IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of applications for resource consent from the Grey District Council and West Coast Regional Council to undertake mineral sand mining and associated activities
BETWEEN	TIGA Minerals and Metals Ltd
	WCRC: RC-2023-0046 GDC: LUN3154/23
	Applicant
AND	G and G Langridge, the GA Langridge Family Trust, R Langridge and D Vandenberg, D Langridge and S Langridge and R Wildbore
	Submitters

Statement of Evidence of Professor Brian L. McGlynn on behalf of G and G Langridge, the GA Langridge Family Trust, R Langridge and D Vandenberg, D Langridge and S Langridge and R Wildbore

Dated January 25 2024.

Introduction

[1] My full name is Brian Leonard McGlynn

[2] I am employed as a Hydrologist and Biogeoscientist with e3Scientific, Arrowtown, New Zealand. I am also an Adjunct Professor of Hydrology and Biogeosciences in the Nicholas School of the Environment at Duke University, USA.

[3] I am a PhD Hydrologist with expertise in watershed and stream hydrological, ecological, and biogeochemical processes. I have extensive experience investigating natural and disturbed watersheds, stream networks, and groundwater systems. I am currently an Adjunct Professor of Hydrology and Biogeosciences in the Nicholas School of the Environment at Duke University (USA). From 2012–2019, I was a Professor of Hydrology and Biogeosciences at Duke University and Chair of the Division of Earth and Ocean Sciences from 2014–2016. From 2002–2012 I was an Assistant Professor then Associate Professor of Watershed Hydrology at Montana State University. I am a member of the New Zealand Hydrological Society, the American Geophysical Union (Hydrology and Biogeosciences sections), and have been a member of the Society for Freshwater Science, the European Geophysical Union, and the Geological Society of America. I continue to be actively engaged in research and application at the forefront of environmental science understanding.

[4] I hold the following tertiary qualifications; a Bachelor of Arts in Environmental Studies and a Bachelor of Arts in History from Gettysburg College (USA) and a Master of Science in Hydrology and a PhD in Hydrology from the State University of New York College of Environmental Science and Forestry at Syracuse (USA).

[5] I have more than 26 years of experience working in hydrology, biogeochemistry, ecology, soil and geological science, and water quality that began in 1994. I have served in project director roles since 2002. I

have worked across a wide range of environments from the Arctic to the Amazon including Westland, NZ where my PhD research focused on stream water sources, runoff flowpaths, and resultant water chemistry in cooperation with LandCare and NIWA in the Maimai catchments on the east side of the Paparoa Mountains. I have additionally performed hydrological, biogeochemical, and landscape analysis projects for the US National Science Foundation, US Environmental Protection Agency, US Department of Agriculture, Montana State Department of Environmental Quality, US Forest Service, and a number of non-governmental organizations.

[6] I have taught >13 different university courses focused on water science and management, river and catchment hydrology, water quality, ecohydrology, hydrogeology, and spatial analysis to many hundreds of undergraduate and graduate students while individually mentoring dozens of students through research training and experiential learning. I have served as the primary mentor and advisor for more than 9 MS students and 12 PhD students, and 6 post-doctoral professionals who have gone on to successful careers at leading academic institutions, consulting firms, and state and federal agency employment in the water arena.

[7] I have numerous years of US National Science Foundation sponsored experience as project director and investigative scientist focussed on the hydrological and biogeochemical effects of mining related critical zone disturbance highly relevant to this proposal. I co-authored 5 published papers in top international scientific journals from this work. In short, we found that hydrologic and biogeochemical recovery trajectories during and following post mining reclamation likely go far beyond our lifetimes and could persist on geologic time scales.

[8] I have been working in hydrology and biogeoscience environmental consulting with e3Scientific in New Zealand since November 2022 .

[9] I began working with wetland assessment and delineation in the USA in 1994. New Zealand adopted and modified its wetland assessment and delineation from the USA system. I became familiar with the NZ system starting in 2021 and have provided training to NGOs and local government since then. I started performing NZ specific wetland assessment and delineation in 2022 on a variety of consulting projects and reviews (including mining) across Southland and Otago.

[10] Recognition of my scientific contributions are partially reflected in my impact on international hydrological and biogeochemical sciences. These are indicated by: >10,406 Google Scholar citations to >100 peer reviewed scientific research papers, H-index of 51, i10 index of 101. H-Index of 51 means that 51 other published peer reviewed scientific journal articles have cited my work while an i10 of 101 means that 101 of my articles have been cited by at least 10 other articles. http://scholar.google.com/citations?hl=en&user=c2iow7sAAAAJ.

[11] I have a strong understanding of hydrological processes and how water flowpaths, streamflow source areas, and landscape characteristics impact water chemistry and stream and groundwater quality in ecosystems around the world. I have brought this experience and expertise to consulting work in New Zealand and have become familiar with freshwater and wetlands regulations and polices over the last few years.

[12] I am familiar with the catchment hydrology, meteorology, climate, and groundwater hydrology of the West Coast area around the Paparoa Range. I completed my PhD research focussed on catchment hydrology, water flowpaths, water age, and stream biogeochemistry in the Maimai catchments located between Reefton and Greymouth and lived and worked outdoors in the area nearly every day for approximately one year while performing scientific field work. I have a first-hand understanding of the dynamic nature of rainfall and runoff in this highly responsive landscape. I have published extensively on the topic and area in peer reviewed international scientific literature.

[13] Robyn Langridge contacted e3Scientific in December of 2023 and requested an independent hydrological assessment of the resource consent application submitted by TiGa Minerals and Metals Ltd for property adjacent to their family farm. It is my understanding that the Langridges have lived and worked in this area for five generations (youngest children included). I agreed to review the relevant documents, visit the site for an on the ground assessment, and prepare a brief summary of my assessment of some of the potential impacts of the proposed mining in Barrytown Flats on local stream hydrology, hydrogeology, wetlands, and water quality.

