APRIL 1990 FLOODS
INLAND QUEENSLAND

Note

Due to public demand a small number of reprints was organised for sale at $15 per copy to those organisations which missed out on the initial distribution of the report. This copy is one of those reprints.

Since the initial printing in June 1990, a number of confirmed peak river heights have become available which differ from the initial estimates. These are shown as hand corrections in Table 3, Page 14. No attempt has been made to change the text, other tables or figures to match the corrected values in Table 3.

REPRINTED NOVEMBER 1990

The Courier-Mail

Phone 252 6011 Classified 252 0461 BRISBANE, Monday, April 23, 1990 Recommended Price 50c By Air Extra

Gastro outbreak in tent city for 2200

Refugees face epidemic

CARS float like corks down Charleville's main street outside a hotel yesterday . . . drinkers abandoned their vehicles and climbed on to the roof for safety after some of the worst flooding for 100 years.

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FOREWORD

The April 1990 inland floods produced record flood heights and widespread damages over a large area of inland Queensland. The towns of Charleville and Alpha were devastated and a number of smaller towns including Augathella, Jericho and Blackall were very seriously flooded.

Considerable surprise has been expressed that the new record heights reached in these floods are so high above previous record levels. There has been an expressed need for a report on what caused the floods, how the warning system performed and what can be done in the future to minimise the effects of future events.

In consultation with the Commissioner for Water Resources, a decision was made to publish a report fairly quickly after the event, which detailed the main features of the flood event, including the rainfalls which caused the flooding, the peak flood heights reached during the event and other aspects which lead to the record levels being reached.

The report has been produced by the Hydrology Section of the Bureau's Queensland Regional Office under the coordination of Supervising Engineer, Geoff Heatherwick. Data on peak discharges, total flood volumes and annual exceedance probabilities in Chapters 5 and 6 have been contributed by the Water Resources Commission. Chapter 8 on the flood management options available for these inland towns has been totally written by the Water Resources Commission, and I thank the Commissioner for their contribution.

In order to expedite the report, it has not been possible to verify all of the data presented in this publication, however it is the best available at the time of going to print.

I hope the analysis provided in this preliminary report contributes to a better understanding of the great floods of April 1990 in inland Queensland.

Rex Falls
Director (Queensland)

June 1990

THE APRIL 1990 FLOODS IN INLAND QUEENSLAND

1. INTRODUCTION

A number of western Queensland towns experienced record flooding during April 1990 with river levels in some areas exceeding the previous highest flood since European settlement by more than a metre. Damages have not yet been fully estimated but figures are now being quoted in the range $100 million to $200 million which includes damages to both public and private installations and loss of livestock.

Record flooding occurred in the Warrego River, Alice and Barcoo Rivers, Alpha Creek and the Maranoa River and major flooding occurred in the Thomson River and Cooper Creek and the Bulloo, Paroo and Balonne Rivers with the levels in some of these reaching near record levels. Major flooding also resulted in the Belyando, Nogoa, Comet and Dawson Rivers. The areas of record and major flooding are shown in Figure 1.

Rural newspapers and the State Emergency Service have provided an initial list of the significant damages as tabulated below:

Warrego River

Augathella	-	30 houses evacuated and more than 50 houses inundated
Charleville	-	1180 houses inundated from a total of 1470 houses. 2800 residents displaced from a population of about 4000. Inundation of all commercial and industrial premises in town.
Wyandra	-	2 houses affected

Thomson-Barcoo Rivers

Jericho	-	20 houses inundated, 5 houses with major damage, population 170.
Barcaldine	-	Drainage flooding in business premises in main street.
Blackall	-	120 people evacuated from 29 houses. 15 business premises inundated.
Aramac	-	One house flooded.
Longreach	-	20 people evacuated during local flooding.

Alpha Creek-Belyando River

Alpha	-	Worst flood in history with water 3m deep in lowest houses. 68 houses flooded ie 75% of the town. Population of town 600. 15 business premises flooded.

Maranoa-Balonne Rivers

St George	-	partial flooding of low areas of town, 2 houses evacuated.

Damages data has also been made available from a number of sources including:

Initial rural damage estimates (Courtesy of DPI) include:
- sheep 300,000
- cattle 11,000 total $7.5M
- Fencing 9,200 km $10.0M

- Buildings/farm dams	$7M	Total rural with hardship costs,	approx $30M
Railways damages approx	$7.06M	Main Roads (Not Shire)	$6.10M
Shire damages total	$20.10M	Public buildings and equipment	$4.80M
Total damage in Charleville, approx $45M		Damages to small business	approx $10M

Insured losses have been estimated at $8M to $10M and these are believed to be about 3.5 percent of the total losses. It will be many months before more complete information is available.

Although the floods in April 1990 extended through Queensland, New South Wales and Victoria, this report deals only with the flooding in Queensland. Detailed descriptions of the Warrego River flooding and flood warnings are included because of the severity of the disaster in the Warrego River at Charleville and Augathella. Flooding and flood warning information in the other river systems is covered in less detail.

2. LEAD-UP CONDITIONS IN MARCH

Rainfalls for March in the river catchments which flooded in April 1990 were generally in the category of average to very much above average. The serious rainfall deficiencies which existed in the Central Highlands and Central Lowlands districts at the end of February, were removed with the March rainfalls. Some stations in the Central Highlands recorded their highest March totals in their 30 to 40 years record. These include Wyseby which recorded 335mm compared with the previous highest March rainfall of 233mm in 39 years of record, and Winvic, formerly Carrols Creek which recorded 217mm, compared with the previous highest total of 161mm in 28 years of record. Figure 2 shows the rainfall deciles for March 1990.

The Bulloo and Paroo Rivers were in flood but receding in the first half of March and catchments which flooded in April were largely saturated by the end of March.

3. METEOROLOGICAL SITUATION DURING APRIL

3.1 Overview

The series of daily synoptic weather charts Figures 3a, 3b and 3c for the first twenty three days of April all display a broad surface trough over the interior of Queensland. On these charts the dip in the east-west oriented isobars, equatorwards of the high pressure belt, indicates the location of the trough. Throughout this period the prevailing lower-level easterly winds ensured that a moist airmass originating over the Coral and Northern Tasman Sea, was maintained east of the trough. This airmass was relatively unstable throughout allowing the development of deep convection, producing showers and thunderstorms, on most afternoons and evenings.

Rainfalls were heaviest, more prolonged and widespread during episodes of enhanced vertical motion caused by converging low level winds and migratory middle level troughs and lows. These periods of forced vertical motion saw scattered thunderstorm activity change to widespread moderate to heavy rainfall including several individual daily falls which exceeded long term April records.

Three rainfalls events were clearly identifiable by areal extent and rainfall total, viz:

the 48 hours to 9am 2nd,
the 48 hours to 9am 11th and
the 72 hours to 9am 20th.

3.2 First rain event, 48 hours to 9am 2nd April

During this period a stationary middle-level (500 hPa, approx 8km altitude) trough overlay the surface trough which moved eastwards as a 1028 hPa high, centred in the Bight, pushed a ridge into S.E. Queensland. The introduction of the ridge caused an increase in the low-level easterly airflow which in turn increased the convergence of the deep, moist, unstable airmass ahead of the surface trough. The resulting thunderstorm activity produced heavier and more extensive falls during the initial 24 hours because the low level convergence was strongest during this period.

3.3 Second rain event, 48 hours to 9am 11th April

Upper air temperature and humidity soundings indicated that available moisture and airmass instability increased dramatically east of the surface trough from the 8th to the 9th and that these conditions were maintained for the remainder of the period. Surface charts for the 8th, 9th and 10th show an amplifying trough over inland Queensland. This amplification coincided with an increase in convergence of the low level NE to N'ly airflow. Superimposed upon this system were moist, mid level NE to NW'ly winds converging between a ridge over the Coral Sea and a weak trough over central Australia. During the period drier mid level westerly winds gradually intruded upon the airmass as the mid level trough relaxed.

Convergence over Queensland was strongest in both the low and mid levels on the 9th and 10th resulting in the heaviest falls in the 24 hours to 9am 10th, whilst the drying trend contributed to the generally lighter falls during the next 24 hours.

3.4 Third rain event, 72 hours to 9am 20th April

On the 15th a 1030 hPa high in the western Bight extended a ridge to eastern Victoria, and this gradually pushed into the Tasman Sea during the next few days, causing yet another increase in moist low level easterly windflow into Queensland. Simultaneously a middle level or deep tropospheric low developed near Eucla on the 16th, remained stationary but deepened slowly until the 18th, moved slowly east and deepened further until 9am 20th when it was located near Marree. From then on, still deepening, it accelerated away to the southeast.

As the deep tropospheric low developed, the low level trough in the easterly flow progressively amplified until a surface low evolved near Cobar at 9am on the 19th.

Available moisture increased explosively from 16th to the 17th and then steadily until the 20th. Airmass instability increased to a level which would support sustained deep convection.

While the low level winds exhibited increasing convergence as the surface low developed, the mid level flow likewise maintained a convergent N/NW'ly pattern which gradually increased as the deep tropospheric low became mobile.

TABLE 1 APRIL 1990 DAILY RAINFALLS - 1ST TO 20TH (1MM AND ABOVE)

	DATE																			
STATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Woodbine	6	18		27						___	___	15						20	77	71
Tiree				12						8								8	88	79
Tangorin	15	7		21						2	61						2	11	45	84
Muttaburra	53	15		3					6	9	55	1						79	52	42
Clermont		10	3	1		13			4	1	1						1	1	4	5
Aramac	86	23			1				1	7	96					3		188	94	74
Longreach	96	5			1					23	11		3			6	3	18	92	55
Ilfracombe	64	4			6					36		24		9		39		25	58	45
Barcaldine	51	4			4					5	27	1					13	114	56	43
Jericho	6	8			6					11	13						14	26	173	129
Alpha		41		1	32	2			1	9	45							4	159	
Bogantungan		14	4	16	41	6			33	8	2							3	66	
Emerald		8	5	11		19			2		6								12	13
Stonehenge	66	7	69	1						22				6		37	4	31	11	14
Isisford	66				2					137	27						8	1	31	138
Blackall	12				35					25	8	1		4		39	1	43	72	58
Springsure		2	6	2	2	53	___	___	35		5							2	79	19
Jundah	24	23								10				6		15		12		3
Yaraka		17	17	5						___	28	42		15		33			6	
Tambo	6	1			5	7			3	8	14		___	___	___	___	29	14	51	81
Rewan			14	24	22	17			3	7	2		1			2	1	4	225	10
Windorah	12	9	20		6					26	21		14	20	1	20	55	14		14
Tanbah														3		22		15		6
Thylungra	29	117	5					2	5			6	29			17		14		26
Adavale	21	10			11			1		38	1	4		13		9	23	24	34	28
Augathella	___	7			4	22			14	37	8	4					45	3	17	146
Injune		1	1	4	6	44			2	8		2			5	13	1	4	57	20
Eromanga	24	26								___	43			17	___	___	27	11		28
Quilpie	62	77					4		8	1			3	14		13	3	19		27
Charleville	30	4	21			33			26	25	4	7				7			8	77
Morven	1	1			4	29	___	___	8	68	10		___	___	___	___	13	1	16	138
Mitchell			2		1	9			2	44	94	1			15	27		4	30	96
Roma		1				1				20	1	3			2	82			46	21
Wyandra	103	1	5		42	62			29	48	15		5	16		24	3	33	29	43
Tomoo										131	3	8		18	2	8	1	9	8	54
Woodlands					2	4				41	25	25		15	6	10		3	28	67
Surat		1	3			7				3						30	4	4	26	16
Thargomindah	3	4	11		30		1			1	2			23				31		37
Eulo	___	154					31									___	___	___	62	45
Cunnamulla	112	9	27	46	5	19		71		9	5			10		8	5	66	15	51
Bollon					9	2	1		2	59	19	11		17		13	1	23	11	43
St George		1	13	1	1	2		10	1	25	6			47	2	12	1	7	11	59
Dirranbandi			12		1				1	30	12	2	___	___	___	___	21	13	7	34
Hebel	1	6	15			2	___	___	28	90				16	___	___	8	22	29	19

Note: The horizontal lines indicate that the rainfall amount following the line fell over the number of days indicated.

Drier mid level winds progressively intruded into the system as the airflow changed direction from N/NW to W/NW between 19th and 20th. The drying of the mid levels combined with the reduction of convergence, as the "cut-off" accelerated away, to bring an abrupt end to this rainfall event and to the April rains in general which collectively produced record areal April rainfalls to several inland shires and rainfall districts.

4. APRIL 1990 RAINFALLS

Table 1 shows the daily rainfalls for selected rainfall stations in the flooded catchments for the first 20 days of April. As described in Section 3, there were three main rainfall episodes in this period. The first was the 2 day rainfall ended Monday 2nd April, the second was the 2 day rainfall ended 11th April and the third was the 3 day period ended Friday 20th. The third period of rain fell on totally saturated catchments with most streams already in flood and generated the record flooding in several of the inland streams.

