Appendix M – Agricultural Land Assessment

PROJECT

AGRICULTURAL LAND ASSESSMENT – TWEED SAND PLANT EXPANSION, CUDGEN NEW SOUTH WALES

PREPARED FOR

HANSON CONSTRUCTION MATERIALS PTY LTD

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SYNOPSIS This report constitutes an Agricultural Land Assessment (ALA) for the proposed Tweed Sand Plant Expansion located in Cudgen, New South Wales. This report details the findings of desktop and site-based investigations to determine the site's capability as agricultural land.

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SUMMARY

Hanson Construction Materials Pty Ltd (Hanson) commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare an Agricultural Land Capability Assessment (ALCA) for the proposed expansion of their Tweed Sand Plant (TSP) operation located in Cudgen, New South Wales.

Hanson's TSP operation, has a total extraction footprint of approximately 46 hectares (ha). Sand extraction has been undertaken at this location since 1983 with Hanson assuming operation of the site in 2007.

TSP operates under Development Application (DA) DA 152-6-2006 issued on 31 July 2006, as modified on 20 August 2018 (Notice of Modification MOD 1). The current MOD 1 approval remains valid until 1 July 2036 and authorises TSP to produce and transport from the site up to 500,000 tonnes of quarry products per financial year.

To meet ongoing demand for sand, Hanson is proposing to expand its existing operations into lands to the north and west of the TSP site. The footprint of the expansion area is approximately 190 ha, giving a total combined footprint of 236 ha for the existing and future extraction areas.

The proposed expansion area covers lands that had been used for originally for sugar cane production, but in more recent times cattle grazing. As the proposed TSP redevelopment will result in the permanent loss of these lands, an ALCA of the site is required to address the Secretary's Environmental Assessment Requirements (SEARs). To that end, Hanson commissioned G&S to undertake the following:

- An Agricultural Land Capability Assessment (ALCA) within the proposed expansion area.
- An assessment of the adjacent land uses and potential land uses to inform a land use conflict assessment.
- A land use conflict assessment, including defining agricultural buffer requirements for the proposal.
- An estimate of the likely impacts of climate change.

The assessment described in this report evaluates the suitability of the site for future agricultural use. It also aims to determine whether

the development is likely to have a significant impact on any likely preferred uses of land in the vicinity of the development (including any cumulative impacts). The assessment also identifies any ways in which the development may be incompatible with any of those existing, approved or preferred uses for the adjoining land.

Soil characterisation

To sample and characterise the site soils, a drilling program was undertaken from 14 September to 6 November 2020. This included the drilling of soil cores to 1.2 metres below ground level (mBGL) at five observation locations, in addition to the soils information gathered from 20 deeper boreholes (approximately 20 mBGL) constructed as part of a separate Acid Sulfate Soil Investigation.

The soil sampling and classification comprised laboratory analysis and interpretation of results. The results were used to assess and classify the site against the following agricultural land use mapping resources in NSW:

- Land and Soil Capability mapping (LSC)
- Biophysical Strategic Agricultural Land mapping (BSAL)
- Agricultural Land Classification (ALC)
- Important Agricultural Land (IAL)
- Regional Farmland Mapping.

The following soil orders (or types) were identified:

- Tenosols – The soils at the site generally fall within the Tenosol soil type, which are soils exhibiting only weak pedologic organisation apart from the A horizons. The soil order encompasses a rather diverse range of soils, which are nevertheless widespread in many parts of Australia.
- Podosols – These are soils which possess either a Bs horizon (visible dominance of iron compounds) a Bhs horizon (organic-aluminium and iron compounds) or a Bh horizon (organic-aluminium compounds). There horizons may occur singly in a profile or in combination.

Land and soil capability

Based on the findings of the ALCA, the majority of the expansion area has poorly to imperfectly drained soils that exhibit waterlogging – typically between two to greater than three months of the year. The land and soil classification of these parts of the landscape ranges from Class 5 (moderate to low capability) to Class 6 (low capability). The land associated with the mapped BSAL had similar waterlogging characteristics (LSC class 5-6) but was subject to soil structure decline (LSC rating 4) and poor buffering capacity (LSC rating 4). As such the remainder of the site was classified as 'Class 5-6'.

Although the land and soil outcomes suggests a low capability, such land in this location has the potential to be used as a sugar production area (with installation of suitable drainage) or used for specialist estate crops, such as a tea tree oil plantation.

Biophysical Strategic Agricultural Land (BSAL)

The NSW Government has undertaken regional scale mapping of Biophysical Strategic Agricultural Land (BSAL) in the Tweed Shire. The current BSAL mapping included a portion to the north of the existing operational site. The area was mapped as having moderately high soil fertility under the SEED mapping. The Strategic Agricultural Land Map under the SEPP (Mining, Petroleum Production and Extractive Industries) 2007 also showed the mapped area of BSAL.

The BSAL land was assessed using the NSW Government *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (2013). The total area of contiguous mapped BSAL is less than 9 ha and as such does fulfil the minimum size criteria of greater than 20ha. The site was also assessed as moderately low fertility (fertility ranking 2) based on its Australian Soil Classification of bleached orthic tenosol (or grey orthic tenosol) with light sandy textured horizons. In addition, the land and soil capability of Class 5-6 is not consistent with the BSAL classification for land and soil capability classes 1, 2 or 3.

Agricultural land classification

The agricultural suitability classification for the site was found to be class 3 to 4 based on the land's imperfect to poor drainage.

NSW DPI is currently undertaking a mapping program across NSW to assist in the recognition of important agricultural land with an expected completion date of November 2020 (at the date of this report). The overall scope of this report addresses the mapping outcomes of the IAL mapping.

Under various North Coast Region Plan and Strategy documents, the site is identified as important farmland, albeit limited in potential to sugar cane and estate crops such as tea tree oil plantations. Similarly, the Northern Rivers Farmland Protection Project mapped the site as regionally significant farmland based on it sugar cane potential.

Climate change impacts

This report also evaluated the site's long term capability to support agricultural production in the context of climate change. The TSC Climate Change Management Policy, version 1.0 adopts a sea level rise of 0.4 m by 2050 and 0.9 m by 2100 (above 1990 mean sea levels), as well as an increase in the frequency and depth of tidal inundation of low lying lands and poor drainage in low lying areas.

The proposed expansion area is a low-lying coastal floodplain and is currently subject to tidal inflows from the Tweed River for part of the site. The predicted sea-level rise will exacerbate tidal inundation and impede the site's drainage, leading to increased water-logging and salinisation of soils. As time progresses, the site (and indeed adjacent land uses on the same landform) will degrade further with a consequent reduced capacity to support agricultural production.

Surrounding agricultural land use

The Land Use Conflict Risk Assessment found that the adjacent agricultural land uses and any potential land use will not impact the proposed development.

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LIST OF DRAWINGS

1 Introduction

Hanson Construction Materials Pty Ltd (Hanson) Tweed Sand Plant (TSP) operation, located off Altona Road in Cudgen, New South Wales, has a total extraction footprint of approximately 46 hectares (ha). Sand extraction has been undertaken at this location since 1983 with Hanson assuming operation of the site in 2007.

TSP operates under Development Application (DA) 152-6-2006, issued 31 July 2006 and modified on 20 August 2018 (Notice of Modification MOD 1). The MOD 1 approval remains valid until 1 July 2036 and authorises TSP to produce and transport from the site up to 500,000 tonnes of quarry products per financial year. Drawing 12035_001 shows the location of the TSP site.

To meet ongoing demand for sand, Hanson is proposing to expand its existing operations into lands to the north and west of the TSP site. The footprint of the expansion area is approximately 190 ha, giving a total combined footprint of 236 ha for the existing and future extraction areas.

1.1 Expansion proposal

The TSP site is level to gently inclined, exhibits elevations of less than five metres Australian Height Datum (<5 mAHD) and has a current extraction footprint of approximately 46 ha. The proposed expansion would see TSP's operations extend into some 190 ha of lands to the north and west of the existing TSP site.

The sand resource within the expansion area is estimated to be around 30-35 million tonnes and extends to approximately 20 metres below ground level (mbgl). Overburden is limited to topsoils to a depth of about 1 m, while minimal interburden is present throughout the resource. Drawing 12035_002 shows the footprint of the proposed expansion area and existing TSP site with respect to neighbouring operations and roadways.

Consistent with current TSP operations, sand would be extracted using a dredge and pumped to an onshore wash plant, where the target sands are separated from the finer clay and silt materials ('the fines') through a hydrocyclone. To minimise potential environmental impacts associated with these materials, these fines would then be returned to the lake under controlled conditions.

Sand extraction rates would be market driven, but capped at an annual maximum limit of 950,000 tonnes with a proposed project life of some 30 years. Ongoing extraction would, over time, require the site office, washplant, stockpiling area and weighbridge to be moved from their current locations on the site's eastern perimeter, to the northern end of Lot 2 DP1192506. Drawing Z19163-104 provides a conceptual overview of the progression of sand extraction into the proposed expansion area.

The nature and scale of the expansion classifies the proposal as a State Significant Development (SSD). In November 2019, a project Scoping Study was submitted to the NSW Department of Planning, Industry and Environment (DPIE) for its consideration and subsequent issue of site-specific Secretary's Environmental Assessment Requirements (SEARs). These SEARs were issued on 17 December 2019 and form the basis of the Tweed Sand Plant Expansion (SSD – 10398) Environmental Impact Study (EIS), of which this report is a part.

1.2 Scope of this report

The proposed expansion area covers lands that have been used originally for sugar cane production, but in more recent times for cattles grazing. The proposed TSP redevelopment will result in the permanent loss of these lands and as such an Agricultural Land Capability Assessment (ALCA) is required for the site.

The aim of the ALCA is to evaluate the suitability of the site for future agricultural use. It also aims to determine whether any limitations should be placed on the development of the lands given Council's planning provisions for the protection of prime agricultural lands, NSW Department of Primary Industries protection of important agricultural land and the Planning Secretary's Environmental Assessment Requirements.

The ALCA requirements detailed in the SEARS are reproduced below in Table 1.2.1. For ease of reference, this table also cites where each requirement is addressed in this report.

Where the requirements of the SEARs overlap between disciplines, a specific issue may be addressed under separate cover (as indicated in the table).

Table 1.2.1 SEARs relevant to this ALCA

Department/Agency	Secretary's Environmental Assessment Requirements	Section
Tweed Shire Council	Far North Coast Regional Strategy. Whilst the Strategy may identify Regionally Significant Extractive Resources in the Chinderah Road area, it is also noted that the Strategy provides for the protection of productive farmland from development pressures, with the subject area being mapped as Regionally Significant Farmland.	5.9 7.5
	North Coast Regional Plan 2036. Concern is raised with the suitability of the proposed development and the impact of sterilizing the land for future uses and loss of agricultural land.	7
	A significant portion of the site is recognised as Regionally Significant Farmland under the Northern Rivers Farmland Protection Project.	7.5
	The majority of the site is mapped as being Agricultural Land suitable for Grazing Land or land well suited to pasture improvement.	7
	A significant portion of the site is mapped as having a Land Capability suitable for Regular Cultivation.	7
DPIE – Biodiversity and Conservation Division	Detail that the land use is consistent with strategic plans and zone requirements	3.2
	Complete a Landuse Conflict Risk Assessment (LUCRA) to identify potential landuse conflict, in particular relating to separation distances and management practices to minimise odour, dust and noise from sensitive receptors. A LUCRA is described in the DPI Land Use Conflict Risk Assessment Guide.	8.2
	Include a map to scale showing the above operational and infrastructure details including separation distances from sensitive receptors.	Drawing 12035-306
	Describe the current and potential *Important Agriculture Land* on the proposed development site and surrounding locality including the land capability and agricultural productivity.	4.3.4 7.4
	Demonstrate that all significant impacts on current and potential agricultural developments and resources can be reasonably avoided or adequately mitigated.	8
	Consider possible cumulative effects to agricultural enterprises and landholders.	8.4
	Detail the expected life span of the proposed development	1.1
	Detail intentions of existing cane drains and any associated impacts/mitigation requirements	Burchills Stormwater & Flooding assessment G&S Surface Water Assessment 2020

Department/Agency	Secretary's Environmental Assessment Requirements	Section
Planning Secretary's Environmental Assessment Requirements	Land resources – including: • An assessment of the agricultural impacts of the development, paying particular attention to any identified areas of strategic agricultural land; and	4.3.2 5.7 7.2
	• The compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements in Clause 12 of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007, paying particular attention to the agricultural land use in the region.	8

1.3 Objectives

To address the SEARs with respect to agricultural issues, Hanson commissioned G&S to undertake:

- An Agricultural Land Capability Assessment (ALCA) within the proposed expansion area.
- An assessment of the adjacent land uses and potential land uses to inform a land use conflict assessment.
- A land use conflict assessment, including defining agricultural buffer requirements for the proposal.
- An estimate of the likely impacts of climate change.

The assessment described in this report aims to adequately evaluate the suitability of the site for future agricultural use and to determine whether or not the development is likely to have a significant impact on any likely preferred uses of land in the vicinity of the development (including any cumulative impacts) and any ways in which the development may be incompatible with any of those existing, approved or likely preferred uses for the adjoining land.

1.4 Relevant guidelines and documents

This ALCA considered the following relevant guidelines and documents:

- Clause 12 of the State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007.
- State Environmental Planning Policy (Primary production and Rural Development) 2019.
- Tweed Local Environmental Plans (2000 and 2014).
- The National Committee on Soil and Terrain 2009 'Australian Soil and Land Survey Field Handbook (3rd Edition)' CSIRO Publishing Collingwood Victoria.
- New South Wales Agricultural Land Classification Guidelines - Agfact AC.25 (NSW Agriculture, 2002).
- New South Wales Draft Guidelines for Individual Farm Assessments (NSW Agriculture, 1995).
- New South Wales Department of Primary Industries 2012, 'A guideline to identifying important agricultural lands in NSW'.
- NSW Office of Environment and Heritage 'The land and soil capability assessment scheme, Second approximation'.
- Far North Coast Regional Strategy.
- North Coast Regional Plan 2036.
- Northern Rivers Farmland Protection Project.
- Learmonth, R., Whitehead, R., Boyd, B. and Fletcher S.2007, 'Living and Working in Rural Areas: A handbook for managing land use conflict issues on the North Coast'. State of NSW (Department of Primary Industries), Wollongbar NSW.
- NSW Department of Primary Industries 2011 'Land Use Conflict Risk Assessment Guide - Resource Planning and Development unit Primefact 1134', State of NSW.

2 Previous land resource investigations

Previous land resource investigations of the surrounding area were reviewed for their relevance to the site as part of the desktop assessment. The following reports are included as the most relevant to the ALCA.

2.1 The ABLP Report

A report entitled 'Statement of Environmental Effects for the Proposed Aquaculture Development & Water Supply Works, prepared for Australian Bay Lobster Producers Pty Ltd (herein referred to as the 'ABLP Report'), was prepared in 2004 by Australian Fresh Research & Development Corporation Pty Ltd and Planit Consulting Pty Ltd.

The ABLP site is located west of the proposed expansion site. The ABLP report is brief in addressing agricultural impacts. Whilst the report identifies the ABLP land as Class 3 & 4 Agricultural Lands, it makes no reference to the assessment(s) or guideline(s) used to determine the classification, nor does it provide reasoning behind the classification.

The report concluded that in terms of agricultural impacts, the diminishing returns and poor site conditions made continued cultivation unviable. It also stated that the loss of the ABLP land would not weaken the long term viability of the sugar cane industry.

2.2 The TSC History Report

In 2004, Joanna Boileau of the NSW Heritage Office prepared a report entitled 'Community Based Heritage Study – Thematic History' for Tweed Shire Council (herein referred to as the TSC History Report). This report provides valuable insight into the history of the Tweed region in relation to agricultural production, specifically sugar cane production. It notes that the overall contribution of agriculture to the Tweed Shire economy is small and declining, with only 5% of regional economic activity and employment relating directly to agriculture.

The TSC History Report does not include an assessment of the site directly in terms of land capability into the future.

2.3 The 2005 G&S Assessment

G&S prepared a report entitled 'Soil Survey, Acid Sulfate Soil Assessment, Agricultural Land Capability Assessment and Soil and Water Management Plan for Proposed Expansion of Extractive Industry, Lot 2 DP777905, Cudgen, June 2005' (herein referred to as the 2005 G&S Assessment). That report included both new data and data gathered from previous assessments in the years preceding.

As part of the 2005 agricultural land capability assessment, G&S completed a field investigation that involved drilling 20 shallow boreholes to a depth of approximately 700 mm throughout the proposed expansion area. Additional soils data was taken from 11 deep boreholes constructed as part of a separate ASS Investigation.

The site soils within the proposed extraction area were identified as being Oxyaquic Hydrosols – soils with a seasonal or permanent water table in which the major part of the solum is whole coloured (Isbell, 1996).

Based on the assessment, the 2005 G&S Assessment identified the land as Class 3 land using the NSW Agricultural Land Classification (ALC) Guidelines (2002). The report also concluded that physical buffering from the surrounding properties was not considered necessary. The overall conclusion was that the benefits of sand extraction to the community far outweighed the benefits of the marginally viable agricultural use of the land.

3 Site description

3.1 Property description and zoning

The project site comprises eight allotments with a total site footprint of approximately 236 ha (including the existing TSP operation) as shown on Drawing 12035_002. Table 3.1.1 summarises the property description, lot size and land zoning under Tweed Shire Council's (TSC) Tweed Local Environmental Plan (LEP) 2014.

Table 3.1.1 Property description and land zoning*

Property description	Land zoning (LEP 2014)	Lot size (ha)
Lot 22 DP1082435	RU1 – Primary production	74.56
Lot 23 DP1077509	RU1 – Primary production	2.552
Lot 494 DP720450	RU1 – Primary production	0.1042
Lot 1 DP1250570	RU1 – Primary production RU2 – Rural landscape	90.00
Lot 2 DP1192506	RU1 – Primary production	11.12
Lot 3 DP1243752	RU1 – Primary production	1.612
Lot 51 DP1166990	RU1 – Primary production	55.13
Lot 50 DP1056966	RU1 – Primary production	1.094

*Source: NSW Planning Portal, 23 October 2020

3.2 Existing land uses

TSP is located within the Tweed Valley Floodplain and is surrounded by various land uses. Located immediately north of the site is TSC's wastewater treatment facility and open grazing lands. Further to the north lies the Pacific Motorway, the township of Chinderah and the Tweed River. To the north-east is Chinderah Golf Course and some residential properties fronting the Tweed Coast Road.

Immediately to the east lies the Cudgen Lakes Sand Extraction. Further to the east is the townships of Cudgen and Kingscliff and the Pacific Ocean.

The Cudgen Plateau, located immediately south of the project site, is primarily used for agricultural purposes including cropping and orchards. The Cudgen residential area is located to the southeast and incorporates Cudgen Public School directly west of the residential area.

To the west of the site lies open grazing lands, the Australian Bay Lobster Producers Limited facilities and the Pacific Motorway.

3.3 Topography and local drainage

Local topographic mapping indicates that the elevation of the property is uniform, with an average relative level (RL) of 1.0 metres Australian Height Datum (mAHD). The site's slopes are described as level (<1%) to very gently inclined (1-3%).[1] The project site abuts the Cudgen Plateau to the south, where elevations rise steeply to approximately 38 mAHD.

The site is located within the Tweed Valley Floodplain. Most runoff from the site passively infiltrates through the highly permeable sandy soils. Any remaining runoff is currently diverted towards the on-site extraction areas, or conveyed to a network of agricultural drains.

During high intensity rainfall events, the site becomes inundated and peak discharges may potentially flow toward the agricultural drainage lines constructed along the northern and western property boundaries. These drains convey runoff from the surrounding agricultural properties through flood gates to the Tweed River.

3.4 Regional drainage

The project site is located within the lower reaches of the Tweed River Floodplain. The

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[1] McDonald R. C., Isbell R. F., Speight J. G., Walker J. & Hopkins M. S. Australian Soil and Land Survey Field Handbook. Second Edition 1990, Inkata Press Pty Ltd.

headwaters of the Tweed River begin near Kunghur, approximately 50 km southwest of Chinderah and generally flow in a north-easterly direction. Numerous rivers, creeks and tributaries feed into the Tweed River, including the Oxley River approximately 5 km southwest of Murwillumbah, and the Rouse River west of Tumbulgum.

The Tweed River discharges into the Pacific Ocean at the Tweed River mouth, immediately east of Tweed Heads. The tidal influence of the Pacific Ocean extends just upstream of Murwillumbah (WBM, 2005).[2]

The floodplain is criss-crossed by a network of interconnecting agricultural drains and flood gates which convey water from the floodplain to the Tweed River. The main drain through the catchment ('the western drain', shown in blue on Figure 4.4) flows westwards from Tweed Coast Road parallel to Altona Drive. The drain then turns northwards adjacent to the TSP site before discharging into the Tweed River through culverts under the Pacific Highway and Chinderah Bay Drive. These culverts have flood gates installed on the River side, under Chinderah Bay Drive. Other minor drains run east-west and north-south across the floodplain and generally discharge into the western drain.

The floodplain is subject to inundation from both local catchment floods as well as Tweed River overbank floods.

3.5 Soil landscapes

Soil Landscapes within the project site are described in the DPIE's Soil Landscapes of Central and Eastern NSW dataset 2020.[3]

The expansion area is within the 'Tweed landscape' (9541tw). This landscape is described as an extensive marine plain of the lower Tweed catchment, consisting of deep Quaternary alluvium and estuarine sediments.

The marine plain has been created by the in-filling of a large estuary or embayment during the Pleistocene era. Marine clays and muds have dominated these fill materials. Since this period of aggradation, the Tweed River has been creating a covered plain consisting of terrestrial sediments.

The eastern extents of the TSP site are mapped as a 'Tweed landscape variant b' (9541twb) (DPIE, 2020).[4] This landscape is described as consisting of deep Quaternary alluvium and estuarine sediments with landscape variant 'twb', described as Pleistocene sands overlain by alluvial soil material.

The project site lies within the Cudgen 1:25 000 Acid Sulfate Soil Planning Map (DLWC 1997). This mapping indicates that there is a high probability of ASS material being encountered within 1 m to 3 m of the ground surface.

3.6 Geology

A review of the 1:250,000 Geological Series SH56-3 (Tweed Heads) indicates that the site geology is comprised of Quaternary sedimentary deposits of river gravel, alluvium, sand and clay.

A hydrogeological investigation at the eastern neighbouring property described the regional bedrock as interbedded argillite and metagreywacke of the Neranleigh-Fernvale Beds of lower Palaeozoic age. The materials overlying this stratum were described as Quaternary organic clays, which were in turn overlain by Quaternary sands.[5]

The quaternary sands were described as poorly graded medium to fine grained quartzose sands with some coarse grains. These materials had a relatively uniform thickness of around 21 m across the site. The depositional environment for the

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[2] Flood Impact Assessment for the Proposed Sand Quarry Expansion at Crescent Street, Cudgen, WBM Oceanics Australia, 13 June 2005.

[3] Department of Planning, Industry and Environment, 2020, Soil Landscapes of Central and Eastern NSW - v2.1, NSW Office of Environment and Heritage, Sydney.

[4] Ibid, 2020.

