

Before the Waikato Regional  
and Hauraki District Councils

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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

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**Statement of evidence of Tim Sullivan for Oceana Gold (New Zealand) Limited**

23<sup>rd</sup> October 2018

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## Qualifications and experience

- 1 My name is Timothy Daniel Sullivan.
- 2 I am the Chairman of Pells Sullivan Meynink Pty Ltd Engineering Consultants.
- 3 I graduated from Macquarie University in 1973 with a degree majoring in geology. I joined Coffey's in 1974 and was employed with them till 1993. While at Coffey's I was a Director of the firm and established the Mining Geotechnics Group. In 1979-80 I undertook postgraduate studies in London and was awarded an MSc from the University of London and a DIC from the Imperial College of Science and Technology.
- 4 My Professional affiliations include:
  - a) Fellow, Australasian Institute of Mining and Metallurgy;
  - b) Fellow, Institution of Engineers, Australia,
  - c) Chartered Professional Engineer,
  - d) Chartered Professional (Mining),
  - e) Registered Professional Engineer Queensland, and
  - f) National Engineering Register.
- 5 From 1992-1993, I was a Visiting Professor at the School of Mines, University of New South Wales. From 2002 to 2007 I was appointed an Adjunct Professor of Geotechnical Engineering, UNSW. From 1997 to 2000 I undertook the role of advisor to the NSW Coroner investigating the death of 18 people in the Thredbo Landslide. In 1993 I established my own firm Pells Sullivan Meynink and I am now Chairman of the company. In 2008, I was also appointed a Mining Warden by the Victorian Government for the Yallourn Mine Inquiry.
- 6 I have worked in the mining industry for over 40 years. During that time I have been a geotechnical consultant for some of the world's largest mines and companies; including BHP Billiton, Rio Tinto, Xstrata, Glencore, Newmont, Anglo Gold, Pilbara Iron, Ok Tedi Mining Limited and Newcrest. In addition to all the mainland states and territories of Australia, major projects have been located in India, Papua New Guinea, Indonesia, Thailand, Africa, South America, Philippines, Mexico, New Zealand and Fiji. I have worked on over 400 mining projects at all stages from conceptual to operations.
- 7 In addition to the above activities I have given Keynote Addresses and been the invited lecturer at the following National and International Conferences:
  - a) 2007 Keynote Lecture, International Conference on Slope Stability, Perth,
  - b) 2007 Mitsubishi Lecture,

- c) 2010 13th Kenneth Finlay Memorial Lecture,
- d) 2010 Keynote Lecture 11th IAEG Congress, New Zealand,
- e) 2013 Keynote lecture International Symposium on Slope Stability in Open Pit and Civil Engineering;
- f) 2014 Keynote Lecture Australian Earth Science Convention,
- g) 2016 Keynote Lecture Asia Pacific Slope Stability Conference, Brisbane, and
- h) 2018 Keynote Lecture, Glencore International Mining Conference Switzerland.

8 I have been the geotechnical consultant for the Martha Open Pit since 1995. During that time I have undertaken all the geotechnical design studies.

9 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. The statement of evidence by Mike Sandy (Underground mining and underground geotechnical engineering);
- b) The parts of the section 42A report relevant to my area of expertise, and
- c) Submissions relevant to my area of expertise.

10 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 have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

**Scope of evidence**

11 I have been asked by Oceana Gold (New Zealand) Limited (**OGNZL**) to prepare evidence in relation to geotechnical issues, and in particular issues related to the stability of the Martha Pit walls under the expansion works proposed as part of Project Martha. This includes:

- a) Describing the important elements of Project Martha related to my geotechnical studies;
- b) Discussing the impacts of Project Martha on stability relative to ensuring the pit walls are safe and stable;
- c) Discussing the impacts of the historical underground mining,
- d) Describing the stability performance and history of the current Martha Pit;

- e) Discussing the available geotechnical information and how this was used to evaluate stability of the MP4 Pit;
  - f) Describing the investigations for MP4;
  - g) Presenting the stability analysis results and
  - h) Discussing the results of the modelling of the underground and open pit interaction studies.
- 12 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).
- 13 I confirm that I am the primary author of the report dated May 2018 entitled Project Martha, Geotechnical Study Martha Open Pit Phase 4. In addition I confirm that I have reviewed the report Project Martha, Assessment of the Impacts of Proposed Underground Mining on the Martha Open Pit Phase 4. This report and the modelling contained therein were carried out under my direction and I agree with the results and conclusions. These reports are attached as Appendices Q and P respectively to the AEE.

