GULLY MITIGATION FIELD GUIDE

CAPE YORK

MAY 2018

Australian Government

ACKNOWLEDGEMENTS

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NORMANBY CATCHMENT

The Normanby Basin in southeast Cape York is the fourth largest river system flowing into the Great Barrier Reef (GBR) lagoon (Geosciences Australia, 1997). The Normanby Basin, covering 24,228 km², consists of numerous riverine and wetland systems, sacred Aboriginal sites, cattle grazing country, one of Queensland's largest conservation areas at Rinyirru (Lakefield) National Park, and the rich agricultural land at Lakeland Downs. The lower catchment includes the largest aggregation of non-maritime wetlands listed on the Directory of Important Wetlands on the east coast of Australia - the Marina Plains Lakefield Aggregation (Environment Australia, 2001). The extensive seagrass meadows and estuarine salt flats provide diverse and productive habitat for marine and estuarine plants and animals.

The major population centres within the catchment area are Lakeland Downs and Laura. The resident population for the entire catchment area is less than 500 (ABS, 2006).

Conservation areas occupy a significant proportion of the catchment, with Rinyirru (Lakefield) and Jack River National Parks covering approximately 29%, or 703,000 ha. Both of these areas were formerly cattle stations, and feral and domestic cattle continue to access wetlands and rivers within the National Parks.

Grazing is the most extensive land use, with low density grazing occurring on approximately 75% (18,495 km²) of the catchment (2011). Some stations have been purchased over the past 5 years by the Queensland Government to be designated as National Park/ Aboriginal Land, however grazing still occurs on most of these areas. Average cattle density on grazing lands is estimated at 1 animal per 50 ha (Brodie and Mitchell, 2005), but higher concentrations of animals are typically found along river frontage (~1 beast/10 ha).

Horticulture within the catchment is mainly limited to the rich basaltic soils around Lakeland Downs on the upper reaches of the Laura River. Bananas, passionfruit, pineapples, sorghum, teak, and improved pasture for cattle forage are amongst the dominant crops. The horticultural area is estimated to cover 35 km² or 0.1% of the Normanby Catchment (2011), although this area is currently being expanded.

Significant portions of the Normanby River and its tributaries are ephemeral, with late dry season surface water largely stored in a series of waterholes connected via sub-surface flow through river sands. Wet season flood waters feed extensive wetland systems in the alluvial and marine plains of the lower catchment area and connect otherwise isolated wetlands and adjacent river systems.

The delivery of fine-grained sediment and nutrients to the GBR poses a threat to the sustainability of the reef and bay ecosystems.

Various reports have highlighted the Normanby as an erosion hotspot (Brodie et al., 2003; Prosser et al., 2001b) and as such the catchment has been nominated as a priority for erosion mitigation measures (Brodie et al., 2003). Based on these data the Great Barrier Reef Water Quality Protection Plan (2003) identified the Normanby as one of 10 priority river systems exporting significant loads of sediments and nutrients to the GBR.

CROCODILE GAP SITE – NORMANBY BASIN – CAPE YORK

Cape York NRM and Griffith University are working together with Roy and Karlene Shephard (Crocodile Station) to deliver the Reef Trust Gully Erosion Control Programme in the Crocodile Gap area of the Normanby Basin. The Project is called '50% reduction in gully erosion from high priority sub-catchments in the Normanby'.

This project utilises the most advanced spatial gully prioritisation method within the Great Barrier Reef (GBR) catchment to target implementation of cost effective on-ground action to achieve a 50% reduction in sediment load from gully erosion in highest priority sub-catchments in the Normanby Basin. Exclusion fencing of the gully sub-catchment, direct seeding of native grasses and shrubs and strategic gully stabilisation works were targeted at the most actively eroding gullies on Crocodile Station. Training of technical extension officers and grazing land managers ensures that the benefits of the Reef Trust Gully Erosion Control Programme will be communicated to the wider grazing community.

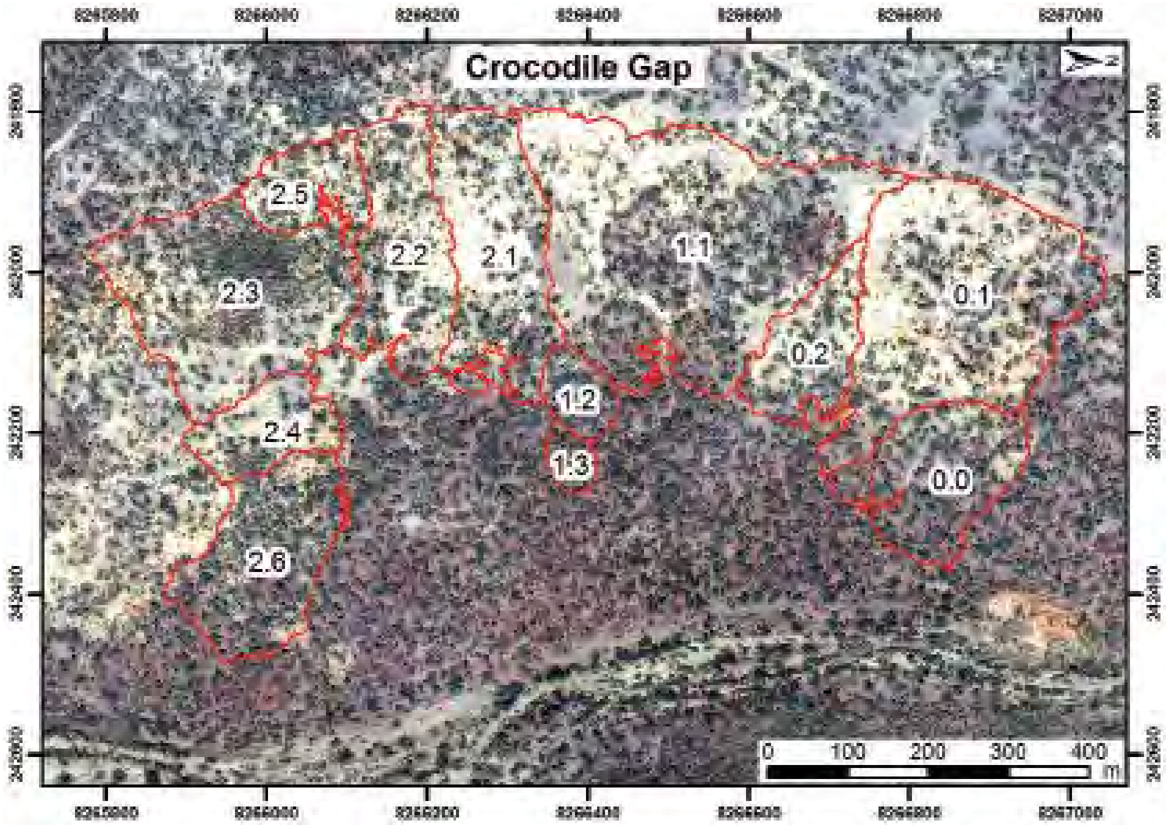
INTRODUCTION TO THE CROCODILE GAP GULLY REMEDIATION SITE

In close proximity to the Laura River a series of 1.5–2.5 m deep active secondary gullies are currently incising through a previously eroded landscape. Above these active secondary gullies, a series of older primary gullies are present with scarps in the order of 0.5–1.0 m high and extensive scalded areas with active rill and sheet erosion. At present these gullies are not directly connected to the channel network as there are large non-channelised areas between the primary gully outlets and the newly incised secondary phase gullies. However, if left unchecked the deep active secondary gullies will continue to grow headwards, having the combined effect of mobilising large volumes of stored sediment, reactivating and expanding the primary gullies and significantly increasing connectivity of the primary gullies to the drainage network. This would lead to a situation that would be much worse than the current situation and much harder to manage.