[5] Coffey Geosciences (1999). Cudgen Sand Extraction – Hydrogeological Assessment and Installation of Monitoring Bores.

Quaternary sands was identified as deltaic, with the presence of shell and organic fragments throughout the sequence, indicative of alternating marine and terrestrial influence.[6]

3.7 Vegetation

The TSP site and proposed expansion area is characterised by open grazing lands which have been largely cleared of native vegetation. Within the TSP site an area of approximately 20 ha is currently cultivated under tea tree.

The agricultural drains that traverse the site contain some native vegetation, which is described in detail under separate cover.

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[6] Coffey and Partners (1985 - 1986). Geotechnical investigation for proposed extractive industry on Lot 2 DPG11021 and DP216705.

4 Methodology

4.1 Desktop assessment

The desktop assessment comprised analysis of available soil and land data from the New South Wales eSPADE and SEED mapping databases, which included the base maps underpinning the Biophysical Strategic Agricultural Land (BSAL).

The eSPADE assessment included an analysis of the following:

- Land and soil maps
- Soil profiles
- Soil and land resource
- Soil landscape
- Land systems
- Acid sulfate soil risk mapping
- Hydrogeological landscape
- Modelled soil properties
- Land use

4.2 Soil sampling and classification

To sample and characterise the site soils, a drilling program was undertaken from 14 September to 6 November 2020. This included the drilling of soil cores to 1.2 metres below ground level (mBGL) at a five observation locations, in addition to the soils information gathered from 20 deeper boreholes (approximately 20 mBGL) constructed as part of a separate Acid Sulfate Soil Investigation.

The soil sampling intensity adopted for this survey complied with the recommended minimum for a ‘very-high’ intensity survey (i.e. 1 borehole/4 hectares with 1-5% being deep borings) specified in the Australian Soil and Land Survey Handbook (1998) and under the 2009 Survey guideline.[7] Drawing No. 12035-301 shows the borehole locations across the site.

A site slope analysis was undertaken, and this is shown on Drawing No. 12035-302.

Soil logging was undertaken at each borehole location in accordance with the Australian Soil and Land Survey Field Handbook (McDonald et al 1990), with samples retained for analysis. All soils were then classified in accordance with the Australian Soil Classification Revised Edition (Isbell et all, 2002). The soil borelogs are attached as Appendix 6. The soil map for the site is shown on Drawing No. 12035-303.

Based on the resultant soils mapping and slope analysis, the site was divided into unique mapping areas (UMA), each represented by polygons.[8] These areas describe portions of land within the site that have similar unique soil type and landform attributes. The UMAs in this case aided the land suitability assessment. Drawing No. 12035-304 shows the UMA map for the site.

From information and data gathered from the site slope analysis, soil classification, and UMA mapping, the land and soil capability class was identified. This land and soil capability class is shown on Drawing No. 12035-305.

4.3 Agricultural Land Assessment

The agricultural land assessment encompassed:

- Land and soil capability.
- Biophysical strategic agricultural land.
- Agricultural land suitability.
- Important agricultural land.
- Regionally significant farmland.
- Land-use conflict and separation.
- Climate change impact.

4.3.1 Land and Soil Capability (LSC)

The NSW Department of Planning, Industry and Environment’s scheme for land and soil capability assessment categorises land into eight classes

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[7] The National Committee on Soil and Terrain 2009 ‘Australian Soil and Land Survey Field Handbook (3rd Edition)’ CSIRO Publishing Collingwood Victoria. (note an updated version of McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S., 1990, ‘Australian Soil and Land Survey Field Handbook (2nd Edition)’. Inkata Press, Melbourne.)

[8] A plane area bounded by a closed path.

based on its general limitations. Table 4.3.1.1 sets out the eight soil and land capability classes.

The NSW land and soil capability assessment scheme (second approximation) uses the biophysical features of the land and soil including landform position, slope gradient, drainage, climate and soil type/ characteristics to derive detailed rating tables for a range of land and soil hazards.

The scheme is based on an assessment of these biophysical characteristics of the land, the extent to which these will limit a particular type of land use, and the current technology that is available for management of the land.

The main hazards and limitations that are assessed include:

- Water erosion, including sheet, rill and gully erosion.
- Wind erosion.
- Soil structure decline.
- Soil acidification.
- Salinity.
- Waterlogging.
- Shallow soils and rockiness.
- Mass movement.

Other limitations that primarily influence agricultural productivity (rather than susceptibility to degradation) can also be a major determinant of ultimate land use. These include moisture stress limitations, fertility, slope and acid sulfate soil (ASS) risk.

The classification outlines the types of land uses appropriate for a particular area of land and the types of land management considerations to prevent soil erosion and maintain the productivity of the land. The assessment criteria are attached in Appendix 2.

4.3.2 Biophysical Strategic Agricultural Land (BSAL)

BSAL is land with high quality soil and water resources capable of sustaining high levels of productivity. Indicative BSAL maps were introduced in 2012. The limitations of these maps are at a state/regional scale with varying accuracies and degrees of confidence. A site verification process is require to determine if the maps are correct at a local scale.

A site verification process[9] has been developed under the State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 to determine the existence of BSAL at the site of potential development.

The assessment flow chart is attached in appendix 3.

Table 4.3.1.1 Soil and land capability

Usage	Class No.	Class description	Land description	Slope
Suitable for regular cultivation	1	Extremely high capability land	Land suitable for a wide variety of uses. Where soils are fertile, this is land with the highest potential for agriculture, and may be cultivated for vegetable and fruit production, cereal and other grain crops, energy crops, fodder and forage, crops, and sugar cane in specific areas. Includes 'prime agricultural land'. This land has no limitations.	<1%

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[9] Interim protocol for site verification and mapping of biophysical strategic agricultural land (2013) New South Wales Government

Usage	Class No.	Class description	Land description	Slope
	2	Very high capability land	Usually gently sloping land suitable for a wide variety of agricultural uses. Has a high potential for production of crops on fertile soils similar to Class 1, but increasing limitations to production due to site conditions. Includes 'prime agricultural land'. This land has slight limitations	1-3%
	3	High capability land	Sloping land suitable for cropping on a rotational basis. Generally used for the production of the same type of crops listed for Class I, although productivity will vary depending on soil fertility. Individual yields may be the same as Classes 1 and 2, but increasing restrictions due to the erosion hazard will reduce the total yield over time. Soil erosion problems are often severe. Generally fair to good agricultural land. Land has moderate limitations.	3-10%
Suitable for grazing	4	Moderate capability land	Land not suitable for cultivation on a regular basis owing to limitations of slop gradient, soil erosion, shallowness or rockiness, climate or a combination of the factors. Comprises the better classes of grazing land ad can be cultivated for an occasional crop (fodder crop or pasture renewal). If used for 'hobby farm' adequate provisions should be made for water supply, effluent disposal and selection of safe building sites and access roads. Land has moderate to high limitations for high-impact land uses.	10-20%
	5	Moderate-low capability land	Land not suitable for cultivation on a regular basis owing to considerable limitations of slope gradient, soil erosion, shallowness or rockiness, climate or a combination of the factors. Soil erosion factors are often severe. Production is generally lower than for grazing lands in Class 4. Can be cultivated for an occasional crop (fodder or pasture renewal). Not suited to the range of agricultural uses listed to Classes 1 to 3. If used for 'hobby farm' adequate provisions should be made for water supply, effluent disposal and selection of safe building sites and access roads. Land has high limitations for high-impact land uses.	10-20%
	6	Low capability land	Productivity will vary due to the soil depth and the soil fertility. Comprises the less productive grazing lands. If used for 'hobby farm' adequate provisions should be made for water supply, effluent disposal and selection of safe building sites and access roads. Land has very high limitations for high-impact land uses.	20-33%

Usage	Class No.	Class description	Land description	Slope
Generally incapable of agricultural land use	7	Very low capability land	Generally comprises areas of steep slopes, shallow soils and/or rock outcrop. Adequate ground protection must be maintained by limiting grazing and minimising damage by fire. Destruction of trees is generally not recommended, but partial clearing for grazing purposes under strict management controls can be practiced on small areas of low erosion hazard. Where clearing of these lands has occurred in the past, unstable soil and terrain sites should be returned to timber cover. Land has severe limitations that restrict most land uses and generally cannot be overcome.	33-50%
	8	Extremely low capability land	Land unsuitable for agricultural or pastoral uses. Recommended uses are those compatible with the preservation of the natural vegetation, namely: water supply catchments, wildlife refuges, national and state parks and scenic areas. Limitations are so severe that the land is incapable of sustaining any land use apart from those listed above.	>50%

4.3.3 Agricultural Land Classification (ALC)

This five class system[10] classifies land in terms of its suitability for general agricultural use. This systems was developed specifically to meet the objectives of the Environmental Planning and Assessment Act 1979, in particular 5(a) (i):

> '*to encourage the proper management, development and conservation of natural and man-made resources, including agricultural land… for the purpose of promoting social and economic welfare for the community and a better environment*'.

The mapping ceased in 2000, however it is still used by local government in land assessment and evaluation. The Department of Primary Industries (DPI) instead encourages the use of Important Agricultural Land (IAL) mapping, outlined in Section 3.4.

Agricultural land is classified by evaluating biophysical, social and economic factors that may constrain the use of land for agriculture. These determine the types of agricultural enterprises that are, or could be, adapted to the area. The assessment criteria are attached in Appendix 4.

Agricultural land classification maps place land into one of five classes according to its suitability for a wide range of agricultural activities, the characteristics for which are described below.

Class 1: Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.

Class 2: Arable land suitable for regular cultivation for crops, but not suited to continuous cultivation. It has a moderate to high suitability for agriculture but edaphic (soil factors) or environmental constraints reduce the overall level of production and may limit the cropping phase to a rotation with sown pastures.

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[10] Hulme, T., Grosskopf, T., Hindle, J., prepared for NSW Agriculture, AgFact AC.25 (2002).

Class 3: Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with sown pasture. The overall production level is moderate because of edaphic or environmental constraints. Erosion hazard, soil structural breakdown or other factors, including climate, may limit the capacity for cultivation and soil conservation or drainage works may be required.

Class 4: Land suitable for grazing but not for cultivation. Agriculture is based on native pastures or improved pastures established using minimum tillage techniques. Production may be seasonally high but the overall production level is low as a result of major environmental constraints.

Class 5: Non-agricultural land. Land unsuitable for agriculture, or at best suited only to light grazing. Agricultural production is very low or zero as a result of severe constraints, including economic factors which prevent land improvement.

The critical criteria for the assessment are:

- Soil depth
- Drainage
- Soil pH
- Salinity
- Sodicity
- Gravel and stone
- Boulders and rock outcropping
- Soil erosion hazard
- Soil erosion present

4.3.4 Important Agricultural Land (IAL)

IAL is the existing or future location of local or regionally important agricultural industries or resources. The mapping includes a combination of biophysical resources and socio-economic requirements for local or regionally important agricultural industries. However, due to scale limitations, IAL maps are not suitable for the assessment of development proposals or for property-specific planning purposes.

NSW DPI has produced '*A guideline to identifying important agricultural lands in NSW*' (April 2017) to identify and map IAL. IAL mapping involves the following four mapping products, that can be developed individually or in combination:

- A current land use map that identifies where agricultural industries are located.
- A simple map of important biophysical resources for agriculture applicable across all agricultural industries.
- An additional extra overlay of socio-economic information also applicable across all agricultural industries.
- An agricultural industry map that uses critical biophysical criteria, access to infrastructure and socio-economic location criteria to identify the locations of specific agricultural industries.

NSW DPI is currently undertaking a mapping program across NSW to assist in the recognition of IAL. The expected completion date for this mapping was November 2020.

4.3.5 Regional Farmland Mapping

Regional Farmland Mapping was developed to identify and protect State Significant, Regionally Significant and Significant Non-contiguous farmland to maintain strong resource base for the current and future production of food and fibre.

The Northern Rivers Farmland Protection Project provides the final map (Sheet 2) identifying the areas of regionally significant farmland on the site.

Regionally significant farmland is considered important to agriculture but is more extensive and less productive generally per unit area. The attributes for identifying regionally significant farmland in the Northern Rivers project will be compared to and assessed against the results gathered during the land and soil capability assessment to determine accuracy of the mapping.

4.4 Land use conflict and separation

The following two-stage approach is used to assess land use conflict and separation:

- Land use conflict risk assessment (LUCRA); and
- Agricultural buffers and mitigation.

4.4.1 Land Use Conflict Risk Assessment (LUCRA)

LUCRA is a system to identify and assess the potential for land use conflict to occur between neighbouring land uses. It helps land managers and consent authorities assess the possibility for and potential level of future land use conflict.

With respect to the ALCA, the LUCRA is a valuable tool to enable a systematic, consistent and site-specific conflict assessment approach to land use planning and development assessment.

The Land Use Conflict Risk Assessment Guide[11] provides the necessary tools and guidance on completing a site specific LUCRA. The risk assessment matrix is provided in Appendix 5.

4.4.2 Agricultural buffers

Appropriate separation from the surrounding land uses and existing agriculture enterprises may be required in accordance with the following:

- TSC's Development Control Plan (Subdivision Manual).
- TSC's Local Environmental Plans (2000 and 2014).
- The New South Wales Department of Primary Industries (DPI) *North Coast Living and Working in Rural Areas Handbook.*
- TSC's Tweed Development Control Plan Section A5, Subdivision Manual (2008).

In this case, the following issues potentially relevant to the site were assessed:

- noise
- odour
- dust and
- chemical spray drift.

Based on the adjacent land use, appropriate agricultural buffers may be required on the site. The Tweed LEP 2000 and 2014 determine the land zoning in the area. Based on the land zoning, the relevant guidelines provide the appropriate buffer distance and design.

4.5 Climate change

An integral part of the agricultural land capability assessment is taking into consideration potential impacts from climate change and the predicted future capability of the land for agricultural production. TSC adopted its 'Climate Change Management Policy, version 1.0' in June 2020. It predicts sea levels to rise above 1990 mean sea levels by 0.4 m by 2050 and 0.9 m by 2100. It also anticipates an increase in the frequency and depth of tidal inundation of low lying lands and poor drainage in low lying areas. Additionally, the policy anticipates the following socio economic and environmental impacts on the Tweed Shire, specifically related to agricultural land capability:

- Increasing heat, soil erosion and drought will impact upon agricultural systems, affecting crop yield and livestock health, farm productivity and the rural economy
- Increased flooding and tidal inundation leading to potential impacts on sugar cane production

The '2020-2021 Interim Climate Change Action Plan' (TSC Sep 2020) outlines Council's response to climate change. It provides a list of 20 climate adaptation actions to highlight key existing and new priorities to improve the resilience of the Tweed to the impacts of climate change.

Sea-level rise will also impact on drainage and groundwater in low-lying coastal floodplains leading to potential increase in the duration of floods, water-logging of soils and soil salination. These impacts may be exacerbated by the infiltration of saline water into coastal aquifers, reducing the quality and viability of groundwater for irrigation.[12]

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[11] Department of Primary Industries, Primefact 1134 'Land Use Conflict Risk Assessment Guide' (Oct 2011) first edition

[12] Climate Change in the Northern Rivers Catchment, prepared for the New South Wales Government by the CSIRO (2007).

5 Results – desktop assessment

The results are divided into the outcomes of the:

- desktop assessment,
- soil and land survey,
- land assessments (i.e. land and soil capability, BSAL assessment, agricultural land class, important agricultural land and regionally significant farmland) and
- land-use conflict and separation.

This section details the results gathered through desktop assessment and a site soil sampling and classification assessment.

The desktop assessment comprised analysis of available soil and land data from NSW eSPADE and SEED mapping databases, which included the base maps underpinning the BSAL.

The site soil sampling and classification comprised laboratory analysis and interpretation of results. The results were used to assess and classify the site against the following agricultural land use mapping resources in NSW:

- Land and Soil Capability mapping (LSC)
- Agricultural Land Classification (ALC)
- Important Agricultural Land (IAL)
- Biophysical Strategic Agricultural Land mapping (BSAL)
- Regional Farmland Mapping.

5.1 Land and soil maps

Australian Soil Classification: According to the eSPADE mapping tool, a large portion of the soils on the expansion site are hydrosols. The eastern portion of the site is mapped as mostly chromosols with some kurosols present toward the southern site boundary. The land extending north and east of the site has been mapped as prairie soils.

Land and soil capability: The land and soil capability mapping tool uses the information available in eSPADE to determine the capability of the soil in terms of production. The majority of the site is mapped as '6', translating to 'very severe limitations'. The eastern portion of the site is mapped as '3', translating to 'moderate limitations', noting that a large portion of this area has already been dredged.

Soil landscape: The expansion area falls within the Soil Landscapes of the Murwillumbah-Tweed Heads 1:100,000 Sheets. The area is mapped as *twb* and *tw.*[13]

5.2 Acid sulfate soil risk mapping

ASS probability: The ESpade mapping tool highlights H1 and H2 ASS probability across the site. H1 covers a small western portion of the expansion area and is a high probability of ASS at < 1 mbgl. H2, covering the majority of the site (expansion area and existing operations) is a high probability of ASS at 1 to 3 mbgl.

ASS process: The site consists of two major process types – aeolian and alluvial. Aeolian sediments are wind deposited materials that consist primarily of sand or silt-sized particles. These materials tend to be very well sorted and free of coarse fragments with some detectable rounding or frosting of mineral grains. Sand wind-blown debris often accumulates to form dunes. Alluvial sediments are fine-grained fertile soil or sediment that has been eroded, reshaped by water in some form and re-deposited in a non-marine environment, often in flood plains or river beds.

ASS elevation: The elevation of ASS probability identified the eastern extent of the site with ASS at 2 to 4 mAHD and the western portion of the site with ASS at 1 to 2 mAHD.

ASS landform element: This element transitions from aeolian sandplains (western part of the site), to alluvial plains (eastern part of the site).

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[13] Tweed, Estuarine/Alluvial Landscapes, Soil Landscapes of the Murwillumbah – Tweed Heads, D.T. Morand 1996, pages 144-149 (hard copy pages 138-143).

A full assessment of acid sulfate soils within the project site is provided under separate cover (G&S, 2020 Acid Sulfate Soil Assessment).

5.3 Modelled soil properties

5.3.1 Cation Exchange Capacity (CEC)

CEC 0-30 cm: CEC is a useful indicator of soil fertility as it shows the soils' ability to supply three important plant nutrients: calcium, magnesium and potassium. CEC influences soil structure stability, nutrient availability, soil pH and the soils' reaction to fertilisers and other ameliorants.

The current operational area of the site is between 20 and 30 cmol_c/kg. The expansion area is shaded primarily orange (>10-15 cmol_c/kg) with small patches of yellow (>15-20 cmol_c/kg). The site has sandy soils with moderate amounts of organic material.

CEC 30-100 cm: The CEC increases slightly with depth, indicating that heavier soils with a higher amount of organic material are present. The site has a CEC ranging between 10 and 30 cmol_c/kg.

5.3.2 pH

pH 0-30 cm: The pH for the top soil (0-30 cm) ranges from approximately 4 to 5.5 across the site. The mapping shows more acidic soils on the expansion site compared to the existing site.

The general pH range for soils is 4.5 to 8.5. Lower values (down to 3.5) are usually associated with peaty soils or severely leached acid soils. Soil pH can affect nutrient availability as long as there is an ample quantity of the nutrient present in the soil. At low levels, aluminium and manganese may present in levels toxic to some plants.[14]

Soil pH can be altered by the following factors:

- Factors which decrease pH: percolation of water; loss of basic cations; lack of aeration; erosion of alkaline surface soil; addition of S, Al, $FeSO_4$; some fertilisers; organic matter build up – acidifying effects of organic aids; organic matter decline – loss of CEC + buffering capacity; and use of gypsum.
- Factors which increase pH: addition of lime or dolomite; use of waters high in Na and Ca; erosion of acid surface soils.

pH 30-100 cm: Compared to the topsoil data, the deeper pH levels area slightly less acidic, however still range from approximately 4 to 5.5.

5.3.3 Electrical Conductivity

EC 0-30 cm: The EC in the topsoil (0-30 cm) ranges from 200-300 μS/cm across the site. The EC is a measure of the total soluble salts concentration of the soil solution. Areas affected by seawater, poor drainage, flooding or irrigation are prone to high EC concentrations, particularly in the subsoils where water percolation is slow.

Table 5.3.3.1 provides an indication of crop resistance to EC levels.[15]

Table 5.3.3.1 Crop tolerance to EC

Conductivity (μS/cm)	Soluble salt rating	Action
< 150	Low (good)	Nil
150-400	Satisfactory	Nil, or leach soluble salts
400-800	Medium (harmful to sensitive plants)	Use tolerant crops, leach soluble salts
800-2,000	High (harmful to all but tolerant species)	Use tolerant plants, improve drainage and leach soluble salts. Consult agronomist
Greater than 2,000	Very high (practically useless for crop growth)	Consult agronomist. Improve drainage and leach soluble salts if possible.

EC 30-100 cm: Similar to the top soil, the majority of the site soil at 30-100 cm ranges from 200-300 μS/cm, with only patches of land within the

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[14] Consolidated Fertilizers Limited *Soil interpretation manual* 1983.

[15] Consolidated Fertilizers Limited *Soil interpretation manual* 1983, p2.35.

existing operational site appearing to exhibit a slightly elevated EC concentration.

5.4 Land use

Land use: The land use mapping tool shows the site is primarily used for production from dryland agriculture and plantation, a true reflection of the current land use (i.e. tea tree plantation). The dredge lake and several drains throughout the site are shown as water on the map.

5.5 Land and soil capability

The land and soil capability (LSC) mapping for NSW shows the site includes areas mapped as *6 – very severe limitations* and *3 – moderate limitations*. The majority of the expansion site falls under very severe limitations.

The land and soil capability dataset uses the second approximation of the NSW Office of Environment and Heritage *The land and soil capability assessment scheme.* Table 2 from document specifies definitions of the mapping categories, provided below.

LSC class 3 (moderate limitations) – defined as high capability land. This land has moderate limitations and is capable if sustaining high-impact uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.

LSC class 6 (very severe limitations) – defined as low capability land. This land has very high limitations for high0impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.

5.6 Soil fertility

The inherent soil fertility classes of the Great Soil Groups is included in the SEED mapping. The soil fertility mapped on the site includes areas of moderately high (existing operational site) and moderately low (proposed expansion site) estimated soil fertility.

The SEED map, coupled with the table outlining the inherent soil fertility[16] show that the proposed expansion site is mapped as *Humic Gleys*, with a moderately low (2) soil fertility.

5.7 Biophysical Strategic Agricultural Land (BSAL)

The available BSAL mapping included a portion of less than 9ha to the north of the existing operational site, the area mapped as having moderately high soil fertility under the SEED mapping. The Strategic Agricultural Land Map[17] under the SEPP (Mining, Petroleum Production and Extractive Industries) 2007 also shows the mapped area of BSAL.

The BSAL mapping coincides with the NSW state-wide land and soil mapping and is identified as a prairie soil under the Australian great soil groups. This soil is also mapped as moderate fertility under the same mapping. The equivalent Australian Soil Classification for a prairie soil is a Dermosol, which requires a soil structure grade more developed than 'weak' for the major part of the B horizon and no clear of abrupt textural B horizon.

