Tonkin+Taylor

Job No: 1016494.0000
10 September 2021

Acanthus Limited
c/- Civix
PO Box 5204
Victoria Street
Auckland 1141

Attention: Nick Mattison

Dear Nick

1 Selfs Road, Papatoetoe
Geological assessment in support of fast-track consenting application

Introduction

1 Acanthus Limited has engaged Tonkin & Taylor Ltd (T+T) to provide a geological assessment of its proposal to construct some 115 dwelling units and lots at 1 Selfs Road, Papatoetoe (the site). This assessment was prepared in accordance with our proposal dated 19 February 2021[1] and approval provided on 7 April 2021[2].

2 The site is subject to an Outstanding Natural Feature (ONF) overlay (ID 22) associated with the Crater Hill/Ngā Kapua Kohuora volcanic centre. As a result, an assessment of effects of the proposal on the geological values of the ONF is required to support the consent application process. I provide the following assessment on behalf of T+T.

Qualifications and experience

3 I am a Principal Environmental Scientist at T+T, a role which I have held for some 10 years.

4 I hold the Degrees of a Bachelor and Master of Science, majoring in Geology, from the University of Auckland.

5 My Masters thesis comprised the geological (geophysical and hydrogeological) assessment of two of Auckland's volcanic centres, Mt Richmond and McLennan Hills.

6 I have since gained over 20 years' experience as an environmental consultant, principally with respect to the assessment, management and remediation of contaminated land, particularly in the Auckland region.

7 A fundamental component of any ground assessment (contamination, geological, geotechnical etc.) is the development of a robust understanding of the geology of the subject site, 'the

[1] 1 Selfs Road, Papatoetoe. Geological, geotechnical and contamination assessments in support of fast-track consenting. Letter to Andrew Fawcet at Myland Partners, dated 19 February 2021.
[2] Email from Andrew Fawcet at Myland Partners to Shane Moore at Tonkin & Taylor Ltd, dated 7 April 2021.

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ground model'. Such geological assessment is part of my daily work. I have worked on developments, from single residential lots to large scale commercial facilities, across all of Auckland's geological terrains, including many of its volcanic centres.

8 I have previously presented evidence to the Auckland Unitary Plan (AUP) Independent Hearings Panel process on the ONF overlays, specifically in respect to the St Heliers volcanic centre.

9 I have recently provided a similar assessment, including evidence to the Council hearing, in support of a successful application by Oceania Healthcare Limited to establish a retirement village on the outer slopes of the tuff ring of the St Heliers volcanic centre (Waimarie Street).

Scope of report

10 This report is a standalone report identifying the geological characteristics of Crater Hill/Ngā Kapua Kohuora as they relate to the site and its proposed development. Specifically, this report addresses:

- a My assessment methodology including detailing site visits and research approach.
- b Describes the site setting.
- c Provides a brief introduction of the development proposal to provide context to this assessment.
- d Identifies the geological characteristics of Crater Hill/Ngā Kapua Kohuora (herein abbreviated to Crater Hill).
- e Sets out the relevant provisions in the AUP.
- f Assesses the effects on the proposal on the ONF; and
- g Summarises my findings.

Assessment methodology

11 I undertook the following to provide an assessment of the geological conditions at the site and assess the effects of the proposed development:

- a Collated geological information for the site from in-house and published sources, including:
  - i Readily available published geological information for the area, a list of material reviewed is provided in Appendix B;
  - ii Historic aerial photographs, both vertical and oblique, available from online sources (for example Auckland Council's GeoMaps[3], Retrolens[4], Digital New Zealand[5] and the National Library[6]);
  - iii Topographic information both from site inspection and information published by Auckland Council; and
  - iv T+T records and the New Zealand Geotechnical Database[7] of geotechnical data from nearby sites.
- b Reviewed relevant evidence provided to the Environment Court in relation to a previous proposal to bring Crater Hill and Pūkaki Lagoon volcanoes within the Rural Urban Boundary (RUB) and to introduce new zoning, including areas for residential development over parts of both features (refer to Appendix B).

[3] https://geomapspublic.aucklandcouncil.govt.nz/viewer/index.html
[4] https://retrolens.co.nz/
[5] https://digitalnz.org/
[6] https://natlib.govt.nz/
[7] www.nzgd.org.nz, accessed on 8 April 2021.

c Obtained and reviewed Council property files for relevant geological information.

d Undertook a walkover of the subject site, parts of the wider Crater Hill volcano (Selfs Farm) and immediate surrounds. Used online resources such as Google Street View to supplement this information (refer to Appendix D).

Site setting

12 The site location is shown in Figure 1. The site is legally described as Lot 1 DP 503731 and comprises an area of some 3.6 hectares. The site layout is shown in further detail in Figure 2. Selected photographs of the site and surrounds are provided in Appendix C.

13 The site is bordered by Portage and Selfs roads, to the north and east respectively, with existing residential properties beyond, except where Aorere College is located opposite the site along Selfs Road. A narrow strip of vacant land, owned by Waka Kotahi NZ Transport Agency, borders the site to its south and west, with the South Western Motorway (State Highway 20 or SH20) beyond. A quarry and filling operation is located across SH20 from the site, within the Crater Hill volcanic centre. The remainder of the volcano is predominantly under pastoral and horticultural uses (Selfs Farm) with Portage Road Reserve occupying its central area (largely now covered by a freshwater lake).

Figure 1: Site location – blue outline (source: Auckland Council GeoMaps)

14 The site is located on the north-eastern flank of the tuff ring derived from the Crater Hill volcanic centre (further discussion of the geological setting is provided in the following section). A steep slope is present beyond the south western boundary of the site, formed by a combination of cutting undertaken to create the SH20 and the original inner slope of the tuff ring/explosion crater. The site itself generally slopes at a moderate gradient to the north-east towards Selfs Road.

15 The site is currently occupied by two residential dwellings, associated ancillary structures (garages and sheds) and landscaping. A tennis court, large barn/equipment shed and stock pens are also located adjacent to the central dwelling (Selfs Homestead). The remainder of the site is being used for pastoral grazing.

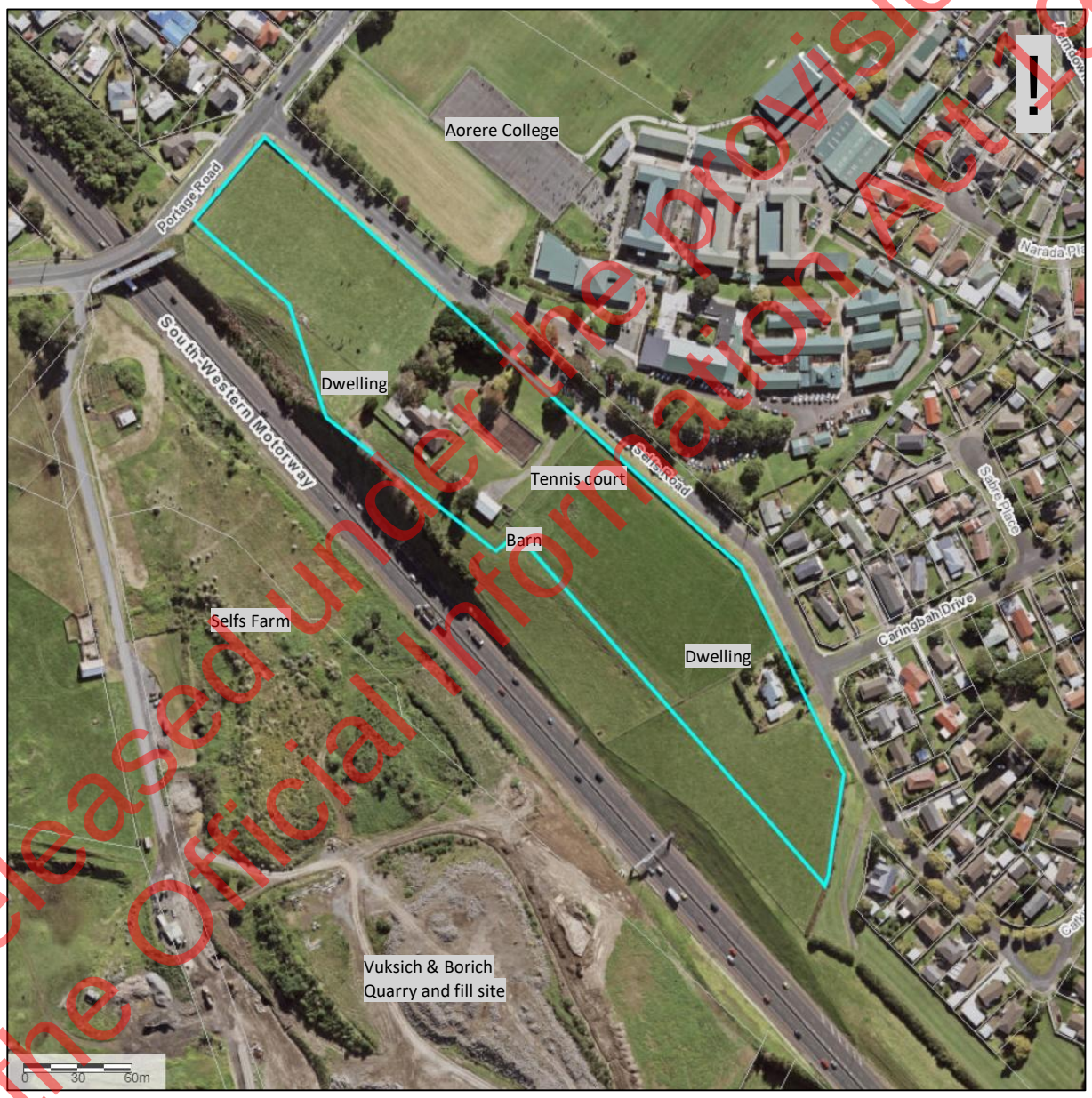

Figure 2: Layout of site (blue outline) and immediate surrounds (source: Auckland Council GeoMaps)

Development proposal

16 I understand that Acanthus Limited is seeking approval via the COVID-19 Recovery (Fast-track Consenting) Act 2020 to construct some 115 dwelling units and lots on the site. Preliminary development plans are provided in Appendix A. The application documents to which this assessment is appended comprehensively describe the proposed development and I only provide a summary below to give context to this assessment.

