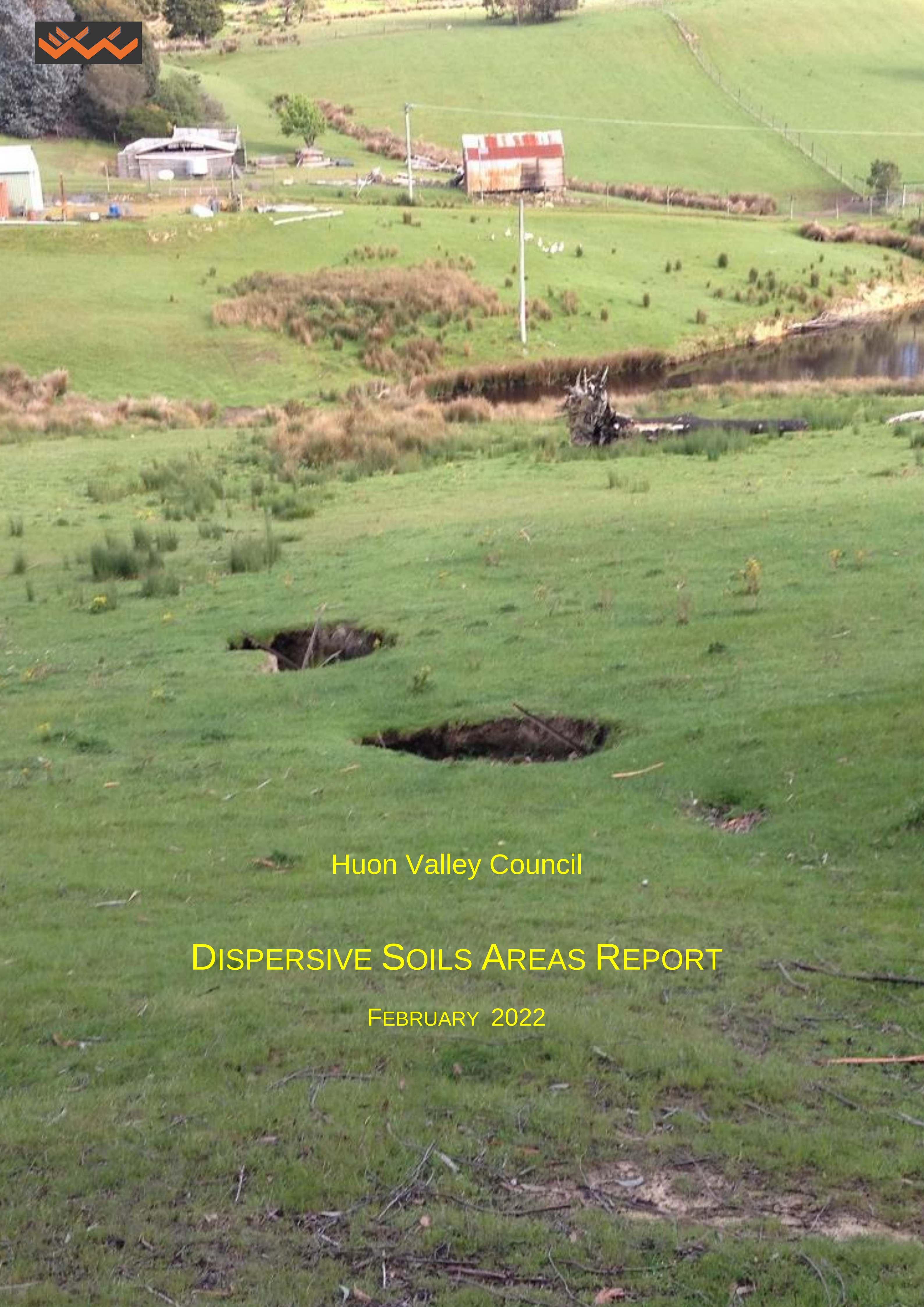


Huon Valley Council

Dispersive Soils Areas Report

February 2022

Cover photo

Collapsed tunnels ("sinkholes") in dispersive soils in a paddock near Brooks Bay in Huon Valley municipality. The sinkholes are up to about a metre deep (erosion depth is limited by shallow bedrock) and they extend in a line downslope for about 75m. The hazard has affected the amenity and value of the land: stock cannot be grazed here for fear of injury from these and other unseen tunnels.

Photo: Bill Cromer

Refer to this report as

Cromer, W. C. (2022). *Dispersive Soils Areas Report.* Unpublished report for Huon Valley Council by William C. Cromer Pty Ltd, 6 February 2022.

SUMMARY

Permian-age and Triassic-age sedimentary rocks are widespread in Huon Valley municipality. These rocks weather to soils which tend to be prone to dispersion and tunnel erosion (other rocks also produce soils with a dispersive nature, but these are much less common).

Soils from fifty sites in the municipality were recently tested for dispersion, with a range of results from full to no dispersion.

The potential hazard occurs in residential and rural areas, and needs to be managed.

The dispersive nature of soils should be established before any development starts.

This report provides a sound basis for compiling a Specific Area Plan for dispersive soils, as part of the Local Provisions Schedule of the *Tasmanian Planning Scheme – Huon Valley Council*.

With minor amendment (suggested here) the Huon Valley Council draft Specific Area Plan for Potential Dispersive Soils adequately provides for the identification and management of dispersive soils in the municipality.

1 INTRODUCTION

1.1 Introduction

Huon Valley Council (HVC) is preparing Local Provision Schedules (LPS) as part of the Tasmanian Planning Scheme currently being adopted by local governments.

The current report describes the occurrence of dispersive soils in rural and residential areas of the municipality (Figures 1 and 2), to support the compilation of a Specific Area Plan (SAP) for such soils as part of the LPS.

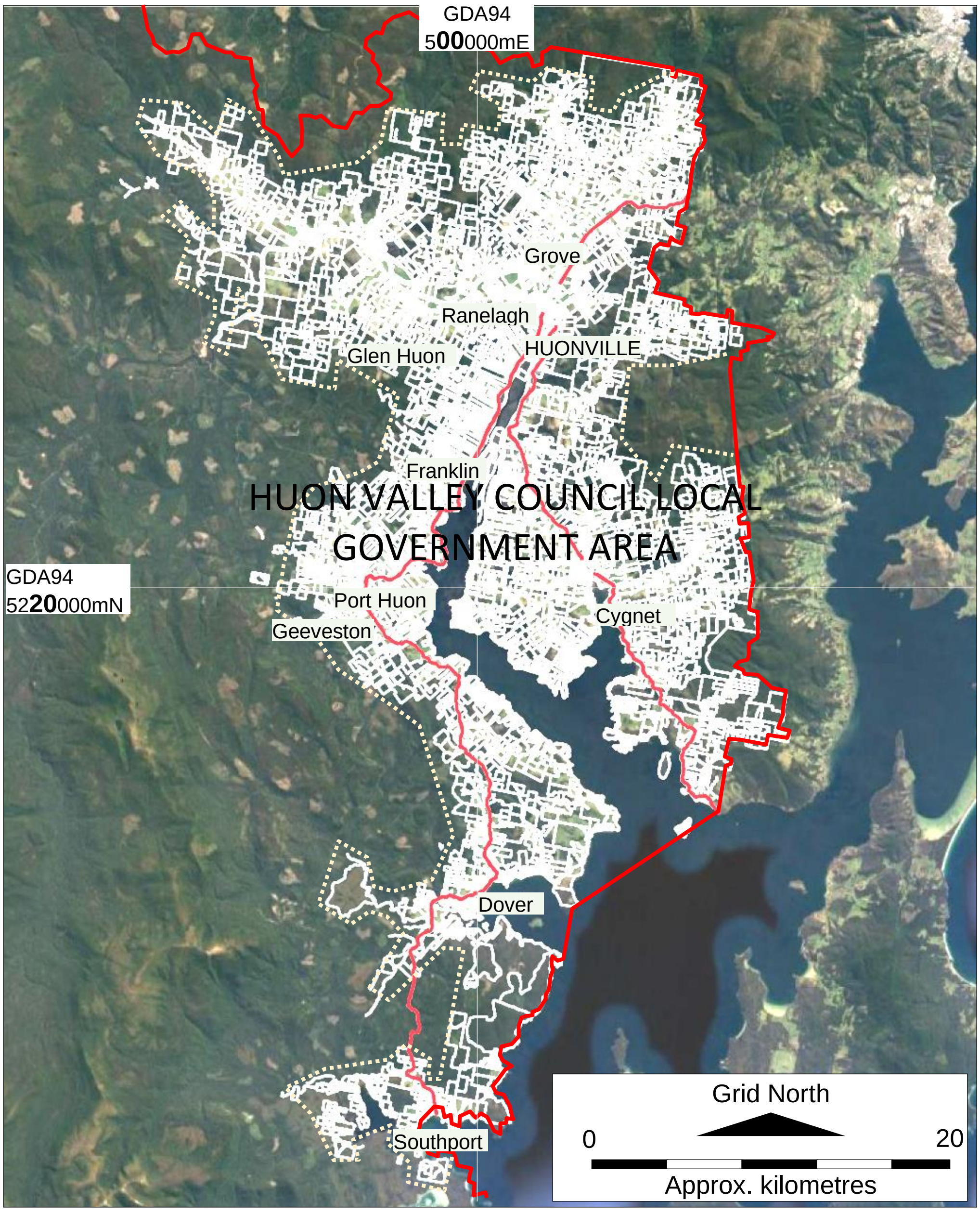


Figure 1. Residential and rural land in the Huon Valley Council Local Government Area.
Source: Huon Valley Council

