Department of Lands, Planning and Environment

Analysis of Groundwater Fed Flows for the Flora, Katherine, Douglas and Daly Rivers

Report 36/2000D

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1. Introduction

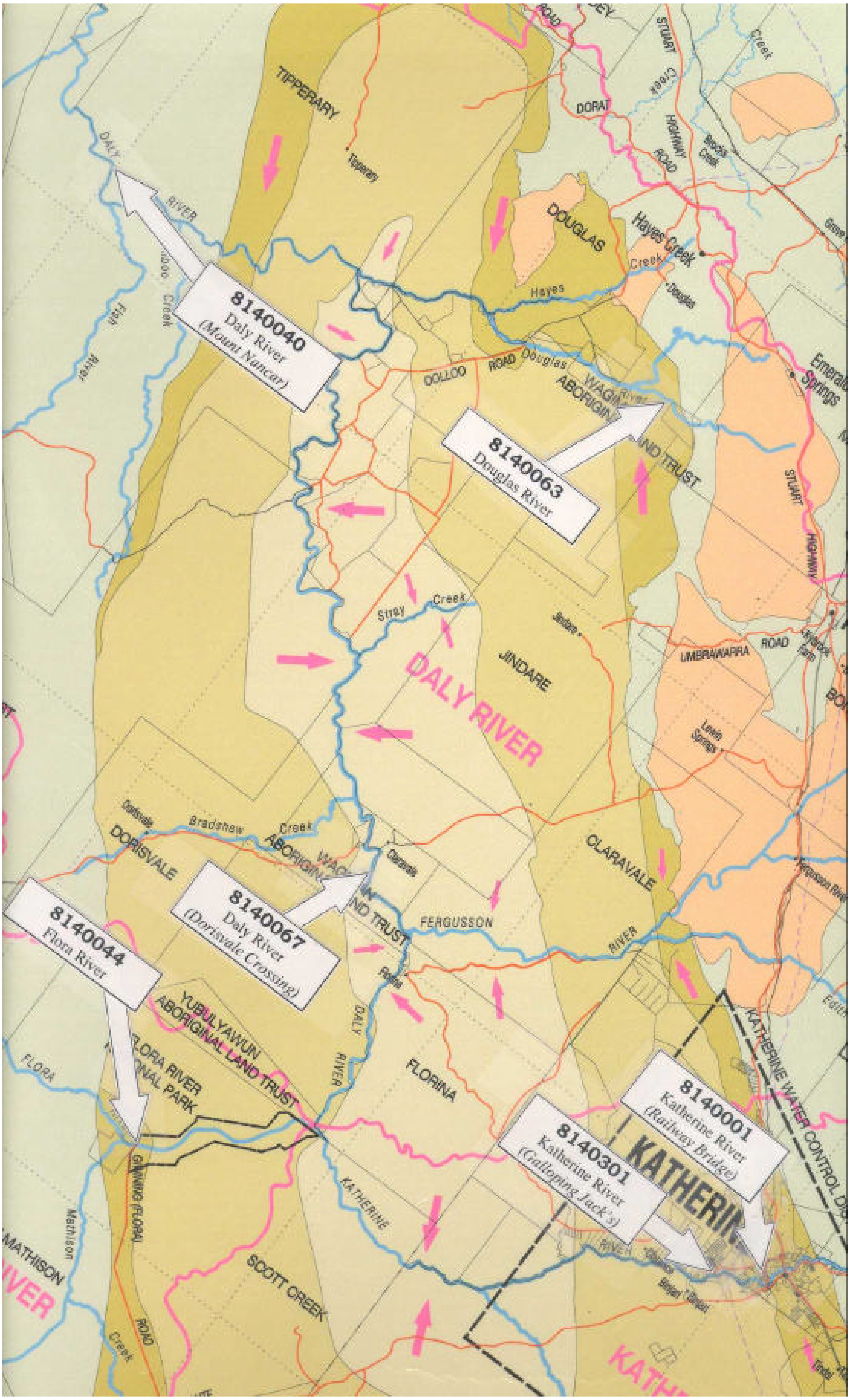
The aim of this study was to undertake a preliminary analysis of groundwater fed flow data. The objective was to develop relationships between rainfall and groundwater fed flows that could be used to predict dry season flows in the absence of detailed low flow gaugings. Good long term daily rainfall data is available for Katherine. The area studied was the Daly Basin with a specific emphasis on the Daly River, the Katherine River, the Flora River and the Douglas River.

Initially, an attempt was made to analyse data from the Daly River in isolation. However, no meaningful results could be achieved. It was then decided that the rivers that are known to be major dry season tributaries to the Daly River should be studied in turn. These rivers are the Katherine River, the Flora River and the Douglas River. The Katherine and Flora Rivers meet to form the Daly River, whilst the Douglas River confluence is approximately 160 kilometres downstream of the junction between the Katherine and Flora Rivers.

Records from Gauging Stations (GS) GS8140001 at the Railway Bridge and GS8140301 at Galloping Jack's, both on the Katherine River, were studied. Records were also analysed for the Flora River at GS8140044; the Daly River at Dorisvale Crossing at GS8140067; the Daly River at Mount Nancar at GS8140040; and the Douglas River at GS8140063. The location of each station is shown on Figure 1.

The primary reference for this work was a paper by Josepf Szilagyi in Volume 1, Number 5 of the journal Groundwater (Sept-Oct 1999). The title of the paper was "On the use of Semi-logarithmic Plots for Baseflow Separation".

Figure 1 Location Map



2. Interpretation of Dry Season Flow Data

The following table indicates the period of record and number of gaugings that have been recorded at each site. A qualitative statement has also been made regarding the quality of data relating to groundwater-fed dry season flows at each site.

Table 1 Gauging Station Details

Location	Number of GS	Period for which flows have been gauged	Number of Gaugings	Poor or good low flow records
Flora River	GS8140044	1966 – 1999	27	Poor
Katherine River at the Low Level	GS8140001	1952 – 1999	290	Good
Katherine River at Galloping Jacks	GS8140301	1974 - 1998	67	Good
Daly River at the Dorisvale Crossing	GS8140067	1957 – 1998	240	Good
Douglas River	GS8140063	1957 – 1997	280	Poor
Daly River at Mount Nancar	GS8140040	1966 – 1999	287	Good

A procedure for evaluating and analysing the available data was developed. The first step in collating all available data was to view a full record of hydrographs for the various gauging stations. The listing of gaugings for each gauging station was then obtained from the database HYDSYS. These hydrographs and listings of gaugings are contained in appendices A to E.

Initially, during the study of the Daly River as a separate entity, monthly stream discharge records for the gauging station at the Dorisvale crossing were extracted from HYDSYS. However, on further examination and after comparing the monthly stream discharge records with the hydrographs and the record of actual gaugings, it was found that the table of minimum stream discharge was not accurate enough. As such it was decided that the minimum stream discharge records would not be used in any further analysis.

The slope of log discharge vs. time since the end of the Wet Season, for a river with a strong groundwater inflow, theoretically has a straight-line relationship for the Dry Season period. The slope of the straight-line portion of the hydrographs for a gauging station is theoretically meant to be the same for each year. The straight line, which has a negative slope, represents the decrease in discharge during the dry season when little or no recharge occurs. An average equation can then be found for the line or lines that best represented the dry season flow data. This analysis was applied for gauged flow data for all gauging stations analysed in this study. This relationship was then used to predict groundwater fed flows for rivers during the dry season.

The relationship is of the form:

$$\text{Log } Q = a - bN$$

Where: Q = groundwater fed flow in cumecs,

a = log of the estimated maximum groundwater flow component,

N = the number of days it would take for the maximum groundwater fed flow to reduce to a given flow value,

b = the slope of the line (negative)

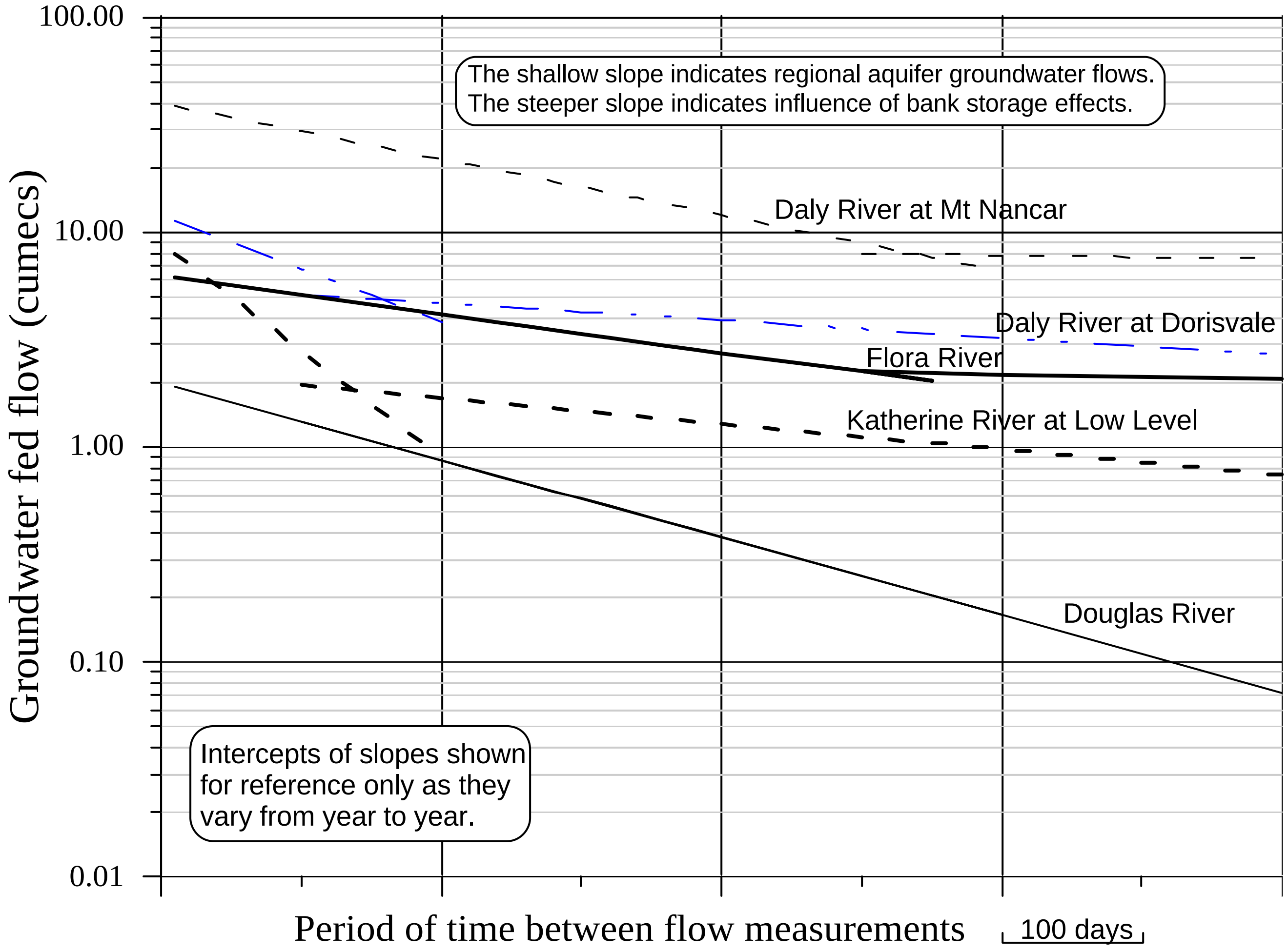
The plot of log Q versus time for the dry season is displayed in Figure 2 for each Gauging Station. The equations for each Station are given in Table 2.

Table 2 Equations for groundwater fed flow at various Gauging Stations

Location	Gauging Station	Equation for higher flows dominated by "bank storage"	Equation for lower flows dominated by regional groundwater resource input
Flora River	GS8140044	Log Q = 0.8 – 0.009N	Log Q = 0.4 – 0.0001N
Katherine River	GS8140301	Log Q = 0.95 – 0.005 N	Log Q = 0.35 – 0.0006N
Daly River at the Dorisvale Crossing	GS8140067	Log Q = 1.08 – 0.0025N	Log Q = 0.75 – 0.0004N
Douglas River	GS8140063	none	Log Q = 0.3 – 0.002N
Daly River at Mount Nancar	GS8140040	Log Q = 1.6 – 0.0013N	Log Q = 0.94 – 0.00008N

It can be seen from the hydrograph plots that there can be two distinct recession responses during the dry season, for the various tributaries to the Daly River. These are individually discussed in more detail in the respective appendices. For dry season recession following average to below average rainfall years, the recession reaches a relatively flat slope from September onwards. After higher rainfall years, the recession has a much steeper slope, and may not reach the expected shallow baseflow slope at all. This response has been attributed to bank storage and recharge to aquifer systems from the river only after river levels have reached a certain height. In other words, controlled by groundwater discharge emanating from recharge close to the river. The shallow slope is controlled by diffuse recharge. In order to validate this, further analysis needs to be made of river heights, recession rates and groundwater levels in the aquifers in the vicinity of the river itself.

Figure 2 Relationship between Groundwater fed flows and time for various Gauging Stations.



3. Comparison of Flows in Each River

For a comparison of flows to be possible, flow data must be available for all rivers for the same period in a given year. The best data sets for the Daly Basin are displayed in the following table.

Table 3 Gauged Flows at Various Stations in early Nov 1970 and 1982

Location		**Flow in early November 1970 (cumecs)**	**Flow in early November 1982 (cumecs)**
Katherine River at the Railway Bridge	GS8140001	0.88	1.94
Katherine River at Galloping Jacks	GS8140301	1.1*	2.34
Flora River	GS8140044	3.1*	3.4*
Sum of Flora River and Katherine River Flows	GS8140301 + GS8140044	4.2*	5.74*
Daly River at Dorisvale Crossing	GS8140067	2.8	5.1
Daly River at Oolloo Crossing	GS8140038	5.9	13
Douglas River	GS8140063	0.26	0.66
Daly River at Bee Boon Crossing	GS8140042	7.7	16.9
Daly River at Gourley	GS8140041	8.2	17.2
Daly River at Mount Nancar	GS8140040	8.5	19.4

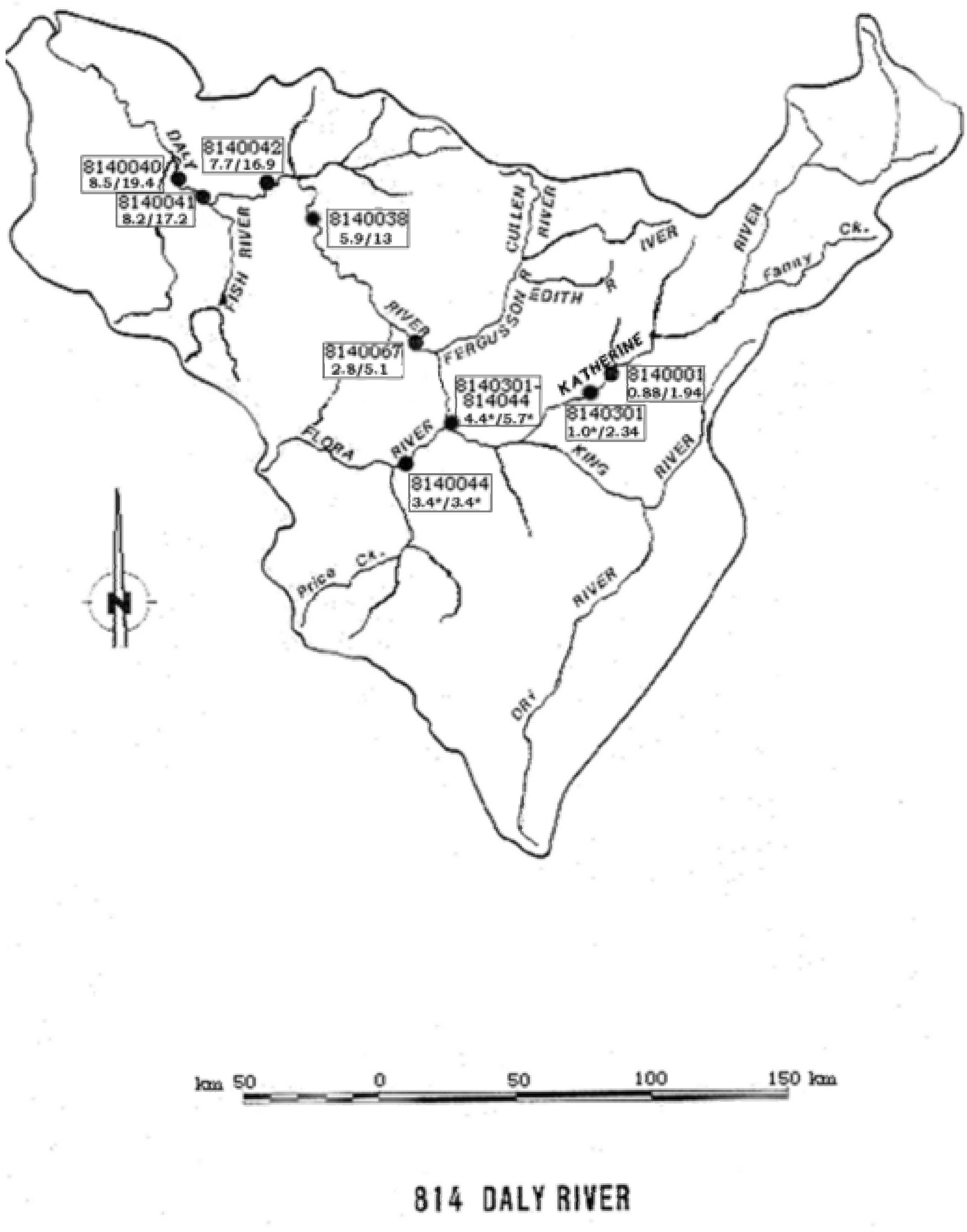
Note: * indicates estimated value.

1970 follows a period of below average wet seasons.

1982 follows a period of average to above average wet seasons.

The Tindall Limestone is the main groundwater source for the Katherine, Flora and Douglas Rivers. The Oolloo Limestone is the major source of groundwater for the Katherine River and Daly River downstream of the confluence of the King and Katherine Rivers. Between Beeboon Crossing and Mount Nancar, the Daly River should receive more springflow from the Tindal Limestone. However, the level of input of the Tindal Limestone to this part of the Daly River is not known.

Figure 3 Gauged Flows at Various Stations in early November in 1970 and 1982



Note:

- Displayed are gaugings from 1970 and 1982, eg. “1970/1982”.
- * indicates estimated value

4. Relationship Between Rainfall and Potential Recharge in the Katherine Region

The estimation of potential recharge to the limestone aquifers in the Katherine region is based on the rainfall records obtained from the Katherine Post Office site, DR014902, during the period 1872 to 1999.

Potential recharge was calculated from the daily rainfall record, using estimates for the end of dry season soil moisture deficit and daily losses (evapotranspiration etc). A soil moisture deficit of **150 mm** and wet season evapotranspiration (ET) of **5mm/day** were chosen. It was assumed that there was little surface runoff from the ground overlying the limestone aquifers.

Daily potential recharge is calculated using the following formulae :

If	$SMD_d + PPT_d - ET \le -150$	then	$SMD_{d+1} = -150$
Else if	$SMD_d + PPT_d - ET \le 0$	then	$SMD_{d+1} = SMD_d + PPT_d - ET$
Else if	$PPT_d - ET > 0$	then	$SMD_{d+1} = SMD_d + PPT_d - ET$
Else if	$PPT_d - ET \le 0$	then	$SMD_{d+1} = 0$

Where SMD = soil moisture deficit (mm)
PPT = daily rainfall (mm)
ET = evapotranspiration (mm)
$_d$ = day
$_{d+1}$ where 1 = number of days since previous SMD_d value

Daily recharge R = $SMD_{d+1} - SMD_d$

Once daily recharge has been calculated, recharge events can be identified from the daily recharge record, and are summarised in Table 5. This is done by summing consecutive daily recharge values to give discrete events. Annual rainfall (1 October to 30 September) and potential annual recharge are given in Table 4 for the period

1884 to 1999 and plotted on Figure 4. The data indicates that an annual rainfall of about 700mm is required before any significant recharge occurs.

Figure 4 Relationship between Annual Rainfall and Estimated Annual Recharge

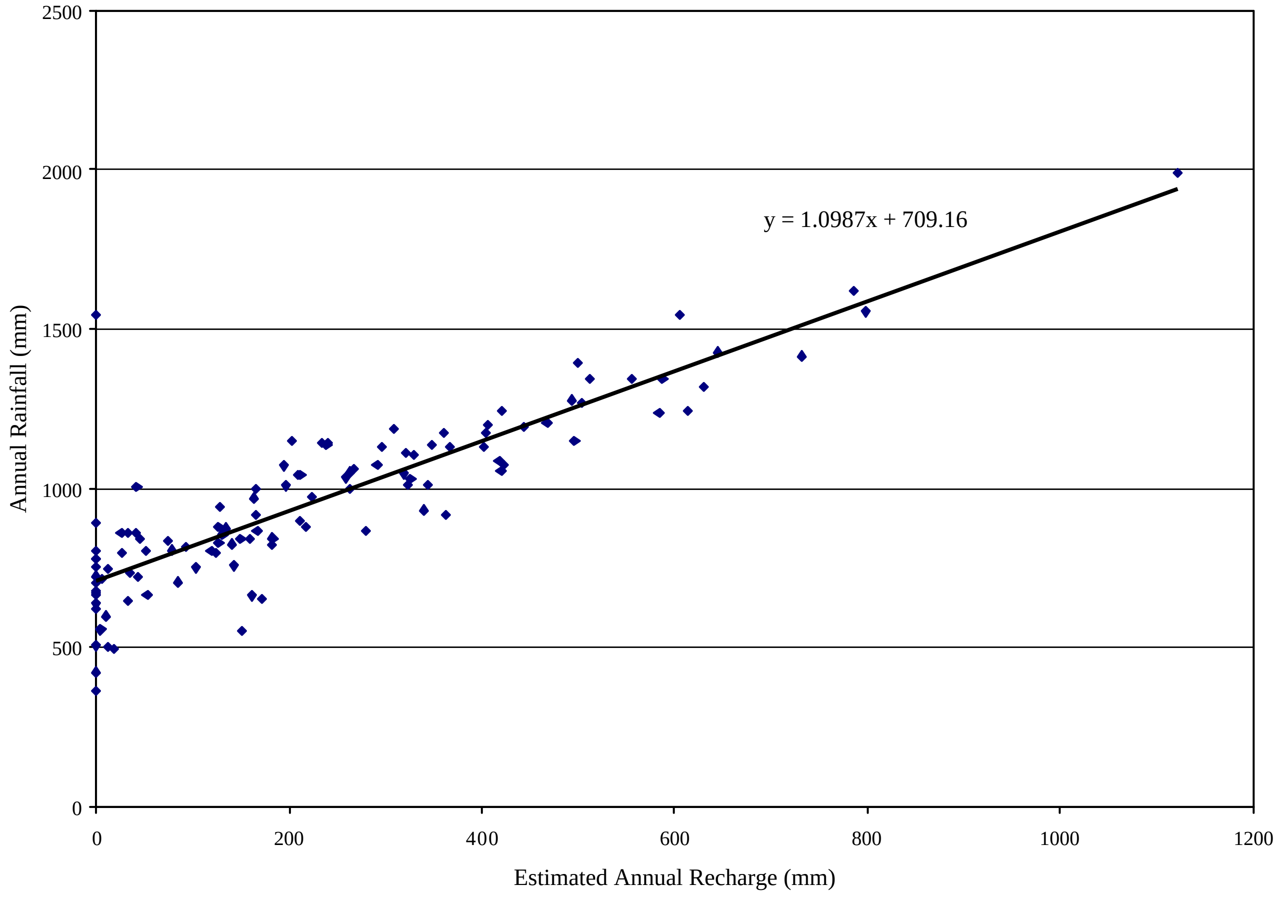


Table 4 Annual Rainfall and Estimated Annual Recharge Details – DR014902

Date	Total Annual Rainfall (mm)	Total Annual Recharge (mm)	Date	Total Annual Rainfall (mm)	Total Annual Recharge (mm)
1884/1885	653	172	1944/1945	805	51
1885/1886	821	182	1945/1946	916	363
1886/1887	N/A	N/A	1946/1947	841	160
1887/1888	552	151	1947/1948	860	26
1888/1889	1033	259	1948/1949	796	124
1889/1890	1136	348	1949/1950	997	263
1890/1891	817	92	1950/1951	1172	360
1891/1892	424	0	1951/1952	364	0
1892/1893	804	119	1952/1953	829	127
1893/1894	1071	194	1953/1954	1103	329
1894/1895	1149	203	1954/1955	1004	42
1895/1896	1045	209	1955/1956	841	46
1896/1897	933	340	1956/1957	1345	588
1897/1898	1990	1121	1957/1958	942	128
1898/1899	1554	798	1958/1959	861	33
1899/1900	725	0	1959/1960	1010	324
1900/1901	1319	630	1960/1961	804	0
1901/1902	498	18	1961/1962	502	13
1902/1903	807	79	1962/1963	1051	263
1903/1904	1543	606	1963/1964	703	0
1904/1905	720	42	1964/1965	861	41
1905/1906	638	0	1965/1966	757	142
1906/1907	1277	493	1966/1967	1131	402
1907/1908	1243	421	1967/1968	1342	555
1908/1909	679	0	1968/1969	1010	344
1909/1910	1202	406	1969/1970	647	34
1910/1911	747	12	1970/1971	1137	238
1911/1912	973	223	1971/1972	1043	212
1912/1913	857	131	1972/1973	899	211
1913/1914	825	141	1973/1974	1345	512
1914/1915	751	103	1974/1975	1051	263
1915/1916	1071	291	1975/1976	1395	499
1916/1917	1142	233	1976/1977	1267	504
1917/1918	1208	468	1977/1978	1131	366
1918/1919	622	0	1978/1979	1063	268
1919/1920	667	0	1979/1980	1194	444
1920/1921	1113	321	1980/1981	1085	418
1921/1922	841	150	1981/1982	1008	197
1922/1923	996	166	1982/1983	756	0
1923/1924	1076	422	1983/1984	1620	786
1924/1925	865	167	1984/1985	894	0
1925/1926	600	10	1985/1986	778	0
1926/1927	663	162	1986/1987	869	279
1927/1928	781	0	1987/1988	915	166
1928/1929	506	0	1988/1989	1137	239
1929/1930	1055	420	1989/1990	714	7
1930/1931	1186	309	1990/1991	1236	584
1931/1932	664	53	1991/1992	557	5
1932/1933	733	34	1992/1993	881	217
1933/1934	970	163	1993/1994	845	183
1934/1935	1142	240	1994/1995	836	75
1935/1936	798	27	1995/1996	675	0
1936/1937	1147	496	1996/1997	1244	613
1937/1938	706	85	1997/1998	1415	732
1938/1939	1031	326	1998/1999	1128	296
1939/1940	1427	644			
1940/1941	876	134			
1941/1942	878	127			
1942/1943	1046	319			
1943/1944	1176	404			

