Before the Waikato Regional
and Hauraki District Councils

Under	the Resource Management Act 1991 (**RMA**)
In the matter of	An application for resource consents to extend the Waihi Gold Mine via underground and open pit mining methods known as Project Martha
By	**Oceana Gold (New Zealand) Limited**
	Applicant

Statement of evidence of Mike Sandy for Oceana Gold (New Zealand) Limited

29 October 2018

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Qualifications and experience

1 My name is Michael Sandy. I am a geotechnical engineering consultant specialising in underground mining.

2 I am employed as a principal geotechnical engineer and global practice lead (geotechnical engineering) by AMC Consultants (AMC).

3 I have worked in the mining industry for about 40 years. My experience includes working as a geotechnical engineer on underground mines in Zambia and in Northwest Queensland for a total of about 15 years. For the past 23 years I have worked as a mining geotechnical consultant. During that period, I have visited and given geotechnical advice to more than 100 underground mines. My current workload involves providing geotechnical advice for the design and establishment of new mines and ongoing geotechnical reviews of established mines. In that capacity I have been engaged on several occasions to provide independent geotechnical advice to Oceana Gold in relation to some of its operations and proposed operations.

4 My qualifications and professional affiliations include:

- B.Sc. (Hons) Mining Geology, ARSM, Royal School of Mines, University of London.
- M.Sc. Engineering Rock Mechanics, DIC, Imperial College.
- Fellow and Chartered Professional (Geotechnical), Australasian Institute of Mining and Metallurgy.
- Registered Professional Engineer of Queensland
- Member, Institution of Materials, Minerals and Mining (UK).

5 In preparing this evidence I have reviewed:

(a) The reports and statements of evidence of other experts giving evidence relevant to my area of expertise, including:

(i) **Entech** 2017. Martha Drill Drive project ground surface stability assessment, February 2017.

(ii) **Ground Control Engineering** 2012. Martha Exploration Project decline and portal ground support design, 16 April 2012.

(iii) **Newmont** 2014. Waihi-Correnso Gate Report for Stage 2/3, internal unpublished report 4 June 2014.

(iv) **OGNZL** 2016. Slevin Underground Project Area (SUPA) & Martha Drill Drive Project (MDDP) Void Management Plan, November 2016.

(v) **Parrott** T 2012. Geotechnical report for Correnso Underground Mine within the Golden Link project area, 14 June 2012.

(vi) **Richards** L 2012. Newmont Waihi Gold: Correnso Underground Mine project review of geotechnical (mine stability) studies. Report 11105.1.3.

(vii) **Richards** L, Mazengarb C, Beetham D, Brathwaite B and Smith W 2002. Waihi underground mine workings Stage II investigations, Institute of Geological & Nuclear Sciences client report 2002/46 to Waihi Underground Mine Workings Technical Working Party, August.

(viii) **SRK** 2012. Geotechnical input for the Martha Deeps project pre-feasibility study, unpublished report March 2012.

(ix) **SRK** 2014. Correnso Underground Stage 2 geotechnical study, unpublished memo 15 April 2014.

(x) **SRK** 2016. Martha Mine Scoping Study, unpublished report October 2016.

(xi) **SRK** 2017. Martha Mine Design, unpublished report August 2017.

(xii) **PSM** 2018. Assessment of the impact of proposed underground mining on the Martha Open Pit Phase 4, unpublished report April 2018.

(xiii) **Evidence of** Christopher Simpson, Timothy Sullivan and Trevor Matuschka under the Resource Management Act 1991 (RMA) In the matter of An application for resource consents to extend the Waihi Gold Mine via underground and open pit mining methods known as Project Martha.

(b) The parts of the section 42A report relevant to my area of expertise.

(c) Submissions relevant to my area of expertise.

