ASSESSMENT OF ENVIRONMENTAL EFFECTS

DISCHARGE OF CONTAMINANTS INTO AIR FROM THE OPERATION OF AN ALLUVIAL GOLD MINE

PREPARED FOR:

HAWKESWOOD MINING LIMITED
TEVIOT ROAD
MILLERS FLAT

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Glossary

Site	The extent of the land titles that operations will take place on
Activity boundary	The extent of all activities (dredging, stockpiling, accessways) within the site (68 ha)
Active area	The extent of all activities (dredging, stockpiling, accessways) at any one time (max 27 ha)
Dredging	The activity of operating the pit and dredge
Target alluvial material	The alluvial material to be processed through the dredge

1. Introduction

Hawkeswood Mining Limited ('HML') is seeking resource consent to establish and operate an alluvial gold mine on the subject site, including on-site processing of the gold-bearing target alluvial material and progressive rehabilitation back to pasture.

The site boundary is located approximately 1 kilometre (km) north-east of the township of Millers Flat, on the eastern (true left) bank of the Clutha River / Mata-Au, as shown on Figure 1. Over the life of the operation, it is anticipated that approximately 12 million cubic metres (m^3) of alluvial gravels will be mined over an area of 68 hectares (ha).

Processing of alluvial material will involve the removal and temporary stockpiling of topsoil and overburden, sluicing of the material using a mobile floating barge (referred to as 'dredging' in this report) and the progressive rehabilitation of the open sluicing area. In total, at any one time, an active working area (comprising the open pit, stockpiles and roadways) of no more than 27 ha will be exposed.

This report provides an assessment of the potential effects of discharges to air from the proposed activity. Its purpose is to support a resource consent application to Otago Regional Council (ORC).

The main discharge to air from the proposed activity, and the focus of this assessment, will be dust generated from the alluvial material, including respirable fractions.

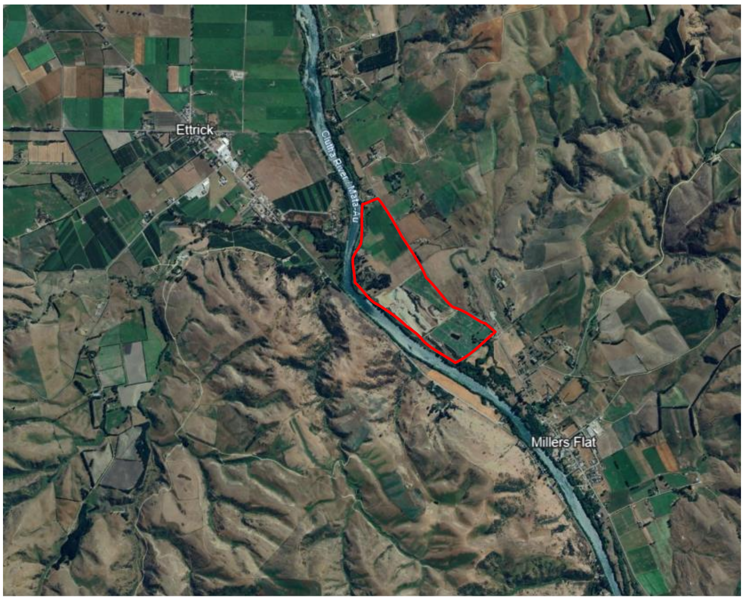


Figure 1. Location map illustrating the proposed mining site (red outline) in relation to the township of Millers Flat and Ettrick (base map sourced from Google Earth)

2. Description of the proposal

2.1. Overview

This section provides an overview of the proposed mining development to the extent that it is relevant for this assessment. In general terms the development includes site preparation, the dredging operation including overburden removal, and rehabilitation.

The activity area is illustrated in Figure 2 and covers a total of 68 ha. It is expected the dredging can be completed within 5-7 years based on continuous operations throughout the year.

2.1.1. Site preparation and bunding

A test pit area has already been established on the site. Infrastructure to support the test pit area include site access, office and kitchen facilities, access roading into the mining areas, the test pit itself and bunding of the perimeter area around the test pit. Overburden has been used to create a series of bunds around the perimeter of the site. Excess overburden has been stockpiled, ready for use in the progressive rehabilitation.

The test pit has been established in a central location on the site and will be used as the commissioning location for the floating dredge (shown in Appendix 1; Figure 5). Further bunding along the western extent of the site, adjacent to the Clutha River / Mata-Au, will also take place prior to commencing the dredging.

Prior to commencing dredging the test pit will be enlarged to the full 'working pit' size. Overburden and topsoil associated with establishing the pit will be stockpiled on site.

2.1.2. Topsoil and overburden removal / re-establishment

Topsoil and over burden will need to be removed to gain access to the target alluvium. Appendix 1; Figure 1 illustrates a cut from the current test pit and the approximate depth of the topsoil, overburden and target alluvium. Topsoil and overburden will be removed progressively as the pit advances. It is expected that this will take place approximately once per week, exposing up to 750 m^2 of the target alluvium. A high proportion of this material will be used to immediately backfill overtop of the dredge's tailings. Depending on logistics and available area to rehabilitate, some of this material may also be temporarily stockpiled.

2.1.3. Dredging

The chosen mining method will make use of a floating gold plant located at the base of the 'working pit'. The target material to be mined is isolated in the lower part of the alluvial materials that sit above the base schist.

The target alluvium is dug up using an excavator and placed into a hopper on the floating gold plant. Gold is separated from the alluvial material using water and gravity to separate and settle out the denser gold particles. The tailings are then returned to the mine pit. The proposed process does not use any chemicals in the collection process. Approximately 180 cubic meters (m^3) of alluvium will be processed per hour (~330 tonnes).

The extent of the working pit will be 150 m by 100 m (1.5 ha) at up to 18 m depth, with the excavator and dredge working the active face. As material is processed it will be ejected out the back of the dredge progressively filling in the working pit. Mining will progress in 4 stages, as shown in Figure 2, with the working pit traversing from side to side within the activity boundary. Rehabilitation (backfilling with tailings, overburden and finally top soil) will occur progressively.

2.1.4. Hours of operation and staffing

The proposed hours of operation are 7 am to 7 pm Monday to Friday and 7 am to 1 pm on Saturdays. No earthworks or dredging operations will occur on Sundays or Public Holidays. Some machinery maintenance and dust control activities may occur on Saturday afternoons, Sundays or Public Holidays. There will typically be around 20 staff employed on site.

2.1.5. Screening and setbacks

The proposed activity area is illustrated in Figure 2. A 4 m-high bund will be constructed around the edge of the works (Figure 2 also). This bund is designed primarily as visual mitigation, but will also assist in providing wind shelter for activities undertaken in the immediate vicinity. Trees along the bank of the Clutha River / Mata-au and in the south-eastern extent of the site will also provide some limited wind breaks.

2.1.6. Rehabilitation and end use

Post-reinstatement of the topsoil, the intention is for the topsoil to be seeded with grass and returned back to pasture. This will enable continuation of farming practises after the mining operations have been completed.