Table 5 Summary of Recharge Events

Date	Recharge Event	Date	Recharge Event	Date	Recharge Event	Date	Recharge Event
01/02/1885	9	12/03/1898	203	04/02/1916	50	28/01/1937	49
20/02/1885	81	31/03/1898	239	07/03/1916	6	31/01/1937	5
25/02/1885	33	02/01/1899	42	03/01/1917	55	12/03/1937	50
28/02/1885	4	09/01/1899	16	03/02/1917	132	16/02/1938	68
05/03/1885	12	17/01/1899	198	27/02/1917	5	22/02/1938	17
11/03/1885	33	21/01/1899	37	06/03/1917	23	25/01/1939	105
26/12/1885	81	19/03/1899	440	24/03/1917	19	13/02/1939	108
06/02/1886	81	24/03/1899	67	19/11/1917	41	22/02/1939	17
10/02/1886	20	04/01/1901	7	05/12/1917	48	27/02/1939	96
11/01/1888	87	09/02/1901	54	14/12/1917	23	10/01/1940	238
28/01/1888	44	01/03/1901	51	21/12/1917	27	20/01/1940	50
18/02/1888	17	18/03/1901	518	06/01/1918	39	26/01/1940	18
23/02/1888	3	04/02/1902	18	17/01/1918	87	06/02/1940	49
21/02/1889	108	18/02/1903	40	31/01/1918	124	11/02/1940	11
08/03/1889	11	26/02/1903	35	09/02/1918	71	23/02/1940	2
28/12/1889	31	02/01/1904	43	16/02/1918	10	29/02/1940	102
04/01/1890	53	14/01/1904	396	07/01/1921	81	05/03/1940	57
20/01/1890	101	30/01/1904	118	27/02/1921	42	29/03/1940	119
25/01/1890	52	08/03/1904	36	19/03/1921	159	09/03/1941	27
01/02/1890	44	26/03/1904	13	28/03/1921	39	30/03/1941	107
08/02/1890	5	08/02/1905	42	19/03/1922	150	09/01/1942	21
15/02/1890	63	26/12/1906	86	05/01/1923	40	07/02/1942	96
24/01/1891	56	18/01/1907	71	11/01/1923	40	22/02/1942	10
09/02/1891	36	08/02/1907	105	05/04/1923	86	01/01/1943	6
21/02/1893	119	11/02/1907	2	29/12/1923	205	16/01/1943	9
25/01/1894	114	16/02/1907	127	10/01/1924	27	28/02/1943	202
06/02/1894	18	25/02/1907	103	21/02/1924	115	12/03/1943	102
12/02/1894	31	14/12/1907	8	04/03/1924	76	17/01/1944	4
16/02/1894	16	23/12/1907	150	15/02/1925	18	31/01/1944	1
05/03/1894	15	28/12/1907	19	01/03/1925	131	09/02/1944	14
23/01/1895	20	07/01/1908	58	11/03/1925	18	15/02/1944	26
27/01/1895	3	06/02/1908	71	11/01/1926	10	05/03/1944	268
10/02/1895	112	16/02/1908	10	28/12/1926	116	17/03/1944	82
17/02/1895	26	10/03/1908	95	27/01/1927	46	04/03/1945	51
23/01/1896	11	28/03/1908	10	02/01/1930	10	30/12/1945	103
29/01/1896	7	22/11/1909	12	10/01/1930	42	20/01/1946	27
06/02/1896	44	04/12/1909	135	17/02/1930	134	27/01/1946	53
15/02/1896	43	13/01/1910	175	24/02/1930	67	16/02/1946	180
26/02/1896	33	07/02/1910	11	26/12/1930	42	22/02/1947	71
03/03/1896	20	01/03/1910	73	30/01/1931	147	27/02/1947	32
12/03/1896	46	16/02/1911	12	04/04/1931	119	18/03/1947	16
02/04/1896	6	04/02/1912	29	21/03/1932	53	27/03/1947	41
07/12/1896	32	20/02/1912	29	29/12/1932	34	04/01/1948	26
09/01/1897	266	02/03/1912	10	03/01/1934	80	22/02/1949	8
09/02/1897	42	17/03/1912	156	08/01/1934	63	07/03/1949	44
10/02/1897		23/02/1913	85	03/02/1934	21	19/03/1949	73
10/12/1897	308	08/03/1913	33	25/01/1935	23	30/12/1949	68
18/12/1897	14	28/03/1913	14	11/02/1935	30	17/01/1950	37
31/12/1897	140	06/01/1914	54	08/03/1935	169	26/01/1950	59
07/01/1898	30	15/01/1914	61	29/03/1935	18	07/02/1950	58
21/01/1898	31	29/01/1914	26	12/01/1936	23	16/02/1950	41
03/02/1898	23	21/01/1915	47	29/02/1936	0	06/01/1951	70
07/02/1898	13	01/02/1915	37	04/03/1936	3	16/01/1951	151
20/02/1898	85	14/02/1915	20	08/01/1937	316	07/02/1951	6
23/02/1898	8	24/12/1915	205	15/01/1937	18	16/02/1951	96
01/03/1898	25	19/01/1916	29	22/01/1937	59	23/02/1951	6

Date	Recharge Event	Date	Recharge Event	Date	Recharge Event	Date	Recharge Event
02/03/1951	3	02/03/1972	70	23/01/1984	146	15/02/1998	11
08/03/1951	14	09/03/1972	22	30/01/1984	103	30/12/1998	77
07/02/1953	75	17/03/1972	93	20/02/1984	47	10/01/1999	8
08/04/1953	52	21/01/1973	35	25/02/1984	36	16/01/1999	4
01/02/1954	320	07/02/1973	81	06/03/1984	102	19/01/1999	47
26/02/1955	4	14/03/1973	95	17/03/1984	245	08/02/1999	22
09/03/1955	31	18/02/1974	147	07/02/1987	24	17/02/1999	16
05/02/1956	34	25/02/1974	16	11/02/1987	35	25/02/1999	33
19/02/1956	12	02/03/1974	26	14/02/1987	32	14/03/1999	85
20/12/1956	65	09/03/1974	120	18/02/1987	31		
08/01/1957	25	14/03/1974	7	23/02/1987	126		
20/01/1957	25	25/03/1974	196	26/02/1987	30		
11/02/1957	54	17/01/1975	151	13/02/1988	166		
07/03/1957	419	24/02/1975	81	16/12/1988	8		
23/12/1957	47	28/02/1975	31	24/12/1988	17		
29/12/1957	52	09/02/1976	16	30/12/1988	46		
17/01/1958	29	24/02/1976	229	01/02/1989	19		
22/01/1959	17	28/02/1976	17	20/03/1989	138		
08/04/1959	16	05/03/1976	34	24/03/1989	11		
31/01/1960	65	09/03/1976	29	10/03/1990	7		
15/02/1960	165	17/03/1976	128	13/12/1990	41		
25/02/1960	4	23/03/1976	47	22/12/1990	77		
15/03/1960	90	07/02/1977	3	12/01/1991	217		
07/02/1962	10	11/02/1977	26	22/01/1991	19		
16/02/1962	2	21/02/1977	81	05/02/1991	79		
22/02/1962	1	05/03/1977	231	16/02/1991	40		
27/01/1963	194	22/03/1977	164	20/02/1991	27		
01/02/1963	28	18/01/1978	22	23/02/1991	67		
18/02/1963	13	30/01/1978	187	28/02/1991	18		
22/02/1963	4	13/02/1978	6	13/02/1992	3		
02/03/1963	24	25/02/1978	150	26/02/1992	2		
04/12/1964	41	27/01/1979	50	30/01/1993	91		
05/02/1966	133	04/02/1979	22	04/02/1993	24		
12/02/1966	10	11/02/1979	16	09/02/1993	42		
08/02/1967	59	20/02/1979	35	12/02/1993	51		
21/02/1967	100	09/03/1979	145	19/02/1993	1		
02/03/1967	165	06/02/1980	50	28/12/1993	37		
16/03/1967	77	12/02/1980	68	05/01/1994	10		
27/01/1968	129	17/02/1980	98	10/01/1994	7		
02/02/1968	19	26/02/1980	119	03/03/1994	74		
14/02/1968	164	22/03/1980	109	08/03/1994	56		
24/02/1968	128	13/01/1981	160	27/01/1995	30		
11/03/1968	116	17/01/1981	33	02/02/1995	4		
05/02/1969	103	23/01/1981	7	08/02/1995	8		
17/02/1969	1	27/01/1981	5	06/03/1995	34		
28/02/1969	178	02/02/1981	3	04/01/1997	277		
16/03/1969	62	07/02/1981	77	08/01/1997	6		
24/12/1969	34	16/02/1981	101	22/01/1997	124		
19/02/1971	11	20/02/1981	31	25/01/1997	17		
03/03/1971	40	11/02/1982	45	23/02/1997	132		
13/03/1971	3	15/02/1982	26	26/02/1997	15		
24/03/1971	157	26/02/1982	71	04/03/1997	43		
04/04/1971	28	02/03/1982	54	27/12/1997	33		
17/12/1971	8	01/01/1984	23	03/01/1998	249		
25/12/1971	6	07/01/1984	37	21/01/1998	101		
02/01/1972	12	17/01/1984	46	28/01/1998	340		

5. Relationship Between Estimated Recharge and Groundwater Fed Baseflows for the Katherine River at the Low Level Crossing

Hydrographs for GS8140001 and gauged flows at the Low Level Crossing, 3km downstream of the gauging station, were examined to determine increases in annual springflow correlated with the potential annual recharge, as were predicted in Section 4. These increases have been summarised in Appendix B. A linear relationship representing the correlation between probable increases in flow and recharge events was determined:

Change in Q (in cumecs) = A x (Recharge event in mm)

where A = slope of best fit line

Table 6 shows annual potential recharge and the corresponding estimated annual rise in baseflows for the Low Level Crossing, and the relationship is plotted in Figure 5. A line of best fit through this data gives a linear relationship of :

Change in Q (in cumecs) = 0.0012 x (Recharge event in mm)

This relationship can then be applied to each individual recharge event in order to calculate the corresponding change in baseflow.

Table 6 Estimated Annual Increase in Baseflow for the Katherine River at the Low Level Crossing, 3km downstream GS8140001

Water Year	**Annual Rainfall (mm)**	**Potential Recharge (mm)**	**Rise in Baseflow (cumecs)**
1963/1964	703	0	0
1964/1965	861	41	0.1
1965/1966	728	142	0.3
1966/1967	1160	402	0.5
1967/1968	1293	555	0.45
1968/1969	1058	344	-
1969/1970	649	34	0
1970/1971	1103	238	0.3
1971/1972	1078	212	0.2
1972/1973	867	211	0.3
1973/1974	1361	512	1.05
1974/1975	1055	263	0.4
1975/1976	1412	499	0.8
1976/1977	1267	504	0.6
1977/1978	1127	366	-
1978/1979	1026	268	-
1979/1980	1236	444	0.7
1980/1981	1066	418	0.4
1981/1982	1026	197	0.2
1982/1983	751	0	0
1983/1984	1618	786	1
1984/1985	889	0	0
1985/1986	677	0	0.1
1986/1987	980	279	0.2
1987/1988	915	166	0.1
1988/1989	1137	239	0.3
1989/1990	714	7	0.2
1990/1991	1233	584	0.6
1991/1992	558	5	0
1992/1993	884	217	0.3
1993/1994	845	183	0.3
1994/1995	833	75	0
1995/1996	677	0	0

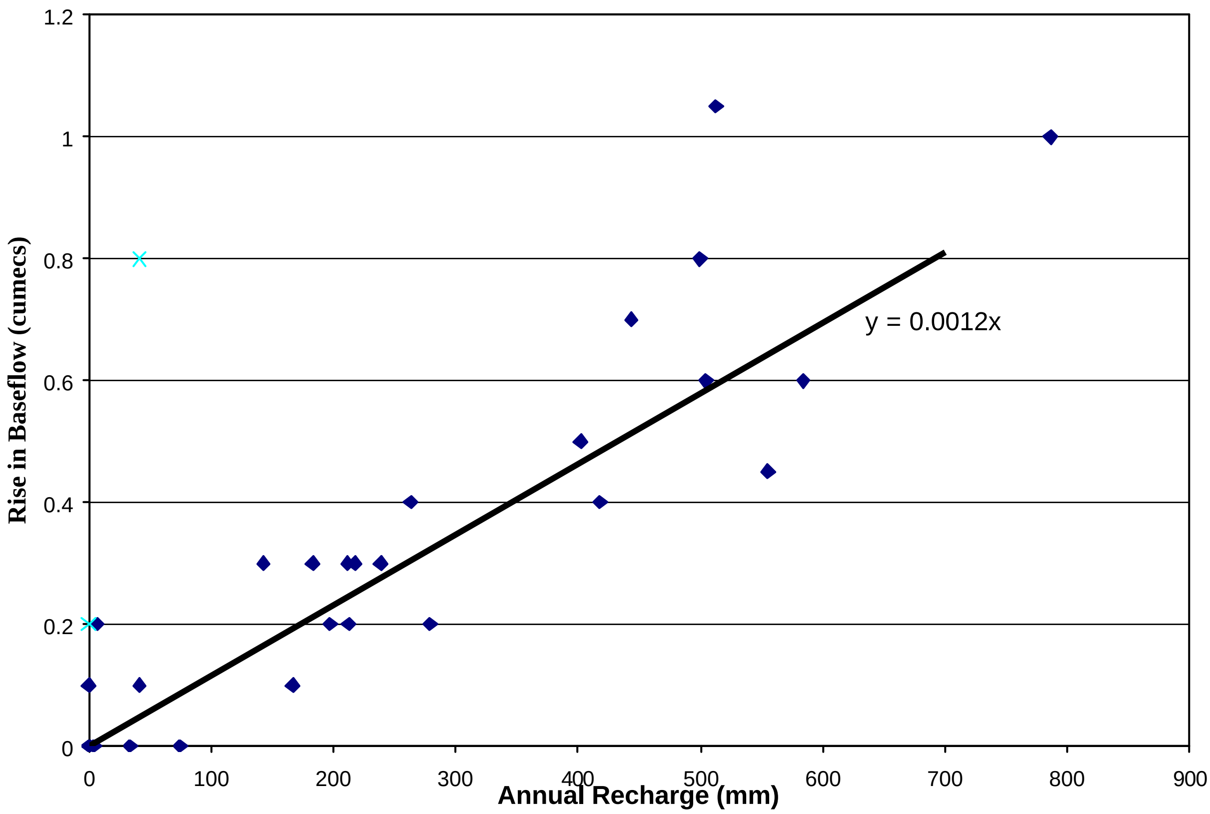


Figure 5 Relationship between Increase in Springflow and Annual Recharge for the Katherine River at the Low Level Crossing, 3km downstream of GS8140001

6. Synthesis of Baseflow Record

The relationships developed in Sections 2, 4 and 5 were used to predict the groundwater baseflow component of the hydrograph for the Katherine River. The flows were calculated using an Excel spreadsheet and the formulae and logical expressions given below.

Formulae used to synthesise springlow (derived from Szilagyi's paper)

Using $\textbf{\textit{Log}}\ \mathbf{Q = a - bN}$ where a = log (flow)

b = slope of recession

\ $Q = e^{(\log(flow) - b(time\ since\ recharged))}$

If $SF_d > MSF$ then SF_{d+1} = increase in flow + $10^{(\log(MSF) - b(time\ since\ recharged))}$

Else SF_{d+1} = increase in flow + $10^{(\log(SF_d) - b(time\ since\ recharged))}$

Where SF_d = spring flow (cumecs)

MSF = max spring flow when aquifer fully recharged (cumecs)

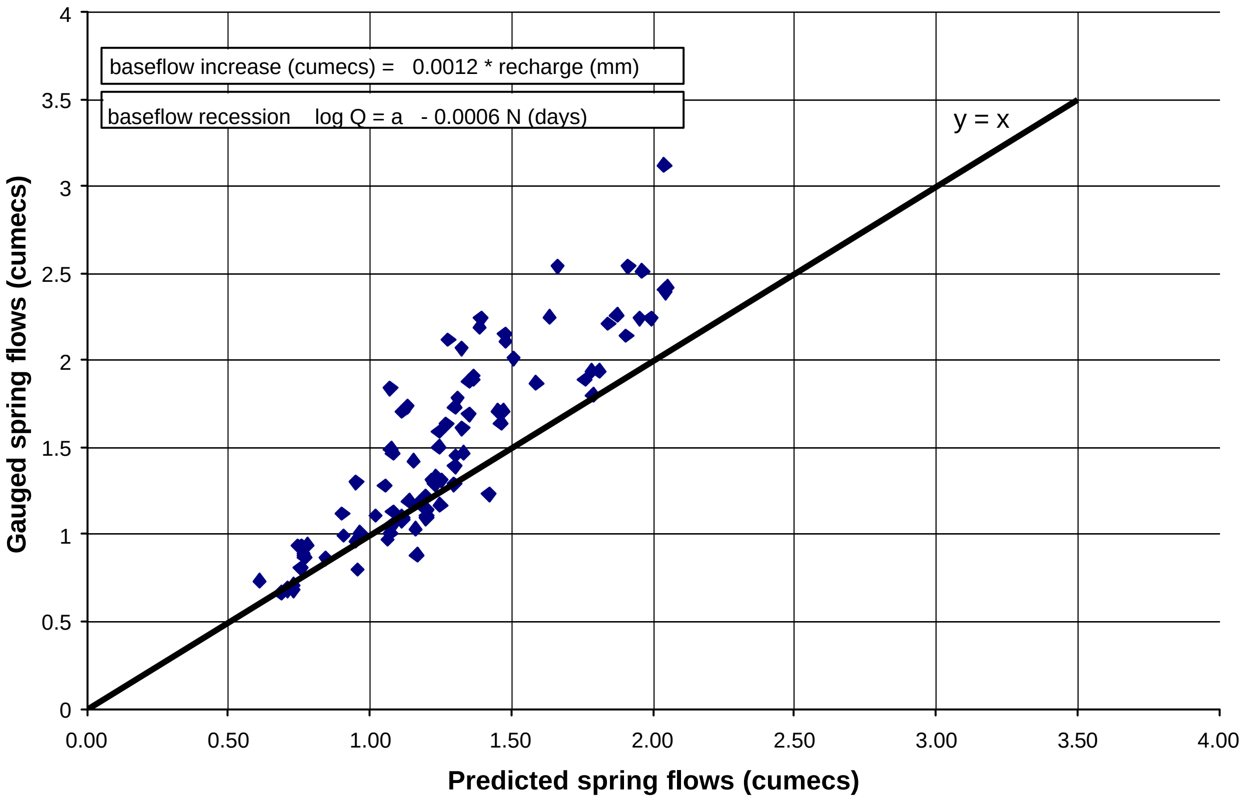
d = day

$d+1$ where 1 = number of days since previous SF_d value

This method produces a baseflow hydrograph, which represents the groundwater fed flow of the river system. It does not include the runoff or flood flow component. In order to check to validity of modelled baseflow, a comparison is made between actual gauged dry season flows and predicted synthesised baseflows for the same dates. This is in effect, a calibration stage of the modelling, and allows a basic sensitivity analysis to be carried out in order to verify or adjust the parameters and variables.

This synthesis has been carried out for the Katherine River (GS814001) and the results are shown in Figures 6 and 7 and in Appendix B.

Figure 6 Comparison between predicted and actual groundwater fed flows for the Katherine River at the Low Level Crossing, 3km downstream of GS8140001



The gauged flows at the Low Level Crossing represent only a portion of the dry season flow which is fed from the Tindall Limestone aquifer. The gauging site GS8140001 at Galloping Jacks was established to gauge flows for the total dry season flow fed by the Tindall Limestone aquifer. Data plotted in Appendix B (Figure B6) indicates flow at GS8140301 is 17% greater than flows at the Low Level Crossing. This relationship has been used to synthesise groundwater fed flows at GS8140301 (refer Figure 8). This data represents the flow record for discharges into the Katherine River from the regional aquifer developed in the Tindall Limestone.

Figure 7 Synthesised groundwater fed flows from the regional Tindall Limestone Aquifer into the Katherine River at Low Level Crossing, 3km downstream of GS8140001.

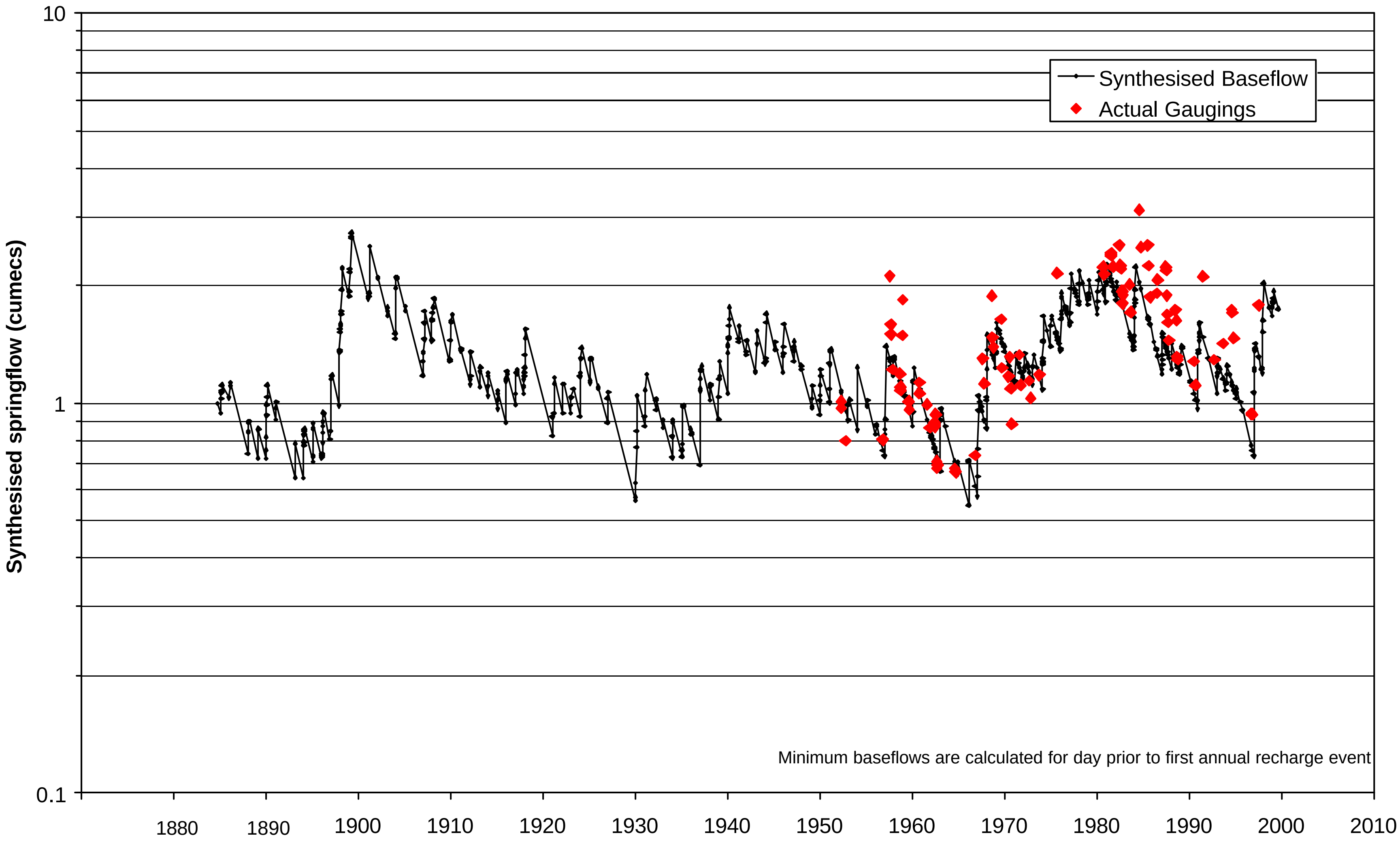
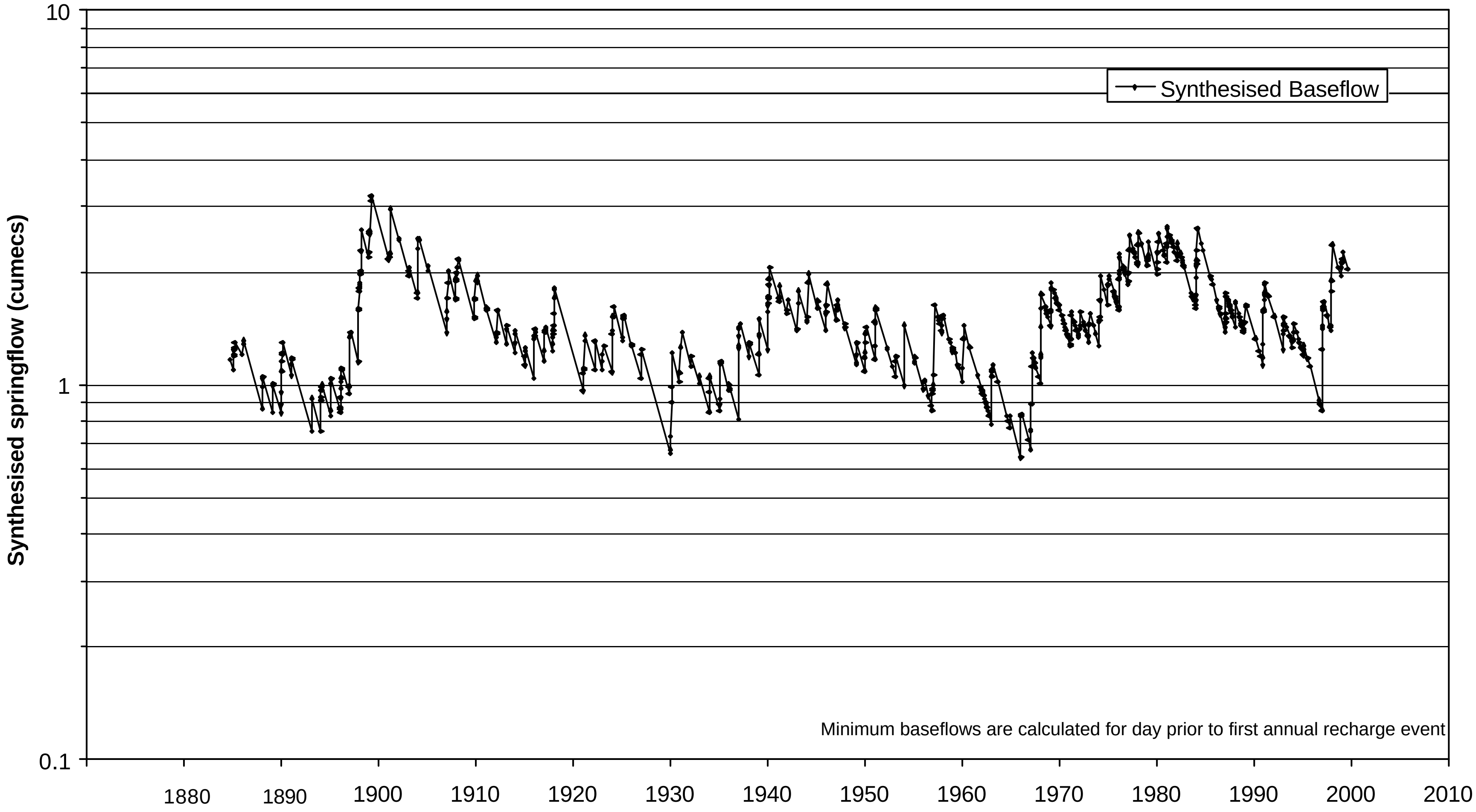


Figure 8 Synthesised groundwater fed flows from the regional Tindall Limestone Aquifer into the Katherine River at Galloping Jacks, GS8140301



7. Summary

Relationships have been developed between groundwater fed flows at 6 gauging stations and time (signified in graphical form by Log Q vs Time). Those Gauging Stations are :

1. G8140044 Flora River
2. G8140001 Katherine River at Railway Bridge
3. G8140301 Katherine River at Galloping Jacks
4. G8140067 Daly River at Dorisvale Crossing
5. G8140063 Douglas River
6. G8140040 Daly River at Mount Nancar

There appears to be two distinct relationships at all stations (except GS8140063). One is controlled by discharge from the regional aquifer, the other is controlled by discharge from the aquifer adjacent to the river, discharge which has been derived from recharge from wet season river flows.

Analysis of Katherine rainfall records and dry season baseflows in the Katherine River has allowed the synthesis of the groundwater components of flows fed by discharges into the Katherine River from the regional aquifer system developed in the Tindall Limestone.This has been done for the period 1885 to present. This analysis indicated that these groundwater fed flows range between a low of approximately 0.65cumecs (1930 and 1966), and a high of about 2.5cumecs (around 1900 and 1980).

8. Recommendations

1) Refine the recharge estimations derived from Katherine rainfall data. This refinement should initially focus on quantifying runoff for the various times of the wet season.
2) Further develop the relationship between near river recharge to the aquifer during the wet season, and subsequent discharge to the Katherine River.
3) Redo the synthesis of groundwater fed flows to the Katherine River once (1) and (2) are completed.
4) Undertaking similar exercises for groundwater fed flows at gauging stations GS8140044, GS8140063, GS8140067 and GS8140040.
5) Determine the reason for the apparent increase in dry season flow at GS8140044 on the Flora River.
6) Utilise the data gained in these studies to calibrate regional groundwater flow models for aquifers developed in the Tindall Limestone and Oolloo Limestone in the Daly Basin.

Appendix A

Flora River

GS8140044 is located upstream of Kathleen Falls on the Flora River. This gauging station is situated on a large waterhole that extends from Kathleen Falls, eleven kilometres upstream to where the river narrows into a smaller watercourse. A recorder has been installed for 34 years, although in that time only 27 gaugings have been carried out.