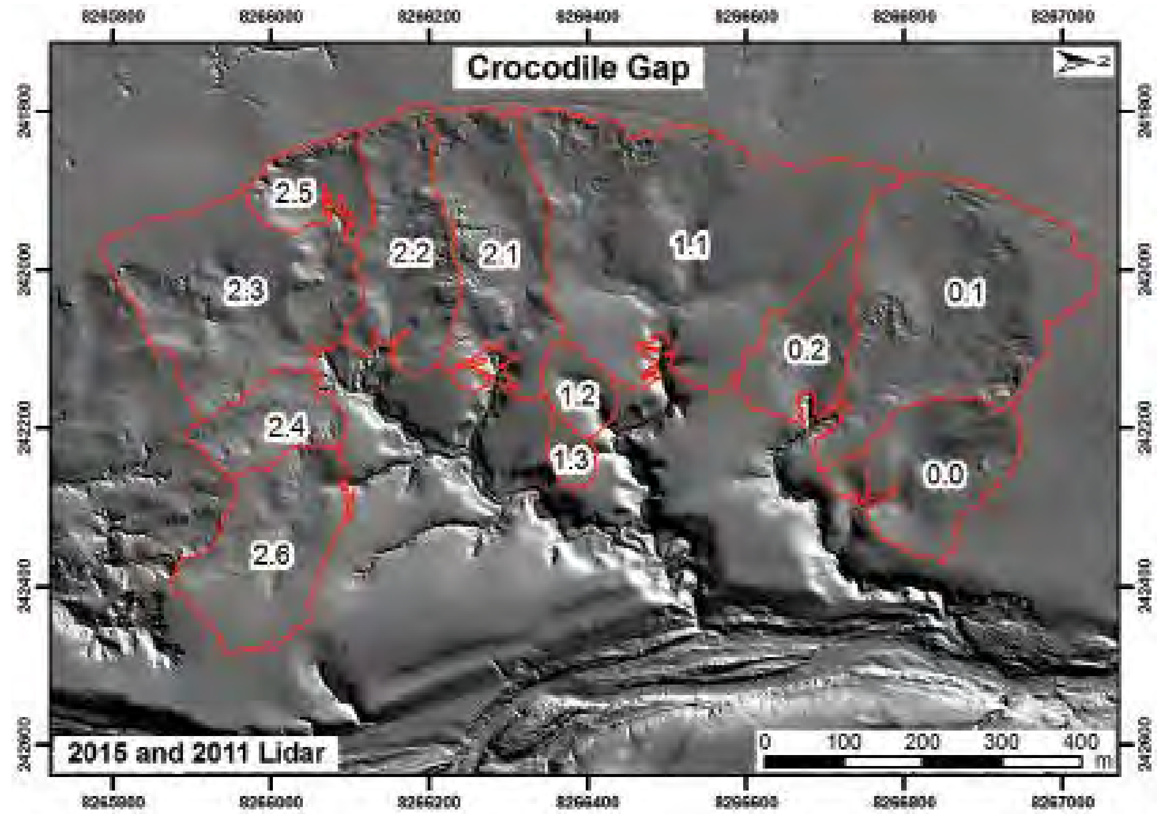
Primary gully scarps and scalds

Deep active secondary gullies

Gully erosion was analysed in the Normanby catchment as part of the Normanby sediment budget study (Brooks et al., 2013) and this analysis was further refined in the Normanby Basin Gully Prioritisation report (Brooks et al., 2015) to inform the Eastern Cape York Water Quality Improvement Plan. This analysis demonstrated that the Crocodile Gap area was a major sediment source hotspot at the catchment scale and an appropriate place to begin to focus large scale gully rehabilitation efforts. A total of 24 gully complexes have been identified in the Crocodile Gap area on both sides of the Peninsular Development Road (PDR). The proximity of the PDR makes this the easiest of all sites to access in the Normanby Basin, which means that the rehabilitation of these sites are some of the most cost effective. The 6 sub-catchments that overlay LiDAR block 16 are in the top 100 sediment yielding sub-catchments within the Normanby Basin. Total erosion from these 24 complexes, was 7107 t/yr for the sample period. Active lobes of gully complexes range in area from 40m² to several hectares. It should be highlighted that the measured erosion rates are absolute minimum values because of the 'limit of detection' of the aerial LiDAR technique. Actual erosion rates are likely to be at least double those reported.



Satellite image of site showing sub-catchment boundaries



Aerial LiDAR image of site showing sub-catchment boundaries

SOILS AND SOIL MATERIALS OF THE CROCODILE GAP GULLY REHABILITATION SITE - A PRELIMINARY ANALYSIS

Work and contributions by:
Peter Zund, Dept Environment and Science (Soils)
Robin Thwaites, Griffith University (Soil Materials)

THE GEOMORPHIC LANDSCAPE (P. Zund & R. Thwaites)

The Crocodile Gap study area is located in the northern end of the Butchers Hill depression, a large basin which has been filled with sediments from surrounding mountain ranges, as well as a basalt flow near Lakeland. It is flanked by the Deighton Tableland to the north and the Byerstown Range to the south with the Laura River draining the area (Domagala, Robertson & Bultitude 1993). The study site is mainly composed of alluvial deposits from the Laura River Earls (or Redbank) Creek and Laura River deposited during the Quaternary Period (the Pleistocene and Holocene Epochs: up to about 2 million years ago).

Downstream of the study site, the Laura River passes between the Byerstown Range and the Deighton Tableland, which acted as a constriction on the Quaternary Laura River, causing the build-up of alluvial deposits upstream where the sediment transporting energy was reduced. This created a plain of alluvial sediments with accumulated salts resulting in unstable materials that are now being re-incised owing to the lower flow levels of the Laura River and tributary creeks.

Within the Crocodile Gap study area the landscape can be divided into three geochronological geomorphic units described, from oldest to youngest and in Table 1, as:

- colluvial fans of greywacke, slate, mudstones as well as sandstones and conglomerate originating from the Byerstown Range to the west;
- relict alluvial plain of fine sediments probably originating from the Earls (Redbank) Creek catchment to the south-west, Laura River sediments, and possibly comprising of materials eroded from higher and older relict (possibly Tertiary) plains in the catchment; and
- active channel benches and terraces of the Laura River and tributaries, with recent alluvial deposition.

Table 1. Depositional layers and landforms within the study site. (P. Zund)

Depositional land unit	Definition
Recent alluvia	Alluvial sandy sediment deposits originating from the Laura River catchment.
Older alluvia	Alluvial fine sandy and clay sediment deposits originating from both the Earls (Redbank) Creek catchment and the Laura River.
Colluvial fan and alluvial fans	Colluvial fan deposits and associated soils from the Byerstown Range made up of greywacke, slate, mudstones, as well as sandstones and conglomerate. Alluvial fans from these deposits.

The soil-geomorphic features of the study area are shown in Figure 2. The main area of gully formation is in a central 'valley' zone of sandy clay alluvial material between higher ridges of red clay and sandy loam materials. These possibly represent the remnants of an older land surface, maybe modified, or terraces / benches of a larger Earls Creek tributary, or a branch of the, then braided, Laura River. Upstream in the Earls Creek catchment are further examples of elevated residual land surfaces, often lateritized (deeply weathered with red soils and ironstone gravels).

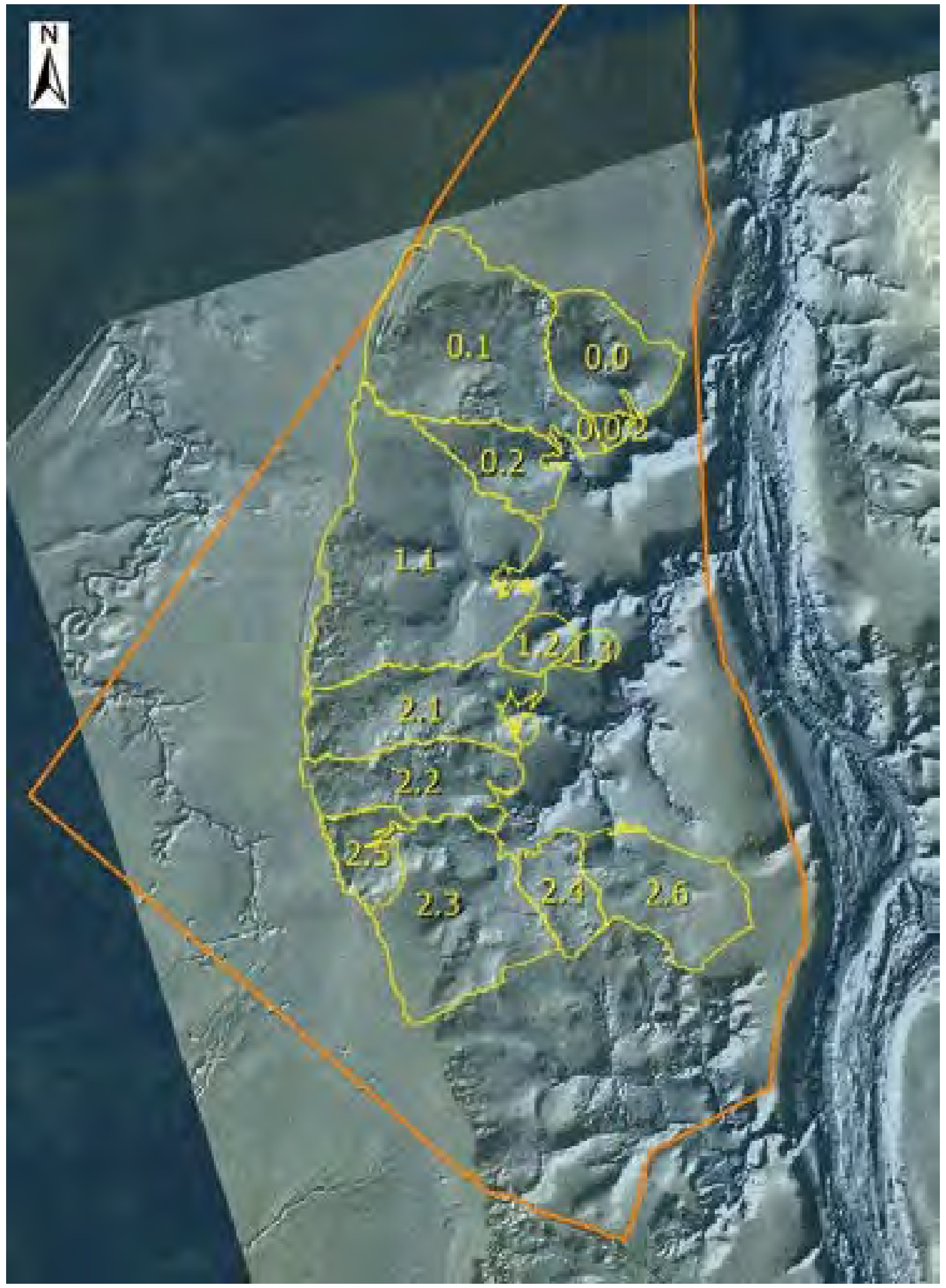


Figure 1. Physiography of the Crocodile Gap study area, using a DEM from 2009 1 m LiDAR and satellite imagery, as a basis of the geomorphic and soil materials description in this section. Includes the outlines and IDs of the gully catchments under investigation (yellow) and boundary exclosure fence (orange). Laura River is on the right. Earls Creek is at bottom right. The pale outline is the approximate boundary to figures 2 and 5. (R. Thwaites)

The red soil rises in the study area are possibly an extension of these old land surfaces and are of similar age. To the west of the central red clay rise is an old backplain deposit that accommodates a series of low-lying depressions with sodic soils. The backplain creek arises here and flows across the alluvial plain to the Laura River further north. The backplain is bounded to the west by colluvial soils and deposits and alluvial fans related to the Byerstown range slopes by the main Laura–Lakeland highway.