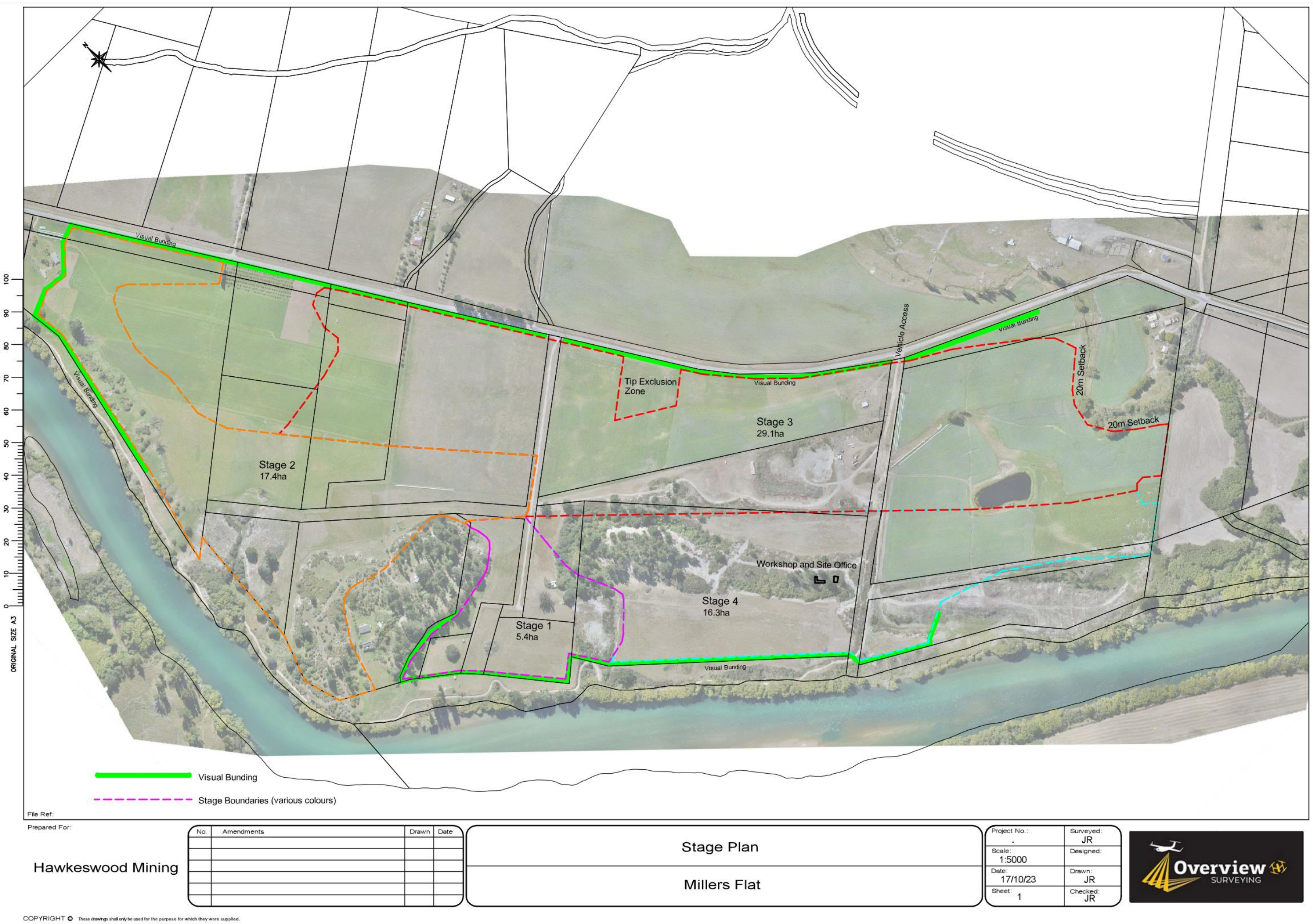


Figure 2. Aerial map illustrating the stage plan for the dredging operations and the extent of the visual bunding.

2.2. Nature of discharges to air

The main source of discharges into air will be dust. Table 1 below outlines the various activities undertaken onsite and their potential to generate dust. These activities have been categorised here and will be used throughout this report when assessing the controls and determining the potential affects.

Table 1. Activities undertaken as part of the site operations and their potential to generate dust

Activity	Potential to generate dust (relative scale)	Description
Topsoil and overburden removal and transport	High	Topsoil contains a high proportion of finer grained material (silt and sand).
Stockpiling of topsoil and overburden	Moderate	Increased risk of windblown dust from exposed stockpiles and bunds.
Dredging of the wash with excavator	Low	Undertaken as a wet process.
Processing of alluvium through the gold plant	Low	Undertaken as a wet process.
Replacing overburden and topsoil	High	Topsoil contains a high proportion of finer grained material (silt and sand).
Vehicle movements on roads and accessways	Low-Moderate	Unsealed roads and accessways.

Dust can broadly be split into two categories: nuisance effects and health effects. A description of both is provided below.

2.2.1. Nuisance effects

The most common concerns relating to dust discharges are nuisance impacts. These generally impact people's amenities. Adverse effects can also occur on sensitive vegetation during significantly high dust deposition loadings, but are typically only a concern in very close proximity to a source. Impaired visibility effects can occur when there are significant dust discharges. However, these are usually only a concern in the immediate vicinity of the source or where they pose a hazard to people, for instance a 'dust cloud' across a roadway.

There are no quantitative standards or thresholds for dust nuisance in New Zealand. However, MfE (2016) does provide a dust 'nuisance trigger' recommendation for total suspended particulate (TSP) of 150 $\mu g/m^3$. The intention of the TSP trigger is for it to be used to monitor and proactively manage dust emissions from sites. For deposited dust MfE (2016) also provides a trigger value of $4 g/m^2/30$ days; as the results are a cumulative value averaged over the previous 30 days, its use is more reactive than proactive to a dust issue.

Instances where the trigger value is reached does not necessarily mean that dust nuisance effects have or will occur. Instead, this value is intended as an indicator that the dust mitigations controls may not be adequate and should be checked and re-evaluated or activity ceases until more favourable conditions (i.e reduced windspeeds) occur.

The approach for assessing potential dust nuisance effects from the proposed site is provided in Section 4.1.

2.2.2. Health effects

Potential health effects resulting from suspended dust are associated with the smaller respirable fractions. Particles of less than 10 microns in diameter (PM_{10}) are typically the focus in relation to adverse health effects and assessments. These sized particles can be generated from a range of sources including combustion processes, industrial manufacturing, quarrying/mining and from non-anthropogenic sources including marine aerosols. New Zealand has a National Environment Standard for PM_{10} which limits the 24-hour average concentration to 50µg/m^3.

Research indicates that $PM_{2.5}$ particles (particles less than 2.5 microns in diameter) represents the greatest concern with respect to human health risks from fine particulate exposure. $PM_{2.5}$ particles are typically associated with combustion processes, such as domestic fires and motor vehicles. The $PM_{2.5}$ fraction of dust generated by mining of alluvial materials such as is proposed by HML, is expected to be very low. As such the health-based effects assessment in this report is focussed solely on PM_{10}.

With regards to nuisance dust, MfE (2016) also provided guidance on appropriate trigger values for PM_{10} discharges from various activities. Instances where the trigger value is reached does not necessarily mean that health effects have or will occur, but instead is intended as an indicator that PM_{10} levels are elevated and controls should be assessed.