Hydrographs display the relationship between discharge and time over the period of a gauging station's operational existence. This set of data for GS8140044 was the first to be considered, as hydrographs are a visual representation of the behaviour of a river's flow. As emphasis in this study has been placed on low flows, most attention has been given to the period encompassing the dry season, especially between the months of April and October.

The Flora River was a difficult river to study, since water levels, in many cases, rose over the dry season. As a general rule, during the dry season, water levels drop, as shown in the hydrographs. However, this rule did not always seem to apply in the case of the Flora River. A hydrogeological formation known as tufa occurs prominently along the length of the Flora River. Deposits of carbonate build up during the dry season and combine to form what are known as tufa dams. These 'dams' interfere with water level readings obtained from the gauging station on the bank of the river. Quite often when the flow readings have been distorted it is because during the dry season instead of water levels decreasing, they appear to increase due to the tufa dams.

A straight-line relationship should exist between the hydrograph depicting the log of river flow for each year. However, the limited data indicated that 2 slopes occurred, a steep slope for the early dry season and a shallower one for the late dry season. It is thought that the steeper line is due to discharge resulting from recharge close to the river, or from Mathieson Creek, where it overlies the Tindall Limestone. The flatter line represents the impact of outflows from the regional aquifer in the Tindall Limestone, which underlies the large to the south of, and including, the Dry River.

Due to the poor low flow control and paucity of gaugings, the straight line relationship has been estimated based on only a few low flow gaugings.

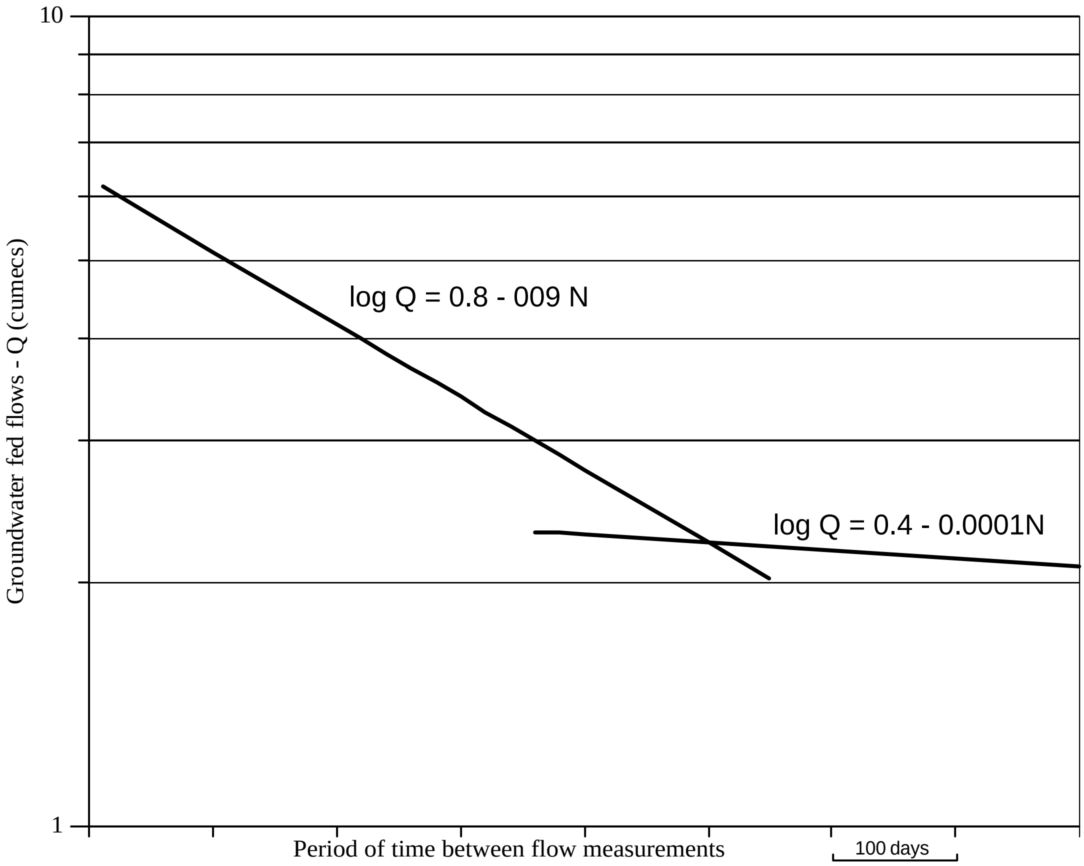
The estimated relationships are :

Log Q = 0.8 - 0.009 N (steep slope)

Log Q = 0.4 - 0.0001 N (shallow slope)

Detailed fieldwork is required at this site to further refine the above equations.

Figure A1 Relationship between groundwater fed flow and time for Flora River at GS8140044



List of Gaugings for GS8140044

Gauge No	Date	Start Time	Flow
1	07/01/1966	1400	2.68
2	16/08/1966	1415	2.76
3	29/08/1967	930	2.89
4	13/09/1968	900	2.73
5	19/11/1968	1545	2.69
6	29/09/1970	0	3.43
7	07/03/1984	1520	483
8	07/03/1984	1745	456
9	08/03/1984	800	194
10	08/03/1984	1050	153
11	07/06/1984	855	4.68
12	22/08/1984	1540	3.78
13	04/10/1984	1515	3.58
14	25/07/1985	910	3.45
15	15/08/1986	830	3.7
16	15/08/1989	1615	3.76
17	03/10/1989	1145	2.97
18	16/06/1990	1035	3.44
19	03/06/1991	1500	3.54
20	26/08/1992	815	3.231
21	16/06/1993	814	3.352
22	21/09/1994	845	3.48
23	01/08/1995	1110	3.341
24	14/05/1996	910	3.298
25	15/06/1998	1120	2.335
26	07/10/1998	1100	3.608
27	25/08/1999	1156	3.33

• **Table A1**
List of Gaugings for GS8140044 – Flora River

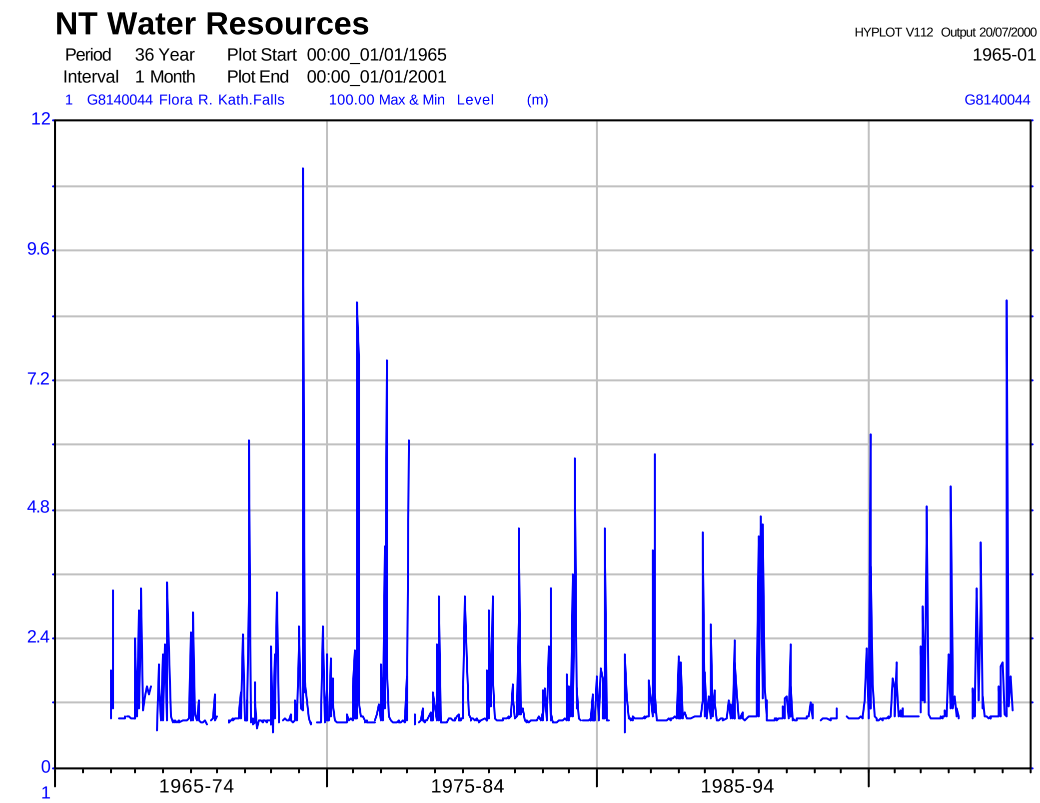


Figure A2(a) Max and Min water levels GS8140044

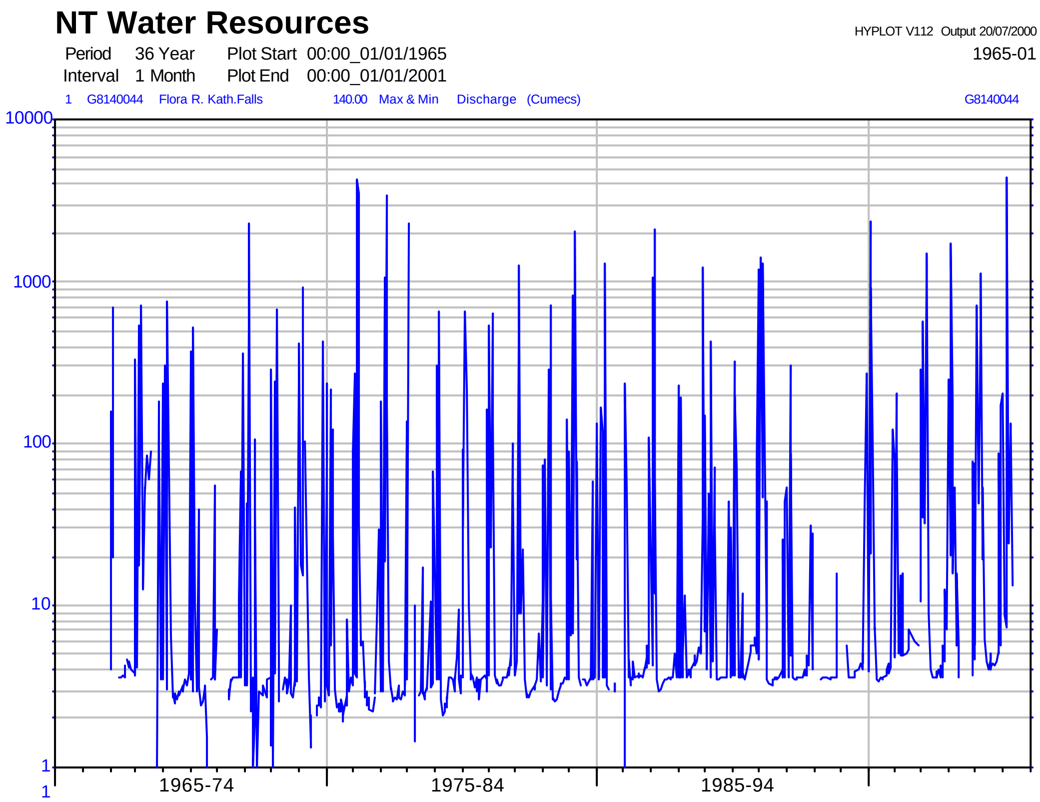
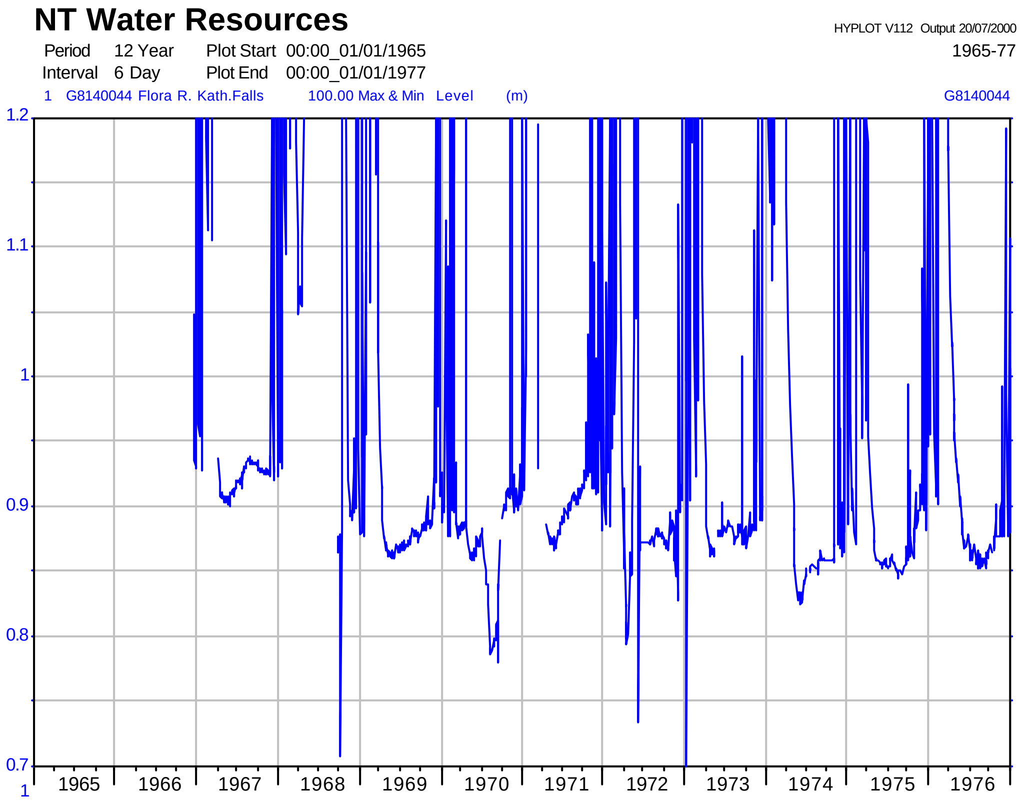
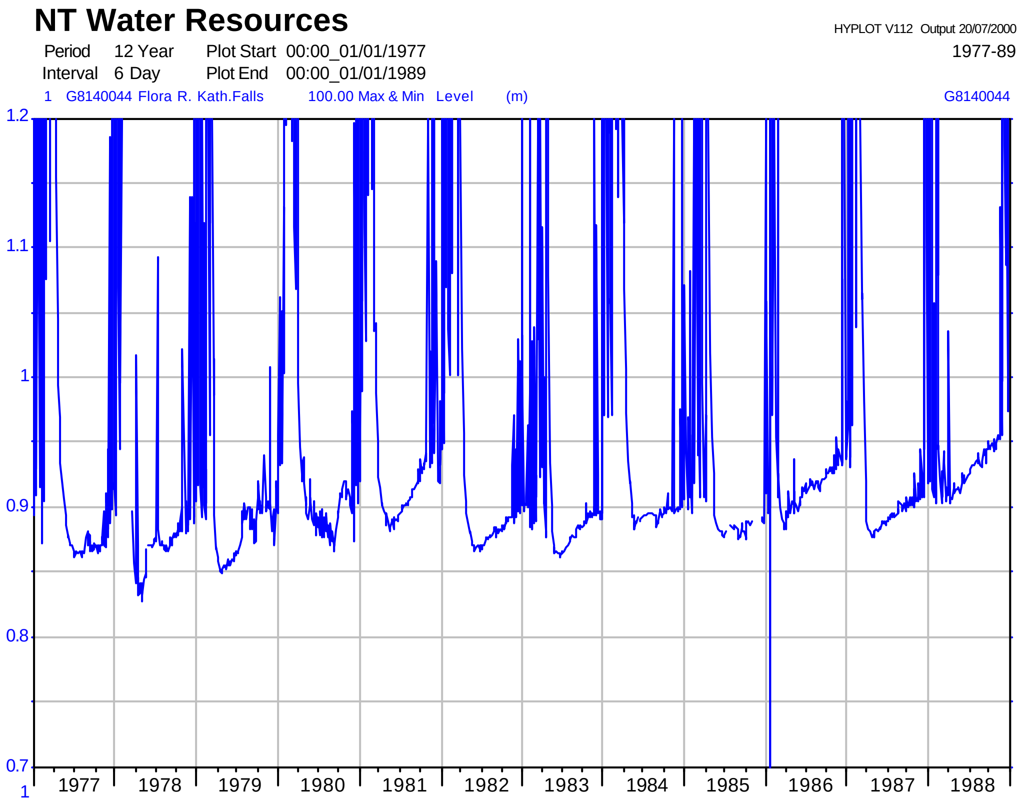


Figure A2(b) Max and Min discharge (cumecs) GS8140044

Figures A2 (c,d,e) Expanded Minimum Discharge Hydrographs GS8140044



(c)



(d)

(e)

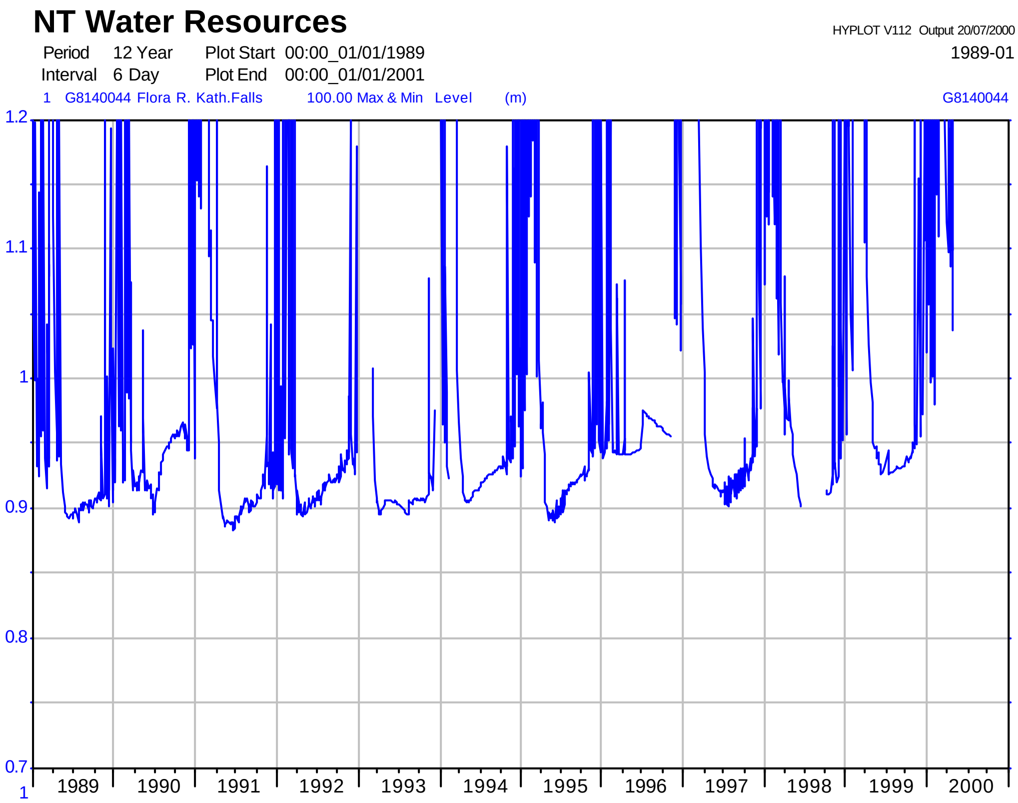

NT Water Resources
HYPLOT V112 Output 20/07/2000
Period 12 Year Plot Start 00:00_01/01/1989
Interval 6 Day Plot End 00:00_01/01/2001
1989-01
1 G8140044 Flora R. Kath.Falls 100.00 Max & Min Level (m)
G8140044
1.2
1.1
1
0.9
0.8
0.7
1
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000

Photo A1 Flora River Gauging Station

Photo A2 Spring flowing into the Flora River

Photo A3 Spring flowing into the Flora River

Photo A4 Spring flowing into the Flora River

Photo A5 The springs and the limestone bank of the Flora River

Photo A6 Kathleen Falls on the Flora River

Photo A7 Aerial photograph of a tufa dam on the Flora River

Photo A8 Tufa formations on the river

Photo A9 Aerial photograph of Kathleen Falls, Flora River

Photo A10 Tufa formations

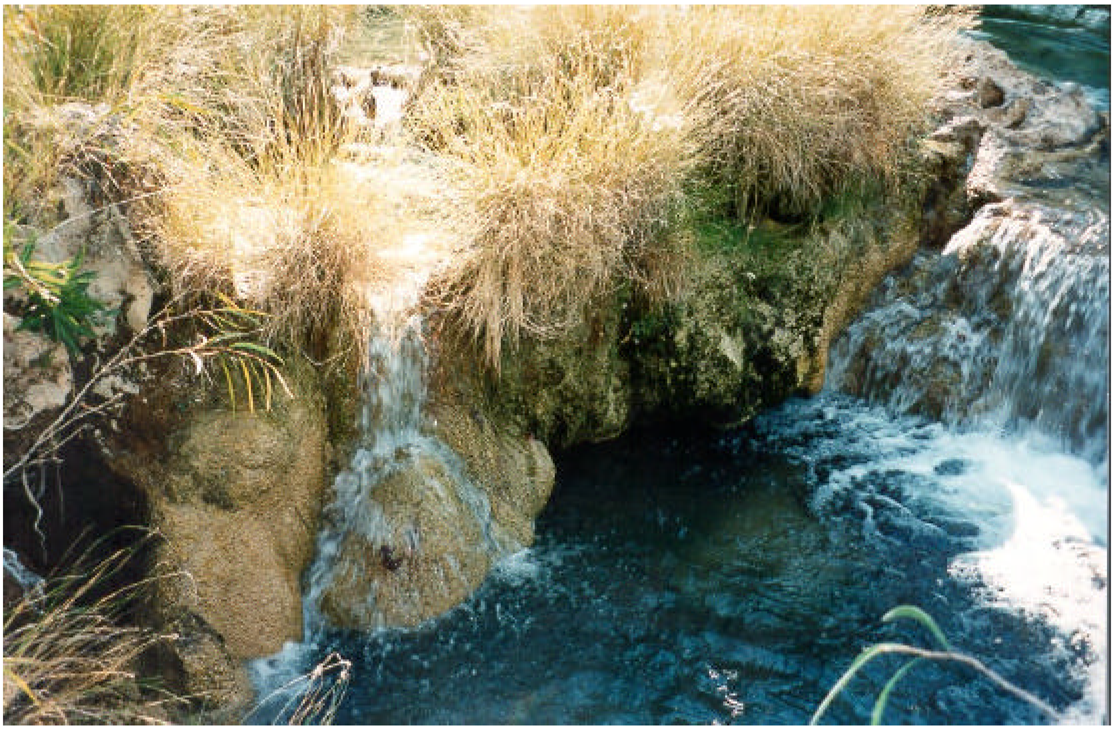


Photo A11 Limestone bank of the Flora River

Photo A12 Limestone bank of the Flora River

Photo A13 Confluence of the Flora River and Mathison Creek

Appendix B

Katherine River

The gauging station GS8140001, while located at the Railway Bridge on the Katherine River, is rated to measure groundwater fed flows at the Low Level Crossing, 3km downstream of GS8140001. GS8140301 is located at Galloping Jacks, a rapids section approximately 15km downstream of the Low Level Crossing.

Hydrographs from the program HYDSYS were used to give an idea as to the general behaviour of the river at GS8140001 throughout the years. A continuous recorder has been installed here since 1960, and gaugings have been carried out at the Low Level crossing since 1952. It can be seen from the hydrograph plots that there are two distinct recession responses during the dry season. For dry season recession following average to below average rainfall years, the recession reaches a relatively flat slope from september onwards. After higher rainfall years, the recession has a much steeper slope, and may not reach the expected shallow baseflow slope at all. This response has been attributed to bank storage and shallow aquifer systems that are activated only after river levels have reached a certain height. In other words, controlled by groundwater discharge emanating from recharge close to the river (refer Figure B1, showing water levels in bores on the levee banks and remote from the river). The shallow slope is controlled by diffuse recharge or subsurface groundwater inflows into the Tindall Limestone. In order to validate this, further analysis needs to be made of river heights, recession rates and groundwater levels in the aquifers in the vicinity of the river itself.

The hydrographs were analyzed in order to ascertain the baseflow recession. The decline of the river's groundwater fed flow in the Dry Season can be represented by two equations of the form **log Q = a – bN**, where **Q** is dry season flow (cumecs), **N** is the number of days between groundwater-dominated flow in the dry season, and **a** represents the maximum groundwater fed flow. For years when river flow heights are low and recharge was estimated to be zero, the following dry season recession will tend to be dominated by discharge from the regional aquifer developed in the Tindall Limestone (eg 1985/86, 1969/70). This allows a best fit line to be fitted to the recession plot of two consecutive years.

The relationship for GS8140001 was found to be **log Q = 0.35 – 0.0006 N**

For years when river flow heights are high, and hence recharge to the aquifer near the river is high, groundwater fed flows ared dominated by discharges from the aquifer near the river. During these years the relationship was found to be :

$$\log Q = 0.95 - 0.005 N$$

After plotting the recession slope, the annual rise in baseflow due to recharge could be taken directly from the hydrographs.

The relationship between annual recharge (as previously calculated and explained in Section 4) and change in baseflow is shown in Figure B4. The line of best fit shows a linear relationship of the form :

Change in Q (in cumecs) = 0.0012 x (Recharge event in mm).

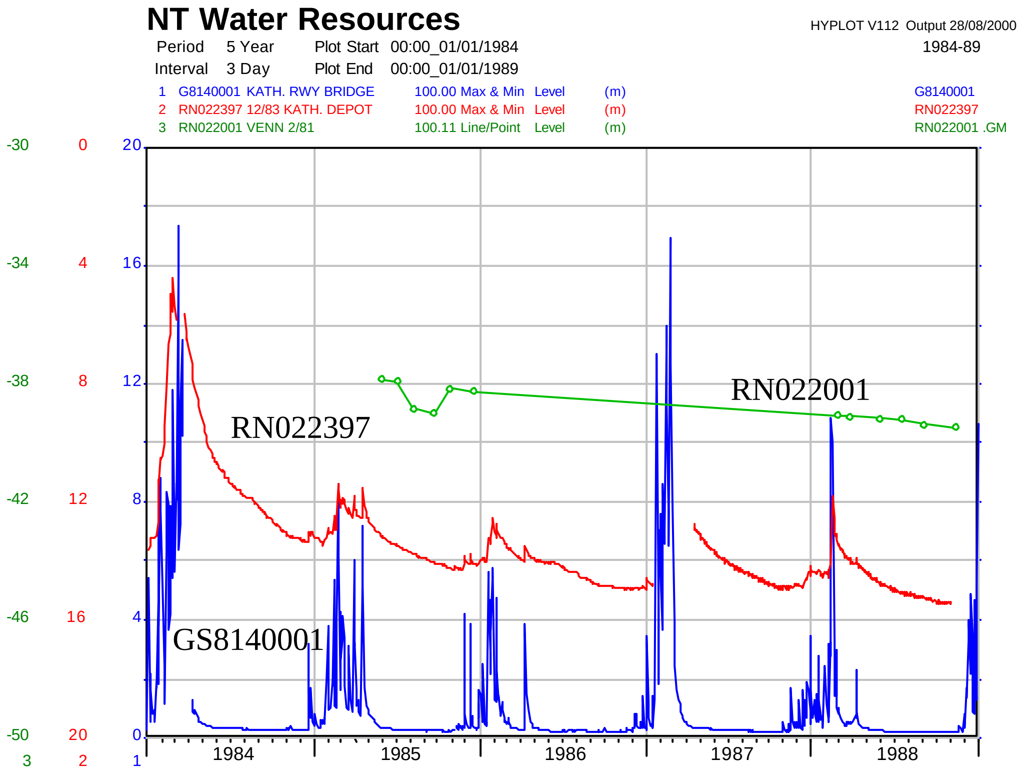
This relationship was used to calculate the change in groundwater fed flows in the Katherine River at the Low Level Crossing for each recharge event.

