A Compendium of Ecological Information on Australia's Northern Tropical Rivers

REPORT 3

Preliminary analysis of streamflow characteristics of the tropical rivers region

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Disclaimer

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Executive Summary

The Tropical Rivers Inventory and Assessment Project is aiming to categorise the ecological character of rivers throughout Australia's wet-dry tropical rivers region. As part of this project, a preliminary analysis of the flow characteristics of streams within this mostly undisturbed, and relatively data-limited, region was conducted, which could later be used to assess the impacts of potential development.

In general, the tropical rivers region experiences a distinct wet season from October to April, and a dry season for the remainder of the year. Stream flow, as a consequence, is highly seasonal. Long-term discharge records of streams within three relatively well-gauged catchments – Daly (NT), Fitzroy (WA) and Flinders (Qld) rivers – have been analysed to group streams into flow regime units. Hydrological variables based on flow variability, flood regime and intermittency, were derived for the complete record of each stream. Cluster analysis indicated that streams could be grouped broadly into four flow regime groups: (1) perennial, (2) seasonal, (3) dry seasonal, and (4) seasonal-intermittent streams. The coefficient of variation of total annual flow and the mean number of zero flow days were the two most significant variables for classifying streams into flow units.

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Glossary

The purpose of this Glossary is to define the hydrological terms used in this report.

Bankfull – the stage or discharge at which streamflow fills the channel and first begins to overflow onto the floodplain.

Baseflow – part of the discharge which enters the stream channel from groundwater. In the wet-dry tropics, baseflow is generally relatively high during the wet season compared to the dry season where groundwater stores are progressively depleted.

Cease to flow (CTF) value – the gauge height at which stream discharge becomes zero.

Dry seasonal stream – a stream which, similar to a seasonal stream, flows throughout the wet season but generally for less than half the year. In the wet-dry tropics these streams are characterised by high annual variability.

Gauged stream – a stream with a continuous discharge record.

Gauging control – the channel cross section which determines the upstream gauge height-discharge relationship.

Gauging station – the site on a stream where hydrological data are collected.

Perennial stream – a permanently flowing stream which, in the wet-dry tropics, is generally characterised by low annual variability.

Rating curve – the relationship between gauge height and discharge established at a gauging station in order to convert continuously recorded stage data to a continuous discharge record. It is derived by collecting a number of velocity-area gaugings over a range of gauge heights.

Seasonal stream – a stream which generally flows throughout the wet season and ceases flow during the dry season.

Seasonal-intermittent stream – a stream which is dry for most of the year and generally only flows as a result of a large storm event during the wet season. These streams are characterised by high annual variability.

Velocity-area gauging – the field measurement of stream discharge at a certain gauge height. Mean flow velocity, measured by a current meter, is multiplied by the cross sectional area to estimate stream discharge. A number of velocity-area gaugings are required at a range of gauge heights to construct a reliable rating curve for a site.

1 Introduction

A description of the hydrological characteristics of streams within the wet-dry tropics is one component of a multi-disciplinary study of the ecological characterisation of the tropical rivers region. NGIS Australia (2004) defined the tropical rivers region as the area which includes all catchments draining into the Timor Sea and Gulf of Carpentaria drainage divisions (Fig 1.1). An understanding of the hydrological characteristics of these rivers will assist in the management and assessment of any possible future plans to develop areas within the region.

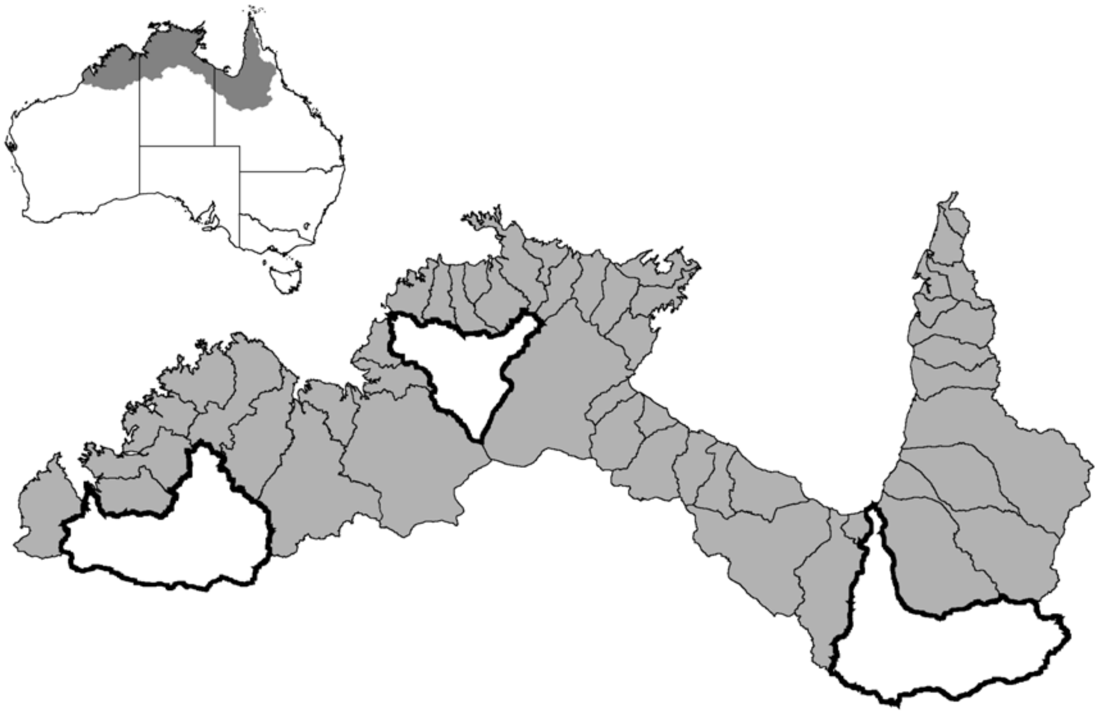

Figure 1.1 Wet-dry tropical rivers region of Australia. The three focus catchments are also shown.

The issues with flow data across this region are well documented (NGIS Australia 2004), and include:

- The gauging stations have relatively short-term flow records,
- Many stations have no, or an unreliable, rating curve to convert stream height data to flow data,
- Many stations have extensive periods of missing data within the flow record, and
- Many catchments are ungauged.

Nevertheless, an attempt has been made to describe the basic flow characteristics of the region using observed flow data collected at gauging stations within the region. Only stations with at least 20 years of complete annual flow data have been studied in order to estimate the long-term trends of streams. Three 'focus' catchments within the tropical rivers region were selected for more detailed ecological characterisation – Daly (NT), Fitzroy (WA) and Flinders (Qld) rivers (Fig 1.1). A more detailed assessment of the flow data and data quality was conducted for these three focus catchments.

NGIS Australia (2004) recommended that streams within the tropical rivers region be classified based on hydrological features. Studies have shown that certain hydrologic variables can be used to describe various aspects of streamflow regime (ie Poff & Ward 1989, Hughes & James 1989, Puckeridge et al 1998, Growns & Marsh 2000, Olden & Poff 2003). These hydrological variables are generally based on overall flow variability, flood patterns and extent of intermittency and they can be established using long-term streamflow data from a gauging station. In this study, we have derived hydrological variables using long-term flow data for stations located within the three focus catchment areas of the tropical rivers region – Daly, Fitzroy and Flinders rivers. It is considered that these catchments provide a good representation of various flow regimes prevailing across the wet-dry tropics.

In summary, the purpose of this report is to:

- Present flow data collected at gauging stations throughout the tropical rivers region,
- Estimate the general flow statistics, such as mean annual and monthly runoff and annual variability, of streams throughout the entire region, and
- Determine the flow regime of streams within three focus catchments using hydrological variables derived from long-term flow data.

1.1 Climate

Historical climate data for the tropical rivers region are readily available as both mean monthly and mean annual data sets (NGIS Australia 2004). Gridded mean monthly and annual rainfall data were obtained from the Bureau of Meteorology. These gridded data were generated using the Australian National University 3-D Spline (surface fitting algorithm) at a point resolution of 0.025 degrees (approximately 2.5km) (Bureau of Meteorology pers comm. 2005). Approximately 6000 stations were used in the analysis. The mean data are based on a 30-year period between 1961–1990. Figure 1.2 shows the mean annual rainfall across the tropical rivers region.

Figure 1.3 shows the location of the long term rainfall stations (stations with at least 20 y of complete annual rainfall data) within the three focus catchments and the mean monthly rainfall at each of these stations. These rainfall stations are operated by both the Bureau of Meteorology and the relevant state agencies (Table A.1 – Appendix A). The mean monthly rainfall data indicate a distinct wet season period in which almost the entire annual rainfall occurs during six months of the year (November to April), particularly for the Daly River catchment. Relatively little rainfall occurs during the dry season (May to October).

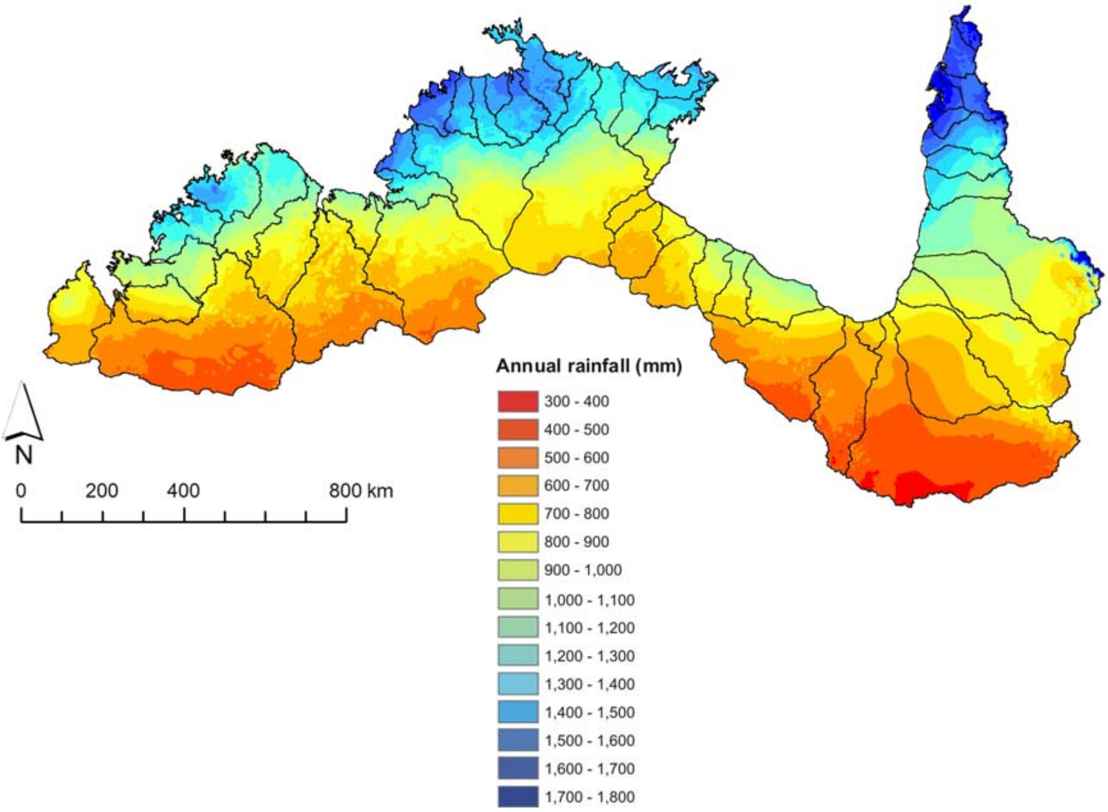

Figure 1.2 Mean annual rainfall data over the tropical rivers region

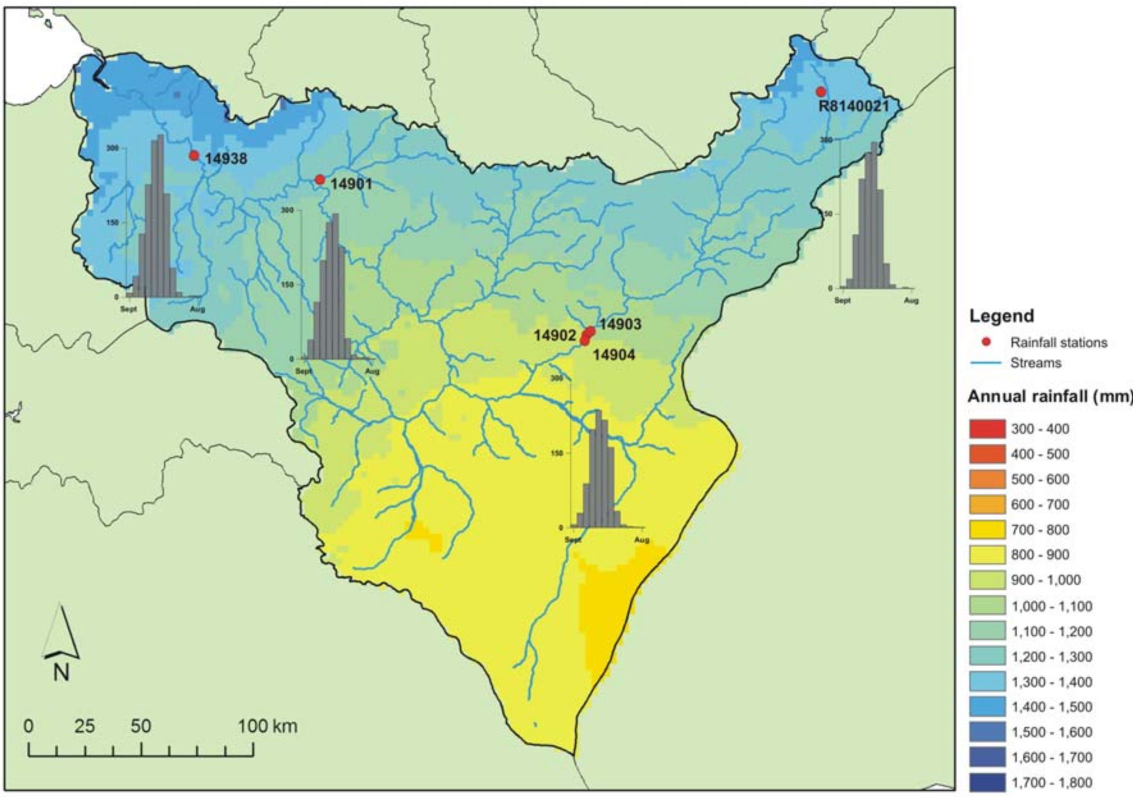

Figure 1.3a Mean monthly rainfall at long-term rainfall stations within the Daly River catchment. The gridded mean annual rainfall data are also shown.

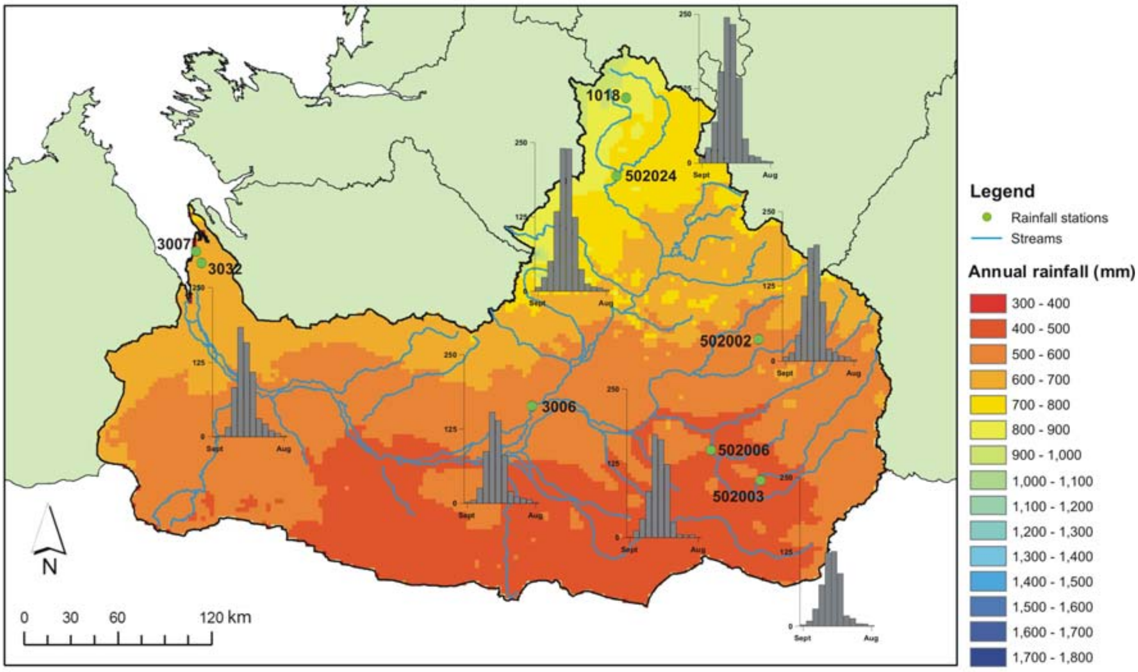

Figure 1.3b Mean monthly rainfall at long-term rainfall stations within the Fitzroy River catchment. The gridded mean annual rainfall data are also shown.

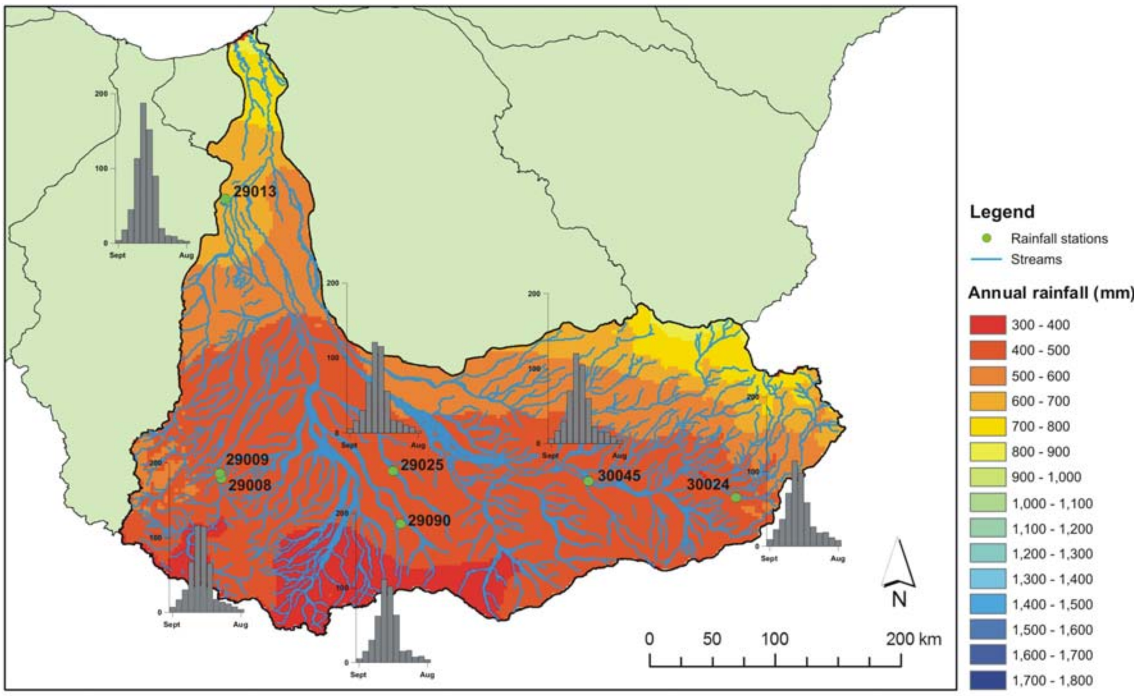

Figure 1.3c Mean monthly rainfall at long-term rainfall stations within the Flinders River catchment. The gridded mean annual rainfall data are also shown.

2 Hydrology

Flow records for gauging stations throughout Northern Territory, Western Australia and Queensland are available from the NT Department of Natural Resources, Environment and the Arts (NRETA), Department of Environment of Western Australia (DoE(WA)) and Queensland Department of Natural Resources and Mines (QDNRM) respectively.

Approximately 630 gauging stations have operated, or are still currently operating, in the entire tropical rivers region (Bureau of Meteorology pers comm. 2005). Of the 630 gauging stations, 241 stations have a period of record greater than or equal to 20 years. Many of these stations either have (1) significant periods of missing data throughout the flow record, or (2) no associated rating curve to convert stage to discharge. The stations with at least 20 y of complete annual runoff data were identified and numbered 105 across the entire region (Fig 2.1).

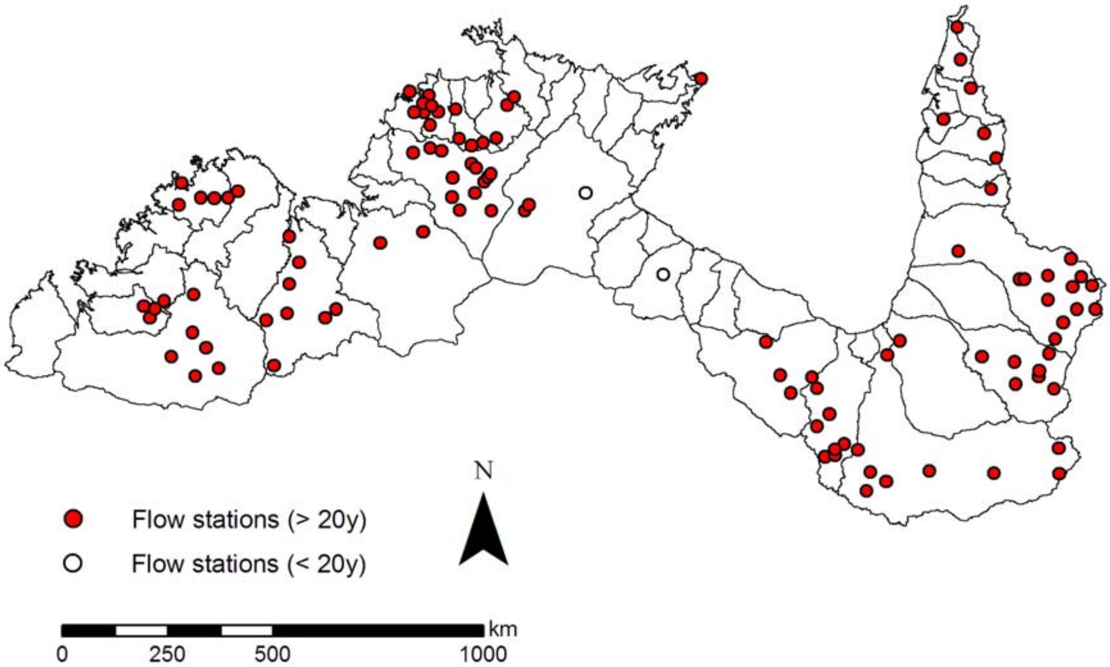

Figure 2.1 Location of long-term flow stations across the tropical rivers region. Two stations with less than 20 y data are also shown.

2.1 Annual flow

The flow data collected at these 105 gauging stations were used to determine the mean annual runoff and the coefficient of variation of total annual flow (CoV) at each station. These basic flow statistics were used to produce contour maps showing the spatial variation in mean annual runoff and CoV across the tropical rivers region (Figs 2.2 and 2.3 respectively). The contours were produced using an inverse distance weighted interpolation technique in the Spatial analyst extention of ArcView v9 (McCoy & Johnston 2002) (using a power setting of 3 and number of points set at 12). Flow data from two additional stations, with less than 20 years of complete annual data, were also used in the analysis in an attempt to 'infill' the western gulf area of the tropical rivers region (Fig 2.1). These two stations, both with 15 years of flow data, had the best flow record within this data-limited region. Details of each of these 107 gauging stations, including station number and number of complete years of record, are given in Appendix B.

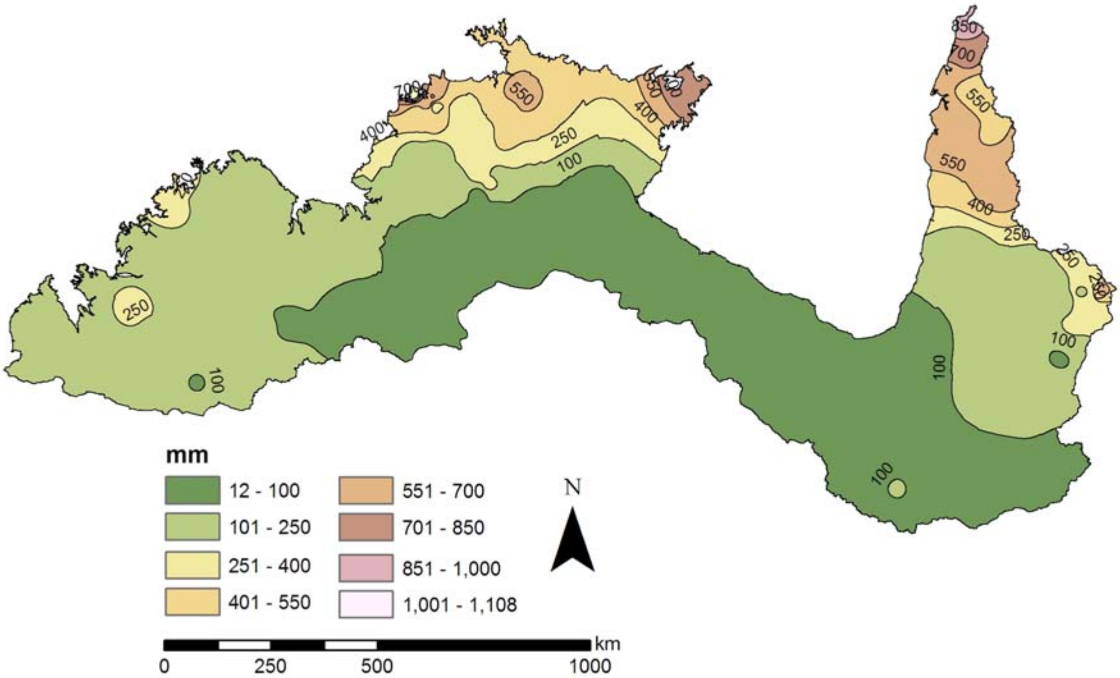

Figure 2.2 Contour map showing mean annual runoff across the tropical rivers region

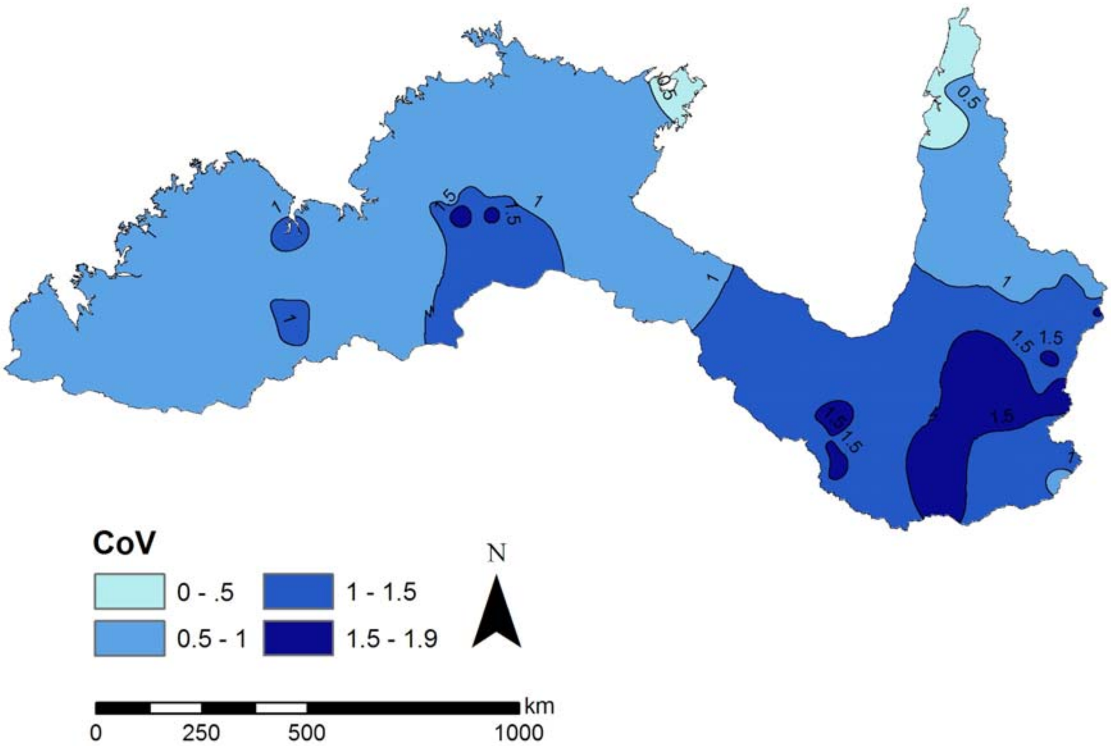

Figure 2.3 Contour map showing coefficient of variation of total annual flow across the tropical rivers region

These contour maps update similar maps produced by McMahon (1979) which were based on fewer long-term stations across the wet-dry tropics. The annual flow data for stations within Queensland and Western Australia were obtained from QDNRM and DoE(WA) agency websites, respectively. The annual flow data for stations within Northern Territory were obtained from the NRETA Hydstra database. Except for stations within the Daly, Fitzroy and Flinders River catchments (discussed in Section 2.3 – Focus catchments), the quality of the flow data used to derive the annual runoff and CoV values for each station were not checked.