#### **Executive summary**

- 14 Project Martha comprises the Martha Phase 4 Pit (MP4) and the Martha Underground. The two mines will operate in parallel and the components are linked in engineering terms. This is because waste rock for underground stabilisation comes in large part from MP4. As part of the planned works the underground will also be backfilling and hence stabilising some of the existing historical underground workings below the open pit.
- 15 In conventional mining terms MP4 is simply a cutback to stabilise the north wall failure. It entails excavation of the eastern end of the north wall, a change to 20% of the existing pit. This cutback will also allow access to the pit base to complete the East Layback Pit.
- 16 It is a normal part of good mining practice that if a failure occurs during operations, the failure is cutback to re-establish stable conditions in the pit, to re-establish access and to allow completion of the pit as planned.
- 17 The MP4 pit is a much flatter overall slope than the north wall of the current pit.
- 18 There have now been four pits excavated at Waihi; Licensed Pit, Extended Pit, South Stability Cutback (SSC), which was originally aimed at pit closure; and East Layback (Pit 66D). Sections of the last three pits now form the existing walls of the Martha Pit.

- 19 Both the two previous pits at Waihi, SSC and Pit66D were designed to achieve more stable conditions by moving the new pit walls as far as practical outside the rock mass zone affected by the historical underground workings. This process has generally been successful. The MP4 pit is a continuation of that stabilisation process. MP4 is a remedial cutback of a failure undertaken in order to re-establish the mine, which is a normal part of conventional mining activities and there is nothing unique or special in the planned cutback.
- 20 The MP4 pit is in large part an existing structure that has already been constructed and its performance has been monitored over time. The existing pit stability condition is the starting point for MP4. Monitoring has now been in place for up to two decades and does not show large scale pit wall instability movements. Consequently in engineering terms there has been a mine scale validation of the ultimate material properties used for the design of the pit walls.
- 21 There are also two key positives of the Project Martha:
- a) The cutback pit wall will be further outside the disturbance envelope from the historical underground mining; and
  - b) The Martha Underground will stabilise many of the existing openings immediately below MP4.
- 22 These stabilisation works will make a significant difference to the long term post mining risk situation in Waihi.
- 23 An investigation has been carried out to evaluate the potential for other structural planes to that which contributed to the north wall failure. This study has not identified any related structures behind MP4.
- 24 The stability has been checked and overall the factors of safety are high for the MP4 pit. The lower slope is potentially affected by underground stopes and disturbed rock mass. It is recommended that locally some of the open stopes in the Martha Lode for a distance of approximately 30 m below the toe of MP4 are filled where practicable as the mining progresses. The details should be determined based on the performance and exposures during mining.

### **Description of Project Martha**

- 25 Project Martha comprises:
- a) The Martha Phase 4 Pit and
  - b) The Martha Underground including the Rex Orebody.
- 26 The existing Martha Pit has been operating since 1987 and most of the pit walls are quite old. MP4 only entails a cutback to approximately the eastern half of the north wall, a change to only approximately 20% of the pit. The cutback is

designed at a much flatter overall angle compared to the current pit and hence stability will be improved. The MP4 pit is in large part an existing structure that has already been constructed and its performance monitored over time.

- 27 The MP4 cutback will be mined in a single top down sequence and will take around eight years to mine. Ore and waste will be mined by conventional drill and blast methods. The controlled blasting practices used over the last two decades will be continued. The horizontal drain hole drilling will be continued as required in the cutback. There will be no change to the mining methods used for the existing pit.
- 28 The open pit and underground components are partly linked, interact with each other and will operate partly in parallel. MP4 will operate from project years 3 to 10 and the Martha Underground from project years 1 to 11.
- 29 Waste material mined from MP4 will be used as backfill for the Martha Underground.

