Top End Waterways Project

ROPER RIVER CATCHMENT

An Assessment of the Physical and Ecological Condition of the Roper River and its Major Tributaries

Technical Report No. 36/2001

J.J. Faulks
Natural Resources Division
Department of Lands, Planning and Environment
Katherine, NT

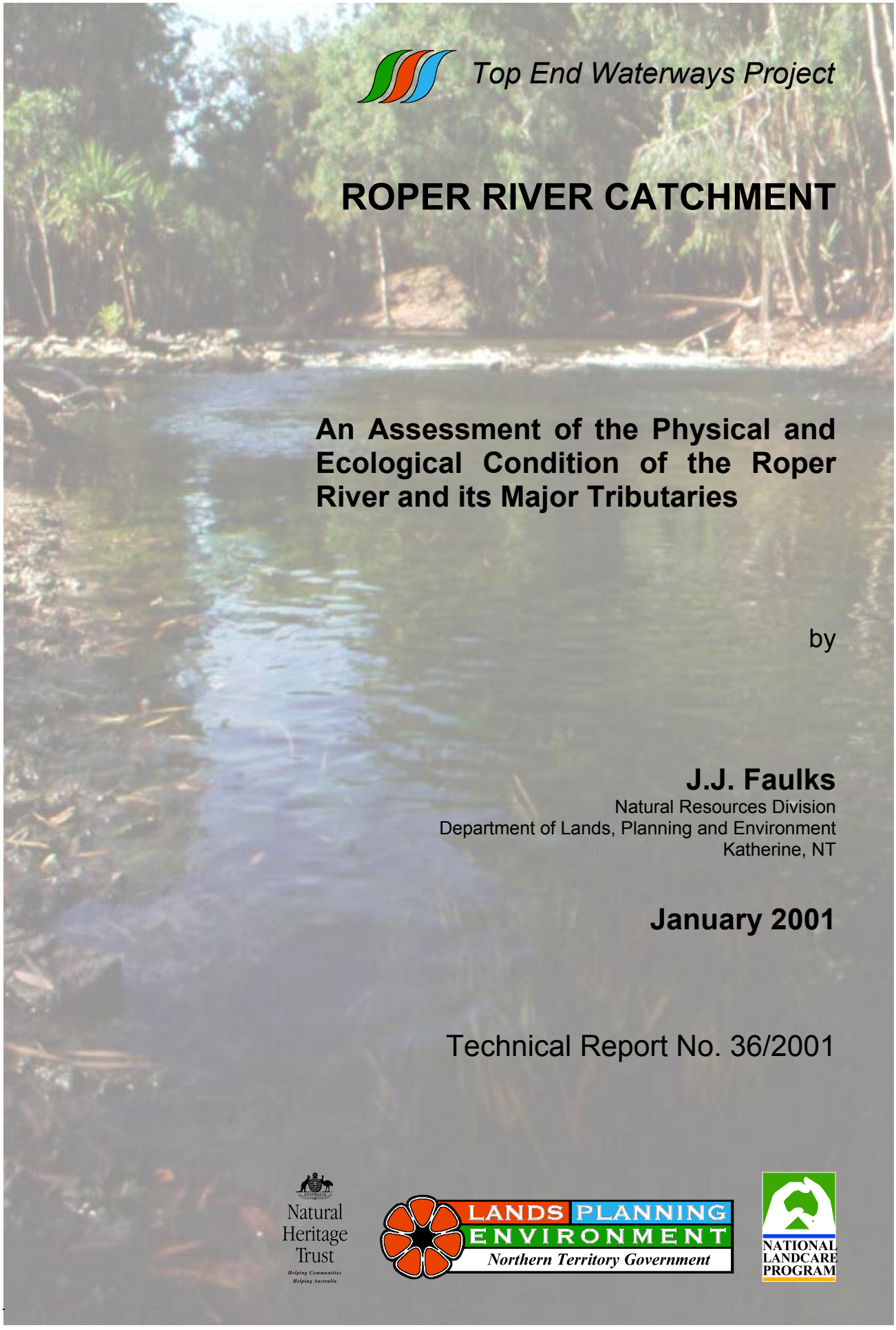
January 2001

Natural Heritage Trust
Helping Communities Helping Australia

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATIONAL LANDCARE PROGRAM

Central photograph front cover: *Aerial view of Roper River and environs along Red Lily Lagoon (also called 2-Mile Waterhole)*



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The report is available from the Parks and Wildlife Commission of the Northern Territory (PWCNT) Library, the AZRI Library in Alice Springs and the National Library, Canberra, through interlibrary loan.

The report, both as a hard copy and in digital form (as a pdf), may also be obtained from the Katherine Regional Office of the Department of Lands, Planning and Environment (DLPE). Inquiries should be addressed to:

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Acknowledgements

The project commenced in July 1998 and has been partly funded by the Natural Heritage Trust. I was employed to undertake the field assessment of the Roper River and major tributaries; produce a database to store the information collected and assist with data analysis; and to produce a report and associated maps detailing findings and management issues.

The field surveys were conducted between August to November 1998 and April to July 1999. The following people assisted me with my field survey work:

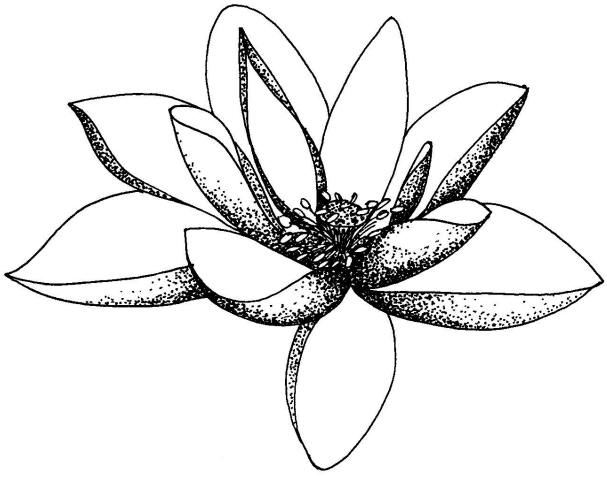
Chris Heydon
Kenneth Nayda
Murray Knyvett
Kenny Murray (T.O. from Bulman)

At times the survey work was 'challenging' and the helpfulness of everyone throughout the field surveys was extremely appreciated. The great sites and experiences will never be forgotten.

The contribution made by the following people was very much appreciated:

I am extremely grateful to Redgum Technology for the tireless effort made in designing and implementing the database and associated queries. The GIS support, mapping and vegetation sketches were provided by Caroline Green DLPE (Katherine), whose attention to detail and expertise was extremely appreciated. Data entry and general assistance was provided by Jenny Orton, Megan Morris and Gwen Anderson. Flow and water quality data was supplied by Simon Cruickshank, Bob Masters and Peter Dostine, DLPE (Darwin). Support, information and water quality data, collected as part of the 'Ausrivas Project', was supplied by Jane Suggit, previously DLPE (Darwin). Background information was supplied by various people within DLPE (Darwin), the Roper River Landcare Group Co-ordinator, PWCNT and DPI&F. Stream ordering was undertaken by Dave Williams, DLPE (Darwin). Regrouping of landform information was undertaken by Miriam Lang, DLPE (Katherine). Identification of the large quantity of vegetation samples was carried out by the NT Herbarium (PWCNT). Support, information and comments were also supplied by a number of other DLPE staff members within the Katherine and Darwin offices as well as the Roper River Landcare Group, Roper River Best Practice Group, PWCNT, DPI&F and Northern Territory University. I am very thankful for the time and effort made by Steven Tickell and Caroline Green (interactive maps) in creating a CD for this project.

I am very grateful to the property owners/managers and Aboriginal communities who allowed access to the survey sites located on their lands and provided background information on the rivers and creeks.



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EXECUTIVE SUMMARY

Overview

The 'Top End Waterways Project (Mark 2)' commenced in 1998 and has been jointly funded by the Natural Heritage Trust and the Northern Territory Government. The Department of Lands, Planning and Environment has overseen the project.

The overall aim of the project was to assess, describe and report on the land and water resources of the major waterways in the Katherine Region of the Northern Territory and to prepare for publication a comprehensive report on each of those waterways. As part of a previous study, the major tributaries within the Daly River and Victoria River catchments were assessed throughout 1995-1997. This report provides an assessment of the Roper River catchment and major tributaries, in terms of the physical and environmental condition of these streams at the time of survey. The use and management of the waterways within the Roper River catchment have been identified, major river management issues have been highlighted and broad river management recommendations have been proposed.

The general methodology framework that has been adapted for this project was developed by J.R. Anderson for the Queensland Department of Primary Industries, where it is currently used to assess river condition and stability on a catchment by catchment basis. From the Qld 'State of the Rivers' methodology, the 'Top End Waterways Project' adapted the sampling strategy, survey methods and data collection sheets. The condition and stability ratings developed by J.R. Anderson were reviewed and modified by a NT Technical Working Group so that the results would reflect Northern Territory conditions. Section 3 discusses in more detail the methods used including the sampling strategy, survey components and the condition and stability ratings.

It is expected that the main users of the information provided by this project will be the Northern Territory Government and other groups interested in waterway management, including landcare and community groups, best practice groups and property owners or managers.

The information provided by this project is intended to assist in developing regional and catchment management strategies. Linkages to other projects and initiatives that address other issues relating to rivers is important to aid overall river management decision-making processes. The 'Top End Waterways Project' has established links with, for example, the Ausrivas project and riparian vegetation assessments by overlapping survey sites with those projects in order to allow possible correlations to be drawn between these studies. Linkages to long term water flow and quality databases (eg Hydsys), vegetation databases, Wild Rivers assessments would also prove useful.

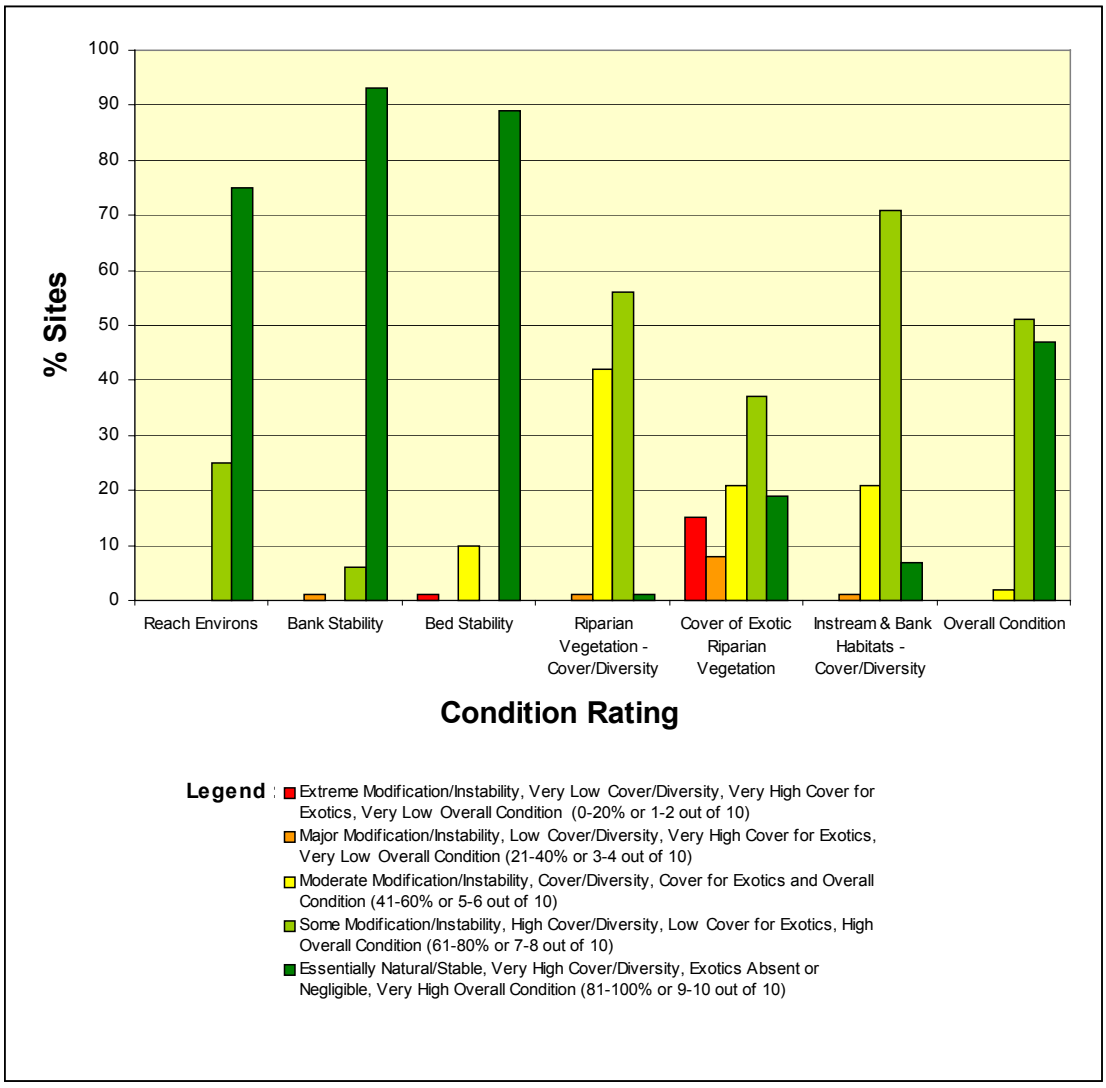
The project will help to identify key issues, problems and priorities with the rivers. It will also help to recognise the extent, processes and causes of river degradation and thereby pinpoint actions that would have to be taken in order to reverse any deterioration. Rivers and creeks that are showing signs of degradation (eg weed infestation, accelerated erosion, concentrated use, *etc*) will be highlighted as requiring more specific river management guidelines or plans.

The project, through the collection of baseline data, provides a reference point or "snap-shot" of what the rivers and creeks are like now. Follow-up surveys of rivers in priority areas would need to be carried out over time in order to look at the rate of change in condition and stability. The project therefore can be used as a monitoring tool.

Summary of Roper River Catchment Condition

Maps 10-25 show the results for the condition and stability ratings and other attributes examined.

A summary of the condition and stability rating results recorded for the Roper River Catchment are shown below:



- *Reach Environs and Site Features*

Three-quarters of sites assessed were rated as having essentially natural reach environs, while one-quarter had some modification to the reach environs. Generally, the sites with essentially natural reach environs had relatively low impact land uses, undisturbed vegetation and few local disturbances. Those sites that had some modification to the reaches recorded local disturbances (ie grazing, concentration of animals at watering points, tracks, roads, river works and causeways) that reduced the ratings from essentially natural.

Subjective disturbance ratings indicated that over three-quarters of the sites recorded a low to very low disturbance level with respect to the reach environs. Very few sites were moderately disturbed and no sites were highly, very highly or extremely disturbed. A low or low to moderate disturbance rating meant that the riparian vegetation was generally intact but was being impacted on by things like stock/feral animals (eg trampling, grazing, watering), people, clearing for cattle watering points, infrastructure (eg tracks, crossing, pumps, buildings), exotic vegetation, severe flooding and bank erosion.

The majority of land adjacent to stream reaches studied was under either freehold or leasehold tenure, including Aboriginal land. The major land uses recorded adjacent to the streams in the catchment was grazing on virgin native pasture or Aboriginal land. Grazing activity, roads/tracks and watering points for stock and feral animals were the three major disturbances to stream reaches.

- *Channel Habitat Types, Diversity and Dimensions*

Reaches studied averaged 1,819m in length. Pools were the dominant type of habitat located throughout the catchment. Pools also dominated the reach lengths, averaging 73%. Riffles and runs were also quite prevalent and occurred at over half the sites. Waterfalls were associated with areas of steeper topography (eg gorge systems, tufa formations and upper catchment sites) and were found on Arnold, Roper and Waterhouse Rivers and Flying Fox Creek. Cascades were also associated with steeper river sections, gorge systems and tufa formations and were recorded on Arnold, Hodgson, Roper, Strangways and Wilton Rivers, and Bella Glen and Maiwok Creeks. Rapids were found along Roper and Wilton Rivers.

When the sites were assessed for their variability or diversity of channel habitat types, over half the sites rated highly and nearly one-quarter of sites rated very highly. Sites recording a high channel type diversity had mostly two habitat types present although the proportion of the reach occupied by habitats other than pools was mostly between 10-30% or >30%, which increased the diversity ratings for these reaches. Reaches with a very high diversity of channel habitat types were associated with rocky, steeper sections or sections where the number of habitat types recorded was three to five and the proportion of the reach occupied by non-pool habitats was either 10-30% or >30%.

Sites recording moderate channel type diversity (ie two habitat types with <10% of the reach occupied by riffles, runs or cascades) were located on Roper River at Red Rock, Rocky Bar Crossing, 57-Mile Waterhole, Red Lily Lagoon (also called 2-Mile Waterhole) and along lower Hodgson River. The mid- to lower tidal reaches on Roper and Phelp Rivers and Painnyilatya Creek rated low or very low with regard to channel type diversity because only uniform, tidal pools existed. Other reaches that recorded very low or low diversity of channel types were located on Elsey Creek (near Roper Highway) which recorded a uniform, intermittent pool, and Minyerri Billabong, which was isolated from Hodgson River.

- *Bank Condition and Stability*

The majority of river banks throughout the catchment were stable with a few (ie 5 sites) that had limited instability. Only one site recorded river banks that were suffering from extensive instability (ie Site 1d/6 – an arm of Roper River that is undergoing extensive channel widening). A subjective assessment of bank stability indicated that the majority of sites recorded minimal to low overall bank instability. Whereas, one-third of sites had low-moderate to moderate bank instability, and only one site recorded a high overall bank instability. Similar percentages were recorded for the susceptibility of banks to erosion.

Even though the river banks were mostly stable, some form of erosion processes were recorded at the majority of sites, whilst aggradation along the river banks was confined to only a few sites. Lower banks were more stable than upper banks with an average of 95% and 88% of the bank length respectively being recorded as stable. The erosion was occurring mostly at obstacles, outside bends and irregularly. Aggradation was predominantly irregular, all along or at inside bends.

The major factor affecting bank stability was high flow, recorded at nearly three-quarters of sites, and to a lesser extent, stock, vermin and infrastructure (ie roads, tracks, river crossings, culverts, bridges, *etc*). The only types of artificial bank protection measures recorded were fencing along the river and/or at stock watering points, which occurred at several sites, and rock treatment at one site.

- *Bed and Bar Condition and Stability*

An assessment of the overall bed stability indicated that the majority of sites had stable river beds, while nine sites recorded moderate bed aggradation and one site recorded severe bed erosion problems. Moderate bed aggradation was located on Waterhouse River (4 sites), Wilton and Mainoru Rivers and Flying Fox Creek (2 sites) and Cattle Creek. These site reaches had relatively flat, uniform and shallow river beds, large sandy bars and were transporting a large amount of sediment (ie sands). The site recording severe erosion problems, including both bed and bank erosion, was located on an arm of Roper River (Site 1d/6) that has been receiving an increased volume of flow and, as a result, is widening and deepening.

Bars were widespread and were recorded at nearly three-quarters of sites, averaging 17% of the bed and ranging to as high as 70%. Bars with encroaching vegetation and alternate/side irregular bars were the two most prevalent bar types.

There were relatively few sites where bed stability was being impacted on. The major factor that was considered to affect bed stability, although only recorded at 8% of sites, was instream siltation.

- *Bed and Bank Sediments*

A range of size classes, from clays to boulders, was recorded for river beds. Pool and run habitats had a higher proportion of smaller bed sediments; riffles had a range of bed sediment sizes; rapids and cascades had a higher proportion of larger bed sediments; and waterfalls had boulder beds. The sediments along the lower and upper banks for all habitat types consisted mainly of smaller sediment sizes, except cascade and waterfall habitats, which had a higher proportion of boulders. Lower and upper banks consisted mainly of clays and small sand. Organic material was present in both bed and bank material.

- *Riparian Vegetation*

Over half the reaches assessed were rated as having riparian vegetation that had a high cover and structural diversity with less than half the reaches being rated has having moderate cover and structural diversity. The reach recording a very high cover and structural diversity for the riparian vegetation was located along Roper River at Red Lily Lagoon (also called 2-Mile Waterhole), and a lower estuary site dominated with mangroves had riparian vegetation with a low cover and diversity.

The results provide an indication of how structurally diverse and dense the riparian vegetation is throughout the catchment. Generally the riparian vegetation is relatively in tact and has not been impacted on by extensive clearing or development, although stock and vermin activity, and infrastructure were recorded as factors affecting river banks to varying degrees at between 21-37% of sites.

The average width of the riparian zone was 30m, which can be considered to be the 'natural' width because the riparian vegetation is generally in tact and little clearing has occurred. Those sites that recorded a riparian zone width of >31m were mostly located on the Roper, Wilton, Hodgson, Phelp and Mainoru Rivers and Flying Fox and Elsey Creeks. Very narrow riparian zones (<5m wide) were located on sections of Maranboy Creek and Strangways River.

Throughout the catchment, grasses and regenerating trees were present at all sites. Woody shrubs, forbs, trees (2-30m) and vines were very prevalent and were present at >90% of sites. Rushes and sedges were present at over half the sites whereas palms, mangroves, phragmites, ferns and trees taller than 30m varied in their prevalence and distribution. Trees (2-30m tall) and grasses dominated the riparian vegetation providing the highest covers. The other structural categories each averaged <10% cover. The overstorey (that is, trees and shrubs greater than 1.3m tall) provided a greater cover than the understorey (or ground cover) vegetation.

Eucalyptus camaldulensis was the most widespread native overstorey species. *Pseudoraphis spinescens* (Spiny Mudgrass) was the most prevalent native ground cover species. The palm species, *Livistona rigida*, which has a limited distribution in the NT, was recorded along sections of Roper and Waterhouse Rivers, and Roper, Bella Glen and Elsey Creeks. Mangrove species were confined to the Roper River estuary.

Exotic riparian vegetation species were widespread being recorded at over three-quarters of sites. Noxious vegetation species were located at nearly half the sites. The number of different types of exotic species recorded at any one site ranged from 0-8. Of the 30 different exotic species recorded, 12 are declared noxious within the NT. Just over one-third of sites recorded a low level of invasion by exotic vegetation species (between 1-5% cover), whereas nearly half the sites (44%) recorded a greater level of invasion (>5% cover and up to 34%). Exotic riparian vegetation covers ≥16% were recorded along Roper River (3 sites), along upper Wilton River (3 sites), and 1-2 reaches on Mainoru, Strangways and Hodgson Rivers and Flying Fox and Maiwok Creeks.

Overall, exotic species within the riparian zone averaged 7% cover and were predominantly vines and forbs. *Passiflora foetida,* a naturalised vine, and *Hyptis suaveolens* were the two major species recorded throughout the catchment and were recorded at 62% and 31% of sites, respectively.

Other notable exotic species included *Parkinsonia aculeata, Melochia pyramidata*, *Sida acuta*, *Calotropis procera* and *Pennisetum pedicellatum*.

Passiflora foetida was very widely distributed being recorded in all sub-sections except for Jalboi River, although covers were generally low (1-5%). Higher covers for *Passiflora foetida* were recorded along Roper River at 12-Mile Yard and further downstream below Elsey Falls where the riparian vegetation had been disturbed following the 1998 floods. Of the noxious species, *Hyptis suaveolens* had a relatively wide distribution, although covers were generally low. Higher covers for Hyptis were recorded from upper Wilton River, Mainoru, Jalboi and Waterhouse Rivers and Flying Fox and Derim Derim Creeks. Parkinsonia was restricted in its distribution and was recorded along 57-Mile Waterhole on the Roper River upstream to within Elsey National Park, as well as along sections of Roper River estuary and Longreach Waterhole on Elsey Creek. Low covers were recorded for Parkinsonia (ie between 1-5%).

- *Aquatic Vegetation*

Over three-quarters (84%) of sites recorded the presence of aquatic vegetation. Emergent aquatic vegetation was more widespread (78% of sites) than submerged vegetation (54% of sites) and covers were generally high for both types (ie between 11-15% on average). Floating vegetation was more scattered in its distribution and was found at 12% of sites.

Phyla nodiflora (Lippia), located on Elsey Creek, was the only aquatic vegetation species recorded that was exotic and recorded a cover of 18%.

Both emergent and submerged aquatic vegetation types were present in all sub-sections except Jalboi River, in which submerged aquatic vegetation was not recorded. All Roper River sites, except for the lower tidal section, recorded moderate to very high covers for submerged aquatic vegetation. Floating vegetation recorded a limited distribution throughout the catchment and was recorded at Minyerri Billabong, Arnold River, Longreach Waterhole on Elsey Creek, Strangways River at Rocky Hole Yard, and sections of Roper, Bella Glen and Beswick Creeks, and Roper, Chambers (arm of) and Wilton Rivers.

- *Instream and Bank Habitats*

Nearly three-quarters of sites were rated as having high cover and diversity of instream and bank habitats, while nearly one-quarter of sites rated moderately. A section on Western Creek rated the worst in the Roper River catchment. The sites recording very high cover and diversity of instream and bank habitats were located on Roper River and a section along Wilton River. Over three-quarters of sites were subjectively rated as having a good to very high overall aquatic rating.

The most commonly occurring instream cover types included branches, leaves and twigs, tree roots, logs, permanent pools deeper than 1m and rock faces. Stream bed cover provided from the banks was dominated by vegetation canopy cover, vegetation overhang which was less than 1m from the water and root overhang. The canopy cover occurred along a mean of 76% of the bank length.

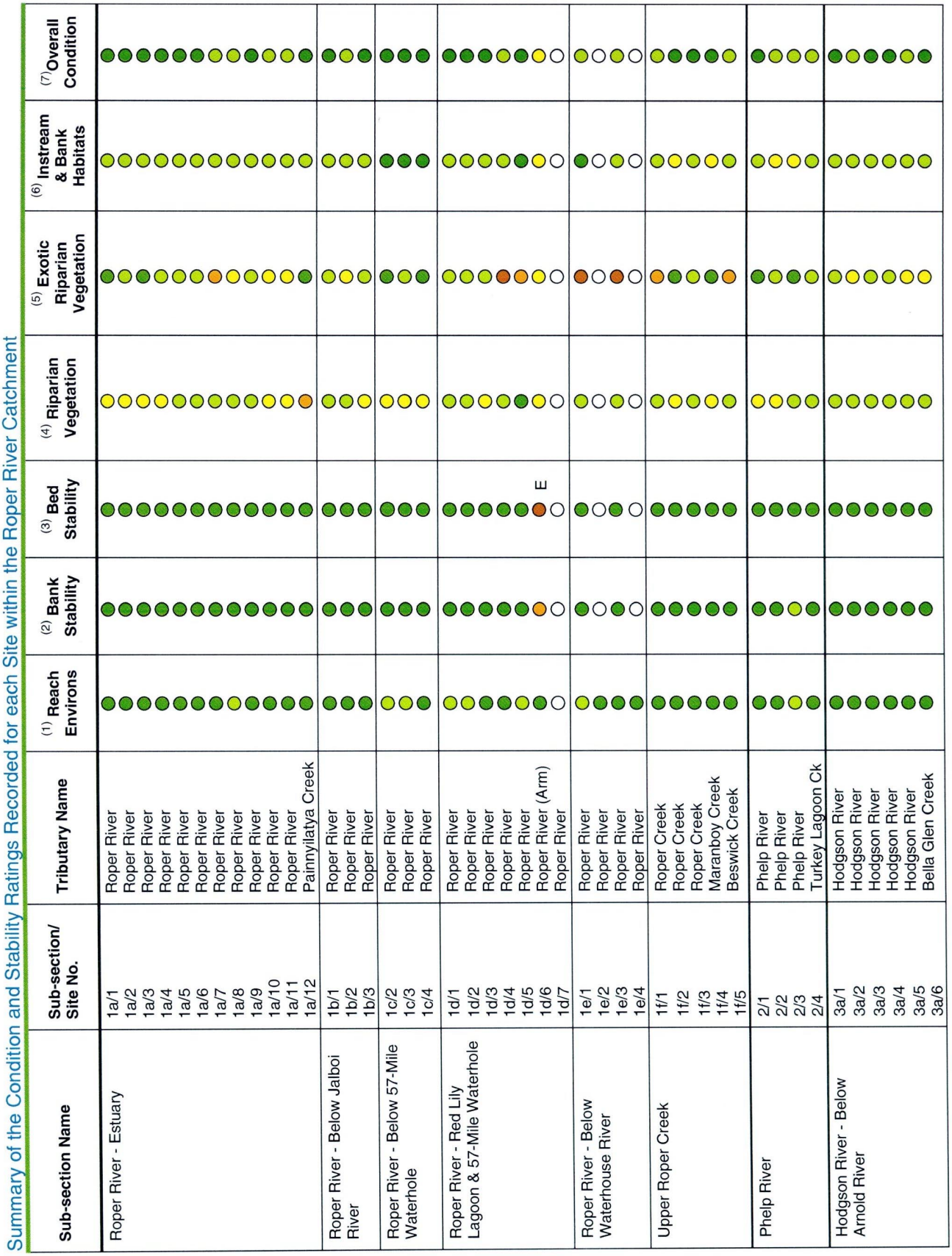
Passage for aquatic organisms at nearly half the sites was generally partly to very restricted at the time of the survey, although nearly one-quarter of sites had no passage. Assessments of passage at the water mark indicated that some form of restriction remained at half the sites, while 6% of sites had no passage.

- *Overall Condition*

The majority of sites recorded either a high overall condition rating (51% of sites) or a very high overall condition rating (47%). No sites were rated as being degraded overall. Reaches that rated very highly overall were located within all sub-sections except for Mainoru and Waterhouse River sub-sections. Two reaches recorded a moderate overall condition, the worst rating in the catchment, and these were located on the West Branch of Wilton River and an arm of Roper River downstream of Little Red Lily Lagoon.

Summary of Roper River Sub-catchments Condition

A summary of the condition and stability ratings recorded for each site is shown below.



Sub-section Name	Sub-section/ Site No.	Tributary Name	(1) Reach Environs	(2) Bank Stability	(3) Bed Stability	(4) Riparian Vegetation	(5) Exotic Riparian Vegetation	(6) Instream & Bank Habitats	(7) Overall Condition
Hodgson River - Above Arnold River	3b/1	Hodgson River							
	3b/2	Hodgson River							
	3b/3	Hodgson River							
Arnold River	4/1	Arnold River							
	4/3	Arnold River							
Wilton River - Below Mainoru River	5a/1	Wilton River							
	5a/2	Wilton River							
	5a/4	Wilton River							
	5a/5	Wilton River							
Wilton River - Above Mainoru River	5b/1	Wilton River							
	5b/2	Wilton River							
	5b/3	Wilton River							
	5b/4	Wilton River							
	5b/5	Wilton River- West Branch			A				
Mainoru River	6/1	Mainoru River							
	6/2	Mainoru River							
	6/3	Mainoru River							
	6/5	Mainoru River			A				
Jalboi River	7/1	Jalboi River							
	7/2	Jalboi River							
	7/3	Jalboi River							
	7/4	Quibobikwi Creek							
Flying Fox Creek	8/1	Flying Fox Creek							
	8/2	Flying Fox Creek							
	8/3	Flying Fox Creek			A				
	8/4	Flying Fox Creek			A				
	8/5	Flying Fox Creek							
	8/6	Derim Derim Ck							
Maiwok Creek	9/1	Maiwok Creek							
	9/2	Maiwok Creek							
	9/3	Maiwok Creek							
	9/4	Maiwok Creek							
Strangways River	10/1	Strangways River							
	10/2	Strangways River							
	10/3	Strangways River							
	10/4	Strangways River							
	10/5	Cattle Creek			A				
Chambers River	11/1	Chambers River							
	11/2	Chambers River							
	11/3	Chambers R (Arm)							

Sub-section Name	Sub-section/ Site No.	Tributary Name	(1) Reach Environs	(2) Bank Stability	(3) Bed Stability	(4) Riparian Vegetation	(5) Exotic Riparian Vegetation	(6) Instream & Bank Habitats	(7) Overall Condition
Elsey Creek	12/1	Elsey Creek							
	12/2	Elsey Creek							
	12/3	Western Creek							
	12/4	Birdum Creek							
Waterhouse River	13/1	Waterhouse River			A				
	13/2	Waterhouse River			A				
	13/3	Waterhouse River			A				
	13/4	Waterhouse River - West Branch							
	13/5	Waterhouse River			A				

Legend:

- Essentially Natural (1); Stable (2) and (3); Very High Cover/Diversity (4) and (6); 0% Cover for Exotics (5); and Very High Overall Condition (7). ***(Rating 81-100%)***
- Some Modification (1); Limited Instability (2); High Cover/Diversity (4) and (6); 1-5% Cover for Exotics (5); and High Overall Condition (7). ***(Rating 61-80%)***
- Moderate Modification (1); Moderate Instability (2); Moderate Erosion (E) or Aggradation (A) (3); Moderate Cover/Diversity (4) and (6); 6-10% Cover for Exotics (5); and Moderate Overall Condition (7). ***(Rating 41-60%)***
- Major Modification (1); Extensive Instability (2); Low Cover/Diversity (4) and (6); 11-15% Cover for Exotics (5); and Low Overall Condition (7). ***(Rating 21-40%)***
- Extreme Modification (1); Extreme Instability (2); Severe Erosion (E) or Aggradation (A) (3); Very Low Cover/Diversity (4) and (6); 16-32% Cover for Exotics (5); and Very Low Overall Condition (7). ***(Rating 0-21%)***
- Site Not Assessed

Conclusions, Broad Management Issues and Recommendations

The five major issues identified within the Roper River catchment are:

- Level of weed invasion of the riparian zone (13 sub-sections);
- Disturbances to reach environs and river banks from such things as grazing, animal watering points, infrastructure (eg roads, tracks and crossings), high flows and people (8 sub-sections);
- Impact on river banks, river beds and reaches by feral animals (8 sub-sections);
- Bed aggradation (5 sub-sections); and
- The need to recognise and conserve significant riverine areas and habitats including the *Livistona rigida* palm community, river reaches containing tufa formations and sections along Arnold River including Minimere Lagoon and associated gorge system, and a large waterhole near the abandoned Cox River homestead.

The major conclusions that can be drawn from the survey of the Roper River and its tributaries, including broad management issues and recommendations, are:

1. Overall, the condition of the majority of rivers and creeks studied throughout the Roper River catchment was very good.

When all six components that make up the overall condition rating were taken into account river reaches rated highly. Even though the overall condition rating results were relatively consistent, the six components that make up the rating did vary extensively. The major issues identified meant that generally the waterways were physically stable, although sections were experiencing bed aggradation problems or, in one instance, bed erosion problems. Reach environs and river banks were being impacted upon by such things as stock and vermin, who were utilising rivers to water, graze and shelter; infrastructure like tracks and river crossings; high flows; and people. These disturbances often caused localised erosion problems. The degree of modification to the reach environs reflected the fact that intensive development along floodplains for agriculture, horticulture or extensive clearing did not exist. The riparian vegetation was relatively intact and the cover and structural diversity was generally moderate or high. Instream and bank cover varied. The degree of invasion of the riparian zone by exotic species also varied greatly.

The two sites (Wilton River – West Branch and an arm of Roper River downstream of Little Red Lily Lagoon) that recorded a below average condition rating were physically unstable, ecologically not as diverse and had riparian zones that were invaded by exotic species.

As the overall condition of the reaches surveyed was high, there is an opportunity to monitor for any deterioration in this high status over time.

2. Very few sites recorded reach environs that were unimpacted even though three-quarters rated as being essentially natural.

The degree of modification to the reach environs depended on the level of intensity of the land use and the types and extent of local disturbances. Grazing was the major land use and disturbance factor recorded throughout the Roper River catchment. Even though this grazing did cause localised problems along waterways it is generally less disturbing to the reach environs than extensive clearing and development for rural or urban residential areas or cropping (including broadacre cropping and horticulture). Only small areas that border waterways, on one side only, have been cleared for cropping purposes and these were located near Mataranka, although the reach environs were still in good condition. The other main disturbances to reach environs, besides the impact from stock and vermin using waterways to graze, water and shelter, included infrastructure and people causing localised problems.

Steps to ensure that the river corridor and reach environs are kept intact need to be implemented. Any regional strategy should ensure that the riparian vegetation is protected, ad hoc access points and river crossings are restricted, fencing and off-river watering points for stock are encouraged and that weed invasion of the riverine environment is managed. As a general rule, in the future any areas where:

(i) land uses and disturbances to the reach environs becomes more intensive and diversified through increased agricultural activity (eg cropping and horticulture);

(ii) clearing of floodplains occurs; and
(iii) the sub-division of lands bordering rivers and creeks into smaller units or rural residential blocks occurs,

the modification to the reach environs will change (rate lower) over time from being essentially natural to having some or a greater level of modification. It will, therefore, be important to particularly monitor the state of the reach environs in areas where (i), (ii) and (iii) (mentioned above) are occurring.

3. The majority of river banks throughout the catchment were stable.

Monitoring the proportion of bank lengths that are stable, eroding or aggrading assists with monitoring the extent of change in bank stability over time throughout the catchment. It will also be possible to make the link between bank stability and whether any increase in the rate or extent of erosion or sedimentation can be attributed to human activities within the catchment.

Nearly all river banks surveyed throughout the Roper River catchment were stable, however, some form of erosion was recorded at most sites. Of the few sites that recorded limited bank instability problems, most were also suffering from bed aggradation problems. The only site to record a below average bank stability rating was suffering from extensive erosion (ie channel widening and deepening). High flow, associated with the wet season, was contributing to the erosion of river banks as was stock and vermin accessing the streams to water, shelter or graze. Infrastructure, such as roads, tracks and crossings, was identified as the fourth major factor affecting bank stability and, in several instances, was the cause of localised bank instability problems.

The high level of bank stability recorded throughout the catchment is reflected in the fact that the riparian vegetation is relatively in tact and has not been impacted on by extensive clearing or development.

Bank protection measures, such as controlled stock access points to rivers and fencing along rivers, were present at few sites at the time of this survey. If, over time, there is deterioration in the stability of the river banks, practices like those mentioned above will need to be encouraged. River reaches containing important riparian habitat or unique riparian vegetation communities, in particular the *Livistona rigida* palm community, should be protected from the impact of stock, feral animals and ad hoc infrastructure (eg tracks).

The fencing of specifically identified riparian areas by members of the Roper River Landcare Group, through Natural Heritage Trust funding, is a reflection of the commitment to protect these important areas. When fencing along rivers does occur, the responsibility for management of the riverine corridor needs to be addressed so that activities, such as, weed and feral animal control and maintenance of fencing does occur.

4. The river beds throughout the catchment were mostly stable.

Most sites surveyed had stable river beds. This high level of bed stability is quite probably linked to low interference to flow and sediment regimes as well as a relatively low level of clearing throughout the catchment. Of the nine sites that were suffering from moderate bed aggradation problems, eight of these were located within or downstream of sandstone country (ie Arnhem Land and Wilton River Plateau and escarpments which consist predominantly of Kombolgie sandstone).

The river systems that fell within the sandstone areas and had aggrading river beds included Waterhouse River, in particular, as well as upper Wilton and Mainoru Rivers and Flying Fox Creek. These reaches were also relatively remote, and, aside from feral animals and fires, had low impact land uses. These river channels were generally very flat, uniform in cross-sectional shape, wide and very shallow in places and were observed to be carrying a large amount of sediment, mostly sands. Large bars and high flow deposits were often very common along the reaches experiencing moderate levels of aggradation. The sandstone rock formations could be a source of sand to these river systems following high flow and runoff events. High flow events would be required to transport this sediment through the river system.

Only one site (ie an arm of Roper River downstream of Little Red Lily Lagoon) recorded severe bed erosion. The extensive changes that are occurring along this reach is possibly due to this section of channel receiving an increased volume of flow when flooding occurs along Red Lily Lagoon. These increased flows have resulted in channel widening and deepening. As a result of these channel alterations, there could possibly be a change in the flow direction through the braided sections of Roper River downstream of Red Lily Lagoon (ie

less flows through Lindsay's Crossing and more flows through this eroded section) and loss of infrastructure, including fences and river crossings, as the channels continue to erode.

A more detailed investigation into the causes and implications of this change in channel size would be necessary to assist with making further management recommendations.

5. The riparian vegetation was relatively intact and predominantly had a high or moderate cover and structural diversity.

Riparian zones are a vital link between land and water environments. Riparian vegetation perform many essential functions, including: the protection of river banks from erosion processes; acting as a buffer or filter for sediments; maintaining good water quality; providing organic material, shade and shelter for instream communities; increasing the physical habitat diversity in aquatic ecosystems; and acting as a wildlife corridor. The effectiveness of the riparian zone in carrying out these functions is significantly influenced by its structural diversity, width and integrity (species diversity, overall cover, and the degree of invasion and impact caused by exotic species).

It was found from this study that the riparian vegetation was relatively intact and had generally not been impacted on by extensive clearing or development. Several factors, of varying degrees, were found to be impacting on the reach environs and river banks at many sites, including grazing/stock activity, vermin, high flows, infrastructure like roads and crossings, and people.

When the cover and structural diversity were assessed, the riparian vegetation rated highly or moderately in all but two instances. The riparian vegetation along Roper River at Red Lily Lagoon contained extensive stands of *Livistona rigida* palms and rated very highly. A mangrove-dominated section along Painnyilatya Creek rated low due to a lack of diversity of structural types and lower covers. The results showed that the diversity of the different vegetation structural types present (eg small or large trees, palms, woody shrubs, forbs, grasses, vines, *etc*) generally rated higher in the majority of cases than did the cover provided by these structural types.

Although most sites recorded the presence of many structural types, aside from trees (2-30m tall) and grasses, most structural categories recorded low covers. Overstorey and understorey vegetation (trees and shrubs >1.3m) generally provided a greater cover than did ground cover vegetation, although sites within Elsey, Flying Fox, Maiwok and Roper Creeks, and Arnold, Chambers, Strangways and Hodgson River sub-sections had grass-dominated riparian vegetation communities. Possibly, the density of shrubs and ground covers is naturally low due to seasonal aspects. Continual high flows over the wet season and deposition of sediment during this period, or water availability or fires during the dry season, may influence the occurrence of ground covers and, therefore, the structural diversity and covers recorded.

The cover and structural diversity of the riparian vegetation varied somewhat, even in instances when the stability of the river banks did not vary. River bank stability does influence the condition of the riparian zone but, as has been shown in these results, other factors were also contributing to the cover and diversity of the riparian vegetation. These factors may include aspects like water availability, climate and location within the catchment.

The average width of the riparian zone throughout the catchment was 30m. The width of riparian vegetation is the 'natural' width at most sites and, therefore, this width can be used as a guideline for planning or recommending appropriate buffer zone widths throughout the catchment. From this study the following average riparian vegetation widths and ranges were recorded for the three stream sizes (as categorised on Map 8 ' Stream Orders'):

- Minor streams (stream orders 1 and 2) – 19m (range 3-48m)
- Medium-sized streams (orders 3 and 4) – 28m (range 7-87m)
- Major streams (stream orders 5 and 6) – 40m (range 13-200m)

Larger bands of vegetation are required along larger streams. The size of the buffer zone should, therefore, reflect the size of the stream. Any recommended riparian buffer zone widths should aim to protect and provide a buffer for the stream channels and associated riparian vegetation.

Further interpretation of the vegetation species found throughout the catchment is also required in order to identify important or unique riparian vegetation communities. Once identified, steps should be taken to ensure that these riparian vegetation communities are protected. The *Livistona rigida* palm is an important species with a very limited distribution within the Northern Territory and, as such, larger stands should be protected. *Livistona rigida* was recorded along sections of Roper and Waterhouse Rivers, and Roper, Bella Glen and Elsey Creeks.

6. The distribution of exotic riparian vegetation was widespread and was a major issue.

Weed invasion of the riparian zone was identified as a major issue. Exotic vegetation species, particularly vines and forbs, were widely distributed throughout the Roper River catchment. The degree of invasion of the riparian zone by exotic species varied greatly, with nearly half the sites recording a greater level of invasion (>5% cover). At times, the reaches rated poorly for exotic species compared to the other attributes assessed.

The sub-sections where high weed invasion was considered a major issue included: Roper River (tidal section and upstream of 57-Mile Waterhole to the upper catchment), Hodgson River above Arnold River, upper Wilton River, Mainoru River, upper Jalboi River, Flying Fox Creek, Maiwok Creek, Strangways River, Elsey Creek and Waterhouse River. Some river reaches that recorded high weed invasion were located in areas near major roads like the Central Arnhem Road, tracks, crossings and areas frequented by people, including Elsey National Park. Other areas, in particular upper Wilton River, were located in very remote areas and it was considered that feral animals (eg buffalo) could be aiding in the spread of weeds in these areas.

Thirty different species of exotic vegetation were recorded throughout the catchment and up to eight different species were recorded at one site. The two major exotic species recorded included *Passiflora foetida* (a naturalised vine) and *Hyptis suaveolens* (a noxious forb). Other more fairly widespread species included *Melochia pyramidata*, *Parkinsonia aculeata*, *Sida acuta* and *Calotropis procera* (Rubber Bush). *Parkinsonia aculeata* is the target of a weed control program being implemented by the Roper River Landcare Group, utilising biological control methods.

Noxious weeds should be controlled in protected and high use areas, such as National Parks. Other high use areas and recreational areas along rivers and creeks, including Roper Bar and other access points on the Roper River, should be targeted for the control of noxious weeds in order to prevent their spread by people to other areas. This is particularly the case for weeds that readily attach themselves to clothing (eg Noogoora Burr) and which can be transported via vehicles (eg Hyptis). Weed invasion of riparian areas containing important or unique vegetation communities, in particular *Livistona rigida* palms, should also be given priority for weed control programs (eg Red Lily Lagoon).

Controlling weeds along streams should be approached on a catchment basis. There is limited use in controlling weeds and preventing their spread in one particular area if a continual supply of weed seed is brought into that area from upstream. In order to manage weed control on a catchment basis, it is imperative that weed control strategies and distribution maps are formulated. Such strategies and maps are also required in order to monitor the distribution and abundance of weeds, to target specific weeds and to make best use of available resources.

The active involvement of land owners and managers along rivers in controlling weeds is required. Public awareness of what weed species should be controlled and information on how to undertake this is important.

7. The distribution of aquatic vegetation was widespread.

Aquatic vegetation was widely distributed throughout the catchment, particularly emergent types and, to a lesser extent, submerged types. Covers provided by these two types were generally high. Floating aquatic vegetation (eg water lilies) was much more limited in its distribution, being confined to several waterholes or slow flowing pools, and the cover was generally low for this type. The only exotic aquatic vegetation species recorded was *Phyla nodiflora* (Lippia) found on Elsey Creek. This species is common in the Top End, occupying a wide range of moist habitats.

8. Instream and bank habitats were diverse and provided good cover.

The majority of sites rated highly with regard to the cover and diversity of instream and bank habitats. A section on Western Creek rated below average, while five sections along Roper River and a section on Wilton River rated highly for this attribute.

The ratings reflect the level of cover and diversity provided by instream organic debris, aquatic vegetation and other habitat types on the river bed, as well as the cover and diversity provided by the canopy and other habitats along the river banks. The vegetation canopy along the banks did not provide a continuous cover, averaging 76% of the bank length.

The results suggest that the instream and bank habitats were diverse and provided a good degree of cover or habitat areas to support a diversity of instream fauna, including macro-invertebrates, and fauna associated with the riparian zone. A comparison with other fauna diversity studies, such as the 'Ausrivas Program' and recent studies of bird populations in riparian zones, would be required to determine if this is the case.

9. The diversity of channel habitat types was predominantly high or very high.

Channel type diversity reflects the extent to which pools dominate the reach. For example, very long waterholes, like Red Lily Lagoon and 57-Mile Waterhole on the Roper River, rated moderately. Tidal sites which consisted of very long pools and billabongs, like Minyerri Billabong, did not have the diversity of depths or the presence of other habitat types and, as a result, rated low. Elsey Creek at Roper Highway rated very low because only one habitat was sampled. Other sites along Roper River that rated only moderately recorded only two habitat types, of which pools dominated extensively.

The location of the reach within the catchment and the geology and topography influence the channel type diversity rating. The results, therefore, reflect not only the diversity of channel habitats along rivers, but also the natural variations throughout the catchment. Waterfalls and cascades were associated with areas of steeper topography (ie gorge systems, tufa formations, upper catchment sites). Rapids were associated with steeper river gradients (eg along Roper and Wilton Rivers).

A comparison with other studies of fauna diversity, such as the 'Ausrivas Program', would be required to determine whether the high channel habitat diversity has influenced the diversity of fauna throughout the Roper River catchment.

10. Grazing and stock or feral animal activities were identified as the most common detrimental influence impacting upon stream and riparian attributes.

Grazing and stock or feral animal activity were identified as the main disturbance to stream reaches and river bank stability at many sites and, therefore, the impacts of this activity should be monitored.

Consideration should be given to fencing off any areas along rivers and creeks that are showing signs of localised erosion problems or are suffering from stock or feral animal activity. Stock watering points away from rivers can be used where fencing along rivers has occurred. There is also a need to control the large number of feral animals (including buffaloes, donkeys and pigs) that are impacting upon rivers. Sub-sections where feral animals were a major issue included Arnold, Chambers, Phelp, Wilton and Waterhouse Rivers and Elsey and Flying Fox Creeks.

11. Measures required to maintain or, in some cases, to improve the stability and condition of rivers.

As the majority of rivers and creeks within the Roper River catchment are physically quite stable, the Northern Territory is well placed to be proactive in order to ensure that the streams are not degraded over time and that they remain in a stable condition. Measures that are required to maintain or, in some cases, to improve the stability and condition of rivers include:

- Maintaining and protecting the riparian vegetation and, in so doing, the aquatic habitat;
- Ensuring that tracks and river crossings are properly designed, constructed and maintained; and
- Monitoring and controlling the impacts of grazing and stock or feral animal activity along rivers (discussed in 10).

Ensuring that riparian vegetation is kept in tact will help to maintain a good level of bank stability. As well, the riparian vegetation can perform its many other essential roles. In so doing, the condition of the aquatic habitat is maintained because instream cover is largely provided by organic material derived from riparian vegetation, and bank cover mostly involves the presence of trees and shrubs.

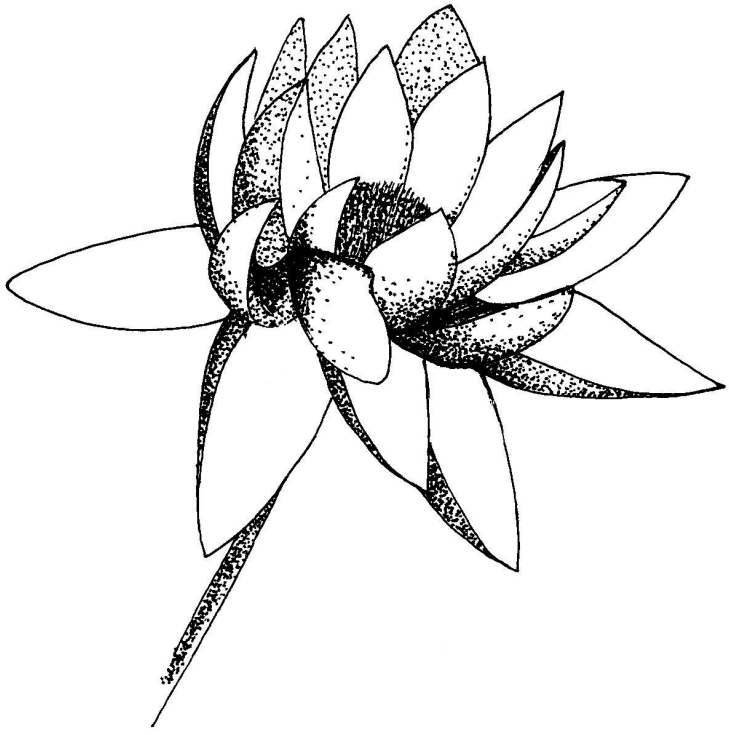
Extensive clearing or development within the riparian zone should be avoided. This allows the banks to have a greater chance of withstanding the annual high flows during the wet season that was identified, along with stock activity, as the major factor affecting bank stability.

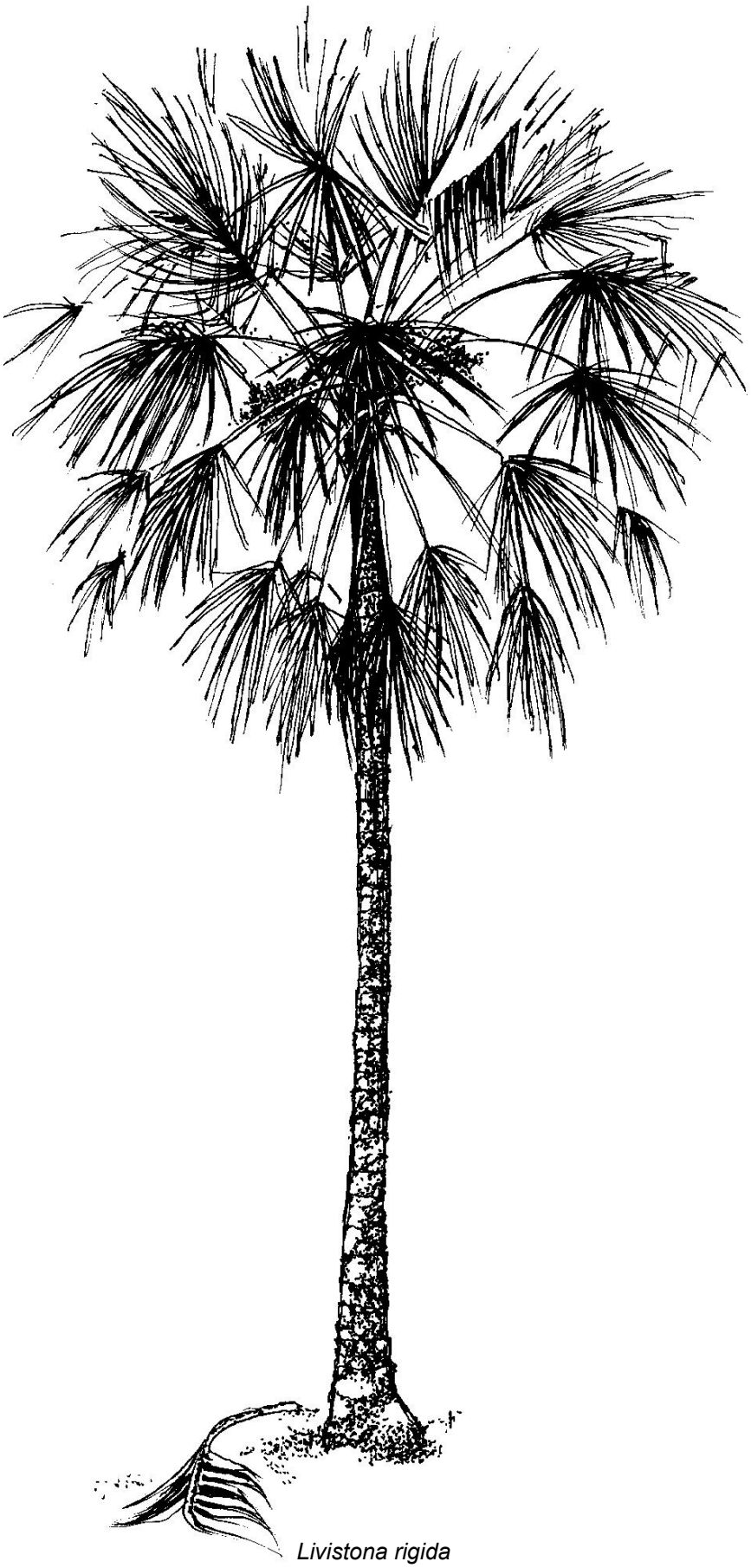
Infrastructure, such as roads, tracks and crossings, were identified as a major disturbance to reach environs and river banks. Several reaches were experiencing localised problems due to eroding river crossings and/or access tracks. The results show that poor track and river crossing design and maintenance can influence the condition of streams at a local scale.

It is important to properly locate crossings, avoiding outside bends or steep banks, and targeting areas where the creeks are shallower and have larger sediments along the bed, like gravels, cobbles or boulders. As little riparian vegetation should be disturbed as possible when constructing the crossings. Tracks should be maintained on a regular basis and should be designed so as not to concentrate flows along their length, otherwise erosion will occur.

12. There is a need to actively involve the community in river management.

Land tenure along the rivers and creeks is predominantly freehold or leasehold. Therefore, any on-ground river management activities or promotion of river management issues (eg through river management plans, regional or catchment planning), needs to actively involve the landowners, property managers and community groups. The Roper River Landcare Group provides an avenue for addressing any river management issues on a catchment basis. There is a 'window of opportunity' within the Northern Territory to be proactive with regard to river management issues because the rivers and creeks within the Roper River catchment are not degraded. Maintaining or, in some cases, improving the condition of rivers and creeks and, in so doing, preventing river degradation, should be a priority.





Livistona rigida

1. INTRODUCTION

Major waterways of the Northern Territory are being utilised for recreation, pastoralism, cropping, horticulture and mining. Little is known about the condition of these rivers. The waterways are a major resource and require appropriate management in order to minimise their degradation and to achieve sustainable use.

Each of Australia's major drainage divisions can be topographically sub-divided into river basins. Each basin defines the watershed or the catchment area of each major river system. The drainage divisions and basins for the Northern Territory, as defined by the Australian Water Resources Council, are shown in Map 1.

The 'Top End Waterways Project (Mark 2)' commenced in July 1998 and has been jointly funded by the Natural Heritage Trust and the NT Government. The Department of Lands, Planning and Environment has overseen the project.

The overall aim of the study was to assess, describe and report on the land and water resources of the major waterways in the Katherine Region of the NT and to prepare for publication a comprehensive report on each of those waterways.

As part of a previous study, the major tributaries within the Daly River (Faulks, 1998a,b) and Victoria River catchments were assessed throughout 1995-1997. The field surveys for the Roper River Catchment were conducted between August to November 1998 and April to July 1999.

The objectives of the project were to:

(i) identify the current physical and ecological condition of the major waterways and land corridors within each river catchment studied;
(ii) identify the use and management of the waterways (ie land tenure, types and levels of use, impacts, *etc*), highlight major river management issues and propose appropriate broad river management recommendations;
(iii) establish a "baseline" for use in the long-term monitoring of the condition of these river systems; and
(iv) raise the profile of river management issues.

The general methodology framework (ie sampling strategy, survey methods and data sheets) that has been adapted for this project was developed by J.R. Anderson as part of a 'State of the Rivers' assessment in Queensland. (refer 'Methods').

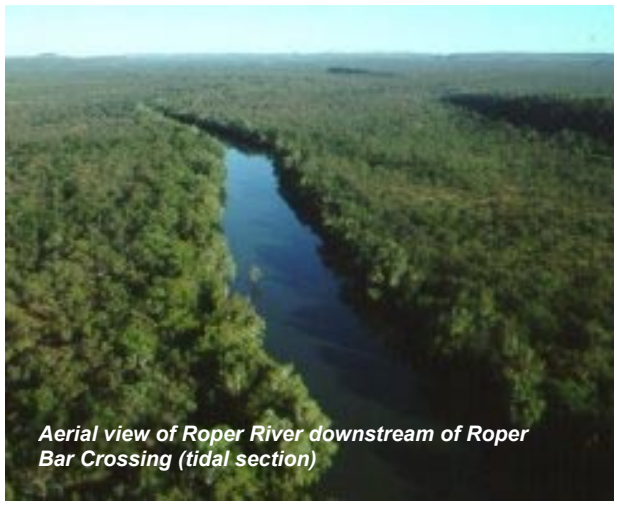
Unlike the majority of other states, the Northern Territory has no Integrated Catchment Management (ICM) framework in place. The Northern Territory government has a statutory requirement to monitor natural resource condition and has responsibilities for *State of the Environment* reporting and, more recently, the *National Land and Water Resources Audit.*

It is expected that the main users of the information provided by this project will be the Northern Territory Government and other groups interested in waterway management, including landcare and community groups, best practice groups and property owners and managers. The information provided by this project is intended to assist in developing regional and catchment management strategies.

The project will help to identify key issues, problems and priorities with the rivers. It will also help to recognise the extent, processes and causes of river degradation and thereby pinpoint actions that would have to be taken in order to reverse any deterioration. Rivers and creeks that are showing signs of degradation (eg weed infestation, accelerated erosion, *etc*) will be highlighted.

The project, through the collection of baseline data, provides a reference point or "snap-shot" of what the rivers and creeks are like now. Follow-up surveys of rivers in priority areas would need to be carried out over time in order to look at the rate of change in condition and stability. The project can be used as a monitoring tool.

The Roper River Catchment report provides and overview of the Roper River catchment, the methodology and the results on an overall catchment basis as well as for each sub-catchment.



Aerial view of Roper River downstream of Roper Bar Crossing (tidal section)

2. OVERVIEW OF THE ROPER RIVER CATCHMENT

2.1 Location

The study area includes the catchment of the Roper River and its tributaries (refer Map 2). The Roper River is a large, perennial flowing river and has a catchment area of 81,794 km^2, which is one of the largest river catchment areas in the Katherine region. The study area is drained by ten rivers and three major creeks, some of which are also perennial: the Roper, Phelp, Hodgson, Arnold, Wilton, Mainoru, Jalboi, Strangways, Chambers and Waterhouse Rivers, and Maiwok, Flying Fox and Elsey Creeks.

The Roper River starts as Roper Creek (also called Little Roper River) and becomes the Roper River downstream of Waterhouse River junction near Mataranka. The Elsey Creek system drains the large Sturt Plateau region, which is located in the south-western section of the catchment. The Arnhem Land Plateau, rising up to 440m, and the Wilton River Plateau are located in the northern section of the catchment, and consist predominantly of Kombolgie sandstone. The middle section of Roper River consists of a very braided river channel. The Roper River flows generally in an easterly direction, although the geology of the catchment influences the direction of the drainage systems. The normal tidal limit of the Roper River is at Roper Bar Crossing (shown on Map 2). From this crossing, the Roper River traverses the alluvial coastal plain eastward for 145km before entering the Gulf of Carpentaria. There are currently no large surface water storages on the Roper River or its tributaries.

Within the Roper River catchment there are several small towns and communities, of which Mataranka is the regional centre. Others towns and communities include: Barunga, Beswick, Bulman, Daly Waters, Larrimah, Hodgson Downs, Roper Bar and Ngukurr.

Aerial View of Roper Bar Crossing (May 1999)

2.2 Climate

The study area is located within the monsoonal tropics. The dominant feature of the north-west monsoon is the occurrence of two distinct seasons, an almost rainless dry season from May to September, and a wet season from November to March. April and October are transitional months. (Woodroffe *et al.*, 1986).

Table 2.1 summarises climate details for the following locations in the Roper River catchment: Daly Waters, Larrimah, Ngukurr and Flying Fox Station. In addition to the four locations summarised in Table 2.1, the mean annual rainfall recorded for Mataranka Homestead Resort, Nutwood Downs, Mainoru and Maranboy is 792.6 mm, 694.2 mm, 747.3 mm and 823.3 mm respectively (NT Bureau of Meteorology, 2000).

Over 90% of the mean annual rainfall throughout the Roper River catchment falls during the wet season (November to March). The mean monthly rainfall varies from 0 mm during the dry season to 216.2 mm during the wetter months. Figures 2.1 and 2.2 show the mean monthly rainfall recorded for Mataranka Homestead Resort and Ngukurr.

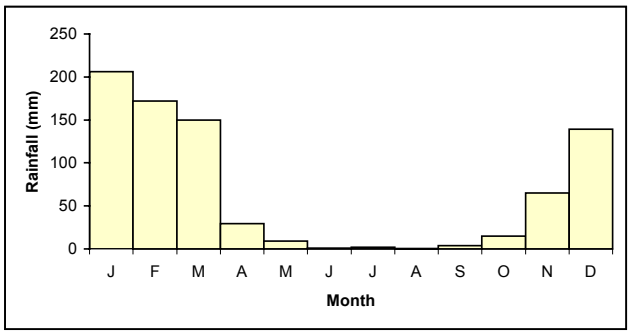


Figure 2.1 Mean Monthly Rainfall for Mataranka Homestead Resort (1916 - 1999)

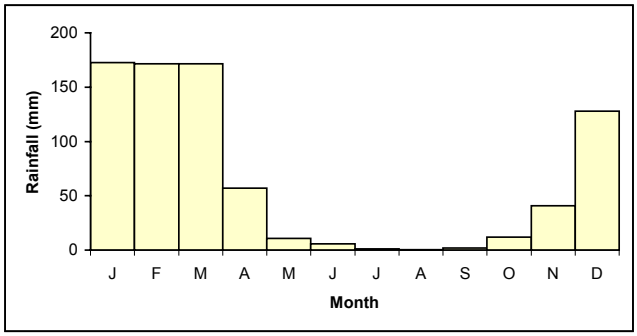


Figure 2.2 Mean Monthly Rainfall for Ngukurr (1910 - 1999)

Table 2.1 Summary of Climate Data for Locations within the Roper River Catchment

	Daly Waters (1873 - present)	Larrimah (1952 - present)	Ngukurr (1910 – present)	Flying Fox Stn (1996 – present)
Mean Daily Min-Max Temp. Range (°C)	19.1 – 34.2	19.8 - 34.0	20.8 – 34.2	20.3 – 34.9
Mean 9am Relative Humidity (%)	54.4	62.0	65.8	64.1
Mean 3pm Relative Humidity (%)	30.6	35.4	35.3	39.5
Mean Annual Rainfall (mm) [No. years]	669.2 [101]	805.3 [45]	752.4 [55]	992.7 [3]
Mean Monthly Rainfall Range (mm)	1.6 – 163.0 (July - Feb)	0.3 – 198.8 (Aug - Jan)	0.4 – 172.5 (Aug – Jan)	0 – 216.2 (Aug - Feb)
Highest Recorded Daily Rain (mm)	180.1 (Nov 1896)	408.6 (Jan 1987)	271.5 (Jan 1976)	117.1 (Feb 2001)
Mean Number of Rain Days per Year	56.4	66.7	51.4	74.8
Mean Total Annual Evaporation (mm)	2,405.5	-	2,219.2	1,523.3

Source: Climate and Consultancy Section, NT Bureau of Meteorology (2000-2001)

Throughout the Roper River catchment mean monthly temperatures range from 19.1°C to 34.9°C (Table 2.1). The lowest temperature recorded for these four stations was 0.6°C whilst the highest temperature recorded was 44°C. Relative humidity varies daily and seasonally. Dry season (May – September) relative humidity averages range from 43.4 - 68.2 per cent at 9am and 20.6 - 34.7 per cent at 3pm. Whilst wet season (November to March) relative humidity averages range from 51.6 - 83 per cent at 9am to 25.7 - 62.5 at 3pm.

The average yearly evaporation greatly exceeds the average rainfall, which is typical for the northern Australian climate (Sivertsen and Day, 1985). Lucas and Manning (1989) reported that evaporation exceeds rainfall for nine months of the year at Mataranka and peaks at the start of the build up season (October and November).

Figures 2.3 and 2.4 show the total annual rainfall recorded for Larrimah (1953-1999) and Nutwood Downs (1936-1999) respectively. Rain is usually high-intensity falls. Most of the region's rain comes as hard, intermittent, tropical showers, oftern associated with thunder and lightning (Bauer, 1964) or as monsoon troughs and tropical lows, which are often the remains of cyclonic depressions.

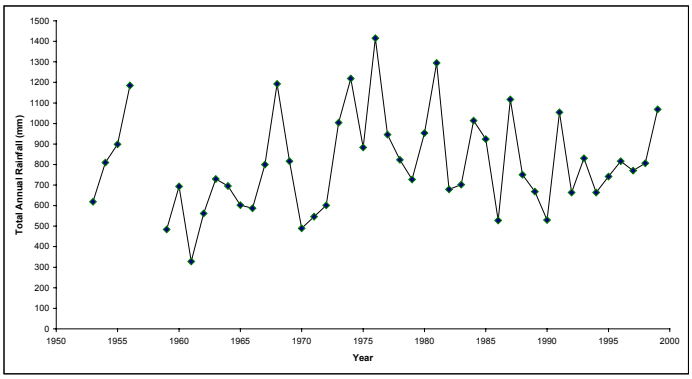


Figure 2.3 Total Annual Rainfall for Larrimah (1953 – 1999)

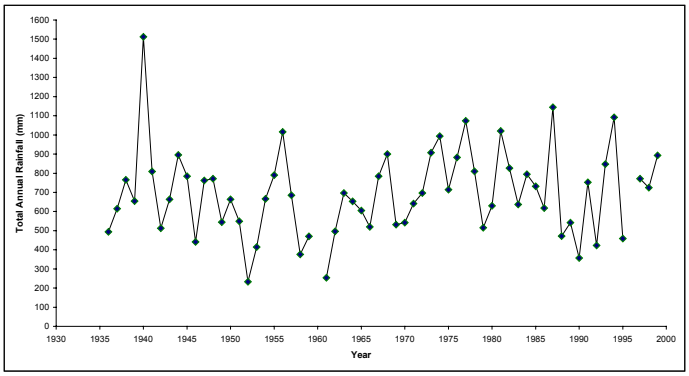


Figure 2.4 Total Annual Rainfall for Nutwood Downs (1936-1999)

2.3 Geomorphology and Landform

Surveys providing detailed land systems, land unit or soils mapping have been carried out for areas throughout the Roper River catchment. Figure 2.5 shows the location and reference details of these surveys. Map 3 shows the predominant landforms throughout the Roper River Catchment. This map is based on the Northern Territory Soil Survey mapping at a scale of 1:2,000,000 (Northcote, 1968) which has been used because it is the only survey that covers the entire Roper River catchment. The soil survey information has been re-grouped according to landform. Within the Roper River catchment there were six major landforms identified ranging from plateau surfaces; plateau escarpments; gorges and ridges associated with the dissected plateau and hills; plains; drainage lines, associated floodplains and billabongs; salt pans and tidal flats.

