Mapping environmental characteristics important for Reef water quality

Burdekin and Mackay-Whitsunday priority catchments

Assessment methodology

Science Delivery
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Introduction

The Queensland Government through the Reef Protection Package has funded research, extension, education and regulatory activities; to reduce the level of sediment, nutrients and pesticides (contaminants) leaving commercial sugarcane properties and cattle grazing properties >2000 ha within priority catchments (Wet Tropics, Burdekin and Mackay-Whitsunday). The quantities of these contaminants reaching the Great Barrier Reef (GBR) have increased substantially since European settlement and are now recognised as posing a serious threat to the long-term viability of the GBR. Not all parts of the landscape contribute equally to this problem, initial water quality modelling has already identified that some GBR sub-catchments contribute much more than others. This uneven distribution of contributions from across the landscape can be attributed in part to differences in land use and land management practices. However, areas with similar land use and land management may contribute varying amounts of contaminants depending on their natural features (i.e. their ‘environmental characteristics’).

The aim of the Reef Protection Package in priority catchments is to encourage adoption of land management practices that reduce contaminant loads moving off-property. In order to effectively support sugarcane growers to adopt risk-based management, the Reef Science program is coordinating a range of projects focused on answering the following questions:

1. What and where are the environmental characteristics that predispose landscapes to contribute above-natural levels of sediment and deliver nutrients and herbicides offsite through water movement?
2. What systems/practices are being used on sugarcane and grazing properties to manage environmental characteristics?
3. Within the priority catchments, what and where are the main risks associated with sugarcane and grazing activities?
4. What are the management systems that should be adopted to minimise risk?
5. What information on environmental characteristics could be provided to assist landholders in determining appropriate practices to minimise movement of contaminants off-site?

This project identifies and maps some of the natural features (‘environmental characteristics’) within sugarcane growing areas of the Burdekin and Mackay-Whitsunday priority catchments. Outputs of this project will assist in addressing questions 1 and 5 above.

Background

Environmental characteristics mapping for the Wet Tropics priority catchment was completed in 2011. Maps, spatial data and a guide on how to interpret the maps were developed (DERM 2011). The methodology used in the Wet Tropics is applied in this project across the Burdekin and Mackay-Whitsunday priority catchments to produce similar mapping. The four environmental characteristics that are detailed in this report are:

- Erosion potential (i.e. the inherent potential of soil to undergo hillslope, gully or streambank erosion according to slope and soil features)
- Flooding potential (i.e. the flooding regime of landscapes that may transport contaminants to watercourses)
- Water pathway (i.e. the potential of soils to generate runoff or deep drainage which can mobilise and transport contaminants)

- Soil transport potential (i.e. the inherent potential for soil particles to be transported long distances).

In addition to this report, outputs of the project include:

- Spatial data sets for the four environmental characteristics across the Burdekin and Mackay-Whitsunday priority catchments
- User guides for each catchment, which assist users to understand and interpret the environmental characteristic maps.

Conceptual model

In using this information it is important to be aware of its context. The environmental characteristics of an area indicate whether land is predisposed to contribute contaminants to surface waters. The extent to which contamination actually results will depend on how the land is used, and the management activities applied to it. The conceptual framework which describes the interaction between the natural environment and land management in determining landscape behaviour is illustrated in Figure 1.

It is important that environmental characteristic information is considered in parallel with land management to determine the likelihood that sugarcane production systems will impact on water quality. The availability of current spatial information on sugarcane management systems is limited; however these data are being collected as part of the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program and the Reef Protection Package.

Once information about management systems is available, there is the potential to combine the spatial data sets for environmental characteristics and management systems in order to identify areas that present a higher risk of transporting sediment, nutrients and herbicides to surface water via run-off. This information could be used to more effectively target extension and investment activities of the Reef Protection Package and ensure that growers in areas of higher risk receive support to adopt management systems appropriate to their local conditions.

Users of environmental characteristic maps should also be aware of the intended use of these maps. Environmental characteristic maps can assist users to understand the variability and general features of soils found across cane farms (e.g. farms of 50 hectares or greater). However, because of the scale of mapping they do not precisely identify the location of soil boundaries and cannot support detailed property planning, e.g. precision agriculture. The user guides that accompany this technical report provide further information about how the maps can support identification of general property features, for example as part of desktop assessment processes.

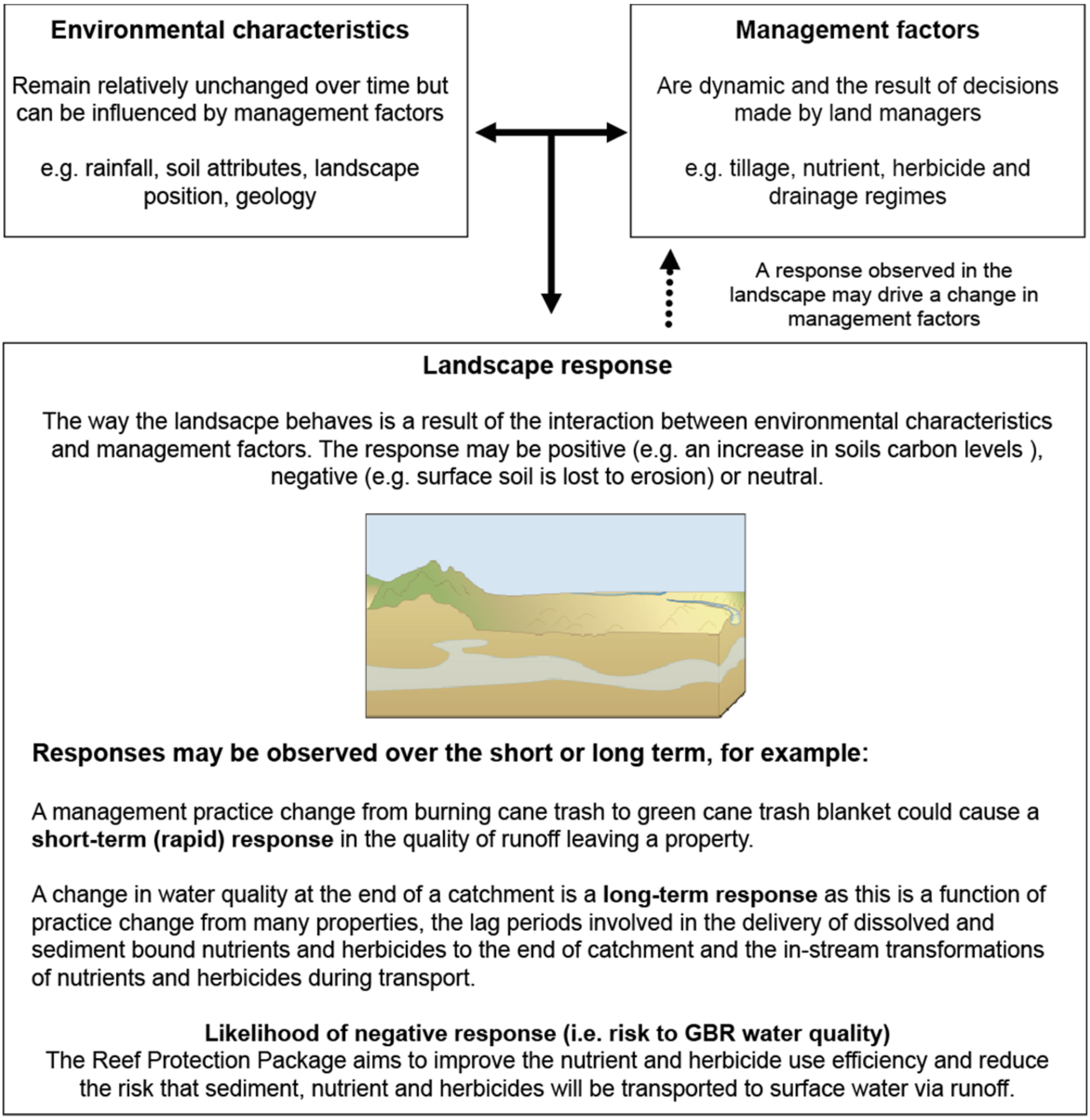


Figure 1. Conceptual overview showing the interaction between environmental characteristics, management activities and landscape response.

Project scope

This project was undertaken to:

1. Provide information on the natural landscape features (or environmental characteristics) that influence the movement of contaminants off-property via surface water transport processes[1].
2. Present the analysis in a way that is easily understood by landholders and extension officers.

Project area

The project area is delineated by the sugarcane production areas within the Burdekin and Mackay-Whitsunday priority catchments (known hereafter as Burdekin and Mackay-Whitsunday catchments). The project area and the extent of sugarcane production are displayed in Figure 2. The sugarcane land use extent is taken from the 2009 land use data mapped by the Queensland Land Use Mapping Project (DERM 2009). Sugarcane production occurs mainly on the alluvial soils of the coastal plain east of the Great Dividing Range. In the Burdekin catchment this is confined to the Lower Burdekin area below the Burdekin Falls Dam. Sugarcane production covers nearly all of the area in the Mackay-Whitsunday catchment; from the Proserpine sub-catchment in the north to the Plane Creek sub-catchment in the south.

Climate classification based on the Köppen system (Stern *et al.* 1999) delineates tropical, subtropical and grassland climate groups across the project area (Figure 3).

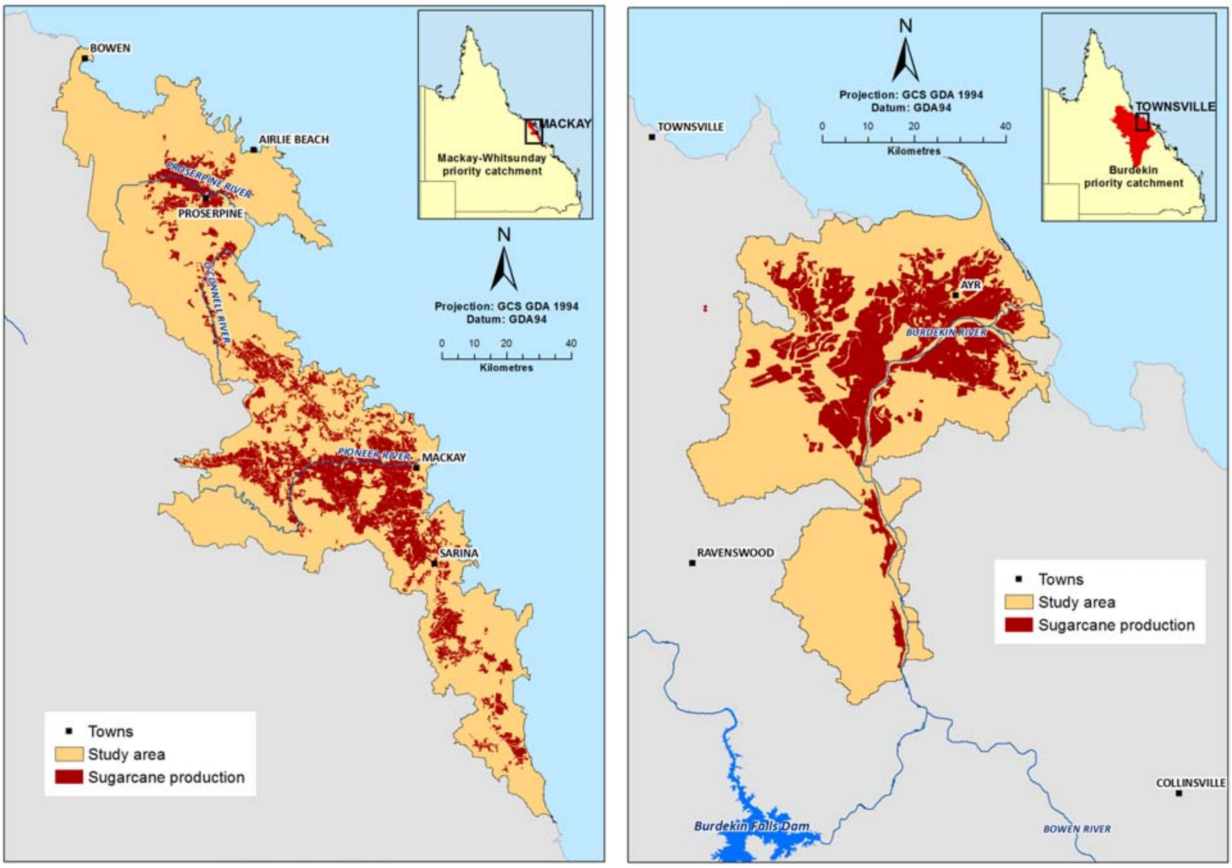


Figure 2. Project area and extent of sugarcane production in the Burdekin (right) and Mackay-Whitsunday (left) catchments – taken from 2009 land use data (DERM 2009).

[1] While it is recognised that groundwater processes are also important for GBR water quality, this report does not consider the vulnerability of landscapes to transport contaminants via groundwater.