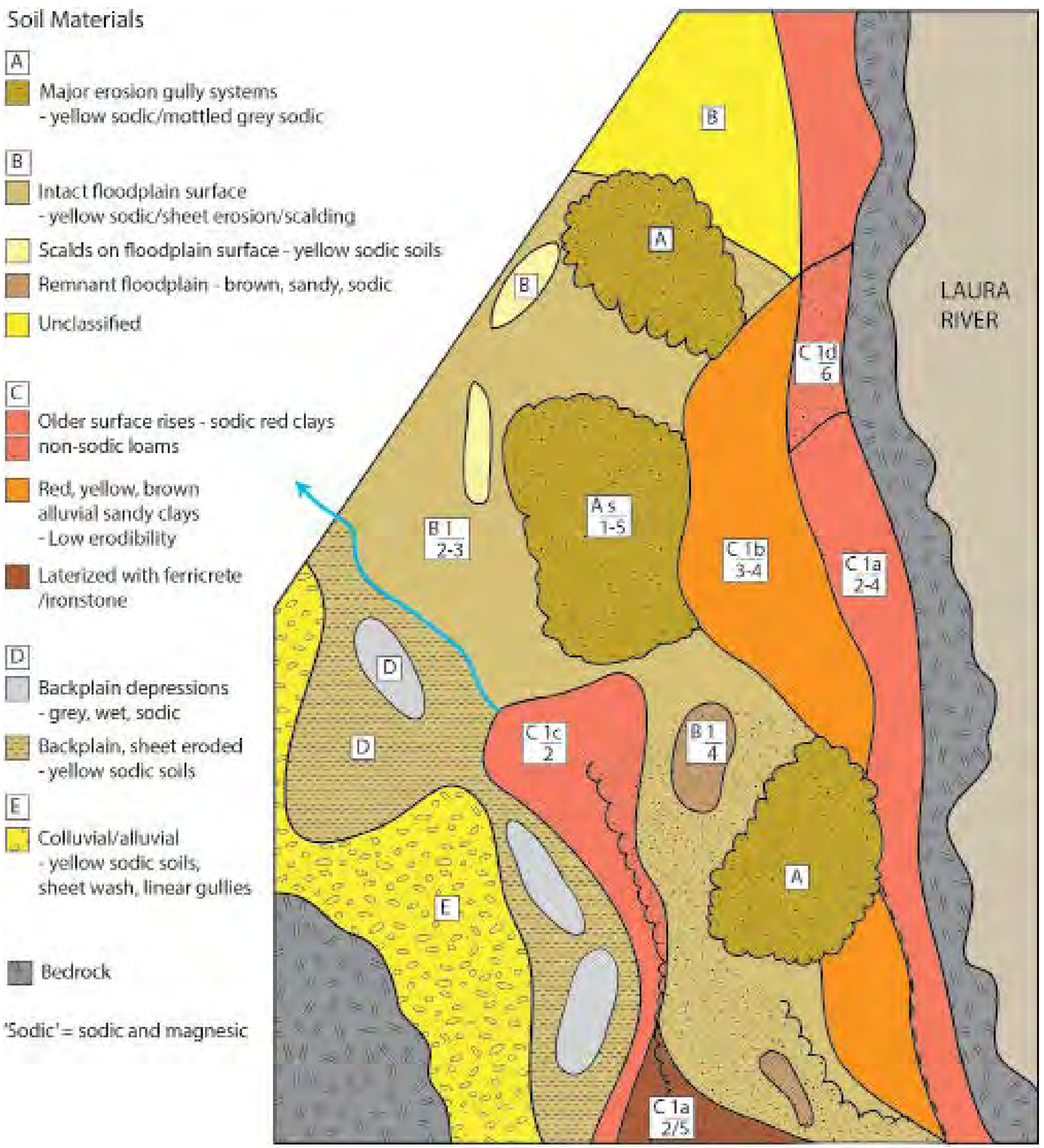


Figure 2. Schematic conceptual map of the main geomorphic forms and units in the Crocodile Gap study area. (R. Thwaites)

THE SOILS AND SOIL MATERIALS *(P. Zund)*

The Crocodile Gap study area is still being assessed for the characteristics of the soil materials and their spatial distribution. This is being done specifically for interpreting the soil and alluvial materials with respect to erosion susceptibility, gully analysis, and for rehabilitation of the alluvial gullies and eroding land.

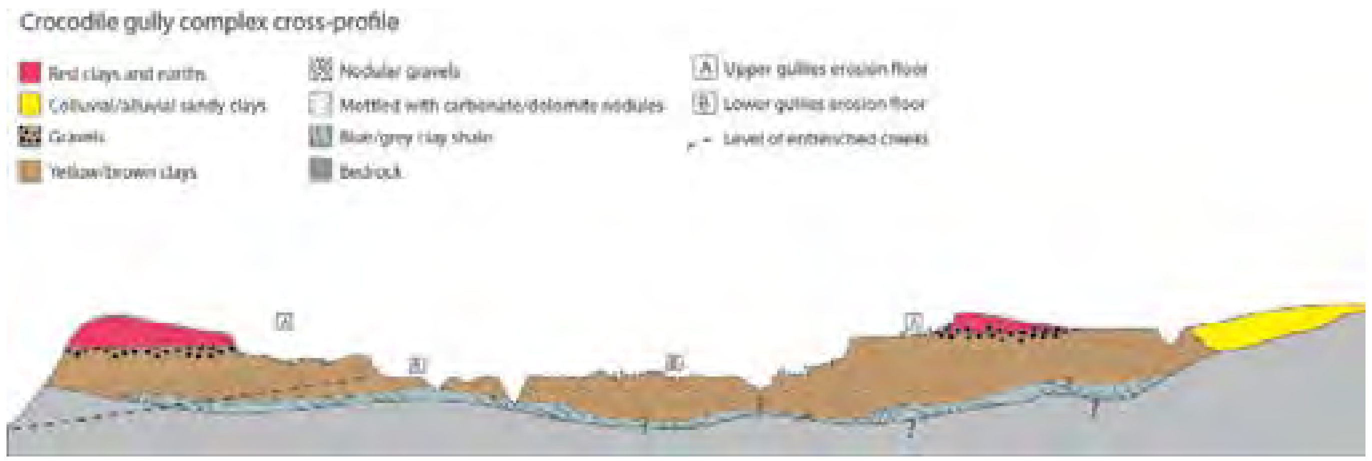


Figure 3. Schematic conceptualised cross-section of the main gully zone in the study area from east to west from The Laura River to the slopes of the Byerstown Range. (R.Thwaites)

Soils

A survey of the soils was undertaken in 2017 and the soil types identified have been tied into the regional soil mapping that has occurred in the past and is still underway in the Lakeland district. This soil survey provides an understanding of spatial arrangement of the erodible and non-erodible soils and the reasons for their erosion susceptibility. It gives an insight into the types of soil materials that must be handled for rehabilitation purposes and also provides an impression of what usable topsoil materials may be available as a primary growth medium (or 'topsoil') for rehabilitated sites. This soil mapping also gives a valuable insight into whether the remaining soils may be prone to erosion (or further erosion) or whether they may be less of a risk as an erosion hazard in the area, and where those boundaries are. This information can also then be transferred to other areas in the region to give an indication of erosion hazard and severity for similar surface soil types. The soils are grouped into Soil Profile Classes with local soil names and the map colours are based on the Australian Soil Classification orders such as Sodosols, Dermosols, etc. to allow ease of correlation with other mapping in the area.

Soil materials

A parallel assessment of the soil materials (which includes the ancient alluvial sediments) is on-going. This intends to establish the characteristics and spatial distribution of the 'subsoil' materials below the range of the soil type characterisation, which largely describes and classifies the top 1–1.5 m of the earth materials that make up the area that has been eroded and transported through the drainage network. The 'soil materials' are made up of the surface soils (where pedogenic (soil forming) processes dominate as A and B horizons, as well as the alluvial layers (strata) below, which have also been influenced by surface pedological and geomorphological processes. Like mapping geological strata, only the surface exposure of materials can be shown in two-dimensional map form, whereas the strata, or layers, below have to be mapped or visualised in a form of three-dimensions by a series of cross-sections and fence diagrams, and digital 3D spatial modelling. We are attempting to characterise and map these materials in three dimensions, with photo and field description of units, which is much more useful for gully erosion mapping, and rehabilitation planning and management.

Preliminary interpretations are summarised here. More detailed classification, description and mapping will be available in the near future from the Griffith University research team.

To enable the tracing of eroded sediment, soil samples have also been analysed for rare earth metals and the particle size has been determined using a laser diffraction methodology. As a result a link can be determined between the sample sites and suspended solids samples taken downstream.

All raw data for the soil survey part of the NESP 3.1.7 project is stored within the Queensland Government Soil and Land Information (SALI) database and this information will eventually be accessible via the Queensland Globe.
The soils and map

The soils have been described and recorded to the Australian standards to a maximum depth of about 1.5 m. Samples were taken from some of these described soil profiles to characterise the chemistry of the dominant soil profile classes and distinct soil materials that were identified. Samples of soil and sedimentary materials were also taken from some gully walls to characterise the chemical and physical characteristics of the distinct soil material units (SMUs). The elevation above Australian Height Datum (AHD) was determined for the ground level of each soil site using data from the 1-m airborne LIDAR survey. Soil horizon depths and sample depths were related to elevation above AHD so that a 3-D model of soil material units and their analytical properties can be constructed.

A two-dimensional representation of dominant soils has been created as a map with dominant and minor soil profile classes (SPCs) (Figure 4). SPCs are a group of soil profiles that all meet the definition of the class of some soil classification system. The profiles are related by similarity of properties but are not necessarily related spatially.