6 I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note 2014. This evidence has been prepared in accordance with it and I agree to comply with it. I confirm that my evidence is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Scope of evidence

7 I have been asked by Oceana Gold (New Zealand) Limited (**OGNZL**) to prepare evidence in relation to geotechnical matters relating to the proposed mining underground as part of Project Martha. This comprises the Martha Underground Mine (which will access underground ore in the area of the existing Martha Open Pit) and the Rex Lode (which is a new underground mining area immediately to the southeast of the Martha Open Pit). This includes:

(a) A description of the geotechnical investigations that have been undertaken to date and a presentation of the resulting geotechnical characterisation of the underground conditions likely to be encountered.

(b) A discussion of important geotechnical considerations for underground mining.

(c) Recommendations for suitable consent conditions to allow mining to proceed.

8 I confirm that my evidence relates to the proposal known as Project Martha as described in Chapter 3 of the Assessment of Environmental Effects dated 25 May 2018 (**AEE**).

9 I confirm that I am the author of a report dated 7 June 2018 titled Project Martha – Oceana Gold (New Zealand) Limited attached as Appendix M to the AEE. I also confirm that I am responsible for additional information supplied in response to questions asked under section 92 of the RMA. This information was presented in a report dated 13 July 2018 titled Project Martha – Addendum Oceana Gold (New Zealand) Limited.

Executive summary

10 I have been asked by Oceana Gold (New Zealand) Limited (**OGNZL**) to prepare evidence in relation to geotechnical matters relating to the proposed mining underground as part of Project Martha. This comprises the Martha Underground Mine (which will access underground ore in the area of the existing Martha Open Pit) and the Rex Lode (which is a new underground mining area immediately to the southeast of the Martha Open Pit). This includes:

(a) A description of the geotechnical investigations that have been undertaken to date and a presentation of the resulting geotechnical characterisation of the underground conditions likely to be encountered.

(b) A discussion of important geotechnical considerations for underground mining.

(c) Recommendations for suitable consent conditions to allow mining to proceed.

Geotechnical investigations

11 Investigations have been conducted by OGNZL into the potential for underground mining at Martha. For underground mining projects common industry practice is to drill diamond drill holes to investigate and define the underground mineral resource. OGNZL has conducted extensive diamond drilling to investigate the mineral resources in and around the Martha pit.

12 The drill core from the diamond drill holes can be used to assess the ground conditions in the potential underground mine. Ground conditions affect the stability of underground excavations, in turn affecting the choice of mining methods and the scale of the proposed excavations.

13 In my view the ground conditions data available for assessing the underground project is sufficient for a preliminary assessment of potential mining methods. However, detailed mine design and mine planning will require additional data to be collected in certain areas. This is not unusual at this stage in project development, and additional data for detailed mine design and planning would be acquired in the ordinary course of development.

14 OGNZL proposes to conduct systematic additional investigations into the ground conditions and the status of historical workings in the areas where information is sparse to address these issues. These investigations will include diamond drilling, development of tunnels and probe drilling with non-coring drills. Bore hole cameras and survey tools will be used to investigate the condition and extent of historical stope voids, through the probe holes and diamond drill holes.

Underground mining methods

15 OGNZL has proposed using supported mining methods that will not cause surface disturbance. Key aspects of ensuring this are that the excavations are designed to be stable in the short term. Mining will involve developing tunnels to access the ore, and then excavating ‘stopes’ to extract the ore and then backfilling the stopes.

16 The size of the tunnels is based on consideration of equipment requirements, safety and the need for the tunnels to be stable during their service life. Ground ‘support’ is placed in the tunnels to improve stability and ensure the operations can be carried out safely.

17 The size of the stopes is also based on ensuring stability during the removal of the ore, after which the excavation is backfilled. Estimates of stable stope size are based on ground conditions (as currently indicated by drilling) and reference to empirical stope design methods, used widely in the mining industry. These methods have been used successfully at other OGNZL underground operations at Waihi (Favona, Trio and Correnso).

18 The backfilling process ensures long term stability and for Project Martha is the critical requirement irrespective of which mining method is adopted. Any residual voids, including the access tunnels are of such a small size and far enough below surface that they cannot cause any surface disturbance unless the development is stacked. Where development is stacked such as in the spiral declines or in ventilation shafts it is recommended that these drives or shafts be backfilled prior to closure.

