TERRA INSIGHT

No 3 (Lot 3 DP 1018217) Dido Street, Kiama, 2533

Combined Preliminary (Contamination) Site Investigation and Geotechnical Site Investigation

Prepared for:

SET Consultants

Our Ref: TERRA18228 Rep 1 Rev 0

Prepared for:
Mr Al-Said
C/ SET Consultants

22 October 2018

Attention: Mr S Al-Said

RE: No 3 (lot 3 DP 1018217) Dido Street, Kiama, 2533
Stage One Preliminary Site Contamination with Soil Sampling

Dear Sam

EXECUTIVE SUMMARY

Please find enclosed our report for the proposed residential redevelopment of No 3 (Lot 3 DP 1018217) Dido Street, Kiama (the Site). The Site is currently zoned for Primary Production and is currently in rural residential use. It is understood the Site is proposed to be subdivided for low density residential use.

This report documents the results of a Preliminary Site Investigation (PSI) for contamination and a Detailed Geotechnical Investigation which includes a landslide risk assessment (LRA).

The objectives of the PSI were to assess the potential for site contamination to exists on the Site (where site contamination is defined within Section 5 of the *Contaminated Land Management Act* 1997 (CLM Act)) and if present, to assess the requirement for any particular contaminated land site management. The objective of the geotechnical investigation was to assess the subsurface conditions and provide geotechnical advice to facilitated design for the proposed residential subdivision.

The Site is underlain by topsoil, residual soil which grades into weathered rock at depths between 0.2 and 0.9m. No groundwater was encountered during the investigation. It is expected that a locally perched water table may occur seasonally, above the weathered rock - soil boundary. Groundwater and surface flows are likely to occur to the south-east, towards Spring Creek.

Conclusions

The PSI desk study identified the potential for the following contaminants to be present on the site, from historical site use:

- Isolated hydrocarbon, PAH, heavy metals and BTEX contamination from spills associated with the use of vehicles on the site, in particular the access driveway;
- Pesticides associated with control of vegetation or pastoral care of animals on the site; and
- Foreign material (including asbestos) and heavy metals associated with the existing access road, historical buildings on the site and illegal dumping of waste.

The site walkover did not identify evidence of existing buildings being present on the site or the illegal dumping of waste. The PSI assessment therefore assessed the risk of the above contaminants being on site as low. Based on the findings above, the Site is determined to not be contaminated significantly enough to warrant regulation, pursuant to the CLM Act.

The geotechnical investigation identified that the site has a low and tolerable risk of landslide. The site classifications for each proposed lot are assessed as Class P due to the sloping nature of the site and the presence of existing vegetation. Footings for the proposed residential building are to be founded on weathered rock at depths varying between 0.2 and 0.9m.

Recommendations

Terra Insight recommends that a short-term Construction Management Plan (CEMP) be developed for the Site to facilitate the following:

- Off-site disposal of General Solid Waste (GSW) materials (subject to waste classification);
- Off-site disposal or reuse of V/ENM material generated by site earthworks (subject to V/ENM certification);
- Unexpected findings of contaminated material and management of adjacent or underlying soil guidelines exceedances;

This report should be read in conjunction with the attached document 'About Your Report' provided in Appendix A. Should you have any questions please contact the undersigned.

For and on behalf of Terra Insight

Karen Gates
Principal Engineer/ Director
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1 Introduction

At the request of SET Consultants, on behalf of Mr S Al-Said (the Client), Terra Insight Pty Ltd (Terra) has carried out the following for No 3 Dido Street, Kiama, 2533, New South Wales (hereafter referred to as the Site):

- a preliminary (contamination) site investigation (PSI); and
- a geotechnical site investigation(GSI) including landslide risk assessment (LRA) and site classification.

2 Proposed Development

It is understood the Client proposes to rezone the property from RU1 Primary Production to residential zone R2 (Low Density Residential) or R5 (Large Lot Rural Residential). The potential lot layout, provided by the client, indicates the Site will be subdivided into 10 smaller residential lots with a bisecting road corridor from east to west (please refer to Appendix B the conceptual site development plans).

3 Investigation Objectives

The objectives of the combined contamination and geotechnical investigation are as follows:

- Geotechnical Site Investigation (GSI):
  - Provision of a landslide risk assessment of the site in general accordance with Australian Geomechanics Volume 42, No 1, March 2007;
  - Provision of site classifications for each proposed lot in accordance with AS2879; and
  - Provision of general recommendations in relation to geotechnical aspects associated with the proposed works, specifically: slope stability, foundations, and site drainage.
- Preliminary Site Investigation – Contamination (PSI):
  - to assess the potential for site contamination (as defined in Section 5 of the *Contaminated Land Management Act*, 1997) to be present on the Site from previous and current site activities;
  - to assess whether this contamination will impact on the proposed use of the Site; and
  - to assess the need for further investigation and/or site remediation.

We note that the *Contaminated Lands Management Act* 1997, defines the contamination of land as the presence (in, on, or under the land) of a substance at a concentration above the concentration at which the substance is normally present (in, on, or under the land respectively in the same locality), being a presence that presents a risk of harm to human health or any other aspects of the environment. However, land is not, for the purposes of this Act, contaminated land:

- Merely because in any surface water standing or running through the land, a substance is present in such concentration, or
- Merely because of the presence of a substance prescribed by the regulations, or
- In circumstances prescribed by regulations.

It is understood that the findings and conclusions of the PSI assessment will be used by Council to determine the need for any particular site management to occur to facilitate the redevelopment of the Site. It is noted that if land is contaminated but this contamination is not determined to be 'significant enough to warrant regulation' then the *Contaminated Land Management Act 1997* does not apply. In such cases, the provisions within the planning legislation and/or the *Protection of the Environment Operations Act 1997* may be the appropriate mechanism for management of such contamination.

4 Scope of work

The proposed scope of work for the combined geotechnical and environmental assessment comprised the following:

- Desk top study involving the review of publicly available information including geological mapping, topography mapping, slope stability mapping, ground water information, EPA records, council records and land registry records.

- Development of an environmental (contamination) conceptual site model (CSM) for the site based on the desk study findings;
- A walkover of the Site by a principal geo-environmental engineer to observe the surface conditions and to visually identify and observe:
  - surrounding land uses;
  - topography, noting visual evidence of filling and potential indicators of slope instability and historical earthworks;
  - nearby sensitive environments;
  - potential areas of environmental concern (AECs) and chemicals of potential concern (COPC) associated with potentially contaminating activities; and
  - the appropriateness of the CSM including the impact of past activities on the Site which may have resulted in the potential for contamination and potential sources of contamination;
- Site preparation including dial before you dig submission and Health and Safety Plan;
- Field Investigation including augering of boreholes on the Site and collection of samples of subsurface materials.
- Geotechnical and Environmental laboratory testing where required;
- Review of the field and laboratory results; and
- Report on activities above in relation to the objective outlined in Section 3.

5 Desk Study Findings

The desk study was based on records available on line, with Kiama Shire Council (Council) and from Broadcrests Mapping and Spatial Services' SiteInfo report which is provided in Appendix C.

5.1 Site Location and Setting

The Site is in Kiama, as shown on Figure 1. The Site is comprised of one lot (known as Lot 3 on deposited plan DP1018217) with an area of approximately 9500m^2. A summary of key property details is provided in Table 5.1.

Table 5-1: Summary of site identification, ownership and use information

Item	Detail	
Road Address	No 3 Dido Street, Kiama NSW	
Title Identifiers	Lot 3 on DP 1018217	
District/Division Name	Kiama Municipal Council	
Site Description	The Site is located on the western side of Dido Street, the site is undeveloped with private road which transects the Site, providing access to No 17 Dido Street to the west.	
Area	~ 9500m^2	
Current Zoning	Zoned RU1 – Primary Production Zone refer appendix C	
Proposed zoning	Zone R2 - Low Density Residential or Zone R5 - Large Lot (Rural) Residential	
Current Site Use	Large lot residential – the site is undeveloped and currently not in use	
Proposed Site Use	Low density residential	
Surrounding Land Use	North	Rural residential and farming (zoned RU1) - refer Appendix CB
	South	Rural residential and farming (zoned RU1) - refer Appendix C
	East	Low density residential – single dwellings and units (zoned R2) - refer Appendix C
	West	Rural residential and farming (zoned RU1) and E2 Environmental Conseravtion associated with a natural drainage channel (Spring Creek) - refer Appendix C

5.2 Surface Topography

A site topographical map and slope heat map are provided in Appendix C. Based on these maps the site can be divided into three distinct zones, as follows:

- Zone 1: This area includes the north-eastern third of the Site, north of the current access driveway. This part of the Site slopes moderately to steeply to the east (about 15 m vertical to 50 m horizontal) towards Dido Street. Within this part of the site are some near level terraces which are possibly man made or flat rock outcrops. Site elevations vary from 50m AHD to the west to 30m AHD to the east. This Zone includes proposed Lots 1 and 10 and the eastern half of proposed lots 2 and 3.
- Zone 2: This area includes the north-western part of the site, north of the current access driveway. This area includes the part of the Site with the highest elevation (about 60 AHD in the north west corner of the site). The slopes on this part of the site fall gently to moderately to the south-east to an elevation of about 45m AHD. This Zone includes the proposed western half of proposed lots 2 and 3 and proposed Lots 4 and 5.
- Zone 3: This part of the Site includes the third remaining part of the site to the south of the current access road. This part of the site has gently to moderate slopes which fall to the south-east. This part of the site has elevations between 50 AHD on the western site boundary and 50m AHD on the south-eastern corner. This zone includes lots 6 to 9.

The current access road which transitions through the site has a gentle to moderate slope between 9 and 15 degrees. The heat slope mapping shows quarries have been excavated to the north of the site. A property to the north of the site has also been constructed on a terrace, which has been cut into the hillside.

5.3 Site Geology

The 1:250,000 geology sheet for Wollongong (refer Figure 1) indicates the site located near a transition in subsurface geology. This includes the following:

- North-western part of the site (Zone 2): This part of the site is mapped as underlain by Blowhole Latite (Pbh) of the Gerringong Volcanics (Shoalhaven Group), which is comprised of Latite; and
- Remainder of the site (Zone 1 and 3): This part of the site is mapped as underlain by Kiama Tuff of the Gerringong Volcanics (Shoalhaven Group). This is comprised of trachytic tuff with pebbly bands.

The SiteInfo report shows the 1:100,00 geological mapping for Kiama. This shows the following:

- The north-western part of the site (Zone 2) is underlain by dark grey to black porphyritic basalt with columnar jointing and breccia zones.
- The eastern and south-eastern parts of the site (Zone 1 and 3) are underlain by red-brown or green-grey lithic to feldspathic sandstone with minor inbedded siltstone and pebble conglomerate.

Based on the above mapping it is expected the site will be underlain by fine grained igneous rock (latite/basalt) and sedimentary igneous rocks (Tuff) with the potential for sandstone or meta-sandstone to overlying these bed rocks.

5.4 Acid Sulphate Soils Mapping

The online Acid Sulphate Map for Kiama shows that the Site is not located on or near an Acid Sulphate Soil risk areas.

5.5 Surface hydrology and Subsurface Hydrogeology

Surface water will flow down slope to the south-east. The surface waters will be interested by Dido Street and will then flow via council stormwater services or natural drainage channels towards Spring Creek, located to the south-east of the site. Spring Creek flows onto Bombo beach about 1000 m downstream of the site.

There are no water monitoring bores listed with the NSW Department of Industry Office of Water within 500m of the Site (refer Image 1 and Appendix C). Ground water is also inferred to follow surface topography, falling with ground elevation to the south-east, towards Spring Creek.

Image 1: Location of Groundwater bores

5.6 Historical slope mapping

The site is in a hillside area on the foot slopes of the Illawarra escarpment. The slopes of the Illawarra escarpment have been mapped on several occasions for landslide risk, since the early 1970s. Neville mapped the risk associated with landslide for slopes around Kiama in 1977. The mapping for the site is shown on Image 2.

Reference to Neville's Geological Hazards indicates the site is located within an area mapped as potentially unstable land. This terrain is described as comprised of 'land with steep slopes of 15 to 20 degrees and includes areas of lessor slope on talus covered benches. Excavation or fill placement in this region or seepage could cause instability. Urban development is not recommended. Detailed geotechnical investigations should precede any site development'.

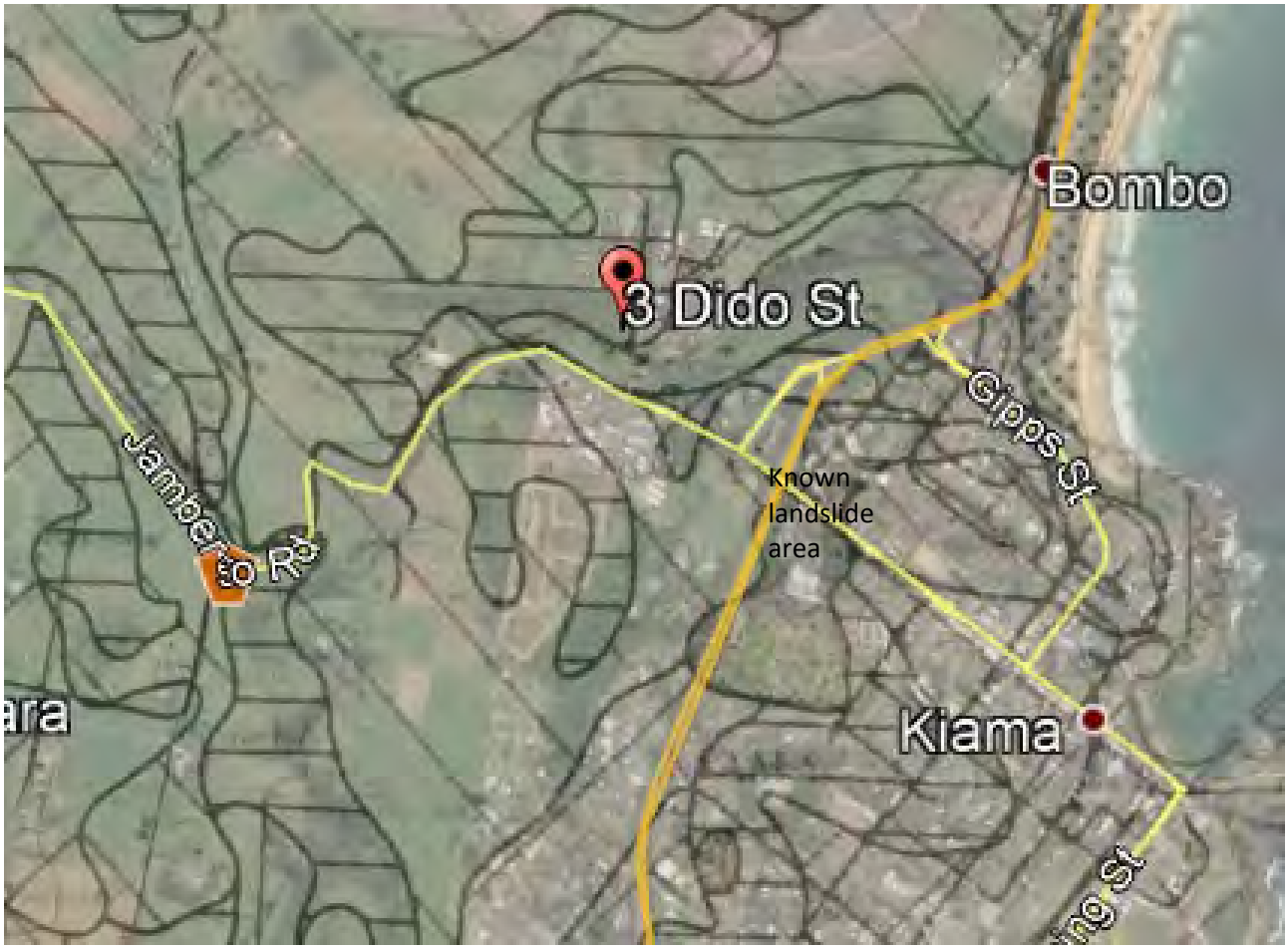


Image 1: Historical Land Stability Mapping

The Siteinfo report provides a list of known landslides within the Kiama area. This report does not identify any known landslides within 1000m of the site.

5.7 Site history data sources

Information on the Site history was obtained from:

- A search of NSW EPA register for listings of the Site and nearby sites;
- Review of historical aerial imagery;
- Council Records; and
- Land registry records.

A summary of the information obtained and reviewed is provided in subsequent sections.

5.7.1 NSW EPA records

Based on an online search conducted by Broadcrest, there are currently no notices for the Site (or neighbouring sites) on the NSW EPA contaminated land record or *Protection of the Environment Operations Act 1997* public register within 1000m of the site (refer Appendix C).

5.7.1 Review of council and land registry records

Terra Insight made an informal request to Council to review relevant information pertaining to the site. This included property files, development applications (DA), complaints history, issues relating to contamination and current and previous zoning. Documentation held by council indicates the site has been in rural (farming use). Searches of the NSW land registry were also undertaken to identify previous owners of the site. These documents are provided in Appendix D and summarised in Table 5.3 on page 8.

5.7.2 Historical Aerial Imagery

Select aerial imagery from the 1960's to present day was reviewed on six maps, google earth software and at Council. A select collection of historical images of the Site between the 1960's and 2018 are shown on Figure 2. Aerial images are also provided in Appendix E. Table 5.2 following on Page 7 presents a summary of observations made during the review.

5.8 Summary of desktop findings

The following is a summary of the history of the Site:

- The site has been in rural use since the late 1800's. The site has been used for farming. The use of the Site has not changed.
- The site prior to 2011 was mainly grassed. Within the last 20 years, matures trees have become established on the site.
- An access road has been cut into the slope across the middle of the site. The access road traverse across the site from Dido Street in the east to No 17 Dido Street in the west.
- There is no evidence, on the historical aerial images, of previous structures having been constructed on the site (eg buildings, animal treatment or storage pens), that the site has been quarried, and/or that earthworks (including landfilling) have been undertaken on the site.

Table 5-2: Summary of historical aerial photographs

Image Date	Onsite Observations	Offsite Observations
Broadcrest Site Info Report 1964 Refer Figure 2	The earliest image of the site is in 1964. This shows the site in rural (farming) use. The site is fenced. There are no visible access tracks or drainage lines. The site is grassed.	Land around the Site is typically grassed and in rural (farming) use. Dido Street is visible. Two existing dwellings are visible immediately to the south of the site and to the east of Dido Street and the site. Spring Creek is visible south of the Site.
Broadcrest Site Info Report 1974 Appendix E	There is little notable change on the Site.	There is no notable change on adjacent sites. Several new residential dwellings are visible within the general area around the Site.
Broadcrest Site Info Report 1984 Figure 2 and Appendix E	The access road to NO 17 Dido Street has been constructed through the site, otherwise, there is little notable change on the Site.	A dwelling is now visible on No 17 Dido Street to the west of the site. There is no other notable change on adjacent sites. Residential development is occurring within the general area around the Site with new roads under construction.
Broadcrest Site Info Report 1993 Appendix E	There is little notable change on the Site.	There is no other notable change on adjacent sites. Residential development is continuing to occur within the general area around the Site with new roads and new dwellings now visible.
Google Earth 2005	There is little notable change on the Site. Some large shrubs / small trees have become established within the middle of the site and along the site's northern, eastern and southern boundaries. A track to a power pole is visible on the eastern part of the site.	There is no other notable change on adjacent sites. Residential development is continuing to occur within the general area around the Site with new roads and new dwellings now visible.
Broadcrest Site Info Report 2011 Appendix E	Mature trees now vegetate about 50% of the site. There is little other notable change on the Site.	A dwelling is now visible on the Lot to the north of the site. Vegetation density has also increased on adjacent sites. There is no other notable change on adjacent sites. Residential development is continuing to occur with land to the east of Dido Street now residentially developed.
Broadcrest Site Info Report 2018 Appendix E	Mature trees now vegetate about 75% of the site. There is a bare area of ground within Zone 2. This area is associated with outcropping bedrock. There is little other notable change on the Site.	Vegetation density has increased on adjacent sites. There is no other notable change on adjacent sites. Residential development is continuing to occur to the east of Dido Street.