17 The proposal will involve benching into the existing slope to form level generally northeast-southwest oriented building platforms stepping up from Selfs Road. The building platforms will be supported by a combination of low retaining walls and batters. Cut depths and retained heights will be subject to detailed design but are currently anticipated to be less than approximately 3 m, and typically less than 2 m.

18 Earthwork volumes across the site are estimated at 31,143 m^3 of cut and 575 m^3 of fill with the excess cut being removed from site (refer to cut fill plans provided in Appendix A).

19 Of particular relevance to the geological characteristics of the site, the development proposal is set back from and below the crest of the slope formed by construction of the SH20 and the original inner slope of the tuff ring/explosion crater (refer to Figure 3).

20 We understand the ridgeline is to remain in private ownership and is to be managed by the Residents Society. Legal mechanisms for on-going preservation and maintenance of the walkway, with iwi involvement, including planting and hard landscaping elements (sculptures, storey boards and the like) to recognise and educate regarding iwi affiliations with the site are currently being explored. The relevance of this is discussed further in the following sections.

Figure 3: Render of proposed development, looking south along crater rim (see original drawing in Appendix A)

Geological setting

21 The geological setting of the site is summarised (after Edbrooke 2001) in Figure 4. As indicated in Paragraph 14, the site is located on the north-eastern flank (outer slope) of the tuff ring derived from the Crater Hill volcanic centre.

22 Crater Hill is one of some 50 volcanoes that have erupted across Auckland's urban area, within some 20 kilometres of its centre, forming what is known as the Auckland Volcanic Field. The Auckland Volcanic Field has erupted spasmodically over the last 200,000 years or so. Most of Auckland's individual volcanoes are thought to have resulted from a single separate, relatively short-lived eruption sequence, lasting from just days to a few months.

23 The volcanoes are thought to arise from a 'hot spot' located some 80 km beneath Auckland. Periodically a batch of molten rock or magma gains enough buoyancy to ascend through the surrounding rock and, if it reaches the surface, to erupt as a volcano.

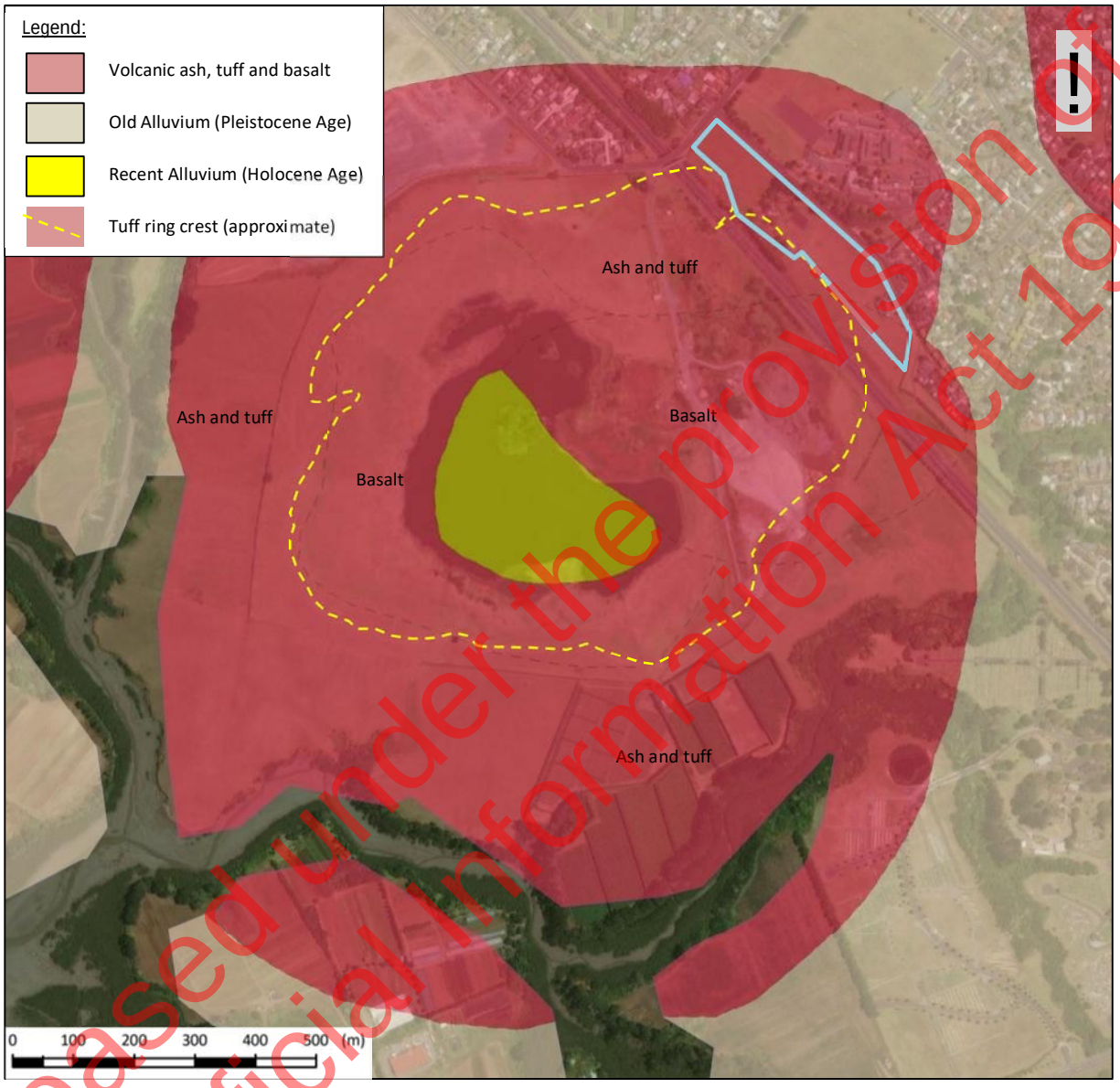

Figure 4: Mapped geology (after Edbrooke 2001) showing approximate site location (blue outline)

24 The shape of the volcano that forms depends on the eruptive style, with three primary types recognised:

a Wet explosive (phreatomagmatic) eruptions occur when rising magna violently explodes to the surface following contact with shallow groundwater. These eruptions produce explosion craters (maar) and tuff cones or rings may be formed from ash and tuff.

b Fire fountaining (Hawaiian) is a dry eruptive style where gases released from the magma cause liquid rock to be sprayed into the air, sometimes up to tens of metres high, producing scoria, spatter, lava bombs. Fire fountaining may result in the formation of scoria cones.

c Lava flows occur when the magma is less gaseous and its viscosity allows it to flow from vents, or breach scoria cones. The form of the flow is controlled by the rate of eruption, temperature and surrounding topography, spreading out across subdued lands or flowing down and filling stream valleys where present. In some instances, caves form by the lava cooling on the outside, with the hotter core draining out, leaving an empty tube or cave.

25 The geological history and features of Crater Hill are well described by the authors of previous assessments (including Brown, Hayward, Jamieson, Kermode). I do not repeat the history here, rather I summarise the key formation processes and associated features.

26 The Crater Hill volcanic centre erupted some 30,000 years ago, initially as a wet explosive eruption. The exploded materials (volcanic ash and fragmented country rock) then fell back to ground mantling the surrounds of the explosion crater and hardening to form tuff. A raised tuff ring, up to some 15 m in height and 1,000 m across (measured at its crest), formed across multiple eruptive cycles.

27 As shown in Figure 5, the greatest thickness of tuff generally develops closest to the crater(s) with deposits thinning with distance away from the eruption centre and grading onto the surrounding topography. The subject site is located on the upper part of the outer slopes of tuff ring that formed during eruption of the Crater Hill volcano. Crater Hill is one of about 34 Auckland volcanoes with explosion craters (Kermode 1992).

