KUR-World

Appendix 1

Soils and Geology

Environmental Impact Statement

Environmental Approval & Compliance Solutions

KUR-World Soils and Geology Technical Report

Reever and Ocean Developments Pty Ltd

Document Control Summary

NRA Environmental Consultants

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Report Summary	
Key Words	KUR-World, soil, geology, Strategic Cropping Land, EIS, Important Agricultural Areas, Strategic Cropping Areas, Priority Agricultural Areas
Abstract	The geology and soils technical report addresses items 10.6, 10.7, 10.8, 11.8 and 11.12 of the *Terms of reference for an environmental impact statement: KUR-World Integrated Eco-Resort, October 2016*.

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This report should be cited as: NRA 2017, *KUR-World EIS Geology and Soils Technical Report*, R03, prepared by NRA Environmental Consultants for Reever and Ocean Developments Pty Ltd, November 2017.

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Certified Integrated Management System
AS/NZS ISO 9001:2008 (Quality)
AS/NZS ISO 14001:2004 (Environment)
AS/NZS 4801:2001 (Safety)

ENVIRONMENTAL CERTIFIED COMPANY JAS-ANZ AS/NZS ISO 14001:2004 Registration No: 150
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1. Introduction

1.1 Context

KUR-World is an 'Integrated Eco-Resort' proposed by Reever and Ocean Developments Pty Ltd (R&O). The project site is near Myola, 2.5 kilometres east of Kuranda in the Mareeba Shire. The site comprises 12 titles[1] and covers an area of approximately 680 ha[2] comprising rainforest, regrowth forest and woodland, watercourses and pasture (**Figure 1**).

Preliminary investigations and feasibility works were completed in late 2015. A formal application seeking consideration of the KUR-World Integrated Eco-Resort project ('the project') as a 'Coordinated Project' was submitted on 30 May 2016. The project was subsequently declared a 'Coordinated Project' for which an Environmental Impact Statement (EIS) is required. A final Terms of Reference (TOR) for the EIS was released on the 18 October 2016.

1.1.1 Project description

KUR-World Integrated Eco-Resort will include a combination of short-term and permanent residential options, as well as education, recreation, wellbeing/rejuvenation and rural tourism facilities. The current master plan (Version G, 29 September 2017) features four sequential development stages over 7.5 years commencing in 2018 (**Figure 2**).

Stage 1A (2018):

- Farm Theme Park and Equestrian Centre (Phase 1)
- Residential Precinct: Queenslander Lots (21 lots)
- Organic Produce Garden
- Services and Infrastructure (Phase 1)
- Environmental Area (Phase 1).

Stage 1B (2019-2020):

- Farm Theme Park and Equestrian Centre (Phase 2)
- Residential Precinct: Lifestyle Villas (56 lots)
- Open Space
- KUR-Village (Phase 1)
- Four Star Business and Leisure Hotel and Function Centre (Phase 1, 60 rooms)
- Residential Precinct: Premium Villas (39 lots)
- Rainforest Education Centre and Adventure Park
- Services and Infrastructure (including a sewerage treatment plant, access road from Haren Road to rainforest education centre) (Phase 2)

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[1] The property data presented is based on the publicly available DNRM tenure data at the time of reporting. A submission has been made and is currently being processed by the Department of Natural Resources and Mines (DNRM) to combine lots and remove road easements within the project area (*pers. comm.* Stephen Whitaker, Planner, Cardno, 11 October 2017).

[2] This is the total land area within the proposed property boundary including easements and road access area

- Environmental Area (Phase 2).

Stage 2 is planned to start immediately after the completion of Stage 1 and be constructed over a further two year period from 2021-2022. Stage 2 will include:

- KUR-Village (Phase 2)
- Four Star Business and Leisure Hotel and Function Centre (Phase 2, 210 rooms)
- Sporting Precinct
- Golf Club House and Function Centre
- Golf Course
- Residential Precinct: Premium Villas (154 lots and 60 units)
- Services and Infrastructure (Phase 3)
- Environmental Area (Phase 3).

Stage 3 is planned to start immediately after the completion of Stage 2 and be constructed over a one year period in 2023-2024. Stage 3 will include:

- Health and Wellbeing Retreat (60 rooms)
- Residential Precinct: Premium Villas (93 lots)
- Five-Star Eco-Resort (200 rooms)
- KUR-World Campus
- Services and Infrastructure (Phase 4)
- Environmental Area (Phase 4).

1.1.2 Site description

The project area comprises 12 lots, all zoned rural under the Mareeba Shire Council (MSC) Planning Scheme July 2016 (MSC 2016). Details of each lot are provided in **Table 1** and shown on **Figure 1**.

Table 1: Lots comprising the project area

Lot/Plan*	Area (ha)
Lot 22 N157227	37.26
Lot 1 RP703984	16.19
Lot 2 RP703984	48.31
Lot 17 N157227	57.71
Lot 18 N157227	63.01
Lot 19 N157452	39.60
Lot 95 N157452	34.05
Lot 20 N157423	70.62
Lot 131 N157491	64.75
Lot 129 NR456	65.89
Lot 43 N157359	64.51
Lot 290 N157480	64.75

Source: State of Queensland (Department of Natural Resources and Mines (DNRM)), 11 October 2017.

*The property data presented is based on the publicly available DNRM tenure data at the time of reporting. A submission has been made, and is currently being processed by the Department of Natural Resources and Mines (DNRM), to combine lots and remove road easements within the project area (*pers. comm.* Stephen Whitaker, Planner, Cardno, 11 October 2017). This excludes easements that may occur between lots.

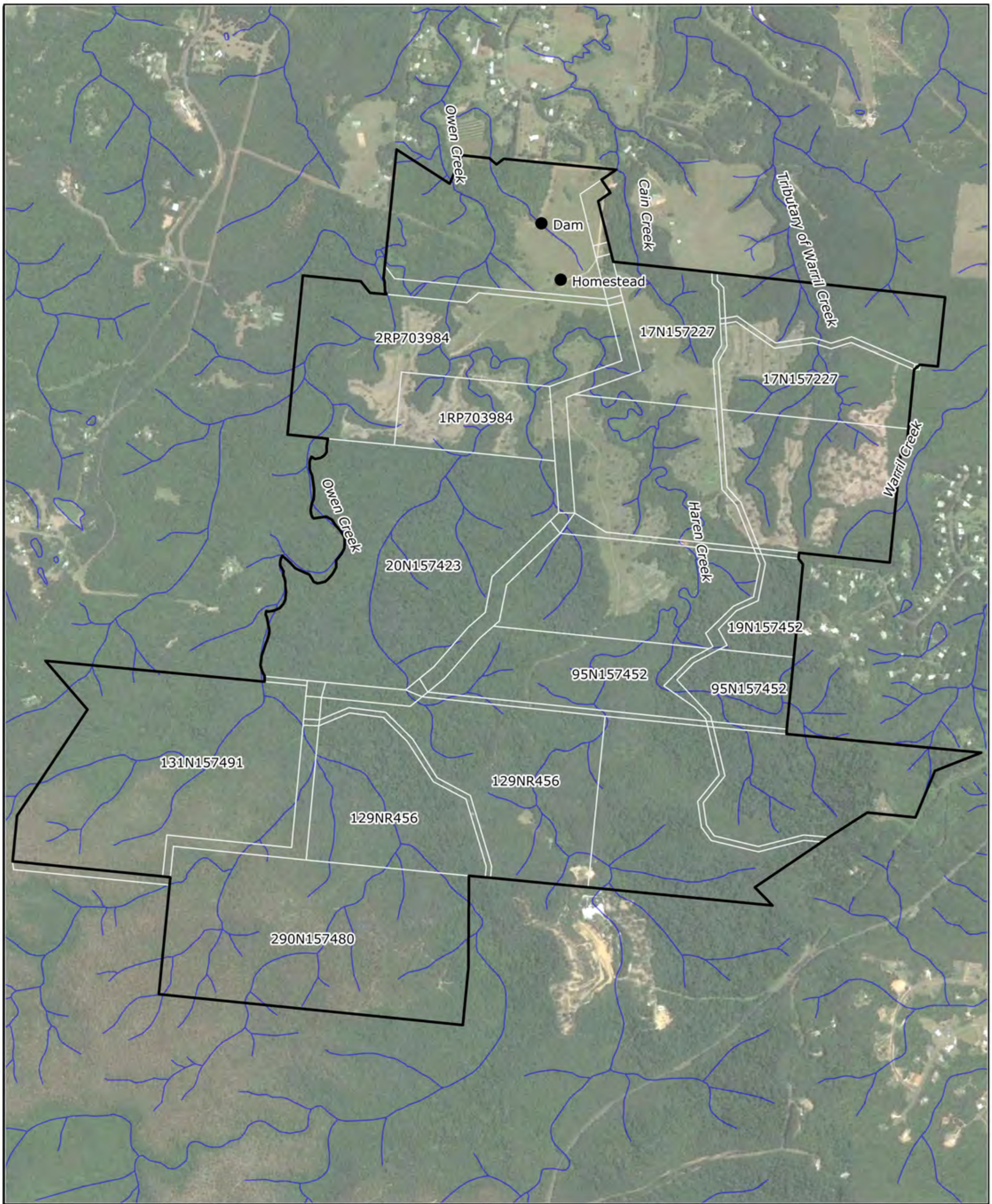

Figure 1: KUR-World project area

Project: KUR-World: Geology and Soils Technical Report

KUR-World project area

Property boundaries

Drainage

Source:
© State of Queensland (Department of Natural Resources and Mines) 2017. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//, Google Earth

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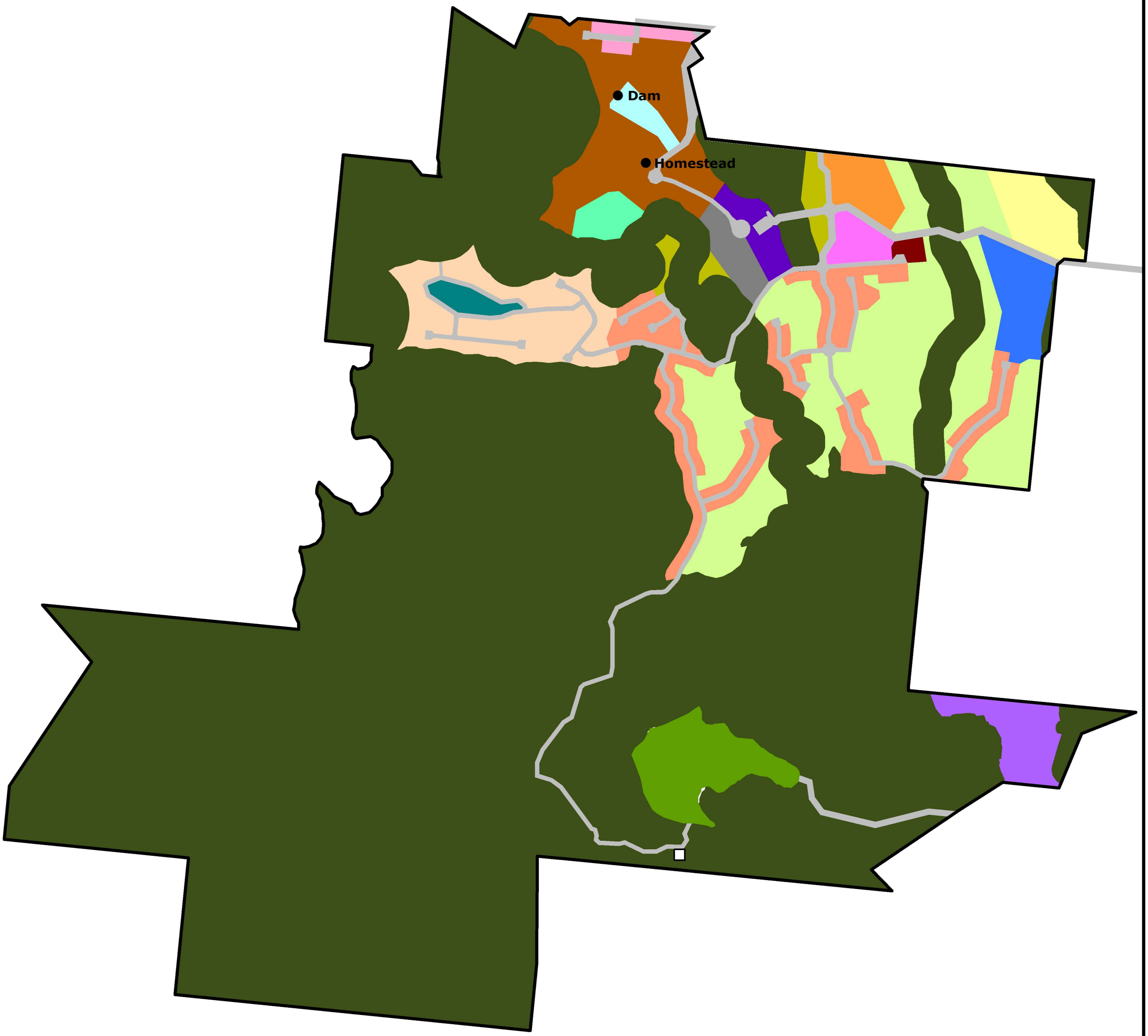

Figure 2: KUR-World master plan

Project: KUR-World: Geology and Soils Technical Report

- Kur-World project area

KUR-World Masterplan Revision G

- Lifestyle Villas
- Queenslander Lots
- Premium Villas
- KUR-Village
- Five Star Eco Resort
- Golf Course
- Golf Clubhouse and Function Centre
- Business and Leisure Hotel and Function Centre
- Health and Wellbeing Retreat
- Sporting Precinct
- Farm Theme Park and Equestrian Centre
- KUR-World Campus
- Rainforest Education
- Open Space
- Produce Garden
- Glamping
- Service / Infrastructure
- Dam
- Road
- Helipad
- Environmental Area

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The northern portion of the project area is characterised by low undulating rises dissected by steep gullies. The topography in this area varies between 340 m Australian Height Datum (AHD) to 360 mAHD. Historical aerial photograph interpretation shows the majority of the northern portion (Lots 1, 2, 17, 18, 19 and 22) was largely or partially cleared of vegetation during a number of clearing episodes commencing prior to the 1940s and continuing until the early 1990s. No large scale clearing occurred between the early 1990s and 2014, when approximately 46 ha of regrowth were cleared to re-establish pasture.

Current development comprises a homestead, cattle yards, animal enclosures, a dam and a weir on Haren Creek. New fencing has been constructed since 2014 and a number of paddocks established. Cattle have access to creeks for watering.

The two largest streams within the project area traverse the northern section; Owen Creek (along the western boundary) and its tributary, Haren Creek. A tributary of Warril Creek arises in the eastern section of the site and the headwaters of Cain Creek lie inside its northern boundary (**Figure 1**).

Grazing of cattle and horses is occurring on all cleared areas within the northern portion. While many of the paddocks are fenced to the top of the creek banks, cattle ingress to waterways is still occurring in places, resulting in trampling of riparian zones.

The southern portion of the site (Lots 20, 43, 95, 129, 131 and 290) is generally characterised by gently to steeply inclined topography (between RL 340 mAHD to RL 430 mAHD) dissected by a number of smaller waterways. Remnant vegetation dominates this area, with aerial photograph analysis suggesting a lack of recent clearing activity (at least since the 1930s). Small areas of historical disturbance are evident in Lots 43, 95, 129 and 131 (AES 2015a).

All-Terrain Vehicle (ATV) tracks occur within the southern portion, in particular within Lots 29 and 131. Lot 129 displays disturbance impacts from an outdoor activity (paintball) venue encroaching from beyond the southern boundary of the project area.

1.2 Scope

The scope of works for the Soils and Geology Technical Report is based on the requirements outlined in the letter *Request for an expanded fee proposal to address additional elements in relation to the Terms of reference for an environmental impact statement: KUR-World Integrated Eco-Resort, October 2016*. The report is to address the following items from the TOR.

10.6. *Where relevant, describe and map in plan and cross-sections the geology and landforms, including catchments, of the project area. Show geological structures, such as aquifers*[3]*, faults and economic resources (such as agricultural products) that could have an influence on, or be influenced by, the project's activities.*

10.7. *Where relevant, describe, map and illustrate soil types and profiles of the project area at a scale relevant to the proposed project. Identify soils that would require*

[3] Groundwater hydrology, including a geological cross section and a description of aquifers and groundwater resources, is presented in a separate technical report (*KUR-World Groundwater Report, Reever and Ocean Pty Ltd*, prepared by Rob Lait & Associates – RLA 2017). The general geology and landforms are described here.

particular management due to waterlogging, erosivity, depth, acidity, salinity or other features.

10.8. Identify potential and actual areas of acid sulfate soils. Where potential areas are identified, further investigations (including field surveys) should be undertaken in accordance with the State Planning Policy (SPP) and accepted industry guidelines.

11.8. If the project impacts on Strategic Cropping Land (SCL), describe the approach to addressing the requirements of the Regional Planning Interests Act 2014 (RPI Act). Document the necessary studies and discussions that have been completed preceding any SCL protection decision. Identify any agricultural land Class A or B as defined in the SPP.

11.12. Detail any known or potential sources of contaminated land. Describe how any proposed land use may result in land becoming contaminated.

2. Relevant Legislation and Policies

Commonwealth and State legislation specify the manner in which development projects can be carried out and the permit requirements for particular activities associated with the development (such as sewage treatment plants or fuel storage).

2.1 State (Queensland) legislation

2.1.1 Policies and guidelines

Land use and land quality

Legislation designed to protect productive land with agricultural or other economic activities includes:

- *State Planning Policy*
- *Regional Planning Interests Act* 2014 (RPI Act).

Protection of environmental quality and values

Legislation designed to protect environmental quality and values relevant to land and water, and which provides frameworks for the approval of environmentally relevant activities that may impact on these values, includes:

- *Environmental Protection Act* 1994
- *Environmental Protection (Water) Policy* 2009 (EPP (Water)).

2.2 Commonwealth legislation

There is no relevant Commonwealth legislation relevant to the values covered by this report.

In planning the assessment of values associated with soils and geology, reference has been made to the Queensland Department of Environment and Heritage Protection (EHP) *EIS information guideline - Contaminated land* and *EIS information guideline – Land*[4] and in particular the *Useful references and guidelines* sections in these guidelines.

[4] Available at http://www.ehp.qld.gov.au/management/impact-assessment/eis-processes/eis-tor-support-guidelines.html - last accessed 25 May 2017.

3. Methods

3.1 Project area

The site of KUR-World is located at Barnwell Road, Myola, approximately 2.5 km west of Kuranda on the Atherton Tablelands. The total land holding comprises of 12 titles and an area of approximately 680 ha. The location is shown in **Figure 1**.

3.2 Desk-based research

3.2.1 Geology

The following published information and spatial data were used to describe and map the underlying geology of the project site.

- 1:100,000 Cairns 8064 series map sheet (DNRM 1989).
- Detailed surface geology – Queensland (1:100,000) spatial data layer (DNRM 2011).
- Watercourse lines – Queensland spatial data layer (DNRM 2014).
- Urban Sync Planning and Development (USPD) KUR-World Integrated Eco-Resort – Initial Advice Statement (USPD 2016).
- Soil Reconnaissance Survey – Kuranda/Myola and Clohesy/Koah areas (Nagel *et al.* 1996).

Additional descriptions of significant geological structures, local aquifers and their relationship with the underlying geology in the region were derived from the groundwater hydrology assessment (RLA 2017).

3.2.2 Topography

Contour data (generated from LiDAR survey data referred to in USPD 2016) at 1 m intervals produced for the project was used to generate slope analysis and relief mapping for the project area. Supplementary information included in the topographic maps was derived from the following sources.

- DNRM Drainage 25k – Queensland, spatial data layer (DNRM 2016b).
- Relief mapping presented by Astrebla Ecological Services (AES 2015a).

Landform patterns present across the project site were described according to the Australian Soil and Land Survey Field Handbook, 3rd Edition (Speight 2009).

3.2.3 State and Regional interests (agricultural land)

State interests, relating to land areas requiring protection for sustainable agriculture, are recognised by the *State Planning Policy – July 2017* (DILGP 2017). They include Important Agricultural Areas (IAAs) as identified by the Queensland Agricultural Land Audit (DAFF 2013). Designation of land as an IAA is based on Agricultural Land Classification (ALC[5]) (DILGP 2017) with ALC Class A and ALC Class B land protected for sustainable agricultural use. This land is regarded as having all the requirements for agriculture to be

[5] This concept was documented in the *Planning guidelines: The identification of good quality agricultural land* (DPI/DHLGP 1993).

successful and sustainable, is part of a critical mass of land with similar characteristics, and is strategically significant to the region or the State (DILGP 2017). Together, these ALC classes are commonly referred to as Good Quality Agriculture Land (GQAL[6]). Although the term GQAL is no longer referred to in the *State Planning Policy – July 2017* (DILGP 2017) or the *State Interest Guideline – Agriculture* (DILGP 2016), it still appears in the MSC Planning Scheme July 2016 (MSC 2016). The term is absent from the Agricultural Land overlays associated with the MSC Planning Scheme July 2016, which refer only to Class A and Class B land, which has been interpreted as identifying IAAs and thus State interests associated with the planning scheme.

Regional interests (relating to agricultural land) are designated in the RPI Act. *Electronic mapping data for Strategic Cropping Land in Queensland under the RPI Act 2014 v3.4* (DNRM 2016c) was used to identify Regional interests. This is the approved mapping data that includes areas of Strategic Cropping Land (SCL) and is used to define areas of Regional interest, such as Strategic Cropping Areas[7] (SCAs) and Priority Agricultural Areas[8] (PAAs), as defined in the RPI Act.