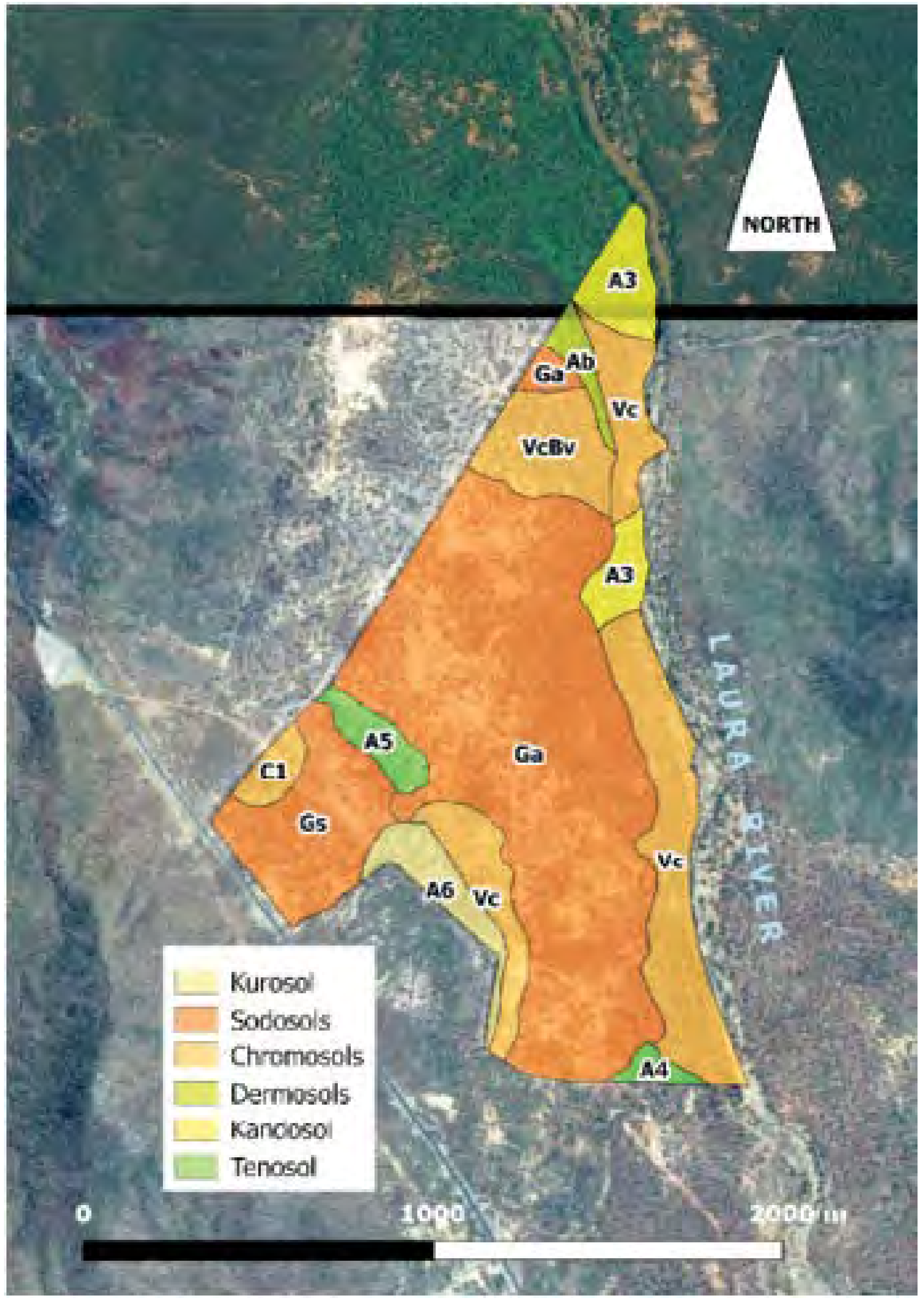


Figure 4. Map of soil types found in the study area with outlines of gully catchments of gullies under investigation. (P. Zund)

The map incorporates SPCs from local soil surveys including the Cape York Peninsula Land Use Strategy (CYPLUS) (Biggs & Philip 1995) and the Lakeland Irrigation Area (Grundy & Heiner 1994) and from a current survey in the Lakeland area (N. Enderlin, pers. comm.).

Field work for the Crocodile Gap study involved 30 soil profile description sites and 47 samples taken from eight (8) gully systems. The map (Figure 2) shows the soil distribution when classified using the local SPC classification.

To enable a quick overview, the variety of surface soil materials found can be summarised using the Australian Soil Classification (ASC) soil orders and sub-orders and related to the SPCs. These and the main soil characteristics are shown in Table 2.

Table 2. Summary of soils found in the study area and legend to the soil map (Figure 4). (P. Zund)

Soil Profile Class	Australian Soil Order	Concept / distinguishing features
A		Soils formed from older alluvial deposits
Victor	Red Chromosol	Moderately deep, clayey sand to sandy loam surface over acid (pH 5.5-6), non-saline, non-sodic, red sandy clay. Occurs on the rises above the plain as narrow bands of residual materials (see Fig. 1). Considerable amounts of this soil on the periphery of these rises has eroded, owing to undercutting of unstable lower materials, and deposited onto the floor of large gullies and formed a prominent scarp face gully type system. Molloy Red Box, Cooktown Ironwood and Bloodwood open forest.
Victor Brown variant	Brown Chromosol	Similar to Victor but mottled throughout with a brown layer in the top of the B2 horizon.
Antbed	Yellow, Brown to Grey Dermosol	Shallow (< 0.2 m), bleached, sandy clay loam to clay loam fine sandy surface over an alkaline sodic mottled yellow, brown or grey clay. Molloy Red Box, Cooktown Ironwood and Beefwood open woodland.
a3 / Mitchel	Red/Brown Orthic Tenosol or rarely Kandosol	Deep uniform or gradational red, yellow or brown massive sandy soils on terrace of major streams and rivers.
a4	Orthic Red or Brown Tenosol	Massive loamy sand surface over a brown to red sand with angular coarse fragments throughout on terrace of stream.
a5	Bleached-Orthic Tenosol	Deep loose bleached sand to sandy clay loam surface over a rudimentary soil of grey to yellow clayey sand. Dry vine scrub.
Greenant	Yellow, Grey or Brown Sodosol	Shallow to moderately deep bleached sand to fine sandy clay loam surface over an alkaline strongly sodic mottled grey or brown clay with abundant manganiferous root linings and calcium carbonate nodules. Subsoils are strongly sodic, saline, magnesic and have an alkaline pH and are extensively eroded (representing the main gully zone).
a6	Yellow Kurosol	Bleached fine sandy loam surface over acid mottled yellow fine sandy light medium structured clay.
C		Colluvial – alluvial fan deposits from the Byerstown Range
Gibson	Yellow or Grey Sodosol	Deep bleached sand to sandy loam surface over an alkaline sodic mottled yellow or grey sandy light medium clay. Subsoils are moderately sodic and saline but still magnesic and have an acid to neutral pH and few divergent linear gullies.
c1	Yellow Chromosol	Cobbly to stony ground surface with a sandy loam surface over a mottled yellow sandy clay over rock.

Soil materials and mapping in the main gully erosion complex (R. Thwaites)

The following is a work in progress and is presented here as a preliminary analysis and interpretation from the current soil material sampling and observations undertaken so far. The soil material layers have been initially ascribed to soil material systems (SMS) that are shown in Figure 5, further defined by soil material layers as a series of soil material units (SMU). An example of soil material layers at Gully 0.1 is given in Figure 6.

The main gully erosion complex comprises several material layers of yellow brown to grey, mottled (with yellow, orange, red and grey) fine sandy clays and sandy clays (A and B system soil materials). These are sometimes topped with recent surface wash deposition, deep in places (40–50 cm), with evidence of several periods of depositional events (laminations), with erosion in between. These surface materials are both sodic and magnesic. The subsurface layers usually exhibit sparse to dense carbonate nodules, occasionally to depths over a metre. These nodules are often enriched with magnesium to form a much denser dolomite mineral than the usual calcite. It is this dolomitic nodulation that forms the characteristic 'coral' of the southern gullies and Earls Creek form root channel mineralisation.

The red soils (Victor SPC and associations, SMS C) in the main gully complex are more stable (non-dispersive) magnesic with large amounts of both ferro–manganiferous (Fe–Mn) nodules and iron (Fe) nodules (ironstone), particularly in the 'lateritic' zone. This is indicative of an older land surface (pre-Quaternary in age) with evidence of advanced, strong weathering, possibly of earlier alluvial deposits of the palaeo-Earl's Creek / palaeo-Laura River system. Under these materials are 3–4 m of yellow brown sandy clay materials which are moderately to non-dispersive in which the main drainage from the erosion gully complex has entrenched in meandering gorges of alluvium, and bedrock near the outlets to the Laura River.

Underlying these soil material layers, above the bedrock, is a variable depth layer (SMU A5) of blue, dense clay, strongly mottled with grey and gley colours (indicative of 'waterlogging', anoxic, reducing conditions). This layer appears to be a weathered zone of the underlying Hodgkinson's Formation meta-shales and greywackes.

Summary of some soil material chemical and physical characteristics

Sodicity and dispersion in the main gully erosion complex

The soil materials in the main gully complex (SMS A/B; Greenant and Antbed) show high dispersivity and/or slaking characteristics, although this is not all due to exchangeable sodium (sodicity) levels in the materials. The majority of the soil materials appear to be also highly magnesic. Highly exchangeable Mg (magnesic) materials can also induce high levels of dispersion, slaking and erosion. The exchangeable sodium percentage (ESP) values are, in fact, very variable, whereby in Gully 1.1 material at 2.2 m depth shows an ESP of 5.2% (non-sodic), but with an R1 dispersion of 99% owing to an (exchangeable magnesium percentage (EMP) of 54% (extremely magnesic), and a high fine sand, silt content.

However, there are many sites where the ESP is over 40% and in places is over 60% with the highest recorded being 86.7% in the southern part of the gully complex. These must rate as some of the highest ESP levels in Queensland.

Yellow/brown soil materials of soil material systems (SMS) A and B

- Field aggregate dispersion tests indicate a high degree of slaking and dispersion in the subsoil and deeper layer materials and in the surface wash deposition materials.
- EMP levels generally are in the magnesic to extremely magnesic range (Ca:Mg very low).
- Salinity is moderate to very high, and generally saline to very saline.
- pH levels are predominantly alkaline.

