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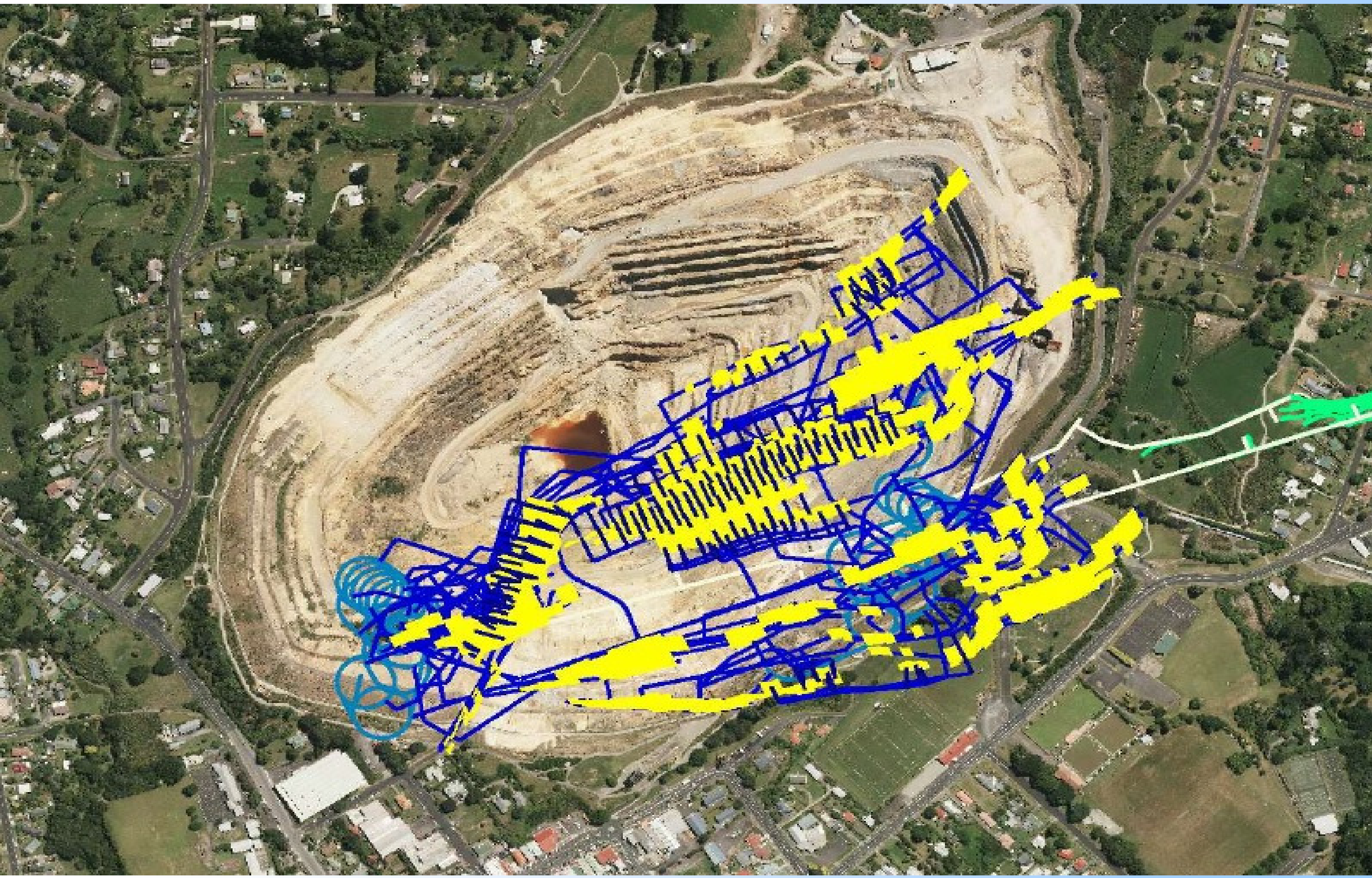
APPENDIX H

Groundwater Assessment
(GWS Limited)

GWS Limited



Project Martha

Assessment of Groundwater Effects

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Waihi 3610
New Zealand

Report Prepared for: OceanaGold NZ Ltd

20th April 2018

FINAL REPORT

Contents

1. Introduction 1
   1.1 Project Description 1
   1.2 Scope of Work 1
2. Hydrogeologic Setting 2
   2.1 Regional Geology 2
   2.2 Regional Hydrogeology 4
3. Mine Dewatering 17
   3.1 Historic Workings 17
   3.2 Historic Dewatering 18
   3.3 Historic Dewatering Effects 20
   3.4 Recent Mine Dewatering 20
   3.5 Observed Dewatering Effects 22
4. Groundwater Effects Assessment 24
   4.1 Martha Underground Dewatering - Groundwater Inflows 24
   4.2 Martha Underground Dewatering – Drawdown Effects 25
   4.3 Martha Underground Dewatering - Effects to Surface Waters 28
   4.4 Martha Underground Dewatering – Effects to Groundwater Resource 29
   4.5 Martha Underground Dewatering – Effects to Plant Growth 33
   4.6 Rex and Martha Phase 4 Pit Dewatering – Groundwater Inflows 33
   4.7 Rex and Martha Phase 4 Pit Dewatering – Drawdown Effects 33
   4.8 Martha Underground Post Closure –Rewatering Rate 33
   4.9 Martha Underground Post Closure – Long Term Discharge 34
   4.10 Martha Underground Post Closure – Effects on Surface Waters 40
   4.11 Rex and Martha Phase 4 Pit Post Closure – Effects on Pit Wall 40
5. Recommendations 41
   5.1 Dewatering 41
   5.2 Rewatering and Post-Closure 42

Tables

Table 1 Aquifer Hydraulic Properties 16
Table 2 Calculated Pumping Rate for Proposed Martha Underground 24
Table 3 Groundwater Availability Calculations 29
Table 4 Private Bore Information from Council Database 31
Table 5 Calculated Rewatering Volumes 34
Table 6 Shaft and Adit Elevations below 1104 m RL 38

Figures

Figure 1 Generalised Geology in the Waihi Area 3
Figure 2 Ore Body Distribution 3
Figure 3 General Geology and Structural / Hydrogeologic Domains 4
Figure 4 Conceptual Water Balance for the Waihi Area (Modified after GCNZ, 1985) 5
Figure 5 Groundwater Levels in Alluvium / Ash 7
Figure 6 Groundwater Levels - Groundwater System in Younger Volcanics 8
Figure 7 Groundwater Levels - Andesite Rock Aquifer 9
Figure 8 Water Table Map 10
Figure 9 Hydrological Cross-Section Locations 11
Figure 10 Hydrological Cross-Section Pit to P92 11
Figure 11 Hydrological Cross-Section Pit to P95 12
Figure 12 Hydrological Cross Section Pit to P102 12
Figure 13 Conceptual Model of Andesite Permeability and Vein Interconnection 15
Figure 14 Historical Workings Void Filled by Levels 17
Figure 15 Historical Martha Annualised Average Pumping Rates and Levels 19
Figure 16 Mine Pumping Schematic 21
Figure 17 Pumping Rates for Martha and Correnso from 2003 to 2016 23
Figure 18 Proposed Martha Underground Development and Dewatering Schedule 25
Figure 19 Multilevel Piezometer P3 Data. 26
Figure 20 Pressure Gradient P3 27
Figure 21 Locations of Private Bores from Council Data Base 30
Figure 22 Private Bore Monitoring Data 32
Figure 23 Conceptual model of Mine Hydraulic Interconnectivity 35
Figure 24 Approximate Location of 1104 m Contour 37
Figure 25 Historical Adit Levels – Union Hill 38
Figure 26 Elevations of Historical Shafts – Union Hill 39

Appendices

Appendix A Dewatering Model
Appendix B Rewatering Model
Appendix C Numerical Modelling

EXECUTIVE SUMMARY

OceanaGold NZ Ltd (OceanaGold) is seeking Resource Consents for its Waihi operation to extend a section of the north wall of the Martha Open Pit and commence underground mining operations of the Martha ore body that, together, are referred to as Project Martha. GWS Limited has been engaged to quantify the volumes required to dewater and rewater the Martha Underground and to indicate the consequent effects on groundwater levels and pressures. The scope of this report is focussed on the development of the Martha Underground and Martha Phase 4 Pit.

The geological and hydrological setting of the area is well understood and has been described in numerous previous reports. In summary, the ore body to be mined comprises near-vertical quartz veining with relatively elevated permeability and groundwater storage within an andesite rockmass of lower permeability and storage.

The andesite rockmass is overlain, in part, by younger volcanic materials comprising rhyolitic tephras and ignimbrite flows, breccias and tuffs. Paleosols and sedimentary deposits are occasionally interspersed or located at the base of these deposits. These deposits infill a paleovalley system between the outcropping andesite elevation highs. This paleovalley system extends from beneath East Waihi and passes between Martha Hill and Union Hill.

The groundwater in the younger volcanic deposits is separated from the deeper groundwater in the andesite rock by a weathered, lower permeability upper layer of the andesite rockmass.

Vein and fault intersections provide interconnections between the Martha, Trio and Correnso mines. These intersections have been enhanced by mine developments. While the Favona mine was, initially, hydrologically separate from the other mines, now a low level drive provides connection to the other mines above 823 m RL.

As a result of the interconnections, dewatering of one vein also dewaters the interconnected veins to a similar elevation, but the andesite rockmass surrounding and between the veins is dewatered to a lesser degree such that steep hydraulic gradients develop between the veins and the rockmass.

This dewatering effect is substantially attenuated by the low permeability layer at the top of the andesite rockmass such that only close to Union Hill, where the low permeability layer appears to be thinner, has an effect on the water pressures at the base of the younger volcanics been observed as a departure from the natural hydrostatic gradient. Further north of Union Hill, this effect reduces until it is absent.

This dewatering effect on the younger volcanic rocks developed early in the current mining phase and is not sufficient to alter the primarily horizontal groundwater movement within that rock unit.

The current dewatering level of the Martha, Trio and Correnso vein systems (as at early 2018) is at approximately 770 m RL with the consented dewatering depth being 700 m RL. Historical dewatering has been undertaken to approximately 540 m RL and with the proposed Martha Underground Mine to extend to 500 m RL, only some 40 m of previously non-dewatered ground would be dewatered.

While current mine dewatering has been ongoing since 1989, groundwater level monitoring has shown that water pressures in the younger volcanic rocks and the upper parts of the andesite rockmass have remained stable since the early to mid-1990's when the dewatering level in the veins dropped below the base drainage elevation of the younger volcanic rocks.

Previous (GWS, 2010, 2012) and current finite element modelling (Appendix C) has also demonstrated that dewatering of the veins has little impact on the water pressures in the overlying younger volcanic materials.

Currently, water is pumped from the Correnso mine to the water treatment plant via the Favona decline using a number of pumps and lifts. Pumping rates in excess of 15,000 m^3/d have been recorded but are currently some 10,000 m^3/d. The water pumped from underground comprises:

- Water sourced from storage within the interconnected old workings, vein systems, and where present, from post mineralisation faulting.
- Water released from groundwater storage in the surrounding country rock.
- Rainfall within Martha Pit catchment which enters the historical workings from the pit floor.

Dewatering Effects Martha Underground

Groundwater Inflow Volumes

With the proposed development of the Martha Underground, pumping sites will be extended to that mine but it is understood that the current discharge infrastructure is to be maintained.

An estimate of the expected averaged daily pumping rates to dewater from the consented 700 m RL at the beginning of the Martha Underground project to the completion of that project are as follows.

Table A Calculated Pumping Rate for Proposed Underground Development

Dates	Depths (m RL)	Averaged Pumping Rate (m^3/d)
1/1/2020 to 1/2/2021	700 to 681	13,833
1/2/2021 to 1/1/2024	691 to 619	14,959
1/1/2024 to 1/3/2026	679 to 500	15,411

The above estimates were derived using a spreadsheet model based on actual water levels and associated pumping volumes recorded at the historical Martha Mine. This is described in Appendix A.

The model provides averaged pumping rates to achieve a desired amount of dewatering. In practice, variations in vein geometry and hydraulic parameters and variations in rainfall inflow via Martha Pit in response to event rainfall, would result in a need for higher pumping rates on occasions to maintain the desired rate of dewatering.

Groundwater Drawdown Effects

Dewatering from 700 m RL to 500 m RL will be achieved by pumping water inflows from vein systems collected in underground sumps. Groundwater monitoring to date has shown that pressure change in the vein systems has had little effect on groundwater levels in the overlying younger volcanic rocks during mine dewatering since approximately the mid-1990's.

In summary, expected drawdown effects from pumping vein water levels from 700 m RL to approximately 500 m RL are assessed as follows:

- Groundwaters in Younger Volcanic Rocks

The current water table is expected to remain unaffected due to persistent surface recharge. Minor pressure changes may develop at the base of the thicker parts of the younger volcanic rocks (at lower elevation) where the thickness of the weathered andesite layer could be affected by stoping.

- Groundwaters in Low Permeability Weathered Andesite

Negative pressure gradients (reducing pressure with depth) through this layer may steepen as a result of pressures within the layer adjusting to a dewatered state as a consequence of nearby mine development.

Current positive pressure gradients (increasing pressure with depth) may steepen and possibly become negative in limited areas where nearby stoping reduces the thickness of the low permeability layer.

With an increase in the negative pressure gradients, a small increase in seepage from the overlying younger volcanic rocks may develop in some locations but given the low vertical permeability of this layer, this would not affect any groundwater flows or the water table in the overlying materials, i.e. recharge from rainfall will still exceed any increase in seepage.

- Higher Permeability Andesites (approximately 1000 m RL to 700 m RL)

This zone has responded to current dewatering (approximately 770 m RL) in the veins. The current response is interpreted to be variable depending on localised permeability. A phreatic surface is expected to have developed within the rockmass, curving upwards and away from vein water level and encompassing the dewatered zone (i.e. a cone of depressurisation). Modelling shows this to lead to a maximum width of the dewatered zone within the low permeability layer, a process which has been ongoing since the dewatering level dropped below the base of the low permeability layer. Dewatering to approximately 500 m RL may lead to a nominal widening of the dewatered zone beneath the low permeability layer over parts of the system and possibly, to some movement of the dewatered zone up into the base of the low permeability layer. But effects on pressures in the overlying younger volcanic rocks are shown by predictive modelling and past monitoring observations to be minimal.

- *Lower Permeability Andesites (approximately 700 m RL to below 500 m RL m RL)*

The modelling shows that dewatering veins to approximately 500 m RL in the deeper, low permeability andesite rockmass is unlikely to lead to development of a substantial dewatered zone in the adjacent country rock. The indication is that the rockmass will drain slowly and the phreatic surface will be steep and sub-parallel to the vein systems in this zone.

Effects on Surface Waters

Monitoring data collected over the period since dewatering began has indicated no adverse effects on shallow groundwater or base flow to surface waters. This is, largely, a consequence of the perched nature of the surface water bodies in the shallow groundwater system. The proposed deepening will have no additional effect to surface waters

Effects on the Groundwater Resource

- Groundwater Availability

This assessment has shown that there is sufficient groundwater available in the Waihi Basin deep aquifer system to allow the proposed average daily take of 15,000 m^3 for dewatering to take place. It is of note that the proposed groundwater take is for dewatering purposes, and that this water will, in-fact, be discharged into surface waters locally. This water is, therefore, not lost from the catchment, rather it is put back into the Waihi Basin system at a higher level, thereby having a net neutral effect on the catchment water balance.

- Other Aquifers

The groundwater take for mine dewatering is from the deep andesite rockmass. Close monitoring of shallow and deep groundwater levels has been undertaken since the commencement of modern mine dewatering in 1989. These records clearly show that pumping of the deep groundwater system does not impact on the shallow groundwater system due to the low permeability strata that separates the two. As the abstracted groundwater will be discharged back into the surface water environment, there is a neutral effect on the catchment water balance. As the abstracted groundwater will be discharged at the surface, there will be a net positive benefit by enhancing stream flow locally.

- Other Users

OceanaGold NZ Ltd (OceanaGold) maintains a complaints database in accordance with its existing consent conditions. The Company has responded to queries on some bore performance issues in the past and is currently understood to be working with one bore user who had identified a water level drop in their bore. Further deepening of the mine is not expected to affect existing groundwater users, however the same approach as under the existing conditions is expected to adequately manage potential effects on other bores.

Effects on Plant Growth

This was an issue raise during the first application for modern mining at Waihi. Plant growth relies on soil moisture retention in the near-surface soils, which is a function of rainfall infiltration. The demonstrated lack of effects on shallow groundwater from deep dewatering supports the observation that drainage effects will not alter shallow soil moisture contents and, therefore, plant growth.

Martha Post Closure Effects

Re-watering Rate

A spreadsheet groundwater rewatering model was developed to provide an estimate of the inflows to the underground developments and the pit lake following mine closure. The rewatering model focuses on groundwater inflow as the primary input parameter, with rainfall into the pit and diverted Ohinemuri River water as additional sources for re-filling within the Martha and Waihi East groundwater systems, as well as the Martha Mine Lake. This model is described in Appendix B.

The groundwater rewatering model estimates are based on a specific set of values for a range of inputs, and the combination of these effects is assessed in more detail in the Water Management Report (GHD, 2018). This report provides a first estimate inflow volumes required to re-fill the system from 500 m RL to the proposed lake overflow elevation of 1104 m RL with average river contributions of 9,000 m^3/d and 15,000 m^3/d as follows:

Table B Calculated Rewatering Volumes

River Recharge Rate (m^3/d)	**9,000**	**15,000**
Total Storage (m^3)	70,190,170	70,190,170
Total Groundwater (m^3)	9,008,720	6,291,944
Rainfall (m^3)	14,215,137	9,820,513
Total River Recharge (m^3)	46,966,313	54,077,713

Long Term Discharge

While the Waihi ore bodies had limited hydrological comunication with the Favona ore bodies prior to mining, the construction of the low level Trio Incline (800 m RL to 823 m RL) and high level Trio Decline (1015 m RL to 1060 m RL) from the Favona mine to the Trio Mine will result in a combined water level rise within both systems once groundwater level recovers above 823 m RL.

To assist in understanding the connectivity between the mines, a conceptual model has been developed and is shown in Figure A. The model considers the system as a series of plumbing components where the bucket represents the open pit, storage tanks represent the underground workings and pipes represent features that provide interconnection. Veins, historical workings and recent mining are considered as open conduits for flow, whereas late phase faulting provides fewer open connections.

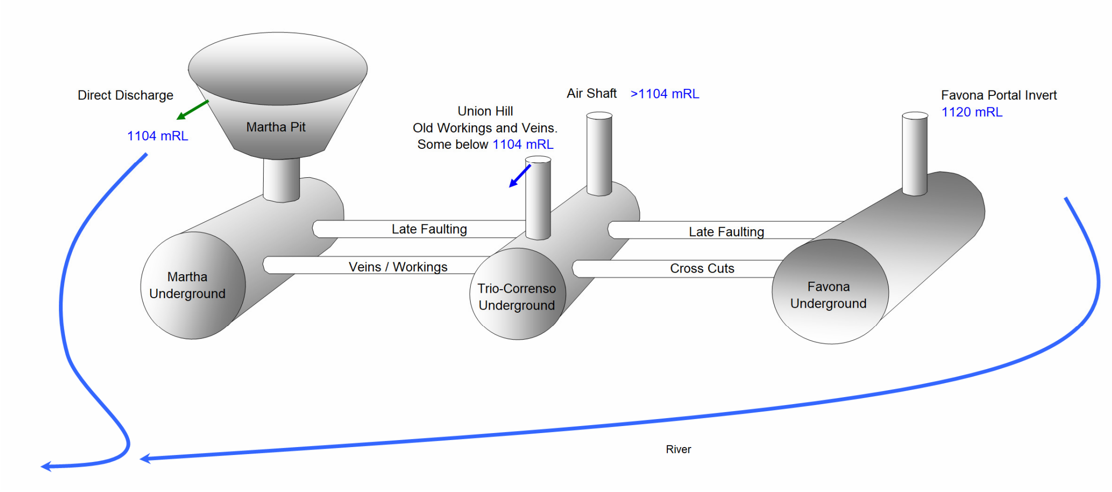

Figure A Conceptual Model of Interconnections

On mine closure, and once refilling of the underground workings and Martha Pit has occurred, the mine lake is planned to discharge to the Mangatoetoe Stream from an outfall structure at 1104 m RL at the western end of Martha Mine Lake. There are, potentially, two pathways in the system that are at elevations lower than the proposed Martha Mine Lake level that may allow some discharge from the groundwater system. These are:

- Natural pathways through the younger volcanic rocks from the exposure of these rocks in the eastern pit lake wall to their outcrop in the Eastern Stream;
- Existing historical workings at Union Hill;

<u>- Natural Pathways</u>

As a result of the open pit mining, there will be an area of younger volcanic rocks (including a layer of fractured, welded Ignimbrite) in the east wall of the pit exposed to the water ponded in the lake. That geology is expected to allow seepage from Martha Mine Lake to the surrounding groundwater system.

Figure 22 of the report shows the approximate extent of the outcrop of younger volcanic rocks in the pit and the approximate location of the 1104 m RL contour around Martha and Union Hill. Areas below this level may provide possible discharge zones for mine waters where geology and elevation permit. The figure shows that most of the Waihi urban area would be above Martha Mine Lake level. Those parts of town below lake level are indicated to be relatively distant from the lake.

The most likely potential discharge site is in the bed of the Eastern Stream where jointed and fractured ignimbrite rock outcrops; the pathway is the shortest; and hydraulic gradient is the greatest. The potential seepage from Martha Mine Lake is calculated to be some 0.5 to 1 L/s.

The calculated volume of leakage is a small volume when compared to the expected Martha Mine Lake discharge volume of combined groundwater flow and rainfall. It is expected that if a small leakage from Martha Mine Lake does develop through the welded ignimbrite layer, it will be lake water, which will contain only a small proportion of groundwater which may have moved through the closed underground mines. The effect of such a small discharge of diluted mine water is considered to be minimal.

While there may be other potential seepage locations, such discharge is assessed as being much smaller than calculated for the Eastern Stream.

- Historical Workings Discharge Pathway

Prior to mining, the water level measured in No. 7 Shaft at Martha Hill varied around 1110 m RL. Given the proposed lake outfall level of 1104 m RL, groundwater from the surrounding areas will move towards the Martha Mine Lake, i.e. the lake would generally remain an inward gradient location.

Pre-mining, groundwater levels in andesite rocks around Martha Mine were indicated to be relatively flat indicating groundwater flow paths were closely interconnected. The flat water levels extended to Union Hill where the Union Shaft groundwater levels were similar to Martha Hill shaft groundwater levels and southwards to, at least, Gilmour Lake. The only observed discharge from the historic mine workings was a warm spring at an elevation of 1106 m RL flowing from a collapsed drive on the east side of the Mangatoetoe Stream. The historic linkages are unlikely to have been substantially altered by current mining. As a consequence, post-mining groundwater levels are expected to return to a flat hydraulic gradient with this flat gradient extending to all the interconnected mine workings.

Figures 23 and 24 in the main report provide the historical adit elevations and shaft collar elevations on Union Hill. These indicate that several historical adits and shafts are at elevations below 1104 m RL (Martha Mine Lake Control level) and these are presented in Table C.

Table C Shaft and Adit Elevations below 1104 m RL

Shaft Collars (m RL)	Adit Inverts (m RL)
1102	1090
1103	1094
	1095

Two shafts and three adits would be below the inferred recovered groundwater elevations in the veins and workings below Union Hill.

Given the indicated close connection between Martha and Union workings and veins, water levels in the historical Martha Mine workings should have dropped to some 1094 m RL, 2 m above the lowest discharge point at Union Hill prior to open pit mining, if discharge was taking place through the Union Hill adits and shafts. No discharge was, in fact, observed.

This suggests that groundwater discharges from the lower elevation shafts and adits around Union Hill did not occur prior to open pit mining, or that if discharges did occur, they were of too small a volume to affect groundwater levels in the veins and workings in Union Hill or Martha Mine. Collapsed adits or shafts may account for the lack of, or the minor, groundwater discharge. These observations indicate pre-mining water levels above the adit and shaft elevations on Table C and that those adits and shafts were not influencing water levels in the andesite rock outside of Union Hill. With the control level on Martha Mine Lake being set lower than historical groundwater levels in Martha Hill, there is a reduced possibility of seepages from the historical adits and shafts on Union Hill.

Other old adits and shafts are present around the Martha, Union and Favona Mines. These are all indicated to be in the more elevated areas and to have invert levels above 1104 m RL.

Effects On Surface Waters

Following closure of the mine there will be a direct discharge from the Martha Lake at an elevation of 1104 m RL into the Mangatoetoe Stream. It is not expected that there will be any other significant groundwater discharges to surface waters following recovery of the water level. It is possible that localised discharges associated with former mine workings could develop. However, any discharges that may occur will be controlled such that any discharge is of a very small volume.

Recommendations

Dewatering

Ongoing dewatering will be required to develop Project Martha, and in particular the Martha Underground, to its proposed depth of 500 m RL. Currently, existing mining consents require a Dewatering and Settlement Monitoring Plan be prepared and actioned. The Dewatering and Settlement Monitoring Plan 2016 (WAI-200 PLN 009) combines the monitoring plans for Martha, Favona Trio and Correnso/SUPA into one document given their similar monitoring networks and frequencies.

In relation to dewatering and settlement, the plan describes the monitoring regime designed to assess the effects of:

a) Mine dewatering on the regional groundwater system.
b) Mine dewatering on settlement.

The objectives of the current Dewatering and Settlement Monitoring Plan are:

- To outline the monitoring systems in place for dewatering, groundwater and settlement and the requirements for these systems in accordance with the relevant consent conditions.

- To identify trigger limits that will indicate when contingency mitigation and/or monitoring may be necessary.

- To identify what contingency mitigation and/or monitoring would be undertaken in the event that the trigger levels are exceeded, in order to ensure that adverse environmental effects are avoided, remedied or mitigated.