### **Discussion of the Impacts of Project Martha on Stability**

#### **Impacts of proposed underground mining**

- 30 There are many elements of the Martha Underground mining that are very important for MP4 stability:
- a) 30% of the existing unfilled historical stopes will be stabilised by filling with rockfill;
  - b) Approximately half of these stopes are located in the upper levels immediately below the MP4 Pit;
  - c) In addition, 30% of the planned mining will entail re-mining of existing historical stopes (remnant mining, in addition to the 30% above);
  - d) A very large proportion of these stopes are located immediately below the MP4 Pit;
  - e) The underground mining will be top down, and
  - f) Cemented Aggregate Fill (CAF) or Cemented Rock Fill (CRF) will be used extensively in this mining.
- 31 Because of the mining sequence and the timing discussed above, the area of historical workings immediately below the current pit will be stabilised (as discussed above) in the early years even before commencement of MP4.
- 32 The Rex Lode is a small, short life, narrow vein underground mine that is isolated from the historical and planned new underground mining. The Rex Lode mining will not impact on the open pit.

33 In summary the planned changes and the planned underground mining are all positive for stability and will substantially improve the current situation.

34 I am aware that two submissions on the Resource Consent Application for Project Martha (Ruth Ordish and Juan Fisher) raise concerns about the stability of the underground tunnels formed as part of the planned underground mining. The concerns are about what happens with re-watering, potential removal of fines and gradual deterioration. Although I understand this aspect is covered in the evidence of Mike Sandy I have direct experience over the last 23 years with close inspection of all the tunnels intersected by the open pit mines. All of these tunnels were essentially stable and did not show any evidence of gradual deterioration or loss of fines. The mechanism and the concern is not supported by the evidence.

#### **Overall setting of MP4 relative to considerations of stability**

35 There are a number of general positives associated with the Phase 4 Pit, including:

- a) There is a long history and understanding from mining in the materials in the current Martha Pit;
- b) There is good drilling coverage in most areas,
- c) The planned cutback slope is relatively close to the existing pit wall,
- d) In the cutback area, the MP4 pit will be further outside the potential disturbance envelope from the historical underground mining;
- e) The pit walls are largely depressurised; and
- f) The Martha Underground will stabilise many of the existing openings immediately below the open pit.

36 This stabilisation will make a significant improvement to the long term post mining risk situation in Waihi.

#### **Discussion of potential negative impacts of Project Martha on stability**

37 I consider there are two other factors associated with Project Martha that need to be addressed:

- g) The pit life will increase, and
- h) The groundwater level in Martha Underground will be lowered by an additional 200 m.

38 The life of the MP4 pit is 10 years, which is an increase over previous planned mine lives. The plan for all previous pits was to limit the time between completion of ore mining and pit flooding. There is no scientific data available

either Waihi site specific or generally, to indicate this increased pit life will adversely impact on stability.

- 39 In regards to the second point there has also been no evidence that dewatering has had any negative impacts on pit stability, rather the opposite is the case and fully dewatered pit slopes have been a major benefit for pit stability.

### **Discussion on Impacts of Historical Underground Mining**

- 40 Underground mining at Waihi started in 1878 and continued up till 1952. Unfortunately only limited, poor quality records of the rock mass deformations and subsidence are available for this 70 year period.

- 41 In around 2001 to 2003 it became evident that the impacts of this historical mining on the open pit mining were significant, because:

- a) The full extent of the underground workings, both laterally and vertically, is very large relative to the open pit;
- b) Large scale block subsidence and sliding on the hanging wall and footwall of the main lodes occurred early during mining around 90 years ago,
- c) Large underground openings were left unsupported,
- d) There were renewed mining activities superimposed over older workings and mining often recommenced even in areas of previous failures; and
- e) In the later years of the old underground mine, unplanned and then planned caving activities took place, referred to as the Milking Cow.

