Lake Pūkaki Hydro Storage and Dam Resilience Works

Air Quality Assessment – Rip-Rap Placement

Meridian Energy

5 November 2025

→ **The Power of Commitment**

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Abbreviations

Term/ acronym	Definition
CALMET	The meteorological model portion of the CALPUFF modelling package
CALPUFF	A pollution dispersion model recognised by regulatory authorities for the assessment of dust.
DMP	Dust management plan
EPA	Environment Protection Authority
FIDOL	A qualitative assessment that considers the factors of **F**requency, **I**ntensity, **D**uration, **O**ffensiveness and **L**ocation of a dust source.
FTAA	Fast Track Approvals Act
GHD	GHD Pty Ltd
ha	Hectares
IAQM	Institute of Air Quality Management
kg	kilograms
kg/day	kilograms per day
km	kilometres
km/h	kilometres per hour
m	Metres
m^3	cubic metres
MFE	Ministry for Environment (New Zealand)
mm	millimetres
Mt	megatonnes
Mtpa	megatonnes per annum
MW	megawatts
NPI	National Pollution Inventory (Australia)
NZ	New Zealand
^oC	Degrees Celsius
OCC	Official Conservation Campaign
PC1	Plan Change 1. Conducted in 2012.
PC3	Plan Change 3.
PM_{10}	Particulate matter less than 10 µm in aerodynamic equivalent diameter
$PM_{2.5}$	Particulate matter less than 2.5 µm in aerodynamic equivalent diameter
rip-rap	Loose stone used to form a foundation for a breakwater or other structure. Placed at along the dam wall for thew prevention of wave erosion of the dam embankment.
RL	Reference level (refers to dam water level in metres above sea level)
SO	System Operator
SSA	Security of Supply Alert
t	Tonnes
tpa	Tonnes per annum
tpd	Tonnes per day
TSP	Total suspended particulate. Generally corresponds to particulate sizes of less than 80 to 100 µm.

Term/ acronym	Definition
WAP	Waitaki Catchment Allocation Regional Plan
WPS	Waitaki Power Scheme

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1. Introduction

Meridian Energy Limited (Meridian) have engaged GHD Limited (GHD), to assist with obtaining consents to authorise the operation of Lake Pūkaki below the current normal minimum level of 518 m above mean sea level (m RL) for a three-year period, and for civil works at Pūkaki Dam to improve the structures resilience to wave action during lower lake operational levels.

1.1 Project Background

1.1.1 Waitaki Power Scheme

The Waitaki Power Scheme (WPS) is a nationally and regionally significant component of New Zealand's electricity supply infrastructure. It is New Zealand's largest and most flexible hydroelectricity power scheme and therefore has a critical role to play in the electricity system and economy. It consists of eight power stations (two owned by Genesis Energy and six owned by Meridian Energy), commissioned between 1935 and 1985, together having an installed capacity of 1,761 MW, being ~32% of New Zealand's installed hydro capacity

Lake Pūkaki is a modified natural lake and is managed as part of the WPS. It is New Zealand's largest hydro storage lake and provides an average of 1,767 GWh of stored water in normal operating conditions, with an additional 546 GWh available during a national hydro shortage.

Meridian is currently authorised to dam the Pūkaki River to control and operate Lake Pūkaki between the levels of 518 m RL (normal consented minimum lake level) and 532.5 m RL (maximum consented storage level).

1.1.2 Meridan's Application

Meridian is seeking approvals under the Fast Track Approvals Act (FTAA) to enable access to water stored in Lake Pūkaki below 518 m RL, without the currently applicable security of supply triggers, thereby enabling the better planning and utilisation of the available stored generating capacity. Further information on the background to the proposal and the benefits of allowing access to additional water is provided in the Substantive Application[1] document that supports the FTAA application.

In addition to the temporary ability to lower the lake level, Meridian seeks consent for the installation of rip-rap on the face of the Pūkaki dam and its left and right abutments to provide protection from wave erosion, when operating the lake below 518 m RL. Rip-rap will be placed to a maximum depth of 510.5 m RL, with earthworks/site preparation activities extending to a maximum depth of 509.6 m RL. Rock armouring will take a total of 12 to 18 weeks to complete but is expected to be done over multiple stages over several years and works may be required to be completed beyond 2028.

Meridian has stockpiled rock for this purpose on its land adjacent to the Pūkaki dam since 2014, but the rock armouring has not been undertaken due to the existing supply triggers never being initiated by the SO, with the result that the lake level has not been low enough over that period to allow the works to be completed.

1.2 Purpose of this report

The purpose of this report is to briefly describe the proposal, review of available information regarding meteorology and dust generating processes, and to provide a quantitative assessment of air quality during additional rip-rap placement associated with the Pūkaki High Dam.

Note: The air quality assessment associated lowering of the lake level and dust storm events is provided in a separate report.

[1] Lake Pukaki Hydro Storage and dam resilience works - Substantive Application under the Fast-track Approvals Act 2024 dated 5 November 2025

1.3 Assumptions

This document has been prepared based on the following assumption(s):

– Lake Pūkaki will only be operated below its existing consent level for no more than a three-year period ending in 2028.
– The representative meteorological year is 2015. Refer to Section 7.2.2.
– CALMET used with TAPM 3km resolution 3D wind fields and two surface observations stations (Maryburn and Pūkaki Aero) provides an accurate representation of the short term (1-hour) and longer term (annual) wind parameters of speed direction and turbulence. Refer to Appendix D.
– Emissions source characterisation is representative of actual dispersion. Refer to Appendix D.
– A threshold friction velocity of 0.4 m/s is representative of the wind erosion of the glacial till.
– The particle size distribution of sources expected to have a high fraction of glacial till component is as defined in Section 5.5, consisting of 57 percent PM_{10} and 23 percent $PM_{2.5}$.
– The particle size distribution of haul road sources is based on NPI (Mining (2012) estimation formulae for TSP and PM_{10} based on a silt content of 23 percent. This does result in lower PM_{10}:TSP ratio of 57 percent but maintains consistency with the application of NPI formulae.
– Rip-rap placement methodology is as described in 10.2.
– Rip-rap placement will only commence once the lake level is low enough.
– Rip-rap placement may take a number of years to complete, with construction undertaken in smaller periods, expected to be in at least three (3) week blocks, on an as forecast basis by Meridian when lake levels are to drop below 518 m RL.
– The quantitative air quality modelling assumed active placement of rip-rap will occur during a period of between 15 July and 17 November, when lake levels are likely to be lowest, based on historical records. The quantitative modelling results are considered to be valid if construction activities differed from this window by say seven days, or such a time as meteorological patterns differ from those assessed.
– Additional rip-rap material required for dam construction will be trucked into the primary stockpiles on a continuous basis, anytime throughout the year. However, only that portion of the material hauled to site occurring during rip-rap placement activities will be assessed as a contributing source to total dust from combined activities. Assessment of dust emissions for the delivery of rip-rap material outside of rip-rap placement activity times has not been assessed as this activity is understood to have been previously approved.
– Exhaust emissions from the operation of trucks and earth moving equipment, i.e., internal combustion engines, has been assumed to be negligible with respect to dust generated through the earthworks activities themselves and therefore have not been explicitly assessed.
– It has been assumed that any of the material excavated from the dam and placed on the shore – up bank – are either wet or remain sufficiently moist for any generated dust from its disturbance to be minimum to negligible.

1.4 Scope of work and document structure

This document consists of:

– A description of the background reasons for the project and the assessment scope. (Section 1)
– A description of the proposed activities. (Section 2)
– A general description of Lake Pūkaki. (Section 3)
– A summary of the reviewed information supplied by Meridian relevant to this assessment (Section 4)
– A review of generalised dust generation mechanisms and the potential dust sources and characteristics associated with wind erosion from around Lake Pūkaki. (Section 5)
– A summary of the relevant ambient dust concentration criteria for areas around Lake Pūkaki. (Section 6)

– An analysis of the meteorology around Lake Pūkaki. (Section 7)
– Identification of sensitive receptors around Lake Pūkaki. (Section 8)
– A quantitative assessment of construction dust potential. (Section 9)
– Concluding comments. (Section 10)
– The appendices contain:
  - Assessors' curriculum vitae
  - A construction dust emissions inventory.
  - A summary of the CALMET and CALPUFF dispersion modelling.

1.5 Associated concurrent reports

This report should be read in conjunction with the following reports that provide supplementary and complementary information.

– GHD Report Pūkaki Reservoir Hydro Storage and Dam Resilience Works – Air Quality Assessment – Wind Erosion (12656630-REP-Air_Quality_Phase2_Air_Qual_Assessment_lake_dust, 9 October 2025). (GHD 2025a).
– GHD Report Lake Pūkaki Reservoir Hydro Storage and Dam Resilience Works Pūkaki Dam Rip-Rap Design and Construction Methodology (Document No. 12656630-GHD-Pukaki Dam Resilience Works-RPT-GE-00001-S0-REV01-251030.docx, 31 October 2025). GHD 2025b.

1.6 Report Author and Contributions

The qualifications and experience of the report authors are set out in Appendix A. The author confirms that they have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note (2023) and agree to comply with it. In that regard the lead author confirms that this air quality report is written within their expertise, except where stated that the author is relying on the assessment of another person. The author confirms that they have not omitted to consider material facts known to them that might alter or detract from the opinions expressed.

1.7 Limitations

This report has been prepared by GHD Limited on the instructions of Meridian Energy, in accordance with the agreed scope of work. It is intended to support Meridian's application under the Fast-track Approvals Act 2024 and may be relied upon by the Expert Panel and relevant administering agencies for the purposes of assessing the application.
While GHD Limited has exercised due care in preparing this report, it does not accept liability for any use of the report beyond its intended purpose. Where information has been supplied by the Client or obtained from external sources, it has been assumed to be accurate unless otherwise stated.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described throughout this report and particularly in this report (refer section(s) 1.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

2. Proposed activities

Meridian is proposing two activities, being:

- Over a three-year period, having the ability to lower the lake levels below 518 m RL to a minimum level of 513 m RL, so that stored lake water can be used to generate electricity.
- When the lake levels are low, this enables civil works near the Pūkaki Dam, specifically extending rip-rap armouring to reduce the risk of erosion on the dam face and other critical infrastructure.
  - It is unlikely that all the rip-rap work will be completed within the three year window. Therefore, Meridian is requesting consent to continue the work beyond the three year window.

The focus of this report will be on the construction activities associated with the placement of rock rip-rap armouring on the Main Dam, and the right and left abutments. The following provides a summary of the construction activities that are expected to occur.

The approach adopted for this assessment is detailed in Sections 4 to 9.

2.1 Dam resilience works

The works are described in the Rip-Rap Design and Construction Methodology (GHD, 2025b). In general, the installation of rip-rap on the face of the Pūkaki dam and its left and right abutments to provide protection from wave erosion Figure 1). The works will include:

- Site establishment, including temporary building.
- Constructing access tracks and ramps.
- Transporting rock armour from the current location to a designated stockpile area.
- Constructing work benches.
- Constructing toe/key along High Dam.
- Rock placement on High Dam.
- Rock placement on abutments.
- Stockpile access for rock material.
- Decommission of site.

A detailed description of the works is provided in Section 10.2 of this report, which have been used as a basis for the air quality assessment.

Figure 1 Work zones

3. Site description

3.1 Location

Lake Pūkaki is located in the South Island of New Zealand and makes up part of the McKenzie Basin. It is located approximately 200 km west-southwest of Christchurch, in the middle of New Zealand's South Island and almost directly south of Mount Cook (Aoraki), as shown in Figure 2 and Figure .

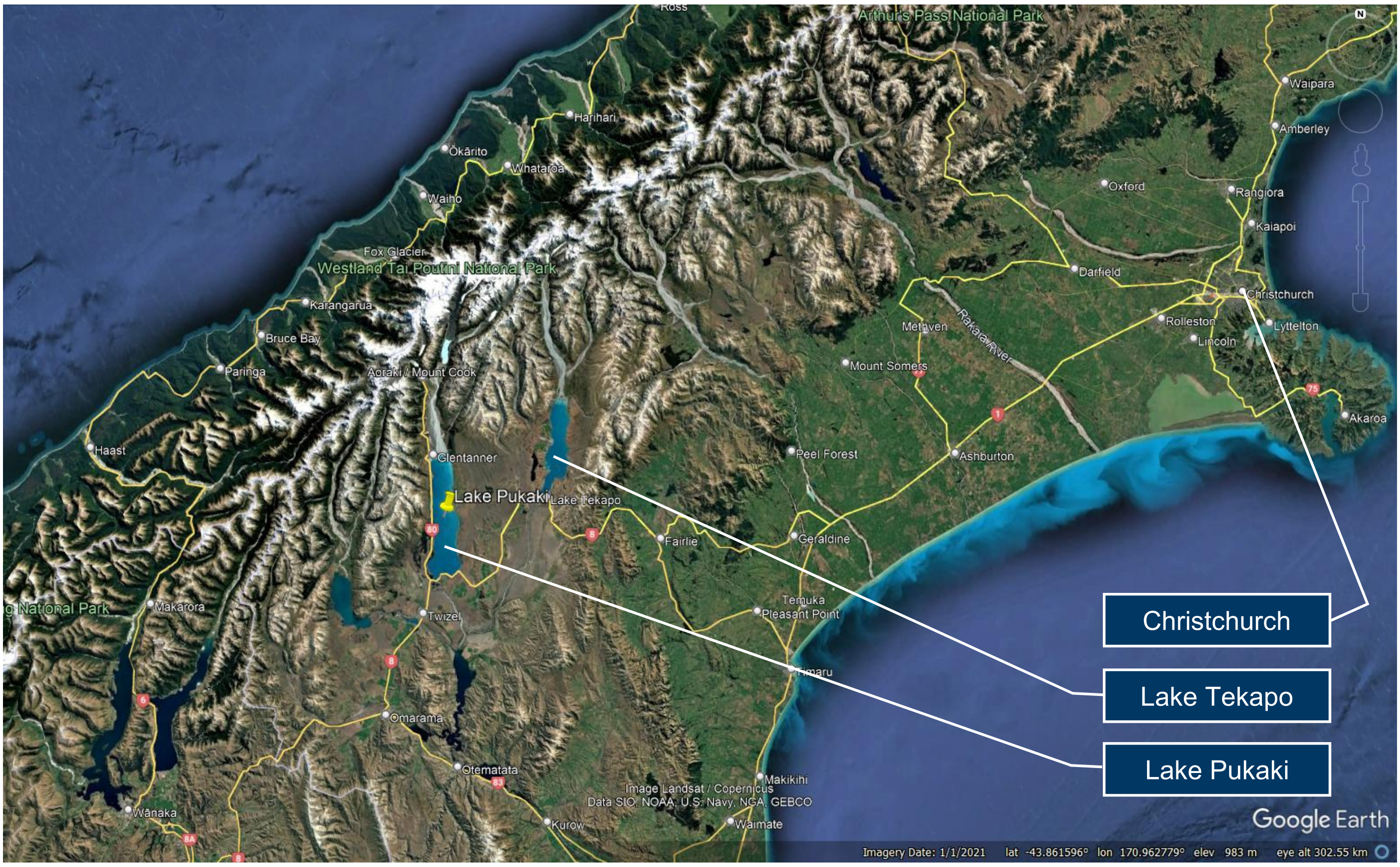


Figure 2 Location of Lake Pūkaki with respect to other locations on the South Island of New Zealand

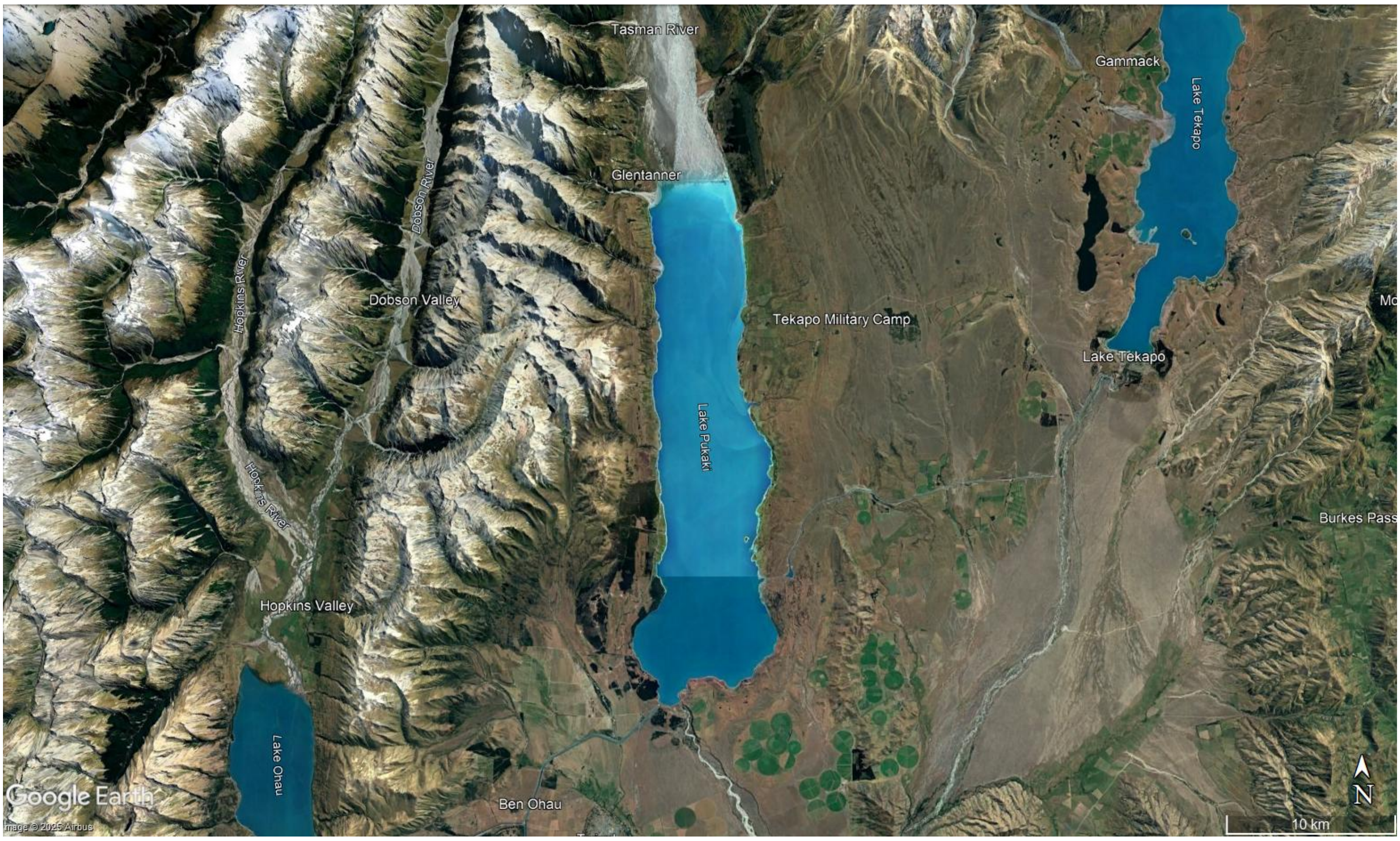


Figure Drag Location of Lake Pūkaki

3.2 Pūkaki High Dam location

The dam is located at the southern end of the lake. The nominal flow direction in the lake is from north to south, with water discharging from the lake via Gate 18 (into the Pūkaki canal) or Gate 19 into the Pūkaki Riverbed.

3.3 Lake levels

Under resource consent CRC905321.7, Meridian is authorised to dam the Pūkaki River to control and operate Lake Pūkaki between the levels of 518 m RL (normal consented minimum lake level) and 532.5 m RL (maximum consented storage level). There are various operational procedures in place to manage the lake between these levels, all of which are beyond the scope of this assessment.

4. Review of supplied information

Meridian supplied a range of documents pertaining to the operations, existing conditions, previous environmental studies, and proposed changes. A total of 116 documents were key word searched with documents identified as being of high relevance being reviewed in more detail regarding information about air quality and/or able to inform air quality studies.

Information pertinent to this construction dust assessment has been summarised below.

4.1 Climate change

Based on reviewing supplied documents relating to climate change impacts, the annual impact appears to be minimal, especially in the short term. There have been identified seasonal trends due to differing climate patterns such as El Nino, Southern Annular Mode, etc. However, with regards to lake inflows and catchment rainfall, decreases in one season appear to be offset by increases in another, i.e., little net annual impact (National Institute of Water & Atmospheric Research Ltd (NIWA), 2024).

Therefore, given the short duration of the proposed lower lake levels, the impact of climate change is expected to be negligible.

4.2 Amenity

The landscape and visual amenity of the Pūkaki Dam, lake and surrounding environs is described by Goodfellow (2025), which is appended to the Substantive Application. The landscape assessment by Goodfellow (2025) stated that the MacKenzie Basin is recognised an an Outstanding Natural Landscape in the Canterbury Regional Landscpe Study 2010, and notes that the Waitaki Power Scheme (which includes Pukaki Dam) does not detract from the scale or quality of the Mackenzie Basin.

A document prepared by Stephen Brown (March 2024) (Brown, 2024) described the Mackenzie Basin and Pūkaki Lake area as:

– *"Aesthetic Values*
  - *The vast basin large river valleys and enclosing mountain ranges form a dramatic and spectacular landscape. While some parts of the basin have been substantially modified by residential hydro and agricultural development, the basin as a whole retains its openness and largely coherent character.*
  - *Impressive views up the wide u-shaped valleys to the snow and ice covered peaks of the Alps are experienced from the basin.*
  - *Pūkaki* [sic] *and Tekapo reflect a striking milky-blue colour in sunlight. They form an integral part of one of the most memorable landscapes in the country.*
  - *The golden tussock-laden slopes which surround the basin have high aesthetic values.*

– *Transient Values*
  - *Snow coats the ranges and basin floors during much of the winter months.*
  - *The distinctive turquoise colour of the lakes in sunny conditions is spectacular.*
  - *Nowhere else in the country can the effects of 'norwester' weather patterns and the rainfall gradient from west to east be as vividly experienced as in the Mackenzie Basin."*

4.3 Jeff Bluett evidence August 2012

In August 2012, Jeff Bluett provided an extensive written opinion – expert advice – to Merdian Energy with regards to Plan Change 1 to Waitaki Catchment Water Allocation Regional between Meridian Energy Limited and Environment Canterbury. The advice was in regards to "*the increased potential for dust storm effects associated* *with lowering the minimum level of Lake Pūkaki to 512 metres above sea level (masl)."* The advice consisted of the following.

– Description of the processes and sources which generate dust storms in the Lake Pūkaki basin
– Summary of the outcomes of a sediments survey of the head of Lake Pūkaki
– Description of the receiving environment potentially impacted from Lake Pūkaki dust storm events
– Outline four main potential adverse effects that can be created by dust storms in the Pūkaki Basin
– Detailed the meteorological risk factors for dust storms
– Detailed the hydrological risk factors for dust storms
– Investigated the influence that lowering the lake level will have on the frequency, duration and intensity of dust storms
– Assessed the potential adverse effects of increased dust storm intensity
– Summarised dust related issues raised by submitters on the plan change
– Discussed dust relevant planning issues from Environment Canterbury's Proposed Policy Statement and the Waitaki Water allocation plan

The advice provided by Bluett (2012) was extensive and upon review is still considered to be valid for the current proposal. Whilst it is acknowledged that Bluett (2012) did not consider the proposed placement of rip rap as described in this document, there is pertinent information regarding the 2012 assessment which informs the current assessment approach, as summarised below.

4.3.1 Dust storms

Bluett (2012) states that "*dust storms are natural events that form an integral component in the evolution of the landscape. Historically, dust storms have been instrumental in the formation of extensive loess deposits that cover the eastern South Island. However, dust storms are currently confined to geomorphically active areas in the landscape where unconsolidated surfaces are exposed to strong winds, such as the inner mountain basins and river valleys of the Southern Alps.*"

The sources of the dust storms are the dry braid channels of the Tasman River, the exposed lacustrine delta of the Tasman River at the northern end of the lake and numerous smaller river deltas that enter Lake Pūkaki at points along the eastern and western lake shores.

Fine sediments are deposited onto these areas by "*fluvio-glacial processes"*, which varies diurnally and seasonally with rainfall and snowmelt.

Minor sources of dust, particularly for locations in close proximity to the source are "*degraded tussock grasslands, gravel roads, scree slope and lakeshore cliffs*."

4.3.1.1 Dust storm criteria

Bluett (2012) identified from previous studies (McGowan et al. 1995) that dust storms usually occurred during moderate to strong "foehn wind" events, defined as wind speeds greater than 10 m/s. This has been adopted as an assessment metric for this study. An additional metric was added for dust storm potential by Bluett in that the high wind conditions had to occur for a period of at least two hours.

Bluett (2012) identified these events as "*typically associated with warm ambient air temperatures and low humidity, which promote the drying of the surface sediments and increase their susceptibility to entrainment by the wind."*

4.3.1.2 Dust size

Bluett (2012) stated, based on McGowan et al. (1995) that the primary particulate size in dust storms was between 7 to 63 μm.

4.3.1.3 Rainfall

Bluett (2012) found that rainfall has two opposing effects on dust storm prevalence. Firstly, rainfall wets the surface silt and therefore suppresses its tendency to become airborne during high wind events. However, it is equally responsible for depositing the silt in the lake regions that once the water recedes, becomes exposed to the wind. Bluett (2012) conclude that "*following a flood there is an increased risk of a dust event due to the greater amount of silt material available to be entrained by winds.*"

4.3.1.4 Meteorological risk

Bluett (2012) identifies that the combination of wind speed and low rainfall risks lead to spring and summer as being the highest risk periods for dust storms, insofar as there more chance of a rainfall/flood event that deposits silt, followed by a combination of warmer temperatures and foehn winds that both dry and entrain the deposited silt. Bluett (2012) states that "*anecdotally dust storms occur most frequently in spring*."

4.3.1.5 Lake level

Bluett (2012) identified that a lower lake level will increase the risk of dust storms. The provided advice went further in identifying that the lowest lake levels will tend to occur during the end of winter to early spring, with lake refilling during spring/summer and peaking in March/April.

4.3.2 Potential impact of dust storms

4.3.2.1 Human health

Bluett (2012, cl.12.3) provided advice that the current prevalence of dust storms and any increased frequency or intensity of the storms will be unlikely to impact human health.

4.3.2.2 Stock health

Bluett (2012, cl.12.8) provided advice that increased dust storm activity would be unlikely to affect the lungs or eyes of stock within the area.

4.3.2.3 Amenity and nuisance

Bluett (2012) stated that during a dust storm event, with a lower lake and potentially a more intense storm, visual amenity would be degraded more than currently occurs.

Additionally, there is likely to be greater nuisance dust deposited into the wool of sheep around Lake Pūkaki due to a lower lake level, however, Bluett was unable to quantify the impact.

5. Dust generation

This assessment is limited to dust generated as a result of rip-rap placement activities at the dam wall. The focus of this assessment is on the areas of the proposed works, including existing stockpile areas, haul roads, site access points, new temporary stockpile areas, and associated soil disturbance activities which are outlined in the construction methodology report (GHD, 2025b)

5.1 Geology

The geology of the Tasman River delta, which is the primary source of water for Lake Pūkaki, is fed sediment from the Tasman Glacier.

Glacial till, defined as unsorted sediments deposited directly by a glacier and moraines (accumulations of rock debris along the glacier edges) dominate the sediment load. As the glacier retreats, large quantities of gravel, sand, and silt are carried downstream, forming braided river systems.

The Tasman River is a braided river, characterised by multiple interwoven channels. This morphology reflects high sediment loads and fluctuating water flows. The river deposits layers of gravel, sand, and finer sediments, which are redistributed by water flows and seasonal flooding.

The delta itself is an active depositional environment, with new material constantly added from glacial meltwater and tributaries. The sediment is primarily composed of greywacke, schist, and other rocks derived from the Southern Alps. Grain sizes range from coarse gravels and rocks near the glacier to finer silts and sands further downstream.

The delta is highly dynamic due to the interplay of glacial retreat, sediment supply, and water flow. Seasonal variations, heavy rainfall, and periodic floods results in a continual supply of new sediments to the delta and Lake Pūkaki.

The geology of the area of proposed rip-rap placement is summarised in the groundwater assessment report (GHD, 2025c). A conceptual model of the site geology is shown in Figure 3 . Near the southern edge of the lake, near the dam, there is a complex arrangement of sediments with sands and silts underlying the dam, with outwash gravels occurring to the south (Figure 3). The silt (CSS in Figure 3) can be seen in outcrop to the north of the dam and are assumed to be present along the southern margin of the lake.

It is expected that the earthworks at the dam wall will result in disturbance of glacial till material that will likely be the primary component in any construction dust emission.

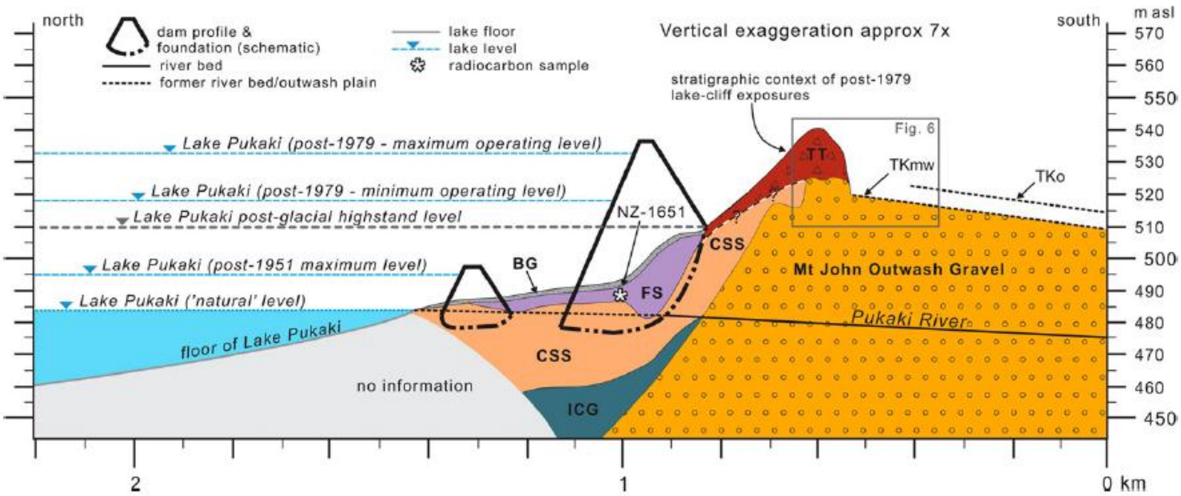


Figure 3 ***Schematic of the geology near the dam. From Barrell and Read (2014). TKmw, Tekapo meltwater terrace surface; TT, Tekapo Till; ICG, Ice Contact Gravel; CSS, Contorted Sediments Silt; FS, Fancy Sands; BG, Beach Gravel***

5.2 Dust generation mechanisms

Dust from a construction site is generally generated via two mechanisms, either mechanically derived by physical equipment disturbing soil and dislodging particulates into the air or by particles being dislodged and becoming airborne by wind.

5.2.1 Vehicle exhaust

Vehicle and plant exhaust, especially from diesel powered equipment will be a source of particulate matter, in particular in the smallest size fractions of PM2.5 or lower. However, in the overall scheme of this project, diesel emissions are considered to be negligible and are therefore not assessed as a source of particular matter.

5.3 Moisture content

Dust/dirt that has a higher moisture content will be less inclined to become airborne as it will agglomerate to other particles. Examples of two extremes moisture contents are mud and talcum powder.

5.4 Dust suppression

There are many different possible methods of dust suppression however, a detailed analysis of them all is beyond the scope of this assessment. However, a common technique used to prevent dust generation via wind erosion is to treat a particulate surface with a wetting agent such as a chemical or water.

The Australian National Pollution Inventory Estimation Manual for Mining (Mining, 2012b, Table 4) specifies that water sprays onto stockpiles and haul roads, at a rate of 2 $L/m^2/h$ will result in wind erosion suppression by 50 percent. This implies continual water application where cohesive forces between particles is maintained.

5.5 Dust particle size distribution

Bluett (2012) indicated that dust storm particulate sizes range between 7 to 63 μm. Measurements of Lake Pūkaki sediments by Chikita et al. (2000) are shown in Figure 4. Site A in Figure 4 is the most representative of the potential location of dust storm origin as it is located closest to the Tasman River delta and potentially in an area that could be exposed during a lake lowering event below 518 m.

Site A sediments vary between phi scale values of approximately 5.5 to 9.5 (10^{th} to 90^{th} percentiles), corresponding to sizes of 22 to 1.4 μm.[2] The mean phi scale value is 7.09, corresponding to a size of 7.3 μm. The Chikita et al. (2000) study is more conservative than the Bluett (2012) advice and therefore has been used in this assessment.

A particle size distribution profile for modelling dust dispersion and deposition has been created and is detailed in Table 1.

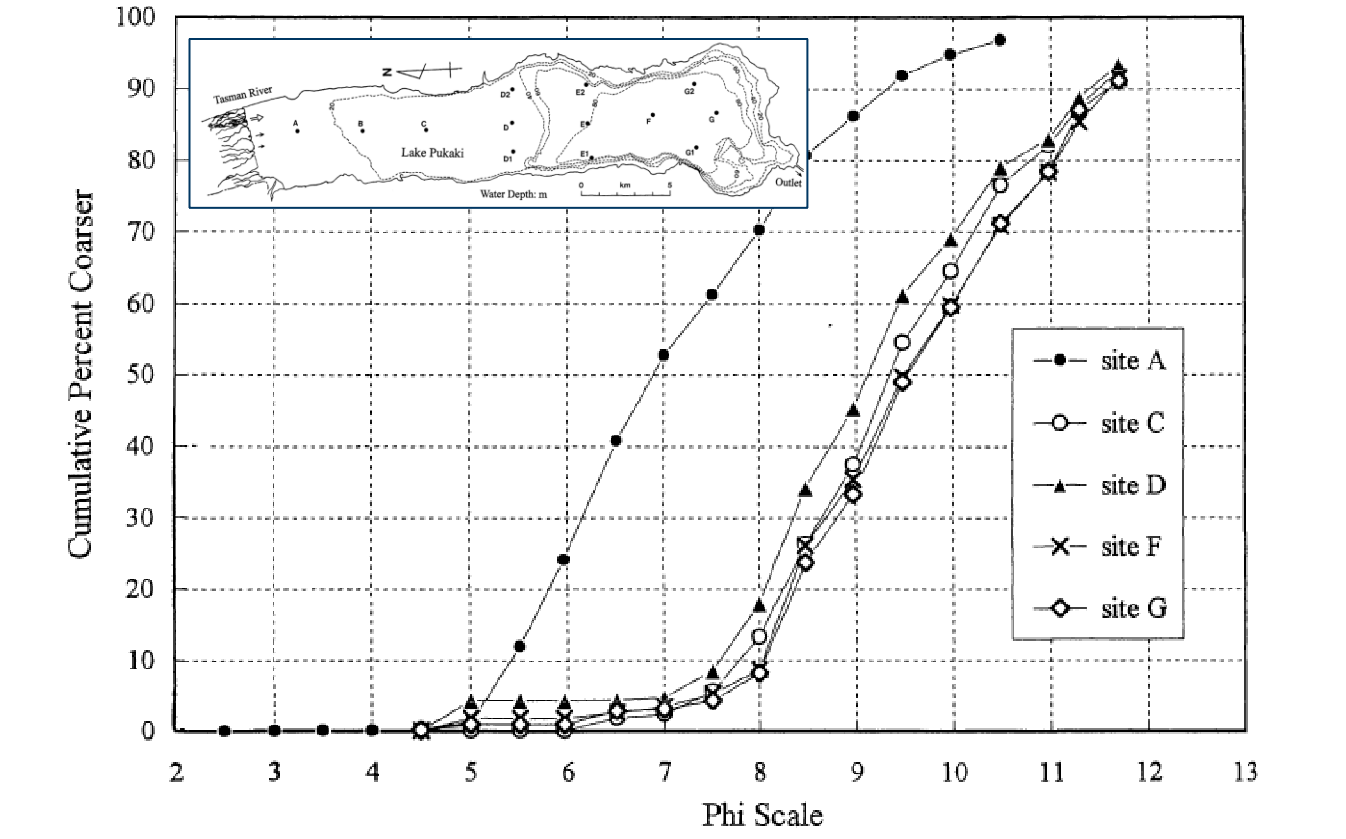


Fig. 11 Grain size distributions of lake bottom sediment sampled at sites A, C, D, F, and G.

