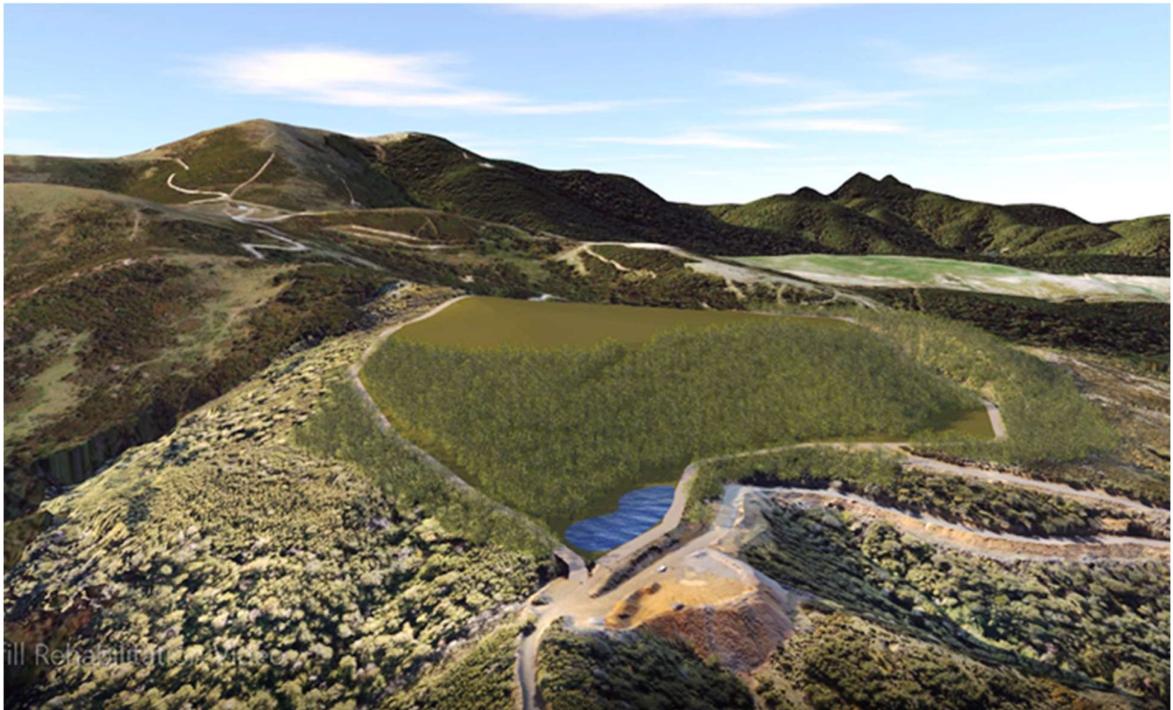


Woodstock Landfill

Environmental Risk Assessment



INDIGENOUS REGENERATION *through* **INNOVATIVE LANDFILL PRACTICE**

DOCUMENT OWNER	
Document Owner:	Woodstock Quarries Ltd
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DOCUMENT CONTROL				
Issue	Date:	Prepared	Reviewed	Approved for Issue
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1.0 Introduction

Woodstock Quarries Ltd (WQL) has commissioned this review to assist with the identification of risks associated with the development, operation, closure, and aftercare of the proposed Trig Road Landfill (the landfill) located below Mt Wilson, approximately 16 km west of Oxford, North Canterbury. This will be achieved through the following:

- The review of information relating to the proposed design, construction, operation, closure, and aftercare of the landfill.
- The classification of key risks associated with the design, construction, operation, closure, and aftercare of the landfill.

2.0 Risk Assessment Framework

2.1 Context

WQL will be responsible for the design, construction, operation, closure, and aftercare of the landfill. WQL seeks to ensure that the landfill is designed and operated in such way that any potential adverse human health and environmental effects are avoided, managed, or mitigated. The following presents the context for the risk management assessment:

- Significant risks to the community, landowners and the environment are identified and analysed to understand them in terms of likelihood and consequence.
- This risk identification and analysis provides the basis for evaluating the risks qualitatively.
- The mitigation measures that are proposed as part of good engineering design, construction, operational management, and closure are considered to derive the mitigated risk.
- Any risks assessed as High or Extreme following mitigation will be further assessed quantitatively for development of the bond.

2.2 Risk Identification and Categories

The risk identification process involves finding, recognising, and describing the risks. This includes identification of sources of risk, the events and circumstances that could affect the event occurring along with the potential consequences of the event occurring as well as the receptors. **Table 1** presents a summary of the risk categories nominated for the landfill. **Table 2** presents a summary of receptors.

2.3 Risk Consequences

A single event can generate a range of consequences which can have both positive and negative effects. Initial consequences can also escalate through knock-on effects. For each of the risk categories noted above potential risk consequence guidelines are outlined in **Table 3**.

2.4 Risk Likelihood

Likelihood is the chance that the event might happen. Likelihood can be defined, determined, or measured objectively or subjectively and can be expressed either qualitatively or quantitatively as outlined in **Table 4**.

2.5 Risk Assessment Method

Risk is a combination of Likelihood and Consequences, and is typically expressed in the form

$$\text{Risk} = \text{Likelihood} \times \text{Consequences}$$

For this review, scores for both Likelihood and Consequence have been assigned based on the criteria summarised in **Tables 3** and **4**. From this, each identified risk has been assigned a rating (calculated as above), both with and without mitigation, and then assessed as explained in Section 3 below.

Table 1 Summary of Risk Categories and Definitions

Risk Category	Definition
Environment and Human Health	The nature and extent of potential adverse effects to the environment and/or human health of a discharge to soil, air, surface water or groundwater from the landfill. Aspects to be considered include: <ul style="list-style-type: none"> • Site specific conditions. • Source pathway-receptor linkages. • Sensitivity of environmental receptors.
Financial	Compliance with statutory or common law, delegations, regulations, and contractual requirements; including the potential financial consequences for not complying. This risk category includes the requirement to comply with the Resource Management Act (1991). Aspects to be considered include: <ul style="list-style-type: none"> • Potential resource consent conditions. • Non-compliance with regulatory or contractual requirements with respect to the potential for legislative action to be taken against WQL i.e., fines, prosecution, legal action etc.
Social	Public or cultural sensitivity to a discharge or perceived discharge and the potential for adverse comment or media coverage. Aspects to be considered include: <ul style="list-style-type: none"> • Site specific conditions. • Sensitivity of environmental receptors. • Sensitivity of human health receptors. • Current or intended land-use. • Cultural practices. • Loss of amenity. e.g., noise or nuisance.