Surface subsidence and open pit interaction

19 I am aware that the consulting firm Pells Sullivan Meynink (PSM) has been retained by OGNZL to assess the interaction between the existing Martha pit, surface areas outside the pit, and historical and proposed underground workings, primarily through the use of three-dimensional numerical modelling. I have reviewed the results of their analysis and in my assessment the work has been conducted using appropriate industry-standard methods with suitable inputs.

20 The main conclusions from the PSM analysis are that; underground mining will have a negligible effect on the stability of the current or proposed (Project Martha) pit slopes provided that the stopes are backfilled; and that the proposed backfilling of some of those existing historical voids to be mined or that will be affected by the proposed mining will result in a significant improvement in the overall rock mass conditions in the zone underlying the Martha pit.

Rex lode interaction with surface

21 The stoping width at Rex will be considerably narrower than at Correnso, typically less than 3 m.

22 In all but the final level, there will always be ore drives above the current stoping level, that could be used for monitoring and to implement a filling programme through boreholes if stope instability were to develop.

23 Nonetheless, a cautious approach is considered warranted at this stage to evaluating the stability of the Rex crown pillar. The approach presented in the Correnso application used the empirical crown pillar stability method developed by Carter and Miller (1995) and updated by Carter et al, 2008. This is commonly used in steep dipping orebodies.

24 For Rex conditions and geometry, a crown pillar thickness of 40 m would be necessary for long term (>100 year) stability if there was a large open stope below the pillar at the end of mining. However, it is important to note that in the current proposal all voids will be backfilled, including the top ore drive as far as is practicable, so the consideration of a long term 'crown pillar' is somewhat academic. Nonetheless, an analysis such as the Carter approach provides a high level of confidence that the mining of Rex will not cause any risk of surface disturbance.

25 In addition to the empirical assessment, I conducted a two-dimensional modelling study using the RS2 code (Rocscience) of the effects of mining the Rex Lode. This indicated that the zones of significant disturbance or displacement are closely confined to the Rex stopes. I concluded that surface disturbance or displacement is minimal, and likely to be substantially less than has already occurred as a result of previous mining in the Martha pit and the surface settlements reported by other consultants.

Monitoring

26 Various types of monitoring are available to understand the response to creating underground excavations. At Martha underground it is proposed to use borehole extensometers drilled from underground positions and in some cases from surface. These can detect very small displacements (of the order of millimetres) and will be used to confirm that the disturbance from creating the stopes is confined to their immediate vicinity.

27 After backfilling, the extensometers will continue to be read to confirm that stability has been achieved and that no unexpected displacement response is developing, and that the underground mining has no measurable effect on surface.

28 In addition, the monitoring systems used at Correnso will be reviewed to determine their effectiveness and potential application at Rex. It is recommended that the seismic system coverage should be extended to include the Martha Underground. Seismicity is expected to be low order, and it is very unlikely that any damaging events will be experienced, unless mining proceeds to considerable depth. However, seismic monitoring can provide a large scale, three-dimensional understanding of the ‘global’ response to mining that is not available from discrete instruments such as extensometers.

Recommendations for implementation

29 My key recommendations to ensure that the underground mining at Martha is conducted with an acceptable risk of avoiding disturbance or displacement at the surface would include the following:

30 Conduct a sufficient investigation programme to develop an adequate understanding of the ground conditions, and verify the location, status and extent of historical mine workings.

31 Review the information from the investigation programme and adjust the mine designs and stope designs to ensure that there is a high level of confidence that the stopes will be stable prior to backfilling and in the long term.

32 Design and implement ground displacement monitoring systems to ensure that the designed stopes perform as expected.

33 Ensure all future stope voids are backfilled as required to ensure short term and long-term stability.

34 Identify and ensure that historical open voids formed from caving or stoping that could cause localised disturbance or displacement as a result of interaction with future stoping are backfilled to ensure short term and long-term stability.

