Consulting Geotechnical Engineers

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BACCHUS MARSH PROPERTY GROUP PTY LTD

HOPETOUN PARK NORTH RESIDENTAL DEVELOPMENT

INTERPRETIVE GEOTECHNICAL INVESTIGATION

REPORT NO V2211-1R2, MAY 2023

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RD1	draft for client review
RD2	second draft for client review
R1	final issue
R2	clarifications in section 2.5.1, clarifications in section 2.5.2, addition of section 2.5.3 (pipeline route), addition of section 2.5.4 (construction)

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Conditions may differ between investigation points or below investigation depths, which may invalidate recommendations provided in this document.

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1.0 GENERAL

1.1 Purpose of investigation

This report presents the results of a geotechnical investigation performed at the proposed Hopetoun Park Road residential subdivision.

An open space network plan provided by Weir and Co is shown in Image 1 with the proposed building lots area shown in pale yellow (800 m^2 lots) and orange (1,500 m^2 lots).

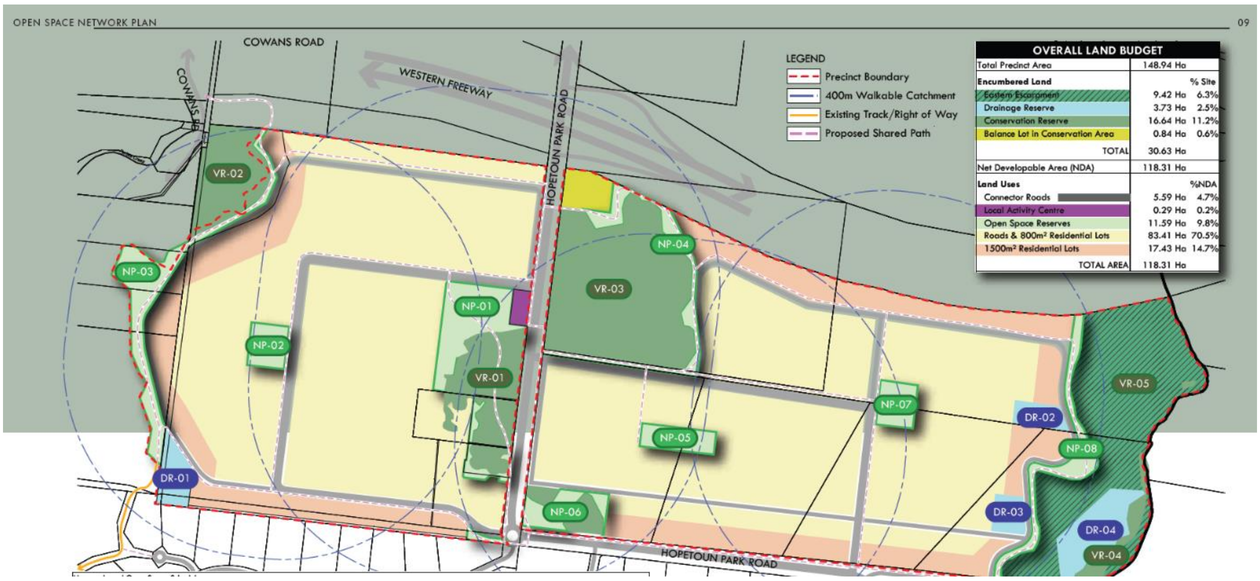

Image 1 – Open space network plan Hopetoun Park North by Weir and Co.

The purpose of the investigation is best described in the brief provided by Urban Land Developments in October 2022, reproduced below.

1. ***That the proposed setbacks from the top of the escarpment are appropriate**. As mentioned above, we have agreed to increase the width of the lineal reserve from the top of the escarpment from 10m to 20m as recommended by DELWP. This lineal reserve will contain a shared path for pedestrian and cyclists. (Please see attached Millar Merrigan definition of the top of the escarpment). Note that in various sections the lineal reserve will be greater than 20m where there are various 'jut outs'. Adjoining the lineal reserve will be an active road frontage. (Whilst local roads are proposed in a 17.3m road reservation it is hoped that this might be reduced slightly as the reserve can act as the verge on the reserve side.) The lots fronting the road along the escarpment are all required to be 1,500m2 minimum in size with a minimum 10m front setback. This means that dwelling will be setback a minimum of 47.3m from top of escarpment (or slightly less if 17.3m road reservation reduced but still likely to be 45m). We will require a geotechnical assessment to confirm the appropriateness of these setbacks.*

2. ***The appropriateness of the proposed outfall locations and any design requirements.** There are proposed to be 1 drainage pipe down the west escarpment and one down the east. Piping the outfalls was a recommendation from the Geomorphology assessment. Careful consideration has been given to the proposed location of each outfall to be cognisant of: ensuring the stormwater engineering requirements work, choosing an alignment which is less steep and able to be practically constructed and likely to minimize erosion, avoiding vegetation loss where possible. Please see attached the proposed alignments for west and east. We require an assessment of the appropriateness of these locations from a geotechnical perspective and any specific design considerations.*

The brief also included items concerning the retarding basins and Hopetoun Park Road pavement, which are discussed separately in the Black Geotechnical reports V2211-2R1 and V2211-3R1.

1.2 Proposed development

The proposed subdivision occupies about 150 hectares and with potentially about 600 lots. There is an existing residential subdivision (Hopetoun Park) immediately to the south of proposed subdivision. The existing subdivision occupies about 350 hectares and contains 260 lots, all of which appear to have been developed. It is understood that the subdivision was developed in the early 2000s.

The site is on an elevated plain with escarpments to the west towards Pyrites Creek and the Werribee River, and east towards Djerriwarrh Creek.

Two piped stormwater outfalls are proposed, one in the south east corner of the site and one in the south west, connected to retarding basins. It is understood the Frankische piped product is being considered as one option as it is suitable for construction on steep slopes (refer Afflux Consulting response to Melbourne Water comments). Conventional concrete pipe design is also being considered.

The location of the retarding basins and proposed pipeline routes down the escarpments is included in an image from Afflux Consulting, shown below in Image 2.

It is important to note that the drainage report and proposed layout provided by Urban Land Development shows that overland flows will be substantially reduced. The roads are designed to act as overland flow paths which will limit surface flow, and combined with AG drains, and crushed rock backfilled service trenches flow through the soil will also be limited. Further flow reductions are made by the connection of houses to the underground drainage system.

It is understood water tanks for the properties are being considered. It is recommended these are adopted as they will further improve the drainage conditions.