Dust emissions from aggregate extraction can contain a fraction of respirable crystalline silica (RCS). Exposure to RCS has a potential to cause silicosis, where people may be exposed to high levels of … for prolonged periods. The potential for an activity to generate airborne RCS is related to the level of crystalline silica in the rock/gravels being processed and the type of processing. The activities carried out onsite will not involve any crushing and grinding of material and therefore the potential for the activity to generated RCS is low. Furthermore, the alluvial material will be processed wet avoiding potential discharges of RCS. On this basis the assessment of effects and subsequent controls relating to PM_{10} are adequate to also control the potential release of RSC.

3. Receiving environment

3.1. Surrounding land use

The site is located in Miller Flat, Central Otago. A full description of the site is provided in the resource consent application. For the purpose of this assessment a brief description is provided here as it relates to air quality.

The proposed mine site is located at 1346–1536 Teviot Road, Millers Flat. The site topography is relatively level to gently undulating on a terrace above the Clutha River / Mata-Au. The proposed site is illustrated in Figure 3 below. The surrounding area is rural with land predominantly used for pastoral farming activities. The township of Millers Flat is located approximately 700 m to the south-east at the closest point. The township of Ettrick is located approximately 800 m north-west of the site.

The Clutha River / Mata-Au is located to the west and southwest of the site. The river is a Statutory Acknowledgement Area and has a range of intrinsic, cultural, recreational and aesthetic values, and is used by the general public for fishing, boating and other recreational uses.

The Clutha Gold Cycle Trail (the 'cycle trail') is a compacted gravel track, running between Roxburgh and Lawrence, and linking to other cycle trails in Central Otago. The cycle trail runs along the Clutha River / Mata-Au to the west and south-west of the site, before cutting through the site via the paper road, to then travel along Teviot Road toward Millers Flat as shown in Figure 3.

HML has obtained written approval from a range of the neighbouring property owners as shown in Figure 3 (adapted from Town & Planning AEE, 2022).

Figure 3 also shows properties adjacent to the site, 'A' – 'O', where written approval has not been obtained; these have been included in the assessment of effects in Section 4. Table 2 contains a description of identified receptors along with their separation distance and their expected sensitivity to the effects of dust based on the MfE (2016) guideline. Individual properties with dwellings have been identified in Table 2 and are referred to as 'rural residential'; pastoral land with no dwellings have been grouped together for simplicity and referred to as 'rural'.

Effects on dwellings not identified in Figure 3 and Table 2 (i.e. greater separation distances) are also discussed in the assessment of effects (Section 4).

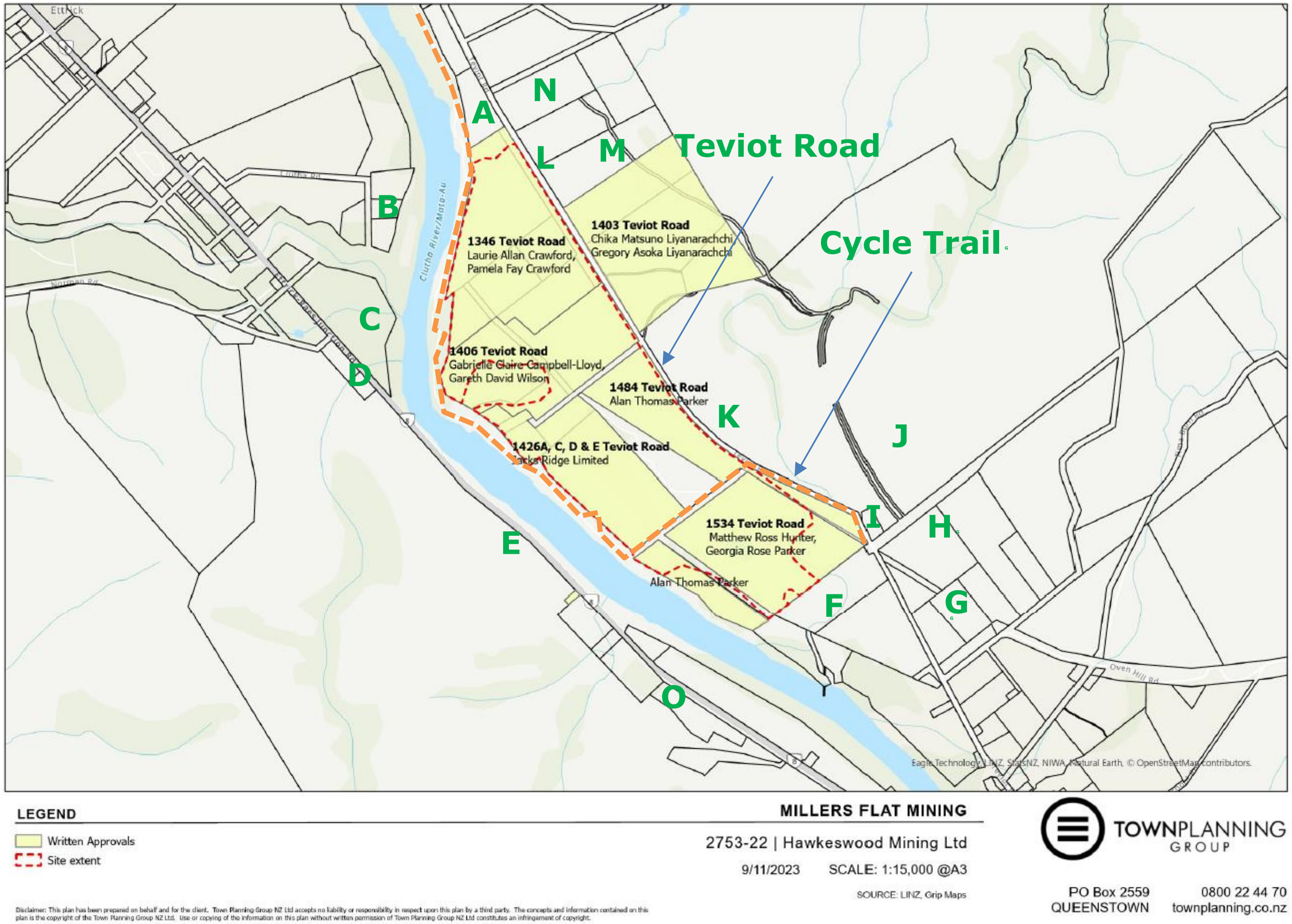


Figure 3: Adjacent properties in relation to HML's site. Red outline areas denote the proposed mining area.

Table 2. Summary of the land use types surrounding the site, distance from the activity boundary and anticipated sensitivity of the land use. Bolded properties are considered higher risks based on the screening level assessment (Section 4).