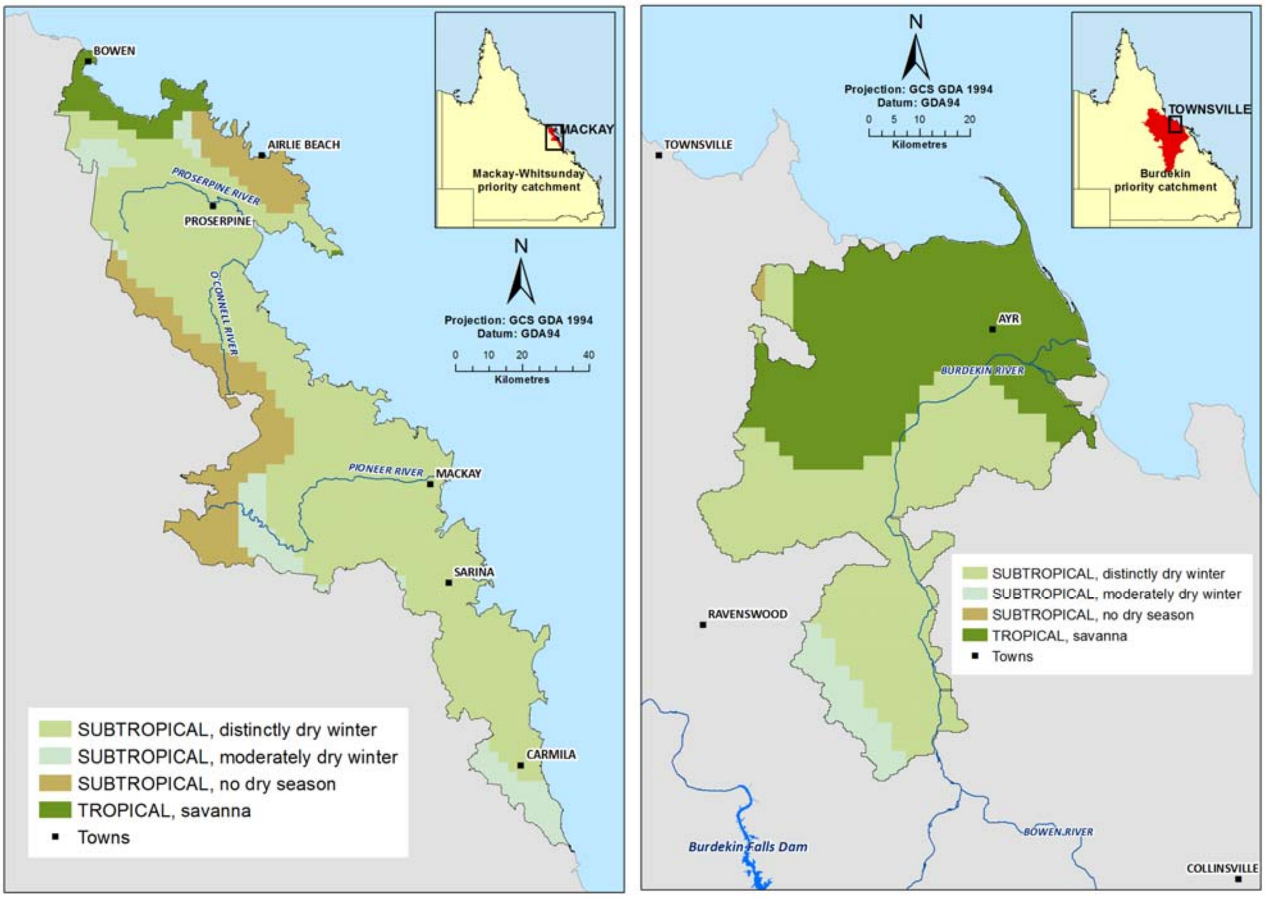


Figure 3. Köppen climate zones for the Burdekin (right) and Mackay-Whitsunday (left) catchments.

Project methodology

The environmental characteristics mapping for the Burdekin and Mackay-Whitsunday catchments was developed based on the methodology of the Wet Tropics project in 2011 - '*Mapping environmental characteristics important for Reef water quality – Wet Tropics priority catchment*". For a full outline of the methodology refer to the technical report produced for the Wet Tropics (DERM 2011).

The method used for all three catchments followed a three stage approach:

- Stage 1 Identify data sets that would support the conceptual model of contaminant delivery to the reef.
- Stage 2 Peer review and field validation of information products.
- Stage 3 Refine data sets and maps based on outcomes from peer review process.

The Wet Tropics methodology is available to download through the Department of Environment and Heritage Protection (EHP) library catalogue http://dermqld.softlinkhosting.com.au/liberty/libraryHome.do

Stage 1

A conceptual model was developed to describe how contaminants travel from land to the GBR, in order to identify the environmental characteristics that support contaminant movement. Nutrients and pesticides are primarily transported to waterways via water movement. Water can erode landscapes and transport contaminants in soluble form as well as those in insoluble forms that are attached to soil particles (Finalyson & Silburn 1996). Therefore environmental characteristics relevant to GBR water quality are those inherent landscape features that promote soil and water movement. A range of relevant environmental characteristics and available data sets were initially identified and assessed for suitability of use. Appendix A presents a list of all data sets considered and the rationale for inclusion or exclusion of each.

The environmental characteristics that can be represented by available data sets include erosion potential, flooding potential, water pathway (runoff potential) and soil transport potential.

Stage 2

The second stage of the project comprised the following:

- A review of data sets
- Field validation of products

A review process was conducted to assess the appropriateness of the data sets used to generate maps. Stakeholders from different backgrounds (technical and non-technical) and different groups (government, industry and community) were asked to provide comment on the data sets used. The outcomes of this peer review process are summarised below.

Generally the mapping lined up with the reviewer's knowledge of the landscape. Most comments received regarded the management principles provided in the user guide. Comments were focused on highlighting how management principles were different across the two priority catchments (i.e. different principles between the Mackay-Whitsunday and Burdekin catchments due to the difference in irrigated vs non irrigated sugarcane production). These comments have been incorporated into the user advice for each priority catchment.

Broad-scale field validation was carried out for the water pathway and soil transport potential data sets. Field validation sites were selected in a variety of soils and landscapes e.g. erodible soils under cane, cane production on steep slopes, areas of frequent flooding etc (Figure 4). At each site, the data on surface soil texture and dominant water pathway were compared to field results for these attributes. Appendix F provides a summary of the field validation exercise, i.e. what was observed in the field and actions taken to rectify data sets. It was beyond the scope of this assessment to validate the original land resource data used for erosion potential and flooding as the data were captured at a finer scale than the broad-scale work described here. This is not a concern however, as the original land resource survey method included a data validation component

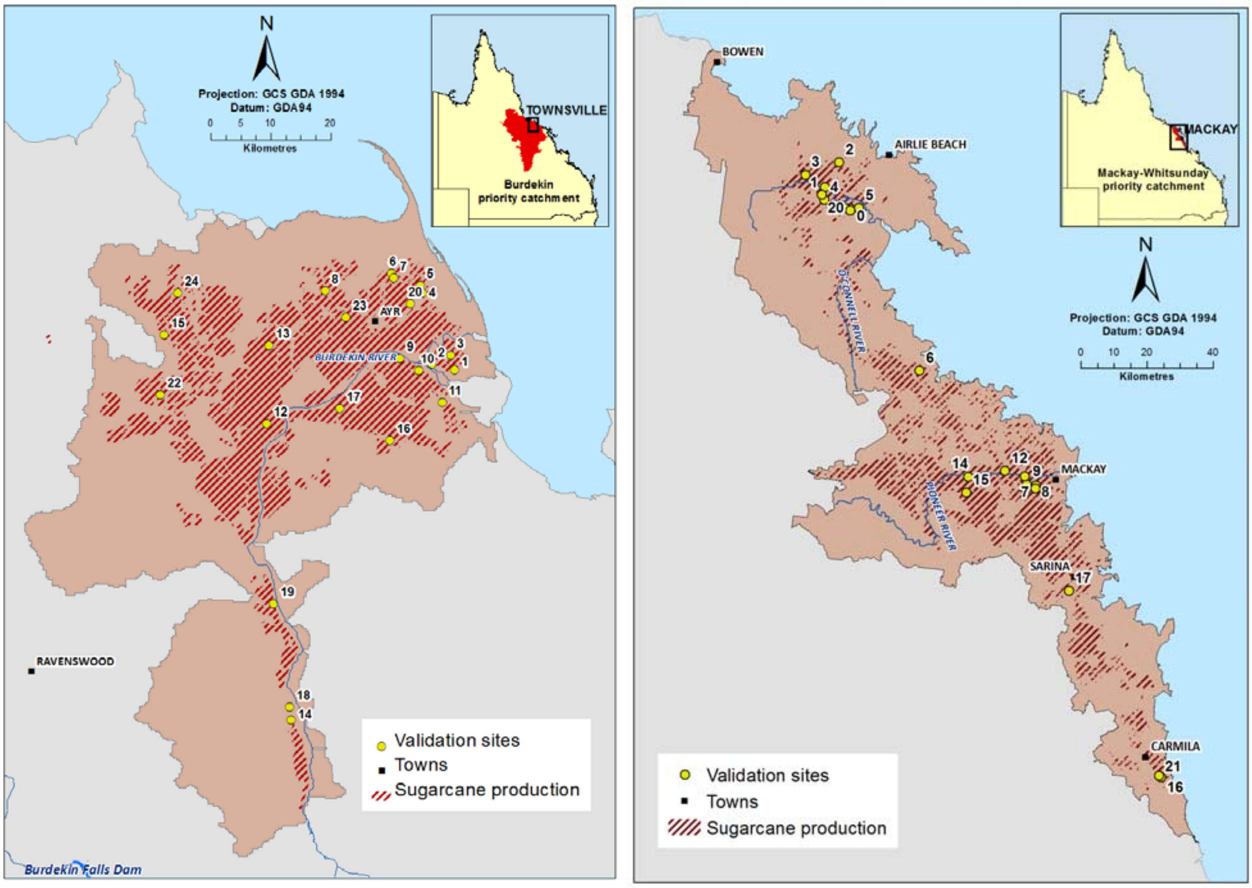


Figure 4. Validation sites for Burdekin (left) and Mackay-Whitsunday (right) catchments

Notes on validation sites:

Mackay-Whitsunday

The majority of validation sites were concentrated around key cane areas in the Mackay-Whitsunday catchment, i.e. the Proserpine and Pioneer. This is due to these areas being mapped at a smaller scale and having more variation, whereas the Plane creek catchment is mapped at 1:100 000 scale and has less variation. Fewer validation sites were therefore required in the Plane Creek sub-catchment to validate water pathway and soil transport potential attributes.

Burdekin

The validation sites for the Burdekin were spread between the soils of the delta area and the Burdekin River Irrigation Area (BRIA).

Stage 3

The third and final stage of the project will use the outcomes of the review process and field validation to refine data sets and maps for the four environmental characteristics of erosion potential, flooding potential, water pathway and soil transport potential. Feedback received during the Wet Tropics review processes has already been incorporated into this technical report and user guides for the Burdekin and Mackay-Whitsunday catchments. For example, the influence of other characteristics (e.g. rainfall, vegetation cover and drainage networks) in determining water quality has been included as contextual information in the user guides for Burdekin and Mackay-Whitsunday catchments.

The four environmental characteristics are described in the following sections

Environmental characteristics described

Erosion potential

The erosion potential of the landscape is a fundamental characteristic in determining soil movement. Hillslope, gully and streambank erosion processes are considered in this assessment of Burdekin and Mackay-Whitsunday cane areas. The erosion potential from hillslope erosion processes (i.e. rill, sheet and scald) was assessed according to slope (which can increase the velocity of runoff), and the natural erodibility of the soil, e.g. the soils with the highest potential to contribute to sediment loss are those which are erodible on steep slopes.

Existing gullied areas and areas of streambank erosion have also been mapped during land resource surveys in these catchments.

Areas which have been mapped as having existing gullies and streambank erosion are not allocated an erosion potential category, because it cannot be determined from the original land resource reports whether the erosion present was caused by the inherent characteristics of the landscape (e.g. soils and slope) or by management practices. These areas are identified as ‘mapped eroded land’ in the environmental characteristics mapping. The ‘mapped eroded land’ areas show a range of undifferentiated known eroded land, gully and streambank eroded areas identified at the time of surveys and could range from minor to severe occurrences. However, there may have been subsequent changes to land use and land management since the surveys were undertaken (refer to Appendix B for the list of land resource surveys in the Burdekin and Mackay-Whitsundays). Consequently this ‘mapped eroded land’ category may not indicate the current state or extent of erosion.

Flooding potential

The majority of contaminants that reach the GBR are delivered during flood events (Brodie *et al.* 2008). The timing and magnitude of the first flood event is particularly important due to the ‘first flush’ phenomenon in floodplain environments. The first flood typically contains larger contaminant loads, likely due to the mobilisation of contaminants that have accumulated both on the land surface and within watercourses (Wallace *et al*. 2009). Floodwaters moving through sugarcane production areas may mobilise contaminants and transport these to the GBR. There is a greater potential for floodwaters to transport soluble nutrients and pesticides to the GBR, due to limited trapping opportunities. Timing and method of nutrient and pesticide application is therefore important in environments that frequently flood.

Flooding potential is derived from two sources; soils mapping and vegetation mapping.

Information on flooding frequency and extent is derived from data collected during land resource surveys. In areas where soil mapping is at a scale better than 1: 100 000, the soils mapping is used in preference as there is also a description of frequency.

Where detailed land resource survey information is not available flooding potential is derived from vegetation mapping i.e. pre-clearing vegetation cover of particular land zones (Table 1). This gives an indication of potential areas of inundation or the extent of the floodplain.

Table 1. Attributes used to determine flooding extent.

Attribute	Description
Pre-clear Regional Ecosystem (RE) vegetation cover (Neldner VJ *et al* 2005).	Regional ecosystems (REs) are vegetation communities that are consistently associated with a particular combination of geology, and land form in a bioregion. The pre-clearing mapping is derived primarily from 1960s aerial photographs in conjunction with a range of other imagery and other information.
Land zones (DERM 2012a)	A land zone is a simplified geology/substrate-landform classification for Queensland. For this assessment, land zones 1 and 3 were used to determine extent of flooding and are described below. Land zone 1: Quaternary estuarine and marine deposits subject to periodic inundation by saline or brackish marine waters. Includes mangroves, saltpans, off-shore tidal flats and tidal beaches. Land zone 3: Quaternary alluvial systems, including floodplains, alluvial plains, alluvial fans, terraces, levees, swamps, channels, closed depressions and fine textured palaeo-estuarine deposits. Also includes estuarine plains currently under fresh water influence, inland lakes and associated dune systems (lunettes).
Soil mapping Soil and Land Information (SALI) database, Brisbane. (DERM 2012b)	Soil limitation mapping from land suitability studies was used to determine potential extent and frequency of flooding.