Figure 4 *Lake Pūkaki sediment particle size distribution. Inset image: site locations with respect to Lake Pūkaki. Site A furthest north. Site G closest to outlet (south). Size scaling based on Phi scale.[2] Source: Chikita et al., 2000. Sedimentary environments in Laker Pūkaki, New Zealand. J.Sed.Soc.Japan, No.51, 55-66, 2000*

Table 1 *Adopted PM size distribution for dispersion modelling of non-haul road sources. Based on distribution shown in Figure 4*

Modelled PM diameter [µm]	Fraction of total dust [%]	Contributes to criteria for:
1.2	23	$PM_{2.5}$, PM_{10}, TSP
6.3	34	PM_{10}, TSP
15	26	TSP
25	17	TSP

5.6 Common emissions factors

Emission factors supplied by either US EPA AP42 or the Australian National Pollution Inventory Emission Factor Manuals (NPI) are considered acceptable factors for dust projects in New Zealand.

[2] Phi scale. $D = D_0.2^{-(phi)}$ $D_0 = 1000$ µm. For phi = 7, $D = 1000.2^{-7} = 1000\ (0.00781) = 7.8$ µm

5.7 Potential area of dust emissions

5.7.1 Construction activities

The proposed construction activities are described in Pūkaki Dam Rip-Rap Design and Construction Methodology (GHD, 2025b).

Construction activities associated with the rock armouring at the Pūkaki High Dam wall will be a source of short-term dust emissions, (i.e., only present for the duration of the works), and will only commence once the lake level has lowered to 518 m RL and is forecast to continue to decline. Thus, enabling works to commence.

The proposed works are to occur over a lake shore length of approximately 1700 m, with all three work zones operating concurrently. Compared to the wider lake environs, the construction zone makes up approximately 2.5 percent of the total lake perimeter affected by reduced water levels. There are a number of temporary material stockpiles, located south of the dam wall, within 1 km of the lake, that will be utilised during the works.

Construction activities associated with the rock armouring have been identified as the following:

- Loading, unloading and placement of rip-rap material from/to trucks and the dam upstream face.
- Haulage of rip-rap material between the primary stockpile sites to the dam construction zones.
- Haulage of additional rip-rap material from regional quarries to the primary stockpile sites.
- Wind erosion from construction and stockpile sites.

Additional information is provided in Section 10.2.

5.7.2 Wind erosion

Wind erosion is assessed from exposure stockpiles and shoreline sources within the work zones. Shoreline wind erosion outside of the work zones is discussed in the following section.

5.7.2.1 Shoreline wind erosion outside work zones

Wind erosion from exposed shoreline due to a lowered lake level is trivial in comparison to the rip-rap active placement generated dust. The average grade of the high dam slope is 40 percent (22°), as shown in Figure 5.

With a maximum lake lowering of 5 m from 518 to 513 m, the angled length of newly exposed shoreline above what is currently allowed is 13.5 m. Based on the Bluett (2012) advice that some of this length will remain moist due to capillary seepage and/or wave action, a rection factor of 30 percent has been applied. This results in an effect distance from the water of 9.4 m where wind erosion could generate dust emissions.

A length of shoreline of approximately 1000 m would equate to one hectare of additional exposed bare glacial till sediments. Assuming a default TSP emissions factor of 0.4 kg/ha/h, to add 10 percent of additional uncontrolled dust (refer to Table 11), or 4 kg/h, approximately 10 ha or 10 km of shoreline outside of the work zones would need to be added to the model.

Given that the rip-rap placement works are going to commence well before the lake level nears 513 m, this 10 km of shoreline estimate is likely to be far greater at over 20 km. The shoreline wind erosion issue has been addressed in the accompanying lake lowering report and will not be explicitly modelled in this assessment.

For the purposes of this assessment, the addition of shoreline erosion outside of the work zones was assessed qualitatively after quantification of all other dust sources, refer to Section 10.8.2.

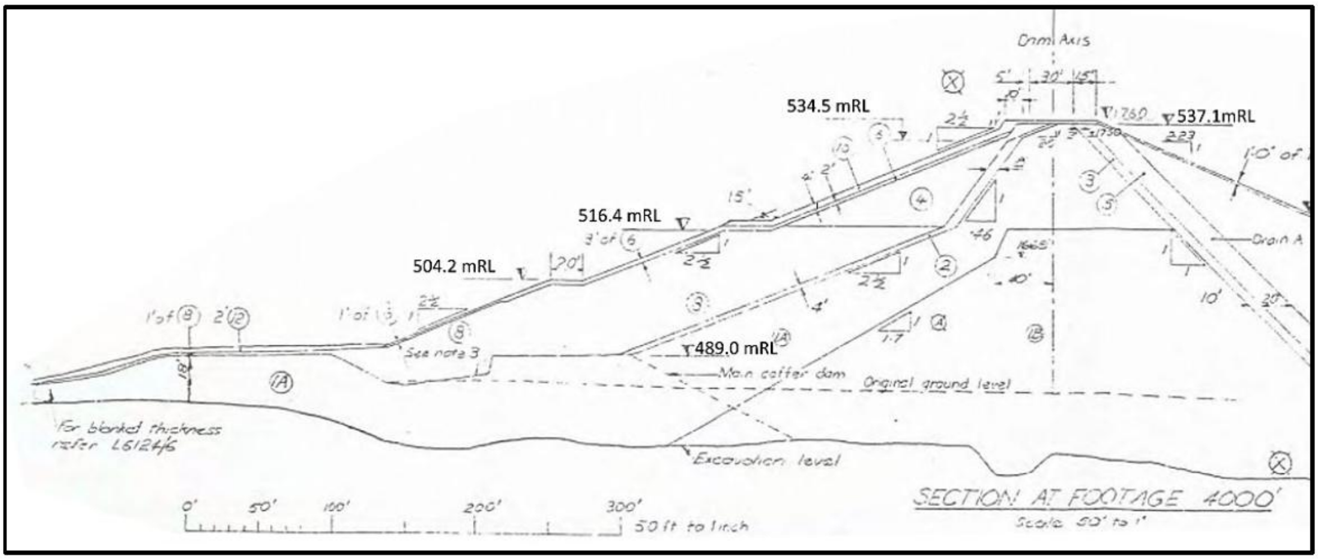


Figure 5 *Main dam typical cross section. Extract from Pūkaki Dam Rip-Rap Design and Construction Methodology Report (GHD, 31 October 2025, Figure 2).*

6. Dust assessment criteria

The assessment criteria and methodology for assessing dust impacts in New Zealand is best described in the *Good Practice Guide for Assessing and Managing Dust* (*Good Practice Guide*, Ministry for the Environment New Zealand (MFE), 2016).

6.1 Health

The ambient particulate matter (dust) criteria are tabulated in Table 2. These criteria are applied everywhere in the open air, including residences, businesses, and parks.

PM_{10} and $PM_{2.5}$ are non-threshold contaminants, i.e., substances with no known safe level of exposure. Any increase in ambient concentrations will result in adverse effects. This means that the air quality criteria for PM_{10} and $PM_{2.5}$ should not be used as a limit to pollute up to.

The Canterbury Air Regional Plan (Environment Canterbury, Regional Council, October 2017) has values that are the same as the Ministry for the Environment, New Zealand.

Table 2 ***Ambient air quality guidelines for particulate matter***

Pollutant	Concentration limit [μg/m³]	Averaging time	Comment
PM_{10}	50	24-hours	Allowance of one exceedance per year.
	20	Annual	-
$PM_{2.5}$	25	24-hours	-
	10	Annual	-

6.1.1 Trigger levels

MFE (2016, Section 3.1.3, Table 5) has a “trigger level” for TSP (multiple) and PM_{10}. These are values that can be used when there is an active monitor that provides feedback to an activity. Exceedance of these values, shown in Table 3 means that the chance of exceeding a regulated ambient air quality guideline is high, thus allowing for active operations to be modified.

Table 3 ***Amenity air quality Trigger Levels for particulate matter in a high sensitivity environment***

Pollutant	Averaging time	Trigger concentration [μg/m³]
PM_{10}	1-hour	150
TSP	5-minute	250
	1-hour	200
	24-hours	60

6.2 Amenity

The *Good Practice Guide* (MFE, 2016) contains a qualitative risk assessment guide, rating land use categories with respect to a relative sensitivity rating. The areas around Lake Pūkaki are rated as “high” sensitivity for the following reasons:

– The *Good Practice Guide* (2016) specifies that District Councils provide guidance with regards to the amenity expectations.

- The *Good Practice Guide* (2016, Section 2.4, Table 2) rates “tourist, cultural, conservation” land use as highly sensitive as these areas have high environmental values where adverse effects are unlikely to be tolerated.
- Mackenzie District policy (Mackenzie District Council) describes the area around Lake Pūkaki as:

  “*The landscape value of areas close to Lakes Tekapo, Pūkaki, Ohau and Benmore and their rivers is high. This value is largely due to the naturalness of this environment with little or no built development. These riparian areas are also a great recreational asset as they provide a setting for a variety of activities and also provide access to waterbodies*.”

  “*The Mackenzie Basin contains two of the South Island’s significant ‘Southern Lakes’; Tekapo and Pūkaki. … Although modified and in two cases man-made, these lakes variously are jewels of the Basin, and of the most outstanding value. Pūkaki and its setting is a tourist icon, both visually and as the approach to Mount Cook/Aoraki and the National Park.*”
- Stephen Brown (Brown, 2024) report description of the area.
  - “Aesthetic Values
    - The vast basin large river valleys and enclosing mountain ranges form a dramatic and spectacular landscape. While some parts of the basin have been substantially modified by residential hydro and agricultural development, the basin as a whole retains its openness and largely coherent character.
    - Impressive views up the wide u-shaped valleys to the snow and ice covered peaks of the Alps are experienced from the basin.
    - Pūkaki [sic] and Tekapo reflect a striking milky-blue colour in sunlight. They form an integral part of one of the most memorable landscapes in the country.
    - The golden tussock-laden slopes which surround the basin have high aesthetic values.
  - Transient Values
    - Snow coats the ranges and basin floors during much of the winter months.
    - The distinctive turquoise colour of the lakes in sunny conditions is spectacular.
    - Nowhere else in the country can the effects of 'norwester' weather patterns and the rainfall gradient from west to east be as vividly experienced as in the Mackenzie Basin.”

6.2.1 Deposition modelling

Dust deposition modelling has not been undertaken as part of this assessment.

As a general rule, higher estimates of dust concentration will correlate with higher dust deposition rates.

6.3 Background dust

There is little information regarding background dust concentrations in the region around Lake Pūkaki. It is known to be low – except during dust storm events – and this is part of the reason why there is little information, i.e., little monitoring of ambient dust levels.

A New Zealand Transport Agency (NZTA) (2023) report regarding background concentrations for air quality studies was reviewed. It is noted that the background levels reported by the NZTA are generally focused on urban areas and transport applications. Thus, they may have limited application for this assessment.

A review of the NZTA (2023) document indicates that the correlation between the annual dust concentrations and the 24-hr avg values is based on a 99th percentile, or 4th highest day, with justification being that high background urban smoke occurs at the same time that transport emissions during poor dispersive conditions occur.

It is agreed that the annual averages in the NZTA document are representative of the remote Lake Pūkaki location. However, basing the 24-hour background on a 99th percentile value for an operation that is expected to take no longer than 18 weeks but could be as short as three weeks, is considered to be ultra conservative.

Some calculations have been undertaken by GHD, using the approach adopted in the NZTA information and adjusted for an operation with less than 52 weeks occurrence. For an 18 week program, an applicable percentile is estimated to be 97.1 %, or 10.5th highest day per year. Assuming a normal distribution, effective standard deviations have been back calculated, and a 97th percent correlation for 24-hour averages is estimated to be 7.5 μg/m³ and 16.3 μg/m³ for $PM_{2.5}$ and PM_{10} respectively.

Given the location and lack of monitoring in the area, applying a background concentration resolution of less than 1 μg/m³ is not considered to be reasonable.

Note that if this same scaling methodology was applied to a three week construction program, the resultant $PM_{2.5}$ and PM_{10} 24-hour background concentrations equate to approximately 5 and 12 μg/m³.

This assessment will assess construction dust on an incremental increase basis and where required, will assume an annual average background PM_{10} concentration of 7 μg/m³ and a 24-hour average value of 16 μg/m³.

Background $PM_{2.5}$ values of 2 and 7 μg/m³ will be applied to annual and 24-hour averages where required.

7. Meteorology

7.1 General meteorology

The prevailing wind in the Lake Tekapo and Pūkaki region is from the northwest, however, due to the mountainous terrain in places, local winds can vary with topography. A publicly available wind rose for the Lake Tekapo area is shown in Figure 6. Lake Tekapo is a local flat area where the winds tend to originate from more westerly than northwest, which compares to the insert wind rose from Mount Cook Village, at the northern end of the Tasman River, which has a very strong northwest alignment that corresponds to the valley it is located in.

Wind speeds are highest during the summer months, as shown in the average monthly wind speed plot in Figure 7. These higher wind speeds also correspond to lower rainfall, which may result in higher wind erosion rates.

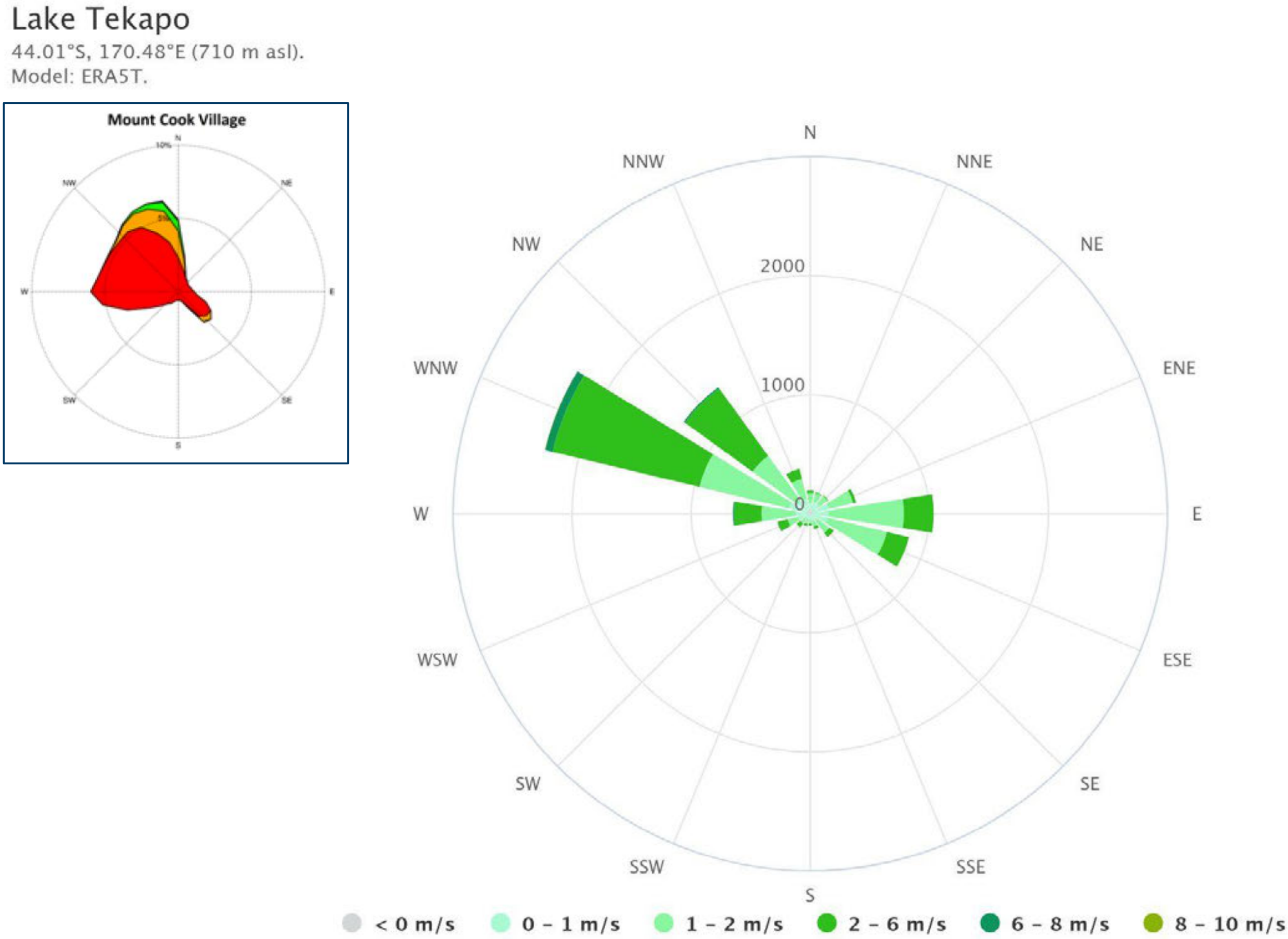


Figure 6 *Wind rose for Lake Tekapo (Meteoblue, n.d.) Insert image: Month Cook Village wind rose (Macara, 2016).*

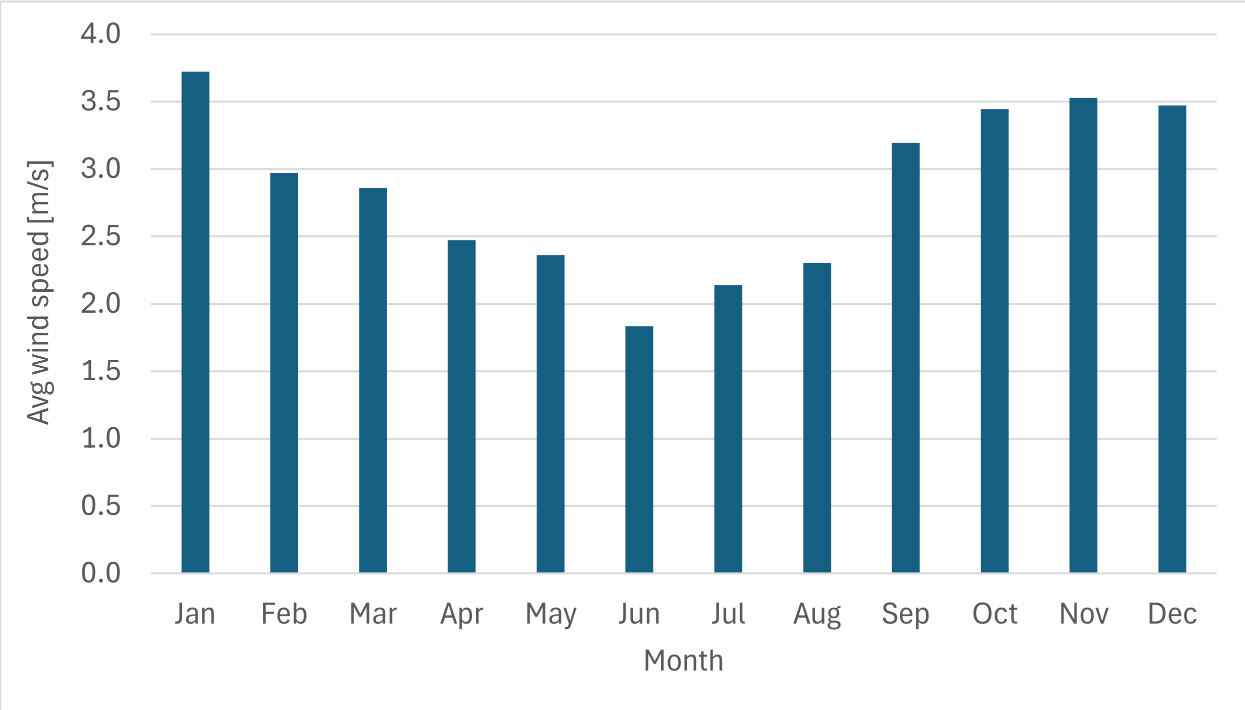


Figure 7 Average wind speed at Pūkaki Aerodrome. Source: Macara (2016)

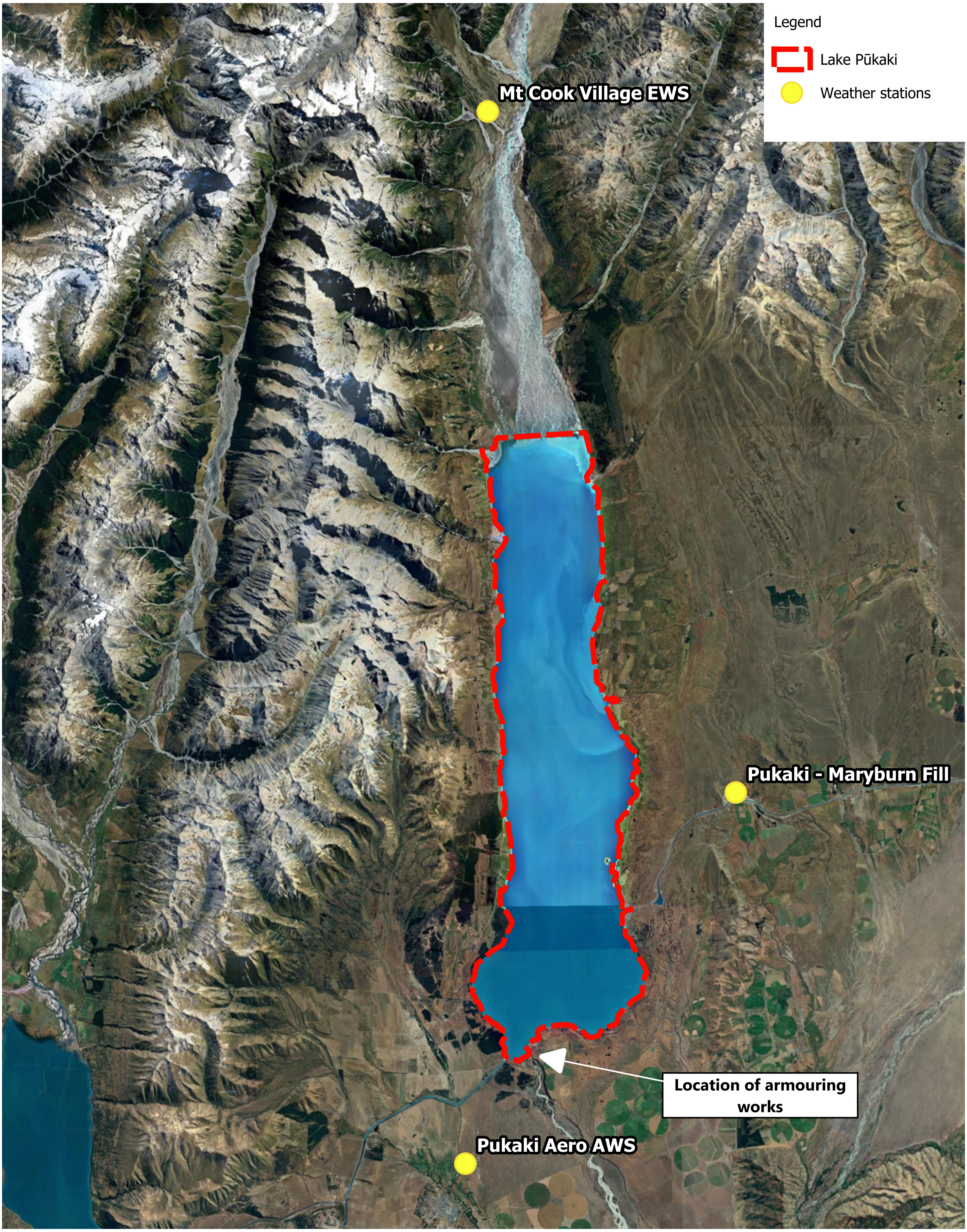
7.2 Detailed meteorology

Meridian supplied detailed meteorological data for three locations surrounding Lake Pūkaki. Data for two of the sites was kindly supplied by Met Services New Zealand for use in this project only. Information regarding the three sites and data is summarised in Table 4, with their locations shown graphically with respect to the construction site location in Figure 8.

Table 4 Summary of observational data used in this assessment.

Site name	Maryburn	Pūkaki Aero	Mt Cook Village
Source	Meridan	Met Service	Met Service
Location (UTM 59 G)	442,494 mE, 5,120,112 mS	429,498 mE, 5,100,535 mS	430,054 mE, 5,153,860 mS
Distance and direction from dam construction site	17 km, NE	6.6 km, SSW	47 km, N
Period	16 February 2006 to 28 May 2025	13 December 2008 to 2 June 2025	7 September 2012 to 2 June 2025
Number of full years[3]	17 (2007-2016, 2018-2024)	16 (2009-2024)	11 (2013-2014, 2016-2024)
Frequency	Hourly observations	Hourly observations	Hourly observations
Observational parameters	Wind speed, wind direction, temperature, humidity, pressure, rainfall	Wind speed, wind direction, temperature, humidity, pressure, rainfall, cloud cover, cloud height, weather description, visibility, gust speed	Wind speed, wind direction, temperature, humidity, pressure, rainfall, gust speed
Notes	Wind direction to 1° increments	Wind direction to 10° increments	Wind direction to 10° increments

[3] A “full year” here is considered to be one that is >90 % complete and can be easily gap filled using US EPA methodology to generate a complete data year of 8760 hours (or 8784 for leap years).



Paper Size ISO A4

0 5 10 km

Map Projection: Universal Transverse Mercator
Horizontal Datum: WGS 84
Grid: UTM Zone 59 South

N

GHD

Meridian Energy
WPS Pūkaki FTC

Location of meteorological observation stations

Project No. 12656630
Revision No. B
Date 24/10/2025

FIGURE 8

Document Path: \\ghdnet\ghd\NZ\Christchurch\Projects\51\12656630\GIS\Maps\Working\Lake_Pukaki_James_D.qgz
Print Date: 24/10/2025

Data Source:Google Earth Imagery 2025.
Created By: rwilson3

7.2.1 Annual wind roses

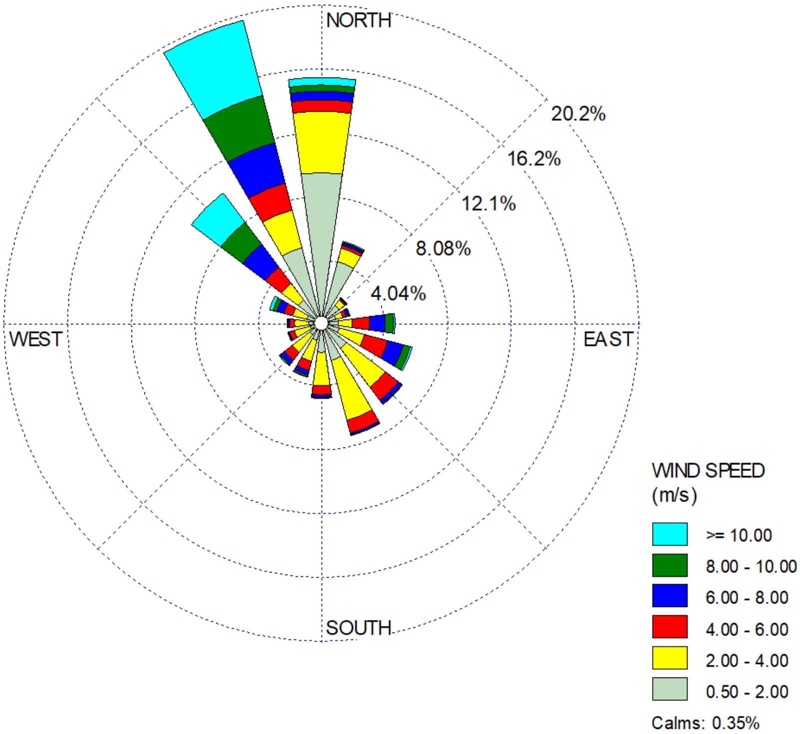
Annual wind roses based on all observational data for each site are shown in Table 5. Significant differences can be observed in both wind directions and wind speeds for each of the sites.

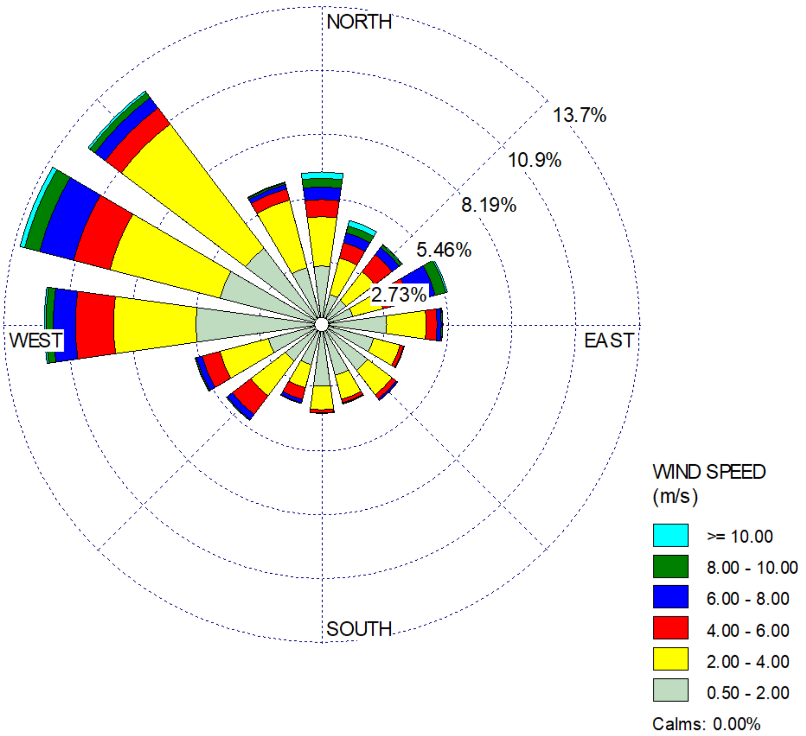
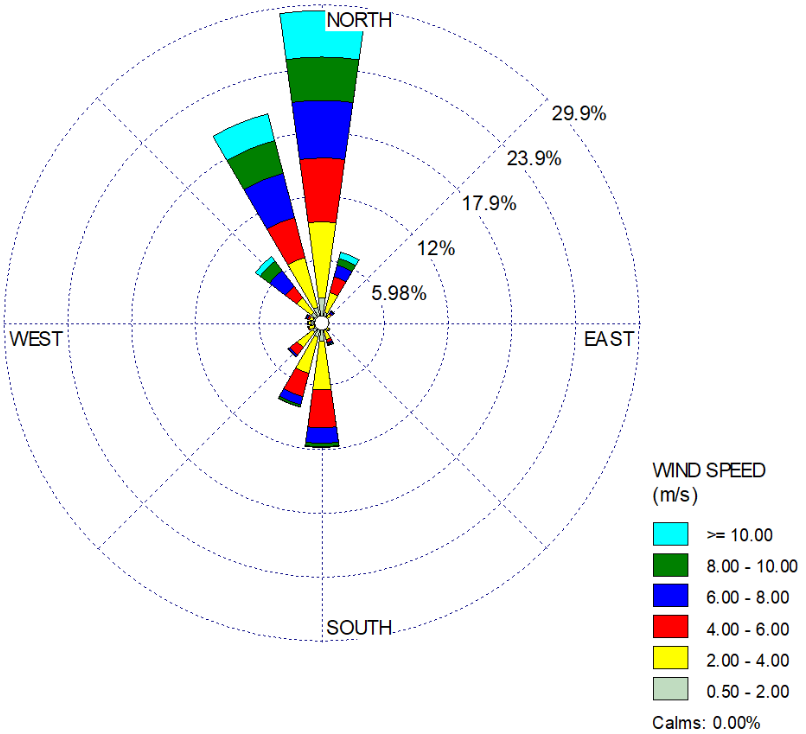
At the Mt. Cook Village site, the winds are highly northerly due to the terrain features surrounding the site.

At the Maryburn site, the wind speed is lower and the direction has rotated slightly to the west with NNW winds dominant, however, there is a considerable SE wind component that has been identified as predominantly occurring during daylight hours, thus indicating an interaction between land and lake conditions especially in the absence of strong northwest winds.

At the Pūkaki Aero site, wind speeds are significantly lower than the other two sites, especially noticeable by a much lower proportion of wind speeds greater than 10 m/s and have a significant westerly component.

Table 5 Annual wind roses for observational sites. Full data periods.

Site	Annual wind rose
Maryburn Avg WS = 4.1 m/s Years = 2006 to 2025	

Site	Annual wind rose
Pūkaki Aero Avg WS = 2.8 m/s Years = 2008 to 2025	
Mt Cook Village Avg WS = 4.9 m/s Years = 2012 to 2025	

7.2.2 Selected single year – 2015

For a detailed quantitative air quality assessment, a single year was selected so that site-specific CALPUFF modelling could be undertaken (refer to Appendix D). This single year was to be used for all air quality assessments for this project, not just the assessment detailed in this report.

A multi-criteria assessment was used of all the available data, which included the following parameters.

– Annual rainfall
  - A drier year is generally associated with more frequent dust storms, i.e., dust wind erosion.
– July to December rainfall
  - Dust storms tend to occur during the latter half of the year.
– Annual average relative humidity
  - Lower relative humidity is generally favourable for exposed surfaces to lose moisture.
– Annual average wind speed
  - Wind erosion and dust storms increase in intensity with wind speed.
– Number of hourly observations with wind speed 10+ m/s
  - Highest wind speeds are associated with dust storms, consistent with Bluett (2012).
– Number of periods where the wind speed exceeded 10 m/s for longer than 24 consecutive hours.
  - Long duration high wind events are more likely to result in dust storms and exposed surface drying.
– Number of missing hours
  - Validity of the analysis needs to be maintained.
  - Used to exclude 2017 as a usable year given 52.5 percent of data was missing from the Maryburn site.

More weighting was given the observations from Maryburn and Pūkaki Aero rather than Mt Cook Village given their better proximity to the construction site and representation of winds across the plains east of Lake Pūkaki.

