2. OVERVIEW OF THE VICTORIA RIVER CATCHMENT

2.1 Location

The study area for this report is the Victoria River catchment, which covers approximately 87,900km^2 and includes the Victoria River and its major tributaries (refer Map 2). The 12 sub-catchments covered in the study area include the Armstrong, Angalarri, Baines, Bullo, Camfield, Victoria, Wickham and Humber River catchments, as well as Battle, Giles or Wattie , Gordon, Gregory and Delamere Creeks, and Jasper Creek catchments.

The Victoria River originates on Riveren Station and travels approximately 720 kilometres through a mixture of grassy plains, rolling savannas, rocky Spinifex country, mesas and plateaux before draining into the Joseph Bonaparte Gulf and ultimately the Timor Sea to the north. Most of the catchment lies less than 450 metres above sea level. The Victoria River is generally shallow with extensive sandbars and rockbars. The major tributaries run into the Victoria River along its course, culminating at the mouth which is more than 10 kilometres wide and characterised by mudflats and extensive mangrove stands. The tidal extent of the Victoria River reaches approximately 500 kilometres, to a series of rapids 20 kilometres upstream of Timber Creek.

There are a number of small settlements in the Victoria River catchment, Timber Creek (300 people) and Top Springs, as well as four major Aboriginal communities, two minor Aboriginal communities, and 13 family outstations. The four major Aboriginal communities are Amanbidji, Daguragu, Kalkarindji and Yarralin, all of which have greater than 100 people, the largest being Yarralin with around 500 people. The nearest major population centres are Katherine to the east and Kununurra to the west (refer Map 2).

Top Springs, July 1996

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).

Over 90% of the mean annual rainfall in the Victoria River catchment falls during the wet season (November to March). The mean monthly rainfall varies from 0.2 mm during the dry season to 233 mm during the wetter months. Figures 2.1 and 2.2 illustrate the mean monthly rainfall recorded for Timber Creek and Victoria River Downs.

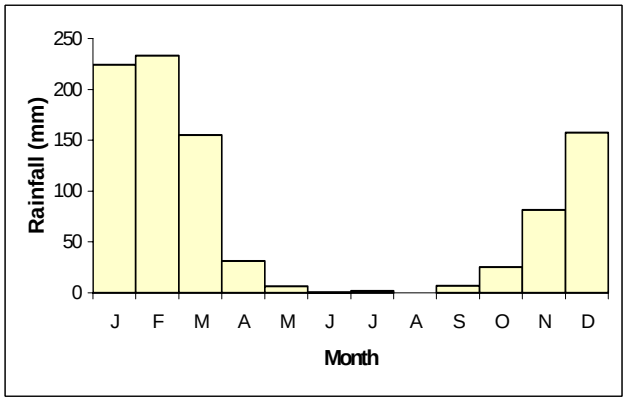


Figure 2.1 Mean Monthly Rainfall for Timber Creek (1981 - 2003)

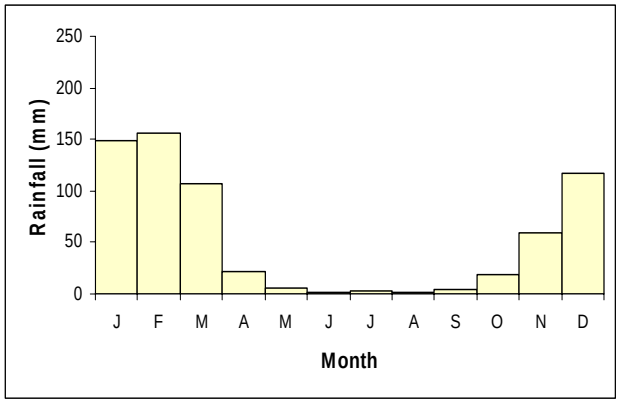


Figure 2.2 Mean Monthly Rainfall for Victoria River Downs (1885 - 2003)

Table 2.1 summarises climate details for two locations in the Victoria River catchment, Timber Creek and Victoria River Station.

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

	Timber Creek (1981 – 2003)	Victoria River Downs (1885 – 2003)
Mean Daily Min-Max Temp. Range (°C)	14.9 – 38.2	11.6 – 38.4
Mean 9am Relative Humidity (%)	61	57
Mean 3pm Relative Humidity (%)	37	35
Mean Annual Rainfall (mm) [No. years]	924 [22]	644.6 [115]
Mean Monthly Rainfall Range (mm)	0.2 – 233 (Aug – Feb)	1.1 – 156 (Aug – Feb)
Highest Recorded Daily Rain (mm)	164 (27 Jan 1998)	222.3 (20 Feb 1927)
Mean Number of Rain Days per Year	75.8	53.1
Mean Total Annual Evaporation (mm)	-	2,466.4

Source: Bureau of Meteorology Website (http://www.bom.gov.au/climate/averages/tables/ca_nt_names.shtml)

Mean daily temperatures recorded at Timber Creek and Victoria River Downs range from 11.6°C to 38.4°C, with the lowest temperature recorded as 1.3°C, and the highest, 45.4°C. Relative humidity varies both daily and seasonally, with typical dry season (May–September) relative humidity averages ranging between 40-53% at 9am and 23-31% at 3pm. Wet season (November to March) relative humidity averages range from 45-83% at 9am to 26-58% at 3pm.

Total annual rainfall is highest in the north of the Victoria River catchment with 926.9mm at Timber Creek, decreasing to 729mm at Kidman Springs, and 635.6mm at Victoria River Downs further to the south. Total annual rainfall is illustrated in Figures 2.3, 2.4 and 2.5. Rain is usually high-intensity falls. Most of the region's rain comes as hard, intermittent, tropical showers, often associated with thunder and lightning (Bauer, 1964) or as monsoon troughs and tropical lows, which are often the remains of cyclonic depressions.

Average annual evaporation also varies across the catchment, with 2,548mm at Kidman Springs and 2,466.4mm at Victoria River Downs. It is evident from these figures that annual average evaporation greatly exceeds total annual rainfall, which is typical of the north Australian climate (Sivertsen and Day, 1985).

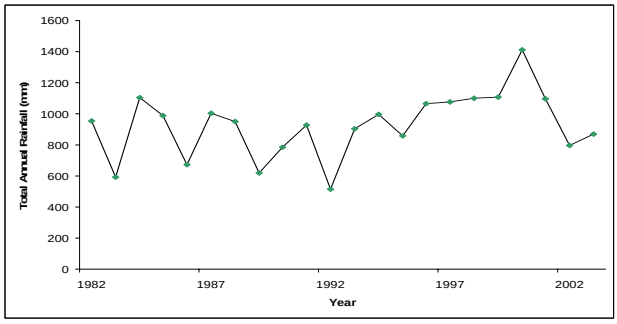


Figure 2.3 Total Annual Rainfall for Timber Creek (1982 – 2003)

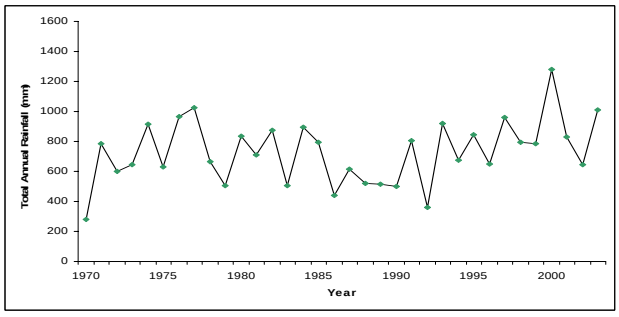


Figure 2.4 Total Annual Rainfall for Kidman Springs (1970 – 2003)

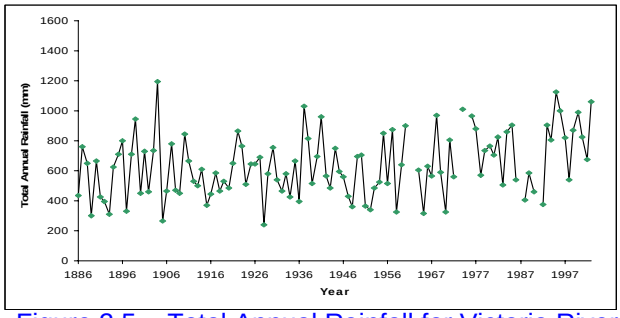


Figure 2.5 Total Annual Rainfall for Victoria River Downs (1886 – 2003)

2.3 Geology, Geomorphology and Landform

The Victoria River region is renowned for its spectacular escarpments, mesas and river environment. Other notable features include the karst formations and cave systems found in Gregory National Park, particularly east of the East Baines River, near its junction with Limestone Creek. Stromatolites, Rillen-karen, tufa, calcite flows and caves can be found around the Limestone Gorge area of the Park (PWCNT, 2002a).

Sandstone Plateaux and associated valley floors – Victoria River in Gregory National Park

Estuarine Plains – mudflats in Victoria River estuary

Land system 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, can also be used to describe the potential or capability of the land (Aldrick and Robinson, 1972).

Many surveys providing detailed land systems, land unit or soils mapping have been carried out for areas throughout the Victoria River catchment.

Figure 2.6 shows the location and reference details of these surveys. Map 3 shows the predominant landforms throughout the Victoria River catchment, based largely on the Land Systems of the Ord-Victoria Area, Western Australia and Northern Territory (Stewart *et al,* 1970). The Atlas of Australian Soils (Northcote, 1968) was used to complete the southern part of the catchment.

Seven major geology types and landforms found in the Victoria River catchment are described below:

1. **Sandstone plateaux and associated valley floors** - includes the rugged sandstone plateaus, steep valleys and scarps of Jasper Gorge at the southern end of Humbert River Station and the northern boundary of Mt Sanford Outstation. The headwaters of the Wickham River and to the west and south of Kalkaringi, as well as the Spencer Ranges north east of Newry Station to Bradshaw and Innesvale Stations also fall into this category.
2. **Sturt plateau remnants and associated valley floors** – is typically flat, and forms the south eastern and south western boundaries of the catchment.
3. **Limestones and calcareous and dolomitic sediments** – This limestone-derived material is generally undulating, and is restricted to the headwaters of Timber Creek, Skull Creek and the headwaters of Jasper Gorge Creek.
4. **Country derived from basalt rock** – is typically undulating to hilly country, comprising major rivers, and are dominated by cracking clay soils.
5. **Sand Dunes** – are found along the southern boundary of the catchment on edges of the Simpson Desert.
6. **Estuarine Plains** – are restricted to the coastal regions at the mouth of the Victoria and Bullo Rivers.

The relationship between geology, geomorphological groups, land systems, soils and pastoral productivity is summarised in Table 2.2.

Other land-related studies undertaken in the region include a Natural Resource Assessment Project to describe the potential 'economic value' of natural resources in the Victoria River Region (Nasca, 1981); A Reconnaissance Erosion Survey of part of the Victoria River District (Condon, 1986); A Land Conservation Strategy for the Victoria River District (Condon, 1988); and A Review of Strategic Options: VRD Land Conservation Proposal (RCS, 1988).

