Union Hill Heritage Features Monitoring Plan

(Trio, & Correnso Mines)

February 2023

Department	Sustainability
Location/Site	Waihi

Approval Table

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1.1	05/02/2015	All		Review	Feb 2015
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3.0	01/02/2023	All		Suspension of monitoring	Feb 2023

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Foreword

Numerous heritage features in the Waihi Battery site on Union Hill have heritage classifications, and monitoring the impact of underground blasting on the features is a requirement of the Land Use Consents for the Trio and Correnso mines (operated by OceanaGold New Zealand Ltd (OGNZL)). The required monitoring of these features was undertaken in accordance with the approved Union Hill Heritage Features Monitoring Plan (Plan). Land Use Consent RC-15774 Condition 21A) allows refinements or changes in monitoring, subject to comment from Heritage New Zealand Pouhere Taonga (HNZPT) and written approval by the Manager – Planning and Environmental, Hauraki District Council (HDC). As the applicable blasting has now ceased, and monitoring has not detected any blasting-related impacts, the Plan has been revised and discontinuation of active monitoring has been agreed between OGNZL and the regulatory authorities.

The discussion of monitoring in this Plan serves to indicate the monitoring that has occurred in the past when applicable blasting was occurring, and the monitoring that would need to be re-initiated if blasting was to resume in the future.

1. Introduction

1.1 Background

The Waihi Battery site on Union Hill is a significant historical area dating from the earliest period of Waihi's mining history and is located at the northern end of Union Hill, south of Barry Road and the Walmsley Road Junction.

Many of the features of this historic site remain and have heritage classifications. Two features of special significance include the Air Agitation (Cyanide) Tanks and the Ore Roasting Kilns. The battery site is believed to have the potential to be developed into a tourist attraction that incorporates the early mining features.

In 2011 Newmont Waihi Gold (OGNZL predecessor) was granted a Land Use Consent (RC-15774) to extend the Favona underground operations into the Trio Project Area beneath Union Hill. The extension targeted the Union, Amaranth & Trio mineralised veins, collectively referred to as the Trio system. This was followed by another consent (LUSE-202.2012) granted in 2013 for the adjacent Correnso Mine. The proximity of these mines to the Union Hill historic features resulted in a Plan to monitor and, if necessary, mitigate any detrimental effects from mine blast vibration

The first period of production mining in Trio ceased on 24 November 2014. However, Trio and Correnso are hydraulicly linked, and the lowering of water levels for Correnso enabled deeper levels in Trio to be accessed. A second phase of Trio production was recommenced in 2019 and concluded in February 2020. The Correnso operation, which occurred subsequent to the first Trio phase and alongside the second Trio phase, has also completed its primary production phase, and only small-scale narrow-vein mining is being undertaken to extract remaining accessible ore.

Many monitoring requirements are only necessary if:

- stope blasting is resumed at Trio, or
- a blast-related 10mm/s PVS triggers at Trio Vent Shaft, or
- a blast-related extensometer trigger alert occurs.

Now that production mining of a magnitude capable of meeting any trigger requirements has concluded, and monitoring has been continued for some years after the primary Trio production, OGNZL has discontinued active monitoring of the heritage features. Physical attachments to heritage features (bunkers, extensometers, accelerometers) will remain in case future mining or monitoring is envisaged, but electronic monitoring and manual recording has ceased (as of February 2023).

1.2 Purpose

Prior to, and during, production mining within the Trio system the purpose of the Plan was to provide early warning of any potential adverse effects on the historic cyanide tanks and roasting kilns caused by the Trio mining operations, to enable the implementation of appropriate mitigation before damage relating to the operations occurs to the relics. Any required monitoring was designed to cover all the anticipated potential deleterious effects from blast-related vibration. Initially, the conditions of consent only applied to Trio mine-related effects and that OGNZL was required by its consents to implement mitigation to address those effects only[1]; the monitoring requirement was extended to apply to the Correnso operation in the unlikely event that blasting was modelled to generate 5mm/s at the heritage features.

Following production mining, the purpose of the monitoring was to provide continual notification of any potential adverse effects on the cyanide tanks and ore kilns due to both natural degradation and blast-related vibration, albeit in a more reduced programme. The potential for continuing environmental degradation is considered likely to far exceed that caused by the mining of the Trio ore bodies. That period of post mining monitoring has passed and monitoring of the heritage features in relation to the consent requirements has been discontinued.

Possible threats are seen to be:

Ore Kilns:
- Organic pressure on the brick rings
- Consolidation pressure on the rings from rain infiltration
- Erosion of the supporting ground surrounding the kiln bases from rain/groundwater erosion
- Consolidation pressure on the rings from blasting vibration
- “Walking” of unbounded bricks off the stacks from blasting vibration
- Gross movement of the underlying ground from collapse of the new or unknown old workings
- Vandalism/accidental mechanical damage

Cyanide Tanks:
- Foundation softening from production blast vibration
- Foundation softening through rain infiltration/groundwater
- Exacerbation of current mechanical and organic degradation of the tank/leg structures from vibration
- Extension of the existing cracking pattern due to ongoing carbonation (and associated cast-in steel degradation) and micro-organic growth
- Extension of the existing cracking pattern due to production blast vibration.
- Vandalism/accidental mechanical damage

1.3 Objectives

The key objective has been to monitor blast-related impacts on the heritage listed cyanide tanks and ore kilns in a manner that ensures early warning of any potential adverse effects, and subsequently allow for appropriate mitigation strategies to be implemented.

To achieve this objective, prior to and during applicable blasting, OGNZL has had to:

1. Comply with the resource consent conditions as they relate to Trio Mine Heritage Items Monitoring (refer to s2.0).

2. Provide continual monitoring of potential adverse effects on the historic cyanide tanks and roasting ore kilns from blast related vibration.

[1] OGNZL may choose to take remedial action to rectify environmental degradation of the relics but is not compelled to do so.

3. Design the monitoring plan in such a manner as to separate the cause of degradation, and to capture both foreseen and unforeseen factors.

4. Determine and respond appropriately and efficiently to any adverse effects identified.

1.4 Responsibilities

Table 1 summarises the primary responsibilities for heritage feature monitoring at Union Hill.

Table 1 - Responsibilities

Role	Responsibilities
Environmental Superintendent	▪ Review and approval of all heritage features monitoring plans and reports ▪ Management of initiation of response to trigger value exceedance
Senior Environmental Advisor	▪ Review of all heritage features monitoring plans and reports ▪ Review of monitoring results ▪ Review and implementation management of mitigation measures required
Environmental Advisor	▪ Authoring of monitoring plans and reports ▪ Monitoring of heritage features ▪ Implementation of any mitigation measures required

2. Hauraki District Council Conditions

2.1 Trio Mine Heritage Items Monitoring (RC-15774)

18) The consent holder shall undertake all reasonable measures to ensure that the operation of the Trio Underground Mine does not adversely affect the heritage items identified in the Proposed Hauraki District Plan (as at 06/11/2010) located on the surface of Union Hill.

19) To confirm compliance with Condition 18, the consent holder shall, prior to the commencement of this
consent, submit a Heritage Items Monitoring Plan for written approval by the Manager - Planning and Environmental Services. This Heritage Items Monitoring Plan shall be in accordance with the statement of objectives and approaches outlined in the report prepared by Dunning Thornton (Union Hill Cyanide Tanks and Roasting Kilns, Waihi, Condition Monitoring Plan, dated June 2011) and shall include the following matters:

a) A methodology to undertake a condition survey for the Cyanide Tanks and Ore Kilns to be carried out by a qualified structural engineer acceptable to the Manager, Planning and Environmental Services. As a minimum, this survey shall include:

- *Surveyed ground levels at the base of and in the vicinity of the structures.*
- *Descriptions of the structures including and identifying cracks and subsurface imperfections.*
- *A video and still photographic record of all existing built surfaces and defects*

The condition survey shall be undertaken prior to the exercise of this consent and be repeated at least annually during the exercise of this consent and the results reported to Hauraki District Council.

b) *A methodology to undertake ongoing monitoring of the structures to identify any cracking or other changes to the structures. This methodology shall:*

- *Be prepared by a suitably qualified independent expert acceptable to the Manager - Planning and Environmental Services. Monitoring methods may include glass slides, crack gauges, use of control survey points or a combination of these or such similar measures.*
- *Include requirements for regular inspection during production blasting (at a minimum of weekly intervals where electronic or other remote monitoring is not provided for).*
- *Provide for prompt reporting of any evidence of instability or damage to the structures to the Council.*

c) *Establish response triggers for vibration related effects. These response triggers shall be confirmed following completion of the baseline monitoring required by Condition 20. Responses will depend on the scale and nature of the monitored evidence of instability or damage to the structures and may include, but not be limited to, ongoing observation, investigation and reporting, changes to blasting practice, and cessation of blasting until Council approves recommencement. Responses to vibration induced damage to either the Ore Kilns or Cyanide Tanks shall specifically include the cessation of blasting operations until written approval from the Manager, Planning and Environmental Services, Hauraki District Council has been obtained for re-commencement. d) Blast vibration monitoring as required by Condition 11.*

e) *Reporting requirements for incidental and annual reports to Council.*

20) *The consent holder shall undertake a programme of baseline monitoring agreed in writing by the Council for a period of at least 3 months prior to the exercise of this consent to establish a baseline regarding the behaviour of the structures. The baseline monitoring programme shall be in accordance with the statement of objectives and approaches outlined in the report prepared by Dunning Thornton (Union Hill Cyanide Tanks and Roasting Kilns, Waihi, Condition Monitoring Plan, dated June 2011).*

21) *Following completion of the baseline monitoring required by condition 20, the consent holder shall review the Heritage Items Monitoring Plan and, in particular:*

- *Review the monitoring methodology*
- *Confirm or establish response triggers for vibration related effects where monitoring shows evidence of instability or damage to the structures*
- *Confirm or establish required actions where response triggers for vibration related effects are exceeded including procedures to repair any damage to heritage structures identified as having resulted from activities at the Trio Underground Mine*

The consent holder shall submit the reviewed Heritage Items Monitoring Plan for comment to the New Zealand Historic Places Trust (NZHPT) and provide a copy of such comments to Council.

The consent holder shall submit the reviewed Heritage Items Monitoring Plan for written approval by Council's Manager – Planning and Environmental Services. This consent shall not be exercised until the reviewed Heritage Items Monitoring Plan receives approval.

Following approval, the Heritage Items Monitoring Plan shall be implemented by the consent holder.