Although the spatial data reviewed identified no State or Regional interests relating to agricultural land in the project area, a reconnaissance survey conducted by Nagel *et al.* (1996) was reviewed to assess land suitability and identify any significant areas with agricultural potential in the project area that have yet to be formally recognised under planning instruments. When considering the agricultural potential of the land and likely impacts associated with the project, it was also necessary to consider the existing site context (location and aerial extent of potentially suitable areas). This included consideration of neighbouring land use and how this may limit agricultural development due to potential land use conflicts. The land use mapping spatial data layer for the *Wet Tropics NRM region 2015* (DSITI 2016) was included in the data review.

3.2.4 Soils

A review of available land unit and soil mapping has been conducted.

The only published soil mapping for the area is *The Atlas of Australian Soils* (Northcote *et al.*, 1960-68). It was compiled by CSIRO in the 1960s and comprises a series of ten maps and associated explanatory notes. The maps are published at a scale of 1:2,000,000, but the original compilation was at scales from 1:250,000 to 1:500,000. At this scale, the mapping provides broad land units that may contain several different soils types.

Soil mapping at a more appropriate scale for planning has been produced for areas surrounding the project site. This includes mapping of soil and land quality in coastal districts to the east of the site (Murtha *et al.* 1996) and soil and land suitability mapping to the south and west on the Atherton Tablelands extending to the land around Lake Tinaroo

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[6] *Good Quality Agriculture Land* was defined by DPI/DHLGP (1993) as "land which is capable of sustainable use for agriculture, with a reasonable level of inputs, and without causing degradation of land or other natural resources," including "crop land" (Class A) with minimal to moderate limitations and "limited crop land" (Class B), which may be better suited for pasture.

[7] *Strategic Cropping Areas* consist of land with soil, climate and landscape features that are highly suitable for cropping (RPI Act). The GIS metadata associated with the mapping notes that SCAs consist of the areas shown on the SCL trigger map as Strategic Cropping Land *ie* SCA is equivalent to SCL.

[8] *Priority Agricultural Areas* contain regions of highly productive agriculture or regionally significant water sources (RPI Act).

(Laffan 1988, Malcolm *et al.* 1999). This mapping covers land areas with the same range of geology, topography and climate as the project site and was used to infer soils likely to occur in the project area. The information gathered through this review, aided by Murtha and Smith (1994), was used to produce preliminary mapping of soil types likely to occur in the project area as a guide to fieldwork.

The review included an assessment of the likelihood of actual or potential acid sulfate soils being present at the project site.

3.2.5 Contaminated land

A desk-based study was conducted to identify land within the project area that may have been contaminated by past activities. Database searches were conducted using lots that make up the current project area (USPD 2016) (**Table 2**) and adjoining lots with the potential to be included as property access (*pers. comm.* Neil Boland, NRA Environmental Consultants, 30 January 2017) (**Table 3**).

A database search of the EHP Environmental Management Register (EMR) and Contaminated Land Register (CLR) (EHP 2017) was conducted on 25 and 31 January 2017. The EMR maintains a public record of land on which a current or historical '*notifiable activity*[9]' has been reported in Queensland. Records are listed under the CLR where necessary action was required to protect human health and prevent serious environmental harm (EHP 2015).

Table 2: Landholdings comprising the project area

Lot and Plan Details[1]	Area (hectares)
Lot 17 on N157227	57.71
Lot 18 on N157227	63.01
Lot 22 on N157227	37.26
Lot 43 on N157359	64.51
Lot 20 on N157423	70.62
Lot 19 on N157452	39.60
Lot 95 on N157452	34.05
Lot 290 on N157480	64.75
Lot 131 on N157491	64.75
Lot 129 on NR456	65.89
Lot 1 on RP703984	16.19
Lot 2 on RP703984	48.31

[1] As defined in the *Initial Advice Statement* (USPD 2016).

Table 3: Adjoining lots with potential to be included as property access

Lot and Plan Details	Area (hectares)
2/RP720923	25.07
1/RP728072	13.28

[9] *Notifiable activities*, as defined under section s.320A of the *Environmental Protection Act* 1994, include any activity "that is causing, or is reasonably likely to cause, serious or material environmental harm".

The EMR and CLR do not include records of contamination or notifiable activities occurring on road reserves (*pers. comm.* Gavin Lucke, Customer Services Officer, Environmental Management/Contaminated Land Registry, 31 January 2017). However, the following conclusions were drawn from discussions with Gavin Lucke (Customer Services Officer, Environmental Management/Contaminated Land Registry, 31 January 2017).

- Searches for lots will include all historical records associated with the land parcel *ie* search results will incorporate historical records of the complete land parcel, of which part may now be a road reserve. Once that land is converted to a road reserve, however, records are no longer updated for this specific section of the land parcel.
- Searches for lots adjacent to road reserves will only identify spills or contamination within those road reserves if the contamination crossed the boundary or spilled over into said adjacent lot. Therefore, if the spill originated in and was confined to the road reserve, it is not likely to be identified by searches to adjacent lots.

In summary, because the assessment has included lots adjacent to road reserves, and given the historical activities undertaken on the project area, the likelihood of contamination being confined to road reserves only (and thus not identified through database searches) is considered to be very low. No further assessment of contamination within road reserves was considered necessary.

As noted in EHP EMR/CLR search responses, the EMR/CLR do not include:

- land that is contaminated land (or a complete list of contamination) if EHP has not been notified
- land on which a notifiable activity is being, or has been, undertaken (or a complete list of activities) if EHP has not been notified.

As the project area has been used for cattle grazing, the EMR/CLR searches were supplemented with a review of aerial photography captured in 1943, 1951, 1971, 1982 and 1994, presented by AES (2015b-f). Images were inspected for features that were consistent between images that may indicate the presence of stock dips.

Access in some form may also be obtained via existing roads (Barnwell Road and Warril Drive). As these are existing formed Council roads they were not included in the EMR/CLR searches.

3.3 Field investigations

A field investigation was conducted to ground-truth the preliminary soil mapping produced through the desktop review (see **Section 3.2.4**). The field investigation was also used to collect relevant soils data to assist with planning soil and land management practices, including effluent irrigation and erosion and sediment control (ESC).

The two main soil types identified as likely to occur on the site (Galmara and Bicton) are distinguishable by differences in colour in the upper B (subsoil) horizon, and this makes it possible to differentiate soil presence using shallow auger borings or excavations. Opportunistic observations were made of soils in existing cuttings/excavations.

Ten soil observations were made in the areas of high intensity land use. Detailed soil descriptions were made in soil pits excavated into representative areas of the two main soil types. Soil descriptions were made using the methods described in NCST (2009). This included key properties that may affect soil and environmental management (such as erosion and sediment control planning) at the project site:

- soil texture
- soil colour (matched to the Munsell Colour Chart), including mottling (colour and %) as an indicator of drainage conditions
- boundary, including horizon depth and nature of the boundary *eg* clear and distinct, or wavy and diffuse between layers
- structure, including the size, shape and coherence of soil aggregates (peds) where these could be discerned
- presence of carbonate or other segregations
- presence of coarse fragments (stones, gravel) or inclusions (nodules).

Field measurements of bulk density were made. Three to five steel cores of known dimension were driven into each soil horizon, trimmed of excess soil and bagged. Total sample weight and sample moisture content were measured to provide total soil dry weight. Soil dry bulk density (D_b) was calculated by the formula:

$$D_b\ (g/cm^3) = \text{sample dry weight}\ (g) \div \text{sample volume}\ (cm^3)$$

Soil samples were collected from representative soil profiles for analysis to assess properties relevant to erosion potential and impacts on water quality. Analysis included the following:

- pH (to assess acidity) and EC (to assess salinity)
- organic matter and total nitrogen content (surface layer only)
- cation exchange capacity(CEC), exchangeable cations, exchangeable acidity and exchangeable sodium percentage (ESP – a measure of sodicity)
- air dry moisture content (moisture content of soil after drying to 40ºC at 0-10 cm only)
- KCl extractable ammonium and nitrate nitrogen
- phosphorus sorption capacity including initial soil P
- particle size analysis (and estimation of plant available water capacity and hydraulic conductivity)
- Emerson aggregate test (soil stability and dispersion for erodibility and fine sediment export risk).

Photographs were taken and the location of soil observations marked using GPS.

4. Results

4.1 Geology

Geological units in the Kuranda region are primarily of metamorphic origin (Nagel *et al.* 1996). The KUR-World development is located mainly over a geological formation known as the Barron River Metamorphics, which is a lithological correlative of the Hodgkinson Formation. Minor Quaternary Alluvium units associated with the Barron River occur north of the site (**Figure 3**). No major geological structures were identified in proximity to the project area at the current mapping scale (1:100,000) (DNRM 2011).

The Hodgkinson Formation is contained in the Hodgkinson Province (Mossman Orogen). The age of the formation is estimated to be early Carboniferous (360 Ma) to late Silurian (420 Ma) (Geoscience Australia 2017). The Barron River Metamorphics is composed of low-grade metamorphic rocks including micaceous schist, phyllite and slate. These rocks tend to be steeply dipping, strongly folded, and often overturned with prominent cleavage (Willmott *et al*. 1988). Despite local variation noted in the 1:100,000 Cairns 8064 series map sheet (DNRM 1989), current digital spatial data (DNRM 2011) describes the Hodgkinson Formation as mainly dark grey, thin-bedded mudstone, subordinate thin to thick-bedded arenite with minor chert and basalt units (**Figure 3**).

4.2 Topography

Elevation and slope classes for the project site are illustrated by **Figures 4** and **5**, respectively.

The elevation across the project site ranges from approximately 300 m to 500 m and has high relief according to the classification of Speight (2009). There is a gradient in elevation across the project area. The highest elevations (490-509 m) are recorded in the south-east (Mount Haren) and south-west corners, grading towards the lowest point in the north of the site. The landscape is dissected by a network of small creeks and streams that follows the general landscape gradient (**Figure 4**) and flow towards the north of the site eventually discharging into the Barron River.

The results of the slope analysis are presented in **Figure 5**. The area is largely moderately inclined (slope 10-32 %) and the dominant landform would be classified as rolling hills. Areas of high elevation have steeper slopes (slope >32%) and would be classified as steep hills. The area is dissected by drainage lines that are, in some cases, steeply sided (slopes can exceed 32%). These drainage features are interspersed with distinct ridgelines (also discernible in **Figure 4**) that are level to gently inclined (slopes 0-10%).

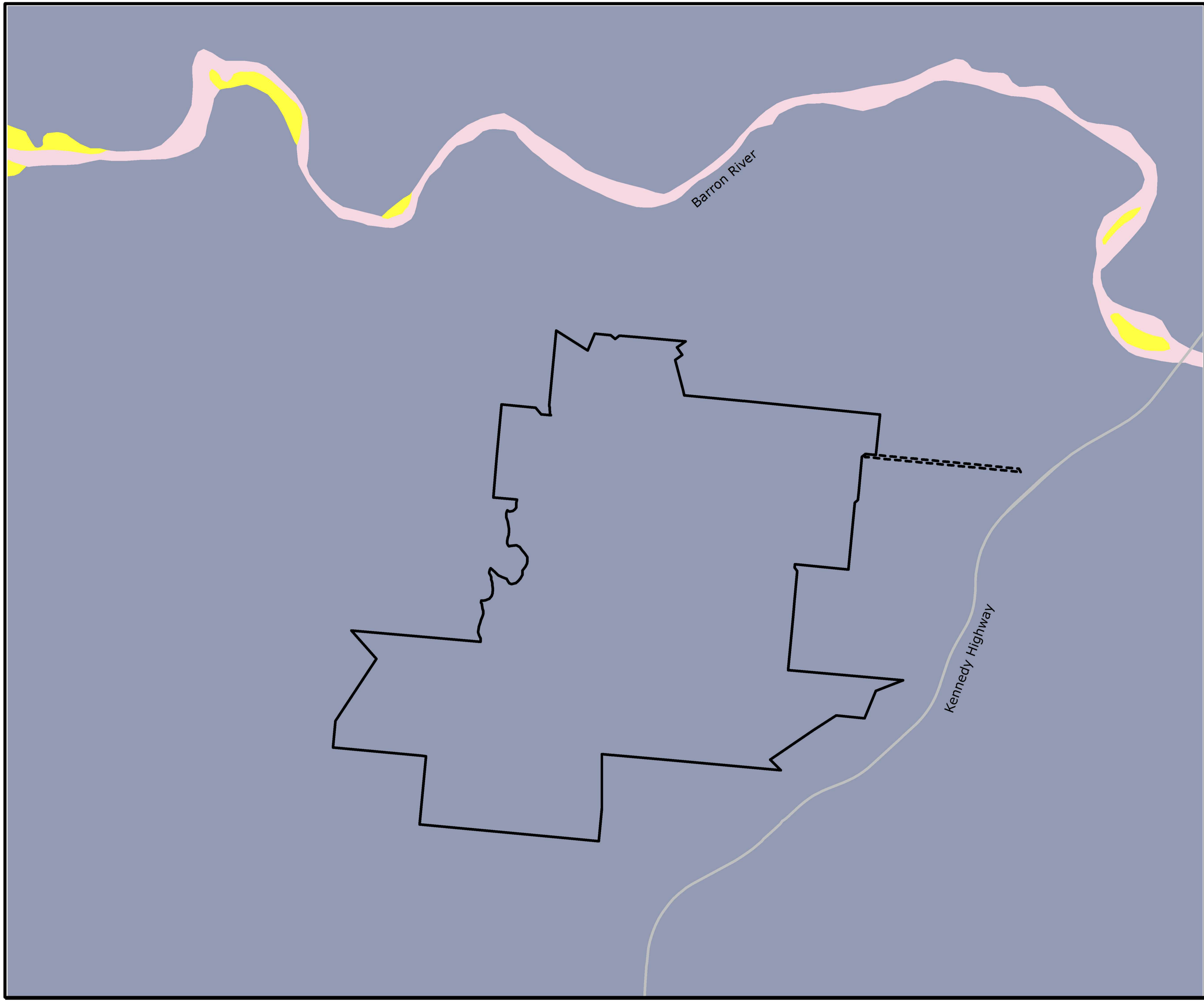

Figure 3: Project site surface geology

PROJECT: KUR-World: Geology and Soils Technical Report

KUR-World project area
Proposed access road
Major roads

Surface Geology (DNR&M 1:100K)

Hodgkinson Formation/m (Dh/m) - Mainly dark grey, thin bedded, mudstone, subordinate thin to thick bedded arenite beds, minor chert and basalt

Qa-QLD (Qa) - Clay, silt, sand and gravel; flood-plain alluvium

Water body (unspecified) (W)

Source:
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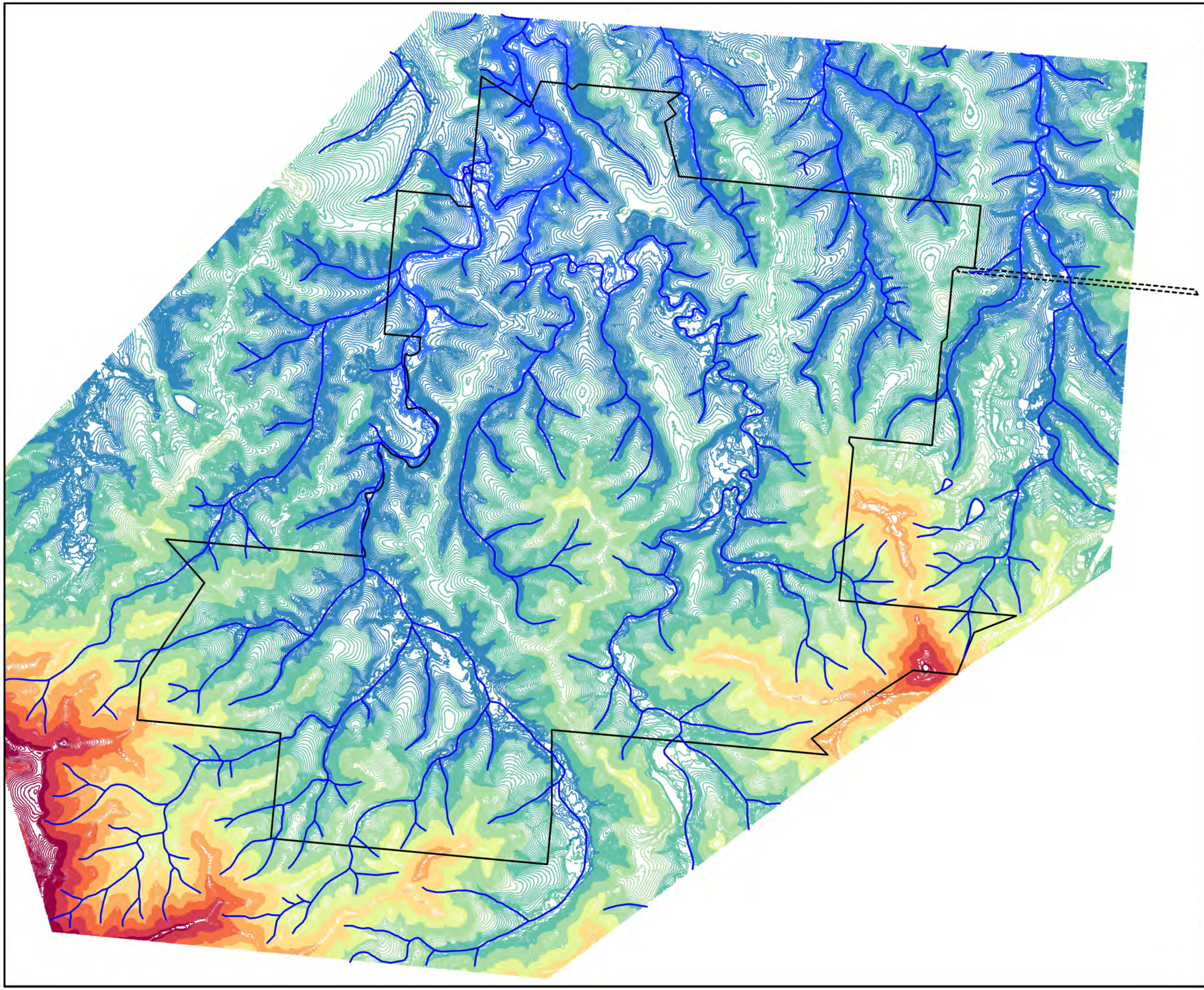
Figure 4: Project site elevation

Project: KUR-World: Geology and Soils Technical Report



KUR-World project area

Proposed access road

Drainage

Contours - 1m interval

490 to 509
472 to 490
454 to 472
436 to 454
418 to 436
400 to 418
382 to 400
364 to 382
346 to 364
328 to 346

N

0 0.5 1

Kilometres

Source:
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Date: November 2017

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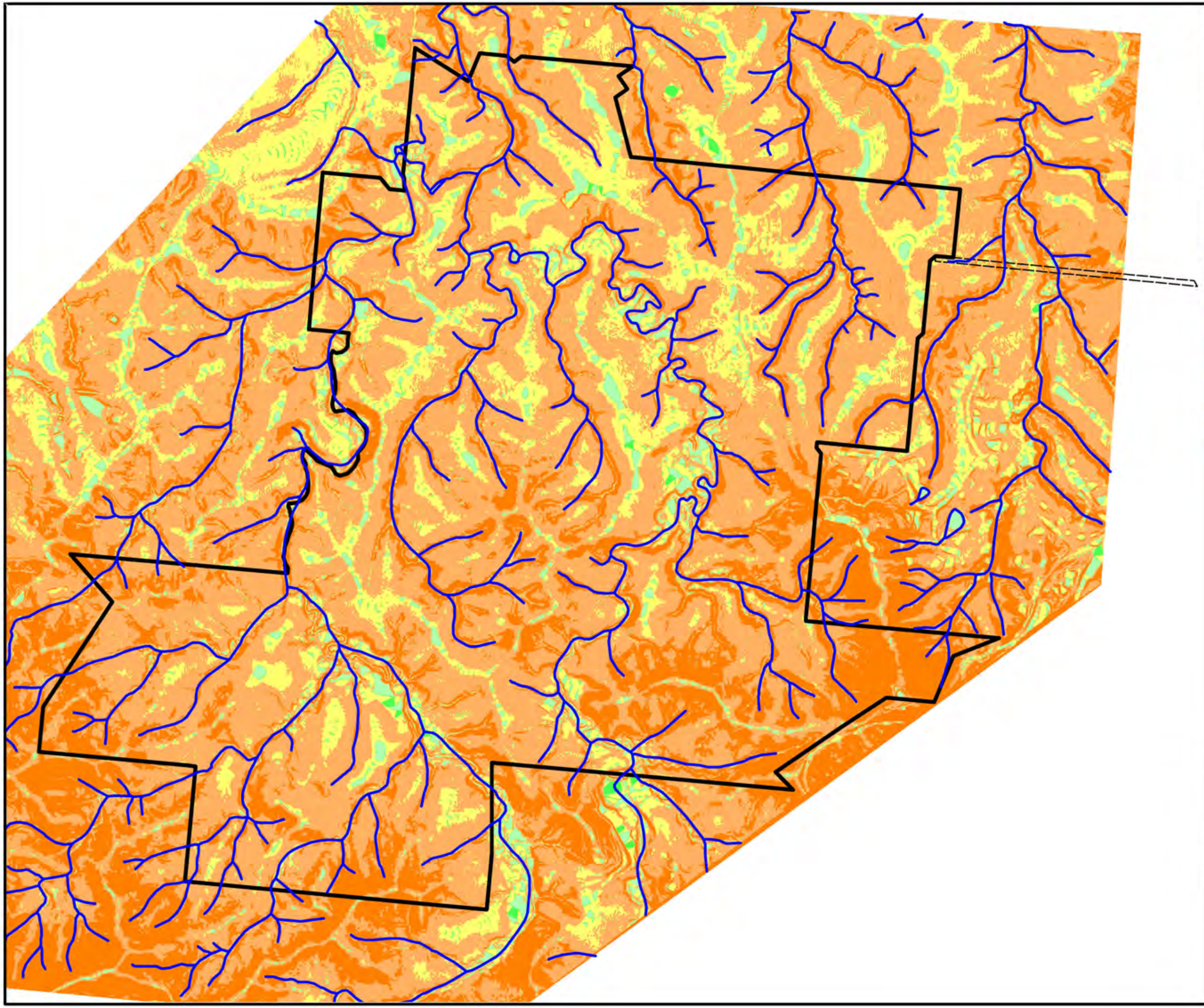

Figure 5: Project site slope classes

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NRA Ref: 424104.01
Date: November 2017

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4.3 State and Regional interests

No areas of GQAL (ALC Class A or B) were identified within or adjacent to the project site (**Figure 6**). It is therefore concluded that no IAAs exist within or adjacent to the project site. Based on the data available, no recognised State interests, with respect to the protection of strategic agricultural land, will be impacted by the project.