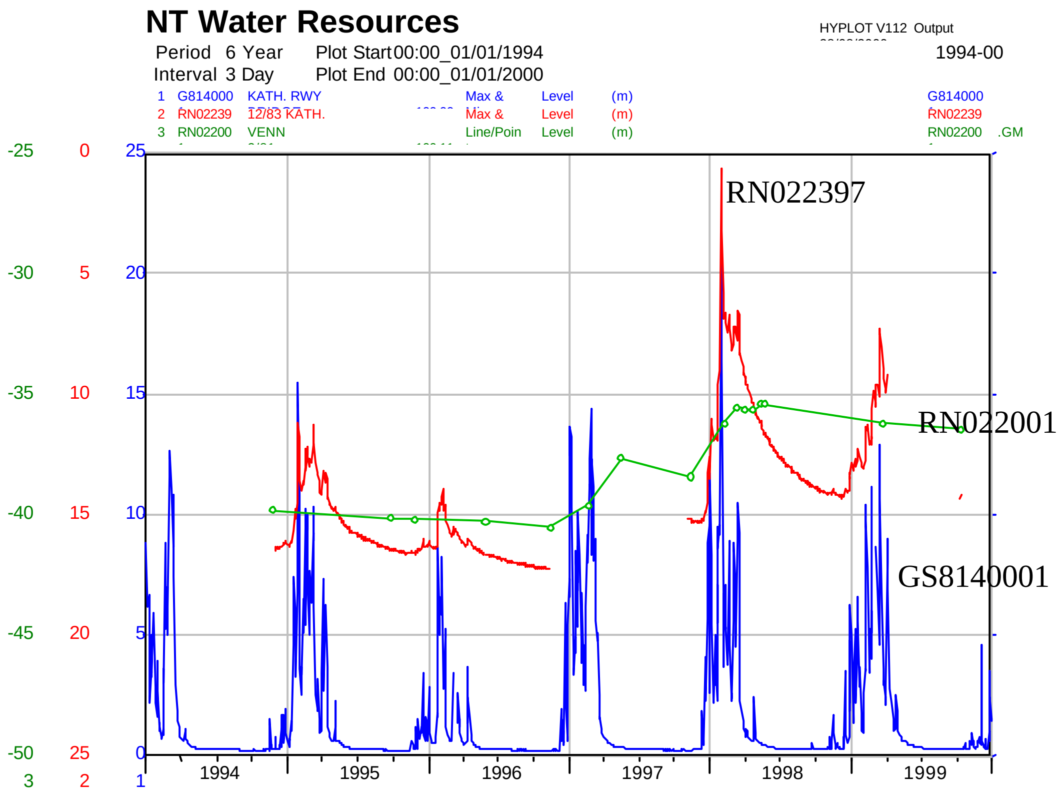
Groundwater fed flows derived from discharges from the regional Tindall Limestone Aquifer were then synthesised as shown in Figure B6. Actual gaugings are also plotted on this hydrograph.

The comparison between predicted baseflow and gauged flows are shown in Figure B5. The line of linear fit passes through the majority of the low flow gaugings. For higher flows, the model underpredicts slightly. This could be due to the higher flows being influenced by discharges from that part of the aquifer that was recharged by the Katherine River during the wet season.

A comparison has also been made between the late dry season gauged flows at the Low Level crossing and Galloping Jacks. There is a good linear relationship between baseflows at these locations, with flows at Galloping Jacks being consistently 1.17 times higher than at the Low Level crossing. This is presented in Figure B7.

Figure B1 Groundwater Levels in the Tindall Limestone Aquifer





RN022397 Located on the levee banks of the Katherine River in Katherine

RN022001 Located in the Tindall Limestone at Venn, remote from the Katherine River

Figure B2 Relationship between groundwater fed flow and time for Katherine River at GS8140001

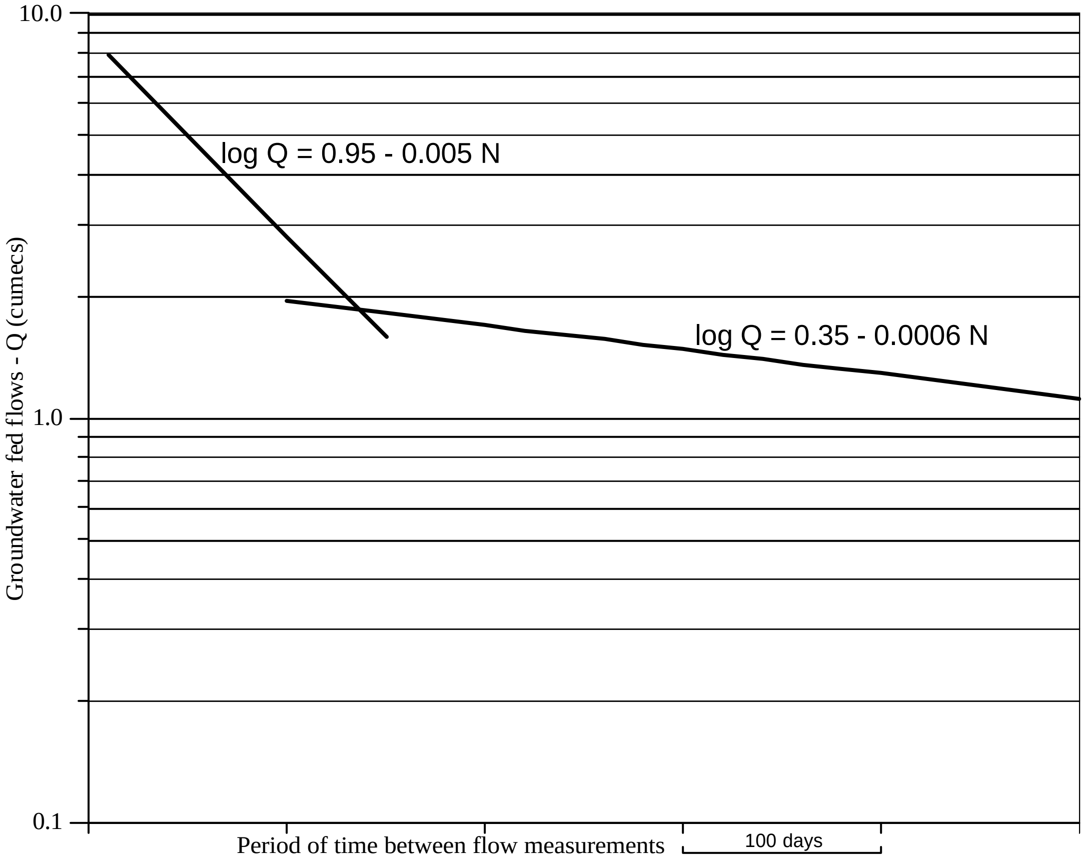


Table B1(a) List of Gaugings for GS8140001 – Railway Bridge

Gauge No	Date	Start Time	Flow	Gauge No	Date	Start Time	Flow
1	24/04/1952	0	0	53	09/08/1961	1415	0.991
2	24/04/1952	1030	1.01	54	07/12/1961	1445	0.864
3	08/05/1952	730	0.97	55	16/12/1961	1430	3.65
4	30/10/1952	1500	0.799	56	18/12/1961	1015	9.2
5	19/02/1953	1500	29.6	57	22/01/1962	1500	453
6	01/04/1953	830	19.6	58	28/03/1962	1550	3.96
7	08/04/1953	1000	156	59	04/05/1962	1650	1.08
8	08/04/1953	2330	98.5	60	08/06/1962	1640	0.87
9	30/01/1954	120	204	61	21/06/1962	1245	0.878
10	01/02/1954	910	691	62	21/06/1962	1315	0.892
11	02/02/1954	1000	301	63	28/06/1962	950	0.934
12	03/02/1954	900	188	64	27/07/1962	1635	0.934
13	04/02/1954	1045	95.3	65	05/09/1962	1420	0.68
14	15/02/1956	915	212	66	05/09/1962	1620	0.708
15	21/02/1956	1015	177	67	23/10/1962	1645	0.694
16	21/02/1956	1430	170	68	02/11/1962	1530	7
17	23/02/1956	930	117	69	20/08/1963	1515	1.27
18	30/03/1956	235	756	70	06/02/1964	1720	18.4
19	12/05/1956	830	52.7	71	01/08/1964	750	0.68
20	15/05/1956	300	29.2	72	24/09/1964	1740	0.665
21	15/05/1956	800	31.4	73	18/02/1965	930	4.25
22	16/05/1956	315	26.9	74	01/11/1966	1445	0.733
23	30/07/1956	1045	2.18	75	09/05/1967	1530	4.11
24	30/07/1956	1115	2.24	76	22/06/1967	1230	1.87
25	30/10/1956	1300	0.807	77	12/08/1967	920	1.3
26	30/10/1956	1415	0.807	78	11/11/1967	1700	1.12
27	09/03/1957	1300	2760	79	11/05/1968	1145	9.68
28	26/03/1957	1415	70	80	12/06/1968	1420	5.58
29	28/05/1957	1500	5.49	81	18/06/1968	1610	5.21
30	10/07/1957	915	2.94	82	23/07/1968	830	3.88
31	07/08/1957	1140	2.12	83	29/08/1968	845	1.88
32	18/09/1957	805	1.59	84	24/09/1968	1500	1.47
33	18/09/1957	840	1.5	85	30/10/1968	1800	1.39
34	22/11/1957	1400	1.22	86	15/04/1969	1620	11.2
35	07/12/1957	900	2.18	87	27/05/1969	1645	3.13
36	11/09/1958	1010	1.19	88	02/07/1969	1640	2.13
37	15/10/1958	1430	1.08	89	19/08/1969	900	1.64
38	15/10/1958	1510	1.1	90	18/09/1969	830	2.57
39	15/10/1958	1550	1.08	91	08/10/1969	910	1.23
40	13/12/1958	1240	1.49	92	08/04/1970	830	2.93
41	19/12/1958	1530	1.84	93	22/05/1970	820	1.81
42	13/08/1959	1320	1.01	94	30/06/1970	1000	1.17
43	08/09/1959	945	0.963	95	07/08/1970	930	1.31
44	02/02/1960	1700	309	96	05/09/1970	1655	1.09
45	03/02/1960	917	261	97	21/10/1970	1740	0.884
46	15/02/1960	1500	552	98	21/11/1970	1435	1.56
47	09/03/1960	1050	25.6	99	21/01/1971	1510	4.5
48	10/03/1960	0	20.5	100	13/07/1971	1425	2.17
49	17/10/1960	1045	1.06	101	18/08/1971	900	1.33
50	19/10/1960	1045	1.13	102	04/10/1971	900	1.11
51	11/01/1961	900	9.77	103	30/06/1972	1315	2.38
52	09/02/1961	1115	167	104	27/07/1972	1455	1.74

Gauge No	Date	Start Time	Flow	Gauge No	Date	Start Time	Flow
105	16/09/1972	1405	1.14	157	29/06/1976	1040	7.67
106	11/11/1972	855	1.03	158	07/07/1976	1123	6.31
107	17/07/1973	1725	3.23	159	14/07/1976	1100	5.77
108	08/10/1973	1420	1.18	160	21/07/1976	1120	5.63
109	21/03/1974	1915	0	161	28/07/1976	1330	5.68
110	03/07/1974	1730	6.28	162	04/08/1976	1040	4.66
111	15/08/1974	1155	3.38	163	11/08/1976	1047	4.53
112	12/09/1974	1500	6.99	164	20/08/1976	945	3.88
113	08/05/1975	1445	30.3	165	26/08/1976	1310	3.89
114	15/05/1975	1045	20.1	166	02/09/1976	1047	3.71
115	22/05/1975	1020	16.4	167	09/09/1976	932	3.46
116	28/05/1975	1407	12.7	168	21/09/1976	1055	2.92
117	02/06/1975	1455	11.9	169	27/09/1976	1450	2.81
118	09/06/1975	1340	9.69	170	04/10/1976	1115	2.76
119	18/06/1975	1045	8.23	171	11/10/1976	1140	2.7
120	25/06/1975	1115	8.68	172	01/12/1976	1600	7.68
121	07/07/1975	1440	7.15	173	11/08/1977	1358	4.64
122	15/07/1975	1520	5.56	174	30/08/1977	1445	3.41
123	19/07/1975	1000	5.61	175	27/09/1977	1405	3.06
124	07/08/1975	1415	3.62	176	28/10/1977	1500	2.59
125	14/08/1975	1320	3.33	177	22/02/1978	1610	627
126	18/08/1975	1310	3.47	178	14/03/1978	1155	58.5
127	11/09/1975	1025	2.41	179	20/03/1978	1500	31.7
128	26/09/1975	1335	2.15	180	26/06/1978	1436	4.12
129	03/10/1975	1300	2.37	181	11/09/1980	1110	2.24
130	23/10/1975	1400	3.52	182	22/10/1980	840	2.14
131	06/11/1975	1400	2.82	183	19/05/1981	840	4.6
132	25/11/1975	1440	2.65	184	17/06/1981	1045	3.18
133	28/01/1976	1430	79.3	185	14/07/1981	850	2.98
134	11/02/1976	1415	271	186	06/08/1981	833	2.77
135	16/02/1976	1110	555	187	06/08/1981	835	2.8
136	17/02/1976	1000	1070	188	06/08/1981	852	2.67
137	17/02/1976	1630	1150	189	06/08/1981	902	2.47
138	17/02/1976	2050	1180	190	06/08/1981	1000	2.7
139	18/02/1976	1410	1120	191	06/08/1981	1004	2.47
140	20/02/1976	1035	899	192	06/08/1981	1040	2.42
141	24/02/1976	1115	1110	193	06/08/1981	1100	2.6
142	25/02/1976	1515	747	194	12/08/1981	849	2.39
143	26/02/1976	900	571	195	14/08/1981	900	2.41
144	27/02/1976	1403	558	196	23/09/1981	845	2.24
145	03/03/1976	925	313	197	10/11/1981	1345	2.23
146	11/03/1976	950	1040	198	19/05/1982	1100	4.6
147	17/03/1976	915	1490	199	17/06/1982	855	3.05
148	17/03/1976	1600	1810	200	24/06/1982	1045	2.54
149	18/03/1976	830	1900	201	29/07/1982	845	2.26
150	20/03/1976	830	1440	202	25/08/1982	845	2.21
151	31/03/1976	1530	127	203	24/09/1982	1055	1.94
152	09/04/1976	1415	57.5	204	14/10/1982	1510	1.8
153	23/04/1976	1045	27.8	205	19/10/1982	1331	1.94
154	29/04/1976	1527	22.8	206	11/11/1982	830	1.89
155	05/05/1976	1440	18.4	207	20/04/1983	1100	12.1
156	02/06/1976	1350	10.2	208	06/05/1983	1340	12.7

Gauge No	Date	Start Time	Flow
209	23/05/1983	1530	5.33
210	26/07/1983	1310	2.01
211	07/09/1983	905	1.71
212	27/09/1983	1100	1.71
213	19/08/1984	1345	3.12
214	23/10/1984	1036	2.51
215	25/07/1985	1040	2.54
216	22/08/1985	1045	2.25
217	10/10/1985	0	1.87
218	26/03/1986	828	0
219	04/06/1986	850	2.28
220	18/06/1986	1055	1.91
221	11/08/1986	1040	2.07
222	12/02/1987	1408	815
223	13/02/1987	1002	1210
224	13/02/1987	1406	1280
225	14/02/1987	1301	1430
226	16/02/1987	1413	1010
227	17/02/1987	1005	735
228	18/02/1987	932	567
229	19/02/1987	1004	501
230	20/02/1987	958	386
231	22/02/1987	901	2380
232	22/02/1987	1406	2410
233	24/02/1987	1008	1900
234	25/02/1987	1336	1210
235	26/02/1987	1401	1170
236	27/02/1987	1013	886
237	02/04/1987	1330	12.3
238	13/04/1987	1400	7.33
239	23/04/1987	1330	6.67
240	29/04/1987	1300	5.56
241	08/05/1987	1120	4.98
242	14/05/1987	1335	4.13
243	05/06/1987	1400	2.93
244	09/06/1987	1230	2.97
245	17/06/1987	1350	2.65
246	08/07/1987	1355	2.24
247	16/07/1987	1030	2.19
248	11/08/1987	1325	1.89
249	31/08/1987	1415	1.69
250	29/09/1987	1340	1.61
251	28/10/1987	1005	1.45
252	11/02/1988	920	154
253	11/02/1988	1325	134
254	24/02/1988	950	106
255	25/02/1988	850	55.3
256	26/02/1988	900	43.5
257	29/02/1988	910	38.9
258	01/03/1988	840	29
259	02/03/1988	900	24
260	03/03/1988	850	19.6
261	04/03/1988	850	16.1
262	17/03/1988	910	16.8
263	20/04/1988	850	7.14
264	08/06/1988	1120	2.16
265	12/07/1988	1505	1.73
266	19/08/1988	820	1.63
267	14/09/1988	1320	1.31
268	12/10/1988	900	1.29
269	29/06/1989	1455	4.51
270	18/07/1990	816	1.28
271	12/09/1990	850	1.11
272	16/07/1991	835	2.11
273	25/09/1992	1140	1.29
274	26/05/1993	1200	2.973
275	01/09/1993	803	1.421
276	07/06/1994	817	3.729
277	16/08/1994	1108	1.735
278	15/09/1994	1138	1.705
279	03/11/1994	1416	1.468
280	20/07/1995	1126	3.403
281	14/10/1995	1218	1.729
282	19/09/1996	1521	0.938
283	08/11/1996	854	0.935
284	01/05/1997	1251	8.178
285	22/07/1997	1054	1.783
286	11/11/1997	1512	2.106
287	28/01/1998	1333	8400
288	27/01/1998	0	9300
289	06/10/1998	743	3.381
290	07/09/1999	1106	3.385

Table B1(b) List of Gaugings for GS8140301 – Galloping Jack's

Gauge No	Date	Start Time	Flow
1	15/08/1974	1700	4.08
2	25/06/1975	1425	8.86
3	19/07/1975	1125	6.02
4	18/08/1975	1445	3.99
5	11/09/1975	1525	2.89
6	29/06/1976	1455	9.1
7	07/07/1976	1430	7.19
8	14/07/1976	1400	6.72
9	21/07/1976	1415	6.22
10	28/07/1976	1600	6.23
11	04/08/1976	1300	5.69
12	11/08/1976	1437	5.25
13	20/08/1976	1110	4.76
14	26/08/1976	1510	4.55
15	02/09/1976	1435	4.19
16	09/09/1976	1115	4.16
17	21/09/1976	1445	3.63
18	27/09/1976	1630	3.1
19	04/10/1976	1440	3.16
20	11/10/1976	1440	3.3
21	11/08/1977	1602	5.17
22	27/09/1977	1537	3.19
23	11/09/1980	1445	2.81
24	19/05/1981	1140	5.4
25	17/06/1981	847	4.42
26	14/07/1981	1110	3.58
27	11/08/1981	1345	2.82
28	23/09/1981	1100	2.61
29	10/11/1981	1540	2.57
30	19/05/1982	1455	5.21
31	17/06/1982	1040	3.36
32	29/07/1982	1035	2.93
33	25/08/1982	1020	2.53
34	24/09/1982	1000	2.53
35	19/10/1982	920	2.34
36	11/11/1982	1040	2.42
37	24/05/1983	1430	5.61
38	24/06/1983	900	2.88
39	26/07/1983	1000	2.26
40	07/09/1983	1120	1.93
41	27/09/1983	856	1.87
42	30/09/1983	900	1.65
43	15/08/1984	930	3.91
44	25/07/1985	840	3.29
45	22/08/1985	845	2.42
46	10/10/1985	0	2.36
47	18/06/1986	920	2.19
48	11/08/1986	1250	2.37
49	09/06/1987	1025	3.65
50	12/08/1987	1506	2.42
51	02/09/1987	948	1.97
52	29/09/1987	1005	1.86
53	13/07/1988	1350	1.83
54	18/07/1990	920	1.46
55	12/09/1990	945	1.35
56	16/07/1991	925	2.6
57	21/07/1992	1419	1.624
58	25/05/1993	1455	3.36
59	31/08/1993	1430	1.767
60	06/06/1994	1630	4.109
61	15/09/1994	1545	1.801
62	03/11/1994	1302	1.693
63	20/07/1995	808	3.751
64	14/10/1995	958	1.864
65	19/09/1996	1434	1.157
66	03/10/1998	1152	4.319
67	15/07/1998	1458	5.623

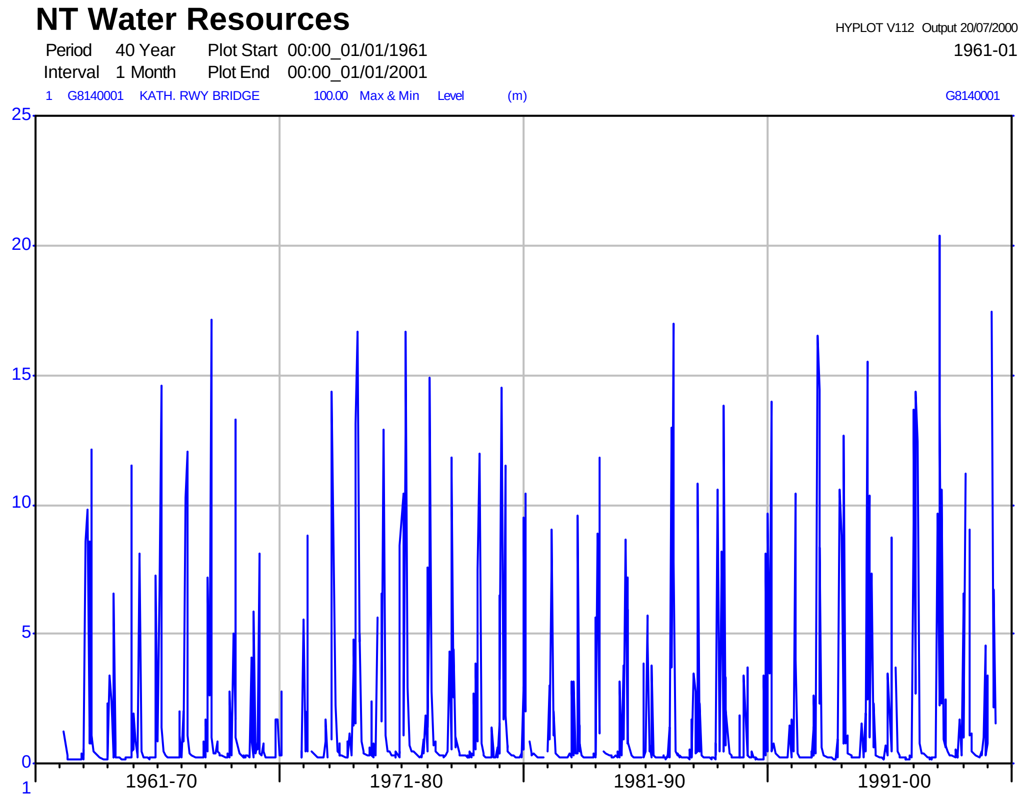


Figure B3(a) Maximum and Minimum Water Levels GS8140001

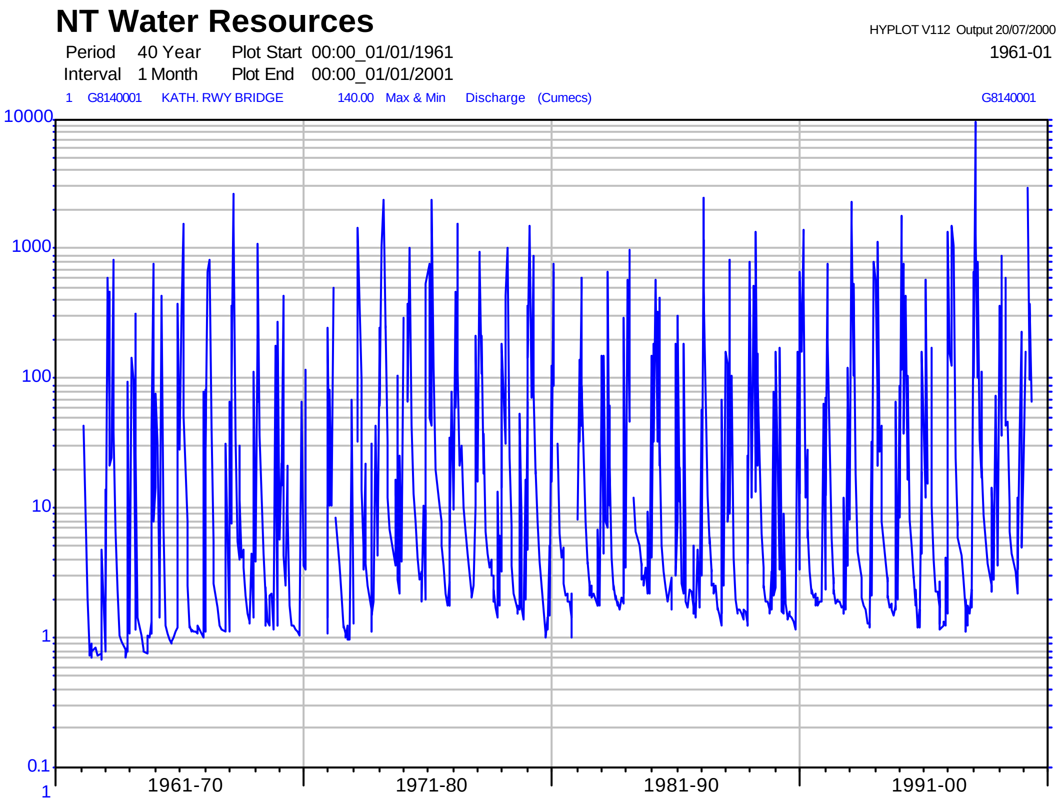
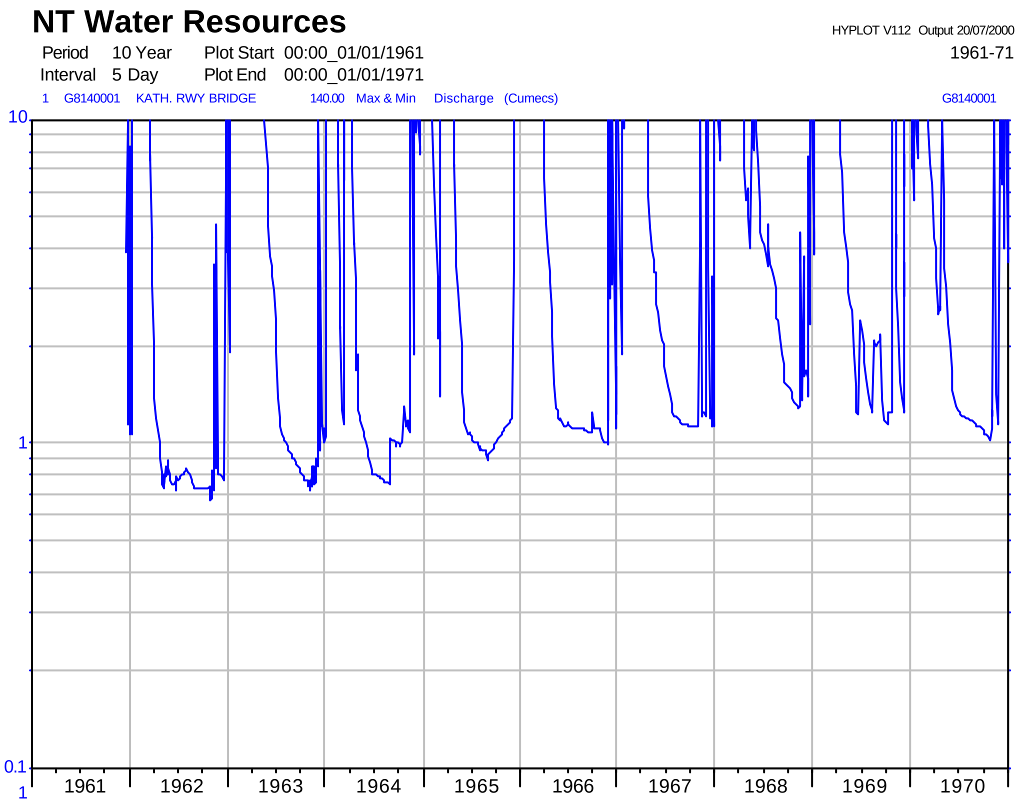
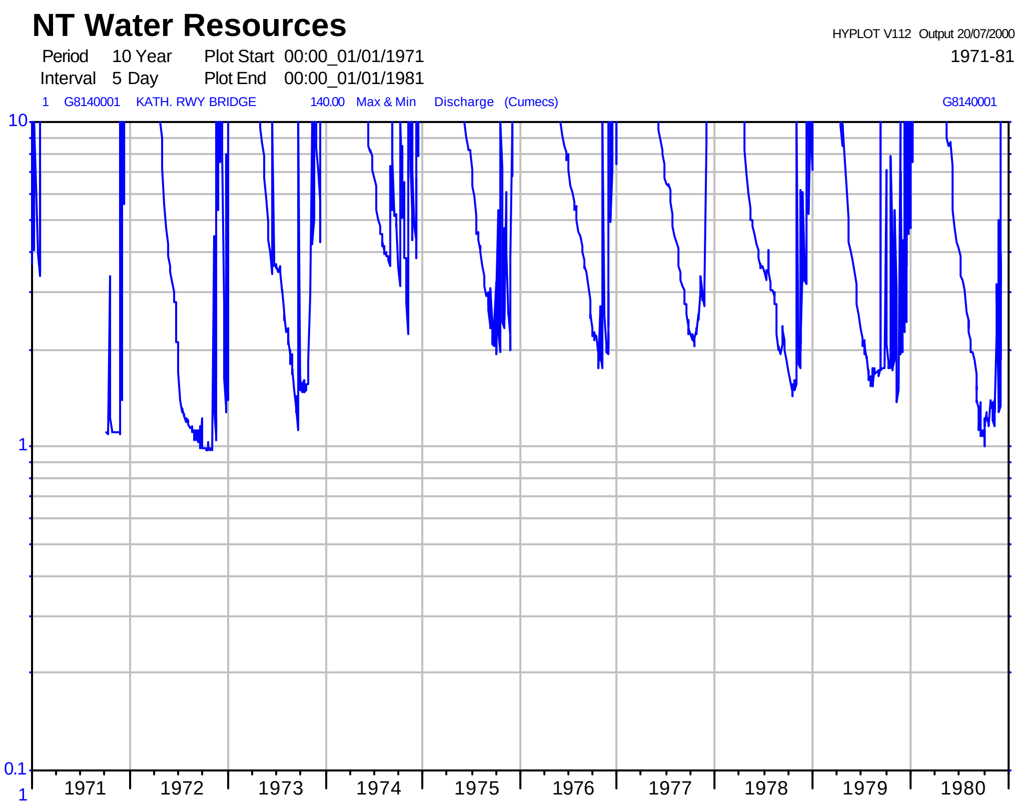