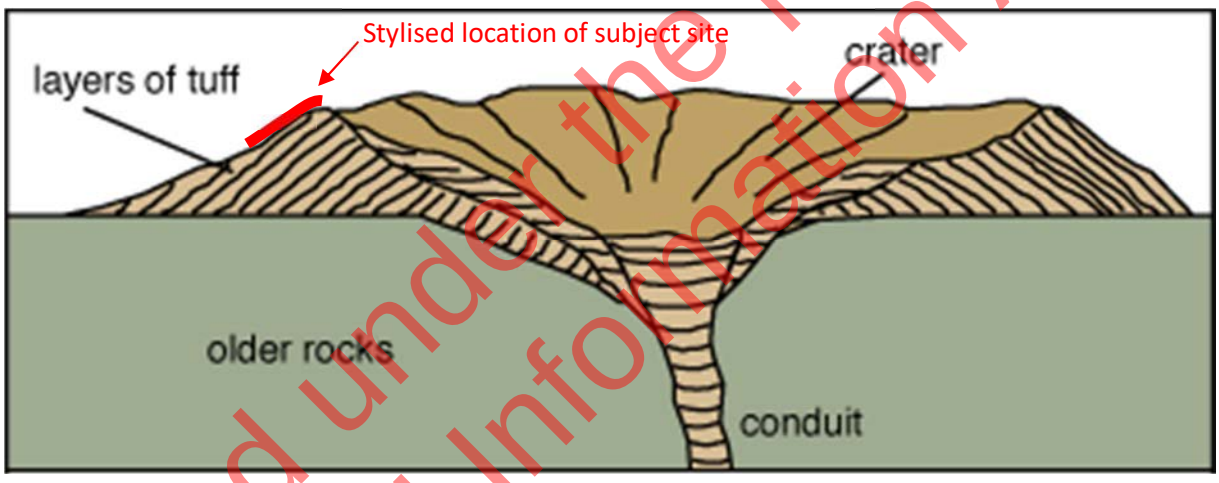

Figure 5: Stylised cross-section of an explosion crater and tuff ring, the subject site is primarily located on the upper part of the outer slopes of the tuff ring

28 In addition to its explosion crater and associated tuff ring the Crater Hill volcano includes a number of other geological features. The features are generally most evident in aerial photographs from the 1950-1960s, excerpts of which are provided as Figure 6 and Figure 7. The key features are summarised as follows:

a A lava lake which partially filled the crater ultimately withdrew leaving basalt crusts as 'tide marks' around the inner slopes of the crater/tuff ring. Crater Hill is the best preserved of only four maar craters within the Auckland Volcanic Field that contain evidence of a lava lake having partly filled the crater.

b A pile of basalt slabs and boulders forms an island above the main vent. This is inferred to be solidified portions of the crust that formed on the lava lake surface that were not drawn back down the vent as the lava lake drained.

c The rim of the crater/tuff ring has a scalloped form, indicating a number syn-eruption slump scarps that are believed to have been produced by wet ash/tuff slumping back into the crater as the tuff ring was still forming.

d Secondary explosion craters have also been identified within the wider feature. The most prominent is located in its north-eastern portion, adjoining the subject site. This feature has largely been destroyed by construction of SH20. What remains has also been modified as evidenced by the inclusion of concrete debris in the rock outcrop (see Photograph Appendix C.9 to Photograph Appendix C.13).

e Two lava caves, Selfs and Underground Press, exist beneath the remnant crust on the south side of the crater. These are reported to be the only New Zealand examples of lava caves formed beneath the solidified surface crust of a lava lake. A number of smaller lava caves or blisters have also been mapped around the former extent of the lava lake.

f Quarrying of the scoria cone and tuff within the crater has previously provided exposures that recorded the eruption sequence of the volcano. However, these exposures have now been covered by filling operations and the approximate original form of this part of the tuff ring has now been restored.

g Today the floor of the crater is occupied by a freshwater lake. Crater Hill is one of only two maar craters in Auckland still retaining its original freshwater lake. The lake largely coincides with Portage Road Reserve, an Auckland Council reserve that covers the central part of the crater.

In the past the lake was used to supply water to Dominion Breweries in Otahuhu. It was also reportedly drained by a tunnel, presumably to support quarrying operations. I understand from discussions with Mr Mark Self (landowners representative) that since these activities ceased the lake has become a more permanent feature. Areas of the crater floor that were previously farmed when the lake was ephemeral now typically remain submerged. Groundwater continues to be taken from Crater Hill to support the farming and horticultural (kiwifruit) activities that are the primary use of the wider volcanic centre.

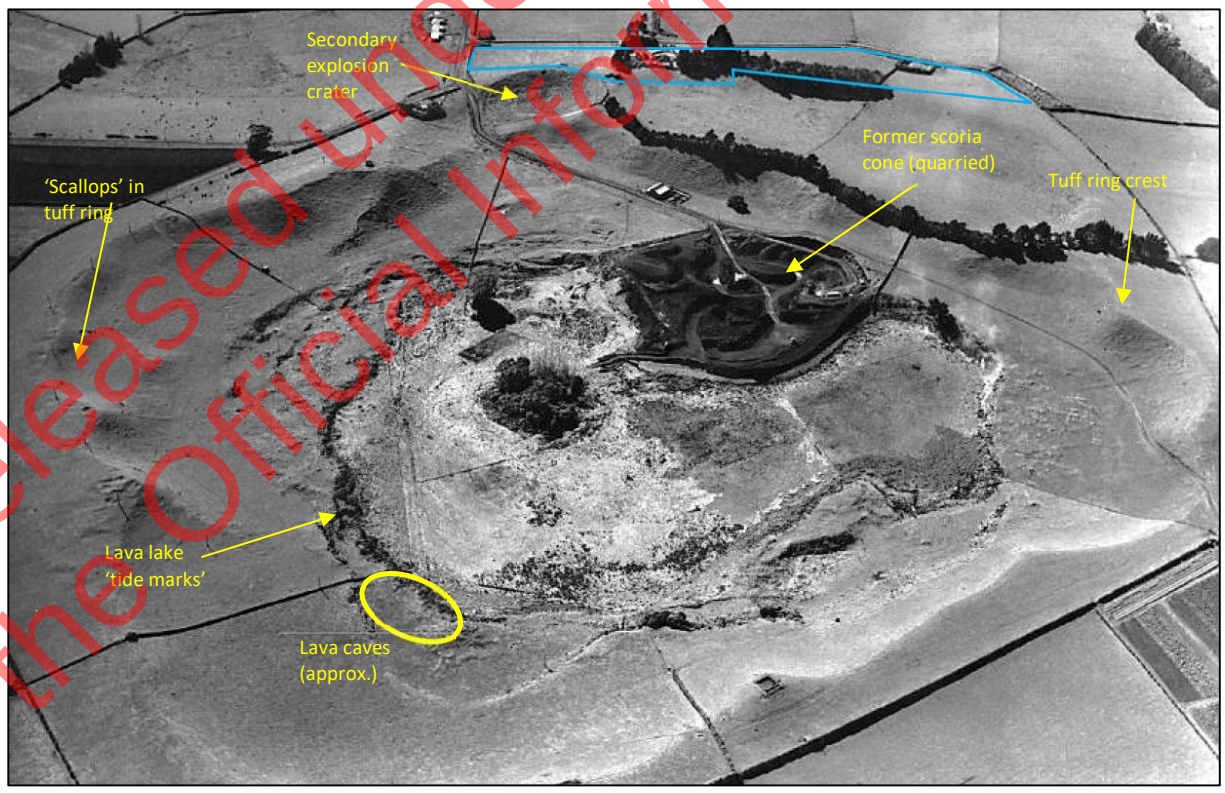

Figure 6: Crater Hill in the late 1950s showing key features relative to site, blue outline (source: Whites Aviation, reproduced from Hayward 2019)