21A) *The Heritage Items Monitoring Plan may be reviewed and updated at any time to provide for improvements, refinements or changes in monitoring, to modify response triggers where indicated as required or reasonable by the monitoring data, or for any other reasonable purpose. The review may be initiated by either the consent holder or the Council, following consultation. The consent holder shall submit the reviewed Heritage Items Monitoring Plan, including comments from the NZHPT, for written approval by Council's Manager – Planning and Environmental Services. Following approval, the reviewed Heritage Items Monitoring Plan shall be implemented by the consent holder*

2.2 Correnso Mine Heritage Protection (LUSE-202.2012)

Heritage Protection

66 *Heritage Protection 66 Should modelling show that any activity authorised by this consent will generate ground vibration levels of 5mm/sec (instantaneous vector sum of velocity components) within 20m of the Union Hill Cyanide Tanks or Union Hill Ore Roasting Kilns, the Heritage Items Monitoring Plan as approved for the Trio Mine Land Use Consent and dated June 2012 (NOW-ENV-012- SYS-M44 Version 1) shall be activated and the baseline data updated (or continued if still operating) to the satisfaction of the Council.*

3. Monitoring

3.1 Overview

The below (s3.0 to S6.0) sets out the requirements for the Union Hill Features Monitoring Plan should production blasting be reinitiated within the Trio Mining License area. At the time of this dated version of the Monitoring Plan, all production blasting within the Trio Mining License area had ceased (since February 2020) and Correnso had moved to narrow vein mining; accordingly the monitoring regime has discontinued in accordance with the latest plan review as set out in Section 7.

3.2 Static Baseline and Condition Surveys

A well-documented baseline condition survey is essential before any monitoring regime commences, and to compare the results of each successive survey to identify any trends in deterioration.

An initial walkover survey was completed by consultants Dunning Thornton in June 2011 and included a thorough digital photographic survey of the tanks and kilns and a review of past reports on, and photographs of, the relics. While applicable blasting is occurring, the structures were to be re-inspected annually (Condition 19, RC-15774 Trio), and any material differences occurring between surveys noted, including an assessment of the likely cause for the change. The initial condition survey of the relics is attached as Appendix A of this Plan, including the photos of the relevant areas of the relics taken during that survey and that show the key features of interest that are the focus of the ongoing monitoring inspections. A full copy of all the photographs taken during the initial survey is contained on a DVD that is stored separately in the OceanaGold Moresby Avenue Administration Office. Copies of the DVD were provided to HDC and HNZPT.

Subsequent annual condition surveys would;

- Record (including updated photographs) and compare the relics' overall condition with that documented in the previous year's survey report.
- Compare the areas of specific interest as documented in the original condition survey (refer photographic record in Appendix B for the relevant areas).
- Identify any new areas of deterioration or damage that need to be added to the areas of specific interest

- Photograph and document any new areas of specific interest.
- Identify and record any areas of deterioration between successive condition surveys as well as the most likely cause(s) for the observed change(s).
- Where the cause is identified as Trio production blast vibration, recommend appropriate mitigation action(s) – refer s6.0.

3.3 Baseline Monitoring

Baseline monitoring covered the period between completion of the initial static baseline survey and the start of production blasting at Trio. The objective of baseline monitoring was to establish "normal" patterns of movement of the ground, e.g. to measure the effects of the "cyclical" pattern of wetting and drying, along with those associated with temperature changes, to establish the "background" natural degradation. The ground and relics movement during the life of mine can be assessed against this baseline, any movement beyond that considered to be within the "normal" range of movements may be related to the mining activity being potentially associated with mining activity at Trio.

Baseline monitoring comprised all of the activities described below in s3.4 - Routine Monitoring Methods. As outlined in s3.4, reviews of the real-time monitoring data and visual surveys have been carried out monthly.

The conditions of consent stipulated a minimum period for baseline monitoring of three months (condition 20) prior to the start of production blasting.

3.4 Routine Monitoring Methods

"Indicator bricks" and points of interest within the kilns were selected specifically to allow simple monitoring of overall trends from a few points. These points were either fitted with extensometers (2) to provide real-time monitoring or are part of the photographic record in Appendix B, the conditions of which are to be compared with the original and subsequent photos to identify any trends.

3.4.1 Kilns

The layout and numbering of the kilns is shown below in Figure 1.

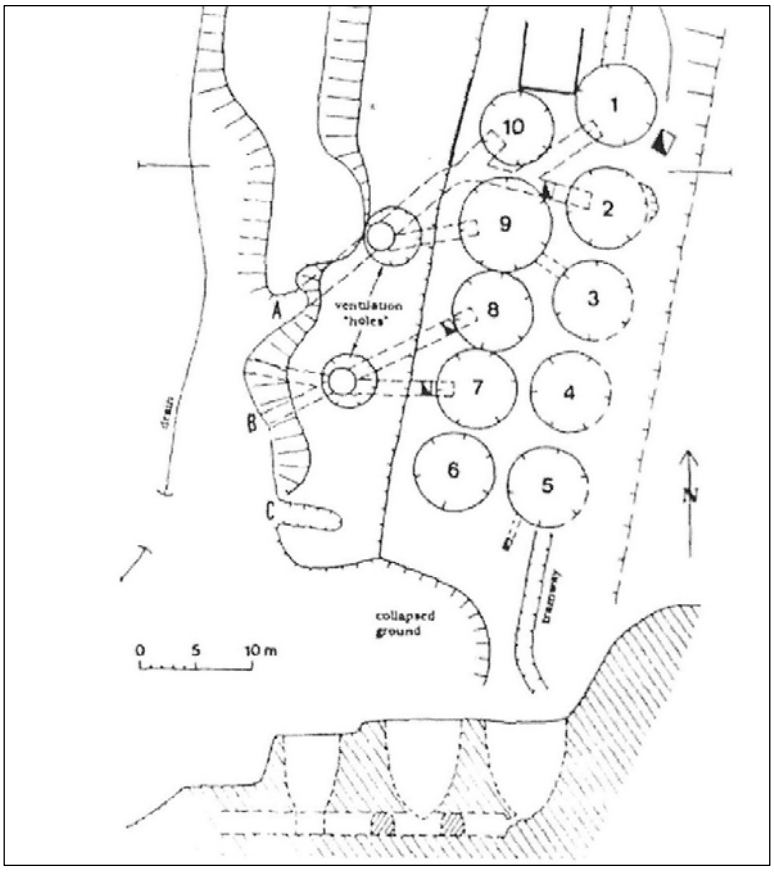


Figure 1. Layout and Numbering of Union Hill Kilns

Visual Monitoring

Visual monitoring was carried out monthly during the baseline monitoring. Upon the commencement of production blasting on 27 June 2012, monitoring began weekly. Monitoring frequency was returned to monthly following approval by HDC in 2015. The visual record prepared by Dunning Thornton referenced above (and provided in Appendix B) provided a reference point for the observations and enabled the observer to note any minor changes as they occur. In general, the visual monitoring consisted of the following:

Item	Purpose
Kilns 9 & 7: Monitoring of two “indicator areas” one driven by organic pressure (roots) and one without signs of vegetation locally at	Indication of degree of organic pressure versus Trio blast vibration related movement.
Kiln 5: Monitoring of one “indicator area” without signs of vegetation locally where the vent / loading area comes into the kiln.	Indication of any dislodging of stones caused by Trio blast vibration.
Overall crack pattern and condition	Overall weather / degradation and any vandalism.

Real-time Monitoring

Prior to the completion of the baseline monitoring programme, real-time monitoring comprising two extensometers mounted in Kiln 10 were installed for assessing movement, consolidation, spreading and/or earth volume changes associated with the kiln wall. The real-time data was transmitted for logging and interpretation by the Environmental Advisor.

3.4.2 Tanks

The layout and numbering of the tanks is shown in Figure 2 below.

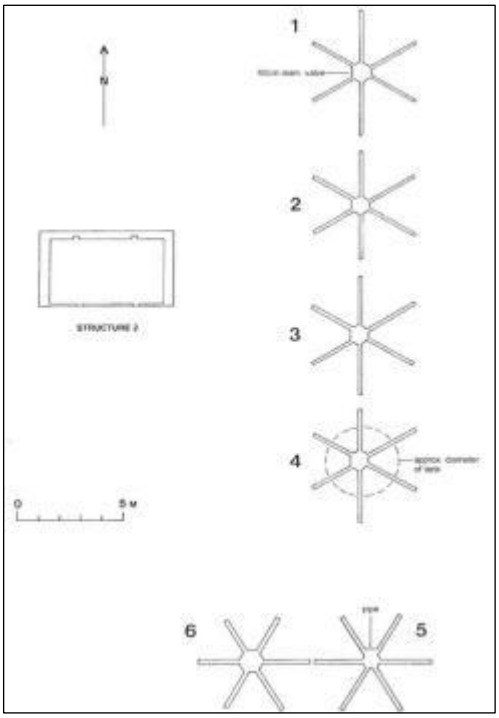


Figure 2. Layout and Numbering of Union Hill tanks

Visual Monitoring

Visual monitoring was carried out monthly during the baseline monitoring. Upon the commencement of production blasting on 27 June 2012, monitoring began weekly. Monitoring frequency was returned to monthly following approval by HDC in 2015 (Appendix E).

Item	Purpose
Tank 1: Visual monitoring of damage to the top rim	Detection of cracking growth from existing upper tank defect.
Tank 1: Visual monitoring of existing spalling on south leg	Benchmarking of continued degradation of existing defects.
Tank 2: Visual monitoring of leakage –changes in flow/mould growth.	Detection of any change in tank micro-cracking
Tank 3: Vernier Calliper monitoring of pins	Detection of active movement on an existing
Visual monitoring of pipe positions on the top	Detection of walking of loose pipes resulting

Real-time Monitoring

Real-time monitoring for the cyanide tanks consisted of the following:

Item	Purpose
Tank 5: Extensometer fitted across the crack on the damaged (SE) buttress.	Detection of sufficient tank resonance / movement that is causing degradation at the structure's weak point.
Tank 4: Should the extensometer on Tank 5 be triggered, accelerometer analysis of Tank 4 is available for analysis to investigate potential causes and effects.	Examine recent pattern of accelerometer 'V' axes. In addition, possible analysis of oscillation time after a shock more than 1/10 of the decay period.

Results from real-time monitoring were transmitted to an electronic database throughout the Trio life of mine. The database was interrogated by an Environmental Advisor each month, and the data reviewed and interpreted to determine any trends that may indicate the potential onset of damage to the relics.

If a trigger level was exceeded, a notice of the exceedance was automatically emailed to the Environmental Department. Blast times were correlated to instrumentation movement to determine if the possible cause was mine related.

Survey Monitoring

The OGNZL Surveyor conducted a quarterly physical survey of the cyanide tanks during production mining. Results are kept an electronic database throughout the Trio life of mine. The database was interrogated by an Environmental Advisor each quarter and the data reviewed and interpreted to determine any trends in movement of the relics.

3.4.3 Other Features

In addition to the relics specifically mentioned in the conditions of the Land Use Consent, Dunning Thornton has identified two other features on Union Hill that it considers worthy of routine visual monitoring; the open cut (or collapse) features over the historic Union Mine workings; and the stone walls of the battery site.

Historic Union Workings

A series of surface depressions exist to the east of the kilns. These have been interpreted as either small open cut mines, as identified by the archival plans, but may also represent the surface expression of collapses into the old working (the features directly overlie a portion of the historic Union Mine workings).

Movement of the surface features above the historic Union underground workings is unlikely to directly affect the stability of the roasting kilns and cyanide tanks but could be a precursor to stability issues that could potentially affect Trio. Monthly visual inspections of the features were therefore primarily required for worker safety. However, any stability issues within the Trio mine could have the potential to affect the Union Hill relics, and any observed changes of the collapse features were to initiate a full investigation into the stability of both the historic Union workings and the Trio Mine.

Item	Purpose
Visual survey of the depressions over the old workings	Risk of gross failure related to mining propagating towards the heritage site.

