RS SANDS HYDROLOGY

A REPORT BY

MIKE CHAPMAN

PROJECT

RS SANDS -
77 NEWCOMBE ROAD

TE MIRO WATER CONSULTANTS

TE MIRO. WATER

RS SANDS HYDROLOGY

Version	Date	Author	Reviewer	Change Description
V1	24/05/21	M Chapman 021 477 801 mike@temirowater.co.nz	Britta Jensen	Draft
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TE MIRO. WATER

RS SANDS HYDROLOGY

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TE MIRO. WATER

1. Background

RS Sand is proposing to develop a sand quarry at 77 Newcombe Road, Cambridge. Te Miro Water were engaged by RS Sand to assess the effects of the proposed sand quarry (excavation) on hydrology and surface water drainage. This report therefore simply covers the existing surface water features on the site including the existence of any primary or secondary flow channels.

TMW understand that the stormwater disposal from the site over the lifetime of the quarry operation in terms of treatment, attenuation and erosion and sediment control is discussed in a separate report along with proposed solutions. The hydrogeological landscape and potential effects on groundwater is undertaken separately by WGA Consultants with details provided in their report dated 17 February 2021 (Doc No. WGA201888-RP-HG-0001 Rev. A).

2. Topography

The topography is outlined in the HD Geo Tech and WGA hydrogeology reports. The land where the proposed quarry is planned is at an elevation of approximately 72 m RL, based on the local site topographical survey (Precision Aerial Surveys 2020). The quarry is proposed to be excavated to a final floor level of 40 m RL (Figure 1). The adjacent stretch of the Karapiro Stream (within a steeply incised gully) is at an elevation of 30 m RL (survey by Precision Aerial Surveys 2020), approximately 10 m below the proposed final floor of the sand quarry (Stage 4) (WGA, 2021). The proposed quarry staging is shown in Appendix B.

Figure 2 shows the main Karapiro Stream at the base of the incised gully. This stream was once the main Waikato River channel which was sidelined from the current river alignment due to debris blockage from an eruptive volcanic event. The WGA report discusses the minimal/less than minor impacts on stream baseflow from the quarry operation.

A 2D rain on grid model was undertaken using TUFLOW software to check the proposed quarry floor level in relation to the 100yr flood level for Karapiro Stream. The 100yr existing flood map is show in the appendix. The maximum level is below the proposed lowest quarry floor level due to the incised stream and wide floodplain in this area.

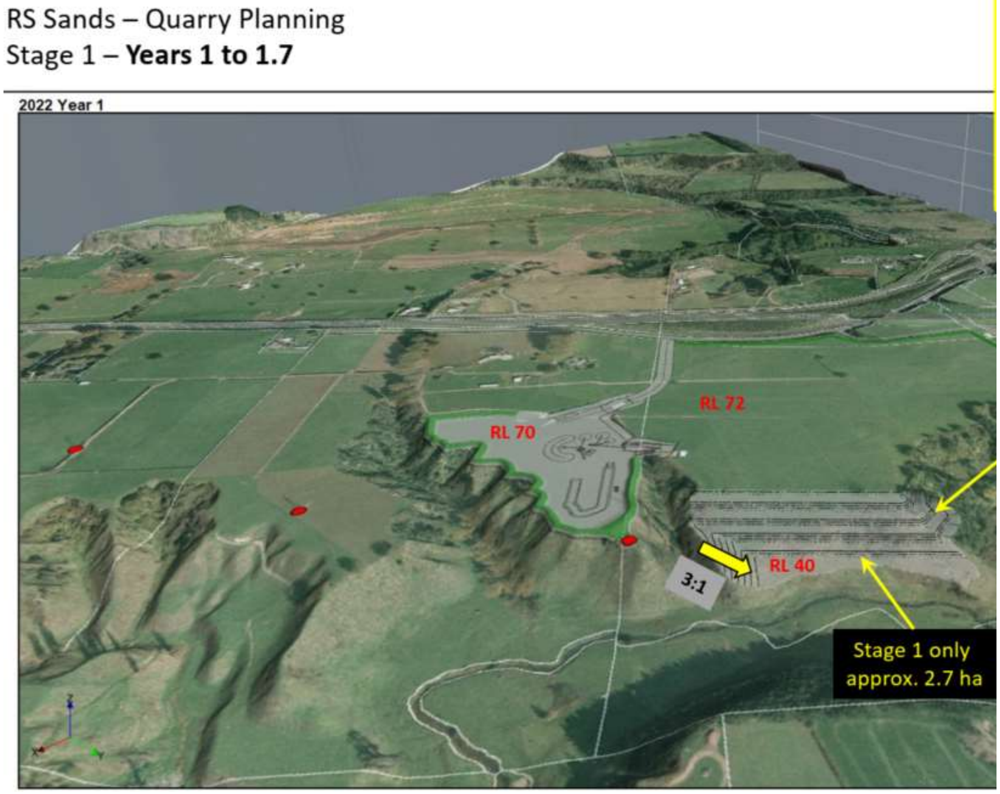


Figure 1: Proposed Lowest Quarry Floor Level RL 40m (plan from 30 June 2022).

Figure 3 shows one of the small side gullies located within the site. During the site visit, no noticeable flow was observed in the gully head (or other two gully heads within the site), however seepage was apparent where the side gully joined the main Karapiro Stream (edge of the floodplain) at the approximate location of the black arrow in Figure 2. This level is approximately 2-3 metres above the top of Karapiro Stream bank. This indicates the side gullies do not have a permanent baseflow in their upper reaches, seepage zones emerge within the lower level as is consistent with seepage zones along most of the gully edge (ref WGA, 2021). This observation is supported by the 2D model which highlights depression storage areas within the site but no noticeable overland flow paths or watercourses leading to the small side gullies - only minor sheet flows are shown by modeling less than 100mm during extreme events (Appendix A).

No other channels or obvious overland flow paths/ephemeral streams were observed across the site which gives further indication that the side gullies are remnant features from when the Karapiro Gully was in an active channel forming phase as part of the main Waikato River.

Figure 2: Karapiro Stream and gully outlet between plant and pit area looking downstream South-East

Figure 3: Top of Side Gully – Dry, no flow observed until Gully Reaches Main Gully Floor (2-3 m above stream bank).

3. Effects on Surface Water Features

- The site currently slopes gradually towards the Karapiro Stream gully edge at a very flat grade with minor depression areas as remnant features during the Karapiro Stream fan to channel forming phase.
- There are no noticeable overland flow paths or permanent waterways within the site. Likewise, there are no obvious large scale flood depression storage areas or active floodplain. This is typical of many river terraces adjacent to steeply incised gullies surrounding Cambridge. Rain that falls across the site will either pond temporarily in localised low points during larger storm events or soak directly to ground during smaller more frequent rain events.
- There is approximately a 5m or greater height separation between the proposed lowest quarry floor level (40m RL) and the maximum 100yr flood level based (Karapiro Stream 30m RL) on 2D modelling of the Karapiro Stream catchment (flood depths and extent in Appendix A).
- The side gullies may display some surface flows during extreme events due to local runoff from the side walls however most of the water that lands on the site will not reach these gullies due to the flat typography and well drain soils. As discussed earlier, these gullies are remnant features connected to the main Karapiro Stream channel forming system and as such they are not actively conveying permanent water or actively undergoing erosion and continued incision from stream flow.
- The site visit did not reveal presence of farm drains or underdrain network which is not unexpected given the well-drained in situ sub soils and deep groundwater table.
- Groundwater levels are typically deep with no active channels or contributing catchments to form floodplains or flood hazards that would need to be managed as part of a new development.

4. Conclusions

- There are no permanent or ephemeral channels or streams within the site. The site is almost flat with some slight undulations typical of the river terraces adjacent to deeply incised gullies surrounding Cambridge.
- There are 3 side gullies which are steep and protrude into the site. These side gullies connect to the main Karapiro gully, and they display no permanent water other than seepage flows in the lower reaches approximately 2-3 m above the top of stream bank (Figure 2).
- Excavation for quarrying (for each stage Figure 1) show proposed contours reducing alongside the gully side walls (and blending with the gully side as required for each stage), surface flows are not expected to be impacted because there is no identifiable catchment flowing to each side gully and no permanent stream flow within the gully for most of its length until seepage flow where it drops to the gully floor.

- The gullies are remnant features from a time when the Karapiro Stream was much larger and actively incising river system.
- There is no floodplain within the site (no channel inflows, no connection to active river/stream floodplain) and therefore management of existing flood hazard is not required.
  2D TUFLOW flood modeling indicates maximum 100yr depths from Karapiro Stream are below the proposed lowest quarry floor level.

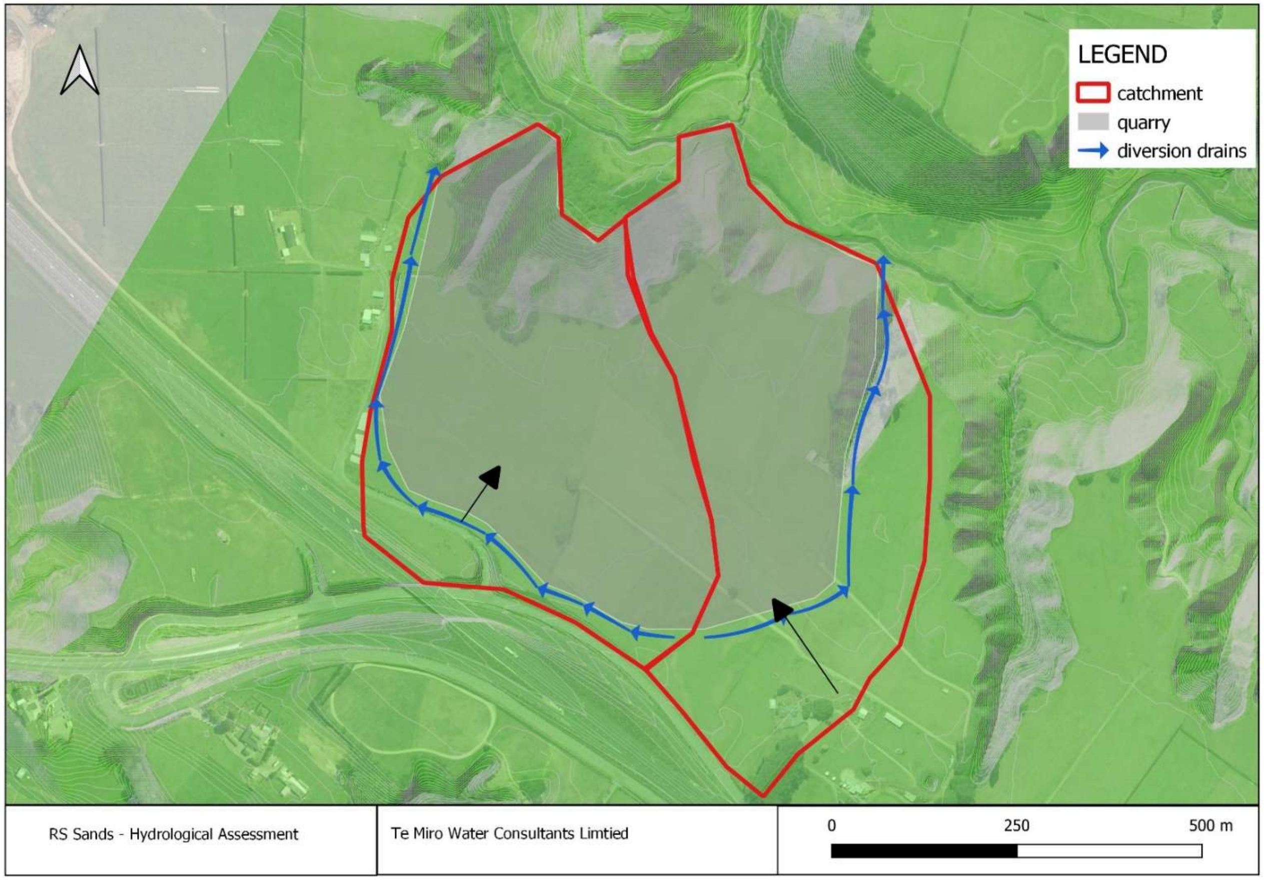
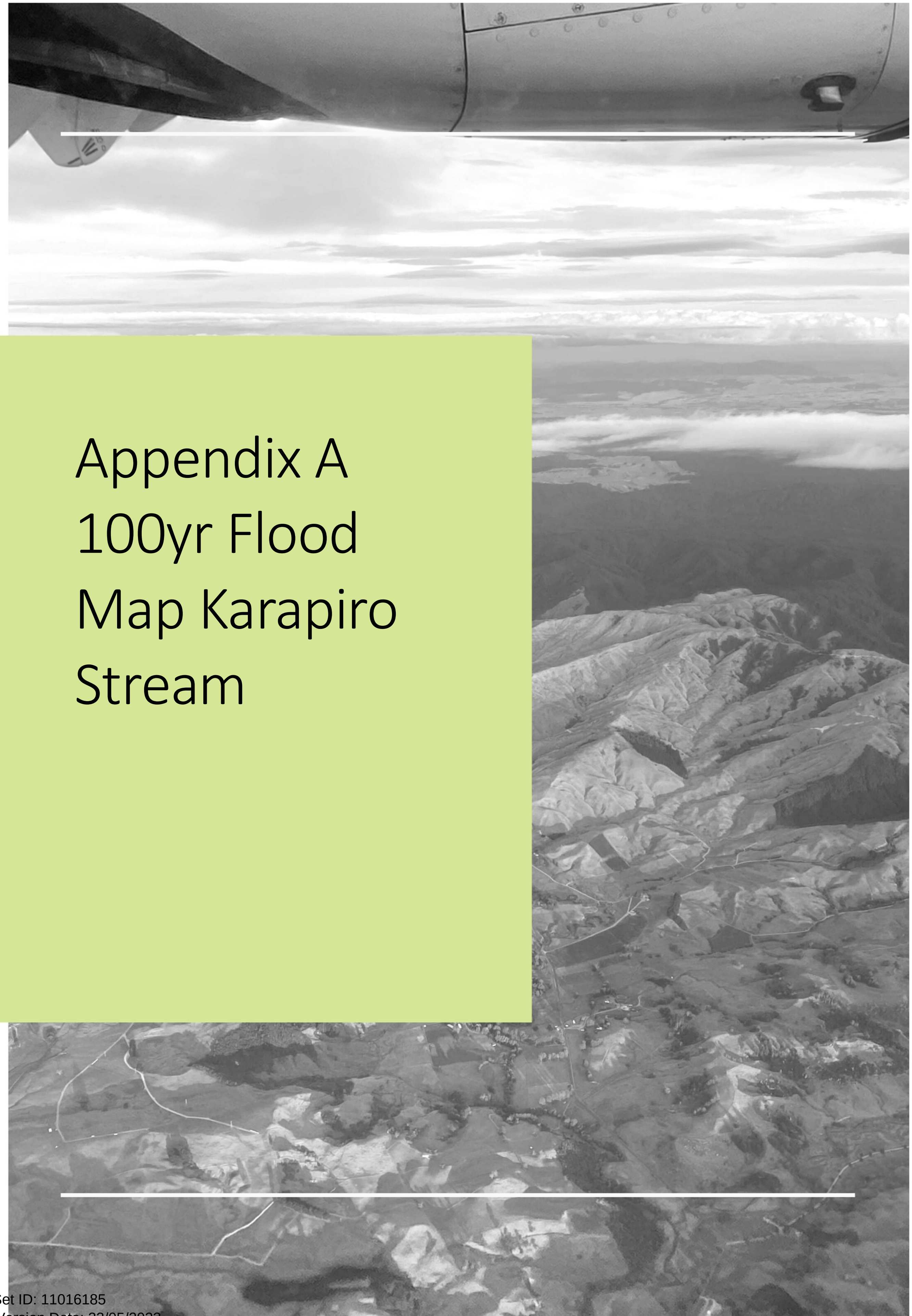


Figure 3: Existing Sheet Flows into the Site. No identifiable stream or channel across the site.



Appendix A 100yr Flood Map Karapiro Stream

Legend

Model Extent

Maximum Depths (m)

- <= 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

Project:
J000026: Fulton Hogan-RS Sands

Title:
100yr ARI event.
Overland flow paths

Map: 01
Sheet Number: 01

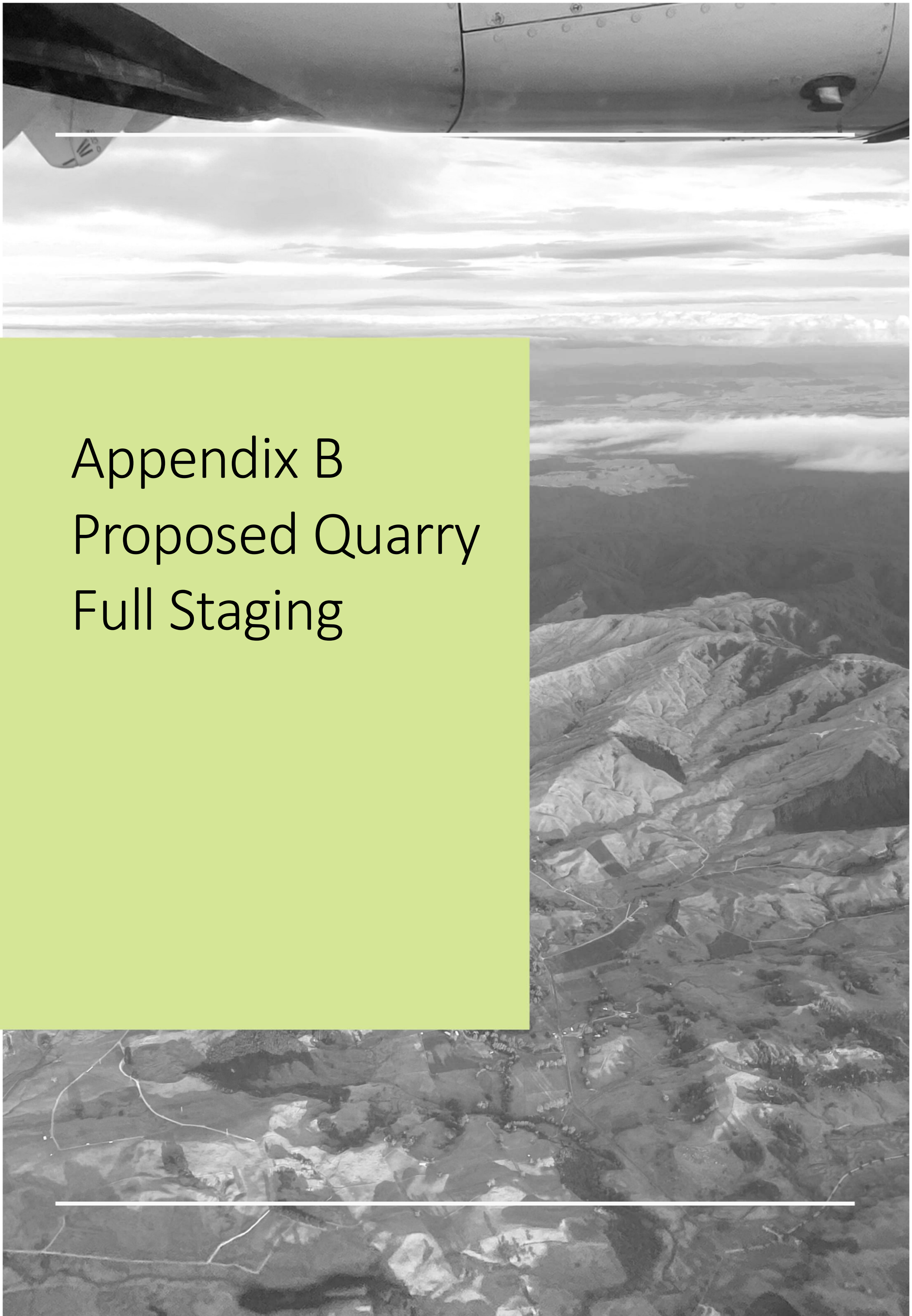
TE MIRO WATER

Drawn: RJG
Approved: MC
Approved Date: 19/06/2021

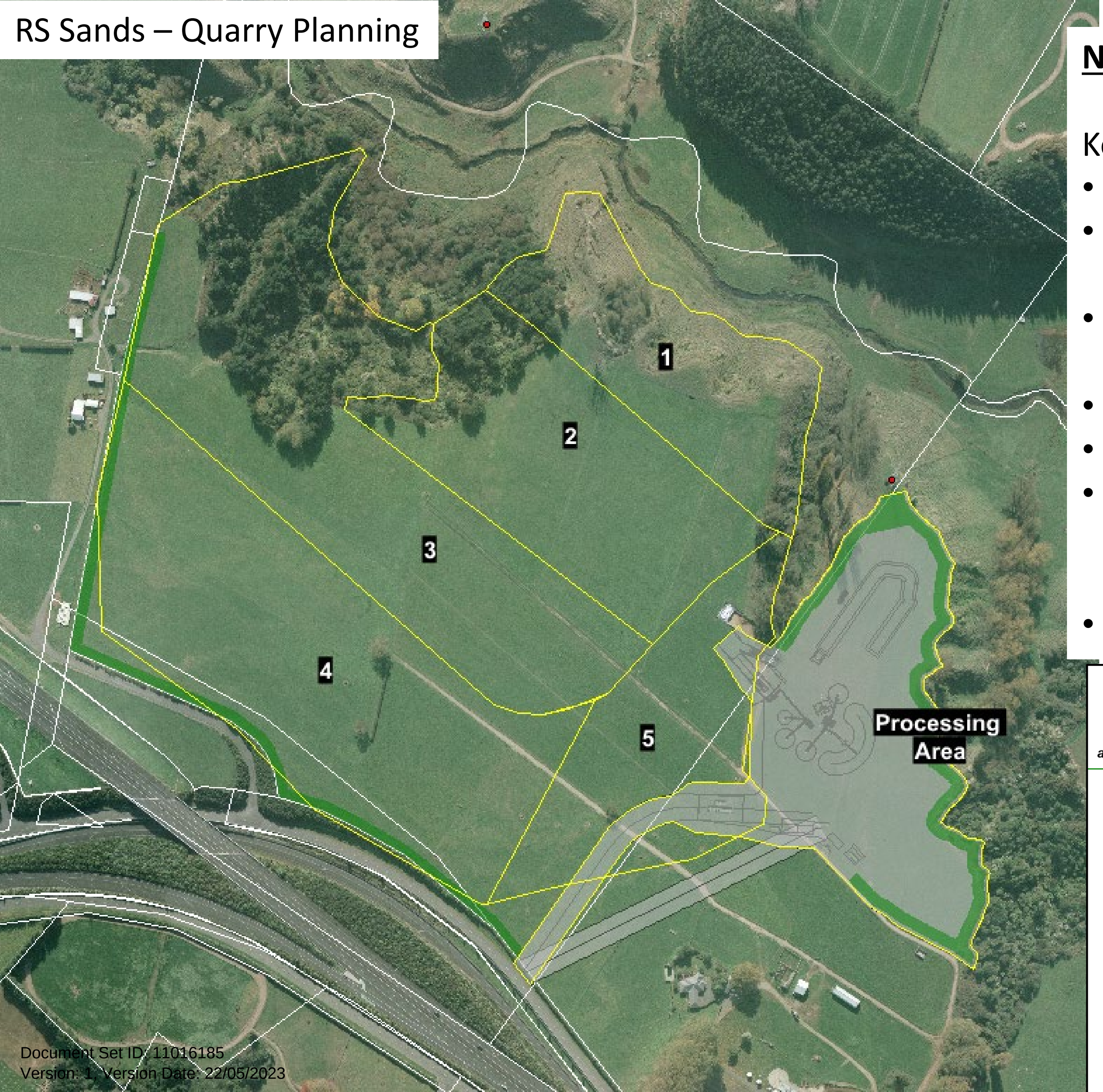
Scale: 1:4000
Original Size: A3

Graphic Scale:
0 50 100 150 200 m

Appendix B Proposed Quarry Full Staging



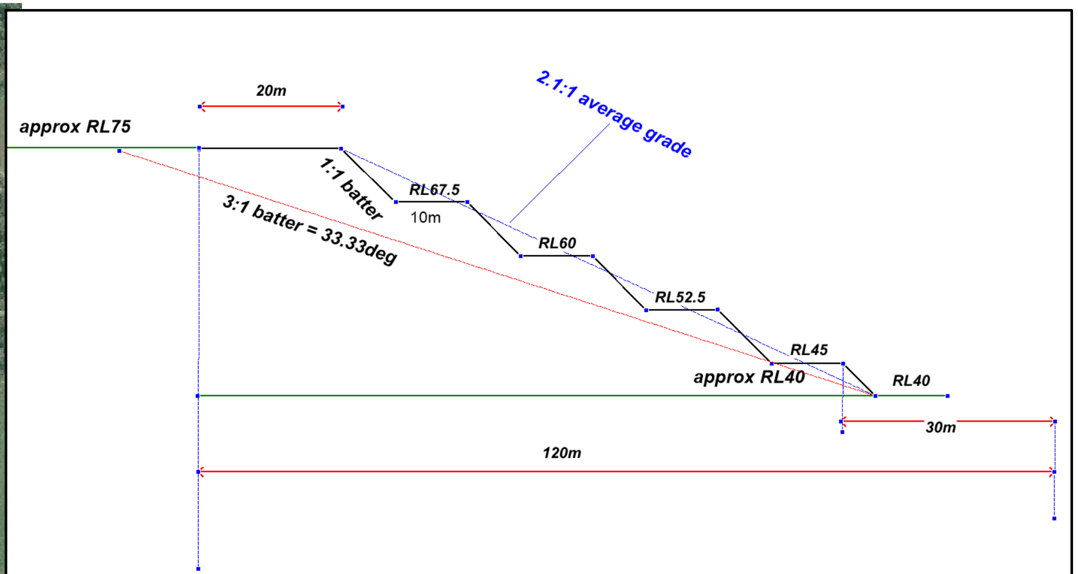
RS Sands – Quarry Planning



Newcombe Road entrance and Area A staging

Key points

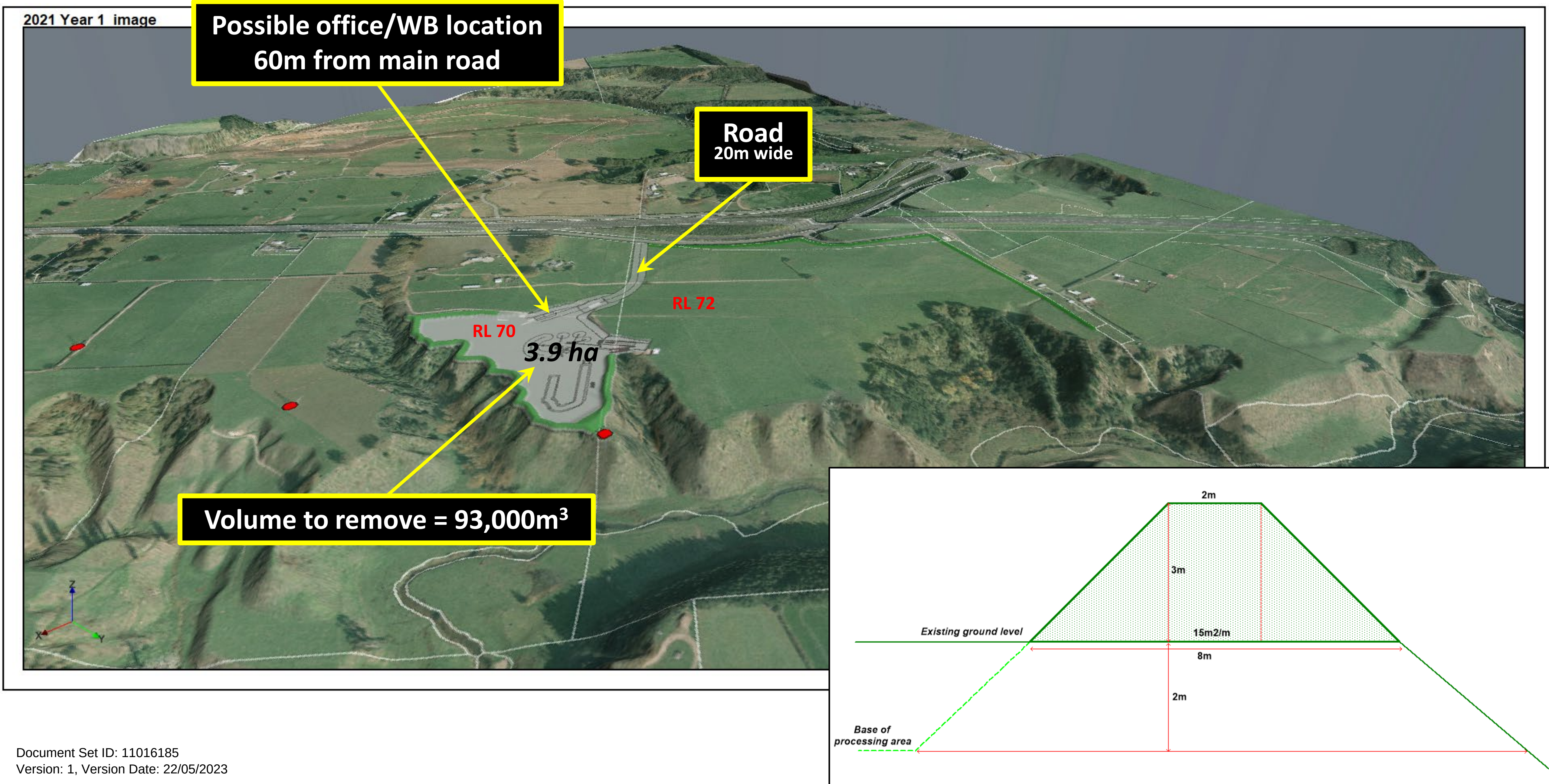
- Yellow lines indicative only
- Batters on the yellow lines reflect interim batters (see figure below)
- Batters on the outer edges which = the contours shown are 3:1
- Sales are estimated at 300,000tpa
- Sand density used = 1.8t/m^3
- Have assumed RL 67.5 = top of sand everything above this is a 50-50 split between overburden and pit sand
- Balance = concrete sand approx. 27.5m