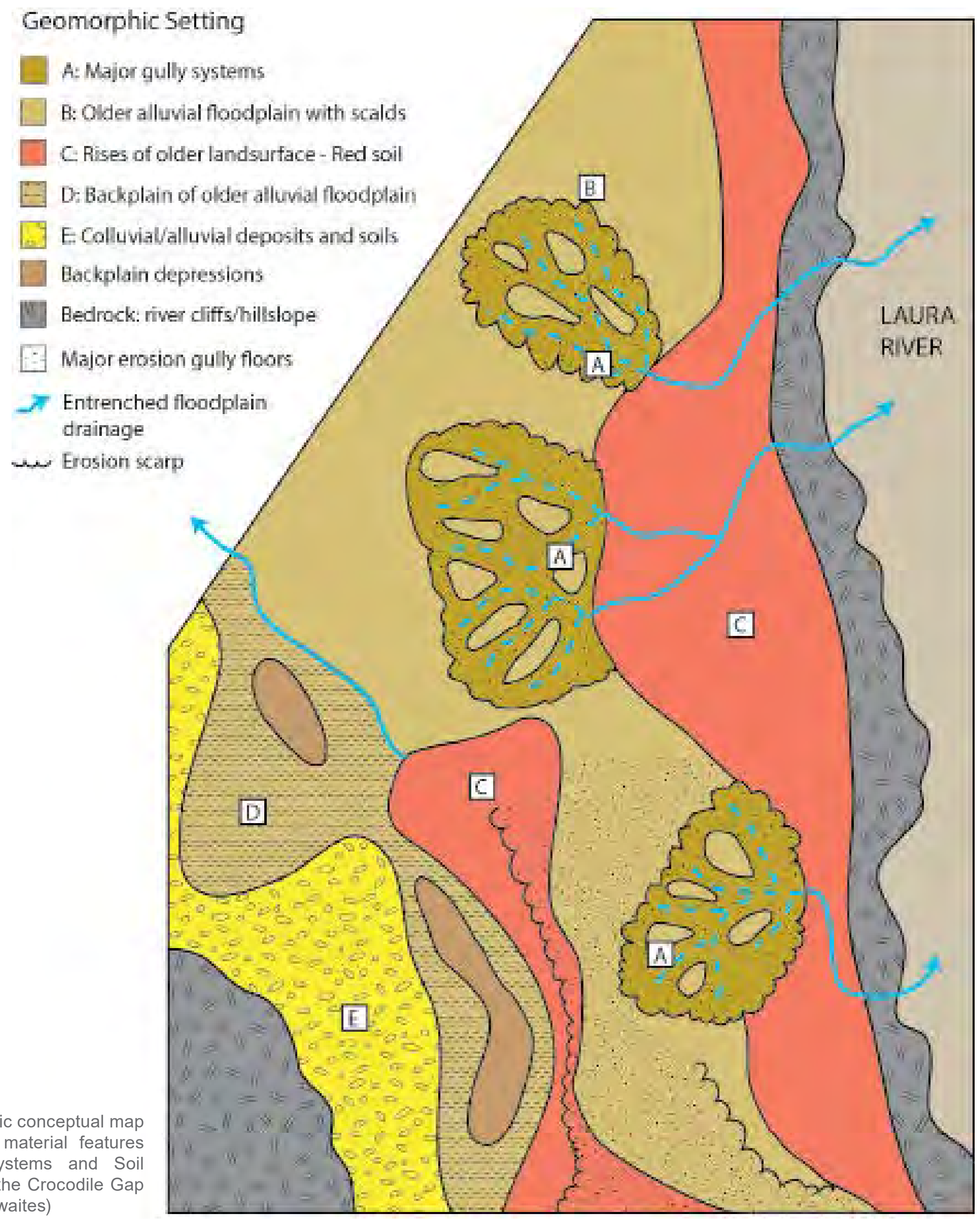


Figure 5. Schematic conceptual map of the main soil material features (Soil Material Systems and Soil Material Units) in the Crocodile Gap study area. (R. Thwaites)

Fine sediments

Sediment particles less than 20 µm in size are of concern to GBR lagoon water quality. The less than 20 µm size fraction includes all clay (< 2 µm) and silt (2–20 µm) sized particles. In the main gully erosion complex the subsurface materials are overwhelmingly fine sandy clays with commonly high proportions of silt-sized sediment. The representative site for the Greenant SPC (SMS B) at 1.2 m depth (Layer 3, i.e. B 3), the proportions of fine sand : silt : clay sized material is 30 : 25 : 43%.

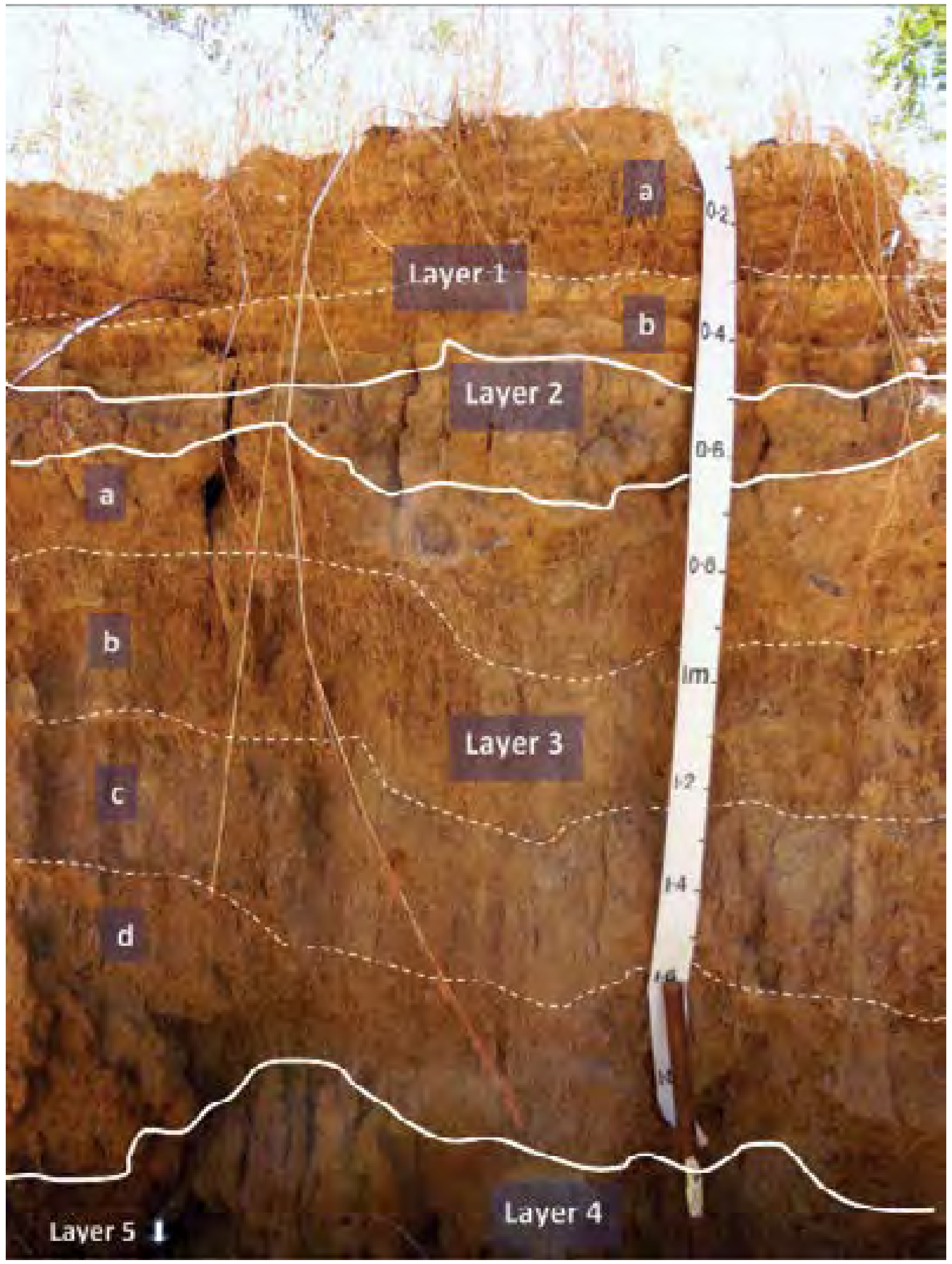


Figure 6. An example of the soil material layers at the head of Gully 0.1 in the A soil material system (SMS). (R. Thwaites)

Table 3. Selected soil material units found at Gully 0.1 (Figure 6) as an example of SMU definition. (R. Thwaites)

Soil Material System	Soil Material Unit	Equivalent units	Concept / distinguishing features	Common thickness (cm)	Texture	Colour	Mottles	Nodules	Disp / slake*
A	5	-	One to several laminations/ layers of surface wash materials	5–40	ZCL	Pale – yellow whole	-	-	Y/Y
A	1	-	Buried A-horizon / hardsetting topsoil	5–10	Z-FSLC	Yellow –brown. Bleached	Grey/ dark grey	-	N/Y
A	2	B 3?	3–4 sublayers of dispersive mottled FS clays	I00	Z-FSMC/ Z-FSLMC	Brown	Yellow/ orange	Maybe some calcite at base	Y/Y
A	3	B 4?	Reticulated mottled slaked FS-silty clays	60–80	FS-ZMC	Yellow-red	Grey	Some calcite	Y/Y

