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EGL Ref: 9215

OCEANA GOLD (NEW ZEALAND) LIMITED
WAIHI OPERATION
WAIHI NORTH PROJECT
TAILINGS STORAGE AND ROCK DISPOSAL
VOLUME 1
NATURAL HAZARDS AND OPTIONS ASSESSMENT TECHNICAL REPORT

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OGNZL Document Reference: WAI-985-000-REP-LC-0002

Revision: 2

Prepared for:
OceanaGold (New Zealand) Ltd
P O Box 190
WAIHI 3641

14 February 2025

DOCUMENT CONTROL

Document information

Title	OceanaGold (New Zealand) Limited – Waihi Operation – Waihi North Project – Tailings Storage and Rock Disposal – Volume 1 – Natural Hazards and Options Assessment Technical Report
Revision	2
Date	14/02/2025
EGL Reference	9215
Client Reference	WAI-985-000-REP-LC-0002
File Name	WAI-985-000-REP-LC-0002_Rev2.docx

Document roles and approvals

Role	**Name**	**Credentials**	**Signature**	**Doc. Rev.**	**Date**
Author	T. Matuschka	BE (Hons) Civil, PhD, FEngNZ, CPEng		2	14/02/2025
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EGL Approval	T. Matuschka	EGL Director		2	14/02/2025

Final copy issue requires signatures.

Document revision and issue record

Revision.	**Date**	**Revision Description**	**Issue by**
0	23/06/2022	Resource Consent Issue	E. Torvelainen
1	18/12/2024	Fast Track RC Issue	E. Torvelainen
2	14/02/2025	Fast Track RC Issue following comments	E. Torvelainen

Draft revisions are given alphabetic characters. Final copy issue and subsequent revision are given numeric characters.

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1.0 INTRODUCTION

Engineering Geology Ltd (EGL) has been appointed by Oceana Gold (New Zealand) Limited (OGNZL) to prepare a series of technical reports for resource consent for tailings storage and rock disposal for the Waihi North Project.

This report is Volume 1 of a 4-part series of reports on tailings storage and rock disposal for the Waihi North Project. This report documents a review of natural hazards, and the locations and best available technologies for tailings storage and rock disposal for the Waihi Operation. Volume 2 is a technical report on the use of the proposed Gladstone Open Pit (GOP) as a Tailings Storage Facility (TSF). This will involve partial backfilling of GOP with rock, so the GOP TSF provides for both tailings storage and rock disposal for the Waihi North Project. The technical report for GOP TSF is prepared by GHD (Ref. 1). Volume 3 is a technical report on a new TSF named Storage 3, located east of Storage 1A. It provides for both tailings storage and rock disposal for the Waihi North Project. Volume 4 is a technical report on the Northern Rock Stack (NRS). It provides for disposal of rock and is located north of the existing TSF Storage 2. These preferred facilities are compared against a range of options.

This report covers:

- Waihi Operation location and site description.
- An overview of the climate, geology, hydrology, hydrogeology, and seismicity of the Waihi area.
- An overview of the Waihi Operation existing storage facilities which have performed well geotechnically and environmentally.
- A comparison of the Waihi TSFs with practices seen globally.
- Waihi North Project tailing storage and rock disposal requirements.
- Locations for tailings storage and rock disposal.
- Tailings storage best available technologies.
- Rock disposal best available technologies.
- Assessment of options.
- Proposed Waihi North Project tailings and rock disposal strategy.

The chosen options for tailings storage and rock disposal take into consideration a wide range of inputs to result in designs that provide: long term security for the disposal of rock and containment of tailings; minimise impacts on groundwater, receiving waters and landform; create rehabilitated landforms that will provide the opportunity for a net-gain in terms of biodiversity, minimise risk to people and property. To achieve these objectives requires a collaborative approach with input from a wide range of technical experts (geologists, hydrogeologists, hydrologists, geochemists, engineers), scientific experts (ecologists, biologists, dust and noise consultants), landscape architects and consultation with iwi. The aim is to meet obligations under the Fast Track Approvals Act and the Resource Management Act, meet community and iwi expectations, and to design and construct structures that meet structural stability and durability requirements under the Building Act, and comply with company and international standards for tailings and rock storage.

It is noted that early assessments of suitable options drove subsequent decisions around land acquisition and the Overseas Investment Act approvals processes and completion of land purchases that followed. These represent significant milestones in the project that would be difficult, highly uncertain and time-consuming to unwind and re-execute in the event of new land acquisition being required.

2.0 WAIHI OPERATION LOCATION AND SITE DESCRIPTION

2.1. Location

Waihi is a long-standing mining town in the Hauraki District. For over a century Waihi has been associated with gold mining. Waihi Township is located at the southern end of the Coromandel Peninsula and is within the area covered under the Hauraki District Council and Waikato Regional Council jurisdictions. By road it is 144 km southeast of Auckland, 68km northwest of Tauranga City and 21 km east of Paeroa Township.

The existing Waihi gold operation is partly located in the township of Waihi around Martha Open Pit and partly to the southeast, accessed via SH2 and Baxter Road, where the two existing TSFs (Storage 1A and 2) are located. They are shown in Figure 1.

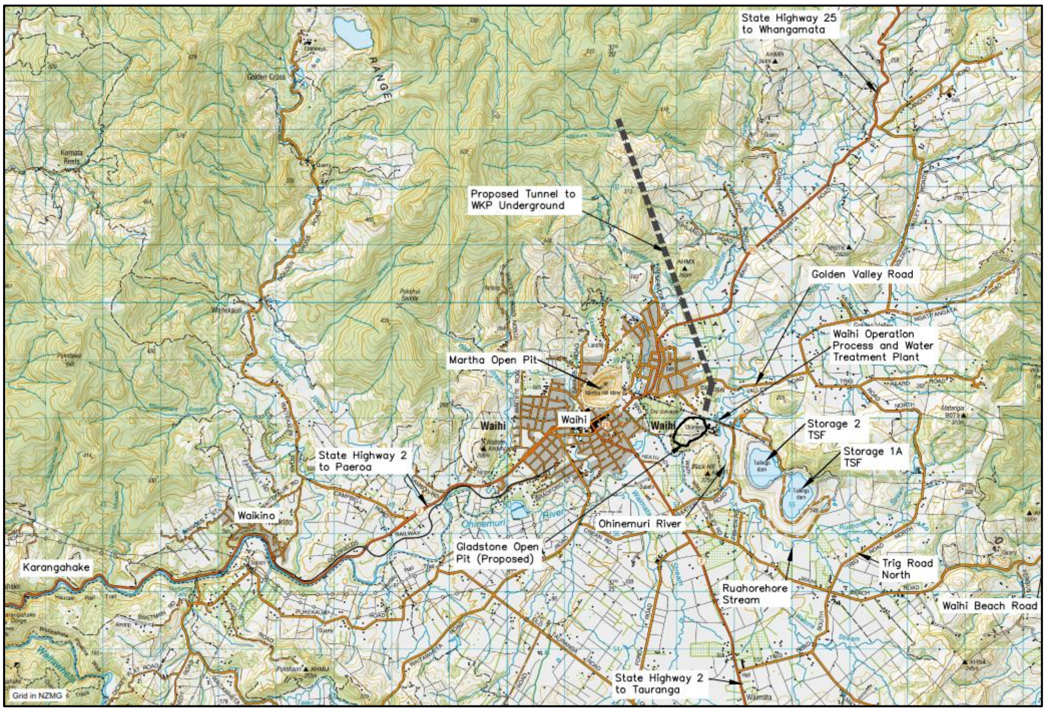


FIGURE 1: LOCATION OF EXISTING TAILINGS STORAGE FACILITIES STORAGE 2 AND STORAGE 1A

2.2. Waihi Mine site description

In 1988 open pit mining of Martha Hill commenced. Open pit mining realised parts of the resource that were previously uneconomic and importantly for the Waihi Operation created a source of earth and rock fill to construct downstream embankment dams for storage of tailings. Downstream embankments are typically the safest type of dam for tailings slurry storage. Other construction techniques such as upstream construction are higher risk if not properly designed, constructed and operated.

Martha Open Pit mine is located in the township, centred on a small hill known as Martha Hill. It is shown in Figure 2. A series of underground mines and most of the old historical mine workings are located beneath the eastern side of the Waihi township, and within or immediately adjacent to Martha Open Pit. Further underground mines are located to the southeast of the township towards the Process Plant on the west side of the Ohinemuri River. Figure 2 indicates the locations and names of the underground mines and historic workings. Martha Underground Mine (under Project Martha) is currently being developed and is aligned beneath the south wall of Martha Open Pit.

The two TSFs; Storage 1A and 2 and associated rock stockpiles are located to the east of the Ohinemuri River away from the underground working as shown in Figure 1. The tailings storage and rock disposal, and the Water Treatment Plant and Processing Plant area is called the Development Site. The two existing TSFs are shown in the oblique aerial photo in Figure 3, with Storage 2 to the left and Storage 1A to the right. This photo was taken in 2018.

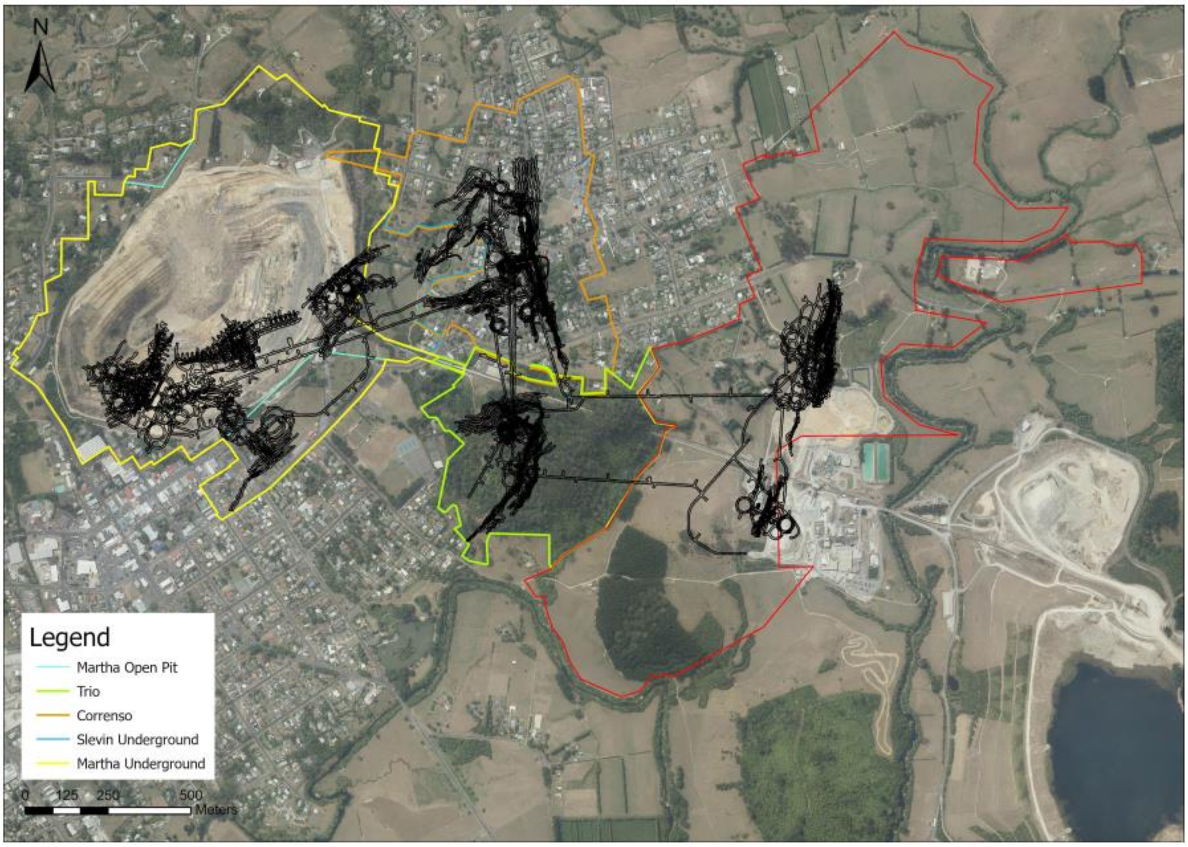


FIGURE 2: MARTHA OPEN PIT AND UNDERGROUND MINE LOCATIONS

FIGURE 3: AERIAL PHOTO OF STORAGE 2 (LEFT) AND STORAGE 1A (RIGHT) WHICH STORE THE TAILINGS AT THE WAIHI OPERATION

The existing TSFs approximately 3 km south-east of the Waihi Township are connected to the Martha Open Pit by a conveyor indicated on Figure 1, which transports rock and soil between the two areas without truck movements. At Martha Open Pit a crusher breaks the rock down before being placed on the conveyor. Material can be offloaded at the Process Plant or at the Loadout which is located up at the level of the crest of Storage 2. This provides an effective location to then transport the earth and rock fill to the TSFs or stockpile via haul routes on or behind the TSFs.

Both existing TSFs are formed by construction of ‘U shaped’ embankments which abut the naturally rising land to the northeast, to form the impoundments which store the tailings. The embankments provide the disposal location for rock from the pits.

Storage 2 was constructed first, starting in 1987, followed by Storage 1A with preliminary works starting in 1998 and first tailings discharge in 2001. Since May 2001, virtually all tailings produced on site have been disposed into Storage 1A. Between 2001 and 2005 a small amount of tailings were deposited within Storage 2 and since July 2005 no tailings have been deposited in Storage 2. Storage 2 has been successfully rehabilitated and water in the pond of Storage 2 is now clean and able to be discharged direct to the Ohinemuri River.

Raising of Storage 2 to RL160.7 is within the consented Life of Mine (LOM) works and will see the embankment crest raised up to 4.7m above its current level. Tailings deposition will resume into Storage 2 and supernatant water in the tailings pond will be pumped back to the Water Treatment Plant for processing before discharge to the Ohinemuri River. Following completion of tailings discharge Storage 2 will again be rehabilitated so the water is clean for discharge direct to the Ohinemuri River.

Storage 1A has a crest level of RL176.4 as of March 2024 and it is consented for raising to RL182 to provide storage for the resource associated with the Martha Underground and MOP4.

3.0 SITE CONDITIONS

3.1. Climate

The climate within Waihi is temperate. Mean monthly temperatures range from 8.9 °C in July to 18.9 °C in January.

Waihi township is approximately 100 m above sea level and receives on average between 1500 to 3000 mm of rainfall per annum, with approximately 31% of rainfall expected within the winter months between June and August and 22% of rain in the summer months between December and February.

3.1.1. Climate change

NIWA has published information on possible effects of climate change. The effects will generally result in higher temperatures, lower annual rainfall but higher intensity rainfall in extreme events. Higher temperatures and lower annual rainfalls are considered unlikely to affect tailings or rock disposal. Higher intensity rainfall events can be considered in the design of drains, surface water collection ponds, and freeboard within the TSF impoundments. NIWA provides high intensity rainfall data for different climate change scenarios.

3.2. Geological setting

3.2.1. Tectonic setting

Earthquake hazard at the Waihi operation was assessed by the Institute of Geological and Nuclear Sciences (GNS) in 2017 (Ref. 2). GNS is a New Zealand Crown Institute and is one of New Zealand's leading authorities on seismicity in this country.

The Waihi operation is in the northwestern region of the New Zealand tectonic setting, which is experiencing tectonic crustal extension as shown on Figure 4, as opposed to dextral (lateral) or contractional tectonic mechanisms present in other parts of New Zealand. This extensional region typically experiences lower seismicity compared to more central parts of New Zealand because of its distance from the interface between the Australian and Pacific Plates shown in Figure 4. The Waihi operation location is marked MH for Martha Hill. To the southeast and east of Waihi is the more active Extensional Havre Trough, Taupo Rift, North Island Fault Belt and the Northwest dipping Hikurangi Subduction Zone regions.

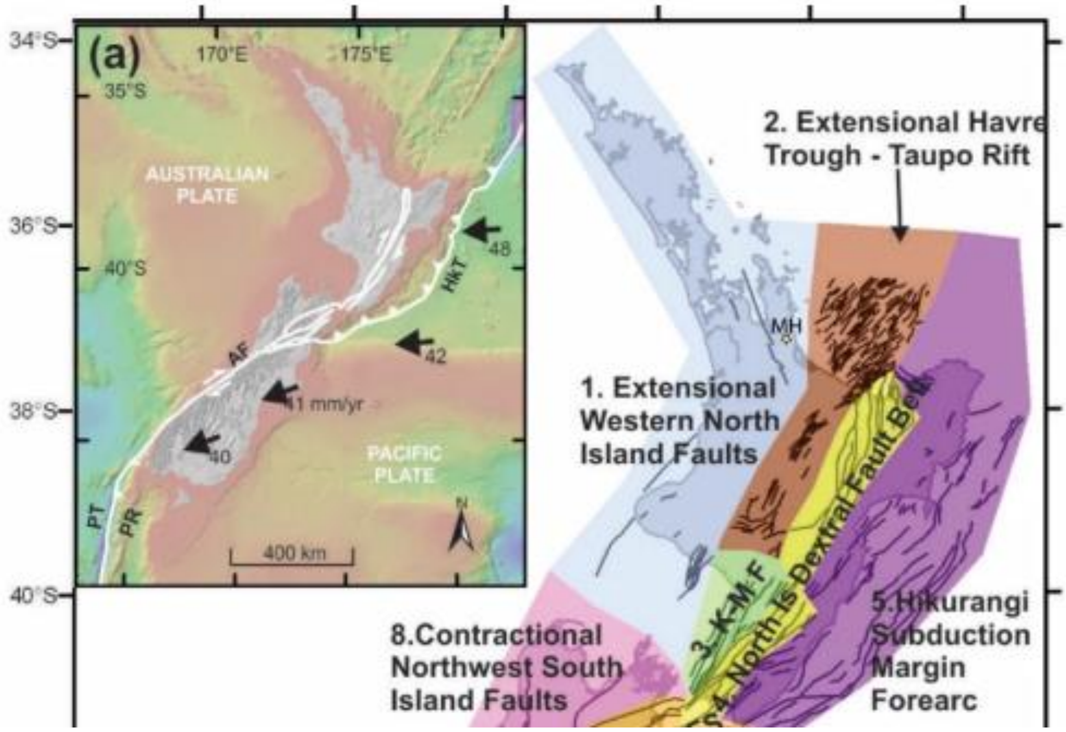


FIGURE 4: WAIHI MINE (LABELLED MH) IS LOCATED IN THE EXTENSIONAL WESTERN NORTHERN FAULT ZONE, WHICH IS ADJACENT TO THE EXTENSIONAL HAVRE TROUGH AND TAUPO RIFT. AT DEPTH TO THE SOUTHEAST IS THE HIKURANGI SUBDUCTION ZONE (GNS, 2017)

The closest known active faults to the Waihi operation are those of the Kerepehi Fault System, located in the Hauraki Rift beneath the Hauraki Plains and the Firth of Thames in Figure 5. This fault system runs up through the Hauraki Plains and the Firth of Thames. As is common to faulting in the region, the Kerepehi Fault System is characterised by extensional normal faulting (Persaud et al. 2016, Ref. 3).

The Hikurangi Subduction Zone to the east of Waihi dips from east to west beneath the North Island and is capable of magnitude 9 (Mw) earthquakes. The distance from Waihi to the Hikurangi Subduction Zone is over 200 km. This distance provides some attenuation of the shaking.

The Coromandel was once an active volcanic area approximately 2 to 12 million years ago (Ref. 4). The Waihi area was part of this activity, and the Waihi Basin is a past caldera volcano (similar to Lake Taupo) that is now filled in with sediments associated with being a lake and other volcanic activity. Calderas result in faults around their edges as large blocks of the earth crust drop downwards toward the centre of the Caldera as the volcanic process is occurring. Some fault traces around the Waihi area are associated with past tectonic or volcanic activity. However, they are understood not to be seismically active today.

Earthquakes do occur on unknown faults. A record of historic earthquakes is documented on the Geonet New Zealand Earthquake Database. In Figure 6, a search of the database for historic earthquakes greater than magnitude (Mw) 5 and less than 100km deep shows isolated historic earthquakes in the region, with more activity to the southeast in the Bay of Plenty closer to the plate boundary. The historic earthquakes in the region are not necessarily on known active fault traces. The GNS (Ref.2) study considers earthquakes on smaller unknown faults in the region, including those potentially closer to the Waihi operation than the Kerepehi Fault, using historic earthquake activity rates in the region.

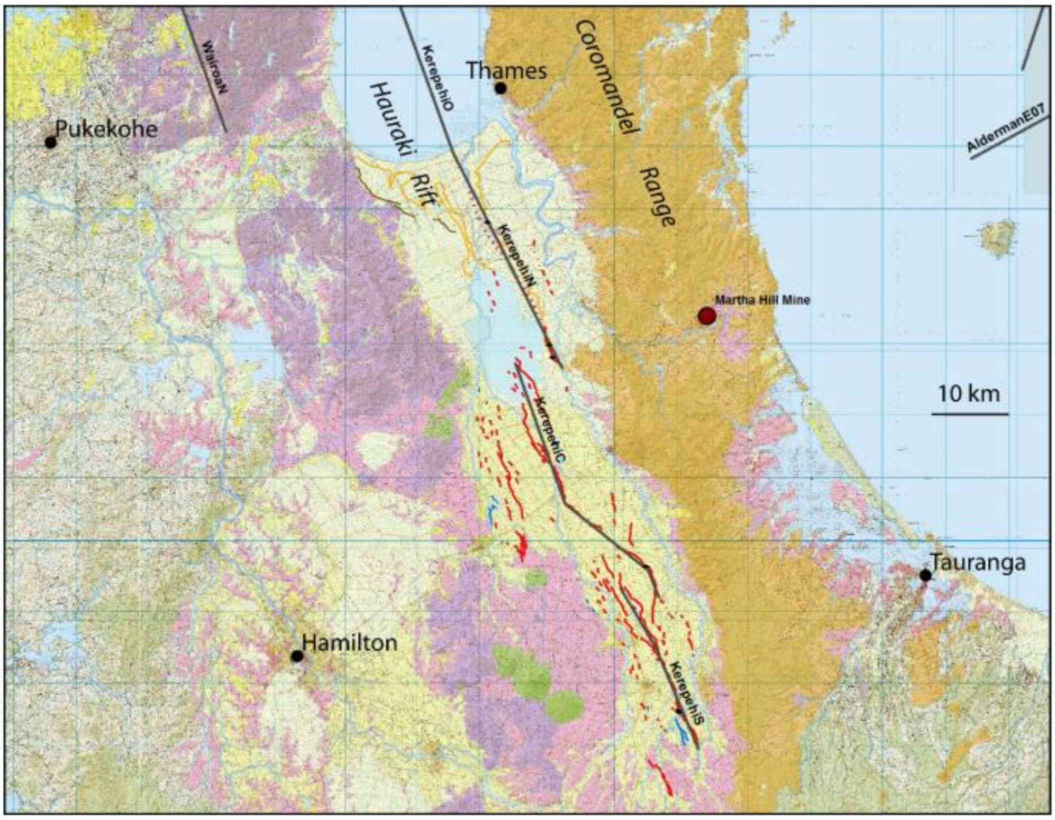


FIGURE 5: HAURAKI RIFT AND KEREPEHI FAULTS (GNS, 2017)

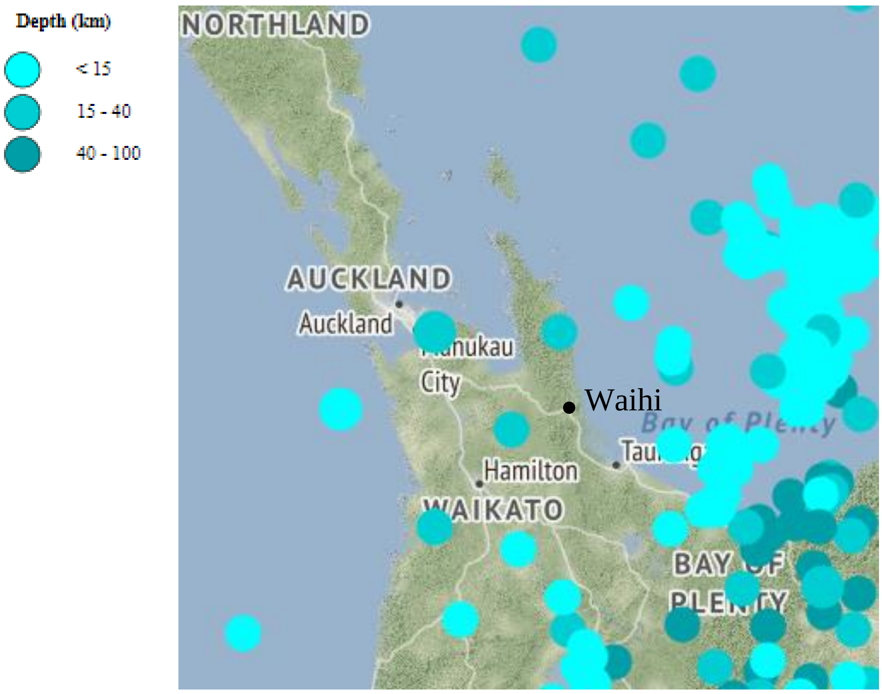


FIGURE 6: GEONET NEW ZEALAND EARTHQUAKE DATABASE - EARTHQUAKES MAGNITUDE 5 AND GREATER, LESS THAN 100KM DEEP RECORDED IN HISTORY

3.2.2. Regional Geology

The Waihi operation is located on the eastern side of the Waihi Basin which comprises extrusive and intrusive volcanic rocks of various ages, and lacustrine (lake) deposits. These materials are mantled by tephras (volcanic airfall deposits) such as ignimbrites, tuff, volcanic ash, and colluvial and alluvial deposits.

Brathwaite and Christie (Ref.5) interpret the geology of the Waihi Basin as part of the Coromandel Volcanic Zone, a sub-aerial 8-million-year-old (late miocene) to 1.5 million-year-old (early pleistocene) andesite-dacite-rhyolite sequence that forms the Coromandel-Kaimai ranges. The sedimentary or metamorphic basement rock is likely at considerable depth below the volcanic sequence.