Heavy rainfalls for the 20 day period were centred around three main areas including the Isisford, Blackall, Aramac area where rainfalls of 400 to over 500mm were recorded, in the Carnarvon Ranges area where rainfall totals exceeded 300mm and in the lower Warrego between Charleville and Cunnamulla where rainfalls over 400mm were recorded. The 20 day rainfall isohyets are shown in Figure 4.

Rainfalls in the three days ended 9am Friday 20th April leading to the major flood peaks exceeded 200mm in the Barcaldine, Jericho, Muttaburra areas with Aramac exceeding 300mm in the same period. Another centre of high rainfall was in the Carnarvon Ranges where the three day total was above 200mm. This is shown in Figure 5.

The rainfalls which caused the record Warrego River flood started with falls up to 200mm in the 24 hours to 9am Thursday 19th April in the Carnarvon Ranges (headwaters of the Warrego River) with lesser falls of 100mm around Babbiloora and 50mm around Augathella. This generated a large flood in the headwaters draining towards Augathella. In the next 24 hours (to 9am Fri 20th) the centre of heavy rain moved to the Augathella area where rainfalls of about 140mm were dumped on to the flood approaching Augathella. At the same time Bradley's Creek and the Wellwater had received 80 to 140mm rainfalls in the 24 hours ended Friday 20th April. Major flooding in Bradley's Gulley and the Wellwater on the morning of Friday 20th caused rapid rises in the Warrego River at Charleville and the initial evacuations of some 20 families. The main body of Warrego River floodwater from upstream then reached Charleville on the evening of Friday 20th before water levels in Bradley's Gulley had time to recede. The one day rainfalls for the 19th and 20th are shown in Figures 6 and 7. (See Chapter 6 for further details.)

Rainfalls in the first 20 days exceeded the record monthly rainfalls for April in many areas of the Maranoa, Warrego, Central Lowlands and Central Highlands. The area of record monthly rainfall is shown on Figure 8. The monthly totals were 10 times the average monthly rainfall in many areas.

A number of daily rainfall records were also broken for April as shown in Table 2.

TABLE 2 RECORD DAILY RAINFALLS FOR APRIL 1990 FOR ALL YEARS OF RECORD

STATION		APRIL 1990		PREVIOUS HIGHEST		
name	number	amount	date	amount	date	years of record
Alpha	035000	159	19	133	1/1890	98
Rewan	035090	225	19	161	20/1928	45
Jericho	035256	173	19	90	9/1941	87
		129	20			
Aramac	036004	188	18	104	5/1913	82
Mitchell	043020	94	11	79	19/1894	100
		96	20			
Augathella	044002	146	20	106	9/1955	96
Cunnamulla	044026	112	1	80	1/1988	103
Hebel	044042	90	10	79	3/1959	88
Morven	044050	138	20	90	23/1918	97
Wyandra	044076	103	1	83	30/1968	91
Thylungra	045018	117	2	76	5/1921	83

5. FLOODING

5.1 Overview

Rainfalls at the end of March and the first few days of April marked the onset of initial river rises and flooding in the Warrego, Paroo, Bulloo, Barcoo and Thomson Rivers. During the first ten days of April, minor to moderate flooding in these streams generally eased slowly, however the saturation of catchments continued and run-off potential steadily increased as rainfalls continued in central and southern Queensland.

With wet catchment conditions causing high run-off from rainfall, the second burst of general heavy rain in the period Monday 9th April to Wednesday 11th April produced sharp renewed rises and subsequent major flooding in the Warrego, Paroo, Bulloo, Barcoo and Thomson Rivers and Cooper Creek. The heavy rain extended to the western Darling Downs causing the onset of major flooding in the Maranoa River and moderate flooding in the lower Balonne River.

During the following six days from Wednesday 11th April, general rain with some heavy falls persisted over central and southern inland Queensland. Runoff from the saturated catchments maintained high flows in most of the major streams, with fluctuating river levels in response to the heavier falls, and multiple flood peaks in the river systems.

The final, and heaviest, episode of rain occurred in the central and southern inland from Tuesday 17th April to Friday 20th April, as described in Chapter 4. High level major flooding, and in many areas, record flooding, developed in the tributaries and main river channels of the Maranoa, Mungallala/Nebine Creeks system, Warrego, Paroo, Bulloo and the Thomson-Barcoo. The heaviest rain also extended to the headwaters of the Belyando, Nogoa, Comet and Dawson Rivers which flow eastwards from the Dividing Range, causing in particular, record flooding along Alpha Creek, a headwater tributary of the Belyando River. Towns which were most seriously affected by floodwaters included Alpha, Jericho, Blackall, Charleville and Augathella. Selected flood hydrographs showing the time sequence of river heights on key river gauges and the prolonged flooding in a number of catchments are shown in Figure 9. Peak heights for key stations are summarised in Tables 3 and 4.

A description of the flooding in each river basin is given in the following sections, with the Warrego River flood covered in detail in Chapter 6.

5.2 Thomson and Barcoo Rivers, and Cooper Creek

Local runoff and flooding commenced in the Thomson and Barcoo Rivers and tributaries at the start of April, with Isisford on the Barcoo River recording a moderate flood peak of about 5.2 metres overnight Monday 2nd April. The combined flood flows from the Thomson and Barcoo Rivers produced a flood peak of 5.4 metres at Windorah on Cooper Creek by the following Sunday 8th April which is 0.4 metres above the 5 metre threshold of major flooding. The renewed heavy rain on the 9th and 10th April caused major flooding to develop along the Thomson and Barcoo Rivers, with Isisford peaking at about 6.2 metres on Wednesday 11th April, and a subsequent second peak at Windorah of 6.45 metres on Tuesday 17th April.

Very heavy rain was recorded in the Aramac (188mm) and Barcaldine (114mm) areas during the 24 hours to 0900 Wednesday 18th April, with general 50 to 100 millimetre falls over the Thomson, Barcoo and Alice Rivers and tributary streams. Barcaldine experienced flooding from drainage surcharge in some main street business premises. This was followed by further heavy rain during the next 48 hours to Friday 20th April with highest totals including Tangorin 129mm, Aramac 168mm, Longreach 147mm, Jericho 302mm, Blackall 130mm and Isisford 169mm. High level major flooding developed quickly in the Thomson, Barcoo and Alice headwaters during this period. The small town of Jericho (population 170) on Jordan Creek, a headwater stream of the Alice River, recorded its highest flood in living memory. About twenty houses were inundated, and it is reported that five of these had major structural damage. There was extensive damage to bridges, roads, railways and other public utilities.

The resulting flood peaks along the Alice and Barcoo were at least the highest this century. The flood peaks were Blackall 7.3 metres on Friday 20th April, Barcaldine 7.9 metres on Sunday 22nd April and Isisford 9.2 metres on Monday 23rd April. In Blackall, one hundred and twenty people were evacuated from about 30 homes, and 15 business premises were inundated.

The major flooding which peaked along the Thomson River system south from Muttaburra (Landsborough River) to the Thomson-Barcoo junction was the highest since the record floods of January 1974. The flood peak at Longreach was 5.04 metres on Sunday 22nd April which required the evacuation of about 20 people and the sandbagging of low-lying parts of the town. The flow on the Thomson River was measured by the Water Resources Commission at 7,000 cumecs on 24th April at Longreach and the peak flow on 22nd April was 8200 cumecs. The peak downstream at Jundah on Thursday 26th April was about 0.8 metres below the 1974 flood. Before the flood peak, a new higher level road was constructed to prevent the hospital from becoming isolated from the township. (One cumec is one cubic metre per second.)

On Cooper Creek, the main flood peak at Windorah was 7.95 metres on Saturday 28th April causing high level major flooding particularly in the eastern Cooper channels. For comparison, the 1974 flood peak at Windorah was 8.48 metres, and 7 metres in May 1989. Although the flood peak at Windorah was only about half a metre below the record flood of 1974, the total volume of floodwaters was much less. The 1974 flood volume has been estimated to be about 23 cubic kilometres compared with about 12 cubic kilometres for this event. However, the duration of major flooding at Windorah was lengthy, remaining above 5 metres almost continuously from about 6th April to 10th May. The leading edge of the main body of floodwaters reached Nappamerrie at the South Australian border on Thursday 10th May, and subsequently peaked on Wednesday 16th May at a height of 9.4 metres. The 1974 flood peak was 10.13 metres. At the time of writing this report, it was expected that some of the Cooper Creek floodwaters would reach Lake Eyre during the winter months.

5.3 Paroo and Bulloo Rivers

Paroo River

Thunderstorm rainfalls during the four days to Friday 23rd February produced initial rises and minor to moderate flooding in the Paroo and Bulloo Rivers. At Eulo on the Paroo River, the river level peaked at 4.05 metres on Wednesday 4th March, which is just about major flood level and about one metre above the main road bridge. The river level remained above the road bridge continuously from 1st April to 4th May. Two main flood peaks were recorded during this period. On Saturday 14th April, the river level at Eulo reached 5.2 metres which was similar to the 1983 flood, and following the main burst of rain, Eulo peaked at 5.80 metres on Sunday 22nd April. Floodwaters encroach low-lying parts of the town at this level which is the highest on record since the 1890 flood of 5.84 metres. The resulting peak downstream at the border town of Hungerford was 2.92 metres on Thursday 26th April which was a little higher than the 1974 flood, however this level does not affect town buildings.

Bulloo River

The Bulloo River at Quilpie remained above minor flood level of 3 metres from 1st April until 28th April with a succession of flood peaks at about the threshold of major flooding (5 metres). The highest and final peak at Quilpie was 6.16 metres on Monday 23rd April (similar to the flood peak in May 1989) which causes little problem to the township other than the cutting of the main road bridge.

5.4 Balonne and Maranoa Rivers

Heavy 48 hour rainfalls to Wednesday 11th April produced the initial occurrence of major flooding in the Maranoa River. Highest rainfalls for this period included Mitchell 138mm, Amby 111mm and Woodlands 67mm. The 9.75 metre peak at Springfield at midnight on Wednesday 11th April was a little below the flooding of May 1983. Moderate flooding also developed in the Balonne River above Beardmore Dam from tributary inflows, with St George downstream from the dam reaching 7.8 metres on Sunday 15th April.

The final heavy burst of rain in the 48 hours to Friday 20th April on the saturated Maranoa River headwaters produced fast river rises and high level major flooding. The Maranoa River at Mitchell peaked at about 9 metres at 0300 Friday 20th April which was the highest on record since 1924. The flow on the Maranoa at Mitchell was measured by the Water Resources Commission on 20th April at 1700 cumecs with velocities up to 3.77m/sec. The flood peak downstream at Springfield (10.44 metres) occurred during Friday afternoon and was slightly higher than the record July 1950 flooding. The Water Resources Commission operate an automatic telemetry recording station at Cashmere on the lower Maranoa river to monitor inflows to Beardmore Dam from the Maranoa. The instrumentation is in an elevated hut, and this was flooded during Sunday morning with river levels rising rapidly to a record peak during Sunday evening (22nd April).

Combined floodwaters from the Maranoa and Balonne produced very fast rises downstream at St George during Sunday night. The St George peak of 12.24 metres on Monday evening (9pm) is exceeded this century only by the 1950 flood. Historical records show that a higher flood of 13.1 metres occurred in 1890. The flood peak was about 1.5 metres above the St George road bridge, and floodwaters entered low lying areas of the town requiring the evacuation of two houses.

At the peak of the flood in the Balonne River, Beardmore Dam which has a storage capacity of 101,000 megalitres, was discharging some 275,000 megalitres per day, or 2.7 times its storage capacity, per day. Under these conditions the dam had little or no flood mitigating effect. It is estimated that approximately 1,708,000 megalitres passed over the dam into the Balonne-Culgoa system during the floods in April augmenting the already large run-off in the Darling River system which had resulted from widespread rainfall over northern New South Wales.

The vertical gates on Beardmore Dam are designed to open fully when discharge over the spillway reaches 400,000 megalitres per day. Releases from the dam up to this discharge are varied so as to maintain the storage at full supply level. In the April flood, the discharge reached 275,000 megalitres per day which required the operation of all twelve gates. During the period of peak discharge, the water level downstream from the dam rose to approximately fixed crest level.

Estimation of the inflow and hence determination of outflow is made using Weribone (Balonne River near Surat) and Cashmere (Maranoa River new Old Cashmere) gauging stations. Both stations incorporate dial up recorders using a digital radio concentrator system. During floods the gauging station at Cotswold (Condamine River) is used to give early estimates of inflow to the dam. Both stations provided useful flood information up to the point at which the station at Cashmere was submerged. Although this posed no threat to the safety of the dam or its operation, greater effort was required by the operator to manage the outflow from the dam by the operation of the gates.

Precautionary sandbagging of the Dirranbandi levee was carried out ahead of the peak in the Balonne, Bokhara, Culgoa and Narran River system below Dirranbandi which was similar, and in some areas slightly higher, than the serious flooding of May-June 1983. The State Emergency Service coordinated fodder drops to stranded stock in this area. The main flood peak did not reach the New South Wales border until early May.