*Disp / slake = disperses / slakes

CONSTRUCTION


Regrading of gully headcut 2.2


Pushloading scraper


Cutting of apron on gully 2.3


Loading gypsum with Bobcat


Spreading gypsum on contour bank


Apron prepared for geotextile lining


Placement of geotextile in apron of rock chute


Geotextile being covered with capping material


Ripped capping material ready for transport to site

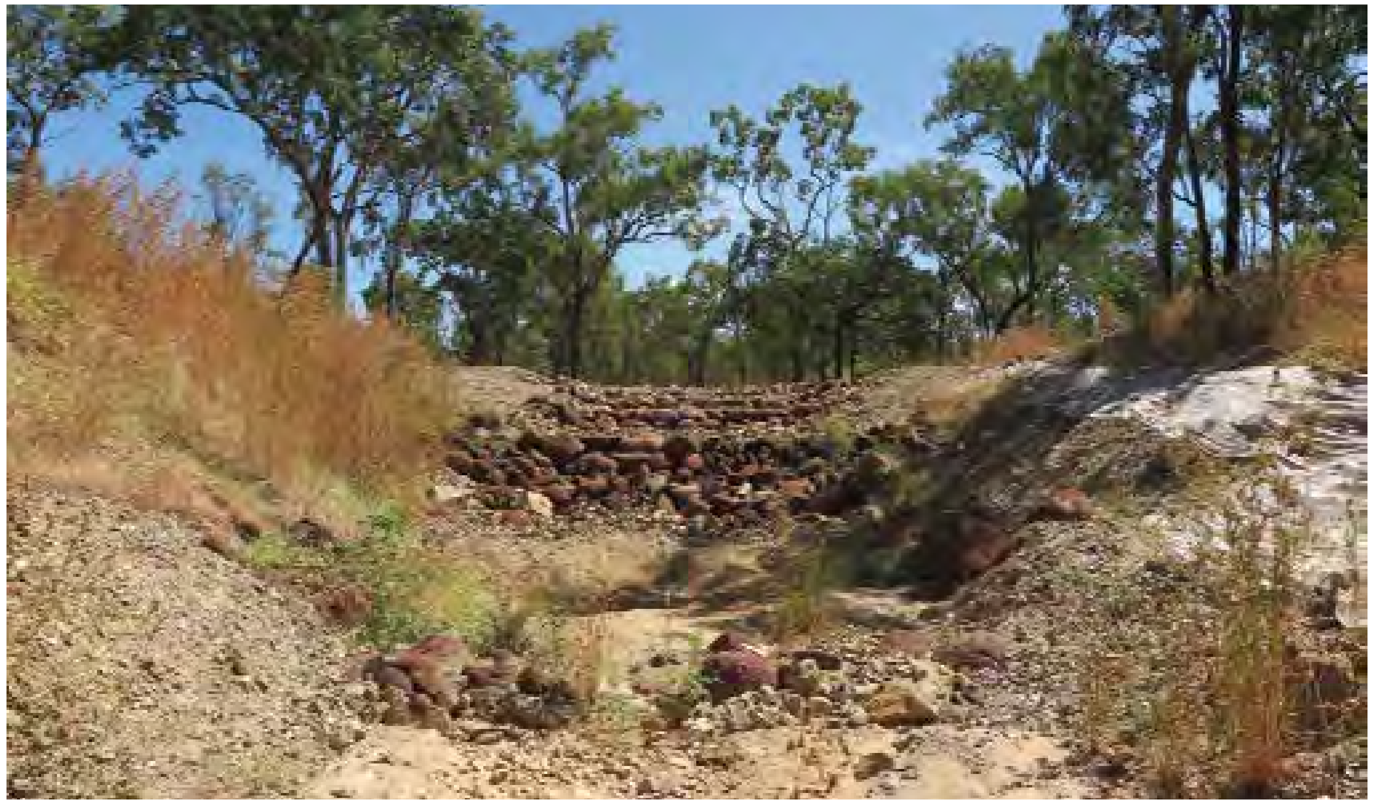

Laying of capping material in gully floor


Placement of grade control structures


Completed works November 2016

GULLY 0.1

Gully 0.1 before earthworks



Gully 0.1 looking upstream from channel

Gully 0.1 Aerial view of engineered rock chute

Gully 0.1 during rainfall event

Gully 0.2 before earthworks

Gully 0.2 looking upstream from channel

Gully 0.2 aerial view of engineered rock chute

Gully 0.2 during rainfall event

GULLY 1.1

Gully 1.1 before earthworks

Gully 1.1 looking upstream from channel

Gully 1.1 aerial view of engineered rock chute

Gully 1.1 during rainfall event

Gully 2.1 headcut August 2016

Gully 2.1 headcut 2018

Gully 2.1 looking downstream August 2016

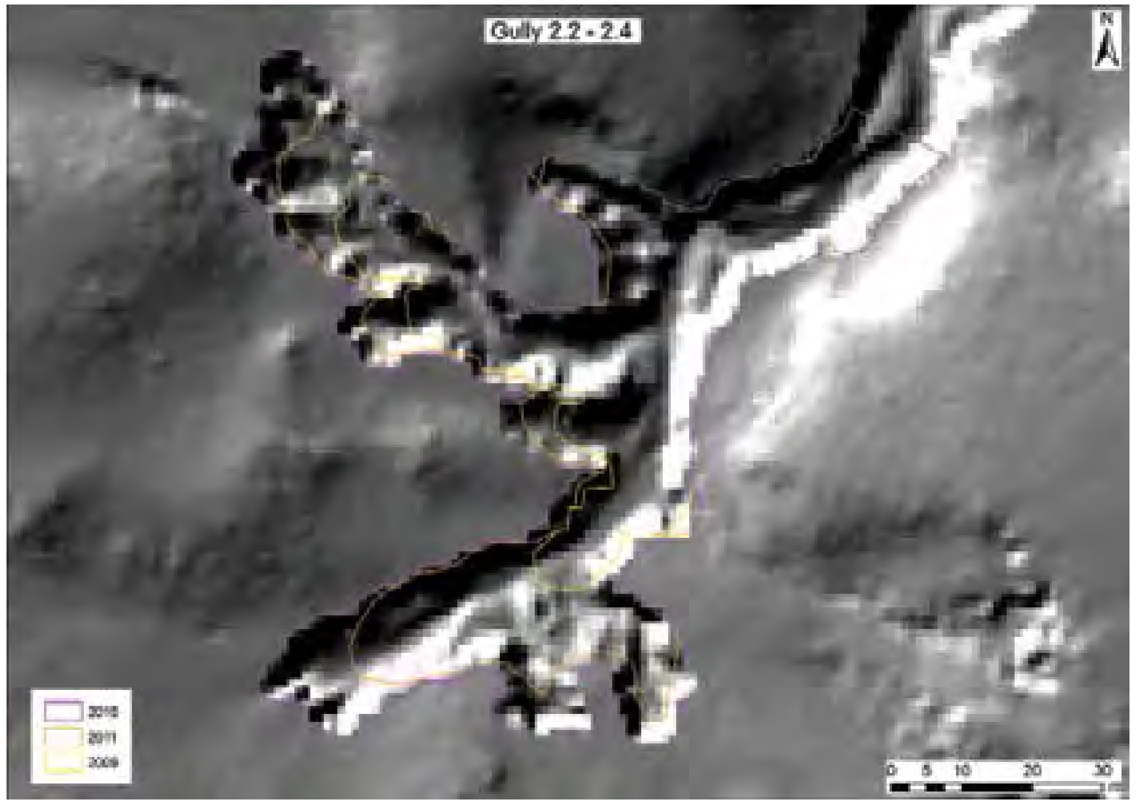
Slumping above Gully 2.1 due to tunnelling during the 2017-18 wet season