Water pathway

Landscapes that are prone to generating runoff are more likely to facilitate the movement of sediment, nutrient and pesticides, as runoff provides the medium for entrainment and transport. Runoff is generated as a result of rainfall rate exceeding the rate of infiltration (infiltration excess) or the soil reaching saturation and therefore being unable to store any additional rainfall (storage excess) (Finlayson & Silburn 1996). The water pathway matrix represents the storage excess model by considering the soil profile characteristics of permeability and drainage, as recorded during land resource surveys (Appendix B). As soil permeability and drainage decrease (i.e. soils are less permeable and poorly drained), the likelihood of runoff increases.

Soil transport potential

Clay-sized particles (< 0.002 mm) are the smallest soil particles and are more easily transported long distances by water than silt and sand-sized particles. As a result, soils with high water-dispersible clay content have a greater potential to contribute sediment particles that may reach the GBR. Because water dispersible clay contents are not available for soils in the Burdekin and Mackay-Whitsunday catchments, surface soil texture has been used in this project as an indicator of soil transport potential. The relative proportion of primary particles (sand, silt, clay) in the surface soil can be inferred from surface soil texture, as described in the field during land resource surveys. It is assumed that the higher the clay content of the soil, the more likely it is to contribute clay-sized particles in runoff, and this characteristic is used to identify soils with higher transport potential. Furthermore, soils with high clay content are also more likely to bind to nutrients and pesticides, due to the negative charge of clay particles, therefore increasing the nutrient and pesticide transport potential (Finlayson & Silburn 1996, Hunter & Walton 2008, Faithful *et al.* 2007).

Data sets

The reference and description for data sets used to represent environmental characteristics are outlined in Table 2.

Table 2. Data sets used to represent each environmental characteristic.

Environmental characteristic	Dataset reference	Data description
Erosion potential	Soil and Land Information (SALI) database, Brisbane. (DERM 2012b). For a complete list of the land resource information utilised in this assessment see Appendix B.	These data describes erosion potential from hillslope erosion processes (rill, sheet and scald) based on soil attributes and slope. These data also identify known eroded land ('mapped eroded land'), including gully and streambank eroded areas, recorded at the time of surveys. Information on erosion potential and known eroded land is derived from the land resource surveys which focused on areas suitable for intensive agricultural production and therefore data are limited to these areas.
Flooding potential	SALI database, Brisbane. (DERM 2012b). For a complete list of the land resource information utilised in this assessment see Appendix B. Pre-clear Regional Ecosystem (RE) mapping (Neldner VJ *et al* 2005).	These data indicates potential flooding extent of sugarcane production areas from two sources: Data on the extent and frequency of flood events are derived from land resource surveys which focused on areas suitable for intensive agricultural production. These data are limited to these areas. For areas where detailed land resource information is not available, data are derived from the pre-clear RE* mapping. For this assessment, areas mapped as land zones 1 (estuarine) and 3 (alluvium) in pre-clear RE* mapping were used to identify potential flooding extent. * Regional ecosystems (REs) are vegetation communities that are consistently associated with a particular combination of geology, and land form in a bioregion. The pre-clear RE mapping shows the REs likely to be present before clearing and is derived primarily from 1960s aerial photographs, in conjunction with a range of other information.

Environmental characteristic	Dataset reference	Data description
Water pathway	Brough DM, Claridge J, & Grundy MJ (2006) *Soil and landscape attributes: A Report on the Creation of a Soil and Landscape Information System for Queensland*, Natural Resources, Mines and Water, Brisbane. QNRM06186. Moody PW & Cong PT (2008) 'Soil Constraints and Management Package (SCAMP): guidelines for sustainable management of tropical upland soils', *ACIAR Monograph* No. 130, 86pp.	These data are derived by combining drainage and permeability soil attributes, which are collected during land resource surveys. The drainage and permeability data are interpreted from information contained in the SALI database as per Brough *et al.* (2006). The decision matrix to identify either runoff or drainage landscapes is defined by Moody and Cong (2008) and described in Appendix C
Soil transport potential	Brough DM, Claridge J, & Grundy MJ (2006) *Soil and landscape attributes: A Report on the Creation of a Soil and Landscape Information System for Queensland*, Natural Resources, Mines and Water, Brisbane. QNRM06186.	These data describe the generalised soil texture of the surface horizon in terms of sand, loam or clays. The data are interpreted from information in the SALI database as per Brough *et al.* (2006). Appendix D outlines the specific soil texture that is allocated within each category (sand, loam or clay).

Limitations of mapping

It is important to be aware of the limitations associated with the data used as this influences the confidence and accuracy of environmental characteristic maps. Data limitations are primarily associated with the coverage of historical soil surveys and the density of the site information collected.

One of the concerns for data quality in this assessment is historical database management. Land resource information is stored in the Soils and Land Information (SALI) database. An inventory of historical data in SALI was undertaken to support this project. This inventory revealed data gaps, some of which were able to be remedied by making sure that all existing land resource data had been entered into SALI. This process also identified genuine gaps in current data, where information did not exist for particular soil types. These gaps then became the focus for a field data collection program (including detailed soils descriptions and laboratory analysis). This gap-filling program was conducted independently of the field validation program described in the project methodology section. Results from the gap-filling field program, including description of soil characteristics and laboratory data, have been incorporated into SALI. This improves the quality of data in SALI, which has benefits for all projects that use these data. The sites which were sampled as part of the gap-filling project are outlined in Appendix E.

The scale at which land resource data is collected (survey scale) can be another limitation. The survey scale is primarily determined by the density of observations, i.e. sites described within a measured area (Table 3).

Table 3. Correlation between survey scale and site inspection density (McKenzie et al. 2008).

Survey scale	Site inspection density
1:2 500	>4 sites per ha
1:10 000	1 per 0.5 ha
1:25 000	1 to 5 per 25 ha
1:50 000	1 to 5 per 100 ha
1:100 000	<1 per 100ha

It was determined, through an extensive peer review process of the environmental characteristic maps produced for the Wet Tropics, that detailed land resource studies (i.e. scales of 1:50 000 or finer) can support assessment of environmental characteristics at the farm level for intensive land uses, such as sugarcane production. The data within sugarcane production areas of the Burdekin and Mackay-Whitsunday catchments are mostly at this level of detail (Figure 5). The particular land resource surveys used for each catchment are described in further detail below.

The sugarcane production area of the Burdekin catchment is largely covered by soils mapping at a scale finer than 1:50 000. The exception is a small proportion of cane grown in the 'upper' Lower Burdekin catchment, which is mapped at 1:100 000.

The sugarcane production area in the Mackay-Whitsunday catchment is largely covered by 1:50 000 soils mapping. The exception is the Plane Creek sub-catchment which is covered by 1:100 000 scale mapping.

Soil surveys at 1:100 000 scale are still considered to be appropriate for identifying possible landscape features present on a property as a guide only for property planning/ERMPs.

NOTE: The user guides that accompany this technical report explain how environmental characteristic maps should be used to support identification of property features, given the scale at which land resource data is collected.

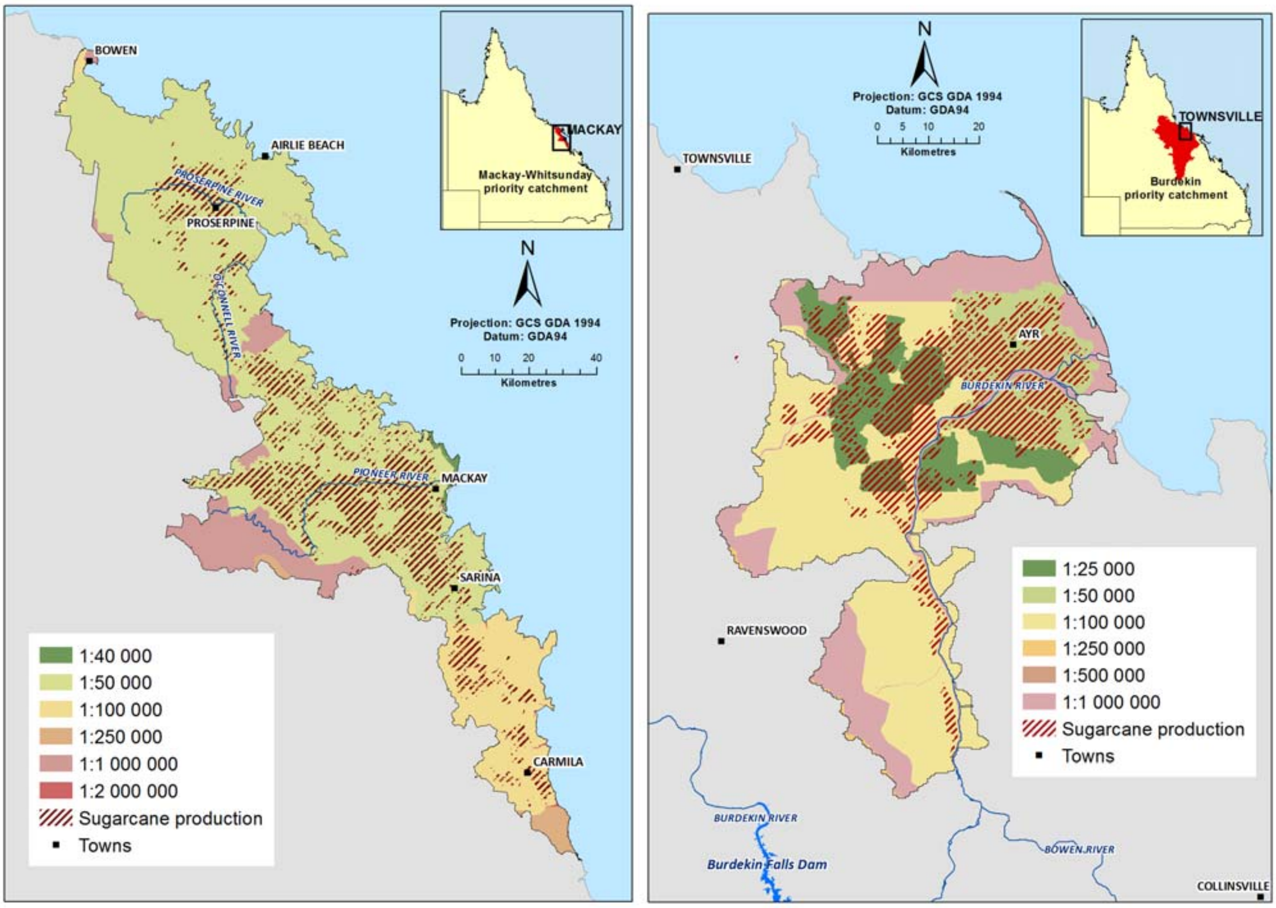


Figure 5. Scale of land resource mapping in the Burdekin (right) and Mackay-Whitsunday (left) (DERM 2012a). Linear distinctions between mapping scales represent boundaries of different land resource mapping projects.

Environmental characteristic maps

The maps presented in this report incorporate the improvements facilitated through field validation and database improvements. Each environmental characteristic is displayed in a separate map. Data have not been combined to produce a single overlay map because it is extremely difficult to generalise the relative importance of individual characteristics in different locations. Each map must therefore be considered separately.

Boundaries between land resource survey projects are distinctly evident as linear features in the data and maps. As a consequence of these boundaries, variations in soil type may appear linear on the map, when in fact the soils are more likely to change continuously and gradually across the landscape. These edge anomalies are inevitable when using information from land resource surveys with distinct survey boundaries and different scales of mapping.

Erosion potential

The erosion potential data indicate the inherent susceptibility of landscapes to generate erosion. However, the likelihood of soil eroding is largely dependent on land management practices. Hence, soils that are naturally prone to erosion may not actually erode under good land management practices. Conversely, soils with a low erosion potential may erode under poor management practice. The data on erosion potential are drawn from land resource studies where the effect of erosion on agricultural productivity was assessed by considering slope (which can increase the velocity of runoff), and the natural erodibility of soils. These land resource studies were focused on areas suitable for intensive agricultural production and therefore these data are limited to these areas. The highest erosion potential exists where inherently erodible soils occur on steep slopes.

The classification of erosion potential differs between the two catchments (Burdekin and Mackay-Whitsunday), due to the description of soil and slope attributes being different across land resource surveys. The attributes that contribute to erosion potential categories are summarised in Table 4 (Burdekin) and Table 5 (Mackay-Whitsunday) below.

Environmental characteristic maps for erosion potential only refer to propensity of a soil to erode in its natural state. No consideration is given to land use or management practices applied to an area.

Burdekin catchment

The attributes that contribute to each category of erosion potential are detailed in Table 4 and the spatial extent of these categories is shown in Figure 6.

Table 4. Categories for erosion potential – Burdekin catchment.

