Before a joint hearing of the

Dunedin City Council	**LUC-2016-230 and LUC-2013-225/A**
Otago Regional Council	**RM16.138**
Waitaki District Council	**201.2016.779 and 201.2013.360-1**

Under	the Resource Management Act 1991
In the matter of	applications by Oceana Gold (New Zealand) Limited for resource consents for the Coronation North Project

Statement of evidence of Paul Weber for Oceana Gold (New Zealand) Limited

14 October 2016

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Qualifications and experience

1 My name is Paul Weber.

2 I am a Principal Geochemist at O'Kane Consultants (NZ) Limited (**OKC**), part of an international consulting company that provides mine waste management and mine closure services to the mining industry worldwide. OKC has offices in New Zealand, Australia, Wales, USA, and Canada and has been consulting to the mining industry for 20 years.

3 I completed my Bachelor's degree in geology at the University of Canterbury (awarded 1993). I completed my Master's degree in environmental science at the University of Canterbury (awarded 1995). I completed a Ph.D. in applied science specialising in the area of acid mine drainage research at the University of South Australia (awarded 2003). I am the University of South Australia 2003 Post Graduate Research Student of the Year and received the 2003 Ian Wark Research Institute Medal for best Ph.D. I have been involved in a number of mining related projects that have received awards (e.g., Ronald Hicks Memorial Award, 2012). I am an AusIMM Chartered Professional (Environment). I have been an author of over 50 publications relating to environmental management of mining operations; mostly these are related to the geochemistry; the management of waste rock; and the treatment of mine impacted waters.

4 I worked in Australia as a geologist for 5 years before undertaking my Ph.D. I have worked in the New Zealand mining industry since 2004. This includes working for Solid Energy New Zealand Limited and more recently for OKC. In both instances, the work related to investigations into the geochemical effects of mining operations and determining solution for adverse environmental effects of mining.

5 I have experience working at Oceana Gold (New Zealand) Limited's (**OceanaGold**) Reefton Globe Progress Mine, having undertaken my M.Sc thesis on the same site, and recently being engaged by OceanaGold to design conceptual passive treatment systems for the site; develop pit lake models; and treatment options for pit lake water. I have also been engaged this year by OceanaGold to provide geochemistry support for the Macraes Gold Project (**MGP**), specifically for the proposed Coronation North Waste Rock Stack (**WRS**) and the management of sulfate reporting from the WRS is basal seeps.

6 I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note. My evidence has been prepared in accordance with it and I agree to comply with it.

Scope of evidence

7 I have been asked by OceanaGold to prepare evidence regarding options that may be available to the company for the design of the Coronation North WRS that may reduce the discharge of sulfate-impacted seepage from the WRS to surface waters.

8 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) AEE Appendix 4 by Golder Associates on surface water modelling for the MGP; and

(ii) AEE Appendix 14 by Engineering Geology Limited on erosion and sediment control for the MGP;

(b) The submissions lodged on behalf of submitters as relevant to sulfate in surface waters;

(c) The recommending report prepared for the Otago Regional Council (**ORC**); and

(d) The submissions by Craig and Erin Howard; David and Jocelyn Kinney; Nga Runanga, and the Director-General of Conservation (Lewis Vernon Sanson).

Background

9 OceanaGold engaged me to assess options that could be implemented to reduce sulfate concentrations and sulfate load from the Coronation North WRS. Currently the method proposed to manage sulfate concentrations reporting to the receiving environment is the construction of the Coal Creek Freshwater Dam (the Dam) to supply base flow and dilute the sulfate concentrations to an acceptable standard. OceanaGold sought my opinion in regards to options that might lessen the dilution that would be required and in turn might enable the scale of the Dam to be reduced.

10 OceanaGold will use my assessment to develop a Best Practicable Options (**BPO**) report for the management of sulfate concentrations and sulfate loads from the proposed Coronation North WRS to inform decision-making on mitigation options. An adaptive management process should be implemented to manage the effects of sulfate on the downstream surface water receiving environment using the knowledge gained from the BPO report.

Sulfate management options

Oxidation – generation of sulfate

11 When waste rock is removed from above an ore body as part of the mining process it often transitions into an oxidising environment (associated with atmospheric oxygen). In such an environment the sulfide minerals present in the waste rock will oxidise. Such processes are typically explained by the oxidation of pyrite, which results in the generation of metals, acidity, and sulfate.