Notation on Figure 3	Steet address (if applicable)	Type of activity (based on MfE categories)	Sensitivity to dust (based on MfE categories)	Distance to property boundary (m)	Distance to dwelling (m)
A	**1334 Teviot Road**	**Rural Residential**	**Moderate-high**	**70**	**90**
B	**61 Clutha Road**	**Rural Residential**	**Moderate-high**	**210**	**260**
	67 Clutha Road	**Rural Residential**	**Moderate-high**	**210**	**260**
	69 Clutha Road	**Rural Residential**	**Moderate-high**	**210**	**260**
	68 Clutha Road	Rural Residential	**Moderate-high**	320	330
C	-	Rural	Low-moderate	170	-
D	**5280 Ettrick-Raes Junction Road**	**Rural Residential**	**Moderate-high**	**270**	**280**
	5330 Ettrick-Raes Junction Road	**Rural Residential**	**Moderate-high**	**230**	**220**
E	-	Rural	Low-moderate	230	-
F	-	Rural	Low-moderate	170	-
G	23 Oven Hill Road	Rural Residential	Moderate-high	470	545
	23a Oven Hill Road	Rural Residential	Moderate-high	370	520
	1518 Teviot Road	Rural Residential + Holiday accommodation	Moderate-high	330	460
H	1537 Teviot Road	Rural Residential	Moderate-high	220	420
I	**1535a Teviot Road**	**Rural holiday accommodation**	**Moderate-high**	**150**	**180**
J	1535a Teviot Road	Rural Residential	Moderate-high	20	360
	1535a Teviot Road (rear house)	Rural Residential	Moderate-high	Adjacent	540
K	-	Rural	Low-moderate	Adjacent	-
L	-	Rural	Low-moderate	Adjacent	-

Notation on Figure 3	**Steet address (if applicable)**	**Type of activity (based on MfE categories)**	**Sensitivity to dust (based on MfE categories)**	**Distance to property boundary (m)**	**Distance to dwelling (m)**
M	**1377 Teviot Road**	**Rural Residential**	**Moderate-high**	**Adjacent**	**270**
N	**1333 Teviot Road**	**Rural Residential**	**Moderate-high**	**50**	**240**
O	5434 Ettrick-Raes Junction Road	Rural Residential	Moderate-high	370	420
Cycle trail	**-**	**Recreation**	**Moderate-high**	**Adjacent**	**-**
Teviot Road	Teviot Road	Public Road	low	Adjacent	-

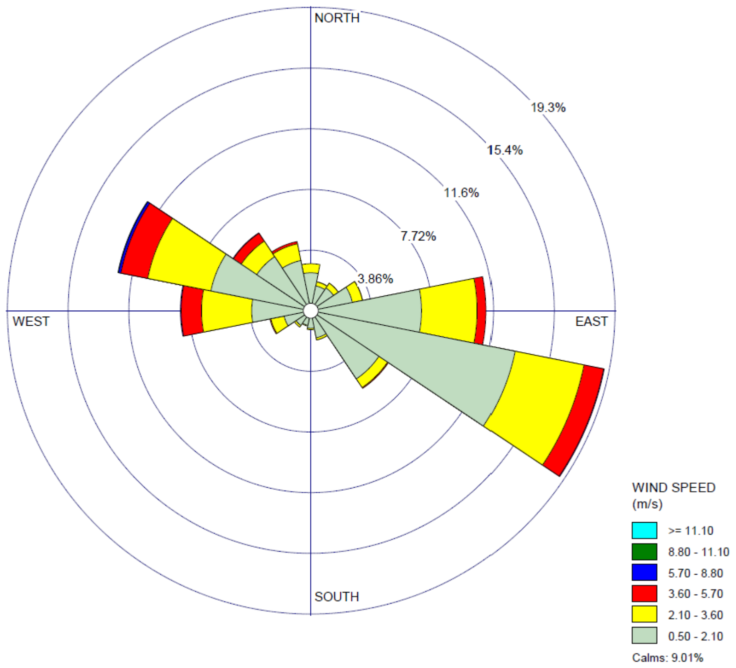
3.2. Meteorology

A wind rose has been generated from Metservice's automatic weather station (AWS) (C75834) at Millers Flat (displayed in Figure 4) based on calendar years 2021 and 2022. Given its proximity to the site, this AWS is expected to be an excellent representation of the local wind conditions.

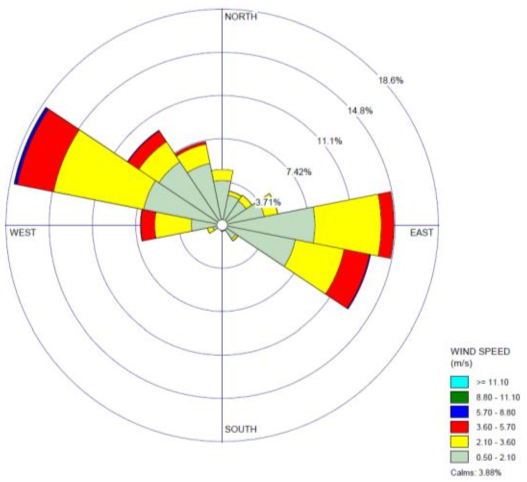
The data illustrates two very prominent wind directions from the west north-west (247.5 - 337.5 degrees) and east south-east (67.5 – 157.5 degrees) directions. Wind from these two sectors occurs for 41% and 32.5% respectively. Calm conditions (<0.5 m/s) account for 9.5% of the record and the balance (17%) from all other directions.

The wind data has also been presented as daytime (7 am-5 pm) and nighttime (5 pm-7 am) in Figure 4. Of most relevance is the daytime conditions as this is when HML will generally be operating. Not unexpectedly wind during the daytime has increased speed, although the two predominate wind directions are more evenly distributed. Nighttime conditions have lower wind speeds with the highest proportion of calms (<0.5 m/s). The met station's mast is ~6 m tall and the relevance of this is discussed further in the assessment of environmental effects.

All hours



Daytime
(7:00am – 5:00pm)



Nighttime
(5:00pm – 7:00am)

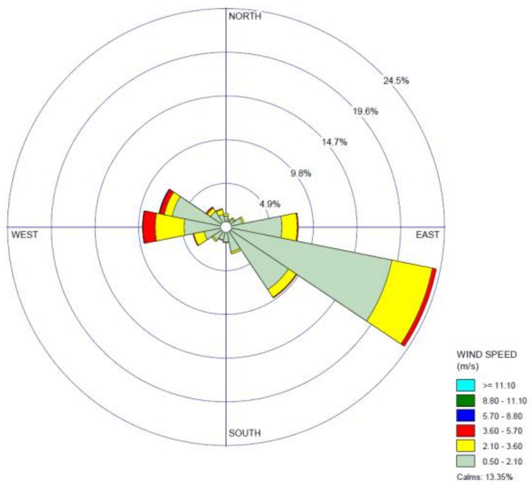


Figure 4. Wind rose for 2021-2022 as measured at Metservice's AWS at Millers Flat.

Central Otago is the driest region of New Zealand, with the Millers Flat area receiving ~650 mm of rainfall annually, resulting in soils being moisture deficient for 6 months of the year (Macara, 2015). Dry spells of more than two weeks occur relatively frequently in Central Otago. Temperatures are on average lower than over the rest of the country with frosts and snowfalls occurring relatively frequently each year in the winter months. However daily maximum temperatures in summer can exceed 30°C, especially about inland areas of Otago (Macara, 2015).

3.3. Air Quality

Regional Councils and Unitary Authorities have identified areas where air quality could reach levels higher than the National Environmental Standards for Air Quality Regulations 2004 (NESAQ). These areas are called Airsheds.

Airsheds have been identified based on a Regional Council's knowledge of existing air quality data and the location of significant sources and factors that affect the spread of pollution (such as local geography and weather). These Airsheds have been published in the New Zealand Gazette and Councils are required to monitor, manage and report air quality within the airshed in accordance with the NESAQ. The applicant's site is not within a designated Airshed and defaults to the 'rest of Otago' airshed under The Regional Plan: Air for Otago (the Air Plan). The nearest urban Airshed is Roxburgh, located 10.5km to the north-east. HML's activity is not expected to have any measurable effect on the air quality in this Airshed.