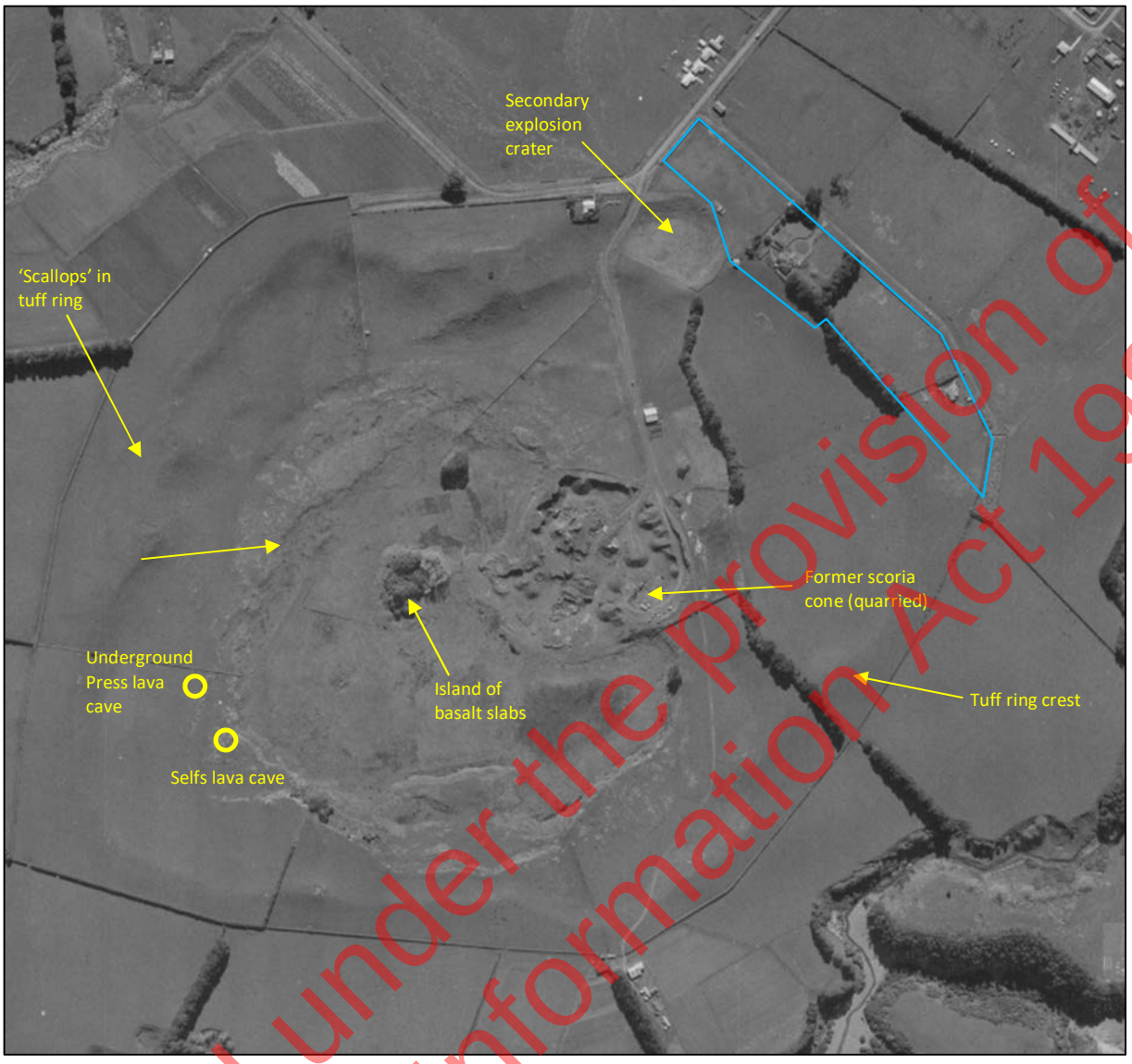

Figure 7: Crater Hill in 1960 showing key features relative to the site, blue outline (source: Retrolens)

29 As described above and shown in Figure 6 and Figure 7, while the Crater Hill volcanic centre includes a number of notable geological features, the subject site is significantly set back from the majority of these. Only a secondary explosion crater (largely destroyed/modified) and the crest of the main tuff ring/explosion crater adjoin the subject site.

Scheduling of the ONF

30 The Auckland Regional Policy Statement 1999 (APRS 1999) notes that Auckland's sense of place is in part defined by its volcanic field. Much of the city is built over and out of its volcanoes. Auckland is unique internationally as a city situated on a volcanic field of this type. It is therefore appropriate to protect the outstanding features of the volcanic field. However, the APRS also promotes a balanced and judgement-based approach to management. I interpret this as protecting those areas and features that have significant geological value while being accepting of responsible further modification to areas and features of lesser or impaired value.

31 One of the challenges assessing the effects of this proposal on the ONF is that the AUP includes little specific detail as to the values for which the subject site is scheduled, other than being part of the wider Crater Hill volcanic centre. I have reviewed scheduling details relating to Crater Hill to provide further, site specific evidence of its geological value.

32 The first detail provided in relation to Crater Hill appears to be its listing in Appendix B of the APRS 1999. Where it was described as (underline added for emphasis):

> *"CRATER HILL east of Pukaki is larger and less regular, the tuff ring having been destroyed by subsequent eruptions to the north east as far as the present railway line at Papatoetoe. The inner slopes of the tuff ring have also been eroded back by a freshwater and at times swampy lake. These processes make it unique in the Auckland field and protection, at least in part, is therefore warranted. A strip section down the inside of the crater showing the processes of construction would be appropriate. The area has been exploited as a source of peat, the eastern side modified by a road and parts of the area have been quarried. Crater Hill is considered to be of national importance."*

33 As emphasised, it appears that protection in part was being considered at this time, although it is noted in the APRS 1999 that the feature was considered to be of national importance.

34 Crater Hill was later identified on the Regionally Significant Volcanic Features (Map Series 2a Sheet 4) through the appeals process for Auckland Regional Policy Statement Plan Change 8 – Landscapes and Volcanic Features. This appears to be the first time that the extent of the Crater Hill ONF was published[8]. The extent appears to be consistent with the current ONF overlay, which is reproduced in Figure 8.

35 As shown in Figure 8, not all of the mapped extent of Crater Hill is included in the ONF overlay, rather it only captures unmodified areas of the feature. It is also unclear why the southern and northern extents of the tuff ring are not captured by the ONF overlay. The southern extents remain in use for horticultural and cemetery purposes (i.e. minimally disturbed) today. The outer slopes of the north-western portion of tuff ring were also under horticultural use, and the same zoning (Mangere Puhinui Rural Zone) at the time that the Regionally Significant Volcanic Features maps were published (refer to Figure 9). The north-western portion, adjoining Tidal Road, has subsequently been rezoned and is under development, with a large steel framed building under construction (see Photograph Appendix C.19 to Photograph Appendix C.23). It seems that Council has applied a lesser value to the outer tuff ring in this area.

8

Figure 8: ONF overlay (green dots) versus geology (after Edbrooke 2001) with mapped extent of tuff shown (red)

Figure 9: Outer slopes of the north-western portion of tuff ring, now under development for (source Google Street View, image captured in 2012)

36 Schedule 6 Outstanding Natural Features Overlay Schedule of the AUP now describes Crater Hill (ONF 22) as follows. I provide comment in the context of the subject site:

Scheduling description	Comments
Crater Hill is one of the two best remaining explosion craters and tuff rings in Manukau City.	While accurate this statement is misleading as Crater Hill should be assessed in the context of the entire Auckland Volcanic Field, not on a local basis. As described above, Crater Hill is one of about 34 Auckland volcanoes with explosion craters (Kermode 1992). It is one of 19 explosion craters with surrounding tuff rings in the Auckland Volcanic Field (Hayward et al. 2011). It is therefore rare but not unique in the region.
It is a complex volcanic centre including a large, embayed tuff ring 600m in diameter, enclosing a (quarried) scoria cone and small lava flow.	This description can be applied to many of the 50-some volcanic centres that comprise the Auckland Volcanic Field. It is not an appropriate measure of its uniqueness.
Crater Hill has a unique example in the Auckland volcanic field of the cooled remnants of a lava lake that filled the crater and later withdrew down the vent.	Agreed. However, these features are located a considerable distance from the subject site (>250 metres).
It is also the only remaining explosion crater in the Auckland field where the external slopes of the volcano outside the crater rim are nearly entirely intact and unmodified.	This is a somewhat subjective statement. Based on its mapped extent (by Edbrooke 2001, see Figure 4) some 27 hectares of the outer slopes of Crater Hill have been developed, with some of this development being permitted as recently as 2016 (refer to Paragraph 35). This equates to some 16% of the total mapped extent (~170 ha) of the entire feature, or some 25% of the external slopes. This statement is more accurate with respect to the western and south external slopes, which remain largely in use for pastoral farming.
Two lava caves are present. Selfs lava cave is about 48m long and circumferentially oriented within the volcanic crater. Underground Press lava cave is 40m long lava cave with a large main chamber, reputedly used as a base for clandestine, subversive publishing during World War II.	Agreed. However, these features are located a considerable distance from the subject site (>700 metres).
The Crater Hill quarry exposures are a useful educational site with excellent exposures of lithic tuff, basaltic lapilli, crater rim collapse features and a thin layer of rhyolitic tephra from the central North Island.	These exposures have now been covered by filling operations and therefore provide limited (if any) ongoing educational value. They are also located some distance from the subject site (>100 metres).

37 The criteria set out in Policy B4.2.2(4) of the AUP have been used by Council to schedule ONFs. Council has assessed that criteria a, b, c, d, e, g and i (in grey highlight below) apply to the Crater Hill ONF. As indicated in Paragraph 31, Council does not detail its assessment. However, Hayward 2013 provides an assessment of both the wider Crater Hill volcano as a whole and specific features of it, including the eastern portion of the tuff cone on which the subject site is located. I consider that this is an appropriate way to treat the site considering its dislocation from the wider volcanic centre by SH20. I provide the following comments as context to my assessment of the geological effects of this development proposal:

Scheduling criteria	Hayward 2013	Comment
a. the extent to which the landform feature or geological site contributes to the understanding of the geology or evolution of the biota in the region, New Zealand or the earth (includes type localities of rock formations, minerals and fossils)	"moderate, retains eastern edge of small crater on cone crest, highest point on tuff cone provides excellent views over rest of volcano"	Agreed. However, as shown in Figure 3 and Figure 10 neither the crest (crater rim) nor small crater (secondary explosion crater) will be materially impacted by the proposed development as a setback has been intentionally maintained from these features. The sites contribution to the understanding of the geology will therefore not be compromised. The development will provide public access, that is not currently available, to the excellent views over the rest of the volcano (see examples in Photograph Appendix C.6 to Photograph Appendix C.8).
b. the rarity or unusual nature of the site or feature	"moderately low, this eastern crest of the tuff cone and some of its outer slopes are only slightly modified compared with majority of other tuff cones in Auckland Volcanic Field"	I apply this criterion as being rare or unusual from a geological perspective, rather than reflecting its level of modification, since the state of preservation or modification is addressed by criteria i. As described previously Crater Hill is one of 19 explosion craters with surrounding tuff rings in the Auckland Volcanic Field (Hayward et al. 2011). It is therefore rare but not unique in the region. As described in response to point a., the crest of the tuff cone/ring will not be materially impacted by the proposed development.
c. the extent to which the feature or site is an outstanding representative example of the diversity of natural landforms and geological features in Auckland	"moderately high, as part of the highly-rated whole Crater Hill Volcano, downgraded because it is dislocated from it"	As described in response to point b., Crater Hill is one of 19 explosion craters with surrounding tuff rings in the Auckland Volcanic Field (Hayward et al. 2011). This section of it is no longer an outstanding representative example as it has been extensively modified and dislocated by the construction of SH20. Nevertheless, the development proposal provides protection of the remanent features, being the crest/rim.
d. the extent to which the landform, geological feature or site is part of a recognisable group of features	"moderate, when viewed from numerous passing aeroplanes and the south; this is the highest and therefore most visible part of the volcanic cone"	Parts of the development may be visible from within the crater, beyond SH20 (see Photograph Appendix C.14 to Photograph Appendix C.17) or from aircraft. Nevertheless, by setting back from and below the tuff ring rim I consider that the proposed development does not further alter the ability to recognise the feature as part of the wider tuff ring. In addition: · The crater is not currently accessible to the public; and