5.5 Macintyre River

A minor flood occurred in Macintyre Brook during Saturday 21st April which led to moderate flooding in the Macintyre River below Goondiwindi during the following week. Goondiwindi reached 8 metres on Monday 23rd April. Coolmunda Dam filled and overflowed releasing water into the Macintyre Brook. Prior to the flood the dam was 94 percent full.

5.6 Alpha Creek and Belyando River

During the 24 hours to 9 am Thursday 19th April, very heavy rain was recorded in Alpha Creek, a headwater tributary of the Belyando River. The rainfall total at the town of Alpha was 159 millimetres. The resulting flood at Alpha overnight Thursday 19th and Friday 20th April was well above the previous record flood of 1950, with water about 3 metres deep in houses in the low-lying areas. Approximately 70 houses were flooded (75% of town) as well as all fifteen business premises, and the evacuees had to take refuge at the local golf club.

Little is known of the flood in the upper and middle reaches of the Belyando River during the following week other than reports indicated it to be higher than the record flood of 1950. Native Companion Creek, a tributary of the Belyando River, recorded a peak discharge of 2880 cumecs, exceeding the previous highest of 309 cumecs in 1973. The Commission's gauging station on Native Companion Creek at Violet Grove was overtopped. The flood peak reached the lower Belyando at Mt Douglas station on Monday 1st May and Scartwater station on the Suttor River on Thursday 3rd May.

5.7 Fitzroy River Basin

Major flooding developed in the upper Nogoa and Comet Rivers during Thursday 19th and Friday 20th April. The flood peak at Raymond on the Nogoa River was the highest since 1956. The peak at Rolleston on the Comet River was the highest since records began in 1958. Fairbairn Dam spilled to a maximum level of 2.45 metres (110,000 megalitres per day) metres above the spillway on Tuesday 24th April, after being only about 63% full at the start of April. This was the third largest ever flow over the spillway since the dam was completed in 1968. Historically the flood in the Nogoa River was the largest since November 1950 and similar to the flood in April 1956. However, Fairbairn Dam had a significant mitigating effect on the flood height. The existence of the dam reduced the river height at the road bridge across the Capricorn Highway by around 3 metres and reduced the discharge to one third of that which would have occurred without the dam. Only moderate flooding was recorded along the Mackenzie River, and the eventual peak at Tartrus on Monday 30th April was well below minor flood level.

Although major flooding was reached at Taroom, only minor flooding was generally recorded along the Dawson River. The combined flows from the Mackenzie and Dawson produced a peak of 11.3 metres at Riverslea on Tuesday 1st May which is also below minor flooding.

6. WARREGO FLOOD

6.1 Catchment Description

Figure 10 shows the catchment of the Warrego River.

The drainage areas above Charleville which contribute to the nature and size of Charleville floods include :

- the upper Warrego River and tributary creeks above Augathella. The headwaters are in the Carnarvon Ranges about 170 kilometres to the north east of Augathella. Catchment area to Augathella is about 7,500 square kilometres.

- the Nive River (catchment area 5000 square kilometres) which rises in the Warrego Range to the north, and enters the Warrego River about 25 kilometres below Augathella.

- creek systems entering the Warrego between the Nive River junction and Charleville. The Kennedy Creek - Wellwater system to the northeast of Charleville has a catchment area of about 800 square kilometres and enters the main Warrego River about 10 kilometres upstream from Charleville. Bradleys Creek rises 40 kilometres to the east of Charleville and flows through the town centre (Bradley's Gully) to join the Warrego. Drainage area of Bradleys Creek is about 300 square kilometres.

The total catchment area above Charleville is approximately 16,600 square kilometres which, for comparison, is slightly larger than the entire Brisbane River catchment.

Below Charleville, the Langlo and Ward River system flow into the Warrego from the northwest, and Angellala Creek enters from the east. Between Wyandra and Cunnamulla, a number of large distributary streams allow part of the Warrego River overflows to bypass Cunnamulla.

6.2 Preliminary Flooding During April

Initial flooding in the Warrego River system commenced at the end of March and reached moderate to major flood levels in the Warrego above Charleville, and in the Langlo and Nive Rivers. Further heavy rain was recorded in the 24 hours to 9 am Sunday 1st April mainly to the south of Charleville. Highest reported rainfalls included Cunnamulla 112mm, Wyandra 103mm, and Charleville 30mm. Minor flooding peaked along the Warrego River below Charleville to Cunnamulla during the period Tuesday April 3rd to Saturday 7th April. At the same time, renewed rises developed in the upper Warrego and tributaries and a peak just above major flood level was again recorded at Augathella (5.7 metres on Friday 6 April).

At the start of the next week, widespread heavy rain fell over the upper and middle reaches of the Warrego River catchment. The 72 hour totals to Wednesday 11th April included Augathella 59mm, Charleville 55mm, Morven 86mm, Wyandra 92mm and Cunnamulla 14mm. Runoff from the saturated catchment produced moderate to major flooding in all tributary streams. Augathella reached a major flood peak of 6.1 metres on Thursday 12th April. Downstream at Charleville, the river peaked just below 5 metres on Thursday 12th from local runoff, and reached a final peak of 5.3 metres late on Saturday 14th. This floodwater caused renewed rises with generally moderate flooding downstream from Charleville.

6.3 The Record Warrego Flood

Local heavy rainfalls continued in the Warrego catchment during 14th to 18th April causing fluctuating river levels to about major flood level. Charleville reached a peak of about 5.5 metres on Wednesday 18th April. (See Figure 9.)

With thoroughly saturated conditions, the record flood began with a band of rain of 50 to 100 mm over the upper reaches of the Warrego, Nive and Ward Rivers during the 24 hours to 9 am Thursday 19th. The headwaters of the Warrego River in the western quarter of the Carnarvon Ranges had rainfalls of 100 to 200 mm in the same period. (See Figure 6.) On the eastern side of the Carnarvon Range, Rewan reported 225 mm for the 24 hours.

The Warrego River rose quickly at Augathella to reach 6.1 metres during Thursday afternoon.

Very heavy rain intensified during Thursday particularly during the night hours, with the heaviest rain centred over the Warrego catchment above Charleville and Angellala Creek. The rainfall isohyets for the 24 hour period to 9 am Friday 20th are shown at Figure 7. Rainfalls reported for the 24 hours included Augathella 146mm, Morven 138mm, and Charleville 77mm. With river levels already at major flood level, fast river rises re-commenced during Thursday night and Friday morning to reach record levels well above previous records. The stage hydrographs (river heights plotted with time) are given for the Bureau flood warning river height stations in Figure 11.

At Augathella, the Warrego River peaked at an estimated 7.3 metres at 3pm Friday with reports of about 50 houses in the town being inundated. Flood levels also peaked at Biddenham on the lower Nive River during Friday afternoon.

At Charleville, heavy rain to the east towards Morven caused flash flooding in Bradleys Creek overnight Thursday. Low lying properties and business premises were flooded in Charleville during Friday morning by the overflow from Bradleys Gully. Bradleys Gully flooding appeared to peak around midday Friday, however by this time, the main body of Warrego floodwaters was reaching Charleville. Between 9am and 6pm on Friday 20th, the river level at Charleville rose almost one metre (6pm reading was 7.15 metres) and had exceeded the previous record of 6.96 metres set in April 1956.

Overnight Friday and Saturday morning (21st April) the Charleville river level continued to rise quickly and was above 8 metres by daylight Saturday. Floodwater velocities through the town were high in the lower parts of the town. The peak occurred early Saturday afternoon at an estimated height of 8.2 metres. The river fell slowly during Saturday night, falling only about half a metre by Sunday morning.

The town was severely flooded with about 1180 homes (from a total of 1470 dwellings) and all of the commercial/business premises inundated including the police station, post office, banks and the telephone exchange. The State Emergency Service coordinated the total evacuation of the town to temporary accommodation at the airport.

Downstream from Charleville, record flooding accompanied the peak. The Murweh flood peak was 11.2 metres at 9pm on Sunday 22nd April. At Wyandra, the flood peaked at 10 metres on Monday 23rd April and two homes were reported to be affected.

The Warrego River at Cunnamulla reached about 9.5 metres during Sunday 22nd April from the earlier flood in the Warrego, and then commenced to rise again on Monday afternoon as the main floodwaters arrived. The final peak at Cunnamulla was 10.15 metres on Wednesday 25th April. The flood peaks along the Warrego River at Charleville, Murweh and Wyandra were significantly higher than the April 1956 flood (0.74 metres higher at Wyandra), however the Cunnamulla peak was only about two centimetres higher than 1956. This is the result of a series of major overflow channels below Wyandra including the Kudnapper, Widgeegoara, and Noorama Creeks which enable part of the high flood flows to leave the main Warrego River channel and bypass Cunnamulla. Cunnamulla was also protected by the levee bank which had been constructed following major floods in the early 1970's and raised in parts by sandbags in the few days immediately prior to the peak.

Record flooding extended to the New South Wales border by the end of April.

Table 3 gives a list of peak flood heights recorded at the Bureau's river height reporting network together with comparative data on the highest peaks previously recorded. The peak height records for key river height reporting stations in the Warrego River catchment are given in Appendix 1. Table 4, by courtesy of the Water Resources Commission, gives peak flows, volumes and estimated annual exceedance probability for selected stations.

7. FLOOD WARNING SYSTEM & WARNING PERFORMANCE

7.1 Overview of the Queensland Flood Warning System

The Bureau of Meteorology has had primary responsibility for flood warning services in Australia since 1908. The development and operation of flood warning services for flood prone communities in the State of Queensland is the role of the Hydrology Section which is a specialist team of professional engineers, a meteorologist, and technical officers (eleven officers in total) with extensive training and experience in water engineering and flood behaviour of Queensland streams. The Hydrology Section is a part of the Queensland Regional Office based in Brisbane. The expertise and resources of other units in the Regional Office also contribute significantly to the operational flood warning service, including in particular the Regional Forecast Centre (weather forecasts) and the Severe Weather Section (cyclones, thunderstorms).

The basic data reporting network consists of the following in Queensland :

River height reporting stations including telemetry stations	approx 240
Special heavy rainfall stations including telemetry stations	approx 140
Daily rainfall stations reporting at 9am, including the special heavy rainfall and synoptic stations	approx 490
Synoptic stations reporting meteorological elements (pressure, temperatures, wind etc) as well as rainfall, at 3 hourly intervals	approx 80

The Bureau's flood warning reporting networks for the main rivers flooded in April 1990 are shown in the maps of Figures 12, 13, 14 and 15. Most of the floodwarning rainfall and river height stations in western Queensland are manned by volunteer observers recruited by the Bureau. Most of these observers send their observations to the Bureau at pre-set schedules using a Remote Observation Terminal, a calculator-like device, that connects to their telephones. The readings are automatically received and partially processed by the Bureau computers, and are analysed by the Hydrology Section staff manning the Floodwarning Centre in Brisbane.

TABLE 3 APRIL 1990 PEAK FLOOD HEIGHTS FOR FLOOD WARNING NETWORK

NOTE: SOME PEAKS ESTIMATED - SUBJECT TO LATER CONFIRMATION

	APRIL 1990 PEAK			PREVIOUS RECORD		FIRST YEAR	MAJOR
STATION	HT(m)	TIME	DATE	HT(m)	YEAR	OF DATA	FLOOD HT
WARREGO							
Augathella	7.30	1500	20/4	6.35	1950	1910	5.5
Biddenham	7·20 ~~7.00~~	1500	20/4	5.94	1955	1955	5.5
27 Mile	6·98 ~~7.50~~	0300	21/4	5.69	1956	1956	4.0
Charleville	8·54 ~~8.20~~	1500	21/4	6.96	1956	1910	6.0
Mt Morris	5.30		20/4	5.64	1971	1970	5.0
Bakers Bend	~~12.00~~ 12·10		22/4	10.72	1971		9.0
Murweh	11.20	2100	22/4	10.34	1971	1956	9.0
Wyandra	10.00	1200	23/4	9.89	1910	1910	9.0
Cunnamulla	10.15	2100	25/4	10.13	1956	1924	9.0
BALONNE-MARANOA							
Mitchell	9.00	0300	20/4	6.87	1950	1922	5.0
Springfield	10.44	1400	20/4	10.48	1950	1950	8.0
Woodlands	7.25	1200	21/4	7.10	1983	1959	7.0
Cashmere	9.71	PM	22/4	7.47	1983	1969	6.8
St George	12.24	2100	23/4	13.10	1890	1917	6.0
Dirranbandi	5.20		26/4	5.26	1922	1917	5.0
Hebel	2.18	0900	2/5	2.30	1983	1971	1.5
WALLAM-MUNGALLALA							
Homeboin	4.00	1800	21/4	3.91	1950	1950	3.0
Bollon	1.44	1800	22/4	1.53	1983	1977	1.0
Tomoo	6.75	0600	21/4	6.40	1950	1950	6.0
Deelamon	6.15	0100	22/4	3.85	1983	1980	3.5
BELYANDO							
Alpha approx	~~12.50~~ 10·26		20/4				7.0
Mt Douglas	7.86		30/4	11.61	1958	1950	9.0
THOMSON-BARCOO-COOPER							
Muttaburra	7.15		22/4	8.71	1968	1951	8.0
Camoola Park	6.80		21/4	7.16	1974	1954	5.0
Longreach	5.04		22/4	5.99	1974	1894	4.0
Bogewong	7.90		24/4	8.64	1974	1955	6.0
Stonehenge	5.86		25/4	6.88	1974	1968	3.0
Jundah	7.55		26/4	8.38	1974	1949	5.0
Barcaldine	7.90		22/4	7.52	1950	1990	6.0
Blackall	~~7.30~~ 7·40		20/4	6.91	1906	1906	5.0
Isisford	9.20		23/4	8.92	1906	1906	6.0
Retreat	12.00		24/4	11.00	1989	1981	5.0
Windorah	7.95		28/4	8.48	1974	1971	5.0
Durham Downs	4.16		6/5	4.4	1974	1985	3.6
Karmona	5.38		7/5	4.15	1989	1985	3.0
Nappamerrie	9.38		15/5	10.13	1974	1949	8.0
PAROO							
Eulo	5.80	1200	22/4	5.99	1890	1890	4.0
Hungerford	2.92		26/4	2.90	1974	1974	2.0
BULLOO							
Adavale	5.00		21/4				4.2
Quilpie	6.16		23/4	7.85	1963	1961	5.0
Sth Comongin	5.20		24/4	6.10	1968	1968	5.0
Thargomindah	5.10		28/4	6.78	1974	1949	6.0