Gully 2.2 - 2.4 before earthworks

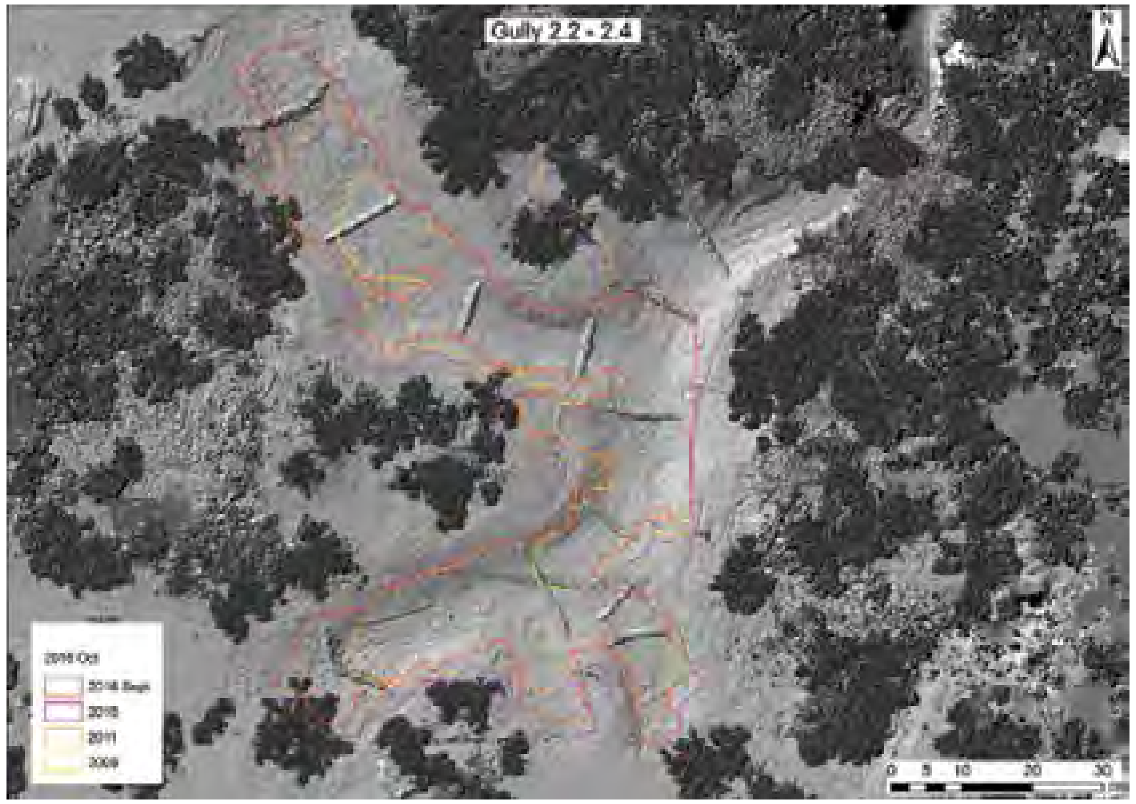

Gully 2.2 looking downstream


Gully 2.2 - 2.4 aerial view of engineered gully

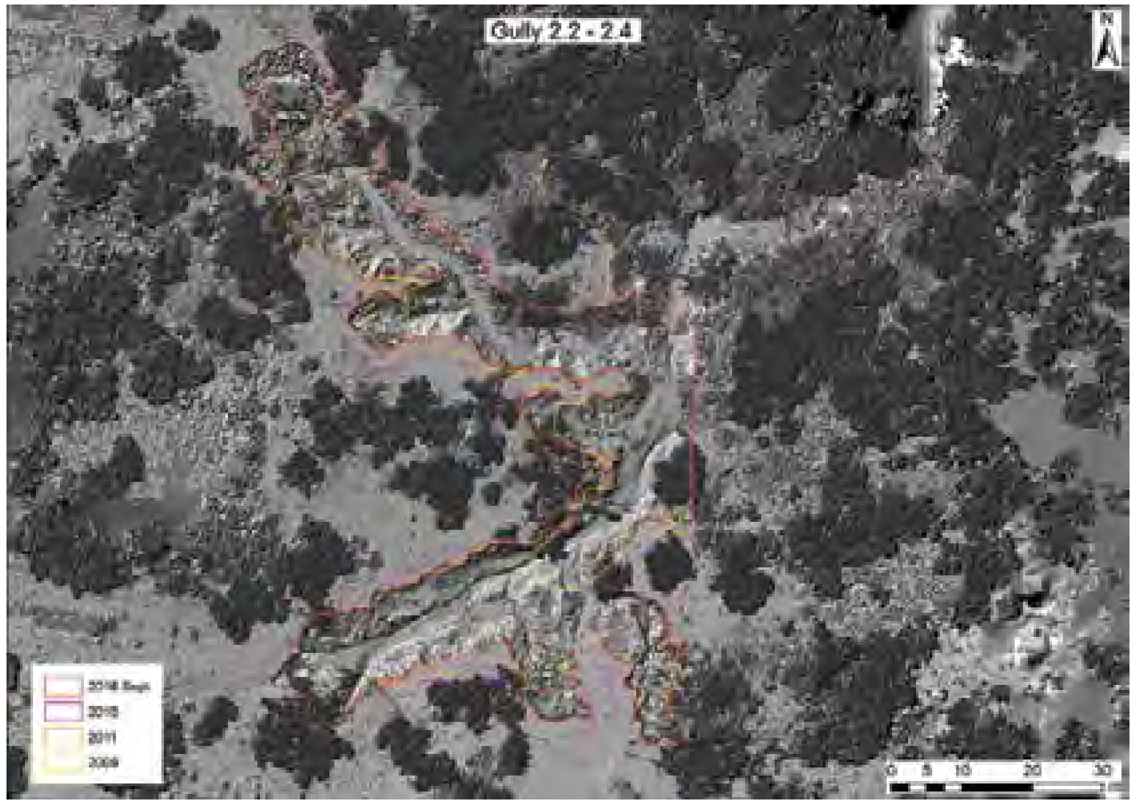

Gully 2.2 - 2.4 during rainfall event



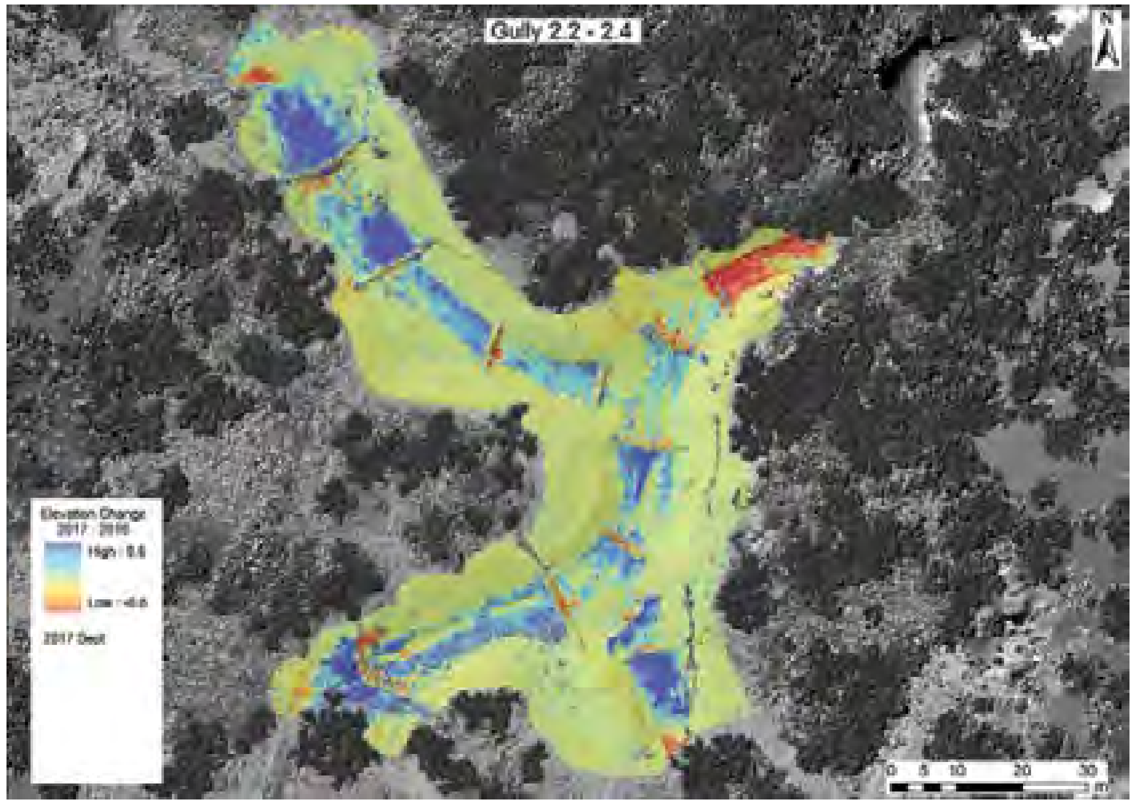
Aerial LiDAR 2009-2016



Post works October 2016



Pre works September 2016



September 2017 showing elevation change

The Scope of Works for Normanby Station included:

- Feral cattle management - two cattle trap yards (holding/ exclusion paddocks) designed to support feral cattle management to improve sediment loss from the highest priority gully erosion sub catchments on Normanby Station; and
- Box Flat gully remediation - gully headcut stabilisation and porous check dams using local materials in the Box Flat area.

FERAL CATTLE MANAGEMENT

The Balnggarrawarra Rangers and South Cape York Catchments are working with the Department of Agriculture and Fisheries and Cape York NRM to develop and implement a grazing management plan to greatly reduce feral cattle grazing pressure in the less productive areas of Normanby Station. This long-term management of feral cattle will help to ensure that active gully management activities are supported into the future.

The Balngarrawarra Rangers have completed the fencing of both the Lucerne Paddock and the Box Flat Paddock adjacent to the Puckleys Creek sub-catchment. These new paddocks are designed to act as cattle traps and holding yards for feral cattle management within the Puckleys Creek sub-catchment and the Nine Mile sub-catchments.

The Balnggarrawarra Rangers have helicopter mustered the Puckleys Creek and Nine Mile area of Normanby Station as in-kind to the project during 2017. Future years of helicopter mustering have been incorporated into the Reef Trust Phase IV project design.

BOX FLAT GULLY REMEDIATION

Box Flat is easy to access from the Normanby Station homestead. The gullies at Box Flat presented an ideal opportunity for the Balnggarrawarra Rangers to increase their experience in active gully remediation techniques.

The Balnggarrawarra Rangers have taken responsibility for the site monitoring, design and construction of small headcut drop structures and porous check dams to stabilise the channel bed of relatively small but active gullies at Box Flat.

The Balnggarrawarra Rangers have also collected and direct seeded native grasses into the remediation areas at Box Flat.

Monitoring cattle numbers using a camera trap

Multiple cattle pads

Hessian lined cattle race

Feral cattle in holding yard after muster

Box Flat gully 1.2 before works

Box Flat gully 1.2 post works


Looking across post construction


Looking across post wet season


Looking up post construction


Looking up post wet season


Looking down post construction


Looking down post wet season

CROCODILE GAP - CONTOUR BANKS

As a means to utilise the highly dispersive soils from gullies 2.2 - 2.4 we constructed contour banks. The banks acted as a means to slow and distribute the flow of water from the sub-catchments.

The dispersive soil was capped with a rock lining to prevent erosion.

The contour banks have created small wetlands that have become feeding grounds for numerous species of wetland birds.


Laying of material for contours


Contour bank


Contour bank


Contour bank

CROCODILE GAP - FLOW CONSTRICTOR

The flow constrictor was built to create an obstruction in the convergence area of the two sub-catchments (one 9.5-hectare and one 2-hectare). The difference in water flow volume between these two sub-catchments had previously caused uneven pressure on the rock chute. With the flow constrictor in place, water is now distributed evenly.

Placement of rocks

Backfilling between rocks

Completed flow constrictor

Aerial view of flow constrictor

CROCODILE GAP - GEOTEXTILE LINED LOG STRUCTURES

The log structures are constructed using Cooktown ironwood, which is resistant to termites and is often used to build cattle yards. The purpose of these structures is to create a series of grade controls to filter sediment and reduce water run-off.

Construction of log structure

Geotextile fastened to structure

Rock apron

Completed structures

Log structures after rainfall event

CROCODILE GAP - HAY BALE WEIR

The hay bale weir was installed as a temporary measure to slow the flow of run-off from the sub-catchment above the structure. Due to the scalding below the structure, and the loosening of the soil during construction on gullies 2.2 - 2.4, large quantities of soil were at risk of being dislodged. This temporary structure was used to slow and distribute the flow over a wider area to reduce the possibility of sheet erosion, and to allow for grasses to establish around the site.

Placement of bales

Hay bale structure

Hay bale structure after the 2017-18 wet season

CROCODILE GAP - ROAD GULLY REPAIR

The purpose for repairing the road crossing was to increase the efficiency of the heavy earthmoving machinery bringing materials to the gully areas being remediated. Over time the track had been constantly moving around the gully headcut into the low lying area above. This repair has completely halted the movement of the headcut and removed the erosion risk to the seasonally inundated landscape above.

Road crossing before repair

Road crossing during 2016-17 wet season

Road crossing after 2017-18 wet season

A ground cover trial site was established to check the effectiveness of different materials to remediate scalded areas in the upper catchment. The trial sites were established as a controlled experiment with a control site at the northern end. All of the trial sites were treated by reprofiling of the shallow gullies and associated scalded areas and were treated with gypsum with a target ESP of 5%. Three different materials were used in the trial. These materials were all locally sourced and consisted of Mulch, Rock and Compost.

Gully lobe treatments in upper gully 1.1 catchment

Gully Lobe	Approx. area (m^2)	Treatment
A	650	Regrade, gypsum, compost and grass seed
B+C	1670	Regrade and capping
D	1070	Regrade, gypsum, dolichos mulch and seeding
E	680	Control
F	1050	Control

Upper catchment of gully 1.1 treatment layout

Aerial view of trial sites 2016

Control site E post 2017-18 wet season

CROCODILE GAP - GROUND COVER TRIAL SITES MULCH

Mulch was sourced from a Lakeland farm and consists of the trash from harvested Dolichos. Dolichos mulch is high in nitrogen and has proven to be a good ground cover, more so in the second year as it creates a large amount of heat when decomposing. The outcome of this trial is that the mulch layer has achieved near 80% vegetation cover in 2017-18.

Mulch after rolling out 2016

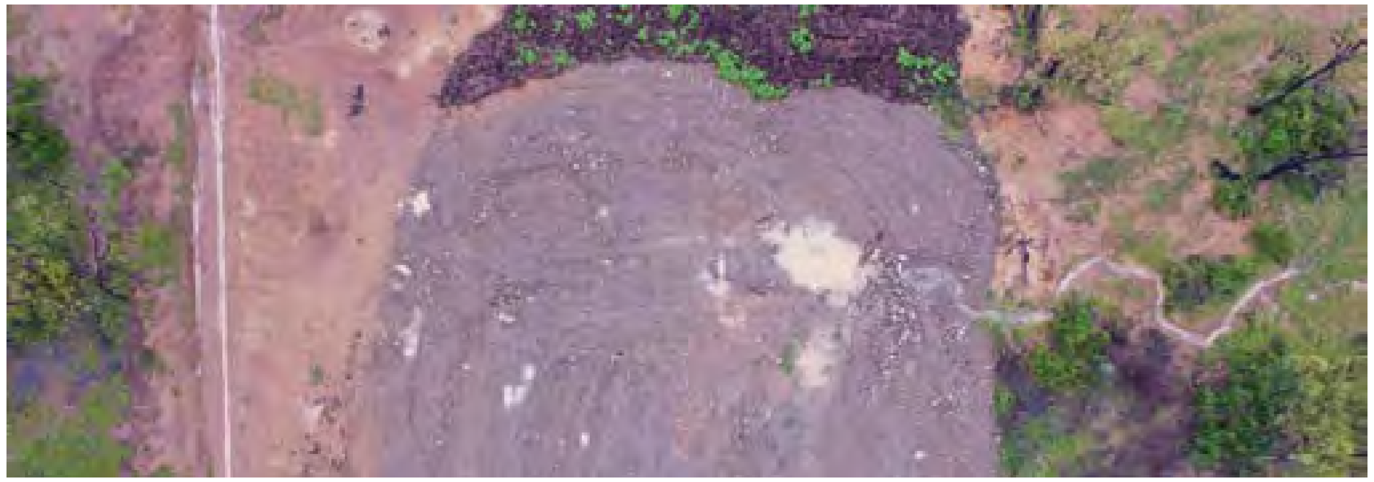
Mulch during 2016-17 wet season

Mulch after 2017-18 wet season

CROCODILE GAP - GROUND COVER TRIAL SITES ROCK

Rock used to cover this trial site was locally sourced from the Crocodile Gap area, the rock has proven to be a reliable cover but is difficult to establish vegetation in and has achieved less than 5% cover in the 2017-18 wet season, this is however an increase in cover from the 2016-17 wet season.