RS Sands – Quarry Planning
As surveyed June 2020

Now 2021

RS Sands – Quarry Planning
Processing area and bunds



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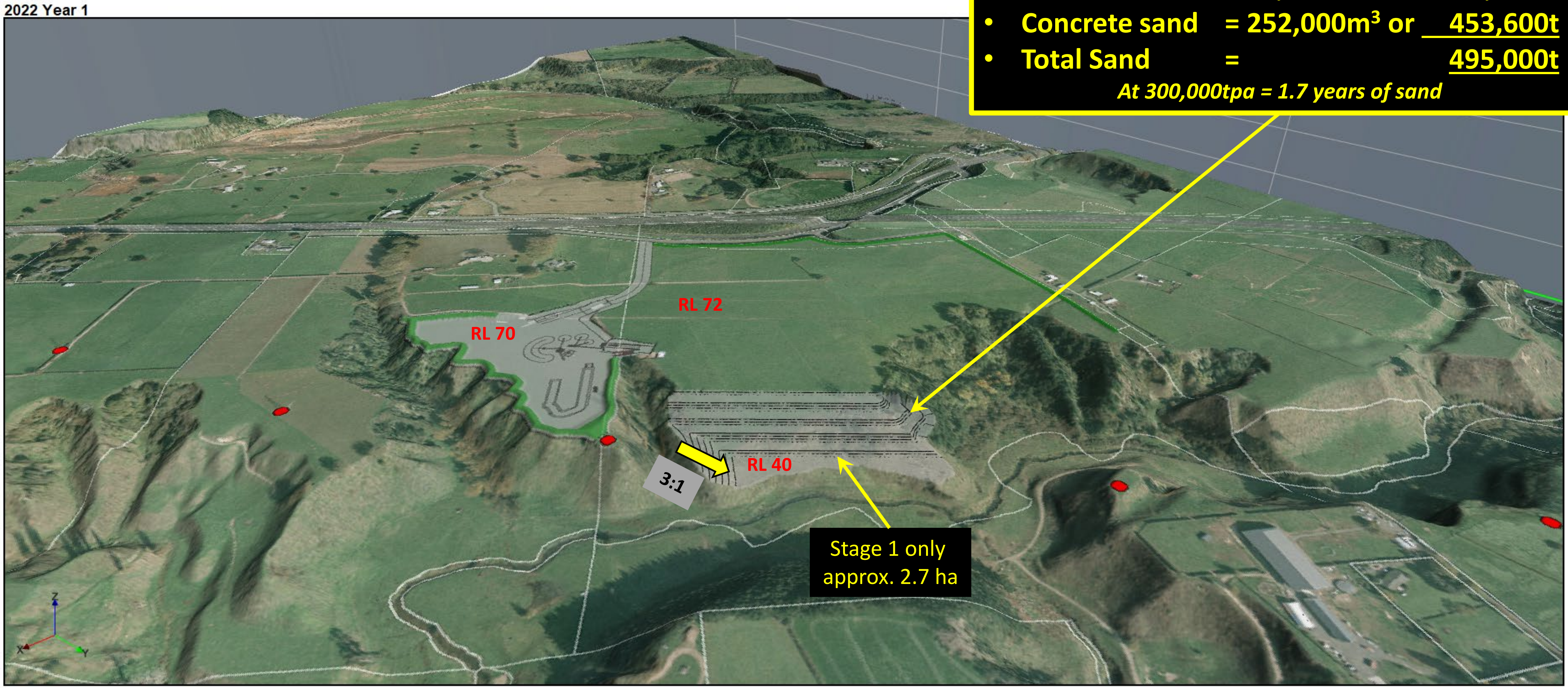
Version: 1, Version Date: 22/05/2023

RS Sands – Quarry Planning
Stage 1 – **Years 1 to 1.7**



- **Overburden = 23,000m³**
- **Pit sand = 23,000m³ or 41,4000t**
- **Concrete sand = 252,000m³ or 453,600t**
- **Total Sand = 495,000t**

At 300,000tpa = 1.7 years of sand

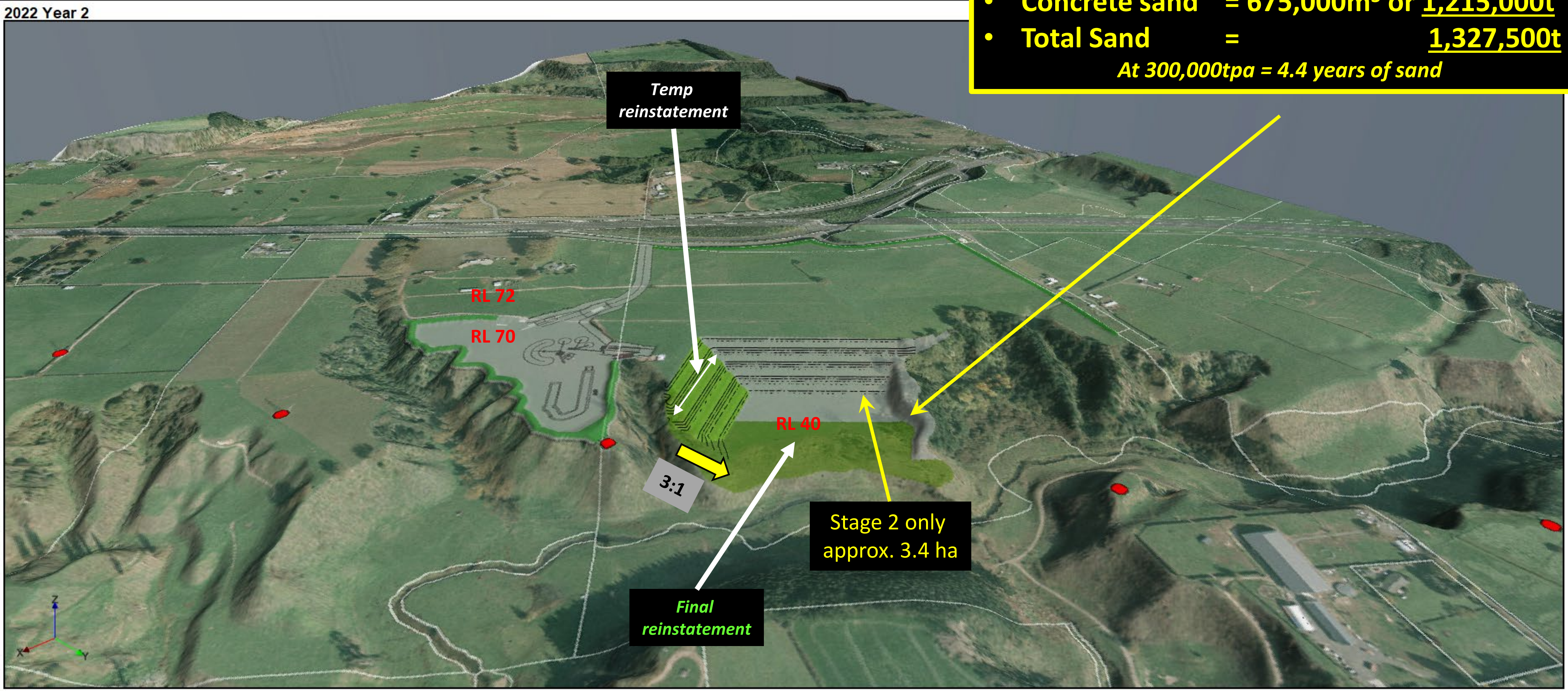
Viewpoint at the end of each stage – including reinstatement

RS Sands – Quarry Planning

Stage 2 – **Years 1.7 to 6.1**

- **Overburden = 62,500m³**
- **Pit sand = 62,500m³ or 112,500t**
- **Concrete sand = 675,000m³ or 1,215,000t**
- **Total Sand = 1,327,500t**

At 300,000tpa = 4.4 years of sand



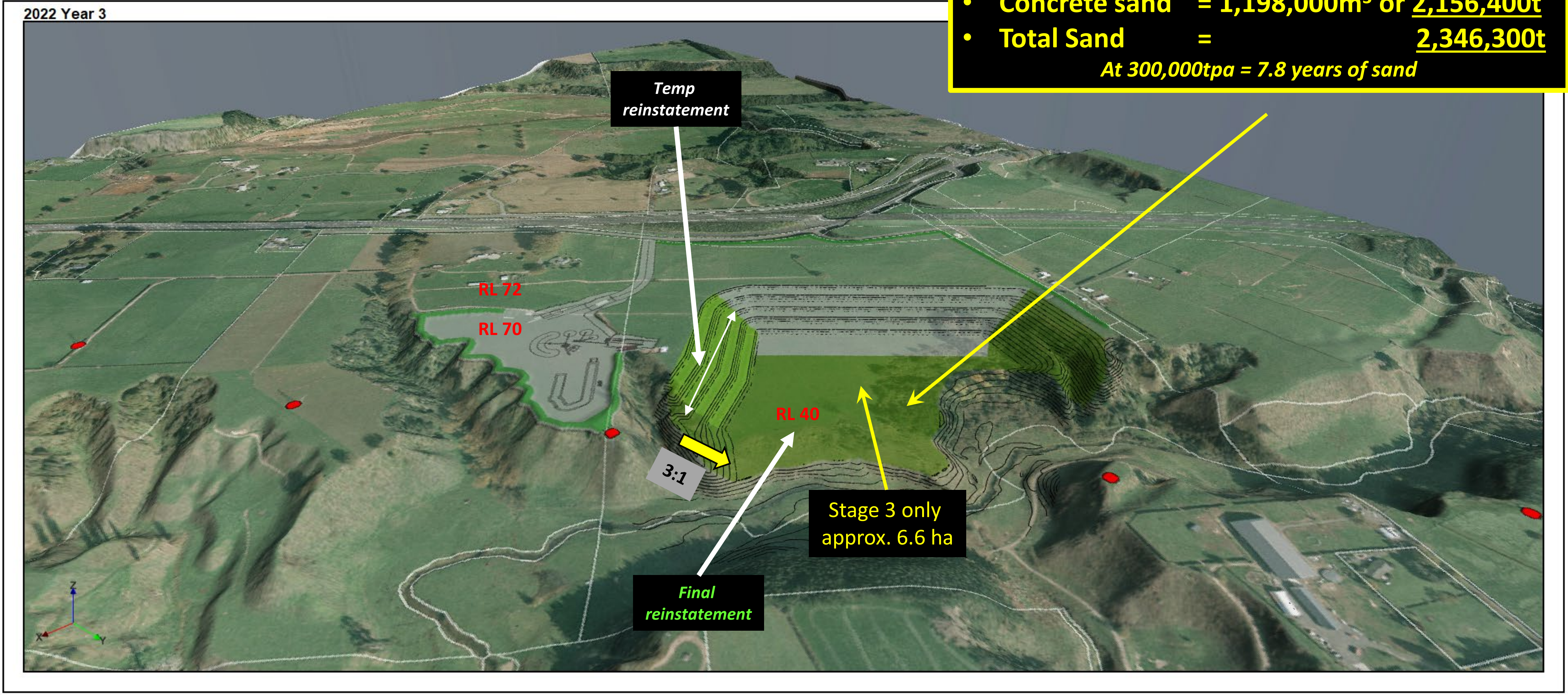
Viewpoint at the end of each stage – including reinstatement

RS Sands – Quarry Planning

Stage 3 – **Years 6.1 to 13.9**

- **Overburden = 105,500m^3**
- **Pit sand = 105,500m^3 or 189,900t**
- **Concrete sand = 1,198,000m^3 or 2,156,400t**
- **Total Sand = 2,346,300t**

At 300,000tpa = 7.8 years of sand



Viewpoint at the end of each stage – including reinstatement

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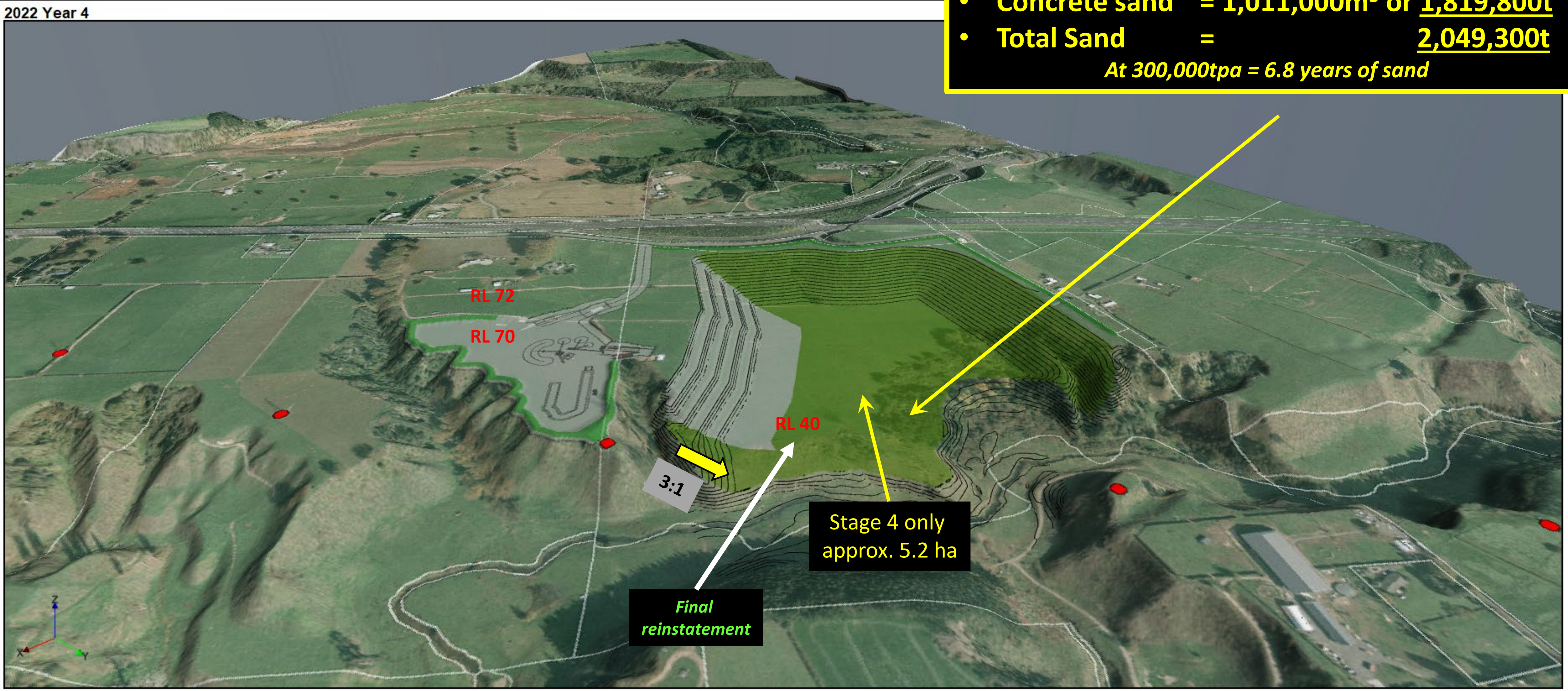
RS Sands – Quarry Planning
Stage 4 – **Years 13.9 to 20.7**

- **Overburden** = 127,500m³
- **Pit sand** = 127,500m³ or 229,500t
- **Concrete sand** = 1,011,000m³ or 1,819,800t
- **Total Sand** = 2,049,300t

At 300,000tpa = 6.8 years of sand



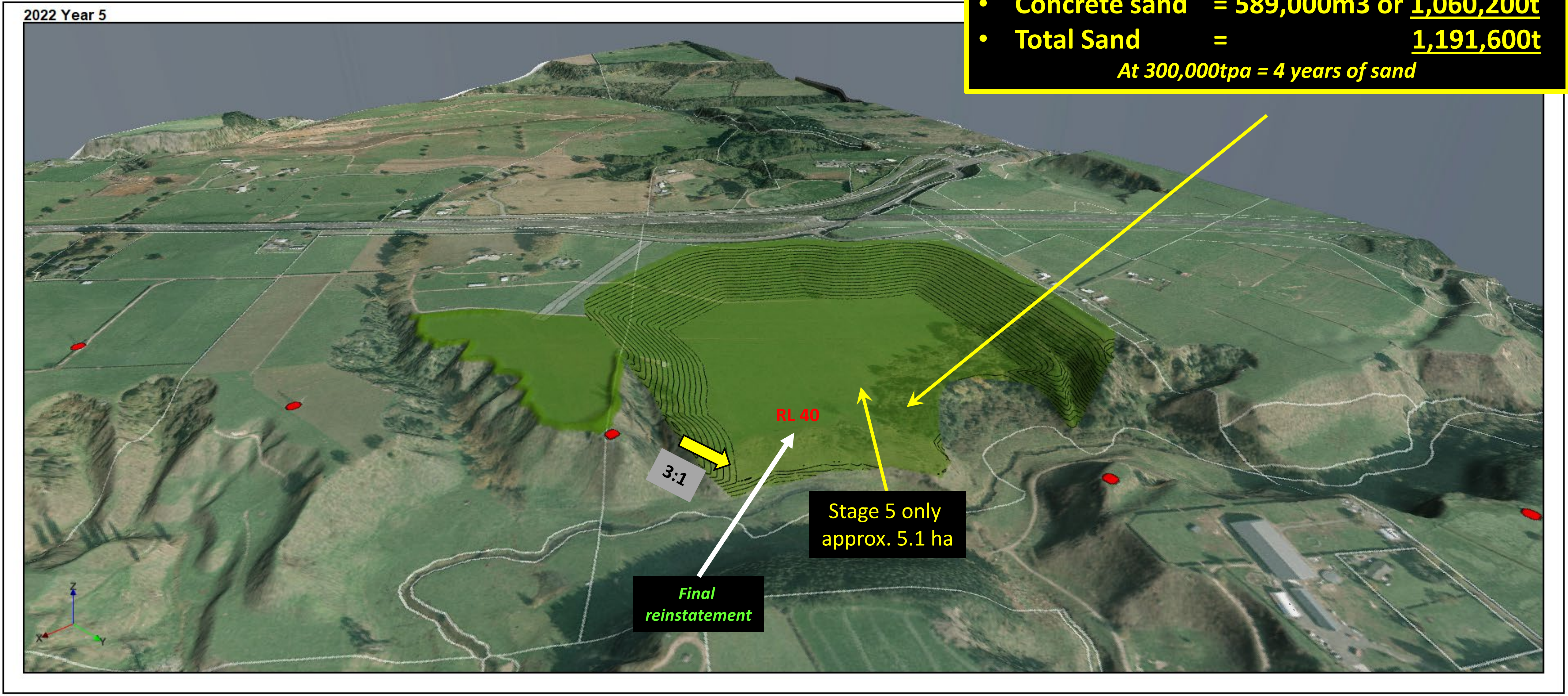
Viewpoint at the end of each stage – including reinstatement

RS Sands – Quarry Planning

Stage 5 – **Years 20.7 to 24.7**

- **Overburden = 73,000m^3**
- **Pit sand = 73,000m3 or 131,400t**
- **Concrete sand = 589,000m3 or 1,060,200t**
- **Total Sand = 1,191,600t**

At 300,000tpa = 4 years of sand



Viewpoint at the end of each stage – including reinstatement

Summary

	m3			t			years
	Overburden	Pit sand	Concrete Sand	Pit sand	Concrete Sand	Subtotal	
Stage 1	23,000	23,000	252,000	41,400	453,600	495,000	1.65
Stage 2	62,500	62,500	675,000	112,500	1,215,000	1,327,500	4.43
Stage 3	105,500	105,500	1,198,000	189,900	2,156,400	2,346,300	7.82
Stage 4	127,500	127,500	1,011,000	229,500	1,819,800	2,049,300	6.83
Stage 5	73,000	73,000	589,000	131,400	1,060,200	1,191,600	3.97
Sub total	391,500	391,500	3,725,000	704,700	6,705,000	7,409,700	24.70
Totals			4,508,000		7,409,700		24.70

WALLBRIDGE GILBERT AZTEC

RS Sand

Assessment of Effects of Proposed Quarry on Groundwater

ASSESSMENT OF ENVIRONMENTAL EFFECTS

Project No. WGA201888
Doc No. WGA201888-RP-HG-0001
Rev. B
09 August 2022

Revision History

Rev	Date	Issue	Originator	Checker	Approver
A	17/2/2021	DRAFT	CHO	BAS	CHO
B	9/8/2022	Final	CMH	CHO	CHO

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1 INTRODUCTION

1.1 BACKGROUND

RS Sand is proposing to develop a sand quarry at 77 Newcombe Road, Cambridge. RS Sand intends to apply for resource consents authorising the development and operation of the quarry. To support the consent application, WGA has been engaged by RS Sand to assess the effects of the proposed excavation on groundwater and nearby groundwater users.

1.2 SCOPE OF WORK

WGA has been engaged to provide support for the resource consent application by undertaking the following tasks:

- Review and assess available information on the hydrogeology of the area.
- Provide a preliminary high-level evaluation of the potential effects of the proposed quarry on groundwater and nearby groundwater users.
- Make recommendations on the design of a monitoring well network for the proposed quarry.
- Present the outcomes of the above work in a report suitable for lodging with the Waikato Regional Council in support of the application for resource consents.

This report covers the findings of the initial groundwater assessment and recommendations for groundwater monitoring. WGA understands this report will be incorporated as an appendix to an overarching report on potential water drainage and hydrological effects.

This assessment is based on the results of geotechnical investigations at the site, information available from Waikato Regional Council, aerial photographs and a site visit carried out in December 2020.

1.3 QUARRY LAYOUT

The proposed quarry at 77 Newcombe Road is planned to be excavated to a final floor elevation of approximately 40 m RL in at least four stages (Figure 1). The top 7.5 m of sediment will be treated as overburden due to a number of silt and clay layers interspersed with the sand to this depth. The final quarry floor level (40 m RL) is 10 m above the level of the nearby Karapiro Stream (Figure 1). More detail on the quarry layout is presented in Appendix A.

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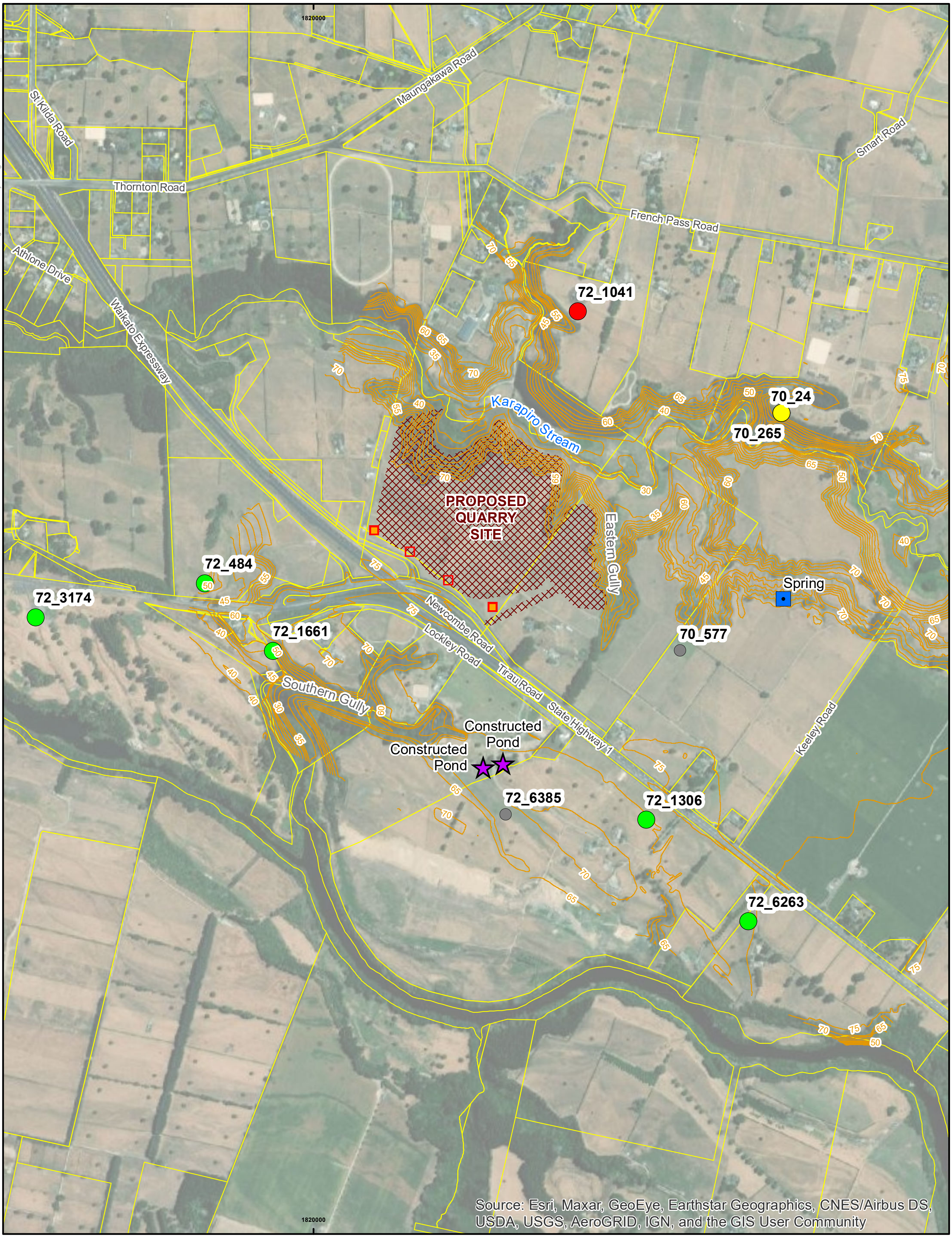

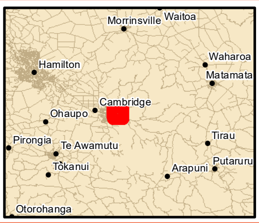

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0 100 200 300 400 m

Scale 1:15,000 @ A4

Coordinate System: NZGD 2000 New Zealand Transverse Mercator

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2021

LEGEND

Bore (Depth (m))

- 0 - 10
- 25 - 50
- > 100
- 10 - 25
- 50 - 100
- Unknown
- Shallow Piezometer (7m)
- Shallow & Deep Piezometer (50m)
- Spring
- Parcel
- Contours
- Quarry Extent
- Constructed Pond

WGA
WALLBRIDGE GILBERT AZTEC

Figure 1
Cambridge Sand Quarry
Site Map

1.4 TOPOGRAPHY

WGA carried out a site inspection of the area of the proposed quarry on 26 November 2020. A historical branch of the Waikato River has formed a steep sided gully along the northern edge of the proposed quarry. This steeply incised gully now contains the Karapiro Stream (Figure 2 and Figure 3).

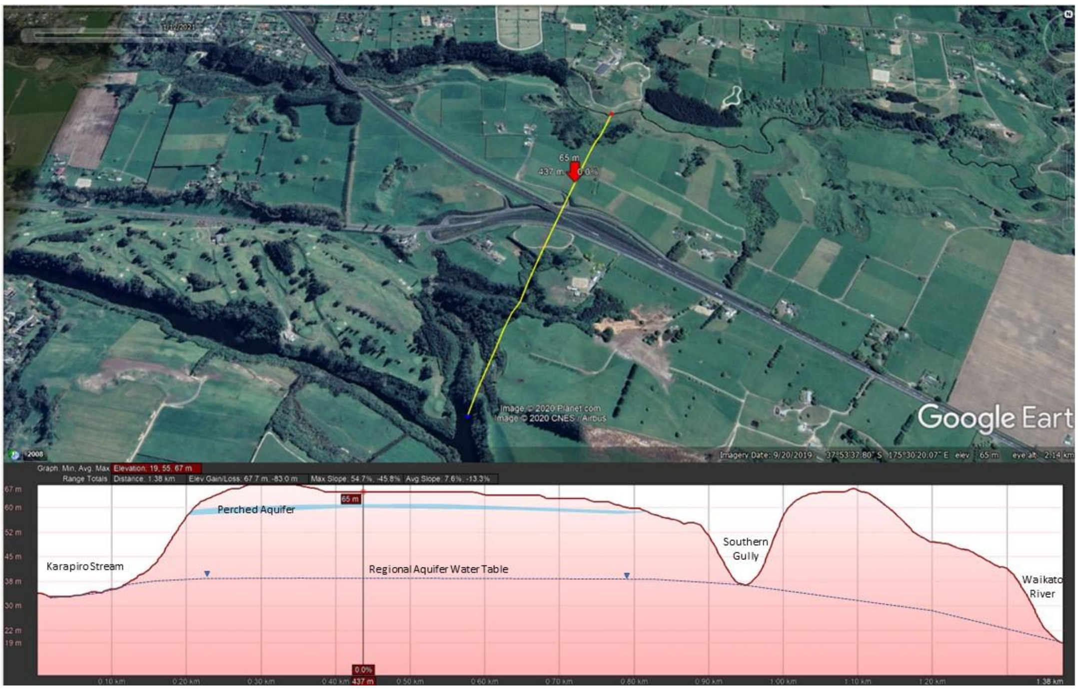
The land where the proposed quarry is planned is at an elevation of approximately 72 m RL, based on the local site topographical survey (Precision Aerial Surveys 2020). The quarry is proposed to be excavated to a final floor level of 40 m RL. The adjacent stretch of the Karapiro Stream is at an elevation of 30 m RL (survey by Precision Aerial Surveys 2020; Figure 1), approximately 10 m below the proposed final floor of the sand quarry (Stage 4).