Figure 2.4 indicates a significant correlation between mean annual runoff and the coefficient of variation of total annual flow for the region based on flow data from the 107 gauging stations (shown in Fig 2.1). In general, where mean runoff is relatively low, such as the southern regions of the wet-dry tropics throughout NT and Queensland (Fig 2.2), CoV values are high (> 1) (Fig 2.3). The north-eastern area of NT and the top of Queensland are relatively high runoff regions (Fig 2.2) and these areas have the lowest annual flow variability (Fig 2.3). A similar trend has been observed elsewhere throughout Australia (ie McMahon 1979, Hughes & James 1989). The fitted relationship between mean annual runoff and CoV for the tropical rivers region (Fig 2.4) is very similar to that fitted by McMahon (1979) for the Timor Sea drainage division (Eqn 2.1).

$$\text{CoV} = 3.1(\text{mean annual runoff})^{-0.30} \quad (R^2 = 0.86,\ n = 4) \qquad (2.1)$$

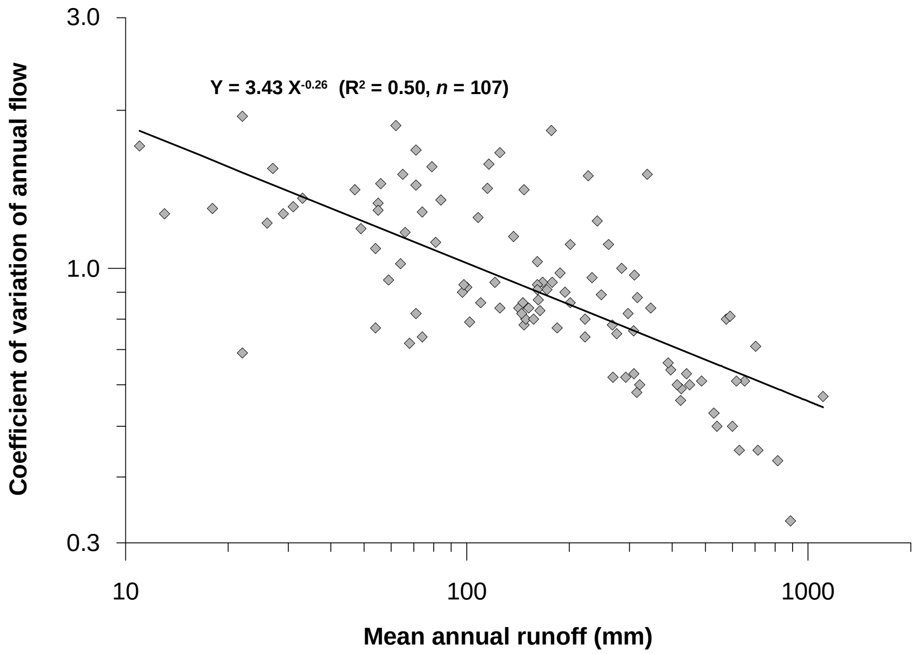

Figure 2.4 Relationship between coefficient of variation of annual flow and mean annual runoff for the tropical rivers region

2.2 Monthly flow

The median runoff for every month of the year was derived for all 107 stations (see Section 2.1 – Annual flow) and used to produce contour maps showing the spatial variation in monthly runoff across the entire region. Initially, the median monthly contour maps showed that streams within the southern reaches of the Victoria River and Roper River catchments flowed all year, which was not an expected result. This is probably attributable to the fact that there were gaps in the spatial data (ie there are no long-term gauging stations in this region – see Figure 2.5).

Therefore, median monthly flows were derived for six extra stations to 'infill' gaps across the region (Fig 2.5). Station G0280009, located outside the tropical rivers region, had 30 years of complete annual flow data. The remaining five stations had less than 20 years of complete flow data, but were considered to have the best flow records within these data-limited regions. Details of the six extra stations are given in Appendix B.

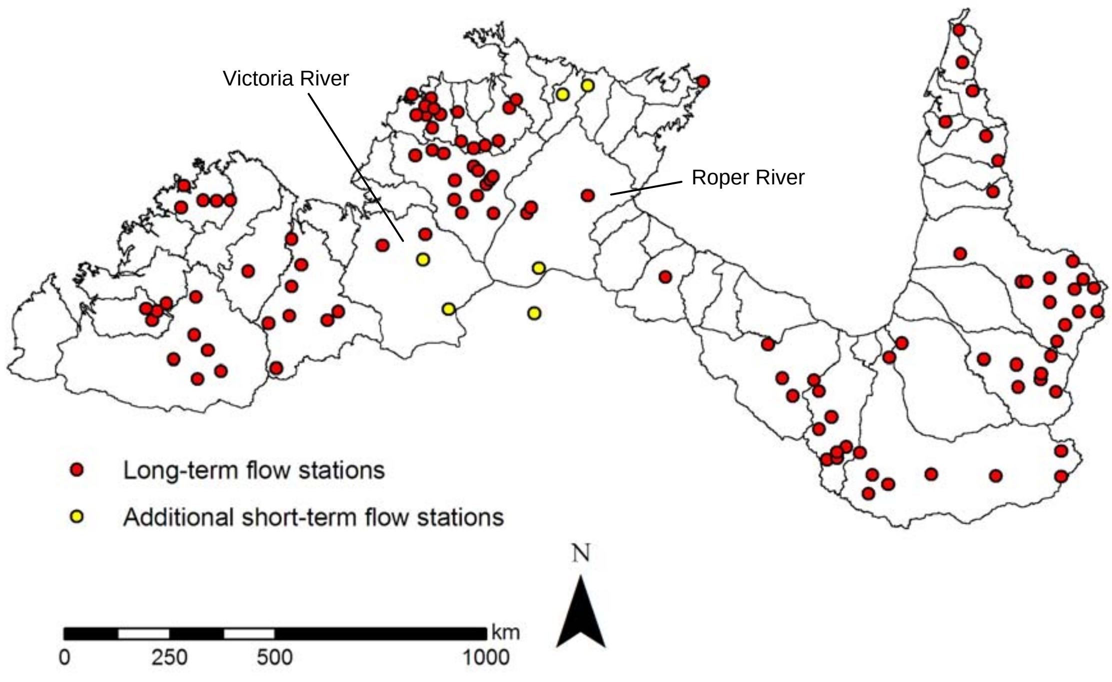

Figure 2.5 Location of long-term flow stations and the six extra stations used to construct monthly median flow contour maps in Figure 2.6

The median monthly contour maps (Fig 2.6), which incorporate median monthly flow data from the six extra stations, indicate that the lower reaches of the Victoria and Roper River catchments do not flow during the dry season, which is an expected result. (Similar to Figures 2.2 and 2.3, the contours were produced using an inverse distance weighted interpolation technique in the Spatial analyst extension of ArcView v9 (in this case, using a power setting of 6 and the number of points set at 6).)

Figure 2.6 shows that the majority of flow within the region occurs during the wet season, particularly during January, February and March. Most of the streamflow ceases by late-dry and, therefore, the majority of streams throughout the wet-dry tropics can be considered seasonally-flowing. Some streams within areas across northern Queensland and some of the larger catchments throughout the Northern Territory can be considered perennial. Figure 2.6 also indicates that all of the streams within Western Australia, including the Fitzroy River catchment, can be considered seasonal as flow stops during the dry season. This result supports the study conducted by the Water and Rivers Commission (1997) which stated that, except for streams in the extreme Northwest of Western Australia, most of this region is dry for approximately four to five months of the year.

However, it should be stressed that the monthly runoff maps (Fig 2.6) should be treated with a great deal of caution, particularly those showing monthly runoff during the dry season (June to November).

Many areas of the tropical rivers region are spatially data-limited (ie across Arnhem Land) and, as such, the monthly runoff maps given in Figure 2.6 are not sufficiently accurate to reliably classify specific streams in these areas as ‘seasonal’ or ‘perennial’. Regional hydrographic and surface water maps, which have been established for Arnhem Land by Zaar et al (1999), George (2001) and Zaar (2003) should be referred to for streamflow classification within this region, instead of those shown in Figure 2.6.

Furthermore, as discussed above, the quality of the flow data used to construct the monthly runoff maps from most of the stations have not been checked. Large errors in flow measurements commonly occur during both high flows and low flows. Errors in low flow measurements at stations may strongly influence the monthly runoff contour maps for the dry season months. It is considered that, given a comprehensive check on the flow data has not been made, the monthly runoff maps for the dry season months are unreliable.

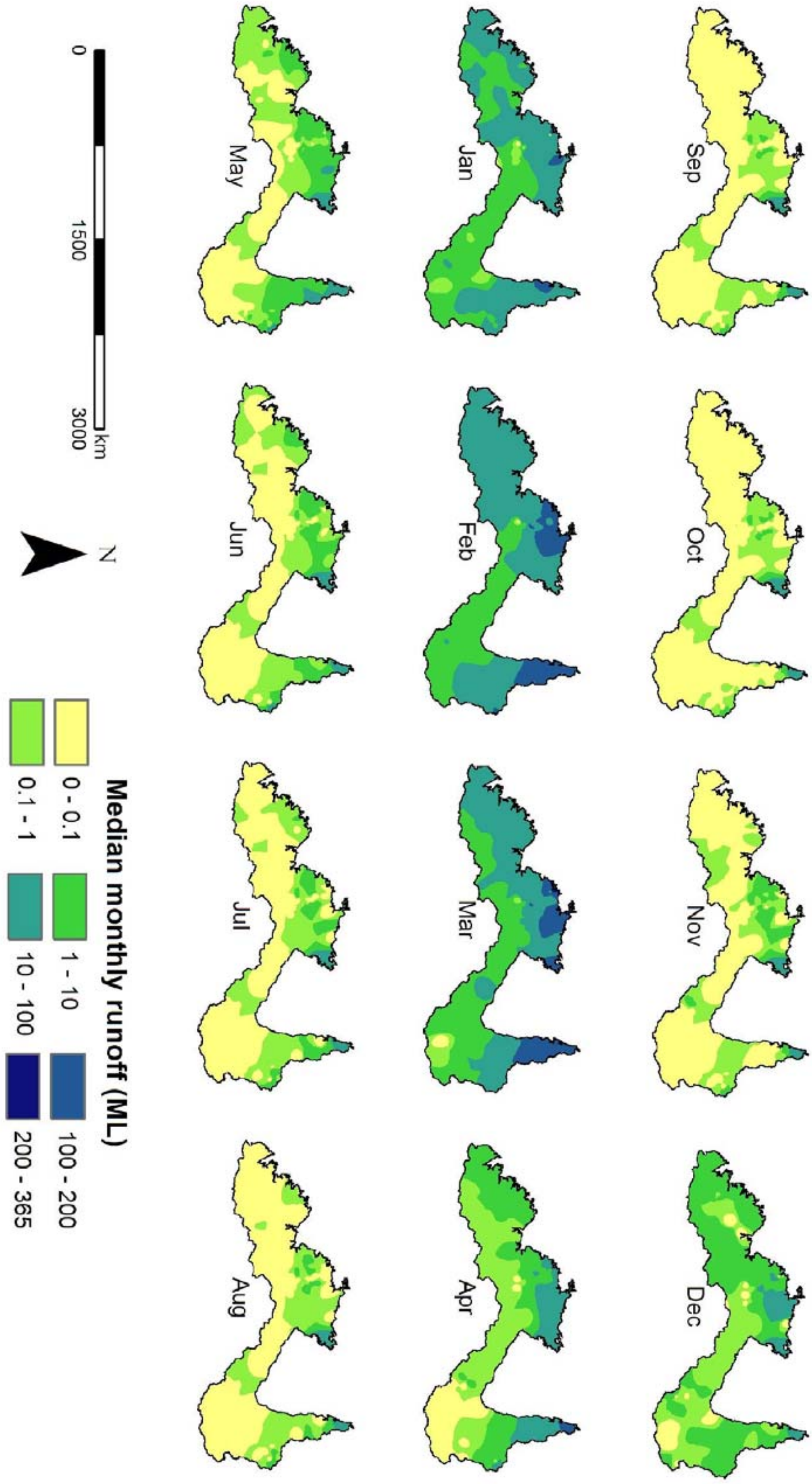

Figure 2.6 Contour map showing median runoff across the region for each month of the year (Sept – Aug)

2.3 Focus catchments

As discussed in the Introduction, three major catchments within the tropical rivers region were selected for more detailed hydrological analysis (Fig 1.1).

2.3.1 Data

According to the agency databases, there are 70, 18 and 24 gauging stations that have been operated, or are still currently operating, within the Daly, Fitzroy and Flinders river catchments, respectively. Stage data (stream level in metres) have been collected at all of these stations on an almost continuous basis. However, of these stations, only 31, 12 and 23 have an associated rating curve to convert stage data to discharge data, respectively. Figure 2.7 shows the location of these flow stations within the respective catchment areas. Stations still in operation are indicated. Details of each of these stations, including station name, stream name, period of record and number of complete years of data, are given in Appendix A.

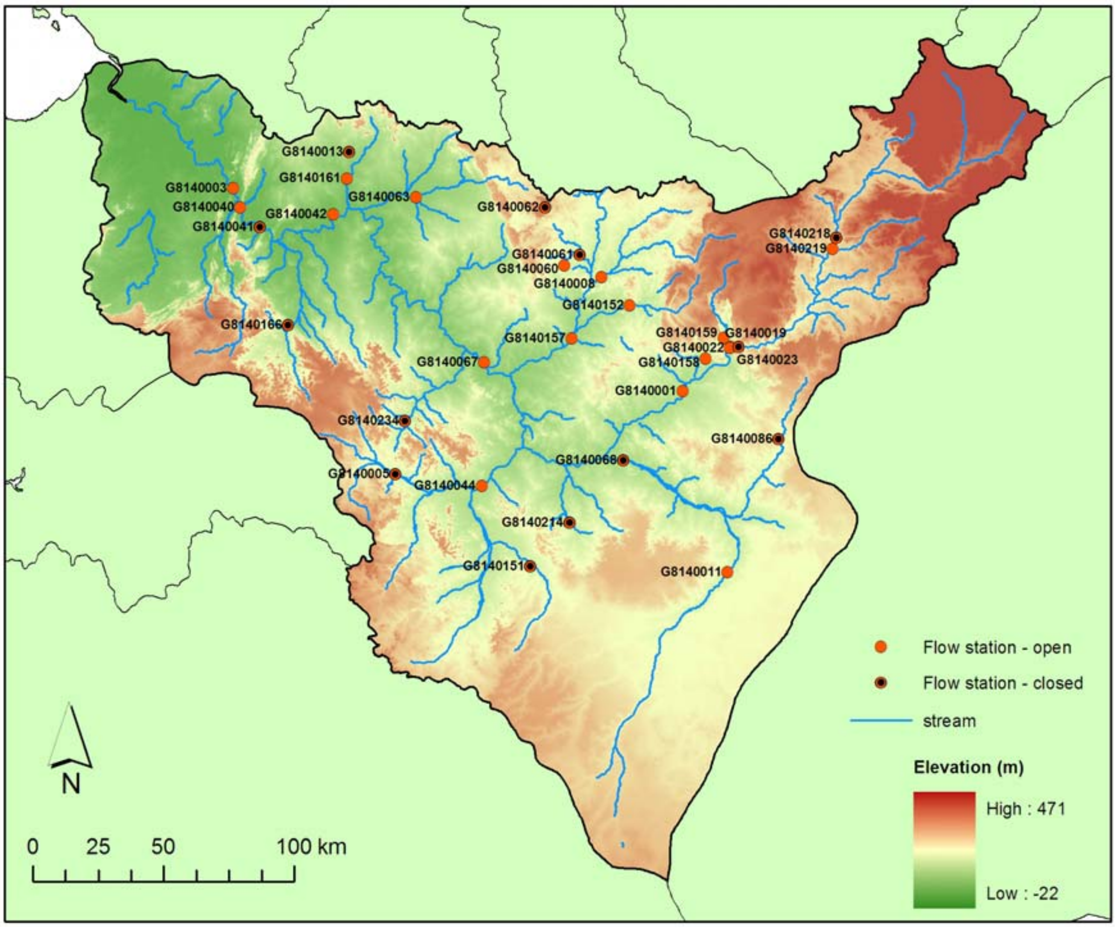

Figure 2.7a Daly River catchment area showing the location of the flow gauging stations

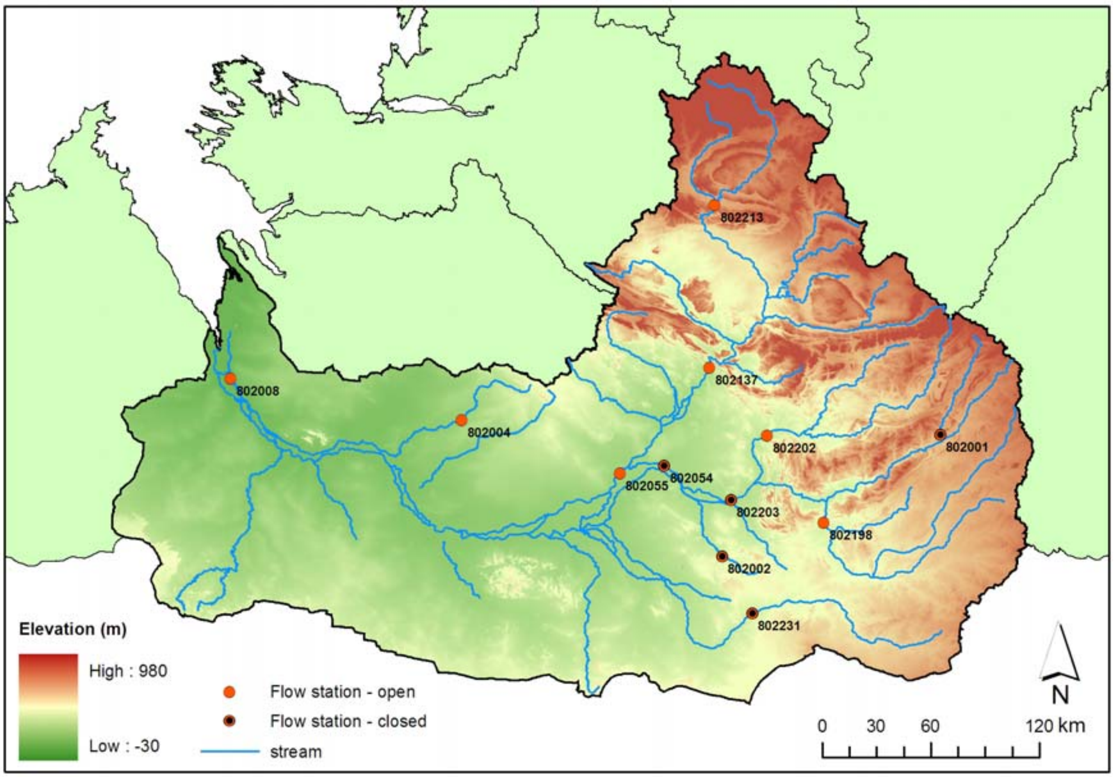

Figure 2.7b Fitzroy River catchment area showing the location of the flow gauging stations

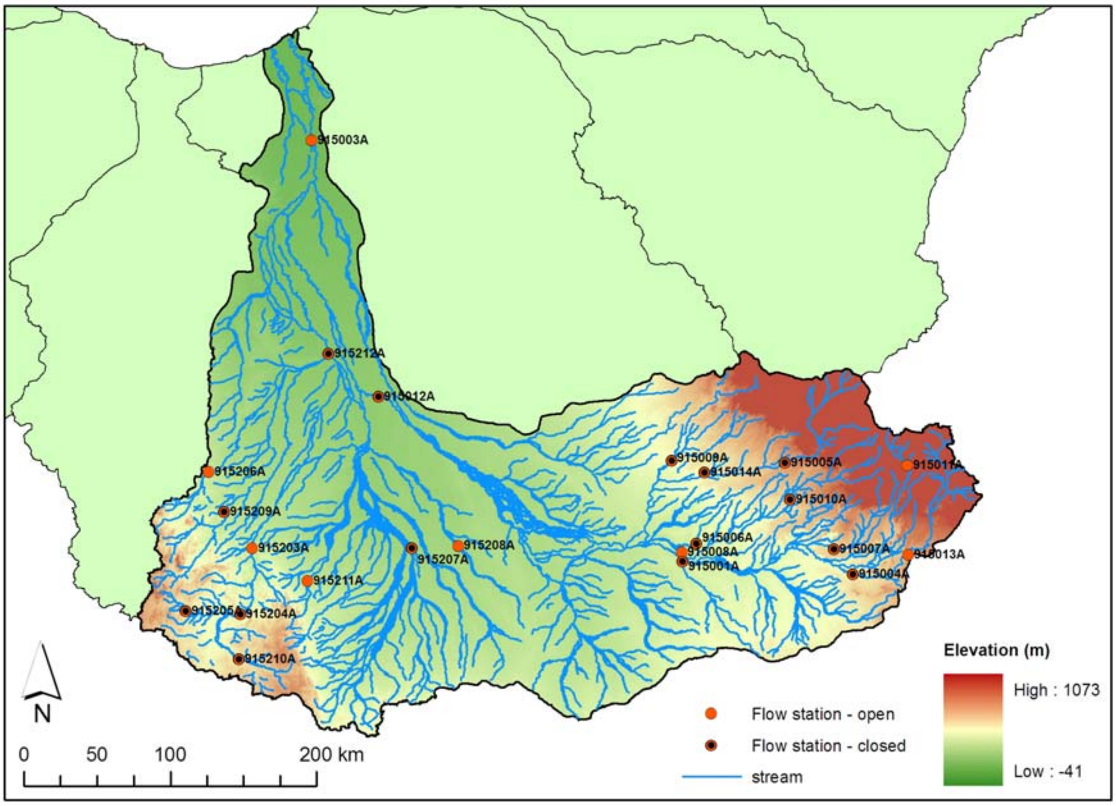

Figure 2.7c Flinders River catchment area showing the location of the flow gauging stations

Flow data from stations with periods of record greater than 20 years were obtained from the relevant agencies and added to the ***eriss*** database for analysis. Of these stations, general flow summary statistics were derived for those with at least 20 years of *complete* annual flow data. Most of the stations within the three catchments are not only relatively short-term (ie less than 50 y period of record), but also have significant periods of missing data (Table 2.1). Therefore, it was not possible to analyse the flow data over a given time period using concurrent station data. Instead, flow statistics were derived for each station using only the years with complete annual runoff data (September to August). Table 2.1 shows the years which had complete annual flow data for each station.

Some station records had relatively minor gaps in runoff data which occurred during low flow periods and these gaps occurred because (1) flow had dropped below instrument height, or (2) the equipment was removed for maintenance for a period when the stream was dry. The gaps in data are generally given a certain quality code within the agency's Hydstra database which explains why these gaps have occurred. Nevertheless, where these minor gaps occurred, flow records for nearby stations were examined to see if any runoff events had been recorded during the missing period. If not, the gaps were infilled by either: (1) interpolating the runoff across the gap; or, less frequently (2) assuming a discharge value of zero at the midpoint of the gap (Fig 2.8). (These adjustments were not made to the original databases at NRETA, DoE(WA) or DNRM.) The years where minor gaps were infilled were considered reliable for statistical analysis. However, years which contained gaps in the runoff record that either occurred over extended time periods or during periods of high flow were excluded from the analysis. For example, Figure 2.9 shows a period of missing data which occurred during January 1993 at G8140040 in the Daly River catchment. Although the gap was minor in terms of length of time, the gap occurred during relatively high flow and therefore the 1992–93 hydrograph was ignored for statistical analysis.

Table 2.1 Timeline of years with complete annual flow data at long-term stations (> 20y) within the Daly (yellow), Fitzroy (green) and Flinders (blue) River catchments. Years with no data or gaps in the annual flow record are unshaded.

Station No.	1956-60	1961–65	1966–70	1971–75	1976–80	1981–85	1986–90	1991–95	1996–00	2001–05
G8140001										
G8140008										
G8140011										
G8140040										
G8140044										
G8140063										
G8140067										
G8140068										
G8140151										
G8140152										
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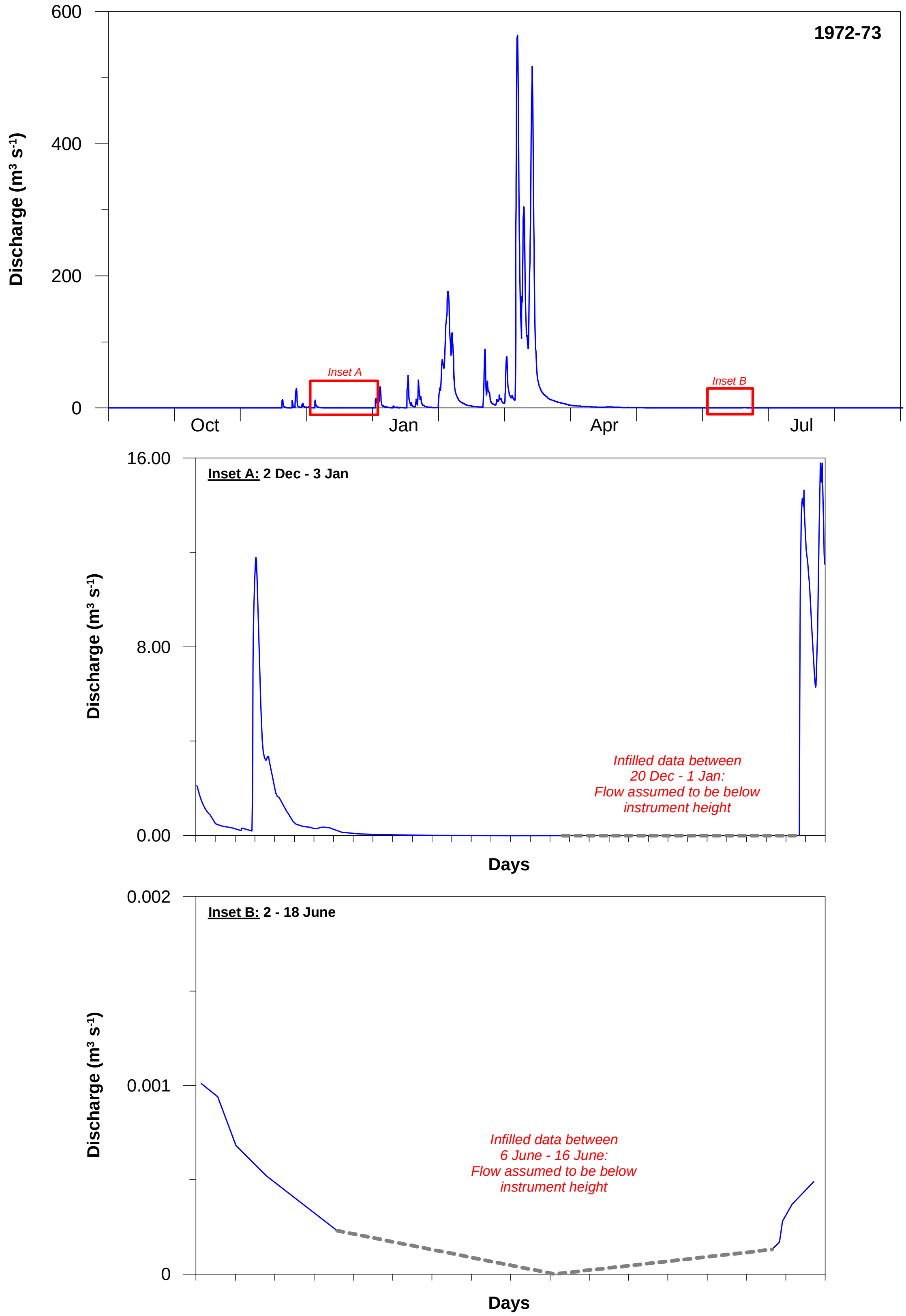

Figure 2.8 Two periods of the 1972–73 hydrograph at G8140008 in the Daly River catchment where infilling procedures using methods 1 and 2 (Inset A and B respectively) were adopted for periods of missing data at low flow

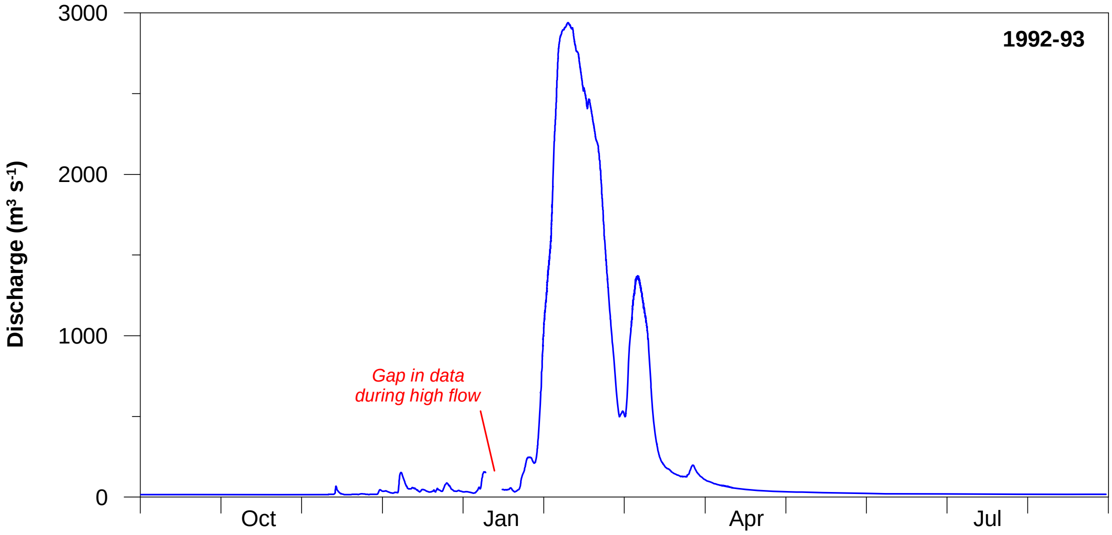

Figure 2.9 Period of the 1992–93 hydrograph at G8140040 in the Daly River catchment where a gap in data occurred. This year was ignored for statistical analysis.

