EHS Support's assessment, additional investigations are required to enable completion of an ecological risk assessment for the Site and the receiving environment.

5. References

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

ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

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Ministry for the Environment. 2021a Contaminated Land Management Guidelines No. 1 Reporting on Contaminated Sites in New Zealand. 2021.

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Woodward Clyde New Zealand Ltd. 1994. Groundwaters of Tiwai Peninsula. Volume 1. 1994.

Attachment A Tabulated Review Comments

Attachment A Tabulated Review Comments

TABLE 1 DRAFT REVIEW COMMENTS ON NZAS REPORTS

Comment #	Page #	Section	Paragraph	Comment/Action
August 2021 NZAS DSI Report				
1.	i	Executive Summary	6	The Executive summary references the PSI process correctly and notes that it is the process of identifying areas of potential contamination. No formal PSI was provided with the DSI and Appendix B of the GHD memo is not considered a PSI. The deficiencies in the PSI process were not addressed in this report. A key deficiency that needs to be addressed is that historic investigation and monitoring data for the site (including the landfills) needs to be collated and summarised in this report. A chronology of investigations and detailed discussion of the results and findings of these assessments with figures should be provided as part of the DSI scope of work. The DSI should re-assess these areas and evaluate changes in concentration over time. Further the lack of inclusion of stormwater/sediment data from routine monitoring is a clear omission. This is the primary mode of impact from the facility on the receiving environment. In the context of historical data, the temporal groundwater and surface water is very important to evolution of site understanding and describing the fate and transport of constituents. Lastly the report should include data for all sites in the assessment report (including the landfills) as the groundwater flow regime and groundwater data from these areas are important to development of a robust understanding of the site. All contaminated areas of the site are contributing to mass loadings in the receiving environment (groundwater and surface water discharges to the coastal marine environment). Numerous data sets and reports are referenced in Appendix E of the DSI however this information has not been collated to aid Environment Southland in their review and assessment. Notes in the table make clear reference to historical issues and data collection.
2.		General – Air deposition (Figure 2-1)		A critical omission from the report was a robust assessment of atmospheric deposition. The predominance of westerly winds means that the peninsula will be subject to atmospheric deposition from the plant. No systematic assessment was conducted to assess the impacts of atmospheric deposition on soils at the site and abutting sites. Further the background locations were located

Comment #	Page #	Section	Paragraph	Comment/Action
				downwind (to the east) of the plant making them unsuitable as a background site. Soil samples have been collected downwind of the site, but a robust statistical assessment was not provided include longitudinal studies to characterize the extent of area impacted by atmospheric deposition.
3.		Section 3.1	1	The document references a CSM that was developed as part of the PSI. From our review of the GHD memo (which was not labelled PSI) this document only discusses possible sources by area. A CSM must discuss sources, pathways, and targets (receptors) and through this process identify relevant and applicable screening criteria, define investigation locations hydraulically downgradient of sources and consider historical data that will inform collection of data on the fate and transport of contaminants. This was not adequately done, and inherently major uncertainties and data gaps remain (most notably in the characterisation of groundwater conditions and impacts).
4.		3.3, 3.4 and 3.5 – Tables and Text		The CSM provided in the text and the documents in Appendix K and L appropriately separate terrestrial/avian and aquatic receptors. Please provide a detailed summary of what terrestrial receptors could be affected by the potentially complete exposure under current and future conditions. For the terrestrial environment, the potential receptors need to be defined and better assessed in terms of current and future exposure conditions. For example, at Portland Victoria the majority of impacts on herbivores was associated with atmospheric deposition and fluoride accumulation on foliage. One important consideration is that the soil depth needs to be aligned with exposure scenario/receptors (the biologically active zone is likely limited to the top 100 -150 mm at this site). Please define the biologically active zone in the terrestrial environment. A systematic assessment of mass flux to aquatic receptors (stormwater/groundwater) is needed to demonstrate the presence/absence of unacceptable risk to aquatic receptors and determine if remedial actions are required.
5.		4.2 Groundwater Sampling		The groundwater analytical suite did not include important parameters that would aid in the analysis of data and risk. This includes: a) TSS – a number of the aluminium values are above the solubility limits. This could be a function of fine colloids (post filtering) in the samples. b) The analytical suite did not consider incorporate key ameliorating factors (Toxicity Modifying Factors) such as hardness and alkalinity which will be important for metals and fluoride toxicity evaluations in the groundwater to surface water pathway.

Comment #	Page #	Section	Paragraph	Comment/Action
				c) The testing did not include all forms of Cyanide (free/total and WAD). Please provide detailed justification for all analytical suites selected and how the selected constituents align with known operations (e.g., why does the metal suite does not contain metals known to occur as impurities in alumina or core constituents in dross, SPL, or other residual wastes).
6.		Section 4		The shallow soil sampling depth of up to 0.2 m is not a surface sample and therefore may not be appropriate for assessment of atmospheric deposition and impacts to terrestrial receptors from incidental contact and ingestion. For livestock the majority of fluoride uptake is associated with ingestion of foliage and atmospheric deposition of materials onto the leaf surfaces. Please describe how the selected sampling program was designed to specifically test exposure conditions that could be potentially complete under current and future scenarios.
7.		Section 4		The use of low flow groundwater sampling methodologies is an excellent approach to limit TSS and turbidity in samples. Despite this it does appear that some solids impacted on aluminium results.
8.		Section 4		Please break out sediment as a separate sub-section and provide detailed rationale to the analytical suite selected for analysis in each drain feature. We note significant omissions of important constituents as well as critical co-factors (e.g., grain size, total organic carbon, etc.) that would permit appropriate sediment assessment.
9.	33	Section 5.10.1		Numerous visual observations of windblown coke, alumina and cryolite. These observations are consistent with typical operations at aluminium smelters and in combination with stormwater runoff is a major mass loading on the receiving environment. While a downwind transect was completed for the site the rigour of assessment and analysis was limited to determine the impacts on the receiving environment of atmospheric deposition on soils and foliage. In addition, the text and reports need better associated with the visual observations and the analytical results. Sometimes affirmative language is provided telling the reader this area was sampled. In other areas the language is vague. Later in the report we need to associate the analytical results with the areas of “worst” visual evidence of potential contamination. In Zone D the presence of significant Coke and Alumina in the drains (in combination with sediment sampling data) indicates that discharge of materials in stormwater is a very important pathway

Comment #	Page #	Section	Paragraph	Comment/Action
				which may impact on the receiving environment. The absence of appropriate sediment values for Al, F, CN and PAHs which are protective of aquatic and benthic organisms is a critical omission from this report. Please provide rationale for exclusion of aqueous parameters that align with the sediment parameters and provide Environment Southland with any available aqueous data that exists for the drain features.
10.	38	6. Geology, Hydrogeology and Hydrology	General	There is limited integration of new data into the discussion. Information is largely referenced directly from an earlier Woodward-Clyde report. Despite acquisition of five groundwater samples for detailed inorganic geochemistry analysis, and several samples for a more limited suite of geochemical analysis, no discussion of the groundwater geochemistry results in the context of the geo-hydro CSM is provided.
11.			General	No verification or documentation of instrument calibration is provided. Field parameter measurements cannot be considered representative without calibration verification.
12.			General	A detailed description of historical and current plant operation and the smelting process used should be included. This is a critical basis for selection of the sampling strategy.
13.		Figure 6-1	General	Figure 6-1 shows seeps W1 and W2 but this is not discussed in the document. The presence of seeps and historical monitoring data is very important as this is a direct pathway to receptors.
14.	38	Section 6.1.1		The geology section highlights using Figure 6-1 the use of fill in a depression at the site and the potential importance of this feature. What is the importance of this feature in terms of contaminant migration? No discussion provided. Did we see these fill materials during the investigation and what did they comprise? No discussion specific to this area provided in the report. Need to consider placing this feature on the investigation maps and actually discussing the physical nature of fill and analytical results within and outside this feature.
15.	409	Figure D1	Figure	1. The depiction of a groundwater 'sink' at C_MW-_B14 is unlikely, unless there is knowledge of infrastructure at this location that would support this interpretation?

