ABN 31 105 704 078
13 Brock Street, Thomastown
Victoria 3074
(P) +61 3 9464 4617
(F) +61 3 9464 4618
www.groundscience.com.au

COASTAL ACID SULFATE SOILS – PRELIMINARY HAZARD ASSESSMENT

LOGANS BEACH COASTAL AREA WARRNAMBOOL, VICTORIA

PREPARED FOR INSIGHT PLANNING CONSULTANTS PTY LTD

Report Reference: E2503.1

Date: 14 December 2016

ABN 31 105 704 078
13 Brock Street, Thomastown
Victoria 3074
(P) +61 3 9464 4617
(F) +61 3 9464 4618
www.groundscience.com.au

PROJECT DETAILS

Project Reference	E2503.1	Rev	AA
Project Title	Coastal Acid Sulfate Soils – Preliminary Hazard Assessment		
Project Location	Logans Beach Coastal Area, Warrnambool	State	VIC
Date	14 December 2016		

CLIENT DETAILS

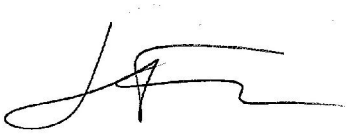
Prepared for (Client)	Insight Planning Consultants Pty Ltd		
Project Principal	Jason Black		
Client Address	PO Box 5381, Mordialloc	State	VIC

DISTRIBUTION

Original Held By	Ground Science Pty Ltd
One (1) Electronic Copy	Insight Planning Consultants Pty Ltd

This draft document presents the results of the above project and is detailed for the sole use of the intended recipient. Should you have any questions related to this report please do not hesitate to contact the undersigned.

PREPARED BY:



Jordan Fraser, MIEAust
Environmental Engineer

REVIEWED BY:

Tim Hodgson
Engineering Geologist

Ground Science

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1. INTRODUCTION

Ground Science Pty Ltd has prepared this report to present the findings of a preliminary coastal acid sulfate soils (CASS) hazard assessment undertaken for the Logans Beach coastal area in Warrnambool, Victoria (herein referred to as the 'Study Area').

Ground Science was engaged by Insight Planning Consultants Pty Ltd to conduct the assessment in general accordance with the Ground Science proposal GSPE2016126 AA, dated 29 August 2016.

2. BACKGROUND AND OBJECTIVES

Land within the Study Area is currently zoned a mix of Rural Living, Public Conservation and Recreation, as well as some areas of General Residential land use. Previous development has been guided by the Logans Beach Local Plan 2008, which has detailed minimum lot and subdivision sizes, and has been succeeded by larger development strategies for the Council area.

It is anticipated that development pressure within the Study Area will increase following recent rezoning in the adjacent Coastal / Hopkins River Environment growth area and extension of local utility infrastructure. Several key influences on future development within the Study Area have been identified, including CASS, which is known to exist within the municipality.

In order to guide future planning and development decisions within the Study Area, Council have requested a Strategic Framework Plan be prepared in line with the issues, considerations, and expected outputs detailed within the Project Brief. Ground Science has been requested to undertake a preliminary assessment to identify any areas susceptible to CASS and to provide recommendations regarding potential management options.

3. SCOPE OF WORK

The scope of work undertaken as part of the preliminary hazard assessment included the following:

- A desktop review of the Study Area including local and regional topographic, geological and hydrogeological information, Victorian CASS risk area maps, and potential geomorphic indicators to assess whether the Study Area contains potential risk areas;
- A field inspection to determine whether any soil and/or water indicators of CASS are present within the Study Area; and
- Review of background information as well as likely and potential development opportunities to assess whether high risk activities are expected to occur.

4. POLICY FRAMEWORK

The strategies and policy documents considered for the overall Strategic Framework Plan have been detailed in the Project Brief.

The primary guideline adopted for the assessment of potential CASS risk is the Department of Sustainability and Environment (DSE) *Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils* (2010). The guidelines implement the actions and objectives of the *Victorian Coastal Acid Sulfate Soils Strategy 2009* and were produced to assist landowners, developers, planners and relevant authorities to make decisions about the assessment and management of CASS. CASS risk identification and assessment procedures are detailed within the DSE 2010 guidelines, with a copy of the process diagram presented in Appendix A.

Where acid sulfate soil is to be disturbed and managed for disposal and/or reuse, the Victorian Government *Industrial Waste Management Policy (Waste Acid Sulfate Soils)* (1999), and the Victorian EPA *Information Bulletin 655.1 – Acid Sulfate Soil and Rock* (2009) must also be consulted.

5. COASTAL ACID SULPHATE SOILS

Acid sulfate soils, which include CASS, occur naturally in coastal and inland settings. These soils generally contain metal sulfide minerals, which can react with oxygen to form sulfuric acid if drained and exposed to air. If left undisturbed, CASS are generally inert and do not present great risk. However, once disturbed, CASS are likely to result in acid production unless suitably managed.

CASS disturbance can have associated environmental, health, engineering, social and economic impacts. These impacts can be mitigated through the implementation of appropriate management procedures, which must be considered prior to any intrusive works.

6. STUDY AREA DETAILS

The Northern FIA is located east of central Warrnambool and is surrounded by the Hopkins River to the north west and west, the Coastal / Hopkins Environmental Growth Area to the north east and east, and Warrnambool Bay to the south.

The Study Area is shown in Figure 1, with further details provided in Table 1.

Table 1: Summary of Study Area Details

Municipality	Warrnambool City Council
Approximate area	100 hectare
Planning Zones	Rural Living Zone (RLZ) General Residential Zone (GRZ1) Public Conservation and Resource Zone (PCRZ) Public Park and Recreation Zone (PPRZ)
Planning Overlays	Design and Development Overlay (DDO2) Environmental Significance Overlay (ESO1/2) Significant Landscape Overlay (SLO1) Heritage Overlay (HO347) Areas of Aboriginal Cultural Heritage Sensitivity

6.1 CURRENT STUDY AREA CONDITIONS

The Study Area predominantly consists of residential and ecological land use, with a greater density of residential properties north of Hopkins Point Rd. Significant features within the Study Area include Blue Hole Reserve at the Hopkins River mouth and the Logan Beach whale watching platform in the south east area.