There are 13, 6 and 9 stations at the Daly, Fitzroy and Flinders river catchments, respectively with at least 20 y of complete annual runoff data (Appendix A). The annual volume of runoff and corresponding annual peak discharge for each year (September to August) for each long-term station within the Daly, Fitzroy and Flinders River catchments are given in Appendix D. The years where minor gaps have been infilled for each station are also indicated. Figure 2.10 shows the mean monthly flow volume over the period of record for each long-term station. Similar to Figure 2.5, most of the runoff occurs over 3 months for each focus catchment, indicating the strong seasonally-flowing nature of streams in the wet-dry tropics. Figure 2.10 also highlights the variation in flow characteristics across the Daly River catchment, from high wet season flows around the upper Katherine Gorge area to very low wet season flows in the southern lowland regions. In contrast, flow characteristics throughout the Fitzroy River catchment appear to be relatively similar.

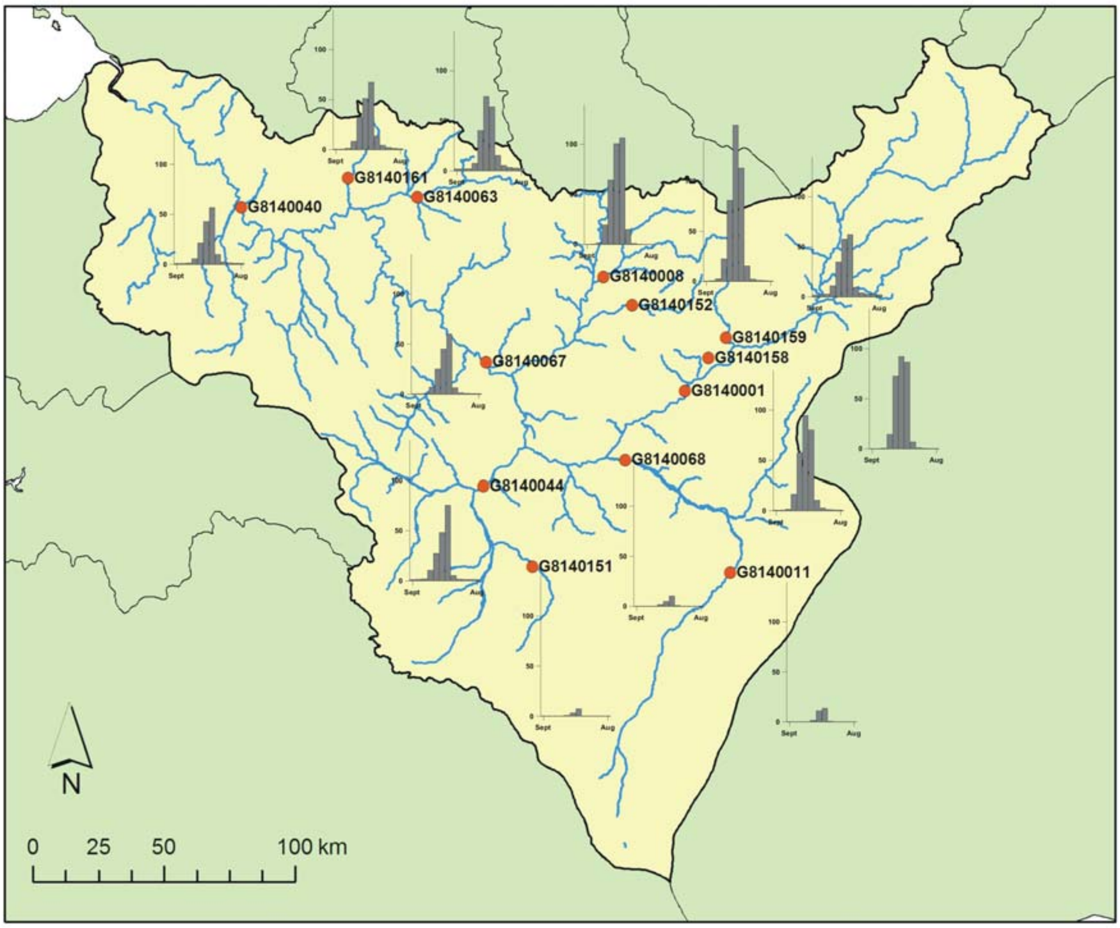

Figure 2.10a Mean monthly flow at long-term gauging stations within the Daly River catchment

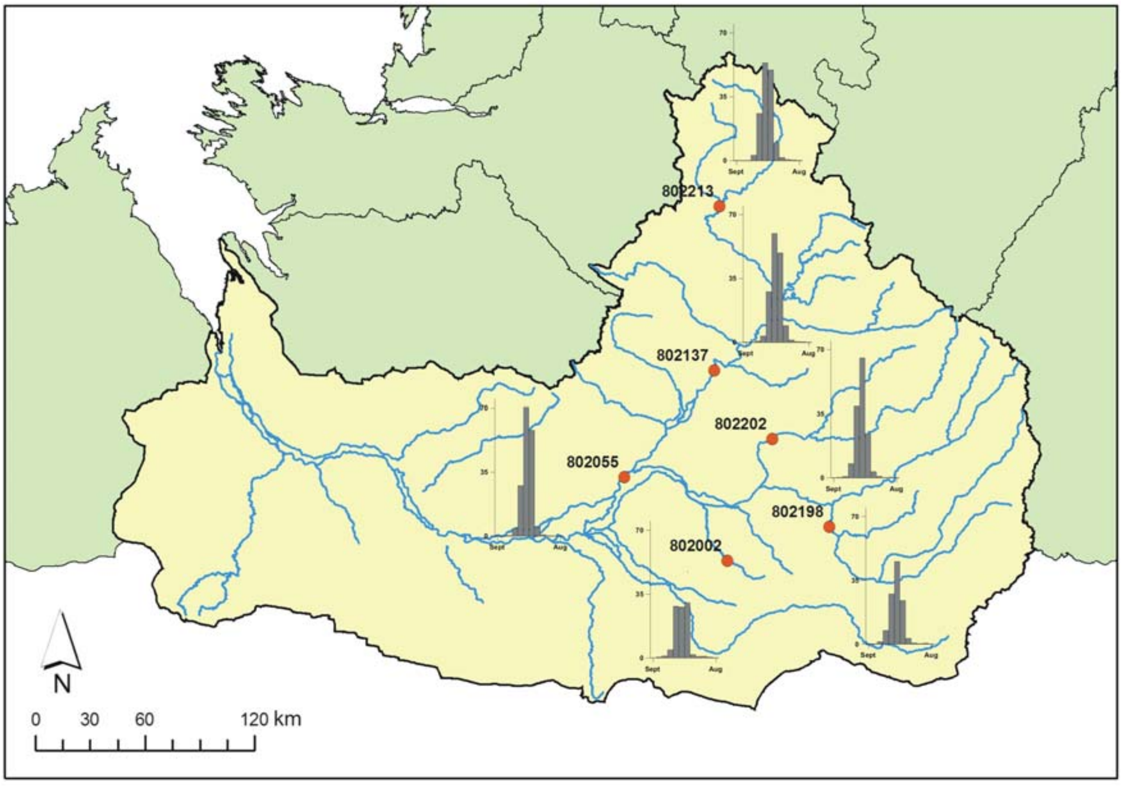

Figure 2.10b Mean monthly flow at long-term gauging stations within the Fitzroy River catchment

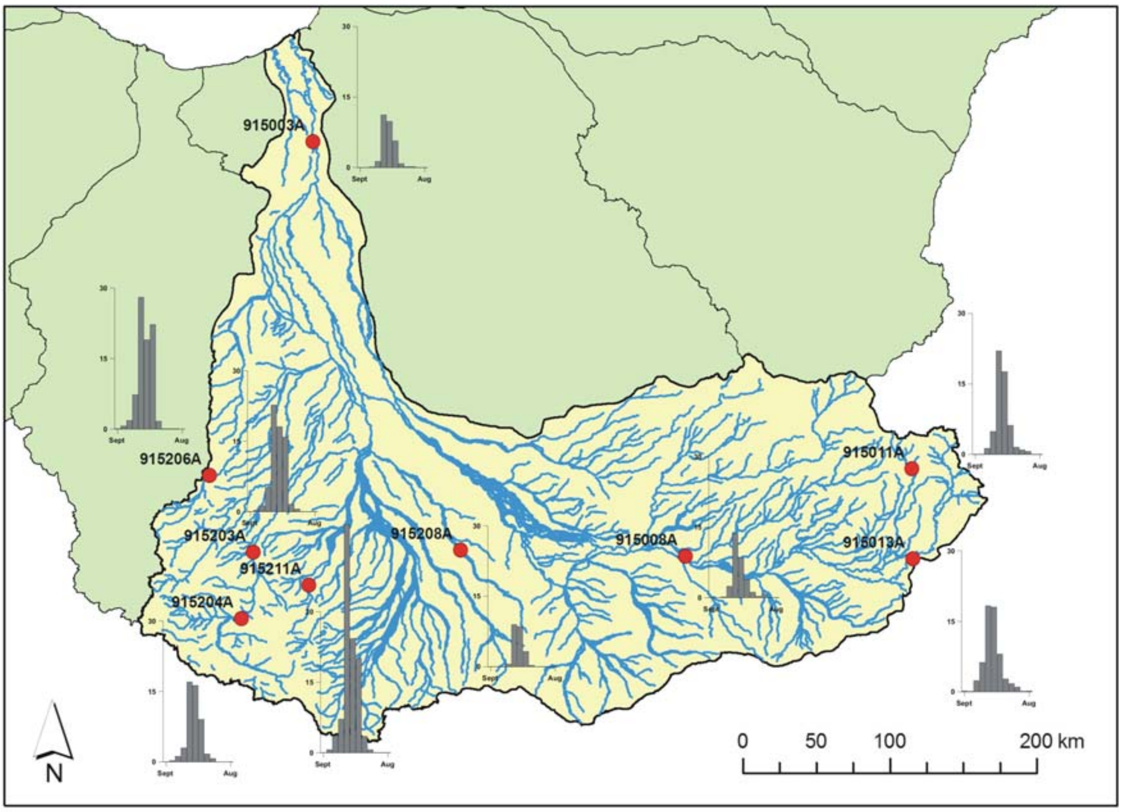

Figure 2.10c Mean monthly flow at long-term gauging stations within the Flinders River catchment

2.3.2 Data quality

It is well understood that the accuracy of the runoff data is influenced by the quality of the rating curve fitted for the station. The quality of the curve is not only dependant on the number of gaugings taken at the site, but also the range of flows at which gaugings were conducted. For example, more than 100 gaugings have been conducted at some of the long-term stations within the Daly river catchment over almost the entire range of flows (G8140001, G8140040, G8140063 and G8140068) (Appendix A). It is considered that at these stations, runoff data are relatively accurate for most flow conditions. However, at other stations only a few gaugings have been conducted at relatively low flows (ie G8140044 and G8140151 within the Daly River catchment) (Appendix A), or numerous gaugings (>100) were conducted all at relatively low flows (ie 915011A, 915203 and 915211A within the Flinders River catchment) (Appendix A). At these stations, the accuracy of the runoff data at high flows is likely to be low. The flow statistics derived for these stations, including annual volume of runoff and annual peak discharges, may have significant errors. Stations with a moving bed control (ie sandy channel bed) could have unreliable flow data during the dry season or low flow periods. Flow statistics, such as mean annual number of zero flow days, for these stations may also be unreliable. Station G8140044 within the Daly River catchment has unreliable low flow data because of the presence of tufa dams, a carbonate derived deposit which builds up along the channel during the dry season and interferes with the water level readings (often flow appears to rise during the dry season instead of dropping) (Jolly et al 2000). It is considered that perhaps only stations with accurate long-term data should be used to determine flow characteristics for a catchment. Nevertheless, irrespective of the data quality, hydrological variables were derived for each long-term station (see Section 3). The possible implications that poor data quality may have for particular parameter values are discussed later in Section 3.2.1 – Effect of flow data quality on hydrology variables.

3 Streamflow classification

The classification of streamflow regimes within the tropical rivers region was conducted using long-term discharge records from gauging stations located within the three focus catchments – the Daly River, Fitzroy River and Flinders River. Each of these catchments are not only relatively well-gauged, but provide a reasonable representation of various flow characteristics across the wet-dry tropics. A selection of hydrological variables were derived for each of these long-term stations. These variables, which are based on those used by Poff and Ward (1989), are used to describe the flow regime of a stream and can be divided into three broad categories: (1) overall flow variability, (2) flood regime pattern, and (3) intermittency.

3.1 Derivation of variables

A selection of hydrological variables were calculated for each long-term station within the three focus catchments (Table 3.1). As mentioned above, these variables describe the flow conditions, such as variability, flood pattern and extent of intermittency of each stream over the period of record. Two variables describing general stream conditions were also included.

Table 3.1 Hydrological variables derived for each station as defined by Poff and Ward (1989)

Variable	Definition
Catchment descriptor	
AREA	Total catchment area (km^2) upstream of the stream gauging station.
Qann	Mean annual discharge divided by AREA (mm).
Overall flow variability	
PredQ	Colwell's (1974) predictability for all mean daily flows over the period of record. (0 < PredQ < 1)
C/P	Proportion of predictability (PredQ) comprised by constancy (C). (1 – C/P = proportion comprised by contingency.)
CoV	Mean annual coefficient of variation. The mean annual flow for the period of record divided by the standard deviation.
Flood regime pattern	
FloodFREQ	Flood frequency (mean number of floods per year)
FloodDUR	Mean duration of floods (days).
Flood60D	Index of flood predictability. Maximum proportion of total number of floods over the period of record that occur in any common 60-day period.
Extent of intermittency	
ZeroDAY	Mean annual number of zero flow days (divided by 365 days).

Catchment descriptor

Catchment area upstream of each station was obtained from the relevant agencies (Table 3.2). Flow per unit catchment area (Qann) for each station, defined as the ratio of mean annual runoff to the catchment area upstream of the station for the years with complete annual flow data, is also given in Table 3.2.

Flow variability

Three measures of flow variability were used. The coefficient of variation of total annual flow (CoV) assessed the overall streamflow variability and was calculated by dividing the mean annual runoff volume at a station by the standard deviation. The CoV values for each station within the three focus catchments are given in Table 3.2.

Colwell (1974) defined variables which describe the predictability of periodic phenomena. Previous studies such as Poff and Ward (1989) and Pegg and Pierce (2002) have used these variables to describe the overall flow variation of a stream. The predictability value (PredQ) ranges from zero to one, where high predictability indicates low variability, and is comprised of two components – flow constancy (C) and flow contingency (Colwell 1974). For example, a stream with relatively uniform flow may have a predictability value near one, almost entirely due to the constancy component (ie C/P value is high). Alternatively, a stream with flow that varies dramatically would also have a high predictability value if similar flow occurred with a consistent periodicity (ie high contingency value). A detailed description of these variables is given in Colwell (1974), Poff and Ward (1989) and Gordon et al (2004). In this study, PredQ and C/P were derived for each station using mean daily flow data for the years with complete annual flow data (given in Table 3.2). A matrix was constructed for each station where rows represented flow intervals and columns represented each time period (day). There were 12 flow intervals used in this study (e^i where i = 0, 1, 2, ..., 11) which spanned the entire range of daily flow values for all the streams combined. A natural logarithmic scale was used rather than a linear one, as recommended for streamflow by Poff and Ward (1989) and Gordon et al 2004. Therefore, the entire dataset for each stream was contained within a 12 row by 365 column matrix (for leap years, day 366 of the year (August 31) was deleted). Entries in the matrix were the number of days in which flow fell within a given interval.

An example spreadsheet for the derivation of PredQ and C/P is given in Appendix E. For illustration purposes, the spreadsheet demonstrates the derivation of PredQ and C/P values for a station using total monthly volume of flow rather than mean daily flow (a matrix of 12 flow intervals (rows) by 12 months (columns) instead of a 12 x 365 matrix). The Colwell parameter values in this study were derived on a daily basis rather than monthly (Appendix E) because the smaller time step is more sensitive to rapid changes in the hydrograph that may be obscured over a larger time interval (Poff & Ward 1989).

Table 3.2 Hydrology variables for streams within the three focus catchments

Catchment	Station number	Station name	Stream name	AREA (km^2)	Qann (mm)	CoV	PredQ	C/P	FloodFREQ (yr^{-1})	FloodDUR (d)	Flood60D	ZeroDAY ($d\ yr^{-1}$)
Daly	G8140001	Railway Br	Katherine	8640	268	0.62	0.48	0.49	0.76	2.8	0.88	0
	G8140008	Old Railway Br	Fergusson	1490	309	0.63	0.68	0.71	0.79	0.9	0.93	0.40
	G8140011	Manbulloo Boundary	Dry	6290	27	1.55	0.83	0.89	1.48	5.0	0.92	0.78
	G8140040	Mount Nancar	Daly	47100	147	0.78	0.57	0.65	0.84	12.3	0.89	0
	G8140044	U/S of Kathleen Falls	Flora	5900	178	0.94	0.58	0.75	1.21	1.3	0.86	0
	G8140063	D/S Old Douglas H/S	Douglas	842	222	0.80	0.63	0.72	1.15	1.1	0.85	0
	G8140067	U/S Dorisvale Crossin	Daly	35800	149	0.80	0.49	0.54	0.89	5.9	0.96	0
	G8140068	D/S Victoria HWY	King	11000	18	1.30	0.78	0.84	1.13	5.1	0.95	0.63
	G8140151	Victoria HWY	Mathieson Ck	725	11	1.71	0.96	0.97	1.50	0.8	0.94	0.90
	G8140152	Dam Site	Edith	590	396	0.64	0.73	0.74	0.79	0.3	0.83	0.20
	G8140158	Dam Site	McAdden Ck	133	275	0.75	0.85	0.88	1.10	0.2	0.76	0.39
	G8140159	Waterfall View	Seventeen Mile Ck	619	194	0.90	0.68	0.82	1.14	0.3	0.79	0
	G8140161	Tipperary	Green Ant Ck	435	184	0.77	0.76	0.82	1.17	1.0	0.84	0.14
Fitzroy	802002	Mt Pierre Gorge	Mount Pierre Ck	318	97	0.90	0.92	0.95	1.00	0.3	0.78	0.44
	802055	Fitzroy Crossing	Fitzroy	46133	167	0.94	0.45	0.53	0.76	3.7	0.86	0.18
	802137	Dimond Gorge	Fitzroy	17152	152	0.84	0.54	0.64	1.10	2.1	0.92	0.39
	802198	Me No Savvy	Margaret	7646	110	0.86	0.70	0.81	0.65	1.1	0.84	0.45
	802202	Mt Winifred	Leopold	5115	142	0.84	0.71	0.79	1.07	0.9	0.93	0.57
	802213	Phillips Range	Hann	5070	145	0.82	0.62	0.70	0.91	1.2	0.86	0.39
Flinders	915003A	Walkers Bend	Flinders	107150	29	1.27	0.65	0.73	0.81	11.4	0.79	0.59
	915008A	Richmond	Flinders	17382	31	1.31	0.80	0.90	0.71	3.3	0.76	0.69
	915011A	Mt Emu Plains	Porcupine Ck	540	55	1.29	0.90	0.95	0.79	0.4	0.89	0.55
	915013A	Glendower	Flinders	1958	59	0.95	0.78	0.92	0.88	0.4	0.76	0.65
	915203	Cloncurry	Cloncurry	5859	66	1.17	0.80	0.90	0.89	1.0	0.74	0.66
	915204A	Damsite	Cloncurry	4240	49	1.19	0.84	0.91	0.77	0.6	0.75	0.75
	915206A	Railway Crossing	Dugald	660	81	1.12	0.88	0.94	1.06	0.3	0.78	0.74
	915208A	Julia Ck	Julia Ck	1353	22	1.95	0.94	0.97	0.86	2.0	0.96	0.88
	915211A	Landsborough HWY	Williams	415	108	1.25	0.90	0.95	1.06	0.4	0.78	0.83

Flood regime pattern

Floods occur when flow fills an alluvial channel and begins to overflow onto the floodplain (Leopold et al 1964, Grayson et al 1996). The recurrence interval of the bankfull discharge is generally within the range of one to two years (Leopold et al 1964), although for tropical regions this figure has been shown to be closer to one year (McDermott & Pilgrim 1983, Pilgrim 2001). In this study the recurrence interval for bankfull discharge has been assumed to be two years, which is a relatively conservative flood frequency estimate.

Annual peak discharges were determined for each station for the years with complete annual flow data. The annual hydrograph for the years with missing data were checked against the hydrograph from nearby stations to determine if a runoff event had occurred during the gap and hence whether it was likely that the annual peak discharge could have occurred during the gap in data. If not, the annual peak discharge was also determined for these years and included in the analysis.

For example, to assess the likelihood of the annual peak discharge occurring during a gap in data collected at G8140067 (in the Daly River catchment), the hydrograph at G8140067 was checked against the hydrograph at G8140040, a station located approximately 100 km downstream of G8140067. Figure 3.1 shows that the hydrographs for these two stations are relatively similar in terms of the timing of flood events. Figure 3.2a shows the annual hydrograph for G8140067 during 1999–00 where significant gaps in flow data occurred. The corresponding hydrograph at G8140040 indicates that these gaps occurred at lowflow (December–January) and during the falling stage of an event hydrograph (March). It is unlikely that the annual peak discharge occurred during these gaps and, therefore, the observed annual peak discharge for this year is included in the analysis. However, Figure 3.2b shows the annual hydrograph at G8140067 for 2000–01 where gaps have occurred in the record, but in this case, the G8140040 hydrograph indicates that a major flood event occurred during the gap (January). Therefore, given that it is possible that the annual peak discharge may have occurred during this gap in data, the observed annual peak discharge for 2000–01 at G8140067 is not included in the analysis.

The annual peak discharges for each long-term station throughout the three focus catchments are given in Appendix D.

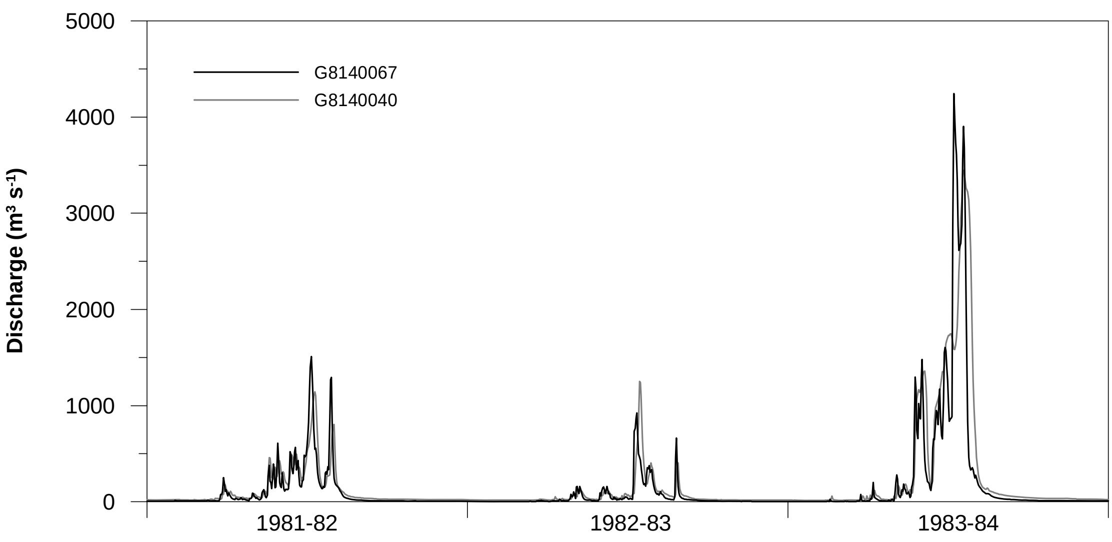

Figure 3.1 Hydrographs for G8140040 and G8140067 between September 1981 and September 1984

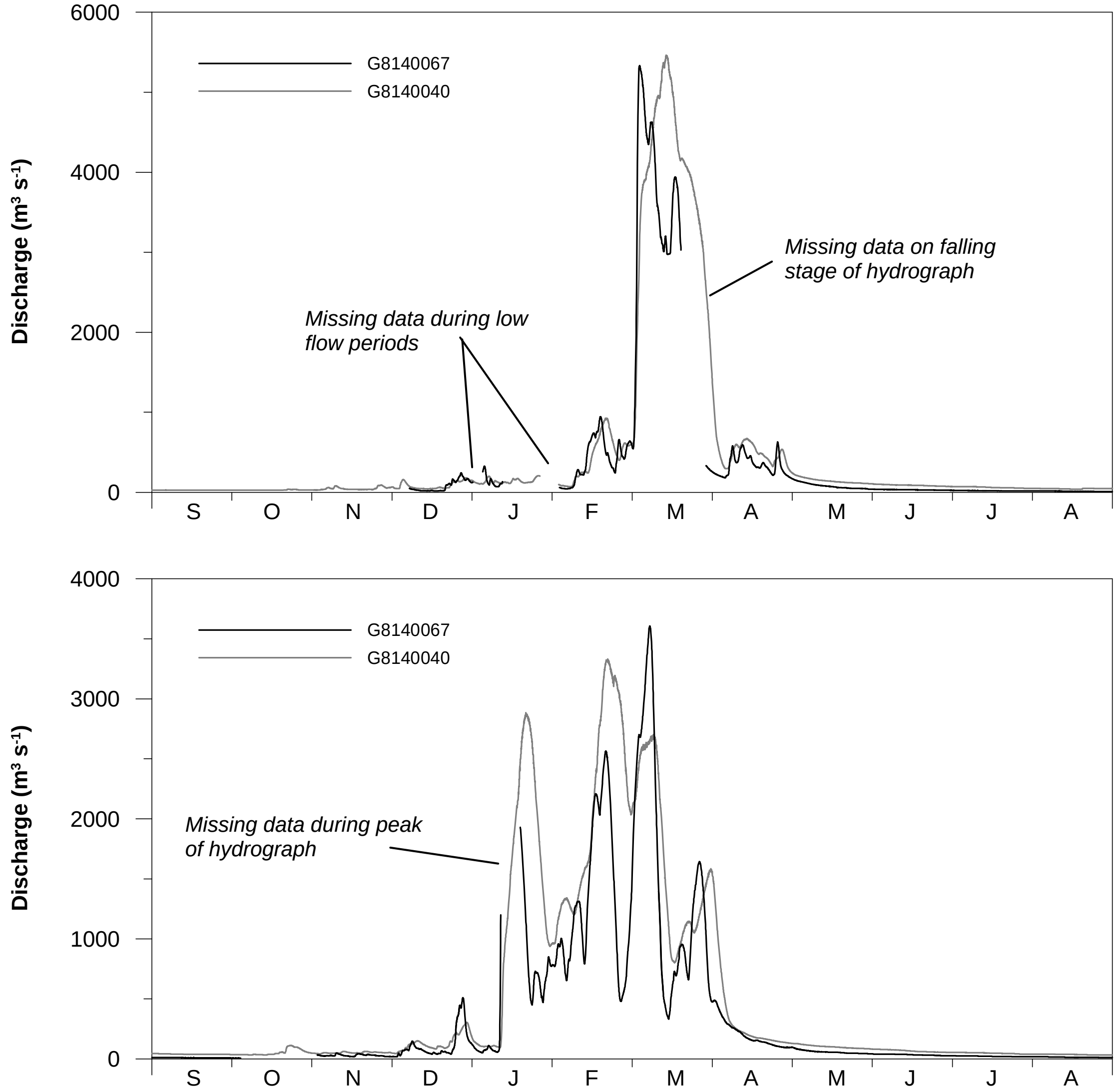

Figure 3.2 The annual hydrograph for G8140067 compared against G8140040 (a) during 1999–00 where it is unlikely that the annual peak discharge occurred during the gap in the record, and (b) during 2000–01 where it is possible that the annual peak discharge occurred during the gap in the record

A log Pearson III analysis was used to determine the 1:2 y discharge for each station. The mean (M), standard deviation (S) and skewness (g) of the logarithms of the annual peak discharges were calculated for each station. The bankfull discharge was calculated using equation (3.1) (Pilgrim 2001):

$$Ry = M + Ky\ S \qquad (3.1)$$

where, Ry = the logarithm of peak discharge having an annual exceedance probability of 1 in 2 years; Ky = frequency factor found from Tables in Pilgrim (2001) for the required AEP.