Battery Walls

For the most part, the relics associated with the battery are mass concrete (machinery foundations etc.) and are immune to any blast-related vibration effects. However, there is a masonry wall that separated the upper and lower stampers that is more susceptible to damage than the mass concrete and is deteriorating due to natural degradation, visitor climbing, and vegetation (refer Figure 3 for location).

As with the other relics, the risk to the wall from blast vibrations is minimal and ongoing natural degradation and vegetation are the main threats to the wall's stability. However, monitoring of the wall for block movement was desirable, and monthly visual inspections of the wall were therefore included.

Item	Purpose
North west wall: Monitoring of three "indicator areas" at risk of stone earth or brick movement.	Indication of stone block movement and its likely cause.
South west wall: Monitoring of three "indicator areas" at risk of stone earth or brick movement.	Indication of stone block movement and its likely cause.

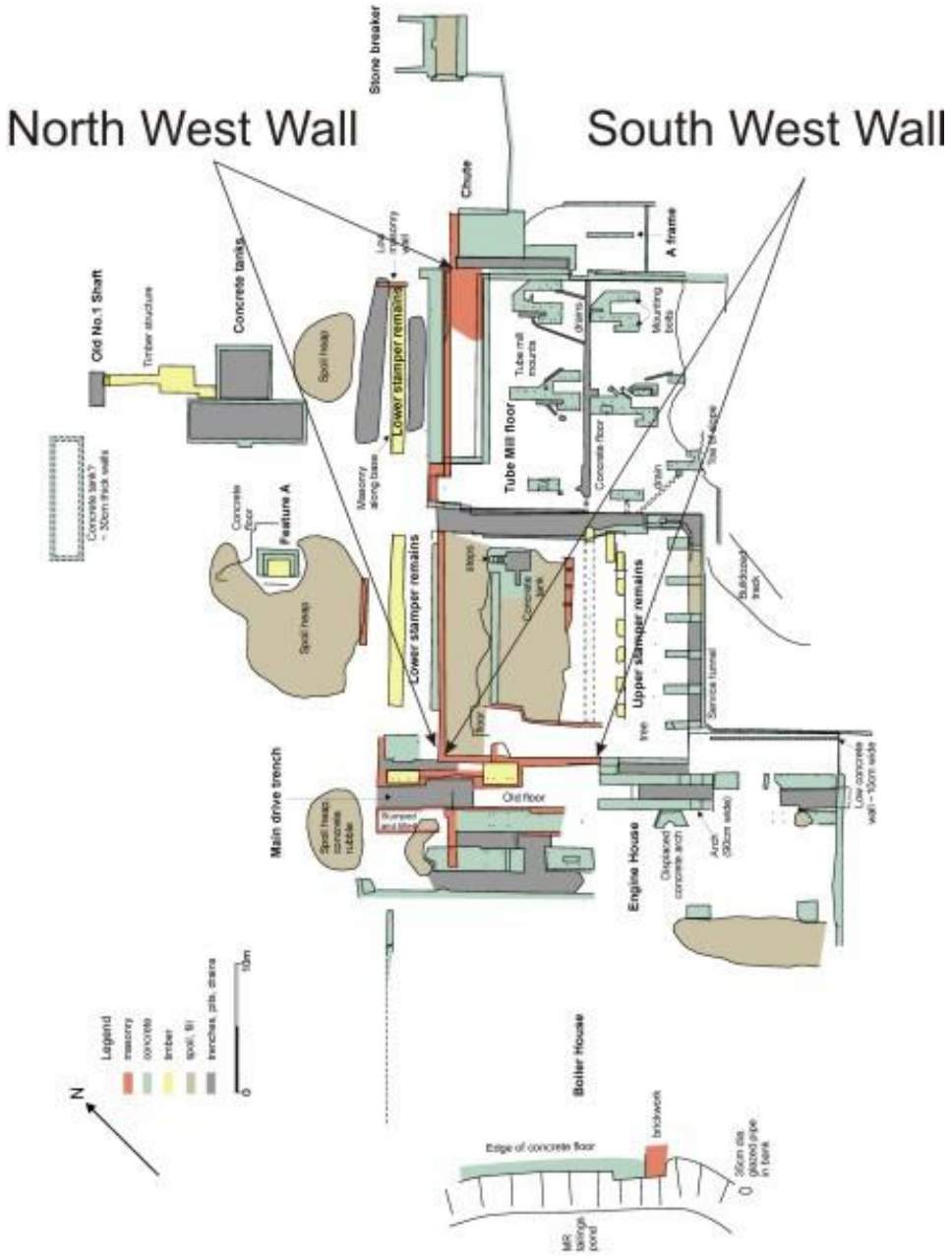


Figure 3. Location of Battery Walls

3.4.4 Weather

The data produced by the OGNZL meteorological station is maintained in an electronic database and has been throughout the Trio life of mine. The data on weather and rainfall events allows for changes in relics' condition to be related to changes in weather, especially rainfall events.

4. Monitoring Summary

Table 1 below summarises the monitoring that has been carried out as well as those responsible for its completion.

Table 1. Frequency & Responsibility for Monitoring

Type of Monitoring	Responsible Person
Monthly review of Real-time monitoring data	OGNZL Environmental Advisor
Annual Inspection	Engineer as approved by council
Incidental reporting of a yellow or red trigger alert (within 2 weeks) to council	OGNZL

Checklists to be used to guide and complete the monthly monitoring inspections, along with the comparative condition photographs from the initial condition survey, are provided in Appendix B. A copy of the checklists was taken and completed during each monthly inspection and review of the real-time monitoring data, and an updated photographic record made of the inspection areas of interest, as detailed in the initial condition survey.

5. Triggers

A system of warning trigger values was developed at the end of the baseline monitoring period and included in the Plan that applied throughout the operational monitoring period over the life of mine. The “traffic light” concept applied to the trigger value system such that;

- A “Green” condition existed for any observation or measurement that remains within the stated trigger levels.
- An “Orange” condition occurred when any observation or measurement achieves or exceeds a stated trigger level.
- With the exception of Tank 2, a “Red” condition occurred when an observation or measurement exceeds a value that is three times the stated trigger level. For tank 2 a “Red” condition occurred when an observation or measurement exceeds a value that was 5 times the stated trigger level.

If a trigger level was exceeded and an orange condition occurs, the triggered observation or measurement was immediately (within 2 days) investigated by OGNZL staff. Should the Trio mining activity be considered a likely or possible cause, an appropriately qualified structural engineer would investigate to determine the likely cause(s) and the engineer would recommend appropriate mitigation to ensure the on-going protection of the relic against the effects of the mining activity (refer s6.0 for a range of possible mitigation actions).

If a red condition occurred, mining operations (production blasts) would cease immediately until an investigation by an appropriately qualified structural engineer was completed. Production blasting could only restart if, following the investigation, the engineer’s conclusions were that the observed/measured effect could be discounted as being related to the mining activities, or following the implementation of the engineer’s recommended mitigation actions to safeguard the relics from the ongoing mining activity. Written approval was required from the Council before mining operations could recommence.

Table 2 provides revised trigger levels.

Table 2. Revised Trigger Levels

Item	Trigger Level
Kilns	
Visual Monitoring – Kilns 9 & 7	
Identification of two "indicator areas" (one driven by organic pressure (roots) and one without signs of vegetation locally) at risk of stone earth or brick movement.	Any conspicuous failure of earth or brick
Identification of one "indicator area" (one without signs of vegetation locally) where the vent / loading area comes into the kiln. (Kiln 5)	Any significant conspicuous failure of earth or brick
Overall crack pattern and condition.	Lengthwise growth of cracks more than 25mm
Visual survey of old Union Workings.	Any signs of slumping showing through the current vegetation.
Real-time Monitoring – Kiln 10	
Extensometer fitted across one crack in the vertical mortar end joint in the brick rings[4].	Greater than 0.25mm permanent movement over a 3-day period
Extensometer fitted across one open horizontal crack in the brick rings at the perimeter.	Greater than 1.0mm permanent movement over a 3-day period
Tanks	
Visual Monitoring	
Tank 1: Visual monitoring of damage to rim.	Conspicuous cracking growth.
Tank 2: Visual monitoring of leakage, changes in flow/mould growth.	New leaks or unusual changes in wet/mould days.
Tank 3: Vernier Calliper monitoring of pins installed across existing crack in leg.	Greater than 0.5mm movement (consecutively).
Real-time Monitoring	
Tank 5: Extensometer fitted across the crack in the damaged tank leg buttress.	Greater than 0.25mm permanent movement over a 3-day period.
Tank 4: Accelerometers fitted at the base of a tank leg and on an upper level of the tank	Subsequent to the extensometers on Tank 5 or Kilns triggering, due to blast related vibration, data from the accelerometers would be examined to provide analysis of tank behaviour.

6. Mitigation Actions

Mitigation actions were not required for organic/environmental degradation.

For causes associated with the mining activity, the selected mitigation action would depend on such considerations as the cause, magnitude, and timing of the effect. The following outlines some of the major mitigation options that could be implemented.

For the kilns, temporary pegging of loose bricks around the edges to the soil behind could be considered. Work shoring the base of the kilns would have to be considered on an individual basis and would generally comprise the use of timbers similar to the construction methods of the day.

For the tanks, epoxy injection of the critical cracks around the fractured buttress could be considered if they were accelerating. Monitoring of the remainder of cracks was expected to be the best option as further opening of these cracks was unlikely to lead to destabilisation, but again epoxy injection could be considered.

Other mitigation actions could include;

- Cessation of production blasts (under orange condition if advised following inspection; expected to be used in conjunction with other actions that would allow blasting to recommence).
- Cessation of all blasts (ditto).
- Adjusting the production blast design, especially in the higher levels of the mine closest to the relics.
- Providing temporary support, e.g. for the remaining life of mine.
- Installing permanent support or undertaking minor reconstruction / repair works.
- Detailed investigations of the historic workings (in the case of observed settlement into the old Union workings, as outlined in evidence at the council hearing for Trio).
- Changes to the monitoring plan to the trigger levels and possibly to the monitoring locations.
- Other actions as deemed necessary and appropriate following inspection.

7. Description of Revised Plan Updates

The initial version of this Plan provided the Standard Operating Procedure for the baseline survey required under condition 20 of the land use consent for the Trio project. Prior to the date of the first production blast, an updated version of the Plan was submitted to HDC for its review and approval. A copy of the draft plan was provided to HPT for comment.

Further updates to the Plan were provided for by condition 21A of the land use consent. The Plan submitted to HDC prior to the start of production blasting provided for a period of relatively intense monitoring. However, as professional advice indicated that Trio blasting had no material effect on the structural integrity of the relics, it was considered reasonable that the frequency of monitoring be reduced in subsequent plans.

7.1.1 2014 Monitoring Plan Review

The Union Hill Heritage Features Monitoring Plan 2014 (dated February 2015) included some changes to the original draft monitoring plan submitted, all of which have been subsequently made to this Plan. Changes requested included:

- A reduction in the frequency of visual inspections from weekly to monthly.
- The removal of the accelerometer trigger limits. The accelerometers would continue operating and the data recorded, but analysis would only occur if other monitoring (either extensometer data or visual monitoring) triggered an investigation.
- To rely on the extensometer, pin displacement information and visual survey data to provide triggers for response.