6.2 POTENTIAL FOR DEVELOPMENT

No specific development outline has been prepared at this stage. Information presented during the Framework Plan project indicated that potential for residential redevelopment within the low density residential/agricultural land in the central and eastern areas exists. Residential land to the north of Hopkins Point Rd and Serendipity Drv is understood to exist within a Body Corporate management structure and is unlikely to be proposed for development in the short-term.

High risk activities (activities which may disturb or generate CASS) associated with the potential development may include excavation of soil/sediment (>1000m^3) and filling land or stockpiling soil over in-situ CASS during residential development and/or construction of roads and utilities.

Based on the likely land use, significant extraction of groundwater, production of crops with the potential to lower water tables, and coastal or inshore dredging are not considered potential high risk activities.

7. ENVIRONMENTAL SETTING

7.1 CLIMATE

Average monthly and annual rainfall data was obtained from the Australian Bureau of Meteorology (BoM) Warrnambool Airport Ndb Climate Station. The mean annual rainfall from this station is 719mm per year, with significantly higher rainfall events in winter months. No nearby climate stations reported monthly evaporation data, however representative evaporation is likely to exceed rainfall based on landform and exposure.

7.2 GEOLOGY

The Geological Survey of Victoria map *Port Campbell Embayment* (1994) indicates the overall Hopkins Point and Logan Beach landform is generally comprised of Quaternary Period, Pleistocene Epoch coastal dune deposits. Due to its age (>10,000 years old) and calcareous nature, this soil is seen to have a low potential to be classified as CASS and generate significant volumes of acid.

The sedimentary unit may be overlain by areas of Newer Volcanics tuff in the central and northern Study Area, and coastal dune and beach sands along the southern boundary. Recent Quaternary aged sediments may present a greater risk of producing metal sulfides leading to CASS development. Additionally, the current coastal dunes may overlie historical geomorphological features (lagoons or marshes) formed by coastal and marine processes.

7.2.1 SOILS

Agriculture Victoria describes the soils derived along coastal plains landforms as deep sandy soils with grey sandy loam topsoil. The physical structure is noted as being dependent mainly on the organic matter content of this soil and may deteriorate under cultivation. The soil is generally moderately acid with pH (water) ranging from 5.5 to 6.

7.3 HYDROGEOLOGY

The Department of Natural Resources and Environment (DNRE) Victorian Groundwater Beneficial Map Series indicates the major hydrogeological unit is expected to be the Upper Tertiary aquifer system within the Port Campbell Limestone Formation, representative of Segment B quality groundwater (1,000-3,500mg/L total dissolved solids [TDS]). The State Environmental Protection Policy (SEPP) *(Groundwaters of Victoria)* (1997) requires the protection of the following beneficial uses of groundwater for Segment B quality:

- Maintenance of ecosystems;
- Primary contact recreation;
- Potable mineral water supply;
- Irrigation (agriculture) and stock watering;
- Industrial water use; and
- Protection of buildings and structures.

The Visualising Victoria's Groundwater (VVG) website maintains a database of groundwater bores registered by the Department of Primary Industries (DPI) across Victoria. A search of the database identified 23 registered bores within the Study Area, generally completed for domestic/stock use or groundwater observation purposes.

Bores were generally installed with screened intervals at depths between 5-35 metres below grade (mbg) in sandstone and deeper limestone units. The depths to groundwater are expected to be influenced by topography

within the Study Area but no indications of extremely shallow groundwater with direct surface water recharge were reported.

7.3.1 HYDROLOGY

The Study Area is surrounded by Hopkins River to the north west and west, and Warrnambool Bay to the south. Surface water and stormwater system drainage is expected to be discharged into Hopkins River, however no local streams or surface water features (including wetlands and swamps) were identified within the Study Area.

7.4 TOPOGRAPHY

Topography within the Study Area has been historically modified by coastal dune deposition and erosion processes. The landform north of Hopkins Point Rd consists of a steep rise from the south and west (Hopkins River) to elevations between 30-40m Australian Height Datum (AHD). Land within the Study Area south of Hopkins Point Rd is undulating and predominantly characterised by the low-lying area that follows Logans Point Rd east to west, as well as the raised dunes along the eastern boundary of the Study Area (coastal buffer zone).

Areas considered at risk of potential CASS based on topography are those below 10m AHD, which are present within the low-lying area in the central Study Area and along the coastal reserve and Hopkins River frontage. A representation of the Study Area topography is presented in Figure 2.

7.5 VEGETATION

Vegetation throughout most of the Study Area has been historically cleared for residential or grazing purposes. Vegetation along the coastal reserve and Hopkins River frontage in the west of the Study Area has been described with the Biosis Research *Warrnambool Coast Vegetation Management Plan* (2012) as generally consisting of native Coastal Dune Scrub and Coastal Dune Grassland.

7.6 CASS MAPPING

Mapping land with potential or likely CASS occurrence is generally based on topography and soil type information.

The DPI *Coastal Acid Sulfate Soil Hazard Map – Mortlake T7421* (2002) indicates areas of probable acid sulfate soils exist within the central Study Area and within the Hopkins River system (areas exposed during low-flow). The Victorian Resources Online *Coastal Acid Sulfate Soils Distribution – Map 1 for Far South-West Coast of Victoria* produced in 2010 does not identify these areas as prospective CASS occurrences, however the large scale of the map is noted.

The Australian Soil Resource Information System (ASRIS) online mapping database details acid sulfate soil probability zones utilising publicly available information. The database details a high probability of occurrence (with low confidence) for land within the eastern side of the Hopkins River system and within the coastal dune formations along the south of the Study Area. The low-lying zone within the central Study Area is detailed as having a low probability of acid sulfate soil occurrence (also with low confidence).

The above risk mapping sets reviewed are presented in Appendix B.