The current monitoring approach is considered to be appropriate for managing any dewatering effects that may develop during Project Martha. The plan can be revised and be re-issued having regards to the following:

- Separately measure and record daily the water volume pumped from Martha

Underground and other underground mine areas.

- Sample the discharge waters from the separate underground mine areas. This, together with the volume pumped, can be used to calibrate the Martha Mine Lake chemistry models.

- Measure and record water levels weekly. This can be done in piezometers drilled underground to intercept veins/historical workings or in the absence of underground piezometers, in sumps at the lowest elevation in the mine. Both methods have been used during current mining.

Groundwater Monitoring

The existing network of piezometers is generally considered adequate to enable observation of dewatering effects related to project Martha. As can be seen in Figure 8, there are a number of areas where the monitoring network is less dense. This includes the area to the south and southwest of the pit which is shown to be in Settlement Zones 4, 5 and 6 (EGL, 2018). Given the proposal is to extend dewatering by a further 200 m depth, additional multi-level piezometers in these areas would assist with modelling the ongoing settlement and the re-bound post-closure. The exact locations of these piezometers would be included in an updated Dewatering and Settlement Monitoring Plan.

Rewatering and Post-Closure

- It will be important to monitor the rate of water level recovery during closure to validate and update the rewatering model. It will also be important as a guide to the volume of river water diversion needed during filling.

- The location of instrumentation to record recovery would depend on what structures are to remain during closure and into post-closure. The location and the setting of such instrumentation would need to be decided and in place before water level recovery began.

- The current monitoring network will need to be reviewed to check that it will be suitable to monitor water level recovery in the shallower rock units during closure and post-closure and to update the monitoring plan where any modification to this network is identified or proposed.

- The monitoring plan should include a requirement to undertake site inspections of potential leakage zones once the Martha Mine Lake water level reaches final elevation. Should any leakage outside of the constructed discharge location be identified, the plan should include a requirement to undertake an effects assessment and, if necessary, to design and implement mitigation measures.

1. Introduction

1.1 Project Description

OceanaGold NZ Ltd. (OceanaGold) is seeking Resource Consents for its Waihi operation to extend a section of the north wall of the Martha Open Pit and commence underground mining operations of the Martha ore body that together are referred to as Project Martha. The elements of the project, referred to as project Martha, will generally consist of the following:

- Martha Phase 4 pit
- Martha Underground, including the Rex Ore Body

Each of these project areas has been the subject of study by the various technical disciplines and this report is intended to address the dewatering effects associated with the Martha Underground Mine development.

1.2 Scope of Work

GWS Limited has been engaged to quantify the volumes required to dewater and rewater the Martha Underground Mine and to indicate the consequent effects on groundwater levels and pressures. The scope of this report is focussed on the development of the Martha Underground and Martha Phase 4 Pit. This assessment includes effects related to short term dewatering during operations, and effects associated with the long term discharge from the mine following closure. The purposes of this report are to determine:

- Groundwater inflows
- Drawdown effects
- Re-watering effects
- Potential for effects on other aquifers
- Potential for effects on surface water
- Potential for effects on other groundwater users
- Potential for effects on plant growth

This report has been prepared based on historical and recent information that provides an understanding of the site groundwater systems. This has been confirmed as appropriate and robust by monitoring over the period of mining to date (approximately 30 years). This understanding has been taken forward alongside the Project Martha scope and has included further technical analysis to enable dewatering and rewatering responses of the groundwater systems to be quantified.

2. Hydrogeologic Setting

2.1 Regional Geology

2.1.1 Basement Rocks

The geology of the area has been previously described by GNS (1996) which defines the Waihi Basin as a structurally controlled depression that is likely part of a former caldera structure. Basement rocks in the region comprise Coromandel Group andesite and dacite volcanic rocks which are present in the form of horst and graben structures (up thrown and down thrown blocks) due to past faulting. These structural controls provided pathways for epithermal fluid migration that ultimately led to the deposition of precious metal bearing quartz veins that have been mined in historical and recent times. The structural controls in the basement rocks are, largely, extensional features, with the greatest density of these features centred around the former Martha Hill area.

Davies (2002) defined district-scale northeast trending grabens based on general stratigraphic patterns and fault data. The western margin of one of these structures is referred to as the Waihi Graben which is host to the Martha-Favona epithermal system. At mine scale, the Martha Graben is host to the Martha, Empire, Royal and Rex ore Bodies. Further to the east, fault relays form the Trio, Union, Mascotte and Amaranth ore bodies. All of these structures are north-east trending. The Correnso ore body is a north trending structure which, along with a number of post-mineralisation faults, cuts through the north-east trending ore bodies resulting in a high degree of connectivity.

Further east, the Union Horst (Union and Amaranth ore bodies) forms a paleo-topographic high that separates the Martha Graben from the Favona-Moonlight Graben. The Union horst structure is considered to act as a physical barrier between the more structurally permeable areas of the Martha Graben and Favona-Moonlight structures. The hydraulic connectivity between the Martha system and the Favona system is considered to be weak. The separation between the systems is at the approximate location of No. 9 Fault (shown on Figure 1).

In summary, the fault controls in the basement rocks create discontinuous structures in the rockmass that have implications for groundwater movement and form the hydrogeologic domains which are discussed in this document. Figure 1 provides a conceptual geologic model for the area and Figure 2 identifies the ore body vein distribution. Figure 3 shows the structural features and the hydrogeologic domains that define the Martha East ore bodies and the Waihi East ore bodies.

2.1.2 Post Mineralisation Deposits

In the Martha Graben, the basement andesite volcanic rocks are overlain by a series of younger rhyolitic volcanic deposits. These latter materials are highly variable in thickness depending on the paleo topography beneath. These deposits vary in composition from rhyolitic tephras and ignimbrites in the form of flows, breccias and tuffs. Paleosols and sedimentary deposits, such as alluvium and boulder alluvium, mark the top of the eruption sequences. Boulder alluvium is also present at the base of the rhyolitic tephras. To the east of the Favona-Moonlight Graben, a thick sequence of post mineralisation dacite volcanics are present overlying the andesite rock and forming Black Hill. A rhyolitic intrusion protrudes through the entire sequence to the east of Black Hill and this is where the rock and tailings storage facilities are located.

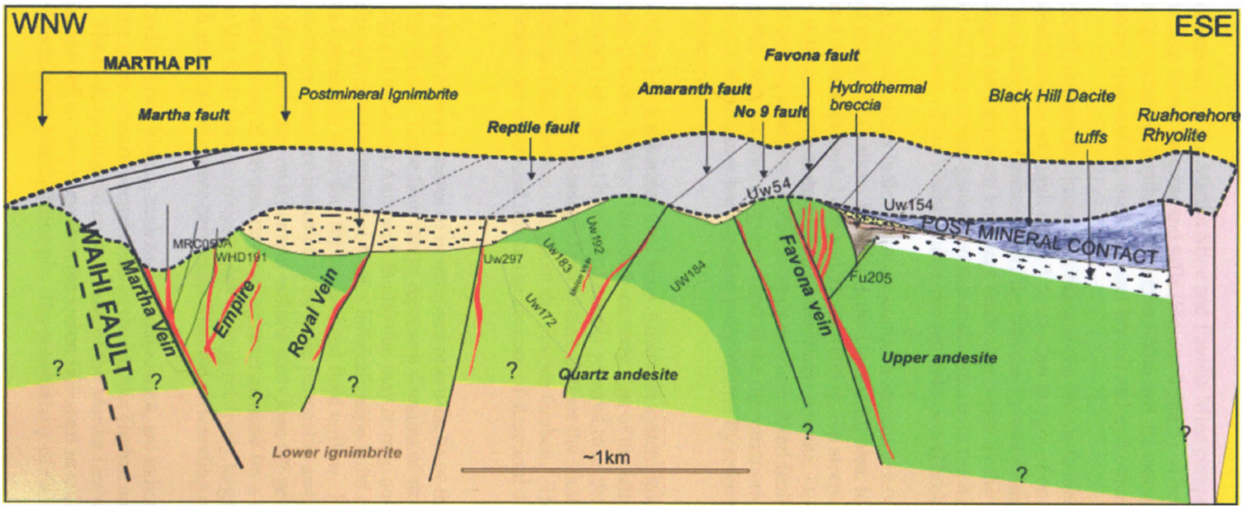

Figure 1 Generalised Geology in the Waihi Area

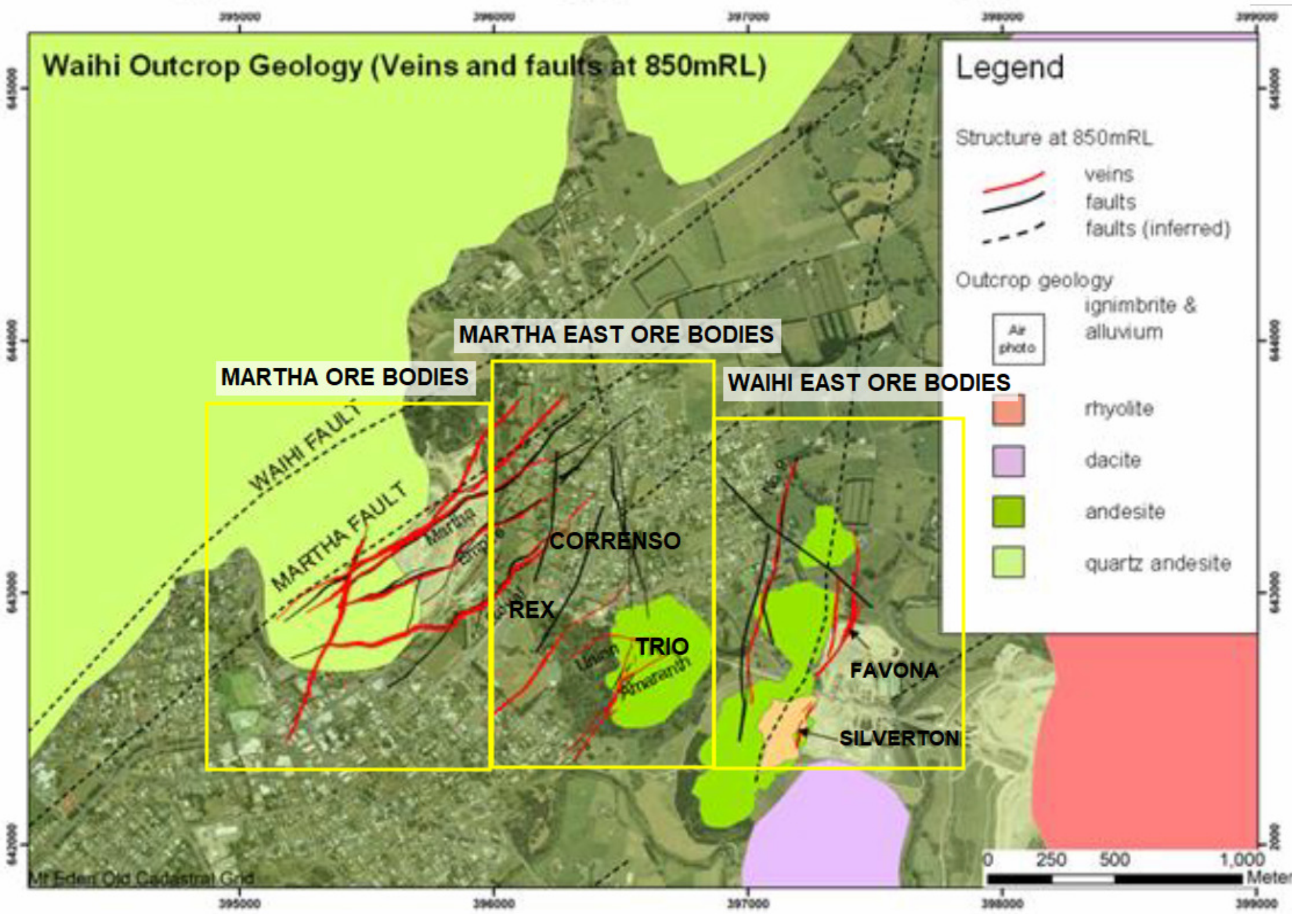

Figure 2 Ore Body Distribution

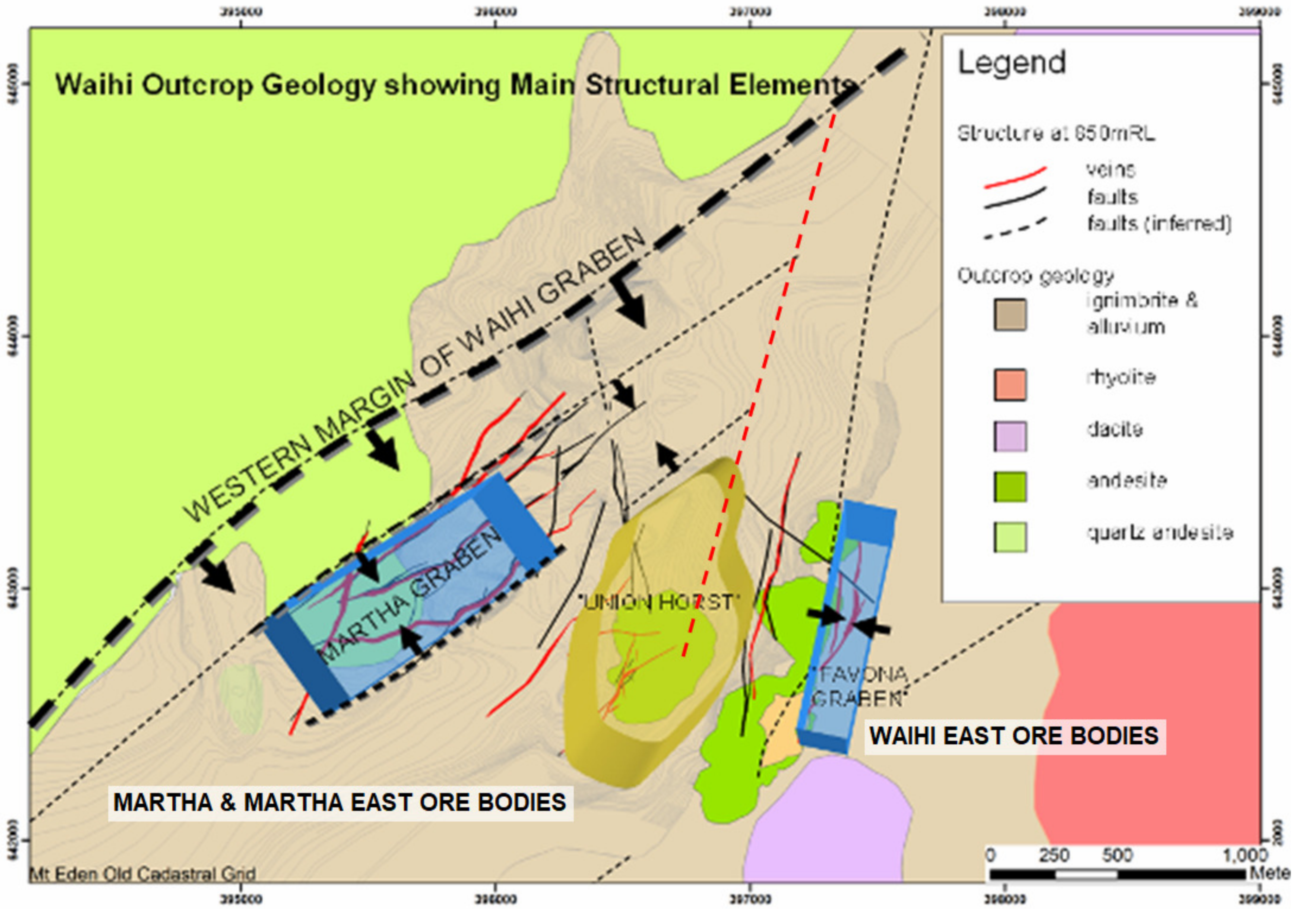

Figure 3 General Geology and Structural / Hydrogeologic Domains

2.2 Regional Hydrogeology

2.2.1 Groundwater Recharge and Discharge

Groundwater recharge in Waihi is from direct rainfall infiltration to the shallow groundwater system. Average rainfall is 2170 mm per year and potential evapotranspiration is in the order of 800 mm per year. The rainfall that infiltrates the ground surface enters the shallow groundwater system and, after some residence time in this system, discharges locally as springs and base flow to streams. Infiltration to the deep groundwater system is a small proportion of the water balance and is a result of direct rainfall infiltration where the andesite is exposed at the surface, and due to some leakage from the shallow groundwater system through the upper surface of the andesite rockmass. Figure 4 provides a conceptual water balance model.

Prior to the current mining activity, a warm spring at an elevation of approximately 1106 m RL discharged deep mine water from a collapse adit into the Mangatoetoe stream with a relatively small flow of approximately 6 L/s (515 m^3/d). Water levels around Martha Hill at that time were approximately 1110 m RL indicating a flat groundwater gradient. Note that levels are expressed as mine datum, which is approximately 1,000 m below mean sea level (i.e. 1,000 m RL mine datum is approximately sea level).

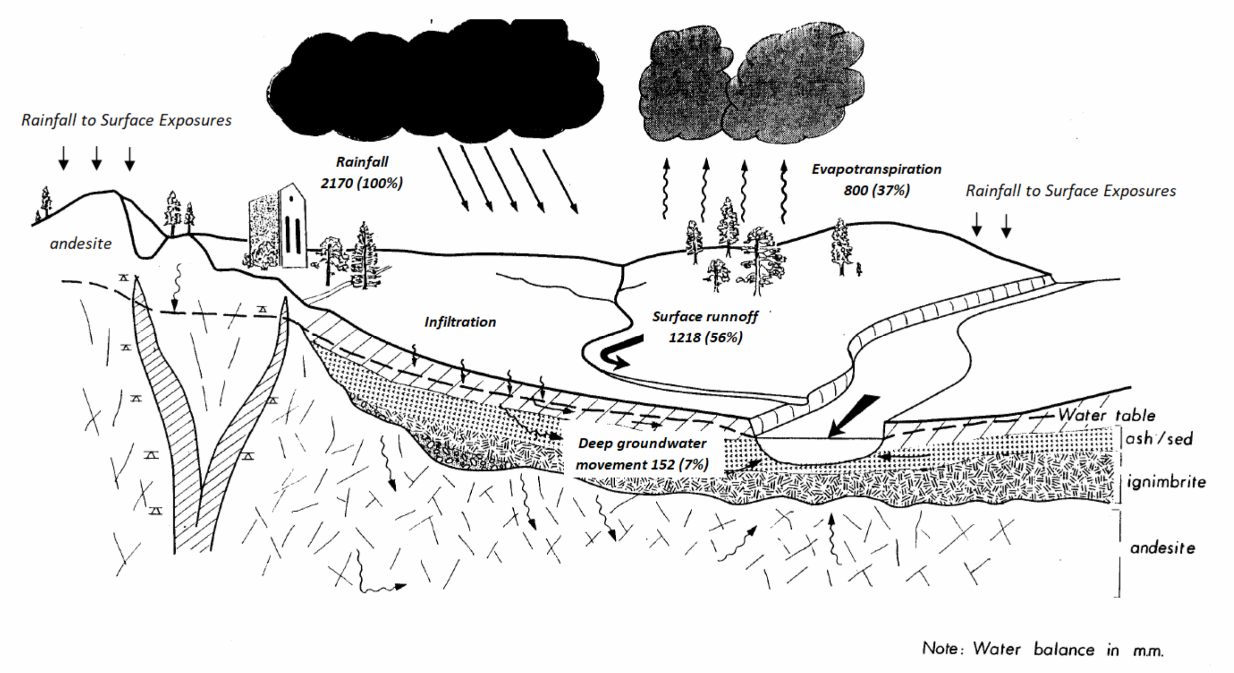

Figure 4 Conceptual Water Balance for the Waihi Area (Modified after GCNZ, 1985)

2.2.2 Groundwater Systems

Three groundwater flow systems are considered to exist in the Waihi area: A shallow system within the alluvium and recent volcanic ashes (water table aquifer); a transitional system within unweathered, young volcanic rocks; and a deep system within the andesite rocks.

Groundwater monitoring wells and piezometers have been installed in shallow and transitional (upper levels of the andesite rockmass) groundwater systems. Groundwater levels in veins were monitored in pumped shafts or pumping wells and currently, with underground dewatering, from sumps. Figures 5, 6 and 7 provide the groundwater monitoring data for the three geological units being alluvium/ash; young volcanics; and andesite.

Figure 5 shows that dewatering has not affected groundwater levels in alluvium but that seasonal rainfall is the cause of measured level fluctuations.

Figure 6 shows that after a small early adjustment in some monitoring wells, generally completed by the mid 1990's, water levels have remained relatively stable except for seasonal fluctuations. The variation in the magnitude of seasonal fluctuations reflects the depth of the monitoring well with most fluctuations in shallow wells. No response to ongoing dewatering is evident in Figure 6 after the mid 1990's

Figure 7 provides the water levels in the andesite monitoring wells outside vein systems. Vein water levels are also shown for comparison. While Figure 7 shows a number of the shallower andesite monitoring wells to have been unaffected by dewatering, some of the deeper wells showed an immediate response, but stabilised by the mid to late 1990's despite the ongoing dewatering. These are highlighted on Figure 7. Water level dropped below Well P2-1 elevation by the start of Year 2000. This well is also highlighted on Figure 7.

The Waihi ore bodies are hosted by altered andesitic lava flows, breccias and tuffs, the upper part of which is weathered and/or thermally altered, and provides a low permeability zone. This low permeability zone provides an aquitard layer that separates the deeper groundwater system in the andesite from the shallower groundwater systems in the overlying younger volcanic rocks and alluvium i.e. it perches the groundwater in the overlying younger materials.