- 42 All of the above activities resulted in a weakening of the rock mass, largely extending from the Royal Lode in the south to the footwall of the Martha lode in the north. Over time it has become increasingly evident that there has been widespread ongoing deformation, subsidence and movement over a large area both inside and outside the current open pit.

- 43 I am aware that two submissions on the Resource Consent Application for Project Martha (Ruth Ordish and Juan Fisher) raise a number of concerns about the stability of the area around Seddon Street adjacent to the south wall of the Martha Pit. The concerns deal generally with the history of this area, the fact the Pumphouse was relocated previously because of movement concerns and that there are signs of movement in Seddon Street, termed relaxing of the pit wall. In addition a number of specific concerns are raised:



- a) That blasting vibrations will cause the block of land (the area as described in the preceding paragraph) to “*start to move again*”;
- b) That increased dewatering will cause the block of land (as described in the preceding paragraph) to “*start to move again*”;
- c) That there is “*significant slipping inside the pit on that block*”; and
- d) That historically there have been multiple sinkholes in the area; how likely is it that more sinkholes will occur and if so who is responsible.

44 I have dealt extensively with this aspect in my report and this is also summarised in the paragraphs above. The area started moving during the period of underground mining and has continued moving to a smaller extent ever since. The south wall of the Extended Pit was located within the zone of rockmass weakened by the underground mining. The Pumphouse was then located at the top of this wall and was also moving. In order to stabilise the wall and to preserve the Pumphouse the wall was cutback and the Pumphouse was moved. The long term monitoring shows this was successful.

45 The blasting at Waihi is near the lower limit of blasting for open pit mining on a world-wide basis. I have reviewed all the monitoring data regularly over the past 23 years and at no time has there ever been any movements, no matter how small, attributed to blasting.

46 I have regularly reviewed the historic dewatering and assessed possible impacts of movements. There is no evidence in support of dewatering causing movements.

47 The slippage inside the pit is at a location where an historic underground subsidence intersects the pit wall, refer to paragraph 40 b) above. This is not related to pit wall instability or movement.

48 Sinkholes have occurred in the past in the area and even occurred well before open pit mining commenced. All sinkholes are related to open unsupported stopes in the poor rockmass around the Royal Lode. Sinkholes could definitely occur in the future but there is no evidence to link these with open pit mining. All future underground stopes will be backfilled and hence it is not possible for sinkholes associated with these future stopes to occur.

### **Stability Performance and History of the Current Martha Pit**

49 There have now been four pits excavated at Waihi; Licensed Pit, Extended Pit, South Stability Cutback (SSC), which was originally aimed at pit closure; and East Layback (Pit 66D). Sections of the last three pits now form the existing walls of the Martha Pit.

- 50 All failures to date in the Martha Pit, both large and small, have occurred in sections of the rock mass substantially affected by the historical underground workings. This includes the north wall failure in April 2016, which is the focus for the MP4 cutback.
- 51 Both the SSC and East Layback pits were designed to achieve more stable conditions by moving the new pit walls as far as practical outside the rock mass zone affected by the historical underground workings.
- 52 The MP4 pit is a continuation of that stabilisation process, because the cutback removes the north wall failure, and moves the north wall further outside the rock mass zone affected by the historical underground mining.
- 53 This process has proven successful as demonstrated by the performance and success to date of the SSC and the East Layback.
- 54 MP4 is a remedial cutback of a failure undertaken in order to re-establish the mine. This is a normal part of conventional mining activities and there is nothing unique or special in the planned cutback.
- 55 The existing Martha Pit has been operating since 1987 and is in large part an existing structure, constructed and its performance monitored over time. Consequently in engineering terms there has been a mine scale validation of the ultimate material properties used for the design of the pit walls. The situation is the starting point for MP4.
- 56 The scarp left by the north wall failure has been in existence for over two years but is a relatively new slope. Additional monitoring was installed after the failure and this shows no global movement is occurring on or behind the failure scarp. This new slope is stable overall. The cutback will be excavated at a much flatter angle in the rock mass behind the scarp.
- 57 The long term monitoring data shows no movements of the pit walls except for three areas:
- a) The upper central portion of the south wall, in the area affected by historical underground subsidence, where very minor creep movements are occurring; and
  - b) One portion of the east wall where there is continued subsidence in and around the historical Milking Cow; and
  - c) Minor creep movements in the area where the historical clay filled Martha Stopes intersect the pit wall.