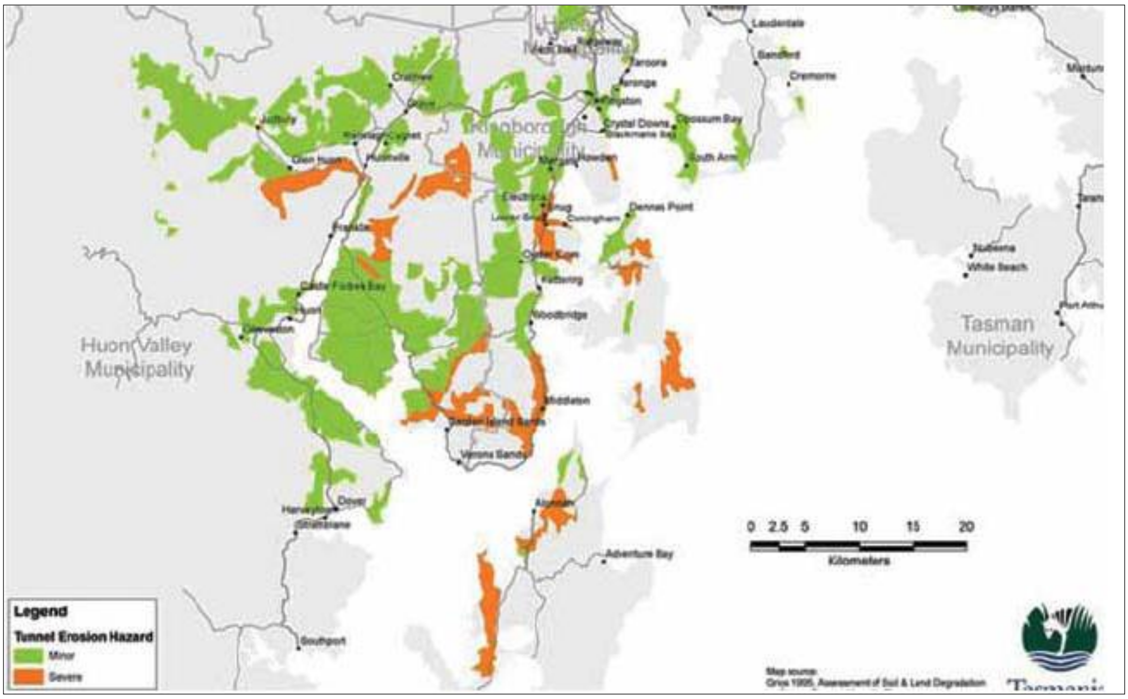


Figure 2. Land with potentially dispersive soils prone to tunnel erosion is widespread in the Huon Valley municipality (Legend: green = minor tunnel erosion hazard; Orange = severe tunnel erosion hazard)

Source: Huon Valley Council Planning Information Sheet 13: Land prone to tunnel erosion – Dispersive soils. The map is derived from Figure 3 of DPIW *Dispersive Soils and their Management – Technical Reference Manual (April 2009).*

1.2 Dispersive soils

1.2.1 Dispersive soils and tunnel erosion

Dispersive soils are sodic soils with an exchangeable sodium percentage (ESP) greater than 6%. When these soils get wet, the soil aggregates (small peds and clods) collapse because individual clay particles disperse into solution.

Water may enter the subsurface in dispersive soils via soil shrinkage cracks, burnt-out tree roots, rabbit and other animal burrows, and human activity (for example, downpipes from roofs, trenching for electricity, sewerage, water and communications services). When this happens and soil aggregates break down, the subsurface openings enlarge, forming cavities which permit increasingly larger volumes of water to enter. This positive feedback creates tunnels which may eventually extend for long distances downslope. Groups of tunnels may develop like an underground braided stream system (Figure 3a).

Tunnels may remain undetected, but their presence is often evidenced by yellowish brown sediment fanning out from their downslope ends (Figure 3b). As erosion continues, the roofs of tunnels may sag and then collapse, producing a line of open channels (Figure 3c) and “sinkholes”. Downward deepening of channels and sinkholes continues until bedrock is reached. Most collapses are less than a metre or two deep (Figure 3d), but in some deeper soils channels up to five metres or more deep have been recorded (Figures 3e, 3f and 3g).

1.2.2 Distribution of dispersive soils and tunnels

Dispersive soils and tunnel erosion are widespread in southern Tasmania (Figure 2). They occur on soils developed on many bedrock types, but particularly on soils developed on Triassic-age and Permian-age rocks. These rocks are widespread in Huon Valley municipality.

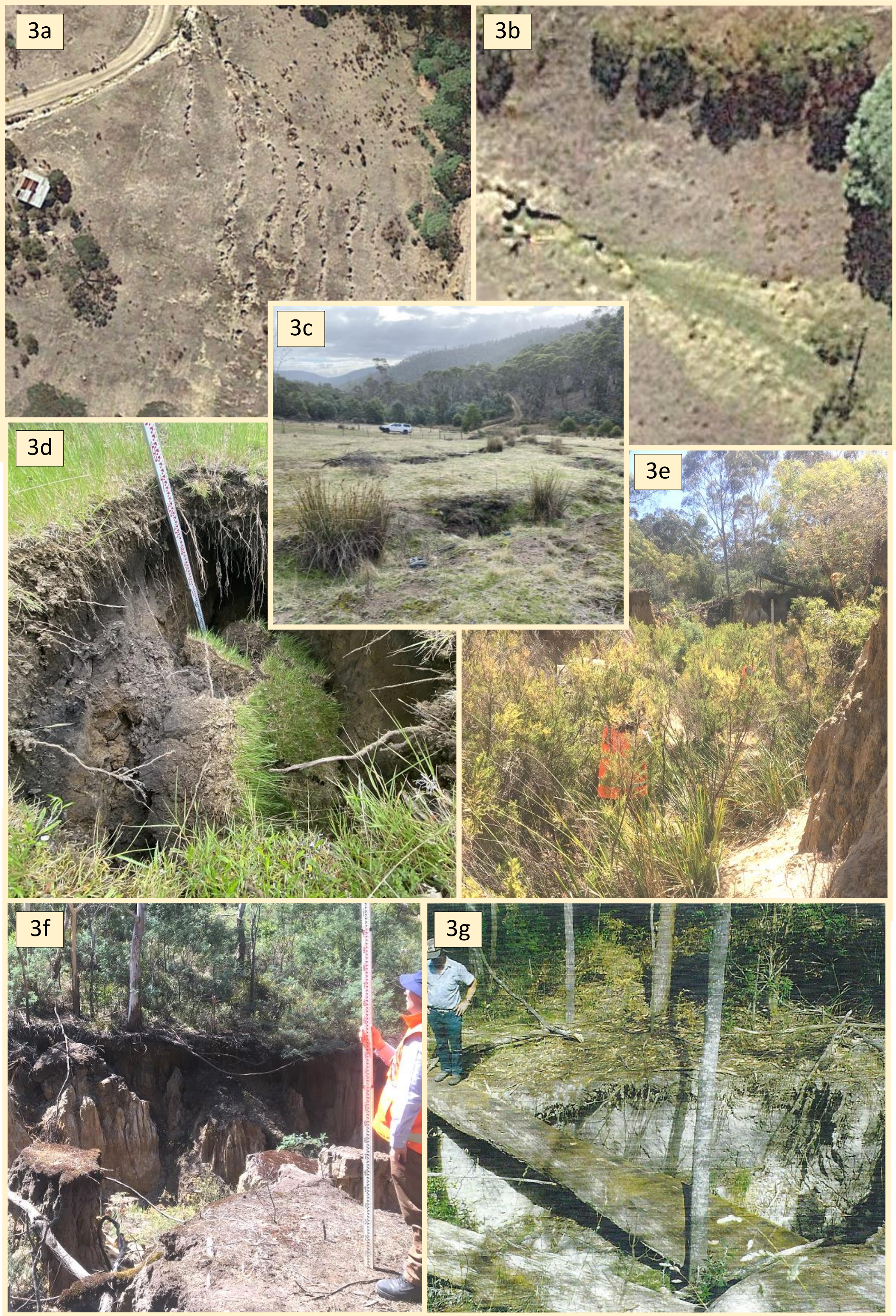


Figure 3. Examples of tunnel erosion in southeastern Tasmania.
Sources: Google Earth (Figs. 3a and 3b) and Bill Cromer

1.2.3 Management of dispersive soils

Dispersive soil and tunnel erosion have significant effects on land amenity and value, and their management is difficult. Efforts focus on (a) reducing or eliminating the upslope sources of water which create and maintain the hazard, and (b) rehabilitating the downslope affected land.

Various publications[1] relate to tunnel erosion and its management in southern Tasmania. Experience suggests some management methods are of dubious value[2], and it is clear that full remediation of the hazard is difficult and often unsuccessful.

In addition to the usual recommendations of minimising cut and fill, retention of topsoil etc., other suggestions for managing tunnel erosion are:

- minimise or eliminate upslope sources of rainwater/stormwater to the soil, including point discharges from downpipes, etc. In residential areas, all runoff from roads and hardstands should be diverted to stormwater pipes which discharge to a reticulated system or drainage lines.
- do not backfill collapsed tunnels with soil, sand or clay in an attempt to block the flow of water (erosion will continue around the blockage). Instead, backfill collapsed tunnels with durable, screened aggregate to provide support for the sinkhole, yet allowing water flow in the same path.
- line service trenches with geofabric before backfilling.

Attempts at rehabilitation are a waste of time if the sources of water causing the problem are not identified and mitigated. A further issue is the difficulty of identifying all tunnel eroded areas on a site: rehabilitation naturally focuses on collapsed tunnels and many others nearby may remain undetected and continue to develop.

[1] For example: (1) *Dispersive Soils – High Risk of Tunnel Erosion.* (Fact Sheet 4 jointly produced by the Tas and Aust governments, NRM South and Derwent Estuary Program, December 2008); (2) Hardie, M. (undated) *Management of Dispersive Soils in Urban Areas.* Tasmanian Institute of Agricultural Research. PowerPoint presentation. (3) *Dispersive Soils and Their Management – Technical Reference Manual*. DPIW (April 2009).

[2] For example, "Tunnel systems will need to be dug out along their entire path using an excavator" (as suggested in DPIW *Dispersive Soils and their Management*, page 31) is not recommended because there is no certainty that all tunnels will be exposed, and also because such soil disruption might induce new tunnels to form. Repacking exposed tunnels with compacted clay is also not recommended – tunnels are likely to simply migrate sideways around the blockage.

2 METHODOLOGY FOR THIS REPORT

This report has adopted the following staged methodology:

1. ascertain from HVC the distribution of residential and rural land in the municipality (Figure 1),
2. review published geological maps of the municipality,
3. create a set of ten Geology Maps showing the published distribution of Permian-age and Triassic-age rocks (which compared to other rock types in Tasmania are significantly more likely to produce soils with a dispersive nature),
4. undertake a sampling program (under the supervision of an experienced geologist) of soils developed on Permian-age and Triassic-age,
5. conduct laboratory dispersion testing of the samples,
6. review the provisions of the draft HVC SAP for potential dispersive soils, and
7. compile the present report with sample locations on the Geology Maps, laboratory results of dispersion, field notes and selected site photographs, and if appropriate, suggest amendments to the draft SAP.

3 RESULTS

3.1 Presentation of results

Figure 4 shows the locations of the fifty soil sampling sites labelled D1 – D50, and the numbered Geology Maps 1 – 10. Attachment 1 presents the ten Geology Maps showing the sample locations with respect to Permian- and Triassic-age bedrock occurrences. Attachment 2 contains site photographs, and Attachment 3 presents the field notes from the survey and the results of laboratory dispersion sampling of fifty soil samples.