[14] On January 19, 2024 I visited the area surrounding the proposed mining site and walked the creeks, wetlands, lagoons, springs area, pastures, and shoreline to gain on-the-ground verification of observations made with remote data including mining application materials and maps, available remote sensing, LiDAR data, drone imagery and footage, wetland maps, and other available GIS layers. Robyn Langridge provided access to family property and public access points. On this visit I also made specific conductance measurements (handheld meter) of local springs, creeks, lagoons, and wetland areas as a gross indicator of local water sources (e.g. ocean water, more recent rainfall, and likely older stored groundwater).

[15] I have not received nor sought compensation from any parties involved in this application or its assessment. To date, my time as an e3Scientific employee has been donated by me to the community in the spirit of independent assessment. Given the complexity and volume of the application materials supplied by TiGa Minerals and Metals Ltd. and its consultants, the lay community might not be able to fully assess the technical aspects of the application and the hydrology of the area. This evidence seeks to support independent assessment otherwise not available to the community.

[16] While I have read the application materials related to hydrology, water quality, modelling, water management, and ecology, I do not critique

them in detail due to their length, complexity, unknown assumptions, data availability, and inability to replicate analyses. Instead this evidence provides a higher level assessment of potential impacts of the proposed activities.

Code of Conduct

[17] Although this is not an Environment Court proceeding, I have read the Environment Court's Code of Conduct for Expert Witnesses (Part 7 of the Environment Court Code of Practice), and I agree to comply with it. I confirm that the issues addressed in this evidence statement, and Annexure are within my area of expertise, except where I have noted otherwise.

[18] I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed. I have specified where my opinion is based on limited or partial information and identified any assumptions I have made in forming my opinions.

Scope of evidence

[19] In short, TiGa proposes to extract and process approximately 4.8 million tonnes of material from the subsurface of a ~34 ha area within the larger > 63 ha farm mining disturbance area. The actual disturbance from the mining would likely propagate well beyond the farm's boundaries. The proposed mining area is located on the narrow coastal plain and depositional fans emanating from the Paparoa mountains and its stream catchments that terminate at the Tasman Sea. Streams and wetlands surround and likely lie inside the proposed mining area while intact wetlands and lagoons lie adjacent to and downgradient of the proposed mining area between it and the Tasman Sea.

[20] The extracted mining material would be transported across the site to a wet processing plant where the Heavy Mineral Concentrate (HMC) would be extracted and transported out of the area via State Highway 6. Non-mineral concentrate tailings material would be left on site and used to fill pits excavated in the landscape (up to 15m deep). This "replacement" process would result in previously stratified and structured native soils and subsurface sands, silts, clays, and gravels being exchanged for unsorted and scrambled tailings with strongly altered geochemical, water storage, and transport characteristics.

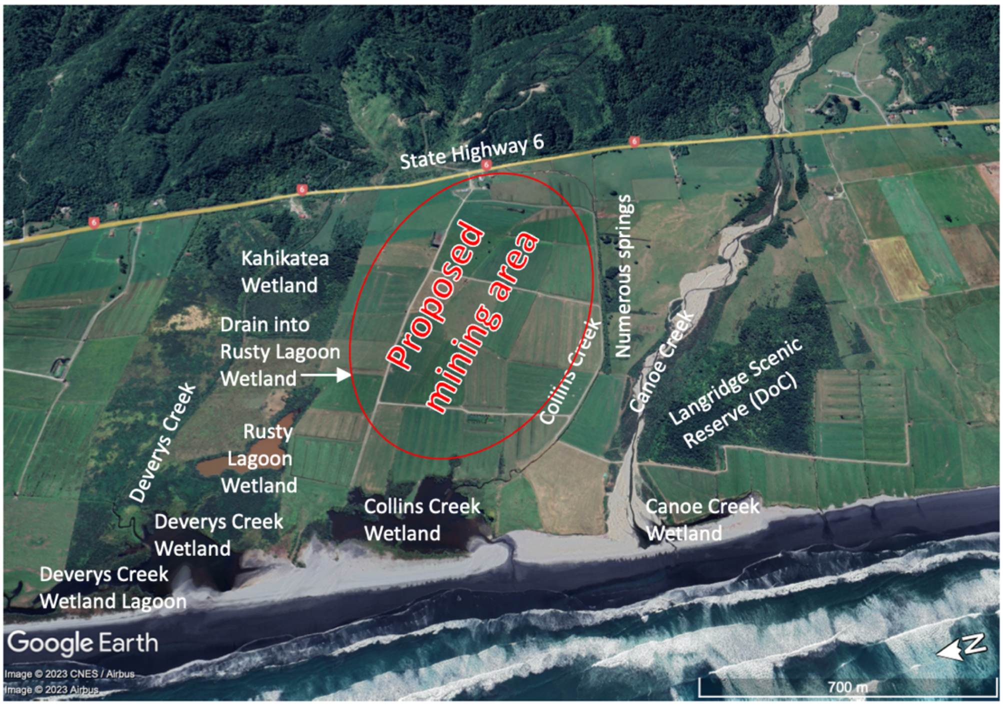

Figure 1 Landscape setting for the proposed mining area. Note the surrounding streams, wetlands, and ecologically critical lagoon habitat between the mountains and the sea.

Scope of evidence

[21] The purpose of this evidence is to provide an independent high level assessment of the potential hydrologic and biogeochemical effects of the proposed mining operations. It describes the general landscape hydrologic setting of the proposed mining area as context . Specifically, it

addresses the effects of the proposed mining operations on water quantity and water quality in:

a. groundwater and local springs;
b. creeks, streams, and small drainages; and
c. wetlands and associated lagoons.