Figure B3(b) Maximum and Minimum Discharge (cumecs) GS8140001

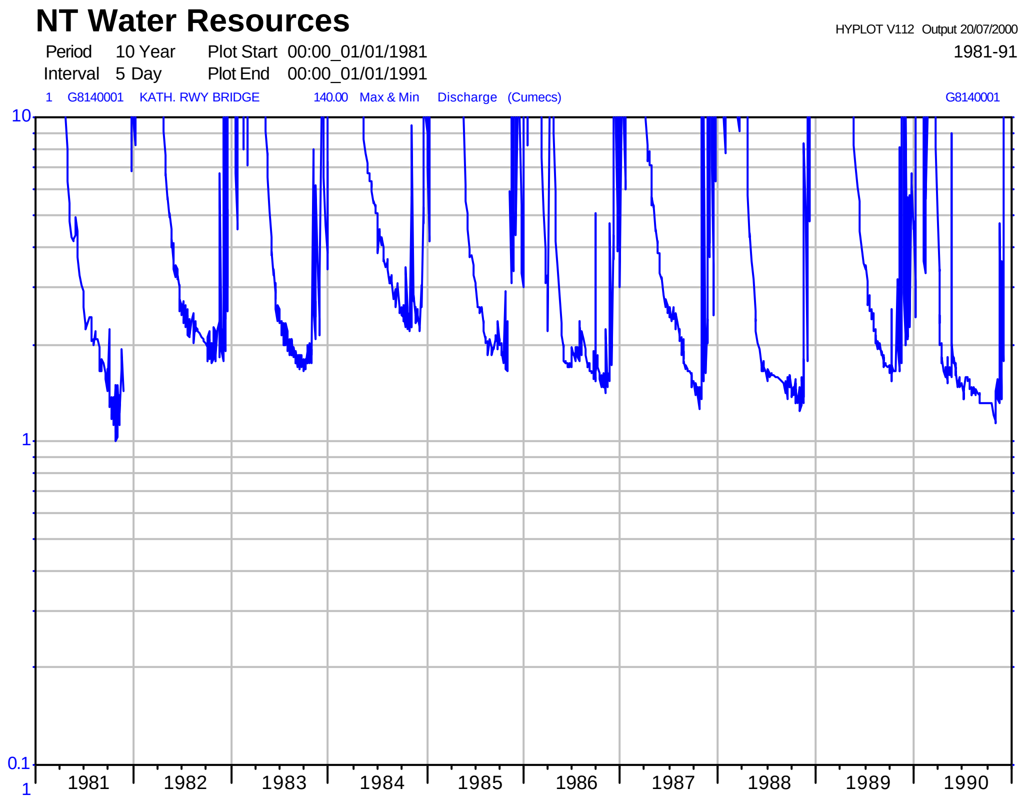
Figure B3(c,d,e,f) Expanded Minimum Discharge Hydrograph GS8140001



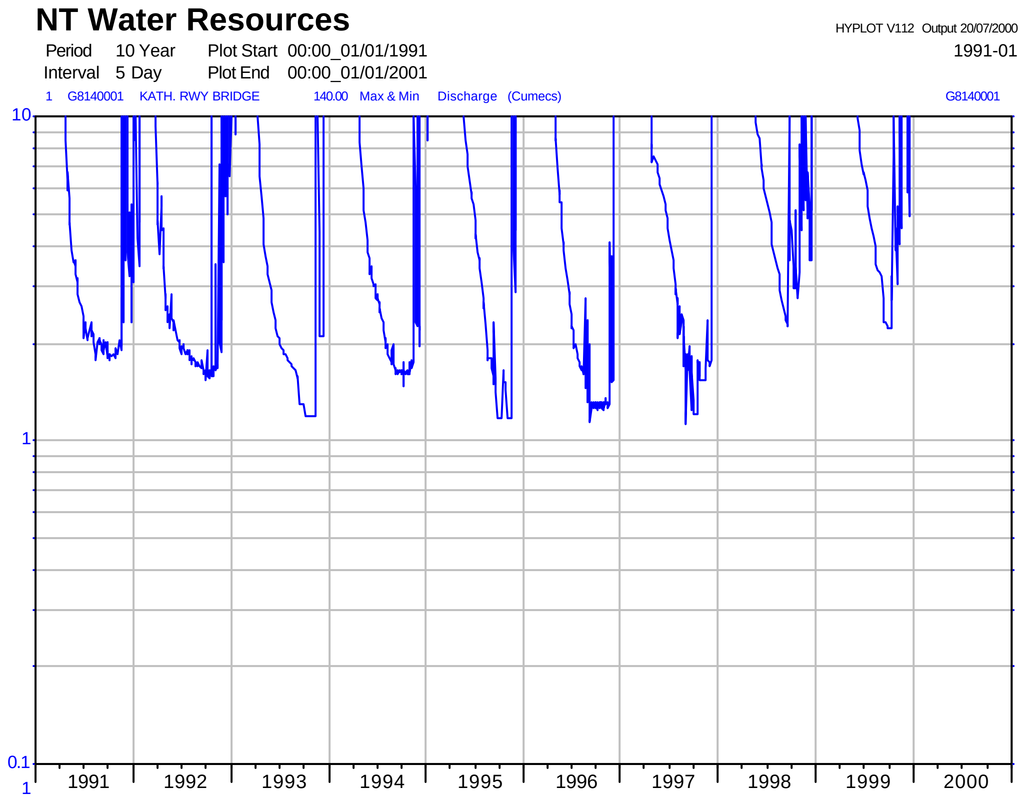
B3(c)



B3(d)


NT Water Resources
HYPLOT V112 Output 20/07/2000
Period 10 Year Plot Start 00:00_01/01/1981
Interval 5 Day Plot End 00:00_01/01/1991
1981-91
1 G8140001 KATH. RWY BRIDGE 140.00 Max & Min Discharge (Cumecs)
G8140001
10
1
0.1
1
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990

B3(e)


NT Water Resources
HYPLOT V112 Output 20/07/2000
Period 10 Year Plot Start 00:00_01/01/1991
Interval 5 Day Plot End 00:00_01/01/2001
1991-01
1 G8140001 KATH. RWY BRIDGE 140.00 Max & Min Discharge (Cumecs)
G8140001
10
1
0.1
1
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000

B3(f)

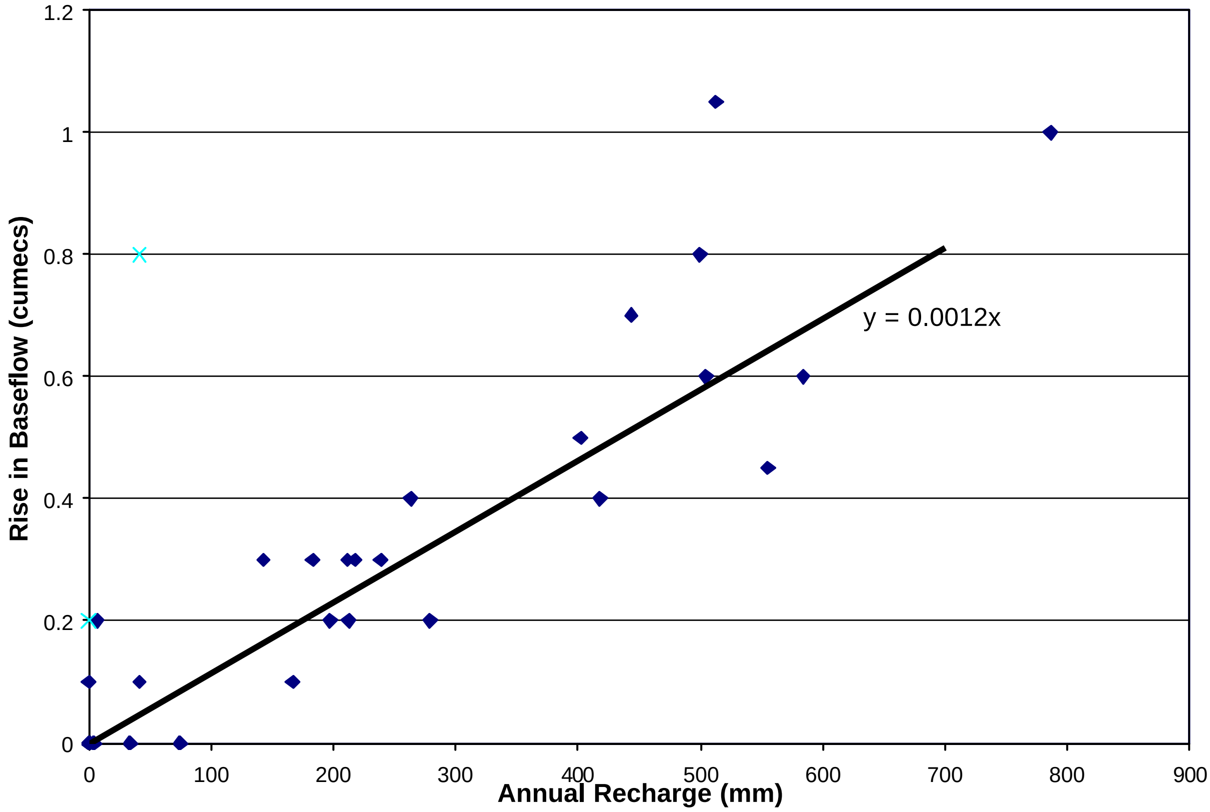


Figure B4 Relationship between increase in springflow and annual recharge for Katherine River at Low Level Crossing, 3km downstream of GS8140001.

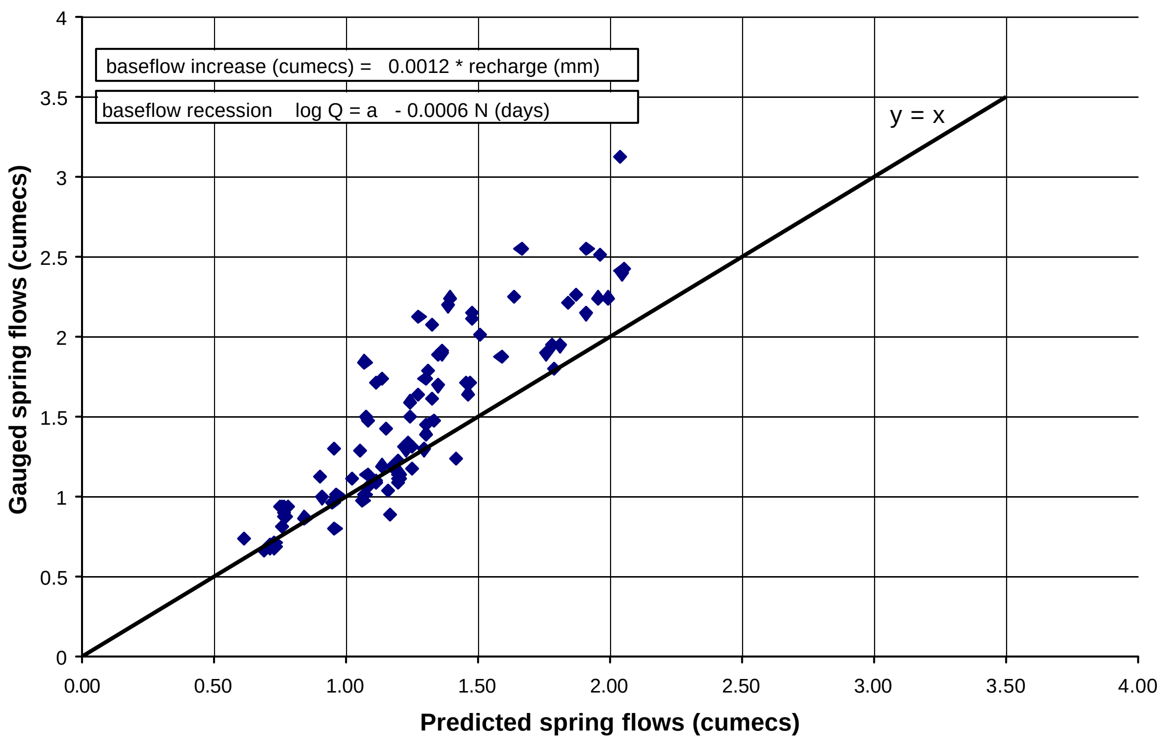


Figure B5 Comparison between predicted and actual baseflows for Katherine River at Low Level Crossing, 3km downstream of GS8140001.

Figure B6 Synthesised groundwater fed flows the regional Tindall Limestone Aquifer into the Katherine River at the Low Level Crossing, 3km downstream of GS8140001

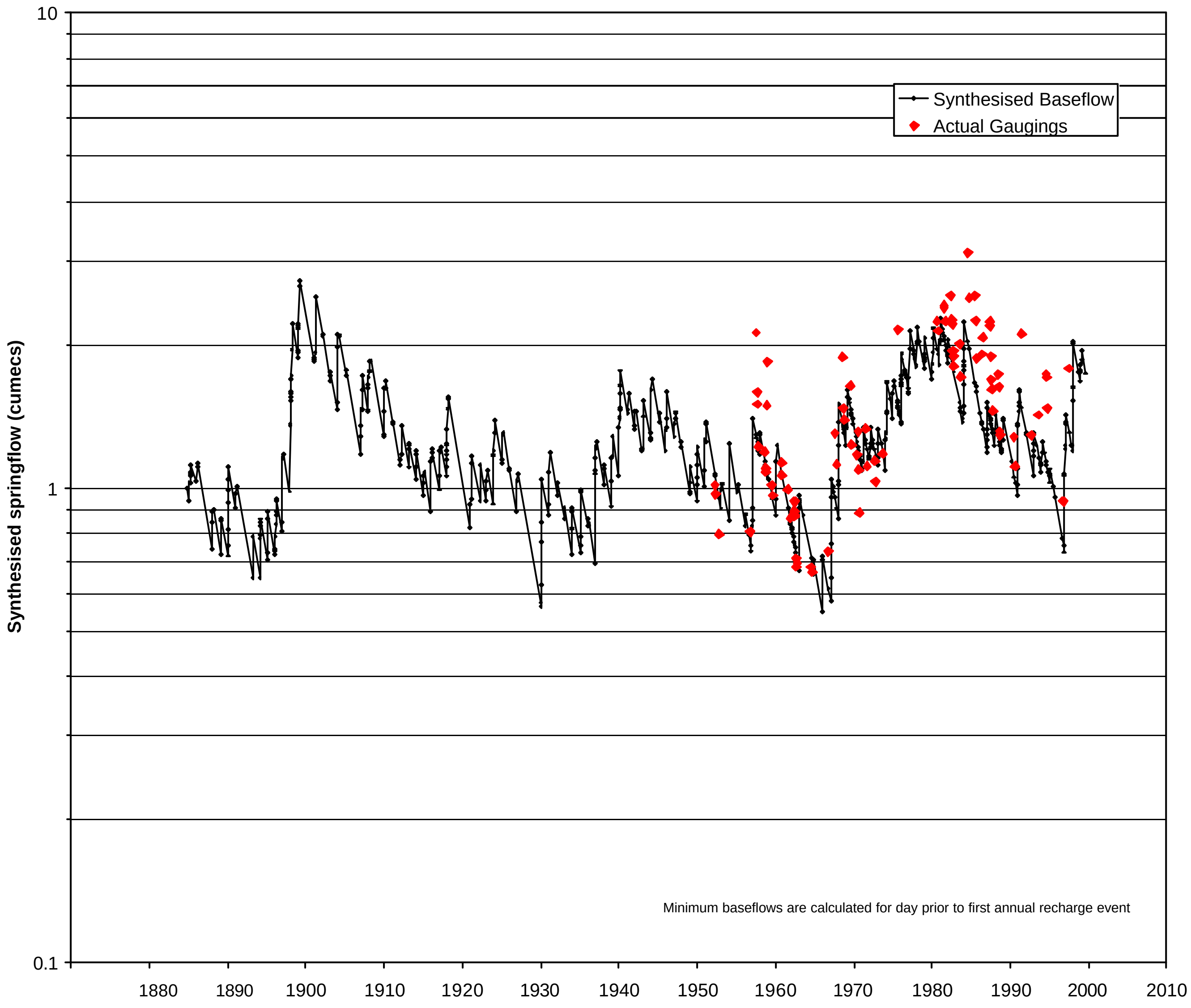


Figure B7 Comparison between the gauged flows for the gauging stations GS8140001 and GS8140301

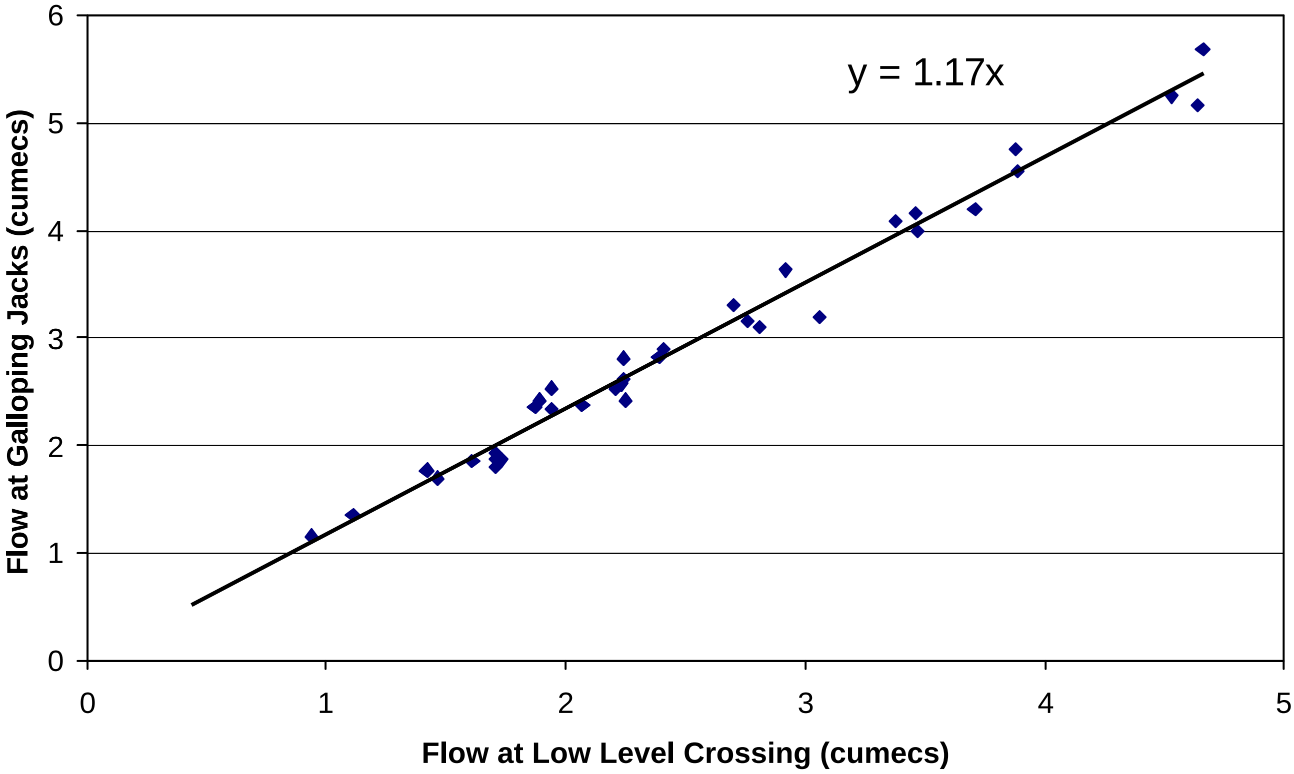


Photo B1 Katherine River at Low Level Crossing

Appendix C

Daly River at Dorisvale

GS8140067 was established and surveyed in 1957. The station is located 3km downstream of Dorisvale station upstream of the road crossing on the Daly River.

The hydrographs from GS8140067 were used to estimate the average slope of the decline in flow and discharge over the Dry Season. Where inconsistencies occurred between the hydrograph and gauged flows, the gauged flow data was used to estimate the average slope. In the gauging station file, there were several notes about changes that had happened in the surrounding environment that impacted on the low flow control. The road crossing that is situated downstream of the gauging station was improved, and subsequently raised, several times over the period of the station's operation. Other changes that occurred involved minor alterations to the road and a new station coming into operation.

There is a good record of gaugings for this station, from 1957 to present. Analysis of the dry season gaugings showed that the baseflow recession has two components, for the early and late Dry Season respectively.

The relationships were found to be :

Log Q = 1.08 - 0.002 N (steep/early)

Log Q = 0.75 - 0.0004 N (shallow/late)

Figure C1 Relationship between groundwater fed flow and time for Daly River at Dorisvale GS8140067

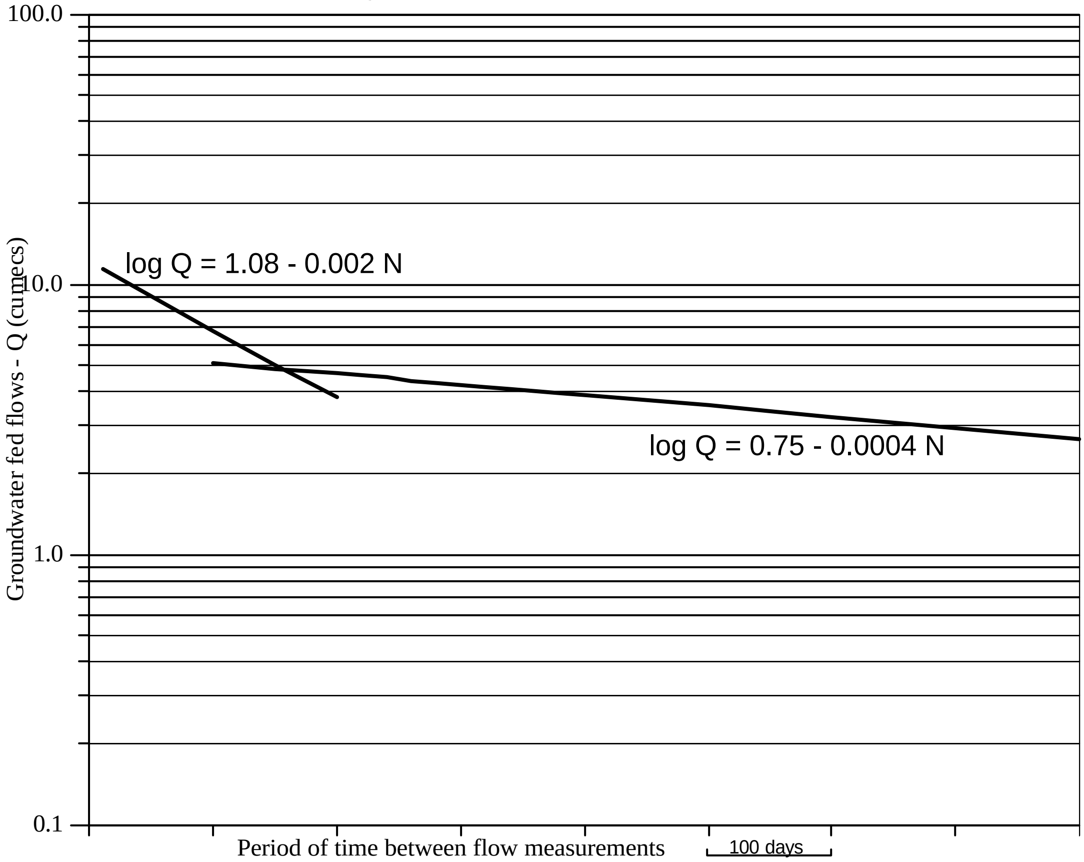


Table C1 List of Gaugings for GS8140067 – Dorisvale Crossing, Daly River

Gauge No	Date	Start Time	Flow	Gauge No	Date	Start Time	Flow
1	29/07/1957	1730	5.8	53	03/04/1965	1820	428
2	20/02/1958	1055	56.6	54	04/04/1965	1005	333
3	20/02/1958	1630	94.9	55	04/04/1965	1450	300
4	21/02/1958	915	133	56	04/04/1965	1800	278
5	28/02/1959	1055	82.1	57	20/05/1965	1515	4.96
6	28/02/1959	1545	77.9	58	15/10/1965	1300	2.17
7	03/02/1959	930	93.4	59	10/05/1965	1330	4.39
8	03/12/1960	1605	35.4	60	16/08/1966	1645	2.94
9	04/06/1960	1430	66.5	61	17/05/1967	830	6.94
10	04/08/1960	1200	51	62	15/08/1967	900	3.6
11	04/09/1960	1050	46.7	63	28/08/1967	1630	3.34
12	04/09/1960	1740	46.7	64	11/10/1967	1800	2.74
13	04/10/1960	945	42.5	65	20/10/1967	815	2.59
14	18/08/1960	1200	4.16	66	23/11/1967	820	2.59
15	25/09/1960	945	3.37	67	10/05/1968	1700	14.7
16	01/11/1961	1210	28.3	68	21/06/1968	945	9.26
17	01/12/1961	1020	24.1	69	10/09/1968	1610	4.13
18	01/12/1961	1600	21.8	70	12/12/1968	905	3.51
19	13/01/1961	1000	19.5	71	20/06/1969	1540	5.61
20	18/01/1961	1550	11.3	72	13/08/1969	1510	4.44
21	02/09/1961	1740	326	73	26/09/1969	1700	3.38
22	14/02/1961	1540	193	74	04/12/1969	1900	3.96
23	15/02/1961	930	164	75	16/04/1970	1230	4.77
24	15/02/1961	1555	147	76	01/07/1970	815	3.6
25	16/02/1961	915	168	77	21/07/1970	1210	3.43
26	15/05/1961	1330	3.37	78	04/09/1970	1030	2.89
27	07/10/1961	1100	3.28	79	20/10/1970	1425	2.78
28	19/12/1961	1525	15.3	80	19/06/1971	1400	6.83
29	20/03/1962	1055	21.2	81	07/10/1971	1625	3.03
30	06/07/1962	1700	3.48	82	11/07/1971	925	4.71
31	13/08/1962	1215	2.83	83	06/10/1974	1630	3.26
32	19/09/1962	1600	2.32	84	06/09/1974	1655	8.5
33	24/10/1962	1530	2.46	85	14/05/1975	1215	31.9
34	11/01/1962	1600	5.3	86	11/06/1975	1530	13.9
35	28/11/1962	1130	4.44	87	16/07/1975	1510	10.3
36	22/08/1963	1330	3.82	88	28/08/1975	825	6.53
37	27/09/1964	1015	2.38	89	19/09/1975	1510	5.76
38	05/03/1965	950	145	90	02/06/1976	1145	21.9
39	05/03/1965	1415	140	91	30/07/1976	1016	11.6
40	05/03/1965	1700	135	92	06/09/1976	1300	8.41
41	06/03/1965	1000	133	93	22/09/1976	1650	7.76
42	06/03/1965	1755	152	94	02/10/1976	1156	7.55
43	07/03/1965	1215	271	95	22/10/1976	1250	7.09
44	07/03/1965	1650	284	96	30/11/1976	1548	7.19
45	08/03/1965	1600	267	97	12/05/1976	1430	35.8
46	09/03/1965	955	204	98	28/07/1977	1610	11.9
47	09/03/1965	1550	199	99	19/10/1977	1315	6.38
48	10/03/1965	1215	219	100	20/07/1978	1625	10.4
49	10/03/1965	1530	213	101	02/11/1978	1450	11.3
50	02/04/1965	1145	507	102	30/11/1978	1615	12
51	02/04/1965	1650	515	103	13/12/1978	905	27.8
52	04/03/1965	1010	456	104	31/01/1979	1340	189

