Management Plan

Slevin Underground Project Area (SUPA) & Martha Drill Drive Project (MDDP)

Void Management Plan

WAI-400-PLN-011

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Site:	Waihi

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1.0	18 Nov 16			New document prepared for SUPA	19 Nov 2016
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3.0	27 Feb. 18	various		Surface Monitoring (Section 6) and Scheduled update. Table 3 (probe drilling summary) replaced	

Next Document Review

	15 February 2019				

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1 INTRODUCTION

1.1 Purpose and Scope

This document is a detailed management plan for mining activity within the SUPA (Slevin Underground Permit Application) area, and for the construction of two tunnels within the MDDP (Martha Drill Drive Project) area. The purpose of the plan is two-fold: for the protection of mine workers and ensuring the stability of mine voids, both current and historical.

SUPA and MDDP are areas with known historic workings (***Error! Reference source not found.***). The MDDP will evaluate the extent of remaining ore west of SUPA, in the general vicinity of the Martha open pit. If old workings are encountered, the information in this document details how they will be managed.

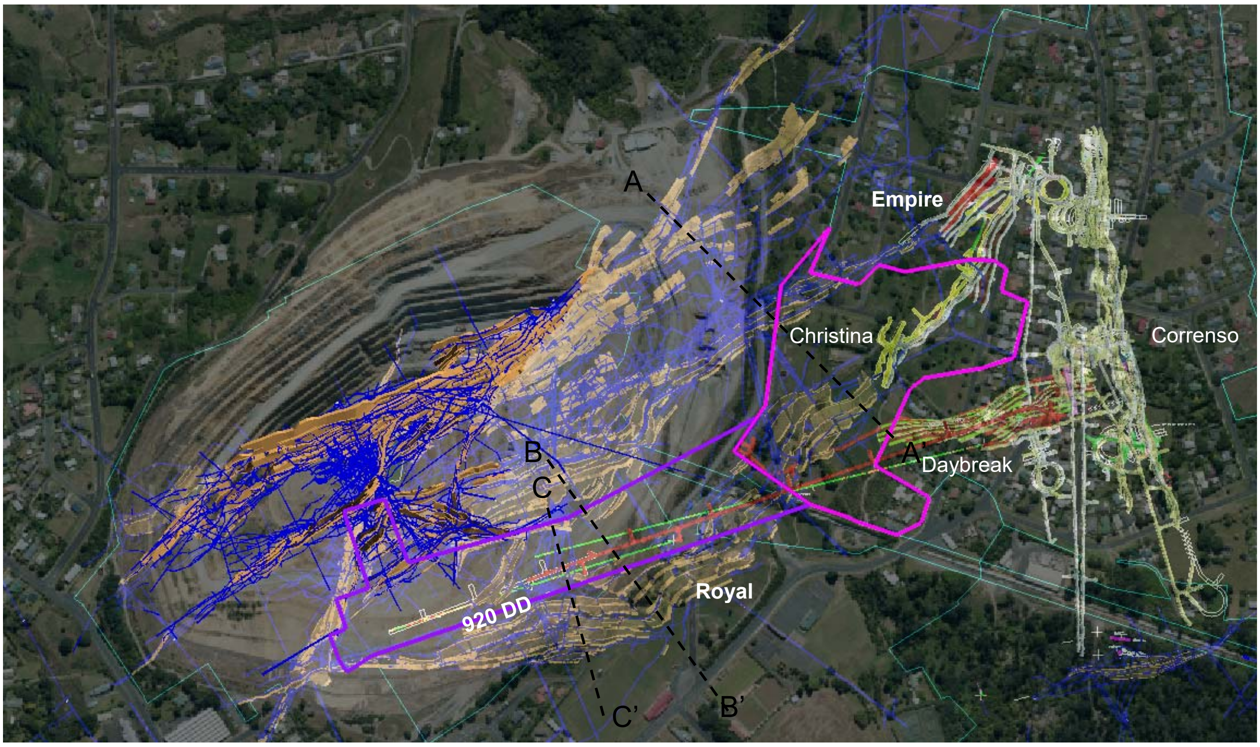

Figure 1. Plan view of SUPA (pink) and MDDP (purple) in relation to current and historic mining areas,

The plan is a requirement of Condition 17 of the Hauraki District Council (HDC) Land Use Consent for SUPA which states:

"Prior to the first exercise of this consent as provided for by condition 4, the consent holder shall provide to the Council for its written approval a Void Management Plan. The objective of this Plan is to confirm the location and shape of old unfilled and filled mine voids potentially affected by the activities authorised by this consent, and to identify the risks and controls required to ensure ground surface stability. The Plan will include, but will not be limited to modelling, probe drilling, stand-off distances, remedial measures and procedures for intersecting development, monitoring and operating procedures. The consent holder shall review and update the Plan as necessary and shall provide the updated Plan to the Council for approval."

The plan is also a requirement of Condition 23 of the HDC Land Use Consent for MDDP which states:

"Prior to the first exercise of this consent as provided for condition 4, the consent holder shall provide to the Council for its written approval a Void Management Plan. The objective of this Plan is to confirm the location and shape of old unfilled and filled mine voids potentially affected by the activities authorised by this consent, and to identify the risks and controls required to ensure ground surface stability. The Plan will include, but will not be limited to modelling, probe drilling, standoff distances, remedial measures and procedures for intersecting historical development, monitoring and operating procedures including the

monitoring of prisms within the potential hazard of altered low strength rock mass in the upper part of the southern pit wall when the drives are within 50m of the boundary of that zone in plan. The consent holder shall review and update the Plan as necessary including whenever there is any change to the methods or procedures used for void detection monitoring or operating procedures and shall provide the updated Plan to the Council for approval."

The MDDP project consists of two development drives with dimensions of 5.0m wide and 5.5m high, at depths of 190m and 350m below the ground surface with no stoping.

Because MDDP does not include stoping, it should be noted that within this document, references to planned development drives apply to SUPA and MDDP whereas references to planned stoping relate to the SUPA project only.

The plan is in accordance with the Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016 and the Health and Safety at Work Act 2015 (HSWA).

The primary intent of this plan is to ensure the management of risks and hazards associated with mining in the vicinity of old workings, in particular the caving potential of voids to the extent that surface stabilities may be affected. Without appropriate management sub-surface workings such as stoping and tunnelling can result in changes to the ground surface for a variety of reasons including (but not limited to) surrounding geology, general rock mass conditions, size and shape of the excavations and time dependency. It is recognized that mine activity in the vicinity of old voids can have an adverse effect on the stability of the void.

Management and mitigation measures are detailed below. In particular active monitoring of the voids using technology such as the Cavity-Auto-scanning Laser Scanner (C-ALS) will be a primary management strategy. This will give on-going up-to-date accurate data therefore providing valuable information on the nature of historic voids which should in-turn assist in determining long-term stability risks. Data will be managed using proprietary software.

The other relevant plans that relate to mining in the vicinity of old workings are the Principal Hazard Management Plan (PHMP) for Ground Control and Strata Instability; The Ground Control Management Plan (GCMP) and The Principal Hazard Management for Inundation and Inrush.

As described above, this Void Management Plan will apply to all underground mining operations in the SUPA and MDDP areas. It is expected that the plan will be updated as an increasing understanding is gained regarding the nature of the voids and as the SUPA mine is developed. The plan will be reviewed on an annual basis or sooner should the need arise.

1.2 Overview

Void management will be through a number of controls.

- Mining of SUPA will be by methods that do not leave unfilled voids. This is a condition of the Land Use Consent. Tight filled voids cannot cave to an extent that there is any risk to ground surface stability.
- For mining in the vicinity of historic stopes the default control will be maintaining sufficient stand-off distances from voids.
- Probe-drilling is to be carried out whenever historic stopes are identified as being within 30 m of any development; or within 15 m of historic tunnels. The purpose is to confirm and check the position and nature of historic openings which also allows real time update of the 3D historic working model.

- Monitoring, and knowledge of the nature of the voids, particularly unfilled stopes, will be vastly enhanced by the use of a Cavity Auto-scanning-Laser Scanner (C-ALS). This will assist in assessing if any caving has occurred and if it constitutes an on-going risk, as well as confirming the accuracy of the existing voids model. The C-ALS instrumentation will also allow improved assessment of rock mass conditions immediately surrounding the historic workings.

- Blast-vibrations in the vicinity of voids are managed by adjusting the charge weights when in the area of influence. Peak particle velocities (ppvs) of less than 150 mm / sec are considered to have no effect on mine workings and at 250 mm / sec are unlikely to have stability impacts. In general, the permitted surface vibration levels will control these levels. However, blast designs can be modified to achieve lower levels close to historic workings.

- Modelling of stope stabilities will include the Potvin / Mathews Stope Stability Method to manage temporary openings (i.e. stopes being mined that will be filled). This is an industry standard and has proven to be a good predictor of stope behaviour over many years of production and several different ore-bodies at the Waihi Underground Operations. Additional computer-based numerical modelling to assess stress redistributions and rock strengths around historic workings may also be carried out.

- As an additional mitigation measure the company may elect to fill historic developments or stope voids. This would reduce any caving and subsidence risk. The company also recognizes an obligation for remediation if it is identified that significant instability and caving has occurred due to proximal SUPA mining activity.

Details of the above controls are described in the following sections of the management plan.

1.3 Legal Requirements

OGNZL acknowledges that compliance with the Health and Safety at Work Act 2015 (HSE Act) and the Health and Safety in Employment (Mining Operations and Quarrying Operations) Regulations 2016 (HSE Regulations) is mandatory. This plan has been created in accordance with these acts and regulations.

It is also understood that compliance with this plan is a condition of the permit to mine in the SUPA area, and to construct the MDDP drill drives.

Internal and independent external audits are undertaken to monitor site performance in relation to the relevant plans referenced above.

2 HAZARD IDENTIFICATION

Hazards specific to this plan are propagating voids that have the potential to impact ground surface stability or affect the stability of underground workings where personnel may be exposed.

The tools and processes used by OGNZL to identify these hazards include but are not limited to:

- Geotechnical cover holes
- Probe drilling in the vicinity of old workings
- On-going survey and validation of historic plans
- Accurate surveying and mapping of underground voids
- Monitoring of underground voids
- Monitoring rock mass responses (micro-seismic system / extensometers)
- Modelling of rock mass stresses
- JHAs / Risk Assessments
- Safety audits

- Subject Matter Experts (SME's)

Tools to mitigate hazards include:

- Borehole grouting
- Borehole management plans / procedures
- Compliance with relevant acts, regulations and standards
- Backfill management
- Operator training and competency
- Workplace inspections
- Management inspections

Approved PHMPs exist for the management of ground stability, and inundation and inrush. This document is consistent with these PHMPs but focuses on the specific control measures for void management in SUPA and MDDP.