Scheduling criteria	Hayward 2013	Comment
		· I place limited weight on the momentary views provided from aircraft. When approaching from the east the development will merge with its existing urban neighbours and the crater and lake beyond SH20 are likely to become the focal point for observers. When approaching from the west the current (modified by SH20) inner face and crest of the tuff ring will remain recognisable. · The images provided in Appendix D[9] show that the site has a subdued form from all but its western side. It is primarily discernible because it is undeveloped relative to its surrounds. Once developed it is likely to merge with its existing urban neighbours. The site's western frontage onto SH20 will not be materially changed by the proposed development. However, even passengers (or drivers in stationary traffic) only get partial, and normally momentary, views of the wider Crater Hill volcano when travelling along SH20 (see Photograph Appendix D.23 and Photograph Appendix D.24).
e. the extent to which the landform or geological feature or site contributes to the value of the wider landscape	[no comment provided by Hayward]	The site contributes to the wider form of the Crater Hill volcanic landscape, albeit modified and dislocated by SH20. As described in response to the previous points, the development proposal is not expected to materially change this contribution.
f. the community association with, or public appreciation of, the values of the feature or site	[no comment provided by Hayward]	I cannot comment conclusively on the community association with, or public appreciation of the values of the feature. However, given its limited discernibility and accessibility I expect that the general public has a low level of appreciation of the feature. As described in response to point a., the development will provide public access to the excellent views over the rest of the volcano. This has the potential to greatly increase the public appreciation of the wider Crater Hill volcanic centre. The unique features of the wider Crater Hill volcanic centre clearly have a high value to a small special interest group. However, as indicated above, these features will not be impacted by this proposal.
g. the potential value of the feature or site for public education	"moderate, as a view point over the volcano and surrounding countryside" [note comment is erroneously provided against point f. by Hayward]	I give more weight to the educational value that the excellent views this development will provide over the wider Crater Hill.
h. the potential value of the feature or site to	"moderately low as potential for research	Agreed.

[9] Images were captured from Google Street View (in April 2021)

Scheduling criteria	Hayward 2013	Comment
provide additional understanding of the geological or biotic history of the region	on base surges and on the small explosion crater remnant" [note comment is erroneously provided against point g. by Hayward]	
i. the state of preservation of the feature or site	"moderate, with significant damage and loss of value as a result of the motorway" [note comment is erroneously provided against point h. by Hayward]	Agreed.
j. the extent to which a feature or site is associated with an historically important natural event, geologically related industry, or individual involved in earth science research	[no comment provided by Hayward]	While not relevant to the reason for its inclusion as an ONF, I am not aware of the feature being associated with an historically important natural event, geologically related industry, or individual involved in earth science research, excepting the respected authors who have written about Crater Hill. However, as far as I am aware none of the authors is specifically recognised with respect to Crater Hill, rather all have been involved more widely in the study of the Auckland Volcanic Field.
k. the importance of the feature or site to Mana Whenua	[no comment provided by Hayward]	I am unable to comment on the importance of the feature or site to Mana Whenua but note that this was not considered to be a matter of relevance to the reason for its inclusion as an ONF.

38 In his assessment Hayward (2013) concludes that *"the high eastern portion of the tuff cone rim (east of the motorway)"* is *"regionally rare and outstanding"*. He assesses *"…that Crater Hill volcano as a whole (tuff cone and crater) is of national importance"*.

39 I concur with the approach of assessing the eastern portion of the tuff cone/ring, on which the subject site is located, separately from the wider Crater Hill volcanic centre from which it has been dislocated by the construction of SH20.

40 I also agree that the remnant inner slope of the tuff ring and its rim remain of significance. Accordingly, this development proposal seeks to protect the inner slope and rim of the tuff rim adjacent to the site.

41 However, in my opinion, the outer tuff ring which, except for the subject site, has been almost entirely built over (across its northern and eastern portions), has much lower geological value and therefore does not warrant the same level of protection as the inner slope and rim of the tuff ring. Its modification is of much lower significance. Rather, consideration should be given to maintaining the general visual form of the outer tuff ring. This can be achieved by establishing new structures and/or vegetation which are sympathetic to the general form, rather than needing to limit excavation or development in these areas.

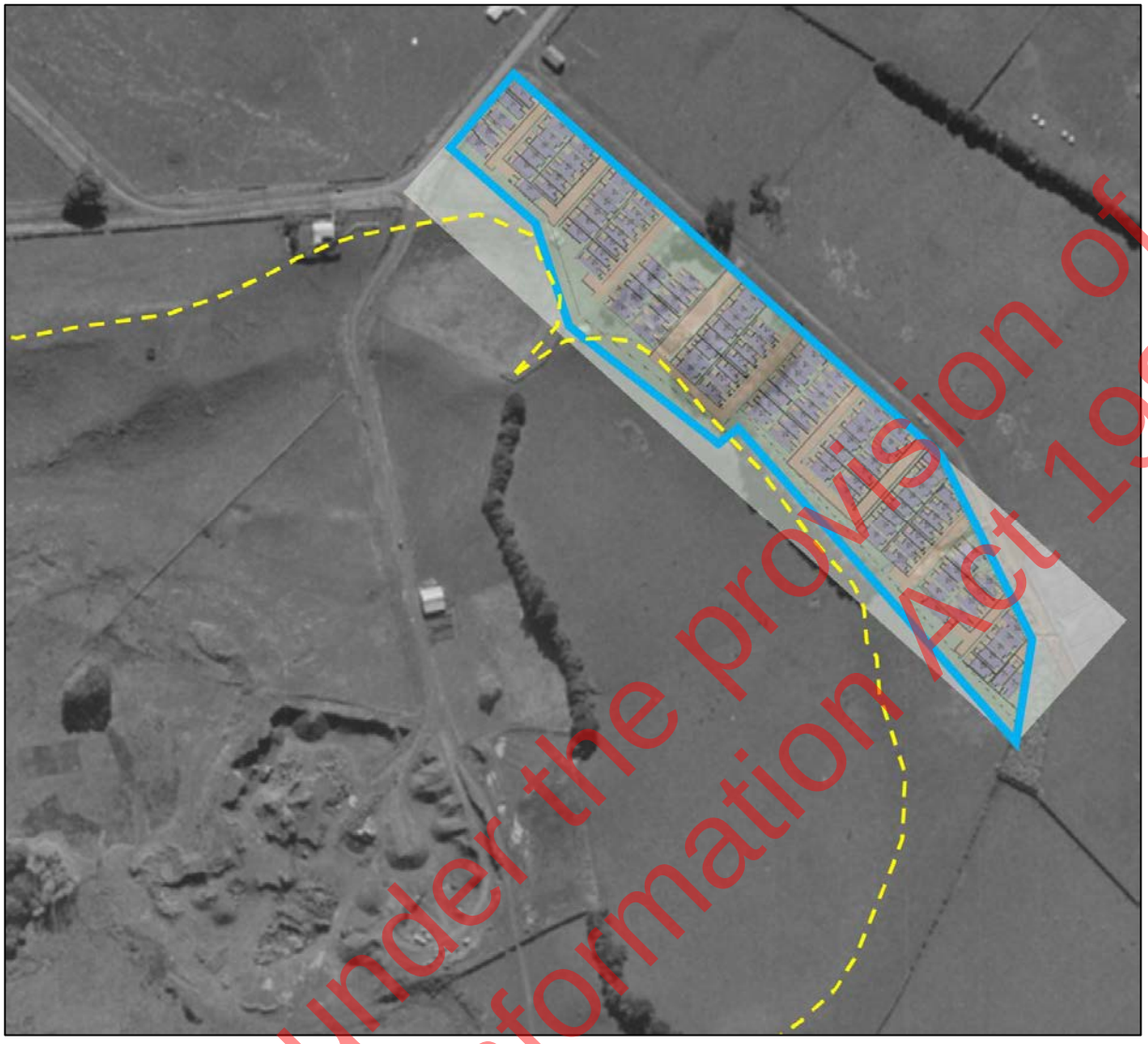

Figure 10: Relationship between the site (blue outline), tuff rim crest from 1960s aerial (yellow dashed line) and proposed development plan (see original in Appendix A). Aerial sourced from Retrolens, refer to Figure 7.

Assessment of effects of the proposal on the ONF

42 Section D10.4.2 of the AUP requires that any development of buildings and structures (Activity A1 on Feature Codes V2[10] and F2[11]) is a Restricted Discretionary Activity (RDA). Section D10.8.2 states that Council will consider the relevant assessment criteria from the list below for RDAs. I interpret that criteria 1 to 3 (in grey highlight below) are relevant to geological aspects, responses are provided to the other matters but the reader is referred to the landscape assessment prepared by Boffa Miskell[12] for more detail on those items.