Geotechnical Investigations

35 Investigations have been conducted by OGNZL into the potential for underground mining at Martha. For underground mining projects common industry practice is to drill diamond drill holes to investigate and define the underground mineral resource. OGNZL has conducted extensive diamond drilling to investigate the mineral resources in and around the Martha pit.

36 The drill core from the diamond drill holes can be used to assess the ground conditions in the potential underground mine. Ground conditions affect the stability of underground excavations, in turn affecting the choice of mining methods and the scale of the proposed excavations.

37 OGNZL logged the diamond drill core using industry standard rock mass characterisation schemes. I conducted a review of the core logging processes of some of the core on site to confirm that the OGNZL logging had been conducted correctly. In addition, I have reviewed core photographs of holes logged by OGNZL and classified the ground conditions observed based on the degree of weathering into ‘completely weathered’, ‘strongly (highly) weathered’, ‘moderately weathered’, ‘slightly weathered’ and ‘unweathered’ (fresh).

38 In addition to my review of geotechnically logged holes at Martha, geotechnical consultants Pells Sullivan Meynink (PSM) have conducted a comprehensive review of ground conditions using a scheme based on the degree of disturbance, as indicated by diamond drill core. I have reviewed the results from this work, which were compiled and presented on a series of cross sections through the Martha

project. In my assessment, the sections present a useful summary of the general information on ground conditions in the project.

39 In my view the ground conditions data available for assessing the underground project is sufficient for a preliminary assessment of potential mining methods. However, detailed mine design and mine planning will require additional data to be collected in certain areas. This is not unusual at this stage in project development, and additional data for detailed mine design and planning would be acquired in the ordinary course of development.

40 There are also numerous historical mine workings at Martha. Some of these are known to be backfilled or collapsed whilst others are known to be unfilled or 'open'. However, where drilling information is sparse, the condition and exact location of the historical workings is unknown.

41 OGNZL proposes to conduct systematic additional investigations into the ground conditions and the status of historical workings in the areas where information is sparse to address these issues. These investigations will include diamond drilling, development of tunnels and probe drilling with non-coring drills. Bore hole cameras and survey tools will be used to investigate the condition and extent of historical stope voids, through the probe holes and diamond drill holes.

Underground Mining Methods

42 In underground mining the methods used fall broadly into two categories. Those in which the mining excavations are supported with either pillars or backfill, and those in which the excavations are unsupported. In the latter category, the removal of the ore results in voids that may eventually collapse in a process described as 'caving'.

43 Caving is largely driven by gravity and usually progresses more or less vertically upwards. Depending on the size of the void created by the mining excavation, the depth below surface and the amount of 'bulking' that occurs during the caving process, the disturbance created by cave propagation may eventually reach surface.

44 In supported mining methods the excavations are designed to be stable during operation, and in the longer term. Stability is commonly achieved using pillars, restricting open spans or by backfilling. With backfilling, the void created by mining is filled with a suitable material (usually waste rock or waste materials from the ore processing plant). The backfill provides confinement to the excavation walls preventing any progressive loosening which might otherwise lead to instability (and eventually caving).

45 OGNZL has proposed using supported mining methods that will not cause surface disturbance. Key aspects of ensuring this are that the excavations are designed to

be stable in the short term. Mining will involve developing tunnels to access the ore, and then excavating 'stopes' to extract the ore and then backfilling the stopes.

46 The size of the tunnels is based on consideration of equipment requirements, safety and the need for the tunnels to be stable during their service life. Ground 'support' is placed in the tunnels to improve stability and ensure the operations can be carried out safely.

47 The size of the stopes is also based on ensuring stability during the removal of the ore, after which the excavation is backfilled. Estimates of stable stope size are based on ground conditions (as currently indicated by drilling) and reference to empirical stope design methods, used widely in the mining industry. These methods have been used successfully at other OGNZL underground operations at Waihi (Favona, Trio and Correnso).