Figure 2.7 shows the elevations throughout the Victoria River catchment in metres and illustrates the predominant landforms.

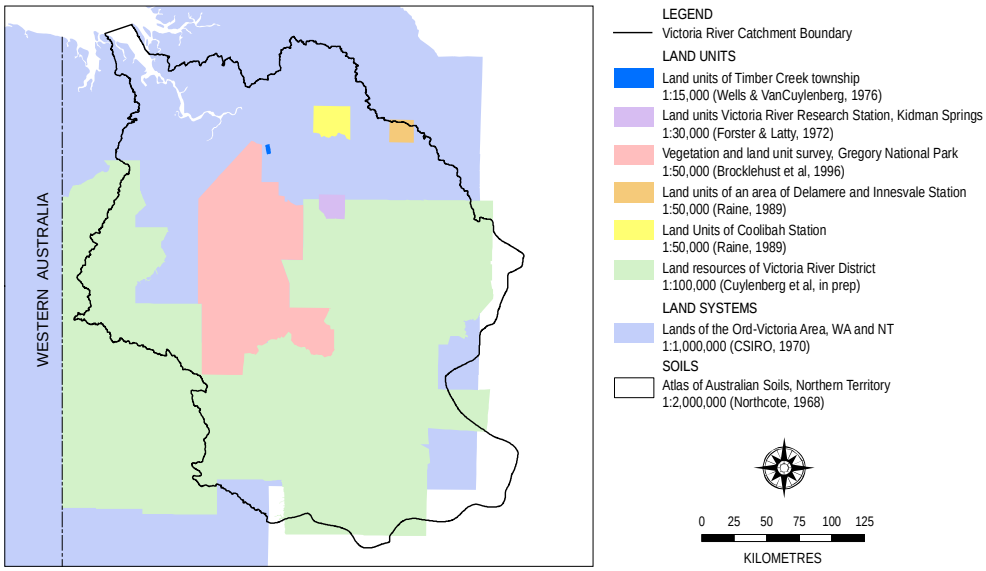
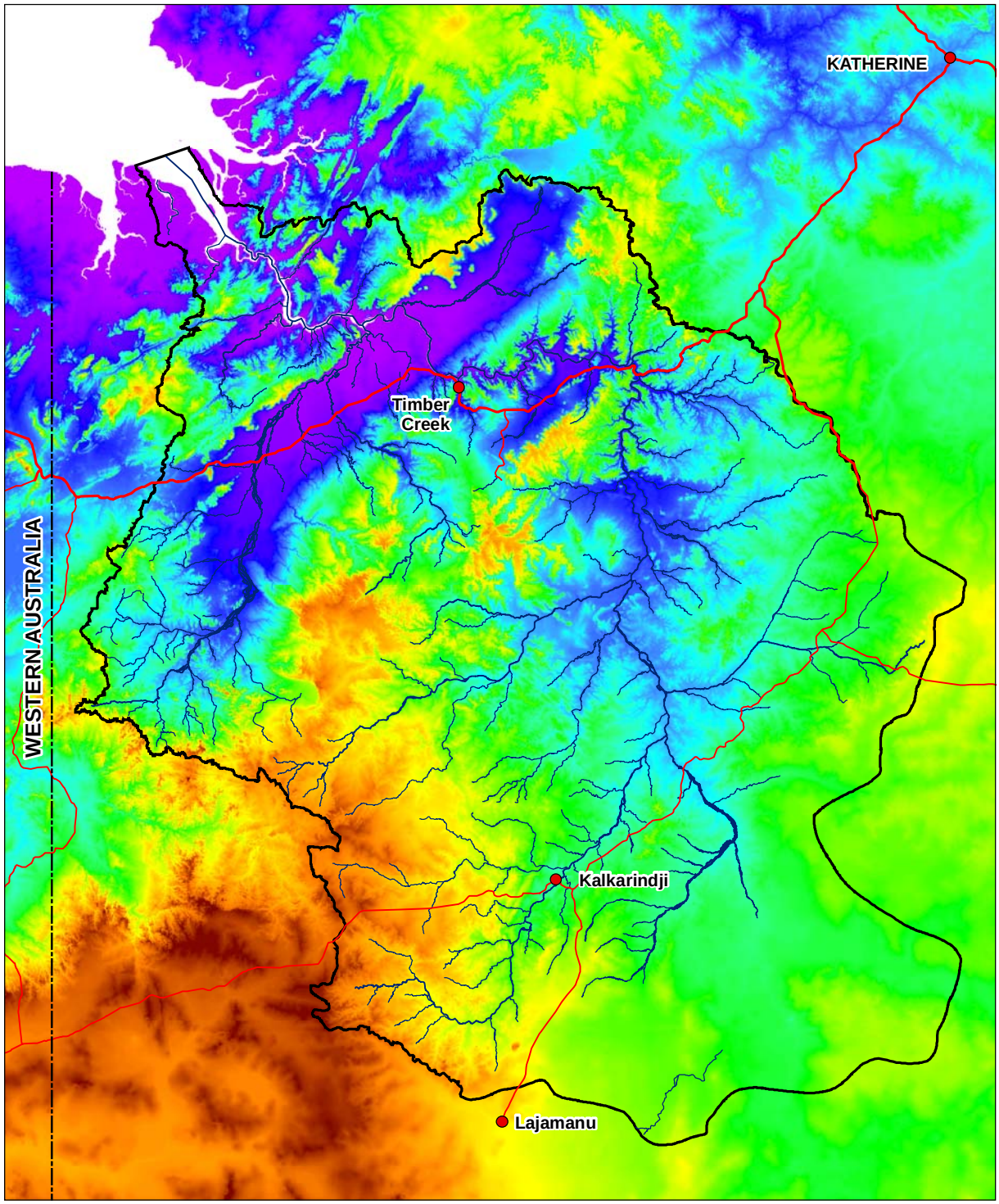


Figure 2.6 Location and Reference Details for Land System, Land Unit and Soil Mapping Surveys in the Victoria River Catchment

Table 2.2 Major Landforms and Land Systems in the Victoria River Catchment

Geological Group	Geomorphological Group	Land Systems	Soils	Pastoral Productivity
Sandstone plateaux and associated valley areas	Rugged stony plateaux and hills	Pinkerton, Wickham	Rock outcrops	Low to very low, much inaccessible
	Plateaux	Franklin, Mullaman, Wingate	Lateritic outcrops with pockets of shallow, sandy reddish soils	Low to very low, much inaccessible
Sturt Plateau remnants and associated valley areas	Lateritic plains	Birrimbah, Barry, Cockatoo, Coolindie, Geebee, Hawk, Redsan	Deep red and yellow sands and earths, sandy loam over laterite; minor grey cracking clays	Low to very low, some inaccessible
Limestones, calcareous and dolomitic sediments	Hilly limestone country	Humbert, Tanmurra	Limestone outcrops; pockets of shallow soils	Mostly moderate, some low with decreasing rainfall. Some inaccessible.
	Undulating shale country	Cockburn	Rock outcrops and shallow, very gravely, skeletal soils	Mostly moderate, some low with decreasing rainfall. Some inaccessible.
	Undulating limestone country	Gordon	Shallow grey to yellow-brown calcareous loamy soils; scattered crops and boulders of limestone	Mostly moderate, some low with decreasing rainfall. Some inaccessible.
	Plains on limestone	Dinnabung, Montejinni	Many limestone boulders and outcrops; red and yellow earths and brown calcareous earths	Mostly moderate, some low with decreasing rainfall. Some inaccessible.
Country derived from basalt rocks	Undulating basalt country	Frayne, Willeroo	Brown loam merging into dark red clay; some brown clay skeletal soils	Moderate to high
	Hilly basalt country	Antrim, Napier	Rock outcrops with basalt boulders and pockets of red clayey soil	Moderate to high
Ancient and recent alluviums and coastal floodplains	Clay plains	Inverway, Argyle	Grey and brown cracking clays	Very high
	Alluvial floodplains	Angallari, Dillinya Ivanhoe	Grey sandy loam over mottled yellow clay; grey and brown cracking clays	Moderate to high
	Coastal floodplains	Legune	Grey sandy loam over mottled clay, grey cracking clays	Moderate
Sandunes	Dunefields	B32*	Red siliceous sands with stable flanks and mobile crests	Very low
Estuarine plains	Littoral plains	Carpentaria	Highly saline clays	Low to very low

*No Land System Information available. Table adapted from Condon, 1986; Stewart *et al*, 1970; and Northcote, 1986.



DATA SOURCE

Digital Terrain Elevation: Department of Defence
Edition 3, Date 26 Apr 2000, Pixel size is approx 90 m

Rivers: Geoscience Australia (1:250,000 topographic data)
Roads: Geoscience Australia (1:1,000,000 data)

The Victoria River catchment boundary was delineated for the Top End Waterways Project using 1:100,000 and 1:250,000 topographic map sheets taking into account contour lines and spot heights.

0 30 60 90
KILOMETRES

LEGEND

Elevation (metres) within catchment
High : 450
Low : 0
Victoria River Catchment Boundary
River / Creek
Major road

Figure 2.7 Elevations throughout the Victoria River Catchment

2.4 Vegetation, Important Habitat Areas and Fauna

2.4.1 Vegetation

The Victoria River catchment extends from the higher rainfall forests in the north, to the arid and semi-arid shrublands and grasslands in the south. There is a general decline of species richness from north to south (Kraatz, 2000). However, the flat landscape and lack of barriers has resulted in a broad ecological gradient with a widespread flora, typical of much of northern Australia (PWNCT, 1998).

Prior to 1985, the NT 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 Eucalyptus with grass understorey, *etc*) and structural formation (eg open-forest, woodland, *etc*).

Wilson *et al* (1990) describes 112 vegetation communities in the NT, 33 of which occur in the Victoria River catchment (refer Map 4). The dominant vegetation communities include Eucalyptus sp. with grass or hummock grass understorey, comprising woodlands, low woodlands and low open-woodlands. Riparian areas are mostly grasslands, consisting of Mitchell Grass, Golden Beard Grass and Bluegrass mixed with scattered trees and shrubs, and there is a strip of Melaleuca forest/woodland with Sorghum understorey in the vicinity of the West Baines River, and littoral saline tidal flats occur in the estuarine areas. Hummock grasslands dominated by Spinifex sp. with acacia overstorey between sand dunes occur in the more arid regions in the south, as well as lancewood communities in the south east of the region (refer Map 4). This broad scale mapping provides an overview of vegetation in the region, however neglects small or rare communities such as monsoon vineforest which are not specifically described due to the narrowness of the strips along watercourses, or the small size of the patch (Wilson *et al*., 1990).