Table 2 Summary of Receptors

Receptor	Description
Surface Water/Aquatic Ecosystems	<ul style="list-style-type: none"> • Tributaries of the Eyre River. • Eyre River. • Ecological Areas and Wetlands. • Aquatic organisms including fish and macro-invertebrates
Groundwater	<ul style="list-style-type: none"> • Groundwater that discharges into surface water via springs and seeps. • Groundwater that is no extracted or discharged but is legacy groundwater for future users and generations.
Terrestrial Ecosystems	<ul style="list-style-type: none"> • All flora including native vegetation, exotic forest, and pasture areas. • Terrestrial fauna.
Air	<ul style="list-style-type: none"> • Dust. • Landfill gas. • Thermal discharges and emissions from combustion. • Odour.
Human Health – Workers	<ul style="list-style-type: none"> • Dermal contact. • Ingestion. • Inhalation. • Noise and vibration
Human Health - Public	<ul style="list-style-type: none"> • Ingestion. • Inhalation. • Noise and vibration.
Cultural and Social Values	<ul style="list-style-type: none"> • Loss of amenity (e.g., increase in ambient noise, increase in traffic). • Visual effects. • Cultural values.

Table 3 Summary of Risk Consequences

Consequence	Negligible	Minor	Moderate	Major	Catastrophic
Score	1	2	3	4	5
Environmental	Minimal adverse environmental effects.	Minor environmental damage. Transient effects.	Environmental impact requiring treatment, or modifications to process, inside or outside of the landfill. Persistent adverse effect.	Environmental harm requiring restoration and/or remediation, or modifications to process, inside or outside of the landfill.	Permanent material damage to environment requiring ongoing remediation, or change of use, and monitoring with possible regulatory involvement.
Human Health	No measurable / detectable adverse human health effects.	Easily preventable, non-permanent health effects on humans.	Easily preventable, permanent health effects on humans.	Medium / long term (chronic) effect to human health.	One or more fatalities (public or workers).
Social and Cultural	No significant community or cultural issues; and/or no significant adverse comment or media coverage; and/or no complaint to management.	Local community or cultural concerns; and/or adverse comment on local media.	Significant community or cultural concerns causing delays and modifications to planned use of the landfill.	Widespread significant community or cultural concerns, delays, and modifications to planned use of the landfill.	Major community or cultural concerns causing major re-think or complete failure of planned use of the landfill.
Financial	<\$10K.	\$10K to <\$100K.	\$100K to <\$1M	\$1M to <\$10M	≥\$10M.

Table 4 Summary of Risk Likelihood

Likelihood	Rare	Unlikely	Possible	Likely	Almost Certain
Likelihood score	1	2	3	4	5
Description	Circumstances are such that events are not expected to occur even in the long term	Circumstances are such that events could occur in the long term	Circumstances are such that events could occur in next 10 -100 years	Circumstances are such that such an event is expected to occur in next 10 years	Circumstances are such that an event is likely to occur once a year or more often

3 Risk Analysis

A semi-quantitative approach has been applied to this risk assessment. This approach attributes values or multipliers to the likelihood and consequence groupings described in Section 2 above

The consequence will be multiplied by the likelihood for each risk category to produce a Risk Score (refer **Table 5**).

Table 5 Summary of the Risk Rating Matrix

Likelihood		Very Unlikely	Unlikely	Possible	Likely	Almost Certain
Consequence		1	2	3	4	5
Negligible	1	1	2	3	4	5
Minor	2	2	4	6	8	10
Moderate	3	3	6	9	12	15
Major	4	4	8	12	16	20
Catastrophic	5	5	10	15	20	25

The calculated product, or Risk Score, will fit into a range that indicates the necessary actions to address the Risk (refer **Table 6**).

Table 6 Summary of Risk Rating

Risk Score		Classification of Risk	Likely Action
Extreme	17-25	Intolerable (intense management)	Severe harm to a defined receptor is highly likely or has already occurred. The risk is likely to result in a substantial liability. Urgent investigation (if not already undertaken) is likely to be required. Urgent action or remediation is likely to be required.
High	13-16	Tolerable with active management to reduce risk to as low as reasonably practicable	Harm to a defined receptor is likely, but severe harm is unlikely. The risk is likely to result in a major liability. Investigation (if not already undertaken) is required to clarify the level of potential liability and risk. Remediation is likely to be required.
Medium	9-12	Tolerable with active management to reduce risk to as low as reasonably practicable	Potential harm to a defined receptor is possible, but severe harm is very unlikely. The risk is likely to result in a moderate liability. Investigation (if not already undertaken) maybe be required to clarify the level of potential liability and risk. Some remediation may be required in the longer term.
Low	5-8	Tolerable	Harm to a defined receptor is possible but is likely to be moderate at worst. Liabilities could theoretically arise but are unlikely. Further investigation is not required at this stage. Remediation is unlikely to be required.
Very Low	1-4	Tolerable	No special action required. Risks are managed within day to day operating procedures.

4.0 Risks Register

4.1 Overall Summary

The full risk register is included in **Appendix A**. In summary:

A total of 66 risks are presented in the risk register which have been divided into five categories:

- Uncontrolled contaminant and or sediment release.
- Uncontrolled leachate release to surface water and or groundwater.
- Uncontrolled gas or odour release.
- Uncontrolled dust release.
- Landfill construction and operations nuisance.

Of the 66 risks identified:

- No risks are identified with a risk score of Extreme (after mitigation).
- No risks are identified with a risk score of High (after mitigation).
- There were 11 risks identified with a risk score of Medium (after mitigation) and these are listed in Section 4.2 below with further details provided in Appendix A.