[22] I have reviewed the application documents, peer reviews, and submissions related to the application as they pertain to hydrology and water quality. Review materials include but are not limited to:

- Application for Resource Consent to Grey District Council and West Coast Regional Council – Mineral Sand Mining Activities at Barrytown prepared for TiGa Mineral and Metals Ltd. prepared by Tai Poutini Resources
- Barrytown Mineral Sands Mine Hydrological Impact Assessment. Kōmanawa Solutions technical report
- Water Management, Monitoring and Mitigation Plan, REV 2. Report produced by Kōmanawa Solutions Ltd
- Review of TiGa resource consent application – Barrytown Mine, hydrological and hydrogeological aspects of the application by Brett Sinclair, WGA NZ Ltd
- Section 42A Officer's Report dated 15 January 2024, and the Grey District Council
- Barrytown Mineral Sand Operation Erosion and Sediment Control Plan. Report produced by Ridley Dunphy Environmental Limited 2023
- Wetland Construction and Riparian Planting Plan. Report produced by EcoLogical Solutions 2023
- Statement of Evidence by Jens Rekker, January 19 2024
- Statement of Evidence by Mark Roper, January 19 2024

[23] This assessment is not intended to critique the complex details and convoluted modelling and water management contingencies described in the water quantity and quality management plans and the hydrologic impact assessment including alternative options provided by TiGa Mineral and Metals consultants. I do not believe that this is possible nor productive at this stage given they are focused on mining operations rather than whether it is appropriate to mine here using the general approach outlined. It would be extremely time consuming and in many cases not possible to reproduce or fully assess the analysis they present. For example, attempting to replicate or verify the hydrogeologic modelling would not be feasible given all of its inherent assumptions, data limitations, data availability, uncertainties, and undocumented decisions necessarily made in the process and not available to the public. Models such as those as employed here are merely hypothesis and almost certainly wrong, representing only first approximations of the assumptions and limited data used to initialise and constrain them. Models such as MODFLOW can be self-fulfilling prophecies and are sensitive to almost countless assumptions, data and model limitations, and unforeseen parameter interactions and uncertainty propagations.

[24] This evidence does provide an overview assessment of the general hydrologic and hydrogeological setting of the area and the proposed activities with particular focus on surface water streams, wetlands, and lagoons reliant on the hydrogeology of the area, catchment rainfall – runoff processes and the current and potential future subsurface architecture of the soils and the deposited and weathered sediments and gravels in the area. Time scales of the processes that set the current hydrology of the area include relatively recent surficial drainage changes but more importantly the subsurface and landscape level hydrology that has been set on geologic and glacial time scales with recovery from disturbance trajectories expected to be of similar length.

Body of evidence

General hydrologic setting

[25] The Barrytown Flats area lies between the Paparoa Mountains to the east and the Tasman Sea to the west. The Barrytown Flats are a mountain front and coastal plain / flats area composed of alluvial outwash from the Paparoa Mountains and a series of prograded marine beach strandlines that together with groundwater discharge (upward gradients) support extensive historic and contemporary wetlands in the area. Local Quaternary sand deposition has been attributed to longshore drift in the area (Burlett and Lee, 2019). In addition to groundwater moving toward the sea, the area is drained by a number of creeks originating in the Paparoa Mountains including Canoe Creek, Collins Creek, and Devereys Creek (in order south to north) that bracket and flow through the proposed mining site. There are also a number of small streams and farm drainage ditches traversing the area with perennially and intermittently surface saturated and near saturated ground present from State Highway 6 to the ocean. At least 11 groundwater springs (Figure 4) have been identified just to the south of the proposed mining area with contributing areas in the Paparoa Mountains and likely the proposed mining area with the balance dependent on seasonal and uncharacterised local groundwater gradients.

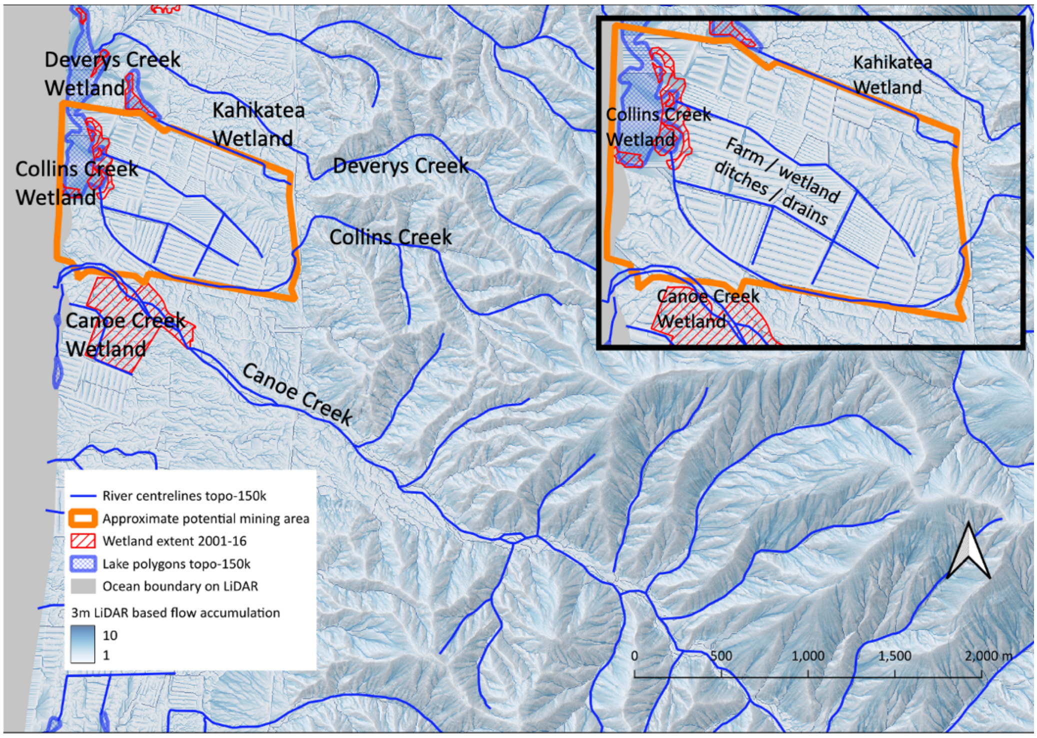

Figure 2 Larger mountain front and hydrological context for the proposed mining area (outlined in orange) and its critical ecological location between the mountains and the sea. Darker blue areas indicate areas of more water accumulation. This landscape context has not been adequately considered in the numerical modelling or conceptual modelling in the provided reports. Nor has the rainfall–runoff hydrology that dominates shallow groundwater and streamflow dynamics of the West Coast region been adequately considered and assessed.