Gauge No	Date	Start Time	Flow	Gauge No	Date	Start Time	Flow
105	31/01/1979	1711	175	157	28/02/1980	1010	1890
106	01/02/1979	1348	161	158	29/02/1980	830	1630
107	02/02/1979	1608	191	159	01/03/1980	1709	1110
108	03/02/1979	1000	159	160	02/03/1980	955	1160
109	04/02/1979	822	345	161	03/03/1980	1012	422
110	04/02/1979	1336	322	162	05/03/1980	1130	335
111	05/02/1979	826	451	163	05/03/1980	1750	353
112	05/02/1979	1614	418	164	06/03/1980	1015	370
113	06/02/1979	824	253	165	07/03/1980	1000	340
114	06/02/1979	1425	227	166	08/03/1980	1030	274
115	12/03/1979	2035	1730	167	08/03/1980	1638	253
116	13/03/1979	855	1570	168	13/05/1981	1345	11.9
117	13/03/1979	1730	1530	169	12/06/1981	845	9.76
118	14/03/1979	1110	1220	170	16/09/1981	1225	6.43
119	14/03/1979	1625	1170	171	28/10/1981	1415	5.35
120	15/03/1979	925	927	172	23/04/1982	1305	23.8
121	15/03/1979	1620	866	173	19/05/1982	1115	10.5
122	16/03/1979	825	696	174	26/06/1982	1625	7.55
123	16/03/1979	1535	590	175	16/07/1982	1335	7.2
124	16/03/1979	2105	495	176	31/08/1982	1325	6.15
125	17/03/1979	1050	387	177	28/09/1982	910	5.46
126	17/03/1979	1750	361	178	09/11/1982	1525	5.12
127	28/04/1979	1325	17.7	179	08/12/1982	740	9.4
128	27/06/1979	1050	8.62	180	04/03/1982	943	28.1
129	19/09/1979	1155	6.68	181	01/06/1983	1630	9.43
130	05/02/1980	940	0	182	14/07/1983	1640	5
131	06/02/1980	950	1760	183	15/08/1983	1410	5.37
132	07/02/1980	0	0	184	01/09/1983	1510	5.78
133	10/02/1980	940	1290	185	26/09/1983	1605	4.62
134	10/02/1980	1655	1160	186	24/11/1983	1615	14
135	11/02/1980	930	0	187	30/05/1984	1204	15
136	13/02/1980	1730	1670	188	16/07/1984	1500	10.8
137	14/02/1980	915	1810	189	03/09/1984	1500	7.48
138	14/02/1980	1635	1700	190	16/10/1984	1320	6.58
139	15/02/1980	1015	1670	191	19/11/1984	1145	7.44
140	16/02/1980	1100	1820	192	09/07/1985	900	8.58
141	17/02/1980	1015	2050	193	30/08/1985	1230	6.62
142	17/02/1980	1630	2040	194	31/10/1985	1515	5.5
143	18/02/1980	925	2090	195	09/05/1986	755	9.72
144	19/02/1980	1015	1990	196	24/06/1986	1520	5.18
145	20/02/1980	810	1910	197	07/08/1986	1625	6.04
146	21/02/1980	920	1700	198	15/09/1986	1230	4.7
147	21/02/1980	1710	1660	199	12/11/1986	1630	5.44
148	23/02/1980	925	1840	200	22/04/1987	1710	13.2
149	23/02/1980	1700	1880	201	04/06/1987	1355	6.95
150	24/02/1980	1150	1990	202	31/07/1987	1110	5.84
151	24/02/1980	1725	2250	203	09/09/1987	1234	5.34
152	25/02/1980	905	2240	204	15/10/1987	923	5.96
153	25/02/1980	1640	2450	205	26/11/1987	805	21.8
154	26/02/1980	830	2410	206	24/03/1988	1140	18.4
155	27/02/1980	830	2150	207	26/05/1988	1245	6.6
156	27/02/1980	1618	2230	208	18/07/1988	1500	4.31

Gauge No	Date	Start Time	Flow	Gauge No	Date	Start Time	Flow
209	01/09/1988	830	4.33	225	21/05/1992	1035	6.46
210	13/10/1988	1100	4.4	226	14/07/1992	1400	4.75
211	09/11/1989	1630	3.78	227	01/09/1991	910	4.64
212	20/04/1989	1244	11.3	228	04/11/1993	1029	4.62
213	27/06/1989	1500	8.59	229	19/05/1993	1300	8.35
214	24/08/1989	1000	5.2	230	27/07/1993	1309	5.763
215	04/10/1989	1550	5.08	231	02/06/1994	1100	9.115
216	16/11/1989	1502	5.53	232	01/11/1994	953	5.277
217	14/05/1990	1431	5.74	233	12/04/1995	1510	170.466
218	10/07/1990	1230	4.43	234	28/09/1995	1010	4.515
219	27/08/1990	1520	4.18	235	25/07/1996	827	6.198
220	17/10/1990	1240	2.76	236	16/09/1996	1512	4.824
221	21/05/1991	1130	9.08	237	23/07/1997	1448	8.098
222	09/07/1991	1310	7.22	238	10/06/1998	1350	14.824
223	04/09/1991	1152	5.12	239	30/09/1998	1316	12.899
224	13/11/1991	1407	4.61	240	10/12/1998	1346	12.223

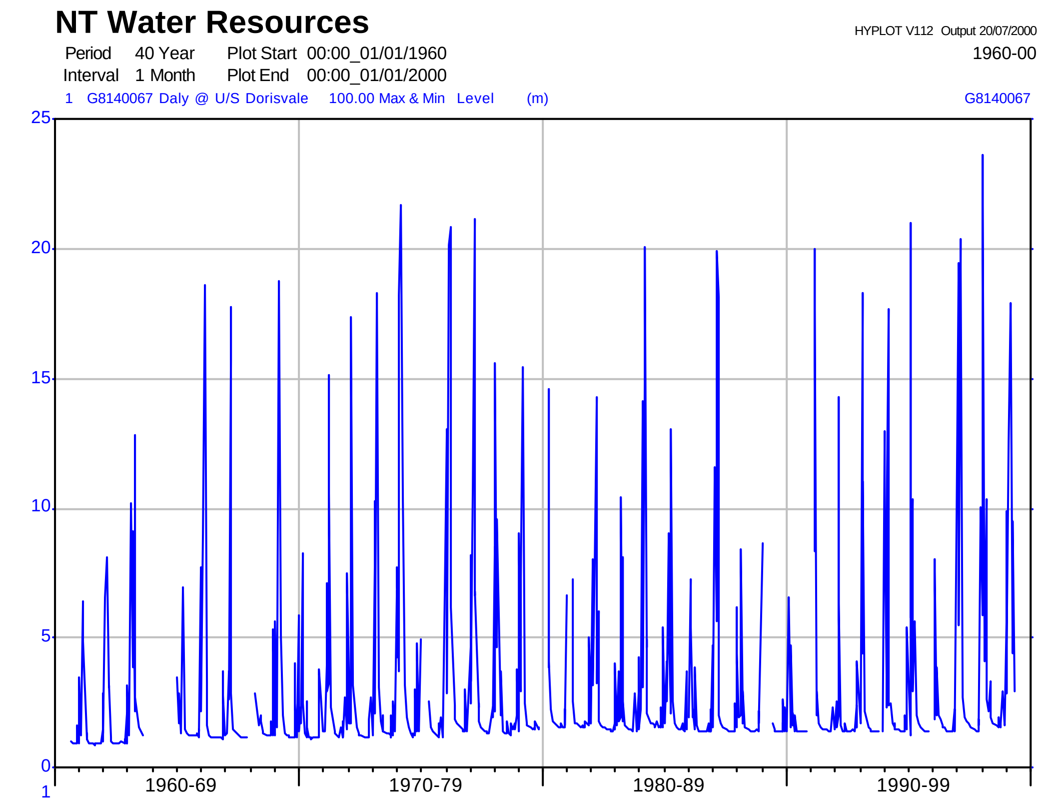


Figure C2(a) Max and Min Water Lavel at GS8140067

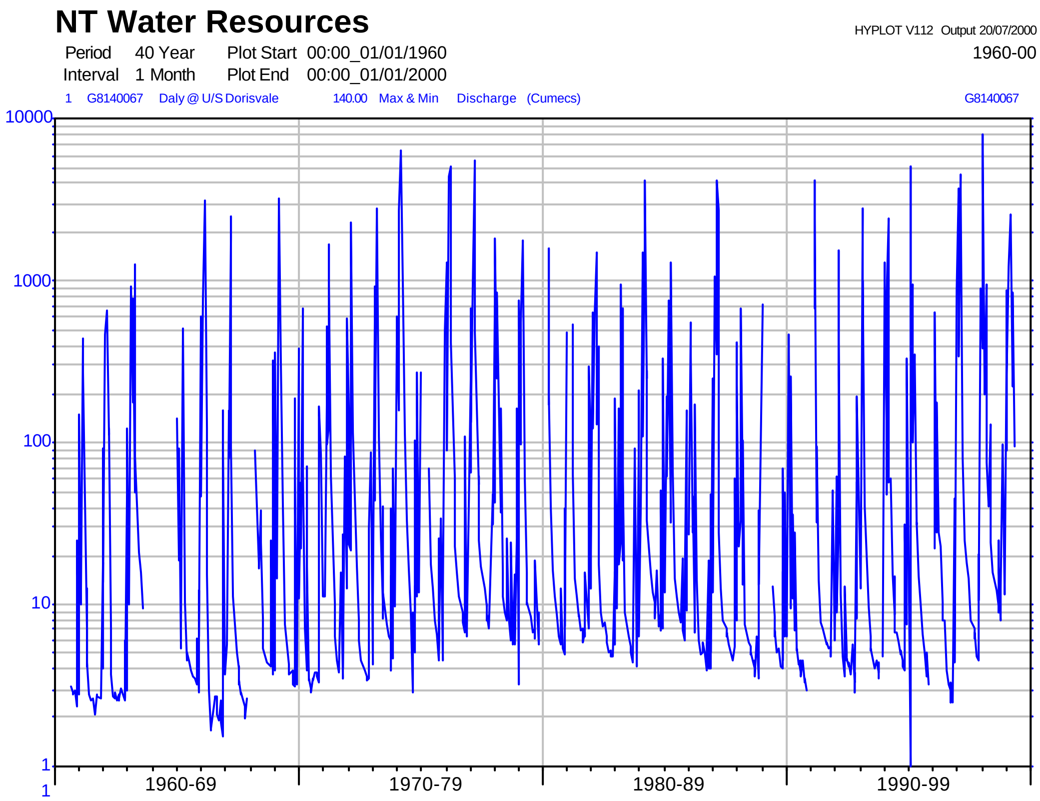
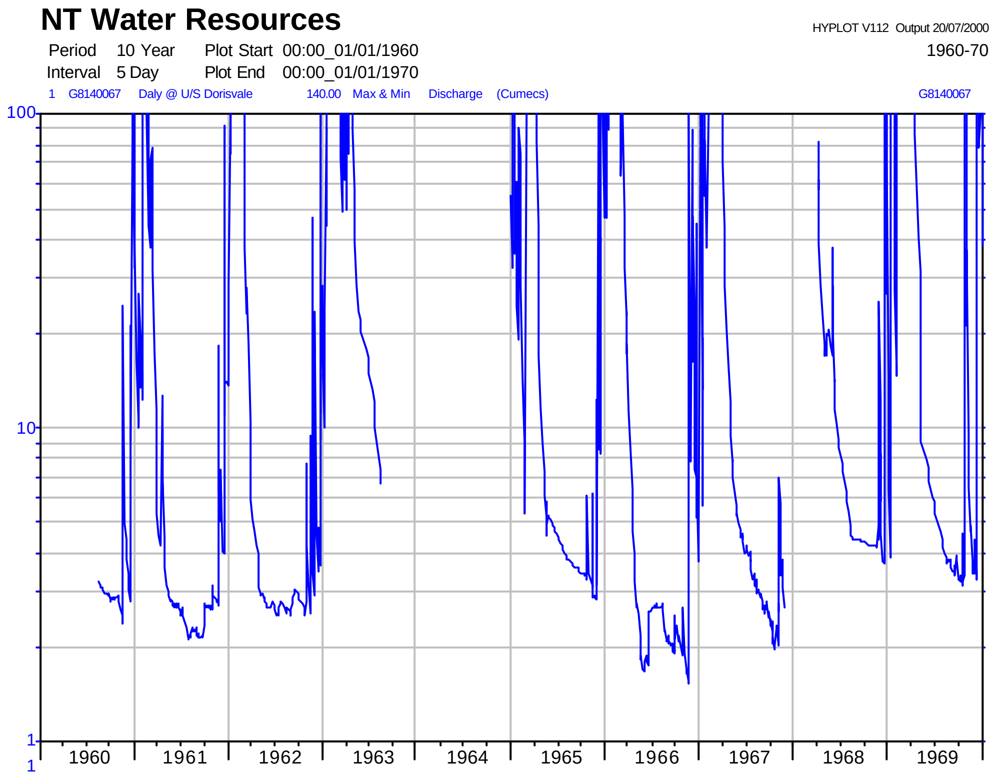
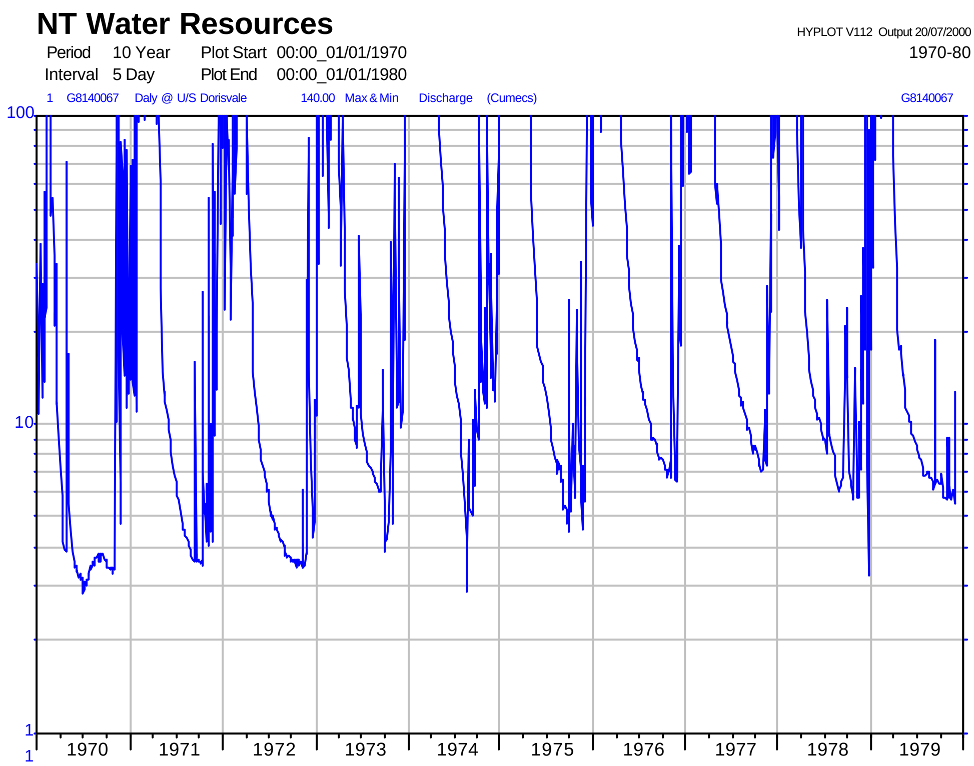


Figure C2(b) Max and Min Discharge (cumecs) at GS8140067

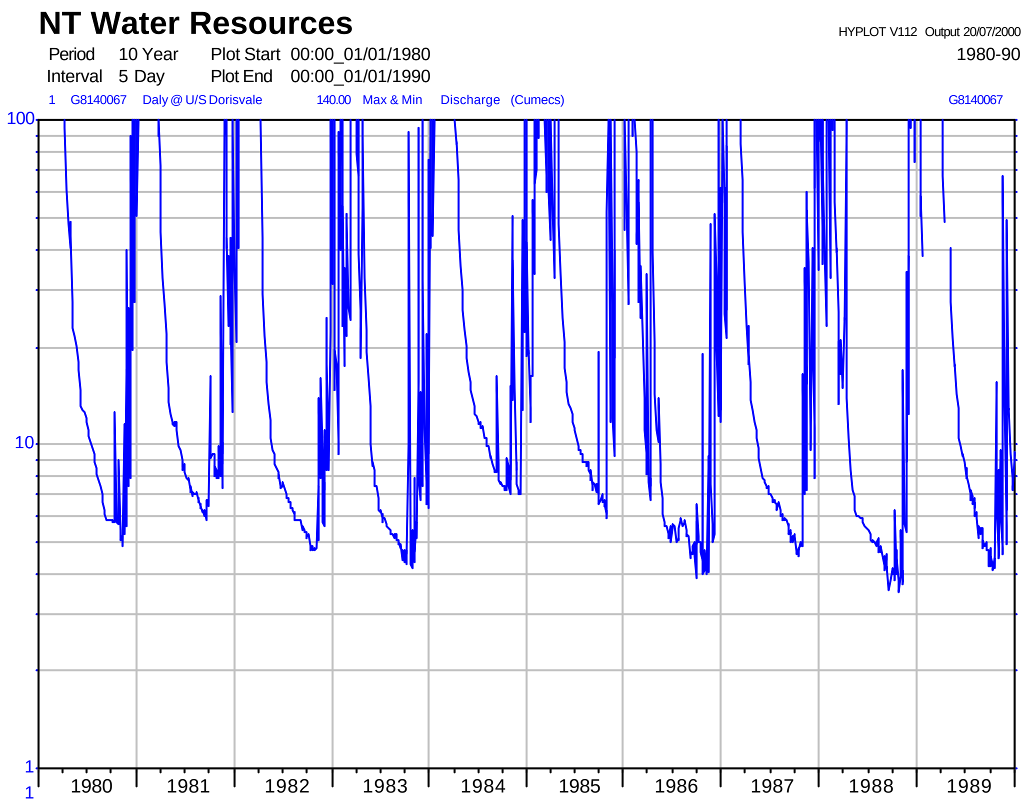
Figure C2(c,d,e,f) Expanded Minimum Discharge Hydrograph for GS8140067



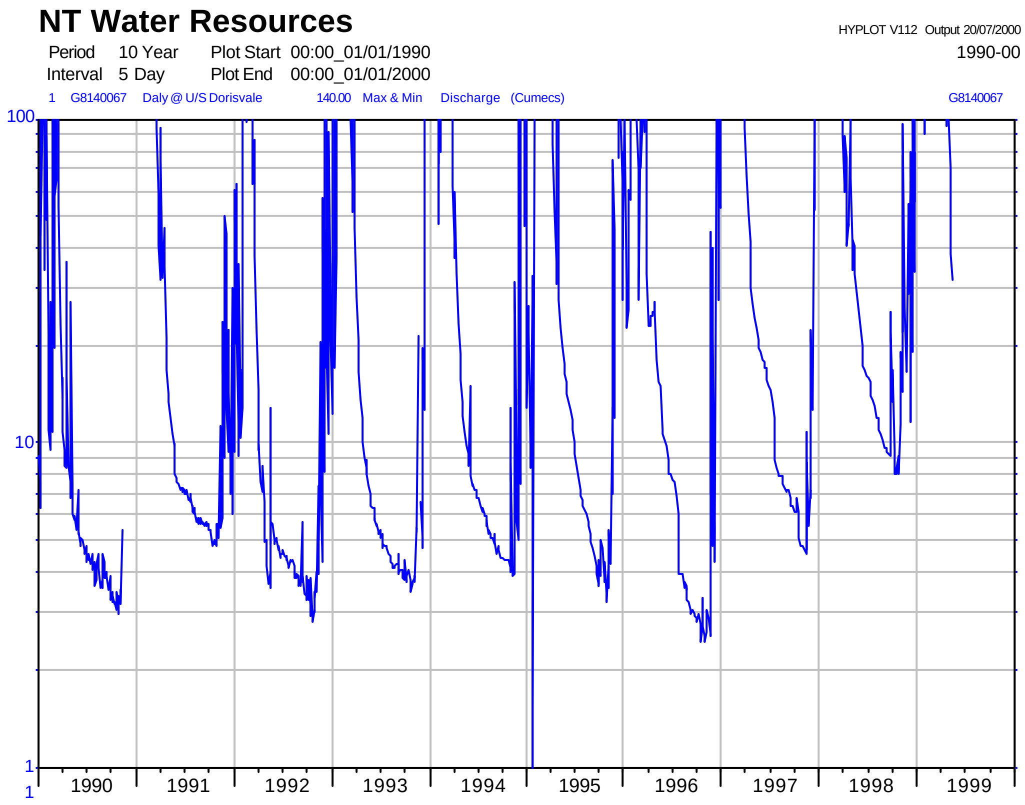
(c)



(d)

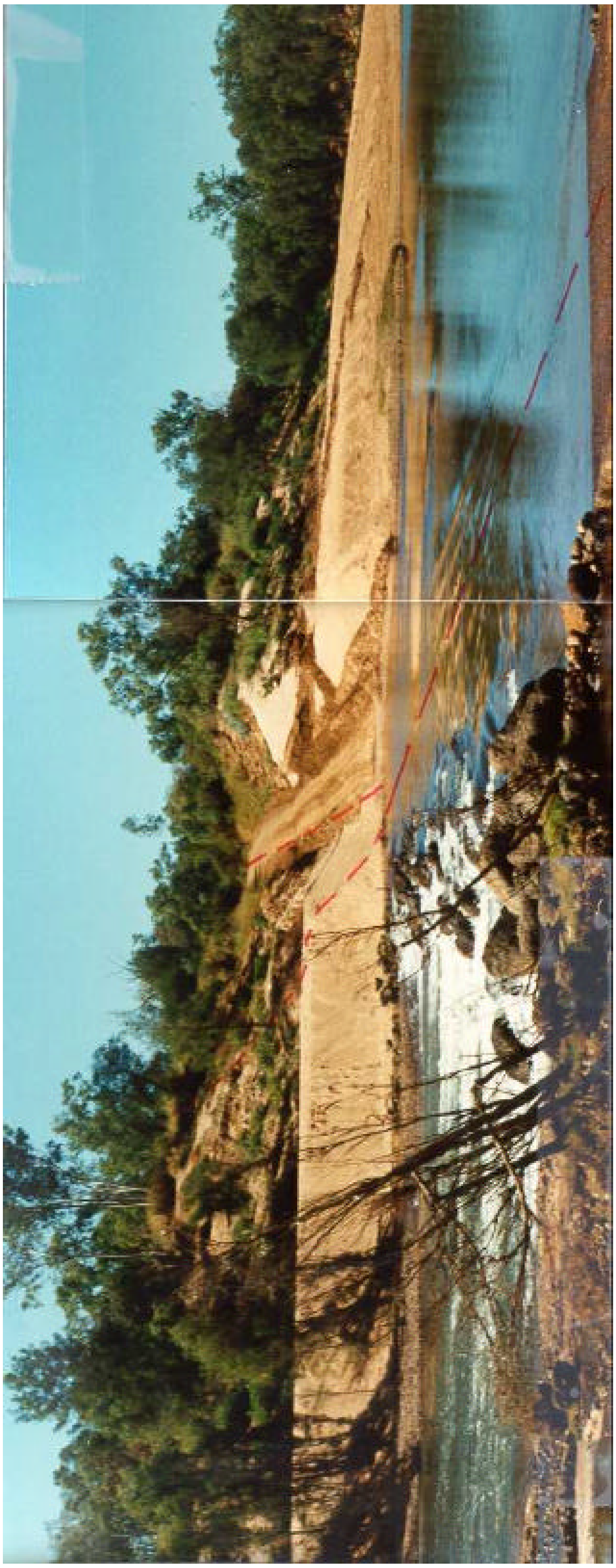

NT Water Resources
HYPLOT V112 Output 20/07/2000
Period 10 Year Plot Start 00:00_01/01/1980
Interval 5 Day Plot End 00:00_01/01/1990
1980-90
1 G8140067 Daly @ U/S Dorisvale 140.00 Max & Min Discharge (Cumecs) G8140067
100
10
1
1
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989

(e)


NT Water Resources
HYPLOT V112 Output 20/07/2000
Period 10 Year Plot Start 00:00_01/01/1990
Interval 5 Day Plot End 00:00_01/01/2000
1990-00
1 G8140067 Daly @ U/S Dorisvale 140.00 Max & Min Discharge (Cumecs) G8140067
100
10
1
1
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

(f)

Photo C1 Dorisvale Crossing on the Daly River



Appendix D

Douglas River

GS8140063 is located downstream of the old Douglas Homestead. The records of both hydrographs and gaugings are very comprehensive and extensive, extending from 1957 to 1997.

The single straight-line relationship is clearly evident on the hydrographs. The straight-lines for the hydrograph for each dry season were parallel. The equation derived for the line which denotes the groundwater fed flow of the Douglas River was:

$$\log Q = 0.3 - 0.002\ N$$

To check that the equation was correct, gaugings were plotted for each year, fitting the line well. Care should be taken when using gauged spring flow data at this location. From year to year, the location at which flows were gauged changed. Unfortunately large springflows occur along the section of the river on which the gauging locations moved.

Two (2) cumecs is estimated to be the maximum groundwater input into the Douglas River from the Tindall Limestone at this locality.