2.1 Assumptions

In preparing this Void Management Plan the following assumptions were made:

- In general, the locations of all underground workings are known and plans/models of old workings provide good guidance however it is recognised that this may not always be the case and appropriate measures to manage the uncertainty are specified in this document . Mining to-date in the vicinity of old workings and associated probe-drilling has confirmed records of old workings to be mostly within a few metres of historical plans.
- Notwithstanding the above, probe drilling will be carried out when in the vicinity of known workings.
- Further to the above it is recognized that not all production from historic stopes may have been fully documented and; there is potential for void migration i.e. although the location of historic workings may be well documented the present-day extent may not be fully known.
- There is good understanding of the regional groundwater system based on previous studies and confirmed in practice through mining at Martha, Favona, Trio and Correnso.

3 PREVIOUS WORK

The most relevant recent studies are described below:

SUPA

- Geotechnical Study by Entech Mining: Slevin Underground Project Area Ground Surface Stability Assessment Consent Document, June 2016, T Parrott lead author;
- Assessment of Vibration from the SUPA Project, Heilig and Lane (2016); and,
- Slevin Underground Project Area (SUPA Project) Surface Settlement Assessment, Matuschka (2016).

The Entech Geotechnical Study included a detailed assessment of the current mining method with regard to ground conditions and surface stabilities. The executive summary concludes: "*By applying mitigation and monitoring strategies stated within this report, the influence of underground mining on ground surface stability will be reduced to a level where there are no effects generating damage to properties (including buildings and land).*"

MDDP

- Geotechnical Study by Entech Mining: Martha Drill Drive Project Ground Surface Stability Assessment, Consent Document, February 2017, T Parrott lead author;
- Exploration Drive Blasting Assessment, Heilig (2017).

The Entech Geotechnical Study concluded that: "*Due to the size of the drive, the high strength rock mass and favourable geological structure, the ventilation drive will not have any adverse effect on pit stability.*"

The above reports and studies are specific to the SUPA and MDDP projects and consent applications and the information contained will not be repeated in this document unless necessary for clarification and justification.

4 GEOLOGICAL SETTING

The site geology has been investigated extensively. In the area southeast of the Martha Pit, where the SUPA project is located, the basement bedrock is a quartz-andesite which hosts the mineralisation. The quartz-andesite is unconformably overlain by an upper feldspar andesite and some mineralization persists into this unit albeit at sub-economic levels in this part of the district. The andesites are overlain by younger volcanic deposits consisting of rhyolitic tephras and ignimbrites. Occasionally paleosols (buried soils) and sedimentary deposits such as alluvium and boulder alluvium are present at the top of successive eruption sequences. A thin layer, up to about 8m thick, of geologically young ash, alluvium and completely weathered and rhyolitic tephras blankets much of the younger volcanic deposits.

Matuschka (2016) notes: the younger volcanic deposits (rhyolitc tephras and ignimbrites) are more compressible than the underlying andesites. Much of the historic dewatering induced settlement is considered to be associated with these deposits. However, future drainage of these deposits as a result of ongoing dewatering is considered unlikely and future settlements are considered more likely to be associated with the andesites.

Exploration associated with the MDDP is focussed on the quartz veins contained within the host andesite rocks. The geology, mineralogy and chemistry of the MDDP area is consistent with that found in Martha, Trio, Correnso and SUPA mines.

4.1 Hydrology

The hydrogeology of the Waihi area is generally well understood and there is direct connectivity between SUPA and the adjacent Correnso mine. The majority of groundwater within the SUPA area is contained within major structures. Dewatering from the Correnso mine will draw the groundwater level below that required to dewater the proposed SUPA mining area which is expected to be completely dewatered by the time development is scheduled to commence.

No additional dewatering is required for SUPA or MDDP beyond what is required for Correnso. Consequently, the SUPA project should not have any effect on the Hazard Zones (Matuschka 2016).

In relation to past collapses within subsidence hazard zones, Braithwaite *et al* (2002) reported that "*there is no evidence available to indicate that lowering the deep groundwater table … has increased the possibility of voids migrating to the surface from the old underground mine workings*".

5 MINING METHOD

The mining methods to be used in SUPA are those methods "that require stope voids to be backfilled to provide an operating floor for further stoping to proceed"[1]. Modified Avoca will be the primary method but there may be localised areas utilising Overhand Cut and Fill, also known as flatbacking. Both methods

[1] Condition 23 of the Correnso LUC.

involve sequential filling of voids as the mining front progresses. As the mining methods to be utilised for SUPA do not leave voids any significant collapse of newly created voids leading to surface instability is not considered to be conceivable.

The dimensions of the drives to be created by MDDP are too small to pose a credible risk to the stability of the ground surface.

The stability of openings created by the proposed mining for SUPA will be further managed by:

- Geotechnical mapping of ore development drives[2] and detailed characterisation by an SME of the rock mass prior to stoping operations to ensure stable stoping spans.
- Limiting open stope spans even when the rock mass design charts indicate larger spans are possible.
- Reducing stope spans in areas identified with poorer ground conditions to ensure overall stability during the short cycle life of a stope.
- Leaving stability pillars if necessary to ensure stable stope walls.
- Prompt backfilling of all stope voids in the mining cycle (which is implicit within the mining method selected), and some development drives where necessary to ensure long-term stability.
- Selective cable bolting of discrete structures to improve stope stability where structures may affect stability locally.
- Leaving a sufficiently sized remnant pillar to separate new workings from the ground surface and the ignimbrite-andesite contact to minimise impact on ground surface stability.

There is extensive site-experience with the mining methods to be used and the ground conditions expected to be encountered.

6 STABILITY MANAGEMENT OF HISTORICAL VOIDS

6.1 Historical Tunnels

By and large the location of all old workings is known. The exceptions may be where historical exploration drives have been extended at a late-stage in the mining operation, and not fully documented. Regardless the small scale of the historical development, typically less than 2 m wide by 2 m high, means they are not a significant stability or caving risk. On their own, they lack sufficient volume to ever present an issue for ground surface stability.

Historical development drives are of the order of less than 2m x 2m and do not constitute a risk to surface stability (Parrott 2016). OceanaGold Standard Operating Procedure (SOP) document WAI_418_PRO_015 contains the procedure for managing breakthrough into historical tunnels.

As specified in the PHMP for Inundation and Inrush probe drilling will be carried out to confirm or establish the exact position of the old workings. This is to occur when the historical tunnels are within 15 m of the current mine development.

The potential local instability created by the acute intersection of historic tunnels (or any other strong discontinuities) in the hanging wall will be assessed during the normal stope design and approval process and potential stability strategies may include:

- Restricting panel lengths: Short panels to isolate the area of intersection and associated halo of influence. This significantly reduces the potential extent of any wall failure. Stopes are promptly backfilled as soon as the ore has been extracted. In the event of any instability stopes are backfilled

[2] Also applies for MDDP

early. This has been a standard and successfully utilised procedure for mining the Waihi underground ore-bodies.

- Planning of panel lengths: Includes ensuring the area of intersection and potential overbreak is not in the middle of the panel. These areas rarely represent a problem at the ends of stope panels as the abutment gives increased support.
- Installation of additional support: The level spacing within the SUPA mining area is 10 m and the intersections of historic tunnels can be reinforced by cable bolts both from the upper and lower levels. Cable bolts held on site are 6 m, 9 m and 12 m lengths and the intersection areas and associated areas of potential over break can be cable-bolted. Well positioned cable bolts are a proven and an effective method for limiting over break. Again this is a standard implemented additional control during mining at Waihi.
- Probe drilling: Is routinely carried out as per the consent conditions and the CALS instrumentation gives quality information as to the true extent, position and nature of the voids. Particular emphasis is and will be given to any historic tunnels likely to have any effect at all on proposed mining activity. This allows good planning decisions relating to the management of mining in any areas of influence. In many cases the CALS surveys are showing the historic tunnels to be significantly smaller than the 2 m x 2 m dimensions often quoted.
- Stope design: Depending on the placement of the historic tunnel in relation to the proposed stope, stopes can be designed to extract the historic tunnel as part of the stope therefore removing any instability hazard.
- Pillars: Pillars can be left within the stope design to stabilise the walls of the stope during extraction.
- Blasting practices: modified wherever there is an assessed HW stability risk. Blast timings are designed so that the HW holes are fired last thereby directing blast energy away from the HW. Maximum Instantaneous Charge (MIC) weights may also be reduced. Again these are successfully utilised controls while mining through areas of potentially problematic areas.
- An additional control, although one not previously used at Waihi, could be the flooding of the historic void with a thick cement to stabilise and secure.
- Formal risk assessments will be carried out whenever an historic tunnel is in the vicinity or is expected to be intersected by any stoping activity to ensure all risks are assessed and appropriately mitigated. This may in fact mean that a pillar needs to be left to ensure there is no instability associated with the intersection but for the most part it expected that these can be routinely managed by the standard controls referenced above.

Intersections of historic tunnels with the foot wall (FW) of stopes is not considered a significant caving risk.

6.2 Historic Stope Voids

Proposed mining associated with the SUPA project will include minimum stand-off distances from historical unfilled stopes as detailed in Section 6.3.

At least two areas of unfilled historic stopes are known in SUPA, the Empire Vein and the Royal Vein. Caving to surface has previously occurred above unfilled sections of the Royal lode due to time-dependant effects.

Stability in the vicinity of historic voids will be managed by:

- appropriate standoff distances,
- ensuring peak particle velocities (ppvs) are less than damage limits,
- monitoring of the historical stope voids,
- sterilisation of ore and/or premature cessation of mining if damage to the rock mass surrounding the voids is suspected or measured through the monitoring strategy, and;
- backfilling voids to the extent re-stabilisation is achieved if it is identified that SUPA mining activity has exacerbated instabilities to a significant extent.

Greater detail of the management methods listed above is in subsequent sections.

6.3 Stand-off Distances

Proposed development and stoping activities for the SUPA Project are planned to approach the unfilled stoping voids of both the Empire and Royal Lodes. Planned Empire workings will approach historical Empire stopes, and Planned Daybreak workings will approach the historical Royal stopes. Proposed mining

activities will occur within/on the footwall side of the historical Empire and Royal stopes (***Error! Reference source not found.***). Modern day mining activities have previously mined close to historical workings at Trio (historical tunnels and stopes) with appropriate monitoring, mitigation and controls in place including stand-off distances.

In the case of the proposed Empire stoping, mining is parallel, but dips in the opposite direction to historical Empire stope voids. In the case of the proposed Daybreak stoping, mining is also parallel, but dips in the same direction as the historical Royal stope voids (***Error! Reference source not found.***).

Parrott (2016) modelled the induced stresses that proposed SUPA development and stoping would create around the upper parts of the historical Royal stopes using 2D finite element modelling software (***Error! Reference source not found.***).

Proposed development is far smaller than stoping voids, and causes less disturbance to the rock mass and this was confirmed by the modelling. Based on this modelling, planned development should provide for a minimum stand-off distance of 10 m to historical stoping voids.

Greater volumes of rock are mined when stoping, and this results in greater changes in the mining stress field. Modelling indicated that stoping adjacent to historical stopes (as per the proposed mining shapes for SUPA) does not appear to cause significant changes in stress until the proposed stoping is level with the crown (top) of the historical stope void.