An incised gully approximately 650 m to the south of the proposed sand quarry contains a tributary of Waikato River. This gully is incised to approximately 19 m RL close the Waikato River confluence, which is approximately the level of the Waikato River. At the top end of this gully there are two constructed ponds (Figure 1).

The relative levels of the gullies and Waikato River are shown on the topographical cross section based on Google Earth (Figure 4). WGA notes that the elevation information presented in the cross section is not as accurate as the local aerial survey data and the cross-section is presented for schematic purposes only.

Figure 2: View of Karapiro Steam Looking Southeast from Top of the Terrace.

Figure 3: View of Karapiro Steam Looking Northwest from Top of the Terrace.



Note: The elevation level based on local aerial survey indicated that the land surface in the vicinity of the proposed quarry is approximately 72 m RL and the perched aquifer is shown at approximately 65 m RL. Google Earth shows a lower elevation and the aquifers are shown as schematic only.

Figure 4: Topographical Cross-Section from Google Earth Showing WGA's Estimated Depth of Regional and Local Perched Aquifers.

2 HYDROGEOLOGY

2.1 GEOLOGY

The proposed RS Sand quarry is situated within the Hamilton Basin, a large tectonic basin centred on Hamilton City with an area of approximately 2,000 km^2 and traversed by the Waikato River. The basin is surrounded by ranges of Mesozoic (Manaia Hill Group) and Tertiary age (Te Kuiti and Waitemata Groups) rocks. The basin is infilled with Tauranga Group alluvial sediments dating from the Pliocene to the middle Holocene, overlain by late Holocene unconsolidated alluvial and colluvial sediments. The Tauranga Group sediments are up to 300 m thick and include gravels, sands, silt, muds and peats of fluvial, lacustrine and distal ignimbritic origin (Appendices B and C). Basement greywacke underlies the sedimentary deposits at depth (GNS 2005).

The Hinuera Formation of the Tauranga Group underlies much of the Hamilton basin. This formation was deposited by braided river systems of the Waikato River, initiated by the supply of large volumes of sediment from volcanism in the Taupo Volcanic Zone (Petch 1987).

2.2 GROUNDWATER SYSTEM

The Hinuera Formation contains the aquifers used most extensively across the Hamilton Basin for water supplies. Within this formation, the most productive aquifers consist of well sorted coarse sands and gravels. Discontinuous sequences of rhyolitic and pumiceous gravelly sands and gravels are interspersed with pumiceous silt, clay and peat. Lithological variability generally results in a number of zones of higher permeability within each of the formations rather than a single, continuous aquifer (Figure 5; Schofield 1972). The upper layers contain perched aquifers which can dry out over the summer period and will drain to the closest gully system.

Literature values for the hydraulic conductivity of sediments in the Hamilton Basin range from 0.5 m/day in the silts and peat layers to 13.5 m/day in the course gravelly sands. Aquifer transmissivity values derived from pumping tests range from 10 m^2/day to 1,000 m^2/day but are usually less than 100 m^2/day. The deeper aquifers have variable aquifer properties and local pumping tests have resulted in transmissivities calculated at between 20 m^2/day and 300 m^2/day. Storativity values vary from 0.001 for deep, confined or semi-confined aquifers to 0.1 for shallow, unconfined aquifers in the Hamilton Basin (Petch and Marshall 1988). In some areas these discontinuous aquifers may provide bore yields of up to 30 L/s (Petch 1987).

Regional groundwater flows in the area of Cambridge are generally towards the northwest, from the basin edges to the southeast. Major groundwater discharge occurs into the Waikato River and its tributaries located in deeply incised gullies (Petch and Marshall 1988).

The Hinuera Aquifer is used in nearby rural areas for domestic and stock water supplies. The deeper Hautapu Aquifer is used by the Fonterra Hautapu Dairy Factory to supply water to the plant. Other irrigation bores in the area also tap this deeper aquifer.

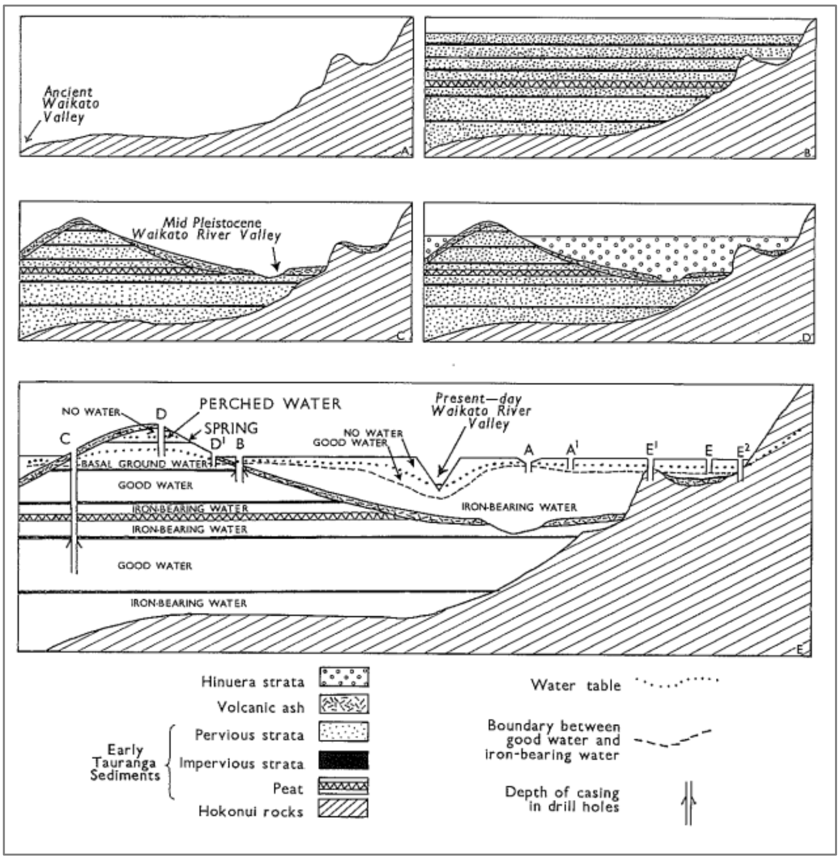


Figure 5: Simplified Geological History and Formation of Local Aquifers (Schofield 1972).

2.3 LOCAL AQUIFER PROPERTIES

Drilling carried out at the quarry site for geotechnical purposes has been reviewed in terms of the observed groundwater levels and lithology. In addition, a production bore was drilled on site in April 2022 for the purposes of supplying water for dust suppression and processing during the life of the quarry (WGA 2022).

From the drilling results and knowledge of the local hydrogeology, WGA understands that there are at least three aquifers at the site:

- A Perched Aquifer at approximately 65 m RL (7 m deep).
- An Unconfined Aquifer at approximately 33 m RL (39 m deep).
- A Confined Aquifer at approximately 19 m RL (53 m deep).

The Perched Aquifer is evident in the drilling results at approximately 6 m to 7 m below ground (Appendix B and Appendix C). This perched aquifer is also identifiable on orthophotos of the site taken during prolonged dry periods. The discharge seepage from this aquifer to the incised river valley to the north of the site occurs at approximately 65 m RL. This perched water seepage (spring) is used locally for stock water and dairy shed use, as detailed further in Section 3.2.

Both deeper aquifers defined from the onsite bore lithological logs (Unconfined Aquifer and Confined Aquifer) are considered to be part of the regional aquifer. The Unconfined Aquifer was not evident in some bore holes located on the Site to a depth of 44 m bgl (approximately 28 m RL, Appendix C). However, the Unconfined Aquifer is evident by seepage features observed in orthophotos at the level of the Karapiro Stream (32 m to 30 m RL). Groundwater was intersected in a bore hole approximately 800 m from the Karapiro Stream at approximately 40 m RL (Appendix C, Bore Hole 1). However, the sediments described in the bore log are finer grained (silt) than those described in logs from other nearby bores of similar depth (Appendix C, Bore Hole 2 and 3) so some groundwater perching could be occurring in proximity to Bore Hole 1. Silt layers are present at differing depths and extents in the nearby bores and is associated with flooding of the ancestral river. The silt layers will affect confinement and perching across the regional aquifer.

The deep Confined Aquifer is evident in the new production bore lithology (gravel, sand pumice) from 53 m deep. The aquifer testing on this production bore showed that the aquifer is highly confined in this location (WGA 2022).

In terms of groundwater quality, water in the shallow Hinuera Aquifer to the north of the Karapiro Stream has been identified locally as having high nitrate-nitrogen concentrations, especially in the Hautapu area. For example, a nearby long-term water quality monitoring bore in the Hinuera Aquifer (70_47, 3.8 km to the north on Aspin Road) indicates that the local aquifer has nitrate-nitrogen concentrations generally between 2 g/m³ and 5 g/m³ and a 5-year median of 2.5 g/m³. This shallow monitoring bore is only 4.5 m deep and is located in a rural area. Local groundwater quality data are not available to confirm if shallow water quality on-site is similar. A search of the WRC bore database revealed no local groundwater quality information.

2.4 GROUNDWATER RECHARGE

To estimate the current maximum groundwater inflow to the quarry footprint, WGA carried out a high-level calculation based on an estimated groundwater catchment area of 16 ha and a local annual recharge (contributing to baseflow to the Karapiro Stream) of between 288 mm and 500 mm per year. This recharge compares to the average annual rainfall of 1,224 mm as measured at Hamilton Airport[1]. A previously published shallow recharge estimate (delayed flow) is 288 mm per year (Petch and Marshall 1988). The higher recharge rate of 500 mm per year was used as an upper recharge limit representing approximately 40% of rainfall.

The results indicated 1.5 L/s to 2.5 L/s average flow over one year derived from recharge within the proposed sand quarry excavation area. If all recharge in this area was contributing to the perched aquifer and then outflowing to the Karapiro Stream terrace edge, over an estimated seepage discharge length of approximately 720 m, the resulting seepage would only be evident during dry periods. However, WGA considers that some of the recharged water will slowly percolate down to the regional aquifer, which is considered to be locally discharging directly to the Karapiro Stream and the Waikato River. The length of Karapiro Stream (as opposed to terrace seepage length) to which the local seepage is contributing is approximately 620 m.

[1] Cliflo data from NIWA for Hamilton AWS, agent number 2112, https://cliflo.niwa.co.nz/.

3 EFFECTS ON GROUNDWATER

3.1 EFFECTS OF PROPOSED QUARRY

The effect of the excavation on groundwater will be limited to an area close to the excavated pit. In terms of the shallow perched aquifer, the incised gully to the east of the proposed site (Eastern Gully) will restrict any potential effects in the eastern direction. This is discussed in more detail in Section 3.2.

Groundwater drawdown in the perched aquifer is expected to propagate to the south beyond the expressway. To the south of the expressway the incised tributary of the Waikato River (refer Figure 4) limits the extent of the local perched aquifer. Any effects that groundwater drawdown resulting from the pit development may have on the expressway are beyond the scope of this report and are to be covered in the geotechnical assessment.

To the north, the incised gully of Karapiro Stream will limit the extent to which any groundwater drawdown effects propagate. The seepage from the proposed quarry in this direction is considered to be significantly less than approximately 2.5 L/s averaged over one year. Under the proposed activity, recharge water will still flow to the Karapiro Stream but will percolate through the quarry floor rather than through farmland soils and the perched aquifer which will be removed in the area of the quarry. Recharge to the regional aquifer may be slightly higher once the quarry has been developed compared to the current farming land use.

To the west there could be a decline in the groundwater level in the shallow perched aquifer within about 400 m of the quarry, as the quarry will form a new groundwater discharge area closer than the discharge areas under present conditions. There are no registered bores in this affected area. However, the source of water to the neighbouring farm to the west is not evident from desktop assessment and they might be using an unregistered bore.

3.2 EFFECTS ON NEARBY BORES

There are 12 bores within one kilometre of the proposed sand quarry listed on the WRC database (Table 1). Six of these bores are to the north of Karapiro Stream and are not considered to be affected by the proposed quarry. The incised Karapiro Stream valley provides a hydraulic boundary limiting groundwater drawdown in this direction and the final floor level of the quarry is 10 m above the level of the stream.

In addition to the registered bores, the neighbouring property to the west could be using a bore for domestic and stock water supply. This property has an old dairy shed (no longer used), which would have required a water supply. Although there are no registered bores for this property on the WRC mapping system, the property does not appear to have a town water supply or significant rainfall water storage. A shallow bore in the location of the house or cow shed, which is close to the proposed quarry excavation area, would be expected to be materially affected by groundwater drawdown arising from the proposed earth works. Mitigation options for any effect on a bore on this property include the deepening of the bore or the provision of another water supply to the property.

Most of the six bores located to the south of Karapiro Stream, are closer to the southern incised gully than to the proposed quarry. The gully will have a stronger influence on local groundwater levels than the proposed quarry. Development of the quarry will effectively move the northern groundwater discharge location for the perched aquifer southwards from Karapiro Stream. Bore 70_577 is located to the east of the proposed quarry and has an unknown depth. Although this bore could be tapping the perched aquifer, it is located on the far side of the eastern gully (tributary of Karapiro Stream), which is sufficiently incised to restrict drawdown effects in this direction.

Table 1: Bores Within One Kilometre of the Proposed Sand Quarry.

Bore ID	Completion date	Ground elevation (m RL)	Bore depth (m)	Position relative to the proposed quarry
70_577	-	70.6	Unknown	Closest bore: Approximately 460 m to the east
72_1661	17/Oct/2001	50.8	78.7	Approximately 460 m to the southwest near southern incised gully.
72_484	22/Mar/2001	57.7	60	530 m to the west southwest
72_6385	-	62	Unknown	550 m to the south
72_1306	30/Aug/2002	69.1	62	Approximately 770 m to the southeast
72_3174	01/Jun/1973	42	62.18	Golf Club bore; located 1 km to the west southwest
72_6263	03/Apr/2013	63	86	1 km to the south east
70_24	-	60	Unknown	North of Karapiro Stream
72_1041	01/Oct/2000	71.9	6	North of Karapiro Stream
70_263	18/Sep/1990	71.5	48.77	North of Karapiro Stream
70_264	18/Sep/1990	71.5	48.77	North of Karapiro Stream
70_24	-	60	Unknown	North of Karapiro Stream
70_265	19/Nov/1990	71.5	39.01	North of Karapiro Stream

Source: WRC bores database

There are four consented groundwater takes within one kilometre of the proposed site (Table 2). As the construction of the expressway has been completed it is considered that the resource consent to take water in association with construction of the expressway is no longer operative apart from any fixed dewatering structures. The effects of the proposed quarry on the expressway are covered in the separate geotechnical assessment.

Table 2: Resource Consents for Groundwater Takes Within One Kilometre of the Proposed Quarry.

Consent Number	Details
AUTH140637.01.01	Resource Consent: Take up to 180 cubic metres per day of groundwater for golf green irrigation purposes
AUTH122320.01.01	Resource Consent: Take groundwater in association with the Cambridge Section of the Waikato Expressway
AUTH126930.01.01	Resource Consent: To take groundwater Agricultural farming - dairy
AUTH126762.01.01	Resource Consent: To take water from a spring.

The take for irrigation of the golf course is from a 62 m deep bore (72_3174), which is located close to the Waikato River. This bore is not considered to be significantly affected by the proposed quarry excavation due to its depth and position close to the Waikato River.

There is a nearby consent to take water from a spring (Figure 1) for use in a dairy shed (Table 3). A review of aerial photographs (taken during summer) has identified a groundwater seepage line along the southern gully slopes of Karipiro Stream at approximately 65 m RL. The consented spring take is considered to be abstracting water from this perched aquifer layer, which corresponds to the wet sandy layer occurring above a clay horizon observed in the drill holes (Appendix B). This perched layer will be removed in the excavated area of the quarry. The discharge location for the perched aquifer to the northwest of the spring will therefore be changed. However, in terms of the effect of the quarry on the spring, the incised gully which is present between the spring and most of the proposed excavation area (Eastern Gully) will act as a hydraulic boundary to limit the drawdown effect. The Eastern Gully is incised to approximately 40 m RL, well below the perched wet layer at approximately 65 m RL.

There is a consent to take groundwater for dairy farming for up to 35.62 m^3/day located approximately 850 m to the southeast of the proposed quarry. This take is likely to be associated with bore 72_1306. The bore has a depth of 62 m and is not considered to be affected by the proposed quarry excavation due to its depth.

Table 3: Details of Consented Spring Takes.

Consent Number	AUTH126762.01.01
Applicant / holder	Whitehall Fruit packers Holdings Limited
Activity description	To take water from a spring.
Net take daily total	19.81 m^3/day
Net take annual total	7,231 m^3/year
Water use – Primary	Agriculture
Water use – Secondary	Shed wash

3.3 EFFECTS ON STREAMS AND BASEFLOW

Groundwater below the proposed quarry is predominantly contributing flows to the Karapiro Stream. As discussed in Section 3.2, the planned quarry will only have localised effects on groundwater due to the proximity of incised gullies surrounding the site (Figure 1). Groundwater that would have discharged into the Karapiro Stream through recharge over the area of the proposed quarry will continue to discharge to the stream along the same reach of the stream.

There are two constructed ponds to the south of the proposed sand quarry (Figure 1) that appear to have been constructed to approximately 65 m RL. WGA has not visited the ponds, but they are potentially sourcing shallow groundwater from the perched aquifer. They appear to have been constructed in April 2019 within a historical gully. The discharge area for the perched aquifer will be moving closer to these ponds under the proposed quarry excavation to the north. The discharge area will move from being approximately 850 m to the north of the ponds to eventually approximately 500 m to the north. However, the strong influence of the nearby Southern Gully at 150 m to the west, will be the main controlling factor in controlling groundwater levels in the ponds.

3.4 RECOMMENDED MONITORING

To monitor the effects of quarry development and associated groundwater drawdown in the shallow perched aquifer in the direction of the expressway and the two artificial ponds, a series of at least four shallow piezometers and two deeper piezometers along the southern boundary of the quarry is recommended. In addition to monitoring the perched aquifer system, it is also recommended that at least two piezometers screened in the regional aquifer be installed along the southern boundary of the quarry. The piezometers are recommended to be set at approximately 150 m apart following the southern boundary of the quarry. The piezometers are recommended to have pressure transducers installed to automatically record water levels and be downloaded every 3 months. Recording water levels for at least 6 months but preferably 1 year prior to the excavation starting is recommended to establish a baseline.

WGA recommends a discussion with the neighbours to the west to determine if they have a bore and the potential effects on that bore if it exists.

4 CONCLUSIONS

Underlying the area of the proposed sand quarry there is an interpreted perched aquifer at approximately 65 m RL and two regional aquifers below approximately 33 m RL. The effect of the quarry excavation on groundwater will be limited to drawdown in the perched aquifer, in the immediate vicinity of the excavated pit. Incised gullies to the north, east and south of the proposed sand quarry will limit the extent of any drawdown effects in these directions.

Nearby registered bores and springs are not considered to be potentially affected due to the limiting effect of the incised gullies on quarry-induced drawdown or their proximity to other discharge locations such as the Waikato River. If the neighbour to the west of the planned quarry has an unregistered bore, it could be materially affected and WGA recommends that a discussion with the landowner take place to determine the depth and location of any bore on the property.

Groundwater level monitoring in both the perched and regional aquifers is recommended for the southern boundary of the property in at least six piezometers in four locations.

5 REFERENCES

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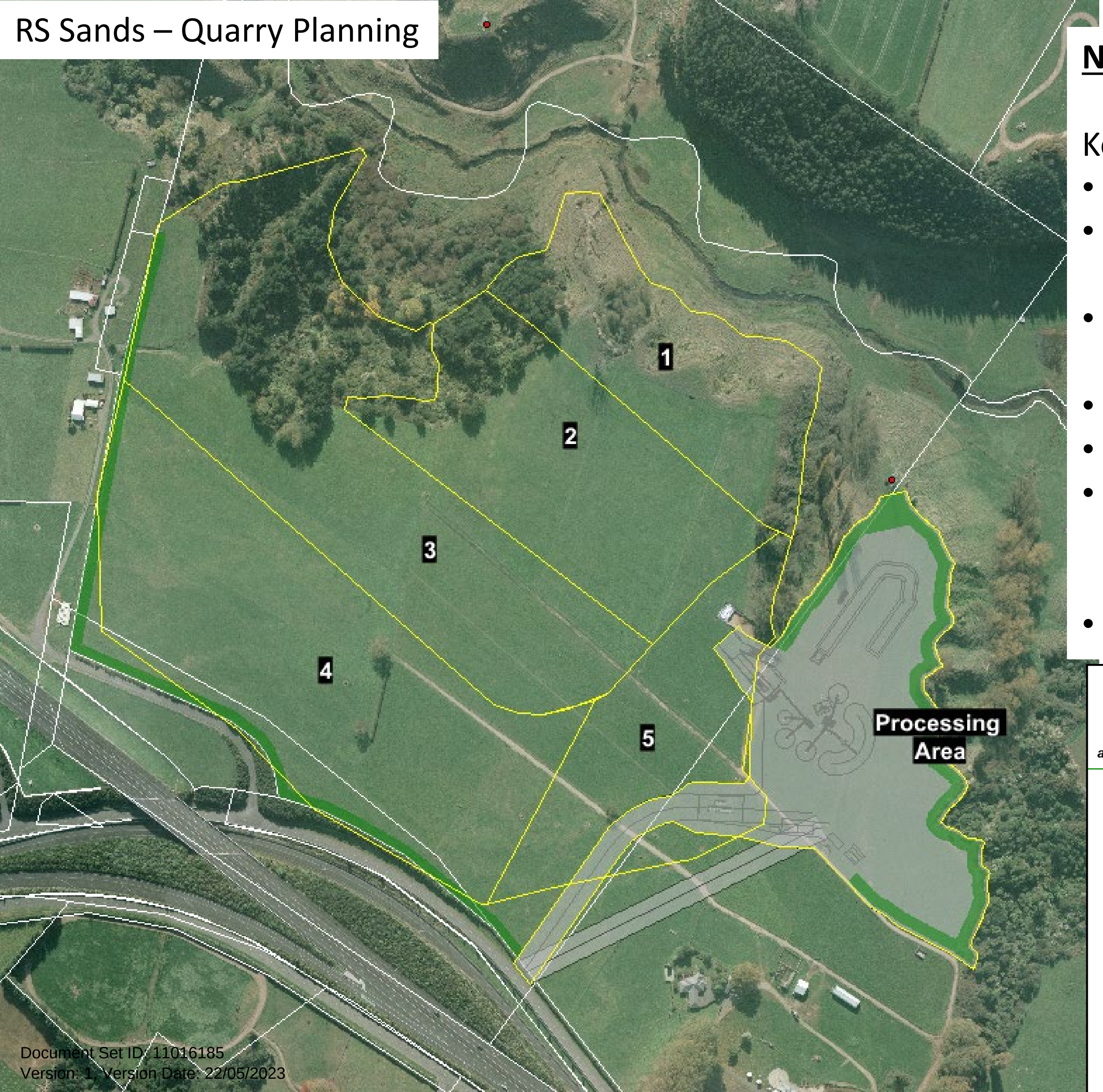
APPENDIX A

QUARRY LAYOUT PLANS

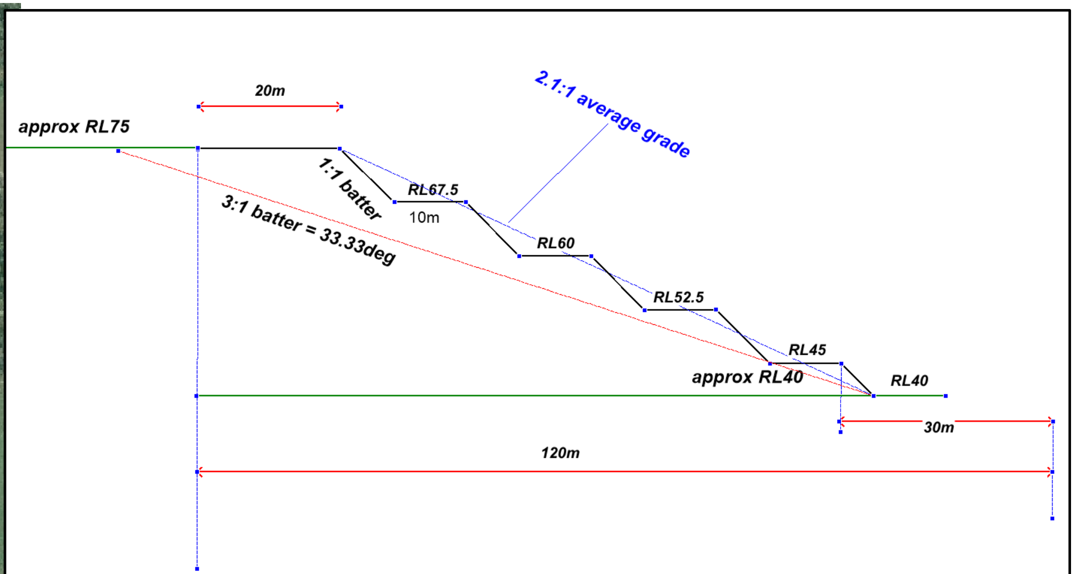
RS Sands – Quarry Planning



Newcombe Road entrance and Area A staging

Key points

- Yellow lines indicative only
- Batters on the yellow lines reflect interim batters (see figure below)
- Batters on the outer edges which = the contours shown are 3:1
- Sales are estimated at 300,000tpa
- Sand density used = 1.8t/m^3
- Have assumed RL 67.5 = top of sand everything above this is a 50-50 split between overburden and pit sand
- Balance = concrete sand approx. 27.5m

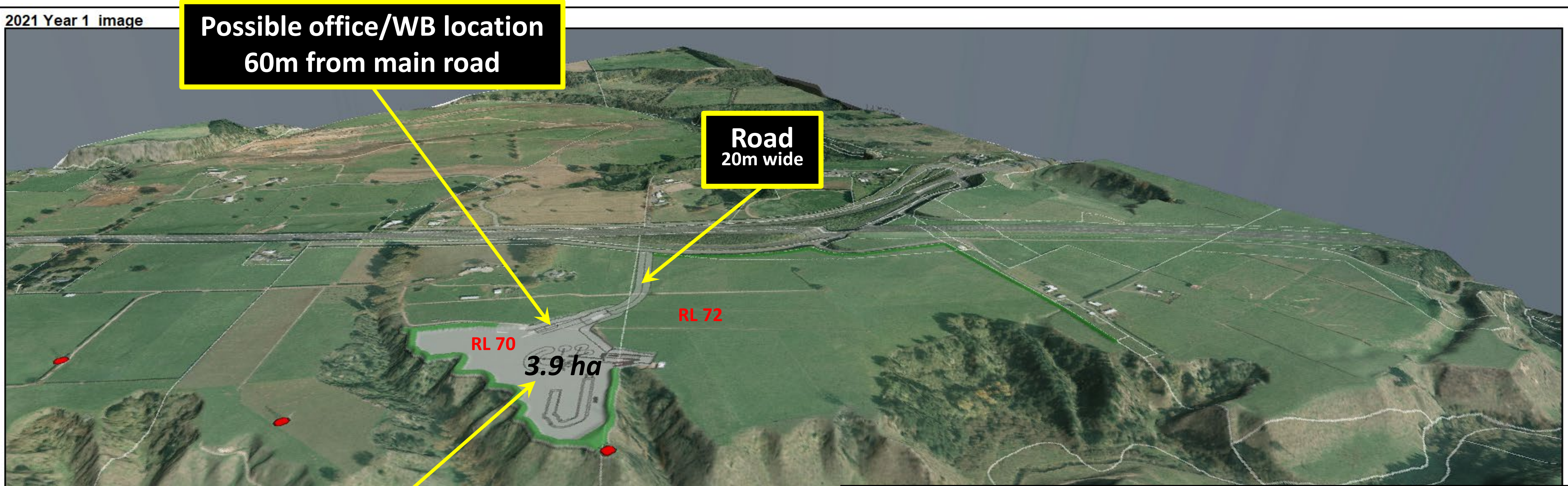


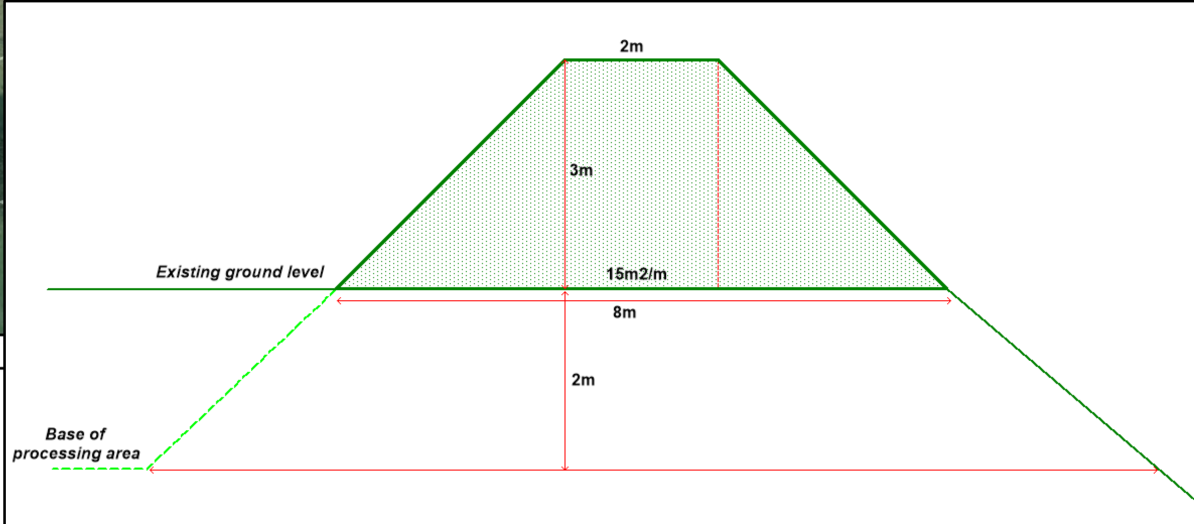
RS Sands – Quarry Planning
As surveyed June 2020