4.2 Medium Residual Risks (after Mitigation)

As outlined in Table 6, a Medium risk is considered tolerable on the basis that active risk management is in place to ensure that the risk is mitigated to as low as reasonably practicable.

Tables 7 – 10 below list the Medium risks (after mitigation) identified. As shown in Appendix A mitigation measures specific to each of these risks have been identified.

Table 7 Medium residual risks resulting in potential contaminant and/or sediment release

Item	Event
1.2	Treatment standard not met (suspended solids) in the discharge from sediment pond
1.4	A slip occurs, outside of the areas of the landfill development that is not in the sediment ponds catchment.
1.5	Water Quality criteria not met in the discharge from sediment pond
1.6	Earthworks are undertaken prior to the implementation of erosion and sediment control measures.

Table 8 Medium residual risks resulting in potential leachate release to surface water and/or groundwater

Item	Event
2.15	Landfill instability
2.16	Stormwater pipe or swales fail/block and up catchment stormwater cannot discharge.
2.19	Leachate enters stormwater from recirculation.

Table 9 Medium residual risks resulting directly from construction or operation.

Item	Event
5.1	Subsurface landfill fire
5.4	Landfill fire migrating to adjacent forestry and bush areas.
5.9	Oil or fuel spills.
5.13	Waste acceptance criteria not met and hazardous waste received.

5.0 Conclusion

The outputs of this risk assessment are used as the basis for identifying the key potential risks posed by the landfill that should be actively managed or mitigated.

This semi quantitative approach can also be used to identify risks that should be considered in the calculation of a bond for the landfill.