Parrott (2016), based on this modelling, recommends that stoping when parallel to historical stope voids should not occur within 20 m. When stoping adjacent / level to the crown of the historical unfilled stopes, then that standoff distance should be increased to 30 m, unless appropriate means for monitoring and managing the unfilled void are put in place.

The recommended stand-off distances apply when mining within the footwall of historical unfilled stopes. These do not apply when mining within the hanging wall of unfilled stopes. A separate risk assessment and on-going monitoring will be undertaken if mining activity is to occur on the hanging wall or crown pillar of an historic unfilled stope but at the time of writing this plan no such activity is proposed.

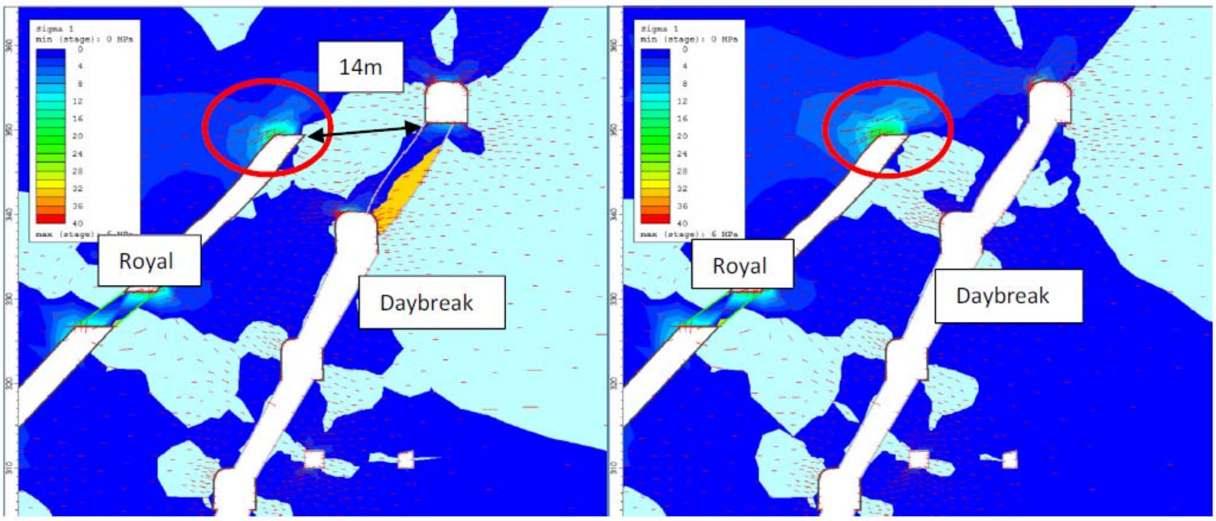

Figure 2 Model results showing Sigma 1 just prior to stoping adjacent to Royal stope Crown (left), and mining step just after showing greatest step change (although minor) in induced stresses around the crown of the Royal lode (right) (Parrott 2016)

Based on the Parrott (2016) modelling and recommendations from the Council peer reviewer the SUPA consent conditions specify the following stand-off distances from unfilled stopes as listed below in Table 1.

Table 1. SUPA stand-off Distances

Mining Activity	Historical Mining	Stand-Off Distances
Development Drives and AVOCA stopes	Development, Rises and Access Drives	Historical development shall only be intersected where required for ensuring mine stability, or where required for effective mining operations.
Development Drives	Unfilled portions of Stopes	Development drives shall have a minimum standoff distance of 10 m to unfilled portions of historical stopes.
Avoca Stopes	Unfilled portions of Stopes	Stoping shall not occur within 25m of unfilled portions of historical stopes
Avoca Stopes	Crown Pillars	Standoff distance shall be increased to 30m, unless mitigation measures can be put in place. Mitigation measures include monitoring with laser scanning devices such as CAL-S, or filling of the unfilled void via one or more boreholes from a location outside the standoff zone.

The stand-off conditions proposed for MDDP are as listed in Table 2:

Table 2 – MDDP Stand-Off Distances

Historical Mining	Stand-Off Distances
Development, rises and access drives	Historical development shall only be intentionally intersected where required to implement remedial works for ensuring stability of the MDDP drives, or where required for effective development drive construction and operation.
Unfilled portions of stopes	Development drives shall have a minimum stand-off distance of 10m to unfilled portions of historical stopes.

It is recognized that although the location of old workings is known the extent of the workings may be larger than originally mined / documented. To ensure stand-off distances are maintained the location and extent of voids will be determined primarily by probe drilling, C-ALS surveys, and 3D re-modelling of the historic voids. Details are described in Section 6.4.

6.4 Probe Drilling

Once mining development activity is within the vicinity of old workings as specified above in *Table 2* targeted probe drilling will be undertaken. Initial probe drilling will occur before stand-off distances are reached. The purpose of the drilling will be to confirm the exact position of the workings and to obtain information as to the nature of the workings, for example if they have been filled or remain open.

The process to be followed is:

1. Identification of areas of historic workings using the updated 3D model developed by OceanaGold.

2. Probe drilling from mine development drives.

3. Where the approximate location of voids is known, the probe drilling will be in the direction of the workings. If there is uncertainty probe drilling patterns as shown below in **Error! Reference source not found.** will be undertaken. The need to design and undertake probe drilling will form part of the management design signoff / checklist for permitting the development to advance.

4. All probe holes will be entered into a database noting the dip / azimuth and distance the void was intercepted.

5. If historic workings are intersected by the probe holes, the 3D model will be updated as needed to reflect actual void locations.

6. Stope and tunnel (development) voids will be further assessed using C-ALS instrumentation. Models of the historic workings will be updated if there is variance from historic records.

7. Additional probe drilling will be undertaken if inconsistencies between adjacent probe holes or the 3D model exist.

8. If it is found that mine development is inside appropriate stand-off distance from the historic workings or as determined by subsequent risk assessments then either the stoping panel will be removed from the mining plan or the ore development drive will be realigned such that the appropriate stand – off distances are maintained.

Cover holes are also routinely drilled ahead of development in SUPA as an additional safety measure even where no old workings have been documented. The same will apply for MDDP. The forward cover hole is 6 metres long. This ensures cover drilling is always at least a round in advance of development. Each development blast achieves an advance of about 3 m.

Mining regulations and site procedures require that any mine worker who inadvertently holes into old workings must immediately notify the Shift Supervisor, who must then notify the Mine Manager and work may only recommence when the hazards associated with the interaction have been assessed and a plan for future works has been approved by the mine manager.

The frequency and density of probe drilling and probe hole designs are based on Parrott (2016) recommendations and depend on proximity to old workings / stopes. Intensive probe drilling occurs for example if development drives are within 20 m of the FW of stopes. Monitoring of the stope will be by C-ALS inserted into the probe holes.

Plans and zones may be adjusted as exact position of historic voids is confirmed. *Figure 3* below is a plan view of 800 level showing the position of historic voids in relation to the SUPA boundary. Four zones are outlined based on probe drilling requirements: An Intensive Probe Drilling Zone (red dashed line), Intermediate Probe Drilling (orange dashed line), Limited Probe Drilling (yellow dashed line) and Other SUPA (all other areas within the SUPA boundary shown by the purple solid line. The same probe drilling zones will be applied on all levels.

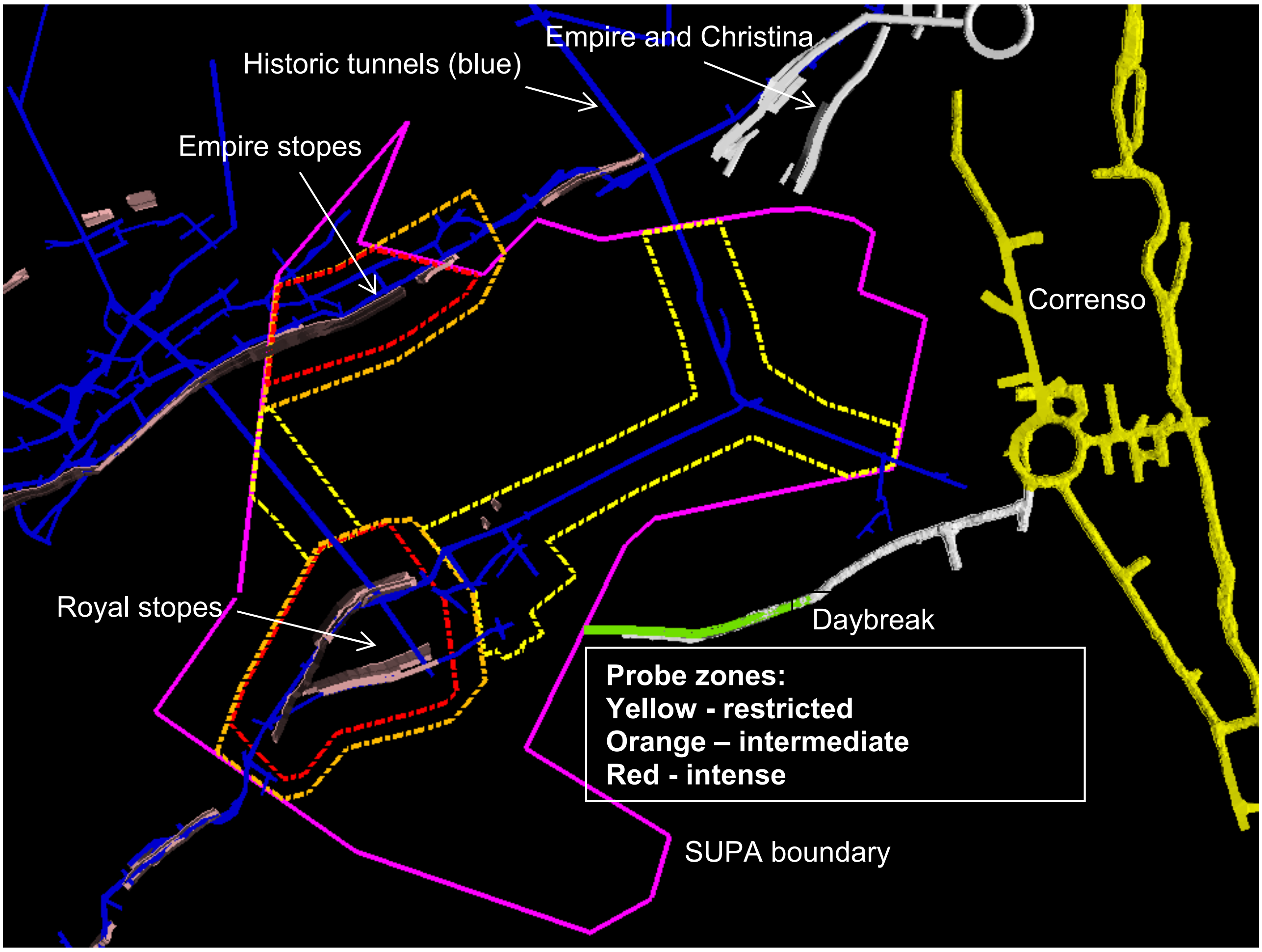

Figure 3 Plan View 800 m RL showing historic tunnels (blue) historic stope voids (brown) and the probe drill zones associated with historic voids. Red dashed line is 25 m from the FW and 30 m from the HW of historic stopes. Orange is 30 m from stopes. Yellow dashed line is 15 m around historic tunnels. Stand-off and probe drilling distances shown in this figure will apply on all levels. Note that a 30 m stand-off applies at crown pillar levels.