Comment #	Page #	Section	Paragraph	Comment/Action
				2. Most groundwater contours are drawn perpendicular to the coastline. This suggests the groundwater system is isolated from the surrounding lagoon and ocean, which has not been verified and is not supported by the site geology. Contours should be parallel to the coastline. 3. A critical data gap is the configuration of the groundwater divide that must be located between the landfill and main plant. The location of this groundwater divide and how it responds to daily or seasonal variations in the groundwater system is critical for understanding mass flux and contaminant transport mechanisms. 4. There is no discussion on why it is appropriate to include water levels from Well No. 15 (total depth >30 m) in contouring of the remainder of wells that have total depths generally around 5 to 8 m. A co-located well here would provide the means to establish vertical groundwater gradients. Lack of vertical groundwater gradient data at several locations is a data gap. 5. It should be verified that monitoring well locations listed in the table on page 136 align with the locations plotted on this figure. 6. It appears data from some of the 13 historical wells are missing from the figure.
16.		General		A comprehensive well construction table with (at minimum) coordinates, elevations, and screen intervals, and screen units is absent from the report. This table should include all existing and new well details plus an assessment of the well integrity of the NZAS wells (given their age) and their suitability for long term groundwater monitoring.
17.		General GW analysis methodology/screening		Aqueous samples need to be aligned to their relevant fraction for screening. It is recommended to design an analytical program to include total and dissolved fractions when relevant for the purpose of better understanding dynamics between fractions. USEPA RSLs should be screened against total fractions, not dissolved/filtered.
18.	39	6.1.2		The figure provided in the Appendices to support this discussion does not show catchment and surface topography. Based on atmospheric deposition from the plant and other ancillary activities (bath management, etc.) and the observations of alumina and coke and debris on the ground surface, runoff of contaminants from the site is a critical mode of transport. Not all stormwater will enter drains and

Comment #	Page #	Section	Paragraph	Comment/Action
				sheet flow will go to soakage in select areas of the site resulting in impacts to soil and groundwater. A Digital Elevation Model with flow paths would aid the reader. Further as noted in general comments given the importance of this mechanisms stormwater data for the outfalls needs to be incorporated into the report. Data interpretation of sediment data would be aided with paired surface water sampling data.
19.	41	6.1.3	3	"Woodward-Clyde concluded that a number of different interpretations could be made based on the scattered water level data…". The same comment is true of the 2021 water levels contours produced by GHD, and this should be acknowledged in the text.
20.	41	6.1.3	3	Under the 4th bullet, 'mapped' should be 'maps'.
21.	42	6.1.3	Images	The images are of low quality and well names are not possible to read. A discussion is missing on which wells Woodward-Clyde used still exist or were abandoned.
22.	43	6.1.3	General	The influence of daily (tidal) effects on the groundwater system is presently unknown and constitutes a major data gap in the CSM. The tidal range immediately adjacent to the site encompasses the range of groundwater elevations reported by Woodward Clyde for 1992 and by GHD in this report. Mention of marine influences on the groundwater system is restricted to a couple of very minor mentions on pages 43 and 88. Additionally, seasonal variations in the groundwater system are not captured by single monitoring event from the expanded well network. At minimum, a conductivity-temperature-depth (CTD) transducer study should be implemented to define temporal shifts in the groundwater system and marine mixing contributions.
23.	43	6.1.3	3	That water levels were only measured on a falling tide has implications for all subsequent groundwater flow and hydrogeochemical conclusions, which should be acknowledged. Specifically, if there is a tidal influence: 1. Groundwater gradients (Table 6-1) would be approaching a daily extreme, and all subsequent mass flux and contaminant travel time estimates would be exaggerated and should be flagged with high bias. 2. If samples were also collected on a falling tide and there is marine influence, groundwater chemical character may reflect regional groundwater, and contaminant loading would represent an extreme that is undiluted by any infiltrating marine water. Thus, contaminant flux estimates based

Comment #	Page #	Section	Paragraph	Comment/Action
				on samples collected during a falling tide should be flagged with 'high bias', if there is appreciable marine mixing. To summarise, the role of tidal influence constitutes a major data gap.
24.	43	6.1.3	2	"Dips' should be 'depths'.
25.	43	6.1.3	6	"Contours show a much flatter gradient across the centre of the smelter which coincides with areas of sealed surfaces where infiltration is reduced." No doubt infiltration is reduced at paved areas. However, not everywhere are gradients flatter beneath paved areas, indicating that there are elements of the groundwater flow system that are not presently understood.
26.	43	Table 6-1	Table	Groundwater gradients reported here should be considered meaningless until diurnal/tidal effects are assessed.
27.	43	Table 6-1	Table	It is not clear how calculated gradients - or the piezometric surface map - relate to the screened intervals of wells. No discussion or assessment is provided on the similarity (or differences) in groundwater elevations in wells with different screened intervals/depth ranges.
28.	43	6.1.4	General	This section would benefit from a figure to conceptualise the discharge and infiltration locations discussed. The word 'infiltration' should be considered for inclusion in the title. There is no mention of the implications of infiltration for groundwater elevations and groundwater constituent concentrations, which constitutes a data gap.
29.	44	6.2.1	General	This section on peninsula geology lacks discussion of the geological processes that formed the peninsula. There is no integration of information obtained from the numerous wells and borings installed by GHD. Without a conceptual geologic model, the spatial distribution and stratigraphic relationships of geologic units cannot be estimated. This data gap precludes effective implementation of future sampling efforts, if required, and development of robust groundwater flux models.
30.	45	6.2.2	1	There is no mention of precipitation or infiltration, which are essential elements of a hydrology discussion.
31.	45	6.2.3	General	"Historical Data". How do results for flow velocities, etc. from the GHD effort compared to the former Woodward Clyde data? There is no integration of data from the GHD effort. A critical data gap in the groundwater velocities that are presented are possible variations in the groundwater gradient, and assumptions/data sources for hydraulic conductivity data and effective porosity.
32.	45	6.2.4	4	"The down hydraulic gradient well " - better to say down gradient well?

Comment #	Page #	Section	Paragraph	Comment/Action
33.	46	6.3.1	2	Grammatical errors require attention.
34.	46	6.3.1	3	Structural characteristics of bedrock should be documented and verified beyond the statement 'poorly fractured'. The structural nature of bedrock is a key element of the landfill hydrogeological CSM and constitutes a data gap.
35.	46	6.3.1	4	The elevation of bedrock beneath the landfill should be verified through review of historical site reports and data, or by direct investigation. The elevation/configuration of bedrock beneath the landfill relative to sea level is a key data gap.
36.	46	6.3.1	General	There is a lot of published literature on the structure, geochemistry, and nature of bedrock at Bluff and Tiwai Point that could be incorporated to strengthen the Landfill CSM.
37.	47	6.3.2	1	The outfall and configuration of the drainage/peripheral ditches should be clarified.
38.	47	6.3.2	General	A water shed map of the landfill area, and site in general, is lacking in the hydrology assessment. This data gap should be addressed to better understand the locations of infiltration divides and planning for future infrastructure design, if needed.
39.	48	6.3.3	2	Groundwater recharge to the north of the landfill is inconsistent with 2001 groundwater contours. Some comparison or assessment of this statement by Woodward-Clyde is warranted in light of the GHD data.
40.	48	6.3.4	1	Inclusion of groundwater elevation data from the landfill piezometer network would greatly strengthen the hydrogeological conceptual model.
41.	88	9.4.1	6	"The chemical results can be assessed to determine the hydrochemical facies of the water. Plotting of the results from the five samples show they cluster closely within the area known as 'Sodium Chloride Type'. This is typical of a regime with rapid recharge and coastal saline groundwater influence." This information (marine contributions) is critical for consideration in the hydrogeological CSM and is surprisingly mentioned in this single paragraph. Note, other samples are provided for which chloride and sulfate were analysed. There is an opportunity to use these analytical results to strengthen the hydrogeological CSM. Well 15 is technically a mixed or Ca-Cl water type, although plots close to a NaCl type.
42.		7.1 Soil		This section and Table 7-1 provide a clear anthropogenic focus. Few ecological criteria have been selected and used in the screening process. This is despite the CSM (included in the Appendix L and

Comment #	Page #	Section	Paragraph	Comment/Action
				K), that clearly identifies terrestrial and marine fauna and flora as being potentially exposed and the pathways being determined to be complete. In the context of current conditions there is natural habitat around the periphery of the site and in a future recreational development scenario additional habitat would be present on site. Relevant and applicable ecological criteria need to be identified and used for screening. The omission of these criteria makes the analysis contained within the report flawed. Additional comments are provided below that outline potential relevant and applicable criteria for ecological receptors. Attached Table 2A and Table 2B provide example relevant and applicable criteria.
43.		7.1 Sediment		This section and Table 7.2 outline sediment criteria. Only the ANZG sediment guideline values that were used are relevant to aquatic ecological receptors. Exceedances of ecological criteria were noted in later sections of the report. Rather than use other internationally accepted sediment guidelines GHD has used NEPM and USEPA soil human health guidelines which are not designed to be protective of aquatic or benthic receptors. This is a significant omission and additional comments on relevant and applicable sediment criteria are provided. Attached Table 2A and Table 2B provide example relevant and applicable criteria.
44.		7.1 Groundwater		Similar to soil and sediment, the groundwater criteria do not consider discharge of groundwater to surface water and the maintenance of aquatic ecosystems. ANZG (2018) aquatic ecosystem and other international criteria are needed to assess the potential for unacceptable risk to the aquatic environment. Environment Southland Rule 46 is not appropriate for assessment of ecological risk – it is a resource consent trigger.
45.	49	7.2	1	Missing period between “samples the selection” at the end of the first sentence.
46.		Section 7.2	Table 7-1	Hierarchy of screening criteria does not include relevant ecological screening criteria. Guidelines are predominately selected for human health criteria except for PFAS criteria which includes ecological screening values, which is inconsistent with the rest of the approach. There is no rationale listed as to why the analytical suite listed was selected (no reference to PCSM). Does SVOC represent total SVOCs? USEPA guidelines for Al/F do not represent current state of knowledge for ecological screening criteria for these constituents and should be further evaluated. Failure to select