Brocklehurst *et al* (1996) has undertaken vegetation mapping in Gregory National Park at a scale of 1:250 000. He describes 69 floristic groups within 15 community structures, recording 230 genera and 584 species, including 15 introduced, and ten rare, or poorly known, species (PWCNT, 2002a). He also describes the more discrete communities such as the monsoon vine-thickets consisting of *Celtis philippensis* and *Xanthostemon psidioides* occurring on sandstone plateaux sideslopes, and *Livistonia sp.* palm forests found near plateau rims in seepage zones (Brocklehurst *et al,* 1990).

The Interim Biogeographic Regionalisation of Australia (IBRA) describes two bioregions in the Victoria River catchment. The Victoria Bonaparte Bioregion comprising *Sporobolus* grasslands and open savannah tall grasses in the Bonaparte Basin, low tree savannas and hummock grasslands on the Victoria Plateau, and low Snappy Gum with hummock grasslands and *Melaleuca minutifolia* and annual sorghums on the floodplain country (Environment Australia, 2000). The Ord Victoria Plains Bioregion comprises grasslands with scattered Bloodwood and Snappy Gum with Spinifex and annual grasses. Both Bioregions are considered to be dry, hot and tropical, with semi-arid summer rainfall (Environment Australia, 2000).

There are two national parks in the Victoria River catchment, Gregory National Park, and part of Keep River National Park (refer Map 5). Ranger Training Camps are conducted in National Parks throughout the NT each year, where biological surveys are undertaken. Three reports have been written for Gregory National Park: the Mueller Commemorative Expedition (PWCNT, 1996a); Upper Wickham River Survey (PWCNT, 1998); and Victoria River Sector (PWCNT, 2001). One Ranger Training Camp has been held at Spirit Hills (near Keep River National Park) (PWCNT, 1996b), and an aquatic fauna survey was conducted in Keep River National Park in 1999 (Larson, 1999). There is a draft Plan of Management for Gregory National Park (PWCNT, 2002a), a draft Plan of Management for Keep River National Park (PWCNT, 2002b), and a concept plan for Spirit Hills Wilderness Conservation Area (PWCNT, 1997). Additional biodiversity inventories in the Victoria River region include studies by Fisher & Woinarski (2002) and Harvey *et al* (2002) in the Bradshaw (Juliki) field training area.

Woodland and grassland communities along Victoria River

PWCNT (1998) described 23 vegetation communities in the Wickham River area of Gregory National Park during a Ranger Training Camp in 1998. The vegetation communities were further categorised according to structure as open forest communities, woodland communities, open woodlands, grasslands and shrublands. During the survey, it was noted that there were very few introduced weed species along the Wickham River, even though *Calotropis procera, Parkinsonia aculeata* and *Martynia annua* are serious weed species known to occur along rivers in the same climatic zone. It was suggested that the overall lack of access to the Wickham River may be the reason for the absence of weeds in this location (PWCNT, 1998).

Species of conservation significance found in the Victoria River region listed on the NT *Territory Parks and Wildlife Conservation Act* include: six vulnerable, 42 near threatened, and 146 data-deficient plant species; 13 vulnerable, 29 near threatened, and 35 data-deficient vertebrate fauna species; and four vulnerable invertebrate fauna species. 41 migratory species known to occur in the Victoria River region are listed under international agreements (Sample, 2004).

The mangrove plant communities along the Victoria River, as well as all other river systems in Joseph Bonaparte Gulf and those in the Gulf of Carpentaria 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). Wells (1985) suggested that low species diversity might be due to these systems lying in seasonally arid regions, and the fact that northern Australia experiences unfavourable currents for colonisation during the wet season monsoon season, which coincides with most species fruiting (Wells, 1985). The mangrove species recorded along the Victoria River estuary area are shown in Table 2.3.

Mangrove communities along a tributary flowing into Victoria River estuary

Table 2.3 Mangrove Species Recorded along Victoria River Estuary

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

(Source: Wells, 1985)

* 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

Weeds in the Victoria River catchment are concentrated in the riverine habitats, spread by wet season floodwaters or associated with water-holding black soil areas (PWCNT, 2002a; Sample, 2004). Weeds are a major threat to the integrity of ecosystems, and are directly affecting productivity on Pastoral Leases. Eradication of weed species over large areas is generally not feasible, and landholders, including Parks and Wildlife Service, are concentrating on eradication and control in selected areas, and prevention of spreading further downstream where possible.

There are currently 34 weed species listed in Gregory National Park, including Devils Claw (*Martynia annua*), Rubber Bush (*Calotropis procera*), Parkinsonia (*Parkinsonia aculeata*), Noogoora Burr (*Xanthium occidentale*), Khaki Burr (*Alternanthera pungens*), Hyptis (*Hyptis suaveolens*), Sida (*Sida acuta*) and Senna (*Senna occidentalis*) (PWCNT, 2002a). The Northern Land Council have recorded 37 weed species on Aboriginal Land Trust properties in the Victoria River area, and a total of 19 species were recorded during the surveys conducted for this Report (refer Section 4, Catchment Results).

There is a draft Victoria River District Weed Management Plan (DPIF, 1997). This Plan outlines species specific control measures for prevalent weeds in the region. Control measures include chemical, biological and mechanical means, as well as grazing management techniques and suggestions for further research. Major weed species of the Victoria River District are shown in Table 2.4.

Table 2.4 Major Weed Species of the Victoria River District

Priority Rating	Species Name	Common Name
Very High	*Xanthium occidentale*	Noogoora Burr
	Parkinsonia aculeata	Parkinsonia
	Leonotis nepetifolia	Lions Tail
	Martynia annua	Devil's Claw
	Acacia nilotica	Prickly Acacia
High	*Datura spp.*	Thornapple
	Senna obtusifolia	Sickle Pod
Moderate	*Prosopis limensis*	Mesquite
	Tribulus cistoides	Caltrop
	Hyptis suaveolens	Hyptis
	Calotropis procera	Rubber Bush

(Source: DPIF, 1997)

Other weed species listed on the Weed Management Branch database (DIPE, Katherine) include Bellyache Bush, Khaki Weed, Goats Head Burr, Sida, Snake Weed, Grader Grass, Mission Grass and Mossman River Grass.

2.4.2 Important Habitat Areas and Fauna

The Victoria River and most of its tributaries only flow for about six months of the year, breaking up into chains of waterholes which last for varying periods depending on their depth and whether or not they are spring fed (Tickell & Rajaratnam, 1998). The only permanent flowing streams in the Victoria River catchment are the Wickham River, upstream of Humbert River junction, and a short section of the Angalarri River (Midgley, 1981). The seasonality of the rivers makes waterholes, lakes, springs, dams and tanks extremely important habitat areas for flora and fauna in the region.

There are many semi-permanent waterholes and lakes in the Victoria River catchment, including several wetlands of national significance identified in the Australian Wetlands Database (2005). Birrindudu Waterhole and Floodplain (NT015) and Nongra Lake (NT016) are believed to be part of an internal drainage basin, disconnected from the Victoria River by dune movement, resulting in elevated salinity readings (Tickell & Rajaratnam, 1998).

Birrindudu wetlands support the largest coolibah-cooba woodland in the NT, as well as diverse shrub swamps and marshes which provide an important waterbird breeding area for over 50 waterbird species, seven of which are migratory shorebirds utilising the site as a stopover (Australian Wetlands Database, 2005).

Birrindudu wetlands have a particularly soft substrate which is thought to prevent stock access, allowing plants such as lignum and bluebush to grow and provide shelter and nest sites for birds.

Nongra Lake supports the largest examples of Acacia-wooded swamp in the NT. This wetland provides habitat for around 29 species of waterbird, and becomes particularly important when Birrindudu wetlands are dry.

Legune Wetlands (NT030), comprising both the Legune Homestead Swamps and Osmans Lake System, support significant numbers of waterbirds during the dry season, and provide breeding habitat for Mapgpie Geese, *Anseranas semipalmata*, in the wet season (Australian Wetlands Database, 2005). Legune Homestead Swamps are dominated by Eleocharis sedges in deeper areas, and also support *Melaleuca argentea* and *Barringtonia acutangula*, as well as other sedges, grasses and lilies. Some areas are fenced to exclude stock. The Osmans Lake System consists of a lake and more than 15 associated claypans. The lake is the largest such waterbody in the NT, and is dominated by Beetle Grass, *Sesbania cannabina, Chenopodium auricomum, Xerochloa imberbis,* and *Sporobolus virginicus.* The Legune Wetlands support over 47 bird species, including migratory shorebirds.

Bradshaw Field Training Area (NT033) supports approximately 70% of the rare and endangered species of the Victoria-Bonaparte Bioregion, as well as being surrounded by protected areas on all sides, making these wetlands an important component of the conservation network in the Bioregion (Australian Wetlands Database, 2005). There is a *Xerochloa* grassland habitat in the wetland, and nine of the rare and endangered vertebrate species recorded for the Bioregion. The area also contains many sacred Aboriginal sites, 129 archaeological sites and 55 historic sites. The land is managed by the Department of Defence, and is subject to their stringent Environmental Management Systems. The area is also subject to a Native Title Claim (Australian Wetlands Database, 2005).

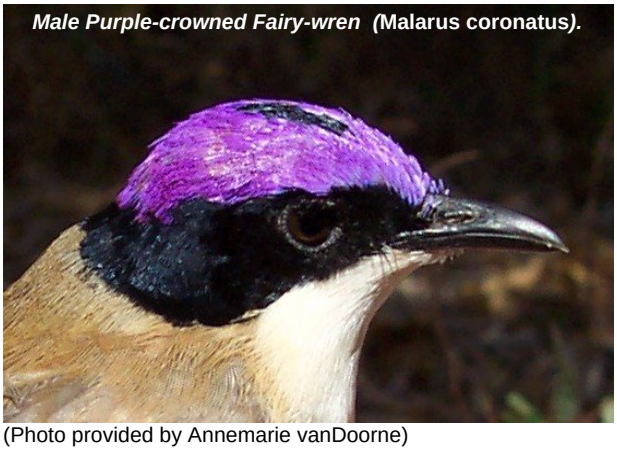
Fisher and Woinarski (2002) have identified areas of conservation significance in the Victoria River region due to their physical isolation, and subsequent value as refuge areas from frequent fire. Small "islands" in the tidal mudflats of the Victoria River estuary, and rugged sandstone areas such as the Victoria River Gorge and mesas are examples of areas that provide important habitat for fire sensitive flora and fauna species.

Riparian vegetation provides another important habitat area for fauna. Although these lands occupy only a small proportion of the landscape, they frequently have a much higher species richness and abundance of animal life than adjacent habitats (Lynch and Catterall, 1999). Riparian vegetation along the Victoria River includes *Pandanus aquaticus, Eucalyptus camaldulensis, Terminalia platyphylla, Melaleuca* spp., *Lophostemon lactifluus, Ficus* Spp., *Nauclea orientalis* and others (refer Sections 4.6 and 4.7).