A ranked multi-criteria analysis was applied for each of the sites. Detailed ranking tables are supplied in Appendix D that indicated the year 2015 was the most conducive for dust storm and wind erosion events.

7.3 Dam construction site meteorology

The meteorology at the dam construction site is complex. The construction site is on the bank of Lake Pūkaki, shown in Figure 9.

To highlight the complexities of the meteorology at the water's edge, two annual wind roses based on the CALMET generated wind fields were extracted, location shown in Figure 9. Site 1 is about 300 m onshore while site 2 is about 120 m offshore. Noting that CALMET spatial resolution is 300 m, these two locations are diagonally adjacent to each other in the CALMET model. Annual wind roses for the two locations are shown in Table 6.

The two wind roses shown in Table 6 do have similarities but are distinctively different to each other. For most of the year the winds immediately on and off shore are similar to each other in terms of speed and direction, however there are times where the interaction of terrain elevation and land (water) types results in differences, as shown in two wind cases in Figure 10 and Figure 11. Additionally, the atmospheric stability class of the wind changes between the lake (always neutral D class) and the land that can vary between highly unstable (A class) to stable (F class), as shown by the stability rose (inset image) in Table 6.

Given the identified complexities in the local flow around the dam construction site, the use of the CALPUFF package for the assessment is warranted.

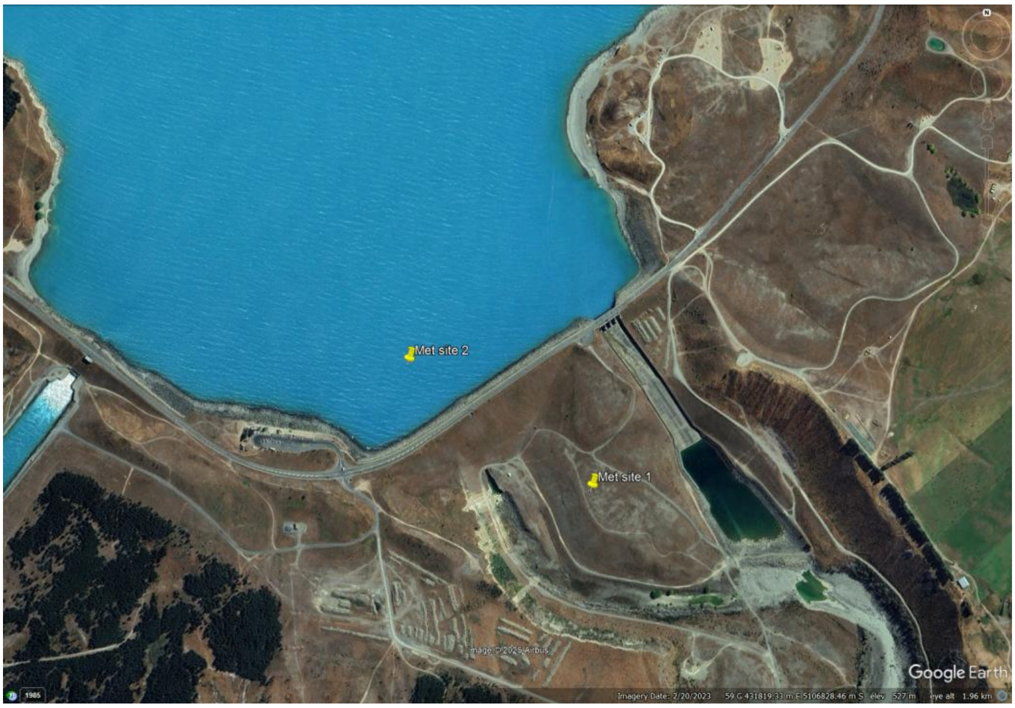
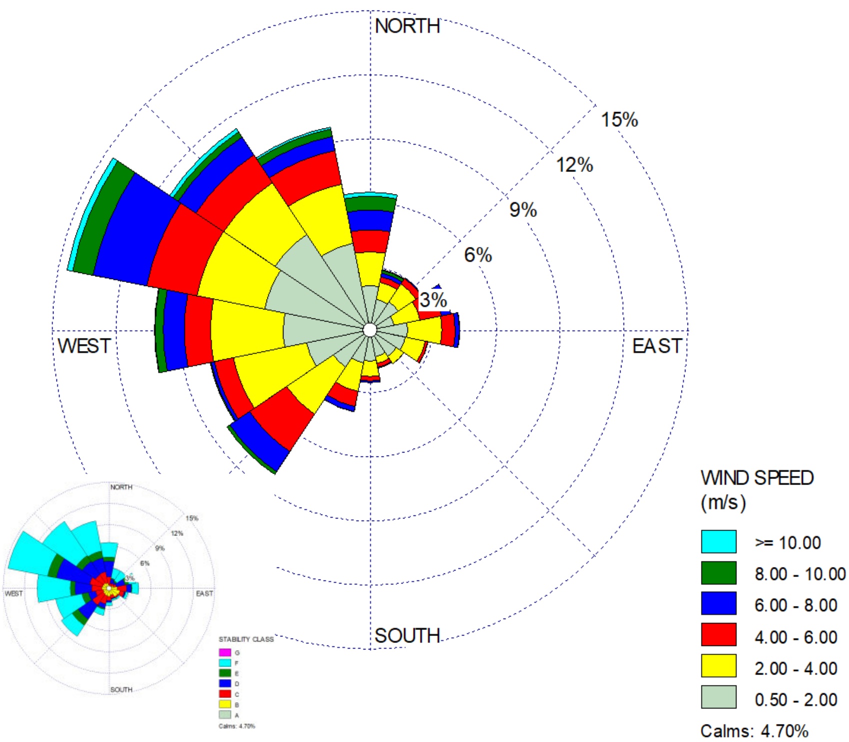
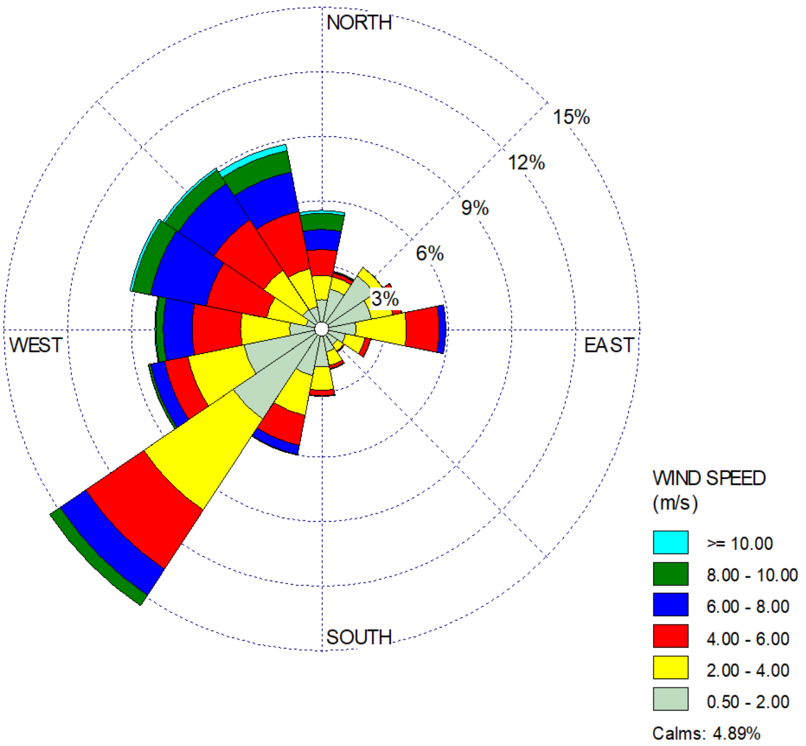


Figure 9 *Dam construction site. CALMET results stations for dam wall construction.*

Table 6 *CALMET generated annual wind roses for either side of dam construction site.*

Site	Annual wind rose
Construction site 1 Onshore Avg WS = 3.0 m/s Inset: stability rose	

Site	Annual wind rose
Construction site 2 Offshore Avg WS = 3.4 m/s	

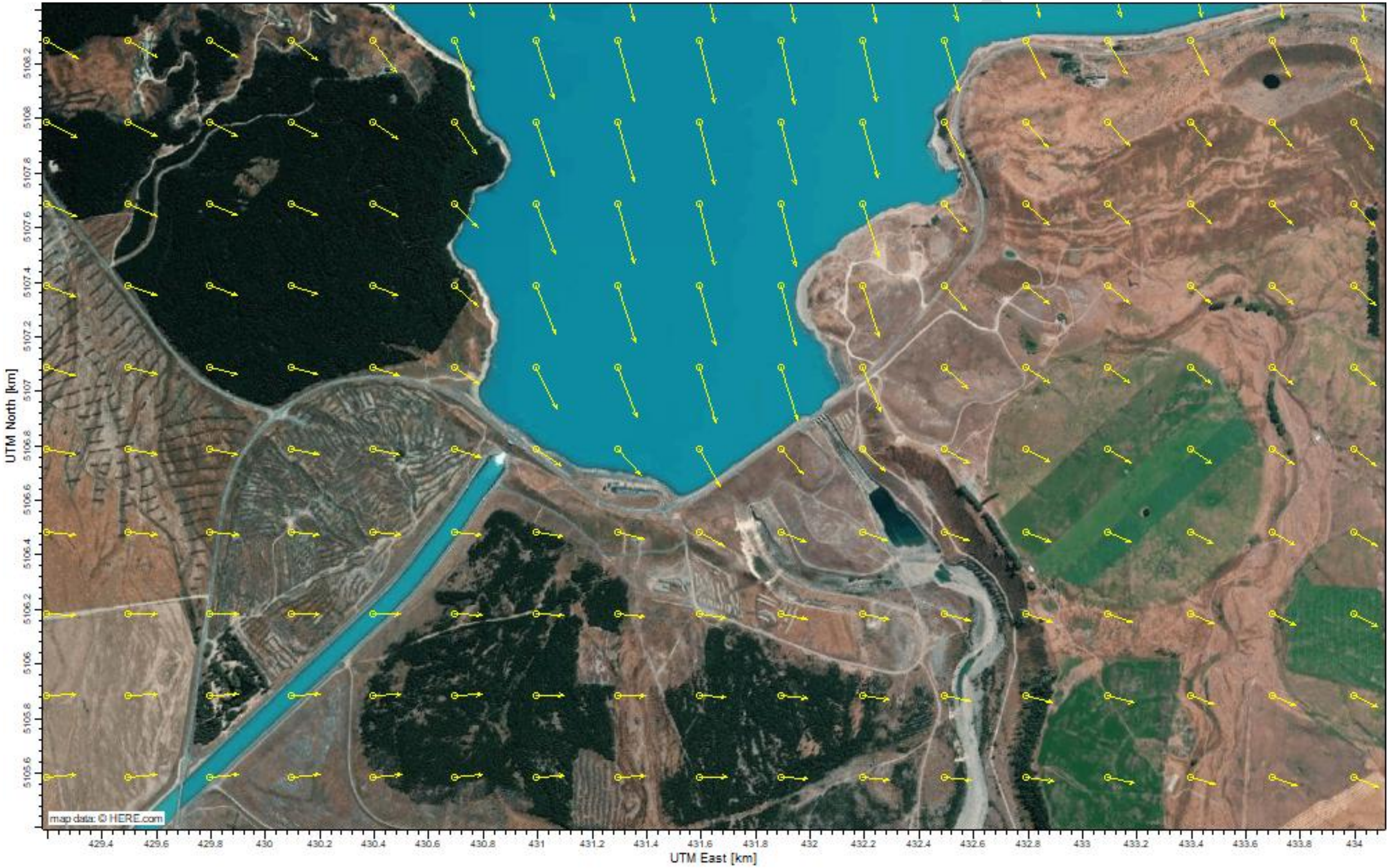


Figure 10 *CALMET generated wind velocity vectors @ 10 m for 11 pm 28 March 2015.*

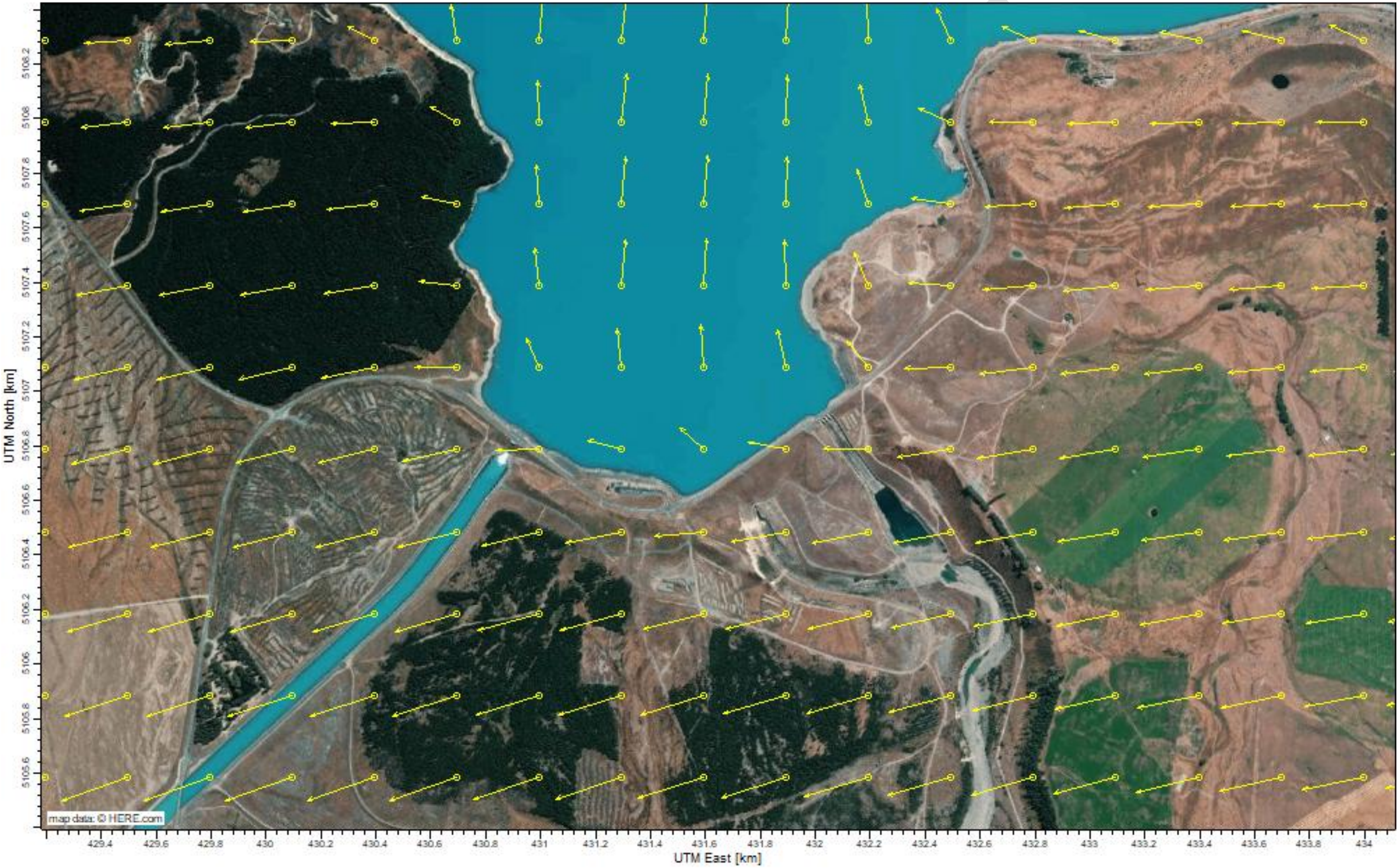


Figure 11 *CALMET generated wind velocity vectors @ 10 m for 5 pm 28 September 2015.*

7.3.1 Mixing height

A plot of the diurnal variation of the atmospheric boundary layer mixing height, as estimated by CALMET for the assessed year is shown in Figure 12. These data are for the offshore meteorological site detailed in the above section.

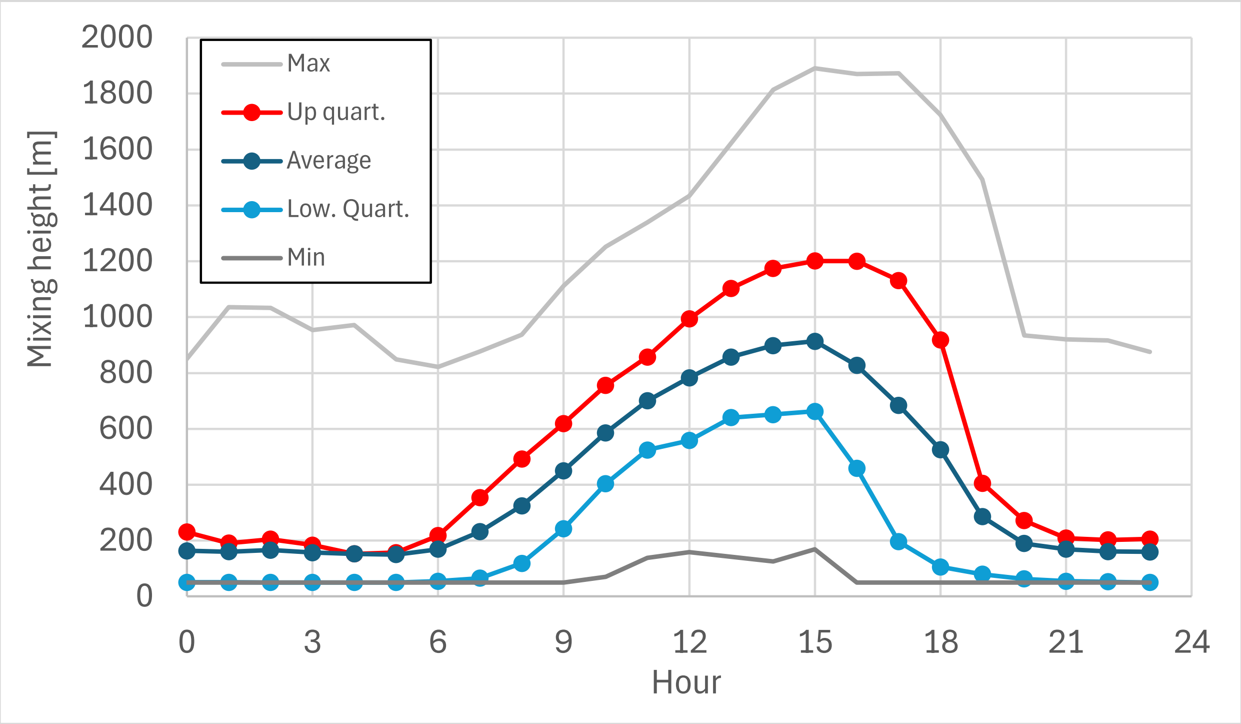


Figure 12 Dam construction site 2 CALMET estimated mixing height. Diurnal distribution.

8. Sensitive receptors

The following section provides an overview of the potential sensitive receptors that may be exposed to changes in air quality associated with the proposed construction works at the high dam and abutments. The broader air quality impacts associated with the temporary lowering of lake levels on the wider environment are addressed in GHD (2025a).

8.1 Definition

The *Good Practice Guide* (MFE, 2016) provides guidelines on the classification of sensitive receptors and their sensitivity ratings, as shown in Table 7. Lookouts, which are frequently found around Lake Pūkaki, have been designated as “open space recreational”.

Note: Lake Pūkaki itself can be considered as a sensitive receptor. In general, glacial till is more likely to be hydrophilic and therefore dust is likely to become suspended in the water and eventually settle at the bottom of the lake. However, if the till is hydrophobic, a layer of fine dust may settle on the water surface, dependent on wave and wind actions.

Table 7 Classification and sensitivity of sensitive receptors (MFE, 2016)

Land use	Sensitivity
Hospitals, schools, childcare facilities, rest homes, marae	High
Residential	High
Open space recreational	Moderate to high
Tourist, cultural, conservation	High
Commercial, retail, business	Moderate to high
Rural residential/countryside living	Moderate to high
Rural	Low for rural activities; moderate or high for other activities
Heavy industrial	Low
Light industrial	Moderate
Public roads	Low

8.2 Construction site nearest receptors

A detailed list of identified potentially sensitive receptors around the whole lake is provided in GHD (2025a). A consolidated list of lake environs receptors from GHD (2025a) is provided in Table 8, which includes the distance from the works (represented as the distance from Gate 19). The sensitive receptors that are closest to the dam earthworks sites are identified as R22, R24, R26, R67 and R68, and shown visually in Figure 13.

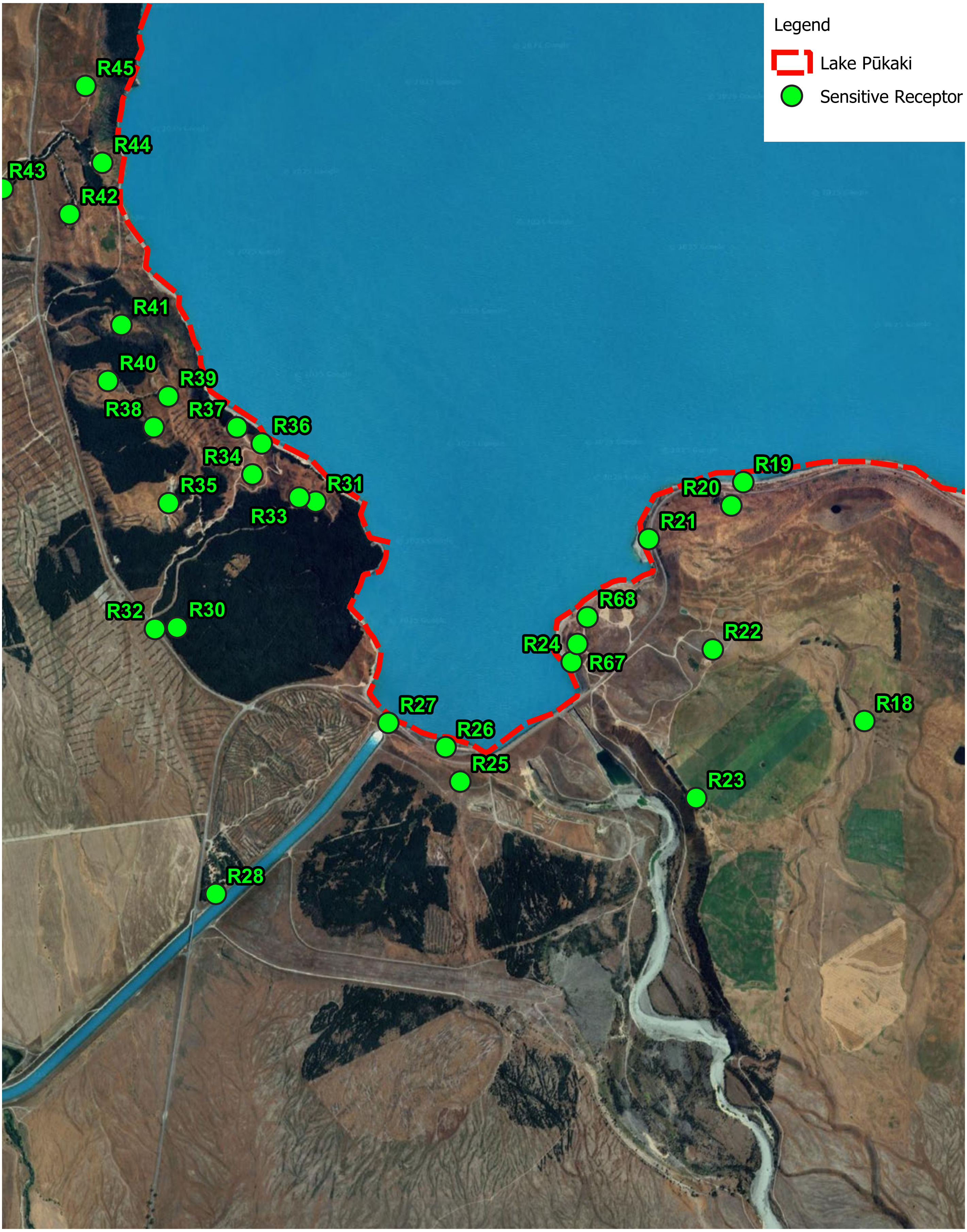
Of these receptors the following is noted:

- Receptor R26 (Mt Cook alpine salmon shop) is immediately adjacent to the Right abutment construction site but it is to be closed for the duration of any works and is therefore not required to be assessed.
- Receptor R22 is located about 760 m from the Left abutment work site.
- Receptor R24 is a photo point immediately adjacent to the Left abutment site. This is a place where people will transit through.
- R67 (overnight campervan / caravan parking) at The Pines freedom camping area is considered to be potentially the most exposed to a potential change in air quality associated with the proposed works, located at a distance of about 105 m from the northeast corner of the Left abutment construction site.

– R68 (overnight camping) is considered to have high exposure but less than R67 due to a greater distance from the Left abutment work zone.

Table 8 Identified receptors exposed to the proposed construction works (from Table 8 of GHD 2025a)

Name	Classification of land use	Label	Easting [m]	Northing [m]	Distance from Gate 19 [m]
House	Residential	R18	433,862	5,106,822	1,833
Viewing spot	Tourist, cultural, conservation	R19	433,111	5,108,304	1,763
Lakestone lodge	Rural residential/countryside living	R20	433,037	5,108,159	1,603
walk photo spot	Tourist, cultural, conservation	R21	432,525	5,107,951	1,152
House	Residential	R22	432,922	5,107,266	959
Farm Implement Shed /Barn	Farming infrastructure	R23	432,819	5,106,344	971
Lake Pūkaki photo point / public toilet	Tourist, cultural, conservation	R24	432,047	5,107,188	278
Electrical transformer	Industrial (Meridian asset)	R25	431,356	5,106,446	819
Mt Cook alpine salmon shop (to be moved)	Commercial, retail, business	R26	431,265	5,106,660	806
Lake Pūkaki Gate 18 outlet (Meridian Asset)	Dam infrastructure	R27	430,910	5,106,810	1,126
Lake wardel campside	Tourist, cultural, conservation	R28	429,840	5,105,749	2,480
Lake Poaka Campsite	Tourist, cultural, conservation	R29	427,569	5,104,864	4,909
The moraine fine dining restaurant	Commercial, retail, business	R30	429,601	5,107,402	2,479
Mt Cook lakeside retreat, high country	Rural	R31	430,459	5,108,183	2,022
House	Residential	R32	429,463	5,107,393	2,613
House	Residential	R33	430,357	5,108,209	2,119
House	Residential	R34	430,067	5,108,352	2,436
The moraine- luxury wedding and events venue	Commercial, retail, business	R35	429,548	5,108,174	2,786
House	Residential	R36	430,125	5,108,544	2,510
House	Residential	R37	429,972	5,108,644	2,691
House	Residential	R38	429,455	5,108,645	3,105
House	Residential	R39	429,545	5,108,836	3,144
House	Residential	R40	429,171	5,108,932	3,502
Karaerea Lakehouse	Residential	R41	429,255	5,109,280	3,650
House	Residential	R42	428,933	5,109,967	4,352
Pūkaki adventures	Tourist, cultural, conservation	R43	428,519	5,110,125	4,761
Pūkaki lakeside getaway	Rural	R44	429,136	5,110,286	4,447
House	Residential	R45	429,032	5,110,763	4,882
The Pines Overnight Campervan parking	Tourist, cultural, conservation	R67	432,082	5,107,300	393
Lake Pūkaki Overnight Campervan parking / camping	Tourist, cultural, conservation	R68	432,145	5,107,466	567
Red Cat Biplane Flights	Tourist, commercial	R69	429,483	5,101,760	5,746
Twizel	Residential	R70	428,275	5,099,834	8,012



Paper Size ISO A4

0 0.5 1 km

Map Projection: Universal Transverse Mercator
Horizontal Datum: WGS 84
Grid: UTM Zone 59 South

N

GHD

Meridian Energy
WPS Pūkaki FTC

Identified sensitive receptors near construction works

Project No. 12656630
Revision No. A
Date 02/09/2025

FIGURE 13

Document Path: \\ghdnet\ghd\NZ\Christchurch\Projects\51\12656630\GIS\Maps\Working\Lake_Pukaki_working_air.qgz
Print Date: 02/09/2025

Data Source:Google Earth Imagery 2025.
Created By: ylim

9. FIDOL assessment

According to the *Canterbury Regional Air Plan Schedule 2*, the Canterbury Regional Council:

"for the purposes of assessing compliance with permitted activity conditions, resource consent conditions, or sections 17(3)(a), 314(1)(a)(ii) of the RMA, and resource consent applicants carrying out assessments pursuant to this Schedule, will have regard to the following matters when determining whether or not a dust discharge has caused objectionable or offensive effect:

1. *The frequency of dust events; and*
2. *The intensity of dust events, as indicated by dust quantity and degree of effect; and*
3. *The duration of each dust event; and*
4. *The offensiveness of the discharge having regard to the nature of the dust, including soiling of materials or structures and any potential health effects; and*
5. *The location of the dust, having regard to the sensitivity of the receiving environment, including taking into account the relevant zone(s) and provisions in the relevant District Plan."*

The above-listed metrics are captured in a FIDOL assessment. FIDOL assessment for dust and discussions of the indicators are presented in the section below. The table with the FIDOL indicators presents a description of the activities and conditions and give an indication of the impacts as high, medium, or low. It should be noted that the condition impacts are given relative to the size of the site and are not compared, for instance, to a large, long-term construction project. Thus, "high" impacts may specify high frequency, occurring most days of the year, or encompassing most of the lake area. In contrast, "low" impacts refer to infrequent activities with a short duration and/or a small footprint.

9.1 Dust FIDOL

Dust is likely to be generated from construction activities at the site. The dust FIDOL is presented in Table 9 below.

Table 9 ***Dust FIDOL***

FIDOL Indicator	Activities
Frequency	Frequency relates to how often dust impacts will be experienced at off-site receptor locations. The construction programme indicates that rip-rap placement will be completed over a period of approximately 18 weeks. However, this work most likely will not be completed in a single phase of construction. Construction activities cannot commence prior to the lake level being forecast to fall below a level of 518 m, with that forecast also indicating that it is likely to stay below this 518 m level for at least 3 weeks. Based on historical records, prolonged periods of low lake levels are extremely infrequent. It is therefore more probable that construction will be undertaken in small stages, between 3 to 6 weeks in duration. The lowest lake levels typically occur in late winter and early spring. Thus, construction will likely occur for short periods over several years. If a six-week period of construction is undertaken in a single year, this would comprise a frequency of 11.4% (6/52 weeks). Note that construction works can cease very rapidly in response to rainfall, within a matter of hours to days subject to rainfall as rapid lake level rises of up to 1 m within a day and 3 m within a week are possible.
Intensity	The following dust generating activities will be undertaken as part of the construction: – Material handling of rip-rap – Hauling on unpaved haul roads – Loading and unloading of material from trucks – Wind erosion from stockpiles Based on the amount of material to be placed, there is a potential for significant intensity of dust impacts beyond what would be considered typical for the area.

FIDOL Indicator	Activities
Duration	As mentioned in the frequency section above, the duration of the construction works will total approximately 18 weeks, to occur in shorter phases over a period of several years. The minimum duration of individual construction periods is of a few weeks (at least 3), and to continue as long as conditions are favourable (e.g., lake levels are low enough for the areas to remain accessible) or the works are completed. Construction activities will occur from 6:30am-7:30pm daily, except during Easter, five days during the Christmas/New Year period, and NZ public holidays. Because the duration of works is daily, over a period of several weeks, 24-hour average criteria may be exceeded. However, annual criteria are highly unlikely to be exceeded. In addition, dust deposition rates, typically measured over 30-day periods, are also unlikely to be exceeded, due to the limited duration of each work period. The staged shorter duration works, with likely irregular spacing, will result in lower longer duration cumulative dust impacts, thus assisting with ameliorating any negative impacts of emissions. In addition, the shorter duration periods of works also means that work processes can be amended and refined over time. For instance, if a complaint is received or if off-site impacts are observed, the staged approach allows for process and management adaption over time, thus serving to benefit the overall works and environmental outcomes.
Offensiveness	When detected off-site, dust from the proposed works has the potential to be offensive. Because this is an area that is rural and is subject to natural dust storms generated by winds lifting silt from the shore of the lake as part of the natural geomorphic processes of the region, there is likely some level of tolerance for occasional dusty conditions. However, these conditions are short-lived (typically less than a few hours) and are natural in origin. The tolerance for continual dust due to anthropogenic activity in a largely natural area is likely to be low. Given the scale of the proposed activity and the proximity of some receptors (discussed below), the most proximal locations where a person may be located and may find the dust from the construction activities offensive are mostly temporary in nature. More distally-located receptors are likely to report lower levels of offensiveness.
Location	To a large extent, the location of the dust sources in proximity to sensitive receptors is possibly the most important of the FIDOL factors. With increased distance, dust has greater time to disperse, therefore becoming lower in intensity as it travels from source to receptor. The site is located in a rural setting which already experiences dust storms and regular high winds. Therefore, some degree of dust may be considered acceptable. Five receptors have been identified as being particularly vulnerable to impacts from construction activities, due to their proximity to the construction areas. They are: – Mt. Cook Alpine Salmon Shop, which is located immediately adjacent to the right abutment – A public observation/scenic lookout location – Two freedom campsites immediately to the north of the left abutment work zone, and – A residential receptor located approximately 760 m from the left abutment work zone. The Alpine Salmon Shop will be closed for the duration of the works, so it does not need to be assessed for potential impacts. The public observation/scenic lookout location is an area where people transit through, so it is unlikely that receptors will be impacted by dust from a health criteria perspective (e.g., over a 24-hour period). The residential receptor 760 m from the left abutment work zone is likely too far away to be adversely affected. The highest potential impact is on the overnight campsites and toilet facility immediately to the north of the left abutment work zone.
FIDOL conclusion	Overall, GHD considers that there is a potential risk for uncontrolled construction activities to lead to adverse outcomes, particularly for the receptors located immediately adjacent to the north side of the left abutment work zone. This outcome is broadly indicated by the proposed intensity of the activities and the location of these receptors in relation to the work zones. Of secondary consideration is the duration of the activities, occurring for periods of time longer than 24-hours and wind erosion from disturbed surfaces when construction is not actively occurring, such as at night. The short duration, irregular frequency of the proposed works are likely to be positive mitigating factors, in that the staged works approach provides opportunity for construction approaches and activities to be revised and adapted, if necessary, in response to observations and feedback from nearby sensitive receptors. Because of this elevated risk and the high sensitivity (environmental, cultural and economic/tourist) of the environment, GHD explicitly modelled construction activities to quantify the potential impacts

FIDOL Indicator	Activities
	of dust emissions on nearby sensitive receptors. Mitigation options that may be undertaken by Meridian to limit their impacts are also discussed and quantified within this report.

Due to the potential impacts of dust on nearby sensitive receptors, explicit modelling has been undertaken to quantify the impacts of construction dust on surrounding receptors. The emissions and outcomes of this modelling are discussed in the following sections.

10. Construction dust assessment

10.1 Purpose of construction

The purpose of the construction works is to place rip-rap, or rocks along the upstream face of the dam embankment, to prevent dam erosion due to wave action.

There currently exists rip-rap along the dam upstream face. However, the rock armouring is inadequate to protect the dam and associated infrastructure if water levels were drawn below 518 m RL.