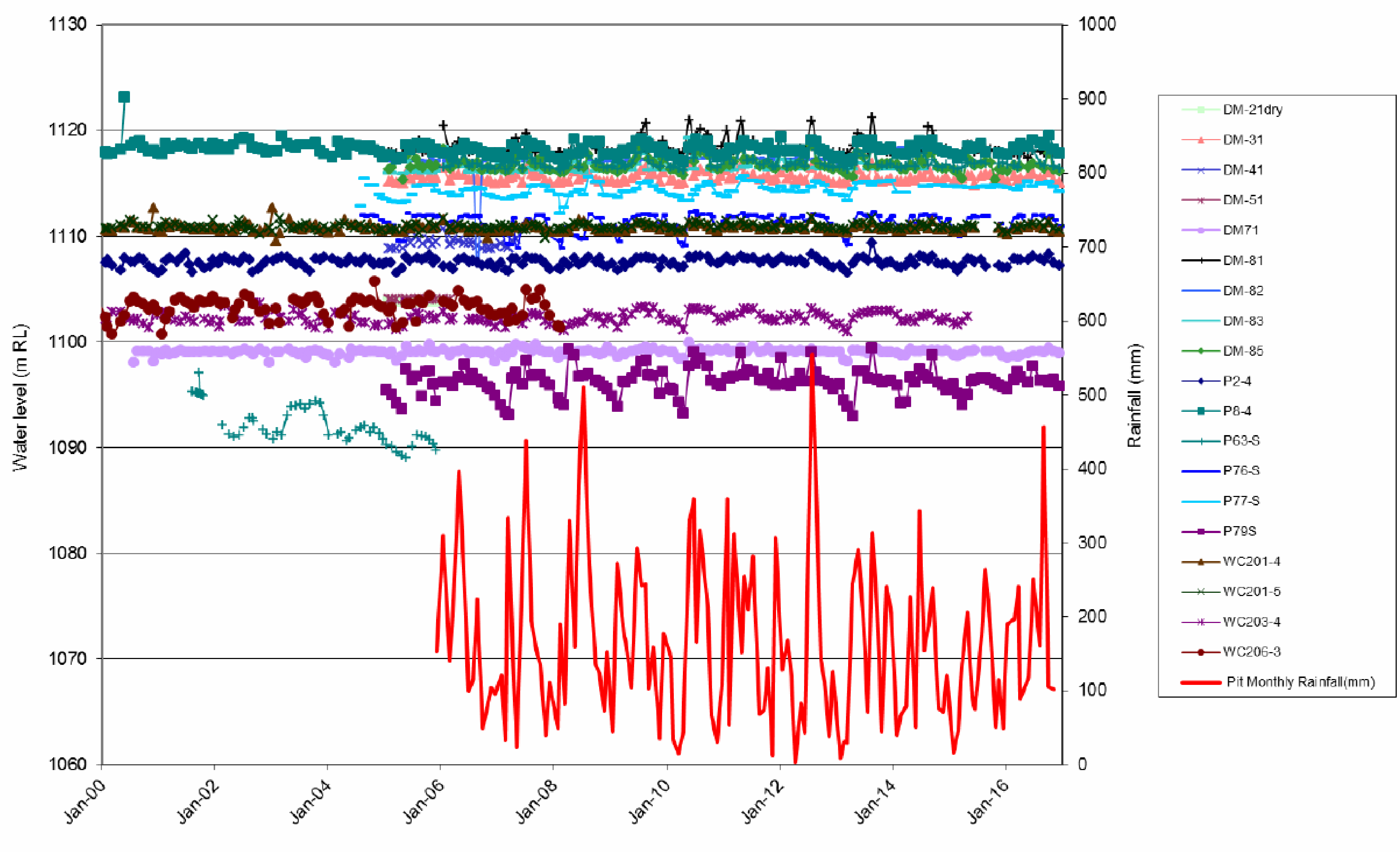

Figure 5 Groundwater Levels in Alluvium / Ash

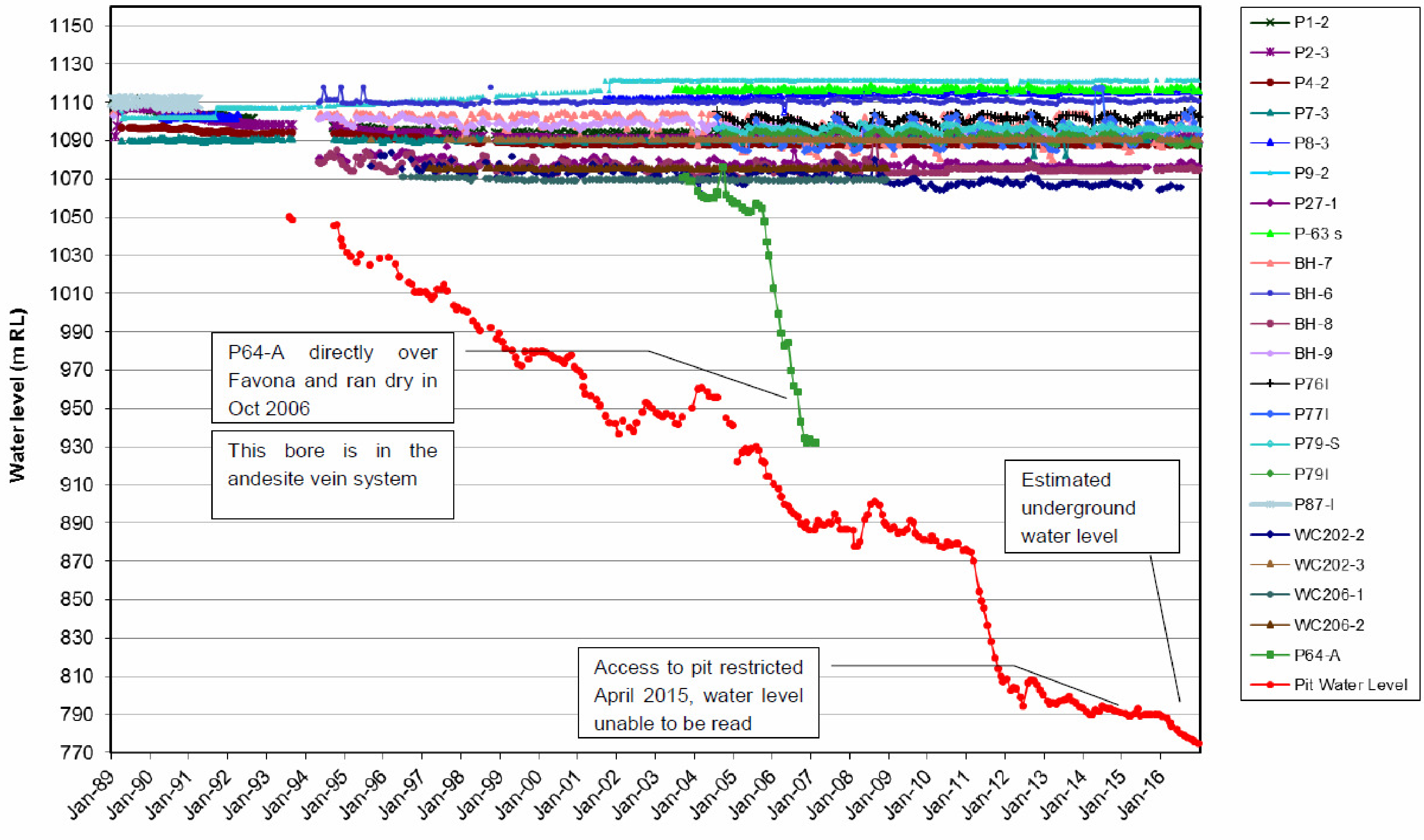

Figure 6 Groundwater Levels - Groundwater System in Younger Volcanics

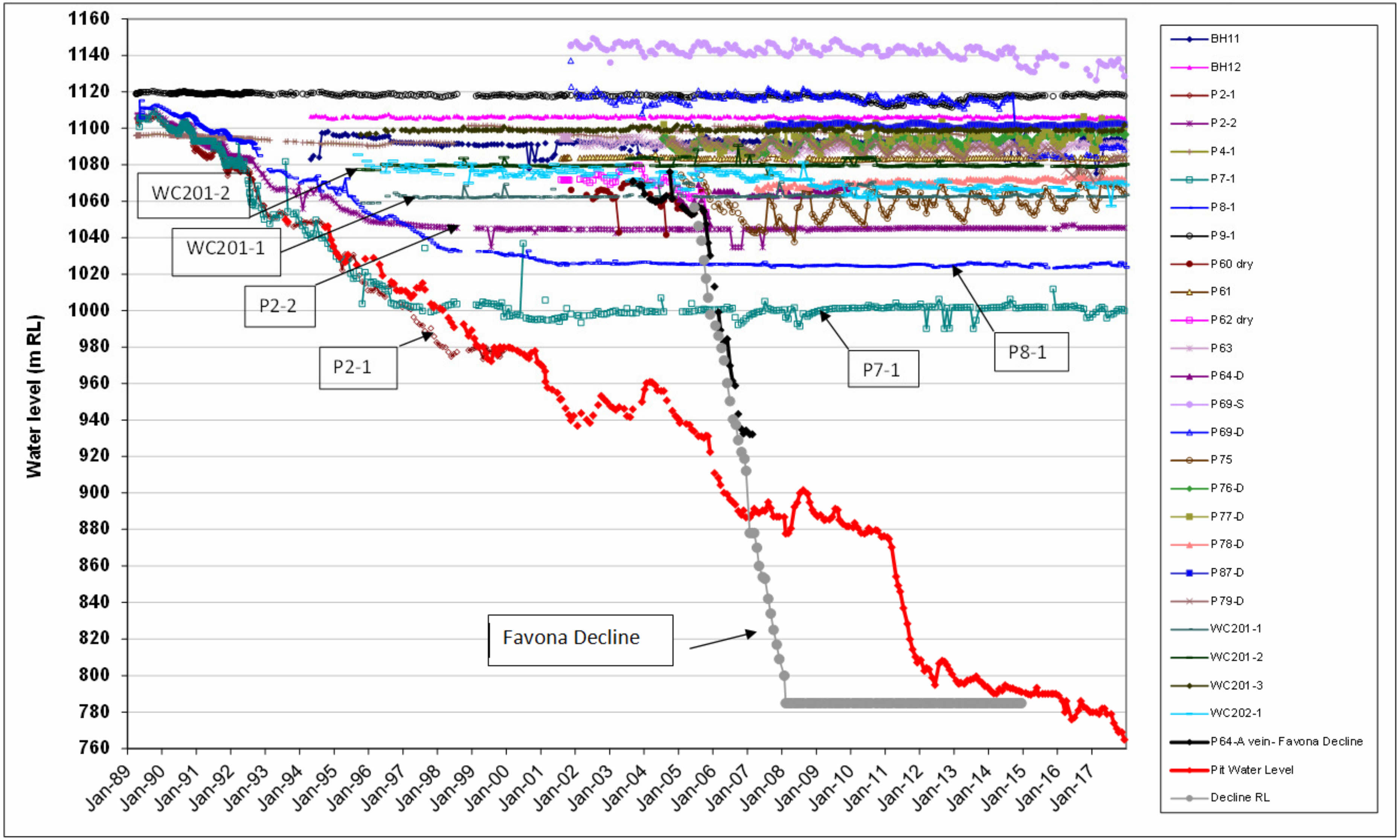

Figure 7 Groundwater Levels - Andesite Rock Aquifer

Shallow Groundwater System

Figure 8 shows an interpretation of the water table around Waihi. The water table surface shown on Figure 8 generally reflects the topography, except to the east of Martha Pit where the water table has been affected by drainage due to the exposure of younger volcanic rocks in the pit face or, possibly, drainage to the Milking Cow block cave where the base of the younger volcanic rocks is at approximately 1015 m RL.

Under East Waihi area, the inferred water table is relatively flat and lies between approximately 1110 m RL near Union Hill rising to 1120 m RL at Wharry Road. A broad north-south trending ridge is indicated as extending from Union Hill to Wharry Road. Under Central Waihi the inferred water table slopes southwards from approximately 1120 m RL to 1090 m RL adjacent to the Ohinemuri River.

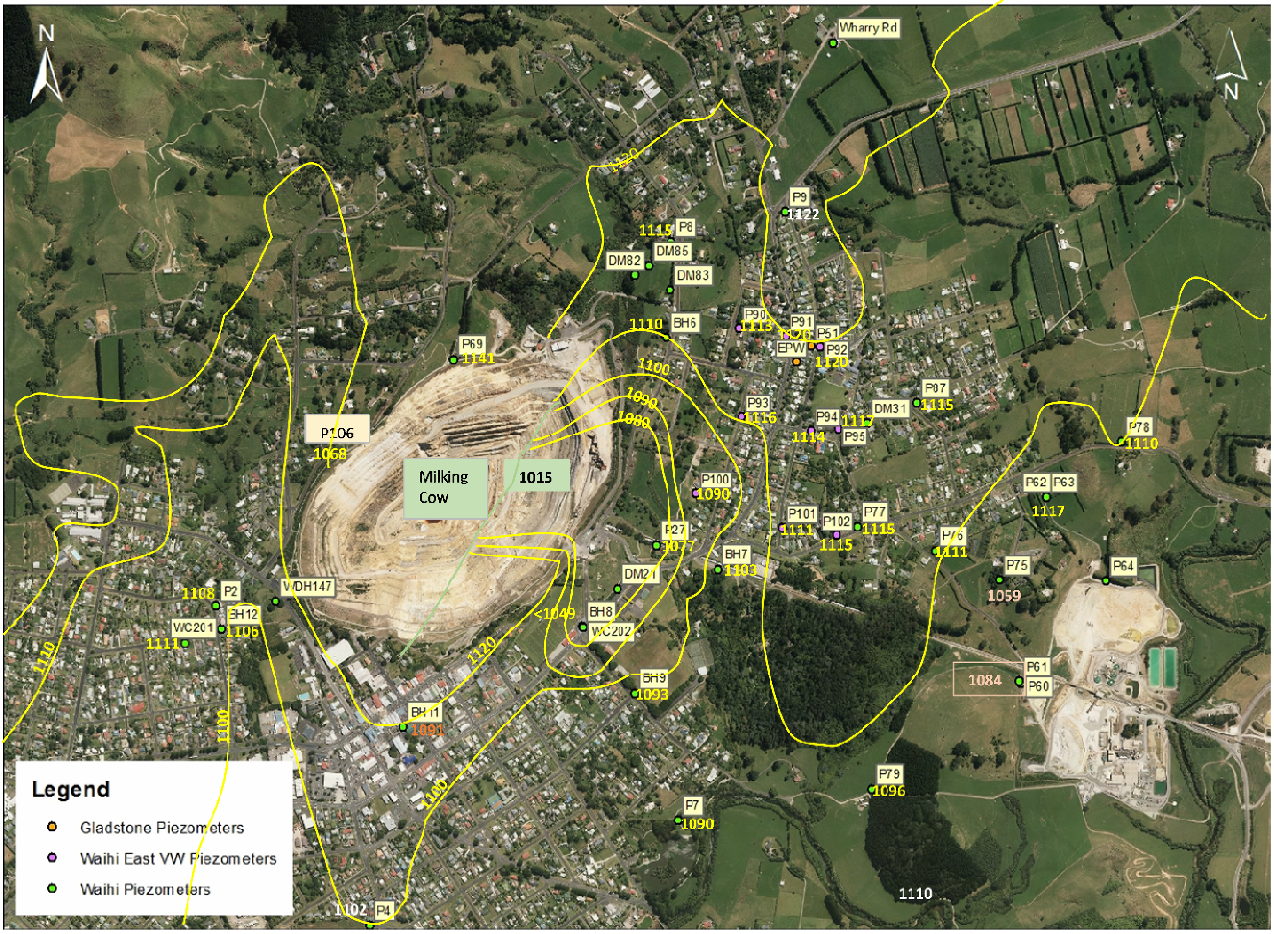

Figure 8 Water Table Map

Transitional Groundwater System

Groundwater flow directions in the unweathered younger volcanic rocks are controlled by the paleo-surface formed in the underlying andesite rock. This flow pattern has been modified by diversion to the Martha Mine pit. Groundwater movement through the low permeability weathered andesite below the younger volcanic rocks (the transition zone) is primarily vertical.

Figure 9 provides the section lines for three hydrological cross-sections through the shallow and transitional systems. Figures 10, 11 and 12 provide the hydrological cross-sections (as at 20/9/2017).

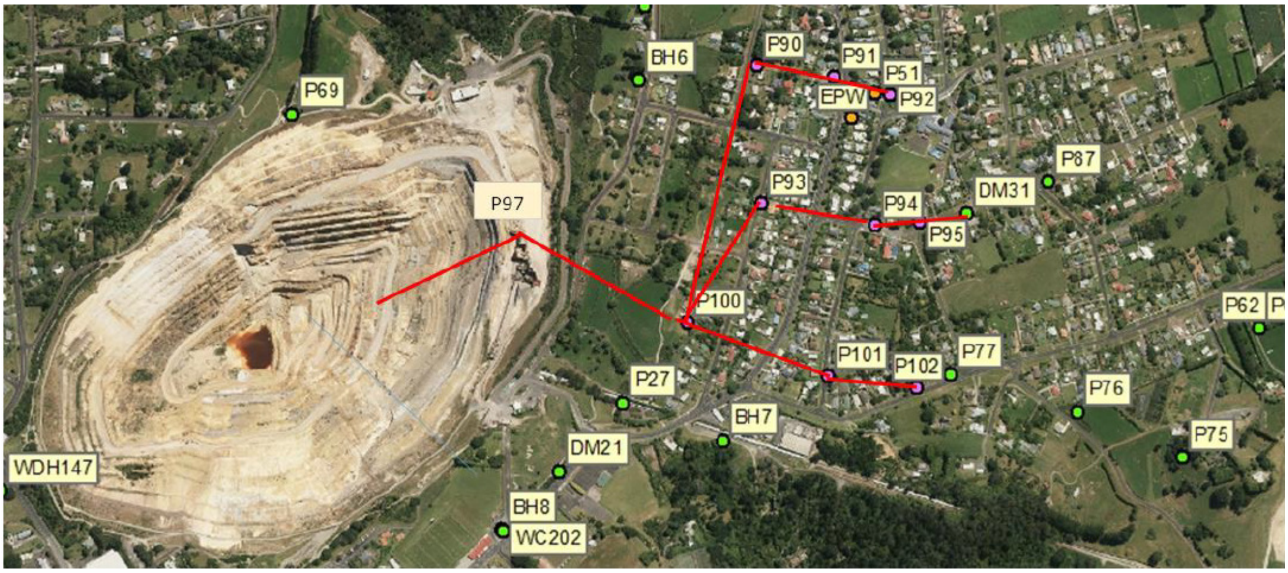

Figure 9 Hydrological Cross-Section Locations

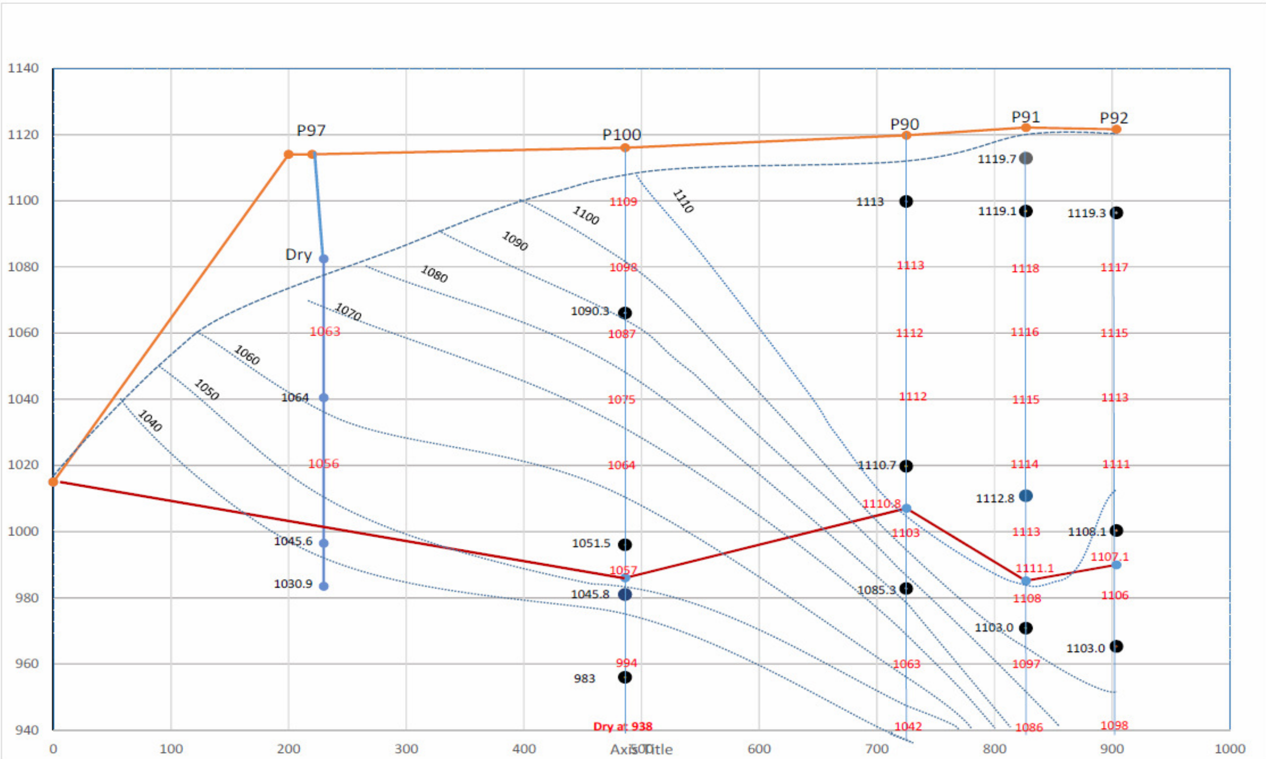

Figure 10 Hydrological Cross-Section Pit to P92

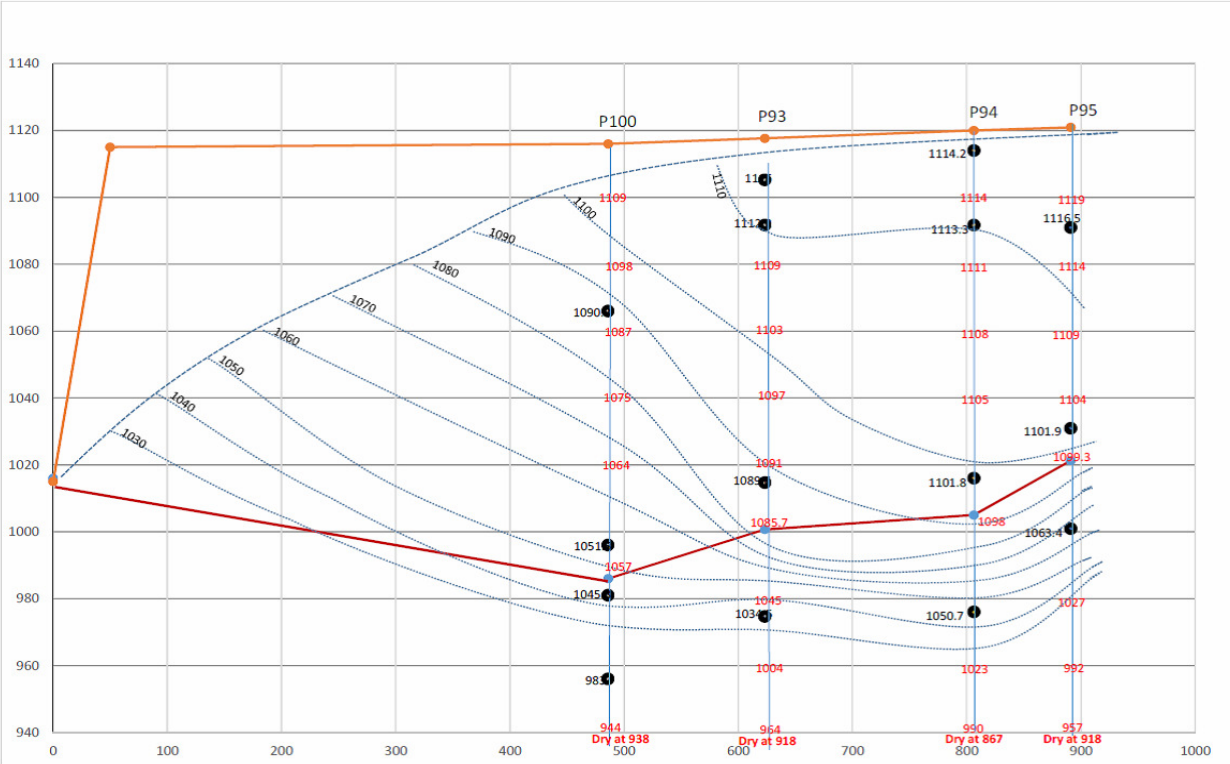

Figure 11 Hydrological Cross-Section Pit to P95

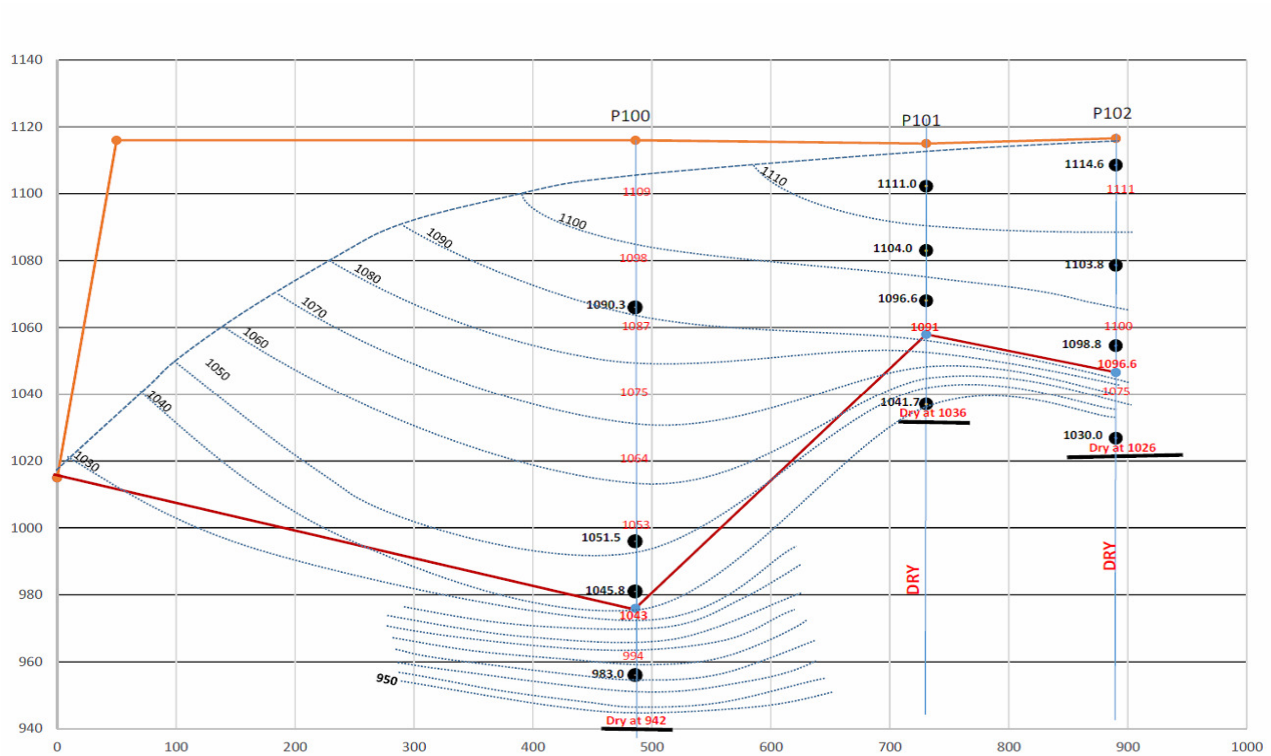

Figure 12 Hydrological Cross Section Pit to P102

Measured pressure heads and calculated intermediate pressure heads derived from the multi-level piezometer data were used to construct these cross-sections. The solid red lines on Figures 10 to 12 represent the estimated contact between the upper flow system in the younger volcanic rocks and the top of the low permeability weathered andesites. Elevation is shown as m RL on the vertical axis and distance from Martha pit is shown on the horizontal axis.

Piezometers P90 to P92 (Figure 10) are indicated to be in a zone of horizontal flow through the younger volcanic rocks, more or less normal to the plane of that part of the cross-section. Both vertical and lateral pressure gradient components are indicated for the upper andesite.

The cross-section containing P93 to P95 (Figure 11) also appears to have mainly horizontal flow in the younger volcanic rocks but with a vertical component indicated. Within the weathered low permeability andesite, vertical pressure gradients predominate. Dry areas are indicated at depth within the andesite rockmass.

The third cross-section (Figure 12) shows the andesite rockmass to extend much closer to the surface at this location, possibly as a result of faulting. Vertical gradients with a minor horizontal flow component are indicated in the shallow younger volcanic rocks. Strong vertical gradients reflecting the low permeability of the weathered andesite are indicated, with dry conditions present a short distance below the contact.

From P100 to the pit the phreatic surface slopes indicating discharge at the outcrop contact between the ignimbrites (younger volcanics) / andesite in the pit or to the Milking Cow Block Cave.

When comparing the three cross sections, the dewatered condition (zero pressure) appears to extend to greater depth in moving from south (P100 – P102) to north (P90-P92).

Deep Groundwater System

- Andesite Rock

Andesite rock forms the local basement rock body for the area and hosts the mineralisation. The andesite rocks were formerly exposed at the surface where the weathering profile developed that perches groundwater in the overlying younger materials and acts as the transition zone between groundwater in the andesite and the shallower groundwater systems. This transition zone is indicated to extend up to 24 m or more in thickness (P102). Within the upper part of the unweathered andesite (above about 700 m RL to approximately 1000 m RL), fracturing is more widespread due to relaxation of the rockmass. With increasing depth, the density and aperture of the fractures reduces, resulting in lower permeability.