A broad-scale survey of bird distribution in riparian vegetation in the Top End of the NT found that despite their relatively small total extent, riparian areas were extremely important for birds (Woinarski *et al*., 2000). 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 sp.* (Woinarski *et al*., 2000).

One species of conservation significance in the Victoria River catchment that relies on the riparian habitat is the Purple-crowned Fairy-wren, *Malurus coronatus*. This bird is listed as a vulnerable species under the Commonwealth's *Environment Protection and Biodiversity Conservation Act*. It is strictly a riparian species, inhabiting the Canegrass, *Chionachne cyathopoda,* which grows along the banks of the Victoria River and its tributaries (vanDoorn, in press). *Chionachne cyathopoda* is susceptible to grazing and trampling by stock and feral animals, and has been reduced and fragmented in the region. This, combined with other threats to the riparian habitat, such as weed invasion, erosion and fire, are further threatening the fragile habitat of this species. A comprehensive Management Plan is currently being prepared to ensure the long-term survival of this Fairy-wren through protection of its important riparian habitat (vanDoorn, in press).

Male Purple-crowned Fairy-wren (*Malarus coronatus*).



(Photo provided by Annemarie vanDoorne)

Gregory National Park is in a transition zone between the semi-arid and wet-dry climatic zones, and its geographic location and size are reflected in the diversity of its flora and fauna (PWCNT, 2002a). Over 1200 plant species have been recorded in the National Park, 13 of which are of conservation significance, including *Boronia jucunda, Gleichenia microphylla, Stenostegia congesta* and *Fimbristylis blakei.* Small patches of monsoon vineforest occur throughout the park, and the lancewood population, *Acacia shirleyi,* is the most westerly recorded population. Both the monsoon vine-forest and the lancewood population are intolerant of fire, and therefore restricted to small remnant stands. Around 444 species of fauna have been recorded in the National Park, including 39 mammals, 76 reptiles, 169 birds, 21 frogs, 34 fish, 52 families of aquatic invertebrate and 58 species of cave invertebrate fauna (PWCNT, 2002a). Species of conservation significance include the Purple-crowned Fairy-wren (*Malurus coronatus*) and the Gouldian Finch (*Erythrura gouldiae*) (PWCNT, 2002a).

Estuarine crocodiles (*Crocodylus porosus*) and freshwater crocodiles (*Crocodylus johnstoni*) inhabit the waters of the Victoria River. Fish species recorded in the Victoria River and its tributaries include Silver Barramundi (*Lates calcarifer*), Blue Catfish (*Arius graeffei*), Black Bream (*Hephaestus jenkinsi*), Drysdale Grunter (*Syncomistes rastellus*), Angalarri Grunter (*Scortum sp.*), Long Tom (*Strongylura krefti*), Ox-eye Herring (*Megalops cyprinoides*), Giant Chanda Perch (*Parambassis gulliver*), Sleepy cod (*Oxyeleotris lineolata*) and Purple Spotted Gudgeon (*Mogurnda mogurnda*) (Midgley, 1981; PWCNT, 2002a). Angalarri Grunter is listed as vulnerable under NT legislation, and is restricted to the Victoria River catchment.

Larson (1999) recorded a total of 35 fish species in the Keep River and Sandy Creek region. Of note were the Dwarf Sawfish (*Pristis clavata*), and the Freshwater Sawfish (*Pristis microdon*), as they are of national and international significance, respectively. The Freshwater Sawfish is listed on the IUCN's Red List as "potentially threatened". Larson notes that only ten of the 35 fish species recorded in the Keep River system are estuarine compared to 181 estuarine species in Kakadu National Park, and 107 from the Roper River estuary. It is thought that perhaps more species occur in the Keep River estuary than were recorded during this survey (Larson, 1999).

Aquatic macroinvertebrates recorded in the Victoria River catchment as part of the 'Ausrivas' (Australian Rivers Assessment) Scheme included a total of 53 macroinvertebrate groups, with an average of 26 family groups per site (PWCNT, 2002a). This is comparable to other catchments in

the Top End. Organisms included shrimps, prawns, worms, mites, nematodes, aquatic bugs, adult beetles and a large variety of insect larvae such as mayflies, dragonflies, damselflies, caddisflies, midges and beetles (PWCNT, 2002a).

Cave fauna in the Victoria River region have been investigated by the Top End Speleological Society (TESS). The majority of species described by this group have been found in the surface environments and may be widespread throughout the region, however some species are adapted to cave dwelling, and others are totally restricted to the karst region (PWCNT, 2002a). Aside from invertebrate fauna, the most common cave dwellers recorded were bats such as the Common Sheathtail Bat (*Taphozous georgianus*), Orange Horseshoe Bat (*Rhinonycteris aurantius*), Ghost Bat (*Macroderma gigas*), Dusky Horseshoe Bat (*Hipposideros ater*) and Common Bent-wing Bat (*Miniopterus shreibersii*) (PWCNT, 2002a).

A number of feral animal species occur throughout the Victoria River catchment including buffalo (*Bubalus bubalis*), feral horses (*Equus caballus*), donkeys (*Equus asinus*), feral cattle (*Bos taurus*), feral pigs (*Sus scrofa*), feral dogs (*Canis familiaris*), camels (*Camelus dromedarius*). Domestic mice (*Mus domesticus*) and the Black Rat (*Rattus rattus*) have also been found around human settlements (PWCNT, 2002a). Buffalo and pigs are not widespread in the Victoria River catchment, however donkeys and horses in particular are considered to be in plague proportions in some areas. Camel numbers have also increased dramatically since they were introduced, and feral cats pose a threat to native wildlife (PWCNT, 2002a).

Parks and Wildlife Service staff undertook an aerial survey in 1996 to assess the feral animal population in the Victoria River District. In 1999, a "Pest Control Area" was declared, and between 1999 and 2004 a total of 134,277 donkeys and feral horses were culled in the area. Collaring programs, using radio transmitters, and subsequent aerial culls have been used to control donkey numbers.

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).

Landholders are responsible for feral animal control on their property under the *Pastoral Land Act* and the *Territory Parks and Wildlife Conservation Act.* Difficulties arise with the enforcement of the legislation, the resilience of these species to drought conditions, lack of fences in the region, and the limitations of the pet meat industry (DIPE, 2004).

The Cane Toad (*Bufo marinus*), an introduced animal, first entered the NT in the 1983/84 wet season (Dept of Lands and Housing, 1991) and reached the Victoria River catchment in 2004. This species competes with native fauna such as frogs, and is known to poison animals that prey on it, such as birds, reptiles and mammals. No practical control method is presently known which can effectively halt the toad invasion of northern Australia (CCNT, 1994a).

(Photo provided by Patrick Carmody, PWS)

2.5 Land Tenure, Use and Management

Current land classification within the Victoria River catchment is shown on Map 5. The majority of land is under Perpetual Pastoral Lease, however other land tenure types include Right to Freehold Title held by Aboriginal Land Trusts, Perpetual Crown Leases held by Parks and Wildlife, and Term Crown Lease land held by the Department of Defence. Most leases contain covenants to control the usage or development of the land. Term leases are usually issued to allow development to proceed, with land often being converted to freehold title or perpetual leasehold once the development is completed satisfactorily.

It is believed Aboriginal people may have occupied the Victoria River region when they first arrived in Australia in dug-out canoes as far back as 40,000 years ago (Makin, 1992). More recent archaeological remains are common in the area including surface scatters of stone tools and ochre quarries, burial sites, rock shelter occupation deposits and numerous rock art sites (Lewis and

Rose, 1987). Many sites of Aboriginal archaeological significance are listed and protected by the Aboriginal Areas Protection Authority under the *Northern Territory Aboriginal Sacred Sites Act, 1989.*

The Victoria River Aboriginal people believe that the rock art in the district is of Dreaming origin and depicts Dreaming Beings and their activities. Many different language groups claim traditional links to the Victoria River district including Ngaliwurru, Ngarinyman, Nungali, Bilinara, Jaminjung, Karrangpurru and Wardaman (PWCNT, 1998). The history of the people and the district is maintained and transmitted in non written form, and the culture relies heavily on ceremony, art and the older generations to pass on beliefs and practises to the young.

The first European to visit Victoria River was Phillip Parker King in 1819. He sailed into Joseph Bonaparte Gulf and the mouth of the Victoria River, however returned due to bad weather. Later in 1893, Captain John Clements Wickham and Lieutenant John Lort Stokes re-discovered and named the Victoria River. They named the River after her Majesty Queen Victoria, and continued by boat to where Timber Creek is today and proceeded further upstream on foot, a total distance of 230 kilometres from the sea (PWCNT, 2002a). The next expedition up the Victoria River was led by Augustus C. Gregory in 1855. Gregory established a base camp (Gregory's Tree) on the bank of the Victoria River below Timber Creek for eight months, and is believed to have made the first friendly contact with the Aboriginal people in the Victoria River district (Lewis, 1997). Gregory led expeditions to the junction of the Wickham and the Victoria Rivers, and down the Wickham River along Sturt Creek into the Sandy Desert to Lake Gregory. Whilst these expeditions were taking place, the base camp team explored the East Baines River upstream from Bullita Homestead (Birman, 1979). The last European exploration prior to the first settlers arriving was led by Alexander Forrest in 1879, who followed the Overland Telegraph Line from the Kimberley (Lewis, 1997).

European settlers arrived in 1883. Nat Buchanan claimed the upper Victoria River, stocking Wave Hill Station with 4,500 head of cattle from Queensland. Buchanan was then contracted to overland a further 20,000 head of cattle to Victoria River Downs for Victorian investors, Fisher and Lyons. Pastoral companies such as Bovril and Vesteys from London moved into the region and took over many stations from about 1910 (PWCNT, 2002a). By the early 1900s most of the district consisted of large, mostly unfenced cattle and sheep stations (Lewis, 2002).

Aboriginal people initially resisted and impeded pastoral development due to mutual fear and competition for land resources. After a period of violence and confrontation however, Aboriginal people were enticed into the workforce by the promise of food and shelter, and eventually the industry came to rely heavily on their contribution to both stock work and domestic duties. Aboriginal people worked on the stations during the dry season and went 'bush' during the wet, when they used their time to maintain their religious life and to educate younger people in the knowledge, skills and values pertaining to their own country and culture (Rose, 1991). By the 1920s Station economies were almost reliant upon the Aboriginal workforce, and during the Second World War Aboriginal people took on even more responsibility with management. The Aboriginal people were also responsible for teaching survival skills to many army personnel in return for shelter and access to clothing, food and medical assistance (Lewis, 1997).