8. STUDY AREA INSPECTION

A walkover and field inspection of the Study Area was undertaken by Ground Science personnel on 15 November 2016 to assess desktop findings and identify any CASS indicators. Details included:

- Land use within the Study Area predominantly consisted of low-medium density residential and some low-intensity agriculture (grazing);
- Study Area topography was observed to be representative of desktop findings, with elevated land north of Hopkins Point Rd, a low-lying depression following the northern side of Logans Beach Rd, and raised coastal dunes along the southern boundary;
- Zones within the eastern side of the Hopkins River system identified by CASS risk mapping were predominantly observed to be below the water level and are expected to be exposed during periods of low flow only – unlikely to be within potential development areas for future growth;
- Estuarine vegetation within a low-lying area adjacent to the Hopkins Point Rd bridge within the Study Area was identified (refer to Photos 1 and 2);
- The low-lying zone along the northern side of Logans Beach Rd identified by CASS risk mapping was not generally characterised by swamp or estuarine features. However, it was noted to be a floodplain and an area of surface water ponding was observed (refer to Photo 7);
- Coastal dunes were observed along the southern boundary of the Study Area within the coastal buffer zone. Vegetation was mainly comprised of dune scrub and grasses. Some residential development has already occurred along the northern side of the dunes, which included excavation into dune sediments;
- No significant physical indicators of CASS (swamps, scalded/bare surfaces, staining within soil/sediments, etc.) were observed throughout the Study Area.

Study Area photographs are presented in Appendix C.

8.1 PRELIMINARY FIELD SAMPLING

Several soil and surface water samples were collected for preliminary analysis of potential CASS indicators. Results of sample analysis are detailed in Table 2, with sampling locations presented in Figure 3 and borehole logs detailed in Appendix D.

Table 2: Sample Analysis Summary

Sample no.	Location	Description	pH
BH1/1	Eastern end of Logans Beach Rd – 0.2mbg	Damp, black clayey silt, trace organics	6.7
BH1/2	Eastern end of Logans Beach Rd – 0.9mbg	Moist, white gravelly sand, weathered rock	8.8
BH2/1	Western end of Logans Beach Rd – 0.2mbg	Damp, light brown silty sand	8.7
BH2/2	Western end of Logans Beach Rd – 0.35mbg	Damp, light brown silty sand	8.9
BH3/1	Estuarine area – 0.9m depth	Saturated grey/black sand, organic odour	8.5
SW-1	Hopkins River – north of stormwater outlet	Clear surface water with some sediment	6.8
SW-2	Hopkins River – south of stormwater outlet	Clear surface water with some sediment	6.7

Note that not all conditions/features within the Study Area were assessed based on access limitations.

9. PRELIMINARY CASS ASSESSMENT FINDINGS

A summary of the findings of the preliminary hazard assessment for the Study Area is detailed in Table 3.

Table 3: CASS Hazard Assessment Summary

Indicator		Comments	Risk
High risk activities		Some potential for bulk excavation and/or filling of soils over in-situ CASS (if present)	Potential high risk activities may occur
Previously identified CASS		No previous CASS assessment reports were available	No associated risk
CASS risk area mapping		Risk areas identified in the Hopkins River System and within the central Study Area	Potential risk *(variable risk levels on different maps)*
Geomorphology	Recent geological sediments	Recent (Holocene) and Pleistocene sediments within the Study Area	Potential risk
	Land elevations <10m AHD	Low-lying areas in the central Study Area and along coastal/estuarine zones	Potential risk
	Current tidal lakes and sediments	None identified within the potential development area	No associated risk
	Coastal landforms	Coastal sand dunes along the southern boundary and waterlogged area observed north of Logans Beach Rd	Potential risk
	Vegetation indicators	Estuarine/marine vegetation observed south of the Hopkins Point Rd bridge – likely to be outside the development area	Potential risk
Soil and water field indicators		No low pH or visual indicators. Some sulphurous odour within deeper estuarine sediments	Potential risk

The conditions observed within the Study Area demonstrate an overall low potential CASS risk. However, based on this preliminary hazard assessment in line with the DSE risk assessment process, any area identified with a potential to present a CASS risk must be considered.

Three primary potential risk areas have been outlined in Figure 3, which include:

- Low-lying land generally following the alignment of Logans Beach Rd in the central Study Area;
- Costal dune formations along the southern boundary of the Study Area; and
- Estuarine area south of the Hopkins Point Rd bridge.

10. MANAGEMENT RECOMMENDATIONS

In order to further assess Study Area and soil conditions and determine the actual CASS risk within the Study Area, a detailed soil site assessment should be undertaken. The assessment may include soil sampling and laboratory analysis based on the size of the potential risk areas and would provide more accurate baseline soil conditions with consideration of CASS risk.

Alternatively, requirements for further assessment may be based on the potential occurrence of high risk activities. Planning approval processes may consider this preliminary hazard assessment and request detailed assessments for any development with the potential for the following high risk activities within the identified risk areas:

- Excavation of soil or sediment volumes >1,000m3 (i.e. major utilities, basement excavations);
- Extracting or lowering groundwater (i.e. dewatering for pools/basements);
- Filling land or stockpiling soil volumes >100m3 with an average depth of 0.5m over in-situ potential acid sulfate soils (i.e. temporary storage or permanent placement);
- Planting vegetation that may potentially lower the water table (i.e. significant crops or plantations); and
- Coastal or inland dredging (i.e. modifications to Hopkins River).

Detailed soil assessments should be undertaken by suitably qualified personnel and may include detailed field testing and analysis programs.

11. LIMITATIONS

Ground Science has prepared this document in accordance with the scope of works and for the purpose outlined in the accepted proposal (GSPE2016095 AC, dated 16 May 2016) and this report.

The advice given in this report is based on the assumption that the conditions are representative of the overall Study Area. However, it should be noted that actual conditions might differ from those assumed. If detailed sampling reveals environmental conditions significantly different from those assumed, Ground Science must be consulted.

It is recognised that the passage of time affects the information and assessment provided in this document. Ground Science's assessment is based on information that existed at the time of the preparation of this document. It is understood that the services provided allowed Ground Science to form no more than an opinion of the actual Study Area conditions observed and cannot be used to assess the effects of any subsequent changes in the quality of the Study Area, or its surroundings, or any laws or regulations.

Any drawings or figures presented in this report should be considered only as pictorial evidence of our work. Therefore, unless otherwise stated, any dimensions should not be used for accurate calculations or dimensioning.