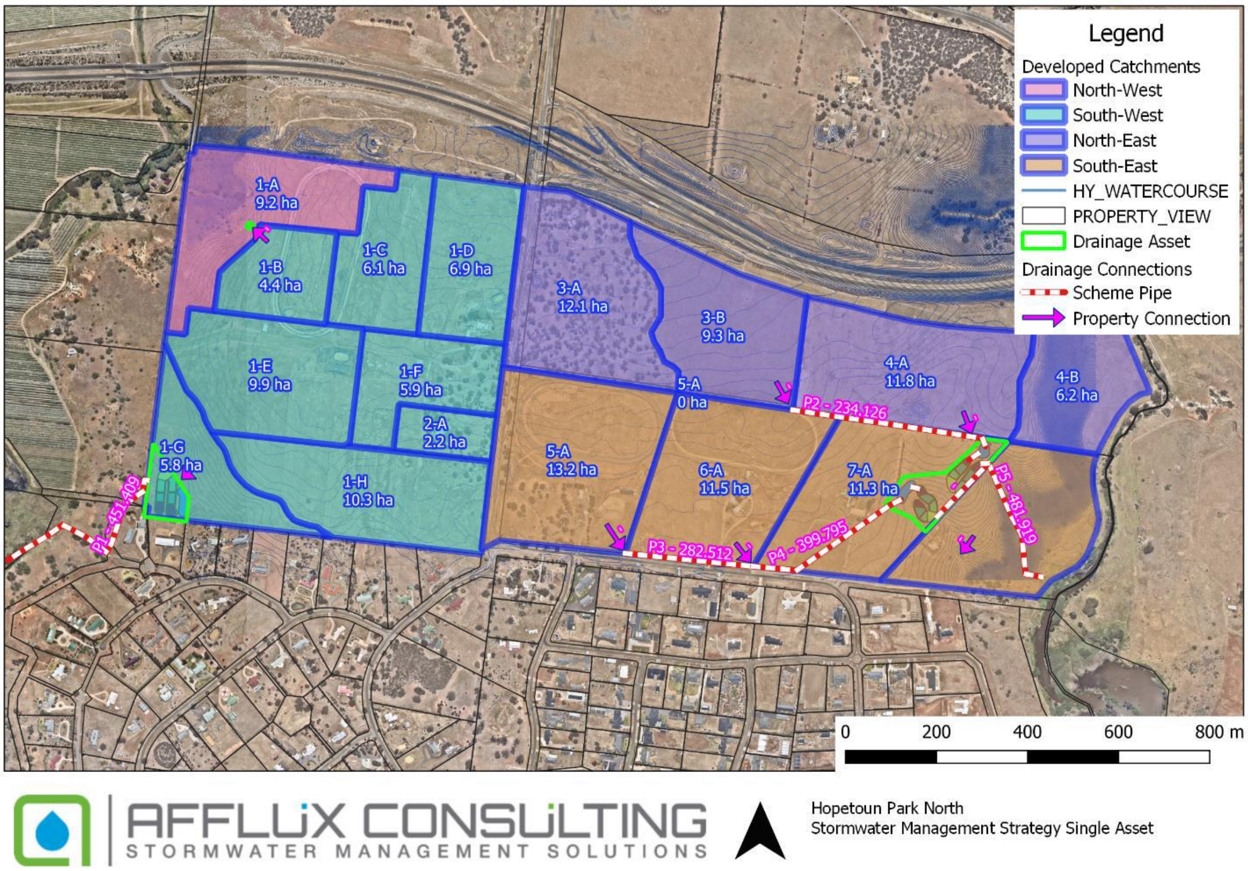

Image 2 – Proposed retarding basins and pipeline routes.

2.0 ENGINEERING GEOLOGY

2.1 Engineering geology review

The GeoVic3 online, 1: 50,000 Series, state wide geological database, indicates the site surface geology is relatively complex across the site. The surface geology at the western and eastern escarpments is described below:

Eastern escarpment

The database shows Neogene - Quaternary Period Newer Volcanics (Neo - basalt) on the approach to the slope. Going down the slope, Neogene – Quaternary Period conglomerate and sandstone (Czg – conglomerate, quartz sandstone and siltstone, conglomerate commonly ferruginised) is shown within the upper third, or so, of the slope, with much older Ordovician period Riddell Sandstone (Osrg – sandstone, black shale, black and grey siltstone) shown below.

Western escarpment

The database shows the Neogene – Quaternary Period Darley Gravel (Nxr – gravel, sand and silt) on the approach to the slope. Going down the slope, the Newer Volcanics are shown within the top third, or so, of the slope, with Neogene Period Werribee Formation (-Pxe – sand, silt, clay, gravel) shown below this to the toe of the slope. Beyond the toe of the slope, Quaternary period alluvium associated with Pyrites Creek and the Werribee River is shown.

Central plain

The database shows the Neogene – Quaternary Period Darley Gravel across much of the site, and Neogene – Quaternary period Newer Volcanics in the north and east of the site.

An extract from the GeoVic3 database in shown below in Image 3.

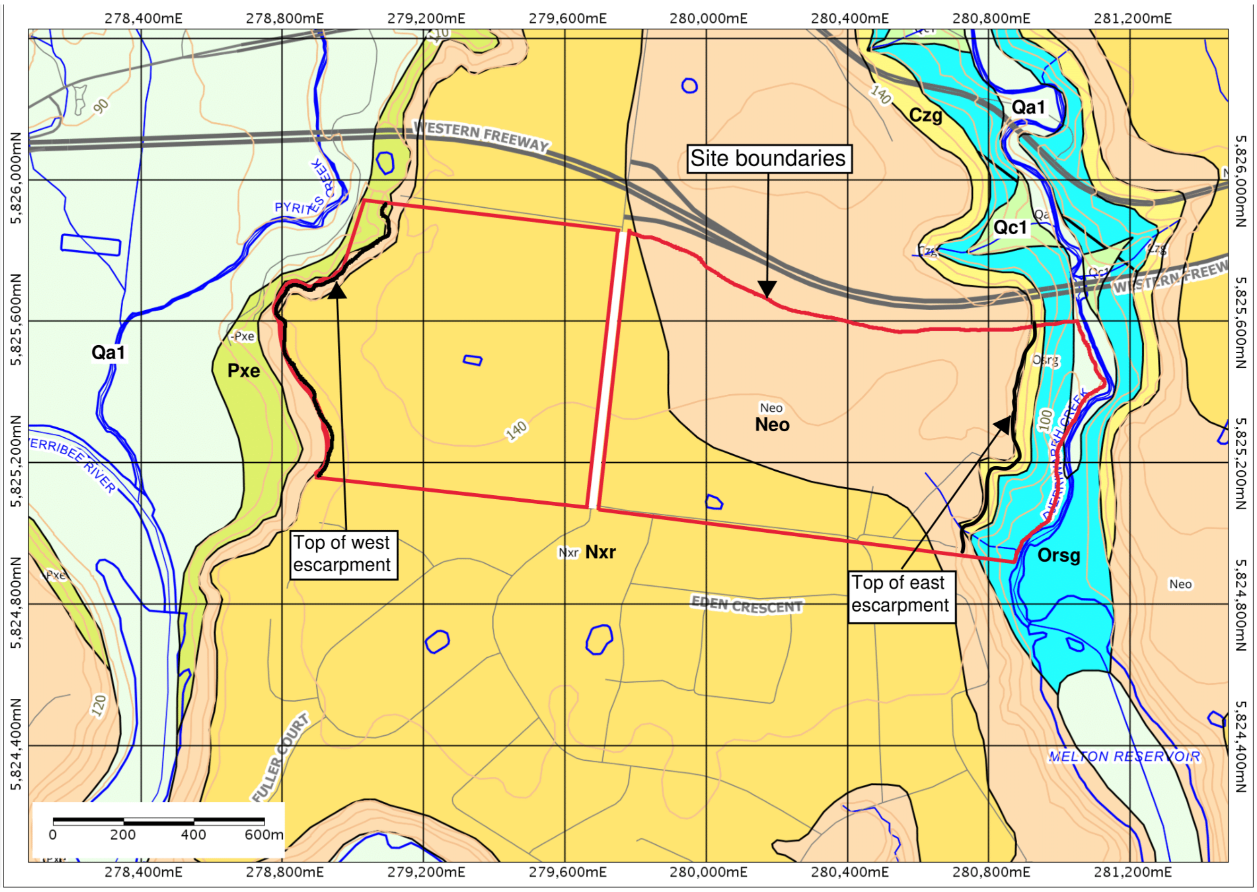

Image 3 – GeoVic3 database extract.

Historical information available on Geovic3 show boreholes were drilled in 1983 between the north west corner of the site and the old Western Highway. Within the borehole information is a reference to a Soilmech Pty Ltd report titled "*Report on Investigation for Proposed Sand Pits at Bacchus Marsh"*, January 27, 1984. The report shows an existing sand pit located between the north west corner of the site and Cowans Road to the west of the site. The historical sand pit extents are well away from the site boundaries and will not affect the development.

These boreholes are also shown in the GeoVic3 database.