Table 3 summarises the probe hole drilling requirements in SUPA for each zone based on proximity to historic workings.

Table 3 Probe Drilling Zones Summary table

Zone	Definition	Criteria	Accountability
Intense probe zone	25 m from the FW and 30 m from the HW of historic stopes	. Probe drilling to intersect and confirm stope voids ensuring stand-off distances are maintained	Survey to issue probe plans with development designs. Approval by senior planning engineer and / or technical services superintendent.
Intermediate probe zone	30 m from historic stopes in areas where model information is inaccurate or unconfirmed	Probe holes to 25 m in the direction of the stope to ensure stand-off distances are maintained	
Limited probe zone	15 m from historical tunnels.	Probe drilling to target and confirm position of historic tunnels	
Other areas		One 6 m long cover hole ahead of development unless a diamond drill cover hole has already tested drive design	Shift supervisor and operator. Standard for development in SUPA

6.5 Remedial Measures for Historical Development

Condition 17 of the SUPA consent and condition 23 of the MDDP consent require this plan to include remedial measures and procedures for intersecting historical development. The procedures for design, ground support and monitoring are detailed in the OceanaGold SOP for planning and mining of development breakthrough into old workings, WAI_418_PRO_015.

Intentional intersection of the historic development, rises and access drives will be undertaken in the following circumstances:

- If the top of a historic working is close to the floor of a development drive, the historic workings will be intersected and backfilled,
- If the historic development is at approximately the same level as a development drive, the historic workings will be intersected, supported and either barricaded or backfilled. The exception will be if it is necessary to follow the trend of the historic tunnel. In this case the historic tunnel will be kept below the level of back height of the new development so the on-going installation of ground support is into relatively undisturbed ground.

Historic tunnels, even though the dimensions are relatively small (generally around 2 m high by 2 m wide) are a potential hazard when they are close to the floor of the development drives due to the risk of unrecognised propagation. The worst-case scenario is that a breakthrough occurs with potential for worker injury. There is no risk of large scale propagation due to the small size of the openings but mining activity when immediately proximal to historic tunnels may trigger localised instability.

The position of the historic tunnels will be accurately determined by on-going probe drilling as drives are advanced. Where backfilling is required, the historic tunnel will be intersected by a routine and planned firing, generally a 3 m advance; or if immediately below the floor level holes will be drilled into the floor designed to break into the tunnel. Immediate backfilling or support installation will then occur. If the historic tunnel trends across the drive direction the intersection point(s) will be barricaded or backfilled to prevent personnel access.

6.6 Managing Blast Vibration

The level of vibration at the perimeter of any existing voids will vary according to the proximity of the stope blasting as well as the explosive quantity within the blast hole. There is a direct relationship between blast quantity and vibration levels and an inverse relationship between blast location and distance to e.g. a stope wall. Vibrations induced by blasting are measured and modelled as peak particle velocities (ppv) in mm / sec.

Controlling or reducing the ppv at the walls of a void is primarily through:

- Reducing explosive charge weights as required to lower peak particle velocities (ppvs)
- Increasing the distance from the blast location
- Reducing the number of blast events e.g. only one blasting event if within stand-off zones or if potential void wall damage is identified.
- Modifying blast designs (deckings, timing, decoupling, sequencing)

The formula for calculating ppv for the Correnso Underground is given by Heilig and Lane (2016) as:

$$PPV_{Average} = 1620\left(\frac{d}{\sqrt{w}}\right)^{-1.49}$$

$$PPV_{Effective\ 95\ Percentile} = 2760\left(\frac{d}{\sqrt{w}}\right)^{-1.49}$$

Where *d* is the distance between the blast and monitoring location in metres and *w* is the explosive weight per delay in kilograms.

The vibration relationship is estimated from previous blasting at Favona and Trio and used for Correnso production blasting. Recent blast vibration measurements however are consistently lower than predicted by the model and it may be that model revisions would suggest lower blast vibration impacts. Until there is an increased understanding of SUPA rock mass responses to blast vibrations the above formula is to be used to assess likely ppvs at stope wall boundaries Table 4 below gives the calculated ppvs for a range of maximum instantaneous charge weights (MIC) and distances from the blast locations as derived from the Heilig and Lane (2016) formula. Both the 50 percentile and 95 percentile values are given.

It is noted that in most cases the permitted vibration level at surface will override the blasting level within historic workings but the SME will assess both during the design phase.

The 95 percentile equation is initially to be used for an even greater level of conservatism but the model and parameters may be subsequently refined.

Table 4. Calculated PPVs for charge weights and distances from blast centroids for SUPA

MIC (kg)	Distance (m)	ppv(p95)	ppv (p50)
5	10	296.2	173.9
10	10	496.5	291.4
15	10	671.6	394.2
20	10	832.1	488.4
25	10	982.6	576.7
30	10	1125.5	660.6
5	15	161.9	95.0
10	15	271.4	159.3
15	15	367.0	215.4
20	15	454.8	266.9
25	15	537.0	315.2
30	15	615.2	361.1
5	20	105.5	61.9
10	20	176.8	103.7
15	20	239.1	140.3
20	20	296.2	173.9
25	20	349.8	205.3

30	20	400.7	235.2
5	25	75.6	44.4
10	25	126.8	74.4
15	25	171.5	100.6
20	25	212.4	124.7
25	25	250.9	147.2
30	25	287.4	168.7
5	30	57.6	33.8
10	30	96.6	56.7
15	30	130.7	76.7
20	30	161.9	95.0
25	30	191.2	112.2
30	30	219.0	128.5

Overseas studies show that vibrations less than about 50mm/s are not able to cause damage around an opening, irrespective of rock mass quality (Braithwaite et al 2002). A summary of the levels in terms of peak particle velocity and the corresponding type of damage is shown in Table 5 (Yu 1980). The values in Table 4 show the necessary vibration to produce the identified impact from blasting activities. Based upon this data, and as an example, subjecting a rock mass to a vibration of around 250mm/s is considered unlikely to induce a new fracture pattern in the rock mass and subsequently result in the dislodgement of rock from an unlined tunnel. For the range of vibration levels quoted in Table 4 vibration of this magnitude could only be achieved when blasting at close proximity to the existing void. Mining activity even as close as 20 m from a void can be relatively easily carried out without exceeding 250 mm / sec ppv by reducing MICs

Table 5 Summary of vibration levels that can impact upon the rock mass (Yu, 1980)

Peak Particle Velocity (mm/s)	Type of Damage
250 mm/s	No noticeable damage to underground workings. Maximum tolerable vibration level for permanent drifts.
300 mm/s	Fall of rock in unlined tunnels.
500 mm/s	Minor scabbing failure observed. Maximum tolerable level for main drifts.
750 mm/s	Development of cracks in weak ground. Timber sets required to support scabbing wall. Maximum tolerable vibration level for temporary accesses.
1000 mm/s	Possible formation of cracks 15mm wide along weak plane of geological structures causing severe dripping of water and a potential failure.
1500 mm/s	Possible formation of cracks 15mm wide in drifts of competent rock resulting in abandoned accesses.

This data compares favourably with other published information on damage to rock masses. Other groups have also proposed that the on-set of damage in hard rock occurred at a vibration level in the range of 700 to 1000 mm/s. Table 5 data suggests maintaining a vibration level at the existing workings of less than 250mm/s will limit the likelihood of fall of **newly** created blocks of rock created by introducing a fresh set of fracturing into the rock mass. Whilst other unstable blocks may become dislodged at lower vibration levels, it is proposed that these same blocks would become displaced through other impacts and / or loosen with time.

There is however a wide range of vibration levels given by various authors. While reassurance is given by the above studies the blast damage index (BDI) proposed by Yu and Vongpaisal (1996) suggests damage may occur at lower ppv levels albeit not ***new*** damage.

The calculation for the BDI is given as:

$$\text{Blast Damage Index (BDI)} = \frac{\text{Induced stress}}{\text{Damage resistance}}$$

$$BDI = \frac{V \times d \times C}{K_r \times T}$$

where

V = vector sum of peak particle velocity (m/s)
d = density of rock mass (g/cc)
C = compressional wave velocity of rock mass (km/s)
K_r = site quality constant, up to 1.0
T = dynamic tensile strength of rock mass (MPa)

V,d,C and T can be measured or reasonably approximated.

d = 2.5
C = 3.8 (from Correnso seismic modelling by IMS)
T = 7.9 (SRK Correnso Stage 2B Report)

The site quality constant K_r ranges from 0.1 (extremely poor) to 1.0 (very good). A greater understanding of the nature of the rock mass in the vicinity of old workings is expected to be obtained from monitoring and probe drilling but as an example if K_r was considered to be 0.4 (fair to poor) then the BDI calculation that might be used for historic openings in SUPA could be given as:

BDI = 2.5 x 3.8 x V / 0.4 x 7.9 = 3 x V (m/s) *(or 0.003 x V (mm/s))*

As general guidance the BDI target would be less than 0.5 which correlates to minor and discrete scabbing effects in the Blast Damage Index Table (Table 6). A higher K_r would correlate to lower BDI values. The studies cited are from Kidd Creek and represent an overall competent rock mass however the surface of the more brittle rock mass appears to be more prone to blast vibration damage.

The BDI can be therefore considered a lower level conservative reference for the purposes of guidance. The ability to actually monitor stope voids using the C-ALS tool will ultimately provide validation of the modelling.

The principal determining factor is the nature of the rock mass around the stope void, and in particular the HW and crown pillar conditions. Case–by-case assessments will be made based on drilling data, modelling and information gained from the C-ALS surveys. Any blasting will be initially designed to keep calculated p95 PPVs below 250 mm / sec and below 150 mm /sec if potential instability is suspected. Standoff distances mean it will not be possible to measure ppvs at the margins of historic workings so vibration calculations will be derived from the Heilig and Lane (2016) formula. The p95 parameter ensures a level of conservatism.

On-going monitoring will assist in determining instability risk and will provide a mechanism for validation of models.

Table 6. Blast Damage Index (Yu and Vonpaisal 1996). Note that figure references in the table do not relate to this document

BDI	Type of damage
≤ 0.125	No damage to underground excavations (Fig. 2).
	Maximum allowable value for key permanent workings, e.g., crusher chambers, shafts, permanent shops, ore bins, pump houses, etc.
0.25	No noticeable damage (Fig. 3).
	Maximum tolerable value for long term workings, e.g., shaft accesses, rescue stations, lunch rooms, main sub-stations, main shops, vent raises, ore passes, etc.
0.5	Minor and discrete scabbing effects (Fig. 4).
	Maximum tolerable value for intermediate term workings, e.g., main drifts, main haulage ways, etc.
0.75	Moderate and discontinuous scabbing damage (Fig. 5).
	Maximum tolerable value for temporary workings, e.g. cross-cuts, drill drifts, stope accesses, etc.
1.0	Major and continuous scabbing failure, requiring intensified rehabilitation work (Fig. 6).
1.5	Severe damage to an entire opening, causing rehabilitation work difficult or impossible (Fig. 7).
≥ 2.0	Major caving, normally resulting in abandoned accesses (Fig. 8).