12. REFERENCES

- Australian Soil Resource Information System (ASRIS) online mapping database, accessed from http://www.asris.csiro.au/#
- Biosis Research *Warrnambool Coast Vegetation Management Plan* (2012)
- Bureau of Meteorology (BoM) *Warrnambool Airport Ndb Climate Station* (accessed from http://www.bom.gov.au/)
- Department of Environment, Land Water and Planning *Landata online databases* (accessed from https://www.landata.vic.gov.au/)
- Department of Environment and Primary Industries (DEPI) Victorian Water Resources online (accessed from http://www.depi.vic.gov.au/forestry-and-land-use/forest-management/maps/interactive-maps)
- Department of Natural Resources and Environment (DNRE) Victorian Groundwater Beneficial Map Series *South Western Victoria Regional Aquifer Systems* (1995)
- Department of Sustainability and Environment (DSE) *Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils* (2010)
- DSE *Victorian Coastal Acid Sulfate Soils Strategy 2009*
- Federation University Australia *Visualising Victoria's Groundwater (VVG)* – accessed http://www.vvg.org.au/ (2016)
- Geological Survey of Victoria, *Port Campbell Embayment* map sheet – scale 1:100,000)
- SEPP *(Groundwaters of Victoria)* (1997)
- Victorian Department of Primary Industries (DPI) *Coastal Acid Sulfate Soils Distribution - Map 1 Far South West Coast of Victoria* (2010)
- Victorian DPI *Coastal Acid Sulfate Soil Hazard Map – Mortlake T7421* (2002)
- Victorian EPA *Information Bulletin 655.1 – Acid Sulfate Soil and Rock* (2009)
- Victorian Government *Industrial Waste Management Policy (Waste Acid Sulfate Soils)* (1999)
- Warrnambool City Council *Logans Beach Strategic Framework Plan Project Brief* (2016)

FIGURES

LOGANS BEACH COASTAL AREA
WARRNAMBOOL

STUDY AREA

FIGURE 1

LEGEND

SITE BOUNDARY

JOB NO: E2503
DATE: 7 DEC 2016
DRAWN: JF
SCALE: NOT TO SCALE

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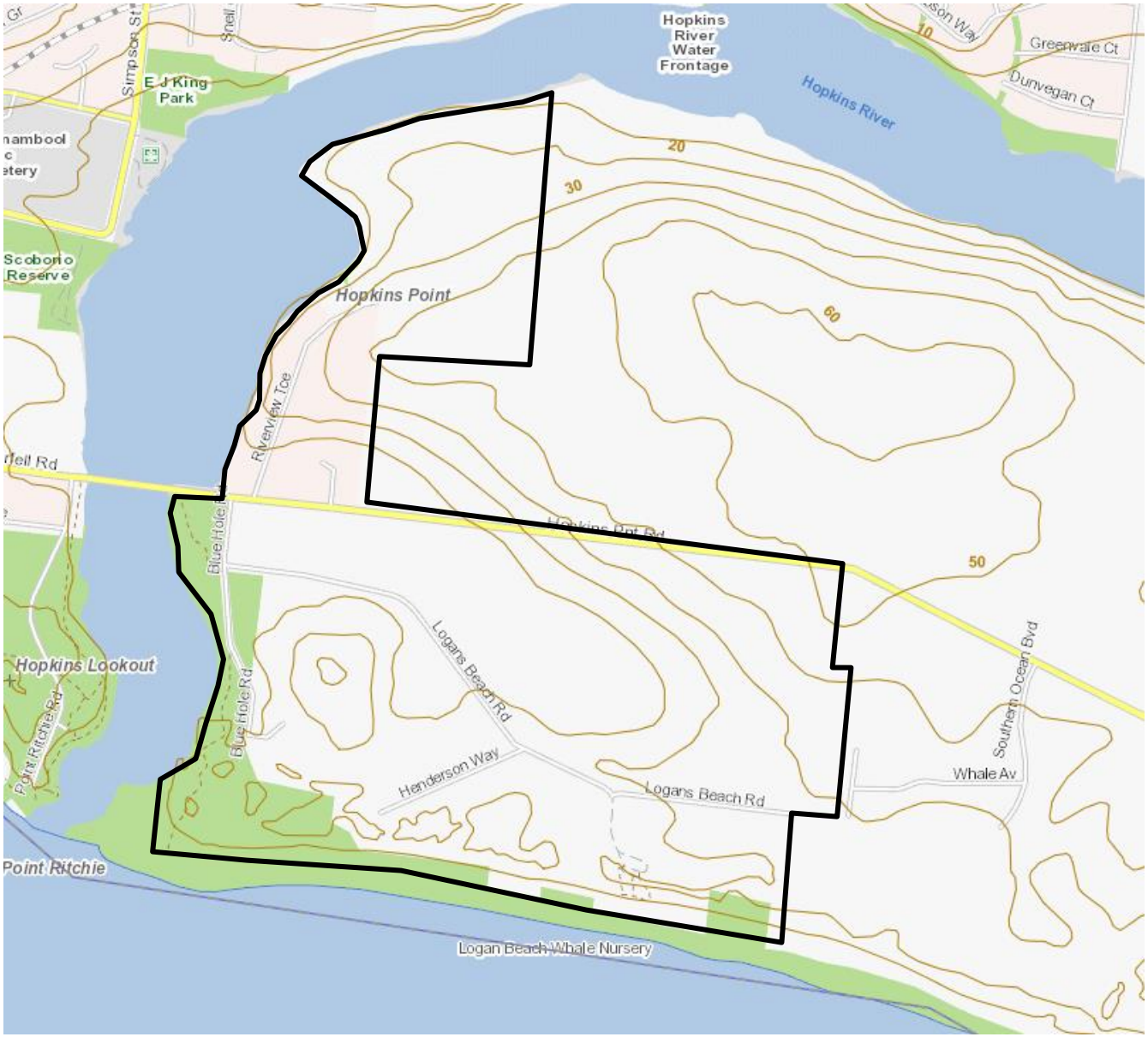
LOGANS BEACH COASTAL AREA
WARRNAMBOOL

STUDY AREA TOPOGRPAHY

FIGURE 2



LEGEND

- APPROXIMATE STUDY AREA
- 60 TOPOGRAPHIC CONTOUR (10m)

JOB NO: E2503
DATE: 7 DEC 2016
DRAWN: JF
SCALE: NOT TO SCALE

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LOGANS BEACH COASTAL AREA
WARRNAMBOOL