3.2 Results of dispersion testing

Results are summarised in Table 1:

- one sample (on Permian-age bedrock) showed complete dispersion (Emerson No. of 1)
- 4 samples (equally on Permian- and Triassic-age bedrock) showed some dispersion (Emerson No. of 2)
- 18 samples (equally on Permian- and Triassic-age bedrock) showed slight dispersion (Emerson No. of 3)
- 20 samples (16 on Permian-age bedrock) showed slight or no dispersion (Emerson Nos. of 4, 5 or 6), and
- 7 samples (5 on Triassic-age bedrock) showed no dispersion (Emerson Nos. of 7 and 8)

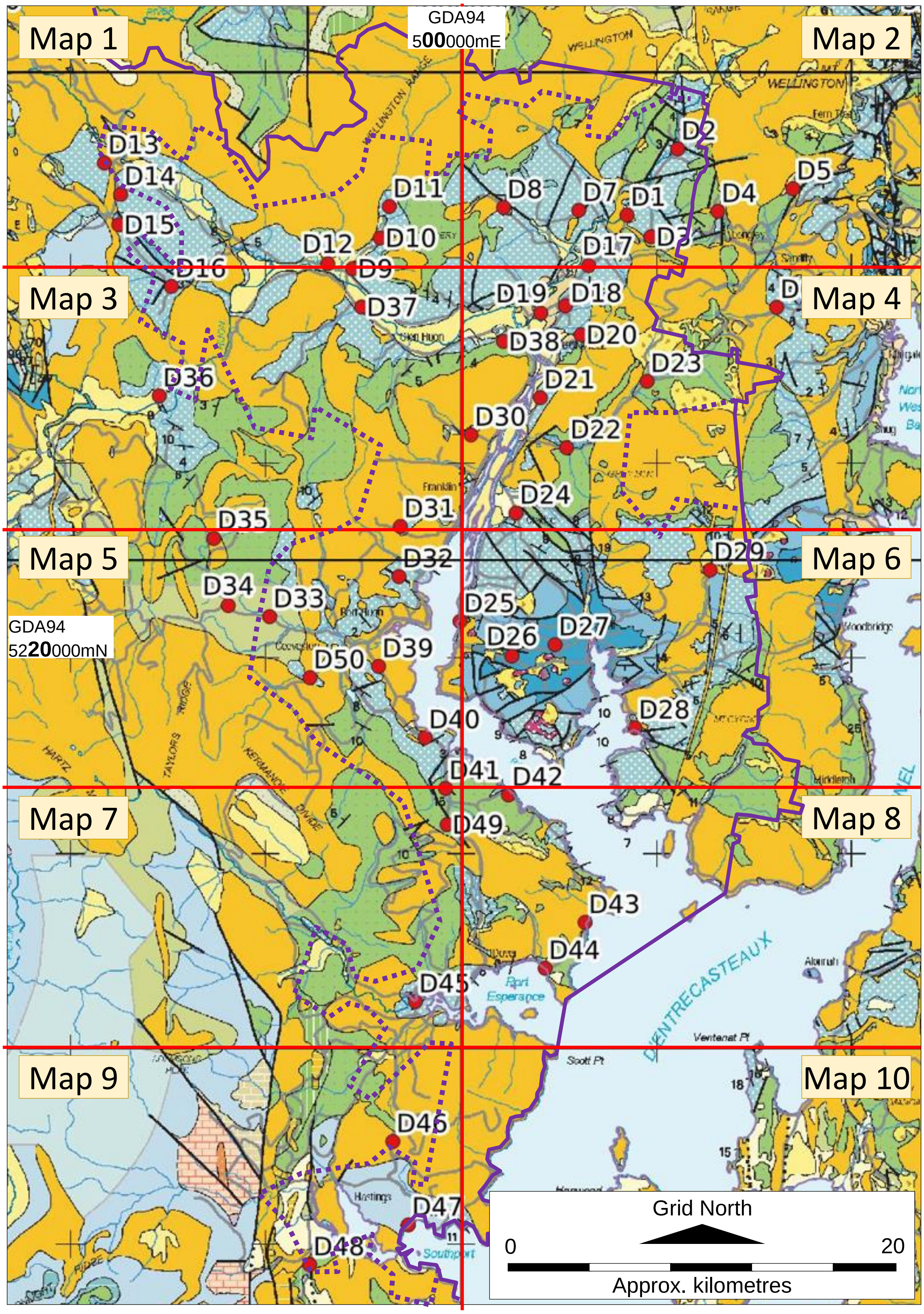


Figure 4. Geological map of Huon Valley municipality, showing the locations of soil samples D1 – D50 collected in January 2022 for dispersion testing. For more detailed locations, refer to the maps in Attachment 1. Samples were collected only from areas shown as Permian-age sedimentary rocks (blue, dark blue and stippled blue areas – except the blue areas in the southwest corner of the map) and Triassic-age sedimentary rocks (green areas). The other dominant rock type on the map is Jurassic-age dolerite (orange). The purple line is the boundary to the municipality; the dotted purple line is the approximate boundary to the residential/rural areas defined in Figure 1.

Source of geology map: Forsyth, S. M. *et. al.* (compilers). 2005. Geology of Southeast Tasmania. Edition 2012.1. Digital Geological Atlas 1:250,000 Scale Series. Mineral Resources Tasmania.

4 DISCUSSION

4.1 Limitations of the soil sampling and analysis

4.1.1 Scales of published geological maps

Published geological maps of the residential and rural areas of Huon Valley municipality include maps at 1:25,000, 1:50,000 and 1:250,000 scales. Most of the sampled area is at 1:250,000 scale which lacks geological detail. As a result, some of the sample sites shown to be on Permian or Triassic-age rocks may be on either rock type, or neither.

4.1.2 Field sampling

Field sampling was restricted to surface soils in road cuttings and road verges (rather than subsurface soils from auger holes, test pits etc). Samples will have been variably exposed to weather, which may have affected their behaviour in dispersion testing.

4.2 Sources of samples

Of the fifty soil samples, 32 were from soils developed on Permian-age bedrock, and 18 from soils on Triassic-age bedrock[3].

Other bedrock types in Tasmania are known to produce soils with a dispersive nature, but their occurrence is relatively rare, and they have not been considered in this report.

4.3 Suggested addition to the draft Potential Dispersive Soils SAP

The HVC draft SAP HUO-S5.0 refers to potential dispersive soils.

In Section HUO-S5.4 (Definition of Terms), dispersive soil "means soil or sediment with an exchangeable sodium percentage greater than 6% or which demonstrates dispersive behaviour when in contact with fresh water."

Potential dispersive soil is not defined.

It is suggested that potential dispersive soil should also be defined. A workable definition could be: potential dispersive soil "means soil or sediment which may have an exchangeable sodium percentage greater than 6% or which might demonstrate dispersive behaviour when in contact with fresh water."

With this addition, in my view the draft SAP for potential dispersive soils adequately addresses its aim: "To minimise and mitigate adverse impacts from development occurring on land that contains potential dispersive soils."

4.4 Application of the draft Potential Dispersive Soils SAP

It is intended that the HVC dispersive soils SAP apply at least to all areas of Permian- and Triassic-age rocks indicated by the blue- and green-hatched areas respectively in the Geology Maps in Attachment 1. Defining potential dispersive soils in the SAP acknowledges other rock

[3] This difference in sample numbers reflects the more common occurrence of Permian-age rocks in the residential and rural areas of the municipality.

types may also produce soils with a dispersive nature, so that assessors should test for dispersive soils as a matter of course[4] irrespective of geology.

5 Conclusions

The published occurrences of Permian- and Triassic-age rocks in the residential and rural areas of Huon Valley municipality – and the potential for dispersive soils and tunnel erosion to develop on them – constitute a firm basis for compiling a Potential Dispersive Soils Specific Area Plan to address the hazard.

The application of the SAP should not be limited to soils on Permian- and Triassic-age rocks, and this is achieved by defining "potential dispersive soils".

Under section 32(4) of the Land Use Planning and Approvals Act 1993 at least the land reviewed in this supporting report needs to be subject of the SAP as it has .. *particular environmental, economic, social or spatial qualities that require provisions, that are unique to the area of land, to apply to the land in substitution for, or in addition to, or modification of, the provisions of the SPPs.*

With one addition (suggested here) the draft SAP is a suitable instrument to manage potential dispersive soils in the municipality.

W. C. Cromer
Principal

This report is accompanied by and must not be separated from the following Attachments:

Attachment 1. HVC Geology Maps showing soil sample locations (11 pages)

Attachment 2. Photographs of six of the 50 dispersion sample sites showing the full range of dispersion results (4 pages)

Attachment 3. Field notes with laboratory dispersion results, and photographs of laboratory results (6 pages)

4 For example, assessors Australia-wide very commonly conduct "soil tests" for domestic wastewater, and house site classifications. Two relevant Australian Standards are respectively AS/NZS1547 – 2012 *On-site domestic wastewater management,* which in Section E7 explicitly requires that soils for wastewater application shall be tested for dispersion, and AS2870 – 2011 *Residential slabs and footings* which in Section 1.3.3 implies that soils with "abnormal moisture conditions" should be identified.

Table 1. Results of dispersion testing, colour-coded with respect to the scheme at bottom. See Attachment 3 for more details.

		GDA94			
Site	Map	Easting	Northing	Bedrock Type	Est. Emerson No.
D20	4	506123	5236562	Permian sandstone	1
D3	2	509702	5241584	Triassic? sandstone	2
D19	4	504065	5237666	Permian sandstone	2
D25	5, 6	499934	5221875	Permian sandstone	2
D35	3, 5	487332	5226121	Triassic sandstone	2
D1	2	508477	5242693	Permian? sandstone	3
D7	2	506014	5242933	Permian sandstone	3
D22	4	505384	5230773	Triassic sandstone	3
D23	4	509503	5234176	Triassic sandstone	3
D24	4	502800	5227428	Permian sandstone	3
D27	6	504794	5220680	Permian sandstone	3
D28	6	508887	5216416	Permian sandstone	3
D29	6	512725	5224501	Permian sandstone	3
D30	3, 4	500495	5231428	Triassic sandstone	3
D32	5	496809	5224170	Permian siltstone	3
D33	5	490192	5222115	Triassic sandstone	3
D34	5	488073	5222685	Triassic sandstone	3
D37	3	494894	5237982	Triassic? sandstone	3
D39	5	495766	5219569	Permian sandstone	3
D40	5	498151	5215920	Permian siltstone	3
D43	8	506331	5206451	Triassic sandstone	3
D47	9	497289	5190949	Permian siltstone	3
D48	9	492238	5188915	Permian? siltstone	3

1	Emerson Class No. 1 (complete dispersion)
2	Emerson Class No. 2 (some dispersion)
3	Emerson Class No. 3 (slight dispersion)
4, 5, 6	Emerson Class No. 4, 5 or 6 (slight to no dispersion)
7, 8	Emerson Class No. 7 or 8 (no dispersion)

Other practitioners may adopt a different descriptive scale for the eight Emerson Nos.