The Arnhem Land Plateau, dominated by Kombolgie sandstone, rises up to 440m above sea level. Other plateaus include Wilton River Plateau and the Sturt Plateau.

Land systems mapping is based on recurring patterns of topography, soils and vegetation (Christian and Stewart, 1952). Each land system can be described in terms of its component parts, which are land units. Each unit, while generally representing a uniform assemblage of data on topography, soils and vegetation, also describes the potential or capability of the land represented (Aldrick and Robinson, 1972).

A total of 62 land systems were mapped and described as part of the 'Land Systems of the Roper River Catchment, Northern Territory' survey (Aldrick and Wilson, 1992). These land systems have been grouped into six "geomorphic provinces" which are summarised in Table 2.2. These geomorphic provinces provide a basis for predicting the susceptibility of land to degradation (Aldrick and Wilson, 1992).

The Sturt Plateau, covering the south-western section of Roper River catchment, has been described as an old uplifted erosion surface of some 250m elevation. It is a flat to gently undulating plain that is deeply weathered, covered by thick laterite and associated soils and supports predominantly savannah vegetation (Day *et al.*, 1985). A total of 19 land systems were mapped and described as part of the 'Land Resources of the Sturt Plateau' survey (Day *et al.*,1985); eight of these land systems comprise gently sloping to almost level plains and four comprise alluvial plains on the Sturt Plateau.

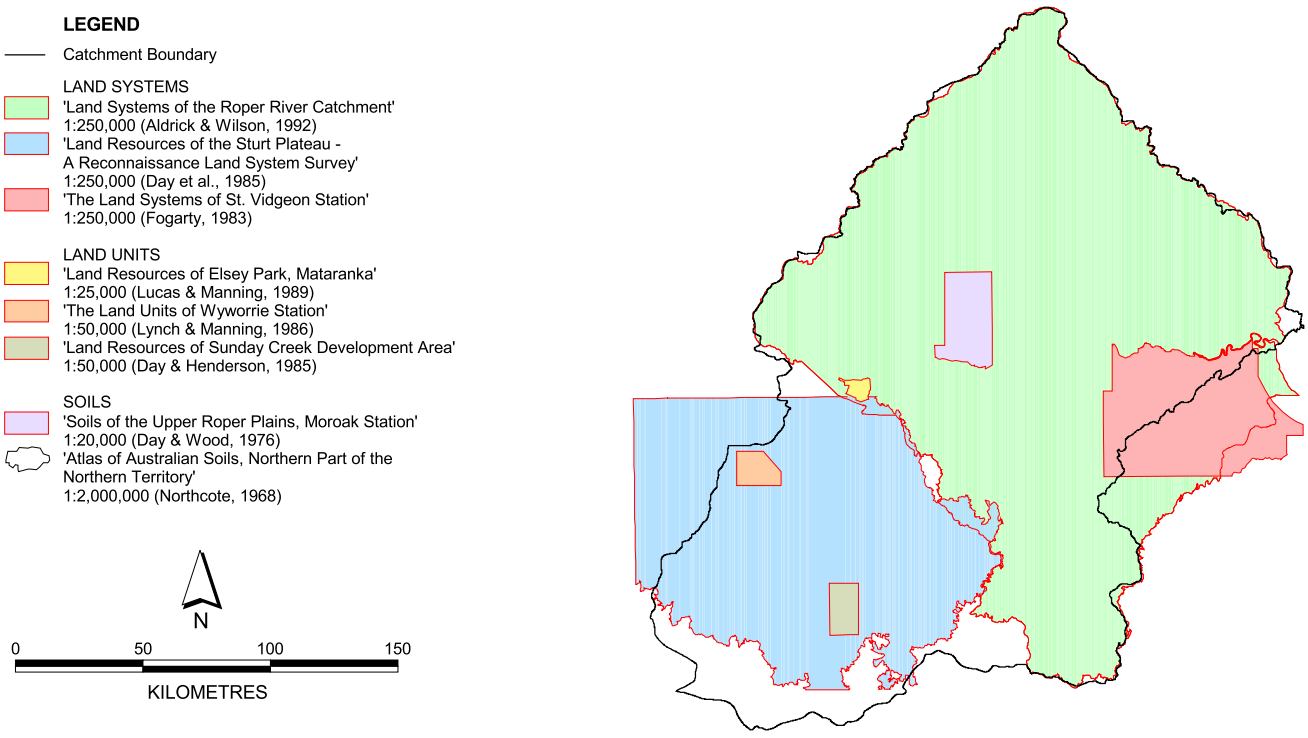


Figure 2.5 Location and Reference Details for Land System, Land Unit and Soil Mapping Surveys Conducted throughout the Roper River Catchment

Table 2.2 Major Geomorphological Provinces within the Roper River Catchment (Adapted from Aldrick and Wilson, 1992)

Geomorphic Province	General Topography and Main Characteristics of the Geomorphic Province	Rate of Natural Erosion	Major Vegetation Communities and Soils
G1	Very low relief. Gently undulating plains and rises. Intact areas of mature laterite on old, stable erosion surfaces.	Very slow (erosionally stable; little sediment produced due to very low relief; permeable soils; and very old, stable drainage network)	Mid-high open woodland. Ferruginous lithosols, lateritic podzolics, red and yellow earths, earthy sands and brown clays.
G2	High relief. Escarpments, low hills, footslopes and gentle plains that occur around the inland edges of the area, and occasionally within it as well.	Rapid due to soft rocks with high relief and competent streams; laterite, clay or sandstone cap rock has been incised, exposing softer underlying materials.	Mid-high open woodland or tall open woodland. Tall fringing riparian vegetation along fluvial corridors. Cliffs and slopes have *Acacia shirleyi*. Lithosols, siliceous and earthy sands, yellow earths, brown earths, red earths, minor black earths or grey and brown clays.
G3	High relief. High rocky sandstone plateaus and ridges such as the Arnhem Land and Wilton River Plateaus.	Slow due to erosion resistant sandstone and igneous rock. Rate of sediment removal would be rapid due to high relief and stream competence, however little sediment available for transport.	Mid-high open woodland. Lithosols, shallow siliceous sands or earthy sands, some red and black earths and red clays.
G4	Flat to gently undulating plains; gently undulating to undulating rises; low to undulating hills; rugged rocky plateaus and steep, linear ridges, dissected plateaus; broad and narrow fluvial corridors, channels, levees, floodplains, back-plains and associated swamps, billabongs and springs.	Slow to moderate. Local base levels and sediment accumulation lead to broad, shallow valleys. Only upper parts of relief are subject to strong erosion, but these are mostly erosion-resistant rocks. Drainage is strongly controlled by structure. A series of linear, mainly sandstone ridges lie across the direction of drainage, and have inhibited the normal down-cutting of the streams (eg Hell's Gate Ridge near Roper Bar).	Mid-high open woodland; tall open woodland; tall fringing riparian vegetation along fluvial corridors; mid-high woodland; low-open woodland and mixed grasslands associated with drainage lines and floodplains. Tall open forest of *Livistona rigida* and *Melaleuca* forests fringing spring-fed swamps. Lithosols (some calcareous); red, brown, yellow and black earths (including sandy, loamy and calcareous); earthy and siliceous sands; brown, grey and red clays; humic gleys; sandy solodic soils; and yellow or lateritic podzolics.
G5	Low relief. Level to gently undulating plains; broad and narrow fluvial corridors; swamps and low-lying areas; and undulating rises to low hills.	Slow to moderate due to low relief. Gentle erosional slopes on the coastward side of the sandstone ridges that influence G4.	Mid-high open woodland, mid-high woodland or tall open woodland. Tall fringing riparian vegetation along fluvial corridors. Yellow, red and minor black earths; earthy and siliceous sands; lithosols; lateritic and yellow podzolics; grey and brown clays; humic gleys.
G6	Very low relief. Almost flat coastal terraces. Level to very gently undulating plains; broad or narrow fluvial corridors, swamps and low-lying areas; broad depositional floodplains; tidal mud flats with channels and estuaries; coastal sand sheets, dunes and cheniers. Some undulating rises to low hills.	Very slow due to the very low relief and a very young, immature, weakly developed drainage pattern, and permeable soils. This geomorphic province occurs near the coast and coastal influences are prominent.	Mid-high open woodland; tall open woodland; tall fringing riparian vegetation along fluvial corridors; mid-high woodland of *Melaleuca* forests associated with low-lying, swampy areas. Patches of *Melaleuca* forests and forbs adapted to saline conditions with fringing mangroves along shorelines and tidal waterways. Tall grassland with scattered trees along coastal dunes. Lithosols; siliceous and earthy sands; red and yellow earths; yellow podzolic soils; humic gleys; grey, brown clays and alluvial soils; and undifferentiated marine deposits associated with tidal mud flats along channels and estuaries.

In addition to the surveys outlined in Figure 2.5, satellite imagery interpretation work is currently being undertaken to map land cover units at a scale of 1:100,000 for the majority of the Sturt Plateau (Mullin, 2001).

Geologically the Roper River catchment is complex (Aldrick and Wilson, 1992). The geology of the Roper River catchment has been mapped and described at a scale of 1:250,000 by the Northern Territory Geological Survey and Australian Geological Survey Organisation (formerly Bureau of Mineral Resources). A geological map of the Northern Territory, at a scale of 1:2,500,000, has been compiled using the 1:250,000 geological map series (Ahmad, 2000).

2.4 Vegetation, Important Habitat Areas and Fauna

2.4.1 Vegetation

Prior to 1985, the Northern Territory had no systematic vegetation mapping program, although much local and regional mapping had been carried out in the course of land system/unit surveys (Wilson *et al.*, 1990). There has also been remarkably little research on riparian systems, their conservation value, condition or ability to withstand increased use (Sattler, 1993; Woinarski, 2000). Map 4 is based on the 'Vegetation Survey of the Northern Territory, Australia' (Wilson *et al.*, 1990), mapped at a scale of 1:1,000,000. The information has been further grouped according to the dominant vegetation community (eg Eucalypt with grass understorey, *etc*) and structural formation (eg open-forest, woodland, *etc*).

Within the Roper River catchment, which lies within the 'Humid Zone' and 'Semi-Arid Zone', Eucalypt woodland with grass understorey is the dominant vegetation type occurring. Of the map units that have been grouped together under woodland (refer Map 4), *Eucalyptus bleeseri, E. dichromophloia, E. ferruginea, E. latifolia, E. miniata, E. papuana, E. patellaris, E. polycarpa, E. tectifica, E. tetradonta, E. terminalis and Callitris intratropica* are the dominant overstorey species. Grass understorey species include *Chrysopogon fallax*, *Plectrachne pungens*, *Sehima nervosum* and *Sorghum*.

This broad scale mapping meant that some distinctive communities (eg riparian *Casuarina* forests) or rare communities (eg *Livistona rigida* woodland) were not specifically described due to the narrowness of the strips along watercourses or the small size of the patch (Wilson *et al*., 1990).

Day *et al.* (1985), as part of land systems mapping, described 15 major vegetation communities and 12 minor communities associated with the northern portion of the Sturt Plateau, of which 11 of these were associated with stream channels, flood-outs and depressions. As part of land systems mapping of the Roper River Catchment, Aldrick and Wilson (1992) recognised 49 vegetation communities, ranging from tall open woodlands to low open grasslands, with 411 species recorded from the area. Of the 31 vegetation communities that were considered major communities, 11 of these were located on plains; and a further 18 vegetation communities were considered minor communities, of which six were associated with river channels, levees, swamps, depressions and plains.

Fogarty (1983) described 21 vegetation associations, grouped according to the broad landform zones in which they occur, and 152 plant species as part of the land systems mapping of St. Vidgeon Station (now part of the proposed Limmen National Park) that covered an area of 6,812km^2. Of these vegetation associations, two communities were associated with watercourses, including the Roper River, as well as swamps, and a further two were littoral associations (mangrove forest and saline flats) along lower Roper River. The major vegetation species associated with Roper River on St. Vidgeon Station included *Eucalyptus camaldulensis*, *Melaleuca* spp., *Cathormion umbellatum*, *Barringtonia acutangula*, *Atalaya hemiglauca* and various vines.

As part of the land resource survey of the 138km^2 Elsey National Park (Lucas and Manning, 1989), 20 vegetation communities were identified and grouped into the following six main categories based on landform: undulating rises of the sandstone country; level to undulating plains of the limestone country; drainage lines and depressions; broad calcrete depressions and spring hollows; levees; and stream channels and banks. The majority of Elsey National Park is dominated by mid-high to tall open Eucalypt woodlands. The riparian vegetation adjacent to the Roper River within Elsey National Park was described as being diverse, both floristically and structurally. *Pandanus aquaticus*, *Terminalia erythrocarpa*, *Melaleuca* spp., *Eucalyptus camaldulensis* and *Livistona rigida* form dense stands along the river banks. Lush communities of *Livistona rigida* as well as *Ficus platypoda* were associated with springs. *Nymphaea gigantea*, *Phragmites karka*, *Schoenoplectus litoralis* and/or *Cynodon dactylon* were also recorded either in backwaters or lining broad level banks.

A biological survey of Elsey National Park (Griffiths, 1997) identified the distinctive tall palm, *Livistona rigida*, as a notable plant species because it has a restricted population in the Northern Territory. Six other plant species of conservation significance present within the Park include: *Drosera subtilis*, *Eleocharis geniculata*, *Hibiscus geranioides*, *Schoenus falcatus*, *Tephrosia subpectinata* and *Whiteochloa multiciliata*. Approximately 360 plant species have been listed by the Herbarium of the NT for Elsey National Park (Griffiths, 1997). High species richness was observed in the Poaceae family with 19% of species belonging to this family (Griffiths, 1997). The vegetation community occurring next to river and creek channels or drainage depressions was described as a *Livistona rigida* – *Melaleuca* spp. tall open forest (Griffiths, 1997).

The vegetation of Wyworrie Station was described as mostly mid-high to tall open woodland dominated by *Eucalyptus dichromophloia* and *E. tetrodonta* with occasional *E. ferruginea and E. patellaris* over mixed grasses (Lynch and Manning, 1986). Four main vegetation types were identified on Sunday Creek Development Area (Day and Henderson, 1985) including communities associated with alluvial plains, Sunday Creek stream bed and flood-out areas. The dominant vegetation communities associated with clay levees, braided channels and major tributaries of Roper River on Moroak Station have been described as part of land unit mapping surveys (Day and Wood, 1976).

The mangrove plant communities along Roper River, all other river systems in the Gulf of Carpertaria (except the Limmen Bight River) and the Victoria, Moyle and Daly Rivers in the Joseph Bonaparte Gulf, show the lowest level of floristic diversity (ie 4-14 species) of all tidal waterways surveyed across the Northern Territory and Kimberley region of Western Australia (Wells, 1985). It is considered by Wells (1985) that the mangrove plant communities are greatly influenced by climatic variations and that there is a gradual decline in mangrove species richness southwards on both the east and west coasts of Australia. The mangrove species recorded along the Roper River estuarine area are shown in Table 2.3.

Table 2.3 Mangrove Species Recorded along Roper River Estuary
(Source: Messel *et al*., 1980; Wells, 1985)

Mangrove Species Name – *Genus species*	**Frequency Category***
Acanthus ilicifolius	B
Aegialitis annulata	C
Aegiceras corniculatum	C
Avicennia marina	C
Bruguiera exaristata	C
Bruguiera gymnorrhiza	B
Bruguiera parviflora	B
Ceriops tagal var. *australis*	C
Excoecaria agallocha	C
Lumnitzera racemosa	C
Osbornia octodonta	C
Rhizophora stylosa	C
Xylocarpus australasicus	C

* The frequency category is based on Wells (1985):
A. Species that were recorded infrequently
B. Species that occur, in most instances, in systems throughout the less seasonally arid areas
C. Species that are often encountered at least in some portion of most tidal systems

Messel *et al*. (1980) noted that mangrove associations form the fringing riverside vegetation up to 100km along Roper River from the mouth. Freshwater plant species begin to appear amongst riverside vegetation 67km from the Roper River mouth.

Weed species (in particular Parkinsonia, Hyptis and Grader Grass) were perceived to be causing localised problems throughout the catchment, particularly in disturbed areas, intensive use areas and along watercourses (Kerin, 1993). A number of weed species have invaded sections of Elsey National Park (CCNT, 1994a). There were 17 introduced plant species listed for the Park including *Parthenium hysterophorus*, Devil's Claw (*Martynia annua*), Parkinsonia (*Parkinsonia aculeata*) and Rubber Bush (*Calotropis procera*) (Griffiths, 1997). The last two species are easily dispersed, and form dense thickets that can substantially alter natural environments. *Parkinsonia aculeata* was identified by landholders and the Roper River Landcare Group as the major weed species in the Roper River catchment and, as a result, has been the focus of biological control methods utilising a seed-eating beetle, *Penthobruchus germaini* (Flanagan *et al*., 1996).

2.4.2 Important Habitat Areas and Fauna

There are two important wetlands identified within the Roper River Catchment (ANCA, 1993) and these are shown in Map 4. They are: (i*) Limmen Bight (Port Roper) Tidal Wetlands System,* which is the second-largest area of saline coastal flats in the Northern Territory and is a good example of a system of tidal wetlands (intertidal mud flats, saline coastal flats and estuaries), with a high volume of freshwater inflow, typical of the Gulf of Carpentaria coast; and (ii) *Mataranka Thermal Pools* which is a good example of tropical springs and associated permanent pools (one of the best known in the Northern Territory).

Excellent cover provided by mangrove communities along the tidal section of lower Roper River

The *Tidal Wetlands System* (shown as 1 in Map 4) is a major migration stop-over area for shorebirds (especially godwits and knots), and one of the most important coastal sites in the Northern Territory in terms of shorebird numbers, especially the Port Roper mudflats. The seagrass beds are a major breeding area for prawns and an important feeding area for Dugong and the Green Turtle (Poiner *et al*., 1987; ANCA, 1993). Medium densities of the Saltwater Crocodile (*Crocodylus porosus*) occur in the Roper River estuary (ANCA, 1993) and, overall, the area of suitable nesting habitat for *C. porosus* is extensive on the Roper River System (Messel *et al*., 1980). Marine turtles use nest sites on offshore islands.

The *Mataranka Thermal Pools* (shown as 2 in Map 4), located within Elsey National Park, are maintained by permanent thermal springs. The pools are fringed mainly by *Livistona rigida*, although *Pandanus* and *Melaleuca* spp. also occur. The *Livistona rigida* palm community has a restricted distribution in the Top End Region and, as such, is considered a special community (ANCA, 1993; CCNT, 1994a; Griffiths, 1997).

The perennial nature of the spring-fed Roper River; the floristic diversity and restricted range of the riparian vegetation; and the representation of "tufa" formations have been identified as important natural resources within Elsey National Park (CCNT, 1994a). The Park is considered to have moderate conservation values in a regional context and contains a number of flora and fauna species of conservation significance (Griffiths, 1997). A total of 223 vertebrate species are listed for Elsey National Park, comprising 11 fish, 12 frog, 54 reptile, 127 bird and 19 mammal species, including 4 feral mammal species. The riparian forest dominated by *Livistona rigida* and *Melaleuca* spp. contained a rich frog fauna. Notable vertebrate species recorded for the Park (Griffiths, 1997) include: the Small-mouthed Catfish (*Cinetodus froggatti*) only known in Australia from the Waterhouse River, the frog *Cyclorana cryptotis* not previously recorded in a conservation reserve in the Northern Territory, a yet to be described skink *Ctenotus* sp., Red Goshawk, Grey Goshawk, White-browed Robin, Hooded Parrot, the rodent *Leggadina lakedownensis* and the Ghost Bat (*Macroderma gigas*). The endangered Gouldian Finch (*Erythrura gouldiae*) has previously been recorded in this area (Griffiths, 1997).

Riparian lands occupy only a small proportion of the landscape but they frequently have a much higher species richness and abundance of animal life than adjacent habitats (Lynch and Catterall, 1999).

A broad-scale survey of bird distribution in riparian vegetation in the Top End of the Northern Territory (Woinarski *et al*., 2000), found that despite their relatively small total extent, riparian areas were extremely important for birds. The study concluded that the bird fauna of riparian areas is distinct from that of the surrounding savannas, and this was especially so in lower rainfall areas. Species richness and the total abundance of birds was greater in the riparian zones than in non-riparian zones especially where they contained more extensive cover of rainforest plants and *Melaleuca* (Woinarski *et al*., 2000). This study concentrated on the mid-reach of rivers with permanent freshwater pools (that is, the Roper, Wilton, Mainoru, Hodgson, Arnold and Waterhouse Rivers and Flying Fox Creek within the Roper River catchment).

As part of a Northern Territory wide project into the biodiversity values of cracking clay systems, surveys of all vertebrate fauna and flora have been carried out at sites on heavy clay soils on Moroak and Maryfield Stations and Hodgson Downs Aboriginal land (Puckey, pers. com.). The information will assist in managing these cracking clay systems.

Pig-nosed Turtles, *Carettochelys sp.*, are of international significance and have been recorded from Roper River in the vicinity of Roper Bar (Dept of Lands and Housing, 1991). The Freshwater Crocodile (*Crocodylus johnstoni*) is quite common within the Roper River and its tributaries (CCNT, 1994a). The Saltwater Crocodile (*C. porosus*) has been recorded upstream along the Roper River to Elsey Station (Griffiths, 1997).

A number of feral animal species occur throughout the Roper River catchment including the Water Buffalo (*Bubalus bubalis*), horses, donkeys, pigs and feral cats (Dept of Lands and Housing, 1991) and many concentrate in and contribute to degradation of riparian areas (Sattler, 1993). Griffiths (1997) recorded several feral animals in Elsey National Park including feral cats, pigs, European cattle, water buffalo and donkeys. Of these feral animals, donkeys and pigs were identified as an environmental concern (CCNT, 1994a). In particular, donkeys were found to occur in all habitats and it was recommended that management priorities should focus on the continued reduction of the donkey population (Griffiths, 1997).

The damage caused by feral animals includes: overgrazing; trampling and foraging causing soil disturbance, accelerated erosion, invasion and

spread of weed species; destruction of habitats by rooting, burrowing and wallowing, reducing the aesthetic and productive value of land and reducing the lands ability to resist erosion (CCNT, 1994a; Telfer, 1998). The feeding behaviour of these introduced animals has the potential to modify the natural floristic composition of certain areas and/or result in competition for food with native herbivores (CCNT, 1994a).

The Cane Toad *Bufo marinus*, an introduced animal, first entered the Northern Territory in the 1983/84 wet season (Dept of Lands and Housing, 1991) and are now located throughout the Roper River catchment area. No practical control method is presently known which can effectively halt the toad migration throughout the Northern Territory (CCNT, 1994a).

2.5 Land Tenure, Use and Management

Current land classification within the Roper River catchment is shown in Map 5. The majority of land is held under pastoral lease or Aboriginal land trusts as private freehold. Crown leases contain covenants that control their usage or development and can be issued for any length of time, including "in perpetuity". Term leases are normally issued to allow developments to proceed and can often be converted to freehold title or perpetual leasehold once the development is complete. Pastoral leases are for broadacre areas specifically used for pastoral purposes.

The history of exploration and European settlement has been described in the 'Gulf Region Land Use and Development Study' (Dept of Lands and Housing, 1991). The earliest recorded visitors to the Gulf country were Macassan trepangers who commenced their seasonal travels as early as the 1600's. Other explorers of the Gulf coastline included Abel Tasman in 1644 and Captain Matthew Flinders in 1802. Overland exploration did not commence until 1845 when Dr Ludwig Leichhardt led an expedition through the Gulf naming many rivers including the Roper, Hodgson and Wilton Rivers. The Leichhardt route became the basis for the "coast track" from Queensland. Augustus Gregory and Ernest Favenc explored the Gulf country in 1856 and during the 1880's, respectively, encouraging the establishment of grazing industries. The first cattle were driven to the Gulf country in the early 1870's along Leichhardt and Gregory's path.

The construction of the overland telegraph in 1872 and opening of the Pine Creek goldfields in the 1880's established grazing and trade as the two main early industries of the Gulf region. During this period of development (ie 1870 to 1889), coastal shipping was relied upon to supply the necessities of settlement, including supplies for the overland telegraph. Both Roper Bar and Borroloola became very busy ports for trade. The wreckage of the steamship "*Young Australian*" which ran aground and sank in the Roper River in 1872, bears witness to this period of development. Coastal shipping continued on an irregular basis until World War II, but then was largely replaced by road transportation.

Holmes (1986) identified several options for broad-area use of the lands of the Gulf District: cattle grazing; nature conservation; recreation; aboriginal purposes; and vacant land, reserved for later determination. Land Use Objectives and Concept Plans for Sturt Plateau and Roper River have been proposed by Hockey (1998a and b).

Pastoralism has continued to be the main industry in the Gulf region since European settlement, but it is considered "low key" when compared to other rangelands in the Australian tropics (CCNT, 1994b) because of the limited extent of suitable pastoral land resources in the region (Dept of Lands and Housing, 1991). The Gulf region has been described as having low pastoral productivity in relation to carrying capacity, that is 2.5 head per km^2, and live weight of cattle (Holmes, 1986).

Aboriginal lands support a variety of uses, mainly as traditional or semi-traditional living areas with some areas being utilised for pastoralism (eg Elsey Station). Other industries include mining, tourism and conservation, recreational and commercial fishing.

The major mining lease within Roper River catchment is the Mataranka Lime Mine located on Elsey Station. The mine is owned by Northern Cement Limited and has been operational since 1991. Limestone is mined and processed at the nearby plant to produce quicklime, which is sold within the Northern Territory.

The tourist industry is a small, but significant part of the local Gulf economy and visitation to the region is highly seasonal with most occurring during the May through September dry season (Dept of Lands and Housing, 1991). The primary attractions include remote camping, river fishing,

opportunities for four wheel driving and access to the sea (cited in Dept of Lands and Housing, 1991). Station and outback tours, including game hunting, also exist. Of the attractions, recreational barramundi fishing (or freshwater fishing) is the primary tourist activity within the Roper River catchment (Dept of Lands and Housing, 1991). Major public boat ramps on Roper River are located at Roper Bar and 30kms downstream, at Port Roper (two locations) and within Elsey National Park at 12 Mile Yards.

The two national parks that lie within Roper River catchment (refer Map 5) are Elsey National Park, declared in 1990 under the *Territory Parks and Wildlife Conservation Act*, and the proposed Limmen National Park, which takes in St. Vidgeon, Nathan River and Billengarah. The Rainbow Spring and associated Thermal Pool sector of Elsey National Park (ie Mataranka Thermal Pools) are a major tourist attraction for the area.

The Gulf's fishing industry is very significant within the region. Prawning is the largest single fishery in the Gulf and accounted for 96% of the value of the Gulf fisheries catch in 1990 (Dept of Lands and Housing, 1991). The prawn industry operates up to 60 nautical miles off shore. An unloading facility on the Roper River is used to tranship prawns from the Gulf. An aquaculture farm for prawns was operating at Port Roper until 1995.

Other major fisheries include commercial barramundi fishery and mud crabs. The possible impact of commercial fishing on the recreational/ tourist fishing resource led to the closure of Roper River to commercial barramundi fishing in 1991. All other major river systems in the Gulf region (not including the rivers of Arnhem Land) are commercially netted for barramundi on an annual basis (February to September) and a commercial fishing base exists near Port Roper (Kelly, pers. com.). Mud Crabs are harvested in Port Roper.

Aborigines comprise almost 60% of the Gulf population (Dept of Lands and Housing, 1991). Aboriginal communities are located at Barunga, Beswick, Bulman, Ngukurr, Hodgson Downs and Djilkminggan. Sites of cultural significance to the Aboriginal people exist throughout the Roper River catchment, including along waterways and wetlands. These sites are listed with the Aboriginal Areas Protection Authority under the *Northern Territory Aboriginal Sacred Sites Act, 1989.* Traditional use of the wetlands associated with the Limmen Bight (Port Roper) tidal wetlands system is still practised (ANCA, 1993).

Riverine corridors, by their very nature and linear shape, are vulnerable to 'edge effects', and can suffer from management problems such as: infestation and modification by pests and weeds, rubbish-dumping, clearing, overgrazing, stream bank erosion, pollution, difficult access, and private occupation and use (LCC, 1989).

Unlike other states, the NT has no Integrated Catchment Management (ICM) framework in place. Currently, the responsibility for river management in the Northern Territory lies predominantly with the NT government. The *Northern Territory Water Act* (1992) has been the major legislative framework for managing rivers. The *Water Act* was amended in 2000 in accordance with Council of Australian Governments (COAG) requirements for water reform. The Act provides a process for the allocation of water resources to beneficial uses, including the environment, and to enable trade in water licences. The legislative framework sets targets for cost recovery and pricing, institutional reform, water allocation (including the development of regional water allocation plans) and trading, environment and water quality and public consultation and education.

The *NT Water Act* restricts and controls the way in which water quality can be affected. 'Beneficial Uses', or preferred uses, are determined for natural waterways under the Act. The uses include (1) protection of aquatic ecosystem; (2) recreation and aesthetics; (3) raw water for drinking water supply; (4) agricultural water supply; and (5) industrial water supply. Beneficial Uses have not been declared for waterways within the Roper River catchment.

Other NT legislation that has relevance to river management includes:

- *Aboriginal Sacred Sites Act* (1989);
- *Environmental Assessment Act* (1982);
- *Fisheries Act* (1996);
- *Heritage Conservation Act* (1991);
- *Mining Act* (1990);
- *Noxious Weeds Act* (1994);
- *Pastoral Land Act* (1992);
- *Planning Act* (1999);
- *Soil Conservation and Land Utilisation Act* (1992); and
- *Waste Management and Pollution Control Act* (1998)

Management plans currently in place include:

- Elsey National Park Plan of Management - Draft (CCNT, 1994a).

The Northern Territory Government is currently drafting vegetation clearing guidelines and an associated policy that are relevant to all lands within the Northern Territory. Clearing guidelines that are pertinent to Pastoral Leases are already in existence. The draft vegetation clearing guidelines have recommended buffer widths suitable for riparian protection.

The Roper River Landcare Group (RRLCG), established in 1993, operates within the Roper River catchment. The Group involves members from the pastoral and tourism industries, Aboriginal communities, Mataranka Town Council and Elsey National Park. In 1997, the RRLCG developed an 'Integrated Resource Management Plan' that had the primary aim "to develop, promote and ensure a coordinated approach to sustainable use and management of land, water, vegetation and other related resources within the Roper River Catchment" (Daw, 1997).

2.6 Water Resources

2.6.1 Water Resource Studies

The major water quality survey that has been conducted on rivers within the Roper River Catchment, based on surveys during 1980 and 1986, is:

- 'Baseflow Water Quality Surveys in Rivers in the Northern Territory, Volume 11 – Roper, Wilton and Hodgson Rivers' (Field, 1988).

The water resources of the Sturt Plateau region, comprising 23 properties and land trust areas over 30,000 km^2, was studied between 1997 and 2000. The following maps and reports have been produced:

- 'Water Resources Development Map - Sturt Plateau Region' (Yin Foo & Matthews, 2001). This map covers the entire Sturt Plateau region at 1:250,000 scale and presents the overall water development options as:
  1) Piping from natural waterholes where present;
  2) Surface water (ie build a dam or excavated tank and capture rainfall runoff);
  3) Groundwater (ie bore); and
  4) Surface water or groundwater.

- Water Resources Development Maps and Commentary Notes (Yin Foo, 2000a,b,c,d) at pastoral property scale. This is a series of 4 maps, at 1:250,000 scale, based on the following sub-areas of the Sturt Plateau region:
  1) Bloodwood Downs, Cow Creek, Dry River, Gilnockie, Gorrie, Lakefield, Larrizona, Margaret Downs, Nenen and Wyworrie Stations;
  2) Elsey Station and Wubalawun Aboriginal Land Trust;
  3) Avago, Birdum Creek, Maryfield, Middle Creek, Sunday Creek, Tarlee, Vermelha and Western Creek Stations; and
  4) Kalala and Hidden Valley Stations.

  The maps and commentary notes are intended for use by the individual property owners to assist them with planning the future development of their property.

- '1:250,000 Hydrogeology Map – Sturt Plateau Region' (Yin Foo & Matthews, 2000). This map covers the entire Sturt Plateau region at 1:250,000 scale and provides a regional indication of groundwater prospects (ie aquifer type, anticipated yield, likelihood for success).

Water resources of the Katherine region and south west Arnhem Land (George, 2001a,b,c,d) was studied during 1999-2001. A 'Water Resource Map' was produced at a scale of 1:250,000 and provides an explanation of the groundwater and surface water resources. The groundwater resource has been classified according to the supply potential and the surface water resource has been classified according to the minimum river flow recorded at the end of the dry season (ranging from rivers that are ephemeral, to rivers with a flow of more than 100L/sec).

2.6.2 Stream Flow and Groundwater

Stream flow gauging commenced in the Northern Territory in 1952 and the first flow gauge station was set up in the Roper River catchment in 1953 at Elsey Homestead (Dept of Transport and Works, 1980). Figure 2.6 shows the location of the flow gauge stations within the Roper River catchment. The five operational stations are shown along with 11 closed stations.

Rainfall data for the region are supplemented by information from pluviometer stations. In addition to daily rainfall recordings carried out by the Bureau of Meteorology there are nine pluviographs (automatic rainfall recorders) operating in the Roper River catchment for flood hydrology work. These are located at Beswick; on Chambers and Daly Waters Creeks; and Roper River downstream of Mataranka and at Red Rock.

OPEN FLOW GAUGE STATIONS

Station	Tributary	Location	Years Recording
G9030124	Daly Waters Ck	Daly Waters	1961-present
G9030001	Elsey Ck	Warloch Ponds	1966-present
G9030176	Roper Riv	D/stream Mataranka Hstead	1961-present
G9030250	Roper Riv	Red Rock	1966-present
G9030089	Waterhouse Riv	At Road Bridge	1972-present

CLOSED FLOW GAUGE STATIONS

Station	Tributary	Location	Years Recording
G9030008	Birdum Ck	Railway Bridge	1970-1978
G9030090	Chambers Ck	Wattle Hill	1973-1993
G9030108	Flying Fox Ck	Mainoru Rd Crossing	1960-1986
G9030102	Hodgson Riv	Wulli Pulli	1965-1986
G9030074	Mainoru Riv	Mainoru Homestead	1959-1973
G9030012	Roper Riv	Police Station	1954-1987
G9030013	Roper Riv	Elsey Homestead	1953-1987
G9030123	Roper Riv	D/stream Moroak Hstead	1963-1973
G9030088	Waterhouse Riv	Near Beswick Hstead	1960-1971
G9030003	Wilton Riv	Bulman Waterhole	1967-1978
G9030146	Wilton Riv	Qualari Waterhole	1963-1986

WATER QUALITY SAMPLING POINTS

Code	Station	Tributary	Location
1	G9030005	Mainoru Riv	The Craters
2	G9030178	Roper Riv	Roper Mission Ngukurr
3	G9035009	Roper Riv	Pump Intake, Dieter's Landing
4	G9035025	Hodgson Riv	Minyerri Billabong
5	G9035027	Roper Ck	Near Mataranka
6	G9035030	Salt Ck	Road Crossing
7	G9035036	Roper Riv	Pt A
8	G9035041	Roper Riv	Pt F
9	G9035052	Roper Riv	Pt Q
10	G9035057	Roper Riv	Pt V
11	G9035077	Roper Riv	Pt Ap
12	G9035085	Roper Riv	Mataranka Hstead crossing
13	G9035111	Wilton Riv	N86
14	G9035113	Mainoru Riv	Gove Rd crossing
15	G9035114	Mainoru Riv	R86
16	G9035125	Roper Riv	Mole Hill
17	G9035141	Waterhouse Riv	U/s Beswick, Arnhem Hwy
18	G9035142	Wilton Riv	Arnhem Hwy crossing
19	G9035143	Hodgson Riv	South Roper Bar
20	G9035144	Roper Riv	Rocky Bar Crossing

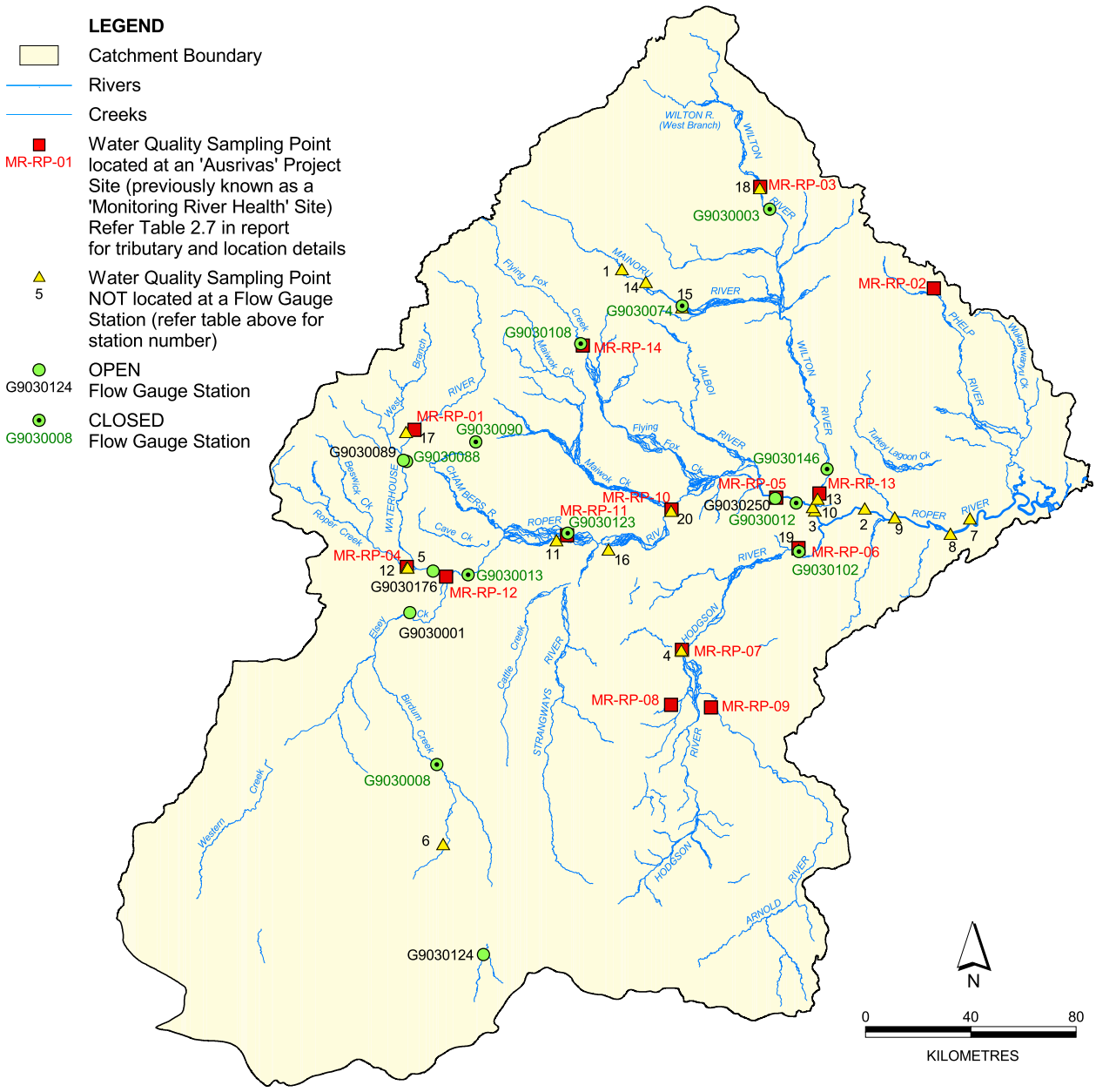


Figure 2.6 Location of Flow Gauge Stations and Water Quality Sampling Points throughout the Roper River Catchment

Table 2.4 summaries the stream flow information for all the open flow gauge stations as well as 3 closed stations in Roper River catchment. Gauge station G9030250, at Red Rock, is located the furthest downstream on the Roper River and records a mean annual flow volume of 2,269 million m^3 (ie 2,269,000 ML) or a mean annual discharge of 88.8 m^3/sec.

The stream flow contributions to the Roper River from Elsey and Flying Fox Creeks, Hodgson, Waterhouse and Wilton Rivers (on which flow gauge stations exist or have existed) vary considerably. In particular, the flow from the Elsey Creek system has a small contribution despite having the largest catchment area in the Roper River catchment.

The mean monthly discharges for the Roper River and several tributaries are shown in Figures 2.7 to 2.9. The concentration of monsoonal rains during the wet season, November to March, is reflected in marked seasonal changes in stream flows. In the wet season, river flows increase due to rainfall runoff. Generally, river discharge tends to increase as the wet season advances even though, in a normal wet season, the rainfall may be more or less uniformly distributed from December through March. Rainfall can be variable and high intensity falls can occur (eg highest daily rain recorded at Larrimah was 408.6 mm and occurred in January 1987).

Those gauge stations recording a minimum monthly discharge that is greater than zero throughout the year (refer Figures 2.7 to 2.9), are located on Hodgson, Waterhouse, Wilton and Roper Rivers, and Flying Fox Creek. The dry season flows or "baseflow" in these river systems is attributed to groundwater discharge from springs or seepage points. The contribution of groundwater becomes increasingly important as the dry season progresses because these river systems would otherwise become isolated pools or dry up completely. The many springs in the Mataranka area and in the reach of the Roper River as far as Elsey Homestead, are due to discharges from the regional limestone aquifer - Tindal Limestone (Yin Foo, 2000b). The springs are natural outflow points for groundwater, occurring where the watertable has been incised by the river bed. The result is that the flow in the Roper River is maintained throughout the year. Goundwater discharge from aquifers in the Dook Creek Formation provides dry season flow in Flying Fox Creek, Mainoru River and some of the Wilton River (George, 2001a).

Figure 2.7 shows the mean monthly discharge recorded for two gauge stations located on Roper River as well as gauge stations on Hodgson and Wilton Rivers. These rivers are perennial or permanent flowing rivers recording flows throughout the dry season.

Table 2.4 Summary of Stream Flow Information for the Roper River Catchment

Gauge Station Number	Tributary	Catchment Area (km^2)	Mean Annual Flow Volume (m^3)	Mean Annual Discharge (m^3/sec)	Median Annual Discharge (m^3/sec)	Mean Monthly Discharge (min-max) (m^3/sec)
G9030124	Daly Waters Creek	777	8,691,000	1.0	0.6	1.1 (0-5.1)
G9030001	Elsey Creek	18,785	98,330,000	10.1	4.6	8.3 (0-54.1)
G9030176	Roper River	5,610	500,700,000	20.5	13.6	20.4 (0.7-182.5)
G9030250	Roper River	47,400	2,269,000,000	88.8	66.9	100.9 (0-420.4)
G9030089	Waterhouse River	3,110	184,900,000	9.8	7.6	11.2 (0.3-77.4)
G9030108*	Flying Fox Creek	1,350	31,280,000	1.2	0.7	1.5 (0.1-5.3)
G9030102*	Hodgson River	14,200	1,044,000,000	83.7	78.7	89.6 (2.4-254.4)
G9030146*	Wilton River	12,400	1,565,000,000	65.6	65.9	127.1 (0-282.5)

* Closed Gauge Station

Source: Figures obtained from 'Hydsys' and were up-to-date at the time of extraction (2001). Stream flow information is based on data from some stations that are no longer in operation or have a limited number of gaugings and, consequently, the ratings that generate the stage-to-discharge relationship cannot be guaranteed.

The highest mean monthly discharge along the Roper River occurs in March and ranges from 83m^3/sec near Mataranka (G9030176) to 509m^3/sec at Red Rock (G9030250). The lowest mean monthly discharge along Roper River occurs in September and October and ranges from 1.5m^3/sec near Mataranka to 1m^3/sec at Red Rock. The highest mean monthly discharge recorded for Wilton and Hodgson Rivers occurs in March and is 557m^3/sec and 377m^3/sec respectively. The lowest mean monthly discharge recorded for these two stations occurs in July and August and is 0.5m^3/sec and 0.2m^3/sec respectively.

The mean monthly discharge recorded at gauge stations on Flying Fox Creek and Waterhouse River is shown in Figure 2.8. These stations recorded their highest mean monthly discharge in February-March and their lowest discharge in September-October. Mean monthly discharges for Flying Fox Creek and Waterhouse River ranged from 0.4-6m^3/sec and 0.2-34m^3/sec respectively. Both of these systems recorded flows during the dry season indicating that they are spring-fed (ie groundwater discharge is contributing to these flows).

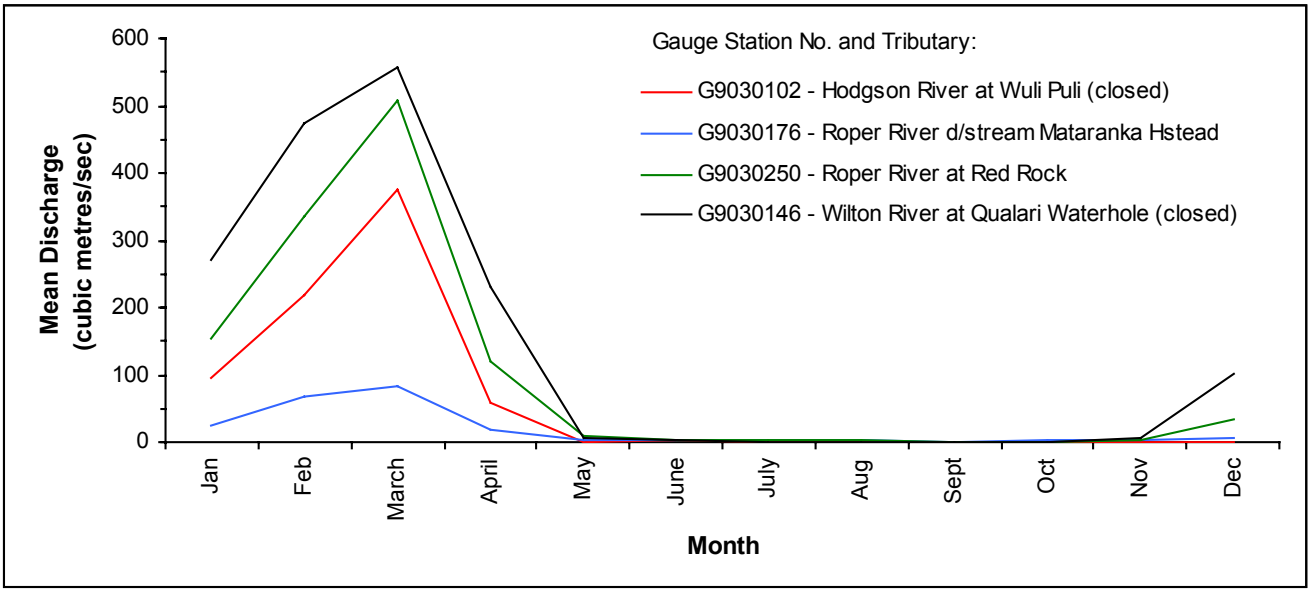


Figure 2.7 Mean Monthly Discharge Recorded for Hodgson, Wilton and Roper Rivers

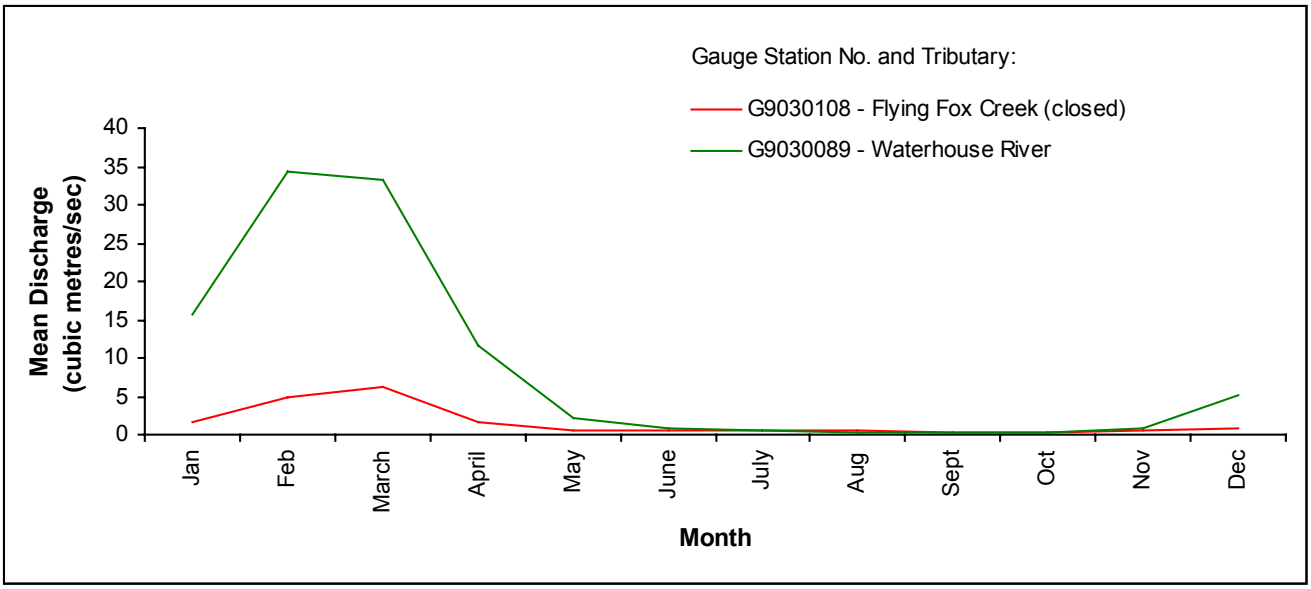


Figure 2.8 Mean Monthly Discharge Recorded for Flying Fox Creek and Waterhouse River

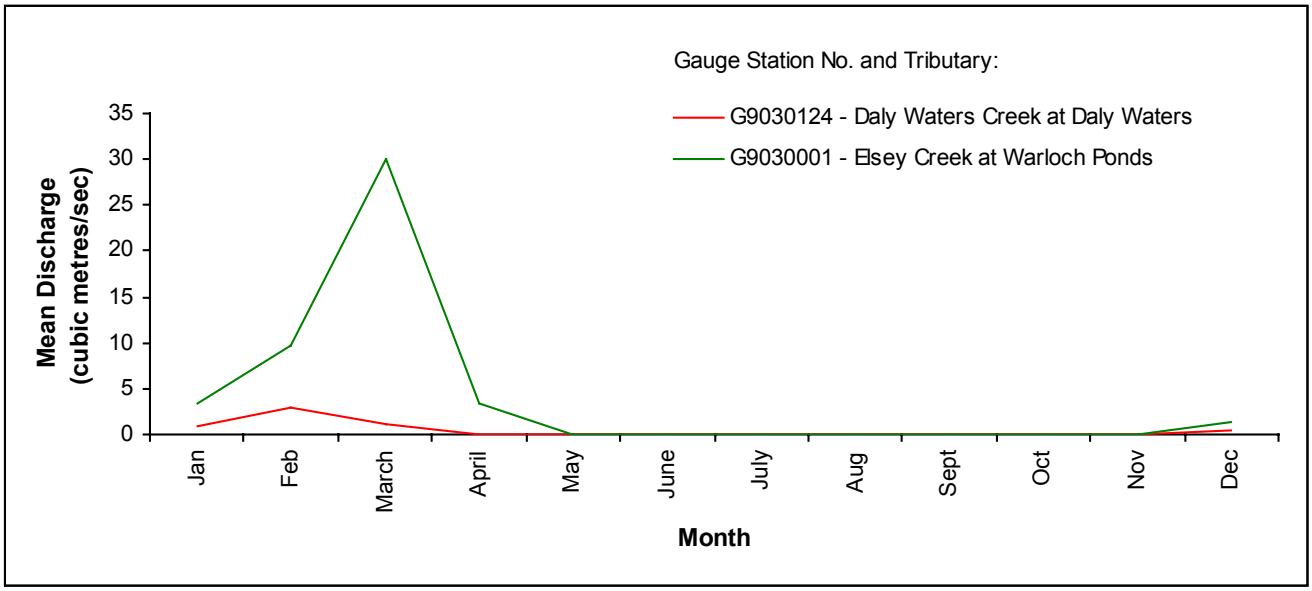
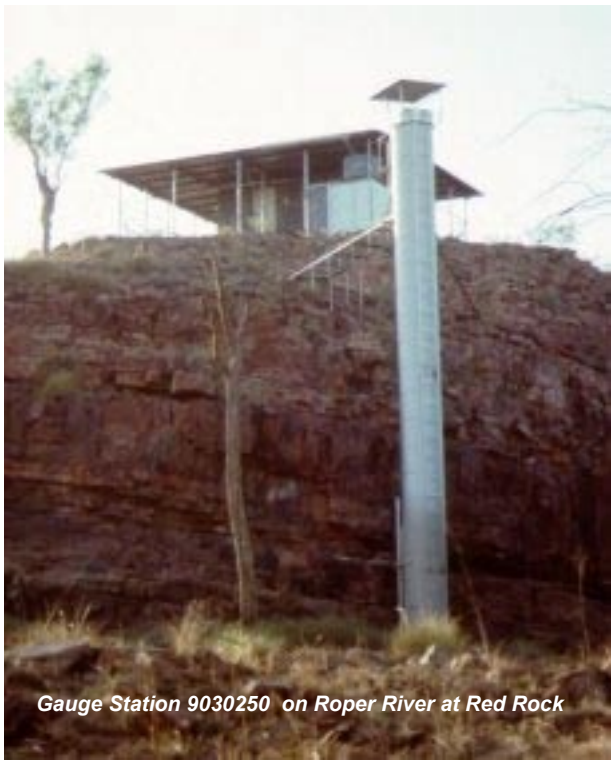


Figure 2.9 Mean Monthly Discharge Recorded for Daly Waters and Elsey Creeks

The mean monthly discharge recorded for the intermittent or "ephemeral" tributaries – Daly Waters and Elsey Creeks, is shown in Figure 2.9. Flows in Elsey Creek, which drains the flat Sturt Plateau region and includes Western and Birdum Creek systems, only occurs during the wet season after the catchment has been adequately wet or following significant rainfall events. Typically, as the dry season progresses, the drainage systems deplete to form isolated pools in the rivers and waterholes. The majority of these are dry by August or September. A few waterholes within the Elsey Creek system (eg Longreach Waterhole downstream of Warloch Ponds) persist throughout the year as do some waterholes within the Western and Birdum Creek systems and adjacent floodplains (Yin Foo, 2000a,b,c). Daly Waters Creek and Elsey Creek have a mean monthly discharge that ranges from 0–3m^3/sec and 0-30m^3/sec respectively.

Extraction of water from rivers and creeks (ie surface waters) occurs for stock and domestic purposes within the Roper River catchment. Where greater volumes of surface waters are needed for irrigation, domestic or mining purposes, 'Water Extraction Licences' are required. These extraction licences are issued and managed by the Department of Lands, Planning and Environment under the *NT Water Act*. There are currently six Water Extraction Licences for the Roper River. Four of these licenses are for community water supply purposes and another two are located at Roper Bar for domestic purposes and maintenance of gardens. The maximum yearly extraction figures set for these six licences totals 403 ML.



Gauge Station 9030250 on Roper River at Red Rock

2.6.3 Water Quality

It was not until 1984 that a surface water quality network was established in the Northern Territory and a program of spot measurements for basic key quality parameters (ie pH, temperature, electrical conductivity and turbidity) was introduced at flow gauge stations (Dept of Mines and Energy, 1986). Total phosphorus and total alkalinity are two other water quality parameters that are measured at some gauge stations on an irregular basis.

Water quality monitoring is carried out on a project basis and is managed by the Department of Lands, Planning and Environment (DLPE). Water quality sampling stations (located away from flow gauge stations) has generally been carried out on an ad hoc basis and may have been part of a one-off water quality survey. There is no long-term time series data collection without it being an identified requirement of an endorsed project.

The location of 50 water quality sampling points throughout the Roper River catchment is shown in Figure 2.6. These sampling points have been divided into 3 categories. That is, those located at a flow gauge station, those away from a flow gauge station and those at an 'Ausrivas' (Australian River Assessment Scheme) Project site. 'Ausrivas' is part of the National River Health Program and has been developed as a rapid, integrated way of assessing the ecological health of rivers, involving sampling aquatic macro-invertebrates (insects and crustaceans).

Tables 2.5, 2.6 and 2.7 summarise the results for the water quality sampling points shown in Figure 2.6. The results, where available, are for 6 water quality parameters: electrical conductivity (EC), turbidity, water temperature, pH, total alkalinity and total phosphorus. The water quality results have not been analysed on a monthly basis, in order to show trends between the wet and dry season, due to the general scarcity of results and ad hoc nature of the data collection.

Table 2.5 summarises the water quality information for 4 open and 10 closed gauge stations. Roper River recorded the highest EC levels (ranging from 834-1,873µS/cm). Higher turbidity levels (ie >100 NTUs) were recorded on sections of Roper and Waterhouse Rivers and Daly Waters Creek. Stations located on Daly Waters and Chambers Creeks recorded pH levels of <6.5. Higher total alkalinity levels (influenced by groundwater discharge into rivers) were recorded for Roper, Mainoru and Wilton Rivers and Flying Fox Creek.

Table 2.5 Summary of Water Quality Information for Sampling Points Located at a Flow Gauge Station

Gauge Station Number**	Tributary	Mean Electrical Conductivity – Lab (µS/cm) (No. of results)	Mean Turbidity – Lab (NTUs) (No. of results)	Mean Water Temp – Field (°C) (No. of results)	Mean pH – Lab (No. of results)	Mean Total Alkalinity – Lab (mg/L) (No. of results)	Mean Total Phosphorus – Lab (mg/L) (No. of results)
G9030124	Daly Waters Creek	31 (9)	112.0 (4)	-	6.28 (9)	12 (9)	-
G9030001	Elsey Creek	126 (6)	19.0 (1)	-	6.88 (6)	56 (6)	-
G9030176	Roper River	1,048 (17)	28.1 (19)	-	7.60 (17)	271 (7)	-
G9030250	Roper River	924 (31)	236.9 (23)	-	7.67 (31)	199 (17)	0.06 (4)
G9030090*	Chambers Creek	33 (10)	54.4 (7)	-	6.09 (10)	9 (10)	-
G9030108*	Flying Fox Creek	400 (7)	-	-	7.88 (7)	200 (6)	0.01 (2)
G9030102*	Hodgson River	152 (8)	89.4 (7)	-	6.83 (8)	22 (7)	-
G9030074*	Mainoru River	520 (1)	-	-	8.20 (1)	290 (1)	
G9030012*	Roper River	834 (11)	74.7 (3)	-	7.91 (14)	235 (12)	-
G9030013*	Roper River	1,873 (6)	100.0 (1)	-	7.73 (6)	420 6)	-
G9030123*	Roper River	1,781 (11)	100.0 (1)	30.4 (1)	8.13 (11)	285 (10)	0.03 (3)
G9030088*	Waterhouse River	37 (5)	144.5 (2)	-	6.61 (5)	14 (5)	-
G9030003*	Wilton River	382 (3)	60.0 (1)	-	7.89 (3)	231 (2)	-
G9030146*	Wilton River	265 (17)	20.0 (15)	-	7.51 (17)	133 (6)	-

* Closed Gauge Stations ** Refer to Figure 2.6 for location details
Source: Figures obtained from 'Hydsys' and were up-to-date at the time of extraction (2001)

Table 2.6 summarises the water quality information for sampling points not located at a flow gauge station, where there were two or more results recorded for at least one of the parameters. Generally, EC levels in excess of 800µS/cm cause a deterioration in taste (ANZECC, 1992). Roper River, Roper Creek and Salt Creek recorded EC levels in excess of this level. Turbidity levels varied from 0.5 to 100 NTUs. pH levels were between 6.6 to 8.4. Most natural freshwaters have a pH close to 7 (ANZECC, 1992). pH and salinity (EC) are largely determined by the geology and soils of the catchment. Higher total alkalinity levels (influenced by groundwater discharge into rivers) were recorded for Mainoru, Roper and Wilton Rivers and Roper and Salt Creeks. Total phosphorus levels were low, ranging from 0.01 to 0.03 mg/L.

Table 2.6 Summary of Water Quality Information for Sampling Points Not Located at a Flow Gauge Station

Gauge Station Number*	Tributary	Mean Electrical Conductivity – Lab (µS/cm) (No. of results)	Mean Turbidity – Lab (NTUs) (No. of results)	Mean Water Temp – Field (°C) (No. of results)	Mean pH – Lab (No. of results)	Mean Total Alkalinity - Lab (No. of results)	Mean Total Phosphorus – Lab (mg/L) (No. of results)
G9035025	Hodgson River	73 (10)	-	32.5 (2)	6.60 (10)	27 (10)	0.03 (3)
G9035143	Hodgson River	69 (3)	-	-	7.03 (3)	25 (3)	0.01 (3)
G9030005	Mainoru River	568 (2)	-	-	8.08 (2)	302 (2)	-
G9035113	Mainoru River	469 (4)	-	-	8.20 (4)	257 (4)	0.01 (3)
G9035114	Mainoru River	510 (2)	-	-	8.25 (2)	275 (2)	0.01 (1)
G9035027	Roper Creek (Little Roper River)	1,080 (7)	-	-	7.41 (7)	342 (7)	0.01 (2)
G9030178	Roper River	743 (203)	29.3 (39)	-	7.55 (88)	101 (100)	-
G9035009	Roper River	1,099 (3)	-	-	8.17 (3)	224 (3)	-
G9035036	Roper River	12,623 (4)	100.0 (3)	-	8.05 (4)	107 (2)	-
G9035041	Roper River	3,095 (2)	72.0 (1)	-	8.30 (2)	93 (1)	-
G9035052	Roper River	399 (2)	14.0 (1)	-	8.40 (2)	75 (1)	-
G9035057	Roper River	881 (2)	0.5 (1)	-	8.35 (2)	194 (2)	-
G9035077	Roper River	1,920 (2)	-	-	8.40 (2)	334 (2)	-
G9035085	Roper River	1,125 (3)	-	-	7.37 (3)	284 (3)	0.02 (1)
G9035125	Roper River	955 (2)	-	-	7.25 (2)	199 (2)	-
G9035144	Roper River	1,627 (3)	-	-	8.33 (3)	232 (3)	0.01 (1)
G9035030	Salt Creek	5,803 (3)	-	-	7.87 (3)	350 (3)	0.01 (2)
G9035141	Waterhouse River	196 (3)	-	-	6.97 (3)	78 (3)	0.01 (3)
G9035111	Wilton River	319 (3)	-	-	8.13 (3)	154 (3)	0.02 (2)
G9035142	Wilton River	323 (2)	-	-	7.85 (2)	138 (2)	0.02 (2)

* Refer to Figure 2.6 for location details

Source: Figures obtained from 'Hydsys' and were up-to-date at the time of extraction (2001). These water quality sampling points had ≥2 results recorded for at least one of the parameters.

Table 2.7 Summary of Water Quality Information for Sampling Points Located at an 'Ausrivas' Project Site

Site Number*	Tributary and Location Description	Mean Electrical Conductivity – Field (µS/cm)	Mean Turbidity – Field (NTUs)	Mean Water Temp – Field (°C)	Mean pH – Field	Mean Total Alkalinity – Lab (mg/L)	Mean Total Phosphorus – Lab (mg/L)
MR-RP-09	Arnold River at Minimere Waterhole	35	3.4	29.6	6.65	9	0.012
MR-RP-08	Bella Glen Creek at Bella Glen Waterhole	123	5.2	28.3	6.71	50	0.020
MR-RP-14	Flying Fox Creek at East Arnhem Hwy Crossing	444	2.8	26.2	7.94	261	0.007
MR-RP-06	Hodgson River – south of Roper Bar	61	16.2	30.2	7.50	29	0.011
MR-RP-07	Hodgson River at Minyerri Billabong	76	24.8	30.8	7.70	31	0.025
MR-RP-02	Mainoru River at East Arnhem Hwy Crossing	472	1.8	25.8	8.08	270	0.007
MR-RP-04	Roper Creek (Little Roper River) – upstream of Mataranka Homestead Crossing	1,357	1.4	29.9	7.24	489	0.010
MR-RP-05	Roper River at Red Rock	942	2.5	29.6	8.04	186	0.013
MR-RP-10	Roper River at Rocky Bar Crossing	1,560	5.4	28.6	8.15	264	0.009
MR-RP-11	Roper River at Crossing to Moroak Station	1,528	23.8	27.0	8.05	336	0.019
MR-RP-12	Salt Creek	4,240	2.3	28.9	7.86	354	0.008
MR-RP-01	Waterhouse River at Beswick	167	10.9	28.7	6.84	56	0.009
MR-RP-03	Wilton River at East Arnhem Hwy Crossing	216	26.5	27.1	8.12	168	0.012
MR-RP-13	Wilton River at crossing to Ngukurr	275	5.3	29.7	7.90	131	0.011

Source: Figures obtained from the 'Ausrivas' Project. Four to five water quality tests were carried out between 1994 and 1996 predominantly during the months of May, June, August, September, November and December.

Table 2.7 summarises the water quality information for 14 sampling points located at an 'Ausrivas' project site. Salt Creek, Roper River and Roper Creek recorded elevated EC levels compared to other points. Generally, EC levels in excess of 800µS/cm cause deterioration in taste if water is used for drinking purposes (ANZECC, 1992). Turbidity levels were low. Water temperatures ranged from 26°C to 31°C. Most natural freshwaters have a pH close to 7 and the pH level, as well as the EC level, are influenced by the geology and soils of the catchment. Water running off limestone areas would have relatively higher pH levels (ANZECC, 1992). The pH levels recorded ranged from 6.7-8.2. Total alkalinity levels are influenced by groundwater discharge into rivers. Higher total alkalinity levels were recorded for Roper, Flying Fox and Salt Creeks, along with Roper and Mainoru Rivers, all of which are influenced by groundwater discharge. Total phosphorus levels recorded were low.

Seasonal changes in water quality are a feature of streams in the Top End, due to the influence of a wet and dry season. During the dry season water levels are reduced and in rivers and creeks which eventually dry up, most of the water is confined in relatively small areas (ie broken channels, billabongs and swamps) where evaporation and chemical changes occur. The first storms of the wet season bring minor freshes ('early wet season flushes') down the river that are very turbid, resulting from surface wash in the catchment. Turbidity tends to decrease as the wet season becomes established but is very variable depending on the actual flow conditions. The early wet season rains also flush high levels of decayed organic matter from stagnant pools in the river bed and from surface wash, which have a high bacterial pollution and low oxygen content. These flushes have resulted in fish deaths and a rapid deterioration of water quality (Townsend *et al*., 1992).

3. METHODS

3.1 Background to Methodology

The 'Top End Waterways Project' was required to assess, describe and report on the current physical and ecological condition of the major rivers and their tributaries within the Katherine Region. Developing a suitable methodology was beyond the scope of the project. Therefore, an appropriate methodology, that could be adapted for use by the 'Top End Waterways Project', had to be selected for this study.

The 'State of the Rivers' methodology (Anderson, 1993b,c) was assessed and selected to provide a general framework for the 'Top End Waterways Project'. The methodology was developed by J.R. Anderson for the Queensland Government where it is currently being utilised, following its testing and validation, to assess the States' rivers on a catchment by catchment basis (Anderson, 1993a,b,c; Phillips and Moller, 1995).

Other existing studies and approaches to measuring stream condition that were reviewed and considered for possible implementation included:

- An Index of Stream Condition (ISC) – Development of an Index of Stream Condition, Reference Manual, User's Manual and Trial Applications (CEAH & ID&A Pty Ltd, 1995 & 1997; ID&A Pty Ltd & CEAH, 1997a,b);
- Conservation Value and Status of Victorian Rivers – Part 1 Methodology and Part 2 East Gippsland Rivers (Macmillan & Kunert, 1990; Macmillan, 1990);
- The Environmental Condition of Victorian Streams (Mitchell, 1990);
- Environmental Flow Studies for the Wimmera River, Victoria – Parts A-E (Anderson & Morison, 1989a,b,c,d; Anderson *et al.*, 1989e);
- Rivers and Streams Special Investigation – Victoria (Land Conservation Council, 1989);
- Water Victoria – An Environmental Handbook (Dept of Water Resources Victoria, 1989);
- State of the Environment Report 1988 – Victoria's Inland Waters (Office of the Commissioner for the Environment, 1988); and
- Statewide Assessment of Physical Stream Conditions – Phase 1 (Ian Drummond & Associates Pty Ltd, 1985).

Of the approaches reviewed, the ISC method could have had possible application within the Northern Territory to benchmark stream condition, but because the concept was still being developed in 1995 and had not been trialed, the ISC method was not considered appropriate for this study.

From the 'State of the Rivers' methodology (refer Anderson, 1993b,c), the 'Top End Waterways Project' adapted the sampling strategy, survey methods and data collection sheets for use in assessing the condition of rivers in the Katherine Region. Following the collection, preliminary analysis and presentation of the data for a previous catchment that was studied (ie Daly River catchment – Faulks, 1998a,b), the condition and stability ratings developed by Anderson (1993b,c) were modified or completely altered by a NT Technical Working Group. The alterations to the condition and stability ratings were thought necessary so that results would reflect Northern Territory (ie wet/dry tropical) conditions more closely. Sections 3.4, 3.5 and 3.6 discuss in more detail the sampling strategy, survey components and the condition and stability ratings, respectively.