Extracts from GeoVic3 database showing the borehole locations, and from the report showing the location of the sand pit are shown below in Images 4 and 5
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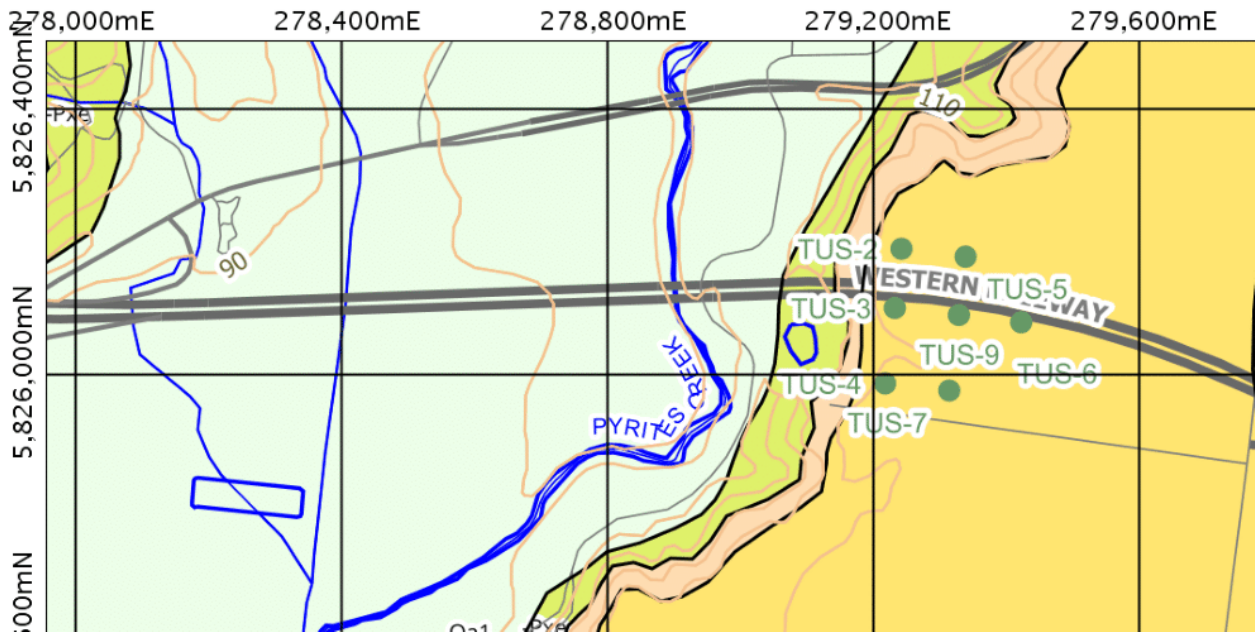

Image 4 – GeoVic3 extract showing historical boreholes.

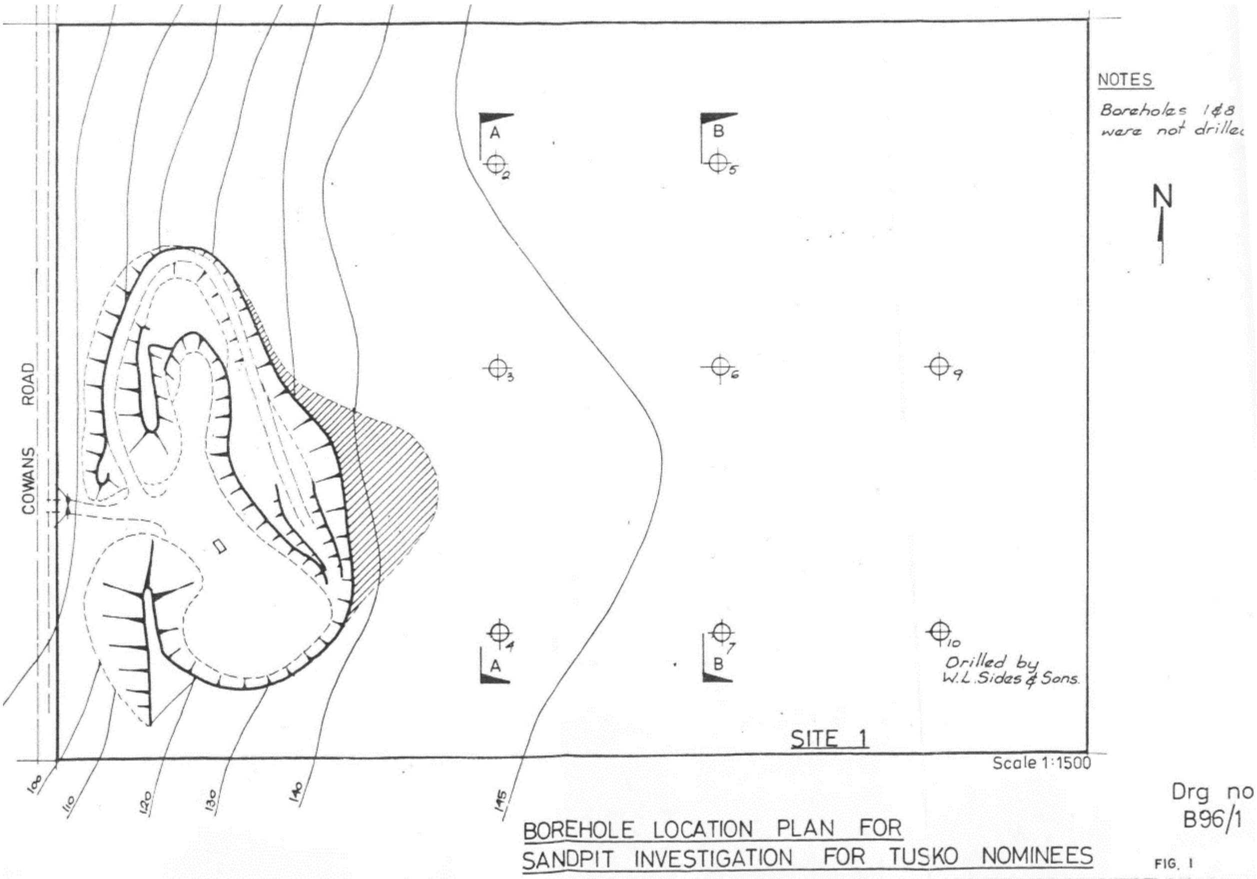

Image 5 – Extract from 1984 Soilmech report showing same historical boreholes and the existing sand pit.

2.2 Sites of geological and geomorphological significance

2.2.1 Anthony's Cutting – L11

Sites of geological and geomorphological significance are described on the Victorian Resources Online website (now archived).

Site L11 is Anthony's Cutting which is just to the north of the site on the old Western Highway, and is described by Neville Rosengren as follows:

The cutting on the southern side of the Western Freeway reveals an important section into lava flows from Mount Bullengarook and Tertiary and Quaternary sediments. Flows of strongly jointed basalt outcrop at road level at the Melbourne end of the cutting and these are overlain by a 15 m thick deposit of cross-bedded non-marine Pleistocene sands and gravels. One hundred meters along the cutting (towards Bacchus Marsh), sandy clays, sands and gravels of the middle Tertiary Werribee Formation that underlies the Bullengarook lava flow are exposed at road level and the lavas are 10 to 15 m above road level. At the top of the Werribee Formation (beneath the lava flow) is a reddish zone in the sediments that is the weathering horizon and soil of the pre-basaltic land surface. It is therefore an example of paleosol. Several types of jointing and weathering occur in the volcanics.

This description matches the observed conditions on the western escarpment, except that the Darley Gravel (described as the non-marine Pleistocene sand and gravels by Rosengren) are much thinner on this site. It is considered likely that historical extraction of the Darley Gravel has reduced the thickness on site to negligible amounts. An image of Anthony's Cutting is shown below in Image 6.

Image 6 – Anthony's Cutting, photo dated 2015. Image source: www.expressway.online

2.2.2 Tabletop Hill – site L18

Rosengren describes the conditions at Tabletop Hill (which lies just west of Bacchus Marsh) as follows:

Tabletop hill is capped by a remnant of Newer Volcanics basalt which overlies sediments of the Werribee Formation. The southern hillslope includes an extensive area of mass movement including rotational slumps and earthflows. Other extensive mass movements occur on the opposite valley slope above the alluvial floodplain of the Werribee River.