Comment #	Page #	Section	Paragraph	Comment/Action
				background criteria is not explained, "trace elements" needs to be specified. Hydrocarbon screening does not match what is listed in guidance table and it is recommended that direct contact/ingestion criteria be compared to vapor inhalation criteria. There is a misalignment between what is listed in the table as a guideline and what is presented in the appendix screening tables notes (wrong tables are cited). No rationale for using USEPA RSLs is provided, and no indication of THQ used to derive criteria and why. We recommend screening soil samples against human health and ecological criteria based on the provided hierarchies (EHS Support Attachment B Table 2A).
47.		Section 7.2	Table 7-2	Proposed table of guideline values does not include ecological screening criteria, nor does it include justification for analytical suite selected. Based on this approach there are other constituents that have criteria that were not included (antimony) without rationale. No mention of background values for comparative screening. No mention of screening based on grain size. Sediment screening criteria is recommended to have multiple lines of evidence approach. A mixture of human health and ecological criteria is used in guideline selection. Sediment must be screened against soil human health guidelines and sediment guidelines for ecological receptors. We recommend screening sediment samples against human health and ecological criteria based on the provided hierarchies (EHS Support Attachment B Table 2B).
48.		Section 7.2	Table 7-3	No explanation for suite of analytes measured. Ecological criteria are considered for PFAS screening but not for any other analyte group. No mention of background values. It is not clear which USEPA RSL criteria is used and there is no rationale given to identify the source of these guidelines.
49.		Section 7/Appendix L/K		Ecological screening indicated that there are several constituents that may be a source of risk to ecological receptors. Considering that the DSI indicates complete or almost complete pathways for ecological receptors, it is crucial to further evaluate site related constituents on the basis of risk to ecological receptors. It is recommended that a hierarchical screening approach be utilized to fully encompass the range of relevant and available ecological screening criteria. The inclusion of site-specific background information and basic additional sampling parameters is recommended for the derivation of criteria for several constituents, specifically NEPM EILs, which represent the most protective measure for ecological receptors.
50.		General	General	NZAS background values are cited as the average of four surface samples collected on the peninsula (Section 7.4.5). NZAS background soil concentrations in all soil concentration tables indicates that background values were developed from 95th percentile of 12 site specific samples. It is unclear how background sample set was derived and to what value on-site samples were screened against.
51.		Section 7.2		No mention of waste management criteria used in screening tables in Appendix F

Comment #	Page #	Section	Paragraph	Comment/Action
52.		Soil Data	General	Consistent with aluminium smelting activities the primary contaminants of concern are aluminium and fluoride across the site with some more focused areas of PAH, TPH and trace metal impacts. The absence of PCB impacts detected in the investigation is likely attributable to the key PCB sources (switchyard and other smaller transformer locations) not being investigated. The biggest concerns with the soil data and assessment are the lack of ecological screening criteria (as noted above) but also that the surface soil samples could be as deep as 0.2 m and not surface soil samples where ecological exposures would mainly occur (especially for livestock if grazing is conducted in the area). Additional details on the soil sampling methodology are warranted. The absence of major cyanide detections is also of interest and may be an artifact of the sampling program. Review of the size of the site and identification of impacts (as shown on the figures) supports the need for additional sampling to support delineation of impacts. More detailed comments will be provided once the data has been screened against all criteria (including ecological criteria)
53.		Soil/Sediment Data – Area D		Exceedances of Commercial/Industrial and Recreational criteria were noted in the drain for Al, TPH, PAHs with sediment contamination highest in the east and declining downstream. This clearly indicates that runoff is facilitating the transport of alumina, carbon, and other waste products off-site in stormwater. Based on the years of operation of the facility, significant flux of alumina, cryolite, carbon and PAHs would be anticipated to have occurred into the receiving environment. No PCBs analyses were conducted in sediment. What was the rationale for not including PCB analysis? As noted above the absence of ecological criteria has not allowed proper assessment of ecological risks. More detailed comments will be provided once data has been appropriate screened against ecological criteria.
54.		8.5		In section 3 of the report, it is noted that firefighting foam was used in this area. Why does it state that firefighting foam had potentially been discharged in Section 8.5.1? Please provide detailed justification for the suitability of the employed study design to effectively assess PFAS related compounds and their historical use site wide.

Comment #	Page #	Section	Paragraph	Comment/Action
55.		Soil Data – Inalco Area		The concentrations of fluoride in the Inalco area are indicative of waste materials deposited at surface. The presence of F concentrations of 8.3% and 16% by weight is a concern and aeolian transport and surface runoff of these materials will have a major impact on the receiving environment. What interim measures are being proposed for this area to address poor housekeeping and prevent impacts in the receiving environment.
56.		9.2		LNAPL was noted to be present in one well. No work has been done to assess the source of LNAPL and the extent of LNAPL impacts. This is a data gap that needs to be addressed.
57.		9.2 Sediment		No PCB testing was conducted in the south, north and west drain sediments. At other smelter sites PCBs have commonly been detected in sediment with large scale remediation required. As noted in other comments, the presence of PCBs is associated with the switchyard, site transformers and potentially heat transfer and high temperature hydraulic fluids. This in combination with the absence of soil investigations in the switchyard and other transformer sites means PCB contamination at this site is effectively unassessed.
58.	86	9.3 Groundwater		No TSS was analysed for in the groundwater samples and as noted earlier suspended solids less than 0.45 µm may explain the elevated aluminium (above solubility limits).
59.	87	9.3 Groundwater		Statements of attenuation for aluminium are not necessarily supported by data and no additional analysis was conducted by GHD to show lateral attenuation. The concentration gradients in many areas of the site would in many cases not support a concentration drop below the 0.15 mg/L aluminium criteria.
60.	87	9.3 Fluoride		The fluoride discussion references the landfill or leakage from the south drain as a possible source of fluoride (at D_MW_B13. It also notes this is an exceedance of ES Rule 46. This statement supports the need for integration of all wells (including the landfills) into a comprehensive site wide groundwater sampling event.
61.		9.3		The map of fluoride in groundwater shows high concentrations north of the reduction plant (well MC11126c) what additional delineation is being proposed for this area.
62.	88	9.4.2	General	Background trace metal concentrations, particularly in bedrock, should at minimum be assessed from a literature review. Given the geological setting in which bedrock was formed, elevated background copper and arsenic might be expected.
63.		11		Historical soil, waste surface water and groundwater monitoring data are required for the landfill sites before an assessment of these areas can be completed. This section provides no detailed

Comment #	Page #	Section	Paragraph	Comment/Action
				hydrogeologic discussion of the area, information on the nature of landfill closure and data that can aid in an understanding of waste in place and migration of constituents into and with groundwater. As it is anticipated that NZAS will be potentially seeking to manage these landfills in place (as part of the consent renewal or surrender for the landfills) a more comprehensive assessment of data is required (including supplemental investigations) before an understanding of risk and closure requirements can be provided. Further survey data is required for this area as a primary concern is the permanency of these landfills in the context of anticipated future sea level rise (and associated issues).
64.		12		RPD discussion is inadequate. Based on the major differences in analytical results more discussion is needed on to determine the impact that variability in results could have on data interpretation. The fact that we adopted analytical test methods for some constituents that are not aligned with international standards supports the need for triplicate samples being tested at another lab to ensure the method is accurate. The biggest red flag at this point is the limited CN detections in key areas and the absence of high concentrations in soil samples in waste processing areas. Also, the QA/QC section has no other discussion of field and trip blanks and laboratory QA/QC reviews. This is important especially if the data is going to be used for risk-based decision making. Please provide a detailed QA/QC section for review.
65.	96	12.4	General	It is noted that the majority of soil duplicate results are outside of acceptance criteria. No mention is made of how sample concentration values are displayed on maps. Were maximum values used? Minimum values? Average values?
66.		Figure A3	General	The rationale for the development of the investigation zones is unclear as several of them are largely uninvestigated. Additionally, no zone is situated west of the Zone E where historical seeps were identified. How do the drawn zones relate to the titled boundaries of the site versus leased lands or crown lands?
67.		Figure A4	General	How were sample locations identified? Was a grid-based approach or random sampling plan employed? What is the sample density (samples per hectare) in each zone and does GHD feel this is sufficient to characterize exposure conditions? No soil sampling was conducted on the eastern portion of Zone J – CCG Yards. Review of historical aerials indicate that this area was used for stockpiling of materials and has extensive land