Table 5-3: Summary historical records search

Site	Reference and Date	Comments
No. 3 Dido Street, Kiama	16/7/1889 to 4/12/1993	The land was owned by George Dawes of Kiama, Farmer
	4/12/1993 to 31/12/1953	The site was owned by Harold Dawes of Kiama and his estate
	31/12/1953 to 13/8/1974	The property was owned by Mr James Lymbery of Terara, a farmer
	13/8/1974 to 11/12/2000	The site was owned by Terralong Estates Ltd
	11/12//2000	Purchase of the land by Mr Hazim Al-Said and May Al-Said

6 Conceptual Site model (CSM)

6.1 Potential sources of contamination

Site history information and site observations indicate that a limited number of potentially contaminating activities have occurred at the Site. These activities and potential sources of contamination are limited to use of the site as farm land and include:

- Control of vegetation potentially using pesticdes/herbicides;
- Pastoral use of the land by animals which results in increased nutrients;
- Potential demolition of unidentified old structures on the site; and
- Use of vehicles on the land and along the access driveway.

6.2 Potential Contaminants of Concern (PCoCs) and their persistence in the environment

The following potential contaminants of concern have been identified at the Site based on the potential sources of contamination:

- **Pesticides:**
  The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others. Among these, organochlorine (OC) insecticides (used successfully in controlling a number of diseases, such as malaria and typhus) were banned or restricted after the 1960s. This was followed by the introduction of synthetic insecticides including organophosphate (OP) insecticides in the 1960s, carbamates in 1970s and pyrethroids in 1980s. Pesticides are likely to have been used on the site to manage weeds and insects. When sprayed on crops or in gardens, pesticides can be blown by the wind to other areas. They can also flow with rain water into nearby streams or can seep through the soil into ground water. Pesticides differ according to their effects on various organisms. Selective pesticides are toxic only to the target pests (eg termite treatment). Their persistent in the environment is dependent on each individual chemical's composition and the environment in which they are used. Typically, persistence is less than 5 years, with DDT and copper-based pesticides being a few of the exceptions.
- **TRH, PCBs and BTEX:**
  These contaminants may potentially exist if fuel or oil was spilled accidently or disposed of on the Site. TRH and BTEX are not considered to be persistent in the environment due to their volatile nature. PCBs are generally non-soluble in water, non-volatile and resistant to flame, thermal and chemical degradation. PCBs are therefore relatively persistent in the environment and can bio-accumulate.
- **Asbestos and heavy metals:**
  Asbestos and metals (such as lead, chromium, and zinc) were used in the construction of buildings prior to the 1990's. Although asbestos can enter the environment through the breakdown of natural deposits, the presence of asbestos on site is mainly via the deterioration of manufactured asbestos products. Asbestos fibres do not breakdown in air or dissolve in water, and so they have the potential to be suspended or re-suspended and to travel large distances (by air and/or water) before settling. The larger fibres tend to settle more readily. Asbestos fibres do not readily move through the soil, and in general do not breakdown to other compounds, and therefore persist in the environment.

6.3 Potential Areas of Environmental Concern (AECs)

Table 6.1 (on the following page) summarises the areas of environmental concern (AECs) identified for the site based on the desk study findings. The approximate location of each AEC is also shown on Figure 3.

Table 6-1: Summary of Potential Areas of Environmental Concern (AEC) identified by desk study

AEC	Potentially Contaminating Activity/Source	Sub Component / Description	Potential Areas of Environmental Concern (See also Figure 3)	Likelihood of Contamination*	Potential Chemicals of Concern
AEC A	Deterioration (weathering) and demolition of former (unidentified) structures within the site or from illegal dumping on the site	Weathering of hazardous building materials such as lead paint, ACM and galvanised iron from former site structures. Use of pesticides under old foundations	Typically, contamination associated with this source is identified adjacent to and/or beneath former site structures. Generally near surface soils are potentially affected.	**There is a very low likelihood of these contaminants being present on the site as no former structures or evidence of former structures is visible on aerial images the site.** Future risk can be managed by ensuring any accidental finds procedures is adopted for the site during construction.	Asbestos, lead, zinc, arsenic,
	Localised petrol or oils spills within the Site from use of farm machinery -	Spillage of fuels and oils from vehicle and farm equipment	Associated mainly with the existing driveway but may also be present within the site due to use of farm equipment. Soil, groundwater and vapour media can potentially be affected.	**LOW** likelihood of contamination based on historical site use.	TRH, BTEX, PAHs including, B(a)P, heavy metals
	Pesticides	Spillage from containers, spraying of pesticides onto the ground and onto vegetation	Mainly associated with surface soils, but likely to be concentrated around drainage lines and where commonly used (eg along the existing access driveway and property boundaries). Generally near surface soils are affected. Water soluble pesticides may seep into groundwaters.	**Low likelihood of contamination based on historical site use.** The site appears to have been mainly used for open grazing. There is no evidence of crops having been grown on the site on historical aerial images	Pesticides including OPP, OCP, DDT, copper and arsenic

6.4 Potential receptors of concern

In summary, based on the review of historical aerial photographs and surrounding land uses the potential receptors of concern are as follows:

- Current users of the (eg farmer);
- Transient users of the Site (e.g. construction and maintenance workers);
- End users (eg building occupiers);
- Flora and fauna on the Site and surrounding areas; and
- Aquatic ecosystem of Spring Creek via council stormwater services.

In this CSM, a contaminant can be any substance, which is in, on or under the land and which has the potential to cause harm or to cause pollution of controlled waters. A pathway is defined as one or more routes or means by, or through, which a receptor is being exposed to, or affected by, a contaminant or could be so exposed or affected. Table 6.2 details the potential receptors of concern and the potential pathways.

Table 6-2: Potential contamination-based pathways and receptors

PCoCs	Pathway	Receptor
Asbestos impacted soils	Inhalation of fugitive dust	Current site users (farmer)
		Construction and maintenance workers
		Future site occupiers (home owners)
		Local Fauna
Metals within shallow soils	Inhalation of fugitive dust	Current site users (farmer)
		Construction and maintenance workers
		Future site occupiers (home owners)
	Ingestion and absorption by direct contact	Current site users (farmer)
		Construction and maintenance workers
		Future site occupiers (home owners)
	Migration by surface run-off or solution	Surface waters
		Groundwater
		Nearby aquatic environments of Spring Creek
	Plant uptake	Local flora
Petroleum hydrocarbons, PAH, TPH and BTEX	Inhalation of vapours	Current site users (farmer)
		Construction and maintenance workers
		Future site occupiers (home owners)
	Ingestion and absorption by direct contact	Current site users (farmer)
		Future site occupiers (home owners)
	Migration by surface run-off	Surface waters
	Migration by liquid flow	Surface waters
		Aquatic systems
	Plant uptake	Local flora

7 Site walkover and surface observations

A site walkover by a principal geo-environmental engineer was undertaken of the site on 28th of September 2018 to visually identify and observe surface conditions with respect to:

- potential sources of contamination;
- surrounding land uses and topography including noting visual evidence of filling;
- evidence of structural distress related to ground conditions;
- nearby sensitive environments; and
- potential areas of environmental concern (AECs) and chemicals of potential concern (COPC).

Images taken during the Site inspection are provided in Appendix F for reference. The following observations were made during the Site visit:

- The site is located on the side of a hill, with slopes that fall to the south-east typically moderate to steep slopes.
- The site has been divided into three (3) zones as follows:
  - Zone 1: is comprised of the north-eastern part of the site including proposed lots 1 and 10 and the eastern half of proposed lots 2 and 3. Within this area is an existing dirt track which provides access to a personal power pole as shown on photograph 1. The slopes on this part of the site are moderate to steep as shown on photograph 2. The Zone is well vegetated with trees and shrubs including invasive weeds as shown on photographs 1 to 3. The eastern part of the existing driveway passes through the southern part of this zone as shown on Photograph 4. The proposed new driveway bisects this zone.
  - Zone 2: is comprised of the north-western part of the site including the western half of proposed lots 2 and 3 and proposed lots 4 and 5. The eastern part of the proposed driveway is also located partly within the southern part of this lot, immediately to the north of the current driveway as shown on photograph 5. This part of the site has gentle to moderate slopes as shown on photographs 6 and 7. The zone is mainly grassed with some stands of mature tall shrubs and small trees. On the eastern part of this zone, rock is visible outcropping at the ground surface as shown on photographs 8 to 9. Some boulders are also visible as shown on photographs 10 and 11. This zone includes the part of the site with the highest elevation, towards the crest of a hill, were the slope is gently to near horizontal as shown on photograph 12 and 13.
  - Zone 3: This part of the site is located south of the existing and proposed access road and includes proposed lots 6 to 9. The site has moderate to steep slopes which are typically well vegetated with small mature trees and large shrubs as shown on photographs 14 to 16. Rock boulders are visible within the near surface soils on the higher elevated parts of the site. A rock wall is located along the sites southern boundary as shown on photograph 17.
- The vegetation on the north-west section of site includes mainly grass with sparsely spaced shrubs and trees. The remainder of the site is predominantly forested with medium to large mature trees and grass cover. This dense tree cover limited safe access for inspection and test pitting on parts of the site.
- There is an existing concrete driveway providing access from Dido Avenue through No. 3 Dido Street to No. 17 Dido Street, as shown in Photograph 4 and 5. This concrete driveway also included steel rails in parts.
- During the walk over, visual inspection of the surface was undertaken. No foreign material other than the concrete driveway, electricity pole and walls/fences along the site boundaries was visible.
- No fragments of asbestos containing material were observed on the surface of the site or within the materials excavated from the test pits.
- No evidence of previous structures was observed on the site.
- No groundwater seepages were observed.
- Rock was visible as outcrops and embedded boulders on the site.
- There was no notable signs of large scale or localised slope instability. Erosion of the near surface soils due to overland surface water flows was visible, however no large rills or gullies where observed.

8 Subsurface and laboratory investigation

8.1 Subsurface conditions

The field Investigation was undertaken on the 28th of September 2018 and involved the following:

- Service clearance of the proposed borehole locations;
- Excavation of five (5) test pits at the Site using an excavator equipped with a bucket attachment.
- Photographs of the test locations were taken and are provided in Appendix F.
- The location of each test pit was recorded using a GPS.
- The supervision of the excavation, and the logging and sampling of the materials encountered was undertaken by a Principal Geotechnical Engineer;
- Each test pit was backfilled with tailings to surface level.
- No DCP testing was undertaken due to the shallow depth to rock.

The locations of the boreholes are shown on Figure 4. The engineering logs of the test pits with soil and rock description explanation sheets are presented in **Appendix G** and should be referred to for a detailed description of the materials encountered. The subsurface conditions underlying the Site were found to comprise the following:

- Top soil: a layer of silty clay topsoil with fine to medium sand.
- Residual: Sandy clay with latite cobbles in some locations, grading into
- Latite, light brown with grey and purple colouring.

A summary of the sub surface conditions encountered are provided in Table 8.1 on Page 14.

8.2 Geotechnical laboratory test findings

A sample of material was taken from TP05 and tested in a NATA accredited laboratory according to AS1289.6.1.1. The purpose of the testing was to obtain the California Bearing Ration (CBR) and other properties of the soil. The results are summarised in table 8.2 on page 14. This testing indicates the soil underlying the site are of medium to high plasticity with a high potential for reactive soil movements. Laboratory certificates are provided in Appendix H.

Table 8-1: Summary of subsurface investigation

Subsurface conditions *(Soil name, plasticity or particle characteristics, colour, secondary components and minor components)*	Structure and other comments	Depth encountered in test pit/exposure (m)				
		TP01	TP02	TP03	TP04	TP05
Silty CLAY: with sand, low to medium plasticity, brown, fine to medium sand, trace of grass roots, firm.	Top soil	0.0-0.3	0.0-0.1	0.0-0.2	0.0-0.2	0.0-0.2
Sandy CLAY: with cobbles in some locations, medium plasticity, brown, fine to medium grained sand, firm to stiff.	Residual	0.3-0.6	0.1-0.2r	0.0-0.5	0.2-0.4r	0.2-0.4
Sandy CLAY: medium plasticity, orange brown to yellow brown with trace of grey mottling, fine to medium grained sand, stiff.	Residual	0.6-0.9				
Latite: light brown with grey and purple, stiff.	XW Material	0.9-1.5r		0.5-0.6r		

Notes * - End of hole at target depth; ^{r} - Early refusal on rock, VR- Virtual refusal, NE – not encountered

Table 8-2 Summary of Laboratory Results

Parameter	Laboratory Test Result	
	TP03 (0.2 to 0.5m depth)	TP05 (0.2 to 0.4m depth)
CBR at 5.0mm (%)		8
Maximum Dry Density (t/m3)		1.58
Optimum Moisture Content (%)		23.3
Swell (%)		0.5
Liquid Limit (%)	53	53
Plastic Limit (%)	29	32
Plastic Index	24	21
Linear Shrinkage (%)	11.5	14.0

9 Landslide Risk Assessment

9.1 Introduction

A geotechnical landslide risk assessment was undertaken for the proposed property. The risk to the property due to landslide has been assessed in accordance with the risk assessment method described in Appendix C of the journal, Australian Geomechanics, Vol. 42, No. 1, dated March 2007 (refer to Appendix I of this report). This paper is also referred to in Wollongong City Councils' Geotechnical Development Control Plan, updated in 2014.

Assessment of landslide risk considers the frequency and consequences of a particular failure event. The landslide risks considered herein, are those that directly impact on existing and proposed structures and their users.

Desktop studies using aerial photo, stability maps, and survey from Google Earth do not show any obvious signs of past deep-seated instability within the site boundaries. However, this information does show potential landslide activity down slope of the site, which could impact on the site over time.

No. 3 Dido Street, Kiama is on a small hill slope west of Kiama. The onus is on the owner (or potential owner or party) to decide whether the assessed level of risk is acceptable, considering possible economic consequences of the risk and geotechnical constraints. The 'Risk to Life' and property are assessed in the following sections.

9.2 Potential landslide risks

Based on AGS 2007, recent site observations and knowledge of slope conditions in the general area, potential landslide hazards/ events that could affect this site at the time of the assessment include:

- Localised soil creep;
- Localised slope failure;
- Boulder roll; and
- Large scale slope failure uphill or downhill from the site, which could impact on the site.

9.3 Risk to Property

Risk to property is assessed based on the proposed conditions of the site, including any risk management implemented as part of the proposed additions to the site. As there is no structure currently on this part of the site, the existing risk has not been assessed.

Risk assessment for property loss was undertaken using the Risk Matrix according to AGS (2007). The Risk Matrix defines a qualitative terminology for likelihood, consequence and risk. The frequency estimate is expressed as an annualised probability, considering the probability of spatial impact and is expressed qualitatively as likelihood.

The result of this assessment is summarised in Table 9.1. As the proposed development is residential, an assigned Importance Level of Structure of 'Two' has been adopted in accordance with AGS, 2007 (Appendix D, pg 86) for residential buildings. This assessed level of risk post the proposed site works, is based on the advice provided within this report being implemented on the site (refer section 5).

Table 9-1: Landslide event - likelihood and consequences to property

Case	Event	Likelihood	Consequences to property	Level of Risk
Future				
1	Localised soil creep	Possible	Insignificant	Very Low
2	Localised slope failure	Unlikely	Minor	Low
3	Large scale slope failure	Rare	Catastrophic	Moderate
4	Boulder roll	Unlikely	Minor	Low

Note to Table: * It is assumed that the recommendations in Section 10 are adopted/implemented.

9.4 Risk to Loss of Life

For this assessment, the risk to 'Loss of Life' was considered for the potential landslide events detailed in section 9.2 and considering the site segmented into three zones, as shown in Figure 4. The annual probability of loss of Life, R (LOL) post implementation of the proposed site works, is assessed as follows:

$$R\ (LOL) \quad = P\ (H)\ x\ P\ (S{:}H)\ x\ P(S{:}T)\ x\ V\ (D{:}T)$$

Where

P(H) is the probability of landslide per annum

P(S:H) is the probability of spatial impact which considers the potential travel distance, size of the slide and the geometry of the site.

P(T:S) is the temporal spatial probability which considers the time a person may be on site and the time they may occupy the part of the site impacted by the landslide.

V(D:T) is the vulnerability of the individual on the site.

Table 9-2: Zone 1: Landslide event - likelihood and consequences for Loss of Life

Case	Hazard	P(H)	P(S:H)	P(S:T)	V(D:T)	$P_{(LOL)}$
Future Risk						
Zone 1 and 3						
1	Local soil creep	$1x10^{-3}$	0.1	0.1	0.05	0.5E-06
2	Localised slope instability	$1x10^{-4}$	0.4	0.5	0.4	0.8E-05
3	Large scale slope failure	$5x10^{-5}$	0.7	0.7	0.8	0.2E-05
4	Boulder Roll	$1x10^{-4}$	0.4	0.5	0.4	0.8E-05
Zone 2						
1	Local soil creep	$0.5x10^{-3}$	0.1	0.1	0.05	0.3E-06
2	Localised slope instability	$1x10^{-4}$	0.4	0.5	0.4	0.8E-05
3	Large scale slope failure	$1x10^{-6}$	0.5	0.8	0.8	0.3E-05

10 Conclusions and Recommendations

10.1 Preliminary (Contamination) Site Investigation Findings

10.1.1 Conceptual Site Model

The preliminary CSM for the site was reviewed post the site walkover. This walkover did not detect visible signs of previous buildings having been present on the site. No foreign material was observed on the site or within the test pits except for the following:

- Concrete and steel rails within the access driveway;
- Timber post associated with the private power pole;
- Timber, wire, rocks and mortar associated with the fences/walls along the boundary lines.

No asbestos containing material was observed on the site. No evidence that material has been buried on the site was observable. There is no evidence that the site has been quarried on the historical aerial images. The depth to rock on the site was found to be typically shallow. The CSM was revised based on these findings as detailed in Table 10.1.

Table 10-1: Conceptual Site Model based on desk study and site walkover findings

AEC	Potentially Contaminating Activity/Source	Sub Component / Description	Potential Areas of Environmental Concern (See also Figure 3)	Likelihood of Contamination*	Potential Chemicals of Concern
AEC A	Deterioration (weathering) and demolition of former (unidentified) structures within the site and from illegal dumping of waste	Weathering of hazardous building materials such as lead paint, ACM and galvanised iron from former site structures.	Typically, contamination associated with this source is identified adjacent to and/or beneath former site structures. Generally near surface soils are potentially affected.	**There is a very low likelihood of these contaminants being present on the site** as no former structures or evidence of former structures are visible on the site or on historical aerial images. There were no signs of illegal dumping of waste on the site. The site has been used for grazing with no building history. The likelihood of asbestos being present in accordance with the WA guideline is therefore assessed as 'unlikely'. Future risk can be managed by ensuring an accidental finds procedure is adopted for the site during construction.	Asbestos, lead, zinc, arsenic, OCP/OPP, herbicides
	Localised spills within the Site-	Spillage of fuels and oils from vehicle and farm equipment	Associated mainly with the driveway but may also be present within the site due to use of farm equipment. Soil, groundwater and vapour media can potentially be affected.	**There is a LOW likelihood of contamination** based on historical site use and field observations. The access road appears to have been cut into the slope,. However, there is the potential for some localised areas of fill and road building materials (concrete, steel rails). This fill material may have been imported.	TRH, BTEX, PAHs including , B(a)P, heavy metals
	Pesticides	Spillage from containers, spraying of pesticides onto the ground and onto vegetation	Mainly associated with surface soils, but likely to be concentrated around drainage lines and where commonly used (eg along the existing access driveway and property boundaries). Generally near surface soils are affected. Water soluble pesticides may seep into groundwaters.	**Very low likelihood of ongoing contamination based on historical site use** (eg no evidence if the site having been used as an orchard or for commercial crops) **.**	Pesticides including OPP, OCP, DDT, copper and arsenic

10.1.1 Conclusions

The risk of contamination on the site is assessed as low. The site has been in rural residential use. The main contaminants likely to be present on the site are foreign materials from illegal dumping or road building and localised areas of hydrocarbon spills associated with use of the driveway.