Category	Description of soil and slope[2] attribute	Other mapping units included in erosion potential category
Lower potential	0.5 – 1% slope for texture contrast soils with a sodic horizon by 60 cm soil depth or 1.0 – 2.0 % slope for other soils 1.0 - 2.0 % slope for texture contrast soils with a sodic horizon by 60 cm soil depth or 2.0 - 4.0 % slope for other soils No erosion risk. < 0.5 % slope for texture contrast soils with a sodic horizon by 60 cm soil depth or < 1 % slope for other soils	Urban Miscellaneous water map units Swamps Rock
Moderate potential	2.0 - 3.0 % slope for texture contrast soils with a sodic horizon by 60 cm soil depth or 4.0 - 5.0 % slope for other soils 3.0 - 5.0 % slope for texture contrast soils with a sodic horizon by 60 cm soil depth or 5.0 - 10.0 % slope for other soils	Disturbed land other Hills Miscellaneous mining quarry units
Higher potential	> 5.0 % slope for texture contrast soils with a sodic horizon by 60 cm soil depth or > 10.0 % slope for other soils	
Mapped eroded land	Eroded land Minor existing gully or streambank erosion Moderate to severe existing gully or streambank erosion	
Not assessed	NA – Out of detailed soil mapping area	

[2] Each slope class was analysed separately, therefore they are not grouped together within each category of erosion potential.

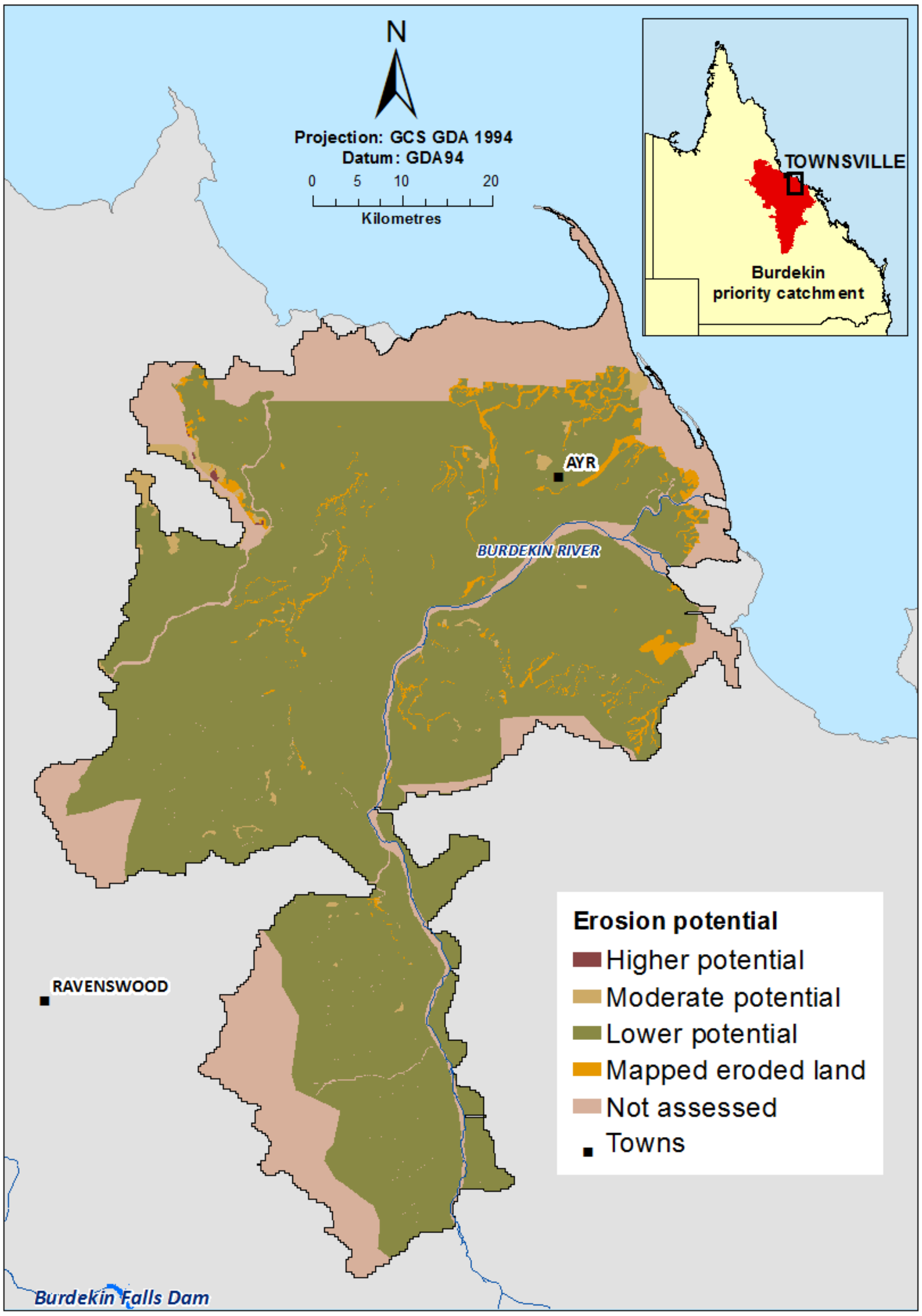


Figure 6. Erosion potential – Burdekin catchment

Note 1. The scale of map does not precisely identify location of soil boundaries and is not indicative of actual erosion as many areas may be well managed and are in good condition.

Note 2. The erosion potential was assessed according to slope and the natural erodibility of soils. The majority of mapped land is in the lower erosion potential category. This is largely because most of this lower Burdekin floodplain is relatively flat and doesn't have steep slopes.

Note 3. The mapped eroded land category includes a range of undifferentiated known eroded land, including gully and streambank eroded areas, recorded at the time of land resource surveys (refer to Appendix B for the list of surveys).

Mackay-Whitsunday catchment

The attributes that contribute to each category of erosion potential are detailed in Table 5 and the spatial extent of these categories is shown in Figure 7.

Table 5. Categories for erosion potential – Mackay-Whitsunday catchment.

Category	Description of soil and slope[3] attribute	Other mapping units included in erosion category
Lower potential	Gradational and uniform soil types, slope < 1% Gradational and uniform soil types, slope 1 - 2% Gradational and uniform soil types, slope 2 - 4% Gradational and uniform soil types, slope 4 - 8% Non sodic duplex soils, slope < 1% Non sodic duplex soils, slope 1 - 2% Non sodic duplex soils, slope 2 - 4% Sodic duplex soils, slopes < 1% Sodic duplex soils, slopes 1 - 2% 0.5 - 1 % slope for soils with a sodic horizon by 60 cm soil depth or 1.0 - 2.0 % slope for other soils 1.0 - 2.0 % slope for soil with a sodic horizon by 60 cm soil depth or 2.0 - 4.0 % slope for other soils No erosion risk. < 0.5 % slope for soils with a sodic horizon by 60 cm soil depth or < 1 % slope for other soils	Depositional or low energy environment, no or minimal erosion; e.g. swamps and mangroves Miscellaneous Urban Miscellaneous water map units Mangroves
Moderate potential	Gradational and uniform soil types, slope 8 - 14% Non sodic duplex soils, slope 4 - 10% Non sodic duplex soils, slope 10 - 14% Non sodic duplex soils, slope 14 - 20% Sodic duplex soils, slopes 2 - 4% Sodic duplex soils, slopes 4 - 10% 2.0 - 3.0 % slope for soils with a sodic horizon by 60 cm soil depth or 4.0 - 5.0 % slope for other soils	Hills
Higher potential	Gradational and uniform soil types, slope 14 - 20% Gradational and uniform soil types, slope 20 - 30% Gradational and uniform soil types, slope > 30% Non sodic duplex soils, slope 20 - 30% Non sodic duplex soils, slope > 30% Sodic duplex soils, slopes 10 - 20% Sodic duplex soils, slopes > 20% Highly erosive sodic duplex soils, slopes 1 - 4%. Thin < 0.15m A horizon. B horizon ESP > 25% Highly erosive sodic duplex soils, slopes > 4%. Thin < 0.15m A horizon. B horizon ESP > 15%	NA
Mapped eroded land	Moderate to severe existing gully or streambank erosion Gullies	NA
Not assessed	Miscellaneous mountain mapping units Stream channel	NA

[3] Each slope class was analysed separately, therefore they are not grouped together within each category of erosion potential.

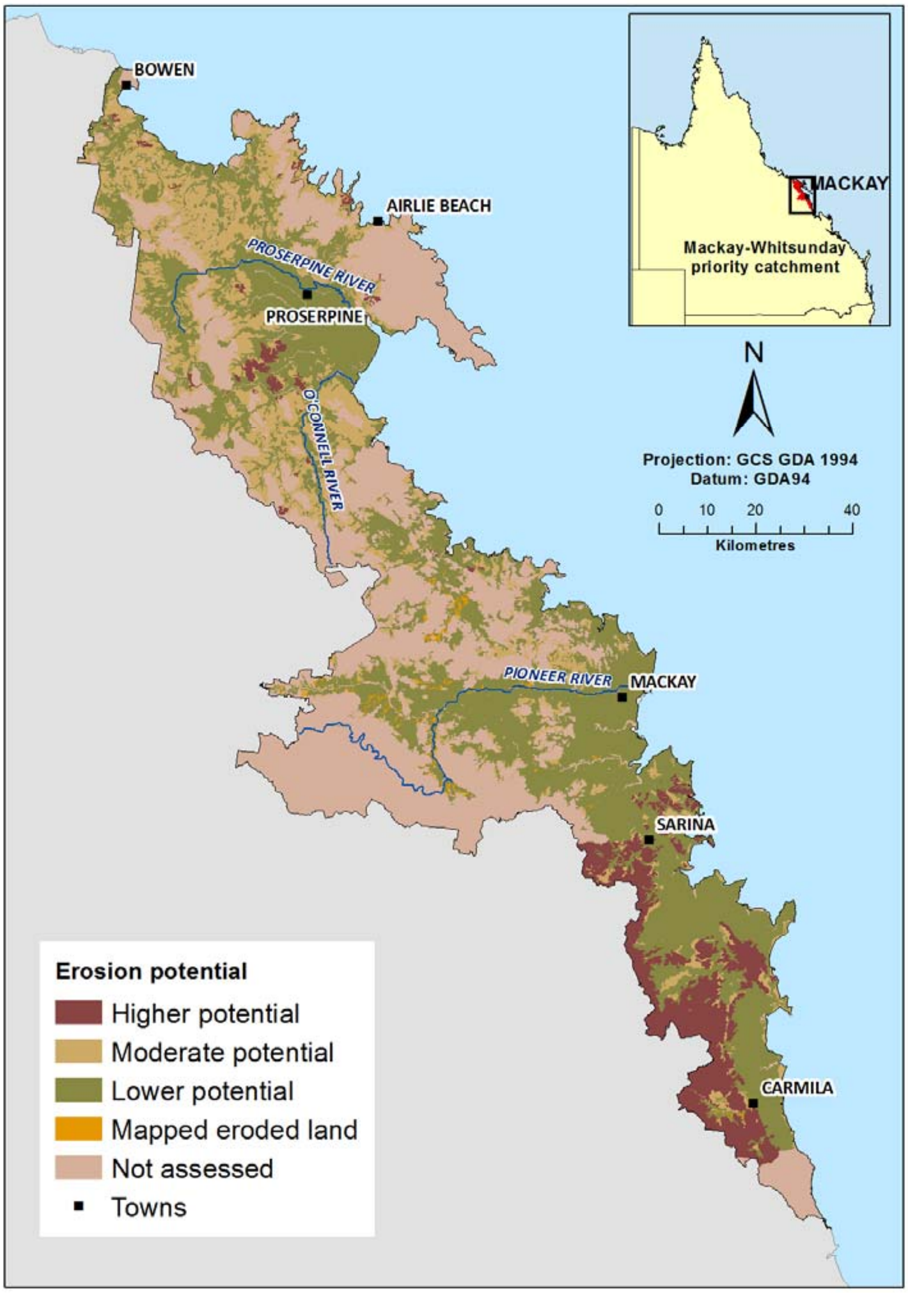


Figure 7. Erosion potential – Mackay-Whitsunday catchment

Note 1. The scale of map does not precisely identify location of soil boundaries and is not indicative of actual erosion as many areas may be well managed and are in good condition.

Note 2. The erosion potential was assessed according to slope and the natural erodibility of soils. The majority of cane growing areas are in the lower erosion potential category, as they are on the lower slopes of the coastal plain. The higher potential areas identified in this assessment are mainly located in the higher slope areas.

Note 3. The mapped eroded land category includes a range of undifferentiated known eroded land, including gully and streambank eroded areas, recorded at the time of land resource surveys (refer to Appendix B for the list of surveys).

Flooding potential

Where sugarcane land use occurs in frequently flooded environments, there is a higher potential for contaminants (particularly soluble forms) to be transported to watercourses. This assessment uses the pre-clear Vegetation Mapping of Land zone 3 (Alluvium) and Land zone 1 (Estuarine) and the Soil Flooding Limitation Mapping in SALI to determine potential areas of inundation and, where the soil mapping is available, frequency of flood events. These areas have a higher potential to transport contaminants (particularly recently applied nutrient or herbicide) via floodwaters. In areas where soil mapping is at a scale better than 1: 100 000, the soils data were used, instead of the vegetation mapping, as there is a higher confidence in these data.

Where detailed soils mapping is available the flooding potential layer indicates potential flood extent and frequency. Where detailed soils mapping is not available vegetation mapping is used to indicate potential extent of inundation (the active floodplain) but **NOT** frequency.

The classification of flooding potential differs between the two catchments (Burdekin and Mackay-Whitsunday), due to the description of flooding limitations categories being different across land resource surveys. The attributes that contribute to flooding potential categories are summarised in Table 6 (Burdekin) and 7 (Mackay-Whitsunday) below. Flooding potential is mapped in Figure 8 for the Burdekin catchment and in Figure 9 for the Mackay-Whitsunday catchment.