[26] The simplified conceptual model that describes the general hydrologic setting found at Barrytown Flats can be termed mountain-front recharge, mountain-block hydrology, or mountain-front hydrology. In essence it describes the hydrology of mountain-front to valley or in this case coastal plain transitions that can be characterised into zones of 1) water accumulation in mountain catchments, 2) percolation into deep groundwater flowpaths in the mountain block, 3) net loss of streamflow to shallow groundwater at the mountain front recharge zone (often in alluvial sediments or alluvial and colluvial aquifers), and 4) valley bottom or coastal plains exhibiting upward groundwater hydraulic gradients and net gaining stream reaches (Wilson and Guan, 2004; Covino and McGlynn, 20007) (Figure 3). The conceptual figure from Covino and McGlynn (2007) outlines this pattern observed around the world and can be useful for

visualising the larger scale hydrologic setting of the proposed mining extraction area.

W10431 COVINO AND MCGLYNN: STREAM GAINS AND LOSSES ACROSS A TRANSITION W10431

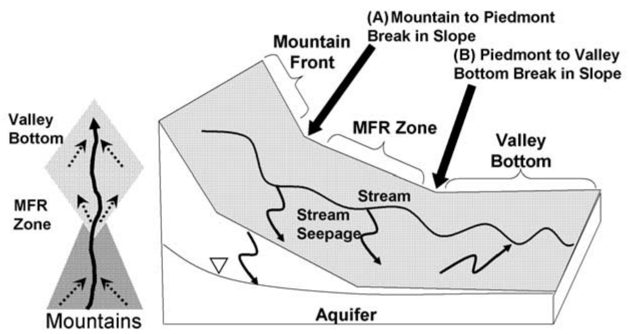

Figure 1. Conceptual diagram illustrating the mountain front recharge (MFR) zone, and the valley bottom in plan form and three-dimensional slice. The MFR zone is the region between points A and B. Arrows out of the stream represent stream seepage (groundwater recharge), and arrows into the stream represent groundwater discharge (adapted from *Wilson and Guan* [2004]).

Figure 3 This conceptual model from a mountain catchment on the other side of the world exhibits similar landscape level hydrology to the Barrytown flats (Covino and McGlynn, 2007). These types of settings have been studied and documented worldwide. Key messages in common are the critical roles of surface water – groundwater exchange across mountain – valley (in this case coastal plain) transitions that sustain streamflow and wetland ecosystems. The proposed mining area is located on the conceptual plan view as a diamond (left panel) and traverses the MFR to valley bottom zone indicated on the right cross-section panel.

[27] Implications of this large-scale hydrologic setting for this application area include local groundwater gradients in the mining area that are likely upward indicating that major sections if not most of the Barrytown Flats are groundwater discharge zones. Groundwater discharge (upward hydraulic gradients) would lead to extensive wet ground (e.g. surface saturation and wetlands) and stream reaches reliant on uninterrupted groundwater support from the local aquifer. Groundwater discharge across the flats would also complicate pit dewatering and result in little available subsurface storage for waste mine water, especially during the wet winter season and wet periods that can occur any time of the year at this location.

[28] In summary, the landscape hydrologic setting of the proposed mine area leads to the following critical characteristics of the site:

A. The area is surface or near surface saturated much of the year thus has supported and continues to support natural inland wetlands across the area that are protected according to the NPS-FM 2020 and NES-FW 2020. Diverting water that would naturally flow toward the wetlands and/or discharging of waste water to the wetlands will alter the natural hydrologic function of the natural inland wetlands in unpredictable ways.

B. In order to dewater the soil surface for use as pasture, some local residents (e.g. the proposed mine site) have resorted to ditching, draining, and surface contouring (e.g. hump and hollow system of drainage) in an attempt to dry the area for stock use (see gridded pattern evident in Figure 1 and Figure 2 for examples). Despite this, wetland hydrology indicators (peat and gleyed soil, elevated water tables, and wetland plant species still appear across the area indicating that the discharge of groundwater and rainfall is in excess of drainage efforts to date.

C. A close connection between local groundwater, shallow rain driven throughflow, and local streams and wetlands means that any changes to subsurface water levels, hydraulic gradients, water quality, and subsurface alluvium/colluvium/soil architecture in the area will likely impact local springs, streams, and creeks even if distal to the immediate disturbance site.

[29] At Barrytown, this upwelling groundwater and its quality is critical for sustaining creeks and wetlands. **Any change in subsurface conditions and altered water flow amounts and pathways will impact local streams and wetlands in unpredictable ways. Mining will undoubtedly change the system permanently and have groundwater, stream, and wetland effects well beyond the localised excavation and burial of waste materials. If mining is to proceed as proposed, it should be clear that**

hydrological and ecological conditions in the area will be permanently altered and natural conditions and dynamics sacrificed.

Figure 4 Map of groundwater springs (blue circles) identified by the Langridge family in ~2021 located between Canoe Creek and the proposed mining area.

Groundwater and springs

[30] The area including and surrounding the proposed mining site exhibits high water tables throughout the year due to its location within the larger hydrologic landscape. This is described in more detail in the *General hydrologic setting* section above and in Figure 2 and Figure 3**.** This setting results in strong bi-directional connectivity between local groundwater, streamflow, and wetland environments that can change seasonally and even within individual rain events.

[31] Efforts to drain the area appear to have begun with more intensive agricultural use of the area in the mid to late 1900s and 2000s. Thery increased over time until the drainage pattern evident today as visualised by the pattern of water accumulation shown in Figure 2. Despite these efforts, ground surface saturation at or near the ground surface persists at least seasonally across the area as evidenced visually, by wetland plant species (hydrophytes) present across the area, and evidence of flowing drainage ditches, groundwater springs, and standing water. Clearly, if groundwater discharge and high water tables in the area with little to no

available subsurface storage were not present then such extensive drainage attempts would not have been necessary.