Table 1 (continued)

Site	Map	GDA94 Easting	GDA94 Northing	Bedrock Type	Est. Emerson No.
D6	2, 4	516133	5237966	Permian sandstone	4, 5 or 6
D8	2	502166	5243080	Permian sandstone	4, 5 or 6
D9	1	494437	5239951	Permian sandstone	4, 5 or 6
D10	1	495843	5241522	Permian siltstone	4, 5 or 6
D11	1	496319	5243129	Permian sandstone	4, 5 or 6
D12	1	493164	5240199	Permian sandstone	4, 5 or 6
D13	1	481737	5245363	Permian sandstone	4, 5 or 6
D14	1	482570	5243756	Permian sandstone	4, 5 or 6
D15	1	482474	5242196	Permian sandstone	4, 5 or 6
D16	1	485166	5239036	Permian sandstone	4, 5 or 6
D17	2	506512	5240100	Permian sandstone	4, 5 or 6
D18	2, 4	505329	5238043	Permian sandstone	4, 5 or 6
D21	4	504041	5233338	Permian sandstone	4, 5 or 6
D26	6	502585	5220100	Permian siltstone	4, 5 or 6
D31	3, 5	496882	5226734	Permian sandstone	4, 5 or 6
D38	4	502157	5236217	Triassic sandstone	4, 5 or 6
D41	6	499189	5213313	Triassic sandstone	4, 5 or 6
D44	8	504291	5204097	Triassic sandstone	4, 5 or 6
D45	7	497649	5202391	Permian sandstone	4, 5 or 6
D49	7, 8	499274	5211463	Triassic? sandstone	4, 5 or 6
D5	2	516968	5244040	Triassic sandstone	7
D36	3	484546	5233431	Permian sandstone	7
D46	9	496497	5195225	Triassic siltstone	7
D50	5	492257	5218990	Triassic sandstone	7
D2	2	511073	5246082	Permian sandstone	8
D4	2	513126	5242884	Triassic? sandstone	8
D42	6	502410	5212980	Triassic siltstone	8

Attachment 1

(11 pages including this page)

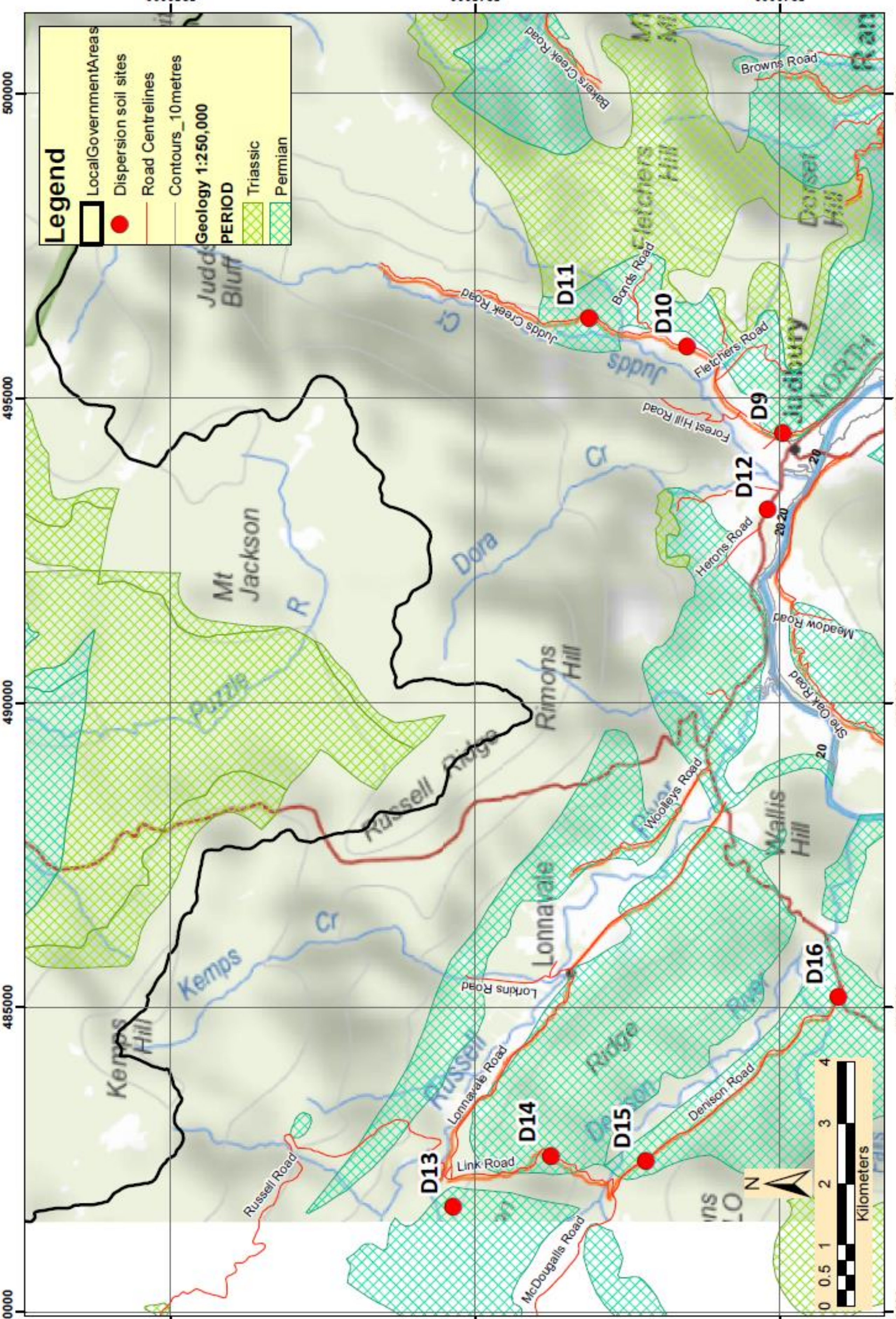
HVC Geology Maps showing soil sample locations

Source of base maps: www.thelist.tas.gov.au

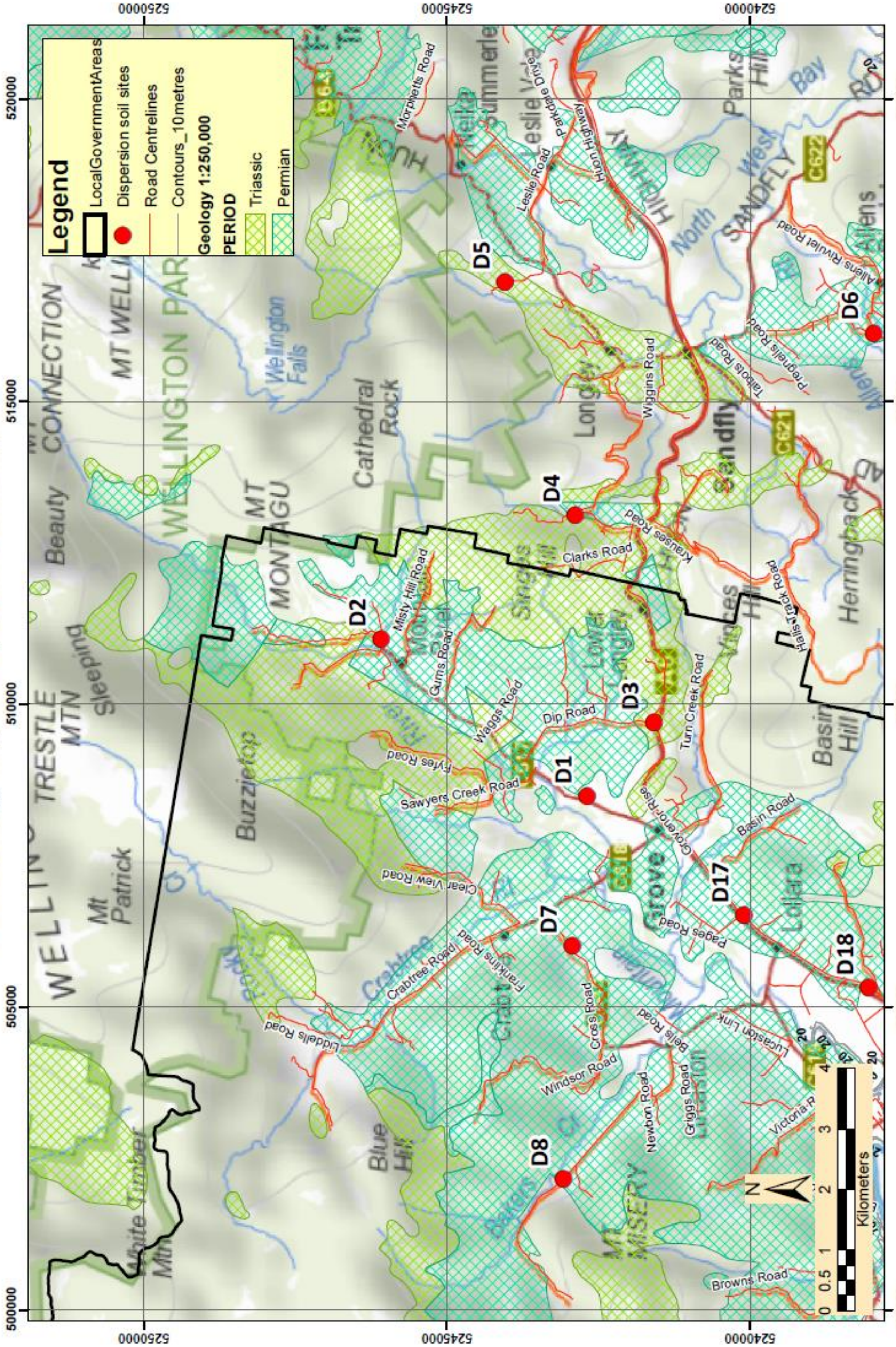
The ten maps are numbered 1 – 10

Brief field notes of the numbered soil sampling sites shown on all maps are presented in Attachment 3. Photographs of selected sites are presented in Attachment 2.