10.2 Construction methodology

The construction methodology summarised below with additional details provided in Appendix B, has been taken from GHD Report Lake Pūkaki Fast-Track Consent –Pūkaki Dam Rip-Rap Design and Construction Methodology (Document No. 12656630-GHD-Pūkaki Dam Resilience Works-RPT-GE-00001-S0-REVB-250924, 5 November 2025), Section 9.

10.2.1 Programme

If the rip-rap placement programme is completed in a single stage, the estimated duration is up to 18 weeks. However, Meridian have informed GHD and potential constructors that it is unlikely the lake level will be maintained below 518 m RL for an extended period allowing all works to be completed in one continuous phase.

Additionally, the lowest lake level achieved during any event is more likely to be nearer to 518 m than 513 m RL.

The construction methodology is based on the following programme.

- Construction activities may be short in duration (a few weeks) and occur over multiple stages.
- It may take multiple years to complete all the required works.
- Access is expected to be more frequent at higher lake levels within the 518 m to 513 m range, rather than at the lower end.
- The assumed approach is for rip-rap placement in a multi-stage process with rip-rap being placed when lake levels allow.
- Forecasting lake levels within a period of a few weeks is generally achievable based on predicted generation flows from the lake, predicted inflows, and predicted rainfall events in a 1-to-2-week window.
  - Based on this data, guidance can be provided to a contractor as to when lake levels are likely to reach required levels for construction to commence and how long they are likely to stay low in the short to medium term.
- Given the time required to mobilise and demobilise from the site, contractor guidance indicates that the minimum duration for any construction stage is 3 weeks.
- Inflow events, whether predicted or not, can result in a relatively rapid rise in lake level. Historical data indicates that the lake can rise up to 1 m in one day and 3 m in one week. Therefore, the construction sequence must include contingency plans for rapid site demobilisation, ensuring the site is left in a safe and environmentally appropriate condition prior to water inundating the works area.
- Historical data indicates that low lake levels at Lake Pūkaki most frequently occur during mid to late winter and early spring.
- Construction activities will be restricted to the following schedule:
  - Daily: 6:00 a.m to 7:30 p.m.
  - No work during the following periods:
    - Good Friday to Easter Monday (inclusive)
    - 24, 25 and 26 December (inclusive) and 31 December to 1 January (inclusive)
    - New Zealand Public Holidays

10.2.1.1 Modelled construction operations

Within the limits of the modelling methodology and its assumptions, and to enable statistical representative results to be determined, the construction dust modelling has assumed the following:

- Construction commences 15 July of the modelled year.
- Construction is completed 17 November of the modelled year.
  - An 18-week construction duration period.
  - A continuous period is modelled as the exact 3-week window of actual construction activities will take place cannot be established with any further precision.
  - Enables greatest capture of statistically representative wind patterns during construction activities, i.e., a particular high wind event will not be missed due to its occurrence one day outside of a 3-week activity period.
- Daily construction activities commence at 6 am and stop at 7 pm
  - Hour ending 7 am to hour ending 7 pm
  - 13 hours per day.

10.2.2 General work zones and approach to construction

10.2.2.1 Rip-rap

The rip-rap placement works are to be divided into three primary work zones, as shown in Figure 14.

- Right abutment
- Left abutment
- Main Dam

Rip-rap placement for Tranche 2 will only commence once Tranche 1 is fully completed.

Each tranche will be implemented ***concurrently*** across all three work zones.

It is likely that each tranche will be constructed in multiple stages, depending on lake level conditions and site accessibility.

10.2.2.1.1 Modelling of rip-rap placement

Given that the modelling approach has assumed a single 18-week construction period, the construction dust assessment has assumed that all three primary work zones are concurrently operational for the whole of the 18-week period.

Figure 14 Work zones

10.2.2.2 Rock supply and stockpile management

Rock material has been previously harvested and stockpiled near the site. The locations of the existing stockpiles are shown on Figure 15.

At present, approximately 23,000 tonnes of rock is available, which is sufficient to complete the proposed works across all three work zones down to 514 m RL.

As the existing stockpiles are depleted, additional rock will be brought to site from existing quarries within the region. An additional 50,000 tonnes of rock will be required to support lake operation to 513 m RL, which includes rip-rap placement to 510.5 m RL plus rip-rap bedding.

Prior to the commencement of active construction, rock will be transported by road trucks to two designated stockpile areas as shown in Figure 15.

Figure 15 *Stockpile locations*

10.3 Proposed equipment

The following equipment listed in Table 10, or equivalent alternatives, is expected to be required to complete the proposed construction works. This assessment assumes that construction activities will be undertaken concurrently across all three work zones: the Main Dam, Left Abutment, and Right Abutment.

Table 10 *Proposed equipment list*

Task	Resource	Number
Transferring rock to project designated stockpile areas	27-tonne road truck	3
Sorting and loading rock from stockpile area	20-tonne excavator	2
Enabling and construction of Tranche 1 works on Main Dam, left abutment and right abutment	45-tonne excavator Long-reach excavator	3 0
Enabling and construction of Tranche 2 works on Main Dam, left abutment and right abutment	45-tonne excavator Long-reach excavator	3 1
Carting gravel and rock to/from Main Dam and right Abutment	11-tonne road truck	3

10.4 Material placement

A total of 73,000 tonnes of rip-rap material is to be used and placed on the dam wall and abutments.

23,000 tonnes of this material is already present at the current stockpile areas.

An additional 50,000 tonnes of material is required to be trucked to site using State Highway 8.

10.4.1 Additional material haulage

This assessment has excluded the haulage of required additional rip-rap material to the site except for during rip-rap placement operations.

GHD understand that prior approval for the haulage of this material has been provided.

This assessment has assumed that all additional rip rap material would be brought to site – to the southern stockpile – within a 12-month period and that the potential dust emissions associated with the additional material haulage and handling during rip rap placement operations has been pro-rated.

10.4.2 Wet material

Material removed from the dam and abutments, assumed to be taken from below water level, has been considered in this assessment to be wet and/or sufficiently moist as to prevent dust emissions when loaded/unloaded. Emissions due to truck haulage, generally associated with mechanical tyre/wheel generation processes have been included in the assessment.

10.5 Emissions inventory

An emissions inventory of dust resulting from construction operations was compiled. Tabulated information is provided in Appendix C. Descriptions of the emissions compilation methodology is provided in the following sub-sections.

The construction methodology as detailed in Sections 10.2, 10.3 and 10.4 were used to inform the inputs.

Reasonable worst-case assumptions were made.

10.5.1 Rip-rap distribution

This assessment has assumed that each of the three dam construction zones – high dam, right abutment and left abutment – will all require an equal amount of rip-rap material, i.e., 24,333 tonnes each.

10.5.2 Stockpile distribution

Two primary stockpiles were modelled.

The east (smaller) stockpile was assumed to provide rip-rap solely to the left abutment construction zone.

The west (larger) stockpile was assumed to provide rip-rap to the high dam ad right abutment construction zones.

Therefore, twice the amount of material was moved to, move from and handled at the west stockpile compared to the east stockpile.

10.5.3 Haul roads

Two haul roads were assumed in the assessment.

Haul road 1, between the west stockpile and the high dam/right abutment construction zones, was modelled as 1000 m long and unsealed.

Haul road 2, between the east stockpile and the right abutment construction zone, was modelled as 300 m long and unsealed.

No haulage was modelled along State Highway 8 between the two abutment sites.

All haulage and truck movements along the State Highway was assumed to have negligible dust emissions. Based on the applied assumption of each primary stockpile servicing the adjacent construction zone, the zero road dust emissions assumption only affects haulage of the additional material to the site.

10.5.3.1 Haul trucks

Haul trucks between the primary stockpiles and the construction zones were modelled as having an 11-tonne capacity and a total loaded mass of 17-tonne. They were modelled with an empty mass of 6-tonne for the return trip from the construction zones.

Haul trucks delivering the additional rip-rap material during rip-rap placement operations were modelled with a capacity of 22-tonne and a total loaded mass of 27-tonne. When existing the primary stockpile areas via the unsealed haul roads, the unloaded mass of the trucks was modelled as 10-tonne.

10.5.3.2 Operational hours

Haul truck movements between the primary stockpiles and the construction zones was modelled from hour ending 7 am to hour ending 7 pm, 13 hours per day.

Haul truck deliveries of the additional rip-rap was modelled from hour ending 10 am to hour ending 5 pm, 8 hours a day.

Trucks were modelled as operating every day with their assumed loaded capacity modelled as slightly exceeding the required material tonnage movement for the whole works. This conservative assumption was applied so the representative meteorology of worst-case conditions would not be overlooked in the assessment.

10.5.3.3 Number of truck movements

The number of truck movements between the west primary stockpile and the high dam construction zone was modelled as averaging 3.15 loaded truck movements per hour, equating to 34.7 tonnes per hour of rip-rap being unloaded/moved and placed on the high dam/right abutment site.

The number of truck movements between the east primary stockpile and the left abutment construction zone was modelled as averaging 1.6 loaded truck movements per hour, equating to 17.3 tonnes per hour of rip-rap being unloaded/moved and placed on the left abutment site.

For additional rip-rap material haulage to the primary stockpile sites, if this operation was to take one year, a total of 1,852 loaded trips were estimated, equating to 0.9 trucks per hour during the operational hours of the day. This 0.9 trucks per hour delivery of additional rip-rap material during placement activities on the dam was assumed only for the period of dam works. Two thirds of the trips were assumed to the west stockpile, with the remaining one third to the east primary stockpile. Additional rip-rap material being delivered directly to the construction zones was not assumed. Should direct loads go to the construction zones, less overall dust would be generated as there would be less material handling. However, this is a non-conservative assumption and can only occur when the construction zones are actually operational.

10.5.3.4 Emission factors

Dust emissions from unsealed haul roads was modelled using advice from the Australian NPI Mining Emissions Estimation guideline (2012, Appendix A 1.1.11).

Emissions (per vehicle kilometre travelled, VKT) are dependent on vehicle mass and unsealed road silt content.

Loaded and unloaded (empty) truck movements were modelled separated, with the vehicle wheel emissions then combined for a total haul road dust discharge.

10.5.3.4.1 Silt

Haul road silt content was assumed to be 23 percent, consistent with the proportion of $PM_{2.5}$ in the lake sediments (Section 5.5, Table 1). Note that the default value used in NPI Mining (2012) is 10 percent.

10.5.4 Loading emissions

Loading of rip-rap material, either to a haul truck or placement on the dam were modelled at all of the primary stockpile sites and construction zones.

Emission factors were based on Australian NPI Mining (2012) emission factors (Appendix A 1.1.2 – excavators on overburden). The default value was applied.

10.5.5 Unloading emissions

Unloading or dumping of rip-rap was modelled at all locations.

Emission factors were based on Australian NPI Mining (2012) emission factors (Appendix A 1.1.6 – truck dumping on overburden). The default value was applied.

It is recognised that placement of rip-rap material under the water level will generate negligible dust emissions, however, the number of unknowns and variables for this situation is large, such as but not limited to picking up the rip-rap material or a water level that does not prevent dust from all locations. The adopted approach is considered to be reasonable worst case.

10.5.6 Wind erosion

This assessment has only considered wind erosion from the construction sites – dam, primary stockpiles and haul roads. Wind erosion due to lowered lake level are NOT considered in this assessment report. Refer to Section 1.5.

Wind erosion has been modelled from the following sites. Values of the estimated site areas used in the modelling are also supplied.

– West primary stockpile – 9.82 ha
– East primary stockpile – 1.01 ha
– High dam construction zone – 1.76 ha
– Right abutment construction zone – 2.04 ha
– Left abutment construction zone – 2.59 ha

It is recognised that not all of the assessed sites will have wind erosion, either due to some areas not (or never) being disturbed or wet/moist material has been placed on the ground, such as during dam excavation from under the water level. However, this assessment has taken a reasonably conservative approach in the estimation of emissions.

10.5.6.1 Emission factors

The assessment has taken the simple, but conservative approach of assuming constant wind erosion emission factors based on Australian NPI Mining (2012) default values of 0.4 kg/h/ha of TSP, 0.2 kg/h/ha of PM_{10} and 0.09 kg/h/ha of $PM_{2.5}$. The $PM_{2.5}$ value has been derived based on 23 percent $PM_{2.5}$ in the lake sediments (Section 5.5, Table 1).

10.5.7 Total dust emissions – Uncontrolled

A tabulated dust emissions inventory is provided in Appendix C. A summary of total dust emissions as estimated during an hour of construction and additional rip-rap material delivery is provided in Table 11, with a summarised breakdown by source provided in Table 12.

Table 11 Summary of total uncontrolled dust emissions

Emitted dust size fraction	Emission rate (during operational hours) [kg/hr]	Effective fraction of TSP (net glacial till and haul road source fraction)
TSP	42.51	1
PM_{10}	16.17	0.38
$PM_{2.5}$	9.44	0.23

Table 12 Breakdown of uncontrolled dust source contribution. Combined rip-rap placement and additional rip-rap delivery

Emissions	TSP (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)
Loading material at primary stockpile 1	0.867	0.49	0.113
Loading material at primary stockpile 2	0.433	0.245	0.056
Dumping material at high dam	0.208	0.118	0.027
Dumping material at right abutment	0.208	0.118	0.027
Dumping material at left abutment	0.208	0.118	0.027
Placing rip-rap at high dam	0.433	0.245	0.056
Placing rip-rap at right abutment	0.433	0.245	0.056
Placing rip-rap at left abutment	0.433	0.245	0.056
Loaded truck haulage to high dam	14.98	5.22	3.45
Empty truck haulage from high dam	9.37	3.27	2.16
Loaded truck haulage to left abutment	2.25	0.78	0.52
Empty truck haulage from left abutment	1.41	0.49	0.32
Dumping material at primary stockpile 1	0.192	0.11	0.025
Dumping material at primary stockpile 2	0.096	0.054	0.012
Loaded truck haulage to primary stockpile 1	3.99	1.39	0.92
Empty truck haulage from primary stockpile 1	2.21	0.77	0.51
Loaded truck haulage to primary stockpile 2	0.6	0.21	0.14
Empty truck haulage from primary stockpile 2	0.33	0.12	0.08
Wind erosion High Dam	0.7	0.35	0.16
Wind erosion right abutment	0.82	0.41	0.19
Wind erosion left abutment	1.04	0.52	0.24
Wind erosion Primary stockpile 1	1.18	0.59	0.27
Wind erosion Primary stockpile 2	0.12	0.06	0.028
TOTAL	**42.51**	**16.17**	**9.44**

10.6 Dust mitigation modelling

Dust mitigation and control modelling was undertaken as a post processing exercise to the uncontrolled emissions assessment.

Controls were applied to specific rip-rap placement activities based on guidance in MfE (2016) and NPI Mining (2012). Control factors for different activities as provided in Appendix E. Controls range from application of water sprays to operations and haul roads to construction of site appropriate porous wind breaks and/or screen around stockpile areas as is feasible based on the potential wind loading for the area, the duration of the works – both active and in standby modes, i.e., awaiting low lake levels for greater than a six month period.

10.7 CALPUFF modelling

10.7.1 PM size fractions

CALPUFF modelling of dust emissions was undertaken explicitly for TSP for all the modelled sources.

Modelling for PM_{10} and $PM_{2.5}$ concentrations applied a scaling value, based on the effective fraction as specified in Table 11 (column 3). It is recognised that some sources are different emitters of smaller size fractions, however, this distinction between the sources will not make a significant difference to receptors located at distances greater than (nominally) 500 m.

10.7.2 CALPUFF source characteristics

All CALPUFF sources were modelled as volume source type, with appropriate initial lateral spread (sigma-y) values applied.

Many of the emission locations were divided into numerous volume sources. For example, the dust emitted from the dam high wall construction zone was modelled using four (4) volume sources equally spaced across the approximate 500 m long construction zone.

Full source characteristics are tabulated in Appendix D.

10.7.3 Modelled domain

The CALPUFF modelled domain was 15 km by 15 km in size. It was a subset of the entire CALPUFF/CALMET domain and is shown in Appendix D.

A subset of the full set of identified sensitive receptors (Section 8) were included in the modelling so that time series responses could be easily extracted.

Gridded sampling receptors were spaced at 150 m intervals, a nesting factor of two (2).

10.7.4 Modelled sources

The CALPUFF modelling involved the modelling of the time period 15 July to 17 November only. During this period, all construction operations were modelled as occurring throughout a normal workday. This time period was selected based on the balance of probabilities that rip-rap placement outside of this period during any year would be unlikely due to dam (historic) water levels.

Activity type emissions were modelled as generating dust 13 hours per day as per expected operational hours.

Wind erosion type emissions were modelled as continuous. It was assumed that all dam construction zone areas emitted wind eroded dust (overnight) as the surface was assumed to be disturbed during that day. For stockpile areas, the 30 percent disturbance factor was applied, noting that not all areas of a large stockpile will be used every single day of operations.

Note that an 18-week single construction period has been modelled. This is conservative given that it is expected that the construction activities will be undertaken over numerous years in multiple blocks of about 3-weeks each. An alternative approach would have been to model rip-rap placement activities occurring all throughout the year, however, this would introduce the risk that the assessment and therefore rip-rap placement operations may be limited by meteorological conditions occurring between January and June when lake levels have been historically highest and therefore less likely that rip-rap placement operations on the dam would occur, i.e., the project becoming controlled by extreme or unusual conditions.

10.8 Potential dust concentrations

10.8.1 During construction operations

10.8.1.1 Trigger levels

The dust dispersion has been assessed against the MfE trigger levels for PM_{10} and TSP (Section 6.1.1). A contour plot of maximum one-hour averaged PM_{10} concentrations estimates with no controls are shown in Figure 16.

Tabulated values of TSP and PM_{10} against the trigger level values are provided in Appendix F.

None of the identified sensitive receptors are estimated to exceed the short-term trigger level concentrations for 5-minute and one-hour. However, the 24-hour TSP trigger level is exceeded at four identified receptors. Two of these receptors are irrelevant as one is the Salmon shop that is to be closed and another is an electrical transformer. Only the campsite receptors of R24 and R67 to the north of the left abutment work site have an exceedance estimated, with controls applied.

10.8.1.2 PM_{10} – 24-hour

A contour plot of the estimated maximum 24-hour averaged PM_{10} concentration with no controls applied is shown in Figure 17.

Tabulated receptor concentrations are provided in Appendix F.

Three receptors are estimated to exceed the PM_{10} 24-hour health-based criterion, with controls applied, however, two of these – being the Salmon shop and the electrical transformer are not relevant. The campsite toilet block receptor R24 is estimated to exceed the PM_{10} criteria – with background applied – by at least 50 percent with controls applied.

10.8.1.3 $PM_{2.5}$ – 24-hour

A contour plot of the estimated maximum 24-hour averaged $PM_{2.5}$ concentration with no controls is shown in Figure 18.

Tabulated receptor concentrations are provided in Appendix F.

Like PM_{10}, the campsite/toilet block receptor R24 is estimated to exceed the $PM_{2.5}$ 24-hour health criterion by at least 50 percent, with controls applied.

10.8.1.4 Annual averages

Assessing an annual average impact for construction zone operations that will run for likely 3-weeks per year and at most 18-weeks is not considered to be a valid assessment, or a valid criteria to assess against.

10.8.1.5 Tabulated results

A comprehensive list of results for all receptors has been provided in Appendix F with and without dust mitigation controls applied.

The campsite receptors immediately to the north of the left abutment work zone are likely to experience high dust levels even with controls applied. The exposure averaging period of most concern is 24 hours insofar as the TSP trigger levels for 5-minute and 1-hour and the 1-hour PM_{10} trigger levels are not exceeded. An exceedance of greater than 50 percent of the health-based criteria can be expected, even with dust mitigation controls applied.

All other relevant receptors are compliant with amenity and health-based criteria.

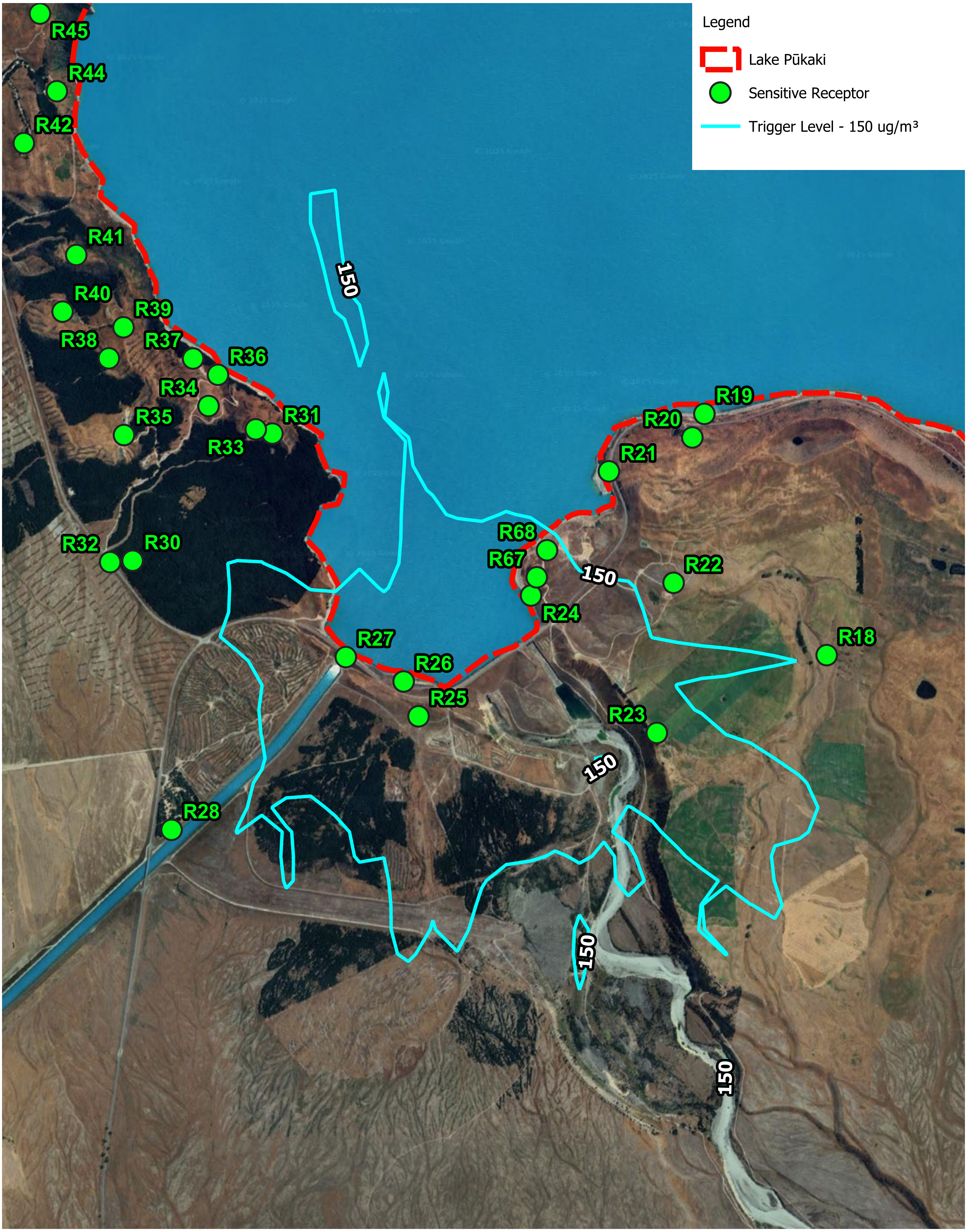
10.8.2 Cumulative shoreline passive dust

As identified in Section 5.7.2.1, there will be some wind eroded dust from newly exposed shoreline included in the dust from work zone activities. This wind erosion will originate from a small strip of shoreline, no wider than about

10 m but distributed around the entirety of the lake. Placing controls along a length of lake shore measured in kilometres is not feasible.

The Dust Management Plan (Appendix G) enables the cumulative impact of dust from the shoreline and construction activities to be minimised by reducing or modifying the work zone activities when high wind speed conditions are 1) forecast and 2) observed. Therefore, reduced work zone activities during high wind conditions should prevent cumulative impacts from becoming any higher than what has been estimated.

Note that in relation to the left abutment adjacent campsites, the work zones are not upwind of the prevailing northwest winds, therefore, any cumulative dust impacts should not result in any dust concentration at this receptor being higher than the current estimate (Appendix F).



Paper Size ISO A4

0 0.25 0.5 km

Map Projection: Universal Transverse Mercator
Horizontal Datum: WGS 84
Grid: UTM Zone 59 South

N

GHD

Meridian Energy
WPS Pūkaki FTC

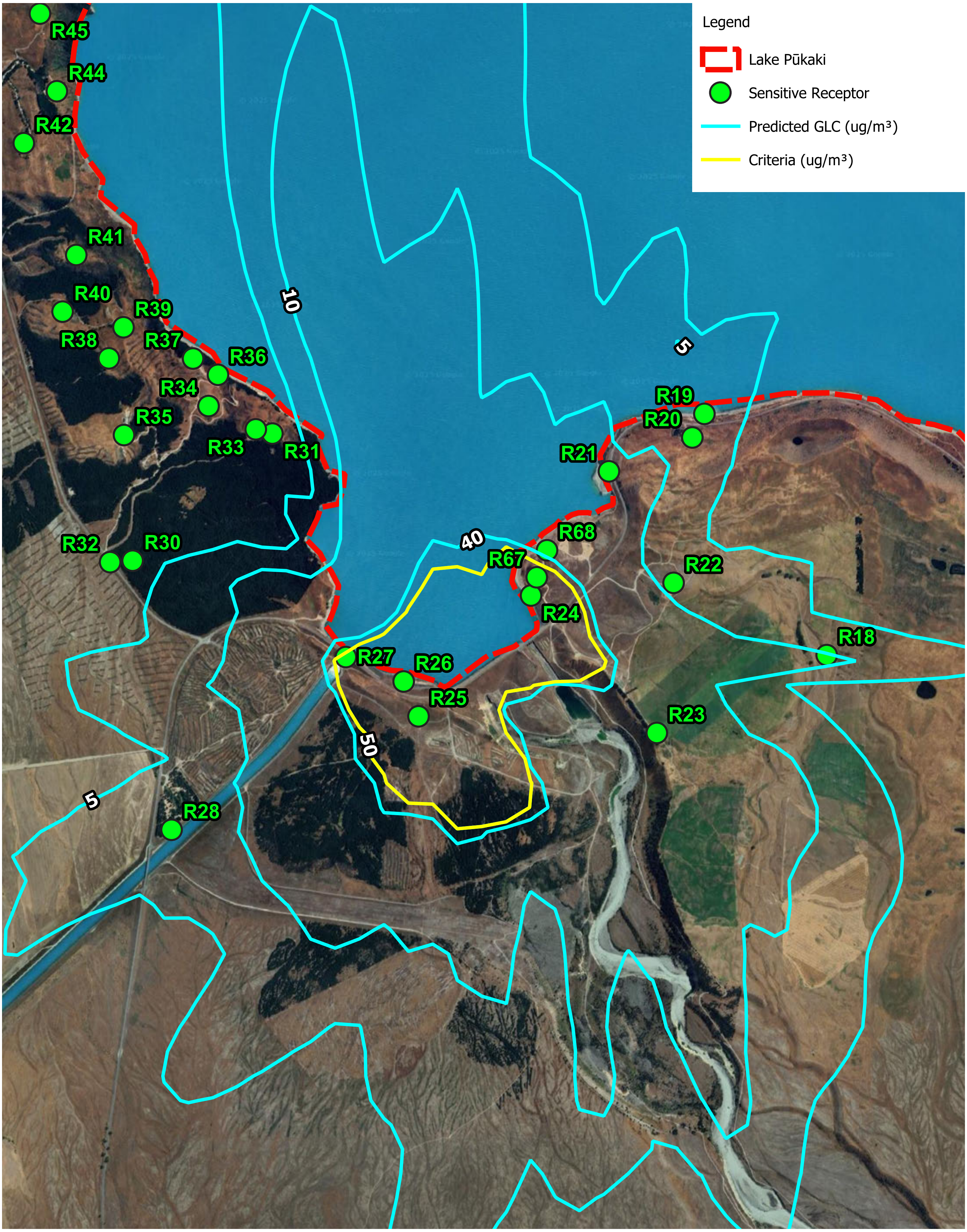
Construction operational dust as PM10. Trigger level of 150 ug/m³ (1-hour average) increment shown. Maximum value.

Project No.	**12656630**
Revision No.	B
Date	**24/10/2025**

FIGURE 16

Document Path: \\ghdnet\ghd\NZ\Christchurch\Projects\51\12656630\GIS\Maps\Working\Lake_Pukaki_James_D.qgz
Print Date: 24/10/2025

Data Source:Google Earth Imagery 2025.
Created By: rwilson3



Paper Size ISO A4

0 0.25 0.5 km

N

Map Projection: Universal Transverse Mercator
Horizontal Datum: WGS 84
Grid: UTM Zone 59 South

GHD

Meridian Energy
WPS Pūkaki FTC

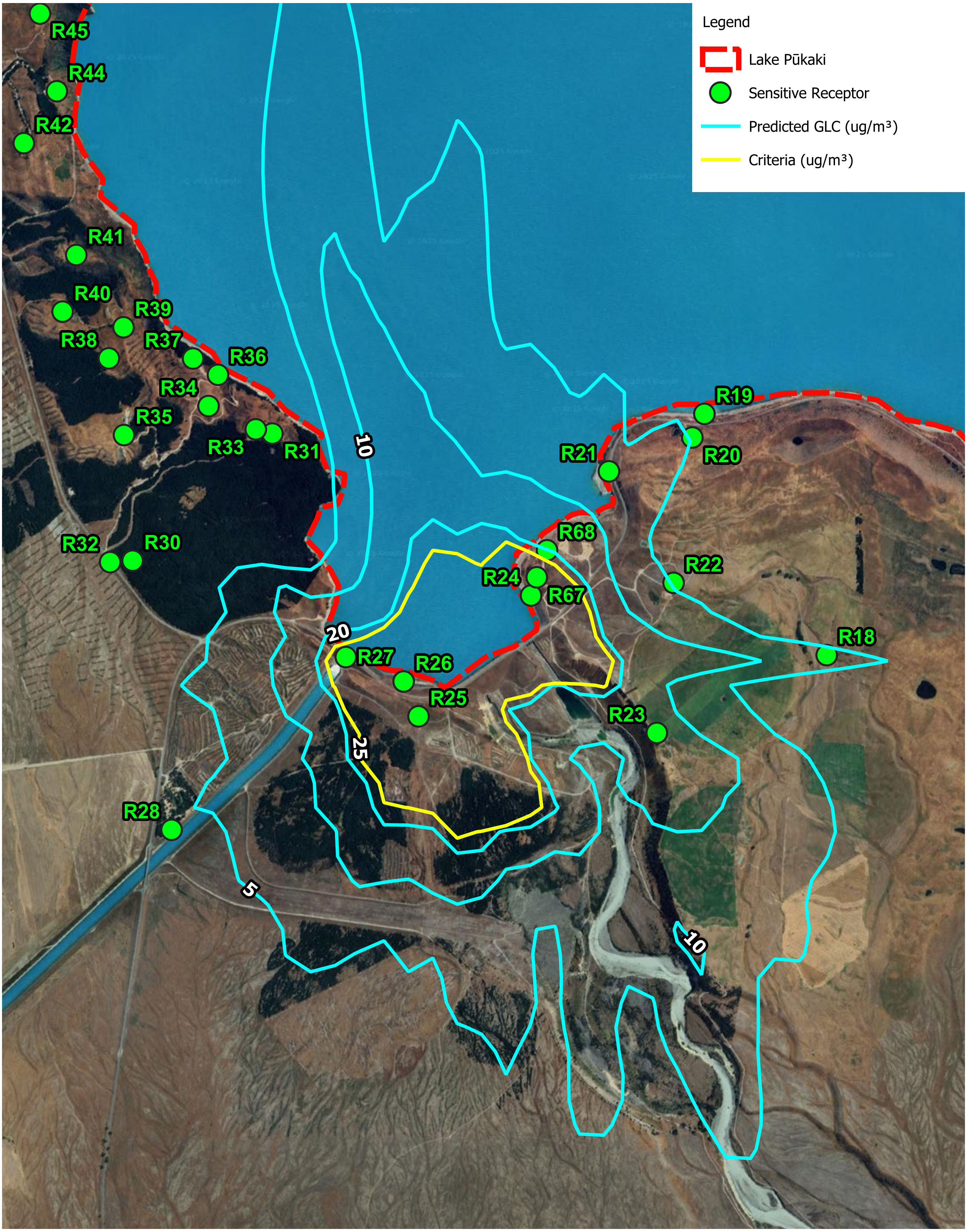
Construction operational dust as PM10. Maximum incremental 24-hour average

Project No. 12656630
Revision No. A
Date 24/10/2025

FIGURE 17

Document Path: \\ghdnet\ghd\NZ\Christchurch\Projects\51\12656630\GIS\Maps\Working\Lake_Pukaki_James_D.qgz
Print Date: 24/10/2025

Data Source:Google Earth Imagery 2025.
Created By: rwilson3



Paper Size ISO A4

0 0.25 0.5 km

Map Projection: Universal Transverse Mercator
Horizontal Datum: WGS 84
Grid: UTM Zone 59 South

N

GHD

Meridian Energy
WPS Pūkaki FTC

Construction operational dust as PM2.5. Maximum incremental 24-hour average.

Project No. 12656630
Revision No. A
Date 24/10/2025

FIGURE 18

Document Path: \\ghdnet\ghd\NZ\Christchurch\Projects\51\12656630\GIS\Maps\Working\Lake_Pukaki_James_D.qgz
Print Date: 24/10/2025

Data Source:Google Earth Imagery 2025.
Created By: rwilson3

11. Assessment of environmental effects

The assessment of environmental effects presented here focuses on the impacts of the proposed activity on air quality associated with the rock armouring of the high dam and abutments.

This report and the conclusions provided below is subject to, and must be read in conjunction with, the limitations and assumptions set out in section 1 and the assumptions and qualifications contained throughout the Report.

11.1 Air quality effects (rock armouring and associated activities)

The process undertaken to assess the potential effects on air quality associated with the proposed rock armouring works was based on the assessment criteria and methodology for assessing dust impacts in New Zealand (MfE, 2016) for health and amenity.

This report provides a detailed description of the processes for dust generation and suppression, the meteorological data that is relevant to the site, and identification of potential receptors and their likely sensitivity to dust in the vicinity of the proposed works.

The review of meteorological data using a multi-criteria analysis process was undertaken to identify a set of parameters to adopt in the modelling. The 2015 year was selected as it was assessed as more appropriate than other years for dust storm and wind erosion events and was used for the rock armouring works assessment to maintain consistency across studies.

The construction methodology and sequencing, as described in Section 10 and Appendix B, were used to inform the core model input assumptions. The model also included assumptions associated with the time of year when the works would occur. The assessment assumed that all construction works will operate for one 18-week period starting 15 July and finishing 17 November. In reality, this is a conservative assumption insofar as works could be undertaken in block times as short as 3-week over numerous years, as natural dam water level variation allows, but not as conservative if works were assumed for a whole year period at the same activity intensity. If rip-rap placement works were to occur for a short time outside of the modelled 18-week period, for example, within one to two weeks either side of the modelled period, the assessment results are likely to still be valid as general meteorological wind patterns are still going to be similar to those during the assessment period.