TABLE 4 APRIL 1990 PEAK FLOWS, VOLUMES AND ESTIMATED ANNUAL EXCEEDANCE PROBABALITY

BY COURTESY OF WATER RESOURCES COMMISSION

STREAM	CATCHMENT AREA (km^2)	START OF RECORDS	TYPE OF RECORD (1)	ESTIMATED PEAK DISCHARGE (cumecs) (2)	DATE OF OCCURRENCE	ESTIMATED FLOOD VOLUME (megalitres) (3)	ESTIMATED ANNUAL EXCEEDANCE PROBABILITY (%) (4)	PREVIOUS MAXIMUM RECORDED DISCHARGE (cumecs) (5)	DATE
WARREGO RIVER									
Charleville	16,590	1926	S	2,480	21/4/90	581,900 (11)	<0.7	1,271	3/4/56
Wyandra	42,865	1967	C	3,626	23/4/90	1,668,991 (12)	<5	3,035	30/12/71
Cunnamulla	48,690	1961	S	1,150	25/4/90	978,300 (20)	3	1,240	1956
THOMSON RIVER									
Longreach	58,015	1947	C	8,200	22/4/90	4,850,000 (31)	3	14,000	28/5/55
Stonehenge	88,060	1966	C	9,900	25/4/90	8,999,500 (48)	7	16,600	31/1/74
ALICE RIVER									
Barcaldine	7,565	1967	C	1,630	23/4/90	545,000 (31)	NA	195	21/5/83
BARCOO RIVER									
Blackall	5,855	1969	C	1,650	20/4/90	207,000 (18)	3	780	24/5/83
DARR RIVER									
Darr	2,730	1969	C	600	20/4/90	160,150 (12)	NA	963	28/3/73
COOPER CREEK									
Windorah	150,220	1939	C	16,900	28/4/90	7,790,000 (21)	4	25,000	2/2/74
Nappa Merrie	236,985	1949	C	4,840	15/5/90	6,942,400 (39)	7	8,560	16/2/74
BALONNE RIVER									
St George	75,370	1917	C	2,603	23/4/90	1,708,000 (39)	3	2,906	31/7/50
Weribone	51,540	1969	C	1,268	21/4/90	600,387 (11)	25	2,346	10/5/83
MARANOA RIVER									
Mitchell	11,920	1922	C	1,966	20/4/90	963,300 (6)	3	3,002	27/7/50
Cashmere	19,490	1969	C	1,480	22/4/90	522,160 (10)	<2	768	27/5/83

(1) C Denotes continuous record
S Denotes manually read staff gauge
(2) Denotes cubic metres per second
(3) Figure in Brackets indicates approximate flood duration in days used for volume calculation
(4) Denotes the probability of the event being equalled or exceeded in any year (based on frequency analysis of available flow data and estimate of 1990 flood peak)
(5) These are the highest flows since stream flow records began. Higher events may have occurred prior to the commencement of records.

Note : NA denotes insufficient data to compute annual exceedance probability for the April 1990 event.

The Bureau uses some 130 Water Resources Commission river level gauging stations in locations suitable for flood warning purposes. The Commission has installed telephone telemetry at some 150 of their stations and data from these sites are collected in addition to the Bureau's river height reporting network.

Two types of flood warning systems are operated in Queensland river basins.

Qualitative warning systems describe the severity of flooding at each location in terms of minor, moderate or major flooding. Flood warning river gauge stations have an established flood classification which details heights on gauges at which minor, moderate, and major flooding commences as shown in Table 5. These threshold levels are selected following consultation with observers, police, S.E.S. and local authority officials. The levels of flooding have a standard definition which underlie the adopted flood classification, as follows:

Minor Flooding : Causes inconvenience such as the closing of minor roads and submergence of low level bridges and makes the removal of river pumps necessary.

Moderate Flooding : Causes inundation of low lying areas requiring the removal of livestock and the evacuation of isolated houses. Main traffic bridges may be closed.

Major flooding : Causes inundation of large areas, isolated towns and cities. Major disruptions occur to road and rail traffic and other communications. Evacuation of many houses and business premises may be required.

The second type providing a higher level of service is the quantitative forecasting systems where the forecast height for a key river gauge is disseminated to the public. Warning lead times may vary from say 6 hours in the shorter coastal streams to a number of days in the large river systems. The time taken to develop flood forecasting systems can vary from several months to several years and depends largely on the quality and quantity of historic data and the method of analysis for the particular catchment.

7.2 Flood Warning Service

The flood warning service provided by the Bureau during periods of flooding in Queensland consists of four main components which are briefly described below.

. **River Height Bulletins & Flood Data**

The river height reports received at the Regional Office in Brisbane are grouped into bulletins based on geographical and drainage areas of Queensland and are telexed to local radio stations for broadcast, police headquarters in Brisbane for onforwarding to regional police stations by the police computer message switching system, the State Emergency Service, and some additional organisations on a needs basis. For each area in flood, a river height bulletin is issued up to five times per day (6.45am, 9.45am, 3.45pm, 6.45pm and 9.45pm) when reports are available. This ensures that the data is available to the counter-disaster organisations and the public as soon as possible (about one hour delay) after the scheduled reporting time of the station. At each location, the bulletin indicates whether the

TABLE 5 FLOOD CLASSIFICATIONS FOR FLOOD WARNING NETWORK
ALL HEIGHTS IN METRES

STATION	FIRST REPORT HT	BRIDGE HT	MINOR FLOOD	MODERATE FLOOD	MAJOR FLOOD	TOWNS/ HOUSES
WARREGO						
Augathella	2	5.9	4	4.5	5.5	5.5
Biddenham	1.5		2	4	5.5	
27 Mile	2		2	3	4	5.0
Charleville	2.5	4.6	4	5	6	4.6
Mt Morris	1		3	4	5	
Bakers Bend (Closed)	1.5		5	7	9	
Murweh	1	1.5	5	7	9	
Wyandra	3	7.6	6	8	9	
Cunnamulla	3	7.9	5	8	9	
BALONNE-MARANOA						
Mitchell	0.6	7.6	2 d/s	3 d/s	5 d/s	7.6
Springfield	1.5		6	7	8	
Woodlands	2		5	6	7	
Cashmere			4.8	5.5	6.8	
St George	1.5	10.7	4	4 d/s	6 d/s	12.1
Whyenbah	3	5.3	4	6	7	
Dirranbandi	2	5.2	4	4	5 d/s	
Hebel	1		1	1	1.5	
WALLAM-MUNGALLALA						
Homeboin	0.5	0.5 X	2	2.5	3	3.5
Bollon	0.4	0.6 C	0.5	0.7	1	1.0
Tomoo	0.5		2	5	6	
Deelamon	0.3	0.0 X	1	2	3.5	
BELYANDO						
Alpha	2	3.7	7	7	7	7.3
Mt Douglas	4	5.3	5	8	9	
THOMSON-BARCOO-COOPER						
Muttaburra	3	4.0	5	6	8	8.2
Camoola Park	1		3	5	5	
Longreach	1	2.2	2	3	4	5.4
Bogewong	0.3	3.1	2	4	6	
Stonehenge	1	1.8	2	2	3	
Jundah	1	3.7 A	2.5	4	5	4.6
Barcaldine	2	5.6	3	5	6	
Blackall	1	2.7	2	4	5	5.5
Isisford	1	4.0	4	5 d/s	6 d/s	
Retreat	2	1.7 C	3	4	5	
Windorah	3	4.4 A	4	4	5	
Durham Downs	2.45	2.45	2.45	3	3.6	
Karmona	0.9	0.0 X	1	2	3	
Nappamerrie	1.5	0.6 X	4	6	8	
PAROO						
Eulo	1	3.2	2	3	4	
Hungerford	0.5	1.0 X	1	1.5	2	2.5
BULLOO						
Adavale	1.5	2.2 X	2.6	3.6	4.2	4.2
Quilpie	2	4.6	3	4 d/s	5 d/s	5.9
Sth Comongin	1	1.2	4	4 d/s	5 d/s	
Thargomindah	3	4.1	4	5	6	6.1

NOTE: X denotes crossing; C denotes causeway; A denotes approaches; d/s denotes downstream river is rising, steady or falling and, where a road bridge or crossing is in the vicinity of the river gauge, the heights above or below the bridge or crossing are given. (See a sample bulletin at Table 6.)

During operational periods, the Bureau's Flood Warning Centre also provides a considerable amount of basic rainfall and river level data, both for the current flooding and for past floods. Past flood data plays an important role in the effectiveness of the warning system. For example, comparisons of expected flooding with recent or notable floods ("flood levels expected to be similar to the 1983 flood") provide a tangible understanding of the flood threat and the appropriate mitigating actions to local landholders and communities.

TABLE 6 SAMPLE RIVER HEIGHT BULLETIN

RIVER HEIGHT BULLETIN
ISSUED AT 0944 AM ON MONDAY, 23/04/1990
BY THE BUREAU OF METEOROLOGY, BRISBANE.

STATION	TIME	HT(M)	TENDENCY	
WARREGO RIVER & TRIBUTARIES				
CUNNAMULLA	0900	9.35	STATIONARY	1.45M ABOVE BRIDGE
PAROO RIVER				
EULO	0900	5.60	FALLING SLOWLY	2.40M ABOVE BRIDGE
HUNGERFORD	0900	2.32	RISING	1.32M ABOVE CROSSING
THOMSON-BARCOO & TRIBUTARIES				
MUTTABURRA	0900	6.95	FALLING SLOWLY	2.95M ABOVE BRIDGE
CAMOOLA PARK	0630	6.63	FALLING SLOWLY	
LONGREACH	0600	5.00	FALLING SLOWLY	2.80M ABOVE BRIDGE
BOGEWONG	0700	7.80	RISING	4.70M ABOVE BRIDGE
STONEHENGE	0900	4.95	RISING	3.15M ABOVE BRIDGE
JUNDAH	0900	4.90	RISING	1.20M ABOVE APPROACHES
BLACKALL	0850	4.30	FALLING SLOWLY	1.60M ABOVE BRIDGE
BARCALDINE	0900	7.70	FALLING SLOWLY	2.10m ABOVE BRIDGE
ISISFORD	0600	9.20	STATIONARY	5.20M ABOVE BRIDGE
RETREAT	0800	10.64	RISING FAST	
COOPER CREEK & TRIBUTARIES				
WINDORAH	0900	5.95	FALLING SLOWLY	1.55M ABOVE APPROACHES
FLINDERS RIVER & TRIBUTARIES				
RICHMOND	0900	4.25	FALLING FAST	1.55M BELOW BRIDGE

. **Flood Warnings & River Height Forecasts**

The rainfall and river level data from the reporting networks, as well as the assessment of current and forecast weather conditions, are analysed for the formulation and issue of flood warnings for each river basin. Flood warnings typically contain a summary of the rain which has fallen over the catchment, key river heights observed, weather conditions expected, a summary of the severity of existing flooding and an assessment of the expected degree of flooding. The flood warning is an end product of a long chain of observations, analyses using established hydrological techniques, interpretation and estimates. River height predictions for key locations are included in the flood warning where there is an effective quantitative forecast system.

Flood warnings are usually issued in the period one and a half to two hours after the reporting time. The frequency of issue varies from once daily to three hourly according to the flood warning needs, the type of warning system, and the extent to which the flood conditions are changing. The flood warnings are transmitted directly to the State Emergency Service, Police, other selected State Government Departments, radio and television stations and in some areas to the local Councils and agencies.

. **Professional Advice & Consultations**

An important component of the Bureau's flood warning service is the professional assessments provided directly (usually by telephone) to officials in key organisations including the State Emergency Service, police and local authorities. During major flood situations, consultations of this nature are numerous, and cover topics such as the severity and timing of flooding, the risk of critical levels being reached and the extended outlook for counter disaster operations. Members of the business community and the public who are threatened by flooding also contact the Bureau's Flood Warning Centre staff for detailed advice.