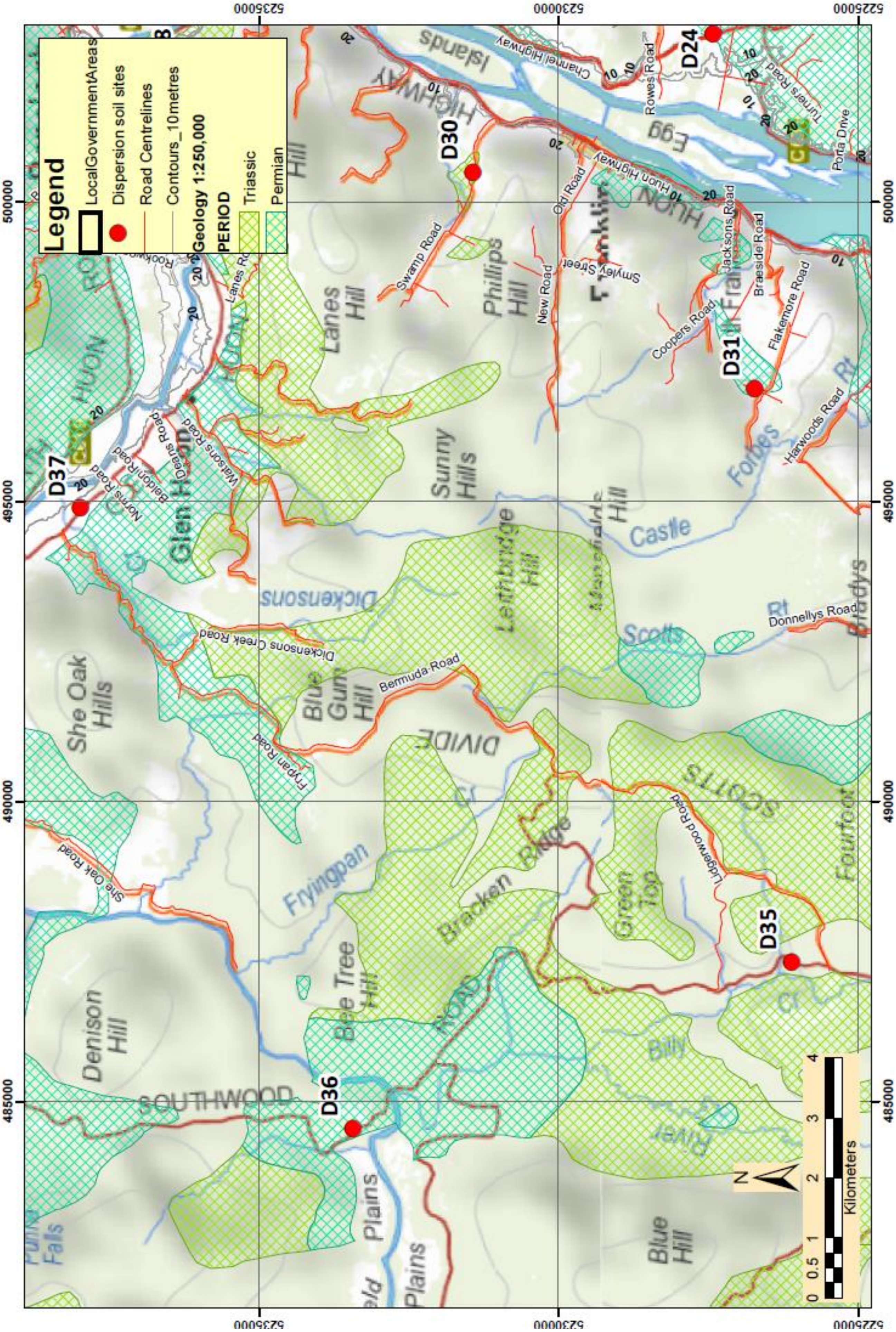
HVC Geology Map 1. Dispersion soil sampling



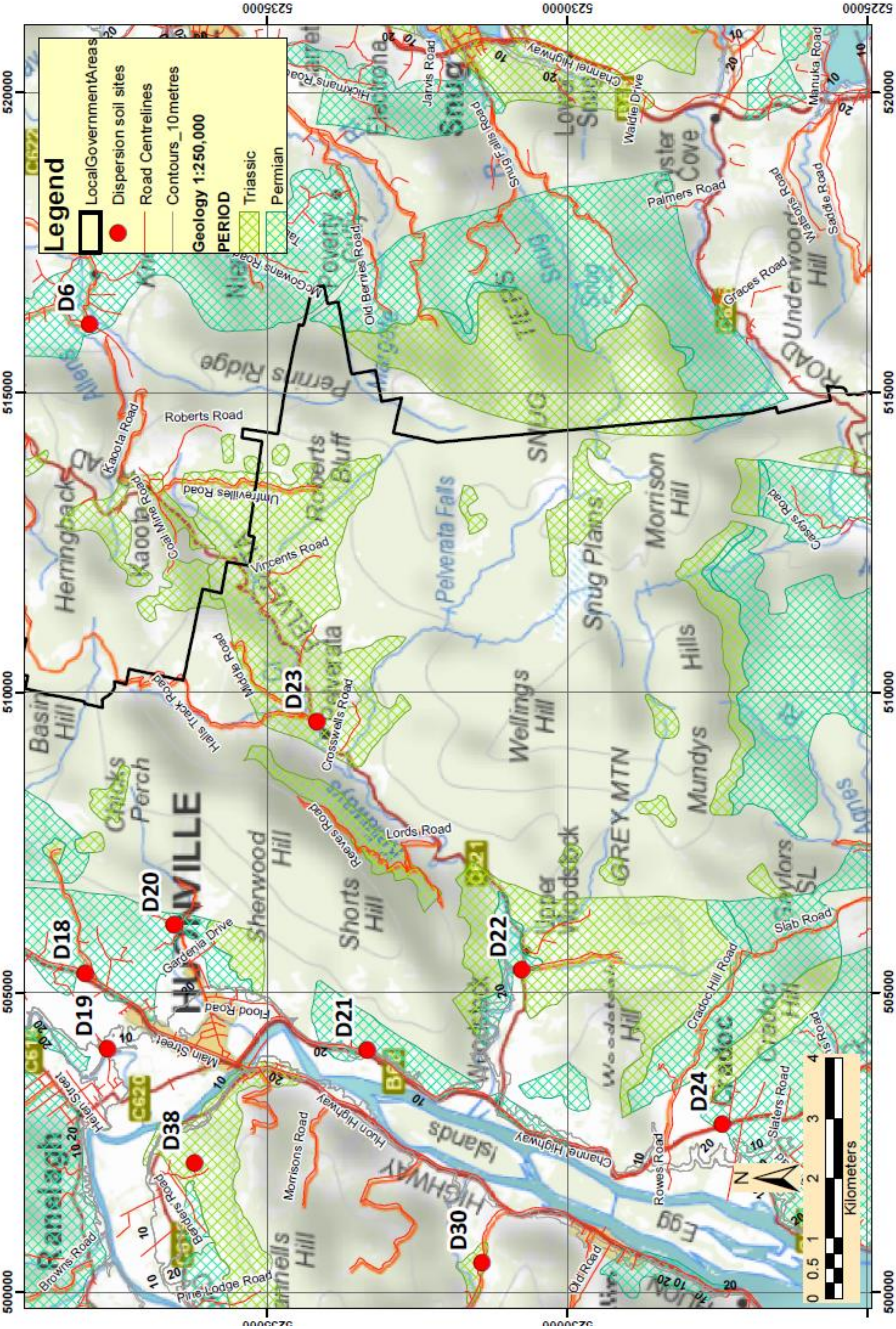
HVC Geology Map 2. Dispersion soil sampling



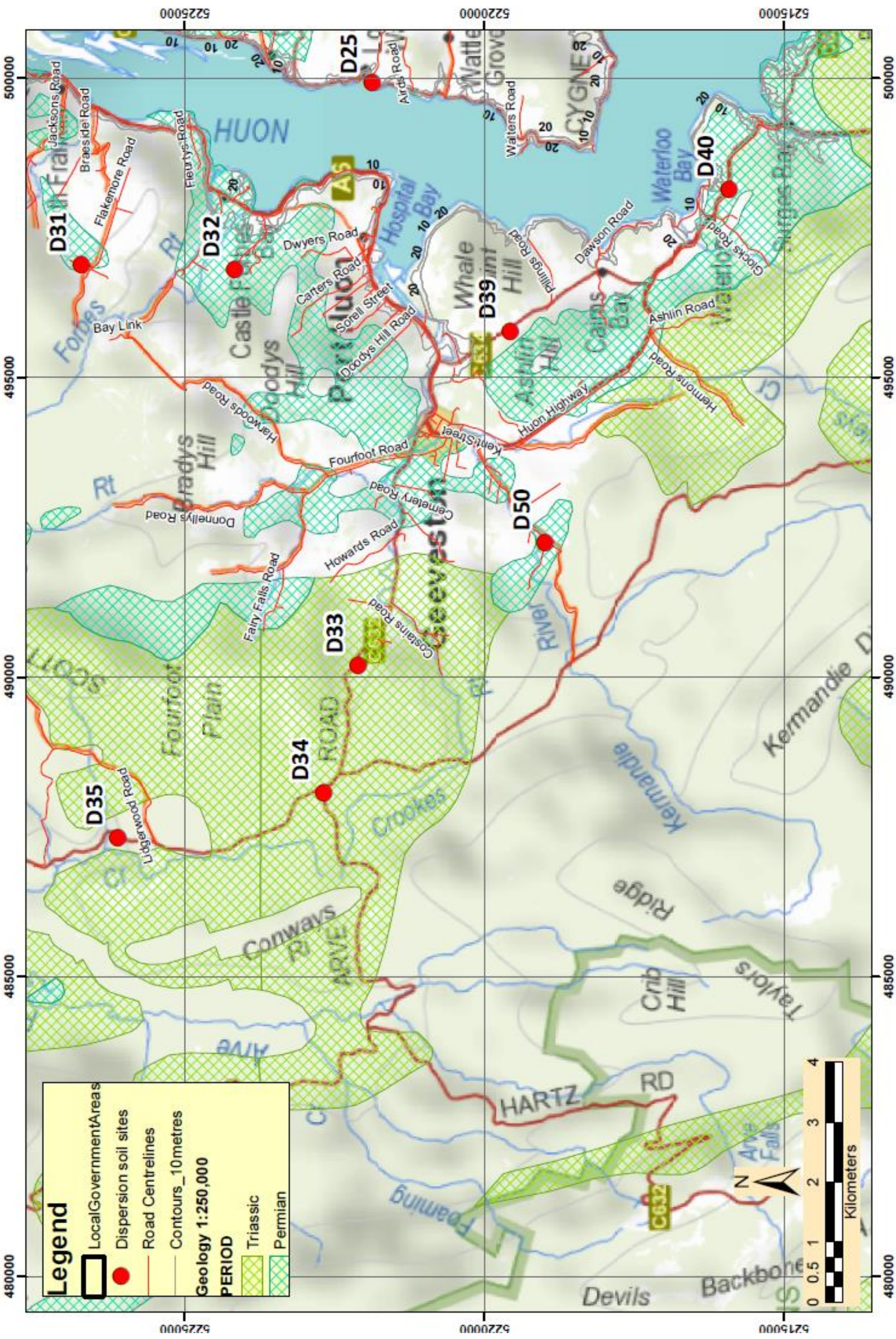
HVC Geology Map 3. Dispersion soil sampling