Comment #	Page #	Section	Paragraph	Comment/Action
				modifications. Please provide a detailed summary of what activities were conducted in the eastern portion of the CCG Yards and why this was not investigated. No soil sampling was conducted on the western portion of Zone L – East Gate. Review of historical aerials indicate that this area had several historical drainage flow paths and land disturbance adjacent to the switchyard was present. Moreover, the foreshore area directly south of the Inalco exposure area is unevaluated. Please provide detailed rationale as to why this area was not investigated.
68.		Figure A-19		Aluminium concentrations in select wells are above the solubility limits inferring solids entrainment. This is most evident in wells MC11126C, MC346076 and C_MW_B12
69.		Figure A-20		The fluoride criteria being applied as screening criteria is not appropriate. The primary exposure is via impacts to aquatic receptors and criteria should have been proposed or developed for fluoride which along with aluminium is likely to have the greatest mass flux and potential impact on aquatic receptors.
70.		Appendix F	Table K3/K4 and 15/16	Data does not match between Tables 15 and 16. Appears as though values were ordered differently between tables, but constituent names were not reordered to match.
71.		Appendix K		The risk assessment tables rightly identify terrestrial and aquatic receptors as being in complete or potentially complete exposure pathways. However, the report had no relevant criteria to complete the assessment. Additional detailed assessment of direct contact vs dietary exposure routes warranted. Please describe why direct contact ecological exposure was not considered.
April 2021 NZAS Sampling and Analysis Quality Plan				
72.		General		The absence of a PSI is a critical omission as the nature of historic and current operations is poorly described in the document and inadequate to determine the needs of the investigation, uncertainties, and data gaps. The old reports for the site should be summarised and included in the report so that the scope of work can validate the presence of contamination and/or demonstrate natural attenuation. PSI's by definition need to leverage all historic data and provide a discussion of processes and waste management practices. A number of omissions were noted within SAQP (on a by expectation basis):

Comment #	Page #	Section	Paragraph	Comment/Action
				(a) The need for a better discussion of stormwater catchment areas and drainage lines (offsite runoff of contaminants is a key pathway that must be discussed) and no inclusion of historical stormwater and sediment monitoring data (to define the loadings/discharge of contaminants to the receiving environment) (b) A more robust discussion of current and historical waste storage areas. Appendix has some notes on storage, etc. but this report and the DSI needs a detailed discussion on the history of SPL storage and treatment, what about cathodised butt storage, bath storage, reuse of refractory bricks from the carbon bakes (which would be contaminated). (c) Where is ingot casting conducted and are there other high temperature oils or hydraulic fluids on-site which may have historically contained PCBs. (d) In addition to switchyard there is likely to be transformers located around the site serving offices and other maintenance/engineering functions. A map showing all transformer locations and specifications on transformers is needed. The words site, Site, plant, and Smelter are used interchangeably with no definitions. It is not clear if this an intended distinction between operational areas vs. non-operational areas, or some other parceling. Whereas background sample are prescribed on Table 1, there is no mention of background samples in the text. What was the rationale for selected locations and analytical suites?
73.	2	Section 1.3		The document notes that the Electrical Switchyard and main potline buildings could not be accessed. For the electrical switchyard additional information needs to be included in the report including (a) a discussion of PCB use (b) when PCB oils were replaced (c) where drainage from the switchyard goes to. In the context of (c) the absence of PCB testing in drainage lines from the switchyard is a critical omission. While the activities within the pot rooms are unlikely to be sources of contamination, releases outside the pot room (such as via air emissions) can be sources of contamination. There is no discussion on the construction of the pot rooms, if there is under pot material (UPM) which can be deposited below elevated floors of the pot room or contaminants can enter the courtyards between the pot lines. Are there centralised courtyards between the pot lines where this UPM can be accessed and is there drainage in the courtyards? What is being done to prevent UPM and wastes getting into the stormwater system? How is UPM or materials falling out of the pots currently being handled/managed?

Comment #	Page #	Section	Paragraph	Comment/Action
74.	8	2.3	2	It is not clear why herbicide application is an exception to a common activity? Recommend rewording this sentence for clarity. Details of the specific herbicides used, and duration/extent of application needed. Please clarify.
75.	9	3	General	The PFAS Sampling program and methodology seems incomplete and inadequate across all matrices. Please provide detailed procedures used to ensure PFAS sampling was conducted appropriately and rationale as to why PFAS compounds were not analyzed in areas where PFAS was stored? Detailed justification for where PFAS sampling was conducted is needed.
76.	10	3.3	1	The methods to collect sediments seem inadequate and not thoroughly thought out. How were discrete sediment intervals sampled without contamination from overlying water if the sample was collected with a hand auger or shovel? Why weren't acrylic core liners and coring methods used exclusively? What was the homogenization procedure? How were VOCs and SVOCs sampled versus metals? DI alone is not sufficient for decontamination between samples. Why wasn't alconox (or equivalent) used? What sediment lithology was collected? A detailed sediment sampling program is needed in line with the considerations of ANZG (2018).
77.	10	3.5	1	1. There is no mention of plans to collect water level and sampling data at a specific point in the tidal range. 2. There is no mention of methods to correct water levels if non-aqueous phase liquid is encountered.
78.	10	3.6.1	General	There is no mention about the need to (or not) for collecting samples at a specific point in the tidal cycle or how this might be verified.
79.	11	3.6.2	1	How was flow rate determined? Was drawdown monitoring a criteria for establishing sampling flow rate?
80.	13	4	General	Detailed justification for the analytical suites is needed. The following constituent groups need additional explanation: Metals – please elect a constituent suite that is aligned with known COCs linked to aluminium feedstocks and/or residual wastes. For example, Ba, Fe, Ti, Li, and other notable metals do not appear to be analysed.

Comment #	Page #	Section	Paragraph	Comment/Action
				Organics – it does not appear that total organic carbon (or dissolved organic carbon) was analysed across the site. This is critical for TOC normalising benchmarks. Cyanide – The cyanide methods do not align with the reported results in the report. WAD, free and total cyanide measurements are likely needed where total cyanide is detected. Fluoride – What soluble fractions of fluoride were measured in soils and sediments? Please consider additional analytes.
81.	14	4.1		No discussion of the source of alumina and associated impurities has been provided. This is an important source of heavy metals and the listing of heavy metals included in the analytical suite needs to align with contaminants likely to be present in the alumina.
82.	16	4.2	2	It is not clear if cation/anion samples were field filtered.
83.	16	4.2	6	Why was turbidity not included in field parameters?
84.	17	5.2.1	1	Why were samples 'selectively' analysed for different parameters? What criteria and data quality objectives were used inform the selections?
85.	17	5.2.3	1	The first sentence should be re-written as the meaning is not clear.
86.	18	5.2.4	1	What was the source of the rinsate blank water? Also, 'accompanies" should be "accompanied".
87.		Figure A2		Aerial photograph shows a significant amount of phytotoxic stress. Some of these areas have been sampled and others not. The report needs to discuss these observations and also address atmospheric deposition as a source of fluoride impacts to surficial soils
88.		Appendix B		For Zone B there is no discussion on possible stormwater flow to the south into the abutting natural landscape. Sample needs to be conducted around the periphery of this area. For Zone C there is no discussion on solvent usage in the workshops. PCE and TCE has been detected at other smelters associated with maintenance and repair activities. In addition, the table notes a current firefighting practice area. Were there others? Was the only other former area ID77 in Area E? For Zone F the table notes the use of Heat Transfer Fluids. What type of heat transfer fluids were being used. Many historically were oils containing PCBs.

Comment #	Page #	Section	Paragraph	Comment/Action
				There is no reference to a grit blast building for cleaning the pots. Where is/was this located For Zone J there is reference to removal of contaminated sediment in the drains. Are there any reports of these activities? This suggests that discharges of contaminated sediment were occurring to the receiving environment.

Attachment B Relevant and Applicable Ecological Screening Values

Attachment B Assessment of Relevant and Applicable Ecological Screening Values

Introduction

EHS Support New Zealand Ltd (EHS Support) has been retained by Environment Southland (ES) to undertake a technical review of the following documents relating to the New Zealand Aluminium Smelters Ltd (NZAS) Tiwai Point manufacturing facility (Site):

1. NZAS Closure Preliminary Study – Sampling and Analysis Quality Plan Summary (SAQP). GHD New Zealand Ltd (GHD). 7 April 2021.
2. New Zealand Aluminium Smelters Ltd. NZAS Closure Preliminary Study. Contaminated Sites Detailed Site Investigation (DSI) Report. GHD. August 2021.

The review by EHS Support and associated comments provided in the technical review (EHS Support, 2022) identified areas within these documents that represent significant omissions in the GHD investigations. A key focus of the technical review (EHS Support 2022) was the lack of ecological screening of Site media. As part of the technical review process, EHS Support compiled a preliminary list of ecological screening values (ESVs) for the matrices considered in the DSI (soil, sediment, and groundwater). It should be noted that no surface water data was collected as part of the DSI in Site drains, which is needed prior to comparison to the discussed preliminary surface water ESVs. The preliminary ESVs are recommended for the purpose of a conservative assessment of the potential for risk to ecologic receptors.

Approach to Identifying Relevant and Applicable Criteria

Relevant and applicable criteria were identified to assess ecological risk for each Site media using the following approach. Ecological guidance for soil, sediment, and surface were reviewed from New Zealand, Australia, Canada, and the United States. ESVs were collated using a systematic approach to identify appropriate conservative numeric limits for preliminary screening. Generally, this followed a hierarcial approach whereby preference was given to guidelines sourced from countries in the following order: New Zealand, Australia, Canada, and the United States. The following subsections describe the specific considerations to soil, sediment, and surface water ESV selection.

Soil Screening Levels

Table 1 presents the recommended guideline hierarchy for identifying soil ESVs.