- Some changes in the visual monitoring trigger levels, however the real-time monitoring trigger levels remained as they were. Explanation of the proposed changes are outlined in Table 3.

Table 3. Explanation of visual monitoring changes

Visual monitoring	Initial plan text	Updated plan text	Explanation for change
Kilns 9 & 7	Movement more than 7mm. Increase in slip area to kiln 7 by 100mm in any direction	Any conspicuous failure of earth or brick	To measure movement of 7mm or 100mm would require personnel on harness to descend into the kilns each survey. Aside from the hazardous nature of this activity, the human contact will inevitably damage the kilns. Looking for conspicuous movement was reasonable, practical, and less damaging.
Kiln 5	Indication of any dislodging of stones caused by Trio blast vibration.	Any conspicuous failure of earth or brick	Difficult to determine if any dislodged stones were caused by blast vibration. Because the cause cannot necessarily be definitive, the text change would relate to any earth or brick failure.
Tank 1	Detection of 25mm cracking growth from existing upper tank defect	Conspicuous cracking growth	The upper tank defect could not be measured from ground level. The defect is 15m above the monitoring point. The 25mm measure was impractical.
Tank 2	New leaks or increased wet/mould area greater than 50mm if no rain in previous 7 days.	New leaks or unusual changes in wet/mould	If visual surveys were monthly, the previous 7-day comparison is impractical. Also, this area could not be measured from the ground and would require a ladder/working at height.

This revised plan was approved by HDC on 5 March 2015 (Appendix E).

7.1.2 2017 Monitoring Plan Review

As set out in the previous Union Hill Features Monitoring Plan, approved by HDC on 5 March 2015, upon cessation of production blasting in the Trio mining license, visual monitoring surveys and tank physical surveying were discontinued. Electronic instrumentation (Trio Vent Shaft vibration monitor, Kiln and Tank extensometers, Figure 4) remained in place. Data was analysed should the Correnso mining operation trigger an extensometer or a 10mm/s PVS at the Trio Vent Shaft (the latter was recommended by Heilig and Associates (Appendix F)).

Figure 4. Heritage feature locations, plus Trio Vent Shaft

The Trio Vent shaft vibration monitor continued to operate and reported to council via Blasthub e-mails, either during the production blasting period of Correnso or until such a time council was satisfied that excessive blast vibration was not affecting the heritage features.

An annual monitoring report continued to be provided in an abbreviated form. An annual condition report of the heritage items was to be undertaken and included in the annual monitoring report if:

- stope blasting was resumed at Trio, or
- a blast-related 10mm/s PVS triggers at Trio Vent Shaft, or
- a blast-related extensometer trigger alert occurs.

If either of the latter two points occur, an incidental report was to be submitted to council within two weeks.

Additionally, Condition 66 of HDC Correnso consent LUC 202.2012 stated that if any modelled blast of 5mm/s PVS or greater within 20m of the Union Hill Cyanide Tanks or Union Hill Ore Roasting Kilns occurred; the Heritage Items Monitoring Plan was to be activated. Modelling was conducted indicating the maximum Correnso blast vibration to be 2.2mm/s at the Kilns and 2.7 mm/s at the Tanks (Appendix G). Any Correnso related blast vibration data recorded at Trio Vent Shaft was to be included in the annual monitoring report.

Should production blasting be reinitiated within the Trio Mining License area, the Union Hill Features Monitoring Plan would be reinstated, and all associated surveys and electronic data analysis would recommence.

7.1.3 2019 Monitoring Plan Review

The interconnected groundwater system between Correnso and Trio meant that dewatering of Correnso 'Deeps' allowed access to previously inaccessible ore in the deeper zones of Trio. OceanaGold proposed to reinstate Trio production mining in 2019; as such the Heritage Feature Monitoring Plan was revised and reinitiated.

7.1.4 2023 Monitoring Plan Review

Monitoring of Trio and Correnso production mining has shown the mining has had no detectable effect on the Union Hill heritage features. No triggers have been initiated in response to blast vibration, and inspections and monitoring have shown that the primary risk to the heritage features continues to be environmental degradation and surface human impacts (visitors and vandalism). With Trio production mining again in abeyance since early 2020 and Correnso mining effectively concluded (there is limited potential for small-scale narrow-vein mining), OGNZL will remove electronic monitoring equipment and discontinue all active monitoring. Fixtures (bunkers, extensometers, and accelerometers) attached to the heritage features themselves will remain, in case monitoring is required to be reinitiated in the future. In the event that monitoring is again required, it is anticipated that this monitoring would be in accordance with the 2019 Plan review (and subject to HDC approval).

With no active monitoring ongoing, reporting will also be discontinued. Reporting will correspondingly be reinstated if monitoring is reinstated (should this be required by mining resuming in Trio, or high modelled vibration levels in Correnso). As per the monitoring, this reporting would also likely be in line with that of the 2019 approved plan.

8. Hauraki District Council Reporting

Initial Condition Report	Contained (Appendix A)
Initial Photographic Record	Provided (DVD)
Initial Tank Survey	Contained (Appendix C)
Base Data interpretation and conclusions	Contained (Dunning Thornton recommendations (Appendix D)).
Incidental reporting of a yellow or red trigger alert (within 2 weeks) to council	OGNZL
Annual Condition Report	By HDC approved engineer
Annual Monitoring Report	OGNZL

9. Abbreviations

Term	Description
OGNZL	OceanaGold (New Zealand) Ltd
NWG	Newmont Waihi Gold
HDC	Hauraki District Council
HNZPT	Heritage New Zealand Pouhere Taonga

APPENDIX A – INITIAL CONDITION SURVEY

INITIAL CONDITION SURVEY

Introduction

The initial condition survey was conducted in several phases.

- In April 2011, Dunning Thornton completed an initial survey, the purpose of which was to update its earlier survey of 2004 and included establishing the best means of monitoring the Union Hill relics. The outcomes of this survey were reported in a draft monitoring plan (Dunning Thornton, Union Hill Cyanide Tanks and Roasting Kilns, Waihi, Condition Monitoring Plan. June 2011).

- On 31 May 2011, Dunning Thornton completed the initial condition survey by photographing the complete outside surfaces of all six cyanide tanks and of as much of the kilns as was safely accessible and visible, including close-up photographs of elements of each kiln.

- Additional photographs of the battery site walls and of the collapse features over the old Union workings were taken by Mark Samson on 18 November 2011.

- NWG completed the initial survey of the position and orientation of each of the cyanide tanks on 6 December 2011.

For the most part, the initial condition survey relies on the photographic record and initial survey. The following descriptions have been extracted from the draft Dunning Thornton condition monitoring plan (June 2011) and a later memo (22 September 2011) in which Dunning Thornton detailed the specific areas of the relics that are the subject of this monitoring plan and which referenced the relevant photos to be used for comparative purposes in the visual inspections.

Current Condition of Union Hill Features

Kilns

The kilns are in poor condition with only kilns 1 and 10 having intact brick linings. The remaining kilns are more akin to holes in the ground.

Detail of the condition of the kilns is shown in the photographs on the following pages.

Cyanide Tanks

The tanks are in good condition for their age although there are some areas of spalling caused by corrosion of the underlying reinforcement in the concrete, predominantly around the base of the tanks. This is considered to be fairly benign considering the age of the structures.

Tank 5 has sustained significant physical damage to one buttress and there are loose objects (pipes and loose sections of plaster) sitting on top of the tanks.

Detail of the condition of the cyanide tanks is shown in the photographs in the following pages.

Item: Kilns	Location / Status
Kiln 10: Extensometer fitted across one crack in vertical mortar end joint in the brick rings – real time monitoring	
	
	
Kiln 10: Extensometer fitted across one open horizontal crack in the brick rings at the perimeter – real time monitoring	

Kiln 9: Identification of two “indicator areas” (one driven by organic pressure (roots) and one without signs of vegetation locally) at risk of stone earth or brick movement – visual monitoring	
Kiln 7: Identification of two “indicator areas” (one driven by organic pressure (roots) and one without signs of vegetation locally) at risk of stone earth or brick movement – visual monitoring	
Kiln 7: Identification of two “indicator areas” (one driven by organic pressure (roots) and one without signs of vegetation locally) at risk of stone earth or brick movement – visual monitoring	

Kiln 5: Identification of one “indicator area” (one without signs of vegetation locally) where the vent / loading area comes into a kiln – visual monitoring	
	
	
	

Item	Location / Status
Tanks	
Accelerometer on ground at Tank Four – real time monitoring	
Accelerometer on top Tank Four – real time monitoring	
Extensometer fitted across the crack in the Tank 5 damaged tank leg buttress – real time monitoring	

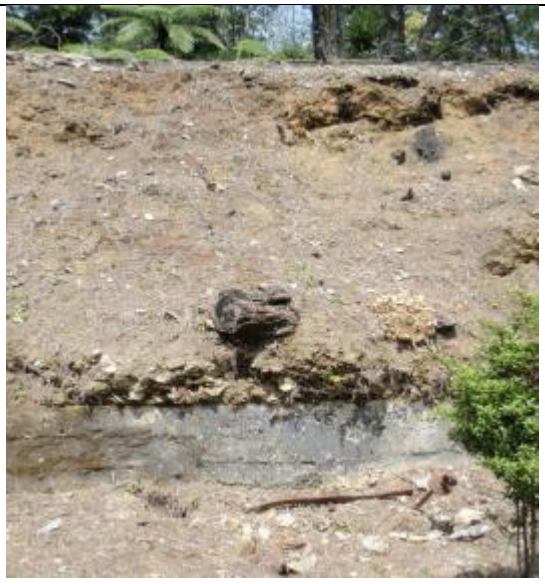
Visual Monitoring of existing spalling from continued corrosion of reinforcement in Tank One South Leg	
	
Visual monitoring of leakage from Tank 2 – changes in flow / mould growth	
	

Vernier Calliper monitoring of pins installed across the existing crack in Tank 3 Leg	
General - Pipes on Top of Tanks	

Visual monitoring of damage to Tank 1 Rim – Annual Inspection	
	
	
	
	
	
	

Visual monitoring of pipe positions atop tanks – Annual Inspection	
	
	
	
	
	
	

Visual monitoring Battery Site Walls	
Area1 South West Wall (SW1)	
Area 2 South West Wall (SW2)	
	

Area 1 North West Wall (NW1)	
Area 2 North West Wall (NW2)	
Area 3 North West Wall (NW3)	

APPENDIX B – ROUTINE MONITORING CHECKLISTS

Monitor's Name: _____ **Date:** _____

Tanks	Observation	Y	N	Comments Attach any relevant information including photographs
Tank 1: Visual monitoring of damage to rim Photo (1): Tank 1 rim	Detection of cracking growth from existing upper tank defect. Any fresh surfaces exposed or signs of fallen concrete fragments?			
Tank 1: Visual monitoring of existing spalling on north leg Photo (2): Tank 1 North Leg & spalling detail Visual monitoring of existing spalling on south leg Photo (2): Tank 1 Base 6 & detail	New crack area outside existing spalling Change in shape of existing spalling Signs of new spalling occurring			
Tank 2: Visual monitoring of leakage, changes in flow/mould growth Photo (2): Tank 2 Base 3 & leak detail	New leaks			
Tank 3: Digital calliper monitoring of pins installed across existing crack in leg Photo (2): Tank 3 Base 3 & pins detail	Greater than 0.5mm movement. Baseline: Between pins A and B Between pins A and C Between pins B and C			
General: Visual monitoring of pipe positions on top of the tanks Photo (1): Pipes on top of tanks	Detection of 'walking' of loose pipes			
New photography for comparison with previous	Tank 1 north leg Tank 1 south leg Tank 2 leaks Tank 3 pins			