Appendix A
Risks Register

Site		Woodstock Quarries Ltd		Woodstock Landfill		BEFORE		BEFORE		RISK	BEFORE		AFTER		AFTER		RISK
Ref	Location	Event	Detail	Receptor	Likelihood	Impact	1-5	1-5	BEFORE	Potential Consequence	Controls / Mitigation	Likelihood	Impact	1-5	1-5	AFTER	
1 Uncontrolled Contaminant/Sediment Release The construction of the landfill and associated access road requires large scale earthworks. Stormwater treatment pond/s are proposed to treat runoff from exposed areas prior to discharge offsite. The catchment characteristics will vary over the life of the landfill, but will include existing scrub areas, clay and topsoil stockpiles, completed areas of landfill cover, landfill liner areas while under construction, temporary access road and the unsealed perimeter road. Runoff from uncapped waste areas will be treated as leachate. The receiving environment for stormwater discharges from the site are all tributaries of the Eyre River Separate stormwater treatment ponds will be constructed for any stockpile areas outside the main landfill area.																	
1.1	Landfill	Stormwater treatment pond embankment failure	The pond embankment is compromised, leading to failure and direct loss of sediment and/or failure to treat subsequent runoff.	Woodstock Stream	Likely	Major	4	4	16	Sedimentation of downstream environment. Failure to treat subsequent flows until reinstated.	Design to be undertaken by a Chartered Professional Engineer. Design to be peer reviewed. Specification and quality assurance programme for pond embankment construction (QA/QC). Overflow/spillway design including armouring. Ability to temporarily pump water to alternative ponds for treatment.	Unlikely	Major	2	4	8	
1.2	Landfill	Treatment standard not met (suspended solids) in the discharge from sediment pond	There is not enough settling time provided within the pond to achieve consented suspended solids and/or contaminant limits. This could be due to a number of different events including: flood event, catchment area increased beyond pond capacity, sediment does not settle readily. The design of the pond is such that large runoff events receive a low level of treatment with smaller runoff events receiving a high level of treatment.	Woodstock Stream	Almost Certain	Moderate	5	3	15	Partial treatment of runoff leads to short term increase in suspended solids being discharged to surface water .	Pond to be designed (volume, shape and depth) to achieve sediment removal. Progressive stabilisation of exposed areas. Diversion of clean water around exposed areas. Pre-treatment by additional silt traps before water reaches the pond system. Pond to be designed to convey a 100 year flood event. Use of flocculants if required. Secondary containment pond in lower valley prior to final discharge	Almost Certain	Minor	5	2	10	
1.3	Landfill	Major snow event	Major snow event blocks parts of the drainage network leading to overflows from the drainage channels	Woodstock Stream	Possible	Moderate	3	3	9	Runoff leads to short term increase in suspended solids being discharged to surface water.	Drainage channels to be designed to convey a 100 year flood event. Earthmoving equipment already on site.	Unlikely	Moderate	2	3	6	
1.4	Landfill	A slip occurs, outside of the areas of the landfill development that is not in the sediment ponds catchment.	A slip in the steep catchment areas lead to increased sediment release without treatment.	Surface Water/Aquatic Ecosystems	Likely	Moderate	4	3	12	Discharge of untreated sediment laden runoff to downstream environments	Geotechnical assessments undertaken to identify high risk areas with stability measures installed for high risk areas identified, i.e. retaining walls, maximum batter slopes.	Possible	Moderate	3	3	9	
1.5	Landfill	Water Quality criteria not met in the discharge from sediment pond	Runoff impacted by contaminants from refuse enters stormwater ponds and discharges without being isolated.	Woodstock Stream	Likely	Moderate	4	3	12	Aquatic organisms downstream impacted .	Operational management of site to ensure water contacting refuse is not discharged. This water will be treated as leachate. Continuous electrical conductivity monitoring at the inlet of sediment pond Scheduling and internal approval process for earthworks (within the refuse) to avoid exposure and manage cover placement.	Likely	Moderate	4	3	12	
1.6	Landfill	Earthworks are undertaken prior to the implementation of erosion and sediment control measures.	Sediment laden runoff from exposed catchment areas discharge into waterways without treatment.	Surface Water/Aquatic Ecosystems	Likely	Moderate	4	3	12	Discharge of untreated sediment laden runoff to downstream environments	Erosion and sediment control plans for all earthworks to be implemented prior to soil disturbance. The majority of the earthworks will be undertaken in the summer months.	Possible	Moderate	3	3	9	
1.7	Access Road	Tracking of mud and dirt onto public roads.	Wet conditions and unsealed sections of road, cause mud to stick to the wheels and undercarriage of vehicles which could then be tracked onto public road	Woodstock Stream	Almost Certain	Moderate	5	3	15	Mud on the road could create unsafe road conditions by reducing traction. Mud on the road, when dried, could create dust. Any mud tracked onto roads will runoff to waterways during rain events without receiving treatment.	All vehicles leaving the landfill (working face and any bare earthworks areas) will pass through a wheelwash and travel along 2 km of road prior to exiting on to a public road. Runoff from the access road will receive treatment in a sediment pond prior to discharge. High standard of roading and roadside drainage	Likely	Minor	4	2	8	
1.8	Landfill	Increased flooding risk caused by site development.	Filling and/or changing of the catchment runoff properties.	Human Health – Public Surface Water/Aquatic Ecosystems	Possible	Negligible	3	1	3	Changes in the landform could alter the runoff characteristics of the catchment	The runoff from the various catchments are not altered by construction of the landfill and all runoff from the landfill area will be attenuated as it is treated in the sediment ponds. There are not expected to be any effects on the proposed landfill and associated works from on-site flooding.	Unlikely	Negligible	2	1	2	
2 Uncontrolled Leachate Release to Surface Water/Groundwater An engineering lining system is to be constructed to contain leachate within the landfill where it is collected for treatment and disposal. It is proposed to collect leachate in a series of collector drains on the liner. Leachate will then be pumped up to storage tanks from where (initially), the leachate will be recirculated through the waste. In the event that leachate generation is greater than that which can be recirculated tankers will remove the leachate for offsite disposal. Intermediate and final cover will be installed to control seepage of water into the underlying waste materials, minimise landfill gas escape, leachate generation, provide a barrier to the underlying waste and to provide a growth medium for cover vegetation.																	
2.1	Landfill	Leachate disposal system compromised.	Onsite leachate storage capacity within the tanks is exceeded following: A flood or slip event blocks/damages access road leading to the leachate storage tanks not being emptied. Issues with leachate acceptance at the disposal facility meaning there is nowhere to accept the leachate for disposal.	Stormwater	Possible	Minor	3	2	6	Leachate head within the landfill will temporarily increase while the leachate disposal system is restored.	Leachate Monitoring and Management Plan including maintenance requirements. The design includes a contingency storage volume. Recirculation to the working face can be increased.	Unlikely	Minor	2	2	4	
2.2	Landfill	Unforeseen leachate production.	Prolonged high rainfall leads to a large increase in leachate generation	Groundwater	Possible	Moderate	3	3	9	Leachate head and within the landfill will temporarily increase while the extra leachate volume is treated/disposed of. The cover is unlikely to fail on a scale that would present issues for leachate management.	Prompt daily, intermediate and final cover installation. Clean water diversions with freeboard allowance.	Unlikely	Negligible	2	1	2	
2.3	Landfill	Leachate pumping and disposal system compromised.	Tanks and/or pipework compromised, leading to direct loss of leachate to surface water.	Woodstock Stream	Possible	Major	3	4	12	Leachate release to surface water.	Tank design, installation and maintenance. Tank level alarms, monitoring. Secondary containment/bunding. Perimeter bollards. Any leachate loss would need to pass through at least one stormwater treatment pond, where the inlet is monitored for electrical conductivity.	Unlikely	Major	2	4	8	
2.4	Landfill	Leachate collection pipework failure within landfill.	The leachate collection pipes (within the landfill) become blocked leading to a reduced ability to remove leachate from within the landfill.	Groundwater	Possible	Moderate	3	3	9	Increased head on the liner.	Cleanout risers installed to flush leachate collection pipework. Leachate pipes are drilled and installed within a gravel drainage layer. Flow through surrounding drainage layer will prevent significant head increase.	Possible	Negligible	3	1	3	
2.5	Landfill	Leachate disposal tanker accident.	The leachate disposal tanker responsible for removing leachate from the site is involved in an access road incident where the tanker containment is compromised and leachate released to surface water.	Woodstock Stream	Unlikely	Moderate	2	3	6	Leachate release to surface water.	Access road and intersection designed for safety. Onsite speed restrictions. Contingency plan preparedness for temporary damming of affected drains and pumping to other tankers.	Unlikely	Minor	2	2	4	
2.6	Landfill	Toe bund failure.	The structural bund at the toe of the landfill fails and leachate is no longer contained within the liner system.	Woodstock Stream	Unlikely	Catastrophic	2	5	10	Leachate is released to the groundwater and surface water resulting contamination until remediated.	Design review, conservative specification and certification of constructed works.	Unlikely	Moderate	2	3	6	