No SCAs or PAAs were identified within or adjacent to the project site (**Figure 7**). Based on the data available, no recognised Regional interests, with respect to the protection of strategic agricultural land, will be impacted by the project.

Based on reconnaissance mapping by Nagel *et al.* (1996), 56.4 ha of land potentially suitable for agriculture were identified within the project area (**Figure 8**). Potentially suitable land relevant to the project area includes areas identified as Unique Map Area (UMA) 62 and 58 (Nagel *et al.* 1996). UMA 62 encompasses an area of 51.6 ha, approximately 49.1 ha of which is situated in the northern section of the project site. UMA 62 is largely cleared and is used for grazing or water storage. UMA 58 covers 226.8 ha and two small sections, 7.3 ha in total, fall within the project site.

The work by Nagel *et al.* (1996) did not involve detailed soil and land surveys required to classify land according to an ALC (DPI/DHLGP 1993). The mapping product associated with the work clearly states that the mapping *does not indicate GQAL but land that is potentially suitable for agriculture*. The areas with agricultural potential mapped by Nagel *et al.* (1996) have not been formally recognised or protected as State or Regional interests. There are both land quality and surrounding land use constraints that affect the agricultural potential of areas within the UMAs mapped in the project area, and this has been considered in evaluating the information provided by Nagel *et al.* (1996).

The principles of the superseded *State Planning Policy 1/92* (*Development and the conservation of agricultural land*) (DHLGP 1992) are useful assisting decision-making on land use where agricultural/residential conflicts may arise. As stated in SPP 1/92, the proximity of residential developments can limit the extent to which the inherent quality of agricultural land can be exploited.

DNR/DLGP (1997) recommends that a buffer width of 300 m (assuming open ground conditions) be maintained between areas of agricultural and residential land use to minimise conflicts and risks associated with dust and spray drift.

By 2015, 110 ha of UMA 58 (48.5 %) had already been converted to residential land use (based on DSITI 2016) and **Figure 8** shows that if a 300 m buffer is applied around these areas, intensive agricultural use would likely be in conflict with existing land use. Therefore, regardless of land quality and the potential of the land for intensive agricultural use in the future, the majority of UMA 58 could not be exploited for intensive agriculture without risking conflicts with neighbouring land users.

Potential land use conflicts would also reduce the area that could be exploited within UMA 62 to less than 50 ha. Some of this land is already used for water storage (*ie* the farm dam footprint is within UMA 62). The remaining land has significant areas with slopes over 10% and is dissected with numerous small drainage lines. Although it may be the best quality land on the property for agricultural use, it is not considered to be exploitable for intensive uses, and it is best suited to grazing (its current land use).

Figure 6: Areas of State interest (agricultural land) in the Mareeba and Cairns Local Government Areas surrounding the project site

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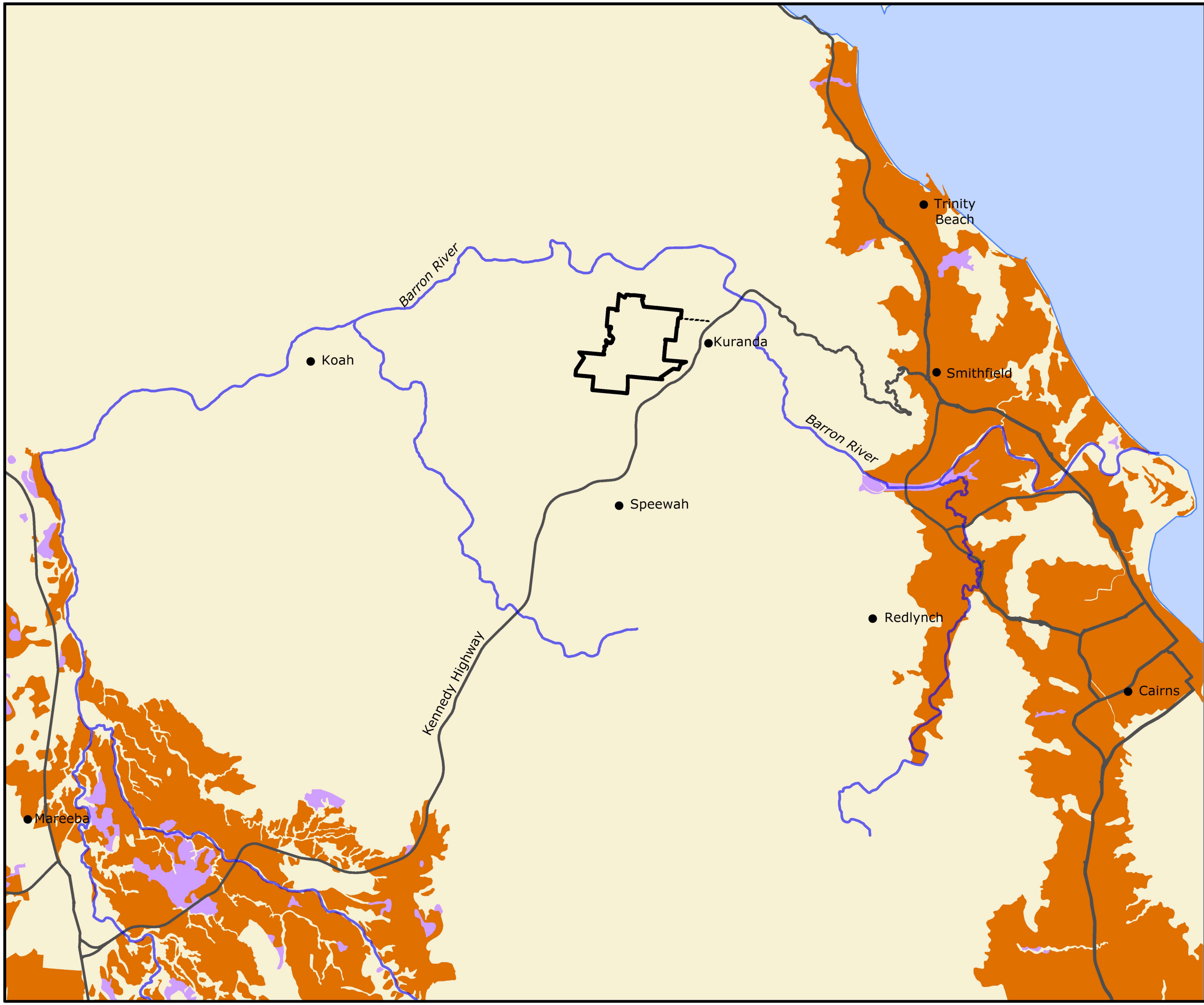

KUR-World project areas
Proposed access road
Drainage
Major roads
Good Quality Agriculture Land (DAFF 2013)
Class A
Class B

N

0 2.5 5 7.5
Kilometres

Source:
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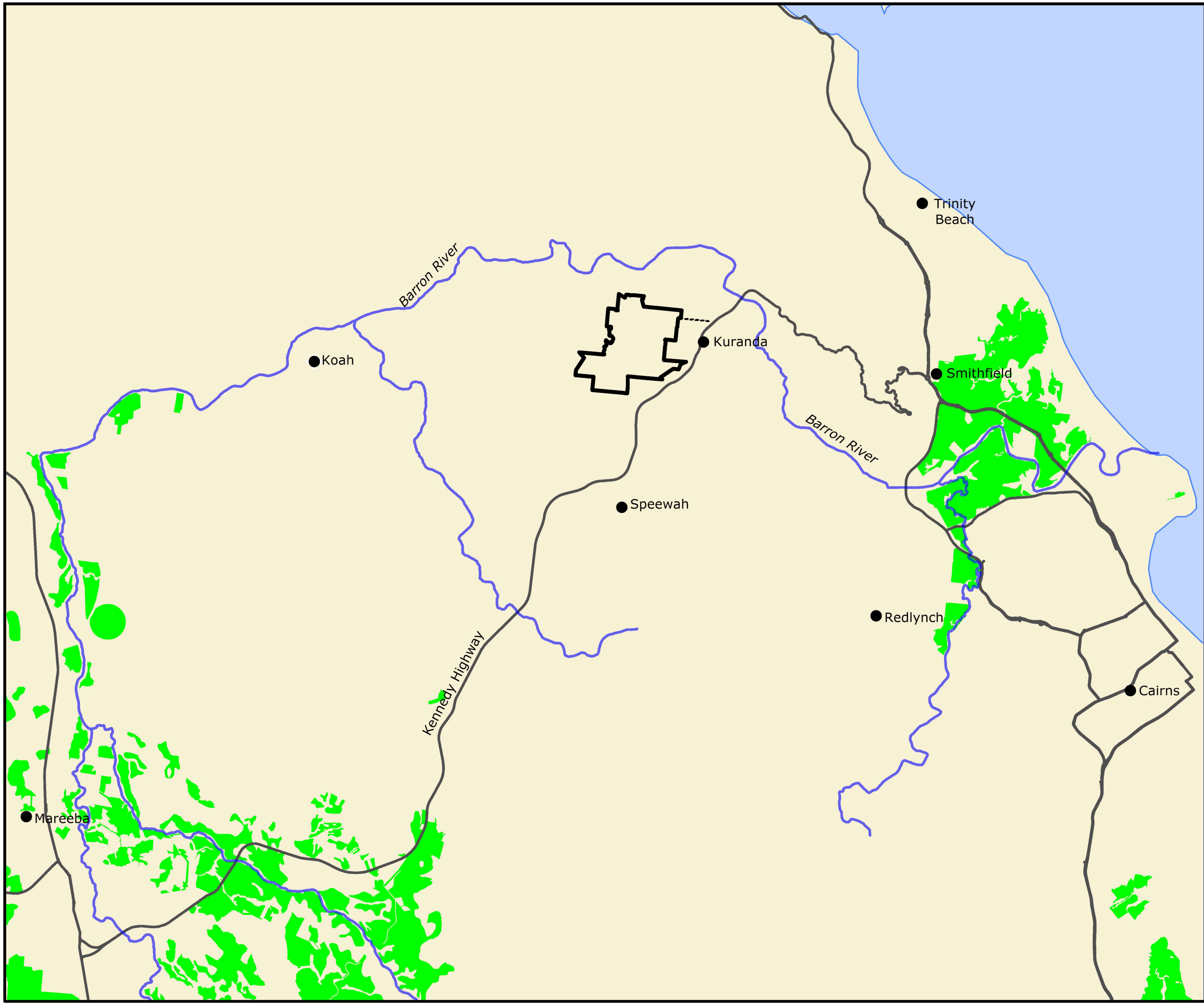

Figure 7: Areas of Regional interest (agricultural land) in the Mareeba and Cairns Local Government Areas surrounding the project site

PROJECT: KUR-World: Geology and Soils Technical Report

- KUR-World project areas
- Proposed access road
- Drainage
- Major roads
- Strategic Cropping Areas (SCA)

N

0 2.5 5 7.5
Kilometres

Source:
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NRA Ref: 424104.01
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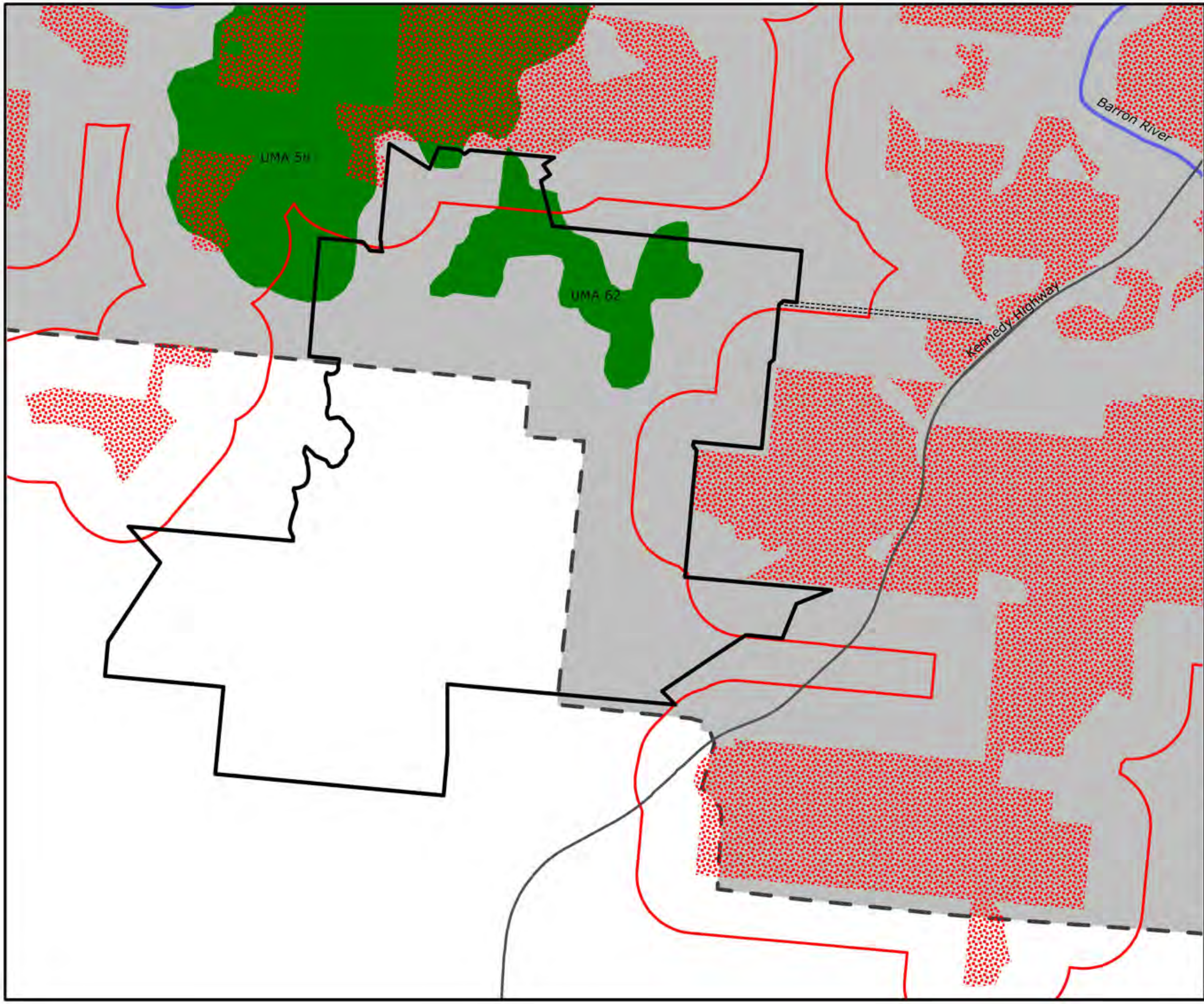

Figure 8: Land potentially suitable for agriculture

PROJECT: KUR-World: Geology and Soils Technical Report

KUR-World project area
Proposed access road
Drainage
Major roads
Residential land
300m buffer around residential land

Land potentially suitable for agriculture
(Nagel et al. 1996)

Land potentially suitable for agriculture
Land not potentially suitable for agriculture
Extent of Nagel et al mapping

N

0 250 500 750 1000
Metres

Source:
© State of Queensland (Department of Science, Information, Technology and Innovation) 2017, © State of Queensland (Department of Natural Resources and Mines) 2017, Nagal, Sinclair and Klein 1998, Reever and Ocean Pty Ltd

NRA Ref: 424104.01
Date: November 2017

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Recommended print size: A4

On this basis, further assessment of the areas identified by Nagel *et al.* (1996) as having agricultural potential is not justified and the land does not have the qualities that could be considered of State or Regional interest. The field soil survey component therefore concentrated on soil related opportunities and constraints with respect to the development and potential impacts on soil resources and the receiving environment.

4.4 Soils

4.4.1 Desktop assessment

Soil types and classification

Two main soil types (referred to as soil profile classes SPCs or soil series), namely Bicton and Galmara, have been mapped by Malcolm *et al.* (1999) as occurring on metamorphic rocks under similar rainfall, temperature and landform patterns on the Atherton Tablelands to the west of the project site. As well as Bicton and Galmara series, Murtha *et al.* (1996) and Murtha and Smith (1994) described additional soil types that develop on the metamorphic rock in the Cairns hinterland. Of these, Seymour, which occurs on steeper slopes or ridgelines, may occur in the project area. Due to the topography of the site, soils that occur on alluvial or colluvial fans of metamorphic origin described by Murtha *et al.* (1996) and Murtha and Smith (1994) (such as Mission) are likely to be confined to isolated sections of the larger drainage lines in the central or southern sections of the site where slopes are level or gently inclined. At the scale of the mapping, it is difficult to isolate areas of Seymour and Mission series soils and they are likely to co-occur with the dominant Bicton and Galmara series.

The central concepts of the soils likely to occur in the project area are described in **Table 4**.

Table 4: Soil types described by Malcolm *et al.* (1999) and Murtha *et al.* (1996) with the potential to occur on the project site

Soil Profile Class or Soil Series	Australian Soil Classification	Landform	Concept
Bicton	Brown Dermosol[1] Soils with a structured subsoil and lacking strong texture contrast between topsoil and subsoil. Colours in the upper 0.5m of the subsoil have a hue yellower than 5YR and a value of 5 or less and a chroma of 3 or more.	Rolling (20-32%) and steep (>32%) low hills.	Moderately deep or deep, mottled yellowish brown, pedal, gradational (increasing clay content with depth) soils with acid reaction trend formed *in situ* (*ie* not on alluvium or colluvium) on metamorphic rocks.
Galmara	Red Dermosol Soils with a structured subsoil and lacking strong texture contrast between topsoil and subsoil. Colours in the upper 0.5m of the subsoil have a hue of 5YR or redder and a chroma of 3 or more	Gently sloping rises to steep low hills (3->32%).	Deep, red, pedal, gradational soils with acid reaction trend formed *in situ* on metamorphic rocks.

Soil Profile Class or Soil Series	Australian Soil Classification	Landform	Concept
Seymour	Orthic Tenosol Soils with little soil profile development and a weakly differentiated (by structure, colour or texture) or low clay content (15% or less subsoil).	Hills and mountains including narrow ridges and crests (>32%).	Shallow gravelly soils formed *in situ* on metamorphic rocks.
Mission	Red Kandosol Soils with a massive or weakly structured subsoil and lacking strong texture contrast between topsoil and subsoil. Colours in the upper 0.5m of the subsoil have a hue of 5YR or redder and a chroma of 3 or more.	Gently sloping rises (1-10%) (lower slopes and valleys).	Deep, red, massive, gradational soils formed on alluvial/colluvial fans on metamorphic rocks.

[1] Some profiles within this SPC may be classified as Yellow Dermosols particularly in higher rainfall areas.

Presence of acid sulfate soils

Mareeba Shire is not included in the SPP as an 'acid sulfate soil affected area' *ie* it is not recognised as an area where acid sulfate soils are present or may be present.

Potential acid sulfate soils (PASS) are generally associated with land areas below 5 m AHD. This includes soils that occur below 5 m AHD even if the land surface elevation is above 5 m AHD. Land in alluvial valleys with surface elevations less than 20 m may still contain pyritic (potentially acid forming) material at depth (DLGP 2002). The SPP (State interest water quality) does not apply to land with an elevation above 20 m AHD.

The minimum elevation at the project site is approximately 300 m AHD. PASS do not occur at these elevations in wet topical environments, and there is no risk of exposing PASS during the development. Field observations did not indicate any soil features that would be consistent with the presence of PASS. No further assessment of PASS is required.

4.4.2 Field assessment

Soil types and distribution

The main soil types identified in **Section 4.4.1** (Galmara and Bicton) were confirmed to dominate the project site. Based on observations and the desktop review, these soils are thought to occur across the majority of the site. Soil observation locations are shown in **Figure 9**.

The Bicton soil type appears to be confined to very gently inclined or level ridge tops (slopes <3%) with restricted drainage, and Galmara dominates on better drained gently to steeply inclined areas. **Plate 1** shows the typical landscape position of the Bicton series soils described for this site. **Plates 2** and **3** show the typical landscape position for Galmara series soils. It is well recognised that these soils types can occur in the same landscape position seemingly randomly (Murtha *et al.* 1996) and it is likely that units mapped as one soil type will include areas of the other.