The remainder of the proposed development site is mapped as Humic gleys, and is not identified as BSAL.

5.8 Soil landscapes

The proposed expansion of the sand extraction area is wholly contained within the land scape unit identified as the Tweed landscape unit (Tw and Twb). The Landscape Limitations identified for this land unit are

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[16] Charman, P.E.V. 1978 (ed.), *Soils of New South Wales: Their Characterisation, Classification and Conservation,* Tech. Handbook No. 1, Soil Conservation Service of NSW, Sydney.

[17] Sheet STA_057.

- Permanently high water tables
- Flood hazard
- Waterlogging

The landscape is described as deep Quaternary alluvium and estuarine sediments. The soils of the Tweed soil landscape are dominated by Humic Gleys and peat materials with brown clays associated with the river levees. The area identified as twb are mapped as prairie soils.

5.9 Regional Farmland Mapping

Regional Farmland Mapping was developed to identify and protect State Significant, Regionally Significant and Significant Non-contiguous farmland to maintain strong resource base for the current and future production of food and fibre.

Regional farmland objectives are recommended to guide decision-making on development in farmland areas. This includes the objective to:

> '*establish the priority of legitimate rural uses (farming, conservation, extractive industry, forestry, rural industry) over non-rural uses, without one rural use necessarily having preference over another rural use.*'

As noted in the Tweed LEP, extractive industries are permitted with consent in the RU1 and RU2 zoned areas (see Section 3).

The Northern Rivers Farmland Protection project provides the final map (Sheet 2) identifying the aforementioned farmland. A portion of the site is mapped as Regionally Significant Farmland, with the southern portion of the site mapped as Other Rural Land.

Regional significant farmland is considered important to agriculture but is more extensive and less productive generally per unit area. However, the soil landscapes which were selected as significant farmland in the Northern Rivers Project did not include the tenosols and podosols identified on the site. Therefore the site does not appear to meet the attributes of significant farmland.[18] The site again fails the criteria as it is not well drained or flood free.

5.10 Agricultural Land Classification (ALC)

Existing land use may not always be a good indicator of appropriate land use and hence land class. The system of land classification is aimed as assessing physical, social and economic attributes of land rather than its current use.

The mapping ceased in 2000, however it is still used by local government in land assessment and evaluation. The Department of Primary Industries (DPI) instead encourages the use of Important Agricultural Land (IAL) mapping.

Since the last of the maps were made, landscapes in many regions have significantly changed through urban expansion, industrial and mining developments, vegetation regrowth, soil degradation and clearing of native vegetation, with accompanying changes in economic and environmental values. The amount of high quality land available for agriculture is significantly different from that indicated in the earlier maps.

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[18] Department of Primary Industries, 'Northern Rivers Farmland Protection Project', (2005), p11.

6 Results – soil and land survey

This section includes the results of the site soil sampling and land assessments to form the soil description and classification.

6.1 Soil and land survey

A drilling program undertaken from 14 September to 6 November 2020 included the drilling of soil bores to 1.2 mBGL at five locations to sample and characterise the site soils (herein referred to as the AG boreholes). These five 'observation' locations were complemented by 20 deeper boreholes (approximately 20 mBGL) constructed as part of the Acid Sulfate Soil Investigation (herein referred to as the ASS boreholes).

Shown on Drawing no. 12035-301, the borehole locations were:

- AG boreholes: AG1 (AS44); AG2 (AS41); AG3 (AS5); AG4 (AS20); and AG5 (AS25).
- ASS boreholes: AS1; AS4; AS6; AS9; AS11; AS13; AS15; AS19; AS21; AS24; AS25; AS27; AS28; AS30; AS32; AS33; AS38; AS39; AS40; and AS42.

Samples were retrieved at relevant depth intervals (minimum of 0.5 metres) from AG1 to AG5 and sent to a NATA accredited laboratory for analysis of the total soil suite. This included the analysis of pH, EC, S, P, Na, K, Ca, Mg, Al, Cl, Cu, Zn, Mn, Fe, B, NH4, NH3, organic matter, colour, texture, lime requirement, CEC, Ca/Mg ratio, % base saturation and P(BSES).

A summary of the depths at which samples were collected is provided in Table 6.1.1

Results discussed below are across all AG borehole locations. Samples retrieved were approximately 500g.

6.1.1 pH

pH ranged from 4 to 5.6. The median value for the dataset was a pH of 4.7.

Table 6.1.1 Summary of sample collection locations and depths

Location	Samples depths (mBGL)
AG1	0.0; 0.3; 0.4; 0.6; 0.7; 0.9; and 1.2
AG2	0.0; 0.2; 0.3; 0.4; 0.5; 0.7; and 1.0
AG3	0.0; 0.5; and 1.0
AG4	0.0; 0.3; 0.5; 0.7; 1.0; and 1.2
AG5	0-150; 200-300; 400-500; 500-700; 750-850; and 1-1.2[19]

6.1.2 Electrical Conductivity

The EC values ranged from 500 to 6,000 μS/cm. The EC median for the dataset was 2,000 μS/cm.

6.1.3 Nitrite and Nitrate

The results for nitrite and nitrate were primarily below the laboratory limit of reporting (<LOR). Of the samples sent for laboratory analysis, only two (AG5 0-150 and 200-300) returned results that were above the LOR; both 2 mg/kg.

6.1.4 Phosphorus

Results ranged from 2 to 15 mg/kg. The median result was 2 mg/kg for the dataset. Typically the phosphorus concentration was highest in the topsoil at all locations.

6.1.5 Potassium

Results ranged from 1.95 to 107 mg/kg. The median value for the dataset was 9 mg/kg. The potassium result that was highest in concentration (107 mg/kg) was AG4 topsoil (0.0 m). The 1.95 value was technically below the laboratory limit for reporting (<LOR). The 20th and 80th percentile range was 5.6 to 29.4 mg/kg respectively.

6.1.6 Calcium

Results ranged from 56 to 491 mg/kg across all samples. The median for the dataset was 191 mg/kg.

6.1.7 Magnesium

Results ranges from 8 to 97 mg/kg. The median value for the dataset was 50 mg/kg.

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[19] Depth range in mm below ground level.

6.1.8 Sulfur

Results ranged from 1 to 19 mg/kg. Median value for the dataset was 4 mg/kg. The highest results were recorded in the topsoil at AG4 (0.0 and 0.3 with results of 16 and 19 mg/kg respectively).

6.1.9 Trace elements

Iron – results ranged from 7 to 294 mg/kg. Median value for the dataset was 40 mg/kg. Iron concentration generally decreased with depth.

Manganese – manganese results ranged from 0.1 to 3.5 mg/kg. The median result for the dataset was 0.3 mg/kg.

Copper – results ranged from 0.2 to 0.9 mg/kg. The median value for the dataset was 0.4 mg/kg.

Zinc – results ranged from 0.05 (<LOR) to 2 mg/kg. The median result for the dataset was 0.2 mg/kg.

Boron – The majority of results were below the LOR. The remaining results ranged between 0.1 and 0.2 mg/kg.

6.1.10 CEC

Results ranged from 0.49 to 8.09 meq/100g. As predicted, the CEC generally decreased with depth. Sandy soils rely heavily on the high CEC or organic matter for the retention of nutrients in the top soil. The CEC of soils varies according to the type and percentage of clay, soil pH and the amount of organic matter. Sand generally has a lower CEC (<2 mew/100g). This is consistent with the median result of 1.87 mg/kg of the dataset.

6.1.11 P(BSES)

This analysis was completed due to the historic sugar cane production on the land. This analysis is an indicator of likely slow-release phosphorus reserves. The P(BSES) results decrease with depth in each of the boreholes. The top soil (0-300 mm) generally ranges from 17-40 mg/kg, with the deeper samples recovered (1m BGL) ranging from 7-9 mg/kg.

6.1.12 Soil model data assessment

The comparison of the soil properties modelled by the NSW data sets and the actual values (tables 6.12.1. to 6.12.3 below) for the soil sample sites shows the modelled properties unreliable in determining the soil characteristics., in particular CEC, EC and pH at depth. The prediction of pH at the surface is mixed with 3 of the 5 values being within the expected range.

Table 6.1.12.1 Comparison of soil samples from sample site average cation exchange capacity (cmol/kg) with NSW spatial data modelling soil properties for 0-30 cm and >30 cm depths

	Site data soil depth (m)		Modelled value soil depth (m)	
Site	0-30cm	>30cm	0-30cm	>30cm
Ag1	3.09	1.68	20-30	10-30
Ag2	3.20	1.24	10-15	10-30
Ag3	8.09	1.63	10-15	10-30
Ag4	6.33	1.92	10-15	10-30
Ag5	3.39	1.27	10-15	10-30

Table 6.1.12.2 Comparison of soil samples from sample site average electrical conductivity (ds/m) with NSW spatial data modelling soil properties for 0-30 cm and >30 cm depths

	Site data soil depth (m)		Modelled value soil depth (m)	
Site	0-30cm	>30cm	0-30cm	>30cm
Ag1	0.02	0.01	0.2-0.3	0.2-0.3
Ag2	0.02	0.01	0.2-0.3	0.2-0.3
Ag3	0.02	0.01	0.2-0.3	0.2-0.3
Ag4	0.05	0.02	0.2-0.3	0.2-0.3
Ag5	0.04	0.02	0.2-0.3	0.2-0.3

Table 6.1.12.3 Comparison of soil samples from sample site average pH (pH units) with NSW spatial data modelling soil properties for 0-30 cm and >30 cm depths

	Site data soil depth (m)		Modelled value soil depth (m)	
Site	0-30cm	>30cm	0-30cm	>30cm
Ag1	5.95	6.56	4.0- 5.5	4.0- 5.5
Ag2	5.90	6.20	4.0- 5.5	4.0- 5.5
Ag3	5.30	6.15	4.0- 5.5	4.0- 5.5
Ag4	5.30	5.40	4.0- 5.5	4.0- 5.5
Ag5	5.15	5.80	4.0- 5.5	4.0- 5.5

6.1.13 Soil classification

20 locations were chosen from the wider drilling scope to be included as observation locations for the agricultural assessment. These complement the five agricultural boreholes.

Colour was recorded in-situ using the Munsell Soil Colour Chart,[20] and provided by the laboratory analysis. The colour results from the laboratory was either grey, pale grey or dark grey. The colour recorded in-situ is provided on the borelogs in Appendix 6.

Texture was collected in-situ using the Australian Land and Soil Handbook,[21] and provided by the laboratory analysis. The laboratory texture was either sand or sandy loam. In this instance the texture provided in-situ by suitably qualified G&S personnel is a more appropriate characterisation.

Observation holes aided in the determination of soil type and depth of resource. The soil map is provided in Drawing No. 12035-303.

The following soil orders (or types) were identified:

> **Tenosols** – The soils at the site generally fall within the Tenosol soil type. Tenosols are generally only weak pedologic organisation apart from the A horizons. The soil order encompasses a rather diverse range of soils, which are nevertheless widespread in many parts of Australia.
>
> **Podosols** – Soils which possess either a Bs horizon (visible dominance of iron compounds) a Bhs horizon (organic-aluminium and iron compounds) or a Bh horizon (organic-aluminium compounds). There horizons may occur singly in a profile or in combination.

A previous report (G&S 2005) identified the soils as Oxyaquic Hydrosols – soils with a seasonal or permanent water table in which the major part of the solum is whole coloured (Isbell, 1996). The climate and land use may be playing a role in the interpretation of the waterlogged nature of this landform. The recent survey was undertaken during an extended low rainfall period and the existing lake has established an alternate water table regime.

In the event of extended wet seasons climate change and the sea level rise it is likely these soils would display the hydrosol properties that would result in permanent waterlogging and development of swamp-like landform.

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[20] Munsell Soil Colour Charts (2015) Produced by Munsell Colour.

[21] The National Committee on Soil and Terrain, Australian Soil and Land Survey Handbook (3rd edition), CSIRO publishing.

7 Results – Land assessments

The results in this section include interpretation of the soils and landform to derive:

- Land and soil capability.
- BSAL Assessment.
- Land suitability assessment.

7.1 Land and Soil Capability (LSC) assessment

The following limitations were assessed to be applicable to the site. The decision tables for individual hazards in the land and soil capability assessment scheme were used to identify the land suitability class (see Table 4.3.1.1, page 20).

Each hazard is assigned one of the eight classes, where Class 1 represents the least hazard and Class 8 represents the greatest hazard. The final hazard assessment for the site is based on the highest hazard in that parcel of land (for example the land may be assessed to have no significant hazard for several limitations, but a Class 8 hazard for mass movement hazard; therefore the land is Class 8 land).

A summary of the results from the assessment is provided in Table 7.1.1, with the overall suitability class for each UMA. Drawing No. 12035-305 show the soil and land capability class for the site based on the identified limitations.

The land and soil classification of these parts of the landscape ranges from Class 5 (moderate to low capability) to Class 6 (low capability).

Although the land and soil capability suggests a low capability, such land in this location has the potential to be used as sugar production area (with installation of suitable drainage) or used for specialist estate crops such as a tea tree oil plantation.

7.1.1 Water erosion

Water erosion hazard refers to the likelihood of soil detachment and movement under the effects of raindrop impact, initiation of runoff, and flowing water. In assessing the water erosion hazard for the site, a slope analysis was completed. The slope analysis is provided in Drawing 12035-302 and shows the majority of the site as being <1% slope. The agricultural drains shown on the drawing as disregarded as they are not representative of the true slope on the site. Using Table 4 in the assessment scheme the site is located in the eastern and central division of NSW, and the slope percentage categorizes the site into Class 1 land for both UMA 1 and 2.

7.1.2 Wind erosion

Wind erosion hazard refers to the likelihood of soil detachment and movement under the effects of wind blowing across the soil surface. Wind erosion tends to be more prevalent in coastal areas. The major effects of wind erosion are loss of soil from the landscape and subsequent deterioration in the land's productive capacity.

Table 7.1.1 Limitations and determined suitability subclasses for the site

Limitations and suitability subclass (1 to 8)	UMA 1 Tenosol on <1% slope	UMA 2 Podosol on <1% slope
Water erosion	1	1
Wind erosion	4	4
Soil structure decline	3	3
Soil acidification	3-4	3-4
Salinity hazard	2	2
Waterlogging hazard	5-6	5-6
Shallow soils and rockiness hazard	NA*	NA*
Mass movement hazard	1	1
Overall Land Class	**5-6**	**5-6**

NA* - not applicable to the site

The surface soil at the site falls under a loam, clay loam or clays (all with >13% clay), however because the site is in an open plain the wind erosive power would be considered high. In addition to the high average rainfall (>500 mm annually), the site fall into Class 4 land.

7.1.3 Soil structure decline

Soil structure decline refers to the breakdown of the physical arrangement of soil particles and pore spaces in the soil, typically as a result of compaction and tillage. The effects of poor soil structure include low infiltration and runoff resulting in water erosion and less than optimum use of rainfall for plant growth, overall poor plant growth, poor germination ad emergence of crops and poor friability of soil making them difficult and costly to till and sow.

The field texture of the site's surface soil were primarily clay loam, which means the land falls into Class 3 land for soil structure decline hazard.

7.1.4 Soil acidification

Soil acidification hazard is a major limitation in many important areas of agricultural production in NSW. As soil acidification can dramatically impact plant growth, it therefore has the potential to decrease farm productivity. This is associated with an increased potential for soil erosion and increased recharge into groundwater systems, leading to increased salinity hazard.

The buffering capacity of UMA 1 is estimated to be high as the surface soils in that area are primarily clays. Using the soil texture and the pH of the natural surface soil (in the general range of 4.0 to 4.7), the land class for soil acidification for UMA 1 is Class 3.

The buffering capacity of UMA 2 is estimated to be moderate as the surface soils in that area are primarily loams and clay loams. Using the soil texture and the pH of the natural surface soils (in the general range of 4.7 to 6.0), the land class for soil acidification for UMA 1 is Class 3.

7.1.5 Salinity hazard

Salinity hazard is the potential for salts to be mobilised in a catchment and brought to the ground surface and waterways by changes in land use and land management. Widespread vegetation clearing, excessive irrigation inputs and other land management practices that increase recharge to groundwater are major drivers for this hazard.

Salt has a highly adverse effect on plant growth by increasing the difficultly for plants to extract water, increasing the level of toxic elements to plants, and increasing sodicity levels in soils with results soil structure decline. Reduced plant growth is associated with reduced crop and pasture productivity and increase soil erosion.

Salinity hazard requires consideration of the recharge potential, discharge potential and salt stores. For the site the recharge potential is considered high, the discharge potential moderate due to the high water table, and a low salt store according to Figure 7 in the assessment scheme. These factors group the site into Class 2 land for salinity hazard.

7.1.6 Waterlogging hazard

Waterlogging is a major limitation in low-lying areas of the landscape. Waterlogging can severely affect agricultural production and land use as it restricts or prevents the supply of oxygen to plant roots. The majority of agricultural crops and pasture plants will suffer, in addition to increased access difficulties for vehicles, tillage and sowing operations and stock management.

The drainage regime is dominated by the landform and the presence of a shallow water table (at a depth of 0.5 to 1.0 m). The depth of this water table restricts the site's vertical drainage.

The landform has a slope of less than 1% and water ponds on the site for extended periods of time. The existing drainage system is made up of shallow surface drains (to depths of approximately 0.3 m) discharging to the constructed drains of about 1 m depth. These main drains allow tidal waters to enter the site.

It is estimated that the site's typical waterlogging duration (in months) e is between 2 and greater than 3 months per annum depending on the location within each UMA. This estimation indicates that a land class for waterlogging hazard of between 5 and 6 to reflect poorly to imperfectly drained landform with extended periods of waterlogging after rainfall events. The resultant LSC rating for each UMA is assessed as class 5 (moderate to low capability) to class 6 (low capability).

7.1.7 Shallow soils and rockiness hazard

Shallow soils and rockiness recued the land-use capability of soils and land. The more rock outcrop and the shallower the soils, the less volume of soil available for storing nutrients and water. Upon assessment of the site, there are no obvious rock outcrop and the soils do not appear to have any impediments in terms of depth. The decision table in the assessment scheme for this particular hazard does not apply as there is no appropriate application for rock outcrop or soil depth. In this instance, this hazard is not applied in the assessment.

7.1.8 Mass movement hazard

Mass movement relates to the large scale movement of earth under the force of gravity. It is a function of the gravitational stress acting on the land and the resistance of the surface soil, sand or rock material to dislodgement. Certain combinations of slope, soils, landform, climate and geology are more susceptible to mass movement. Disturbance of soils in some land management actions can also increase the likelihood of mass movement.

The mean annual rainfall (>500mm), negligible likelihood for mass movement to be present, and little to no slope on the site means the land class for mass movement hazard is Class 1 for the site.

7.2 Biophysical Strategic Agricultural Land (BSAL)

The land mapped as BSAL on the site is an isolated parcel that is not contiguous with any other BSAL. This is because:

- the mapped BSAL east of the site is occupied by an existing sand extraction area and is unequivocally alienated from agricultural production;
- the land to the north is occupied by a existing sewage treatment plant and again is unequivocally alienated from agricultural production;
- the land to the south is not land but a lake; and
- the land to the west is not BSAL.

The total area of contiguous mapped BSAL is less than 9ha and as such does fulfil the minimum size criteria of greater than 20 ha.

The relevant soil description associated with the BSAL mapped on the site was AG1 and acid sulfate assessment bore AS42.

Bore AG1 had a 0.3m A horizon of a silty clay loam overlying loamy sands and sands. A conspicuous bleached layer was 0.4 to 0.6 mBGL. The water table was encountered at approximately 0.8 mBGL. Its Australian soil classification was assessed as a bleached orthic tenosol.

The bore AS42 on the boundary of the mapped BSAL a similar silty clay loam A horizon but to approximately 0.4mBGL underlain by a sandy loams and loamy sand at depth. The sand underlying the A horizon was wet with free water encountered at 0.9m (BGL)

Australian soil classification of bleached orthic tenosol (or grey orthic tenosol) with light sandy textured horizons(<15% clay) is identified as moderately low fertility (fertility ranking 2 as per Appendix 2 of the interim protocol for BSAL). The land unit fails the seventh criteria of at least moderate soil fertility.

Furthermore, the land and soil capability of Class 5-6 is not consistent with the intent of the BSAL classification to be based on land and soil capability classes 1, 2 or 3.

7.3 Agricultural land suitability

Both UMA on the site display imperfect to poor drainage. This single characteristic places the site within the agricultural suitability class 3 to 4.

The assessment of each UMA is outlined in tables 7.3.1 and 7.3.2.

Table 7.3.1 Agricultural suitability assessment criteria and results for UMA 1

Criteria	UMA1	Suitability rating
Soil depth	>0.5m	1
Drainage	Imperfect to poor	3-4
Soil pH	>4	1
Salinity	<5dS/m	1
Sodicity	ESP<10%	1
Gravel and stone	nil	1
Boulders and rock outcropping	nil	1
Soil erosion hazard	low	1
Soil erosion present	nil	1
Final suitability		3-4

Table 7.3.2 Agricultural suitability assessment criteria and results for UMA 2

Criteria	UMA2	Suitability rating
Soil depth	>0.5m	1
Drainage	Imperfect to poor	3-4
Soil pH	>4	1
Salinity	<5dS/m	1
Sodicity	ESP<10%	1
Gravel and stone	nil	1
Boulders and rock outcropping	nil	1
Soil erosion hazard	low	1
Soil erosion present	nil	1
Final suitability		3-4

7.4 Important Agricultural Land (IAL)

NSW DPI is currently undertaking a mapping program across NSW to assist in the recognition of IAL with an expected completion date of November 2020 (at the date of this report).

7.5 Regional significant farmland

Planning documents that outline the region's future include:

- the North Coast Regional Plan 2036; and
- the Far North Coast Regional Strategy 2006-2031.

The North Coast Regional Plan 2036 estimates the gross value of agriculture (2014-2015) to be $930 million. However, rapid population growth and a growing number of tourists visiting the region has resulted in a change from an economy dominated by agriculture to one now dominated by service sector industries (84%) and manufacturing and construction (12%).[22]

An assessment of socio-economic aspects revealed that the potential for agricultural production in the area was generally restricted. This was because crops suited to the area can be more efficiently produced on a larger scale in areas such as the Atherton Tablelands and Bundaberg due to economies of scale (larger farms) and improved logistics, allowing the transport of produce from these areas to major markets throughout Australia. Local producers, with relatively small landholdings in the region, are unlikely to be competitive in this market due to the scale and nature of the larger operations.

Nevertheless the site is mapped under these planning documents as important farmland albeit limited in potential to sugar cane and estate crops such as tea tree oil plantations.

Similarly, the Northern Rivers Farmland Protection Project mapped the site as regionally significant farmland based on it sugar cane production potential.

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[22] NSW Department of Planning, Far North Coast Regional Strategy 2006 to 2031, (2006)

8 Results – Land use conflict and separation

This section presents the results addressing the land use conflict and separation issues.