Now 2021

Document Set ID: 11016185
Version: 1, Version Date: 22/05/2023

RS Sands – Quarry Planning
Processing area and bunds

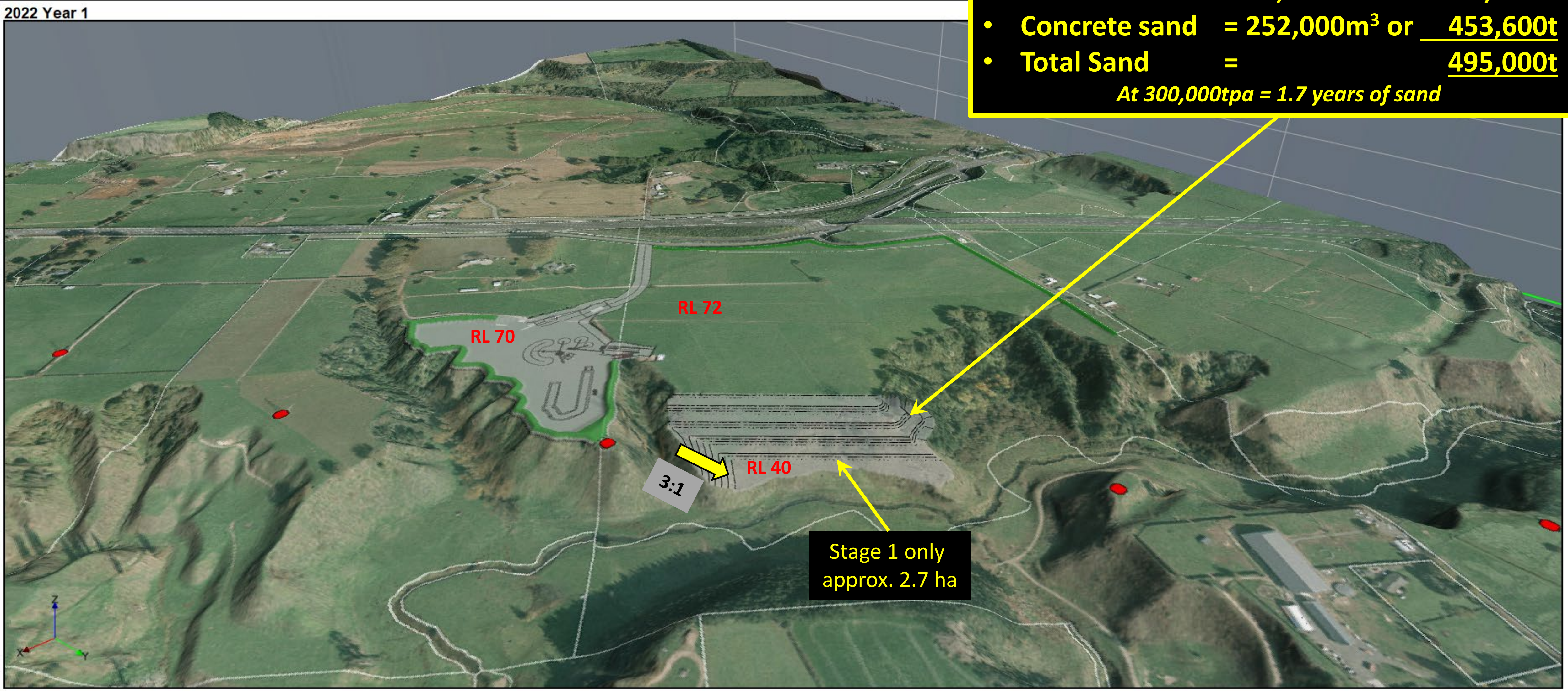




RS Sands – Quarry Planning
Stage 1 – **Years 1 to 1.7**

- **Overburden = 23,000m³**
- **Pit sand = 23,000m³ or 41,4000t**
- **Concrete sand = 252,000m³ or 453,600t**
- **Total Sand = 495,000t**

At 300,000tpa = 1.7 years of sand

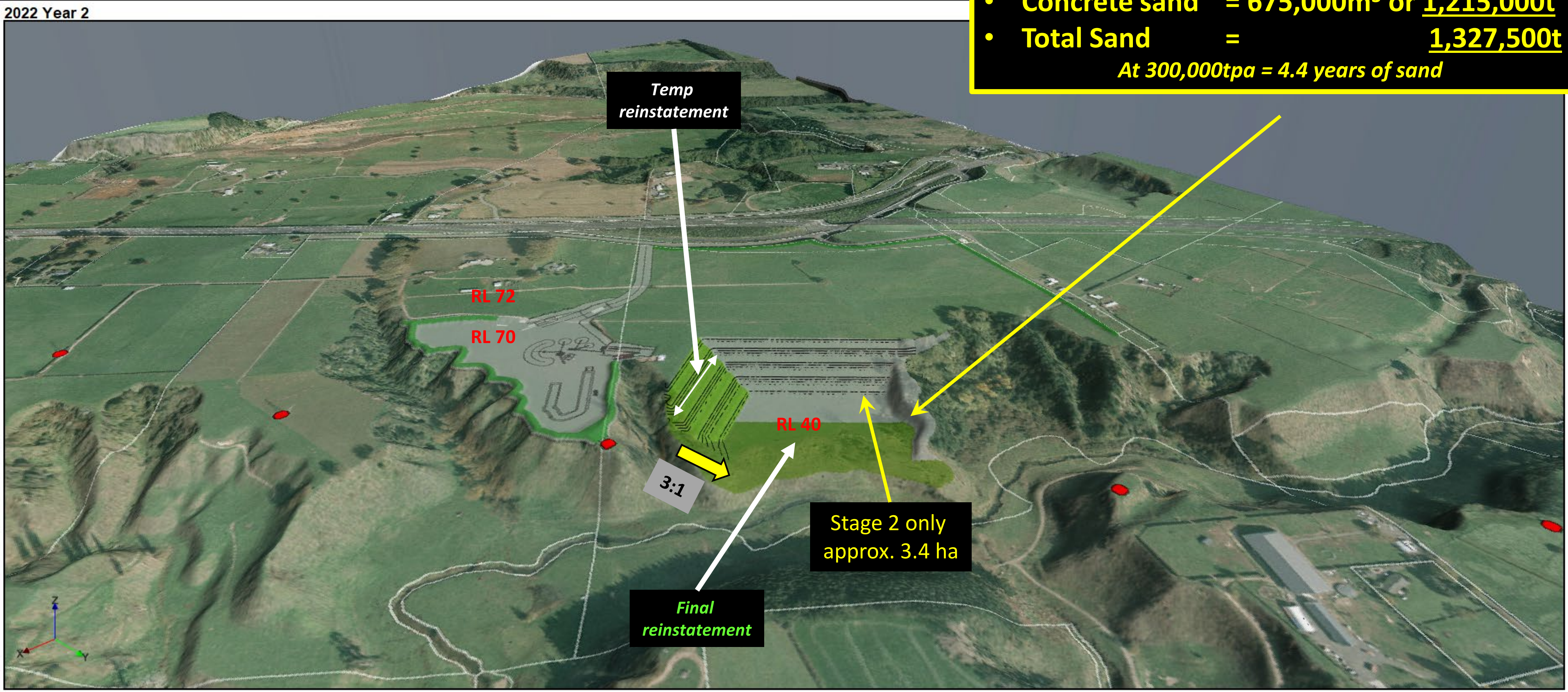


Viewpoint at the end of each stage – including reinstatement

RS Sands – Quarry Planning
Stage 2 – **Years 1.7 to 6.1**

- **Overburden = 62,500m^3**
- **Pit sand = 62,500m^3 or 112,500t**
- **Concrete sand = 675,000m^3 or 1,215,000t**
- **Total Sand = 1,327,500t**

At 300,000tpa = 4.4 years of sand



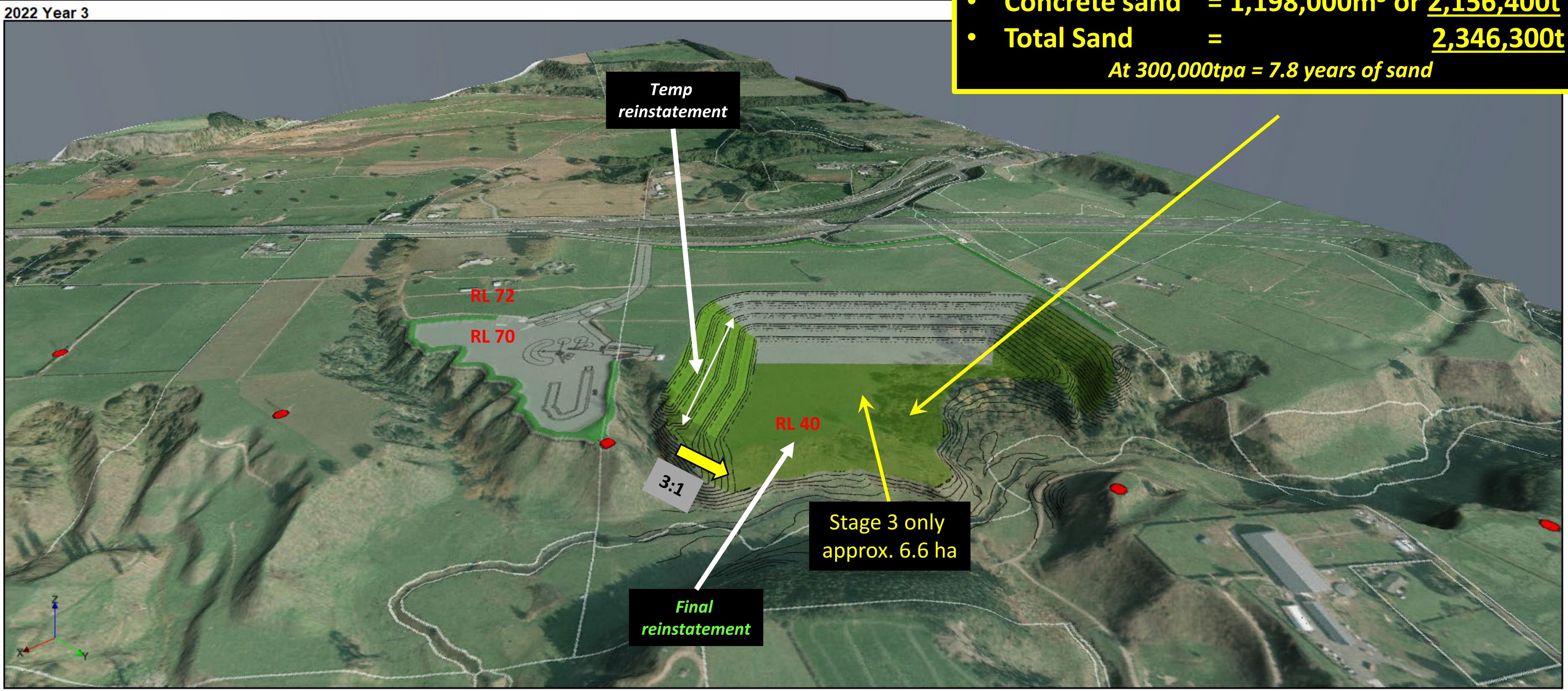
Viewpoint at the end of each stage – including reinstatement

RS Sands – Quarry Planning

Stage 3 – **Years 6.1 to 13.9**

- **Overburden = 105,500m³**
- **Pit sand = 105,500m³ or 189,900t**
- **Concrete sand = 1,198,000m³ or 2,156,400t**
- **Total Sand = 2,346,300t**

At 300,000tpa = 7.8 years of sand

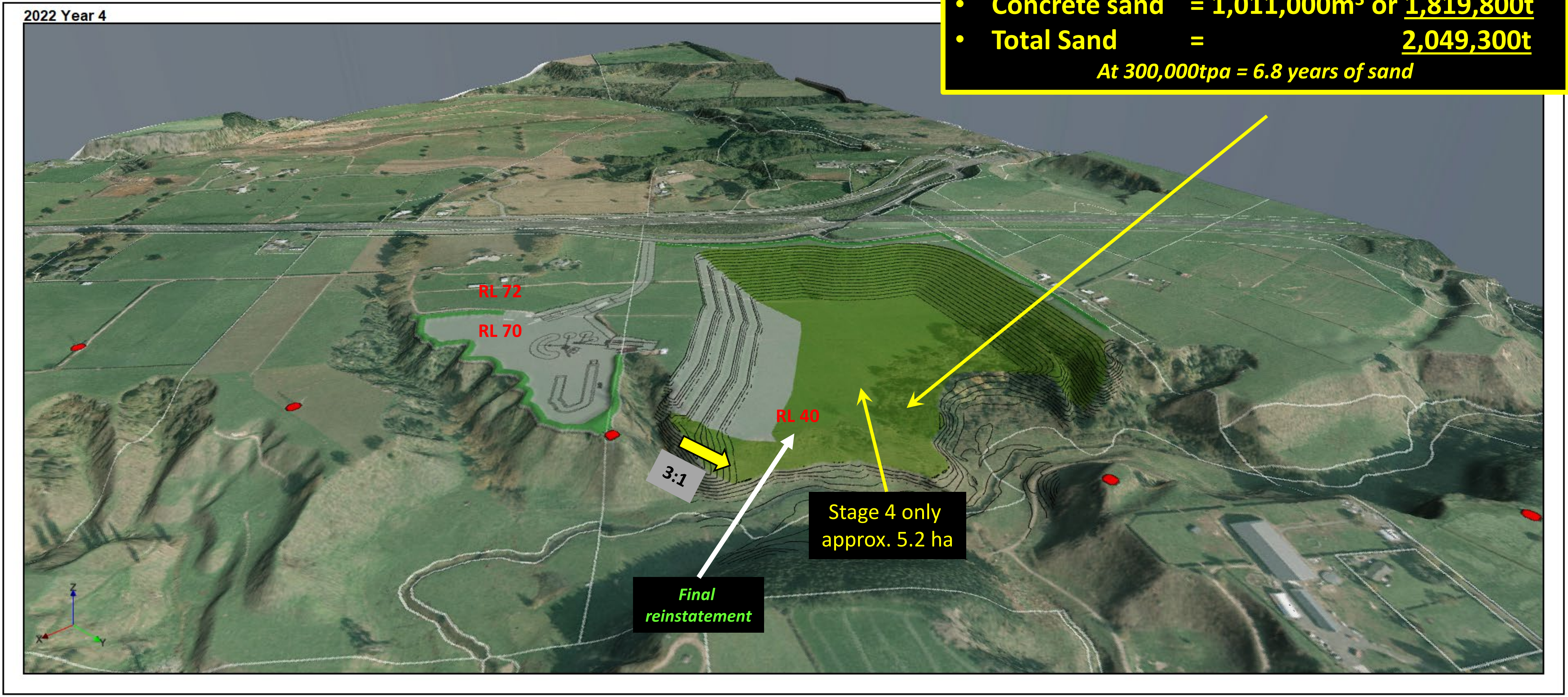


Viewpoint at the end of each stage – including reinstatement

RS Sands – Quarry Planning
Stage 4 – **Years 13.9 to 20.7**

- **Overburden = $127,500m^3$**
- **Pit sand = $127,500m^3$ or 229,500t**
- **Concrete sand = $1,011,000m^3$ or 1,819,800t**
- **Total Sand = 2,049,300t**

At 300,000tpa = 6.8 years of sand



Viewpoint at the end of each stage – including reinstatement

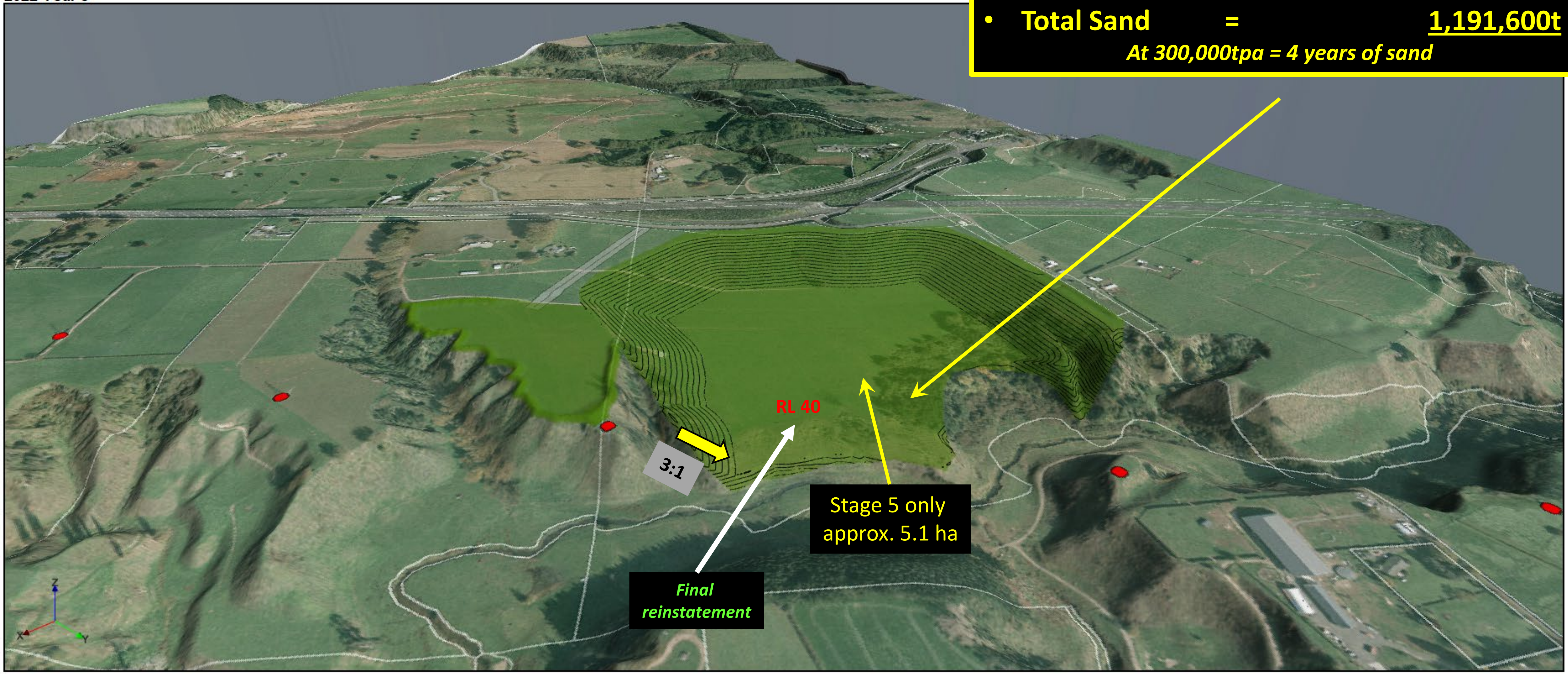
RS Sands – Quarry Planning

Stage 5 – **Years 20.7 to 24.7**

- **Overburden = 73,000m^3**
- **Pit sand = 73,000m3 or 131,400t**
- **Concrete sand = 589,000m3 or 1,060,200t**
- **Total Sand = 1,191,600t**

At 300,000tpa = 4 years of sand

2022 Year 5



Viewpoint at the end of each stage – including reinstatement

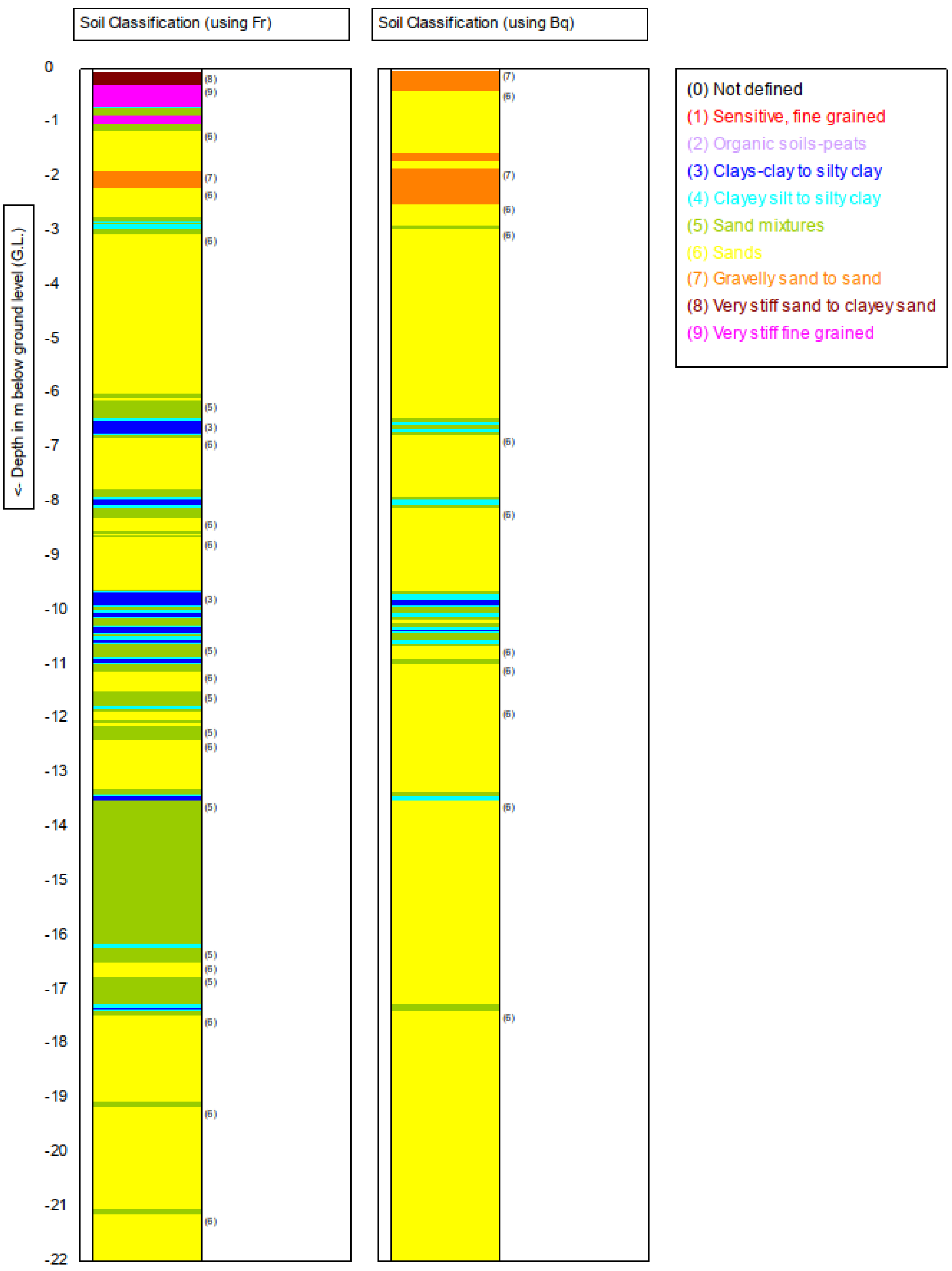
Document Set ID: 11016185
Version: 1, Version Date: 22/05/2023

Summary

	m3			t			years
	Overburden	Pit sand	Concrete Sand	Pit sand	Concrete Sand	Subtotal	
Stage 1	23,000	23,000	252,000	41,400	453,600	495,000	1.65
Stage 2	62,500	62,500	675,000	112,500	1,215,000	1,327,500	4.43
Stage 3	105,500	105,500	1,198,000	189,900	2,156,400	2,346,300	7.82
Stage 4	127,500	127,500	1,011,000	229,500	1,819,800	2,049,300	6.83
Stage 5	73,000	73,000	589,000	131,400	1,060,200	1,191,600	3.97
Sub total	391,500	391,500	3,725,000	704,700	6,705,000	7,409,700	24.70
Totals			**4,508,000**		**7,409,700**		**24.70**

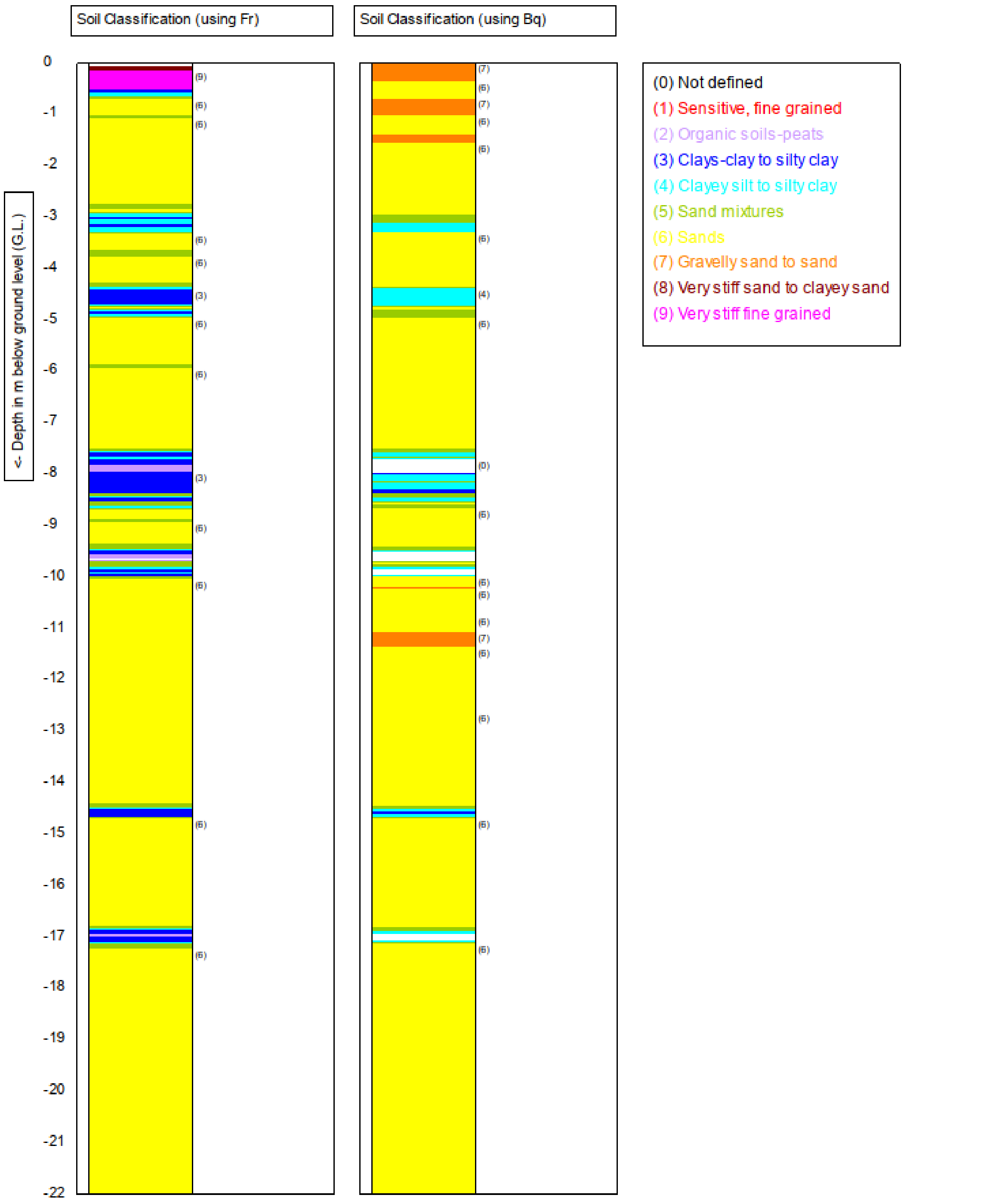
APPENDIX B

SOIL CLASSIFICATION FROM CPT LOGS



Graphs on this page are not IANZ accredited

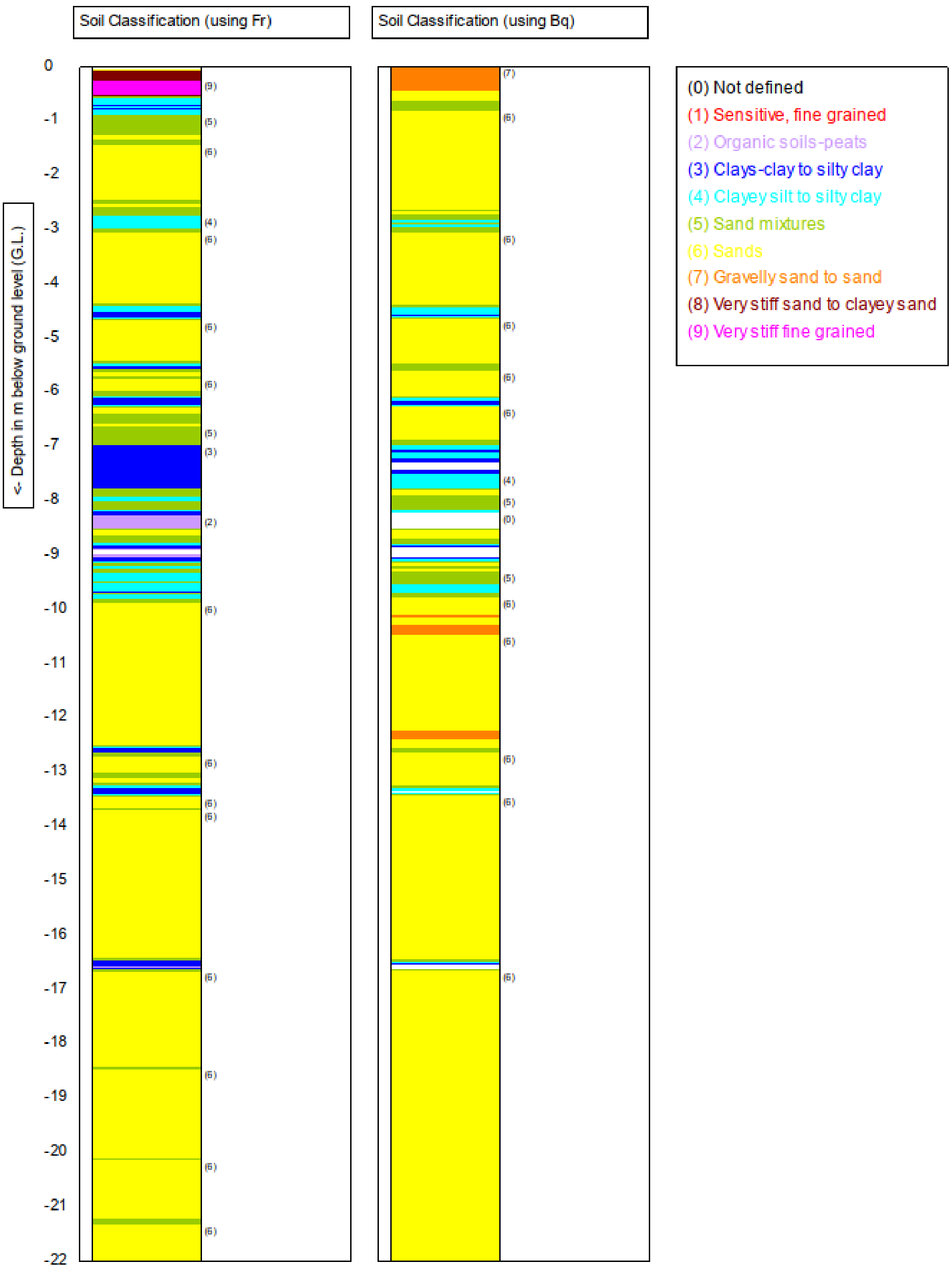
Test according ASTM D5778:12 & ISO 22476-1:2012		Predrill:	**0.00 m Predrilled**
G.L.: **0.00 m MSL**	W.L.: **-10.50 m**	Date:	**3/12/2020**
Project: **77 Newcombe Rd**		Cone no.:	**C10CFIIP.C15215**
Location: **Cambridge (HD1684)**		Project no.:	**2-68007.00_HA6677**
Position: **1820584, 5803229 NZTM**		CPT no.:	**HD1684-CPT01** 7/12



wsp

Graphs on this page are not IANZ accredited

u2 150 cm² 10 cm²	Test according ASTM D5778:12 & ISO 22476-1:2012		Predrill:	0.00 m Predrilled
	G.L.: **0.00 m MSL**	W.L.: **-2.10 m**	Date:	**3/12/2020**
Project:	**77 Newcombe Rd**		Cone no.:	**C10CFIIP.C15215**
Location:	**Cambridge (HD1684)**		Project no.:	**2-68007.00_HA6677**
Position:	**1820248, 5803092 NZTM**		CPT no.:	**HD1684-CPT02** 7/12