As mentioned void stability is influenced by primarily rock mass conditions in the halo around the void, including the presence of discontinuities; the dimensions of the open void and the dip of the hanging wall of the void. The shallower the dip the greater the cross-sectional width of the void with accordingly increased likelihood of instability.

Evaluations of potential instability take all these factors into account.

6.7 Surface Monitoring of the Open Pit

Condition 23 of the MDDP consent requires this Plan to include the monitoring of prisms within the potential hazard of altered low strength rock mass in the upper part of the southern pit wall when the drives are within 50m of the boundary in that zone in the plan.

All walls of the Martha open pit are monitored continuously via robotic Leica total stations. Surveyed prisms have previously been installed at ~50m intervals over the entirety of the pit including the area of low strength rock mass in the upper southern wall. This gives complete broad coverage of the pit walls and provides an early indication of any developing instability. Prisms are measured on a four hourly time cycle, and this can be increased to two hourly intervals if there are stability concerns. Prism data is checked daily for any developing trends. Movement outside of set thresholds triggers immediate automatic email notifications to relevant site personnel including the open pit geotechnical engineer and the Senior Underground Geotechnical Engineer.

Thresholds vary depending on a number of factors. Levels are documented in section B of the Open Pit Geotechnical Management Plan – WAI -350-PLN-001. As general guidance if movement occurs on two adjacent prisms on two consecutive readings of more than 100 mm (note that 38 mm is the level of survey accuracy) then the drive would be stopped subject to readings being confirmed. Wall assessments would be conducted and peer reviewers notified. Further mitigation may include moving the GroundProbe SSR-XT slope stability monitoring radar to monitor the south wall.

Continuous prism monitoring ensures a high-level of monitoring during MDDP development of the 920 drill drive within the inferred low-strength rock mass as modelled by PSM.

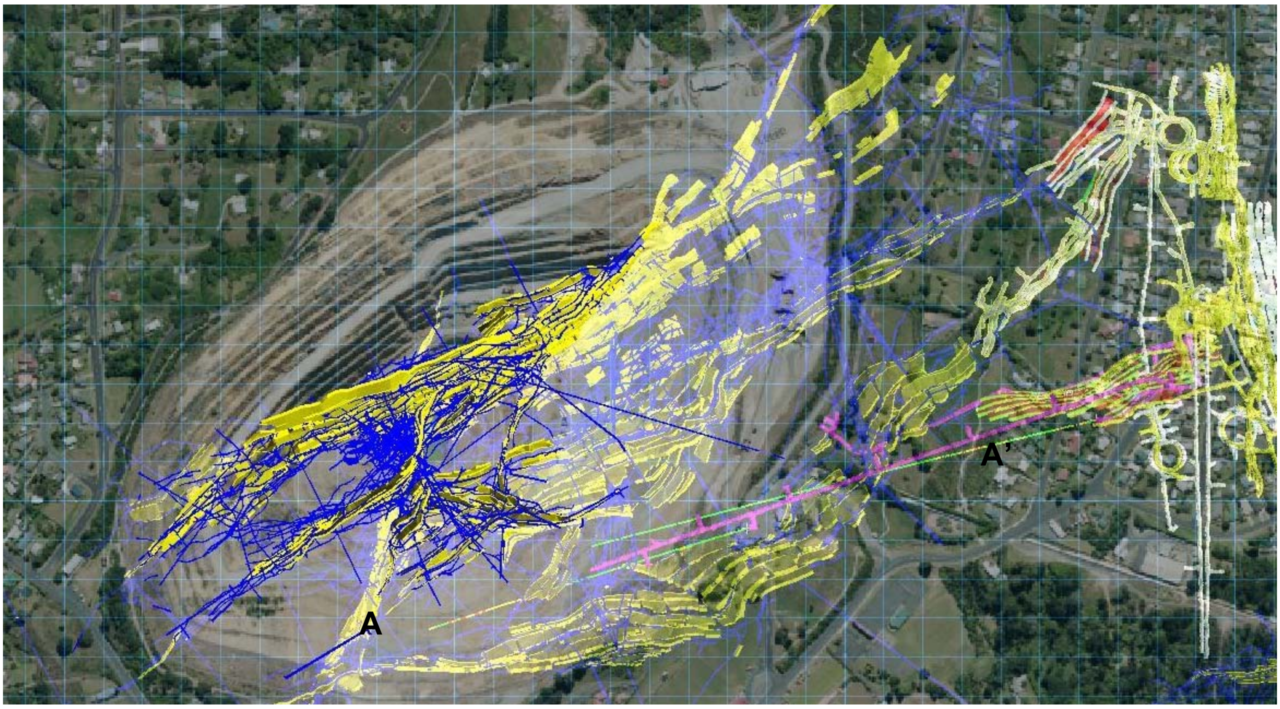

Figure 4 Aerial photo of the open pit and surrounds showing projections of the historic workings and current mine development. The MDDP drives are shown in pink. The traces of the two geotechnical cover holes testing the 920 drill drive are also shown. A – A' shows the line of the cross-section shown in Figure 5 below

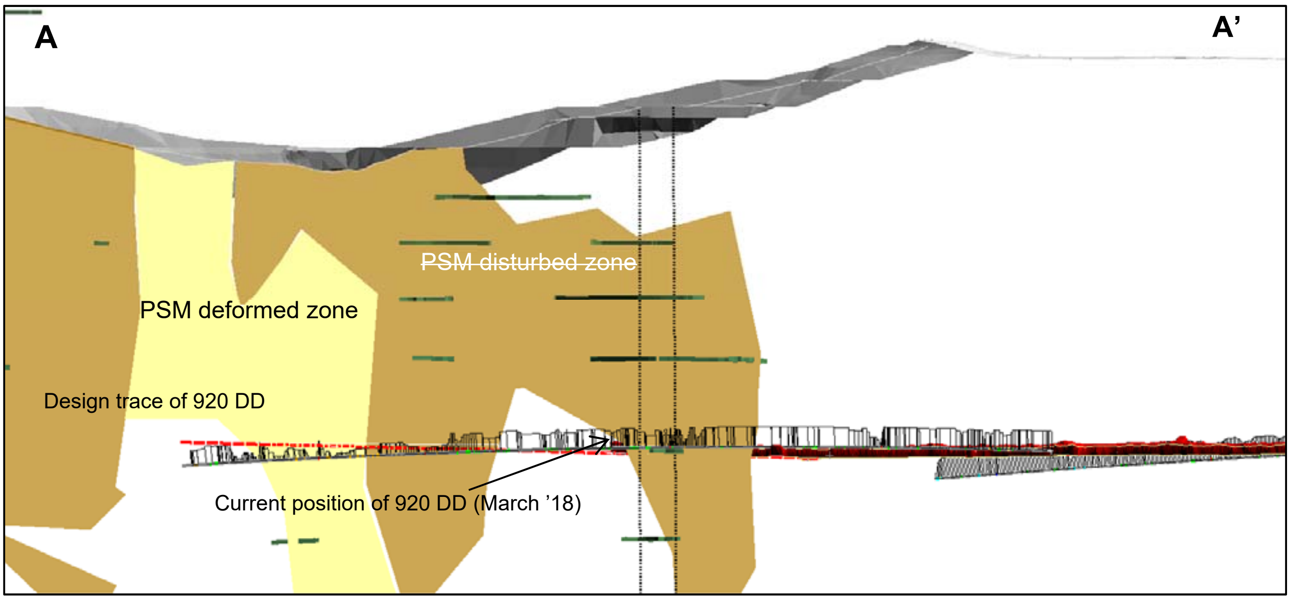

Figure 5 Cross section through the MDDP 920DD showing current drive position and histogram plots of RQD values from the two cover holes. The upper values represent 100 % RQD. The PSM modelled deformed and disturbed zones are also shown

7 MONITORING, MODELLING AND MITIGATION

7.1 CAVITY AUTO-SCANNING LASER SYSTEM

The Company has employed a cavity monitoring system (CMS) since the commencement of mining at the Waihi Underground Operations in 2006 to survey the stope voids. An advancement of this methodology is a similar system whereas the hardware can be inserted and retrieved from a borehole. This is the C-ALS system which is now used for assessing and monitoring SUPA underground workings. This allows mapping of inaccessible old workings and unfilled stopes and will facilitate soundly based assessments of the condition and extent of the voids.

This improves the understanding of the nature of the historic voids and their caving potential and / or the extent of any caving over time. Additionally it is expected that this will allow for on-going assessments and monitoring of the old workings while mining in SUPA and constructing the development drives within MDDP.

The C-ALS is designed specifically for void scanning in mining operations. The probe head is inserted down a drillhole into the void where it then laser scans the void – effectively as far as the line of sight in three dimensions. The point-cloud data is then used to build detailed three-dimensional shapes which can be readily viewed and understood (refer *Figure 6*). Additionally, a camera function allows an assessment of rock mass conditions in the critical zone adjacent to the void.

Figure 6 C-ALS image of the inside of a stope void (http://www.controlsystem.ca/?cs-cavity-scanning,90)

The existence of an underground void does not necessarily represent a significant hazard. The scan enables determination of the size and extent of the opening enabling evaluation and accurate risk assessment. Key data is therefore obtained on the nature of the stope excavation and infill; a void location is obtained and the geometry and condition of the mine workings can be assessed (intact / unstable / collapsed). Void volumes are obtained and can be compared against old mine records. Potential failure mechanisms can also be assessed.

The data will be used as part of the risk assessment process and for on-going monitoring. Wall conditions of the void will be assessed from images obtained and the camera function will assist in assessments of the nature of the rock mass immediately proximal to the void.

The use of the monitoring C-ALS will provide an improved resolution of the old workings extents and enable better understanding of the subsidence risk and extent of the hazard areas.

7.1.1 APPLICATION

Assessment of the void will occur from development drives while still outside the recommended stand-off distances although there is a practical limitation of 30 – 35 m due to having to manually feed and retrieve the tool and less if drilled using the Solo production rig. The C-ALS is inserted into probe holes and initial images obtained. These are compared against historic data. On-going assessments will be through comparisons of images after relevant blasting activity. Priority will be given to obtaining C-ALS surveys of stope voids as soon as possible.

Initial void assessment will occur from development drives once probe holes break into the stope void. If development (as opposed to stoping) is on-going within relevant stand-off distances of an open historic stope then surveys will be at regular intervals as required to monitor the void. If any production blasting is occurring then a C-ALS of the historic void will be carried out after every production blast or, in both cases, until such time as it is determined that mining activities are not having any affect and are completed.