After the bankfull discharge value was determined for each station (Appendix D), the flood regime patterns for the period of record were evaluated with respect to three variables (Table 3.1). Flood frequency (FloodFREQ) was the mean number of floods per year over the period of record. In the counting of flood events a suitable criterion for independence of successive peaks (Hoggan 1997) was applied where two flood peaks were considered to be independent if separated by periods of approximate baseflow conditions. That is, for events separated by a period of baseflow it is interpreted that overland flow from the catchment has ceased. The baseflow at each gauging station was estimated by applying the Lyne and Hollick digital filter (Nathan & McMahon 1990; Grayson et al 1996) to the entire period of record (60-min interval; filtering factor of 0.925; 3 passes of the data). For example, Figure 3.3 shows a period of the 1996–97 hydrograph at station 802137 in the Fitzroy River catchment where flow exceeded bankfull discharge on five occasions. The first two occasions were considered part of the same multi-peak event, as the two peaks were not separated by baseflow conditions. The remaining three overbank flow events were clearly separated by baseflow conditions. Therefore, it was assumed that four floods occurred during 1996–97 at 802137.

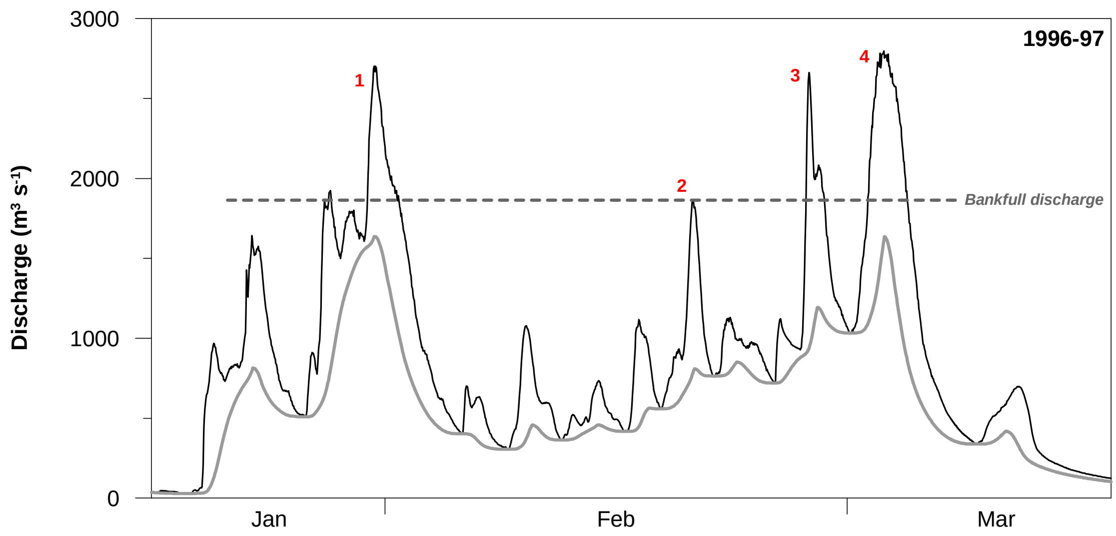

Figure 3.3 Period of the 1996–97 annual hydrograph at 802137 in the Fitzroy River catchment where four flood events occurred. The grey line indicates approximate baseflow conditions.

The mean duration of flood events (FloodDUR) was simply calculated by determining the number of days each flood lasted. The predictability of flooding was assessed by calculating the maximum proportion of floods occuring in any 60-day period common to all years in the flow record (Flood60D). The mean number of floods per year (FloodFREQ), mean flood duration (FloodDUR) and flood predictability (Flood60D) for each station within the three focus catchments are given in Table 3.2.

Extent of intermittency

The mean annual number of zero flow days (ZeroDAY) was determined for each stream and used to assess stream intermittency (Table 3.2). The number of zero flow days was derived from the mean daily flow record for each station for the years with complete annual flow data. Some annual hydrographs had gaps in the record that occurred during high flow periods, where it was clear zero flow days would not have occurred, and these years were also included in the analysis (Appendix D).

3.2 Multivariate analysis

Multivariate analysis of the fitted hydrology variables (Table 3.2) was used in an attempt to identify groups of streams with similar flow regimes. In this study, the Primer v5 software package (Clarke & Gorley 2001) was used to conduct the analysis. The cluster technique was based on Euclidean distance between streams (stations) and a group average linkage. This is a similar technique to other studies on streams in the United States (Poff & Ward 1989, Pegg & Pierce 2002).

Initially, however, variables directly related to catchment size were removed from the cluster analysis (ie AREA and FloodDUR). It was considered that both these variables had little influence on the flow regime of a stream (Pegg & Pierce 2002) and hence may unnecessarily skew the analysis. Furthermore, the variable Qann was also removed from the analysis because this variable was (1) two to three orders of magnitude greater than the other hydrology variables, and (2) not independent of the variable CoV (as shown in Table 3.1, CoV is Qann divided by the standard deviation of the annual series). The strengths of the linear relationships between the remaining six variables were assessed using Pearson correlation coefficient (Table 3.3). Statistically significant relationships were observed between some of the hydrology variables (as indicated in Table 3.3), but this was partly due to the relatively high number of stations used in the analysis. For all but one of the relationships, the correlation coefficients were generally low indicating that there is considerable variability within these relationships. Inspection of all pairwise plots of the hydrology variables (Fig 3.4) supports the correlation analysis (Table 3.3). The relationship between variables PredQ and C/P is clearly significant and, as a result, the variable C/P was excluded from the cluster analysis.

Table 3.3 Matrix of Pearson correlation coefficients for six variables

	CoV	PredQ	C/P	FloodFREQ	Flood60D	ZeroDAY
CoV	1.00					
PredQ	0.63(1)	1.00				
C/P	0.63(1)	0.96(1)	1.00			
FloodFREQ	0.28	0.27	0.29	1.00		
Flood60D	0.15	-0.24	-0.33	0.26	1.00	
ZeroDAY	0.76(1)	0.77(1)	0.75(1)	0.13	-0.10	1.00

(1) statistically significant ($p < 0.01$)

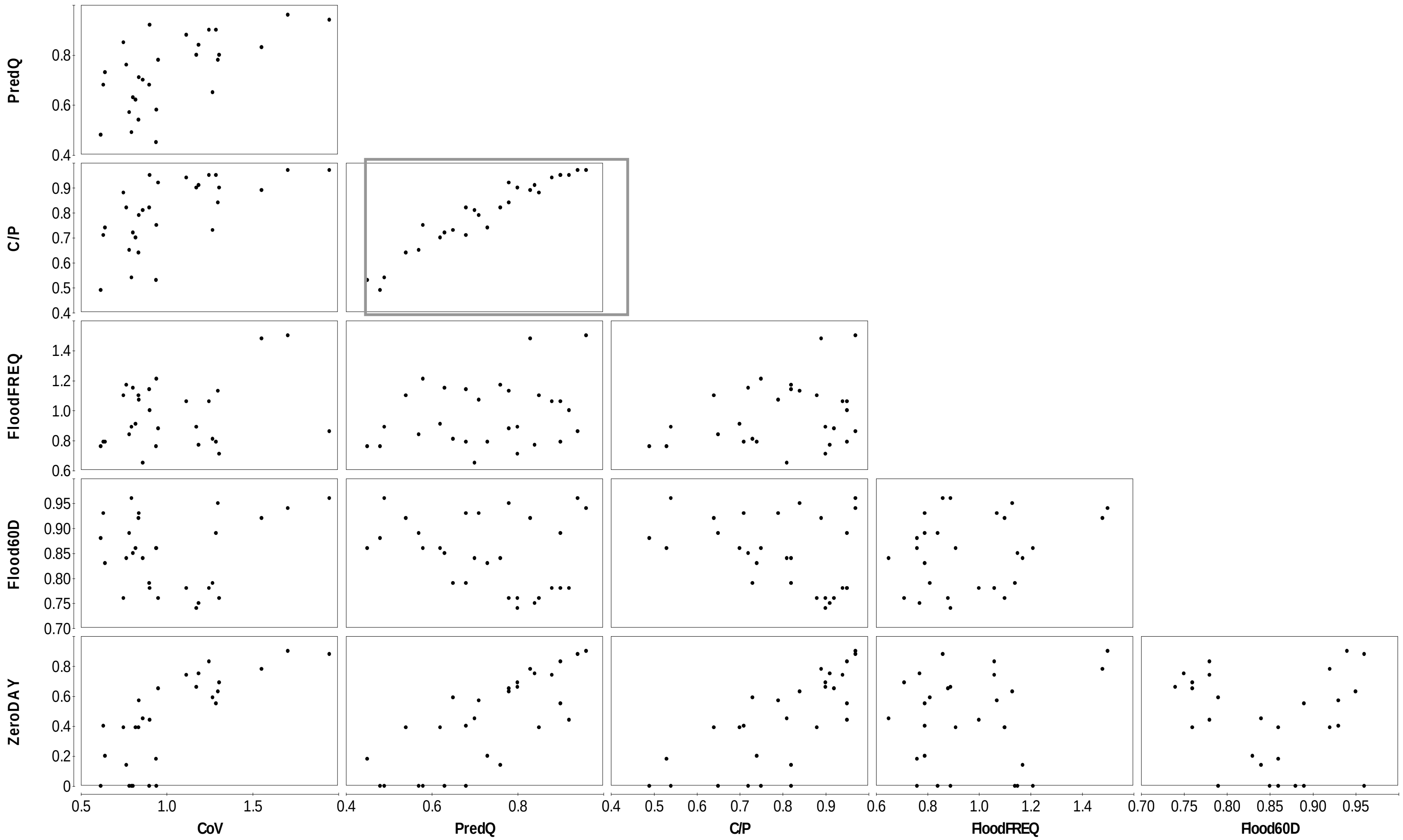

Figure 3.4 Matrix of correlation plots between pairs of hydrology variables fitted for each long-term station. The relationship between PredQ and C/P is highlighted.

Values of the five remaining hydrology variables (CoV, PredQ, FloodFREQ, Flood60D and ZeroDAY) for each station were used as input into the cluster analysis (Table 3.2). From these five variables, cluster analysis indicated that streams could be grouped (at a distance threshold of approximately 0.4) broadly into (1) perennial, (2) seasonal, (3) dry seasonal, and (4) seasonal-intermittent streams (Fig 3.5). One station, 915208A, was placed *a posteriori* within the seasonal-intermittent group, despite the fact cluster analysis identified this station as its own group.

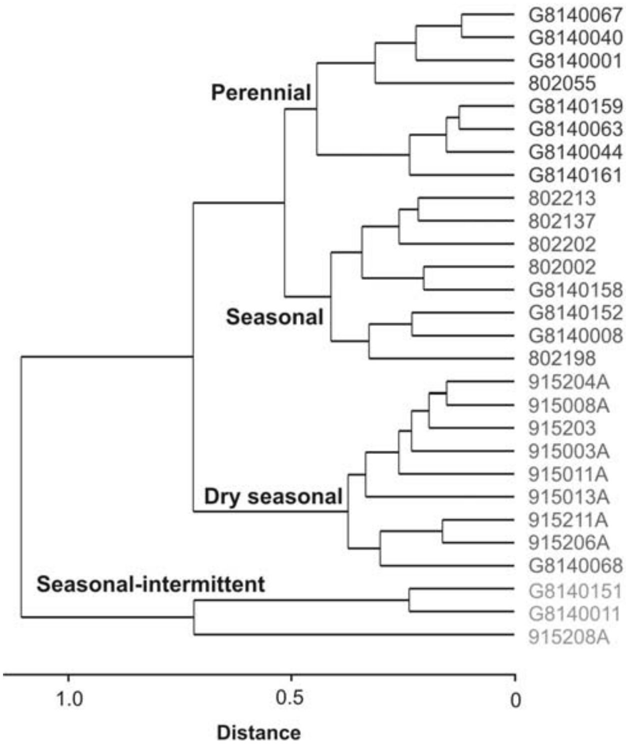

Figure 3.5 Flow regime unit groupings of the long-term flow stations used in cluster analysis

BIOENV analysis was used to identify the variables which 'best explain' the flow regime pattern shown in Figure 3.5. Using the Spearman rank correlation method, two of the original five variables were identified as contributing significantly to the clustering of stations into similar flow regime units. Variables CoV and ZeroDAY contribute 79% and 76% to the cluster analysis respectively. The other three variables each contribute less than 50%. The combination of the two variables, CoV and ZeroDAY, explain 94% of the flow regime pattern. Cluster analysis for these two variables showed that the revised flow regime unit groupings of the stations (Fig 3.6) changed very little from that done using the original five variables (Fig 3.5). This is an expected result given the dominant contribution of these two variables.

The station, 915208A, which was originally identified as a single-station group, is now within the seasonal-intermittent cluster group (Fig 3.6). Only two stations were reclassified by this two-variable approach – G81400152 and 915013A. They were identified as perennial and seasonal streams, respectively. Overall, this analysis has shown that only two variables, CoV and ZeroDAY, may be appropriate for classifying streams into flow regime units for the tropical rivers region. Interestingly, the variables describing flood regime pattern do not have a large influence on the classification of streams into flow units for the region. This result reflects the similarity in flood parameter values (FloodFREQ and Flood60D) between the long-term stations throughout the three focus catchments.

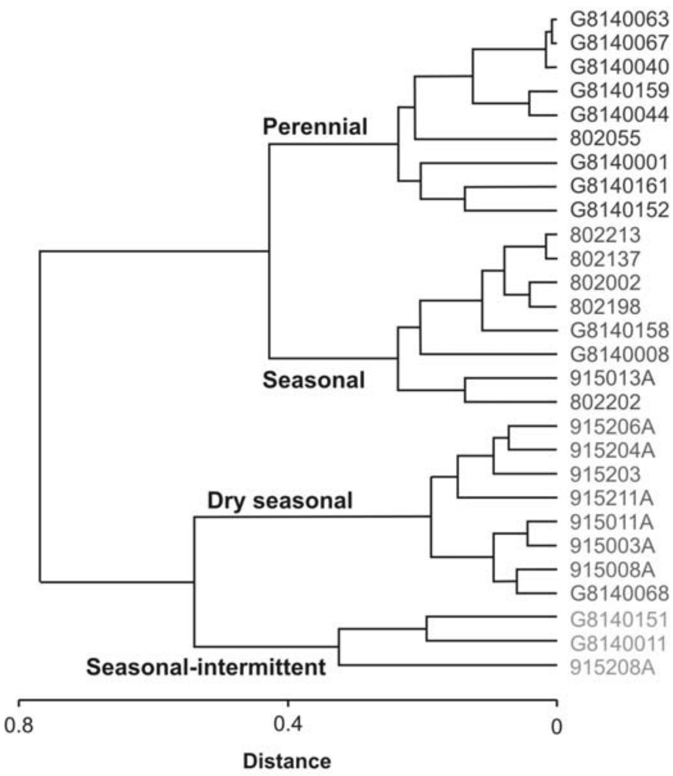

Figure 3.6 Revised flow regime unit groupings of the long-term flow stations used in cluster analysis using two of the original five variables – CoV and ZeroDAY

Table 3.4 shows the mean value of the two variables, CoV and ZeroDAY, for the four cluster groups. The *perennial* streams were characterised by low annual variability and had no more than occasional zero flow days. *Seasonal* streams have a similar annual variability to the perennial streams but are characterised by zero flow during most of the dry season. *Dry seasonal* streams are characterised by high annual variability and are dry for more than half of the year. Only three streams were classified as *seasonal-intermittent*, and these streams are dry for almost the entire year, have very high annual variability and flow generally only occurs as a result of a large storm event during the wet season.

Table 3.4 Mean and standard deviations of the two significant hydrology variables for four clusters

	Perennial	Seasonal	Dry seasonal	Seasonal-intermittent
CoV	0.80 (0.12)	0.82 (0.10)	1.24 (0.07)	1.74 (0.20)
ZeroDAY	0.06 (0.09)	0.46 (0.10)	0.68 (0.09)	0.86 (0.06)

Figure 3.7 shows the classification of streams within the three focus catchments according to the cluster analysis based on two variables. The perennial streams in the Daly River catchment generally occurred throughout the lowland areas of the catchment. Dry season flow throughout this region is generally maintained by groundwater emanating from regional aquifers (DLPE 1999, Jolly 2002). For example, regional aquifers in the Tindall Limestone are the source of dry season inflows at stations along the Katherine (G8140001), Flora (G8140044) and Douglas (G8140063) Rivers (Jolly et al 2000, Jolly 2002). Regional aquifers developed in the Oolloo Limestone are the source of dry season inflows into the Daly and Douglas Rivers (Jolly 2002). Regional groundwater discharges from cretaceous sandstones provide the dry season flow for Seventeen Mile Creek (G8140159) (Jolly 2002). It is assumed that most streams throughout the Katherine Gorge escarpment area are classified as seasonal streams. Many of these streams have relatively small catchment areas and runoff would generally not continue long after wet season rainfall ceased over the relatively impervious sandstone escarpment. For this reason, it is likely that, aside from some sections of the channel being spring-fed, the ungauged main channel along the upper Katherine gorge region above G8140001 should also be classified as seasonal (Fig 3.7a). The two most southern streams in the Daly River catchment are classified as seasonal-intermittent. These two streams lie in the driest portion of the Daly River catchment, with rainfall in this area approximately half that of the northern region (Fig 1.3). Most of the runoff in this region is obtained from the carbonate sediments of the Daly Basin and runoff is usually low unless the groundwater level rises to, or above, the surface during heavy rainfall years (Jolly 2002).

Most of the Fitzroy River catchment can be considered to comprise seasonal streams. Although not all streams have been classified (Fig 3.7b), it is likely that all streams above station 802055 will have a similar flow regime given the rainfall characteristics throughout this region are relatively uniform (Fig 1.3). The stations upstream of 802055 are located in either impervious sandstone or 'blocky' quartz country (L Bowyer pers comm. 2006) which would explain why these streams cease to flow relatively soon after the end of the wet season rainfall. The main channel of Fitzroy River downstream of station 802055 can be considered perennial, with the occasional zero flow period occurring during the dry season. Downstream of the station 802055, the morphology of the river is dominated by floodplain, which is very different to the upper reaches of the Fitzroy River catchment. High flows during the wet season can contribute to the recharge of the sandy floodplain soil which subsequently discharges to the river during the dry season (L Bowyer pers comm. 2006).

In contrast, almost all of the streams within the Flinders River catchment can be considered to be dry-seasonal. There is no flow within this catchment for more than half of the year and this is attributed to the fact that rainfall is relatively low in this system compared to the rest of the tropical rivers region (Fig 1.2). Streamflow at the eastern most region of the catchment is seasonal and this may reflect the higher rainfall which occurs over this area (Fig 1.2). One stream, gauged at station 915208A is classified as seasonal-intermittent and this may be attributed to the fact that rainfall upstream of this station is the lowest for the Flinders River catchment (Fig 1.2).

It should be noted that near the outflow of each of these catchments there is a tidal limit where the river becomes estuarine (Fig 3.7). In this tidal-estuarine region of the catchment, the stream could be classified as 'tidal' (ie a fifth flow regime unit) rather than perennial, in the case of the Daly and the Fitzroy Rivers, or dry seasonal, in the case of the Flinders River.

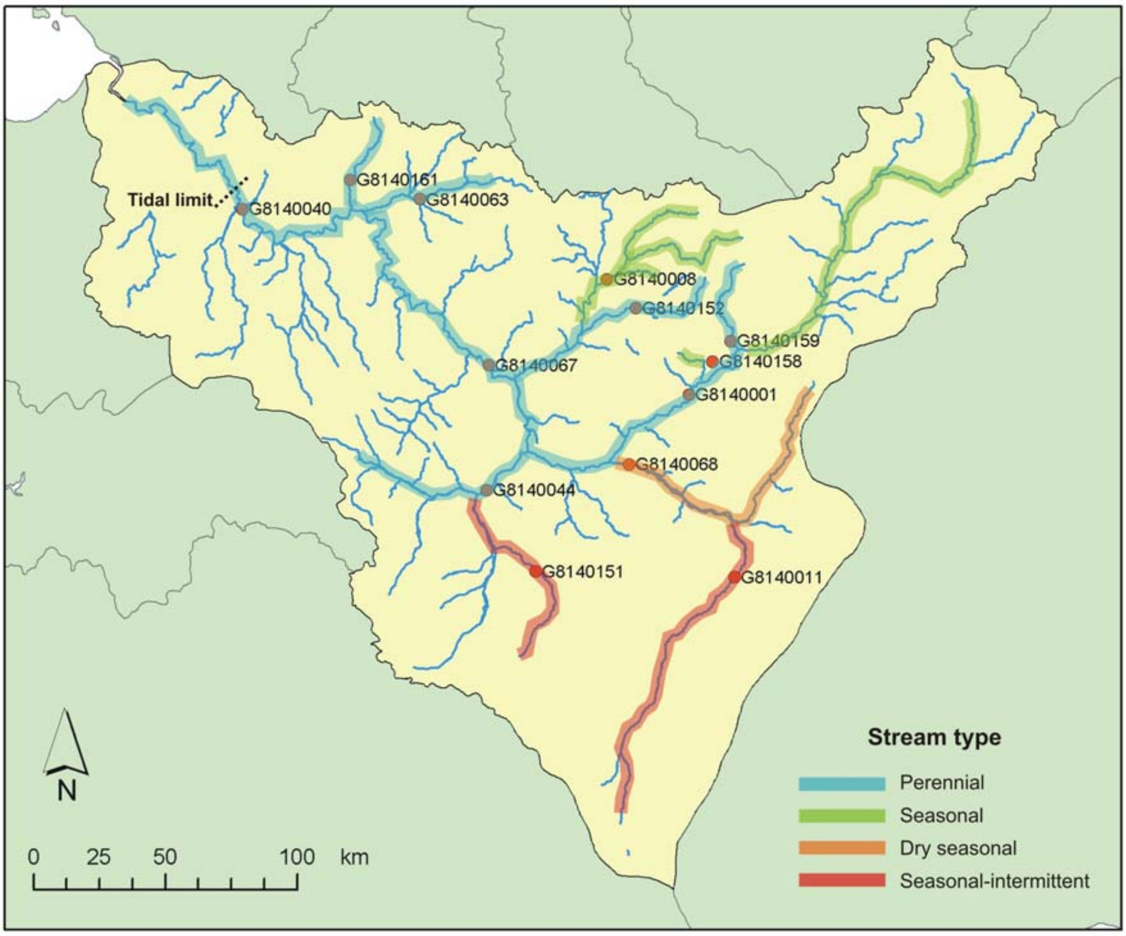

Figure 3.7a Classification of streams within the Daly River catchment based on the cluster analysis

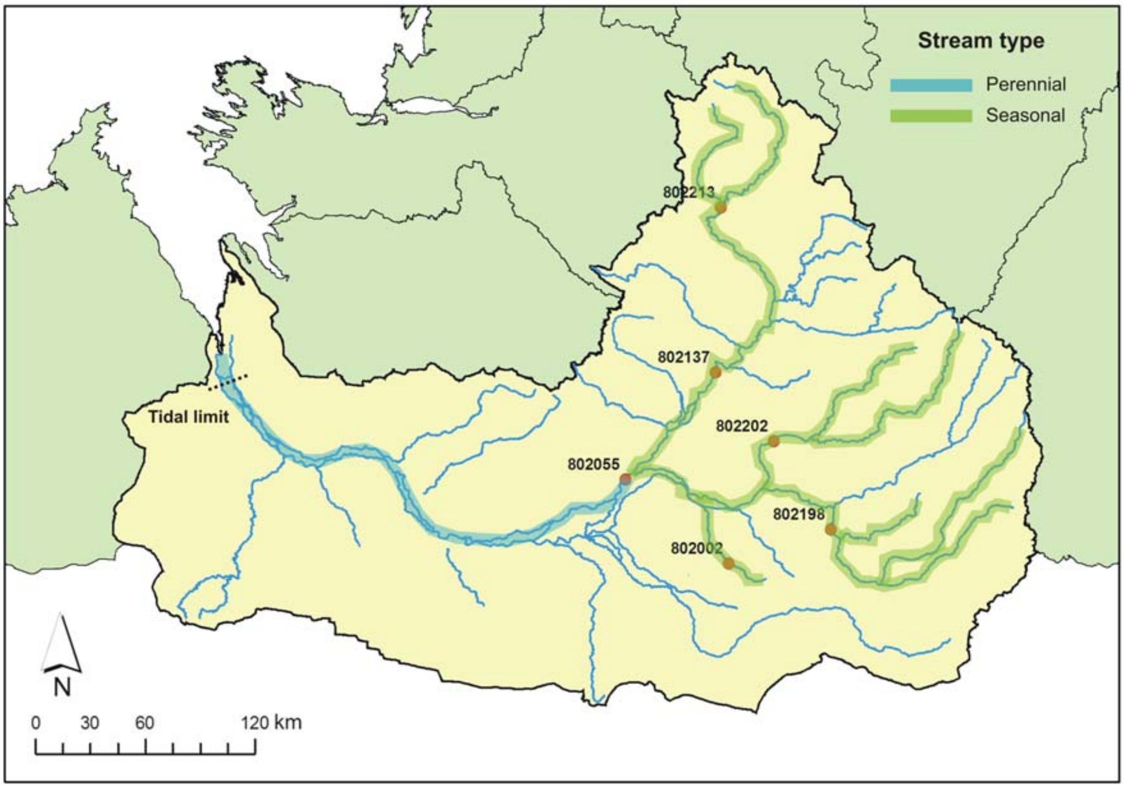

Figure 3.7b Classification of streams within the Fitzroy River catchment based on the cluster analysis

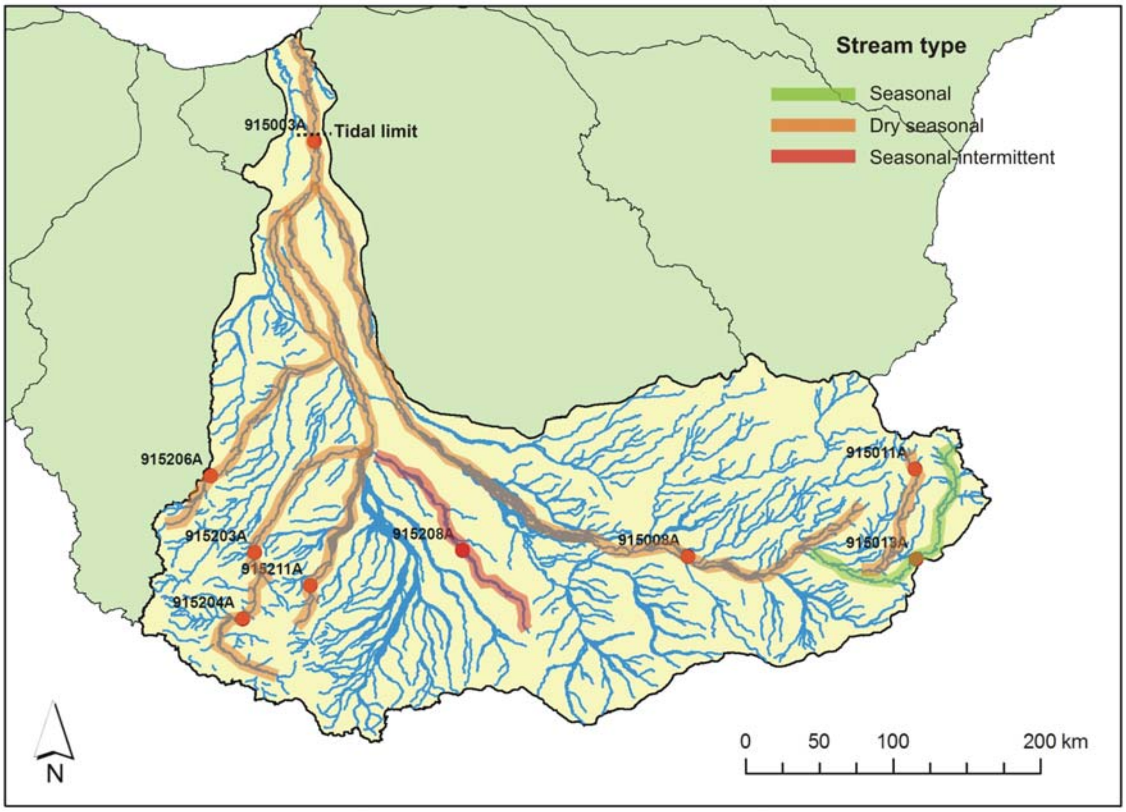

Figure 3.7c Classification of streams within the Flinders River catchment based on the cluster analysis

3.2.1 Effect of flow data quality on hydrology variables

As discussed above, some of the stations within the focus catchments used in this analysis have relatively poor rating curves, particularly in terms of estimating high flows. The quality of the rating curve has a strong influence on the quality of the flow data for a stream. In turn, the reliability of any hydrology variables derived for a stream is dependent on the quality of the flow data. As shown in the previous section, the two hydrology variables CoV and ZeroDAY are the two most significant variables in terms of classifying the streams into flow units. Most importantly, for the reasons given below, the quality of the rating curve fitted for a station, particularly at the high-flow end of the curve, will have less effect on these two variables than other variables such as those used to describe the flood regime pattern.