. **Media Briefings**

The Bureau's flood warning officers provide extensive briefing to the news services of newspapers and radio and television stations. These include "live" interviews with the flood warning engineers on radio stations that broadcast to the flooded or flood-threatened areas.

7.3 Performance of the Warning System

7.3.1. Comments

The Bureau of Meteorology's flood warning system forms only part of the total warning system. Various organisations from the three levels of Government have key roles in an effective warning system - the Bureau (Federal Government) in the provision of services described above, the Local Authorities in relating warnings to the detailed local consequences, and the State Counter Disaster Organisation (Police, S.E.S.) for response actions. The short discussion presented here provides information regarding the Bureau's warning service during the floods, but does not attempt to evaluate the performance of the total warning system. Such an evaluation would need to take into account the complex technical, organisational and social issues and is likely to be the subject of longer-term debriefings and research.

7.3.2 River Height Bulletins and Flood Data

River height bulletins for the flooded rivers were provided up to five times per day, being automatically prepared and disseminated by the Bureau computer using all available data. It is understood that radio stations generally broadcast the information, with ABC stations in particular also providing further detailed information provided directly by landholders. Some criticisms that reports from specific stations were not heard in the broadcasts were received by the Flood Warning Centre. These were usually associated with delayed reports arriving after the bulletin preparation time, or loss of telephone communications at the observing site.

Comparisons with past floods were provided for many areas to describe the expected severity of flooding. Where appropriate, they were included in the flood warning and used extensively in telephone briefings and 'on air' radio interviews.

7.3.3 Flood Warnings and River Height Predictions

Initial flood warnings for the Paroo, Bulloo, Warrego, Thomson and Barcoo Rivers were commenced at the start of April and remained current until early May. Warnings for the Balonne-Maranoa River basin commenced on the 11th April, and the Belyando and Fitzroy River basin warnings on Thursday 19th April. Warnings were generally issued once or twice per day for each river basin, but more frequently (three to four daily) for the Warrego and Balonne during the one or two days where there were significant changes in flood conditions. About 200 flood warnings were issued in April, with further warnings during May. A number of the key flood warnings are given in Appendix 3.

Whilst the areal and time coverage of the warnings were mostly accurate, a general criticism of the warnings is the tendency not to adequately warn of the onset of flooding in headwater streams. It applies to severely affected towns such as Jericho, Blackall and Augathella and other upstream river height monitoring stations, and is mainly because of the lack of rainfall and river level networks in these headwater areas, as can be seen from the network maps in Figures 12 to 15. Although flood warnings for the western rivers are qualitative (flooding described in terms of minor, moderate and major) in many areas, river height predictions are made where possible and flooding is compared with previous floods. In addition, many landholders maintain their own records of past flooding and are able to compare these with the observed flood heights given in the warnings and bulletins. The qualitative warnings are prepared with careful attention to wording particularly in relation to the adopted flood classifications, and although the major organisations receive hard copy which can be examined closely, the full meaning of the warning is not necessarily conveyed through listening to radio broadcasts. The Bureau has available flood information booklets for most river basins which are designed to assist the interpretation of flood warnings.

River height predictions provided in the flood warnings during April are given in Table 7. As can be seen from Table 7, the lead time (the time to reach the predicted height) varies from about 12 hours to seven days depending on the specific location and the nature of the flood. It is important for Local Authorities to be able to interpret the predicted height into detailed local effects of areas and depths of inundation. This is done well by some Authorities, but not by others. (See discussion in next section.)

One of the complicating factors in the flood warning system is the prevalence of other "non-official" flood predictions which are offered with good intentions by individuals in the local area or organisations. Some of this advice is accurate and contributes positively to the warning system, however in many cases it is inaccurate. Where the unofficial advice differs from the flood warnings, the Bureau requests counter-disaster organisations to contact the Flood Warning Centre. The Bureau has little direct control over the use of unofficial predictions by the media which often results in confusion in the flood threatened community.

7.3.4 Flood Warnings for the Warrego River

Charleville

Key warnings for the Warrego River are given in Appendix 3. In relation to the devastating flood of Charleville, the warning issued on Thursday April 19th did not anticipate the very heavy rain which occurred during Thursday night. On Friday morning, the renewed Warrego warning reported the heavy rain in the catchment, and warned that "HIGH LEVEL MAJOR FLOODING IS EXPECTED AT CHARLEVILLE DURING THE WEEKEND". Later on Friday, the 4.30pm warning stated that "FLOODWATERS FROM THE UPPER WARREGO AND TRIBUTARIES WILL CAUSE SEVERE MAJOR FLOODING AT CHARLEVILLE DURING THE NEXT 24 HOURS". During Friday morning, there was already flooding of some Charleville properties from Bradleys Gully.

The devastating nature of the Charleville flood was not foreseen for a number of reasons. Firstly, it was impossible to predict how high Charleville would reach from the upstream observations. There are three flood warning river height stations above Charleville as shown on the network map at Figure 12. Augathella was able to provide a full set of observations including an estimated peak of 7.3 metres at 3pm on Friday 20th April. Because this station monitors less than half of the total drainage area above Charleville, the resulting floods at Charleville compared with Augathella vary markedly. For example, a major flood of 6 metres at Augathella can produce a minor flood or a major flood at Charleville depending on the contributions and nature of the flood from the remaining parts of the catchment.

The river height station at Biddenham on the Nive River was only established in recent years and there are insufficient historical records to accurately describe the effect of Nive River inflows to the Warrego. The station reported its readings during the flood event, and its value to the warning system will grow as future floods are recorded. The Bureau river height station at 27 Mile Garden, below the junction of the Nive and upper Warrego Rivers, is ideally located to provide about 12 hours warning of the likely magnitude of Charleville flooding. Readings could not be obtained from this station as the property owners were evacuated for safety reasons on the Thursday afternoon prior to the main river rises on Thursday night and Friday. This problem could be overcome in future by installing a telephone telemetry system, providing telephone communications remain serviceabler in future flood events.

Flooding at Charleville itself is also difficult to predict because of the added complications of Bradleys Gully flooding and the effect of the Wellwater which enters the Warrego just above Charleville. For example, flood levels in parts of the town had almost peaked by noon on Friday, well before the main peak on Saturday 21st April. In this event, the final flood peak at Charleville was over one metre above the previous highest on record. The last one metre of rise, which took the flood from serious to devastating, occurred during the night hours of Friday. Many residents had sought refuge in higher properties that were believed to be safe from floodwaters, only to find their escape routes flooded during darkness.

TABLE 7 FLOOD FORECASTS APRIL 1990 INLAND QUEENSLAND

LOCATION	ISSUE DATE & TIME	PREDICTION	LEAD TIME	OBSERVED
BALONNE				
St George	20/4/90 11 AM	8.5 metres by Monday 23/4	3 days	11.25 metres rising Monday
St George	20/4/90 5.00 PM	10.0 metres by late Monday 23rd	3 days	11.25 metres rising Monday 23rd
St George	22/4/90 11-10 AM	10.5 metres by Tuesday 24th	2 days	12.24 metres peak @ 6 AM Tuesday 24th
St George	22/4/90 4-50 PM	12.2 metres by early tomorrow	12 hours	11.92 metres rising @ 9 AM Monday 23rd
St George	23/4/90 7-00 AM	12.5 metres by this evening	12 hours	12.24 metres steady @ 6 PM Monday 23rd
Dirranbandi	21/4/90 11.30 AM	5.1 metres by Wednesday 25th	4 days	5.14 metres rising 6 AM Wednesday 25th
Dirranbandi	22/4/90 4-50 PM	5.1 metres by Tuesday 24th	36 hours	5.02 metres rising @ 9 AM Tuesday 24th
Dirranbandi	23/4/90 7-00 AM	5.2 metres by Thursday 26th	3 days	5.2 metres rising @ 9 AM Thursday 26th
Dirranbandi	25/4/90 10-45 AM	Peak just below 5.2 metres tomorrow (Thursday 26th)	24 hours	peaked @ 5.2 metres Midday Thursday 26th
Hebel	20/4/90	1.50 metre peak by Wednesday 25/4	5 days	1.67 metre peak Monday 23/4
Hebel	24/4/90 11-15 AM	2.4 metres by Thursday 3rd May	8 days	peaked @ 2.18 metres Wednesday 2nd May
Hebel	25/4/90 10-45 AM	Peak at about 2.3 metres by Thursday 3rd May	7 days	peaked @ 2.18 metres 9 AM Wednesday 2nd
Hebel	26/4/90 11-30 AM	Peak at about 2.3 to 2.4 metres by Thursday 3rd	6 days	peaked @ 2.18 metres 9 AM Wednesday 2nd

TABLE 7 CTD

LOCATION	ISSUE DATE & TIME	PREDICTION	LEAD TIME	OBSERVED
WARREGO				
Cunnamulla	22/4/90 10-15 AM	10.0 metres by late Monday 23rd and peak by Wednesday or Thursday	30 hours 3 days	9.45 metres rising @ 9 PM Monday 23rd
Cunnamulla	22/4/90 4-45 PM	10.3 metres by the afternoon of Tuesday 24th. Peak on Wednesday 25th.	24 hours 3 days	10.0 metres rising slowly @ 3 PM Tuesday 24th. Peaked 10.13 at 5pm Wednesday 25th.
PAROO/BULLOO				
Hungerford	21/4/90 11.00 AM	rise to 2.6 metres by Tuesday 24th	3 days	2.6 metres rising @ 9 AM Tuesday 24th
Hungerford	22/4/90 11.00 AM	rise to 2.80 metres by late Wednesday 25th	3 days	2.85 metres rising @ 9 AM Wednesday 25th
Hungerford	25/4/90 11.45 AM	Peak at about 2.85 metres next 24 hours	24 hours	peaked at 2.92 metres @ 7 AM Thursday 26th
COOPER				
Longreach	20/4/90 1100	5.0 - 5.5 metres next 24 - 48 hours	24 - 48 hours	5.04 metres 7.30 AM 22/4
Longreach	21/4/90 11.45	5.4 metre peak on Monday 23/4	2 days	5.04 metres peak Sunday 22/4
Jundah	24/4/90 11.50	7.5 metre peak by Friday 27/4	2-3 days	7.55 metre peak 1900 26/4
Windorah	25/4/90 12.15	8 metre peak over weekend 28th-29th	3-4 days	7.95 metres peak 1500 Saturday 28/4
Windorah	26/4/90	8 metre peak late on weekend 28th-29th	3 days	7.95 metre peak 1500 Saturday 28/4

Cunnamulla

The Warrego River flood warning of 4-30pm on Friday 20th April, the day prior to the Charleville peak, provided the following advice for downstream areas and Cunnamulla.

"SEVERE MAJOR FLOODING WILL DEVELOP ALONG THE WARREGO DOWNSTREAM FROM CHARLEVILLE DURING THE WEEKEND AND EARLY NEXT WEEK WITH A MAJOR FLOOD PEAK EXPECTED TO REACH CUNNAMULLA ON ABOUT WEDNESDAY OR THURSDAY OF NEXT WEEK."

On Saturday 21st April, this was clarified further by indicating that "WIDESPREAD MAJOR FLOODING APPROACHING RECORD LEVELS WILL ACCOMPANY THE PEAK".

River height predictions for Cunnamulla were given in the flood warnings as shown in Table 7. Telephone discussions continued between the Bureau flood warning engineers and officials of the State Emergency Service and Paroo Shire Council, primarily concentrating on the timing of the river rises at Cunnamulla and the assessed risk of overtopping of the Cunnamulla levee banks. The warning of 4-45pm on Sunday 22nd April predicted that river levels at Cunnamulla would "REACH 10.30 METRES BY THE AFTERNOON OF TUESDAY 24TH" and peak on the next day.

A number of unofficial predictions were made for Cunnamulla which were inaccurate in timing and indicated flood depths of one metre above the levee bank. During this period, the Bureau was closely involved with the State Emergency Service Headquarters and the Paroo Shire in providing advice as to the true risk of overtopping requiring evacuations. Mr Allan Tannock, a retired stock and station agent, was also providing advice locally in Cunnamulla which supported the views of both the Bureau and the Paroo Shire. Mr Tannock is a well-respected river "watcher" with forty years experience and up until recently provided a river height information service on the local radio station.

8. POTENTIAL FOR FUTURE FLOOD MANAGEMENT

8.1 Overview

The provision of a suitable water supply is paramount in siting any township.

In light of the activities and damaging flooding which occurred in April, it is clear that consideration of immunity from serious flooding should also be a very high priority.

Many towns and communities in Western Queensland are sited on land adjacent to major water courses because of the early expectation and importance of obtaining reliable fresh water supplies. However, very few streams in Australia are perennial and because of the extreme variability of streamflow and the lack of suitable storage sites, alternative water supplies were ultimately developed from groundwater sources, mainly from the Great Artesian Basin.

Nevertheless, as a result of the early planning decisions which led to their present locations, many towns are vulnerable to the ravages of major flooding, the magnitude of which would not have been known at the time of settlement due to lack of reliable records.