12 At the MGP the acidity generated by sulfide oxidation is neutralised by the inherent acid neutralisation capacity of the waste rock, which is related to the carbonate minerals present such that drainage waters (basal seeps) from the waste rock stacks (**WRSs**) are circum-neutral in pH. However, sulfate concentrations in WRS basal seeps remain elevated.

13 If ongoing sulfide oxidation can be reduced then the potential sulfate content within the WRS can also be reduced. Hence, minimising oxygen ingress into the WRS will help reduce sulfate production.

14 Sulfide minerals present in waste rock represent about 72 - 75% of the total sulfur within the Coronation Pit and similar trends are expected in the Coronation North Pit.

15 I have recommended to OceanaGold that further work be undertaken to understand sulfur speciation in the Coronation North Pit. OceanaGold have indicated that 700 samples from the project are being analysed for sulfur based on this recommendation. Such data can be used to create a sulfur waste rock block model for the *in-situ* overburden. The model can be used to determine if higher sulfur zones are present.

16 If higher sulfur waste materials can be identified, and differentiated from lower sulfur waste material in a manner suitable for mining methods, this will enable OceanaGold to construct a mine plan and mining schedule to preferentially manage waste rock with higher sulfur content.

17 Management options could include encapsulating the higher sulfide bearing waste rock within an engineered cell in the core of the Coronation North WRS where exposure to oxygen will be reduced, and placing lower sulfide material around the perimeter of the WRS. Further work is required to determine the benefits of such an approach.

18 Another mitigation option to reduce sulfide oxidation, which would benefit from a field trial, would be to reduce the height of tipheads. Currently waste rock is tipped from dump trucks and pushed over a tiphead of ~20 metres height. This produces a lift within the WRS; the next lift (and tiphead) is started on top. From published literature and my experience at other operations, if the height of the tiphead is reduced, for example to 5 metres, there is a significant reduction in the oxygen ingress into the WRS due to minimising grainsize segregation and the formation of rubble layers at the base of the WRS. It is recommended investigations be undertaken to determine the benefits of lower tipheads in the range of 5 – 10 m and the associated costs to determine the optimum approach for tiphead height as part of the adaptive management strategy.

19 Less oxidation means less stored sulfate oxidation products that can then be mobilised by net percolation.

Net percolation – transport of sulfate

20 If there is no water flow through the WRS then the mobile sulfate load cannot be transported to the receiving environment.

21 Reducing water ingress into the Coronation North WRS would reduce the opportunity for sulfate to be transported from the WRS in basal seepage waters. There are various options available for controlling water ingress into the WRS. Some of these include:

(a) Making the upper surface of the WRS shed water by ensuring all lifts and final surfaces have a slight gradient, rather than encouraging ponding on flat surfaces;

(b) Avoiding having constructed ponds on the WRS as such waters will infiltrate downwards into the waste rock;

(c) Stopping run-on of water onto the WRS from the upper catchment by installing diversion channels around the WRS and piped drains through the WRS footprint; and

(d) Progressive rehabilitation of WRS lifts, as the final cover system using 0.3 metres of oxidised waste rock, and a soil layer with vegetation is likely to reduce net percolation; however further investigations are required to confirm this is correct.

22 A concentrating effect may also be occurring in WRSs at sites where sulfate concentrations increase along the net percolation pathway. Minimising the length of net percolation pathways where waters interact with sulfate bearing waste rock will reduce sulfate concentrations. This can be achieved by reducing the amount

of sulfide oxidation and the use of waste rock with no or low sulfur along key drainage paths (such as the basal drainage layer).

23 It is recommended that column leach tests be established using appropriate materials to understand expected water quality, contaminant loads, and concentrating effects from the waste rock using flow rates in the column leach test that are comparable to those expected in the proposed Coronation North WRS. This would provide key information for forecasting long term water quality.

Compaction

24 Generally compaction of waste rock (having sufficient fines) can result in lower net percolation and oxygen flux. However, such effects are site specific and will require further investigations and modelling.

25 Compaction of the 0.3 metre oxidised waste layer on the surface of the WRS may have benefit for reducing net percolation and oxygen ingress. Investigations are recommended to confirm any benefits.

26 Suitable compaction may be achieved by mine vehicle trafficking on the WRS. This would reduce oxygen ingress and net percolation. A traffic management process should be considered to maximise compaction, which should be tested and validated by some form of operational quality control.

27 Compaction of surface drainage pathways on the WRS may reduce net percolation. Investigations are recommended to confirm any benefits.