Table 1 includes assessed aquifer hydraulic properties for the andesite groundwater system. Overall, the andesite rockmass is of low permeability due to the low density of fractures in most areas. Exceptions to this occur where post-mineralisation faulting has taken place, known to result in fracture zones of higher permeability. Vein systems and associated fracturing provide planar zones of higher permeabilities within the rockmass. The contrast between rock mass permeability and vein zone permeability is marked by full and rapid water losses from investigation drill holes when vein and associated fracture zones are intercepted.

Groundwater levels in the andesite rocks are influenced by current mine dewatering. This is evident in Figures 10 to 12 where water levels in the veins and interconnected features are at approximately 770 m RL but were at higher elevations elsewhere in the andesite rockmass. Groundwater levels and directions are controlled by the presence and interconnections (where they occur) of the workings, vein systems and post mineralisation structures (faults and fracture zones).

The extent of dewatering in the andesite rock mass is limited in spatial extent due to low rock mass permeability. To the north and west the extent of the dewatering effect is understood to be limited by faulting which act as hydraulic barriers to groundwater flow. A restricted area of dewatering is observed to the south west that is considered to be due to drainage along north-south oriented vein structures. Dewatering effects are noted to reduce further east in the Martha and associated ore bodies as these structures terminate. To the south east a wide area of dewatering is noted to occur which extends throughout the Martha ore bodies that encompasses the Trio and Correnso vein systems. This pattern of dewatering is a function of the high degree to which these systems are connected via workings, veins and faulting.

As set out at the beginning of this document, the Martha and Martha East ore bodies, while still part of the same wider groundwater system, form a separate hydrogeological domain from the Waihi East ore bodies that incorporate the Favona and Moonlight vein systems. Around the Waihi East ore bodies the pattern of dewatering in the andesite rock is limited to the immediate surrounds of the country rock. This disconnection is considered a function of the thick block of relatively competent andesite that separates the localities, and the absence of cross cutting structures connecting it to the wider system. While it is noted that there is limited natural connectivity between the Martha ore bodies and the Waihi East ore bodies at this time, recent mining has excavated high level and low level cross cuts that now connect the Favona mine to the Trio mine, thereby connecting the Martha and Waihi East groundwater systems.

- *Vein Systems*

Epithermal vein systems occur as a result of ancient faulting or a series of faults where dilatent movement has allowed the opening of fracture systems that enable thermal fluids at depth to rise. The properties of epithermal vein systems are inherently variable, ranging from vuggy and cavernous to dense and monolithic, often depending on the vertical location within the structure. Typically, it is common to observe more open veins at shallower depths. The width of the veins can vary from small scale to >20 m wide in places. The veins are generally sub-vertical and form as hanging wall deposits, but may be sub-horizontal on footwall structures, depending on the structure and stresses involved. Generally, the historical information shows that with increasing depth (below approximately 700 m RL) the vein systems become narrower, tend to converge and become less open.

The Martha and Martha East ore bodies are highly interconnected due to their conjugate orientations which means they cut through each other based on the various phases of formation (Figure 13).

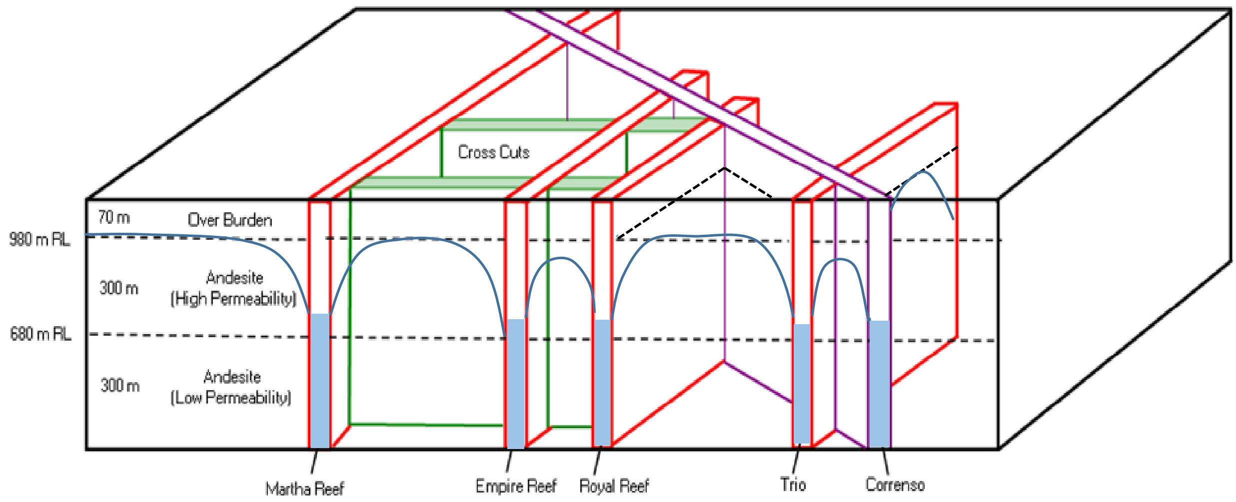

Figure 13 Conceptual Model of Andesite Permeability and Vein Interconnection

Interconnection of the ore bodies is also caused by post mineralisation faulting and, in some areas, due to cross cuts made between the ore bodies during historical mining. These conduits are important in controlling the groundwater levels observed in the vein system's andesite host rocks throughout the Martha and Martha East ore bodies and which separate the Waihi East ore bodies at the current level of mining.

The vein systems are, typically, more permeable due to their vuggy or cavernous nature and the presence of historical mine workings adds to this. The storage characteristics of the veins are similarly variable depending on their openness and the extent of previous workings. Table 1 summarises the inferred vein hydraulic parameters. The permeability within the veins is, by nature, anisotropic with maximum values in the plane of the structures as a result of deposition from fluids and subsequent displacements along the planes. As a result, elongated dewatering develops parallel with the structures with a sharp reduction in dewatering occurring in the surrounding country rocks normal to the structures.

2.2.3 Hydraulic Properties

The hydraulic properties of the materials comprising the groundwater system vary depending on the nature of the volcanic materials which can appear as welded Ignimbrites dominated by fracture flow or as sandy-like ashes where porous flow dominates. The hydraulic properties of the materials in the groundwater systems are indicated in Table 1.

Table 1 Aquifer Hydraulic Properties

	Hydraulic Conductivity			Storativity	
Material	**Max** (m/s)	**Min**(m/s)	**Geomean** (m/s)	**Max**	**Min**
Shallow Aquifers					
Ash / Alluvium	1×10^{-4}	1×10^{-7}		0.3	0.1
Ignimbrite	1×10^{-5}	1×10^{-8}		0.01	0.001
Rhyolitic Tephra	1×10^{-6}	1×10^{-7}		0.1	0.05
Deep Aquifer					
Andesite Surface	3×10^{-5}	2×10^{-6}	5×10^{-6}	0.3	0.1
Andesite to 50 m Depth	7×10^{-9}	6×10^{-9}		0.01	0.005
Andesite to 100 m Depth	6×10^{-7}	6×10^{-9}	3×10^{-8}	0.01	0.005
Andesite	1×10^{-5}	1×10^{-8}		0.05	0.001
Un-Mined Vein	1×10^{-3}	1×10^{-7}		0.05	0.01

Generally, the materials that form the shallower groundwater systems are of higher permeability and storage.

3. Mine Dewatering

3.1 Historic Workings

Mining of the Martha ore bodies commenced in 1878 with a series of open cut operations at the elevated location of Martha Hill where gold could be extracted above the water table. Dewatering began once the water table was reached (1110 m RL; 1893) and progressed at a relatively steady rate of approximately 18 m/year depth. Later mining of the Martha veining and other prospects to the east of the Martha Mine required the sinking of shafts to access the ore body at depth. In the Martha ore bodies the deepest documented shaft was the Waihi No 5 shaft that extended to a depth of 557 m RL (mine datum). The other workings along the Martha veins to the east were recorded to have reached a depth of 541 m RL.

The mining operations resulted in a series of shafts being sunk across the Martha ore bodies, with drives along the length of the veins at various levels to enable stoping of the ore bodies, thereby increasing interconnection. The openness of the old workings after mining is reasonably well documented as shown in Figure 14, although consolidation and adjustment of rockmass into the stoped areas is likely to have reduced void space. The original Martha Mine was closed in 1952.

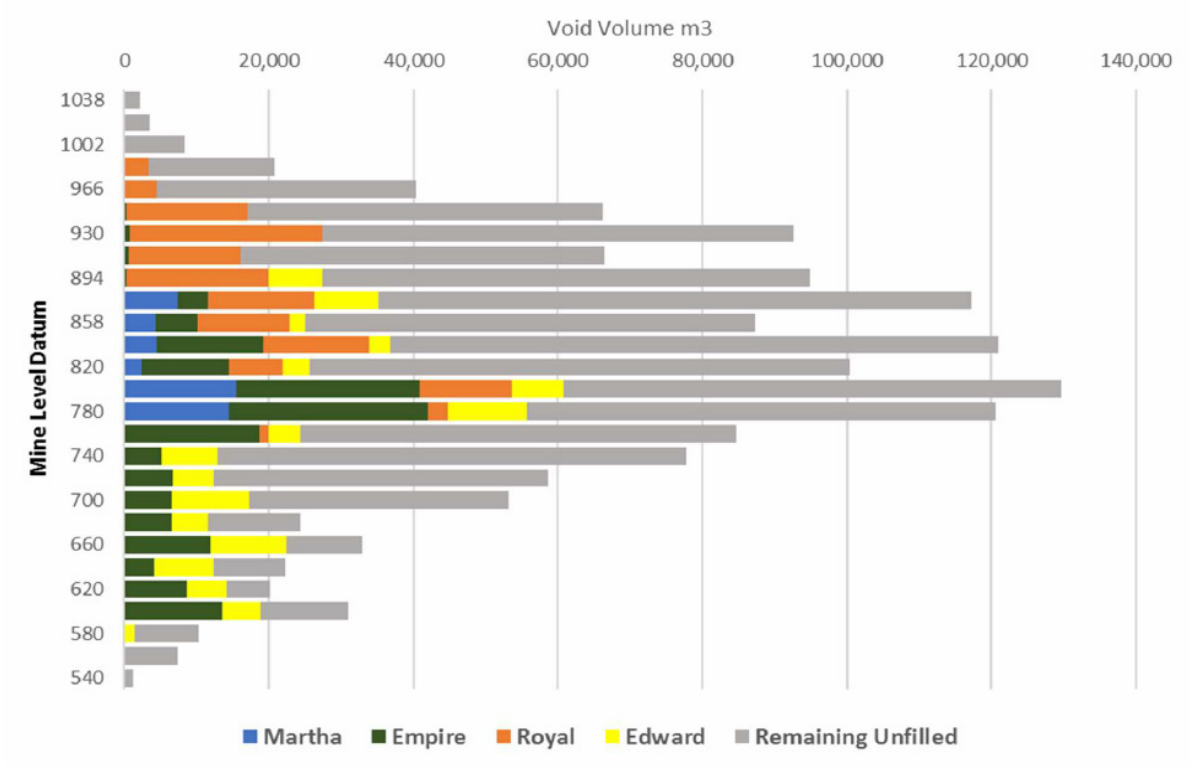

Figure 14 Historical Workings Void Filled by Levels

It should be noted that Figure 14 does not include any estimates of the void volumes available in historically non-mined veins and fault systems. Nor does it indicate void reduction by closure by ground adjustment or collapse.

In 1989 dewatering at Waihi recommenced with the Martha pit operation. Mining of the veins and surrounding country rock took place until 2015 when pit access was stopped by a rockfall on the north wall, however, underground mining has continued to extract the Trio and Correnso veins. The Martha open pit reached an elevation of approximately 880 m RL (old Level 7) prior to this closure.

Given the proposal to mine to 500 m RL, old mine workings will be encountered to a depth of 541 m RL. Dewatering of the veins and workings will be required to reach the target mine depth. Inflows will be from storage within the workings, veins and the rockmass. In addition, rainfall infiltrating the base of the pit will report to the Martha Underground during mining. Small pockets of perched groundwater may also be encountered in old mine workings. Below 550 m RL previously un-mined veins are expected, so only water from the veins, rockmass and Martha Pit will be removed.

3.2 Historic Dewatering

Dewatering of the Martha ore bodies was problematic during former mining. Limitations in pumping technology meant that groundwater inflows impeded the access to reserves at increasing depth. Relatively good records of pumped volumes of water were kept after 1900 and the average daily inflows relative to shaft depth are included in Figure 15. As shaft depths increased, periods of high initial groundwater inflows were experienced reaching some 9000 m^3/d. The water levels in the mine and shafts between Levels 6 and 11 (950 to 730 m RL) were stated to have been pulled down after several months of pumping at a rate of 13,000 m^3/d, which reduced to between 4,900 and 6,500 m^3/d over time. Peak inflows were noted to occur immediately after accessing the veins at a new level. It was reported by the Chief Engineer in 1912 (McAra J.B, 1988) that inflows at Level 10 (780 m RL) were estimated to be 26,000 m^3/d when first cut. In the 1920's and 1930's the mine was expanded along strike between Levels 13 and 15 (650 to 557 m RL) and groundwater inflows stabilised to 4,200 m^3/d. This rate of pumping was considered "normal" for the Martha mine. It was noted that the inflows reduced from Level 11 to Level 15 (730 to 550 m RL) and was thought to reflect the narrower and less cavernous lodes and tighter country rock.

There were a number of occasions, historically, where pump failures or shut downs occurred that resulted in recovery of the water levels within the mines. In 1912, as a result of a miners' strike, the water level rose 45 m over a period of 68 days from 728 m RL to 773 m RL. And in 1945 and 1949 the water level rose 30 to 40 m from 678 m RL to 708-718 m RL over the period of one year.

After the closure of the historical mines the old workings were collapsed locally and allowed to fill with water, thereby forming the depression of what became the Martha Lake. The water level in the lake recovered to an elevation of approximately 1110 m RL which reflected the groundwater level through the interconnected vein system.

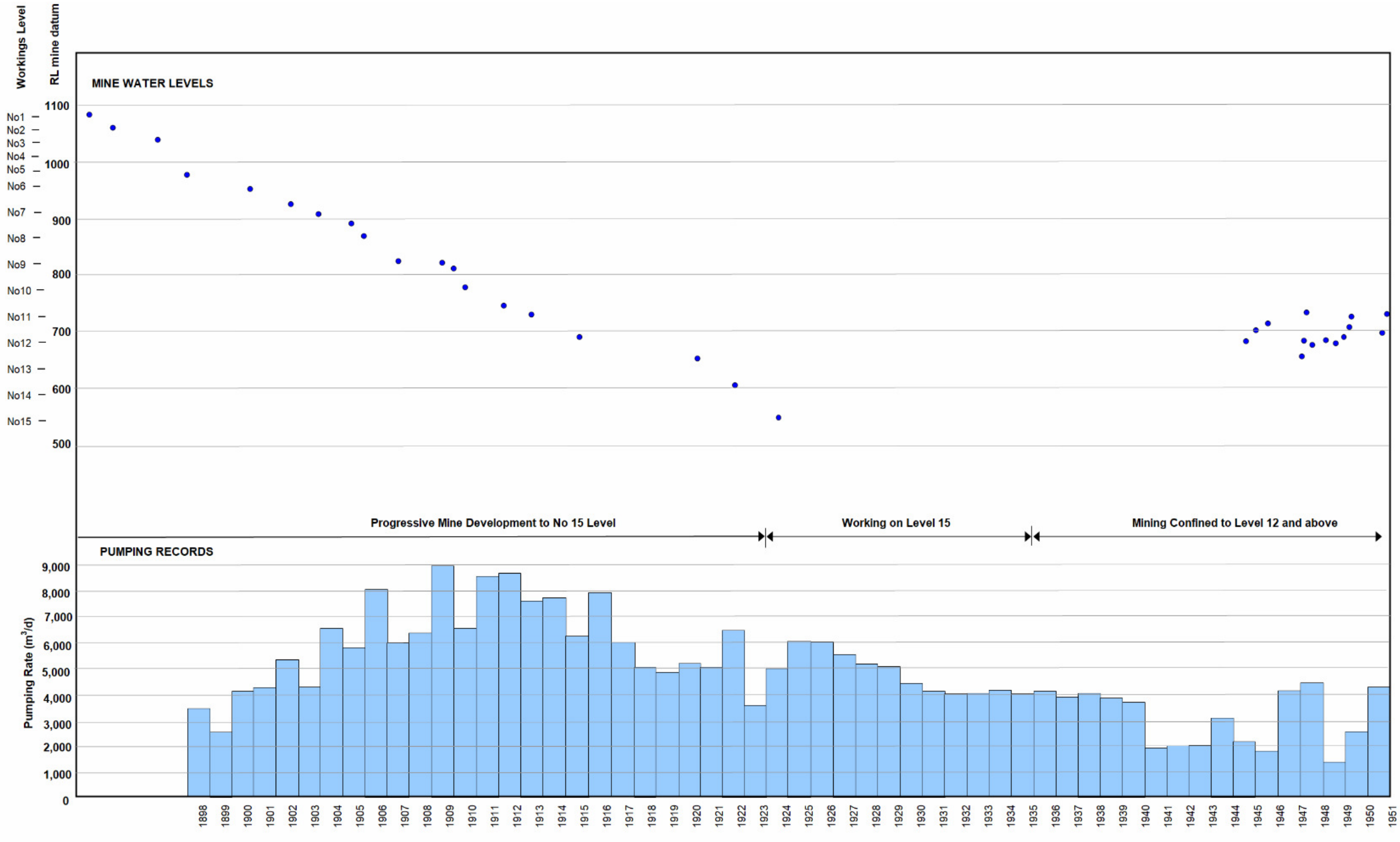

Figure 15 Historical Martha Annualised Average Pumping Rates and Levels

3.3 Historic Dewatering Effects

There was little documentation recorded relating to environmental effects due to historical dewatering, however, the extent of drawdown was estimated by Johnson in 1944 (in Groundwater Consultants NZ Ltd 1985) based on water levels measured in shafts. The map prepared showed an elongated cone of depression that was some 1,000 to 1,500 m in radius.

No adverse effects on stream flows or ground settlement were reported following 60 years of dewatering. The groundwater being discharged was noted to be of good quality being a dominantly bicarbonate type water, with only minor acidic waters encountered locally.

3.4 Recent Mine Dewatering

Since the re-commencement of mining, dewatering has been a necessary part of the operation since 1989 in order to access the reserves. The Martha Open Pit operation required initial dewatering of the Lake and then progressively from the workings as excavation advanced. Dewatering was undertaken until 2011 from the old No.7 shaft which is within the footprint of the mine. In 2011 three bores constructed from a bench within the pit at 940 m RL (mine datum) were used for dewatering. In May 2015, pumping from Correnso mine commenced. Figure 16 shows a schematic of the dewatering system for the underground mining. Correnso water is pumped to the Trio decline and exits the underground at the Favona Portal to discharge following treatment at the water treatment plant. Favona water is now pumped up the Trio incline, lifted to the Trio Decline and, thence, to the Favona portal.

The water pumped from the underground comprises

- Water sourced from storage within the interconnected old workings, vein systems, and where present, from post mineralisation faulting.
- Water released from groundwater storage in the surrounding country rock.
- Rainfall within Martha Pit catchment which enters the historical workings from the pit floor.

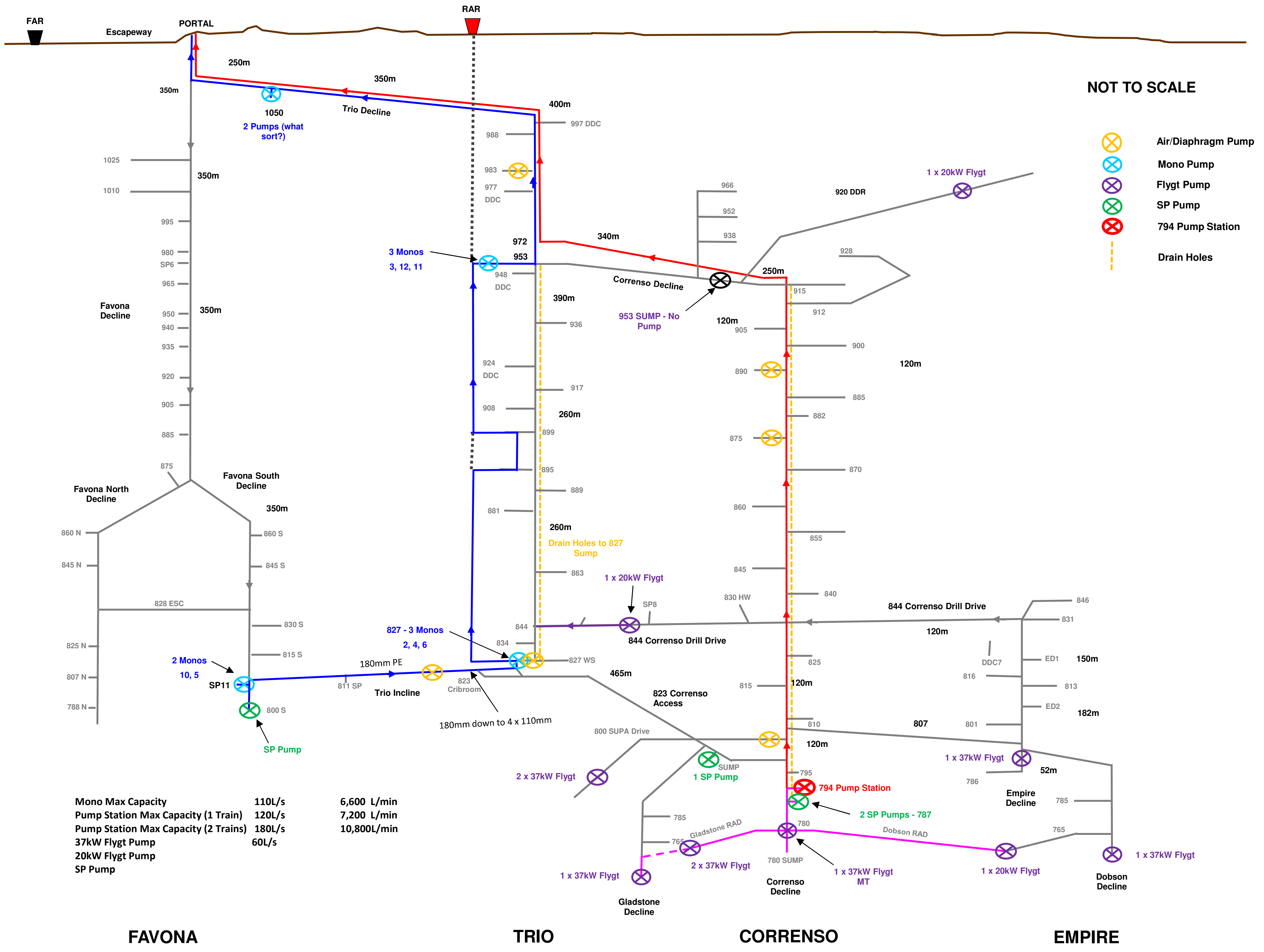

Figure 16 Mine Pumping Schematic

The groundwater response to dewatering at the Martha Pit and the underground mines has been observed at a network of piezometers located around the Waihi area. It has been shown, over time, that the vein systems of the Martha ore bodies (Martha, Empire, Royal, Trio and Correnso) are all highly interconnected and are separated from the Waihi East ore bodies (Favona, Moonlight). As parallel development of the underground mines and at the Martha Pit continued, it became apparent that dewatering at Martha had the effect of dewatering the other vein systems. This was also known and utilised historically.

Pumping records for the combined water take from the Martha and Correnso operations are included in Figure 17 from 2003 to 2016. From 2003 to 2008 these data show high initial pumping rates (>7,000 m^3/d) as deepening of the mine took place and water levels were rapidly pumped down. From 2008 to 2010 a stable volume of dewatering from 4,000 to 5,000 m^3/d was reached, with these volumes consistent with historical inflows. In 2010 the Trio underground mining operation commenced and, due to the connectivity with other vein systems and the rate of mine development, the pumping rate increased to greater than 15,000 m^3/d as the water levels were rapidly being drawn down. From 2010 to 2015 these volumes diminished until the pumping rate stabilised between 4,000 and 5,000 m^3/d, reflecting inflow from the rockmass plus rainfall infiltration via Martha pit. At this time dewatering of Trio was undertaken by the 3 pumping bores located in the Martha Pit. When access to the pit stopped in 2015, dewatering was relocated from the Martha vein system to the Correnso underground operation which dewaters the Martha East associated ore bodies (Trio, Correnso etc.). The water levels within the vein systems in all of the ore bodies are held approximately constant at the pumped level from wherever dewatering takes place. As there is no direct hydraulic connection, groundwater from the Martha East (Trio/Correnso) and Waihi East (Favona/Moonlight) underground operations are pumped separately to the Favona portal as shown on Figure 16.

In 2015 and 2016 a gradual increase in pumped volumes is noted, and this is interpreted to be a result of an increased rate of development to deeper levels resulting in further release of water from storage, bringing the water level down from the 795 m RL. At this time, flows from the Martha East and Waihi East mines were combined with the total discharge measured, and this showed as an increase in the discharge from the mine. The resource consent for Correnso dewatering allows for the water level in the veins to be pumped down to 700 m RL. This is expected to be achieved by the end of 2019. A further 200 m of dewatering will be required to enable mining down to 500 m RL for the proposed Martha Underground project. Historical workings will be dewatered to approximately 540 m RL after which un-mined veins will be dewatered to 500 m RL. The proposed underground mine development will, therefore, require only a further 40 m of dewatering below the depth to which previous dewatering has already taken place.

3.5 Observed Dewatering Effects

Aside from depressurisation in the andesite rockmass which has been observed through groundwater monitoring, there has been only one incident of localised dewatering of the younger volcanics. This occurred in 2012 when a geotechnical borehole, CGD008, was incompletely grouted through the weathered andesite zone and this resulted in drainage of the shallow groundwater system in the younger volcanics for a period. This drainage resulted in some ground settlement effects (EGL, 2018). The drainage occurred rapidly and was of a reasonable magnitude and after re-grouting the groundwater level recovered quickly in the younger volcanics. This pattern of response suggests the younger volcanic rocks were of low storativity at this location. This occurrence was not, therefore, a direct result of mine dewatering.