Table 6. Categories for flooding potential Burdekin Catchment

Category	Description	Source
Annually flooded areas	Flooding at least or almost annually or areas subject to erosive flooding	Soils mapping
Less than annually flooded areas	Areas subjected to local flooding at frequency of 1 in 5 -10 years Area subjected to local flooding at frequency > 1 in 5 years Areas subjected to local flooding at frequency <1 in 10 years	Soils mapping
Indicative floodplain (no frequency data)	Approximate inundation extent but not frequency	Vegetation mapping
Not assessed	Miscellaneous mining quarry units	Soils mapping

Table 7. Categories for flooding potential Mackay-Whitsunday catchment

Category	Description	Source
Annually flooded areas	Flooded on almost an annual basis Flooding at least or almost annually or areas subject to erosive flooding	Soils mapping
Less than annually flooded areas	Areas subjected to local flooding at a frequency of 1 in 5-10 years Flooded 1 in 1 to 10 years; depth usually >1 m Flooded 1 in 1 to 10 years; depth usually <1 m Flooded 1 in 10 to 50 years; depth usually >1 m	Soils mapping
Indicative floodplain (no frequency data)	Approximate inundation extent but not frequency	Vegetation mapping
Subject to severely erosive flooding (no frequency data)	Subject to severely erosive flooding; streambeds and gullies	Soils mapping

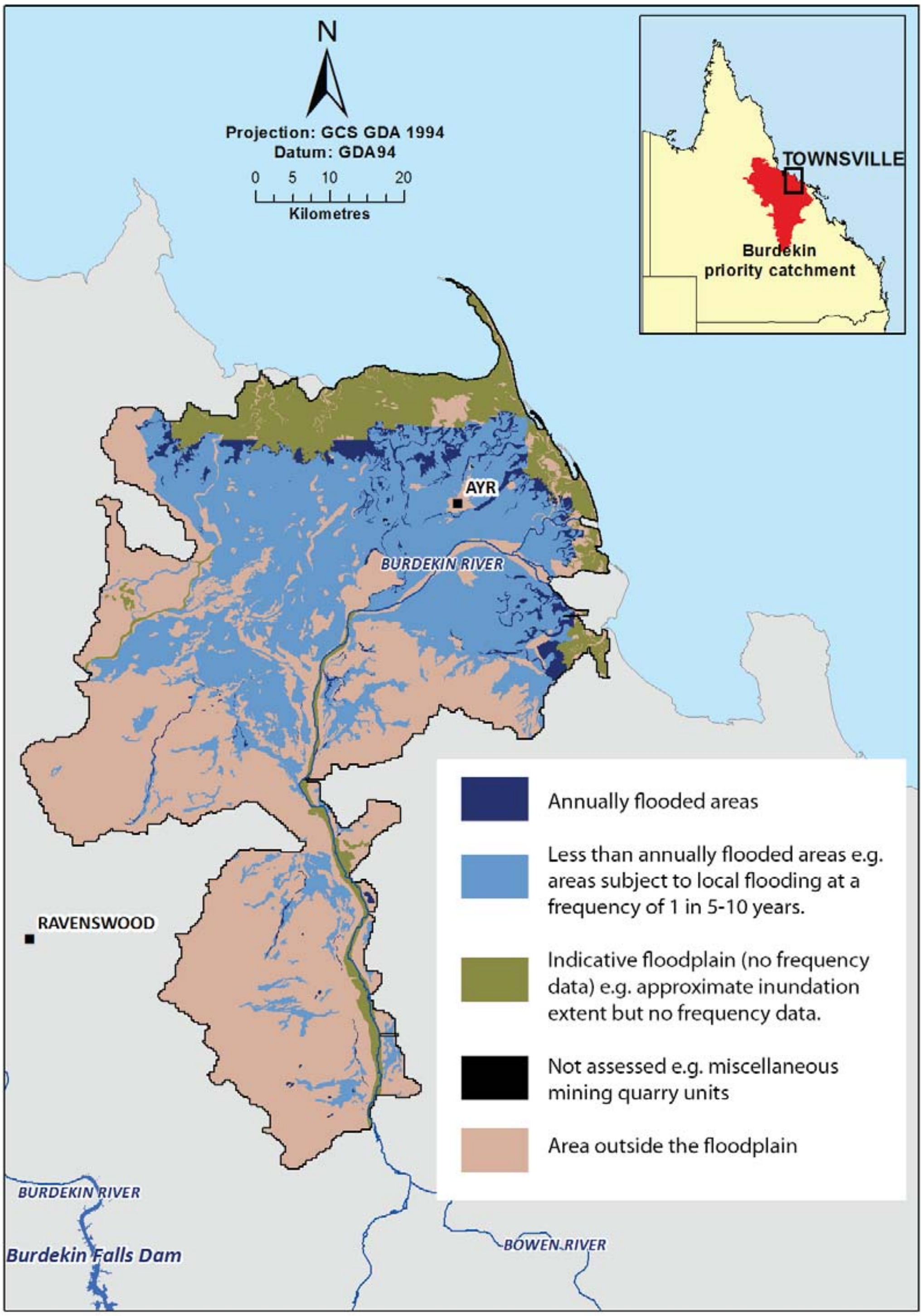


Figure 8. Flooding potential – Burdekin catchment

Note 1: Most of the cane area in the Burdekin is covered by detailed soils mapping which has an indication of frequency of flood events.

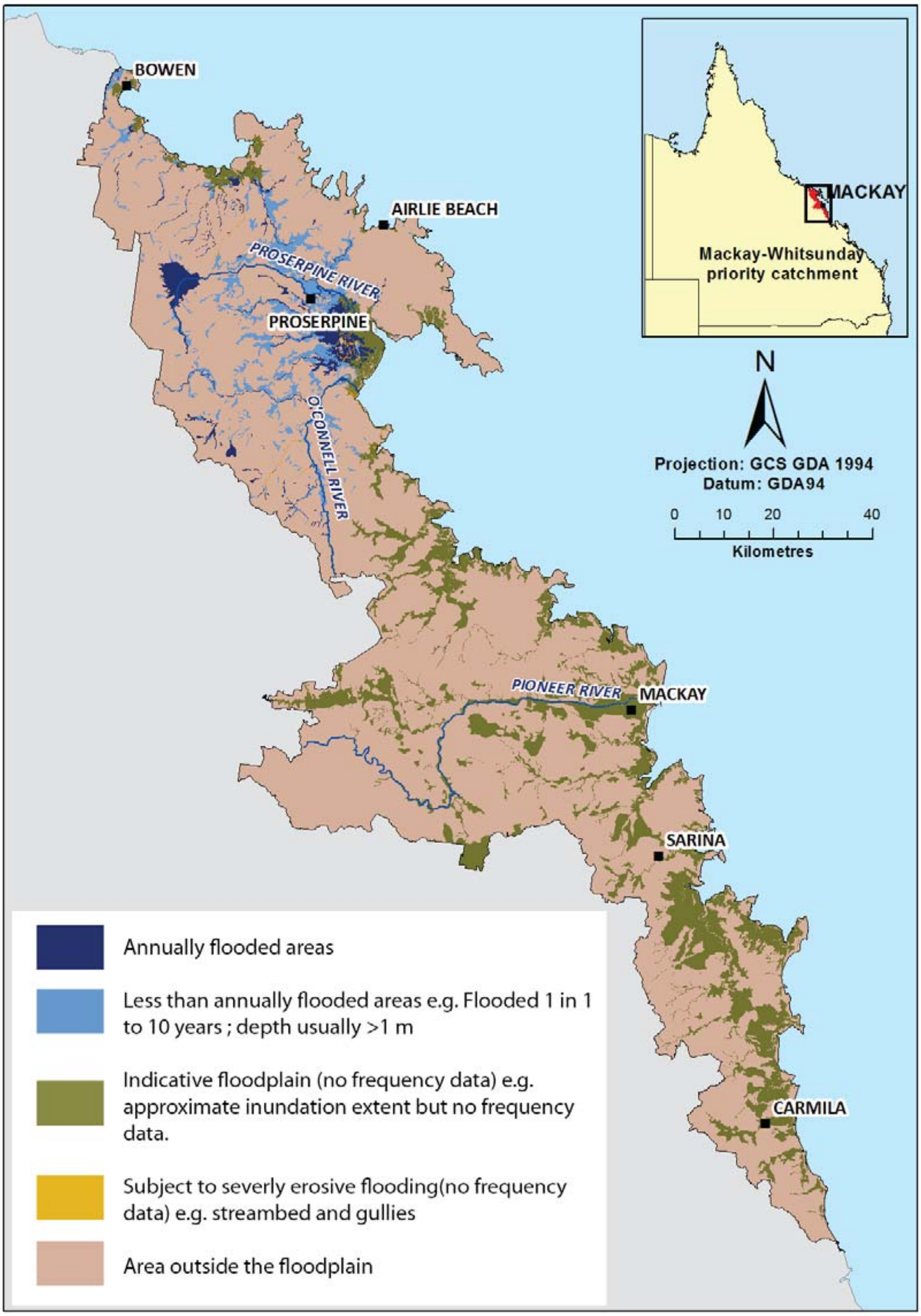


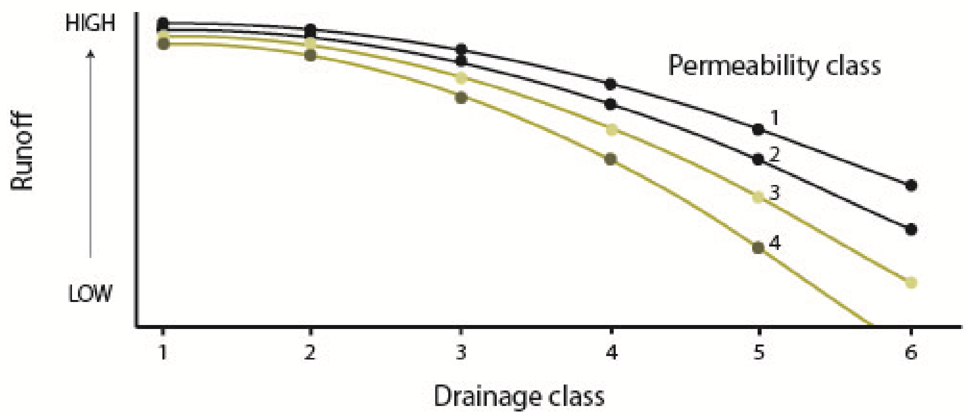
Figure 9. Flooding potential – Mackay-Whitsunday catchment

Water pathway

Landscapes that are prone to generating runoff are more likely to facilitate the movement of contaminants, as water provides the medium for entrainment and transport. The relationship between soil permeability and drainage determines the potential for a soil to generate runoff (Figure 11). For example, as soil permeability and drainage decrease (i.e. soils are slowly permeable and poorly drained), the likelihood of generating runoff increases.

This assessment combines the drainage and permeability characteristics of soil profiles to produce a water pathway matrix, as detailed in Moody and Cong (2008). The water pathway matrix groups soils into three categories, which indicate whether a soil will predominantly facilitate drainage or generate runoff.

Appendix C details the matrix used to derive the dominant water pathway, as well as drainage and permeability class definitions.



Permeability classes
1 – very slowly permeable
2 – slowly permeable
3 – moderately permeable
4 – highly permeable

Drainage classes
1 – very poorly drained
2 – poorly drained
3 – imperfectly drained
4 – moderately well drained
5 – well drained
6 – rapidly drained

Figure 10. Soils permeability and drainage class matrix used to determine runoff generation (adapted from Moody & Cong 2008).

The classification of water pathway categories is the same across both catchments (Burdekin and Mackay –Whitsunday). These are summarised in Table 7. The dominant water pathway for the Burdekin catchment is mapped in Figure 11 and for the Mackay-Whitsunday catchment in Figure 12.

Table 7. Categories for dominant water pathway and corresponding soil permeability and drainage characteristics.

Category	Soil permeability and drainage characteristics
Drainage	Highly permeable and well drained soils have a lower potential to generate runoff.
Runoff and/or drainage	Permeable and imperfectly drained soils have a moderate potential to generate runoff.
Runoff/ponding	Poorly drained and slowly permeable soils have a greater potential to generate runoff.

NOTE: Although this assessment does not address groundwater transport of nutrients and pesticides, this may be inferred from the water pathway layer by considering parts of the landscape that are prone to facilitate drainage.