For the Millers Flat area, air quality is considered to be generally good. At times air quality will be affected by local activities including rural activities such as dust from field ploughing and fertilizer applications, and emissions from open fires, and domestic activities such as home fires and to a lesser degree transport emissions on local roads. Weather and climate in the area is likely to affect the level of contaminant's discharged, for example elevated dust discharges during drier summer months.

3.4. Consent requirements

Rule 16.3.5.2 of the Regional Plan: Air for Otago states:

The discharge of contaminants into air from the sorting, crushing, screening, storage and conveying (including loading and unloading) of fertilisers, grains, berries, coal, coke, wood chips, sawdust, wood shavings, bark, sand, aggregates, and other powdered and bulk products whether in dry or liquid form, where:

(1) The total capacity of outside storage of bulk materials is less than 1,000 m3 if located on a site in Air Zone 1 or 2; and

(2) The crushing and screening of bulk materials is at a rate less than 100 tonnes an hour;

is a permitted activity, providing any discharge of odour, or particulate matter is not offensive or objectionable at or beyond the boundary of the property.

Rule 16.3.5.3 of the Regional Plan: Air for Otago states:

The discharge of contaminants into air from:

(1) The extraction of minerals from the surface or from an open pit at a rate less than 20,000 cubic metres per month and 100,000 cubic metres per year; or

(2) The crushing and screening of minerals at a rate less than 200 tonnes an hour; or

(3) The drying or heating of minerals from single activities or a combination of activities on one site with equipment that has a heat generation capacity of less than 500 kW; or

(4) The making of refractory, bricks or ceramic products at a rate less than 200 kg/hr of products;

is a permitted activity, providing:

(a) The mineral extraction, crushing and screening activities are located in Air Zone 3; and

(b) In the case of equipment installed after 28 February 1998, any chimney complies with Schedule 6 ("Determination of Chimney Heights"); and

(c) *Any discharge of smoke, odour or particulate matter is not noxious, dangerous, offensive or objectionable at or beyond the boundary of the property.*

The proposed site is within Air Zone 3, however as the gold plant will be wet screening at a rate of up to 330 tonnes per hour (180 m^3 of gravel), it cannot meet the permitted activity provisions of Rules 16.3.5.2 and 16.3.5.3 and therefore defaults to a ***discretionary activity*** in accordance with Rule 16.3.5.9.

4. Assessment of environmental effects

The processes undertaken on site are described in Section 2. The emissions to air that require consideration in this AEE are limited to particulate matter and this has been undertaken below.

4.1. Nuisance effects

The assessment of potential dust nuisance effects from the site has followed the MfE's '*Good Practice Guide for Assessing and Managing Dust*' (MfE 2016). An initial screening evaluation using separation distance guidance has been undertaken, followed by a more detailed consideration of identified sensitive locations. The FIDOL factors (described in more detail in Section 4.1.2) at each location was used to evaluate the risk of impacts.

HML operations are unique from that of a typical quarry or mine as the activity (activity area and processing facility) will progressively move over the 68ha site, resulting in continuous changes to downwind receptors locations and separation distances. For the purpose of this assessment a conservative approach has been taken by assessing the minimum distances and accounting for any sensitive receptors that may be downwind of the activity area at any time. Mining operations across the whole site are expected to take 5-7 years to complete; any risks of adverse effects from dust, at any one sensitive receptor, is likely to be only for a fraction of this time period, in the vicinity of the active area.

4.1.1. Screening assessment

The initial screening assessment is based on the separation distance between sensitive neighbours and dust-generating activities. By having a suitable separation distance, dust emissions can be dispersed, diluted and deposited to such an extent that their effects at sensitive locations should be minimised to an acceptable level.

MfE (2016b) notes that "*Separation distance guidelines are not intended to be used as a pass/fail test, rather as a trigger for more detailed assessment to determine the appropriate separation distance for a particular site*". They are generally designed to provide a level of mitigation for acute discharges (i.e. high wind events) where the employed site dust controls may not be fully effective. Site specific factors which may influence discharge rates and how they are dispersed, for example terrain or any specific controls are not taken into account.

Environment Protection Authority Victoria publishes a 'recommended separation distances for industrial residual air emissions' (EPA Victoria, 2013). In New Zealand these buffer guidelines have been extensively used and are accepted as appropriate separation distances.

In accordance with the EPA Victoria (2013) guidelines, a separation distance of 250 m from the active area to sensitive areas would be applicable in this instance based on '*Mine for other minerals'*.

Many of the identified dwellings are on larger lifestyle or farm blocks. Separation distances have been calculated based on the distance to a neighbouring dwelling (as opposed to the property boundary). This is referred to as Method 2 'the rural method' in EPA Victoria (2013) and is appropriate for this assessment.

Taking into account the location of sensitive receptors as described in Table 3, four of the neighbouring dwellings are within 250 m of an active area. These are locations **A** (1334 Teviot Road), **B** (61-69 Clutha Road), **I** (1535a Teviot Road) and **N** (1333 Teviot Road) and are shown in bold in Table 2. Location **D** (5280 & 5330 Ettrick-Raes Junction Road) and **M** (1377 Teviot Road) are just outside of the 250 m separation zone, however have been identified as higher risk for the purpose of this screening level assessment. Applying a 250 m separation distance is expected to be conservative for routine dust emissions. Other Regional Plan's permitted activity provisions for discharges of dust to air specify 200 m separation distances for mining and extraction activities (i.e. *Environment Canterbury and Auckland Council*).

Sensitive areas, including dwellings, beyond 250 m from the proposed activity area are considered unlikely to experience a significant level of nuisance dust effects. The cycle trail and Teviot Road are within 250 m of the active areas and the actual and potential effects on these locations is covered in the FIDOL (detailed) assessment.

Receptor **E**, **F**, **C**, **K** and **L** and (representative rural properties with no dwellings) were identified as being within 250 m of the site. Rural pastoral areas have low-moderate sensitivity to dust (MfE, 2016); Air Matters considers that the sensitivity in this region is at the lower end of the scale. Potential effects are likely limited to dust deposition onto pasture. High rates of deposition generally occur in very short distances from source (<100 m) and therefore unlikely to be an issue for the surrounding rural pasture.

4.1.2. FIDOL Assessment

This section provides a detailed FIDOL assessment that focuses on the exposure of sensitive locations to dust emissions. For dust emissions to become an adverse effect beyond the site boundary there are two aspects to consider.

- Firstly, the suspension of dust into the air from the activity. For HML a range of site activities have the potential to generate dust emissions as described in Table 1. Elevated wind speeds across exposed surfaces can also generate dust. Avoiding and minimising the generation of dust can be achieved through good management practises and active dust control which is discussed in more detail in section 5.
- The second aspect is the meteorological conditions which will disperse the generated dust offsite and towards sensitive receptors. Amount and timing of rainfall is also an important meteorological aspect to understand the potential intensity of dust-generating activities.

In this context the FIDOL assessment has been applied to the proposed activity as described below.

Frequency (How often an individual is exposed to the dust)

Watson *et al*. (2000)* concluded that PM_{10} levels begin to increase at wind speeds of 4 to 5 m/s and that large increments in PM_{10} are not observed until wind speeds exceed 7 m/s with concentrations increasing rapidly for winds speeds in excess of 10 m/s. This study and others have assisted in the development of the MfE (2016) recommended wind speed trigger level of 10 m/s (as a short-term average).