Furthermore, because of the large volumes of runoff which are possible, coupled with a lack of adequate defined drainage channels, the potential for mitigating the effects of such large natural occurrences is very limited.

Severe flooding is a normal part of the pattern of climatic extremes which are a characteristic end product of the geography of much of outback Australia.

Nevertheless the severity of flooding, both in terms of the depths of inundation and the speed of occurrence, has been exacerbated as a result of poor land management practices.

Extensive land clearing which occurred in the early days of settlement and continued over subsequent decades, has created a landscape which is unstable as typified by the extensive erosion and siltation which occurs in many river systems. As a consequence of extensive land clearing, flood runoff which previously would have been retarded by the presence of vegetation and the storage capacity of stream channels, now occurs more readily with the result that floods from a given rainfall event are larger in magnitude (both volume and height) and occur more quickly.

Better land management practices which seek to restore the original landscape would reverse this trend. These practices are being actively encouraged by the Landcare Program now being widely developed across Queensland.

8.2 Structural Considerations

8.2.1 Damsites

It would be ideal if large storages could be built to mitigate the effects of floods and so protect the western towns. However, very limited potential exists for the construction of large dams for significant mitigation of flooding of streams in western Queensland.

There are very few damsites, because of the generally flat topography, and what limited sites there are, are located mainly in the upper reaches of catchments. Most of the drainage systems are very large and complex. As a result there is no opportunity to control the very large runoffs which can occur low down on the catchment, by means of storages in the upper reaches of most river systems.

In the Warrego catchment the total flood volume at Charleville over the period 16th to 27th April was some 581,900 megalitres (or 0.6 cubic kilometres). There is no known storage or combination of storage sites in the upper reaches of the catchment that could provide any significant mitigation of the flooding at Charleville and Cunnamulla.

Some 85% of the catchment of the Warrego River Basin above Cunnamulla is located above the junction of the Warrego River and Angellala Creek. While this northern portion has higher terrain relief and drainage line gradients than the southern portion, there is little scope for the construction of dams in the area that could provide mitigation of flooding downstream.

A similar situation exists at Longreach where the total flood volume over the period 10th April to 10th May is estimated to have been around 4,850,000 megalitres (4.8 cubic kilometres). There are no significant damsites in the catchment above Longreach.

8.2.2 Levee Banks

Drainage in the catchment area above Charleville is generally towards the Warrego River while below Angellala Creek major floods break out of the Warrego and flow down a myriad of overflow channels.

Because of this, flood levels in Charleville are much more sensitive to peak flood discharges than they are in Cunnamulla. In the April flood, the flood peak flowing down the Warrego from Augathella co-incided with peaks in overland flow reaching Charleville. This resulted in record flood heights being recorded in the town.

Levees and diversion channels would have provided very little benefit in an event such as this, the flood level in Charleville being more a function of the distribution and timing of the rainfall.

The impact of the flooding in Charleville is a result of the unfortunate siting of the town on an area of lower terrain adjacent to the river.

Cunnamulla is better located with the major part of the town on relatively high land. Parts of the centre are, however, located across a flood channel to the north of town and construction of a permanent levee across this depression could assist in protecting that part of the centre from flood waters from the Warrego.

Construction of the proposed Keanes Crossing Weir will not increase the level of flooding at Cunnamulla. It has been designed so that the maximum increase in water level attributed to the weir is 170 mm when the flow is 600 cumecs. This corresponds to a gauge height of 8.46 metres.

The April flood was measured at 1,200 cumecs and rose to 10.15 m (EL 188.2). Under these conditions the weir would be completely drowned out and have no affect on flood height.

The construction of major diversion works around townships such as Charleville and Cunnamulla is not feasible. Apart from the problems of siting a suitable and stable point for diversion, there remains the difficult and costly problem of diverting very large flood flows at shallow depth over large areas of sandy soils.

The complex patterns of distributary channels is testimony to the instability of the country under large and varying flood flows.

8.2.3 Raising of Buildings

At the peak of the flood at Charleville in April, the town was inundated to depths of up to two metres over most of the town resulting in widespread damage to property.

Areas near the State High School and water tower are at a higher elevation and consequently were largely unaffected by the flood.

A large amount of damage to buildings in the town also resulted from erosion of the sandy soils and subsequent undermining and collapse of structures.

Nevertheless, the primary cause of damage was due to the direct effects of floodwaters on buildings and the depth of inundation. In the absence of any other feasible solutions to the problems of flooding and in view of the large number of buildings and facilities that will require to be rebuilt or refurbished, consideration needs to be given to the progressive elevating of buildings in towns such as Charleville suitably braced and anchored typical of the "Queenslander" style to provide immunity from events of similar magnitude to the April flood.

8.2.4 Relocation of Key Facilities

The only real strategy for management of future floods could be to relocate those structures which were most affected to higher ground, above flood level. Detailed examination would be necessary to establish whether this is economically or practically feasible. Such action has been taken in the past, eg Clermont was devastated by a flood in 1916 and subsequently the town was relocated to higher ground.

It may be possible for those key facilities which were effected during the April floods to be relocated and re-established on higher ground. In addition, future town planning should take this flood into account and seriously consider the construction of new facilities, shops and services on higher ground. Key to the future planning of towns affected or vulnerable to flooding is the collection of detailed flood plain information which clearly delineates the incidence, depth, extent or immunity from flooding. This data is essential for any future counter disaster planning.

This data may take the form of flood plain maps. The responsibility for such mapping presently rests with local authorities as the bodies responsible for land use planning. Clearly flood zonings form an important part of a Local Authority Town Plan and should be recognised in the development of such plans.

These matters will be considered in more detail by the Flood Warning Consultative Committee. (See Section 9.2 for details.)

8.3 **Non-Structural Considerations**

A major problem during any emerging flood situation is one of access to timely, reliable information. At present flood information is provided by means of gauging stations, some of which can be remotely interrogated by telephone or radio and others by gauge readers.
During a major flood event public utilities can become disrupted or inoperable. In extreme situations property owners who elect to manually read gauges are forced to evacuate their properties thus closing off a potentially vital source of information.

These problems are perhaps more evident in areas of western Queensland because of the problem of remoteness, and the nature and extent of possible flooding.

Some of the difficulties experienced in obtaining necessary flood warning information during the April floods could be alleviated by the more extensive use of up to date telemetry systems. This is discussed in more detail in Chapter 9.

9. IMPROVEMENTS TO THE WARNING SYSTEM

9.1 Overview

Discussion so far in this report has centred on the meteorology and hydrology of the April 1990 flooding and the performance of the flood warning service provided by the Bureau of Meteorology. It is necessary however when considering improvements to the warning system to review the "total warning system", the end product of which is the response to warning of people in the area threatened by flooding.

All three levels of Government have a role to play in the total warning system. The Bureau's role has been outlined in detail as the issuer of the initial warning messages which are broadcast by radio stations. Local Authorities have a role in the preparation of plans for coping with flood disasters in the planning phase, but also in the interpretation of the warnings and local conditions in terms of the seriousness of an expected event and in providing expert information on the most vulnerable areas and the likely depths of inundation. The State has a role through the Police responsibilities for protection of life and property, as well as formally through the Disaster District Coordinators for a District, who are usually the local Police Inspector or Police Superintendent. The State Emergency Service also has a most important role in marshalling and training local volunteers to assist the statutory organisations.

After any major flood and in particular after record flooding, all components of the total warning-response system need to review their own performance so that plans can be adjusted or modified in the light of past experience.

Commonwealth policy on flood warning services acknowledges that an effective flood warning system for Australia in the future will require the involvement of all three levels of Government. Although the Bureau continues to be the lead agency, the Bureau will share with State/Local Authorities the costs of upgrading flood warning services mainly through the introduction of telemetry data acquisition systems. Flood Warning Consultative Committees have been established in each State to provide advice to the Bureau and participating Government agencies on the upgrade requirements and associated priorities.

9.2 **Flood Warning Consultative Committee**

Improvements to the Bureau's flood warning system are a matter for the consideration of the Commonwealth - State Flood Warning Consultative Committee (FWCC) which has been established by agreement between the State and Commonwealth Governments. The FWCC, which advises the Bureau of Meteorology, has the task of developing a five year rolling program for upgrading flood warning services in Queensland. This program involves the installation of telemetered data acquisition systems in projects which are cooperatively and jointly funded by the Bureau and State/Local Authorities. The terms of reference of the FWCC include making recommendations to Government on appropriate priorities for the upgrading of services.

It is expected that the Bureau and/or the FWCC will receive submissions from local authorities and other representative organisations on the need for new or improved flood forecasting services. The FWCC will also seek data and information to assess and rank the demands for flood warning services.

The Commonwealth policy on flood warning services and full terms of reference of the FWCC are as given in Appendix 2.

9.3 Volunteer Reporting Network

The flood warning reporting network in inland Queensland is based on volunteer observers who forward reports via telephone using a computer based system which was introduced during 1989. The network of rainfall observers largely report only daily at 9am following rainfall in the previous 24 hours. These daily reporters are totally voluntary and are unpaid for their observations. The river level network observers report several times each day when the river level is above a pre-determined threshold and usually report more frequently in major floods.

Reports from the network are analysed for each river basin and river level forecasts and warnings formulated for dissemination to key organisations and the public via the media.

The flood warning river reporting network proved to be vulnerable when telephone communications services in the Charleville area were cut as a result of the flooding of the telephone exchange at Charleville. The Post Office, at least one bank and the Police Station are located adjacent to the river in the lower end of Charleville and suffered some of the higher levels of flood inundation. Reports were not received from a number of river reporting stations for a number of reasons including:

* failure of telephone communications;
* some observers evacuated their homes because of the dangerous flooding;
* at least one observer was absent from his property.

In western areas however the volunteer river level and rainfall reporting network has been the backbone of the flood warning service for more than 50 years and volunteers will continue to be the principal means of data collection in the west for many years to come. The basic flood warning network is not yet fully developed in inland Queensland. There are still a number of important tributaries in most of the river systems which flooded where flood levels should be monitored by volunteer observers. These will be identified and brought to the attention of the FWCC.

9.4 Telemetry

In areas where the telephone communications are deemed to be reliable, there is potential to install telemetry equipment at existing stream gauging stations owned and operated by the Queensland Water Resources Commission. The Commission is undertaking a programme of installing telemetry at all of its gauging stations. Preference is being given to telephone telemetry where the Telecom connection fee is within an acceptable limit. Satellite telemetry is proposed for more remote installations when it becomes available. There is also potential for the Bureau to upgrade current volunteer river level reporting stations to landline telemetry stations in situations where the observer has to evacuate in high level flooding.

A major weakness in the warning system for Charleville is the absence of a reporting network in Bradley's Creek and the Wellwater and little, if any warning is available to Charleville before Bradley's Gully is in "flash flood". This will be a matter for consideration of the FWCC in consultation with Murweh Shire. One possibility which will be investigated is the installation of a network of telephone telemetry stations at strategic locations in both Bradley's Creek and the Wellwater some of which could be fitted with an alarm device to automatically alert a specific telephone number in Charleville that predetermined creek levels have been reached or exceeded. This project would require the support of Murweh Shire, both in shared funding of the capital purchase of telemetry equipment and installation, and also in the ongoing servicing and maintenance that such a system would require. A factor in considering the viability of this project would be the cost of Telecom connections in the more remote areas of both creek catchments. If there was to be an investment in a telemetry system for the local "flash flood" streams, Council would need to develop a warning and response plan to ensure appropriate mitigating actions in the short lead time available.

10. CONCLUDING REMARKS

The record flooding which occurred in Augathella, Charleville, Blackall, Alpha and Jericho are disasters which have devastated communities. Some towns will take a considerable length of time before the community infrastructure returns to normal. Stock losses have been very high and early estimates put losses at 300,000 sheep and cattle 11,000 valued at some $7.5 million, but it may be months before more accurate figures are available. An estimated 9200km of fencing has been severely damaged or destroyed costing some $10 million.

In the case of Charleville, the previous record height was exceeded by some 1.2 metres turning a major flood into a disaster where no one expected the previous record level to be exceeded by so much. The total damage in Charleville has been estimated at about $45 million.

A unique set of circumstances came together in this event to produce the record flooding to such an extent. Firstly, the March rainfalls were normal to above normal over the subject catchments and some catchments had stream rises and flooding during March. In April heavy rainfall and flooding commenced as early as the first two days in most of the inland catchments between the Balonne/Maranoa and the Thomson/Cooper Creek. The second rainfall episode for the month ended on 11th and caused renewed flooding at higher level. When the third rainfall episode arrived between the 17th and 20th of April flood runoff was immediate and devastating.

The opportunities for structural flood management are limited in western towns with some of the few options available being the raising of floor levels of houses on elevated stumps and, in some cases the gradual relocation of key installations to higher ground.

Flood warning systems will continue to provide a cost-effective means of reducing the physical, economic and sociological impact of serious floods. The Bureau of Meteorology, as the agency responsible for flood warning services in Australia, is progressively developing and upgrading flood warning services within the framework of the current policy arrangements approved by the Commonwealth Government in 1987, and according to relative priorities and resource constraints. The application of technological advances in data gathering and communications will continue to provide incremental improvements to the flood warning services.