Figure D1   Relationship between groundwater fed flow and time for Douglas River at GS8140063

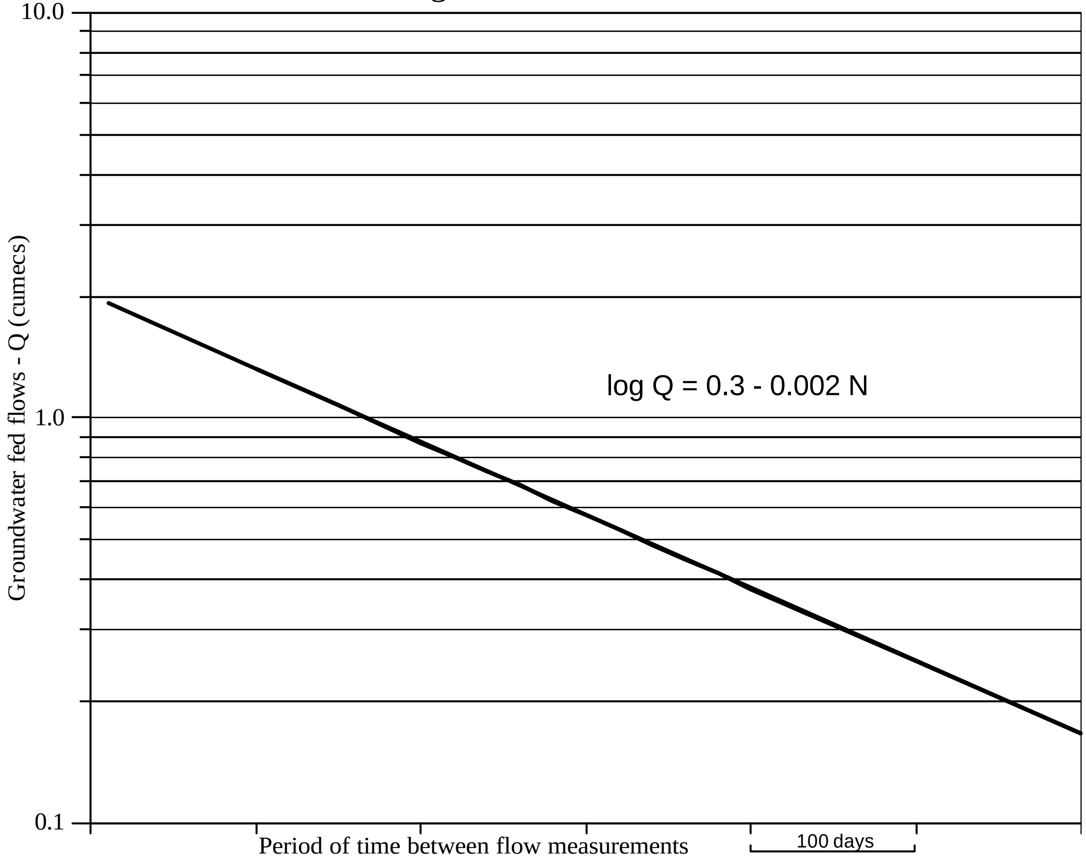


Table D1 List of Gaugings for GS8140063 – Douglas River

Gauge No	Date	Start Time	Flow	Gauge No	Date	Start Time	Flow
1	11/06/1957	1600	1.42	53	21/02/1963	1440	32.6
2	04/07/1957	1640	1.16	54	21/02/1963	1645	31.1
3	21/07/1957	1030	0.58	55	21/02/1963	1800	27.8
4	13/08/1957	1640	0.963	56	22/02/1963	925	23.8
5	14/09/1957	1610	0.651	57	22/02/1963	1055	23.8
6	12/06/1958	1125	0.623	58	22/02/1963	1355	27.5
7	30/10/1958	1440	0.28	59	22/02/1963	1455	31.1
8	30/10/1958	1450	0.278	60	22/02/1963	1635	34
9	30/10/1958	1515	0.309	61	22/02/1963	1740	32.6
10	26/11/1958	1430	0.368	62	22/02/1963	1840	41.1
11	26/11/1958	1530	0.34	63	23/02/1963	850	22.4
12	13/02/1959	1635	2.41	64	15/03/1963	900	4.39
13	07/08/1959	1010	0.566	65	04/04/1963	920	3.82
14	04/09/1959	1100	0.467	66	16/11/1963	1330	0.224
15	20/05/1960	1015	2.29	67	06/01/1964	1150	0.311
16	25/08/1960	1820	0.411	68	19/02/1964	1150	0.722
17	17/12/1960	0	0.821	69	07/08/1964	1650	0.238
18	26/01/1961	1525	0.496	70	02/10/1964	840	0.202
19	08/03/1961	1530	1.95	71	28/01/1965	1600	1.08
20	09/03/1961	905	1.78	72	07/04/1965	1240	7.5
21	09/03/1961	1727	1.78	73	07/06/1965	1000	0.606
22	24/03/1961	1340	0.934	74	17/08/1965	835	0.367
23	07/04/1961	1100	0.708	75	15/08/1966	1110	0.538
24	03/07/1961	1240	2.32	76	30/10/1966	945	0.34
25	15/08/1961	1545	0.354	77	12/05/1967	1530	0.929
26	14/12/1961	1600	0.368	78	12/08/1967	1130	0.64
27	10/01/1962	1017	0.51	79	14/10/1967	940	0.428
28	18/01/1962	1435	0.453	80	16/01/1968	1715	0.433
29	07/03/1962	1540	1.42	81	09/04/1968	1240	4.13
30	08/03/1962	940	1.42	82	06/05/1968	1145	2.15
31	14/03/1962	1635	0.651	83	11/06/1968	1700	1.43
32	22/03/1962	935	0.807	84	29/08/1968	1730	0.92
33	22/03/1962	1130	0.552	85	09/12/1968	1655	0.733
34	22/03/1962	1215	0.467	86	09/05/1969	1520	1.59
35	30/03/1962	1707	0.595	87	21/05/1969	810	1.27
36	31/03/1962	920	0.283	88	29/08/1969	1530	0.889
37	18/04/1962	930	0.552	89	17/10/1969	1450	0.674
38	29/05/1962	1140	0.354	90	25/03/1970	900	0.878
39	29/05/1962	1330	0.144	91	20/06/1970	1315	0.419
40	04/07/1962	1110	1.15	92	22/07/1970	930	0.371
41	04/07/1962	1200	0.28	93	19/09/1970	1220	0.262
42	23/08/1962	1115	0.278	94	17/10/1970	830	0.255
43	21/09/1962	1525	0.201	95	12/01/1971	915	0.368
44	26/10/1962	1510	0.229	96	17/01/1971	1020	0.714
45	23/01/1963	1655	4.11	97	24/09/1971	1720	0.334
46	24/01/1963	1000	3.82	98	22/10/1971	950	0.422
47	24/01/1963	1530	49.6	99	29/05/1972	1610	1.23
48	24/01/1963	1700	42.5	100	27/07/1972	1425	0.858
49	24/01/1963	1755	36.8	101	09/09/1972	930	0.725
50	25/01/1963	935	8.92	102	10/10/1972	1420	0.535
51	13/02/1963	1700	5.52	103	10/10/1972	1445	0.541
52	14/02/1963	925	5.95	104	10/10/1972	1500	0.538

Gauge No	Date	Start Time	Flow	Gauge No	Date	Start Time	Flow
105	09/01/1973	1715	0.566	157	22/01/1982	830	51.8
106	17/04/1973	1310	3.37	158	22/01/1982	1030	64.8
107	10/07/1973	1020	1.04	159	22/01/1982	1220	63.8
108	28/08/1973	1415	0.869	160	09/02/1982	1630	11.3
109	03/10/1973	1445	0.704	161	10/02/1982	840	30.1
110	13/11/1973	1640	0.796	162	10/02/1982	1225	28.5
111	12/06/1974	1330	2.22	163	11/02/1982	910	23.5
112	23/10/1974	1615	1.07	164	12/02/1982	810	14.8
113	12/11/1974	1405	0.997	165	15/02/1982	825	48.1
114	12/06/1975	1440	1.58	166	15/02/1982	1100	49.3
115	14/08/1975	1715	1.19	167	10/03/1982	1100	8.98
116	19/11/1975	1155	0.899	168	15/04/1982	1342	3.23
117	28/05/1976	920	2.68	169	06/05/1982	1350	1.65
118	22/06/1976	910	2.4	170	12/05/1982	1107	1.54
119	22/07/1976	1530	1.58	171	28/05/1982	810	1.49
120	10/09/1976	1045	1.05	172	29/06/1982	1010	1.26
121	09/10/1976	1530	0.946	173	01/07/1982	1020	1.37
122	24/11/1976	900	1.17	174	16/07/1982	1340	1.15
123	06/05/1977	1215	4.73	175	29/07/1982	1558	1.13
124	17/07/1977	1420	1.68	176	18/08/1982	0	0.979
125	16/08/1977	1530	1.07	177	02/09/1982	1044	0.989
126	02/11/1977	1030	0.922	178	02/09/1982	1107	0.952
127	11/04/1978	1115	1.28	179	23/09/1982	1545	0.806
128	02/06/1978	850	0.57	180	07/10/1982	1325	0.787
129	31/08/1978	1250	0.907	181	29/10/1982	900	0.655
130	07/09/1978	1350	0.693	182	15/11/1982	1400	0.677
131	07/11/1978	1150	0.814	183	17/12/1982	1320	0.696
132	13/12/1978	840	0.846	184	17/01/1983	1630	0.665
133	26/07/1979	1111	0.689	185	28/01/1983	1200	0.651
134	26/09/1979	1610	0.464	186	25/02/1983	1140	0.654
135	08/11/1979	1049	0.476	187	10/03/1983	1855	4.27
136	06/12/1979	1520	0.654	188	12/03/1983	1225	2.16
137	13/06/1980	1644	1.17	189	17/03/1983	1715	5.07
138	22/07/1980	1220	0.981	190	22/04/1983	1450	1.43
139	22/07/1980	1347	1.02	191	17/05/1983	1450	0.926
140	25/07/1980	915	0.822	192	03/06/1983	1700	0.774
141	28/08/1980	1025	0.63	193	08/07/1983	1655	0.541
142	28/08/1980	1048	0.617	194	28/07/1983	1748	0.584
143	09/10/1980	950	0.486	195	19/08/1983	1400	0.528
144	09/10/1980	1008	0.46	196	15/09/1983	1255	0.462
145	12/11/1980	0	0.472	197	06/10/1983	1130	0.363
146	17/12/1980	926	0.619	198	17/11/1983	1725	0.37
147	08/05/1981	1520	1.52	199	09/01/1984	1420	0.728
148	18/06/1981	1415	0.956	200	02/02/1984	910	5.58
149	18/06/1981	1445	1.06	201	15/02/1984	1800	12.5
150	14/07/1981	1200	0.869	202	24/02/1984	1050	38
151	11/08/1981	1315	0.705	203	29/02/1984	1230	29.8
152	23/09/1981	1533	0.573	204	29/02/1984	1455	33.2
153	09/11/1981	1605	0.462	205	09/03/1984	1145	23.4
154	11/12/1981	1059	1.1	206	16/03/1984	1145	84.6
155	21/01/1982	900	9.61	207	16/03/1984	1340	86.4
156	21/01/1982	1415	10.2	208	16/03/1984	1430	74.5

Gauge No	Date	Start Time	Flow
209	20/03/1984	1041	33.3
210	09/05/1984	1545	2.05
211	01/07/1984	1445	1.29
212	16/08/1984	1355	0.768
213	03/10/1984	945	0.659
214	12/11/1984	1600	0.63
215	05/12/1984	1545	0.565
216	10/01/1985	1520	0.915
217	07/02/1985	1230	2.085
218	22/02/1985	1205	7.77
219	06/03/1985	1310	16
220	18/06/1985	1135	0.884
221	23/07/1985	1100	1.04
222	28/08/1985	1535	0.783
223	24/10/1985	1608	0.417
224	14/01/1986	1140	0.753
225	24/01/1986	1230	5.05
226	12/02/1986	1305	2.17
227	12/03/1986	1308	1.25
228	17/04/1986	1550	0.945
229	20/05/1986	830	0.552
230	16/07/1986	1140	0.422
231	10/09/1986	1735	0.274
232	12/11/1986	1005	0.343
233	18/12/1986	1335	0.242
234	13/01/1987	1140	0.918
235	31/03/1987	935	1.39
236	30/06/1987	1547	0.561
237	04/08/1987	1125	0.447
238	10/09/1987	1600	0.476
239	26/10/1987	1400	0.23
240	03/12/1987	800	0.612
241	15/01/1988	1400	1.32
242	19/02/1988	1400	1.16
243	16/03/1988	830	0.589
244	30/04/1988	1620	0.402
245	09/06/1988	810	0.398
246	19/07/1988	1345	0.261
247	08/09/1988	1415	0.177
248	30/11/1988	915	0.273
249	24/01/1989	1152	7.8
250	03/03/1989	954	5.74
251	15/06/1989	1420	1.46
252	17/07/1989	1305	1.17
253	18/08/1989	1112	0.964
254	06/10/1989	845	0.745
255	17/11/1989	1010	0.634
256	16/01/1990	1640	0.775
257	07/03/1990	834	3.91
258	10/04/1990	1150	1.08
259	16/05/1990	1450	0.784
260	20/06/1990	1043	0.634
261	04/09/1990	1516	0.37
262	19/10/1990	800	0.299
263	27/11/1990	1345	0.42
264	24/05/1991	900	1.45
265	10/07/1991	1103	1.01
266	14/08/1991	1504	0.778
267	07/10/1991	1050	0.654
268	07/11/1991	1555	0.506
269	21/04/1992	1440	2.33
270	19/05/1992	926	1.75
271	17/07/1992	1135	0.889
272	03/11/1992	1423	0.725
273	22/07/1993	915	1.11
274	10/12/1993	900	0.631
275	08/07/1994	1020	1.086
276	02/12/1994	920	2.48
277	17/11/1995	835	1.045
278	06/03/1996	1040	2.345
279	18/11/1996	1535	0.621
280	11/07/1997	905	1.507

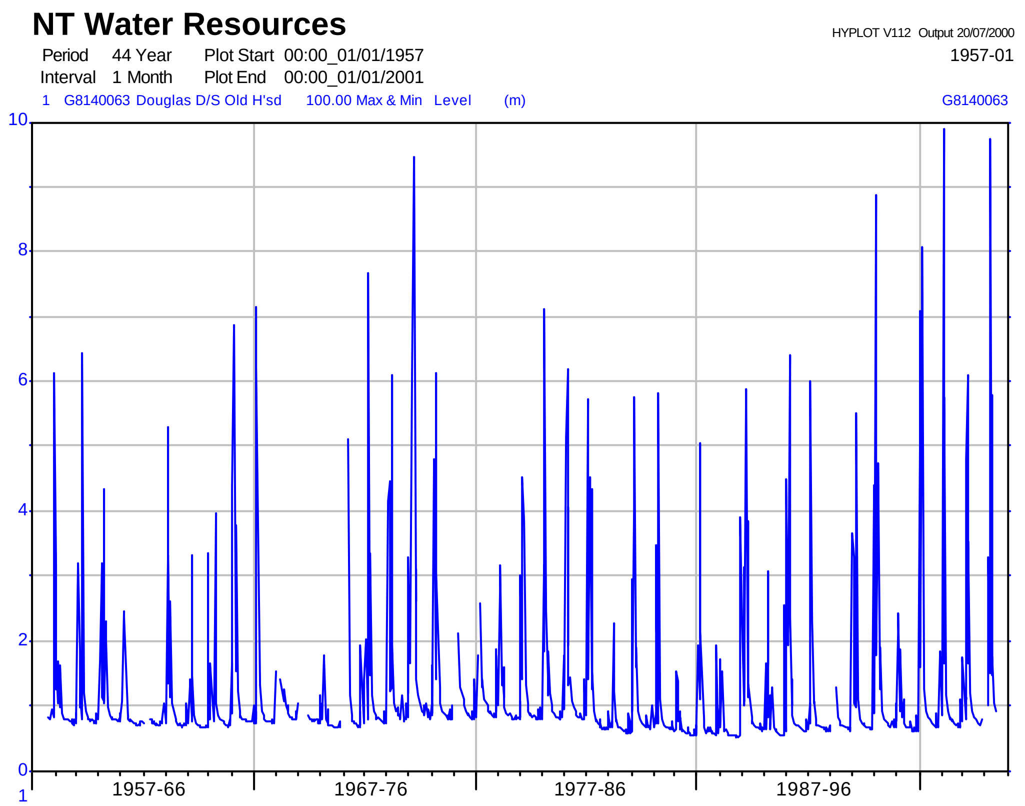


Figure D2(a) Max and Min Water Level at G8140063

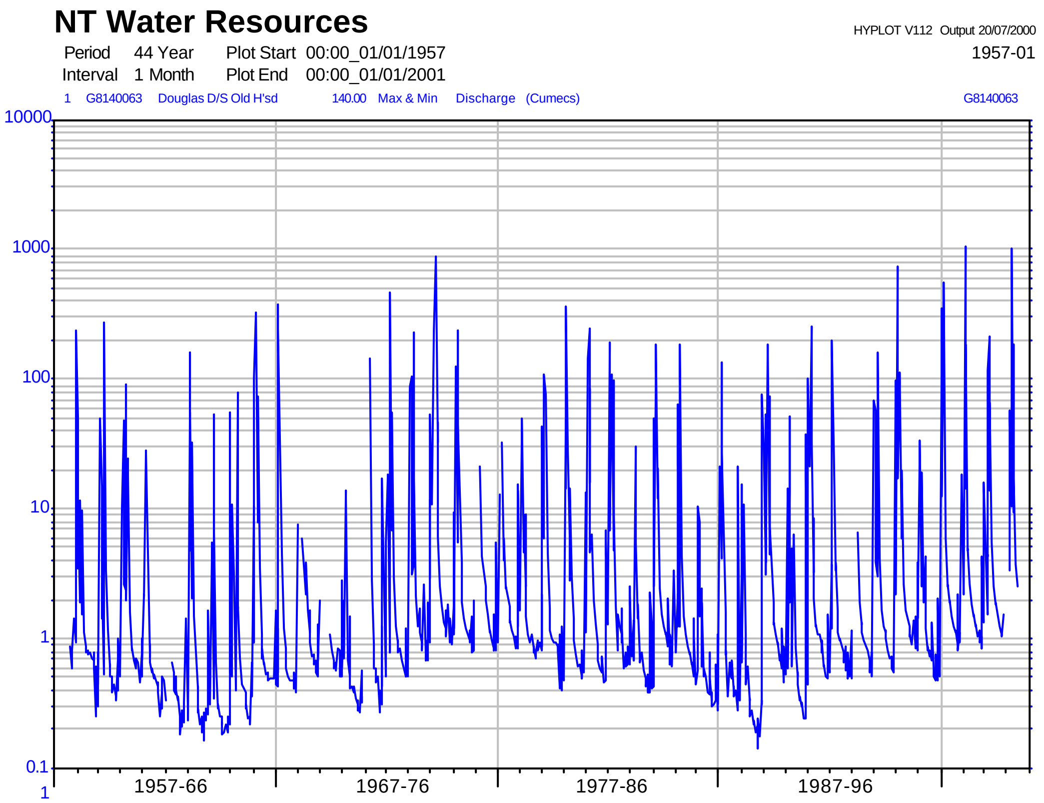
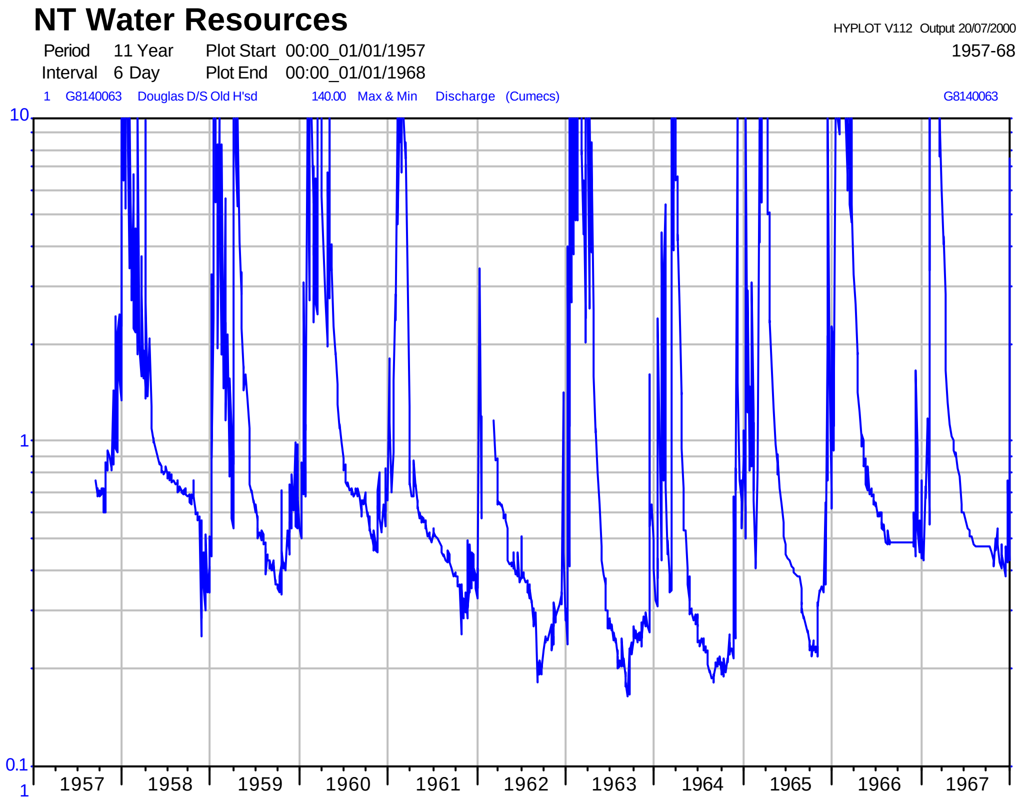
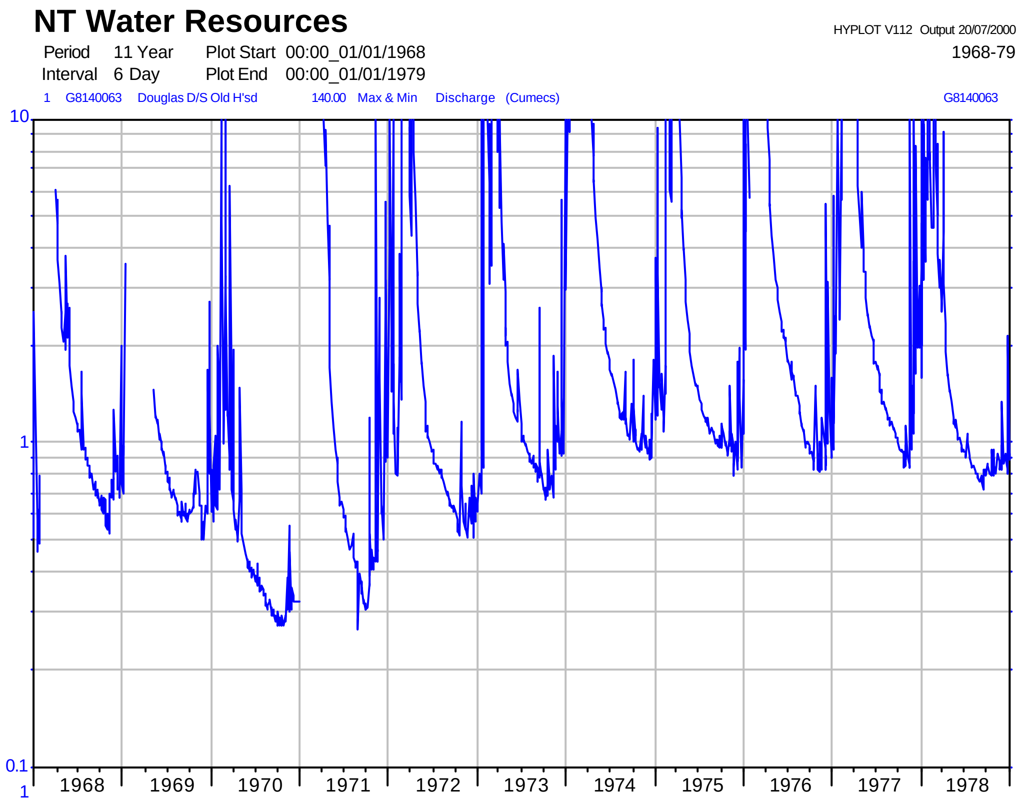


Figure D2(b) Max and Min Discharge (cumecs) at G8140063

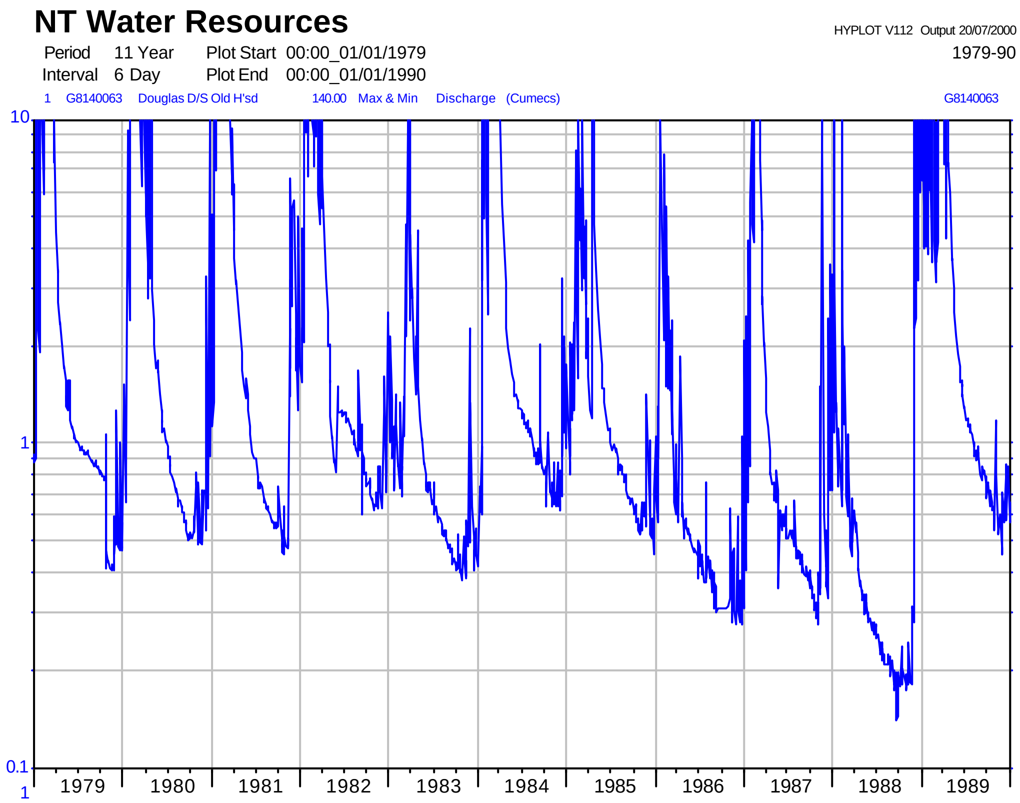
Figure D2(c,d,e,f) Expanded Minimum Discharge Hydrograph for G8140063



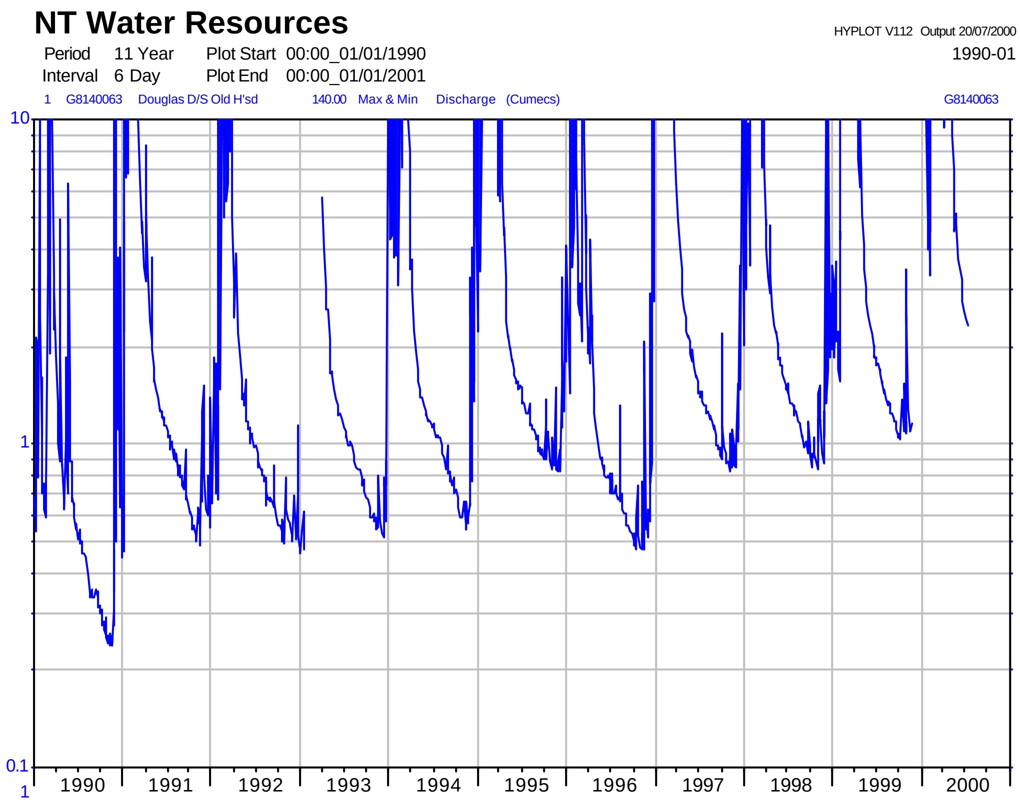
(c)



(d)


NT Water Resources
HYPLOT V112 Output 20/07/2000
Period 11 Year
Interval 6 Day
Plot Start 00:00_01/01/1979
Plot End 00:00_01/01/1990
1979-90
1 G8140063 Douglas D/S Old H'sd 140.00 Max & Min Discharge (Cumecs)
G8140063
10
1
0.1
1
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989

(e)


NT Water Resources
HYPLOT V112 Output 20/07/2000
Period 11 Year
Interval 6 Day
Plot Start 00:00_01/01/1990
Plot End 00:00_01/01/2001
1990-01
1 G8140063 Douglas D/S Old H'sd 140.00 Max & Min Discharge (Cumecs)
G8140063
10
1
0.1
1
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000

(f)

Appendix E

Daly River at Mount Nancar

GS8140040 is located at Mt Nancar on the lower part of the Daly River. Downstream of the confluence between the Daly River and the Douglas River, Mount Nancar is the most downstream point on the Daly River system that was studied.