7.2 ADDITIONAL MONITORING

Monitoring of proposed (modern) stoping voids will be undertaken via regular Cavity Monitoring Survey (CMS) of stopes once they are emptied, as is the current practice at the Correnso Underground Mine. This allows the capture of detailed and accurate 3D void models. It will also enable the mine to measure performance of stopes against designs, which are fed back into the design loop for improvement where required. Active stopes will also be visually inspected by mine employees on typically a shift by shift basis as part of routine activities.

Monitoring of the rock mass response to proposed mining activities may take the form of:

- Use of instrumentation such as multi-point borehole extensometers, vibrating wire stress meters and survey traverses underground to measure displacement of the rock mass during mining.
- Use of C-ALS to initially measure and to monitor unfilled stope voids of the Empire and Royal lodes as previously described.
- Extension of the existing micro-seismic monitoring system to measure and monitor ground noise activity and rock mass and structure response to mining.
- Surface network of survey stations to measure displacement above SUPA.

7.3 POTVIN / MATHEWS STABILITY METHOD

The Potvin-Mathews Stability Graph method is a widely used industry standard for assessing stope stabilities and site experience over 10 years of mining underground at Waihi has shown it to be a good predictor of stope stability.

The method is principally based on the use of Q' (Barton 1974), which classifies the rock mass based on rock mass quality (how broken it is) the number of sets of joints, the nature of the joints and the alteration or infill of the joints. Three other factors are then applied to account for stress (Factor A), structural orientation (Factor B) and gravity effects (Factor C), giving N' a modified stability number.

i.e. Where $Q' = RQD/Jn \times Jr/Ja$

And $N' = Q' \times A \times B \times C$

- RQD is Rock Quality Designator, the cumulative sum of core pieces with length >10cm within a core run, represented as a cumulative percentage.
- Jn: Joint set number, which takes into consideration the number of discontinuity sets present within the rock mass.
- Jr: Joint roughness number, which takes into consideration small and large scale asperities and undulations on the joint surface.
- Ja: Joint alteration number, which takes into consideration the chemical alteration of a joint surface affecting its frictional and strength properties.
- Factor A is a ratio of intact rock strength to induced mining stresses, downgrading the overall N'-value
- Factor B measures the effect of least favourably oriented joint set affecting stope surface.
- Factor C measures the effect of gravity on potential failure modes (slabbing, sliding failures)

The N' stability number is used in conjunction with the hydraulic radius (a factor relating shape and dimensions) to assess stability on an empirical chart (*Figure 7*).

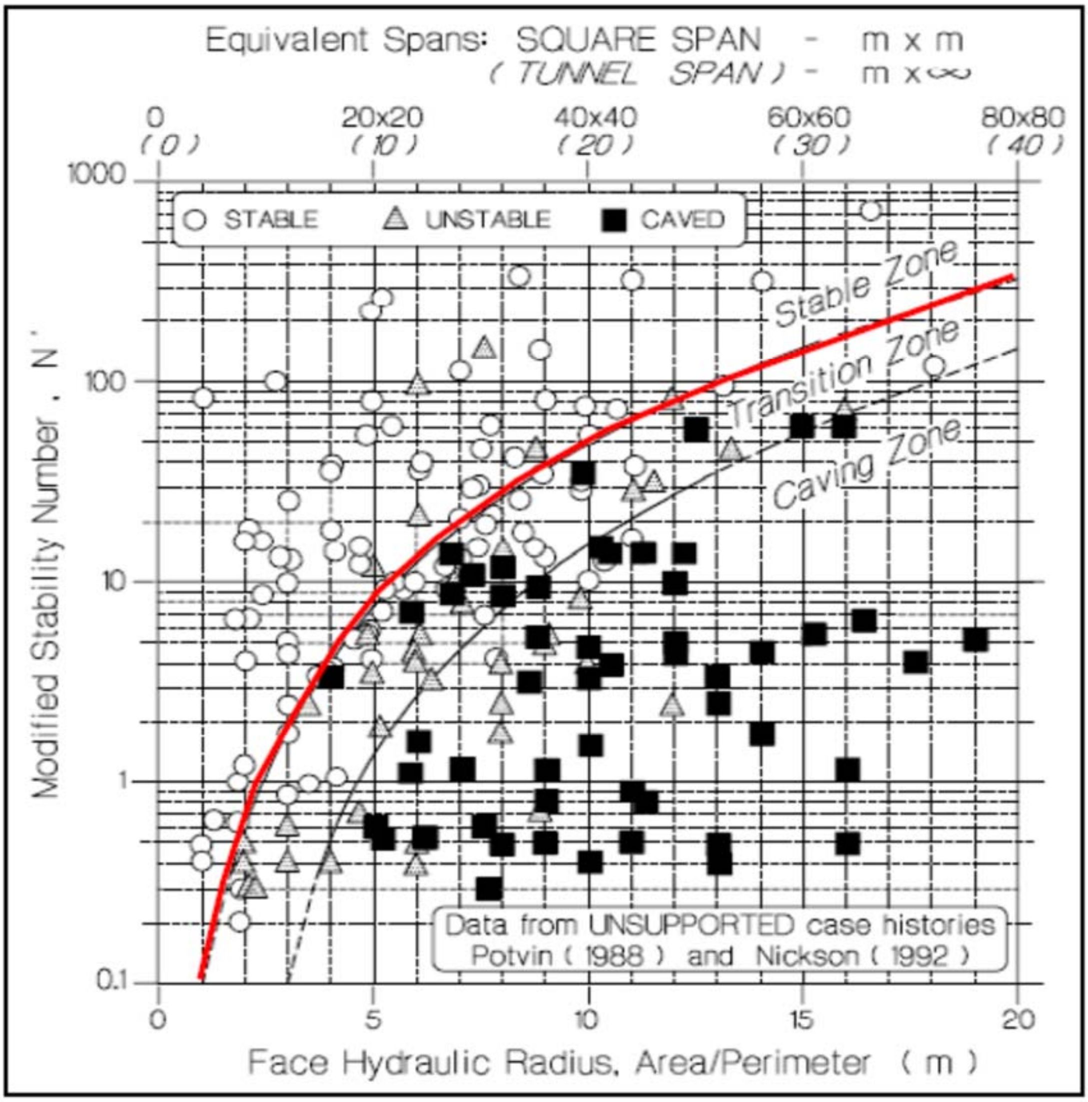

Figure 7 Mathews / Potvin Stability Graph (Potvin 1988) for Stable Unsupported Stope Spans. The red line indicates the Stable Unsupported Limit for stope spans.

Parrott (2012) used a probabilistic approach to determine Q’ when assessing stope stabilities for Correnso and a similar approach is proposed for assessing stabilities of historic stopes. This means a conservative Q’ of P25 can be used to assess stabilities if mining within standoff distances is to be considered i.e. the low 25 percentile for Q’ values is used in the initial model calculations until better knowledge is gained. This ensures a high degree of conservatism is applied. Due to a much lower amount of data available it may be necessary to introduce artificial factors to ensure sufficient conservatism, for example applying a higher value for Jn.

The factors for N’ take account of the dip of the stope walls, an important parameter of stope stability.

Q’ values will be re-estimated for each proximal void based on information from the C-ALS tool and camera / video images of the immediate void walls as described below and N’ values will be recalculated from the most up-to-date information.

Assessments of void stabilities, both historical and current, will incorporate the Stability Graph as a parameter. The model is recognised as providing guidance but is not, in isolation, the sole determining parameter for assessments and does not recognise the time-dependency factor for historic stope voids.

7.4 ADDITIONAL MITIGATION

If there is an unacceptable risk to local stability as determined by the methods described above, the Company may elect not to mine a particular stope, or mine within a specified area, thereby sterilising that part of the ore-body. This issue may be identified even if the activity is outside the stand-off distances previously detailed.

If an intersection with historic voids does occur, appropriate measures will be taken including use of ground control techniques (reinforcement, surface support and backfill) to provide a serviceable workplace and to ensure no adverse effect on ground surface stability.

If the stability of historic stopes is determined to be significantly affected by SUPA mining activity, and this would be likely determined through on-going C-ALS monitoring, then remediation measures will be undertaken. This would possibly involve, but would not be restricted to, backfilling of the affected area. The appropriate remediation and methodology would be identified through the risk assessment process and Council approval obtained.

C-ALS assessments of stopes may also identify that significant overbreak has occurred in a void that is unlikely to be related to SUPA activity i.e. the activity has been well outside stand-off areas and blast vibrations would have been expected to be well-below damage-levels. Caving of unfilled voids can occur simply through time-dependant weakening. In this event the information will be reported to Council in the first instance. Subsequent reviews may involve changes to the mining plan to ensure SUPA / MDDP activity does not exacerbate stability issues.

8 RISK ASSESSMENT AND MANAGEMENT

8.1 HAZARD ASSESSMENT

Risks are typically associated with events resulting from hazards within a given system. Risk identification involves a detailed review of the system under study to identify the type of energies and associated hazards that are present. The hazards specific to this management plan will be the stability of historical and current voids in SUPA and MDDP. Once these hazards are understood, a systematic process to identify the associated risks needs to be followed. There are various techniques available for the identification of hazards as follows:

- Experience/judgment – experienced personnel at all levels provide a sound basis for hazard identification
- Checklists – provide hazards that are common to a particular task or system
- Legislation and OceanaGold Standards - legislation, industry and company standards reflect collective knowledge and experience, accumulated on a broad operational and historic basis
- Accident/Incident investigation – often accident/incident investigations identify hazards that require management action

Hazards may also be identified using any of the following methods:
- Team based risk assessments
- Preliminary hazard assessment
- Job Hazard Analysis (JHA)
- Workplace inspections
- Monitoring
- Internal/external audits
- Environmental monitoring
- Community complaints and consultation
- Accident and incident investigations
- Hazard reports

The team based risk assessments will be a staged process beginning with the gathering of information from drillholes, historical records, probes and C-ALS surveys.

The subsequent assessments will consider but will not be limited to:
- whether voids are filled or unfilled,
- the morphology (shape and dip) of the void,
- void dimensions,
- rock mass conditions including discontinuities,
- potential failure mechanisms and caving potential; and,
- potential blast vibration impacts.

8.1.1 RISK MANAGEMENT PROCESS

The OceanaGold risk management process is shown below in *Figure 8*.

Assessments are undertaken using the risk ranking table, risk matrix and risk management table detailed in the appendices.