STUDY AREA
PRELIMINARY CASS RISK

FIGURE 3

LEGEND

- SITE BOUNDARY
- BOREHOLE LOCATION
- SURFACE WATER SAMPLE LOCATION

CASS RISK AREAS

- LOW LYING, FLOOD-PRONE ZONE
- COASTAL DUNES
- ESTUARINE AREA WITH SOIL INDICATORS

JOB NO: E2503
DATE: 7 DEC 2016
DRAWN: JF
SCALE: NOT TO SCALE

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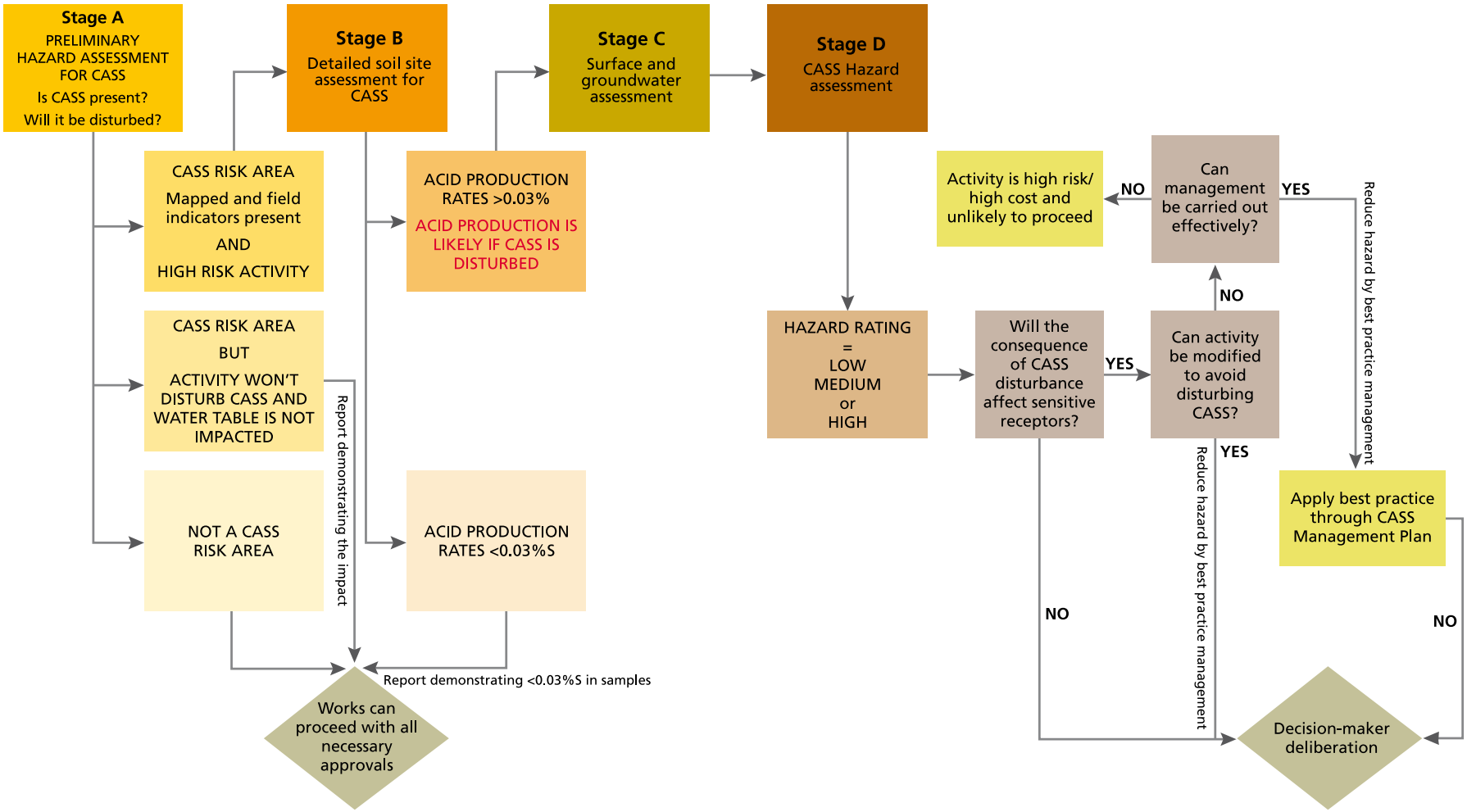
APPENDIX A – CASS RISK IDENTIFICATION PROCESS

Figure 1: Flow diagram for the Victorian Coastal Acid Sulfate Coils (CASS) risk identification process



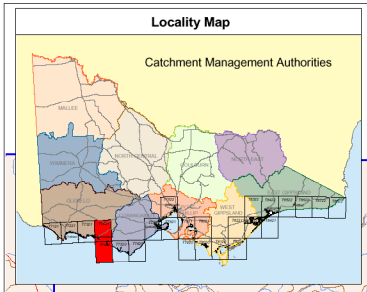
This document is a guide for how to implement each phase of the CASS risk identification process.

APPENDIX B – CASS RISK MAPPING

Coastal Acid Sulfate Soil Hazard

Mortlake T7421 Port Campbell T7420

Universal Transverse Mercator Zone 54



GLENELG CMA

T7321

T7521

T7420

Mortlake
Tullorus
Glenormiston North
Glenormiston
Glenormiston South
Noorat
Terang
Dixie
Tarrion
Mumblin
Elliersie
Ballangeich North
Framlingham East
The Sisters
Ballangeich
Framlingham
Purnim
Grassmere
Purnim West
Grassmere Junction
Rushfield
Wangoom
Panmure
Cudgee
Garvoc
Laang
Allansford
Allans Forest
Nanngat
Naringal East
Mepunga West
Mepunga East
Ayrford
Eckin South
Glenfyne
Nullawarre
Nirranda East
Brucknell
Timboon
Springvale
Nirranda
Timboon West
Nirranda South
Cobden
Lower Heytesbury
Newfield
Port Campbell
41
40

ACID SULFATE SOIL

- No acid sulfate soils

Shallower than 1 m

- Low acid sulfate soils
- Moderate acid sulfate soils
- High acid sulfate soils

Deeper than 1 m

- Low acid sulfate soils
- Moderate acid sulfate soils
- High acid sulfate soils

Estimated extent of probable acid sulfate soils

LEGEND

- Freeway
- Major roads
- Watercourses
- Contours
- Waterbodies
- Public land
- 1:100 000 map tile
- Catchment management authority boundaries

Local government areas

- COLAC OTWAY
- CORANGAMITE
- GLENELG
- MOYNE
- GOLDEN PLAINS
- SURF COAST
- WARRNAMBOOL

Information on acid sulfate soils

The information for the acid sulfate soil mapping is comprised of two separate sources:
1) The estimate of the extent that acid sulfate soil (either potential acid sulfate soil or actual sulfate soil) is most likely to occur.
This is a calculated approximation and due to the scale of the mapping there may be areas outside the estimated regions that also have acid sulfate soils.
2) The site information has been analysed for the presence of oxidsable sulfur. These sites indicate only that point at which it is marked and may not truly represent the entire area in which it is located.