11.1.1 Short term potential impacts –Trigger levels

A Trigger Level assessment for amenity (TSP) and health (PM_{10}) was conducted. This assessment found that for short durations of 5-minute and one-hour, no exceedances were identified.

For the longer duration criterion of 24-hours, the TSP (amenity) level was exceeded at the closest campsite receptors immediately to the north of the left abutment work zone, even with dust mitigation controls applied.

These sensitive receptors are identified as:

- R24 –public toilet and lake viewing area
- R67 is an overnight freedom camping area.

The main concern is for those areas of public access in and around the works on the left abutment. Even with mitigation there remains the potential for disamenity to this public area.

11.1.2 Health impacts

Section 6 provides a description of the MfE guidelines for ambient air quality for PM_{10} and $PM_{2.5}$ over a 24-hour average period and an annual average.

With regards to health-related impacts of dust, only the camping area immediately to the north of the left abutment construction zone has been identified as potentially exceeding a health-based criteria for PM_{10} and $PM_{2.5}$ averaged over a 24-hour period. This elevated impact will only occur during construction activities even with mitigation measures adopted.

11.1.3 Amenity (deposited dust) impacts

The broader effects of dust generation on amenity values have not been quantified in this report in terms of a dust deposition rate. Generally, dust deposition is measured in durations of months. Thus, the potential short duration of any rip-rap placement works may not even be detectable if dust deposition monitoring was enacted.

11.2 Recommended mitigation measures

The assessment has included the application of mitigation/control measures, detailed in Appendix E with results discussed in Section 10.8.1 and tabulated results presented in Appendix F.

Management and mitigation measures and their intended use are provided in a draft Dust Management Plan, provided in Appendix G.

11.3 Summary

The overall impacts on air quality associated with the rock armouring works have been assessed using both qualitative (FIDOL) and quantitative modelling and applying reasonably conservative input assumptions, most notably a works duration six times longer than it may actually be in any 12-month period. The assessment has indicated that construction activity mitigation measures will significantly reduce offsite dust impacts for all areas surrounding the work zones except for the campsite locations immediately to the north of the left abutment work zone.

The assessment considers that these localised impacts can be mitigated and managed, either through exclusion, i.e., reducing access to the public, and via dust and works management measures, some of which are detailed in the attached Dust Management Plan (draft) (Appendix G). There may be a small residual impact on farm workers for Catherine Fields property, which can be reduced further with the implementation of a communications strategy, as outlined in the Dust Management Plan (draft).

The amenity value impacts, namely deposited dust, were not modelled in this assessment. However, the modelled impacts of dust concentration on air quality provide a good indication that the nuisance effects of dust from the works are likely to be largely contained to within the site area and in close proximity to the actual works, namely adjacent to the left abutment work zone. Hence, any amenity impacts are implicitly addressed when overall dust is minimised.

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Appendices

Appendix A

Curriculum vitae

GHD

Rebecca Wilson PHD

Senior Air Quality Consultant

Location

Brisbane, QLD

Experience

11 years

Qualifications/Accreditations

- Certified Air Quality Practitioner (CAQP), Clean Air Society of Australia/New Zealand, 2025
- PhD in Env Science and Atmospheric & Env Science, Macquarie & Edinburgh Universities, 2018
- Master of Science of Public Health in Env Sciences and Engineering, University of North Carolina-Chapel Hill, 2008
- Bachelor of Science in Meteorology, Texas A&M University, 2004

Key technical skills

- Atmospheric models: CALPUFF, AERMOD, TAPM, WRF, MLC-CHEM
- Programming languages: Python, SQL, R, FORTRAN

Memberships

- CASANZ: GHD is a member firm

Relevant experience summary

Dr Rebecca Wilson is an atmospheric chemist and meteorologist with a background in measuring, monitoring, and modelling of aerosols and other gaseous and particulate emissions to air. Her PhD research examined the emission of isoprene, a response to and protection from warming temperatures, from Australia's tropical forests. Her Masters research developed a method of dilute mixing of reactants in an outdoor smog chamber and applied it to a dark α-pinene-ozone system, with implications for human and environmental health.

Rebecca combines her atmospheric and meteorological training with scripting and data visualisation skills to understand and communicate climate risk and air quality issues for a range of Australian industries and organisations. She applies atmospheric dispersion models including CALMET/CALPUFF, AERMOD, and TAPM, with coding and spatial Geographic Information System (GIS) modelling to address and manage air quality for human and environmental health.

Project experience

Technical advice and guidance recommendations – Middle Arm Sustainable Development Precinct

Senior Consultant | Department of Logistics and Infrastructure | Darwin, NT

Rebecca provided a range of peer review and technical advice relating to air quality for the Middle Arm Sustainable Development Precinct (MASDP).The project included several elements: technical advice regarding the suitability of the MASDP Air Quality Model, recommendations for the location of a Precinct air quality monitoring station and periodic monitoring, and guidance documentation for the approach to establishing air quality targets for the Precinct in the context of the larger Darwin airshed.

Risk Assessment of Extreme Meteorological Events

Senior Consultant | Confidential – Defence | Australia

Conducted an assessment to determine the frequency of extreme meteorological events (high straight line winds, severe storms, cyclones, dust storms and precipitation events) and relative risk of such events to a defence site. The study used publicly available data and historical records from the Bureau of Meteorology and the study methodology followed an international safety standard suitable for use at the site.

Air Quality Assessment – Renewable Energy

Senior Consultant | Confidential | Gladstone Region, QLD

Conducted an air quality assessment for a first-of-its-kind renewable energy facility in the Gladstone region of Queensland. Emergency and routine flare modelling was undertaken as part of this work. This assessment required additional support in the form of an academic literature review to assist the client and regulatory professionals with understanding the potential implications of the proposed activities.

Operation Expansion - Granite Quarry

Technical Lead | Joyful View | Cherrabah, QLD

Rebecca led an air quality impact assessment for a proposed expansion of a previously approved but not constructed granite quarry using the CALPUFF dispersion model. Predicted dust deposition was modelled and the potential impacts of Respirable Crystalline Silica (RCS) were considered. This assessment was undertaken as part of a larger Environmental Impact Statement (EIS).

Proposed Coal Seam Gas (CSG) Project

Senior Consultant | Epic Environmental and Comet Ridge Mahalo North | Emerald, QLD

Rebecca led an air quality assessment for a proposed CSG Project in the Bowen Basin. The Project comprises up to 68 wells (34 lateral, 34 vertical), gas gathering lines, a petroleum pipeline, and a gas compression facility. Dispersion modelling was undertaken using CALPUFF and ground-level concentrations of NOx and CO were determined at nearby sensitive receptors and across a Cartesian grid of the region. This project formed part of an application for Environmental Authority (EA).

Proposed LNG compressor stations

Senior Consultant | APA | Tibooburra, NSW

Rebecca conducted an air quality assessment of a proposed series of compressor stations using the CALPUFF dispersion model. Predicted concentrations were used to ensure that the neighbouring and on-site work camps were located appropriately within the project site. The work further contributed to a larger EIS of the proposed work.

Air Quality Management Plan – Mount Morgan Mine

Technical Lead | Heritage Minerals | Mount Morgan, QLD

Rebecca reviewed planned operations at the historic Mount Morgan Mine and drafted an Air Quality Management Plan to support operations and minimise impacts to the surrounding community. The plan included activities to be maintain compliance with the air quality-related conditions of the site's Environmental Authority (EA), identified activities that were likely to produce atmospheric emissions, and provided employees and contractors with clear roles and responsibilities in relation to air quality management. A monitoring plan and advice for continuous improvement was also included in the plan. This project contributed to an EA Amendment for the client.

Dust Assessment – Landfill

Senior Consultant | Liverpool Plains Shire Council | Willow Tree, NSW

Rebecca undertook an air quality assessment to consider the impacts of a planned expansion of an existing landfill. In this project, CALPUFF was used to undertake a risk-based assessment of dust and odour on nearby receptors throughout both the construction and operational phases. This assessment formed part of the larger EIS work undertaken by GHD for the client.

Air Quality Advice and CFD modelling

Senior Consultant | Valmont Coatings | Carole Park, QLD

Rebecca conducted a records review of stack maintenance and site visit for a zinc galvanizing facility as part of a larger body of work to locate and identify sources contributing to groundwater contamination. A computational fluid dynamics study was further undertaken to test the hypothesis and role of roof condensation as a potential source

Remediation of Waitakere Landfill

Senior Consultant | Auckland Council | Auckland, New Zealand

Rebecca undertook an air quality assessment that considered the impact of remediation works on a landfill near sensitive areas in a regional area outside Auckland, New Zealand. In this assessment, particular care was taken to work with the design engineering team to ensure that the proposed remediation plan minimised impacts to nearby residential areas. Care was also taken to ensure that the proposed remediation would have the least impact on the climate compared to alternative methods.

Mine Expansion Project

Lead | Bowen Basin Coal | Moranbah, QLD

An air quality assessment was undertaken to assess a proposed expansion of Lake Vermont mine. The proposed expansion is to develop an underground mining project and a satellite open-cut mine. CALPUFF software was used to model particulate dust impacts of the proposed project. Predicted concentrations were paired with modelled outputs from existing mine operations and locally relevant background monitoring data to form a cumulative impact assessment of the proposed project.

Haul Road Investigation

Lead | Epic Environmental and Glencore | Western QLD

Lead the air quality modelling to quantify heavy metal deposition and accumulation due to haulage activities along the road connecting Mt. Isa Mine and George Fisher Mine in western Queensland. Soil sampling indicated elevated soil concentrations of heavy metals in proximity to the road, which, left untreated, may contaminate nearby waterways and be ingested by grazing livestock. Atmospheric dispersion models were used to identify locations most likely to be affected by haulage activities and estimate a schedule for commencing soil monitoring and remediation.

Bimonthly, Quarterly and Annual Reporting

Senior Consultant | Port Hedland Industries Council | Port Hedland, WA

Conducted regular analysis and reporting of air quality conditions in Port Hedland. Analysis was undertaken using custom R scripts. The reporting included monitoring data capture rates, calculation of 24-hour averages and exceedance analysis to determine if exceedances were due to industrial activities or larger regional events. A meteorological discussion was also included in the reports to provide context and a basis for any dust events that may have occurred in the reporting period.

Data Centre Expansion

Senior Consultant | iSeek | Eagle Farm, QLD

An air quality assessment was undertaken for an expansion of an existing data centre located near Brisbane Airport. Atmospheric dispersion modelling was undertaken using AERMOD, and built upon previously undertaken research to determine the safest emissions protocols, given the CASA requirements for the site.

Proposed Data Centre

Air Quality Scientist | AirTrunk | Blacktown, NSW

An air quality assessment was undertaken for a proposed large data centre near Blacktown, NSW. Atmospheric dispersion modelling was undertaken for normal operations, a variety of backup generator testing regimes, and emergency conditions. Consideration was required for the staging of installation of pollution control technology throughout the Project’s staged development and its evolving testing regime.

Review of Net Zero Business Cases

Senior Consultant | NSW Department of Environment, Climate Change and Water | Sydney, NSW

Rebecca conducted a global review of the methodologies used to calculate the cost of air pollution and the benefits of Net Zero policies. The review included methodologies derived in New Zealand, the United States, Canada, the United Kingdom, and the European Union. The survey considered the pollutants included, health endpoints, and various methods of determining cost, both to the individual and larger society. From this survey, she determined which approaches form best practices for calculating costs and worked with DECCW to form connections with other departments and lay the groundwork to develop an approach suitable for use in New South Wales.

Proposed Residential Development

Lead | Gorman Property Group | Ipswich, QLD

An air quality assessment was undertaken for a proposed residential subdivision located adjacent to a historic neighbourhood and a cleared area which had formerly been quarried and carried a current mining lease. CALPUFF software was used to model particulate matter impacts of both the proposed and the historic residential developments should quarrying re-commence, and a relative risk assessment was undertaken to characterise the potential exposure risk of each development.

Technical Advice of Odour at LMWQCC

Technical Lead | Icon Water | Ginninderry, ACT

Rebecca provided technical advice and undertook a peer review of modelling and monitoring works of a wastewater treatment plant outside Canberra prepared by a 3rd party. The outcomes of the review process highlighted areas of improvement for the 3rd party and helped Icon Water identify areas where their odour control efforts would be the most impactful.

Climate Risk Assessment for Space Launch Facility

Senior Consultant | Equatorial Launch Australia | Arnhem Land, NT

Rebecca assisted Equatorial Launch Australia (ELA) with a climate risk assessment for their rocket launch facility in Arnhem Land, Northern Territory. The assessment considered current and future temperature, rainfall, wind patterns, storms, and forest fire danger impact (FFDI) days, with particular attention to the impacts of these elements on the health and safety of employees, clients, and the nearby Aboriginal community, and the operational impacts on the company. In addition, Rebecca developed four future climate scenarios for consideration by the client. Scenarios were selected based on their likelihood of occurrence and severity of health and/or operational impacts. The scenarios were used to assist ELA with the development of their safety protocols and emergency response plans.

Nationwide Climate Risk Assessment for Equipment Hire Facilities

Senior Consultant | Seven Group Holdings | Various

A physical climate risk assessment was undertaken to assist Seven Group Holdings with their Task Force on Climate-related Financial Disclosures (TCFD) reporting. The assessment, conducted for 200+ Coates and WestTrac sites across the country, considered temperature, extreme rainfall, sea level rise, forest fire danger index (FFDI).

Air Quality Assessments – Brisbane City Council

Senior Consultant | Various clients | Brisbane region

The list below comprises a selection of air quality assessments undertaken for various clients proposing developments within Brisbane City Council.

- Service station | Citimark Properties | Kedron
- Data centre | Smart Capital Property & Investment | Tenerife
- VJ manufacturing | Easycraft | Wynnum West
- AQ Traffic Assessment – Proposed residential | confidential | Sandgate
- AQ Traffic Assessment – Proposed residential | City Developments Limited | Toowong
- Service station | McAndrew Property Group | Bridgeman Downs
- Childcare centre | Explorers Early Learning | Cannon Hill
- Blast Shed | confidential | Carole Park
- Residential development | Steffan Town Planning | Kedron
- Pilot Pyrolysis Plant | confidential | Rocklea
- Microbrewery | West End Craft Brewery | West End
- Aquamation facility (cremation) | Pure Souls | Virginia, QLD
- Smallgoods manufacturing | confidential | Coopers Plains

Air Quality Assessments – beyond Brisbane

Consultant | Various clients | Various locations

The list below comprises a selection of air quality assessments undertaken for various clients proposing developments elsewhere in Australia and beyond.

- Spray booth | confidential | Ipswich, QLD
- Concrete batching plant | Holcim | Lithgow, NSW
- Proposed generator | Newcrest | Lihir Island
- Burnie Chip Loading Facility | TasPorts | Burnie, TAS
- Proposed chicken farm | Coominya Chooks | Coominya, QLD

Career history

2023 - present	GHD, Senior Air Quality Consultant
2021 - 2023	Katestone Environmental, Senior Air Quality Consultant
2019 - 2021	Trinity Consultants Australia/Air Noise Environment, Environmental Consultant

Appendix B

Construction methodology

The construction methodology summarised below has been taken from GHD Report Lake Pūkaki Reservoir Hydro Storage and Dam Resilience Works Pūkaki Dam Rip-Rap Design and Construction Methodology (Document No. 12656630-GHD-Pukaki Dam Resilience Works-RPT-GE-00001-S0-REV01-251030.docx, 31 October 2025), Section 9.

Programme

If the rip-rap placement programme is completed in a single stage, the estimated duration is up to 18 weeks. However, Meridian have informed GHD and potential constructors that it is unlikely the lake level will be maintained below 518 m RL for an extended period allowing all works to be completed in one continuous phase.

Additionally, the lowest lake level achieved during any event is more likely to be nearer to 518 m than 513 m RL.

The construction methodology is based on the following programme.

- Construction activities may be short in duration (a few weeks) and occur over multiple stages.
- It may take multiple years to complete all the required works.
- Access is expected to be more frequent at higher lake levels within the 518 m to 513 m range, rather than at the lower end.
- The assumed approach is for rip-rap placement in a multi-stage process with rip-rap being placed when lake levels allow.
- Forecasting lake levels within a period of a few weeks is generally achievable based on predicted generation flows from the lake, predicted inflows, and predicted rainfall events in a 1-to-2-week window.
  - Based on this data, guidance can be provided to a contractor as to when lake levels are likely to reach required levels for construction to commence and how long they are likely to stay low in the short to medium term.
- Given the time required to mobilise and demobilise from the site, contractor guidance indicates that the minimum duration for any construction stage is 3 weeks.
- Inflow events, whether predicted or not, can result in a relatively rapid rise in lake level. Historical data indicates that the lake can rise up to 1 m in one day and 3 m in one week. Therefore, the construction sequence must include contingency plans for rapid site demobilisation, ensuring the site is left in a safe and environmentally appropriate condition prior to water inundating the works area.
- Historical data indicates that low lake levels at Lake Pūkaki most frequently occur during mid to late winter and early spring.
- Construction activities will be restricted to the following schedule:
  - Daily: 6:00 a.m to 7:30 p.m.
  - No work during the following periods:
    - Good Friday to Easter Monday (inclusive)
    - 24, 25 and 26 December (inclusive) and 31 December to 1 January (inclusive)
    - New Zealand Public Holidays

Modelled construction operations

Within the limits of the modelling methodology and its assumptions, and to enable statistical representative results to be determined, the construction dust modelling has assumed the following:

- Construction commences 15 July of the modelled year.
- Construction is completed 17 November of the modelled year.
  - An 18-week construction duration period.
  - A continuous period is modelled as the exact 3-week window of actual construction activities will take place cannot be established with any further precision.

- Enables greatest capture of statistically representative wind patterns during construction activities, i.e., a particular high wind event will not be missed due to its occurrence one day outside of a 3-week activity period.

– Daily construction activities commence at 6 am and stop at 7 pm
  - Hour ending 7 am to hour ending 7 pm
  - 13 hours per day.

General work zones and approach to construction

Rip-rap

The rip-rap placement works are to be divided into three primary work zones, as shown in Figure B.1.

– Right abutment

– Left abutment

– Main Dam

It is proposed that the rip-rap will be installed during two sequential tranches, defined by dam elevation ranges.

– Tranche 1 Is
  - Main dam – from 518.6 m to 514.5 m RL.
  - Abutments – from 517.3 m to 513.0 m RL.

– Tranche 2
  - Main dam – from 514.5 m to 509.6 m RL.
  - Abutments – from 513.0 m to 510.5 m RL.

Rip-rap placement for Tranche 2 will only commence once Tranche 1 is fully completed.

Each tranche will be implemented ***concurrently*** across all three work zones.

It is likely that each tranche will be constructed in multiple stages, depending on lake level conditions and site accessibility.

Modelling of rip-rap placement

Given that the modelling approach has assumed a single 18-week construction period, the construction dust assessment has assumed that all three primary work zones are concurrently operational for the whole of the 18-week period.

Figure B.1 Work zones

Site security during construction

During construction, site security will be maintained through the installation of temporary fencing and controlled access measures.

Temporary fencing will be erected to prevent public access to the designated work area. The proposed fencing layout is shown on Figure B.2 and Figure B.3.

To ensure safety and minimise public interference, access to the existing carpark will be closed for the full duration of construction. The installation of the fencing and access control is expected to require approximately two days to complete.

Dust modelling

Dust generated from fence construction is expected to be almost negligible and has therefore been excluded from this assessment.

Figure B.2 *Dam and right abutment - security fencing, closed access, access ramps and temporary buildings*

Figure B.3 *Left abutment - security fencing, closed access and access ramp*

On-Site facilities

Temporary offices and work room facilities/ablutions will be established on site for the duration of each construction event. The proposed locations are shown on Figure B.2 and Figure B.3.

Construction access

Access to the right abutment and Main Dam will be established via the main carpark site entrance (see Figure B.2). Dedicated access ramps will be established using an excavator as required, followed by the placement of granular material to infill voids. This process will create a stable running surface suitable for road truck movement.

Access to the left abutment will be provided via the existing unsealed road (see Figure B.3).

The constructed access ramps are expected to be partially inundated between the construction activities and as lake levels rise. The ramps will remain in place between construction events. Prior to site demobilisation, sections of ramps vulnerable to wave action will be backfilled with rip-rap materials specified in this project to enhance durability and reduce erosion risk.

Minor reinstatement works may be required for each ramp prior to each construction event to restore access affected by wave action.

The expected duration for the initial ramp construction is 10 days.

Dust modelling of construction ramps

Ramp construction is included in the modelled 18-week construction period.

Modelling of ramp reinstatement works is not required.

Rock supply and stockpile management

Rock material has been previously harvested and stockpiled near the site. The locations of the existing stockpiles are shown on Figure B.4.

At present, approximately 23,000 tonnes of rock is available, which is sufficient to complete the proposed works across all three work zones down to 514 m RL.

As the existing stockpiles are depleted, additional rock will be brought to site from existing quarries within the region. An additional 50,000 tonnes of rock will be required to support lake operation to 513 m RL, which includes rip-rap placement to 510.5 m RL plus rip-rap bedding.

Prior to the commencement of active construction, rock will be transported by road trucks to two designated stockpile areas as shown in Figure B.4:

– Pūkaki Dam stockpile area at the existing carpark
– Upstream stockpile area on the left abutments

Both stockpile areas shall be managed by a 20-tonne excavator, responsible for directing the stockpiling of different sizes of rock within the stockpile zones. This excavator will also be used to load the rip-rap onto road trucks for delivery to active work areas for final placement.

Figure B.4 Stockpile locations

Construction sequencing

Full details of the construction sequencing can be found in GHD Report Dam Protection Works (Document No. 12656630-GHD-Pūkaki Dam Resilience Works-RPT-GE-00001-S0-P01-250808, 15 August 2025, Section 9). A summary of pertinent details is provided here.

Tranche 1 – Main dam

An existing construction bench, approximately 11 m wide, exists along the Main Dam at 517.3 m RL. The bench is currently covered with approximately 1.2 m thick material, which must be removed to allow access. Machinery access will begin once lake levels reach 517.9 m RL or lower, as the proposed earthmoving equipment is capable of operating in up to 600 mm depth of water (refer to Figure B.5).

An approximately 5 m wide strip along the outer edge of the track will be stripped of existing material using a 45-tonne excavator. Material meeting the specified grade for rip-rap will be stockpiled upslope to be re-used. Excavated material not to be used as rip-rap will be transported and disposed of at an approved off-site disposal facility. This material will either be taken from under the water level or will be sufficiently moist/wet to prevent dust emissions.

Construction of the key toe installation[4] and rip-rap placement will proceed in 40 m wide sections, from the true left end of the Main Dam, progressing back toward the access track to minimise exposure to wave action. Placement of this rip-rap will be underwater. No dust emissions are expected as works are expected to be below water.

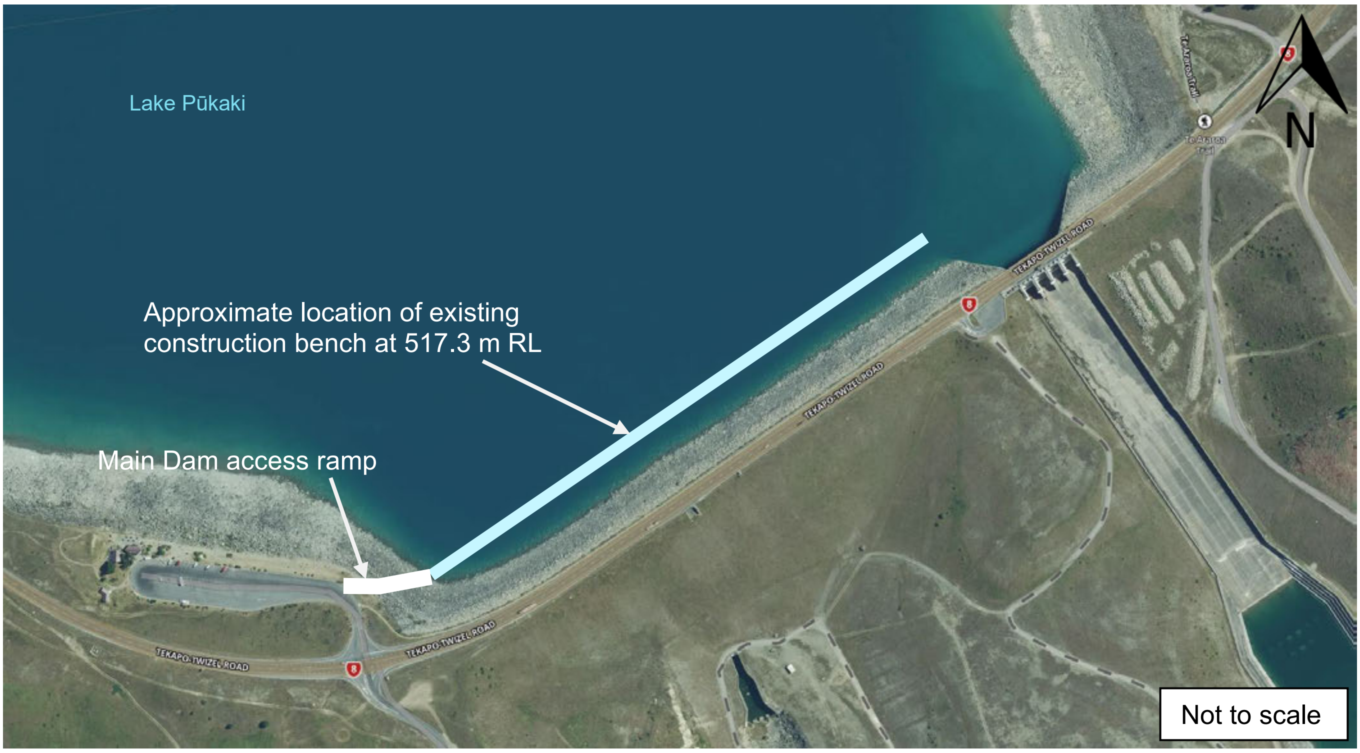


Figure B.5 *Site plan (Main Dam) and indicative 517.3 m RL construction bench*

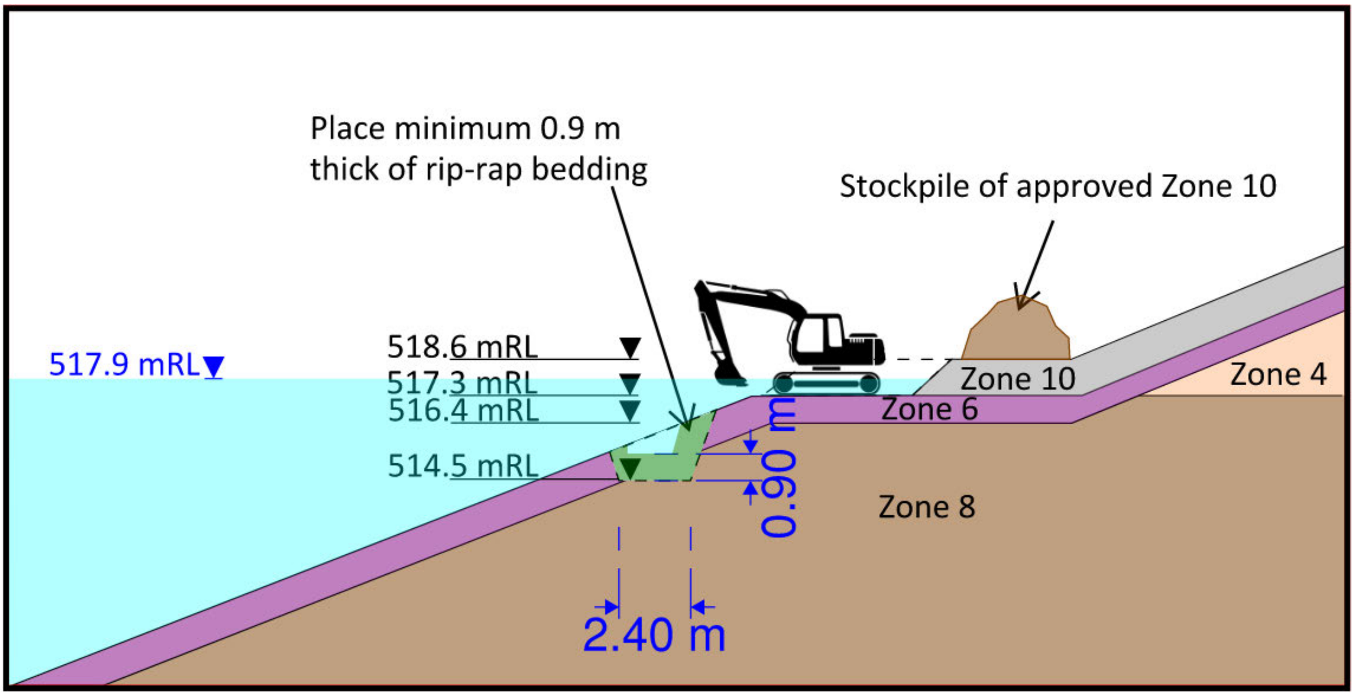


Figure B.6 *Schematic sketch – Tranche 1 – Main Dam – construction of key toe at 514.5 m RL and installation of rip-rap bedding*

[4] A dam wall structure under the water level to assist with dam structural integrity.

Tranche 1 – Abutments

It is assumed that Tranche 1 construction for the left and right abutments will be undertaken concurrently with the Main Dam Tranche 1 construction. Construction areas are depicted in Figure B.7.

The method of construction is similar to that of the main dam:

– Removal of material from potentially under the water level
– Stockpiling of acceptable grade material for rip-rap re-use
– Offsite removal of material not of acceptable grade
– Placement of new rip-rap material under the water level.

A process schematic is shown in Figure B.8.

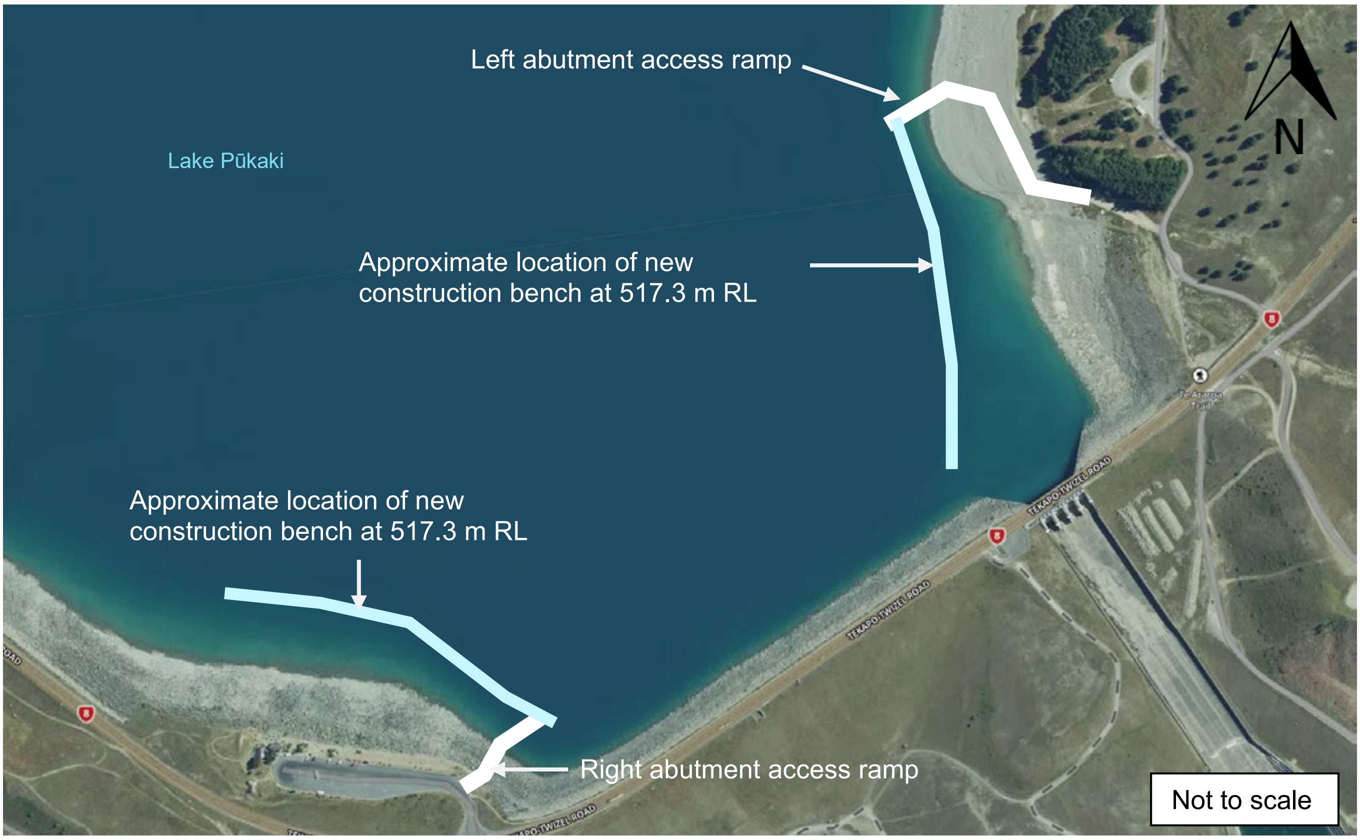


Figure B.7 Site plan (abutments) and indicative 517.3 m RL construction bench

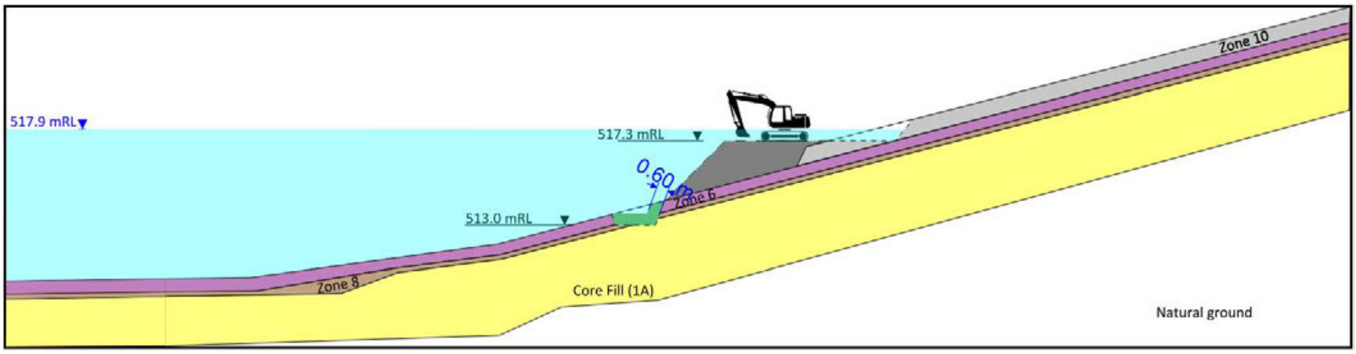


Figure B.8 Schematic sketch – Tranche 1 – abutments - construction of key toe at 513.0 m RL and installation of rip-rap bedding

Tranche 2 – Main dam

Tranche 2 construction will only commence following the completion of Tranche 1.