Graphs on this page are not IANZ accredited

Test according ASTM D5778:12 & ISO 22476-1:2012

G.L.: **0.00 m MSL** W.L.: **-3.50 m**

Project: **77 Newcombe Rd**
Location: **Cambridge (HD1684)**
Position: **1820458, 5802847 NZTM**

Predrill: **0.00 m Predrilled**
Date: **3/12/2020**
Cone no.: **C10CFIIP.C18488**
Project no.: **2-68007.00_HA6677**
CPT no.: **HD1684-CPT03** **7/12**

APPENDIX C

BOREHOLE LOGS

Initial Drilling Results

(Fulton Hogan, 2019)

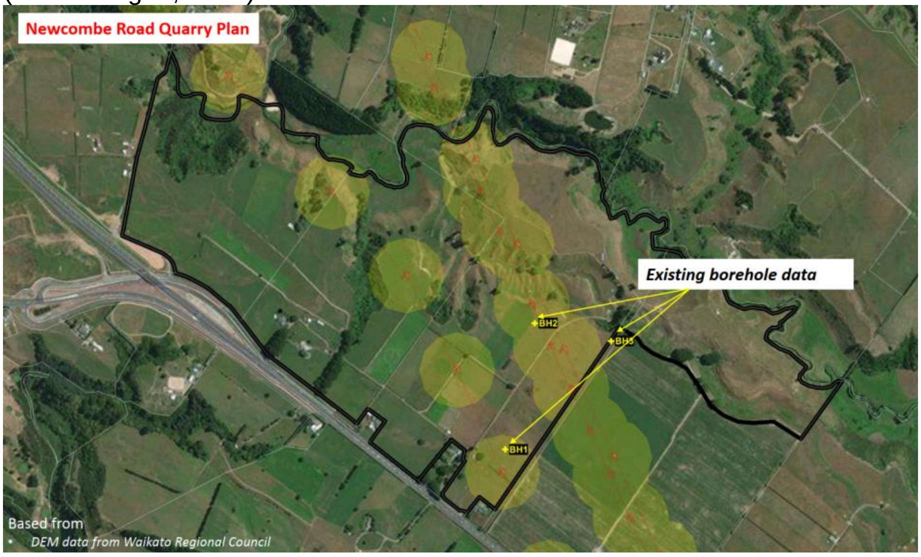


Figure C1: Location of Initial Bore Hole Data

In Bore Hole 1 the perched aquifer evident at 6 to 12 m depth. Regional aquifer at approximately 34 m bgl. Elevation approximately 74 m RL.

Bore Hole 1

Hole ID	From	To	Size Description	Colour		Observations
Bore No 1	0	1	Silt - fine sand	Light Brown	Dry	Uniform
Bore No 1	1	2	Silt	Dark Brown	Dry	Some fine sand
Bore No 1	2	3	Silt and Gravel		Dry	Rounded and angular aggregates
Bore No 1	3	4	Silt - fine sand	Dark Brown	Dry	Some medium sand
Bore No 1	4	5	Medium - Coarse Sand	Light Brown	Dry	Some fine Gravel, Some silt
Bore No 1	5	6	Coarse sand - fine grave	Grey	Dry	Pumice rich
Bore No 1	6	7	Medium sand	Light Brown	Wet	Some silt, Some Pumice
Bore No 1	7	8	Silty sand	Light Brown	Wet	Well graded
Bore No 1	8	9	Silty sand	Light Brown	Wet	Well graded
Bore No 1	9	10	Fine - medium sand	Grey	Wet	Some coarse sand
Bore No 1	10	11	Fine - medium sand	Grey	Wet	Some coarse sand
Bore No 1	11	12	Fine Sand	Grey	Wet	Some pumice medium - coarse sand sized
Bore No 1	12	13	Fine sand	Grey	Dry	Some medium sand, some pumice
Bore No 1	13	14	Fine - medium sand	Grey	Dry	well graded
Bore No 1	14	15	Fine - medium sand	Grey	Dry	Some coarse sand
Bore No 1	15	16	Fine - medium sand	Grey	Dry	Some coarse sand
Bore No 1	16	17	Fine Sand	Grey	Dry	Some medium - coarse sand
Bore No 1	17	18	Fine - medium sand	Grey	Dry	well graded
Bore No 1	18	19	Fine - medium sand	Grey	Dry	Some coarse sand
Bore No 1	19	20	Fine - medium sand	Grey	Dry	Some fine - medium gravel
Bore No 1	20	21	Medium sand - mediun	Grey	Dry	Well graded
Bore No 1	21	22	Clay/silty sand	Light Brown	Dry	Some fine Gravel
Bore No 1	22	23	Clay/silt	Light Brown	Dry	Some fine sand
Bore No 1	23	24	Silt/Clay	Light Brown	Dry	Uniform
Bore No 1	24	25	Fine - Coarse Sand	Grey	Dry	Well graded, some silt
Bore No 1	25	26	Fine - medium sand	Grey	Dry	Some coarse sand
Bore No 1	26	27	Fine - medium sand	Grey	Dry	Some coarse pumice sand, gap graded
Bore No 1	27	28	Fine sand	Grey	Dry	Some coarse pumice sand, gap graded
Bore No 1	28	29	Fine - medium sand	Grey	Dry	Some medium pumice sand
Bore No 1	29	30	Fine -medium sand	Grey	Dry	medium - coarse pumice sand
Bore No 1	30	31	Sandy silt	Light Brown	Dry	Some clay
Bore No 1	31	32	Fine - medium sand	Grey	Dry	coarse pumice sand
Bore No 1	32	33	Fine Sand	Grey	Dry	Medium pumice sand
Bore No 1	33	34	Silt - fine sand	Light Brown	Dry	Some medium pumice sand
Bore No 1	34	35	silt/clay - very fine sand	Light Brown	Wet	
Bore No 1	35	36	Sandy clay/silt	Grey	Wet	fine sands
Bore No 1	36	37	Sandy clay/silt	Grey	Wet	fine sands
Bore No 1	37	38	Sandy clay/silt	Grey	Wet	fine sands
Bore No 1	38	39	Silt - very fine sand	Grey	Wet	Some medium sands
Bore No 1	39	40	Silt - very fine sand	Grey	Wet	Some medium sands
Bore No 1	40	41	Silt - very fine sand	Grey	Wet	Some medium sands
Bore No 1	41	42	Silt - very fine sand	Grey	Wet	Some medium sands

Figure C2: Bore Log Bore Hole 1

In Bore Hole 2 the perched aquifer evident at 8 to 10 m depth. The regional aquifer was not encountered at 44 m bgl (bore elevation at 73 m RL so bore drilled to approximately 29 mRL).

Bore Hole 2

Hole ID	From	To	Size Description	Colour		Observations
Bore No 2	0	1	Medium - Coarse Grave	Grey	Dry	Some silt
Bore No 2	1	2	Silt - Fine Sand	Grey	Wet	Some coarse gravel
Bore No 2	2	3	Clay/silt - fine sand	Grey	Wet	Some fine gravel
Bore No 2	3	4	Sandy silt/clay	Grey	Dry	well graded
Bore No 2	4	5	Sandy silt/clay	Grey	Dry	well graded
Bore No 2	5	6	Sandy silt/clay	Grey	Dry	well graded
Bore No 2	6	7	Sandy silt/clay	Grey	Dry	well graded
Bore No 2	7	8	Sandy silt/clay	Light Brown	Dry	well graded
Bore No 2	8	9	Sandy silt/clay	Light Brown	Wet	well graded
Bore No 2	9	10	Silt - Medium Sand	Light Brown	Wet	Well graded
Bore No 2	10	11	Silt - Medium Sand	Light Brown	Wet	Well graded
Bore No 2	11	12	Fine - medium sand	Grey	Dry	Some silt
Bore No 2	12	13	Fine - Coarse Sand	Grey	Dry	Well graded, some silt
Bore No 2	13	14	Fine - Coarse Sand	Grey	Dry	Well graded, some pumice
Bore No 2	14	15	Silt - Medium Sand	Light Brown	Dry	Well graded
Bore No 2	15	16	Silt - Medium Sand	Light Brown	Dry	Well graded
Bore No 2	16	17	Silt - Medium Sand	Light Brown	Dry	Well graded
Bore No 2	17	18	Silt - Medium Sand	Light Brown	Dry	Well graded
Bore No 2	18	19	Silt - Medium Sand	Light Brown	Dry	Well graded
Bore No 2	19	20	Silt - fine sand	Light Brown	Dry	Well graded
Bore No 2	20	21	Silt - fine sand	Light Brown	Dry	Some medium sands
Bore No 2	21	22	Medium Sand	Grey	Dry	Some coarse sand - fine gravel
Bore No 2	22	23	Medium - coarse sand	Grey	Dry	Some pumice, Some fine - medium gravel
Bore No 2	23	24	Silt - fine sand	Light Brown	Dry	uniform
Bore No 2	24	25	Medium sand	Grey	Dry	Some pumice, Some Silt
Bore No 2	25	26	Medium - coarse sand	Grey	Dry	Some fine gravel, some pumice
Bore No 2	26	27	Medium - coarse sand	Grey	Dry	Some fine gravel, some pumice
Bore No 2	27	28	Coarse sand - medium	Grey	Dry	Some silt
Bore No 2	28	29	Coarse sand - medium	Grey	Dry	Some silt
Bore No 2	29	30	Fine - medium sand	Grey	Dry	Some gravel
Bore No 2	30	31	Medium sand	Grey	Dry	Well graded
Bore No 2	31	32	Silt - Medium Sand	Grey	Dry	Well graded
Bore No 2	32	33	Medium sand	Grey	Dry	Some silt
Bore No 2	33	34	Coarse sand	Grey	Dry	Uniform
Bore No 2	34	35	Medium - coarse sand	Light Brown	Dry	Some silt
Bore No 2	35	36	Medium - coarse sand	Grey	Dry	Some fine gravel
Bore No 2	36	37	Fine - medium sand	Grey	Dry	some silt/clay
Bore No 2	37	38	Fine - medium sand	Grey	Dry	Uniform
Bore No 2	38	39	Fine - Coarse Sand	Grey	Dry	Well graded, some pumice
Bore No 2	39	40	Fine - Coarse Sand	Grey	Dry	Well graded, some pumice
Bore No 2	40	41	Fine - Coarse Sand	Grey	Dry	Well graded, some pumice
Bore No 2	41	42	Sandy silt	Light Brown	Dry	
Bore No 2	42	43	Clay/silt - fine sand	Light Brown	Dry	
Bore No 2	43	44	Clay/silt - fine sand	Dark Brown	Dry	

Figure C3: Bore Log Bore Hole 2.

In Bore Hole 3 the perched aquifer was evident at 8 to 10 m depth. The regional aquifer was not encountered at 44 m (bore elevation at 73 m RL so bore drilled to approximately 29 mRL).

Bore Hole 3

Hole ID	From	To	Size Description	Colour		Observations
Bore No 3	0	1	Medium - coarse gravel	Grey	Dry	
Bore No 3	1	2	Sandy silt	Light Brown	Dry	Some gravel
Bore No 3	2	3	Sandy silt	Dark Brown	Dry	
Bore No 3	3	4	Silty sand	Light Brown	Dry	Some fine gravel
Bore No 3	4	5	Silty sand	Light Brown	Dry	Fine - medium gravel
Bore No 3	5	6	Fine - Coarse Sand	Light Brown	Dry	Some gravel
Bore No 3	6	7	Fine - medium sand	Light Brown	Dry	Some fine gravel
Bore No 3	7	8	Silt - fine sand	Dark Brown	Wet	Uniform
Bore No 3	8	9	Sandy silt	Light Brown	Wet	Unifrom
Bore No 3	9	10	Silty sand	Light Brown	Wet	Uniform
Bore No 3	10	11	Medium sand	Grey	Dry	Well graded
Bore No 3	11	12	Medium sand	Grey	Dry	Well graded
Bore No 3	12	13	Medium sand	Grey	Dry	Some fine Gravel
Bore No 3	13	14	Medium sand	Grey	Dry	Well graded
Bore No 3	14	15	Medium sand	Grey	Dry	Some silt
Bore No 3	15	16	Medium sand	Grey	Dry	Uniform
Bore No 3	16	17	Medium sand	Grey	Dry	Some Silt
Bore No 3	17	18	Medium sand	Grey	Dry	Little silt
Bore No 3	18	19	Medium sand	Light Brown	Dry	Some silt/clay
Bore No 3	19	20	Medium - coarse sand	Grey	Dry	Well graded
Bore No 3	20	21	Fine - medium sand	Grey	Dry	Some coarse sand
Bore No 3	21	22	Medium - coarse sand	Grey	Dry	Well graded
Bore No 3	22	23	Medium - coarse sand	Grey	Dry	Some fine gravel
Bore No 3	23	24	Fine - medium sand	Grey	Dry	Some fine gravel
Bore No 3	24	25	Fine - medium sand	Grey	Dry	Some fine gravel
Bore No 3	25	26	Medium sand - Fine gra	Grey	Dry	Well graded
Bore No 3	26	27	Medium sand - Fine gra	Grey	Dry	Well graded
Bore No 3	27	28	Medium sand - mediun	Grey	Dry	Well graded
Bore No 3	28	29	Medium sand	Grey	Dry	Some fine gravel
Bore No 3	29	30	Medium sand	Grey	Dry	Some fine gravel
Bore No 3	30	31	Fine - medium sand	Grey	Dry	Well graded
Bore No 3	31	32	Fine - Coarse Sand	Grey	Dry	Well graded
Bore No 3	32	33	Silt - coarse sand	Light Brown	Dry	Gap graded
Bore No 3	33	34	Coarse sand - fine grave	Grey	Dry	Well graded
Bore No 3	34	35	Medium - coarse sand	Grey	Dry	Some fine gravel
Bore No 3	35	36	Fine - Coarse Sand	Grey	Dry	Well graded
Bore No 3	36	37	Fine - coarse sand	Grey	Dry	Some fine gravel
Bore No 3	37	38	Fine - medium sand	Light Brown	Dry	Some silt
Bore No 3	38	39	Medium - coarse sand	Grey	Dry	Well graded
Bore No 3	39	40	Fine sand	Light Brown	Dry	Some medium - coarse sand
Bore No 3	40	41	fine sand	Light Brown	Dry	Little coarse sand
Bore No 3	41	42	Very fine sand	Light Brown	Dry	Uniform, some silt
Bore No 3	42	43	Very fine sand	Light Brown	Dry	Some silt, some fine gravel
Bore No 3	43	44	Very fine sand	Light Brown	Dry	Some silt, some fine gravel

Figure C4: Bore Log Bore Hole 3.

Water Supply Bore

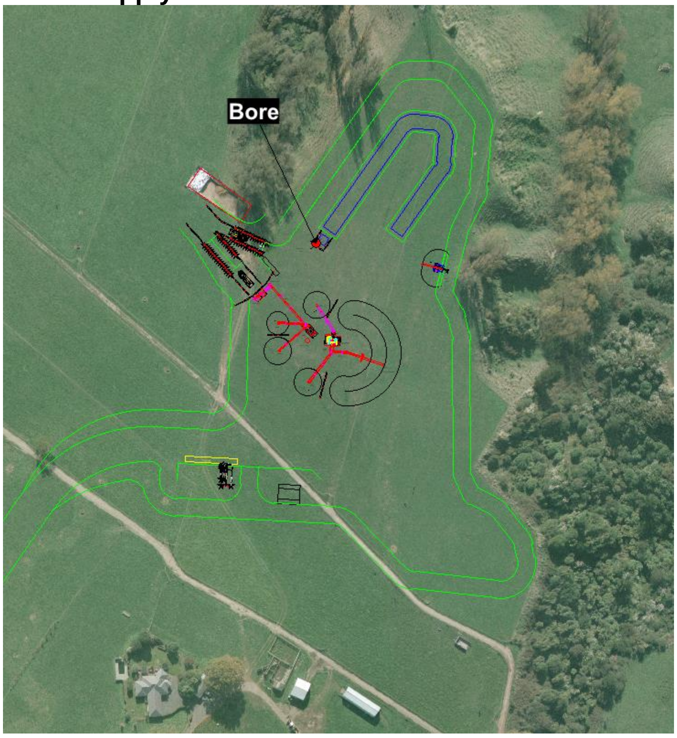


Figure C5: Location of Water Supply Bore (72_10873)

BROWN BROS
DRILLING

April 2022

RS Sands Geology 200mm/8" Production Bore 77 Newcombe Road
SWL = 42.85

Depth From (m)	Depth To (m)	Geology
0.00	5.63	Sand Silt
5.63	7.95	Grey Sand Pumice
7.95	9.13	Silt, Sand, Pumice
9.13	19.00	Brown Silt
19.00	37.87	Grey Pumice Sand
37.87	39.10	Red Gravel Sand
39.10	43.45	Grey Sand Gravel
43.45	53.11	Grey Sand
53.11	60.27	Grey Gravel Sand
60.27	64.15	Grey Yellow Sand Pumice
64.15	66.50	Silt Sand Gravel
66.50	68.43	Yellow Sand
68.43	70.46	Silt Sand
70.46	74.01	Brown Sand
74.01	78.79	Silt Sand
78.79	80.09	Sand Gravel
80.09	82.49	Silt Gravel
82.49		Blade Refusal – Rock - EOH

Figure C4: Bore Log Bore 72_10873.

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WALLBRIDGE GILBERT AZTEC

RS Sand

Groundwater Take, Newcombe Road Quarry

TECHNICAL ASSESSMENT OF EFFECTS

Project No. WGA201888
Doc No. WGA201888-RP-HG-0002
Rev. B

09 August 2022

Revision History

Rev	Date	Issue	Originator	Checker	Approver
A	8 July 22	Draft to Client	CMH	CHO	CHO
B	9 August 22	Final	CMH	CHO	CHO

CONTENTS

Figures

Tables

Appendices

1 INTRODUCTION

1.1 BACKGROUND

Wallbridge Gilbert Aztec (WGA) has been retained by RS Sand Limited (RS Sand) to evaluate the effects of abstracting groundwater from a newly drilled bore located at their proposed Newcombe Road Quarry, Cambridge (Figure 1).The water is proposed to be used for dust suppression and quarry sand processing.

The site is located on three records of title, although the quarry is only proposed on approximately 27 ha in the western portion of the properties. The quarry is composed of a 23 ha pit area towards the western boundary and a 4 ha plant area (for processing and stockpiling) to the east of the pit. The pit area is estimated to contain 7,409,700 tonnes (4,116,500 m^3) of sand resource, comprising a mixture of pit sand and concrete sand. The quarry is proposed to extract and process up to 400,000 tonnes of sand from the pit area per year (depending on demand) for approximately 25 years.

The new Production Bore (72_10873) was drilled and constructed in 2022. A stepped rate test and constant rate pumping test were carried out on the Production Bore. One observation bore was monitored during the constant rate pumping test. The purpose of this report is to assess the effects of the proposed groundwater take in support the application for a resource consent to take water from the bore. WGA have carried out an earlier assessment (WGA 2021) of the effects of the quarry excavation which will also be included in the resource consent application for the quarry.

1.2 SCOPE OF WORKS

WGA have been asked to provide hydrogeological technical support for the installation of the new bore and lodging of a groundwater take application for resource consent, including:

- Design a stepped rate test and constant rate pumping test to obtain data on the hydrogeological characteristics of the source aquifer and the yield of the bore.
- Analyse the pumping test data to determine the hydrogeological characteristics of the source aquifer.
- Evaluate the proposed water abstraction rates to identify potential effects on the availability of water at nearby bores and the potential for stream depletion.
- Document the analysis and results in a technical assessment of effects report suitable for lodging with the regional council in support of the application for resource consent.

1.3 WATER REQUIREMENTS AND USE

Water is required for dust suppression in the plant area, on internal roads and within the quarry on the open benches and batter areas. Water will also be required for use in the plant for processing purposes. RS Sand is seeking to abstract groundwater at the following rates:

- Dust suppression:
  - Maximum daily abstraction of up to 500 m^3/day.
  - Maximum annual abstraction of up to 110,000 m^3 (based on 220 days per year usage (Table 1)
- Processing:
  - Maximum daily abstraction of up to 600 m^3/day.
  - Maximum annual abstraction of up to 180,000 m^3 (based on 300 days per year (50 weeks, 6 days).

In total RS Sand is seeking up to **1,100 m^3/day** and **290,000 m^3** annually.

RS Sand intend to take the water and an instantaneous flow rate of 29 L/s (105 m^3/hr).

In order to assess the suitable number of days for dust suppression WGA carried out an assessment on the number of rainfall days with more than 3 mm rainfall. This is based on an assumption that a day with more than 3 mm rainfall would not require dust suppression. WGA acknowledges that, on any day, other factors such as wind strength and temperature will also control the requirement for dust suppression. In addition to our simplified modelling, the cumulative rainfall will also affect the dust suppression requirements (i.e. soil moisture levels will be high following periods of sustained rainfall). Rainfall data from Hamilton Airport[1] were used in the assessment. In addition to the rainfall days per year a set number of days of dust suppression were added to the annual total to represent the irrigation/water-application contribution from the production bore (Table 1). Based on this assessment 220 days appears to be a reasonable number of days to cover between 75% to 86% of days in a year. This recognises that the quarry will generally operate up to six days per week (approximately 86% of days in a year) and cumulative rainfall will reduce the need for dust suppression requirements in the wetter winter months.

RS Sand propose to apply water at up to 5 mm per day for dust suppression in 20% of the plant area, equivalent to 0.8 ha, 2 ha of internal roads and a maximum open quarry area of 7.25 ha. Therefore, the total area is approximately 10.05 ha which, at a rate of 5 mm per day is 503 m^3/day.

RS Sand plans to process 1,455 tonnes of sand per day and requires 1.5 m^3 of water per tonne of sand and they intend to reuse 75 % of the processing water. Therefore, only on additional 0.4 m^3 water per tonne of processed sand is required from the bore, which is equivalent to 582 m^3/day.

[1] Cliflo data from NIWA for Hamilton AWS, agent number 2112, https://cliflo.niwa.co.nz/.

Table 1: Number of Days with More Than 3 mm Rainfall (Hamilton Airport).

Month/Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
January	7	3	6	5	4	2	4	6	10	6	6	6	6	5	6	6	1	4	6	6	7	1	5	3	4	6	9	2	2	5
February	2	4	4	7	6	5	5	1	2	7	2	4	15	4	3	2	4	8	4	2	7	2	1	5	6	6	10	1	1	4
March	6	7	5	5	6	10	7	4	4	3	4	7	2	6	8	6	2	3	1	8	6	3	0	7	3	11	4	3	5	8
April	4	6	9	9	11	4	7	6	8	2	8	3	4	3	11	2	7	6	3	7	2	11	13	9	4	8	10	6	4	8
May	9	7	13	5	10	5	7	6	8	12	7	5	9	12	9	5	5	12	9	10	7	10	8	8	15	9	11	4	4	8
June	9	13	10	13	11	7	9	9	10	3	11	4	10	7	10	11	13	7	17	12	9	9	9	6	9	6	10	8	9	8
July	10	1	12	21	10	5	13	12	7	7	11	7	11	9	6	11	16	10	6	13	8	4	6	8	15	7	12	8	10	7
August	16	9	8	9	13	9	9	10	8	10	6	6	13	8	10	11	16	9	17	5	10	7	8	10	7	12	13	16	9	10
September	14	6	11	10	10	8	4	7	10	4	9	14	6	8	2	7	7	8	15	6	8	10	14	12	12	15	6	10	8	9
October	7	3	11	8	8	6	11	3	8	7	6	7	13	15	9	9	8	13	6	12	9	7	6	4	12	9	8	8	5	9
November	4	8	9	9	8	8	5	14	7	11	10	9	4	6	6	2	5	5	2	4	3	5	9	7	11	5	10	5	10	3
December	12	6	2	6	9	6	3	6	8	16	8	12	14	10	7	6	7	6	8	12	10	6	5	2	5	3	12	4	6	6
Total	**100**	**73**	**100**	**107**	**106**	**75**	**84**	**84**	**90**	**88**	**88**	**84**	**107**	**93**	**87**	**78**	**91**	**91**	**94**	**97**	**86**	**75**	**84**	**81**	**103**	**97**	**115**	**75**	**73**	**85**
Days per year with irrigation or rain	320	293	320	327	326	295	304	304	310	308	308	304	327	313	307	298	311	311	314	317	306	295	304	301	323	317	335	295	293	305
% of days during the year with irrigation or rain	88	80	88	90	89	81	83	83	85	84	84	83	90	86	84	82	85	85	86	87	84	81	83	82	88	87	92	81	80	84

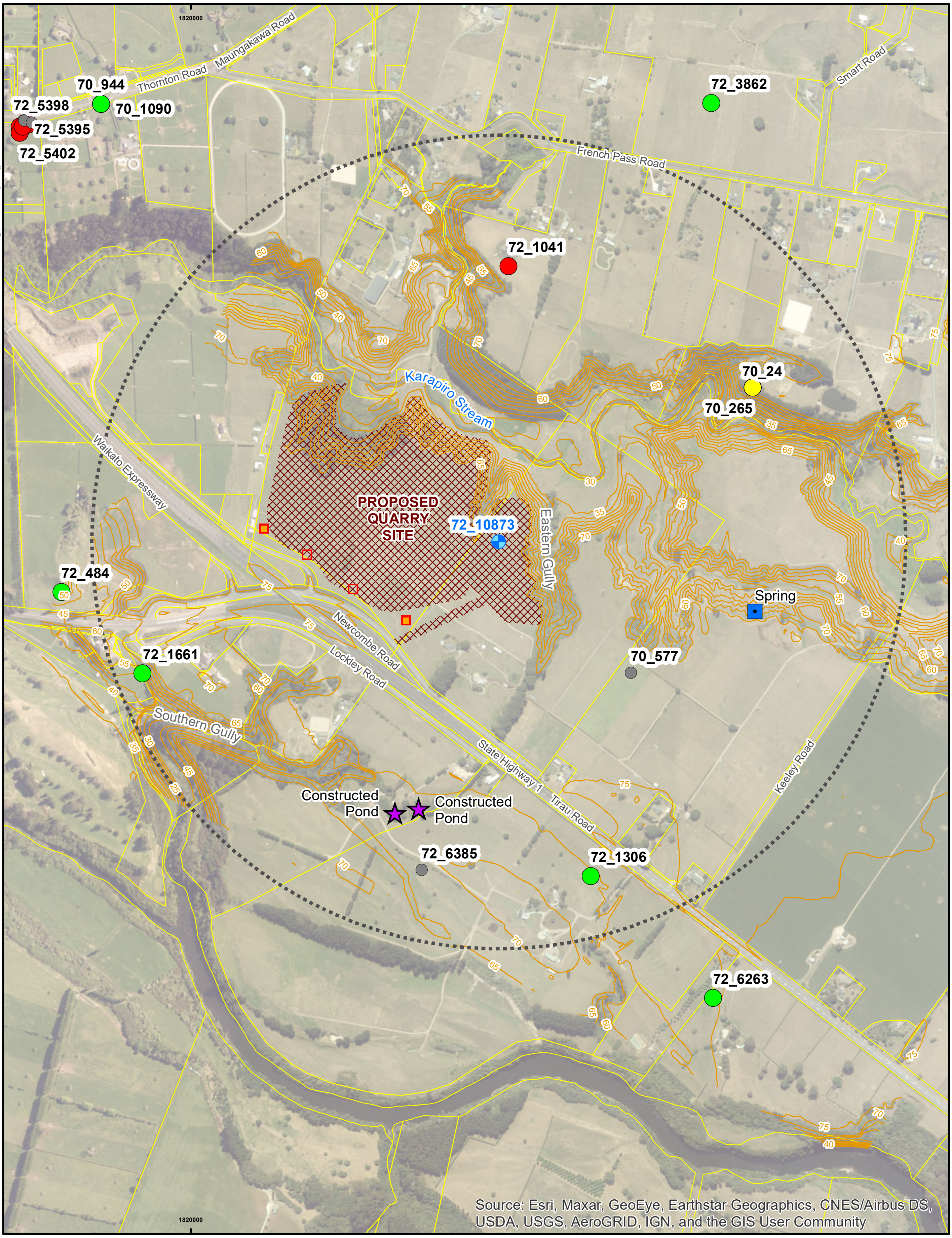
1.4 WELL CONSTRUCTION

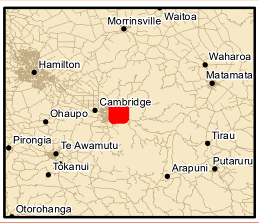
The well construction details for the RS Sand production bore are summarised in (Table 2). The bore was drilled to approximately 82.5 m deep with an 18 m length of screen from 56.8 m below ground level (bgl) to 74.8 m bgl.