FOR MORE INFORMATION
SEE THE ASSOCIATED
Guidelines for the Use of Coastal Acid Sulfate Soil Hazard Maps for Victoria

N

1:100 000

0 1 2 3 4 5

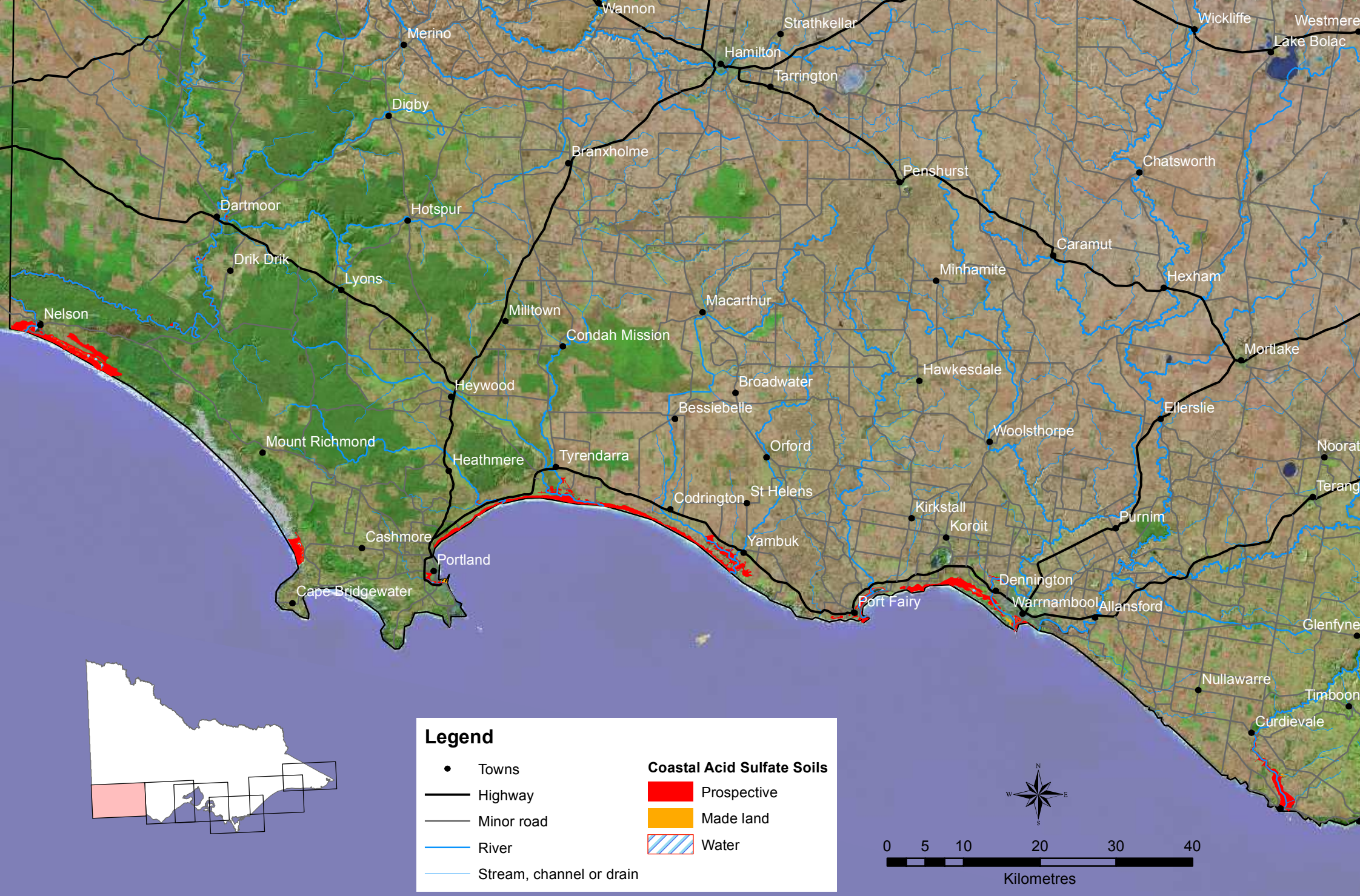
Kilometres

Base data such as roads, rivers, public land (1:100 000) towns, CMA boundaries and irrigation areas (1:250 000) are sourced from the NRE Corporate Geospatial Data Library.

This map may be of assistance to you but the State of Victoria and its employees do not guarantee that the map is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this map.

Department of Primary Industries - Bendigo
Centre for Land Protection Research
Cnr Midland Hwy & Taylor St,
Epsom Victoria 3551
(PO Box 3100 Bendigo Delivery Centre 3554)
Ph: (03) 54 304444
Fax: (03) 54 304304
email: clpr@nre.vic.gov.au