The primary objective of Tranche 2 construction at the Main Dam is to establish a key toe at 509.6 m RL to facilitate the placement of rip-rap along the targeted upstream face. The wok site and method schematic are shown in Figure B.9 and Figure B.10.

Work will be undertaken using a long-reach 45-tonne excavator. Removed material from beneath the water level will be stockpiled and sorted upslope. Material deemed satisfactory for rip-rap use will be retained while other material will be removed and sent to an appropriate disposal site. Additional rip-rap material will be trucked to site from the nearby stockpiles and placed on the upstream face.

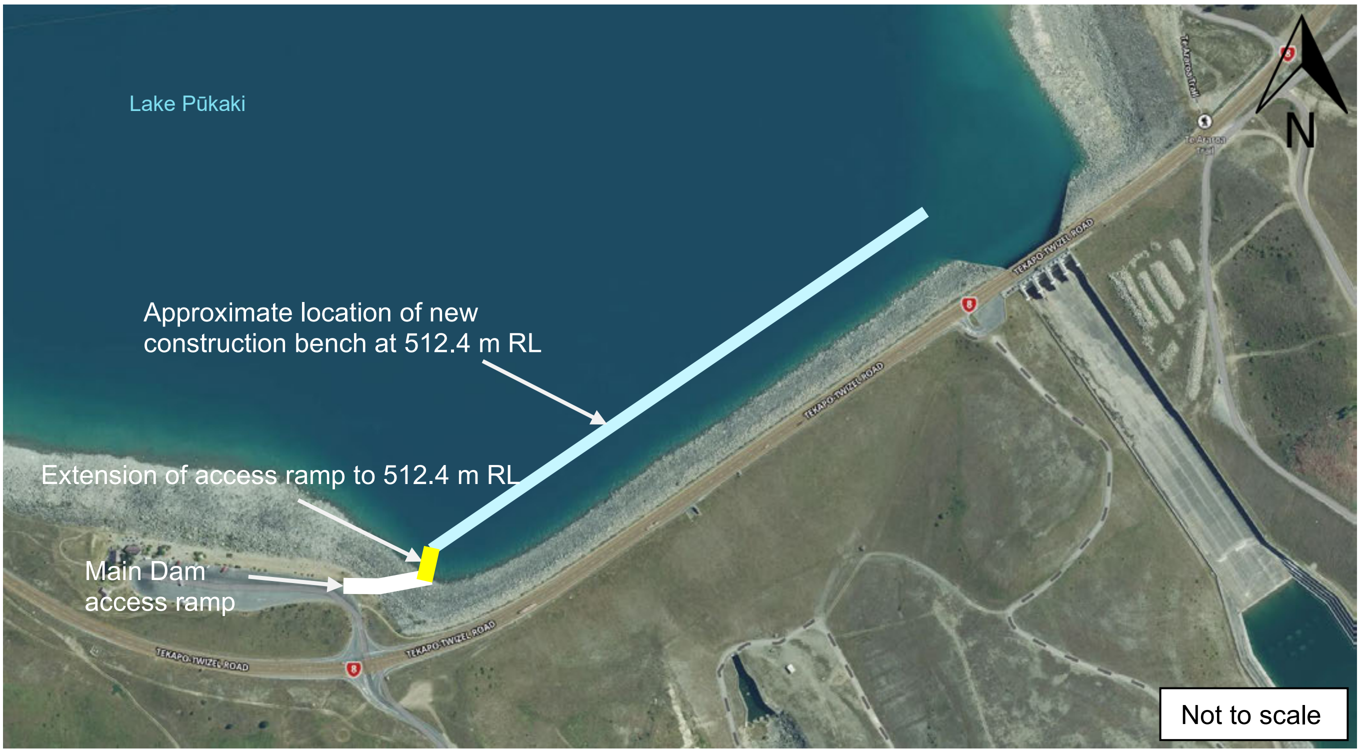


Figure B.9 ***Site plan (Main Dam) and indicative 512.4 m RL construction bench***

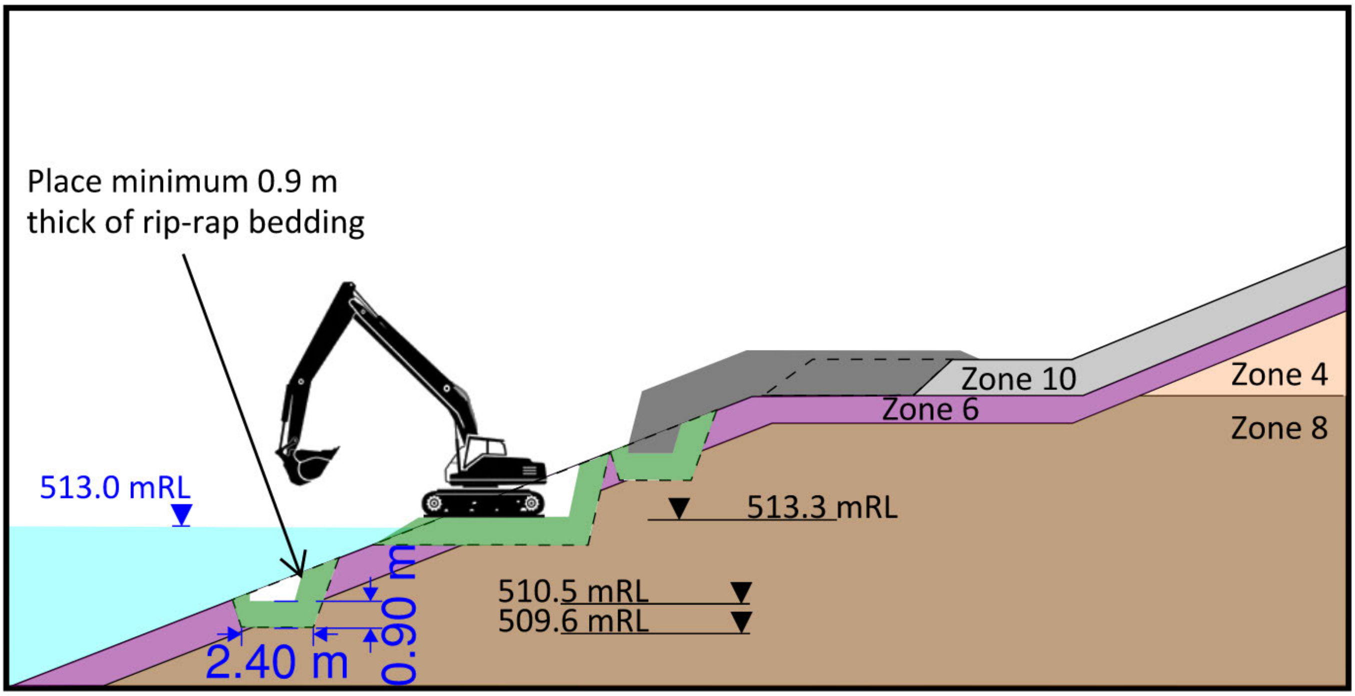


Figure B.10 ***Schematic sketch – Tranche 2 – Main Dam – construction of key toe and installation of rip-rap bedding***

Tranche 2 – Abutments

Tranche 2 construction will only commence following the completion of Tranche 1.

The primary objective of Tranche 2 construction at the abutments is to install a minimum of 1.5 m of rip-rap at 510.5 m RL. The work site and method schematic are shown in Figure B.11, Figure B.12, and Figure B.13.

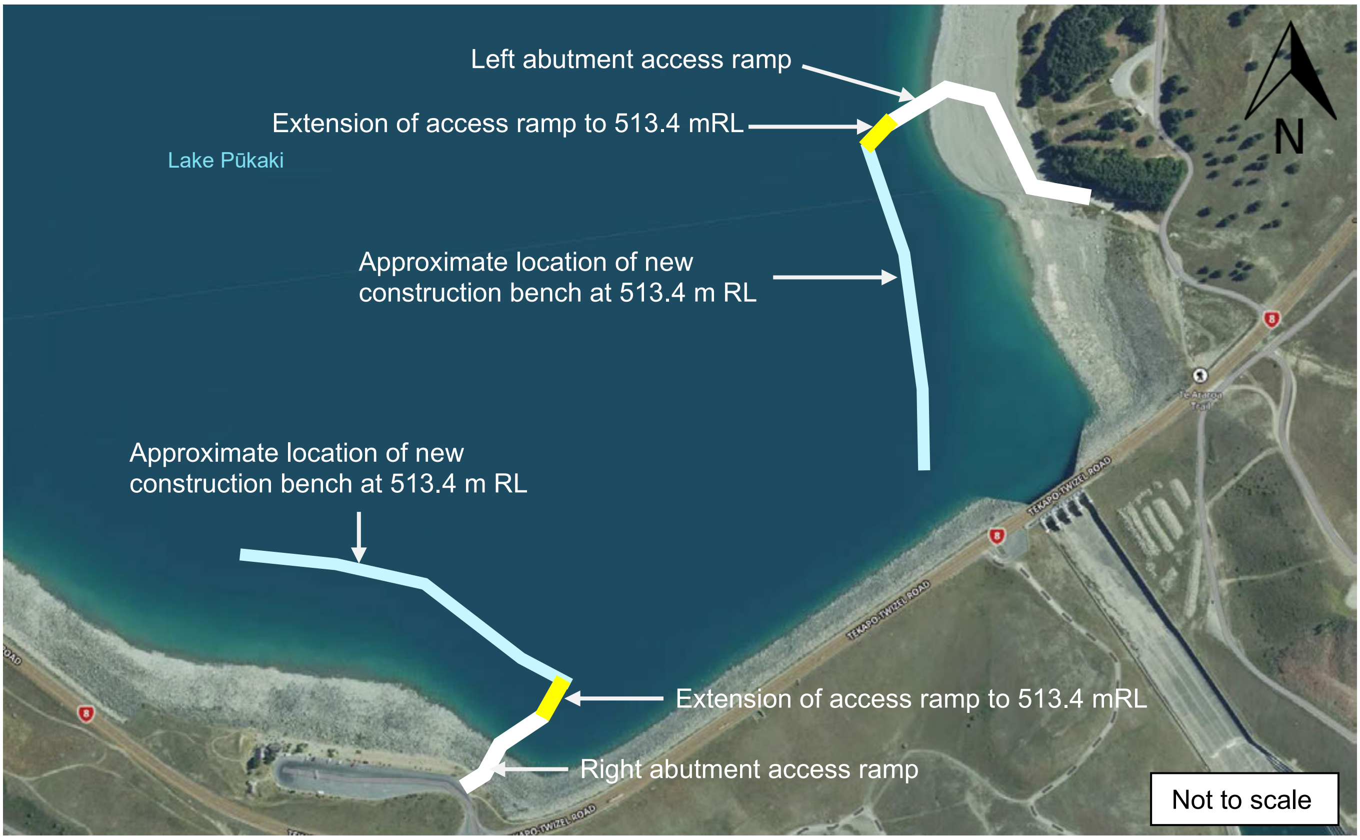


Figure B.11 ***Site plan (abutments) and indicative 513.4 m RL construction bench***

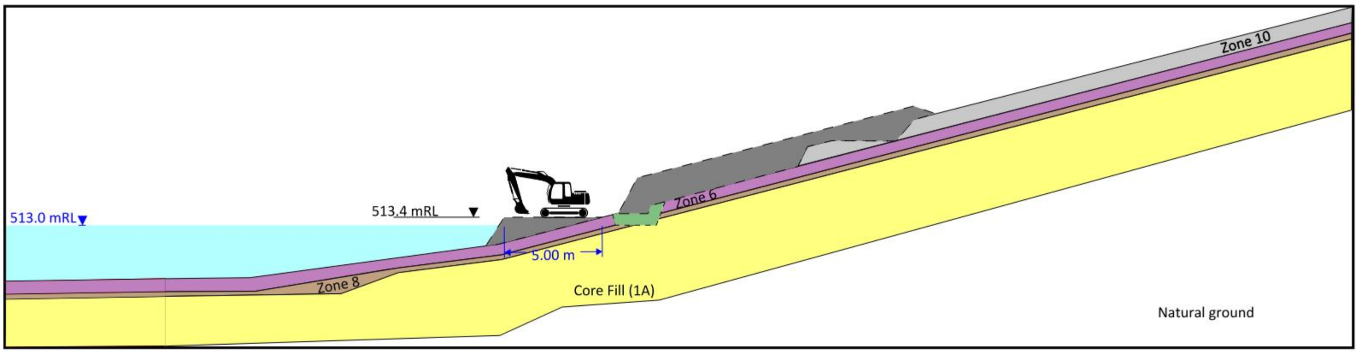


Figure B.12 *Schematic sketch – Tranche 2 – abutments – establishment of construction bench at 513.4 m RL*

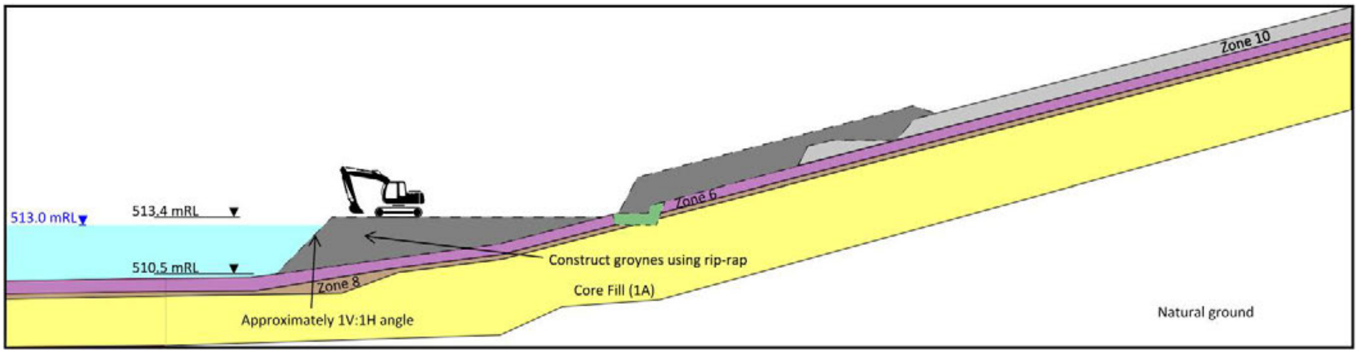


Figure B.13 *Schematic sketch – Tranche 2 – abutments – construction of groynes*

Appendix C

Dust emissions inventory estimates

Emissions during construction at construction site

Table C.1 General parameters

Item	Value	Units (and notes)
Haul road silt =	23	% - 10% is NPI default. Using a value that equals the $PM_{2.5}$ fraction
PM_{10} : TSP ratio =	0.57	Assumed equal to sediments of lake
$PM_{2.5}$: TSP ratio =	0.23	Assumed equal to sediments of lake

Table C.2 Construction activity information

Item	Value	Units (and notes)
Construction duration	18	weeks
Days per week	6	
Construction days	108	days
Construction hours per day	13	hours per day
Total construction hours	1404	hours
Rip-rap material total	73000	tonne for placement on dam upstream wall
Rip-rap average placement rate	52.0	tonne per hour
High dam rip-rap placement	17.33	tonne per hour - Assume even amount of material.
Left abutment rip-rap placement	17.33	tonne per hour
Right abutment rip-rap placement	17.33	tonne per hour
Rip-rap moved from primary stockpile to Sec stockpile 1 (high dam and right abutment)	34.66	tonne per hour.
Rip-rap moved from primary stockpile to Sec stockpile 2 (left abutment)	17.33	tonne per hour
Loading trucks at Primary stockpile 1 (high dam)	34.66	tonne per hour
Loading trucks at Primary stockpile 2 (left abutment)	17.33	tonne per hour
Unloading trucks at Secondary SP 1	34.66	tonne per hour
Unloading trucks at Secondary SP 2	17.33	tonne per hour
Truck capacity between primary and secondary SP	11	tonne
Number of loaded truck movements to secondary SP 1	3.15	trucks per hour
Number of loaded truck movements to secondary SP 2	1.58	trucks per hour
Distance from primary SP 1 to secondary SP 1	1	km
Distance from primary SP 2 to secondary SP 2	0.3	km
Single trip VKT primary SP 1 to secondary SP1	3.15	VKT/hr
Single trip VKT primary SP 2 to secondary SP2	0.47	VKT/hr
Empty 11-tonne haul truck mass	6	tonne
Full 11-tonne haul truck mass	17	tonne

Table C.3 Construction activity emission factors – uncontrolled

Emission factors	TSP	PM_{10}	$PM_{2.5}$	Source
Loading material - excavator [kg/tonne]	0.025	0.014	0.0033	From NPI Mining 2012, App. A 1.1.2 on overburden - Default value. App A 1.2.2 has been considered.
Truck dumping material [kg/tonne]	0.012	0.0068	0.0016	From NPI Mining 2012, App. A 1.1.6 on overburden - Default value. App A 1.2.2 has been considered.
Loaded truck movement between stockpiles [kg/VKT]	4.75	1.66	1.09	From NPI Mining 2012, App. A 1.1.11
Empty truck movement between stockpiles [kg/VKT]	2.97	1.04	0.68	From NPI Mining 2012, App. A 1.1.11

Table C.4 Construction activity emissions – uncontrolled

Emissions	TSP (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)
Loading material at primary stockpile 1	0.867	0.490	0.113
Loading material at primary stockpile 2	0.433	0.245	0.056
Dumping material at high dam	0.208	0.118	0.027
Dumping material at right abutment	0.208	0.118	0.027
Dumping material at left abutment	0.208	0.118	0.027
Placing rip-rap at high dam	0.433	0.245	0.056
Placing rip-rap at right abutment	0.433	0.245	0.056
Placing rip-rap at left abutment	0.433	0.245	0.056
Loaded truck haulage to high dam	14.98	5.22	3.45
Empty truck haulage from high dam	9.37	3.27	2.16
Loaded truck haulage to left abutment	2.25	0.78	0.52
Empty truck haulage from left abutment	1.41	0.49	0.32
TOTAL	**31.230**	**11.588**	**6.861**

Table C.5 Modelled construction source emission rates – uncontrolled

Emission source	TSP (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)
Primary stockpile 1	6.95	2.61	1.51
Primary stockpile 2	1.65	0.67	0.34
High Dam	6.73	2.49	1.48
Right abutment	6.73	2.49	1.48
Left abutment	1.86	0.79	0.36
Haul road 1	6.09	2.12	1.40
Haul road 2	1.22	0.42	0.28
TOTAL	**31.23**	**11.59**	**6.86**
Wind erosion High Dam	0.70	0.35	0.16
Wind erosion right abutment	0.82	0.41	0.19
Wind erosion left abutment	1.04	0.52	0.24

Additional rip-rap material haulage

Table C.6 Activity information

Item	Value	Units (and notes)
Number of days	261	weekdays per year
Hours per day	8	hours - between 9am and 5pm
Total trucking hours	2088	
Haul trucks to primary stockpile - add material	27	tonne per truck
Total additional material	50000	tonne
Number of trips loaded	1851.9	trips loaded
Number of trips empty	1851.9	trips empty
Single trip trucks per hour	0.89	trucks per hour
Single trip VKT pri SP 1 haul road	0.59	VKT/hr
Single trip VKT pri SP 2 haul road	0.09	VKT/hr
Empty truck mass	10	tonne
Loaded truck mass	37	tonne

Table C.7 Activity emission factors – uncontrolled

Emission factors	TSP	PM_{10}	$PM_{2.5}$	
Truck dumping material [kg/tonne] =	0.012	0.0068	0.0016	From NPI Mining 2012, App. A 1.1.6 on overburden - Default value. App A 1.2.2 has been considered.
Loaded truck movement between stockpiles [kg/VKT] =	6.75	2.35	1.55	From NPI Mining 2012, App. A 1.1.11
Empty truck movement between stockpiles [kg/VKT] =	3.74	1.31	0.86	From NPI Mining 2012, App. A 1.1.11

Table C.8 Activity emissions– uncontrolled

Emissions	TSP (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)
Dumping material at primary stockpile 1	0.192	0.11	0.025
Dumping material at primary stockpile 2	0.096	0.054	0.012
Loaded truck haulage to primary stockpile 1	3.99	1.39	0.92
Empty truck haulage from primary stockpile 1	2.21	0.77	0.51
Loaded truck haulage to primary stockpile 2	0.60	0.21	0.14
Empty truck haulage from primary stockpile 2	0.33	0.12	0.08
TOTAL	**7.42**	**2.65**	**1.68**

Table C.9 Modelled source emission rates – uncontrolled

Emission source	TSP (kg/hr)	PM10 (kg/hr)	PM2.5 (kg/hr)
Primary stockpile 1	3.29	1.19	0.74
Primary stockpile 2	0.56	0.22	0.12
High Dam	0	0	0
Right abutment	0	0	0
Left abutment	0	0	0
Haul road 1	3.10	1.08	0.71
Haul road 2	0.47	0.16	0.11
TOTAL	7.42	2.65	1.68
Wind erosion Primary stockpile 1	1.18	0.59	0.27
Wind erosion Primary stockpile 2	0.12	0.060	0.028
Primary Stockpile all year round active area factor	0.3		

Appendix D

CALMET-CALPUFF modelling

Modelling

Emissions and meteorology for the project were assessed using the CALPUFF modelling system, a transport and dispersion model that tracks "puffs" of material from emission sources, accounting for their dispersion and transformation over time. The model utilises meteorological data generated by the CALMET pre-processor, which incorporates temporal and spatial variations in weather conditions.

CALPUFF produces hourly concentration outputs at specified receptor locations, which are further processed using the CALPOST post-processor to summarise results over user-defined averaging periods.

CALPUFF is a more advanced dispersion modelling package than a Gaussian plume model such as AERMOD or AUSPLUME. It takes into consideration three dimensional atmospheric wind affects.

For the meteorology around Lake Pūkaki, the CALPUFF system has been selected due to the following complexities that were identified prior to and subsequently following initial meteorological modelling.

– Large body of water – Lake Pūkaki
– High mountains immediately adjacent to Lake Pūkaki with steep sides resulting in terrain elevation rises of about 1500 m.
– Steep valley winds, particularly at the Tasman delta end of Lake Pūkaki.
– Large relative flat plains consisting of grasslands and glacial riverbeds extending kilometres from Lake Pūkaki.
– Dust sources located at the edge of the lake.

Given the above identified complexities, and after reviewing the *Good Practice Guide for Atmospheric Dispersion Modelling* (2004)[5] the CALPUFF modelling package was identified as the most appropriate model for quantitatively assessing dust emissions from the proposed project.

The CALPUFF modelling package was accessed using the Lakes Environmental CALPUFF View software that provides a user-friendly GUI interface for model set up and results analysis.

Meteorological modelling

Meteorological processes significantly influence the dispersion, transformation, and removal of pollutants in the atmosphere. Vertical dispersion depends on atmospheric stability and surface mixing layer depth, while horizontal dispersion is driven by wind speed and direction. Wind speed affects pollutant transport and dilution, with mechanical turbulence, influenced by surface roughness, further aiding dispersion. Wind direction determines pollutant pathways and crosswind spreading, causing concentrations to fluctuate with changes in stability, mixing depth, and wind patterns (Oke, 2002).[6]

For this project, a site-specific three-dimensional meteorological dataset was developed using TAPM, surface observational data and CALMET, as detailed in the following sections.

Selection of Meteorological Year

The single year for the modelling was selected based on a multi-criteria analysis, as described in Section 7.2.2 and repeated here for convenience.

A multi-criteria assessment was used of all the available data, which included the following parameters.

– Annual rainfall
    - A drier year is generally associated with more frequent dust storms, i.e., dust wind erosion.
– July to December rainfall

[5] Ministry for the Environment, New Zealand, 2004. Good Practice Guide for Atmospheric Dispersion Modelling. ME number: 522, June 2004.
[6] Oke, T. R. (2002). *Boundary Layer Climates.* Routledge.

    - Dust storms tend to occur during the later half of the year.
- Annual average relative humidity
    - Lower RH is generally favourable for exposed surfaces to lose moisture.
- Annual average wind speed
    - Wind erosion and dust storms increase in intensity with wind speed.
- Number of hourly observations with wind speed 10+ m/s
    - Highest wind speeds are associated with dust storms, consistent with Bluett (2012).
- Number of periods where the wind speed exceeded 10 m/s for longer than 24 consecutive hours.
    - Long duration high wind events are more likely to result in dust storms and exposed surface drying.
- Number of missing hours
    - Validity of the analysis needs to be maintained.
    - Used to exclude 2017 as a usable year given 52.5 percent of data was missing from the Maryburn site.

More weighting was given the observations from Maryburn and Pūkaki Aero rather than Mt Cook Village given their better proximity to the dam wall construction site and representation of winds across the plains east of Lake Pūkaki.

A ranked multi-criteria analysis was applied for each of the sites with ranking tables shown below.

The year 2015 was selected as it ranked highest (lower number) than the other years. Although 2015 was ranked poorly for the number of consecutive hours greater than 10 m/s, it had a very large number (rank 2) of total hours greater than 10 m/s.

The annual wind rose for the year 2015 for Maryburn and Pūkaki Aero are shown below.

Table D.1 Maryburn site multi-criteria assessment for modelling year selection

Year	Total Rainfall	RH avg	WS Avg	24hr consect 10+m/s	10+m/s	missing data	Rain last 6months of year	Total Rainfall	RH avg	WS Avg	24hr consect 10+m/s	10+m/s	Rain last 6months of year	rank sum
								Rankings						
2007	436.5	67.8	4.2	5	710	170	258	1	16	7	7	11	5	47
2008	595	67.0	4.0	4	700	75	370.5	5	13	10	9	12	10	59
2009	637	65.8	4.4	0	896	47	223.5	8	6	3	11	4	3	35
2010	750.5	66.8	4.3	8	827	7	428.5	13	11	5	6	5	14	54
2011	732	66.9	4.1	4	726	0	379.5	12	12	9	9	10	11	63
2012	731	68.4	3.9	0	692	4	407	11	17	12	11	13	13	77
2013	686.5	66.4	4.2	9	752	2	282	10	9	6	5	8	6	44
2014	612	67.1	4.3	11	914	12	241	7	14	4	4	3	4	36
2015	**488**	**64.4**	**4.5**	**0**	**936**	**30**	**176.5**	**2**	**4**	**2**	**11**	**2**	**1**	**22**
2016	602	65.9	4.6	5	965	0	309	6	7	1	7	1	8	30
2017						4606								
2018	847	66.4	3.8	0	533	71	346.5	16	10	16	11	16	9	78
2019	672.5	63.0	4.1	0	774	4	392.5	9	1	8	11	6	12	47
2020	547	64.1	4.0	34	739	80	303	4	3	11	1	9	7	35
2021	809.5	65.0	3.9	28	652	0	457.5	15	5	13	2	14	15	64
2022	847	67.1	3.5	0	443	51	491.5	16	15	17	11	17	16	92
2023	521.5	66.0	3.8	17	620	46	202	3	8	15	3	15	2	46
2024	767.5	63.8	3.9	0	761	32	565	14	2	14	11	7	17	65

Table D.2 *Pūkaki Aero site multi-criteria assessment for modelling year selection*

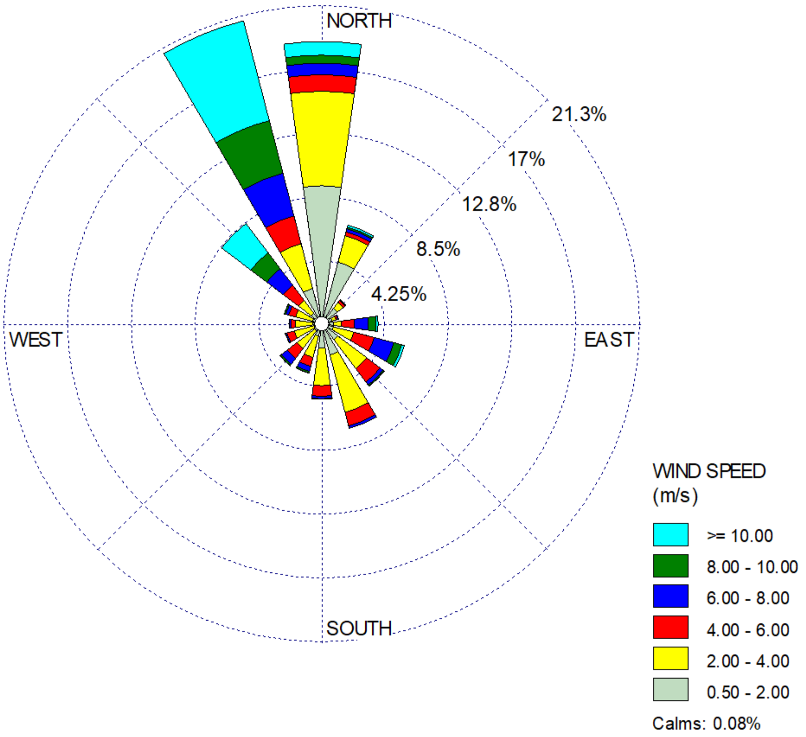
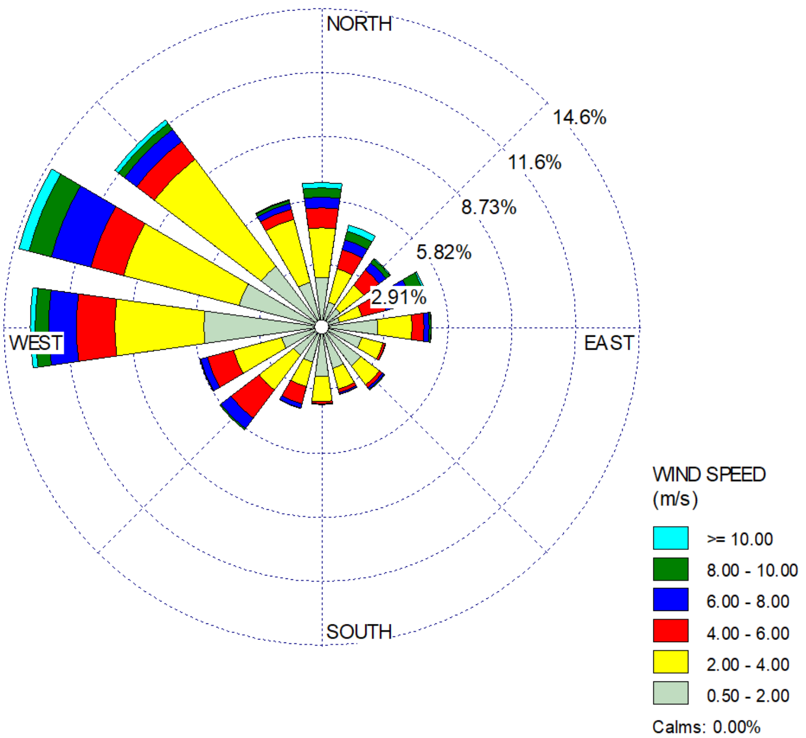
Year	Total Rainfall	RH avg	WS Avg	10+m/s	missing data	Rain last 6months of year	Total Rainfall	RH avg	WS Avg	10+m/s	Rain last 6months of year	rank sum
							Ranking					
2009	648.2	68.9	3.0	139	104	232.2	8	2	2	2	3	17
2010	698.2	69.6	2.9	126	71	353.2	12	4	5	4	9	34
2011	661.6	69.8	2.9	113	39	358.8	10	6	6	6	10	38
2012	727.4	71.8	2.7	87	77	367.6	13	12	13	9	12	59
2013	636.6	71.6	2.8	102	97	271.6	6	11	9	7	5	38
2014	599.2	70.7	3.0	122	54	244.8	5	8	3	5	4	25
2015	**477.6**	**65.9**	**3.1**	**141**	**90**	**152.6**	**2**	**1**	**1**	**1**	**1**	**6**
2016	578.6	70.1	2.9	130	61	318.8	4	7	4	3	7	25
2017	661	71.9	2.7	62	15	362.4	9	13	11	14	11	58
2018	876.2	73.9	2.6	41	76	349	16	15	14	16	8	69
2019	689	70.7	2.9	68	8	393.8	11	9	7	13	14	54
2020	550	69.2	2.8	84	10	291.4	3	3	10	10	6	32
2021	737.8	72.6	2.6	79	26	470	14	14	15	11	16	70
2022	753.2	75.2	2.5	53	40	389.8	15	16	16	15	13	75
2023	422.8	71.2	2.7	76	27	176.8	1	10	12	12	2	37
2024	647.8	69.7	2.8	89	21	445	7	5	8	8	15	43

Table D.3 *Mt Cook Village site multi-criteria assessment for modelling year selection*

Year	Total Rainfall	RH avg	WS Avg	10+m/s	missing data	Rain last 6months of year	Total Rainfall	RH avg	WS Avg	10+m/s	Rain last 6months of year	rank sum
							Ranking					
2013	2861.6	62.5	4.8	608	198	1510.2	11	2	8	10	10	41
2014	2551.4	65.4	4.8	697	454	1219.2	8	8	9	7	6	38
2015	**2224**	**62.0**	**5.1**	**789**	**916**	**1057.8**	**4**	**1**	**3**	**4**	**2**	**14**
2016	2581.2	65.0	4.7	650	737	1275.8	10	7	10	8	7	42

Year	Total Rainfall	RH avg	WS Avg	10+m/s	missing data	Rain last 6months of year	Total Rainfall	RH avg	WS Avg	10+m/s	Rain last 6months of year	rank sum
2017	2202.4	67.6	4.6	584	359	1097	3	10	12	11	3	39
2018	1972.8	66.8	5.0	632	111	949	1	9	6	9	1	26
2019	3334.6	64.3	5.3	868	76	1867.2	12	3	1	2	12	30
2020	**2132.2**	**64.6**	**5.2**	**912**	**112**	**1137.6**	**2**	**5**	**2**	**1**	**4**	**14**
2021	2558.8	67.8	5.0	779	90	1492.6	9	11	4	5	9	38
2022	2485.4	68.6	4.7	572	200	1456.4	6	12	11	12	8	49
2023	2263	64.5	4.9	721	38	1151.8	5	4	7	6	5	27
2024	2545.4	64.8	5.0	811	44	1611	7	6	5	3	11	32

Table D.4 Annual wind roses for 2015, used in CALMET modelling

Site	Annual wind rose
Maryburn Avg WS = 4.5 m/s	
Pūkaki Aero Avg WS = 3.1 m/s	

TAPM Meteorological Modelling

TAPM (v4.0.4), developed by CSIRO Australia, was used to generate meteorological data for input into CALMET modelling. This model predicts parameters such as wind, temperature, and turbulence using input from terrain, vegetation, and synoptic meteorological data. TAPM observational assimilation ability was not used in this assessment.

TAPM modelling at smaller spatial resolution scales of 1 km or smaller was attempted however, numerical instabilities occurred that prevented solutions for the entire modelled period of time. For the purposes obtaining three dimensional coarse grid meteorology as an initial guess filed in CALMET, 3 km resolution was considered to be adequate.

TAPM parameters used for this study are presented in Table D.2.