The 'State of the Rivers' method adopted a "snapshot" survey approach with the aim of comparing different stream sections within a catchment in terms of their current physical and ecological condition, and assessing the extent to which that condition has deteriorated from a "pristine" condition. The 'Top End Waterways Project' seeks to establish the condition of the streams at the time of the survey relative to a benchmark. The benchmark used is an "ideal" undisturbed or natural state that has been defined by the NT Technical Working Group as well as from a preliminary analysis of previous data.

The snapshot highlights the most severe and urgent problems and also sets a baseline or benchmark against which future trends and the rate of change can be assessed. It does not directly measure the rate of change or trend but relies on comparisons between the condition at the time of the survey and after follow-up surveys.

3.2 Scope and Limitations

The methodology is a snapshot of stream condition in whole catchments or sub-catchments at one point in time and does not allow for close examination of particular areas or reaches. This is principally due to the lack of survey sites at that scale and the likelihood that survey sites are put in areas of easier access.

The method is not intended to provide all the information that managers may require about stream condition when planning management programs. It will help to identify key issues, problems and priorities and also help to broadly recognise what processes are causing river degradation. It will also help to identify where more detailed investigations are needed. Consequently, it is an important management tool but it should be only one source of information on which to base decision making processes.

The 'State of the Rivers' survey is focussed on collecting physical and ecological information on instream and riparian habitats (ie the river itself, the banks and the channel). The survey does not include lakes and wetlands (eg billabongs, swamps and oxbows) unless they occur along defined stream channels. The ecological condition assessment is based on assessing the condition of the instream aquatic and riparian habitats and the vegetation structure, rather than conducting flora and fauna surveys or assessing community structure or integrity. The abundance and type of aquatic life (eg macroinvertebrates, fish, *etc*) or other fauna using the riparian zone has not been assessed. The 'Top End Waterways Project' has incorporated a vegetation survey component to more adequately describe the riparian vegetation.

Stream flow measurements are not an obligatory part of the methods. To overcome this lack of information, the 'Top End Waterways Project' has summarised the stream flow information that exists for gauge stations within the Roper River catchment (refer Section 2.6.2). The extent of changes to hydrology is not an inherent part of the methods. This would involve taking into account any change in volume and seasonality of flows from natural conditions; and changes to the balance and interaction between ground and surface water, which is particularly important during the dry season when groundwater maintains baseflows in several of the larger rivers and creeks. The influence of artificial barriers on the hydrology of streams is also not assessed.

Water quality measurements are also not an obligatory part of the 'State of the Rivers' methods. It was felt that rather than carry out one-off water quality sampling as part of the 'Top End Waterways Project', it would prove more useful to summarise longer term water quality information that currently existed for the Roper River catchment (refer Section 2.6.3). Temporal variability in water quality (eg seasonal changes, influence of groundwater particularly during the dry season) was not assessed.

The survey includes estuaries. Their inclusion was important for completeness, but the survey methodology was primarily designed for the non-estuarine sections of rivers and streams, and so certain additions were made to the 'State of the Rivers' methodology to allow for estuaries to be included, rather than specifically designing estuarine survey techniques.

Linkages to other projects and initiatives that address other issues relating to rivers is important to aid overall river management decision-making processes. The 'Top End Waterways Project' has established links with, for example, the Ausrivas project and riparian vegetation assessments by overlapping survey sites with those projects in order to allow possible correlations to be drawn between these studies. Linkages to long term water flow and quality databases (eg Hydsys), vegetation databases, Wild Rivers assessments would also prove useful.

3.3 Follow-up Surveys

The 'State of the Rivers' survey methods were designed for use as a baseline or benchmark against which future trends (ie rate of change in condition) can be established through follow-up replicate surveys (Anderson, 1993a). The method allows for future partial or complete follow-up surveys to not only assess the rate of change but to try and assess the effectiveness of remedial measures. This has been achieved by adopting a standard methodology that can be repeated at a later date. Photographs, access notes, sketches and a GPS recording for each site will enable survey sites to be re-located for future surveys.

In order to monitor the rate of change in river condition as has been benchmarked by the 'Top End Waterways Project', or to look at management induced improvements or areas where management practices/land uses have changed or intensified, it would be necessary to conduct follow-up surveys. Selected priority sub-sections (or preferably sub-catchments) could be targeted in any follow-up surveys if whole catchments could not be re-surveyed. Long time periods (5 years or more) are generally required before changes in indicators like river channel physical form (eg river bank and bed stability) and the streamside zone (eg assessment of riparian vegetation and reach environs) can be measured.

3.4 Sampling Strategy

A stratified sampling approach is the basis of classifying the current physical and ecological condition of the streams, as described in the Qld 'State of the Rivers' methodology (Anderson, 1993a,b,c; Phillips and Moller, 1995). The catchment being studied is divided into "homogeneous stream sections" which represent stream sections that share similar natural features and conditions.

The delineation of the "homogeneous stream sections" involved a progressive division of the catchment into smaller and smaller units. Initially, the Roper River catchment was divided into 11 major sub-catchments (shown in Map 6). These represent the major tributaries within the Roper River catchment.

The major tributaries were further sub-divided into 20 sub-sections (shown in Map 7). Planning of these sub-section boundaries was done using 1:250,000 topographic map sheets initially and finalised using 1:100,000 sheets, along with landsat imagery. Generally, sub-section boundaries were established at major tributary junctions. Attributes including geology, stream gradient, altitude, landuse and the tidal limit assisted with sub-dividing tributaries like the Roper River further.

The number of sub-sections delineated for this project was substantially less than selected for Qld 'State of the Rivers' projects to date. The reasons for this include: variation in altitude does not exist within the Roper River catchment as compared to the river catchments being studied in Queensland (ie all of the Roper River catchment is less than 460m); there are very few artificial barriers, like weirs, on rivers; the rivers are not impounded by dams; the catchments are far less developed; access is far more difficult and time consuming; the resources available (ie time, staff) to sample a large number of sub-sections is not available.

It was the aim of this project methodology to select a number of sites within each sub-section to represent the range and extent of stream types and conditions, including a range of stream orders.

Map 8 shows the 6 stream orders for the Roper River catchment, based on the Strahler system and on a 1:250,000 map scale. The Roper River recorded the largest stream order of 6, on which 24 sites were sampled along an approximate stream length of 367km.

Map 8 also shows the approximate stream length and number of sites sampled for each stream order. The minor stream orders (1 and 2) make up a large proportion of the stream lengths although this is not reflected in the number of sites surveyed. It was generally felt that due to the constraints on the number of sites that could be sampled, a greater focus should be placed on the medium and larger-sized rivers and creeks.

Landsat imagery, 1:250,000 topographic map sheets, aerial photography along Roper River estuary and background information provided by the Roper River Landcare Group were used to select sites within each sub-section. Access for both vehicles and boats are a major determinant of the precise location of the sites. If a structure existed within the river (eg a low level crossing or bridge), the site would be selected upstream of it where possible so as to avoid any influence/ interference it may be causing.

A total of 93 sites were sampled throughout the Roper River catchment (refer Map 9 and Appendix A, which lists all sites and provides a location description). Of these sites, 89 were full survey sites. The remaining four 'photo sites' were visited in order to gain a greater understanding of the range and extent of stream types throughout the catchment. On average, 1-2 sites were sampled per day by a team of two people (ie 93 sites sampled over 59 days). Some of the more remote sites, including upper catchment sites, were accessed using a helicopter.

The Qld 'State of the Rivers' methodology was designed as a rapid survey where 8-10 sites could be surveyed per day. The considerably fewer number of sites sampled per day, as well as throughout the Roper River catchment, reflects the difficult access, particularly in remote areas; the greater distance between sites; the requirement to use boats to undertake surveys because of the presence of crocodiles; the collection of additional information (eg longitudinal profile and vegetation surveys, *etc*); and the limited resources available (staff, timeframe, *etc*).

To allow for the fewer number of sub-sections that were delineated for the Roper River catchment and the fewer number of sites that were surveyed, the condition and stability rating results for each site have been shown individually rather than as a result for the entire sub-section. It was felt that although a site provides an indication of the condition of the stream along a particular reach, from this a general interpolation of the results or trends can be made regarding the condition of the stream length between sites within a sub-section.

3.5 Survey Components

At each full survey site, the boundary for the survey (ie the "reach") was chosen in the field. The reach was generally representative of the channel habitat types, instream physical and ecological condition. Each reach usually consisted of at least two complete pools and riffle/run habitats.

Assessments are made on data sheets that are set up to describe the stream, the river banks and environs. The components of the field surveys are summarised below. Refer to Appendix B for a summary of the data sheet information. Those survey components that have been modified from the 'State of the Rivers' method or are new additions are highlighted in Appendix B.

- *Site Description*

Information relating to the survey (such as date, recorders, site number, tributary name, type of site, whether or not tidal) are recorded. A location description for each site, including an access sketch, is provided so that the site, and each sample point where a cross-section survey has been done, can be relocated for follow-up surveys. A GPS is used to provide a grid reference for the site and each sample point.

A standard set of colour slides is taken at each site including upstream and downstream views, at each bank, along the reach environs and at other key features. These slides are numbered sequentially and are accompanied by an associated description.

- *Reach Environs and Site Features*

Reach environs are those lands immediately adjacent to the riparian zone along the reach and include the floodplain and valley flat. Local information is recorded about these lands including land use, local disturbance, land tenure, local vegetation/habitat type and floodplain features. This information is important for classification purposes and for identifying processes and potential causes of changes in condition in the stream. A subjective overall disturbance rating, based on the extent of clearing, and replacement of vegetation by exotic species in the riparian zone and adjacent land, is also recorded.

The water level at the time of sampling is also recorded along with the local channel pattern (eg regular meanders, braided channel, *etc*).

- *Channel Habitat Types, Diversity and Dimensions*

The segments of the reach were categorised into the following channel habitat types: waterfall, cascade, rapid, riffle, glide, run, pool or backwater. The average reach length surveyed was recorded (ie average for study was 1,819m; range 59m to 20,600m). The pool chosen was usually the largest and deepest in the area. Longitudinal profile surveys, that is depth measurements along the streams' "thalweg", assisted with determining the location of the four habitat types that would make up the reach (ie at least two complete pools and riffle/run habitats).

The length, percentage of the reach covered, depth and width of each channel habitat type present, along with a sketch, was recorded. This information allows for an assessment to be made of the diversity of habitat types present in the area, which is important ecologically. Two sample points were usually selected, one at a pool habitat and one at a shallow habitat-type like a riffle, run or rapid.

A cross-section survey was done across each sample point/habitat type at right angles to the bank. The survey was aimed to pass over the point of maximum depth and minimum flow in a pool section and maximum flow and minimum depth in a riffle/run habitat. The extremes were chosen in order to establish the range of substrates, depths and channel parameters within the reach.

The cross-section surveys also took into account the width, height and slope of the lower and upper bank on each side of the stream to the high bank. The slope and shape of the banks along the reach were also ranked.

A rangefinder was used to measure the stream width at each cross-section. A depth sounder and boat were used to measure cross-section depths where water was present and boat access was available. The depth measurements made are dependent on the prevailing discharge at the time of the survey but are also referenced to the "water mark". If the river or creek bed was dry, or isolated pools were present, a tape measure and measuring pole were used to measure the depths and widths in relation to the 'water mark'.

The concept of a "water mark" is used to provide a reference point for standardising the channel measurements and for defining the boundary between the lower and upper banks (refer to Glossary).

Cross-sections provide a basic picture of the channel size, shape and form. They also provide baseline information for follow-up surveys when changes in channel dimensions may be detected. Cross-section graphs have been created and have been stored in the projects' database.


Boat and sediment grab equipment


Measuring bed sediments

- *Bank Condition and Stability*

The assessment of the banks is made in terms of the percentage of the bank length, for both lower and upper banks, that is recorded as being stable or unstable (eroding or aggrading). That is, the dominant process at the time of sampling is recorded. The location of the instability (for example at bends, obstacles, irregularly, *etc*) and the local factors affecting stability are also assessed to help to identify the processes involved. Overall subjective ratings of the condition of the bank stability is also made. The presence of artificial bank protection measures, such as tree planting and fencing off of river banks, is recorded.

- *Bed and Bar Condition and Stability*

The type of bar and its relative percentage of the total surface area of the bed, above water mark, is assessed. Overall subjective ratings of the stability of the bed and what is the dominant process at the time of sampling (ie whether stable, aggrading or eroding) is also made. Local factors affecting stability is assessed. Features relating to the gravel angularity and shape, bed compaction and the type of controls (eg rock outcrops, culverts, *etc*) stabilising the bed are also recorded.

- *Bed and Bank Sediments*

At the time of undertaking the cross-section surveys, the sediment composition of the bed, from three samples, and the lower and upper banks was also recorded. A grab-type sediment sampler was used to sample bed sediments. The contribution made by each sediment size class (ie fines, sands, gravels, cobbles, boulder and rocks), expressed as a percentage of the total volume, was determined by visual inspection. The sediment size classes are those of the Standards Association of Australia. From this data the mean size of the sediment has been determined for each of the major channel types.


Different bed sediment size classes

Stream invertebrate distribution and abundance is very much influenced by the type of substrate present and the relationship between flows, depths and substrates.


Measuring river depths

- *Riparian Vegetation*

Riparian vegetation was assessed in terms of percentage cover for the various structural groups: trees >30m, 10-30m, 2-10m; regenerating trees <2m; woody shrubs <2m; vines; rushes/sedges; phragmites; herbs; grasses; ferns; mangroves; and palms. The covers for native versus exotic species, within each structural category, are recorded separately. The total percentage cover of exotic species within the riparian zone for each bank is also assessed. The width of the riparian zone for each bank is recorded and is measured from "water mark" to the edge of the distinct band of riparian vegetation.

The percentage of the lower and upper bank length that was bare of vegetation cover, separated into overstorey versus understorey cover, was also assessed. The overstorey comprised trees and shrubs (>1.3m tall) whereas the understorey included the remaining ground covers.

This project also undertook vegetation surveys or compiled vegetation lists of the major species for each site. A vegetation profile was completed at 42 sites. The 10m-wide belt transect was located at right angles to the water's edge and extended to the upper bank or edge of riverine vegetation. Measurements (such as diameter at 1.3m, bole and tree height, and crown width) for each tree, greater than 1.3m tall and located within the profile, was recorded. Ground covers, such as grasses and herbs, were recorded within this vegetation profile through the use of a $1m^2$ quadrat, usually located at 5m intervals along the profile length starting at the water's edge. Percentage covers for each species type located within the quadrat was recorded.

Collecting vegetation samples for identification

- *Aquatic Vegetation*

Aquatic vegetation was divided into either submerged (eg filamentous algae, Chara/Nitella, Vallisneria, Myriophyllum and other herb-like forms), floating (eg water lilies, *etc*) or emergent (eg Phragmites, Typha, rushes/sedges, Pandanus, Melaleuca, *etc*) groups and was assessed in terms of percentage cover for the various structural types. The presence of exotic species was also recorded. Identification of the major aquatic vegetation was also undertaken.

- *Instream and Bank Habitats*

Instream cover for organic debris (such as logs, branches, leaves and twigs), emergent and aquatic vegetation, rocks and permanent pool habitats deeper than 1m was assessed in terms of percentage cover. Bank habitat types providing cover along the stream (such as canopy cover, low vegetation, root and bank overhang) were assessed in terms of percentage of bank length and average width provided by each type.

An overall aquatic rating for all aquatic life was subjectively assessed. The rating took into account the diversity of depths and substrates, level of disturbance, diversity and extent of cover, extent of canopy and other vegetation cover, and whether or not the stream dries up. Passage for fish and other organisms at the time of the survey and when the water is at its normal level was also assessed.

- *Additional Sources of Information*

Stream flow information collected at flow gauge stations throughout the Roper River catchment, and extracted from a database system called 'Hydsys', have been used to summarise flow volumes and monthly discharges.

Water quality information collected throughout the catchment for flow gauge stations and other water quality sampling points on rivers and creeks, that have been extracted from 'Hydsys', have been used to summarise results for the following parameters: Electrical conductivity (EC), turbidity, water temperature, pH, total alkalinity and total phosphorus. Water quality information collected at 'Ausrivas' (Australian River Assessment Scheme) project sites, have also been summarised.

Background information on the catchment has been gained through a literature review, as well as liaising with landowners/ managers, aboriginal groups, councils, other government departments and the Roper River Landcare Group.

3.6 Data Analyses and Presentation of Information

An Access Relational Database, designed for the 'Top End Waterways Project', has been used to enter, verify, store and analyse the raw data. This database can be used as an ongoing management tool to store and analyse the information collected over time. This database can also be directly interfaced with the GIS package 'ArcView'.

Data analysis or queries have been designed to provide summaries of the data for the entire catchment as well as for each sub-section. Only those sites where information has been collected on a particular field component are included in determining percentages for that component.

The raw data recorded for each of the components at a site is used to produce a series of condition or stability ratings for each site. The ratings developed by Anderson (1993b,c) were modified or completely altered by a NT Technical Working Group so that results would reflect Northern Territory conditions more closely. Appendix C summarises the condition and stability ratings, including the formulae, used for this project. Those that have been modified or completely altered have been highlighted in Appendix C. The condition or stability ratings include:

- state of the reach environs;
- channel type diversity;
- bank stability;
- bed stability;
- cover and structural diversity of riparian vegetation;
- cover of exotic riparian vegetation;
- cover and diversity of instream and bank habitats; and
- overall condition.

The overall condition is the result of combining equally the condition and stability ratings for the reach environs, bank and bed stability, riparian and exotic vegetation, and instream and bank habitats. **The derived rating for channel type diversity is not used to produce the overall condition rating**. Maps 10-25 shows the results for the condition and stability ratings and other attributes for each site (refer 'Catchment Results').

Each rating category for each site is scored as a percentage or a number, with 100% or 10 representing an ideal, undisturbed or natural state and 0% or 1 being very disturbed or unstable. A summary of the overall condition and stability rating categories used are outlined in Table 3.1.

Table 3.1 Condition & Stability Rating Categories

Condition and Stability Categories	Rating (%)	Rating (out of 10)
Essentially Natural (1) Stable (2) & (3) Very High Cover/Diversity (4) & (6) Exotics Absent (5) Very High Overall Condition (7)	81 - 100	9 - 10
Some Modification (1) Limited Instability (2) High Cover/Diversity (4) & (6) Low Cover for Exotics (5) High Overall Condition (7)	61 - 80	7 - 8
Moderate Modification (1) Moderate Instability (2) Moderate Erosion or Aggradation (3) Moderate Cover/Diversity (4) & (6) Moderate Cover for Exotics (5) Moderate Overall Condition (7)	41 - 60	5 - 6
Major Modification (1) Extensive Instability (2) Low Cover/Diversity (4) & (6) High Cover for Exotics (5) Low Overall Condition (7)	21 - 40	3 - 4
Extreme Modification (1) Extreme Instability (2) Severe Erosion or Aggradation (3) Very Low Cover/Diversity (4) & (6) Very High Cover for Exotics (5) Very Low Overall Condition (7)	0 - 20	1 - 2

(1) State of the reach environs
(2) Bank stability
(3) Bed stability
(4) Cover and structural diversity of riparian vegetation
(5) Cover of exotic riparian vegetation
(6) Cover and diversity of instream and bank habitats
(7) *Overall condition*

The results for each of the ratings are presented as the number or percentage of sites in each rating category. Although the results are not directly related to the actual proportion of the river system in each of these categories, it is felt that these results provide an indication of the major condition and stability rating trends for each sub-section. In 'Sub-catchment Results', charts that summarise the overall condition rating score (out of 60) for sites within each sub-section are provided. The overall condition rating score takes into account categories 1-6 shown in Table 3.1.

Presentation of the map series has been done using ArcView GIS package. Catchment and sub-section boundaries were drawn and digitised off 1:100,000 topographic map sheets. Cross-sections have been produced using Excel and have been stored within the projects' database. A CD containing the report, the map series, a selection of site photographs and an interactive GIS (using 'Arc Explorer') is being used to distribute the projects' results.

Below are examples of a range of condition and stability ratings found throughout the Roper River catchment:

State of the reach environs:

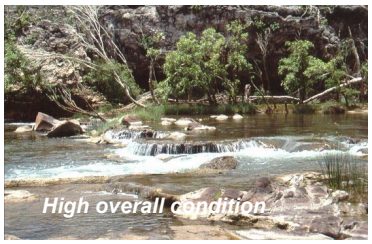
Bank stability:

Bed stability:

Cover and structural diversity of riparian vegetation:

Cover and diversity of instream and bank habitats:

Overall condition:



4. CATCHMENT RESULTS

Maps 10-25 show the results for the condition and stability ratings and other attributes discussed in this section.

4.1 Reach Environs and Site Features

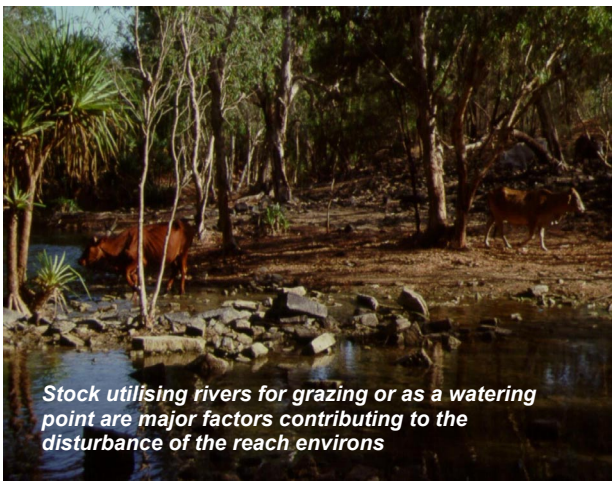
As shown on Map 10, the majority of land adjacent to stream reaches studied was under either freehold or leasehold tenure, including Aboriginal land (97% of sites). The only other land tenure type recorded was National Parks (3%).

The major land use recorded adjacent to the streams in the catchment was grazing on virgin native pasture (69% of sites). The dominant land uses in the catchment bordering the streams are recorded in Table 4.1.

Table 4.1 Land Use Adjacent to Reach Environs

Land Use Type	Percent of Sites (%)
Grazing - native - virgin	69
Aboriginal land	42
Grazing - native - thinned	7
Park or Reserve	3
Horticulture tree crops/fruit	1

The major types of disturbances likely to affect streams were recorded at each site and these are summarised in Table 4.2. The results indicate that grazing activity (recorded at 80% of sites), roads or tracks (47% of sites) and watering points for stock and feral animals (34% of sites) were the three major disturbances to streams. At 7% of sites no local disturbance was recorded.



Stock utilising rivers for grazing or as a watering point are major factors contributing to the disturbance of the reach environs

Table 4.2 Major Factors Contributing to the Disturbance of the Reach Environs

Disturbance Type	Percent of Sites (%)
Grazing	80
Road / track	47
Watering point for stock/ferals	34
Causeway / river crossing	25
People	11
Bridge / culvert	5
River works	2
Boat ramp	1

Subjective disturbance ratings indicated that nearly three-quarters of the sites (71%) recorded a low disturbance level with respect to the reach environs (refer Table 4.3). Few (2%) sites were moderately disturbed and no sites were highly, very highly or extremely disturbed.

Table 4.3 Disturbance Levels along Reach Environs based on Subjective Ratings

Disturbance Category	Percent of Sites (%)
Very Low	7
Very Low to Low	8
Low	71
Low to Moderate	12
Moderate	2
Moderate to High	0
High	0
Very High	0
Extreme	0

Sites recording a very low subjective disturbance rating had native vegetation present on both sides of the river with a virtually intact canopy that was in good condition and there were few introduced species. Disturbances observed along the reach included some impact from animals and recreational activities although these were minor.

A low or low to moderate disturbance rating meant that the riparian vegetation was generally intact but was being impacted on by things like stock/feral animals (eg trampling, grazing, watering), people, clearing for cattle watering points, infrastructure (eg tracks, crossing, pumps, buildings), exotic vegetation, severe flooding and bank erosion.

A summary of the state of the land corridor along the survey reach and on the floodplain adjacent to the reach (from derived ratings which take into account the land use and local disturbances) is shown in Table 4.4 and Map 11.

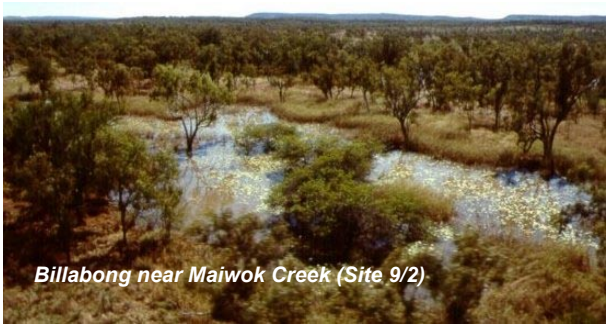
The results indicate that the sites throughout the catchment were classified as having either essentially natural reach environs (75% of sites) or some modification to the reach environs (25%). Generally, the sites with essentially natural reach environs had relatively low impact land uses, undisturbed vegetation and few local disturbances. Those sites that had some modification to the reach environs recorded local disturbances (ie concentration of animals at watering points, grazing, tracks or roads, river works and causeways) that reduced the ratings from essentially natural.

Table 4.4 State of the Reach Environs

Reach Environs Category (Rating)	Number of Sites (%)
Essentially Natural (81-100%)	68 (75)
Some Modification (61-80%)	23 (25)
Moderate Modification (41-60%)	0 (0)
Major Modification (21-40%)	0 (0)
Extreme Modification (0-20%)	0 (0)

The floodplain features were recorded at each site. The major feature included billabongs/oxbows (43% of sites), prominent flood channels (27%) and floodplain deposits (7%). The dominant channel patterns included regular meanders (41% of sites), irregular meanders (26%) and braided channels (18%).

Flood channels and swamps along Roper River at Red Lily Lagoon (also called 2-Mile Waterhole)



Billabong near Maiwok Creek (Site 9/2)

4.2 Channel Habitat Types, Diversity and Dimensions

The mean reach length studied was 1,819m (range 59-20,600m). The channel habitat types recorded are listed in Table 4.5. The dominant habitat types that occurred were pools (98% of sites), riffles (61%) and runs (51%). Pools generally occurred in conjunction with a riffle or a run. Waterfalls were associated with areas of steeper topography (eg gorge systems, tufa formations and upper catchment sites) and were found on Arnold, Roper and Waterhouse Rivers and Flying Fox Creek. Cascades were also associated with steeper river sections, gorge systems and tufa formations and were recorded on Arnold, Hodgson, Roper, Strangway and Wilton Rivers, and Bella Glen and Maiwok Creeks. Rapids were found along Roper and Wilton Rivers.

Table 4.5 Channel Habitat Types

Channel Habitat Type	Number of Sites (%)
Pool	87 (98)
Run	45 (51)
Glide	0 (0)
Riffle	54 (61)
Rapid	4 (4)
Cascade	7 (8)
Waterfall	5 (6)
Backwater	0 (0)

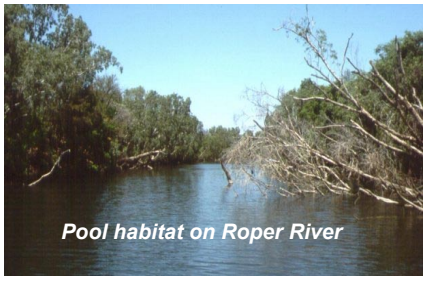
As the majority of the surveys were conducted during the dry season, the rivers and creeks (not fed by springs) were either completely dry (7% of sites) or had isolated pools (17%). The water level at sampling time at other sites was recorded as moderate but less than the normal level (23% of sites), normal at water mark (22%) or high (15%). Tidal influences (eg high/low tide, incoming/ outgoing tides) were recorded at 16% of sites located along the tidal reaches of the Roper River.

The channel dimensions of each habitat type is shown in Table 4.6. To allow for the variation in water level at the time of survey, measurements of channel width and depth were taken at the water mark (the normal water level) and the water surface level. Only those recorded at the water mark are listed in Table 4.6 for each habitat type.

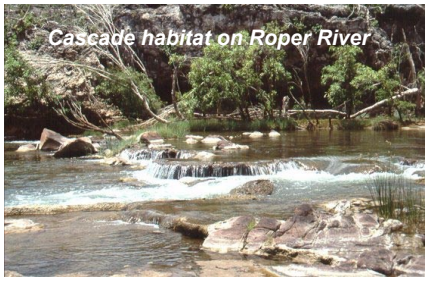
Pools dominated the reaches studied with an average of 73% of the reach covered by this habitat type. Pools had an average length of 990.6m (range 18-9,200m), an average depth of 3m and an average width of 66m.

Table 4.6 Channel Dimensions for each Habitat Type

Channel Habitat Type	Mean Percent of Reach Covered by Habitat Type and Range (%)	Mean Length of Habitat Type and Range (m)	Mean Depth (D) or Height (H) at Water Mark and Range (m)	Mean Width at Water Mark and Range (m)
Pool	72.8 (22-100)	990.6 (18.0-9,200.0)	D 3.0 (0.1-10.1)	66.0 (1.2-818.0)
Run	21.5 (2-66)	156.3 (5.0-2,200.0)	D 1.3 (0.1-8.2)	22.4 (1.9-164.4)
Riffle	27.8 (1-100)	134.0 (4.0-600.0)	D 0.7 (0.01-6.0)	26.4 (1.0-233.0)
Rapid	9.8 (1-27)	89.8 (20.0-143.0)	D 0.7 (0.5-1.1)	34.3 (15.0-60.0)
Cascade	6.3 (1-15)	35.7 (2.0-120.0)	H 0.7 (0.4-1.0)	17.8 (7.0-48.8)
Waterfall	2.6 (1-8)	6.3 (1.5-12.0)	H 3.4 (1.5-7.0)	10.5 (2.0-17.0)


Pool habitat on Roper River


Riffle habitat on Wilton River


Cascade habitat on Roper River


Isolated pool on Birdum Creek

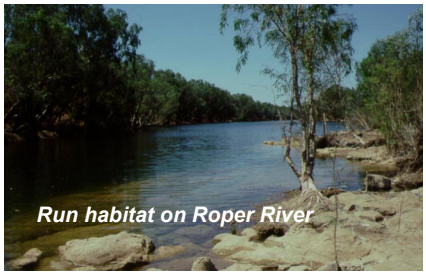

Dry riffle habitat on Hodgson River

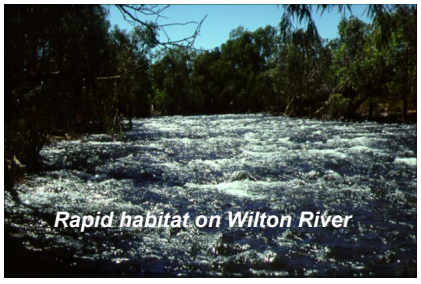

Dry cascade on Strangways River

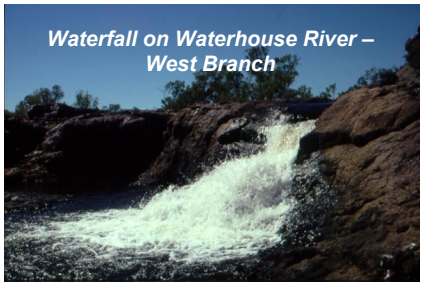

Isolated spring-fed pool on Strangways River


Rapid habitat on Roper River


Waterfall on Roper River


Run habitat on Roper River


Rapid habitat on Wilton River


Waterfall on Waterhouse River – West Branch

The average upper bank dimensions for each channel habitat type are shown in Table 4.7. The upper bank, for all habitat types, had an average width of 14.2m, an average height of 3m and an average slope of 21.4° (range 0.4-80.5°). The lower bank (ie below water mark), for all habitat types, had an average width of 2.4m (range 0-50m); an average height of 0.6m (range 0.1-1.5m); and an average slope of 31.2° (range 0.3-90°).

Table 4.7 Upper Bank Dimensions for each Habitat Type

Channel Habitat Type	Upper Bank Mean Width and Range (m)	Upper Bank Mean Height and Range (m)
Pool	10.7 (0.2-150.0)	3.0 (0.1-28.0)
Run	13.0 (0.9-60.0)	3.0 (0.2-15.0)
Riffle	20.5 (0.5-400.0)	2.9 (0.3-8.5)
Rapid	53.2 (4.4-102.0)	3.5 (2.4-4.6)
Cascade	12.8 (2.5-33.0)	3.9 (0.6-10.0)
Waterfall	23.1 (4.5-49.0)	2.5 (1.2-3.7)
Overall Mean - All Habitats	14.2 (0.2-400.0)	3.0 (0.1-28.0)

The major bank slope recorded was moderate (30-60°). The remainder of slopes recorded included steep (60-80°), low (10-30°), flat (<10°) and vertical (80-90°).

The major bank shape recorded was convex and to a lesser extent concave. Other bank shapes recorded included a wide lower bench, stepped or cliffs.

When the sites were assessed for their variability or diversity of channel habitat types, the majority (81%) of sites recorded either a high diversity or a very high diversity (refer Table 4.8 and Map 12). The diversity categories take into account the number of different channel habitat types present as well as the proportion of the reach occupied by pools versus other habitat types (ie riffles, rapids, runs, glides, cascades and waterfalls).

Table 4.8 Channel Type Diversity

Diversity Category (Rating)	Number of Sites (%)
Very High Diversity (9-10)	20 (23)
High Diversity (7-8)	52 (58)
Moderate Diversity (5-6)	5 (6)
Low Diversity (3-4)	10 (11)
Very Low Diversity (1-2)	2 (2)

The mid- to lower tidal reaches on Roper and Phelp Rivers rated low for channel type diversity because only uniform, tidal pools existed. Painnyilatya Creek also had a uniform pool habitat and, as a result, rated very low. Other reaches that recorded very low or low diversity of channel types were located on Elsey Creek (near Roper Highway) which recorded a uniform, intermittent pool, and Minyerri Billabong, which was isolated from Hodgson River. These sites make up the 15% of sites that recorded only one habitat type present.

The site reaches studied were generally dominated by two channel habitat types (53% of sites), although 26% of sites recorded three habitat types and 6% of sites recorded either four or five channel habitat types.

Sites recording moderate channel type diversity (6% of sites) were located on Roper River at Red Rock, Rocky Bar Crossing, 57-Mile Waterhole, Red Lily Lagoon (also called 2-Mile Waterhole), and along lower Hodgson River. These reaches recorded some variety of habitats (ie two types) but pools dominated these reaches extensively with only <10% of these reaches being occupied by riffles, runs or cascades.

Sites recording a high channel type diversity (58% of sites) had mostly two habitat types present although the proportion of the reach occupied by habitats other than pools was mostly between 10-30% or >30%, which increased the diversity ratings for these reaches.

Those streams recording reaches with a very high diversity of channel habitat types (23% of sites), were associated with rocky, steeper sections or sections where the number of habitat types recorded was three to five and the proportion of the reach occupied by non-pool habitats was either 10-30% or >30%.

Very high diversity of channel habitat types along upper Flying Fox Creek (Site 8/5)

4.3 Bank Condition and Stability

A summary of the stability of river banks throughout the catchment, based on derived ratings, is shown in Table 4.9 and Map 13. The majority of sites had river banks that were stable (93%). Only one site recorded river banks that were suffering from extensive instability (ie Site 1d/6 – an arm of Roper River that is undergoing extensive channel widening). Even though the river banks were mostly stable, some form of erosion processes were recorded at 94% of sites, whilst aggradation along the river banks was confined to 6% of sites.

Table 4.9 Bank Stability Ratings

Stability Category (Rating)	Number of Sites (%)
Stable (81-100%)	83 (93)
Limited Instability (61-80%)	5 (6)
Moderate Instability (41-60%)	0 (0)
Extensive Instability (21-40%)	1 (1)
Extreme Instability (0-20%)	0 (0)
Dominant Process Recorded	
Aggradation	5 (6)
Erosion	84 (94)

A subjective assessment of the stability of the banks indicated that the majority (90%) of sites recorded minimal to low overall bank instability (refer Table 4.10). Whereas, 33% of sites had low-moderate to moderate bank instability, and only 1% of sites recorded a high overall bank instability. Similar percentages were recorded for the susceptibility of banks to erosion.

Table 4.10 Overall Bank Condition based on Subjective Ratings

Bank Stability Category	Percent of Sites (%)	
	Overall Instability	Susceptibility to Erosion
Minimal	21	21
Minimal to Low	8	7
Low	61	67
Low to Moderate	29	21
Moderate	4	3
Moderate to High	0	0
High	1	1

The location of instabilities along the banks, both lower and upper, is summarised in Table 4.11.

Erosion was the dominant process affecting bank stability throughout the catchment. Bank erosion was recorded mostly at obstacles, outside bends and irregularly. Other major locations where bank erosion occurred were at seepage and runoff points or at floodplain scours. Aggradation was predominantly irregular, all along or at inside bends.

Table 4.11 Location of Instability along Banks

Location of Instability	Percent of Sites (%)	
	Erosion	Aggradation
Bends - Outside	46	1
- Inside	1	4
Floodplain Scours	9	0
Obstacles	82	3
Seepage / Runoff Points	27	1
Irregular	44	10
All Along	1	6

Factors affecting bank stability are listed in Table 4.12. The instability recorded at survey sites was attributed predominantly to high flow, stock, vermin and infrastructure (ie roads, tracks, river crossings, culverts, bridges, *etc*). Only 3% of sites recorded no factors affecting bank stability.

Table 4.12 Factors Affecting Bank Stability

Factor	Percent of Sites (%)
High Flow	74
Stock	37
Vermin	35
Roads/tracks, Crossings, Bridges	21
Runoff	13
Tidal Influence	10
People Tracks	7
Floodplain Scours/Breakouts	2
Other	2
Clearing of Vegetation	1

Lower banks were more stable than upper banks (Table 4.13). The average percent of the bank recorded as being stable was 95% for the lower bank and 88% for the upper bank. The majority of sites (94%) recorded ≥90% of the lower banks as being stable, compared to 54% of sites having upper banks ≥90% stable. The average percent of erosion occurring along the upper bank was 10%, though this varied from 0% to as high as 80%.

Table 4.13 Stability of Lower Banks Compared to Upper Banks

Stability Comparisons	Bank Location	
	Lower Bank	Upper Bank
Percent Sites (%) where:		
≥90% Stable	94	54
≥50% Stable	99	98
≥50% Eroding	1	1
≥50% Aggrading	0	1
Mean Percent Stable and Range (%)	95 (45-100)	88 (20-100)
Mean Percent Eroding and Range (%)	5 (0-55)	10 (0-80)
Mean Percent Aggrading and Range (%)	<1 (0-10)	2 (0-55)

The only types of artificial bank protection measures recorded for all survey sites were fencing (along the river and/or at stock watering points), which occurred at 6% of sites, and rock treatment (1% of sites).

Vermin (buffalo) impacting on bank stability (Site 2/3: Phelp River)

Tracks impacting on bank stability (Site 3a/4: Hodgson River)

4.4 Bed and Bar Condition and Stability

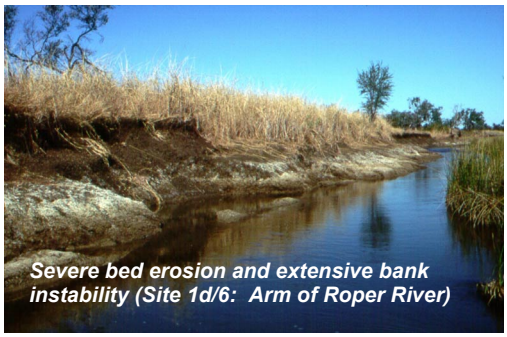
A summary of the overall bed stability throughout the catchment, based on a subjective assessment made in the field of whether the river bed is stable, moderately eroding or aggrading, or severely eroding or aggrading, is shown in Table 4.14 and Map 14. The majority (89%) of sites had stable river beds. Some (10%) sites recorded moderate bed aggradation and one site recorded severe bed erosion problems.

Table 4.14 Overall Bed Stability Ratings

Stability Category (Rating)	Number of Sites (%)
Stable (10)	79 (89)
Moderate Erosion or Aggradation (6)	9 (10)
Severe Erosion or Aggradation (2)	1 (1)
Dominant Process Recorded	
Aggradation	9 (10)
Erosion	1 (1)
No process (bed stable)	79 (89)

The sites recording moderate bed aggradation were located on Waterhouse (4 sites), Wilton and Mainoru Rivers and Flying Fox (2 sites) and Cattle Creeks. These site reaches had relatively flat, uniform and shallow river beds, large sandy bars and were transporting a large amount of sediment (ie sands). The site recording severe erosion problems, including both bed and bank erosion, was located on an arm of Roper River that has reportedly been receiving an increased volume of flow and, as a result, is widening and deepening.

Moderate bed aggradation along Waterhouse River – shallow river, sandy bars and high flow deposits (Site 13/3)



Severe bed erosion and extensive bank instability (Site 1d/6: Arm of Roper River)

Bars were widespread (73% of sites). At sites which recorded a bar, 57% of bar types were encroaching vegetation bars, while a further 49% were alternate/side irregular bars (refer Table 4.15). The total percentage of bed surface along the reach protruding out of the water at water mark and forming a bar averaged 17% of the bed, ranging to as high as 70%.

Table 4.15 Bar Types Recorded

Bar Type	Percent of Sites (%)	Percent of Bar Types (%)
Encroaching Vegetation	42	57
Alternate / Side Irregular	36	49
High Flow Deposits	10	14
Point	10	14
Mid-channel Island	8	11
Around Obstacles	2	3
Channel Bar Plain	2	3

Large point bar along Roper River (Site 1b/3)

Gravel features recorded for the bed and bars showed that the gravel was mostly covered by algae or silt (77% of sites); and was composed of sub-angular (70% of sites), rounded (26%) or angular (25%) material. The major shapes recorded for the gravel was disc-shaped (63% of sites), spherical (36% of sites) or blade-shaped (15%). The bed compaction ranged from low (43% of sites), tightly packed and armoured (27%), moderate (26%), packed but not armoured (19%) or very low compaction (16%). Generally, those sites that had bar material that was armoured or well packed indicate that they would be only slightly mobile in times of moderate flow.

The only controls stabilising the bed that were recorded included rock outcrops (51% of sites) and structures like crossing and culverts (4%). No bed stabilising controls were recorded for 47% of sites.

There were relatively few sites where bed stability was being impacted on. The major factor that was considered to affect bed stability was instream siltation but this factor was only recorded at 8% of sites. Other processes affecting bed condition are listed in Table 4.16. No factors were found to be affecting bed stability at 87% of sites.

Table 4.16 Factors Affecting Bed Stability

Factor	Percent of Sites (%)
Instream Siltation	8
Agriculture or Grazing	4
Bank Erosion	1
Bed deepening / lowering	1

4.5 Bed and Bank Sediments

Table 4.17 shows the mean bed and bank sediment sizes recorded for all habitat types across the study area. From these results it can be noted that a range of size classes, from clays to boulders, was recorded for beds. Lower and upper banks consisted mainly of clays and small sand. Organic material was present in both bed and bank material ranging from 9-14%.

Table 4.17 Bed and Bank Sediments Recorded for all Habitat Types

Sediment Size Classes	Mean Composition of Sediment Types (%)		
	Bed	Lower Bank	Upper Bank
Fines / Clays (<0.06mm)	32	58	69
Small Sand (0.06-0.5mm)	16	15	15
Large Sand (0.5-2mm)	9	5	3
Small Gravel (2-5mm)	5	2	1
Medium Gravel (5-20mm)	4	3	1
Large Gravel (20-60mm)	5	3	1
Cobbles (60-300mm)	8	4	2
Boulders (>300mm)	21	10	8
Organic Material	14	12	9

Tables 4.18, 4.19 and 4.20 show the sediment sizes recorded for beds, lower and upper banks, respectively, for each habitat type. Pool and run habitats have a higher proportion of smaller bed sediments; riffles have a range of bed sediment sizes; rapids and cascades have a higher proportion of larger bed sediments; and waterfalls have boulder beds. The sediments along the lower and upper banks for all habitat types consisted mainly of smaller sediment sizes, except cascade and waterfall habitats, which had a higher proportion of boulders. Rock outcrops were recorded at 65% of sites and where present, they were mostly located in the bed, and to a lesser degree, the lower and upper banks.

Table 4.18 Bed Sediments Recorded for Each Habitat Type

Sediment Size Classes		Mean Composition of Sediment Types for Beds (%)					
		Pool	Run	Riffle	Rapid	Cascade	Waterfall
Fines / Clays	(<0.06mm)	46	34	12	0	<1	0
Small Sand	(0.06-0.5mm)	21	20	10	<1	0	0
Large Sand	(0.5-2mm)	10	13	5	2	<1	0
Small Gravel	(2-5mm)	4	4	6	5	<1	0
Medium Gravel	(5-20mm)	3	3	8	6	<1	0
Large Gravel	(20-60mm)	3	4	11	12	1	0
Cobbles	(60-300mm)	4	7	16	53	3	0
Boulders	(>300mm)	9	15	32	22	95	100

Table 4.19 Lower Bank Sediments Recorded for Each Habitat Type

Sediment Size Classes		Mean Composition of Sediment Types for Lower Banks (%)					
		Pool	Run	Riffle	Rapid	Cascade	Waterfall
Fines / Clays	(<0.06mm)	75	58	34	48	14	1
Small Sand	(0.06-0.5mm)	15	17	17	3	7	1
Large Sand	(0.5-2mm)	3	10	6	1	4	0
Small Gravel	(2-5mm)	1	2	5	1	1	0
Medium Gravel	(5-20mm)	1	2	6	3	1	0
Large Gravel	(20-60mm)	1	2	6	4	1	0
Cobbles	(60-300mm)	1	2	10	15	2	0
Boulders	(>300mm)	3	7	16	25	70	98

Table 4.20 Upper Bank Sediments Recorded for Each Habitat Type

Sediment Size Classes		Mean Composition of Sediment Types for Upper Banks (%)					
		Pool	Run	Riffle	Rapid	Cascade	Waterfall
Fines / Clays	(<0.06mm)	78	66	63	35	17	35
Small Sand	(0.06-0.5mm)	14	17	18	13	9	6
Large Sand	(0.5-2mm)	3	3	4	4	3	0
Small Gravel	(2-5mm)	<1	1	1	3	<1	<1
Medium Gravel	(5-20mm)	<1	<1	1	3	<1	<1
Large Gravel	(20-60mm)	<1	1	2	3	2	<1
Cobbles	(60-300mm)	<1	1	4	19	2	0
Boulders	(>300mm)	4	11	7	20	66	57

Sandy river bed and bars along Wilton River – West Branch (Site 5b/5)

Boulder bed material along Waterhouse River – West Branch (Site 13/4)

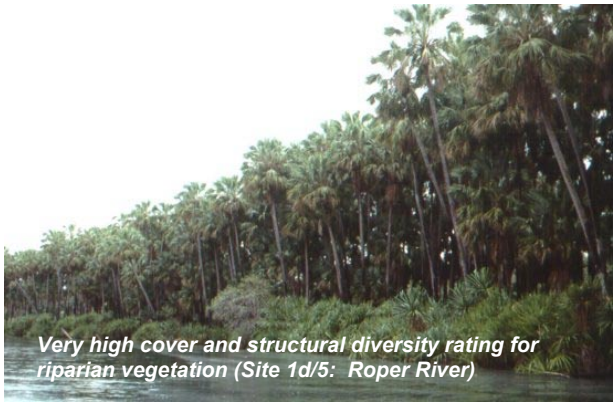
4.6 Riparian Vegetation

The majority of sites (84%) had vegetation that was associated with freshwater streams. That is, these channels form corridors lined with a narrow belt of characteristic vegetation typified by *Melaleuca* and *Pandanus* species (Brock, 1993). This distinct corridor of vegetation along the edge of a stream or river is called the 'riparian zone'. This zone is inextricably linked with the stream both in providing litter, from leaves and branches, to the stream and being affected by the extra moisture that is available. Other vegetation types recorded included mangroves (9% of sites), *Eucalyptus* woodland (4%) and *Melaleuca* swamp (2%).

A summary of the cover and structural diversity of riparian vegetation throughout the catchment is shown in Table 4.21 and Map 15. The ratings take into account the foliage cover or density provided by the overstorey, understorey and ground cover vegetation types or growth forms and the structural diversity or number of different growth forms present. A large proportion of the riparian vegetation was rated as having high cover and diversity (56% of sites), with a further 42% being rated has having moderate cover and diversity. The reach recording a very high cover and structural diversity for the riparian vegetation was located along Roper River at Red Lily Lagoon (also called 2-Mile Waterhole).

Table 4.21 Cover and Structural Diversity of Riparian Vegetation

Riparian Vegetation Category (Rating)	Number of Sites (%)
Very High Cover/Diversity (9-10)	1 (1)
High Cover/Diversity (7-8)	50 (56)
Moderate Cover/Diversity (5-6)	37 (42)
Low Cover/Diversity (3-4)	1 (1)
Very Low Cover/Diversity (1-2)	0 (0)



Very high cover and structural diversity rating for riparian vegetation (Site 1d/5: Roper River)

The average width of the riparian zone was 30m (range 2.5-300m) and is almost double the average width recorded for upper banks (14.2m, range 0.2-400m). Only 2% of sites had a riparian zone width of <5m; 13% were between 5-10m; 40% between 11-20m; 36% between 21-30m; 24% between 31-40m and 29% of sites had a riparian zone width of >40m. Map 16 shows the riparian vegetation width category for each site, averaged for both river banks. Those sites that recorded a riparian zone width of >31m were mostly located on the Roper, Wilton, Hodgson, Phelp and Mainoru Rivers and Flying Fox and Elsey Creeks. Very narrow riparian zones (<5m wide) were located on sections of Maranboy Creek and Strangways River.

The structural types recorded for the vegetation in the riparian zone, including both native and exotic species, are shown in Table 4.22. Grasses and regenerating trees were present at all sites. Woody shrubs, forbs, trees (2-30m) and vines were very prevalent and were present at >90% of sites. Rushes and sedges (present at 60% of sites), palms (11%), mangroves (10%), phragmites (4%), ferns (4%) and trees taller than 30m (1%) varied in their prevalence and distribution.

Table 4.22 Structural Categories Present in the Riparian Zone and Cover for all Vegetation (Native and Exotic)

Structural Category	Percent of Sites (%)	Mean Percent Cover and Range (%)
Trees (>30m)	1	<0.1 (0-2)
Trees (10-30m)*	94	27.3 (0-52)
Trees (2-10m)*	99	26.4 (0-48)
Regen. Trees (<2m)*	100	7.4 (2-30)
Woody Shrubs (<2m)*	99	7.1 (0-16)
Vines	92	9.1 (0-30)
Rushes and Sedges*	60	4.0 (0-20)
Phragmites*	4	0.3 (0-10)
Forbs (or Herbs)*	98	8.7 (0-32)
Grasses*	100	34.0 (0-90)
Ferns*	4	0.2 (0-5)
Mangroves*	10	5.5 (0-90)
Salt Marsh	0	0
Palms	11	1.7 (0-45)

* Can be included as riparian and emergent aquatic vegetation

Assessment is also made in terms of the percentage cover of the surface area for each structural type (refer Table 4.22). Trees, within the category of 2-30m tall, and grasses provided a higher percentage of cover within the riparian zone than the other structural categories, totaling 54% and 34% covers respectively.

The percentage of the lower and upper bank length that was bare of vegetation cover was assessed. The overstorey (that is, trees and shrubs greater than 1.3m tall) provided a greater cover than the understorey (or ground cover) vegetation. The lower bank recorded an average of 91% bare (range 50-100%) for understorey vegetation cover and 82% bare (range 5-100%) for the overstorey. The upper bank, on the other hand, recorded an average of 60% bare (range 10-90%) for understorey vegetation cover and 57% bare (range 5-85%) for the overstorey. Grass-dominated vegetation communities existed along Beswick, Birdum, Cattle, Flying Fox, Maranboy, Maiwok and Roper Creeks and Arnold and Hodgson Rivers.

Riparian vegetation dominated by grasses (Site 1f/5: Beswick Creek)

Map 17 shows the cover of exotic riparian vegetation throughout the catchment as well as the number of different types of exotic species recorded at a site, if present, which ranged from 1-8 different species. The rating takes into account the degree of invasion or percentage cover recorded for exotic species within the riparian zone. Exotic vegetation species were widespread being recorded at 81% of sites (refer Table 4.23). Nearly half the sites (44%) recorded covers for exotic riparian vegetation that were >5% and up to 34% cover, whereas 37% of sites recorded relatively low covers for exotic riparian vegetation (between 1-5%). Exotic riparian vegetation covers ≥16% were recorded along Roper River (3 sites), along upper Wilton River (3 sites), and 1-2 reaches on Mainoru, Strangways and Hodgson Rivers and Flying Fox and Maiwok Creeks.

The mean total cover of exotic species in the riparian zone was 7% (with a range of 0-36%). The structural types and percentage covers recorded for the exotic vegetation are shown in Table 4.24. The most common exotic structural types were vines and forbs. The average percentage covers for the exotic vegetation was low with both vines and forbs averaging 3% cover. Exotic species that are declared as noxious within the Northern Territory were located at 45% of sites.

Table 4.23 Cover of Exotic Riparian Vegetation

% Cover Category (Rating)	Number of Sites (%)
0 (10)	17 (19)
1 - 5 (8)	33 (37)
6 - 10 (6)	19 (21)
11 - 15 (4)	7 (8)
16 - 34* (2)	13 (15)

* The maximum % cover recorded for exotic vegetation within the riparian zone, averaged for both river banks at a site, was 34%. The maximum % cover recorded along a river bank was 36%.

Table 4.24 Structural Categories Present in the Riparian Zone and Cover for Exotic Vegetation

Structural Category	Percent of Sites (%)	Mean Percent Cover and Range (%)
Trees (2-10m)	12	0.2 (0-5)
Woody Shrubs (<2m)	19	0.7 (0-10)
Vines	62	2.8 (0-22)
Forbs (or Herbs)	54	2.9 (0-24)
Grasses	10	0.6 (0-16)

The more common native overstorey species, including trees, low trees and shrubs, recorded at or greater than 10% of sites are shown in Table 4.25. *Eucalyptus camaldulensis* was the most widespread species. The major native ground cover species (including forbs, ferns, rushes, sedges, grasses and vines) are shown in Table 4.26. *Pseudoraphis spinescens* (Spiny Mudgrass) was the most prevalent of these species. A full list of the riparian vegetation species recorded in Roper River catchment is shown in Appendix D.

The palm species, *Livistona rigida*, which has a limited distribution in the NT, was recorded along sections of Roper and Waterhouse Rivers, and Roper, Bella Glen and Elsey Creeks.

Mangrove tree and shrub species, which were confined to the Roper River estuary, consisted of *Avicennia marina* (9% of sites), *Excoecaria ovalis* (5%), *Aegiceras corniculatum* (5%), *Lumnitzera racemosa* (3%), *Rhizophora stylosa* (3%), *Ceriops australis* (3%), *Bruguiera exaristata* (2%), *Xylocarpus mekongensis* (2%) *and Aegialitis annulata* (2%).

Table 4.25 More Common Native Riparian Overstorey Vegetation (trees, low trees and shrubs)

Plant Name – *Genus species*	Common Name	Structural Type	Percent of Sites (%)
Eucalyptus camaldulensis	River Red Gum	Tree	69
Barringtonia acutangula	Freshwater Mangrove	Low tree / shrub	59
Terminalia platyphylla	Durin	Tree	57
Acacia holosericea	Candelabra Wattle / Soap Bush	Low tree / shrub	55
Atalaya hemiglauca	Whitewood	Low tree / shrub	49
Excoecaria parvifolia	Guttapercha Tree	Tree	49
Melaleuca leucadendra	Cajaput / Weeping Paperbark	Tree	48
Pandanus aquaticus	River Pandanus	Tree	48
Cathormion umbellatum	Cathormion / Bean Tree	Low tree / shrub	44
Casuarina cunninghamiana	River Oak / River She-Oak	Tree	43
Strychnos lucida	Strychnine Bush	Tree	36
Antidesma ghaesembilla	Murrungun	Low tree / shrub	34
Melaleuca argentea	Silver Paperbark	Tree	33
Lophostemon grandiflorus	Northern Swamp Box	Tree	33
Eucalyptus microtheca	Coolibah	Tree	32
Flueggea virosa	White Current Bush	Low tree / shrub	31
Nauclea orientalis	Leichhardt Tree	Tree	31
Hibiscus meraukensis	Merauke Hibiscus	Low tree / shrub	27
Phyllanthus reticulatus		Low tree / shrub (or liane)	27
Terminalia volucris	Rosewood	Tree	22
Ficus coronulata	Peach-leaf Fig	Tree	21
Grewia retusifolia	Emu Berries	Low tree / shrub	21
Pandanus spiralis	Screw Palm	Tree	20
Sida rohlenae	Shrub Sida	Low tree / shrub	20
*Eucalyptus bella**	Ghost Gum	Tree	18
Hibiscus panduriformis	Yellow Hibiscus	Low tree / shrub	16
Ficus racemosa	Cluster Fig	Tree	15
Lysiphyllum cunninghamii	Bauhinia	Tree	14
Terminalia pterocarya		Tree	14
Dodonaea platyptera		Low tree / shrub	13
Melaleuca viridiflora	Green Paperbark	Low tree / shrub	13
Terminalia erythrocarpa		Tree	12
Grewia sp.		Low tree / shrub	12
Waltheria indica		Low tree / shrub	12
Acacia auriculiformis	Earpod Wattle	Tree	11
Grevillea pteridifolia	Fern-leaved Grevillea	Tree	11
Livistona rigida		Palm	11
Acacia umbellata		Low tree / shrub	10
Alphitonia excelsa	Red Ash	Low tree / shrub	10
Erythrophleum chlorostachys	Cooktown Ironwood	Tree	10

* Previously called *Eucalyptus papuana*

Table 4.26 More Common Native Riparian Ground Cover Vegetation (forbs, ferns, grasses and vines)

Plant Name – *Genus species*	Common Name	Structural Type	Percent of Sites (%)
Pseudoraphis spinescens	Spiny Mudgrass	Grass	36
Gymnanthera oblonga		Vine	34
Panicum mindanaense		Grass	34
Flagellaria indica	Vine Reed-cane	Vine (liane)	33
Heteropogon contortus	Bunch Speargrass	Grass	32
Mnesithea rottboellioides		Grass	27
Hygrophila angustifolia		Forb	24
Nelsonia campestris		Forb	24
Paspalidium distans		Grass	24
Eragrostis cumingii	Cuming's Lovegrass	Grass	23
*Vallisneria nana**	Eelweed, Ribbon Weed	Forb (aquatic)	23
Dichanthium fecundum	Curly Bluegrass	Grass	22
Achyranthes aspera	Chaff-flower	Forb	21
Alternanthera nodiflora	Common Joyweed	Forb	21
Chara sp.		Forb (aquatic)	20
Chionachne cyathopoda		Grass	20
Vetiveria pauciflora		Grass	20
Merremia gemella		Forb / Climber	16
Eragrostis tenellula	Delicate Lovegrass	Grass	13
Iseilema sp.		Grass	13
Sorghum grande		Grass	13
Chrysopogon fallax	Golden Beard Grass	Grass	12
Cyperus holoschoenus		Forb	12
Sehima nervosum	Rats Tail Grass	Grass	11
Arundinella nepalensis	Reedgrass	Grass	10
Cayratia trifolia		Vine	10
Fimbristylis littoralis		Forb	10
Vetiveria elongata		Grass	10

* Previously called *Vallisneria spiralis*

The major exotic species recorded with their percentage covers, where present, are shown in Table 4.27. *Passiflora foetida,* a naturalised vine, and *Hyptis suaveolens* were the two major species recorded throughout the catchment and were recorded at 62% and 31% of sites, respectively. Other notable exotic species included *Parkinsonia aculeata, Melochia pyramidata*, *Sida acuta*, *Calotropis procera* and *Pennisetum pedicellatum*. Of the 30 different exotic species recorded, 12 are declared noxious within the Northern Territory. Refer to Appendix D for a full list of the riparian vegetation species recorded throughout Roper River catchment, including several exotic species not shown in Table 4.27.

Maps 18, 19 and 20 show the cover and distribution throughout the catchment of *Passiflora foetida*, *Hyptis suaveolens* and *Parkinsonia aculeata*, respectively.

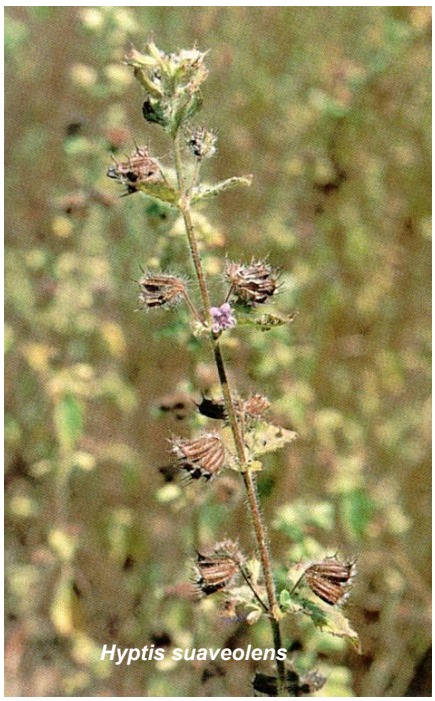
Passiflora foetida was very widely distributed throughout the catchment being recorded in all sub-sections except for Jalboi River, although covers were generally low (1-5%). Higher covers for *Passiflora foetida* were recorded along Roper River at 12-Mile Yard and further downstream below Elsey Falls where the riparian vegetation had been disturbed following the 1998 floods. Of the noxious species, *Hyptis suaveolens* had a relatively wide distribution, although covers were generally low. Higher covers for Hyptis were recorded from upper Wilton River, Mainoru, Jalboi and Waterhouse Rivers and Flying Fox and Derim Derim Creeks. Parkinsonia was restricted in its distribution and was recorded along 57-Mile Waterhole on the Roper River upstream to within Elsey National Park, as well as along sections of Roper River estuary and Longreach Waterhole on Elsey Creek. Covers recorded for Parkinsonia were between 1-5%.

Table 4.27 More Common Exotic Riparian Vegetation

Plant Name - *Genus species*	Structural Type	Percent of Sites (%)	Mean Percent Cover and Range (%)
Passiflora foetida (Stinking Passion Flower)	Vine (climber)	62	5.1 (2-22)
Hyptis suaveolens (Hyptis)*	Forb	31	5.7 (2-15)
Melochia pyramidata	Forb	13	2.0 (1-5)
Parkinsonia aculeata (Parkinsonia)*	Low tree / shrub	13	3.8 (2-5)
Sida acuta (Spiny Head Sida)*	Forb / sub-shrub	11	4.0 (1-15)
Calotropis procera (Rubber Bush)*	Low tree / shrub	9	2.8 (1-5)
Pennisetum pedicellatum	Grass	8	4.6 (3-8)
Triumfetta pentandra	Forb	8	2.0 (2-2)
Acacia farnesiana (Mimosa Bush)	Low tree / shrub	7	2.4 (2-3)
Senna obtusifolia (Sicklepod)*	Low tree / shrub	7	4.8 (2-10)
Echinochloa colona (Awnless Barnyard Grass)	Grass	4	3.0 (2-4)
Euphorbia hirta (Asthma Plant)	Forb	4	1.3 (1-2)
Bidens bipinnata (Cobbler's Pegs)	Forb	3	2.2 (2-3)
Crotalaria goreensis (Gambia Pea)	Forb	3	4.0 (1-6)
Phyla nodiflora (Lippia)	Forb	3	4.6 (1-18)
Dactyloctenium aegyptium (Coast Button Grass)	Grass	2	3.0 (3-3)
Euphorbia heterophylla (Painted Spurge)	Forb	2	1.5 (1-2)
Sida cordifolia (Flannel Weed)*	Forb / sub-shrub	2	2.3 (1-5)
Urochloa mosambicensis (Sabi Grass)*	Grass	2	4.8 (3-8)

* Declared Noxious Weed within the Northern Territory


Passiflora foetida (a naturalised vine)


Hyptis suaveolens


Parkinsonia aculeata seed pods


Parkinsonia aculeata tree

4.7 Aquatic Vegetation

Over three-quarters (84%) of sites recorded the presence of aquatic vegetation as either submerged, floating or emergent vegetation types. The average percentage bare (that is, no aquatic vegetation) was 77% (range 17-100%).

Most aquatic vegetation was present as emergent vegetation (78% of sites). It recorded an average of 15% cover (range 0-55%). Submerged vegetation was present at 54% of sites and recorded an average cover of 11% (range 0-53%). Floating vegetation was more scattered in its distribution and was found at 12% of sites and recorded an average cover of 1.8% (range 0-45%). Table 4.28 shows the structural categories recorded for submerged, floating and emergent aquatic vegetation and their percentage covers.

Table 4.28 Structural Categories and Cover for Vegetation in the Aquatic Zone

Structural Category	Percent of Sites (%)	Mean Percent Cover and Range (%)
Submerged:		
- Filamentous algae	27	2.2 (0-20)
- Chara / Nitella	22	3.4 (0-25)
- Vallisneria / strap like	30	3.4 (0-30)
- Herb like forms	17	2.4 (0-30)
- Myriophyllum	1	0.2 (0-12)
Floating:		
- Water lilies	10	1.5 (0-40)
- Other floating veg	6	0.3 (0-5)
Emergent:		
- Phragmites*	6	0.7 (0-12)
- Typha	2	0.7 (0.18)
- Rushes / Sedges*	25	2.1 (0-15)
- Pandanus*	13	2.1 (0-20)
- Melaleuca*	47	9.7 (0-22)
- Other shrubs/trees*	35	2.8 (0-25)
- Other ground covers*	15	1.3 (0-18)

* Can be included as riparian and emergent aquatic vegetation

The cover and distribution of submerged, emergent and floating aquatic vegetation throughout the catchment is presented in Maps 21, 22 and 23 respectively. Emergent vegetation recorded a more widespread distribution than did submerged aquatic vegetation. Both types were present in all sub-sections except Jalboi River, in which submerged aquatic vegetation was not recorded.

All Roper River sites, except for the lower tidal section, recorded moderate to very high covers for submerged aquatic vegetation. Floating vegetation recorded a limited distribution throughout the catchment and was recorded at Minyerri Billabong, Arnold River, Longreach Waterhole on Elsey Creek, Strangways River at Rocky Hole Yard, and sections of Roper, Bella Glen and Beswick Creeks, and Roper, Chambers (arm of) and Wilton Rivers.

Major species recorded (at greater than 5% of sites) for submerged, floating and emergent vegetation and their percentage covers, where present, are shown in Table 4.29. *Phyla nodiflora* (Lippia) was the only aquatic vegetation species recorded that was exotic. This emergent-type aquatic vegetation was located on Elsey Creek and recorded a cover of 18%.

Table 4.29 Major Species and Cover Recorded for Aquatic Vegetation

Plant Name / Aquatic Zone*	Percent of Sites (%)	Mean Percent Cover and Range (%)
Melaleuca leucadendra (E)	25	7.7 (2-15)
*Vallisneria nana*** (S)	24	9.4 (2-20)
Chara sp. (S)	20	12.9 (2-25)
Melaleuca argentea (E)	18	10.4 (2-22)
Pandanus aquaticus (E)	13	7.9 (2-20)
Nymphaea violacea (F)	8	6.3 (2-10)
Pseudoraphis spinescens (E)	7	7.0 (5-10)
Schoenoplectus litoralis (E)	7	12.5 (8-15)
Triglochin dubia (S)	7	9.7 (3-30)
Eleocharis geniculata (E)	6	5.8 (1-10)
Phragmites karka (E)	6	7.0 (3-12)
Cyperus holoschoenus (E)	6	4.4 (2-10)
Barringtonia acutangula (E)	6	5.0 (2-10)

* Zones include: S = Submerged F = Floating E = Emergent
** Previously called *Vallisneria spiralis*

Water lily, Nymphaea violacea, most widespread floating aquatic vegetation species (Site 12/2: Elsey Creek)

4.8 Instream and Bank Habitats

A summary of the cover and diversity of instream and bank habitats throughout the catchment, based on derived ratings, is shown in Table 4.30 and Map 24. The ratings are based on a combination of the cover and diversity provided by instream organic debris, aquatic vegetation and other habitat types on the bed, as well as the cover and diversity provided by the canopy and other habitats along the river banks. The majority of sites were rated as having high cover and diversity of instream and bank habitats (71% of sites) or moderate cover and diversity (21%). A section on Western Creek rated the worst in the Roper River catchment. The sites recording very high cover and diversity of instream and bank habitats were located on Roper River (5 sites) and a section along Wilton River.

Table 4.30 Cover and Diversity of Instream and Bank Habitats

Instream/Bank Habitat Category (Rating)	Number of Sites (%)
Very High Cover/Diversity (81-100%)	6 (7)
High Cover/Diversity (61-80%)	63 (71)
Moderate Cover/Diversity (41-60%)	19 (21)
Low Cover/Diversity (21-40%)	1 (1)
Very Low Cover/Diversity (0-20%)	0 (0)

Very high cover and diversity of instream and bank habitats (Site 1c/3: Roper River)

The overall aquatic rating for all aquatic life was also subjectively assessed (refer Table 4.31). The assessment took into account the diversity of depths and substrates, level of disturbance, diversity and extent of cover, extent of canopy and other vegetation cover, and whether the stream dries up completely. Over three-quarters (78%) of sites were subjectively rated as having a good to very high overall aquatic rating.

Table 4.31 Overall Aquatic Condition based on Subjective Ratings

Condition Category	Percent of Sites (%)
Very High / Pristine	0
Good to Very High	13
Good	65
Poor to Good	17
Poor	5
Very Poor	0

Instream and bank habitat types are summarised in Tables 4.32 and 4.33. The most commonly occurring instream cover types included branches, leaves and twigs, tree roots, logs, permanent pools deeper than 1m and rock faces. Stream bed cover provided from the banks was dominated by vegetation canopy cover, vegetation overhang which was less than 1m from the water and root overhang. The canopy cover provided a mean width of 3.3m and occurred along a mean of 76% of the bank length.