The estimation of CoV appears to be relatively insensitive to errors in the rating curve. For example, station G8140041 is only 7 km upstream of station G8140040 within the Daly River catchment with an almost identical catchment area upstream of each station (46300 km^2 and 47100 km^2 respectively). However, calculated peak discharges during runoff events at G8140040 are up to 50% higher than corresponding flood discharges observed at G8140041 (Appendix C). These differences can be attributed to the two stations having different rating curves, particularly at the higher flows. Despite this difference, the CoV value for these two stations for concurrent years are similar (0.70 and 0.67 at station G8140040 and G8140041 respectively).

The quality of the rating curve at the higher flows has no effect on the ZeroDAY parameter value. For this variable, the accuracy of the rating curve at the lower flows, particularly the estimation of the CTF (cease to flow) value, is of primary importance. For stations without a fixed control (weir or causeway), velocity-area gaugings are taken within the stream across a channel bed which can change in time. When the channel bed changes, the CTF value will also change. If such a record of changes in CTF has not been made during the period of record for non-perennial streams, errors in the number of zero flow days estimated to occur during a year could be significant. Table 3.5 shows that most of the stations within the Daly River catchment have a fixed control. Therefore, it can be assumed that the ZeroDAY value for these stations should be reliable. (Of the non-perennial stations within the Daly River catchment, only station G8140158 has a moving bed control.) Most of the stations within the Fitzroy River catchment have the low flow control over a stable rock bar (Table 3.5), which indicates that CTF is unlikely to change significantly with time (L Bowyer pers comm. 2006). (Only the perennial station 802055 has a moving bed control.) In contrast, most of the stations within the Flinders River catchment have a moving bed control. The accuracy of the CTF values during the period of record at these stations has not been validated in this study and, therefore, the ZeroDAY value derived for these stations may be unreliable. However, many of the stations within the Flinders River catchment have a gravel or sand gravel bed (Table 3.5) and, consequently, CTF is not expected to change dramatically over time for most flow conditions (other than major flood events). The effect of minor errors in the number of zero flow days (up to a week or two) as a result of small changes in CTF on the ZeroDAY parameter value is minimal.

Table 3.5 Gauging control structure for long-term stations within the focus catchments

Catchment	Station number	Flow regime	Control
Daly	G8140001	Perennial	High flow: Low level bridge concrete weir
			Low flow: Downstream of bridge, moving bed
	G8140008	Seasonal	Concrete shallow “V” notch
	G8140011	Seasonal-intermittent	Low profile weir (grouted rocks)
	G8140040	Perennial	Shifting sand
	G8140044	Perennial	Rock bar
	G8140063	Perennial	Concrete shallow “V” notch
	G8140067	Perennial	Rock bar and shifting sand
	G8140068	Dry seasonal	Concrete weir
	G8140151	Seasonal-intermittent	Old road crossing
	G8140152	Perennial	Rock bar
	G8140158	Seasonal	Natural gravel, subject to change
	G8140159	Perennial	Low profile concrete weir
	G8140161	Perennial	Concrete shallow “V” notch
Fitzroy	802002	Seasonal	Consolidated sand and limestone
	802055	Perennial	Sand
	802137	Seasonal	Rock bar
	802198	Seasonal	Rock bar
	802202	Seasonal	Rock bar
	802213	Seasonal	Rock bar
Flinders	915003A	Dry seasonal	Causeway
	915008A	Dry seasonal	Sand
	915011A	Dry seasonal	Control weir
	915013A	Seasonal	Sand
	915203	Dry seasonal	Sand gravel
	915204A	Dry seasonal	Sand gravel
	915206A	Dry seasonal	Gravel
	915208A	Seasonal-intermittent	Mud rock
	915211A	Dry seasonal	Sand gravel

Obviously, it is important that the rating curve for a station should be reliable throughout the range of flow conditions in order to obtain accurate flow data for a stream. However, in terms of using the flow data to derive variables CoV and ZeroDAY to classify the flow regime of a stream, the quality of the rating curve may not be so critical, particularly for stations with a fixed gauging control.

3.3 Validation

As discussed above, the use of two hydrological variables, coefficient of variation of total annual flow (CoV) and mean annual number of zero flow days (ZeroDAY), may be acceptable for classifying streams into flow regime units for the tropical rivers region. The analysis was based on 28 long-term stations within three catchments within the region. In this section, long-term stations (> 20 y complete annual flow data) within three other catchments of the tropical rivers region (South Alligator River, East Alligator River and Nicholson River – indicated as catchment 1, 2 and 3 respectively in Figure 3.8) were used to check this model. The CoV and ZeroDAY values for each station within the three validation catchments are given in Table 3.6. The Nicholson River catchment was selected as a good test of the model's applicability to the region because of it's unusual flow characteristics. Despite the fact the Nicholson River catchment is located within a relatively low rainfall area (Fig 1.2), most of the major creeks within this catchment are perennial. Streams within the nearby Flinders River catchment, which has similar rainfall characteristics, are almost entirely dry seasonal (Fig 3.7c). The other two validation catchments – South and East Alligator Rivers – were selected because of data availability and extent of ***eriss***' historical work in this region.

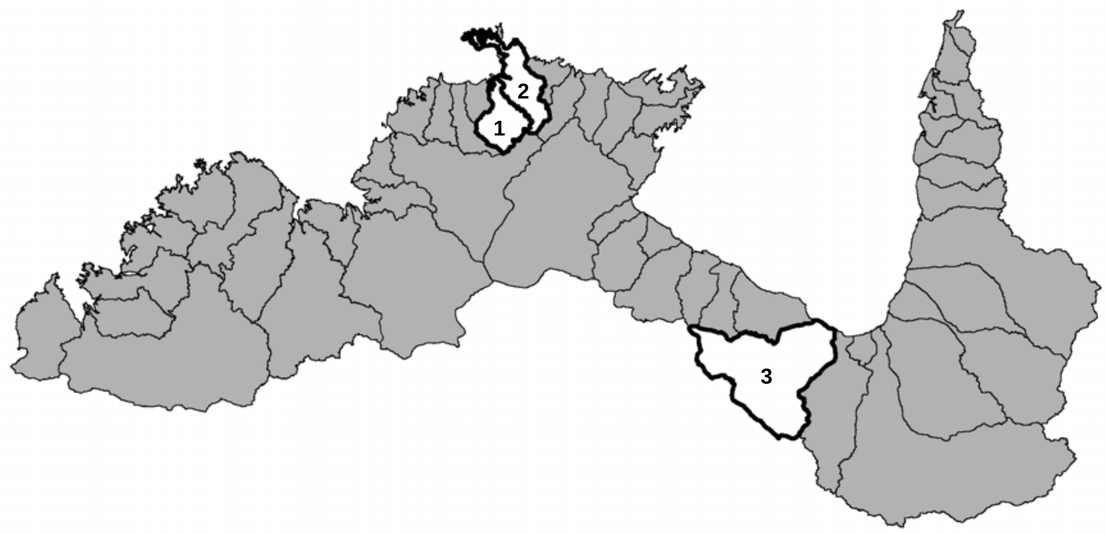

Figure 3.8 The three validation catchments within the tropical rivers region – South Alligator (1), East Alligator (2) and Nicholson (3) rivers

Table 3.6 Hydrology variables for streams within the three validation catchments

Catchment	Station Number	Station name	Stream name	Area (km^2)	CoV	ZeroDAY (d yr^{-1})
Sth Alligator	G8200045	El Sherana	Sth Alligator	1300	0.63	0.04
	G8200112	Oenpelli Rd Crossing	Nourlangie	2220	0.57	0.46
East Alligator	G8210009	Downstream Jabiru	Magela	605	0.50	0.46
Nicholson	912101A	Gregory Downs	Gregory	12845	1.06	0
	912103A	Lawn Hill No. 2	Lawn Hill	3520	1.22	0.06
	912105A	Riversleigh No. 2	Gregory	11489	1.02	0
	912107A	Connollys Hole	Nicholson	13880	1.28	0.55

The hydrological variables derived for the seven stations for these three catchments were added to the previous compilation of hydrological variables for the 28 focus catchment stations and used as input into cluster analysis. The cluster analysis showed that the flow regime groupings for the original 28 stations (Fig 3.9) remained unchanged to that derived previously (Fig 3.6). Four of the validation stations were classified as perennial (G8200045, 912101A, 912103A and 912105A), two were classified as seasonal (G8200112 and G8210009) and one was classified as dry seasonal (912107A) (Fig 3.9). These long-term stations within the three validation catchments were classified into their correct flow regime groups based on the two hydrological variables, CoV and ZeroDAY, which supports the use of these two hydrological variables to classify streams into flow units for the tropical rivers region.

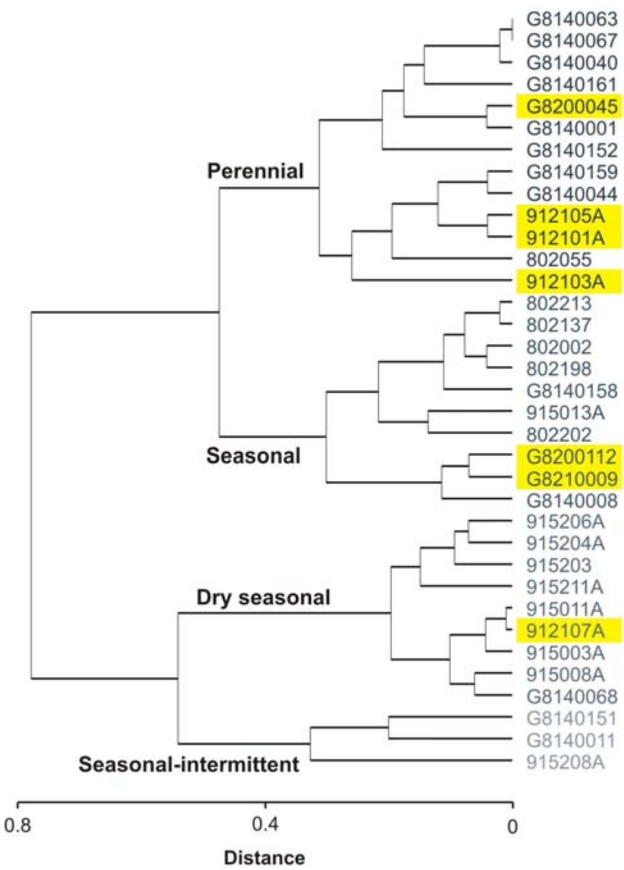

Figure 3.9 Flow regime unit groupings of the long-term flow stations used in cluster analysis. Long-term stations within the three validation catchments are shaded

4 Conclusions and recommendations

Flow statistics, mean annual runoff and coefficient of variability, derived for gauging stations with long-term flow data were used to determine the spatial variation in annual runoff and variability across the entire tropical rivers region. Monthly runoff data for each of these stations highlighted the strong seasonal nature of streams throughout the wet-dry tropics and also showed regions where perennial flow is likely to occur.

Streamflow characteristics were derived in more detail for three focus catchments within the region – the Daly, Fitzroy and Flinders Rivers. A total of 28 gauging stations were identified within these three catchments to have at least 20 years of complete annual flow data. Several hydrology variables were derived for each of these stations, based on flow variability, flood regime pattern and intermittency. These hydrology variables were used to classify streams within these three catchments into four flow regime groups: (1) perennial, (2) seasonal, (3) dry seasonal, and (4) seasonal-intermittent streams. The coefficient of variation of total annual flow and the mean annual number of zero flow days were the two most significant variables for classifying streams into flow regime types. These two hydrology variables were derived for seven long-term stations within three other catchments of the tropical rivers region – East Alligator, South Alligator and Nicholson rivers. Cluster analysis classified these validation stations into their correct flow regime groups, indicating that these two hydrological variables may be used to correctly classify streams into flow regime types elsewhere in the tropical rivers region.

There are almost 80 gauging stations within the tropical rivers region, outside the three focus catchments, with at least 20 years of flow data. It is recommended that hydrological variables are derived for some or all of these stations to provide a more comprehensive classification of streamflow regimes for the region. Furthermore, many streams throughout the region have little or no flow data available for such analysis. Therefore, it is also recommended that an investigation be conducted to determine whether there is a link between the most influential hydrological variables (coefficient of variation of total annual flow and mean annual number of zero flow days) and rainfall and geomorphological characteristics. If such a relationship exists, these catchment characteristics could be used to predict hydrology variables, which can then be used to classify the flow regime of data-limited streams within the tropical rivers region.

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Appendix A – Rainfall and flow gauging stations within the focus catchments

Table A.1 Long-term rainfall stations within the Daly River, Fitzroy River and Flinders River catchment

Catchment	Station No.	Station name	Data source	No. complete years	Mean annual rainfall	Latitude	Longitude
Daly	R8140021	Katherine R @ Upper Reaches	NRETA	32	1180.9	-13.481	133.198
	14901	Douglas	BoM	31.3	1207.9	-13.835	131.187
	14902	Katherine council	BoM	125.6	976.1	-14.459	132.257
	14903	Katherine Aviation museum	BoM	28.3	1099.2	-14.444	132.274
	14904	Katherine Exp farm	BoM	24	870.2	-14.483	132.250
	14938	Mango farm	BoM	23.8	1328.5	-13.738	130.683
Fitzroy	502002	Leopold R @ Mud Springs	DoE(WA)	25	707.4	-17.812	126.866
	502003	Margaret R @ Margaret R Homestead	DoE(WA)	27	486.1	-18.623	126.879
	502006	Margaret R @ Me No Savvy	DoE(WA)	20	623.1	-18.448	126.593
	502024	Hann R @ Phillips Range	DoE(WA)	24	884.5	-16.869	126.051
	1018	Mt Elizabeth	BoM	30.8	948.2	-16.418	126.103
	3007	Derby PO	BoM	105.2	622.4	-17.304	123.629
	3032	Derby Aero	BoM	40.6	622.1	-17.371	123.661
	3006	Fitzroy Crossing Comp.	BoM	106.7	541.2	-18.192	125.564
Flinders	29008	Cloncurry McIllwraith St	BoM	116.8	473.6	-20.709	140.519
	29009	Cloncurry Aero	BoM	36.1	470.8	-20.672	140.508
	29013	Donors Hill station	BoM	107.3	655.5	-18.714	140.547
	29025	Julia Ck PO	BoM	90.8	465.6	-20.657	141.746
	29090	Toorak Res station	BoM	49.3	439.3	-21.034	141.801
	30024	Hughenden PO	BoM	117.2	491.3	-20.845	144.199
	30045	Richmond PO	BoM	114.6	474.9	-20.729	143.143

Table A.2 Flow gauging stations within the Daly River catchment. Long-term stations (complete years > 20 y) are shaded.

Station No.	Station name	Stream name	Area (km²)	Date opened	Date closed	No. complete years	No. gaugings	Max GH: max height(1) (%)	Latitude	Longitude
G8140001	Railway Br	Katherine	8640	Mar-57		30	303	98	-14.465	132.257
G8140003	Police Stn	Daly	48400	Jun-52		3	34	88	-13.767	130.708
G8140005	Piker Pocket	Flora(Upper)	829	Nov-67	Nov-86	15	67	17	-14.750	131.267
G8140008	Old Railway Br	Fergusson	1490	Jun-57		37	138	61	-14.072	131.977
G8140011	Manbulloo Boundary	Dry	6290	May-67		29	55	53	-15.087	132.412
G8140013(2)	Pig Hole	Billycan Ck	26	Dec-68	Aug-77	*na*	30	13	-13.642	131.108
G8140019	Gorge	Katherine	6390	Nov-54	Aug-87	19	117	79	-14.313	132.450
G8140023	Gorge Caravan Park	Katherine	6404	Mar-73		0	55	62	-14.313	132.422
G8140040	Mount Nancar	Daly	47100	Jan-67		37(3)	322	100	-13.833	130.733
G8140041	Gourley	Daly	46300	Nov-59	Aug-81	16	234	82	-13.900	130.800
G8140042	Beeboom Crossing 2KM	Daly	41000	Nov-81		15	115	87	-13.857	131.052
G8140044	U/S of Kathleen Falls	Flora	5900	Jul-57		29	30	23	-14.790	131.565
G8140060	Railway Br	Cullen	445	Jan-59		2	26	71	-14.033	131.850
G8140061	Blue Hole	Copperfield Ck	306	Oct-57	May-78	13	31	26	-13.995	131.902
G8140062	Chinamans Camp	Copperfield Ck	9.2	Sep-72	Jan-87	13	82	100	-13.833	131.783
G8140063	D/S Old Douglas H/S	Douglas	842	Sep-57		39	322	93	-13.798	131.338
	U/S Dorisvale Crossin	Daly	35800	Aug-60		30	255	77	-14.365	131.573
G8140068	D/S Victoria HWY	King	110[illegible]	Nov-[illegible]	Nov-86	21	112	92	-14.7[illegible]	132.0[illegible]
G8140086	D/S Stuart HWY	King	484	Jan-64	Jun-87	16	110	89	-14.630	132.588
G8140151	Victoria HWY	Mathieson Ck	725	Dec-63	Jun-87	24	8	24	-15.067	131.733
G8140152	Dam Site	Edith	590	Jun-62		24	138	40	-14.170	132.075
G8140158	Dam Site	McAdden Ck	133	Nov-62		25	70	27	-14.352	132.337
G8140159	Waterfall View	Seventeen Mile C	619	Nov-62		32	259	45	-14.282	132.398
G8140161	Tipperary	Green Ant Ck	435	Aug-66		32	156	67	-13.733	131.100
G8140166	Gorge	Fish	992	Sep-63	Jan-87	19	108	39	-14.238	130.898
G8140214	Victoria HWY	Scott Ck	528	Jan-69	Jun-87	18	26	10	-14.917	131.867
G8140218	Mt Epsworth	Katherine	3700	Sep-64	Jan-00	1	33	7	-13.937	132.787
G8140219(2)	D/S Birdie Ck Confluence	Katherine	?	Aug-97		*na*	6	4	-13.975	132.775
G8140234	Wambungi Rd Crossing	Bradshaw Ck	240	Aug-65	Jun-81	12	3	3	-14.567	131.300
G8140022(2)	Nitmiluk centre	Katherine	?	Oct-98		*na*	46	82	-14.316	132.421
G8140157(2)	U/S Bondi Ck	Fergusson	?	Sep-00		*na*	10	50	-14.283	131.875

(1) The ratio of the maximum stage height above CTF when a velocity gauging was conducted to the maximum recorded stage height above CTF

(2) Due to the brevity of the record period, flow data were not analysed at these stations

(3) The record at G8140040 was combined with that at G8140041 (see Appendix C). Original number of complete years of flow data for G8140040 is 26 years.

Table A.3 Flow gauging stations within the Fitzroy River catchment. Long-term stations (complete years > 20 y) are shaded.

Station No.	Station name	Stream name	Area (km^2)	Date opened	Date closed	No. complete years	No. gaugings	Max GH: max height[1] (%)	Latitude	Longitude
802001[2]	Mt Amhurst	Watery	859	Jan-67	Jan-79	*na*	3	11	-18.013	127.170
802002	Mt Pierre Gorge	Mount Pierre Ck	318	Sep-70	Nov-98	22	41	11	-18.618	126.088
802004	Ellendale	Mt Wynne Ck	722	Nov-86		17	11	23	-17.940	124.795
802008[2]	Willare	Fitzroy	91902	Jul-98		*na*	8	100	-17.736	123.648
802054[2]	Fossil Downs	Margaret	21530	Jan-56	Jan-72	*na*	?		-18.168	125.800
802055	Fitzroy Crossing	Fitzroy	46133	Nov-57		24	70	91	-18.207	125.580
802137	Dimond Gorge	Fitzroy	17152	Dec-63		40	126	37	-17.683	126.025
802198	Me No Savvy	Margaret	7646	Oct-65		36	74	23	-18.452	126.592
802202	Mt Winifred	Leopold	5115	Nov-65		28	127	71	-18.017	126.310
802203[2]	Mt Krauss	Margaret	18728	Jan-64	Jan-79	*na*	37	65	-18.338	126.132
802213	Phillips Range	Hann	5070	Nov-66		35	18	25	-16.873	126.050
802231[2]	Bohemia Downs	Christmas Ck	3421	Jan-66	Jan-79	*na*	17	60	-18.902	126.237

(1) The ratio of the maximum stage height above CTF when a velocity gauging was conducted to the maximum recorded stage height above CTF

(2) Due to the brevity of the record period, flow data were not analysed at these stations

Table A.4 Flow gauging stations within the Flinders River catchment. Long-term stations (complete years > 20 y) are shaded.

Station No.	Station name	Stream name	Area (km^2)	Date opened	Date closed	No. complete years	No. gaugings	Max GH: max height[1] (%)	Latitude	Longitude
915001A	Richmond	Mitchell Grass C	6	Aug-68	Aug-91	19	84	3	-20.755	143.137
915003A	Walkers Bend	Flinders	107150	Dec-69		31	202	32	-18.165	140.857
915004A	Hughenden	Flinders	2519	Oct-69	Oct-88	19	144	82	-20.832	144.185
915005A	Thirty Mile Hut	Stawell	2274	Sep-71	Oct-88	17	79	28	-20.148	143.768
915006A	Revenue Downs	Mountain Ck	203	Oct-70	Oct-88	18	81	31	-20.643	143.222
915007A	Alstonvale	Betts Gorge Ck	1077	Oct-69	Oct-88	19	85	15	-20.678	144.068
915008A	Richmond	Flinders	17382	Sep-71		33	172	72	-20.698	143.133
915009A	Patience Ck	Woolgar	3391	Sep-71	Oct-88	17	80	26	-20.133	143.070
915010A	Perisher	Dutton	1458	Oct-71	Oct-88	17	75	32	-20.373	143.798
915011A	Mt Emu Plains	Porcupine Ck	540	Sep-71		34	122	26	-20.163	144.518
915012A	Etta Plains	Flinders	46131	Sep-72	Oct-88	16	70	7	-19.742	141.267
915013A	Glendower	Flinders	1958	Sep-72		33	130	46	-20.713	144.525
915014A	Walkers Park	Stawell	3852	Sep-72	Oct-88	16	79	29	-20.205	143.272
915203[3]	Cloncurry	Cloncurry	5859	Jul-68		36	184	28	-20.673	140.492
915204A	Damsite	Cloncurry	4240	Oct-68	Oct-94	26	141	53	-21.077	140.417
915205A	Black Gorge	Malbon	425	Oct-70	Oct-88	18	81	17	-21.058	140.082
915206A	Railway Crossing	Dugald	660	Oct-69		33	141	56	-20.202	140.223
915207A	Gilliat	Gilliat	6073	Oct-69	Oct-88	19	86	30	-20.672	141.472
915208A	Julia Ck	Julia Ck	1353	Oct-70		35	137	64	-20.658	141.758
915209A	Main Rd	Corella	1587	Oct-71	Oct-88	17	88	38	-20.450	140.318
915210A	Agate Downs	Cloncurry	1089	Oct-70	Oct-88	17	84	21	-21.355	140.410
915211A	Landsborough HWY	Williams	415	Oct-70		35	139	23	-20.873	140.832
915212A	Canobie	Cloncurry	41222	Sep-72	Oct-88	16	72	14	-19.477	140.960

(1) The ratio of the maximum stage height above CTF when a velocity gauging was conducted to the maximum recorded stage height above CTF

(2) Due to the brevity of the record period, flow data were not analysed at these stations

(3) The record at 915203 is a combination of station 915203A (1968–94) and 915203B (1994–pres)

Appendix B – Long-term flow stations throughout the tropical rivers region

Table B.1 Long-term flow stations throughout the tropical rivers region within Northern Territory

Catchment	Station No.	Area (km^2)	No. complete years	Qann	CoV	Latitude	Longitude
Victoria River	G8110004	2432	32	100	0.92	-15.767	130.033
	G8110007	44900	20	74	0.74	-15.533	130.950
Daly River	G8140001	8640	30	268	0.62	-14.465	132.257
	G8140008	1490	37	309	0.63	-14.072	131.977
	G8140011	6290	29	27	1.55	-15.087	132.412
	G8140040	47100	37	147	0.78	-13.833	130.733
	G8140044	5900	29	178	0.94	-14.790	131.565
	G8140063	842	39	222	0.80	-13.798	131.338
	G8140067	35800	30	149	0.80	-14.365	131.573
	G8140068	11000	21	18	1.30	-14.702	132.052
	G8140151	725	24	11	1.71	-15.067	131.733
	G8140152	590	24	396	0.64	-14.170	132.075
	G8140158	133	25	275	0.75	-14.352	132.337
	G8140159	619	32	194	0.90	-14.282	132.398
	G8140161	435	32	184	0.77	-13.733	131.100
Finniss River	G8150018	101	34	702	0.71	-12.607	131.073
	G8150096	38.5	28	1108	0.57	-12.533	130.667
	G8150097	71	33	488	0.61	-12.967	130.967
	G8150098	174	34	651	0.61	-12.772	130.948
	G8150180	1048	34	440	0.63	-12.972	130.760
Adelaide River	G8170002	632	22	425	0.59	-13.242	131.108
	G8170005	1606	23	413	0.60	-12.957	131.270
	G8170011	93	39	297	0.82	-12.833	131.133
Mary River	G8180026	466	24	315	0.58	-13.617	132.233
	G8180035	5700	32	321	0.60	-12.908	131.645
	G8180069	352	26	389	0.66	-13.533	131.717
	G8180252	122	26	292	0.62	-13.683	131.983
South Alligator R	G8200045	1300	31	420	0.63	-13.525	132.520
	G8200112	2220	32	515	0.57	-12.818	132.742
East Alligator R	G8210009	605	32	600	0.50	-12.642	132.900
Buckingham River	G8260054	14.2	25	815	0.43	-12.250	136.883
Roper River	G9030001	13000	23	13	1.27	-15.087	133.123
	G9030176	6630	32	68	0.72	-14.945	133.207
	G9030250(1)	47400	15	54	0.77	-14.700	134.417
McArthur River	G9070132(1)	10400	15	22	0.69	-16.450	136.083

(1) Stations with less than 20 y flow data used to infill gaps in the analysis

Table B.2 Long-term flow stations throughout the tropical rivers region within Western Australia

Catchment	Station No.	Area (km²)	No. complete years	Qann	CoV	Latitude	Longitude
Fitzroy River	802002	318	22	97	0.90	-18.618	126.088
	802055	46133	24	167	0.94	-18.207	125.580
	802137	17560	40	152	0.84	-17.683	126.025
	802198	7646	36	110	0.86	-18.452	126.592
	802202	5115	28	142	0.84	-18.017	126.310
	802213	5070	35	145	0.82	-16.873	126.050
Lennard River	803001	1069	35	222	0.74	-17.373	125.112
	803002	450	31	248	0.89	-17.168	125.225
	803003	68.1	30	308	0.76	-17.125	124.985
Isdell River	804001	1829	25	164	0.83	-17.010	125.425
King Edward R	806001	1575	26	267	0.78	-14.950	125.737
	806003	68.2	21	316	0.88	-14.488	125.795
	806004	1289	24	157	0.80	-14.792	126.792
	806005	1328	24	162	0.87	-14.808	126.498
	806006	1622	23	201	0.86	-14.795	126.208
Pentecost River	808001	4088	27	121	0.94	-16.318	127.177
Ord River	809306	59	23	161	1.03	-15.625	128.100
	809310	552	30	102	0.79	-17.427	127.598
	809312	30.6	23	84	1.35	-17.280	128.055
	809315	7406	32	71	0.82	-17.178	129.092
	809316	19513	29	98	0.93	-17.373	128.853
	809317	457	27	125	0.84	-18.395	127.767
	809321	1632	28	161	0.93	-16.187	128.297
	809322	2528	27	146	0.86	-16.650	128.093

Table B.3 Long-term flow stations throughout the tropical rivers region within Queensland