Plate 1: Typical landscape position where Bicton soil was observed (site S02)

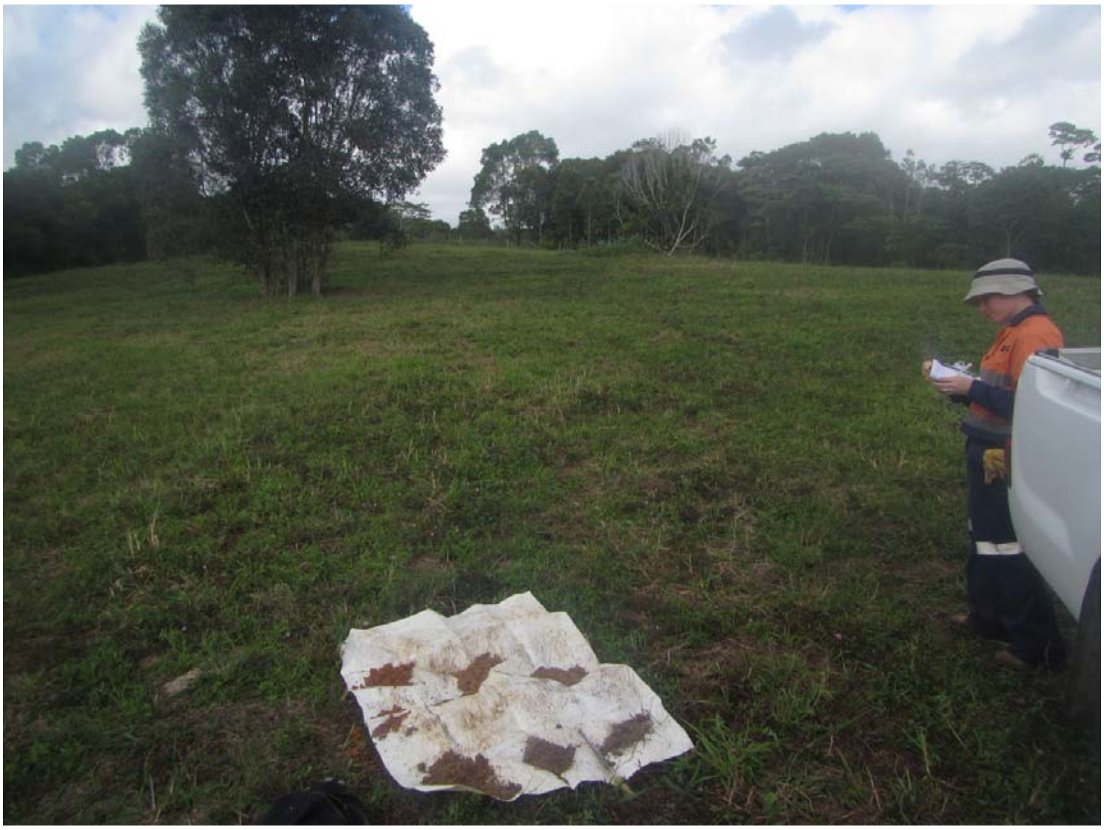

Plate 2: Typical landscape position where Galmara soil was observed (site S03)

Plate 3: Typical landscape position where Galmara soil was observed (site S04)

No profiles consistent with the properties of Mission or Seymour soil series were described; however, based on the topography of the site, they are expected to co-occur in areas of Galmara soil, and the mapping delineates where they may be co-dominant. As the Mission series soils are located generally within 50-100 m of the creek lines, they occur outside the current planned project disturbance envelope (**Figure 10**). As these soils are developed on material that has been transported, the areas where they exist may be an ongoing source of sediment to creeks downstream. This appears to be consistent with site observations and water quality analysis (*pers. comm.* Neil Boland, NRA Environmental Consultants, 25 May 2017). Should these soils need to be disturbed, specific soil erosion and sediment controls will be required. Seymour soils are most likely restricted to areas with slopes over 32%, but may be encountered in the southern part of the project (around the Rainforest Education centre) (**Figure 10**).

The distribution of the main soil types known or expected to occur on the site are presented in **Figure 9**. **Figure 10** shows the location of soil types with reference to the project elements in the master plan.

Figure 9: Distribution of soils on the project site

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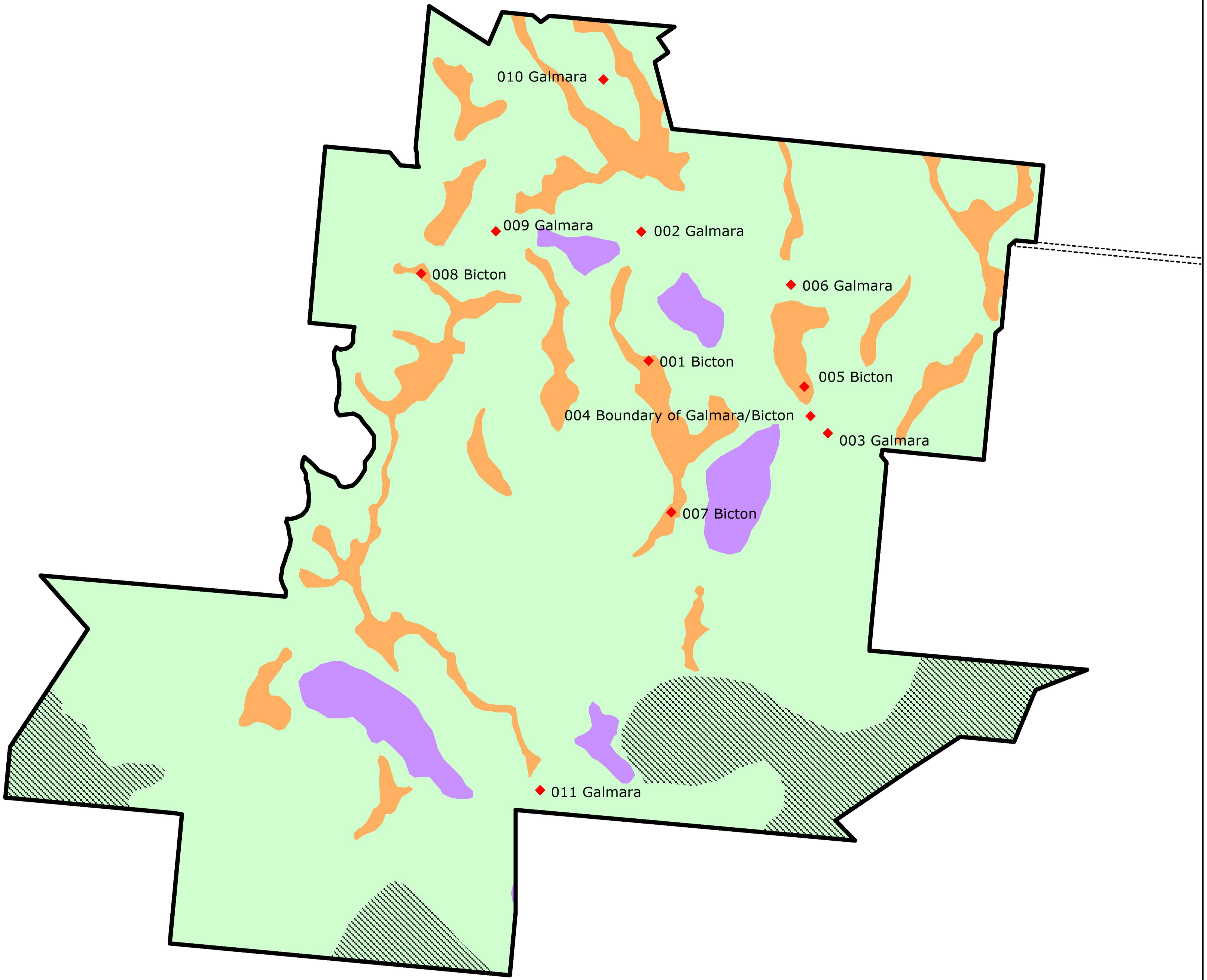

KUR-World project area

Proposed access road

Soil observation locations

Soil types

Bicton

Galmara

Galmara (Seymour)

Mission

N

0 0.5 1

Kilometres

NRA Ref: 424104.01
Date: November 2017

Source:
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Recommended print size: A4

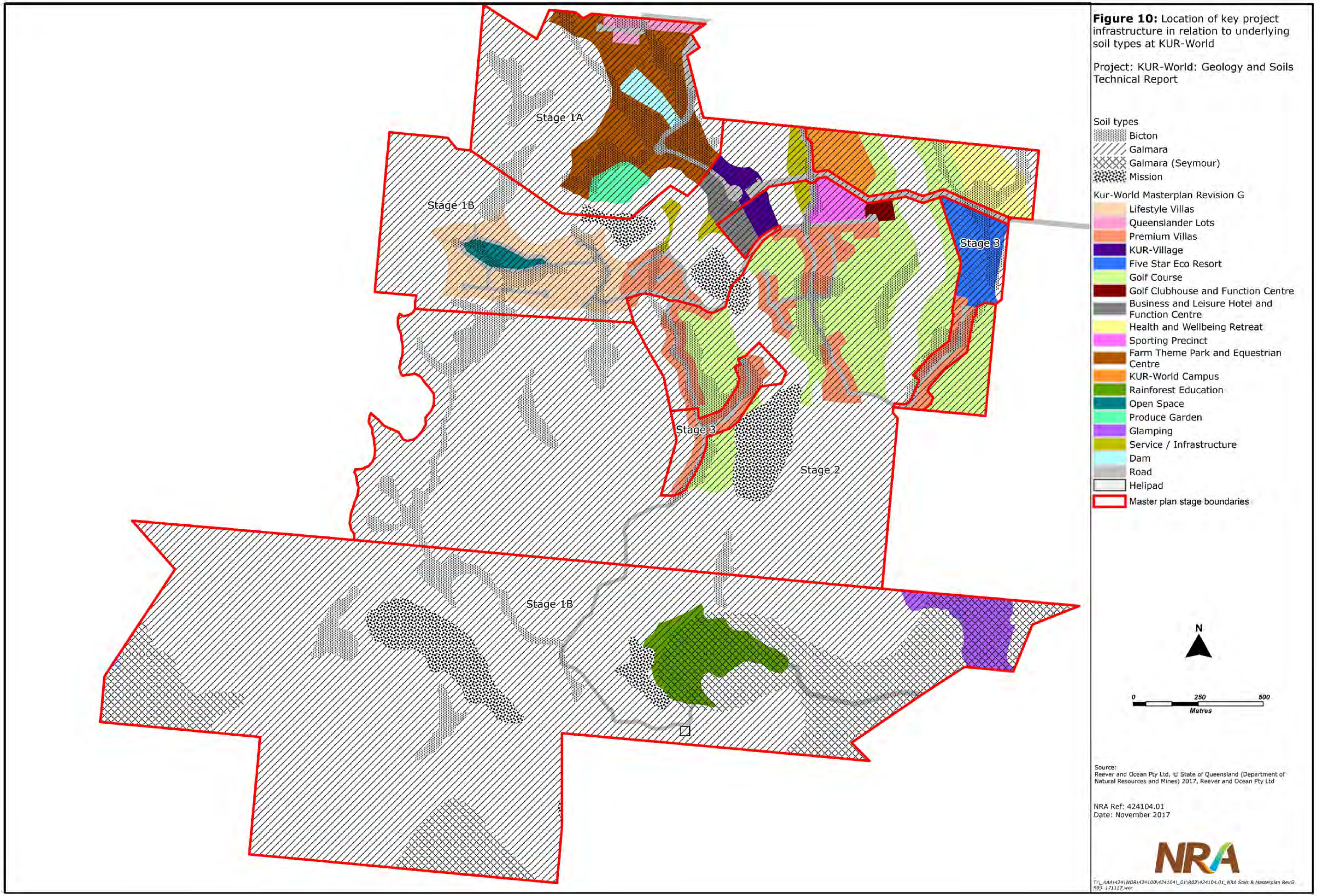

Figure 10: Location of key project infrastructure in relation to underlying soil types at KUR-World

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Recommended print size: A3

Description of main soil types

Below is a description of the Galmara soil encountered at site 003. Note that this profile contained few coarse rock (stone) fragments, but stone content can vary and was observed to be higher in areas with steeper slope angles (such as at observation point 011 in **Figure 9**).

Site: 003	Soil series: Galmara
Landform element: Upper slope	Landform pattern: Rolling hills
Slope: 3-10%	Surface course fragments: None
Vegetation: permanent pasture - grazed	Surface condition: Hard

Horizon	Depth (cm)	Soil description
A1	0-10	Dusky red; clay loam; very few medium pebbles; firm; moderate 5-10 mm sub-angular blocky structure; distinct smooth boundary.
B21	10-35	Dark red; silty clay loam; few medium pebbles firm; moderate 10-20 mm sub-angular blocky structure; district smooth boundary.
B22	35-75	Dark red; light clay; firm; moderate 10-20 mm sub-angular blocky structure; district smooth boundary.
B23	75-120+	Dusky red; light clay; firm moderate 10-20 mm sub-angular blocky structure.

Below is a description of the Bicton soil encountered at site 005.

Site: 005	Soil series: Bicton
Landform element: Closed depression in mid slope	Landform pattern: Rolling hills
Slope: 3-10%	Surface course fragments: None
Vegetation: permanent pasture - grazed	Surface condition: Firm

Horizon	Depth (cm)	Soil description
A1	0-15	Brown; very few <5 mm faint orange mottles; clay loam, firm; moderate 5-10 mm sub-angular blocky structure; distinct smooth boundary .
B21	15-50	Brownish yellow; common <5mm faint orange mottles; sandy clay loam; firm; moderate 10-20 mm sub-angular blocky structure; district irregular boundary.
B22	50-95	Yellow; common 5-15 mm faint orange mottles; silty clay; firm; moderate 10-20 mm sub-angular blocky structure; district irregular boundary.
B23	95-120+	Reddish yellow; many 5-15 mm distinct orange mottles; silty clay loam; few small pebbles; firm; moderate 10-20 mm sub-angular blocky structure.

Photographs of example profiles are presented in **Plate 4** (pits are 120 cm deep).

Plate 4: Photographs of soil pits in Galmara series (left) and Bicton series (right) soils

Soil properties relevant to the development – Galmara

A summary of soil analytical results for the Galmara samples is presented in **Table 5**. Full laboratory results are provided in **Appendix A** with chain of custody documentation.

Soil acidity and aluminium saturation

The topsoil is moderately acid (pH <6), but pH declines in the subsoil and is strongly acid (pH <5) at 10-35cm depth. This results in an increasing proportion of exchangeable acidity and, in particular, exchangeable aluminium with depth. Exchangeable aluminium is usually low or absent at pH values above 5.5 and this is consistent with the results in **Table 5**. The pH range is not unusual for mineral soils in the humid tropics. The pH and exchangeable aluminium results for the subsoil would be acceptable for acid tolerant species (many native tropical species), but may be unsuited to more sensitive species used in amenity planting or to grasses used in hydromulching of exposed subsoils. Soil pH effects in the subsoil may be exacerbated by a high magnesium to calcium ratio leading to a calcium deficiency (see further comments on general soil fertility below).

Soil salinity and sodicity

The Galmara soils are non-saline and non-sodic.

Cation exchange properties and soil chemical fertility

The Galmara topsoil has moderate (5-15 $cmol^+/kg$) CEC and adequate reserves of major cation nutrients (calcium, magnesium and potassium). The topsoil has adequate supplies of available phosphorus.

The subsoil CEC is low (<5 $cmol^+/kg$). This means that the subsoils soils have a low capacity for cation nutrient retention and are prone to leaching. This may be a limitation for the application of high strength effluent. However, it is understood that waste water will be tertiary treated as a minimum, and low subsoil cation exchange capacity is not a significant limitation to irrigation of low strength effluent.

Table 5: Summary of Galmara soil analytical results

Soil property	Units	Sample depth (cm)			
		0-10	10-35	35-75	75-120
pH (1:5 water)		5.87	4.98	5.08	5.16
EC (1:5 water)	dS/cm	0.074	0.028	0.056	0.009
Salinity rating		Very low	Very low	Very low	Very low
Exchangeable Ca	$cmol^+/kg$	3.36	0.22	0.06	0.03
Exchangeable Mg	$cmol^+/kg$	1.40	0.72	0.6	0.55
Exchangeable K	$cmol^+/kg$	0.40	0.11	0.01	0.05
Exchangeable Na	$cmol^+/kg$	0.08	0.04	0.04	0.04
Exchangeable Al	$cmol^+/kg$	0.03	1.59	1.34	1.47
Exchangeable H	$cmol^+/kg$	0.12	0.56	0.64	0.61
Effective CEC	$cmol^+/kg$	5.39	3.24	2.68	2.75
ESP	%	1.5	1.1	1.3	1.6
Sodicity class		Non-sodic	Non-sodic	Non-sodic	Non-sodic
Ca:Mg ratio		2.4	0.3	0.1	<0.1
Aluminium saturation	%	0.6	49.2	50.1	53.5
Total carbon	%	3.12	-	-	-
Total nitrogen	%	0.22	-	-	-
C:N ratio		14.2:1	-	-	-
Nitrate N (KCl)	mg/kg	13	5.2	0.7	0.5
Ammonium N (KCl)	mg/kg	6.4	3.1	2.1	1.0
Colwell P	mg/kg	43.8	34.5	7.7	9.8
Maximum P adsorption at equilibrium	µg P/g	1,562	1,500	1,925	1,888
Maximum P adsorption capacity in horizon#	kg P/ha	1,546	4,613	10,164	11,385
Dry bulk density	g/cm^3	0.99	1.23	1.32	1.34
Total porosity	% v/v	60.5	52.5	49.8	49.3
Gravel >2 mm	%	0.7	0.6	<0.1	<0.1
Sand 0.02 – 2 mm	%	44.6	28.5	13.3	9.7
Silt 0.002-0.02 mm	%	38.6	42.9	39.2	50.2
Clay <0.002 mm	%	16.8	28.6	47.5	40.1
Texture Class		Silty loam	Silty clay loam	Silty clay	Silty clay
EAT Class		4	4	4	4
Saturated water content[1]	v/v	0.51	0.48	0.50	0.49
Field capacity (10Kpa)[1]	v/v	0.47	0.42	0.41	0.41
Wilting point[1]	v/v	0.10	0.11	0.16	0.14
PAWC[1]	%v/v	37	31	25	27
Estimated KSat[1]	mm/hr	58.3	11.5	5.4	4.0

[1] Soil moisture characteristic curve parameters derived from pedotransfer functions described by van Genuchten *et al.* (2000) based on field bulk density and laboratory particle size and organic matter input data.

The subsoil contains low reserves of nutrients and amenity planting in to, or hydromulching directly on to, exposed subsoils would require fertiliser applications (preferably in a slow release form).

Organic matter and total nitrogen content are normal for soils under pasture in high rainfall areas (Baldock & Skjemstad 1999). The subsoil was low in readily extractable nitrogen species, and subsoil N concentrations can be used as a tool for monitoring the impacts of effluent irrigation on nitrate leaching and accumulation beyond the rootzone. The soil has adequate supplies of available phosphorus.

Phosphorus adsorption capacity

This soil has a high capacity for phosphorus adsorption, making it suitable for long-term effluent irrigation application. The likelihood of breakthrough of phosphorus leaching from the profile is very low.

Soil physical fertility and drainage properties

The topsoil is loose, with a low bulk density (0.99 g/cm^3). This is a reflection of the good organic matter content in the surface soils (>5%). Soil bulk density increases in the subsoil, but is not high enough to significantly limit root penetration.

The soils have good water holding capacity (c. 280 mm/m of soil) as would be expected for medium textured to light clay soils with some structural development.

The saturated hydraulic conductivity is moderate to moderately slow in the upper profile, but slow in the deeper subsoil. This has implications for soil drainage and wetness in amenity areas, particularly the Golf Course and Sporting Precinct. These soil properties will need to be considered in planning soil drainage requirements and irrigation application management.

Soil properties related to erosion risk

The soils are non-sodic and non-dispersive (EAT Class 4). The laboratory reported a reaction with hydrochloric acid suggesting the presence of carbonate, but pH results did not indicate that secondary carbonate would be present (not expected below approximately pH 8.3). There may be traces of added lime in the surface soils and particulate carbonate in parent material in the subsoil, but these are unlikely to have influenced dispersion properties. This soil type should not be prone to tunnel formation and subsequent gully erosion. This does not mean that gully formation is not possible in circumstances where concentrated flow is directed over this soil.

The erodibility of the soil in terms of sheet and rill erosion has been assessed using the Revised Universal Soil Loss Equation (RUSLE) K factor (Rosewell 1993). The relevant parameters and K factor determinations are presented in **Table 6**.

Table 6: Estimates of RUSLE K factor for Galmara soil type

Soil property	Units	Sample depth (cm)			
		0-10	10-35	35-75	75-120
Organic matter	%	5.50	2.32 [2]	0.69 [2]	0.34 [2]
Clay	%	16.8	28.6	47.5	40.1
Silt	%	38.6	42.9	39.2	50.2
Fine sand[1]	%	24.9	14.1	6.3	8.7
Coarse sand[1]	%	19.7	14.4	7.0	1.0
Permeability class		4	4	4	4
Structure class		3	3	3	3
RUSLE K factor		**0.035**	**0.039**	**0.028**	**0.042**
Erodibility rating[3]		**Moderate**	**Moderate**	**Moderate**	**High**

[1] Soil particle size analysis included determination of USDA and ISSS size classes allowing estimation of coarse and fine sand fractions required for calculating RUSLE K factor.

[2] Subsoil organic matter content estimated from profile data in Murtha *et al.* (1996).
[3] Rating for sheet and rill erosion (excludes gully erosion) based on Rosewell and Loch (2002).

The reasonable organic matter content in the surface soil (>3%) and the relatively high clay content in the upper subsoil mean that surface soils are estimated to be moderately erodible. Below 75 cm, however, the soils have a high silt content, making them poorly cohesive and highly erodible.

The high silt and clay content of the subsoils (particularly the deeper subsoils) makes them a high fine sediment export risk. As the capture of mobilised fine sediment is difficult, particular attention will need to be paid to minimising erosion of exposed subsoils during site clearance and earthworks activities.

The exposed subsoil will have a relatively slow infiltration rate and, if compacted, these soils may also generate high rates of run-off and accelerated erosion, particularly on slopes >2%.