Victoria
The Place To Be

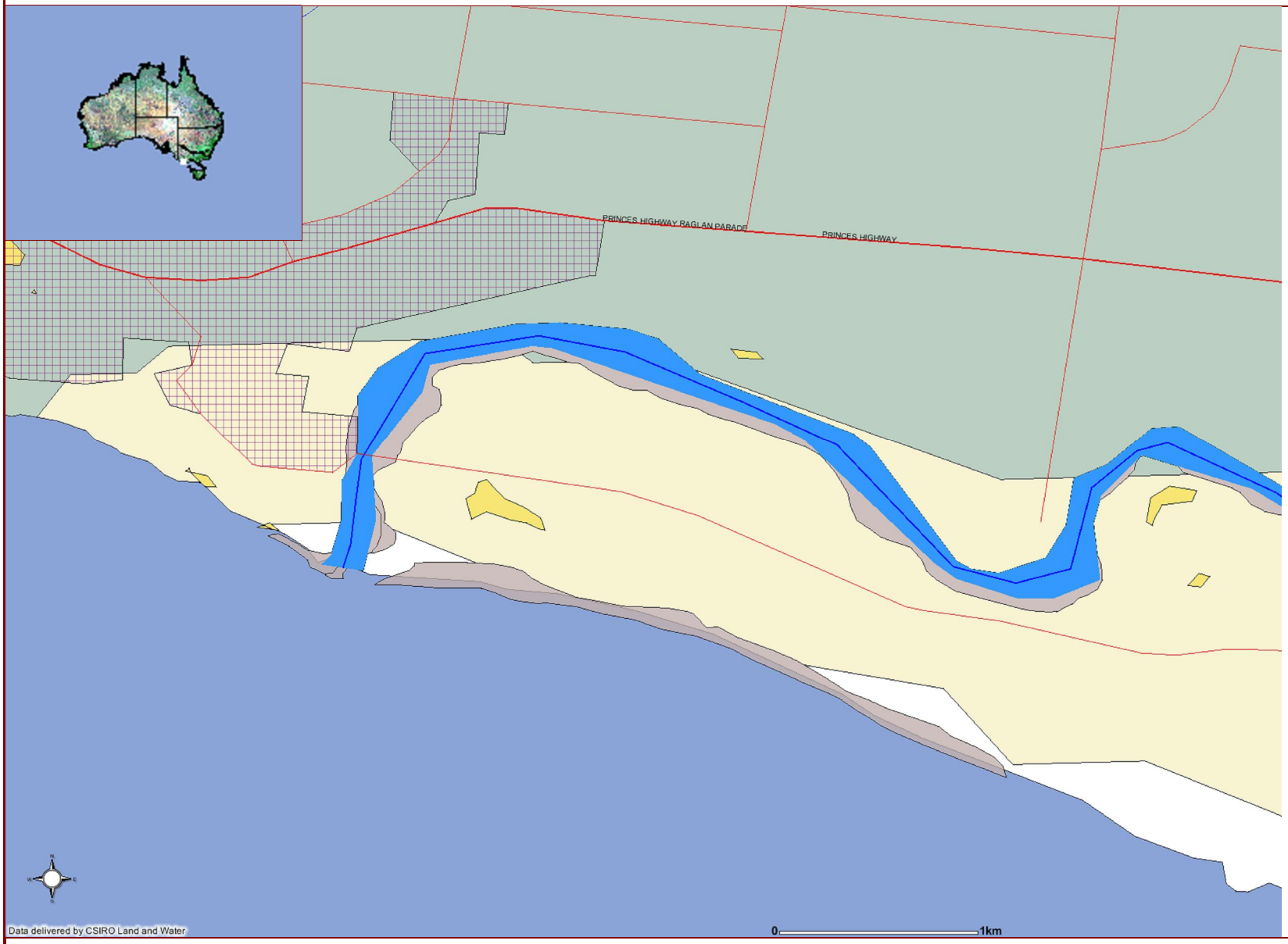


Coastal Acid Sulfate Soils Distribution - Map 1 for Far South-West Coast of Victoria

Victorian Resources Online
www.dpi.vic.gov.au/vro

State Government Victoria

ASRIS



Locations
Roads (1:250K)
Highway
Other Roads
Streams
Major
Minor
Builtup Areas
Inland Water Bodies
ASS Reference Sites
National ASS Atlas
A1 High Probability/High Confidence
A2 High Probability/Moderate Confidence
A3 High Probability/Low Confidence
A4 High Probability/Very Low Confidence
A- High Probability/Confidence Unknown
B1 Low Probability/High Confidence
B2 Low Probability/Moderate Confidence
B3 Low Probability/Low Confidence
B4 Low Probability/Very Low Confidence
B- Low Probability/Confidence Unknown
C1 Extremely Low Probability/High Confidence
C2 Extremely Low Probability/Moderate Confidence
C3 Extremely Low Probability/Low Confidence
C4 Extremely Low Probability/Very Low Confidence
C- Extremely Low Probability/Confidence Unknown
Base-Map

Ground Science 6 Dec 2016

APPENDIX C – STUDY AREA PHOTOGRAPHS

Hopkins River estuary discharge to Warrnambool Bay – facing south

Low tide level in Hopkins River north of the Hopkins Point Rd bridge with exposed sediment

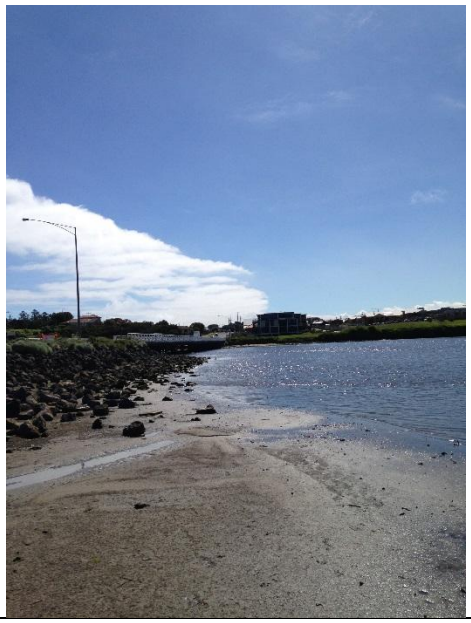
Coastal dune formations along the south of the Study Area – facing west

Landform and existing development north of the coastal dunes in the eastern Study Area

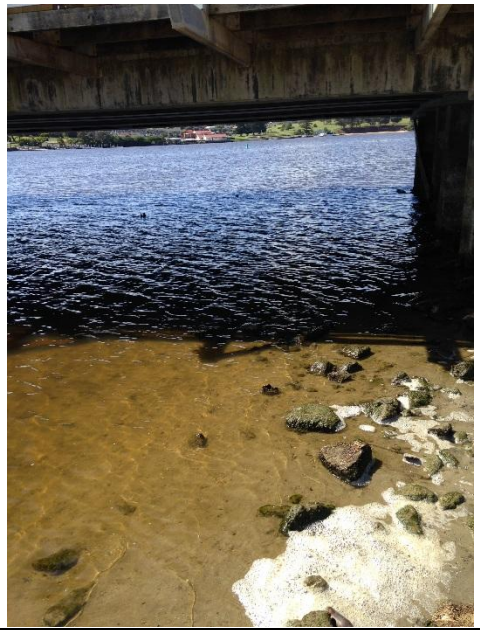
Landform and existing development north of Logans Beach Rd in the central Study Area