10.1.2 Recommendations

The following recommendations are made:

- Testing of the material which has been used to cosnstruct the existing driveway shall be undertaken to facilitate removal and disposal of these road building materials;
- Waste classification of the near surface topsoils, to facilitate disposal if required; and
- To managed unexpected finds during construction, it is recommended that a construction environmental plan is developed for the site as detailed in the following section.

10.1.3 Construction Environmental Management Plan (CEMP)

The main objectives of the CEMP would be to:

- Provide appropriate management measures for the handling and disturbance of unexpected finds of contaminated materials.
- Provide environmental management procedures and advice regarding the development of the Site in the construction phase; and
- Provide advice to act in accordance with regulatory requirements to manage, amongst other aspects, the excavation, stockpiling and transport of materials.

The CEMP would also outline, to contractors on Site, the requirements for identification and management of unexpected finds of ACM or other materials which could be encountered during construction.

The CEMP shall address items such as:

- Off-Site disposal of materials impacted by hydrocarbons, chromium, lead and and nickel including waste certification, where required; and
- Management of unexpected findings of contaminated material and adjacent or underlying EIL/ HIL exceedance material.

It should be noted that general environmental protection measures (related to issues such as, water quality, dust, sediment and erosion), are to be implemented in accordance with the Contractors EMP. The CEMP will cover the entire Site including an Unexpected Finds Protocols.

In summary, the Construction Environmental Management Plan (CEMP) will be developed mainly:

- To provide a framework for implementation during construction phases of development;
- To include Incidental Finds Protocol for visible asbestos if encountered during GSW and ABM removal works in terms of isolation, management, assessment, classification and verification of the underlying clean layer;
- To include an Unexpected Finds Protocol in terms of other potential contaminants and waste;

10.1.4 Preliminary Waste Classification Assessment

The results of the preliminary site investigation indicate the following potential waste classification for disposal of the natural materials encountered on the Site:

- **Waste material 1 - Near surface natural materials (ENM):** These soils include topsoils and residual soils near the ground surface across the site. This material can be reused on or off site as ENM subject to laboratory testing and waste classification and ENM certification.
- **Waste material 2 – Residual material and weathered rock (VENM):** These soils are located below the top soil at depths of at least 0.3m across the site. This material can be reused on or off site as VENM subject to VENM certification.
- **Waste material 3- Near surface fill materials associated with the access road:** The near soils are expected to comprise some localised fill material and road building materials. Testing of these materials is recommended to allow waste classification for of site disposal. It is expected these materials can be disposed of off-site as general solid waste. They cannot be reused off site as ENM/VENM.

Waste and ENM certificates will be required for disposal or re-use of materials respectively.

10.2 Geotechnical Investigation Findings

10.2.1 Landslide Risk Evaluation and Management

In summary, the risk in terms of landslide is assessed as follows:

- **Damage to property: Is assessed as 'Low'.** For an Importance Level of Structure 2, the suggested acceptable upper limit of qualitative risk for an existing slope and new development is 'Low' (Table C10, pg 135, AGS 2007). Thus, for the Site the future risk to property is deemed acceptable.
- **Loss of life:** AGS suggested a tolerable loss of life of $1x10^{-5}$ per annum for newly developed/ constructed slope sites and $1x10^{-4}$ for existing slopes. For acceptable losses, this risk reduces to $1x10^{-6}$ and $1x10^{-5}$ respectively. The Site is classed as a new slope. T**he risk level is considered within the tolerable range.**

The options for managing landslide risk are to reduce the frequency of sliding or to reduce the potential impact on the proposed residential development of the site due to landslide. This means putting in place stabilisation measures to control the initiating circumstances during and after development and/or placing vulnerable structures/individuals at greater distance from a potential slide. Even with these measures in place, it does not mean that the risk of failure is removed, and that failure will never occur. The approach adopted is to reduce and maintain the risk associated with landslide at a low and tolerable levels.

10.2.2 Guidance for developments on sloping sites

Guidance on the good hill side practice for residential developments on sloping site is provided in LR08 AGS guide (refer Appendix J). This recommends the following:

- Water should not be allowed to discharge straight on to the hill side. Roadways and parking areas should incorporate kerbs and stormwater drainage;
- Retaining walls shall be design by competent engineers to consider the effects of sloping ground.
- Surface waters from roofs shall be piped to a suitable discharge point rather than being allowed to soak into the ground. This includes overflow from stormwater storage tanks. Discharge should be to council stormwater or where possible nearby lined storm water surface drains or natural water bodies.
- Light weight flexible structures are preferable because they can tolerate reasonable movement with minimal signs of distress and maintain their functionality. If masonry structures are to be adopted (to cater for fire zones, noise proofing, insulation requirements etc), then articulation must be provided.
- Foundation should be taken to a depth which is below the level at which a landslide is likely to occur. In natural conditions, it is preferable to support foundations in rock.
- Clearance of vegetation should be kept to a minimum. Large scale clearing can result in a rise in the groundwater table, which in turn can increase the likelihood of slope failure (eg landslide).

To attain and maintain the risk at low to moderate levels, in respect of the consequences of a landslide event during and after development, risk management practices are detailed in the following sections.

10.2.3 Site classification

The site classification for each lots has been assessed based on the following:

- The site is underlain by topsoil and residual soil with low strength highly weathered to moderately weathered latite encountered at variable depths between 0.0 to 0.9m. The depth to rock was deeper within Lots 4 and 5 at about 0.5 to 0.9m depth. On Lots 1 to 3 and 6 to 10, the depth to rock expected to be approximately 0.5m depth .
- Laboratory testing conducted on the near surface resdiual soils obtained a linear shrinkage of 11.5% and 14%. A nominal Shrink Swell Index of 4% has therefore been adopted for the assessment;
- The site is in Climatic Zone 1;
- The characteristic movement for each lot is dependent on the depth to rock. The characteristic surface movements for the site have been calculated at approixmately 30 mm for Lots 1 to 3 and 6 to 9. These movenments increase to approxinmately 40 mm for lots 4 and 5. Where large mature trees (>3 m in hight) are allowed to establish within 6m of the proposed structures on the allotments, surface characterisitc movements are expected to increase to between 40mm and 50mm. Larger and/or closer trees will increase these movements.
- Zones 1 and 3 are well vegetated. All allotments have large mature trees on site apart from proposed lot 4. However, Lot 4 has trees nearby which may impact the site classification. During the development of the sub-division, it is expected many of the trees will be removed. The removal of the trees may cause abnormal moisture conditions, in particular, increased moisture contents within the near surface clayey soils, potentially resulting in swelling of the soils. This could increase the seasonally movements on the site by an additional 10mm to 20mm.
- The site is located on a slope with a low risk of landslide.

In accordance with AS2870 and considering the above, the lots on the site are is classified as a Class P site. The site classification for each lot are detailed in Table 10.2. These site classes and the footing recommendations detailed herein are for the site conditions advised at the time of fieldwork. Consequently, the site classification may need to be reviewed if the proposed earthworks are changed (eg the site is further filled or cut).

Table 10-2: Summary of Lot Classifications

Lot Number	Landslide risk	Directly affected by existing vegetation	Characteristic Movement due to soil reactivity and including potential tree impact (ys, mm)	Classification
1	Low Risk	Yes	30-40mm	P (M movements)
2	Low Risk	Yes	30-40mm	P (M movements)
3	Low Risk	Yes	30-40mm	P (M movements)
4	Low Risk	Partly	40-60mm	P (H1 movements)
5	Low Risk	Yes	35-50mm	P (H1 movements)
6	Low Risk	Yes	35-40mm	P (M movements)
7	Low Risk	Yes	30-40mm	P (M movements)
8	Low Risk	Yes	30-40mm	P (M movements)
9	Low Risk	Yes	30-0mm	P (M movements)
10	Low Risk	Yes	30-40mm	P (M movements)

10.2.4 Footing design parameters

It is recommended that:

- All footings should be designed and constructed in accordance with AS 2870-2011, Residential Slabs and Footings, with consideration to the site classifications presented in Section 10.2.3.
- All topsoil and soft spots should be stripped from the building footprint.
- All footings for the same structure should be founded on strata of similar stiffness and reactivity to minimise the risk of differential movements, with articulation provided where appropriate.
- It is noted that excavations into the slope are likely to expose weathered rock at shallow depth. Therefore it is recommended that footings are located in weathered rock below the any topsoil or soft material. This rock is expected to be encountered at depths between 0.2 and 0.5m except for Lots 4 and 5, where the depth to rock is likley to be between 0.5 and 1.0m.
- No further fill is to be imported onto the site without further consultation with a geotechnical engineer. Importation of fill may change the site classification and could increase the risk of landslide.

At ground slabs founded on latite rock at shallow depth, may be proportioned for an allowable bearing capacity of 150kPa. Piers adopted on the site are likely to comprise bored piers due to the shallow depth tor rock. Piers designed to bear on the latite rock at variable depths between 0.2-0.9m, can be designed based on a nominal ultimate end bearing pressure of 1MPa. Skin friction must not be relied on within the zone of seasonal moisture content variation (eg the top 1.5 m depth from the surface). A geotechnical strength reduction factor of 0.45 shall be applied to the ultimate end bearing for bored piers.

We note that the ultimate end bearing provide is dependent on a clean base of bored hole. Inspection of high level or pier footings excavations should be undertaken to confirm the founding conditions and the base should be cleared of fall-in prior to the formation of the footing.

If foundations for proposed structures are located within the zone of influence of any service trenching, the service trench shall be bridged with the structure supported by pier footings. The depth of the pier footing should be extended below the zone of influence ignoring shaft adhesion. A structural engineer should be consulted for detailing.

10.2.5 Footing maintenance

Appendix B of AS 2870-2011 indicates that to reduce but not eliminate the possibility of damage, trees should be restricted to a distance from the building ¾ × the mature height. Where rows or groups of trees are proposed, the distance from the building should be increased.

Designs and design methods presented in AS 2870-2011 are based on the performance requirement that significant damage can be avoided if Site conditions are properly maintained. Performance requirements and foundation maintenance are outlined in Appendix B of AS 2870.

The Site classification above assumes that the performance requirements as set out in Appendix B of AS 2870 are acceptable and that Site foundation maintenance is undertaken to avoid extremes of wetting and drying. Details on appropriate Site and foundation maintenance practices are presented in Appendix B of AS 2870-2011 and in CSIRO Information Sheet BTF 18, Foundation Maintenance and Footing Performance: A Homeowner's Guide, which is attached as Appendix K.

While the site has been classified as one for which the standard footing details and consequent level of performance are not covered by AS2870, specific engineering design and the continued maintenance of the site in accordance with the guidelines in the attached copy of CSIRO Builders Technology File 18, 2011-Foundation Maintenance and Footing Performance: A Homeowners Guide, should result in a level of performance like that expected for a "normal" site covered by the standard.

10.2.6 Surface Protection, Storm Water and Vegetation

All roof-water not stored for reuse, and surface run-off, should be piped to the street. On-site disposal of storm-water by concentrated soakage is not recommended based on the increased risk reactive clay movement. Subsoil drainage is recommended on the upslope side of slab on ground structures to limit the ingress of seepage beneath the slab.

Surface water flows, which could occur downhill toward buildings, should be diverted around buildings and trained to flow away from building envelopes to lower slopes or storm water drainage facilities to be installed along the access road.

Exposed soil should be protected from erosion, by means of directing surface water to the lower part of the slope and revegetating the surface with grasses or small to medium sized plants. Sick or dying trees, which may fall, should be removed before they can impact on the slope.

10.2.7 Site preparation

Ground preparation should allow for the stripping of topsoil from structural footprints. Stripped soil would not be suitable for structural fill and must be processed to exclude cobbles and foreign material (where present) and then used for landscape applications if determined to be suitable for this purpose.

Surplus excavated materials may need to be exported or disposed of off the Site. Structural fill underneath building platform and the access road should be limited to no more than 300mm thickness and comprised of granular material compacted in layers not exceeding 200mm thick compacted thickness to achieve a minimum density ratio of not less than 98% standard dry density (SDD).

Construction during Site preparation works may impact on the existing trees. This may result in disturbance to the soil and changes to in situ moisture regimes which will need to be considered in the preparation of subgrades for pavements on the western side of the Site.

10.2.8 Fill

No additional general filling should be undertaken on the Site greater than 0.3m in thickness without further geotechnical advice.

10.2.9 Ease of excavation

This ease with which materials can be excavated on Site has been assessed using the Kirsten eight-point classification system provided in Table 10.3 below.

Table 10-3: Kirsten's eight-point excavation classification system

Class	Material Type	Description of Excavatability
1	Soil / Detritus	Hand spade (Dozer D3)
2		Hand pick and spade
3		Power tools
4	Rock	Easy ripping (Dozer D7)
5		Hard ripping (Dozer D8)
6		Very hard ripping (Dozer D9)
7		Extremely hard ripping / blasting (Dozer D10)
8		Blasting

The topsoil and residual materials encountered are expected to meet a Kirsten Classification of Class 2 to 4 and should be readily excavated using conventional earthmoving equipment such as hydraulic excavators,

backhoes, and dozers. Weathered rock is expected to range from Kirsten Class 4 to 6 to about 0.5 to 1.0m depth. Below this depth, extremely hard ripping is likely to be required.

10.2.10 Temporary and permanent retention of slopes

Excavations and fill slopes less than 0.6m in height in the overburden soils may be battered not steeper than 1V:1.5H, and vegetated or covered to limit erosion. Cut slopes in the weathered rock can be battered at no steeper than 1V:1H. Alternatively, cut and filled slopes can be retained. Further advice shall be sort from a geotechnical engineer for cut or fill slopes greater than 0.6m in height.

11 Limitations

The findings contained in this report are the result of discrete/specific methodologies used in accordance with normal practices and standards. Under no circumstances can it be considered that these findings represent the actual state at all points. The subsurface conditions may vary significantly on the other parts of the Site, particularly where no nearby sampling and testing work has been carried out. This report does not provide a complete assessment of the contamination status of the Site or surrounding area. The report is limited to the scope of work and objectives as outlined herein.

12 List of Acronyms

ACM	Asbestos containing materials
AECs	Areas of environmental concern
AF	Asbestos fines
ANZECC	Australian and New Zealand Environmental Conservation Council
ARCP	Asbestos removal control plan
BTEX	Benzene, toluene, ethylbenzene and xylene
CLMP	Contaminated land management plan
CMP	Construction management plan
COCs	Contaminants of concern
CSM	Conceptual Site model
DESA	Detailed environmental Site assessment
DQO	Data quality objective
EIL	Ecological Investigation level
EPA	Environmental protection Agency
FA	Fibrous Asbestos
GME	Groundwater Monitoring event
GSW	General solid waste
GWMP	Groundwater management plan
HIL	Health Investigation limits
JSA	Job Safety analysis
LAA	Land application area
LOR	Limit of report
LLD	Lower limit of detection
ML	Management limits
NATA	Nata Association of Testing Authorities
NEPC	National Environmental Protection Council
OCP	Organochlorine pesticides
OHS	Occupation Health safety
OPP	Organophosphorus pesticides
PAH	Polyaromatic Hydrocarbons
PBILs	Phyto-toxicity based investigation levels
PCBs	Polychlorinated bisphenols
PESA	Preliminary environmental Site assessment
PID	Photoionization detector
QC	Quality Control
RAP	remedial action plan
REF	Review of Environmental factors
RSW	restricted solid waste
SVOC	Semi-volatile organic compounds
TRH	Total recoverable hydrocarbons
VOC	Volatile organic compounds
WHS	Work health and safety

13 List of Definitions

Airborne asbestos: means any fibres of asbestos small enough to be made airborne. For the purposes of monitoring airborne asbestos fibres, only respirable fibres are counted.

Asbestos: means the asbestiform varieties of mineral silicates belonging to the serpentine or amphibole groups of rock-forming minerals, including actinolite asbestos, grunerite (or amosite) asbestos (brown), anthophyllite asbestos, chrysotile asbestos (white), crocidolite asbestos (blue) and tremolite asbestos.

Asbestos containing material (ACM): means any material or thing that, as part of its design, contains asbestos.

Asbestos removalist: means a person conducting a business or undertaking who carries out asbestos removal work.

Asbestos removal work means:

- Work involving the removal of asbestos or ACM
- Class A asbestos removal work or Class B asbestos removal work as outlined in Part 8.10 of the WHS Regulations.

Class A Licence: Can remove any amount or quantity of asbestos or ACM, including any amount of friable asbestos or non-friable asbestos or ACM.

Class B Licence: Can remove any amount of non-friable asbestos or ACM.

Friable asbestos: means material that is in a powder form or that can be crumbled, pulverised or reduced to a powder by hand pressure when dry, and contains asbestos.

NATA-accredited laboratory: means a testing laboratory accredited by the National Association of Testing Authorities (NATA), Australia, or recognised by NATA either solely or with someone else.

Non-friable asbestos: means material containing asbestos that is not friable asbestos, including material containing asbestos fibres reinforced with a bonding compound.

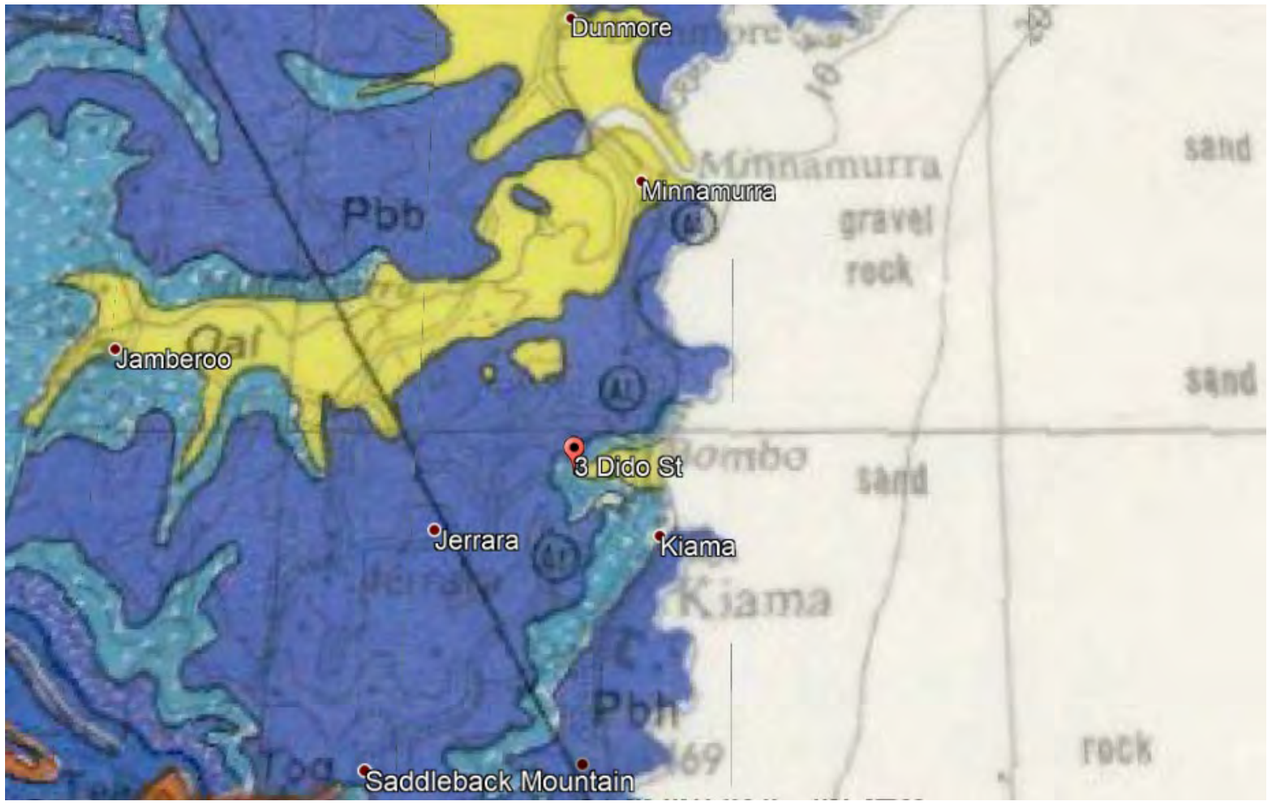
Project Works Boundary: Fence to be erected for duration of construction works and operational maintenance areas.