The Waihi Basin itself is a caldera (large volcanic centre) within the Coromandel Volcanic zone (Ref. 6, 7, and 8) as interpreted by Hayward (Ref. 2).

The oldest volcanic formations in the Waihi area are andesites and dacites of the Late Miocene Waiwawa Subgroup of the Coromandel Group and includes the Waipupu Formation which are 7.9-6.3 million years old.

Dating (K-Ar) indicates a geological erosional time break of about 1 Ma (million years) between the andesites and dacites of the Waiwawa Subgroup and the eruption of andesites and dacites of the Kaimai Subgroup, which contains dacites belonging to the Uretara Formation which are 5.6-4.3 million years old.

Of similar age to the Kaimai Subgroup are rhyolites of the Minden Rhyolite Subgroup within the Whitianga Group, which includes domes of Homunga Rhyolite which is 5.5-5.2 million years old and forms the Ruahorehore Dome on and against which the existing TSFs Storage 1A and 2 are predominantly located (Ref. 5).

The Waihi Basin caldera is infilled with pliocene to early pleistocene lacustrine (lake) sediments and ignimbrites of the Whitianga Group. At the base are lacustrine sediments of the Romanga Formation (4.5-3.0 million years old) part of the Coroglen Subgroup. Lacustrine sediments have also been found around the Martha Open Pit.

The overlying ignimbrites are grouped into the Ohinemuri Subgroup consisting of Corbett ignimbrites at 2.9 million years old and Owharoa ignimbrites (late pliocene) and Waikino ignimbrite at 1.5 million years old (early pleistocene).

Eruptions of ash and pumice blanketed the area. Typical ash soils found in the area include the Waihi Ash series, the Hauparu Ash and the Rotoehu Ash (Ref. 9).

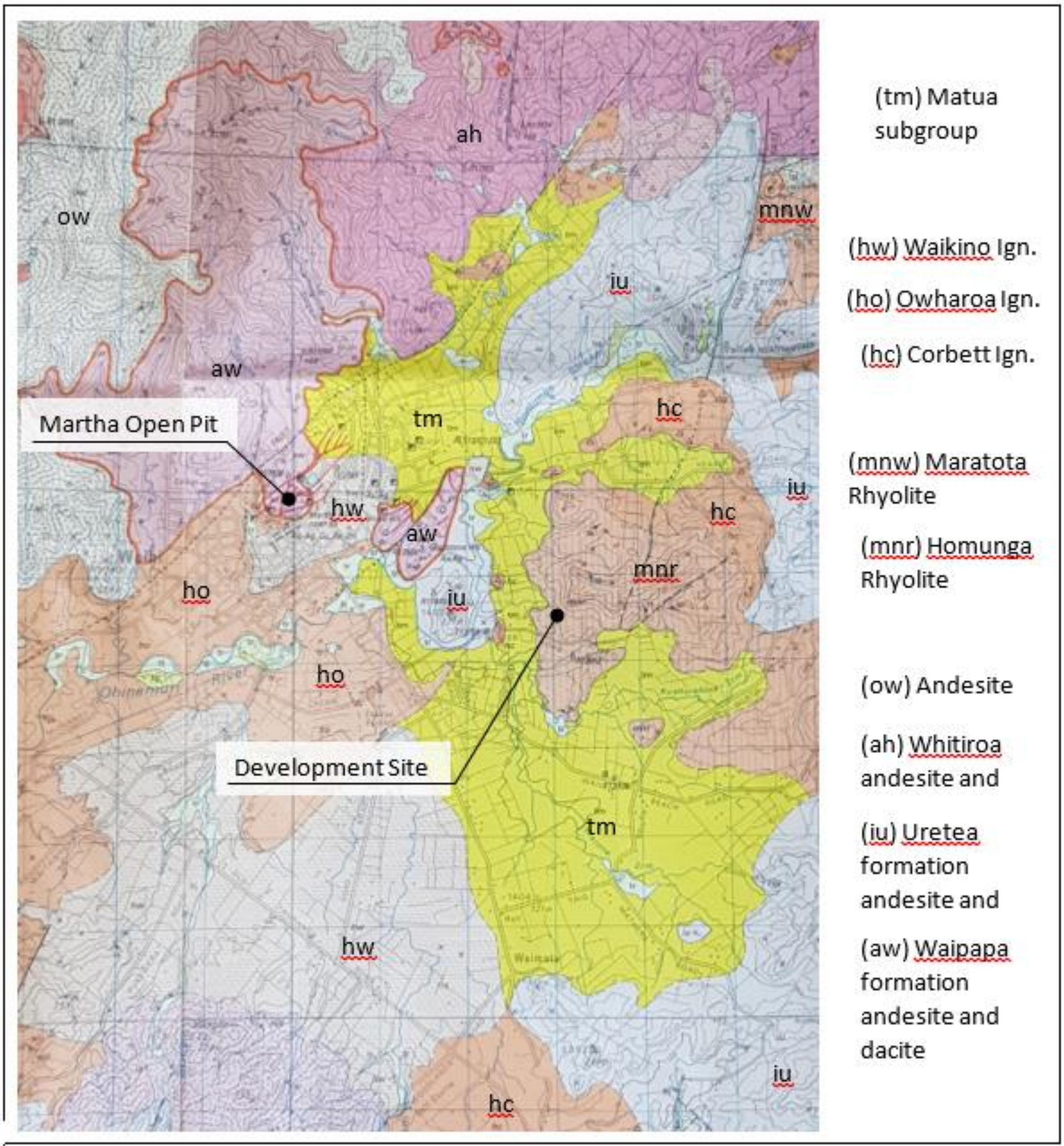


FIGURE 7: 1:50000 GEOLOGY OF THE WAIHI AREA MAP FROM BRATHWAITE AND CHRISTIE (1996) WITH MAIN UNITS MARKED

3.2.3. Geology Around the Development Site

The Development Site area, where Storage 1A and 2 are situated, is underlain by a sequence of ignimbrite, lacustrine deposits, rhyolite, dacite, and finally andesite. The older dacite dips beneath the rhyolite. The dacite outcrops approximately along the Ohinemuri River to the west and is observed in borehole WG4 beneath Storage 1A's southwest toe at 16.5 m down hole depth. Toward the northeast side of Storage 1A a deep borehole GTO20 indicates dacite at 156 m, beneath the rhyolite of the Ruahorehore Dome which is visible as the hills behind Storage 1A and 2. The west toe of Storage 2 is founded on ignimbrite over the dacite. The rest of Storage 2 is founded on rhyolite. Storage 1A is constructed over a series of Rhyolite ridges, knolls and gullies. Figure 8 shows the general geology of the Development Site.

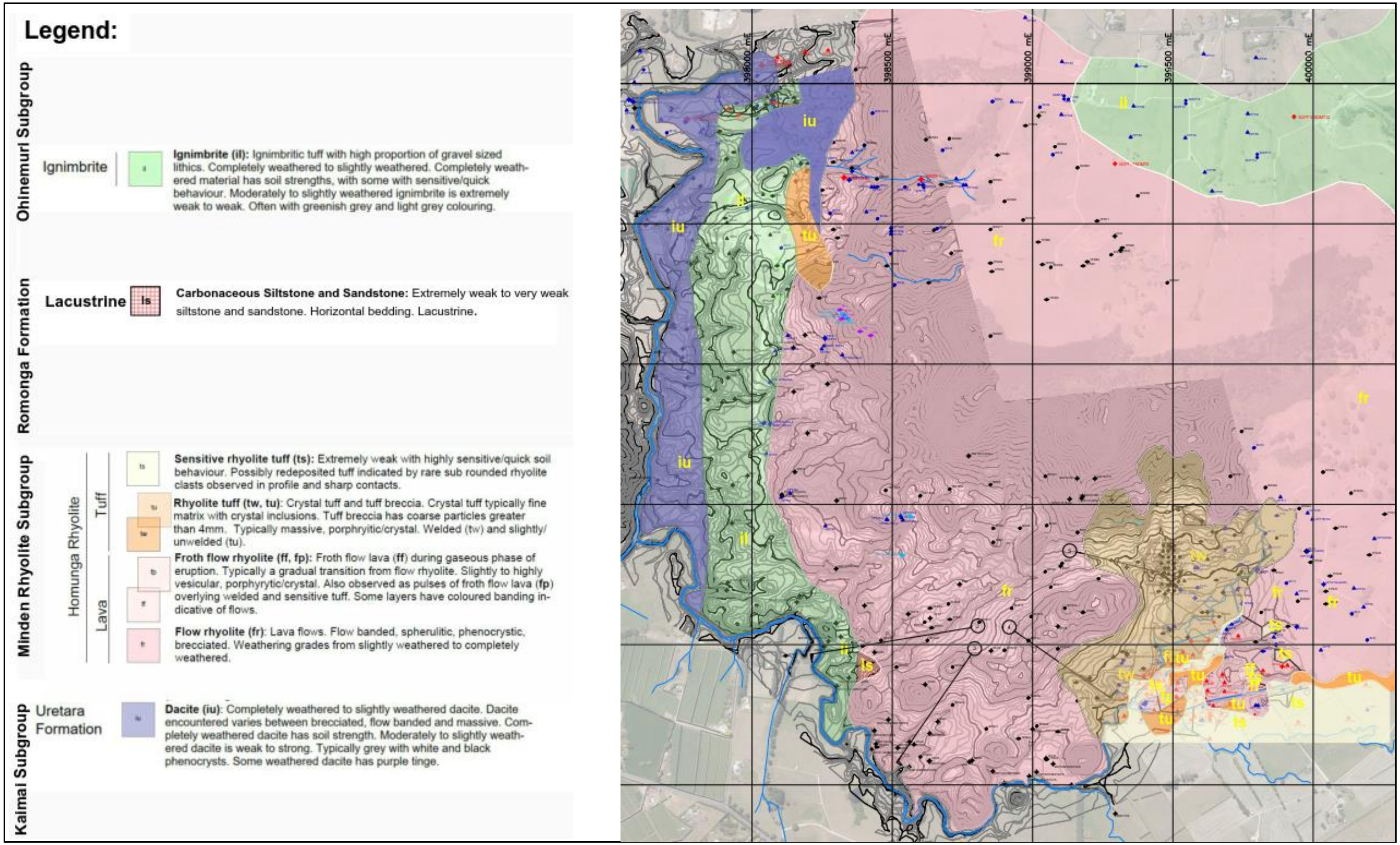


FIGURE 8: DEVELOPMENT SITE GEOLOGICAL MAP

3.3. Waihi operation site specific seismic hazard

The design of all structures, including dams to store tailings, needs to be informed by the natural hazard posed by potential earthquakes. For that purpose, the New Zealand Dam Safety Guidelines (NZDSG) set out the approach that should be taken to the identification of seismic risk. This in turn informs the design of large dam structures so that appropriate safety features are incorporated in the design so structures perform appropriately under seismic loads. This is so even under the worst credible earthquake scenario (which would cause widespread damage in the area) there will not be a loss of contents from the TSFs. Seismic loads are also considered in the design of rock storage facilities.

Estimates of seismic hazard for the site have been provided by GNS Science in 2007 and 2017 (Ref. 2). The 2017 update incorporated the latest knowledge of the Kerepehi Fault System (Ref. 3), the Hikurangi subduction zone and updated estimates of background seismicity.

The Kerepehi Fault System is comprised of several faults and is 21 km from the site at its closest point. It is the closest known active fault to the site and is the Controlling Maximum Earthquake (CME) as defined by the NZDSG. The largest rupture scenario for this fault system is when all segments of the fault rupture together. This scenario represents a rupture length of about 81 km, a magnitude (Mw) of 7.3, resulting in normal (dip-slip) fault displacement of about 3.6 m. This scenario has a recurrence interval of approximately 10,000 years.

Very large earthquakes, up to magnitude (Mw) 9, are associated with the Hikurangi subduction zone and contribute to the seismic hazard at the site. The subduction zone is approximately 200km distant from the site and so ground motions are attenuated and are not as significant as those from nearby smaller background earthquakes or the Kerepehi Fault.

The GNS study 2017 considered research published updating the understanding of the Kerepehi Fault (Ref. 3). A rigorous approach was adopted by GNS for determining estimates of seismic hazard that accounted for epistemic uncertainty (systematic uncertainty due to the method of assessment) as required by the NZDSG for High Potential Impact Classification (PIC) dams. As the Kerepehi Fault is comprised of several segments, GNS modelled different representations of the Kerepehi Fault to address uncertainty in the knowledge of how different segments could combine. There was negligible difference in results for the different representations that were considered. GNS consider the best estimate model is that representing the most up-to-date information regarding the Kerepehi Fault, and therefore, the recommended spectra are those produced using this best estimate model.

The GNS 2017 study provided both probabilistic and deterministic (i.e., scenario based) estimates of horizontal peak ground accelerations (PGAs) and acceleration response spectra (weighted and unweighted). Probabilistic estimates were determined for return periods of 150, 2500 and 10,000 years.

The 2017 probabilistic estimates of spectra are lower than the 2007 estimates. This is principally because there has been a reduction in the rate of seismicity associated with the local distributed earthquake source in the national seismic hazard model (Ref. 2). This source contributes the most to seismic hazard at the site.

Deterministic estimates were calculated for the Kerepehi Fault worst-case scenario (Mw7.3 discussed previously) and the most likely scenario, which is considered to involve a rupture length of 65 km, with a magnitude of Mw7.2, resulting in normal (dip-slip) fault displacement of 2.9 m. There was insignificant difference between the two scenarios in terms of estimated shaking intensity at the Development Site.

The 150-year return period spectrum is commonly adopted as the Operating Basis Earthquake (OBE) for dam design as defined by the NZDSG.

For a High PIC dam, the NZDSG recommend that the Safety Evaluation Earthquake (SEE) be taken as the 84th percentile level ground motion associated with the CME if developed by a deterministic approach. Furthermore, this need not exceed the 10,000-year return period ground motion developed by a probabilistic approach. The 84th percentile level shaking from a CME on the Kerepehi Fault and 1 in 10,000-year return period ground motion has been adopted for the SEE design, along with an aftershock one magnitude less.

The uniform hazard spectral accelerations from the probabilistic and deterministic estimates of seismic hazard are shown in Figure 9. The spectra are for a 5% damped oscillator, for the larger horizontal component ordinate for rock conditions.

Horizontal Peak Ground Acceleration (PGA) values and corresponding average magnitudes at the base of the embankment at the rock surface are as follows:

150-year return period (OBE):	PGA = 0.10g,	M_w = 6.3
84^{th} percentile level for CME (SEE):	PGA = 0.23g	M_w = 7.3
2,500-year return period:	PGA = 0.27g	M_w = 6.6
10,000-year return period:	PGA = 0.39g,	M_w = 6.9

PGA and spectral acceleration values are provided as values of gravitational force (g) i.e., 0.1g is 10% of the force of gravity.

Amplification of ground accelerations do occur through soil profile as well as the embankment. This amplification is allowed for in specific design calculations as it varies with each application.

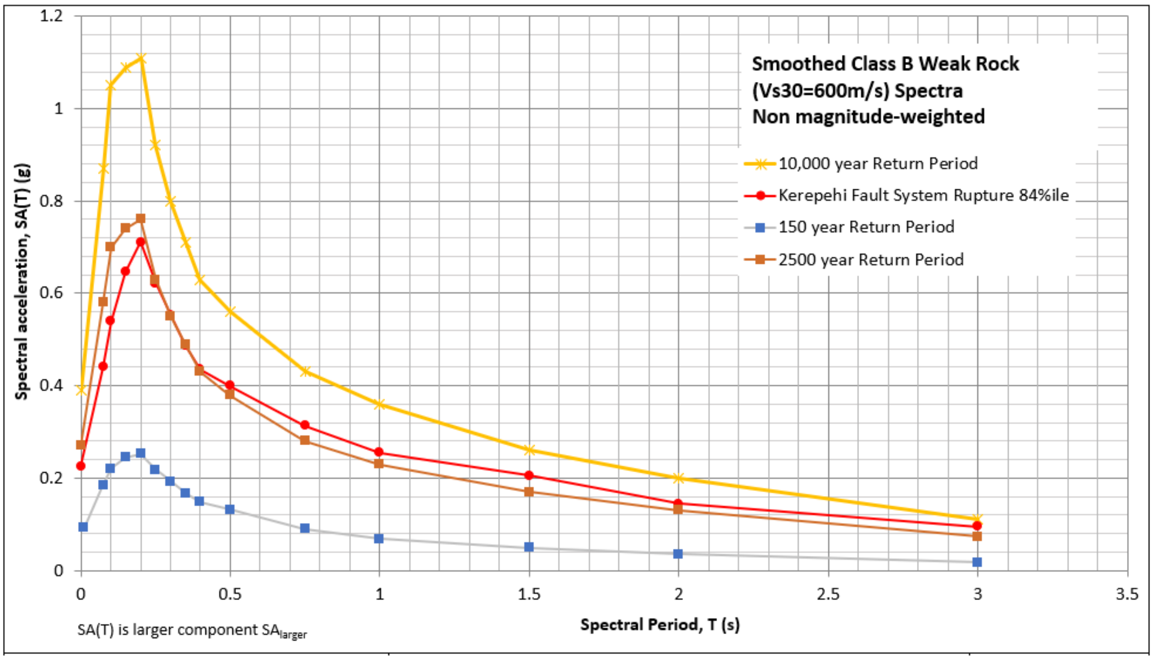


FIGURE 9: WAIHI EARTHQUAKE HORIZONTAL SPECTRAL ACCELERATIONS FOR ROCK SITES

The National Seismic Hazard Model was updated in 2022. The NSHM (2022) numbers are higher than the 2017 study numbers shown in Figure 9. However, experience at Waihi finds these changes do not make a material difference to the assessed performance of the TSFs. For consistency, the 2017 study has been applied across the Waihi North Project. In detailed design seismic hazard estimates will be updated.

3.4. Hydrology

Waihi receives on average 1500 to 3000 mm of rain per year making it one of the wetter regions in the North Island. NIWA provides statistical rainfall depths and intensities through their national high intensity rainfall database (HIRD by NIWA), based on monitoring sites across the region. Statistical estimates of rainfall depths and estimates for storm events in Waihi based on historic data are included in Table 1 and Table 2 for different durations.

Rainfall occurring in the Waihi area runs off into the Ohinemuri River and its tributaries. The Ohinemuri River flows to the west, past the Storage 2 and Waihi Township, along SH2 through the Karangahake Gorge, past Paeroa, into the Waihou River, which then flows out into the Firth of Thames near the Thames Township.

The Ohinemuri River is without stopbanks in its natural channel as it passes the Waihi Operation Site. Flood estimates for a 100-year Average Recurrence Interval (ARI) event have been developed around the Waihi Operation Development Site and the TSFs are currently located above the 100-year flood extent. The flood extent is shown in Figure 10.

FIGURE 10: 100 YEAR ARI FLOOD EXTENT PAST STORAGE 1A AND 2

TABLE 1: HIRDS (V4) RAINFALL DEPTHS FOR ANNUAL RECURRENCE INTERVAL

ARI (yrs)	AEP	Duration (hr)									
		10min	20min	30min	1hr	2hr	6hr	12hr	24hr	48hr	72hr
1.58	0.633	9.38mm	14.7	19.1	29	43.1	75.1	101	131	161	177
2	0.5	10.4	16.3	21.1	32.1	47.5	82.8	112	144	177	194
5	0.2	13.9	21.9	28.2	42.8	63.2	110	148	190	232	255
10	0.1	16.7	26.1	33.7	51	75.2	130	175	224	274	300
20	0.05	19.6	30.6	39.4	59.6	87.8	151	203	260	317	347
30	0.033	21.4	33.4	43	64.9	95.5	164	220	282	343	376
40	0.025	22.7	35.4	45.6	68.8	101	174	233	298	362	396
50	0.02	23.8	37	47.6	71.8	106	181	243	310	377	412
60	0.017	24.6	38.4	49.3	74.4	109	188	251	321	390	426
80	0.012	26	40.5	52	78.4	115	197	264	337	409	447
100	0.01	27.1	42.2	54.2	81.6	120	205	274	350	425	464
250	0.004	31.7	49.3	63.2	94.9	139	237	316	403	488	532
1000	0.001	37.2	57.9	74.2	111.3	162.9	277.4	369.6	471.0	569.8	620.9
10000	0.0001	46.4	72.1	92.3	138.5	202.6	344.4	458.6	583.8	705.5	768.4
PMP*											1200^

* PMP stands for Probable Maximum Precipitation

^ PMP scenario is used in the calculation to determine the water volume used to set the required freeboard condition

TABLE 2: HIRDS (V4) RAINFALL INTENSITY FOR ANNUAL RECURRENCE INTERVAL

ARI (yrs)	AEP	Duration									
		10min	20min	30min	1hr	2hr	6hr	12hr	24hr	48hr	72hr
1.58	0.633	56.3mm/hr	44.2	38.1	29	21.5	12.5	8.46	5.46	3.35	2.45
2	0.5	62.3	48.9	42.2	32.1	23.8	13.8	9.31	6.01	3.68	2.7
5	0.2	83.7	65.6	56.4	42.8	31.6	18.3	12.3	7.91	4.84	3.54
10	0.1	100	78.4	67.3	51	37.6	21.7	14.6	9.35	5.71	4.17
20	0.05	118	91.9	78.9	59.6	43.9	25.2	16.9	10.8	6.61	4.82
30	0.033	129	100	86	64.9	47.7	27.4	18.4	11.8	7.16	5.22
40	0.025	136	106	91.1	68.8	50.5	29	19.4	12.4	7.55	5.5
50	0.02	143	111	95.2	71.8	52.8	30.2	20.2	12.9	7.86	5.73
60	0.017	148	115	98.6	74.4	54.6	31.3	20.9	13.4	8.12	5.91
80	0.012	156	122	104	78.4	57.5	32.9	22	14	8.53	6.21
100	0.01	163	127	108	81.6	59.8	34.2	22.8	14.6	8.84	6.44
250	0.004	190	148	126	94.9	69.4	39.5	26.4	16.8	10.2	7.39
1000	0.001	223.5	173.7	148.3	111.3	81.5	46.2	30.8	19.6	11.9	8.6
10000	0.0001	278.6	216.4	184.7	138.5	101.3	57.4	38.2	24.3	14.7	10.7
PMP*											16.7

*PMP stands for Probable Maximum Precipitation

3.5. Hydrogeology

The hydrogeology of the Waihi Mine area is currently controlled by the Ohinemuri River (and its tributaries) and dewatering of the underground and open pit mines. Around the Mine Site to the west of the Ohinemuri River the underground and open pit mines draw down the natural ground water table in the deep rock. Mining only has a minor effect on shallow groundwater tables. Once mining stops, water levels in the deep rock will return. To the east of the Ohinemuri River at the Development Site the ground water flows to the Ruahorehore Stream and the Ohinemuri River as there are no open pits or underground mines to draw the groundwater down and the surrounding ground and TSFs are higher. Subsoil drains beneath the TSFs intercept groundwater, which is flowing beneath the TSFs, driven by the head or water in the surrounding hills.

4.0 WAIHI OPERATION – EXISTING TAILINGS STORAGE AND ROCK DISPOSAL

4.1. Nature of the ore and overburden at Waihi

Typically, mining operations remove both ore-bearing rock and non-ore-bearing rock.
At Waihi ore bearing rock is crushed, ground and processed to extract the gold and silver and forms the by-product known as tailings (See Section 4.2).

The non-ore bearing rock and overlying soils at Waihi associated with Martha Open Pit and the underground mines requires transfer and placement for long term storage. This material is currently placed in the TSF embankments and associated stockpiles.

As described above in Section 3.2, the rock and soils at Waihi are associated with a past geological time of volcanism. Some of the rocks are Potential Acid Forming (PAF) when exposed to air and water, and some of the rocks are Non-Acid Forming (NAF). The potential for acid generation is related to the geochemistry of each rock source and testing is undertaken to determine which rocks are PAF.

Acid generated from exposed PAF can mobilise heavy metals in the rock into solution which can be transported into the wider environment if not mitigated. The disposal of rocks at Waihi requires special mitigation measures to limit any effects from PAF rock and tailings. This includes:

- Testing of the source rock;
- Controls over rock handling and placement;
- Liming of the PAF rock, zoning of the embankments to limit oxygen ingress;
- Placement of NAF material on the final external surface;
- Leachate and subsoil seepage collection systems; and
- Ground water monitoring.

4.2. Nature of tailings at Waihi

4.2.1. General

Tailings is the common by-product of processing the ore-bearing rock to extract the valuable metals and minerals. Tailings at the end of the mineral extraction process typically take the form of a slurry consisting of fine particles and water. The fine particles are typically clay to sand sized and are created by the crushing and grinding of the ore bearing rock, and processing of the grind using methods such as leaching and adsorption to extract the valuable metals and mineral. Some processing operations also use methods to remove water from the tailings slurry for the purpose of water conservation or so the tailings can be transferred and placed at a higher density in their final storage location. Water is removed from tailings using plant called thickeners and filter presses. The nature of tailings leaving the process plant is, therefore, a function of the:

1. Ore-bearing rock processed;
2. The ore processing method;
3. The water management processes;

Tailings which remain suspended in water as a slurry are pumped to the storage facility via a discharge delivery pipe. The amount of water in the slurry depends on the extent of thickening undertaken at the process plant. Thicker slurries are more difficult to pump. Filtered tailings are transported by truck.

Cement can also be added to a thickened slurry to form a paste which when left to harden has improved strengths and is often used for filling underground workings.

Tailings which have water removed using a filter press behave as a soil and are transferred by dump trucks or conveyors to their final storage location.

Tailings slurries and filter pressed tailings consolidate to form soil-like deposits. These deposits can be tens to hundreds of metres thick. The profile, permeability and strength of the tailings deposit formed depends on the tailings properties, degree of dewatering, and placement method.

Tailings which are transported as a slurry can be discharged:

- Sub-aqueous (below a water surface); or
- Sub-aerial (above a water surface).

Discharge methods include:

- Simple discharge from the end of a large pipe called end pipe discharge;
- Discharge from a series of smaller pipes known as spigot pipe discharge;
- Discharge from a tailings cyclone, a device which separates the coarse and fine fractions of the tailings and some of the water from the solid particles before final discharge.