[32] Early mining in the area appears to have been largely confined to the upper terraces in this section of Barrytown Flats and the localised area associated with the "blow-up". The lagoons in the area appear to be natural and they and their associated wetlands are consistent with the expected geomorphology of the area given the coastline, flats, significant groundwater flow, and creeks in the area. Irrespective of the areas history, the NPS-FM (2020) Policy 6 states: "*There is no further loss of extent of natural inland wetlands, their values are protected, and their restoration is promoted."* The intent of Policy 6 is that the extent of all individual natural inland wetlands is maintained, regardless of their ecological state or size. Thus, natural wetlands include degraded wetlands. The NPS-FM 2020 definition of 'natural wetland' applies regardless of wetland condition and the wetland delineation protocols do not distinguish based on wetland condition. Both native/endemic and exotic species are considered when assessing wetland vegetation.

[33] The presence and history of land drainage efforts and their ineffectiveness even in relatively dry times clearly indicate that there is little available excess water storage in the area and that any changes to water management will have cascading effects through the surrounding hydrological and ecological system. Turbidity in mining associated water will undoubtedly be challenging to manage given presence of silts and clays in the area and the disturbance associated with mining. High groundwater water tables, surface saturation, dense drain networks, and surface runoff connectivity during rain events across the area indicates that water quality in receiving springs, streams and wetlands would likely be compromised by turbid water and other water quality constituents bound to transported material (e.g. heavy metals).

[34] In addition, any changes to the flow of groundwater, subsurface material architecture, or redox state of the water or underground environment in

the area will have geochemical consequences that could jeopardize local groundwater water quality with follow-on impacts to spring water quality, local streams, and wetlands.

[35] The potential water level, water delivery, and water quality impacts of the proposed activities could occur throughout the year but will likely be most impactful during times of drought and during the frequent rain events that can last from hours to days and result in major subsurface and surface runoff across this wet landscape with springs, streams, wetlands, and coastal lagoons as the receiving environment. The rainfall runoff dynamics in this region are among the most responsive in the world given the adjacent steep mountain environment, saturated or near statured local soils, and high annual rainfall and storm event intensities and magnitudes (McGlynn et al., 2002) making water quantity and quality management associated with mining in this location extremely challenging even if approached with the best intentions.

[36] Changes to groundwater levels, water quality, and flow patterns are not reliably predictable by available models especially with such limited internal and adjacent area data, boundary condition uncertainties, complex subsurface architecture, dynamic rainfall / runoff, and connections to local streams, wetlands, tidally influenced lagoons, and dynamic coastlines. This is the situation facing the proposed mining site and adjacent properties and indicates major uncertainty in conclusions and management plans drawn from such modelling efforts.

[37] Water management for proposed mining activities such as pumping/drawdown of mine pit water, infiltration galleys for water disposal, and discharge to ground and or nearby drainages would all significantly alter area hydrology. For example, attempts to dewater excavated mine pits would require constant pumping and disposal of wastewater. Pits and pumping would lower water tables to distances dependent on subsurface materials, material architecture, preferential flow, and groundwater gradients while water disposal to ground or

attempted infiltration pits/galleys would result in groundwater mounding if significant storage is even available (unlikely during wet conditions). Each of these processes would change flow fields, water quality, and connectivity to surrounding groundwater, springs, streams, and wetlands. In turn each rain event or season will again perturb this altered system and change the flow field and complicate any mitigation efforts. High magnitude rain events or flooding in the area would further exacerbate water management and unintended adverse consequences to the surrounding environment.

[38] Changes to local groundwater dynamics and quality have direct ramifications for local springs which are themselves a surface expression up upwelling groundwater and therefore sensitive to changes in hydraulic gradients, subsurface material organization potentially even hundreds of metres away, and changes to groundwater redox state and water quality. Of particular concern are mapped springs located to the immediate south of the proposed mining area that are used for household drinking water, stock water, and contribute to nearby streams, wetlands, and lagoons. There are likely many more unmapped spring areas across the area surrounding the proposed mine that are critical refugia and ecological habitats connected to the area's streams, wetlands, and lagoons.

Figure 5 Drone captured image of the Barrytown coastal plain and its precarious position between the Paparoa mountains and the Tasman sea. Note the indicated wetlands surrounding the proposed mine site, remnants of the once extensive Barrytown flats wetland complex.

Streams and creeks and small drainages

[39] The drainage density of streams and creek across the Barrytown Flats is high because of the local water balance components (e.g. rainfall), lack of available subsurface water storage, and proximity to the Paparoa Mountains. Local efforts to drain saturated soils and high groundwater tables have increased this drainage density significantly (i.e. Figure 2). There exist strong and bi-directional connections between the area's creeks and drainages and local groundwater and surface conditions such that small changes to groundwater levels or the strength of gradients can lead to magnified changes in streamflow generation and sustenance. Essentially, streams in this area lose water to groundwater in some sections and times of the year and gain water from groundwater in other sections and times of the year and the same stream reaches often exhibit both behaviours. Therefore, any changes to groundwater levels and quality will manifest in stream and wetland condition.

[40] Canoe Creek drains an extensive area of the Paparoa mountains and is the largest creek in the area surrounding the mining proposal. Its alluvial outwash deposition appears to have contributed material to the proposed mining property. Even at low flow it could be contributing significant groundwater to the proposed mining area on the southern and eastern end of the property based on relative elevations gleaned from the available LiDAR data. This would be especially true during high flow conditions. In turn, Canoe Creek could receive groundwater from the mining area when their relative elevations are reversed, especially in lower reaches of Canoe Creek and its associated wetlands and lagoon. Given the size and flow of Canoe Creek, its flow magnitude is likely the least impacted relative to the other two major streams associated with the mining area. However, its water quality could be adversely affected by any surface or subsurface discharge of mining related water to its surface water or incoming subsurface water. Its riparian and coastal wetlands and lagoon could also be adversely impacted by mining disposal water.