8.1 Surrounding land use compatibility

Under the LEP 2014, the majority of the site is mapped as RU1 defined as Primary Production and a small portion in the southern portion of the site is zoned as RU2, Rural Landscape. The objectives of the RU1 zone are:

- *To encourage sustainable primary industry production by maintaining and enhancing the natural resource base.*
- *To encourage diversity in primary industry enterprises and systems appropriate for the area.*
- *To minimize the fragmentation and alienation of resource lands.*
- *To minimize the conflict between land uses within this zone and land uses within adjoining zones.*
- *To protect prime agricultural land from the economic pressure of competing land uses.*

It is noted that 'Extractive industries' are permitted with consent in this zone under the LEP 2014.

The site's southern portion is zoned as RU2 Rural Landscape, with objectives of the zone including:

- *To encourage sustainable primary industry production by maintaining and enhancing the natural resource base.*
- *To maintain the rural landscape character of the land.*
- *To provide for a range of compatible land uses, including extensive agriculture.*
- *To provide for a range of tourist and visitor accommodation-based land uses, including agri-tourism, eco-tourism and any other like tourism that is linked to an environmental, agricultural or rural industry use of the land.*

As with RU1, the land zoned as RU2 also permits with consent 'Extractive industries'.

The adjacent agricultural land is currently used for tea tree planation, cropping/horticulture or cattle grazing. Drawing No. 12035-306 shows the surrounding agricultural land including potential land use based on the biophysical characteristics of the landform.

An impact assessment of the proposed development on the surrounding sensitive receptors and the mitigation strategies are the subject of a separate assessment and report.

8.2 Land Use Conflict Risk Assessment

A Land Use Conflict Risk Assessment (LUCRA) was completed to accurately identify and address potential land use conflict issues and risk of occurrence. The results are provided in Table 8.2.1 (on the following page). The assessment was based on the current and potential land use permitted in the relevant land zoning.

The impact of adjacent agricultural activities on the proposed sand extraction development is unlikely to occur because the development is an extractive industry with no residence and human occupied areas are remote from agricultural activities. Any consequence of the agricultural activity would be minor because of the inherent nature of the proposed development.

8.3 Agricultural buffer zone

The role of the agricultural buffers is to protect the proposed sand extraction industry from the surrounding activities of existing and potential agricultural activities on the site boundary. The proposed development involves no residential, commercial or business activities on the site. The activities on site requiring personnel are limited to the sand extraction (i.e. shifts that are limited to daylight hours), with activities occurring at a site office, weighbridge, amenities area and a repair workshop. As such the proposed activity does not require protection from the surrounding agricultural pursuits.

Table 8.3.1 LUCRA - agricultural uses adjacent to development site

Hazard	Mitigating factors	Consequence	Probability	Score
Land Use Zone 1 (Potential cropping - sugar and tea tree plantations)				
Spray drift	• Class 5-6 land • Restricted access development site is a sand extraction area with limited numbers of personnel on suite, Staff office, crib room and workshops remote from agricultural activities and separated from potential farm land by a distance greater than 300m • burning of stubble is undertaken on the local sugar cane paddocks but are distant (>1km) from the office, crib rooms and workshop area of the development	Negligible	D	2
Odour		Negligible	D	2
Noise		Negligible	D	2
Dust/smoke and ash		Negligible	D	2
Land Use Zone 2 (Grazing)				
Odour	• Class 5-6 land • Restricted access at site boundary because project is a sand extraction area	Negligible	D	2
Noise		Negligible	D	2
Land Use Zone 3 (Infrastructure)				
No agricultural uses				
Land Use Zone 4 (Sand extraction)				
No agricultural uses				
Land Use Zone 5 (Waste Water Treatment Facility)				
No agricultural uses				
Land Use Zone 6 (Residential)				
No agricultural uses				
Land Use Zone 7 (Cultivation - horticulture)				
spray drift	• Activity remote from site – > 300m • Vegetation buffer separating work area of proposed development site from agricultural activities • Restricted access to development site	Negligible	D	2
Dust		Negligible	D	2
Noise		Negligible	D	2
Land Use Zone 8 (Golf Course)				
No agricultural uses				

Indeed the guideline[23] (at table 6, page 90) does not include 'extractive industry' as an activity that requires separation from primary industries. The proposed extractive industry operation at TSP is considered a primary industry itself.

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[23] Learmouth R, Whitehead R, Boyd B and Fletcher S 2007 Living and working in rural areas – A handbook for managing land use conflicts on the NSW north coast NSW Department of primary industries ISBN 978-0-646-48527-0.

8.4 Cumulative impact on agricultural use – sugar

The agricultural assessment indicates the highest and best use of the land in agricultural terms is most likely sugar cane. Although Tea tree plantations are possible the market is limited and the capital cost significant in comparison with an existing sugar cane production area. As such the impact of conversion of this land to a sand mine is most appropriate to use sugar as the assessment yard stick

The historical data for the Condong mill is outlined in table 1 (next page). The data set span the period from 2000 to 2019 and describes the cane areas, yields, sugar content and income per hectare for each year. The amount of cane farmed and harvested over that period has had a decline from 8131.7ha (2000) to 6557.8ha (2019) and 5509.4 (2000) to 4454.6 (2019) respectively. The decline is significant with a Mann-Kendall trends analysis indicating that there is at least a 99.9% probability that the decline is real or statistically significant. The area farmed seems to have stabilised at about the 6550ha area.

The loss of cane farmland may be due to a multitude of influences some to encroachment from non-rural activities but mainly due to landholders leaving the industry and undertaking alternate land use such as grazing, and horticulture on sites less constrained than the proposed development site. Further influences on land use relate to the changing age distribution of farmers and the realignment of these farmers to activities less intensive than cane farming.

Within the Condong mill area this loss of farm land equates to some 1574ha of cane farm land being converted to alternate purposes. The proposed development of the sand extraction is in an area that has not been in cane production for approximately a decade and this redeployment of the land to alternate uses to sugar cane has already occurred.

The total area of additional land redeployed to the expansion of the sand extraction will be approximately 190ha. This expansion area is approximately 12% of the total loss of cane farm land to other purposes. In total the combined foot print for the sand extraction area is 236ha. Cane production on this site has been not undertaken for over a decade. In any event, there would be still significant un-used cane farm land that present an opportunity to be converted back to cane farming if the market mechanisms and community will was sufficient undertake the task

The conversion of this land to a sand mine will have no material impact on the cane industry.

Table 8.4.1 Historical sugar cane harvest , farming yields and income from 2000 to 2019 (inclusive) with a statistical description of each parameter. (Source: Condong crop and variety report 2019 season sunshine sugar)

Year	Harvest. Area	Farm Area	%Harvest	Tonnes Cut	CCS	Cane T/Ha Harv.	CaneT/Ha Farmed	SugarT/ha Harv'	SugarT/Ha Farmed	$/Ha Harv'	$/Ha Farmed
2000	5509.4	8131.7	67.80%	507,258	11.89	92	62	10.9	7.4	$1,902	$1,289
2001	5450.8	7993	68.20%	542,834	11.86	100	68	11.8	8.1	$2,207	$1,505
2002	5943.7	8070.9	73.60%	687,813	11.45	116	85	13.2	9.8	$2,062	$1,519
2003	5669.6	8047.4	70.50%	627,012	11.83	111	78	13.1	9.2	$1,490	$1,050
2004	5780.5	7964.9	72.60%	608,803	11.8	105	76	12.4	9	$1,805	$1,310
2005	5003.7	7935.5	63.10%	618,192	10.76	124	78	13.3	8.4	$2,169	$1,368
2006	5112.6	7762.9	65.90%	676,671	10.8	132	87	14.3	9.4	$2,683	$1,767
2007	4722.5	7665.4	61.60%	525,852	10.55	111	69	11.7	7.2	$1,826	$1,125
2008	3975.9	7428.1	53.50%	487,070	9.41	123	66	11.5	6.2	$1,773	$949
2009	4846.1	7285	66.50%	456,410	11.7	94	63	11	7.3	$2,667	$1,774
2010	4507.4	7159	63.00%	458,127	10.42	102	64	10.6	6.7	$2,334	$1,470
2011	3635.1	7017.9	51.80%	312,852	11.08	86	45	9.5	4.9	$2,061	$1,068
2012	4306.8	6803.3	63.30%	301,379	12.27	70	44	8.6	5.4	$2,080	$1,317
2013	4191.1	6891.1	60.80%	321,454	11.71	77	47	8.9	5.4	$2,004	$1,219
2014	4542.5	6858.6	66.20%	536,697	10.93	118	78	12.8	8.5	$2,521	$1,669
2015	4508.8	6662.5	67.70%	551,288	11.94	122	83	14.6	9.9	$2,545	$1,722
2016	4688.5	6636.8	70.60%	558,780	12.06	119	84	14.1	10	$3,542	$2,502
2017	4455.2	6554	68.00%	522,813	11.9	117.3	80	14	9.5	$3,149	$2,140
2018	4512.6	6524.1	69.20%	530,167	11.73	117.5	81	13.8	9.5	$2,734	$1,891
2019	4454.6	6557.8	67.90%	520,322	12.2	116.8	79	14.3	9.7	$2,694	$1,830
Mean	4791	7297	66%	517,590	11.41	107.7	70.9	12.2	8.1	$2,312	$1,524
Median	4616	7222	67%	528,010	11.72	113.5	77.0	12.6	8.5	$ 2,188	$1,487

9 Conclusions

To meet ongoing demand for sand, Hanson seeks to expand its existing operations into 190 ha of lands to the north and west of the TSP site, giving a total combined footprint of 236 ha for the existing and future extraction areas.

The proposed expansion area covers lands that had been used originally for sugar cane production, but in more recent times cattle grazing, resulting in the permanent loss of these lands. As such an Agricultural Land Capability Assessment is required for the site.

Hanson commissioned G&S to address the Secretary's Environmental Assessment Requirements regarding agricultural issues by:

- Completing an Agricultural Land Assessment (ALA) within the proposed expansion area.
- Assessing the adjacent land uses and potential land uses to inform a land use conflict assessment.
- Completing a land use conflict assessment, including defining agricultural buffer requirements for the proposal.
- Estimating the likely impacts of climate change.

The assessment described in this report evaluated the suitability of the site for future agricultural use determined the development's direct and cumulative impacts on any likely preferred uses of land in the vicinity of the development, together with ways in which the development may be incompatible with any of those existing, approved or likely preferred uses for the adjoining land.

A drilling program involving soil cores to 1.2 mBGL at five locations to sample and characterise the site soils was conducted. These five 'observation' locations were complemented by soils data from 20 deeper boreholes constructed to approximately 20 mBGL as part of an Acid Sulfate Soil Investigation.

The site soil sampling and classification comprised laboratory analysis and interpretation of results. The results were used to assess and classify the site against the following agricultural land assessment methods for NSW:

- Land and Soil Capability mapping (LSC)
- Biophysical Strategic Agricultural Land mapping (BSAL)
- Agricultural Land Classification (ALC)
- Important Agricultural Land (IAL)
- Regional Farmland Mapping.

The following soil orders (or types) were identified:

- Tenosols; and
- Podosols.

Based on the findings of the Agricultural Land Assessment, the majority of the expansion area exhibits poorly to imperfectly drained soils with waterlogging typically between 2 months to greater than 3 months of the year.

The land and soil classification of these parts of the landscape ranged from Class 5 (moderate to low capability) to Class 6 (low capability). The land associated with the mapped BSAL had similar waterlogging characteristics LSC class 5-6 but was subject to soil structure decline (LSC rating 4) and poor buffering capacity (also LSC rating 4). As such the remainder of the site was classified as 'Class 5-6'.

Whilst the land and soil capability suggests a low capability, such land in this location may be used as sugar production area (with installation of suitable drainage) or for specialist estate crops such as a tea tree oil plantation.

The NSW Government has undertaken regional scale mapping of BSAL in the Tweed Shire. The current BSAL mapping included a portion to the north of the existing operational site. The area was mapped as having moderately high soil fertility under the SEED mapping. The Strategic Agricultural Land Map under the SEPP (Mining, Petroleum Production and Extractive Industries) 2007 also showed a mapped area of BSAL.

The BSAL land was assessed using the NSW Government Interim protocol for site verification and mapping of biophysical strategic agricultural land (2013). The total area of contiguous mapped BSAL is less than 9 ha and as such does fulfil the minimum size criteria of greater than 20 ha. The site was also assessed as moderately low fertility (fertility ranking 2) based on its Australian Soil Classification of bleached orthic tenosol (or grey orthic tenosol) with light sandy textured horizons. Also, the land and soil capability of Class 5-6 is not consistent with the of BSAL classification for land and soil capability classes 1, 2 or 3.

The agricultural suitability classification for the site was found to be class 3 to 4 based on the land's imperfect to poor drainage.

NSW DPI is currently undertaking a mapping program across NSW to assist in the recognition of important agricultural land with an expected completion date of November 2020 (at the date of this report). The overall scope of this report addresses the mapping outcomes of the IAL mapping.

The site is mapped under the North Coast Regional Plan and strategy planning documents as important farmland, albeit limited in potential to sugar cane and estate crops such as tea tree oil plantations. Similarly, the Northern Rivers Farmland Protection project mapped the site as regionally significant farmland based on it sugar cane potential.

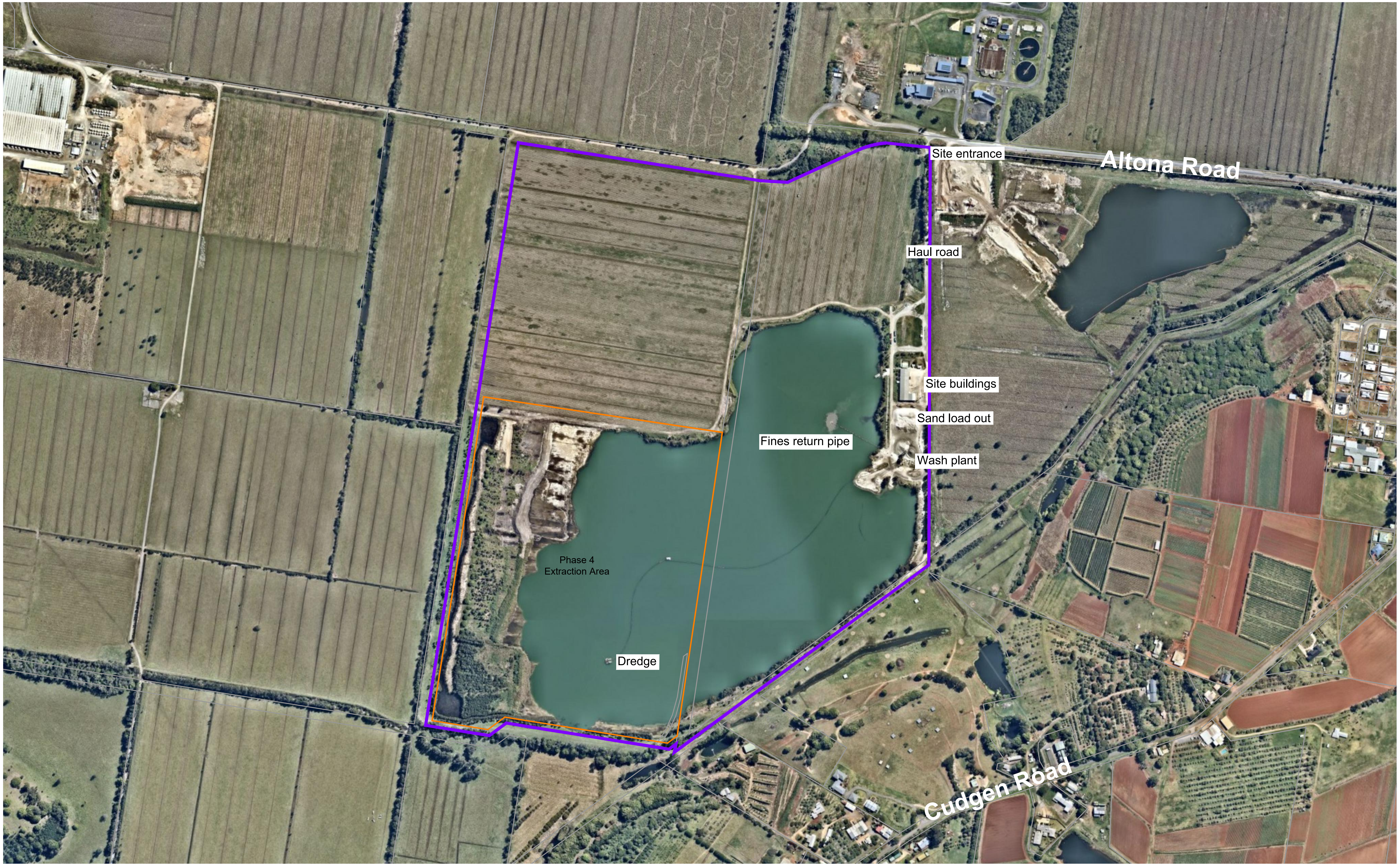
The site's long term capability to support agricultural production was evaluated with respect to climate change. The future agricultural production potential of this land was limited, based on TSC's Climate Change Management Policy's adoption of a sea level rise of 0.4 m by 2050 and 0.9 by 2100 (above 1990 mean sea levels), as well as its predicted increase in the frequency and depth of tidal inundation of low lying lands and poor drainage in low lying areas.

The proposed expansion area is a low-lying coastal floodplain which is currently subject to tidal inflows from the Tweed River for part of the site. The predicted sea level rise will exacerbate the tidal inundation and will impede the site's drainage, leading to increased water-logging and salinisation of soils. As time progresses the site (and indeed the adjacent land uses on the same landform) will degrade further with a consequent reduced capacity to support agricultural production.

The Land Use Conflict Risk Assessment found that the adjacent agricultural land uses and any potential land use will not impact the proposed development.

Detailed findings of this ALCA will be reported in the EIS, including further consideration of Important Agricultural Lands, Regional Farmland Mapping, BSAL and climate change impacts.

10 Appendix 1 – Drawing package



ORIENTATION

SCALE

50 100 150 200 250 300
metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND

— Site Boundary
▭ Phase 4 Extraction Area (indicative only)

SOURCES

Image: Nearmap 2020. Image date: 14/09/2020

PROJECT	CLIENT	DRAWING
TWEED SAND PLANT EXPANSION	HANSON CONSTRUCTION MATERIALS	EXISTING TWEED SAND PLANT OPERATION

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
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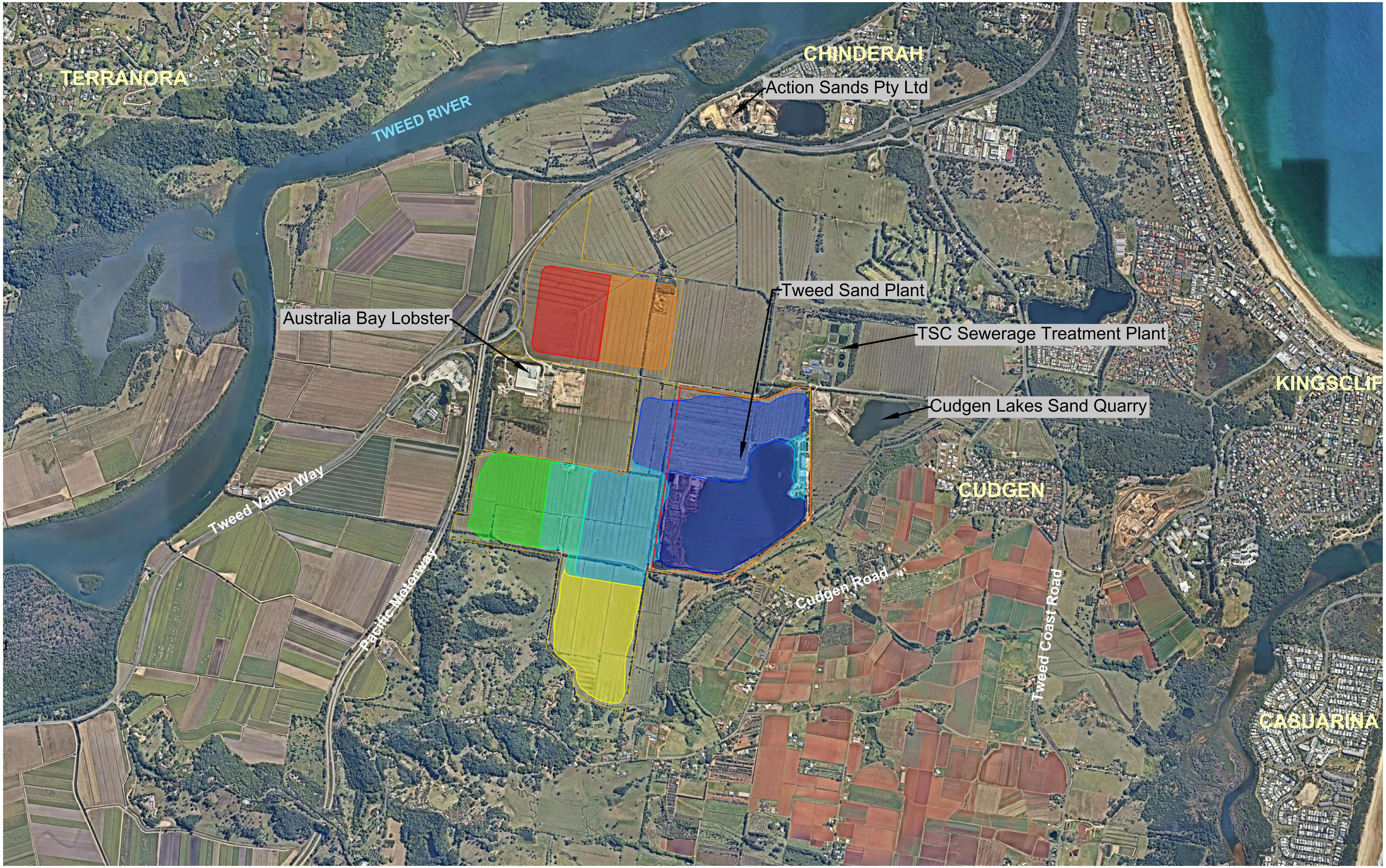
GILBERT SUTHERLAND



ORIENTATION

SCALE

200 400 600 800 1000
metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND

- 🟥 Site boundary - existing
- 🟨 Site boundary - expansion area

INDICTIVE EXPANSION AREA PHASES

- 🟦 Phases 1-4 (approved)
- 🟦 Phase 5
- 🟦 Phase 6
- 🟩 Phase 7
- 🟩 Phase 8
- 🟨 Phase 9
- 🟧 Phase 10
- 🟥 Phase 11