Soil properties relevant to the development – Bicton

A summary of soil analytical results for the Bicton samples is presented in **Table 7**. Full laboratory results are provided in **Appendix A** with chain of custody documentation.

Soil acidity and aluminium saturation

The topsoil is slightly alkaline (pH 7-8) and appears to have been limed. The upper subsoil is moderately acid (pH <6), but pH declines in the subsoil and is strongly acid (pH <5) below 50 cm depth. The pH range is not unusual for mineral soils in the humid tropics. This results in an increasing proportion of exchangeable acidity and, in particular, exchangeable aluminium with depth. Exchangeable aluminium is usually low or absent at pH values above 5.5, and this is consistent with the results in **Table 7**. The pH and exchangeable aluminium results for the subsoil would be acceptable for acid tolerant species (many native tropical species), but may be unsuited to more sensitive species used in amenity planting or to grasses used in hydromulching of exposed subsoils. Soil pH effects in the subsoil may be exacerbated by a high magnesium to calcium ratio, leading to a calcium deficiency (see further comments on general soil fertility below).

Soil salinity and sodicity

Salinity was apparently moderate in the surface soils, but this is likely to be an artefact of the presence of fine agricultural lime. For soil management purposes, the soils can be regarded as non-saline and non-sodic.

Cation exchange properties and soil chemical fertility

The Bicton soils have good (>15 $cmol^+$/kg) CEC in the topsoil, and moderate CEC in the subsoils (5-15 $cmol^+$/kg) in the subsoil. Topsoils have adequate reserves of major cation nutrients (calcium, magnesium and potassium), and the soils have a moderate to good capacity for cation nutrient retention. The soil has adequate supplies of available phosphorus.

Organic matter and total nitrogen content are normal for soils under pasture in high rainfall areas (Baldock & Skjemstad 1999). The subsoil is low in readily extractable nitrogen species, and subsoil N concentrations can be used as a tool for monitoring the impacts of effluent irrigation on nitrate leaching and accumulation beyond the rootzone.

The subsoil contains relatively low reserves of major nutrients and amenity planting in to, or hydromulching directly on to, exposed subsoils would require fertiliser applications (preferably in a slow release form).

Table 7: Summary of Bicton soil analytical results

Soil property	Units	Sample depth (cm)			
		0-15	15-50	50-95	95-120
pH (1:5 water)		7.82	5.07	4.94	4.89
EC	dS/cm	0.274	0.039	0.035	0.035
Salinity class		Medium	Very low	Very low	Very low
Exchangeable Ca	$cmol^+/kg$	16.79	1.1	0.06	0.04
Exchangeable Mg	$cmol^+/kg$	3.39	1.35	0.37	0.24
Exchangeable K	$cmol^+/kg$	0.91	0.44	0.24	0.24
Exchangeable Na	$cmol^+/kg$	0.17	0.14	0.22	0.21
Exchangeable Al	$cmol^+/kg$	0.05	5.53	10.20	11.15
Exchangeable H	$cmol^+/kg$	<0.01	2.80	3.63	3.86
Effective CEC	$cmol^+/kg$	21.30	11.36	14.71	15.76
ESP	%	0.8	1.3	1.5	1.3
Sodicity class		Non-sodic	Non-sodic	Non-sodic	Non-sodic
Ca:Mg ratio		5.0	0.8	0.2	0.2
Aluminium saturation	%	0.3	48.6	69.3	70.8
Total carbon	%	2.43	-	-	-
Total nitrogen	%	0.19	-	-	-
C:N ratio		12.8	-	-	-
Nitrate N (KCl)	mg/kg	4.5	0.9	0.6	0.5
Ammonium N (KCl)	mg/kg	4.2	0.9	0.6	0.8
Colwell P	mg/kg	69.6	20.2	29.0	15.1
Maximum P adsorption at equilibrium	µg P/g	926	820	619	658
Maximum P adsorption capacity in horizon	kg P/ha	1,861	3,817	3,928	2,270
Dry bulk density	g/cm^3	1.34	1.33	1.41	1.38
Total porosity	% v/v	47.3	49.0	46.6	47.8
Gravel >2mm	%	1	0.2	<0.1	0.1
Sand 0.02 – 2 mm	%	48.1	26.7	22.8	38.0
Silt 0.002-0.02 mm	%	31.1	37.7	57.9	56.8
Clay <0.002 mm	%	20.8	35.6	19.3	5.2
Texture Class		Silty loam	Silty clay loam	Silty loam	Silty loam
EAT Class		4	2(1)	2(2)	2(1)
Saturated water content[1]	v/v	0.42	0.47	0.43	0.37
Field capacity (10Kpa)[1]	v/v	0.36	0.40	0.39	0.33
Wilting point[1]	v/v	0.09	0.13	0.09	0.06
PAWC[1]	% v/v	27	27	30	27
Estimated KSat[1]	mm/hr	7.5	5.7	7.2	22.7

[1] Soil moisture characteristic curve parameters derived from pedotransfer functions described by van Genuchten *et al.* (2000) based on field bulk density and laboratory particle size and organic matter input data.

Phosphorus adsorption capacity

This soil has a high capacity for phosphorus adsorption, making it suitable for long-term effluent irrigation application. The likelihood of breakthrough of phosphorus leaching from the profile is very low.

Soil physical fertility and drainage properties

Soil bulk density is similar through the profile and is not expected to significantly limit root penetration.

The soils have good water holding capacity (c. 285 mm/m of soil) as would be expected for medium textured soils with some structural development.

The saturated hydraulic conductivity is estimated to be slow in the majority of the profile (<10 mm/hr). This has implications for soil drainage and wetness in amenity areas, particularly the Golf Course and Sporting Precinct. These soil properties will need to be considered in planning soil drainage requirements and irrigation application management.

Soil properties related to erosion risk

The topsoils are non-sodic and non-dispersive (EAT Class 4). The presence of carbonate was noted by the laboratory, and this is consistent with other results that indicate the soil has been limed. The lime in the surface soils is likely to have influenced dispersion properties, and properties may be different where liming has not occurred.

The subsoils were reported to have some dispersion under laboratory conditions, and this may be due to the high magnesium to calcium ratio and generally very low exchangeable calcium saturation. The soils are not expected to be susceptible to tunnel formation and subsequent gully erosion. This does not mean that gully formation is not possible in circumstances where concentrated flow is directed over this soil.

The erodibility of the soil in terms of sheet and rill erosion has been assessed using the Revised Universal Soil Loss Equation (RUSLE) K factor (Rosewell 1993). The relevant parameters and K factor determinations are presented in **Table 8**.

Table 8: Estimates of RUSLE K factor for Bicton soil type

Soil property	Units	Sample depth (cm)			
		0-15	15-50	50-95	95-120
Organic matter	%	4.30	1.59 [2]	0.32 [2]	0.19 [2]
Clay	%	20.8	35.6	19.3	5.2
Silt	%	31.1	37.7	57.9	56.8
Fine sand[1]	%	17.0	14.1	13.9	12.3
Coarse sand[1]	%	31.1	12.6	8.7	25.7
Permeability class		4	4	4	4
Structure class		3	3	3	3
RUSLE K factor		**0.030**	**0.035**	**0.067**	**0.076**
Erodibility rating[3]		**Moderate**	**Moderate**	**Very high**	**Very high**

[1] Soil particle size analysis included determination of USDA and ISSS size classes allowing estimation of coarse and fine sand fractions required for calculating RUSLE K factor.

[2] Subsoil organic matter content estimated from profile data in Murtha *et al.* (1996).

[3] Rating for sheet and rill erosion (excludes gully erosion) based on Rosewell and Loch (2002).

The reasonable organic matter content in the surface soil (>3%) and the relatively high clay content in the upper subsoil mean that surface soils are estimated to be moderately erodible. Below 50 cm, however, the soils have a very high silt and fine sand content, making them poorly cohesive and very highly erodible.

The high silt and clay content of the subsoils (particularly the deeper subsoils) makes them a high fine sediment export risk. As the capture of mobilised fine sediment is difficult, particular attention will need to be paid to minimising erosion of exposed subsoils during site clearance and earthworks activities.

The exposed subsoil will have a relatively slow infiltration rate and, if compacted, these soils may also generate high rates of run-off and accelerated erosion, particularly on slopes >2%.

4.5 Contaminated land

The results of the EMR and CLR search are presented in **Table 9** (search responses for each lot in the project area are reproduced in **Appendix B**). No positive results for inclusion on the EMR or CLR were identified.

Table 9: Summary of contaminated land database search results

Lot Number	Plan	EMR/CLR Status*
17	N157227	Not listed
18	N157227	Not listed
22	N157227	Not listed
43	N157359	Not listed
20	N157423	Not listed
19	N157452	Not listed
95	N157452	Not listed
290	N157480	Not listed
131	N157491	Not listed
129	NR456	Not listed
1	RP703984	Not listed
2	RP703984	Not listed
2	RP720923 #	Not listed
1	RP728072 #	Not listed

* *Environmental Management Register and Contaminated Land Register* (EHP 2017).
\# Adjoining lots not within in proposed project boundary (refer to Table 6 in Section 3.2.6).

A review of aerial imagery for the project area (AES 2015b-f) did not find any features that indicated the presence of stock dips that may have been in long-term use.

Although the desktop assessment has not identified any potential land contamination that would warrant or allow for targeted investigation, it is possible that isolated areas of buried waste may exist. The property may not have had access to waste collection services in the past and waste may have been disposed of on-site. Wastes may include:

- domestic waste
- animal carcasses (and possibly pathogens including Anthrax[10])
- agrochemical containers
- scrap (including building materials such as asbestos sheeting)
- treated or painted timber, which, when burnt, may release heavy metals into the soil.

Although some scrap was observed, no significant features consistent with concentrated waste dumping were identified during fieldwork. Despite the findings and observations, the possibility remains that small tip sites may be encountered during earthworks.

[10] The risk of Anthrax infections has been assessed by Strategic Disaster Solutions (2017).

5. Relevant Project Activities and Potential Impacts

5.1 Proposed action and threats

R&O is proposing to develop the project area into a luxury tourism, health and education experience featuring the following components:

- KUR-Village
- Residential Precinct: Queenslander Lots, Premium Villas, Lifestyle Villas
- Four Star Business and Leisure Hotel and Function Centre
- Health and Wellbeing Retreat
- Five-Star Eco-Resort
- KUR-World Campus
- Farm Theme Park and Equestrian Centre
- Rainforest Education Centre and Adventure Park
- Sporting Precinct
- Golf Club House and Function Centre
- Golf Course
- Organic Produce Garden
- Services and Infrastructure (including wastewater treatment plant, roads)
- Open Space
- Environmental Area.

The Project has the potential to result in a range of direct and indirect threats to soil and land environmental and economic values. The potential project-related impacts are described below.

Changes in general topography are expected to be minor and are not discussed here. Effects on aquifers and water resources (associated with the underlying geology) are described in RLA (2017).

5.2 State and Regional interests

5.2.1 Summary of values and existing threats

No areas of State or Regional interest (agriculture) were identified. The project area does not contain land that is recognised at State level as being of high quality or strategic value.

Parts of the project site are currently used for grazing and Nagel *et al*. (1996) identified small areas of land that may have had some agricultural potential. This study determined that there are both land quality and surrounding land use constraints that detrimentally affect the agricultural potential of those areas.

The greatest existing threat to the exploitation of any potentially suitable land on the project site is proximity to existing residential areas. This is because of potential conflicts between agricultural and residential land use associated with, for example, dust and spray drift risk. The balance of the areas identified by Nagel *et al*. (1996) not affected by potential land use conflicts was found to be small (affecting commercial feasibility), included land with slopes over 10% and was dissected with numerous small drainage lines.

In summary, parts of the project site are suitable for grazing, but land quality limitations and existing threats would prevent intensive land use.

5.2.2 Potential impacts

The project area does not contain land that is recognised at State level as being of high quality or strategic value. The project will not impact on agricultural land resources of State significance.

The area contains land that has potential for grazing use and some of this land will be permanently lost under areas to be used for Queenslander Lots, Premium Villas, Sporting Precinct, KUR-World Campus and the Business and Leisure Hotel and Function Centre.

Some areas will be retained for grazing and small scale agricultural/horticultural use, but only within the context of the resort style development. These areas would not likely be viable in the future for a stand-alone agricultural enterprise.

The loss of a small parcel of grazing land in a region with extensive reserves of grazing land is not considered to be significant.

5.2.3 Recommended mitigation measures

No mitigation measures are necessary to protect State and Regional interest.

5.3 Contaminated land and acid sulfate soils

5.3.1 Summary of values and existing threats

No acid sulfate soils are expected to occur on-site.

No contaminated land has been identified through desktop searches and research, but given the nature of the past land use, farm and domestic waste may have been buried on the site.

5.3.2 Potential impacts

If the volumes of petroleum products stored on-site (for back-up generators or operational vehicle refuelling) exceed the thresholds nominated for notifiable activity number 29 (as defined in the Queensland *Environmental Protection Act* 1994), this would require the land to be entered on the EMR or the CLR. No other notifiable activities are expected to occur on the project.

In addition, land may become contaminated through:

- spills of petroleum hydrocarbons, cleaning and disinfection products and other operational chemicals
- stormwater, containing petroleum hydrocarbons, pesticides, metals and metalloids associated with urban sources, directed through constructed swales (part of the envisaged water sensitive urban design measures)
- application or agrochemicals (such as artificial fertilisers and plant protection products for amenity areas) and pest control products

- applications of organic fertiliser derived from recycled waste organics (such as composts, animal manures or biosolids) if source materials contain elevated concentrations of common contaminants such as lead, copper and zinc.

The application of treated wastewater (through effluent irrigation) from a non-industrial operation is unlikely to cause land contamination. A separate technical report on the feasibility of effluent irrigation (relating to sustainable nutrient loading) has been prepared (NRA 2017a).

Although no existing contamination has been identified on-site, it is possible that small amounts of domestic or farm waste may be buried in unmarked locations. If they exist and are disturbed by earthworks, contaminants may be released including pathogens such as Anthrax (Strategic Disaster Solutions 2017).

5.3.3 Recommended mitigation measures

The volumes of petroleum hydrocarbons stored on-site should be kept below the thresholds nominated for notifiable activity number 29 (as defined in the Queensland *Environmental Protection Act* 1994). If these thresholds are exceeded, the administering authority must be notified of this change in writing.

All potentially contaminating substances should be stored in accordance with applicable Australian Standards (*eg* Australian Standard AS1940 *The storage and handling of flammable and combustible liquids*).

Appropriate spill kits should be made available at locations where potentially contaminating substances are stored or transferred to intermediate containers. A contingency plan should be developed for larger spills or incidents involving potentially contaminating substances (see Strategic Disaster Solutions 2017 for more details).

The KUR-World farm is operated using organic farming principles. Where appropriate, organic or integrated pest management approaches should be employed for adjacent amenity areas[11].

If wastewater treatment plant (WWTP) effluent is to be applied to land, the feasibility and potential impacts of effluent irrigation should be examined (reported separately in NRA 2017a).

Measures for managing soil contamination through stormwater run-off or retention should be included in the Stormwater Management Plan

All contractors should be made aware that farm and domestic waste may have been buried in unmarked locations on-site. They should be required to include procedures in their environmental management plans for identifying, reporting and managing such sites if they are found or disturbed during earthworks or infrastructure installation.

[11] It is understood the KUR-Cow operation is seeking organic certification. Management practices on other parts of the development may affect maintenance of certification. This should for example be taken into account in any covenants that may be applied to residential lots.

5.4 Soil quality and erosion

5.4.1 Summary of values and existing threats

The majority of the project area is covered by deep gradational Red or Brown Dermosols (Galmara and Bicton) formed *in situ* from metamorphic parent material. On slopes >32%, smaller areas of shallow Orthic Tenosols (Seymour) are likely to occur within areas dominated by Dermosols, and small isolated areas of Red Kandosols (Mission) are likely to occupy shallow slopes on colluvial/alluvial deposits that occur in wider drainage lines.

The soils are non-saline and non-sodic, with an acid reaction trend down the profile. Existing agricultural land use has affected soil quality. In some locations, the surface soil has been limed and may have received fertiliser additions. In the locations where soils were analysed (on Bicton and Galmara), topsoils had good organic matter and nutrient reserves.

There are isolated areas of existing soil erosion where clearing has occurred. These include the Helipad, areas used by neighbouring tourist operations (including ATVs) in the south and unsealed tracks throughout the site. On the whole, however, existing soils remain undisturbed and in good condition.

There are three soil properties that may contribute to project impacts or affect project construction and operation.

- Erodibility and fine sediment export potential. The soils likely to be disturbed during development are non-sodic and are not expected to be prone to tunnel erosion. The undisturbed topsoils over much of the site are relatively stable, particularity when good vegetation cover is maintained. Upper subsoils are moderately erodible, but deeper subsoils are highly or very highly erodible in Galmara soils (below 75 cm) and Bicton soils (below 50cm). If deeper subsoils are exposed during earthworks, particular attention will be required to manage erosion risks. Both major soil types have a high fines (silt and clay) content and there is a risk of fine sediment being mobilised from eroding soils into the receiving environment. The subsoils have other properties that may hinder revegetation efforts (see further discussion below). Failure to take these soil properties into account during revegetation works may lead to poor plant establishment, low ground cover and accelerated erosion.
- Soil acidity. The pH and exchangeable aluminium results for the subsoil would be acceptable for acid tolerant species (many native tropical species), but may be unsuited to more sensitive species used in amenity planting or to grasses used in hydromulching of exposed subsoils. For revegetation that is required on exposed subsoils, soil pH effects would be exacerbated by poor soil fertility.
- Restricted internal drainage. The Bicton soils that occupy the flatter ridge tops on the site have some restricted internal drainage. The saturated hydraulic conductivity is estimated to be relatively low in the majority of the profile (<10 mm/hr). This has implications for soil drainage and wetness in amenity areas, particularly the Golf Course and Sporting Precinct that occupy areas mapped as Bicton (see **Figure 10**). The drainage properties of the Galmara soils are better in surface soils, but hydraulic conductivity is relatively low in deeper subsoils. If land levelling is required, these subsoils may be exposed. Soil drainage properties must be considered in planning landscape and amenity planting, soil drainage requirements and irrigation management.

5.4.2 Potential impacts

Figure 10 shows that the project infrastructure will be largely confined to areas of Bicton and Galmara soils types. The Rainforest Education centre may include areas where shallow Seymour soils occur.

As discussed in **Section 5.3.2**, the subsoils in areas likely to be disturbed by earthworks associated with the development are highly erodible and constitute a fine sediment export risk. This has the potential to impact on environmental and conservation values in the receiving environment (as identified in Water Quality and Flora and Fauna technical reports; NRA 2017b and NRA 2017c).

5.4.3 Recommended mitigation measures

Erosion and sediment control planning

An appropriately qualified professional should be engaged to prepare an Erosion and Sediment Control Plan (ESCP) for the construction and operational phases of the project. The ESCP should be certified by a Certified Professional in Erosion and Sediment Control (CPESC). Measures identified in the ESCP should be developed in accordance with the *Best Practice Erosion & Sediment Control* guidelines (IECA 2008).

All construction earthworks must be conducted within the framework of the core principals of erosion and sediment control. A summary is provided below.

- Project planning.
  - Understand the particular risks on the site as identified in this report.
  - Integrate ESC practices and measures into the overall project construction schedule.
  - Incorporate mandatory hold points (used to verify appropriate implementation of critical elements of the ESCP) into the overall project construction schedule.
  - Understand that the ability to retain sediment-laden water on-site in containment structures during the wet season is limited in particular by high rainfall.
  - Schedule earthworks to avoid or minimise works in high rainfall months (nominally December to April inclusive).
  - Establish clear lines of responsibility.
  - Provide sufficient resources to implement the ESCP.
  - Have contingency plans in place for extreme weather events (*eg* cyclones) during the wet season and unexpected/unseasonal rainfall during the dry season.
- Drainage control.
  - Divert clean water around the site in a safe manner using appropriately designed structures.
  - Direct dirty water to on-site structures designed to settle or otherwise treat suspended sediment.
- Erosion control.
  - Minimise vegetation clearing extent via planning and implementation of systems/controls during construction and operation (*eg* permit to clear system and clearly marking clearing extents prior to disturbance).
  - Develop a topsoil management plan and strip and store topsoils and subsoils separately.
  - Avoid or minimise disturbance and exposure of high risk soils.
  - Replace stored topsoil or as required ameliorate exposed subsoils as required prior to or as part of revegetation works.
  - Establish vegetative or other forms of ground cover (*eg* natural fibre matting, mulch or rock) on areas with exposed soil as soon as is practicable but at least prior to the wet season. A minimum target of 80% cover is recommended (to be confirmed in the ESCP). Soil surface preparation techniques (such as dozer tracking) can assist in minimising erosion prior to vegetation establishment.

- Sediment control.
  - Install appropriately designed and constructed sediment control features or structures in all locations where sediment may be generated (*eg* silt fencing around stockpiles, check dams in drainage lines, formal sediment traps or basins).
  - Plan locations for significant structures so that they can be incorporated into the operational stormwater management plan if required.
  - Maintain sufficient storage capacity in sediment control structures prior to the wet season and following significant flow events.
- Monitoring and management.
  - Inspect, maintain or repair ESC measures following run-off events (trigger to be nominated in the ESCP). Review the adequacy of the ESC measures prior to each wet season, and implement alterations or reparations prior to 1 November.
  - The ESC maintenance schedule is to remain in place until areas are signed off as completed and stable in accordance with the ESCP specifications.
  - Monitor the performance of ESC measures against measureable criteria (*eg* discharge water quality targets) as nominated in the ESCP.

Land management

Planning for sports and amenity land uses should take into account soil chemical and physical constraints identified in the report.