Records of gaugings at Mount Nancar have been kept since 1966. The hydrographs for this gauging station were available from 1968 onwards.

It appears that the baseflow recession for the river had two components, a steep high river level slope and a more shallow lower river level slope. In order to fully understand this response, the cummulative effect of the upstream inflows from the Katherine, Flora and Douglas rivers must be taken into account.

The relationship for groundwater fed flow was found to be :

$$\text{Log } Q = 1.6 - 0.0013\ N \qquad \text{(high level)}$$

$$\text{Log } Q = 0.94 - 0.00008\ N \qquad \text{(lower level)}$$

Figure E1 Relationship between groundwater fed flow and time for Daly River at Mount Nancar GS8140040

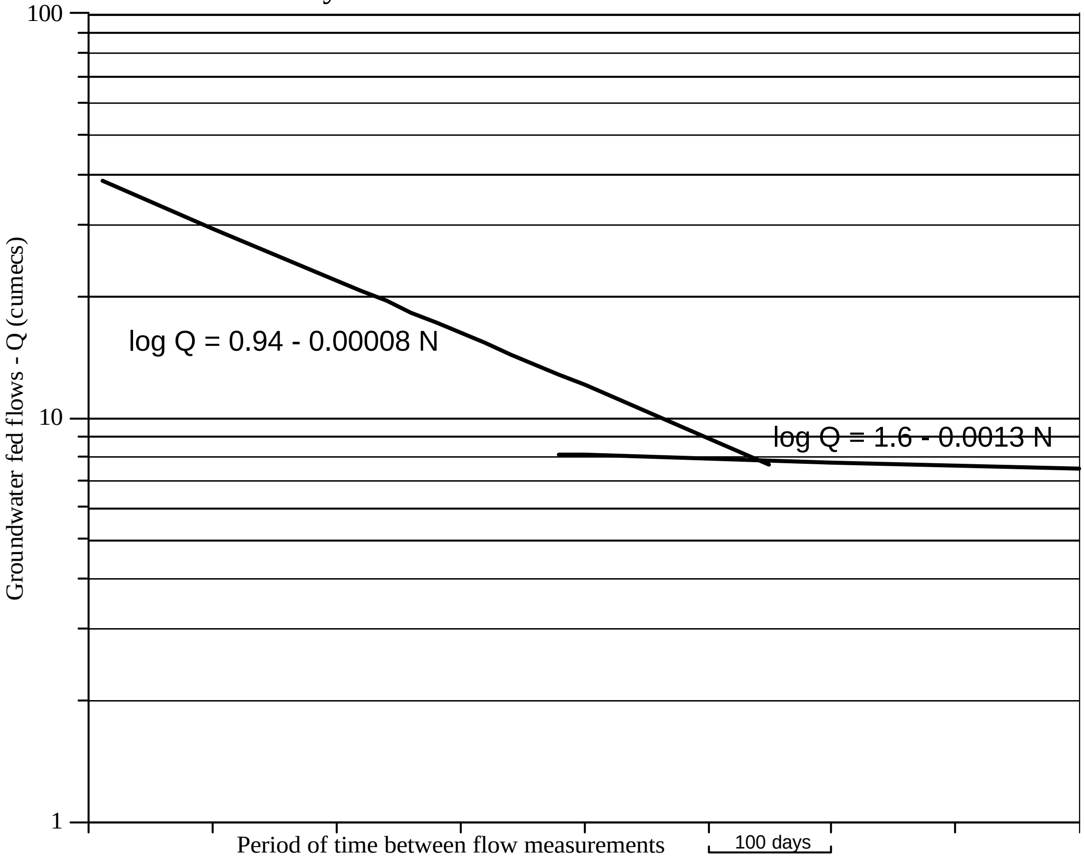


Table E1 List of Gaugings for GS8140040 – Mt Nancar, Daly River

Gauge No	Date	Start Time	Flow	Gauge No	Date	Start Time	Flow
1	02/12/1966	1200	27.9	53	13/03/1967	1230	946
2	12/01/1967	1115	24.3	54	13/03/1967	1720	912
3	11/02/1967	953	402	55	14/03/1967	815	748
4	11/02/1967	1350	379	56	14/03/1967	1230	742
5	11/02/1967	1700	408	57	14/03/1967	1715	722
6	12/02/1967	820	402	58	15/03/1967	800	637
7	12/02/1967	1455	408	59	15/03/1967	1230	665
8	13/02/1967	827	416	60	15/03/1967	1715	648
9	13/02/1967	1312	481	61	16/03/1967	815	648
10	13/02/1967	1720	583	62	30/03/1967	1305	173
11	14/02/1967	800	694	63	31/03/1967	930	156
12	14/02/1967	1350	759	64	01/04/1967	930	139
13	14/02/1967	1740	708	65	01/04/1967	1530	128
14	15/02/1967	810	722	66	02/04/1967	1120	121
15	15/02/1967	1245	695	67	03/04/1967	950	113
16	15/02/1967	1707	699	68	09/05/1967	1400	20.6
17	16/02/1967	800	656	69	01/09/1967	1540	12.2
18	16/02/1967	1235	646	70	12/08/1969	1545	14.3
19	16/02/1967	1740	657	71	22/04/1970	1600	12.6
20	17/02/1967	755	657	72	17/06/1970	1200	10.9
21	17/02/1967	1252	677	73	23/07/1970	1115	9.85
22	17/02/1967	1740	663	74	26/09/1970	1015	8.61
23	18/02/1967	815	637	75	03/11/1970	1800	8.35
24	18/02/1967	1315	595	76	26/06/1971	935	14.4
25	18/02/1967	1650	583	77	27/09/1971	1420	8.95
26	19/02/1967	815	538	78	07/06/1973	1225	21.3
27	19/02/1967	1200	513	79	07/06/1973	1405	23.1
28	19/02/1967	1600	532	80	07/06/1973	1450	22.7
29	20/02/1967	800	617	81	07/06/1973	1515	22.4
30	20/02/1967	1150	697	82	07/10/1973	755	11.6
31	20/02/1967	1445	708	83	31/10/1975	920	25.3
32	21/02/1967	810	837	84	23/01/1976	1035	1280
33	21/02/1967	1327	977	85	24/01/1976	745	1370
34	22/02/1967	800	1030	86	24/01/1976	1605	1340
35	22/02/1967	1615	1050	87	25/01/1976	750	1320
36	23/02/1967	815	1190	88	26/01/1976	855	1170
37	23/02/1967	1320	0	89	26/01/1976	1650	1150
38	23/02/1967	1600	1310	90	27/01/1976	820	934
39	24/02/1967	745	1430	91	27/01/1976	1655	818
40	24/02/1967	1600	1390	92	28/01/1976	825	674
41	25/02/1967	815	1500	93	28/01/1976	1715	582
42	25/02/1967	1430	1500	94	29/01/1976	830	423
43	26/02/1967	815	1550	95	29/01/1976	1750	372
44	26/02/1967	1445	1590	96	30/01/1976	820	253
45	27/02/1967	800	1630	97	30/01/1976	1815	234
46	09/03/1967	845	1840	98	31/01/1976	740	191
47	10/03/1967	815	1780	99	02/03/1976	1815	3400
48	11/03/1967	845	1740	100	05/03/1976	1305	2000
49	12/03/1967	815	1500	101	06/03/1976	1435	2340
50	12/03/1967	1230	1400	102	07/03/1976	800	2250
51	12/03/1967	1700	1350	103	08/03/1976	830	1970
52	13/03/1967	800	1090	104	08/03/1976	1845	1850

Gauge No	Date	Start Time	Flow	Gauge No	Date	Start Time	Flow
105	09/03/1976	915	1870	157	14/04/1976	835	199
106	10/03/1976	1330	1660	158	14/04/1976	1815	213
107	11/03/1976	1400	1660	159	15/04/1976	830	200
108	12/03/1976	900	1770	160	22/04/1976	1550	141
109	13/03/1976	815	1830	161	29/04/1976	1650	98.3
110	14/03/1976	805	2070	162	07/05/1976	825	80.6
111	14/03/1976	1745	1970	163	21/05/1976	1345	64.4
112	15/03/1976	755	2380	164	10/06/1976	1430	50.7
113	15/03/1976	1310	2440	165	23/06/1976	1635	48.1
114	15/03/1976	2020	0	166	26/07/1976	1600	33.7
115	16/03/1976	755	3050	167	08/09/1976	1510	25.8
116	16/03/1976	1410	3150	168	12/10/1976	1630	21.9
117	16/03/1976	2120	3370	169	25/11/1976	1705	20.7
118	17/03/1976	1855	4250	170	22/05/1977	1000	60
119	18/03/1976	725	4450	171	19/07/1977	1225	36.2
120	18/03/1976	1605	4840	172	07/10/1977	830	23.9
121	19/03/1976	815	5070	173	29/10/1977	1245	22.1
122	20/03/1976	840	5370	174	25/11/1977	850	31.5
123	21/03/1976	830	5270	175	18/05/1978	1225	30.3
124	23/03/1976	805	5260	176	12/07/1978	1630	30.2
125	24/03/1976	820	5700	177	29/08/1978	1000	22
126	25/03/1976	820	5930	178	29/08/1978	1120	22.1
127	26/03/1976	820	5960	179	29/09/1978	1020	21
128	26/03/1976	1730	5780	180	25/10/1978	1510	18.4
129	27/03/1976	815	5610	181	06/12/1978	1830	31.3
130	27/03/1976	1810	5350	182	25/04/1979	1535	36.9
131	28/03/1976	845	5390	183	16/06/1979	1705	22
132	29/03/1976	815	4890	184	20/07/1979	1630	21.1
133	30/03/1976	1125	4550	185	28/07/1979	1605	20.7
134	30/03/1976	1700	4370	186	28/08/1979	1310	19.2
135	31/03/1976	800	3910	187	07/09/1979	1130	19.7
136	31/03/1976	1700	3850	188	06/10/1979	920	15.3
137	01/04/1976	810	3370	189	15/11/1979	1345	17
138	01/04/1976	1245	3330	190	13/12/1979	827	23
139	01/04/1976	1750	3230	191	29/05/1980	1240	39.2
140	02/04/1976	810	2740	192	25/06/1980	1415	29.9
141	02/04/1976	1250	2540	193	19/07/1980	1630	24.7
142	02/04/1976	1645	2560	194	20/07/1980	1220	27.4
143	03/04/1976	800	2010	195	20/07/1980	1345	26
144	07/04/1976	1105	475	196	20/07/1980	1735	24.3
145	07/04/1976	1700	436	197	12/08/1980	1635	20.8
146	08/04/1976	845	366	198	17/09/1980	1655	18.7
147	09/04/1976	905	289	199	16/06/1981	1045	29.5
148	09/04/1976	1710	280	200	16/06/1981	1145	29
149	10/04/1976	950	264	201	15/07/1981	1630	25.5
150	10/04/1976	1815	252	202	02/09/1981	905	20
151	11/04/1976	935	252	203	02/10/1981	1114	24.2
152	11/04/1976	1810	234	204	14/11/1981	824	26.8
153	12/04/1976	830	232	205	22/05/1982	1715	29.8
154	12/04/1976	1815	208	206	11/07/1982	1115	22.6
155	13/04/1976	905	227	207	12/08/1982	1507	20.3
156	13/04/1976	1800	202	208	18/09/1982	1238	19.8

Gauge No	Date	Start Time	Flow
209	23/10/1982	952	17
210	18/11/1982	900	19.4
211	21/04/1983	1100	56.8
212	19/05/1983	1225	29.1
213	02/06/1983	1035	23.2
214	11/07/1983	1220	19.2
215	26/07/1983	1430	17.7
216	26/07/1983	1600	17.8
217	26/07/1983	1635	17.4
218	27/07/1983	1020	18.7
219	27/07/1983	1200	18.5
220	27/07/1983	1500	18.4
221	27/07/1983	1510	18.5
222	27/07/1983	1700	18.4
223	28/07/1983	815	18.5
224	28/07/1983	915	19
225	28/07/1983	1130	18.4
226	21/08/1983	1205	17.7
227	08/10/1983	945	15
228	27/06/1984	1240	35.6
229	21/08/1984	1810	25.9
230	12/10/1984	945	19.2
231	20/11/1984	1450	22
232	08/05/1985	1050	61
233	10/07/1985	1545	22.2
234	16/08/1985	1015	20.9
235	25/09/1985	1320	19.1
236	22/04/1986	1340	41.7
237	27/05/1986	1035	16.3
238	21/07/1986	1045	17.6
239	15/09/1986	945	16.1
240	07/11/1986	1010	13.9
241	17/12/1986	915	28
242	28/01/1987	1115	992
243	29/01/1987	900	1020
244	29/01/1987	1740	1160
245	30/01/1987	830	827
246	30/01/1987	1730	627
247	31/01/1987	900	656
248	31/01/1987	1725	661
249	02/02/1987	1720	1090
250	03/02/1987	900	1110
251	24/04/1987	1025	29.8
252	17/06/1987	1000	20.4
253	22/09/1987	1135	14.5
254	27/10/1987	751	13.3
255	27/10/1987	900	13.2
256	08/06/1988	1030	15.5
257	21/07/1988	1030	13.9
258	06/09/1988	1353	13.7
259	18/10/1988	1745	12
260	29/11/1988	1005	58.1
261	20/07/1989	1130	20.2
262	31/08/1989	912	16.6
263	12/10/1989	1145	16.9
264	24/11/1989	1036	36.7
265	18/05/1990	854	16.3
266	17/07/1990	1150	14.3
267	29/08/1990	1515	13
268	22/10/1990	1500	12.3
269	06/12/1990	1230	103
270	16/05/1991	1355	28.7
271	15/07/1991	1510	19.4
272	02/09/1991	1425	18.3
273	06/11/1991	1440	16.1
274	04/09/1992	945	14.7
275	25/05/1993	1552	24.6
276	30/07/1993	1325	17.9
277	28/09/1993	1425	15.493
278	25/07/1995	1350	24.226
279	14/11/1995	835	21.4
280	26/06/1996	1505	19.6
281	21/04/1997	1500	58.6
282	10/07/1997	1000	26.65
283	02/02/1998	1356	7700
284	04/02/1998	1317	8140
285	10/06/1998	1230	38.382
286	17/12/1998	1157	79.524
287	30/03/1999	1400	612

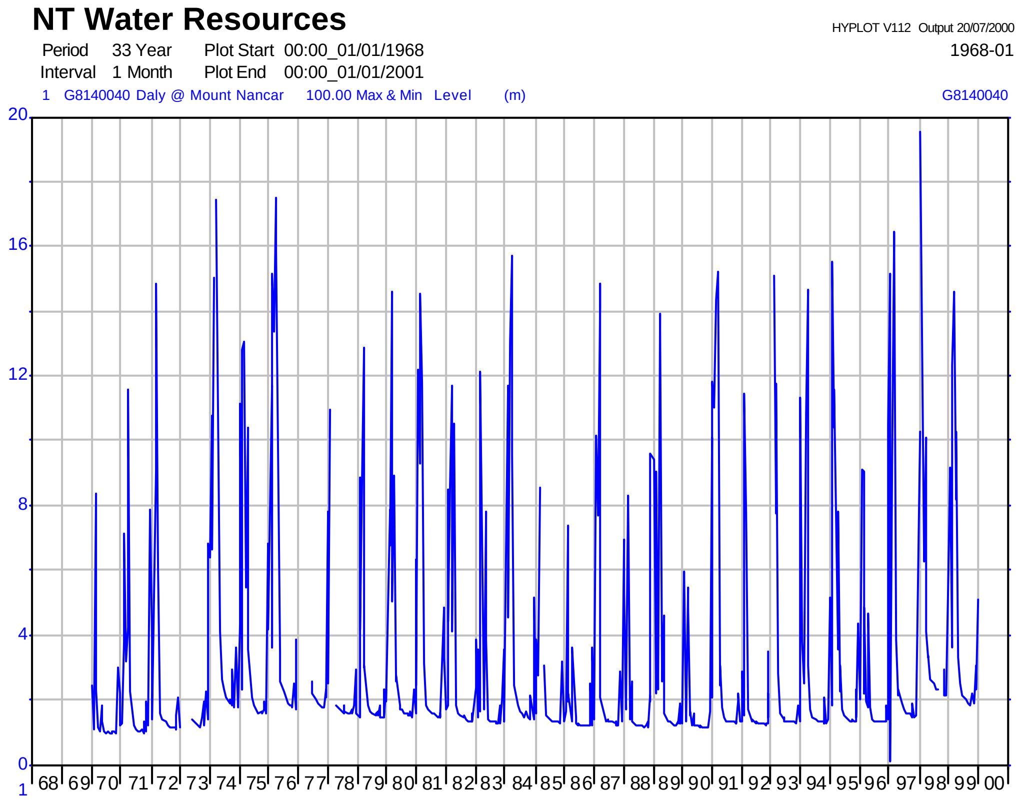


Figure E2(a) Max and Min Water Levels at G8140040

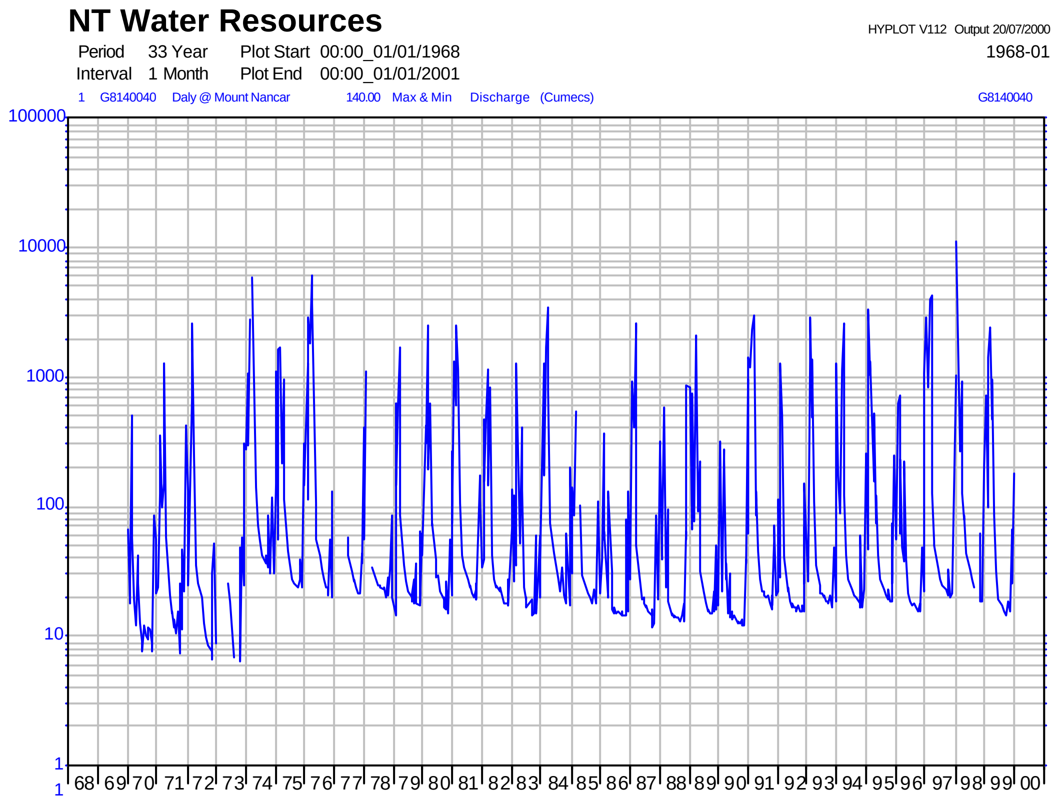
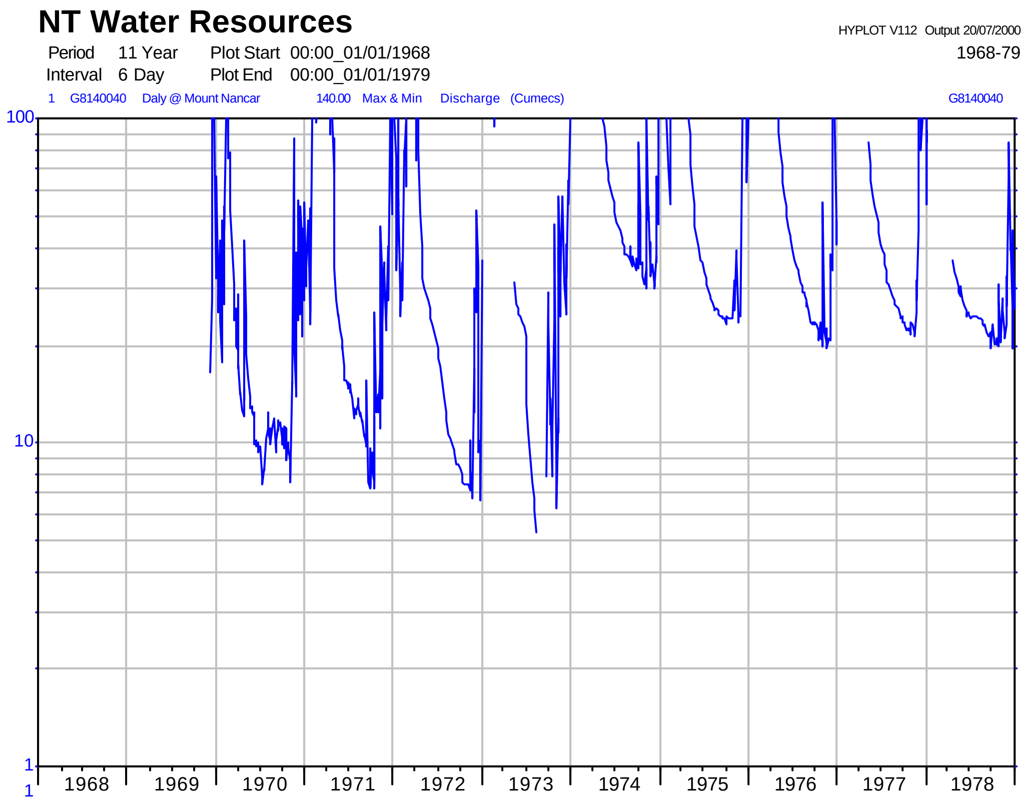
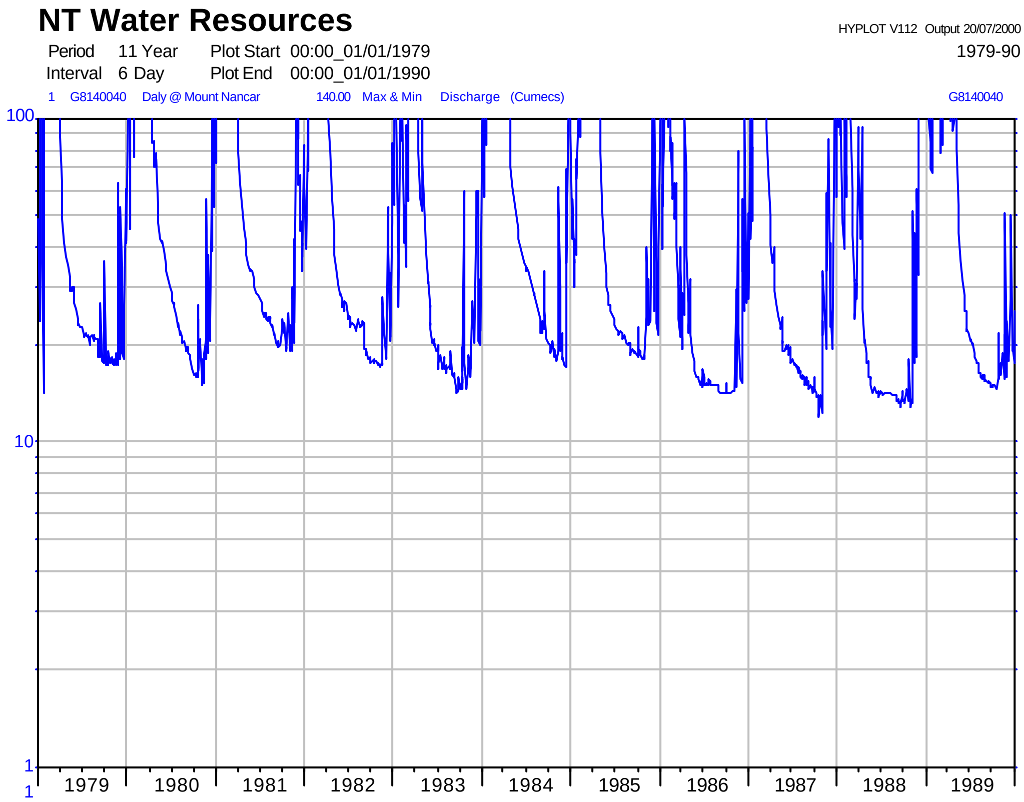


Figure E2(b) Max and Min Discharge (cumecs) at G8140040

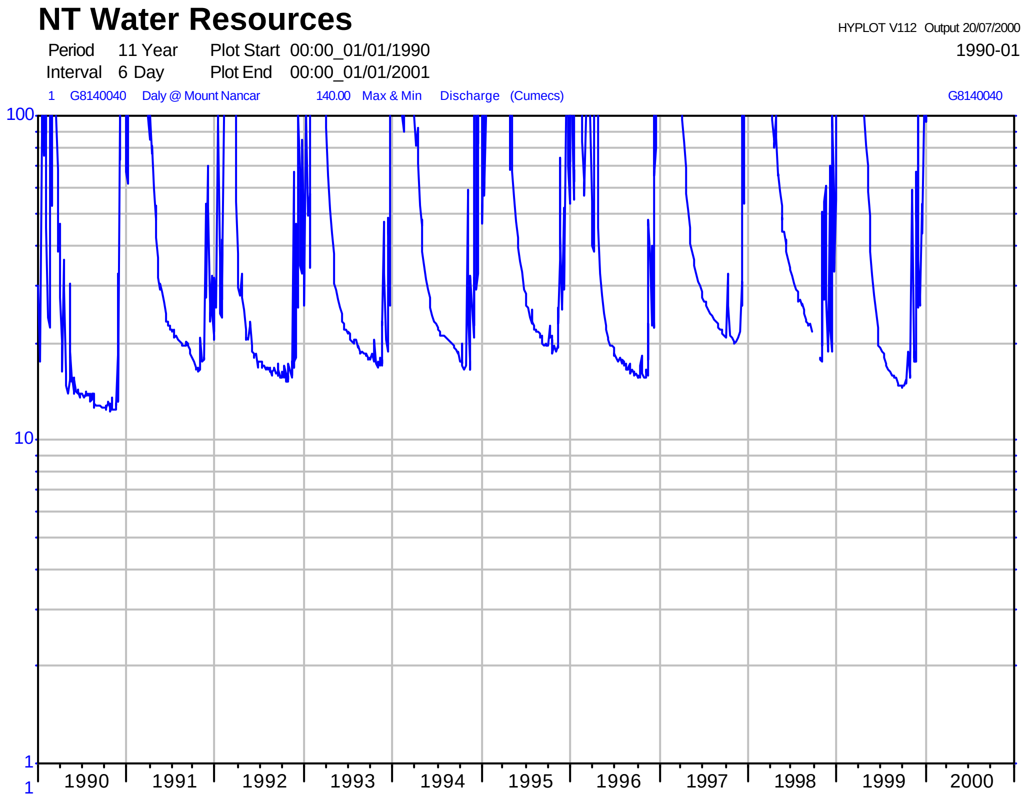
Figure E2(c,d,e) Expanded Minimum Discharge Hydrograpgh for G8140040



(c)



(d)



NT Water Resources
HYPLOT V112 Output 20/07/2000
Period 11 Year
Interval 6 Day
Plot Start 00:00_01/01/1990
Plot End 00:00_01/01/2001
1990-01
1 G8140040 Daly @ Mount Nancar 140.00 Max & Min Discharge (Cumecs) G8140040
100
10
1
1
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000

(e)