SOURCES

Image: Nearmap 2020. Image date: 14/09/2020

PROJECT
TWEED SAND PLANT EXPANSION

CLIENT
HANSON CONSTRUCTION MATERIALS

DRAWING
PROPOSED TWEED SAND PLANT EXPANSION

SCALE	**DATE**	**DRAWN**	**CHECKED**	**PROJECT**	**DRAWING**	**REVISION**
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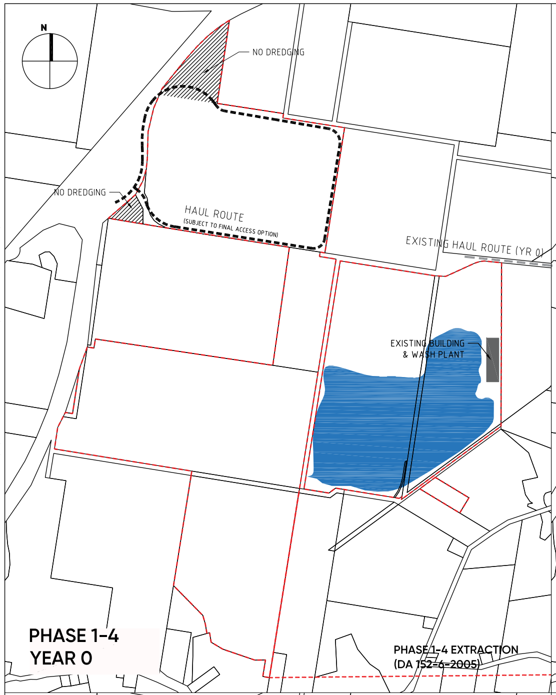
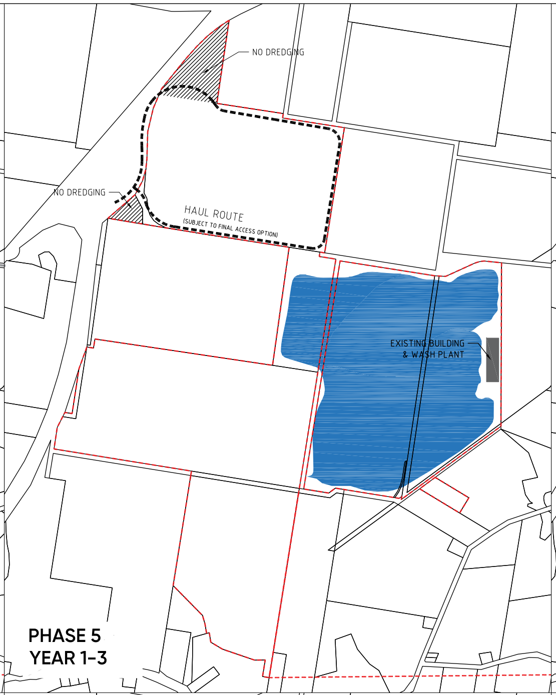

PHASE 1-4
YEAR 0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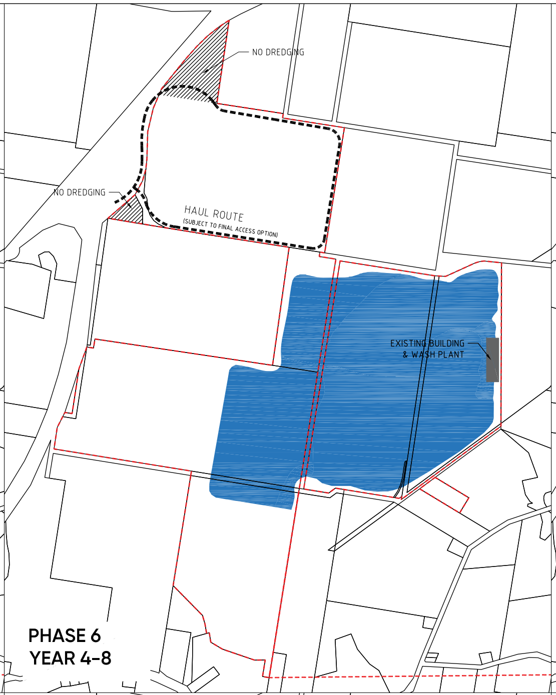
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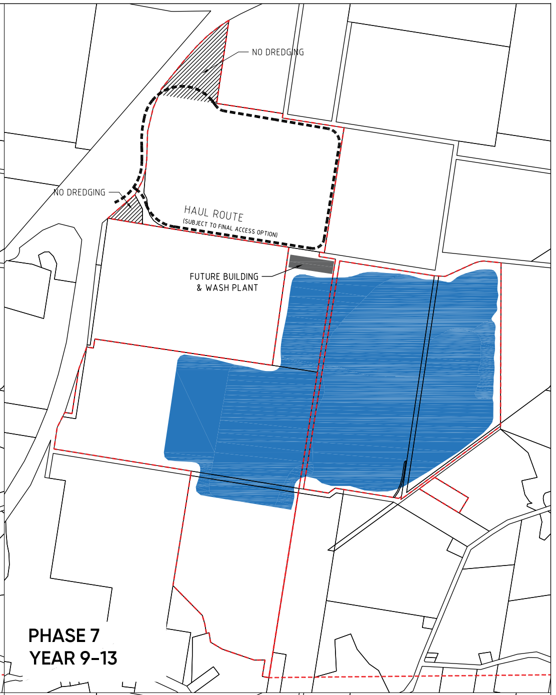
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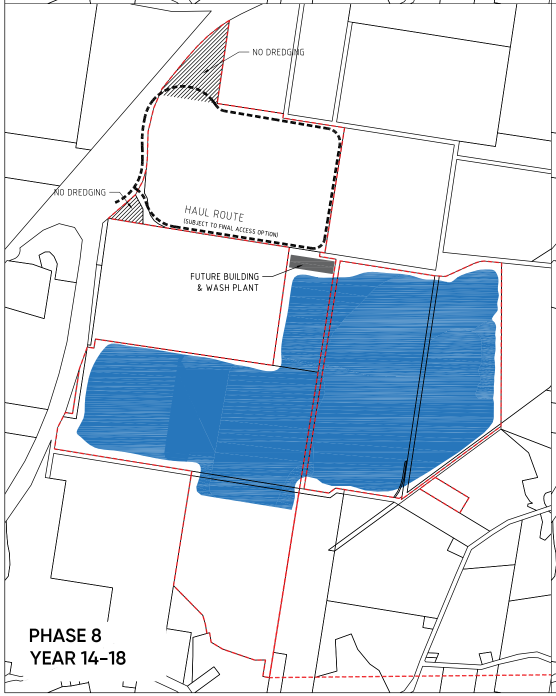
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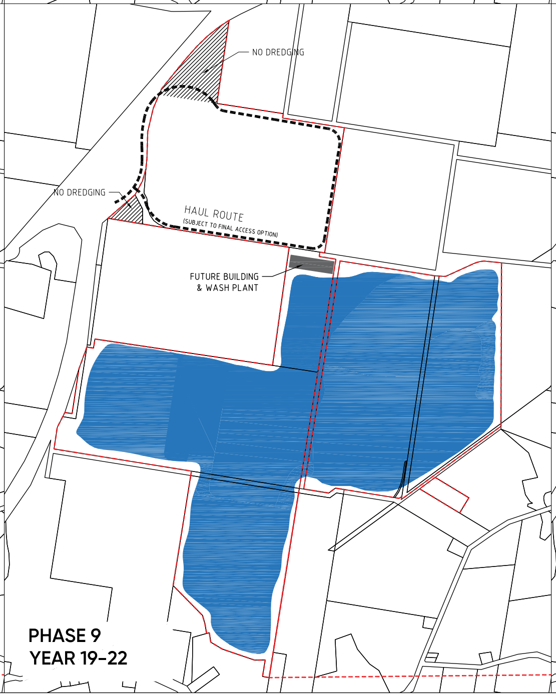
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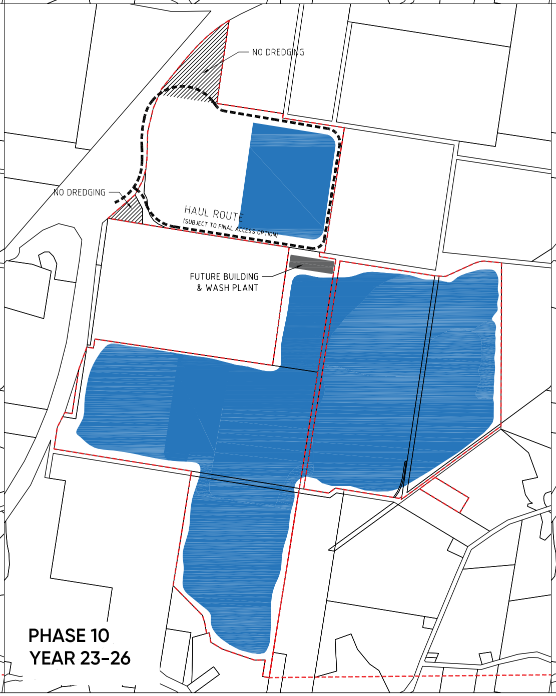
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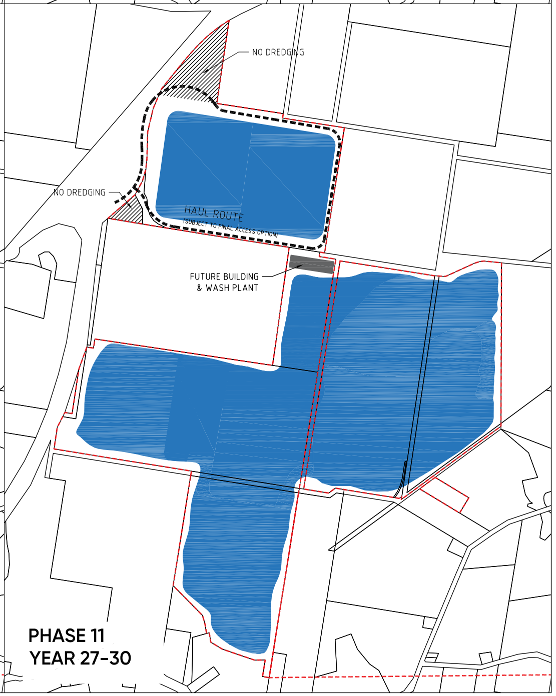
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YEAR 27-30

PROJECT TITLE

HANSON TWEED SAND PLANT

PHASE 5-11

DRAWING TITLE

CONCEPT DEVELOPMENT PHASING

REV	DESCRIPTION	DATE	DRAWN	DESIGN	CHECK	APPROVED
A	PASHING ARRANGEMENT CHANGES - REQ. PLANNER	25.01.2021	ZP	LN	LN	LN

ISSUE: PRELIMINARY

CLIENT: HANSON CONSTRUCTION MATERIALS PTY LTD

BASE PROVIDED BY: SIXMAPS DCDB

MANAGER: LANCE NEWLEY

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JOB / DRAWING NO:
Z19163- 104

SHEET NO.
SHEET 01 OF 01

ORIENTATION

SCALE 1:12 500
100 200 300 400 500 600
metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND

—	Assessment Boundary
⊕	ASS Boreholes
⊕	AG Boreholes

SOURCES

Image: Nearmap 2020. Image date: 14/09/2020

PROJECT
TWEED SAND
PLANT
EXPANSION

CLIENT
HANSON
CONSTRUCTION
MATERIALS

DRAWING
BOREHOLE LOCATIONS

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
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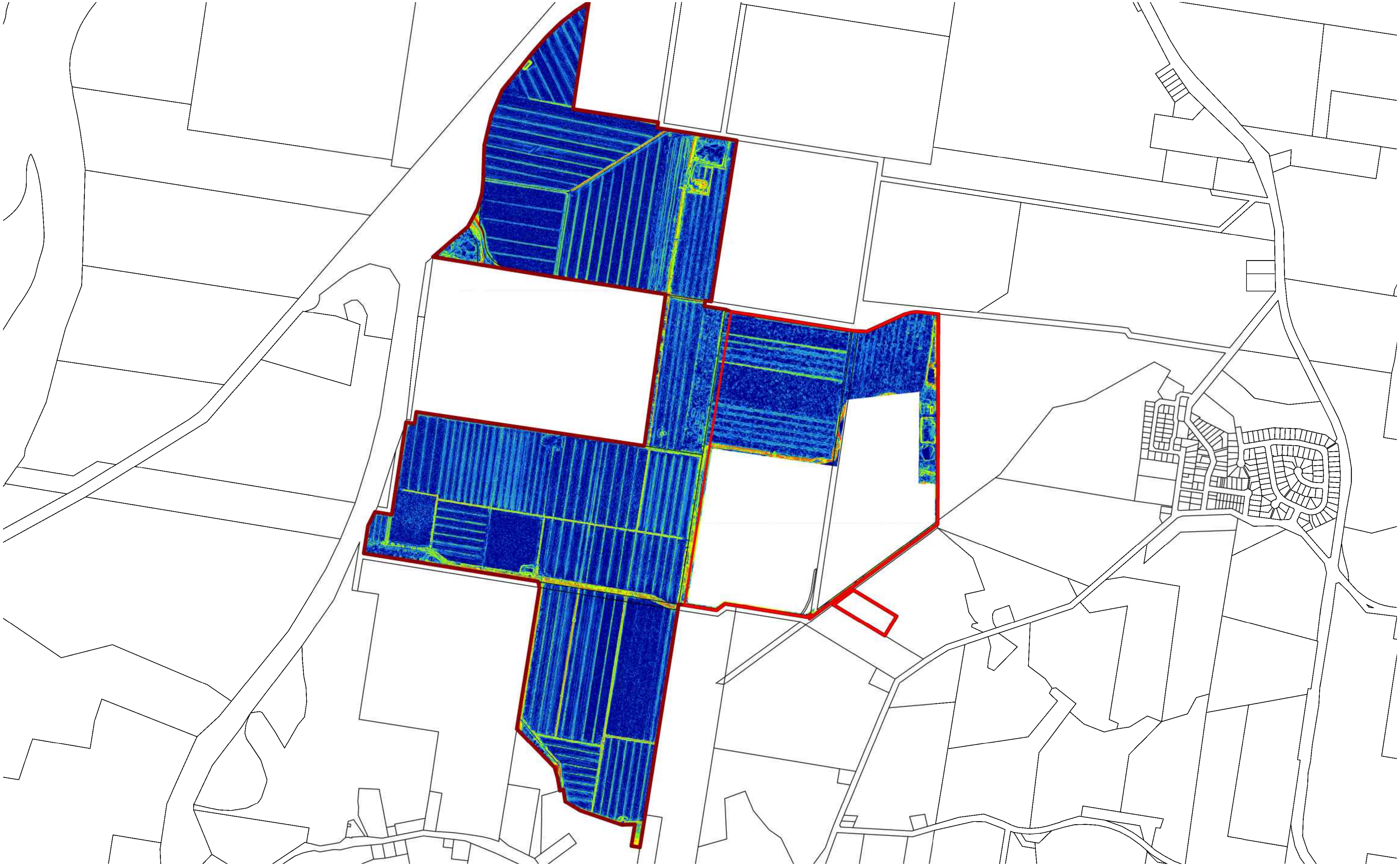

ORIENTATION

SCALE

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metres

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LEGEND

SLOPE (%)

🟦 0 to 1	🟧 20 to 33
🟦 1 to 3	🟥 33 to 50
🟩 3 to 10	🟥 > 50
🟨 10 to 20	

SOURCES

Slope analysis: Based on 1 metre LiDAR for Tweed Heads Region (September 2013), ANZLIC

PROJECT
TWEED SAND PLANT EXPANSION

CLIENT
HANSON CONSTRUCTION MATERIALS

DRAWING
SLOPE ANALYSIS

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
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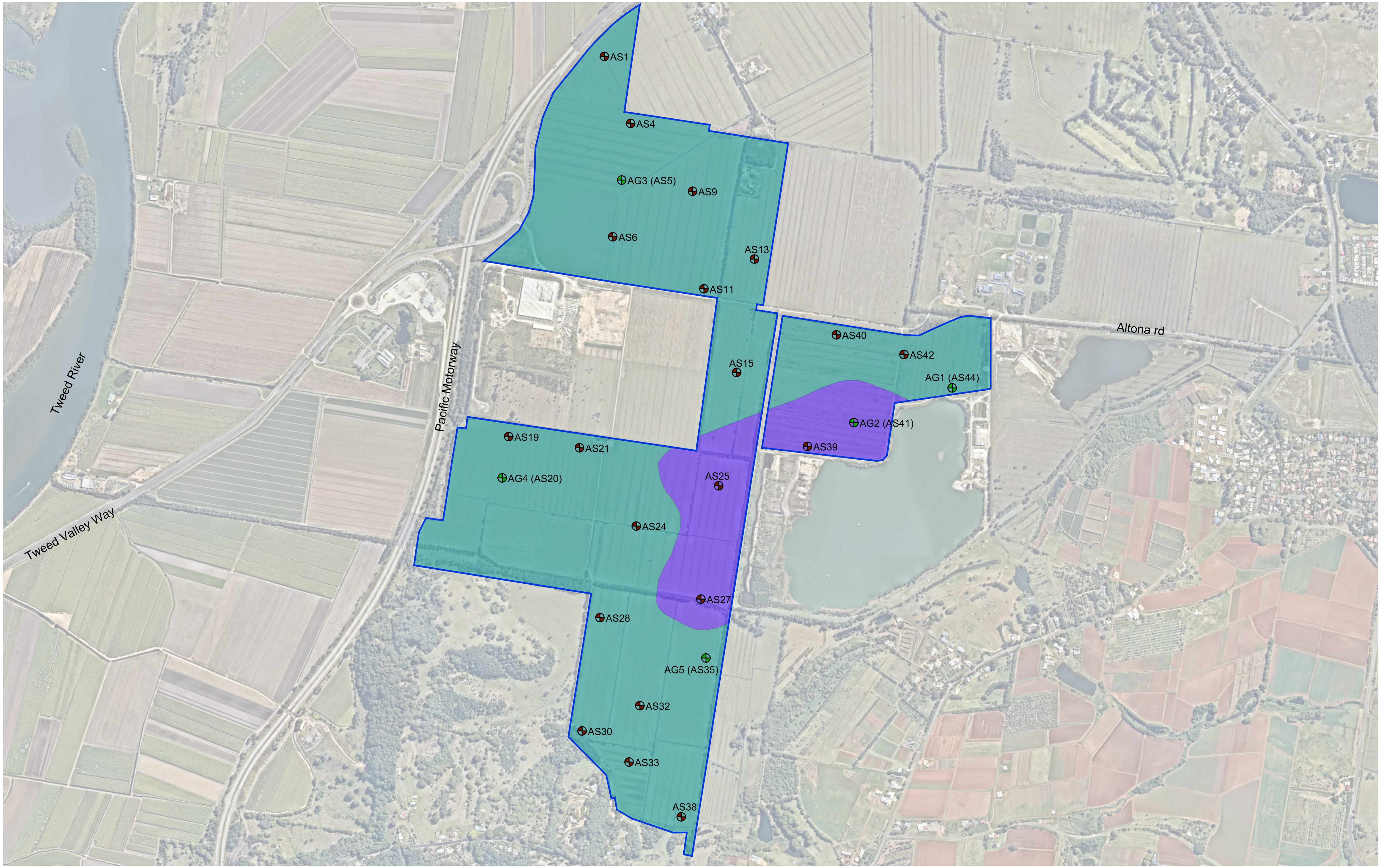
GILBERT SUTHERLAND



ORIENTATION

SCALE 1:12 500

100 200 300 400 500 600
metres

ROBINA

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LEGEND

—	Assessment Boundary
⊕	ASS Boreholes
⊕	AG Boreholes
🟩	Soil Type - Tenosols
🟪	Soil Type - Podosols

SOURCES

Image: Nearmap 2020. Image date: 14/09/2020

PROJECT

TWEED SAND
PLANT
EXPANSION

CLIENT

HANSON
CONSTRUCTION
MATERIALS

DRAWING

SOIL MAP

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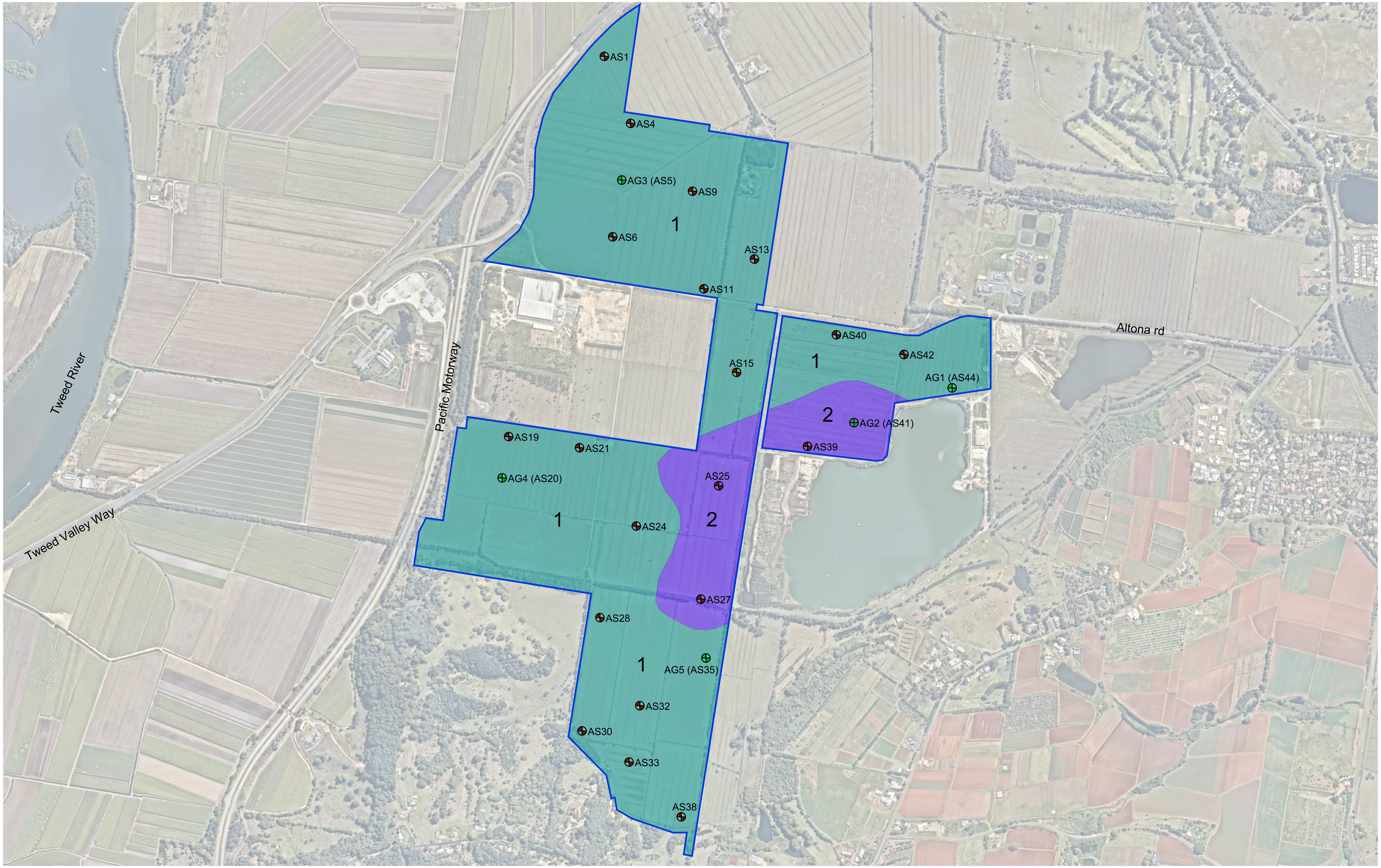