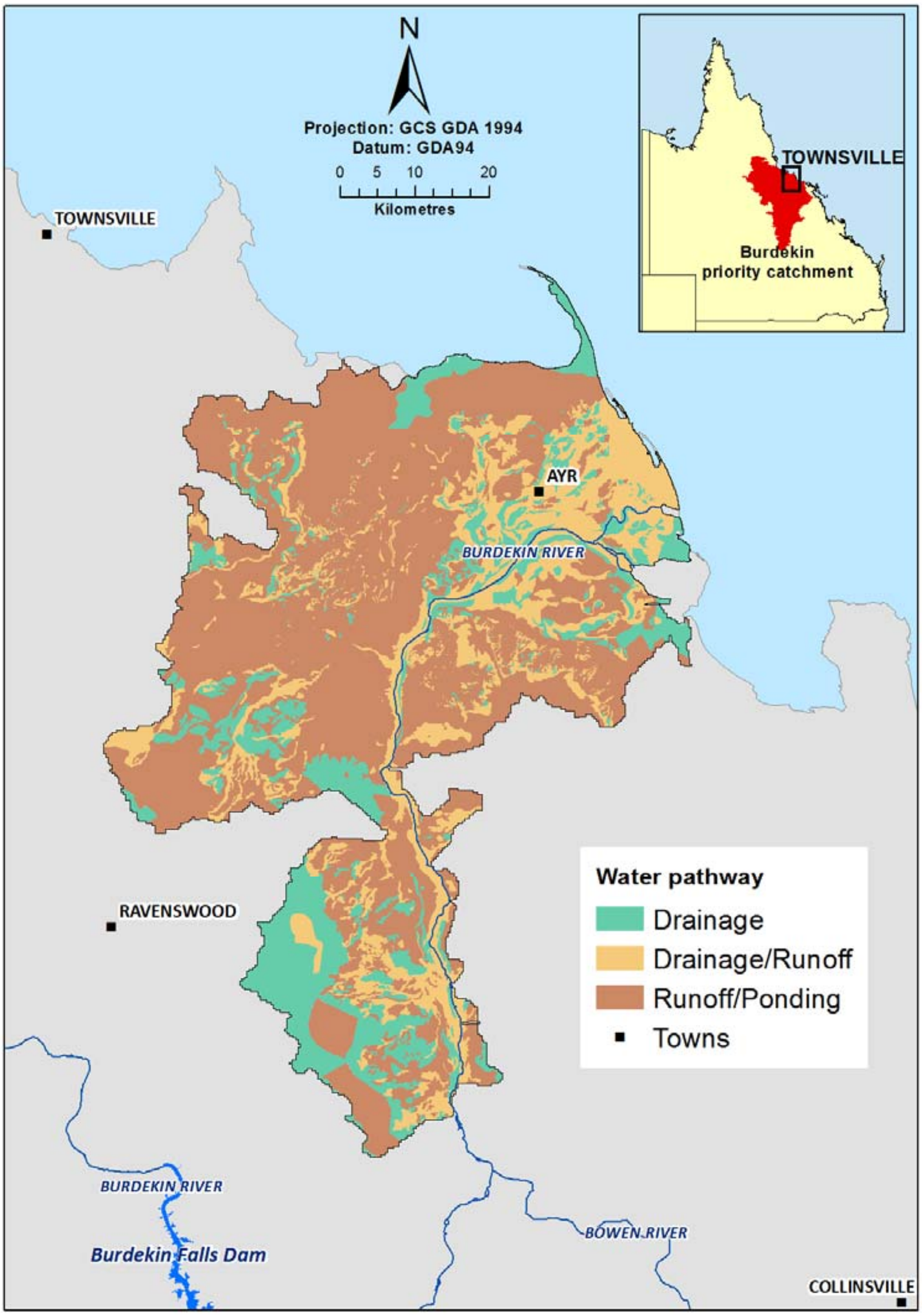


Figure 11. Dominant pathway of water movement – Burdekin catchment

Note 1. The scale of map does not precisely identify soil boundaries for water pathway, it indicates the likely water pathway based on soil characteristics

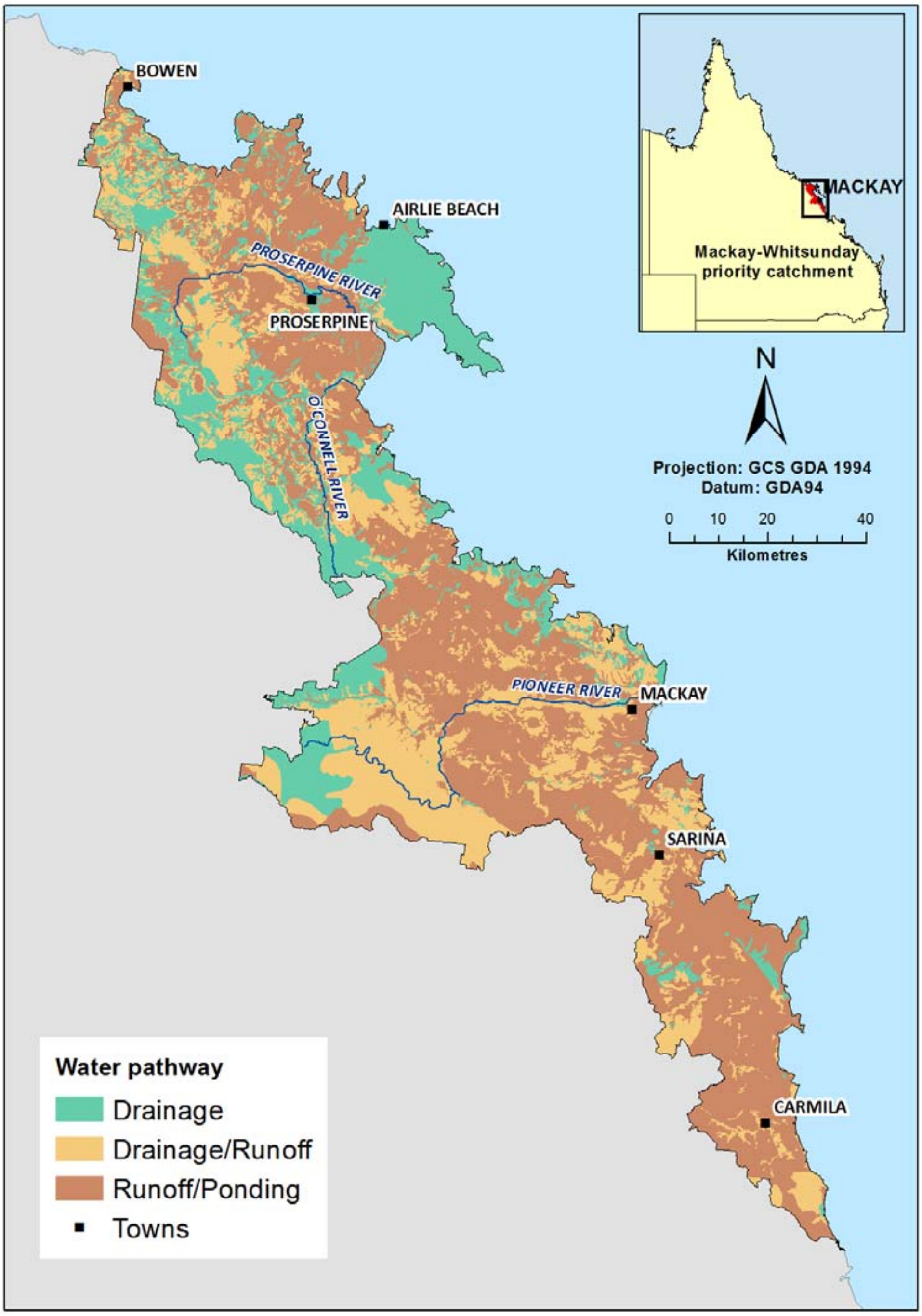


Figure 12. Dominant pathway of water movement – Mackay-Whitsunday catchment

Note 1. The scale of map does not precisely identify soil boundaries for water pathway, it indicates the likely water pathway based on soil characteristics.

Soil transport potential

Clay-sized particles (< 0.002 mm) are more easily transported long distances by water than silt and sand-sized particles. As a result, soils with high water–dispersible clay content have a higher potential to be transported further and are more likely to reach the GBR. Because water dispersible clay contents are not available for soils in the Burdekin and Mackay-Whitsunday catchments, surface soil texture has been used as an indicator of soil transport potential. It is assumed that the higher the clay content of the soil, the more likely it is to contribute clay-sized particles in runoff, and this characteristic is used to identify soils with higher transport potential. Furthermore, soils with high clay content are more likely to bind nutrient cations and electro-positively charged pesticide compounds, due to the negative charge of clay particles. The high surface area of clays results in an enhanced capacity to transport such nutrient and pesticide forms.

Chemical vs. water dispersible soil particles

The distinction between chemically dispersed and water dispersed particles is important.

Chemically dispersed silt particles are mainly primary soil minerals whereas water dispersed silt – **sized** particles may be micro-aggregates of clay minerals as occurs in Ferrosols.

This is the same for clays– chemically dispersed clay particles are essentially primary clay minerals whereas water dispersible clay-**sized** particles may not necessarily be primary clay minerals.

This assessment uses the surface soil texture attribute described during land resource surveys to determine the relative proportion of mineral particles (sand, silt, clay) and the potential for long-distance transport.

A complete list of soil texture codes considered in this assessment and their classification into four categories (sand, loam, clay and other) is provided in Appendix D.

The classification of surface soil textures is similar across both catchments (Burdekin and Mackay-Whitsunday). These categories are summarised in Table 8. Surface soil texture is mapped for the Burdekin catchment in Figure 13 and the Mackay-Whitsunday catchment in Figure 14.

Table 8. Categories for soil transport potential and corresponding surface soil textures.

Category	Surface soil texture
Sands (lower transport potential)	Sand (general equivalent field texture: sand, loamy sands, clayey sands).
Loams (moderate transport potential)	Loam (general equivalent field texture: sandy loams, loam, clay loams, silty loams).
Clays (higher transport potential)	Clay (general equivalent field texture: light clays, medium clays, heavy clays)
Not recorded	No surface soil texture category is recorded

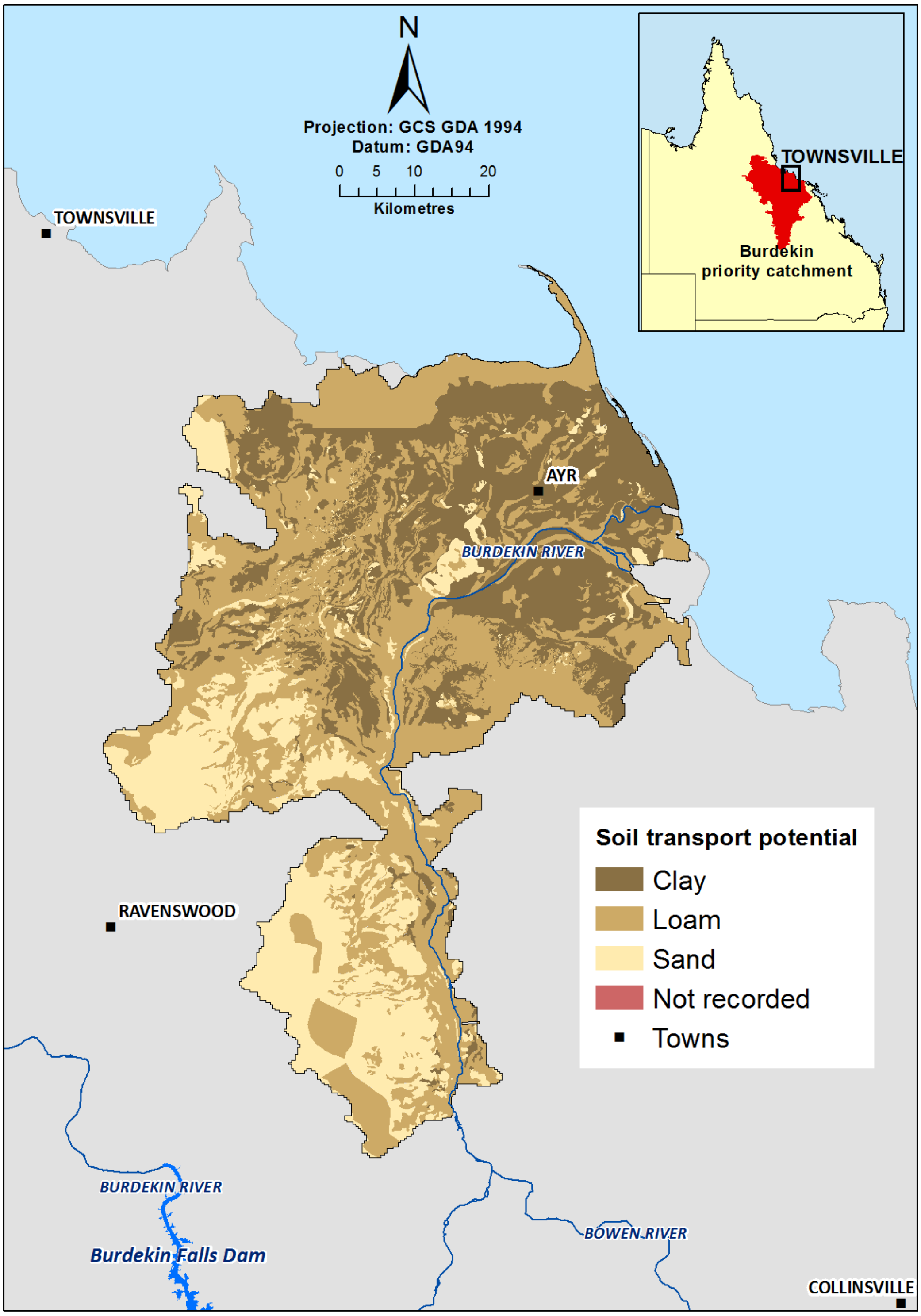


Figure 13. Soil transport potential – Burdekin catchment.

Note 1. The scale of map does not precisely identify surface soil texture boundaries, it indicates the likely soil transport potential based on soil texture.

Conclusion

Environmental characteristic maps have been developed for the cane production areas of the Burdekin and Mackay-Whitsunday catchments.

The four environmental characteristics in this report describe:

- Soil erosion potential (i.e. the inherent potential of soil to erode according to slope and soil features)
- Flooding potential or areas of inundation (i.e. the flooding regime of landscapes that may transport contaminants to watercourses)
- Water pathway (i.e. the potential of soils to generate runoff which can mobilise and transport contaminants)
- Soil transport potential (i.e. the inherent potential for soil fractions to be transported long distances).

It is anticipated that over time, environmental characteristic maps could be used with information about management practices to identify areas that present a higher risk of transporting sediment, nutrients and herbicides via run-off to the Great Barrier Reef (Figure 15). This would assist in the following processes:

- identification of research and information gaps, which can be input into monitoring programs and shared through extension programs
- assist landholders and extension officers to understand how landscape characteristics interact with management systems at a property or regional scale.

Once information about management systems is available, there is the potential to combine the spatial data sets for environmental characteristics and management systems in order to identify areas that may present a higher risk of transporting sediment, nutrients and herbicides via run-off to the GBR. This information could be used to more effectively target extension and investment activities of the Reef Protection Package and ensure that growers in areas of higher risk receive support to adopt management systems appropriate to their local conditions.