Project Works Zone: Construction area and potential ancillary Sites within project works boundary.

Proposed Property Boundary: Future land title covering Road to be owned by LMCC Road Corridor: Cadastral boundaries associated with the proposal.

Figures

N



Site Geology

Pbk – Shoalhaven Group, Gerringong Volcanos, Kiama Tuff,
Trachytic tuff with pebbly bands.

Site location

revision	description	drawn	approved	date
	Site location	KEG	KEG	4/10/2018

TERRA INSIGHT

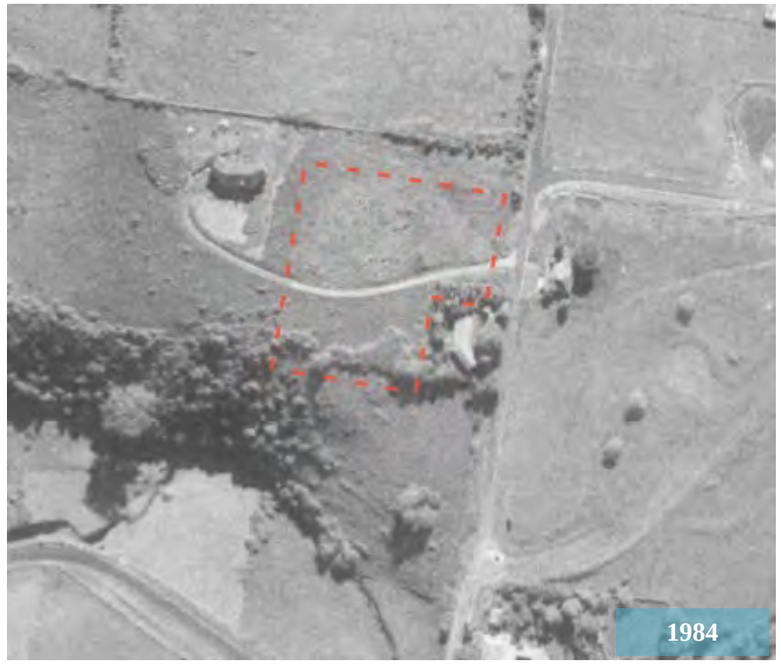
scale	NTS
original size	**A3**

client: **SET Consultants**

project: **Proposed residential subdivision Lot 3 DP 1018217 Dido Street, Kiama**

title: **Site Location**

project no: **TERRA18228** | figure no: **FIGURE 1**



revision	description	drawn	approved	date
	Aerial images	LE	KEG	23/05/18

TERRA INSIGHT

scale	NTS
original size	**A3**

client: **SET Consultants**

project: **Proposed residential subdivision Lot 3 DP 1018217 Dido Street, Kiama**

title: **Historical Aerial Images**

project no: **TERRA18228** figure no: **FIGURE 2**

N

Legend

Area of Environmental Concern (AEC1)

revision	description	drawn	approved	date
	Aerial images	HJP	KEG	10/10/2018

TERRA INSIGHT

scale	NTS
original size	**A3**

client: **SET Consultants**

project: **Proposed residential subdivision Lot 3 DP 1018217 Dido Street, Kiama**

title: **Areas of Environmental Concern**

project no: **TERRA18228** figure no: **FIGURE 3**

N

Legend

Test site

Test Site Locations

revision	description	drawn	approved	date
	Aerial images	LE	KEG	18/10/2018

TERRA INSIGHT

scale	NTS
original size	**A3**

client: **SET Consultants**

project: **Proposed Residential Redevelopment 26 Willow Grove, Corrimal NSW**

title: **Site Plan and Test Locations**

project no: **TERRA18228** figure no: **FIGURE 3**

Appendix A: Your Report

TERRA INSIGHT

Your Report

These notes have been prepared to help you understand the advice provided in Your Report and its limitations.

Your Report is based on what you tell us

Your Report has been developed based on the information you have provided such as the scope and size of your project. It applies only to the site investigated. If there are changes to the proposed works, then the advice provided within Your Report may need to be reviewed

Your Report is written with your needs in mind

The advice provided within Your Report is also not relevant to another purpose other than that originally specified at the time the report was issued. Please seek advice from Terra Insight before you share Your Report with another third party – except for the purpose for which the report was written.

Terra Insight assumes no responsibility and will not be liable to any other person or organisation for, or in relation to, any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in Your Report.

Your Report is based on what we observed

The advice provided within Your Report assumes that the site conditions, revealed through selective point sampling (undertaken in accordance with normal practices and standards) at a particular point in time, are indicative of the actual conditions on your site. However, the nature of the materials underlying your site is affected by natural processes and the activity of man. Under no circumstances can it be considered that these findings represent the actual state at all points. The subsurface conditions may vary significantly on the other parts of the site, particularly where no nearby sampling and testing work has been carried out.

As a result conditions on your site can change with time; they can also vary spatially. As a result, the actual conditions encountered may differ from those detailed within Your Report. Although nothing can be done to change the actual site conditions which exist, steps can be taken to gain a better understanding of the subsurface conditions underlying your site and reduce the potential for unexpected conditions to be encountered

The advice within Your Report also relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it. Only Terra Insight is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If the details of your project have changed, the site conditions have changed or a significant amount of time as elapsed since our report was written, the advice provided within Your Report may need to be reviewed.

Your Report has been written by a Professional

The report has been prepared using accepted procedures and practices of the consulting profession at the time it was prepared, and the opinions, recommendations and conclusions set out in the report are made in accordance with generally accepted principles and practices of that profession.

Your Report is better when it is kept together

Your Report presents all the findings of the site assessment and should not be copied in part or altered in any way. Keeping Your Report intact reduces the potential for yourself or other design professionals to misinterpret the report.

Your Geo-Environmental Report

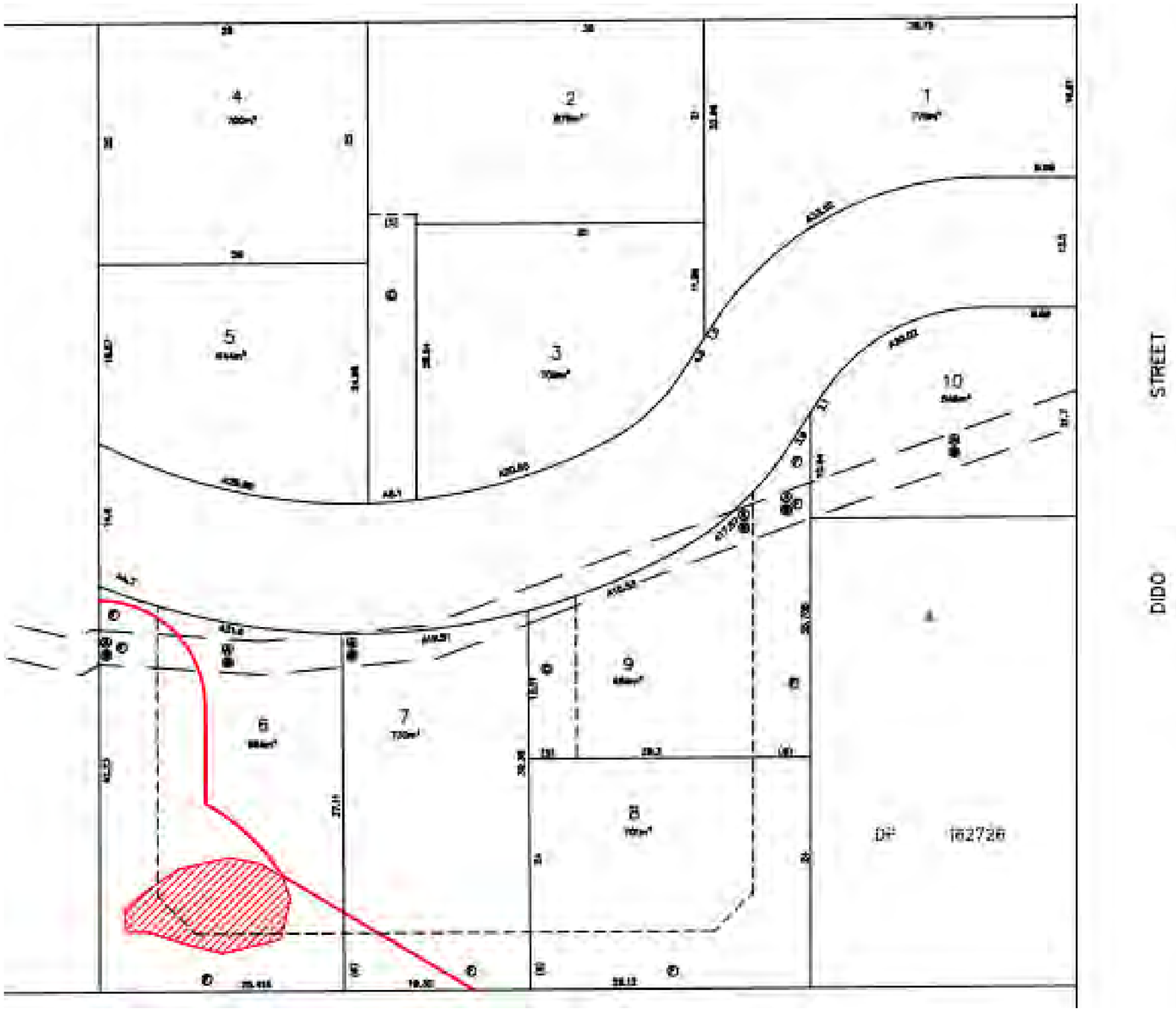
If Your Report is for geotechnical purposes only, it will not relate any findings, conclusions, or recommendations about the potential for hazardous materials to exist at the site unless you have specifically asked us to do so. If your report is written for Geo-Environmental purposes the following should be noted in addition to the above:

- Advancements in professional practice regarding contaminated land and changes in applicable statues and/or guidelines may affect the validity of this report. Consequently, the currency of conclusions and recommendations in Your Report should be verified if you propose to use this report more than 6 months after its date of issue;
- Your Report is based on information gained from environmental conditions (including assessment of some or all of soil, groundwater, vapour and surface water) and supplemented by reported data of the local area and professional experience. The assessment has been scoped with consideration to industry standards, regulations, guidelines and your specific requirements, which includes budget and timing;
- The characterisation of site conditions is an interpretation of information collected during assessment, in accordance with industry practice. Any interpretation in Your Report is not a complete description of all material on or in the vicinity of the site, due to the inherent variation in spatial and temporal patterns of contaminant presence and impact in the natural environment.
- We may have relied on data and other information provided by you and other qualified individuals in preparing Your Report. We have not verified the accuracy or completeness of such data or information except as otherwise stated in Your Report. For these reasons Your Report must be regarded as interpretative, in accordance with industry standards and practice, rather than being a definitive record.
- For each purpose, a tailored approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible quantify, risks that both recognised and potential contamination posed in the context of the agreed purpose. If the proposed use of the site changes, the assessment may no longer be valid and will need to be reviewed.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Appendix B: Proposed Site Development

N



revision	description	drawn	approved	date
	Site location	KEG	KEG	4/10/2018

TERRA INSIGHT

scale	NTS
original size	**A3**

client: **SET Consultants**

project: **Proposed residential subdivision**
Lot 3 DP 1018217 Dido Street, Kiama

title: **Proposed Site Development**

project no: **TERRA18228**

figure no: **FIGURE B1**

Appendix C: Site Info Report

BROADCREST
MAPPING & SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au | 1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	**Map** Site Location with Terrain
Location 3 Dido Street, Kiama LOT: 3 DP 1018217	**LGA** THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
Geoscience Australia | Obtained on 18.07.2018
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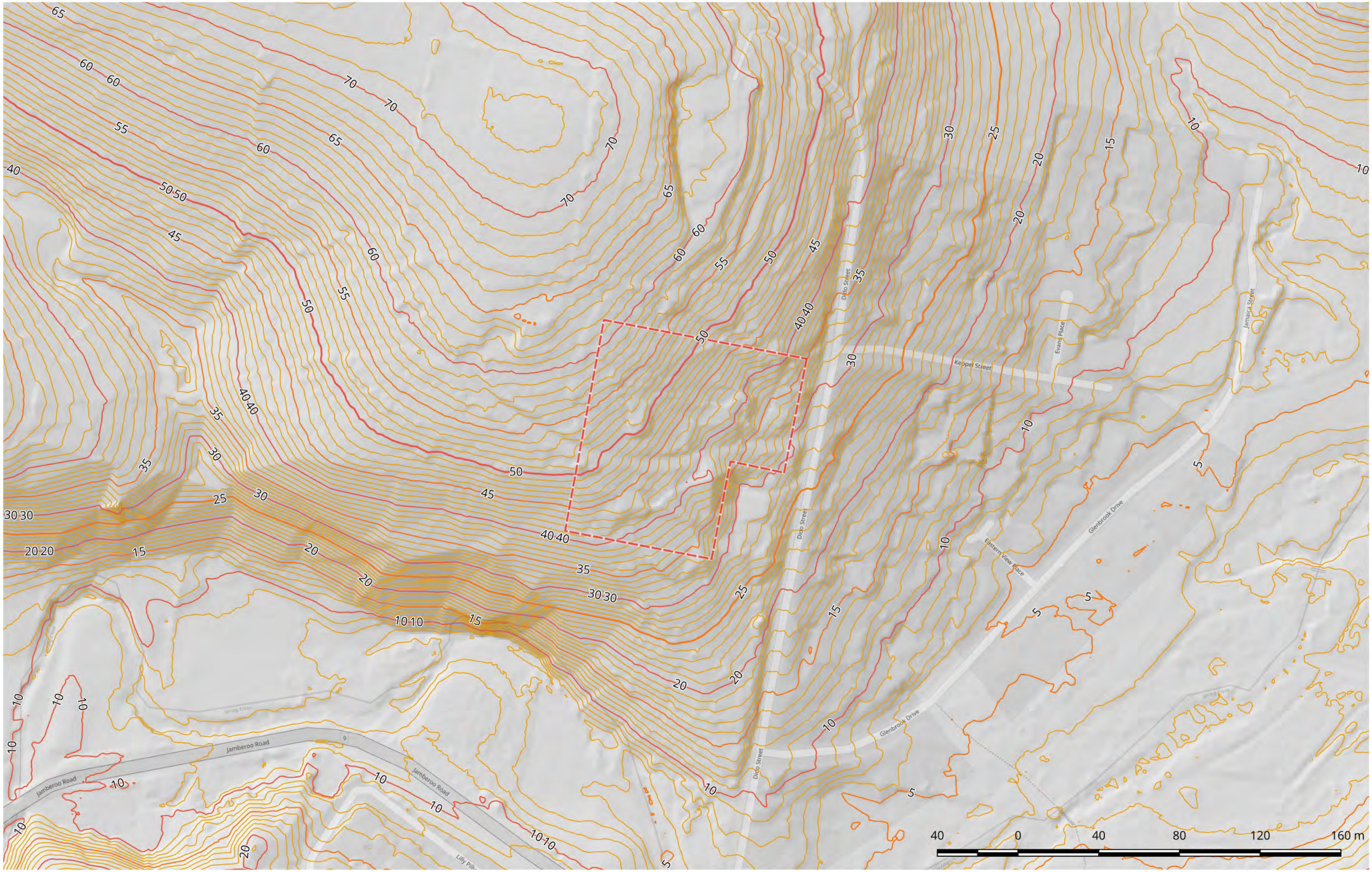
Base map
atial Services Imagery | © Department of Finance, Services & Innovation 2017
Street Maps | Creative Commons 3.0 - OpenStreetMap Contributors

Scale
1:10000

Project
206



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MAPPING & SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au | 1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	**Map** Topography
Location 3 Dido Street, Kiama	**LGA** THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
Derived from LiDAR Data | Geoscience Australia | Obtained on 18.07.2018
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Base map
treet Maps | Obtained on 2.10.2018
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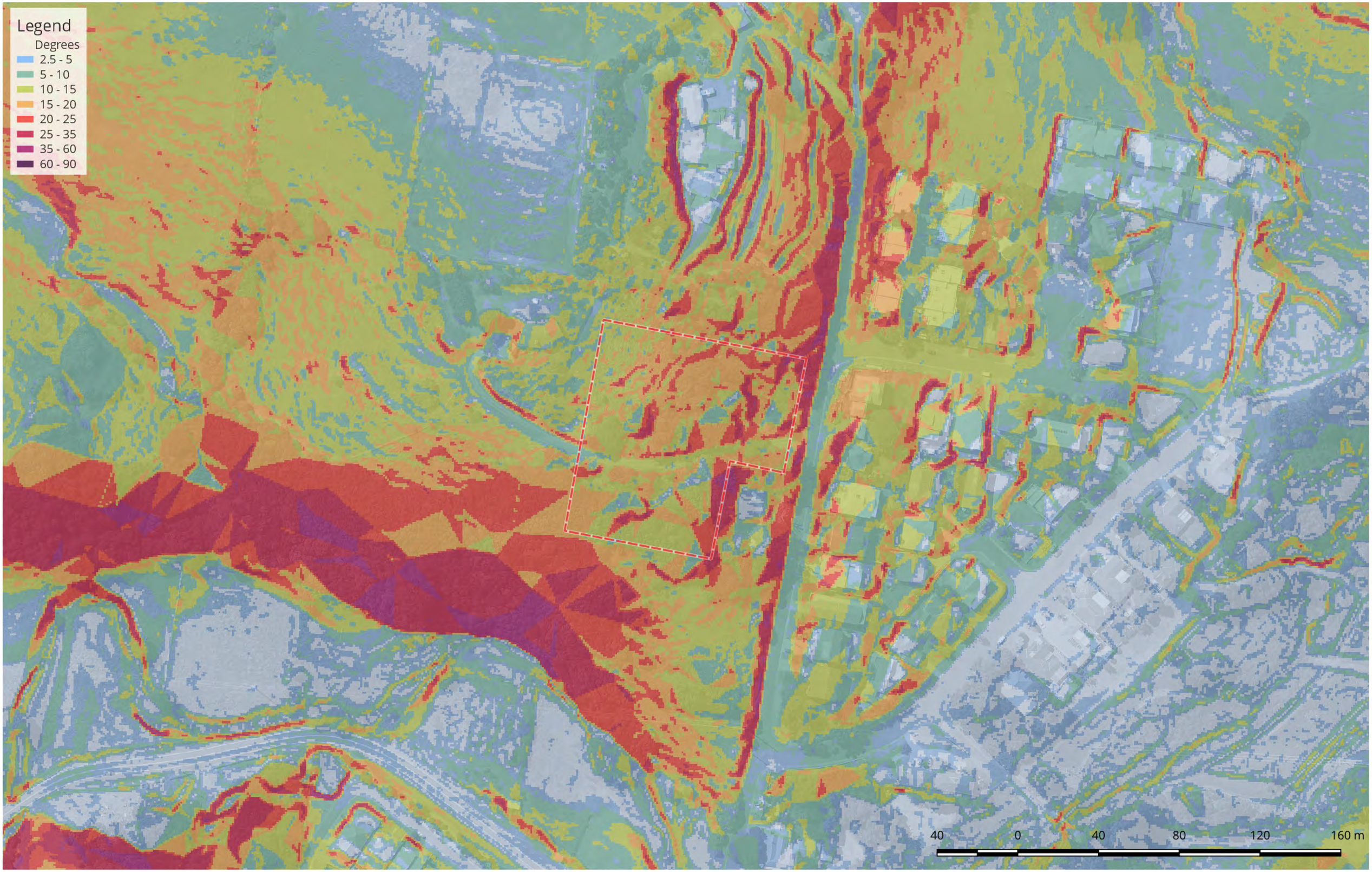
Scale 1:2000	
Project 206	