There was general dissatisfaction amongst the Aboriginal people with housing and work conditions remaining unresolved following the war (Lewis, 1997; PWCNT, 2002a). This dissatisfaction eventually led to the "Wave Hill walk out" in 1966, when the Guringji people left the station to camp in the Victoria River bed, demanding full wages and improved conditions. Ultimately the Aboriginal people demanded formal title of their land, and the strike action continued from 1966 to 1972, causing turmoil to the regional economies (Lewis, 1997). Some stations were able to negotiate labour agreements, and work conditions were ultimately improved, however the extent of the industrial action also led to an increase in expenditure on fencing and other infrastructure, as well as the shift away from large numbers of low paid stockmen in favour of trucks and later, helicopters (Lewis, 1997). The strikes led to the establishment of the *Aboriginal Land Rights Act (NT), 1976*. Kildurk, Fitzroy, Mistake Creek, a large section of Wave Hill and the Hooker Creek Aboriginal Reserve came under Aboriginal control, and areas of Crown Land such as stock routes, reserves and small town commons were also excised from stations as 'living areas'.

Aboriginal people run several cattle stations in the region today, including Amanbidji, Malngin 1 (formerly Mistake Creek), and Malngin 2 (formerly Brumby Plains). Fitzroy and Innesvale Stations are owned by the Daguragu Land Trust and are also used for pastoral purposes (Kraatz, 2000).

The Australian Defence Force purchased Bradshaw Station in 1996. The Station had been used for pastoralism since the late 1800s, and was purchased as a major training resource for Australian and possibly combined foreign forces.

An Environmental Impact Statement (EIS) was prepared in 1998 to assess the potential impact of wastes and unexploded ordinances in the area. The EIS was approved and an Environmental Management Plan was developed for ongoing management of the property. Weeds, fire and feral animal control programs are in use, de-stocking is complete, and fencing of important wetland areas has been undertaken on Bradshaw Field Training Area (Kraatz, 2000). Department of Defence also undertake military activities on other nearby stations with landholder agreement (Sample, 2004). Aerial bombing practise is conducted on Delamere Range creating local disturbances, however this activity is also subject to strict regulation (Sample, 2004).

Keep River National Park was declared on 1 May 1981. Spirit Hills is also managed by Parks and Wildlife Service, and it is hoped that this area will eventually be declared as an extension of Keep River National Park. Gregory National Park was declared in 1990. The original park boundary has been altered due to successful Aboriginal land claims, including the excision of the Stokes Range section which created the gap between the two sectors. A portion of Mt Sanford Station in 1996 significantly extended the park boundary to encompass most of the Wickham River catchment, however this portion has not yet been formally declared. Gregory National Park also includes Gregory Tree Historical Reserve, Victoria River Depot Historical Reserve (located outside the park), and the proposed Drover's Rest Boab Precinct.

Tourism in the Victoria River region is highly seasonal, occurring mostly during the dry season between May and September. The primary attractions include Gregory and Keep River National Parks, and activities include remote camping, bushwalking, four-wheel driving, boating and fishing. The harsh climate and the remoteness from population centres keeps visitor numbers relatively low in the two National Parks, adding to the appeal for those that do visit (PWCNT, 2002a).

Fishing in the Victoria River and its tributaries includes commercial operators, fishing tour operators and recreational fishermen. There are two public boat ramps in the vicinity of Gregory National Park, at Big Horse Creek and the Victoria River Gorge Picnic Area. However, landholders with access to the river presumably have their own boat ramps, which are used with the owners' permission. There are no public boat ramps in the Keep River National Park, however again, it is assumed that landholders with river access would have boat ramps.

In 2003, in the area extending from Moyle River to Keep River (including the Fitzmaurice River), there were six commercial licensees from three fisheries (Barramundi, Shark and coastal line fisheries) (Sample, 2004). There was only one Barramundi fishing operator in the Victoria River itself, restricted to waters downstream of Bullo River. The catch from the commercial fishing operators equated to less than 2% of the total 2003 NT harvest value for the combined fisheries in 2003 (cited in Sample, 2004). Midgley (1981) commented that the Victoria River has never had a reputation for large fisheries production. Sample (2004) suggested that this is not due to the lack of fish, but rather to the large tidal flows making netting difficult, limited land access, and the NT Government policy of "buyback" of commercial fishing licenses. There is no aquaculture in the Victoria River, however there is a commercial crocodile breeding operation specialising in skin production (Sample, 2004). There were eight fishing tour operators licensed for the Victoria River in 2003, representing 7% of those in the NT. Barramundi fishing dominates the fishing tour operator business, others include game fishing, bottom fishing and crabbing (Sample, 2004). Recreational fishing is pursued in the Victoria River by boat and from the shore, and is relatively infrequent, compared to other rivers closer to population centres.

Currently, the responsibility for river management in the NT lies predominantly with the NT Government. The *Northern Territory Water Act, 1992* is the major legislative framework for managing rivers. 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). The *NT Water Act* restricts and controls the way in which water quality can be affected.

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);
- *Weeds Management Act* (2001);
- *Pastoral Land Act* (1992);
- *Planning Act* (1999);
- *Soil Conservation and Land Utilisation Act* (1992); and
- *Waste Management and Pollution Control Act* (1998)

National legislation of relevance to river management includes the *Environmental Protection and Biodiversity Conservation Act, 2000.* This Act protects significant wetlands and threatened and vulnerable flora, fauna and ecological communities.

Management plans and guidelines currently in place include:

- Gregory National Park Plan of Management - Draft (PWCNT, 2002a);
- Keep River National Park Plan of Management – Draft (PWCNT, 2002b);
- Katherine Regional Weed Management Strategy (Katherine Regional Weed Advisory Committee, 2004);
- Victoria River District Weed Management Plan - Draft (DPIF, 1997);
- Clearing Guidelines for Pastoral Land (Pastoral Land Board, 2004); and
- Resource Management Guidelines for the Northern Territory, Land Clearing Guidelines (DIPE, 2002).
- The Victoria River District Natural Resource Plan (Sample, 2004)

Katherine Regional Weeds Strategy provides direction for strategic weed management in the region, including the Victoria River catchment. The Strategy does not provide species specific information. Advice on control of individual species is provided in the Victoria River District Draft Weed Management Plan (DPIF, 1997). The Resource Management Guidelines for land clearing do not apply where there are existing clearing guidelines (eg on Pastoral Leases and where town planning policies apply). The Resource Management Guidelines recommend buffer widths suitable for riparian protection, which vary depending on the stream order (eg 20m for drainage lines, 200m for wetlands) (DIPE, 2002).

The Victoria River District Conservation Association (VRDCA) was founded by land managers in 1987. The impetus behind forming the group was largely rangeland management and erosion control, and has expanded to include natural resource management in general (Sample, 2004). The current membership of the VRDCA includes pastoral land managers, Aboriginal Land Trusts, Defence Force, Local Government, Crocodile farmers, Parks and Wildlife Service, and some Non Government Organisations. The VRDCA has been granted funding for many natural resource management projects, increasing the knowledge base of its membership, as well as considerable on ground improvements.

2.6 Water Resources

2.6.1 Water Resource Studies

Water resources of the Victoria River District (VRD) were mapped, described and evaluated between 1993 and 1998. The project was requested by the VRDCA to assist landholders in property planning and management. The project was jointly funded by VRDCA, Northern Territory Government and Landcare. The following maps and reports were produced:

- Water Resources of the Victoria River District (Tickell & Rajaratnam, 1998). This report covers the Victoria River drainage basin and includes:
  1) water resource maps for supply options of both groundwater and surface water;
  2) a description of groundwater systems including aquifer type and water quality;
  3) a description of surface water including waterholes, lakes, springs, tanks and dams;
  4) a discussion of the sustainability of water supplies in terms of effects of drought on water sources, present water usage and reducing the effects of drought; and
  5) information about water resource data, location and availability.

- Water Resources Development Maps and Commentary Notes (Tickell & Rajaratnam, 1996a, b, c, d, e, 1997) at pastoral property scale. This is a series of maps, at 1:250,000 and 1:100,000 scale, based on the following areas of the Western Victoria River District:
  1) Hooker Creek Station and Lajamanu Community;
  2) Mistake Creek Station;
  3) Mt Sanford Station (part of Victoria River Downs Station);
  4) Limbunya and part of Riveren Station;
  5) Daguragu; and
  6) Fitzroy Station and NT Portion 3122.

  There are also separate reports for each pastoral property in this area.

- Assessment of Surface Water Resources for Stock Watering in the Victoria River District (Rajaratnam, 1998). This report assesses the potential of storing surface water for stock watering, and identifies suitable areas for excavated tanks. The report provides guidance on design and dimensions of excavated tanks and provides a map of surface water storage potential.

- Isotope sampling in the VRD (Tickell, 1998).

The main source of stock water in the VRD is groundwater, extracted from bores and pumped to a storage tank such as a turkeys nest or steel tank before being gravity fed to one or more troughs (Tickell & Rajaratnam, 1998). Five aquifer types occur in the area, and water availability varies greatly depending on the characteristics of the underlying aquifer, and the depth of the bore. The majority of the region is underlain by a fractured rock aquifer with low yields, typically in the order of 1 litre per second. A limestone aquifer lying along the eastern side of the region supports higher yielding bores of around 2 litres per second. It is suggested that if these bores were drilled deeper, they could yield between 5-15 litres per second (Tickell & Rajaratnam, 1998). Groundwater resources are recharged by annual rainfall, when weekly rainfall exceeds 100mm (Tickell, unpublished). Groundwater has a short residence time in the VRD, most water is less than 50 years old, the oldest being 3,000 years old. The majority of groundwater in the VRD is fresh and suitable for stock (Tickell & Rajaratnam, 1998).

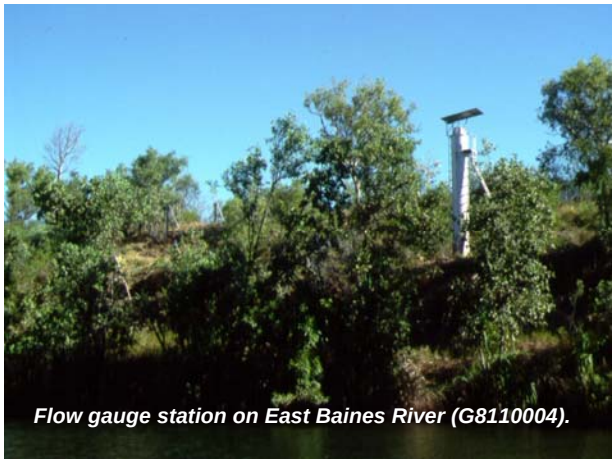
As discussed in Section 2.4.2, the Victoria River and most of its tributaries only flow for four to six months of the year, before drying into intermittent waterholes. Spring flows and seepages mostly occur low in the landscape, mainly in the headwaters of the Victoria River between Mount Sanford and Top Springs, where the watertable is generally shallow (Tickell & Rajaratnam, 1998). Springs also occur due to geological formations, such as where an aquifer is faulted against an impermeable rock like siltstone, and the groundwater flow is forced to the surface (eg Campbell Springs on Limbunya Station), or where the contact between two aquifers is dissected by a creek (eg Buchannan Springs on Riveren Station). The majority of springs in the Victoria River region are ephemeral. Unidait Spring on Limbunya and Depot Spring on Mount Sanford are the only permanent springs, all the others dry up during the dry season, depending on the amount of rain that fell during the previous wet season (Tickell & Rajaratnam, 1998). Surface water sources accessible by stock are generally less efficient than those that are fenced and regulated through a turkeys nest or steel tank, as unrestricted stock access tends to cause erosion and siltation, making waterholes shallow and more prone to water quality problems (Tickell & Rajaratnam, 1998).