ORIENTATION

SCALE 1:12 500

100 200 300 400 500 600
metres

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LEGEND

Assessment Boundary
ASS Boreholes
AG Boreholes
🟩 UMA 1
🟪 UMA 2

SOURCES

Image: Nearmap 2020. Image date: 14/09/2020

PROJECT

TWEED SAND
PLANT
EXPANSION

CLIENT

HANSON
CONSTRUCTION
MATERIALS

DRAWING

UMA MAP

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
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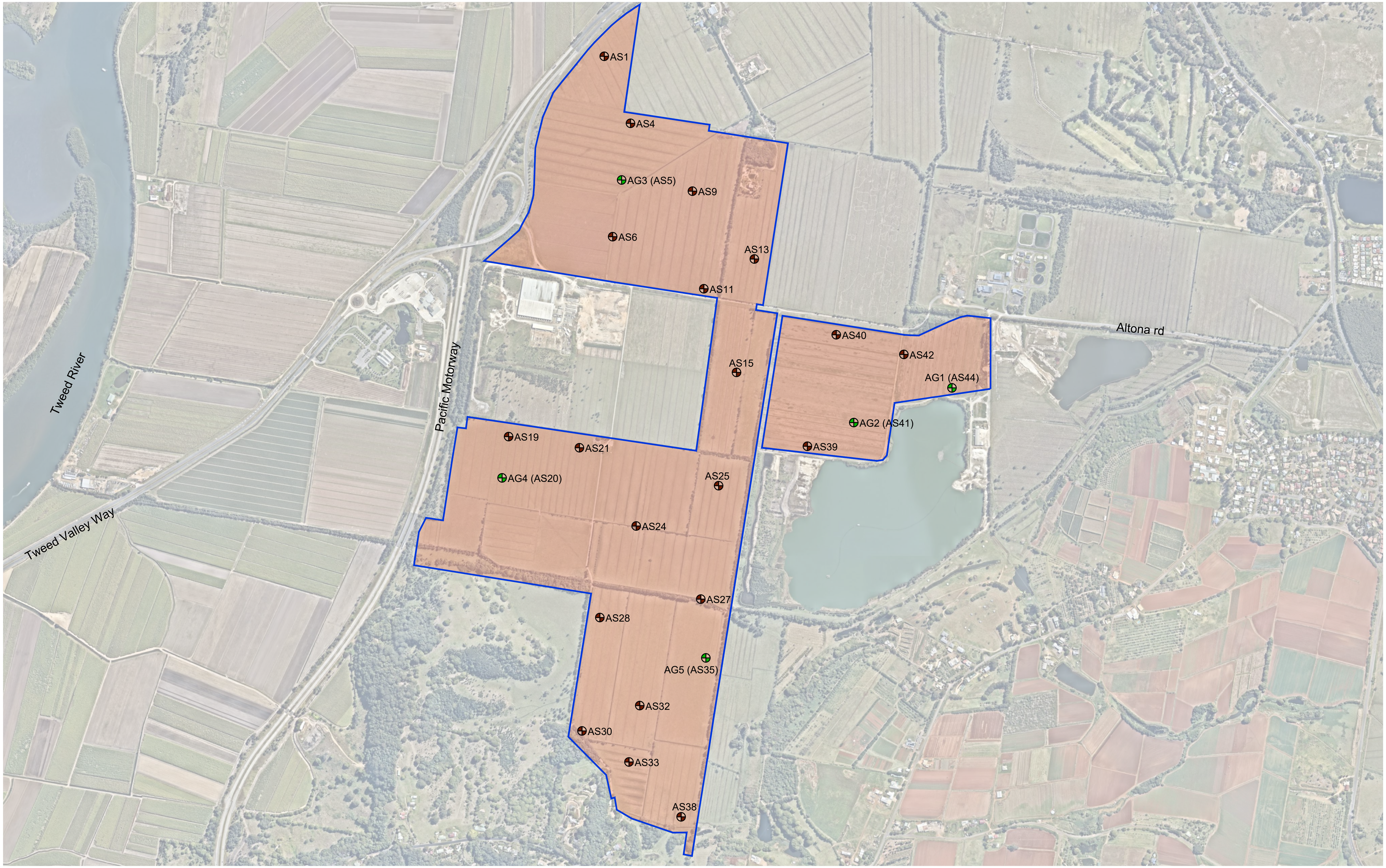

ORIENTATION

SCALE 1:12 500

100 200 300 400 500 600
metres

ROBINA

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LEGEND

- Assessment Boundary
- ⊕ ASS Boreholes
- ⊕ AG Boreholes
- ▨ Class 5-6

SOURCES

Image: Nearmap 2020. Image date: 14/09/2020

PROJECT	CLIENT	DRAWING
TWEED SAND PLANT EXPANSION	HANSON CONSTRUCTION MATERIALS	LAND AND SOIL CAPABILITY CLASS

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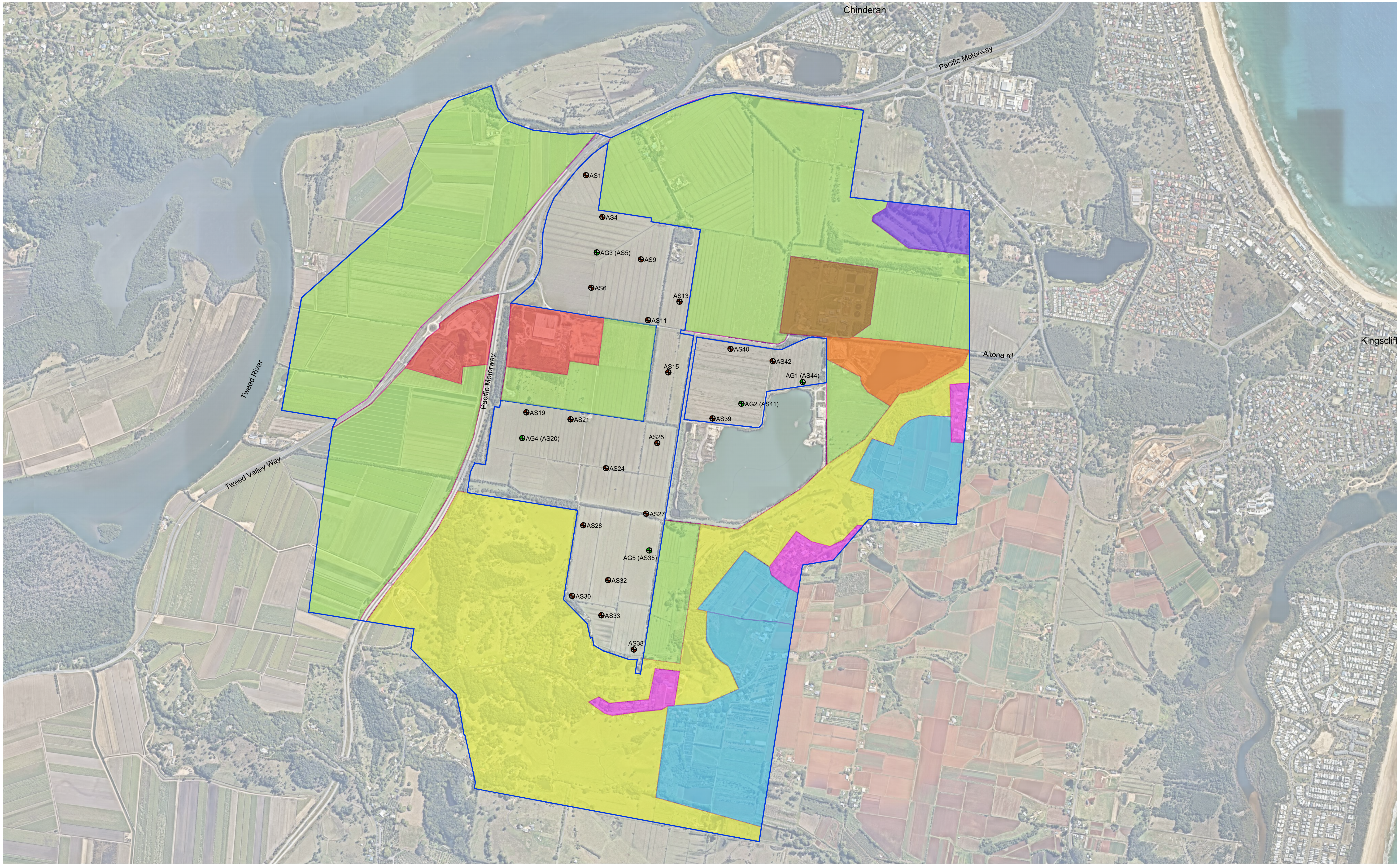

ORIENTATION

SCALE 1:20 000

200 400 600 800 1000
metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
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LEGEND

―	Site Boundary
⊕	ASS Boreholes
⊕	AG Boreholes
🟩	Land Use Zone 1
🟨	Land Use Zone 2
🟥	Land Use Zone 3
🟧	Land Use Zone 4
🟫	Land Use Zone 5
🟪	Land Use Zone 6
🟦	Land Use Zone 7
🟪	Land Use Zone 8

SOURCES

Image: Nearmap 2020. Image date: 14/09/2020

PROJECT
TWEED SAND
PLANT
EXPANSION

CLIENT
HANSON
CONSTRUCTION
MATERIALS

DRAWING
SURROUNDING LAND
USE

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
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GILBERT SUTHERLAND

11 Appendix 2 - Land and soil capability criteria

5 Decision tables for individual hazards

5.1 Introduction

The decision tables in the LSC assessment scheme are an essential part of the scheme and are partly based on those in the *Native Vegetation Regulation 2005 environmental outcomes assessment methodology* (DECCW 2011). They use landscape, soils and climate data on the various hazards or limitations to allocate a tract of land to an LSC class for each hazard or limitation. The logic tables for each hazard or limitation are outlined below. The operation of the logic tables requires several sources of data and these are outlined below.

Each hazard is assigned one of eight LSC classes where Class 1 represents the least hazard and Class 8 represents the greatest hazard. Each hazard is assessed individually and in this way a profile of hazards is developed for the parcel of land being assessed. The final hazard assessment for a parcel of land is based on the highest hazard in that parcel of land (see Figure 4). For example, a parcel of land may be assessed to have no significant hazard for several limitations but a Class 8 hazard for mass movement hazard; this land will be Class 8 land.

5.2 Base information

Various base information is required to commence assessment of LSC. Some of the base information, such as climate and slope, feeds into other hazard assessments, while other base information, such as that on landform features and existing erosion, is sufficient to identify the capability immediately. The data required to determine the LSC class of a parcel of land is summarised in Table 3.

5.3 Water erosion hazard

Water erosion hazard refers to the likelihood of soil detachment and movement under the effects of raindrop impact, initiation of runoff, and flowing water (Geeves et al. 2007).

The amount of water erosion is controlled by:

- the slope gradient and slope length, which control the erosive power of water flowing down the slope
- the erodibility of the soil, which can be assessed on the detachability and transportability of the soil
- the amount of vegetation cover on the landscape, as this can intercept raindrop impact and attenuate the effects of rainfall erosivity
- the condition of the soil, whether in a loose, tilled or settled coherent condition: soils in a loose, tilled condition are more easily detached and transported.

While the coast has the most intense rainfall, usually it is the cropping areas in the north-west of the State (Namoi and Border rivers) that have the highest water erosion hazard. These lands have the combination of relatively intense rainfall, highly erodible soil (easily detached and transported) and the common occurrence of cropping, meaning that there is the potential for the soil to have a low surface cover for significant periods of the year. Soils in a loose, tilled condition are highly susceptible to water erosion.

5.3.1 Effects of water erosion

The major effects of water erosion are:

- loss of the soil from the landscape and a subsequent deterioration in the productive capacity of the landscape and its capacity to deliver ecosystem functions
- movement of soil materials and associated nutrients and chemicals into waterways and storages, with consequent reductions in water quality and the storage capacity of reservoirs
- damage to infrastructure caused by both erosion and deposition of soil materials.

Table 3. Data requirements for determining LSC classes

	Water erosion	Wind erosion	Soil structure decline	Soil acidification	Salinity	Water-logging	Shallow soils and rock	Mass movement
NSW Division	✓							
Sand dune or mobile sand body	✓							
Slope %	✓							✓
Scree or talus slope								✓
Footslope or drainage plain receiving high run-on	✓							
Gully erosion or sodic dispersible subsoils	✓							
Annual rainfall		✓		✓				✓
Wind erosive power		✓						
Exposure to wind		✓						
Surface soil texture		✓	✓	✓				
Surface soil texture modifier			✓					
Great Soil Group				✓				
pH of surface soil				✓				
Surface soil modifier				✓				
Parent material				✓				
Recharge potential of landscape					✓			
Discharge potential of landscape					✓			
Salt store of landscape					✓			
Waterlogging duration						✓		
Return period of waterlogging						✓		
Rocky outcrop							✓	
Soil depth							✓	
Presence of existing mass movement								✓

5.3.2 Assessment of water erosion hazard

The rule set for water erosion hazard is in Table 4. These rules are based on slope classes in the original rural land capability scheme (Emery 1986) and these were based on more than 20 years' field experience of the SCS throughout NSW.

The Western Division is distinguished from the Eastern and Central divisions because of its drier climate, resulting in less protective groundcover.

The data required to complete this assessment may be derived from topographic maps, digital elevation models, direct field measurement with a clinometer or from existing soil-landscape maps.

The influence of specific localised issues such as highly erodible soils, potential for crusting or hardsetting topsoils, shallow texture contrast soils and long slope length have not been directly addressed in this version of the scheme.

5.3.3 Effects of water erosion

The major effects of water erosion are:

- loss of the soil from the landscape and a subsequent deterioration in the productive capacity of the landscape and its capacity to deliver ecosystem functions
- movement of soil materials and associated nutrients and chemicals into waterways and storages, with consequent reductions in water quality and the storage capacity of reservoirs
- damage to infrastructure caused by both erosion and deposition of soil materials.

Table 4. **Slope class for each LSC class used to determine water erosion hazard**

NSW division	Slope class (%) for each LSC class							
	Class 1	Class 2	Class 3	Class 4[1]	Class 5[2]	Class 6	Class 7	Class 8
Eastern and Central divisions	<1	1 to <3	3 to <10 or 1 to <3 with slopes >500 m length	10 to <20	10 to <20	20 to <33	33 – <50	>50
Western Division[3]	<1	1 to <3 or <1 for hardsetting red soils	1–3	3–5	3–5	5–33	33–50	>50

Sand bodies are classified as Class 1 for water erosion hazard.

[1] No gully erosion or sodic/dispersible soils are present.

[2] Gully erosion and/or sodic/dispersible subsoils are present.

[3] Western CMA provided advice on the slope classes.

5.4 Wind erosion hazard

Wind erosion hazard refers to the likelihood for soil detachment and movement under the effects of wind blowing across the soil surface (Leys 2007; Leys and McTainsh 2007). Wind erosion hazard tends to be the highest in coastal areas and on the inland plains.

Wind can detach and transport soil particles over a range of distances. Three major transport processes occur in wind erosion:

- creep, as the soil particles (>0.5 mm) roll and bump along the unstable surface as result of the impact of other fast moving particles
- saltation, where particles are transported short distances in a series of bounces – particles in the size range 0.1–0.5 mm are detached and transported this way; this is the material that often builds up along fences and other barriers with active wind erosion
- suspension, whereby soil particles are suspended in the air and transported large distances (hundreds or thousands of kilometres); this is the material seen in dust storms and particles in the size range <0.1 mm are transported this way.

The wind erosion hazard is dependent on the:

- wind erosive power or wind erosivity, which is influenced by overall wind patterns but also by the potential for local modifications by landform, trees and buildings
- exposure of the land to wind, taking into account local variation in wind power. Areas exposed to long wind fetches tend to be subjected to higher wind erosive power. In some landforms the wind flow is channelled and accelerated, increasing the wind erosive power, such as between hills or across saddles. Elevated areas of the landscape will likely have higher exposure than valley floors, while some landforms have naturally high exposure, for example beach fronts, sand dunes on plains, and the crests of ridgelines.
- detachability and transportability of the soil particles to wind. Generally, sandy soils are more erodible than clayey soils. While sand particles are more readily detached by wind they tend to travel only short distances under the process of saltation. It is the clay and silt particles in the sandy soils or aggregated clays that travel long distances and create the familiar dust storm clouds associated with severe wind erosion.

5.4.1 Effects of wind erosion

The major effects of wind erosion are:

- loss of the soil from the landscape and a subsequent deterioration in the productive capacity of the land and in the capacity of the land to perform ecosystem functions. There is a disproportionate loss of nutrients and organic carbon from soils affected by wind erosion as the finer and more nutrient-rich fractions are winnowed out by wind erosion.
- movement of soil materials at close range (saltation) onto fences, roads and buildings that can result in infrastructure damage, or at least the need to remove the deposited soil material at considerable cost.
- movement of suspended soil materials at some distance from the original site. This material is moved as dust clouds that can adversely affect visibility, deposit dust and lead to air quality and infrastructure problems.

5.4.2 Assessment of wind erosion hazard

The LSC assessment scheme uses the following factors:

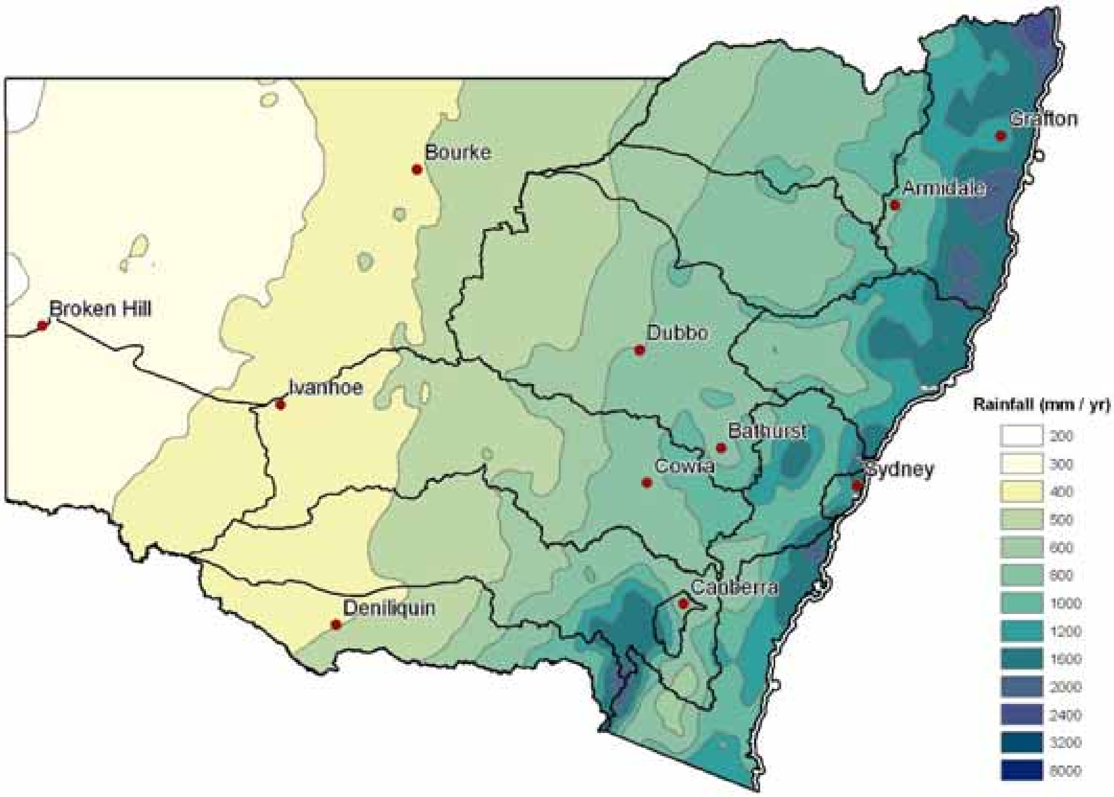
- the average rainfall which determines the capacity of the land to maintain surface cover and keep the soil wet. The wind erosion hazard increases as the average annual rainfall declines (Figure 5).
- the wind erosive power or wind erosivity based on overall wind patterns. Figure 6 is a map of the wind erosive power for NSW.
- the exposure of the tract of land to wind, taking into account local variations in wind power. For example, at the local scale, the landform might channel the prevailing wind into some areas (Table 5).
- the soil erodibility to wind. This is largely determined by the texture of the soil as this determines the detachability and transportability of the soil particles (Table 5).

In assessing the wind erosion hazard, the assumption is made of land management associated with low surface cover. This is consistent with the objective of identifying the land management practices that can be imposed on the landscape without causing long-term degradation. The LSC class for different annual rainfall regimes is shown in Table 6.

Table 5. Factors in assessing wind erosion hazard

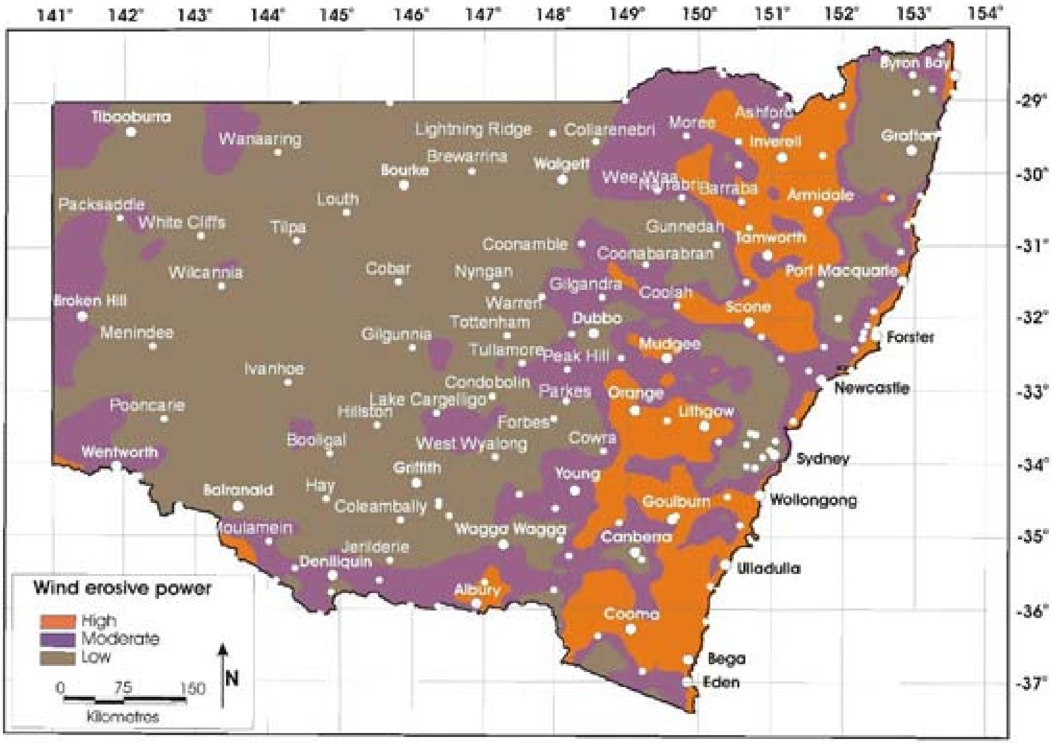
Class	Factor		
	Surface soil texture	Site exposure to prevailing winds	Wind erosive power*
Low	Loams, clay loams or clays (all with >13% clay)	Sheltered locations in valleys or in the lee of hills	Low
Moderate	Fine sandy loams or sandy loams (all with 6–13% clay); also includes organic peats	Intermediate situations – not low or high exposure locations	Moderate
High	Loamy sands or loose sands (all with <6% clay).	Hilltops, cols or saddles, open plains or exposed coastal locations	High

* See Figure 6.