It is noted that there have been two sinkholes (1999 and 2001) that developed in young volcanic materials since modern mining commenced. These collapses are known to be the result of unfilled shrink stopes in the andesite that migrated through the younger volcanic rocks and to the ground surface through chimney caving. There is no relationship between the development of these collapses and groundwater or drainage effects in the younger volcanic rocks. At the location of the sinkholes, the younger volcanics were dewatered by drainage into the pit and/or the milking cow (as shown in Figure 8). Groundwater monitoring in the surrounding network of piezometers did not elude to such events taking place nor is there evidence of these events having affected groundwater levels in the younger volcanics elsewhere.

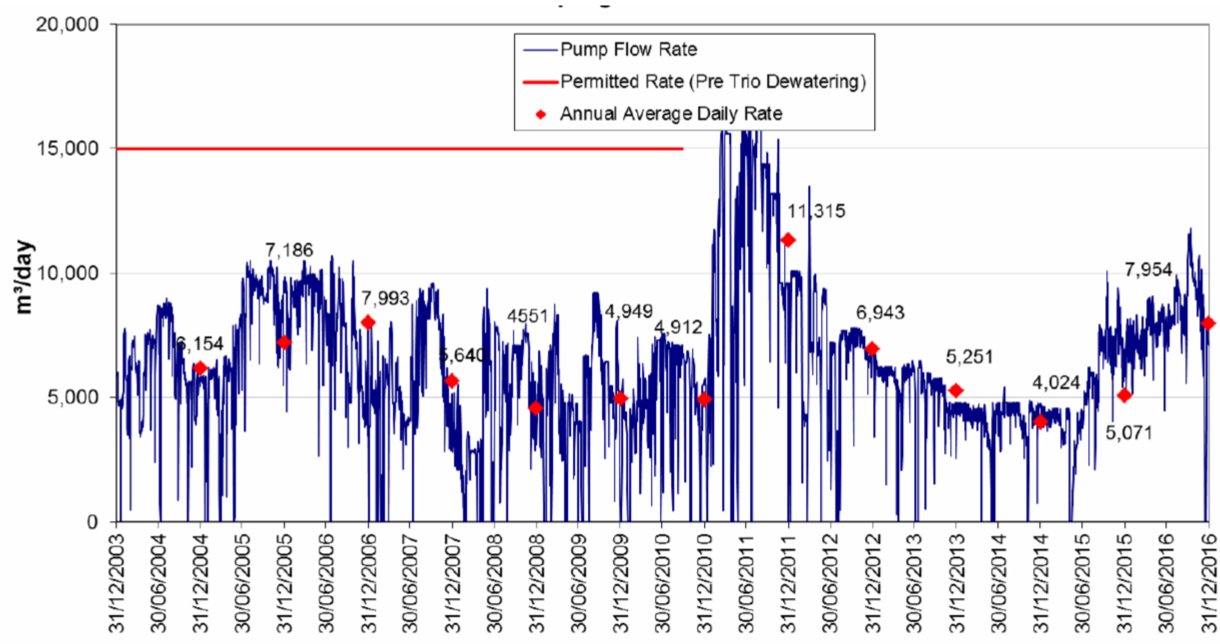

Figure 17 Pumping Rates for Martha and Correnso from 2003 to 2016

4. Groundwater Effects Assessment

The following Section of this report provides an assessment of effects associated with the proposed dewatering from 700 m RL to 500 m RL assuming an underground mining operation of the Martha ore bodies.

4.1 Martha Underground Dewatering - Groundwater Inflows

Modelling of the groundwater inflows to the Martha Underground has been undertaken using an analytical model (Appendix A) that is based on the historical dewatering data set for the historical Martha Mine (Figure 15) given that this mining will extend below the permitted dewatering elevation of 700 m RL. The discharge volumes in Figure 15 are shown to increase with depth to a maximum at approximately 800 m RL before reducing. This pattern conforms to gold production which also historically peaked at about this elevation (Braithwaite, 2006). Discharge from the historical mine was sourced from storage in interconnected vein systems and groundwater inflow from the surrounding rock mass. Vein water storage was greatest where the veins were widest. These were also the areas of maximum gold yield. Groundwater sourced from the rockmass was considered to be a minor contributor to the historical discharge. Previous mining took place to a depth of approximately 541 m RL. Backfilling of stopes was variable and collapse and compression of stopes will have modified the void space following historical mining. It is assumed that the sum of these void increases and decreases has not substantially altered the original groundwater storage capacity.

The spreadsheet model developed to calculate groundwater inflows was calibrated against the historical inflows down to the 541 m RL level where mining ceased. The observed mine elevation and inflow relationships have then enabled predictions of inflows for the remaining 41 m of un-mined vein to the proposed level of mining at 500 m RL. The methodology for the calculation of the groundwater inflows is described in Appendix A.

Figure 18 provides the proposed development elevations from the start of the Martha Underground Project. Table 2 provides the dewatering schedule and calculated average pumping rates.

Table 2 Calculated Pumping Rate for Proposed Martha Underground

Dates	Depths (m RL)	Averaged Pumping Rate (m^3/d)
1/1/2020 to 1/2/2021	700 to 681	13,833
1/2/2021 to 1/1/2024	681 to 619	14,959
1/1/2024 to 1/3/2026	619 to 500	15,411

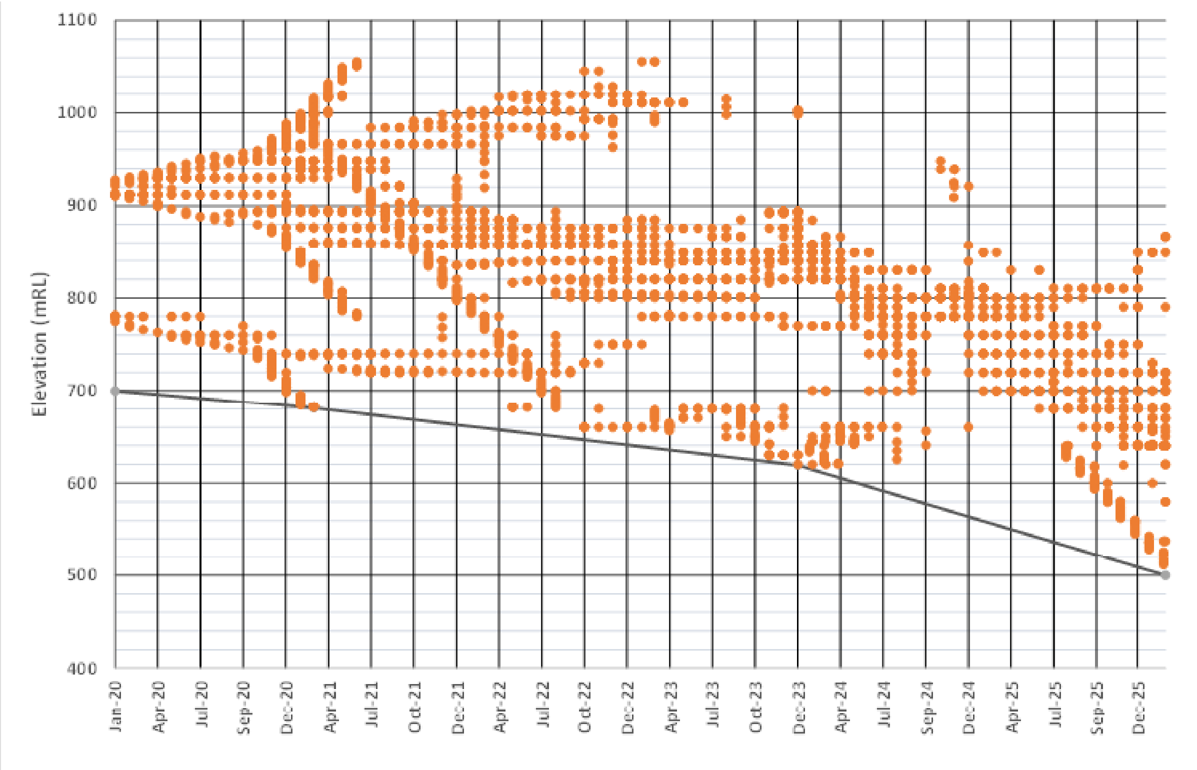

Figure 18 Proposed Martha Underground Development and Dewatering Schedule

The average daily dewatering rate due to development of the Martha Underground (from 700 m RL over the given time interval) is expected to be approximately 14,608 m^3/d. The daily discharge rates will vary depending on whether country rock is being excavated (lower inflows); whether hanging wall fractures and veins are encountered (higher initial inflows followed by recessions); whether pumping is maximised; or whether heavy rainfall events occur. As a consequence, actual daily flows may be greater or less than the calculated daily averages.

4.2 Martha Underground Dewatering – Drawdown Effects

Dewatering from 700 m RL to approximately 500 m RL will be achieved by pumping water inflows from vein systems collected in underground sumps. Lowering water level in the veins will result in a corresponding pressure response in the andesite country rock. Groundwater monitoring to date has shown that this pressure change in the vein systems has had little effect on groundwater levels in the overlying younger volcanic rocks during mine dewatering as shown in Figure 6 and in Figure 19 below. Figure 19 is a typical example of the multilevel piezometer data.

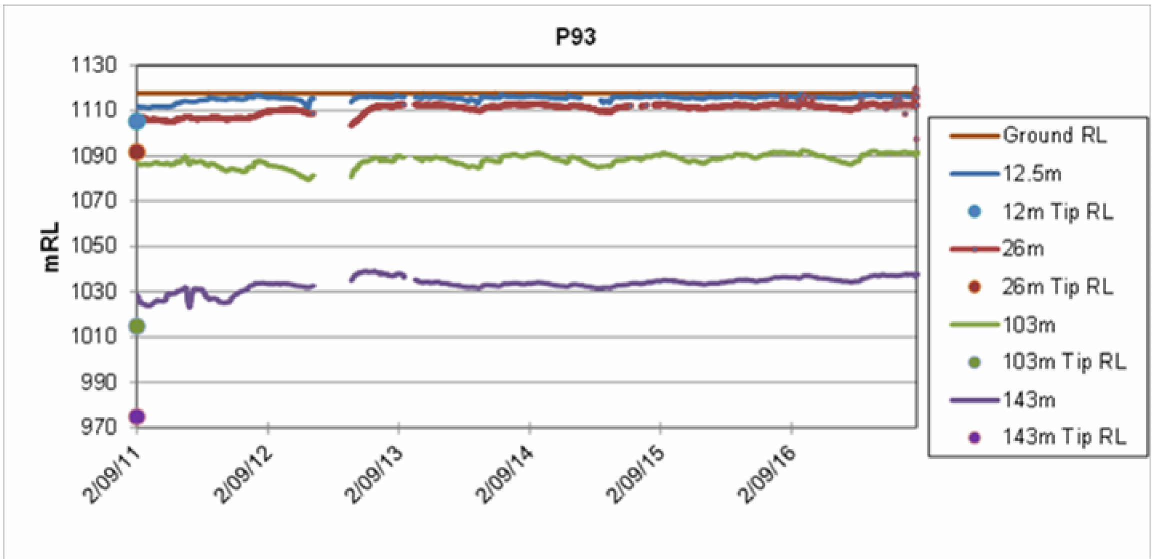

Figure 19 Multilevel Piezometer P3 Data.

The deep piezometer in Figure 19 is sealed within the low permeability weathered andesite. The other three piezometers are located within the younger volcanics.

Figure 19 shows decreasing groundwater pressures with depth, indicating a downward vertical hydraulic gradient exists (i.e. an under drainage effect). These data have been used to prepare pressure graphs as shown on Figure 20 for each piezometer location. Figure 20 shows pressures within the younger volcanics increase with depth to the base of the unit and then the gradient reverses through the low permeability andesite layer. In the case of P93 and other locations (P94 and P95, P100 to P102) with negative pressure gradients (pressure reducing with depth) through the low permeability layer, the gradient in the younger volcanics is steeper than the hydrostatic gradient. This indicates that a pressure response has developed within the younger volcanics but Figure 6 shows this to have been early (mid to late 1990s) in the current dewatering phase. Piezometers with positive gradients (pressure increasing with depth) through the younger volcanics (P90 to P92) show a pressure gradient in the younger volcanics approximating the hydrostatic gradient.

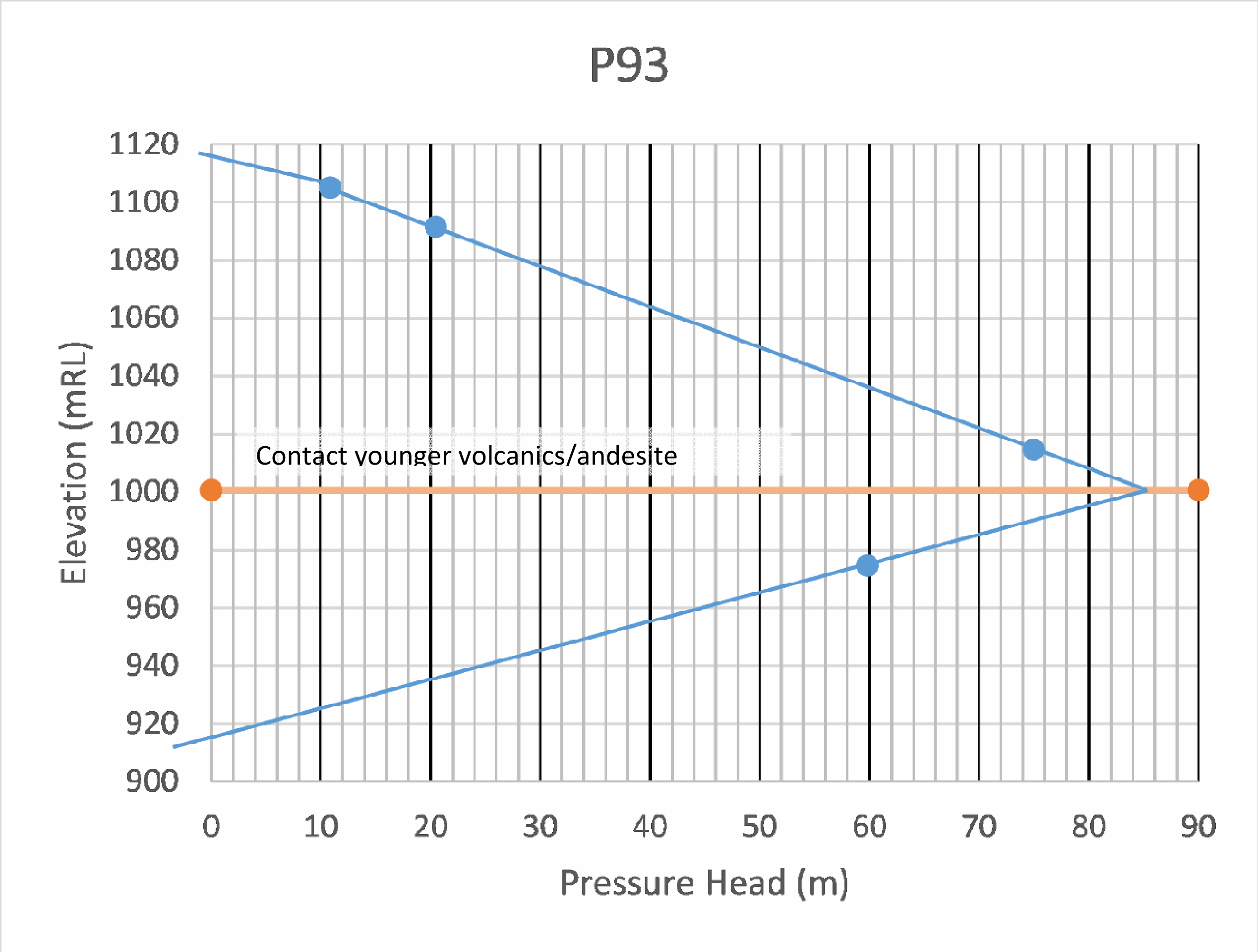

Figure 20 Pressure Gradient P3

The monitoring data from the multilevel piezometer network in the East Waihi area shows that the weathered upper layer of low permeability andesite rock restricts transference of the pressure changes from the deeper andesite to the younger volcanics. This is evident in the pressure graph provided as Figure 20

Previous 2D modelling (Trio, Correnso) supported the observed monitoring data and current modelling (Appendix C) has further demonstrated that limited effects can be expected on pressures in the younger volcanics from dewatering to 500 m RL. However, reducing the thickness of the low permeability layer has been shown by monitoring and demonstrated by modelling to result in greater pressure change developing at the base of the younger volcanics leading to a steepening of the pressure gradient in those materials.

In summary, drawdown effects from pumping vein water levels from 700 m RL to 500 m RL are assessed as follows:

Groundwaters in Younger Volcanics

The current water table is expected to remain unaffected due to persistent surface recharge. Minor pressure changes may develop at the base of the thicker parts of the younger volcanics (lower elevation) where the thickness of the weathered andesite layer could be affected by historic erosion and stoping.

The effects of drainage of the younger volcanics to the Martha pit or the Milking Cow Block cave is shown in Figure 8. The drainage elevation point is well above current water level and the current drainage pattern will remain unaffected during Martha Underground mining. Other historic shaft also have drainage points above current water level and any drainage that developed by the mid 1990's will not be affected by the proposed Martha Underground mining.

Groundwaters in low permeability weathered Andesite

Negative pressure gradients through this layer may steepen as a result of pressures within the layer adjusting to a dewatering influence as a result of nearby mining. This can only occur in limited areas.

Current positive pressure gradients may steepen and, possibly, become negative where nearby stoping reduces the thickness of the low permeability layer.

With an increase in the negative pressure gradients, a small increase in seepage from the overlying younger volcanic rocks may develop in some limited locations but given the low vertical permeability of this layer, this would not affect any groundwater flows in the overlying materials.

It is of note that groundwater pressures within the andesite rockmass have been stable since the mid to late 1990's (as shown in Figure 7) and as mining has continued deeper underground, there have been no changes in the pressure regime. From this it is reasonable to conclude that deepening the mine to 500 m RL will similarly have little effect on the pressure distribution within the andesite and overlying strata, as the main dewatering effect has already occurred.

Higher Permeability Andesites (approximately 1000 m RL to 700 m RL)

This zone has responded to current dewatering (approximately 770 m RL) in the veins. This response is expected to be variable depending on rockmass permeability. A phreatic surface (surface of zero water pressure), defining the dewatered zone, is expected to have develop within the rockmass, curving upwards and away from the vein water level. Modelling shows this to lead to a maximum width of the dewatered zone at the base of the low permeability layer at the top of the andesite rockmass, a process which has been ongoing since the dewatering level dropped below the base of the low permeability layer. Dewatering to 500 m RL may lead to a widening of the dewatered zone beneath the low permeability layer over parts of the system and movement of the dewatered zone up into the base of the low permeability layer. But effects on pressures in the overlying younger volcanic rocks are shown by modelling to be minimal.

Lower Permeability Andesites (approximately 700 m RL to below 500 m RL)

The modelling shows that dewatering veins to 500 m RL in the deeper, low permeability andesites is unlikely to lead to development of a substantial dewatered zone in the adjacent country rock. The indication is that the rockmass will drain slowly and the phreatic surface will be steep and sub-parallel to the vein systems in the zone.

4.3 Martha Underground Dewatering - Effects to Surface Waters

Monitoring data collected over the period since dewatering began has indicated no adverse effects on shallow groundwater or base flow to surface waters, including the Mangatoetoe Stream and the Ohinemuri River. This is, largely, a consequence of the perched nature of the surface water bodies in the shallow groundwater system.

4.4 Martha Underground Dewatering – Effects to Groundwater Resource

4.4.1 Groundwater Availability

The site is located within the Waihi Basin aquifer management area as identified by the Waikato Regional Council (WRC, 2012). This catchment is further subdivided into the Waihi Basin shallow aquifer system (0.5 to 30 m depth) and the Waihi Basin deep aquifer system (>30 m depth), which correlates to the younger yolcanic rocks and andesite rock aquifers as defined in this report. The proposed take for mine dewatering is from the Waihi Basin deep aquifer system.

The availability of groundwater has been determined based on catchment area, rainfall recharge and NES provisions for maintaining surface water and groundwater flows. These are as follows:

Table 3 Groundwater Availability Calculations

Catchment Area	125,699,400	m^2
Rainfall Rate	2.17	m/y
Rainfall	272,767,698	m^3/y
Deep Aquifer Recharge (7% Rainfall)	19,093,739	m3/y
NES Reserve - Outflow (35%)	6,682,809	m3/y
Allocation Limit Deep Aquifer	**12,410,930**	m3/y
Existing Allocated	732,732	m3/y
S14 Takes (10%)	1,241,093	m3/y
This Proposal	5,475,000	m3/y
Allocation Remaining	4,962,105	m3/y

Based on these calculations there is sufficient available groundwater in the deep aquifer system to allow the proposed groundwater take for dewatering from the Waihi Basin deep aquifer of 5,475,000 m^3/year.

It is of note that the proposed groundwater take is for dewatering purposes, and that this water will, in-fact, be discharged into surface waters locally. This water is, therefore, not lost from the catchment, rather put back into the Waihi Basin system at a higher level. It is expected that much of this water will ultimately become recharge back into the shallow and deep groundwater systems, thereby having a net neutral effect on the catchment water balance.

On this basis the potential effects to the groundwater resource are considered to be less than minor.

4.4.2 Other Aquifers

The groundwater take for mine dewatering is from the deep andesite rock aquifer. Close monitoring of shallow and deep groundwater levels has been undertaken since the commencement of modern dewatering in 1989. These records clearly show that pumping of the deep aquifer system does not impact on the shallow groundwater system due to the low permeability strata that separates the two. As discussed above, the abstracted groundwater will be discharged back into the surface water environment resulting in a neutral effect to the catchment water balance. As a consequence, groundwater will be introduced into the shallow aquifer from the deep aquifer system, thus resulting in a net positive benefit by enhancing stream base flow and shallow aquifer recharge

It is, therefore, considered that the effects on other aquifers from the proposed groundwater take will be less than minor.

4.4.3 Other Users

Figure 21 shows the locations of private water bores as available from the Waikato Regional Council data base. Table 4 provides the details available from the data base for these bores. A number of these bores are understood to no longer be in use.

Figure 21 Locations of Private Bores from Council Data Base

The bore log records held by council is incomplete. Most bores are indicated to tap younger volcanic materials, however, bores close to the southern side of Union Hill are indicated to have intercepted andesite.

Table 4 Private Bore Information from Council Database

Bore Number	Bore Name	Altitude	Completion Date	Bore Depth (m)	Bore Diameter (mm)	Casing Depth (m)	Screen diameter (mm)	Screned From (m)	Screened to (m)	Screen Type	Slot Saize (mm)	NZMG Easting	NZMG Northing
63_128	BATES G	98	1990-08-31	43	100	32.5						2763900	6417800
72_961	MULLAN, D (WB3)	90.1	2000-02-17	126	100							2763186	6418729
72_1223	HOLLAND D.C & F.K	109.931	1988-11-22	92.5	120	19.1				Stainless Steel		2763967	6421157
72_5193	DE WINTER .G	120	1988-12-16	86	120	56				Steel		2763300	6421000
72_4879	CULLEN WT ESTATE	131	2005-04-21	30	100	16				Steel		2764400	6421700
72_4671	CD MCDONALD	198	2002-10-18	126	100	71.5				Steel		2760300	6420800
72_9336	BLACKHILL ORCHARD		1965-01-01	183	100	61				Steel		2763214	6418330
63_398	RILEY A, WAIHI BEACH ROAD	101.5	1900-01-01	80								2764400	6417300
72_4839	STUBBENHAGEN	101	2005-01-14	84	100	65	65	64	84	Steel		2763800	6417600
72_8693	JG & JM WRIGHT	107		30	100					Steel		2764989	6417001
63_267	MCGLADE P	103.8	1991-01-08	53	100	32.5						2764100	6421300
63_198	DIVINE J	112.9	1983-12-01	98	100	52						2763800	6417100
63_207	SHREEVES K	91.2	1992-09-08	46	100	33						2763900	6418000
63_234	LYNHARD FARMS	98.3	1985-06-06	87.8	100	52						2763400	6417800
63_249	BUCKLEY I	141.2	1994-12-08	74	100	45.5	65	45.5	74	Steel		2762700	6421500
63_124	FORD RD SUPPLY	101	1991-05-22	110	100	78						2763100	6417200
63_96	BOYD P & R	91.3	1994-10-12	140	100	91						2761500	6417800
63_3	BEACH RD 2 OPEN	99.6	1984-10-30	106.29	100							2764500	6417600
72_16	LG MERCER	89.3	1999-10-12	55	150	39						2761700	6418400
72_960	MULLAN, D (WB2)	92.4	2000-02-14	85	100							2763300	6418700
63_388	SCOTHERN PS&CN	138.4	1982-10-08	50	100							2761900	6420500
63_389	MORTONS GARAGE	119.4	1997-08-19	6	50	4.5	50				0.5	2761800	6419600
63_11	HCB CREAN RD #1	95.79	1984-10-19	169.7	100							2762400	6417400
63_4	BEACH RD 2 SHORT	101.81	1984-10-30	106.29						Steel		2764400	6417400
63_5	BEACH RD 2 TALL	101.84	1984-10-30									2764400	6417500
72_3956	BOURNE G.R & L.N	100	2008-08-22	60	100	31.5						2763500	6417700
72_959	MULLAN, D (WB1)	92.4	1999-10-30	72	100							2763300	6418700
72_771	REEHAL VE	96.6	1998-11-20	86	100	50				Steel		2764300	6420000
63_236	LYNHARD FARMS 2	105	1985-06-15	88	112	52.5						2763600	6417700
63_95	BLUETT	83.4	1991-05-10	105	100	17						2761700	6417800
63_266	HOPE P	97.9	1983-08-29	128.02	100	36.57						2764400	6418300

It is of note that water levels in nine private bores were initially monitored to the north, east and south of Martha Pit with the agreement of the bore owners. Over the years, monitoring of these bores was discontinued for a number of reasons including:

- Purchase of the property by the Company.
- Change of property ownership and access withdrawal.
- Problems with insertion of instrumentation into bores.
- Hazardous access to bore.
- Bore no longer used/owner no longer requires the information.