Table 4.32 Instream Habitat Types

Instream Habitat Type	Percent of Sites (%)	Mean Percent Cover and Range (%)
Logs	97	10.1 (0-35)
Log Jam		
- <50% dense	18	1.2 (0-15)
- >50% dense	6	0.4 (0-10)
Branches	99	10.0 (0-25)
Branch Piles		
- <50% dense	45	2.9 (0-18)
- >50% dense	2	0.2 (0-10)
Leaves and Twigs	99	9.7 (0-55)
Macrophyte Fragments	3	0.2 (0-5)
Algal Clumps	45	4.2 (0-25)
Large Submerged Plants - Freshwater	20	2.7 (0-35)
Mangroves	9	2.0 (0-60)
Floating Vegetation	12	1.5 (0-40)
Emergent Vegetation	29	3.2 (0-25)
Tree Roots	98	10.3 (0-45)
Rock Faces	65	21.6 (0-100)
Permanent Pool >1m Deep	73	38.1 (0-100)
Built Structures/ Debris	19	1.1 (0-20)

Table 4.33 Bank Habitat Types

Bank Cover	Percent of Sites (%)	Mean Bank Length and Range (%)	Mean Width of Type and Range (m)
Canopy	100	76.0 (8-100)	3.3 (0.5-15)
Vegetation Overhang	98	34.3 (0-100)	1.7 (0-12)
Root Overhang	98	25.7 (0-90)	0.5 (0-12)
Bank Overhang	26	1.2 (0-10)	0.1 (0-1)
Built Structures	7	0.3 (0-5)	0.6 (0-25)

Extensive riparian vegetation canopy cover and overhanging vegetation along lower Roper River (Site 1a/10)

Branches, logs, leaves, twigs and tree roots are some of the most commonly occurring instream habitat types (Site 1c/3: Roper River)

At the time of the survey, 23% of sites had no passage for fish and other aquatic organisms; 46% were partly to very restricted; and 31% had good or unrestricted passage. If the water level was normal or at 'water mark', 6% sites were totally restricted (that is, had no passage); 50% of sites had some form of restriction in place; and 44% of sites had good to unrestricted passage.

4.9 Overall Condition

The result of combining equally the ratings for the following six components is shown in Table 4.34:

- State of the Reach Environs
- Bank Stability
- Bed Stability
- Cover and Structural Diversity of Riparian Vegetation
- Cover of Exotic Riparian Vegetation
- Cover and Diversity of Instream and Bank Habitats

Table 4.34 Overall Condition Rating

Overall Condition Rating (%)	General Term Used to Describe Overall Condition	Number of Sites (%)
81-100*	Very High	42 (47)
61-80	High	45 (51)
41-60	Moderate	2 (2)
21-40	Low	0 (0)
0-20	Very Low	0 (0)

* 100% = Ideal, undisturbed or natural state

The results indicate that the majority of sites recorded either a high overall condition rating (51% of sites) or a very high overall condition rating (47%). No sites were rated as being degraded overall. Map 25 shows the overall condition ratings for sites throughout the catchment. Reaches that rated very highly overall were located within all sub-sections except for Mainoru and Waterhouse River sub-sections. Two reaches recorded a moderate overall condition, the worst rating in the catchment, and these were located on the West Branch of Wilton River and an arm of Roper River downstream of Little Red Lily Lagoon (refer to Section 5 'Sub-catchment Results' for a description of these sites).

Very high overall condition rating (Site 5a/5: Wilton River)

Very high overall condition rating
(Site 9/2: Maiwok Creek)

Very high overall condition rating
(Site 1d/2: Roper River)

5. SUB-CATCHMENT RESULTS

Maps 10-25 show the results for the condition and stability ratings and other attributes for the whole of the Roper River Catchment (refer Section 4). Figures 5.1-5.20 show each sub-section within the Roper River catchment.

The Roper River catchment has been divided into the following 11 major sub-catchments (shown in Map 6):

- Roper River
  - Estuary
  - Below Jalboi River
  - Below 57-Mile Waterhole
  - Red Lily Lagoon & 57-Mile Waterhole
  - Below Waterhouse River
  - Upper Roper Creek
- Phelp River
- Hodgson River (including Hodgson River below and above Arnold River and Arnold River sub-sections)
- Wilton River (including Wilton River below and above Mainoru River and Mainoru River sub-sections)
- Jalboi River
- Flying Fox Creek
- Maiwok Creek
- Strangways River
- Chambers River
- Elsey Creek
- Waterhouse River

The following information is presented for each of the sub-sections that have been grouped according to the major sub-catchments in the Roper River catchment (listed above):

1. **A map showing each sub-section.**
   Figures 5.1-5.20 show each sub-section within the Roper River catchment. Each figure shows the location of sites, sample points and vegetation profiles within each sub-section. The location of longitudinal profile surveys (ie depth measurements along the streams' 'thalweg') is highlighted. Boundaries of nature parks and/or national parks and the location of towns and communities are also shown.

2. **A chart summarising the results for the overall condition ratings for each sub-section.**
   Charts 5.1-5.20 show the overall condition rating score for sites within each sub-section. The six components that make up the overall condition rating are:

   - State of the Reach Environs
   - Bank Stability
   - Bed Stability
   - Cover and Structural Diversity of Riparian Vegetation
   - Cover of Exotic Riparian Vegetation
   - Cover and Diversity of Instream and Bank Habitats

   Each of the six components is rated out of 10 giving a final 'Overall Condition Rating Score' out of 60. 10 represents an ideal, undisturbed or natural state and 1 is very disturbed or unstable.

3. **A summary of the major findings and issues within each sub-section.**

   "Major" disturbances or exotic species means that they were recorded at ≥33% of sites.
   "Minor" disturbances or exotic species means that they were recorded at <33% of sites.

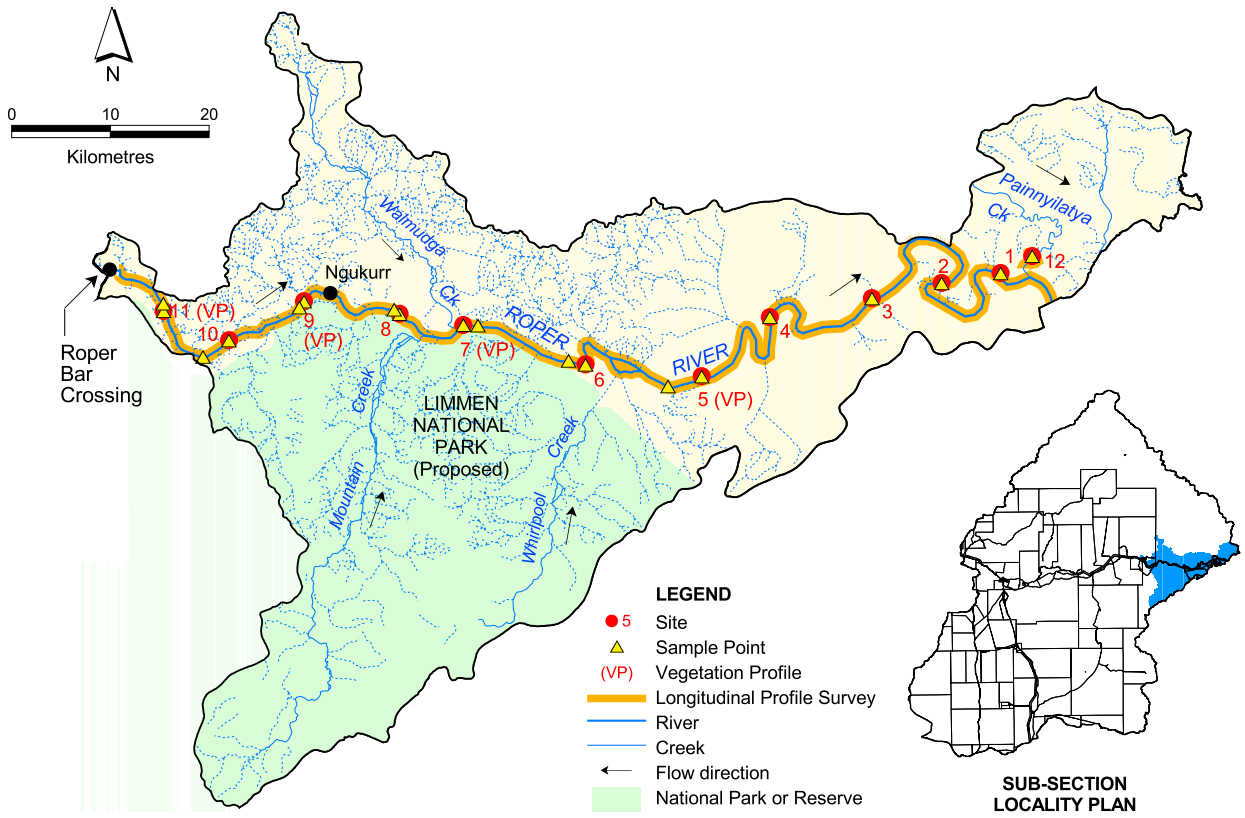


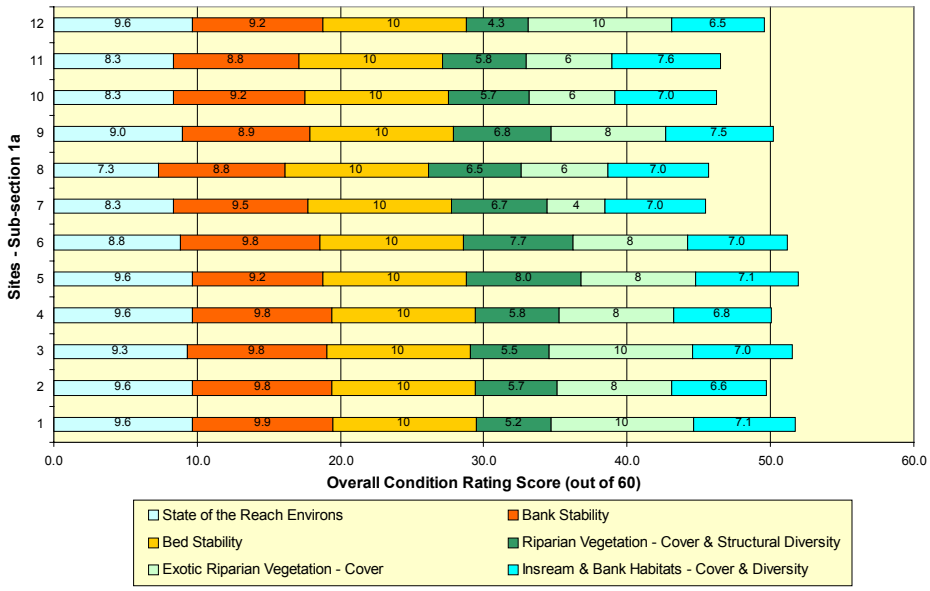
Figure 5.1 Locality Map of Sub-section 1a - Roper River Estuary

5.1 Roper River

5.1.1 Roper River Estuary

Sub-section 1a incorporates the tidal section of Roper River, downstream of Roper Bar Crossing. Eleven sites were located on the Roper River as well as one site on Painnyilatya Creek. All sites were fully assessed.

Chart 5.1 Summary of the Overall Condition Rating Score for Sub-section 1a – Roper River Estuary



Summary of the major findings for Sub-section 1a – Roper River Estuary

Reach environs: All reaches were rated as being essentially natural except for Site 1a/8 that had some modification due to grazing and the presence of an animal watering point.

Disturbances: Major - grazing;
Minor - roads/tracks, people and an animal watering point.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - tidal influence;
Minor - stock, vermin, runoff, people tracks and high flow.

Bed stability: All sites were rated as having stable river beds.

Channel habitat types: Pools were present at all sites, whereas riffles and runs were present at 1-2 sites. Diversity of channel habitat types was high along the upper tidal section, but was low or very low along the mid- to lower tidal sections.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation ranged from moderate, high and, in one instance, low. Mangroves were the dominant vegetation community on the mid- to lower tidal section of Roper River whilst vegetation associated with freshwater streams was present at nearly half the sites. *Avicennia marina* was the most widespread mangrove species. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 58% whilst ground covers averaged 32%. The mean width of the riparian vegetation was 40m (range 14-100m).

Exotic riparian vegetation: Three-quarters of sites recorded the presence of exotic species and, where recorded, the level of invasion ranged from low (1-5% cover), moderate (6-10% cover) to high (11-15% cover). *[Note * = species declared noxious in NT]*

Major species: *Passiflora foetida*;
Minor species: *Sida acuta**, *Parkinsonia aculeata**, *Melochia pyramidata* and *Senna obtusifolia**.

Aquatic vegetation: Over 80% of sites recorded the presence of aquatic vegetation mostly as emergent and submerged types. *Vallisneria nana* was the most widely distributed species.

Instream and bank habitats: All sites were rated as having high cover and diversity of instream and bank habitats. The canopy cover along the bank was excellent, averaging 91% of the bank length.

Overall condition: Two-thirds of sites rated very highly overall, with the remainder rating highly.

MAJOR ISSUE: Moderate to high weed invasion along some tidal sections of Roper River.

Excellent cover provided by mangroves and emergent aquatic vegetation(ie rushes) along the tidal section of Roper River (Site1a/5)

Submerged aquatic vegetation (ie Vallisneria nana) along the water's edge of Roper River (Site 1a/8)

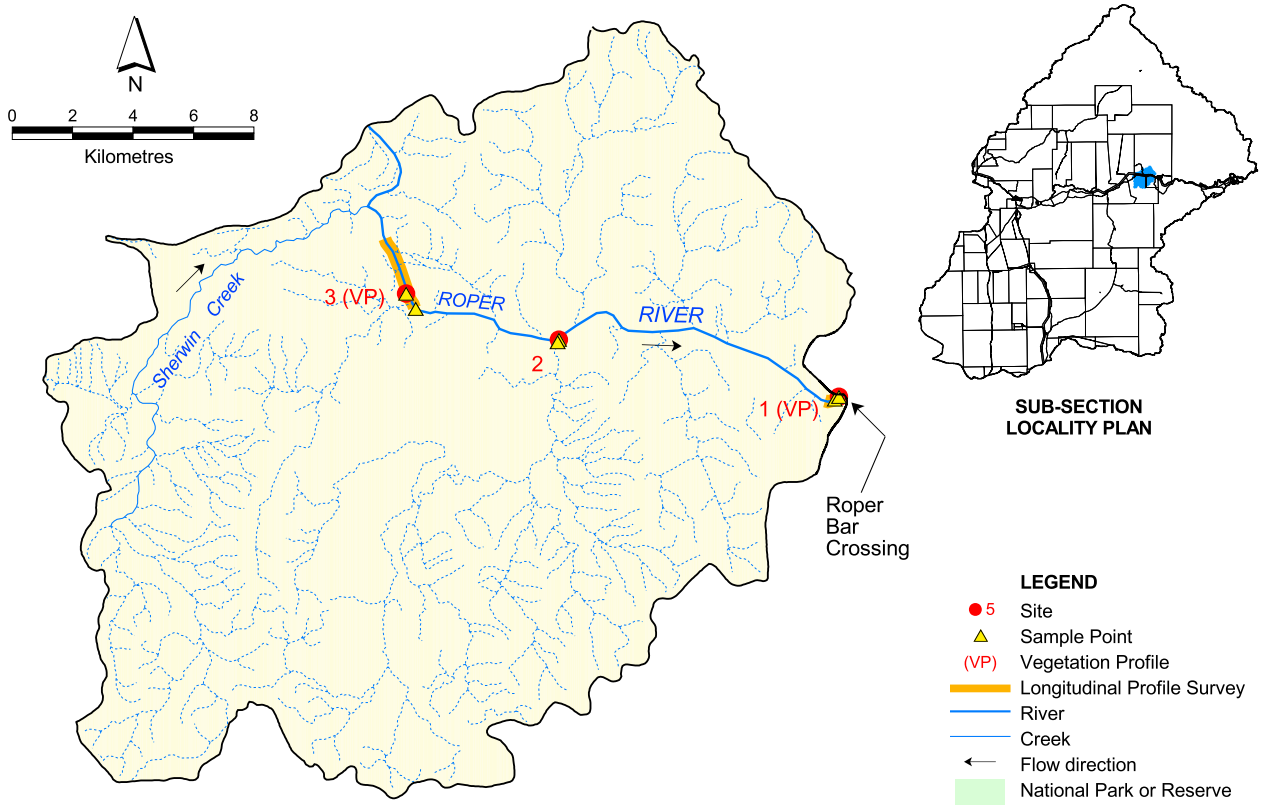
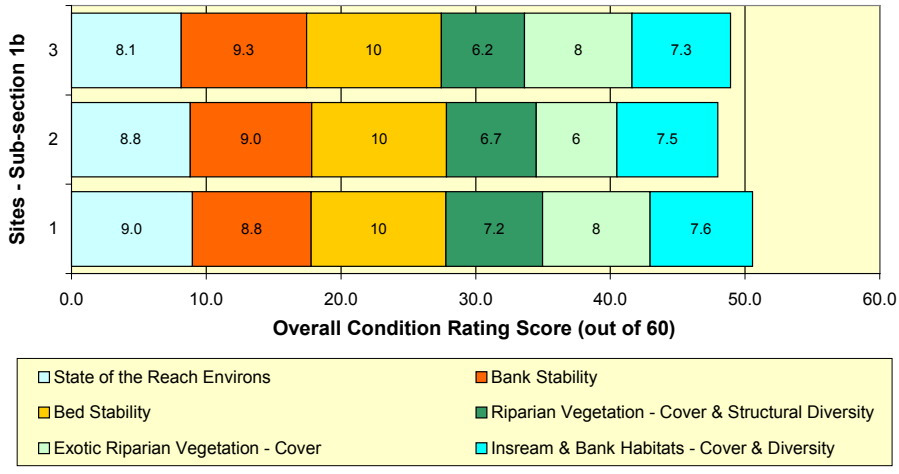


Figure 5.2 Locality Map of Sub-section 1b – Roper River below Jalboi River

5.1.2 Roper River – Below Jalboi River

Sub-section 1b encompasses the Roper River from Roper Bar Crossing upstream to Jalboi River junction. Three sites, located on Roper River, were fully assessed in this sub-section.

Chart 5.2 Summary of the Overall Condition Rating Score for Sub-section 1b – Roper River below Jalboi River



Summary of the major findings for Sub-section 1b – Roper River below Jalboi River

Reach environs: All reaches were rated as being essentially natural.

Disturbances: Major - grazing, roads/tracks, people and a river crossing.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - high flow, stock, people tracks and infrastructure (eg track and river crossing).

Bed stability: All sites were rated as having stable river beds. Bars were present at all sites and were relatively large, averaging 22% of the bed surface.

Channel habitat types: Pools were present at all sites. Other habitat types included riffles, runs and rapids. Diversity of channel habitat types rated either very highly, highly or moderately.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation ranged from high to moderate. Vegetation associated with freshwater streams was present at all sites. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 44% whilst ground covers averaged 39%. The mean width of the riparian vegetation was 35m (range 22-55m).

Exotic riparian vegetation: All sites recorded the presence of exotic species and the level of invasion ranged from low (1-5% cover), to moderate (6-10% cover).

Major species: *Passiflora foetida*, *Melochia pyramidata* and *Stylosanthes hamata.*

Aquatic vegetation: All sites recorded the presence of aquatic vegetation as emergent and submerged types. *Vallisneria nana* (a submerged type) and *Melaleuca argentea* (an emergent type) were the two most widely distributed species being present at all sites.

Instream and bank habitats: All sites were rated as having high cover and diversity of instream and bank habitats. The canopy cover along the bank was very good, averaging 86% of the bank length.

Overall condition: Two-thirds of sites rated very highly overall, with one site rating highly.

Aerial view of Roper River at Red Rock (Site 1b/2) - high overall condition

Pool reach along Roper River (Site 1b/3) - very high overall condition

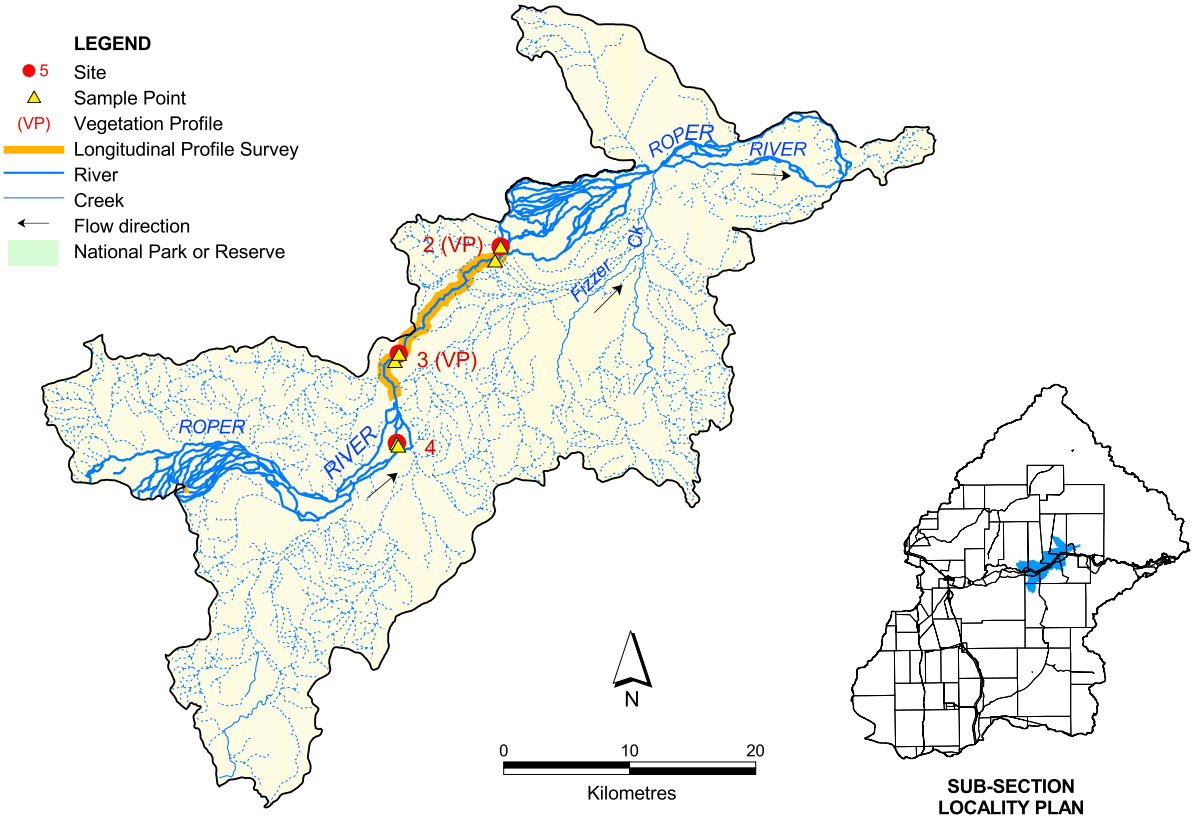
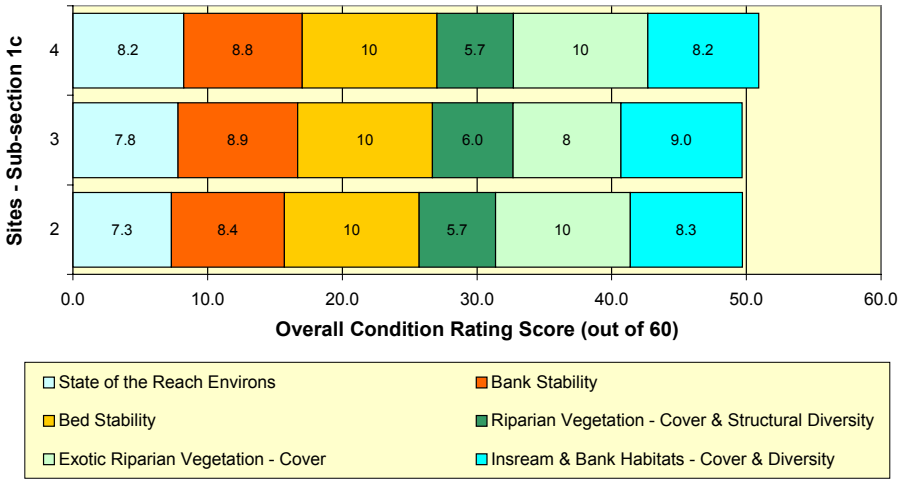


Figure 5.3 Locality Map of Sub-section 1c – Roper River below 57-Mile Waterhole

5.1.3 Roper River – Below 57-Mile Waterhole

Sub-section 1c encompasses the Roper River from the junction with Jalboi River upstream to 57-Mile Waterhole (but not including the waterhole). Three sites, located on Roper River, were fully assessed in this sub-section.

Chart 5.3 Summary of the Overall Condition Rating Score for Sub-section 1c – Roper River below 57-Mile Waterhole



Summary of the major findings for Sub-section 1c – Roper River below 57-Mile Waterhole

Reach environs: Two reaches were rated as having some modification due to disturbances whilst the remaining reach was essentially natural.

Disturbances: Major - grazing, animal watering points, roads/tracks and a river crossing.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - stock, high flow, runoff and infrastructure (eg tracks and a river crossing).

Bed stability: All sites were rated as having stable river beds. Bars were present at all sites.

Channel habitat types: Pools and riffles were present at all sites, whereas runs were present at only one site. Diversity of channel habitat types rated highly or moderately.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was moderate. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 49% whilst ground covers averaged 21%. The mean width of the riparian vegetation was 26m (range 20-37m).

Exotic riparian vegetation: One-third of sites recorded the presence of exotic species and, where recorded, the level of invasion was low (1-5% cover).

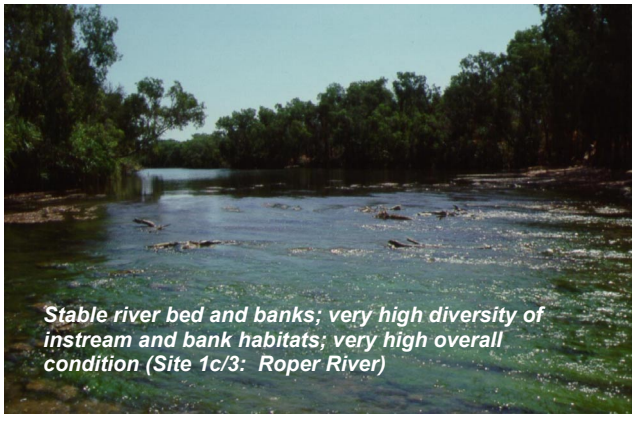
Major species: *Passiflora foetida*

Aquatic vegetation: All sites recorded the presence of aquatic vegetation as emergent and submerged types. *Pandanus aquaticus*, *Melaleuca argentea*, *Vallisneria nana* and *Chara* sp. were present at all sites.

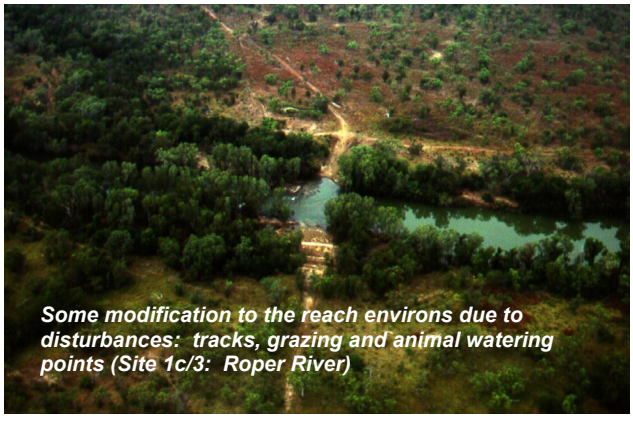
Instream and bank habitats: All sites were rated as having a very high cover and diversity of instream and bank habitats, making this the highest rating sub-section within Roper River catchment. The canopy cover along the bank was very good, averaging 89% of the bank length.

Overall condition: All sites rated very highly overall.

MAJOR ISSUE: Some disturbance to reach environs by stock utilising river corridors to water, graze and shelter.



Stable river bed and banks; very high diversity of instream and bank habitats; very high overall condition (Site 1c/3: Roper River)



Some modification to the reach environs due to disturbances: tracks, grazing and animal watering points (Site 1c/3: Roper River)

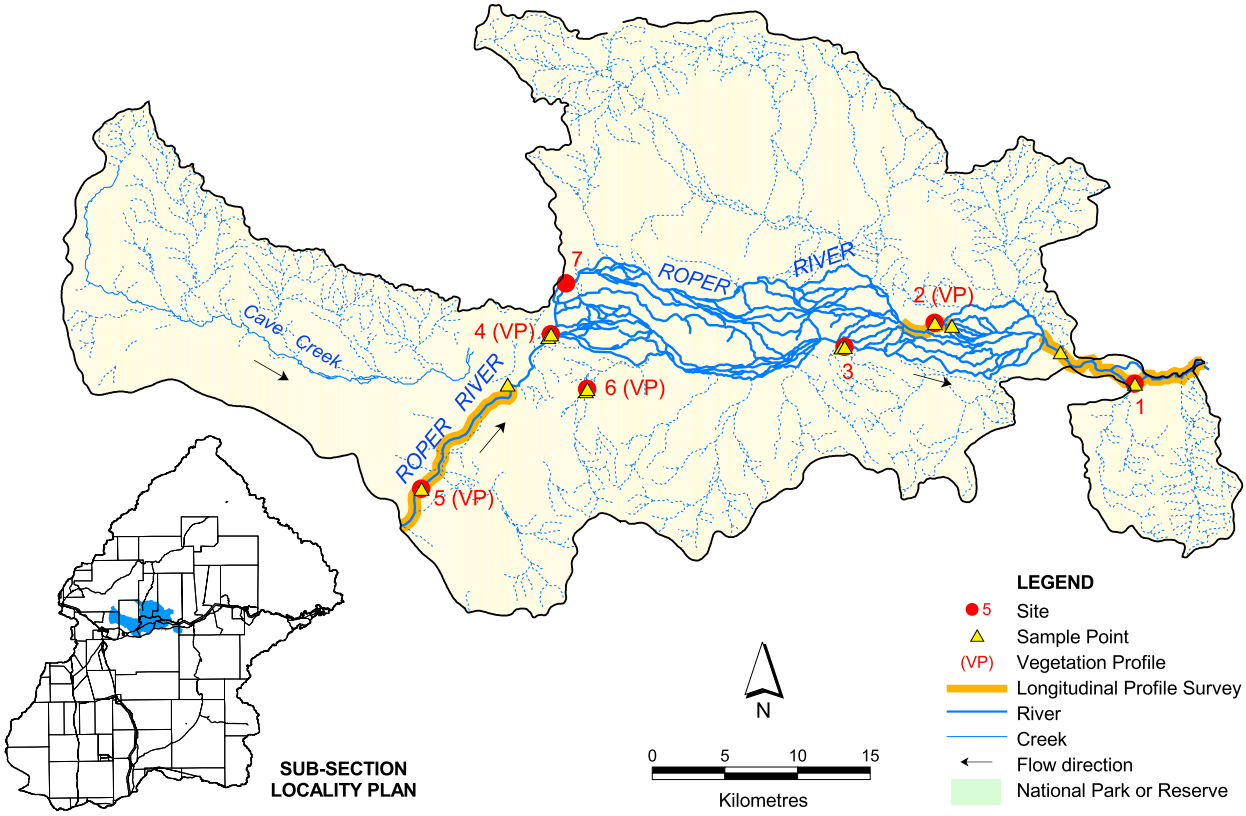
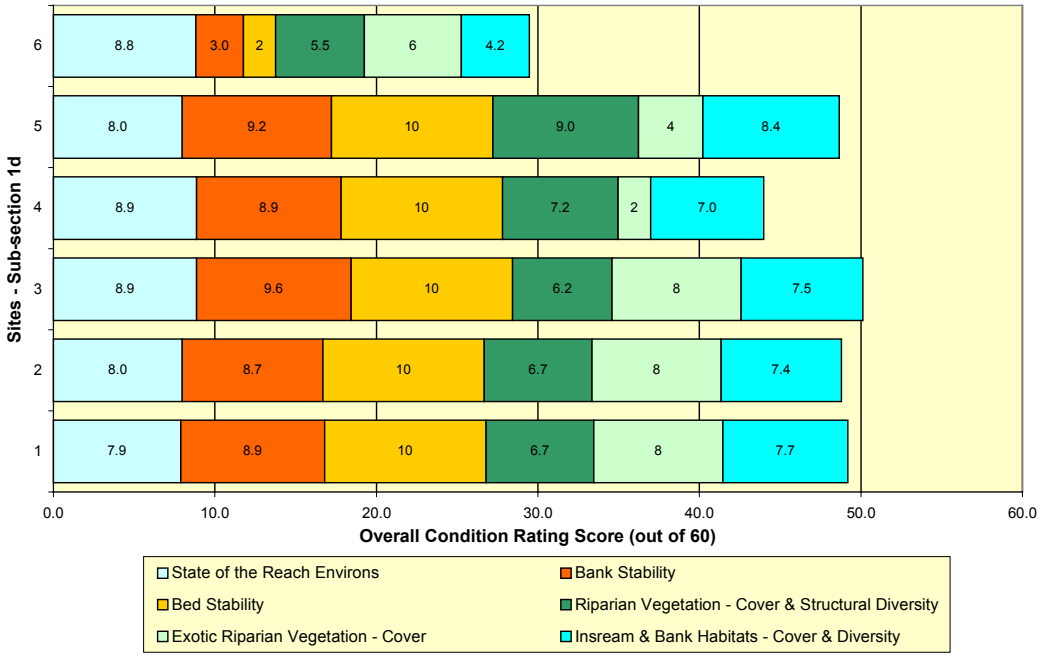


Figure 5.4 Locality Map of Sub-section 1d – Roper River encompassing Red Lily Lagoon and 57-Mile Waterhole

5.1.4 Roper River – Encompassing Red Lily Lagoon and 57-Mile Waterhole

Sub-section 1d encompasses Red Lily Lagoon (also called 2-Mile Waterhole) and 57-Mile Waterhole on the Roper River. Of the seven sites in this sub-section, six were fully assessed.

Chart 5.4 Summary of the Overall Condition Rating Score for Sub-section 1d – Roper River encompassing Red Lily Lagoon and 57-Mile Waterhole



Summary of the major findings for Sub-section 1d – Roper River encompassing Red Lily Lagoon (also called 2-Mile Waterhole) and 57-Mile Waterhole

Reach environs: Reaches were either essentially natural or had some modification due to disturbances.

Disturbances: Major - grazing, tracks, watering points and river crossings;
Minor - river works.

Bank stability: All sites were rated as having stable river banks except for Site 1d/6, an arm of Roper River downstream of Little Red Lily Lagoon that was rated as having extensive bank instability.

Disturbances: Major - high flow, stock and infrastructure;
Minor - clearing of vegetation.

Bed stability: All sites were rated as having stable river beds except for Site 1d/6 that was rated as having extreme bed instability (ie bank erosion and bed deepening) the worst rating possible.

Channel habitat types: Pools and runs were present at all sites, whereas riffles were present at two-thirds of sites. Diversity of channel habitat types rated very highly, highly or moderately.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation ranged from high, moderate to very high along Red Lily Lagoon, the highest site rating in the catchment. *Livistona rigida*, a palm species, was present at half the sites. The cover provided by overstorey vegetation along the upper banks averaged 42% whilst ground covers averaged 28%. The mean width of the riparian vegetation was 29m (range 5-49m).

Exotic riparian vegetation: All sites recorded the presence of exotic species and the level of invasion ranged from low (1-5% cover), moderate (6-10% cover), high (11-15% cover) along Red Lily Lagoon, to very high (16-32% cover) at Lindsay's Crossing. *[Note * = species declared noxious in NT]*

Major species: *Passiflora foetida*, *Parkinsonia aculeata**, *Acacia farnesiana*, *Hyptis suaveolens** and *Calotropis procera**.

Aquatic vegetation: Submerged (eg *Chara* sp.) and emergent aquatic vegetation types were present at all sites.

Instream and bank habitats: Most sites were rated as having high cover and diversity of instream and bank habitats, whilst Red Lily Lagoon rated very highly and Site 1d/6 rated only moderately. The canopy cover along the bank was good, averaging 69% of the bank length.

Overall condition: Two-thirds of sites rated very highly overall, with the remainder rating highly or, in the case of Site 1d/6, moderately (the worst rating in the catchment).

MAJOR ISSUES:

(1) Site 1d/6 is very unstable and is undergoing extensive channel changes (ie is widening and deepening). The cause of these changes is possibly due to this tributary receiving increased volume of flow from the Roper River when flooding occurs along Red Lily Lagoon. Floodwaters overtop the low banks along Red Lily Lagoon and flow in a southerly direction through black clay soils meeting up with this tributary downstream of Little Red Lily Lagoon. Channels have been forming across the black soil plains over the last several decades. Large floods (eg January 1998) initiated further development or erosion of these channels. Implications: (a) a change in the flow direction through the braided sections of Roper River downstream of Red Lily Lagoon (ie less flows through Lindsay's Crossing); and (b) loss of infrastructure, including fences and river crossings, as the new channels keep eroding. (2) Moderate to very high weed invasion along sections of Roper River (eg at Lindsays Crossing and along Red Lily Lagoon). (3) Disturbance to some reach environs from stock and infrastructure. (4) Recognition and conservation of the *Livistona rigida* palm community, particularly along Red Lily Lagoon although it was also recorded along 57-Mile Waterhole and at Lindsay's Crossing. This species has a limited distribution within the NT.

Aerial view of Site 1d/6 which is undergoing extensive channel changes (widening and deepening)

Aerial view of Red Lily Lagoon on Roper River (Site 1d/5), lined with Livistona rigida palms. Also area where channels have been forming across the black soil plains.

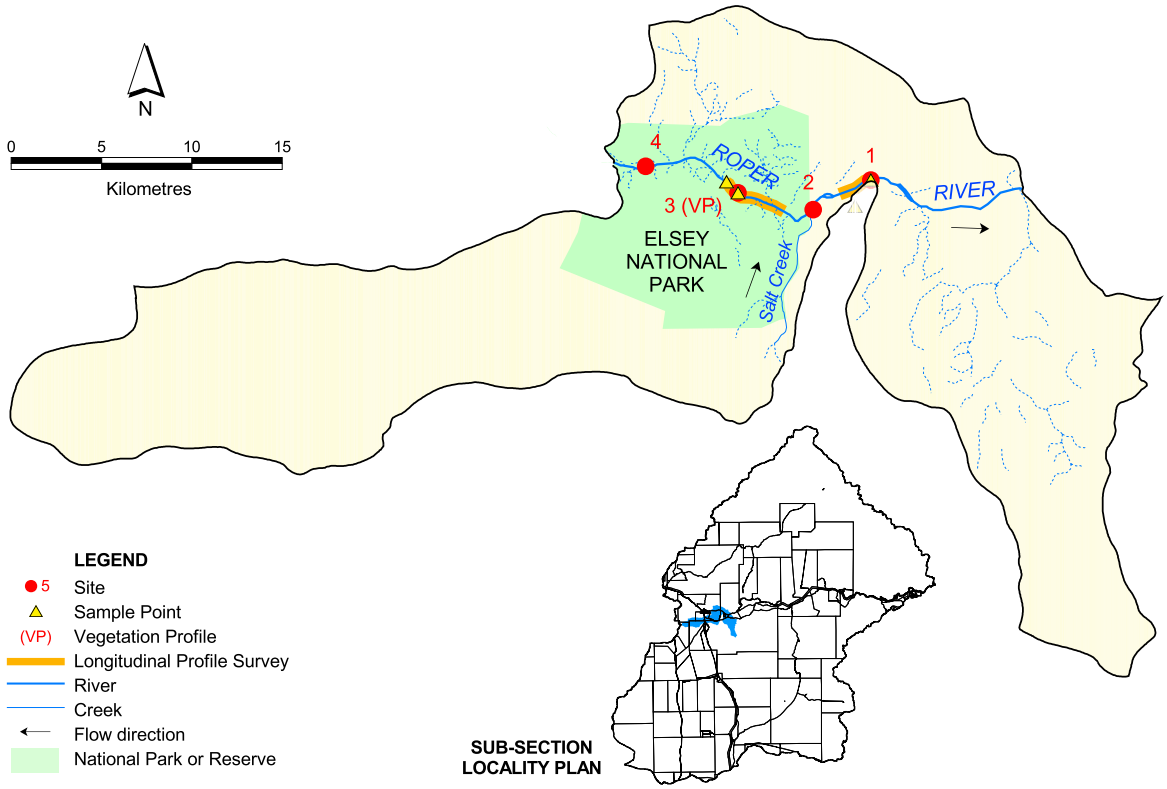
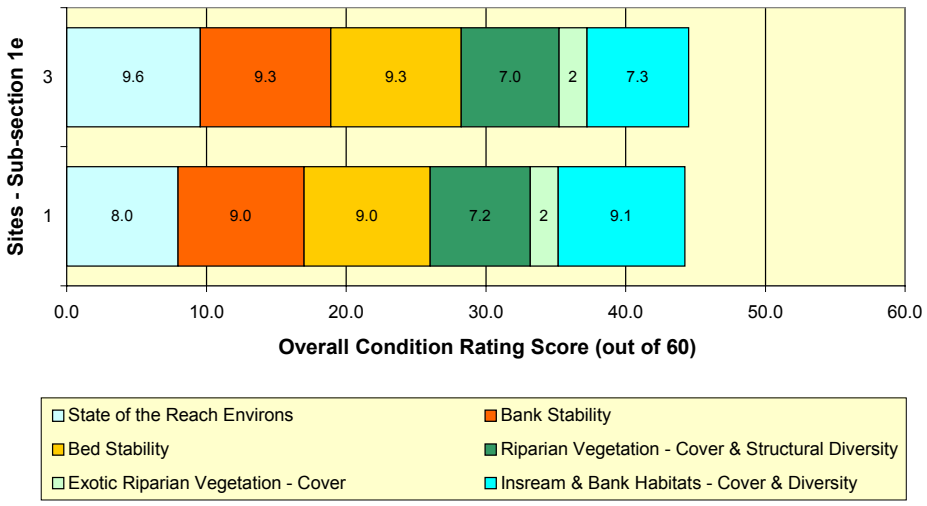


Figure 5.5 Locality Map of Sub-section 1e – Roper River below Waterhouse River

5.1.5 Roper River – Below Waterhouse River

Sub-section 1e encompasses the Roper River upstream of Red Lily Lagoon (also called 2-Mile Waterhole) to junction with Waterhouse River. Of the four sites in this sub-section, all of which were located on Roper River, two were fully assessed.

Chart 5.5 Summary of the Overall Condition Rating Score for Sub-section 1e – Roper River below Waterhouse River



Summary of the major findings for Sub-section 1e – Roper River below Waterhouse River

Reach environs: All reaches were rated as being essentially natural except for Site 1e/1 that had some modification due to tracks, grazing and animal watering points.

Disturbances: Major - roads/tracks and people;
Minor - a boat ramp, grazing and an animal watering point.

Bank stability: The two sites assessed were rated as having stable river banks.

Disturbances: Major - high flow, people tracks and stock.

Bed stability: The two sites assessed were rated as having stable river beds and bars were present at both sites.

Channel habitat types: Both sites recorded four different types of channel habitats resulting in a very high channel type diversity rating. Cascades, waterfalls and rapids were associated with 'tufa' formations within Elsey National Park and downstream at Elsey Falls.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was high. *Livistona rigida*, a palm species, was present along these reaches. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 40% whilst ground covers averaged 23%. The mean width of the riparian vegetation was 33m (range 20-40m).

Exotic riparian vegetation: All sites recorded the presence of exotic species and the level of invasion was very high (16-32% cover). *[Note * = species declared noxious in NT]*

Major species: *Passiflora foetida*, *Parkinsonia aculeata** and *Euphorbia hirta*.
Minor species: *Melochia pyramidata*, *Urochloa mosambicensis*, *Acacia farnesiana*, *Hyptis suaveolens**, *Jatropha gossypiifolia** and *Calotropis procera**.

Aquatic vegetation: Emergent, submerged and floating aquatic vegetation types were present at both sites. *Phragmites karka* was the most widely distributed species.

Instream and bank habitats: The two sites were rated as having either very high or high cover and diversity of instream and bank habitats. The canopy cover along the bank was good, averaging 74% of the bank length.

Overall condition: The two sites rated highly overall.

MAJOR ISSUES: (1) Very high weed invasion, including noxious species, particularly throughout Elsey National Park that receives a high number of visitors, which may assist in their spread. (2) Recognition and conservation of areas of special significance (ie river reaches containing tufa formations and lined by the palm community, *Livistona rigida*).


A tufa waterfall along Roper River at Elsey Falls


Aerial view of boat ramp and camp ground at 12-Mile Yards, Elsey National Park. Riparian vegetation along Roper River recovering following 1998 floods.

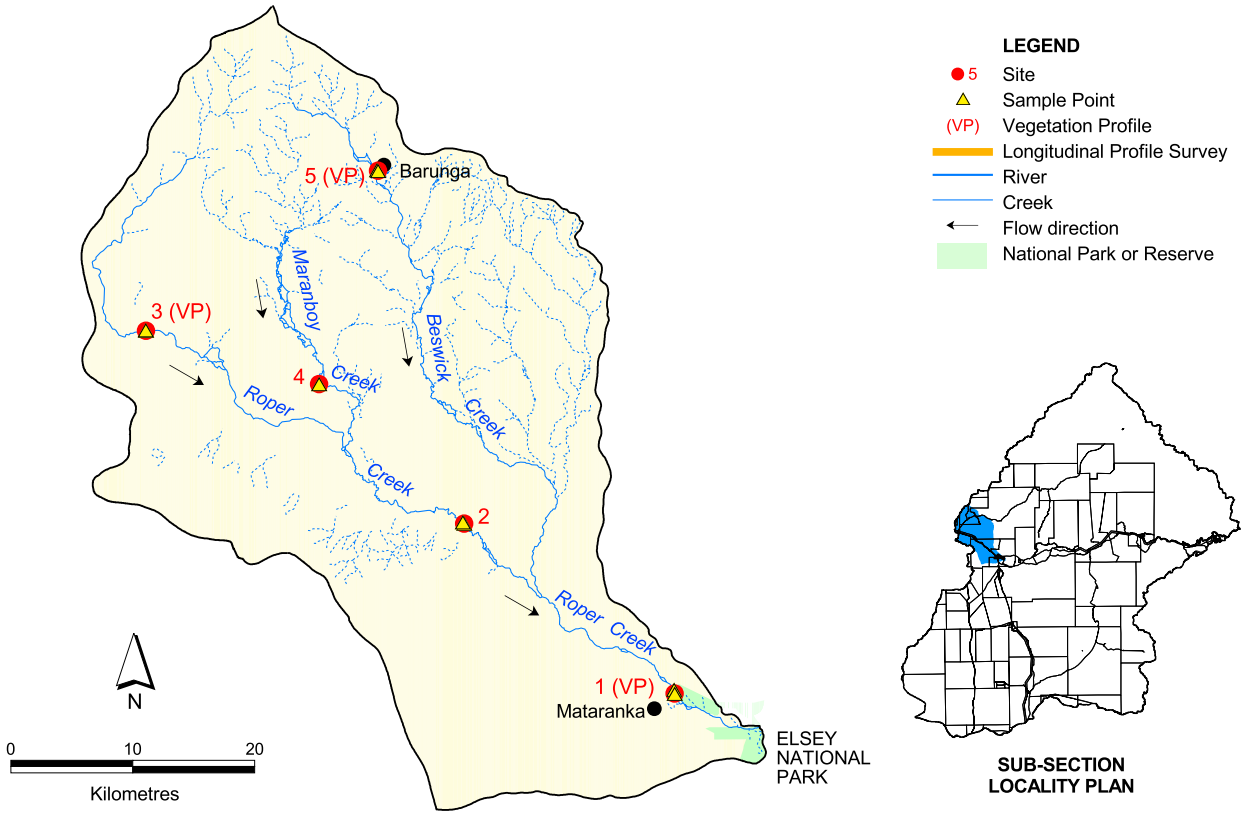
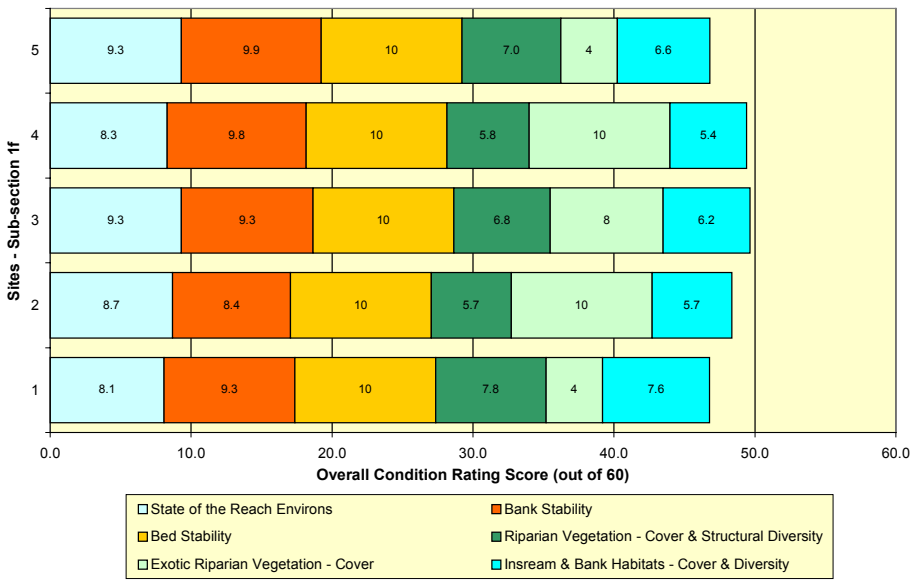


Figure 5.6 Locality Map of Sub-section 1f – Upper Roper Creek

5.1.6 Roper River – Upper Roper Creek

Sub-section 1f encompasses Roper River (called Roper Creek) upstream of the junction with Waterhouse River to the headwaters. Of the five sites in this sub-section, three were located on Roper Creek, one was located on Maranboy Creek and one site was on Beswick Creek. All sites in this sub-section were fully assessed.

Chart 5.6 Summary of the Overall Condition Rating Score for Sub-section 1f – Upper Roper Creek



Summary of the major findings for Sub-section 1f – Upper Roper Creek

Reach environs: All reaches were rated as having essentially natural reach environs.

Disturbances: Major - bridge/culvert, river crossing, roads/tracks and grazing.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - high flow and infrastructure;
Minor - stock, vermin and runoff.

Bed stability: All sites were rated as having stable river beds although grazing was identified as a factor affecting bed stability at one site.

Channel habitat types: Pools were present at all sites, whereas riffles and runs were present at 2-3 sites. The channel type diversity rated highly.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation ranged from high to moderate. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 30% whilst ground covers averaged 66%. The mean width of the riparian vegetation was 10m (range 3-30m). *Livistona rigida* was located along lower Roper Creek.

Exotic riparian vegetation: Less than two-thirds of sites recorded the presence of exotic species and, where recorded, the level of invasion ranged from high (11-15%) to low (1-5% cover). *[Note * = species declared noxious in NT]*

Major species: *Passiflora foetida* and *Hyptis suaveolens**.
Minor species: *Leucaena leucocephala*, *Acacia farnesiana*, *Crotalaria goreensis*, *Clitoria ternatea*, *Euphorbia hirta*, *Euphorbia heterophylla* and *Calotropis procera**.

Aquatic vegetation: Three of the five sites recorded the presence of aquatic vegetation including emergent, submerged and floating types. *Chara* sp. was the most widely distributed species.

Instream and bank habitats: Sites were rated as having either high or moderate cover and diversity of instream and bank habitats. The canopy cover along the bank was moderate, averaging 57% of the bank length.

Overall condition: Less than two-thirds of sites rated very highly overall, with the remainder rating highly.

MAJOR ISSUE: High weed invasion along lower Roper Creek and upper Beswick Creek.

Roper Creek at Site 1f/2 showing a dry channel (November 1998)

Large spring-fed pool along Maranboy Creek near Site 1f/4 (November 1998)

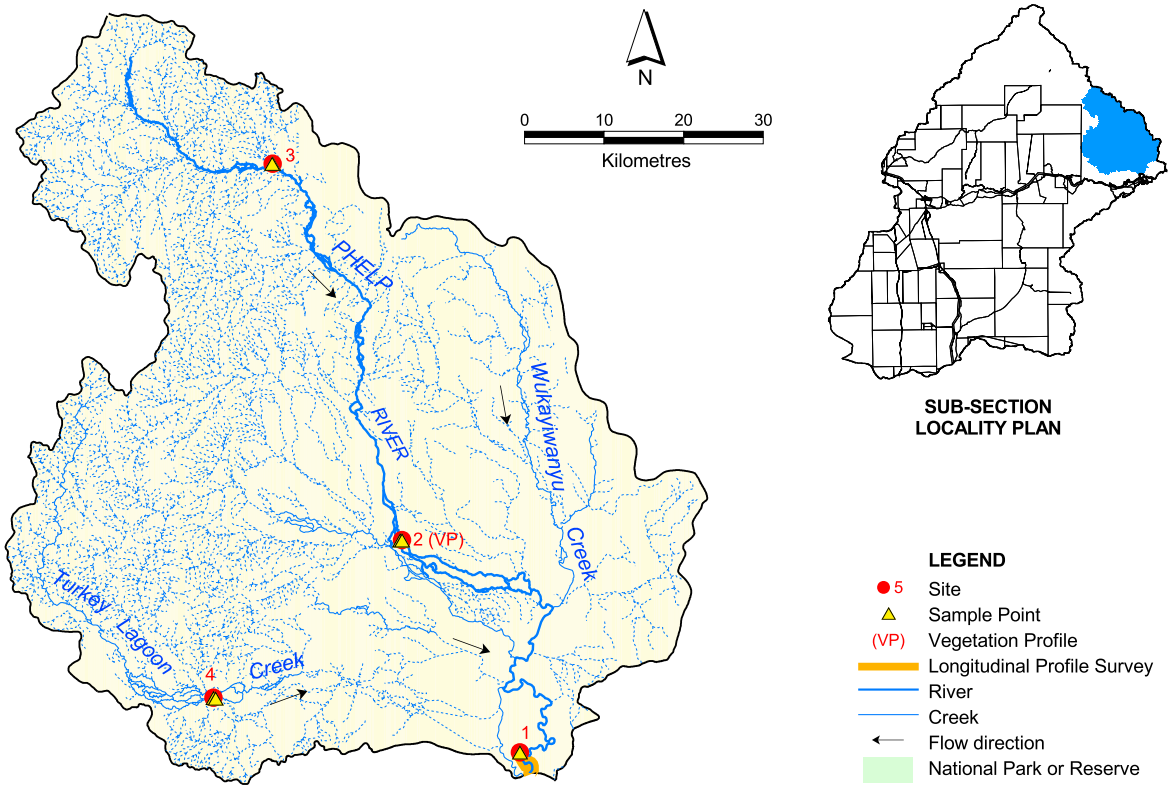
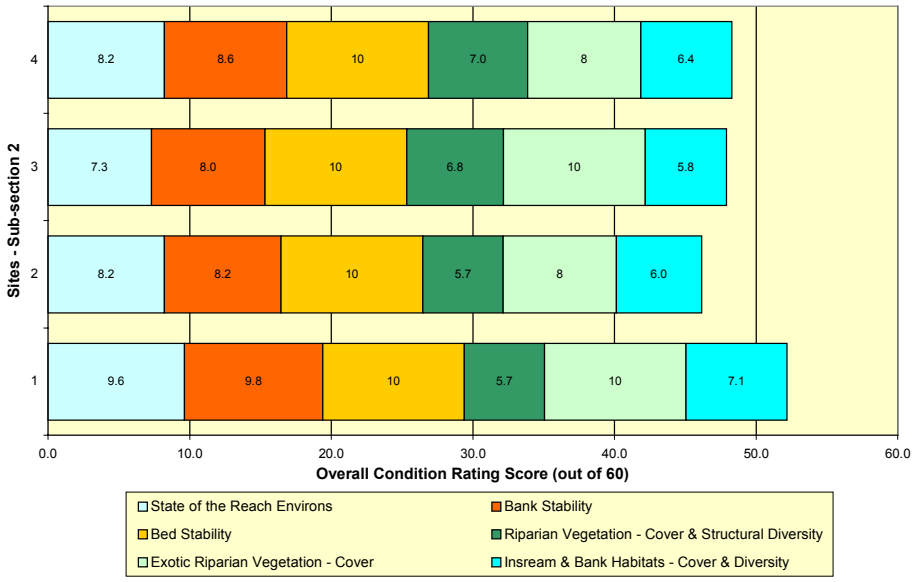


Figure 5.7 Locality Map of Sub-section 2 – Phelp River

5.2 Phelp River

Sub-section 2 includes the catchment area of Phelp River. Of the four sites located within this sub-section, three were located on Phelp River and another site was located on Turkey Lagoon Creek. All of these four sites were fully assessed.

Chart 5.7 Summary of the Overall Condition Rating Score for Sub-section 2 – Phelp River



Summary of the major findings for Sub-section 2 – Phelp River

Reach environs: All reaches were rated as being essentially natural except for Site 2/3 on upper Phelp River that had some modification due to grazing and the presence of an animal (eg buffalo) watering point.

Disturbances: Major - grazing, animal watering points, river crossings and roads/tracks.

Bank stability: All sites were rated as having stable river banks except for Site 2/3 on upper Phelp River where animals, mainly buffalo, were trampling river banks causing erosion and disturbance to native vegetation. Site 2/2 also recorded disturbance to the river banks by animals, particularly buffaloes.

Disturbances: Major - high flow, vermin (eg buffalo), runoff and infrastructure (ie tracks and river crossings);
Minor - tidal influence.

Bed stability: All sites were rated as having stable river beds although grazing was identified as a factor affecting bed stability at Site 2/2 on Phelp River.

Channel habitat types: Pools were present at all sites, whereas riffles and runs were present at 2-3 sites. Diversity of channel habitat types ranged from low, high to very high.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation ranged from moderate to high. Mangroves were the dominant vegetation community on lower Phelp River. The cover provided by overstorey vegetation along the upper banks averaged 46% whilst ground covers averaged 36%. The mean width of the riparian vegetation was 36m (range 13-75m).

Exotic riparian vegetation: Half the sites recorded the presence of exotic species and, where recorded, the level of invasion was low (1-5% cover). No noxious species were recorded.

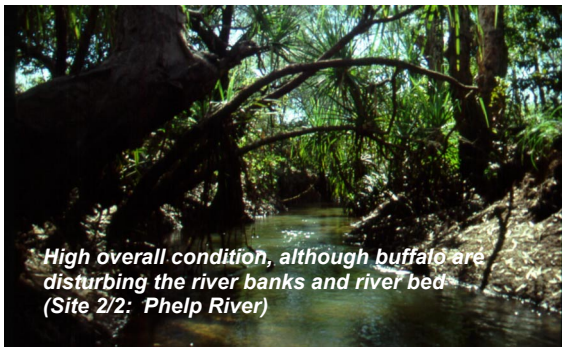
Major species: *Passiflora foetida*
Minor species: *Melochia pyramidata*

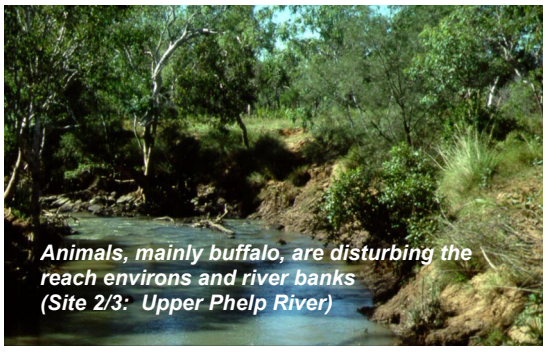
Aquatic vegetation: Three-quarters of sites recorded the presence of aquatic vegetation as either emergent and submerged types.

Instream and bank habitats: The sites were rated as having either high or moderate cover and diversity of instream and bank habitats. The canopy cover along the bank was good, averaging 78% of the bank length.

Overall condition: The tidal section of Phelp River rated very highly overall and the remainder of sites rated highly.

MAJOR ISSUE: Impact of vermin, particularly buffaloes, on reach environs, river banks and river beds along mid- to upper Phelp River.


High overall condition, although buffalo are disturbing the river banks and river bed (Site 2/2: Phelp River)


Animals, mainly buffalo, are disturbing the reach environs and river banks (Site 2/3: Upper Phelp River)

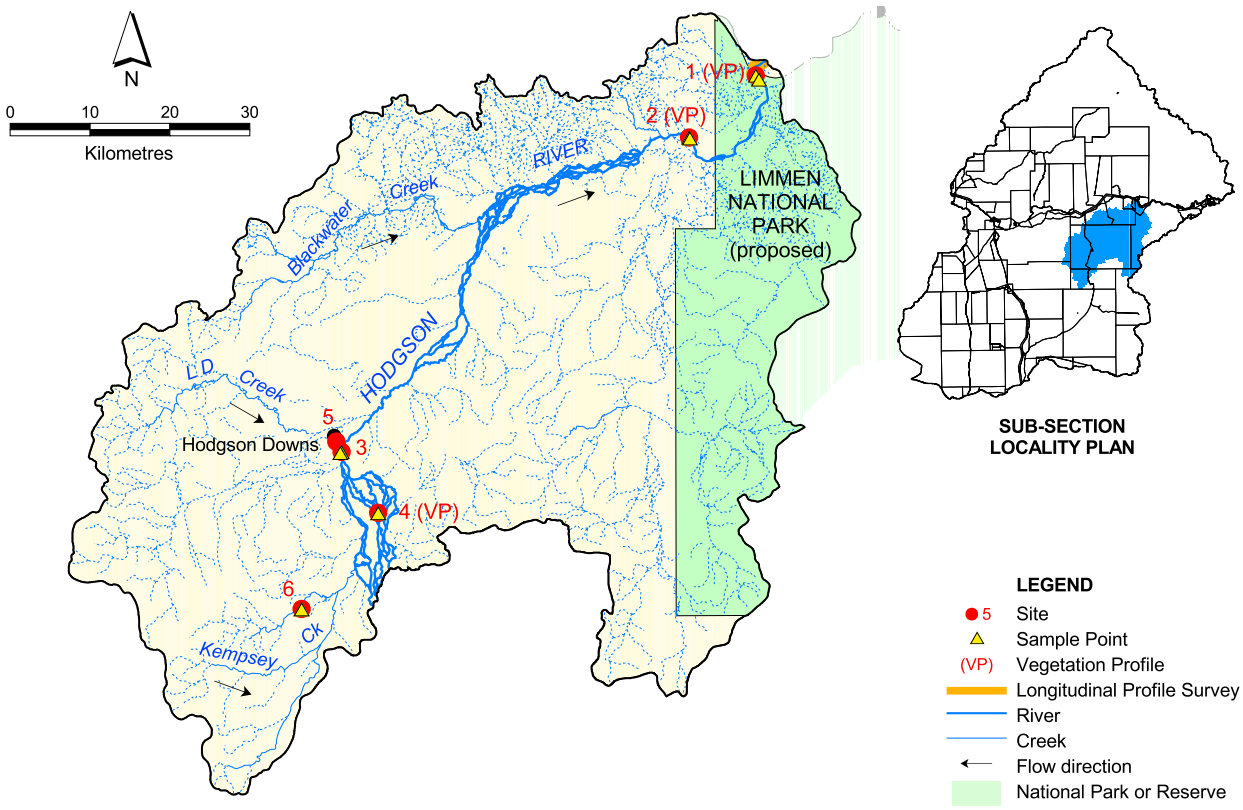


Figure 5.8 Locality Map of Sub-section 3a – Hodgson River below Arnold River

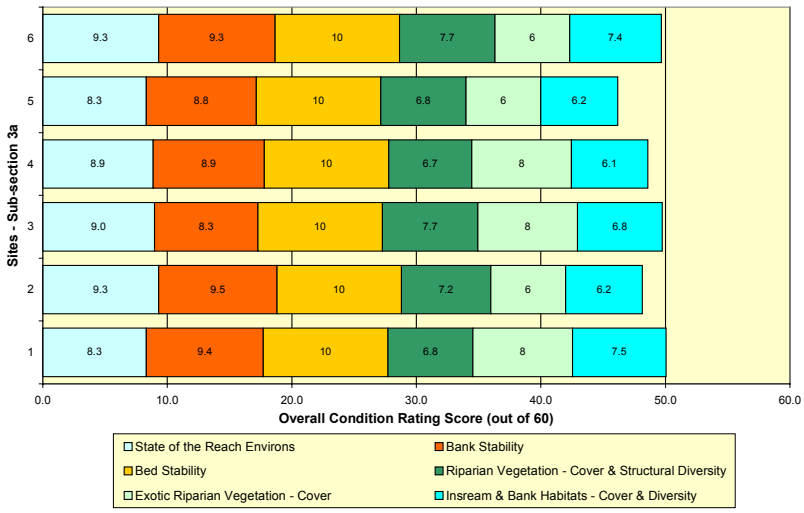
5.3 Hodgson River

The Hodgson River sub-catchment includes Hodgson River (below and above Arnold River) and Arnold River sub-sections.

5.3.1 Hodgson River – Below Arnold River

Sub-section 3a encompasses the catchment area of Hodgson River downstream of the junction with Arnold River. Of the six sites located within this sub-section, four were located on Hodgson River and the other two sites were located on Minyerri Billabong and Bella Glen Creek. All six sites were fully assessed.

Chart 5.8 Summary of the Overall Condition Rating Score for Sub-section 3a – Hodgson River below Arnold River



Summary of the major findings for Sub-section 3a – Hodgson River below Arnold River

Reach environs: All reaches were rated as being essentially natural.

Disturbances: Major - grazing, roads/tracks, people and river crossings;
Minor - an animal watering point.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - high flow, people tracks and infrastructure;
Minor - runoff, stock and vermin.

Bed stability: All sites were rated as having stable river beds. Two-thirds of sites had bars that were relatively large.

Channel habitat types: Pools were present at all sites, whereas riffles, runs and cascades were present at 2-3 sites. Diversity of channel habitat types ranged from low at Minyerri Billabong, moderate, high to very high at Bella Glen Waterhole.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was high. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 45% whilst ground covers averaged 39%. The mean width of the riparian vegetation was 27m (range 12-70m). *Livistona rigida* was recorded along Bella Glen Creek.

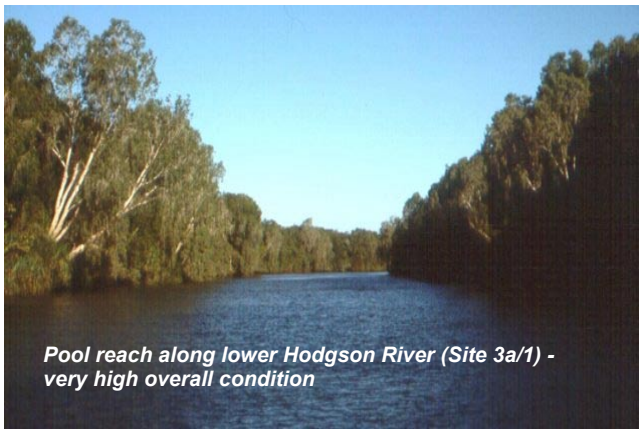
Exotic riparian vegetation: All sites recorded the presence of exotic species and the level of invasion was either low (1-5% cover) or moderate (6-10% cover).
*[Note * = species declared noxious in NT]*

Major species: *Passiflora foetida*
Minor species: *Hyptis suaveolens**

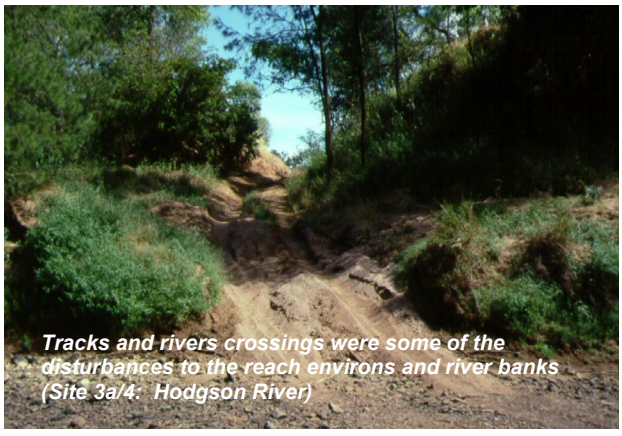
Aquatic vegetation: All sites recorded the presence of aquatic vegetation mostly as emergent and submerged types, although floating vegetation (eg water lilies) was also present at one-third of sites. Over ten species of aquatic vegetation were recorded.

Instream and bank habitats: All sites were rated as having high cover and diversity of instream and bank habitats. The canopy cover along the bank was very good, averaging 80% of the bank length.

Overall condition: Two-thirds of sites rated very highly overall, with the remainder rating highly.