28 The benefits of compaction of the engineered high sulfur cell within the WRS core should be investigated to determine the benefits.

Pit backfilling

29 There exists the option to backfill waste rock into Coronation Pit once it is mined to stage completion, and the preferential disposal of high sulfur waste rock into the pit. Such waste rock would eventually become saturated below the long-term water table, reducing ongoing sulfide oxidation. The presence of any stored sulfate and other oxidation products would need to be considered.

Adding limestone to WRS

30 Limestone could be installed at the base of the WRS along the expected drainage paths for net percolation. Limestone could also be spread on each lift of the WRS to provide an additional source of calcium carbonate that could dissolve to release calcium. This could remove a portion of the sulfate by the formation of gypsum. However, initial assessment indicates the addition of calcium will decrease sulfate by only a small amount, and sulfate in drainage waters will not

be lower than ~1,800 mg/L, making it a partial option at best, although it could be one option within a greater adaptive management process for sulfate.

Sulfate reducing bacteria within WRS

31 Passive treatment systems can be installed within a waste rock dump. Observations at OceanaGold's Reefton Globe Progress Mine suggest that the placement of vegetation and organic matter at the base of the WRS has created conditions suitable for sulfate reducing bacteria (**SRB**). SRB utilise organic matter to reduce sulfate to sulfide, which is often immobilised as a solid precipitate. A similar system could be developed within the Coronation North WRS and further investigations are required to confirm the benefits of in-dump passive treatment by SRB.

Water treatment

32 Seepage waters reporting to the WRS basal seepage collection points could be treated before they report to the receiving environment to reduce the sulfate concentration and thus the overall sulfate load from the WRS. If treatment was utilised as a management tool it is likely that the process would involve treatment in perpetuity.

33 It is likely that passive treatment would be the most preferred approach and could utilise the sediment ponds at the base of the WRS. Wetlands using SRB to remove sulfate would be the most likely approach, although other options should be investigated. Research being undertaken by OKC and CRL Energy Limited has shown that sulfate can be removed by passive treatment systems amended with water soluble organic carbon products which can reduce sulfate concentrations in low pH mine-impacted waters from ~1,200 mg/L to ~ 500-800 mg/L. Field trials will be required to assess the effectiveness of this treatment option at Macraes and are recommended.

Recommendations

34 As outlined earlier, I have recommended to OceanaGold that further work be undertaken in a number of instances. I understand that the Dam is not required immediately, hence there is the opportunity to undertake investigations and field trials, and to look at mitigation strategies to minimise the sulfate load from the Coronation North WRS. Such mitigation strategies may defer construction of the Dam and reduce the flow rate required from the Dam for dilution purposes.

35 I propose a detailed monitoring and investigative programme be initiated to validate the WRS design to reduce the sulfate load reporting from the WRS toe as basal seepage as well as treatment of sulfate-rich drainage. This could include:

(a) Undertaking a waste rock block model and integrating such data into the mine plan and scheduling to manage high sulfur waste rock;

(b) It is recommended that column leach tests be established to understand expected water quality, contaminant loads, and concentrating effects from the waste rock using flow rates in the column leach tests comparable to those expected in the proposed Coronation North WRS. This would provide key information for forecasting long term water quality;

(c) Investigations into methodologies to reduce oxygen flux into the WRS;

(d) Investigations into methodologies to reduce net percolation into the WRS;

(e) Regular water quality and flow monitoring of all basal seeps on site to understand WRS drainage characteristics and the geochemical evolution of such waters;

(f) Develop a sulfate load model for the site to make informed decisions about the management of water impacted by sulfate; and

(g) Passive treatment trials looking at treatment options within the WRS and external to the WRS.

Conclusion

36 OceanaGold has a range of opportunities to minimise the sulfate load from the Coronation North WRS, although these opportunities still require validation. However, the company has demonstrated a commitment to undertaking this work:

(a) 700 samples are now being tested for total sulfur, based on my recommendations to do so, which will form the basis for the sulfur block model and the subsequent mine plane and mine schedule. Management options can be developed once the issue is quantified.

(b) OKC has already submitted a proposal to OceanaGold to test SRB passive treatment options using novel technologies developed through a research programme that OKC is a partner to.

37 I think it reasonable to consider an adaptive management process for the management of sulfate loads from the Proposed Coronation North WRS, provided the options are assessed.

38 I look forward to identifying practical and effective sulfate management options for the Coronation North project as part of the BPO report.

Paul Weber

14 October 2016