For most of the time (>98 %) windspeeds are less than 7 m/s equivalent^ as an hourly average based on the onsite measured data. During these conditions, the adoption of standard dust mitigation measures is expected to be effective in controlling any wind-entrained dust from active areas, including bunds and stockpiles, to the extent that offsite adverse effects should not occur. Short gusts of wind may exceed 7 m/s at times, but are not expected to exceed the 10 m/s short-term average MfE (2016) trigger frequently.

Predominate wind from the 'west north-west' and 'east south-east' would result in generated dust being carried towards sensitive receptor locations that include Receptors **A**, **B**, **D** and **I** that were identified in the screening level assessment as having an elevated risk. Figure 5 below illustrates the wind directions overlayed on an aerial map of the active area and the locations of all the higher risk receptors identified in the screening level assessment.

* Based on measurements using a reference 10 meter high mast.
^ Wind conditions at the monitored height (~6 m) are likely to be reduced from that those measured at a full 10m mast due to ground 'shear stress'. A simple calculation using a wind shear exponent of 0.15 (open grass) resulted in an equivalent wind speed at 6 m height of 6.3m/s. This value (6.3m/s) has been used as the high wind threshold in this assessment.

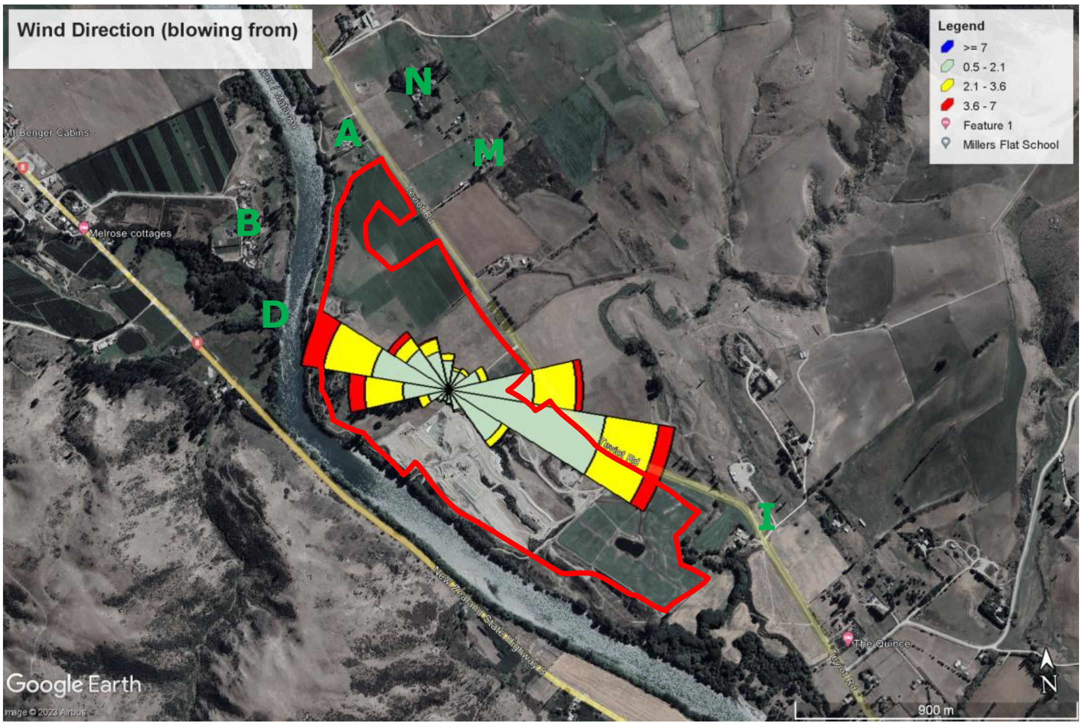


Figure 5. Aerial map overlayed with a site wind rose. Red outline denotes the approximate location of the active area (please note this is for illustrative purposes only and Figure 3 should be referred to for accurate boundaries.

It is important that dust mitigation practices are maintained and increased during dry conditions especially when sensitive receptors are downwind of the site. During dry and windy conditions, dust mitigation using water application will be less effective due to surfaces drying much more rapidly.

Analysis of the rainfall data over 2021 and 2022 illustrated that the average annual rainfall was 480 mm (excluding the high rainfall event in January 2021) with a <30 % chance of this falling over the summer months (December – April) when elevated temperatures occur. This analysis is in line with the expected long-term rainfall for the Millers Flat and wider Central Otago areas (refer Section 3.1).

Based on this there is an increased risk of dust generating events over the drier, warmer summer months if appropriate mitigations are not applied.

Intensity (The concentration of the dust)
Suspended dust levels will disperse and dilute with increased distance from the emission source and larger particles will deposit on surfaces closest to the source. Separation distance to downwind sensitive neighbours is therefore relevant when considering the intensity of potential dust impacts.

The separation distances to sensitive receptors have been discussed in Section 4.1.1. Receptors **A**, **B**, **D**, **I**, **M** and **N** are the closest receptors, being within 250 m. Other sensitive neighbours are situated further away. Because of the close proximity of receptor **A** (i.e., within 100 m), they have the highest risk of experiencing elevated dust intensities including deposited dust if appropriate management practices and mitigation measures are not applied and monitored to ensure they are effective. Very high dust levels that may pose a hazard due to reduced visibility to vehicles on Teviot Road or cyclist on the cycle trail are not expected to occur.

Duration (The length of exposure)
There are two matters to be considered regarding the duration of potential dust impacts. These are (A) the duration of dust generating activities and/or strong wind events causing elevated emissions from site and (B) the duration a receptor may experience these effects. In regards to (A), high dust generating activities (for example topsoil and overburden removal or high wind events) will only occur for limited periods of time and therefore duration is expected to be low.

In regards to (B), residential dwellings are generally accepted as having people present 24 hours per day. This, combined with the predominance of the wind directions and location of the identified sensitive receptors, means there is the potential to have extended durations of exposure at receptors **A**, **B**, **D** and **I**. Other activities such as cyclists using the cycle trails will be very transient through the site and the duration of exposure would be low.

Offensiveness (The type of dust)
The type of dust generated form the activity will be of natural origin from the topsoil and underlying alluvial material. This material is brown/grey dust in colour (refer Figure 4 Appendix 1 for example photo of materials). This dust is consistent with dust generated from surrounding properties during normal agricultural activities and use of unsealed roads and accessways. As such the dust is not out of character with the surrounding area and has low offensiveness potential.

Location (The type of land use and nature of human activities in the vicinity of the dust source)
The nature of the receiving environment has been discussed in Section 3. The surrounding rural land is expected to have a relatively low sensitivity to dust impacts. However, rural/lifestyle residential dwellings and commercial holiday properties are expected to have a moderate to high sensitivity to dust impacts and have therefore been the focus of the above analysis.

4.2. Health effects

Health effects of PM_{10} & $PM_{2.5}$ include increased frequency of respiratory and cardiovascular illness, and increased mortality, especially in those who are suffering from significant illness. These studies have also shown a correlation with increased prevalence of asthma symptoms. In 2004, PM_{10} standards for ambient (outdoor) air quality were introduced in New Zealand under the Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins and Other Toxics) Regulations 2004 (NESAQ). This set a limit of 50ug/m^3 as a 24-hour average. As described in Section 3.2 the air quality in the area is expected to be generally good and to not exceed the NESAQ, although could be adversely affected by surrounding agricultural practises at times.