Pool reach along lower Hodgson River (Site 3a/1) - very high overall condition



Tracks and rivers crossings were some of the disturbances to the reach environs and river banks (Site 3a/4: Hodgson River)

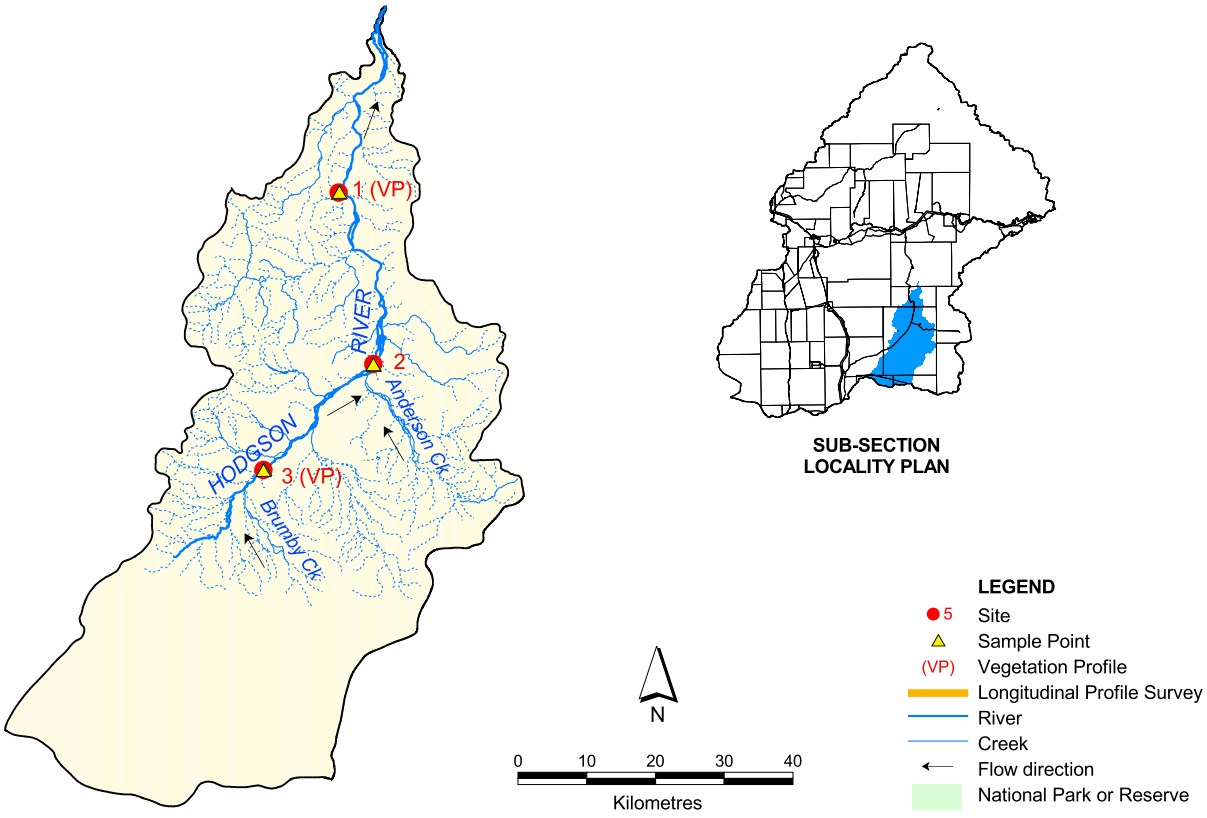
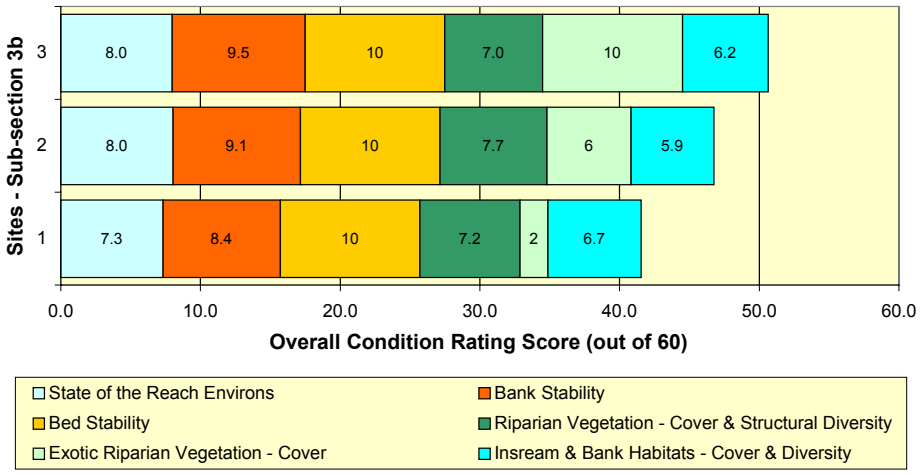


Figure 5.9 Locality Map of Sub-section 3b – Hodgson River above Arnold River

5.3.2 Hodgson River – Above Arnold River

Sub-section 3b encompasses the catchment area of Hodgson River upstream of the junction with Arnold River. Three sites, located on Hodgson River, were fully assessed in this sub-section.

Chart 5.9 Summary of the Overall Condition Rating Score for Sub-section 3b – Hodgson River above Arnold River



Summary of the major findings for Sub-section 3b – Hodgson River above Arnold River

Reach environs: All reaches were rated as having some modification due to disturbances.

Disturbances: Major - grazing, animal watering points, roads/tracks and a river crossing.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - high flow and stock.

Bed stability: All sites were rated as having stable river beds. All sites had bars that were relatively large.

Channel habitat types: Pools and riffles were present at all sites whereas runs were present at two-thirds of sites. Diversity of channel habitat types rated highly or very highly.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was high. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 44% whilst ground covers averaged 46%. The mean width of the riparian vegetation was 27m (range 12-63m).

Exotic riparian vegetation: Two-thirds of sites recorded the presence of exotic species and, where recorded, the level of invasion was either moderate (6-10% cover) or very high (16-32% cover). *[Note * = species declared noxious in NT]*

Major species: *Passiflora foetida, Triumfetta pentandra, Pennisetum pedicellatum, Echinochloa colona, Dactyloctenium aegyptium, Hyptis suaveolens* and Bidens bipinnata.*

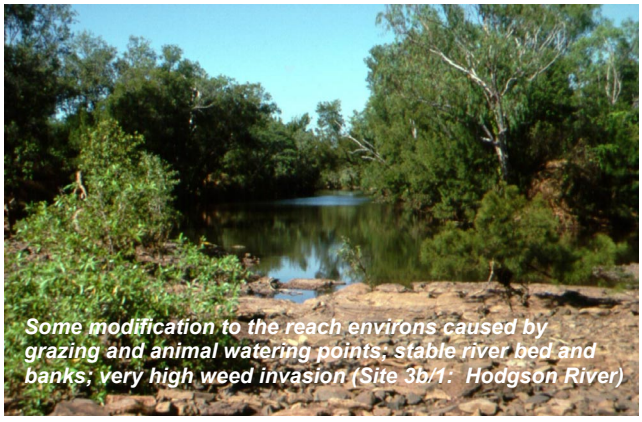
Aquatic vegetation: All sites recorded the presence of aquatic vegetation mostly as emergent types although submerged types (ie *Chara* sp.) were present at one-third of sites.

Instream and bank habitats: The sites were rated as having either high or moderate cover and diversity of instream and bank habitats. The canopy cover along the bank was very good, averaging 83% of the bank length.

Overall condition: Two-thirds of sites rated highly overall, with the remainder rating very highly.

MAJOR ISSUES:

(1) Moderate to very high weed invasion along sections of Hodgson River.
(2) The widespread level of disturbances to the reach environs (ie some modification to all reaches surveyed along Hodgson River).



Some modification to the reach environs caused by grazing and animal watering points; stable river bed and banks; very high weed invasion (Site 3b/1: Hodgson River)

Some modification to the reach environs caused by tracks, grazing and animal watering points; stable river bed and banks (Site 3b/3: Hodgson River)

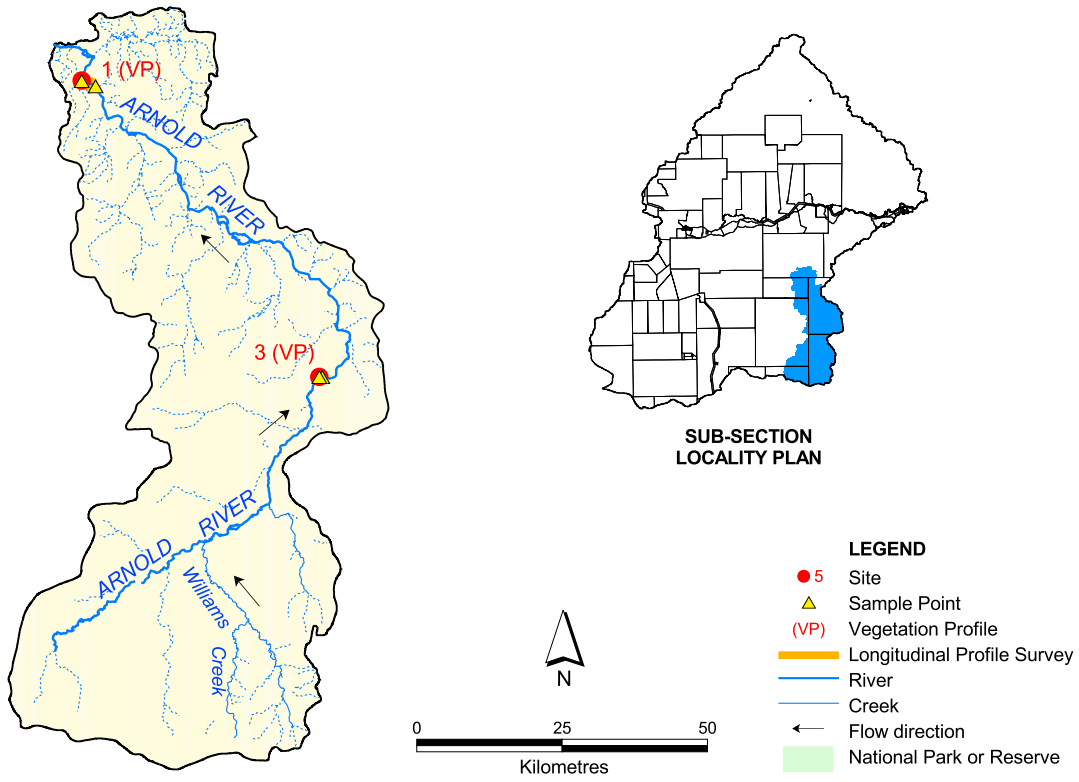
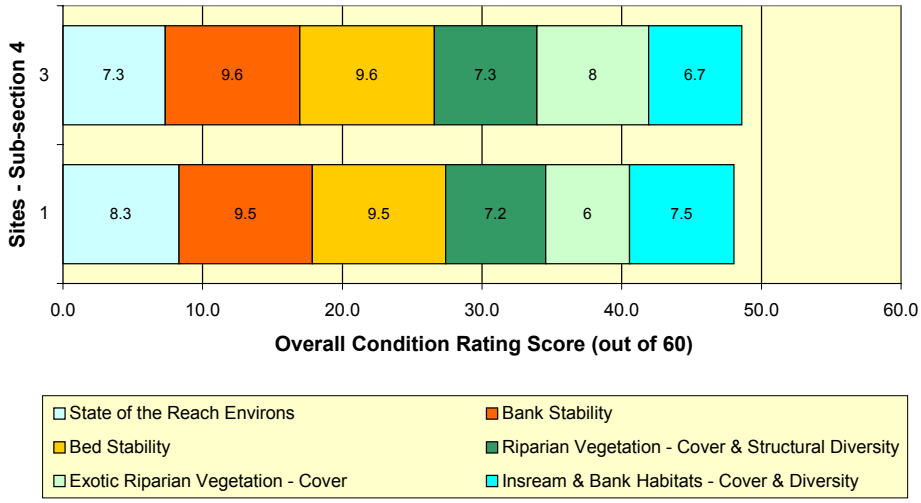


Figure 5.10 Locality Map of Sub-section 4 – Arnold River

5.3.3 Arnold River

Sub-section 4 includes the catchment of Arnold River. Two sites were fully assessed within this sub-section and these sites were located on Arnold River.

Chart 5.10 Summary of the Overall Condition Rating Score for Sub-section 4 – Arnold River



Summary of the major findings for Sub-section 4 – Arnold River

Reach environs: One reach was rated as being essentially natural whilst the other reach had some modification due to grazing and the presence of an animal water point.

Disturbances: Major - grazing and an animal watering point.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - vermin (eg donkeys) and high flow.

Bed stability: All sites were rated as having stable river beds.

Channel habitat types: Pools, riffles and runs were present at all sites, whereas waterfalls and cascades were present on Arnold River above Minimere Lagoon. Diversity of channel habitat types rated very highly.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was high. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 37% whilst ground covers averaged 51%. The mean width of the riparian vegetation was 36m (range 25-50m).

Exotic riparian vegetation: Both sites recorded the presence of exotic species and the level of invasion was low (1-5% cover) or moderate (6-10% covers).
*[Note * = species declared noxious in NT]*

Major species: *Passiflora foetida* and *Hyptis suaveolens**.

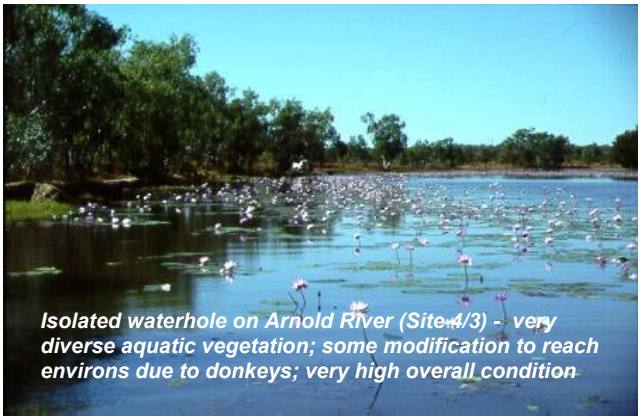
Aquatic vegetation: Both sites recorded the presence of aquatic vegetation. Emergent types were present at both sites, while along Arnold River at the abandoned Cox River homestead all aquatic vegetation types (ie emergent, submerged and floating) were recorded. Nearly 20 species were recorded from the two sites surveyed.

Instream and bank habitats: Both sites were rated as having high cover and diversity of instream and bank habitats. The canopy cover along the bank was good, averaging 73% of the bank length.

Overall condition: Both sites rated very highly overall.

MAJOR ISSUE: (1) Recognition of the conservation significance of both areas surveyed along Arnold River, one located along Minimere Lagoon, including the gorge system upstream, and the other located at a large waterhole near the abandoned Cox River homestead. (2) Impact of vermin (eg donkeys) on the reach environs along Arnold River at Cox River (Site 4/3).

Gorge system above Minimere Lagoon on Arnold River (Site 4/1) - very high overall condition



Isolated waterhole on Arnold River (Site 4/3) - very diverse aquatic vegetation; some modification to reach environs due to donkeys; very high overall condition

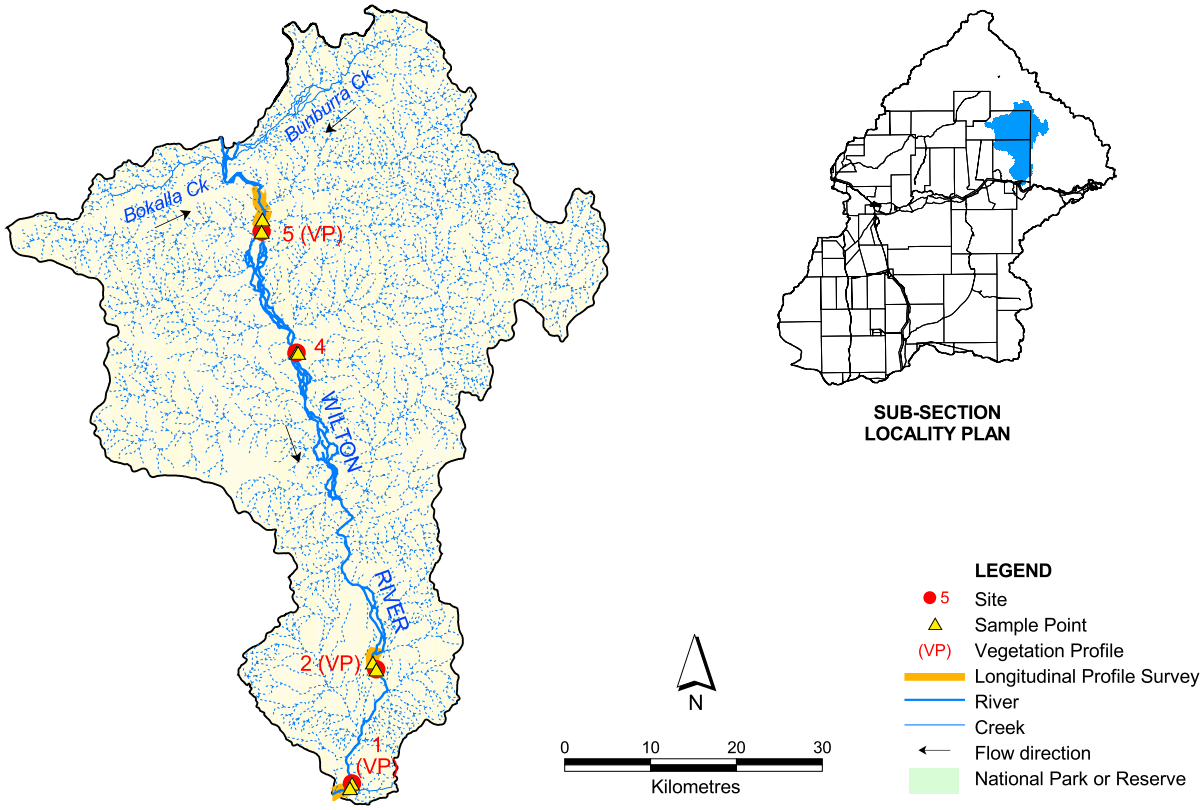


Figure 5.11 Locality Map of Sub-section 5a – Wilton River below Mainoru River

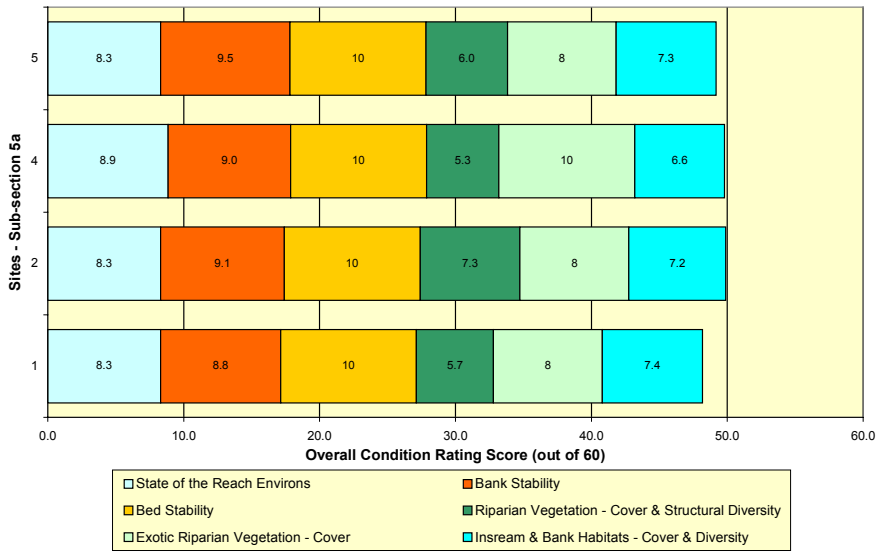
5.4 Wilton River

The Wilton River sub-catchment includes Wilton River (below and above Mainoru River) and Mainoru River sub-sections.

5.4.1 Wilton River – Below Mainoru River

Sub-section 5a encompasses the catchment area of Wilton River downstream of the junction with Mainoru River. Four sites were located within this sub-section on Wilton River and all were fully assessed.

Chart 5.11 Summary of the Overall Condition Rating Score for Sub-section 5a – Wilton River below Mainoru River



Summary of the major findings for Sub-section 5a – Wilton River below Mainoru River

Reach environs: All reaches were rated as being essentially natural.

Disturbances: Major - grazing;
Minor - roads/tracks a river crossing.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - high flow, stock, vermin (eg buffalo, *etc*) and infrastructure.

Bed stability: All sites were rated as having stable river beds. Three-quarters of sites had bars that were relatively large.

Channel habitat types: Riffles were present at all sites, whereas pools, runs, rapids and cascades were present at 1-3 sites. Diversity of channel habitat types rated highly or very highly. This section of Wilton River is a very diverse system, ranging from very rocky, steep sections to large waterholes (eg Wongalara Waterhole).

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was either moderate or, in one instance, high. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 38% whilst ground covers averaged 32%. All sites recorded the presence of *Eucalyptus camaldulensis*, *Casuarina cunninghamiana*, *Excoecaria parvifolia*, *Barringtonia acutangula*, *Acacia holosericea*, *Melaleuca leucadendra* and *Pandanus aquaticus*. The mean width of the riparian vegetation was 33m (range 18-47m).

Exotic riparian vegetation: Three-quarters of sites recorded the presence of exotic species and, where recorded, the level of invasion was low (1-5% cover). No noxious species were recorded.

Major species: *Passiflora foetida*
Minor species: *Melochia pyramidata*

Aquatic vegetation: Three-quarters of sites recorded the presence of aquatic vegetation as emergent and submerged types.

Instream and bank habitats: All sites were rated as having high cover and diversity of instream and bank habitats. The canopy cover along the bank was good, averaging 78% of the bank length.

Overall condition: Three-quarters of sites rated very highly overall, with the remaining site rating highly.

MAJOR ISSUE: Vermin, particularly buffaloes, are having an impact on the river banks though not to the degree to lower the stability rating at this stage.

A rocky riffle section on Wilton River (Site 5a/4) - very high overall condition

Wongalara Waterhole on Wilton River (Site 5a/5) - very high overall condition

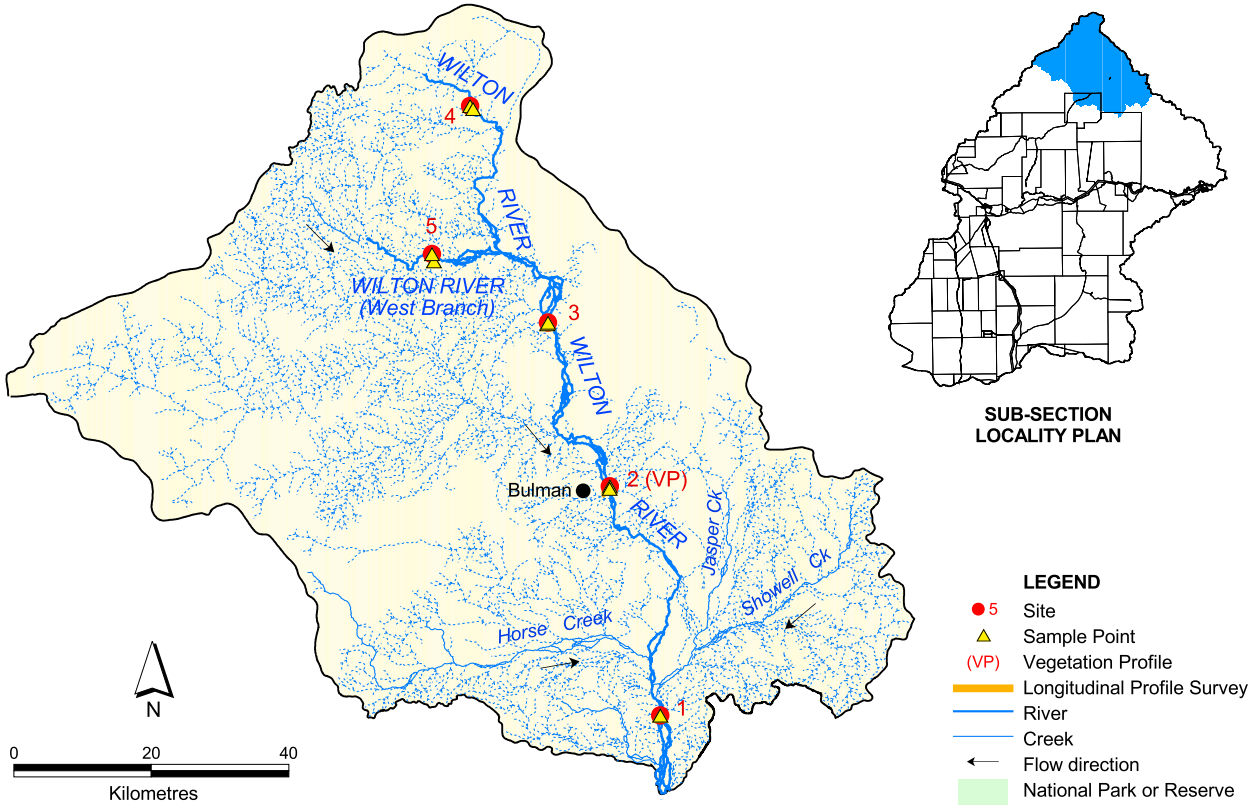
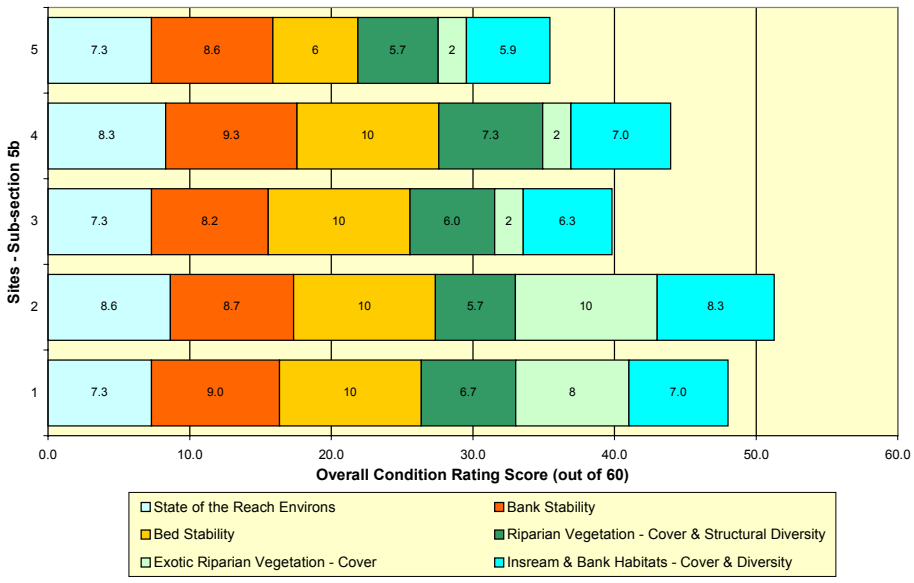


Figure 5.12 Locality Map of Sub-section 5b – Wilton River above Mainoru River

5.4.2 Wilton River – Above Mainoru River

Sub-section 5b encompasses the catchment area of Wilton River upstream of the junction with Mainoru River. Of the five sites located within this sub-section, four were located on Wilton River and one site was located on the West Branch of Wilton River. All five sites were fully assessed.

Chart 5.12 Summary of the Overall Condition Rating Score for Sub-section 5b – Wilton River above Mainoru River



Summary of the major findings for Sub-section 5b – Wilton River above Mainoru River

Reach environs: Three of the five reaches were rated as having some modification due to grazing and the presence of animal watering points, while the remaining reaches were essentially natural.

Disturbances: Major - grazing and animal watering points;
Minor - a river crossing.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - high flow and vermin (eg buffalo, pigs, donkeys, *etc*);
Minor - stock, infrastructure and runoff.

Bed stability: All sites were rated as having stable river beds except for Site 5b/5 on Wilton River above Bulman Gorge. This site had large point bars and a moderately aggrading river bed that was affecting bed stability. All sites had bars.

Channel habitat types: Pools were present at all sites, whereas riffles and runs were present at 3 sites. Diversity of channel habitat types was rated as high or very high.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was either moderate or high. The cover provided by overstorey vegetation along the upper banks averaged 43% whilst ground covers averaged 44%. The mean width of the riparian vegetation was 24m (range 12-49m).

Exotic riparian vegetation: Over three-quarters of sites recorded the presence of exotic species and, where recorded, the level of invasion was very high (16-32% cover) or, in one instance, low (1-5% cover). *[Note * = species declared noxious in NT]*

Major species: *Passiflora foetida, Sida acuta** and *Hyptis suaveolens**.
Minor species: *Calotropis procera*, Melochia pyramidata, Pennisetum pedicellatum, Sida cordifolia*, Senna obtusifolia** and *Triumfetta pentandra.*

Aquatic vegetation: All sites recorded the presence of aquatic vegetation mostly as emergent types, although submerged and floating vegetation types were also recorded.

Instream and bank habitats: Sites were rated as having high, very high or moderate cover and diversity of instream and bank habitats. The canopy cover along the bank was very good, averaging 82% of the bank length.

Overall condition: Sites mostly rated highly overall, although one site rated very highly and Site 5b/5 rated only moderately overall (the worst rating in the catchment).

MAJOR ISSUES: Very high weed invasion and vermin (ie buffalo, pigs, donkeys, *etc*) along upper Wilton River and Wilton River - West Branch. Site 5b/5 above Bulman Gorge was suffering from aggradation issues, reach environs disturbances, high weed invasion along with other issues and, as a result, rated only moderately overall.

Upper Wilton River (Site 5b/4) – very high weed invasion and vermin were major issues

Bulman Gorge on Wilton River – West Branch. Site 5b/5, located upstream, was suffering from aggradation, weed invasion and other issues.

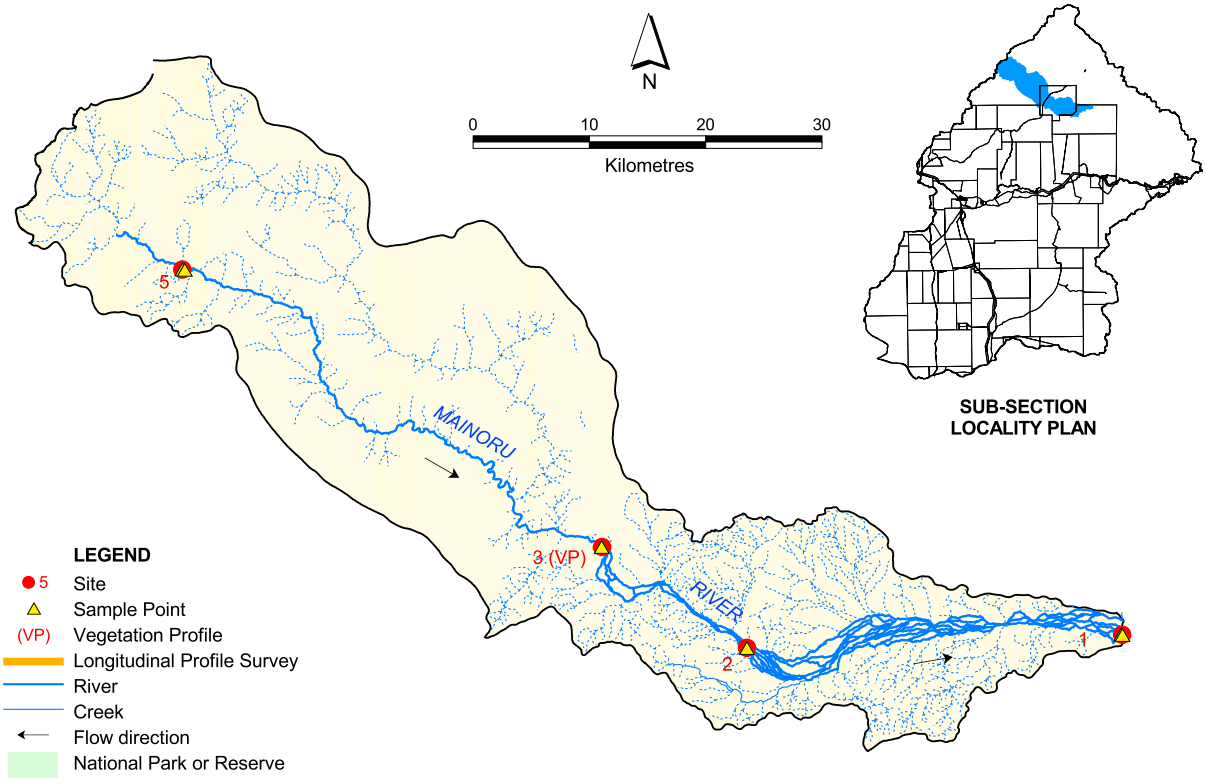
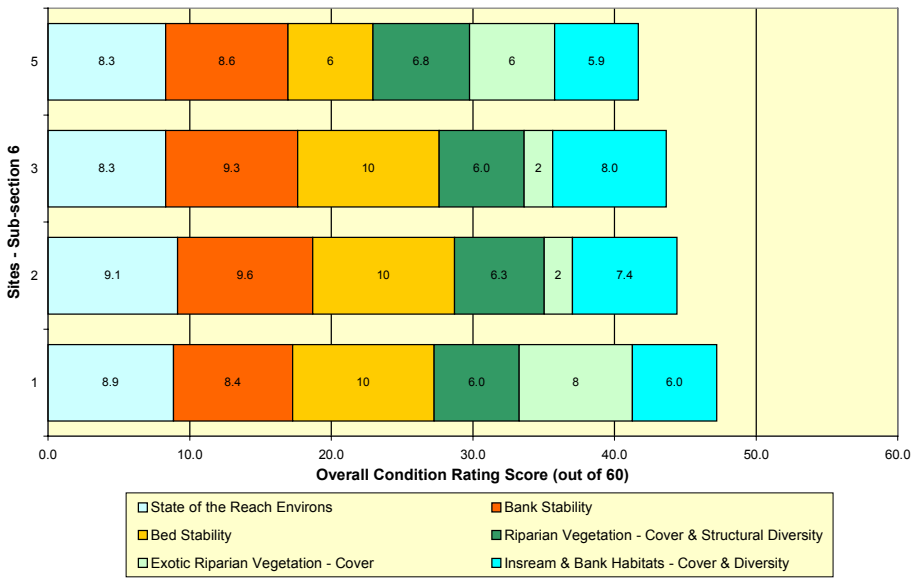


Figure 5.13 Locality Map of Sub-section 6 – Mainoru River

5.4.3 Mainoru River

Sub-section 6 includes the catchment area of Mainoru River. Four sites, located on Mainoru River, were fully assessed within this sub-section.

Chart 5.13 Summary of the Overall Condition Rating Score for Sub-section 6 – Mainoru River



Summary of the major findings for Sub-section 6 – Mainoru River

Reach environs: All reaches were rated as being essentially natural.

Disturbances: Major - grazing, roads/tracks and river crossings.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - high flow and vermin;
Minor - infrastructure.

Bed stability: All sites were rated as having stable river beds except for Site 6/5 which is located on upper Mainoru River. This site had a moderately aggrading river bed and instream siltation was affecting bed stability. The channel was flat and uniform in shape and there was a large amount of sand material present.

Channel habitat types: Pools, riffles and runs were present at 2-3 sites. Cascades and waterfalls were present at one site. Diversity of channel habitat types was high or very high.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was moderate and, in one instance, high. The cover provided by overstorey vegetation along the upper banks averaged 47% whilst ground covers averaged 35%. *Pandanus aquaticus* was the most prevalent species. The mean width of the riparian vegetation was 30m (range 12-50m).

Exotic riparian vegetation: All sites recorded the presence of exotic species and the level of invasion ranged from very high (16-32% cover), moderate (6-10% cover) to low (1-5% cover). *[Note * = species declared noxious in NT]*

Major species: *Calotropis procera*, Hyptis suaveolens** and *Pennisetum pedicellatum*;
Minor species: *Echinochloa colona, Melochia pyramidata, Passiflora foetida, Senna obtusifolia**, *Themeda quadrivalis**, *Xanthium occidentale**.

Aquatic vegetation: Three-quarters of sites recorded the presence of aquatic vegetation as either emergent or submerged types.

Instream and bank habitats: Sites were rated as having either moderate or high cover and diversity of instream and bank habitats. The canopy cover along the bank was very good, averaging 86% of the bank length.

Overall condition: All sites rated highly overall.

MAJOR ISSUES: Moderate to very high weed invasion along mid- to upper Mainoru River and river bed aggradation at Site 6/5 on upper Mainoru River.


Moderate cover and diversity of riparian vegetation; very high weed invasion (Site 6/3: Mainoru River)


Moderate river bed aggradation; moderate weed invasion (Site 6/5: upper Mainoru River)

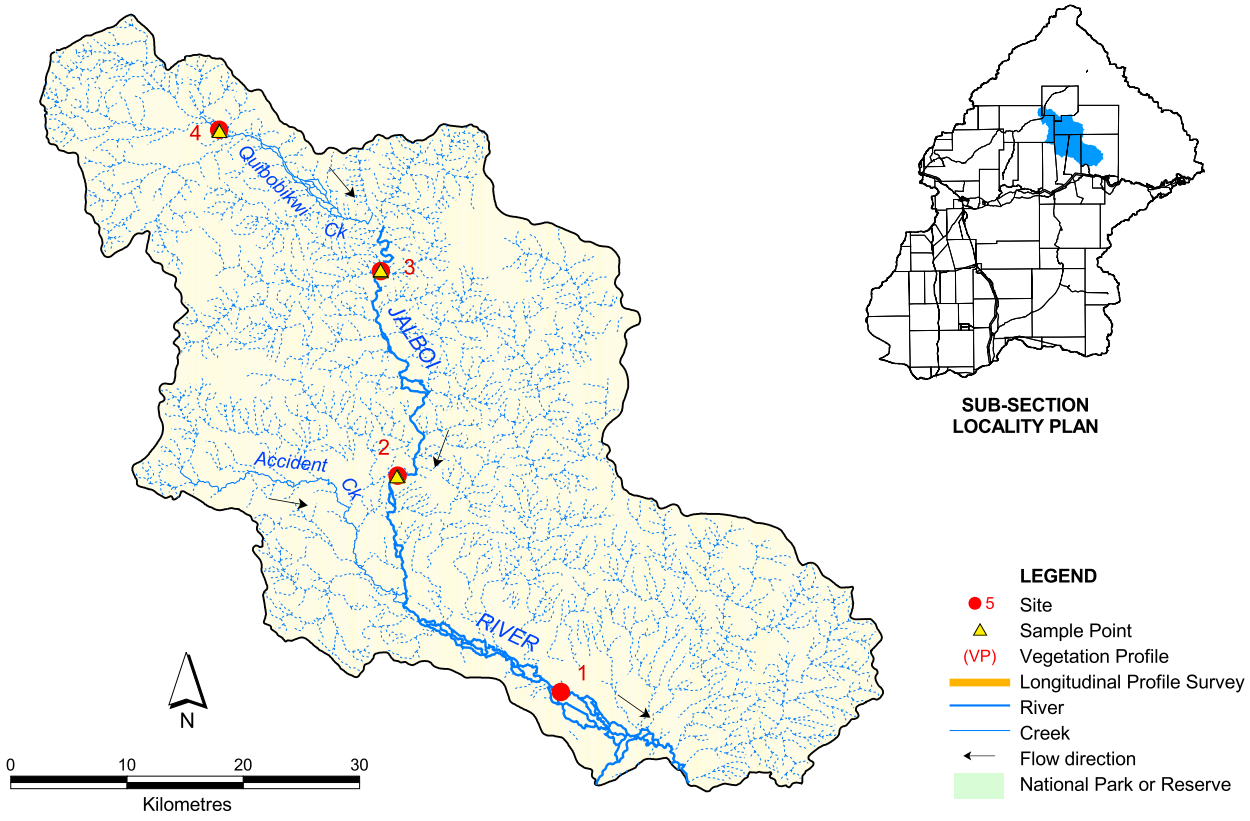
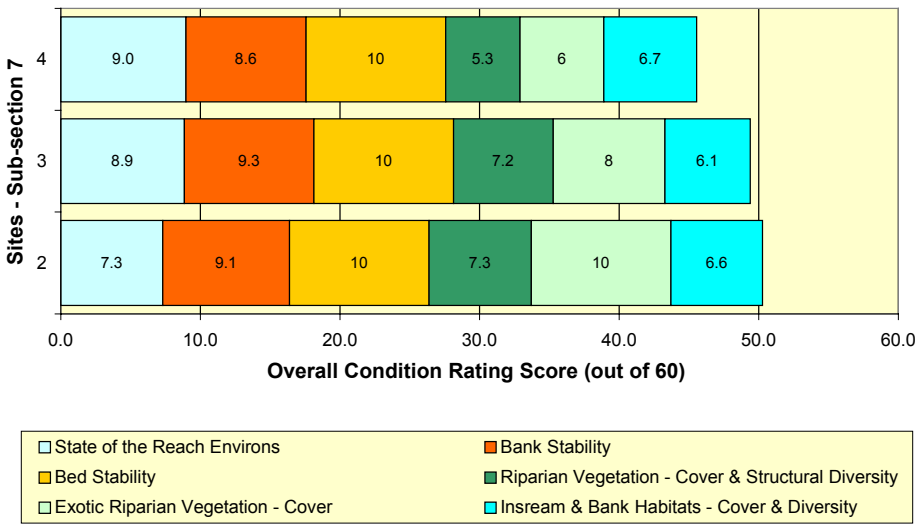


Figure 5.14 Locality Map of Sub-section 7 – Jalboi River

5.5 Jalboi River

Sub-section 7 includes the catchment area of Jalboi River. Of the four sites in this sub-section, three sites were located on Jalboi River and one site was on Quibobikwi Creek. All sites were fully assessed within this sub-section except for one site on Jalboi River.

Chart 5.14 Summary of the Overall Condition Rating Score for Sub-section 7 – Jalboi River



Summary of the major findings for Sub-section 7 – Jalboi River

Reach environs: All reaches were rated as being essentially natural except for Site 7/2 that had some modification due to grazing and the presence of an animal watering point.

Disturbances: Major - grazing, roads/tracks, river crossings and an animal watering point.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - high flow, stock and vermin.

Bed stability: All sites were rated as having stable river beds. Bars were present at all sites.

Channel habitat types: Pools were present at all sites, whereas riffles and runs were present at 2 sites. Diversity of channel habitat types was high or, in one instance, very high.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was high or, in one instance, was moderate. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 32% whilst ground covers averaged 49%. *Arundinella nepalensis*, *Eucalyptus camaldulensis* and *Terminalia pterocarya* were the most prevalent species. The mean width of the riparian vegetation was 18m (range 10-29m).

Exotic riparian vegetation: Two-thirds of sites recorded the presence of exotic species and, where recorded, the level of invasion was low (1-5% cover) or moderate (6-10% cover). *[Note * = species declared noxious in NT]*

Major species: *Hyptis suaveolens**

Aquatic vegetation: All sites recorded the presence of aquatic vegetation as an emergent type. *Melaleuca leucadendra* and *Terminalia pterocarya* were the two species recorded.

Instream and bank habitats: All sites were rated as having high cover and diversity of instream and bank habitats. The canopy cover along the bank was moderate, averaging 58% of the bank length.

Overall condition: Two-thirds of sites rated very highly overall, with the remaining site rating highly.

Jalboi River (Site 7/2) – Some modification to the reach environs; very high overall condition

Jalboi River (Site 7/3) – very high overall condition

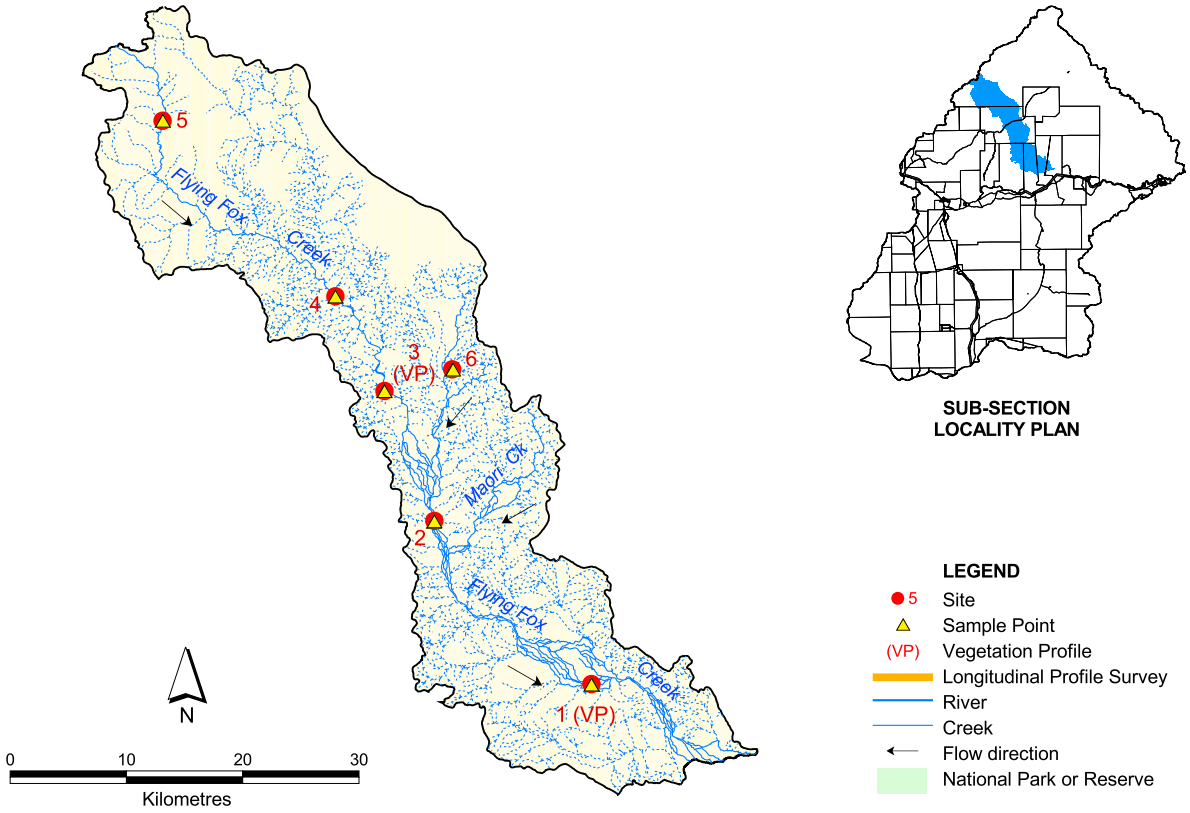
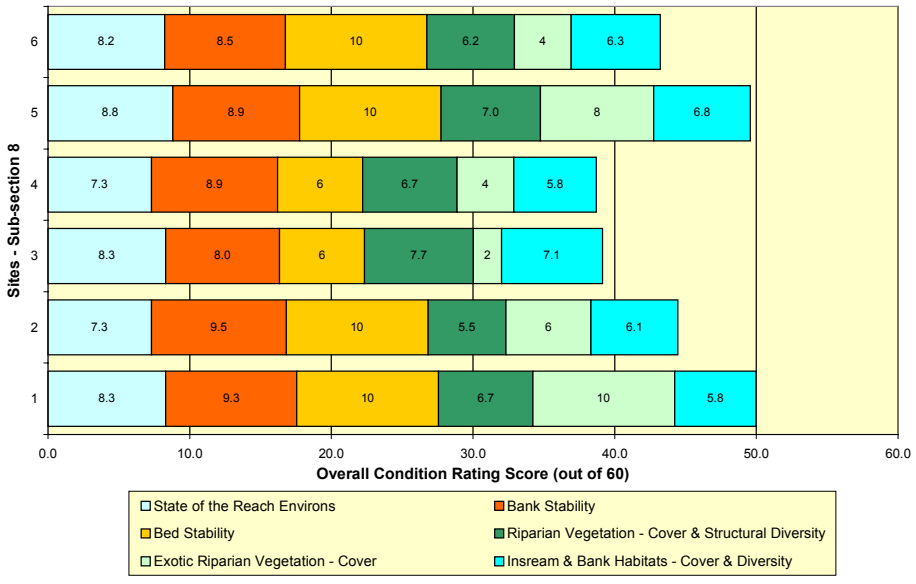


Figure 5.15 Locality Map of Sub-section 8 – Flying Fox Creek

5.6 Flying Fox Creek

Sub-section 8 includes the catchment area of Jalboi River. Of the six sites in this sub-section, five sites were located on Flying Fox Creek and one site was on Derim Derim Creek. All sites were fully assessed within this sub-section.

Chart 5.15 Summary of the Overall Condition Rating Score for Sub-section 8 – Flying Fox Creek



Summary of the major findings for Sub-section 8 – Flying Fox Creek

Reach environs: Two-thirds of reaches were rated as being essentially natural whilst the remainder had some modification due to grazing and the presence of animal watering points.

Disturbances: Major - grazing, animal watering points, roads/tracks;
Minor - river crossing.

Bank stability: All sites were rated as having stable river banks except Site 8/3 which recorded limited bank instability.

Disturbances: Major - high flow, stock and vermin (eg buffalo, *etc*);
Minor - runoff.

Bed stability: Two-thirds of sites were rated as having stable river beds whilst the remainder had moderate aggradation problems and instream siltation was affecting there stability. Nearly all sites recorded the presence of relatively large bars, which ranged from 3-70% of the bed surface.

Channel habitat types: Pools were present at all sites, whereas riffles, runs and waterfalls were present at 1-5 sites. Diversity of channel habitat types rated highly or very highly.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was either moderate or high. The cover provided by overstorey vegetation along the upper banks averaged 39% whilst ground covers averaged 37%. The mean width of the riparian vegetation was 35m (range 8-92m).

Exotic riparian vegetation: All sites, except Site 8/1, recorded the presence of exotic species and, where recorded, the level of invasion ranged from low (1-5% cover), moderate (6-10% cover), high (11-15% cover) to very high (16-32% cover).
*[Note * = species declared noxious in NT]*

Major species: *Hyptis suaveolens*, Triumfetta pentandra, Passiflora foetida* and *Sida acuta**;
Minor species: *Bothriochloa pertusa, Crotalaria goreensis, Euphorbia hirta, Senna obtusifolia*.*

Aquatic vegetation: Two-thirds of sites recorded the presence of aquatic vegetation mostly as emergent and submerged types.

Instream and bank habitats: Sites were rated as having either moderate or high cover and diversity of instream and bank habitats. The canopy cover along the bank was good, averaging 70% of the bank length.

Overall condition: Two-thirds of sites rated highly overall, with the remainder rating very highly.

MAJOR ISSUES: (1) Moderate to very high weed invasion along sections of Flying Fox and Derim Derim Creeks. (2) River bed aggradation along sections of Flying Fox Creek. (3) Some disturbance to reach environs by vermin (ie buffaloes, *etc*).


Moderate bed aggradation; very high weed invasion (Site 8/3: Flying Fox Creek)


Very high diversity of channel habitat types (Site 8/5: upper Flying Fox Creek)

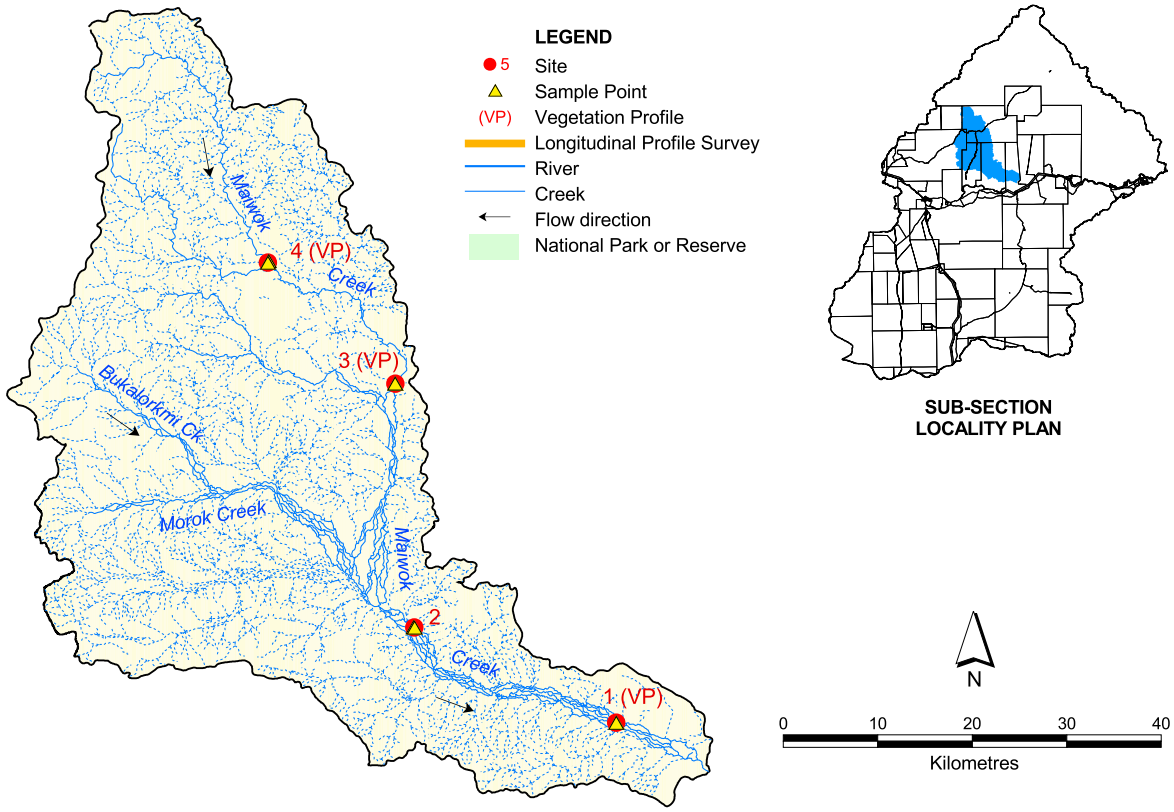
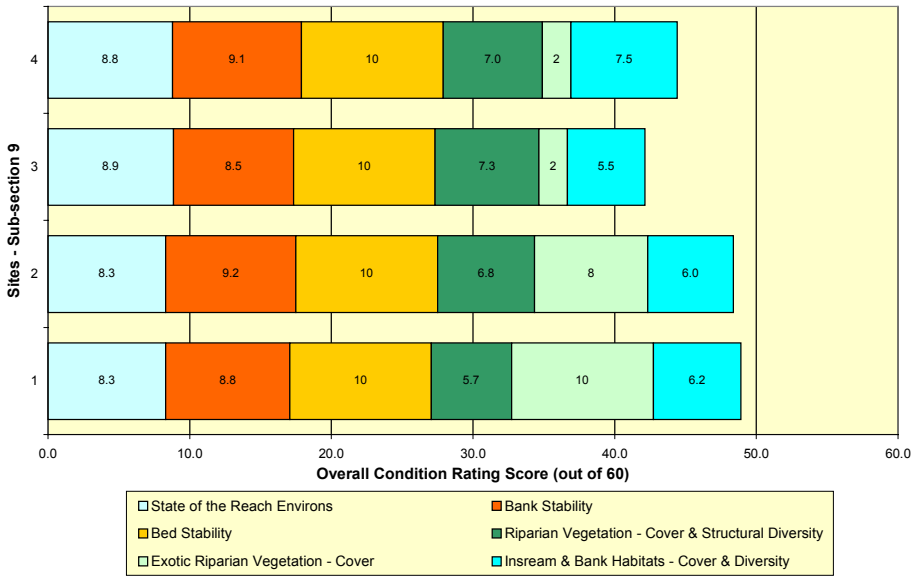


Figure 5.16 Locality Map of Sub-section 9 – Maiwok Creek

5.7 Maiwok Creek

Sub-section 9 includes the catchment area of Maiwok Creek. Four sites were located in this sub-section on Maiwok Creek and all were fully assessed.

Chart 5.16 Summary of the Overall Condition Rating Score for Sub-section 9 – Maiwok Creek



Summary of the major findings for Sub-section 9 – Maiwok Creek

Reach environs: All reaches were rated as being essentially natural.

Disturbances: Major - grazing, roads/tracks and river crossings.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - high flow, stock, vermin and infrastructure;
Minor - runoff.

Bed stability: All sites were rated as having stable river beds.

Channel habitat types: Pools were present at all sites, whereas riffles, runs and cascades were present at 1-2 sites. Diversity of channel habitat types rated highly.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was high and, in one instance, moderate. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 39% whilst ground covers averaged 44%. *Atalaya hemiglauca*, *Barringtonia acutangula* and *Terminalia platyphylla* were the most widespread species. The mean width of the riparian vegetation was 24m (range 13-47m).

Exotic riparian vegetation: Three-quarters of sites recorded the presence of exotic species and, where recorded, the level of invasion was very high (16-32% cover) and, in one instance, low (1-5% cover). *[Note * = species declared noxious in NT]*

Major species: *Hyptis suaveolens*, Passiflora foetida, Sida acuta* and Triumfetta pentandra*;
Minor species: *Calotropis procera**, *Dactyloctenium aegyptium, Echinochloa colona*, *Euphorbia heterophylla*, *Pennisetum pedicellatum*, *Senna obtusifolia** and *Tribulus terrestris**.

Aquatic vegetation: Half the sites recorded the presence of aquatic vegetation as submerged and emergent types.

Instream and bank habitats: Sites were rated as having either high or moderate cover and diversity of instream and bank habitats. The canopy cover along the bank was good, averaging 72% of the bank length.

Overall condition: Half the sites rated very highly overall, with the other half rating highly.

MAJOR ISSUE: Very high weed invasion along mid- to upper Maiwok Creek.


Very high overall condition (Site 9/2: Maiwok Creek)


Very high weed invasion; high overall condition (Site 9/3: Maiwok Creek)

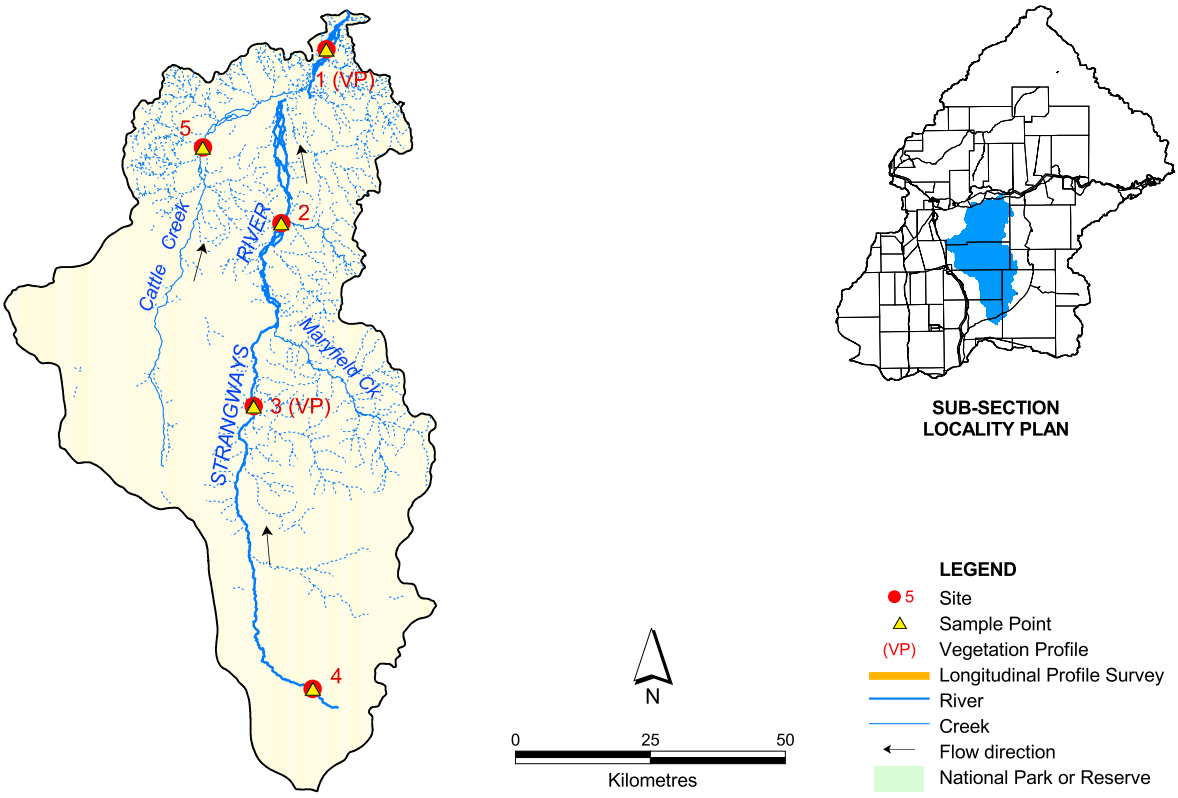
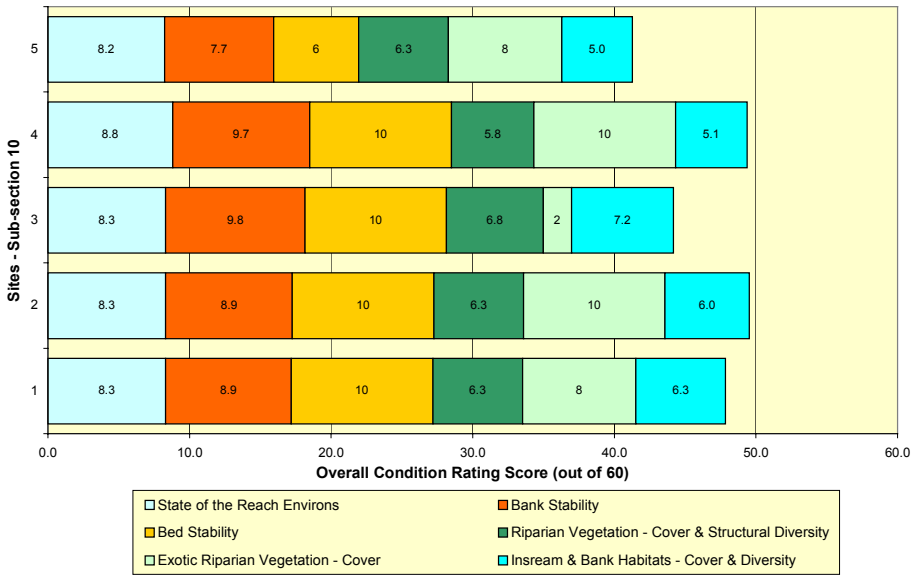


Figure 5.17 Locality Map of Sub-section 10 – Strangways River

5.8 Strangways River

Sub-section 10 includes the catchment area of Strangways River. Of the five sites in this sub-section, four sites were located on Strangways River and one site was on Cattle Creek. All five sites were fully assessed.

Chart 5.17 Summary of the Overall Condition Rating Score for Sub-section 10 – Strangways River



Summary of the major findings for Sub-section 10 – Strangways River

Reach environs: All reaches were rated as being essentially natural.

Disturbances: Major - grazing, roads/tracks and animal watering points;
Minor - river crossing and bridge/culvert.

Bank stability: All sites were rated as having stable river banks except Site 10/5 on Cattle Creek, which recorded limited bank instability due high flows and stock activity.

Disturbances: Major - high flow and stock;
Minor - vermin and infrastructure.

Bed stability: All sites were rated as having stable river beds except Site 10/5 on Cattle Creek, which was moderately aggrading and recorded instream siltation as a factor affecting bed stability. Cattle Creek appeared to be carrying a large amount of sediment and, as a result, the bed was flat, uniform and shallow.

Channel habitat types: Pools were present at all sites, whereas riffles and runs were present at 3-4 sites. Only one site recorded cascades. Diversity of channel habitat types rated highly and, in one instance, very highly.

Riparian vegetation: The cover and structural diversity for the riparian vegetation was moderate and, in one instance, high. The cover provided by overstorey vegetation along the upper banks averaged 36% whilst ground covers averaged 54%. The mean width of the riparian vegetation was 13m (range 3-28m).

Exotic riparian vegetation: Nearly two-thirds of sites recorded the presence of exotic species and, where recorded, the level of invasion ranged from low (1-5% cover) and, in one instance, very high (16-32% cover). *[Note * = species declared noxious in NT]*

Major species: *Melochia pyramidata*;
Minor species: *Bidens bipinnata*, *Hyptis suaveolens**, *Passiflora foetida*, *Pennisetum pedicellatum* and *Urochloa mosambicensis*.

Aquatic vegetation: Over half the sites recorded the presence of emergent aquatic vegetation, whereas floating vegetation (ie water lilies) and submerged vegetation (ie *Potamogeton javanicus*) were recorded at one site.

Instream and bank habitats: Nearly two-thirds of sites were rated as having moderate cover and diversity of instream and bank habitats, whilst the remainder rated highly. The canopy cover along the bank was good, averaging 67% of the bank length.

Overall condition: Nearly two-thirds of sites rated highly overall, with the remainder rating very highly.

MAJOR ISSUES: (1) Very high weed invasion at Rocky Hole Yard on Strangways River.
(2) Moderate river bed aggradation and bank instabilities due to high flows and stock activity on Cattle Creek at Site 10/5.


Isolated, spring-fed pool on Strangways River at Rocky Hole Yard (Site 10/3)


Limited bank instability; moderate bed aggradation (Site 10/5: Cattle Creek)

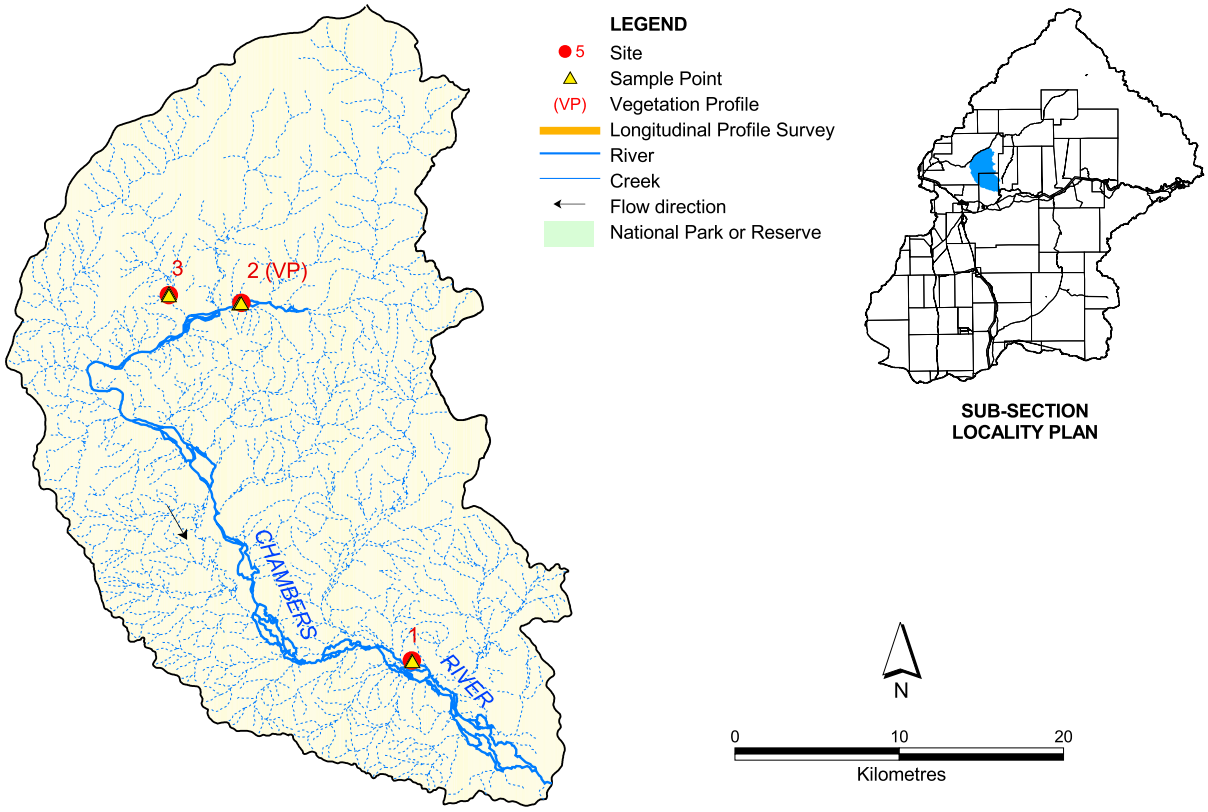
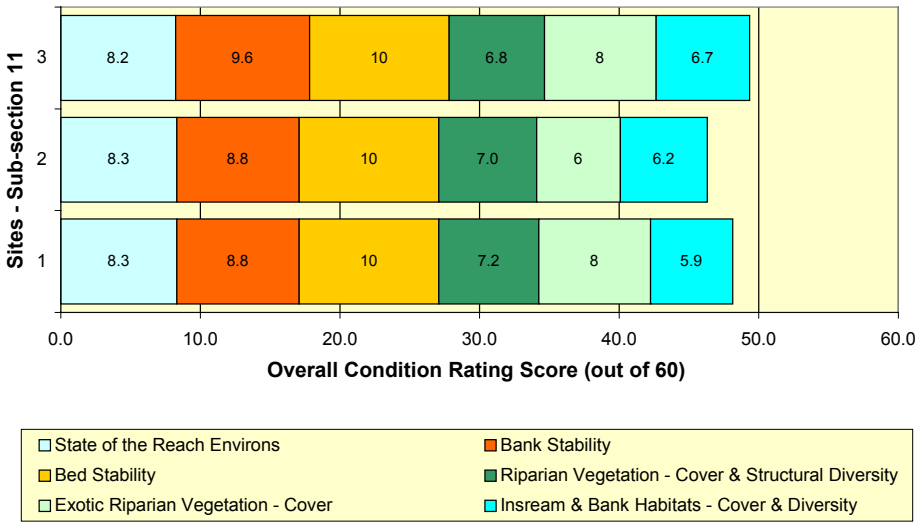


Figure 5.18 Locality Map of Sub-section 11 – Chambers River

5.9 Chambers River

Sub-section 11 includes the catchment area of Chambers River. Of the three sites in this sub-section, two sites were located on Chambers River and one site was on an arm of Chambers River. All three sites were fully assessed.

Chart 5.18 Summary of the Overall Condition Rating Score for Sub-section 11 – Chambers River



Summary of the major findings for Sub-section 11 – Chambers River

Reach environs: All reaches were rated as being essentially natural.

Disturbances: Major - grazing, an animal watering point, road/track and a river crossing.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - high flow and vermin.

Bed stability: All sites were rated as having stable river beds.