[41] Collins Creek has undergone significant alteration including relocation, deepening, and straightening associated with historic land uses. Its upper reaches appear relatively intact but its lower reaches appear to function more like a farm drain (however this assessment was done from afar and with remote data). The most pertinent aspects of Collins Creek for this proposal are its importance for spring water quantity and quality on the Langridge property (including drinking water) and its dominant influence on the Collins Creek wetland and coastal lagoon. **Any change or impact to Collins Creek will have direct magnified impacts on the Collins Creek wetland and coastal lagoon. This is in addition to groundwater impacts from the bulk of the mining activities proposed immediately upgradient of the Collins Creek wetland.**

[42] Deverys Creek emanates from the Paparoa Mountains. Its catchment area is greater than Collins Creek but significantly less than Canoe Creek.

Deverys Creek is on the northern side of the proposed mining area with the Kahikatea wetland, the Rusty Lagoon, and regenerating bush between it and the mining area. However, the extensive Deverys Creek Wetland and lagoon labelled in Figure 5 are strongly connected to both Deverys Creek and water emanating directly from the proposed mining land and runoff routed into and through Rusty Lagoon.

[43] The farm drainages and unnamed streams crossing the proposed mining area will be dramatically altered and impacted by the proposed mining activities. Flow from these or newly altered drainages will have direct impacts on Collins Creek, Collins Creek Wetland, Canoe Creek, Canoe Creek Wetland, the Deverys Creek Wetland, Devreys Creek Wetland Lagoon, Rusty Lagoon Wetland. The nature and magnitude of these impacts is challenging to predict but they will likely be strong and variable during any proposed mining and weather events/seasons and would likely be long lasting.

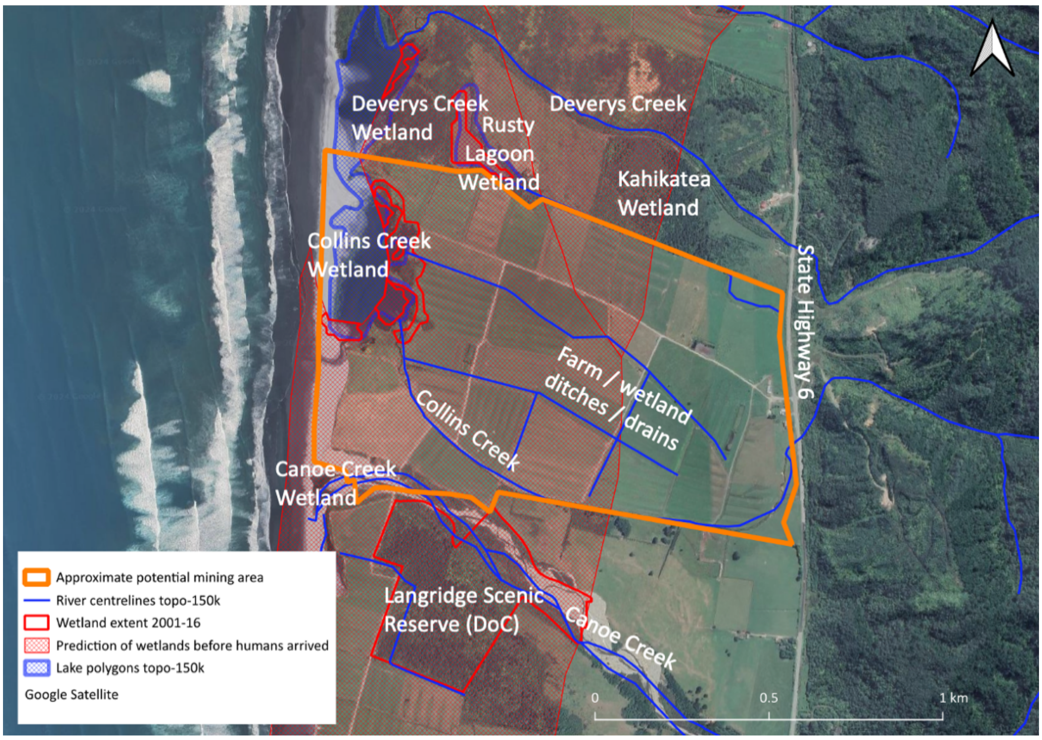

Figure 6 Historic and mapped contemporary wetland extent. Both are likely significant underestimates and coarse approximations. Adequate wetland assessment and mapping has

not been accomplished using well established soils, vegetation, and hydrology rubrics. Reference: Wetlands before humans arrived. Identifier: https://data.mfe.govt.nz/x/tseGot.

Wetlands

[44] Wetlands are defined in the Resource Management Act (1991): "*Wetland includes permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions*." (RMA, 1991).

[45] Te Mana o Te Wai provides the context for freshwater management and the protection and of wetlands and other waterbodies including perennial and intermittent streams.

> "*Te Mana o te Wai refers to the vital importance of water. When managing freshwater, it ensures the health and well-being of the water is protected and human health needs are provided for before enabling other uses of water. It expresses the special connection all New Zealanders have with freshwater. By protecting the health and well-being of our freshwater we protect the health and well-being of our people and environments. Through engagement and discussion, regional councils, communities and tangata whenua will determine how Te Mana o te Wai is applied locally in freshwater management.*" (Essential Freshwater: Te Mana o te Wai factsheet, 2020)

[46] The NPS-FM 2020 specifies that every regional council must give effect to *Te Mana o te Wai* and apply the following hierarchy of obligations: first, the health and well-being of waterbodies and freshwater ecosystems; second, the health needs of people (such as drinking water); and last, the ability of people and communities to provide for their social, economic, and cultural well-being, now and in the future.

[47] Much of the Barrytown Flats area was coastal plain, riparian, coastal lagoon, and/or groundwater seepage (or slope) wetlands before land alteration by humans. The large-scale landscape hydrologic setting described in previous sections explains why the area is wet and exhibits water table elevations at or close to the ground surface, indicating wetland hydrology which promotes wetland soil development, and

supports wetland vegetation. Although relatively coarse, The New Zealand wide “Wetlands before humans arrived” GIS layer maps approximately 2/3 of the proposed mining area as historic wetlands (Figure 6). The area under discussion was also mapped as “swamp” (wetland) as early as 1907 as indicated by the red circle on Figure 7.