Pastes can be deposited in underground workings or above ground in impoundments. Slurries without binders are typically limited to tailing impoundments, either in-pit or above ground tailings dams.

Tailings which are filter pressed to form a soil are tipped from trucks at their final location and spread out by a bulldozer and compacted to form soil stockpiles.

4.2.2. Ore-bearing rock

The existing consented ore sources at the Waihi Operation comprise the existing Martha Open Pit (MOP) and Martha Underground (MUG) mines. Ore associated with the Waihi North Project will be sourced from the proposed new mines (Gladstone Open Pit (GOP) and Wharekirauponga Underground Mine (WUG)). The ore bearing rock is andesite at MOP, MUG and the GOP, and rhyolite at WUG. Some of the ore is PAF and therefore a proportion of the tailings are also PAF. The closure design is for a perimeter capping and pond. This will ensure the tailings remain saturated which will mitigate the oxidation of the tailings and potential release of heavy metals.

4.2.3. Process and water treatment plant setup

At the current Waihi Process Plant the processing operations consist of a two-stage grinding process followed by a conventional carbon-in-pulp (CIP) circuit. Tailings are pumped to the TSF as a conventional slurry.

4.2.4. Tailings delivery and discharge

Tailings are pumped as a slurry from the Process Plant into Storage 1A TSF through rubber lined steel and polyethylene pipelines. Two 250 mm diameter pipelines are used to deliver the tailings slurry from the Process Plant to the TSF. The pipelines are contained within open trenches or bunds, which act as a containment device in case of a pipeline rupture or spill. The trenches divert any spill towards collection ponds or tailings ponds. Each pipeline is pressure tested annually to confirm its operability.

There are two 90 kW variable speed Warman primary slurry pumps. Booster pumps are located along the pipelines. Currently the tailings are pumped into Storage 1A over a plan distance of 1,750 m and elevation change of +74 m.

Historically tailings were pumped into Storage 2 over a plan distance of 1,000 m and elevation change of +56 m.

Tailings have typically been discharged via spigots, but end pipe discharge has been used at some times during the operation of Storage 2 and 1A.

Tailings are deposited over short sections on a rotational basis to allow resting and drying. The pond water level is maintained low during operation to expose as large an area of tailings as possible to air-drying. Air-drying has the benefit of achieving higher density and strength. The deposition of tailings onto a beach (subaerial deposition) via spigots promotes segregation of the tailings. The coarsest tailings generally settle out closer to the point of deposition, with the finer fraction (slimes) transported further. The deposition of tailings on a rotational basis result in local variations in tailings characteristics both in between spigots and transverse to the embankment crest. Changes in ore characteristics can also affect the characteristics of the tailings.

FIGURE 11: TAILINGS BEACH IN STORAGE 1A

4.2.5. Tailings impoundment lining and subsurface drains

Storage 2 impoundment is earth lined against the embankment and is unlined on the base and against the hills. Storage 1A is earth lined against the embankment and is unlined on the base. Storage 1A is lined against the hills above approximately RL160. It is unlined below this level. Subsurface drains are installed beneath the tailings and provide some underdrainage of the tailings and collection of seepage through the tailings profile.

Storage 1A and 2 tailings densities achieved are shown in Figure 12 and Figure 13. The density increases with consolidation of the tailings. The density depends on the source material, grind size, discharge rate and method, and depth of the tailings.

The discharge rate of tailings into Storage 2 has varied from approximately 0.8 to 1.0 Mtpa (dry weight) up to 2001 when Storage 1A was commissioned.

The discharge rate of tailings in Storage 1A has varied from approximately 1.1 to 1.5 Mtpa (dry weight) from 2002 to 2006. From 2006 to 2015 discharge varied between about 0.5 to 0.9 Mtpa. Since 2016 tailings discharge has been between about 0.4 to 0.56 Mtpa.

For the Waihi North Project tailings production will increase up to about 0.7 to 1.7 Mtpa.

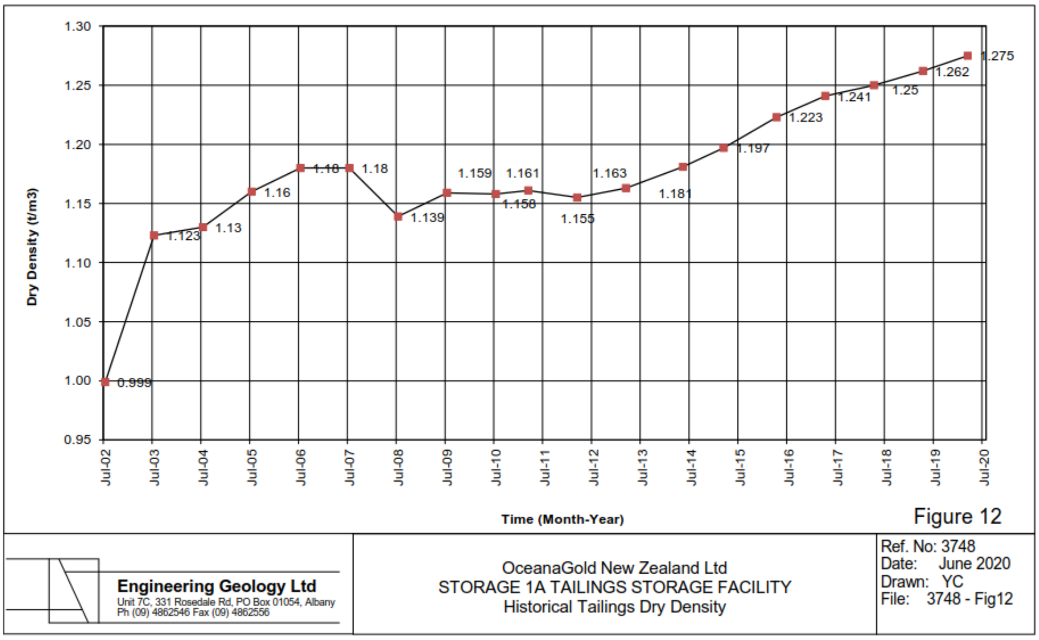


FIGURE 12: STORAGE 1A TAILINGS DENSITIES WITH TIME

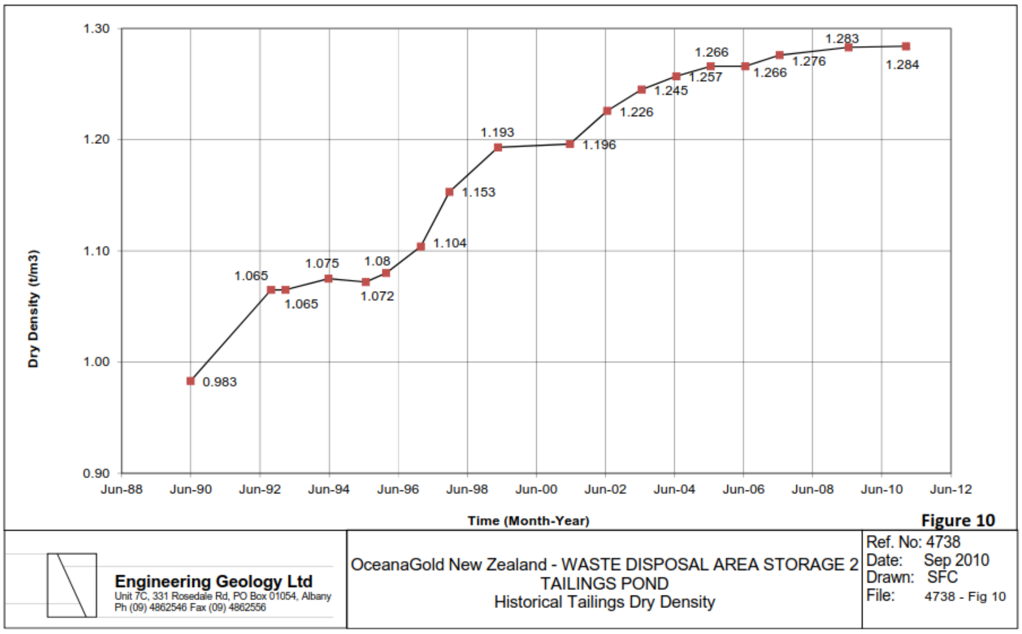


FIGURE 13: STORAGE 2 TAILINGS DENSITIES WITH TIME

4.2.6. Tailings profile within the impoundments

The profile of the tailings in Storage 2 was investigated as part of the approval for the Storage 2 raise to RL160.7. The tailings profile was found to generally comprise of cohesive low plasticity material (sandy silt, clayey silt) with occasional thin lenses of cohesionless (non-plastic) silt/sand material. Lenses rather than layers of sand were inferred from comparison of Cone Penetration Tests (CPTs) located on the same section. Samples of the typical cohesive tailings and cohesionless lenses were obtained for testing. The typical particle size distribution (PSD) and plasticity index (PI) values are shown in Table 2. Most of the tailings are a moderately plastic clayey silt. The sandier lenses are a mixture of silt and sand with a minor amount of clay particles.

TABLE 3: PSD AND PI OF TAILINGS IN STORAGE 2

Tailings	Particle Size Distribution (PSD) Average (Range)			Plasticity Index (PI) Average (Range)
	Clay (%)	Silt (%)	Sand (%)	
Clayey SILT (moderately plastic cohesive)	18 (13-33)	58 (45-73)	24 (4-42)	15 (11-22)
SAND/SILT (cohesionless)	9 (8-10)	48 (31-53)	43 (39-59)	Non-plastic

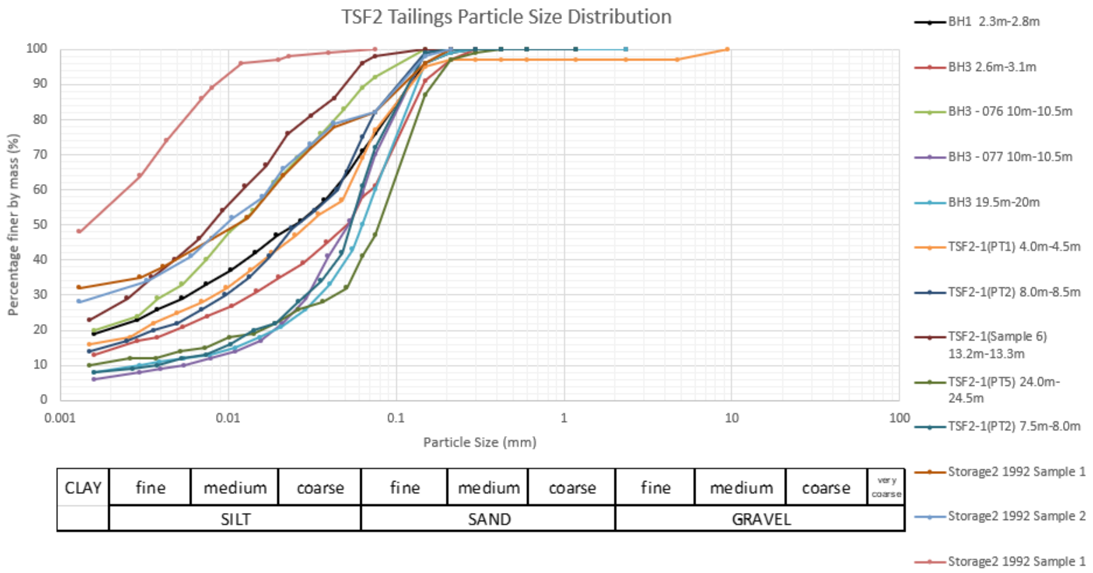


FIGURE 14: PARTICLE SIZE DISTRIBUTION FOR TAILING SAMPLES FROM STORAGE 2

The normalised soil behaviour plots based on CPTs and Seismic Cone Penetration Tests (SCPTs) using the method of Robertson (1990, Ref. 10) indicate that the tailings have behavioural characteristics typical of clay and silty clay with occasional thin lenses of silty sand. This is consistent with the laboratory classification testing.

The fine-grained cohesive nature of the tailings at Waihi results in a low permeability profile. Also, with time and consolidation tailings typically further reduce in permeability. Oedometer testing gives an indication of the permeability of the tailings with consolidation. Oedometer testing has been undertaken on the Storage 2 tailings in 1992 (Langbein, 1993, Ref. 11). The results from the oedometer testing with effective stress are summarised in Figure 15. The grading of the tailings tested indicated that the sampled Zones 1 and 2 were clayey silt and Zone 3 was silty clay. The gradings of the samples are included in Figure 14, labelled 1992 Sample 1, Sample 2 and Sample 3. The depth of tailings in Storage 2 is up to approximately 45 m. With an estimated bulk density (dry tails and water) of 1.75 t/m3 (17.2 kN/m3) and assuming porewater pressures equal to a hydrostatic profile the stress at the base of the impoundment would be at least 330 kPa and the tailings permeabilities are estimated to reduce to less than a value of 1E-8 m/s which is the specified minimum permeability for the earthfill liners for the TSFs.

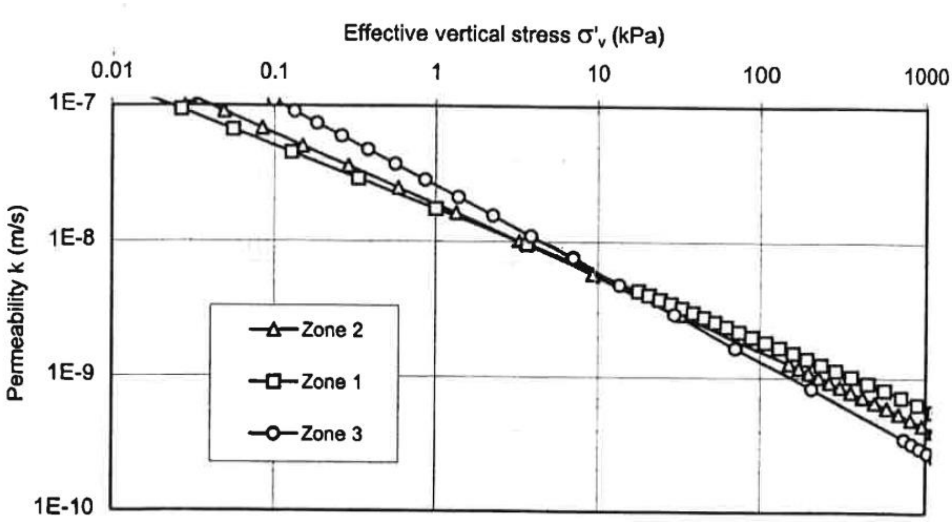


FIGURE 15: OEDOMETER TESTING CALCULATED PERMEABILITIES WITH EFFECTIVE STRESS FROM 1992 TESTING ON STORAGE 2 TAILS

The vane shear strengths were generally greater than 30 kPa around the perimeter of the impoundment and increase with depth to greater than 90 kPa at 17 m. This is equivalent to a firm-stiff cohesive soil.

The tailings pore water is in a sub-hydrostatic state due to the low permeability of the consolidated tailings and some underdrainage. However, as the tailings are still saturated or partially saturated, they can liquefy or cyclically soften in an earthquake where the shaking is equal or greater than that expected every 150 years on average. The embankments themselves are not liquefiable and are designed to hold back a full profile of liquefied tailings.

4.3. Existing zoned embankment design

Both Storage 1A and 2 embankments are designed with a series of different fill zones. The purpose of zoning the embankments is to control seepage of leachate and achieve a stable profile to mitigate any effects possibly caused by natural hazards, like earthquakes and floods. It is this careful attention to zoning in design and construction of the embankments that has set the facilities up to have good performance. This has been demonstrated through regular monitoring, maintenance, and rehabilitation, over thirty years since the commissioning of the first facility, Storage 2, followed by the construction of Storage 1A and its continued operation.

Water seepage through the facility will encounter the tailings and waste rock and therefore may pick up contaminants and heavy metals. This contaminated water seepage is called leachate. The existing embankments have been specifically designed to manage this leachate, by providing for low permeability zones, base and capping layers, subsurface drains and leachate collection drains. These work together by first limiting the generation of acid which can occur when both oxygen and water reach PAF material, secondly limiting their movement through and from the embankment and thirdly collecting leachate at points where it can be monitored and treated (if necessary) before returning clean water to the environment.

The general embankment zoning system is illustrated in Figure 16 and works as a system by providing low permeability zones on the upstream, downstream and base of the embankment. Each zone of the embankment is constructed from specifically selected material that comes from the pit and is compacted to specific standards to achieve the different objectives of each zone. The different zones and their objective are summarised below.

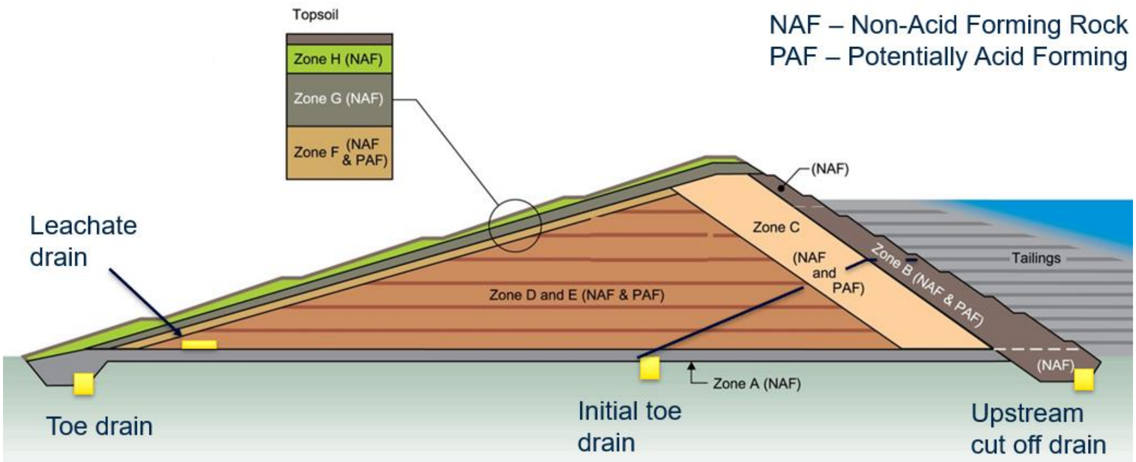


FIGURE 16: ILLUSTRATIVE CROSS SECTION OF EMBANKMENT ZONES

Zone A	-	A low permeability zone at the base of the embankment, made of tightly compacted earth and rock that restricts leachate seepage from the waste rock into the underlying ground. As this layer is in contact with the environment, this layer is non-acid forming (NAF) material.
Zone B	-	A low permeability zone on the upstream face of the embankment which is in contact with the tailings. It is made of tightly compacted earth and rock that restricts leachate seepage from the tailings into the embankment.
Zones C	-	A structural fill zone that provides support to Zone B, by providing a transition between the finer grained material in Zone B and the coarser material in Zones D.
Zones D & E	-	A bulk structural fill zone that accepts the majority of the waste rock, with compaction requirements for stability. This layer contains the majority of PAF material.
Zone F	-	Structural fill zone on the outside shoulder that provides a transition between the coarser material in Zone D and finer material in Zone G. Zone F also provides a drainage path for leachate.

Zone G - Sealing layer on the outside shoulder of the embankment that restricts entry of oxygen and water into the waste rock. This restriction limits the generation of acid leachate by slowing the geochemical reaction. As this layer is in contact with the environment, this layer is created using non-acid forming (NAF) material.

Zone H - Plant growth layer on top of Zone G. This layer is effectively an extension of the upper part of the Zone G layer, which is then ripped to promote plant growth.

Topsoil - Topsoil layer placed for pasture and plant growth on top of Zone H.

These zones work together with a leachate collection system. Both the ponded water and seepage/leachate is collected, piped and treated at the wastewater treatment plant.

At the upstream toe of the embankment any seepage from the tailings impoundment is intercepted with the upstream cutoff drain. The initial toe drain and the downstream toe drain also collect any seepage.

4.4. Storage 2 design and construction

The embankment forming Storage 2 was originally designed in the 1980's by Tonkin & Taylor Limited. Construction commenced in 1987 and it was commissioned in 1988. Since 1989 EGL has been the engineering firm responsible for the modifications to the design and construction of the facility as it has been raised to its current height.

The design of the Storage 2 embankment was revised in May 1997 to allow for raising to RL156, from the previous design crest of RL152. This was completed in 2001. The crest is now approximately 56 m above the banks of the Ohinemuri River which are approximately RL100.

As described in Section 4.3, Storage 2 is zoned. Figure 17 shows the cross-sectional profile of Storage 2. Storage 2 as the first embankment has more weathered rock and earthfill Zone D3 than Storage 1A. This is because the mine overburden from the higher elevations in the Martha Pit was more weathered.

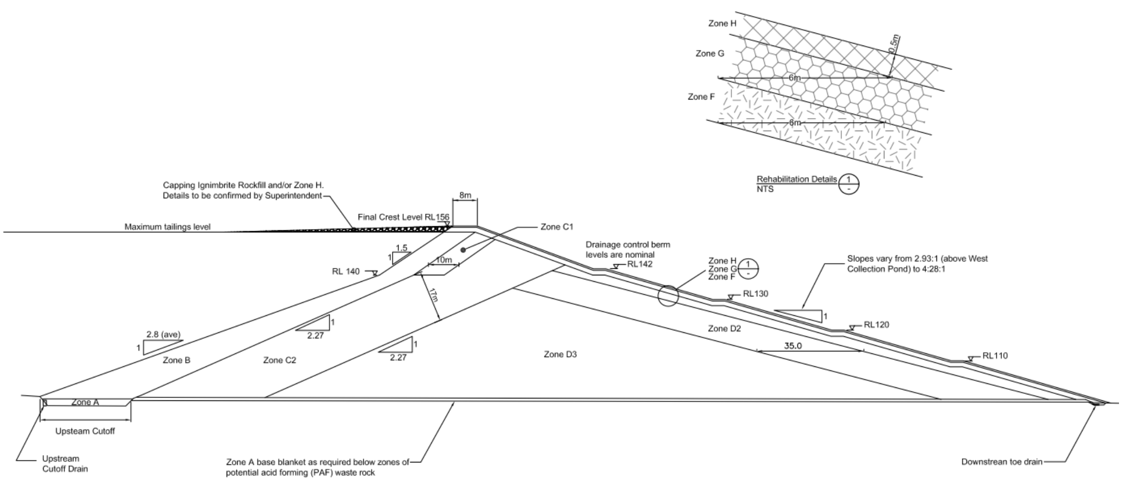


FIGURE 17: TYPICAL SECTION OF STORAGE 2 EMBANKMENT

The upstream shoulder of the embankment slopes at an average grade of 1 m vertical to 2.8 m horizontal (1V:2.8H) up to RL140 and 1V:1.5H above this. Steeper slopes at higher elevations are possible because of the buttressing effects of the tailings against the upstream shoulder, which is not practical for the initial starter embankment.

The downstream shoulder varies from 1V:2.25H to 1V:4.3H between berms. The berms are 4m wide and formed at approximately every 10 m elevation.

An extensive network of underdrains and in-embankment leachate drains exists to intercept seepage from the tailings, leachate from the PAF waste rock that forms much of the embankment and groundwater seepage in the underlying ground beneath. Figure 18 shows a location plan of the underdrains.

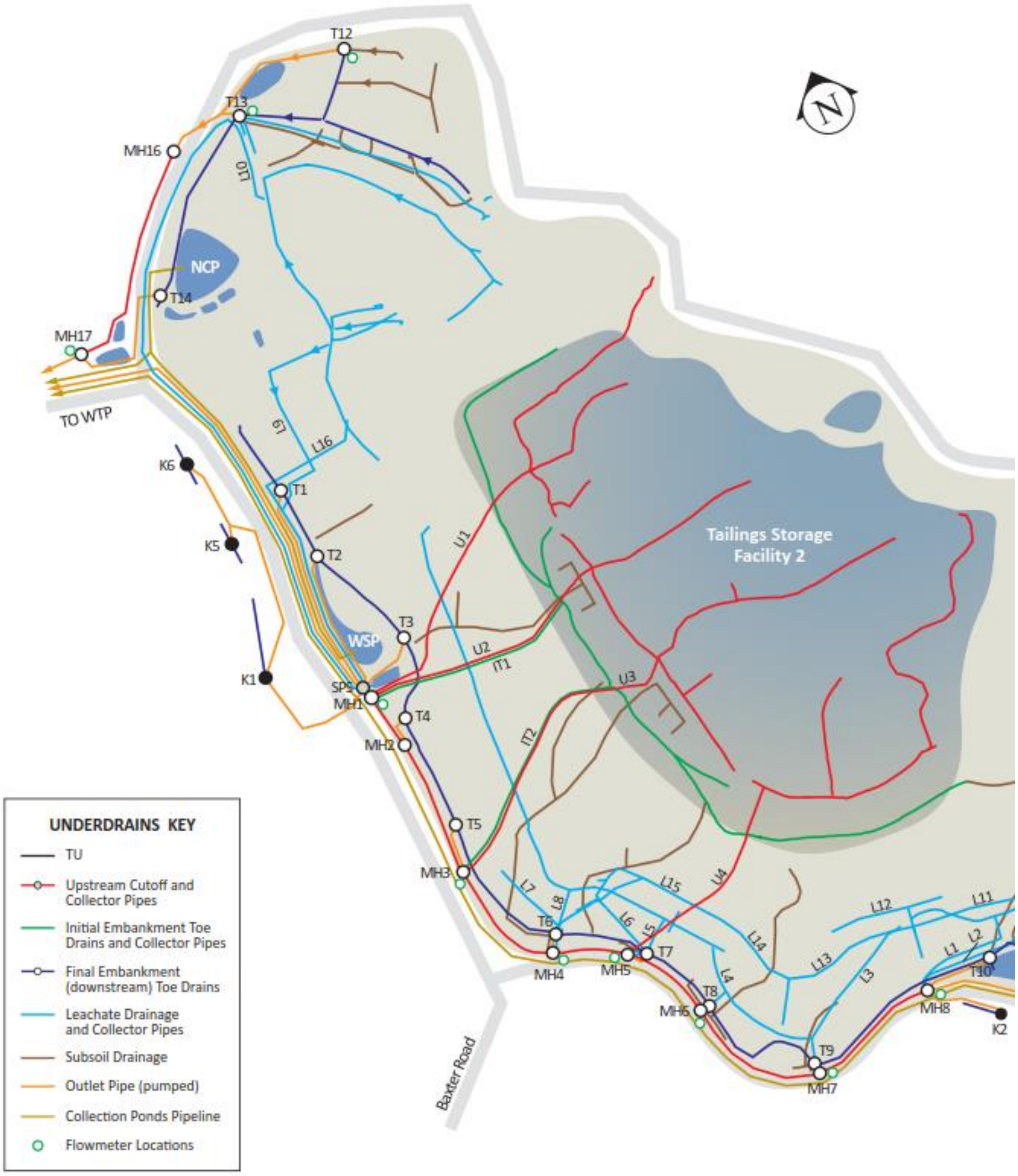


FIGURE 18: STORAGE 2 SUBSURFACE AND LEACHATE DRAINAGE NETWORK

Underdrains are located beneath the tailings and intercept seepage through the tailings. Upstream cutoff drains are located along the upstream toe of Storage 2 embankment and intercept seepage from the tailings. The upstream cutoff drain connects with the tailing underdrains and the combined discharge flows in pipes located beneath the embankment to locations at the downstream toe. There are four outlets U1-U4 which are shown in red in Figure 18.