### **Available Information and how this was used to Assess Stability**

- 58 In the cutback the new pit walls are relatively close to the failure scarp and therefore the geotechnical conditions and the stability of the scarp of the north wall failure itself assist with informing the assessment of the stability of the new MP4 pit walls.
- 59 One focus for the Phase 4 studies has been to use the new drilling undertaken since the East Layback was designed in 2005. This new data shows that MP4 is located in a better quality rock mass and where practicable, further removed from the historical mining influences.
- 60 The available information used to assess MP4 comprises the complete database of drill holes in and around the Martha Pit, which shows there are no large gaps but nevertheless some additional piezometers are planned to further bolster the monitoring.
- 61 The new information available for MP4 since the design of the South Stability Cutback and the East Layback comprises:
- a) In 2016 approximately 31 exploration holes were drilled by Geology, series holes UW469 to UW500, around the existing pit for gold exploration;
  - b) The geology model update was completed in May 2017,
  - c) Previously three long holes had been drilled to the north from inside Martha Pit, UW462 (in centre), UW463 (in east) and UW464 (in west), one of these holes passes through the rock mass in which MP4 will be excavated;
  - d) In 2012/13 a series of holes were drilled for the MEP project, all along the north wall;
  - e) Prior to the north wall failure a number of cored holes and inclinometers were drilled through the north wall to investigate the moving rock mass ; and
  - f) After the north wall failure two cored inclinometer holes were drilled, Inclinometers 7 and 8, to explore the rock mass behind the MP4 pit.
- 62 Hence there is very good data coverage of MP4 and no significant gaps.
- 63 Because of the potential significance of the historical underground mining to pit stability there has also been a major update of the rock mass model. The rock mass model was first developed in 2003 to understand the impacts on the rock

mass caused by the underground mining. This model was updated in 2006, 2010, 2014 and recently as part of the MP4 studies. This recent update included all drill hole data since 2005. There is now a comprehensive 3-d rock mass model for the whole area surrounding the pit showing the underground deformation zones.

#### **MP4 Investigations**

- 64 The north wall failure occurred in April 2016 following a minor failure of the haul road in April 2015. The failure had two main elements:
- a) The main failure plane (a geological structure) in the mid-upper part of the slope and
  - b) Rock mass failure at the toe principally through remnant pillars around the old Martha underground workings.
- 65 Although MP4 is a cutback of a failed slope, there could be the potential for another geological structure of similar orientation, behind the cutback. Consequently detailed geotechnical investigations were undertaken to evaluate this potential.
- 66 The detailed drilling investigations, supplemented by the monitoring over two and a half years, have been assessed in detail and no other large continuous structures have been identified behind the north wall failure plane.
- 67 I am aware that one submission on the Resource Consent Application for Project Martha (Robert and Demelza Burrell) raises concerns about future instability of the cutback slope and whether the remediation will be successful. I have thoroughly checked this possibility as part of my studies using advanced investigation techniques and well accepted analytical methods. No major adverse structures have been identified. The cutback slope has been analysed and acceptable stability has been demonstrated. Furthermore the cutback is being excavated at a much flatter slope than the previous pit wall and this is generally accepted as sound mining practice in these circumstances.

#### **Stability Analyses**

- 68 The MP4 Pit entails a cutback of the north wall failure and completion of the East Layback at depth. Consequently the stability analyses have comprised a check on the overall stability for MP4 plus assessing the deepening of the East Layback to the original planned depth.
- 69 These analyses show high factors of safety and adequate stability for the MP4 pit.

