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

In summary, my evidence describes the geotechnical investigations conducted to date at Waihi that are relevant to the proposed underground mine.

As described at Para 7 of my evidence, this includes:

- 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.

- A discussion of important geotechnical considerations for underground mining.

- Recommendations for suitable consent conditions to allow mining to proceed.

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.

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. This can include rock bolting and surface support such as mesh and shotcrete.

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). (refer to Figure 5.2 in appendix M).

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.

Interaction with the Martha Pit

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.

Referring specifically to the Rex lode and its potential 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.

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. Also, as described in Section 5.3.4 of my report (Appendix M), there are various techniques that can be applied to very ground to ensure a high level of control and stability is maintained at all times, including spiling or 'fore poling' (example shown at Figure 5.3 of my report), the use of deliberately shorter development rounds, and application of fibrecrete including to the face if necessary. Ground consolidation can also be used in material that is prone to unravelling. These techniques have been used with considerable success to develop in unconsolidated backfill, for example at the Broken Hill mine in New South Wales.

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.