Channel habitat types: Pools and riffles were present at all sites. Diversity of channel habitat types rated highly.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was high. The cover provided by overstorey vegetation (ie trees and shrubs greater than 1.3m tall) along the upper banks averaged 33% whilst ground covers averaged 47%. The mean width of the riparian vegetation was 24m (range 8-61m).

Exotic riparian vegetation: All sites recorded the presence of exotic species and the level of invasion was low (1-5% cover) and, in one instance, moderate (6-10% cover).
*[Note * = species declared noxious in NT]*

Major species: *Passiflora foetida, Crotalaria goreensis, Hyptis suaveolens* and Senna occidentalis**.

Aquatic vegetation: All sites recorded the presence of emergent aquatic vegetation, whereas floating and submerged types were recorded at 1-2 sites.

Instream and bank habitats: Two-thirds of sites were rated as having high cover and diversity of instream and bank habitats, with the remaining site rating moderately. The canopy cover along the bank was moderate, averaging 64% of the bank length.

Overall condition: Two-thirds of sites rated highly overall, with the remaining site rating very highly.


Chambers River (Site 11/1) – High overall condition


Chambers River (Site 11/2) – High overall condition

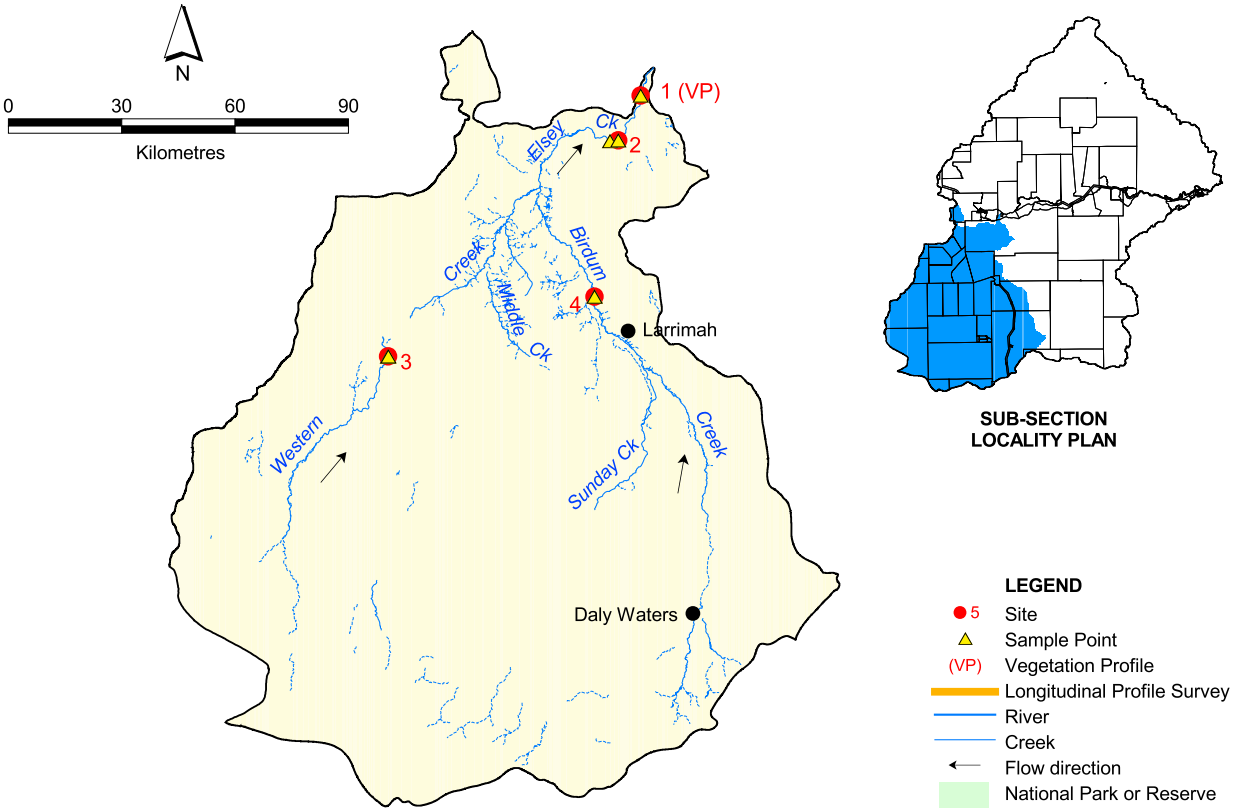
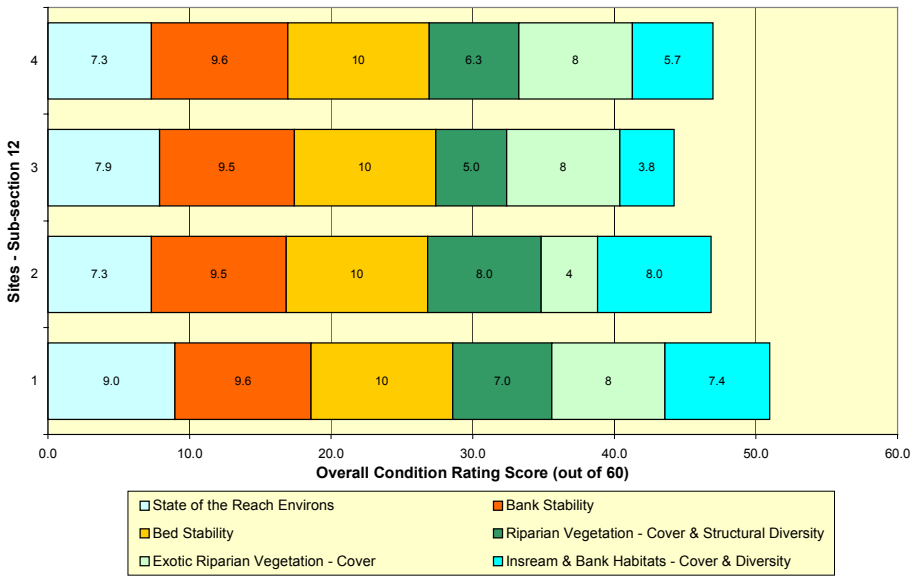


Figure 5.19 Locality Map of Sub-section 12 – Elsey Creek

5.10 Elsey Creek

Sub-section 12 includes the catchment area of Elsey Creek. Of the four sites in this sub-section, two sites were located on Elsey Creek, one site was located on Western Creek and one site on Birdum Creek. All four sites were fully assessed.

Chart 5.19 Summary of the Overall Condition Rating Score for Sub-section 12 – Elsey Creek



Summary of the major findings for Sub-section 12 – Elsey Creek

Reach environs: Three-quarters of reaches were rated as having some modification whilst the remaining reach along lower Elsey Creek was essentially natural.

Disturbances: Major - grazing, animal watering points and roads/tracks;
Minor - bridge/culvert and river works.

Bank stability: All sites were rated as having stable river banks.

Disturbances: Major - vermin and stock;
Minor - high flow.

Bed stability: All sites were rated as having stable river beds although trampling by stock/ ferals was affecting bed stability at Site 12/4 on Birdum Creek.

Channel habitat types: Pools were present at all sites, whereas runs were present at three-quarters of sites. Diversity of channel habitat types rated highly except for lower Elsey Creek where only one habitat type was sampled.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was either high or moderate. The cover provided by overstorey vegetation along the upper banks averaged 41% whilst ground covers averaged 49%. The mean width of the riparian vegetation was 68m (range 12-300m).

Exotic riparian vegetation: All sites recorded the presence of exotic species and the level of invasion was low (1-5% cover) and, in one instance, high (11-15% cover).
*[Note * = species declared noxious in NT]*

Major species: *Passiflora foetida, Phyla nodiflora* and *Melochia pyramidata*;
Minor species: *Parkinsonia aculeata** and *Ziziphus mauritiana**.

Aquatic vegetation: Three-quarters of sites recorded the presence of aquatic vegetation mostly as emergent and submerged types, although one site recorded floating vegetation (ie water lilies). Thirteen different species were recorded

Instream and bank habitats: Sites rated as having either a high, moderate of low cover and diversity of instream and bank habitats. The canopy cover along the bank was good, averaging 66% of the bank length.

Overall condition: Three quarters of sites rated highly overall, with the remaining site rating very highly.

MAJOR ISSUES: (1) Disturbances along three-quarters of reaches, including vermin (eg pigs) along Longreach Waterhole on Elsey Creek. (2) High weed invasion along Longreach Waterhole on Elsey Creek. (3) Low cover and diversity of instream and bank habitats along Western Creek. (4) Recognition and conservation of the *Livistona rigida* palm community along Elsey Creek as it is a species of limited distribution within the Northern Territory.

Livistona rigida palm community along Elsey Creek (Site 12/1)

High weed invasion and disturbance to the reach environs by feral pigs (Site 12/2: Longreach Waterhole on Elsey Creek)

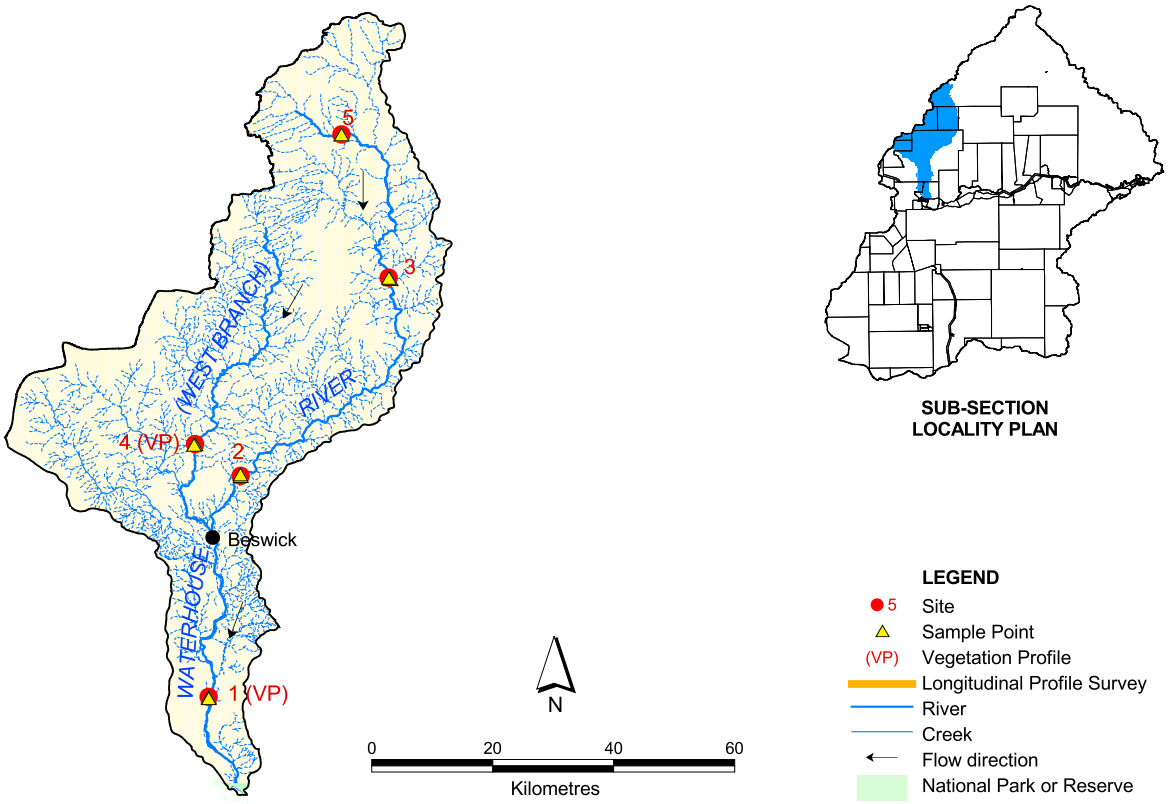
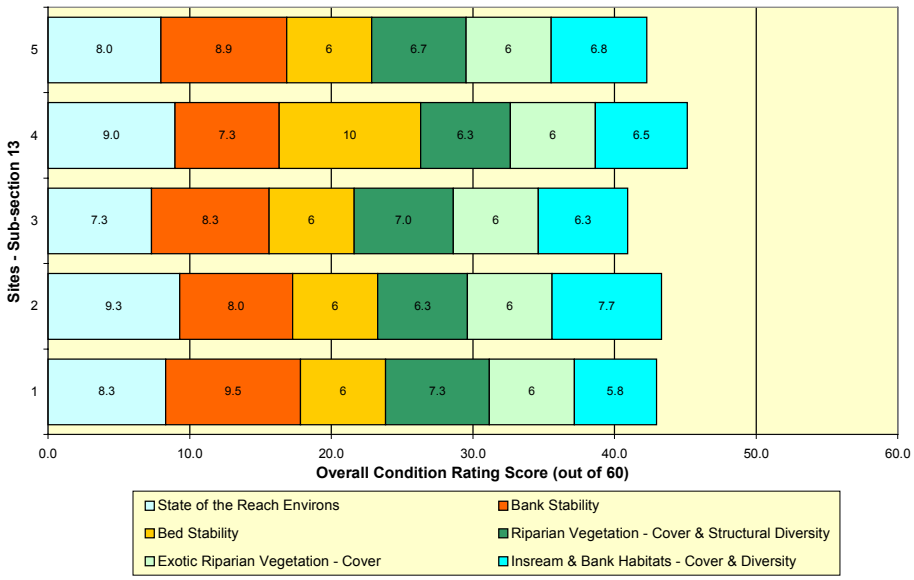


Figure 5.20 Locality Map of Sub-section 13 – Waterhouse River

5.11 Waterhouse River

Sub-section 13 includes the catchment area of Waterhouse River. Of the five sites in this sub-section, four sites were located on Waterhouse River and one site was located on the West Branch of Waterhouse River. All five sites were fully assessed.

Chart 5.20 Summary of the Overall Condition Rating Score for Sub-section 13 – Waterhouse River



Summary of the major findings for Sub-section 13 – Waterhouse River

Reach environs: Nearly two-thirds of reaches were rated as being essentially natural, whilst the remainder had some modification due to disturbances.

Disturbances: Major - grazing, animal watering points, roads/tracks and people;
Minor - river crossing.

Bank stability: Nearly two-thirds of sites were rated as having stable river banks, whilst the remainder had limited bank instability.

Disturbances: Major - high flow and vermin (eg buffalo);
Minor - floodplain scours and infrastructure.

Bed stability: All sites surveyed on Waterhouse River, excluding the West Branch, had moderate bed aggradation and instream siltation was affecting bed stability at 40% of sites. The Waterhouse River appeared to be carrying a large amount of unconsolidated sediment (ie sands) and, as a result the bed was flat, uniform and shallow. Bars were large and included high flow deposits. Trampling of the river bed by vermin (ie buffalo) at one site was impacting on bed stability.

Channel habitat types: Pools were present at all sites, whereas riffles, runs and waterfalls were present at 2-3 sites. Diversity of channel habitat types rated highly or very highly.

Riparian vegetation: The cover and structural diversity rating for the riparian vegetation was either high or moderate. The cover provided by overstorey vegetation and ground covers along the upper banks averaged 36% each. The mean width of the riparian vegetation was 29m (range 6-41m).

Exotic riparian vegetation: All sites recorded the presence of exotic species and the level of invasion was moderate (6-10% cover). *[Note * = species declared noxious in NT]*

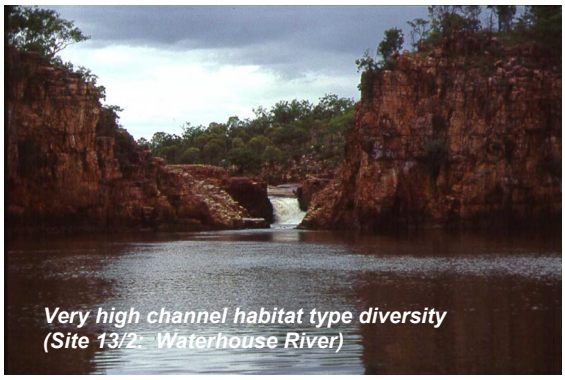
Major species: *Hyptis suaveolens* and Passiflora foetida*;
Minor species: *Echinochloa colona, Sida acuta** and *Sida cordifolia*.*

Aquatic vegetation: All sites recorded the presence of emergent aquatic vegetation, although submerged vegetation was present at over half the sites.

Instream and bank habitats: All sites were rated as having high, or in one instance, moderate cover and diversity of instream and bank habitats. The canopy cover along the bank was good, averaging 74% of the bank length.

Overall condition: All sites rated highly overall.

MAJOR ISSUES: (1) Moderate weed invasion along all reaches. (2) Moderate aggradation along Waterhouse River. (3) Some disturbances to either reach environs or river banks at most sites from such things as vermin, infrastructure and people.


Very high channel habitat type diversity (Site 13/2: Waterhouse River)


Some modification to the reach environs; moderate bed aggradation; moderate weed invasion (Site 13/3: Waterhouse River)

6. SUMMARY – ROPER RIVER CATCHMENT

♦ *Reach Environs and Site Features*

Three-quarters of sites assessed were rated as having essentially natural reach environs, while one-quarter had some modification to the reach environs. Generally, the sites with essentially natural reach environs had relatively low impact land uses, undisturbed vegetation and few local disturbances. Those sites that had some modification to the reaches recorded local disturbances (ie grazing, concentration of animals at watering points, tracks, roads, river works and causeways) that reduced the ratings from essentially natural.

Subjective disturbance ratings indicated that over three-quarters of the sites recorded a low to very low disturbance level with respect to the reach environs. Very few sites were moderately disturbed and no sites were highly, very highly or extremely disturbed. A low or low to moderate disturbance rating meant that the riparian vegetation was generally intact but was being impacted on by things like stock/feral animals (eg trampling, grazing, watering), people, clearing for cattle watering points, infrastructure (eg tracks, crossing, pumps, buildings), exotic vegetation, severe flooding and bank erosion.

The majority of land adjacent to stream reaches studied was under either freehold or leasehold tenure, including Aboriginal land. The major land uses recorded adjacent to the streams in the catchment was grazing on virgin native pasture or Aboriginal land. Grazing activity, roads/tracks and watering points for stock and feral animals were the three major disturbances to stream reaches.

♦ *Channel Habitat Types, Diversity and Dimensions*

Reaches studied averaged 1,819m in length. Pools were the dominant type of habitat located throughout the catchment. Pools also dominated the reach lengths, averaging 73%. Riffles and runs were also quite prevalent and occurred at over half the sites. Waterfalls were associated with areas of steeper topography (eg gorge systems, tufa formations and upper catchment sites) and were found on Arnold, Roper and Waterhouse Rivers and Flying Fox Creek. Cascades were also associated with steeper river sections, gorge systems and tufa formations and were recorded on Arnold, Hodgson, Roper, Strangways and Wilton Rivers, and Bella Glen and Maiwok Creeks. Rapids were found along Roper and Wilton Rivers.

When the sites were assessed for their variability or diversity of channel habitat types, over half the sites rated highly and nearly one-quarter of sites rated very highly. Sites recording a high channel type diversity had mostly two habitat types present although the proportion of the reach occupied by habitats other than pools was mostly between 10-30% or >30%, which increased the diversity ratings for these reaches. Reaches with a very high diversity of channel habitat types were associated with rocky, steeper sections or sections where the number of habitat types recorded was three to five and the proportion of the reach occupied by non-pool habitats was either 10-30% or >30%.

Sites recording moderate channel type diversity (ie two habitat types with <10% of the reach occupied by riffles, runs or cascades) were located on Roper River at Red Rock, Rocky Bar Crossing, 57-Mile Waterhole, Red Lily Lagoon (also called 2-Mile Waterhole) and along lower Hodgson River. The mid- to lower tidal reaches on Roper and Phelp Rivers and Painnyilatya Creek rated low or very low with regard to channel type diversity because only uniform, tidal pools existed. Other reaches that recorded very low or low diversity of channel types were located on Elsey Creek (near Roper Highway) which recorded a uniform, intermittent pool, and Minyerri Billabong, which was isolated from Hodgson River.

♦ *Bank Condition and Stability*

The majority of river banks throughout the catchment were stable with a few (ie 5 sites) that had limited instability. Only one site recorded river banks that were suffering from extensive instability (ie Site 1d/6 – an arm of Roper River that is undergoing extensive channel widening). A subjective assessment of bank stability indicated that the majority of sites recorded minimal to low overall bank instability. Whereas, one-third of sites had low-moderate to moderate bank instability, and only one site recorded a high overall bank instability. Similar percentages were recorded for the susceptibility of banks to erosion.

Even though the river banks were mostly stable, some form of erosion processes were recorded at the majority of sites, whilst aggradation along the river banks was confined to only a few sites. Lower banks were more stable than upper banks with an average of 95% and 88% of the bank length respectively being recorded as stable. The erosion was occurring mostly at obstacles, outside bends and irregularly. Aggradation was predominantly irregular, all along or at inside bends.

The major factor affecting bank stability was high flow, recorded at nearly three-quarters of sites, and to a lesser extent, stock, vermin and infrastructure (ie roads, tracks, river crossings, culverts, bridges, *etc*). The only types of artificial bank protection measures recorded were fencing along the river and/or at stock watering points, which occurred at several sites, and rock treatment at one site.

♦ *Bed and Bar Condition and Stability*

An assessment of the overall bed stability indicated that the majority of sites had stable river beds, while nine sites recorded moderate bed aggradation and one site recorded severe bed erosion problems.

Moderate bed aggradation was located on Waterhouse River (4 sites), Wilton and Mainoru Rivers and Flying Fox Creek (2 sites) and Cattle Creek. These site reaches had relatively flat, uniform and shallow river beds, large sandy bars and were transporting a large amount of sediment (ie sands). The site recording severe erosion problems, including both bed and bank erosion, was located on an arm of Roper River (Site 1d/6) that has been receiving an increased volume of flow and, as a result, is widening and deepening.

Bars were widespread and were recorded at nearly three-quarters of sites, averaging 17% of the bed and ranging to as high as 70%. Bars with encroaching vegetation and alternate/side irregular bars were the two most prevalent bar types.

There were relatively few sites where bed stability was being impacted on. The major factor that was considered to affect bed stability, although only recorded at 8% of sites, was instream siltation.

♦ *Bed and Bank Sediments*

A range of size classes, from clays to boulders, was recorded for river beds. Pool and run habitats had a higher proportion of smaller bed sediments; riffles had a range of bed sediment sizes; rapids and cascades had a higher proportion of larger bed sediments; and waterfalls had boulder beds. The sediments along the lower and upper banks for all habitat types consisted mainly of smaller sediment sizes, except cascade and waterfall habitats, which had a higher proportion of boulders. Lower and upper banks consisted mainly of clays and small sand. Organic material was present in both bed and bank material.

♦ *Riparian Vegetation*

Over half the reaches assessed were rated as having riparian vegetation that had a high cover and structural diversity with less than half the reaches being rated has having moderate cover and structural diversity. The reach recording a very high cover and structural diversity for the riparian vegetation was located along Roper River at Red Lily Lagoon (also called 2-Mile Waterhole), and a lower estuary site dominated with mangroves had riparian vegetation with a low cover and diversity.

The results provide an indication of how structurally diverse and dense the riparian vegetation is throughout the catchment. Generally the riparian vegetation is relatively in tact and has not been impacted on by extensive clearing or development, although stock and vermin activity, and infrastructure were recorded as factors affecting river banks to varying degrees at between 21-37% of sites.

The average width of the riparian zone was 30m, which can be considered to be the 'natural' width because the riparian vegetation is generally in tact and little clearing has occurred. Those sites that recorded a riparian zone width of >31m were mostly located on the Roper, Wilton, Hodgson, Phelp and Mainoru Rivers and Flying Fox and Elsey Creeks. Very narrow riparian zones (<5m wide) were located on sections of Maranboy Creek and Strangways River.

Throughout the catchment, grasses and regenerating trees were present at all sites. Woody shrubs, forbs, trees (2-30m) and vines were very prevalent and were present at >90% of sites. Rushes and sedges were present at over half the sites whereas palms, mangroves, phragmites, ferns and trees taller than 30m varied in their prevalence and distribution. Trees (2-30m tall) and grasses dominated the riparian vegetation providing the highest covers. The other structural categories each averaged <10% cover. The overstorey (that is, trees and shrubs greater than 1.3m tall) provided a greater cover than the understorey (or ground cover) vegetation.

Eucalyptus camaldulensis was the most widespread native overstorey species. *Pseudoraphis spinescens* (Spiny Mudgrass) was the most prevalent native ground cover species. The palm species, *Livistona rigida*, which has a limited distribution in the NT, was recorded along sections of Roper and Waterhouse Rivers, and Roper, Bella Glen and Elsey Creeks. Mangrove species were confined to the Roper River estuary.

Exotic riparian vegetation species were widespread being recorded at over three-quarters of sites. Noxious vegetation species were located at nearly half the sites. The number of different types of exotic species recorded at any one site ranged from 0-8. Of the 30 different exotic species recorded, 12 are declared noxious within the NT.

Just over one-third of sites recorded a low level of invasion by exotic vegetation species (between 1-5% cover), whereas nearly half the sites (44%) recorded a greater level of invasion (>5% cover and up to 34%). Exotic riparian vegetation covers ≥16% were recorded along Roper River (3 sites), along upper Wilton River (3 sites), and 1-2 reaches on Mainoru, Strangways and Hodgson Rivers and Flying Fox and Maiwok Creeks.

Overall, exotic species within the riparian zone averaged 7% cover and were predominantly vines and forbs. *Passiflora foetida,* a naturalised vine, and *Hyptis suaveolens* were the two major species recorded throughout the catchment and were recorded at 62% and 31% of sites, respectively. Other notable exotic species included *Parkinsonia aculeata, Melochia pyramidata*, *Sida acuta*, *Calotropis procera* and *Pennisetum pedicellatum*.

Passiflora foetida was very widely distributed being recorded in all sub-sections except for Jalboi River, although covers were generally low (1-5%). Higher covers for *Passiflora foetida* were recorded along Roper River at 12-Mile Yard and further downstream below Elsey Falls where the riparian vegetation had been disturbed following the 1998 floods. Of the noxious species, *Hyptis suaveolens* had a relatively wide distribution, although covers were generally low. Higher covers for Hyptis were recorded from upper Wilton River, Mainoru, Jalboi and Waterhouse Rivers and Flying Fox and Derim Derim Creeks. Parkinsonia was restricted in its distribution and was recorded along 57-Mile Waterhole on the Roper River upstream to within Elsey National Park, as well as along sections of Roper River estuary and Longreach Waterhole on Elsey Creek. Low covers were recorded for Parkinsonia (ie between 1-5%).

♦ *Aquatic Vegetation*

Over three-quarters (84%) of sites recorded the presence of aquatic vegetation. Emergent aquatic vegetation was more widespread (78% of sites) than submerged vegetation (54% of sites) and covers were generally high for both types (ie between 11-15% on average). Floating vegetation was more scattered in its distribution and was found at 12% of sites. *Phyla nodiflora* (Lippia), located on Elsey Creek, was the only aquatic vegetation species recorded that was exotic and recorded a cover of 18%.

Both emergent and submerged aquatic vegetation types were present in all sub-sections except Jalboi River, in which submerged aquatic vegetation was not recorded. All Roper River sites, except for the lower tidal section, recorded moderate to very high covers for submerged aquatic vegetation. Floating vegetation recorded a limited distribution throughout the catchment and was recorded at Minyerri Billabong, Arnold River, Longreach Waterhole on Elsey Creek, Strangways River at Rocky Hole Yard, and sections of Roper, Bella Glen and Beswick Creeks, and Roper, Chambers (arm of) and Wilton Rivers.

♦ *Instream and Bank Habitats*

Nearly three-quarters of sites were rated as having high cover and diversity of instream and bank habitats, while nearly one-quarter of sites rated moderately. A section on Western Creek rated the worst in the Roper River catchment. The sites recording very high cover and diversity of instream and bank habitats were located on Roper River and a section along Wilton River. Over three-quarters of sites were subjectively rated as having a good to very high overall aquatic rating.

The most commonly occurring instream cover types included branches, leaves and twigs, tree roots, logs, permanent pools deeper than 1m and rock faces. Stream bed cover provided from the banks was dominated by vegetation canopy cover, vegetation overhang which was less than 1m from the water and root overhang. The canopy cover occurred along a mean of 76% of the bank length.

Passage for aquatic organisms at nearly half the sites was generally partly to very restricted at the time of the survey, although nearly one-quarter of sites had no passage. Assessments of passage at the water mark indicated that some form of restriction remained at half the sites, while 6% of sites had no passage.

♦ *Overall Condition*

The majority of sites recorded either a high overall condition rating (51% of sites) or a very high overall condition rating (47%). No sites were rated as being degraded overall. Reaches that rated very highly overall were located within all sub-sections except for Mainoru and Waterhouse River sub-sections. Two reaches recorded a moderate overall condition, the worst rating in the catchment, and these were located on the West Branch of Wilton River and an arm of Roper River downstream of Little Red Lily Lagoon.

7. CONCLUSIONS, BROAD MANAGEMENT ISSUES AND RECOMMENDATIONS

The five major issues identified within the Roper River catchment are:

- Level of weed invasion of the riparian zone (13 sub-sections);
- Disturbances to reach environs and river banks from such things as grazing, animal watering points, infrastructure (eg roads, tracks and crossings), high flows and people (8 sub-sections);
- Impact on river banks, river beds and reaches by feral animals (8 sub-sections);
- Bed aggradation (5 sub-sections); and
- The need to recognise and conserve significant riverine areas and habitats including the *Livistona rigida* palm community, river reaches containing tufa formations and sections along Arnold River including Minimere Lagoon and associated gorge system, and a large waterhole near the abandoned Cox River homestead.

The major conclusions that can be drawn from the survey of the Roper River and its tributaries, including broad management issues and recommendations, are:

1. Overall, the condition of the majority of rivers and creeks studied throughout the Roper River catchment was very good.

When all six components that make up the overall condition rating were taken into account river reaches rated highly. Even though the overall condition rating results were relatively consistent, the six components that make up the rating did vary extensively. The major issues identified meant that generally the waterways were physically stable, although sections were experiencing bed aggradation problems or, in one instance, bed erosion problems. Reach environs and river banks were being impacted upon by such things as stock and vermin, who were utilising rivers to water, graze and shelter; infrastructure like tracks and river crossings; high flows; and people. These disturbances often caused localised erosion problems. The degree of modification to the reach environs reflected the fact that intensive development along floodplains for agriculture, horticulture or extensive clearing did not exist. The riparian vegetation was relatively intact and the cover and structural diversity was generally moderate or high. Instream and bank cover varied. The degree of invasion of the riparian zone by exotic species also varied greatly.

The two sites (Wilton River – West Branch and an arm of Roper River downstream of Little Red Lily Lagoon) that recorded a below average condition rating were physically unstable, ecologically not as diverse and had riparian zones that were invaded by exotic species.

As the overall condition of the reaches surveyed was high, there is an opportunity to monitor for any deterioration in this high status over time.

2. Very few sites recorded reach environs that were unimpacted even though three-quarters rated as being essentially natural.

The degree of modification to the reach environs depended on the level of intensity of the land use and the types and extent of local disturbances. Grazing was the major land use and disturbance factor recorded throughout the Roper River catchment. Even though grazing did cause localised problems along waterways it is generally less disturbing to the reach environs than extensive clearing and development for rural or urban residential areas or cropping (including broadacre cropping and horticulture). Only small areas that border waterways, on one side only, have been cleared for cropping purposes and these were located near Mataranka, although the reach environs were still in good condition. The other main disturbances to reach environs, besides the impact from stock and vermin using waterways to graze, water and shelter, included infrastructure and people causing localised problems.

Steps to ensure that the river corridor and reach environs are kept intact need to be implemented. Any regional strategy should ensure that the riparian vegetation is protected, ad hoc access points and river crossings are restricted, fencing and off-river watering points for stock are encouraged and that weed invasion of the riverine environment is managed. As a general rule, in the future any areas where:

(i) land uses and disturbances to the reach environs becomes more intensive and diversified through increased agricultural activity (eg cropping and horticulture);
(ii) clearing of floodplains occurs; and
(iii) the sub-division of lands bordering rivers and creeks into smaller units or rural residential blocks occurs,

the modification to the reach environs will change (rate lower) over time from being essentially natural to having some or a greater level of modification. It will, therefore, be important to particularly monitor the state of the reach environs in areas where (i), (ii) and (iii) (mentioned above) are occurring.

3. The majority of river banks throughout the catchment were stable.

Monitoring the proportion of bank lengths that are stable, eroding or aggrading assists with monitoring the extent of change in bank stability over time throughout the catchment. It will also be possible to make the link between bank stability and whether any increase in the rate or extent of erosion or sedimentation can be attributed to human activities within the catchment.

Nearly all river banks surveyed throughout the Roper River catchment were stable, however, some form of erosion was recorded at most sites. Of the few sites that recorded limited bank instability problems, most were also suffering from bed aggradation problems. The only site to record a below average bank stability rating was suffering from extensive erosion (ie channel widening and deepening). High flow, associated with the wet season, was contributing to the erosion of river banks as was stock and vermin accessing the streams to water, shelter or graze. Infrastructure, such as roads, tracks and crossings, was identified as the fourth major factor affecting bank stability and, in several instances, was the cause of localised bank instability problems.

The high level of bank stability recorded throughout the catchment is reflected in the fact that the riparian vegetation is relatively in tact and has not been impacted on by extensive clearing or development.

Bank protection measures, such as controlled stock access points to rivers and fencing along rivers, were present at few sites at the time of this survey. If, over time, there is deterioration in the stability of the river banks, practices like those mentioned above will need to be encouraged. River reaches containing important riparian habitat or unique riparian vegetation communities, in particular the *Livistona rigida* palm community, should be protected from the impact of stock, feral animals and ad hoc infrastructure (eg tracks).

The fencing of specifically identified riparian areas by members of the Roper River Landcare Group, through Natural Heritage Trust funding, is a reflection of the commitment to protect these important areas. When fencing along rivers does occur, the responsibility for management of the riverine corridor needs to be addressed so that activities, such as, weed and feral animal control and maintenance of fencing does occur.

4. The river beds throughout the catchment were mostly stable.

Most sites surveyed had stable river beds. This high level of bed stability is quite probably linked to low interference to flow and sediment regimes as well as a relatively low level of clearing throughout the catchment. Of the nine sites that were suffering from moderate bed aggradation problems, eight of these were located within or downstream of sandstone country (ie Arnhem Land and Wilton River Plateau and escarpments which consist predominantly of Kombolgie sandstone).

The river systems that fell within the sandstone areas and had aggrading river beds included Waterhouse River, in particular, as well as upper Wilton and Mainoru Rivers and Flying Fox Creek. These reaches were also relatively remote, and, aside from feral animals and fires, had low impact land uses. These river channels were generally very flat, uniform in cross-sectional shape, wide and very shallow in places and were observed to be carrying a large amount of sediment, mostly sands. Large bars and high flow deposits were often very common along the reaches experiencing moderate levels of aggradation. The sandstone rock formations could be a source of sand to these river systems following high flow and runoff events. High flow events would be required to transport this sediment through the river system.

Only one site (ie an arm of Roper River downstream of Little Red Lily Lagoon) recorded severe bed erosion. The extensive changes that are occurring along this reach is possibly due to this section of channel receiving an increased volume of flow when flooding occurs along Red Lily Lagoon. These increased flows have resulted in channel widening and deepening. As a result of these channel alterations, there could possibly be a change in the flow direction through the braided sections of Roper River downstream of Red Lily Lagoon (ie less flows through Lindsay's Crossing and more flows through this eroded section) and loss of infrastructure, including fences and river crossings, as the channels continue to erode.

A more detailed investigation into the causes and implications of this change in channel size would be necessary to assist with making further management recommendations.

5. The riparian vegetation was relatively intact and predominantly had a high or moderate cover and structural diversity.

Riparian zones are a vital link between land and water environments. Riparian vegetation perform

many essential functions, including: the protection of river banks from erosion processes; acting as a buffer or filter for sediments; maintaining good water quality; providing organic material, shade and shelter for instream communities; increasing the physical habitat diversity in aquatic ecosystems; and acting as a wildlife corridor. The effectiveness of the riparian zone in carrying out these functions is significantly influenced by its structural diversity, width and integrity (species diversity, overall cover, and the degree of invasion and impact caused by exotic species).

It was found from this study that the riparian vegetation was relatively intact and had generally not been impacted on by extensive clearing or development. Several factors, of varying degrees, were found to be impacting on the reach environs and river banks at many sites, including grazing/ stock activity, vermin, high flows, infrastructure like roads and crossings, and people.

When the cover and structural diversity were assessed, the riparian vegetation rated highly or moderately in all but two instances. The riparian vegetation along Roper River at Red Lily Lagoon contained extensive stands of *Livistona rigida* palms and rated very highly. A mangrove-dominated section along Painnyilatya Creek rated low due to a lack of diversity of structural types and lower covers. The results showed that the diversity of the different vegetation structural types present (eg small or large trees, palms, woody shrubs, forbs, grasses, vines, *etc*) generally rated higher in the majority of cases than did the cover provided by these structural types.

Although most sites recorded the presence of many structural types, aside from trees (2-30m tall) and grasses, most structural categories recorded low covers. Overstorey and understorey vegetation (trees and shrubs >1.3m) generally provided a greater cover than did ground cover vegetation, although sites within Elsey, Flying Fox, Maiwok and Roper Creeks, and Arnold, Chambers, Strangways and Hodgson River sub-sections had grass-dominated riparian vegetation communities. Possibly, the density of shrubs and ground covers is naturally low due to seasonal aspects. Continual high flows over the wet season and deposition of sediment during this period, or water availability or fires during the dry season, may influence the occurrence of ground covers and, therefore, the structural diversity and covers recorded.

The cover and structural diversity of the riparian vegetation varied somewhat, even in instances when the stability of the river banks did not vary. River bank stability does influence the condition of the riparian zone but, as has been shown in these results, other factors were also contributing to the cover and diversity of the riparian vegetation. These factors may include aspects like water availability, climate and location within the catchment.

The average width of the riparian zone throughout the catchment was 30m. The width of riparian vegetation is the 'natural' width at most sites and, therefore, this width can be used as a guideline for planning or recommending appropriate buffer zone widths throughout the catchment. From this study the following average riparian vegetation widths and ranges were recorded for the three stream sizes (as categorised on Map 8 ' Stream Orders'):

- Minor streams (stream orders 1 and 2) – 19m (range 3-48m)
- Medium-sized streams (orders 3 and 4) – 28m (range 7-87m)
- Major streams (stream orders 5 and 6) – 40m (range 13-200m)

Larger bands of vegetation are required along larger streams. The size of the buffer zone should, therefore, reflect the size of the stream. Any recommended riparian buffer zone widths should aim to protect and provide a buffer for the stream channels and associated riparian vegetation.

Further interpretation of the vegetation species found throughout the catchment is also required in order to identify important or unique riparian vegetation communities. Once identified, steps should be taken to ensure that these riparian vegetation communities are protected. The *Livistona rigida* palm is an important species with a very limited distribution within the Northern Territory and, as such, larger stands should be protected. *Livistona rigida* was recorded along sections of Roper and Waterhouse Rivers, and Roper, Bella Glen and Elsey Creeks.

6. The distribution of exotic riparian vegetation was widespread and was a major issue.

Weed invasion of the riparian zone was identified as a major issue. Exotic vegetation species, particularly vines and forbs, were widely distributed throughout the Roper River catchment. The degree of invasion of the riparian zone by exotic species varied greatly, with nearly half the sites recording a greater level of invasion (>5% cover). At times, the reaches rated poorly for exotic species compared to the other attributes assessed.

The sub-sections where high weed invasion was considered a major issue included: Roper River (tidal section and upstream of 57-Mile Waterhole to

the upper catchment), Hodgson River above Arnold River, upper Wilton River, Mainoru River, upper Jalboi River, Flying Fox Creek, Maiwok Creek, Strangways River, Elsey Creek and Waterhouse River. Some river reaches that recorded high weed invasion were located in areas near major roads like the Central Arnhem Road, tracks, crossings and areas frequented by people, including Elsey National Park. Other areas, in particular upper Wilton River, were located in very remote areas and it was considered that feral animals (eg buffalo) could be aiding in the spread of weeds in these areas.

Thirty different species of exotic vegetation were recorded throughout the catchment and up to eight different species were recorded at one site. The two major exotic species recorded included *Passiflora foetida* (a naturalised vine) and *Hyptis suaveolens* (a noxious forb). Other more fairly widespread species included *Melochia pyramidata*, *Parkinsonia aculeata*, *Sida acuta* and *Calotropis procera* (Rubber Bush). *Parkinsonia aculeata* is the target of a weed control program being implemented by the Roper River Landcare Group, utilising biological control methods.

Noxious weeds should be controlled in protected and high use areas, such as National Parks. Other high use areas and recreational areas along rivers, including Roper Bar and other access points on the Roper River, should be targeted for the control of noxious weeds in order to prevent their spread by people to other areas. This is particularly the case for weeds that readily attach themselves to clothing (eg Noogoora Burr) and which can be transported via vehicles (eg Hyptis). Weed invasion of riparian areas containing important or unique vegetation communities, in particular *Livistona rigida* palms, should also be given priority for weed control programs (eg Red Lily Lagoon).

Controlling weeds along streams should be approached on a catchment basis. There is limited use in controlling weeds and preventing their spread in one particular area if a continual supply of weed seed is brought into that area from upstream. In order to manage weed control on a catchment basis, it is imperative that weed control strategies and distribution maps are formulated. Such strategies and maps are also required in order to monitor the distribution and abundance of weeds, to target specific weeds and to make best use of available resources.

The active involvement of land owners and managers along rivers in controlling weeds is required. Public awareness of what weed species should be controlled and information on how to undertake this is important.

7. The distribution of aquatic vegetation was widespread.

Aquatic vegetation was widely distributed throughout the catchment, particularly emergent types and, to a lesser extent, submerged types. Covers provided by these two types were generally high. Floating aquatic vegetation (eg water lilies) was much more limited in its distribution, being confined to several waterholes or slow flowing pools, and the cover was generally low for this type. The only exotic aquatic vegetation species recorded was *Phyla nodiflora* (Lippia) found on Elsey Creek. This species is common in the Top End, occupying a wide range of moist habitats.

8. Instream and bank habitats were diverse and provided good cover.

The majority of sites rated highly with regard to the cover and diversity of instream and bank habitats. A section on Western Creek rated below average, while five sections along Roper River and a section on Wilton River rated highly for this attribute.

The ratings reflect the level of cover and diversity provided by instream organic debris, aquatic vegetation and other habitat types on the river bed, as well as the cover and diversity provided by the canopy and other habitats along the river banks. The vegetation canopy along the banks did not provide a continuous cover, averaging 76% of the bank length.

The results suggest that the instream and bank habitats were diverse and provided a good degree of cover or habitat areas to support a diversity of instream fauna, including macro-invertebrates, and fauna associated with the riparian zone. A comparison with other fauna diversity studies, such as the 'Ausrivas Program' and recent studies of bird populations in riparian zones, would be required to determine if this is the case.

9. The diversity of channel habitat types was predominantly high or very high.

Channel type diversity reflects the extent to which pools dominate the reach. For example, very long waterholes, like Red Lily Lagoon and 57-Mile Waterhole on the Roper River, rated moderately. Tidal sites which consisted of very long pools and billabongs, like Minyerri Billabong, did not have the diversity of depths or the presence of other habitat types and, as a result, rated low. Elsey Creek at Roper Highway rated very low because only one habitat was sampled. Other sites along Roper River that rated only moderately recorded only two habitat types, of which pools dominated extensively.

The location of the reach within the catchment and the geology and topography influence the channel type diversity rating. The results, therefore, reflect not only the diversity of channel habitats along rivers, but also the natural variations throughout the catchment. Waterfalls and cascades were associated with areas of steeper topography (ie gorge systems, tufa formations, upper catchment sites). Rapids were associated with steeper river gradients (eg along Roper and Wilton Rivers).

A comparison with other studies of fauna diversity, such as the 'Ausrivas Program', would be required to determine whether the high channel habitat diversity has influenced the diversity of fauna throughout the Roper River catchment.

10. Grazing and stock or feral animal activities were identified as the most common detrimental influence impacting upon stream and riparian attributes.

Grazing and stock or feral animal activity were identified as the main disturbance to stream reaches and river bank stability at many sites and, therefore, the impacts of this activity should be monitored.

Consideration should be given to fencing off any areas along rivers and creeks that are showing signs of localised erosion problems or are suffering from stock or feral animal activity. Stock watering points away from rivers can be used where fencing along rivers has occurred. There is also a need to control the large number of feral animals (including buffaloes, donkeys and pigs) that are impacting upon rivers. Sub-sections where feral animals were a major issue included Arnold, Chambers, Phelp, Wilton and Waterhouse Rivers and Elsey and Flying Fox Creeks.

11. Measures required to maintain or, in some cases, to improve the stability and condition of rivers.

As the majority of rivers and creeks within the Roper River catchment are physically quite stable, the Northern Territory is well placed to be proactive in order to ensure that the streams are not degraded over time and that they remain in a stable condition. Measures that are required to maintain or, in some cases, to improve the stability and condition of rivers include:

- Maintaining and protecting the riparian vegetation and, in so doing, the aquatic habitat;
- Ensuring that tracks and river crossings are properly designed, constructed and maintained; and
- Monitoring and controlling the impacts of grazing and stock or feral animal activity along rivers (discussed in 10).

Ensuring that riparian vegetation is kept in tact will help to maintain a good level of bank stability. As well, the riparian vegetation can perform its many other essential roles. In so doing, the condition of the aquatic habitat is maintained because instream cover is largely provided by organic material derived from riparian vegetation, and bank cover mostly involves the presence of trees and shrubs.

Extensive clearing or development within the riparian zone should be avoided. This allows the banks to have a greater chance of withstanding the annual high flows during the wet season that was identified, along with stock activity, as the major factor affecting bank stability.

Infrastructure, such as roads, tracks and crossings, were identified as a major disturbance to reach environs and river banks. Several reaches were experiencing localised problems due to eroding river crossings and/or access tracks. The results show that poor track and river crossing design and maintenance can influence the condition of streams at a local scale.

It is important to properly locate crossings, avoiding outside bends or steep banks, and targeting areas where the creeks are shallower and have larger sediments along the bed, like gravels, cobbles or boulders. As little riparian vegetation should be disturbed as possible when constructing the crossings. Tracks should be maintained on a regular basis and should be designed so as not to concentrate flows along their length, otherwise erosion will occur.

12. There is a need to actively involve the community in river management.

Land tenure along the rivers and creeks is predominantly freehold or leasehold. Therefore, any on-ground river management activities or promotion of river management issues (eg through river management plans, regional or catchment planning), needs to actively involve the landowners, property managers and community groups. The Roper River Landcare Group provides an avenue for addressing any river management issues on a catchment basis. There is a 'window of opportunity' within the Northern Territory to be proactive with regard to river management issues because the rivers and creeks within the Roper River catchment are not degraded. Maintaining or, in some cases, improving the condition of rivers and creeks and, in so doing, preventing river degradation, should be a priority.

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GLOSSARY

Aggradation	The long term build-up of sediment on a length of stream bed, or filling in of the stream channel, so as to raise its overall surface level and form bars.
Alluvial	Anything that is deposited by stream flow.
Aquatic Vegetation	Plants that live or grow in, on, or near water. Structural categories include submerged, floating or emergent aquatic vegetation.
Aquifer	A layer of sand, gravel or porous rock which holds groundwater and allows it to percolate through to wells or springs.
Armour	A surface layer of large gravel particles which overlays and protects finer sediments beneath it from erosion except during high flows.
Avulsion	A sudden change in the course of a stream by which a portion of land is cutoff, as where a stream cuts across and forms an oxbow.
Bank Protection	Materials placed on the face and toe of a bank to protect it from high flow velocities.
Bankfull	The discharge that results in water levels at the tops of the banks in most places along a stream. This is the flow that usually causes channel change.
Bar	A temporary deposit of sediment (ie sand, gravel or other unconsolidated sediment) within a stream channel that protrudes out of the water at water mark.
Bar Types	The 8 bar types include: point, bars with encroaching vegetation, high flow deposits, mid-channel islands, alternate/side irregular, channel bar plain, bars around obstructions and low flow meander infilled channel.
Baseflow	The low flow within a river or creek during the dry season which may be maintained by the discharge of groundwater.
Baseline Monitoring/ Data	To establish a reference point or benchmark of the condition of rivers and creeks against which changes in condition can be monitored over time through follow-up replicate surveys. Collecting baseline data is particularly important where there is little existing information.
Basin	See 'Catchment'
Bed	The bottom of a channel for the passage of water.
Bedload	The larger, heavier material such as coarse sand, gravel and boulders carried by the natural flow of a stream on or immediately above its bed.
Bedrock	Rock in a stream bed or banks that is resistant to erosion over long periods of time.
Bed Stability	The general stability of the stream bed. Aggradation or erosion (degradation) are forms of bed instability.
Billabong	A section of cut off stream channel on a floodplain which is typically saturated with water.
Braided Stream	A stream flowing in several channels that divide and reunite.
Breakout	The place where flood flow has broken through a bank.
Cascade Habitat	A series of small steps, slides or falls characterised by a step height <1m; gradient 5-60^{o}; and strong currents.

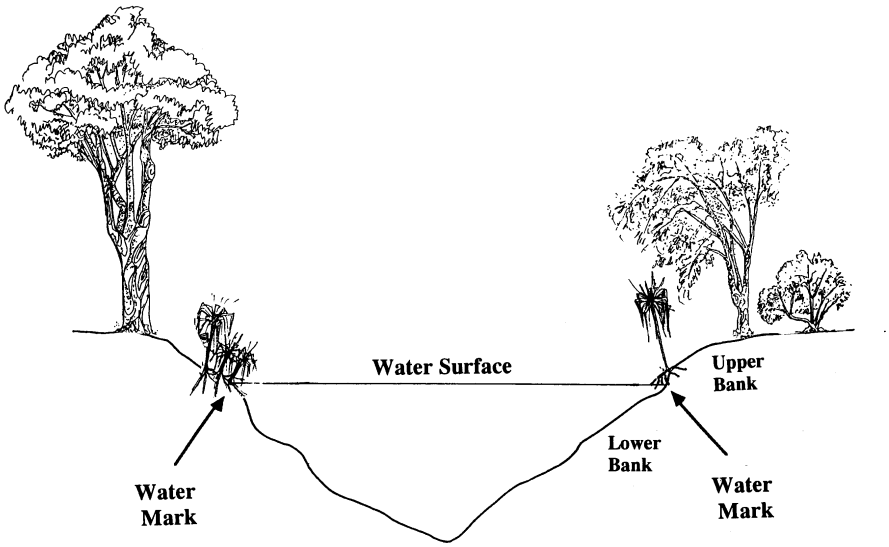
Catchment (river)	An area in which surface runoff collects and from which it is carried by a drainage system, as a river and its tributaries. Also known as drainage basin or watershed.
Causeway or Crossing	A road constructed across the bed of a stream. All stream flow goes over the road.
Channel	The whole area between the two high banks.
Channel Habitat Types	Waterfall, cascade, rapid, riffle, glide, run, pool or backwater
Control (bed)	An erosion-resistant section of stream bed that prevents short term bed degradation (ie lowering of a stream bed by erosional processes) and bed slope changes.
Cross-section	A diagram showing the land surface profile across a stream channel, plotted looking downstream.
Cross-section Survey	Depth measurements across the stream at right angles to the bank.
Cut Off Meander	A stream diversion or cut off through the neck of a meander or horseshoe bend where a new, relatively short channel is formed. This can occur artificially or naturally.
Deposition	An accumulation of sediment.
Degradation	The long term vertical erosion of sediment from a length of river bed so as to lower its overall surface level.
Discharge (Q)	The volume of flow per unit of time. Usually expressed as cubic metres per second (m^3/sec) or megalitres per day (ML/day).
Electrical Conductivity	A measure of salinity. The higher the electrical conductivity of a stream, the greater the salinity.
Ephemeral Stream	A stream which carries water a considerable portion of the time, but which ceases to flow occasionally or seasonally.
Erosion	A loss of material.
Estuary	That part of a river which has a free connection with the open sea, where freshwater comes into contact with sea water and which is affected by tides.
Exotic Species	Introduced species from other regions or countries (ie not indigenous or endemic to an area).
Flood Channel	A channel across a floodplain that only carries water during floods.
Floodplain	Depositional surface adjacent to a river that is flooded periodically forming broad alluvial or coastal floodplains.
Flow Regime	The long term (annual or greater) character of the timing and amount of flow in a stream.
Fluvial	Related to the flow in a river or stream.
Geomorphic Province	An area of land having attributes of landform and/or soil and/or vegetation that differ consistently from those of other terrain, because of the direct influence of geomorphological landscape-forming process or processes operating there but not operating elsewhere at the same rate.
Geomorphology	The study of the processes which shape the landscape.

Glide Habitat	A shallow, slow flowing section of water characterised by a depth <0.1m; gradient 1-3^{o}; small currents; and an unbroken and smooth water surface.
Groundwater	All subsurface water, especially that part that is in the zone of saturation.
Homogeneous Stream Sections	Stream sections which share similar natural features and are in similar condition.
Hydrology	The study of rainfall and runoff processes.
Incise	Erode the bed of a stream, deepen, degrade severely.
Inside Bend	The convex bank on a stream bend as observed from mid-stream.
Instream Habitat	The river itself, the banks and the channel.
Intermittent Stream	See 'Ephemeral Stream'
Left Bank	The left hand bank of a stream when looking downstream.
Levee	An artificial or natural linear ridge on a floodplain, sometimes deposited by a stream on its sides, that holds back flood water.
Longitudinal Profile	A diagram showing the land surface profile along a stream channel, usually along the thalweg (elevation plotted against river distance from the mouth).
Longitudinal Profile Survey	Depth measurements along the streams' thalweg.
Lower Bank	Is that part of the bank between the water mark (or normal dry season inundation level) and the water surface.
Low Flow	The normal discharge in a stream during the dry season, when the tops of most bars are exposed.
Macroinvertebrates	Animals (eg insects, crustaceans, molluscs and worms) that do not have a backbone, are visible to the naked eye and, if aquatic, live in water. The number and variety of these animals found in a stream can give an indication of the relative levels of water pollution and can provide a means of assessing the ecological health of rivers.
Meandering	A channel pattern that looks like a series of tight bends or loops with the river confined to a single channel.
Native Species	Species that are native to a specific region or country (ie are indigenous or endemic to a region).
Noxious Species	A plant declared under the *NT Noxious Weeds Act* to be a "noxious weed".
Outside Bend	The concave bank on a stream bend as observed from mid-stream.
Overstorey Vegetation	Woody plants >1.3m tall, usually with a single stem (eg Eucalypts, Melaleucas, *etc*). Shrubs >1.3m tall have also been included with overstorey vegetation.
Oxbow Lake	A horseshoe-shaped channel or lake on a floodplain created by a cut off and the abandonment of a meander loop.
Perennial Stream	A stream which contains water at all times except during extreme drought.

pH	A measure of the concentration of the acidity or alkalinity of the water (hydrogen ions in water).
Point Bar	A bar located on the inside of a bend of a stream.
Point of Inflexion	The point on the upper bank where the bank changes direction and curves over, away from the river channel.
Pool Habitat	A deep body of still or slow moving water, generally occurring in the main channel in an alternating sequence with riffles or runs. Pools are characterised by a depth >0.5m, where the stream widens or deepens and the current declines.
Rapid Habitat	A section of fast flowing water characterised by a depth >0.3m; gradient 3-5^{o}; strong currents and rocks emerge to break the water's surface.
Reach	A length of stream channel chosen as the boundary for a survey site and generally representative of the channel habitats and the instream condition. Each reach usually consists of at least two complete pools and riffle/run habitats.
Reach Environs	Lands immediately adjacent to the river and the riparian zone along the reach and includes the floodplain and valley flat.
Riffle Habitat	A shallow area of a stream, often separating pools, characterised by a depth 0.1-0.3m; gradient 1-3^{o}; moderate currents and an unbroken/unsmooth water surface.
Right Bank	The right hand bank of a stream when looking downstream.
Riparian Zone	Distinct corridor, including the vegetation, along the edge of a stream. This zone is inextricably linked with the stream both in providing litter (eg leaves, branches, *etc*) to the stream and being affected by the extra moisture that is available.
Riparian Vegetation	A distinct corridor of vegetation located along the edge of a stream or river.
River	A large, natural freshwater surface stream having a permanent or seasonal flow and moving toward a sea, lake, or another river in a definite channel.
Riverine Corridor	The river channel and its riparian land, including part of the adjacent floodplain.
River System	The aggregate of stream channels draining a river basin.
Run Habitat	An area of stream that is too deep to be a riffle and with too large a flow to be a pool. Runs are characterised by a depth >0.3m; gradient 1-3^{o}; small but distinct and uniform current; and an unbroken water surface.
Runoff	That part of rainfall which finds its way into streams after some of it has evaporated, been taken up by plants or seeped into the ground.
Sample Point	Is the point along a reach, at a site, where survey information is collected such as cross-sections. Usually two sample points are selected at each site, one at a pool habitat and one at a shallow habitat-type like a riffle or run.
Scour	Stream bed, bank or floodplain erosion caused by water turbulence shearing or plucking particles away from the surface.
Sediment	Material carried by flowing or mixing water that falls out to the bottom and deposits when the flow or mixing stops. This can include boulders, gravel, sand, silt, clay and organic matter.
Sedimentation	The long term deposition or permanent filling of a stream channel or estuary with sediment.

Siltation	See 'Sedimentation'.
Site	Is a location on a river or creek where information is collected on the condition of the steams. That is, surveys are completed at sample point/s or photographs only are taken.
Spring	a general name for any discharge of deep-seated, hot or cold, pure or mineralised water.
Stable River	The existence in a stream of a balance between erosion and deposition (ie dynamic equilibrium). The channel changes in location but not in pattern, form or slope.
Stratified Sampling	The sample area (ie catchment) is sub-divided into areas which are different (ie sub-sections). Doing this maximises the difference between the areas and minimises the difference within the area. Usually each sub-divided area is sampled randomly.
Stream Order	The designation by a dimensionless integer series (1,2,3,……) of a relative position of stream segments in the network of a drainage basin.
Stream Profile	The longitudinal profile of a stream.
Sub-catchment	Part of a river catchment that has been sub-divided to show the major tributaries within the catchment.
Sub-section	Part of a sub-catchment that has been further sub-divided according to attributes including geology, stream gradient, altitude, natural and artificial barriers, bed and bank substrates, stream order, landuse and the tidal limit.
Surface Water	All bodies of water on the surface of the earth.
Thalweg	A line down a stream linking the deepest parts and sites of greatest flow.
Tidal	Water level affected by the tide.
Total Alkalinity	A measure of a waters acid-neutralising capacity. The sum of all the titratable bases. It is usually a measure of the bicarbonate / carbonate / hydroxide content of water but can also include contributions from phosphates, borates, silicates or other bases if present.
Total Phosphorus	The sum of the concentrations of soluble and in-soluble phosphorus.
Tributary	A stream that feeds or flows into or joins a larger stream or lake.
Tufa	A spongy, porous limestone formed by precipitation from evaporating springs and river waters, often onto leaves and stems of neighbouring plants. Also known as calcareous tufa.
Turbidity	Visible pollution (dirtiness) due to suspended material in the water causing a reduction in the transmission of light.
Understorey Vegetation	Woody plants <1.3m tall, frequently with many stems arising at or near the base). Ground covers (plants without woody stems, eg grasses, sedges *etc*) have also been included with understorey vegetation.
Upper Bank	Is that part of the bank between the water mark (see below) and the high bank where it stops rising and flattens off. Also called 'high bank'.

Vegetation Cover	Used to assess the foliage density of each of the vegetation structural categories (eg trees, shrubs, grasses, submerged aquatic vegetation, *etc*). The cover is estimated in terms of the total imaginary shadow cast by each type of vegetation and is recorded as a percentage. The cover estimates for each type of vegetation are all made independently, and so the total covers do not necessarily add up to 100%.
Vegetation Profile	A survey of riparian vegetation (involving species identification and measurements such as diameter at 1.3m, bole and tree height, and crown width) within a 10m-wide belt transect. This transect is located at right angles to the water's edge and extends to the upper bank or edge of riverine vegetation. The vegetation profiles have also been represented diagrammatically.
Vegetation Width	Width of vegetation from edge of the low flow channel to where the vegetation changes from riparian vegetation to eg woodland vegetation.
Vegetation Zonation	The pattern or zoning of plant communities from the water's edge to the high bank.
Vegetation Structural Categories	The riparian vegetation is broken into structure and size classes including: tall trees >30m, medium trees 10-30m, small trees 2-10m, regenerating trees <2m, woody shrubs <2m, vines, rushes and sedges, phragmites, herbs, grasses, ferns, mangroves, salt marsh and palms. Submerged, floating and emergent aquatic vegetation are also broken into groups.
Velocity	The rate of movement of water in a stream. Usually expressed as metres per second (m/sec).
Water's Edge	The edge of the water at the time of the survey.
Waterfall Habitat	A perpendicular or nearly perpendicular descent of water in a stream. Waterfalls are characterised by a height >1m and gradient >60^{o}.
Water Surface	The surface of the water at the time of the survey.
Water Mark	A mark left on the bank at the 'normal' inundation level for the stream in the dry season (see below), before water levels subside as the dry season progresses. It's location is shown by (i) the edge of terrestrial grasses, ferns (eg *Ampelopteris prolifera*) and other vegetation (eg *Pandanus aquaticus*) which cannot tolerate more frequent and prolonged inundation; (ii) by an area of erosion; or (iii) the boundary between different sediment types.



Wetland	An area characterised by a high content of soil moisture, such as a swamp or bog.

APPENDICES

The following Appendices appear in this section:

Appendix A: List of Sites

Sub-section No. / Site No.	Tributary Name	Location Description
1a/1	Roper River	Estuary - Approximately 7km upstream from Roper River mouth (Port Roper).
1a/2	Roper River	Estuary - Approximately 24km upstream from Roper River mouth.
1a/3	Roper River	Estuary - 8km upstream Phelp River junction and approximately 42km upstream from Roper River mouth.
1a/4	Roper River	Estuary - 57km upstream from Roper River mouth.
1a/5	Roper River	Estuary - Between 74 and 78km upstream from Roper River mouth (downstream Kangaroo Island).
1a/6	Roper River	Estuary - Between 90 and 93km upstream from Roper River mouth (upstream Kangaroo Island).
1a/7	Roper River	Estuary - Between 102 - 104km upstream Roper River mouth.
1a/8	Roper River	Estuary – Approx. 111km upstream from Roper River mouth. Approx. 7km downstream from Ngukurr.
1a/9	Roper River	Estuary – Approx. 123km upstream from Roper River mouth. 4.5km upstream Ngukurr.
1a/10	Roper River	Estuary - Approximately between 132-135km upstream from Roper River mouth. Between 1-5km downstream Hodgson River.
1a/11	Roper River	Estuary - between 141-143km upstream from river mouth. 1.5 - 2.5km downstream of Wilton River.
1a/12	Painnyilatya Creek	Approximately 2km upstream from junction with Roper River (tidal section).
1b/1	Roper River	Immediately upstream Roper Bar Crossing.
1b/2	Roper River	At Red Rock Gauge Station approximately 10.7km upstream Roper Bar Crossing.
1b/3	Roper River	Upstream Scraper Tyre Hole – Mt McMinn Station.
1c/2	Roper River	Upstream Big Island Crossing - Lonesome Dove Station.
1c/3	Roper River	Approximately 2.5-3km upstream of Rocky Bar Crossing - Lonesome Dove Station.
1c/4	Roper River	Riffle at Judy's crossing and pool upstream - Flying Fox Station.
1d/1	Roper River	57-Mile Waterhole - Elsey & Moroak Stations.
1d/2	Roper River	Downstream of bridge crossing near Moroak Station homestead.
1d/3	Roper River	Approx. 9km upstream Moroak Station Homestead.
1d/4	Roper River	At and above Lindsay's Crossing - Goondoolloo Station.
1d/5	Roper River	Red Lily Lagoon/2-Mile Waterhole - Elsey Station.
1d/6	Roper River (Arm)	4-5km downstream of Barramundi Crossing and 6-7km downstream of Little Red Lily Lagoon – Elsey Station.
1d/7	Roper River	Sullivan's Crossing - Goondooloo Station.
1e/1	Roper River	Between Elsey Creek/Roper River junction upstream to Elsey Falls – Elsey Station.
1e/2	Roper River	At Salt Creek/Roper River junction - Elsey National Park (just downstream of Mataranka falls).
1e/3	Roper River	12-Mile Yards, Elsey National Park.
1e/4	Roper River	4-Mile, Elsey National Park.
1f/1	Roper Creek	Upstream crossing on road from Mataranka to Beswick.
1f/2	Roper Creek	Approx. 10km upstream Beswick Creek junction - Mataranka Station.
1f/3	Roper Creek	Upstream Central Arnhem Road crossing.
1f/4	Maranboy Creek	Downstream springs on Beswick Aboriginal Land.
1f/5	Beswick Creek	Upstream of Central Arnhem Road crossing at Barunga.
2/1	Phelp River	Approximately 3-5km upstream from junction with Roper River.
2/2	Phelp River	Upstream of crossing on track to Numbulwar - Arnhem Land Aboriginal Land.
2/3	Phelp River	Upper catchment site – Arnhem Land Aboriginal Land.
2/4	Turkey Lagoon Creek	Downstream of crossing on road to Numbulwar - Arnhem Land Aboriginal Land.
3a/1	Hodgson River	2-3km upstream junction with Roper River.
3a/2	Hodgson River	Approx. 10-11km upstream Queensland crossing - Mt McMinn Station.
3a/3	Hodgson River	Site located at crossing near Hodgson Downs community.

3a/4	Hodgson River	Upstream of crossing on track to Minimere Lagoon on Arnold River - Hodgson Downs.
3a/5	Hodgson River	Minyerri Billabong at Hodgson Downs community.
3a/6	Bella Glen Creek	Bella Glen Waterhole - Hodgson Downs.
3b/1	Hodgson River	Downstream of crossing on Flicks Waterhole - Hodgson River Station.
3b/2	Hodgson River	Upstream of crossing on road into Nutwood Downs Station.
3b/3	Hodgson River	Downstream of crossing in Cow Lagoon Paddock - Nutwood Downs Station.
4/1	Arnold River	Minimere Lagoon and rocky section upstream - Hodgson Downs.
4/3	Arnold River	At abandoned Cox River homestead.
5a/1	Wilton River	2.4-3km upstream of junction with Roper River.
5a/2	Wilton River	At track crossing, approximately 14.5km upstream of Wilton River crossing on road to Ngukurr.
5a/4	Wilton River	<1.0km downstream of crossing near southern boundary - Wongalara Station.
5a/5	Wilton River	Wongalara Waterhole on Wilton River - Wongalara Station.
5b/1	Wilton River	Downstream from Bulman community – Arnhem Land Aboriginal Land.
5b/2	Wilton River	Upstream of Wilton River crossing near Bulman (Central Arnhem Road) – Arnhem Land Aboriginal Land.
5b/3	Wilton River	Upstream of Bulman community – Arnhem Land Aboriginal Land.
5b/4	Wilton River	Upstream of Bulman community – Arnhem Land Aboriginal Land.
5b/5	Wilton River - West Branch	Upstream of Bulman Gorge – Arnhem Land Aboriginal Land.
6/1	Mainoru River	Approx. 2.5km upstream of junction with Wilton River - Wongalara Station.
6/2	Mainoru River	Upstream of old Highway road crossing at Mainoru Station.
6/3	Mainoru River	Upstream of Central Arnhem Road crossing.
6/5	Mainoru River	Upper catchment site – Arhnem Land Aboriginal Land.
7/1	Jalboi River	Approx. 14km upstream from Roper River junction - Urapunga Station.
7/2	Jalboi River	Lonesome Dove Station.
7/3	Jalboi River	Above creek crossing upstream of Jalboi Gorge - Wongalara Station.
7/4	Quibobikwi Creek	Upstream of crossing leading into Mainoru Station 3.15km from turn off.
8/1	Flying Fox Creek	Old BTEC track NW of Rocky Bar Crossing - Flying Fox Station.
8/2	Flying Fox Creek	Tolowan waterhole and riffle downstream - Mountain Valley Station.
8/3	Flying Fox Creek	Approx. 1.4km upstream of Central Arnhem Road.
8/4	Flying Fox Creek	22km upstream of Central Arnhem Road - Mountain Valley Station.
8/5	Flying Fox Creek	Upper catchment site, at and downstream of track crossing - Arnhem Land Aboriginal Land.
8/6	Derim Derim Creek	Site is 20m upstream of Central Arnhem Road crossing - Mountain Valley Station.
9/1	Maiwok Creek	Old BTEC Track NW of Judy's Crossing - Flying Fox Station.
9/2	Maiwok Creek	Moroak Station.
9/3	Maiwok Creek	Upstream of southern boundary fenceline - Mountain Valley Station.
9/4	Maiwok Creek	At and upstream of Central Arnhem Road.
10/1	Strangways River	Upstream of the Roper Highway crossing- Elsey Station.
10/2	Strangways River	To the east of Bayward Paddock Boundary – Elsey Station.
10/3	Strangways River	Rocky Hole Yard - Vermelha Station.
10/4	Strangways River	Upstream of boundary bore track - Kalala Station.
10/5	Cattle Creek	Upstream of old track crossing in Bayward paddock – Elsey Station.
11/1	Chambers River	Approx. 14km upstream of Roper River junction - Elsey Station.
11/2	Chambers River	Near track – Beswick Aboriginal Land.
11/3	Chambers River (Arm)	Above creek crossing - Beswick Aboriginal Land.
12/1	Elsey Creek	Approx 14m upstream of fenceline at Roper Highway crossing.
12/2	Elsey Creek	Large waterhole ('Longreach' waterhole) which starts 1.2km downstream of old Stuart Highway crossing - Elsey Station.