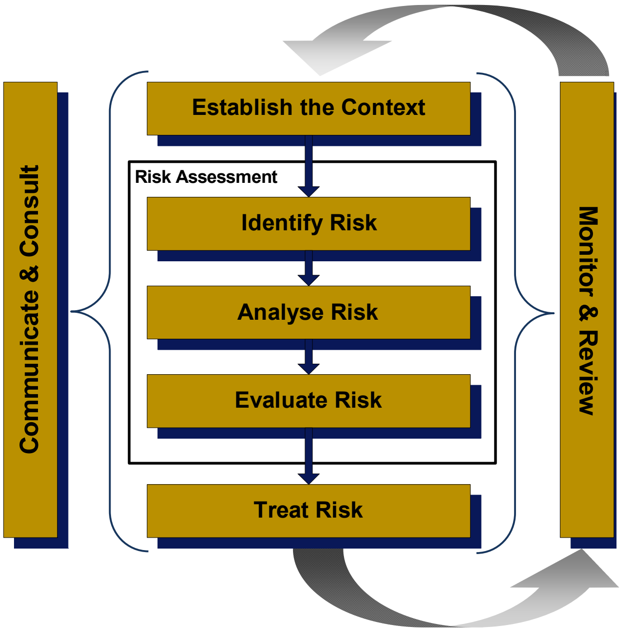

Figure 8 – Waihi risk management process

Team based risk assessments are carried out for any significant hazards and will be an important management tool for mining in SUPA and MDDP, particularly in the vicinity of open voids whether or not activity is proposed within stand-off zones. Any potential destabilisation of voids will constitute a potential risk to operations and will require assessment and controls.

A risk assessment will be carried out as mining activity approaches stand-off distances to stope voids, before stand-off minimums are reached. The risk assessment primary focus will be ensuring mining activity is unlikely to adversely impact void stability and that appropriate monitoring can be safely carried out.

The risk management process is to an extent generic. Each risk is given context, assigned a consequence and likelihood index and then plotted on the risk opportunity matrix (Appendix 3). If the resultant risk ranking is not deemed satisfactory, a number of additional controls are introduced to bring the residual risk ranking down to an acceptable level. The risk register includes the following elements for each risk:

- A description of the risk
- A list of existing controls
- The current consequence rating
- The current likelihood ratings (with existing controls)
- The resulting assessed current risk level
- A list of future controls
- The person accountable for control of the risk
- A cross reference to the Action Management System for any future controls
- The target consequence ratings
- The target likelihood ratings
- The resulting assessed target risk level
- The last date the risk was reviewed
- The foreseeable annual loss for extreme risks

8.1.2 PREVENTATIVE AND CORRECTIVE ACTIONS

To ensure that actions designed to prevent or correct substandard acts, conditions, programs and processes, or to implement opportunities, are properly managed and executed the Waihi Underground Operations have a system for preventative and corrective actions. The system provides the means to:

- Develop actions to address the root cause of the deficiency through prevention or management controls,
- Assign a person(s) responsible for each action
- Monitor progress against each action
- Review effectiveness of the implemented action
- Provide a means to confirm the action has been effectively addressed and closed out.

A Trigger Action Response Plan relating to the management of underground voids in SUPA is detailed in Appendix 2.

9 REGULATORY REQUIREMENTS

As described at the outset, stand-off distances are now incorporated within Condition 16 of the HDC Land Use Consent for SUPA and Condition 22 of the HDC Land Use Consent for MDDP. The intention is that these stand-off distances will apply unless the Council approves otherwise. The proposed condition seeks to balance the need for Council to have set-back distances in place while also considering the Company's desire to retain flexibility to change the set-back distances where justified.

Information to support any application for approval to mine within stand-off distances will include void images and monitoring results; blast vibration management details; stope stability models and risk assessment details. The application will also include details of appropriate mitigation should mining within stand-off zones trigger significant instability to the extent that surface stability may be affected. The Council shall request further information when required but otherwise approve or decline an application to mine within the stand- off distances and this decision shall be advised to the Company within 10 working days of the receipt of the application.

A monthly report will be supplied to Council with probe hole metres drilled during the month, any voids intersected by the probe holes and a brief description of the nature of the void. Any resources considered not mineable due to proximity to old workings will be shown on a long-section.

Experience with the implementation of the VMP may result in the need for refinement or other changes of the VMP. Any such changes must be approved by the HDC.

10 ROLES AND RESPONSIBILITIES

10.1 Site Senior Executive

The Senior Site Executive is responsible for this plan and ensuring operational compliance.

10.2 Mine Manager

It is the responsibility of the Mine Manager to ensure:

- Operational compliance with this plan
- There are adequate resources to identify and confirm the presence and nature of historic workings
- Ensure all relevant notifications are made to WorkSafe, HDC and other regulators

10.3 Technical Superintendent

It is the responsibility of the Technical Services Superintendent to ensure:

- Delegated responsibilities are discharged,

- All parties involved with aspects of this plan are aware of their responsibilities and what actions are required.
- Monitor progress against each action.

10.4 Mine Foreman /Shift Supervisor

It is the responsibility of the Mine Foreman / Shift Supervisor to:

- Ensure all probe hole drilling is conducted as planned
- Notify Mine Manager and geotechnical engineer of any old workings inadvertently intersected.

10.5 Geotechnical Engineer

It is the responsibility of the Geotechnical Engineer to:

- Monitor proximity of mine development to old workings in conjunction with the Mine Surveyor and Planning Engineer
- Ensure mine designs are appropriate for the rock mass conditions for on-going stability
- Ensure appropriate ground support is installed during mining activity
- Liaise with mining personnel to ensure proposed stope designs are appropriate
- Install additional monitoring as required e.g. Extensometers, slough meters
- Ensure the nature of the old workings and surrounding rock mass is properly assessed i.e. filled / unfilled / extent of open void / rock mass characteristics etc.
- Formally report if any voids are identified as having significantly caved.
- Maintains and updates this document.

10.6 Planning Engineer

- Ensure sufficient stand-off distance is maintained between development and old workings
- Liaise with Mine Surveyor and Geotechnical Engineer to ensure appropriate design of probe hole programmes

10.7 Mine Surveyor

It is the responsibility of the Mine Surveyor to:

- Monitor proximity of mine development to old workings
- Carry out C-ALS and or CMS surveys
- Generate 2D and 3D plans of stope voids as additional information becomes available from cavity surveys
- Design probe hole drill programmes in consultation with the Geotechnical Engineer and Planning Engineer
- Determine volumes of mapped voids
- Maintain updated plans of old workings including a current void model.
- Evaluate updated void survey information with comparison to historical data
- Maintain current plans of workings
- Maintain a data base of void surveys.

10.8 Employees

It is the responsibility of all employees to:

- Notify the Shift Supervisor of any holes/structures making water,
- Notify the Shift Supervisor of any old workings inadvertently intersected.

10.9 Training and Competency

All work carried out in relation to this plan such as probe drilling and surveying is carried out as per procedure. Any work to be conducted where a procedure is unavailable will first have a team-based Job Hazard Assessment (JHA) carried out.

11 SUMMARY

Void management at SUPA and MDDP utilising the management, monitoring and mitigation controls detailed in this plan should not only ensure the stability of the historic voids but give an opportunity for increasing the knowledge of the nature of the voids which will in turn allow better assessments as to whether there is actual risk of future instability.

The risk management processes utilising all the controls above are to be implemented whenever SUPA and MDDP mining activity is within the identified potential zone of influence of any historic voids – even if outside the recommended stand-off zones. The area of potential influence can be determined by blast ppv calculations but is not restricted to that alone. All modelling and calculations underpinning the models utilise conservative inputs. As an increased understanding of the nature of the voids is obtained, and the localised blast vibration effects, a less conservative approach might be possible without any increased risk of void instability.

Monitoring of the voids utilizing C-ALS instrumentation will improve the knowledge of the nature of the voids and allow for on-going assessments and checks and model validation.

If SUPA mining activity or construction of the drill drives within MDDP has the effect of destabilising any historic voids to a significant extent the void will be stabilised, most likely by backfilling the area in question. In effect the company commits to the on-going stability or stabilisation of the historic voids in relation to its operations.

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13 APPENDIX 1 PLAN VIEW AND CROSS SECTIONS

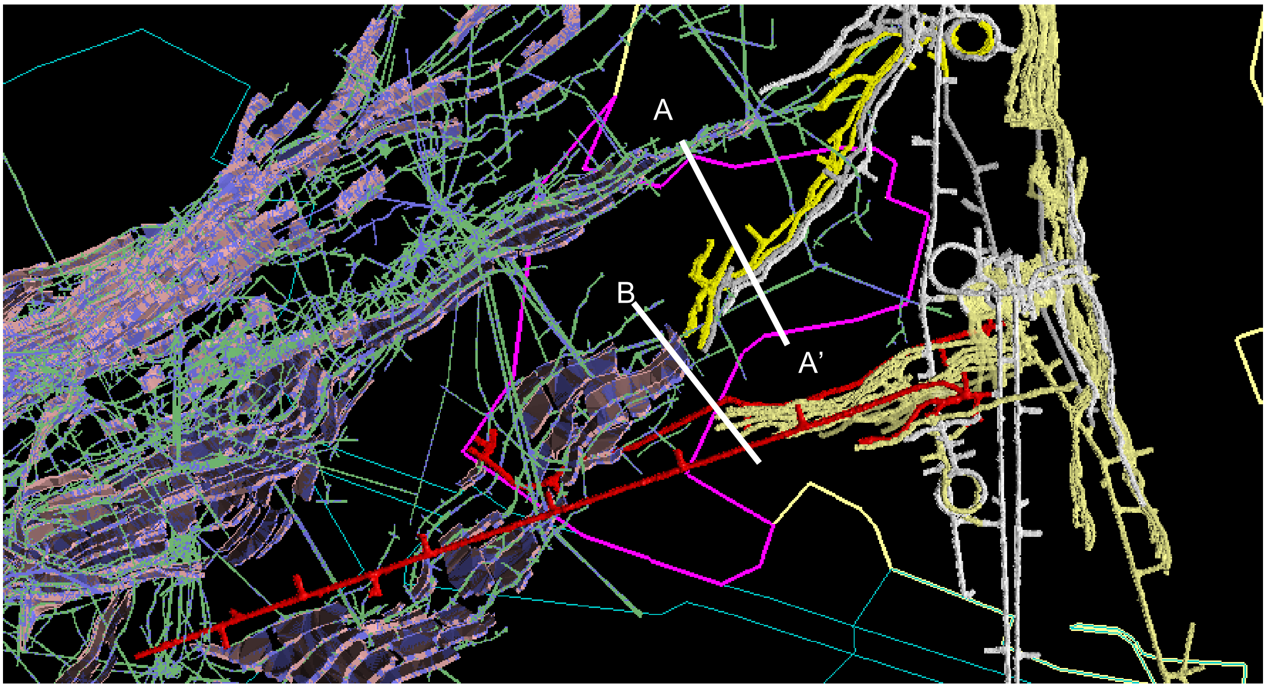

Figure 9. Plan View, all levels showing SUPA boundary and historic workings with the current (Feb 2018) SUPA mining activity on the Empire, Christina and Daybreak Lodes. The MDDP 920 DD and the 800 DD are shown in dark red. Cross-section traces in figures below are also shown