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MAPPING & SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au | 1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	**Map** Slope Heat Map
Location 3 Dido Street, Kiama	**LGA** THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
Derived from LiDAR Data | Geoscience Australia | Obtained on 18.07.2018
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Base map
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Scale 1:2000
Project 206

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MAPPING & SPATIAL SERVICES
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Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client: TERRA INSIGHT	Map: Land Zone Map
Location: 3 Dido Street, Kiama	LGA: THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
NSW Planning and the Environment | Obtained on 18.07.2018
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Base map
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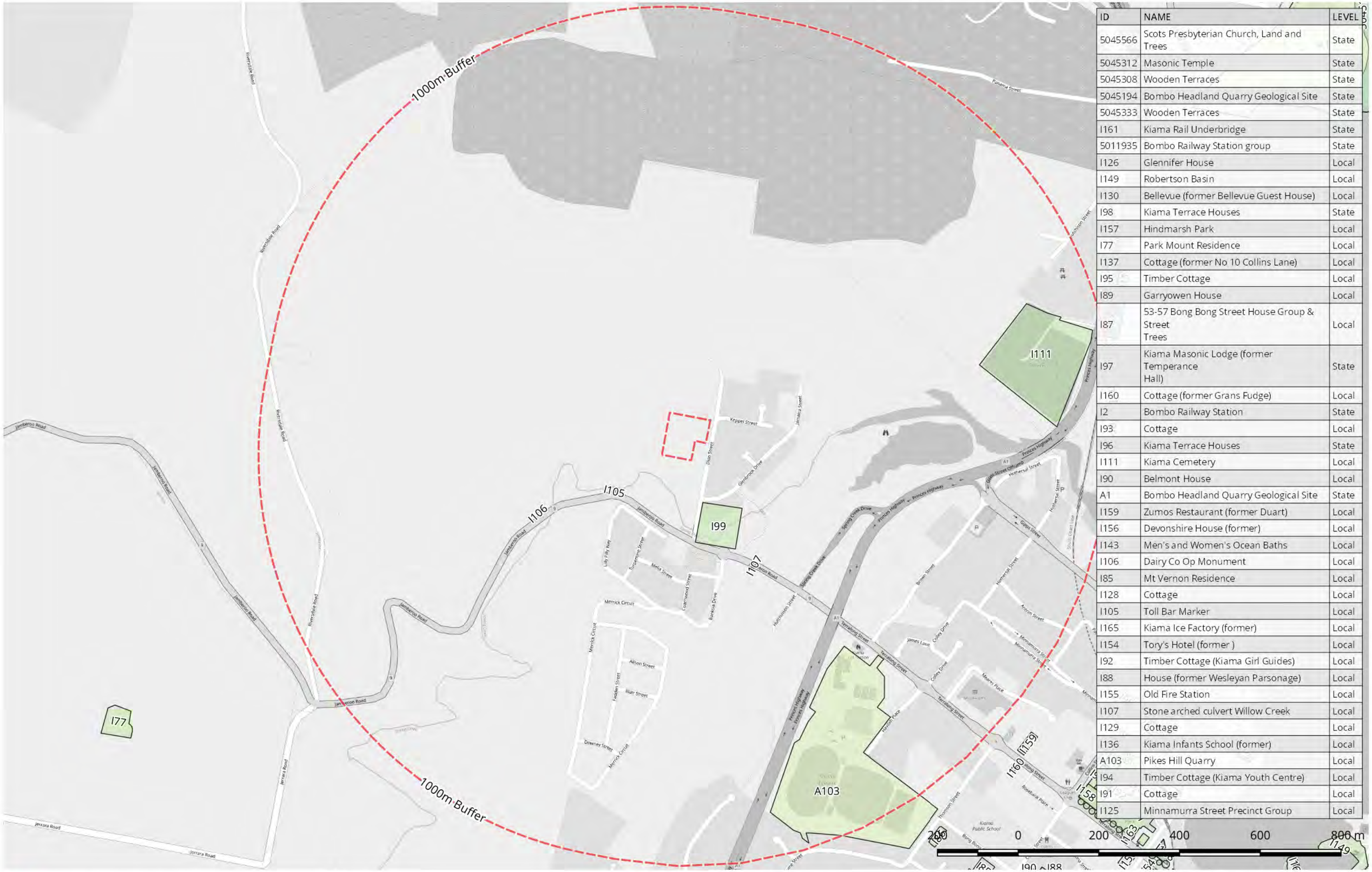
Scale: 1:2000
Project: 206



ID	NAME	LEVEL
5045566	Scots Presbyterian Church, Land and Trees	State
5045312	Masonic Temple	State
5045308	Wooden Terraces	State
5045194	Bombo Headland Quarry Geological Site	State
5045333	Wooden Terraces	State
I161	Kiama Rail Underbridge	State
5011935	Bombo Railway Station group	State
I126	Glennifer House	Local
I149	Robertson Basin	Local
I130	Bellevue (former Bellevue Guest House)	Local
I98	Kiama Terrace Houses	State
I157	Hindmarsh Park	Local
I77	Park Mount Residence	Local
I137	Cottage (former No 10 Collins Lane)	Local
I95	Timber Cottage	Local
I89	Garryowen House	Local
I87	53-57 Bong Bong Street House Group & Street Trees	Local
I97	Kiama Masonic Lodge (former Temperance Hall)	State
I160	Cottage (former Grans Fudge)	Local
I2	Bombo Railway Station	State
I93	Cottage	Local
I96	Kiama Terrace Houses	State
I111	Kiama Cemetery	Local
I90	Belmont House	Local
A1	Bombo Headland Quarry Geological Site	State
I159	Zumos Restaurant (former Duart)	Local
I156	Devonshire House (former)	Local
I143	Men's and Women's Ocean Baths	Local
I106	Dairy Co Op Monument	Local
I85	Mt Vernon Residence	Local
I128	Cottage	Local
I105	Toll Bar Marker	Local
I165	Kiama Ice Factory (former)	Local
I154	Tory's Hotel (former)	Local
I92	Timber Cottage (Kiama Girl Guides)	Local
I88	House (former Wesleyan Parsonage)	Local
I155	Old Fire Station	Local
I107	Stone arched culvert Willow Creek	Local
I129	Cottage	Local
I136	Kiama Infants School (former)	Local
A103	Pikes Hill Quarry	Local
I94	Timber Cottage (Kiama Youth Centre)	Local
I91	Cottage	Local
I125	Minnamurra Street Precinct Group	Local

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Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client: TERRA INSIGHT	Map: Heritage Listed Sites
Location: 3 Dido Street, Kiama	LGA: THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
NSW Planning and the Environment | Obtained on 18.07.2018
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Project: 206

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Client TERRA INSIGHT	Map Bushfire Prone Land
Location 3 Dido Street, Kiama	LGA THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
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Scale
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Project
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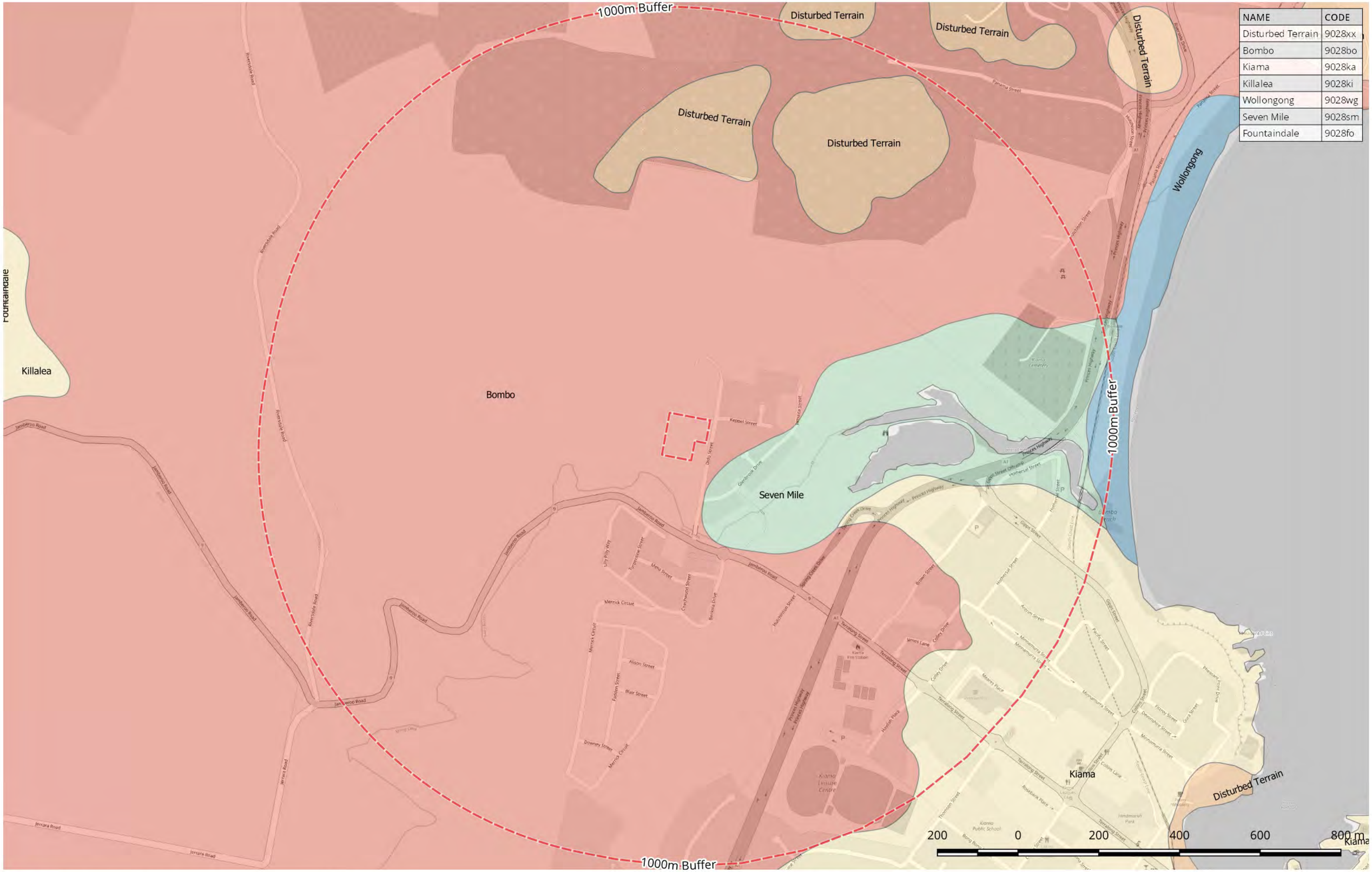

NAME	CODE
Disturbed Terrain	9028xx
Bombo	9028bo
Kiama	9028ka
Killalea	9028ki
Wollongong	9028wg
Seven Mile	9028sm
Fountaindale	9028fo

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Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	Map Soil Landscapes
Location 3 Dido Street, Kiama	LGA THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
Office of Environment and Heritage | Obtained on 18.07.2018

Base map
treet Maps | Obtained on 2.10.2018

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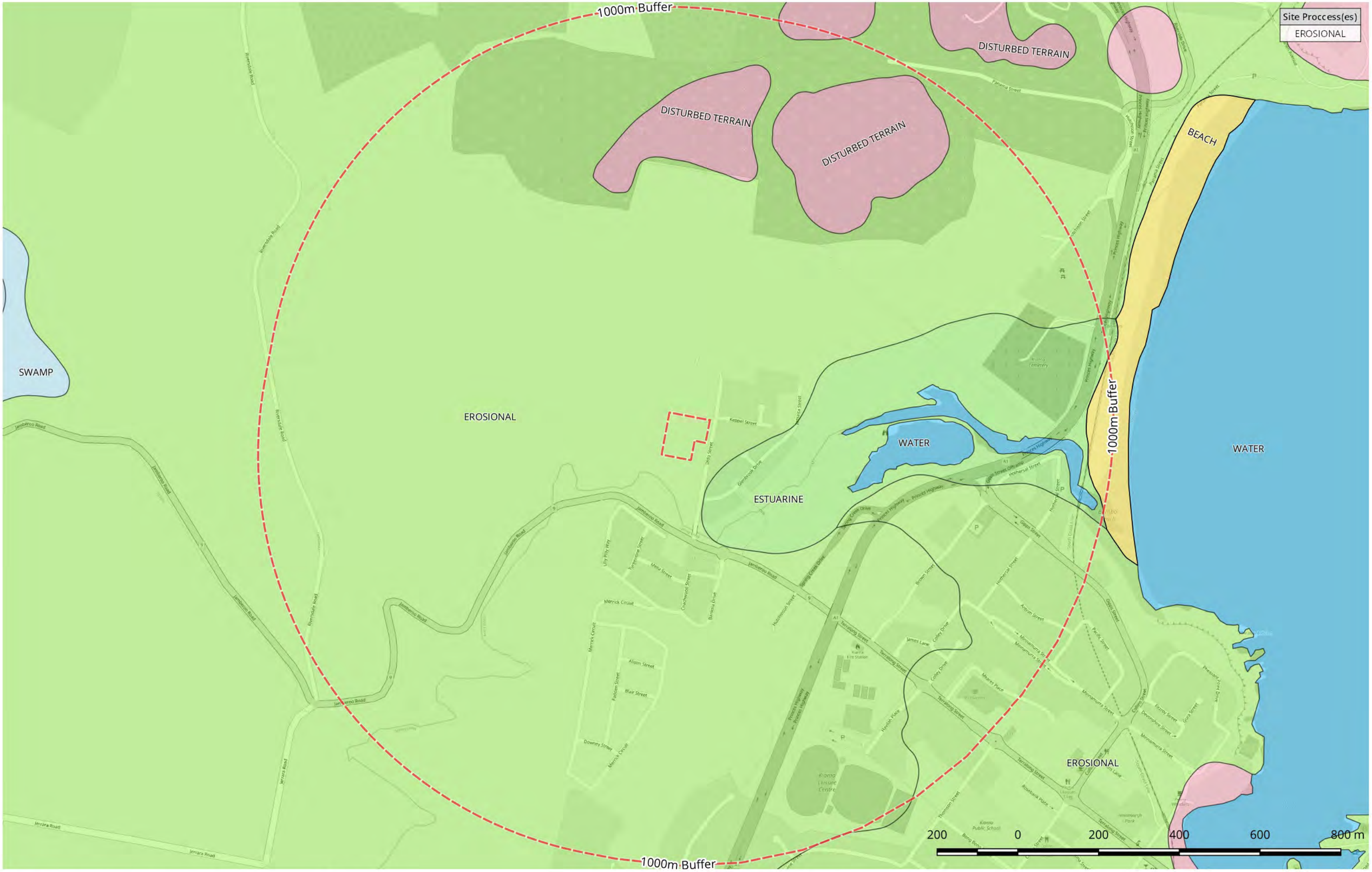

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Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client: TERRA INSIGHT	Map: Soil Formation
Location: 3 Dido Street, Kiama	LGA: THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
Office of Environment and Heritage | Obtained on 18.07.2018
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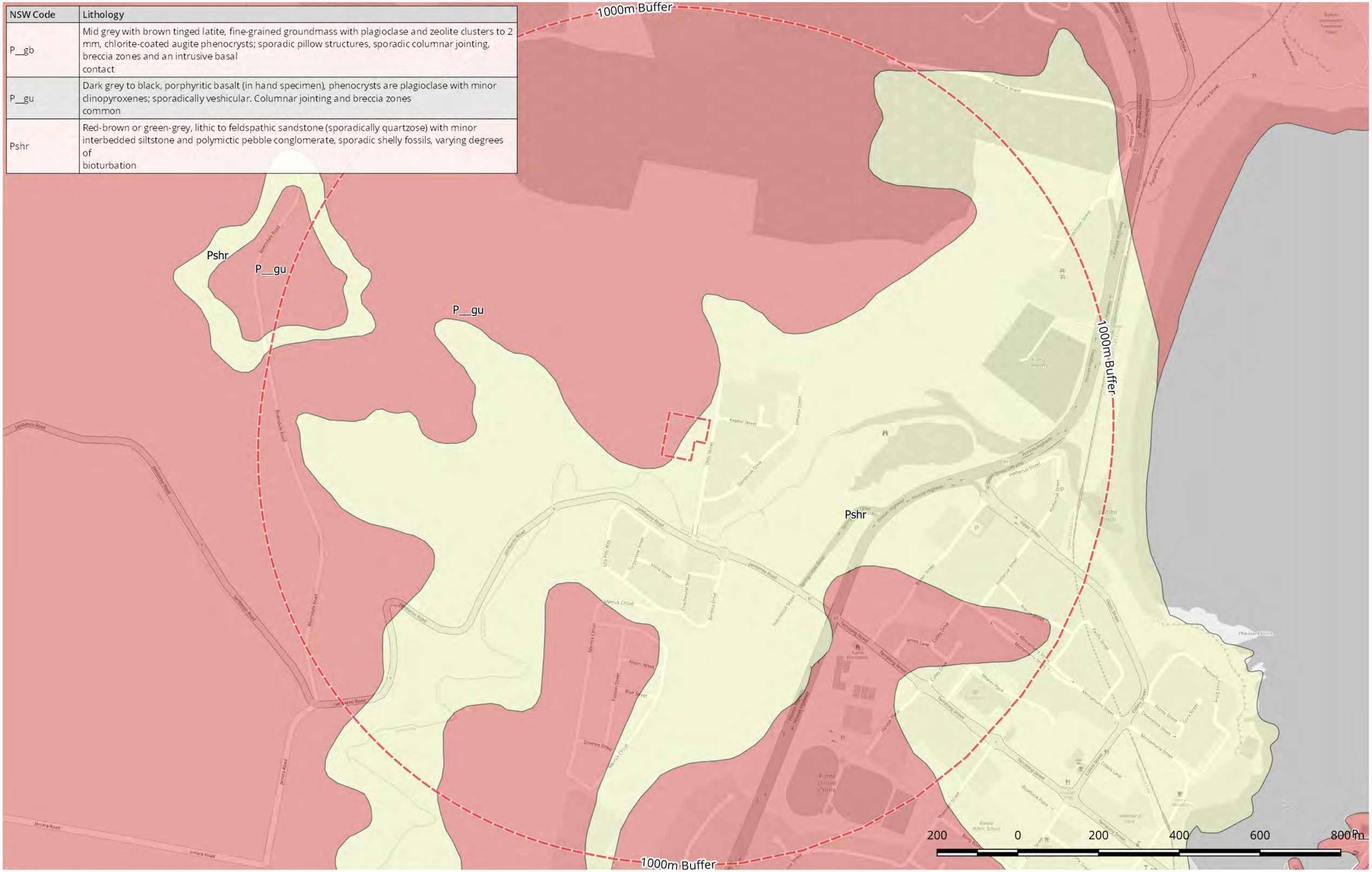
Scale: 1:10000
Project: 206

NSW Code	Lithology
P__gb	Mid grey with brown tinged latite, fine-grained groundmass with plagioclase and zeolite clusters to 2 mm, chlorite-coated augite phenocrysts; sporadic pillow structures, sporadic columnar jointing, breccia zones and an intrusive basal contact
P__gu	Dark grey to black, porphyritic basalt (in hand specimen), phenocrysts are plagioclase with minor clinopyroxenes; sporadically veshicular. Columnar jointing and breccia zones common
Pshr	Red-brown or green-grey, lithic to feldspathic sandstone (sporadically quartzose) with minor interbedded siltstone and polymictic pebble conglomerate, sporadic shelly fossils, varying degrees of bioturbation