[10] V2: the privately owned and partially modified portions of the scoria cones, explosion craters and tuff rings of the Auckland and South Auckland volcanic fields.

[11] F2: lava caves are divided into interior areas within 5 metres of the entrance F1, and exteriors F2. This proposal does not disturb and known lava caves but this feature code is applied to Crater Hill so is included here for completeness.

[12] 1 Selfs Road, Papatoetoe: Landscape Effects Assessment. Report prepared by Boffa Miskell Limited for Myland Partners, dated 1 July 2021. Reference: BM200981_SelfsRoad_ONF_LEA_FINAL.

Assessment criteria	Comment
1. The extent to which the nature, form and extent of the proposed use or development adversely affects the criteria or values for which the feature was scheduled taking into account all of the following:	As shown on Figure 3 and Figure 10, the development proposal seeks to protect the inner slope and rim of the tuff ring adjacent to the site, the key values for which the subject site was scheduled. Where the development encroaches near the crest, works will typically be limited to battering and landscaping, thereby maintaining the crest area in a manner that is sympathetic to its original form.
a. whether the use or development will result in increased erosion, of the feature;	On completion of the development the site will be covered by buildings, pavements, and landscaping vegetation therefore the development will not result in increased erosion of the feature, relative to its recognisable qualities.
b. whether the use or development will result in increased compaction or erosion of the feature, or changes to the vegetation will adversely affect the values for which the feature is scheduled;	The development will not result in increased compaction or changes to the vegetation that will be materially affect the values for which the feature is scheduled.
c. whether the use or development will result in ground disturbance or earthworks that will affect the values for which the feature is scheduled; and	The outer tuff ring, which except for the subject site has been almost entirely built over (across its northern and eastern portions), has much lower geological value and therefore does not warrant the same level of protection as the inner slope and rim of the tuff ring. Its modification is of much lower significance. In addition, except for the rim, which is to be protected, no geological exposures or outcrops of significance exist on the site and therefore none will be modified or lost because of the development. Ground disturbance, with cuts of up 2 m bgl, is required to achieve the proposed development form. Once new structures are built the overall form of the outer slope of the tuff ring will be maintained in a manner that is sympathetic to its original form and consistent with neighbouring sites.
d. whether the use or development will interfere with natural processes associated with the feature.	The use or development will not interfere with natural processes associated with the feature.
2. The extent to which the proposed use or development will cause adverse visual effects, or adversely affect landscape values associated with the feature.	I consider that the proposed development is sympathetic to the original form of the explosion crater/tuff ring. A detailed landscape assessment has been prepared by Boffa Miskell.
3. The extent to which the proposed use or development will cause any significant loss of geological value of a feature, taking into account the extent a feature has already been modified and whether further modification will cumulatively result in a significant loss of geological value.	The development proposal seeks to protect the inner slope and rim of the tuff ring adjacent to the site, the key values for which the subject site was scheduled. The footprint of the development comprises some 2% of the mapped extent (by Edbrooke 2001, see Figure 4) of Crater Hill. Its construction will result in some 18% of the total mapped extent (~170 ha) being developed. The development will occur on the outer slopes of the tuff ring, a feature having lesser geological value, and in an area already extensively developed. The development

Assessment criteria	Comment
	will retain the primary geological value of the site by being sympathetic to the original form of the outer tuff ring. For these reasons the proposed use is not considered to cumulatively result in a significant loss of geological value.
4. The extent to which modification of a feature is necessary to provide for the proposed use or development and the proposed structure has a functional or operational need to be in the location proposed.	Some modification of the feature is required to provide for the proposed development. However, I consider that the proposed development is sympathetic to the original form of the explosion crater/tuff ring. I also consider that the site has much lower geological value than the inner slope and rim of the tuff ring and its modification is therefore of much lower significance.
5. The extent to which the proposed use or development has a specific connection or relationship to the scheduled feature.	Assessment of this criteria is provided by others, but I note that the development will provide public access to previously unavailable views over the rest of the Crater Hill volcano.
6. Whether there are alternative methods and locations available to undertake the use or development that will not affect a scheduled feature.	Assessment of this criteria is provided by others, but I consider that the proposed use results in less than minor effect on the geological value of Crater Hill.
7. Whether any site/s resulting from a subdivision can be developed without adversely affecting the values for which the feature is scheduled.	As noted above, I consider that the site has much lower geological value than the inner slope and rim of the tuff ring and its modification is therefore of much lower significance.
8. The extent to which the proposed works will protect the feature from damage, such as providing for erosion protection, or remediate previous damage, excluding any damage resulting from the use or development itself.	The proposed development is sympathetic to the original form of the explosion crater/tuff ring. Overall the proposal will enhance feature by providing access to previously unavailable views over the rest of the Crater Hill volcano.
9. The extent to which the proposed use or development will adversely affect Mana Whenua values.	I am unable to comment on the potential effect on Mana Whenua values or objectives and policies in E20 Māori Land other than noting that the proposal has sought to recognise these values by maintaining the crater rim / ridgeline in open space, accessible to the iwi and wider public and enabling encompassing views of Ngā Kapua Kohuora from this natural highpoint.
10. The extent to which, having had regard to the objectives and policies in E20 Māori Land, the proposed use and development provides for Mana Whenua, matauranga and tikanga values.	

Summary and conclusions

43 Acanthus Limited has engaged Tonkin & Taylor Ltd (T+T) to provide a geological assessment of its proposal to construct some 115 dwelling units and lots at 1 Selfs Road, Papatoetoe (the site).

44 The site is subject to an Outstanding Natural Feature (ONF) overlay (ID 22) associated with the Crater Hill/Ngā Kapua Kohuora volcanic centre. As a result, an assessment of effects of the proposal on the geological values of the ONF is required to support the consent application process. I have completed a geological assessment of the property and associated development proposal by collating and reviewing geological information for the site from in-house and published sources.

45 I consider that the Crater Hill volcano as a whole has significant geological value. However, the eastern portion of the tuff cone, on which the subject site is located, has been dislocated from the wider Crater Hill volcanic centre by the construction of SH20. While the remnant inner slope of the tuff ring and its rim adjoining the site remain of significance, in my opinion the outer tuff ring, which except for the subject site has been almost entirely built over (across its northern and eastern portions) has much lower geological value and therefore does not warrant the same level of protection. Its modification is of much lower significance.

46 Accordingly, this proposal seeks to protect the inner slope and rim of the tuff rim adjacent to the site by setting back the development back from and below the crest. Once new structures are built the overall form of the outer slope of the tuff ring will be maintained in a manner that is sympathetic to its original form and consistent with neighbouring sites. In my opinion no significant loss of geological value will result.

47 As the development will provide public access to the excellent views over the rest of the volcano I consider that the development has the potential to offer significant educational value and greatly increase the public appreciation of the wider Crater Hill volcanic centre.

Applicability

48 This report has been prepared for the exclusive use of our client, Acanthus Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

49 We understand and agree that our client will submit this report as part of an application for resource consent and that the consenting authority will use this report for the purpose of assessing that application.

50 Recommendations and opinions in this report are based on our desktop review of previous research. The nature and continuity of stratigraphy is inferred but it must be appreciated that actual conditions may vary from the assumed model.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:

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Shane Moore
Principal Environmental Scientist

SRMM
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Appendix A: Preliminary development plans

SELFS ROAD HOUSING PROPOSAL

1 SELFS ROAD, OTAHUHU
AUCKLAND

Sheet Index

Layout ID	Current Revision ID	Layout Name
101	01 - WIP	SITE CONTEXT PLAN
102	01 - WIP	TYPOLOGY SITE PLAN
103	01 - WIP	COVERAGE SITE PLAN
104	01 - WIP	SURVEY SITE PLAN ********
201	01 - WIP	JOAL 1 PLAN
202	01 - WIP	JOAL 1 RETAINING
203	01 - WIP	JOAL 2 PLAN
204	01 - WIP	JOAL 2 RETAINING
205	01 - WIP	JOAL 3 PLAN
206	01 - WIP	JOAL 3 RETAINING
207	01 - WIP	JOAL 4 PLAN
208	01 - WIP	JOAL 4 RETAINING
209	01 - WIP	JOAL 5 PLAN
210	01 - WIP	JOAL 5 RETAINING
211	01 - WIP	JOAL 6 PLAN
212	01 - WIP	JOAL 6 RETAINING
213	01 - WIP	JOAL 7 PLAN
214	01 - WIP	JOAL 7 RETAINING
215	01 - WIP	JOAL 8 PLAN
216	01 - WIP	JOAL 8 RETAINING
217	01 - WIP	JOAL 9 PLAN
218	01 - WIP	JOAL 9 RETAINING
219	01 - WIP	JOAL 10 PLAN
220	01 - WIP	JOAL 10 RETAINING
301	01 - WIP	GROUND FLOOR PLAN A1
302	01 - WIP	GROUND FLOOR PLAN A2
303	01 - WIP	GROUND FLOOR PLAN A3
304	01 - WIP	GROUND FLOOR PLAN A4
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309	01 - WIP	GROUND FLOOR PLAN B3
310	01 - WIP	GROUND FLOOR PLAN B4
311	01 - WIP	GROUND FLOOR PLAN D1
312	01 - WIP	GROUND FLOOR PLAN D2
313	01 - WIP	GROUND FLOOR PLAN D3
314	01 - WIP	GROUND FLOOR PLAN D4
315	01 - WIP	GROUND FLOOR PLAN D5
316	01 - WIP	GROUND FLOOR PLAN D6
317	01 - WIP	GROUND FLOOR PLAN E
318	01 - WIP	GROUND FLOOR PLAN F
319	01 - WIP	GROUND FLOOR PLAN G
320	01 - WIP	GROUND FLOOR PLAN H
321	01 - WIP	GROUND FLOOR PLAN I
322	01 - WIP	GROUND FLOOR PLAN J
323	01 - WIP	GROUND FLOOR PLAN K
324	01 - WIP	GROUND FLOOR PLAN L
325	01 - WIP	GROUND FLOOR PLAN M
401	01 - WIP	ELEVATION JOAL 1
402	01 - WIP	ELEVATION JOAL 2
403	01 - WIP	ELEVATION JOAL 3
404	01 - WIP	ELEVATION JOAL 4
405	01 - WIP	ELEVATION JOAL 5
406	01 - WIP	ELEVATION JOAL 6
407	01 - WIP	ELEVATION JOAL 7
408	01 - WIP	ELEVATION JOAL 8
409	01 - WIP	ELEVATION JOAL 9
410	01 - WIP	ELEVATION JOAL 10
411	01 - WIP	ELEVATION SELFS ROAD
701	01 - WIP	SUN STUDY - WORST CASE
702	01 - WIP	SUN STUDY - STANDARD