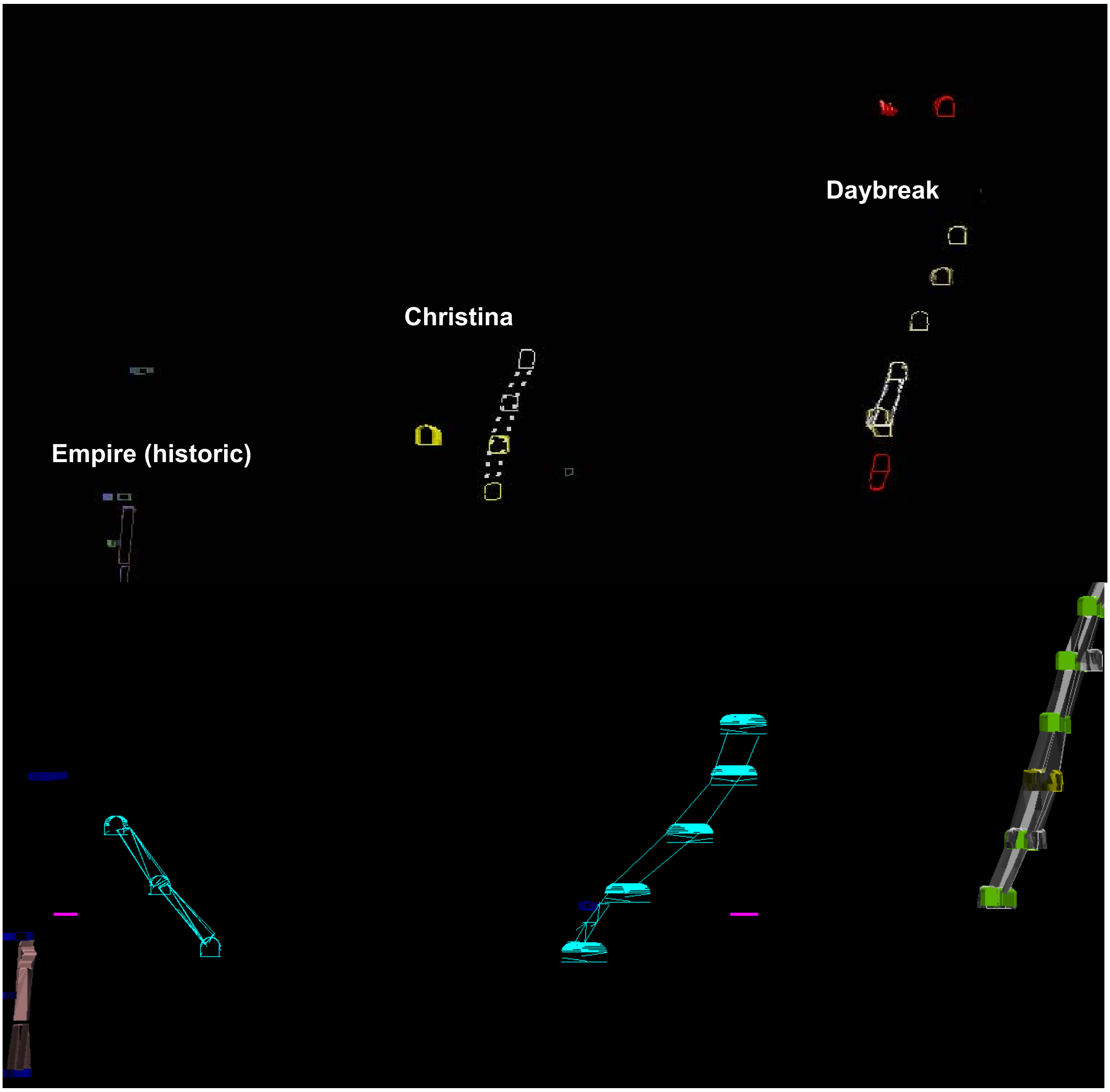

Figure 10. Cross-section A – A' through historic Empire, Christina and Daybreak. There is no longer proposed stoping on the Empire Vein in the SUPA licence. Refer Figure 8 for approximate locations. Length across section is about 320 m

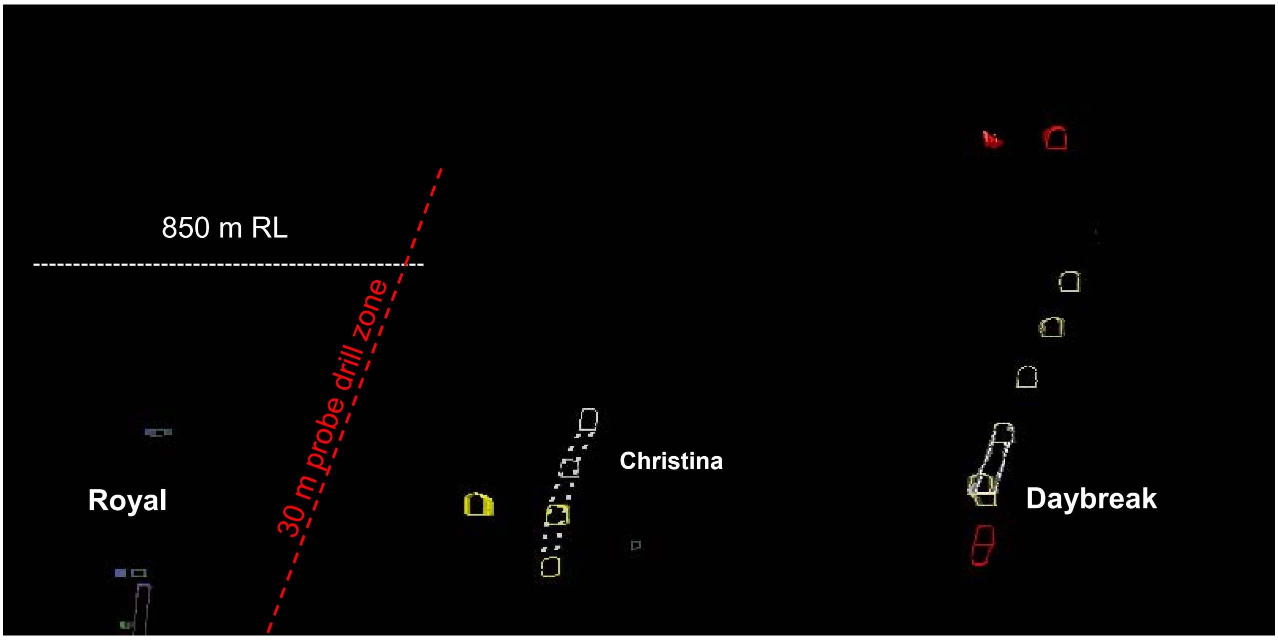

Figure 11 Cross-section B – B' looking northeast through Daybreak, Christina proposed stopes and the historic Royal Stope. Separation at the top of the Royal is 110 m from Christina lower levels

14 APPENDIX 2: TRIGGER ACTION RESPONSE PLAN (TARP)

Stage	Trigger	Action	Authority
Development probe drilling	Unexpected intersections of historic tunnels by probe holes	Review Plan Update 3D voids model Review probe zones, more drilling as required. Geotechnical review by SME and sign-off.	Planning Engineer Survey Geotech Engineer / Planning Engineer
Development	Unexpected breakthrough into old tunnels	Stop work and barricade off. Review probe drilling and old plans Team-based risk assessment Review probe zones Additional probe drilling C-ALS or CMS Update void plan Review development designs	UG Foreman/Shift Supervisor Survey/Geotech/Technical Services Team Geotech Planning Engineer Survey Survey Planning Engineer
Probe drilling	Stope void closer than expected	Additional probe drilling C-ALS Update void plan Review / amend development designs to maintain stand-offs Geotechnical review by SME and sign-off.	Planning Engineer/Geotech Survey Survey Planning Engineer
Development or Production	Significant void propagation id by probe and C-ALS	Stop development C-ALS Caving assessment Advise Council Risk Assessment Review mine designs Update voids model Potential ore sterilisation	Tech Services Super. Survey Geotech Engineer UG Manager Technical Services Team Planning Engineer Survey Tech Services Super/UG Manager
Production	Production blasting exacerbating instability	Stop production Re-assess mine plan Reduce blast vibration? Abandon stope panel If necessary Risk Assessment On-going detailed modelling Additional monitoring if possible Advise Council	Tech Services Super Mine Planning Engineer D and B Engineer UG Manager Tech Services Team Geotech Engineer Geotech Engineer UG Manager

15 APPENDIX 3 RISK ASSESSMENT MATRIX AND TABLES

OCEANAGOLD

1.0 GENERAL SITE FORM

FRM 1.03 OPERATIONAL RISK MATRIX

			1	2	3	4	5
Consequences	People		Minor Injuries (first aid or report only injuries/illness)	Medical treated injury	Lost time or restricted work injury/illness (< 2 weeks)	Serious lost time injury/illness (>2 weeks) or permanent disabling injury	Single or Multiple fatalities
	Equipment Damage or Process Loss		< $1,000 Low financial loss	$1,000 -$5,000 Low financial loss	$5,000 -$50,000 Medium financial loss	$50,000 -$500,000 High financial loss	>$500,000 Extreme financial loss
	Environmental Impact		No measurable environmental impact, contained within Site boundaries, minimal clean-up req. Uncontrolled discharge <40L	Low environmental impact over a small area, contained within Site boundaries. Minor clean-up of the impacted area which can be completed within 24 hours. Technical and administrative non-compliance to regulatory requirements and isolated non-compliance events that have no potential for environmental harm or prosecution.	Measurable environmental impact contained on Site or low environmental impact off Site requiring clean up and remediation efforts up to 7 days. Any breach of regulatory requirement that has potential to cause environmental harm or prosecution, including repeated no-impact, non-compliances.	Measurable environmental impact on-Site or off-site with significant clean up and rehabilitation efforts up to 30 days. Non-compliance event that is likely to generate investigation by a regulator including repeated no-impact non-compliances. Likely potential for prosecution.	Measurable long term environmental impacts on-Site or off-Site outside of approved environmental impacts. Extensive clean up and rehabilitation in excess of 30 days required. Non-compliance events resulting in almost certain prosecution and regulator intervention.
Likelihood	A Common	Happens often, is likely to happen again, has a high frequency of occurrence	11	16	20	23	25
	B Likely	Is a likely occurrence more than once per year	7	12	17	21	24
	C Possible	It could occur at least once every 1 to 5 years	4	8	13	18	22
	D Unlikely	Not expected to occur but could occur once within a 5 to 10 year timeframe	2	5	9	14	19
	E Rare	Has rarely occurred in the industry and/or is not expected to ever occur again	1	3	6	10	15

	ACTION REQUIRED TO ACCEPT RISK	APPROVAL REQUIRED	INCIDENT NOTIFICATIONS
Low (1 – 5)	Accept risk and manage by routine procedures	Supervisor	Supervisor notifies Foreman/Superintendent
Medium (6 – 12)	Develop a corrective and preventative action plan and document in JSA or SOP	Supervisor/Foreman	Foreman/Superintendent notifies Manger
High (13 – 20)	Complete a Risk Assessment and immediately implement the corrective and preventative actions	Superintendent/Manager	Manager notifies General Manager
Extreme (21 – 25)	Complete a formalised Risk Assessment which is reviewed by a subject matter expert	General Manager	General Manager notifies COO