The location of the Tabletop Hill landslides is shown below in Image 7.

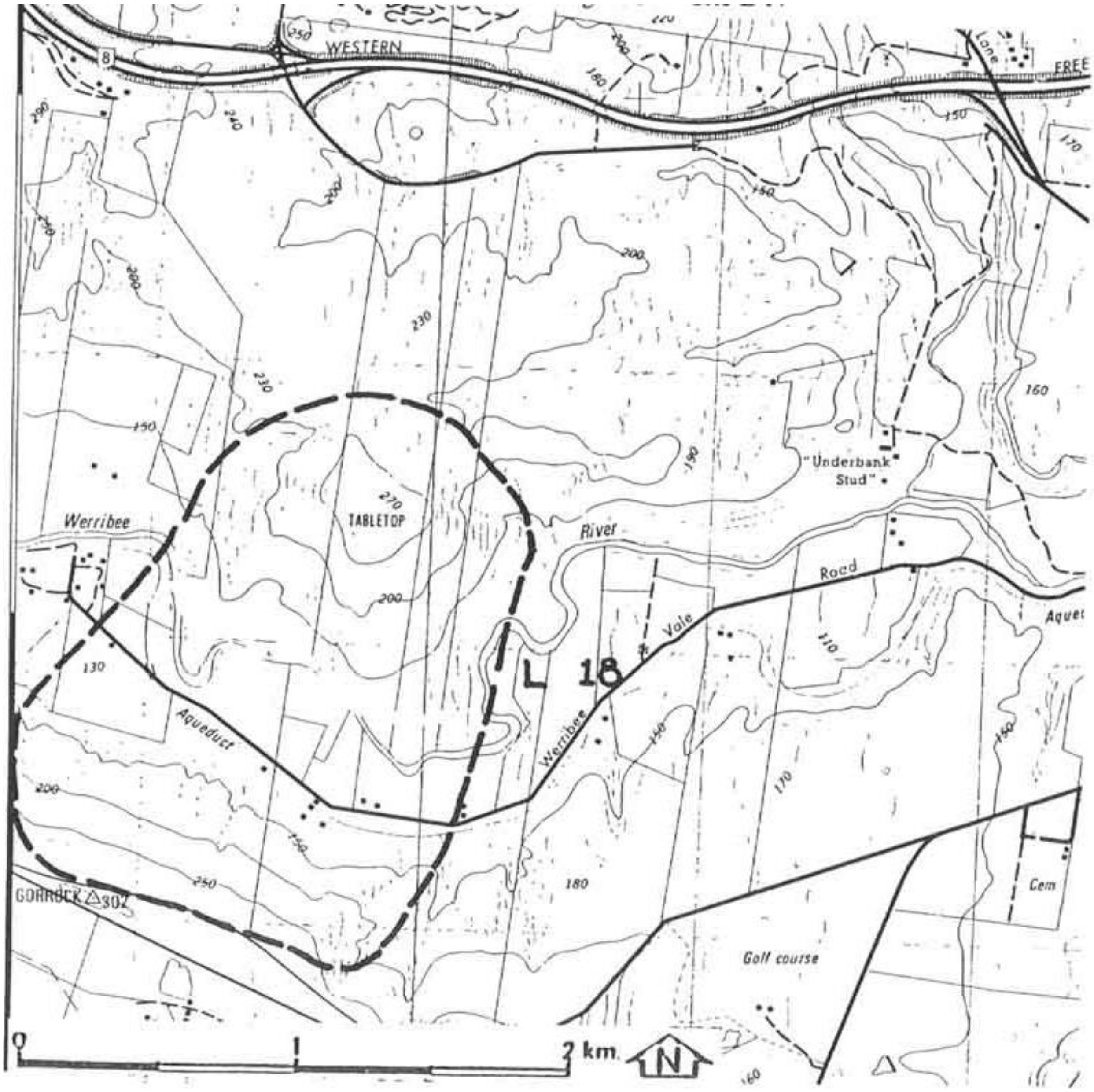

Image 7 – Tabletop Hill location from VRO website.

2.2.3 Cut Hill Landslide – site i6

The geological setting of the Parwan Valley, to the south west of the site, is similar to the western escarpment. A well-known study site, the Cut Hill Landslide (which is some 20 km to the west of the site), describes instability in the Werribee Formation in a report *An Investigation of the Cut Hill Landslide, Rowsley (Parwan) Valley* by R A Wilson in 1983/91. This describes the slope failure types as follows:

The slope failure types include:

1. *Slumping, gully and tunnel erosion, and/or creep of colluvium and other surface materials. These are common and are spread throughout the valley. Although minor in themselves, if not controlled by normal erosion prevention methods, they can lead to any of the following more massive types.*
2. *Gully and tunnel erosion, and chemical weathering combining to reduce the resisting forces of the Werribee Formation. This can lead to non-circular failure along bedding planes at times of excess water head. The Cut Hill slip is an excellent example of this type of failure.*
3. *Weathering and removal of the toe by failures of the above types can lead to circular-type failures through the 'weathered' basalt toe in the Werribee Formation. Once again excess water pressures will be the triggering mechanism. The slip approximately one kilometre to the north-west of the Slip is an example of this type of failure.*
4. *Toppling type failure of the 'fresh' basalt of the Newer Volcanics. Examples of this type of failure are widespread along the escarpment.*
5. *Large scale complex slump failures through the 'fresh' basalt cap which may toe out either in 'weathered' basalt or in the Werribee Formation. This type of failure is potentially the largest type occurring in the valley. A possible recent example of this type is the failure about 2km north west of Cut Hill, and the basaltic block is an obvious ancient example.*

As a simplification the cycle of erosion in the Parwan Valley proceeds from slope failure type (1) to (5), but due to geological and hydrological non-homogeneity, any sequence of events is possible.

2.3 Engineering geology walkover

2.3.1 Engineering geology walkover summary

An engineering geology walkover was conducted over four days, from 17 January to 20 January 2023. The walkover concentrated on the eastern and western escarpments.

Conditions encountered in the walkover broadly aligned with the reported geology discussed in Section 2.1 of this report.

2.3.2 Eastern escarpment

Generally, the eastern escarpment was observed to be steep, with a few gullies incised in the slopes. The overall slope varies from around 2H : 1V in the south, flattening to 3H : 1V in the north. The upper slopes include sub-vertical exposures of basalt.

Two potential geological contacts were noted on site. On the very steep path leading down from the eastern end of Hopetoun Park Road a contact between the Newer Volcanics basalt (Neo) and Ordovician Riddell Sandstone (Osrg) was observed at an elevation of 108 m AHD. On the much less steep access track to the north of this, a contact between the basalt and likely Neogene – Quaternary Period ferruginised conglomerate (Czg) was observed at an elevation of 121 m AHD.

Exposures of the Ordovician Riddell Sandstone were also noted at elevations of 103 m and 93 m AHD in the northern part of the site.

Apart from the two contacts and two exposures noted, the site surface was comprised of basalt rock and residual soil at the top of the slope, and basalt colluvium downslope. Some large boulders were visible well below the expected thickness of basalt indicating toppling occurs periodically.

A small landslide was noted in the bank on the opposite side of the valley. This is likely due to undermining by the Djerriwarrh Creek.

There were no signs of recent large-scale landslides on the eastern escarpment. Some terracettes (indicative of soil creep) were noted near the northern end of the site. Some potential ancient landslides could be present above the gentler track as evidenced by change in grade of the slopes and can be seen in the LiDAR survey data provided by Urban Land Developments, however, this may be partially or entirely due to track construction.

The thickness of basalt rock identified in the eastern escarpment was between 15 m thick in the south to about 6 m thick in the north, although this is difficult to determine accurately due to the presence of colluvium and soil creep.