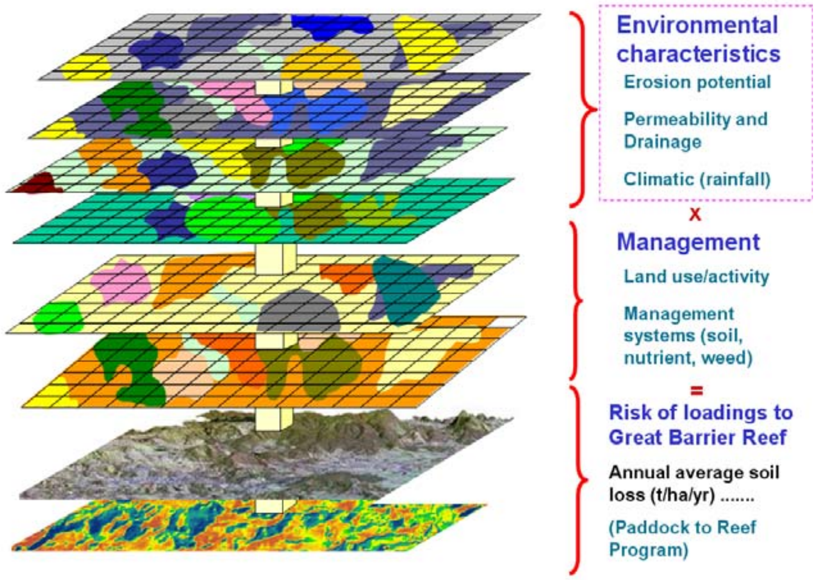


Figure 14. In the future, high-risk areas may be identified by layering environmental characteristics with land management systems

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Appendix A Project stage 1 – identified environmental characteristics and data sets

Stage 1 of the project identified the environmental characteristics that are inherently linked to GBR water quality and the data sources that could be potentially useful to represent environmental characteristics. These are described in the table below, along with the rationale for the inclusion or exclusion of the data in this project.

Environmental characteristic	Data	Comments on data utility	Data limitations	Scale limitations	Data used in assessment
Erodible landscapes (erosion potential)	Erosion limitation data from DERM Versatile Cropping Lands project	These data indicate erodible soils in cropping lands based on parent material and slope. Erosion limitation values assigned to individual polygons during land resource assessment.	Extent limited to cropping lands.	Land resource data vary in scale from 1:25 000 – 1:100 000	Yes
	Universal Soil Loss Equation (USLE) method (only RKLS factors) R = Rainfall erosivity K = Soil erodibility L = Slope length S = Slope steepness	This method is used to estimate long-term annual hillslope erosion.	Does not translate well to non-cropping lands on steep slopes as it was developed from a limited range of slope and soil types (mostly within cropping lands.) USLE does not address gully or streambank erosion.	Grid generated from inputs of various scale. Planned improvements using finer-scale inputs.	No – erosion limitation data considered more appropriate for this project due to derivation method (see above).
	Water Quality Improvement Plans (WQIP)	These data may provide estimates of sediment contributions	WQIP indicates sediment loss at a sub-catchment	Indicative at a coarse scale (sub- catchment).	No – finer-scale information is required for this project.

Environmental characteristic	Data	Comments on data utility	Data limitations	Scale limitations	Data used in assessment
	Burdekin (Dight I, 2009)	from hillslope, bank and gully erosion for sub-catchment in Reef catchments.	scale only. Does not address movement of nutrient or pesticides.		
	Water Quality Improvement Plans (WQIP) Mackay-Whitsunday (Drewy J, Highham W and Mitchell C 2008)	These data may provide estimates of sediment contributions from hillslope, bank and gully erosion for sub-catchment in Reef catchments.	WQIP indicate sediment, nutrient and pesticides loss at a catchment management area scale.	Indicative at a coarse scale (catchment management area)	No – finer-scale information is required for this project.
	Reef regional assessment (Brodie *et al.* 2009)	Data provide estimates of sediment contributions from hillslope, bank and gully erosion for sub-basins in Reef catchments.	Indicative at sub-basin scale. Variable data availability limits confidence in some sub-basins of the Mackay Whitsunday and Burdekin catchments.	Indicative at sub-basin scale. Variable data availability limits confidence in some sub-basins of the Mackay Whitsunday and Burdekin catchments	No – finer-scale information is required for this project.
	Ground Cover Index	Data represent an annual assessment of vegetative ground cover.	Within the context of this project, ground cover is the result of natural landscape characteristics as well as management. Incorporates rocky areas as bare ground even though these areas are not subject to erosion.		No—not appropriate within the context of this project due to ground cover influenced by land management.

Environmental characteristic	Data	Comments on data utility	Data limitations	Scale limitations	Data used in assessment
Flooded landscapes (flooding frequency)	Flooding limitation data from DERM Versatile Cropping Lands project	These data indicate flood-prone areas and the frequency of flooding in cropping lands. Flooding is an important mechanism for contaminant transport to the GBR.	Extent limited to cropping lands.	Land resource data vary in scale from 1:25 000 – 1:100 000	Yes
	Regional ecosystem and vegetation mapping (Neldner *et al.* 2005)	Landzone attributes in these data map the extent of alluvial environments. Flooding is an important mechanism for contaminant transport to the GBR.	Includes non-active alluvial environments. Does not predict the frequency or duration of flood events.	1:100 000 available state-wide	Yes
Distance to stream	1:100 000 drainage	Useful analysis for distance of contaminant transport pathway from farm to watercourse.	Drainage density between map sheets is inconsistent. The application of these data is limited by the lack of knowledge about stream-sediment delivery processes.	1:100 000 available state-wide	No—insufficient knowledge of stream delivery processes.
Runoff generating landscapes (runoff potential)	Dominant water pathway	A set of rules that predicts the predominant water pathway for nutrient transportation for example via runoff/ponding or deep drainage/lateral		Land resource data vary in scale from 1:25 000 to 1:2 000 000	Yes.

Environmental characteristic	Data	Comments on data utility	Data limitations	Scale limitations	Data used in assessment
		flow			
Soil transport potential	Soil surface texture	Indicates potential of soil to bind to nutrients and pesticides and be entrained	Transport process is specific to the type of nutrients and pesticides applied.	Land resource data vary in scale from 1:25 000 to 1:2 000 000	Yes

Brodie J, Mitchell A & Waterhouse J (2009) 'Regional assessment of the relative risk of the impacts of broad-scale agriculture on the Great Barrier Reef and priorities for investment under the Reef Protection Package, Stage 2 Report', ACTFR 09/30, Australian Centre for Tropical Freshwater Research.

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Neldner VJ, Wilson BA, Thompson EJ & Dillewaard HA (2005) 'Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland', version 3.1, Updated September 2005, Queensland Herbarium, Environmental Protection Agency, Brisbane. 128 pp

Appendix B List of land resource publications relevant to the Burdekin and Mackay-Whitsunday cane areas

Land resource reports provide information on the soils of the Burdekin and Mackay-Whitsunday catchments. These reports can be viewed and downloaded through the:

- EHP library catalogue at: <www.derm.qld.gov.au/library/index.html>
- Queensland Digital Exploration Reports system (QDEX) at <www.dme.qld.gov.au/mines/company_exploration_reports.cfm>

Alternatively, reports can be requested by emailing: <productdelivery@derm.qld.gov.au>.

SALI[4] project code	Title
BURDEKIN PUBLICATIONS	
BDS	Burdekin Delta Soils
BER	Soil Survey - Elliot River to Bowen, Molongle Creek to Elliot River
BRB	Land Resources Survey of the Burdekin Right Bank, QLD
BRL	Soils of the Lower Burdekin River Barratta Creek - Haughton River Area
BSA	Soils of the Lower Burdekin Valley, North Queensland Redbank creek to Bob’s creek and south to Bowen River
CCL	Land Resources and Evaluation of the Capricornia Coastal Lands, Broadsound Shire, QLD
GRU	Soils and agricultural land suitability of the Giru area, North Queensland
HTC	Survey of the Burdekin River Irrigation Area - Haughtons Central
HTN	Survey of the Burdekin River Irrigation Area - Haughtons North
HTS	Irrigated land suitability assessment of Haughton Section – Stage 1 Nine Mile Lagoon to Oaky creek
INK	Soil Survey of the Burdekin River Irrigation Area - Inkerman Section
JFD	Soil Survey of the Burdekin Irrigation Area (BRIA) - Jarvisfield Section
LDR	Soil Survey of the Burdekin River Irrigation Area - Leichhardt Downs Relift, QLD
MAJCK	Land Resources of the Major Creek Area North Queensland
MLG	Burdekin River Irrigation Area - Mulgrave Section
NBS	Nebo Broadsound Survey
NHC	Land Resources Survey of the Burdekin River Irrigation Area - Northcote Section
NLH	Soil Survey of the Burdekin River Irrigation Area - Leichhardt Downs
RBO	Sugar-cane land suitability assessment Burdekin River irrigation area Right Bank – Yellow Gin creek to Elliot River
SLK	Land Resources Survey of the Burdekin - Selkirk Area
WTC	Wet Tropical Coast - North Queensland - Ingham and Herbert River Section

[4] Soil and Land Information system (SALI) –corporate data base which stores all soils and land resource information

ZDK2	Survey of the Isaac-Comet Area - Version 2
ZEB	Survey of the Burdekin-Townsville Region Soils
MACKAY WHITSUNDAY PUBLICATIONS	
BPA	Beach Protection Authority - Mackay
MCL	Mackay Sugar Cane Land Suitability Study
PCS	Plane Creek Sugar-Cane Land Suitability Study
WCS	Whitsunday Integrated Land Use Study
SAR	Sarina Soil and Suitability Survey
NON-REGIONAL PUBLICATIONS	
ATLAS	Atlas of Australian Soils - Queensland Coverage

Appendix C Water pathway decision matrix

Soil drainage and permeability characteristics describe how water moves through the soil and are determined during soil sampling by field officers. Drainage and permeability classes were combined to produce a water pathway matrix as detailed in Moody and Cong (2008). The drainage and permeability characteristics for each class are outlined below.

Permeability class [A]	Drainage class [A]					
	1	2	3	4	5	6
1	R/P	R/P	R/P	R/P	R/P	D + R/P
2	R/P	R/P	R/P	D + R/P	D + R/P	D + R/P
3	R/P	R/P	R/P	D + R/P	D	D
4	R/P	R/P	D + R/P	D + R/P	D	D

D= drainage/lateral flow; R/P = runoff or ponding, depending on slope

Drainage and permeability characteristics

Drainage refers to the rate of removal of water from the soil profile and is a statement about soil and site drainage that is likely to occur in most years. It is affected by both internal and external attributes that may act together and/or separately (McDonald *et al.* 1990).

Drainage class	Description
1 Very poorly drained	Water is removed from the soil so slowly that the water remains at or near the surface for most of the year.
2 Poorly drained	Water is removed very slowly from the soil in relation to supply which may result in seasonal ponding. A perched water table may also be present.
3 Imperfectly drained	Water is removed slowly from the soil. Intermittent waterlogging throughout the soil results in many profiles having gleyed, mottled colours or rusty root channel linings.
4 Moderately well drained	Water is removed relatively slowly after supply. Some horizons may remain wet for as long as one week after water addition.
5 Well drained	Water is removed readily but not rapidly from the soil. Some horizons may remain wet for several days after water addition.
6 Rapidly drained	Water is removed from the soil rapidly. The soil is not normally wet for more than several hours after water addition.

Permeability refers to the potential of a soil to transmit water internally and this attribute is assessed for the least permeable horizon in the soil profile. It is independent of the soil's position in the landscape and climate (McDonald *et al.* 1990).

Permeability class	Description
1 Very slowly permeable	Transmission through the least permeable horizon is very slow. It would take at least a month for the profile to reach field capacity after wetting.
2 Slowly permeable	Transmission through the least permeable horizon is slow. It would take at least a week or more after wetting for the soil to reach field capacity.
3 Moderately permeable	Transmission through the least permeable horizon is relatively fast, field capacity Is reached between 1–5 days after wetting.
4 Highly permeable	Transmission through the least permeable horizon is very fast, field capacity is reached within 1–12 hours after wetting.

[A]McDonald RC, Isbell RF, Speight JG, Walker J & Hopkins MS (1990) *Australian Soil and Land Survey Field Handbook*, 2nd edition, Inkata Press, Melbourne.

Moody PW & Cong PT (2008) ‘Soil Constraints and Management Package (SCAMP): guidelines for sustainable management of tropical upland soils’, *ACIAR Monograph No. 130*, 86pp

Appendix D Surface soil texture categories

Soil texture codes for the Burdekin and Mackay-Whitsunday catchments were generalised into four categories (sand, loam, clay and other) as described in the table below. The category 'other' incorporates non-soils (e.g. gravel) and non-mineral soils (e.g. peats).