Based on data provided by Australian Bureau of Meteorology.

Figure 5. Average annual rainfall in NSW



Source: NSW Department of Trade and Investment (undated).

Figure 6. Wind erosive power in NSW

Table 6. LSC class for wind erosion hazard

Wind erodibility class of surface soil	Wind erosive power	Exposure to wind	Average annual rainfall (mm)			
			>500	300–500	200 to <300	<200
Low	Low	Low	1	2	3	6
		Moderate	1	2	3	6
		High	2	3	4	7
	Moderate	Low	1	2	3	6
		Moderate	2	3	4	6
		High	3	4	5	7
	High	Low	2	3	4	6
		Moderate	3	4	5	7
		High	4	5	6	7
Moderate	Low	Low	2	3	4	7
		Moderate	3	4	5	7
		High	4	5	6	8
	Moderate	Low	2	3	4	6
		Moderate	3	4	5	7
		High	4	5	6	8
	High	Low	3	4	5	7
		Moderate	4	5	6	8
		High	5	6	7	8
High	Low	Low	3	4	5	7
		Moderate	4	5	6	8
		High	5	6	7	8
	Moderate	Low	4	5	6	8
		Moderate	5	6	7	8
		High	6	7	8	8
	High	Low	5	6	7	8
		Moderate	6	7	8	8
		High	7 (8*)	8	8	8

* Mobile sand bodies such as coastal beaches, foredunes and blowouts are Class 8.

5.5 Soil structure decline hazard

Soil structure decline refers to the breakdown of the physical arrangement of soil particles and pore spaces in the soil, typically as a result of compaction and tillage. It results in the loss of pore space, fissures and tunnels that allow movement and exchange of air, water, nutrients and penetration of plant roots. It is a hazard for all agricultural systems. Organic matter decline is also often associated with soil structure decline. The approach taken here is that soil structure decline is a sufficiently severe soil degradation problem that it should be assessed as an identifiable hazard, especially in the case of sodic surface soils and some other very hardsetting surface soils high in silt and fine sand.

This assessment concentrates on the surface characteristics as described in Lawrie et al. (2002, 2007) who identified that good soil structure is dependent on soil organic matter in the soils with less clay (sandy loams to loams), whereas the level of sodium becomes more important in soils with more clay (clay loams, light clays and heavy clays) where it leads to clay dispersion. Kay (1990) identified that soil structure is dynamic, and that an assessment of soil structural decline hazard requires an estimation of the current soil structural condition, a prediction of the stability of the structural condition and the capacity of the soil to redevelop soil structure should it become degraded (its resilience). This assessment takes some account of the dynamic nature of soil structure.

The stability of soil structure is very dependent on organic matter in soils with less clay and is more affected by sodium as the amount of sodium increases. The resilience of the soil structure is dependent on the capacity of the soil to shrink and swell, and the capacity of the soil to support plant growth.

5.5.1 Effects of soil structure decline

The major effects of poor soil structure are:

- low infiltration and runoff resulting in water erosion and less than optimum use of rainfall for plant growth
- overall poor plant growth
- poor germination and emergence of crops
- poor friability of soils making them difficult and costly to till and to sow.

5.5.2 Assessment of soil structure decline hazard

The LSC classification assesses the soil structure decline hazard using the nature of the surface soils. The nature of the surface soils is assessed using the following criteria:

- surface soil texture
- degree of sodicity
- degree of self-mulching.

These criteria enable an estimate of the likely structural condition, stability and resilience to be made. The features are estimated by observation in the field using standard procedures as defined in Lawrie et al. (2007) and Murphy et al. (2012). Subsoil character may be incorporated into the assessment in future versions of the scheme.

The soil structure decline hazard is assessed using a combination of Tables 7 and 8. The main assessment is provided in Table 7 and uses the texture, sodicity, degree of self-mulching, amount of organic matter and the presence of iron stabilised peds from basalt-type parent materials. Table 8 provides some guidelines on evaluating the degree of self-mulching and sodicity of clay surface soils.

Soil structure decline in many instances can be more easily overcome by a range of management practices than some of the other hazards; therefore, its effect on the LSC class is generally less than hazards such as water and wind erosion.

Table 7. LSC class for soil structural decline hazard

Field texture (surface soils)	Modifier	Outcome – surface soil type	LSC class
Loose sand	Nil	Loose sand	1
Sandy loam	Nil	Fragile light textured surface soil	3
Fine sandy loam	Normal	Fragile light textured soil	3
	High levels of silt and very fine sand (>60%)	Fragile light textured soil – very hardsetting	4
Loam	Normal	Fragile medium textured soil	3
	Friable/ferric[1]	Friable medium textured soils – includes dark, friable loam soils	1
	High levels of silt and very fine sand	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic loam surface soil	4
	Moderately sodic	Moderately sodic loam surface soil	6
Clay loam	Normal	Fragile medium textured soil	3
	Friable/ferric[1]	Friable clay loam surface soil – includes dark, friable clay loam soils	1
	High levels of silt and very fine sand (>60%)	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic clay loam surface soil	4
	Moderately sodic	Moderately sodic clay loam surface soil	6
Clay	Friable/ferric[1]	Friable clay surface soil	2
	Strongly self-mulching	Strongly self-mulching surface soil	1
	Weakly self-mulching	Weakly self-mulching surface soil	3
	Mildly sodic	Mildly sodic/coarsely structured clay surface soil	4
	Moderately sodic	Moderately sodic/coarsely structured clay surface soil	6
	Strongly sodic	Strongly sodic surface soil	7
Highly organic soils	Mineral soils with high organic matter[2]	Mineral soils with high organic matter	-[2]
	Organosol/peat soils[3]	Organic/peat soils	7

[1] The occurrence of friable or ferric surface soils is associated with (a) basaltic or basic parent materials and soils of the Ferrosols groups in the Australian Soil Classification or the Krasnozems and Euchrozem Great Soil Groups, and (b) the dark loam surface soils of the Chernozems and Prairie Soils on alluvial flats.

[2] Loosely defined here as soils with over 8% organic carbon. These soils revert to the LSC class determined by the mineral component of the soils.

[3] Organosols have organic material layers over 0.4 m thick with minimum organic carbon of 12% if sands or 18% if clays (Isbell 2002).

Table 8. Guidelines for evaluating some surface soil properties of clays

Sodicity/size of soil structural units	Character of surface soil
Very low exchangeable sodium (<3%), high exchangeable calcium, strongly swelling clays (smectitic) as in Vertosols (GSG Black Earths) Peds/aggregates 2–5 mm in an air dry condition	Strongly self-mulching surface soil
Low exchangeable sodium (3–5%), moderate exchangeable calcium, moderately swelling clays (illitic, interstratified, kaolinitic) as in many Dermosols and fertile Chromosols (GSG, Krasnozems, Euchrozems and others) Peds/aggregates 5–10 mm in an air dry condition	Weakly self-mulching surface soil
Moderate levels of exchangeable sodium (5–8%), often moderately low exchangeable calcium relative to exchangeable magnesium (ratio <2:1) Peds/aggregates 10–20 mm in an air dry condition	Mildly sodic surface soils
High levels of exchangeable sodium (8–15%), often low exchangeable calcium relative to exchangeable magnesium (ratio <1:1) Peds/aggregates 20–50 mm in an air dry condition	Moderately sodic surface soils
Very high levels of exchangeable sodium (>15%), often very low exchangeable calcium relative to exchangeable magnesium (ratio <0.5:1) Peds/aggregates >50 mm in an air dry condition	Strongly sodic surface soils

5.6 Soil acidification hazard

Soil acidification hazard is a major limitation in many important areas of agricultural production in NSW. Soils vary considerably in their natural acidity status and in their buffering capacity to resist changes in pH. The climate imposes an acidification potential on the soil by providing a leaching regime than can drive acidifying processes, especially nitrate leaching, but also by increasing plant growth and the plant-related acidifying processes such as nitrogen fixation. Land management practices also vary considerably in their acidification potential. The removal of agricultural produce as grain, vegetable mass or meat adds to the acidification pressure on the soil (Fenton and Helyar 2007; Fenton et al. 1996).

5.6.1 Effects of soil acidification

Soil acidification impacts on plant growth by:

- direct impact on biological and plant growth systems
- increased presence of some toxic elements, including aluminium at pH_{CaCl} levels below 4
- reduction in availability of some plant nutrients.

The resulting poor plant growth means:

- less farm productivity
- increased potential for soil erosion
- increased recharge into groundwater systems leading to increased salinity hazard
- reduced biodiversity.

5.6.2 Assessment of acidification hazard

Buffering capacity is estimated using Table 9, but Tables 10 and 11 may be used if a Great Soil Group classification is not available. The LSC class for soil acidification hazard is estimated using Table 12.

Table 9. Estimating buffering capacity based on Great Soil Group

Great Soil Group	Buffering capacity of surface soil	Great Soil Group	Buffering capacity of surface soil
Acid Peats	VL	Non-calcic Brown soils	M
Alluvial Soils – Light sandy textured (Sands to Sandy Loams)	L	Peaty Podzols	L
Alluvial Soils – Medium textured (Loams clay loams)	M	Podzols	VL
Alpine Humus soils	M	Prairie Soils	H
Black Earths	VH	Red and Brown Hardpan Soils	H
Brown Earths	M	Red-brown Earths	M
Brown Podzolic Soils	M	Red Earths – less fertile (granites and metasediments)	L
Calcareous Red Earths	H	Red Earths – more fertile (volcanics, granodiorites) or highly structured	M
Calcareous Sands	M	Red Podzolic Soils – less fertile (granites and metasediments)	L
Chernozems	H	Red Podzolic Soils – more fertile (volcanics, granodiorites) or highly structured	M
Chocolate soils	M	Rendzinas	H
Desert Loams	M	Siliceous Sands	VL
Earthy Sands	VL	Solodic soils	L
Euchrozems	H	Solonchaks	H
Gleyed Podzolic Soils	L	Solonetz	M
Grey-brown and Red Calcareous Soils	H	Solonized Brown Soils	M
Grey-brown Podzolic soils	L	Solonized Solonetz	L
Grey, Brown and Red Clays	VH	Soloths	L
Humic Gleys	L	Terra Rossa Soils	M
Humus Podzols	L	Wiesenboden	H
Krasnozems	M	Xanthozems	M
Lateritic Podzolic Soils	L	Yellow Earths	L
Lithosols	VL	Yellow Podzolic Soils – less fertile (granites and metasediments)	L
Neutral to Alkaline Peats	M	Yellow Podzolic Soils – more fertile (volcanics, granodiorites) or highly structured	M

Table 10. Estimating buffering capacity based on surface soil texture

Surface soil texture	Buffering capacity of surface soil
Sands and sandy loams – no calcium carbonate	VL
Sands and sandy loams – with calcium carbonate	M
Fine sandy loams – no calcium carbonate	L
Fine sandy loams – with calcium carbonate	M
Loams and clay loams – no calcium carbonate	M
Loams and clay loams – with calcium carbonate	H
Dark loams and clay loams (e.g. topsoils in Chernozems and Prairie Soils)	H
Clays – no calcium carbonate	H
Clays – with calcium carbonate	VH
Clays – with high shrink–swell	VH

Table 11. Estimating buffering capacity based on geology

Nature of parent material	Buffering capacity of surface soil
Highly weathered shales and metamorphic rocks, quartzose sandstones – highly siliceous	VL
Siliceous granites, sandstones	VL to L
Intermediate parent materials – granodiorites, less weathered shales and metamorphic rocks, andesites	M
Intermediate to basic rocks and parent materials – basalts, some andesites, gabbros, dolerites	H
Basic to ultrabasic rocks and parent materials – highly mafic or carbonates present, e.g. limestones	VH
Alluvium with high levels of carbonates and clays	H
Alluvium – sandy light textured	L
Alluvium – medium textured	M

Table 12. LSC class for soil acidification hazard

Texture/ buffering capacity	pH of the natural surface soil				
	<4.0 ($CaCl_2$) <4.7 (water)	4.0–4.7 ($CaCl_2$) 4.7–5.5 (water)	4.7–6.0 ($CaCl_2$) 5.5–6.7 (water)	6.0–7.5 ($CaCl_2$) 6.7–8.0 (water)	>7.5 ($CaCl_2$) >8.0 (water)
Mean annual rainfall <550 mm					
Very low	6*	5	4	3	n/a
Low	5	5	3	3	n/a
Moderate	5	4	3	2	1
High	4	3	2	1	1
Very high	n/a	n/a	1	1	1
Mean annual rainfall 550–700 mm					
Very low	6*	5	5	4	n/a
Low	5	5	4	3	n/a
Moderate	5	4	3	3	1
High	n/a	n/a	2	2	1
Very high	n/a	n/a	1	1	1
Mean annual rainfall 700–900 mm					
Very low	6*	5	5	4	n/a
Low	6*	5	4	4	n/a
Moderate	5	4	3	3	2
High	n/a	n/a	2	2	1
Very high	n/a	n/a	2	1	1
Mean annual rainfall >900 mm or irrigation					
Very low	6*	5	5*	4	n/a
Low	6*	4	4	3*	n/a
Moderate	5	4	3	3	2
High	5	3	2	2	1
Very high	5	3	2	1	1

Based on natural pH status, buffering capacity and climate
* These lands usually have very low fertility.

5.7 Salinity hazard

Salinity hazard is the potential for salts to be mobilised in a catchment and brought to the ground surface and waterways by changes in land use and land management. Widespread vegetation clearing, excessive irrigation inputs and other land management practices that increase recharge to groundwater are major drivers for this hazard.

5.7.1 Effects of salinity

Salinity is a major land degradation problem in NSW. Mobilisation of salts can have the effect of:

- saline outbreaks and scalding on the ground surface
- increased salinity concentration in streams
- increased salt loads leaving the catchment and being transported downstream.

Salt has a highly adverse effect on plant growth by:

- making it difficult for plants to extract water
- increasing the level of toxic elements to plants
- increasing sodicity levels in soils with resulting soil structure decline, crusting and other problems.

Reduced plant growth is associated with reduced crop and pasture productivity, and increased soil erosion.

5.7.2 Assessment of salinity hazard

The LSC classes for salinity hazard provide a simple initial evaluation of salinity hazard. A more detailed assessment of the salinity hazard can be achieved using the Hydrogeological Landscapes framework (Jenkins et al. 2010; Wilford et al. 2010). That system has been developed by OEH and the NSW Department of Primary Industries and is being progressively applied at a range of scales across NSW.

The LSC assessment for salinity hazard is based on the methodology in the environmental outcomes assessment methodology for the Native Vegetation Regulation (DNR 2005; DECCW 2011) and requires the following three inputs.

Recharge potential is the potential for water from rainfall, irrigation or streams to infiltrate past the plant root zone into the underlying groundwater system. This can occur over a whole landscape, or a component of the landscape, where water readily infiltrates soil, sediment or rock. Typically recharge areas have permeable, shallow and/or stony soils and fractured and/or weathered rock.

Recharge potential is highest where there is high rainfall relative to evaporation, low leaf area and plant water use, low water-holding capacity, and high permeability of the soils, regolith and rocks. Under natural conditions it relates to the climate, land use and hydrological characteristics of the catchment. It is exacerbated by land-use practices that disturb the vegetation cover or soil surface.

The value assigned for recharge potential is a qualitative assessment based on aerial photography, field observation and/or available literature, in particular soil landscape maps and reports.

Discharge potential is the potential for groundwater to flow from the saturated zone to the land surface. It is a function of position in the landscape, depth to water table, groundwater pressure, soil type, substrate permeability and evapotranspiration. Discharge may occur as leakage to streams, evaporation from shallow water tables, or as springs and wet areas where water tables intersect the land surface or where narrow breaks occur in low permeability layers above confined aquifers. Typical discharge areas are low in the landscape and have high water tables, or higher in the landscape if sub-surface barriers impede groundwater flow.

Discharge potential is highest when recharge rates are greater than the amount of water that leaves the groundwater system through base flow and evapotranspiration.

The value assigned for discharge potential is a qualitative assessment based on aerial photography, field observation and/or available literature, in particular soil landscape maps and reports.

Salt stores are high for many soils, regolith materials and rock types. This will depend on weathering characteristics, geological structures, rock and soil type, depth of the various materials and salt flux. It is possible to have areas of low salt store and still have a salinity hazard due to evaporative concentration of salts at the soil surface.

Conversely, areas of high salt store can have a lower hazard due to low rainfall. For example, in areas of low rainfall and low slope, salinity hazard can be low. Figure 7 provides a broad indication of salt stores throughout NSW. This map is generalised and local information should be used where available.

These three inputs are combined to provide a simple assessment of salinity hazard as described in Table 13. For localised assessments, it is important to calibrate the LSC estimates to local conditions and to validate against known areas of salinity, as reported in soil-landscape and hydrogeological landscape reports and other available sources. Consideration should be given to factors not used in the simplified LSC ranking, including salt mobility, local climate, soil buffering capacity and position in the landscape.

Table 13. LSC class for salinity hazard

Recharge potential	Discharge potential	Salt store	LSC class
Low	Low	Low	1
		Moderate	3
		High	4
	Moderate	Low	1
		Moderate	4
		High	4
	High	Low	1
		Moderate	4
		High	5
Moderate	Low	Low	1
		Moderate	3
		High	4
	Moderate	Low	2
		Moderate	5
		High	6
	High	Low	1 (3) *
		Moderate	6
		High	6
High	Low	Low	1
		Moderate	4
		High	5
	Moderate	Low	3 (2) *
		Moderate	4
		High	7
	High	Low	2 (3) *
		Moderate	6
		High	7

* The values in brackets are more accurate and should be used in preference to the original rating.

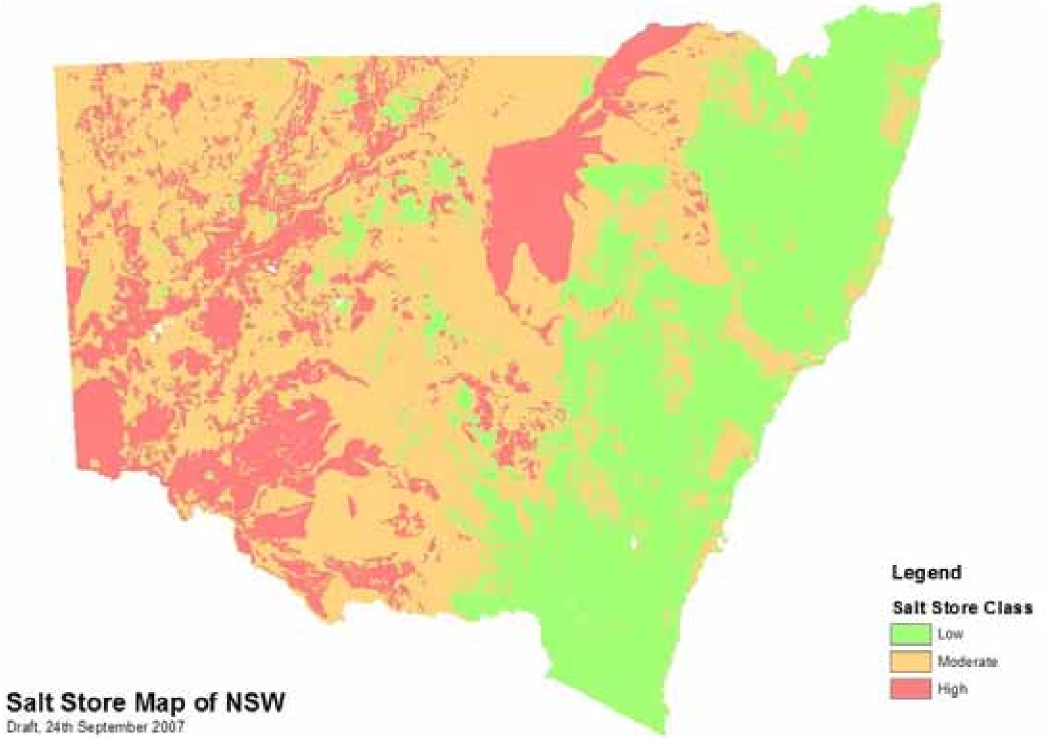


Figure 7. Salt store map

5.8 Waterlogging hazard

Waterlogging of soils is a major limitation in some generally low-lying areas of the landscape. Soils vary considerably in their natural drainage depending on the climate, their position in the landscape and their textural characteristics. Soils may be wet or waterlogged, for short periods, for long periods of several months, particularly in the wetter winter season, or even most of the year.

5.8.1 Effects of waterlogging

Waterlogging can severely affect agricultural production and land use. It restricts or prevents the supply of oxygen to plant roots, thus it can severely impact on plant health and survival. Plants and crops have differing abilities to tolerate waterlogged conditions. For example, rice and cotton require these conditions; however, most agricultural crop and pasture plants will suffer. Waterlogging also inhibits vehicular access, tillage and sowing operations and stock management.

5.8.2 Assessment of waterlogging hazard

Waterlogging hazard assessment is largely based on the drainage classes in NCST (2009). Table 14 is used to assess waterlogging hazard. It relies on information contained in soil landscape reports and other natural resource products or knowledge from local soil and land practitioners to determine the waterlogging duration and return period.

Table 14. LSC class for waterlogging hazard

Typical waterlogging duration (months)	Return period	Typical soil drainage*	LSC class**
0	every year	rapidly drained and well drained	1
0–0.25	every year	moderately well drained	2
0.25–2	every year	imperfectly drained	3
2–3	every 2 to 3 years	imperfectly drained	4
2–3	every year	imperfectly drained	5
>3	every year	poorly drained	6
Almost permanently	every year	very poorly drained	8

* NCST (2009, p.202–4)
** Based on slope position, climate and length of time soils are wet.

5.9 Shallow soils and rockiness hazard

5.9.1 Effects of shallow soils and rockiness

Shallow soils and rockiness reduce the land-use capability of soils and land. The more rock outcrop and the shallower the soils, the less volume of soil available for storing nutrients and water. Rock outcrop impedes access by vehicles and farm machinery and restricts potential for tillage and sowing of crops.

5.9.2 Assessment of shallow soils and rockiness hazard

The criteria used by the LSC classification to assess shallow soils and rockiness hazard are:

- estimated percentage exposure of rocky outcrops
- average soil depth.

The relationship between the criteria in determining the LSC class is shown in Table 15.

5.10 Mass movement hazard

Mass movement relates to the large scale movement of earth under the force of gravity. It is a function of the gravitational stress acting on the land surface and the resistance of the surface soil, sand or rock materials to dislodgement (Hicks 2007). In general the hazard for mass movement increases with an increase in slope and an increase in rainfall when more water is available to saturate and reduce the strength of the soil. Certain combinations of slope, soils, landform, climate and geology are more susceptible to mass movement. Disturbance of soils in some land management actions (for example cutting of batters into slopes) can also increase the likelihood of mass movement.

5.10.1 Effects of mass movement

Mass movement is a serious threat to many land uses. The most serious consequences are damage to or destruction of buildings and other infrastructure, and injury or loss of life of people or livestock.

5.10.2 Assessment of mass movement hazard

The criteria used in the LSC classification to assess mass movement hazard are:

- existing evidence of mass movement
- slope class
- average annual rainfall.