Plants that are endemic to the site should be used where appropriate. Plant selection should be mindful of soil pH and drainage conditions. For some land uses or planting schemes, soil conditions may need to be ameliorated to achieve desired outcomes.

The importation of pathogens and Restricted Biosecurity matters (weeds or insect pests) in imported soil or plant material should be managed through the use and auditing of contract specifications.

6. References

AES 2015a. *Project area showing landscape relief.* Astrebla Ecological Services, October 2015.

AES 2015b. *Reever and Ocean – Myola land holdings, 1942 aerial photo – Overview*. Astrebla Ecological Services, October 2015.

AES 2015c. *Reever and Ocean – Myola land holdings, 1951 aerial photo – Overview*. Astrebla Ecological Services, October 2015.

AES 2015d. *Reever and Ocean – Myola land holdings, 1971 aerial photo – Overview*. Astrebla Ecological Services, October 2015.

AES 2015e. *Reever and Ocean – Myola land holdings, 1982 aerial photo – Overview*. Astrebla Ecological Services, October 2015.

AES 2015f. *Reever and Ocean – Myola land holdings, 1994 aerial photo – Overview*. Astrebla Ecological Services, October 2015.

Baldock, J.A. and Skjemstad, J.O. 1999. Soil Organic Carbon/Soil Organic Matter. In Soil Analysis and Interpretation Manual (Eds. K.I. Peverill, L. A. Sparrow and D. J. Reuter). CSIRO Publishing.

DAFF 2013. Queensland Agricultural Land Audit. Chapter 6 Far North Queensland. Department of Agriculture, Fisheries and Forestry published by the State of Queensland 2013.

DHLGP 1992. *State Planning Policy 1/92: Development and the conservation of agricultural land.* Department of Housing, Local Government and Planning, Brisbane.

DILGP 2016. *State interest guideline – Agriculture – April 2016.* Department of Infrastructure, Local Government and Planning, Brisbane. April 2016.

DILGP 2017. *State Planning Policy – July 2017.* Department of Infrastructure, Local Government and Planning, Brisbane. July 2017.

DNR/DLGP 1997. *Planning guidelines: Separating Agricultural and Residential Land Uses.* Department of Natural Resources & Department of Local Government and Planning, Brisbane, August 1997.

DNRM 1989. *1:100,000 Cairns 8064 series*. Department of Natural Resources and Mines, Brisbane.

DNRM 2011. *Detailed surface geology - Queensland.* Spatial data layer, Department of Natural Resources and Mines, Brisbane. Accessed 2 February 2017, http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=%22Detailed surface geology - Queensland%22.

DNRM 2014. *Watercourse lines – Queensland.* Spatial data layer, Department of Natural Resources and Mines, Brisbane. Accessed 2 February 2017, http://dds.information.qld.gov.au/dds?title="Watercourselines-Queensland".

DNRM 2016a. *Cadastral data - Queensland - by area of interest*. Spatial data layer, Department of Natural Resources and Mines, Brisbane. Accessed 1 February 2017, http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=%22Cadastral data - Queensland - by area of interest%22.

DNRM 2016b. *Drainage 25k – Queensland*. Spatial data layer, Department of Natural Resources and Mines, Brisbane. Accessed 1 February 2017, https://data.qld.gov.au/dataset/drainage-25k-queensland.

DNRM 2016c. *Electronic mapping data for Strategic Cropping Land in Queensland under the RPI Act 2014 v3.4.* Spatial data layer, Department of Natural Resources and Mines, Brisbane. Accessed 1 February 2017, http://qldspatial.information.qld.gov.au/catalogue/.

DPI/DHLGP 1993. *Planning guidelines: The identification of good quality agricultural land.* Department Of Primary Industries & Department Of Housing, Local Government and Planning, Brisbane.

DSITI 2016. *Land use mapping - Wet Tropics NRM region 2015.* Spatial data layer, Department of Science, Information Technology and Innovation, Brisbane. Accessed 8 February 2017, http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=%22Land use mapping - Wet Tropics NRM region 2015%22

EHP 2015. *About the land registers.* Department of Environment and Heritage Protection, Brisbane. Accessed 25 January 2017, https://www.qld.gov.au/environment/pollution/management/contaminated-land/about-registers/.

EHP 2017. *Environmental Management and Contaminated Land Register*. Department of Environment and Heritage Protection, Brisbane. Accessed 25 January 2017.

Geoscience Australia 2017. *Australian Stratigraphic Units Database.* Accessed 2 February, 2017, www.ga.gov.au/products-services/data-applications/reference-databases/stratigraphic-units.html.

IECA 2008, *Best Practice Erosion & Sediment Control*, International Erosion and Sediment Control Association, Australasia, November 2008.

Laffan, M.D. 1988. 'Soils and Land Use on the Atherton Tableland, North Queensland', Soil and Land Use Series No. 61. CSIRO Division of Soils, Townsville.

Malcolm, D.T., Nagal, B.K.A., Sinclair, I. & Heiner, I.J. 1999. Soils and Agricultural Land Suitability of the Atherton Tablelands, North Queensland. DNR Reference DNRQ 980091. Land resources bulletin, Department of Natural Resources, Brisbane.

MSC 2016. Mareeba Shire Council Planning Scheme – July 2016. Available at https://msc.qld.gov.au/planning/#Mareeba_Shire_Council_Planning_Scheme_8211_July_2016 (last accessed 20 October 2017).

Murtha, G.G. & Smith, C.D. 1994. Key to the soils and land suitability of the wet tropical coast – Cardwell to Cape Tribulation. Queensland Government, Department of Natural Resources, Mines, and Energy.

Murtha, G.G., Cannon, M.G. & Smith, C.D. 1996. Soils of the Babinda-Cairns Area, North Queensland. CSIRO Division of Soils, Division Report No. 123.

Nagel B.K.A., Sinclair I.G., Philip S.R. & Klein J.F. 1996. *Reconnaissance Survey Assessing Land Potentially Suitable for Agriculture in the Kuranda/Myola and Clohesy/Koah Areas.* Produced for the FNQ 2010 Natural Resource Strategy, Department of Natural Resources and Water, Brisbane.

NCST 2009. Australian Soil and Land Survey Field Handbook. Third edition. National Committee on Soil and Terrain, CSIRO Publishing, Melbourne.

Northcote, K. H., Beckmann, G. G., Bettenay, E., Churchward, H. M., Van Dijk, D. C., Dimmock, G. M., Hubble, G. D., Isbell, R. F., McArthur, W. M., Murtha, G. G., Nicolls, K. D., Paton, T. R., Thompson, C. H., Webb, A. A. & Wright, M. J. 1960–1968. Atlas of Australian Soils, Sheets 1 to 10 with explanatory data. CSIRO and Melbourne University Press: Melbourne.

NRA 2017a, KUR-World Effluent Irrigation Feasibility Study, R02, prepared by NRA Environmental Consultants for Reever and Ocean Developments Pty Ltd, November 2017.

NRA 2017b, KUR-World Water Quality and Aquatic Ecology Technical Report, R03, prepared by NRA Environmental Consultants for Reever and Ocean Developments Pty Ltd, November 2017.

NRA 2017c, KUR-World Flora and Fauna Technical Report, R02 (in prep), prepared by NRA Environmental Consultants for Reever and Ocean Developments Pty Ltd, November 2017.

RLA 2017. KUR-World Groundwater Report, Reever and Ocean Pty Ltd. Report prepared by Rob Lait & Associates, October 2017.

Rosewell, C.J, & Loch R. J. 2002. Estimation of the RUSLE Soil Erodibility Factor. In N McKenzie, K Coughlan & H Cresswell, (eds) Soil Physical Measurement and Interpretation for land evaluation. CSIRO Publishing.

Rosewell, C.J. 1993. SOILOSS. *A program to Assist in Selection and Management Practices to Reduce Erosion*. Technical Handbook No. 11 (2nd Ed).

Speight 2009. *Landform*. Australian Soil and Land Survey Handbook, Third Edition. CSIRO publishing, Melbourne, pp. 46-47.

Strategic Disaster Solutions 2017. KUR-World Project - Hazards, Health & Safety Assessment. Prepared by Strategic Disaster Solutions for Sustainable Solutions Global Pty Ltd, June 2017

USPD 2016. *KUR-World Integrated Eco-Resort – Initial Advice Statement.* Report prepared by Urban Sync Planning and Development, May 2016.

van Genuchten, M. T., Simunek, J., Leij, F. J. & Sejna, M. 2000. RETC ("RETention Curve") - Code for Quantifying the Hydraulic Functions of Unsaturated Soils. Riverside, CA, US Salinity Laboratory, USDA, ARS.

Willmott, W.F., Trezise, D.L., O'Flynn, M.L., Holmes, P.R. & Hofmann, G.W. 1988. Cairns Region: 1: 100 000 Geological Map Commentary. Queensland Department of Mines. Pages 9-22.

Appendix A:
Soil Laboratory Data

CHAIN OF CUSTODY

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Preservation: (None) / Ice / Ice bricks / Acidified / Filtered / Other:			
Received By:			
Condition on receipt: Ambient / Cool / Frozen / Other:			

Comments:
Soil volume for samples S07__0-10*, S07__15-50, S07__50-95, & S07__95-120 is **904.8 cm³** .
Soil volume for sample S08__0-10 is **1085.1 cm³**.
Soil volume for sample S08__10-35 is **651.1 cm³**.
Soil volume for samples S08__35-75 & S08__75-120 is **542.9 cm³**.

Bulk density for S07__0-10 to be used for estimate of S07_0-15 sample.

Sample Analysis Request
Price List Code (e.g. SW-PACK-06)

Lab Sample No.	Sample ID	Sample Depth	Sampling Date	Your Client	Crop ID	Sample Type (e.g. water, leaf, soil)	Suite 1 (See attached)	Suite 2 (See attached)	Suite 3 (See attached)							
	S07__0-10	0-10	4/5/2017	Kurworld		soil	✓									
	S07__0-15	0-15	4/5/2017	Kurworld		soil		✓								
	S07__15-50	15-50	4/5/2017	Kurworld		soil			✓							
	S07__50-95	50-95	4/5/2017	Kurworld		soil			✓							
	S07__95-120	95-120	4/5/2017	Kurworld		soil			✓							

Comments:
Soil volume for samples S07__0-10*, S07__15-50, S07__50-95, & S07__95-120 is **904.8 cm³** .
Soil volume for sample S08__0-10 is **1085.1 cm³**.
Soil volume for sample S08__10-35 is **651.1 cm³**.
Soil volume for samples S08__35-75 & S08__75-120 is **542.9 cm³**.

Bulk density for S07__0-10 to be used for estimate of S07_0-15 sample.

Sample Analysis Request

Price List Code (e.g. SW-PACK-06)

Lab Sample No.	Sample ID	Sample Depth	Sampling Date	Your Client	Crop ID	Sample Type (e.g. water, leaf, soil)	Suite 1 (See attached)	Suite 2 (See attached)	Suite 3 (See attached)							
	S08__0-10	0-10	4/5/2017	Kurworld		soil	✓	✓								
	S08__10-35	10-35	4/5/2017	Kurworld		soil			✓							
	S08__35-75	35-75	4/5/2017	Kurworld		soil			✓							
	S08__75-120	75-120	4/5/2017	Kurworld		soil			✓							

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Analyte list KUR-World Soils (424104.01)

Suite 1

- Total sample wet weight
- Moisture content (oven drying to 105°C)
- Air dry moisture content (moisture content of soil after drying to 40°C)

Suite 2

- SS-PACK-010 pH and EC
- SS-PACK-011 LECO – Total Carbon and Total Nitrogen
- SS-PACK-001 Exchangeable Cations – Ammonium Acetate – (15D3) No Pre-treatment plus Acidity
- SS-SING-025 Emerson Aggregate (EAT)
- SS-PACK-052 Deep Soil Nitrogen
- SS-SING-039 Phosphorus Sorption Capacity
- SS-SING-013 Moisture Curve – Moisture Holding Capacity (including PSD)

Suite 3

- Total sample wet weight
- Moisture content (oven drying to 105°C)
- SS-PACK-010 pH and EC
- SS-PACK-001 Exchangeable Cations – Ammonium Acetate – (15D3) No Pre-treatment plus Acidity
- SS-SING-025 Emerson Aggregate (EAT)
- SS-PACK-052 Deep Soil Nitrogen
- SS-SING-039 Phosphorus Sorption Capacity
- SS-SING-013 Moisture Curve – Moisture Holding Capacity (including PSD)

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ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9258
No of Samples:	2
Date Supplied:	9th May 2017
Supplied by:	NRA Pty Ltd

Method	Nutrient		Units	Sample 1	Sample 2
			Sample ID:	S07_0-15	S08_0-10
			Crop:	N/G	N/G
			Client:	Kurworld	Kurworld
Method	Nutrient		Units	F9258/1	F9258/2
KCl	Nitrate Nitrogen	N	mg/kg	4.5	13
	Ammonium Nitrogen			4.2	6.4
1:5 Water	pH		units	7.82	5.87
	Conductivity		dS/m	0.274	0.074
Calculation	Estimated Organic Matter		% OM	4.3	5.5
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	16.79	3.36
			kg/ha	7535	1510
			mg/kg	3364	674
	Magnesium	Mg	$cmol^+/Kg$	3.39	1.40
			kg/ha	922	381
			mg/kg	411	170
	Potassium	K	$cmol^+/Kg$	0.91	0.40
			kg/ha	796	347
			mg/kg	355	155
	Sodium	Na	$cmol^+/Kg$	0.17	0.08
			kg/ha	87	41
			mg/kg	39	18
KCl	Aluminium	Al	$cmol^+/Kg$	0.05	0.03
			kg/ha	11	6
			mg/kg	5	3
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.12
			kg/ha	0	3
			mg/kg	0	1
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	21.30	5.39
Base Saturation Calculations	Calcium	Ca	%	78.8	62.4
	Magnesium	Mg		15.9	26.0
	Potassium	K		4.3	7.4
	Sodium - ESP	Na		0.8	1.5
	Aluminium	Al		0.3	0.6
	Hydrogen	H^+		0.0	2.2
Calculation	Calcium / Magnesium Ratio		ratio	5.0	2.4
LECO IR Analyser	Total Carbon	C	%	2.43	3.12
	Total Nitrogen	N	%	0.19	0.22
Calculation	Carbon/ Nitrogen Ratio		ratio	12.8	14.2
	Total Wet Weight		g	1467	1388
	Total Dry Weight		g	1148	1073
	Moisture Content		%	21.7	22.6

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centres, preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 $cmol^+/Kg$ = 1 meq/100g;   1 Lb/Acre = 2 ppm (parts per million);   kg/ha = 2.24 x ppm;   mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg Calcium
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+/Kg$
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+/Kg$ results

Quality Checked: Kris Saville
Manager, Agricultural testing division

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ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9257
No of Samples:	1
Date Supplied:	9th May 2017
Supplied by:	NRA Pty Ltd

	Sample 1
Sample ID:	S07_0-10
Crop:	N/G
Client:	Kurworld

Method	*Nutrient*	*Units*	*F9257/1*
	Total Wet Weight	g	1513
	Total Dry Weight	g	1210
	Moisture Content	%	18.8

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centres, preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 cmol$^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg Calcium
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations cmol$^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable cmol$^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

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ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9256
No of Samples:	6
Date Supplied:	9th May 2017
Supplied by:	NRA Pty Ltd

	Sample 1	**Sample 2**
Sample ID:	S07_15-50	S07_50-95
Crop:	N/G	N/G
Client:	Kurworld	Kurworld

Method	*Nutrient*		*Units*	*F9256/1*	*F9256/2*
KCl	Nitrate Nitrogen	N	mg/kg	0.9	0.6
	Ammonium Nitrogen			0.9	0.6
1:5 Water	pH		units	5.07	4.94
	Conductivity		dS/m	0.039	0.035
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	1.10	0.06
			kg/ha	494	26
			mg/kg	220	11
	Magnesium	Mg	$cmol^+/Kg$	1.35	0.37
			kg/ha	369	101
			mg/kg	165	45
	Potassium	K	$cmol^+/Kg$	0.44	0.24
			kg/ha	384	212
			mg/kg	171	95
	Sodium	Na	$cmol^+/Kg$	0.14	0.22
			kg/ha	74	113
			mg/kg	33	51
KCl	Aluminium	Al	$cmol^+/Kg$	5.53	10.20
			kg/ha	1114	2056
			mg/kg	497	918
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	2.80	3.63
			kg/ha	63	81
			mg/kg	28	36
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	11.36	14.71
Base Saturation Calculations	Calcium	Ca	%	9.7	0.4
	Magnesium	Mg		11.9	2.5
	Potassium	K		3.9	1.6
	Sodium - ESP	Na		1.3	1.5
	Aluminium	Al		48.6	69.3
	Hydrogen	H^+		24.7	24.6
Calculation	Calcium / Magnesium Ratio		ratio	0.8	0.2
	Total Wet Weight		g	1570	1612
	Total Dry Weight		g	1201	1275
	Moisture Content		%	23.5	20.9

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centres, preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 $cmol^+/Kg$ = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg Calcium
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+/Kg$
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+/Kg$ results

Quality Checked: Kris Saville
Manager, Agricultural testing division

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ROUTINE AGRICULTURAL SOIL ANALYSIS REPOR

Job No:	F9256
No of Samples:	6
Date Supplied:	9th May 2017
Supplied by:	NRA Pty Ltd

				Sample 3	**Sample 4**	**Sample 5**	**Sample 6**
			Sample ID:	S07_95-120	S08_10-30	S08_35-75	S08_75-120
			Crop:	N/G	N/G	N/G	N/G
			Client:	Kurworld	Kurworld	Kurworld	Kurworld
Method	*Nutrient*		*Units*	*F9256/3*	*F9256/4*	*F9256/5*	*F9256/6*
KCl	Nitrate Nitrogen	N	mg/kg	0.5	5.2	0.7	0.5
	Ammonium Nitrogen			0.8	3.1	2.1	1.0
1:5 Water	pH		units	4.89	4.98	5.08	5.16
	Conductivity		dS/m	0.035	0.028	0.056	0.009
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	0.04	0.22	0.06	0.03
			kg/ha	19	100	27	12
			mg/kg	8	44	12	5
	Magnesium	Mg	$cmol^+/Kg$	0.24	0.72	0.60	0.55
			kg/ha	66	195	162	150
			mg/kg	29	87	72	67
	Potassium	K	$cmol^+/Kg$	0.24	0.11	0.01	0.05
			kg/ha	208	98	12	44
			mg/kg	93	44	5	20
	Sodium	Na	$cmol^+/Kg$	0.21	0.04	0.04	0.04
			kg/ha	109	18	18	23
			mg/kg	49	8	8	10
KCl	Aluminium	Al	$cmol^+/Kg$	11.16	1.59	1.34	1.47
			kg/ha	2250	321	271	297
			mg/kg	1004	143	121	133
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	3.86	0.56	0.64	0.61
			kg/ha	87	13	14	14
			mg/kg	39	6	6	6
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	15.76	3.24	2.68	2.75
Base Saturation Calculations	Calcium	Ca	%	0.3	6.8	2.2	1.0
	Magnesium	Mg		1.5	22.2	22.2	20.1
	Potassium	K		1.5	3.5	0.5	1.8
	Sodium - ESP	Na		1.3	1.1	1.3	1.6
	Aluminium	Al		70.8	49.2	50.1	53.5
	Hydrogen	H^+		24.5	17.3	23.7	22.0
Calculation	Calcium / Magnesium Ratio		ratio	0.2	0.3	0.1	0.0
	Total Wet Weight		g	1554	1045	940	962
	Total Dry Weight		g	1246	800	715	725
	Moisture Content		%	19.8	23.5	23.9	24.7

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including children preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil re*

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 $cmol^+/Kg$ = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/k
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnes
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+/Kg$
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+/Kg$ results

Quality Checked: Kris Saville
Manager, Agricultural testing division

RESULTS OF MOISTURE CURVE (Page 1 of 1)

2 soil samples supplied by Natural Resource Assessments Pty Ltd on the 9th May, 2017 - Lab Job No. F9258
Analysis requested by Andrew Butler.
(PO Box 5678 CAIRNS QLD 4870)

Sample Site	EAL lab code	Lab. Bulk Density tonne DW/m^3	USDA %Sand (from hydrometer determinations)	%Silt	%Clay	van Genuchten parameters (for WAVES, HYDRUS etc) thetaR (from Rosetta pedotransfer functions in RETC)	thetaS	alpha	n	Ksat (cm/day)	Field capacity (10 kPa)	Field capacity (33 kPa)	Permanent wilting point (1500 kPa)	Available water capacity assuming FC is at 10 kPa	Available water capacity assuming FC is at 33 kPa	Depth of soil (cm) - eg 50cm below: 50 — Available water capacity as a depth of water (cm) FC 10 kPa	Available water capacity as a depth of water (cm) FC 33 kPa
Method No.																	
S07_0-15	F9258/1	1.34	34.6	44.6	20.8	0.0659	0.4173	0.0074	1.5789	17.98	36%	26%	9%	27%	17%	13.51	8.45
S08_0-10	F9258/2	0.99	21.9	61.3	16.8	0.0739	0.5080	0.0042	1.7207	139.88	47%	36%	10%	38%	26%	18.81	12.99

NOTE:

1: The Hydrometer Analysis method was used to determine the percentage sand, silt and clay

2. Soil moisture characteristic curve parameters derived from Rosetta pedotransfer functions within RETC, reference:

van Genuchten, M. T., Simunek, J., Leij, F. J. & Sejna, M. (2000). RETC ("RETention Curve") - Code for Quantifying the Hydraulic Functions of Unsaturated Soils. Riverside, CA, US Salinity Laboratory, USDA, ARS.