Rock capping post construction



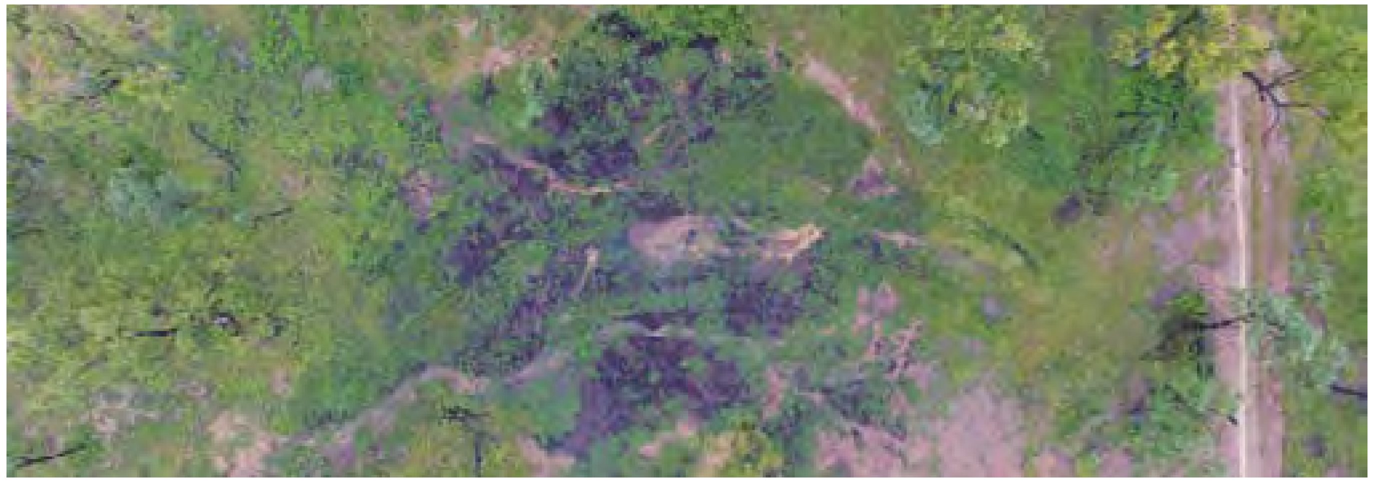
Rock Capping after rainfall during 2016-2017 wet season

Rock Capping post 2017-2018 wet season

CROCODILE GAP - GROUND COVER TRIAL SITES COMPOST

Compost was sourced from a Lakeland compost producer and was spread using a rubber tyred dozer, the compost has proven to be a reliable way to establish grass cover on sodic soils but a large quantity was lost in runoff in the 2016-17 wet season. The compost trial has achieved near 90% vegetation cover at the end of the 2017-2018 wet season.

Compost after spreading with dozer 2016



Compost during 2016-17 wet season

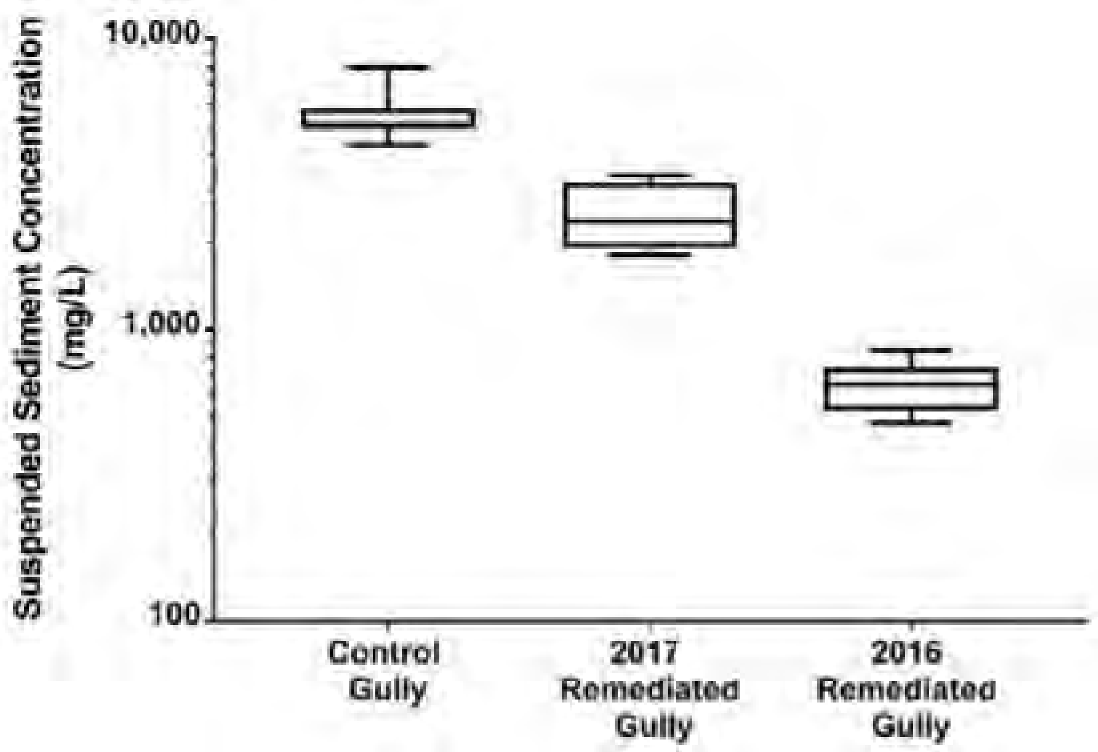
Compost layer post 2017-18 wet season

CROCODILE GAP - WATER QUALITY MONITORING

Contributed by:
Nic Doriean, Griffith University
John Spencer, Griffith University
Andrew Brooks, Griffith University

Four types of water quality monitoring equipment (turbidity loggers and automatic water samplers, rising stage, and pump activated suspended sediment (PASS) samplers) were deployed in three gullies, two of these gullies have been remediated and the third is the control. Rising stage and PASS samplers were placed in an additional two remediated gullies. All five gullies monitored also had water level loggers installed to measure the timing and intensity of water flow. Rain gauges were installed in the catchments of the control and one remediated gully. All of the water quality monitoring equipment were maintained over the 2017/2018 wet season.

Over 100 samples were collected and are currently being processed. Initial water quality results indicate that the remediation works performed on the gullies have successfully reduced the amount of suspended sediment being transported by rain storm driven erosion. For example, the analysis of water samples collected during an isolated rain storm flow event (20-30 mm of rain in under 6 hours) in three of the gullies is shown below. The gullies remediated in 2017 and 2016 had 50% and 85% lower median suspended sediment concentrations, respectively, compared to the control gully.



Box and whisker plots of suspended sediment concentration for the control and remediated gullies at Crocodile Station, QLD. The box and whisker plots present the minimum, 25th percentile, median, 75th percentile, and maximum of each gully dataset from rain storm samples collected on January 24, 2018.

REFERENCES

ABS, 2006. Population data for the Lakeland and Laura Townships (combined). Australian Bureau of Statistics, Canberra.

Biggs, AJW & Philip, SR 1995, Soils of Cape York Peninsula, Queensland Dept. of Primary Industries, Brisbane.

Brodie, J., Furnas, M., Hughes, A.O., Hunter, H., McKergow, L.A., Prosser, I.P., 2003. Sources of sediment and nutrient exports to the Great Barrier Reef World Hertiage Area.

Brodie, J., Mitchell, A.W., 2005. Nutrients in Australian tropical rivers: changes with agricultural development and implications for receiving environments. Marine and Freshwater Research, 56(3), 279-302.

Brooks, A., Spencer, J., Olley, J., Pietsch, T., Borombovits, D., Curwen, G., Shellberg, J., Howley, C., Gleeson, A., Simon, A., Bankhead, N., Klimetz, D., Eslami-Endargoli, L., Bourgeault, A., 2013. An Empirically-Based Sediment Budget for the Normanby Basin: Sediment Sources, Sinks, and Drivers on the Cape York Savannah, Griffith University, Australian Rivers Institute, Final Report for the Australian Government Caring for Our Country - Reef Rescue Program, April 2013, 506pp. http://www.capeyorkwaterquality.info/references/cywq-220

Brooks, A., Curwen, G., and Spencer J., 2015. A framework for prioritising gully management in the Normanby Basin Cape York. Australian Rivers Institute, Griffith University, Brisbane.

Domagala, J, Robertson, AD & Bultitude, RJ 1993, Geology of the Butchers Hill 1:100,000 Sheet Area, Northern Queensland, Geological Survey Queensland, Brisbane.

Environment Australia, 2001. Directory of Important Wetlands in Australia, Third Edition. Environment Australia, Canberra, Australia.

Geosciences Australia, 1997. Australia's River Basins. Bureau of Meterology, Canberra.

Grundy, MJ & Heiner, IJ 1994, Soils of Lakeland Downs, Queensland Dept. of Primary Industries, Brisbane.

Prosser, I.P., Rutherfurd, I.D., Olley, J.M., Young, W.J., Wallbrink, P.J., Moran, C.J., 2001. Large-Scale Patterns of Erosion and Sediment Transport in River Networks, With Examples from Australia (Vol 52, Pg 91, 2001). Marine and Freshwater Research, 52(5), 817-U820.

NOTES

Facing east from Crocodile Gap