The initial toe drain is located along the downstream toe of the initial embankment. This functions to intercept tailings seepage beneath the embankment and to limit saturation of the downstream shoulder of the initial embankment. There are two separate outlets IT1 and IT2 which are shown in green in Figure 18.

The final embankment toe drains are located along the downstream toe of the final footprint of Storage 2 to intercept seepage from either the tailings or from the embankment itself. Seepage flow is collected at 14 sumps along the toe drain T1 – T14 which are shown in navy blue in Figure 18.

Leachate drains are located within the embankment, generally near the downstream shoulder, to collect seepage from within the embankment. There are 16 leachate drains L1 – L16 which are shown in light blue on Figure 18. They discharge into the perimeter manholes that are pumped back to the Water Treatment Plant.

Cutoff drains located west of the perimeter drain function to intercept shallow potentially contaminated seepage from the perimeter drain. There are 5 cutoff drains K1 – K5 which are also shown in navy blue in Figure 18.

All drains discharge to the collector manhole sumps and are pumped back to the Water Treatment Plant. Collection sumps are located around the perimeter of the embankment and the collected leachate is pumped to the Process Plant or Water Treatment Plant.

In addition to the subsurface under drains and leachate drains, Storage 2 has an uphill diversion drain, which diverts clean water from the hills above, north to the Ohinemuri River.

FIGURE 19: CLEAN WATER UPHILL DIVERSION DRAIN - NORTH

Surface water which lands on the embankments is collected by perimeter drains, which discharge to two collection ponds (West Silt Pond and S1). Water collected in the ponds is monitored and either pumped to the Process Plant or Waste Water Treatment Plant to be treated or discharged clean to the Ohinemuri River or Ruahorehore Stream.

FIGURE 20: PERIMETER DRAIN BESIDE PERIMETER ROAD SOUTHEAST SIDE OF STORAGE 2.

Construction to RL152 was mostly undertaken by DML Resources. Construction to RL156 was undertaken by McMahon Contractors Ltd. Earthworks QA/QC was initially undertaken by Waihi Gold staff. Since November 1998 it has been undertaken by an independent testing agency (Geotechnics). During construction EGL undertakes regular site visits and provides technical assistance to mine staff who are responsible for supervising construction.

Storage 2 is consented to be raised to RL160.7 with a centreline lift of 4.7m.

4.5. Storage 1A design and construction

Storage 1A was design by EGL and it was commissioned in May 2001. Since then, virtually all tailings associated with the Martha Mine have been deposited into Storage 1A and it was raised progressively to RL172 by April 2016. Raising of the crest stopped from 2017 to 2020. Since 2020 the facility has been progressively raised and as of March 2024 it was at RL176.4.

Storage 1A is designed using the same zoned embankment design philosophy as Storage 2 and is approximately 78m high. A typical cross-sectional profile is shown in Figure 21. Storage 1A bulk fill is predominantly to Zone D2 specification and only has small proportions of the weaker Zone D3 bulk fill material compared to Storage 2.

Storage 1A was initially designed with a crest at RL166, however, over time, with changes in the mining schedule, the profile has been adjusted, to reduce the fill profile and then finally to maximise storage capacity. Storage capacity has been increased by steepening the upstream and downstream slopes. The consented design has a final crest of RL182. The crest is at RL176.4 as of March 2024. The upstream shoulders vary from 1V:2H to 1V:1H. The downstream shoulder inter-berm slopes vary from about 1V:4H below RL120 to 1V:2.78H above RL140, and will be 1V:2.25H above RL165.

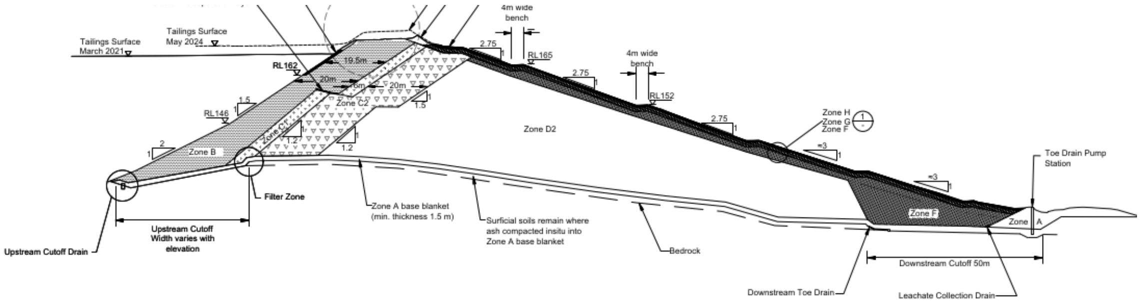


FIGURE 21: TYPICAL CROSS SECTION OF STORAGE 1A EMBANKMENT

Like Storage 2, Storage 1A has an extensive network of subsurface and leachate drains. The locations of the drains are shown in Figure 22. These drains discharge into collection sumps (manholes shown in Figure 23) located around the downstream toe of the embankment and the leachate is pumped to the Water Treatment Plant.

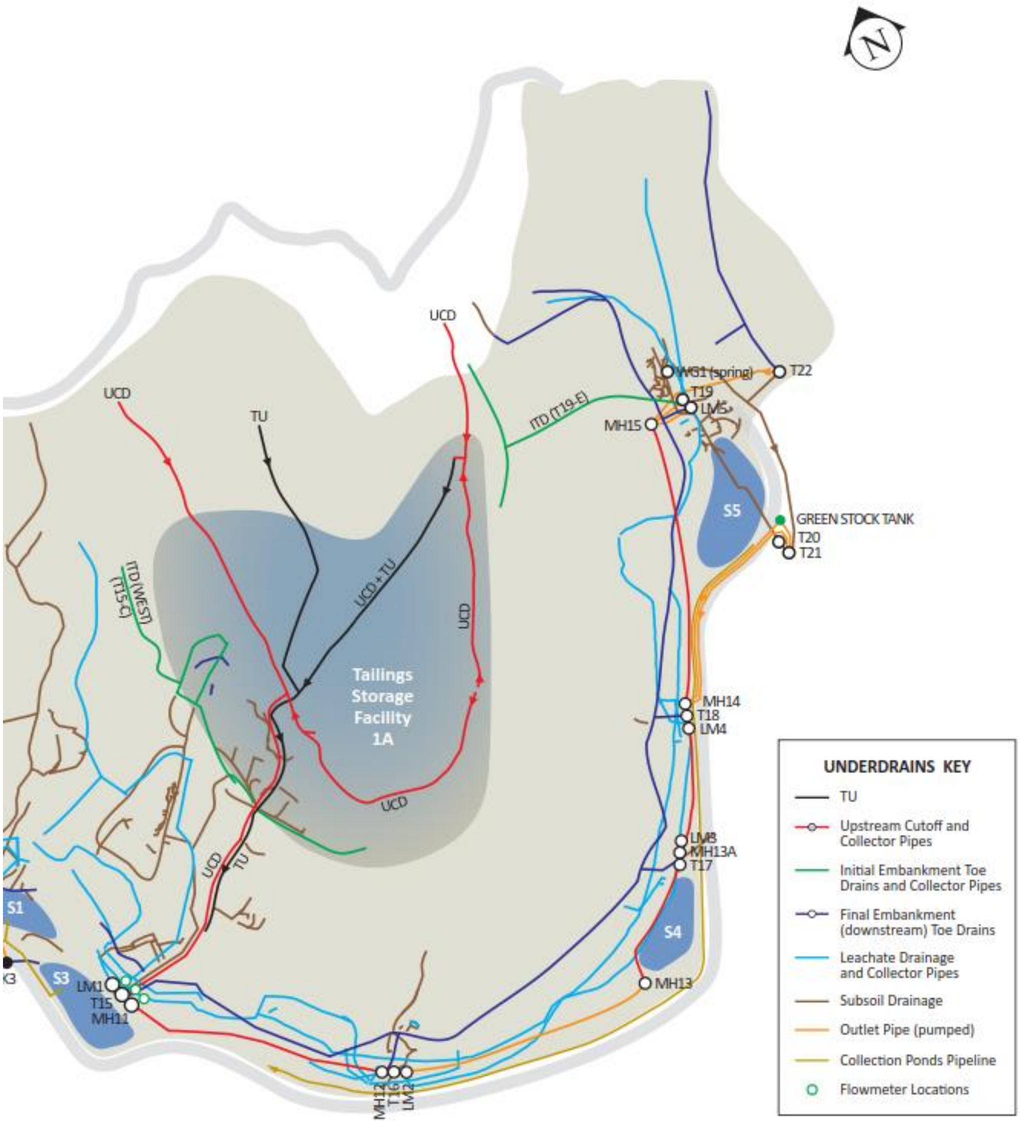


FIGURE 22: STORAGE 1A UNDER DRAINAGE NETWORK

FIGURE 23: COLLECTION SUMP T18 AT TOE OF STORAGE 1A

To manage surface water Storage 1A has an uphill diversion drain, which diverts clean water from the hills, southeast to the Ruahorehore Stream.

There are three collections ponds (S3, S4 and S5) to collect run-off from the Storage 1A embankment during construction and operation as shown in Figure 22. A photo of S5 is shown in Figure 24. These ponds are sized to have a total volume (up to the spillway) equal to the runoff volume from a 10-year ARI 72-hour storm event.

FIGURE 24: STORAGE 1A COLLECTION POND S5, WITH FOREBAY AND MAIN POND

McMahon Contractors Ltd undertook construction of Storage 1A from 1 July 1998 to 28 May 2015. Since then, construction of the Storage 1A embankment and associated facilities has been undertaken by C&R Developments Ltd under the supervision of OGNZL.

4.6. Operation

OGNZL is responsible for operation, maintenance, and surveillance of the tailings storage facilities (TSFs). Storage 1A is the currently active TSF (Figure 25), although water levels in Storage 2 need to be managed to maintain safe freeboard.

Operation involves pumping tailings into the impoundment. Supernatant water on the TSFs is pumped back to Processing Plant or Water Treatment Plant. Water stored on the TSFs needs to be balanced with the demands for treatment of water from the subsurface and leachate drains and underground and pit dewatering.

Monitoring of the freeboard (vertical distance between embankment crest and pond water level) is undertaken frequently to ensure that there is always sufficient volume under normal operation to store the runoff from a 72-hour probable maximum precipitation (PMP) rainfall event with 1 m freeboard. The 1 m freeboard is a condition of the Resource Consent issued and is recommended by NZDSG for TSFs.

FIGURE 25: STORAGE 1A TAILINGS SURFACE WITH PONDED WATER MANAGED BY OGNZL THROUGH THE WATER TREATMENT PLANT

4.7. Monitoring and Surveillance

A comprehensive monitoring and surveillance program is in place to enable the performance and condition of Storage 2 and 1A to be assessed. It is documented in the Operations, Maintenance and Surveillance Manual (Ref. 12). This manual was developed in accordance with the NZDSG.

Monitoring and surveillance associated with the tailings embankment includes:

- Visual inspection on a regular basis;
- Measurement of pore pressures within the embankment fill and tailings by pneumatic, standpipe and vibrating wire piezometers;
- Measurement of subsurface and leachate drain flows;
- Deformation monitoring; and

- Monitoring of materials and construction standards to ensure that the Contract Specification is adhered to.

Storage 2 has piezometers installed along six lines through the embankment, within two gullies, and at an intermediate location.

Storage 1A, has piezometers installed in the embankment on seven sections.

Subsurface and leachate drains are measured at the sumps. Storage 2 is measured manually and Storage 1A is measured using installed flow meters. Measurements are taken approximately every fortnight.

Benchmarks are installed on the berms following rehabilitation to allow measurement of the deformation of the outside shoulder of the embankment. A total of 19 benchmarks have been installed on Storage 1A and 39 on Storage 2.

Control testing to confirm the specified standards for the different zones is undertaken. Earthworks QA/QC was initially undertaken by Waihi Gold staff. Since November 1998 it has been undertaken by an independent testing agency (Geotechnics Ltd). Geotechnics has an on-site laboratory. During construction EGL undertakes regular site visits and provides technical assistance to mine staff who are responsible for supervising construction.

The data from the monitoring and surveillance programme are provided to the Designer, EGL, at regular intervals for review. The performance of Storage 2 and Storage 1A is formally assessed annually by EGL. This involves review of monitoring and surveillance data collected and construction records, a site inspection and stability analyses for the as-built profile and conditions. The reviews are presented in annual inspection reports.

The data and annual inspection report are provided annually to Waikato Regional Council and Hauraki District Council and are independently peer reviewed by the Peer Review Panel.

4.8. Peer review

A Peer Review Panel (PRP) has been in existence since commencement of the project. The panel includes technical specialists who between them have expertise in geochemistry, geotechnical engineering with recognised experience in design and construction of tailings storage facilities, hydrology, and rehabilitation. The specialist dam and geotechnical engineers have been H. Kennedy, Dr L. Wesley and D. Tate.

The primary function of the PRP is to ensure that the conditions of design, construction, operation, and maintenance are met and that such work is undertaken by appropriately qualified personnel in accordance with good practice. They review designs and the Annual Inspection Reports and undertake an annual site inspection and a formal meeting with Waikato Regional Council, Hauraki District Council, OGNZL and consultants. Their role as design reviewers is in addition to the design review process required by the Building Act. The Building Act requirements for independent review of design did not exist at the time of design of Storage 2.

A Comprehensive Dam Safety Review (CDSR) of Storage 1A and 2 was undertaken by T. Pickford in 2020 (Ref. 14). A CDSR is a comprehensive review of the design, construction, operation, and performance of a dam and all the systems and procedures that affect dam safety and a comparison against current dam safety guidelines, standards and industry practice. The CDSR was undertaken in accordance with the recommendations in the NZDSG (Ref. 15). The NZDSG recommend that a CDSR should be undertaken every five years for High PIC dams.

Recent designs to allow raising of Storage 2 to RL160.7 and Storage 1A to RL182 were reviewed by Damwatch Engineering as part of the Building Consent process (Refs. 16 and 17).

4.9. Performance

The piezometers, subsurface and leachate drain flows and deformation monitoring points measured confirm that the performance of the Storage 1A and 2 embankments are as intended by the design.

4.9.1. Seepage

As the embankments were raised, there was a reduction in the seepage into the ground beneath the embankment. This is due to the low permeability of the liners and tailings. This is seen in the records of the subsurface upstream, and initial embankment toe drain and drains under the tailings, which have shown a general decreasing flow with time and raising of the embankments. Figure 26 shows this effect for Storage 2 from 1989. This same effect is evident in the Storage 1A upstream cut off drain and drains under the tailings in Figure 27.

Flows from the final downstream toe drains show relatively consistent trends historically, with generally similar flows over time with peaks in the winter months. This indicates ground water recharge beneath the embankment is affected by rainfall, infiltrating from the hills behind the facilities and groundwater levels downstream of Storage 1A and Storage 2.

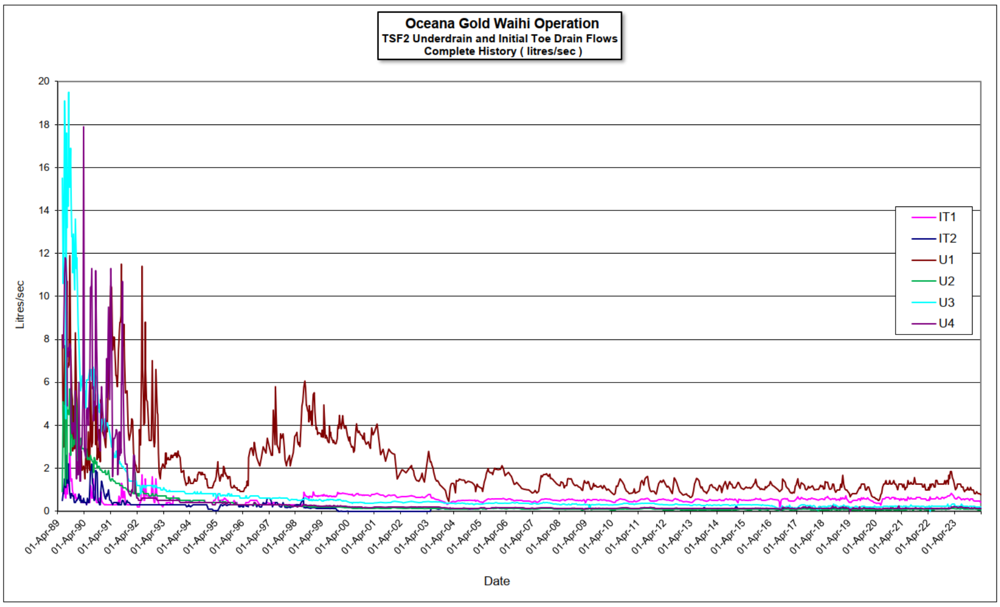


FIGURE 26: STORAGE 2 TAILINGS UNDERDRAIN AND INITIAL TOE DRAIN HISTORIC FLOWS

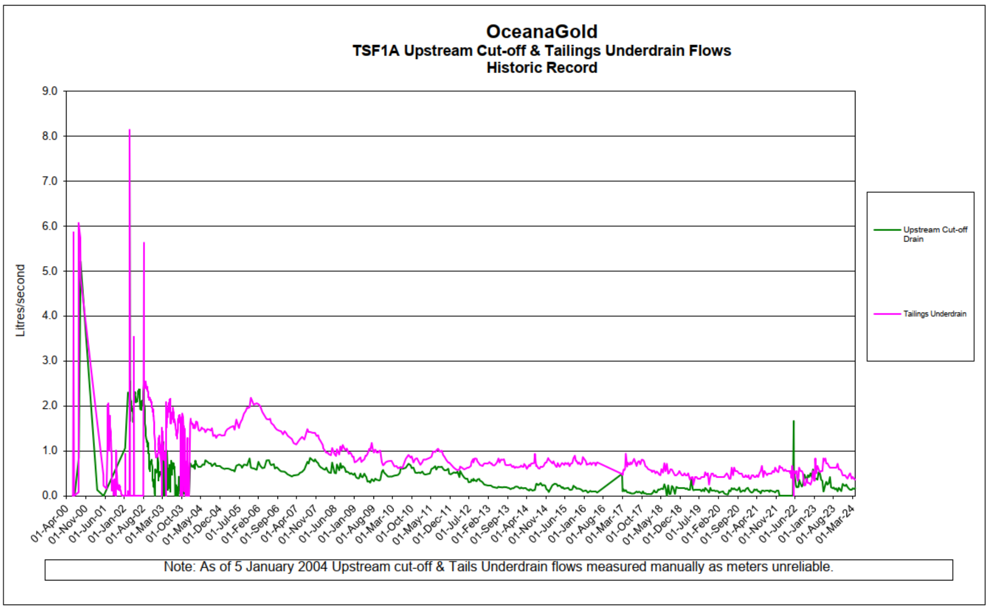


FIGURE 27: STORAGE 1A UPSTREAM CUTOFF AND TAILINGS UNDERDRAIN HISTORIC FLOWS

Leachate drain flows indicate the amount of groundwater passing through the embankment. Figure 28 shows the flows for the leachate drains associated with Storage 2 and includes drains which are beneath the Central Stockpile and Northern Stockpile. What is evident from the data is that most of the leachate drains have very little flow. This is because the Storage 2 embankment surface is now lined on its surface with a lower permeability layer, which limits groundwater and air infiltration. The two drains that still respond to rainfall are L10 and L11. L10 is located largely in the footprint of the Northern Stockpile which is not capped. L11 partially underlies the footprint of the Central Stockpile which is still being filled and is also not capped. This indicates the effect of the capping layer. Once fully capped Storage 1A is expected to experience the same effect.

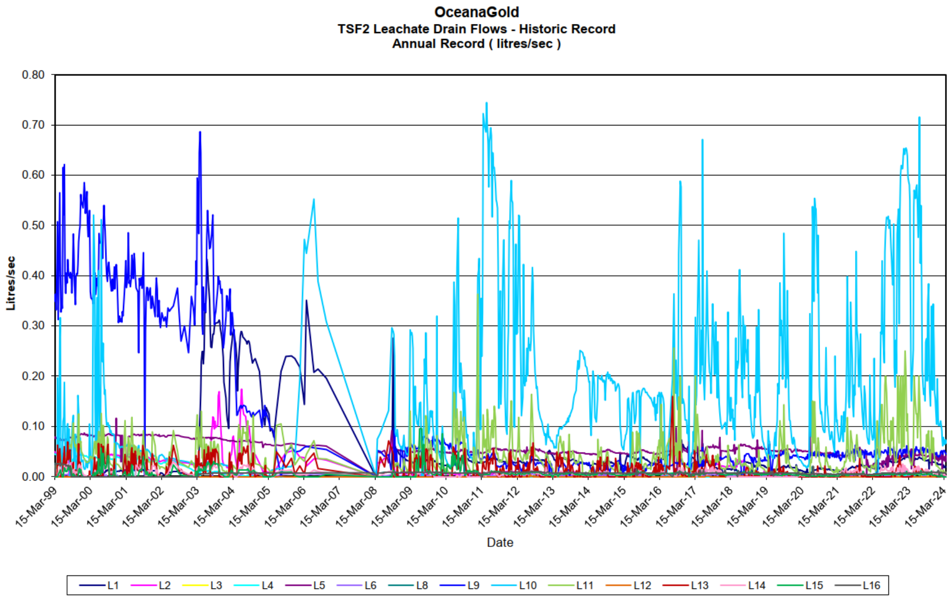


FIGURE 28: STORAGE 2 HISTORICAL LEACHATE DRAIN FLOWS

4.9.2. Porewater Pressures

Monitoring of piezometric pressures over the life of the project indicates a rise is measured in Zone B as tailings are emplaced. Over time as the depth of tailings increases and the tailings consolidate the piezometric levels stabilise and reduce. In the downstream shoulders of Storage 1A and Storage 2 the piezometric levels are generally very low. This is due to the rockfill nature of much of the fill. Some higher piezometric levels were measured in weathered rock (soil like) material in one area of Storage 2 in its early stages. This was because of the high-water content and low permeability of the fill. The higher piezometric levels dissipated as the fill consolidated and drained.

4.9.3. Environmental monitoring

Extensive environmental monitoring is undertaken. This includes sampling and testing of water quality in the TSF, Collection and silts ponds, subsurface seepage drains, and groundwater monitoring wells. Flows in subsurface seepage drains are measured. Water levels in monitoring wells are also measured. Conditions of the resource consents require regular review and interpretation of environmental monitoring and reporting to the Waikato Regional Council. The results are reviewed by the PRP.

4.9.4. Deformation monitoring

Benchmarks have been established on the embankment to enable measurement of embankment deformations (horizontal and vertical) on both Storage 2 and Storage 1A.

The results have been provided in terms of plots of both horizontal components and the vertical component of movement versus time. Since monitoring of the benchmarks began in 1996 for Storage 2, horizontal measurements up to ~50 mm and vertical settlements up to ~140 mm have been recorded on Storage 2. Storage 1A has had up to ~40 mm horizontal movement and vertical settlements up to approximately ~105 mm.

Largest deformations are generally on benchmarks at high elevations which are underlain by greater depth of fill. Measured movements also include a component of creep in the ripped and lightly compacted outer plant growth zone (Zone H).

The maximum settlement measured is ~140 mm on Storage 2. The total settlement in percentage of fill height and is up to ~0.7 % of the fill depth. The measured deformations are within normally expected values for embankment fill. Deformations of the embankment are small. Settlement continue to reduce with time.

The maximum horizontal deformation is ~50 mm on Storage 2. The vectors of horizontal movement are shown in Figure 29. Movements less than 15 mm are not shown as this is the accuracy limit of the survey. The maximum horizontal deformation of ~50 mm is small compared with the size of the embankment. It is also localised and not directly downhill suggesting it is local surficial movement, possibly from disturbance from a vehicle or could be due to redistribution of stress with raising of the embankment. Generally, for Storage 2 the vectors show small displacement, and the direction of movement is downslope. For Storage 1A most of the vectors are within the accuracy of the survey (15 mm) and show little movement.