Kilns:	**Observation**	**Y**	**N**	**Comments** **Attach any relevant information including photographs**
Kiln 9 & Kiln 7: Monitoring of two indicator areas – organic pressure – earth or brick movement Photo (2) Kiln 9 & 7	Vegetation missing / fresh deterioration Signs of tampering / vandalism			
Kiln 5: Monitoring of one indicator area where vent / loading area comes into a kiln. Photo (1) Kiln 5	Vegetation missing / fresh deterioration Signs of tampering / vandalism			
Visual survey of old Union Workings Photo if disturbance	Identification of visual disturbance of vegetation (rather than by reference to a previous survey)			
New photography for comparison with previous inspection	Kiln 5 Kiln 7 Kiln 9			
Weather conditions week preceding inspection: [Total rain (mm); # hours of rain (hrs); Max & Mean wind speed (m/s)]				
Weather conditions on the day of inspection:				
Battery photos: SW wall 3 photos: SW1 wall, measure and photograph cracks SW2 & SW3 NW3 wall 3 photos: NW3 north, middle & south, NW2 wall gap 2 photos: NW2 slab & NW2 gap NW1 wall 4 photos: NW1 north, middle nth, middle south, south.				

Monthly Review of Real-time Monitoring data – Environmental Officer

Date of Review: _____

Tanks	**Trigger Limit**	**Y**	**N**	**Comment**
Tank 5: Strain gauge bonded across the crack on the damaged (SE) buttress	Greater than 0.25mm permanent movement over a 3 day period			
New photography for comparison with previous				
Kilns	**Trigger Limit**	**Y**	**N**	**Comment**
Kiln 10: Strain gauge bonded across one crack in vertical mortar end joint in the brick rings	Greater than 0.25mm permanent movement over a 3 day period			
Kiln 10: Strain gauge bonded across one open horizontal crack in the brick rings at the perimeter	Greater than a 1.0mm permanent movement over a 3 day period			
New photography for comparison with previous				

APPENDIX C – UNION HILL TANK MONITORING RAW RESULTS AND LOCATION PLANS

UNION HILL
TANK MONITORING RAW RESULTS
19/12/2011

TANK 1

BOTTOM PRISM

northing (Y)	easting (X)	RL (Z)	name
642820.323	396366.747	108.738	CT1
642820.322	396366.748	108.737	_1
642820.321	396366.745	108.733	613
642820.320	396366.746	108.736	901
642820.320	396366.745	108.734	601
642820.321	396366.746	108.735	913
642820.325	396366.745	108.734	1001
642820.325	396366.744	108.732	1013
Average	**642820.322**	**396366.746**	**108.735**
		Min	**108.732**
		Max	**108.738**
		Range (mm)	**6**

TOP PRISM

northing (Y)	easting (X)	RL (Z)	name
642820.654	396366.262	121.065	CT12
642820.654	396366.262	121.065	_12
642820.650	396366.261	121.068	9
642820.652	396366.257	121.064	T211
642820.650	396366.261	121.068	T1
642820.652	396366.258	121.064	T200
642820.653	396366.259	121.064	612
642820.653	396366.260	121.062	624
642820.652	396366.260	121.066	912
642820.653	396366.259	121.065	924
642820.652	396366.263	121.062	1012
642820.652	396366.264	121.061	1025
Average	**642820.652**	**396366.261**	**121.065**
		Min	**121.061**
		Max	**121.068**
		Range (mm)	**7**

TANK 2

BOTTOM PRISM

northing (Y)	easting (X)	RL (Z)	name
642814.498	396366.413	109.337	CT2
642814.498	396366.414	109.336	CT20111206_2
642814.497	396366.409	109.335	T209
642814.496	396366.410	109.335	T222
642814.497	396366.409	109.335	602
642814.498	396366.410	109.334	614
642814.497	396366.411	109.337	902
642814.498	396366.410	109.337	914
642814.495	396366.414	109.335	1002
642814.496	396366.414	109.333	1014

TOP PRISM

northing (Y)	easting (X)	RL (Z)	name
642814.607	396366.611	120.692	CT11
642814.607	396366.611	120.692	CT20111206_11
642814.603	396366.609	120.695	T2
642814.603	396366.609	120.695	10
642814.606	396366.607	120.690	T201
642814.605	396366.606	120.691	T212
642814.606	396366.608	120.690	611
642814.606	396366.608	120.689	623
642814.604	396366.609	120.692	911
642814.605	396366.609	120.693	923
642814.604	396366.612	120.689	1011
642814.604	396366.612	120.688	1024

TANK 3

BOTTOM PRISM				TOP PRISM			
northing (Y)	easting (X)	RL (Z)	name	northing (Y)	easting (X)	RL (Z)	name
642808.301	396366.442	109.368	CT3	642808.313	396366.489	120.416	CT10
642808.301	396366.443	109.369	CT20111206_3	642808.313	396366.489	120.416	CT20111206_10
642808.299	396366.438	109.368	T208	642808.309	396366.486	120.419	T3
642808.299	396366.439	109.368	T221	642808.310	396366.486	120.419	11
642808.300	396366.439	109.368	603	642808.312	396366.484	120.415	T202
642808.300	396366.439	109.367	615	642808.311	396366.484	120.415	T213
642808.299	396366.440	109.369	903	642808.312	396366.485	120.415	610
642808.300	396366.440	109.369	915	642808.312	396366.486	120.414	622
642808.298	396366.443	109.367	1003	642808.310	396366.488	120.417	910
642808.299	396366.443	109.366	1015	642808.311	396366.487	120.417	922
				642808.310	396366.489	120.414	1010
				642808.310	396366.490	120.413	1023
Average	**642808.300**	**396366.441**	**109.368**	**Average**	**642808.311**	**396366.487**	**120.416**
		Min	**109.366**			**Min**	**120.413**
		Max	**109.369**			**Max**	**120.419**
		Range (mm)	**3**			**Range (mm)**	**6**

TANK 4

BOTTOM PRISM				TOP PRISM			
northing (Y)	easting (X)	RL (Z)	name	northing (Y)	easting (X)	RL (Z)	name
642802.337	396366.540	109.550	CT4	642802.394	396366.520	120.111	CT9
642802.336	396366.540	109.550	CT20111206_4	642802.394	396366.520	120.111	CT20111206_9
642802.335	396366.536	109.549	T207	642802.391	396366.518	120.114	T4
642802.335	396366.536	109.548	T220	642802.391	396366.517	120.114	12
642802.335	396366.536	109.549	604	642802.393	396366.515	120.110	T203
642802.335	396366.536	109.548	616	642802.393	396366.515	120.110	T214
642802.335	396366.537	109.550	904	642802.392	396366.516	120.110	609
642802.336	396366.536	109.550	916	642802.392	396366.517	120.109	621
642802.334	396366.540	109.548	1004	642802.391	396366.518	120.112	909
642802.334	396366.540	109.547	1016	642802.392	396366.518	120.112	921
				642802.391	396366.520	120.109	1009
				642802.390	396366.520	120.108	1021

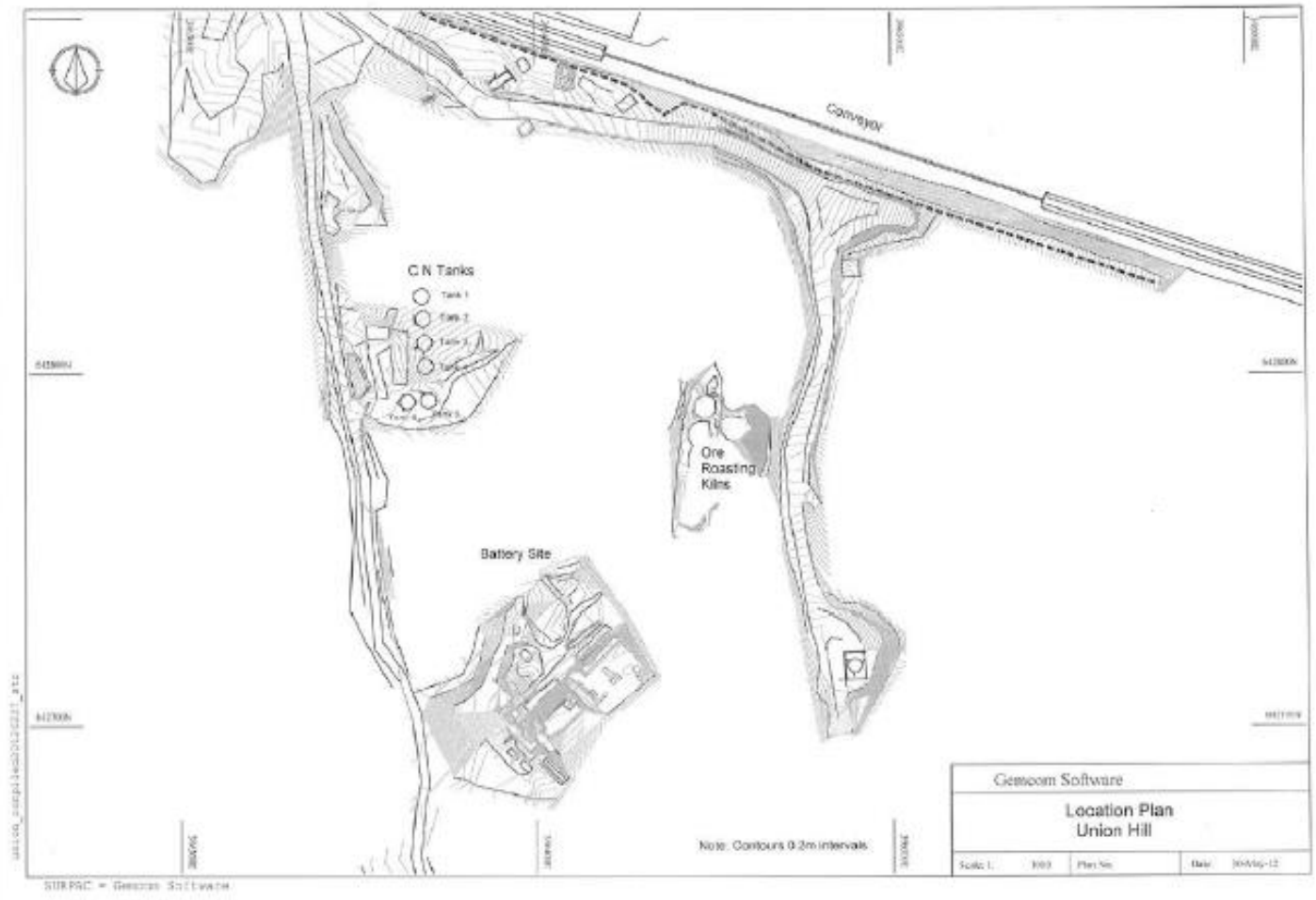
TANK 5

BOTTOM PRISM				TOP PRISM			
northing (Y)	easting (X)	RL (Z)	name	northing (Y)	easting (X)	RL (Z)	name
642793.810	396367.710	109.672	CT5	642793.735	396367.572	119.773	CT8
642793.810	396367.710	109.671	CT20111206_5	642793.735	396367.572	119.774	CT20111206_8
642793.806	396367.706	109.666	T206	642793.733	396367.567	119.773	T210
642793.810	396367.706	109.670	T219	642793.733	396367.567	119.773	T215
642793.810	396367.706	109.670	605	642793.734	396367.568	119.773	608
642793.810	396367.706	109.670	617	642793.733	396367.569	119.771	620
642793.809	396367.707	109.672	905	642793.732	396367.569	119.775	908
642793.810	396367.706	109.672	917	642793.735	396367.571	119.773	920
642793.808	396367.709	109.670	1004	642793.732	396367.572	119.772	1008
642793.810	396367.709	109.670	1017	642793.732	396367.572	119.771	1020