Table 2: Well Construction Details.

	Production Bore	Observation Bore
Bore number	72_10873	N/A
Owner	RS Sand	RS Sand
Address	Newcombe Road	Newcombe Road
Easting NZTM	1820756	1820756
Northing NZTM	5803020	5803025
Depth (m)	74.8	74
Casing depth (m btoc)	56.8	57
Screened interval length (m)	18	17
Static water level (m btoc)	42.85	42.85
Diameter of screen (mm)	200	100

Note: btoc - below top of casing.





N

0 100 200 300 400 m

Scale 1:12,500 @ A4

Coordinate System: NZGD 2000 New Zealand Transverse Mercator

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

LEGEND

Bore (Depth (m))

Unknown · 0 - 10 · 10 - 25 · 25 - 50 · 50 - 100 · > 100

Shallow Piezometer (7m) · Shallow & Deep Piezometer (50m) · Spring · Constructed Pond

Quarry Extent · Parcel · Contours

Buffer (1km) · Production Bore

WGA
WALLBRIDGE GILBERT AZTEC

Figure 1
Cambridge Sand Quarry
Site Map

2 HYDROGEOLOGY

2.1 GEOLOGY

The proposed RS Sand quarry is situated within the Hamilton Basin, a large tectonic basin centred on Hamilton City with an area of approximately 2,000 km^2 and traversed by the Waikato River. The basin is surrounded by ranges of Mesozoic (Manaia Hill Group) and Tertiary age (Te Kuiti and Waitemata Groups) rocks. The basin is infilled with Tauranga Group alluvial sediments dating from the Pliocene to the middle Holocene, overlain by late Holocene unconsolidated alluvial and colluvial sediments. The Tauranga Group sediments are up to 300 m thick and include gravels, sands, silt, muds and peats of fluvial, lacustrine and distal ignimbritic origin. Basement greywacke underlies the sedimentary deposits at depth (GNS 2005).

The Hinuera Formation of the Tauranga Group underlies much of the Hamilton basin. This formation was deposited by braided river systems of the Waikato River, initiated by the supply of large volumes of sediment from volcanism in the Taupo Volcanic Zone (Petch 1987). It is these sand units which are planned to be quarried and processed at the Site.

2.2 GROUNDWATER SYSTEM

The Hinuera Formation contains the aquifers used most extensively across the Hamilton Basin for water supplies. Within this formation, the most productive aquifers consist of well sorted coarse sands and gravels. Discontinuous sequences of rhyolitic and pumiceous gravelly sands and gravels are interspersed with pumiceous silt, clay and peat. Lithological variability generally results in a number of zones of higher permeability within each of the formations rather than a single, continuous aquifer (Figure 2; Schofield 1972). The upper layers contain perched aquifers which can dry out over the summer period and will drain to the closest gully system.

Literature values for the hydraulic conductivity of sediments in the Hamilton Basin range from 0.5 m/day in the silts and peat layers to 13.5 m/day in the course gravelly sands. Aquifer transmissivity values derived from pumping tests range from 10 m^2/day to 1,000 m^2/day but are usually less than 100 m^2/day. The deeper aquifers have variable aquifer properties and local pumping tests have resulted in transmissivities calculated at between 20 m^2/day and 300 m^2/day. Storativity values vary from 0.001 for deep, confined or semi-confined aquifers to 0.1 for shallow, unconfined aquifers in the Hamilton Basin (Petch and Marshall 1988). In some areas these discontinuous aquifers may provide bore yields of up to 30 L/s (Petch 1987).

Regional groundwater flows in the area of Cambridge are generally towards the north west, from the basin edges to the southeast. Major groundwater discharge occurs into the Waikato River and its tributaries located in deeply incised gullies (Petch and Marshall 1988).

The Hinuera Aquifer is used in nearby rural areas for domestic and stock water supplies. The deeper Hautapu Aquifer is used by the Fonterra Hautapu Dairy Factory to supply water to the plant. Other irrigation bores in the area also tap this deeper aquifer.

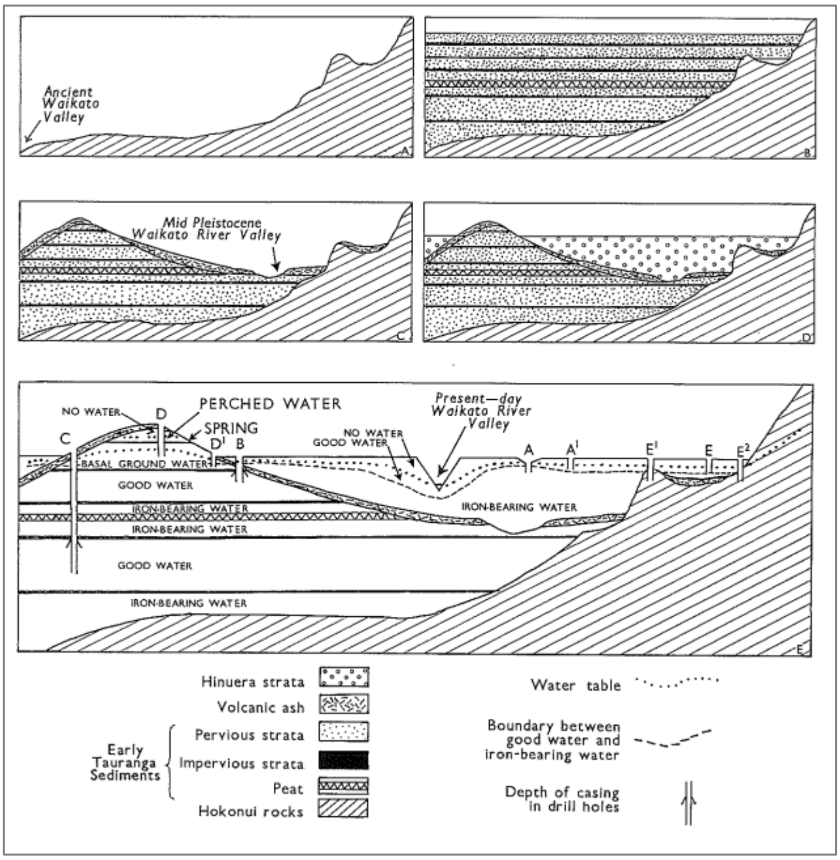


Figure 2: Simplified Geological History and Formation of Local Aquifers (Schofield 1972).

2.3 LOCAL AQUIFER DEFINITION

The geological description of the RS Sand bore is summarised from the driller's log in Table 3. The lithology shows a stratified sequence of sand, gravel and pumice with lower permeability silt layers. The source aquifer consists of sand, gravels and pumice and is confined or semi-confined beneath low permeability units consisting of silts. The pumping test analysis indicated that the aquifer is confined. Although lower permeability layers are not obvious from the generalised drillers log, correspondence with the driller confirmed small silt layers were present in the unit between 43.45 m bgl and 53.11 m bgl (K.Brown pers comms 22 June 2022). These layers are considered to be acting as confining layers above the source aquifer.

Table 3: Bore 72_10873 Geological Log.

<table>
<tr><th colspan="2">Depth (m bgl)</th><th rowspan="2">Description</th><th rowspan="2">Hydrogeological Characteristics</th></tr>
<tr><th>From</th><th>To</th></tr>
<tr><td>0.00</td><td>5.63</td><td>Sand silts</td><td>Unsaturated zone</td></tr>
<tr><td>5.63</td><td>7.95</td><td>Grey sand pumice</td><td>Perched Aquifer</td></tr>
<tr><td>7.95</td><td>9.13</td><td>Silt sand pumice</td><td rowspan="2">Aquitard</td></tr>
<tr><td>9.13</td><td>19.00</td><td>Brown silt</td></tr>
<tr><td>19.00</td><td>37.87</td><td>Grey pumice sand</td><td rowspan="2">Unsaturated zone</td></tr>
<tr><td>37.87</td><td>39.10</td><td>Red gravel sand</td></tr>
<tr><td>39.10</td><td>43.45</td><td>Grey sand gravel</td><td>Unconfined Aquifer</td></tr>
<tr><td>43.45</td><td>53.11</td><td>Grey sand with silt layers</td><td>Aquitard</td></tr>
<tr><td>53.11</td><td>60.27</td><td>Grey gravel sand</td><td rowspan="9">Confined Aquifer</td></tr>
<tr><td>60.27</td><td>64.15</td><td>Grey yellow sand pumice</td></tr>
<tr><td>64.15</td><td>66.50</td><td>Silt sand gravels</td></tr>
<tr><td>66.50</td><td>68.43</td><td>Yellow Sand</td></tr>
<tr><td>68.43</td><td>70.46</td><td>Silt sand</td></tr>
<tr><td>70.46</td><td>74.01</td><td>Brown sand</td></tr>
<tr><td>74.01</td><td>78.79</td><td>Silt sand</td></tr>
<tr><td>78.79</td><td>80.09</td><td>Sand gravel</td></tr>
<tr><td>80.09</td><td>82.49</td><td>Silt gravel</td></tr>
<tr><td>82.49</td><td></td><td>Drilling refusal – Rock – EOH</td><td>Aquitard</td></tr>
</table>

In addition to the new production bore lithological log and recorded lithology from nearby bores, drilling carried out at the quarry site for geotechnical purposes has been reviewed in terms of the observed groundwater levels and lithology. From the drilling results and knowledge of the local hydrogeology, WGA understands that there are three aquifers at the site:

- A Perched Aquifer at approximately 65 m RL (7 m deep).
- An Unconfined Aquifer at approximately 33 m RL (39 m deep).
- A Confined Aquifer at approximately 19 m RL (53 m deep).

The Perched Aquifer is evident in the drilling results at approximately 6 m to 7 m below ground. This perched aquifer is also identifiable on orthophotos of the site taken during prolonged dry periods. The discharge seepage from this aquifer to the incised river valley to the north of the site occurs at approximately 65 m RL. This spring water is used locally for stock water and shed use, as detailed further in Section 3.2.

The Unconfined Aquifer is evident in seepage features near Karapiro Stream (32 m to 30 m RL) shown on orthophotos of the site taken during a prolonged dry period. However, various local silt layers will affect the aquifer confinement across the site.

The deep Confined Aquifer is evident in the new production bore lithology (gravel, sand pumice) from 53 m deep. The aquifer testing on this production bore showed that the aquifer is highly confined in this location (Section 3.6).

The Site is situated in the Hamilton Basin - South Aquifer Management Zone, as defined by the Waikato Regional Plan. This Management Zone is currently not fully allocated and there is water available to accommodate the proposed groundwater take.

3 PUMPING TEST ANALYSIS

3.1 STEPPED RATE PUMPING TEST OBSERVATIONS

Stepped rate tests are carried out to determine an appropriate flow rate from a production bore and the well efficiency. The RS Sand bore was drilled and tested by Brown Bros (NZ) Ltd. A four-hour step test was conducted on 4 April 2022. The bore was pumped at rates of 16, 22, 29 and 33 L/s for an hour per step with manual water level monitoring undertaken. Recovery was monitored manually for 6 and a half hours following the end of pumping. The results of the step test are presented in Table 4, Figure 3 and Figure 4.

Table 4: Results of RS Sand Bore Step Test.

Step	Pumping rate (L/s)	Water level(1) (m bgl)	Drawdown(1) (m)
1	16	44.57	1.72
2	22	45.43	2.58
3	29	46.19	3.34
4	33	46.89	4.04
Recovery(2)	0	42.87	0.02

Notes: 1) Water level and drawdown recorded at end of 60 minute step.
2) Water level and drawdown recorded at the end of monitored recovery (390 minutes).

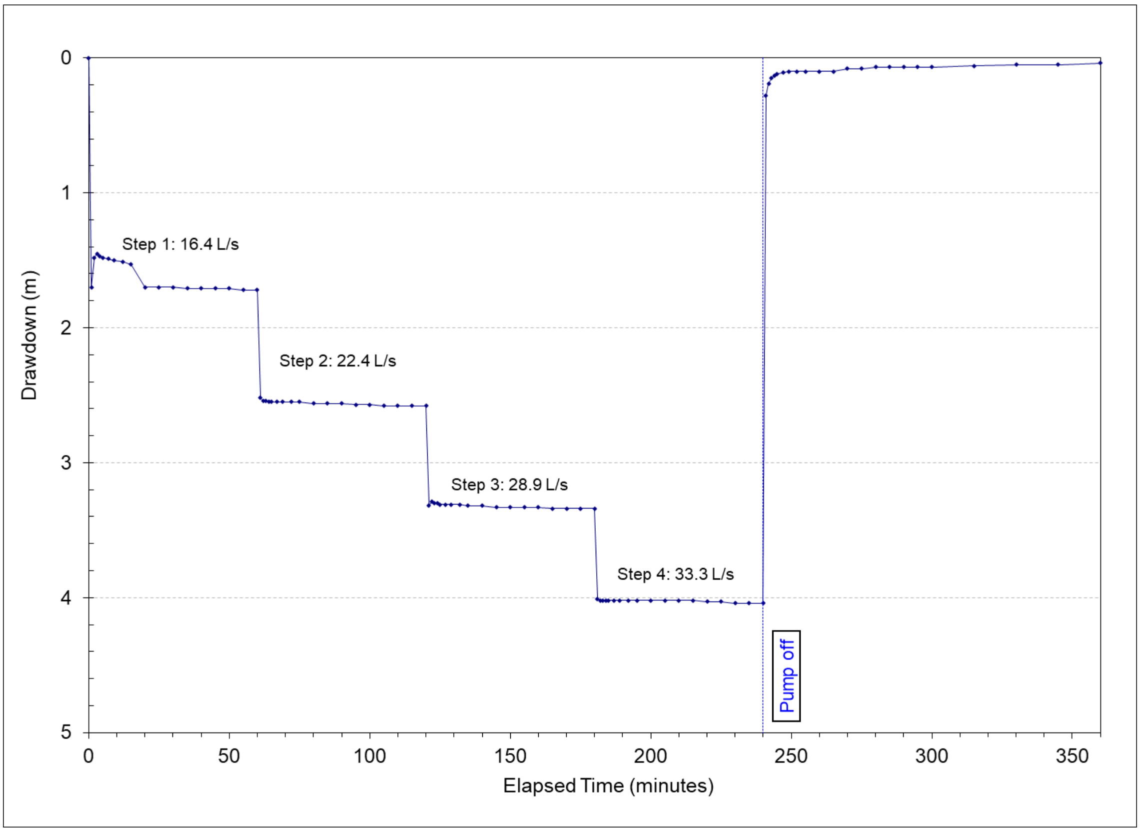


Figure 3: RS Sand Bore Stepped Rate Test Drawdown and Recovery.

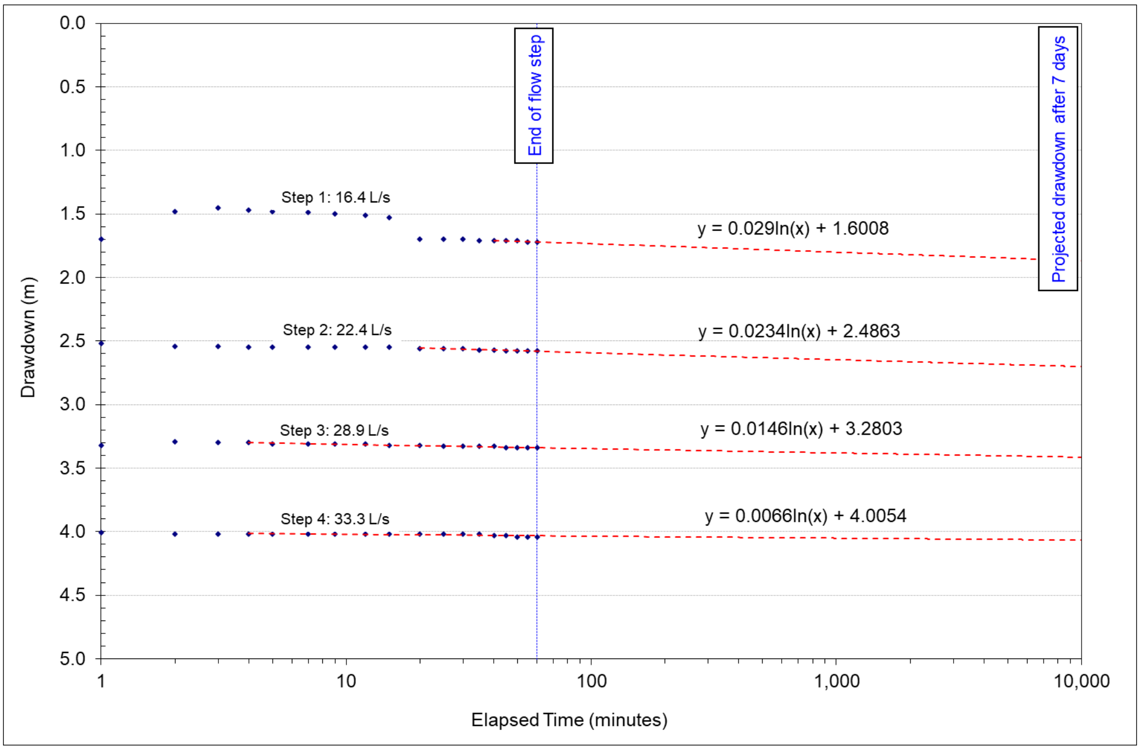


Figure 4: RS Sand Bore Stepped Rate Test Analysis.

To give an indication of transmissivity, data analysis was undertaken on the step rate test data using the AQTESOLV Pro v4 software package from HydroSolve Inc., which is an industry standard pumping test analysis package. The measured drawdown curves were matched against type curves for a confined aquifer using the Theis method and the results are presented in Appendix A. The analysis indicated an aquifer transmissivity of 4,000 m^2/day.

3.2 WELL EFFICIENCY

The step-rate test results were analysed to assess the efficiency of the Production Bore. The results presented in Figure 5 indicate that at a flow rate of 33 L/s, the well efficiency is approximately 77%. At lower flow rates the well efficiency increases, which is normal for production bores. The well efficiency assessment indicates most of the drawdown generated by pumping from the Production Bore is due to the performance of the aquifer rather than performance of the bore itself.

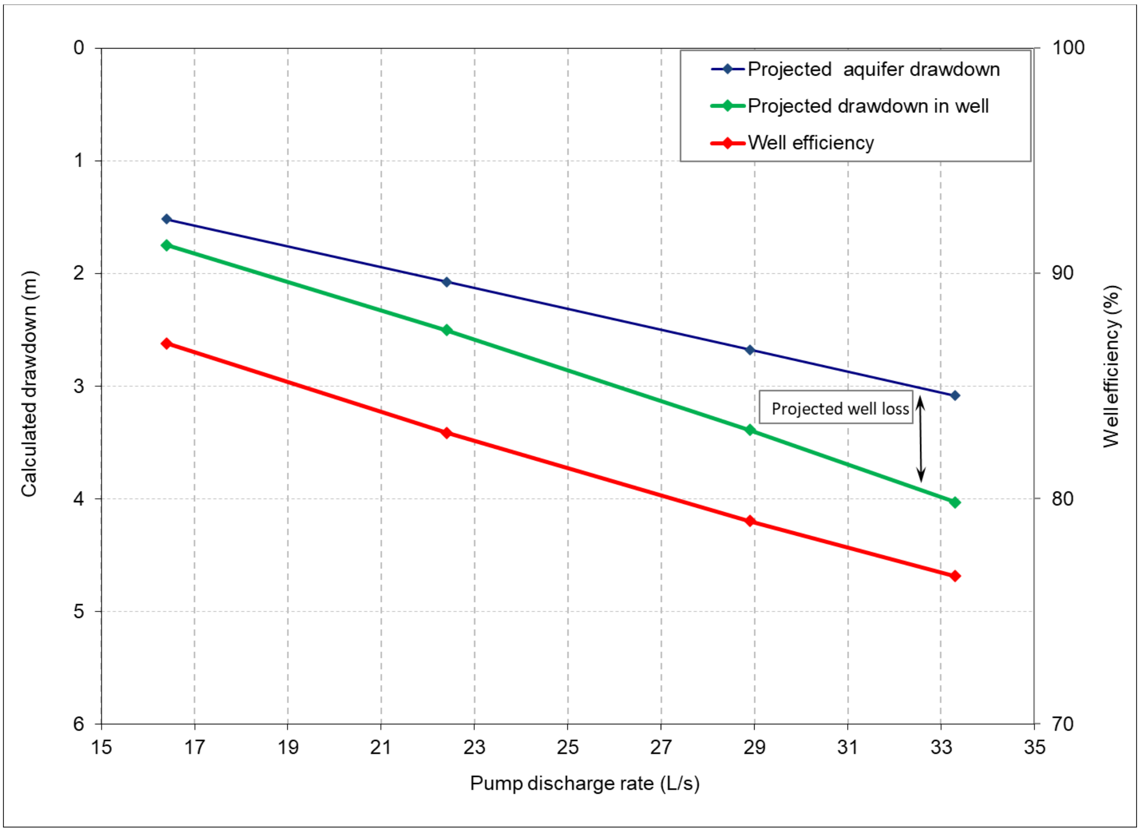


Figure 5: RS Sand Bore Well Efficiency.

3.3 CONSTANT RATE PUMPING TEST

The constant rate pumping test was commenced on 5 April 2022. The bore was pumped at a rate of 29 L/s for 1,440 minutes. Water levels were monitored using a water level logger recording at one-minute intervals in conjunction with manual monitoring. Following cessation of pumping, recovery in the pumped bore was monitored for a further 1,450 minutes. One observation bore was also monitored during the pumping test as follows:

Observation Bore – located 4.71 m from pumping bore and monitored with a transducer logging at minute intervals

3.4 DRAWDOWN AND RECOVERY

3.4.1 Pumping Bore

The static water level was recorded in the pumped bore at 42.85 m bgl prior to the commencement of the constant rate pumping test. The maximum water level of 46.88 m bgl was recorded at 1,440 minutes equating to a maximum drawdown of 4.03 m (Figure 6 and Figure 7). After 1,450 minutes following the end of pumping the pumped bore had recovered to a depth of 42.93 m bgl, a recovery of 98 % of the total drawdown (Figure 8). Extrapolation of the drawdown curve (Figure 9) indicates drawdown in the bore would be approximately 6 m after 300 days of continuous pumping at 29 L/s. In reality, dust suppression will not be required continuously and the planned pump usage is 10.5 hours a day so will not be operated continuously. The bore is cased to a depth of 56.8 m, it is assumed that the pump is located at the bottom of the casing and has a cut off switch above the pump inlet. The long-term drawdown is not expected to exceed 50 m bgl which provides a buffer should seasonal fluctuations occur or the efficiency of the well were to reduce over time. The bore will not be pumped continuously as water use requirements for dust suppression will depend on climate conditions and processing at the plant will not be undertaken continuously.

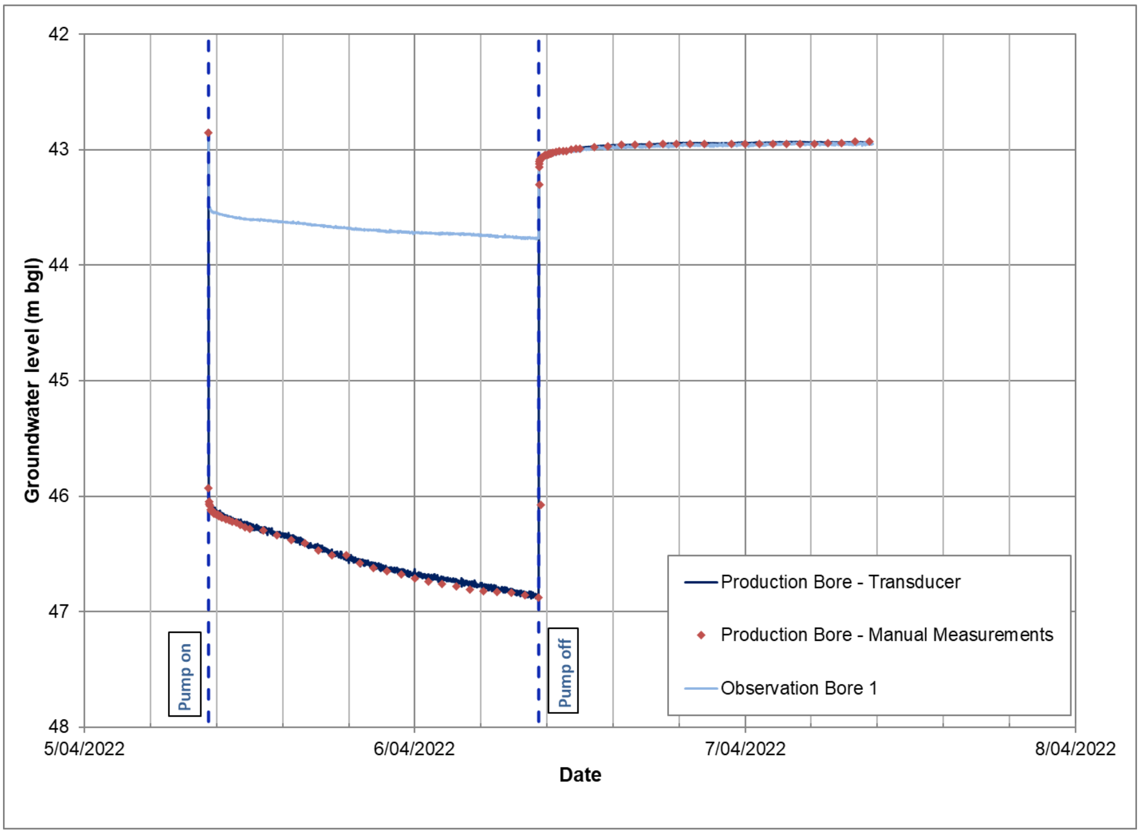


Figure 6: RS Sand Bore Constant Rate Pumping Test Groundwater Levels.