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Ref	Location	Event	Detail	Receptor	Likelihood	Impact	1-5	1-5	BEFORE	Potential Consequence	Controls / Mitigation	Likelihood	Impact	1-5	1-5	AFTER			
							Likelihood before	Impact before	BEFORE								Likelihood after	Impact after	AFTER
2.7	Landfill	Lining system settlement and failure.	The lining system fails due to differential settlement or failure due to an earthquake.	Groundwater	Possible	Catastrophic	3	5	15	Leachate is released to the groundwater resulting in long term contamination.	Robustness in site selection and geotechnical investigation prior to works commencement. Factor of safety provided for lining system design, including seismic design factor of safety. Lining system design comprises multiple layers as back-up if one layer/liner element fails. Strict specification and quality assurance programme for liner placement (testing, independent review). Regular monitoring for leachate indicators in the groundwater from a series of bores around the landfill. Monitoring for leachate indicators in the subsoil drains beneath the liner and management as appropriate.	Unlikely	Major	2	4	8			
2.8	Landfill	Liner materials failure.	The liner fails due to poor quality materials, and/or installation errors.	Groundwater	Unlikely	Catastrophic	2	5	10	Leachate is released to the groundwater resulting in long term contamination.	Strict specification and independent quality assurance programme for liner placement. Independent Peer Review Panel to review as-built construction, testing and independent reports on the lining system prior to waste placement. Lining system comprises three constructed layers/elements to provide back-up if a location suffered a failure.	Rare	Major	1	4	4			
2.9	Landfill	Liner materials failure.	The liner materials are damaged during operations or construction activities (e.g., early fill placement, liner tie in).	Groundwater	Possible	Major	3	4	12	Leachate is released to the groundwater over a prolonged period resulting in contamination.	Geotextile layer and drainage blanket act as mechanical protection to liner. Selection of appropriate waste materials for initial (fluff) waste layers, which is not compacted. Provision of as-built plans to allow for continuity in future works programmes (liner tie-in).	Unlikely	Moderate	2	3	6			
2.10	Landfill	Liner interface failure.	There is a slip at the interface between the different liner components.	Groundwater	Unlikely	Catastrophic	2	5	10	Leachate is released to the groundwater over a prolonged period resulting in contamination.	Material specific lab shear testing to be undertaken to input into design. Floor is designed at flat grade. As waste is placed the vertical load increases the friction between the layers, reducing the likelihood.	Unlikely	Major	2	4	8			
2.11	Landfill	Lining system failure.	Groundwater pressure from beneath the lining system compromises the integrity leading to failure and an increase in leachate volume.	Groundwater	Unlikely	Moderate	2	3	6	Leachate is released to the groundwater over a prolonged period resulting in contamination, groundwater enters the landfill resulting in increased leachate volumes generated.	Subsoil drains to be installed prior to lining system installation. Underlying ground has low permeability. Waste pile increases vertical load and downward pressure to above any vertical groundwater pressure.	Unlikely	Moderate	2	3	6			
2.12	Landfill	Cover failure.	The cover is below permeability specification leading to increased leachate generation breakout and leachate production.	Groundwater & stormwater	Unlikely	Moderate	2	3	6	The cover is unlikely to fail on a scale that would present issues for leachate management.	Design specification for cover. Construction QA and weekly cover inspections.	Unlikely	Moderate	2	3	6			
2.13	Landfill	Cover failure.	The cover is cracked or damaged leading to increased leachate generation. This could be caused by operational activities, dry weather leading to cracking or surface water eroding the cover.	Groundwater & stormwater	Likely	Minor	4	2	8	The cover is unlikely to be compromised on a scale that would present issues for leachate management.	Weekly cover inspections and maintenance.	Possible	Minor	3	2	6			
2.14	Landfill	Leachate surface breakouts.	Leachate breakouts through the cover and discharges into stormwater system.	Woodstock Stream	Likely	Minor	4	2	8	Discharge of leachate to the stormwater system.	Minimising leachate head within the landfill by the installation of leachate drainage and extraction. Real time continuous monitoring of the stormwater collection system for leachate indicators. Operation of the landfill to avoid barriers to downward percolation of leachate. Monitoring to include regular inspections of landfill cover and procedures for prompt corrective actions.	Likely	Minor	4	2	8			
2.15	Landfill	Landfill instability	Slope movement within placed waste leads to waste outside liner containment or a tear in the liner beneath placed waste.	Groundwater	Possible	Major	3	4	12	Leachate from the waste outside of the liner extent discharges to groundwater.	Design criteria with factor of safety for all interim slopes. Compaction of waste and density testing. Option always available to recover slipped material and place it in the unaffected landfill.	Possible	Moderate	3	3	9			
2.16	Landfill	Stormwater pipe or swales fail/block and up catchment stormwater cannot discharge.	Up-catchment surface water cannot be discharged, and dammed water accumulates resulting in interaction with waste.	Woodstock Stream	Likely	Moderate	4	3	12	Increased leachate production. Reduced stability of the waste materials.	Maintenance, redundancy in design. Risk management to develop timely mitigation.	Possible	Moderate	3	3	9			
2.17	Landfill	Subsoil drain failure.	The network of subsoil drains beneath the lining system become blocked or are crushed and are no longer able to drain the groundwater from beneath the liner.	Groundwater	Possible	Major	3	4	12	Increased groundwater pressure on the liner and potential seepage into the fill mass increasing leachate volume.	Subsoil drains designed to exclude sediment from entering the pipe or accumulating within the pipe. Design provisions for cleanout of pipe work.	Unlikely	Moderate	2	3	6			
2.18	Landfill	Cover failure.	The cover is not placed in accordance with the design and consent conditions. It might not be continuous, might not be tracked and graded correctly or it might be too thin (leaving areas of exposed refuse)	Stormwater	Likely	Minor	4	2	8	The additional leachate volume (which will only arise if this occurs during a rain event) will not have a detectable impact on the environment. It will merely increase the volume of leachate that has to be treated.	Design specification for cover. Construction QA and weekly cover inspections.	Likely	Minor	4	2	8			
2.19	Landfill	Leachate enters stormwater from recirculation.	Method of recirculation results in leachate running into the stormwater system.	Woodstock Stream	Likely	Moderate	4	3	12	Discharge of leachate to the stormwater system.	Management plan, procedures, monitoring. Real time continuous monitoring of the stormwater collection system for leachate indicators.	Possible	Moderate	3	3	9			
3 Uncontrolled Gas/Odour Release																			
The discharges to air comprise the following: odour from waste materials, odour from landfill gas emissions, combustion products generated by the burning of landfill gas in a flare or generator, the release of landfill gas directly to the atmosphere.																			
3.1	Landfill	Cover material failure.	The cover is below the permeability required, cover is insufficient, or cover dries out and cracks, leading to uncontrolled gas discharge and the creation of a potentially explosive/asphyxiating atmosphere.	Air Human Health - Workers	Likely	Minor	4	2	8	Discharge of landfill gases directly to the atmosphere.	Adequate cover thickness and permeability. Management of ignition sources. Comprehensive reach of horizontal and vertical gas collectors laid in the waste as the refuse pile is built up. Cover maintenance. Weekly visual inspection of the cover. Prompt topsoil and vegetation cover to retard drying out.	Possible	Minor	3	2	6			
3.2	Landfill	Gas capture ineffective.	The gas capture is ineffective leading to uncontrolled gas discharge and the creation of a potentially explosive/asphyxiating atmosphere.	Air Human Health - Workers	Likely	Minor	4	2	8	Discharge of landfill gases directly to the atmosphere.	Gas vacuum maintenance to optimise extraction. Procedures to be developed for times where wells are not connected to the extraction system (i.e. maintenance, extensions). Stand-by gen-set on site to provide power for continued gas extraction during a power outage.	Likely	Minor	4	2	8			
3.3	Landfill	Damage to gas extraction pipework.	Pipework is damaged (machines, settlement) leading to oxygen being drawn into the landfill, or system becomes blocked and gas unable to be extracted.	Air Human Health - Workers Human Health - Public	Likely	Minor	4	2	8	Discharge of landfill gases directly to the atmosphere.Can lead to increased risk of subsurface landfill fire or ineffective gas capture.	Continuous monitoring of gas composition at the blower. Weekly visual inspection of the cover and wells. Dedicated and trained landfill gas team to install, maintain and monitor the gas extraction network. Permanent standby gas extraction and destruction systems.	Likely	Minor	4	2	8			