Figure 22 shows the monitoring record of three of these bores which extended from 2000 and in one case, to 2016. These three bores were:

Wharry Road = C (Wharry) on Figure 22

Whangamata = D (C Des Forges) on Figure 22

Mataura = E (R Des Forges) on Figure 22

Figure 23 shows that in-well pumping in these bores caused water level fluctuations in the bores which reduced their sensitivity as monitoring wells. Never the less, no long term trends from dewatering are apparent in that monitoring data. As a result, no additional effects are expected on groundwater users by the proposal to mine to 500 m RL.

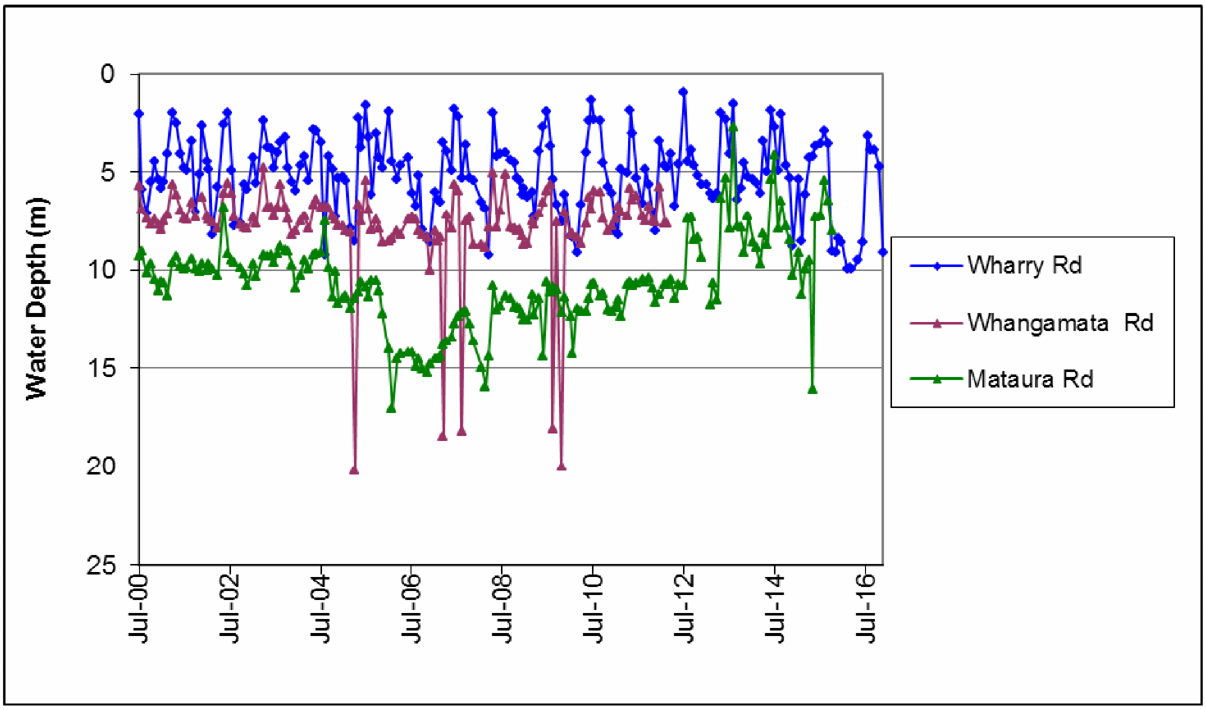

Figure 22 Private Bore Monitoring Data

OceanaGold maintains a complaints database in accordance with its existing consent conditions. The Company has responded to queries on some bore performance issues in the past and is currently understood to be working with one bore user who had identified a water level drop in their bore. It is unclear whether this water level drop in the bore is associated with mine dewatering or is a bore maintenance issue, however, investigations have shown there is sufficient depth of water in the bore for it to continue functioning.

As the monitoring network around Waihi has shown (Section 2.2.2) water level response to mine dewatering in materials overlying the andesite and in the upper layers of andesite have been stable since approximately the mid 1990's. Significant effects on private bores from the proposed Project Martha dewatering are not expected to develop.

4.5 Martha Underground Dewatering – Effects to Plant Growth

This was an issue raise during the first application for modern mining at Waihi. Plant growth relies on soil moisture retention in the near-surface soils, which is a function of rainfall infiltration. The demonstrated lack of effects on shallow groundwater from deep dewatering supports the observation that dewatering effects will not alter shallow soil moisture contents and, therefore, plant growth.

4.6 Rex and Martha Phase 4 Pit Dewatering – Groundwater Inflows

The Rex Ore body and the Martha Pit are at an elevation above that of the present dewatered mine level and, as such, no specific dewatering is required for either of these project elements.

Minor groundwater discharges at the geologic contact between the younger volcanic rocks and the andesite rocks may occur, however, the volume of inflows would, typically, be small based on historical observations. The walls of the current pit have been depressurised using horizontal drain holes that are generally 20 m long with some up to 80 m long. Drain holes in the existing east wall targeted bases of paleo-valleys where noticeable water flows were encountered when first drilled. This dewatering has been monitored with a network of piezometers around the pit. This monitoring will continue under the proposed Phase 4 Pit development.

4.7 Rex and Martha Phase 4 Pit Dewatering – Drawdown Effects

The Rex ore body and the Martha Pit are at an elevation above the present mine dewatered level and as such no additional drawdown effects for either of these project elements is expected.

Groundwater pressure curves have shown the upper andesite restricts drainage due to its generally low permeability. While perched groundwater is present in the north pit wall, this has not been demonstrated for the south wall of the pit. That wall is underlain by variably backfilled historical workings from which drainage effects (cracks, caving) have developed to ground surface thereby providing potential drainage pathways, thus preventing development of a perched water table in those areas.

4.8 Martha Underground Post Closure –Rewatering Rate

With mining to extend to 500 m RL and the Martha Mine Lake to be filled to 1104 m RL some 604 m elevation of old and new workings, unmined veins and lake void are required to be filled. While the Martha Mine Lake void and voids remaining from current mining can be reasonably estimated, there is uncertainty in the void space remaining in the historical underground workings and in the unmined veins. Some of these historical workings were backfilled, others were not and ground pressure adjustments will have reduced void space in some areas. In the rewatering assessment that follows, it has been assumed that the sum of the changes in the void space in the mined areas has not substantially affected the void space pre-mining. While this may introduce some uncertainty, this uncertainty can be addressed in the more detailed Water Balance Model (GHD 2018). It is also considered that the effects of this uncertainty can be reduced during rewatering by monitoring the rate of rise of water level in the workings and adjusting controllable inflow accordingly.

The rewatering model (Appendix B) uses groundwater inflow and rainfall infiltration to the pit, supplemented by diverted Ohinemuri River water as the sources for re-filling the empty void spaces within the Martha and now connected Favona groundwater systems.

Void space was calculated from:

Martha groundwater system Storage;
+
Favona groundwater system Storage
+
Lake Void

Inflows were calculated as:

Martha groundwater inflow
+
Favona groundwater inflow
+
Rainfall onto mine lake catchment able to reach and leak through pit floor
+
Recharge from diverted Ohinemuri River.

The model discretises the void volume for given elevation intervals and calculates the discretised inflows needed to fill the void in those intervals. The groundwater rewatering model estimates are based on a specific set of values for a range of inputs, and the combination of these effects is assessed in more detail in the Project Martha Water Management Report (GHD, 2018). The rewatering model presented here provides an initial estimate of the time of filling from 500 m RL to the proposed lake overflow elevation of 1104 m RL with average river contributions ranging from 9,000 m^3/d to 15,000 m^3/d as follows:

Table 5 Calculated Rewatering Volumes

River Recharge Rate (m^3/d)	9,000	15,000
Total Storage (m^3)	70,190,170	70,190,170
Total Groundwater (m^3)	9,008,720	6,291,944
Rainfall (m^3)	14,215,137	9,820,513
Total River Recharge (m^3)	46,966,313	54,077,713

4.9 Martha Underground Post Closure – Long Term Discharge

While the Martha East ore bodies were hydrologically separated from Waihi East ore bodies prior to mining, the construction of the low level Trio Incline (800 m RL to 823 m RL Figure 16) and high level Trio Decline (1015 m RL to 1060 m RL Figure 16) from the Favona mine to the Trio Mine will result in a combined water level rise within both systems once groundwater level recovers above 823 m RL. The post-closure degree of connectivity, therefore, has implications to the likely locations of the long term discharge from the mines.

To assist in understanding the connectivity between the mines, a conceptual model has been developed and is shown in the attached Figure 23. The model considers the system as a series of plumbing components where the bucket represents the open pit, storage tanks represent storage in the underground workings and pipes represent features that provide interconnection. Veins, historical workings and recent mining are considered as open conduits for flow, whereas late phase faulting provides fewer open connections.

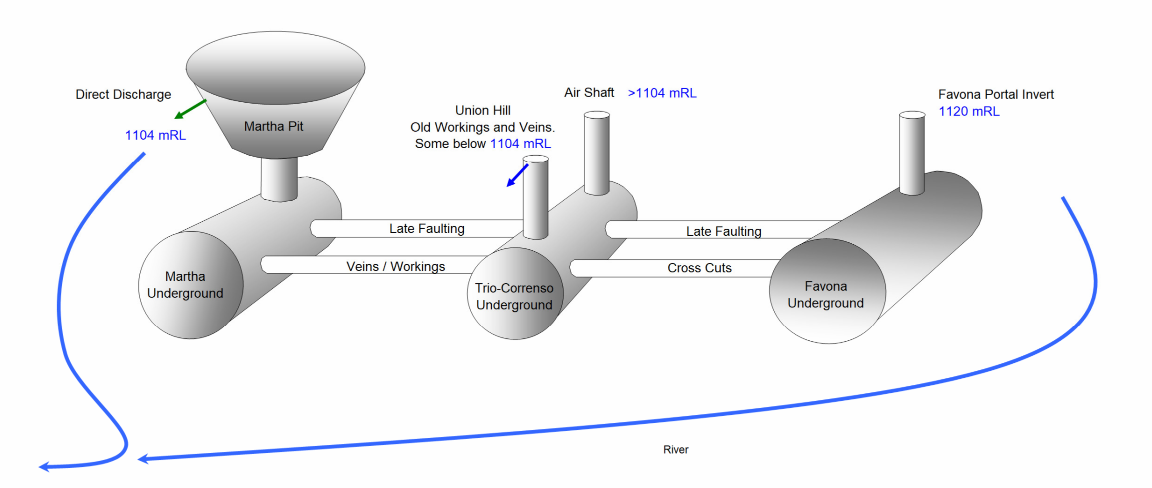

Figure 23 Conceptual model of Mine Hydraulic Interconnectivity

On mine closure, and once refilling of the underground workings and Martha Pit has occurred, the Martha Mine Lake is planned to discharge to the Mangatoetoe Stream from an outfall structure at 1104 m RL at the western end of the lake. There are, potentially, two pathways in the system that are at elevations lower than the proposed Martha Mine Lake level that may allow some discharge from the groundwater system. These are:

- Natural pathways through the younger volcanic rocks from the exposure of these rocks in the eastern pit wall to outcrops in the Eastern Stream;
- Existing historical workings at Union Hill;

The Favona Portal and air shafts are above 1104 m RL elevation and will not become discharge locations.

4.9.1 Natural Pathways

One difference between the historical groundwater flow pattern and the proposed Martha Mine Lake is that, as a result of the open pit mining, there will be an area of younger volcanic rocks (including a layer of fractured welded ignimbrite) in the east wall of the pit exposed to the water ponded in the lake. That geology has the potential to allow seepage from the Mine Lake to the surrounding groundwater system.

Figure 24 shows the approximate extent of the outcrop of younger volcanic rocks in the pit and the approximate location of the 1104 m RL contour around Martha and Union Hills. Areas below this level may provide possible discharge zones for mine waters where geology permits. Figure 25 shows that most of the Waihi urban area would be above Martha Lake level. Those parts of town below lake surface elevation are indicated to be relatively distant from the Lake.

The potential for seepage of groundwater, via this potential sub-surface pathway, is assessed below. Groundwater flow is expressed by Darcy's Law namely:

Flow = Hydraulic Conductivity x Flow Area x Hydraulic Gradient

Data from earlier investigations indicates that, other than for welded ignimbrite, hydraulic conductivities are relatively low. Fractured welded ignimbrite rock is currently exposed in part of the south-eastern wall of the Martha Mine pit. This welded ignimbrite was encountered in a number of drill holes east of Martha pit and is exposed in the bed of Eastern Stream at the foot of Union Hill. The most likely potential discharge site is in the bed of Eastern Stream where jointed and fractured ignimbrite rock outcrops; the pathway is the shortest; and hydraulic gradient is the greatest.

Calculated seepage from the Martha Mine Lake may be some 0.5 to 1 L/s on the basis of the following assumed values:

- Path length 500 m
- Path head drop 4 m
- Path thickness 30 m
- Path width 200 to 300 m
- Hydraulic conductivity $1x10^{-5}$ m/s

The calculated volume of leakage is a small volume when compared to the expected Martha Mine Lake discharge volume of combined groundwater flow and rainfall. It is expected that if a small leakage from the Martha Mine Lake does develop through the welded ignimbrite layer, it will be lake water, which will contain a mixture of rain water and a lesser proportion of groundwater which may have moved through the closed underground mines. The effect of such a small discharge of diluted mine water is considered to be minimal.

While there may be other potential seepage locations, the discharges would be much smaller than calculated for the Eastern Stream.

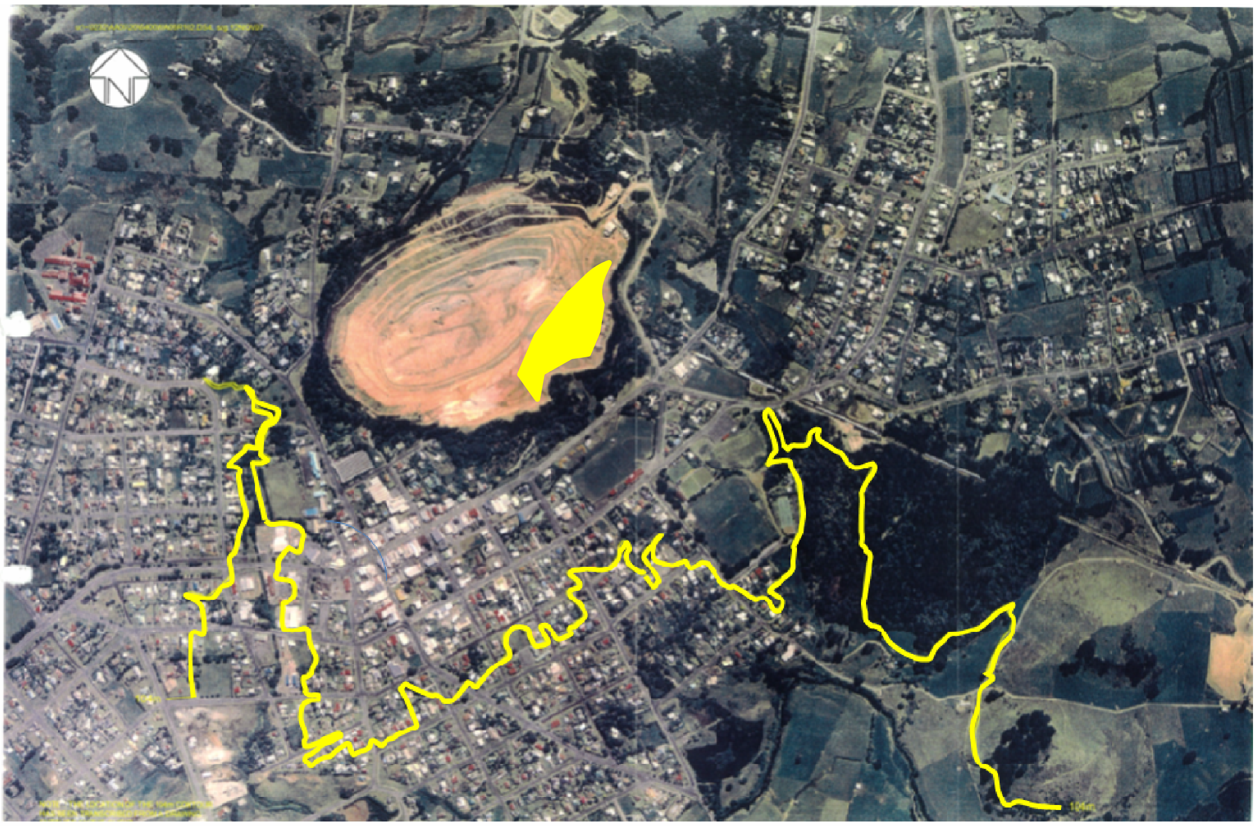

Figure 24 Approximate Location of 1104 m Contour

4.9.2 Historical Workings Discharge Pathway

Prior to mining, water level measured in No. 7 shaft at Martha Hill varied around approximately 1110 m RL. Given the proposed lake outfall level of 1104 m RL, groundwater from the surrounding areas will move towards the Martha Mine Lake, i.e. the lake would generally remain an inward gradient location.

One of the principal discharge locations noted historically was from an unnamed drive west of Moresby Avenue that created a spring near the Mangatoetoe Stream. The elevation of this drive was 1106.5 m RL, and with the water level in the pit being controlled at 1104 m RL, this means the drive will not act as a discharge point.

Pre-mining, groundwater levels in andesite rocks around Martha Mine were indicated to be relatively flat indicating close groundwater flow path connections. The flat water levels extended to Union Hill where the Union Shaft groundwater levels were similar to Martha Hill shaft groundwater levels and southwards to, at least, Gilmour Lake. The only observed discharge from the historical mine workings was the warm spring at an elevation of 1106.5 m RL discharging from the collapsed drive on the east side of the Mangatoetoe Stream referred to above. The historical linkages are unlikely to have been substantially altered by current mining. As a consequence, post-mining groundwater levels are expected to return to a flat hydraulic gradient with this flat gradient extending to all the interconnected mine workings.

Data from water level monitoring during mining indicates water levels in the Correnso vein system were just a few metres above that in the Martha vein system. A difference of some 2 metres with the Martha vein water levels was also observed in the Trio system (GWS, 2010). Given the development workings for the modern mining activity, groundwater levels are expected to be relatively consistent through all the interconnected workings.

Figures 25 and 26 provide the historical adit elevations and Shaft collar elevations on Union Hill. These indicate that several historical adits and shafts are at elevations below 1104 m RL (Martha Mine Lake Control level) and these are presented in Table 6.

Table 6 Shaft and Adit Elevations below 1104 m RL

Shaft Collars (m RL)	Adit Inverts (m RL)
1102	1090
1103	1094
	1095

The data on Table 6 suggests that two shafts and three adits would be below the inferred recovered groundwater elevations in the veins and workings below Union Hill.

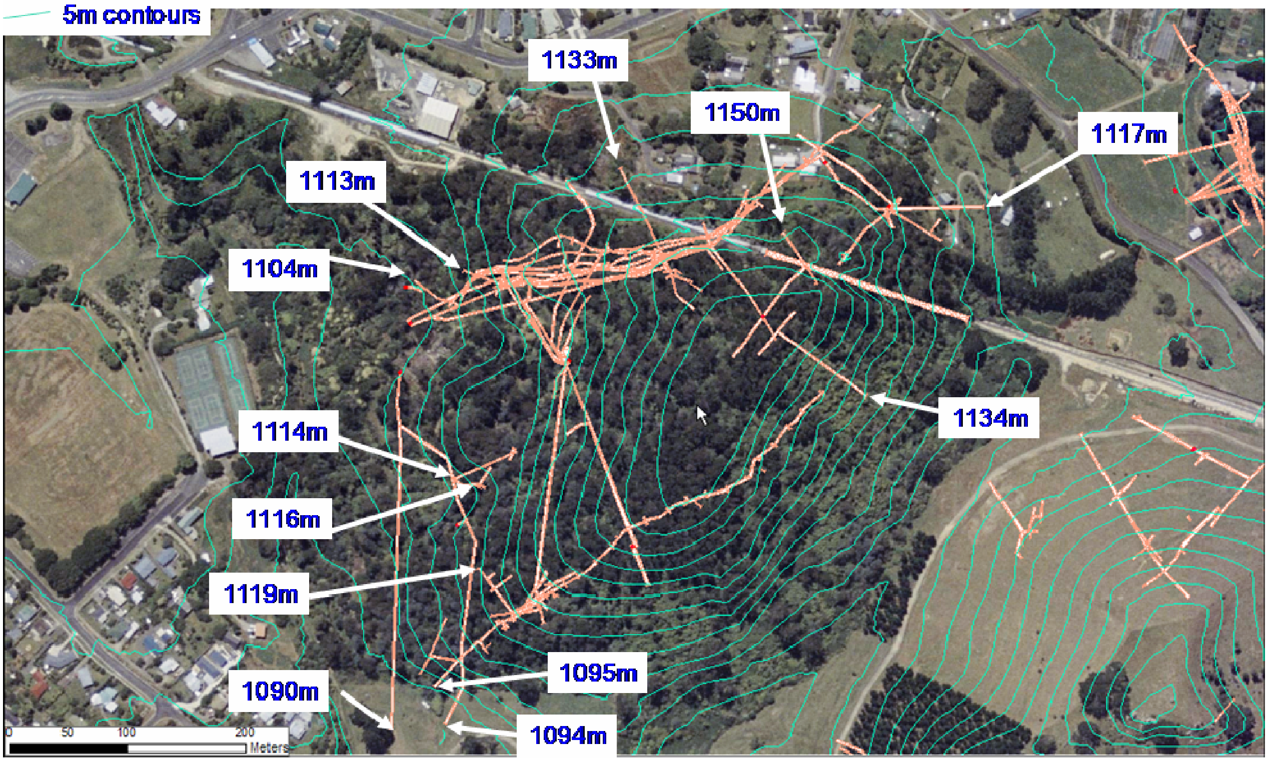

Figure 25 Historical Adit Levels – Union Hill

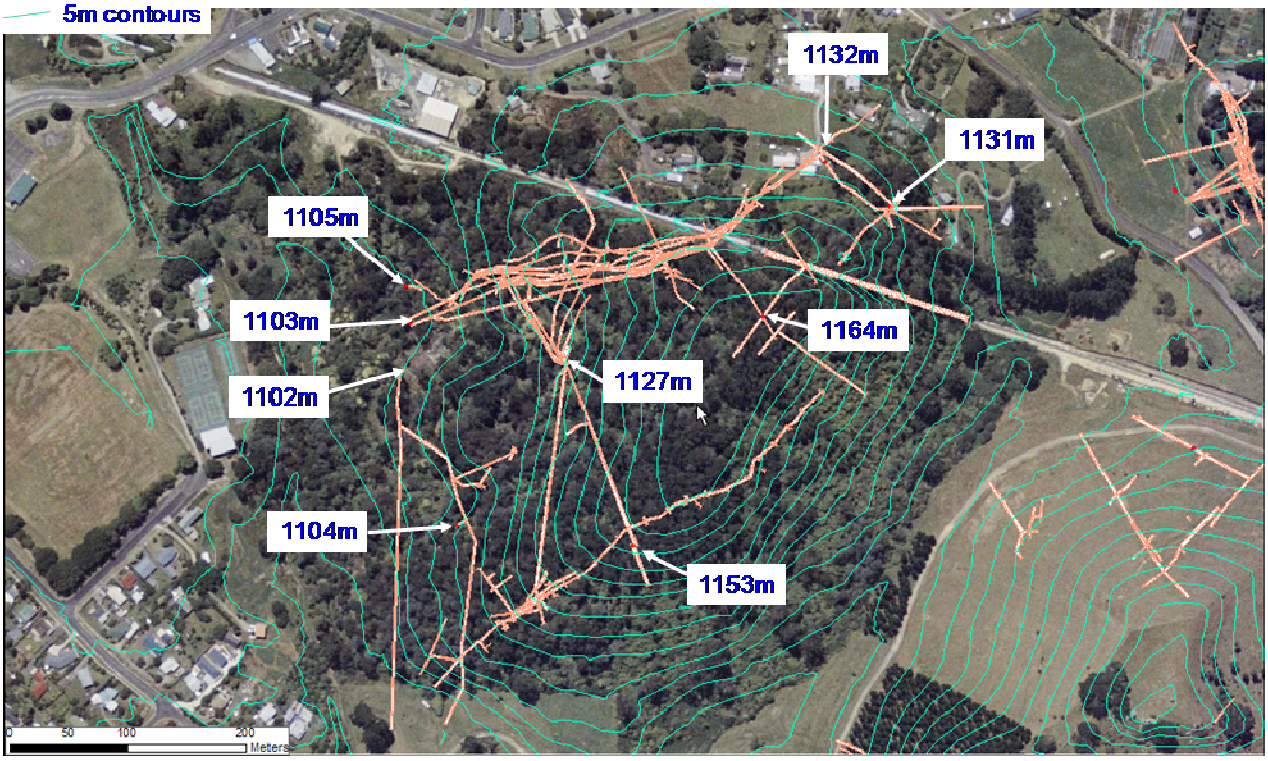

Figure 26 Elevations of Historical Shafts – Union Hill

Given the indicated close connection between Martha and Union workings and veins, if discharge was taking place through the Union Hill adits and shafts, water levels in the historical Martha mine workings should have dropped to some 1094 m RL, 2 m above the lowest discharge point at Union Hill prior to open pit mining. The water level within Martha Hill stood around 1110 m RL and no discharge was, in fact, observed at these locations.