Tanks and dams used to harvest and store surface water flows are not widely used in the VRD, except for where groundwater supplies are difficult to locate (eg the then Bradshaw Station and Auvergne Station). The only areas suitable for excavated tanks to store surface water flows are flat to gently undulating black soil country, where there is adequate soil to excavate to a depth of at least 3.5 metres. There are very few locations in the VRD that fit this criterion (Tickell & Rajaratnam, 1998).

2.6.2 Stream Flow

Stream flow gauging commenced in the NT in 1952, and the first on the Victoria River was set up at Coolibah Station homestead in September, 1952 (Department of Mines and Energy, 1986). Figure 2.8 shows the location of the flow gauge stations within the Victoria River catchment. A total of 18 stations have been established in the Victoria River catchment, eight of which are still operating today.

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 eight pluviographs (automatic rainfall recorders) operating in the Victoria River catchment for flood hydrology work. These are located at gauge stations including Victoria River at the Crossing, Coolibah Station, Dashwood Crossing, Wave Hill Police Station, Williams Crossing and upstream of Timber Creek, as well as on the East Baines and West Baines Rivers at the Victoria Highway. Many pastoralists also report rainfall to the Bureau of Meteorology.



Flow gauge station on East Baines River (G8110004).

Table 2.5 summaries the stream flow information for the flow gauge stations in Victoria River catchment. G8110007 at Coolibah Homestead is the furthest downstream gauge station in the network, and records a mean annual flow volume of 3,185 million m^3, or a mean annual discharge of 162m^3/sec. This can be compared to G8110016 at Wave Hill Police Station, the most upstream gauge station on Victoria River, which records a mean annual flow volume of 432.7 million m^3, or a mean annual discharge of 19.9m^3/sec.

OPEN FLOW GAUGE STATIONS

Station	Tributary	Location	Years Recording
G8110004	East Baines River	Victoria Hwy	1964-present
G8110006	West Baines River	Victoria Hwy	1960-present
G8110007	Victoria River	Coolibah Homestead	1952-present
G8110012	Timber Creek	2 miles u/s Vic Hwy	1968-present
G8110016	Upper Victoria River	Wave Hill Police Stn	1954-present
G8110110	Surprise Creek	VRD Rd crossing	1959-present
G8110113	Victoria River	Dashwood Crossing	1963-present
G8110232	Wickham River	Williams Crossing	1965-present

CLOSED FLOW GAUGE STATIONS

Station	Tributary	Location	Years Recording
G8110018	Victoria River	Victoria Hwy	1972-1993
G8110073	Armstrong River	Top Springs	1959-1986
G8110074	Montejinnie Creek	Montejinni Homestead	1973-1986
G8110101	Dick Creek	Victoria Hwy	1962-1978
G8110107	Saddle Creek	Victoria Hwy	1962-1986
G8110184	Middle Creek	VRD Rd crossing	1963-1981
G8110222	Walsh Creek	Sugarloaf Hill	1965-1977
G8110238	Delamere Cerek	Delamere Hstead	1966-1987
G8110251	West Baines River	Brumby Hill	1965-1965
G8110263	Bullock Creek	1.5 miles d/stream bore	1966-1992

0 25 50 75

KILOMETRES

WATER QUALITY SAMPLING SITES

Code	Station	Tributary	Location
1	G8110001	Blackgin Creek	Blackgin Whole
2	G8110004	East Baines River	Victoria Hwy
3	G8110005	Timber Creek	Police Station
4	G8110006	West Baines River	Victoria Hwy
5	G8110007	Victoria River	Coolibah Homestead
6	G8110009	Kidman Springs	Kidman Springs
7	G8110014	Sullivans Creek	U/stream Fig Tree yard
8	G8110015	Wickham River	VRD Homestead
9	G8110016	Upper Victoria Ri	Wave Hill Police Stn
10	G8110017	Victoria River	Pigeon Hole Hstead
11	G8110018	Victoria River	Victoria Hwy
12	G8110019	Wickham River	Spring Flow
13	G8110073	Armstrong River	Top Springs
14	G8110074	Montejinnie Creek	Montejinni Homestead
15	G8110106	Camfield Creek	Old Road crossing
16	G8110110	Surprise Creek	VRD Rd crossing
17	G8110113	Victoria River	Dashwood Crossing
18	G8110169	Jasper Creek	Jasper Gorge
19	G8110184	Middle Creek	VRD Rd crossing
20	G8110187	Big Horse Creek	Victoria Hwy
21	G8110222	Walsh Creek	Sugarloaf Hill
22	G8110232	Wickham River	Williams Crossing
23	G8110251	West Baines River	Brumby Hill
24	G8110253	Gibble Creek	Wagon Wheel Whole
25	G8110255	Ikymbon River	Inukalen Cateract
26	G8115000	Victoria River	Fitzroy Station
27	G8115005	Kidman Springs	Kidman Springs
28	G8115009	East Baines River	Auvergne Station
29	G8115023	Gordy Springs	Wave Hill Station
30	G8115089	Camallin Spring	Bradshaw Station
31	G8115113	McDonald Creek	McDonald W/hole
32	G8115114	Victoria River	Kalkarindji d/s road br
33	G8115115	Wickham River	Johnston Billabong
34	G8115116	Limestone Creek	Limestone Gorge
35	G8110253	Gibbie Creek	Wagon Wheel Waterhole
36	G8115110	Victoria River	Pigeon Hole
37	G8115117	Cow Creek	Cow Ck Falls
38	G8115118	West Baines River	Hurrican Hills Yd
39	G8115119	Boxer Springs Ck	Boxer Springs Ck

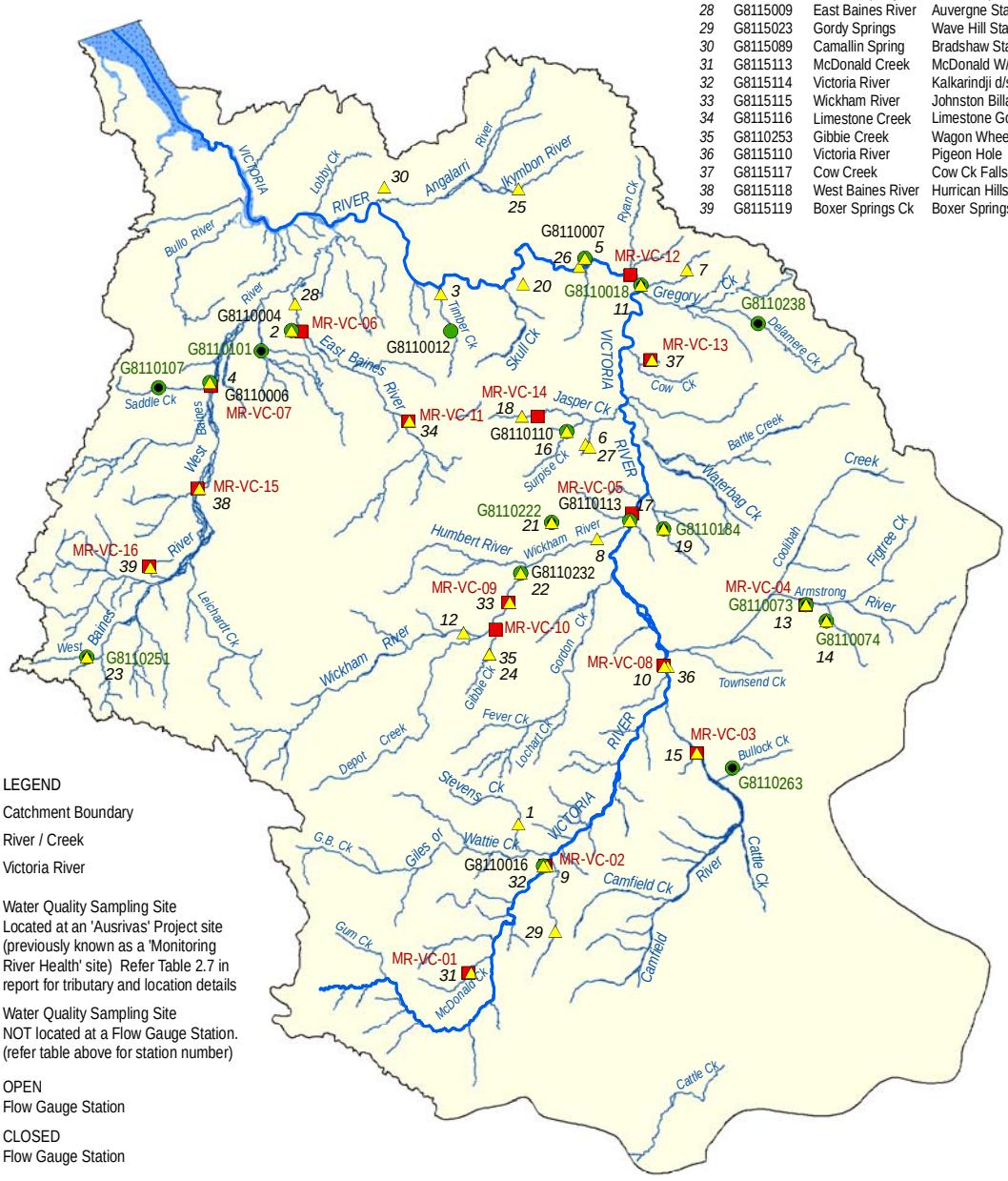


Figure 2.8 Location of Flow Gauge Stations and Water Quality Sampling Sites throughout the Victoria River Catchment

Table 2.5 Summary of Stream Flow Information for the Victoria River Catchment

Gauge Station Number	Tributary	Catchment Area (km2)	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)
G8110004	East Baines River	2,432	238,600,000	12.4	11.3	12.1 (0-2,808)
G8110006	West Baines River	10,204	706,900,000	40	21.7	42.5 (0-3,355)
G8110007	Victoria River	44,900	3,185,000,000	162	118	164.9 (0.1-13,404)
G8110012	Timber Creek	164	25,370,000	1.4	0.9	1.2 (0-704.5)
G8110016	Upper Victoria River	4,916	432,700,000	19.9	17.4	20.3 (0-6,644)
G8110110	Surprise Creek	361	31,960,000	3	2.7	3.2 (0-310.7)
G8110113	Victoria River	33,400	2,206,000,000	125	102	140.2 (0-6,708)
G8110232	Wickham River	5,018	53,060,000	11.9	10.5	12.2 (0.2-127.2)
G8110018*	Victoria River	43,600	4,176,000,000	909	172	844.6 (0-13,411)
G8110073*	Armstrong River	810	84,750,000	3.6	3.3	3.8 (0-1,198)
G8110074*	Montejinnie River	139	2,498,000	0.1	0.1	0.1 (0-13.8)
G8110101*	Dick Creek	888	92,400,000	8.6	6.9	7.0 (0-152.4)
G8110107*	Saddle Creek	234	18,870,000	1.5	1.4	1.2 (0-77.3)
G8110184*	Middle Creek	120	17,850,000	1.9	1.5	1.7 (0-235.8)
G8110222*	Walsh Creek	45	7,343,000	1.5	1.2	1.2 (0-146.7)
G8110238*	Delamere Creek	653	8,221,000	0.8	0.7	0.9 (0-11.4)
G8110251*	West Baines River	168	22,690,000	0.9	0.8	0.8 (0-617.8)
G8110263*	Bullock Creek	474	18,400,000	1.2	0.7	1.0 (0-1,088)

* Closed Gauge Station

Source: Figures obtained from 'Hydsys' and were up-to-date at the time of extraction (2004). 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 stream flow contributions to the Victoria River from the various tributaries vary considerably. Aside from East and West Baines Rivers, the greatest contribution to the Victoria River (on which flow gauge stations exist or have existed), is from Dick Creek, Armstrong and Wickham Rivers. G8110018, a closed gauge station on the Victoria River at the Victoria Highway Crossing, has the largest catchment area and reports the greatest mean annual flow volume of all the measured locations in the Victoria River catchment.