CASA

Collingridge And Smith Architects (UK) Ltd | Beautiful Human Spaces

REV	DESCRIPTION	CHANGE ID	CHANGE NAME	DATE
01 - WIP	Contents Page		Work in Progress	

SELFS ROAD HOUSING PROPOSAL

1 SELFS ROAD, OTAHUHU
AUCKLAND

CASA
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REV	DESCRIPTION	CHANGE ID	CHANGE NAME	DATE

SELFS ROAD HOUSING PROPOSAL

1 SELFS ROAD, OTAHUHU
AUCKLAND

CASA
Collingridge And Smith Architects (UK) Ltd | Beautiful Human Spaces

REV	DESCRIPTION	CHANGE ID	CHANGE NAME	DATE

TYPOLOGY SITE PLAN 1:1000

NOTES

-All survey information shown supplied from **CIVIX**. CASA accept no liability for the accuracy of this information.

-Landscaping and planting shown is indicative only. Refer to Boffa Miskell landscape masterplan for accurate information

N

	TYPE A
	TYPE B
	TYPE D
	TYPE E
	TYPE F
	TYPE G
	TYPE H
	TYPE I
	TYPE J
	TYPE K
	TYPE L
	TYPE M
	SITE BOUNDARY
	SETBACKS
	APPROX TUFF RING

REV	DESCRIPTION	CHANGE ID	CHANGE NAME	DATE
01 - WIP	Contents Page			Work in Progress

JOB TITLE

MYLAND PARTNERS

ADDRESS

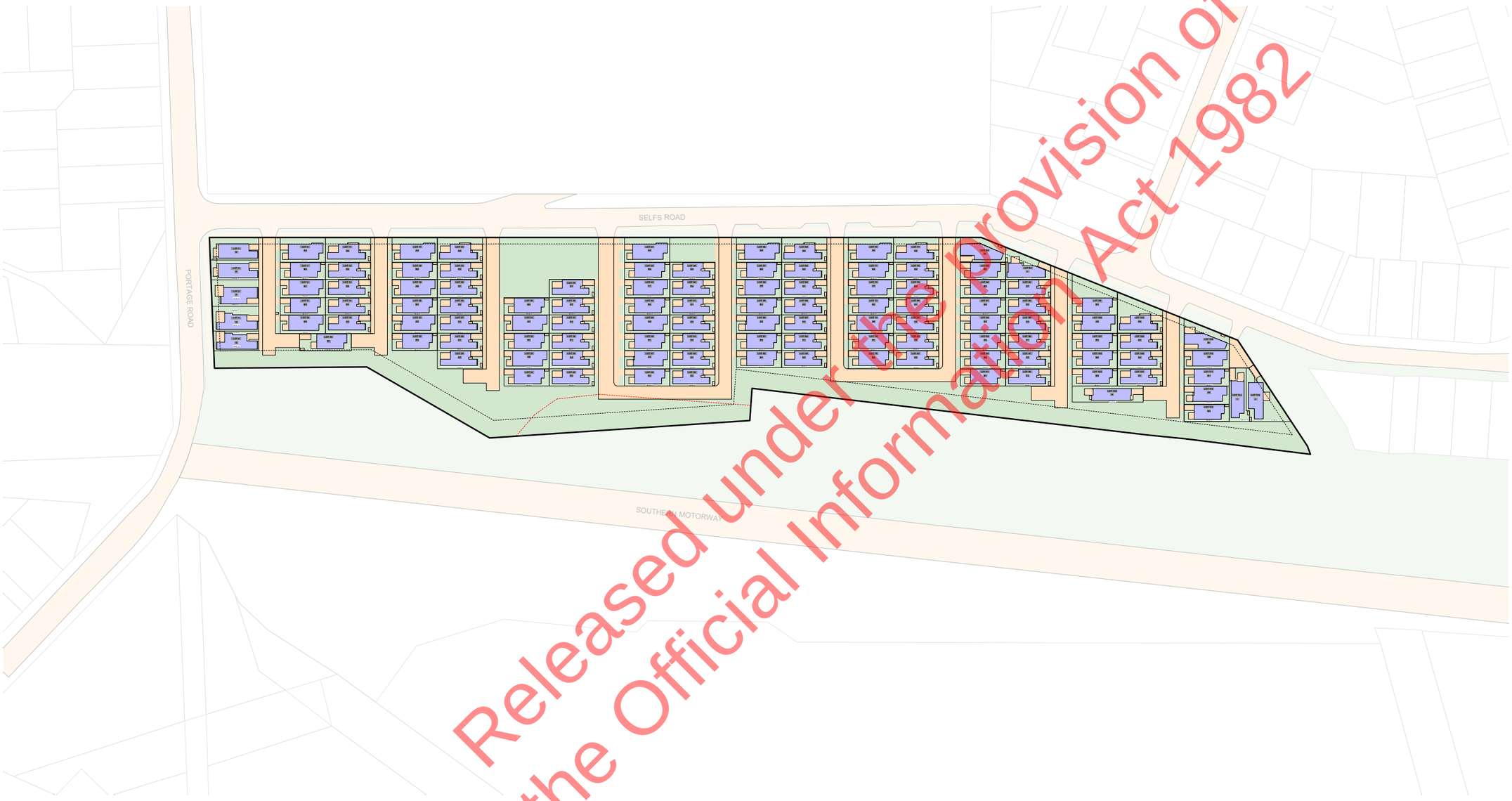
1 SELFS ROAD, PAPATOETOE AUCKLAND

DRAWING TITLE

TYPOLOGY SITE PLAN

SCALE	A1 - 1:1000 A3 - double	JOB NO.	PN-0372
DRAWN	DP	SHEET	REVISION
CHECKED		102	01 - WIP
DATE	7/09/2021		

CASA
Collingridge And Smith Architects (UK) Ltd | Beautiful Human Spaces
Level 1,, 2 Walton Street, Remuera, Auckland, NEW ZEALAND 1050 t : 09 522 2552



COVERAGE SITE PLAN 1:1000

NOTES

-All survey information shown supplied from **CIVIX**. CASA accept no liability for the accuracy of this information.

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MIXED HOUSING SUBURBAN COVERAGE REQUIREMENTS	
IMPERMEABLE	**60% MAXIMUM**
BUILDING COVERAGE	**40% MAXIMUM**
LANDSCAPING	**40% MINIMUM**

PROPOSED SITE COVERAGES TOTAL SITE AREA: 36,396.50m²	
IMPERMEABLE	**54.20%** 19,725.70m²
BUILDING COVERAGE	**29.77%** 10,835.00m²
LANDSCAPING	**45.80%** 16,670.80m²
	SITE BOUNDARY
	SETBACKS
	APPROX TUFF RING

01 - WIP	Contents Page			Work in Progress
REV	DESCRIPTION	CHANGE ID	CHANGE NAME	DATE

JOB TITLE

MYLAND PARTNERS

ADDRESS

1 SELFS ROAD, PAPATOETOE AUCKLAND

DRAWING TITLE

COVERAGE SITE PLAN

SCALE	A1 - 1:1000 A3 - double	JOB NO.	**PN-0372**
DRAWN	DP	SHEET	REVISION
CHECKED		103	01 - WIP
DATE	7/09/2021		

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Level 1, 2 Walton Street, Remuera, Auckland, NEW ZEALAND 1050 : 09 522 2552

LEGEND:

- RETAINING WALLS W DRAINAGE (H=HEIGHT, C=CHAINAGE, ARROWS SHOW FALL DIRECTION)
- EARTHWORKS SECTIONS
- EX. KERBLINES
- rw top and bottom levels
- EARTHWORKS EXTENT
- PROPOSED PAVEMENTS
- PROPOSED BUILDINGS
- NEW PARCELS
- EXISTING PARCELS

CUT(-) FILL(+)