TABLE 1 GUIDELINE HIERARCHY FOR ECOLOGICAL SOIL SCREENING VALUES

Soil ESV Hierarchy
Manaaki Whenua – Landcare Research: Development of soil guideline values for the protection of ecological receptors (Eco-SGVs)
National Environment Protection Council (NEPM) Ecological Investigation Levels (EILs) and Ecological Screening Levels (ESLs)
Canadian Council of Ministers of the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health[1]
United States Environmental Protection Agency (USEPA) Ecological Soil Screening Levels (Eco-SSLs)

[1] = Conservative criteria was selected across all land uses given the ambiguous nature of future site plans.
CCME = Canadian Council of Minsters of the Environment
ECO-SGV = soil guideline values for the protection of ecological receptors
EIL = Ecological Investigation Level
ESL = Ecological Screening Level
NEPM = National Environment Protection Council
USEPA = United States Environmental Protection Agency

Based on this hierarchy, soil ESVs were identified for the majority of constituents that were analyzed in the DSI. A summary of recommended soil ESVs is found in **Table B-1** along with a comparison to th e most conservative screening limit used by GHD noting that no consideration was given to ecological receptors in their evaluation. The process by which soil ESVs were selected for a given constituent is as follows:

- If Landcare Research Eco-SGVs were available, it was retained as the soil ESV.
- Else, the most conservative NEPM ecological screening level (ESL) or Ecological Investigation Level (EIL) was selected. This typically relates to criteria developed that is protective of areas of ecological significance.
- Else, the most conservative Soil Quality Guideline (SQG) from CCME was selected. This typically relates to criteria developed that is protective of residential or parkland land covers or agricultural areas.
- Else, the most conservative USEPA Eco SSL was selected. This typically relates to criteria developed for the protection of avian or plant species.
- The most conservative ecological guideline value PFOA and PFOS were selected from the PFAS HEPA National Environmental Management Plan.
- Given that site-specific fluoride criteria will likely be developed in the absence of promulgated risk-based criteria, a realistic CCME SQG for the protection of agricultural and parkland or residential areas was chosen for fluoride rather than the most conservative.

Sediment Screening Levels

Table 2 presents the recommended guideline hierarchy for identifying sediment ESVs.

TABLE 2 SEDIMENT GUIDELINE HIERARCHY

Soil Screening Level Hierarchy
Australia and New Zealand Guideline (ANZG) Sediment Guideline Values (SGVs)
Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines for the Protection of Environmental and Human Health
United States Environmental Protection Agency (USEPA) Biological Technical Assistance Group (BTAG) Guidelines for Marine Sediment

ANZG = Australia and New Zeland Guideline
BTAG = Biological Technical Asistance Group Guidelines for Marine Sediment
CCME = Canadian Council of Minsters of the Environment
USEPA = United States Environmental Protection Agency

Based on this hierarchy, sediment ESVs were identified for the majority of constituents that were an alyzed in the DSI. A summary of recommended sediment ESVs is found in **Table B-2** along with a co mparison to the most conservative screening limit used by GHD noting that consideration was given to ecological receptors in their evaluation. Not all constituents covered by ANZG default guideline values (DGV) were screened by GHD using DGVs. The process by which sediment ESVs were selected for a given constituent is as follows:

- If a DGV for toxicants in sediment from ANZG was available, it was retained as the sediment ESV.
- Else, the most conservative Sediment Quality Guideline from CCME was selected. Where available, marine sediment quality guidelines were used. Freshwater sediment quality guidelines were used for constituents where no marine sediment quality guideline was available. This typically relates to CCME Interim Sediment Quality Guidelines (ISQGs).
- Else, the most conservative USEPA BTAG sediment benchmark was selected. Where available, marine sediment benchmarks were used. Freshwater sediment benchmarks were used for constituents where no marine sediment benchmark was available.
- Given that site-specific fluoride criteria will likely be developed in the absence of promulgated risk-based criteria, an interim guideline value derived from the literature (Metcalfe-Smith et al. 2003) fluoride.

Surface Water Screening Levels

Table 3 presents the recommended guideline hierarchy for identifying surface water ESVs.

TABLE 3 SURFACE WATER ECOLOGICAL GUIDELINE HIERARCHY

Source	Type
New Zealand National Environmental Mangement Plan	Heads of EPAs Australia and New Zealand (HEPA) PFAS National Environmental Management Plan (NEMP) PFAS
Australia and New Zealand Guidelines (ANZG)	Aquatic Ecosystems Default Guidelines Values (DGVs) for the Protection of Marine Life
Canadien Council of Ministers of the Environment (CCME)	Water Quality Guidelines for the Protection of Aquatic Life: Freshwater Short Term
	Water Quality Guidelines for the Protection of Aquatic Life: Freshwater Long Term
	Water Quality Guidelines for the Protection of Aquatic Life: Marine Short Term
	Water Quality Guidelines for the Protection of Aquatic Life: Marine Short Term
United States Environmental Protection Agency (USEPA)	Region 3 Biological Technical Assistance Group (BTAG) Marine Surface Water Screening Criteria

ANZG = Australia and New Zeland Guideline
BTAG = Biological Technical Asistance Group Guidelines for Marine Sediment
CCME = Canadian Council of Minsters of the Environment
DGV = Defualt Guideline Value for the Protection of Marine Life
ECO-SGV = soil guideline values for the protection of ecological receptors
HEPA = Heads of EPAs Australia and New Zealand
NEPM = National Environment Protection Council
PFAS = per-and polyfluoroalkyl substances
USEPA = United States Environmental Protection Agency

Based on this hierarchy, surface water ESVs were identified for the majority of constituents that were analyzed in the DSI. A summary of recommended surface water ESVs is found in **Table B-3** along with a comparison to the most conservative screening limit used by GHD noting that no consideration was given to surface water in their evaluation. The process by which surface water ESVs were selected for a given constituent is as follows:

- If a Marine Trigger value (MTV) protective of 99% of aquatic species from ANZG was available, it was retained as the surface water ESV. Where available, MTVs were used. Freshwater Trigger Values (FTVs) were used for constituents where no MTV was available.
- Else, the most conservative Water Quality Guideline from CCME was selected. This typically relates to CCME Water Quality Guidelines (WQGs) for the Long Term protection of aquatic life. Where available, marine surface water quality guidelines were used. Freshwater surface water quality guidelines were used for constituents where no marine surface water quality guideline was available.
- Else, the most conservative USEPA BTAG surface water benchmark was selected. Where available, marine surface water benchmarks were used. Freshwater surface water benchmarks were used for constituents where no marine surface water benchmark was available.
- Given that site-specific fluoride criteria will likely be developed in the absence of promulgated risk-based criteria, the British Columbia Ambient Water Quality Guideline protective of marine aquatic life was selected.
- Given the lack of ecological screening values for aluminium, a marine trigger value protective of 99% of aquatic species derived using an SSD approach by van Dam et al. (2018) was selected as the ESV.

- The most conservative ecological guideline value PFOA and PFOS were selected from the PFAS HEPA National Environmental Management Plan.

Application of the ANZG guidelines to surface water requires the consideration of additional values or uses of the environment that would require protection from the effects of stressors. Guidelines for these community values (also called beneficial uses) may be specific to a particular jurisdiction, territory, or state. Due to the uncertain future site plans, it is recommended that these additional guidelines be considered for understanding risk to the receiving environment from surface water along with ESVs. These additional considerations are listed in **Table 4** below. Future investigations should select an appropriate screening level based on these community value including justifiable rationale.

TABLE 4 ADDITIONAL CONSIDERATIONS FOR SURFACE WATER

Source	Type
Australia and New Zealand Guidelines (ANZG)	Primary Industries: Irrigation and Livestock Water
	Cultural and Spiritual Values[1]
	Drinking Water Standards[2]
	Recreational Guideline Values

Note: Aquatic Ecosystems are considered to be a community value. However, guidelines for aquatic ecosystems and subsequently ESVs have been identified from the surface water ESV hierarchy approach.
[1] = Inclusion of the Cultural and Spiritual Guideline values requires a focused assessment and consultation with appropriate stakeholders.
[2] = It is recommended that New Zealand's Drinking Water Standards be considered in this evaluation.
ANZG = Australia and New Zeland Guideline

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Tables

Table B-1

Table B-1
Conservative Screening-Level Ecological Guidance/Values for Soil
DRAFT - FOR DISCUSSION PURPOSES
Project Awarua, Tiwai Smelter DSI Review

Constituent	Most Conservative GHD Soil Value (mg/kg)*	Screening-Level Soil Ecological Value** (mg/kg)	Source	Rationale
METALS				
Aluminium	77000	No Criteria		See Notes[1]
Antimony		20	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Arsenic	70	6	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
Barium		500	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Beryllium	90	4	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Boron	20000	2	CCME	See Notes[3]
Cadmium	400	1.5	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
Chromium (III)		100	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
Chromium (III+VI)	2700	64	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Cobalt	300	40	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Copper	17000	45	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
Lead	880	55	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
Mercury	730	12	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Nickel	1200	5[a]	NEPM EIL/ESL	Table 1B(3) - Protective of National Parks and Areas of High Conservation Value