12/3	Western Creek	Small waterhole near southern boundary fenceline - Gorrie Station.
12/4	Birdum Creek	West of Gorrie WWII airfield - Wubalawun Aboriginal Land.
13/1	Waterhouse River	Approximately 21-22km upsteam of junction with Roper River - Cave Creek Station.
13/2	Waterhouse River	At and downstream of Waterhouse River Falls – Beswick Aboriginal Land.
13/3	Waterhouse River	Upstream of old crossing on track north of Central Arnhem Road - Mountain Valley Station.
13/4	Waterhouse River - West Branch	Above track crossing - Beswick Aboriginal Land.
13/5	Waterhouse River	Upstream crossing on track into Snowdrop Creek – Arnhem Land Aboriginal Land.

Appendix B: Summary of Data Sheet Information

Below is a summary of the raw data collected on each data sheet. Also refer to Anderson (1993b,c).

- *Site Description*

- Basin No.
- Sub-section No.
- Site No.
- Tributary Name → Flows into → Flows into
- Date
- Recorder and Assistant
- Site Description (locality name)
- Location Description
- Type of Site: Photograph only, full survey site, stream gauge, water quality, veg. profile, veg. samples, cross-section/s only.
- Grid reference: Zone (52 or 53), Easting, Northing – using GPS or Other (noting position error)
- Map name, scale and number
- Distance upstream from river mouth
- Stream order number
- Is the site tidal or non-tidal?
- Catchment area (in km^2)
- Altitude
- Photographs taken – film no., shot no. and description. (The standard set consists of one shot looking upstream, downstream, at left and right banks, reach environs and other features).
- Access sketch (to relocate site for follow-up surveys)

- *Reach Environs*

- Overall disturbance rating: very low, low, moderate, high, very high or extreme.
- Water level at sampling time: completely dry, isolated pools with no flow, low flow/low level, moderate < water mark, high > water mark, flood > bankfull, within 1 hr of high tide or low tide, incoming/between tide, outgoing/between tide.
- Channel pattern at a local scale: straight, mildly sinuous, irregular, regular meanders, irregular meanders, tortuous, braided, swampy, channelised.

- Local land use:

Horticulture small crops/vines	horticulture tree crops / fruit
irrigated broadacre row crops	rainfed broadacre row crops
grazing – sown pasture	grazing – native – cleared
grazing – native – thinned	grazing – native – virgin timber
intensive livestock	urban residential
urban manufacturing/processing	national/environment park or reserve
urban park or reserve	rural residential / hobby farm, other

- Local disturbance:

road/track	bridge/culvert
causeway/river crossing/ford	boat ramp
weir	channelisation
river works	discharge pipe
irrigation runoff/pipe outlet	water extraction/pump
sewage effluent	grazing
water point for stock/ferals	forestry activities
dredging	sand/gravel mine
other mine	people
none	

- Floodplain features: oxbows/billabongs, remnant channels, floodplain erosion/scours, floodplain deposits/silt, prominent flood channels.

- Local land tenure: freehold/leasehold, national park, state park, reserve/environmental park, state forest, urban reserve, urban, other/unknown.

- Local vegetation habitat / type:

eucalypt wet sclerophyl	eucalypt open-forest
eucalypt woodland	eucalypt open-woodland
sandstone monsoon vine-forest	monsoon vine-forest on rock
lowland monsoon vine-forest	coastal monsoon vine-forest
freshwater streams	melaleuca woodland
melaleuca swamp	phragmites swamp
floodplain glassland/sedgeland	mangrove
salt marsh/saline tidal flats	grassland
shrubland	heathland
palms	plantation
other	

- *Channel Habitat*

- Channel habitat type/s present:

Waterfall	Height >1m; gradient > 60^{o}.
Cascade	Step height <1m; gradient 5-60^{o}; strong currents.
Rapid	Depth >0.3m (guide only); gradient 3-5^{o}; strong currents; and rocks break surface.
Riffle	Depth 0.1-0.3m (guide only); gradient 1-3^{o}; moderate currents and surface unbroken but unsmooth.
Glide	Depth <0.1m; gradient 1-3^{o}; small currents; surface unbroken and smooth.
Run	Depth >0.3m; gradient 1-3^{o}; small but distinct and uniform current; and surface unbroken.
Pool	Depth >0.5m; where stream widens or deepens and currents declines.
Backwater	Cut-off section away from the channel.

- Average dimensions for each type: % of section length
  height for waterfall and cascade
  depth at water level and water mark for all types except waterfalls and cascades,
  width at water mark.
- Total length of reach.
- Sketch of reach and location of sample points (where cross-section surveys done).
- If boat access is available, a longitudinal profile survey (depth measurements along the river using a GPS and depth sounder) is undertaken in order to select the reach, measure lengths for each habitat type and to locate the deepest section along the reach.

- *Cross-Sections located at Sample Points (usually two are measured for each site)*

- Sample point letter
- Grid reference for each sample point: Zone (52 or 53), Easting and Northing
- Type of habitat: Pool, riffle, run, glide, cascade, rapid, waterfall, backwater
- Dimensions of habitat: length, average width, average depth at water level and water mark
- Cross-section at water surface, bed dry (depths @ water mark) or water mark covered (no lower bank).
- Transect width at the water surface or where transect taken, width at water mark, total channel width.
- Distance and depth measurements across the transect line. These cross-sections have been shown diagrammatically using Excel.
- Width, height and slope of each bank, lower and upper (refer Figure A.1).
- Sketch and measurements for each bank – marking on the 'point of inflexion', upper bank and edge of riverine vegetation / riparian zone (refer Figure A.1).

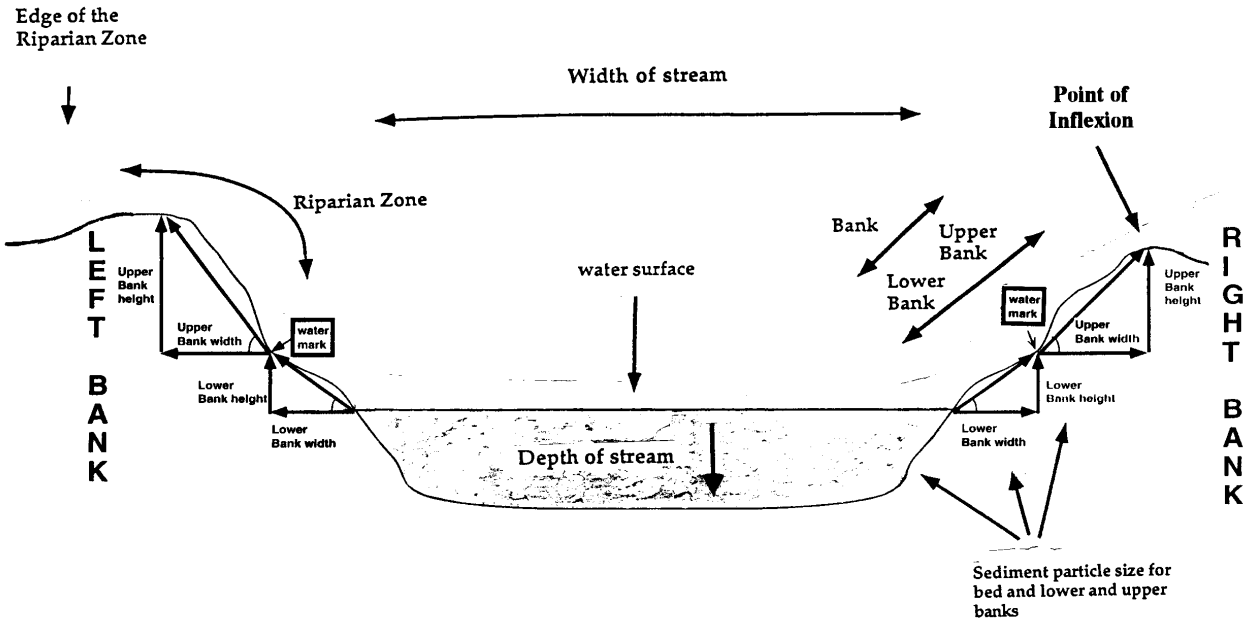


Figure A.1: Diagrammatic Representation of a River Channel Showing the Type of Information Collected During Cross-section Surveys

- Bank sediments for each bank, lower and upper, totalling 100%. Percentage of organic matter within sediment sample. Sediment size classes include:
  - fines (<0.06mm)
  - small sand (0.06-0.5mm)
  - large sand (0.5-2mm)
  - small gravel (2-5mm)
  - medium gravel (5-20mm)
  - large gravel (20-60mm)
  - cobble (60-300mm)
  - boulders (>300mm)
- Bed sediments totalling 100%. Percentage of organic matter within sediment sample. Usually three bed sediment samples are taken at each cross-section.
- Presence and location of rock outcrops – left lower/upper bank, right lower/upper bank, bed, none.

- *Stream Gauging – Flow/Discharge Measurement*

- Method: float or current meter
- Quality of gauging: excellent, good, fair, poor
- Current meter details: body type, body number, fan number.
- Up to three flow measurements are made (using either float method or a current meter) at each cross-section at 60% of the depth in order to calculate a mean velocity and overall discharge.

- *Bank Condition*

- Percentage of each bank, lower and upper, recorded as being stable, eroding or aggrading.
- Location of instability: outside bends, inside bends, at floodplain scours, at obstacles, at seepage and runoff points, irregularly or all along.
- Slope of each banks (ranked): vertical, steep, moderate, low, flat.
- Shape of each bank (ranked): concave, convex, stepped, wide lower bench, undercut, cliff.
- Factors affecting bank stability (ranked):

high flow	wash from boats
tidal influence	seepage
runoff	floodplain scours/breakouts
stock	cultivation near rivers
people tracks	vermin
clearing of vegetation	extraction of sand/gravel
mining	road/river crossings/culvert *etc*
none	other

- Artificial bank protection measures: revegetation works, rock revetment, mesh/gabions, log wall, groynes, concrete wall, fenced watering points/along river, fenced human access.
- Presence of levee banks – height and width.
- Subjective rating of the overall condition of each bank.
  Overall instability and susceptibility rated as either: minimal
  low
  moderate or
  high

- *Bed and Bar Condition*

- Overall bed stability rating: bed stable
  moderate erosion
  severe erosion
  moderate aggradation
  severe aggradation.

- Bar type, if present: point
  alternate/side irregular
  mid-channel island
  encroaching vegetation
  around obstructions
  channel bar plain
  low flow meander infilled channel
  high flow deposits

- Percentage of the bed surface along the reach protruding out of the water at water mark and forming a bar.
- Gravel features (bed and bar) – angularity (very angular, angular, sub angular, rounded, well rounded); shape (sphere, disc, blade or rod-shaped).
- Whether gravel surface covered by algae/silt or whether clean.
- Bed compaction – tightly packed/armoured, packed but not armoured, moderate compaction, low compaction/poor grading, low compaction/loose array.
- Factors affecting bed stability (ranked): bed deepening / lowering
  bank erosion
  in-stream siltation
  channelisation / concentration of flows
  sediment starvation
  extraction (sand, gravel, dredging)
  agriculture or grazing
  none
  other

- Controls stabilising the bed: bridge/river crossing/culvert, rock outcrops, fallen trees, bed stabilising structures, none.
- Passage for fish and other organisms at the time of the survey and @ water mark:
  no passage
  very restricted (<0.1m deep and narrow)
  moderately restricted (<0.3m deep and narrow)
  partly restricted (<0.5m deep and narrow)
  good passage (0.5-1m deep, wide, no torrent)
  unrestricted (>1m deep and almost channel wide)

- *Vegetation (Riparian and Aquatic)*

- Width of the riparian zone for left and right banks.
- Percentage of each bank, lower and upper, that is bare of overstorey (vegetation >1.3m) and understorey (groundcover) vegetation.
- Riparian vegetation – An assessment of the percentage foliage cover or density for native and exotic species is made for each of the following 14 vegetation types or growth forms using the percentage cover diagram (Figure A.2) as a guide:

trees >30m	phragmites
trees 10-30m	herbs
trees 2-10m	grasses
regenerating trees <2m	ferns
woody shrubs <2m	mangroves
vines	salt marsh
rushes/sedges	palms

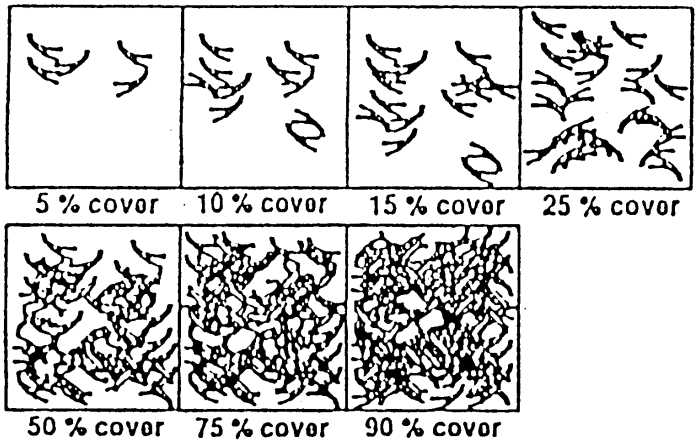


Figure A.2:

Diagrams used in the Field to Estimate Percentage Cover for Riparian Vegetation, Aquatic Vegetation and Instream Habitat

Source:
Anderson (1993 b.c)

- Total percentage of weeds and exotic species in the riparian zone.
- Local species checklist recording whether more common species absent, scattered or abundant. The more common species include: Eucalypts, Melaleuca, Barringtonia, Pandanus, Casuarina, Leichardt Pine, Acacias, Bamboo, Ficus, Leptospermum, Lophostemon, Syzygium, Grevillea, Palms, Phragmites, Fern, Passiflora, Flagellaria vine, Noogoora Burr, Hyptis.

- Aquatic vegetation – percentage cover (refer Figure A.2) for:

submerged vegetation	(algae, Chara/Nitella, Vallisneria, Myriophyllum, Elodea and other herb-like forms)
floating vegetation	(water hyacinth, Azolla, water lilies and other floating vegetation)
emergent vegetation	(Phragmites, Typha, Para Grass, rushes/sedges, Pandanus, Melaleuca, other shrubs/trees and other groundcovers)
exotic aquatic vegetation	

- Vegetation survey / Belt transect: Location of transect including a Grid Reference, transect width (usually 10m wide). The location of the overstorey vegetation (including everything >1.3m tall) is recorded within this transect, along with a trunk diameter, bole and tree height, crown width and species name. The belt transects were located at right angles to the water's edge and extended to the upper bank or edge of riverine vegetation. Other species not located within the belt transect but are present at a site are also recorded. Groundcovers (eg grasses, herbs, ferns, *etc*) were recorded within this vegetation profile through the use of a $1m^2$ quadrat, usually located at 5m intervals along the profile length, starting at the water's edge. Percentage covers for each species type located within each quadrat is recorded.

- Vegetation lists (of the major species) are recorded for sites where a vegetation survey is not undertaken. The lists give no indication of abundance of the species at the site but rather whether they were present.

- *Aquatic Habitat*

- An overall aquatic rating for all aquatic life is subjectively rated for each site as:
  very high/pristine
  good
  poor
  very poor

  The rating takes into account the diversity of depths and substrates, level of disturbance, diversity and extent of cover, extent of canopy and other vegetation cover, and whether the stream dries up completely.

- Percentage bed cover (refer Figure A.2) is recorded for the following instream debris types:

  individual log
  log jam, 50% or >50% dense
  individual branch
  branch pile, <50% or >50% dense
  terrestrial leaves and twigs
  macrophyte fragments
  algal clumps and debris
  large/deep submerged vegetation - freshwater and marine
  mangroves
  large patches of floating vegetation
  emergent vegetation in permanent water >0.5m deep
  tree roots
  rock faces, boulders and cobbles
  permanent pool >1m deep
  man-made structures and debris

- Cover provided by each bank (ie canopy cover, vegetation overhang <1m from the water surface, root overhang, bank overhang and man-made overhang) is recorded as a percentage of the bank length. An average width for each type of cover is also recorded.

Appendix C: Summary of the Condition and Stability Ratings

Below is a summary of the condition and stability ratings and associated formulae used for this project.
** indicates those formulae that have been modified from the 'State of the Rivers' methodology (Anderson, 1993c).*

- *State of the Reach Environs ** *(Map 11)*

The state of the reach environs is based on an assessment of the land corridor along the survey reach and on the adjacent floodplain. The rating takes into account land use and local disturbances. A higher rating is achieved for sites which have undisturbed vegetation and no local disturbances likely to impact directly on streams. Sites in areas where floodplain and valley flat areas have been cleared for grazing, intensive agriculture or for rural residential occupancy are rated more poorly.

The calculated ratings are derived by re-ordering the categories used for recording the various types of local disturbance and land use. The revised categories for each type, land use and disturbance, are determined and then scaled between 0% and 100% (see listing below), before being multiplied by the weightings (ie 50%) and summed to give the final derived ratings. If more than one category is recorded, the average is used.

Land use categories: *(scaled between 0% and 100% - ie 100/14 * category number)*	1	Urban manufacturing	(7%)
	2	Urban residential	(14%)
	3	Intensive livestock	(21%)
	4	Rural residential	(29%)
	5	Urban park	(36%)
	6	Horticulture – small crops	(43%)
	7	Horticulture – tree crops	(50%)
	8	Irrigated broadacre crops	(57%)
	9	Rainfed broadacre crops	(64%)
	10	Grazing – sown pasture	(71%)
	11	Grazing – native – cleared	(79%)
	12	Grazing – native – thinned	(86%)
	13	Grazing – native – virgin	(93%)
		Aboriginal Land	(93%)
	14	Park or Reserve	(100%)
Local disturbance categories: *(scaled between 0% and 100% - ie 100/15 * category number)*	1	Sand/gravel mine	(7%)
	2	Other mine	(13%)
	3	Dredging	(20%)
	4	Sewage effluent	(27%)
	5	Water point for stock/ferals	(33%)
	6	Forestry	(40%)
	7	Irrigation runoff / pipe outlet	(47%)
	8	Channelisation	(53%)
	9	River works	(60%)
	10	Water extraction / pump	(67%)
	11	Grazing	(73%)
	12	Discharge pipe	(80%)
	13	Causeway / crossing / ford	(87%)
		Boat ramp	(87%)
		Weir	(87%)
	14	Bridge / culvert	(93%)
		Road / track	(93%)
		People	(93%)
	15	None	(100%)

These revised and scaled categories are then applied using the formula:

State of the Reach Environs = Local disturbance x (50%) + Land use x (50%)

- *Channel Type Diversity (This component is not used to derive the overall condition rating) * (Map 12)*

The channel type diversity categories take into account:

1. The number of different channel habitat types present (cascades, glides, pools, rapids, riffles, runs and waterfalls); and
2. The proportion of the reach occupied by pools versus other habitat types.

1. Number of Channel Habitat Types

Each site is rated out of 5 according to Table A.1:

Table A.1: Channel Type Diversity Rating based on Number of Channel Habitat Types

Number of Channel Habitat Types	Rating (out of 5)
Uniform habitat or depths (1 type) – (100% riffle or pool in smaller streams with no variation in depth or intermittent pools in larger streams)	1
Slight variety of habitat or depths (1 type) – (100% riffle or pools in smaller streams with some variation in depth or 100% pools in larger streams)	2
Some variety of habitats (2 types)	3
Good variety of habitats (3 types)	4
Wide variety of habitats (≥4 types)	5

2. Proportion of Reach Occupied by Pools Versus Other Habitat Types

Each site is rated out of 5 according to Table A.2:

Table A.2: Channel Type Diversity Rating based on Proportion of Reach Occupied by Pools Versus Other Habitat Types (Adapted from Mitchell, 1990)

Proportion of Reach Occupied by Pools Versus Other Habitat Types*	Rating (out of 5)
100% riffle or pool in smaller streams with no variation in depth or intermittent pools in larger streams	1
100% riffle or pools in smaller streams with some variation in depth or 100% pools in larger streams	2
<10% riffles	3
10-30% riffles	4
>30% riffles	5

* The term 'riffle' refers to habitat types other than pools that may be present. These habitat types include: riffles, rapids, cascades, waterfalls, glides and runs.

Rating results from 1 and 2 above are added to give a final rating out of 10 for each site. A channel type diversity category is assigned to each site according to the following:

1-2	**Very Low Diversity**
3-4	**Low Diversity**
5-6	**Moderate Diversity**
7-8	**High Diversity**
9-10	**Very High Diversity**

- *Bank Stability* *(Map 13)*

Bank stability ratings are determined from the recorded percentages of the banks on each side of the reach which are rated as stable. Upper banks are assigned a greater proportion of the score (80%) than lower banks (20%). The final condition ratings represent the average percentage of the bank that is unstable at the site. A score of 100% is achieved for sites where the entire banks are completely stable. Low scores occur when a high proportion of the bank is unstable (eroding or aggrading). The dominant process at each site (ie erosion or aggradation) is averaged for the river banks and the process recording the highest average represents the dominant direction of the change in condition prevailing at the site at the time of the survey.

Bank Stability Rating = (80%) % upper bank stable* + (20%) % lower bank stable*
(*averaged for each bank)

- *Bed Stability ** *(Map 14)*

Bed stability ratings are determined from a subjective assessment made in the field of whether the river bed is stable; moderately eroding or aggrading; or severely eroding or aggrading. The symptoms for assigning a bed stability category to a site include:

- Stable bed: The river bed is consolidated; bed and bar material is the same size, alluvium balanced; and banks stable.
- Moderate erosion: There is little alluvium; signs of deepening; eroded banks; bed deep, narrow and steep; unconsolidated.
- Moderate aggradation: There is moderate build-up at obstructions and bars; bed is flat, uniform, wide and shallow; some over-bank siltation.
- Severe erosion: The bed is scoured of sand; signs of deepening; bare eroded banks; erosion heads; erosion causes; and a steep bed.
- Severe aggradation: The bed is flat, wide but shallow and channel blocked; bars large, covering most of bed and bank; bed is loose and unconsolidated.

A bed stability rating (out of 10) is assigned to each site according to the following:

2	**Severe Erosion or Aggradation**
6	**Moderate Erosion or Aggradation**
10	**Stable**

- *Cover and Structural Diversity of Riparian Vegetation ** *(Map 15)*

The cover and structural diversity rating for riparian vegetation takes into account:

(1) The foliage cover or density provided by the overstorey, understorey and ground cover vegetation types or 'growth forms'; and
(2) The structural diversity or number of different growth forms present.

A higher rating is only achieved for sites that have recorded a high foliage cover and a diversity of structural types present within the riparian zone. The width of riparian vegetation (refer Map 16) and the cover of exotic riparian vegetation (refer Map 17) are dealt with separately.

There are 14 riparian vegetation types or growth forms and these are divided into three vegetation layers: overstorey, understorey and ground covers. The distinction between these three vegetation layers is:

Overstorey vegetation:	trees >30m tall	(1)
	trees 10-30m tall	(2)
	palms	(3)
Understorey vegetation:	trees 2-10m tall	(4)
	mangroves	(5)
	woody shrubs <2m tall	(6)
	regenerating trees <2m tall	(7)
Ground covers:	vines	(8)
	rushes/sedges	(9)
	Phragmites	(10)
	Forbs/herbs	(11)
	grasses	(12)
	ferns	(13)
	salt marsh	(14)

(1) Foliage Cover or Density

In the field, an assessment of the percentage foliage cover or density (refer Figure A.2) is made for each of the 14 vegetation types or growth forms.

The percentage foliage cover recorded for the growth forms within each stratum are summed. That is, covers for growth forms 1 to 3, 4 to 7 and 8 to 14 (shown above) are summed. If these covers are >100%, they are classed as 100%. **These covers include both native and exotic species**. A negative factor (-15%) is applied to each stratum for the percentage of **bare ground** recorded along the upper bank within the riparian zone. For example:

*sum of % covers for overstorey – (sum of % covers for overstorey * % of bare ground *15%)*

The percentage of bare ground is estimated for the (i) overstorey/understorey and (ii) ground covers in the field for both the upper banks (UB) and lower banks (LB). For the above formula use the following as the "% of bare ground":

*0.1 * % cover for overstorey/understorey[(1)] UB + 0.66 * % cover for ground cover[(2)] UB*

(1) Called 'overstorey bare' in projects' database
(2) Called 'understorey bare' in projects' database

Each stratum (ie overstorey, understorey and ground covers) is rated out to 10 according to Table A.3:

Table A.3: Foliage Cover or Density Categories Used to Rate Each Vegetation Stratum in the Riparian Zone

Vegetation Cover	Foliage Cover or Density* (%)	Rating (out of 10)
Very sparse	<10%	2
Sparse	10-30%	4
Mid-dense (a)	31-50%	6
Mid-dense (b)	51-70%	8
Dense	71-100%	10

* These Foliage Projective Cover categories were defined by Specht (1981)

The ratings for the overstorey, understorey and ground covers are summed to give a rating out of 30 for each river bank at a site and are then re-scaled to give a rating out of 5 **(A).**

2. Structural Diversity

The structural diversity is derived by counting the number of vegetation types or growth forms (out of 14) present along each river bank at a site, and assigning a rating (out of 5) according to Table A.4 **(B)**:

Table A.4 Structural Diversity Rating based on Number of Vegetation Types or Growth Forms

Number of Growth Forms (out of 14)	Rating (out of 5)
0	1
1-4	2
5-7	3
8-10	4
>10	5

The final rating is out of 10 once applied to the formula below. Rating results for each bank are averaged for the site.

Cover and Structural Diversity of Riparian Vegetation Rating = Foliage cover (A) + Structural diversity (B)

- *Cover of Exotic Riparian Vegetation ** *(Map 17)*

The ratings take into account the percentage cover recorded in the field for exotic species within the riparian zone (refer Figure A.2). The average of the percentage exotic species cover recorded for each bank is used. The number of different types of exotic species recorded at a site, if present, is shown on Map 17 but does not contribute to the rating.

A rating (out of 10) is assigned to a site depending on the degree of invasion by exotic species, summarised below:

High Invasion By Exotic Species	% Cover Category	Rating (out of 10)
↑	16 - max. % cover recorded	2
	11 – 15	4
	6 – 10	6
	1 – 5	8
No Invasion By Exotic Species	0	10

- *Aquatic Vegetation ** *(Maps 21, 22 and 23)*

A condition rating for aquatic vegetation **has not been derived**, but rather the cover and distribution of submerged, emergent and floating aquatic vegetation and emergent aquatic vegetation are shown in Maps 21, 22 and 23 respectively.

- *Cover and Diversity of Instream and Bank Habitats ** *(Map 24)*

The instream and bank habitat ratings are based on a combination of:

1. The cover (refer Figure A.2) and diversity provided by instream organic debris (logs, branches, leaves/twigs, *etc*), aquatic vegetation and other habitat types (such as rock, permanent pools) on the bed; and
2. The cover and diversity provided by the canopy and other habitats (low vegetation, roots, bank overhang) along the river banks.

1. Instream Habitat Cover and Diversity

Instream habitat types include:

1. individual log
2. log jam, <50% and >50% dense (Add these % together)
3. individual branch
4. branch pile, <50% and >50% dense (Add these % together)
5. terrestrial leaves and twigs
6. macrophyte fragments
7. algal clumps and debris
8. large/deep submerged vegetation – freshwater and marine (Add these % together)
9. mangroves
10. large patches floating vegetation
11. emergents permanent water >0.5m deep
12. tree roots
13. rock faces, cobbles, boulders
14. permanent pools >1m deep
15. man-made structures/debris

(a) Instream Cover

Ratings are derived for (i) organic debris, (ii) aquatic vegetation, and (iii) other habitat types. The results for (i), (ii) and (iii) outlined below are summed to give a final instream cover rating out of 15. Re-scale to 10.

(i) Organic Debris – Includes instream habitat types 1-6 listed above.
The covers are summed for these 6 types and can be >100%. The sites are rated (out of 5) according to Table A.5:

Table A.5 Instream Cover Rating for Organic Debris (Adapted from Mitchell, 1990)

% Cover	Rating (out of 5)
0	1
1-10	2
11-20	3
21-40	4
>40 (but if log jam >80%, then rate as 2)	5

(ii) Aquatic Vegetation – Includes instream habitat types 7-11 listed above.
The covers are summed for these 5 types and can be >100%. The sites are rated (out of 5) according to Table A.6:

Table A.6 Instream Cover Rating for Aquatic Vegetation (Adapted from Mitchell, 1990)

% Cover	Rating (out of 5)
0 or >80	1
1-5 or 61-80	2
6-20	3
21-30	4
31-60	5

(iii) Other Habitat Types – Includes instream habitat types 12-15 listed above.
Pools strongly influence this rating so are treated separately to the other habitat types.
(a) Add categories 12, 13 and 15 together (can be >100%)
(b) Keep category 14 separate

Rate both (a) and (b) out of 5 according to Table A.7 and use the average.

Table A.7 Instream Cover Rating for Other Habitat Types

% Cover	Rating (out of 5)
0	1
1-10	2
11-20	3
21-50	4
>50	5

(b) Instream Habitat Diversity
Is derived by counting the number of habitat types (out of 15) present at a site and assigning a rating (out of 10) according to Table A.8:

Table A.8 Instream Habitat Diversity Rating based on Number of Habitat Types

Number of Instream Habitat Types (out of 15)	Rating (out of 10)
0	2
1-4	4
5-7	6
8-10	8
>10	10

Add (a) Instream Cover (out of 10) and (b) Instream Habitat Diversity (out of 10) to give a figure out of 20. Re-scale to 50% for inclusion in final formula **(A)**.

2. Bank Habitat Cover and Diversity

Bank habitat categories include:

1. canopy cover
2. vegetation overhang <1m from water surface
3. root overhang
4. bank overhang
5. man-made overhang

(a) Bank Cover
Ratings are derived for (i) canopy cover along bank (% bank length), (ii) vegetation overhang <1m from water surface, and (iii) root, bank and man-made overhang. Rating results for each bank are averaged for the site. The results for (i), (ii) and (iii) outlined below are summed to give a final bank cover rating out of 25. Re-scale to 10.

(i) Canopy Cover along Bank (% Bank Length) – Is bank habitat category 1 listed above. The sites are rated (out of 5) according to Table A.9:

Table A.9 Rating for Canopy Cover along Bank

% Bank Length Cover	Rating (out of 5)
0	1
1-30	2
31-60	3
61-80	4
>80	5

(ii) Vegetation Overhang <1m from Water Surface (% Bank Length) – Includes bank habitat category 2 listed above. The sites are rated (out of 5) according to Table A.10:

Table A.10 Rating for Vegetation Overhang along Bank

% Bank Length Cover	Rating (out of 5)
0	1
1-15	2
16-30	3
31-60	4
>60	5

(iii) Root, Bank and Man-made Overhang (% Bank Length) – Includes bank habitat categories 3-5 listed above. Each of these bank habitat types are rated (out of 5) according to Table A.11:

Table A.11 Rating for Root, Bank and Man-made Overhang along Bank

% Bank Length Cover	Rating (out of 5)
0	1
1-5	2
6-20	3
21-40	4
>40	5

(b) Bank Habitat Diversity

Is derived by counting the number of habitat types (out of 5) present at a site and assigning a rating (out of 10) according to Table A.12:

Table A.12 Bank Habitat Diversity Rating based on Number of Habitat Types

Number of Bank Habitat Types (out of 5)	Rating (out of 10)
0	2
1	4
2	6
3	8
4-5	10

Add (a) Bank Cover (out of 10) and (b) Instream Habitat Diversity (out of 10) to give a figure out of 20. Re-scale to 50% for inclusion in final formula **(B)**.

The rating formula gave higher ratings to sites with a diversity of types present as well as the proportion of the bed or banks with each individual cover types present. In deriving the final rating, 50% contribution was given for the instream habitat cover and diversity and 50% for the bank habitat cover and diversity.

Cover and Diversity of Instream and Bank Habitat Rating	**=**	**Instream cover and diversity (A) (50%)**	**+**	**Bank cover and diversity (B) (50%)**

- *Overall Condition ** *(Map 25)*

Provides an indication of the overall condition of the sites based on the following six components that were assessed:

- State of the Reach Environs
- Bank Stability
- Bed Stability
- Cover and Structural Diversity of Riparian Vegetation
- Cover of Exotic Riparian Vegetation
- Cover and Diversity of Instream and Bank Habitats

The ratings for each of these six components are re-scaled to a number out of 10 (if not already) and then are summed before re-scaling to a rating out of 100%. These six components are combined equally to produce the Overall Condition rating for each site.

Overall Condition Rating	**=**	**State of the Reach Environs +** **Bank Stability +** **Bed Stability +** **Cover and Structural Diversity of Riparian Vegetation +** **Cover of Exotic Riparian Vegetation +** **Cover and Diversity of Instream and Bank Habitats**

Appendix D: Riparian Vegetation Species Recorded in Roper River Catchment

Plant Name – *Genus species*	Common Name	Status	Sub-sections where recorded
Trees, low trees and shrubs			
Abutilon andrewsianum		Native	3a, 10, 12
Abutilon hannii		Native	1e
Acacia ampliceps		Native	1f
Acacia auriculiformis	Earpod Wattle	Native	1f, 2, 5b, 6, 8, 11, 13
Acacia difficilis		Native	4, 5b, 11, 13
Acacia dimidiata	Swamp Wattle	Native	5b
Acacia farnesiana	Mimosa Bush	Exotic	1d, 1e, 1f
Acacia gonoclada		Native	4
Acacia holosericea	Candelabra Wattle / Soap Bush	Native	1a,1b,1e,1f,2,3a,3b,4,5a,5b,6,7,8,9,10,11,12,13
Acacia humifusa		Native	5b
Acacia leptocarpa		Native	7
Acacia multisiliqua		Native	1f
Acacia plectocarpa		Native	3a
Acacia sp.		Native	2, 7
Acacia umbellata		Native	1f, 7, 8, 10, 11, 13
Acacia valida		Native	8, 9
Aegialitis annulata (M)	Club Mangrove	Native	1a, 2
Aegiceras corniculatum (M)	River Mangrove	Native	1a, 2
Alphitonia excelsa	Red Ash	Native	1f, 2, 5b, 6, 9, 11, 13
Antidesma ghaesembilla	Murrungun	Native	1a,1b,1d,1e,1f,2,3a,3b,5a,5b,6,7,8,9,10,11,13
Astartea intratropica		Native	4
Asteromyrtus symphyocarpa	Liniment Bush	Native	2, 4, 5a
Atalaya hemiglauca	Whitewood	Native	1a,1b,1c,1d,1e,1f,2,3a,3b,4,5a,6,8,9,10,12,13
Avicennia marina (M)	White Mangrove	Native	1a, 2
Barringtonia acutangula (E)	Freshwater Mangrove	Native	1a,1b,1c,1d,1e,2,3a,3b,4,5a,5b,6,7,8,9,10,11,13
Brachychiton diversifolius	Northern Kurrajong	Native	1f, 6, 8
Bridelia tomentosa		Native	5a, 7, 8, 13
Bruguiera exaristata (M)	Rib-fruited Mangrove	Native	1a, 2
Buchanania obovata	Wild Mango	Native	11, 13
Cajanus sp.		Native	12
Callitris intratropica	Northern Cypress Pine	Native	5b
Calotropis procera	Rubber Bush	Exotic*	1d, 1e, 1f, 5b, 6, 9
Calytrix arborescens		Native	13
Calytrix brownii		Native	8, 11
Calytrix exstipulata	Kimberley Heather / Turkey Bush	Native	10
Calytrix sp.		Native	3a
Canarium australianum	Mango Bark	Native	1e, 5b, 6, 13
Canthium schultzii		Native	13
Capparis sepiaria		Native	1d, 1e, 3a, 12
Carallia brachiata	Carallia Wood	Native	1a
Casuarina cunninghamiana(E)	River Oak / River She-Oak	Native	1a, 1b, 1c, 1d, 2, 3a, 3b, 5a, 5b, 6, 7, 8, 9, 10
Cathormion umbellatum	Cathormion / Bean Tree	Native	1a, 1b, 1c, 1d, 2, 3a, 3b, 5a, 5b, 6, 8, 9, 10
Ceriops australis (M)		Native	1a
Clerodendrum inerme		Native	1a, 3a

Cochlospermum gregorii	Cotton Tree	Native	3a, 3b
Cordia dichotoma		Native	8
Crotalaria sp.		Native	10
Croton sp.		Native	5a
Cullen balsamica	Clustered Cullen	Native	13
Dichrostachys spicata	Prickly Bush	Native	3b, 9
Diospyros cordifolia		Native	1e, 6, 9
Diospyros humilis	Ebony	Native	1d, 1e, 3a, 4, 8, 13
Dodonaea platyptera		Native	1d, 1e, 3a, 3b, 6, 8, 9, 10, 12
Dolichandrone filiformis		Native	2, 10
Ehretia saligna	Coonta	Native	1d, 2, 3a, 6, 10, 11
Elaeocarpus arnhemicus		Native	2
Erythrina vespertilio	Batswing Coral Tree	Native	3b
Erythrophleum chlorostachys	Cooktown Ironwood	Native	1f, 2, 5a, 5b, 6, 8, 13
Eucalyptus alba	White Gum	Native	8
Eucalyptus aspera	Rough-leaved Range Gum	Native	3a
*Eucalyptus bella***	Ghost Gum	Native	1b, 1d, 1e, 1f, 2, 3a, 3b, 4, 5b, 6, 9
Eucalyptus camaldulensis (E)	River Red Gum	Native	1a,1b,1d,1e,1f,2,3a,3b,4,5a,5b,6,7,8,9,10,11,13
Eucalyptus foelscheana	Fan-leaved Bloodwood	Native	13
Eucalyptus latifolia	Round-leaved Bloodwood	Native	1f, 8
Eucalyptus microtheca	Coolibah	Native	1a, 1b, 1c, 1d, 1e, 3a, 5a, 5b, 6, 10, 12
Eucalyptus oligantha	Broad-leaved Box	Native	6
Eucalyptus patellaris	Weeping Box	Native	1f, 5b, 8
Eucalyptus polycarpa	Long-fruited Bloodwood	Native	1f, 2, 5b, 12
Eucalyptus polycarpa x ptychocarpa		Native	3b
Eucalyptus ptychocarpa	Swamp Bloodwood	Native	1f, 8
Eucalyptus tectifica	Darwin Box	Native	3a, 3b, 4, 11
Eucalyptus tetrodonta	Darwin Stringybark	Native	1f, 13
Excoecaria ovalis (M)		Native	1a, 2
Excoecaria parvifolia	Guttapercha Tree	Native	1a,1b,1c,1d,1e,1f,2,3a,3b,5a,5b,6,7,8,9,10,12
Exocarpos latifolius	Native Cherry	Native	1d, 1e
Ficus coronulata	Peach-leaf Fig	Native	1d, 2, 3a, 5b, 6, 7, 8, 9, 10, 11, 13
Ficus opposita	Sandpaper Fig	Native	1e, 12
Ficus platypoda	Native Fig / Rock Fig	Native	10, 13
Ficus racemosa	Cluster Fig	Native	1a, 1d, 1e, 6, 7, 8, 9, 12
Ficus virens	Banyan	Native	1e, 5b, 10
Flemingia lineata		Native	5b
Flueggea virosa	White Current Bush	Native	1b,1d,1e,1f,2,3a,3b,4,5a,6,7,8,9,10,12,13
Glochidion apodogynum		Native	8
Glochidion perakense	Buttonwood	Native	8
Gossypium hirsutum	Upland Cotton	Exotic	1d
Grevillea pteridifolia	Fern-leaved Grevillea	Native	1f, 3a, 4, 5b, 6, 7, 8, 11, 13
Grevillea sp.		Native	3a
Grevillea striata	Beefwood	Native	2
Grewia breviflora		Native	8, 9
Grewia retusifolia	Emu Berries	Native	1e, 1f, 2, 4, 5a, 6, 8, 9, 10, 11, 12, 13
Grewia sp.		Native	1d, 1e, 7, 8, 9, 10, 11, 12
Gyrocarpus americanus	Stinkwood	Native	1d

Hakea arborescens	Common Hakea	Native	1d, 5b, 8, 10, 13
Hibiscus meraukensis	Merauke Hibiscus	Native	1a, 2, 3a, 3b, 4, 5a, 6, 7, 9, 10, 11, 13
Hibiscus panduriformis	Yellow Hibiscus	Native	1a, 1b, 1c, 1d, 1f, 3a, 5a, 5b, 12
Ixora klanderana		Native	1a
Jatropha gossypiifolia	Bellyache Bush	Exotic*	1e
Leucaena leucocephala	Leucaena	Exotic	1f
Livistona rigida (E) (P)		Native	1d, 1e, 1f, 3a, 12, 13
Lophostemon grandiflorus (E)	Northern Swamp Box	Native	1e, 1f, 2, 3a, 3b, 5a, 5b, 6, 7, 8, 9, 12, 13
Lumnitzera racemosa (M)	White-flowered Black Mangrove	Native	1a, 2
Lysiphyllum cunninghamii	Bauhinia	Native	1c, 1d, 1e, 1f, 3a, 3b, 8, 9
Mallotus nesophilus		Native	1e
Margaritaria dubium-traceyi		Native	2, 11
Melaleuca argentea (E)	Silver Paperbark	Native	1a, 1b, 1c, 1d, 1e, 1f, 3a, 4, 5a, 5b, 6, 12, 13
Melaleuca cajuputi	Cajuput Tree	Native	1f
Melaleuca dealbata	Blue-leaved Paperbark	Native	1f
Melaleuca leucadendra (E)	Cajaput / Weeping Paperbark	Native	1a,1b,1d,1e,1f,2,3a,3b,4,5a,5b,6,7,8,9,10,12,13
Melaleuca viridiflora (E)	Green Paperbark	Native	1f, 2, 4, 5b, 7, 8, 11, 12
Nauclea orientalis	Leichhardt Tree	Native	1a, 1b, 1d, 1e, 1f, 3a, 5a, 5b, 6, 8, 9, 12, 13
Owenia vernicosa	Emu Apple	Native	3a
Pandanus aquaticus (E)	River Pandanus	Native	1a,1b,1c,1d,1e,1f,3a,4,5a,5b,6,7,8,9,11,13
Pandanus sp.		Native	2
Pandanus spiralis	Screw Palm	Native	1f, 2, 5b, 6, 8, 11, 12, 13
Parkinsonia aculeata	Parkinsonia	Exotic*	1a, 1d, 1e, 12
Petalostigma banksii	Smooth-leaved Quinine	Native	5b
Petalostigma quadriloculare	Quinine Bush / Witchetty Bush	Native	11
Phyllanthus maderaspatensis		Native	9
Phyllanthus reticulatus		Native	1a, 1b, 1d, 1e, 2, 3a, 5a, 5b, 6, 9, 12, 13
Phyllanthus sp.		Native	1b, 1d, 1e, 2, 3a, 7, 9, 10
Pouteria sericea		Native	1e
Premna acuminata		Native	5b
Psychotria nesophila		Native	5b
Rhizophora stylosa (M)	Small-stilted Mangrove	Native	1a, 2
Santalum lanceolatum	Plumbush / Sandalwood	Native	2
Senna obtusifolia	Sicklepod	Exotic*	1a, 5b, 6, 8, 9
Senna occidentalis	Coffee Senna	Exotic*	11
Senna venusta		Native	11
Sesbania sp.		Native	10
Sida rohlenae	Shrub Sida	Native	1d, 3a, 3b, 4, 5a, 6, 8, 9, 10, 12, 13
Sida spinosa	Spiny Sida	Native	7
Strychnos lucida	Strychnine Bush	Native	1a,1c,1d,1e,2,3a,3b,5a,5b,6,8,9,10,12,13
Syzygium eucalyptoides	White Apple	Native	4, 5a, 11
Syzygium suborbiculare	Forest Satinash / Red Bush Apple	Native	13
Terminalia erythrocarpa (E)		Native	1d, 1e, 1f, 5a, 5b, 6
Terminalia microcarpa		Native	6
Terminalia platyphylla (E)	Durin	Native	1a,1b,1c,1d,1e,1f,2,3a,3b,5a,5b,6,7,8,9,10,11,13
Terminalia pterocarya (E)		Native	3b, 4, 5a, 5b, 7, 8, 10, 11, 12
Terminalia volucris	Rosewood	Native	1a, 1c, 1d, 3a, 3b, 5b, 6, 8, 9, 10
Thespesia populneoides	Portia Tree	Native	1a, 2

Timonius timon		Native	1d, 3a, 5a, 8, 12
Tribulus terrestris	Caltrop	Exotic*	9
Vitex glabrata		Native	1f, 3b, 4, 5a, 5b, 11
Waltheria indica		Native	1f, 2, 3b, 7, 10, 11, 13
Wrightia pubescens		Native	5b, 6
Wrightia saligna	Milk Bush	Native	5a
Xylocarpus mekongensis (M)		Native	1a, 2
Ziziphus mauritiana	Chinnee Apple	Exotic*	12
Ziziphus quadrilocularis		Native	6
Ground Covers			
Abrus precatorius	Crab's Eyes	Native	1e
Abutilon subviscosum		Native	1d
Abutilon indicum	Indian Lantern Flower	Native	1e
Abutilon sp.		Native	1d, 8
Achyranthes aspera	Chaff-flower	Native	1a, 1b, 1c, 1d, 2, 3a, 3b, 4, 5a, 9, 10, 13
Acrostichum speciosum	Mangrove Fern	Native	1a, 3a
Alternanthera nodiflora	Common Joyweed	Native	1a, 1b, 1c, 1d, 3a, 3b, 5a, 10, 13
Alternanthera sp.		Native	1f
Alysicarpus ovalifolius	Gilbert River Clover	Native	7
Alysicarpus vaginalis	Buffalo Clover	Native	9
Ammannia multiflora	Jerry Jerry	Native	1a, 9, 13
Aristida holathera	Erect Kerosene Grass	Native	2, 5a, 7, 8, 13
Aristida sp.		Native	1a
Arundinella nepalensis	Reedgrass	Native	4, 7, 8, 11, 13
Basilicum polystachon	Musk Basil	Native	1d, 6
Bidens bipinnata	Cobbler's Pegs	Exotic	1d, 3b, 10
Blumea axillaris		Native	1d, 1e, 9
Blumea saxatilis		Native	3a
Blumea tenella		Native	3b, 7, 9, 13
Bonamia pannosa		Native	1e
Bothriochloa bladhii	Forest Bluegrass	Native	1e, 1f, 3b
Bothriochloa ewartiana	Desert Bluegrass	Native	3b, 5a, 5b, 8, 12
Bothriochloa pertusa	Indian Bluegrass	Exotic	8
Brachyachne convergens	Spider Grass	Native	3b
Canavalia papuana		Native	1a, 9
Cayratia maritima		Native	5b
Cayratia trifolia		Native	1a, 1d, 2, 3b, 5a, 6, 10, 12
Centaurium spicatum	Australian Centaury	Native	1b, 1e
Centipeda minima	Spreading Sneezeweed	Native	8, 9
Cheilanthes sp.		Native	1f
Chionachne cyathopoda	River Grass	Native	1a, 1b, 1e, 3a, 5a, 9, 10
Chrysopogon fallax	Golden Beard Grass	Native	1a, 1b, 1c, 1d, 5a, 7, 9, 10
Chrysopogon sp.		Native	1d, 1f, 3b, 10
Cleome viscosa	Tickweed	Native	1b
Clitoria ternatea	Butterfly Pea	Exotic	1f
Coldenia procumbens		Native	1d, 1f
Commelina ensifolia	Wandering Jew	Native	2, 5a, 6, 9
Crinum sp.		Native	1f
Crotalaria crispata	Kimberley Horse Poison	Native	11

Crotalaria goreensis	Gambia Pea	Exotic	1f, 8, 11
Crotalaria montana		Native	1b
Crotalaria retusa	Wedge-leaf Rattlepod	Native	6
Cyanotis axillaris		Native	3a, 4
Cymbidium canaliculatum	Black Orchid	Native	10, 12
Cynanchum carnosum		Native	1a, 2
Cynodon dactylon	Couch Grass	Native	1b, 1c, 1e, 1f, 3a, 8, 12, 13
Cynodon radiatus		Native	12
Cyperus aquatilis (E)		Native	3a, 4, 7, 11
Cyperus conicus		Native	4
Cyperus exaltatus (E)	Giant Sedge	Native	3b, 10
Cyperus haspan (E)		Native	1f, 3a, 4, 8, 9, 11, 13
Cyperus holoschoenus (E)		Native	1f, 3b, 4, 5b, 11, 12, 13
Cyperus javanicus (E)		Native	1a, 1e, 5a, 8, 9, 11, 13
Cyperus polystachyos	Bunchy Sedge	Native	1f, 3a, 6, 8
Cyperus scariosus		Native	1a
Cyperus sp.		Native	1d, 3a, 8
Dactyloctenium aegyptium	Coast Button Grass	Exotic	3b, 9
Dichanthium fecundum	Curly Bluegrass	Native	1a, 1d, 2, 3b, 4, 5a, 6, 7, 8, 9, 10, 13
Dichanthium sericeum	Queensland Bluegrass	Native	1d, 9, 12
Dichanthium sp.		Native	6
Digitaria sp. (D. bicornis or D. ciliaris)	Hairy Finger Grass or Summer Grass	Native	3b, 9, 13
Drosera burmanni	Burman's Sundew	Native	3a, 11
Drosera indica	Flycatcher	Native	4
Drosera sp.		Native	4, 8
Echinochloa colona	Awnless Barnyard Grass	Exotic	3b, 6, 9, 13
Ectrosia leporina	Hare's-foot Grass	Native	4, 8, 11
Ectrosia schultzii		Native	2, 5a, 7
Eleocharis atropurpurea		Native	10
Enteropogon sp.		Native	5a, 6, 9, 10, 13
Epaltes australis	Spreading Nut Heads	Native	1f
Eragrostis cumingii	Cuming's Lovegrass	Native	2, 4, 5a, 5b, 6, 7, 8, 9, 10, 11, 12, 13
Eragrostis sp.		Native	1c, 1e, 8
Eragrostis tenellula	Delicate Lovegrass	Native	1b, 1d, 3a, 3b, 9, 10, 11, 12
Eriachne avenacea		Native	11
Eriachne burkittii		Native	5b
Eriachne glauca	Pan Wanderrie	Native	4, 11
Eriochloa sp.		Native	3b
Eulalia aurea		Native	9
Euphorbia heterophylla	Painted Spurge	Exotic	1f, 9
Euphorbia hirta	Asthma Plant	Exotic	1e, 1f, 8
Fimbristylis acuminata		Native	5b
Fimbristylis dichotoma	Eight Day Grass	Native	3a, 6
Fimbristylis ferruginea (E)		Native	1d, 1e, 1f
Fimbristylis littoralis (E)		Native	2, 3a, 5b, 10, 11, 12, 13
Fimbristylis microcarya		Native	3a, 10
Fimbristylis nutans (E)		Native	1f, 8
Fimbristylis pauciflora (E)		Native	4, 6, 8

Fimbristylis punctata		Native	8
Fimbristylis sp.		Native	1a, 2, 11, 12
Fimbristylis squarrulosa		Native	2
Flagellaria indica	Vine Reed-cane	Native	1a, 1b, 1c, 1d, 1e, 1f, 2, 3a, 5a, 7, 8, 9, 13
Flemingia pauciflora		Native	10, 12
Fuirena ciliaris		Native	3a, 7, 8, 9, 11, 13
Glinus lotoides	Hairy Carpet Weed	Native	1c, 12
Glinus oppositifolius		Native	1b
Glycine tomentella	Rusty Glycine	Native	12, 13
Gonocarpus leptothecus		Native	11
Goodenia sp.		Native	1f
Gymnanthera oblonga		Native	1a, 1b, 1c, 1d, 1e, 2, 3a, 5a, 5b, 6, 7, 8, 9, 13
Halosarcia indica		Native	1a
Heliotropium indicum		Native	5a
Heliotropium ovalifolium		Native	1a, 1b, 1d, 1e
Heterachne gulliveri		Native	6
Heteropogon contortus	Bunch Speargrass	Native	1d, 3a, 3b, 4, 5a, 6, 7, 8, 9, 10, 11, 12, 13
Heteropogon triticeus	Giant Speargrass	Native	6, 8, 11
Hybanthus enneaspermus	Spade Flower	Native	5a
Hydrolea zeylanica		Native	1f, 12
Hygrophila angustifolia		Native	1a, 2, 3a, 3b, 4, 5a, 5b, 6, 7, 9, 10, 11, 12, 13
Hyptis suaveolens	Hyptis	Exotic*	1d, 1e, 1f, 3a, 3b, 5b, 6, 7, 8, 9, 10, 11, 13
Imperata cylindrica	Blady Grass	Native	1b, 12
Indigofera linifolia	Native Indigo	Native	3a, 3b
Ipomoea incisa		Native	1b
Ipomoea nil		Native	3a
Ipomoea plebeia	Bellvine	Native	8, 9
Ipomoea sp.		Native	1a, 10
Ischaemum australe		Native	1a, 1f, 8, 9, 11, 13
Ischaemum sp.		Native	1f
Iseilema sp.		Native	1d, 3a, 3b, 5b, 6, 10, 12
Jasminum molle		Native	9, 10
Leptochloa fusca		Native	1f
Leptochloa neesii	Swampgrass	Native	12
Lipocarpha microcephala	Button Rush	Native	2, 11, 13
Ludwigia octovalvis	Willow Primrose	Native	4, 10, 11, 13
Ludwigia perennis		Native	3b
Luffa cylindrica	Loofah	Native	1b
Melhania oblongifolia	Velvet Hibiscus	Native	12
Melochia corchorifolia		Native	4
Melochia pyramidata		Exotic	1a, 1b, 1e, 2, 5a, 5b, 6, 10, 12
Merremia gemella		Native	1a, 1c, 1d, 2, 3a, 5a, 6
Merremia hederacea		Native	3a
Mnesithea rottboellioides		Native	1d, 1f, 2, 3b, 4, 5a, 5b, 7, 8, 9, 10, 11, 12, 13
Nelsonia campestris (E)		Native	2, 3a, 4, 5a, 6, 7, 8, 9, 10, 11, 12, 13
Neptunia sp.		Native	5b, 6
Nicotiana sp.		Native	1e
Operculina aequisepala		Native	3a, 3b
Ophiuros exaltatus		Native	10, 12

Panicum decompositum	Native Millet	Native	1d, 3b, 4, 8, 10, 13
Panicum mindanaense		Native	1a, 1b, 1d, 2, 3a, 4, 5a, 5b, 6, 7, 8, 9, 10, 11, 13
Panicum trachyrhachis	Coolibah Grass	Native	1f
Panicum trichoides		Native	5b
Paspalidium distans		Native	1a, 1b, 1c, 1d, 2, 3a, 3b, 5a, 5b, 6, 8, 9, 10, 13
Paspalum scrobiculatum	Scrobic	Native	1a, 1d, 1e, 5b, 6, 8, 13
Passiflora foetida	Stinking Passion Flower	Exotic	1a,1b,1c,1d,1e,1f,2,3a,3b,4,5a,5b,6,8,9,10,11, 12, 13
Pennisetum pedicellatum		Exotic	1d, 3b, 5b, 6, 9, 10
Phyla nodiflora (E)	Lippia	Exotic	1d, 12
Physalis minima	Wild Gooseberry	Native	3a
Plumbago zeylanica		Native	3a
Polymeria ambigua	Creeping Polymeria	Native	1f, 2, 5a, 5b, 7, 10
Portulaca sp.		Native	13
Pseudopogonatherum irritans		Native	8
Pseudoraphis spinescens (E)	Spiny Mudgrass	Native	1a,1b,1c,1d,1f,2,3a,4,5a,5b,7,8,9,10,11,12,13
Rhynchosia minima	Rhyncosia	Native	3b, 10
Rhynchospora longisetis		Native	5b, 6, 8
Rostellularia adscendens		Native	3a, 3b, 6
Sacciolepis indica	Indian Cupscale Grass	Native	1f, 6, 8
Sacciolepis myosuroides		Native	11
Schizachyrium fragile	Small Redleaf	Native	6
Schizachyrium sp.		Native	5b, 6, 8
Sehima nervosum	Rats Tail Grass	Native	2, 3a, 3b, 4, 10, 11, 12
Sesbania cannabina	Yellow Pea Bush	Native	1d
Sesbania sp.		Native	1f, 3b
Sesuvium portulacastrum	Sea Purslane	Native	1a
Setaria apiculata	Pigeon Grass	Native	9
Sida acuta	Spiny-head Sida	Exotic*	1a, 5b, 8, 9, 13
Sida cordifolia	Flannel Weed	Exotic*	5b, 13
Sida virgata		Native	1e
Sorghum grande		Native	3a, 3b, 5a, 7, 8, 9, 10
Sorghum matarankense		Native	2, 9
Sorghum sp.		Native	2, 4, 5a, 7, 9, 11, 13
Sorghum stipoideum	Annual Native Sorghum	Native	1f, 2, 13
Spermacoce brachystema		Native	3b
Spermacoce breviflora		Native	11
Sphaeranthus africanus		Native	1a, 2
Sporobolus virginicus	Sand Couch	Native	1a, 1b
Staurogyne leptocaulis		Native	11, 12
Streptoglossa odora		Native	1d
Stylosanthes hamata	Verano Stylo	Exotic	1b
Tephrosia sp.		Native	3a
Themeda arguens		Native	6
Themeda quadrivalis	Grader Grass	Exotic*	6
Themeda triandra	Kangaroo Grass	Native	2, 7, 10, 11
Triumfetta pentandra		Exotic	3b, 5b, 8, 9
Triumfetta sp.		Native	1e
Urena australiensis		Native	13

Urochloa mosambicensis	Sabi Grass	Exotic	1e, 10
Urochloa mutica		Native	1d
Urochloa sp.		Native	12
Vetiveria elongata		Native	1a, 1b, 2, 5a, 7, 12
Vetiveria pauciflora		Native	1f, 3a, 3b, 4, 5a, 5b, 6, 8, 9, 12, 13
Whiteochloa airoides		Native	2
Xanthium occidentale	Noogoora Burr	Exotic*	6
Xenostegia tridentata		Native	11, 13
Xerochloa imberbis	Rice Grass	Native	1a
Aquatic vegetation*			
Aponogeton queenslandicus (S)		Native	4
Aponogeton sp. (S)		Native	5b, 13
Ceratopteris thalictroides (E)	Water Fern	Native	1e
Chara sp. (S)	Stoneworts	Native	1a, 1b, 1c, 1d, 1e, 1f, 3b, 12
Commelina agrostophylla (E)		Native	4, 11
Eleocharis geniculata (E)		Native	1b, 1d, 1e, 3a, 3b, 8
Eleocharis sp. (E)		Native	4, 11
Eriocaulon setaceum (S)		Native	11, 13
Hydrilla verticillata (S)	Water Thyme	Native	1a
Isolepis humillima (E)		Native	9, 12
Lemna aequinoctialis (F)		Native	3a
Limnophila brownii (S)		Native	5b, 8
Limnophila sp. (S)		Native	1f, 4
Marsilea sp. (F)	Nardoo	Native	1a, 1f, 3a, 4, 10
Myriophyllum dicoccum (S)		Native	4
Najas sp. (S)		Native	4, 5b, 12
Nitella sp. or Chara sp. (S)		Native	1a, 3a
Nymphaea violacea (F)		Native	1e, 1f, 3a, 4, 5b, 10, 12
Nymphoides aurantiaca (F)		Native	4
Nymphoides indica (F)	Fringed Waterlily	Native	1f
Nymphoides sp. (F)		Native	4, 11
Ottelia alismoides (S)		Native	1d, 1e, 1f
Persicaria attenuata (E)		Native	5a, 9, 12
Persicaria barbata (E)		Native	1a, 8
Philydrum lanuginosum (E)	Woolly Waterlily	Native	1f
Phragmites karka (E)	Tropical Reed	Native	1d, 1e, 1f, 6
Potamogeton crispus (S)	Curly Pondweed	Native	1d
Potamogeton javanicus (S)		Native	10
Rotala mexicana (S)		Native	13
Schoenoplectus litoralis (E)		Native	1a, 1d, 1e
Triglochin dubia (S)		Native	1d, 1f, 2, 4, 11, 13
Typha domingensis (E)	Cumbungi	Native	1d, 1f
Utricularia gibba (S)		Native	3a
Vallisneria nana (S)		Native	1a, 1b, 1c, 1d, 3a, 5a, 5b, 6, 8

* Declared Noxious Weed within the Northern Territory
** Previously called *Eucalyptus papuana*
*** Previously called *Vallisneria spiralis*
**** Aquatic vegetation categories or zones: E = Emergent, F = Floating, S = Submerged
E Also recorded as emergent aquatic vegetation
M Mangrove species
P Palm species

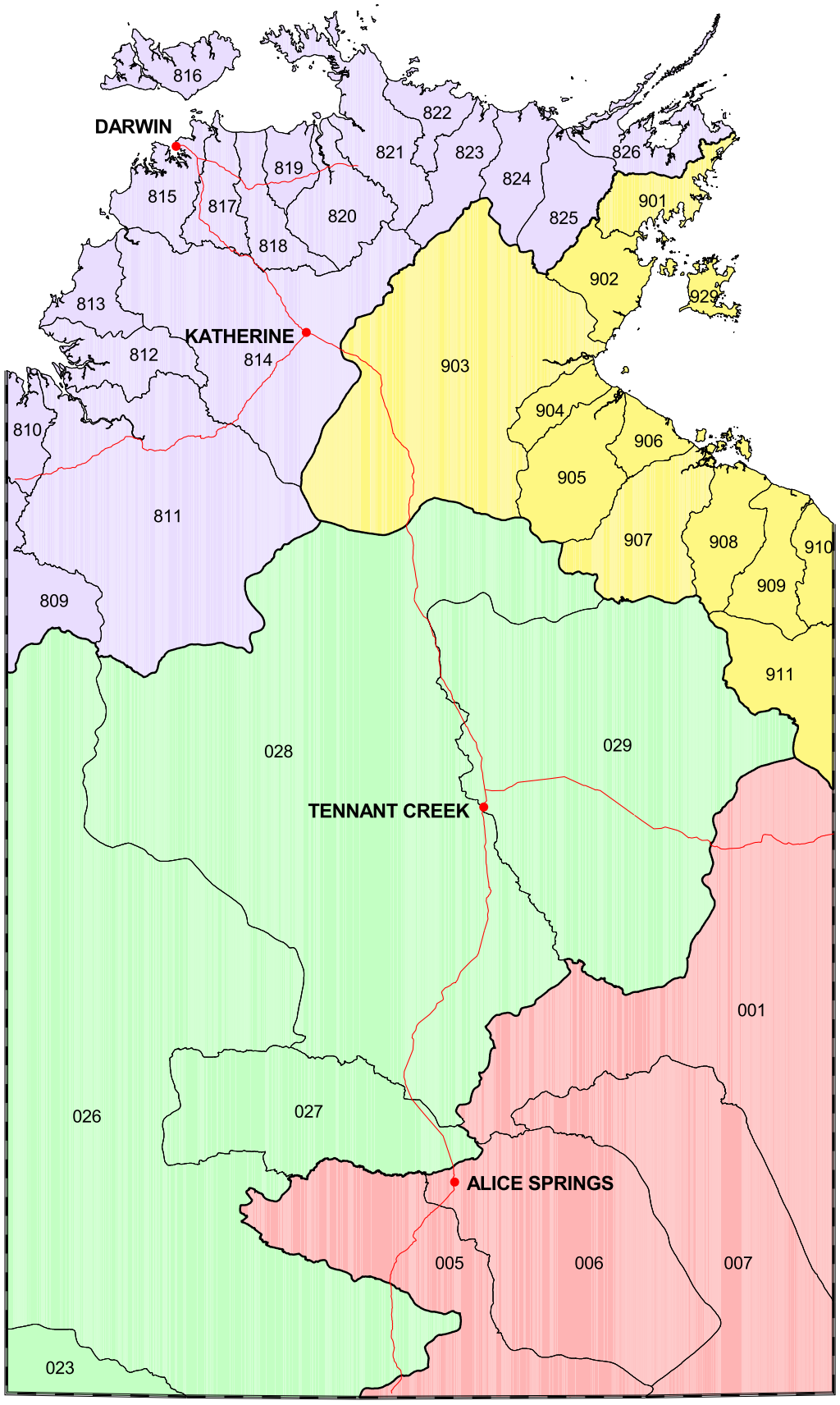
MAPS

The following Maps appear in this section:

The maps published in this report were compiled using Software, ArcInfo and ArcView Geographic Information System, by Natural Resources Division, Department of Lands, Planning and Environment (DLPE), Katherine.