Table D.5 Meteorological Modelling Parameters - TAPM v 4.0.4

Parameter	Model Configuration
Modelling Period	01 January 2015 to 31 December 2015
Centre of analysis	433,244 mE 5,122,236 mS (UTM Coordinates) -44°3'0", 170°10'0" (Latitude, Longitude)
Number of grid points	48 × 48 × 20
Number of grids (spacing)	3 (30 km, 10 km, 3 km)
Data Assimilation	None

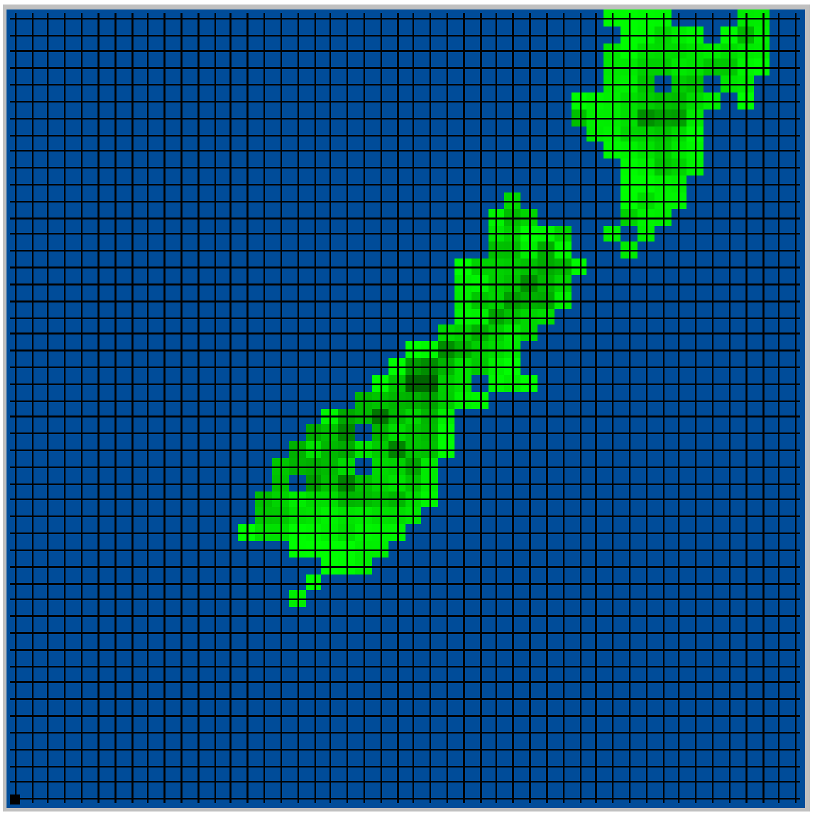


Figure D.1 TAPM model Grid 1 – 30 km

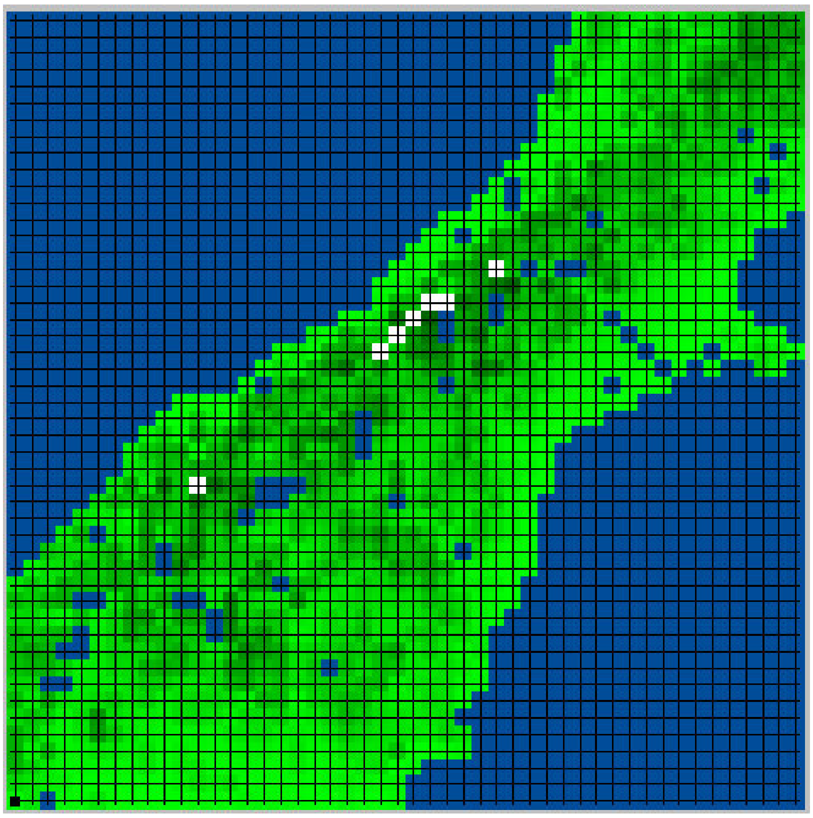


Figure D.2 TAPM model Grid 2 – 10 km

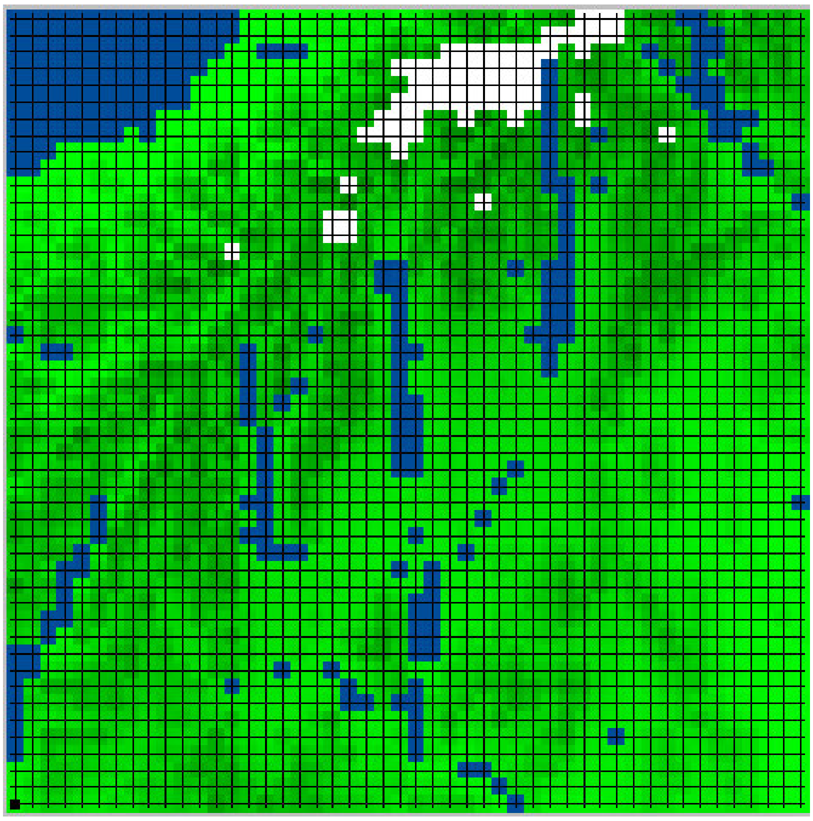


Figure D.3 TAPM model Grid 3 – 3 km

CALMET

CALMET is a meteorological modelling tool that generates hourly wind and other meteorological fields within a three-dimensional gridded domain, which serve as inputs for the CALPUFF dispersion model. The output from CALMET also includes associated two-dimensional fields, such as mixing height, surface characteristics, and dispersion properties.

Within CALMET, the interpolated wind field is adjusted to incorporate the effects of topography, sea/lake breezes, and variations in heating and surface roughness due to diverse land uses throughout the modelling domain, most notably the high mountains immediately to the west of Lake Pūkaki. These adjustments are applied at each grid point to produce a final wind field that accurately reflects local influences.

The CALMET modelling was conducted using the 'Hybrid' approach across a 48 km by 48 km domain with a 300 m resolution. TAPM-generated three-dimensional meteorological data served as the initial wind field for the domain. Two surface stations observations were incorporated into the CALMET model as surface observations. Local topographical and land use data were manually updated to enhance the wind field calculation down to the meteorological resolution of 300 m.

Observation data

The observational stations of Maryburn and Pūkaki Aero were incorporated into the CALMET as surface observations. As per the input requirements of CALMET, all hours of the year had at least one observation. The Pūkaki station was used for cloud cover and cloud height information. Missing data were filled using recognised US EPA hierarchy of methods, namely persistence, interpolation and substitution. Where substitution was used, information from an alternate observational station of the three detailed in this assessment was incorporated. Repetition of previous days data, possible for Gaussian plume models was not done was observational time consistency especially with the TAPM initial guess field was maintained as best as possible.

The Mt Cook Village site was not incorporated into the CALMET modelling as this is located inside the Tasman River delta valley and would therefore require detailed surface station barrier information to be included in the modelling otherwise its observations could adversely affect wind in an adjacent mountain valley.

No upper air observation station was used. TAPM incorporated results through the initial guess field was used for the upper air information.

Some preliminary test runs of shorter time periods – 48 hours – were undertaken to investigate the most appropriate settings for terrain and observational station radius input parameters (TERRAD, R1MAX, R1, etc.). A TERRAD value of 8 km corresponds to the approximate width of the Tasman River delta valley.

Table D.1 outlines the parameters employed in the meteorological modelling to drive the CALMET model.

Table D.6 Meteorological modelling parameters - CALMET

Parameter	Model Configuration
Version	6.5
Modelling period	01 January 2015 to 31 December 2015
Meteorological grid resolution	300 m 160 x 160 cells
Grid southwest corner coordinates	409,244 mE 5,098,236 mS UTM Coordinates
Landuse	Manually adjusted using satellite imagery
Initial guess filed	TAPM output
Surface stations	Maryburn (442,494 mE, 5,120,112 mS)

Parameter	Model Configuration
	Pūkaki Aerodrome (429,498 mE, 5,100,535 mS)
Vertical resolution (cell heights)	10 (0 m, 20 m, 40 m, 80 m, 160 m, 320 m, 640 m, 1200 m, 2000 m, 3000 m, 4000 m)
TERRAD parameter	8 km
Surface station radius of influence	RMAX1 = 12 km RMAX2 = 8 km R1 = 8 km R2 = 6 km

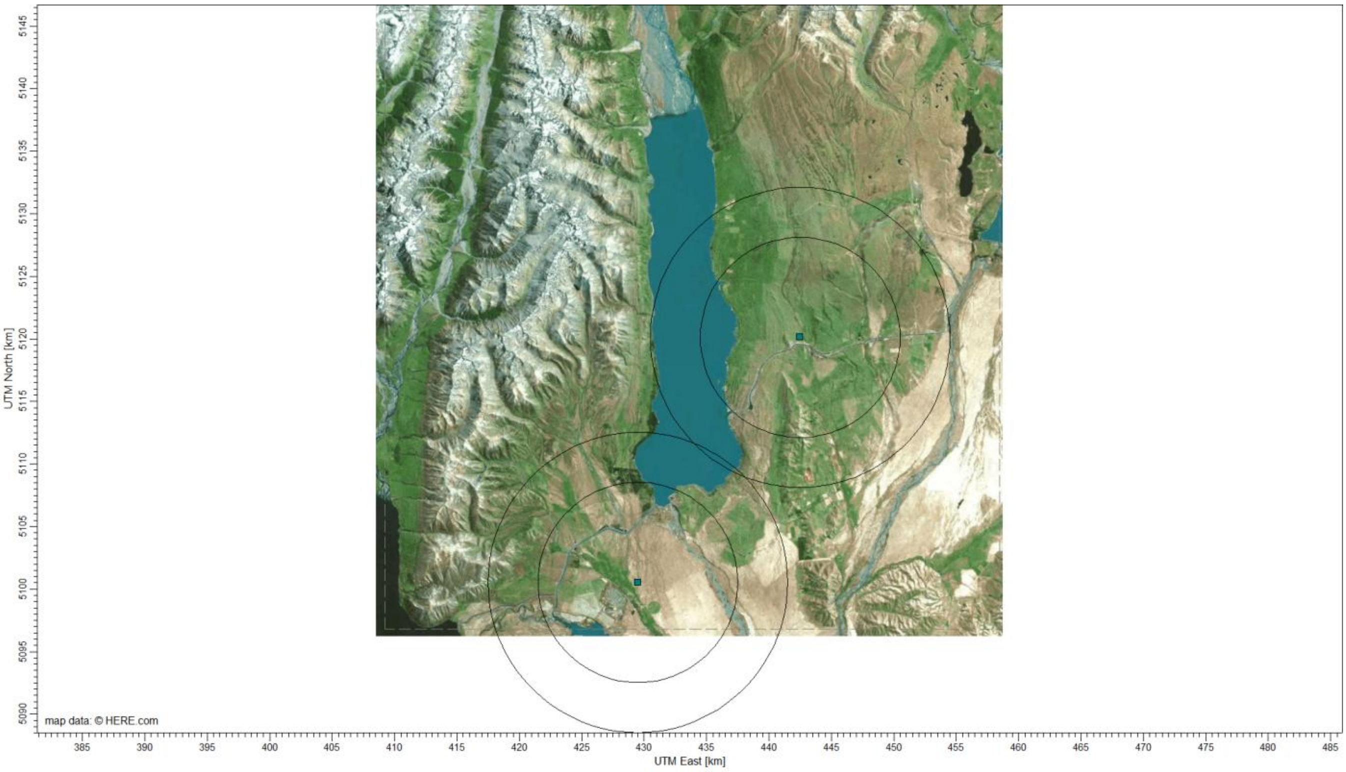


Figure D.4 CALMET satellite terrain with surface observation station location shown, with R1MAX and R1 distances shown

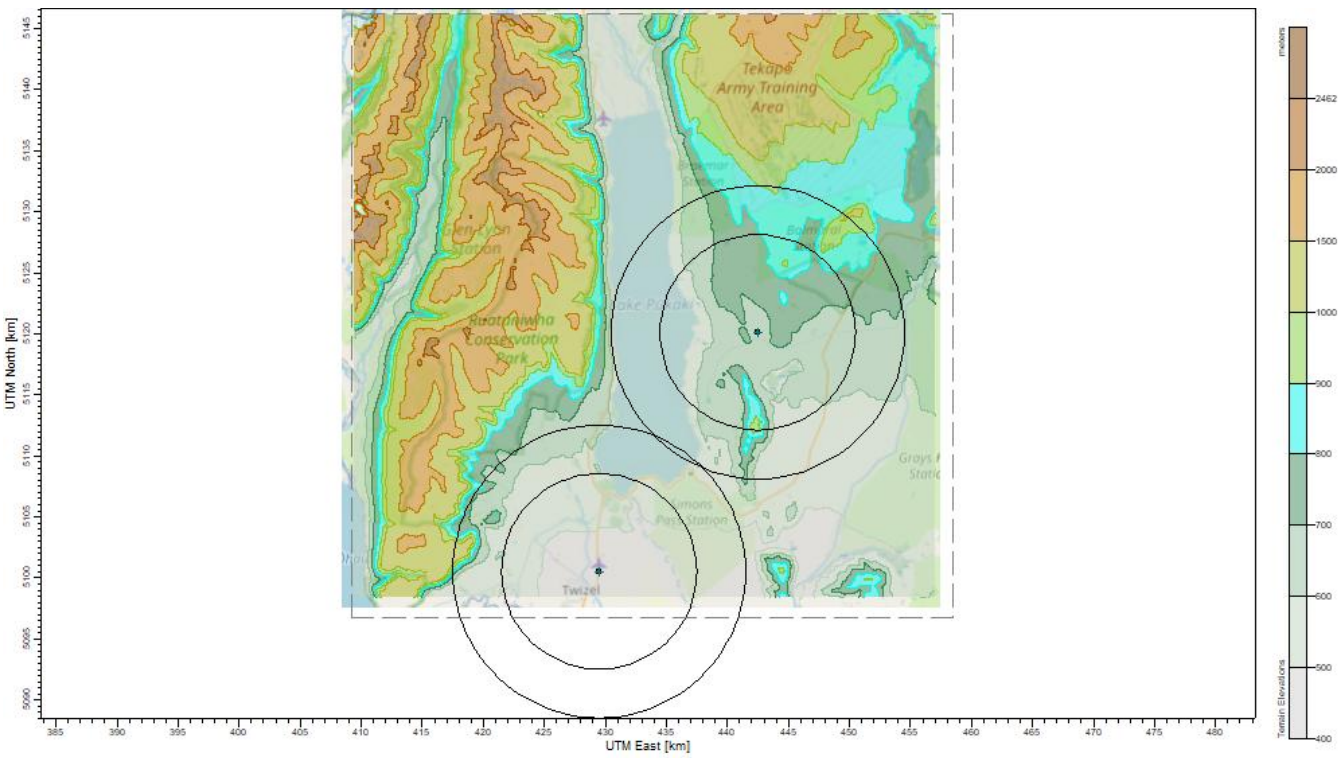


Figure D.5 CALMET terrain elevation with surface observation station location shown, with R1MAX and R1 distances shown

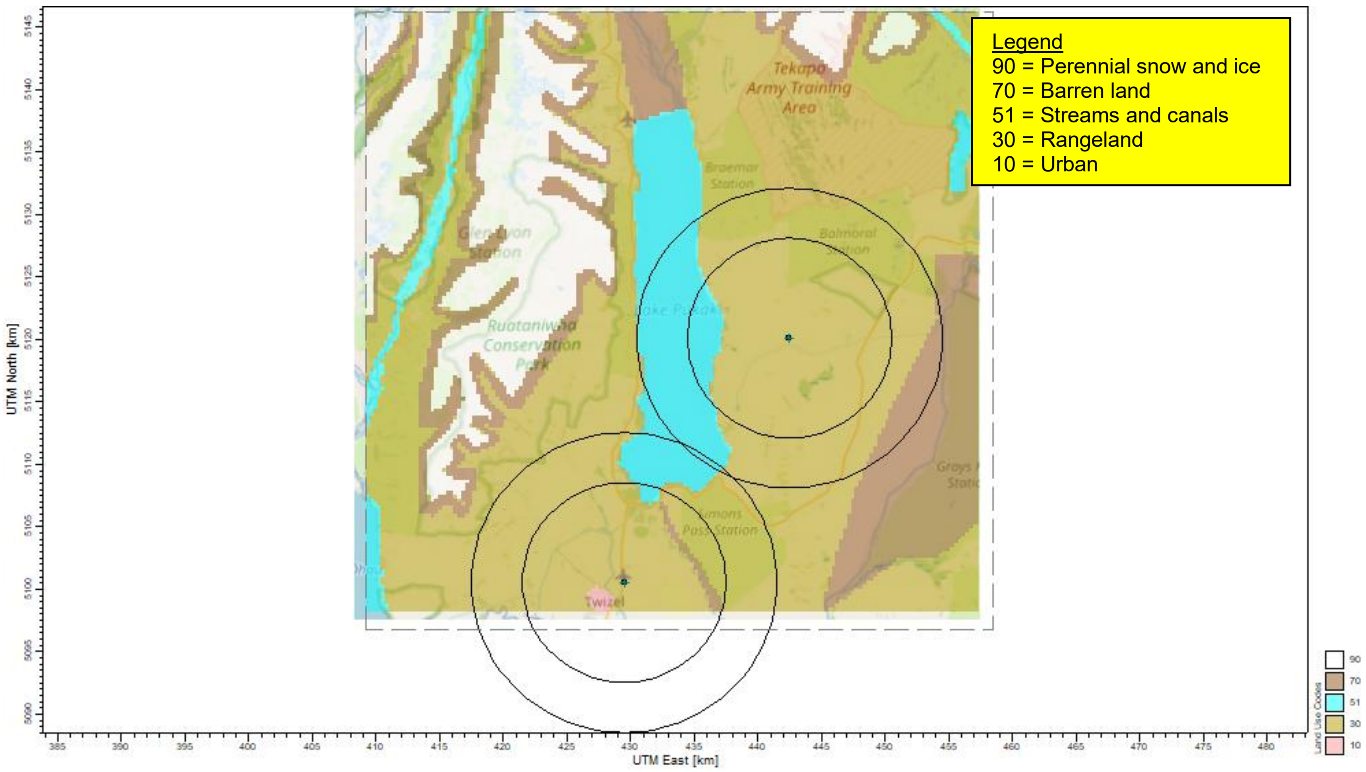


Figure D.6 CALMET landuse with surface observation station location shown, with R1MAX and R1 distances shown. Coloured by CALMET land use codes

Source characteristics and emission rates

Dam construction

CALPUFF modelled source characteristics for the dam construction site modelling are provided in Table D.7.

Many of the sources are located at the same location. For example, stockpile wind erosion and stockpile loading/unloading are all located at the same location. Where precisely each dust event occurs on a day-to-day basis is unknown. This operation 'spread' is modelled via the initial lateral spread (sigma-y) of the source.

Table D.7 CALPUFF source characteristics for dam construction sources

Source	Source	ID	Type	Easting [km]	Northing [km]	Release height [m]	Initial lateral spread (sigma-y) [m]	Initial vertical spread (sigma-z) [m]	Ground elevation [m]	Emission rate [kg/h]
Primary stockpile 1	Construction	CPSP1A	Volume	431.560	5106.290	2.0	75.0	0.5	529.4	3.48
Primary stockpile 1	Construction	CPSP1B	Volume	431.790	5106.200	2.0	75.0	0.5	514.4	3.48
Primary stockpile 2	Construction	CPSP2	Volume	432.140	5106.860	2.0	17.5	0.5	535.3	1.65
High Dam	Construction	CHD1	Volume	431.580	5106.670	2.0	12.5	0.5	533.5	1.68
High Dam	Construction	CHD2	Volume	431.690	5106.740	2.0	12.5	0.5	530.8	1.68
High Dam	Construction	CHD3	Volume	431.795	5106.810	2.0	12.5	0.5	529.7	1.68
High Dam	Construction	CHD4	Volume	431.900	5106.880	2.0	12.5	0.5	532.0	1.68
Right abutment	Construction	CRA1	Volume	431.260	5106.730	2.0	40.0	0.5	534.4	3.36
Right abutment	Construction	CRA2	Volume	431.410	5106.675	2.0	40.0	0.5	534.7	3.36
Left abutment	Construction	CLA1	Volume	432.000	5107.140	2.0	32.5	0.5	537.2	0.93
Left abutment	Construction	CLA2	Volume	432.040	5107.030	2.0	32.5	0.5	537.2	0.93
Haul road 1	Construction	CHR1A	Volume	431.540	5106.470	3.0	3.0	0.8	531.0	3.04
Haul road 1	Construction	CHR1B	Volume	431.460	5106.545	3.0	3.0	0.8	534.1	3.04
Haul road 2	Construction	CHR2	Volume	432.165	5106.980	3.0	3.0	0.8	540.6	1.22
Wind erosion High Dam	Construction	CWEHD1	Volume	431.580	5106.670	2.0	12.5	0.5	533.5	0.18
Wind erosion High Dam	Construction	CWEHD2	Volume	431.690	5106.740	2.0	12.5	0.5	530.8	0.18
Wind erosion High Dam	Construction	CWEHD3	Volume	431.795	5106.810	2.0	12.5	0.5	529.7	0.18
Wind erosion High Dam	Construction	CWEHD4	Volume	431.900	5106.880	2.0	12.5	0.5	532.0	0.18
Wind erosion right abutment	Construction	CWERA1	Volume	431.260	5106.730	2.0	40.0	0.5	534.4	0.41
Wind erosion right abutment	Construction	CWERA2	Volume	431.410	5106.675	2.0	40.0	0.5	534.7	0.41
Wind erosion left abutment	Construction	CWELA1	Volume	432.000	5107.140	2.0	32.5	0.5	537.2	0.52
Wind erosion left abutment	Construction	CWELA2	Volume	432.040	5107.030	2.0	32.5	0.5	537.2	0.52
Primary stockpile 1	Rip-rap delivery	ZPSP1A	Volume	431.560	5106.290	2.0	75.0	0.5	529.4	1.65
Primary stockpile 1	Rip-rap delivery	ZPSP1B	Volume	431.790	5106.200	2.0	75.0	0.5	514.4	1.65

Source	Source	ID	Type	Easting [km]	Northing [km]	Release height [m]	Initial lateral spread (sigma-y) [m]	Initial vertical spread (sigma-z) [m]	Ground elevation [m]	Emission rate [kg/h]
Primary stockpile 2	Rip-rap delivery	ZPSP2	Volume	432.140	5106.860	2.0	17.5	0.5	535.3	0.56
Haul road 1	Rip-rap delivery	ZHR1A	Volume	431.540	5106.470	3.0	3.0	0.8	531.0	1.55
Haul road 1	Rip-rap delivery	ZHR1B	Volume	431.460	5106.545	3.0	3.0	0.8	534.1	1.55
Haul road 2	Rip-rap delivery	ZHR2	Volume	432.165	5106.980	3.0	3.0	0.8	540.6	0.47
Wind erosion primary stockpile 1	Rip-rap delivery	ZWEPSP1A	Volume	431.560	5106.290	2.0	75.0	0.5	529.4	0.59
Wind erosion primary stockpile 1	Rip-rap delivery	ZWEPSP1B	Volume	431.790	5106.200	2.0	75.0	0.5	514.4	0.59
Wind erosion primary stockpile 2	Rip-rap delivery	ZWEPSP2	Volume	432.140	5106.860	2.0	17.5	0.5	535.3	0.12

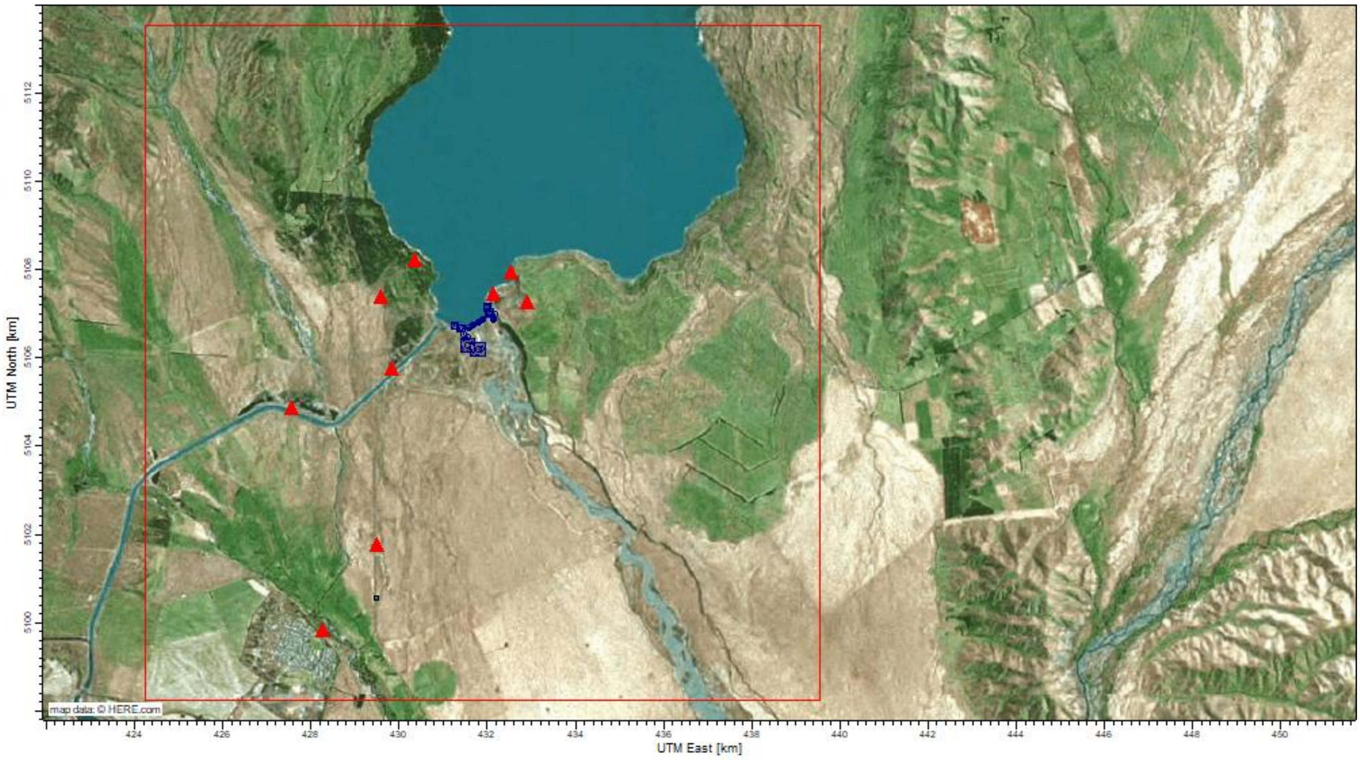


Figure D.7 ***CALPUFF computational domain for construction dust assessment. Domain extent shown by red box. Dust sources shown in blue. Discrete receptors shown with red triangles.***

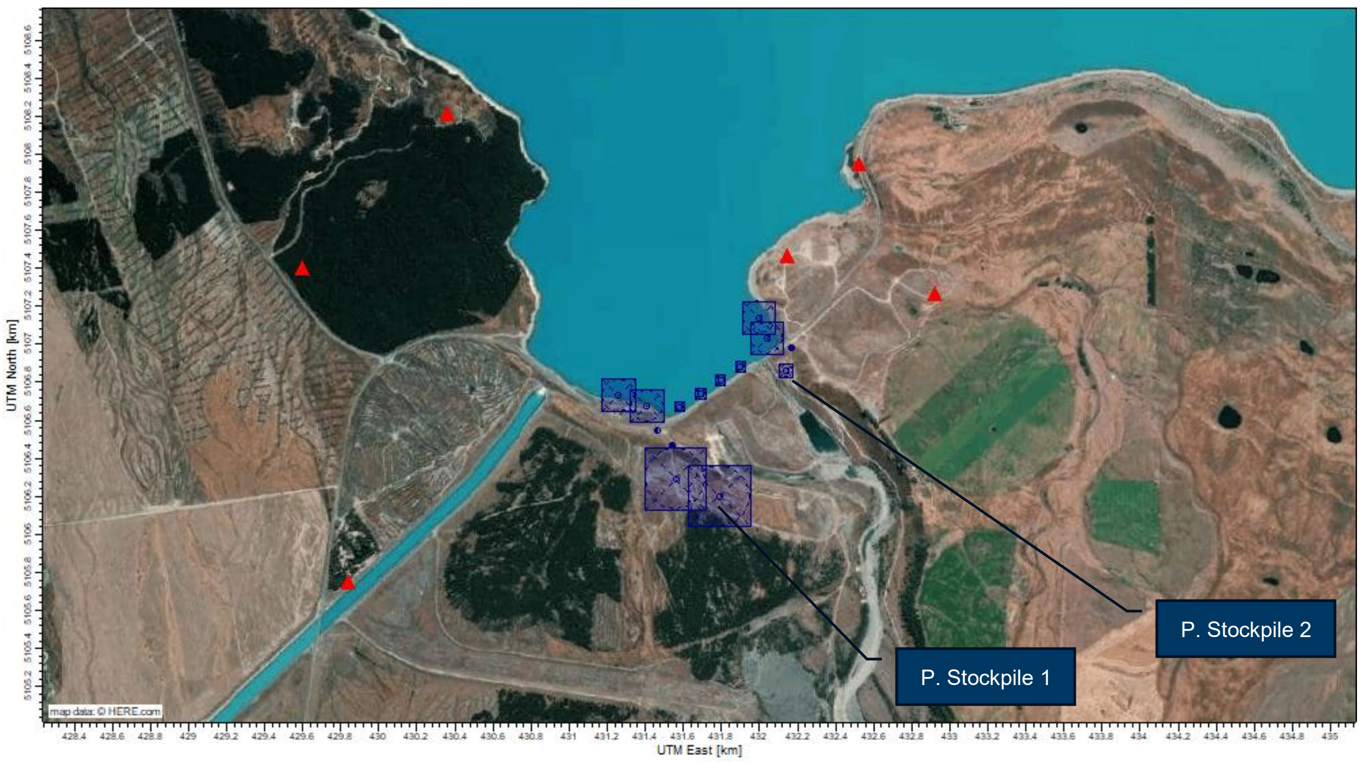


Figure D.8 ***CALPUFF dust sources (blue) and nearest discrete receptors (red triangles). Size of the dust source represents the initial lateral spread and not the magnitude of the dust emitted***

Appendix E

Dust mitigation and controls

Control factors

Control/mitigation factors have been based on information provided in MfE (2016) and NPI (Mining, 2012, Section 5.3, Table 4).

Default values have been based on those provided in NPI, however, adjustments for New Zealand (climatic) conditions have been applied as indicated in MfE (2016). For example, default haul road watering for 50 percent dust suppression in NPI is based on 2 L/m²/h, however, MfE (2016, Section 5.2.3) indicates that 1 L/m²/h would provide equivalent control for New Zealand conditions, which are, in general, not as conducive for water evaporation compared with general Australian conditions.

Estimated control factors and resultant dust emissions are shown in Table 14. The information is based on the estimated uncontrolled dust emission rates as stated in Table 12.

Haul road watering

Haul road watering of greater than 1 L/m²/h is recommended to control dust emissions by 75 percent.

Water sprays

Water sprays are recommended for the following activities.

- Rip-rap unloading at work zones (secondary stockpiles).
- Rip-rap unloading at primary stockpiles.
- Temporary stockpiles in the work zones – as required.
- Primary stockpiles

Water spray can either be fixed permanent or mobile. Mobile water sprays may be possible from a water truck and may be a more efficient option as they can be deployed based on forecast weather and operational conditions.

Wind breaks

Porous screen wind breaks surrounding primary stockpile areas can be considered. Solid walls would be better, however, given the prevailing winds, the foundation requirements for a solid structure may not be cost justifiable when a porous wind break (that slows but not stops wind) is combined with water sprays.

Estimated effective dust control factor

Effective overall dust concentration reduction factors with controls implemented are summarised in Table E.1. These are estimated based on total modelled dust emission rates. Some error is expected in any model.