The relationship between the criteria in determining the LSC class is shown in Table 16.

In some circumstances land that has been classified as Class 7 or 8 because of mass movement hazard may be used for limited agricultural land uses.

Table 15. LSC class for shallow soils and rockiness hazard

Rocky outcrop (% coverage)*	Soil depth (cm)	LSC class**
Nil	>100	1
<30 (localised*)	>100	2
	75– <100	3
	50– <75	4
	25– <50	6
	0– <25	7
30–50 (widespread*)	>100	4
	75–100	5
	25–75	6
	<25	7
50–70 (widespread*)	>100	6
	50–100	6
	25– <50	7
	<25	7
>70	n/a	8

* Rock outcrop limitation from soil landscape report.
** Based on rocky outcrop and soil depth

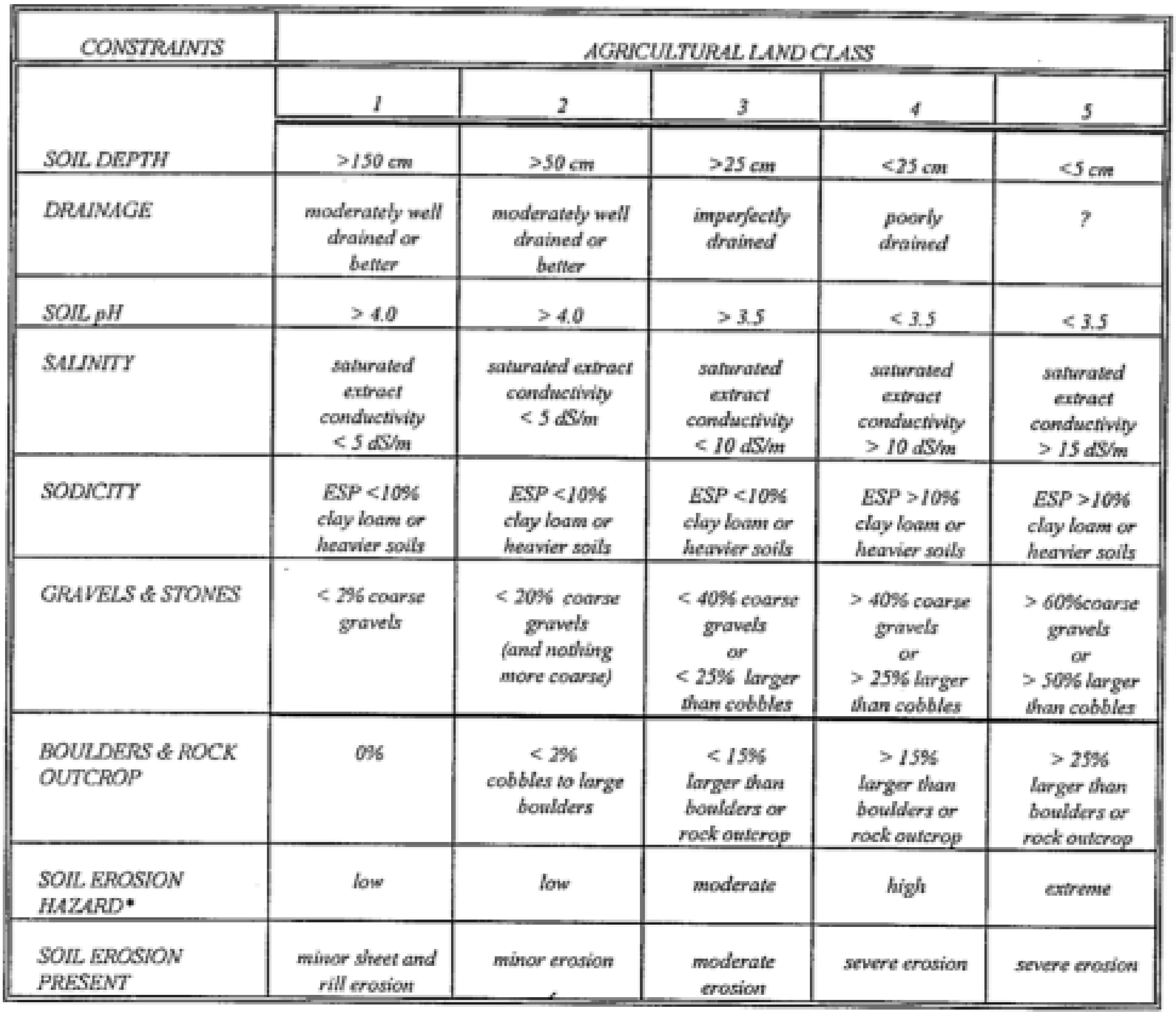
Table 16. LSC class for mass movement hazard

Mean annual rainfall (mm)	Mass movement present	Slope class (%)	LSC class
<500	No	n/a	1
	Yes	n/a	8
>500	No	n/a	1
	Yes	<20	6
		>20–50	7
		>50 or any scree or talus slope	8

Note that scree or talus slopes go automatically into Class 8.

12 Appendix 3 – BSAL decision flow chart

13 Appendix 4 – Agricultural suitability criteria



CONSTRAINTS	AGRICULTURAL LAND CLASS				
	1	2	3	4	5
SOIL DEPTH	>150 cm	>50 cm	>25 cm	<25 cm	<5 cm
DRAINAGE	moderately well drained or better	moderately well drained or better	imperfectly drained	poorly drained	?
SOIL pH	> 4.0	> 4.0	> 3.5	< 3.5	< 3.5
SALINITY	saturated extract conductivity < 5 dS/m	saturated extract conductivity < 5 dS/m	saturated extract conductivity < 10 dS/m	saturated extract conductivity > 10 dS/m	saturated extract conductivity > 15 dS/m
SODICITY	ESP <10% clay loam or heavier soils	ESP <10% clay loam or heavier soils	ESP <10% clay loam or heavier soils	ESP >10% clay loam or heavier soils	ESP >10% clay loam or heavier soils
GRAVELS & STONES	< 2% coarse gravels	< 20% coarse gravels (and nothing more coarse)	< 40% coarse gravels or < 25% larger than cobbles	> 40% coarse gravels or > 25% larger than cobbles	> 60%coarse gravels or > 50% larger than cobbles
BOULDERS & ROCK OUTCROP	0%	< 2% cobbles to large boulders	< 15% larger than boulders or rock outcrop	> 15% larger than boulders or rock outcrop	> 25% larger than boulders or rock outcrop
SOIL EROSION HAZARD*	low	low	moderate	high	extreme
SOIL EROSION PRESENT	minor sheet and rill erosion	minor erosion	moderate erosion	severe erosion	severe erosion

* As defined by Houghton and Charman 1986.

14 Appendix 5 – Risk Assessment

Table A1 Risk Ranking Matrix

PROBABILITY	A	B	C	D	E
Consequence					
1	25	24	22	19	15
2	23	21	18	14	10
3	20	17	13	9	6
4	16	12	8	5	3
5	11	7	4	2	1

Table A2 Probability Table – to score the likelihood of the consequence occurring

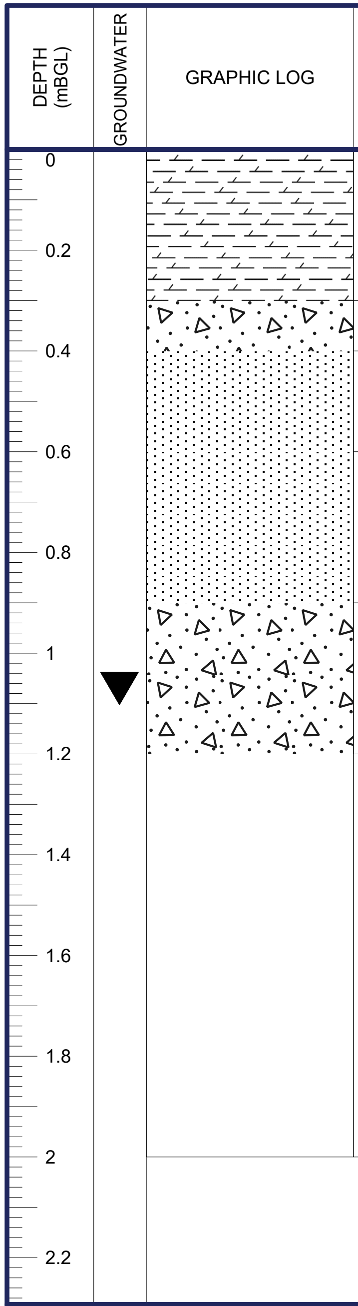
Level	Descriptor	Description
A	Almost certain	Common of repeating occurrence
B	Likely	Known to occur, or 'it has happened'
C	Possible	Could occur, or 'I've heard of it happening'
D	Unlikely	Could possible occur in some circumstances, but not likely to occur
E	Rare	Practically impossible

Table A3 Measure of consequence

Level 1	Descriptor: Severe
Description	• Severe and/or permanent damage to the environment • Irreversible • Severe impact on the community • Neighbours are in prolonged dispute and legal action involved
Example/implication	• Harm or death to animals, fish, birds or plants • Long term damage to soil or water • Odours so offensive some people are evacuated or leave voluntarily • Many public complaints and serious damage to Council's reputation • Contravenes Protection of the Environment & Operations Act and the • conditions of Council's licences and permits. Almost certain prosecution under the POEO Act
Level 2	Descriptor: Major
Description	• Serious and/or long-term impact to the environment • Long-term management implications • Serious impact on the community

	• Neighbours are in serious dispute
Example/implication	• Water, soil or air impacted, possibly in the long term • Harm to animals, fish or birds or plants • Public complaints. Neighbour disputes occur. Impacts pass quickly • Contravenes the conditions of Council's licences, permits and the POEO Act • Likely prosecution
Level 3	Descriptor: Moderate
Description	• Moderate and/or medium-term impact to the environment and community • Some ongoing management implications • Neighbour disputes occur
Example/implication	• Water, soil or air known to be affected, probably in the short term • No serious harm to animals, fish, birds or plants • Public largely unaware and few complaints to Council • May contravene the conditions of Council's Licences and the POEO Act • Unlikely to result in prosecution
Level 4	Descriptor: Minor
Description	• Minor and/or short-term impact to the environment and community • Can be effectively managed as part of normal operations • Infrequent disputes between neighbours
Example/implication	• Theoretically could affect the environment or people but no impacts noticed • No complaints to Council • Does not affect the legal compliance status of Council
Level 5	Descriptor: Negligible
Description	• Very minor impact to the environment and community • Can be effectively managed as part of normal operations • Neighbour disputes unlikely
Example/implication	• No measurable or identifiable impact on the environment • No measurable impact on the community or impact is generally acceptable

15 Appendix 6 – Soil borelogs



SOIL DESCRIPTION	ORIGIN
Black (2.5Y 2.5/1) **silty clay loam**; no coarse fragments; moderately moist; weak subangular structure; weak consistence; common, fine roots; diffuse change to;	NATURAL
Very dark grey (10YR 3/1) **loamy sand** with diffuse transitions to very few, fine sized, distinct, yellow (10YR 8/8) colour patterns due to mechanical mixing of soil material from other horizons; no coarse fragments; moderately moist; massive structure; very weak consistence; no segregations; few, fine roots; gradual change to;	NATURAL
Light grey (10YR 7/1) **sand**; no coarse fragments; moist; single grain structure; very weak consistence; diffuse change to;	NATURAL
Dark grey (10YR 4/1) **sand** with diffuse transitions to few, fine sized, faint, pale orange yellow (10YR 9/2) mottles; no coarse fragments; moist; single grain structure; very weak consistence; no segregations; diffuse change to;	NATURAL
Grey (10YR 6/1) **loamy sand**; no coarse fragments; moist to wet; weak to massive subangular structure; very weak consistence; borehole terminated at 1.2mBGL.	NATURAL

BOREHOLE

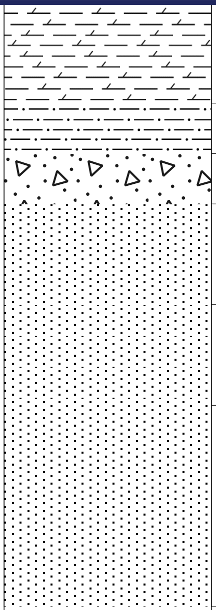
AG1

CLIENT HANSON CONSTRUCTION MATERIALS
PROJECT No. 12035
TOTAL DEPTH 1.2mBGL
DRILL DATE 07-Oct-20

PROJECT TWEED SAND PLANT EXPANSION
SURFACE RL Not surveyed
DRILLED BY G+S
EASTING

LOCATION CUDGEN, NSW
DRILL METHOD HAND AUGER
LOGGED BY SAM
NORTHING

+GILBERT SUTHERLAND



DEPTH (mBGL)	GROUNDWATER	GRAPHIC LOG	SOIL DESCRIPTION	ORIGIN
0			Black (10YR 2/1) **silty clay loam**; no coarse fragments; moderately moist; massive structure; weak consistence; common, medium roots; change to;	NATURAL
0.2			Very dark grey (7.5YR 3/1) **clayey sand** with clear transitions to very few, fine sized, distinct, pale orange yellow (10YR 9/2) mottles; no coarse fragments; moderately moist; massive structure; very weak consistence; few, very fine roots; change to;	NATURAL
			Greyish brown (10YR 5/2) **loamy sand** with diffuse transitions to common, medium sized, distinct, pale orange yellow (10YR 9/2) mottles; no coarse fragments; moderately moist; massive structure; very weak consistence; change to;	NATURAL
0.4			Grey (10YR 6/1) **sand**; no coarse fragments; moist; single grain structure; very weak consistence; change to;	NATURAL
0.6	▼		Brown (10YR 5/3) **sand** with diffuse transitions to many, coarse sized, distinct, yellow (10YR 8/8) mottles; no coarse fragments; moist to wet; single grain structure; very weak consistence; change to;	NATURAL
0.8			Light olive brown (2.5Y 5/3) **sand**; no coarse fragments; wet; single grain structure; very weak consistence; borehole terminated at 1.2mBGL.	NATURAL
1				
1.2				
1.4				
1.6				
1.8				
2				
2.2				

BOREHOLE

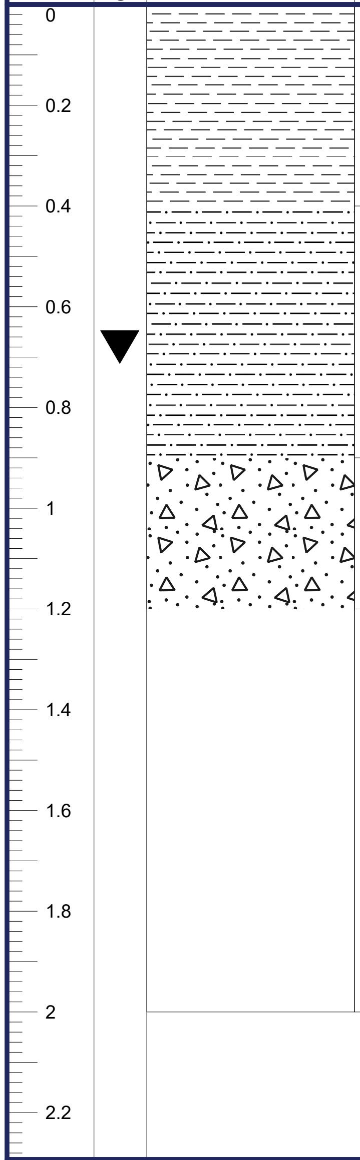
AG2

CLIENT HANSON CONSTRUCTION MATERIALS **PROJECT No.** 12035 **TOTAL DEPTH** 1.2mBGL **DRILL DATE** 07-Oct-20

PROJECT TWEED SAND PLANT EXPANSION **SURFACE RL** Not surveyed **DRILLED BY** G+S **EASTING**

LOCATION CUDGEN, NSW **DRILL METHOD** HAND AUGER **LOGGED BY** SAM **NORTHING**

GILBERT SUTHERLAND

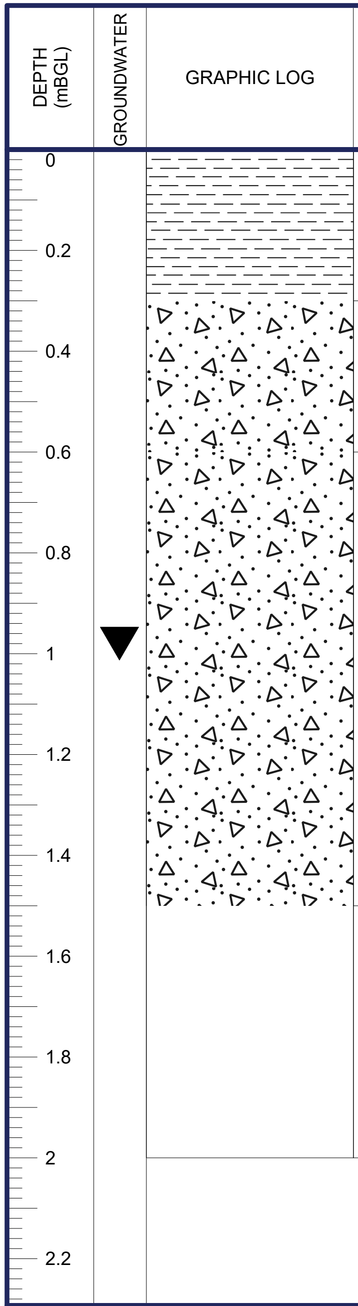
DEPTH (mBGL)	GROUNDWATER	GRAPHIC LOG	SOIL DESCRIPTION	ORIGIN
			Black (7.5YR 2.5/1) **light clay**; no coarse fragments; moderately moist; moderate, 2mm angular blocky structure; weak consistence; no segregations; common, medium roots; change to;	NATURAL
	▼		Brown (10YR 5/3) **clayey sand** with diffuse transitions to common, medium sized, distinct, yellow (10YR 7/6) mottles; no coarse fragments; moist; single grain structure; loose consistence; no segregations; change to;	NATURAL
			Greyish brown (10YR 5/2) **loamy sand** with diffuse transitions to very few, medium sized, distinct, yellow (10YR 7/6) mottles; no coarse fragments; wet; single grain structure; loose consistence; no segregations; borehole terminated at 1.2mBGL.	NATURAL

BOREHOLE

AG3

CLIENT	HANSON CONSTRUCTION MATERIALS	**PROJECT No.**	12035	**TOTAL DEPTH**	1.2mBGL	**DRILL DATE**	07-Oct-20
PROJECT	TWEED SAND PLANT EXPANSION	**SURFACE RL**	Not surveyed	**DRILLED BY**	G+S	**EASTING**	
LOCATION	CUDGEN, NSW	**DRILL METHOD**	HAND AUGER	**LOGGED BY**	SAM	**NORTHING**	

GILBERT SUTHERLAND



SOIL DESCRIPTION	ORIGIN
Very dark grey (10YR 3/1) **light clay**; no coarse fragments; moist; moderate, 2mm angular blocky structure; weak consistence; many, very fine roots; clear change to;	NATURAL
Light brownish grey (10YR 6/2) **loamy sand** with diffuse transitions to common, medium sized, distinct, reddish yellow (7.5YR 6/8) mottles; no coarse fragments; moist; weak, 2mm angular blocky structure; very weak consistence; few, very fine roots; diffuse change to;	NATURAL
Grey (10YR 6/1) **loamy sand** with diffuse transitions to many, coarse sized, prominent, brownish yellow (10YR 6/8) mottles; no coarse fragments; moist; moderate, 3mm angular blocky structure; loose consistence; borehole terminated at 1.5mBGL.	NATURAL

BOREHOLE

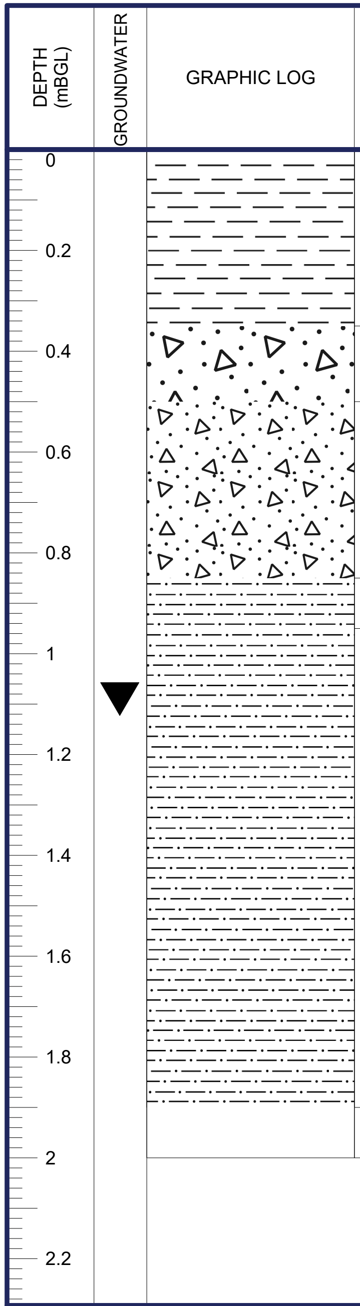
AG4

CLIENT HANSON CONSTRUCTION MATERIALS
PROJECT No. 12035
TOTAL DEPTH 1.5mBGL
DRILL DATE 30-Sep-20

PROJECT TWEED SAND PLANT EXPANSION
SURFACE RL Not surveyed
DRILLED BY G+S
EASTING

LOCATION CUDGEN, NSW
DRILL METHOD HAND AUGER
LOGGED BY SAM
NORTHING

GILBERT SUTHERLAND



SOIL DESCRIPTION	ORIGIN
Very dark grey (10YR 3/1) **light medium clay**; no coarse fragments; moist; moderate, 3mm angular blocky structure; weak consistence; many, fine roots; diffuse change to;	NATURAL
Light grey (10YR 7/1) **sandy loam** with diffuse transitions to few, medium sized, distinct, brownish yellow (10YR 6/8) mottles; no coarse fragments; moist; weak, 2mm subangular blocky structure; very weak consistence; few, fine roots; clear change to;	NATURAL
White (2.5Y 8/1) **loamy sand** with diffuse transitions to few, medium sized, distinct, olive yellow (2.5Y 6/8) mottles; no coarse fragments; moist to wet; single grain structure; very weak consistence; diffuse change to;	NATURAL
Light brownish grey (10YR 6/2) **clayey sand** with diffuse transitions to common, medium sized, distinct, yellow (10YR 7/8) mottles; no coarse fragments; wet; massive structure; very weak consistence; diffuse change to;	NATURAL
Grey (5Y 6/1) **clayey sand** with diffuse transitions to few, fine sized, distinct, yellow (2.5Y 7/6) mottles; no coarse fragments; wet; massive structure; very weak consistence; borehole terminated at 1.9mBGL.	NATURAL

BOREHOLE

AG5

CLIENT HANSON CONSTRUCTION MATERIALS
PROJECT No. 12035
TOTAL DEPTH 1.9mBGL
DRILL DATE 16-Sep-20

PROJECT TWEED SAND PLANT EXPANSION
SURFACE RL Not surveyed
DRILLED BY G+S
EASTING

LOCATION CUDGEN, NSW
DRILL METHOD HAND AUGER
LOGGED BY SAM
NORTHING

GILBERT SUTHERLAND