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Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client: TERRA INSIGHT	Map: Geology (1:100,000 Mapping)
Location: 3 Dido Street, Kiama	LGA: THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
NSW Planning and the Environment | Obtained on 18.07.2018
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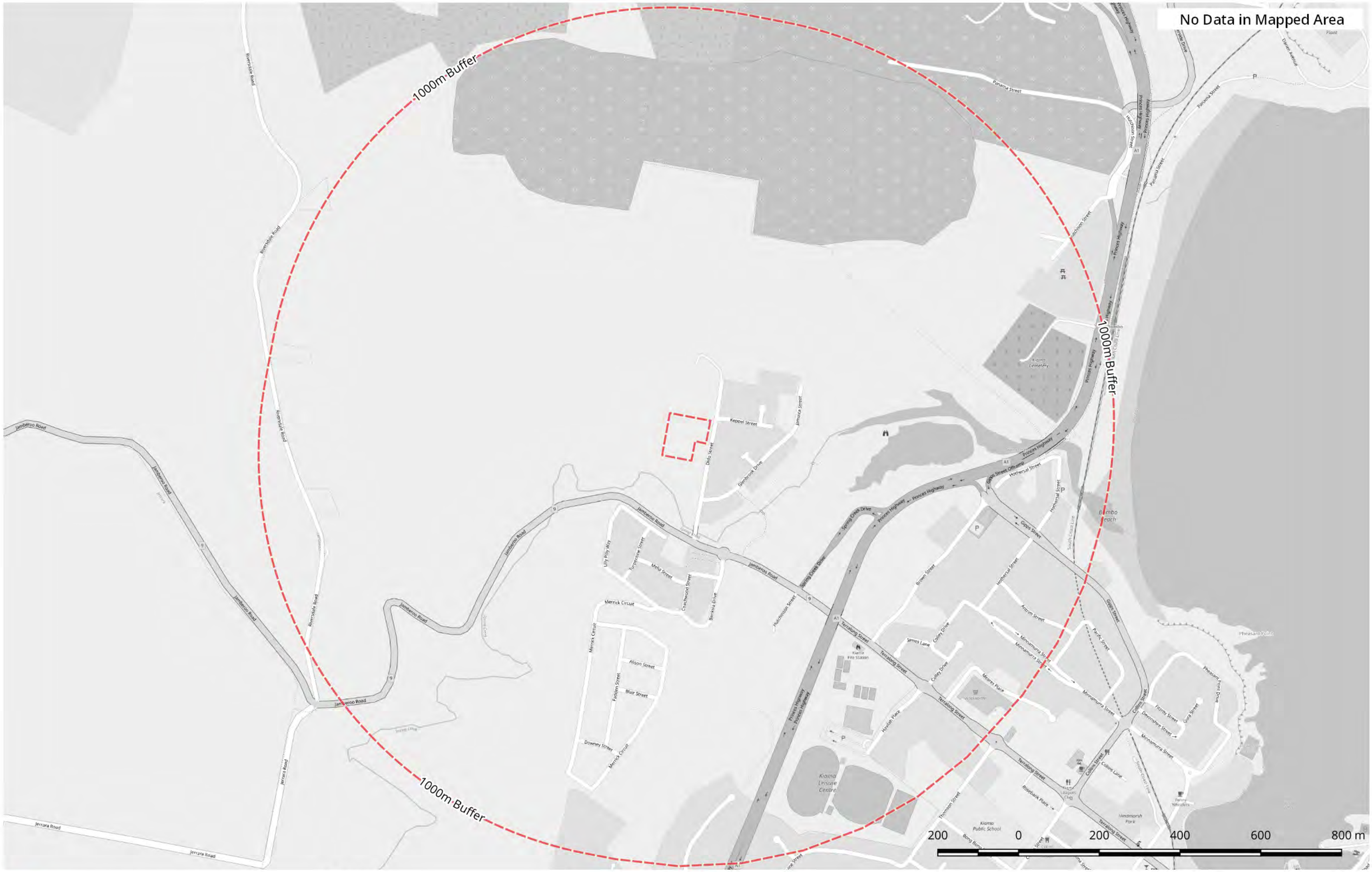
Scale: 1:10000
Project: 206



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Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	Map Hydrogeological Landscapes
Location 3 Dido Street, Kiama	LGA THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
Office of Environment and Heritage | Obtained on 18.07.2018
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206

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Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	**Map** Acid Sulfate Risk map
Location 3 Dido Street, Kiama	**LGA** THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
NSW Planning and the Environment | Obtained on 18.07.2018
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Base map
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Scale
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Project
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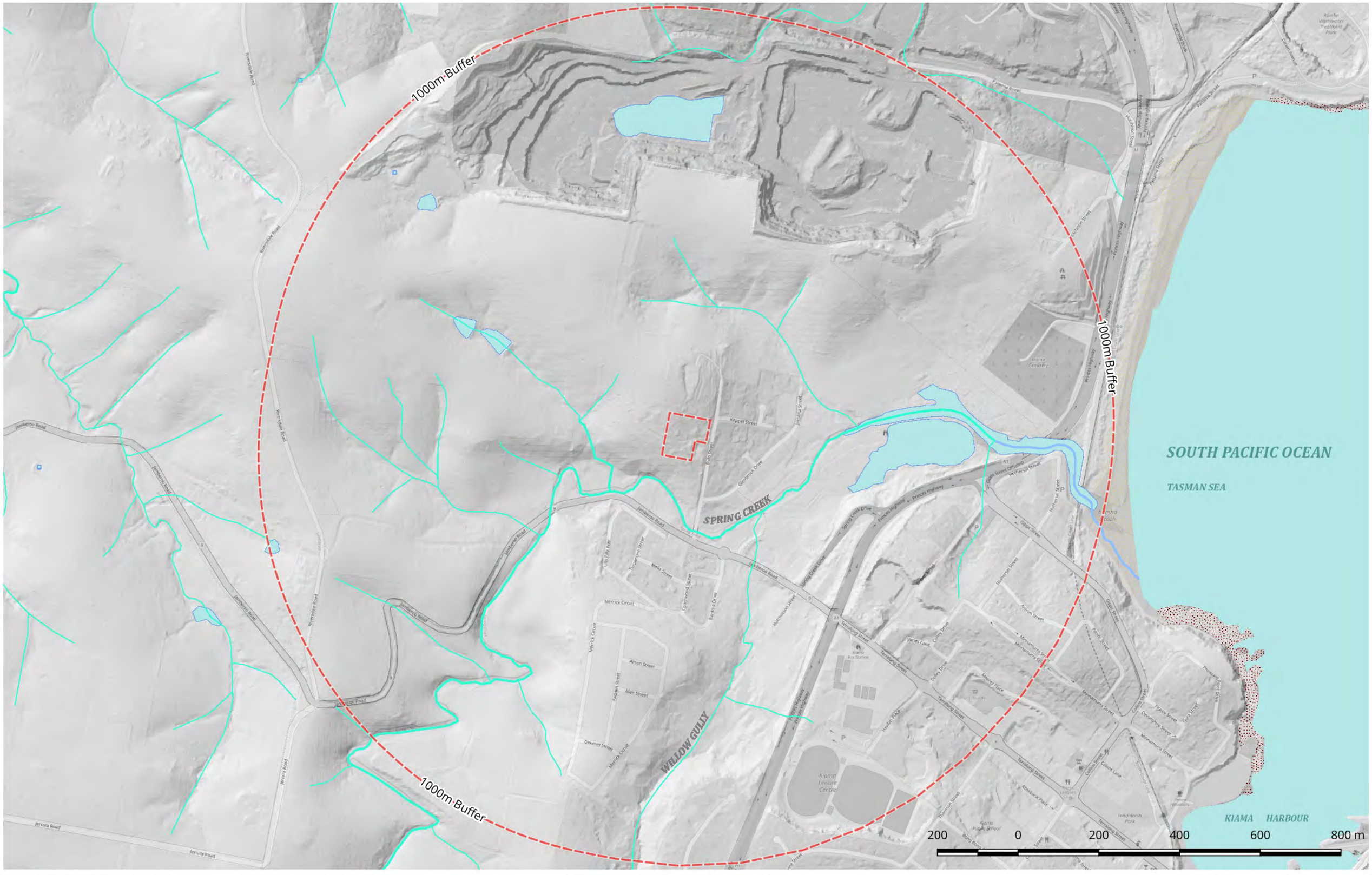

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Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	Map Watercourses and Hydrology
Location 3 Dido Street, Kiama	LGA THE COUNCIL OF THE MUNICIPALITY

Data Source
Department of Finance, Services & Innovation | Obtained on 2.10.2018

Base map
Open Street Maps | Obtained on 2.10.2018

Scale
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Project
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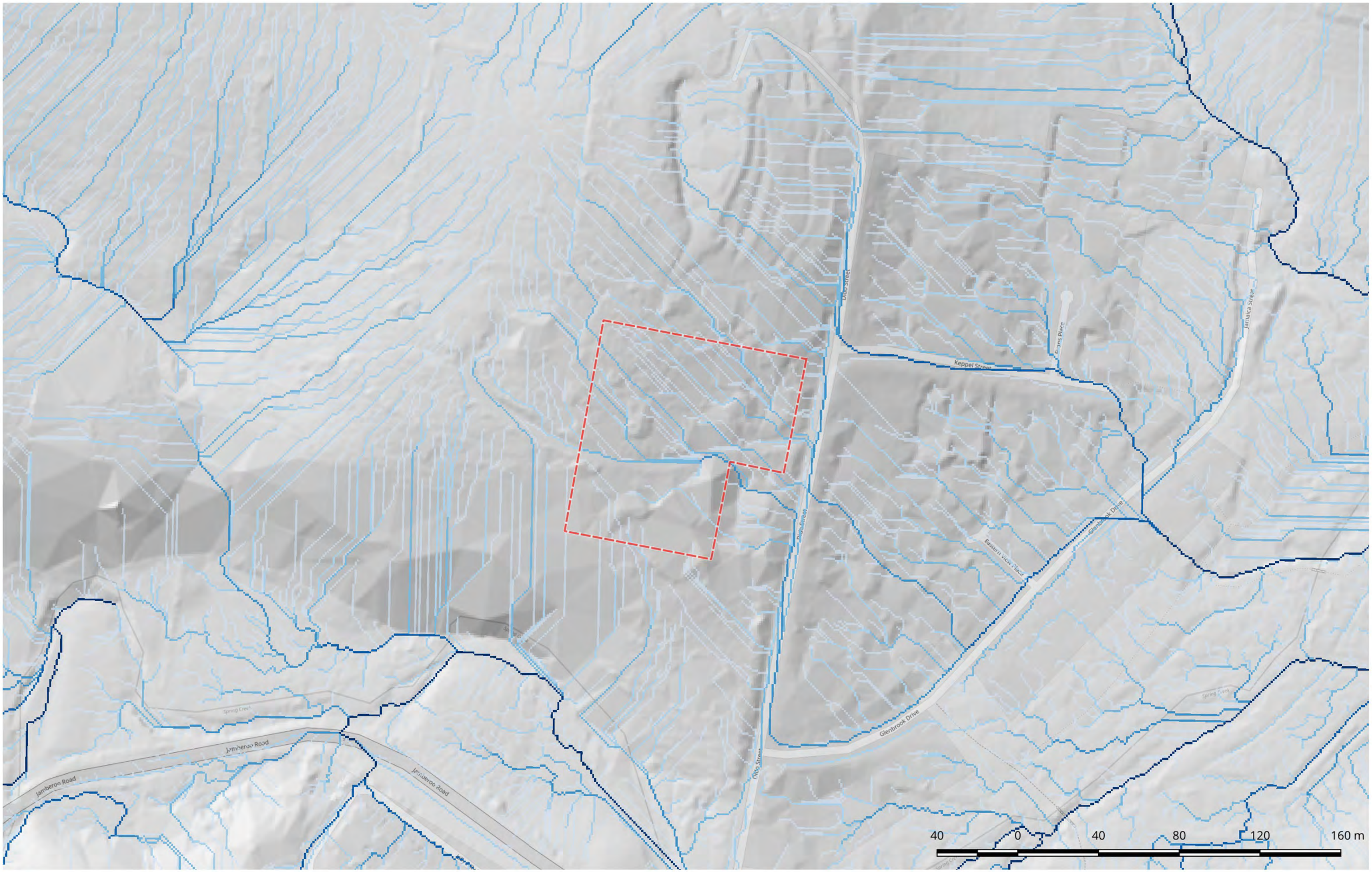

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broadcrest.com.au | contact@broadcrest.com.au | 1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	Map Rainfall Overland Flow Paths
Location 3 Dido Street, Kiama	LGA THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
Derived from LiDAR Data | Geoscience Australia | Obtained on 18.07.2018
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Scale
1:2000

Project
206

HydroCode	Depth	Strata Description	Bore Data
GW107387.1.1	0m - 0.8m 0.8m - 3.5m 3.5m - 4.5m	Clay filling Silty clay Sandstone	Date Drilled: 18/02/2004 Ref Elevation: 20.59 AHD Drill Depth: 4.5m Purpose: Exploration SWL: 3.8m
GW107388.1.1	0m - 0.4m 0.4m - 1.8m 1.8m - 4m	Gravel filling Silty clay Sandstone	Date Drilled: 18/02/2004 Ref Elevation: 20.59 AHD Drill Depth: 4m Purpose: Exploration SWL: 2.3m
GW107389.1.1	0m - 0.7m 0.7m - 3m 3m - 3.3m	Clay filling Silty clay Sandstone	Date Drilled: 18/02/2004 Ref Elevation: 20.59 AHD Drill Depth: 3.3m Purpose: Exploration SWL: m
GW107400.1.1	0m - 2.8m 2.8m - 3m	Sand Sandstone	Date Drilled: 12/01/2004 Ref Elevation: 8.28 AHD Drill Depth: 3m Purpose: Exploration SWL: m
GW107401.1.1	0m - 1.6m 1.6m - 3m 3m - 4.5m	Sand Silty clay Sandstone	Date Drilled: 12/01/2004 Ref Elevation: 9.05 AHD Drill Depth: 4.5m Purpose: Exploration SWL: 2.45m
GW107402.1.1	0m - 3.15m 3.15m - 3.5m	Sandy clay Sandstone	Date Drilled: 12/01/2004 Ref Elevation: 10.54 AHD Drill Depth: 3.5m Purpose: Exploration SWL: 1.05m

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Client TERRA INSIGHT	Map Groundwater Bores
Location 3 Dido Street, Kiama	LGA THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
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Project
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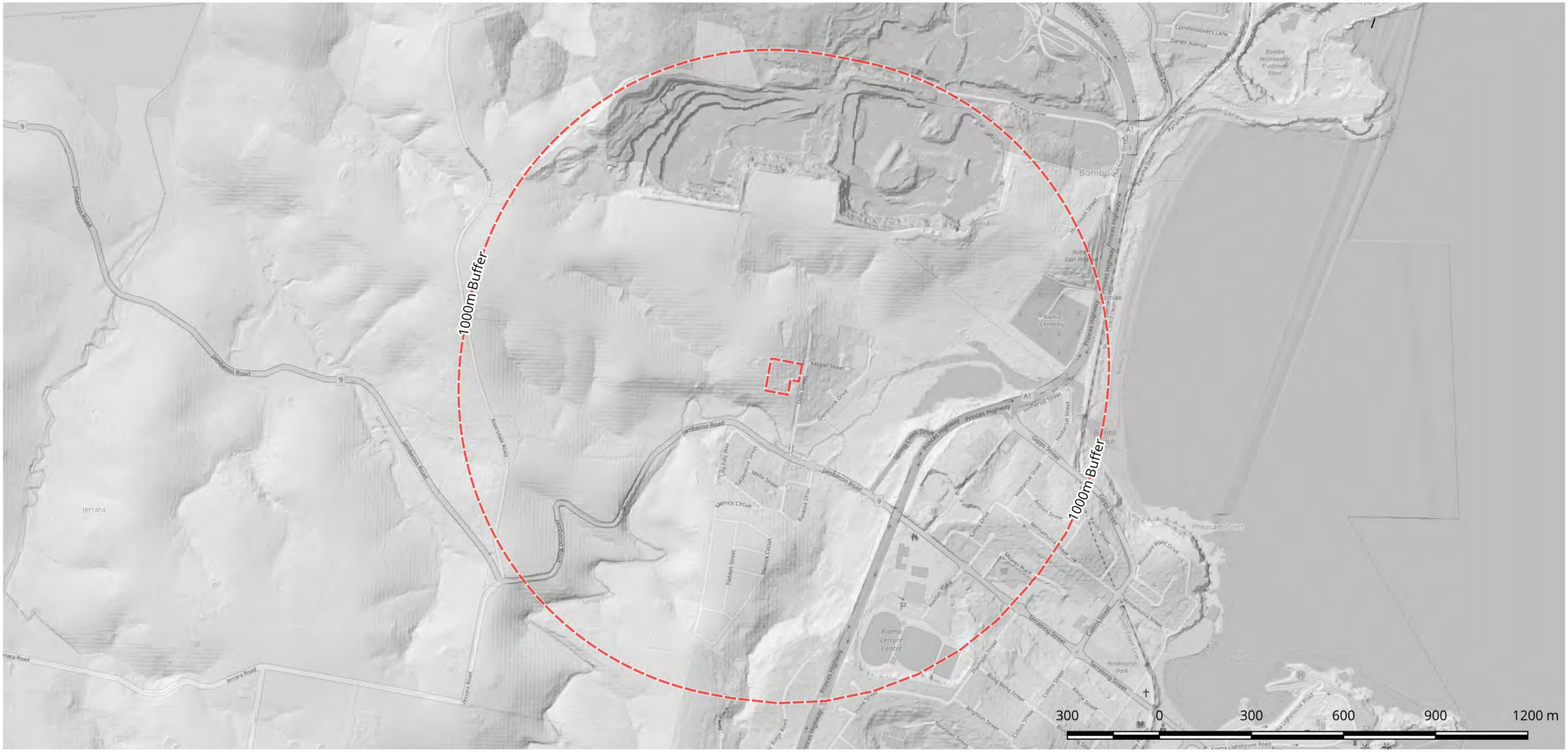

ID	Date	Hazard	Synopsis	Impact Comments
No data in mapped area.				

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broadcrest.com.au | contact@broadcrest.com.au | 1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client: TERRA INSIGHT	Map: Recorded Landslides
Location: 3 Dido Street, Kiama	LGA: THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
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Scale: 1:15000
Project: 206

POEO Registered Schedule 1 Sites

EPL	Organisation Name	Fee-Based Activity	Geocode Reference	Quality
79	SYDNEY TRAINS	Land-based extractive activity	PANAMA STREET BOMBO	Geometric centre
313	BORAL RESOURCES (NSW) PTY LTD	Land-based extractive activity	PANAMA STREET BOMBO	Geometric centre
20127	J.R. & D.A. JEFFREY TRANSPORT PTY. LIMITED	Transport of category 1 trackable waste	44 GIPPS STREET KIAMA NSW	Rooftop

POEO Delicenced Premises

EPL	Organisation Name	Status	Geocode Reference	Quality
6456	PERMIAN RESOURCES PTY LIMITED	Surrendered	PANAMA ST, BOMBO, NSW 2533	Geometric centre

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Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client: TERRA INSIGHT	Map: EPA POEO Licences
Location: 3 Dido Street, Kiama	LGA: THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
NSW Environment Protection Authority | Obtained on 12.09.2018

Base map
treet Maps | Obtained on 2.10.2018

Scale: 1:12500	
Project: 206	

POEO Compliance Audit

EPL	Organisation Name	Status	Geocode Address	Quality
No data in mapped area.				

POEO Mandatory Environmental Audit

EPL	Organisation name	Status	Geocode Address	Quality
No data in mapped area.				

POEO New Licences

EPL	Organisation Name	Type	Status	Geocode Address	Quality
No data in mapped area.					

POEO Notices

EPL	Organisation Name	Type	Status	Geocode Address	Quality
No data in mapped area.					

POEO Pollution

EPL	Organisation Name	Type	Geocoded Address	Quality
No data in mapped area.				

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Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client: TERRA INSIGHT	Map: EPA POEO Registers
Location: 3 Dido Street, Kiama	LGA: THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source: NSW Environment Protection Authority | Obtained on 12.09.2018

Base map: treet Maps | Obtained on 2.10.2018

Scale: 1:12500
Project: 206

EPACS - Contaminated sites notified to EPA

Organisation Name	Address	Type	EPA Management Class
No data in mapped area.			