48 In preparing my report for OGNZL, I have reviewed the ground conditions in the areas that are being considered for stoping at Martha. I found that the conditions in these areas could be described as 'moderately weathered', 'slightly weathered' or 'fresh'. Within each of these categories, there is a range of ground conditions. Taking conservative (lower quartile) values for each of these conditions, and using empirical stope design methods, I developed estimates for the stope spans that can be used for preliminary stope design.

49 The estimated strike length for stable stope hangingwall exposures in 'slightly weathered' to 'fresh' conditions is about 10 m to 11 m for a sublevel interval of 25 m, or about 12m to 13m for a sublevel interval of 18 m. Where the proposed sublevel interval is 15m as it is for most of the Martha Underground, a maximum strike length of 15 m is implied in lower quartile conditions. In more competent ground, longer strike lengths will be possible. Stope spans can be re-calculated once actual rock mass characteristics are measured by drilling and by ore development.

50 In 'moderately weathered' ground, for the lower quartile conditions, much smaller spans are indicated as stable. Longhole stoping is unlikely to be appropriate in these areas. A mining method involving small spans, such as cut-and-fill is more likely to be used.

51 The proposed mining methods in the 'slightly weathered' to 'fresh' conditions include various forms of small scale open stoping described as Avoca, Modified Avoca and the Side Ring method. These are described in detail in SRK's 2017 report. The proposed mining methods involve stope excavations that have a high level of assurance of stability. Stopes will be filled immediately on completion (Modified Avoca and open stoping), or in the case of Avoca stoping, on a continuous basis with the fill being progressively advanced to follow the stope face and to maintain a minimal hangingwall/footwall exposed span.

52 I am aware that several submissions on the Project Martha Resource Consent Application (eg Juan Fisher and Ruth Ordish) raise concerns about long term tunnel stability being affected by 'long term water movement' and 'the removal of fines'. I accept that this mechanism could apply in completely weathered, soil-like materials, under certain hydrogeological conditions. However, OGNZL is not proposing to develop or stope in such materials. In the rock material that will host the OGNZL development and stoping, washing out of fines is not a credible mechanism. If any locally highly or completely weathered zones are encountered, these will be sealed using sprayed concrete ('shotcrete') or similar. This is a well-established method for stabilising and securing for the long-term materials that are prone to washing out.

53 As discussed above, the backfilling process ensures long term stability and for Project Martha is the critical requirement irrespective of which mining method is adopted. Any residual voids, including the access tunnels are of such a small size and far enough below surface that they cannot cause any surface disturbance unless the development is stacked. Where development is stacked such as in the spiral declines or in ventilation shafts it is recommended that these drives or shafts be backfilled prior to closure.

Surface Subsidence and Open Pit Interaction

54 Dr. Matuschka in his evidence has described the surface settlements that could be expected due to dewatering and this type of ground deformation is not covered in my evidence. Surface response can also occur due to the underground excavation which is an elastic response in turn due to relaxation or reduced confinement of the ground and for my evidence I have termed this surface response as disturbance or displacement to distinguish it from settlement.

55 I am aware that PSM has been retained by OGNZL to assess the interaction between the existing Martha pit, surface areas outside the pit, and historical and proposed underground workings, primarily through the use of three-dimensional numerical modelling. I have reviewed the results of their analysis and in my assessment the work has been conducted using appropriate industry-standard methods with suitable inputs.

56 I am also aware that PSM's modelling did not include the relatively small ore zone referred to as the Rex Lode which I will cover separately in my evidence.

57 The main conclusions from the PSM analysis are that; underground mining will have a negligible effect on the stability of the current or proposed (Martha Phase 4) pit slopes provided that the stopes are backfilled; and that the proposed backfilling of some of the existing historical voids will result in a significant improvement in the overall rock mass conditions in the zone underlying the Martha pit.

58 Although the tight backfilling proposed will prevent any large-scale disturbance of the surface, should any unforeseen minor disturbance occur, it would not have an impact on the surface outside of the pit rim.