This suggests that groundwater discharges from the lower elevation shafts and adits around Union Hill did not occur prior to open pit mining, or that if discharges did occur, they were of too small a volume to affect groundwater levels in the veins and workings in Union Hill or Martha Mine. Collapsed adits or shafts may account for the lack of, or the minor, groundwater discharge. These observations indicate pre-mining water levels above the adit and shaft levels on Table 4 and that those adits and shafts were not influencing water levels in the andesite rock outside Union Hill. With the control level on Martha Mine Lake being set lower than historical groundwater levels in Martha Hill, there is a reduced possibility of seepages from the historical adits and shafts on Union Hill.

Other old adits and shafts are present around the Martha, Union and Favona Mines. These are all indicated to generally be in the more elevated areas and to have invert levels above 1104 m RL.

There is some residual uncertainty as to whether discharge from former workings will, in fact, occur given recent mine developments. Mitigation could include plugging of adits, the location and design of which should be part of the closure planning process and written into the Rehabilitation and Closure Plan.

4.10 Martha Underground Post Closure – Effects on Surface Waters

Following closure of the mine there will be a direct discharge from the Martha Lake into the Mangatoetoe Stream at an elevation of 1104 m RL. It is not expected that there will be any other significant groundwater discharges to surface waters following recovery of the water level. The exception to this, as discussed above, is the possible localised discharges associated with former mine workings that are near surface water bodies. Any discharges that do develop at these locations will be controlled such that any discharge is of a very small volume.

In summary we consider the potential for effects to surface waters due to groundwater level recovery will be less than minor.

4.11 Rex and Martha Phase 4 Pit Post Closure – Effects on Pit Wall

As Martha Mine Lake level rises water will enter joints, fractures, and drain holes installed in the pit wall to improve stability. Water movement into drain holes may be considered instantaneous. Where drain holes intercept a number of faults, or joints, water pressures in the joints will increase at about the same rate as the Martha Mine Lake water level rise. This is supported by the rapid response observed in piezometer P69 on the northern wall of the pit when a drill-hole penetrated close to that location and in piezometers P104 and P105 in the pit which show low water pressures where piezometer tips are close to fractures. Where drill-holes are absent, rapid transfer of water and water pressures could be expected where fracture systems occur such that a lag would develop only where fine fracture patterns or sealed fractures exist.

5. Recommendations

5.1 Dewatering

5.1.1 Dewatering and Settlement Monitoring Plan Update

Ongoing dewatering will be required to develop Project Martha and, in particular, the Martha Underground to its proposed depth of 500 m RL. Currently, existing mining consents require a Dewatering and Settlement Monitoring Plan be prepared and actioned. The Dewatering and Settlement Monitoring Plan 2016 (WAI-200 PLN 009) combines the monitoring plans for Martha, Favona Trio and Correnso/SUPA into one document given their similar monitoring networks and frequencies.

In relation to dewatering and settlement, the plan describes the monitoring regime designed to assess the effects of:

c) Mine dewatering on the regional groundwater system.
d) Mine dewatering on settlement.

The objectives of the current Dewatering and Settlement Monitoring Plan are:

- To outline the monitoring systems in place for dewatering, groundwater and settlement and the requirements for these systems in accordance with the relevant consent conditions.
- To identify trigger limits that will indicate when contingency mitigation and/or monitoring may be necessary.
- To identify what contingency mitigation and/or monitoring would be undertaken in the event that the trigger levels are exceeded, in order to ensure that adverse environmental effects are averted, remedied or mitigated.

The current monitoring approach is considered to be appropriate for managing any dewatering effects that may develop during the Martha Project. The plan can be revised and be re-issued having regards to the following.

- Separately measure and record daily the water volume pumped from Martha Underground and other underground mine areas.
- Sample the discharge waters from the separate underground mine areas. This, together with the volume pumped, can be used to calibrate the Martha Mine Lake chemistry models.
- Measure and record water levels weekly. This can be done in piezometers drilled underground to intercept veins/historical workings or in the absence of underground piezometers, in sumps at the lowest elevation in the mine. Both methods have been used during current mining.

5.1.2 Groundwater Monitoring Locations

The existing network of piezometers is generally considered adequate to enable observation of dewatering effects related to project Martha. As can be seen in Figure 8, there are a number of areas where the monitoring network is less dense. This includes the area to the south and southwest of the pit which is shown to be in Settlement Zones 4, 5 and 6 (EGL, 2018). Given the proposal is to extend dewatering by a further 200 m depth, additional multi-level piezometers in these areas would assist with modelling the ongoing settlement and the re-bound post-closure. The exact locations of these piezometers would be included in an updated Dewatering and Settlement Monitoring Plan.

5.2 Rewatering and Post-Closure

- It will be important to monitor the rate of water level recovery during closure to validate and update the rewatering model. It will also be important as a guide to the volume of river water diversion needed during filling.

- The location of piezometers to record recovery would depend on what mine infrastructure is to remain during closure and into post-closure. The location and the setting of such piezometers would need to be decided and in place before water level recovery began.

- Review the current monitoring network to check that it will be suitable to monitor water level recovery in the shallower rock units post-closure and update the monitoring plan where any modification to this network is identified or proposed.

- The monitoring plan should include a requirement to undertake site inspections of potential leakage zones once the Martha Mine Lake water level reaches final elevation. Should any leakage outside of the constructed discharge location be identified, the plan should include a requirement to undertake an effects assessment and, if necessary, to design and implement mitigation measures.

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APPENDIX A

Dewatering Model

The dewatering model has been based on the historic data set for Martha mine (Figure A-1). The discharge volumes in Figure A-1 are shown to increase with depth to a maximum at approximately 800 mRL before reducing. This pattern conforms to gold production which also, historically, peaked at about this elevation (Braithwaite 2005 Figure 6). Discharge from the historic mine was sourced from storage in vein systems and groundwater inflow to the vein systems from the surrounding rockmass.

The averaged daily values on Figure A-1 were derived from the annual pumping volume divided by 365 days. These values include groundwater inflow and vein storage. Values from 1893 to 1898 were assumed based on the later data set. The development elevations are also shown as the red line.

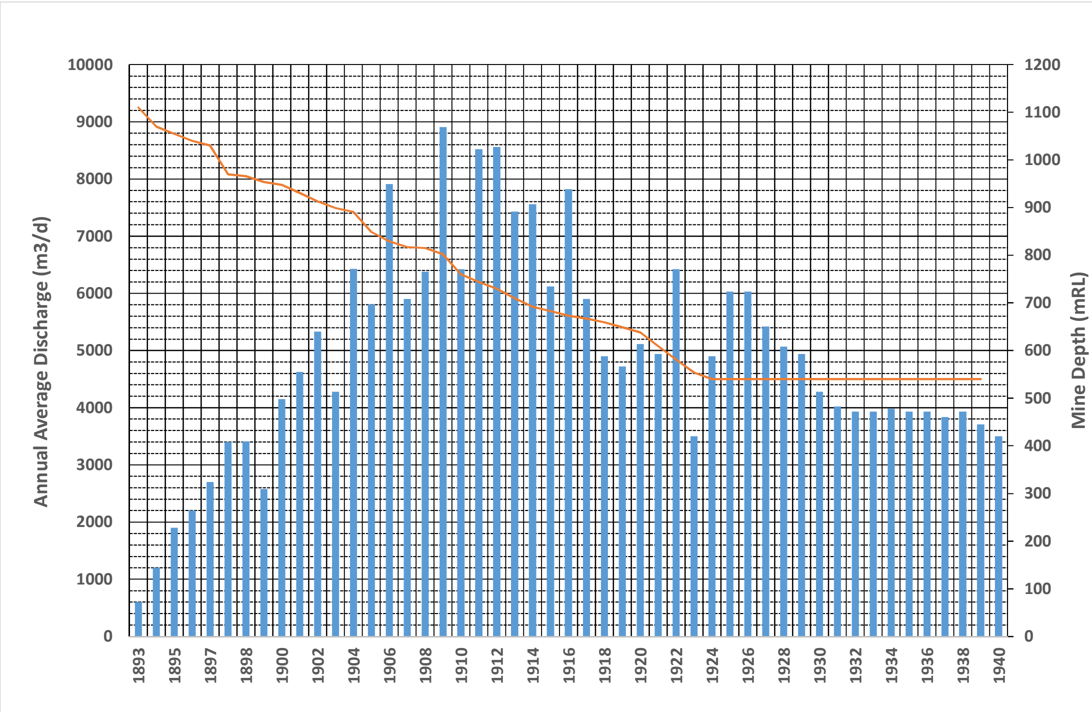

Figure A-1 Martha Mine Historical Dewatering and Development

Figure A-2 shows the model inputs and outputs for a given set of values.

- Dates for the start and end of a dewatering period are entered (Cells F2 and F3) and the number of days of this interval are calculated Cell (F4).
- The start and end elevations of the dewatering period are entered (Cells 6 and 7) and the elevation difference is calculated Cell F8).
- The start and end elevations for each year of historical mine development from Figure A-1 are entered in Columns C and D.
- Conditional equations in Column F are used to calculate the number of metres of drawdown in each elevation interval between the start and end elevations given in Cells F6 and F7.
- Column H on Figure A-2 is the annualised pumping volume for each the elevation interval as derived from Figure A-1.
- Column I is the volume of water per m in each elevation interval and is calculated by dividing

Column H by (Column D – Column E).

- Column J is the water to be pumped from each elevation interval and is the product of Columns I and F.

Once the elevation interval pumping volumes are calculated the Average Total Pumping Rate is calculated as follows:

- Total Volume Pumped given in Cell F33 is the sum of the values in Column J and is copied from Cell J31.

- The Number if Days in Cell F34 is copied from Cell F4.

- Average Pumping Rate in Cell 35 is calculated as Cell F33 divided by Cell F34.

- Rainfall in Cell 36 is copied from Cell F10'

- Favona Pumping in Cell F37 is copied from Cell F12.

- The Total Average Pumping Rate in Cell 39 is the sum of Cells F35, F36 and F37.

The model provides estimates of the combined groundwater inflow and storage between given elevations for the Martha groundwater system. Total pumping from underground would also include soakage to groundwater from rainfall within the Martha Pit catchment.

Pit area during MUG	51 ha
Annual Rainfall	2,168 mm
Runoff Coefficient	say 0.9 (Steep bare slopes)
Soakage	2,724 m^3/d

In addition, underground pumping includes some 1,573 m^3/d pumped from the Favona groundwater system.

The model provides average pumping rates to achieve a desired amount of dewatering. In practice, variations in vein geometry and hydraulic parameters and variations in rainfall soakage via Martha pit in response to event rainfall, would result in a need for higher pumping rates on occasions to maintain the desired rate of dewatering.

Backfilling of stopes generally occurred above 700 mRL with shrink stopes below that elevations. Collapse and compression of stopes will have modified the void space following historic mining. It has been assumed in this model that these changes occurred in only a portion of the vein system and have not significantly altered the overall vein storage capacity.

The model can also be used to calculate the pumping time for increases or decreases in pumping rate or pumping rate for changes in pumping time.

- For changes in pumping rate, Cell F35 can be set to the desired value and Cells F2 or F3 changed using "Goal Seek".

- For changes in dewatering time, the desired values can be set in Cells F2 or F3 and "Goal Seek" used to change Cell F35.

Figure A-2 Example of Model Inputs and Outputs

Co;umn	B	C	D	E	F	G	H	I	J	K
Row										
2	Start Date				1/01/2020					
3	End Date				1/03/2026					
4	No of Days				2251	days				
5					6.2	years				
6	Start WL				700	m				
7	End WL				500	m				
8	WL Change				200	m				
9										
10	Rainall				2724	m3/d				
11							Martha Pumping	Volume	Pumping Volume	Days
12	Favona				1573	m3/d	m3/yr	m3/yr/m/int	m3/yr	
13										
14	m between		802	760	0	m	2,381,430	56,701	0	0
15	m between		760	744	0	m	3,106,086	194,130	0	0
16	m between		744	730	0	m	3,510,053	250,718	0	0
17	m between		730	710	0	m	2,717,460	135,873	0	0
18	m between		710	692	8		2,782,475	154,582	1,236,655	120
19	m between		692	683	9		2,238,983	248,776	2,238,983	217
20	m between		683	673	10		2,886,206	288,621	2,886,206	280
21	m between		673	667	6		2,135,252	355,875	2,135,252	207
22			667	659	8		1,812,005	226,501	1,812,005	176
23			659	649	10		1,734,207	173,421	1,734,207	168
24			649	638	11		1,876,655	170,605	1,876,655	182
25			638	609	29		1,798,856	62,030	1,798,856.3	174
26			609	581	28		2,342,348	83,655	2,342,348.3	227
27			581	554	27		1,268,148	46,968	1,268,148.0	123
28			554	540	14		1,721,423	122,959	1,721,423.3	167
29			540	500	40		2,161,184	54,030	2,161,184.3	210
30										
31	Total Drawdown				200		36,472,769	2,625,444	23,211,922	**2,251**
32										
33	Total Volume Pumped				23,211,922	m3				
34	Number of Days				2,251	Days				
35	Average Pumping Rate				10,311	m3/d				
36	Rainfall				2,724	m3/d				
37	Favona				1,573	m3/d				
38										
39	**Total Average Pumping Rate**				**14,608**	**m3/d**				

Goal Seek can be used to determine the pumping time for increases or deceases in pumping rate or pumping rate for changes in pumping time.

For changes in pumping rate, set Cell F35 to desired value and change Cells F2 or F3.

For changes in dewatering time, set desired values n Cells F2 or F3 and chgange Cell F35.

APPENDIX B

Rewatering Model

Whereas the dewatering model considered the combined groundwater inflow and groundwater Storage in the estimate of pumping volumes, the rewatering model uses groundwater inflow and rainfall supplemented by diverted Ohinemuri River water as the sources for re-filling the void spaces within the Martha and Favona groundwater systems and Martha Mine Lake.

Void space was calculated from:

Martha groundwater system Storage;
+
Favona groundwater system Storage
+
Lake Void

Inflows were calculated as:

Martha groundwater inflow
+
Favona groundwater inflow
+
Rainfall on the mine lake catchment
+
Recharge from diverted Ohinemuri River at high flows.

Figure B-1 provides the historical data (averaged daily pumping rate and Mine Depth) with an estimate of the groundwater inflow provided (red line).

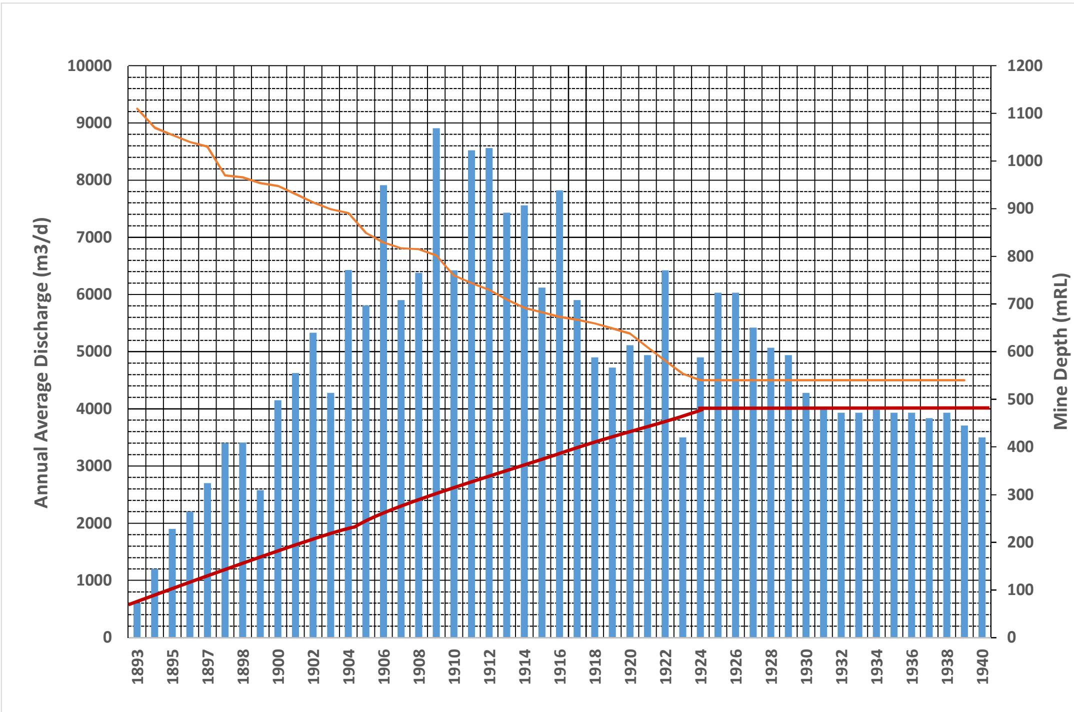

Figure B-1 Historic Pumping Data with Assessed Groundwater inflow Shown

The groundwater line was initiated at approximately 6 L/s (518 m^3/d) as this was the estimated discharge of the warm spring from a collapsed added adjacent to the Mangatoetoe Stream prior to the current mining operations. The line was extended to mid-1924 when mine development reached 540 mRL. Thereafter, a stabilised inflow of 4000 m^3/d was adopted assuming ongoing development resulted in inflows of stored groundwater for a period.

In order to confirm that the slope of this groundwater inflow line was realistic, groundwater inflow was examined based on a Theis calculation assuming the vein system could be conceptualised as a vertical body of high Storage and Permeability within a low Storage and low Permeability rockmass. Groundwater inflow was considered to be sourced from outside of the high Storage and Permeability vein system.

An effective radius of 300 m was assumed to represent the horizontal area of interconnected veining within the Martha groundwater system (*see Braithwaite 2005 Figures 1, 3 and 5*). This was the vertical body of high Storativity and Permeability.

A Transmissivity and Storativity were established for the drawdown at year 1924 when mine deepening ceased and the drawdown stabilised. Pumping rate was considered to approximate 4000 m^3/d. Transmissivity was derived as 4.32 m^2/d based on a hydraulic conductivity of $1E^{-7}$ m/s x 500 m depth. Storativity, by iteration, was $5x10^{-4}$. Goal seek was used to calculate the discharge rate for each annual drawdown. This yielded an approximate straight line similar to that on Figure B-1 when discharge was plotted against pumping time in years. A check at a radius of 200 m would have resulted in lower groundwater discharge rates. If the cross-section area of veining is greater, the hydraulic conductivity of the rockmass would be lower.

Given the indication that groundwater inflow from the rockmass could be represented by a linear relationship over time, the straight line drawn on Figure B-1 between approximately 518 m^3/d inflow at the pre-mining water table elevation (approximately 1110 mRL) to intercept the stabilised inflow (4000 m^3/d) at the time mining depth reached its minimum elevation (in 1924) was accepted as representative.

A table was then established to enable accumulation of the void volumes and the water inflows from different sources for each annual elevation interval of the historical mine development.

- The start and end elevations for each year of historical mine development defined the elevation intervals.
- The annual average daily discharge rates from Figure B-1 times 365 were included for each elevation interval.
- Groundwater inflows for each elevation interval were derived by developing a linear equation between the beginning and the 4000 m^3/d value on the groundwater line on Figure B-1.
- The tabulated groundwater data was subtracted from the elevation interval pumping volumes to obtain an estimate of the groundwater Storage in the veins and faults within the interconnected Martha groundwater system (Waihi Ore bodies) and the rockmass. A similar exercise was undertaken for the Favona groundwater system (Waihi East Ore bodies- Figure B-2).
- The tabulated combined storage (Martha groundwater system, Favona groundwater system and Lake volume) was divided by the elevation intervals to provide the volume per m for each elevation interval. These values were transferred to the model.
- The combined groundwater inflows were also treated in the same manner and transferred to the model.

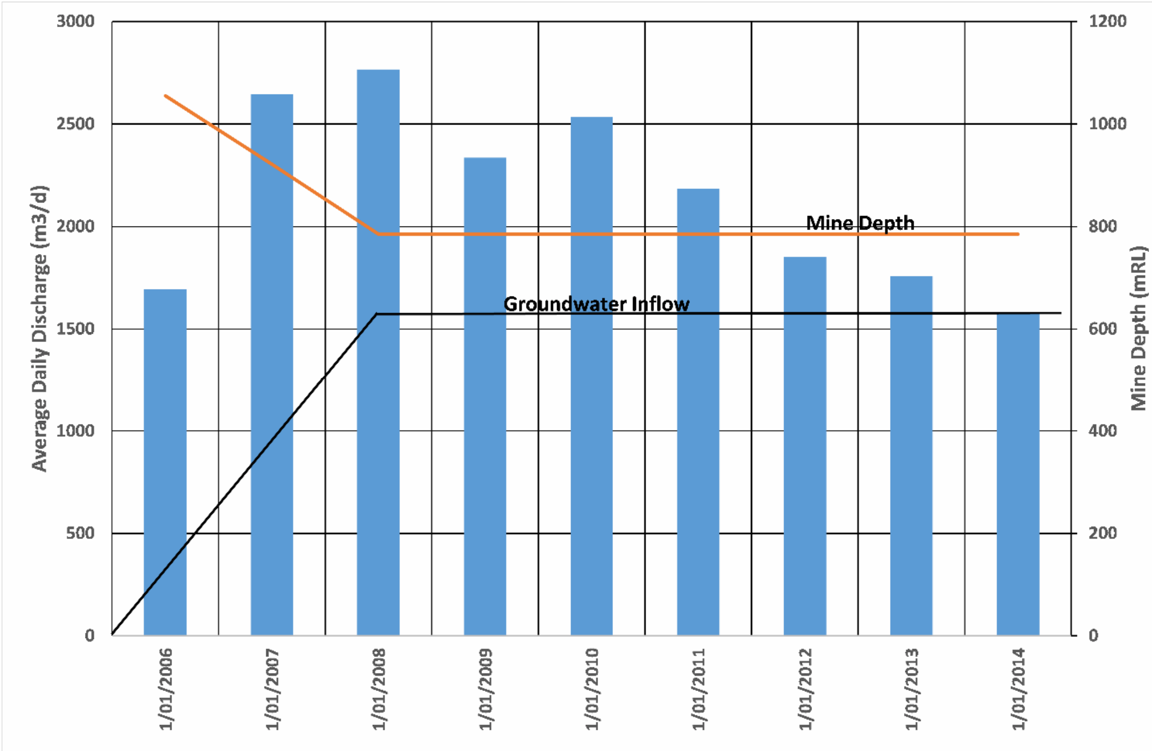

Figure B-2 Favona Pumping rates Mine Depth and Assessed Groundwater inflow

Lake volume (Figure B-3) was discretised to the same elevation intervals as the Martha Mine Storage.

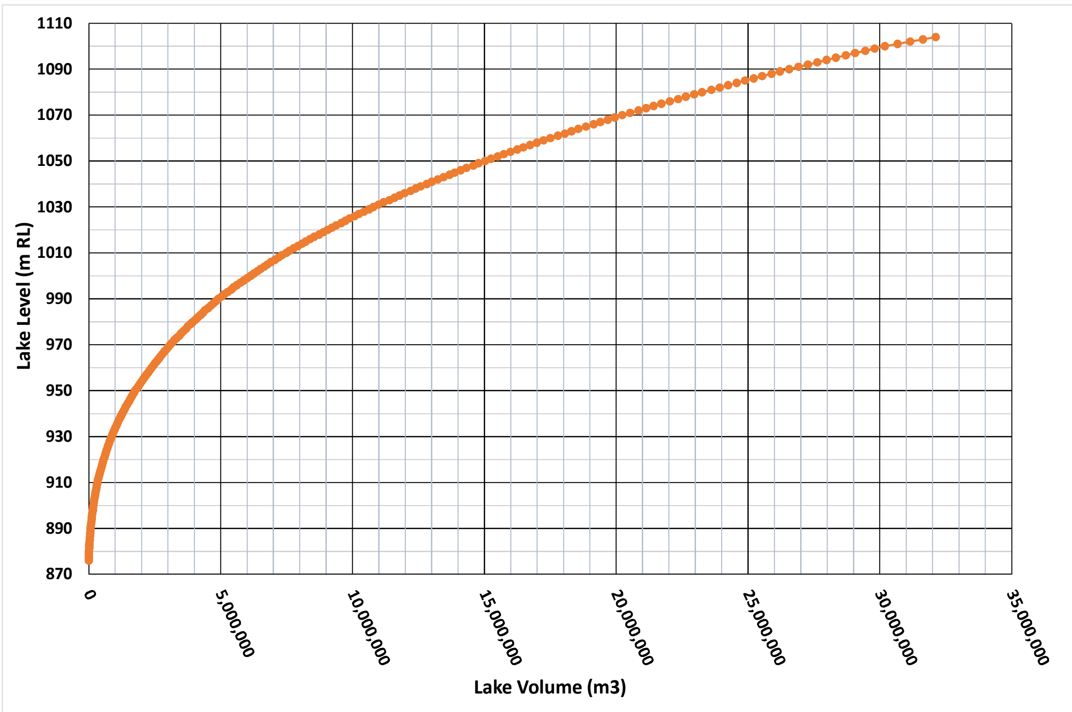

Figure B-3 Lake Void with Elevation

The total void space (groundwater Storage in veins and workings) and the mine lake void was accumulated for each historical elevation interval.   In order to integrate the Favona groundwater flows with the Martha data, the Favona data was recalculated to the Martha elevation intervals as derived from the Historical records. Figure B-3 provides the proposed Lake level volumes as provided by OceanaGold.

Figure B-4 provides an example of the rewatering model inputs and outputs for a given set of values.