For point source discharges (i.e. from a stack), dispersion modelling would be used to quantify an activity's contribution to PM_{10} concentrations and determine compliance with the NESAQ or any other relevant legalisation. MfE's (2016) good practice guide for assessing and managing dust states that "Dispersion modelling is not generally recommended for use with area dust sources (e.g., unpaved surfaces) or fugitive dust sources (e.g., stockpiles)."

Given the above, dispersion modelling is rarely used in New Zealand for assessing dust health effects from quarrying and mining type activities. Instead, the focus of health-based assessment from dust emissions is based on ensuring the mitigation measures employed are best practise to minimise dust emissions to acceptable levels.

PM_{10} emissions will be minimised to acceptable levels provided the dust mitigation measures as detailed in Section 5 are employed. RCS emissions are not expected to be generated from onsite activities as described in Section 2.2.2, however the controls proposed to manage dust and PM_{10} will also adequately control any potential RSC emissions. Specific targeted monitoring, to ensure the proposed mitigations are adequately controlling PM_{10} emissions are also proposed in Section 5.4.

4.3. Summary

Considering the combination of FIDOL factors and the separation distance guidance, it is concluded that sensitive receptors to the north-west and south-east of the activity area have a moderate to high risk of being impacted by events from the proposed operation, assuming no mitigation or monitoring of impacts occurs. This conclusion is based on the following:

- The moderate to high frequencies of exposure based on predominant wind directions blowing towards sensitive receptors.
- The climatic conditions of the areas with large soil moisture deficiencies over the summer months;
- The close proximity of receptors **A**, **B**, **D** and **I** (Figure 3) which could result in moderate to high dust impacts at those locations.

5. Mitigations and controls

As discussed, dredging operations are expected to occur in four stages with rehabilitation occurring progressively. The active area (exposed area), which can be a source of dust during periods of strong, dry winds, will be minimised to 27 ha at any given time.

5.1. Dust suppression

The site will make extensive use of dust suppression via a dedicated watering cart and a mobile sprinkler system. Due to the good supply of water (water take, use and discharge is subject to a separate assessment of effects) watering of the site will be a key dust mitigation. HML are investigating a high-volume water cart that is typically employed on large mining and quarrying sites. The cart has a single load capacity of 100,000 litres meaning it can effectivity provide the daily watering requirements to an area of 2 ha per trip (based on Environment Canterbury's application rate of 5 litres / m^2 / day). HML is currently testing the addition of a wetting agent to aid in dust suspension to reduce the frequency of application. Any use of wetting agents will be undertaken in accordance with the relevant rules in the Otago Regional Plan.

In addition to the watering cart, HML is proposing to use a mobile sprinkler system in areas where the cart cannot access or during activities where continuous dust suppression is required. A further description of the dust suppression is provided below based on each dust generating activity.

5.1.1. Topsoil and overburden removal

Topsoil and overburden removal can give rise to dust emissions during dry weather and strong winds, especially at times when ground surface and underlying overburden have become dry. During topsoil removal and overburden removal, water carts and or sprinklers will be used to pre-dampen the material as far as practical. Mobile sprinkler system will also operate continuously in the immediate vicinity of the excavator to keep the working area wetted and 'knock-down' any emitted dust.

5.1.2. Stockpiles and bunds

Water will be applied as required to ensure that any exposed earth on the bund or stockpiles is dampened or a crust formed to minimise dust during strong wind conditions until the grass cover (where applicable) is established. Once bunds have been formed, re-grassing will be prioritised to establish grass cover as soon as practicable. Chemical dust suppressants and / or geotextile cloth may also be applied as necessary to prevent dust emissions during the establishment of bunds or stockpiles, especially during hot and dry periods where establishing grass may not be feasible.

5.1.3. Dredging and gold processing

Processing of the target alluvium will be undertaken as a wet process and no further dust suppression is required. Tailings from the process will be deposited back into the pit and are not expected to generate dust emissions.

5.1.4. Replacing overburden, topsoil and revegetation

Mobile sprinkler system will operate in the immediate vicinity of the dumping area to keep the working area wetted and 'knock-down' any emitted dust. Once topsoil is placed it will be seeded with grass as soon practical. Watering of this grass seed, especially over the summer months will be critical to ensure its quick establishment. Watering will be undertaken using the sites water cart and/or fixed sprinkler system.

5.2. Vehicle movements and unpaved surfaces

Dust emissions on unpaved surfaces are proportional to the vehicle speed. Vehicle speeds on site will be limited to avoid excessive generation of dust. As the dredging process is undertaken in the pit without the need to transport the target alluvium via roadways, heavy vehicle movements are expected to be minimal. During topsoil and overburden stripping and replacement, heavy vehicle movements will increase. Water cart dust suppression will be targeted on the defined routes while this activity is being carried out. This application rate should, at a minimum, follow the appropriate guidance of 1 l/m^2/hr (MfE, 2016) or 5 l/m^2/day (Environment Canterbury).

5.3. Setbacks and limitation of activities

The following setbacks and limitation of activities are described below:

- All works will have a setback of at least 20 m from the property boundary where practical, this will include the Teviot Road and the cycle trail;
- Total stockpile height will not exceed 7 m;

Addition of a specific management zone (SMZ) will also be included to reflect the limited separation distance to sensitive receptors. The dust mitigation measure as described above are considered sufficient to mitigate the effects on high-risk receptors. However, to provide an additional level of control for any significant acute events outside of HML's control, such as very high wind conditions, the SMZ are proposed. SMZ should be limited to areas where high-risk dust generating activities are within 400 meters of a high-risk sensitive receptors. This would limit SMZ to the north-west and south-east extents of the activity area.

A SMZ adjacent to the cycle trail is not considered necessary based on the transient nature of the cycle trail users and the expected effectiveness of the standard mitigation measures.

Within these SMZ's it is recommended that activities should be limited to winter periods (if practical) or specific controls put in place. Lower wind speed threshold, more frequent dust suppression, stockpile exclusion areas or use of geotextile cloth for exposed high-risk areas may be appropriate specific controls. These measures should be detailed in the Dust Management Plan and follow the principles of adaptive management.

5.4. Monitoring

Weather forecasts for strong winds and extended dry periods will be monitored so that appropriate dust management responses can be planned, particularly during high dust generating activities including topsoil and over-burden removal/replacement and stockpiling. Given this, it is proposed that wind speed, direction and rainfall at the site will be continuously monitored, and high dust generating activities ceased when:

1) Wind speeds are greater than 7 m/s (rolling hourly average);
2) Wind gusts (1-minute average) exceed 10 m/s (during two consecutive 10-minute periods);
2) During extended dry weather conditions (e.g., not practicable to keep surfaces visibly damp).

Operational areas, such as haul roads, will also be monitored by HML to verify dampness and the ongoing need for water cart operation or other dust control measures.

Continuous real-time dust monitoring is also proposed to be undertaken on site to demonstrate the effectiveness of the controls. A mobile dust monitor, capable of measuring PM_{10}, should be located in an appropriate predominate downwind location from the active area and within close proximity of the site boundary. Where any activity is undertaken within 400 m of a high-risk sensitive receptor a dust monitor should be placed directly between the worksite and the high-risk sensitive receptor.