Record floods are by definition beyond the experience of every one, including the key players in the warning and response system and those who are hardest hit in the flood zone, and responses are more often based on the experience of significantly lower floods. Flood disasters such as the inland floods of April 1990 highlight the need for the upgrading of flood warning systems to be considered in the wider context of counter disaster planning and operations, where local authorities and State counter disaster agencies have an increasingly important role.

The flood history available in inland Queensland is generally less than 150 years and this is an exceptionally short record by world standards. In the last 20 years a number of Queensland towns and cities have experienced their highest floods on record. These include Ipswich 1974, Longreach 1974, Stonehenge 1974, Jundah 1974, Windorah 1974, Thargomindah 1974, Warwick 1976, Goondiwindi 1976, Dalby 1981, Cooyar 1988 and now Charleville, Wyandra, Cunnamulla, Augathella, Alpha, Jericho, Blackall, Isisford and Mitchell. The message is clear. Many more Queensland towns will experience new record floods higher than any previously experienced since European settlement at some future date. There is little that can be done to reduce either the volume or peak flow of these floods but disaster plans must take account of their possibility, to ensure the maximum appropriate response to reduce damages and losses.

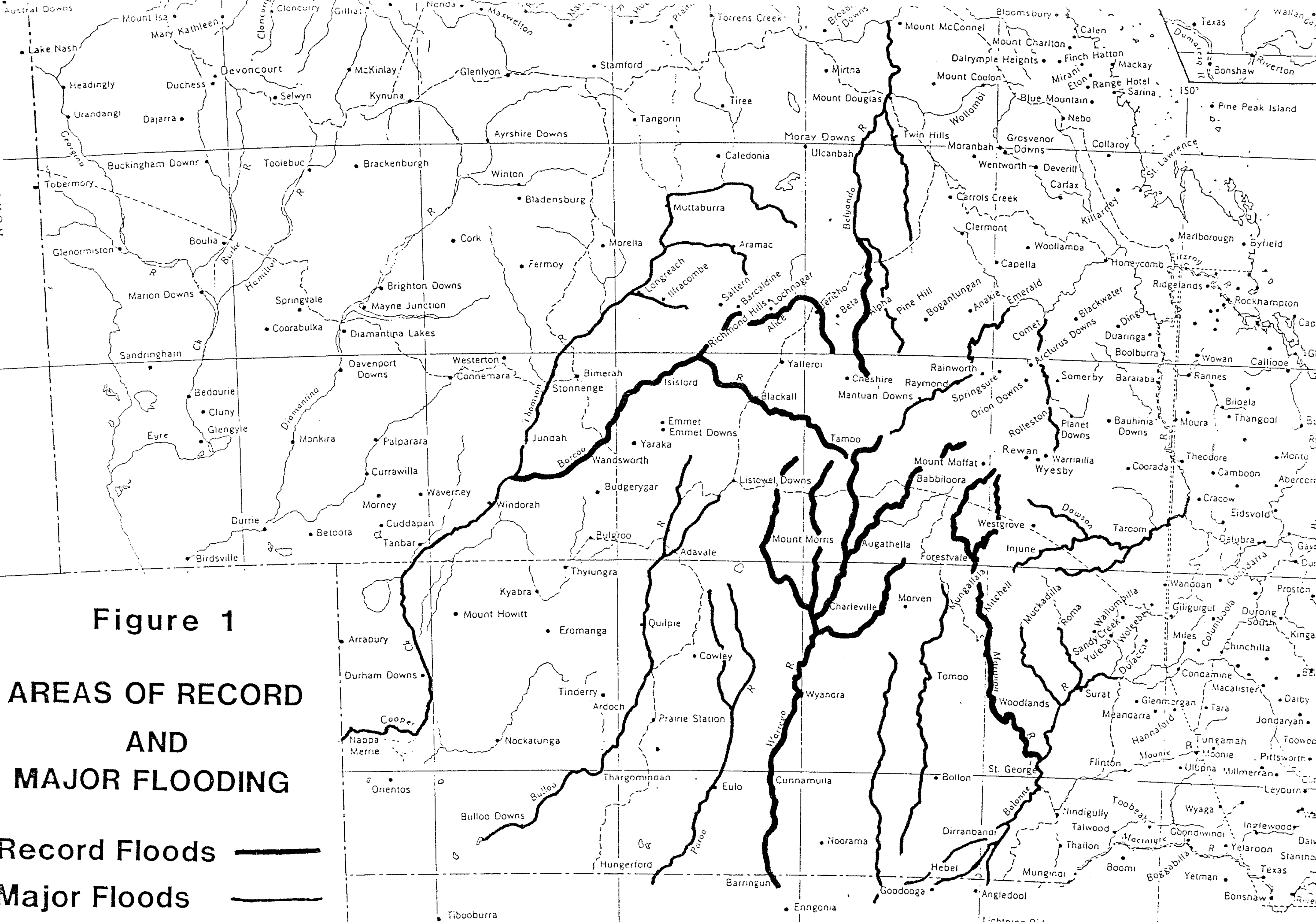


Figure 1

AREAS OF RECORD AND MAJOR FLOODING

Record Floods

Major Floods

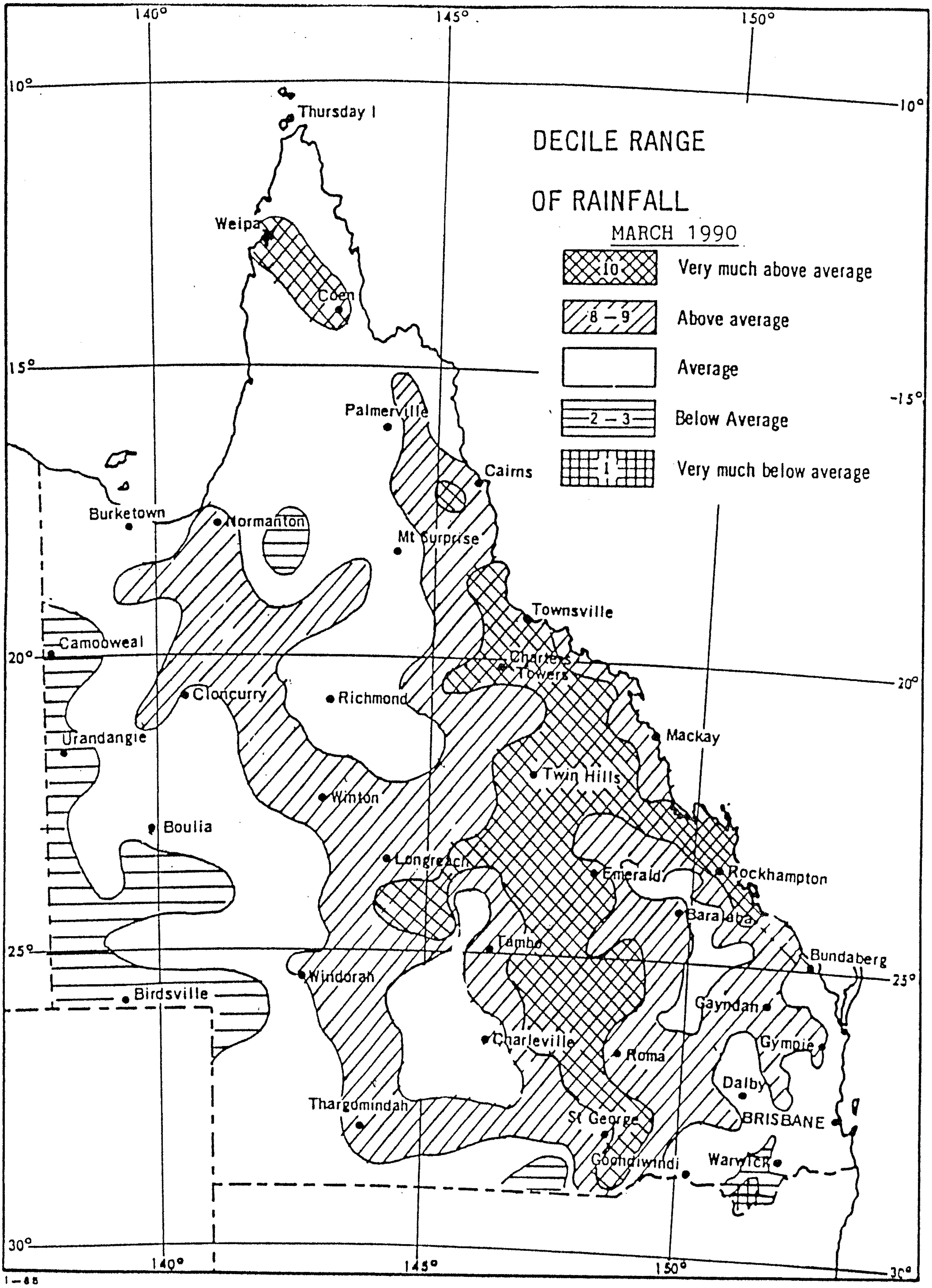


Figure 2 RAINFALL DECILES MARCH 1990

DAILY WEATHER MAPS

0000 K (00 GMT)

1 - 30 April 1990

Dates are ringed left-hand corner of each map.