Average	**642793.809**	**396367.708**	**109.670**	**Average**	**642793.733**	**396367.570**	**119.773**
		Min	**109.666**			**Min**	**119.771**
		Max	**109.672**			**Max**	**119.775**
		Range (mm)	**6**			**Range (mm)**	**4**

TANK 6

BOTTOM PRISM				TOP PRISM			
northing (Y)	easting (X)	RL (Z)	name	northing (Y)	easting (X)	RL (Z)	name
642793.040	396361.694	109.674	CT6	642793.087	396361.737	119.560	CT7
642793.036	396361.692	109.673	CT20111206_6	642793.087	396361.737	119.560	CT20111206_7
642793.035	396361.688	109.673	T205	642793.084	396361.736	119.564	T6
642793.035	396361.689	109.671	T217	642793.084	396361.736	119.563	13
642793.035	396361.689	109.672	T218	642793.086	396361.734	119.559	T204
642793.034	396361.689	109.672	606	642793.085	396361.734	119.559	T216
642793.041	396361.691	109.674	618	642793.086	396361.734	119.559	607
642793.038	396361.691	109.675	906	642793.085	396361.735	119.558	619
642793.041	396361.691	109.674	918	642793.084	396361.736	119.562	907
642793.038	396361.694	109.671	1006	642793.085	396361.736	119.561	919
642793.039	396361.704	109.677	1018	642793.085	396361.737	119.558	1007
				642793.084	396361.737	119.558	1019



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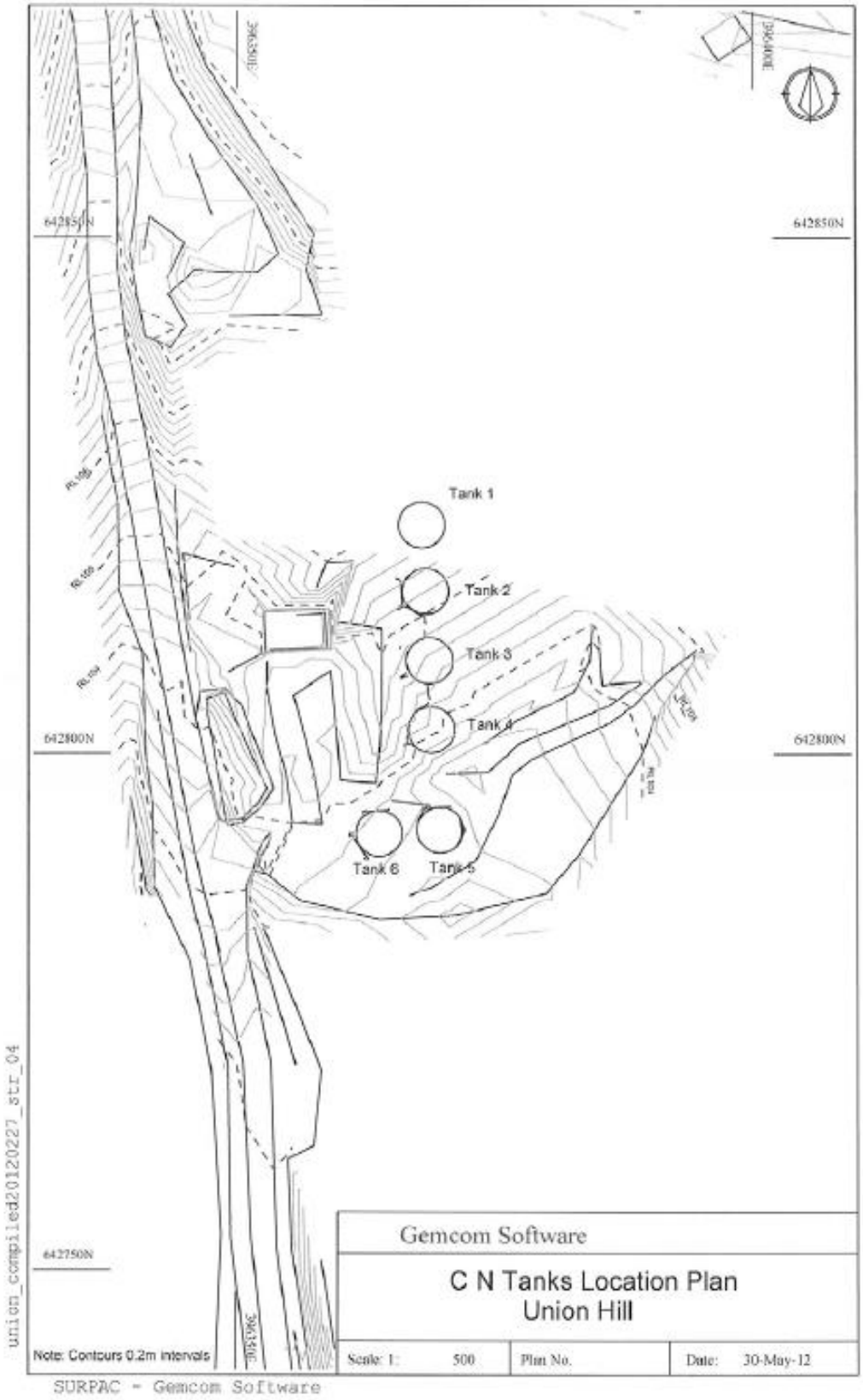
Page No:	38 of 40			Print Date:	01/06/12


642850N
642800N
642750N
Tank 1
Tank 2
Tank 3
Tank 4
Tank 6
Tank 5
Gemcom Software
C N Tanks Location Plan
Union Hill
Scale: 1: 500
Plan No.
Date: 30-May-12
Note: Contours 0.2m intervals
union_compiled20120227_str_04
SURPAC - Gemcom Software

APPENDIX D – DUNNING THORNTON MEMORANDUM 29/5/12

Union Hill Cyanide Tanks and Roasting Kilns, Waihi|

Completion of Baseline Monitoring

Dunning Thornton consultants

Ref: 6887

TO: Newmont Waihi Gold
ATTN: Peter Caruthers Malcolm Lane
FROM: Alistair Cattanach
DATE: 29th May 2012 (Revised 1st June 2012)
RE: Union Hill Cyanide Tanks and Roasting Kilns, Waihi
Completion of Baseline Monitoring

TOTAL PAGES : 16

Further to our site visit on the 23rd April 2012, and subsequent receipt of photograph and monitoring information we confirm we believe adequate baseline monitoring has occurred to date. We have reviewed the information against the trigger criteria and in some cases, made minor comments and alterations, which are detailed below. We believe that the current plan being utilised by NWG to carry out the monitoring should be modified to reflect this, as it is this plan that the operatives are used to referring to. The modifications are detailed below, and the modified plan shall be read in conjunction with this memorandum to satisfy the requirement of Condition 21 of the Trio land use consent.

The monitoring items are listed below, with the changes noted over the monitoring period:

2011 Photographs are from the original condition survey of 30-31 May 2011.

2012 Photographs are from NWG operatives 25 May 2012 (Kilns) and 17 April 2012 (Tanks) unless noted otherwise.

Consulting Structural Engineers
94 Dixon Street, PO Box 27-153, Wellington 6141
Telephone (644) 385-0019, E-Mail: dtcwgtn@dunningthornton.co.nz

Kilns: Visual Monitoring

Kiln 9: Monitoring of area of loose brickwork without local vegetation behind.

2011:

2012:

Observations: Some trampling of earth above edge from monitoring. Localised browning of vegetation. No discernible visual change to ring structure.

Conclusion: No discernible change

Consulting Structural Engineers
94 Dixon Street, PO Box 27-153, Wellington 6141
Telephone (644) 385-0019, E-Mail: dtcwgtn@dunningthornton.co.nz

Kiln7 southern half: Monitoring of area of earth at risk of movement aided by vegetation.

2011: (cropped)

2012:

Observations: Minor localised browning of vegetation. No discernible visual change to moss covered earth projections.

Conclusion: No discernible change

Consulting Structural Engineers
94 Dixon Street, PO Box 27-153, Wellington 6141
Telephone (644) 385-0019, E-Mail: dtcwgtn@dunningthornton.co.nz

Kiln7 northern half: Monitoring of area of earth at risk of movement aided by vegetation.

2011:

2012:

Observations: Slip of loose fractured heavily weathered rock on right side of original condition survey. Slip is also apparent in 18 Jan 2011 photo (see over). Only minor erosion has occurred subsequently leaving the root behind more exposed.

Consulting Structural Engineers
94 Dixon Street, PO Box 27-153, Wellington 6141
Telephone (644) 385-0019, E-Mail: dtcwgtn@dunningthornton.co.nz

Kiln 7 18th January 2012: Showing small localised slip has occurred previously to original condition survey.

Conclusion: Continue to monitor erosion. Good indicator of likely upper edge erosion where subject to weather. Sufficient loose and exposed to rain material still present to justify as indication area, although the south half of this indicator area is more representative of the current condition of the majority of kilns.

Consulting Structural Engineers
94 Dixon Street, PO Box 27-153, Wellington 6141
Telephone (644) 385-0019, E-Mail: dtcwgtn@dunningthornton.co.nz

Kiln 5: Monitoring of one "indicator area" without signs of vegetation locally where the vent / loading area comes into the kiln.

2011:

Consulting Structural Engineers
94 Dixon Street, PO Box 27-153, Wellington 6141
Telephone (644) 385-0019, E-Mail: dtcwgtn@dunningthornton.co.nz

2012:Overall

2012 Detail

Observations: Minor localised change to vegetation. No discernible visual change to moss covered earth/rock projections.