59 Except for the Rex Lode, most of the planned stopes lie below the existing Martha pit or immediately to the south east.

Rex Lode

60 The stoping width at Rex will be considerably narrower than at Correnso, typically less than 3 m.

61 In all but the final level, there will always be ore drives above the current stoping level, that could be used for monitoring and to implement a filling programme through boreholes if stope instability were to develop.

62 The post mineral surface above the andesite thickens to the east and the thickness of the Quartz Andesite and Upper Andesite cover above the uppermost proposed levels in Rex varies from 60 m in the western part of Rex to about 40 m at the eastern end. Total cover above the backs of the uppermost proposed level is about 90 m.

63 A cautious approach is considered warranted at this stage to evaluating the stability of the crown pillar. The approach presented in the Correnso application used the empirical crown pillar stability method developed by Carter and Miller (1995) and updated by Carter et al, 2008. This is commonly used in steep dipping orebodies.

64 The geometry of the possible crown pillar at Rex is different to that at Correnso, because the mining width (of the top drive) will be no more than 4 m and it could extend for a strike length of about 200 m. The dip of the lode is about 70° and density is assumed to be 2.7 t/m3.

65 I calculated the 'scaled crown span' CS for a range of crown pillar thicknesses (40 m, 20 m and 10 m) and derived CS values of 1.1 m, 1.57 m and 2.22 m respectively. Reference to the most recently published Scaled span chart with probability of failure (PoF) contours (Figure 1), using a conservative Q value of 1.0, very poor to poor ground (after Parrott, 2012) indicates that the associated PoF values are 0.5% to 1.0%, <5% and 15% respectively.

Figure 1 Scaled span chart with probability of failure (PoF) contours after Carter et al (2008)

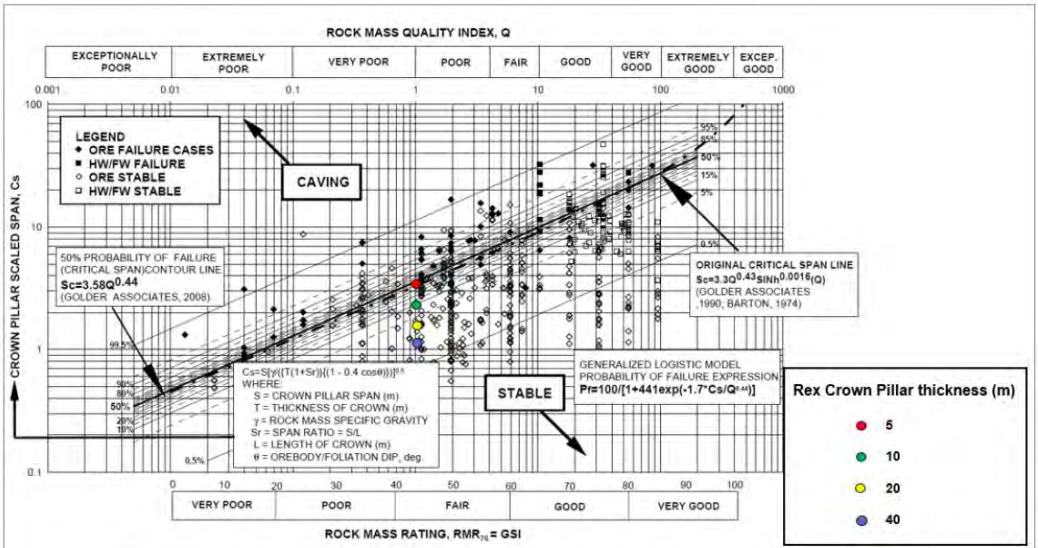

Figure 5 – Updated Scaled Span Chart with Probability of Failure Contour Intervals

66 Carter et al 2008 provide 'acceptable risk exposure guidelines' for crown pillars (Figure 2). For Rex conditions and geometry, a crown pillar thickness of 40 m would be necessary for long term (>100 year) stability if there was a large open stope below the pillar at the end of mining. However, it is important to note that in the current proposal all voids will be backfilled, including the top ore drive as far as is practicable, so the consideration of a long term 'crown pillar' is somewhat academic. Nonetheless, an analysis such as the Carter approach provides a high level of confidence that the mining of Rex will not cause any risk of surface disturbance.