Table E.1 Estimated effective dust concentration reduction factor with controls

Pollutant	Effective dust reduction factor with controls [-]
TSP	0.326
PM_{10}	0.358
$PM_{2.5}$	0.307

Table E.2 Estimated dust emissions rates with full controls applied

Emissions	Uncontrolled TSP (kg/hr)	Controls	Control factor	TSP (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)
Loading material at primary stockpile 1	0.867	No controls	0	0.867	0.490	0.113
Loading material at primary stockpile 2	0.433	No controls	0	0.433	0.245	0.056
Dumping material at high dam	0.208	Water sprays	0.7	0.062	0.035	0.008
Dumping material at right abutment	0.208	Water sprays	0.7	0.062	0.035	0.008
Dumping material at left abutment	0.208	Water sprays	0.7	0.062	0.035	0.008
Placing rip-rap at high dam	0.433	No controls	0	0.433	0.245	0.056
Placing rip-rap at right abutment	0.433	No controls	0	0.433	0.245	0.056
Placing rip-rap at left abutment	0.433	No controls	0	0.433	0.245	0.056
Loaded truck haulage to high dam	14.98	Watering, >1L/m²/h, 75%	0.75	3.75	1.31	0.863
Empty truck haulage from high dam	9.37	Watering, >1L/m²/h, 75%	0.75	2.34	0.818	0.540
Loaded truck haulage to left abutment	2.25	Watering, >1L/m²/h, 75%	0.75	0.563	0.195	0.130
Empty truck haulage from left abutment	1.41	Watering, >1L/m²/h, 75%	0.75	0.353	0.123	0.080
Dumping material at primary stockpile 1	0.192	Water sprays	0.7	0.058	0.033	0.008
Dumping material at primary stockpile 2	0.096	Water sprays	0.7	0.029	0.016	0.004
Loaded truck haulage to primary stockpile 1	3.99	Watering, >1L/m²/h, 75%	0.75	0.998	0.348	0.230
Empty truck haulage from primary stockpile 1	2.21	Watering, >1L/m²/h, 75%	0.75	0.553	0.193	0.128
Loaded truck haulage to primary stockpile 2	0.6	Watering, >1L/m²/h, 75%	0.75	0.150	0.053	0.035
Empty truck haulage from primary stockpile 2	0.33	Watering, >1L/m²/h, 75%	0.75	0.083	0.030	0.020
Wind erosion High Dam	0.7	Water sprays	0.5	0.350	0.175	0.080
Wind erosion right abutment	0.82	Water sprays	0.5	0.410	0.205	0.095
Wind erosion left abutment	1.04	Water sprays	0.5	0.520	0.260	0.120
Wind erosion Primary stockpile 1	1.18	Combination of porous wind breaks and water sprays	0.3	0.826	0.413	0.189
Wind erosion Primary stockpile 2	0.12	Combination of porous wind breaks and water sprays	0.3	0.084	0.042	0.020
TOTAL	**42.51**			**13.85**	**5.78**	**2.90**

Appendix F

Sensitive receptor concentrations

TSP

Table F.1 TSP Trigger Level assessment. Estimated receptor GLCs – Maximum TSP 5-minute average. Trigger level = 250 μg/m³

Name	Label	Distance from Gate 19 [m]	Uncontrolled incremental GLC [ug/m³]	Incremental GLC with controls [ug/m³]	% of trigger [%]	Compliance
House	R18	1,833	26.0	8.5	3.4	Yes
Viewing spot	R19	1,763	19.8	6.4	2.6	Yes
Lakestone lodge	R20	1,603	21.1	6.9	2.8	Yes
walk photo spot	R21	1,152	29.1	9.5	3.8	Yes
House	R22	959	21.2	6.9	2.8	Yes
Farm Implement Shed /Barn	R23	971	59.4	19.3	7.7	Yes
Lake Pūkaki photo point / public toilet	R24	278	425.5	138.6	55.4	Yes
Electrical transformer	R25	819	616.6	200.9	80.3	Yes
Mt Cook alpine salmon shop (to be moved)	R26	806	592.3	192.9	77.2	Yes
Lake Pūkaki Gate 18 outlet (Meridian Asset)	R27	1,126	143.4	46.7	18.7	Yes
Lake wardel campside	R28	2,480	19.1	6.2	2.5	Yes
Lake Poaka Campsite	R29	4,909	8.7	2.8	1.1	Yes
The moraine fine dining restaurant	R30	2,479	10.6	3.4	1.4	Yes
Mt Cook lakeside retreat, high country	R31	2,022	7.7	2.5	1.0	Yes
House	R32	2,613	9.9	3.2	1.3	Yes
House	R33	2,119	7.1	2.3	0.9	Yes
House	R34	2,436	6.9	2.3	0.9	Yes
The moraine- luxury wedding and events venue	R35	2,786	4.9	1.6	0.6	Yes
House	R36	2,510	5.3	1.7	0.7	Yes
House	R37	2,691	4.7	1.5	0.6	Yes
House	R38	3,105	4.7	1.5	0.6	Yes
House	R39	3,144	4.6	1.5	0.6	Yes
House	R40	3,502	2.9	0.9	0.4	Yes
Karaerea Lakehouse	R41	3,650	3.1	1.0	0.4	Yes
House	R42	4,352	1.9	0.6	0.2	Yes
Pūkaki adventures	R43	4,761	2.0	0.7	0.3	Yes
Pūkaki lakeside getaway	R44	4,447	3.2	1.0	0.4	Yes
House	R45	4,882	3.2	1.1	0.4	Yes
Lake Pūkaki Overnight Campervan parking	R67	393	225.0	73.3	29.3	Yes
Lake Pūkaki Overnight Campervan parking	R68	567	89.2	29.1	11.6	Yes
Red Cat Biplane Flights	R69	5,746	4.9	1.6	0.6	Yes
Twizel	R70	8,012	3.7	1.2	0.5	Yes

Table F.2 TSP Trigger Level assessment. Estimated receptor GLCs – Maximum TSP 1-hour average. Trigger level = 200 μg/m³

Name	Label	Distance from Gate 19 [m]	Uncontrolled incremental GLC [ug/m³]	Incremental GLC with controls [ug/m³]	Uncontrolled incremental GLC [ug/m³]	Compliance
House	R18	1,833	15.8	5.1	2.6	Yes
Viewing spot	R19	1,763	12.0	3.9	2.0	Yes
Lakestone lodge	R20	1,603	12.9	4.2	2.1	Yes
walk photo spot	R21	1,152	17.7	5.8	2.9	Yes
House	R22	959	12.9	4.2	2.1	Yes
Farm Implement Shed /Barn	R23	971	36.1	11.8	5.9	Yes
Lake Pūkaki photo point / public toilet	R24	278	258.8	84.3	42.2	Yes
Electrical transformer	R25	819	375.1	122.2	61.1	Yes
Mt Cook alpine salmon shop (to be moved)	R26	806	360.3	117.4	58.7	Yes
Lake Pūkaki Gate 18 outlet (Meridian Asset)	R27	1,126	87.2	28.4	14.2	Yes
Lake wardel campside	R28	2,480	11.6	3.8	1.9	Yes
Lake Poaka Campsite	R29	4,909	5.3	1.7	0.9	Yes
The moraine fine dining restaurant	R30	2,479	6.4	2.1	1.0	Yes
Mt Cook lakeside retreat, high country	R31	2,022	4.7	1.5	0.8	Yes
House	R32	2,613	6.0	2.0	1.0	Yes
House	R33	2,119	4.3	1.4	0.7	Yes
House	R34	2,436	4.2	1.4	0.7	Yes
The moraine- luxury wedding and events venue	R35	2,786	3.0	1.0	0.5	Yes
House	R36	2,510	3.2	1.0	0.5	Yes
House	R37	2,691	2.9	0.9	0.5	Yes
House	R38	3,105	2.8	0.9	0.5	Yes
House	R39	3,144	2.8	0.9	0.5	Yes
House	R40	3,502	1.7	0.6	0.3	Yes
Karaerea Lakehouse	R41	3,650	1.9	0.6	0.3	Yes
House	R42	4,352	1.2	0.4	0.2	Yes
Pūkaki adventures	R43	4,761	1.2	0.4	0.2	Yes
Pūkaki lakeside getaway	R44	4,447	1.9	0.6	0.3	Yes
House	R45	4,882	2.0	0.6	0.3	Yes
Lake Pūkaki Overnight Campervan parking	R67	393	136.9	44.6	22.3	Yes
Lake Pūkaki Overnight Campervan parking	R68	567	54.3	17.7	8.8	Yes
Red Cat Biplane Flights	R69	5,746	3.0	1.0	0.5	Yes
Twizel	R70	8,012	2.2	0.7	0.4	Yes

Table F.3 TSP Trigger Level assessment. Estimated receptor GLCs – Maximum TSP 24-hour average. Trigger level = 60 μg/m³

Name	Label	Uncontrolled incremental GLC [ug/m³]	Incremental GLC with controls [ug/m³]	% of trigger [%]	Compliance	Comments
House	R18	27.3	8.9	14.8	Yes	
Viewing spot	R19	20.8	6.8	11.3	Yes	
Lakestone lodge	R20	22.2	7.2	12.1	Yes	
walk photo spot	R21	30.5	9.9	16.6	Yes	
House	R22	22.3	7.3	12.1	Yes	
Farm Implement Shed /Barn	R23	62.4	20.3	33.9	Yes	
Lake Pūkaki photo point / public toilet	R24	447.1	145.6	242.7	No	Management controls need to be applied.
Electrical transformer	R25	648.0	211.1	351.8	No	No persons here unless for work purposes.
Mt Cook alpine salmon shop (to be moved)	R26	622.4	202.7	337.9	No	To be closed.
Lake Pūkaki Gate 18 outlet (Meridian Asset)	R27	150.7	49.1	81.8	Yes	
Lake wardel campside	R28	20.0	6.5	10.9	Yes	
Lake Poaka Campsite	R29	9.1	3.0	5.0	Yes	
The moraine fine dining restaurant	R30	11.1	3.6	6.0	Yes	
Mt Cook lakeside retreat, high country	R31	8.1	2.6	4.4	Yes	
House	R32	10.4	3.4	5.7	Yes	
House	R33	7.5	2.4	4.1	Yes	
House	R34	7.3	2.4	3.9	Yes	
The moraine- luxury wedding and events venue	R35	5.2	1.7	2.8	Yes	
House	R36	5.5	1.8	3.0	Yes	
House	R37	5.0	1.6	2.7	Yes	
House	R38	4.9	1.6	2.7	Yes	
House	R39	4.8	1.6	2.6	Yes	
House	R40	3.0	1.0	1.6	Yes	
Karaerea Lakehouse	R41	3.3	1.1	1.8	Yes	
House	R42	2.0	0.7	1.1	Yes	
Pūkaki adventures	R43	2.1	0.7	1.1	Yes	
Pūkaki lakeside getaway	R44	3.3	1.1	1.8	Yes	
House	R45	3.4	1.1	1.8	Yes	
Lake Pūkaki Overnight Campervan parking	R67	236.4	77.0	128.4	No	Management controls need to be applied.
Lake Pūkaki Overnight Campervan parking	R68	93.7	30.5	50.9	Yes	
Red Cat Biplane Flights	R69	5.1	1.7	2.8	Yes	
Twizel	R70	3.9	1.3	2.1	Yes	

PM_{10}

Table F.4 PM_{10} Trigger Level assessment. Estimated receptor GLCs – Maximum PM_{10} 24-hour average. Trigger level = 150 $\mu g/m^3$

Name	Label	Distance from Gate 19 [m]	Uncontrolled incremental GLC [ug/m³]	Incremental GLC with controls [ug/m³]	% of trigger [%]	Compliance
House	R18	1,833	6.0	2.1	1.4	Yes
Viewing spot	R19	1,763	4.6	1.6	1.1	Yes
Lakestone lodge	R20	1,603	4.9	1.8	1.2	Yes
walk photo spot	R21	1,152	6.7	2.4	1.6	Yes
House	R22	959	4.9	1.8	1.2	Yes
Farm Implement Shed /Barn	R23	971	13.7	4.9	3.3	Yes
Lake Pūkaki photo point / public toilet	R24	278	98.5	35.2	23.5	Yes
Electrical transformer	R25	819	142.7	51.0	34.0	Yes
Mt Cook alpine salmon shop (to be moved)	R26	806	137.1	49.0	32.7	Yes
Lake Pūkaki Gate 18 outlet (Meridian Asset)	R27	1,126	33.2	11.9	7.9	Yes
Lake wardel campside	R28	2,480	4.4	1.6	1.1	Yes
Lake Poaka Campsite	R29	4,909	2.0	0.7	0.5	Yes
The moraine fine dining restaurant	R30	2,479	2.4	0.9	0.6	Yes
Mt Cook lakeside retreat, high country	R31	2,022	1.8	0.6	0.4	Yes
House	R32	2,613	2.3	0.8	0.5	Yes
House	R33	2,119	1.6	0.6	0.4	Yes
House	R34	2,436	1.6	0.6	0.4	Yes
The moraine- luxury wedding and events venue	R35	2,786	1.1	0.4	0.3	Yes
House	R36	2,510	1.2	0.4	0.3	Yes
House	R37	2,691	1.1	0.4	0.3	Yes
House	R38	3,105	1.1	0.4	0.3	Yes
House	R39	3,144	1.1	0.4	0.3	Yes
House	R40	3,502	0.7	0.2	0.2	Yes
Karaerea Lakehouse	R41	3,650	0.7	0.3	0.2	Yes
House	R42	4,352	0.4	0.2	0.1	Yes
Pūkaki adventures	R43	4,761	0.5	0.2	0.1	Yes
Pūkaki lakeside getaway	R44	4,447	0.7	0.3	0.2	Yes
House	R45	4,882	0.7	0.3	0.2	Yes
Lake Pūkaki Overnight Campervan parking	R67	393	52.1	18.6	12.4	Yes
Lake Pūkaki Overnight Campervan parking	R68	567	20.6	7.4	4.9	Yes
Red Cat Biplane Flights	R69	5,746	1.1	0.4	0.3	Yes
Twizel	R70	8,012	0.8	0.3	0.2	Yes

Table F.5 *PM_{10} assessment. Estimated receptor GLCs – Maximum PM_{10} 24-hour average. Criterion = 50 $\mu g/m^3$. Background = 16 $\mu g/m^3$*

Name	Label	Uncontrolled incremental GLC [ug/m³]	Incremental GLC with controls [ug/m³]	% of criteria w/back. [%]	Compliance	Comments
House	R18	10.4	3.7	39.4	Yes	
Viewing spot	R19	7.9	2.8	37.7	Yes	
Lakestone lodge	R20	8.5	3.0	38.0	Yes	
walk photo spot	R21	11.6	4.2	40.3	Yes	
House	R22	8.5	3.0	38.1	Yes	
Farm Implement Shed /Barn	R23	23.7	8.5	49.0	Yes	
Lake Pūkaki photo point / public toilet	R24	170.1	60.8	153.6	No	Management controls need to be applied.
Electrical transformer	R25	246.5	88.1	208.3	No	No persons here unless for work purposes.
Mt Cook alpine salmon shop (to be moved)	R26	236.7	84.7	201.3	No	To be closed.
Lake Pūkaki Gate 18 outlet (Meridian Asset)	R27	57.3	20.5	73.0	Yes	
Lake wardel campside	R28	7.6	2.7	37.5	Yes	
Lake Poaka Campsite	R29	3.5	1.2	34.5	Yes	
The moraine fine dining restaurant	R30	4.2	1.5	35.0	Yes	
Mt Cook lakeside retreat, high country	R31	3.1	1.1	34.2	Yes	
House	R32	4.0	1.4	34.8	Yes	
House	R33	2.8	1.0	34.0	Yes	
House	R34	2.8	1.0	34.0	Yes	
The moraine- luxury wedding and events venue	R35	2.0	0.7	33.4	Yes	
House	R36	2.1	0.8	33.5	Yes	
House	R37	1.9	0.7	33.4	Yes	
House	R38	1.9	0.7	33.3	Yes	
House	R39	1.8	0.7	33.3	Yes	
House	R40	1.1	0.4	32.8	Yes	
Karaerea Lakehouse	R41	1.3	0.4	32.9	Yes	
House	R42	0.8	0.3	32.5	Yes	
Pūkaki adventures	R43	0.8	0.3	32.6	Yes	
Pūkaki lakeside getaway	R44	1.3	0.5	32.9	Yes	
House	R45	1.3	0.5	32.9	Yes	
Lake Pūkaki Overnight Campervan parking	R67	89.9	32.2	96.3	Yes	
Lake Pūkaki Overnight Campervan parking	R68	35.6	12.7	57.5	Yes	
Red Cat Biplane Flights	R69	1.9	0.7	33.4	Yes	
Twizel	R70	1.5	0.5	33.0	Yes	

$PM_{2.5}$

Table F.6 $PM_{2.5}$ assessment. Estimated receptor GLCs – Maximum $PM_{2.5}$ 24-hour average. Criterion = 25 $\mu g/m^3$. Background = 7 $\mu g/m^3$

Name	Label	Uncontrolled incremental GLC [ug/m³]	Incremental GLC with controls [ug/m³]	% of criteria w/back. [%]	Compliance	Comments
House	R18	6.3	8.9	63.7	Yes	
Viewing spot	R19	4.8	1.5	33.9	Yes	
Lakestone lodge	R20	5.1	1.6	34.3	Yes	
walk photo spot	R21	7.0	2.2	36.6	Yes	
House	R22	5.1	1.6	34.3	Yes	
Farm Implement Shed /Barn	R23	14.3	4.4	45.6	Yes	
Lake Pūkaki photo point / public toilet	R24	102.8	31.6	154.4	No	Management controls
Electrical transformer	R25	149.0	45.8	211.2	No	No persons here unless for work purposes.
Mt Cook alpine salmon shop (to be moved)	R26	143.1	44.0	204.0	No	To be closed.
Lake Pūkaki Gate 18	R27	34.7	10.7	70.6	Yes	
Lake wardel campside	R28	4.6	1.4	33.7	Yes	
Lake Poaka Campsite	R29	2.1	0.6	30.6	Yes	
The moraine	R30	2.6	0.8	31.1	Yes	
Mt Cook lakeside retreat	R31	1.9	0.6	30.3	Yes	
House	R32	2.4	0.7	30.9	Yes	
House	R33	1.7	0.5	30.1	Yes	
House	R34	1.7	0.5	30.1	Yes	
The moraine	R35	1.2	0.4	29.5	Yes	
House	R36	1.3	0.4	29.6	Yes	
House	R37	1.1	0.4	29.4	Yes	
House	R38	1.1	0.3	29.4	Yes	
House	R39	1.1	0.3	29.4	Yes	
House	R40	0.7	0.2	28.8	Yes	
Karaerea Lakehouse	R41	0.8	0.2	28.9	Yes	
House	R42	0.5	0.1	28.6	Yes	
Pūkaki adventures	R43	0.5	0.1	28.6	Yes	
Pūkaki lakeside getaway	R44	0.8	0.2	28.9	Yes	
House	R45	0.8	0.2	29.0	Yes	
Lake Pūkaki Overnight Campervan parking	R67	54.4	16.7	94.9	Yes	
Lake Pūkaki Overnight Campervan parking	R68	21.6	6.6	54.5	Yes	
Red Cat Biplane Flights	R69	1.2	0.4	29.4	Yes	
Twizel	R70	0.9	0.3	29.1	Yes	

Appendix G

Dust Management Plan (Draft)

Dust Management Plan (DRAFT)

Lake Pūkaki Dam Resilience Works

Meridian Energy Limited

4 November, 2025

→ **The Power of Commitment**

Project name	Meridian - WPS Pūkaki FTC						
Document title	Dust Management Plan (DRAFT) | Lake Pūkaki Dam Resilience Works						
Project number	12656630						
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Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
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The Power of Commitment

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1. Introduction

Meridian will create dust emissions as part of construction works at Lake Pūkaki. GHD was commissioned by Meridian to create a Dust Management Plan (Management Plan) to support site construction works and minimise impacts to the surrounding community. This plan was developed in accordance with the Good Practice Guide for Assessing and Managing Dust (MFE, 2016), which outlines management options for dust emitting sites.

This document forms a preliminary Dust Management Plan, that will require updates based on the outcomes of the recommended continuous improvement and future work outlined in Section 6. Management options include prevention, mitigation and rectification measures, all of which may become necessary during the construction of the Project. The management plan outlines strategies to minimise dust impacts at sensitive receptors, resulting from construction processes and activities.

1.1 Purpose of this plan

This purpose of this (draft) Dust Management Plan is to:

- Comply with the *Good Practice Guide for Assessing and Managing Dust*, the *Canterbury Regional Air Plan,* and other relevant regulatory requirements
- Provide a description of the regulatory requirements relevant to dust and air quality that must be met in the course of undertaking construction works at the Project site.
- Provide a description of the existing baseline monitoring data
- Identify the most likely sources of dust emissions that will be encountered during the construction works.
- Provide employees and contractors with clear descriptions of their responsibilities in relation to dust management during the construction works.
- Provide a description of the measures to be implemented by Meridian (and their contractors) to manage and mitigate dust impacts associated with operations.
- Provide a process for responding to feedback and complaints from affected sensitive receptors.

1.2 Assumptions

This dust management plan is subject to the following assumptions:

- Based on the proposed works, planned activities include stockpiling, material handling, and hauling.
- Other construction activities, such as bulk earthworks, drilling, or excavation are not proposed to occur and are not considered in this dust management plan. Should these activities be required, a revision to this plan will be required.
- No baseline monitoring has been undertaken at this site to support this plan.
- An air quality assessment report, including dispersion modelling, has been considered in the development of this plan.
- This plan is to be read in conjunction with the main report and addresses the construction site, emissions sources, and proposed activities only.
- There may be dust impacts arising from construction activities that are not addressed in this report.
- A Trigger Action Response Plan (TARP) has not been developed as part of this plan. Should it become evident that continuous monitoring is required at the site, this Plan may be revised to add a TARP.

1.3 Compliance with relevant legislation and guidelines

Meridian is required to comply with conditions of consent in additional to relevant legislation and guidelines when undertaking construction activities at the project site. The criteria presented in Table 1.1 are those presented in New Zealand's *Ambient Air Quality Guidelines* (2002), which provide details about the requirements for this plan. The ambient criteria are applied everywhere in the open air, including residences, businesses, and parks.

Table 1.1 Ambient air quality guidelines for particulate matter

Pollutant	Concentration limit (μg/m^3)	Averaging period	Comment
PM_{10}	50	24 hours	Allowance of one exceedance per year
	20	Annual	-
$PM_{2.5}$	25	24 hours	-
	10	Annual	-

The Ministry for Environment's *Good Practice Guide for Assessing and Managing Dust* has a 'trigger level' for managing Total Suspended Particulates (TSP) and PM10. These are values that can be used when there is an active monitor that provides feedback to an activity. Exceedance of these values, shown in Table 1.2 means there is a likelihood of exceeding the ambient air quality guidelines, if mitigations are not implemented. Thus, trigger levels may be considered a 'warning' that permits active operations to be modified before exceedances occur.

Table 1.2 Amenity air quality Trigger Levels for particulate matter in a high sensitivity environment

Pollutant	Averaging time	Trigger concentration (μg/m^3)
PM_{10}	1 hour	150
TSP	5-minute	250
	1 hour	200
	24 hours	60

1.4 Revisions and updates

This management plan is not a static document. It is a working document that requires regular review and updating to ensure ongoing stability and effectiveness for environmental management of the construction process.

The management plan shall be reviewed and updated regularly:

- To remain consistent with relevant regulations and guidelines
- Should improvements to the management measures be required.
- To take advantage of new technologies, innovations, and methodologies that are superior to the management measures presented in the current version of the management plan.
- After changes are made with regards to construction processes that may affect management measures in the current version of the management plan.
- If there are repeated non-conformances against dust objectives and targets outlined in Section 1.3.
- In the event of repeated complaints (more than once for the same aspect).

Changes made to the management plan, as well as the reasons for the changes made, will be documented as part of the review process. Copies of the original management plan, as well as all future versions of the management plan, shall be retained by Meridian and made available upon request. The most recent version will be implemented.

1.5 Responsibilities

The Meridian appointed contractor for the rock protection works at Lake Pūkaki is responsible for ensuring the completeness and effective implementation of the Dust Management Plan. To accomplish this, the contractor's employees will be trained in this plan and their responsibilities designated. Responsibilities will include the deployment, maintenance, monitoring and inspection of equipment and the performance of effective actions to control and minimise dust emissions.

The Site Manager is responsible for:

– Maintaining this plan
– Providing training to staff
– Providing guidance on dust control measures
– Ensuring inspections are being undertaken.
– Ensuring that proper records are maintained.

2. Site description

2.1 Location

Lake Pūkaki is located in the South Island of New Zealand and makes up part of the Mackenzie Basin. It is located approximately 200 km west-southwest of Christchurch, in the middle of New Zealand's South Island and almost directly south of Mount Cook (Aoraki).

Lake Pūkaki is approximately 30 km long (north to south) and 5 km wide (east to west). It is approximately rectangular in shape. The lake sits at the southern end of the Tasman River delta, which is comprised primarily of glacial till and sediments. The lake comprises a surface area of approximately 172 km^2 based on an average lake level of 528 m RL and an estimated water volume of 5,604,000,000 m^3 (5.6×10^9 m^3) (Opus International Consultants Limited, 2002).

The Pūkaki High Dam is located at the southern end of the lake. The nominal flow direction in the lake is from north to south, with water discharging from the lake via Gate 18 (into the Pūkaki canal) or Gate 19 into the Pūkaki Riverbed.

2.2 Background

Lake Pūkaki is a modified natural lake and is managed as part of the Waitaki Power Scheme. It is New Zealand's largest hydro storage lake and provides an average of 1,767 GWh of stored water in normal operating conditions, with an additional 546 GWh available during a national hydro shortage.

Meridian is currently authorised to dam the Pūkaki River to control and operate Lake Pūkaki between the levels of 518 m RL (normal consented minimum lake level) and 532.5 m RL (maximum consented storage level).

3. Programme of works

3.1 Proposed construction activities

Meridian is proposing two activities, being:

– Over a three-year period, having the ability to lower the lake levels below 518 m RL to a minimum level of 513 m RL, so that stored lake water can be used to generate electricity. The dust management plan associated with this activity is located within the relevant air quality report and is not discussed in any further detail here.
– When the lake levels are low, extending rip-rap armouring to reduce the risk of erosion on the dam face and other critical infrastructure. Rip-rap currently exists along the dam upstream face; however the rock armouring is inadequate to protect the dam and associated infrastructure if water levels were drawn below 518 m RL.

3.2 Programme

The rip-rap placement programme is scheduled to be completed over a period of approximately 18 weeks. This will likely occur in shorter phases over a period of several years.

The construction methodology is based on the following programme.

– Construction activities may be short in duration (a few weeks) and occur over multiple stages.
– It may take multiple years to complete all the required works.
– Access is expected to be more frequent at higher lake levels within the 518 m to 513 m range, rather than at the lower end.

- The assumed approach is for rip-rap placement in a multi-stage process with rip-rap being placed when lake levels allow.
- Forecasting lake levels within a period of a few weeks is generally achievable based on predicted generation flows from the lake, predicted inflows, and predicted rainfall events in a 1-to-2-week window.
  - Based on this data, guidance can be provided to a contractor as to when lake levels are likely to reach required levels for construction to commence and how long they are likely to stay low in the short to medium term.
- Given the time required to mobilise and demobilise from the site, contractor guidance indicates that the minimum duration for any construction stage is 3 weeks.
- Inflow events, whether predicted or not, can result in a relatively rapid rise in lake level. Historical data indicates that the lake can rise up to 1 m in one day and 3 m in one week. Therefore, the construction sequence must include contingency plans for rapid site demobilisation, ensuring the site is left in a safe and environmentally appropriate condition prior to water inundating the works area.
- Historical data indicates that low lake levels at Lake Pūkaki most frequently occur during mid to late winter and early spring.
- Construction activities will be restricted to the following schedule:
  - Daily: 6:00 a.m. to 7:30 p.m.
  - No work during the following periods:
    - Good Friday to Easter Monday (inclusive)
    - 24, 25 and 26 December (inclusive) and 31 December to 1 January (inclusive)
    - New Zealand Public Holidays

3.3 Dust emission sources

Potential dust sources are grouped into the following:

- Material handling of rip-rap
- Haulage along identified, unpaved haul roads
- Wind erosion from stockpiles
- Transfer of rip-rap material on and off haul trucks.

4. Surrounding environment

4.1 Sensitive receptors

A detailed list of identified potentially sensitive receptors around the whole lake is provided in GHD (2025a). A consolidated list of lake environs receptors is also provided in GHD (2025a).

The sensitive receptors closest to the dam earthworks sites (and potentially most affected by proposed construction activities) are identified as the following:

- A residence is located about 760 m from the Left abutment work site.
- A publicly accessible observation and photo point immediately adjacent to the Left abutment site. This is a place where people will transit through.
- A business (Mt Cook Alpine Salmon Shop) is immediately adjacent to the Right abutment construction site but it is to be closed for the duration of any works and is therefore not required to be assessed.

- The Pines freedom camping area is considered to be potentially the most exposed to a potential change in air quality associated with the proposed works, located at a distance of about 105 m from the northeast corner of the Left abutment construction site.
- A second freedom camping location is considered to have high exposure but less than the one described above due to a greater distance from the Left abutment work zone.

4.2 Baseline data

No site-specific baseline air quality data is available. The study in the main body of this report utilised background dust data from the New Zealand Transport Agency (NZTA) that is focussed on urbanised areas.

5. Dust management

The main features of the dust management strategy are based on prevention, mitigation, and rectification. The mitigation and rectification measures will be implemented as required and their exact details will be determined on a case-by-case basis depending upon the situation and the technical solutions available at the time. The proposed management strategies are described in the following sections.

5.1 Prevention measures

The following prevention measures should be taken at the Project site:

- Prepare dust management education material for inclusion in site inductions, training, and daily toolbox meetings.
- Prepare and undertake a regular audit to ensure compliance with conditions of the permit. Audit records should be stored in the Site Office.
- Plan construction activities to keep exposed areas to a minimum and, where possible, avoid scheduling major emissions-generating activities to occur at the same time.
- All plant and equipment should be fitted with the appropriate emissions controls and maintained according to the manufacturer's specifications.
- Implement on-site traffic and operational controls to prevent unnecessary dust generation from vehicle movements, including regularly watering access roads if rainfall is insufficient to suppress dust, inspecting incoming trucks to ensure trucks transporting material are covered and tailgates are firmly fixed, and enforcing speed limits.
- Do not undertake dust-generating activities during adverse weather conditions when visible plumes of dust are observed to leave the Project boundary.
- Bins, rubbish, and storage areas will be monitored during regular audits and emptied at regular intervals.

Additional prevention measures

In addition to the operational preventive measures outlined above, Meridian may wish to consider the following measures to prevent exposure to dust emissions:

Weather forecast

- Assess upcoming weather conditions for the day and plan site activities accordingly. Pay particular attention to periods of forecast or observed high winds
- If meteorological conditions deteriorate consider:
  - Modifying or ceasing activities that generate dust which have a direct impact at nearby sensitive receptors, or

- Adding additional mitigation measures at source to control adverse dust conditions.

Restricting public access

– Consider closure of the public toilets immediately adjacent to the construction area.

– Short-term closure of the campsite to the north of the left abutment construction area when construction works are being undertaken.

Air quality monitoring

– Consider placement of air quality monitoring at locations that can be used to best assess potential offsite dust emissions.

  - Likely locations are southeast of the primary stockpile site to enable the effect of the frequent norwesters to be assessed, and/or near the campsite adjacent to the left abutment.

– Dust deposition gauges offer the simplest method of assessing dust, however, the requirement for immediate feedback and ability to provide this feedback in a cost-effective way needs to be considered when determining the most appropriate measurement method.

– Should air quality monitoring be implemented at the site, a Trigger Action Response Plan (TARP) will need to be developed for use in conjunction with this Management Plan.

5.2 Mitigation measures

The following mitigation measures are to be taken at the Project site:

– Perform daily inspections for visible emissions along the site boundary of the Project site.

– Use dust suppression techniques (such as watering via watering trucks or sprinkler systems) as needed to maintain moist conditions on cleared or exposed areas, unsealed roads, temporary stockpiles, and high dust generating activities.

– Retain as much vegetative screening between the Project site and the nearest sensitive receptors as possible.

– Instigate progressive rehabilitation as soon as practicable to encourage the establishment of vegetation as soon as possible after the works.

– Consider covering loads in trucks, or spray loads as an alternative.

– Install wind breaks surrounding primary temporary stockpile locations. Given the often-extreme wind conditions experienced at the site, porous wind breaks should be considered in favour of solid wind breaks. Whilst this is a less effective mitigation measure, it will ensure that the wind break does not become a safety hazard under excessive load.

5.3 Rectification measures

The following rectification measures are to be taken at the Project site:

– Record environmental complaints and maintain regular reviews and reporting of performance. Complaints made during an initial block of works may inform preventative measures to be undertaken during subsequent construction works.

– Consider increasing water sprays as needed and/or cover temporary stockpiles when not in use.

– Develop alternative methods to reduce dust generation.

5.4 Corrective actions

Corrective actions are to be undertaken to a level proportional to the severity of complaint. Upon receipt of a valid complaint, the following tasks will be undertaken:

– Conduct a detailed review of all on-site activities undertaken at the time when the complaint was received.
– Identify key on-site activities contributing to off-site impacts. This will be achieved by:
    - Undertaking a visual inspection of construction processes and activities to ascertain the source of dust emissions relevant to the complaint.
    - Assessing weather data during the time period for which the complaint was made.
– Upon identification and attribution of the likely activities/sources responsible for the complaint, revised operations or additional mitigation measures will be trialled to improve (reduce) emissions from the source.
– If the trial proves effective at managing the source, a revision to the standard operating procedures will be documented and implemented across site. If the trial did not prove effective, alternative mitigation options may be trialled until an effective solution is found.

5.5 Training

All personnel should receive induction training prior to entering site. Training should include:

– Location of sensitive receptors.
– Implementation of the dust mitigation measures outlined above.
– Roles and responsibilities in regard to dust mitigation and management.
– Incident response, management and reporting procedures.
– Environmentally safe work methods relating to dust.

Supervisors and workforce representatives that are nominated to undertake monitoring and inspections will be trained specifically for this task. Mitigation measures outlined above will be consistently covered in toolbox talks to serve as a reminder to the workforce.

Other specific topics covered by the toolbox talks will be planning and preparation for high wind or regional dust events. Lessons learned during the construction and operation of the site and updates to this DMP will be communicated to the workforce in toolbox talks.

5.6 Consideration of cultural impacts

It is recognised that temporary restriction of access to areas around the lake could have cultural impacts. Therefore, any discussions and decisions should be made with consultation between all potentially affected parties.

5.7 Communications strategy

Meridian are to develop and implement a communications strategy that includes stakeholder engagement procedures. The communications strategy should include, but not be limited to:

– Procedures for issuing works notification to nearby residents and property owners to informed them of Project staging and operational activities
– Provides communications avenues for members of the public to ask questions and lodge complaints regarding the operations of the site.

Notification regarding specific construction activities should be provided to adjacent residents and property owners likely to be affected by dust emissions from works. Such notification should be provided prior to the activity commencing (typically one week notice) and should provide the following details:

– the reason for the activity
– types of equipment required

– the expected commencement of the activity
– activity hours of operation
– the likely duration and impact of operation at the site and any requirement for subsequent additional works
– contact details for further information and complaints.

Schedule daily follow-ups and check-ins with adjacent residents and property owners regarding dust impacts, where reasonable and practicable.

6. Continuous improvement

This Dust Management Plan is a Site-specific document that identifies fugitive sources of dust emissions from the Site and the Best Management Practices for controlling these sources. This plan will be reviewed and updated on an annual basis, or more frequently as required to reflect changing Site conditions. It will build on current and known practices with a commitment to continuous improvement.

7. Version control

Table 7.1 Document Version Control

Version	Date	Description of Changes
1.0	5/11/2025	DRAFT

Appendices

Appendix A.1

Daily Inspection/Maintenance Report

Appendix A.2

Site Training Log

Appendix A.3

Dust Complaint Report

Appendix A.4

Complaint Response Letter

Appendix A.5

Contractor Dust Management Plan

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