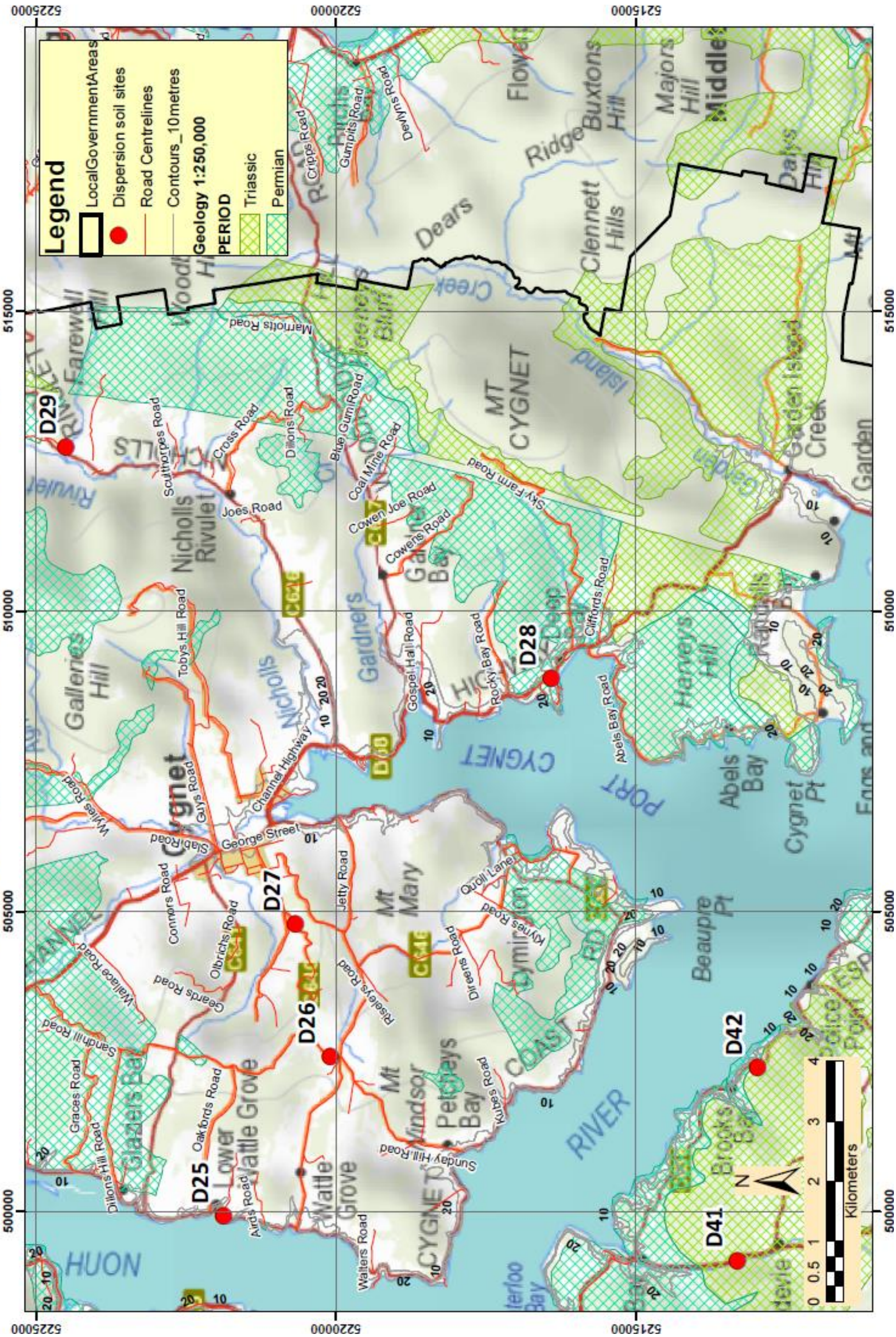
HVC Geology Map 4. Dispersion soil sampling



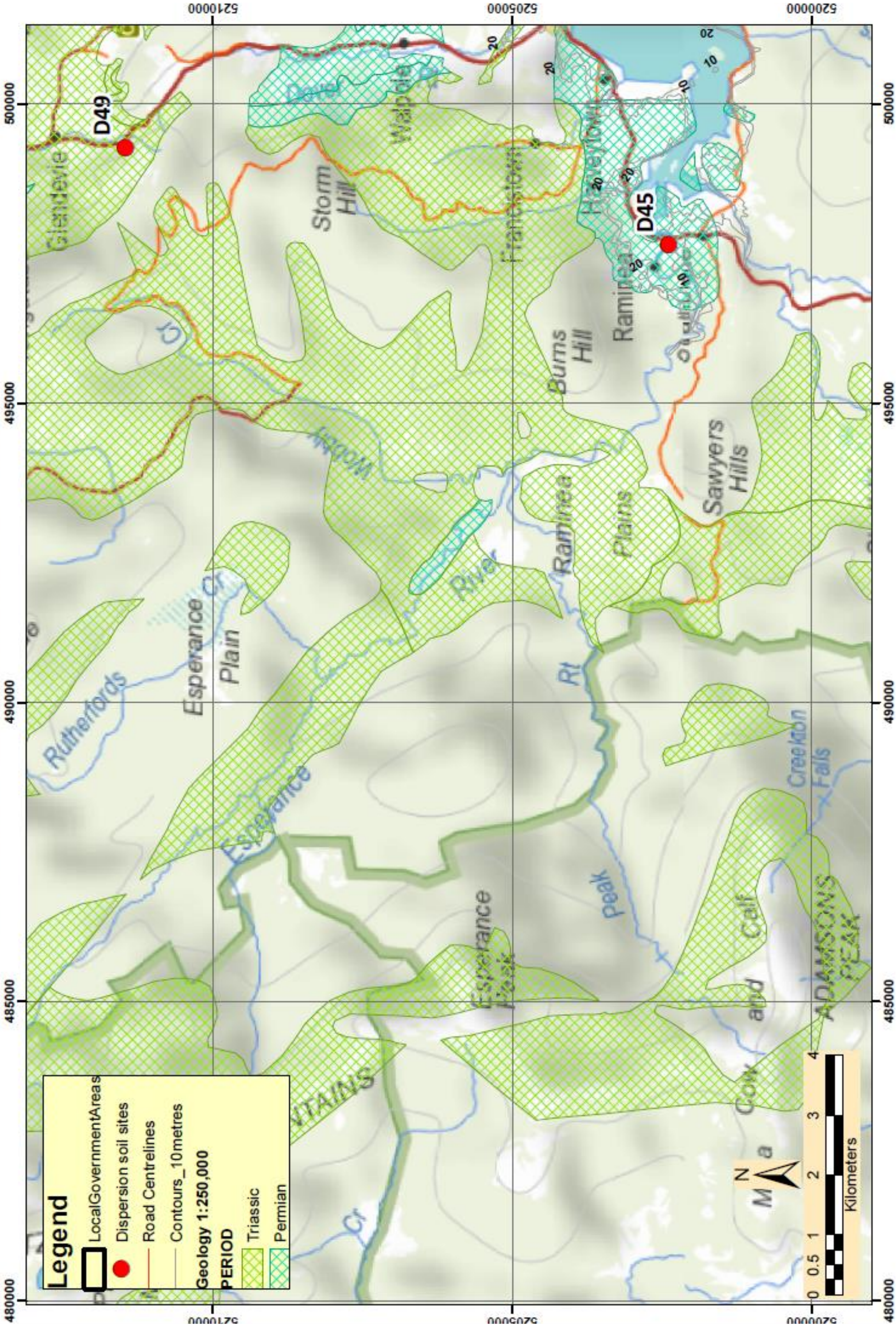
HVC Geology Map 5. Dispersion soil sampling