DATA SOURCE:

Catchment boundaries:	The catchment and sub-section boundaries were delineated by C. Green (DLPE, Katherine) using AUSLIG 1:100,000 topographic map sheets. These boundaries were then digitised.
Cadastre (property boundaries):	Land Information Services, DLPE, Darwin
Park boundaries:	Parks and Wildlife Commission NT, Darwin
Rivers, creeks and roads:	AUSLIG 1:250,000 topographic digital sheets
Landform (Map 3):	Northcote (1968) at a survey scale 1:2,000,000
Vegetation (Map 4):	Wilson *et al.* (1990) at a survey scale 1:1,000,000
Wetlands (Map 4):	ANCA (1993)
Stream Orders (Map 8):	D. Williams, Natural Resources Division, DLPE, Darwin. Stream orders were compiled using ArcGrid. The stream network was generated using a Digital Elevation Model (DEM) and was based on a 1:250,000 map scale. Stream orders have been assigned to rivers and creeks using the Strahler system.
Water resource data:	HYDSYS database, Natural Resources Division, DLPE, Darwin



DRAINAGE DIVISIONS

LAKE EYRE
- 001 Georgina River
- 005 Finke River
- 006 Todd River
- 007 Hay River

WESTERN PLATEAU
- 023 Warburton
- 026 Mackay
- 027 Burt
- 028 Wiso
- 029 Barkly

TIMOR SEA
- 809 Ord River
- 810 Keep River
- ✱ 811 Victoria River
- 812 Fitzmaurice River
- 813 Moyle River
- ✱ 814 Daly River
- 815 Finniss River
- 816 Bathurst & Melville Islands
- 817 Adelaide River
- 818 Mary River
- 819 Wildman River
- 820 South Alligator River
- 821 East Alligator River
- 822 Goomadeer River
- 823 Liverpool River
- 824 Blyth River
- 825 Goyder River
- 826 Buckingham River

GULF OF CARPENTARIA
- 901 Koolatong River
- 902 Walker River
- ▲ 903 Roper River
- 904 Towns River
- 905 Limmen Bight River
- 906 Rosie River
- 907 McArthur River
- 908 Robinson River
- 909 Calvert River
- 910 Settlement River
- 911 Nicholson River
- 929 Grooyte Eylandt

Division Boundary

Basin Boundary

N

0 50 100 150 200

Kilometres

▲ Baseline data collected for Top End Waterways Project - Mark 2 (1998 - 1999)

✱ Baseline data collected for Top End Waterways Project (1995 - 1997)

TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

NATIONAL LANDCARE PROGRAM

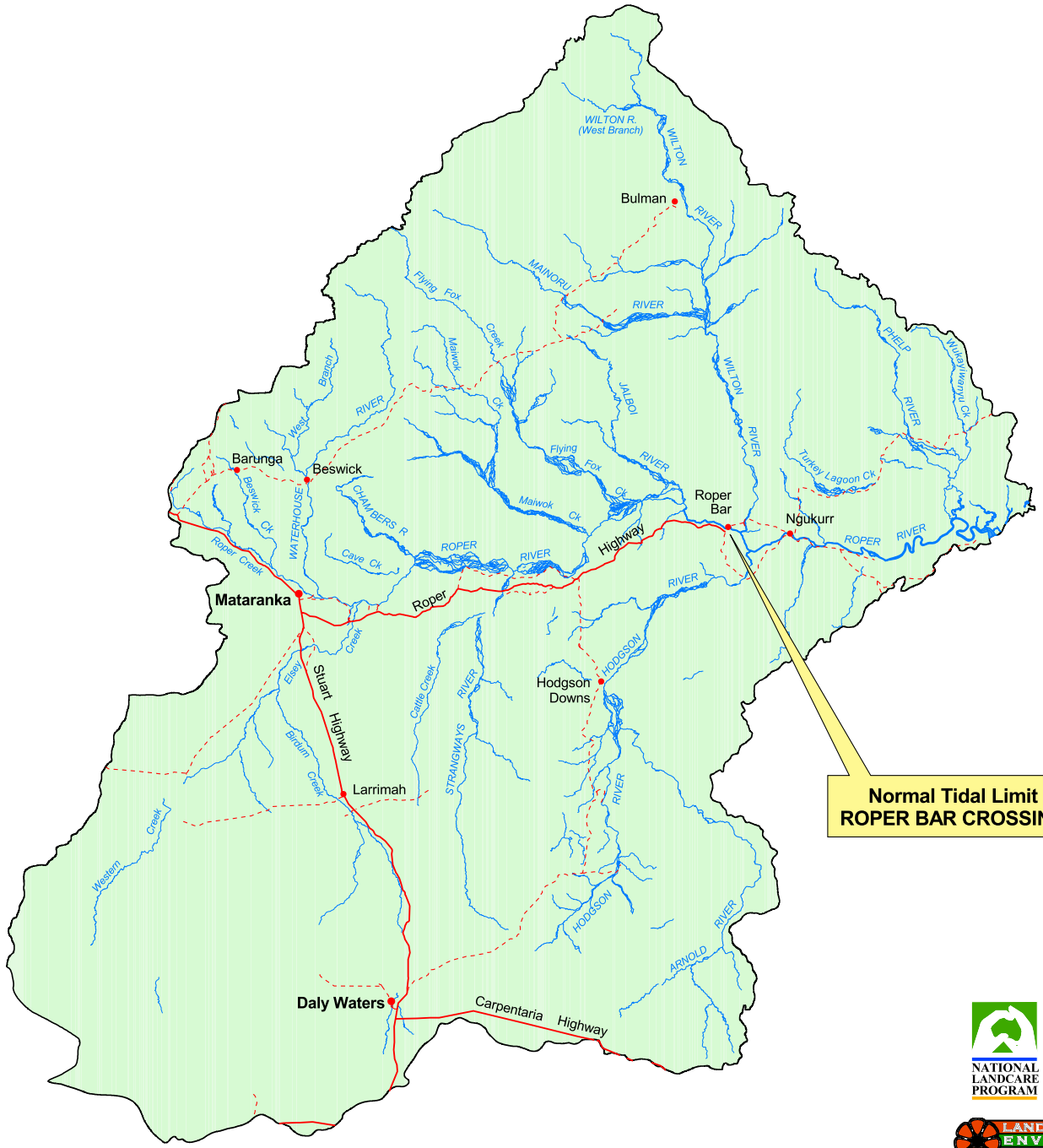
Natural Heritage Trust

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NT DRAINAGE DIVISIONS AND BASINS

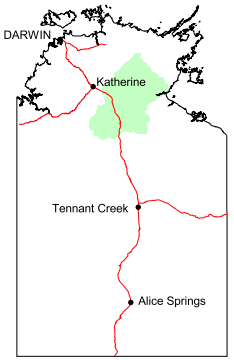
as defined by the Australian Water Resources Council

Map 1



LEGEND

- Catchment Boundary
- Major Road
- Minor Road
- River
- Creek
- Town / Community



CATCHMENT LOCATION

N

0 20 40 60 80 100

Kilometres

NATIONAL LANDCARE PROGRAM

Natural Heritage Trust

LANDS PLANNING ENVIRONMENT
Northern Territory Government

TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

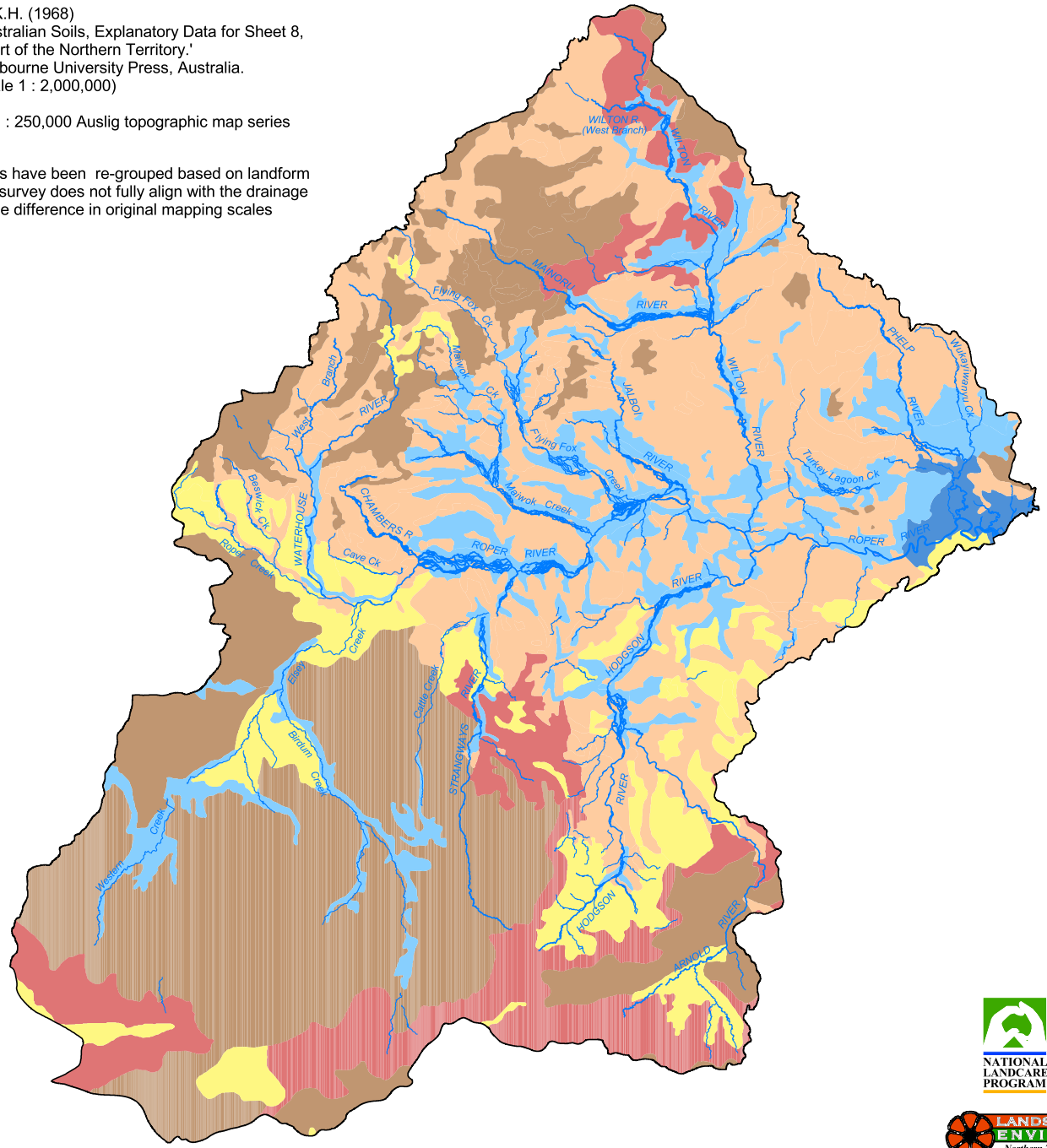
LOCALITY PLAN

Map 2

SOURCE
Northcote, K.H. (1968)
'Atlas of Australian Soils, Explanatory Data for Sheet 8, Northern Part of the Northern Territory.'
CSIRO, Melbourne University Press, Australia.
(Survey Scale 1 : 2,000,000)

Drainage: 1 : 250,000 Auslig topographic map series

NOTE
1. Map units have been re-grouped based on landform
2. The soil survey does not fully align with the drainage due to the difference in original mapping scales



LANDFORM DESCRIPTION

- Plateau surfaces including mesas and buttes. (Map units AB33, AC13, BY1, JV1, JV3, MY2, My79)
- Plateau escarpments, including adjacent rises and associated drainage. (Map units AC14, BY2, BY3, SQ1)
- Ridges, cuestas and associated gorges of the dissected plateau and low to steep hills. (Map units BA7, BA8, BA9, BA14, Cd24, JJ28, JJ31, JJ32, JJ33, JJ34, LK23, Mo24, Mo25, Mo28, My75, My76, OO4)
- Level plains and gently undulating to undulating plains and rises, including associated minor drainage. (Map units AC17, AC18, Cd23, II6, MJ1, Mo26, Ms15, Mt5, My72, My74, My78)
- Major rivers and creeks; their levees, channels, floodplains, backplains and associated billabongs. (Map units CC57, II8, Mb15, Mb16, Mt6, OO2)
- Salt pans and tidal flats inundated by seasonal high tides. (Map unit Io1)

LEGEND

- Catchment Boundary
- River
- Creek

N

0 20 40 60 80 100
Kilometres

NATIONAL LANDCARE PROGRAM

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LANDS PLANNING ENVIRONMENT
Northern Territory Government

TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

LANDFORM
(Broad scale mapping)

Map 3

Important Wetlands Source:
Aust. Nature Conservation Agency (1993)
'A Directory of Important Wetlands in Australia'.

1 **Limmen Bight (Port Roper) Tidal Wetlands System**

(includes all tidal mudflats, estuaries and saline coastal flats associated with Phelp River and Roper River, inland to Mt Roper, as well as the Towns and Limmen Bight Rivers. Also includes adjoining permanent shallow marine waters that support seagrass beds)

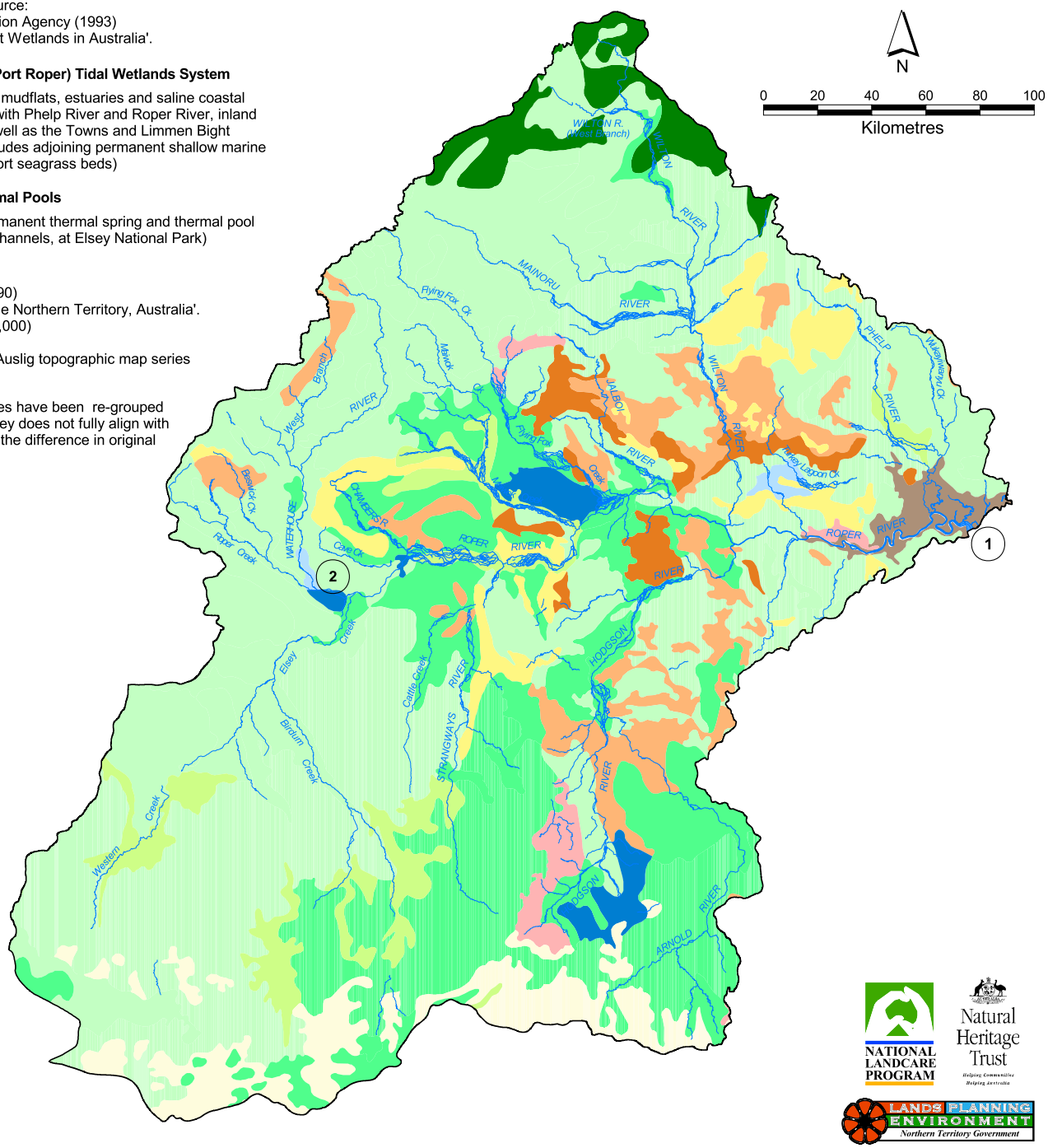
2 **Mataranka Thermal Pools**

(includes the permanent thermal spring and thermal pool and connecting channels, at Elsey National Park)

SOURCE:
Wilson, B.A. *et al.* (1990)
'Vegetation Survey of the Northern Territory, Australia'.
(Survey Scale 1 : 1,000,000)

Drainage: 1 : 250,000 Auslig topographic map series

NOTE
1. Vegetation categories have been re-grouped
2. The vegetation survey does not fully align with the drainage due to the difference in original mapping scales



VEGETATION DESCRIPTION

EUCALYPT WITH GRASS UNDERSTOREY

Open - Forest
E. miniata, E. tetradonta with *Sorghum* grassland understorey

Woodland
E. bleeseri, E. dichromophloia, E. ferruginea, E. latifolia, E. miniata, E. papuana, E. patellaris, E. polycarpa, E. tectifica, E. tetradonta, E. terminalis, Callitris intratropica
Grassland understorey
Chrysopogon fallax, Plectrachne pungens, Sehima nervosum, Sorghum

Low Woodland
E. chlorophylla, E. dichromophloia, E. microtheca, E. pruinosa, E. terminalis, E. tintinnans, Excoecaria parvifolia
Grassland understorey
Chrysopogon fallax, Dichanthium, Plectrachne pungens, Sehima nervosum, Sorghum

Low Open - Woodland
E. microtheca with *Astrebla, Eulalia aurea, Dichanthium* grassland understorey

EUCALYPT WITH HUMMOCK GRASS UNDERSTOREY

Low Woodland
E. phoenicia with *Plectrachne pungens* hummock grassland understorey

Low - Open Woodland
E. dichromophloia, E. leucophloia, E. miniata, E. tetradonta with *Plectrachne pungens* hummock grassland understorey

MELALEUCA WITH GRASS UNDERSTOREY

Low Woodland
Melaleuca citrolens with *Chysopogon fallax* open-grassland understorey

Low Open Woodland
Melaleuca viridiflora, Eucalyptus with *Chrysopogon fallax* grassland understorey

ACACIA WITH GRASS UNDERSTOREY

Open Forest
A. shirleyi (Lancewood) with open-grassland understorey

Low Woodland / Low Open Woodland
A. shirleyi (Lancewood) low woodland mixed with *Eucalyptus* low open-woodland

GRASSLAND
Chysopogon fallax, Dichanthium fecundum grassland

LITTORAL
Saline tidal flats with scattered chenopod low scrubland (Samphire) including areas of mangrove vegetation

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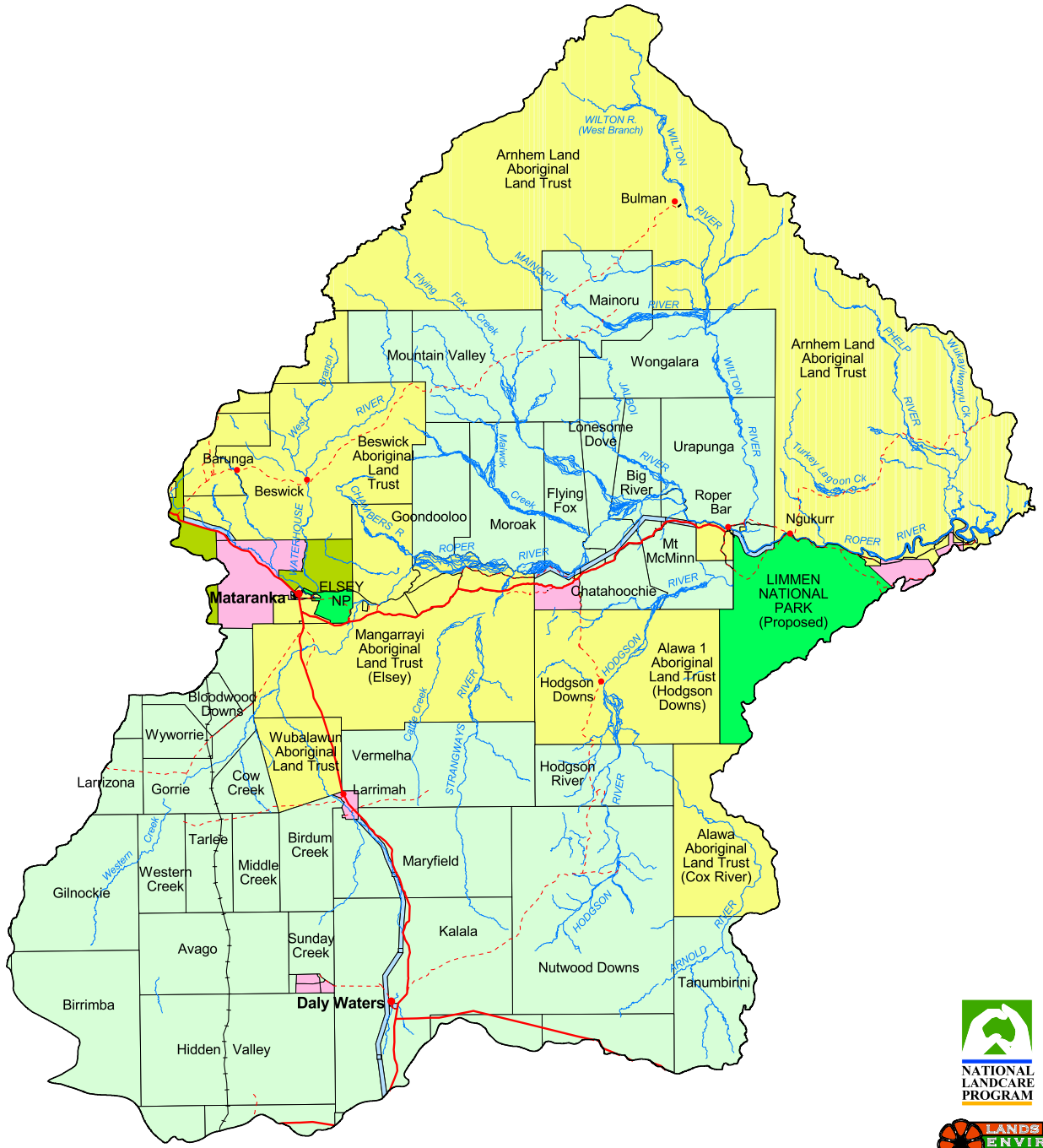
TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

VEGETATION AND IMPORTANT WETLANDS

(Broad scale mapping) **Map 4**



LAND CLASSIFICATION

- National Park or Reserve
- Pastoral Lease
- Vacant Crown Land / Government Use
- Private Freehold
- Crown Lease Term
- Crown Lease Perpetual

LEGEND

- Catchment Boundary
- Major Road
- Minor Road
- River
- Creek
- Railway (under construction)

NOTE

In general, where waterways form property boundaries the bed and banks of the waterway separating such properties is classified as Crown land. Where a waterway lies within a property the bed and banks of the waterway belong to the property owners but the water rights over such waterways belong to the Crown.

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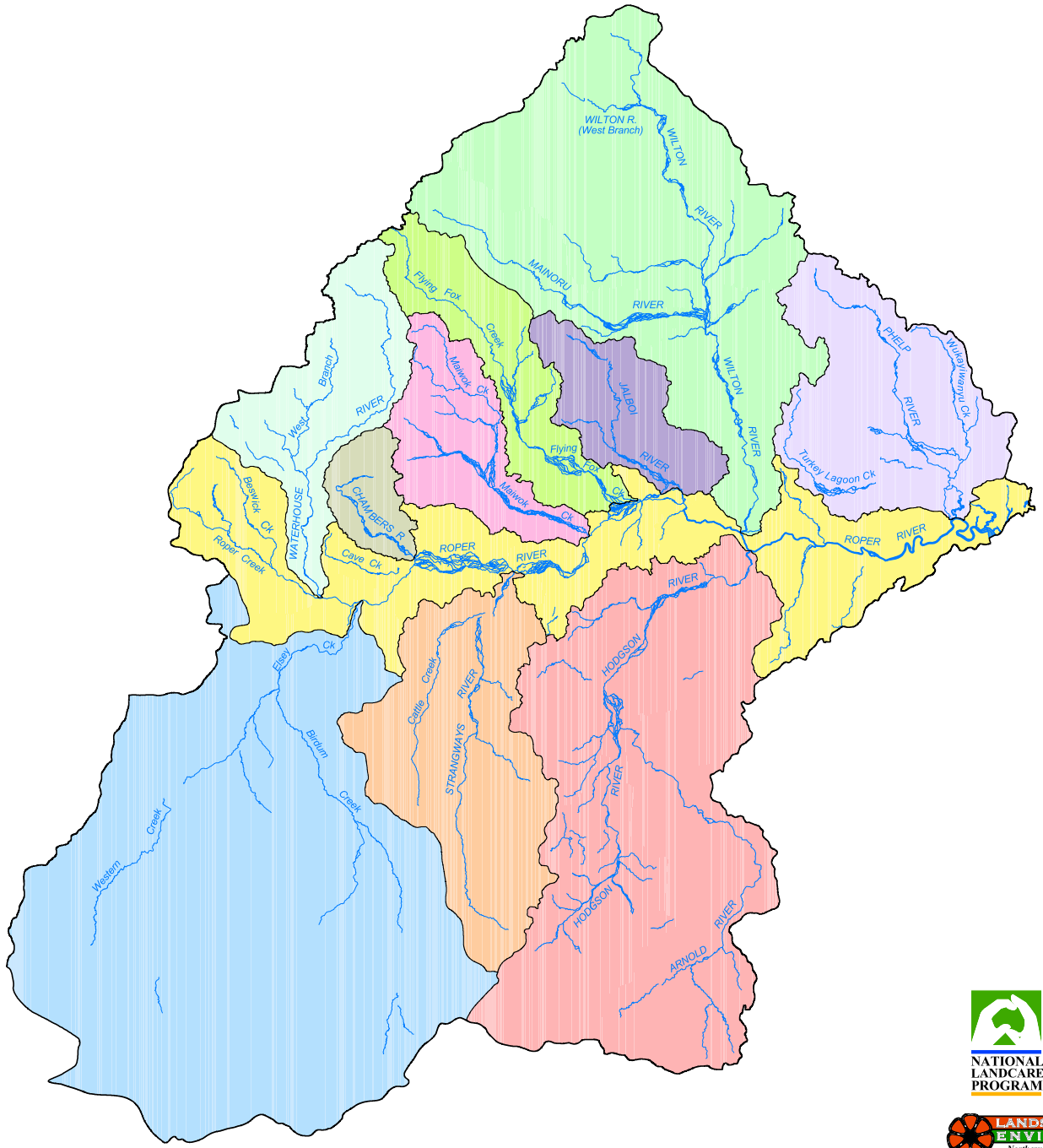
TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

LAND TENURE AND LAND USE

Map 5



MAJOR SUB-CATCHMENTS

- Roper River
- Phelp River
- Hodgson River
- Wilton River
- Jalboi River
- Flying Fox Creek
- Maiwok Creek
- Strangways River
- Chambers River
- Elsey Creek
- Waterhouse River

LEGEND

- Catchment Boundary
- Sub-catchment Boundary
- River
- Creek

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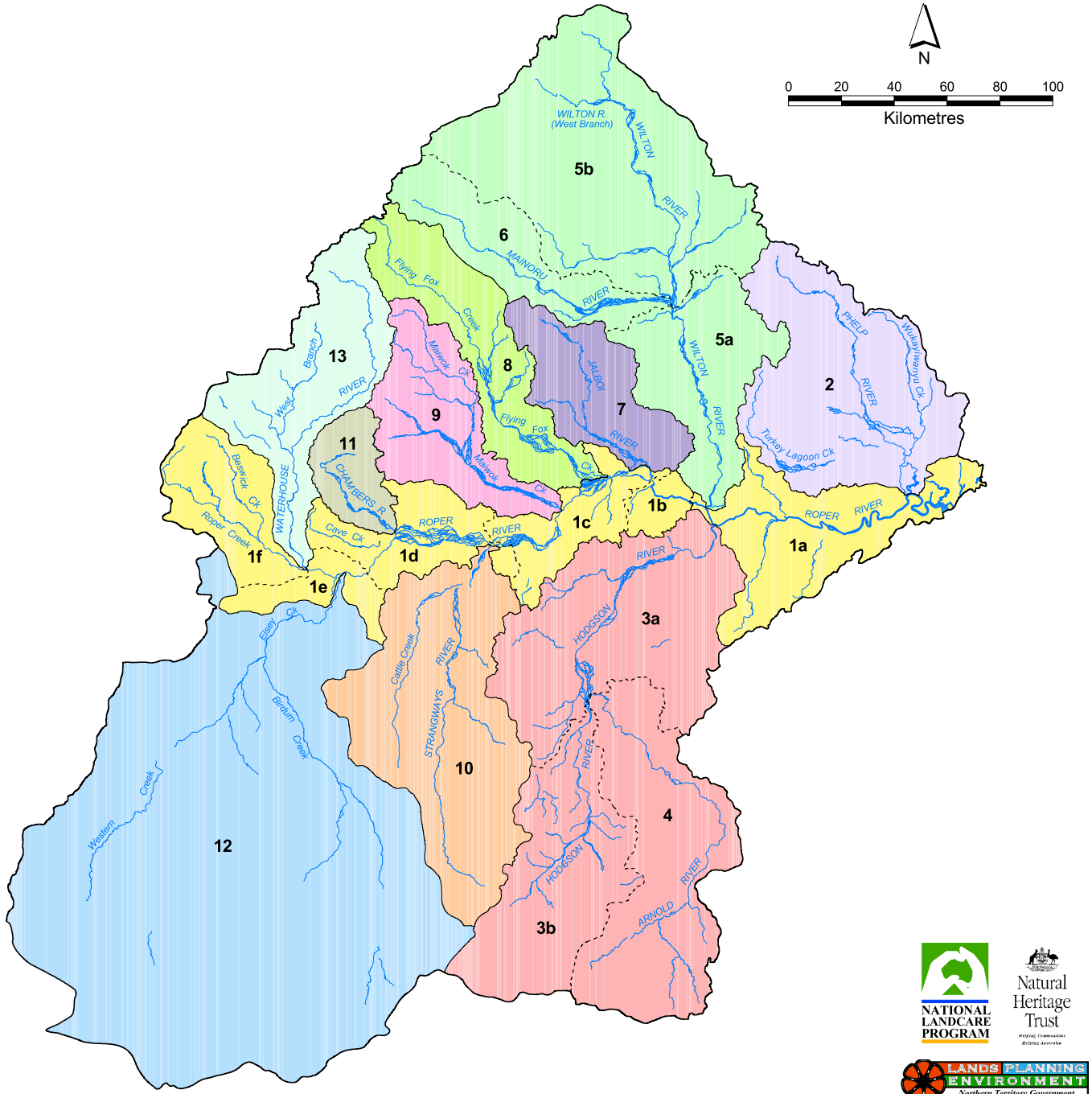
TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

MAJOR SUB-CATCHMENTS

Map 6



SUB SECTION NUMBER	AREA (km²)	SUB SECTION NAME
1	9,556	Roper River
		a. Estuary
		b. Below Jalboi River
		c. Below 57-Mile Waterhole
		d. Red Lily Lagoon, 57-Mile Waterhole
		e. Below Waterhouse River
		f. Upper Roper Creek
2	5,305	Phelp River
3	9,290	Hodgson River
		a. Below Arnold River
		b. Above Arnold River
4	4,819	Arnold River
5	10,423	Wilton River
		a. Below Mainoru River
		b. Above Mainoru River
6	2,271	Mainoru River
7	2,271	Jalboi River
8	3,037	Flying Fox Creek
9	2,770	Maiwok Creek
10	6,142	Strangways River
11	1,051	Chambers River
12	21,210	Elsey Creek
13	3,649	Waterhouse River
TOTAL	**81,794**	**ROPER RIVER CATCHMENT**

LEGEND

- 5a — Sub-section Number
- Catchment Boundary
- Sub-catchment Boundary
- Sub-section Boundary
- River
- Creek

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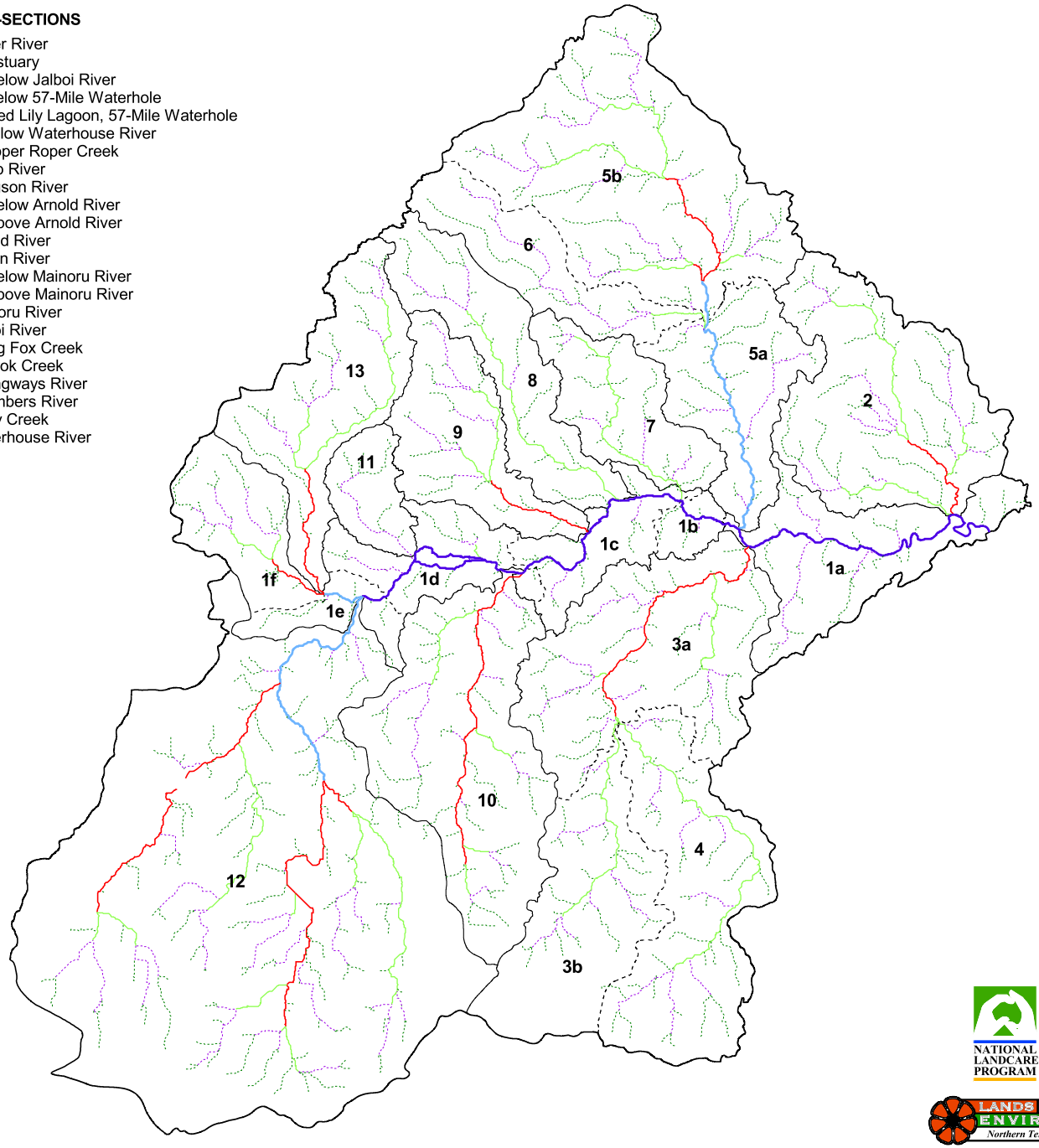
TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

SUB-SECTIONS

Map 7

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River



Stream Order	Stream Length (kms - approx)	No of sites
1	4,854	13
2	2,308	7
3	1,469	24
4	754	14
5	233	11
6	367	24

LEGEND

5a	Sub-section Number
———	Catchment Boundary
———	Sub-catchment Boundary
- - - - -	Sub-section Boundary

NOTE

Stream orders were compiled using ArcGrid. The stream network was generated using a Digital Elevation Model (DEM) and was based on a 1:250,000 map scale.

Stream orders have been assigned to rivers and creeks using the Strahler system. Six stream orders were recorded for Roper River Catchment.

- Minor streams = stream orders 1 and 2.
- Medium - sized streams = stream orders 3 and 4.
- Major streams = stream orders 5 and 6.

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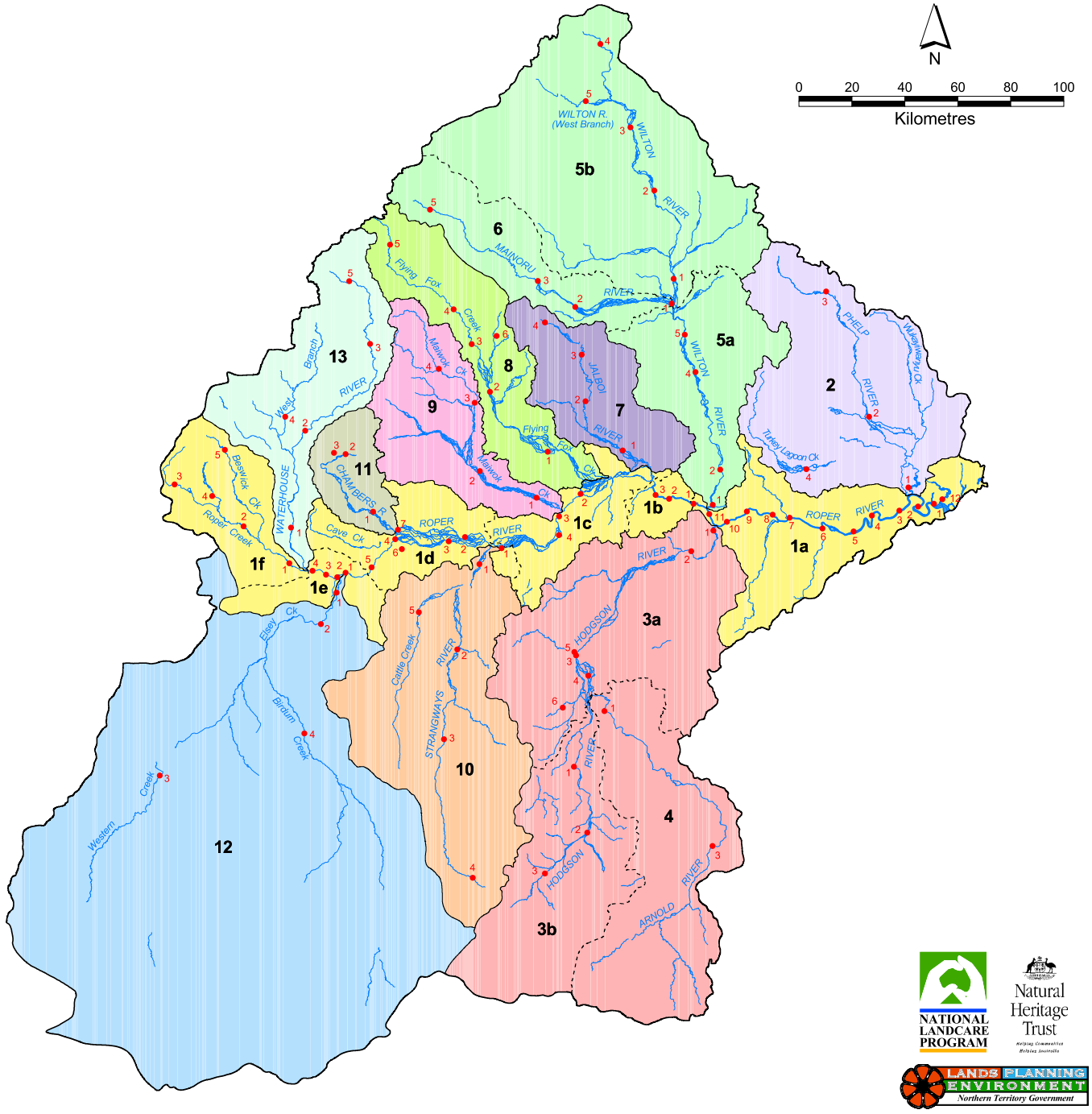
TOP END WATERWAYS PROJECT

ROPER RIVER CATCHMENT

STREAM ORDERS

Map 8



SUB SECTION NUMBER	SUB SECTION NAME
1	Roper River
	a. Estuary
	b. Below Jalboi River
	c. Below 57-Mile Waterhole
	d. Red Lily Lagoon, 57-Mile Waterhole
	e. Below Waterhouse River
	f. Upper Roper Creek
2	Phelp River
3	Hodgson River
	a. Below Arnold River
	b. Above Arnold River
4	Arnold River
5	Wilton River
	a. Below Mainoru River
	b. Above Mainoru River
6	Mainoru River
7	Jalboi River
8	Flying Fox Creek
9	Maiwok Creek
10	Strangways River
11	Chambers River
12	Elsey Creek
13	Waterhouse River

LEGEND

- Site Location
- 5a Sub-section Number
- Catchment Boundary
- Sub-catchment Boundary
- Sub-section Boundary
- River
- Creek

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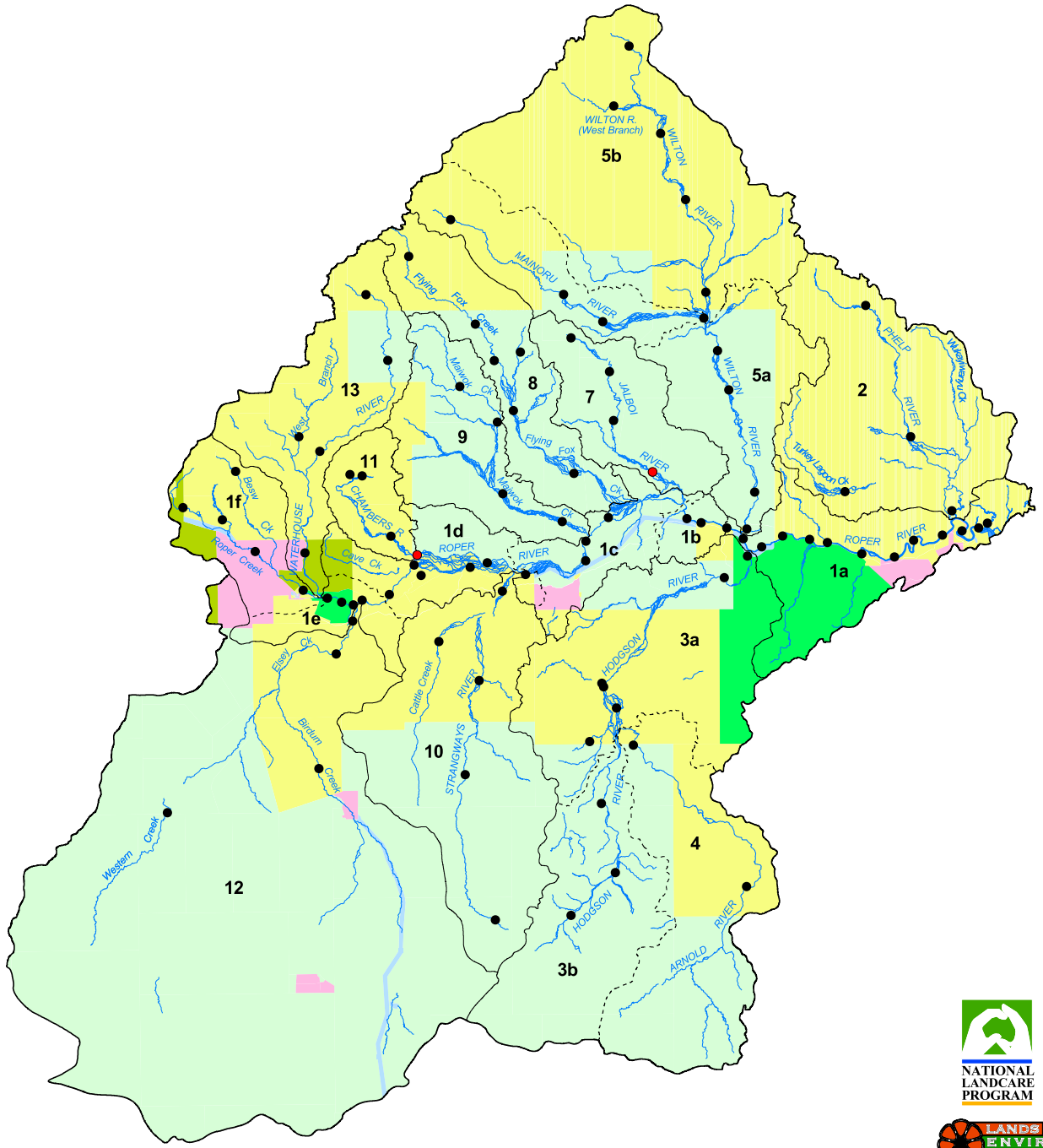
TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

LOCATION OF SITES

Map 9



LAND CLASSIFICATION

- National Park or Reserve
- Pastoral Lease
- Vacant Crown Land / Government Use
- Private Freehold
- Crown Lease Term
- Crown Lease Perpetual

LEGEND

- Surveyed Site
- Site Not Assessed
- 5a Sub-section Number
- Catchment Boundary
- Sub-catchment Boundary
- Sub-section Boundary
- River
- Creek

NOTE

A summary of the land tenure along the reach environs is shown below:

Land Tenure Category	Percent of Sites (%)
Freehold / Leasehold	97
National Park	3
State Park	0
Reserve / Environmental Park	0
State Forest	0
Urban Reserve	0
Urban	0

N

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TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

LOCAL LAND TENURE AT SITES

Map 10

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	REACH ENVIRONS CATEGORY	RATING (%)
●	Essentially Natural	81 - 100
●	Some Modification	61 - 80
●	Moderate Modification	41 - 60
●	Major Modification	21 - 40
●	Extreme Modification	0 - 20
○	Site Not Assessed	

5a — Sub-section Number

Catchment Boundary

Sub-catchment Boundary

Sub-section Boundary

River

Creek

NOTE

State of the Reach Environs -
The rating is based on an assessment of the land corridor along the survey reach and on the floodplain adjacent to the reach. The rating takes into account local land use and local disturbances along the reach environs.

N

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TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

STATE OF THE REACH ENVIRONS

Map 11

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	DIVERSITY CATEGORY	RATING (out ot 10)
●	Very High Diversity	9 - 10
●	High Diversity	7 - 8
●	Moderate Diversity	5 - 6
●	Low Diversity	3 - 4
●	Very Low Diversity	1 - 2
○	Site Not Assessed	

5a Sub-section Number
Catchment Boundary
Sub-catchment Boundary
Sub-section Boundary
River
Creek

NOTE

Channel Type Diversity -
The diversity categories take into account the number of different channel habitat types present (cascades, glides, pools, rapids, riffles, runs, waterfalls) and the proportion of the reach occupied by pools versus other habitat types.

The derived ratings for this component are NOT used to produce the Overall Condition Rating for each site.

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TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

CHANNEL TYPE DIVERSITY

Map 12

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	STABILITY CATEGORY	RATING (%)
●	Stable	81 - 100
●	Limited Instability	61 - 80
●	Moderate Instability	41 - 60
●	Extensive Instability	21 - 40
●	Extreme Instability	0 - 20
○	Site Not Assessed	

DOMINANT PROCESS AT EACH SITE

A — Aggradation

Erosion
(the dominant process at all sites assessed, other than those with an 'A', is erosion)

5a — Sub-section Number

Catchment Boundary

Sub-catchment Boundary

Sub-section Boundary

River

Creek

NOTE

Bank Stability -
The ratings are determined from the recorded percentages of the banks on each side of the reach which are rated as stable. Upper banks are assigned a greater proportion of the score than lower banks. The dominant process at each site (erosion or aggradation) is recorded.

N

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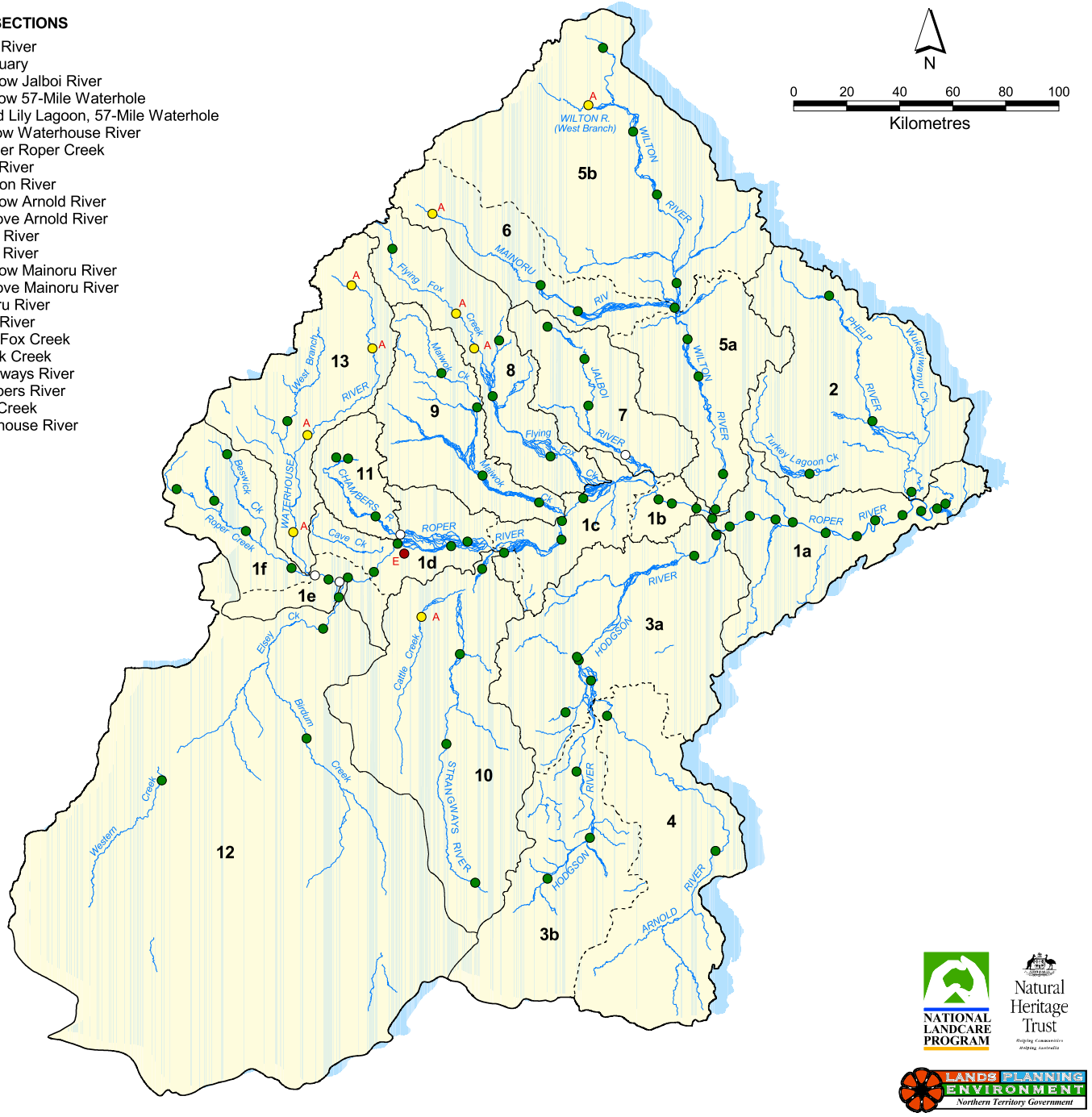
TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

BANK STABILITY

Map 13

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River



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LEGEND

SITE LOCATION	STABILITY CATEGORY	RATING (out of 10)
●	Stable	10
●	Moderate Aggradation or Erosion	6
●	Severe Aggradation or Erosion	2
○	Site Not Assessed	

DOMINANT PROCESS AT EACH SITE

A Aggradation

E Erosion

Stable (No Process) - not labelled

5a Sub-section Number

Catchment Boundary

Sub-catchment Boundary

Sub-section Boundary

River

Creek

NOTE

Bed Stability -
The ratings are determined from a subjective assessment made in the field of whether the river bed is stable; moderately eroding or aggrading; or severely eroding or aggrading. That is,

- Stable bed: The river bed is consolidated; bed and bar material is the same size; alluvium balanced; and banks stable.
- Moderate erosion: There is little alluvium; signs of deepening; eroded banks; bed deep, narrow and steep; unconsolidated.
- Moderate aggradation: There is moderate build-up at obstructions and bars; bed is flat, uniform, wide and shallow; some over-bank siltation.
- Severe erosion: The bed is scoured of sand; signs of deepening; bare eroded banks; erosion heads; erosion causes; and a steep bed.
- Severe aggradation: The bed is flat, wide but shallow and channel blocked; bars large, covering most of bed and bank; bed is loose and unconsolidated.

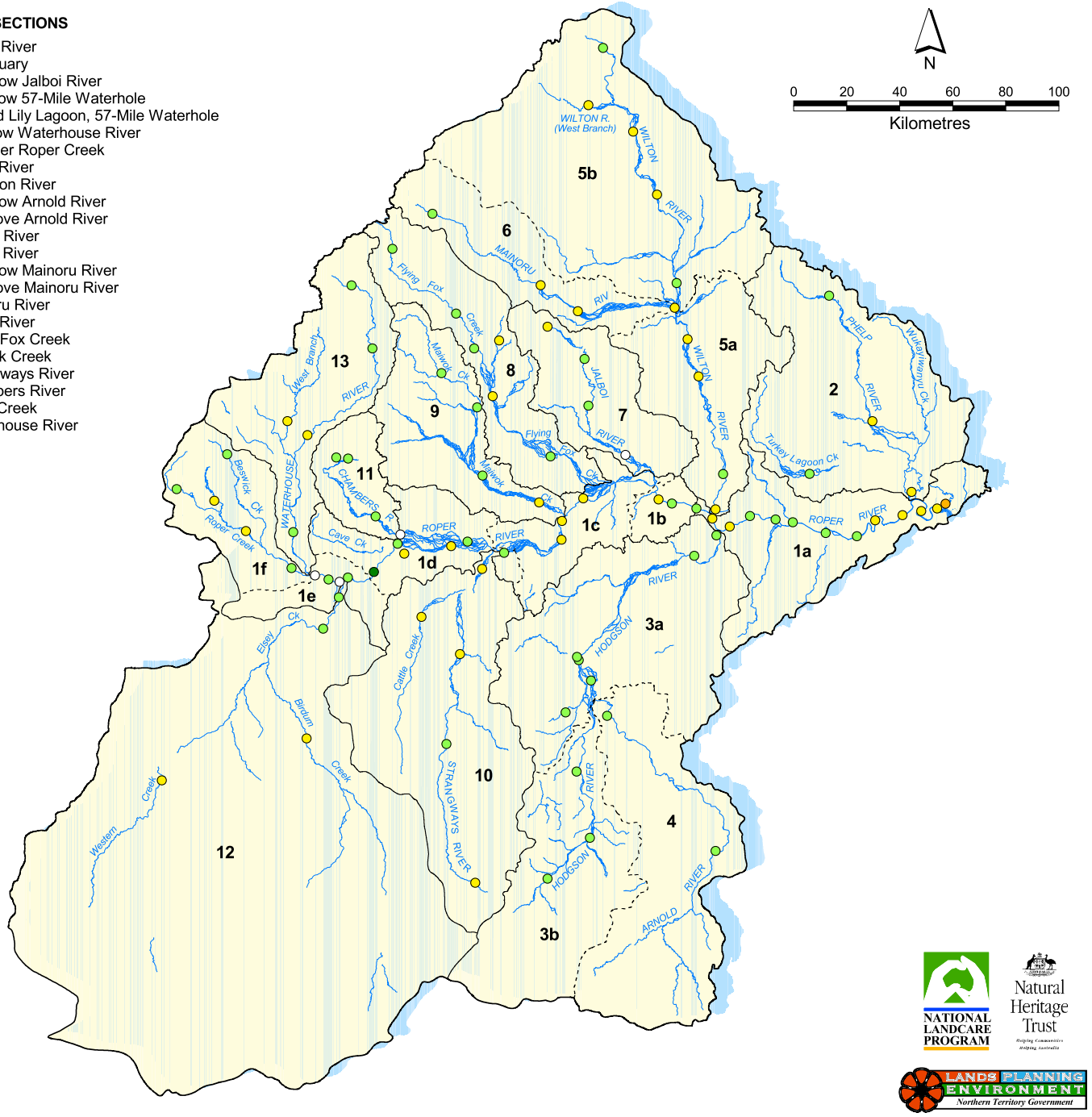
TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

BED STABILITY

Map 14

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River



LEGEND

SITE LOCATION	RIPARIAN VEGETATION CATEGORY	RATING (out ot 10)
●	Very High Cover/Diversity	9 - 10
●	High Cover/Diversity	7 - 8
●	Moderate Cover/Diversity	5 - 6
●	Low Cover/Diversity	3 - 4
●	Very Low Cover/Diversity	1 - 2
○	Site Not Assessed	

5a Sub-section Number

Catchment Boundary

Sub-catchment Boundary

Sub-section Boundary

River

Creek

NOTE

Cover and Structural Diversity of the Riparian Vegetation - The ratings take into account:

a. The foliage cover or density provided by the overstorey, understorey and ground cover vegetation types or growth forms . The distinction between these three vegetation layers is -
   - overstorey vegetation includes large trees (>30m tall), medium-sized trees (10-30m tall) and palms;
   - understorey vegetation includes small trees (2-10m tall), regenerating trees (<2m tall), mangroves and woody shrubs (<2m tall);
   - ground cover vegetation includes vines, rushes/sedges, forbs, salt marsh, ferns, grasses and Phragmites.

   Both native and exotic vegetation species are included when calculating the covers. The extent of bare ground along the river banks within the riparian zone reduce the ratings.

b. The structural diversity or number of different growth forms present (eg trees of different height classes, palms, shrubs, vines, forbs, grasses, ferns, *etc*).

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TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

COVER AND STRUCTURAL DIVERSITY OF RIPARIAN VEGETATION

Map 15

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	RIPARIAN VEGETATION WIDTH CATEGORY (m)
●	> 40
●	31 - 40
○	21 - 30
●	11 - 20
●	5 - 10
●	< 5
○	Site Not Assessed

5a Sub-section Number
Catchment Boundary
Sub-catchment Boundary
Sub-section Boundary
River
Creek

NOTE

The width of the riparian vegetation is averaged for both river banks at a site before being assigned a width category.

N

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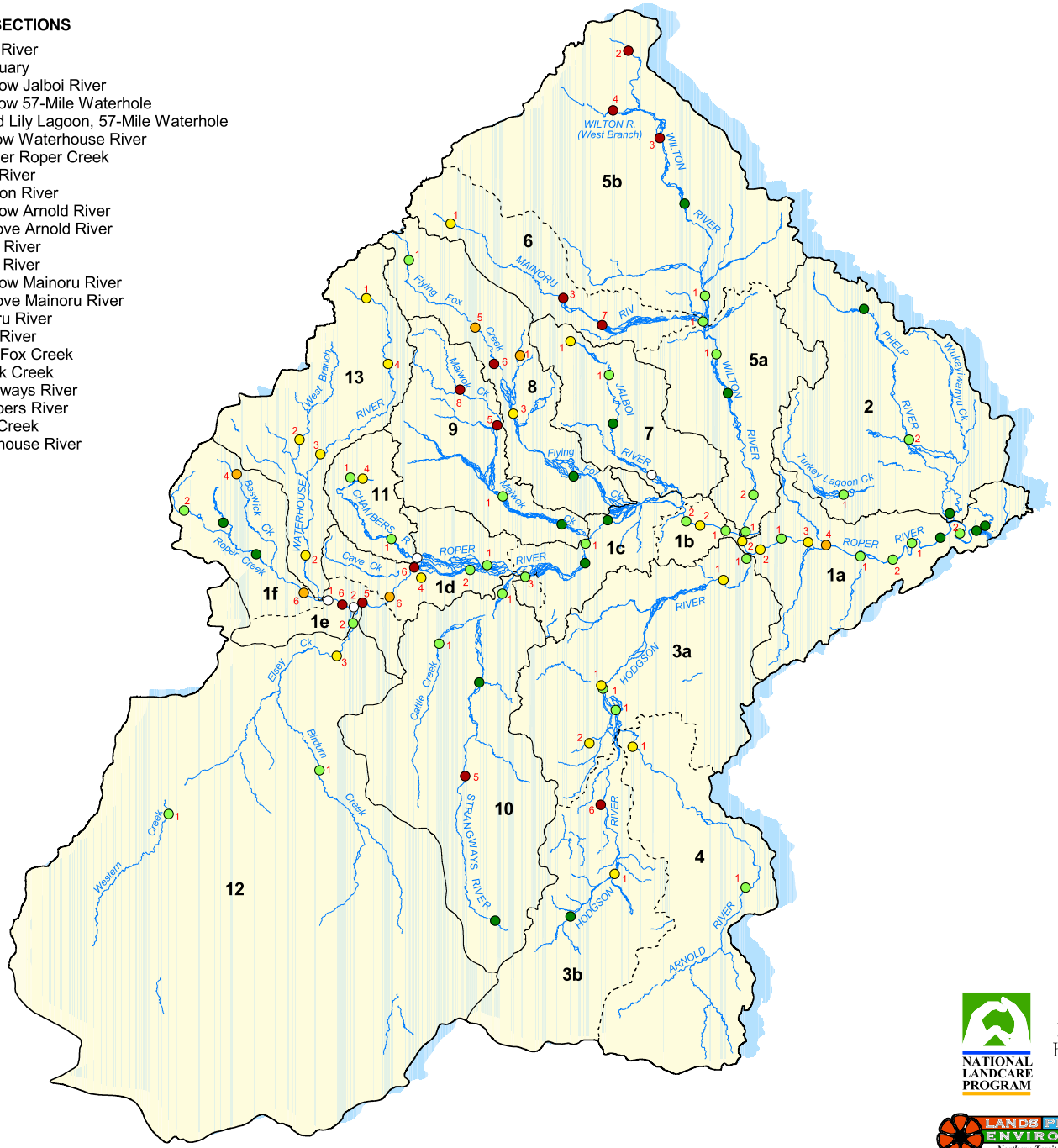
TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

WIDTH OF RIPARIAN VEGETATION

Map 16

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River



LEGEND

SITE LOCATION	% COVER CATEGORY	RATING (out of 10)
●	0	10
●	1 - 5	8
●	6 - 10	6
●	11 - 15	4
●	16 - 34 *	2
○	Site Not Assessed	

NUMBER OF TYPES OF EXOTIC SPECIES

1 - 8	The number of different types of exotic species recorded at a site, if present.
5a	Sub-section Number
———	Catchment Boundary
———	Sub-catchment Boundary
- - - - -	Sub-section Boundary
———	River
———	Creek

NOTE

Cover of Exotic Riparian Vegetation -
The ratings take into account the percentage cover recorded for exotic species within the riparian zone, averaged for both river banks at a site. The higher the percentage cover recorded for exotic species, or the higher the degree of invasion, the lower the rating. The number of different types of exotic species recorded at a site, if present, is shown.

* The maximum percentage cover recorded for exotic riparian vegetation was 34%.

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TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

COVER OF EXOTIC RIPARIAN VEGETATION

Map 17

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	% COVER CATEGORY
●	0
●	1 - 5
●	6 - 10
●	11 - 15
●	16 - 20 *
○	Site Not Assessed

5a Sub-section Number
Catchment Boundary
Sub-catchment Boundary
Sub-section Boundary
River
Creek

NOTE

Passiflora foetida (Stinking Passion Flower), a naturalised vine, was the major exotic species recorded throughout the catchment. Its distribution and the percentage cover recorded are shown. Percentage covers are averaged if the species is recorded for both river banks at a site.

* The maximum percentage cover recorded for *Passiflora foetida* was 20%.

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TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

COVER AND DISTRIBUTION OF *Passiflora foetida*

Map 18

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	% COVER CATEGORY
●	0
●	1 - 5
●	6 - 10
●	11 - 15 *
●	>15
○	Site Not Assessed

5a	Sub-section Number
———	Catchment Boundary
———	Sub-catchment Boundary
- - - - -	Sub-section Boundary
———	River
———	Creek

NOTE

Hyptis suaveolens (Hyptis), a forb, was the second major exotic species recorded throughout the catchment. Its distribution and the percentage cover recorded are shown. Percentage covers are averaged if the species is recorded for both river banks at a site.

* The maximum percentage cover recorded for *Hyptis suaveolens* was 15%.

N

0 20 40 60 80 100

Kilometres

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ROPER RIVER CATCHMENT

COVER AND DISTRIBUTION OF *Hyptis suaveolens*

Map 19

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	% COVER CATEGORY
●	0
●	1 - 5 *
●	6 - 10
●	11 - 15
●	16 - 28
○	Site Not Assessed

5a	Sub-section Number
———	Catchment Boundary
———	Sub-catchment Boundary
- - - -	Sub-section Boundary
———	River
———	Creek

NOTE

Parkinsonia aculeata (Parkinsonia), a low tree, was the third major exotic species recorded throughout the catchment. Its distribution and the percentage cover recorded are shown. Percentage covers are averaged if the species is recorded for both river banks at a site.

* The maximum percentage cover for *Parkinsonia aculeata* was 5%

N

0 20 40 60 80 100

Kilometres

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TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

COVER AND DISTRIBUTION OF *Parkinsonia aculeata*

Map 20

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	% COVER CATEGORY
●	16 - 53 *
●	11 - 15
●	6 - 10
●	1 - 5
●	0
○	Site Not Assessed

5a — Sub-section Number
Catchment Boundary
Sub-catchment Boundary
Sub-section Boundary
River
Creek

NOTE

Cover and Distribution of Submerged Aquatic Vegetation - The categories where covers were recorded include filamentous algae, Chara/Nitella, Vallisneria, Myriophyllum and other herb-like forms. No exotic species were recorded.

* The maximum percentage cover recorded for submerged aquatic vegetation was 53%.

N

0 20 40 60 80 100

Kilometres

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TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

COVER AND DISTRIBUTION OF SUBMERGED AQUATIC VEGETATION

Map 21

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	% COVER CATEGORY
●	16 - 55 *
●	11 - 15
●	6 - 10
●	1 - 5
●	0
○	Site Not Assessed

5a	Sub-section Number
———	Catchment Boundary
———	Sub-catchment Boundary
- - - -	Sub-section Boundary
———	River
———	Creek

NOTE

Cover and Distribution of Emergent Aquatic Vegetation - The categories where covers were recorded include Phragmites, Typha, rushes/sedges, Pandanus, Melaleuca, other shrubs/trees and ground covers. The only exotic species recorded was *Phyla nodiflora* (Lippia), which was located on Elsey Creek at Site 12/1 and recorded a cover of 18%.

* The maximum percentage cover recorded for emergent aquatic vegetation was 55%.

N

0 20 40 60 80 100

Kilometres

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COVER AND DISTRIBUTION OF EMERGENT AQUATIC VEGETATION

Map 22

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	% COVER CATEGORY
●	16 - 45 *
●	11 - 15
●	6 - 10
●	1 - 5
●	0
○	Site Not Assessed

5a Sub-section Number
Catchment Boundary
Sub-catchment Boundary
Sub-section Boundary
River
Creek

NOTE

Cover and Distribution of Floating Aquatic Vegetation - The categories where covers were recorded include water lilies and other floating vegetation. No exotic species were recorded.

* The maximum percentage cover recorded for emergent aquatic vegetation was 45%.

N

0 20 40 60 80 100

Kilometres

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COVER AND DISTRIBUTION OF FLOATING AQUATIC VEGETATION

Map 23

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River

LEGEND

SITE LOCATION	INSTREAM / BANK HABITAT CATEGORY	RATING (%)
	Very High Cover/Diversity	81 - 100
	High Cover/Diversity	61 - 80
	Moderate Cover/Diversity	41 - 60
	Low Cover/Diversity	21 - 40
	Very Low Cover/Diversity	0 - 20
	Site Not Assessed	
5a	Sub-section Number	
	Catchment Boundary	
	Sub-catchment Boundary	
	Sub-section Boundary	
	River	
	Creek	

NOTE

Cover and Diversity of Instream and Bank Habitats - The ratings are based on a combination of the cover and diversity provided by instream organic debris (logs, branches, leaves/twigs, *etc*), aquatic vegetation and other habitat types (such as rock, permanent pools) on the bed, as well as the cover and diversity provided by the canopy and other habitats (low vegetation, roots, bank overhang) along the river banks.

N

0 20 40 60 80 100

Kilometres

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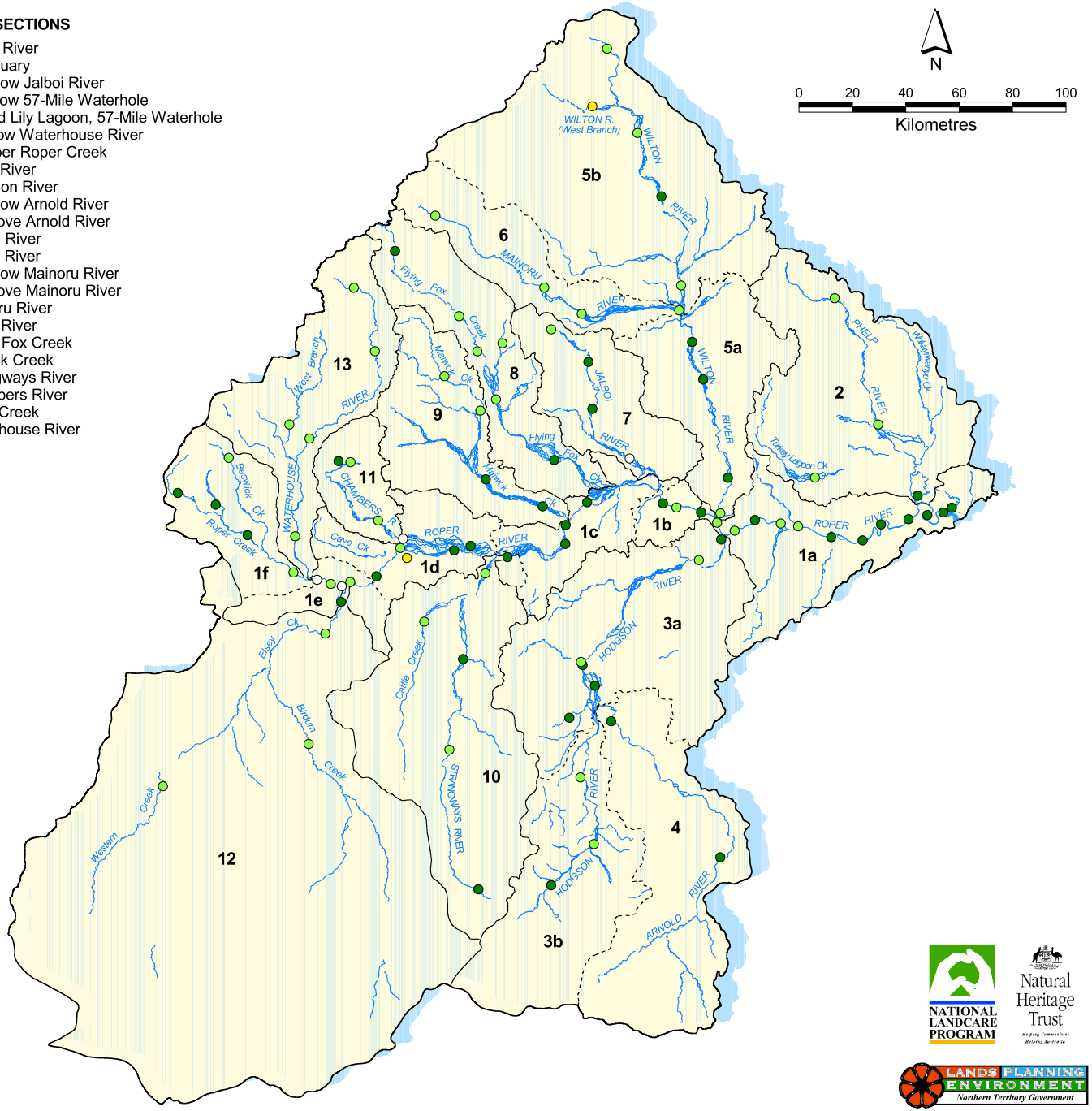
TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

COVER AND DIVERSITY OF INSTREAM AND BANK HABITATS

Map 24

SUB-SECTIONS

1. Roper River
   a. Estuary
   b. Below Jalboi River
   c. Below 57-Mile Waterhole
   d. Red Lily Lagoon, 57-Mile Waterhole
   e. Below Waterhouse River
   f. Upper Roper Creek
2. Phelp River
3. Hodgson River
   a. Below Arnold River
   b. Above Arnold River
4. Arnold River
5. Wilton River
   a. Below Mainoru River
   b. Above Mainoru River
6. Mainoru River
7. Jalboi River
8. Flying Fox Creek
9. Maiwok Creek
10. Strangways River
11. Chambers River
12. Elsey Creek
13. Waterhouse River



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LEGEND

SITE LOCATION	OVERALL CONDITION CATEGORY	RATING (%)
●	Essentially Natural/ Stable, Very High Cover/ Diversity or Exotics Absent/Negligible	81 - 100
●		61 - 80
●		41 - 60
●		21 - 40
●	Extreme Modification/ Instability, Very Low Cover/ Diversity or Very High Cover for Exotics	0 - 20
○	Site Not Assessed	

5a Sub-section Number
Catchment Boundary
Sub-catchment Boundary
Sub-section Boundary
River
Creek

NOTE

Overall Condition -
Provides an indication of the overall condition of the sites based on the following six components that were assessed:

- state of the reach environs
- bank stability
- bed stability
- cover and structural diversity of riparian vegetation
- cover of exotic riparian vegetation
- cover and diversity of instream and bank habitats

The rating for each component is combined equally to produce an Overall Condition Rating for each site.

TOP END WATERWAYS PROJECT
ROPER RIVER CATCHMENT

OVERALL CONDITION

Map 25