[48] Currently efforts are underway (required by law) to map wetlands greater that 0.05 ha (500 $m^{2)}$ across New Zealand although all wetlands are protected equally regardless of size or condition. However, this is a grand challenge since accurate assessment and mapping requires ground-based investigation using wetland hydrology, Soils, and vegetation tools and guidelines. **It does not appear that that the wetlands in the area including the potential mining land and adjacent properties have been surveyed and assessed for wetland presence and extents.** This is highly problematic given the nature of the proposed disturbance (surface and subsurface destruction up to 15m deep and changes to area hydrology and soils), the high degree of protection afforded to wetlands, and the paucity of remaining wetlands and intact in this ecologically irreplaceable area.

[49] Some local wetlands have been identified and mapped as part of regional and national efforts, although these are just a small sample of those that remain in this landscape. Some of these wetlands include the Langridge Scenic Reserve and associated wetlands, the Canoe Creek Wetland, The Collins Creek Wetland, the Kahikatea Wetland, the Rusty Lagoon Wetland, and the Deverys Creek Wetland highlighted in Figure 6 and Figure 5. All of these partially mapped wetlands are subject to mining induced impacts to their form and function, especially given proposed changes to water movement in the area.

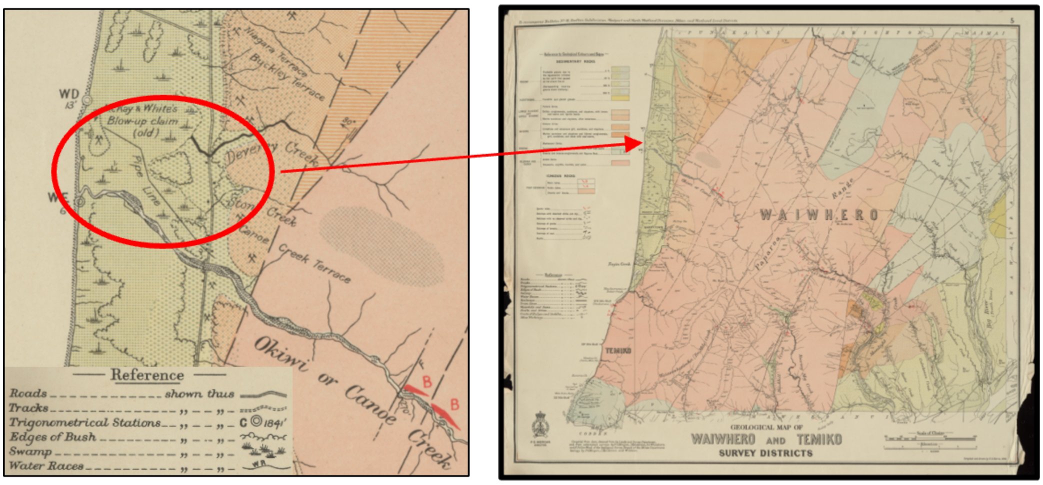

Figure 7 The proposed mining area is indicated by the red circle and is mapped as swamp (wetland), as is much of the coastal plain of Barrytown. Map: New Zealand Geological Survey Branch. 9016 Geological map of Waiwhero and Temiko Survey Districts [cartographic material] / compiled and drawn by G.E. Harris, 1916.. Ref: 830caq 1907-. Alexander Turnbull Library, Wellington, New Zealand. /records/21221

[50] As described elsewhere in this evidence, humans have gone to great lengths in their attempt to fully drain and dry the area for agricultural activities. This is true across the flats and intensively in the area under consideration (e.g. relatively recent hump and hollow drainage manipulation evident in images and Figure 2 and Figure 5). These efforts have been marginally successful such that whilst groundwater tables remain high, soils are typically saturated or near surface saturated; pastoral use and cultivation has been possible at least seasonally. Without active management and drainage, much of the previous wetland area could revert to wetlands that fully meet the NZ hydrology, soils, and vegetation wetland criteria. **In fact much of it would likely be assessed and mapped as natural inland wetland but would be exempt from full protection under the "pasture exclusion". Essentially this exclusion means that it can remain in pasture even though it is potentially natural inland wetland. <u>However</u>, this exclusion does not apply to any change in landuse from active pasture such as mining.**

[51] The NPS-FM (2020) Policy 6 states: "*There is no further loss of extent of natural inland wetlands, their values are protected, and their restoration is promoted*." **The intent of Policy 6 is that the extent of all individual**

natural inland wetlands is maintained, regardless of their ecological state or size. This is to prevent fragmentation of remaining wetland habitat. The NPS-FM (2020) and Freshwater NES-F (2020) apply to areas of any size that meet the 'natural wetland' and 'natural inland wetland' definitions (respectively). This is because damage or loss of many small wetlands would add up to a large net loss.

[52] Earthworks, land drainage, takes, or discharges of water critical to wetland function can occur in, near, or distal to the boundary of wetlands since wetlands are typically an expression of landscape hydrology. 10m or 100m buffers around wetlands are arbitrary and can be inadequate depending on the landscape setting of a given wetland. Significant changes to surface and subsurface water flow patterns, magnitudes, and quality at distances much great than 100m can negatively impact wetland function and health. Assessment of whether a landuse change, drainage change, or major earthworks will negatively impact a given wetland necessitates consideration of the wetland water support areas and pathways regardless of distance.