- The date for the start of a rewatering period is entered (Cell F2).
- The start and end elevations of the dewatering interval are entered (Cells F6 and F7) and the water level rise is calculated Cell F8).
- Rainwater contribution is entered into Cell F10 and River Recharge in Cell F12.
- The start and end elevations for each year of historical mine development from the tabulated data from Figure B-1 are entered in Columns C and D.
- Conditional equations in Column F are used to calculate the number of metres of rewatering in each elevation interval between the start and end elevations given in Cells F6 and F7.
- Column H on Figure B-5 is Storage per metre calculated as described above.
- Column I is the Storage for each elevation interval and is the product of Columns H and F.
- Columns J, K and L are daily flow rates for recharge from the Ohinemuri River; daily rainfall; and groundwater respectively. These are summed in Column M. Conditional statements in Columns J, K and L set each cell to zero if the equivalent cell in Column F is zero. For the conditional statements in Column L, groundwater data is included in Column O.
- Column N is an estimate of the time to fill the Storage volume for a given interval and is calculated as Column I divided by Column N.
- Columns P, Q, R and S are the weighted averages per interval of total interval inflow (as a check against interval Storage); river recharge; rainfall; and groundwater inflow.

Once the elevation interval Storage and inflows are calculated, these are combined as follows:

- Total Storage (Cell F49) is copied from cell I47.
- Total Groundwater is copied to cell F50 from cell S47.
- Total Rainwater is copied to cell F51 from cell R47.
- Total River Recharge is copied to cell F52 from cell Q47.
- Total Combined Recharge is the sum of Cells F50, F51, and F52 and should total cell F49.
- Total Days is copied to cell F54 from cell N47.
- Total Years is Cell F54/365.
- End Date is calculated from Cell F3 + CellF54.

Average daily rainfall (F9) was calculated from:

- Average annual Rainfall at Waihi = 2168 mm/yr
- Mine Lake Catchment =51 ha.

- Evaporation Loss coefficient = 0.9. Assumes bare, steep slopes. No allowance has been made for evaporation loss from the Mine Lake surface.

The groundwater rewatering model estimates are based on a specific set of values for a range of inputs, and the combination of these other effects is assessed in more detail in the Water Management Report (GHD, 2018). Start date, elevation difference, river recharge and rainfall are variables. Evaporation from the Martha Mine Lake surface is not included.

Columns	C	D	E	F	G	H	I	J	K	L	M
Rows											
2	Start Date			7/02/2035							
3	End Date			10/03/2041							
4											
5											
6	Start WL			500	m						
7	End WL			1104	m						
8	WL Change			604	m						
9								**Rewatering**	**Rainfall**	**Groundwater**	**Total Inflow**
10	Rainfall (m/d)			2724				**m3/d**	**m3/d**	**m3/d**	**m3/d**
11								**15000**	**2724**		
12	River Recharge (m/d)			15000		**Total Storage**	**Interval Volume**				
13						**m3/yr/m**	**m3/yr/int**				
14	m betwee	500	540	40	m	17,822	712,880	15,000	2,724	4,003	21,727
15	m betwee	540	554	14	m	19,419	271,869	15,000	2,724	3,985	21,709
16	m betwee	554	581	27	m	0	0	15,000	2,724	3,877	21,601
17	m betwee	581	609	28	m	35,132	983,692	15,000	2,724	3,770	21,494
18	m betwee	609	638	29	m	16,213	470,166	15,000	2,724	3,663	21,387
19	m betwee	638	649	11	m	53,563	589,195	15,000	2,724	3,556	21,280
20	m betwee	649	659	10	m	48,398	483,985	15,000	2,724	3,449	21,173
21	m betwee	659	667	8	m	75,377	603,014	15,000	2,724	3,342	21,066
22	m betwee	667	673	6	m	161,990	971,941	15,000	2,724	3,235	20,959
23	m betwee	673	683	10	m	177,633	1,776,331	15,000	2,724	3,127	20,851
24	m betwee	683	692	9	m	128,577	1,157,193	15,000	2,724	3,020	20,744
25	m betwee	692	710	18	m	97,242	1,750,360	15,000	2,724	2,913	20,637
26	m betwee	710	730	20	m	86,199	1,723,986	15,000	2,724	2,806	20,530
27	m betwee	730	744	14	m	183,626	2,570,770	15,000	2,724	2,699	20,423
28	m betwee	744	760	16	m	146,497	2,343,956	15,000	2,724	2,592	20,316
29	m betwee	760	802	42	m	45,292	1,902,244	15,000	2,724	2,684	20,408
30	m betwee	802	815	13	m	195,271	2,538,523	15,000	2,724	2,530	20,254
31	m betwee	815	817	2	m	754,603	1,509,207	15,000	2,724	2,294	20,018
32	m betwee	817	829	12	m	120,105	1,441,254	15,000	2,724	2,304	20,028
33	m betwee	829	849	20	m	114,751	2,295,022	15,000	2,724	2,291	20,015
34	m betwee	849	891	42	m	39,756	1,669,761	15,000	2,724	2,443	20,167
35	m betwee	891	899	8	m	233,919	1,871,350	15,000	2,724	1,936	19,660
36	m betwee	899	913	14	m	86,668	1,213,350	15,000	2,724	1,899	19,623
37	m betwee	913	931	18	m	109,065	1,963,178	15,000	2,724	1,839	19,563
38	m betwee	931	948	17	m	108,413	1,843,024	15,000	2,724	1,720	19,444
39	m betwee	948	954	6	m	233,906	1,403,438	15,000	2,724	1,484	19,208
40	m betwee	954	970	16	m	98,145	1,570,324	15,000	2,724	1,447	19,171
41	m betwee	970	978	8	m	192,200	1,537,601	15,000	2,724	1,246	18,970
42	m betwee	978	1020	42	m	146,967	6,172,610	15,000	2,724	1,374	19,098
43	m betwee	1020	1046	26	m	220,620	5,736,130	15,000	2,724	1,075	18,799
44	m betwee	1046	1057	11	m	279,698	3,076,674	15,000	2,724	877	18,601
45	m betwee	1057	1078	21	m	298,369	6,265,741	15,000	2,724	770	18,494
46	m betwee	1078	1104	26	m	375,823	9,771,400	15,000	2,724	663	18,387
47											
48	**Total Recovery**			**604**			**70,190,170**	**495,000**	**89,892**	**80,911**	**665,803**
49											
50	**Total Storage (m3)**			**70,190,170**							
51	**Total Groundwater (m3)**			**6,291,944**							
52	**Rainfall (m3)**			**9,820,513**							
53	**Total River Recharge (m3)**			**54,077,713**							
54	**Total Recharge**			**70,190,170**							

Figure B-5 Example of Rewatering Model Inputs and Outputs

APPENDIX C

Numerical Modelling

The changes in groundwater pressures as a result of lowering the groundwater level within the Martha vein system have been assessed using the 2 dimensional finite element model code SEEP/W.

In determining how to model the effects of dewatering the Martha Underground to 500 mRL, the observed response of veins within the Martha groundwater system (which does not include the separate Favona groundwater system) to dewatering at Martha Mine meant that 500 mRL water level in Martha would also develop in veins beneath Waihi, including Martha East ore bodies where mining the Correnso vein is currently taking place. Given the number of existing multi-level piezometers in East Waihi, it was considered that modelling that area would indicate the potential response in the Younger Volcanic rocks to the additional dewatering at that location and this would be representative of the effect on the younger volcanic rocks beneath much of the developed Waihi area. The model, as established, represents a cross-section across that area such that it extends over the deeper part of the younger volcanics and crosses a number of vein locations (Figure C-1).

Model Setup

Figure C-2 provides the model geometry. The model was constructed as four layers. From the surface these layers were: younger volcanic rocks; weathered andesite; relaxed andesite; and andesite. Veins were included as a vertical region(s). The zone of relaxed andesite was included to coincide with the zone of highest groundwater inflows recorded during historic mining.

Hydraulic Conductivity values used in the model are provide in Table C-1 together with hydraulic conductivity ratio's.

Table C1 Model Input Parameters

Material	Hydraulic Conductivity		Kh/Kv Ratio
Ignimbrite	0.0864	m/d	0.1
Weathered Andesite	0.00432	m/d	0.1
Higher K Andesite	0.0864	m/d	10
Lower K Andesite	0.00864	m/d	10
High K Vein	8.64	m/d	10

The model was run as a steady state model with constant heads in the veins set at 750 mRL (i.e. close to the existing dewatered level) and 500 mRL to enable comparison of effects. Calibration was made between the outputs for 750 mRL and piezometer data for September 2017 at P93 to P95. Figure C-3 provides this correlation and shows reasonable fit through the younger volcanic rocks but the gradients through the low permeability layer indicate that the low permeability layer in the model is thinner than present at P93 to P95.

Figure C-4 provides a graphic of the model showing the head distribution for dewatering a single vein to 750 mRL. Graphical comparisons of the modelled pressures at 750 mRL and 500 mRL are provided for vertical profiles at 300 m; 400 m and 500 m distance in Figures C-5; C-6; and C-7. These profiles extend from the ground surface to the base of the model at 400 mRL.

The slopes on the graphs initiating at the highest elevations to the first slope reversal represent the younger volcanic rock response. The second slope represents the response in the low permeability layer. The response in the andesite rocks is shown as the longer slopes. While pressure responses are indicated to develop in the andesite rock mass, as expected, pressure changes in the overlying younger volcanic rocks are shown to be minimal. This outcome is consistent with the longer term groundwater monitoring data.

Additional modelling was undertaken to examine the effects on the younger volcanic rocks from reducing the thickness of the low permeability layer and with multiple veins.

Modelling with reduced low permeability layer thickness did confirm that pressure reductions could develop at the base of the younger volcanic rocks and the hydrostatic gradients through the younger volcanic rocks could steepen as observed for Piezometer locations P101 and P102.

Modelling multiple veins resulted in a greater area of dewatering within the andesite rock mass but little difference in response in the overlying younger volcanic rocks.

In addition, models were run with the permeability of the higher K andesite also applied the Lower K andesite with little difference in outcome.

Based on the model results and interpretation of the long term monitoring data, dewatering of the Martha vein system from 750 mRL to 500 mRL is not expected to significantly affect groundwater pressures within the younger volcanic rocks and on this basis drainage effects in the shallow groundwater system are likely to be minimal.

The modelling demonstrates the probability of pressure reductions in the deeper andesite rocks. This will have been ongoing since the current phase of dewatering commenced.

Figure C-1 Location of Model Profile

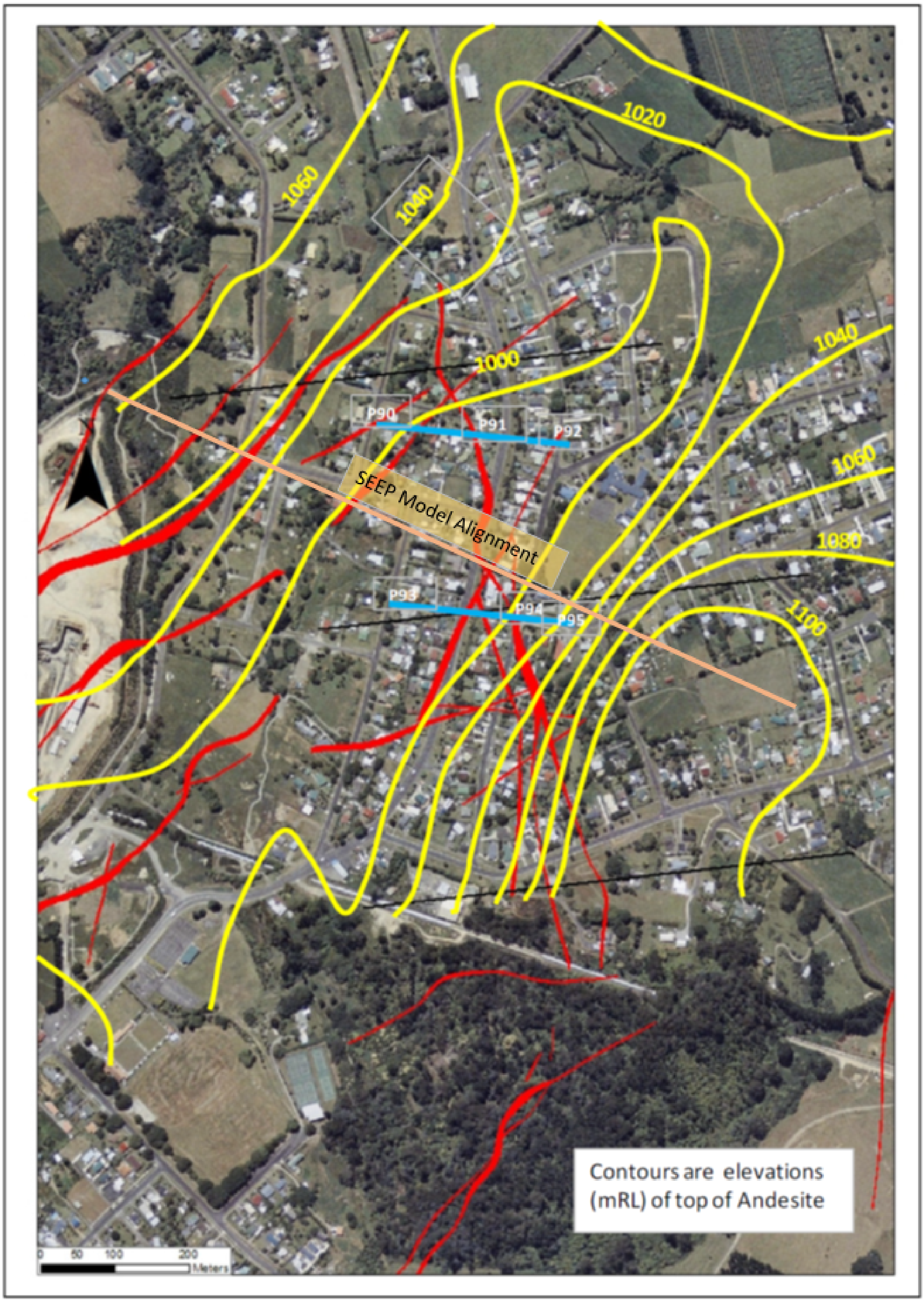

Figure C-2 Model Structure

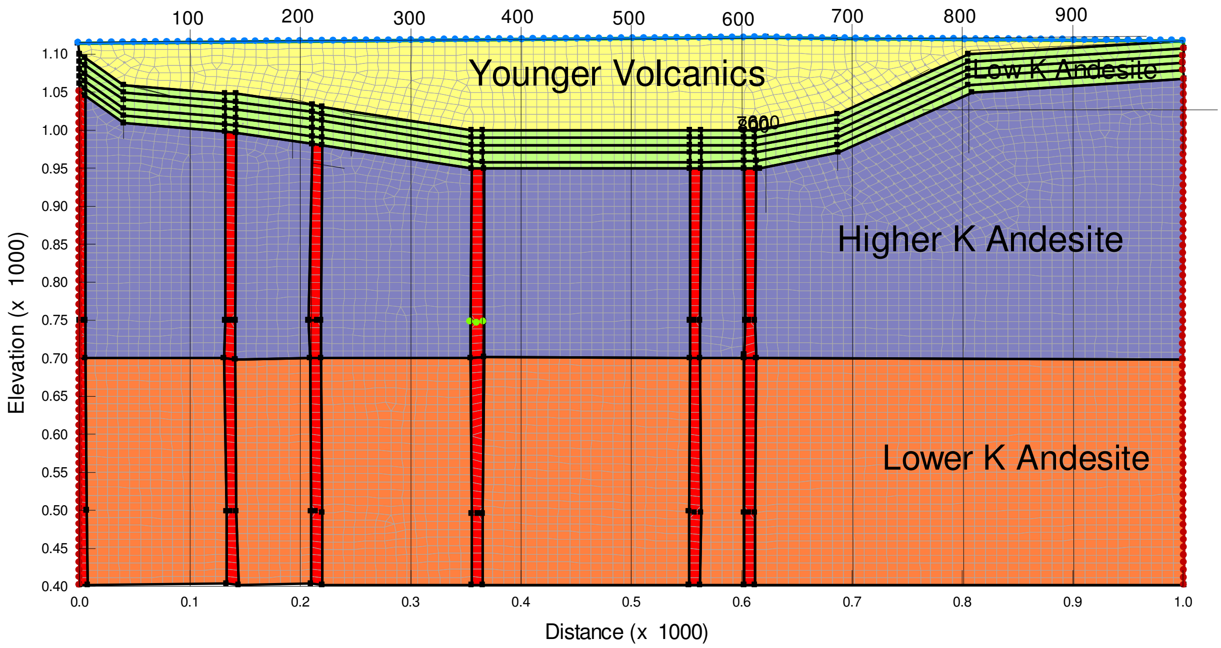

Figure C-3 Calibration to Pressure Profiles

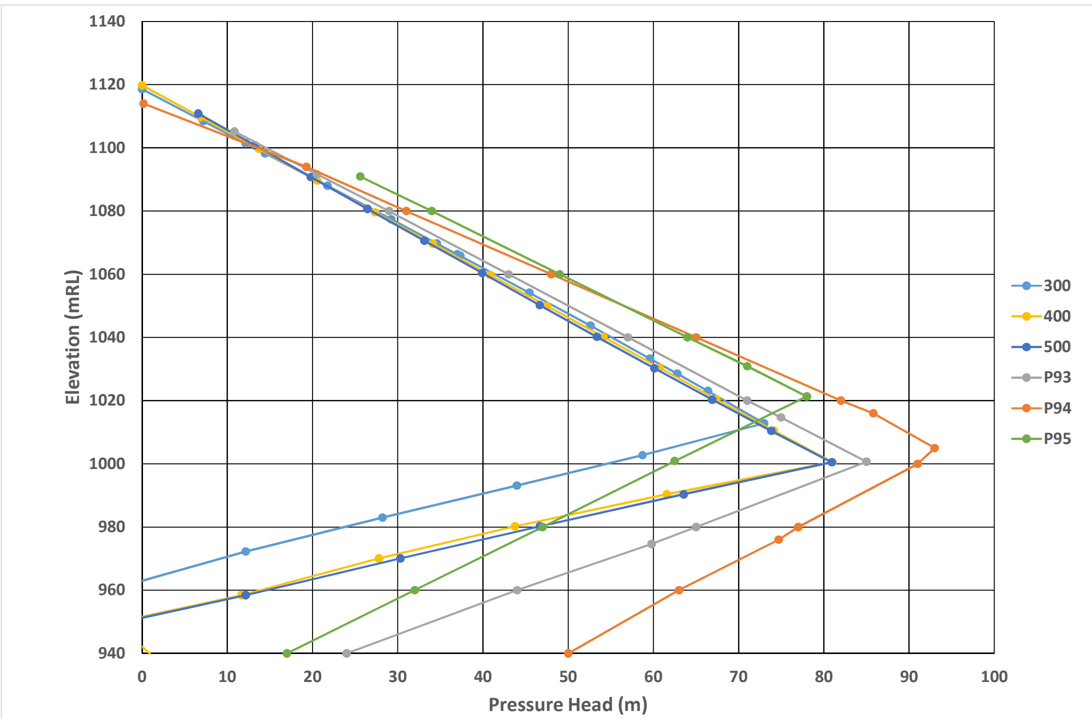

Figure C-4 Head Distribution– 750 mRL Dewatering in Single Vein

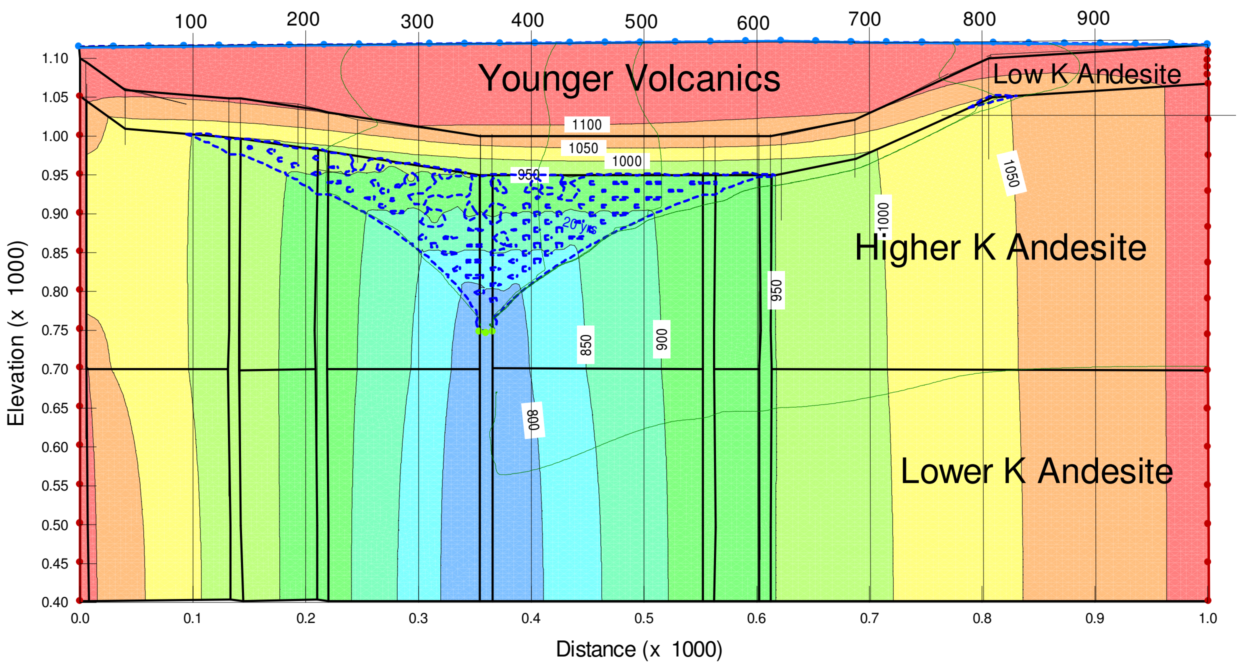

Figure C-5 Pressure Gradients - Single Vein Model - 300 m Distance

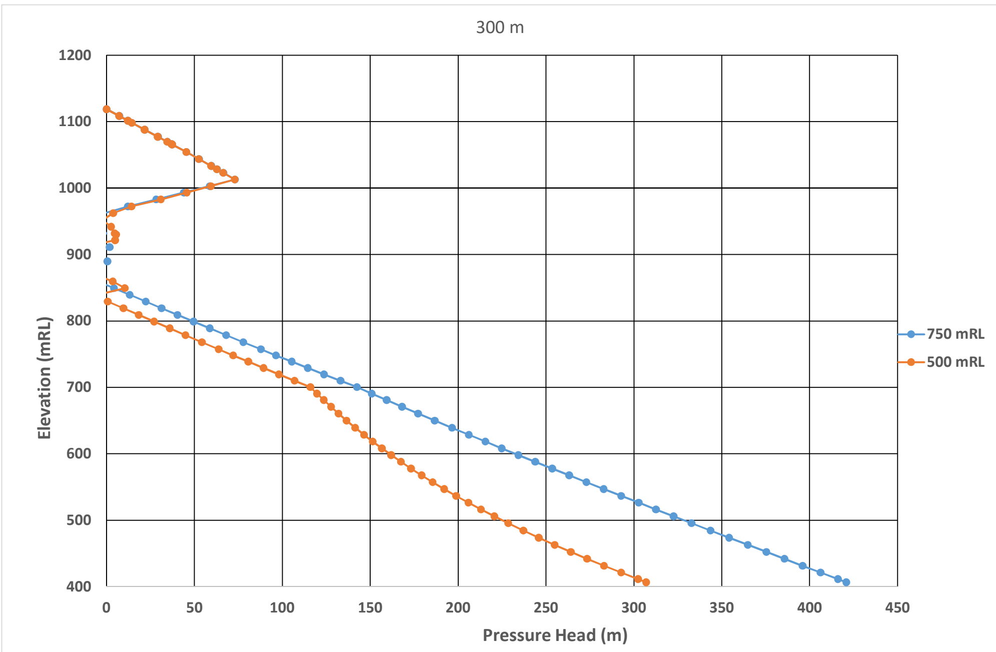

Figure C-6 Pressure Gradients - Single Vein Model - 400 m Distance

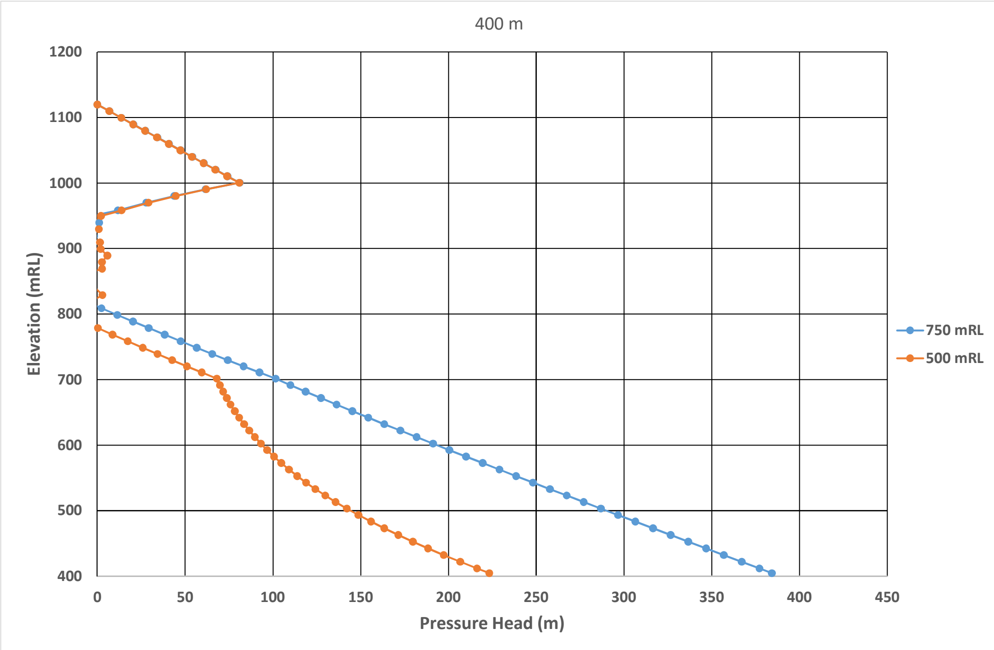

Figure C-7 Pressure Gradients - Single Vein Model - 500 m Distance