Figure 2 Crown pillar acceptable risk exposure guidelines (Carter et al, 2008)

Table 2 – Acceptable Risk Exposure Guidelines - Comparative Significance of Crown Pillar Failure (modified from Carter & Miller, 1995)

Class	Probability of Failure %	Minimum Factor of Safety	Maximum Scaled Span, Cs (= Sc)	ESR (Barton et al. 1974)	Design Guidelines for Pillar Acceptability/Serviceable Life of Crown Pillar				
					Expectancy	Years	Public Access	Regulatory position on closure	Operating Surveillance Required
A	50 – 100	<1	$11.31Q^{0.44}$	>5	Effectively zero	< 0.5	Forbidden	Totally unacceptable	Ineffective
B	20 – 50	1.0	$3.58Q^{0.44}$	3	Very, very short-term (temporary mining purposes only ; unacceptable risk of failure for temporary civil tunnel portals	1.0	Forcibly Prevented	Not acceptable	Continuous sophisticated monitoring
C	10 – 20	1.2	$2.74Q^{0.44}$	1.6	Very short-term (quasi-temporary stope crowns ; undesirable risk of failure for temporary civil works)	2 – 5	Actively prevented	High level of concern	Continuous monitoring with instruments
D	5 – 10	1.5	$2.33Q^{0.44}$	1.4	Short-term (semi-temporary crowns, e.g.under non-sensitive mine infrastructure)	5 – 10	Prevented	Moderate level of concern	Continuous simple monitoring
E	1.5 – 5	1.8	$1.84Q^{0.44}$	1.3	Medium-term (semi-permanent crowns, possibly under structures)	15–20	Discouraged	Low to moderate level of concern	Conscious superficial monitoring
F	0.5 – 1.5	2	$1.12Q^{0.44}$	1	Long-term (quasi-permanent crowns, civil portals, near-surface sewer tunnels)	50–100	Allowed	Of limited concern	Incidental superficial monitoring
G	<0.5	>>2	$0.69\ Q^{0.44}$	0.8	Very long-term (permanent crowns over civil tunnels)	>100	Free	Of no concern	None required

67 As part of my response to questions asked under section 92 of the RMA, I conducted a two-dimensional modelling study using the RS2 code (Rocscience) of the effects of mining the Rex Lode. The inputs (material properties and stress) were based on those derived by PSM. This indicated that the zones of significant disturbance or displacement are closely confined to the Rex stopes. I concluded that surface disturbance or displacement is minimal, and likely to be substantially less than has already occurred as a result of previous mining in the Martha pit and the surface settlements reported by other consultants.

Monitoring

68 Geotechnical monitoring forms an important part of managing mining operations, to ensure the designed excavations are performing as expected.

69 For underground stoping, creating the excavations will cause a local response or disturbance as the surrounding rock mass relaxes into the voids and stresses are redistributed around them. This is quite normal, and the response is generally a very localised effect, becoming undetectable within a few metres of the excavations.

70 After backfilling, the displacements usually cease almost immediately. Provided a high degree of backfilling is achieved, the local and regional stability is assured in the short and long term.

71 Various types of monitoring are available to understand the response to creating underground excavations. At Martha underground it is proposed to use borehole extensometers drilled from underground positions and in some cases from surface. These can detect very small displacements (of the order of millimetres) and will be used to confirm that the disturbance from creating the stopes is confined to their immediate vicinity.

72 After backfilling, the extensometers will continue to be read to confirm that stability has been achieved and that no unexpected displacement response is developing, and that the underground mining has no measurable effect on surface.