[53] Most small wetlands are not currently mapped and can be challenging to decipher remotely. Therefore most small wetland existence must be at least corroborated or discovered and mapped in the field by suitably trained professionals. It does not appear that this has occurred in this area and to support this application. **Before any management hierarchy assessment can be considered, it seems that wetland assessment and mapping would be required for full consideration of the likely effects of any proposed activities.**

Inland and coastal lagoons

[54] Inland wetland lagoons such as Rusty Lagoon, Deverys Creek Wetland Lagoon, and Collins Creek Wetland Lagoon would receive both mine affected groundwater and surface water from small tributaries and larger Creeks such as the Rusty Lagoon Creek inflow drain and Collins Creek. Therefore, any changes to both local groundwater and creek / drainage water magnitudes and chemistry would have direct impacts on these lagoon/wetland complexes. Please note that each of these lagoons exhibited freshwater specific conductance readings during the site visit (not brackish), have significant freshwater inflows, and appear to be elevated above mean high tide and are therefore natural inland wetlands rather than coastal wetlands such as salt marshes or tidal flats.

Proposed land "restoration" during and following proposed mining

[55] The preceding evidence has described the hydrologic setting and the potential impacts of mining on groundwater, spring, stream, wetland, and lagoon water quality and hydrodynamics that directly impact ecological condition. Application materials and supporting documents have alluded to land restoration during and following mining activities that will penetrate up to 15m deep and both take and discharge water to and from nearby water bodies. **I believe that is important to be clear that restoration of the land, subsurface and surface hydrology, water chemistry, and ecological functioning of the mining area and adjacent landscape is essentially not possible.**

[56] Mining and the extraction of buried materials embedded in alluvium, colluvium, geologic formations, and native soils fully disrupts and resets geologic and geomorphic processes that have led to the pre-mining environment. The current subsurface environment has evolved over tens of thousands and hundreds of thousands of years. Natural depositional stratigraphy and *in-situ* subsurface weathering and soil development

required this time to develop and lead to subsurface architecture that is not replicable with heavy machinery. Natural deposition, weathering, and evolution of the subsurface largely determine where, how much, and how quickly water move through the subsurface and how it interacts with surface water such as springs, streams, and wetlands. These dynamics further exert strong influences of subsurface redox states, rates of weathering and ion exchange, and resulting water quality. Land disturbance from ongoing farming is relatively minor with short term effects when considered against the proposed mining.

[57] It will be possible to refill excavated pits with mixed and fully disturbed waste rock and tailings but it will not be possible to restore the hydrologic and water chemical functioning present before wholesale disturbance by mining. Superficial recontouring of landscape does not restore land. Nor does simple vegetation planting. The hydrogeologic system and those adjacent will be forever altered by this activity. Despite best efforts, it is not possible to fully predict the ramifications of these activities and attempts at reclamation.

[58] Restoration of subsurface and surface hydrology during and following mining activities will likewise not be possible. Instead, target hydrologic dynamics and water quality objectives can be pursued but they will remain elusive. This will likely have strong ramifications for the important ecological functioning and integrity of the mined area and adjacent streams, wetlands, and lagoons.

[59] By the admission in the application materials, flow and chemistry of adjacent waterways, wetlands, and lagoons will be affected unless it can somehow be mitigated through relatively complex water management and infrequent chemical sampling. Maintaining *"…the pre-mining function of the freshwater creeks, ponds, wetlands, springs and underlying groundwater systems would be preserved during the proposed mining activities as essentially the same flow patterns would be sustained throughout." (Rekker, 2014 [53])* is in my opinion not credible. Quarterly

and even monthly water quality sampling is wholly insufficient given rainfall driven solute and sediment / turbidity mobilisation. Similarly, even if groundwater levels and gradients are measured frequently they would need to be constantly interpreted and modelled to have any hope of adaptive management. The overwhelming majority of water and material moves during rain events and fluctuates on timescales of minutes to hours to days, not on monthly sampling time scales or annual analysis time scales and this does not appear to be well considered.

[60] In short, the land cannot be restored following the proposed activities. It could be rehabilitated or reclaimed and made more useable for agriculture or turned into a different hydrologic and ecological system. The current hydro-ecological system will be unalterably changed and the details of how this would manifest hydrology, water quality, and stream and wetland ecological dynamics are poorly predictable. There is a high probability of an engineered mess, even with good intentions. I object to the suggestion that the landscape and larger hydrological and ecological system would be improved during and post-mining relative to today and that this would be a water quality benefit.

Summary

[61] The evidence presented here seeks to provide an independent high level assessment of the hydrologic, ecohydrologic biogeochemical implications and potential effects of the proposed mining operations. This evidence describes the general hydrologic setting of the proposed mining area and its implications. Specifically, it addresses the effects of the proposed mining operations and post mining reclamation on water quantity and water quality in:

a. groundwater and local springs;

b. creeks, streams, and small drainages; and

c. wetlands and lagoons.

[62] It is my opinion that the effects of the proposed activities on hydrology and water quality of local groundwater and springs, creeks and small drainages, and wetlands and lagoons will be more than minor during mining operations and long after they cease. I believe that there are significant uncertainties in the subsurface architecture, flow fields, and geochemistry within the site and across the adjacent landscape that could lead to unintended consequences and negative impacts in excess of these anticipated despite even best efforts to the contrary.

[63] I believe that impacts on the areas mapped and extensive unmapped wetlands will be substantial. Before any management hierarchy assessment can be considered, it also seems that at a minimum wetland assessment and mapping would be required for full consideration of the likely effects of any proposed activities. This would be true on the proposed mining property as well as on adjacent properties affected by these activities.

[64] It will be possible to refill excavated pits with mixed and disturbed waste rock and tailings but it will not be possible to restore the hydrologic and water chemical functioning present before wholesale disturbance by mining. Superficial recontouring of landscape does not restore land. Nor does simple vegetation planting. The system that is mined and those adjacent will be forever altered by this activity. Despite best efforts, it is not possible to fully predict the ramifications of these activities and attempts at reclamation.

[65] I conclude that any change in subsurface conditions and altered water flow amounts and pathways will impact local streams and wetlands in unpredictable ways. Mining will undoubtedly change the system permanently and have groundwater, stream, and wetland effects well beyond the localised excavation and burial of waste materials. If mining is to proceed as proposed, it should be clear that hydrological and

ecological conditions in the area will be permanently altered and natural conditions and dynamics sacrificed.

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