Table B-1
Conservative Screening-Level Ecological Guidance/Values for Soil
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Constituent	Most Conservative GHD Soil Value (mg/kg)*	Screening-Level Soil Ecological Value** (mg/kg)	Source	Rationale
Vanadium	390	130	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Zinc	30000	120	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
INORGANICS				
Cyanide, Free	240	0.9	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Cyanide, Total		No Criteria		See Notes[4]
Cyanide, WAD		No Criteria		See Notes[4]
Fluoride	3100	400	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
PAHs				
Anthracene		2.5	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Benz(a)anthracene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Benzene	1.1	10	NEPM EIL/ESL	Table 1B(6) - Protective of Urban Residential and Public Open Space
Benzo(a)pyrene		2.8	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
Benzo(k)fluoranthene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Dibenz(a,h)anthracene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Ethylbenzene	53	1.5	NEPM EIL/ESL	Table 1B(6) - Protective of Urban Residential and Public Open Space
Fluoranthene		7.6	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]

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Constituent	Most Conservative GHD Soil Value (mg/kg)*	Screening-Level Soil Ecological Value** (mg/kg)	Source	Rationale
Indeno(1,2,3-c,d)pyrene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Naphthalene	7.2	10	NEPM EIL/ESL	Table 1B(5) - Protective of National Parks and Areas of High Conservation Value
Pyrene	160	0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Toluene	68	10	NEPM EIL/ESL	Table 1B(6) - Protective of Urban Residential and Public Open Space
Xylenes		10	NEPM EIL/ESL	Table 1B(6) - Protective of Urban Residential and Public Open Space
PCBs				
Total PCBs		1.3	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
PFAS/PFOA				
PFOA	0.632	0.632	HEPA	PFAS HEPA National Environmental Management Plan Version 2.0
PFOS	0.002	0.002	HEPA	PFAS HEPA National Environmental Management Plan Version 2.0
SVOC				
1,2-dichlorobenzene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
1,3-dichlorobenzene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
1,4-dichlorobenzene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
2,4-dichlorophenol		0.05	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Benzo(b)fluoranthene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces

Table B-1
Conservative Screening-Level Ecological Guidance/Values for Soil
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Constituent	Most Conservative GHD Soil Value (mg/kg)*	Screening-Level Soil Ecological Value** (mg/kg)	Source	Rationale
DDT		2.6	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
Dieldrin	10	0.0049	USEPA Eco SSL	USEPA Eco SSL: Protection of Mammals
g-BHC (Lindane)		0.01	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Hexachlorobenzene	10	0.05	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Phenol	40000	3.8	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
TPH* **				
C7-C9		66	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
>C9-C15		45	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
>C15-36		300[b]	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
>C36		1700[b]	Cavanagh and Munir (2019)	Soil Guideline Value Protective of Areas of Ecological Significance[2]
>C10-C16		25[b]	NEPM EIL/ESL	Table 1B(6) - Protective of Areas of Ecological Significance
>C16-C34		300[b]	NEPM EIL/ESL	Table 1B(6) - Protective of Urban Residential and Public Open Space
>C34-C40		2800[b]	NEPM EIL/ESL	Table 1B(6) - Protective of Urban Residential and Public Open Space
C6-C10		125	NEPM EIL/ESL	Table 1B(6) - Protective of Areas of Ecological Significance

Table B-1
Conservative Screening-Level Ecological Guidance/Values for Soil
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Constituent	Most Conservative GHD Soil Value (mg/kg)*	Screening-Level Soil Ecological Value** (mg/kg)	Source	Rationale
VOC				
1,1,1-trichloroethane		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
1,1,2,2-tetrachloroethane		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
1,1,2-trichloroethane		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
1,1-dichloroethane		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
1,1-dichloroethene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
1,2,3-trichlorobenzene		0.05	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
1,2,4-trichlorobenzene		0.05	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
1,2-dichloroethane		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
1,2-dichloropropane		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Carbon tetrachloride		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Chlorobenzene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Chloroform		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Styrene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
TCE		0.01	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces
Tetrachloroethene		0.1	CCME	Protective of Agricultural Limits and/or Residential and Parkland Spaces

Table B-1
Conservative Screening-Level Ecological Guidance/Values for Soil
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Notes:

[1] = Soil aluminium value is dependent on factors affecting aqueous mobility. Value will be determined upon evaluating these parameters.

[2] = Eco-SGVs are reported using the lowest median background concentration per constituent. Site-specific background criteria is required for appropriate SGVs.

[3] = Values presented are for HWSB. Results are presented as TRB. Appropriate values will be derived based on conservative estimates for percentage of HWSB within TRB.

[4] = A full suite of analysis is required in order to appropriately constrain the nature and extent of cyanide, therefore no screening value was selected.

[a] = Screening value was derived using the estimated site specific clay content of 1%, which is the lowest threshold for clay content.

[b] = The conservative screening value for coarse grained particles was selected in absence of site-specific grain size analysis.

* Values presented are the most conservative screening values for each constituent based on the DSI reporting completed by GHD Limited.

** Elected conservative screening values were selected based on relevant guidelines. Further evaluation during the screening process is required to determine guideline applicability.

*** C7-C9 fraction was screened during preliminary screening. However misalignment of fractions prohibited additional screening of TPH constituents.

Ecological Screening Hierarchy was built using the following guidelines. Values for each constituent were selected from the first tier with values for that constituent. Within each tier, a conservative screening value was selected based on site factors including land use and/or marine/freshwater environment.

- Manaaki Whenua - Landcare Research: Development of soil guideline values for the protection of ecological receptors (Eco-SGVs)
- NEPM EIL/ESLs
- CCME Soil Quality Guidelines for the Protection of Environmental and Human Health - values selected across all land uses given the ambiguous nature of future site plans. Realistic values were selected for fluoride rather than selecting the most conservative.
- USEPA Eco SSLs - conservative values selected for all receptors when available

CCME = Canadian Council of Ministers of the Environment
DDD = Dichlorodiphenyldichloroethylene
DDE = Dichlorodiphenyldichloroethane
DDT = Dichlorodiphenyltrichloroethane
DSI = Detailed Site Investigation
EIL = Ecological Investigation Level
ESL = Ecological Screening Levels
GHD = GHD Limited
HEPA = Heads of EPAs Australia and New Zealand
HWSB = Hot Water Soluble Boron
NEPM = National Environmental Protection Measure
PAH = Polycyclic Aromatic Hydrocarbons
PCB = Polychlorinated biphenyl
SGV = Soil Guideline Value
TCE = Trichloroethylene
TRB = Total Recoverable Boron
PFOA = Perfluorooctanoic acid
PFOS = Perfluorooctanesulfonic acid
USEPA = United States Environmental Protection Agency
Eco SSL = Ecological Soil Screening Level

Table B-2

Table B-2
Conservative Screening-Level Ecological Guidance/Values for Sediment
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Constituent	Most Conservative GHD Sediment Values (mg/kg)*	Screening-Level Sediment Ecological Values** (mg/kg)	Source	Rationale
METALS				
Aluminium	77000	No Criteria		See Notes[a]
Antimony		2	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Arsenic	20	20	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Cadmium	1.5	1.5	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Chromium (III+VI)	80	80	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Cobalt		50	BTAG	Marine Sediment Screening Benchmarks
Copper	65	65	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Lead	50	50	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Mercury	0.15	0.15	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Nickel	21	21	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Silver		1	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Zinc	200	200	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
INORGANICS				
Cyanide, Free	240	No Criteria		See Notes[b]
Cyanide, Total		No Criteria		See Notes[b]
Cyanide, WAD		No Criteria		See Notes[b]
Fluoride	3100	290	Metcalfe-Smith et al. 2003	Interim Guideline Value derived from the Literature
PAHs* **				
2-methylnaphthalene		0.0202	CCME	Marine Interim Sediment Quality Guideline Value
Acenaphthene		0.00671	CCME	Marine Interim Sediment Quality Guideline Value
Acenaphthylene		0.00587	CCME	Marine Interim Sediment Quality Guideline Value
Anthracene		0.0469	CCME	Marine Interim Sediment Quality Guideline Value
Benzo(a) pyrene		0.0888	CCME	Marine Interim Sediment Quality Guideline Value
Benzo(g,h,i)perylene		0.17	BTAG	Marine Sediment Screening Benchmarks
Benzo(k)fluoranthene		0.24	BTAG	Marine Sediment Screening Benchmarks
Chrysene		0.108	CCME	Marine Interim Sediment Quality Guideline Value
Dibenz(a,h)anthracene		0.00622	CCME	Marine Interim Sediment Quality Guideline Value
Fluoranthene		0.113	CCME	Marine Interim Sediment Quality Guideline Value
Fluorene		0.0212	CCME	Marine Interim Sediment Quality Guideline Value
Indeno(1,2,3-c,d)pyrene		0.017	BTAG	Marine Sediment Screening Benchmarks