HVC Geology Map 6. Dispersion soil sampling

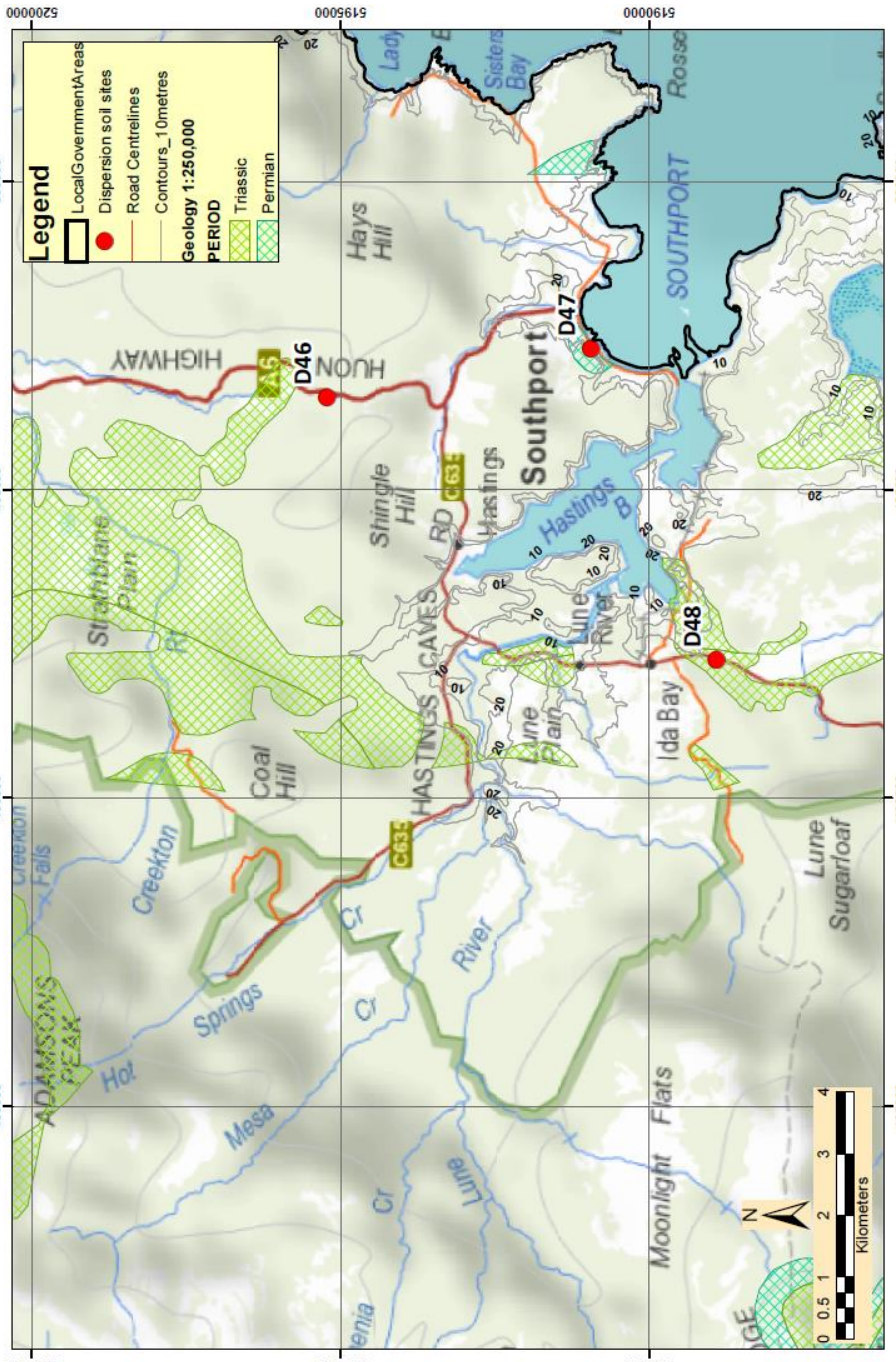


HVC Geology Map 7. Dispersion soil sampling

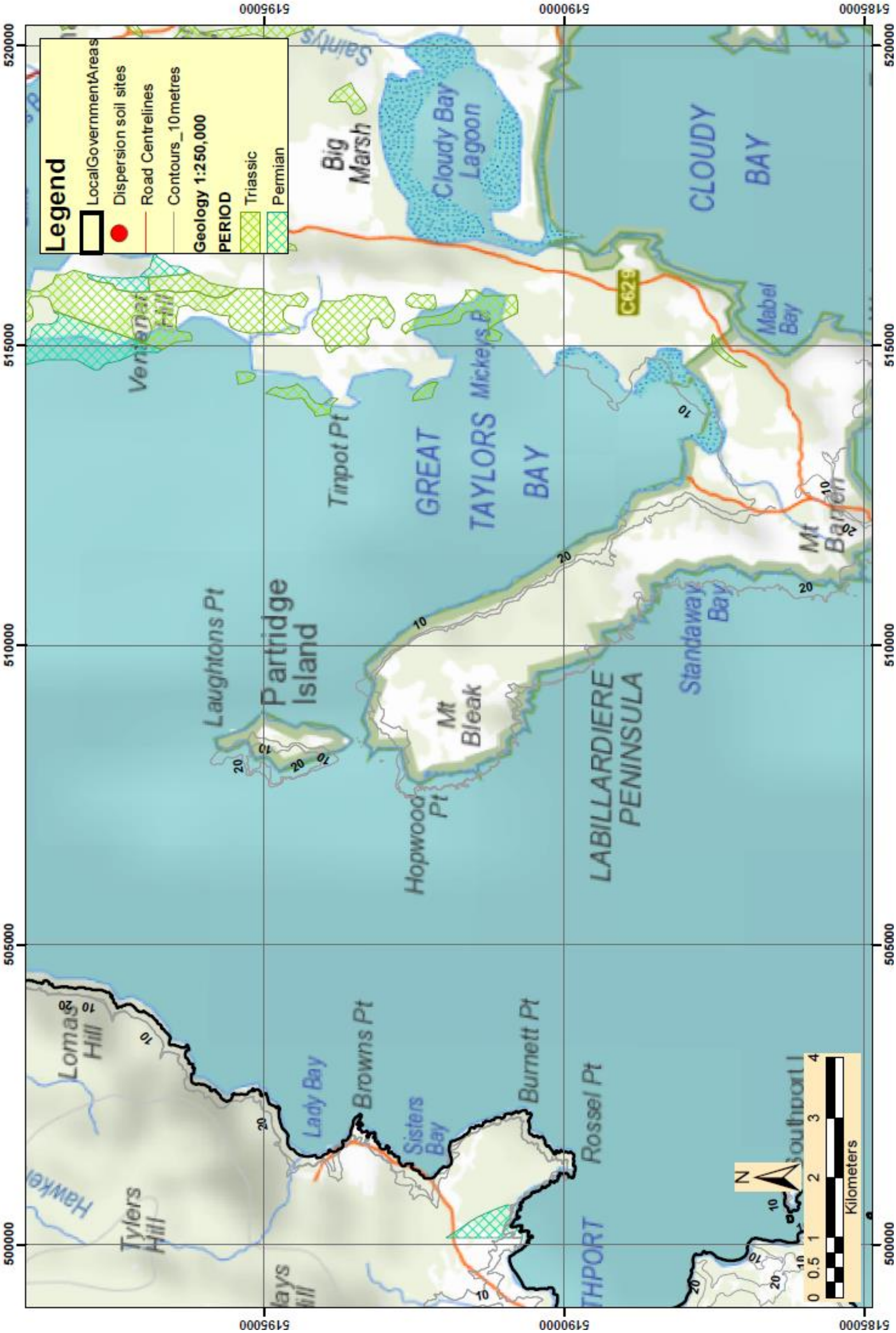


HVC Geology Map 8. Dispersion soil sampling

HVC Geology Map 9. Dispersion soil sampling



HVC Geology Map 10. Dispersion soil sampling



Attachment 2

(4 pages including this page)

Photographs of six of the 50 dispersion sample sites showing the full range of dispersion results

Photography: R. Mackintosh 11 – 13 January 2022
The staff in all photographs is one metre long.

The site numbers in the captions to the photographs correspond to the site numbers in Attachments 1 and 3.

The coloured numbered box at the top right of each photograph is the dispersion test result according to the following degrees of dispersion:

1	Emerson Class No. 1 (complete dispersion)
2	Emerson Class No. 2 (some dispersion)
3	Emerson Class No. 3 (slight dispersion)
4, 5, 6	Emerson Class No. 4, 5 or 6 (slight to no dispersion)
7, 8	Emerson Class No. 7 or 8 (no dispersion)

Other practitioners may adopt a different descriptive scale for the eight Emerson Nos.

Site D20 (above). Massive rippled-marked Permian-age sandstone. Poor topsoil development, silty clay where present. Sand 10%, silt 20%, clay 70%. Tested sample: Emerson Class No. 1 (complete dispersion).

Site D3 (below). Medium-grained white Triassic?-age sandstone weathered to a tan coloured sandy silt. Sand 30%, silt 70%. Tested sample: Emerson Class No. 2 (some dispersion).

Site D48 (above). Orange-white coloured Permian?-age siltstone weathered to a sandy silt. Silt 80%, sand 10%, clay 10%. Tested sample: Emerson Class No. 3 (slight dispersion).

Site D10 (below). Yellow-white coloured Permian-age siltstone weathered to a clayey silt. Clay 30%, silt 70%. Tested sample: Emerson Class No. 4, 5 or 6 (slight to no dispersion).

Site D36 (above). Permian-age feldspathic sandstone weathered to a light brown silty clay. Sand 10%, silt 20%, clay 70%. Tested sample: Emerson Class No. 7 or 8 (no dispersion).

Site D42 (below). Light-brown coloured Triassic-age siltstone weathered to a sandy silt. Silt 80%, sand 20%. Tested sample: Emerson Class No. 7 or 8 (no dispersion).

Attachment 3

(6 pages including this page)

Field notes with laboratory dispersion results, and photographs of laboratory results

Map and site numbers correspond to those in the Geology Maps in Attachment 1, and to the selected site photos in Attachment 2.

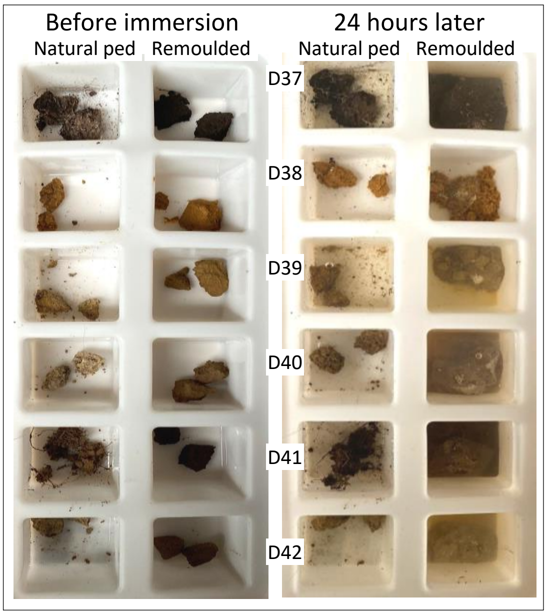
The dispersion test is a slightly modified version of the method described in Section E7 of AS/NZS1547:2012 *On-site domestic wastewater management*. In separate containers, duplicate peds of a soil sample (one ped air dried, the other remoulded) are immersed in water for 24 hours and their performance assessed. The behavior of the peds may be (a) nothing (b) slaking (c) dispersion to produce Emerson Class No. 1 – 8. Estimating the degree of dispersion of a sample to obtain its Emerson Class Number can be subjective. Note also that the test as described does not distinguish between Emerson Class 4, 5 and 6. The laboratory work for dispersion testing was done in the W. C. Cromer Pty. Ltd. laboratory. The laboratory is not NATA-registered for the test. For very useful information, go to http://www.lanfaxlabs.com.au/aggregate_stability.htm