In general, no stability issues apart from slow, albeit ongoing, rock toppling and soil creep were identified. The lack of geological contact exposures in the gullies and partial substantial vegetation indicates that the gullies are replenished with basalt clay colluvium continually and exposure of the underlying units would not occur for a long period of time.

The steepness of the escarpment means that piping stormwater to the base of the escarpment is sensible. Open drainage that concentrates flow could lead to rapid erosion and degradation of the slope.

The conditions indicate that the eastern escarpment is handling the current levels of overland and subterranean flow. No seepage from the slope was observed during the walkover.

The proposed stormwater outfall location along the less steep access track is a good choice. The steeper access track would present significant construction challenges (it is difficult for a human to stand up, for example). The proposed track is still relatively steep and piping the stormwater to the toe of the slope is also a good choice as significant erosion would occur with an open drain.

Images of the eastern escarpment are shown below in Images 8 to 16.

Image 8 – LiDAR contours on Nearmap image, supplied by Urban Land Developments.

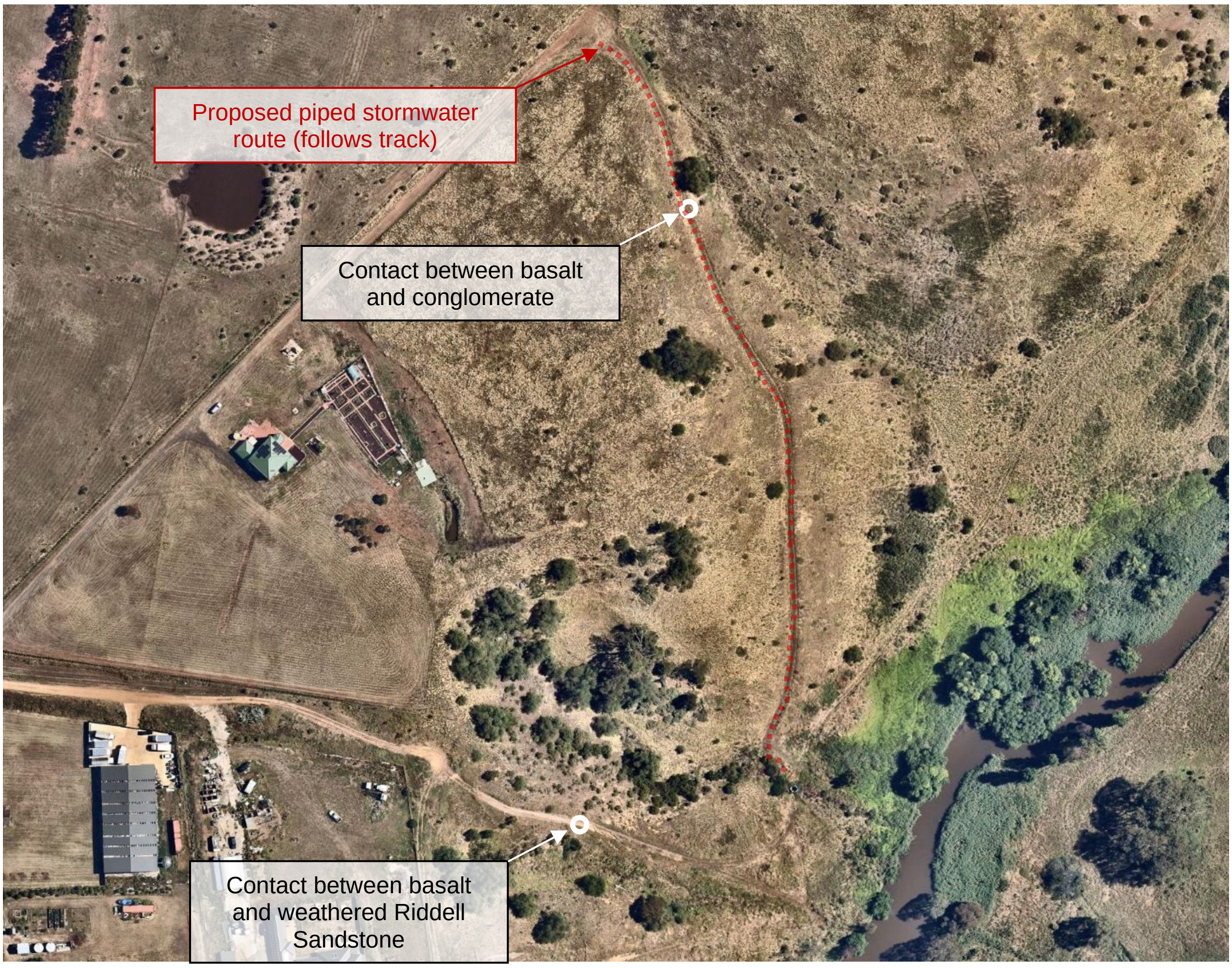

Image 9 – Marked up Nearmap image with geological contacts and proposed pipeline route.

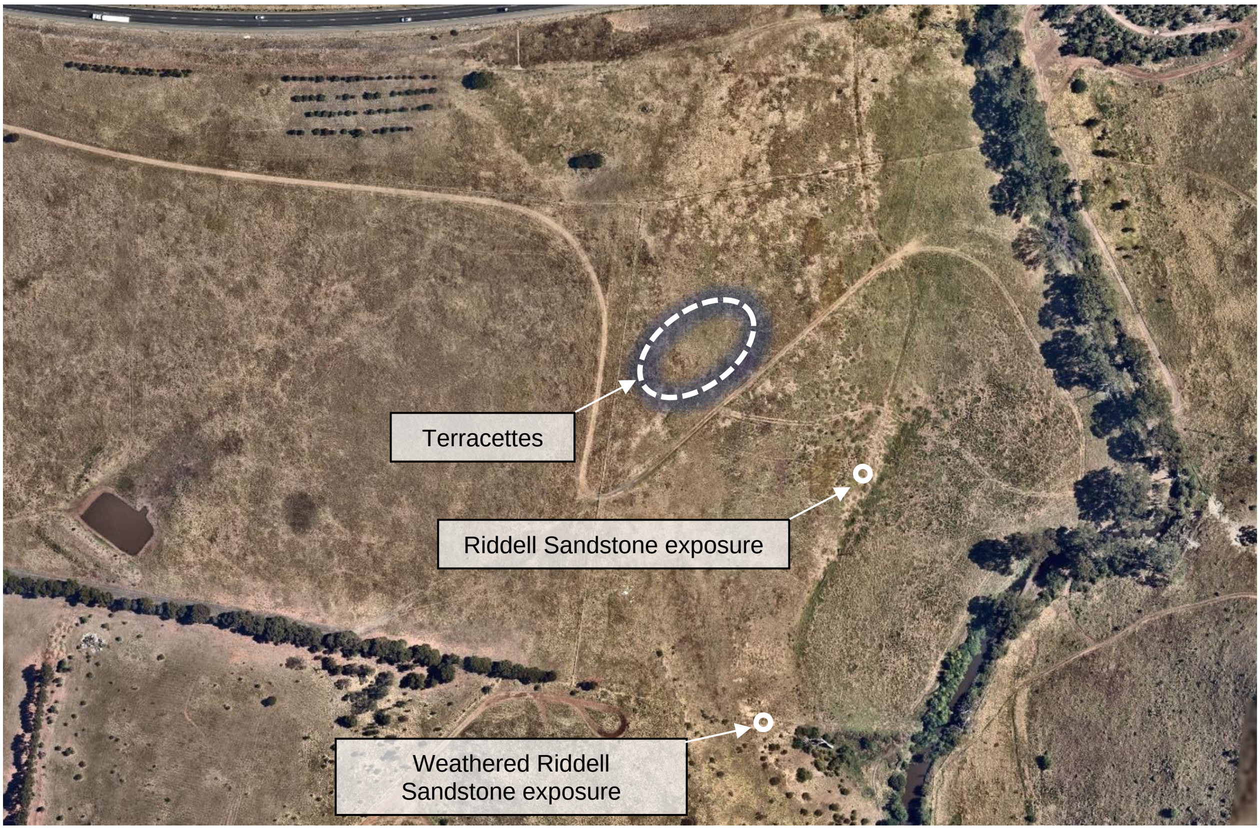

Image 10 – Marked up Nearmap image with geological exposures.