Table B-2
Conservative Screening-Level Ecological Guidance/Values for Sediment
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Constituent	Most Conservative GHD Sediment Values (mg/kg)*	Screening-Level Sediment Ecological Values** (mg/kg)	Source	Rationale
Naphthalene		0.0346	CCME	Marine Interim Sediment Quality Guideline Value
Phenanthrene		0.0867	BTAG	Marine Sediment Screening Benchmarks
Pyrene		0.153	CCME	Marine Interim Sediment Quality Guideline Value
Total PAHs	10	10	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
PCBs				
Total PCBs[1]		0.0034	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
SVOCs				
1,2-dichlorobenzene[1]		0.989	BTAG	Marine Sediment Screening Benchmarks
1,3-dichlorobenzene[1]		0.842	BTAG	Marine Sediment Screening Benchmarks
1,4-dichlorobenzene[1]		0.46	BTAG	Marine Sediment Screening Benchmarks
2,4,5-trichlorophenol[1]		0.819	BTAG	Marine Sediment Screening Benchmarks
2,4,6-trichlorophenol[1]		2.65	BTAG	Marine Sediment Screening Benchmarks
2,4-dichlorophenol		0.117	BTAG	Marine Sediment Screening Benchmarks
2,4-dimethylphenol		0.029	BTAG	Marine Sediment Screening Benchmarks
2,4-Dinitrotoluene		0.0416	BTAG	Marine Sediment Screening Benchmarks
2-chlorophenol[1]		0.344	BTAG	Marine Sediment Screening Benchmarks
4-bromophenyl phenyl ether		1.23	BTAG	Marine Sediment Screening Benchmarks
4-methylphenol		0.67	BTAG	Marine Sediment Screening Benchmarks
4,4-DDE[1]		0.0014	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
3,4- & 4,4-DDD[1]		0.0035	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
a-BHC[1]		1.36	BTAG	Marine Sediment Screening Benchmarks
Aldrin		0.002	BTAG	Marine Sediment Screening Benchmarks
b-BHC		0.005	BTAG	Marine Sediment Screening Benchmarks
Bis(2-ethylhexyl) phthalate		0.182	BTAG	Marine Sediment Screening Benchmarks
Butyl benzyl phthalate[1]		16.8	BTAG	Marine Sediment Screening Benchmarks
Chlordane		0.0045	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
d-BHC		6.4	BTAG	Marine Sediment Screening Benchmarks
Dibenzofuran[1]		7.3	BTAG	Marine Sediment Screening Benchmarks
Dieldrin		0.0028	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Di-n-butyl phthalate[1]		1.16	BTAG	Marine Sediment Screening Benchmarks

Table B-2
Conservative Screening-Level Ecological Guidance/Values for Sediment
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Constituent	Most Conservative GHD Sediment Values (mg/kg)*	Screening-Level Sediment Ecological Values** (mg/kg)	Source	Rationale
Endosulfan[1]		0.000107	BTAG	Marine Sediment Screening Benchmarks
Endosulfan sulphate[1]		0.000357	BTAG	Marine Sediment Screening Benchmarks
Endrin		0.0027	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
g-BHC (Lindane)		0.00032	CCME	Marine Interim Sediment Quality Guideline Value
Heptachlor		0.0006	CCME	Marine Interim Sediment Quality Guideline Value
Heptachlor epoxide		0.0006	BTAG	Marine Sediment Screening Benchmarks
Hexachlorobenzene		0.02	BTAG	Marine Sediment Screening Benchmarks
Hexachlorocyclopentadiene[1]		0.139	BTAG	Marine Sediment Screening Benchmarks
Hexachloroethane[1]		0.804	BTAG	Marine Sediment Screening Benchmarks
Lindane		0.0009	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
Methoxychlor[1]		0.0296	BTAG	Marine Sediment Screening Benchmarks
n-Nitrosodiphenylamine[1]		422	BTAG	Marine Sediment Screening Benchmarks
Phenol		0.42	BTAG	Marine Sediment Screening Benchmarks
Total DDT[1]		0.0012	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
TPH				
TPHs		280	ANZG	Recommended Default Guideline Values for Toxicants in Sediment
VOCs				
1,1,1-trichloroethane[1]		0.856	BTAG	Marine Sediment Screening Benchmarks
1,1,2,2-tetrachloroethane[1]		0.202	BTAG	Marine Sediment Screening Benchmarks
1,1,2-trichloroethane[1]		0.57	BTAG	Marine Sediment Screening Benchmarks
1,1-dichloroethene[1]		2.78	BTAG	Marine Sediment Screening Benchmarks
1,2,3-trichlorobenzene		0.858	BTAG	Marine Sediment Screening Benchmarks
1,2,4-trichlorobenzene[1]		0.473	BTAG	Marine Sediment Screening Benchmarks
Benzene[1]		0.137	BTAG	Marine Sediment Screening Benchmarks
Bromoform[1]		1.31	BTAG	Marine Sediment Screening Benchmarks
Carbon disulfide		0.000851	BTAG	Marine Sediment Screening Benchmarks
Carbon tetrachloride[1]		7.24	BTAG	Marine Sediment Screening Benchmarks
Chlorobenzene[1]		0.162	BTAG	Marine Sediment Screening Benchmarks
Ethylbenzene[1]		0.305	BTAG	Marine Sediment Screening Benchmarks
Styrene[1]		7.07	BTAG	Marine Sediment Screening Benchmarks

Table B-2
Conservative Screening-Level Ecological Guidance/Values for Sediment
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Constituent	Most Conservative GHD Sediment Values (mg/kg)*	Screening-Level Sediment Ecological Values** (mg/kg)	Source	Rationale
Tetrachloroethene[1]		0.19	BTAG	Marine Sediment Screening Benchmarks
Toluene[1]		1.09	BTAG	Marine Sediment Screening Benchmarks
trans-1,2-dichloroethene		1.05	BTAG	Marine Sediment Screening Benchmarks

Notes:

[a] = Sediment aluminium value is dependent on factors affecting aqueous mobility. The screening value will be determined upon evaluating these parameters.

[b] = A full suite of analysis is required in order to appropriately constrain the nature and extent of cyanide, therefore no screening value was selected.

[1] = Values are reported at the default level using 1% TOC and are subject to change based on site specific criteria.

* Values presented are the most conservative screening values for each constituent based on the DSI reporting completed by GHD Limited.

** Elected conservative screening value was selected based on relevant guidelines. Further evaluation during the screening process is required to determine guideline applicability.

*** The ESBTU method is approved for evaluating PAHs in sediment but in the absence of TOC data the following value are recommended

Ecological Screening Hierarchy was built using the following guidelines. The value for each constituent was selected from the first tier with value for that constituent.
Within each tier, a conservative screening value was selected based on site factors including land use and/or marine/freshwater environment.

- ANZG Sediment Guideline Values
- CCME Sediment Quality Guidelines for the Protection of Environmental Health - conservative value selected across all land uses given the ambiguous nature of future site plans. Realistic values were selected for fluoride rather than selecting the most conservative.
- USEPA Region 3 BTAG Guidelines for Marine Sediment

Metcalfe-Smith, J. L., Holtze, K. E., Sirota, G. R., Reid, J. J., & De Solla, S. R. (2003). Toxicity of aqueous and sediment-associated fluoride to freshwater organisms. Environmental Toxicology and Chemistry, 22(1), 161–166. https://doi.org/10.1002/etc.5620220121

ANZG = Australia and New Zealand Guidelines
BHC = beta=Hexachlorocyclohexane
BTAG = USEPA Region 3 Biological Technical Assistance Group
DDD = Dichlorodiphenyldichloroethylene
DDE = Dichlorodiphenyldichloroethane
DDT = Dichlorodiphenyltrichloroethane
ESBTU = Equilibrium Partitioning Sediment Benchmark Toxic Unit
GHD = GHD Limited
PAH = Polycyclic Aromatic Hydrocarbons
PCB = Polychlorinated biphenyl

Table B-3

Table B-3
Conservative Screening-Level Ecological Guidance/Values for Surface Water
DRAFT - FOR DISCUSSION PURPOSES
Project Awarua, Tiwai Smelter DSI Review

Analyte	Most Conservative GHD Groundwater Screening Value* (µg/L)	Surface Water Ecological Screening Value** (µg/L)	Source	Rationale***
METALS				
Aluminium[1]	100	16	van Dam (2018)	Recommended Default Guideline Values for the Protection of Marine Life
Arsenic[2]	10	3	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Barium		4	USEPA BTAG	Marine Surface Water Screening Benchmark
Beryllium	4	0.66	USEPA BTAG	Marine Surface Water Screening Benchmark
Boron[3]	1300	340	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Cadmium	4	0.7	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Chloride	250000	120000	CCME	Water Quality Guideline for the Protection of Aquatic Life
Chromium (III)		7.7	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Chromium (III+VI)	35	5	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Cobalt	150	0.005	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Copper	8	0.3	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Lead	10	2.2	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Manganese		1200	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Mercury	1.4	0.1	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Nickel	80	7	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Sulphate	250000			
Vanadium	280	50	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Zinc	43	3.3	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
INORGANICS				
Cyanide, WAD	14			
Cyanide (Free)		2	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Fluoride[4]	1500	1500	BCMECCS	Ambient Water Quality Guideline for the Protection of Marine Aquatic Species
PAHs				
1-Methylnaphthalene		2.1	USEPA BTAG	Marine Surface Water Screening Benchmark
2-methylnaphthalene		4.2	USEPA BTAG	Marine Surface Water Screening Benchmark
Acenaphthene		5.8	CCME	Water Quality Guideline for the Protection of Aquatic Life
Anthracene		0.01	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Benzo(a)anthracene		0.018	CCME	Water Quality Guideline for the Protection of Aquatic Life
Benzene	100	500	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Benzo(a)pyrene	0.7	0.1	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Ethylbenzene	300	50	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Fluoranthene		1	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Fluorene		3	CCME	Marine Surface Water Screening Benchmark
Naphthalene	120	50	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Phenanthrene		0.6	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Pyrene	1200	0.025	CCME	Water Quality Guideline for the Protection of Aquatic Life
Toluene	800	110	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Xylenes		19	USEPA BTAG	Marine Surface Water Screening Benchmark