70 Even with lower bound strength parameters the factors of safety remain high. The only exception is locally near the toe where the MP4 slope intersects the old workings and deformed rock mass. In this area the factor of safety is marginally less than acceptable for these worst case parameters. This does not mean the slope will fail simply that care needs to be taken when mining through this area and remedial treatment provided as and where necessary based on the conditions exposed. This is part of normal mining practice and has been carried out at Waihi throughout open pit mining.

71 For the east wall adequate factors of safety are achieved.

### **Modelling Studies of the Underground and MP4 Pit Interaction**

72 It is good practice to undertake computer modelling studies to evaluate the interaction between open pits and underground mines. This is particularly the situation for Project Martha, because of the location and historic influence of the historical underground workings.

73 The analysis includes the latest data on topography, lithology, previous underground workings, proposed underground workings and major structures. Other inputs include the compressibility and the strength of the rock mass and major structures, the mining sequence, the influence of stope backfill, and in-situ stress regime. The sensitivity to the adopted material parameters and assumptions were also tested using a number of cases.

74 The modelling has been able to be carried out in sufficient detail and complexity to assess the geotechnical performance of MP4 in response to the Martha Underground.

75 The modelling showed:

- a) The predicted response to the Martha Underground is in accord with the experience and previous performance of the Martha Pits in terms of magnitude, location and distribution of movements;
- b) Relatively small displacements and strains are predicted to occur, provided stopes are backfilled the maximum displacements of MP4 pit walls would be around 8 to 200mm, which is similar to existing movements;
- c) The displacements and strains occur mainly around the new underground stopes and there is little disturbance in areas away from these locations;

- d) Local backfilling of historical unfilled stopes will reduce the possibility of local crushing and or pillar/stope collapse potentially leading to local stability problems with the north wall of MP4; and
- e) The planned backfilling of new stopes and of those existing voids proposed for mining immediately below MP4 will result in a significant improvement in overall rock mass conditions, improve pit stability conditions in both in the short and long term, reduce any impacts of the Martha Underground mining and assist with reducing the long term creep of the rock mass.

### **Recommendations**

- 76 It is recommended that locally some of the open stopes in the Martha Lode for a distance of approximately 30 m below the toe of MP4 are filled where practicable as the mining progresses. The final decision on this remediation should be made as mining of the cutback progresses based on monitoring results.
- 77 A comprehensive review of all prisms and base stations is required prior to the start of MP4.

### **Section 42A Report Proposed Land Use Consent Conditions**

- 78 I have considered the Proposed Land Use Consent Conditions recommended in the Hauraki District Council section 42A report, principally those dealing with Mine Construction and Surface Stability. In summary these conditions appear to be essentially formulated around a number of layers of controls, with;
  - a) Mandated conditions,
  - b) A Void Management Plan,
  - c) Regular reporting of activities and
  - d) Regular Peer Review.
- 79 I understand HDC propose a condition that requires a standoff from the Milking Cow, being 20m from the base, rising as a cone at 65°. I understand this condition is copied from an early conceptual underground mining study by SRK. I have used the historical underground mining data, investigation drill hole data and pit mapping to define a 3-d model of the Milking Cow. This model is now held by Oceana Gold and is an accurate, up to date representation of the Milking Cow Zone. The condition first recommended by SRK is not appropriate and the standoff distance should be with reference to the 3-d model of the Milking Cow held by Oceana Gold.

80 Overall I consider some of the mandated conditions are too prescriptive for the actual mining conditions that will be encountered during mining. Successful safe mining requires a degree of flexibility and this is even more important at Waihi because of the long history of uncontrolled underground mining. I consider many of the mandated conditions would be better managed under the Void Management Plan and then any issues are further covered by the regular reporting and Peer Review. I have read the conditions proposed by Oceana Gold and I support these.

### **Conclusion**

81 Project Martha will result in improvements to all aspects of risk and stability compared to the existing situation.

A handwritten signature in blue ink that reads "Tim Sullivan". The signature is written in a cursive style with a prominent initial "T" and a long horizontal stroke.

**Tim Sullivan**

28th October 2018