Catchment	Station No.	Area (km²)	No. complete years	Qann	CoV	Latitude	Longitude
Nicholson River	912101	12690	31	54	1.09	-18.643	139.253
	912103	3905	20	26	1.22	-18.595	138.570
	912105	11489	31	64	1.02	-18.972	138.802
	912107	13887	20	74	1.28	-17.885	138.265
Leichhardt River	913003	3618	20	71	1.68	-19.427	139.620
	913004	5961	20	47	1.41	-20.075	139.940
	913005	305	20	55	1.33	-20.342	139.518
	913006	2427	31	56	1.45	-19.690	139.357
	913010	722	29	71	1.44	-18.878	139.358
	913014	3524	24	62	1.87	-20.313	139.742
	913015	3806	22	65	1.51	-20.185	139.732
Flinders River	915003	106263	31	29	1.27	-18.165	140.857
	915008	17382	33	31	1.31	-20.698	143.133
	915011	540	34	55	1.29	-20.163	144.518
	915013	1958	33	59	0.95	-20.713	144.525
	915203	5859	36	66	1.17	-20.673	140.492
	915204	4240	26	49	1.19	-21.077	140.417
	915206	660	33	81	1.12	-20.202	140.223
	915208	1353	35	22	1.95	-20.658	141.758
	915211	415	35	108	1.25	-20.873	140.832
Norman River	916001	39364	30	33	1.36	-17.862	141.130
Gilbert River	917001	10987	28	125	1.66	-18.203	142.875
	917002	1019	22	177	1.83	-18.787	143.603
	917104	867	30	227	1.50	-18.308	143.577
	917105	2910	20	147	1.41	-18.630	144.083
	917106	8244	34	115	1.42	-18.502	144.095
	917107	651	32	79	1.56	-18.133	144.305
	917108	1572	20	116	1.58	-18.893	144.418
Mitchell River	919002	1278	22	137	1.15	-17.827	144.442
	919003	7724	29	233	0.96	-16.473	144.288
	919004	1620	21	284	1.00	-17.473	144.602
	919005	366	27	576	0.80	-16.682	145.227
	919007	1702	20	241	1.23	-16.712	144.813
	919009	45872	23	172	0.91	-15.948	142.377
	919011	20315	25	188	0.98	-16.537	143.677
	919013	532	22	346	0.84	-16.498	145.002
	919201	533	29	310	0.97	-16.108	144.777
	919305	326	35	338	1.51	-17.180	145.300
	919309	8651	29	161	0.91	-16.547	143.783
	919310	4927	33	201	1.11	-16.982	144.287
	919311	2792	26	260	1.11	-17.183	144.900
	920001	1077	21	591	0.81	-14.622	143.077
Archer River	922001	2928	29	541	0.50	-13.418	142.920
	922101	172	41	617	0.61	-13.955	143.178
Watson River	923001	1001	24	629	0.45	-13.122	142.053
Wenlock River	925001	3265	38	424	0.56	-12.457	142.638
Ducie River	926002	332	27	713	0.45	-11.833	142.420
Jardine River	927001	2421	28	888	0.33	-11.150	142.352

Table B.4 Additional flow stations used to construct the monthly median contour maps (Fig 2.5)

Catchment	Station No.	Area (km²)	No. complete years	Qann	CoV	Latitude	Longitude
Victoria River	G8110110	361	15	109	0.46	-16.067	130.900
Wiso	G0280009	11100	30	48	1.77	-17.216	133.270
Liverpool River	G8230237	1090	14	543	0.68	-12.533	133.883
Blyth River	G8240001	1187	14	201	0.67	-12.333	134.417
Victoria River(1)	G8110263	474	-	-	-	-17.133	131.450
Roper River(2)	G9030124	777	-	-	-	-16.262	133.370

(1) Station data was incorporated within the monthly median contour maps for Sept, Oct, May-Aug only

(2) Station data was incorporated within the monthly median contour maps for Sept-Nov and May-Aug only

Appendix C – Extension of flow record at G8140040

Flow data collection at G8140040 commenced January 1966 and the station is still currently in operation. Although the period of record for this station is approximately 40 years, only 26 years have complete annual flow data. Many major gaps in the record occurred during the early period of operation. For example, during the first 12 years of operation (Sept 1966 to Aug 1978) only fours years had complete annual hydrographs. The nearby station G8140041, located approximately 7 km upstream of G8140040, commenced operation May 1960 and ceased August 1981 (and consisted of 16 complete annual years of data). The rating curve derived for this station, similar to G8140040, is relatively reliable (P Jolly pers comm. 2006) and therefore flow data collected at G8140041 can be considered to be good quality. The purpose of this section is to investigate whether there is no significant difference between flow data collected at the two stations and, if that is the case, the flow record at G8140040 can be extended using flow data collected at G8140041.

C.1 Comparison between G8140040 and G8140041 flow

There are approximately 6.5 years of concurrent flow record at G8140040 and G8140041 (Jan–Aug 1970, 1970–71, 1971–72, 1973–74 (minus March), 1975–76, 1978–79 and 1979–80). Figure C.1 shows the hydrographs for both stations over a two-year period which indicates that the flow data collected at the stations are similar. Every major and minor runoff event that occurs at G8140041 is also observed at the downstream station G8140040.

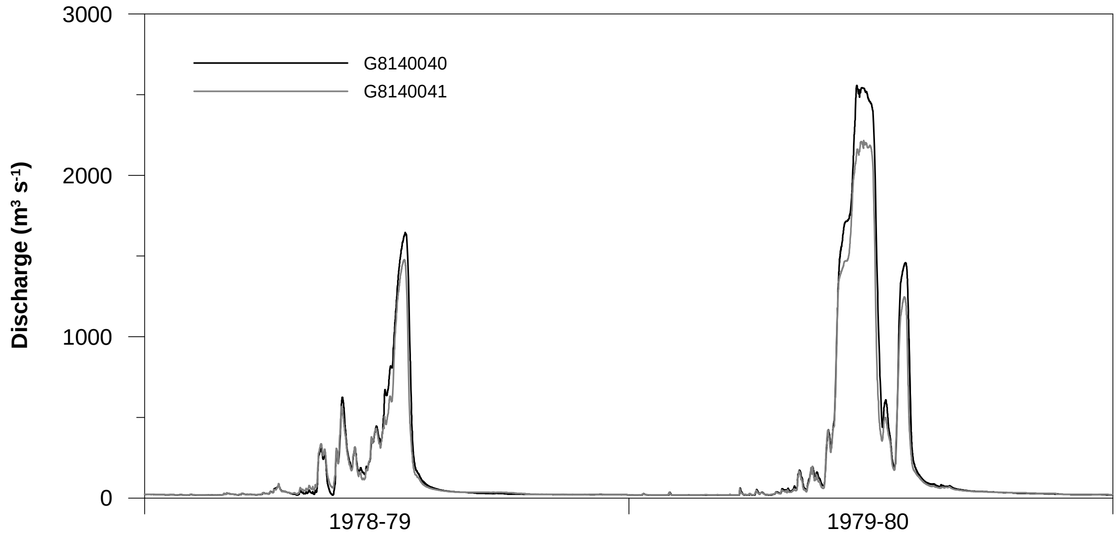

Figure C.1 Hydrograph for G8140040 and G8140041 for the 1978–79 and 1979–80 wet seasons

A student t-test showed that that there is no statistical difference between monthly flow volumes observed at the two stations. Regression analysis showed that there is a strong correlation between the two sets of monthly flow volume data, with flows at G8140040 approximately 22% higher than at G8140041 (Fig C.2).

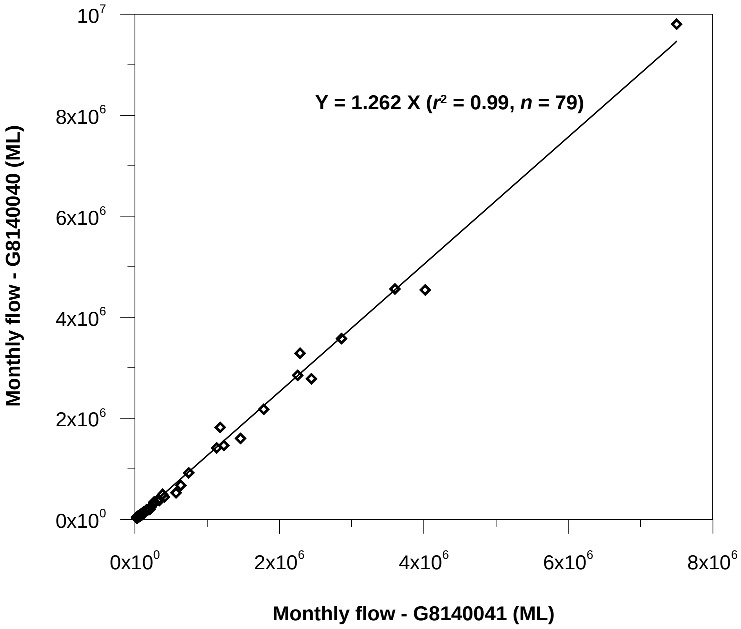

Figure C.2 Comparison of monthly flow volumes at G8140040 and G8140041 for the concurrent record

Regression analysis was also conducted for mean daily discharge data collected at G8140040 and G8140041 and this analysis showed a similar strong correlation between the stations on a daily basis. However, on a daily basis the relationship is not as linear as the relationship between monthly flow volumes. Figure C.3 indicates that the relationship between daily runoff at the two stations is best described by a quadratic equation through the origin.

In summary, the concurrent record at the two stations suggests that there is no statistical difference between the flow collected at G8140040 and G8140041 and, therefore, the flow record at G8140041 can be used to extend the record at G8140040.

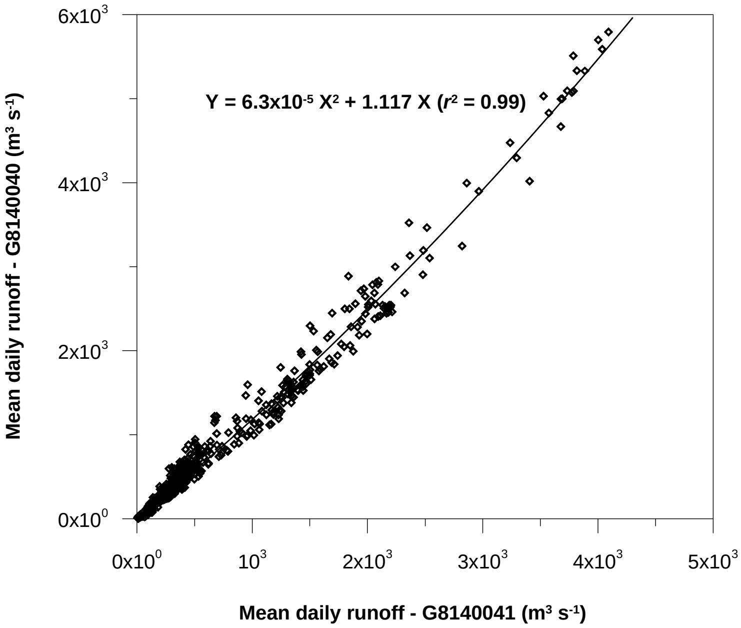

Figure C.3 Comparison of mean daily runoff at G8140040 and G8140041 for the concurrent record

C.2 Extension of flow record at G8140040 using G8140041 data

As mentioned above, although G8140040 commenced operation January 1966, reliable data were not collected at this station until January 1970. The flow record at G8140040 during 1973–74 and 1974–75 were also incomplete. Table C.1 indicates the years G8140041 data were used to extend or infill the record at G8140040. In total, data from G8140041 were used to extend the record at G8140040 by 11 years (9 entire years and 2 partially infilled years) (Table C.1).

Table C.1 Available flow data at G8140040 and G8140041 between 1960 and 1974. Dark grey shading indicates additional complete years added to the flow record at G8140040. Light grey shading indicates additional years added to the annual peak discharge record.

Year	Flow record		Comments
	G8140040	G8140041	
1960/61		Complete	Annual hydrograph at G8140041 used to extend record at G8140040
1961/62		Complete	
1962/63		Complete	
1963/64		Complete	
1964/65		Complete	
1965/66		Complete	
1966/67	Poor data	Complete	
1967/68	Poor data	Gaps(1)	Not used for annual series
1968/69	No data	Complete	G8140041 data used to infill entire year
1969/70	Gaps: Sept-Dec	Complete	G8140041 data used to infill gaps Sept-Dec 1969 period
1970/71	Complete	Complete	Used G8140040 data
1971/72	Complete	Complete	Used G8140040 data
1972/73	Many gaps	Complete	G8140041 data used to infill entire year
1973/74	Gaps: 8-24 March	Complete	G8140041 data used to infill gaps March 1974 period
1974/75	Complete	Gaps	Used G8140040 data
1975/76	Complete	Complete	Used G8140040 data
1976/77	Gaps	Gaps(1)	Not used for annual series

Annual peak discharge unlikely to have occurred during gaps in the annual flow record

Annual data

For the nine years of record at G8140041 which were used to extend the record at G8140040, the total annual runoff at G8140040 was estimated by simply multiplying the annual runoff value measured at G8140041 by the correction factor of 1.262 (Fig C.2). For the two years of record which were partially infilled with G8140041 data (1969-70 and 1973–74), the infilled months were corrected and added to the G8140040 record.

Annual peak discharge

Flow data collected at G8140041 were used to extend the annual peak discharge record at G8140040 by a further 10 years (1960–61 to 1968–69 and 1976–77) (Table C.1). In this case, the estimated peak discharge at G8140040 for these 10 years was derived by applying the correction factor shown in Figure C.3 to the observed annual peak discharge at G8140041. It is considered that the quadratic equation fitted between the mean daily runoff values at the two stations is also valid for instantaneous peak discharge values for flood events. Figure C.4 shows that the annual peak discharges observed at G8140040 and G8140041 for the concurrent record generally lie on the previously fitted line of best fit for mean daily flow data (Fig C.3).

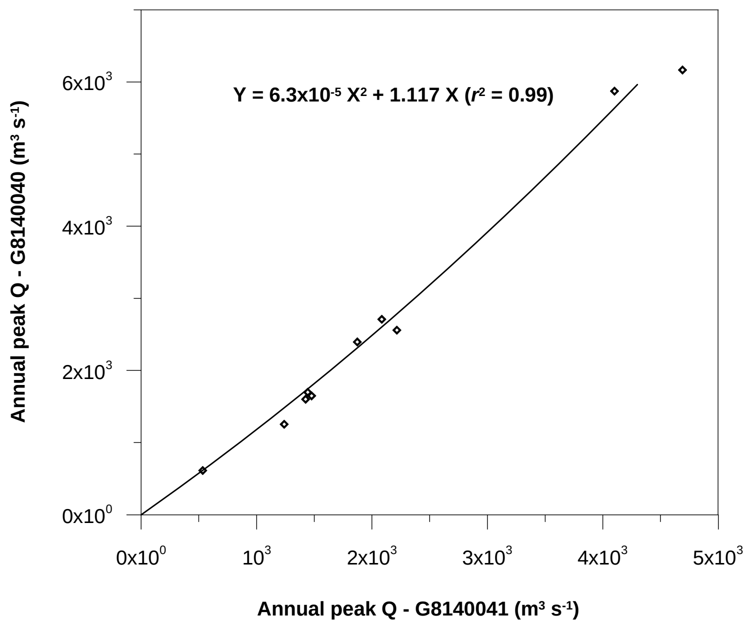

Figure C.4 Comparison of annual peak discharges at G8140040 and G8140041 for the concurrent record. The line of best fit derived for the mean daily runoff record is also shown.

Appendix D – Annual runoff volume and annual peak discharge

G8140001 – Katherine River @ Railway Bridge

Table D.1 Total annual runoff and peak discharge observed at G8140001

Year	Annual runoff (ML)	Peak discharge ($m^3\ s^{-1}$)	[Date]	No. zero flow days	Infilled period
1956/57	gaps				
1957/58	gaps				
1958/59	-				
1959/60	-				
1960/61	-				
1961/62	gaps				
1962/63	1520964	968.7	[17-Apr]	0	
1963/64	381321	334.3	[14-Mar]	0	
1964/65	786186	873.7	[5-Dec]	0	
1965/66	2003562	1401.2	[10-Feb]	0	
1966/67	1629688	953.8	[19-Mar]	0	
1967/68	3296738	2672.6	[24-Feb]	0	
1968/69	1671291	1149.6	[1-Mar]	0	
1969/70	512323	474.4	[12-Feb]	0	
1970/71	gaps				
1971/72	gaps	1004.0 (1)	[17-Mar]		
1972/73	gaps	1292.9 (1)	[10-Mar]		
1973/74	4311688	2026.7	[22-Mar]	0	
1974/75	gaps	1303.8(1)	[16-Jan]		
1975/76	4746299	2060.4	[18-Mar]	0	
1976/77	2823888	1400.1	[4-Mar]	0	
1977/78	1904201	905.9	[30-Jan]	0	
1978/79	1455113	921.7	[9-Mar]	0	
1979/80	2903764	1509.2	[22-Feb]	0	
1980/81	gaps	772.7(1)	[7-Feb]		
1981/82	gaps	599.9(1)	[6-Mar]		
1982/83	822682	669.2	[11-Mar]	0	
1983/84	gaps	2862.2(1)	[8-Mar]		
1984/85	1129830	562.8	[23-Feb]	0	
1985/86	gaps	301.3(1)	[30-Jan]		
1986/87	2927253	2506.7	[23-Feb]	0	
1987/88	684682	847.8	[13-Feb]	0	
1988/89	1882599	1453.8	[20-Mar]	0	
1989/90	237489	171.5	[10-Mar]	0	
1990/91	2677086	1500.7	[22-Feb]	0	
1991/92	604175	784.5	[12-Feb]	0	
1992/93	2505728	2332.3	[29-Jan]	0	
1993/94	2716817	1190.8	[3-Mar]	0	
1994/95	3059985	1931.0	[27-Jan]	0	
1995/96	gaps	568.8(1)	[27-Jan]		
1996/97	4037705	1586.8	[23-Feb]	0	
1997/98	5092124	8922.3	[27-Jan]	0	
1998/99	gaps	1166.4(1)	[14-Mar]		
1999/ 0	gaps	2529.0(1)	[3-Mar]		
2000/ 1	gaps	1617.1(1)	[11-Jan]		
2001/ 2	2478440	2282.7	[14-Feb]	0	Low flow: 2-31 Aug
2002/ 3	3320768	1362.3	[6-Mar]	0	Low flow: 1 Sept – 22 Nov
2003/ 4	5358113	1933.6	[23-Dec]	0	
2004/ 5	gaps				
Mean	2316 GL (*n* = 30)	**Flood**(2) = 1200 $m^3\ s^{-1}$		**Mean** = 0	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

G8140008 – Fergusson River @ Old Railway Bridge

Table D.2 Total annual runoff and peak discharge observed at G8140008

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$) [Date]		No. zero flow days	Infilled period
1956/57	gaps				
1957/58	254179	487.2	[29-Dec]	184	
1958/59	156798	409.6	[6-Apr]	186	
1959/60	392118	466.6	[15-Feb]	155	
1960/61	gaps	205.5(1)	[1-Mar]		
1961/62	188643	423.9	[17-Feb]	203	Low flow: 3-9 Dec
1962/63	524745	399.8	[17-Apr]	87	
1963/64	118693	173.6	[15-Mar]	206	
1964/65	gaps	356.7(1)	[5-Dec]		
1965/66	483449	694.0	[3-Feb]	215	
1966/67	522647	953.4	[19-Feb]	171	
1967/68	645983	997.3	[23-Feb]	133	
1968/69	313144	609.5	[1-Mar]	216	
1969/70	85365	167.6	[11-Feb]	196	Low flow: 24 Nov - 5 Dec
1970/71	464577	621.4	[25-Mar]	105	Low flow: 28 Oct - 7 Nov
1971/72	367218	498.2	[16-Mar]	109	Low flow: 1 Nov
1972/73	345513	564.3	[8-Mar]	166	Low flow: 20 Dec - 1 Jan and 6-16 Jun
1973/74	1054575	1160.7	[19-Mar]	107	
1974/75	322811	652.0	[15-Jan]	124	
1975/76	1149468	1189.4	[9-Mar]	87	
1976/77	662807	1240.1	[22-Mar]	115	
1977/78	505602	523.8	[22-Dec]	159	
1978/79	386656	576.5	[6-Mar]	151	
1979/80	744511	697.1	[11-Feb]	151	
1980/81	652175	835.1	[17-Jan]	143	
1981/82	304796	267.3	[3-Mar]	143	Low flow: 2-19 Nov
1982/83	169181	227.4	[9-Mar]	153	
1983/84	gaps	1268.7(1)	[6-Mar]	136(3)	
1984/85	164803	316.6	[20-Feb]	139	
1985/86	73889	112.0	[6-Feb]	205	
1986/87	gaps	690.5(1)	[21-Feb]	187(3)	
1987/88	54100	80.1	[15-Jan]	187	
1988/89	510002	689.6	[20-Mar]	119	
1989/90	65835	90.7	[12-Mar]	174	
1990/91	617132	332.2	[10-Jan]	171	
1991/92	gaps	634.3(1)	[13-Feb]		
1992/93	538724	399.1	[31-Jan]	124	
1993/94	gaps			127(3)	
1994/95	745183	2743.0	[27-Jan]	101	
1995/96	145956	162.5	[2-Feb]	144	
1996/97	gaps			126(3)	
1997/98	968954	3127.3	[27-Jan]	190	
1998/99	628196	653.1	[13-Mar]	69	
1999/ 0	884825	1687.7	[2-Mar]	45	
2000/ 1	816497	805.4	[11-Jan]	55	
2001/ 2	gaps				
2002/ 3	gaps				
2003/ 4	gaps	907.5(1)	[5-Mar]	110(3)	
2004/ 5	gaps				
Mean	460 GL (*n* = 37)	**Flood(2)** = 533 $m^3 s^{-1}$		**Mean** = 145	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

(3) Gaps occurred during relatively high flow periods, hence these years were also included in the analysis of ZeroDAY.

G8140011 – Dry River @ Manbulloo Boundary

Table D.3 Total annual runoff and peak discharge observed at G8140011

Year	Annual runoff (ML)	Peak discharge (m^3 s^{-1})	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68	433592	379.9	[12-Mar]	279	
1968/69	22543	37.4	[1-Feb]	290	
1969/70	205	1.6	[22-Dec]	359	
1970/71	2315	11.0	[27-Feb]	323	
1971/72	160129	298.0	[12-Mar]	310	
1972/73	10378	14.4	[9-Mar]	313	
1973/74	gaps			223(3)	
1974/75	106347	219.8	[26-Feb]	258	
1975/76	1113356	2671.0	[19-Mar]	221	
1976/77	244568	179.0	[23-Mar]	255	
1977/78	153097	213.3	[1-Feb]	235	
1978/79	28914	50.9	[6-Mar]	295	
1979/80	192756	299.2	[19-Feb]	295	
1980/81	130255	99.9	[19-Feb]	270	
1981/82	gaps				
1982/83	156	1.2	[3-May]	354	
1983/84	214209	169.4	[17-Mar]	245	
1984/85	gaps				
1985/86	265	1.1	[1-Feb]	355	
1986/87	gaps				
1987/88	893	9.3	[29-Jan]	351	
1988/89	21735	22.6	[31-Mar]	275	
1989/90	6469	10.8	[9-Jan]	312	
1990/91	591580	1336.9	[20-Feb]	246	
1991/92	2060	23.1	[4-Feb]	343	
1992/93	12510	10.7	[21-Feb]	320	
1993/94	217397	215.7	[6-Mar]	263	
1994/95	61171	78.6	[27-Mar]	235	
1995/96	16830	55.2	[17-Apr]	346	
1996/97	gaps				
1997/98	31578	128.3	[27-Jan]	284	
1998/99	gaps				
1999/ 0	gaps				
2000/ 1	252794	182.9	[17-Feb]	215	
2001/ 2	105980	154.9	[19-Feb]	310	
2002/ 3	-				
2003/ 4	853340	472.0	[18-Feb]	189	
2004/ 5	-				
Mean	172 GL (*n* = 29)	**Flood**(2) = 71.7 m^3 s^{-1}		**Mean** = 286	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

(3) Gaps occurred during relatively high flow periods, hence these years were also included in the analysis of ZeroDAY.

G8140040 – Daly River @ Mount Nancar

Table D.4 Total annual runoff and peak discharge observed at G8140040

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$) [Date]		No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67	gaps				
1967/68	gaps				
1968/69	-				
1969/70	gaps	612(1)	[14-Feb]		
1970/71	3379016	1251	[30-Mar]	0	
1971/72	5846514	2709	[6-Mar]	0	
1972/73	gaps	2396(1)	[20-Mar]		
1973/74	gaps	6165(1)	[21-Mar]		
1974/75	7708261	1698	[2-Mar]	0	
1975/76	16698201	5873	[26-Mar]	0	
1976/77	gaps				
1977/78	gaps	1600(1)	[7-Feb]		
1978/79	4015222	1645	[16-Mar]	0	
1979/80	8647742	2558	[20-Feb]	0	
1980/81	7069571	2514	[17-Feb]	0	
1981/82	3774736	1144	[11-Mar]	0	
1982/83	2134564	1291	[16-Mar]	0	
1983/84	10803865	3448	[19-Mar]	0	
1984/85	gaps	1639(1)	[19-Apr]		
1985/86	1309166	369	[30-Jan]	0	
1986/87	6545660	2726	[5-Mar]	0	
1987/88	1645745	586	[18-Feb]	0	
1988/89	6315954	2169	[30-Mar]	0	
1989/90	1176486	318	[25-Jan]	0	
1990/91	10276708	3035	[5-Mar]	0	
1991/92	2182120	1295	[17-Feb]	0	
1992/93	gaps	2940(1)	[8-Feb]		
1993/94	7103175	2587	[15-Mar]	0	
1994/95	9032534	3385	[6-Feb]	0	
1995/96	2519186	754	[5-Feb]	0	
1996/97	16777665	4335	[5-Mar]	0	Low flow: 21 Apr – 11 May
1997/98	gaps	8293(1)	[3-Feb]		
1998/99	10227885	2552	[22-Mar]	0	Low flow: 22 Sept - 21 Oct
1999/ 0	gaps	5475(1)	[14-Mar]		
2000/ 1	15150212	3337	[20-Feb]	0	Minor gap on 11 Apr
2001/ 2	7579601	3785	[23-Feb]	0	
2002/ 3	6975410	2800	[18-Mar]	0	
2003/ 4	22051760	4322	[12-Mar]	0	
2004/ 5	gaps	1860(1)	[6-Jan]		
Mean	7575 GL (*n* = 26)	**Flood**(2) = 2299 $m^3 s^{-1}$		**Mean** = 0	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

G8140044 – Flora River @ U/S of Kathleen Falls

Table D.5 Total annual runoff and peak discharge observed at G8140044

Year	Annual runoff (ML)	Peak discharge (m^3 s^{-1}) [Date]		No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66	gaps				
1966/67	gaps				
1967/68	gaps				
1968/69	gaps	764(1)	[28-Feb]		
1969/70	227041	532	[8-Feb]	0	
1970/71	gaps				
1971/72	889426	2313	[2-Mar]	0	
1972/73	617184	685	[10-Mar]	0	Low flow: 23-25 May
1973/74	3705280	6909	[9-Mar]	0	Low flow: 9-14 July
1974/75	377223	426	[10-Nov]	0	
1975/76	2397285	4331	[22-Feb]	0	
1976/77	1565795	3428	[22-Mar]	0	Low flow: 13-15 Oct
1977/78	gaps	2304(1)	[28-Jan]		
1978/79	430321	662	[7-Mar]	0	
1979/80	806049	662	[17-Feb]	0	
1980/81	824445	653	[15-Feb]	0	
1981/82	804125	1270	[5-Mar]	0	
1982/83	293809	717	[26-Apr]	0	
1983/84	1339363	2092	[6-Mar]	0	Low flow: 4 June - 17 July
1984/85	428423	1283	[16-Apr]	0	Low flow: 7-24 July
1985/86	gaps	237(1)	[27-Jan]		
1986/87	887390	2125	[21-Feb]	0	
1987/88	213932	229	[30-Dec]	0	
1988/89	616681	1242	[3-Dec]	0	
1989/90	246122	324	[22-Jan]	0	
1990/91	1677332	1417	[17-Jan]	0	
1991/92	210025	302	[13-Feb]	0	
1992/93	gaps				
1993/94	gaps				
1994/95	812818	2395	[28-Jan]	0	
1995/96	209304	207	[31-Jan]	0	
1996/97	gaps	1519(1)	[4-Mar]		
1997/98	844148	1730	[28-Jan]	0	Low flow: 16 Jun - 31 Aug
1998/99	1329689	1135	[4-Mar]	0	Low flow: 1 Sept - 7 Oct
1999/ 0	2340511	4393	[3-Mar]	0	
2000/ 1	1035817	522	[15-Feb]	0	
2001/ 2	633152	1992	[21-Feb]	0	
2002/ 3	515899	526	[10-Mar]	0	
2003/ 4	4137654	2611	[6-Mar]	0	
2004/ 5	gaps				
Mean	1049 GL (*n* = 29)	**Flood(2)** = 1070 m^3 s^{-1}		**Mean** = 0	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