Image 11 – Geological contact between basalt and underlying Riddell Sandstone. Steepness of track is evident.

Image 12 – The much less steep track / proposed pipeline route.

Image 13 – Base of basalt / potential contact with colluvium above less steep track.

Image 14 – View of gullies and ridgelines, towards the north

continued...

Image 15 – Aerial view of gullies and ridgelines, towards the south.

Image 16 – Aerial view towards the north.

2.3.3 Western escarpment

The western escarpment was also generally steep, however, more variable than the eastern escarpment. Slopes varied from 1.8 H : 1 V to flatter than 3.5 H : 1 V. The upper slopes include sub-vertical exposures of basalt.

The top of the basalt was measured between 127 m AHD in the south, to 136.5 m AHD in the north, reflecting the overall general slope of the plateau to the south. The contact with the Werribee Formation was noted in many locations, which was at around 119 m AHD in the south and 127 m in the north, indicating a basalt thickness of around 8 to 10 m. The top of the plateau in the north west of the site is around 140 m AHD reducing to 130 m AHD in the south. Darley Gravel was clearly present in the north half of the site, however, it reduced to negligible thickness towards the south.

Many gullies are incised in the slopes. On the ridgelines, many contacts between the basalt and the underlying Werribee Formation are visible. Springs have previously formed at the contacts on these ridgelines, with four locations showing evidence of recent water flow and soil movement, with locations shown on Image 17 below. No seepage was noted at the spring locations during the investigation. It is not known how regularly the springs flow, although lack of vegetation at the spring outfall locations indicate it is not a rare event.

The gullies generally appear similar to the eastern escarpment, where they are well vegetated and appear to be replenished with basaltic clay colluvium.

A major erosion zone is present just to the north of the abandoned houses situated mid-slope. The erosion is considerable and has formed large, deep, solution features and vertical to sub-vertical slopes. The runoff from the erosion crosses the track at the base of the escarpment and enters the apple orchards to the west of the site.

The abandoned houses appear to be situated on an ancient landslide, evidenced by the change in grade and also the presence of basalt blocks at a much lower elevation than expected. It is difficult to estimate the age of the landslide, however, the presence of established vegetation, the muted surface features, and difficulty in identifying the landslide in the first place indicates a minimum age in the thousands of years.

To the north of the site, between the north west corner and the Western Highway, significant erosion is also noted. This is in a different form to the erosion in the Werribee Formation, expressed mostly as near vertical piping erosion forming multiple holes spread throughout the slope, although concentrated near the top, below the base of the basalt, and near the toe, just above Cowans Road. This area was previously occupied by the sand pit, discussed in Section 2.1, and is understood to have been filled by VicRoads (now the DOTP) as part of the Western Highway upgrade. The fill is similar in appearance to the Werribee Formation (pale grey and white clay) and is dispersive. It is likely that the Werribee Formation soils excavated as part of the cutting for the Western Highway was used as fill, and this has subsequently failed. Although this is of little relevance to the geotechnical stability of the proposed Hopetoun Park development, it should be highlighted now to provide clarity that the development has not caused this failure.

The existing pumping station pipeline route, which contains sewer and stormwater lines, is along the side of an existing gully, and as with other gullies has basaltic clay colluvium within the gully, which appears to be protective, and is stable. This is a good choice for the proposed stormwater outfall due to the favourable conditions and previous successful construction.

Images of the western escarpment are shown below in Images 17 to 30.

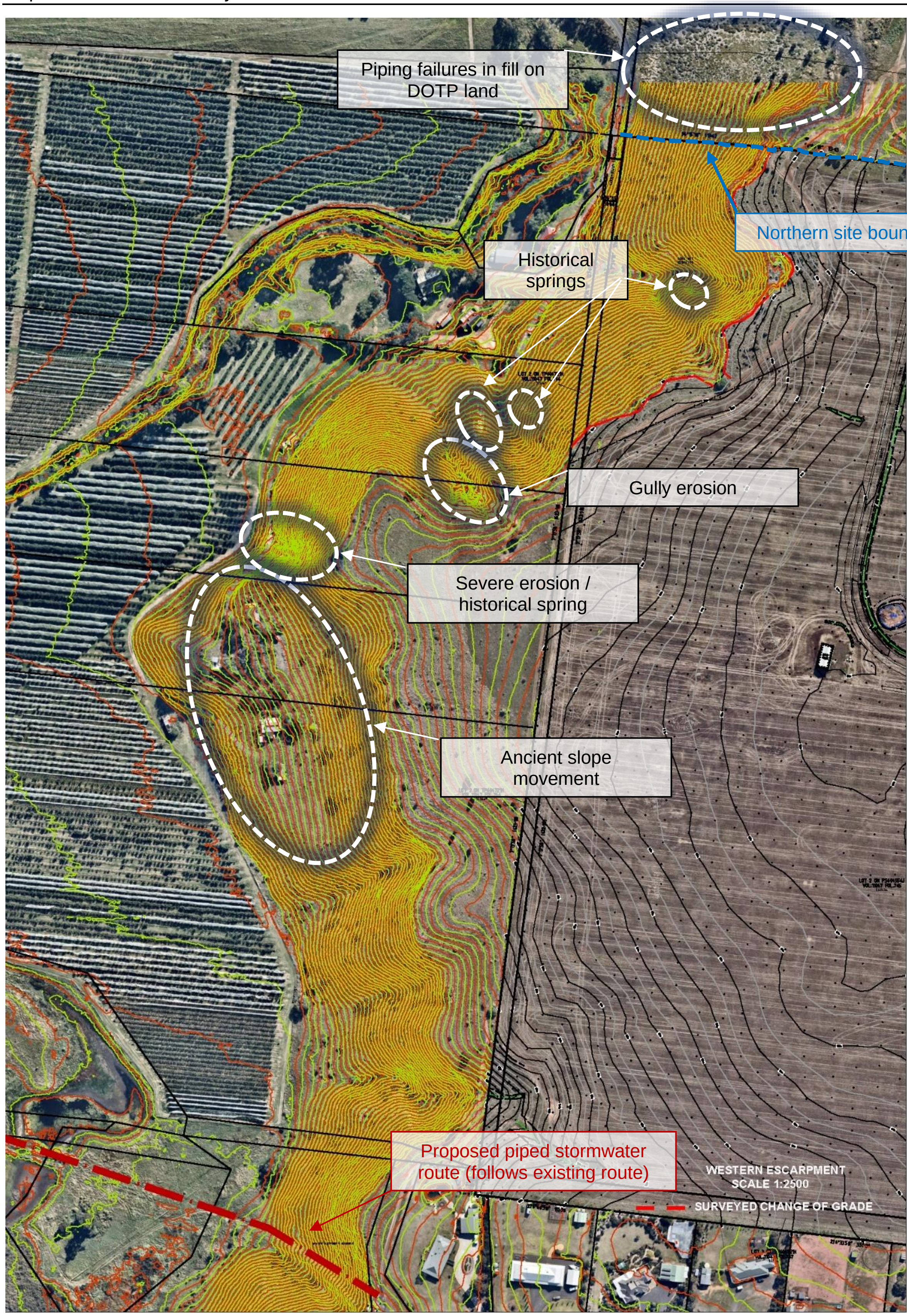

Image 17 – LiDAR contours of western escarpment, provided by Urban Land Developments.


Image 18 – Proposed pipeline route.


Image 19 – Severe erosion below spring.

Image 20 – Broad view of severe erosion area.

Image 21 – Detail of severe erosion.

Image 22 – Gully erosion.