- -4.0--3.0m
- -3.0--2.0m
- -2.0--1.0m
- -1.0-0.0m
- 0.0-1.0m
- 1.0-2.0m
- 2.0-3.0m
- 3.0-4.0m

CUT FILL VOLUMES

ITEM	UNITS	TOTAL	EW01
AREA	m²	**28,328**	28,328
CUT	m³	**31,143**	31,143
FILL	m³	**575**	575
FILL + 15% BULK F.	m³	**661**	661
CUTFILL BALANCE	m³	**-30,482**	-30,482
EST. CUT EXPORT	TRUCKS	**5,081**	-
BULK CF VOLUME	m³	**31,718**	31,718
MAX CUT DEPTH	m	**3.1**	3.1
MAX FILL HEIGHT	m	**1.3**	1.3
TOPSOIL TO STRIP	m³	**0**	-
TOPSOIL TO PLACE	m³	**2,066**	-
TOPSOIL BALANCE	m³	**2,066**	-
TOPSOIL VOLUME	m³	**2,066**	-
TOTAL EW VOLUME	m³	**33,785**	-
EST. TOPSOIL IMPORT	TRUCKS	**345**	-

CUTFILL ANALYSIS NOTES:

A. Ex. Surf is existing ground level

B. Pr. Surf. is to Building, Pavement and Grass Subgrade

NOTES:
1. ALL WORK TO COMPLY WITH COUNCIL AND PUBLIC NETWORK OPERTOR STANDARDS. ANY AMBIGUITY BETWEEN DRAWINGS AND STANDARDS TO BE REPORTED TO THE ENGINEER FOR CLARIFICATION
2. THE CONTRACTOR IS TO PEG INFRASTUCTURE LOCATIONS AND EARTHWORKS LEVELS PRIOR TO ORDERING MATERIALS.
3. UNDERFILL DRAINAGE IS TO BE INSTALLED AT THE DIRECTION OF THE ENGINEER. IF THE CONTRACTOR ENCOUNTERS SPRINGS OR OTHER SOURCES OF WATER, THEY ARE TO NOTIFY THE ENGINEER.
4. EARTHWORKS ARE NOT TO BE EXTENDED INTO ADJOINING SITES UNLESS THE ENGINEER HAS ISSUED SPECIFIC INSTRUCTIONS
5. THE CONTRACTOR IS RESPONSIBILE FOR IDENTIFYING AND PROTECTING EXISTING SERVICES AND DRAINAGE ON SITE
6. THE CONTRACTOR SHALL CLARIFY THE AREAS AND EXTENT OF CLEARING WITH THE ENGINEER BEFORE COMMENCEMENT AND CONFIRM THAT ALL NECESSARY CONSENTS ARE IN PLACE.
7. EARTHWORKS TOLERANCES ARE TO BE +-25mm
8. ALL VOLUMES ARE SOLID MEASURE, NO BULKING FACTOR APPLIED
9. RETAINING WALL SETOUT - EXACT SETTING OUT POSITION OF RETAINING WALLS IN RELATION TO LOT BOUNDARIES AND BUILDINGS TO BE OBTAINED FROM ARCHITECT OR STRUCTURAL ENGINEER PRIOR TO CONSTRUCTION COMMENCING.

REVISION	AMENDMENT	BY

DESIGNED: MO
DRAWN: MO
RELEASED: SB

CIVIX

PROJECT: 7 SELFS ROAD, MANGERE

TITLE: CUT FILL PLANS

STATUS: FOR RESOURCE CONSENT
DRAWING NO: 1100
SCALE & SIZE: 1:2,000 A3
REV: 25/06/2021

Appendix B: References

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Appendix C: Photographs

Photograph Appendix C.1: View to north across northern portion of the site, Aorere College fields to right, SH20 to left

Photograph Appendix C.2: View to south-east along ridgeline, Selfs Homestead to left, SH20 in centre

Photograph Appendix C.3: View to south-east across southern portion of the site, SH20 to right with glimpse of Crater Hill lake to far right

Photograph Appendix C.4: View to north-west across southern portion of the site, second onsite dwelling to the right

Photograph Appendix C.5: View to north-west from southern portion of the site, SH20 in midground with quarry and filling operations visible behind

Photograph Appendix C.6: View to west across Crater Hill from central portion of the site

Photograph Appendix C.7: Closeup of northern portion of Crater Hill from central portion of the site

Photograph Appendix C.8: Closeup of central area of Crater Hill from central portion of the site

Photograph Appendix C.9: Remnant of explosion crater between SH20 and the site

Photograph Appendix C.10: View of remnant of explosion crater and cut of tuff ring created by SH20

Photograph Appendix C.11: Basalt and concrete exposed along top of former explosion crater, as shown in Photograph Appendix C.9 and Photograph Appendix C.10

Photograph Appendix C.12: Natural materials exposed along top of former explosion crater

Photograph Appendix C.13: Concrete debris exposed along top of former explosion crater

Photograph Appendix C.14: View to the east across Crater Hill showing tuff ring crest and the site in distance

Photograph Appendix C.15: Closeup of view to the east across Crater Hill to the site

Photograph Appendix C.16: View to the north-east from access road on Crater Hill towards the site

Photograph Appendix C.17: Closeup of Photograph Appendix C.16

Photograph Appendix C.18: View to the north-west from access road on Crater Hill showing warehouse building under construction

Photograph Appendix C.19: View to the north across Crater Hill showing warehouse building under construction

Photograph Appendix C.20: View to the north-east from the northern flank of across Crater Hill showing warehouse building under construction, Tidal Road to right

Photograph Appendix C.21: View to the south-west from Tidal Road showing development along the northern flank of Crater Hill

Photograph Appendix C.22: View to the west from Tidal Road showing development along the northern flank of Crater Hill

Photograph Appendix C.23: Closeup of Photograph Appendix C.22

Appendix D: Discernability detail

Photograph Appendix D.1: View from Caringbah Road, approaching the site from the east, slight slope change of tuff ring evident in distance (source: Google)

Photograph Appendix D.2: Travelling up Caringbah Road, approaching the site from the east (source: Google)

Photograph Appendix D.3: Intersection of Caringbah and Selfs roads, site in background (source: Google)

Photograph Appendix D.4: View to south-east along Selfs Road, Aorere College to left (source: Google)

Photograph Appendix D.5: View to south-east along Selfs Road near midpoint of site (source: Google)

Photograph Appendix D.6: View to north-west along Selfs Road from southern end of site (source: Google)

Photograph Appendix D.7: View to north-west along Selfs Road from near-midpoint of site, Aorere College to right (source: Google)

Photograph Appendix D.8: View from Portage Road, approaching the site from the east, Aorere College to left (source: Google)

Photograph Appendix D.9: Travelling along Portage Road, approaching the site from the east (source: Google)

Photograph Appendix D.10: Intersection of Portage and Selfs roads, site to left (source: Google)

Photograph Appendix D.11: View from Tidal Road, approaching from the north. The Crater Hill tuff ring is visible (above Tidal Road) from some distance (source: Google)

Photograph Appendix D.12: Travelling along Tidal Road, approaching Crater Hill tuff ring from the north (source: Google)

Photograph Appendix D.13: Travelling from Tidal Road onto Portage Road (swings to the east), Crater Hill tuff ring on the left (source: Google)

Photograph Appendix D.14: Approaching the Portage Road bridge over SH20, a glimpse of the site is visible in the background (source: Google)

App

Photograph Appendix D.15: Approaching the Portage Road bridge over SH20, view of the site is largely obstructed by the bridge and associated infrastructure (source: Google)

Photograph Appendix D.16: View of the site after exiting the Portage Road bridge over SH20, travelling east (source: Google)

Photograph Appendix D.17: Glimpse of Crater Hill tuff ring (background) from Manukau Memorial Gardens (source: Google)

Photograph Appendix D.18: Approaching the site from the south along SH20, Crater Hill is not clearly discernible from its surrounds (source: Google)

Photograph Appendix D.19: Approaching the site from the south along SH20, adjacent to Manukau Memorial Gardens, in the far distance Crater Hill is just discernible from its surrounds (source: Google)

Photograph Appendix D.20: Approaching the site from the south along SH20, cut through tuff ring is visible but not discernible from bund created on the edge of SH20 (source: Google)

Photograph Appendix D.21: Approaching the site from the south along SH20, lower southern portion of site coming into view, barn on high point just visible (source: Google)

Photograph Appendix D.22: Adjacent to site travelling north along SH20, tuff exposure created by SH20 (not natural) visible on right and glimpse of wider Crater Hill on left (source: Google)

Photograph Appendix D.23: Underwhelming (and normally momentary) view of wider Crater Hill when looking to the left while travelling northbound on SH20 (source: Google)

Photograph Appendix D.24: Underwhelming (and normally momentary) view of wider Crater Hill when looking to the right while travelling southbound on SH20 (source: Google)

Photograph Appendix D.25: Only a glimpse of the tuff ring visible travelling to south from Massey Road on SH20 (source: Google)

Photograph Appendix D.26: Volcanic centre not discernible where SH20 cuts through the tuff ring at the Portage Road overbridge (source: Google)

Photograph Appendix D.27: Adjacent to site travelling south along SH20, tuff exposure created by SH20 (not natural) visible on left, wider Crater Hill not readily visible on the right (source: Google)

Photograph Appendix D.28: Adjacent to southern portion of the site travelling south along SH20, quarry/filling operations visible on the right (source: Google)