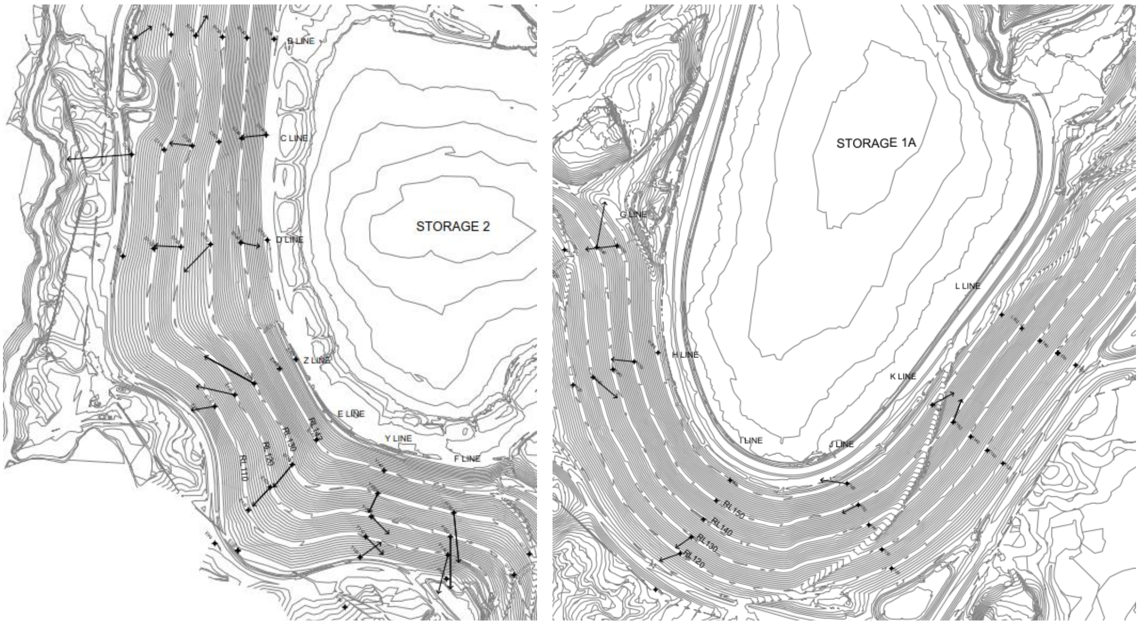


FIGURE 29: DEFORMATION MONITORING VECTOR PLOTS. LESS THAN 15MM IS SHOWN AS ZERO

4.9.5. Surface water diversion and collection ponds

Surface water from above Storage 2 and Storage 1A is diverted away by uphill diversion drains. The Northern Uphill Diversion Drain diverts water from above Storage 2 and part of Storage 1A to the north. The Southern Uphill Diversion Drain diverts water from the other part above Storage 1A to the east. These drains are shown in Figure 30.

Surface water which lands on the embankments is collected by perimeter drains, which discharge to collection ponds around Storage 2 and Storage 1A. The locations of the perimeter drains and collection ponds are shown in Figure 30. The perimeter drains and collection ponds are constructed from low permeability fill with HDPE geomembrane liners in the base of the drains and ponds to mitigate seepage losses to the ground water. Water collected in the collection ponds is monitored and either pumped to the Process Plant for reuse, to the Waste Water Treatment Plant to be treated and discharged to the Ohinemuri River, or discharged directly from the collection ponds to the Ohinemuri River or Ruahorehore Stream if it meets acceptable water quality standards.

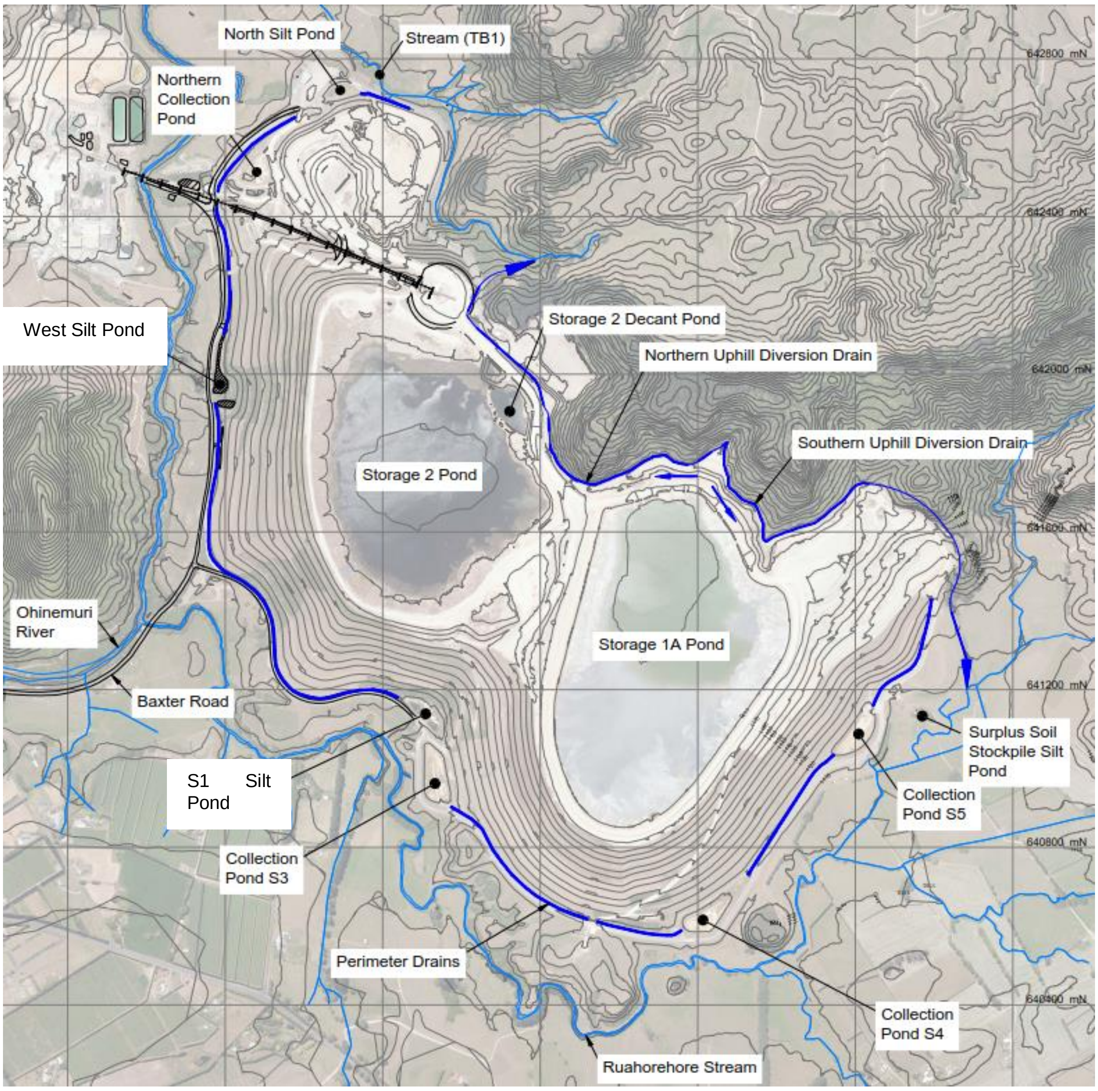


FIGURE 30: SURFACE WATER DRAINS, COLLECTION PONDS AND SILT PONDS

5.0 FAILURE OF TAILINGS STORAGE FACILITIES COMPARED TO WAIHI TSFS

It is estimated that there are at least 18,000 TSFs globally. The NZDSG include recommendations for tailings dams and cover design, construction, and operation. The NZDSG include governance, dam safety of operating dams and requirements for independent review of design and ongoing operations. The NZDSG are rigorous and represent current best international practice.

Unfortunately, some TSFs in other countries have failed due to the nature of their design, construction, and poor governance and dam safety practices during operation. Many of the failures are related to large tailings dams constructed by the upstream construction method which often involves the dams being constructed of actual tailings. Upstream construction is not used at the Waihi Operation and the downstream constructed embankments are constructed of earth and rockfill from Martha Open Pit.

The upstream construction method is often chosen as it is efficient economically or there is no readily available source of earth or rockfill (e.g., underground mining operations that do not have large quantities of overburden that are associated with open pits). Most upstream construction TSFs are designed, constructed, and operated in a safe manner. However, if the design does not include the appropriate drainage to limit the extent of saturation of the tailings, construction occurs without the appropriate management of tailings deposition and drainage within the tailings is not properly constructed, those tailings can be subject to liquefaction when saturated and failures can occur even under normal static conditions.

OceanaGold Corporation, the parent company of OGNZL, has chosen to completely avoid risks associated with TSFs constructed by the upstream construction method by not constructing any new upstream constructed TSFs.

The existing TSFs at the Waihi Operation benefit from the source of earth and rock fill from the Martha Open Pit which is used to construct the TSF embankments using the downstream construction method. The materials used to construct the downstream and centreline embankments are compacted to specified standards with specific fill zoning to contain tailings and seepage which results in a robust embankment which the tailings are impounded behind. These embankments will not liquefy and have good resistance to earthquake loadings.

Other failure modes, like shear planes within the foundation and internal erosion of the embankment, are also possible at any dam or TSF, including Waihi, and are managed through proper design, construction, operation, monitoring and surveillance. This is no different to the safe design, construction, and operation of a water storage dam.

6.0 INPUTS FOR TECHNICAL DESIGN OF TAILINGS STORAGE AND ROCK DISPOSAL

The chosen options for tailings storage and rock disposal take into consideration a wide range of information about the characteristics of each option being evaluated, and relevant to the planning needs. This includes technical, environmental, and socio-economic considerations and project economics.

This section of the report discusses technical inputs to the design that need to be considered to provide long term security for the containment of tailings and rock, minimise impacts on groundwater and surface water, and create a rehabilitated landform that will provide a net-gain in terms of biodiversity. To achieve these objectives requires a collaborative approach with input from a wide range of technical experts (geologists, hydrogeologists, hydrologists, geochemists, engineers), scientific experts (ecologists, biologists, dust and noise consultants), landscape architects and consultation with iwi. The aim is to meet obligations under the Fast-track Approvals Act and Resource Management Act, meet community and iwi expectations and to design and construct structures that meet structural stability and durability requirements under the Building Act.

The following sections of this report summarise storage requirements for tailings and rock, stakeholders, and factors that need to be considered to meet acceptable performance objectives.

6.1. Future Sources of Ore

Future sources of ore for the Waihi Operation includes existing Life of Mine resources (Martha Open Pit (MOP) and Martha Underground Mine (MUG)) and the proposed future Gladstone Open Pit (GOP) and Wharekirauponga Underground Mine (WUG). The existing TSFs (Storage 2 and Storage 1A) have capacity to store tailings associated with the LOM sources of ore. Rock for constructing new or expanding existing TSF embankments and for backfill of the underground mines will be sourced from the Martha Open Pit and Gladstone Open Pit, as well as material currently stockpiled at the Development Site. A summary of ore and rock production associated with the Waihi North Project is provided in the Table 4.

TABLE 4: PRODUCTION SCHEDULE BREAKDOWN INCREMENTAL TONNAGE BY YEAR FOR WNP ONLY, LOM ONLY, AND LOM AND WNP

Year	WNP (GOP and WUG)		LOM (MUG and MOP4)		LOM (MUG and MOP4) and WNP (GOP, WUG)	
	Ore	Overburden	Ore	Overburden	Ore	Overburden
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Year 1	-	-	415,770	428,694	415,770	428,694
Year 2	-	-	415,770	428,694	415,770	428,694
Year 3	-	50,198	438,897	481,208	438,897	531,407
Year 4	-	164,604	509,590	370,655	509,590	535,259
Year 5	-	477,191	504,570	448,839	504,570	926,031
Year 6	-	476,810	542,172	520,269	542,172	997,079
Year 7	-	468,885	542,225	507,989	542,225	976,874
Year 8	200,679	2,293,223	541,716	292,682	742,394	2,585,905
Year 9	475,701	4,663,396	446,114	3,310	921,815	4,666,707
Year 10	949,544	5,002,163	-	-	949,544	5,002,163
Year 11	1,370,039	4,198,549	-	200,000	1,370,039	4,398,549
Year 12	1,695,884	3,335,230	-	200,000	1,695,884	3,535,230
Year 13	1,128,897	878,758	-	500,000	1,128,897	1,378,758
Year 14	814,558	32,478	-	500,000	814,558	532,478
Year 15	808,956	8,903	-	500,000	808,956	508,903
Year 16	797,515	2,730	-	500,000	797,515	502,730
Year 17	494,884	7,691	-	500,000	494,884	507,691
Year 18	102,942	-	-	-	102,942	-
Total	**8,839,599**	**22,060,809**	**4,356,826**	**6,382,341**	**13,196,425**	**28,443,150**

6.2. Affected stakeholders

Affected stakeholders include:

- Neighbours (residential and farmers)
- Iwi
- Waihi Township (residents and businesses)
- Road users

6.3. Geotechnical stability

Factors that affect the stability of the TSFs and rock stacks include:

- Foundation conditions (ground type and groundwater conditions)
- Design concepts
- Construction method
- Experience of Designer and Contractor
- Construction supervision
- Operation
- Performance monitoring and mitigation
- Maintenance

6.4. Geochemical stability

Factors that affect the geochemical stability of the TSFs and rock stacks include:

- Characterization of rock (PAF versus NAF)
- Design concepts
- Construction method
- Experience of Designer and Contractor
- Construction supervision
- Operation
- Performance monitoring and mitigation
- Maintenance

6.5. Groundwater quality

Factors that affect groundwater quality include:

- Catchment
- Hydrogeology
- Design concepts
- Construction method
- Experience of Designer and Contractor
- Construction supervision
- Operation
- Performance monitoring and mitigation
- Maintenance

6.6. Surface water quality

Factors that affect surface water quality include:

- Catchment
- Design concepts
- Construction method
- Experience of Designer and Contractor
- Construction supervision
- Operation

- Performance monitoring and mitigation
- Maintenance

6.7. Rehabilitation

6.7.1. Rehabilitation of slopes

Land use at closure is affected by the rehabilitation strategy proposed. At the time of original consenting the restoration of the previous pastureland was considered to be the best option. Consequently, the rehabilitated surface of the TSFs has been pasture dominated. A rehabilitation strategy that enhances indigenous biodiversity by planting and vegetating more areas in native species has greater value than in the past. Both pasture and native vegetation are considered rehabilitation strategies.

Small areas of Storage 1A and Storage 2 are vegetated, but species are limited to shallow rooting plants to avoid any adverse impact on the integrity of the outer sealing layer (Zone G) which functions to limit ingress of oxygen and water to prevent oxidation and generation of acid leachate in the rock forming the embankments.

6.7.2. Tailings pond surface

Options for closure of the surface of TSFs include dry capping, inundation with water or a combination. The current closure concepts comprise a dry cover against the embankment crest with a wetland zone and a pond of water. A spillway is proposed to control long-term water levels in the pond. This option provides opportunity for biodiversity, will maintain the tailings in a saturated condition which minimises geochemical risks and allows for attenuation of discharge from the surface of the TSF in extreme flood events.

6.8. Sterilisation of resource

Options for disposal of tailings or rock that may potentially sterilise future ore resources need to be considered. Where possible the positioning of TSFs or permanent rock stacks should aim to avoid access to future ore resources.

7.0 REVIEW OF TECHNOLOGIES FOR TAILING DISPOSAL

7.1. Tailings Technologies

The Global Industry Standard on Tailings Management (GISTM, Ref. 18) recommends that projects consider and evaluate different options for disposal of tailings and this should include the available technologies for disposal of tailings. They include:

- Conventional slurry tailings
- Thickened tailings
- Paste
- Filtered tailings

Comments on these options follow.

7.1.1. Conventional slurry tailings

Conventional tailings are pumped to a TSF as a slurry using centrifugal pumps after minimal thickening following processing of the ore to remove gold and silver. This is the conventional technology used at most gold mines. The tailings are pumped and deposited at a high water content. Water separates from the solids upon deposition in the TSF and ponds on the tailings surface. Additional water is released from the tailings as they settle and consolidate. Most of this water rises and ponds on the surface of the tailings. The ponded water is pumped back for re-use in the Process Plant or to a water treatment plant before release. The tailings have a lower density and are weaker than thickened or paste tailings, although they do gain considerable strength and density as they consolidate. They are more susceptible to liquefaction than thickened or paste tailings. Conventional slurry tailings require larger embankments than thickened or paste tailings to safely retain the tailings and pond water and drains to intercept seepage. The Waihi Operation has had large quantities of mine pit overburden to dispose of. This has allowed construction of conservatively designed downstream construction embankments that can safely contain slurry tailings and associated runoff from extreme rainfall events.

7.1.2. Thickened tailings

Tailings can be thickened to reduce water content and volume of material that needs to be disposed. This is achieved by special tanks and flocculants. Thickened tailings require pumping by positive displacement (piston) pumps as the solids concentration increases. The advantages in comparison with conventional slurry tailings include that they can occupy a smaller footprint, have higher strength, the retaining embankment can be smaller, require less water, and water evaporation losses are less. The last two factors are important in dry climates where water resources are scarce. Thickened tailings are typically discharged centrally from the TSF with the tailings sloping down to a perimeter embankment. This is referred to as “central thickened discharge”. They are better suited to flat terrain, areas where there is low rainfall and water is scarce, and where there is limited material available for construction of the perimeter embankment. In a heavy rainfall environment like Waihi separate water storage ponds would need to be provided to store runoff and they could result in an overall larger footprint than conventional TSFs. There can be erosion of tailings in periods of heavy rain, and this needs to be allowed for in the design of the TSF. They can also be susceptible to liquefaction or strength loss, requiring underdrainage to reduce the risks of liquefaction and the perimeter embankment to be higher to contain any earthquake induced slumping of the tailings. The infrastructure and equipment to produce thickened tailings have significantly higher capital cost than conventional slurry tailings.

The terrain, high rainfall, earthquake hazard and high capital cost are factors that make them less desirable than conventional slurry tailings at the Waihi Operation. Another important factor is the Waihi Operation has had large quantities of mine pit overburden to dispose and this has allowed construction of conservatively designed downstream construction embankments that can safely contain slurry tailings.

7.1.3. Paste

Paste are tailings in which the water content is reduced more than thickened tailings to produce a material of higher solids content and strength. This requires additional dewatering of the tailings and requires positive displacement (piston) pumps to transport the paste to where it is disposed. The cost of producing and pumping paste is higher than thickened tailings. Paste tailings are sometimes used to fill the voids associated with underground mining. Cement is mixed into the paste along with other admixtures to result in higher strength and pumpability.

7.1.4. Filtered tailings

Filtered tailing are tailings in which the water is removed by filters and mechanical presses so that they can be mechanically handled. The tailings are still in a moist condition and susceptible to strength loss with the addition of water (e.g., rainfall). In an ideal situation no embankment is required to retain filtered tailings. They are transported by truck and spread and compacted by track rolling with a bulldozer. The resulting mound of tailings is typically referred to as a “dry stack”. A perimeter bund is required to capture and direct runoff to collection ponds. There are significant capital costs associated with producing filtered tailings. They are not suited to areas of high rainfall where earthquakes are possible. In prolonged wet periods the tailings can soften, and it can be very difficult to traffic on the surface and place additional tailings. A conventional TSF is required to allow continuous operation of the Processing Plant at these times and to allow for breakdowns and maintenance of the equipment used to produce filtered tailings. In areas of high rainfall, the tailings at low elevations could become saturated and be susceptible to liquefaction if subjected to strong earthquake ground motions. To mitigate these risks underdrainage and a large perimeter embankment would need to be constructed.

8.0 POTENTIAL LOCATIONS FOR EXPANSION OF TAILINGS STORAGE AND ROCK DISPOSAL

Potential locations for tailings storage and rock disposal are described and discussed in the sections below. The locations of the existing TSFs (Storage 2 and Storage 1A) and stockpiles are shown in Figure A2. The locations of other potential tailings storage and mine overburden disposal sites are shown in Figure A3.

8.1. Existing Storage 2 site

Raising the existing Storage 2 TSF embankments (above already consented design levels) can provide storage for additional tailings and mine open pit overburden material as follows:

- Raising of Storage 2 for increased tailings storage.
- Open pit mine overburden material can be used to raise the existing Storage 2 embankment.
- Storage 2 can be raised by downstream or centreline construction. Downstream construction can provide a significant increase in storage if it was extended beyond the downstream toe of the existing embankment. A

major constraint is that it would not meet the project scheduling requirements because it would require a large volume of fill and would require removal of the existing outer capping layers (Zones G and H), removal and re-siting of the perimeter road and access to the Processing Plant, and removal and reconstruction of the perimeter drain, collection and silt ponds, the seepage/leachate collection system. A small downstream construction raise by steepening of the downstream shoulder above existing higher level benches is an option. A small centreline raise constructed above existing higher level intermediate benches is also an option.

- Dry stacked filtered tailings could be placed above the existing tailings without any raise of the Storage 2 embankment. However, this option is not suited to the climate at Waihi. Capital and operating costs are very high for the infrastructure to undertake dry stacking.
- Mine open pit overburden material could be placed above the existing tailings to create a dry cap. This would compromise future raising to provide additional tailings storage and a dry cap is not considered the best closure option.

8.2. Existing Storage 1A site

Raising the existing Storage 1A TSF embankments (above already consented design levels) can provide storage for additional tailings and mine open pit overburden material as follows:

- Raising of Storage 1A for increased tailings storage.
- Open pit mine overburden material can be used to raise the existing Storage 1A embankment. Downstream construction can provide a significant increase in storage if it was extended beyond the downstream toe of the existing embankment. A major constraint is that it would not meet the project scheduling requirements because it would require a large volume of fill and require removal of the existing outer capping layers (Zones G and H), removal and re-siting of the perimeter road and drain, Collection Ponds S3, S4 and S5 and silt ponds, the seepage/leachate collection system. A small downstream construction raise by steepening of the downstream shoulder above existing higher level benches is an option but still requires removal of Zones G and H. A small centreline raise constructed above existing higher level intermediate benches is also an option.
- Storage 1A can be raised by downstream or centreline construction.
- Dry stacked filtered tailings could be placed above the existing tailings without any raise of the Storage 1A embankment. However, this option is not suited to the climate at Waihi. Capital and operating costs are very high.
- Mine open pit overburden material could be placed above the existing tailings to create a dry cap. This would compromise future raising to provide additional tailings storage and a dry cap is not considered the best closure option.

8.3. North of Storage 2

The potential exists to construct a new TSF or rock stack to the north of Storage 2. Geotechnical investigations, conceptual designs and feasibility studies have been undertaken. Ground conditions are suitable but any TSF in this area has poor storage efficiency (i.e., a large volume of embankment fill is required to provide a relatively small volume of tailings storage). In addition, any option that provides significant storage would impact on a Significant Natural Area (SNA) located on the east boundary and would be located close to Golden Valley Road.

Dry stacked filtered tailings could be located north of Storage 2. However, this option is not suited to the climate at Waihi and capital and operating costs are very high.

8.4. Northeast of Storage 2

A new TSF or rock stack could be developed on land located about 1.2 km to the northeast of Storage 2. The northern boundary of the site is Trig Road North. The land is not owned by OGNZL. Limited geotechnical investigations have been undertaken and a prefeasibility level study completed. No major geotechnical constraints were identified. However, a TSF at this location is very inefficient (i.e., a large volume of embankment fill is required to achieve a relatively small volume of tailings storage). A major constraint is it would not meet the project scheduling requirements because it would require a large amount of fill to provide tailings storage. Other constraints include that the land is not owned by OGNZL, it would impact on a new area and there would be additional affected stakeholders.

Dry stacked filtered tailings could be located northeast of Storage 2. However, this option is not suited to the climate at Waihi. Capital and operating costs are very high.

8.5. Northeast valley

Opportunities to store either tailings or mine open pit overburden are available immediately to the northeast of Storage 2 at the northeast valley and upper northeast sites. OGNZL does not own all this land. The storage capacities for either tailing and mine open pit overburden are limited compared to other options, but they are closer to the Processing Plant and the conveyor/loadout than some other options.

8.6. Site east of Storage 1A

A new TSF or rock stack could be constructed east of Storage 1A. The option for storage of tailings in this area has been investigated in detail and a feasibility study has been undertaken. This option is referred to as Storage 3. The land is owned by OGNZL. Geotechnical investigations indicate that ground conditions are suitable for a TSF subject to removal of weak ground that has been identified by the investigations. The Storage 3 TSF provides for efficient storage of tailings. The embankment construction program meets the current ore and mine pit overburden rock production schedule.

The site would be suitable for storage of mine pit overburden rock. However, there are better options at the existing Development Site that avoid disturbing a new area and have better economics.

Dry stacked filtered tailings could be located east of Storage 1A. However, this option is not suited to the climate at Waihi. Capital and operating costs are very high.

8.7. Beyond the current Development Site

New TSFs or rock stacks beyond the Development Site other than discussed above have not been considered. Any options would be located more distant from existing mine infrastructure, result in disturbance and potential effects on new areas, and affect additional stakeholders. There would be significant consenting issues and capital and operating costs would be higher than other options at the Development Site.

8.8. Martha Open Pit

Tailings associated with the Waihi North Project and overburden rock from Gladstone Open Pit and the north wall of Martha Open Pit could be stored in the bottom of Martha Open Pit. However, there would be several technical as well as health and safety challenges including stabilisation of the pit walls and construction and operation of the facility. It would complicate and possibly prevent the current closure plan to fill the Martha Open Pit with water and create a lake. The cost of constructing and operating a TSF in the Martha Open Pit would be greater than using and developing new TSFs at the Development Site.

Storage of overburden rock in the base of the pit would be easier but there would still be technical and health and safety challenges. The cost of disposing of waste rock in Martha Open Pit would be significantly greater than associated with options at the Development Site due to the haul costs.

A major disadvantage with storage of either tailings or overburden rock in the Martha Open Pit is that it would compromise future options for extending mining operations in the area.