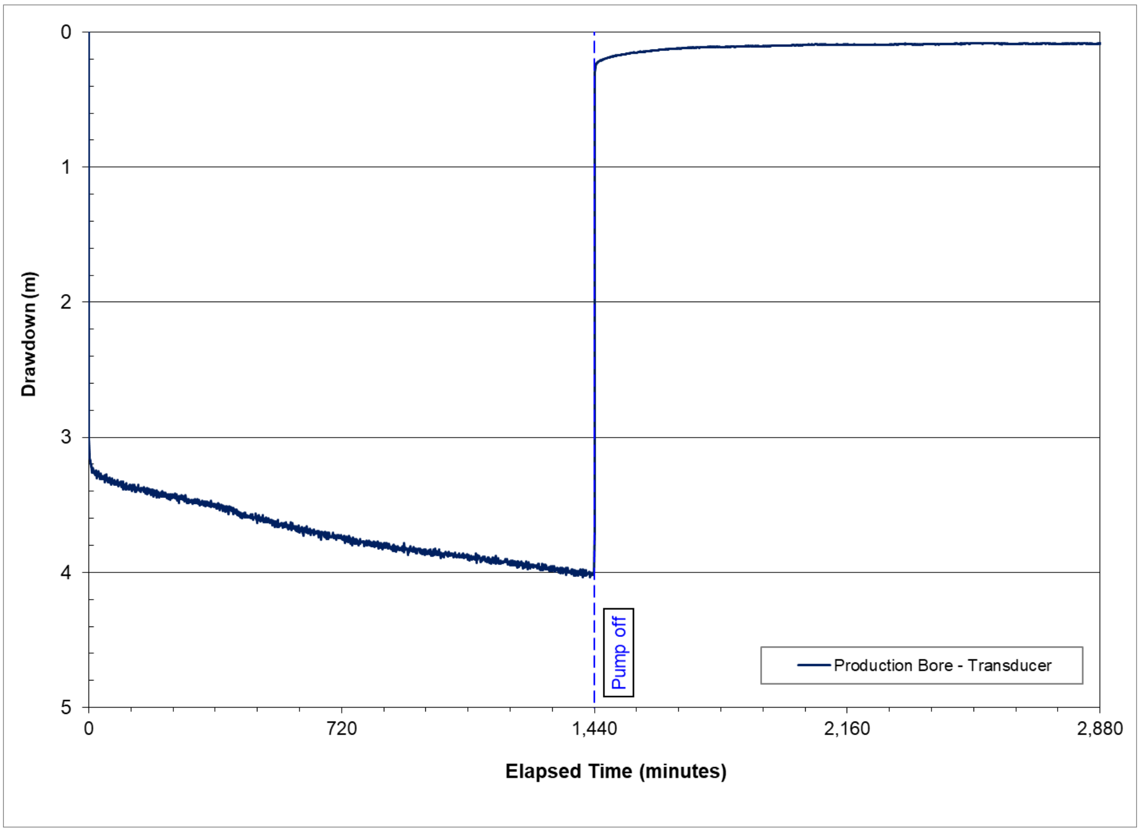


Figure 7: RS Sand Bore Constant Rate Pumping Test Drawdown and Recovery.

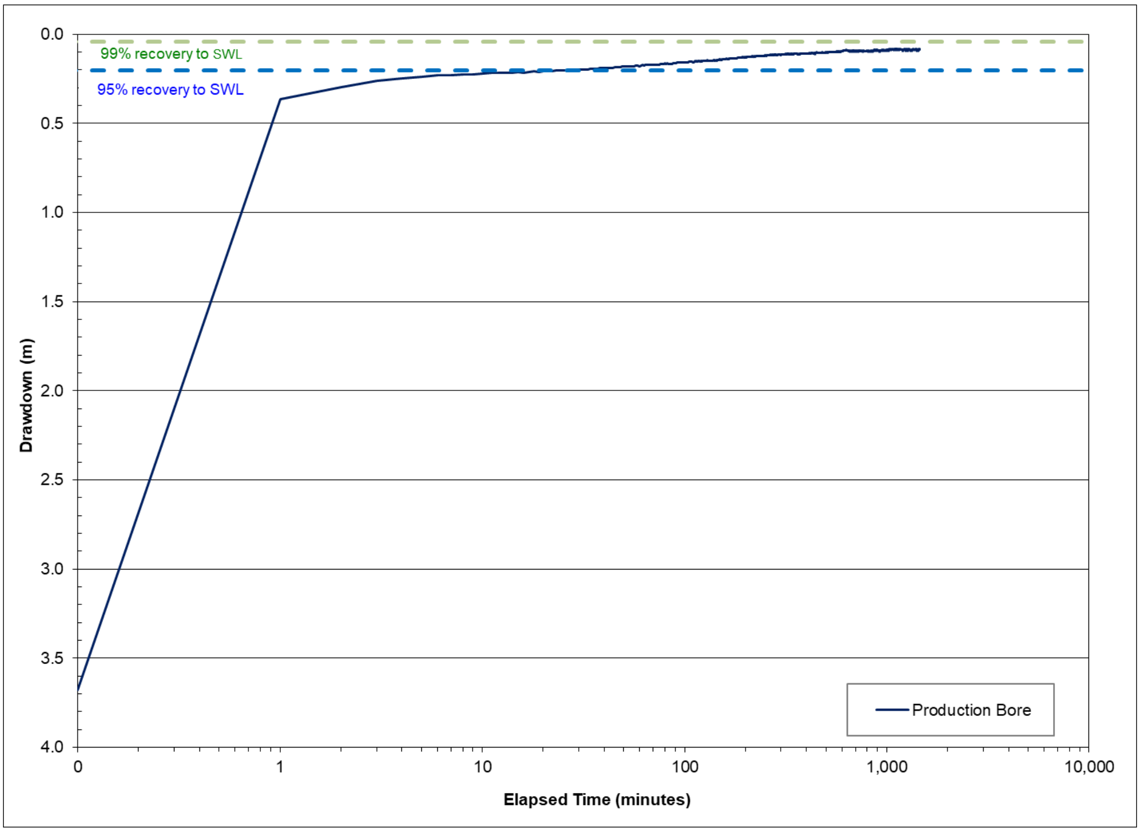


Figure 8: Constant Rate Pumping Test Recovery Percentage.

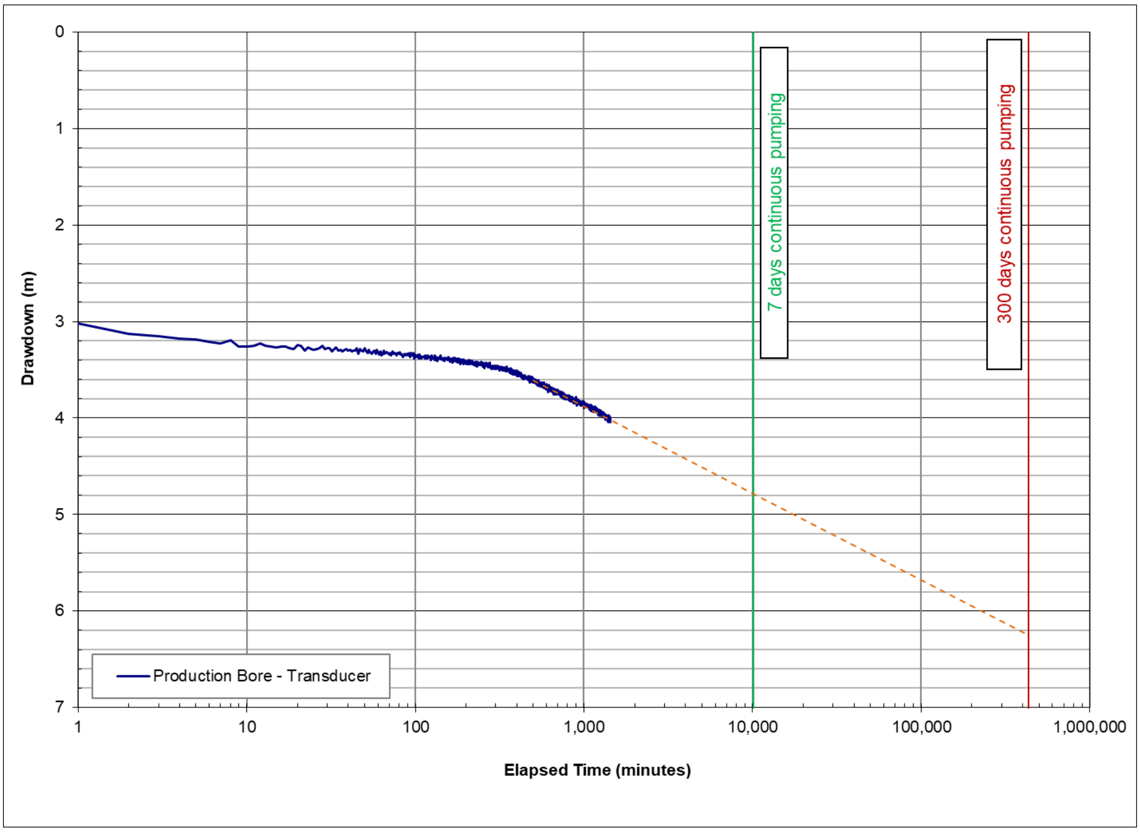


Figure 9: Projected Drawdown in the Production Bore following 300 days Continuous Pumping.

3.4.2 Observation Bore

A static water level of 42.85 was assumed for the observation bore prior to the test. The bore is located 4.7 m from the pumping bore and screened at the same interval and is therefore expected to have the same initial SWL as the pumped bore. Following 1,429 minutes of pumping a maximum drawdown of 0.93 m was recorded (Figure 6).

3.5 DATA ANALYSIS METHODS

Data analysis was undertaken on the constant rate pumping test data using the AQTESOLV Pro v4 software package from HydroSolve Inc., which is an industry standard pumping test analysis package. The measured drawdown curves were matched against type curves for a confined aquifer.

The Theis (1935) solution was used initially to evaluate the aquifer transmissivity. A check using the Cooper Jacob (1946) straight line method was also applied. The following standard set of assumptions is incorporated in the Theis and Cooper Jacob solutions:

1. The aquifer is not leaky and has an "apparent" infinite extent.
2. The aquifer and confining layer are homogenous, isotropic and of uniform thickness over the area influenced by the pumping.
3. The piezometric surface was approximately horizontal prior to the start of the pumping test.
4. The Production Bore was pumped at a constant rate during each of the flow steps of the test.
5. The water removed from storage is discharged instantaneously with decline of head.
6. The diameter of the bore is small, i.e., the storage in the bore can be neglected in the assessment.
7. The head in any underlying or overlying unpumped aquifers(s) remains constant.
8. Storage in the confining layer is negligible.

Flow to the bore is unsteady.

3.6 PUMPING TEST ANALYSIS RESULTS

Aquifer parameters were derived from the pumping test drawdown and recovery data using the methods described in Section 3.5 and summarised in Table 5. The analysis sheets are presented in Appendix B.

Table 5: Results Derived from Pumping Test Analysis.

Bore	Analysis method	Transmissivity (m^2/day)	Storativity
Pumping Bore	Theis (Drawdown and recovery)	1,250	-
	Theis (Recovery – early time)	2,350	-
	Theis (Recovery – late time)	4,950	-
	Cooper Jacob (Drawdown – early time)	2,750	-
	Copper Jacob (Drawdown – late time)	485	-
Observation Bore	Theis (Drawdown and recovery)	2,850	0.0007
	Theis (Recovery – early time)	2,650	-
	Theis (Recovery – Late time)	4,950	-
	Copper Jacob (Drawdown – Late time)	1,650	3×10^{-6}

Notes: 1) Storativity values resulting from analysis of the Production Bore data alone are not considered reliable and have therefore not been reproduced here.

Transmissivity values derived from the pumping test analysis range from 485 m^2/day to 4,950 m^2/day. These values are consistent with expected transmissivity values for the area, although the higher value is higher than most bores in the region. WGA consider that the Production Bore is tapping a high hydraulic conductivity zone, potentially a paleochannel. Close to the bore the transmissivity values are higher (e.g. results from Cooper Jacob early time, and Theis Recovery – late time) as the drawdown cone extends out from the pumped bore, groundwater is derived from a lower transmissivity zone of the aquifer (e.g. results from Cooper Jacob - late time, and Theis Recovery – early time). The more conservative values for drawdown at nearby bores are derived using the lower value of transmissivity which also represents the aquifer properties towards the nearby bores rather than close to the pumped bore.

The value of 0.0007 derived from the Theis drawdown and recovery analysis is considered the most applicable. This value for storativity is indicative of a confined aquifer. If the aquifer was unconfined a flatter curve and much less drawdown would be observed in the observation bore.

Based on the pumping test analysis outcomes, the following properties for a fully confined aquifer were adopted for the purpose of assessing effects on nearby bores and surface water bodies:

- Transmissivity: 485 m^2/day
- Storativity: 0.0007

4 ASSESSMENT OF EFFECTS

4.1 EFFECTS ON NEIGHBOURING BORES

There are nine bores within one kilometre of the RS Sand bore listed on the WRC database (Figure 1,Table 7). Groundwater is proposed to be taken at rate of up to 1,100 m^3/day for the purposes of dust suppression and sand processing (refer Section 1.3; Table 6). As the proposed pumping of the RS Sand bore will not be undertaken continuously, the flow rate and daily demand has been averaged across the year. The period of 220 days represents the longest period that the bore can be pumped at the maximum daily rate. However, in reality, the bore will be operated to daily water requirements depending on the site conditions up to the annual volume. Therefore, the scenario has been assumed for the purpose of producing a conservative estimate of pumping induced drawdown.

Table 6: Abstraction Rates Applied to Drawdown Assessment.

Use	Abstraction Rate		
	Basis	Daily Flow Rate (m^3/day)	Average Flow Rate (L/s)
Annual Abstraction Scenario	Pumping at 1,100 m^3/day over a period of 220 consecutive days.	1,100	12.73

The calculated induced drawdown that would result from the proposed abstraction from the Production Bore after 220 days of continuous pumping has been presented in Table 7. Drawdown was calculated for nearby bores using the Theis (1935) solution, which assumes a confined aquifer as observed in the pumping test.

The closest nearby bore (70_577) on the WRC database is located approximately 450 m to the east of the proposed take and has an unknown depth. If the bore is tapping the same aquifer as the RS Sand bore, projected drawdown would be 1.34 m which would equate to an interference of between 2 % and 3 % of the bore depth. This bore could be tapping the perched aquifer, however, it is located on the far side of the eastern gully (tributary of Karapiro Stream), which is sufficiently incised to act as a hydraulic boundary for the shallow aquifer. The calculated interference for other bores in the area tapping the same aquifer as the RS Sand bore also ranges between 2 % and 3 % of bore depths. Given the projected drawdowns and the distances of the two other bores of unknown depth, it is considered if these are tapping the same aquifer as the RS Sand bore, the interference effects would be less than minor. Therefore, based on the small projected drawdown effect on all nearby bores, the drawdown effect on other users from the proposed RS Sand groundwater abstraction is considered to be less than minor.

Table 7: Bores within approximately one kilometre of the RS Sand bore.

Bore number	Bore depth (m)	Casing depth (m)	Distance from Production Bore (m)	Projected drawdown (m) (1)	Potential Interference(2) (%)
72_10873	74.8	56.8	0	N/A	N/A
70_577	Unknown	Unknown	458	1.34	Unknown
72_1041 (3)	6.00	2.5	678	N/A	N/A
70_263	48.77	Unknown	730	1.17	2
70_264	48.77	45.72	730	1.17	2
70_24	Unknown	Unknown	730	1.17	Unknown
70_265	39.01	Unknown	730	1.17	3
72_6385	Unknown	Unknown	828	1.12	Unknown
72_1306	62.00	60	853	1.08	3
72_1661	78.70	58.5	933	1.05	3

Note: 1) Projected drawdown is based on the drawdown in the pumped aquifer.
2) Potential Interference as a percentage of bore depth.
3) Shallow bore on north side of incised stream (hydraulic boundary) drawdown not expected.

4.2 NEARBY CONSENTED TAKES

There are three consented groundwater takes within one kilometre of the proposed site (Table 8). As the construction of the expressway has been completed it is considered that the resource consent to take water in association with construction of the expressway is no longer operative apart from any fixed dewatering structures.

The consent to take up to 35.62 m^3/day for dairy farming is located approximately 850 m to the south of the proposed take and is likely to be associated with bore 72_1306 which has a depth of 62 m. Projected drawdown at this bore location is expected to be approximately 1 m and therefore the effect on this take is considered to be less than minor.

There is a nearby consent to take water from a spring for use in a dairy shed (Table 8). A review of aerial photographs (taken during summer) has identified a groundwater seepage line along the southern gully slopes of Karapiro Stream at approximately 65 m RL. The consented spring take is considered to be abstracting water from the perched aquifer layer and will therefore not be affected by the proposed water take in the confined aquifer.

Table 8: Groundwater Takes Within One Kilometre of the Proposed Quarry.

Consent Number	Details
AUTH122320.01.01	Resource Consent: Take groundwater in association with the Cambridge Section of the Waikato Expressway
AUTH126930.01.01	Resource Consent: To take groundwater Agricultural farming - dairy
AUTH126762.01.01	Resource Consent: To take water from a spring.

4.3 STREAM DEPLETION

The proposed abstraction is from a confined aquifer. The closest surface water body is Karapiro Stream approximately 215 m to the north of the take.

A conservative stream depletion analysis has been undertaken using the Hunt (2003) method. This method takes into account an aquitard separating the pumped aquifer from the overlying surface water body. The following parameters were applied in the analysis:

- Distance of 215 m from the abstraction bore.
- An aquitard thickness of 5 m (total from various layers in bore log to base of stream).
- Vertical hydraulic conductivity for the aquitard of 0.01 m/day (conservative value for silts, Domenico and Schwartz, 1990).
- Stream bed width of 4.5 m. (measured from aerial photography)

The stream depletion after 220 days of continuous pumping is calculated to be 0.12 L/s (10 m^3/day), which is less than the permitted take rate of 15 m^3/day. The actual effect will be significantly less than this value as the bore will be operated in response to climate conditions to provide dust suppression rather than for 220 days continuously.

The effects of the proposed abstraction from the bore on the stream is less than minor.

4.4 AQUIFER SUSTAINABILITY

The WRC's Waikato Regional Plan defines the aquifer in the area of the proposed groundwater abstraction to be the Hamilton Basin - South Aquifer. This aquifer is not currently fully allocated. The consented abstractions nearby are for small quantities. Therefore, WGA concludes that this proposed take will not cause any long-term sustainability issues.

4.5 OTHER MATTERS

As part of the consideration of the effects Policy 12 of the Waikato Regional plan outlines several aspects to consider in addition to the effects detailed and modelled above. These include the following:

- Saline water intrusion – not an issue for this proposed abstraction given the bore is located inland and not associated with a coastal aquifer.
- Water quality – the proposed abstraction has a small drawdown effect; therefore the proposed take is not expected to cause movement of groundwater with lower quality into the aquifer.
- Aquifer compression – the low magnitude of drawdown and the stability of the aquifer sediments are such that aquifer compression is not expected to result from this proposed take.

5 CONCLUSIONS

RS Sand proposes to take water for processing of sand and dust suppression from a bore 72_10808 located at the proposed Newcombe Quarry.

The proposed maximum groundwater abstraction rates are 1,100 m3/day and 290,000 m^3/year with an instantaneous maximum flow of 29 L/s.

A step rate test and a 24 hour constant rate test were undertaken in April 2022. Following 1,440 minutes of pumping at a rate of 105 m^3/hour (29 L/s) during the constant rate test, a drawdown of 4.0 m was observed in the pumping bore and 0.93 m in the observation bore. Transmissivity values derived from the pumping test analysis range from 485 m^2/day to 4,950 m^2/day. A storativity value of 0.0007 was derived from the pumping test analysis.

The closest nearby bore (70_577) is located approximately 450 m to the east of the proposed take and has an unknown depth. If the bore is tapping the same aquifer as the RS Sand bore, projected drawdown would be 1.34 m which would equate to an interference of between 2 and 3 % based on bore depth. This bore could be tapping the perched aquifer, however it is located on the far side of the eastern gully (tributary of Karapiro Stream), which is sufficiently incised to act as a hydraulic boundary for a shallow bore. Therefore, drawdown interference effects are considered to be less than minor.

Results from stream depletion analysis indicated the potential stream depletion from the Waikato River due to the proposed take would be less than 0.12 L/s (10 m^3/day). It is therefore considered that the proposed take will have less than minor effects on flows in the Karapiro Stream.

There is sufficient allocation available within the WRC regional plan defined aquifer; Hamilton Basin – South to accommodate the proposed abstraction from the Production Bore of up to 290,000 m^3/year.

6 REFERENCES

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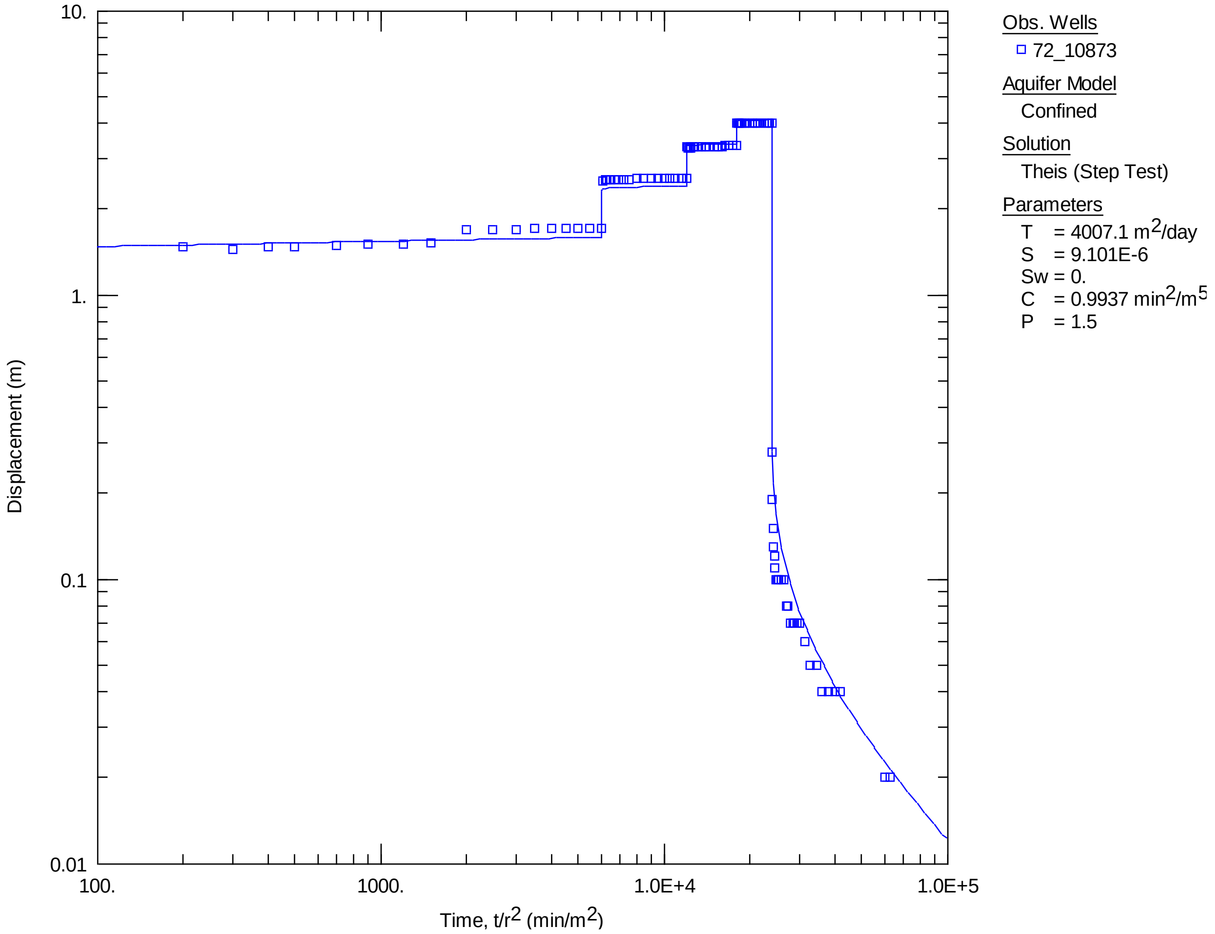
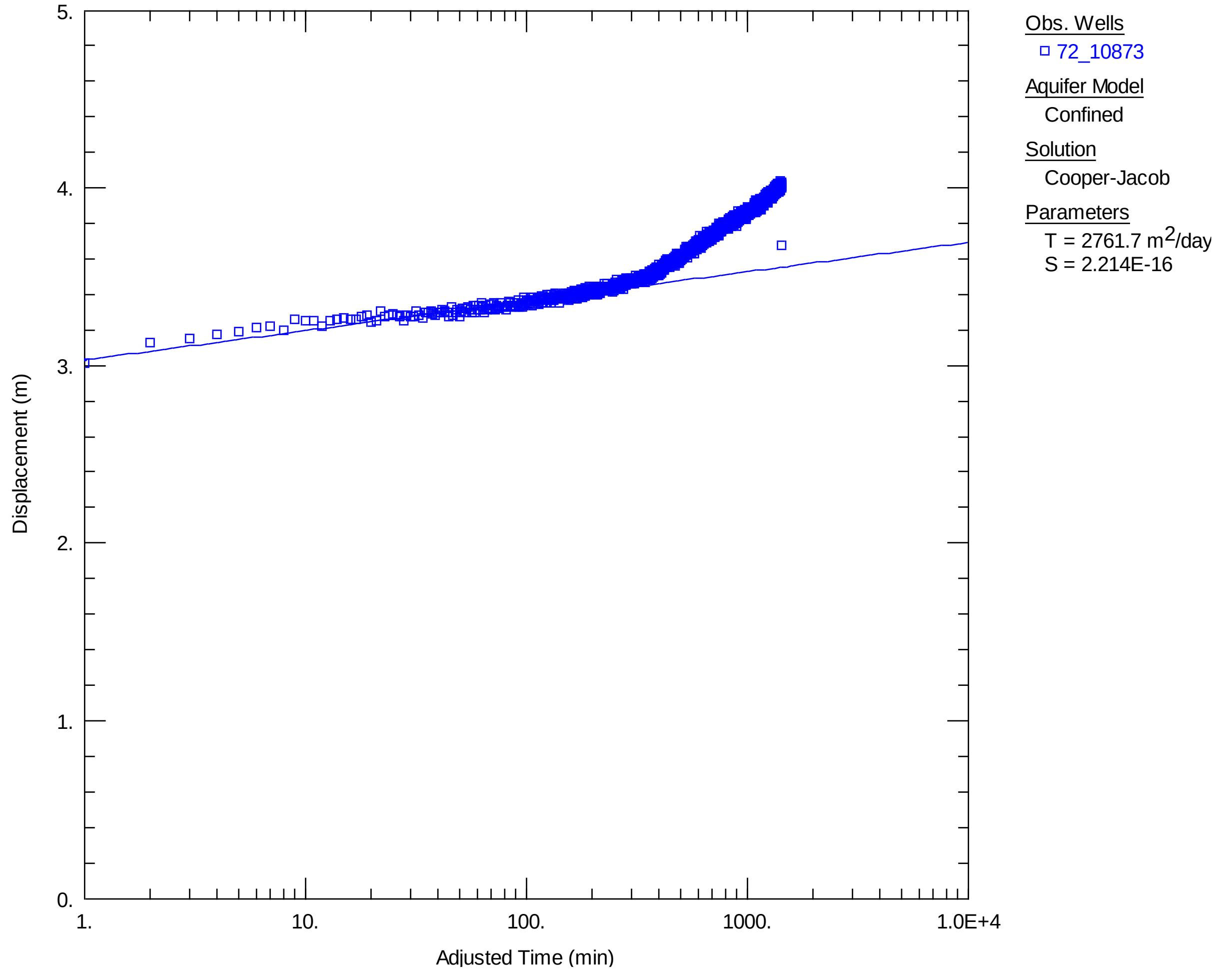
APPENDIX A