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							Likelihood before	Impact before						Likelihood after	Impact after		
3.4	Landfill	Power outage results in flare/blower failing to operate.	Gas flare capacity is exceeded leading to landfill gas being discharged to air without destruction.	Air	Likely	Minor	4	2	8	Discharge of landfill gases directly to the atmosphere.	Provision of a standby flare. Flame out auto-dial. Auto slam shut valve upon flame out. Multiple blowers (standby) and alternative gas destruction capability (flares and generation). Auto flame recognition. Permanent standby power generator to run gas extraction.	Likely	Minor	4	2	8	
3.5	Landfill	Extreme weather event.	The flare is damaged. Leads to discharge of undestroyed landfill gas being released to air.	Air Human Health - Workers	Unlikely	Moderate	2	3	6	Discharge of landfill gases to the atmosphere and failure to treat subsequent flows. This could lead to the creation of a potentially explosive or asphyxiating atmosphere.	Provision of a standby flare and generators. Flame out auto-dial. Auto slam shut valve upon flame out. Auto flame-out recognition and re-ignition.	Unlikely	Moderate	2	3	6	
3.6	Landfill	Odour from the working face.	Odour release through general waste placement, inadequate cover or special waste placement.	Air Human Health - Public Human Health - Workers	Likely	Minor	4	2	8	Discharge of odour beyond site boundary. Minimum distance of 1km to sensitive receptors.	Restricted hours of acceptance. Overly odourous waste not accepted without pre-treatment. Prompt placement of waste in its' final place. Mixing with other wastes. Special burial for known odourous wastes as per waste acceptance criteria and disposal procedure outlined in Landfill Management Plan. Minimise size of the working face. Prompt burial with cover materials and equipment available for burial at all times. Mobile odour neutralising spray units. Daily cover and end of day sign off. Early placement of intermediate and final cover materials. Early planning and installation of gas extraction systems. Buffer distance. Cover materials. Thickening of cover (intermediate) where waste will not be placed for several months. Prevent trees growing in the cover, especially ones with deep roots and weeds that prevent mowing and surface monitoring like gorse and pampas. Active (continuous vacuum) gas extraction. Odour neutralising spray units to be mobilised for any excavation into waste areas. Buffer distance.	Unlikely	Negligible	4	1	4	
3.7	Landfill	Odour from landfill gas emissions through cover.	Landfill gas discharges.	Air Human Health - Public Human Health - Workers	Likely	Minor	4	2	8	Discharge of odour beyond site boundary.	Prevent trees growing in the cover, especially ones with deep roots and weeds that prevent mowing and surface monitoring like gorse and pampas. Active (continuous vacuum) gas extraction. Odour neutralising spray units to be mobilised for any excavation into waste areas. Buffer distance.	Unlikely	Negligible	4	1	4	
4 Uncontrolled Dust Release																	
Large scale earthworks, vehicle movements on unsealed roads have the potential to generate dust. The stormwater treatment ponds on the site will have sufficient capacity to provide water for dust suppression.																	
4.1	Landfill	Dust release from vehicle movements and earthworks areas during the operation and construction within the landfill footprint.	Heavy vehicle movements generate unacceptable dust nuisance.	Air Terrestrial Ecosystem Human Health - Workers Human Health - Public	Likely	Minor	4	2	8	Discharge of dust onto property, trees and roads.	Buffer distance. Limiting working face and exposed earthworks areas during construction. Restriction of vehicle speeds. Dust suppression including provision of an on-site water source. Full time availability of water cart with sprayers.	Possible	Negligible	3	1	3	
4.2	Outside landfill	Dust release from vehicle movements and topsoil stockpiling.	Heavy vehicle movements and earthworks activities generate unacceptable dust nuisance.	Air Terrestrial Ecosystem Human Health - Workers Human Health - Public	Likely	Minor	4	2	8	Discharge of dust onto property, trees and roads.	Rapid stabilisation of completed stockpile areas. Restriction of vehicle speeds. Dust suppression including provision of an on-site water source and water cart.	Possible	Negligible	3	1	3	
4.3	Landfill	Dust release from contaminated soil disposal operations.	Contaminants movement offsite.	Air Terrestrial Ecosystem Human Health - Workers Human Health - Public	Likely	Negligible	4	1	4	Discharge of dust onto property, trees and roads.	Buffer distance. Waste acceptance criteria. Load inspections. Cover materials (daily, intermediate, final). Wetting of soils to prevent dust generation. Appropriate re-use of any contaminated soils.	Possible	Negligible	3	1	3	
4.4	Landfill and outside landfill	Onsite water supply is insufficient to provide for sufficient dust suppression. Especially during long dry periods.	Dust generated by heavy vehicle movements and earthworks activities is unable to be sufficiently controlled.	Air Terrestrial Ecosystem Human Health - Workers Human Health - Public	Likely	Minor	4	2	8	Discharge of dust onto property, trees and roads. Reduced visibility.	Pond level management system to allow for stormwater runoff to be stored for use as dust suppression.	Possible	Negligible	3	1	3	
5 Landfill Construction/Operations/Nuisance																	
5.1	Landfill	Subsurface landfill fire	A buried heat source, resulting from biological decomposition or oxidation, spontaneous combustion if aerobic conditions remain for a long time, mixing of incompatible wastes that may react, elevated oxygen levels from ingress into the waste due to strong vacuum in the gas collection pipes, or inadvertent burial of a heat source.	Air Woodstock Stream Terrestrial Ecosystem Groundwater	Likely	Major	4	4	16	Landfill containment infrastructure is damaged. Leachate collection system, liner, gas extraction system and cover could all be impacted. Smoke and gas emissions rising through the landfill cover.	Continuous monitoring of gas composition and temperature at the blower and regular monitoring and throttling of gas well heads. Good use of cover to minimize oxygen ingress. Pre-acceptance of all waste materials. All wastes accepted under manifest so non-compatible wastes are identified prior to acceptance. Separation of incompatible waste materials at the working face. A permanent on-site water truck. Earthworks machinery available on-site at all times to enable rapid cover placement (soil smothering).	Possible	Major	3	4	12	
5.2	Landfill	Surface landfill fire	Heat source at the surface, hot wastes, lightning, incompatible waste mixing or arson.	Air Terrestrial Ecosystem Human Health - Workers	Likely	Major	4	4	16	Short term surface fire. Discharge of smoke.	Pre-acceptance of all waste materials. All wastes accepted under manifest so non-compatible wastes are identified prior to acceptance. Separation of incompatible waste materials at the working face. Load inspections prior to disposal. Prompt placement of cover materials (daily, intermediate, final) and readily available source of cover materials available at all times. Small working face area. Firefighting training, skills and resources (including a water supply) available on site. Fire breaks and adequate separation of waste pile from forest. Firefighting reserve, training, skills and resources (including a water supply) available on site. Gas header pipes are buried, and grass is maintained (short). No smoking allowed anywhere on site by staff or 3rd parties. Water source on site. Prompt placement of daily, intermediate and final cover.	Likely	Minor	4	2	8	
5.3	Landfill	Forest fire migrating to landfill.	Dry and windy conditions. Arson. Accidental fire starting (i.e. lightning, camping fires, cigarette butts).	Air Terrestrial Ecosystem Human Health - Public Human Health - Workers	Likely	Major	4	4	16	Landfill infrastructure could be damaged. Landfill surface fire could trigger a subsurface fire. Impacts on terrestrial and aquatic animals. Loss of habitat.	Firefighting training, skills and resources (including a water supply) available on site. Fire breaks and adequate separation of waste pile from forest. Firefighting reserve, training, skills and resources (including a water supply) available on site. Gas header pipes are buried, and grass is maintained (short). No smoking allowed anywhere on site by staff or 3rd parties. Water source on site. Prompt placement of daily, intermediate and final cover.	Unlikely	Major	2	4	8	