8.9. Gladstone Open Pit

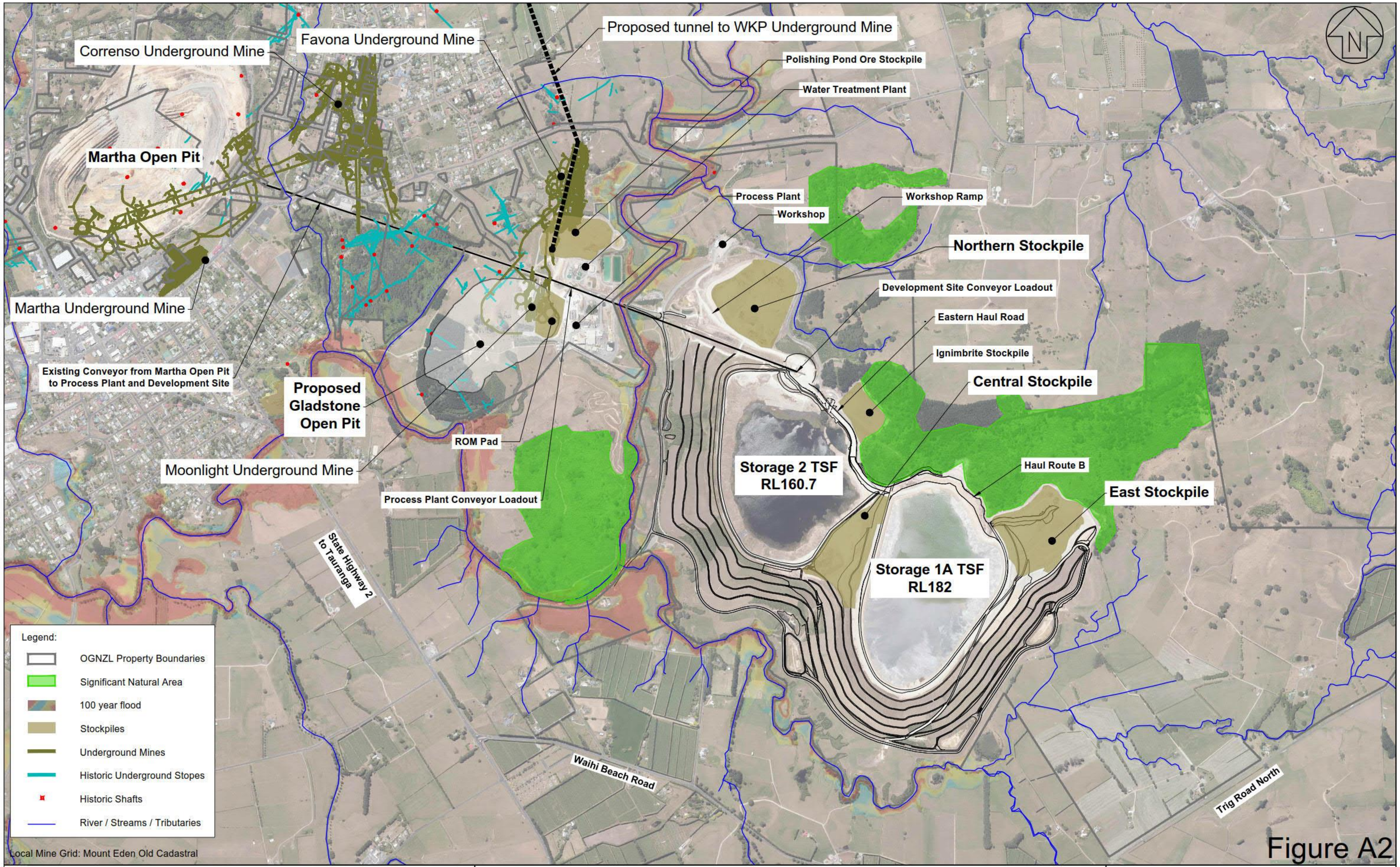
The Gladstone Open Pit could be used for both disposal of tailings and mine pit overburden material. A TSF would require flattening of the pit walls to reduce the risk of instability and lining to prevent tailings seepage from entering the groundwater. A prefeasibility study of this option has been undertaken by GHD (Ref. 1). The Waihi North Project schedule has mining of Gladstone Open Pit commencing in Year 8. This provides a source of fill for constructing a new TSF (Storage 3) which would satisfy the project scheduling requirements.

Gladstone Open Pit could also be used for storage of overburden rock. Some overburden rock is required as partial backfill of the Gladstone Open Pit to form the proposed TSF. However, the option of utilising Gladstone Open Pit just for rock disposal would require expansion of other TSF options and would require stockpiling of large quantities while mining the pit.

8.10. Underground

It is common practice to backfill the voids created by underground mining. Mine pit overburden rock can be used for backfilling of underground mines. This already happens with the current operation and will continue with the Waihi North Project.

Tailings can also be used for filling underground mines. This requires dewatering of the tailings to create a pumpable paste and the addition of cement and other admixtures to improve its pumpability and strength. The resulting mix is commonly referred to as paste backfill. There are significant capital and operating costs associated with paste backfill compared to backfilling with overburden rock.



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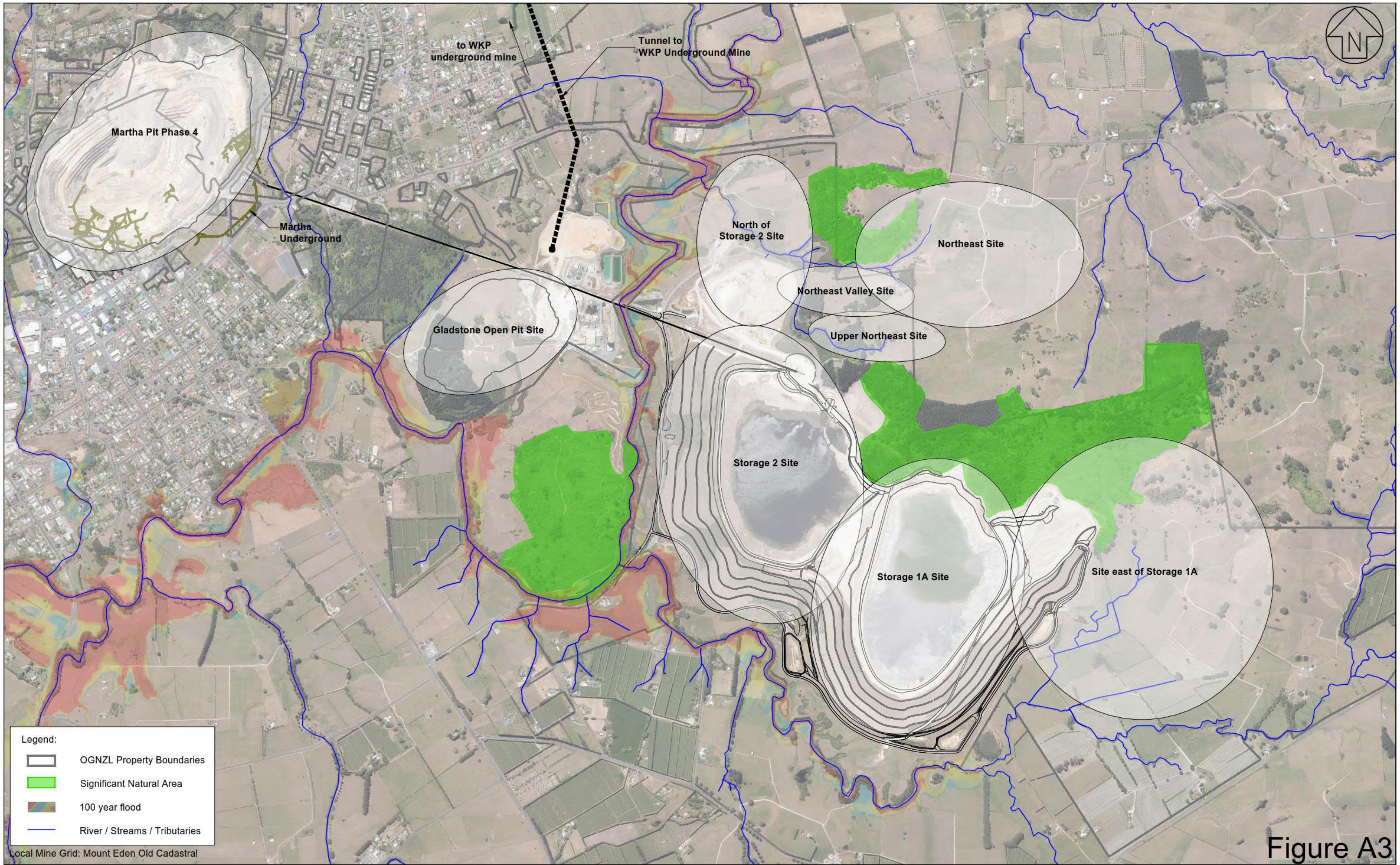
OCEANA GOLD NZ LIMITED - WAIHI
WAIHI NORTH PROJECT
Site Plan

Drawing No.	9215–FigA2
Date:	July 2021
Drawn:	JL
Scale:	1:15,000 @A3
Filename:	9215–FigA2.dwg



EGL Geotechnical, Earthquake and Dam Engineers Engineering Geology Ltd +64 9 486 2546 info@egl.co.nz Unit 7C, 331 Rosedale Road, Albany, Auckland PO Box 301054, Albany, Auckland 0752 www.egl.co.nz	OCEANA GOLD NZ LIMITED - WAIHI WAIHI NORTH PROJECT Tailings Storage and Mine Overburden Disposal Sites	Drawing No. 9215–FigA3 Date: July 2021 Drawn: JL Scale: 1:15,000 @A3 Filename: 9215–FigA3.dwg

9.0 OPTIONS FOR DISPOSAL OF TAILINGS AND MINE PIT OVERBURDEN

The Global Industry Standard on Tailings Management (GISTM, Ref. 18) recommends that projects consider and evaluate different options for disposal of tailings. This also applies to disposal of mine pit overburden. Options for the Waihi Operation are discussed in the following sections.

9.1. Options for tailings disposal

Tailings can be disposed of in different ways including:

- In-pit
- Underground paste
- Above ground paste
- Central thickened discharge
- Dry stacks
- Mixed waste
- Downstream and centreline construction embankment dams
- Upstream embankment construction is another option but is not considered an option for new TSFs by OGNZL.

9.1.1. In-pit disposal

Tailings can be disposed in the pits left after excavation of the overburden and ore. This method has been successfully undertaken at both Macraes and Reefton Mines in New Zealand by OGNZL.

In-pit disposal requires any stopes to be secured, installation of a liner with underdrainage and tailings underdrains unless reliance on hydraulic containment can be demonstrated. Earth or geosynthetic liners can be used as is done in landfills.

In-pit disposal also requires stabilisation of pit slopes above the retained tailings for health and safety reasons and to avoid displacement and release of tailings in the event of a pit wall landslide into the TSF.

In-pit disposal can be complicated by risk of breach into underground mines or sterilisation of potential ore resources.

The benefit of in-pit disposal below the crest of the pit is that it avoids the risk of a dam break or slope failure due to geotechnical factors associated with above surface methods such as dams or dry stacks.

If there was seepage out of the pit into the surrounding ground it may be more difficult to mitigate due to the depth below the ground surface tailings are placed.

9.1.1.1. Martha Open Pit

The use of Martha Open Pit as a TSF was not considered due to its close interaction with the Martha Underground Mine and ore resources surrounding it, and potential health and safety risks.

9.1.1.2. Gladstone Open Pit

The use of Gladstone Open Pit as a TSF is a realistic option.

9.1.2. Underground paste backfill

Underground backfill using paste is a potential option for tailings disposal. To create the paste tailings are thickened and mixed with a binder, like cement. Pastes are expensive due to high capital cost and high operating costs including binders, dewatering and pumping.

Pastes are placed in the ground without a liner; however, cement binders will reduce acid generation until groundwater rises following mining.

If pastes are not properly mixed and placed, that can present a hazard if mining occurs close to previous backfilled stopes, which could result in sterilising resources.

The benefit of paste backfill is that it utilises the underground voids created in the mining process for tailings storage.

Underground paste backfill is an option. However, it would only be able to provide a small proportion of tailings storage requirements for the Waihi Operation. This is because not all the ore is from underground mining and the density of paste backfill is lower than the insitu mined rock.

The feasibility of underground paste depends on costs, risks around ground water contamination, and sterilisation of resource. At the Waihi Operation the use of paste backfill has not been necessary because there has been surplus mine pit overburden material available to backfill voids associated with underground mining. Pumping of pastes present a technical challenge and paste plants are typically located close to the deposition location for this reason.

There are also safety risks with the interconnectivity of the unknown historical voids, resulting in the risk of inundation when paste filling upper levels at the same time as working in lower levels.

9.1.3. Central thickened discharge

Thickened tailing can be discharged from the centre of a TSF with the surface of the tailings sloping down to the perimeter. The tailings are stronger than conventional slurry tailings and a smaller embankment is required. Central thickened tailings are best suited to flat terrain where circular shaped facilities can be constructed, dry climates, and where there is low earthquake hazard. These conditions do not exist at Waihi and combined with higher capital cost are not considered practical or to offer any additional benefit compared to downstream construction embankments with conventional slurry tailings.

9.1.4. Dry stacks

Dry stacking requires tailings to be dewatered using thickeners and filter presses. Filter presses squeeze the water out of the tailings so they are a wet soil and can be transported by truck or on a conveyor. The soil is then compacted in its final location as a stockpile or stack. Dry stacks require good compaction and placement during winter, which would be difficult in Waihi. Dry stacks also require good underdrainage to ensure the tailings do not become saturated as under high vertical stresses from the overlying tailings soils can become normally consolidated again and prone to contraction under shearing or liquefaction. Like an upstream TSF they require consideration of water shedding and internal drainage. A toe buttress constructed out of rockfill can improve long term seismic stability. The tailings at Waihi would achieve a low permeability however a NAF capping would likely be required for rehabilitation. Management of water runoff is required. Due to the high rainfall a large collection pond is required to manage the contaminated water, a function that a tailings impoundment provides for downstream constructed facilities.

Dry stacking is an option; however, this technology is not ideally suited to the climatic and earthquake hazards that exist at the site. At the Waihi Operation there are significant operational issues and risks with the use of filtered tailings due to the high rainfall. The high rainfall combined with the potential for earthquake shaking would likely require construction of perimeter embankments. These factors combined with the high capital and operating cost, are major constraints for the adoption of this technology at the Waihi Operation.

9.1.4.1. Storage 1A dry stack capping

Dry stacks of tailings could be constructed on top of Storage 1A with the surface runoff managed in Storage 2. This would require the Storage 2 not to be closed after raising to its currently consented elevation of RL160.7 until a dry stack on Storage 1A is completed. On its own this option would not be economically viable.

9.1.4.2. Storage 2 dry stack capping

Dry stacks of tailings could be constructed on top of Storage 2. However, surface water management would require large collection ponds formed using earth embankment dams to be constructed to the north of Storage 2 during operation. This would compromise the proposal to develop a rock stack in this area which is required to meet project scheduling requirements. For the above reasons it is not considered a feasible option.

9.1.4.3. Dry stack north of Storage 2 or east of Storage 1A

The areas both North of Storage 2 or East of Storage 1A are on land owned by OGNZL and could be used as dry stack locations. However, for the reasons explained in section 9.1.4 this technology is not ideally suited to the Waihi Operation as there are significant operational issues and risks because of the high rainfall and earthquake hazard.

9.1.4.4. Dry stack northeast of Storage 2

A dry stack could be constructed northeast of Storage 2. This land is not owned by OGNZL. For the reasons explained in section 9.1.4.3 this technology is not ideally suited to the Waihi Operation.

9.1.5. Mixed rock stacks

Mixed waste stacks, sometimes referred to as co-disposal, is a newer concept where tailings (filter pressed) are mixed with mine open pit overburden rock fill to form a stack of tailings and rock that together has better geotechnical properties than tailings. There are few examples of this technology, especially in high rainfall environments. The same issues regarding the management of surface runoff for dry stacks exist for mixed waste stacks. This option is not recommended for use at the Waihi Operation at this stage.

9.1.6. Downstream and centreline embankment dams

Downstream and centreline embankment dams constructed out of compacted earth and rockfill present robust options as the downstream stability of the embankment does not rely on the strength or behaviour of the tailings. The embankment can be zoned so water can also impound against the embankment without concern.

The existing TSFs at the Waihi Operation are of downstream construction. This is generally the most robust type of embankment that can be used for storing tailings. They have been proven as an effective option for the Waihi Operation. The large quantities of mine open pit overburden material have enabled construction of conservatively designed embankments to retain the tailings. They are a robust option in the event of an earthquake.

Centreline embankments are more efficient tailings embankments than downstream embankments. In this option the embankment crest is maintained on the same centreline by placement of some fill upstream of the crest on tailings and some over the downstream shoulder of the existing embankment. The upstream stability during construction needs careful consideration where the embankment is required to be constructed a large height above the tailings to provide storage for tailings and to provide freeboard for extreme flood events. This is the case at Waihi. The practicality of a centreline embankment depends on the rate of rise, with faster rates of raise resulting in less consolidation of the tailings and weaker tailings.

The locations of existing TSFs and potential new TSFs are shown in Figure A3. They are discussed in the following sections.

9.1.6.1. Raising of Storage 1A

Storage 1A could be raised by downstream or centreline construction by steepening the existing embankment slopes as the embankment was conservatively designed and constructed predominately out of rockfill from the Martha Open Pit. This means that it is feasible to steepen the existing downstream shoulder and still meet NZDSG recommended design criteria.

9.1.6.2. Raising of Storage 2

Storage 2 could be raised by downstream or centreline construction. The downstream toe would have to be moved out as steeper slopes over the existing embankment are not possible. This would require the perimeter road and drain and other infrastructure (e.g., West Silt Pond, seepage/leachate collection sumps, pipes and pumps) to be relocated.

9.1.6.3. New downstream embankment dam north of Storage 2

A new downstream embankment could be constructed north of Storage 2. The site is not particularly efficient as there is no natural valley to build the embankment across and the hills to abut into are not as high as those behind Storage 1A and 2. In addition, any option that provides significant storage would impact on a Significant Natural Area (SNA) located on the east boundary and would be located close to Golden Valley Road.

9.1.6.4. New downstream embankment dam northeast of Storage 2

A new downstream embankment could be constructed northeast of Storage 2. The site borders Golden Valley and Trig Roads. The site would be similar to Storage 1A and 2 abutting the hills with a U-shaped embankment. New infrastructure would be required to the site. Limited geotechnical investigations have been undertaken and a prefeasibility level study completed. No major geotechnical constraints were identified. A TSF at this location is very inefficient (i.e., a large volume of embankment fill is required to achieve a relatively small volume of tailings storage). A major constraint is it would not meet the project scheduling requirements because it would require a large amount of fill to provide tailings storage. Other constraints include that the land is not owned by OGNZL, it would impact on a new area and there would be additional affected stakeholders.

9.1.6.5. New downstream embankment in northeast valley

A new downstream embankment could be constructed in a small valley on land immediately northeast of Storage 2. OGNZL does not own all this land. Geotechnical investigations and a prefeasibility study have been undertaken for a potential TSF. It has limited capacity (approximately 2 Mm^3). No major geotechnical constraints were identified. Constraints include the land is not owned by OGNZL and it encroaches into a SNA.

9.1.6.6. New downstream embankment dam east of Storage 1A

The site east of Storage 1A has always been considered as a potential TSF location and extensive geotechnical investigations and a feasibility study have been completed. This site is called the Storage 3 TSF. With Storage 1A it forms a valley which an embankment can be constructed across. This is the most efficient site for a downstream embankment dam within proximity of the existing mine infrastructure and the Process Plant. The Storage 3 design encroaches into a SNA.

9.2. Rock disposal options

9.2.1. Underground backfill

Backfill of the underground stopes is currently done and will continue, however this does not provide anywhere enough storage for the scheduled rock production.

9.2.2. Pit backfill

Backfill of Martha Open Pit or Gladstone Open Pit is possible but depends on sequencing of the pit excavations and timing of closure of the mines.

The pits could be backfilled below the edge of the existing ground surface to allow surface water to saturate all the backfill rock to prevent ARD. Alternatively, if material is placed to a higher level above the ground water level capping and seepage collection could be provided to limit ARD from PAF rock as is done for the existing TSF embankments.

Constraints associated with placing rock in Martha Open Pit include health and safety risks for staff and sterilisation of future ore resources that could be mined underground or by a future pit expansion.

The preferred options for tailings and waste rock disposal require all available overburden for constructing new TSFs (GOP and Storage 3) and the option of backfilling either of these pits does not meet project scheduling requirements.

9.2.3. TSF embankments

Embankments that form the TSFs require large volumes of fill that can be provided by the mine pit overburden material. The TSF embankments have been and will continue to be the principal locations for disposal of mine pit overburden material associated with the Martha Project. The embankments are zoned to allow for the safe long-term storage of PAF rock.

9.2.4. TSF capping

A low-profile mound of rockfill could be placed over the tailings to provide a dry capping. This would differ from the current closure concept of a perimeter capping with wetland and pond. A disadvantage with a dry cap is that runoff flows from extreme flood events are much higher than if a pond is part of the closure strategy. The presence of a pond allows for significant attenuation of flood flows.

9.2.5. Existing stockpiles

There are three existing rock stockpiles at the Development Site (Northern, Central and East) for storage of mine pit overburden material.

They are shown in Figure 30 (Fig A2) and are described below. They are all currently active and material in these stockpiles is the source of fill for future raising of Storage 1A and Storage 2.

9.2.5.1. Northern Stockpile

The Northern Stockpile is located immediately north of Storage 2. It is used for temporary storage of NAF material. It can continue to be used in the future and can be extended further northwards to provide additional storage capacity (refer to section 9.2.6.1).

9.2.5.2. Central Stockpile

The Central Stockpile is located at the junction between Storage 1A and Storage 2. It is used for temporary storage of PAF material. It can continue to be used in the future.

9.2.5.3. East Stockpile

The East Stockpile is located on the northeast side of Storage 1A. It overlies the downstream shoulder of the Storage 1A embankment and currently stores predominantly PAF material. It has potential for future expansion, but this is dependent on whether the area to the east of Storage 1A is developed as a future tailings storage facility.

There is also an existing stockpile immediately north of the Process Plant. It is known as the Polishing Pond Stockpile. It has been used to store ore and rock from development of underground mines. It has a capacity of about 0.6 Mm^3.

9.2.6. New rock stacks

New rock stacks could be developed at several locations that are shown in Figure A3. They are discussed in the following sections.

9.2.6.1. North of Storage 2

A rock stack can be constructed north of Storage 2 in the same locality as a potential TSF. Geotechnical investigations and feasibility designs have been prepared. It would be an extension of the existing Northern Stockpile. It could be developed for storage of PAF material, if necessary, provided appropriate controls were put in place (e.g. low permeability base liner, outer sealing layer, leachate collection drains).

9.2.6.2. East of Storage 1A

A rock stack can be constructed east of Storage 1A. It would occupy the same footprint as the proposed Storage 3 TSF. Geotechnical investigations and pre-feasibility designs have been prepared.

9.2.6.3. Northeast of Storage 2

A rock stack can be constructed northeast of Storage 2 in the same locality as a potential TSF. It is adjacent Golden Valley and Trig Roads. Preliminary geotechnical investigations have been undertaken and pre-feasibility designs have been prepared. Constraints include that the land is not owned by OGNZL, it would impact on a new area and there would be additional affected stakeholders.

9.2.6.4. Northeast valley and upper northeast sites

There are two options for small rock stacks that could be located immediately northeast of Storage 2. The first (Northeast valley) could be developed at the same location as the small TSF referred to in section 9.1.6.5. It would have the capacity to store about 3.5 Mm^3. There is also another option immediately south of the Northeast valley (Upper northeast site). It would have small capacity. The advantage of these options is the proximity to the current conveyor/loadout. One disadvantage is the material would need to be hauled to a higher elevation than some other storage options and it would have high visibility from the northwest. Constraints include the land is not owned by OceanaGold and these options encroach into a SNA.

10.0 OPTIONS FOR ASSESSMENT

10.1. Category, Criteria and Weighting

As per the Global Industry Standard on Tailings Management requirement 3.2 a multi criteria assessment (MCA), as a tool to compare the options, has been undertaken. Only feasible options that meet the project scheduling requirements have been considered. This reduces the number of viable options. The main categories that have been considered are summarised below:

- Technical (e.g., geotechnical, geochemical, mine operations, constructability, operability)
- Environmental (e.g., potential impacts on terrestrial and aquatic ecosystems, groundwater, surface water)
- Socio-economic and permitting (potential social and economic impacts and benefits on communities, Mana Whenua, recreation, archaeological/heritage, and landscape/visual effects)
- Project economics (short-term and long- term capital and operating expenses)

For each category several subcategories have been defined. The weightings given to the main categories and their subcategories are summarised in Table 5.

TABLE 5: MULTI CRITERIA FOR OPTION ASSESSMENT

Category	Subcategory	Category Weighting	Subcategory Weighting
Technical	Future ore resource	0.25	0.1
	Geotechnical		0.15
	Geochemical		0.15
	Constructability		0.1
	Operability		0.1
	Storage capacity and expansion potential		0.15
	Project schedule		0.25
Environmental	Terrestrial ecosystem	0.25	0.2
	Aquatic ecosystem		0.2
	Groundwater		0.15
	Surface water		0.15
	Impact on SNA		0.1
	Dust		0.1
	Noise		0.1
Socio-economic and permitting	Social impact	0.25	0.15
	Mana Whenua		0.25
	Economic		0.1
	Recreation		0.1
	Regulatory approval		0.2
	Archaeological/heritage		0.1
	Landscape and visual		0.1
Project Economics	Land ownership	0.25	0.1
	Capital cost		0.35
	Operating cost		0.35
	Closure and post-closure cost		0.2

Criteria for scoring each category have been established and are summarised in Tables 6 to 9.