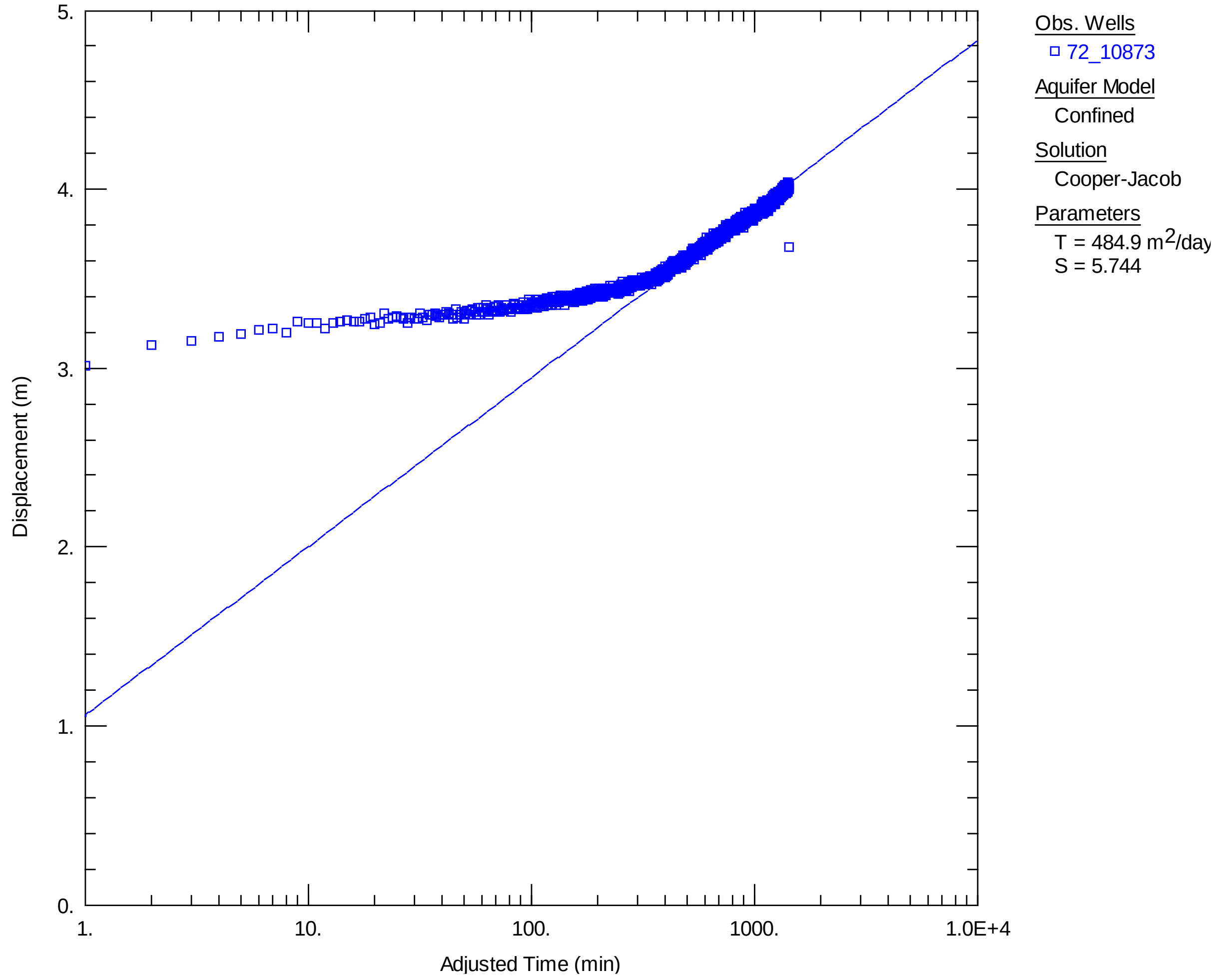
PUMPING TEST ANALYSIS RESULTS



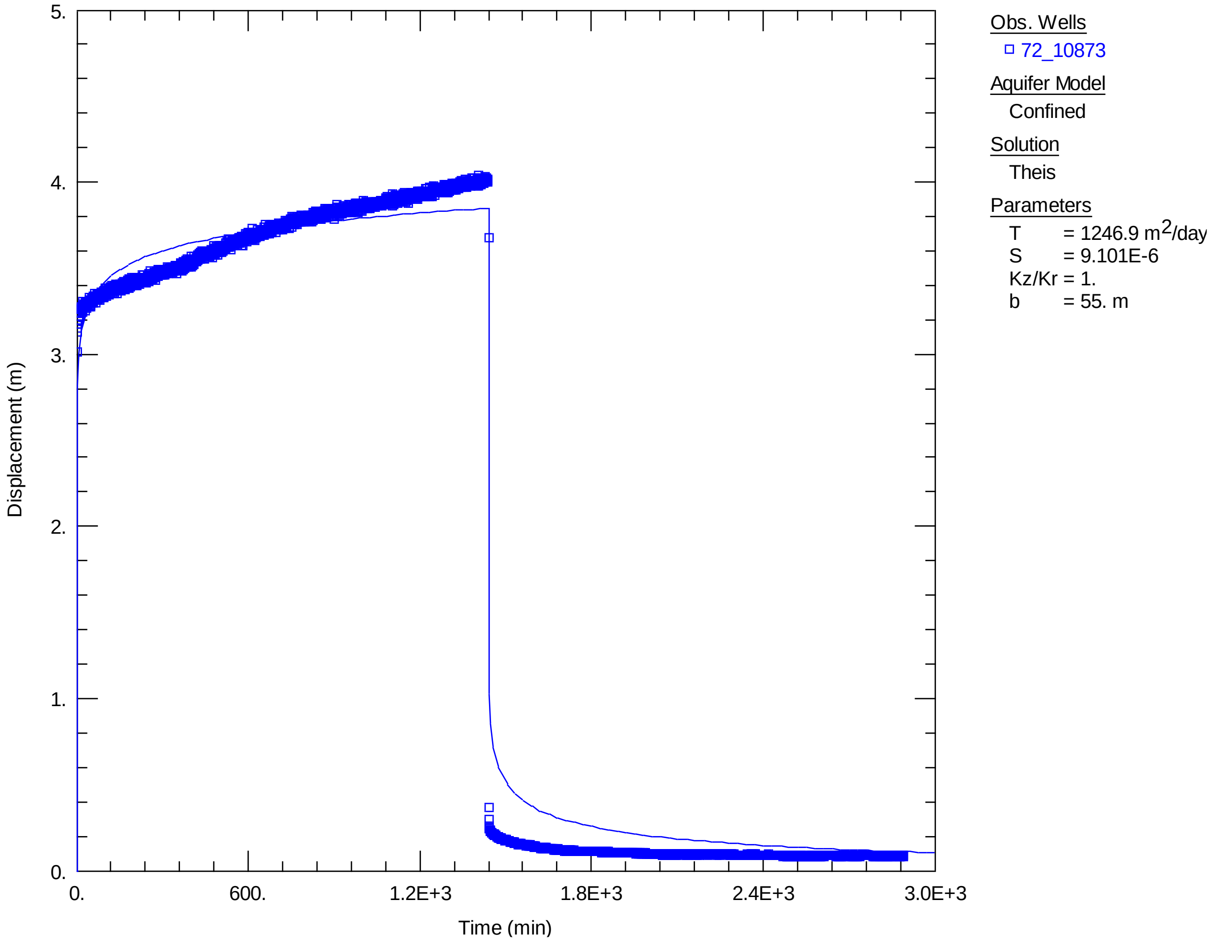
10.
1.
0.1
0.01
Displacement (m)
100.
1000.
1.0E+4
1.0E+5
Time, t/r2 (min/m2)
Obs. Wells
72_10873
Aquifer Model
Confined
Solution
Theis (Step Test)
Parameters
T = 4007.1 m2/day
S = 9.101E-6
Sw = 0.
C = 0.9937 min2/m5
P = 1.5



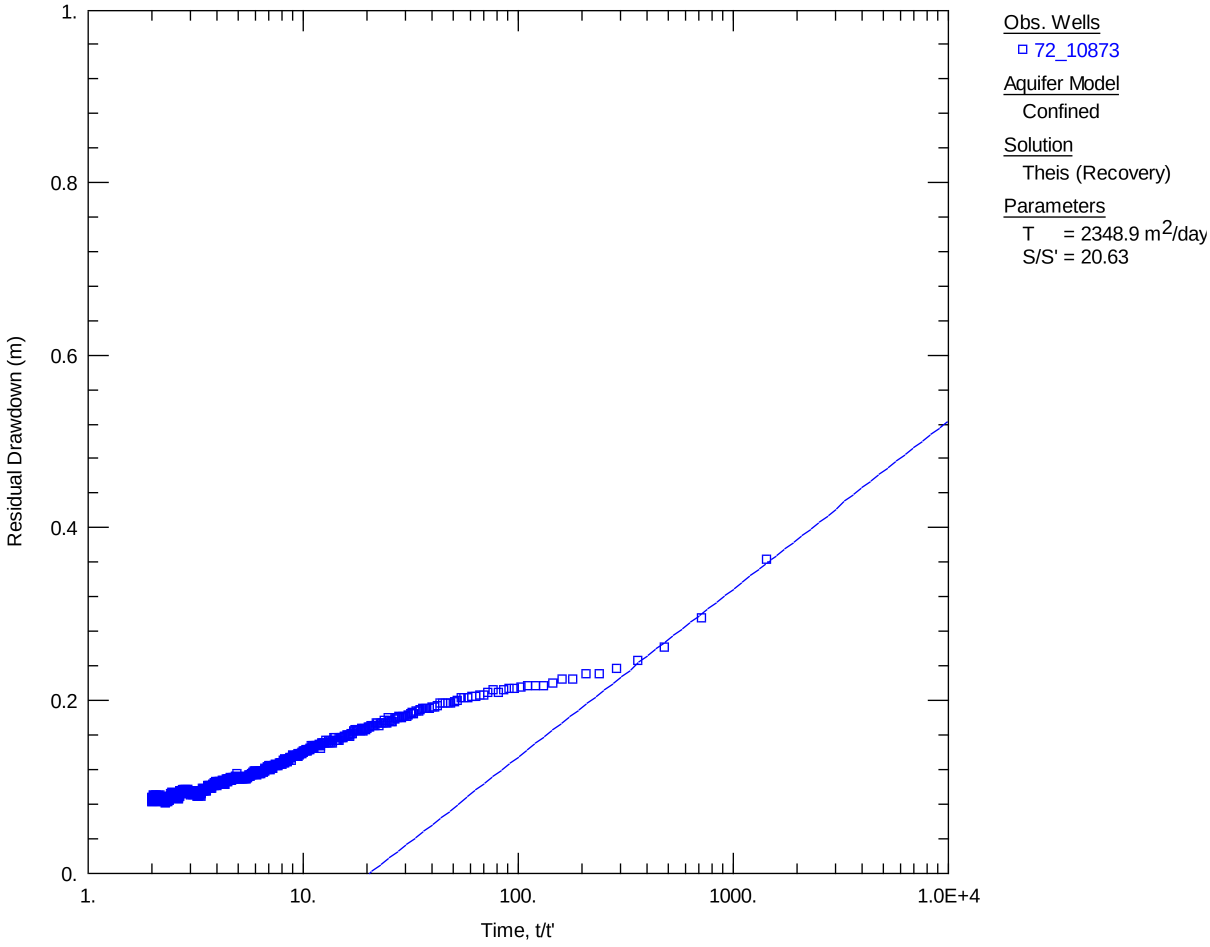
5.
4.
3.
2.
1.
0.
Displacement (m)
1.
10.
100.
1000.
1.0E+4
Adjusted Time (min)
Obs. Wells
72_10873
Aquifer Model
Confined
Solution
Cooper-Jacob
Parameters
T = 2761.7 m2/day
S = 2.214E-16



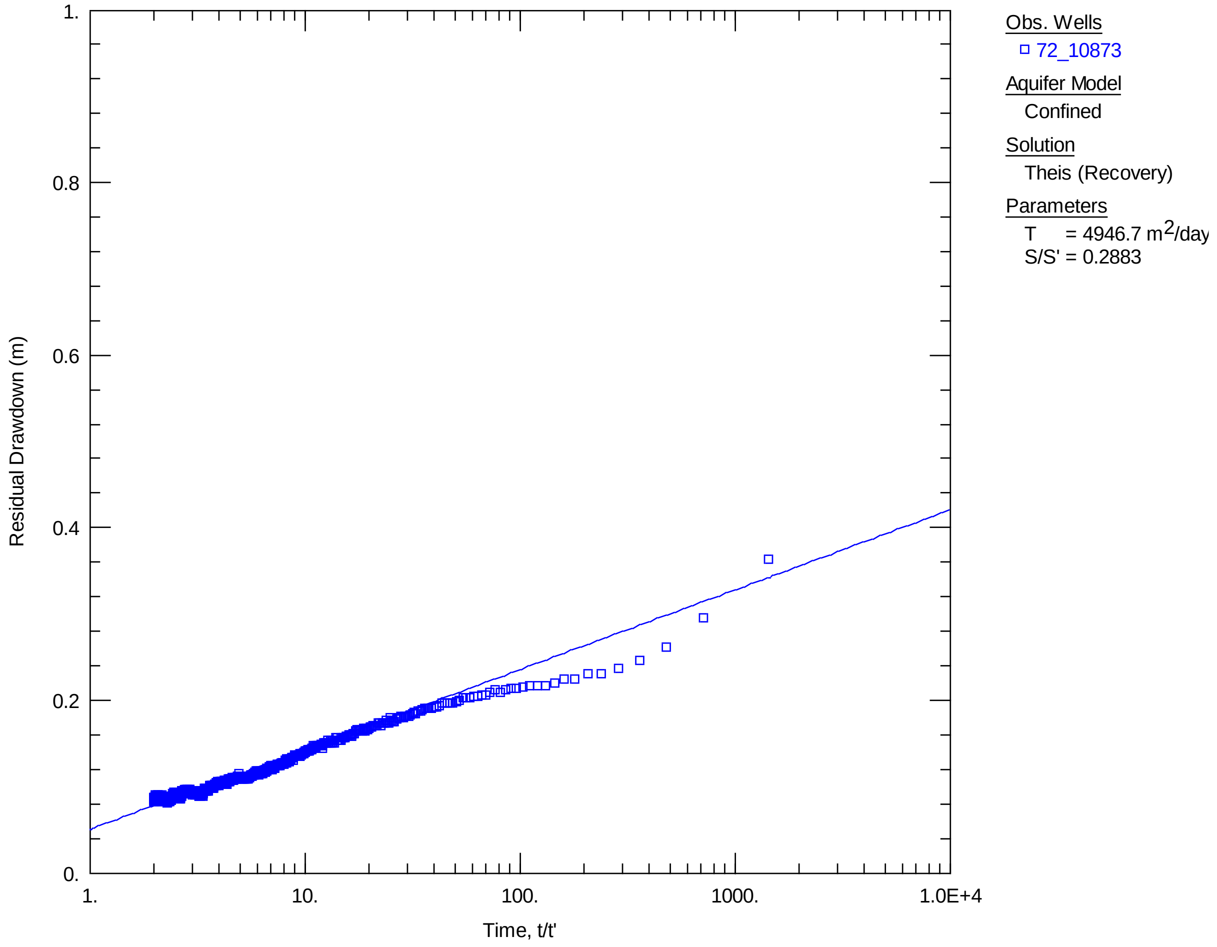
5.
4.
3.
2.
1.
0.
Displacement (m)
1.
10.
100.
1000.
1.0E+4
Adjusted Time (min)
Obs. Wells
72_10873
Aquifer Model
Confined
Solution
Cooper-Jacob
Parameters
T = 484.9 m2/day
S = 5.744

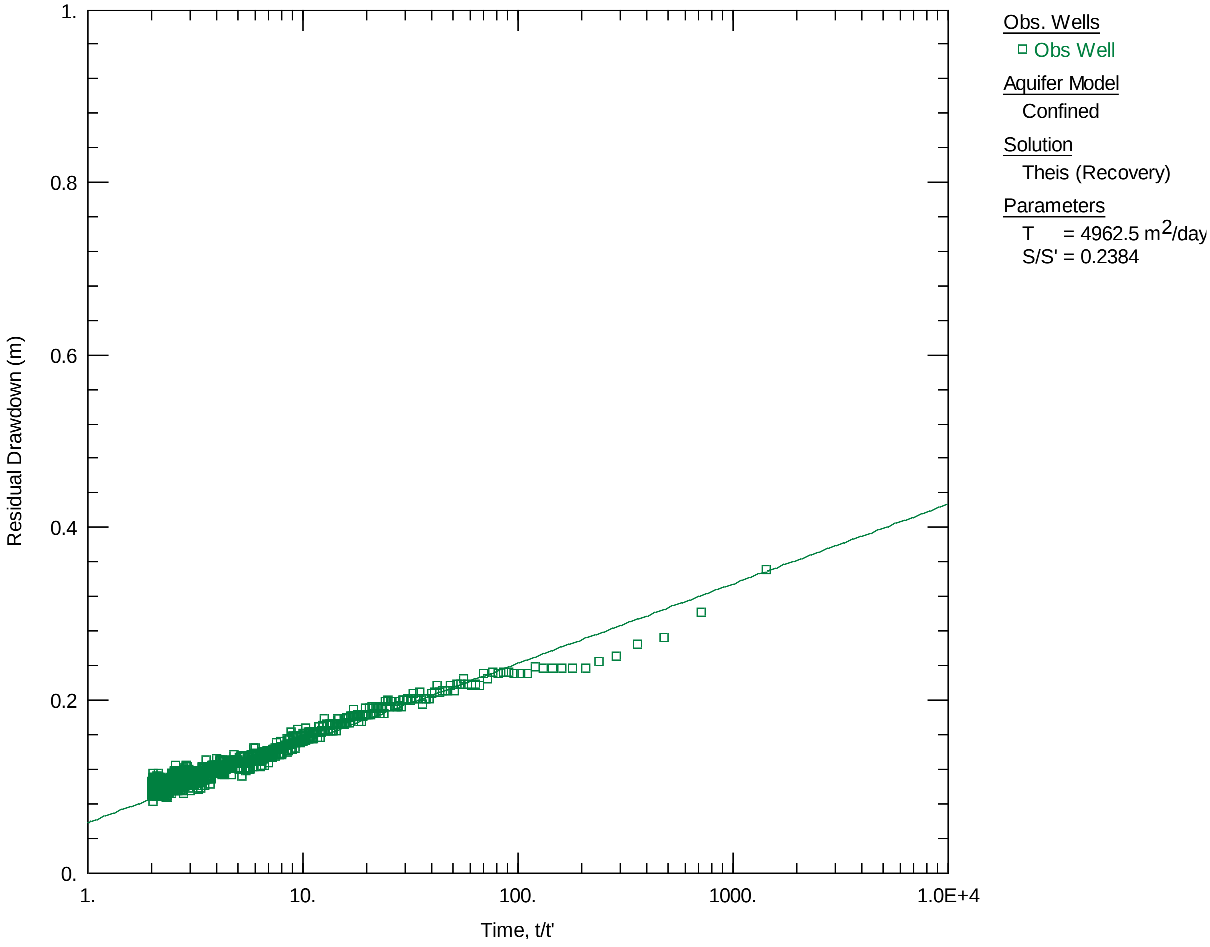


5.
4.
3.
2.
1.
0.
Displacement (m)
0.
600.
1.2E+3
1.8E+3
2.4E+3
3.0E+3
Time (min)
Obs. Wells
72_10873
Aquifer Model
Confined
Solution
Theis
Parameters
T = 1246.9 m2/day
S = 9.101E-6
Kz/Kr = 1.
b = 55. m

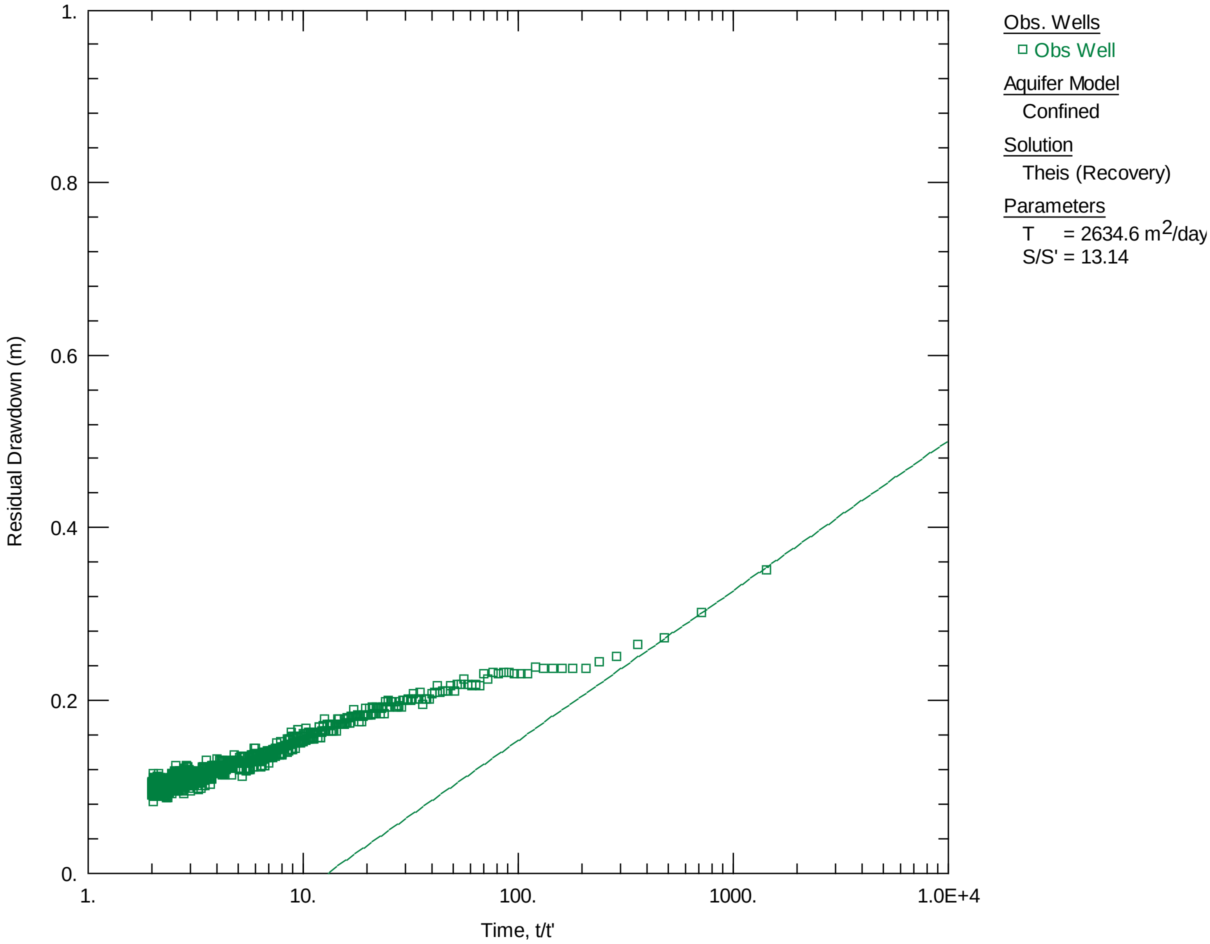


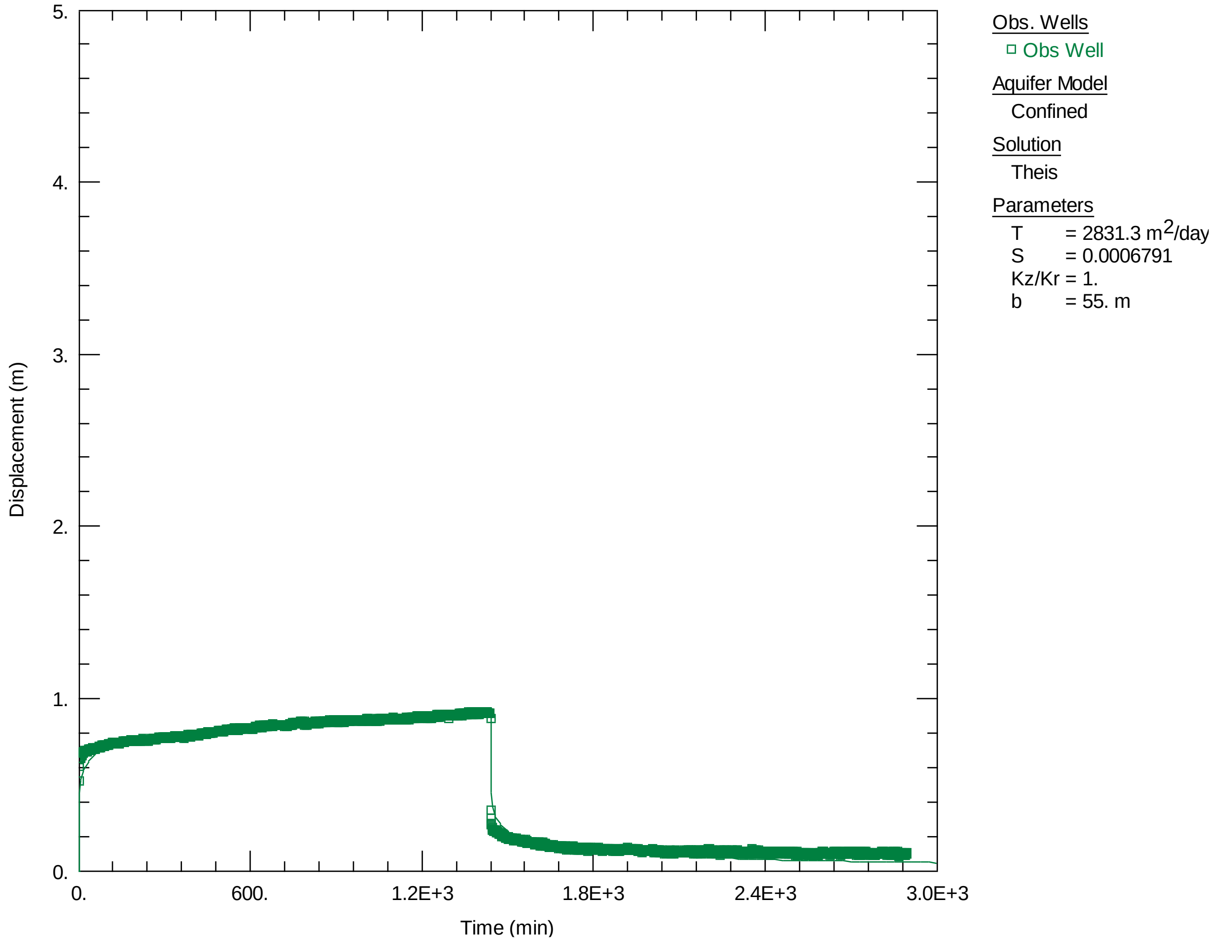
1.
0.8
0.6
0.4
0.2
0.
Residual Drawdown (m)
1.
10.
100.
1000.
1.0E+4
Time, t/t'
Obs. Wells
72_10873
Aquifer Model
Confined
Solution
Theis (Recovery)
Parameters
T = 2348.9 m2/day
S/S' = 20.63


1.
0.8
0.6
0.4
0.2
0.
Residual Drawdown (m)
1.
10.
100.
1000.
1.0E+4
Time, t/t'
Obs. Wells
72_10873
Aquifer Model
Confined
Solution
Theis (Recovery)
Parameters
T = 4946.7 m2/day
S/S' = 0.2883

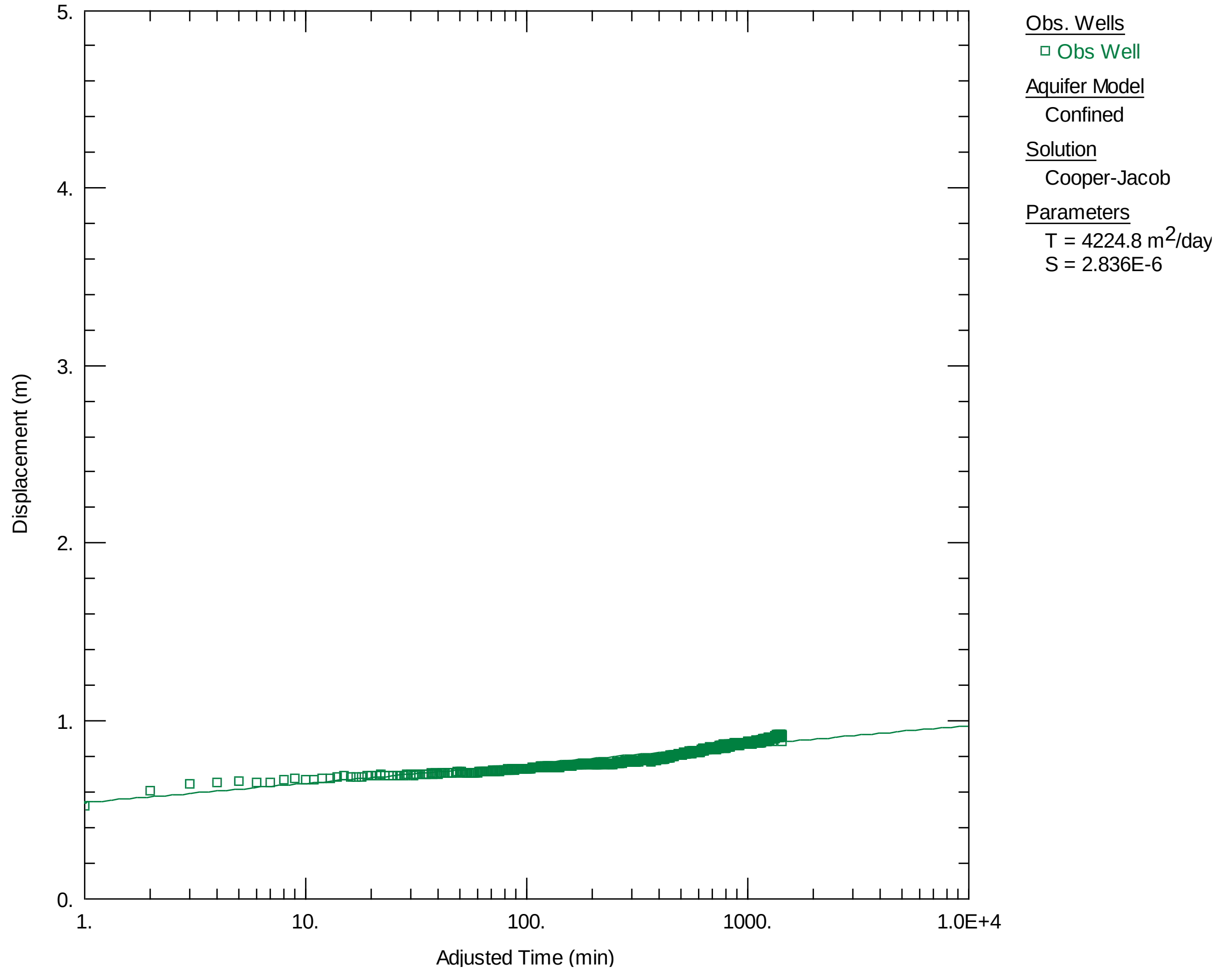


Residual Drawdown (m)
Time, t/t'
1.
0.8
0.6
0.4
0.2
0.
1.
10.
100.
1000.
1.0E+4
Obs. Wells
Obs Well
Aquifer Model
Confined
Solution
Theis (Recovery)
Parameters
T = 4962.5 m2/day
S/S' = 0.2384


1.
0.8
0.6
0.4
0.2
0.
Residual Drawdown (m)
1.
10.
100.
1000.
1.0E+4
Time, t/t'
Obs. Wells
Obs Well
Aquifer Model
Confined
Solution
Theis (Recovery)
Parameters
T = 2634.6 m2/day
S/S' = 13.14



5.
4.
3.
2.
1.
0.
Displacement (m)
0.
600.
1.2E+3
1.8E+3
2.4E+3
3.0E+3
Time (min)
Obs. Wells
Obs Well
Aquifer Model
Confined
Solution
Theis
Parameters
T = 2831.3 m2/day
S = 0.0006791
Kz/Kr = 1.
b = 55. m


5.
4.
3.
2.
1.
0.
Displacement (m)
1.
10.
100.
1000.
1.0E+4
Adjusted Time (min)
Obs. Wells
Obs Well
Aquifer Model
Confined
Solution
Cooper-Jacob
Parameters
T = 4224.8 m2/day
S = 2.836E-6

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