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MAPPING & SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au | 1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client: TERRA INSIGHT	Map: Other Contaminated Sites
Location: 3 Dido Street, Kiama	LGA: THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
NSW Environment Protection Authority | Obtained on 12.09.2018

Base map
treet Maps | Obtained on 2.10.2018

Scale: 1:12500
Project: 206

ID	Name	Address
85	Enhance	35 Collins Street, Kiama
86	Fulton Petroleum	35/41 Collins Street, Kiama
290	Kiama Central Automotive	Unit 9, Kiama Trade Centre, 2 Brown Street, Kiama
291	Repco Authorised Car Service Kiama	9/2 Brown Street, Kiama
292	Illawarra Tyrepower - Kiama	Kiama Trade Centre, 6/2 Brown Street, Kiama
293	Kiama Tyre Service	6/2 Brown Street, Kiama
294	Kiama Auto Services	41 Collins Street, Kiama
295	Kiama Auto Services	41 Collins Street, Kiama
296	Kiama Auto Electrical & Air Conditioning	4/2 Brown Street, Kiama
297	Harts Garage	60 Gipps Street, Kiama
354	Kiama Laundry Services	3/140 Terralong Street, Kiama
355	Kiama Laundry Services	3/140 Terralong Street, Kiama
599	Bombo Quarry Car Park	Unnamed Road, Bombo
600	Dance Sensations Kiama	Unit 6, Quarry Business Park, Brown St, Kiama
601	Westonprint	Quarry Business Park, 3/3 Brown St, Kiama
602	Kiama Leisure Centre	1 Havilah Pl, Kiama
603	Boral Quarries	LOT 1 Panama Street, Bombo
604	Bombo Quarry Car Park	Unnamed Road, Bombo
605	Dance Sensations Kiama	Unit 6, Quarry Business Park, Brown St, Kiama
606	Westonprint	Quarry Business Park, 3/3 Brown St, Kiama
607	Kiama Leisure Centre	1 Havilah Pl, Kiama
608	Boral Quarries	LOT 1 Panama Street, Bombo

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MAPPING & SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au | 1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client: TERRA INSIGHT	Map: Additional Sites for Consideration
Location: 3 Dido Street, Kiama	LGA: THE COUNCIL OF THE MUNICIPALITY OF KIAMA

Data Source
Google | Obtained on 2.10.2018

Base map
treet Maps | Obtained on 2.10.2018

Scale: 1:12500
Project: 206

Appendix D: Land Registry Records

SEARCH REPORT

NSW LAND REGISTRY SERVICES RECORDS BRANCH

Subject property: 3 Dido Street, Kiama

Folio 3/1018217

Ownership from 16/7/1889 up to 2000

From 16/7/1889 to 4/12/1933 - George Dawes of Kiama, Farmer

From 4/12/1933 to 31/12/1953 - Harold Alexander Dawes of Kiama, Farmer & HIS ESTATE

From 31/12/1953 to 13/8/1974 - James Morschel Lymbery of Terara, Farmer

From 13/8/1974 to 11/12/2000 -= Terralong Estates Pty. Limited

SAI GLOBAL PROPERTY

per R Williamson (22-8-2018)

NEW SOUTH WALES LAND REGISTRY SERVICES - HISTORICAL SEARCH

SEARCH DATE
22/8/2018 2:41PM

FOLIO: 3/65/758563

First Title(s): OLD SYSTEM
Prior Title(s): CA63398

Recorded	Number	Type of Instrument	C.T. Issue
28/11/1994	CA63398	CONVERSION ACTION	FOLIO CREATED EDITION 1
17/11/1995	O698313	MORTGAGE	EDITION 2
29/1/1996	O869640	DISCHARGE OF MORTGAGE	
29/1/1996	O869641	MORTGAGE	EDITION 3
29/7/1997	3242385	TRANSFER OF MORTGAGE	EDITION 4
28/7/1998	5158105	DISCHARGE OF MORTGAGE	
28/7/1998	5158106	MORTGAGE	EDITION 5
13/7/1999	5980690	TRANSFER OF MORTGAGE	EDITION 6
27/9/1999	6226797	CAVEAT	
20/10/1999	6281540	WITHDRAWAL OF CAVEAT	
20/10/1999	6281541	CAVEAT	
7/8/2000	6991270	WITHDRAWAL OF CAVEAT	
20/11/2000	DP1018217	DEPOSITED PLAN	FOLIO CANCELLED

*** END OF SEARCH ***

jennfib PRINTED ON 22/8/2018

NEW SOUTH WALES LAND REGISTRY SERVICES - HISTORICAL SEARCH

SEARCH DATE
22/8/2018 3:26PM

FOLIO: 3/1018217

First Title(s): OLD SYSTEM
Prior Title(s): 3/65/758563

Recorded	Number	Type of Instrument	C.T. Issue
20/11/2000	DP1018217	DEPOSITED PLAN	FOLIO CREATED EDITION 1
11/12/2000	7278125	DISCHARGE OF MORTGAGE	
11/12/2000	7278126	TRANSFER	EDITION 2
10/2/2009	AE491096	NOTICE OF DEATH	EDITION 3

*** END OF SEARCH ***

jennfib PRINTED ON 22/8/2018

Appendix E: Historical Aerial Images

BROADCREST
MAPPING AND SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au |1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	**Date** 2018
Location 3 Dido Street, Kiama	**LOT** 3 DP 1018217

Data Source
Department of Finance, Services & Innovation

Base map (shown in blue)
Department of Finance, Services & Innovation

Scale
1:2000

Page

BROADCREST
MAPPING AND SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au |1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	**Date** 2011
Location 3 Dido Street, Kiama	**LOT** 3 DP 1018217

Data Source
Department of Finance, Services & Innovation

Base map (shown in blue)
Department of Finance, Services & Innovation

Scale
1:2000

Page

BROADCREST
MAPPING AND SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au |1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client	**Date**
TERRA INSIGHT	1993
Location	**LOT**
3 Dido Street, Kiama	3 DP 1018217

Data Source
Department of Finance, Services & Innovation

Base map (shown in blue)
Department of Finance, Services & Innovation

Scale
1:2000

Page

BROADCREST
MAPPING AND SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au |1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	**Date** 1984
Location 3 Dido Street, Kiama	**LOT** 3 DP 1018217

Data Source
Department of Finance, Services & Innovation

Base map (shown in blue)
Department of Finance, Services & Innovation

Scale
1:2000

Page

BROADCREST
MAPPING AND SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au |1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

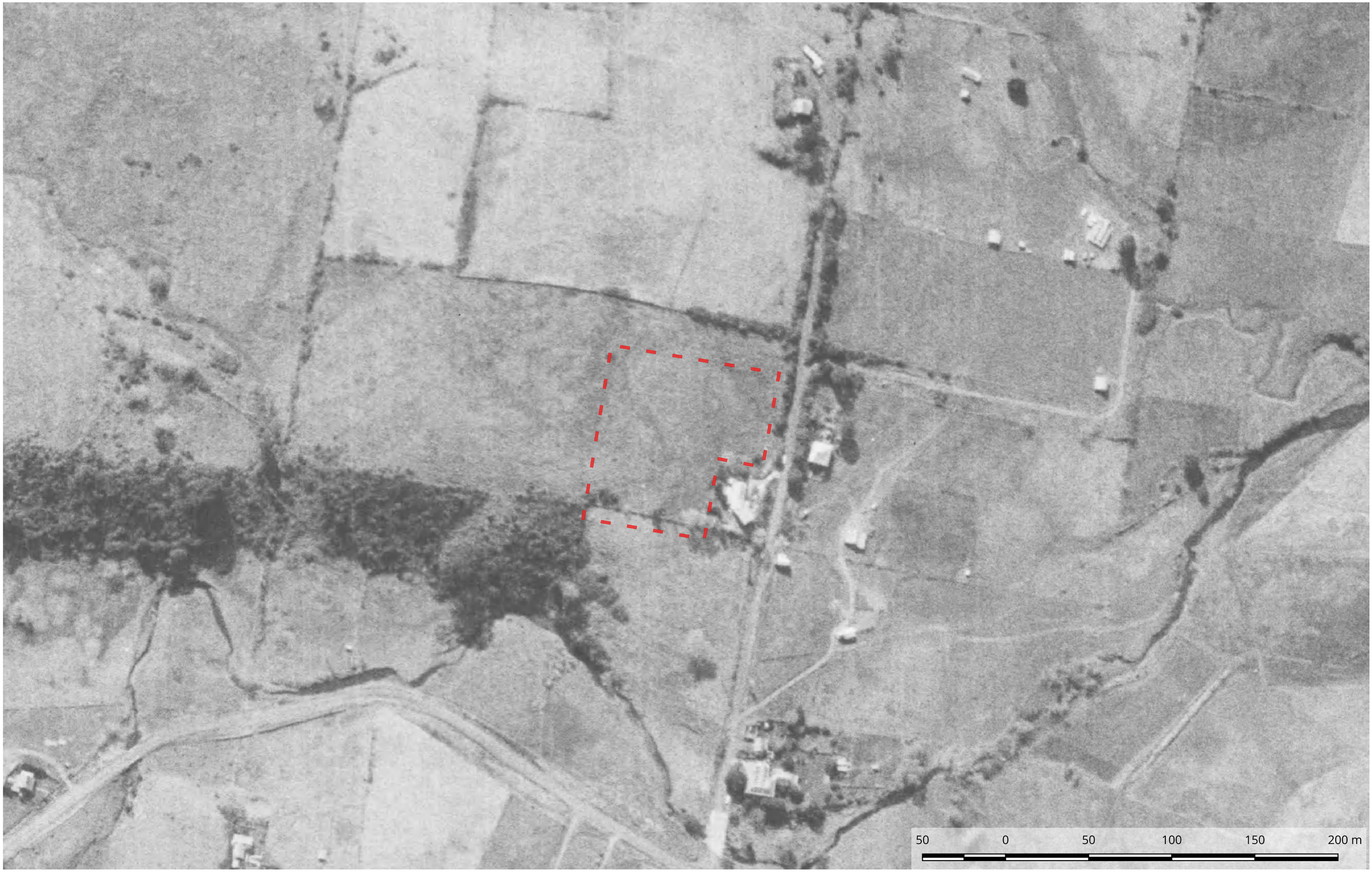
Client TERRA INSIGHT	**Date** 1974
Location 3 Dido Street, Kiama	**LOT** 3 DP 1018217

Data Source
Department of Finance, Services & Innovation

Base map (shown in blue)
Department of Finance, Services & Innovation

Scale
1:2000

Page



BROADCREST
MAPPING AND SPATIAL SERVICES
broadcrest.com.au | contact@broadcrest.com.au |1300 554 945
Broadcrest Consulting Pty Ltd | ABN: 622 508 187

Client TERRA INSIGHT	**Date** 1964
Location 3 Dido Street, Kiama	**LOT** 3 DP 1018217

Data Source
Department of Finance, Services & Innovation

Base map (shown in blue)
Department of Finance, Services & Innovation

Scale
1:2000

Page

Appendix F: Site Images

Photograph 1: View of dirt access track to power pole, located within Lot 1 and Lot 10, looking south towards the existing access driveway

Photograph 2: View of proposed Lot 1, looking north towards the power line.

Photograph 3: View of site looking west towards Proposed Lots 2 and 3, from proposed new access driveway

Photograph 4: View of existing access driveway, looking west from proposed Lot 10 towards proposed lots 3 (left hand side of image) and 9 (right hand side of image).

revision	description	drawn	approved	date
	Site images – plate 1	LE	KEG	18/10/18

TERRA INSIGHT

client:	**SET Consultants**
project:	**Preliminary Site Investigation and Geotechnical Site Investigation for Proposed Residential Subdivision No. 3 Dido Street, Kiama, 2533**
scale	
title:	**Photographs of the site**
original size	**A3**
project no:	**TERRA18228**
Plate no:	**1**

Photograph 5: View of existing access driveway, looking west from proposed Lots 3 and 9 towards proposed lots 5 (left hand side of image) and Lots 6 and 7 (right hand side of image).

Photograph 6: View of proposed lots 2 and 3, looking south-east from proposed lots 4 and 5.

Photograph 7: View of proposed lots 4 and 5, looking west from proposed lot 4 and 5.

Photograph 8: View of bedrock outcropping on site near boundaries between Lots 2 to 5.

revision	description	drawn	approved	date
	Site images – plate 2	LE	KEG	18/10/18

TERRA INSIGHT

client:	**SET Consultants**
project:	**Preliminary Site Investigation and Geotechnical Site Investigation for Proposed Residential Subdivision No. 3 Dido Street, Kiama, 2533**
scale	
title:	**Photographs of the site**
original size	**A3**
project no: **TERRA18228**	Plate no: **2**

Photograph 9: View of latite boulders exposed on the ground surface on proposed lot 5.

Photograph 10: View of latite boulders exposed on the ground surface on proposed lot 5

Photograph 11: View of boundary between site and No 17 Dido Street to the west.

Photograph 12: View of Lot 4, looking east towards lots 2 and 3.

revision	description	drawn	approved	date
	Site images – plate3	LE	KEG	18/10/18

TERRA INSIGHT

client:	**SET Consultants**
project:	**Preliminary Site Investigation and Geotechnical Site Investigation for Proposed Residential Subdivision No. 3 Dido Street, Kiama, 2533**
scale	
title:	**Photographs of the site**
original size	**A3**
project no: **TERRA18228**	Plate no: **3**

Photograph 13: View of Lot 5 looking north-east towards lot 3.

Photograph 14: View of Lot 6 looking south. View of boulders in near surface soils.

Photograph 15: View of Lot 8 and 9, looking south from Lot 9.

Photograph 16: View of Lot 9, looking north from Lot 8

revision	description	drawn	approved	date
	Site images – plate4	LE	KEG	18/10/18

TERRA INSIGHT

client:	**SET Consultants**
project:	**Preliminary Site Investigation and Geotechnical Site Investigation for Proposed Residential Subdivision No. 3 Dido Street, Kiama, 2533**
scale	
title:	**Photographs of the site**
original size	**A3**
project no: **TERRA18228**	Plate no: **4**

Photograph 17: View of rock wall located on southern boundary Lot 8

Photograph 18: View along southern boundary of site, looking west from Lot 8 towards lots 6 and 7

Photograph 19: View the excavation of TP01 within Lot 5

Photograph 20: View of the excavation of TP02 near boundary between lots 2, 4 and 5 2.

revision	description	drawn	approved	date
	Site images – plate 5	LE	KEG	18/10/18

TERRA INSIGHT

client:	**SET Consultants**		
project:	**Preliminary Site Investigation and Geotechnical Site Investigation for Proposed Residential Subdivision No. 3 Dido Street, Kiama, 2533**		
scale		title:	**Photographs of the site**
original size	**A3**	project no: **TERRA18228**	Plate no: **5**

Photograph 21: View of TP03 excavation within Lot 6

Photograph 22: View of TP04 excavation near boundary between lot 8 and Lot 9

Photograph 23: View of TP05 excavation near boundary between lot 1 and 10 within proposed new access road

revision	description	drawn	approved	date
	Site images – plate6	LE	KEG	18/10/18

TERRA INSIGHT

client:	**SET Consultants**		
project:	**Preliminary Site Investigation and Geotechnical Site Investigation for Proposed Residential Subdivision No. 3 Dido Street, Kiama, 2533**		
scale		title:	**Photographs of the site**
original size	**A3**	project no: **TERRA18228**	Plate no: **6**

Appendix G: Engineering Logs

TERRA INSIGHT

How to interpret the engineering logs in Your Report

FIELD DECRIPTIONS OF SOILS

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)				USC	PRIMARY NAME
COARSE GRAINED SOILS More than 65% of materials less than 63 mm is larger than 0.075 mm	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	GRAVEL
			Predominantly one size or a range of sizes with more intermediate sizes missing.	GP	GRAVEL
		GRAVELS WITH FINES Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	SILTY GRAVEL
			Plastic fines (for identification procedures see CL below)	GC	CLAYEY GRAVEL
	SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes	SW	SAND
			Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	SAND
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).	SM	SILTY SAND
			Plastic fines (for identification procedures see CL below).	SC	CLAYEY SAND

FINE GRAINED SOILS More than 35% of material less than 63 mm is smaller than 0.075 mm	IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm (Note a 75Um particle is about the smallest particle that is visible to the naked eye.)				
		DRY STRENGTH	DILATANCY	TOUGHNESS	USC	PRIMARY NAME
	SILTS & CLAYS Liquid limit less than 50	None to Low	Quick to slow	None	ML	SILT
		Medium to High	None	Medium	CL	CLAY
		Low to medium	Slow to very slow	Low	CL	ORGANIC SILT
	SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium	MH	SILT
		High	None	High	CH	CLAY
		Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC	Readily identified by colour, odour, spongy feel and frequently by fibrous texture by fibrous texture.				PT	PEAT

● Low plasticity – Liquid Limit w_L less than 35%. ● Medium plasticity – w_L between 35% and 50%. ● High plasticity – w_L greater than 50%.

Particle size descriptive terms

NAME	SUBDIVISION	SIZE
Boulders Cobbles		>200 mm 63 mm to 200 mm
Gravel	coarse medium fine	20 mm to 63 mm 6 mm to 20 mm 2.36 mm to 6 mm
Sand	coarse medium fine	600 µm to 2.36 mm 200 µm to 600 µm 75 µm to 200 µm

Minor components

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

TERRA INSIGHT

How to interpret the engineering logs in Your Report

Moisture condition

TERM	DEFINITION
Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

Soil structure

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

Consistency of cohesive soils

TERM	UNDRAINED STRENGTH s_u (kPa)	VISUAL OBSERVATION IN FIELD
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 – 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 – 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 – 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 – 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

Density of granular soils

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 – 35
Medium Dense	35 – 65
Dense	65 – 85
Very Dense	Greater than 85

Geological origin

TRANSPORTED SOILS

Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TERRA INSIGHT

How to interpret the engineering logs in Your Report

FIELD DESCRIPTIONS OF ROCK

The descriptive terms used by Terra Insight are given below. They are broadly consistent with Australian Standard AS1726-1993.

Rock Substance — In engineering terms rock substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.

Defect — Discontinuity or break in the continuity of a substance or substances.

Mass — Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

Classification of weathering products

Term	Abbreviation	Definition
Residual Soil	RS	Soil derived from the weatherinç rock; the mass structure and substance fabric are no longer evident; there is a large change volume but the soil has not beer significantly transported.
Extremely Weathered Material	XW	Material is weathered to such ar extent that it has soil properties, it either disintegrates or can be remoulded in water. Original roc fabric still visible.
Highly Weathered Rock	HW	Rock strength is changed by weathering. The whole of the rc substance is discoloured, usuall iron staining or bleaching to the extent that the colour of the orig rock is not recognisable. Some minerals are decomposed to cla minerals. Porosity may be increa by leaching or may be decrease due to the deposition of mineral pores.
Moderately Weathered Rock	MW	The whole of the rock substance discoloured, usually by iron stair or bleaching , to the extent that colour of the fresh rock is no lon recognisable.
Slightly Weathered Rock	SW	Rock substance affected by weathering to the extent that pa staining or partial discolouration the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rc is recognisable; strength proper are essentially those of the fresh rock substance.
Fresh Rock	FR	Rock substance unaffected by weathering.

Notes on Weathering:

AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.

Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

Rock substance strength terms

Term	Abbreviation	UCS (MPa)	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	VL	<2	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	M	6 to 20	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	60 to 200	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	EH	>200	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index Is(50). The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

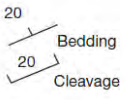
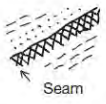
SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

TERRA INSIGHT

How to interpret the engineering logs in Your Report

Common defects observed in rock

Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties			
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.

Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

DEFECT SHAPE TERMS

Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Veneer	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

TERRA INSIGHT

Borehole No.
TP01
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA18228

Client:	SET Consultants	Commenced:	28/09/2018
Project Name:	Geotechinal Investigation	Completed:	28/09/2018
Hole Location:	Lot 3 Dido Street, Kiama NSW	Logged By:	LE
Hole Position:	302257.0 m E 6162474.0 m N MGA94 Zone 56	Checked By:	KG

Drill Model and Mounting:	1.8t excavator	Inclination:	-90°	RL Surface:	58.00 m
Hole Diameter:		Bearing:		Datum: AHD	Operator: LE

Drilling Information								Soil Description					Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm	Structure and Additional Observations
						57.8	0.2		CL-Cl	Silty CLAY: medium plasticity, brown, with fine to medium sand, trace grass roots	M	F		TOPSOIL
						57.6	0.4		CL-Cl	Sandy CLAY: medium to high plasticity, brown, fine to medium grained sand	M	F - St		RESIDUAL SOIL
						57.4	0.6		Cl	Sandy CLAY: Medium plasticity, orange brown-yellow brown with trace grey mottling, fine to medium grained sand		St		
						57.2	0.8							
						57.0	1.0			LATITE: light brown with grey and purple		St		EXTREMELY WEATHERED MATERIAL
						56.8	1.2							
						56.6	1.4							
						56.4	1.6			Hole Terminated at 1.50 m Refusal				
						56.2	1.8							

Method
AS - Auger Screwing
RR - Rock Roller
WB- Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

TERRA INSIGHT

Borehole No.
TP02
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA18228

Client:	SET Consultants	Commenced:	28/09/2018
Project Name:	Geotechinal Investigation	Completed:	28/09/2018
Hole Location:	Lot 3 Dido Street, Kiama NSW	Logged By:	LE
Hole Position:	302261.0 m E 6162448.0 m N MGA94 Zone 56	Checked By:	KG

Drill Model and Mounting:	1.8t excavator	Inclination:	-90°	RL Surface:	54.00 m
Hole Diameter:		Bearing:		Datum: AHD	Operator: LE

Drilling Information								Soil Description					Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description: Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm	Structure and Additional Observations
						53.8	0.2		CL-Cl	Silty CLAY: Low to medium plasticity, brown, with fine to medium grained sand, trace grass roots	M	F		TOPSOIL
									CL-Cl	Sandy CLAY: medium plasticity, brown, fine to medium grained sand, with latite cobbles	M	St		RESIDUAL SOIL
										Hole Terminated at 0.20 m Refusal				
						53.6	0.4							
						53.4	0.6							
						53.2	0.8							
						53.0	1.0							
						52.8	1.2							
						52.6	1.4							
						52.4	1.6							
						52.2	1.8							

Method
AS - Auger Screwing
RR - Rock Roller
WB- Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

TERRA INSIGHT

Borehole No.
TP03
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA18228

Client:	SET Consultants	Commenced:	28/09/2018
Project Name:	Geotechinal Investigation	Completed:	28/09/2018
Hole Location:	Lot 3 Dido Street, Kiama NSW	Logged By:	LE
Hole Position:	302242.0 m E 6162398.0 m N MGA94 Zone 56	Checked By:	KG

Drill Model and Mounting:	1.8t excavator	Inclination:	-90°	RL Surface:	50.00 m
Hole Diameter:		Bearing:		Datum: AHD	Operator: LE

Drilling Information								Soil Description						Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm	Structure and Additional Observations
						49.8	0.2		CL-Cl	Silty CLAY: Low to medium plasticity, brown, with fine to medium grained sand, trace grass roots	D	F		TOPSOIL
				1 D 0.20-0.50 m		49.6	0.4		CL-Cl	Sandy CLAY: medium plasticity, brown, fine to medium grained sand with latitie cobbles	D	F - St		RESIDUAL SOIL
						49.4	0.6			LATITE: extremely weathered material, light brown, fine to coarse grained		St		EXTREMELY WEATHERED MATERIAL
						49.2	0.8			Hole Terminated at 0.60 m Refusal				
						49.0	1.0							
						48.8	1.2							
						48.6	1.4							
						48.4	1.6							
						48.2	1.8							

Method
AS - Auger Screwing
RR - Rock Roller
WB- Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
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D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

TERRA INSIGHT

Borehole No.
TP04
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA18228

Client:	SET Consultants	Commenced:	28/09/2018
Project Name:	Geotechinal Investigation	Completed:	28/09/2018
Hole Location:	Lot 3 Dido Street, Kiama NSW	Logged By:	LE
Hole Position:	302272.0 m E 6162387.0 m N MGA94 Zone 56	Checked By:	KG

Drill Model and Mounting:	1.8t excavator	Inclination:	-90°	RL Surface:	42.00 m
Hole Diameter:		Bearing:		Datum: AHD	Operator: LE

Drilling Information								***Soil Description***				***Observations***
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	**Material Description** Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	**DCP** NO OF BLOWS PER 100 mm	Structure and Additional Observations
						41.8	0.2		CL-Cl	Silty CLAY: Low to medium plasticity, brown, with fine to medium grained sand, trace grass roots		F		TOPSOIL
									CL-Cl	Sandy CLAY: medium plasticity, brown, fine to medium grained sand with latite cobbles		F - St		RESIDUAL SOIL
						41.6	0.4			Hole Terminated at 0.40 m Refusal				
						41.4	0.6							
						41.2	0.8							
						41.0	1.0							
						40.8	1.2							
						40.6	1.4							
						40.4	1.6							
						40.2	1.8							

Method
AS - Auger Screwing
RR - Rock Roller
WB- Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

TERRA INSIGHT

Borehole No.
TP05
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA18228

Client:	SET Consultants	Commenced:	28/09/2018
Project Name:	Geotechinal Investigation	Completed:	28/09/2018
Hole Location:	Lot 3 Dido Street, Kiama NSW	Logged By:	LE
Hole Position:	302321.0 m E 6162437.0 m N MGA94 Zone 56	Checked By:	KG
Drill Model and Mounting:	1.8t excavator	Inclination: -90°	RL Surface: 36.00 m
Hole Diameter:		Bearing:	Datum: AHD Operator: LE

Drilling Information									***Soil Description***				***Observations***
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	**Material Description** Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	**DCP** NO OF BLOWS PER 100 mm	Structure and Additional Observations
						35.8	0.2		CL-Cl	Silty CLAY: low to medium plasticity, brown, with fine to medium grained sand, trace fine to medium sub angular gravel, trace cobbles	D - M	F		TOPSOIL
				1 B 0.20-0.40 m 1 D 0.20-0.40 m					CL-Cl	Silty CLAY: medium plasticity, with fine to medium sand, trace cobbles, trace fine to medium grained sub angular gravel	M	F - St		RESIDUAL SOIL
						35.6	0.4			Hole Terminated at 0.40 m Refusal				
						35.4	0.6							
						35.2	0.8							
						35.0	1.0							
						34.8	1.2							
						34.6	1.4							
						34.4	1.6							
						34.2	1.8							

Method
AS - Auger Screwing
RR - Rock Roller
WB- Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
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Moisture Condition
D - Dry
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Consistency/Relative Density
VS - Very Soft
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VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

Appendix H: Geotechnical Laboratory Test Certificates

South Nowra Laboratory

Coffey Services Australia Pty Ltd
ABN 55 139 460 521
43 Quinns Lane
South Nowra NSW 2541

Phone: +61 2 4429 5000
Fax: +61 2 4429 5099

Material Test Report

Report No: SNOW18S-02073-1
Issue No: 1

Client:	Terra Insight PO Box 414 Unanderra NSW 2526
Principal:	
Project No.:	754-SNOW00090AA
Project Name:	General Testing - 2018
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Evelyn Smith
(Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 16/10/2018

Sample Details

Sample ID:	SNOW18S-02073
Client Sample:	
Date Sampled:	28/09/2018
Source:	Site
Material:	dark brown silty CLAY
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	3 Dido Street, Kiama.
Sample Location:	TERRA18228 TP03

Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Air-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	11.5	
Mould Length (mm)		250	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	53	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	29	
Plasticity Index (%)	AS 1289.3.3.1	24	
Date Tested		4/10/2018	

Comments

N/A

South Nowra Laboratory

Coffey Services Australia Pty Ltd
ABN 55 139 460 521
43 Quinns Lane
South Nowra NSW 2541

Phone: +61 2 4429 5000
Fax: +61 2 4429 5099

Report No: SNOW18S-02074-1
Issue No: 1

Material Test Report

Client:	Terra Insight PO Box 414 Unanderra NSW 2526
Principal:	
Project No.:	754-SNOW00090AA
Project Name:	General Testing - 2018
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Evelyn Smith
(Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 16/10/2018

Sample Details

Sample ID:	SNOW18S-02074
Client Sample:	
Date Sampled:	28/09/2018
Source:	Site
Material:	dark brown silty CLAY
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	3 Dido Street, Kiama.
Sample Location:	TERRA18228 TP05

Test Results

Description	Method	Result	Limits
Sample History	AS 1289.1.1	Air-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	14.0	
Mould Length (mm)		250	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	53	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	32	
Plasticity Index (%)	AS 1289.3.3.1	21	
Date Tested		4/10/2018	

Comments

N/A

South Nowra Laboratory

Coffey Services Australia Pty Ltd
ABN 55 139 460 521
43 Quinns Lane
South Nowra NSW 2541

Phone: +61 2 4429 5000
Fax: +61 2 4429 5099

California Bearing Ratio Test Report

Report No: CBR:SNOW18S-02074
Issue No: 1

Client:	Terra Insight PO Box 414 Unanderra NSW 2526
Principal:	
Project No.:	754-SNOW00090AA
Project Name:	General Testing - 2018
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing.

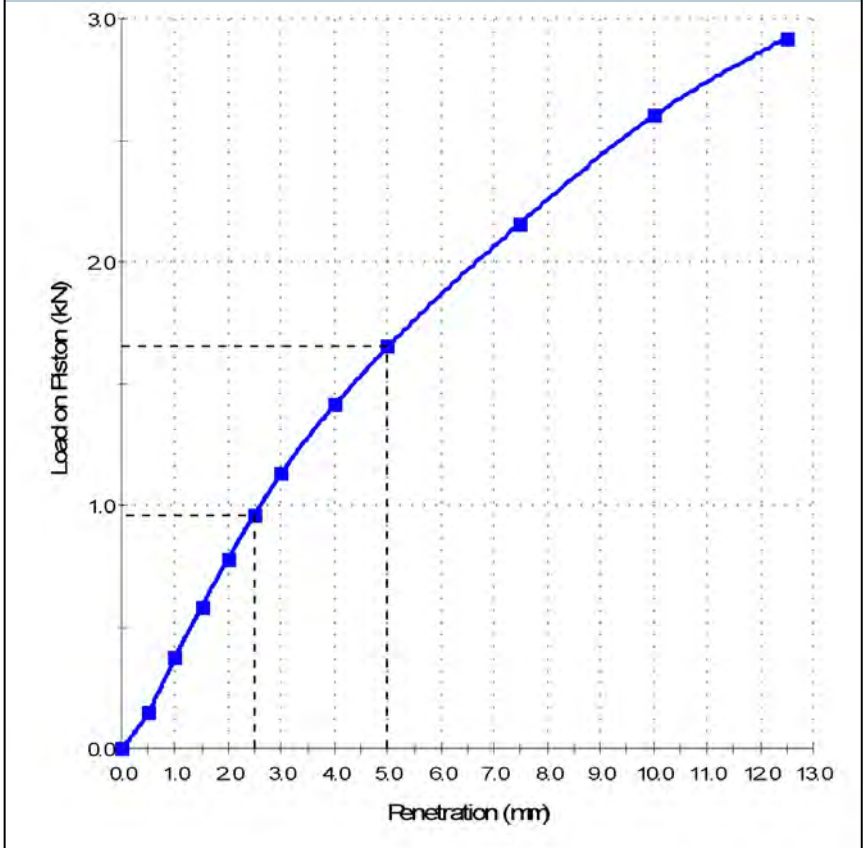
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Evelyn Smith (Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 16/10/2018

Sample Details

Sample ID:	SNOW18S-02074	**Sampling Method:**	Submitted by client
Date Sampled:	28/09/2018	**Material:**	dark brown silty CLAY
Date Submitted:	28/09/2018	**Source:**	Site
Date Tested:	8/10/2018	**Specification:**	No Specification
Project Location:	3 Dido Street, Kiama.		
Sample Location:	TERRA18228, TP05		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 5.0mm (%):	**8**
Maximum Dry Density (t/m³):	1.58
Optimum Moisture Content (%):	23.3
Dry Density before Soaking (t/m³):	1.55
Density Ratio before Soaking (%):	98
Moisture Content before Soaking (%):	23.3
Moisture Ratio before Soaking (%):	100
Dry Density after Soaking (t/m³):	1.54
Density Ratio after Soaking (%):	98
Swell (%):	0.5
Moisture Content of Top 30mm (%):	26.6
Moisture Content of Remaining Depth (%):	25.1
Compactive Effort:	Standard
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Oversize Material:	Excluded
Oversize Material (%):	19.4
Curing Time (Hrs):	27
Plasticity Level Method:	Visual

Comments

Appendix I: Appendix C of the journal, Australian Geomechanics, Vol. 42, No. 1, dated March 2007

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

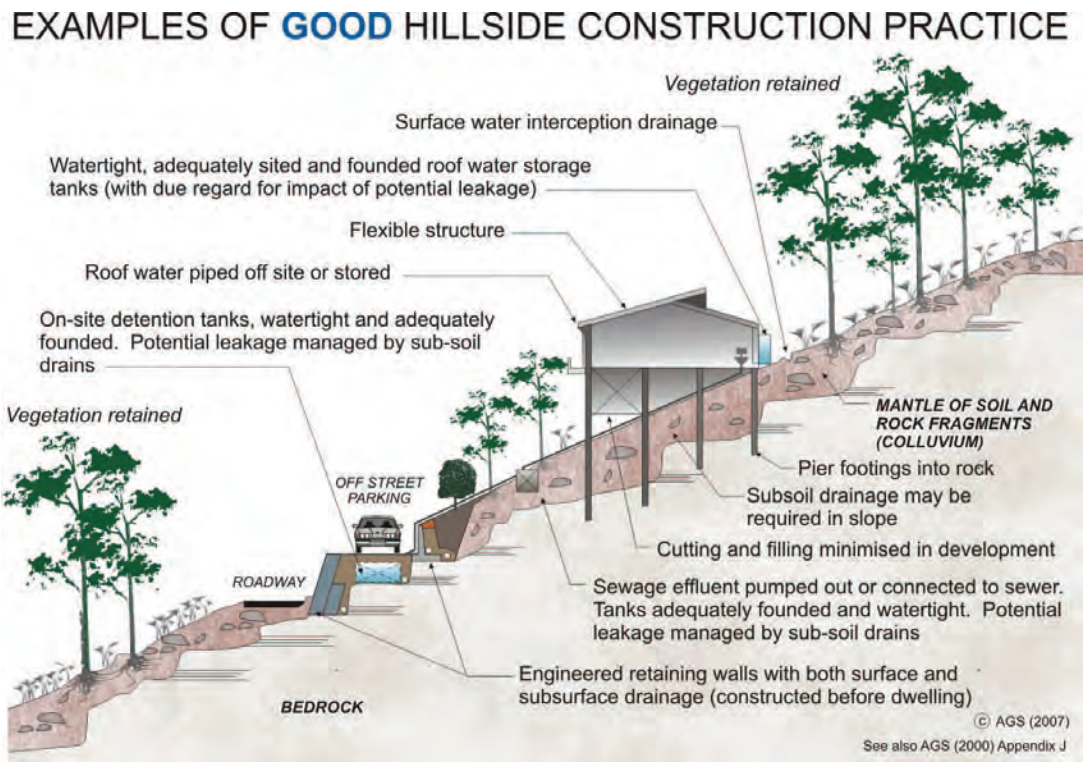
Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Appendix J: GeoGuide Good Hillside practice guidelines LR08

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that in level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfil the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

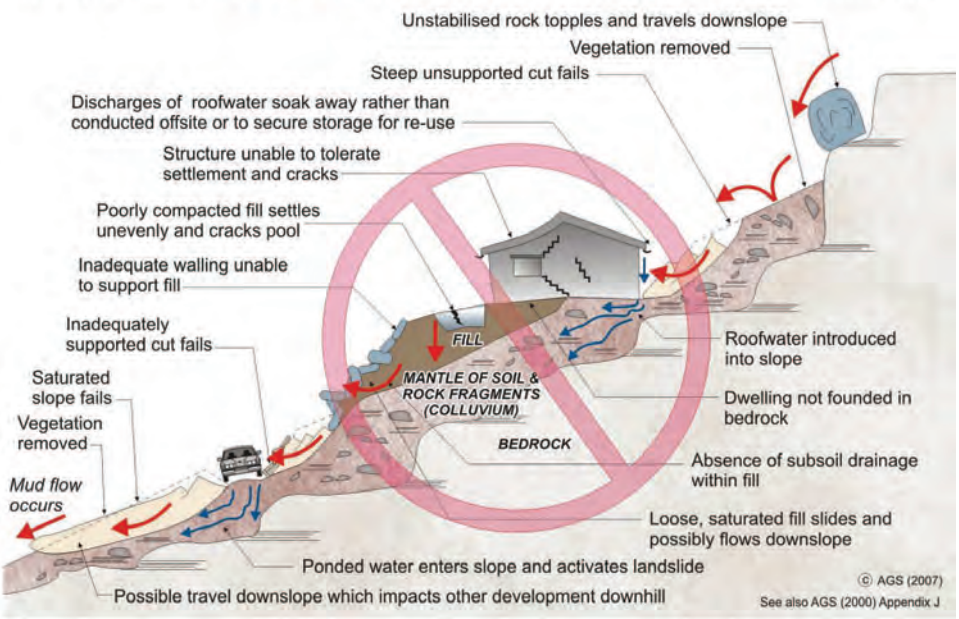
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF POOR HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soak into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herring bone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

Appendix K: CSIRO Guidelines

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

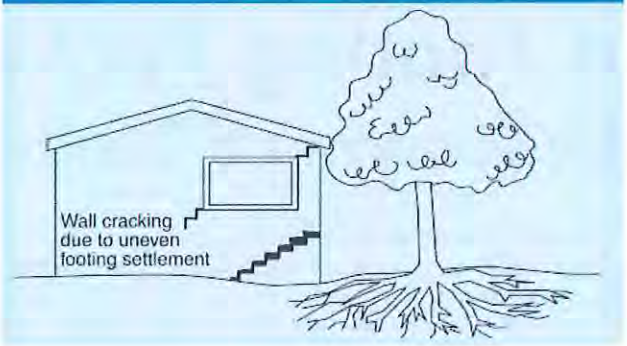
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.

Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

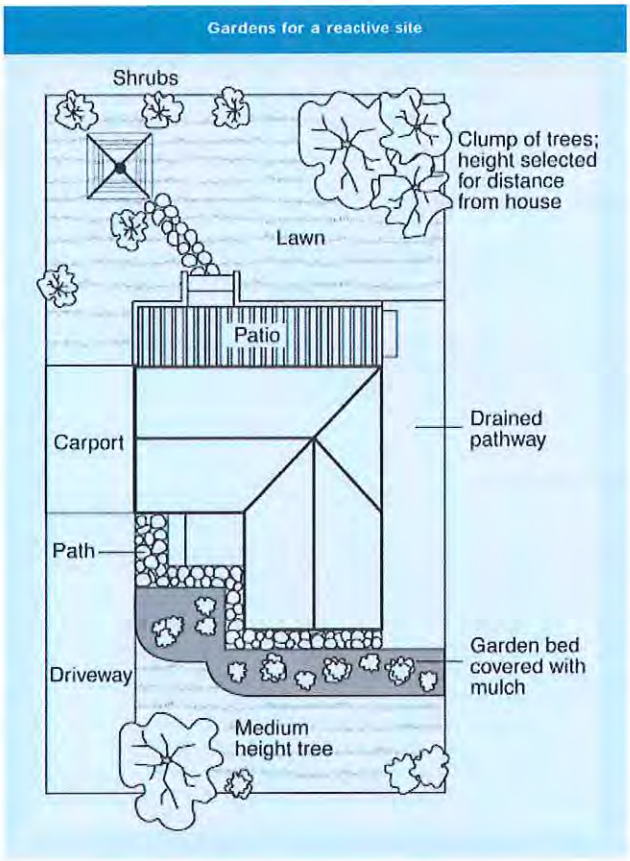
Protection of the building perimeter

It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

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