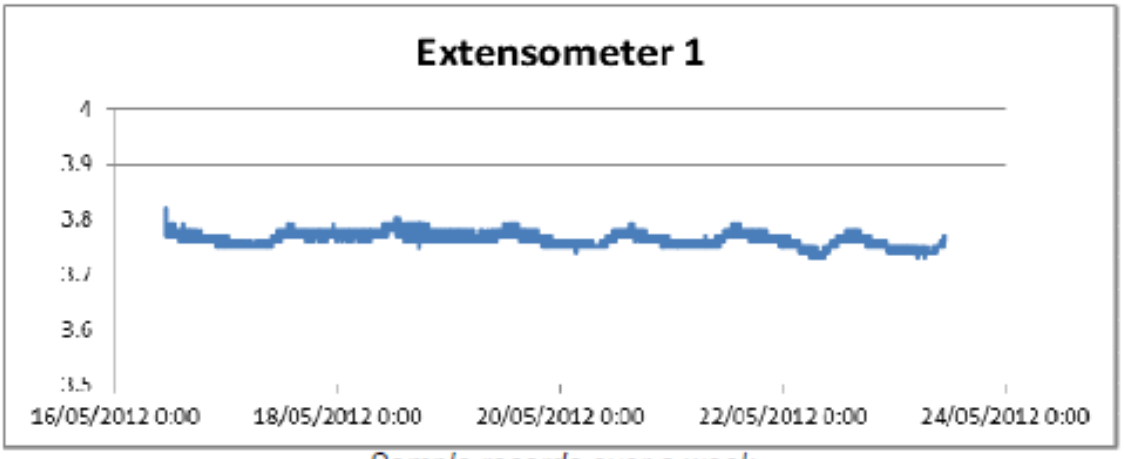
Conclusion: No discernible change

Consulting Structural Engineers
94 Dixon Street, PO Box 27-153, Wellington 6141
Telephone (644) 385-0019, E-Mail: dtcwgtn@dunningthornton.co.nz

Real-time Monitoring

Kiln 10 North Extensometer: measures vertical ring displacement relative to the existing concrete block at the rim edge, and hence heave conditions surrounding the top rings.

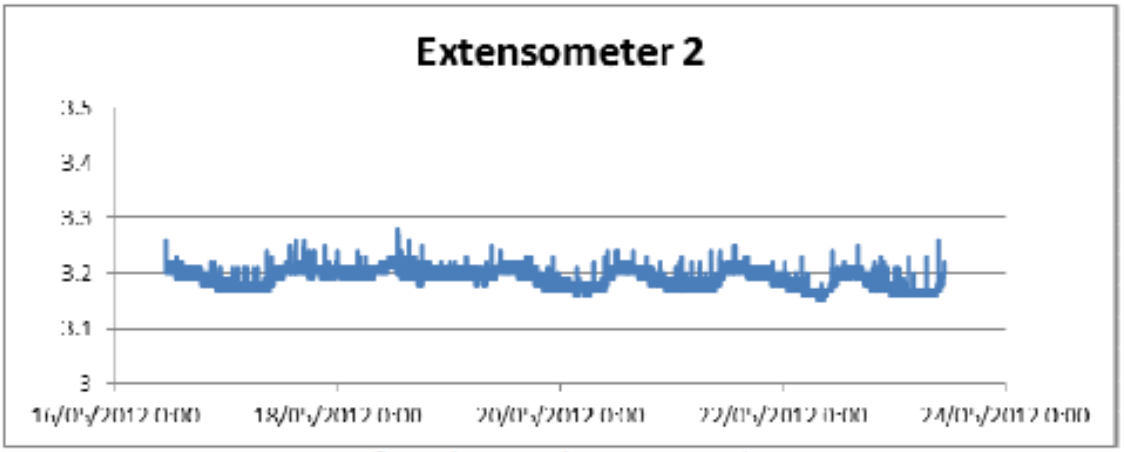
The only noticeable change/trend is that there is a minor cyclical change related to the ground temperature. Movements are certainly negligible from a structural point of view (less than 0.05mm) and are cyclic rather than ratchetting ("walking").



Sample records over a week

Kiln 10 West Extensometer measures actions from the roots of the tall tree adjacent to the ring. Aside from growth displacement this also could measure the effect of tree wind movement on the surrounding earth.

Again only slight temperature (daily) cyclic movements were discerned. No significant wind related movements were noted.

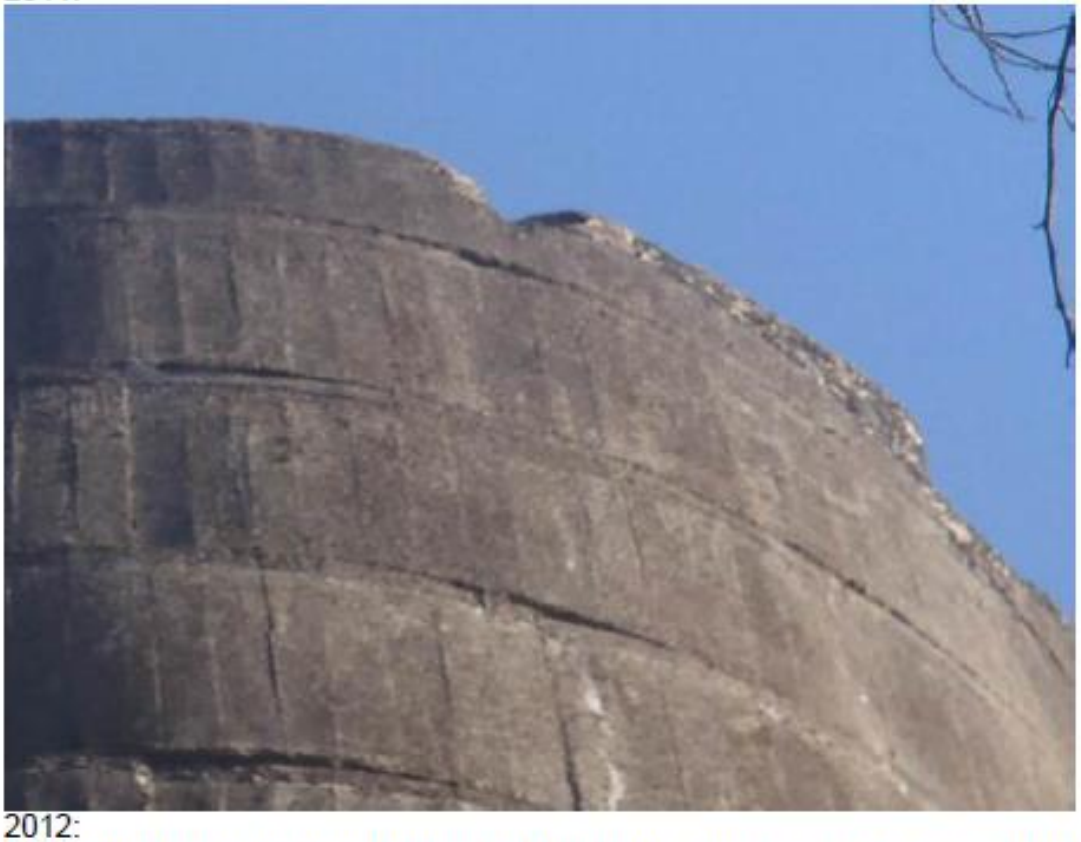


Sample records over a week

Tanks: Visual Monitoring

Tank 1: Visual monitoring of damage to the top rim

2011:



2012:

Observations: Difficult to photograph from below. No downward propagation of cracking evident.

Conclusion: No discernible change

Tank 1: Visual monitoring of existing spalling on south leg

2011:

2012:

Observations: Loss of the bottom of the projecting spalled edge: likely from human intervention. Little distance that "flap" has moved outward.

Conclusion: Negligible outward movement from corrosion. Projecting thin concrete vulnerable to mechanical damage. Photo 16/12/11 shows same break.

Consulting Structural Engineers
94 Dixon Street, PO Box 27-153, Wellington 6141
Telephone (644) 385-0019, E-Mail: dtcwgtn@dunningthornton.co.nz

Tank 2: Visual monitoring of leakage – changes in flow/mould growth.

2011:

2012:

Observations: Leakage and moss growth follows weather pattern based on extent of external drying.

Conclusion: No discernible change

Visual monitoring of pipe positions on the top of the tanks.

2011: (selected photo of one area)

2012: (Photo 15/3/2012 selected as illustrates area more accurately)
Observations: No movement evident after close examination of series. Upward projecting small pipe not moved on unrestrained length.
Conclusion: No discernible change

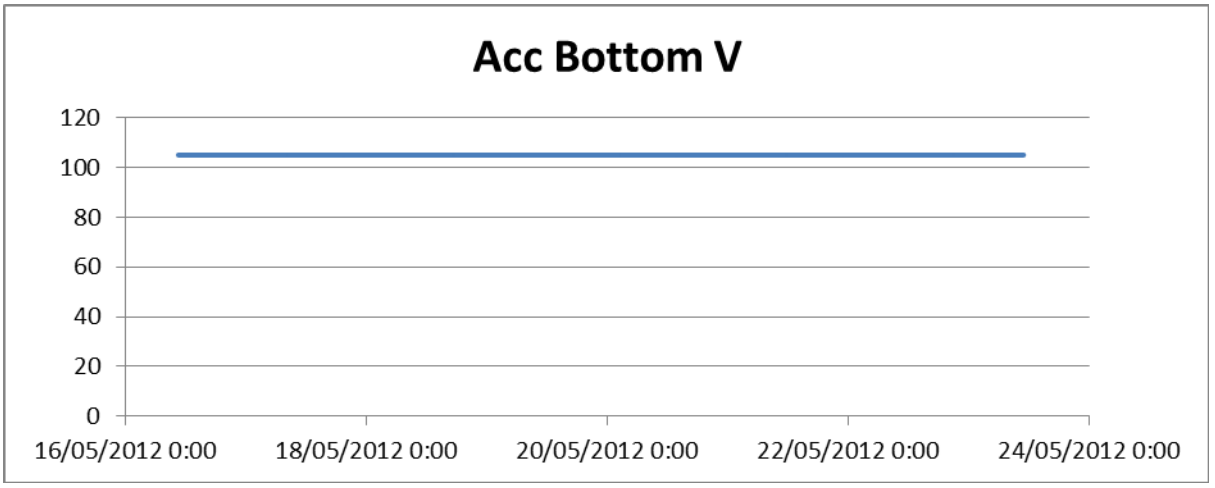
Tank 3: Vernier Calliper monitoring of pins installed across existing crack in tank leg.

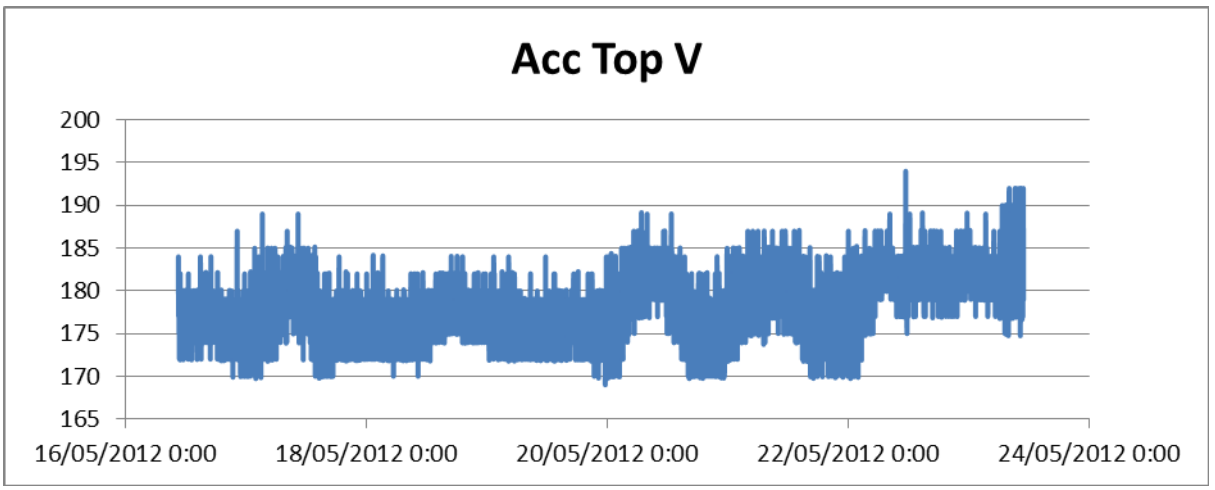
No measurement greater than 0.2mm difference from previous.