checked: ....
Graham Lancaster
Laboratory Manager

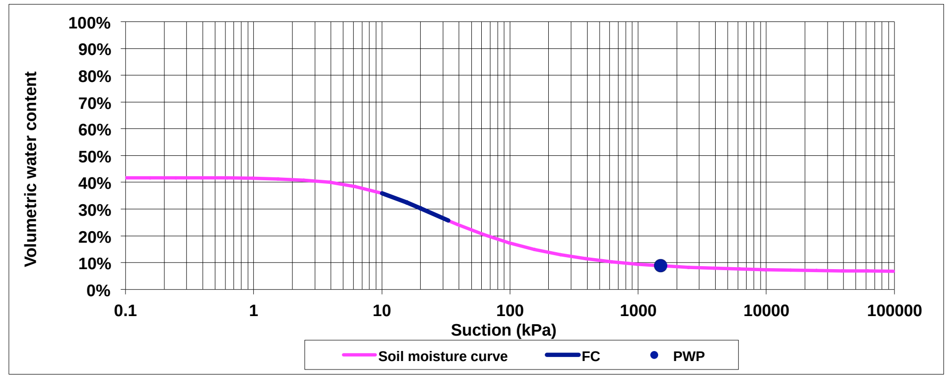
Sample 1

Pedotransfer Function parameters for %Sand/silt/clay+Bulk Density (van-Genuchten parameters from Rosetta neural network prediction)

theta R	0.0659
theta S	0.4173
alpha	0.0074
n	1.5789

m=1-1/n, 0<m<1	0.366647666
thetaS-thetaR	0.3514

Suction (kPa)	Se	Theta	FC	PWP
0.0980665	0.999841565	0.417244326		
0.155424928	0.999672287	0.417184842		
0.246331911	0.999322374	0.417061882		
0.390409768	0.998599818	0.416807976		
0.618757784	0.997110943	0.416284785		
0.980665	0.994056399	0.415211419		
1.554249283	0.987845329	0.413028848		
2.463319107	0.975439379	0.408669398		
3.904097684	0.95150514	0.400258906		
6.187577842	0.908175351	0.385032818		
10	0.833916095	0.358938116	0.36	
15.54249283	0.738467367	0.325397433	0.33	
20	0.675507864	0.303273463	0.30	
33	0.545484806	0.257583361	0.26	
39.04097684	0.503257	0.24274451		
61.87577842	0.397361153	0.205532709		
98.0665	0.309162236	0.17453961		
155.4249283	0.238665817	0.149767168		
246.3319107	0.183515079	0.130387199		
390.4097684	0.140831899	0.115388329		
618.7577842	0.107972621	0.103841579		
980.665	0.082741567	0.094975387		
1500	0.064708722	0.088638645		0.09
1554.249283	0.063392181	0.088176013		
2463.319107	0.048562402	0.082964828		
3904.097684	0.03719989	0.078972041		
6187.577842	0.028495222	0.075913221		
9806.65	0.021827151	0.073570061		
15542.49283	0.016719354	0.071775181		
24633.19107	0.012806801	0.07040031		
39040.97684	0.009809824	0.069347172		
61875.77842	0.007514178	0.068540482		
98066.5	0.005755746	0.067922569		



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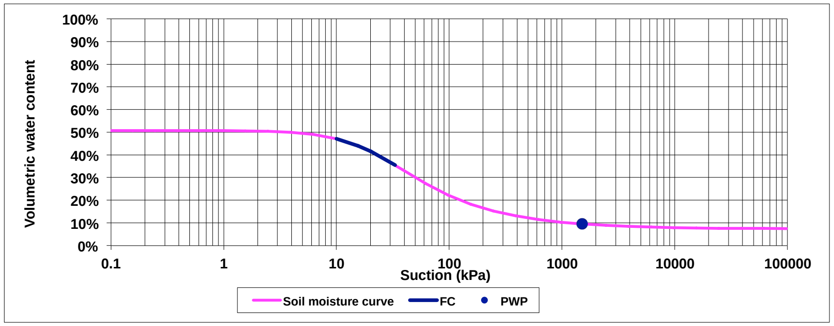
Graham Lancaster
Laboratory Manager

Sample 2 Pedotransfer Function parameters for %Sand/silt/clay+Bulk Density (van-Genuchten parameters from Rosetta neural network prediction)		Suction (kPa)	Se	Theta	FC	PWP
		0.0980665	0.999965932	0.507985211		
theta R	0.0739	0.155424928	0.999924758	0.507967338		
theta S	0.508	0.246331911	0.999833838	0.507927869		
alpha	0.0042	0.390409768	0.99963312	0.507840737		
n	1.7207	0.618757784	0.999190273	0.507648498		
		0.980665	0.998214501	0.507224915		
m=1-1/n, 0<m<1	0.418841169	1.554249283	0.996070683	0.506294284		
thetaS-thetaR	0.4341	2.463319107	0.991390312	0.504262535		
		3.904097684	0.981310981	0.499887097		
		6.187577842	0.9602226	0.490732631		
		10	0.916185032	0.471615922	0.47	
		15.54249283	0.844652735	0.440563752	0.44	
		20	0.788020646	0.415979762	0.42	
		33	0.64838894	0.355365639	0.36	
		39.04097684	0.597351777	0.333210406		
		61.87577842	0.461094102	0.27406095		
		98.0665	0.343593699	0.223054025		
		155.4249283	0.251098376	0.182901805		
		246.3319107	0.181725286	0.152786947		
		390.4097684	0.130912454	0.130729096		
		618.7577842	0.09410625	0.114751523		
		980.665	0.067582084	0.103237383		
		1500	0.049769503	0.095504941		0.10
		1554.249283	0.048512279	0.09495918		
		2463.319107	0.034816428	0.089013811		
		3904.097684	0.024984868	0.084745931		
		6187.577842	0.017928829	0.081682905		
		9806.65	0.012865263	0.079484811		
		15542.49283	0.009231701	0.077907481		
		24633.19107	0.006624347	0.076775629		
		39040.97684	0.004753393	0.075963448		
		61875.77842	0.003410861	0.075380655		
		98066.5	0.002447508	0.074962463		



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RESULTS OF MOISTURE CURVE (Page 1 of 1)

6 soil samples supplied by Natural Resource Assessments Pty Ltd on the 9th May, 2017 - Lab Job No. F9256
Analysis requested by Andrew Butler.
(PO Box 5678 CAIRNS QLD 4870)

Sample Site	EAL lab code	Lab. Bulk Density tonne DW/m^3	USDA %Sand (from hydrometer determinations)	%Silt	%Clay	van Genuchten parameters (for WAVES, HYDRUS etc) thetaR	thetaS	alpha	n	Ksat (cm/day)	Field capacity (10 kPa)	Field capacity (33 kPa)	Permanent wilting point (1500 kPa)	Available water capacity assuming FC is at 10 kPa	Available water capacity assuming FC is at 33 kPa	Depth of soil (cm) - eg 50cm below 50: Available water capacity as a depth of water (cm) FC 10 kPa	Available water capacity as a depth of water (cm) FC 33 kPa
						from Rosetta pedotransfer functions in RETC											
Method No.																	
S07_15-50	F9256/1	1.33	13.96	50.41	35.63	0.0908	0.4732	0.0095	1.4781	13.55	40%	30%	13%	27%	17%	13.63	8.63
S07_50-95	F9256/2	1.41	9.89	70.84	19.26	0.0716	0.4301	0.0054	1.649	17.31	39%	29%	9%	30%	19%	14.80	9.72
S07_95-120	F9256/3	1.38	28.54	66.22	5.25	0.0414	0.3723	0.0061	1.6421	54.54	33%	23%	6%	27%	17%	13.38	8.49
S08_10-35	F9256/4	1.23	16.04	55.39	28.58	0.0847	0.4803	0.007	1.5664	27.52	42%	31%	11%	31%	20%	15.33	9.79
S08_35-75	F9256/5	1.32	7.72	44.76	47.52	0.0996	0.5001	0.0138	1.362	12.87	41%	32%	16%	25%	17%	12.66	8.25
S08_75-120	F9256/6	1.34	1.13	58.81	40.06	0.0962	0.4943	0.0105	1.4327	9.7	41%	32%	14%	27%	18%	13.69	8.80

NOTE:

1: The Hydrometer Analysis method was used to determine the percentage sand, silt and clay

2. Soil moisture characteristic curve parameters derived from Rosetta pedotransfer functions within RETC, reference:

van Genuchten, M. T., Simunek, J., Leij, F. J. & Sejna, M. (2000). RETC ("RETention Curve") - Code for Quantifying the Hydraulic Functions of Unsaturated Soils. Riverside, CA, US Salinity Laboratory, USDA, ARS.

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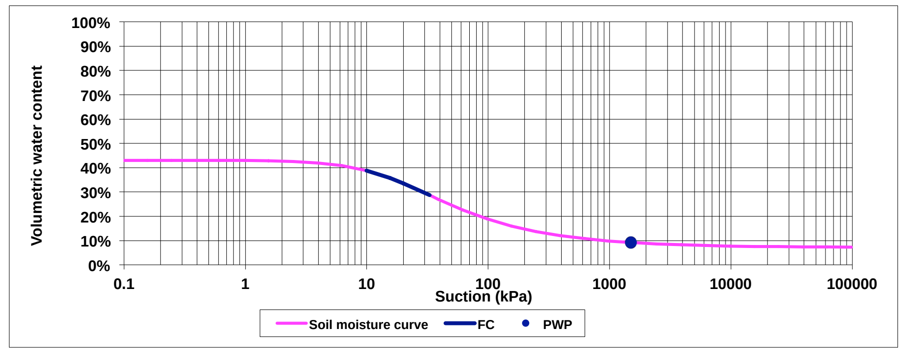
Sample 2
Pedotransfer Function parameters for %Sand/silt/clay+Bulk Density (van-Genuchten parameters from Rosetta neural network prediction)

theta R	0.0716
theta S	0.4301
alpha	0.0054
n	1.649

m=1-1/n, 0<m<1	0.393571862
thetaS-thetaR	0.3585

Suction (kPa)	Se	Theta	FC	PWP
0.0980665	0.999928272	0.430074286		
0.155424928	0.999846742	0.430045057		
0.246331911	0.999672592	0.429982624		
0.390409768	0.999300797	0.429849336		
0.618757784	0.998507917	0.429565088		
0.980665	0.996820988	0.428960324		
1.554249283	0.993249608	0.427679985		
2.463319107	0.98576692	0.424997441		
3.904097684	0.9704221	0.419496323		
6.187577842	0.940267484	0.408685893		
10	0.882491876	0.387973338	0.39	
15.54249283	0.798099908	0.357718817	0.36	
20	0.736860416	0.335764459	0.34	
33	0.598982946	0.286335386	0.29	
39.04097684	0.551662072	0.269370853		
61.87577842	0.42974879	0.225664941		
98.0665	0.326886571	0.188788836		
155.4249283	0.245464769	0.15959912		
246.3319107	0.183135289	0.137254001		
390.4097684	0.13620537	0.120429625		
618.7577842	0.101150765	0.107862549		
980.665	0.075065241	0.098510889		
1500	0.056986531	0.092029671		0.09
1554.249283	0.055688464	0.091564314		
2463.319107	0.041307071	0.086408585		
3904.097684	0.030637413	0.082583513		
6187.577842	0.022722968	0.079746184		
9806.65	0.016852763	0.077641716		
15542.49283	0.012498962	0.076080878		
24633.19107	0.009269905	0.074923261		
39040.97684	0.006875051	0.074064706		
61875.77842	0.005098896	0.073427954		
98066.5	0.003781606	0.072955706		



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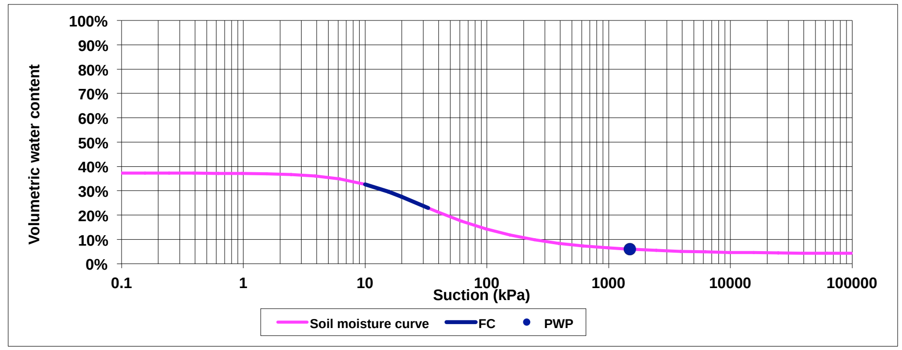
Sample 3

Pedotransfer Function parameters for %Sand/silt/clay+Bulk Density (van-Genuchten parameters from Rosetta neural network prediction)

theta R	0.0414
theta S	0.3723
alpha	0.0061
n	1.6421
m=1-1/n, 0<m<1	0.391023689
thetaS-thetaR	0.3309

Suction (kPa)	Se	Theta	FC	PWP
0.0980665	0.999909755	0.372270138		
0.155424928	0.999807795	0.372236399		
0.246331911	0.999590723	0.37216457		
0.390409768	0.999128876	0.372011745		
0.618757784	0.998147575	0.371687033		
0.980665	0.996068587	0.370999095		
1.554249283	0.991690771	0.369550476		
2.463319107	0.982588593	0.366538565		
3.904097684	0.964147794	0.360436505		
6.187577842	0.928628555	0.348683189		
10	0.862778911	0.326893542	0.33	
15.54249283	0.770787553	0.296453601	0.30	
20	0.706523975	0.275188783	0.28	
33	0.567533117	0.229196708	0.23	
39.04097684	0.521217309	0.213870808		
61.87577842	0.404144246	0.175131331		
98.0665	0.307070778	0.14300972		
155.4249283	0.230821284	0.117778763		
246.3319107	0.172579563	0.098506578		
390.4097684	0.128700503	0.083986996		
618.7577842	0.095859878	0.073120034		
980.665	0.071357739	0.065012276		
1500	0.054328544	0.059377315		0.06
1554.249283	0.053103903	0.058972081		
2463.319107	0.039514448	0.054475331		
3904.097684	0.0294008	0.051128725		
6187.577842	0.021875101	0.048638471		
9806.65	0.016275532	0.046785573		
15542.49283	0.012109259	0.045406954		
24633.19107	0.009009459	0.04438123		
39040.97684	0.006703155	0.043618074		
61875.77842	0.004987231	0.043050275		
98066.5	0.003710561	0.042627825		



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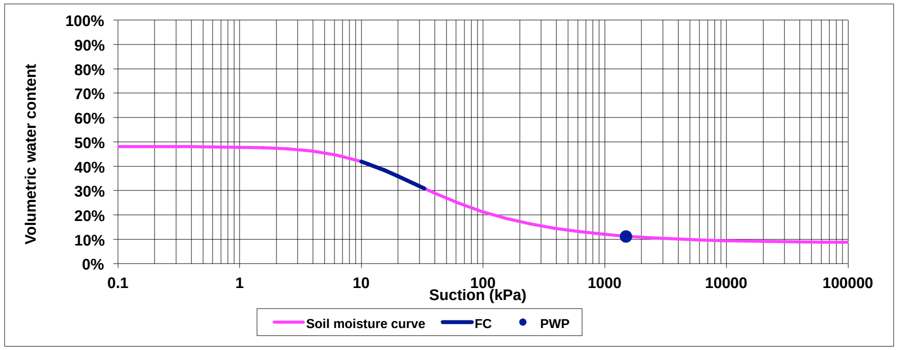
Sample 4

Pedotransfer Function parameters for %Sand/silt/clay+Bulk Density (van-Genuchten parameters from Rosetta neural network prediction)

theta R	0.0847
theta S	0.4803
alpha	0.007
n	1.5664

m=1-1/n, 0<m<1	0.361593463
thetaS-thetaR	0.3956

Suction (kPa)	Se	Theta	FC	PWP
0.0980665	0.999847715	0.480239756		
0.155424928	0.999686811	0.480176103		
0.246331911	0.999356104	0.480045275		
0.390409768	0.998677062	0.479776646		
0.618757784	0.99728557	0.479226171		
0.980665	0.994445766	0.478102745		
1.554249283	0.988698069	0.475828956		
2.463319107	0.977256018	0.471302481		
3.904097684	0.955198709	0.462576609		
6.187577842	0.915116207	0.446719972		
10	0.845676141	0.419249482	0.42	
15.54249283	0.754847064	0.383317498	0.38	
20	0.69396607	0.359232977	0.36	
33	0.5659668	0.308596466	0.31	
39.04097684	0.523791314	0.291911844		
61.87577842	0.416859729	0.249609709		
98.0665	0.32663022	0.213914915		
155.4249283	0.253790574	0.185099551		
246.3319107	0.19634759	0.162375107		
390.4097684	0.15158036	0.14466519		
618.7577842	0.116896361	0.1309442		
980.665	0.090101988	0.120344346		
1500	0.070842161	0.112725159		0.11
1554.249283	0.069431764	0.112167206		
2463.319107	0.053496909	0.105863377		
3904.097684	0.041216703	0.101005328		
6187.577842	0.031754493	0.097262077		
9806.65	0.024464198	0.094378037		
15542.49283	0.018847502	0.092156072		
24633.19107	0.014520286	0.090444225		
39040.97684	0.011186542	0.089125396		
61875.77842	0.008618192	0.088109357		
98066.5	0.006639514	0.087326592		



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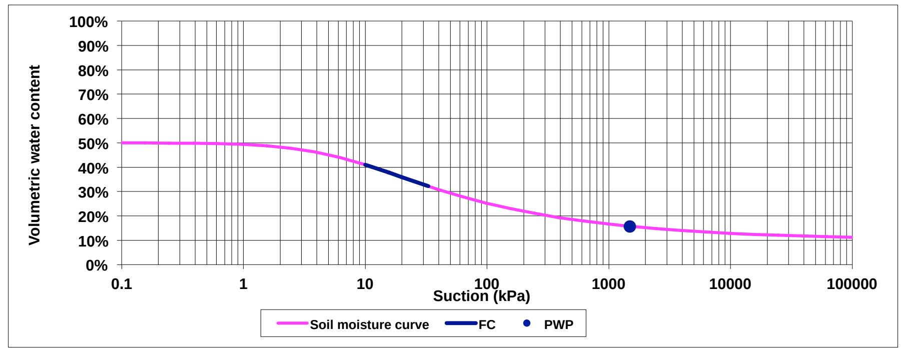
Sample 5

Pedotransfer Function parameters for %Sand/silt/clay+Bulk Density (van-Genuchten parameters from Rosetta neural network prediction)

theta R	0.0996
theta S	0.5001
alpha	0.0138
n	1.362
m=1-1/n, 0<m<1	0.265785609
thetaS-thetaR	0.4005

Suction (kPa)	Se	Theta	FC	PWP
0.0980665	0.999223318	0.499788939		
0.155424928	0.998548077	0.499518505		
0.246331911	0.99728957	0.499014473		
0.390409768	0.994953289	0.498078792		
0.618757784	0.990647907	0.496354487		
0.980665	0.98281882	0.493218938		
1.554249283	0.968914881	0.48765041		
2.463319107	0.945197011	0.478151403		
3.904097684	0.907246793	0.462952341		
6.187577842	0.851844389	0.440763678		
10	0.776322193	0.410517038	0.41	
15.54249283	0.696307827	0.378471285	0.38	
20	0.64877062	0.359432633	0.36	
33	0.556095099	0.322316087	0.32	
39.04097684	0.526437857	0.310438362		
61.87577842	0.450672538	0.280094351		
98.0665	0.383860839	0.253336266		
155.4249283	0.326023675	0.230172482		
246.3319107	0.276467997	0.210325433		
390.4097684	0.234245954	0.193415505		
618.7577842	0.198381387	0.179051745		
980.665	0.167966749	0.166870683		
1500	0.144035806	0.15728634		0.16
1554.249283	0.142196444	0.156549676		
2463.319107	0.120371505	0.147808788		
3904.097684	0.101892534	0.14040796		
6187.577842	0.086248656	0.134142587		
9806.65	0.07300585	0.128838843		
15542.49283	0.061796021	0.124349306		
24633.19107	0.052307267	0.12054906		
39040.97684	0.044275435	0.117332312		
61875.77842	0.037476867	0.114609485		
98066.5	0.031722215	0.112304747		



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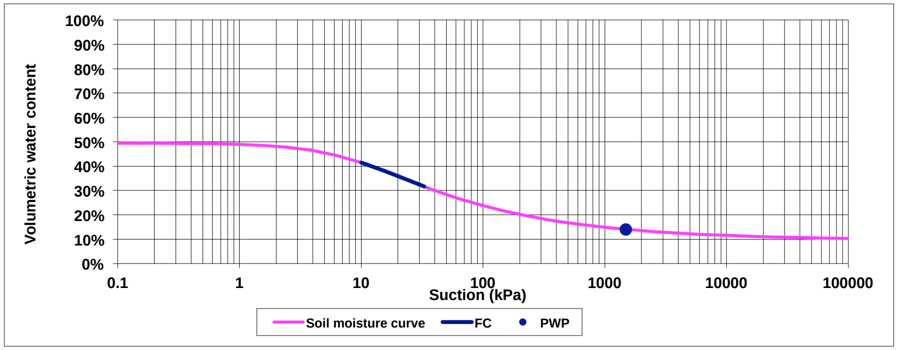
Sample 6		Suction (kPa)	Se	Theta	FC	PWP
Pedotransfer Function parameters for %Sand/silt/clay+Bulk Density (van-Genuchten parameters from Rosetta neural network prediction)		0.0980665	0.99955886	0.494124382		
theta R	0.0962	0.155424928	0.999147428	0.493960591		
theta S	0.4943	0.246331911	0.998353633	0.493644581		
alpha	0.0105	0.390409768	0.99682582	0.493036359		
n	1.4327	0.618757784	0.993898821	0.491871121		
		0.980665	0.988340348	0.489658293		
m=1-1/n, 0<m<1	0.30201717	1.554249283	0.977956846	0.48552462		
thetaS-thetaR	0.3981	2.463319107	0.959131094	0.478030089		
		3.904097684	0.926714703	0.465125123		
		6.187577842	0.875276606	0.444647617		
		10	0.798928602	0.414253477	0.41	
		15.54249283	0.712339277	0.379782266	0.38	
		20	0.65905394	0.358569373	0.36	
		33	0.553212577	0.316433927	0.32	
		39.04097684	0.519178251	0.302884862		
		61.87577842	0.432727289	0.268468734		
		98.0665	0.357842033	0.238656913		
		155.4249283	0.294630223	0.213492292		
		246.3319107	0.242019294	0.192547881		
		390.4097684	0.198558707	0.175246221		
		618.7577842	0.162798064	0.161009909		
		980.665	0.13343346	0.149319861		
		1500	0.11103938	0.140404777		0.14
		1554.249283	0.109346583	0.139730875		
		2463.319107	0.089599758	0.131869663		
		3904.097684	0.0734156	0.125426751		
		6187.577842	0.060153303	0.12014703		
		9806.65	0.049286188	0.115820832		
		15542.49283	0.040382036	0.112276088		
		24633.19107	0.033086417	0.109371703		
		39040.97684	0.027108815	0.106992019		
		61875.77842	0.022211145	0.105042257		
		98066.5	0.018198314	0.103444749		