Coastal dune vegetation with hill to raised north Study Area shown in background

Surface water ponding within the flood-prone area in the central Study Area – facing north from Logans Beach Rd



Surface water conditions as sampling location SW-1



Surface water conditions as sampling location SW-2

Soil conditions within an exposed drainage outlet – eastern Study Area

Stormwater north of the Hopkins Point Rd bridge

APPENDIX D – BOREHOLE LOGS

BOREHOLE LOG

BOREHOLE No: BH1

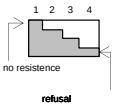
JOB No : E2503

GroundScience

CLIENT:	INSIGHT PLANNING	**TEST DATE:**	15-Nov-16
PROJECT:	LOGANS BEACH	**LOGGED BY:**	DD
LOCATION:	WARRNAMBOOL	**CHECKED BY:**	JF
TEST LOCATION:	REFER TO FIGURE 1		
DRILL METHOD:	HAND AUGER	**EASTING:**	
HOLE DIAMETER:	100mm	**NORTHING:**	
INCLINATION:	90°		
SURFACE RL:	ND		

DRILLING				SAMPLING		FIELD MATERIAL DESCRIPTION						
PENETRATION RESISTANCE 1 2 3 4	WATER	DEPTH (metres)	DEPTH (RL)	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL / ROCK MATERIAL DESCRIPTION	CONSISTENCY DENSITY	MOISTURE	PID (ppm)	CONTAMINATION RANKING	ADDITIONAL OBSERVATIONS
		0.0					SM	silty SAND, low plasticity, Black	S	Dp			TOPSOIL
			0.05				ML	clayey SILT, low plasticity, Black		Dp - M			with trace organics
				BH1/1	E						0	0	
			0.40				CL	sandy CLAY, low plasticity, Dark brown	F				
		0.5	0.50				SM	gravelly SAND, low plasticity, White	S				Weathered Rock
			0.60				CL	sandy CLAY, low plasticity, Brown	F	M			
			0.70				SM	gravelly SAND, low plasticity, White	S				Weathered Rock
				BH1/2	E						0	0	
			0.90					Borehole Terminated @ 0.9m					
		1.0											
		1.5											
		2.0											
		2.5											
		3.0											
		3.5											

PENETRATION



CONSISTENCY	
Vs	very soft
S	soft
St	stiff
VSt	very stiff
H	hard

DENSITY	
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense

MOISTURE	
D	dry
Dp	damp
M	moist
W	wet
S	saturated

TEST NOTES	
U50	undisturbed sample 50mm dia
U63	undisturbed sample 63mm dia
D	disturbed sample
Bs	bulk sample
E	environmental sample

WATER

BOREHOLE LOG

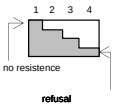
BOREHOLE No: BH2

JOB No : E2503

CLIENT:	INSIGHT PLANNING	**TEST DATE:**	15-Nov-16
PROJECT:	LOGANS BEACH	**LOGGED BY:**	DD
LOCATION:	WARRNAMBOOL	**CHECKED BY:**	JF
TEST LOCATION:	REFER TO FIGURE 1		
DRILL METHOD:	HAND AUGER	**EASTING:**	
HOLE DIAMETER:	100mm	**NORTHING:**	
INCLINATION:	90°		
SURFACE RL:	ND		

DRILLING			SAMPLING		FIELD MATERIAL DESCRIPTION						
PENETRATION RESISTANCE 1 2 3 4	WATER	DEPTH (metres) / DEPTH (RL)	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG / USC SYMBOL	SOIL / ROCK MATERIAL DESCRIPTION	CONSISTENCY DENSITY	MOISTURE	PID (ppm)	CONTAMINATION RANKING	ADDITIONAL OBSERVATIONS
		0.0			ML	sandy SILT, low plasticity, Dark Brown	S	Dp			
		0.10	BH2/1	E	SM	silty SAND, low plasticity, Light Brown			0	0	Weathered Rock
			BH2/2	E					0	0	
		0.35				Borehole Refusal on Rock @ 0.35m					
		0.5									
		1.0									
		1.5									
		2.0									
		2.5									
		3.0									
		3.5									

PENETRATION



CONSISTENCY	
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S	soft
St	stiff
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L	loose
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D	dense

MOISTURE	
D	dry
Dp	damp
M	moist
W	wet
S	saturated

TEST NOTES	
U50	undisturbed sample 50mm dia
U63	undisturbed sample 63mm dia
D	disturbed sample
Bs	bulk sample
E	environmental sample

WATER

BOREHOLE LOG

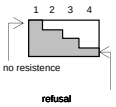
BOREHOLE No: BH3

JOB No : E2503

CLIENT:	INSIGHT PLANNING	**TEST DATE:**	15-Nov-16
PROJECT:	LOGANS BEACH	**LOGGED BY:**	DD
LOCATION:	WARRNAMBOOL	**CHECKED BY:**	JF
TEST LOCATION:	REFER TO FIGURE 1		
DRILL METHOD:	HAND AUGER	**EASTING:**	
HOLE DIAMETER:	100mm	**NORTHING:**	
INCLINATION:	90°		
SURFACE RL:	ND		

DRILLING				SAMPLING		FIELD MATERIAL DESCRIPTION							
PENETRATION RESISTANCE 1 2 3 4	WATER	DEPTH (metres)	DEPTH (RL)	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL / ROCK MATERIAL DESCRIPTION	CONSISTENCY DENSITY	MOISTURE	PID (ppm)	CONTAMINATION RANKING	ADDITIONAL OBSERVATIONS
		0.0					SM	SAND, low plasticity, Light Brown	S	D			with some silt
		0.5											
			0.70					SAND, low plasticity, Grey w/ black mottling		S			marine odours
				BH3/1	E						0	0	
		1.0	1.00					SAND, low plasticity, Dark grey/black					
				BH3/2	E						0	0	
			1.30					Borehole Terminated @ 1.3m					
		1.5											
		2.0											
		2.5											
		3.0											
		3.5											

PENETRATION



CONSISTENCY	
Vs	very soft
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St	stiff
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DENSITY	
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense

MOISTURE	
D	dry
Dp	damp
M	moist
W	wet
S	saturated

TEST NOTES	
U50	undisturbed sample 50mm dia
U63	undisturbed sample 63mm dia
D	disturbed sample
Bs	bulk sample
E	environmental sample

WATER