Site		Woodstock Quarries Ltd		Woodstock Landfill		BEFORE		BEFORE		RISK	BEFORE		AFTER		AFTER		RISK
Ref	Location	Event	Detail	Receptor	Likelihood	Impact	1-5	1-5	BEFORE	Potential Consequence	Controls / Mitigation	Likelihood	Impact	1-5	1-5	AFTER	
												Likelihood after	Impact after		AFTER		
5.4	Landfill	Landfill fire migrating to adjacent forestry and bush areas.	Dry and windy conditions. Subsurface or surface landfill fire (as described above) spreading in windy conditions.	Air Human Health – Public Human Health - Workers	Likely	Major	4	4	16	Risk to offsite 3rd party infrastructure. Impacts on terrestrial and aquatic animals. Loss of habitat.	Fire breaks and adequate separation of waste pile from the surrounding forest areas. Firefighting reserve, training, skills and resources (including a water supply) available on site. Gas header pipes are buried and grass is maintained (short). No smoking allowed anywhere on site by staff or 3rd parties. Prompt placement of daily, intermediate and final cover.	Possible	Major	3	4	12	
5.5	Landfill	Windblown litter.	Windy conditions lead to litter release beyond site boundary. Litter could originate from within the landfill footprint, blown from trucks travelling through the site or from the bin exchange area.	Terrestrial Ecosystem	Almost Certain	Minor	5	2	10	Unightly, can enter streams where the litter can be transported large distances, effect of wildlife (both aquatic and terrestrial).	Prompt placement of daily, intermediate and final cover. Small working face area. Waste trucks to be covered or enclosed. Mobile and semi-permanent litter fences. Litter patrols around the landfill footprint, bin area and entrance.	Likely	Minor	4	2	8	
5.6	Landfill	Windblown litter that is washed offsite down waterways.	Windblown litter is washed into waterways and carried downstream from the site.	Terrestrial Ecosystem Woodstock Stream	Almost Certain	Minor	5	2	10	The majority of the litter generated on the site will be captured in the screens installed around the working face.	Inlet screens, outlet screens to prevent litter leaving the site. Regular inspections and litter picking as required.	Likely	Minor	4	2	8	
5.7	Landfill	Vermin on site.	The presence of waste might attract rats, birds, feral cats and other vermin.	Terrestrial Ecosystem	Likely	Moderate	4	3	12	Increase in vermin may negatively impact terrestrial ecology adjacent to the site. Vermin can act as vectors for waste depositing on neighbouring properties.	Prompt placement of daily, intermediate and final cover. Small working face area. Pest control plan to be implemented.	Likely	Minor	4	2	8	
5.8	Landfill	Members of the public entering the site (unauthorised).	Public access is provided to adjacent forestry areas for recreation. Curious members of the public.	Human Health – Public Human Health - Workers	Likely	Minor	4	3	12	Persons could encounter waste operations and come into contact with waste or operating plant.	Signage, locked gates, and an office at landfill entrance. Security camera system. The landfill operations area will be fenced (stock fencing). Secondary containment of all fuel storage areas. Spill response materials and provision of training to staff. Prompt removal and disposal of contaminated soils associated with contaminated materials.	Likely	Minor	4	2	8	
5.90	Landfill	Oil or fuel spills.	Diesel, petrol and oil storage on site for fuelling and maintaining plant items.	Groundwater Woodstock Stream	Likely	Moderate	4	3	12	Hydrocarbon discharge to ground or water.	Speed restrictions within the site. Clear road signage. Roads and intersections to be designed for safety.	Possible	Moderate	3	3	9	
5.10	Landfill	Onsite traffic accident.	Vehicle accident within the site.	Human Health - Workers	Possible	Catastrophic	3	5	15	Vehicle collision, accident resulting in injury or possibility of a serious injury and/or property damage.	Intersection design to WDC standards. Clear road signage.	Unlikely	Major	2	4	8	
5.11	Landfill	Traffic accident on public road	Traffic accident at the main intersection of site with Woodstock Road	Human Health – Public Human Health - Workers	Possible	Catastrophic	3	5	15	Vehicle collision, accident resulting in serious injury and/or property damage.	Site location and topography. Buffer distance of over >2 km to neighbouring residents. Vehicle and machine specifications that disallow excessive noise. Noise monitoring programme.	Unlikely	Major	2	4	8	
5.12	Landfill	Noise beyond the site boundary.	Noise associated with general landfill operations (including bin exchange) and construction activities.	Human Health - Public	Possible	Minor	3	2	6	Ongoing nuisance and disruption to the public.	Waste declaration and manifest system. Pre-approval for waste to be received with agreement system in place. Approved customers only, no access to the public. Load inspections at weighbridge.	Unlikely	Minor	2	2	4	