G8140063 – Douglas River @ D/S Old Douglas H/S

Table D.6 Total annual runoff and peak discharge observed at G8140063

Year	Annual runoff (ML)	Peak discharge ($m^3\ s^{-1}$) [Date]		No. zero flow days	Infilled period
1956/57					
1957/58	85190	203.4	[29-Dec]	0	
1958/59	104215	224.0	[6-Apr]	0	
1959/60	101469	97.1	[23-Mar]	0	
1960/61	50950	27.1	[17-Feb]	0	
1961/62	gaps				
1962/63	97691	145.7	[18-Feb]	0	
1963/64	39598	54.3	[24-Mar]	0	
1964/65	76942	77.2	[26-Mar]	0	
1965/66	193728	279.4	[10-Feb]	0	
1966/67	143285	319.5	[19-Feb]	0	
1967/68	gaps				
1968/69	gaps				
1969/70	24999	10.9	[28-Feb]	0	
1970/71	gaps	190.7(1)	[25-Mar]		
1971/72	181838	427.7	[2-Mar]	0	
1972/73	164705	195.7	[7-Mar]	0	
1973/74	644699	1430.5	[19-Mar]	0	
1974/75	167116	201.5	[21-Mar]	0	
1975/76	gaps				
1976/77	gaps				
1977/78	101915	51.0	[1-Feb]	0	
1978/79	169293	109.2	[20-Feb]	0	
1979/80	262280	312.5	[5-Feb]	0	
1980/81	271077	219.6	[13-Feb]	0	
1981/82	157372	183.1	[17-Jan]	0	
1982/83	39881	28.9	[28-Mar]	0	
1983/84	219139	166.7	[3-Mar]	0	
1984/85	85232	170.4	[14-Apr]	0	
1985/86	28378	10.7	[25-Jan]	0	
1986/87	99923	128.2	[23-Feb]	0	
1987/88	21972	19.9	[20-Nov]	0	
1988/89	211150	172.8	[21-Mar]	0	
1989/90	41317	52.7	[12-Mar]	0	
1990/91	236797	213.9	[25-Feb]	0	
1991/92	109775	182.4	[13-Feb]	0	
1992/93	gaps				
1993/94	165084	144.6	[9-Mar]	0	
1994/95	330877	1036.6	[28-Jan]	0	
1995/96	67000	27.1	[2-Feb]	0	
1996/97	457057	593.7	[3-Mar]	0	
1997/98	393182	1941.7	[27-Jan]	0	
1998/99	256229	190.0	[11-Mar]	0	
1999/ 0	gaps	1783.1(1)	[3-Mar]		
2000/ 1	549697	870.3	[11-Jan]	0	
2001/ 2	353269	1419.0	[12-Feb]	0	
2002/ 3	128793	153.5	[8-Mar]	0	
2003/ 4	451653	259.4	[13-Jan]	0	
2004/ 5	gaps				
Mean	187 GL (*n* = 39)	**Flood**(2) = 172 $m^3\ s^{-1}$		**Mean** = 0	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

G8140067 – Daly River @ U/S Dorisvale Crossing

Table D.7 Total annual runoff and peak discharge observed at G8140067

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$)	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60	gaps				
1960/61	717702	443	[27-Feb]	0	
1961/62	1591351	653	[8-Feb]	0	
1962/63	3303932	1263	[19-Apr]	0	Low flow: 22 Aug – 1 Sept
1963/64	-				
1964/65	gaps				
1965/66	3990221	3113	[9-Feb]	0	
1966/67	4193583	2481	[3-Mar]	0	
1967/68	gaps				
1968/69	6347230	3192	[27-Feb]	0	
1969/70	917404	672	[9-Feb]	0	
1970/71	3052743	1712	[26-Mar]	0	
1971/72	3650507	2336	[4-Mar]	0	
1972/73	3941024	2807	[15-Mar]	0	
1973/74	13701070	6499	[11-Mar]	0	
1974/75	gaps				
1975/76	14030316	5007	[23-Mar]	0	
1976/77	8995148	5511	[23-Mar]	0	
1977/78	4372539	1826	[1-Feb]	0	
1978/79	3409609	1774	[12-Mar]	0	
1979/80	gaps	2917(1)	[26-Feb]		
1980/81	gaps				
1981/82	3328717	1523	[6-Mar]	0	
1982/83	1610571	943	[12-Mar]	0	
1983/84	8861080	4262	[8-Mar]	0	
1984/85	2174001	1300	[17-Apr]	0	
1985/86	gaps	554(1)	[28-Jan]		
1986/87	5554775	4188	[25-Feb]	0	
1987/88	1185515	690	[16-Feb]	0	
1988/89	gaps				
1989/90	728782	465	[23-Jan]	0	
1990/91	gaps	4236(1)	[26-Feb]		
1991/92	1394695	1567	[14-Feb]	0	
1992/93	4532584	2429	[2-Feb]	0	
1993/94	5153716	2288	[10-Mar]	0	Low flow: 24- 26 Nov
1994/95	4812961	4793	[2-Feb]	0	
1995/96	gaps	656(1)	[30-Jan]		
1996/97	11037029	4131	[22-Feb]	0	
1997/98	9786411	8173	[29-Jan]	0	
1998/99	gaps	2336(1)	[15-Mar]		
1999/ 0	gaps	5342(1)	[4-Mar]		
2000/ 1	gaps				
2001/ 2	gaps	4694(1)	[18-Feb]		
2002/ 3	6725021	3526	[11-Mar]	0	
2003/ 4	17079053	4903	[6-Mar]	0	
2004/ 5	gaps				
Mean	5339 GL (*n* = 30)	**Flood(2)** = 2314 $m^3 s^{-1}$		**Mean** = 0	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

G8140068 – King River @ D/S Victoria Hwy

Table D.8 Total annual runoff and peak discharge observed at G8140068

Year	Annual runoff (ML)	Peak discharge (m^3 s^{-1})	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60	gaps			264(3)	
1960/61	6046.8	73.1	[24-Dec]	298	
1961/62	gaps			304(3)	
1962/63	142116	160.5	[27-Jan]	204	
1963/64	25334	58.7	[5-Dec]	297	
1964/65	12694	32.6	[7-Dec]	287	
1965/66	117073	98.9	[16-Jan]	266	
1966/67	182483	172.3	[19-Mar]	233	
1967/68	360311	214.9	[10-Mar]	266	
1968/69	gaps	55.0(1)	[15-Mar]	271(3)	
1969/70	15977	32.6	[9-Feb]	281	
1970/71	37842	76.7	[21-Mar]	270	
1971/72	gaps				
1972/73	123801	143.7	[12-Mar]	238	
1973/74	gaps			176(3)	
1974/75	gaps	270.3(1)	[22-Feb]	184(3)	
1975/76	1151001	2947.3	[19-Mar]	150	
1976/77	426224	237.6	[6-Mar]	123	
1977/78	292447	231.6	[26-Feb]	221	
1978/79	172229	199.1	[10-Mar]	178	
1979/80	238503	195.0	[21-Feb]	178	
1980/81	203898	108.1	[22-Feb]	235	
1981/82	122485	93.3	[4-Mar]	214	
1982/83	21693	47.5	[11-Mar]	267	
1983/84	512186	247.9	[13-Mar]	133	
1984/85	45176	90.3	[22-Dec]	201	
1985/86	15258	64.0	[27-Jan]	267	
1986/87					
1987/88					
1988/89					
1989/90					
1990/91					
1991/92					
1992/93					
1993/94					
1994/95					
1995/96					
1996/97					
1997/98					
1998/99					
1999/ 0					
2000/ 1					
2001/ 2					
2002/ 3					
2003/ 4					
2004/ 5					
Mean	201 GL (n = 21)	**Flood**(2) = 100 m^3 s^{-1}		**Mean** = 231	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

(3) Gaps occurred during relatively high flow periods, hence these years were also included in the analysis of ZeroDAY.

G8140151 – Mathieson Creek @ Victoria Hwy

Table D.9 Total annual runoff and peak discharge observed at G8140151

Year	Annual runoff (ML)	Peak discharge ($m^3\ s^{-1}$)	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64	36.06	9.4	[14-Mar]	358	
1964/65	19.55	6.6	[6-Mar]	361	
1965/66	90.87	4.6	[11-Dec]	343	
1966/67	1576	22.4	[1-Mar]	334	
1967/68	19588	73.8	[5-Mar]	295	
1968/69	1114	34.0	[21-Dec]	349	
1969/70	550	22.7	[15-Dec]	355	
1970/71	3	1.7	[4-Apr]	361	
1971/72	3484	21.0	[9-Mar]	342	
1972/73	301.5	7.6	[30-Jan]	339	
1973/74	59460	201.6	[9-Mar]	263	
1974/75	1252	25.3	[24-Feb]	339	
1975/76	28665	76.7	[18-Mar]	294	
1976/77	19130	87.5	[27-Feb]	304	
1977/78	5532	32.8	[1-Feb]	321	
1978/79	299.6	6.1	[6-Mar]	338	
1979/80	4295	23.3	[9-Feb]	338	
1980/81	1907	9.4	[16-Feb]	313	
1981/82	1989	24.9	[22-Mar]	328	
1982/83	214.8	13.9	[11-Mar]	355	
1983/84	25455	52.0	[25-Feb]	273	
1984/85	1319	9.8	[22-Dec]	348	
1985/86	1850	44.7	[27-Jan]	351	
1986/87	21780	79.5	[22-Jan]	285	
1987/88					
1988/89					
1989/90					
1990/91					
1991/92					
1992/93					
1993/94					
1994/95					
1995/96					
1996/97					
1997/98					
1998/99					
1999/ 0					
2000/ 1					
2001/ 2					
2002/ 3					
2003/ 4					
2004/ 5					
Mean	8.3 GL (*n* = 24)	**Flood**(2) = 22 $m^3\ s^{-1}$		**Mean** = 329	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

G8140152 – Edith River @ Dam Site

Table D.10 Total annual runoff and peak discharge observed at G8140152

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$)	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63	gaps	274(1)	2-Mar		
1963/64	gaps	240(1)	14-Mar		
1964/65	gaps	204(1)	29-Mar		
1965/66	123523.4	561	5-Feb	105	
1966/67	191293	468	1-Mar	82	
1967/68	264965	515	24-Feb	186	Low flow: 27-29 Nov
1968/69	94930	556	28-Feb	123	
1969/70	gaps	155(1)	22-Dec	220(3)	
1970/71	193903	663	4-Apr	74	
1971/72	153674	258	26-Feb	96	
1972/73	165337	703	7-Mar	120	
1973/74	gaps				
1974/75	188981.7	324	20-Feb	0	Low flow: 27 Nov - 4 Dec
1975/76	523070	1048	9-Mar	0	
1976/77	gaps			0(3)	
1977/78	202559	235	9-Jan	0	
1978/79	gaps	166(1)	16-Feb		
1979/80	324439	607	22-Mar	10	
1980/81	236750	642	17-Jan	44	
1981/82	146444	677	27-Mar	33	
1982/83	98211	467	9-Mar	76	
1983/84	422886	1161	6-Mar	108	
1984/85	61432	263	14-Apr	44	
1985/86	gaps				
1986/87	-				
1987/88	-				
1988/89	-				
1989/90	28818	78	28-Jan	214	
1990/91	353002	609	10-Jan	82	
1991/92	68364.9	408	12-Feb	108	
1992/93	217851.3	302	28-Jan	83	
1993/94	167856.1	304	28-Feb	130	
1994/95	gaps				
1995/96	gaps				
1996/97	gaps				
1997/98	gaps	1298(1)	26-Jan		
1998/99	gaps				
1999/ 0	gaps	1501(1)	2-Mar	0(3)	
2000/ 1	452420	635	10-Jan	0	
2001/ 2	316109	1018	14-Feb	0	Low flow: 18 Jun - 15 Aug
2002/ 3	gaps	388(1)	3-Mar		
2003/ 4	610533	490	22-Dec	49	
2004/ 5	gaps	216(1)	3-Feb		
Mean	234 GL (*n* = 24)	**Flood(2)** = 444 $m^3 s^{-1}$		**Mean** = 74	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

(3) Gaps occurred during relatively high flow periods, hence these years were also included in the analysis of ZeroDAY.

G8140158 – McAdden Creek @ Dam Site

Table D.11 Total annual runoff and peak discharge observed at G8140158

Year	Annual runoff (ML)	Peak discharge (m^3 s^{-1})	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63	gaps			141(3)	
1963/64	5291.94	98.2	[5-Dec]	217	
1964/65	gaps				
1965/66	25709.98	181.0	[5-Feb]	242	Low flow: 14-17 Feb
1966/67	39243.2	170.5	[1-Mar]	132	
1967/68	gaps			128(3)	
1968/69	23916.1	185.2	[1-Mar]	167	
1969/70	1507.4	6.0	[11-Feb]	252	
1970/71	gaps				
1971/72	15428.6	53.8	[15-Mar]	162	
1972/73	gaps	218.9(1)	[7-Mar]		
1973/74	gaps				
1974/75	gaps			22(3)	
1975/76	gaps				
1976/77	80696.9	362.7	[18-Mar]	60	
1977/78	19418.6	58.3	[25-Jan]	110	
1978/79	17161.5	50.0	[9-Mar]	188	
1979/80	53751.5	196.9	[22-Mar]	188	
1980/81	29707.6	117.1	[7-Feb]	152	
1981/82	14643.1	84.3	[2-Mar]	131	
1982/83	gaps	102.0(1)	[9-Mar]		
1983/84	84371.1	339.2	[6-Mar]	94	
1984/85	7774	38.3	[22-Dec]	178	
1985/86	8348	20.1	[25-Nov]	217	
1986/87	gaps	124.6(1)	[13-Feb]		
1987/88	-				
1988/89	-				
1989/90	-				
1990/91	65401.2	209.8	[23-Feb]	96	
1991/92	gaps				
1992/93	gaps			169(3)	
1993/94	gaps				
1994/95	73357.4	981.8	[27-Jan]	68	
1995/96	11003.2	14.7	[29-Jan]	128	
1996/97	102839.3	318.8	[22-Feb]	113	
1997/98	gaps	784.4(1)	[26-Jan]		
1998/99	30569.5	227.4	[23-Feb]	62	
1999/ 0	46844	420.7	[20-Mar]	31	
2000/ 1	51500.5	225.3	[17-Feb]	104	
2001/ 2	33005.9	447.8	[12-Feb]	153	
2002/ 3	29366	160.1	[20-Feb]	233	
2003/ 4	42876.6	207.8	[27-Mar]	207	
2004/ 5	gaps				
Mean	36.5 GL (*n* = 25)	**Flood**(2) = 159 m^3 s^{-1}		**Mean** = 143	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

(3) Gaps occurred during relatively high flow periods, hence these years were also included in the analysis of ZeroDAY.

G8140159 – Seventeen Mile Creek @ Waterfall View

Table D.12 Total annual runoff and peak discharge observed at G8140159

Year	Annual runoff (ML)	Peak discharge (m^3 s^{-1})	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63	gaps	241.4(1)	[16-Apr]		
1963/64	20079.5	35.6	[8-Jan]	0	
1964/65	gaps				
1965/66	61307.7	221.3	[5-Feb]	0	Low flow: 10-20 Nov
1966/67	72046.7	217.1	[16-Mar]	0	
1967/68	gaps	173.1(1)	[23-Feb]		
1968/69	40720.4	153.5	[28-Feb]	0	
1969/70	26538.1	94.3	[17-Dec]	0	
1970/71	64591.4	135.7	[3-Apr]	0	
1971/72	62579	102.7	[16-Mar]	0	
1972/73	86898	327.6	[7-Mar]	0	
1973/74	214048	357.1	[2-Mar]	0	
1974/75	131737	247.7	[14-Jan]	0	
1975/76	324737	295.1	[14-Mar]	0	
1976/77	205459	429.5	[18-Mar]	0	
1977/78	85215	120.4	[23-Feb]	0	
1978/79	gaps				
1979/80	132862	260.7	[22-Mar]	0	Minor gap at low-flow on 14 Sept
1980/81	125380	227.3	[7-Feb]	0	
1981/82	57836	133.3	[10-Feb]	0	
1982/83	45661	115.7	[9-Mar]	0	Low flow: 27-30 Apr
1983/84	202669	461.4	[6-Mar]	0	
1984/85	29915	49.3	[14-Apr]	0	
1985/86	23508	25.4	[28-Nov]	0	
1986/87	84567.2	201.3	[20-Feb]	0	
1987/88	35987.4	84.2	[13-Feb]	0	Low-flow: 2-21 Sept
1988/89	gaps				
1989/90	23568	44.0	[22-Feb]	0	
1990/91	168369.1	282.5	[23-Feb]	0	
1991/92	41184.7	196.2	[12-Feb]	0	
1992/93	115479.6	187.5	[28-Jan]	0	
1993/94	92735	355.8	[22-Dec]	0	
1994/95	148549.9	1179.1	[27-Jan]	0	
1995/96	37844.9	47.0	[4-Feb]	0	
1996/97	325829	518.9	[22-Feb]	0	
1997/98	gaps				
1998/99	gaps				
1999/ 0	gaps	613.0(1)	[2-Mar]		
2000/ 1	gaps	459.9(1)	[10-Jan]		
2001/ 2	gaps				
2002/ 3	269971	350.4	[9-Jan]	0	
2003/ 4	479738	432.7	[27-Mar]	0	Low flow: 14 Jul – 31 Aug
2004/ 5	gaps				
Mean	120 GL (n = 32)	**Flood**(2) = 204 m^3 s^{-1}		**Mean** = 0	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

G8140161 – Green Ant Creek @ Tipperary

Table D.13 Total annual runoff and peak discharge observed at G8140161

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$)	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68	gaps	111.5(1)	[23-Feb]		
1968/69	gaps	132.7(1)	[4-Mar]		
1969/70	-	10.8(1)	[27-Jan]	112	
1970/71	20688	27.1	[6-Mar]	156	
1971/72	58872	434.9	[2-Mar]	85	
1972/73	75808	98.2	[31-Jan]	124	
1973/74	223623	279.4	[19-Mar]	32	
1974/75	135784	158.7	[28-Feb]	0	
1975/76	126730	102.2	[15-Mar]	0	
1976/77	111757	367.6	[22-Mar]	0	
1977/78	20929	33.9	[9-Dec]	14	
1978/79	22262	25.1	[9-Jan]	165	
1979/80	69680	87.8	[5-Feb]	165	
1980/81	102111	107.6	[13-Feb]	61	
1981/82	48868	55.6	[17-Jan]	15	
1982/83	15413.4	60.4	[26-Apr]	85	
1983/84	108923	91.1	[14-Mar]	103	
1984/85	41078	117.5	[14-Apr]	21	
1985/86	13509	17.2	[7-Feb]	4	
1986/87	38462	55.7	[21-Feb]	94	
1987/88	9475.5	19.5	[9-Nov]	180	
1988/89	97469	73.6	[26-Mar]	79	
1989/90	8266.5	24.1	[1-Feb]	40	
1990/91	83725	96.6	[10-Jan]	89	
1991/92	19716	59.8	[12-Feb]	0	
1992/93	80210	66.0	[10-Feb]	68	
1993/94	72924	61.8	[10-Mar]	0	
1994/95	123177	108.1	[28-Jan]	0	
1995/96	19823	22.1	[29-Dec]	0	
1996/97	252084	131.1	[2-Mar]	42	
1997/98	130431	224.6	[28-Jan]	0	
1998/99	169830	112.1	[18-Mar]	0	
1999/ 0	gaps				
2000/ 1	gaps			1(3)	
2001/ 2	88341	125.8	[3-Mar]	0	
2002/ 3	38590	61.7	[4-Mar]	0	
2003/ 4	137305	65.5	[4-Feb]	0	
2004/ 5	gaps				
Mean	80.2 GL (*n* = 32)	**Flood**(2) = 76 $m^3 s^{-1}$		**Mean** = 51	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

(3) Gaps occurred during relatively high flow periods, hence these years were also included in the analysis of ZeroDAY.

802002 – Mount Pierre Creek @ Mt Pierre Gorge

Table D.14 Total annual runoff and peak discharge observed at 802002

Year	Annual runoff (ML)	Peak discharge ($m^3\ s^{-1}$)	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68					
1968/69					
1969/70					
1970/71	22907.8	265.9	[1-Mar]	134	
1971/72	4311	131.6	[27-Nov]	300	
1972/73	gaps				
1973/74	gaps				
1974/75	gaps	245.2(1)	[13-Feb]		
1975/76	19763.3	122.2	[5-Mar]	34	
1976/77	gaps	159.5(1)	[21-Feb]		
1977/78	44771.8	378.6	[21-Jan]	118	Low flow: 24-25 Feb
1978/79	9583.9	276.7	[13-Feb]	142	Low flow: 23-24 May
1979/80	10396	107.0	[31-Jan]	147	
1980/81	gaps				
1981/82	gaps				
1982/83	67340	406.3	[30-Mar]	160	
1983/84	77428	393.8	[13-Mar]	104	
1984/85	9384	185.8	[20-Feb]	129	
1985/86	82790	601.0	[23-Jan]	53	
1986/87	19274	243.4	[12-Feb]	90	
1987/88	4989	97.9	[24-Dec]	302	
1988/89	57059	643.9	[26-Mar]	139	
1989/90	5843	103.6	[1-Mar]	180	
1990/91	74842	366.4	[21-Feb]	115	
1991/92	1461	44.6	[31-Jan]	182	
1992/93	67094	360.0	[21-Mar]	152	
1993/94	2754	33.2	[20-Feb]	197	
1994/95	37004	307.9	[24-Feb]	284	
1995/96	23937	234.2	[9-Mar]	336	
1996/97	23226	162.3	[29-Jan]	122	
1997/98	10709	131.1	[27-Jan]	105	
1998/99	gaps				
1999/ 0					
2000/ 1					
2001/ 2					
2002/ 3					
2003/ 4					
2004/ 5					
Mean	30.8 GL (*n* = 22)	**Flood**(2) = 217 $m^3\ s^{-1}$		**Mean** = 160	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

802055 – Fitzroy River @ Fitzroy Crossing

Table D.15 Total annual runoff and peak discharge observed at 802055

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$)	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58	gaps	2778(1)	[28-Dec]		
1958/59	gaps				
1959/60	gaps				
1960/61	gaps				
1961/62	gaps				
1962/63	3932548	3791	[9-Feb]	125	
1963/64	351774	296	[7-Jan]	106	
1964/65	636900	812	[1-Feb]	207	
1965/66	3053972	8960	[21-Jan]	209	
1966/67	gaps	12208(1)	[17-Feb]		
1967/68	gaps	8801(1)	[10-Mar]		
1968/69	gaps	9226(1)	[11-Mar]		
1969/70	gaps	271(1)	[13-Mar]		
1970/71	gaps	2379(1)	[3-Mar]		
1971/72	gaps	3252(1)	[6-Mar]		
1972/73	gaps	1140(1)	[17-Jan]		
1973/74	gaps				
1974/75	gaps	2664(1)	[16-Feb]		
1975/76	gaps	4266(1)	[20-Feb]		
1976/77	-				
1977/78	gaps	9796(1)	[31-Jan]		
1978/79	-				
1979/80	gaps	12476(1)	[16-Feb]		
1980/81	gaps				
1981/82	16567430	11194	[2-Mar]	0	
1982/83	gaps	29866(1)	[18-Mar]	0(3)	
1983/84	15818025	21382	[14-Mar]	0	
1984/85	558948	1340	[10-Feb]	0	
1985/86	9747146	17804	[24-Jan]	67	
1986/87	2603213	3628	[14-Feb]	91	
1987/88	1918716	7016	[25-Dec]	115	
1988/89	2333424	3250	[30-Mar]	0	
1989/90	1076243	1093	[3-Feb]	70	
1990/91	13928878	23381	[22-Feb]	6	
1991/92	348189	312	[6-Feb]	173	
1992/93	19963922	23190	[24-Feb]	144	
1993/94	2594562	3231	[2-Mar]	58	
1994/95	15351790	10219	[28-Feb]	103	
1995/96	4468588	11025	[10-Mar]	68	
1996/97	9385296	9259	[30-Jan]	109	
1997/98	929168	1093	[12-Feb]	0	
1998/99	8453957	5773	[22-Feb]	0	
1999/ 0	24507499	17242	[11-Mar]	0	
2000/ 1	12990740	14917	[22-Feb]	0	
2001/ 2	12867696	29335	[24-Feb]	0	
2002/ 3	gaps				
2003/ 4					
2004/ 5					
Mean	7683 GL (*n* = 24)	**Flood**(2) = 5692 $m^3 s^{-1}$		**Mean** = 66	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

(3) Gaps occurred during relatively high flow periods, hence these years were also included in the analysis of ZeroDAY.