Texture code	Texture description	Notes	Category
AP	sapric peat	non-mineral soil	other
CFS	clayey fine sand	clay content < 10%	sand
CKS	clayey coarse sand	clay content < 10%	sand
CL	clay loam	30–35% clay	loam
CLFS	clay loam, fine sandy	30–35% clay	loam
CLKS	clay loam, coarse sandy	30–35% clay	loam
CLS	clay loam, sandy	30–35% clay	loam
CLZ	clay loam, silty	30-35% clay, with silt 25% or more	loam
CS	clayey sand	clay content < 10%	sand
FS	fine sand	clay content < 10%	sand
FSC	fine sandy; clay	assume 35 % clay	clay
FSCL	fine sandy clay loam	20–30% clay	loam
FSHC	fine sandy heavy clay	> 40% clay	clay
FSL	fine sandy loam	10–20% clay	loam
FSLC	fine sandy light clay	35–40% clay	clay
FSLMC	fine sandy light medium clay	> 40% clay light medium clay	clay
FSMC	fine sandy medium clay	> 40% clay	clay
FSMHC	fine sandy medium heavy clay	> 40% clay	clay
HC	heavy clay	> 40% clay	clay
IP	fibric peat	non-mineral soil	other
KS	coarse sand	clay content < 10%	sand
KSC	coarse sand, clay	5-10% clay	sand
KSCL	coarse sandy clay loam	20–30% clay	loam
KSL	coarse sandy loam	10–20% clay	loam
KSLC	coarse sandy light clay	35–40% clay	clay
KSLMC	coarse sandy light medium clay	> 40% clay	clay
KSMC	coarse sandy medium clay	> 40% clay	clay
KSMHC	coarse sandy medium heavy clay	> 40% clay	clay
L	loam	25% clay	loam
LC	light clay	35–40% clay	clay
LCFS	light clay, fine sandy	35-40% clay	clay
LCKS	light clay; coarse sandy	35–40% clay	clay
LCZ	light clay; silty	35–40% clay	clay
LFS	loamy fine sand	25% clay	sand
LFSY	loam; fine sandy	25% clay	loam
LKS	loamy coarse sand	clay content < 10%	sand
LMC	light medium clay	> 40% clay light medium clay	clay
LMCFS	light medium clay; fine sandy	> 40% clay light medium clay	clay

Texture code	Texture description	Notes	Category
LMCS	light medium clay, sandy	40-45%	clay
LS	loamy sand	clay content < 10%	sand
LSY	loam, sandy	25%	loam
MC	medium clay	> 40% clay	clay
MCFS	medium clay; fine sandy	> 40% clay	clay
MHC	medium heavy clay	> 40% clay	clay
S	sand	clay content < 10%	sand
SC	sandy clay	assume 35 % clay	clay
SCL	sandy clay loam	20–30% clay	loam
SCLFS	sandy clay loam, fine sandy	20-30%	loam
SL	sandy loam	10–20% clay	loam
SLC	sandy light clay	35–40% clay	clay
SLMC	sandy light medium clay	> 40% clay light medium clay	clay
SMC	sandy medium clay	> 40% clay	clay
SMHC	sandy medium heavy clay	> 40% clay	clay
ZC	silty clay	assume 35 % clay	clay
ZCL	silty clay loam	30–35% clay	loam
ZL	silty loam	25% clay	loam
ZLC	silty light clay	35-40% clay	clay
ZLMC	silty light medium clay	> 40% clay light medium clay	clay
ZMC	silty medium clay	> 40% clay	clay
ZMHC	silty medium heavy clay	> 40% clay	clay

Appendix E Sample sites for gap filling program

The following sites were sampled within the Mackay-Whitsunday catchment as part of the gap filling field program. Soils were sampled based on a quality assurance (QA) process, which was conducted across the soil sites within the Soil and Land Information (SALI) database (the corporate database that holds soils and land resource information).

This QA assessment highlighted soil types within cane production areas of the Mackay-Whitsunday catchment only that did not have adequate information for the representative profiles.

A representative soil profile is one which contains the key attributes of a particular soil type. By obtaining comprehensive information on these representative soil profiles, the understanding of that particular soil type is enhanced and the confidence with which this information can be used for further work is greatly increased.

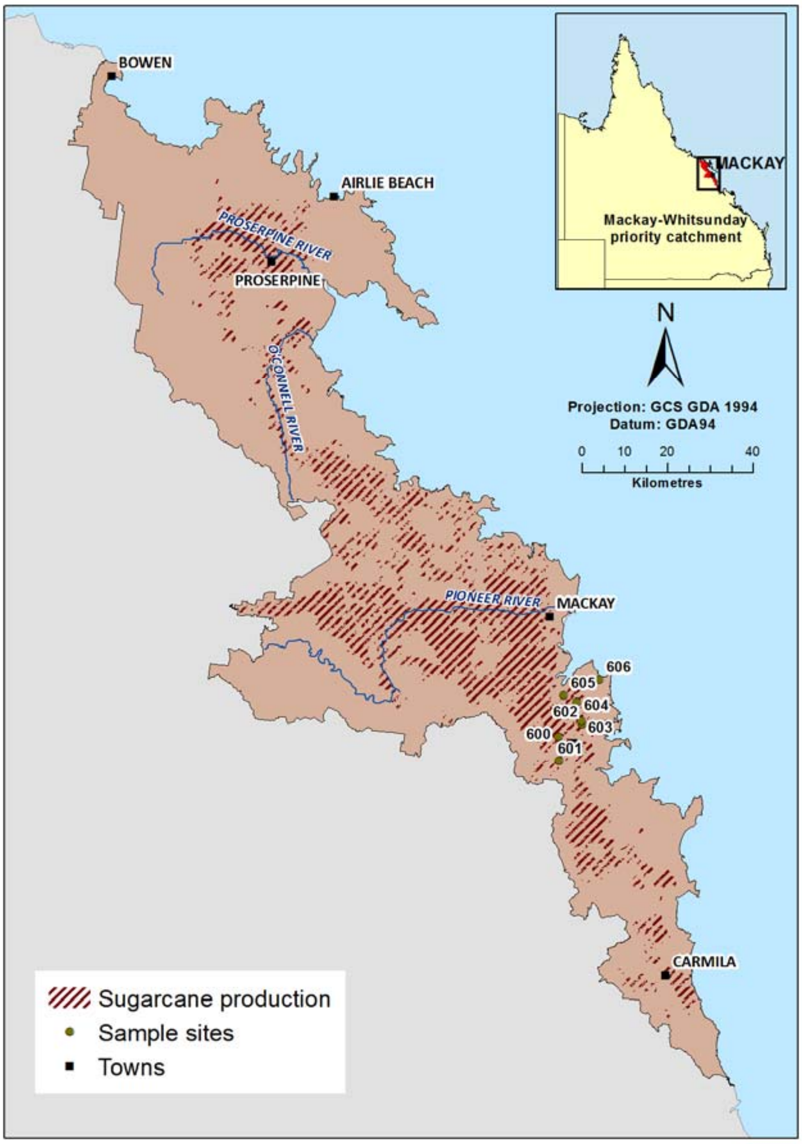

Figure 15. Field sampling sites – Mackay-Whitsunday

Soil type, site number[5]	Description and rationale for sampling	Photo of landscape
Soil name: Eversleigh Australian Soil Classification (ASC): Black Dermosol Project code: SAR Site ID: 600	Revisit of SAR site 146 for sampling under the SALI QA process. This site is considered representative of this soil type. This site was sampled to obtain better chemistry data for this soil type.	
Soil name: Berris ASC: Brown Dermosol Project code: SAR Site ID: 601	Revisit of SAR site 258 for sampling under the SALI QA process. This site is considered representative of this soil type. This site was sampled to obtain better chemistry data for this soil type.	No photo
Soil name: Eversleigh ASC: Black Dermosol Project code: SAR Site ID: 602	Revisit of SAR site 180 for sampling under the SALI QA process. This site is considered representative of this soil type. This site was sampled to obtain better chemistry data for this soil type.	No photo
Soil name: Garrett ASC: Project code: SAR Site ID: 603	Revisit of SAR site 181 for sampling under the SALI QA process. This site is considered representative of this soil type. This site was sampled to obtain better chemistry data for this soil type.	

[5] This is the site number and project code as listed in the Soil and Land Information database (SALI)

Soil name: Haden ASC: Brown Dermosol Project code: SAR Site ID: 604	Revisit of SAR site 85 for sampling under the SALI QA process. This site is considered representative of this soil type. This site was sampled to obtain better chemistry data for this soil type.	
Soil name: Dugeon ASC: Brown Sodosol Project code: SAR Site ID: 605	Revisit of SAR site 96 for sampling under the SALI QA process. This site is considered representative of this soil type. This site was sampled to obtain better chemistry data for this soil type.	
Soil name: Griffiths ASC: Yellow Kandosol Project code: SAR Site ID: 606	Revisit of SAR site 3 for sampling under the SALI QA process. This site is considered representative of this soil type. This site was sampled to obtain better chemistry data for this soil type.	

Appendix F Summary of validation exercise

The table below summarises field observations of sites sampled in the Mackay-Whitsunday catchment and actions taken to rectify data sets, where relevant.

Site no	Field observation	Action taken
0	Water pathway border between well drained and runoff ponding. No discrepancies between observation in field and data sets	None
1	Surface soil texture border between sand and clay. No discrepancies between observation in field and data sets	None
2	Sloped landscape. No discrepancies of what was observed in the field and in data sets	None
3	Cluster of irrigation bores with readings over 1300 EC. Water pathway layer doesn't match common soil layer.	Drainage and permeability attribute are correct in ASRIS soils layer. No action required to the layer used in mapping.
4	Flooded on almost an annual basis. Swamp. No discrepancies between observation in field and data sets.	None
5	Flooded on almost an annual basis. No discrepancies between observation in field and data sets.	None
6	Cane on steep slopes. No discrepancies between observation in field and data sets.	None
7	Check project detail MCL. No discrepancies between observation in field and data sets.	None
9	Pioneer River – active floodplain. No discrepancies between observation in field and data sets.	None
10	Miriani/Marian soils. No discrepancies between observation in field and data sets.	None
11	Pioneer River – active floodplain. No discrepancies between observation in field and data sets.	None
12	Brighly soil. No discrepancies between observation in field and data sets.	None
13	Nabilla soil. No discrepancies between observation in field and data sets.	None
14	Miriani soil. No discrepancies between observation in field and data sets.	None
15	Kinchant soil. No discrepancies between observation in field and data sets.	None
16	Hannon soil. No discrepancies between observation in field and data sets.	None
17	Cane on steep slopes. No discrepancies between observation in field and data sets.	None

18	Sandy soils /groundwater contamination. No discrepancies between observation in field and data sets.	None
19	Victoria Plains soil. No discrepancies between observation in field and data sets.	None
20	Cane on sodosols. No discrepancies between observation in field and data sets.	None
21	Sand over sodic clay. No discrepancies between observation in field and data sets.	None

The table below summarises field observations of sites sampled in the Burdekin catchment and actions taken to rectify data sets, where relevant.

Site no	Field observation	Action taken
1	Beach ridge with sugarcane production adjacent. Landscape features correct. Cane farming not close to beach ridge, area covered with treed vegetation. No discrepancies of what was observed in the field and in data sets.	None
2	Boundary between well drained area and an area which is prone to runoff/ponding. Landscape features correct. No discrepancies of what was observed in the field and in data sets	None
3	Large area of well drained soils in close proximity to the coast. No discrepancies of what was observed in the field and in data sets.	None
4	Area of drainage – in close proximity to a swamp and stream channel. Landscape features correct. No discrepancies of what was observed in the field and in data sets.	None
5	Small area of drainage with a sandy surface soil texture in between large area dominated by runoff and clay surface soil textures. Area is a slight sandy ridge. Landscape features correct. No discrepancies of what was observed in the field and in data sets.	None
6	Cane in close proximity to salt flats. Soil type is different between the common soils and ASRIS layers.	Drainage and permeability attribute are correct in ASRIS soils layer. No action required to use this layer to produce the water pathway and surface soil texture mapping.
7	Large area of drainage close to stream. Landscape features correct. No discrepancies of what was observed in the field and in data sets.	None
8	Border between drainage and runoff – close to stream. Landscape features correct. No discrepancies of what was observed in the field and in data sets	None
9	Cane on Rudosol, next to Burdekin river, area of drainage. Landscape features correct. No discrepancies of what was observed in the field and in data sets	None

10	Large area of heavier textured soils – Vertosols. Landscape features correct. No discrepancies of what was observed in the field and in data sets	None
11	Presence of a mapped eroded land unit. Mapped eroded land is a swamp. No visible signs of erosion. Seems to be a depositional environment rather than an erosional one.	This unit needs to be mapped out as a swamp rather than mapped eroded land.
12	Cane on large area of Sodosols (BRIA). Landscape features correct. No discrepancies of what was observed in the field and in data sets	None
13	Cane on large area of Vertosols (BRIA). Landscape features correct. No discrepancies of what was observed in the field and in data sets.	None
14	Mapped eroded land. Visible signs of gullies and scalds. Landscape features correct. No discrepancies of what was observed in the field and in data sets	None
15	Mapped eroded land – moderate slopes. No signs of erosion however may have been incorporated into the farm.	Need to make it clear that mapped eroded land units were mapped historically and due to farm management i.e. filling in erosion for farm development – this may not be the case now.
16	Sodosol on cane near mapped eroded land, No evidence of erosion. This area is a swamp.	This unit needs to be mapped out as a swamp rather than mapped eroded land.
17	Need to check water pathway as soil is Dermosol with a water pathway of drainage. Buried sandy layers in this soil which may increase drainage and permeability.	None
18	Mapped eroded land. Area largely follows drainage lines which may have been previously eroded.	Need to make it clear that mapped eroded land units were mapped historically and due to farm management i.e. filling in erosion for farm development – this may not be the case now.
19	Large area of Chromosols. Landscape features correct. No discrepancies of what was observed in the field and in data sets.	None
20	Beach ridge. Very clear unit which is not under cane production. Landscape features correct. No discrepancies of what was observed in the field and in data sets.	None
22	Large well drained area. Landscape features correct. No discrepancies of what was observed in the field and in data sets.	None
23	Large area of Vertosols. Landscape features correct. No discrepancies of what was observed in the field and in data sets.	None
24	Cane production in close proximity to creek. Landscape features correct. No discrepancies of what was observed in the field and in data sets.	None