Image 23 – Clear geological contact between basalt and Werribee Formation.

Image 24 – Large solution feature above filled quarry/sand pit, located north of subject site in DOTP road reserve.

Image 25 – 1.9 m deep solution hole towards base of filled quarry/sand pit in DOTP road reserve.


Image 26 – Aerial view of failing fill (grey and white material), located north west of subject site in DOTP road reserve.


Image 27 – Aerial view towards western escarpment. Springs seen as white patches. Large erosion feature to the right.

Image 28 – Aerial view of large erosion feature. Abandoned house to the right on ancient landslide feature.

Image 29 – Aerial view to south from north.

Image 30 – Aerial view to south from midway along western escarpment showing good vegetation cover in gullies.

2.4 Historical aerial imagery

Historical aerial photos were obtained for the site. Of note, the significant erosion noted on the western escarpment is evident as far back as the photos go (1946 is the earliest obtained) and does not appear to have changed in the intervening years. This is a good indication that the erosion has been a slow process.

38 aerial images in total were retrieved. A select few are included below in Images 31 to 33.

Image 31 – 1946 aerial photograph showing similar erosion features near the (now) abandoned houses.

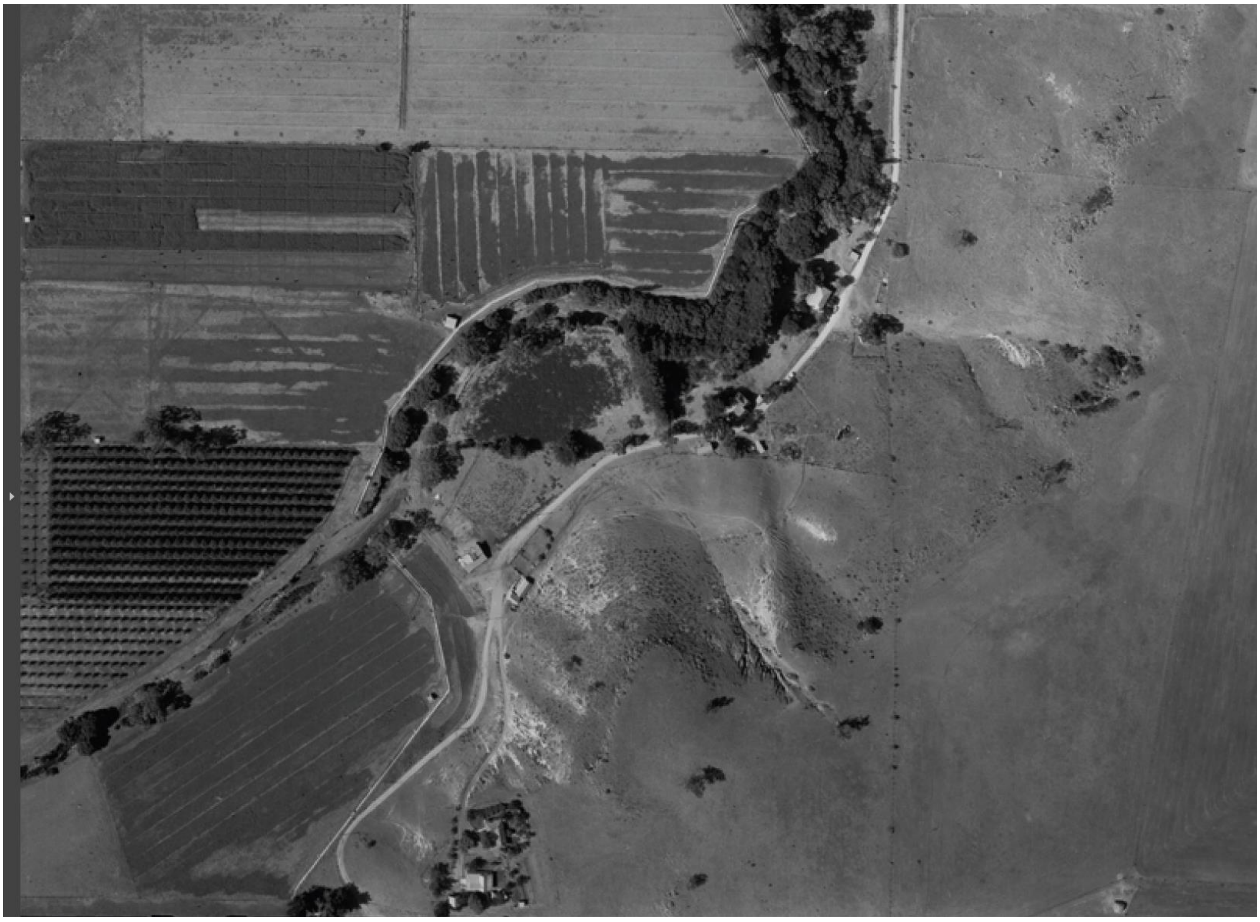

Image 32 – 1968 aerial photograph showing similar spring and erosion features as today.

Image 33 – 1985 aerial image showing similar spring and erosion features as today.

2.5 Slope stability

2.5.1 Landslide risk assessment

A landslide risk assessment following the Australian Geomechanics Society *Practice Note Guidelines for Landslide Risk Management 2007* requires the estimation of the risk of a landslide occurring, the risk of the landslide impacting a building, the risk of the building behind inhabited at the time of the landslide, and the vulnerability of the inhabitants. New developments usually proceed on the basis of achieving a risk to loss of life of less than 10^{-5} per annum, which is the suggested "tolerable" risk to the person most at risk. The most difficult parameter to estimate is the risk of a landslide occurring. On this site, there is one ancient (possibly two) evident, but the exact age of this is not easy to determine. However, as discussed in Section 2.3.3, the minimum age of the landslides is in the thousands of years, and in any case, the size of a future landslide would need to be unreasonably large to affect the proposed buildings due to the geometry of the site and the proposed setbacks.

The risk to loss of life calculation, $R_{(LOL)} = P_{(H)}.P_{(S:H)}.P_{(T:S)}.V_{(D:T)}$, is designed as a risk assessment tool for situations where:

- There are observable landslides that put people at risk.
- There are no observable landslides, but they could be expected due to topography and the landslide would put people at risk.
- There are no observable landslides, but they could be expected due to sub-surface conditions and the landslide would put people at risk.

These conditions do not occur at this site.

The risk calculation as defined in the AGS Practice Note Guidelines is shown below in Image 34.

$$\mathbf{R}_{(LoL)} = \mathbf{P}_{(H)} \times \mathbf{P}_{(S:H)} \times \mathbf{P}_{(T:S)} \times \mathbf{V}_{(D:T)} \quad \mathbf{(2)}$$

Where

$\mathbf{R}_{(LoL)}$	is the risk (annual probability of loss of life (death) of an individual).
$\mathbf{P}_{(H)}$	is the annual probability of the landslide.
$\mathbf{P}_{(S:H)}$	is the probability of spatial impact of the landslide impacting a building (location) taking into account the travel distance and travel direction given the event.
$\mathbf{P}_{(T:S)}$	is the temporal spatial probability (e.g. of the building or location being occupied by the individual) given the spatial impact and allowing for the possibility of evacuation given there is warning of the landslide occurrence.
$\mathbf{V}_{(D:T)}$	is the vulnerability of the individual (probability of loss of life of the individual given the impact).

Image 34 – Extract from AGS Practice Note Guidelines for Landslide Risk Management, 2007.

The only way to estimate $P_{(H)}$, the annual probability of a landslide, in this scenario, is to observe other landslides in a similar geological setting. Here, the setbacks are so large that the size of a landslide that could affect the properties is inconceivably large, i.e. the $P_{(H)}$ term is zero, and the risk is zero. On the other hand, a smaller landslide (like the ancient slope movement noted in the report, and similar ones noted in slopes around the site) might have a $P_{(H)}$ of 10^{-3}, but these would only affect a few metres of the slope edge and wouldn't affect the development, so the $P_{(S:H)}$ term (the spatial term) becomes zero, and again the risk is zero.