802137 – Fitzroy River @ Dimond Gorge

Table D.16 Total annual runoff and peak discharge observed at 802137

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$)	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63	gaps	4065(1)	[8-Feb]		
1963/64	241535	260	[4-Jan]	185	
1964/65	109147	266.8	[28-Jan]	213	
1965/66	1247824	2481	[20-Jan]	142	
1966/67	4187290	2982	[5-Mar]	176	
1967/68	4126310	2399	[5-Feb]	122	
1968/69	5211061	5129	[8-Mar]	72	
1969/70	104284	173.3	[11-Mar]	227	
1970/71	1300355	1148	[5-Mar]	184	
1971/72	695823	1115	[5-Mar]	186	
1972/73	1099442	1163	[16-Jan]	161	
1973/74	6887027	3610	[10-Apr]	82	
1974/75	286829	181.6	[14-Feb]	89	
1975/76	4627660	2516	[13-Feb]	39	
1976/77	271141	157.2	[11-Dec]	197	
1977/78	2898248	3946	[30-Jan]	106	
1978/79	1200013	840.5	[13-Mar]	102	
1979/80	1567587	2499	[15-Feb]	162	
1980/81	gaps				
1981/82	4037978	3152	[6-Mar]	89	
1982/83	4206871	5309	[17-Mar]	99	
1983/84	3759071	2927	[14-Mar]	102	
1984/85	278564	332.1	[9-Feb]	223	
1985/86	3816584	8041	[23-Jan]	117	
1986/87	1233993	1135	[10-Feb]	237	
1987/88	811423	2431	[23-Dec]	207	
1988/89	1527604	1650	[29-Mar]	129	
1989/90	452912	471.8	[1-Feb]	227	
1990/91	3160479	4799	[13-Feb]	174	
1991/92	178599	247.3	[16-Feb]	212	
1992/93	5930095	7615	[23-Feb]	163	
1993/94	1196893	1319	[2-Mar]	219	
1994/95	5965201	3708	[27-Feb]	98	
1995/96	1382821	2729	[9-Mar]	124	
1996/97	5193121	2817	[4-Mar]	114	
1997/98	340883	742.5	[11-Feb]	228	
1998/99	3134215	1325	[21-Dec]	142	
1999/ 0	8230193	4677	[6-Mar]	51	
2000/ 1	4531411	2881	[20-Feb]	9	
2001/ 2	4705167	11025	[23-Feb]	49	
2002/ 3	980422	1965	[26-Feb]	136	
2003/ 4	3318253	1823	[26-Feb]	92	
2004/ 5	gaps				
Mean	2611 GL (*n* = 40)	**Flood(2)** = 1868 $m^3 s^{-1}$		**Mean** = 142	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

802198 – Margaret River @ Me No Savvy

Table D.17 Total annual runoff and peak discharge observed at 802198

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$) [Date]		No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66	439946	4785	[20-Jan]	215	
1966/67	1103359	1823	[17-Feb]	135	
1967/68	805589	3007	[9-Mar]	127	
1968/69	565826	1597	[5-Feb]	212	
1969/70	41687	198	[10-Feb]	261	
1970/71	685221	1254	[24-Mar]	181	
1971/72	499009	2298	[14-Dec]	211	
1972/73	334274	880	[6-Jan]	215	
1973/74	1107156	2401	[18-Jan]	81	
1974/75	393577	1567	[14-Feb]	133	
1975/76	235069	901	[19-Dec]	81	
1976/77	610719	1810	[20-Feb]	197	
1977/78	709596	1365	[7-Feb]	106	
1978/79	255910	623	[11-Jan]	152	
1979/80	1001045	2517	[18-Feb]	239	
1980/81	gaps				
1981/82	2100478	2659	[3-Mar]	111	
1982/83	2207507	8980	[17-Mar]	78	
1983/84	1082753	3639	[14-Mar]	90	
1984/85	214624	1091	[9-Feb]	65	
1985/86	1293208	5537	[23-Jan]	163	
1986/87	480649	2193	[13-Feb]	215	
1987/88	442323	2620	[24-Dec]	240	
1988/89	257276	1468	[27-Mar]	184	
1989/90	322070	615	[17-Jan]	255	
1990/91	2261338	5534	[28-Jan]	140	
1991/92	46956	239	[4-Feb]	239	
1992/93	3153254	9330	[1-Feb]	153	
1993/94	419919	1244	[18-Feb]	200	
1994/95	859925	1483	[6-Mar]	134	
1995/96	731788	2738	[9-Mar]	110	
1996/97	496870	1814	[29-Jan]	186	
1997/98	225006	698	[6-Feb]	196	
1998/99	1798154	2748	[21-Dec]	192	
1999/ 0	gaps				
2000/ 1	1916794	3632	[19-Feb]	91	
2001/ 2	680676	3366	[22-Feb]	137	
2002/ 3	469403	1265	[27-Feb]	166	
2003/ 4	gaps	1016(1)	[13-Feb]		
2004/ 5					
Mean	840 GL (*n* = 36)	**Flood**(2) = 1915 $m^3 s^{-1}$		**Mean** = 164	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

802202 – Leopold River @ Mt Winifred

Table D.18 Total annual runoff and peak discharge observed at 802202

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$) [Date]		No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66	gaps				
1966/67	1297018	3065	[16-Feb]	200	
1967/68	537640	1414	[6-Mar]	157	
1968/69	559309	658	[13-Feb]	205	
1969/70	37075	251	[13-Feb]	266	
1970/71	299534	612	[1-Mar]	224	
1971/72	285983	1017	[5-Mar]	241	
1972/73	299316	461	[15-Jan]	234	
1973/74	1543074	1925	[13-Jan]	153	
1974/75	252039	694	[14-Feb]	184	
1975/76	1043738	1049	[19-Feb]	166	
1976/77	83671	665	[15-Jan]	246	
1977/78	1259053	2587	[29-Jan]	153	
1978/79	278831	493	[21-Feb]	229	
1979/80	335883	750	[15-Feb]	247	
1980/81	gaps				
1981/82	-				
1982/83	-				
1983/84	-				
1984/85	-				
1985/86	858717	2811	[23-Jan]	231	
1986/87	401026	885	[13-Feb]	250	
1987/88	578027	2080	[24-Dec]	250	
1988/89	377656	777	[25-Mar]	209	
1989/90	gaps				
1990/91	1469595	10019	[21-Feb]	192	
1991/92	23800	57	[31-Jan]	214	
1992/93	2461449	7571	[1-Feb]	170	
1993/94	511979	1966	[1-Mar]	235	
1994/95	1396761	2215	[24-Feb]	168	
1995/96	232920	791	[9-Mar]	198	
1996/97	1123071	1423	[29-Jan]	166	
1997/98	70490	225	[19-Jan]	260	
1998/99	1168545	1109	[21-Dec]	218	
1999/ 0	gaps	1958(1)	[18-Feb]		
2000/ 1	1599671	3987	[20-Feb]	121	
2001/ 2	gaps				
2002/ 3					
2003/ 4					
2004/ 5					
Mean	728 GL (*n* = 28)	**Flood(2)** = 1213 $m^3 s^{-1}$		**Mean** = 207	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

802213 – Hann River @ Phillips Range

Table D.19 Total annual runoff and peak discharge observed at 802213

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$) [Date]		No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67	486054	609	[4-Mar]	166	
1967/68	1399076	1152	[7-Mar]	123	
1968/69	2027056	3886	[7-Mar]	50	
1969/70	2448	5	[12-Mar]	310	
1970/71	401943	429	[3-Mar]	137	
1971/72	88234	372	[9-Mar]	211	
1972/73	468997	835	[10-Mar]	153	
1973/74	1852662	1222	[9-Apr]	90	
1974/75	42723	28	[11-Jan]	79	
1975/76	1108733	1028	[12-Feb]	67	
1976/77	105641	107	[9-Mar]	158	
1977/78	830863	742	[30-Jan]	108	
1978/79	471533	455	[12-Mar]	98	
1979/80	376196	673	[14-Feb]	165	
1980/81	gaps				
1981/82	906931	1335	[6-Mar]	108	
1982/83	424705	720	[17-Mar]	87	
1983/84	706226	803	[17-Mar]	70	
1984/85	60858	69	[30-Jan]	217	
1985/86	1240198	3789	[21-Jan]	107	
1986/87	314988	337	[31-Jan]	221	
1987/88	210712	999	[23-Dec]	195	
1988/89	638732	915	[22-Mar]	130	
1989/90	55425	104	[1-Feb]	251	
1990/91	668565	571	[21-Feb]	178	
1991/92	45187	60	[20-May]	204	
1992/93	899636	1483	[20-Feb]	184	
1993/94	285884	749	[4-Mar]	225	
1994/95	1618617	1670	[26-Feb]	105	
1995/96	319595	556	[7-Mar]	138	
1996/97	1416332	2003	[25-Feb]	171	
1997/98	505692	245	[21-Dec]	146	
1998/99	1343971	1171	[19-Feb]	66	
1999/ 0	2121980	1876	[4-Mar]	84	
2000/ 1	1177463	1073	[4-Mar]	26	
2001/ 2	1093803	4851	[22-Feb]	109	
2002/ 3	gaps				
2003/ 4					
2004/ 5					
Mean	735 GL (*n* = 35)	**Flood**(1) = 780 $m^3 s^{-1}$		**Mean** = 141	

(1) Represents the estimated bankfull discharge (ie a 1:2 y event)

915003A – Flinders River @ Walkers Bend

Table D.20 Total annual runoff and peak discharge observed at 915003A

Year	Annual runoff (ML)	Peak discharge ($m^3\ s^{-1}$)	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68					
1968/69					
1969/70	1718044	1129	[13-Feb]	211	
1970/71	4865081	4251	[12-Mar]	138	
1971/72	2171972	2486	[18-Mar]	240	
1972/73	1253601	511	[10-Apr]	188	
1973/74	18001418	6307	[2-Feb]	162	
1974/75	3383862	1965	[24-Jan]	228	
1975/76	3553633	2591	[11-Feb]	202	
1976/77	2096943	999	[9-Feb]	223	
1977/78	321900	270	[4-Feb]	263	
1978/79	5870561	2327	[17-Feb]	242	
1979/80	1129425	1755	[9-Jan]	250	
1980/81	7609292	4067	[29-Jan]	202	
1981/82	282624	284	[24-Mar]	227	
1982/83	358427	166	[11-May]	178	
1983/84	4732341	3551	[24-Jan]	203	
1984/85	97660	189	[12-Dec]	247	
1985/86	63334	93	[13-Mar]	237	
1986/87	1270844	604	[2-Mar]	205	
1987/88	242770	134	[2-Jan]	243	
1988/89	gaps				
1989/90	2171342	769	[19-Jun]	91	
1990/91	13746991	5941	[19-Jan]	222	
1991/92	603802	568	[9-Mar]	235	
1992/93	gaps			225(2)	
1993/94	2653759	2769	[13-Mar]	206	
1994/95	840770	562	[22-Feb]	251	
1995/96	1230084	1336	[13-Mar]	251	
1996/97	gaps				
1997/98	gaps				
1998/99	2938208	3213	[11-Jan]	198	
1999/ 0	3189526	1963	[1-Mar]	188	
2000/ 1	6004549	3573	[1-Jan]	203	
2001/ 2	422697	406	[2-Mar]	245	
2002/ 3	764165	830	[15-Mar]	277	
2003/ 4	3261316	3525	[25-Jan]	266	
2004/ 5	gaps				
Mean	3124 GL (*n* = 31)	**Flood**(1) = 1224 $m^3\ s^{-1}$		**Mean** = 217	

(1) Represents the estimated bankfull discharge (ie a 1:2 y event)

(2) Gaps occurred during relatively high flow periods, hence these years were also included in the analysis of ZeroDAY.

915008A – Flinders River @ Richmond

Table D.21 Total annual runoff and peak discharge observed at 915008A

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$) [Date]		No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68					
1968/69					
1969/70					
1970/71					
1971/72	gaps(1)	1088	[7-Mar]		
1972/73	293000	1124	[24-Feb]	207	
1973/74	3166636	4168	[1-Feb]	103	
1974/75	760329	1201	[6-Jan]	0	
1975/76	376825	374	[10-Feb]	145	
1976/77	181641	302	[23-Dec]	266	
1977/78	0	0		365	
1978/79	819585	1522	[3-Feb]	225	
1979/80	112135	310	[11-Feb]	299	
1980/81	1448776	2659	[21-Jan]	209	
1981/82	57778	159	[25-Jan]	264	
1982/83	141738	285	[3-May]	306	
1983/84	2073611	5208	[12-Jan]	257	
1984/85	1867	23	[4-Jun]	357	
1985/86	57654	219	[8-Feb]	300	
1986/87	78805	292	[31-Jan]	311	
1987/88	25086	141	[23-Aug]	348	
1988/89	129271	301	[6-Feb]	309	
1989/90	1020242	2201	[22-Apr]	213	
1990/91	1630302	1602	[20-Jan]	163	
1991/92	41807	142	[27-Feb]	328	
1992/93	13463	102	[18-Feb]	336	
1993/94	726549	2128	[6-Mar]	277	
1994/95	191464	534	[12-Feb]	311	
1995/96	222713	1119	[10-Jan]	295	
1996/97	373987	1094	[4-Mar]	280	
1997/98	227078	319	[13-Jan]	258	
1998/99	198475	187	[15-Jan]	174	
1999/ 0	406128	1094	[25-Feb]	177	
2000/ 1	1400446	3031	[29-Dec]	155	
2001/ 2	693430	2367	[19-Feb]	236	
2002/ 3	460590	1306	[1-Mar]	289	
2003/ 4	329564	1652	[16-Jan]	295	
2004/ 5	140939	407	[10-Jan]	291	
Mean	539 GL (*n* = 33)	**Flood**(2) = 702 $m^3 s^{-1}$		**Mean** = 253	

(1) Annual peak discharge unlikely to have occurred during gaps in the annual flow record

(2) Represents the estimated bankfull discharge (ie a 1:2 y event)

915011A – Porcupine Creek @ Mt Emu Plains

Table D.22 Total annual runoff and peak discharge observed at 915011A

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$) [Date]		No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68					
1968/69					
1969/70					
1970/71					
1971/72	41490	151.1	[21-Feb]	154	
1972/73	14891	79.8	[22-Feb]	259	
1973/74	142656	245.0	[21-Jan]	110	
1974/75	38087	155.5	[2-Jan]	0	
1975/76	36450	189.6	[24-Mar]	1	
1976/77	27110.2	115.2	[19-Feb]	101	
1977/78	854.8	9.2	[4-Sep]	278	
1978/79	25728.3	133.7	[9-Mar]	120	
1979/80	5562.2	71.6	[7-Jan]	237	
1980/81	136746.5	423.2	[16-Jan]	128	
1981/82	24081.2	100.0	[1-Dec]	46	
1982/83	30311.2	91.8	[30-Apr]	151	
1983/84	37320.4	124.7	[30-Jan]	0	
1984/85	173.7	0.6	[21-Dec]	132	
1985/86	10071.1	112.6	[6-Feb]	224	
1986/87	4677.9	57.6	[30-Jan]	226	
1987/88	1173.1	26.0	[12-Feb]	356	
1988/89	15561.5	84.0	[21-Dec]	198	
1989/90	16368.4	77.0	[5-Jun]	221	
1990/91	136970.9	364.4	[20-Jan]	156	
1991/92	2092.7	19.5	[23-Feb]	304	
1992/93	3864.5	70.2	[12-Jan]	334	
1993/94	16028.1	106.2	[12-Mar]	319	
1994/95	4170.9	49.5	[11-Mar]	270	
1995/96	5876.5	88.8	[8-Jan]	324	
1996/97	17552.3	108.5	[13-Feb]	294	
1997/98	21229.7	127.3	[13-Jan]	207	
1998/99	5136.3	83.7	[9-Mar]	264	
1999/ 0	35935	90.3	[23-Feb]	114	
2000/ 1	65078.8	267.0	[30-Dec]	181	
2001/ 2	68763	1293.0	[15-Feb]	233	
2002/ 3	3460.8	33.4	[2-Mar]	313	
2003/ 4	3294.5	26.4	[23-Jan]	292	
2004/ 5	16723.2	140.3	[24-Jan]	299	
Mean	29.9 GL (*n* = 34)	**Flood**(1) = 120 $m^3 s^{-1}$		**Mean** = 201	

(1) Represents the estimated bankfull discharge (ie a 1:2 y event)

915013A – Flinders River @ Glendower

Table D.23 Total annual runoff and peak discharge observed at 915013A

Year	Annual runoff (ML)	Peak discharge ($m^3\ s^{-1}$) [Date]		No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68					
1968/69					
1969/70					
1970/71					
1971/72					
1972/73	25154	62.5	[22-Feb]	257	
1973/74	359310	534.4	[22-Jan]	179	
1974/75	226577	411.3	[4-Jan]	135	
1975/76	146843	351.3	[24-Mar]	103	
1976/77	119434	434.2	[21-Dec]	195	
1977/78	511	5.3	[5-Sep]	358	
1978/79	128307	533.1	[10-Mar]	232	
1979/80	30591	324.7	[7-Jan]	301	
1980/81	350457	586.0	[21-Jan]	144	
1981/82	33210	112.0	[15-Dec]	266	
1982/83	121755	357.8	[27-Apr]	260	
1983/84	190391	339.3	[30-Jan]	235	
1984/85	12673	137.1	[11-Dec]	314	
1985/86	52958	280.4	[6-Feb]	302	
1986/87	32643	194.3	[30-Jan]	286	
1987/88	32021	144.7	[10-Feb]	316	
1988/89	106653	239.1	[17-Mar]	200	
1989/90	146454	386.6	[6-Jun]	181	
1990/91	413335	1105.9	[5-Feb]	229	
1991/92	14219.7	86.8	[26-Feb]	321	
1992/93	10586.2	403.5	[17-Feb]	330	
1993/94	73000.2	337.8	[4-Mar]	272	
1994/95	34410.6	402.8	[10-Feb]	299	
1995/96	61777.1	652.1	[8-Jan]	305	
1996/97	178285	523.0	[2-Mar]	303	
1997/98	174129	463.7	[14-Jan]	208	
1998/99	42346	146.9	[9-Mar]	191	
1999/ 0	147652	945.7	[23-Feb]	86	
2000/ 1	243389	653.5	[29-Dec]	39	
2001/ 2	229351	2941.1	[16-Feb]	143	
2002/ 3	11924	101.4	[1-Mar]	301	
2003/ 4	8765	43.3	[13-Jan]	275	
2004/ 5	62131	459.6	[24-Jan]	250	
Mean	116 GL (*n* = 33)	**Flood**(1) = 362 $m^3\ s^{-1}$		**Mean** = 237	

(1) Represents the estimated bankfull discharge (ie a 1:2 y event)

915203 – Cloncurry River @ Cloncurry

Table D.24 Total annual runoff and peak discharge observed at 915203

Year	Annual runoff (ML)	Peak discharge ($m^3\ s^{-1}$) [Date]		No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68					
1968/69	42635	415	[25-Mar]	292	
1969/70	187871	789	[24-Dec]	277	
1970/71	913513	3438	[5-Mar]	204	
1971/72	318488	2849	[7-Mar]	274	
1972/73	350262	3272	[28-Mar]	236	
1973/74	1473262	2863	[31-Jan]	143	
1974/75	188678	1243	[25-Feb]	234	
1975/76	233579	544	[13-Dec]	264	
1976/77	644573	1956	[25-Jan]	159	
1977/78	118542	440	[27-Jan]	287	
1978/79	209114	407	[23-Feb]	293	
1979/80	130849	407	[5-Jan]	266	
1980/81	642173	1418	[22-Jan]	246	
1981/82	43638	357	[25-Jan]	286	
1982/83	80059	1091	[20-Mar]	272	
1983/84	491541	2317	[15-Feb]	236	
1984/85	36476	342	[19-Dec]	336	
1985/86	22003	238	[14-Nov]	323	
1986/87	313614	1815	[28-Jan]	259	
1987/88	97201	578	[16-Dec]	275	
1988/89	54906	378	[27-Dec]	306	
1989/90	434027	2032	[22-Nov]	177	
1990/91	1588213	3426	[14-Jan]	234	
1991/92	198767	1804	[28-Feb]	297	
1992/93	119524	378	[16-Feb]	305	
1993/94	gaps				
1994/95	274259	590	[19-Jan]	261	
1995/96	359806	545	[5-Mar]	302	
1996/97	1985569	6482	[2-Mar]	190	
1997/98	117524	342	[15-Dec]	135	
1998/99	495950	3001	[2-Jan]	125	
1999/ 0	177845	779	[25-Dec]	142	
2000/ 1	406033	1324	[17-Dec]	120	
2001/ 2	35101.2	195	[16-Dec]	259	
2002/ 3	119902.5	620	[28-Feb]	301	
2003/ 4	582061	3584	[16-Jan]	150	
2004/ 5	366869	1754	[6-Jan]	259	
Mean	385 GL (*n* = 36)	**Flood**(1) = 979 $m^3\ s^{-1}$		**Mean** = 242	

(1) Represents the estimated bankfull discharge (ie a 1:2 y event)

915204A – Cloncurry River @ Damsite

Table D.25 Total annual runoff and peak discharge observed at 915204A

Year	Annual runoff (ML)	Peak discharge (m^3 s^{-1})	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68					
1968/69	16993	132	[24-Mar]	299	
1969/70	94778	778	[24-Dec]	277	
1970/71	563758	3299	[5-Mar]	226	
1971/72	106777	2149	[7-Mar]	279	
1972/73	282782	3299	[28-Mar]	256	
1973/74	775074	2053	[31-Jan]	160	
1974/75	106587	1212	[25-Feb]	248	
1975/76	120341	487	[4-Feb]	263	
1976/77	313785	1778	[25-Jan]	218	
1977/78	54220	308	[27-Jan]	300	
1978/79	65388	212	[2-Feb]	313	
1979/80	75252	357	[4-Jan]	296	
1980/81	384892	843	[21-Jan]	263	
1981/82	40658	370	[24-Jan]	300	
1982/83	68548	1086	[19-Mar]	295	
1983/84	417346	2011	[15-Feb]	250	
1984/85	27428	205	[19-Dec]	336	
1985/86	13512	211	[8-Dec]	323	
1986/87	200547	1929	[28-Jan]	258	
1987/88	90644	623	[16-Dec]	310	
1988/89	36614	497	[27-Dec]	324	
1989/90	254475	1774	[22-Nov]	226	
1990/91	1015235	2140	[14-Jan]	252	
1991/92	120371	1829	[28-Feb]	306	
1992/93	96838	361	[24-Mar]	238	
1993/94	78126	663	[1-Mar]	279	
1994/95	gaps				
1995/96					
1996/97					
1997/98					
1998/99					
1999/ 0					
2000/ 1					
2001/ 2					
2002/ 3					
2003/ 4					
2004/ 5					
Mean	208 GL (*n* = 26)	**Flood**(1) = 834 m^3 s^{-1}		**Mean** = 273	

(1) Represents the estimated bankfull discharge (ie a 1:2 y event)

915206A – Dugald River @ Railway Crossing

Table D26 Total annual runoff and peak discharge observed at 915206A

Year	Annual runoff (ML)	Peak discharge (m^3 s^{-1})	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68					
1968/69					
1969/70	33493	370.4	[23-Dec]	272	
1970/71	146720	1330.9	[5-Mar]	194	
1971/72	25777	327.4	[7-Mar]	336	
1972/73	37299	285.1	[28-Mar]	293	
1973/74	255151	1108.1	[22-Jan]	102	
1974/75	30407	285.1	[24-Feb]	246	
1975/76	33421	110.5	[19-Dec]	278	
1976/77	99936	295.5	[24-Jan]	190	
1977/78	46731	382.3	[27-Jan]	267	
1978/79	43212	102.7	[29-Jan]	263	
1979/80	16034	90.5	[10-Feb]	312	
1980/81	141421	497.2	[22-Jan]	235	
1981/82	8230.4	117.3	[19-Feb]	307	
1982/83	9991.5	106.5	[19-Mar]	327	
1983/84	49922.4	256.5	[14-Jan]	273	
1984/85	1300.5	38.3	[4-Feb]	346	
1985/86	10833.9	203.0	[20-Jan]	322	
1986/87	40822.8	457.0	[22-Oct]	287	
1987/88	18429.2	267.0	[27-Dec]	322	
1988/89	-				
1989/90	-				
1990/91	-				
1991/92	11023.5	115.1	[6-Feb]	281	
1992/93	49825.2	232.6	[16-Feb]	277	
1993/94	22428.8	277.2	[2-Mar]	320	
1994/95	32479.3	506.9	[10-Feb]	298	
1995/96	63032.7	429.4	[4-Mar]	271	
1996/97	234864	1148.0	[5-Mar]	212	
1997/98	61777	392.5	[26-Jan]	192	
1998/99	39429	297.5	[1-Jan]	245	
1999/ 0	37458	259.9	[25-Feb]	250	
2000/ 1	53870	265.3	[14-Dec]	226	
2001/ 2	6769	62.3	[6-Nov]	293	
2002/ 3	18895.6	228.0	[28-Feb]	324	
2003/ 4	64180.6	325.6	[15-Jan]	261	
2004/ 5	22873.9	156.9	[6-Jan]	298	
Mean	53.6 GL (*n* = 33)	**Flood**(1) = 259 m^3 s^{-1}		**Mean** = 270	

(1) Represents the estimated bankfull discharge (ie a 1:2 y event)

915208A – Julia Creek @ Julia Creek

Table D.27 Total annual runoff and peak discharge observed at 915208A

Year	Annual runoff (ML)	Peak discharge (m^3 s^{-1})	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68					
1968/69					
1969/70					
1970/71	48631	128.1	[5-Mar]	265	
1971/72	38664	203.6	[7-Mar]	340	
1972/73	4931	22.6	[19-Feb]	306	
1973/74	312616	301.3	[24-Jan]	268	
1974/75	15579	100.4	[26-Feb]	320	
1975/76	24358	151.7	[7-Feb]	326	
1976/77	44338	102.4	[25-Jan]	292	
1977/78	1633.3	11.3	[30-Jan]	340	
1978/79	93309.2	245.1	[5-Feb]	331	
1979/80	313.3	6.0	[10-Feb]	356	
1980/81	45422.8	91.3	[20-Feb]	314	
1981/82	0	0		365	
1982/83	0	0		365	
1983/84	19019	74.4	[11-Jan]	322	
1984/85	0	0		365	
1985/86	0	0		365	
1986/87	5515.6	20.0	[26-Feb]	328	
1987/88	2904.5	29.9	[3-Apr]	348	
1988/89	5423.4	36.8	[25-Dec]	338	
1989/90	11853.5	73.0	[15-Dec]	320	
1990/91	125720.3	229.8	[14-Jan]	306	
1991/92	1194.9	8.0	[29-Feb]	340	
1992/93	2396.7	14.3	[22-Feb]	348	
1993/94	82908.5	235.6	[4-Mar]	333	
1994/95	3427	19.5	[8-Feb]	351	
1995/96	9180	133.9	[3-Jan]	353	
1996/97	26138.9	103.0	[30-Jan]	307	
1997/98	18185.7	139.3	[27-Feb]	307	
1998/99	13409	69.1	[7-Jan]	303	
1999/ 0	12236.2	33.1	[18-Feb]	206	
2000/ 1	9014.3	15.2	[29-Dec]	281	
2001/ 2	3055.2	38.1	[8-Jan]	324	
2002/ 3	4459.5	38.1	[1-Mar]	322	
2003/ 4	41712	160.6	[3-Feb]	298	
2004/ 5	1464.3	11.3	[9-Jan]	332	
Mean	29.4 GL (*n* = 35)	**Flood**(1) = 58.7 m^3 s^{-1}		**Mean** = 322	

(1) Represents the estimated bankfull discharge (ie a 1:2 y event)

915211A – Williams River @ Landsborough HWY

Table D.28 Total annual runoff and peak discharge observed at 915211A

Year	Annual runoff (ML)	Peak discharge ($m^3 s^{-1}$)	[Date]	No. zero flow days	Infilled period
1956/57					
1957/58					
1958/59					
1959/60					
1960/61					
1961/62					
1962/63					
1963/64					
1964/65					
1965/66					
1966/67					
1967/68					
1968/69					
1969/70					
1970/71	111536	720.3	[5-Mar]	286	
1971/72	12923	423.9	[6-Mar]	347	
1972/73	11363	120.1	[28-Mar]	314	
1973/74	216307	704.2	[27-Jan]	192	
1974/75	6743	36.3	[25-Feb]	301	
1975/76	30709	336.2	[7-Jan]	283	
1976/77	87727.1	769.0	[21-Feb]	280	
1977/78	19973.9	225.5	[27-Jan]	337	
1978/79	52057.8	300.6	[23-Feb]	303	
1979/80	18293.8	442.4	[5-Jan]	333	
1980/81	78216.1	508.7	[15-Jan]	297	
1981/82	16750.8	360.4	[24-Jan]	318	
1982/83	1330	36.9	[9-Mar]	340	
1983/84	63014	860.7	[10-Jan]	291	
1984/85	2996.6	36.0	[19-Dec]	354	
1985/86	1733.8	50.5	[6-Dec]	350	
1986/87	40116	381.6	[28-Jan]	279	
1987/88	8108	62.0	[30-Nov]	312	
1988/89	6033	148.8	[10-May]	333	
1989/90	52425	614.1	[22-Nov]	258	
1990/91	180957	1419.6	[14-Jan]	289	
1991/92	16852.5	145.0	[27-Feb]	325	
1992/93	9170.7	80.0	[21-Feb]	333	
1993/94	15101	355.2	[1-Mar]	345	
1994/95	19665.4	361.8	[19-Jan]	309	
1995/96	10243.2	85.6	[2-Jan]	328	
1996/97	209629	1202.8	[4-Mar]	243	
1997/98	8564	75.0	[14-Dec]	250	
1998/99	77633	1227.4	[2-Jan]	250	
1999/ 0	26813	163.6	[23-Feb]	285	
2000/ 1	53932	344.2	[13-Nov]	222	
2001/ 2	2694.5	94.4	[16-Dec]	344	
2002/ 3	33385.6	486.6	[27-Feb]	324	
2003/ 4	42349.1	632.5	[15-Jan]	296	
2004/ 5	29141.4	371.9	[6-Jan]	328	
Mean	45.0 GL (n = 35)	**Flood**(1) = 275 $m^3 s^{-1}$		**Mean** = 302	

(1) Represents the estimated bankfull discharge (ie a 1:2 y event)

Appendix E – Derivation of Colwell parameter values

Colwell's predictability (*PredQ*) and constancy (*C*) parameter values are calculated as follows (Colwell 1974):

$$PredQ = 1 - \frac{H(XY) - H(X)}{\log s}$$

$$C = 1 - \frac{H(Y)}{\log s}$$

where *H(X)*, *H(Y)* and *H(XY)* is the uncertainty with respect to time, state, and the interaction of time and state respectively and *s* is the number of states (rows in the matrix).

In terms of our flow matrix (Table E.1), with *t* columns (months) and *s* rows (flow intervals), N_{ij} is assumed to be the number of times for which streamflow was within a certain flow interval *i* for a time period *j*. If X_j, Y_i and *Z* are the column totals, row totals and grand total respectively, then *H(X)*, *H(Y)* and *H(XY)* can be derived as follows:

$$H(X) = -Log\left(\frac{1}{t}\right)$$

$$H(Y) = -\sum_{i=1}^{s} \frac{Y_i}{Z} \log \frac{Y_i}{Z}$$

$$H(XY) = -\sum_{i} \sum_{j} \frac{N_{ij}}{Z} \log \frac{N_{ij}}{Z}$$

Table E.1 Colwell's indices based on monthly flow data from G8140001 in the Daly River catchment. Entries in the matrix are the number of months in which flow falls within a given interval. Each column total is equal to the number of years of data.

Interval	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<1	27	26	15	2	0	0	0	1	7	15	18	23
to 2	2	2	12	4	0	0	0	3	8	8	11	7
to 4	1	2	2	3	2	1	1	7	6	7	1	0
to 8	0	0	0	7	3	2	2	6	9	0	0	0
to 16	0	0	0	3	5	1	2	7	0	0	0	0
to 32	0	0	1	4	6	2	6	4	0	0	0	0
to 64	0	0	0	6	6	7	4	2	0	0	0	0
to 128	0	0	0	1	5	7	10	0	0	0	0	0
to 256	0	0	0	0	2	10	4	0	0	0	0	0
to 512	0	0	0	0	1	0	1	0	0	0	0	0
to 1024	0	0	0	0	0	0	0	0	0	0	0	0
to 2048	0	0	0	0	0	0	0	0	0	0	0	0

Table E.1 is the flow matrix for G8140001 in the Daly River catchment. Data are monthly totals for 30 years and the flow intervals are a log-2 scale. In this case,

s = 12

t = 12

Z = 360 (12 months x 30 years)

Predictability *PredQ* = 0.49

Constancy C = 0.19

C/P = 0.40 (constancy divided by predictability)

The derivation of the Colwell parameter values on a mean daily flow basis is very similar to the above example for monthly runoff. The major difference simply being the size of the matrix (365 columns).