Real-time Monitoring

Tank 4: Accelerometers located at top and bottom of the tank.

The background peak vibration acceleration (measured at the bottom of the tank is almost constant) and similarly the response at the top at approximately twice this.

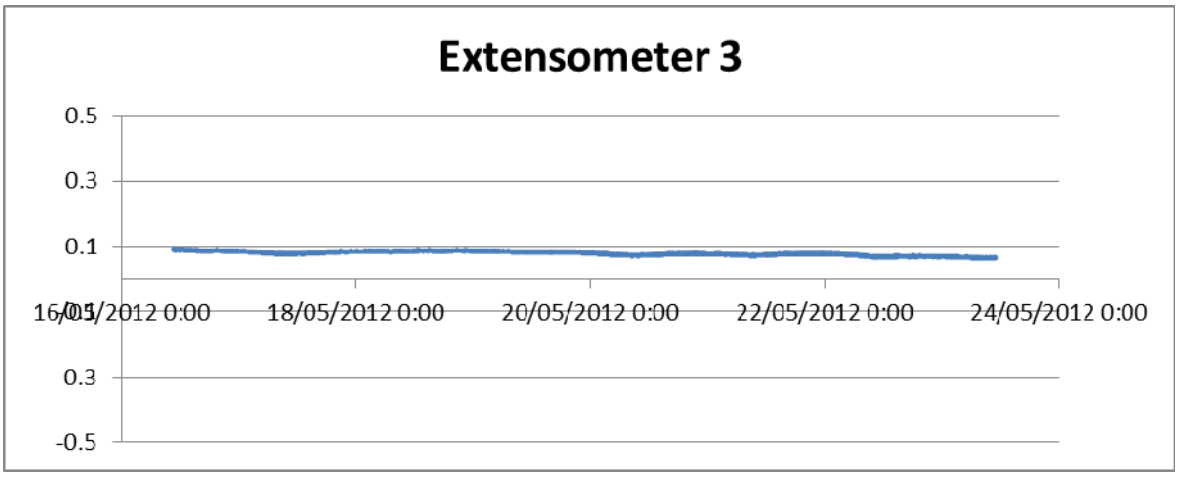




Sample records over a week

Tank 5: Extensometer fitted across the crack on the damaged (SE) buttress

There appears to be little pattern in minor movement responding to background vibration. No significant permanent trend in movement was detected from March to June.



Sample records over a week

Survey Monitoring

Survey results from 19/12/2012, 24/2/2012, 30/4/2012 and 25/05/2012 have been reviewed by NWG and the summary reported to DTC. The reported accuracy by the surveyor is +/- 3mm horizontally and +/- 5mm vertically. Our experience of previous similar surveys suggests horizontal tolerance is more akin to +/- 5mm.

The only result outside normal tolerance variance is a slight (2-4mm) rise in all tank positions. This would be expected as the season changes from summer to winter, with an associated swelling of the underlying clay soils with the additional moisture content.

Changes to Trigger Levels:

As a result of this monitoring we recommend the following:

Item	Trigger Level
Kilns	
Visual Monitoring – Kilns 9 & 7	
Identification of two "indicator areas" (one driven by organic pressure (roots) and one without signs of vegetation locally) at risk of stone earth or brick movement.	Movement more than 7mm Add increase in slip area to kiln 7 by 100mm in any direction
Identification of one "indicator area" (one without signs of vegetation locally) where the vent / loading area comes into the kiln. (Kiln 5)	Movement more than 7mm
Overall crack pattern and condition.	Lengthwise growth of cracks more than 25mm
Visual survey of old Union Workings.	Any signs of slumping showing through the current vegetation.
Real-time Monitoring – Kiln 10	
Extensometer fitted across western side.	Greater than 0.25mm permanent movement over a 3 day period
Extensometer fitted across northern side.	Greater than 1.0mm permanent movement over a 3 day period
Tanks	
Visual Monitoring	
Tank 1: Visual monitoring of damage to rim.	Detection of 25mm cracking growth from existing upper tank defect.
Tank 2: Visual monitoring of leakage, changes in flow/mould growth.	New leaks or increased wet/mould area greater than 10mm. Reduce sensitivity to growth greater than 50mm if no rain in previous 7 days, and "red" value to 5x this.
Tank 3: Vernier Calliper monitoring of pins installed across existing crack in leg.	Greater than 0.5mm movement.
Real-time Monitoring	
Tank 4: Accelerometer on ground and on top of the tank.	An extension of oscillation time after a shock more than 1/10 of the decay period.
Tank 5: Extensometer fitted across the crack in the damaged tank leg buttress.	Greater than 0.25mm permanent movement over a 3 day period.

120529AGC

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APPENDIX E – HEILIG & PARTNERS REVIEW OF UNION HILL ACCELEROMETER DATA MONITORING

July 2014

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- Construction
- Open Pit Mining
- Quarrying
- Underground Mining
- Blast Design
- Blast Permitting
- Vibration Monitoring
- Vibration Analysis

Tuesday, July 22, 2014

Ref:jhh:Union Hill accelerometer data monitoring MB.docx

Mr. Mark Buttimore
Hauraki District Council
PO Box 17
Williams Street
PAEROA
New Zealand

RE: Union Hill accelerometer data monitoring

Dear Mark,

Further to the analyses of the vibration and extensometer data associated with the monitoring of the Union Hill relics, in particular the tanks and the kilns, the following recommendations for the continued monitoring program are submitted for your consideration.

The cyanide tanks are presently monitored using one extensometer and two accelerometers (one positioned at the base and a second at the top of the tank). The kilns are monitored using two extensometers, one positioned across a vertical mortar crack and a second across a horizontal discontinuity. Data from both measurement devices are transferred via modem and analysed to present daily data and trends. In particular, the data are best assessed in terms of the following:

- Extensometer – the trend is more important (than a maximum) and highlights if blasting activities are increasing the natural rate of deterioration through sustained expansion/contraction;
- Accelerometer – The levels monitored are shown to be less than the range of detection making them difficult to use for compliance. The measured levels are less than the lower limit of the values considered to represent the onset of damage. It is therefore inferred that the blasting activities have not caused any damage. Analysing accelerometer data also requires data manipulation, which cannot be simply automated and is therefore not appropriate as a compliance measure.

It is recommended that the monitoring with the accelerometers cease as a component of the routine monitoring program and the data from such are only consulted should the results from the extensometers indicate an anomaly. The use of the accelerometers has shown that they are not conducive to regular monitoring as the signal to noise ratio is poor, they are extremely difficult to interpret against a compliance standard and the duration of vibration shows only a weak resemblance to the nominal blast design and does not permit a comparison between the two different monitoring locations. Whilst the accelerometer information has been difficult to analyse for these reasons, other data, such as the extensometers and vibration results from the geophones combined with weekly visual inspections, show the Union Hill relics have not been affected by the blasting. A review of the measured extensometer and geophone data indicate that the effects of the blasting have been very minor and the levels always well within compliant values.

It is recommended that the extensometers continue to be recorded and the data analysed and reported as is currently undertaken. The system has been shown to be robust and easily comparable against the criteria that have been provided by Dunning Thornton. In the event that the extensometer shows variable or anomalous results, it is suggested that the further analyses should review the accelerometer information to possibly shed information on the

cause for such readings. The accelerometer data should only be reviewed and further detailed analysis of the acceleration values considered in such cases.

The extensometers will be expected to trigger while the accelerometers are still within their normal range. It is therefore appropriate to use the extensometers as the trigger for further investigation. The accelerometers will continue to be monitored, but it is recommended to remove the reporting requirement on them if the extensometers are not triggered. If the extensometers are triggered, an evaluation of accelerometer data may for part of the subsequent investigation.

In addition to the extensometer and accelerometers that are attached to the relics, the Company also has installed in the same area of the relics a "*standard*" vibration monitor. The monitor is referred to as the "*Trio Vent Shaft*" monitor. The data from this monitor is not required for compliance purposes, however assists the Company in differentiating blast events from other spurious vibration recordings. As an additional measure, it is recommended that in the event that the level of vibration at this monitor exceeds an agreed level, the Company would also undertake an assessment of the extensometer and accelerometer data. It is recommended that the level of vibration at which the assessment is initiated is set at 10mm/s. International literature supports that levels of vibration below this value would generally be incapable of inducing damage to even weakened and/or vulnerable structures. When coupled with other trigger and measurement data from the extensometer, the 10mm/s alert value is recommended as appropriate.

As always, you are most welcome to contact me at your convenience to discuss in further detail any of the issues raised in this letter.

Yours truly,

John Heilig

Dr. John Heilig
Principal - Heilig & Partners Pty Ltd

APPENDIX F – HEILIG & PARTNERS EXPECTED VIBRATION AT THE UNION HILL KILNS/TANKS FROM CORRENSO BLASTING

NOVEMBER 2014

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- Construction
- Open Pit Mining
- Quarrying
- Underground Mining
- Blast Design
- Blast Permitting
- Vibration Monitoring
- Vibration Analysis

Tuesday, November 25, 2014

Ref:jhh:Correnso Tanks Kilns.docx

Mr. Mark Burroughs
Newmont Waihi Gold
43 Moresby Avenue
Waihi
New Zealand

RE: Expected vibration at the Union Hill kilns/tanks

Dear Mark,

Further to your question regarding the expected level of vibration at the Union Hill relics (tanks and kilns) from the planned Correnso blasting, I have reviewed the modelling to assess the expected level of vibration from the larger scale stope blasting activities. Explosive quantities from these activities are planned to utilise a charge weight up to 30 kilograms per delay.

Modelling of the stoping activities between 2015 and 2017 show:

- The Union Hill tanks are predicted to receive a maximum level of vibration of 2.7mm/s;
- The Union Hill kilns are predicted to receive a maximum level of vibration of 2.2mm/s.

The modelling results shown as a series of vibration contours are given in the following figure. The outer "red" contour indicates the maximum extent of 1mm/s vibration whilst the "yellow" contour indicates the extent of the 2mm/s vibration value. The inner most "white" contour shows the 5mm/s value which as expected only marginally daylights on the surface. The 10mm/s contour does not intersect the surface.

The green markers represent the location of the stopes. The location of the kilns and tanks are also marked on the image..

As always, you are most welcome to contact me at your convenience to discuss in further detail any of the issues raised in this letter.

Yours truly,

John Heilig

Dr. John Heilig
Principal - Heilig & Partners Pty Ltd