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Laboratory Manager

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

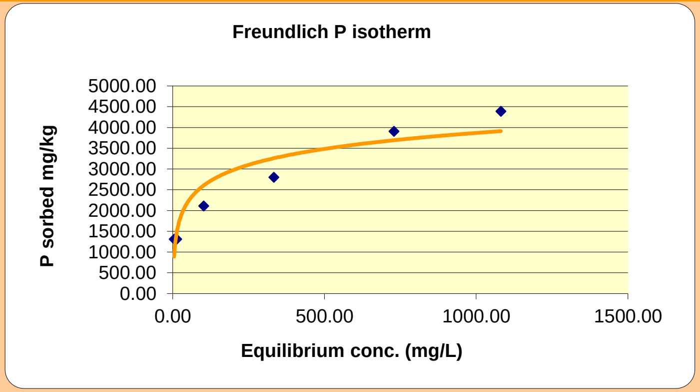
Input data in white cells only

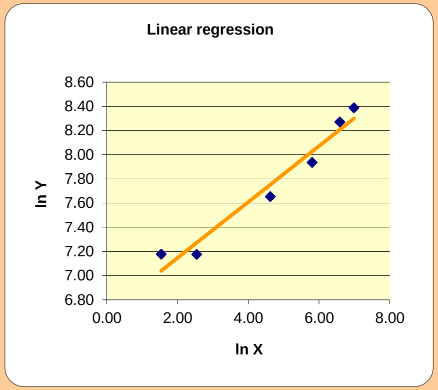
1 Colwell P

	Colwell P mg/kg solution	Solution:soil ratio
S07_0-15	69.61	10

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
65.90	4.66	1308.48
73.80	12.74	1306.68
243.00	102.04	2105.68
543.00	333.04	2795.72
1050.00	729.04	3905.72
1450.00	1080.94	4386.72





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.2312	6.6834	Equation is y = 0.2312x + 6.6834	0.9578

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	**799.05**
Adsorption Exponent (B)	**0.2312**
Desorption Exponent	**0.2197**

Example 1 Orig soln	Soln dilution	soln:soil ratio ?
50	65.90	0.758725341
100	73.80	1.35501355
250	243.00	1.028806584
500	543.00	0.920810313
1000	1050.00	0.952380952
1500	1450.00	1.034482759
	avg	1.008369917

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

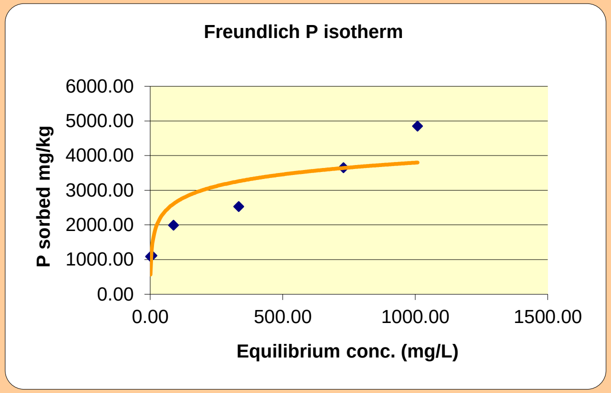
Input data in white cells only

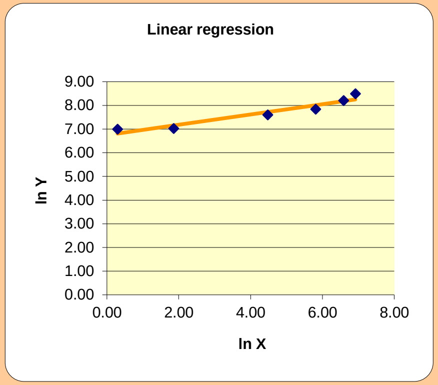
1 Colwell P

	Colwell P mg/kg solution	Solution:soil ratio
S08_0-10	43.84	10

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
65.90	1.35	1083.92
73.80	6.43	1112.07
243.00	88.24	1985.97
543.00	333.94	2529.01
1050.00	729.04	3648.01
1450.00	1008.94	4849.01





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.2176	6.7453	Equation is y = 0.2176x + 6.7453	0.9184

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	**850.03**
Adsorption Exponent (B)	**0.2176**
Desorption Exponent	**0.2067**

Sample 1	Orig soln	Soln dilution	soln:soil ratio ?
	50	65.90	0.758725341
	100	73.80	1.35501355
	250	243.00	1.028806584
	500	543.00	0.920810313
	1000	1050.00	0.952380952
	1500	1450.00	1.034482759
		avg	1.008369917

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

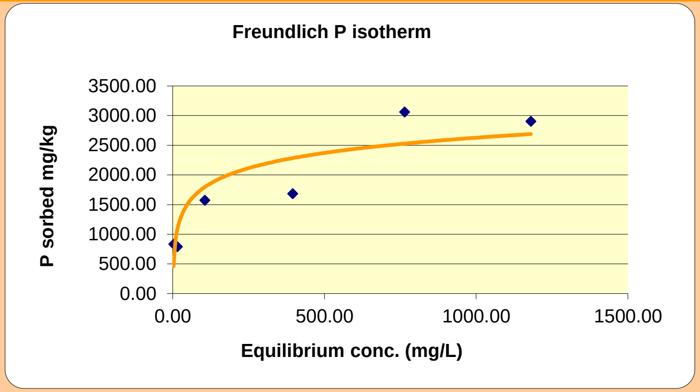
Input data in white cells only

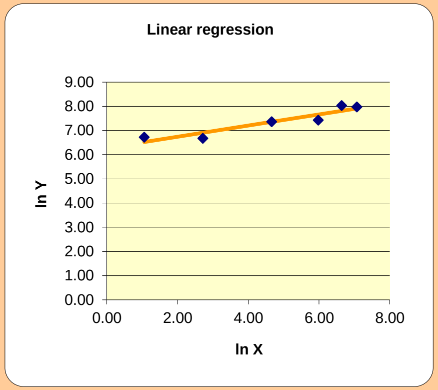
1 Colwell P

	Colwell P mg/kg solution	Solution:soil ratio
S07_15_50	20.19	10

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
65.90	2.89	832.02
73.80	15.14	788.52
243.00	106.04	1571.52
543.00	395.14	1680.56
1050.00	764.14	3060.56
1450.00	1179.94	2902.56





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.2311	6.2800	Equation is y = 0.2311x + 6.2800	0.8829

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	**533.77**
Adsorption Exponent (B)	**0.2311**
Desorption Exponent	**0.2195**

Example 1 Orig soln	Soln dilution	soln:soil ratio ?
50	65.90	0.758725341
100	73.80	1.35501355
250	243.00	1.028806584
500	543.00	0.920810313
1000	1050.00	0.952380952
1500	1450.00	1.034482759
	avg	1.008369917

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

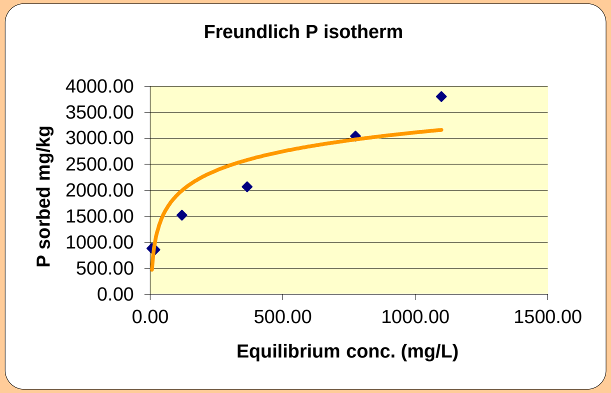
Input data in white cells only

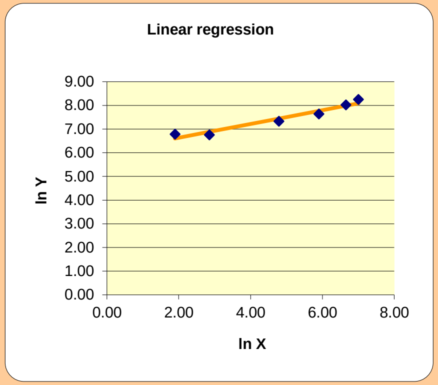
1 Colwell P

	Colwell P mg/kg solution	Solution:soil ratio
S07_50_95	28.96	10

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
65.90	6.64	882.19
73.80	17.34	854.19
243.00	120.04	1519.19
543.00	365.44	2065.23
1050.00	774.94	3040.23
1450.00	1098.94	3800.23





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.2903	6.0517	Equation is y = 0.2903x + 6.0517	0.9448

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	**424.83**
Adsorption Exponent (B)	**0.2903**
Desorption Exponent	**0.2758**

Sample 1	Orig soln	Soln dilution	soln:soil ratio ?
	50	65.90	0.758725341
	100	73.80	1.35501355
	250	243.00	1.028806584
	500	543.00	0.920810313
	1000	1050.00	0.952380952
	1500	1450.00	1.034482759
		avg	1.008369917

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

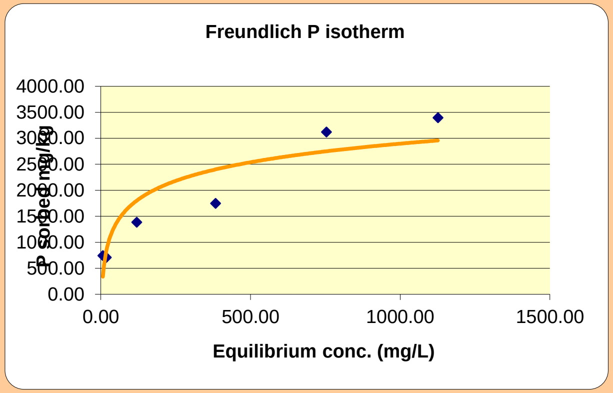
Input data in white cells only

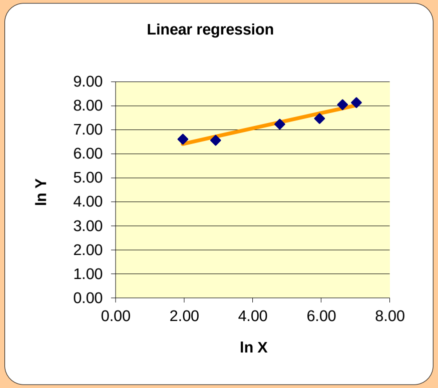
1 Colwell P

	Colwell P mg/kg solution	Solution:soil ratio
S07_95_120	15.14	10

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
65.90	7.09	739.54
73.80	18.54	704.04
243.00	120.04	1381.04
543.00	383.44	1747.08
1050.00	753.34	3118.08
1450.00	1125.94	3392.08





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.3186	5.7848	Equation is y = 0.3186x + 5.7848	0.9348

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	**325.31**
Adsorption Exponent (B)	**0.3186**
Desorption Exponent	**0.3027**

Sample 1	Orig soln	Soln dilution	soln:soil ratio ?
	50	65.90	0.758725341
	100	73.80	1.35501355
	250	243.00	1.028806584
	500	543.00	0.920810313
	1000	1050.00	0.952380952
	1500	1450.00	1.034482759
		avg	1.008369917

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

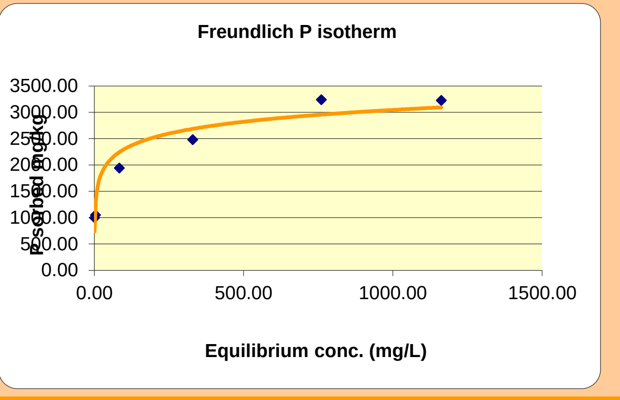
Input data in white cells only

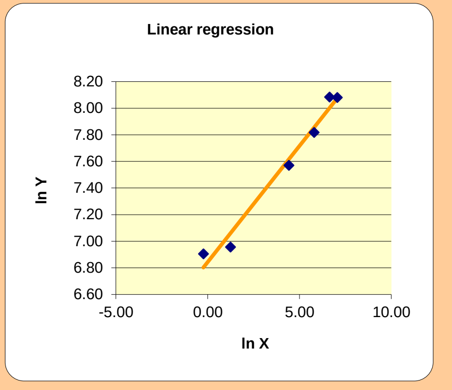
1 Colwell P

	Colwell P mg/kg solution	Solution:soil ratio
S08_10_35	34.54	10

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
65.90	0.79	996.46
73.80	3.46	1048.78
243.00	83.64	1938.98
543.00	329.44	2481.02
1050.00	760.54	3240.02
1450.00	1161.94	3226.02





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.1745	6.8433	Equation is y = 0.1745x + 6.8433	0.9775

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	**937.54**
Adsorption Exponent (B)	**0.1745**
Desorption Exponent	**0.1658**

Sample 1	Orig soln	Soln dilution	soln:soil ratio ?
	50	65.90	0.758725341
	100	73.80	1.35501355
	250	243.00	1.028806584
	500	543.00	0.920810313
	1000	1050.00	0.952380952
	1500	1450.00	1.034482759
		avg	1.008369917

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

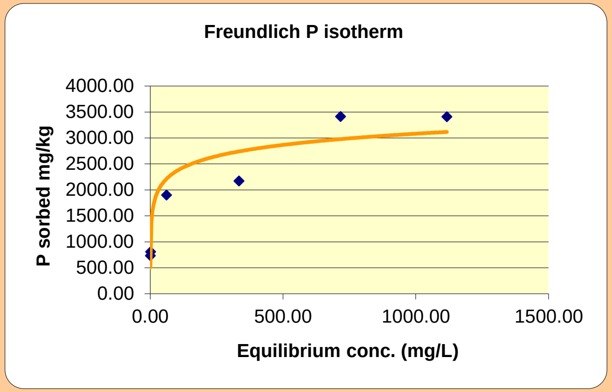
Input data in white cells only

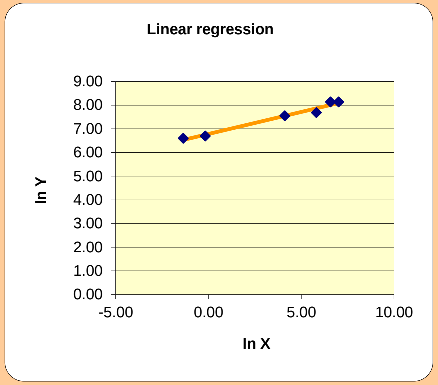
1 Colwell P

	Colwell P mg/kg solution	Solution:soil ratio
S08_35_75	7.70	10

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
65.90	0.26	733.49
73.80	0.84	806.65
243.00	60.94	1897.65
543.00	333.94	2167.69
1050.00	716.44	3412.69
1450.00	1116.94	3407.69





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.1862	6.7827	Equation is y = 0.1862x + 6.7827	0.9739

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	**882.48**
Adsorption Exponent (B)	**0.1862**
Desorption Exponent	**0.1769**

Sample 1	Orig soln	Soln dilution	soln:soil ratio ?
	50	65.90	0.758725341
	100	73.80	1.35501355
	250	243.00	1.028806584
	500	543.00	0.920810313
	1000	1050.00	0.952380952
	1500	1450.00	1.034482759
		avg	1.008369917

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

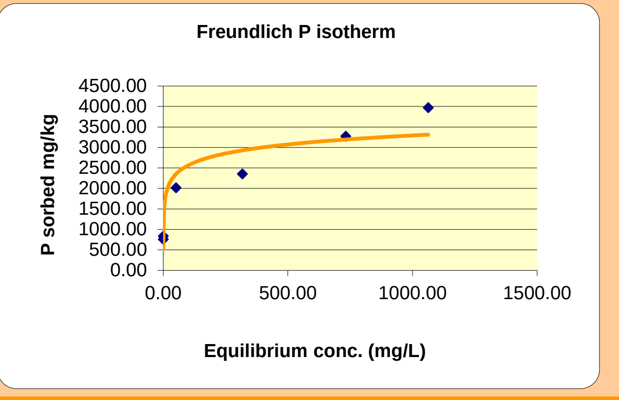
Input data in white cells only

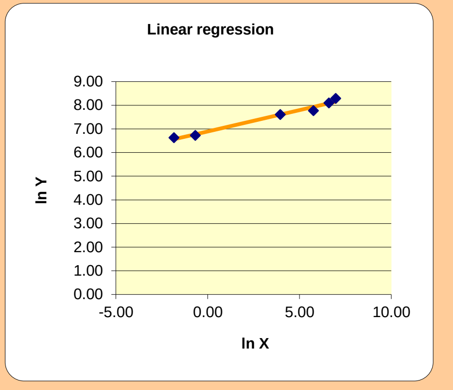
1 Colwell P

	Colwell P mg/kg solution	Solution:soil ratio
S08_75_120	9.83	10

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
65.90	0.16	755.71
73.80	0.51	831.25
243.00	51.74	2010.90
543.00	317.74	2350.94
1050.00	732.64	3271.94
1450.00	1062.94	3968.94





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.1799	6.8944	Equation is y = 0.1799x + 6.8944	0.9776

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	**986.74**
Adsorption Exponent (B)	**0.1799**
Desorption Exponent	**0.1709**

Sample 1	Orig soln	Soln dilution	soln:soil ratio ?
	50	65.90	0.758725341
	100	73.80	1.35501355
	250	243.00	1.028806584
	500	543.00	0.920810313
	1000	1050.00	0.952380952
	1500	1450.00	1.034482759
		avg	1.008369917

Appendix B:
Contaminated Land Search Results

Queensland Government

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE

ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351784 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 129 Plan: NR456
301 BOYLES Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-

1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Queensland Government

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351783 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 131 Plan: N157491
301 BOYLES Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-

1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Queensland Government

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE

ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351792 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 17 Plan: N157227
112 BARNWELL Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-

1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351791 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 18 Plan: N157227
112 BARNWELL Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-
1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

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ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351788 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 19 Plan: N157452
112 BARNWELL Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-
1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351789 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 1 Plan: RP703984
112 BARNWELL Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-
1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50352604 EMR Site Id: 31 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 1 Plan: RP728072
1496 KENNEDY Highway
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-

1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE

ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351787 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 20 Plan: N157423
301 BOYLES Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-

1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Queensland Government

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351793 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 22 Plan: N157227
112 BARNWELL Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-

1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Queensland Government

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
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www.ehp.qld.gov.au

SEARCH RESPONSE

ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351782 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 290 Plan: N157480
301 BOYLES Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-

1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Queensland Government

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400 George St Brisbane, Queensland 4000
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www.ehp.qld.gov.au

SEARCH RESPONSE

ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351790 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 2 Plan: RP703984
112 BARNWELL Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-

1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

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ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50352603 EMR Site Id: 31 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 2 Plan: RP720923
1458 KENNEDY Highway
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-
1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351785 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 43 Plan: N157359
301 BOYLES Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-
1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Queensland Government

Department of Environment and Heritage Protection (EHP)
ABN 46 640 294 485
400 George St Brisbane, Queensland 4000
GPO Box 2454, Brisbane QLD 4001, AUSTRALIA
www.ehp.qld.gov.au

SEARCH RESPONSE
ENVIRONMENTAL MANAGEMENT REGISTER (EMR)
CONTAMINATED LAND REGISTER (CLR)

Grace Derrick
PO BOX 5678
Cairns QLD 4870

Transaction ID: 50351786 EMR Site Id: 25 January 2017
Cheque Number:
Client Reference:

This response relates to a search request received for the site:
Lot: 95 Plan: N157452
301 BOYLES Road
KURANDA

EMR RESULT

The above site is NOT included on the Environmental Management Register.

CLR RESULT

The above site is NOT included on the Contaminated Land Register.

ADDITIONAL ADVICE

All search responses include particulars of land listed in the EMR/CLR when the search was generated.
The EMR/CLR does NOT include:-

1. land which is contaminated land (or a complete list of contamination) if EHP has not been notified
2. land on which a notifiable activity is being or has been undertaken (or a complete list of activities) if EHP has not been notified

If you have any queries in relation to this search please phone 13QGOV (13 74 68)

Administering Authority

Environmental Approval & Compliance Solutions

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