The mean monthly discharges for the Victoria River and several tributaries are shown in Figures 2.9 to 2.11. 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 211mm of rain was recorded at Victoria River Downs Station on 15th April 1985, and the monthly average for April, based on 118 years of records, is 22.1mm).

The mean monthly discharge recorded for the Victoria River (Figure 2.9) is in the order of ten times those of the East Baines, West Baines and Wickham Rivers (Figure 2.10), and one hundred times the mean monthly discharge recorded for smaller tributaries such as Timber Creek, Surprise Creek, Armstrong River and Delamere Creek (Figure 2.11).

Figures 2.9 to 2.11 illustrate the highly seasonal nature of the rivers in the Victoria River catchment, as flows mostly cease between May and November each year. Some small contributions from groundwater discharge from springs or seepage points may be present, however the majority of the streams are ephemeral, and dry into a series of pools by the end of the dry season. Figure 2.9 shows that the highest mean monthly discharge along the Victoria River occurs in March and ranges from 45m^3/sec at Wave Hill Police Station (G8110016) to 1,393m^3/sec at the Victoria Highway (G8110018). The lowest mean monthly discharge along Victoria River occurs in August and ranges from 0.062m^3/sec at Wave Hill Police Station (G8110016) to 0.619m^3/sec at the Victoria Highway (G8110018).

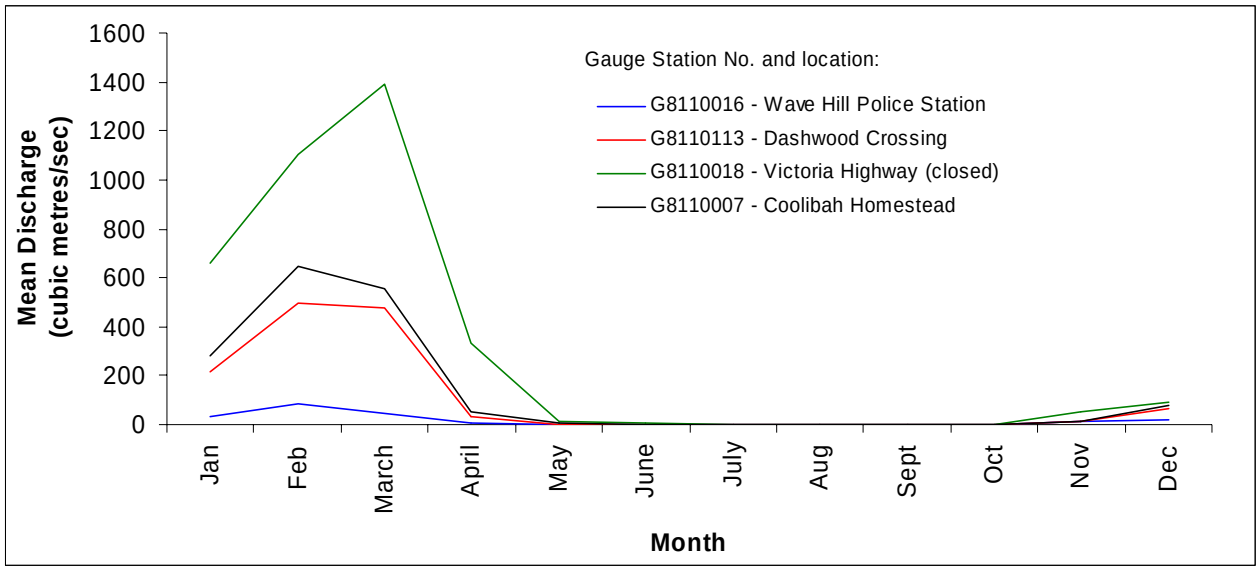


Figure 2.9 Mean Monthly Discharge Recorded for Victoria River

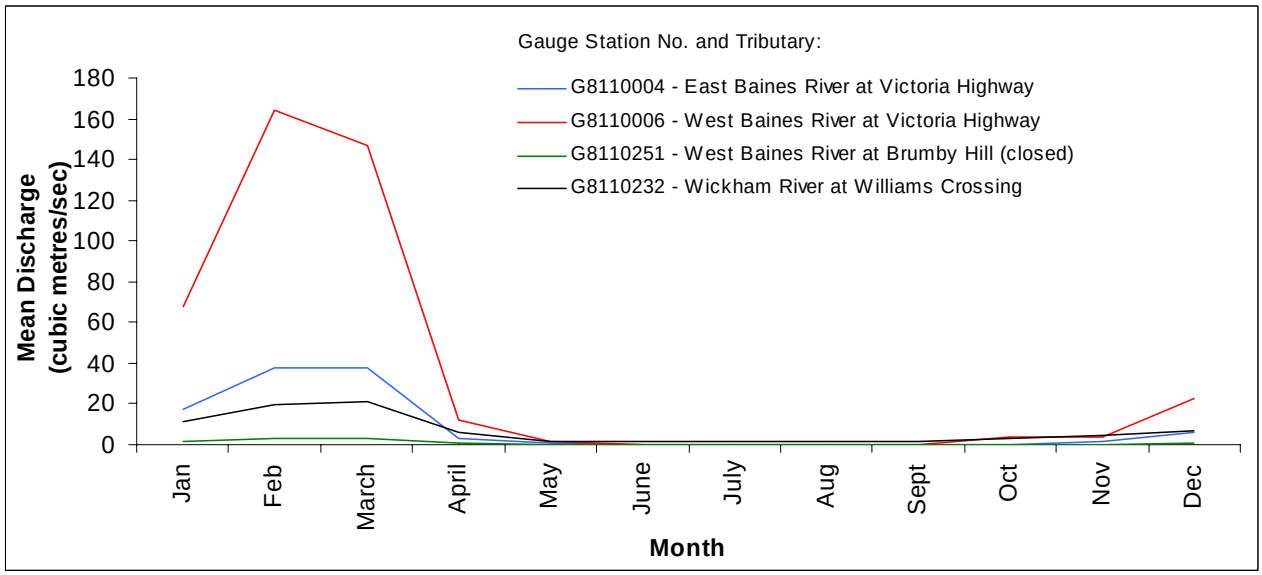


Figure 2.10 Mean Monthly Discharge Recorded for East Baines, West Baines and Wickham Rivers

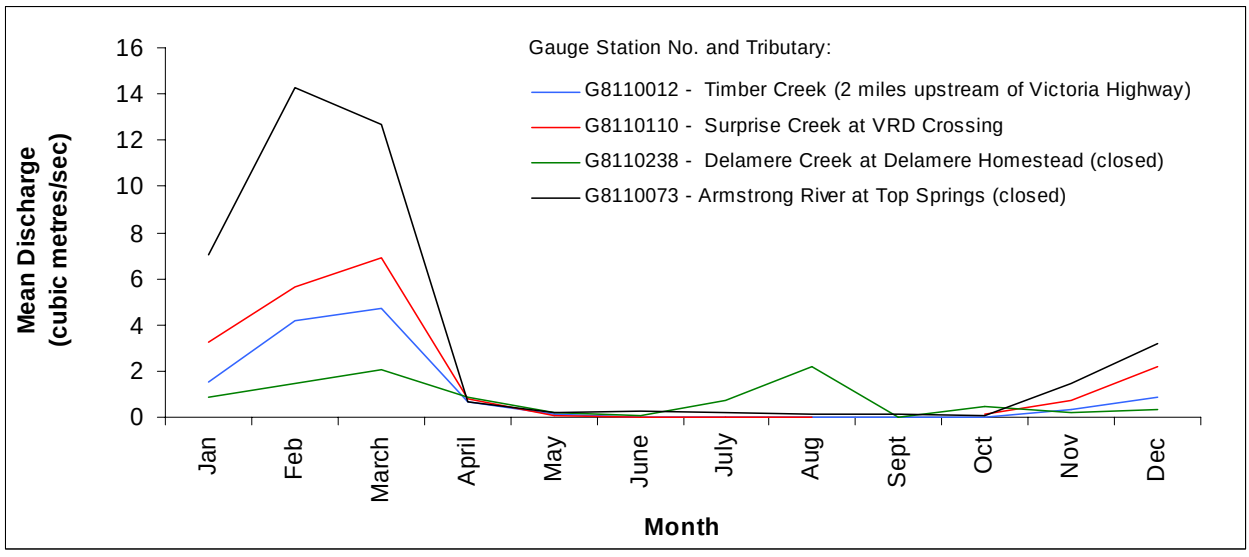


Figure 2.11 Mean Monthly Discharge Recorded for Timber Creek, Surprise Creek, Armstrong River and Delamere Creek.

The highest mean monthly discharge recorded for the Baines and Wickham Rivers occurs in February, and ranges from 164m^3/sec recorded on West Baines River at Victoria Highway (G8110006), to 3m^3/sec recorded on West Baines River at Brumby Hill (G8110251) (refer Figure 2.10). The lowest mean monthly discharge recorded for these two stations occurs in August and September, with 0.1m^3/sec recorded at Victoria Highway and 0.02m^3/sec recorded at Brumby Hill. Likewise with the smaller tributaries, the highest mean monthly discharges are recorded in the downstream sites during the wet season, and the lowest discharges are recorded in the upstream sites during the dry season.

Extraction of water from rivers and creeks (ie surface waters) occurs for stock and domestic purposes within the Victoria 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 Infrastructure, Planning and Environment under the *NT Water Act*. There is currently only one Water Extraction Licence valid in the Victoria River catchment, held by Power and Water Corporation for Bulla Camp Community for 10ML/year. Roadworks licences were issued in 2004, but none were valid at the time of writing this report.