TABLE 6. TECHNICAL SCORING CRITERIA

Subcategory	Description	Criteria for Scoring
Future ore resource	The potential of the site as future source of ore or for other facilities	No potential for ore or for other uses: score=5, No potential for ore, some interference with future expansion of mine facilities: score=3, Located near future sources of ore and some interference with future expansion of mine facilities: score=0
Geotechnical	Stability of TSF embankment and seepage control	Downstream construction, good foundations, meets modern stability performance criteria: score=5, Downstream construction, foundations vulnerable to softening under design earthquake loading, meets modern stability performance criteria or centreline construction, good foundations, meets modern stability performance criteria: score=3, Poor foundations, does not meet modern stability performance criteria: score=0
Geochemical	Control measures to prevent and mitigate acid mine drainage and consequences	Design concepts with proven track record to prevent and mitigate acid mine drainage and consequences: score=5, Design concepts proposed but no proven track record: score=3, No effective control measures: score=0
Constructability	Practicality of construction taking account of proposed design, site conditions and materials available for construction	Design, site conditions (e.g., weather) and construction materials do not significantly affect constructability: score=5, Design, site conditions and construction materials could affect ability to construct or meet construction program: score=3, Serious doubt as to whether can construct and/or meet construction program: score=0
Operability	Ability to operate facility in all site conditions and without interference from other site functions	Can operate in all site conditions and without interference from other site functions: score=5, Some restriction or stoppage of operations maybe necessary at times: score=3, Frequent restrictions, or potential for lengthy stoppage of operations: score=0
Storage capacity and expansion potential	Ability to meet project storage requirements and to be expanded if necessary	Meets project schedule storage requirements with ability to be expanded: score=5, Meets project schedule storage requirements but cannot be expanded: score=3, Does not meet project schedule storage requirements and cannot be expanded: score=0
Project schedule	Ability to meet project scheduling requirements for tailings and open pit overburden rock	Fully meets project scheduling requirements: score=5, Meets either tailings or waste rock scheduling but not both: score=3, Doesn’t meet project scheduling requirements: score=0

TABLE 7. ENVIRONMENTAL SCORING CRITERIA

Subcategory	Description	Criteria for Scoring
Terrestrial ecosystem	Impact on terrestrial ecosystem considering design, construction, operation, closure, and post closure concepts	Impacts on terrestrial ecosystem associated with constructed facility are limited and off-site impacts are controlled: score=5, Some on-site impacts and controlled but small-moderate impacts off-site: score=3, Significant on-site impacts and high off-site impacts: score=0
Aquatic ecosystem	Impact on aquatic ecosystem considering design, construction, operation, and closure concepts	Impacts on aquatic ecosystem associated with constructed facility are limited and off-site impacts are controlled: score=5, Some on-site impacts and controlled but small-moderate effects off-site: score=3, There are some on-site impacts and high off-site: score=0
Groundwater	Impact on groundwater quality and ground water resources and users (e.g., wells used to extract ground water for farming, industrial or domestic purposes)	Impacts are controlled with conventional and proven design concepts and existing controls are proven to be effective: score=5, Unconventional design concepts, or control possible but some uncertainty about effectiveness: score=3, No effective control measures and impact is high: score=0
Surface water	Impact on surface water quality and surface water resources and users (e.g., recreational users, water taken from streams and rivers for farming, industrial or domestic purposes)	Impacts are controlled with conventional and proven design concepts and existing controls are proven to be effective: score=5, Unconventional design concepts, or control possible but some uncertainty about effectiveness: score=3, No effective control measures and impact is high: score=0
Impact on SNA	Area affected and quality and unique characteristics of the SNA	Does not impact SNA: score =5, Moderate impact on SNA (less than 4Ha impacted) and SNA does not have unique or high-quality characteristics: score=3, Significant impact on SNA (greater than 4 Ha impacted) and SNA has unique and/or high-quality characteristics: score =0
Dust	Proximity to affected parties and measures to control hazard	Control measures are required, historical performance demonstrates that air discharge standards can be achieved, there have been no complaints from affected neighbours; score =5, Control measures are required, but there is no history to demonstrate that air quality standards can be achieved: score =3, No control measures are in place to control dust: score=0

Noise	Proximity to affected parties and measures to control hazard	Control measures are required, historical performance demonstrates that noise standards can be achieved, there have been no complaints from affected neighbours; score =5, Control measures are required but there is no history to demonstrate that noise standards can be achieved, affected parties are within 500m of the works: score =3, No control measures are in place to control noise and affected parties are within 500m of the works: score=0

TABLE 8. SOCIO-ECONOMIC SCORING CRITERIA

Subcategory	Description	Criteria for Scoring
Social impact	Social consequences associated with construction and operation of the tailings and open pit mine overburden disposal facilities	Low social impact: score=5, Moderate social impact: score=3, High social impact: score =0
Mana Whenua	Engagement, consultation and consideration of mana whenua values	Engagement and consultation with mana whenua, cultural assessment undertaken, project takes into consideration mana whenua values as far as practical: score =5, Engagement and consultation with mana whenua, no cultural assessment undertaken, project only partly considers mana whenua values, score =3, No engagement or consultation with mana whenua or does not fit with manu whenua values: score =0
Economic	Economic benefit for the community and other parties	Project has considerable economic benefit for the local community (residents and local businesses) as well as to other parties (e.g., suppliers, contractors, consultants): score=5, Project has some economic benefit to the local community as well as to other parties (e.g., suppliers, contractors, consultants): score=3, Minimal economic benefit to the community and other parties: score=0
Recreation	Impact of project on recreational opportunities and users	Project has no impact on recreational users and may provide new recreational opportunities: score =5, Minor impact on recreational opportunities and users: score=3, Significant impact on recreational opportunities and users: score=0
Regulatory Approval	Ability to obtain regulatory approval	Project has minor effects and regulatory approval is anticipated without appeal: score=5, Project has effects, but they can be avoided or mitigated such that Regulatory approval is anticipated: score=3, Project has effects which cannot be avoided or mitigated, and it is unlikely that the project will obtain regulatory approval: score=0
Archaeological/ heritage	Identification and significance, and measures proposed to avoid or mitigate effects	Formal study undertaken to identify and classify significance of archaeological/historical sites. No sites of significance identified, or measures undertaken to avoid so there is no impact: score=5, Formal study undertaken, and significant sites identified and will be affected, although measures to mitigate are proposed: score=3, No formal study undertaken, or formal study undertaken, and significant sites identified and will be destroyed, or no mitigation proposed: score=0.

Landscape and visual	Landscape and visual effects	Visual amenity (change in character and quality of view) both in the short-term and long-term are minimal: score=5, Visual amenity is affected in the short-term but long-term effects are minimal: score=3, Visual amenity (short-term and long-term) are significantly impacted: score =0

TABLE 9. PROJECT ECONOMICS SCORING CRITERIA

Subcategory	Description	Criteria for Scoring
Land ownership	Status of land ownership	Land is owned by OGNZL: score=5, Land is not owned by OGNZL and potentially can be purchased with OIO approval likely: score=3, Land is not owned by OGNZL and not available for purchase or OIO approval unlikely: score=0
Capital cost	Cost ranking based on $/t	Cost ranking is in top one third of options considered: score =5, Cost ranking is in middle one third of options considered: score =3, Cost ranking is in bottom one third of options considered: score =0
Operating cost	Cost ranking based on $/t	Cost ranking is in top one third of options considered: score =5, Cost ranking is in middle one third of options considered: score =3, Cost ranking is in bottom one third of options considered: score =0
Closure and post-closure cost	Cost ranking based on $/t	Cost ranking is in top one third of options considered: score =5, Cost ranking is in middle one third of options considered: score =3, Cost ranking is in bottom one third of options considered: score =0

10.2. Potential project options

Six potential project options have been considered for scoring. They comprise combinations of different TSFs and mine overburden disposal options, and different tailings disposal technologies (e.g., tailings slurry, dry stack, and paste). Embankments constructed to form TSFs are considered as mine overburden disposal options. Some options are unlikely to meet project scheduling requirements but have been scored for comparison purposes. The six options considered are summarised in Table 10 and they are shown in Figures A4 to A9.

Some options considered but that did not meet project scheduling and land ownership requirements are summarised in Table 11.

TABLE 10: POTENTIAL PROJECT OPTIONS FOR TAILINGS STORAGE AND MINE OVERBURDEN DISPOSAL

Option		**Tailings Storage Locations**		**Mine Overburden Disposal Locations**				**Rehabilitation Considerations**	**Other Considerations**
No.	**Description**								
1	**Base Case (Company Preferred Option)** Storage 3 Tailings Slurry TSF to RL155 and GOP Tailings Slurry TSF	Storage 3 TSF Tailings Slurry RL155 8.0Mt*	GOP TSF Tailings Slurry 2.1Mt	Storage 3 TSF RL155 12.0Mt[&]	GOP TSF Backfill 5.3Mt	UG Backfill WUG 4.5Mt MUG 5.4Mt	Northern Rock Stack Stage 1 Up to 15Mt^ (1.3Mt^ remaining in closure)	GOP TSF dry cap or pond/wetland	Impacts SNA at Storage 3 TSF
2	Maximise Storage 3 Tailings Slurry TSF to RL160 and GOP Lake	Storage 3 TSF Tailings Slurry RL160 10Mt		Storage 3 TSF RL160 16.8Mt		UG Backfill WUG 4.5Mt MUG 5.4Mt	Northern Rock Stack Stage 1 Up to 14Mt (4.5Mt in closure)	GOP Lake	Impacts SNA at Storage 3 TSF
3	Storage 3 Dry Stack TSF and GOP Tailings Slurry TSF	Storage 3 TSF Dry Stack RL162 12.6Mt	GOP TSF Tailings Slurry 2.1Mt	Storage 3 TSF Dry Stack RL162 10Mt	GOP TSF Backfill 5.3Mt	UG Backfill WUG 4.5Mt MUG 5.4Mt	Northern Rock Stack Stage 1 Up to 14Mt (6.0Mt in closure)	GOP TSF dry cap or pond/wetland	Storage 3 dry stack avoids SNA. Management of water surface water and erosion is a notable risk in the Waihi climate. Requires tailings slurry discharge to existing TSFs or new GOP TSF. Closure capping.
4	Storage 2 Raise to RL176 Tailings Slurry TSF	Storage 2 TSF Tailings Slurry RL176 9.0Mt		Storage 2 TSF RL176 13.2Mt		UG Backfill WUG 4.5Mt MUG 5.4Mt	Northern Rock Stack Stage 1 Up to 14Mt (8.1Mt in closure)	GOP Lake	Avoids SNA. Conveyor loadout requires relocation to bottom of Storage 2 embankment. Site access road to Process Plant needs relocating. Scheduling issues with large amount of rock to be placed before storage capacity provided.
5	Underground paste backfill and GOP paste backfill and Reinstate Gladstone Hill	GOP Paste backfill no liner 5.9Mt	WUG Underground paste backfill 3.3Mt	GOP Cap as hill 11.7Mt		UG Backfill MUG 5.4Mt	Northern Rock Stack Stage 1 Up to 14Mt (14Mt in closure)		Would require commencement of paste backfill in south end of GOP while mining of main pit continues, and unlikely to meet project scheduling requirements. Paste strength needs to be designed to avoid risks of underground in-rush
6	Underground paste backfill and GOP paste backfill and Rock cap of TSF1A and TSF2	GOP Paste backfill no liner 5.9Mt	WUG Underground paste backfill 3.3Mt	TSF1A Rock Cap 6.4Mt	TSF2 Rock Cap 6.4Mt	UG Backfill MUG 5.4Mt	Northern Rock Stack Stage 1 Up to 14Mt (12.9Mt in closure)		Same issues as Option 5 regards paste backfill into GOP. (i.e., project scheduling and underground in-rush risk)

Notes:
* Includes the local borrow volume within Storage 3 impoundment as outlined in Volume 3 EGL Storage 3 Technical Report.
^ Allows for use of local borrow within Storage 3 impoundment and NRS footprint for Storage 3 starter embankment construction. See Volume 3 EGL Storage 3 Technical Report and Volume 4 EGL NRS Technical Report.
[&]Excludes starter embankment volume constructed out of Storage 3 local borrow material.

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OCEANA GOLD NZ LIMITED - WAIHI
WAIHI NORTH PROJECT
Site Plan -Option 1- Base Case

Drawing No.	9215–FigA4
Date:	Feb 2025
Drawn:	ET
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Figure A5

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WAIHI NORTH PROJECT
Site Plan -Option 2

Drawing No.	9215-FigA5
Date:	Feb 2025
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OCEANA GOLD NZ LIMITED - WAIHI
WAIHI NORTH PROJECT
Site Plan -Option 3

Drawing No.	9215–FigA6
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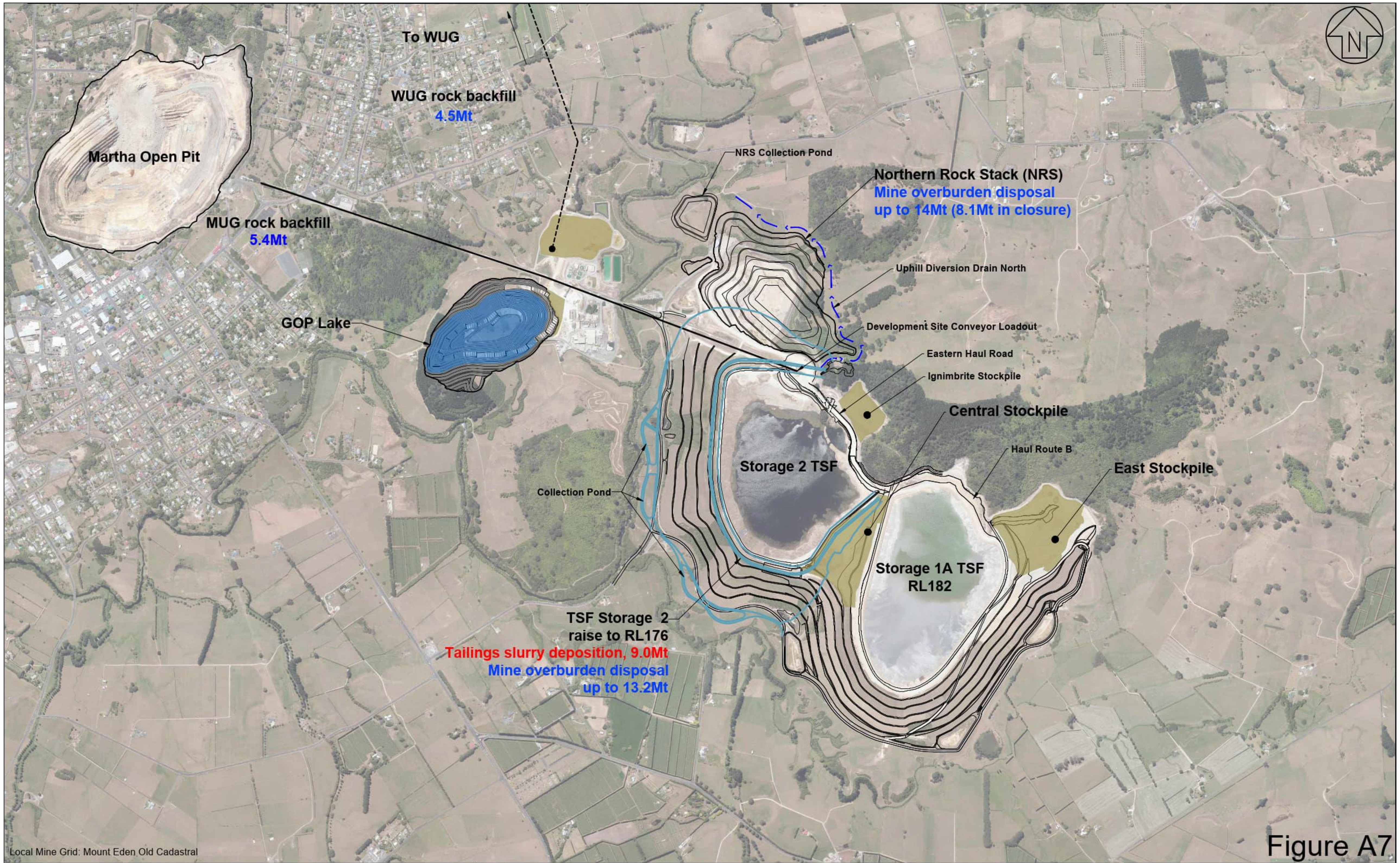

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WAIHI NORTH PROJECT
Site Plan -Option 4

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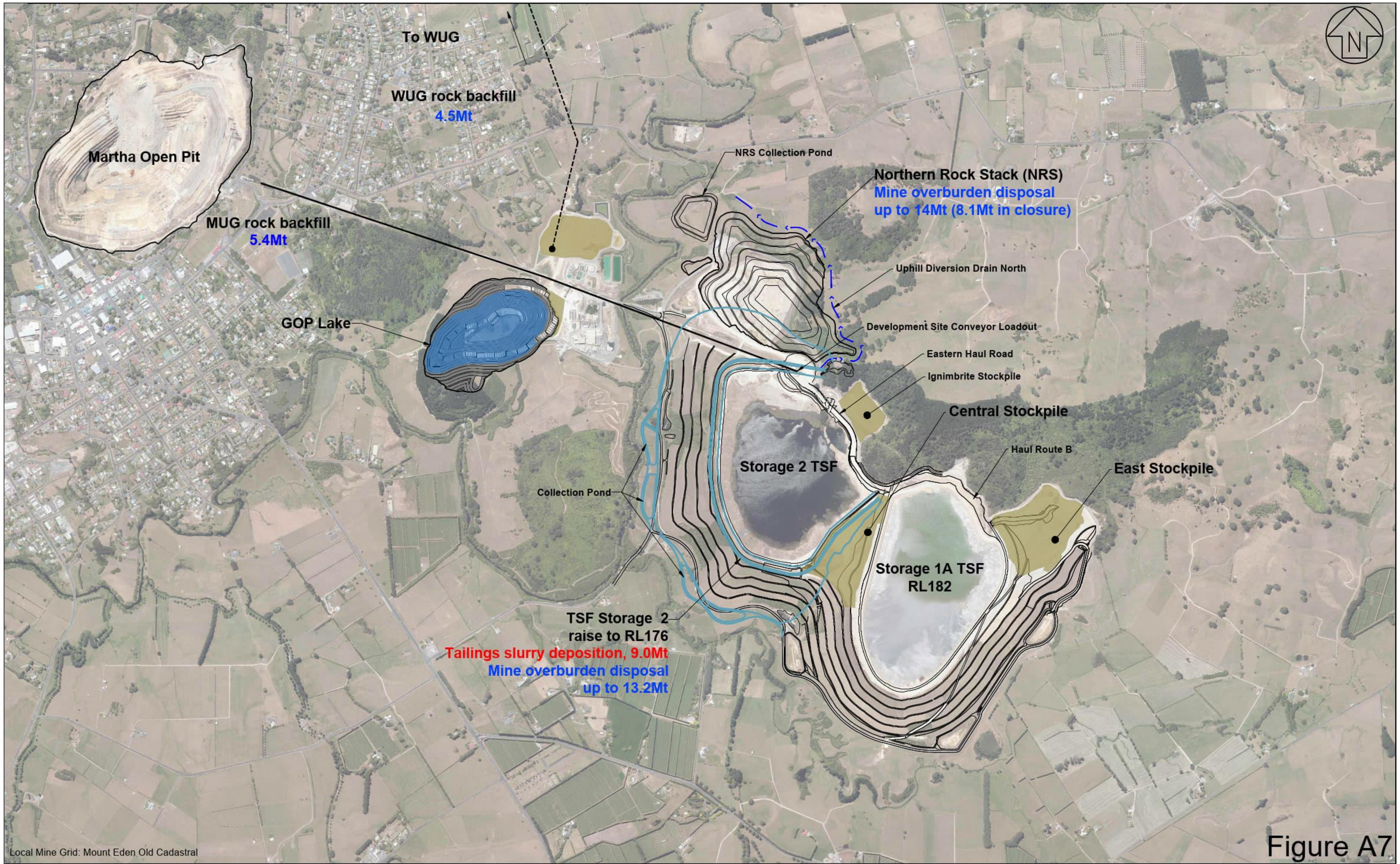

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OCEANA GOLD NZ LIMITED - WAIHI
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Site Plan -Option 4

Drawing No.	9215–FigA7
Date:	Feb 2025
Drawn:	JL
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OCEANA GOLD NZ LIMITED - WAIHI
WAIHI NORTH PROJECT
Site Plan -Option 5

Drawing No.	9215–FigA9
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Drawn:	JL
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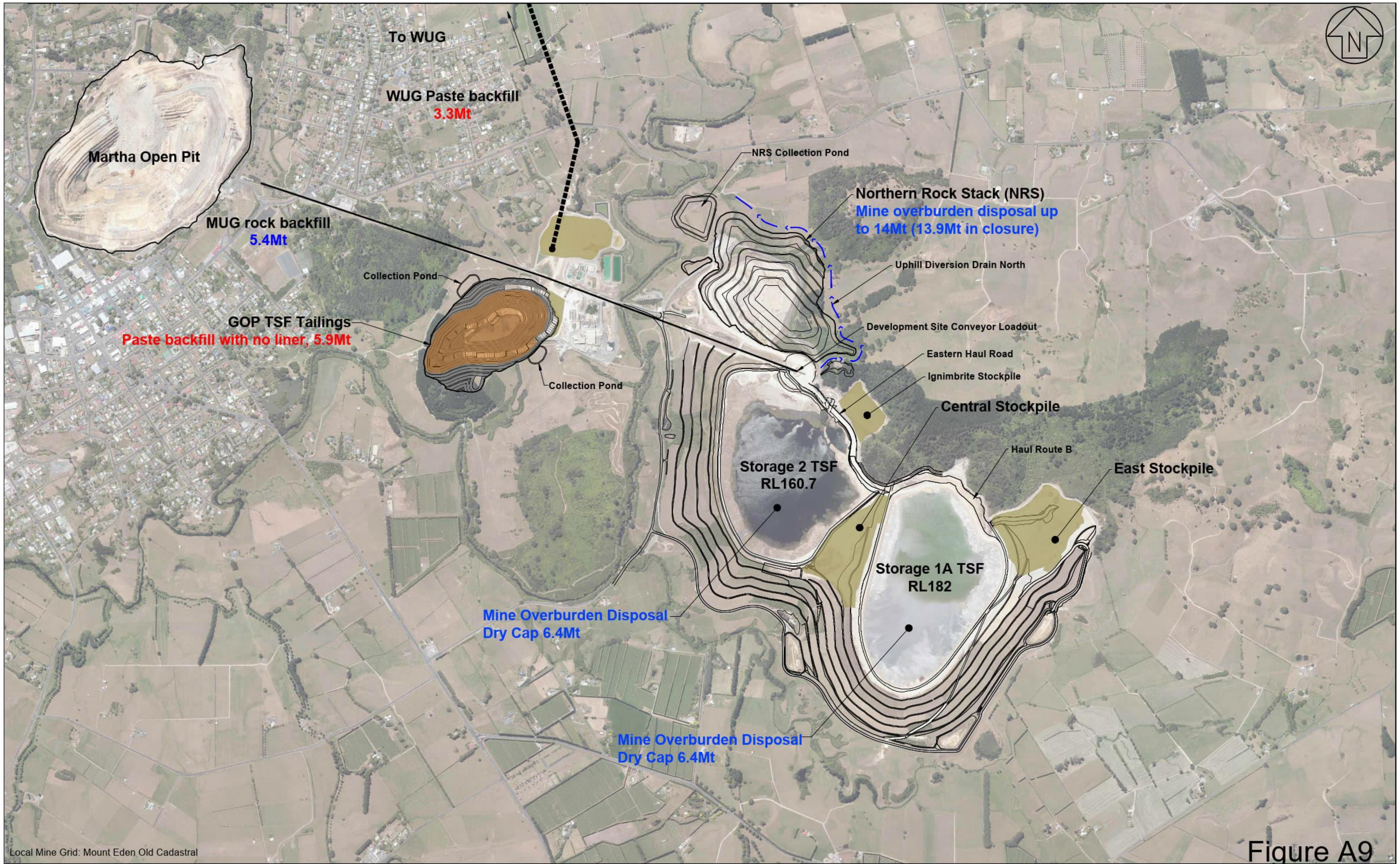

Figure A9

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WAIHI NORTH PROJECT
Site Plan -Option 6

Drawing No.	9215–FigA10
Date:	Feb 2025
Drawn:	JL
Scale:	1:15,000 @A3
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TABLE 11: OPTIONS FOR TAILINGS STORAGE AND MINE OVERBURDEN DISPOSAL THAT DO NOT MEET PROJECT SCHEDULING AND LAND OWNERSHIP REQUIREMENTS

Option		**Tailings Storage Locations**		**Mine Overburden Disposal Locations**			**Additional working stockpile capacity**	**Rehabilitation Considerations**	**Other Considerations**
No.	**Description**								
A	TSF North of Storage 2 and GOP Tailings Slurry TSF	TSF North of Storage 2 RL145 6.8Mt	GOP TSF Tailings Slurry 2.1Mt	TSF North of Storage 2 RL145 12.0Mt	GOP TSF Backfill 5.3Mt	UG Backfill WUG 4.5Mt MUG 5.4Mt	Extend East Stockpile to manage waste 4.0Mt		SNA impacted north of Storage 2. Affects Orchards Property
B	Storage 3 Dry Stack TSF and GOP Backfill with Rock	Storage 3 TSF Dry Stack RL155 8.8Mt		Storage 3 TSF Dry Stack RL155 8Mt	GOP Partial Rock Backfill 13.3Mt	UG Backfill WUG 4.5Mt MUG 5.4Mt	Northern Rock Stack Stage 1 Up to 14Mt (0 Mt required in closure)	GOP Hill Replacement 18Mt	Not sufficient material to backfill GOP to full profile. Avoids SNA at Storage 3. Dry stack management of water surface water and erosion is a material project and closure risk in the Waihi climate.
C	Storage 1A Raise to RL192 Tailings Slurry TSF and GOP Tailings Slurry TSF	Storage 1A TSF Tailings Slurry RL192 4.8Mt	GOP TSF Tailings Slurry 2.1Mt	Storage 1A TSF RL192 7.8Mt	GOP TSF Backfill 5.3Mt	UG Backfill WUG 4.5Mt MUG 5.4Mt	Northern Rock Stack Stage 1 Up to 14Mt (8.2Mt required)	GOP TSF dry cap or pond/wetland	Tailing storage not sufficient

10.3. Assessment of Options

Each option has been scored using the categories, indicators, and weightings in Table 5. Scoring criteria for each category (i.e., technical, environmental, socio-economic and project economics) are presented in Tables 6 to 9, respectively.

A summary of the scoring for each option is provided in Table 12. Scoring for the main categories, the total score and the MCA ranking is provided. The detailed results, including subcategory scorings, are provide for Options 1 to 6 in Tables A1 to A6, respectively, in Appendix A. The project economic scoring is based on ranking each option for the subcategories of capital cost, operating cost, and closure cost. The rankings and scoring for these subcategories are presented in Table A7.

Options 1, 2 and 4 with slurry tailings TSFs score the highest. The reason is primarily because of project economics. Option 1 scores highest and is the company preferred option. It scores higher than Options 2 and 4 for the socio economic and permitting category. This is because it does not include closure of GOP as a lake.