5.13	Landfill	Waste acceptance criteria not met and hazardous waste received.	Leachate contaminants at levels greater than expected. Human health effects - workers. Incompatible waste mixing.	Human Health – Workers Air Discharge	Likely	Major	4	4	16	The waste reacts with other wastes, the leachate compounds generated are unable to be destroyed through the treatment and disposal process.	Site location and topography. Buffer distance of over >2 km to neighbouring residents. Stockpile management and revegetation. Final finished contours to be planted in pasture.	Possible	Major	3	4	12	
5.14	Landfill	Landfill and ancillary operations have a visual impact on the community.	At different stages, portions of the landfill development may be visible from publicly accessible areas.	Human Health - Public	Likely	Negligible	4	1	4	Waste placement area is largely shielded from residential properties. Some earthworks and ancillary operations may be visible for short periods of time.	Onsite treatment and disposal. Operation and management plan which provides for regular monitoring and maintenance of the system.	Possible	Negligible	3	1	3	
5.15	Landfill	Wastewater discharge from ancillary facilities such as the site office.	Discharge of wastewater to ground or waterway.	Groundwater Woodstock Stream	Possible	Moderate	3	3	9	Discharge of wastewater to groundwater or waterway.	Almost certain availability of alternative disposal sites. Waste in bins stored within the bin exchange area will not contain putrescible material	Unlikely	Moderate	2	3	6	
5.16	Landfill	Site access blocked.	If the access road becomes blocked (i.e. slips, flooding etc) then there is no alternative access to the landfill for heavy vehicles. As a consequence, waste stored at the bin exchange area is unable to be placed at the tip face, resulting in odour generation.	Human Health - Public	Unlikely	Minor	3	2	6	Waste cannot be disposed of.	Site location and topography. Buffer distance of over >2 km to neighbouring residents. Operations at night limited to tip face and bin exchange areas only, with no work on stockpiles, and only in exceptional circumstances.	Possible	Negligible	3	1	3	
5.17	Landfill	Light spill from site operations (e.g., tip face or bin park including vehicles using the access road) to neighbouring properties.	Works undertaken at night, or in the early morning or early evening will require lighting. This light may be visible to nearby residents (nuisance).	Human Health - Public	Possible	Negligible	3	1	3	Lights are visible from a distance to nearby residents.	Shrouded lighting. Smart lighting (motion detector, auto dimmers).	Unlikely	Negligible	2	1	2	
5.18	Landfill	Light spill from site operations (e.g., tip face or bin park including vehicles using the access road) to adjacent properties.	Works undertaken at night, or in the early morning or early evening will require lighting. This light may disrupt the activities of nocturnal fauna.	Terrestrial Ecosystem	Possible	Moderate	3	3	9	Temporary adverse effect on fauna.	Waste handling practices (e.g. daily cover, covered bins) to control environment release of seed and vectors. Pest control programme including regular inspections around the landfill footprint and mandatory eradication response provided in Landfill Management Plan.	Possible	Minor	3	2	6	
5.19	Landfill	Increased biosecurity risk.	Waste disposed of could introduce new species or insects or plant species to the area.	Terrestrial Ecosystem Surface Water/Aquatic Ecosystem	Possible	Moderate	3	3	9	Pests and disease are introduced to the area via waste disposed at the site.	Handling of asbestos in accordance with regulations. Operational practices to minimise dispersion of dust from waste areas. Implementation of a waste acceptance policy that avoids friable asbestos becoming exposed. Prompt burial. Buffer. Vibrations standards within the district plan will be met for any blasting undertaken at the site. Design to be peer reviewed. Specification and quality assurance programme for landfill construction (QA/QC).	Unlikely	Moderate	2	3	6	
5.20	Landfill	Asbestos discharged from site (air or water).	Asbestos fragments from onsite disposal are washed or blown from the landfill footprint.	Human Health – Public Human Health - Workers	Possible	Moderate	3	3	9	Most unlikely that asbestos material dust to be blown beyond the site boundary given the mitigation measures.	Design of slopes to be undertaken by a Chartered Professional Engineer. Design to be peer reviewed.	Unlikely	Moderate	2	3	6	
5.21	Landfill	Blasting during construction	Blasting may be required during the construction phase as part of basegrade excavation.	Human Health – Public	Possible	Minor	3	2	6	Vibration effects beyond site boundary.		Possible	Minor	3	2	6	
5.22	Landfill	Rockfall	Rockfall from high wall could occur following earthquake, major rainfall event of freeze / thaw action	Human Health - Workers	Possible	Major	3	4	12	Serious injury or death to workers		Unlikely	Major	2	4	8	