There is no way to assess the accuracy of the risk assessment as the estimation of a landslide occurring involves subjective judgement about very infrequent events. Experience in assessing landslide risk is important.

The only stability risk on site is ongoing slope erosion, which is very slow and well controlled.

Continual erosion of the Werribee formation has the potential to initiate a landslide, however, the most severely eroded area is over 200 m away from the proposed setback on the western escarpment. There is a smaller spring within the property boundary towards the north of the western escarpment, however this is still 40 m away from the edge of the escarpment, so at least 85 m away from the proposed buildings. Even if landslides were to occur in these areas, they would be far too small to pose any risk to the proposed development.

There are no landslide risk concerns impacting the subject site, and the proposed building setbacks are appropriate.

2.5.2 Slope erosion

As discussed, slope erosion will be well controlled, and the risk of continued slope erosion will be reduced as the development will improve overland and subterranean flow to the escarpments.

If overland and subterranean flows were instead increased, erosion could accelerate and potentially impact the development. This is not to say that flows are expected to increase but serves as a comparison to other sites with similar geological settings where landslides have occurred. In fact, the roads for the proposed development are designed to convey 1 in 100 year events and overtopping is unlikely, and in any event the flows will still be reduced from current levels. Considering the lack of observed slope regression since 1946 (refer Section 2.4), and the proposed reduction in flow, no slope regressing due to overland or subterranean flow due to the construction of the development is expected to occur.

The Cut Hill Landslide is an example of where poor slope practises contributed to the ongoing landslide which is still being managed today. It is also a good example of the various environmental factors which can affect the stability of the Hopetoun Park Slope.

As discussed in the Cut Hill Landslide report, that landslide required multiple factors to initiate instability, described by R A Wilson as follows:

As discussed in this report the factors which have contributed to the Cut Hill Slip include:

1. *Lithologies susceptible to erosion and mass movement.*
2. *Uplift of the Parwan Valley.*
3. *Unfavourable dip.*
4. *Montmorillonite on or near the assumed failure plane.*
5. *Poor surface drainage.*
6. *Aquifers leading water into the failure plane.*
7. *Heavy rainfall, which ultimately triggered the failures.*
8. *Uneven topography promoting ponding of water.*
9. *Poor vegetation cover.*
10. *Seepage erosion.*

Items 1, 3, 5, 6, 7, 8, 9, and 10 are relevant to this site and are addressed below.

The lithology is similar at both sites. The dip of the Werribee Formation was difficult to measure as bedding was mostly not apparent, and the formation is likely to be more massive and homogeneous at this site compared to Parwan Valley. The dip direction was measured in two places on the western escarpment which indicated relatively steep dips to the north west and south west, which is unfavourable. Montmorillonite (high plasticity clay) was not noted, however, it was also not specifically targeted during the investigation. Items 5 – 10 are all in the same category in that they involve drainage and are the most relevant for the subject site.

The basalt rock is highly permeable and acts as an aquifer. The presence of springs at the subject site may be associated with thicker deposits of basalt. The pre-basaltic surface would have included gullies, which were subsequently buried by the basalt flow (paleochannels) forming deeper aquifers and higher seepage flow in these areas. It is suspected that the spring areas on the western escarpment align with deeper basalt deposits (which have formed ridgelines on the escarpment). The proposed development will reduce the volume of water directed to the basalt and therefore reduce the occurrence of the spring flowing.

In comparison to the subject site including the proposed drainage systems, the Cut Hill landslide drainage was very poor, with a roadway and culverts directing significant water flow to the Werribee formation upslope, and resulted in removal of material from the toe, destabilising the slope.

Item 8 above is relevant as ponding of water on uneven ground may lead to increased subterranean flow due to increased ground water levels. No ponding will be introduced by the development. The proposed retarding basins will have impermeable bases and will not increase any flow to the escarpments.

Due to the overall better drainage conditions at the subject site, and the proposed further improvement of these conditions, there is no conceivable risk that the conditions that lead to the Cut Hill landslide can occur at the subject site.

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2.5.3 Pipeline route

The proposed outfall pipeline route down the western escarpment is suitable. This route follows the flattest grade down the slope, following the alignment of other services previously constructed. No stability issues are expected in this area.

Any backfill required for the outfall should be placed and compacted in accordance with AS 3798 (Guidelines on Earthworks for Commercial and Residential Developments) and also in accordance with any requirements of the relevant water authorities.

2.5.4 Stability due to construction

Any instability at this site is driven by erosion, not surcharge loading. Any permanent loading more than 10 m back from the escarpment will have no influence on stability. Any short-term loading more than a few metres from the escarpment (i.e. due to construction equipment, including any vibratory effects) will have no influence on stability. As discussed, in Section 2.5.3 there are no stability concerns for the proposed pipeline route.

3.0 CONCLUSION

- There are no landslide risk concerns impacting the subject site, and the proposed building setbacks are appropriate. The landslide risk assessment determined a risk to loss of life of less than 10^{-6} per annum, which is at least 10 times better than the limit of 10^{-5} commonly adopted for new developments.

- The observed surface erosion and springs on the western escarpment are due to overland and subterranean flow. These are a large distance from the proposed setbacks, are progressing slowly, and do not impact the proposed development.

- The rate of these erosion process will be reduced by the development due to the substantial improvement in drainage conditions proposed.

- The failure of the fill in the DOTP road reserve is outside of the property boundary and does not affect the development, however, the DOTP should be advised of this issue.

- The proposed pipeline routes are appropriate and either the Frankische or traditional concrete pipelines proposed would be suitable.

BLACK GEOTECHNICAL PTY LTD

Appendix A – Landslide Risk Assessment Capability Statement.

Black Geotechnical has conducted many landslide risk assessments and slope remediation projects over the years. All personnel conducting the assessment have undertaken multiple courses run by the AGS landslide risk assessment developers and have completed the MEngSc (Geotechnical Engineering and Engineering Geology) degree at UNSW.

A selection of relevant projects is included below.

- Fyansford Green (Geelong) landslide risk assessment (Moltoni Corporation & Robert Luxmore), 2008 – 2014
- Creswick Creek slope remediation (Hepburn Shire Flood Recovery Office), 2013
- Slope stability assessment, Ichthys LNG Export Pipeline project, Darwin (OSD Pipelines), 2015
- Kalimna West Road stability assessment (East Gippsland Shire Council), 2016
- Rocky Valley Creek, Bogong Village landslide risk assessment (AGL), 2017
- Valley Lake landslide risk assessment peer review (Development Victoria), 2018
- Lakes Entrance Lookout landslide risk assessment (East Gippsland Shire Council), 2019
- Stability assessment for very large crude oil tank and containment bund (ExxonMobil), 2019
- Balaclava mine landslide risk assessment (Parks Victoria), 2020
- Lal Lal falls landslide risk assessment (Moorabool Shire), 2020
- Rocky Valley power station tunnel stability assessment (AGL), 2020
- Walhalla Historic Area landslide risk assessment (Parks Victoria), 2021
- Bendigo mine shaft collapse risk assessment (Parks Victoria), 2021
- Maryborough mine shaft collapse risk assessment (Parks Victoria), 2021
- Maddingly roadside landslide risk assessment (Moorabool Shire), 2021
- Newmerella landslide risk assessment (East Gippsland Shire Council), 2022
- Bogong High Plains Road landslide risk assessment (East Gippsland Shire Council), 2022
- Balaclava mine ongoing landslide risk assessment (Parks Victoria), 2022
- Mount Baw Baw Tourist Road slope remediation (Fulton Hogan), 2022
- Darley preliminary landslide risk and historical mine shaft collapse assessment (Moorabool Shire), 2023
- Walhalla roadside landslide risk assessment (Baw Baw Shire Council), 2023
- Walhalla private residence landslide risk assessment (Baw Baw Shire Council), 2023