Options 3, 5, and 6 score lowest primarily because of low scores for project economics. Option 3 uses dry stack tailings and tailings are disposed by paste backfill in Options 5 and 6. These technologies are comparatively expensive for this project.

TABLE 12: SUMMARY OF SCORINGS AND RANKINGS FOR OPTIONS 1 to 6

Option		Category Weighted Scoring				Total Score	MCA Ranking
No.	**Description**	**Technical**	**Environmental**	**Socio-Economic and Permitting**	**Project Economics**		
1	**Base Case (Company Preferred Option)** Storage 3 Tailings Slurry TSF to RL155 and GOP Tailings Slurry TSF	1.13	0.95	0.98	1.08	4.13	1
2	Maximise Storage 3 Tailings Slurry TSF to RL160 and GOP Lake	1.20	0.95	0.64	1.03	3.81	2
3	Storage 3 Dry Stack TSF and GOP Tailings Slurry TSF	0.95	1.00	0.98	0.46	3.39	5
4	Storage 2 Raise to RL176 Tailings Slurry TSF	0.74	1.00	0.83	1.03	3.59	3
5	Underground paste backfill and GOP paste backfill and reinstate Gladstone Hill	1.00	0.95	1.1	0.26	3.36	6
6	Underground paste backfill and GOP paste backfill and Storage 1A and Storage 2 rock cap	1.00	0.95	0.98	0.51	3.43	4

11.0 PROPOSED WAIHI NORTH PROJECT TAILINGS STORAGE AND ROCK DISPOSAL STRATEGY

The results indicate Option 1 scores highest and this is the company preferred option. The report considers natural hazards which can affect the site, best available tailings technologies, potential locations for tailings storage and rock disposal facilities, and a combination of storage and disposal options for the Waihi North Project. A summary of the features of Option 1 follows:

11.1. Mine Overburden Disposal

- Storage 3 TSF downstream embankment RL155 constructed of overburden
- GOP TSF backfill with overburden ready to line the pit to be a TSF
- Northern Rock Stack – working stockpile with engineered landform in closure
- Underground backfill with overburden material

11.2. Tailings Disposal

- Conventional tailings slurry disposal to Storage 3 and GOP TSFs
- Storage 3 TSF constructed from downstream embankment with crest at RL155
- GOP TSF comprising lined in-pit storage

11.3. Closure

- Storage 3
    - Embankment slopes in pasture with some vegetation.
    - Impoundment top surface comprising perimeter cap with wetland and pond. Perimeter cap surface planted in native vegetation.

- GOP TSF
    - Dry capped with small wetland and pond. Capped surface planted in native vegetation.

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APPENDIX A

OPTIONS ASSESSMENT – DETAILED SCORING FOR OPTIONS 1 TO 6

APPENDIX A

OPTIONS ASSESSMENT- DETAILED SCORING FOR OPTIONS 1 TO 6

This appendix includes the results of the detailed scoring of Options 1 to 6. Details of the options are provided in Table 10 of the report. The options have been scored for four main categories (technical, environmental, socio-economic and project economics). Each category has been given equal weighting. Within each category there are several different subcategories, each with their own weighting. Subcategories and their weightings are provided in Table 5. The scoring criteria for the subcategories associated with each main category are provided in Tables 6 to 9.

The scorings for Options 1 to 6 are provided in Tables A1 to A6. The project economic scoring is based on ranking each option for the subcategories of capital cost, operating cost and closure cost and is summarised in Table A7. The rankings and scoring for these subcategories are presented in Table 12 of the report text.

TABLE A1. SCORING FOR OPTION 1

Option 1: Base Case (Company Preferred Option) Storage 3 Tailings Slurry TSF to RL155 and GOP Tailings Slurry TSF

Category	Subcategory	Category Weighting	Subcategory Weighting	Score	Weighted score	Category Score	Final Score	Comments
Technical	Future ore resource	0.25	0.1	3	0.3			Storage 3 will not impact future ore resources. Small risk that GOP TSF may affect future underground mining.
	Geotechnical		0.15	5	0.75			Storage 3 and Northern Rock Stack sites have some weak material in foundations but it will be removed
	Geochemistry		0.15	3	0.45			Storage 3 and Northern Rock Stack will have controls for potential geochemistry effects that have been effective to date and have been adopted and proven to work at other projects. GOP TSF controls are based on sound design concepts that have been applied at other sites, but not proven at Waihi Project with experience.
	Constructability		0.1	5	0.5			Experience with existing TSFs indicates that they can be constructed to meet Specifications. Similar materials will be used for Storage 3 and the NRS.
	Operability		0.1	5	0.5			Storage 3 and GOP TSF can be operated in all conditions and without interference from other site functions.
	Storage capacity and expansion potential		0.15	5	0.75			Storage 3 can be expanded. GOP TSF could be expanded as a mine open pit overburden disposal area with rock placed above tailings
	Project schedule		0.25	5	1.25			Assessment indicates project scheduling requirements can be met
						4.5	1.125	
Environmental	Terrestrial ecosystem	0.25	0.2	3	0.6			Some short term impact on on-site terrestrial ecosystem associated with construction and operation of Storage 3 and GOP TSFs and NRS.
	Aquatic ecosystem		0.2	3	0.6			Minor impact on aquatic ecosystem No known historical impact
	Groundwater		0.15	5	0.75			Potential groundwater impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Surface water		0.15	5	0.75			Potential surface water impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Impact on SNA		0.1	3	0.3			Storage 3 has small impact on SNA
	Dust		0.1	5	0.5			Control measures required and operating history indicates that air discharge standards will be met.
	Noise		0.1	3	0.3			Storage 3 is new TSF, located closer to some rural properties east of the Development Site. Expect minor noise effects, but no operating history at this location.
						3.8	0.950	
Socio-economic and permitting	Social impact	0.25	0.15	5	0.75			Low social impact
	Mana Whenua		0.25	3	0.75			Consultation undertaken, but Mana Whenua prefer backfilling of GOP TSF to recreate maunga rather than use as a lake.
	Economic		0.1	5	0.5			Project has considerable economic benefit to community and other parties
	Recreation		0.1	5	0.5			No impact on recreational users
	Regulatory approval		0.2	3	0.6			Project has effects that can be mitigated
	Archaeological/heritage		0.1	5	0.5			Some remnants of historical mining activities at GOP TSF, but not significant
	Landscape and visual		0.1	3	0.3			Some visual impact from construction of Storage 3 and Northern Rock Stack, but rehabilitation provides long-term mitigation
						3.9	0.975	
Project Economics	Land ownership	0.25	0.1	5	0.5			OGNZL owns all the land required
	Capital cost		0.35	5	1.75			Ranks in top third
	Operating cost		0.35	5	1.75			Ranks in top third
	Closure and post-closure cost		0.2	1.5	0.3			Ranks 4th = and score reflects this
						4.3	1.075	
TOTAL WEIGHTED SCORE:							**4.13**	

TABLE A2. SCORING FOR OPTION 2

Option 2: Maximise Storage 3 Tailings Slurry TSF to RL160 and GOP Lake

Category	Subcategory	Category Weighting	Subcategory Weighting	Score	Weighted score	Category Score	Final Score	Comments
Technical	Future ore resource	0.25	0.1	3	0.3			Storage 3 will not impact future ore resources. Small risk that GOP TSF may affect future underground mining.
	Geotechnical		0.15	5	0.75			Storage 3 and Northern Rock Stack sites have some weak material in foundations but it will be removed.
	Geochemistry		0.15	5	0.75			Storage 3 and Northern Rock Stack will have controls for potential geochemistry effects that have been effective to date and have been adopted and proven to work at other projects. GOP is a lake and so will not store tailings, but has partial backfill with some PAF rock as for GOP TSF.
	Constructability		0.1	5	0.5			Experience with existing TSFs indicates that they can be constructed to meet Specifications. Similar materials will be used for Storage 3 and the NRS.
	Operability		0.1	5	0.5			Storage 3 and GOP TSF can be operated in all conditions and without interference from other site functions.
	Storage capacity and expansion potential		0.15	5	0.75			Storage 3 can be expanded, but not to the same extent as with Option 1.
	Project schedule		0.25	5	1.25			Assessment indicates project scheduling requirements can be met.
						4.8	1.200	
Environmental	Terrestrial ecosystem	0.25	0.2	3	0.6			Some short term impact on on-site terrestrial ecosystem associated with construction and operation of Storage 3 TSF and NRS.
	Aquatic ecosystem		0.2	3	0.6			Minor impact on aquatic ecosystem No known historical impact
	Groundwater		0.15	5	0.75			Potential groundwater impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Surface water		0.15	5	0.75			Potential surface water impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Impact on SNA		0.1	3	0.3			Storage 3 has small impact on SNA
	Dust		0.1	5	0.5			Control measures required and operating history indicates that air discharge standards will be met.
	Noise		0.1	3	0.3			Storage 3 is new TSF, located closer to some rural properties east of the Development Site. Expect minor noise effects, but no operating history at this location.
						3.8	0.950	
Socio-economic and permitting	Social impact	0.25	0.15	5	0.75			Low social impact
	Mana Whenua		0.25	0	0			Consultation undertaken, but Mana Whenua prefer backfilling of GOP TSF to recreate maunga rather than use as a TSF.
	Economic		0.1	5	0.5			Project has considerable economic benefit to community and other parties
	Recreation		0.1	5	0.5			No impact on recreational users
	Regulatory approval		0.2	0	0			Backfill of GOP with water may not get regulatory approval
	Archaeological/heritage		0.1	5	0.5			Some remnants of historical mining activities at GOP TSF, but not significant
	Landscape and visual		0.1	3	0.3			Some visual impact from construction of Storage 3 and Northern Rock Stack, but rehabilitation provides long-term mitigation
						2.55	0.6375	
Project Economics	Land ownership	0.25	0.1	5	0.5			OGNZL owns all the land required
	Capital cost		0.35	5	1.75			Ranks in top third
	Operating cost		0.35	3	1.05			Ranks in middle third
	Closure and post-closure cost		0.2	4	0.8			Ranks 2nd = and score reflects this
						4.1	1.025	
TOTAL WEIGHTED SCORE:							**3.81**	

TABLE A3. SCORING FOR OPTION 3

Option 3: Storage 3 Dry Stack TSF and GOP Tailings Slurry TSF

Category	Subcategory	Category Weighting	Subcategory Weighting	Score	Weighted score	Category Score	Final Score	Comments
Technical	Future ore resource	0.25	0.1	3	0.3			Small risk that GOP TSF may affect future underground mining
	Geotechnical		0.15	5	0.75			Storage 3 and Northern Rock Stack site has some weak material in foundations but they will be removed
	Geochemistry		0.15	3	0.45			Storage 3 and Northern Rock Stack will have controls for potential geochemistry effects that have worked to date and have been adopted and proven to work at other projects. GOP TSF controls are based on sound design concepts that have been applied at other sites, but not proven at Waihi Project with experience.
	Constructability		0.1	5	0.5			Experience with existing TSFs indicates that they can be constructed to meet Specifications. Similar materials will be used for Storage 3 and the NRS.
	Operability		0.1	3	0.3			Dry stack can not be operated in all conditions and there will be down time for maintenance, so will require ability to discharge tailings slurry to existing TSFs. GOP TSF can be operated in all conditions and without interference from other site functions.
	Storage capacity and expansion potential		0.15	5	0.75			Storage 3 can be expanded. GOP TSF could be expanded as a mine open pit overburden disposal area with rock placed above tailings
	Project schedule		0.25	3	0.75			Some uncertainty that filtered tailings can always keep up with project scheduling requirements.
						3.8	0.950	
Environmental	Terrestrial ecosystem	0.25	0.2	3	0.6			Some short term impact on on-site terrestrial ecosystem associated with construction and operation of Storage 3 and GOP TSF.
	Aquatic ecosystem		0.2	3	0.6			Minor impact on aquatic ecosystem No known historical impact
	Groundwater		0.15	5	0.75			Potential groundwater impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Surface water		0.15	5	0.75			Potential surface water impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Impact on SNA		0.1	5	0.5			Avoids SNA.
	Dust		0.1	5	0.5			Control measures required and operating history indicates that air discharge standards will be met.
	Noise		0.1	3	0.3			Storage 3 is new TSF, located closer to some rural properties east of the Development Site. Expect minor noise effects, but no operating history at this location.
						4	1.000	
Socio-economic and permitting	Social impact	0.25	0.15	5	0.75			Low social impact
	Mana Whenua		0.25	3	0.75			Consultation undertaken, but Mana Whenua prefer backfilling of GOP TSF to recreate maunga rather than use as a TSF.
	Economic		0.1	5	0.5			Project has considerable economic benefit to community and other parties
	Recreation		0.1	5	0.5			No impact on recreational users
	Regulatory approval		0.2	3	0.6			Project has effects that can be mitigated.
	Archaeological/heritage		0.1	5	0.5			Some remnants of historical mining activities at GOP TSF, but not significant
	Landscape and visual		0.1	3	0.3			Some visual impact from construction of Storage 3 and Northern Rock Stack, but rehabilitation provides long-term mitigation
						3.9	0.975	
Project Economics	Land ownership	0.25	0.1	5	0.5			OGNZL owns all the land required
	Capital cost		0.35	0	0			Ranks in bottom third
	Operating cost		0.35	3	1.05			Ranks in middle third
	Closure and post-closure cost		0.2	1.5	0.3			Ranks 4 = and score reflects this
						1.85	0.4625	
						TOTAL WEIGHTED SCORE:	**3.39**	

TABLE A4. SCORING FOR OPTION 4

Option 4: Storage 2 Raise to RL176 Tailings Slurry TSF

Category	Subcategory	Category Weighting	Subcategory Weighting	Score	Weighted score	Category Score	Final Score	Comments
Technical	Future ore resource	0.25	0.1	3	0.3			Small risk that GOP Lake may affect future underground mining
	Geotechnical		0.15	3	0.45			No detailed geotechnical investigations to west of current footprint, so some uncertainty about performance
	Geochemistry		0.15	3	0.45			Storage 2 and Northern Rock Stack will have controls for potential geochemistry effects that have worked to date and have been adopted and proven to work at other projects. GOP is a lake and so will not store tailings, but has partial backfill with some PAF rock as for GOP TSF.
	Constructability		0.1	5	0.5			Experience with existing TSFs indicates that they can be constructed to meet Specifications. Similar materials will be used for raising Storage 2 and the NRS. Will need to construct new site access road and maintain existing surface and subsurface collection systems while constructing new systems. Will need new Collection Pond.
	Operability		0.1	5	0.5			Storage 2 and GOP TSF can be operated in all conditions and without interference from other site functions.
	Storage capacity and expansion potential		0.15	5	0.75			Limited opportunity for expansion of Storage 2 for tailings storage using up valuable overburden to develop tailings storage. GOP TSF could be expanded as a mine open pit overburden disposal area with rock placed above tailings. Storage 3 could be developed as a new TSF in the future.
	Project schedule		0.25	0	0			Assessment indicates maybe tight to raise Storage 2 to meet tailings storage requirements. Large volume of embankment fill required to achieve tailings storage.
						2.95	0.7375	
Environmental	Terrestrial ecosystem	0.25	0.2	3	0.6			Some short term impact on on-site terrestrial ecosystem associated with construction and operation of Storage 3 and GOP TSF.
	Aquatic ecosystem		0.2	3	0.6			Minor impact on aquatic ecosystem No known historical impact
	Groundwater		0.15	5	0.75			Potential groundwater impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Surface water		0.15	5	0.75			Potential surface water impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Impact on SNA		0.1	5	0.5			Avoids SNA
	Dust		0.1	5	0.5			Control measure required and operating history indicates that air discharge standards will be met.
	Noise		0.1	3	0.3			Storage 2 is existing TSF. Construction at higher elevation may have some noise implications, but unlikely to be significant.
						4	1	
Socio-economic and permitting	Social impact	0.25	0.15	5	0.75			Low social impact
	Mana Whenua		0.25	3	0.75			Consultation undertaken, but Mana Whenua prefer backfilling to recreate maunga rather than use as a TSF.
	Economic		0.1	5	0.5			Project has considerable economic benefit to community and other parties
	Recreation		0.1	5	0.5			No impact on recreational users
	Regulatory approval		0.2	0	0			Backfill of GOP with water may not get regulatory approval
	Archaeological/heritage		0.1	5	0.5			Some remnants of historical mining activities at GOP TSF, but not significant
	Landscape and visual		0.1	3	0.3			Some visual impact from raising of Storage 2, but rehabilitation provides long-term mitigation
						3.3	0.825	
Project Economics	Land ownership	0.25	0.1	5	0.5			OGNZL owns all the land required
	Capital cost		0.35	3	1.05			Ranks in middle third
	Operating cost		0.35	5	1.75			Ranks in top third
	Closure and post-closure cost		0.2	4	0.8			Ranks 2 = and score reflects this
						4.1	1.025	
						TOTAL WEIGHTED SCORE:	**3.59**	

TABLE A5. SCORING FOR OPTION 5

Option 5: Underground paste backfill and GOP paste backfill and reinstate Gladstone Hill

Category	Subcategory	Category Weighting	Subcategory Weighting	Score	Weighted score	Category Score	Final Score	Comments
Technical	Future ore resource	0.25	0.1	3	0.3			Small risk that GOP TSF may affect future underground mining
	Geotechnical		0.15	5	0.75			Storage 3 and Northern Rock Stack site has some weak material in foundations but they will be removed
	Geochemistry		0.15	3	0.45			Storage 3 and Northern Rock Stack will have controls for potential geochemistry effects that have worked to date and have been adopted and proven to work at other projects. GOP TSF controls are based on sound design concepts that have been applied at other sites, but not proven at Waihi Project with experience.
	Constructability		0.1	5	0.5			Experience with existing TSFs indicates that they can be constructed to meet Specifications. Similar materials will be used for the NRS.
	Operability		0.1	5	0.5			Storage 3 and GOP TSF can be operated in all conditions and without interference from other site functions.
	Storage capacity and expansion potential		0.15	5	0.75			Storage 3 can be constructed in the future. GOP TSF could be expanded as a mine open pit overburden disposal area with rock placed above tailings
	Project schedule		0.25	3	0.75			Unlikely to meet scheduling requirements for talings.
						4	1.000	
Environmental	Terrestrial ecosystem	0.25	0.2	3	0.6			Some short term impact on on-site terrestrial ecosystem associated with construction and operation of Storage 3 and GOP TSF.
	Aquatic ecosystem		0.2	3	0.6			Minor impact on aquatic ecosystem No known historical impact
	Groundwater		0.15	5	0.75			Potential groundwater impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Surface water		0.15	5	0.75			Potential surface water impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Impact on SNA		0.1	5	0.5			Avoids SNA.
	Dust		0.1	5	0.5			Control measure required and operating history indicates that air discharge standards will be met.
	Noise		0.1	3	0.3			Storage 3 is new TSF, located closer to some rural properties east of the Development Site. Expect minor noise effects, but no operating history at this location.
						4.0	1.00	
Socio-economic and permitting	Social impact	0.25	0.15	5	0.75			Low social impact
	Mana Whenua		0.25	5	1.25			Consultation undertaken. Mana Whenua prefer backfilling to recreate maunga rather than use as a TSF.
	Economic		0.1	5	0.5			Project has considerable economic benefit to community and other parties
	Recreation		0.1	5	0.5			No impact on recreational users
	Regulatory approval		0.2	3	0.6			Project has effects that can be mitigated.
	Archaeological/heritage		0.1	5	0.5			Some remnants of historical mining activities at GOP TSF, but not significant
	Landscape and visual		0.1	3	0.3			Some visual impact from construction of Storage 3 and Northern Rock Stack, but rehabilitation provides long-term mitigation
						4.4	1.100	
Project Economics	Land ownership	0.25	0.1	5	0.5			OGNZL owns all the land required
	Capital cost		0.35	1.5	0.525			Ranks 4 = and score reflects this
	Operating cost		0.35	0	0			Ranks in bottom third
	Closure and post-closure cost		0.2	0	0			Ranks in bottom third. High cost to recreate Gladstone Hill
						1.025	0.25625	
TOTAL WEIGHTED SCORE:							**3.36**	

TABLE A6. SCORING FOR OPTION 6

Option 6: Underground paste backfill and GOP paste backfill and rock cap on Storage 1A and Storage 2

Category	Subcategory	Category Weighting	Subcategory Weighting	Score	Weighted score	Category Score	Final Score	Comments
Technical	Future ore resource	0.25	0.1	3	0.3			Small risk that GOP TSF may affect future underground mining
	Geotechnical		0.15	5	0.75			Storage 3 and Northern Rock Stack site have some weak material in foundations but they will be removed
	Geochemistry		0.15	3	0.45			Storage 3 and Northern Rock Stack will have controls for potential geochemistry effects that have worked to date and have been adopted and proven to work at other projects. GOP TSF controls are based on sound design concepts that have been applied at other sites, but not proven at Waihi Project with experience.
	Constructability		0.1	5	0.5			Experience with existing TSFs indicates that they can be constructed to meet Specifications. Similar materials will be used for the NRS.
	Operability		0.1	5	0.5			Storage 3 and GOP TSF can be operated in all conditions and without interference from other site functions.
	Storage capacity and expansion potential		0.15	5	0.75			Storage 3 can be expanded. GOP TSF could be expanded as a mine open pit overburden disposal area with rock placed above tailings
	Project schedule		0.25	3	0.75			Unlikely to meet tailings scheduling requirements.
						4	1.000	
Environmental	Terrestrial ecosystem	0.25	0.2	3	0.6			Some short term impact on on-site terrestrial ecosystem associated with construction and operation of Storage 3 and GOP TSF.
	Aquatic ecosystem		0.2	3	0.6			Minor impact on aquatic ecosystem No known historical impact
	Groundwater		0.15	5	0.75			Potential groundwater impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Surface water		0.15	5	0.75			Potential surface water impacts expected to be controlled with proposed design for facilities and considering performance of existing facilities
	Impact on SNA		0.1	3	0.3			Storage 3 has small impact on SNA
	Dust		0.1	5	0.5			Control measure required and operating history indicates that air discharge standards will be met.
	Noise		0.1	3	0.3			Storage 3 is new TSF, located closer to some rural properties east of the Development Site. Expect minor noise effects, but no operating history at this location.
						3.8	0.950	
Socio-economic and permitting	Social impact	0.25	0.15	5	0.75			Low social impact
	Mana Whenua		0.25	3	0.75			Consultation undertaken, but Mana Whenua prefer backfilling to recreate maunga rather than use as a TSF.
	Economic		0.1	5	0.5			Project has considerable economic benefit to community and other parties
	Recreation		0.1	5	0.5			No impact on recreational users
	Regulatory approval		0.2	3	0.6			Project has effects that can be mitigated.
	Archaeological/heritage		0.1	5	0.5			Some remnants of historical mining activities at GOP TSF, but not significant
	Landscape and visual		0.1	3	0.3			Some visual impact from construction of Storage 3 and Northern Rock Stack, but rehabilitation provides long-term mitigation
						3.9	0.975	
Project Economics	Land ownership	0.25	0.1	5	0.5			OGNZL owns all the land required
	Capital cost		0.35	1.5	0.525			Ranks 4 = and score reflects this
	Operating cost		0.35	0	0			Ranks in bottom third
	Closure and post-closure cost		0.2	5	1			Ranks in top third
						2.025	0.50625	
						TOTAL WEIGHTED SCORE:	**3.43**	

TABLE A7. PROJECT ECONOMIC RANKING AND SCORING

Project Economic Scoring

Capital Cost			
Option	Capital Cost Ranking	Score	Comments
1	1=	5	Requires initial development for Storage 3 and GOP TSFs and NRS
2	1=	5	Requires initial development for Storage 3 TSF and NRS and liner for GOP Lake.
3	6	0	Infrastructure for filtered tailings is expensive and this option also requires initial development for Storage 3 and NRS. Requires larger drains and ponds to manage surface water than slurry TSF option.
4	3	3	High capital cost because Storage 2 needs to be raised to RL160.7 before any additional tailings storage is provided and existing infrastructure needs relocating.
5	4=	1.5	Paste plant and associated pumps/pipe infrastructure expensive and also requires NRS initial development
6	4=	1.5	Paste plant and associated pumps/pipe infrastructure expensive and also requires NRS initial development
Operating Cost			
Option	Operating Cost Ranking	Score	Comments
1	2	5	Similar to Option 2, but lower cost as less rock needs to be transported to Storage 3 which is longer haul and more expensive than to NRS. Tailings pumping costs less than Option 2 because less tailings are pumped to Storage 3.
2	3	3	Similar to Option 1, but has higher operating cost (see comments for Option 1)
3	4	3	High operating cost for dry stack tailings
4	1	5	Close proximity to conveyor and short haul for rock to Storage 2 TSF and NRS. Small quantity of rock to raise Storage 2 above RL160.7. Storage 2 TSF in close proximity to Plant for tailings disposal
5	5=	0	High operating cost for paste
6	5=	0	High operating cost for paste
Closure Cost			
Option	Closure Cost Ranking	Score	Comments
1	4=	1.5	Requires capping of GOP TSF and partial capping of Storage 3 TSF. Capping of NRS is progressive during operation but NRS is almost depleted at end of project. Associated infrastructure (perimeter road drain and seepage collection system) could be removed to return land back to original state.
2	2=	4	Low cost because GOP Lake has minimal closure cost. Capping of NRS is progressive during operation but NRS is almost depleted at end of project. Associated infrastructure (perimeter road drain and seepage collection system) could be removed to return land back to original state.
3	4=	1.5	Requires capping of GOP TSF. Capping of Storage 3 TSF is progressive during operation. NRS has low closure cost as capping is progressive during operation.
4	2=	4	Low cost because GOP Lake has minimal closure cost, NRS has low closure cost as cap layer completed during operation and Storage 3 TSF only requires partial capping
5	6	0	Reinstatement of Gladstone Hill requires large quantity of rock to be transported from stockpile with large cost. NRS will need recapping after material removed for reinstating Gladstone Hill.
6	1	5	Low closure cost as Storage 1A and 2 and NRS will be capped progressively during operation.