Monitoring will be set to record real-time PM_{10} and include a trigger level recommended by MfE (2016) of 150 $\mu g/m^3$. The trigger threshold is a preliminary value and may need to be adjusted depending on the monitor location and any subsequent feedback from neighbours.

The continuous dust monitoring equipment should be fitted with an automated alarm system that, when the trigger threshold is exceeded it sends a warning to the Site Manager or other nominated person who has the responsibility for managing dust effects on the site. The nominated person must be available at all times to take immediate action as it might be necessary to reduce site dust emissions.

5.5. Dust Management Plan

A draft Dust Management Plan (DMP) detailing dust mitigation measures has been prepared as part of the air discharge consent application and will be updated and maintained HML.

5.6. Summary

Table 3 below relates the proposed the mitigations and controls to the key processes and their expected frequency and intensity of dust emissions.

Table 3. Summary of mitigations and controls for key site processes.

Process	Frequency & duration of dust emissions	Intensity of dust emissions	Mitigation/Controls
Topsoil and overburden removal and transport	Infrequent (estimated once per week)	Potential for consistent dust during operation	➢ Pre-damping area and targeted dust suppression ➢ Wind speed monitoring and stop work thresholds ➢ Real-time dust monitoring ➢ Winter works only (or targeted dust measures) near sensitive receptors
Stockpiling of topsoil and overburden	Short duration at time of mine establishment then infrequent (estimated once per week).	Potential for consistent dust during operation	➢ Targeted dust suppression and / or geotextile cloth ➢ Revegetation where practical ➢ Maintain a separation distance from sensitive receptors ➢ Real-time dust monitoring
Dredging of the target alluvium with excavator	Daily activity	Process undertaken wet and therefore low potential for generation of dust.	➢ Natural dampness of material ➢ Real-time dust monitoring
Processing of alluvium through the gold plant	Daily activity	Process undertaken wet and therefore low potential for generation of dust.	➢ Natural dampness of material ➢ Real-time dust monitoring
Replacing overburden and topsoil	Infrequent (estimated once per week).	Process undertaken wet and therefore low potential for generation of dust.	➢ Pre damping material and targeted dust suppression ➢ Wind speed monitoring and stop work thresholds ➢ Real-time dust monitoring ➢ Winter works only (or targeted dust measures) near sensitive receptors
Vehicle movements on roads and accessways	Regular occurrence throughout the day (light vehicles). Heavy vehicles limited to periods of topsoil and overburden transport.	Potential for elevated dust during dry conditions	➢ Limit vehicle speeds on site ➢ Road and accessway dust suppression ➢ Real-time dust monitoring
Exposed surfaces	Infrequent and only during high wind speed events.	Potential for elevated dust during high wind speed events	➢ Wind speed monitoring and stop work thresholds ➢ Real-time dust monitoring ➢ Winter works only (or targeted dust measures) near sensitive receptors ➢ Prompt revegetation ➢ Dust suppression and use of geotextile cloth

6. Conclusion

The effects of the proposed activity have been assessed using the Ministry of Environment's best practise guide for managing dust and applicable overseas guidelines. Based on the separation distances and a detailed FIDOL assessment there is the potential for adverse effects on neighbouring properties if the dust levels are not controlled and mitigated appropriately.

A range of controls to mitigate the risk of adverse dust effects have been proposed in this assessment including: appropriately locating bunds and stockpiles; extensive dust suppression through fixed and mobile watering and monitoring weather conditions to determine when elevated dust risks may occur. In addition to this Specific Management Zones are proposed where dust generating activities are within close proximity to high-risk sensitive receptors. Within the SMZ, additional measures are proposed that will ensure that dust effects are avoided or minimised.

Monitoring of the effectiveness of the controls is proposed through real-time dust monitoring. Monitoring locations will be adaptive as the dreading progresses through the site and priority will be placed to locations between high-risk sensitive receptors and the activity area. Real-time monitoring will be used as a trigger a review the effectiveness of the dust controls and investigate the cause of high dust levels.

Based on the assessment of effects, and subject to the proposed mitigations being implemented, the effects of nuisance and health related dust will be less than minor on the receiving environment.

7. References

"NESAQ" Ministry for the Environment (2004); Resource Management (National Environmental Standards for Air Quality) Regulations 2004.

Regional Plan: Air for Otago (2008).

Ministry for the Environment. (2016): Good practice guide for Assessing and Managing Dust. Wellington: Ministry for the Environment.

Ministry for the Environment. (2016b): Good Practice Guide for Assessing Discharges to Air from Industry. Wellington: Ministry for the Environment.

Victoria Environmental Protection Agency. (2013). Recommended separation distances for industrial residual air - Publication number 1518.

Macara, G.R. 2015. The climate and weather of Otago. NIWA Science and Technology Series 67, 44 pp.

Appendix 1: Site Photos

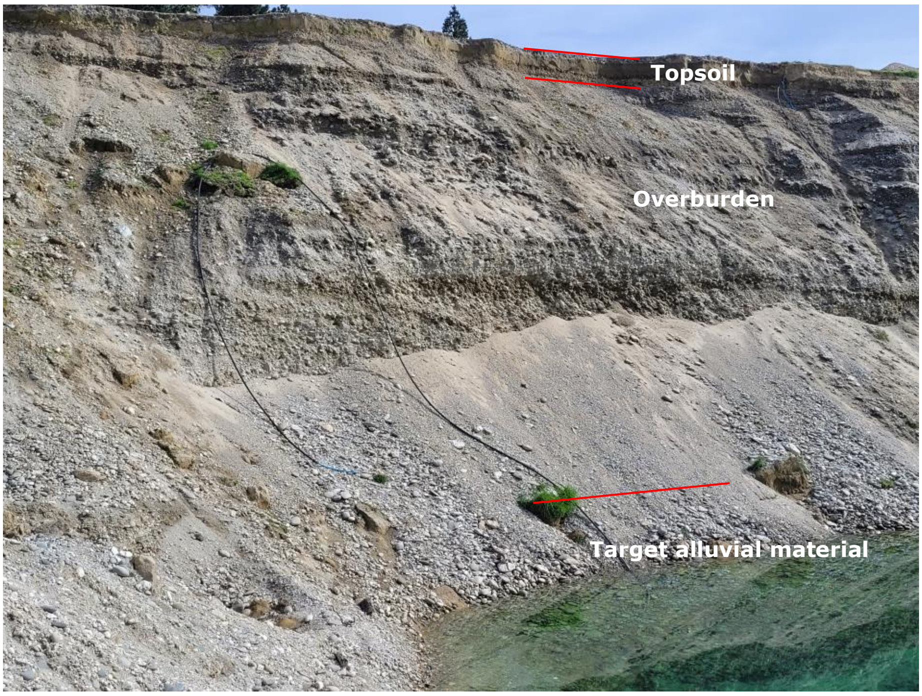


Figure 1. Test pit wall illustrating the extent of the topsoil, overburden and wash.

Figure 2. Example of a constructed stockpile consisting of the overburden material.

Figure 3. Meteorological monitoring station located on the site

Figure 4. Close up example of the overburden material consisting of a range of sizes including finer material that has the potential to become airborne (dust).

Figure 5. Floating gold processing plant currently being constructed at the base of the test pit.