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DRAFT - FOR DISCUSSION PURPOSES
Project Awarua, Tiwai Smelter DSI Review

Analyte	Most Conservative GHD Groundwater Screening Value* (µg/L)	Surface Water Ecological Screening Value** (µg/L)	Source	Rationale***
SVOCs				
1,2-dichlorobenzene	270	120	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
1,3-dichlorobenzene	520	160	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
1,4-dichlorobenzene	100	40	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
2,4,6-trichlorophenol	95	3	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
2,4-dichlorophenol	270	120	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
2,4-Dinitrotoluene	250	16	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
2,6-dinitrotoluene		81	USEPA BTAG	Marine Surface Water Screening Benchmark
2-chlorophenol	870	340	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
2-methylphenol		13	USEPA BTAG	Marine Surface Water Screening Benchmark
2-nitrophenol		1920	USEPA BTAG	Marine Surface Water Screening Benchmark
4,4 DDD		0.011	USEPA BTAG	Marine Surface Water Screening Benchmark
4,4 DDT	0.04	0.006	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
4-bromophenyl phenyl ether		1.5	USEPA BTAG	Marine Surface Water Screening Benchmark
4-chloroaniline		232	USEPA BTAG	Marine Surface Water Screening Benchmark
4-methylphenol		543	USEPA BTAG	Marine Surface Water Screening Benchmark
4-nitrophenol		60	USEPA BTAG	Marine Surface Water Screening Benchmark
Aldrin		0.004	CCME	Water Quality Guideline for the Protection of Aquatic Life
Aniline		8	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Benzyl alcohol		8.6	USEPA BTAG	Marine Surface Water Screening Benchmark
Bis(2-ethylhexyl) phthalate		16	CCME	Water Quality Guideline for the Protection of Aquatic Life
Butyl benzyl phthalate		19	USEPA BTAG	Marine Surface Water Screening Benchmark
d-BHC		141	USEPA BTAG	Marine Surface Water Screening Benchmark
DDT		0.006	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Dibenzofuran		3.7	USEPA BTAG	Marine Surface Water Screening Benchmark
Dieldrin		0.004	CCME	Water Quality Guideline for the Protection of Aquatic Life
Diethylphthalate	5100	900	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Dimethyl phthalate		3000	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Di-n-butyl phthalate		10	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Di-n-octyl phthalate		22	USEPA BTAG	Marine Surface Water Screening Benchmark
Endosulfan		0.005	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Endrin	0.02	0.004	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
g-BHC (Lindane)	1	0.07	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Heptachlor	0.7	0.01	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Heptachlor epoxide		0.0019	USEPA BTAG	Marine Surface Water Screening Benchmark
Hexachlorobenzene		0.05	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Hexachlorobutadiene	0.7	1.3	CCME	Water Quality Guideline for the Protection of Aquatic Life
Hexachloroethane	500	290	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Methoxychlor		0.019	USEPA BTAG	Marine Surface Water Screening Benchmark
Nitrobenzene	1300	230	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
n-Nitrosodiphenylamine		210	USEPA BTAG	Marine Surface Water Screening Benchmark
Phenol	720	270	ANZG	Recommended Default Guideline Values for the Protection of Marine Life

Table B-3
Conservative Screening-Level Ecological Guidance/Values for Surface Water
DRAFT - FOR DISCUSSION PURPOSES
Project Awarua, Tiwai Smelter DSI Review

Analyte	Most Conservative GHD Groundwater Screening Value* (µg/L)	Surface Water Ecological Screening Value** (µg/L)	Source	Rationale***
VOCs				
1,1,1-trichloroethane		130	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
1,1,2,2-tetrachloroethane		200	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
1,1,2-trichloroethane	18000	140	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
1,1-dichloroethane		250	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
1,1-dichloroethene		25	USEPA BTAG	Recreational Guideline Value
1,2,3-trichlorobenzene	30	3	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
1,2,4-trichlorobenzene	300	20	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
1,2,4-trimethylbenzene		33	USEPA BTAG	Marine Surface Water Screening Benchmark
1,2-dichloroethane		1000	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
1,2-dichloropropane		600	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
1,3,5-trimethylbenzene		71	USEPA BTAG	Marine Surface Water Screening Benchmark
1,3-dichloropropane		700	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
2-hexanone (MBK)		99	USEPA BTAG	Marine Surface Water Screening Benchmark
Bromoform		320	USEPA BTAG	Marine Surface Water Screening Benchmark
Carbon disulfide		0.92	USEPA BTAG	Marine Surface Water Screening Benchmark
Carbon tetrachloride	5	150	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Chlorobenzene		5	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Chloroform	400	370	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Dichloromethane	20			
Isopropylbenzene		20	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
MTBE		11070	USEPA BTAG	Marine Surface Water Screening Benchmark
n-propylbenzene		128	USEPA BTAG	Marine Surface Water Screening Benchmark
Styrene	30	72	CCME	Drinking Water Standard
TCE		220	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
trans-1,2-dichloroethene		970	USEPA BTAG	Marine Surface Water Screening Benchmark
Vinyl acetate		16	USEPA BTAG	Marine Surface Water Screening Benchmark
Vinyl chloride		930	USEPA BTAG	Marine Surface Water Screening Benchmark
Xylene (m & p)		190	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
Xylene (o)		200	ANZG	Recommended Default Guideline Values for the Protection of Marine Life
PFAS/PFOA				
PFOA	0.56	19	HEPA	PFAS HEPA National Environmental Management Plan Version2.0
PFOS	0.13	0.00023	HEPA	PFAS HEPA National Environmental Management Plan Version2.0

Notes:

[1] = van Dam et al. (2018); Screening value was derived from revised water quality guidelines presented in the literature based on SSD approach.

[2] = The Australian and New Zealand Guidelines for Fresh and Marine Quality do not provide guidelines for total arsenic in marine waters.
Therefore, the high reliability freshwater trigger value for arsenic (V) were adopted due to the propensity of arsenic to exists as oxyanions of trivalent arsenite [As(II)] or arsenate [As(V)] (Smedley and Kinniburgh, 2001).

[3] = The conservative screening value for coarse grained particles was selected in absence of site-specific grain size analysis.

[4] = Fluoride ecological screening value is based on the British Columbia Ambient Water Quality Guidelines for the protection of Marine Aquatic Species.

* Values presented are the most conservative screening values for each constituent based on the DSI reporting completed by GHD Limited.
** Elected conservative screening values was selected based on relevant guidelines. Further evaluation during the screening process is required to determine guideline applicability.
*** Hierarchy Rationale is listed below:
Ecological Screening Hierarchy was built using the following guidelines. Values for each constituent were selected from the first tier with criteria for that constituent.
Within each tier, a conservative screening value was selected based on the availability of marine/freshwater guidelines.
- ANZG Marine Aquatic Ecosystems Default Guideline Values for Protection of Marine Life (99% species protection was used as the most conservative screening value). Freshwater DGVs were substituted when no Marine DGV was available.
- CCME Water Quality Guidelines for the Protection of Environmental Health - conservative freshwater screening values were selected when no conservative marine screening value was available.
- USEPA Region 3 BTAG Marine Benchmarks - Freshwater surface water benchmarks were utilized where no Marine surface water benchmark was available pursuant to the USEPA Region 3 BTAG guidelines.

References:

van Dam, J. W., Trenfield, M. A., Streten, C., Harford, A. J., Parry, D., & van Dam, R. A. (2018). Water quality guideline values for aluminium, gallium and molybdenum in marine environments. Environmental Science and Pollution Research, 25(26), 26592–26602. https://doi.org/10.1007/s11356-018-2702-y

Smedley, P.L. and Kinniburgh, D. (2001) A Review of the Source, Behaviour and Distribution of Arsenic in Natural Waters. Applied Geochemistry, 17, 517-568.

ANZG = Australia and New Zealand Guidelines
BCMECSS = British Columbia Ministry of the Environment and Climate Change Strategy
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DDD = Dichlorodiphenyldichloroethylene
DDE = Dichlorodiphinyldichloroethane
DDT = Dichlorodiphenyltrichloroethane
DGV = Default Guideline Value
GHD = GHD Limited
PAH = Polycyclic Aromatic Hydrocarbons
PCB = Polychlorinated biphenyl
TCE = Trichloroethylene
MTBE = Methyl tert=butyl ether
PFOA = Perfluorooctanoic acid
PFOS = Perfluorooctanesulfonic acid