2.6.3 Water Quality

A surface water quality network was established in 1984 in the NT with a program of spot measurements for basic key quality parameters (ie pH, temperature, electrical conductivity and turbidity) at flow gauge stations (Dept of Mines and Energy, 1986). Total phosphorus and total alkalinity are also measured at some gauge stations on an irregular basis.

There are also dedicated water quality sampling locations (located away from gauge stations), where monitoring is carried out on a project basis by the Department of Infrastructure, Planning and Environment (DIPE). This sampling has generally been ad hoc, and often provides a snap shot of that particular waterway as a result of a one-off water quality survey. There is no long term series data collection in the Victoria River catchment.

Apart from water quality monitoring undertaken by DIPE, specific water quality studies conducted within the Victoria River catchment include the following reports:

- 'A Biological Resource Study of freshwaters of the Victoria River and its tributaries conducted during August to September, 1981 (Midgley, 1981). Water quality parameters included Tubidity, pH, Total Dissolved Solids, Temperature, Dissolved Oxygen, Alkalinity and Hardness.
- 'Ausrivas' (Australia-wide Assessment of River Health) (Dostine, 2002). The aim of this project was to develop predictive models for the assessment of ecological condition of running water sites using aquatic macroinvertebrates as biological indicators of health. Water quality was also assessed for verification.

The locations of 226 water quality sampling sites in the Victoria River catchment are shown in Figure 2.8 (Section 2.6.2). Tables 2.6, 2.7 and 2.8 summarise the results for six water quality parameters: electrical conductivity (EC), turbidity, water temperature, pH, total alkalinity and total phosphorus. The water quality results have not been analysed to detect seasonal trends due to the general scarcity of results and ad hoc nature of the data collection.

From Tables 2.6, 2.7 and 2.8, mean EC results range from 23μS/cm to 19,300μS/cm. Generally, EC levels in excess of 600μS/cm can cause deterioration in taste (ANZECC, 1992). EC levels exceeded this level at six of the 51 sites recorded. The highest recorded EC result is from Big Horse Creek, with 19,300μS/cm. This is a result from a one off survey, and no further testing has been undertaken at this location to establish the cause. pH was mostly between 7 and 8, with the exception of a low mean pH of 4 recorded at G8110019 on the Victoria River, 6 at Cow Creek Falls, 6.5 on Ikymbon River, and a high mean of 9 recorded at G8110004 on East Baines River. 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, however other factors can affect pH such as the quality of water runoff entering rivers and tributaries.

Turbidity (ie NTUs) indicates water clarity. Stream bank erosion and suspended matter affect turbidity levels, and the ANZECC (1992) recommendation for protection of aquatic ecosystems is that the seasonal mean NTUs should not change by more than 10%, although this does not necessarily apply to the Victoria River and its tributaries, as this can occur naturally due to high flows during the wet season. Median turbidity readings ranged from 1NTU to 5,000NTUs, however some sites recorded consistently high or low levels, whilst others varied greatly. Without long term, strategic monitoring, it is not possible to conclude whether fluctuating turbidity readings in the catchment are related to erosion or disturbances such as river crossings, stock or vermin, or due to natural factors such as high flows or tidal influence.

Table 2.6 Summary of Water Quality Information for Sampling Sites Located at a Flow Gauge Station

Gauge Station Number**	Tributary	Mean Electrical Conductivity - Lab (uS/cm) (No. of results)	Median Turbidity - Lab (NTUs) (No. of results)	Mean pH - Lab (No. of results)	Mean Total Alkalinity - Lab (mg/L) (No. of results)	Mean Total Phosphorous - Lab (mg/L) (No. of results)
G8110001*	Blackgin Waterhole	410 (1)		7.5 (1)	181 (1)	
G8110004	East Baines River	453 (16)		9 (11)	234 (16)	0.013 (3)
G8110005*	Timber Creek	452 (3)		8 (3)	185 (3)	
G8110006	West Baines River	272 (10)	130 (1)	8 (3)	133 (10)	0.033 (2)
G8110007	Victoria River	454 (18)	8 (12)	8 (18)	206 (11)	
G8110009*	Kidman Springs	523 (1)		7.3 (1)	54 (1)	
G8110014*	Sullivans Creek	373 (8)		8 (8)	185 (8)	
G8110015*	Wickham River	588 (4)		8 (4)	349 (4)	
G8110016	Upper Victoria River	413 (7)	73 (7)	7 (7)	173 (7)	
G8110017*	Victoria River	309 (3)			146 (3)	0.026 (3)
G8110018*	Victoria River	449 (8)	4 (1)	4 (8)	211 (8)	0.019 (3)
G8110019*	Wickham River	610 (1)		7.8 (1)	287 (1)	
G8110073*	Armstrong River	212 (17)	1,170 (10)	7 (13)	83 (17)	0.035 (3)
G8110074*	Montejinnie Creek	527 (17)	1 (3)	8 (17)	290 (15)	
G8110106*	Camfield Creek	1,323 (4)		8 (2)	147 (4)	0.027 (2)
G8110110	Surprise Creek	204 (4)		8 (3)	102 (4)	
G8110113	Victoria River	399 (24)	131 (2)	8 (20)	189 (16)	0.012 (3)
G8110169*	Jasper Creek	129 (3)		7 (1)	58 (3)	0.014 (2)
G8110184*	Middle Creek	350 (1)		7.4 (1)	115 (1)	
G8110187*	Big Horse Creek	19,300 (1)		8 (1)	188 (1)	
G8110222*	Walsh Creek	145 (15)	5,000 (59)	7 (15)	73 (15)	
G8110232	Wickham River	522 (19)	14 (6)	8 (16)	281 (15)	
G8110251*	West Baines River	584 (7)		8 (7)	291 (7)	
G8110253*	Gibble Creek	407 (5)	1 (1)	7 (2)	213 (4)	0.015 (3)
G8110255*	Ikymbon River	95 (1)		6.5 (1)	33 (1)	
G8110263*	Bullock Creek	343 (2)	180 (1)	8 (2)	157 (2)	

* Closed Gauge Stations ** Refer to Figure 2.8 for location details
Source: Figures obtained from 'Hydsys' and were up-to-date at the time of extraction (2004)

Table 2.7 Summary of Water Quality Information for Sampling Sites Not Located at a Flow Gauge Station

Gauge Station Number*	Tributary	Mean Electrical Conductivity - Lab (uS/cm) (No. of results)	Median Turbidity - Lab (NTUs) (No. of results)	Mean pH - Lab (No. of results)	Mean Total Alkalinity - Lab (mg/L) (No. of results)	Mean Total Phosphorous - Lab (mg/L) (No. of results)
G8115000	Fitzroy Station (Vic Hwy)	419 (3)		8 (3)	208 (3)	
G8115005	Kidman Springs	523 (3)		8 (3)	282 (3)	
G8115009	East Baines River	367 (5)	1 (1)	8 (5)	178 (5)	
G8115023	Gordy Springs	894 (4)		7 (4)	414 (4)	
G8115089	Camballin Spring	46 (3)	5 (1)		12 (3)	
G8115113	McDonald Waterhole	588 (3)			181 (3)	0.017 (3)
G8115114	Victoria River	438 (3)			209 (3)	0.019 (3)
G8115115	Johnston Billabong	510 (3)			269 (3)	0.011 (3)
G8115116	Limestone Gorge	342 (3)			281 (3)	0.01 (3)

* Refer to Figure 2.8 for location details
Source: Figures obtained from 'Hydsys' and were up-to-date at the time of extraction (2004).

Table 2.8 Summary of Water Quality Information collected at 'Ausrivas' Project Sites

Ausrivas Site Number* (Hydsys Site Number)**	Tributary and Location Description	Mean Electrical Conductivity - Field (mS/cm)	Median Turbidity - Field (NTUs)	Mean Water Temp - Field (oC)	Mean pH - Field	Mean Total Alkalinity - Lab (mg/L)	Mean Total Phosphorus - Lab (mg/L)
MR-VC-01 (G8115113)	McDonald Creek at McDonalds Waterhole	575	16	27.1	8.59	181	0.017
MR-VC-02 (G8110016)	Victoria River at Kalkarindji downstream of road bridge	514	17	27.8	8.34	209	0.019
MR-VC-03 (G8110106)	Camfield River at Camfield Homestead	988	26	28.9	8.12	164	0.025
MR-VC-04 (G8110073)	Armstrong River at Old Top Springs Roadhouse	396	25	26.7	7.60	264	0.029
MR-VC-05 (G8110113)	Victoria River at Dashwood Crossing	430	29	29.5	8.25	245	0.010
MR-VC-06 (G8110004)	East Baines River at Victoria Highway Crossing	414	8	29.4	8.44	239	0.011
MR-VC-07 (G8110006)	West Baines River upstream of Victoria Highway Crossing	261	35	30.0	8.16	138	0.025
MR-VC-08 (G8115110)	Victoria River at Pigeon Hole	393	14	28.0	8.22	146	0.026
MR-VC-09 (G8115115)	Wickham River at Billabong on road to Mt Sanford	504	5	28.8	8.30	281	0.010
MR-VC-10 (G8110253)	Gibbie Creek on road to Mt Sanford	521	8	29.1	8.18	277	0.013
MR-VC-11 (G8115116)	Limestone Creek at Limestone Gorge	513	2	28.4	7.67	287	0.009
MR-VC-12 (G8110018)	Victoria River at Victoria River Roadhouse	420	9	28.6	8.21	221	0.016
MR-VC-13 (G8115117)	Cow Creek Falls on Cow Creek	23	1	26.9	5.94	2	0.010
MR-VC-14 (G8110169)	Jasper Gorge on Jasper Creek	89	8	26.9	7.49	49	0.013
MR-VC-15 (G8115118)	West Baines River north west of Hurricane Hill Yards, Amanbidji	539	19	27.9	8.35	237	0.023
MR-VC-16 (G8115119)	Boxer Springs Creek	902	2	26.6	8.03	522	0.010

Source: Figures obtained from the 'Ausrivas' Project. Four to five water quality tests were carried out during the dry season between 1994 and 1996.
*MR-VC site numbers are from the Monitoring River Health (Ausrivas Project) sites in the Victoria River Catchment.
**G811 site numbers are unique numbers attributed to monitoring sites in the NT Government's Water Resources Database (Hydsys).

Mean total alkalinity ranged from 2-522mg/L. Higher total alkalinity levels are often related to groundwater discharge. The mean total alkalinity results in Tables 2.6-2.8 are not comprehensive enough to draw conclusions about groundwater discharge areas. Total phosphorus levels were generally low, ranging from 0.009 to 0.03mg/L. Water temperature ranged from 26^{o}C to 30^{o}C, which is typical of waterways in northern Australia.

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).

Elevated turbidity due to vehicles crossing

Elevated turbidity due to tidal influence