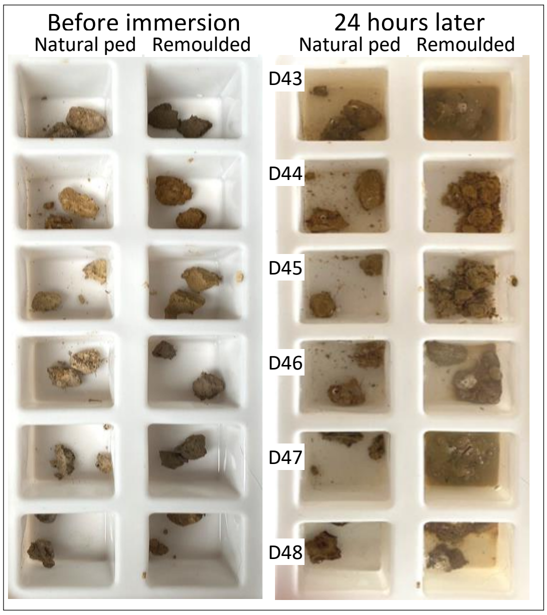
		GDA94				
Site	**Map**	**Easting**	**Northing**	**Bedrock Type**	**Sample description**	**Lab result (est. Emerson No.)**
D1	2	508477	5242693	Permian? sandstone	Silty sand with dolerite gravels to 100mm diameter present in soil profile. Silt 30%, sand 70%.	3
D2	2	511073	5246082	Permian sandstone	Bluish-grey fine-grained sandstone weathered to a light-grey silty sand.	8
D3	2	509702	5241584	Triassic? sandstone	Medium-grained white sandstone weathered to a tan coloured sandy silt. Sand 30%, silt 70%.	2
D4	2	513126	5242884	Triassic? sandstone	Massive medium-grained sandstone weathered to a light brown coloured silty clay. Silt 30%, clay 70%.	8
D5	2	516968	5244040	Triassic sandstone	White medium-grained sandstone weathered to a light brown coloured silty clay. Silt 30%, clay 70%.	7
D6	2, 4	516133	5237966	Permian sandstone	Dark brown coloured clayey silt, some 10mm angular cherty fragments present. Clay 40%, silt 60%	4, 5 or 6
D7	2	506014	5242933	Permian sandstone	Yellow-white coloured fine-grained sandstone weathered to a silty sand. Silt 40%, sand 60%.	3
D8	2	502166	5243080	Permian sandstone	Yellow-white coloured fine-grained sandstone weathered to a sandy silt. Silt 30%, sand 70%.	4, 5 or 6
D9	1	494437	5239951	Permian sandstone	Clean white sandstone weathering to a white silty sand. 10% clay, 20% silt, 70% sand.	4, 5 or 6
D10	1	495843	5241522	Permian siltstone	Yellow-white coloured siltstone weathered to a clayey silt. Clay 30%, silt 70%.	4, 5 or 6
D11	1	496319	5243129	Permian sandstone	Fine-grained tan coloured sandstone weathered to a light brown silty sand. Silt 40%, sand 60%.	4, 5 or 6
D12	1	493164	5240199	Permian sandstone	Fine-grained tan coloured sandstone weathered to a cream-yellow silty sand. Silt 40%, sand 60%.	4, 5 or 6
D13	1	481737	5245363	Permian sandstone	Fine-grained tan coloured sandstone weathered to a off-white silty sand. Silt 40%, sand 60%.	4, 5 or 6
D14	1	482570	5243756	Permian sandstone	Fine-grained white coloured sandstone weathered to a light tan silty sand. Silt 40%, sand 60%.	4, 5 or 6
D15	1	482474	5242196	Permian sandstone	Medium-grained buff coloured sandstone weathered to a light tan silty sand. Silt 40%, sand 60%.	4, 5 or 6
D16	1	485166	5239036	Permian sandstone	Feldspathic sandstone weathered to a light brown sandy silt. Sand 20%, silt 40%, clay 40%.	4, 5 or 6
D17	2	506512	5240100	Permian sandstone	Pebbly sandstone deeply weathered to a silty sand. Silt 30%, sand 60%, gravel 10%.	4, 5 or 6

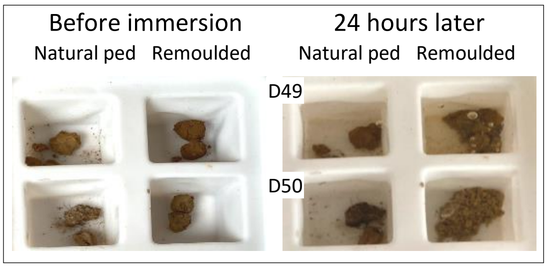
Site	Map	GDA94 Easting	GDA94 Northing	Bedrock Type	Sample description	Lab result (est. Emerson No.)
D18	2, 4	505329	5238043	Permian sandstone	Sandstone with sub-rounded pebbly dropstones, matrix weathered to a light grey silty sand. Silt 30%, sand 60%, gravel 10%.	4, 5 or 6
D19	4	504065	5237666	Permian sandstone	Intensely-weathered feldspathic sandstone. Sample taken of silty clay at bedrock-fluvial interface.	2
D20	4	506123	5236562	Permian sandstone	Massive rippled-marked sandstone. Poor topsoil development, silty clay where present. Sand 10%, silt 20%, clay 70%.	1
D21	4	504041	5233338	Permian sandstone	Pebbly feldspathic sandstone weathered to a clayey silt. Clay 20%, silt 60%, sand 10%, gravel 10%.	4, 5 or 6
D22	4	505384	5230773	Triassic sandstone	Massive white medium-grained sandstone weathered to a light brown coloured silty clay. Silt 30%, clay 70%.	3
D23	4	509503	5234176	Triassic sandstone	Fine-grained tan coloured sandstone weathered to a light brown silty clay. Silt 40%, sand 10%, clay 50%.	3
D24	4	502800	5227428	Permian sandstone	Intensely weathered sandstone, sampled a light grey silty sand. Silt 30%, sand 70%,	3
D25	5, 6	499934	5221875	Permian sandstone	Pebbly sandstone (narrow ~ 600mm thick pebble channel), deeply weathered to a silty sand. Silt 30%, sand 60%, gravel 10%.	2
D26	6	502585	5220100	Permian siltstone	Light grey siltstone weathered to a grey-white coloured sandy silt. Sand 30%, silt 60%, clay 10%.	4, 5 or 6
D27	6	504794	5220680	Permian sandstone	Fine-grained tan coloured sandstone weathered to a grey-white coloured sandy silt. Silt 30%, sand 70%	3
D28	6	508887	5216416	Permian sandstone	Moderately weathered sandstone, sampled a yellow-brown silty sand. Silt 30%, sand 70%,	3
D29	6	512725	5224501	Permian sandstone	Sandstone with sub-rounded pebbly dropstones, matrix weathered to a light grey silty sand. Silt 30%, sand 50%, gravel 20%.	3
D30	3, 4	500495	5231428	Triassic sandstone	Medium-grained buff coloured sandstone weathered to a light tan silty sand. Clay 10%, silt 10%, sand 80%.	3
D31	3, 5	496882	5226734	Permian sandstone	Medium-grained cream coloured sandstone weathered to a light tan coloured silty sand. Silt 40%, sand 60%.	4, 5 or 6
D32	5	496809	5224170	Permian siltstone	Medium-grained buff coloured sandstone weathered to a light tan coloured silty sand. Silt 40%, sand 60%.	3
D33	5	490192	5222115	Triassic sandstone	Massive feldspathic sandstone, silty clay where present. Sand 10%, silt 20%, clay 70%.	3
D34	5	488073	5222685	Triassic sandstone	Medium-grained cream coloured sandstone weathered to a light tan coloured silty sand. Silt 40%, sand 60%.	3

		GDA94				
Site	**Map**	**Easting**	**Northing**	**Bedrock Type**	**Sample description**	**Lab result (est. Emerson No.)**
D35	3, 5	487332	5226121	Triassic sandstone	Ferruginous cream coloured laminated sandstone weakly weathered to a light tan coloured silty sand. Silt 40%, sand 60%.	2
D36	3	484546	5233431	Permian sandstone	Feldspathic sandstone weathered to a light brown silty clay. Sand 10%, silt 20%, clay 70%.	7
D37	3	494894	5237982	Triassic? sandstone	Fine-grained cream coloured sandstone weathered to a light tan coloured silty sand. Silt 10%, sand 80%, gravel 10%.	3
D38	4	502157	5236217	Triassic sandstone	Medium-grained cream coloured sandstone weathered to a yellow-brown coloured silty sand. Silt 40%, sand 60%.	4, 5 or 6
D39	5	495766	5219569	Permian sandstone	Medium-grained light-brown coloured sandstone weathered to a orange-brown coloured silty sand. Silt 20%, sand 80%.	3
D40	5	498151	5215920	Permian siltstone	Orange-white coloured siltstone weathered to a silty sand. Silt 20%, sand 80%.	3
D41	6	499189	5213313	Triassic sandstone	Feldspathic sandstone weathered to an orange-brown sandy silt. Sand 30%, silt 50%, clay 20%.	4, 5 or 6
D42	6	502410	5212980	Triassic siltstone	Light-brown coloured siltstone weathered to a sandy silt. Silt 80%, sand 20%.	8
D43	8	506331	5206451	Triassic sandstone	Medium grained sandstone weathered to an orange-green coloured silty sand. Silt 30%, sand 70%.	3
D44	8	504291	5204097	Triassic sandstone	Medium grained sandstone weathered to an orange-green coloured silty sand. Silt 30%, sand 70%.	4, 5 or 6
D45	7	497649	5202391	Permian sandstone	Medium-grained light brown coloured sandstone very weakly weathered to a yellow-brown coloured silty sand. Silt 40%, sand 60%.	4, 5 or 6
D46	9	496497	5195225	Triassic siltstone	Greenish-yellow coloured siltstone weathered to a sandy silt. Silt 80%, sand 20%.	7
D47	9	497289	5190949	Permian siltstone	Orange-white coloured siltstone weathered to a sandy silt. Silt 80%, sand 10%, clay 10%.	3
D48	9	492238	5188915	Permian? siltstone	Orange-white coloured siltstone weathered to a sandy silt. Silt 80%, sand 10%, clay 10%.	3
D49	7, 8	499274	5211463	Triassic? sandstone	Medium grained sandstone weathered to an orange-green coloured silty sand. Silt 30%, sand 70%.	4, 5 or 6
D50	5	492257	5218990	Triassic sandstone	Medium grained sandstone weathered to an orange-white coloured silty sand. Silt 15%, sand 85%.	7


Before immersion
Natural ped Remoulded
24 hours later
Natural ped Remoulded
D1
D2
D3
D4
D5
D6
Before immersion
Natural ped Remoulded
24 hours later
Natural ped Remoulded
D7
D8
D9
D10
D11
D12
Before immersion
Natural ped Remoulded
24 hours later
Natural ped Remoulded
D13
D14
D15
D16
D17
D18
Before immersion
Natural ped Remoulded
24 hours later
Natural ped Remoulded
D19
D20
D21
D22
D23
D24
Before immersion
Natural ped Remoulded
24 hours later
Natural ped Remoulded
D25
D26
D27
D28
D29
D30
Before immersion
Natural ped Remoulded
24 hours later
Natural ped Remoulded
D31
D32
D33
D34
D35
D36


Before immersion
Natural ped
Remoulded
24 hours later
Natural ped
Remoulded
D37
D38
D39
D40
D41
D42


Before immersion
Natural ped
Remoulded
24 hours later
Natural ped
Remoulded
D43
D44
D45
D46
D47
D48


Before immersion
Natural ped
Remoulded
24 hours later
Natural ped
Remoulded
D49
D50