73 I have read the evidence of Christopher Robert James Simpson in respect to the provision of additional piezometers as generally indicated in his Figure 25, and formally agreed through the Dewatering and Settlement Monitoring Plan that should be installed. I consider that these piezometers would also confirm that the underground mining is not disturbing the upper aquifer.

74 It is recognized that drilling of holes from surface needs to be conducted with care and appropriate procedures to avoid unintended adverse consequences, such as disturbing groundwater conditions which could lead to surface settlement. I understand ground water consultants GWS have advised OGNZL that they have

experience in installing instrumentation in these situations in a way that avoids adverse effects.

75 In addition, the monitoring systems used at Correnso will be reviewed to determine their effectiveness and potential application at Rex. It is recommended that the seismic system coverage should be extended to include the Martha Underground. Seismicity is expected to be low order, and it is very unlikely that any damaging events will be experienced, unless mining proceeds to considerable depth. However, seismic monitoring can provide a large scale, three-dimensional understanding of the 'global' response to mining that is not available from discrete instruments such as extensometers.

Recommendations for Implementation

76 My key recommendations to ensure that the underground mining at Martha is conducted with an acceptable risk of avoiding disturbance or displacement at the surface would include the following:

77 Conduct a sufficient investigation programme to develop an adequate understanding of the ground conditions, and verify the location, status and extent of historical mine workings.

78 Review the information from the investigation programme and adjust the mine designs and stope designs to ensure that there is a high level of confidence that the stopes will be stable prior to backfilling and in the long term.

79 Design and implement ground displacement monitoring systems to ensure that the designed stopes perform as expected.

80 Ensure all future stope voids are backfilled as required to ensure short term and long-term stability.

81 Identify and ensure that historical open voids formed from caving or stoping that could cause localised disturbance or displacement as a result of interaction with future stoping are backfilled to ensure short term and long-term stability.

Section 42A Report

82 Hauraki District Council's Section 42A report includes a review by Dr Peter Fuller. An overall finding from the report is that the separate technical assessments are of the highest standard possible given the current preliminary status of the proposed underground mining part of the project.

83 In Appendix 8A of the Section 42A report, a number of changes are recommended to the consent conditions relating to surface stability. I note that an amendment is

suggested for condition 71a. The condition as written requires the mining of a remnant stope to commence at the top level.

84 Remnant mining may progress in the downwards direction, however I note that OGNZL wishes to retain the option of commencing mining at a level lower than the top of the void. Provided the other requirements I've already discussed for ensuring void and surface stability are met, the level at which mining starts and/or the direction of mining have no effect on short or long-term stability.

85 As a general observation, my view is that given that mining proposed for the Martha Underground is at an early stage of design, it is preferable to include the detail relating to the remnant mining methods, methods for backfilling, monitoring and operating procedures etc in the Void Management Plan. This plan requires review and certification by the Council and will be a key document for the peer review panel. The inclusion of this information within the Void Management Plan will provide OGNZL with the flexibility that it needs at this early stage of the Martha Underground while ensuring that all matters relating to surface stability are appropriately considered.

Conclusions

86 OGNZL proposes to conduct underground mining in various lodes in the vicinity of the Martha pit, using modest scale open stopes with backfill. Ground conditions will be carefully and progressively investigated, and designs will be adjusted to ensure the stopes are appropriate for the conditions.

87 Monitoring will be undertaken to ensure that the local and regional response to mining is as expected.

88 All future stopes and some development will be backfilled on completion, providing a high level of assurance for the long term that the effects on surface will be negligible.

Mike Sandy

29 October 2018

References

Carter TG and Miller I, 1995. 'Crown Pillar Risk Assessment – Planning Aid for Cost Effective Mine Closure Remediation' TransIMM, Section A – Vol 104, pp A41-A57.

Carter TG, Cottrell BE, Carvalho, JL and Steed CM, 2008. 'Logistic Regression improvements to the Scaled Span Method for dimensioning surface crown pillars over civil or mining openings' 42nd US Rock Mechanics Symposium and 2nd US – Canada Rock Mechanics Symposium, ARMA, San Francisco.