LEGEND

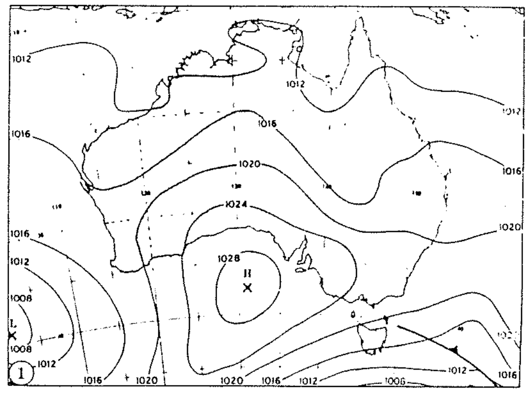
Isobars are drawn at 4 hPa intervals

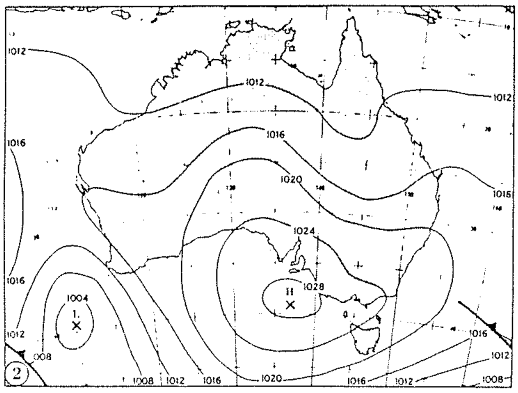
Cold Front

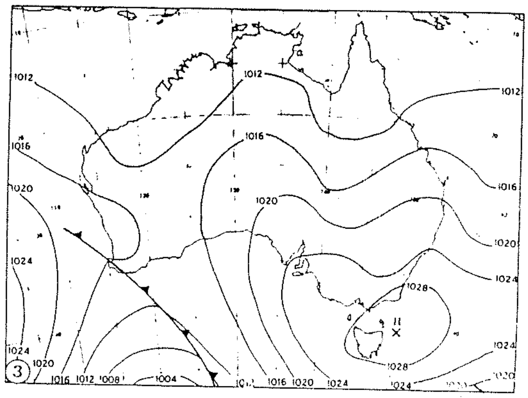
Warm Front

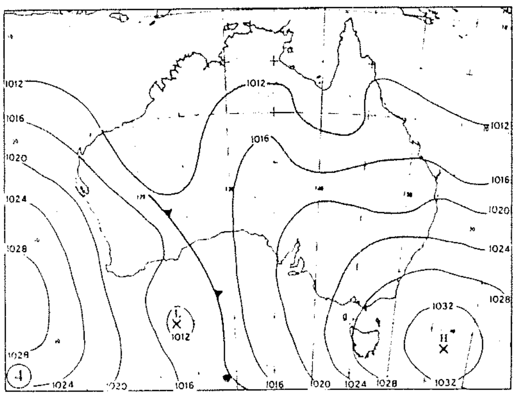
Occlusion

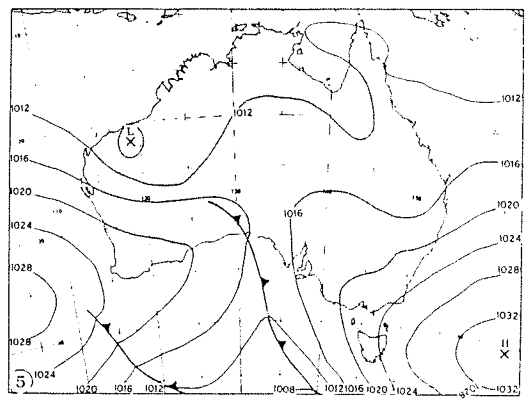
Trough

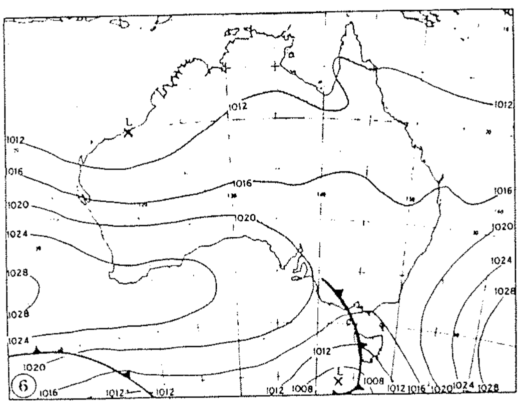


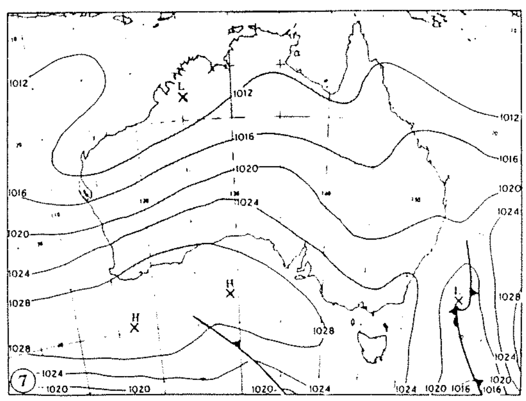






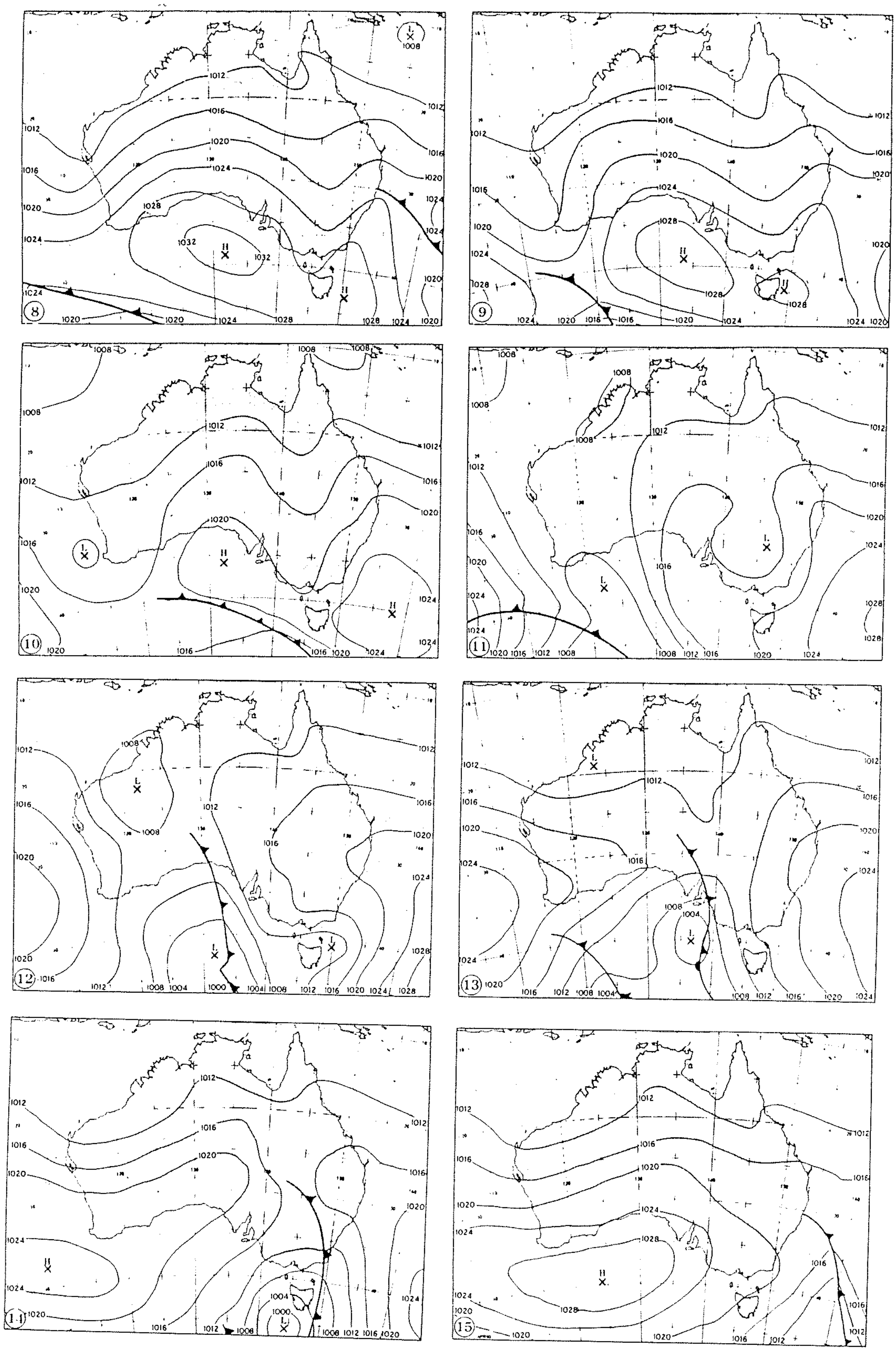






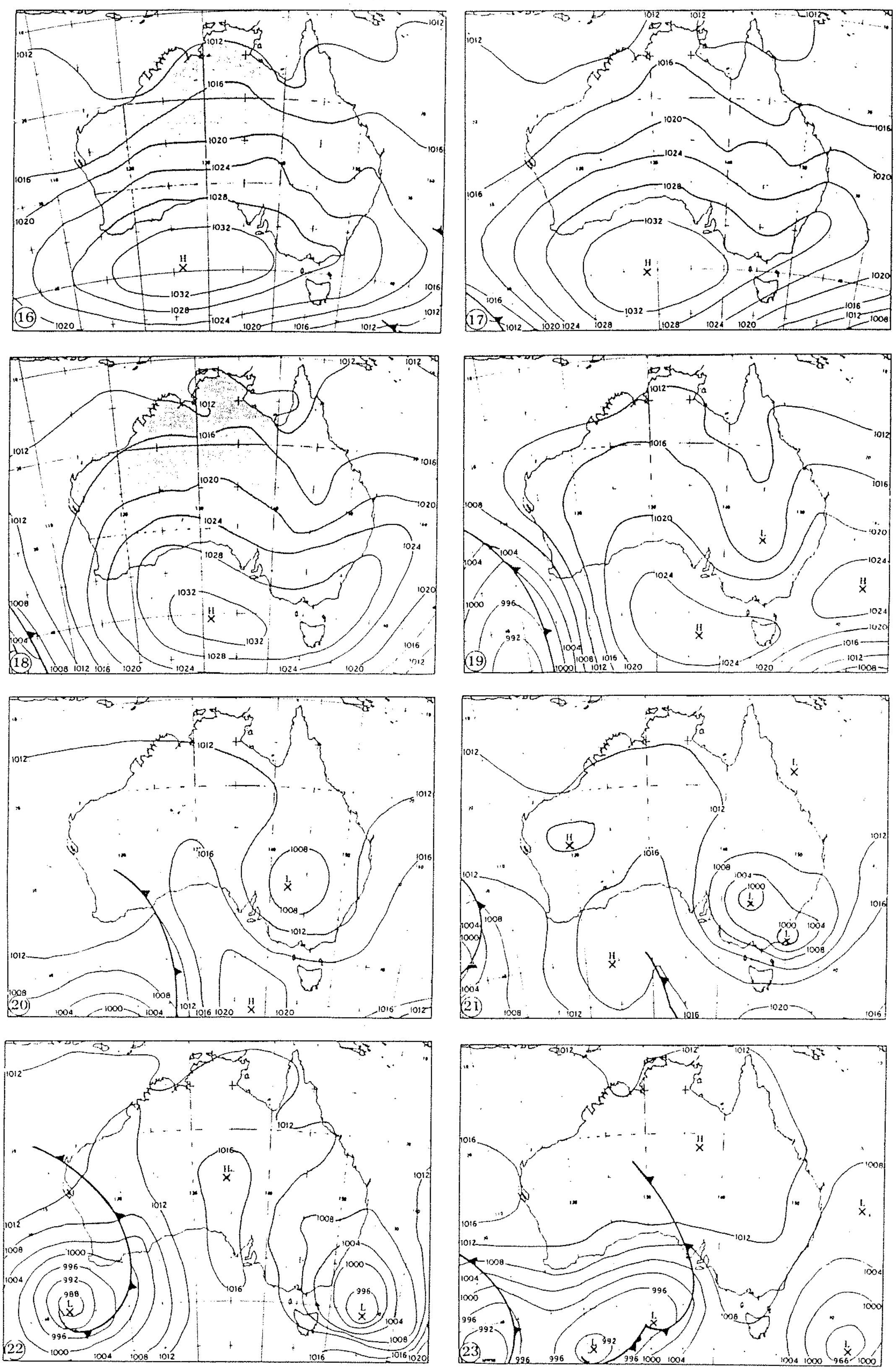
DAILY WEATHER MAPS 1st to 7th April

Figure 3a



DAILY WEATHER MAPS 8th - 15th April

Figure 3b



DAILY WEATHER MAPS 16th - 23rd April

Figure 3c

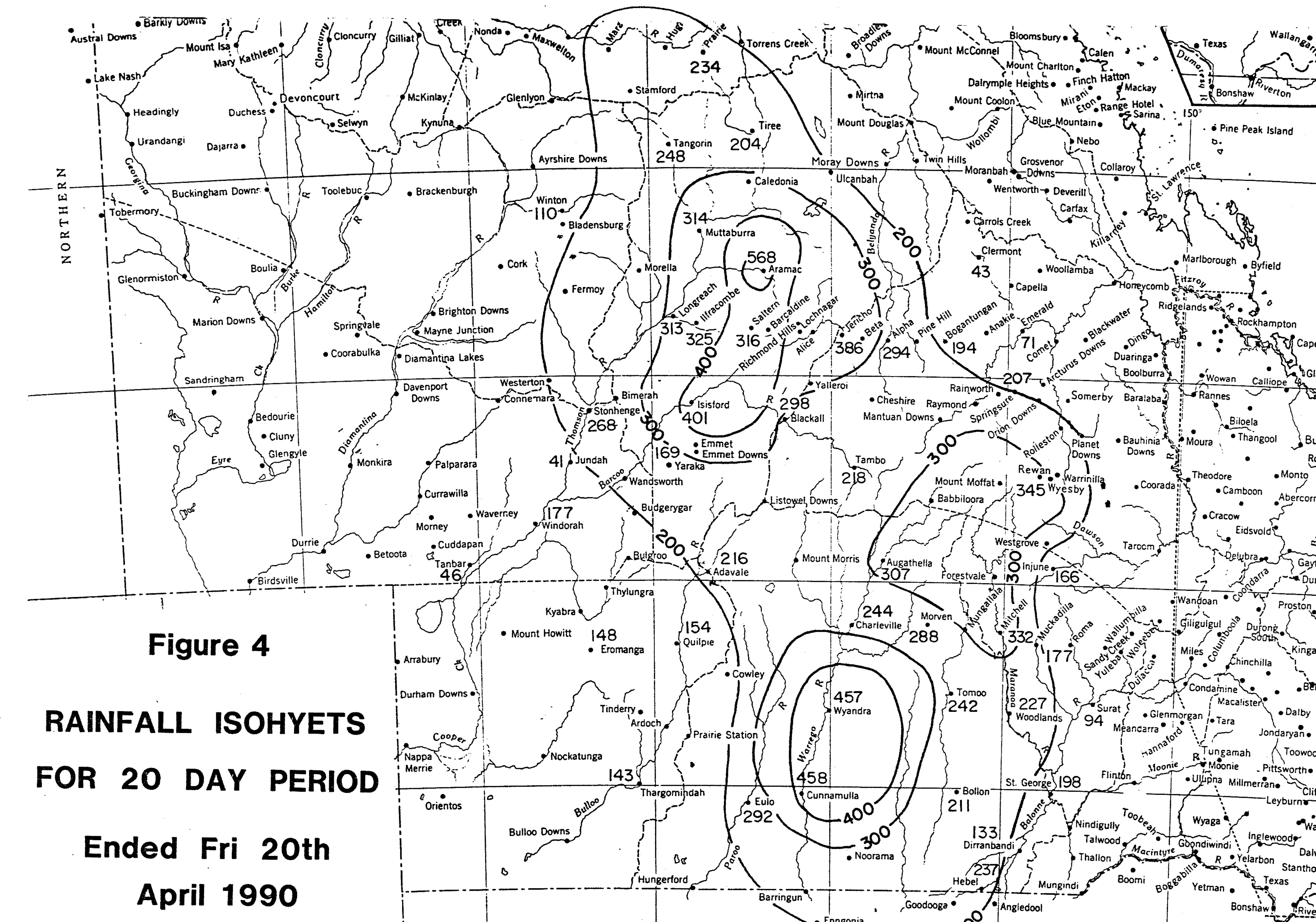


Figure 4

RAINFALL ISOHYETS FOR 20 DAY PERIOD

Ended Fri 20th April 1990

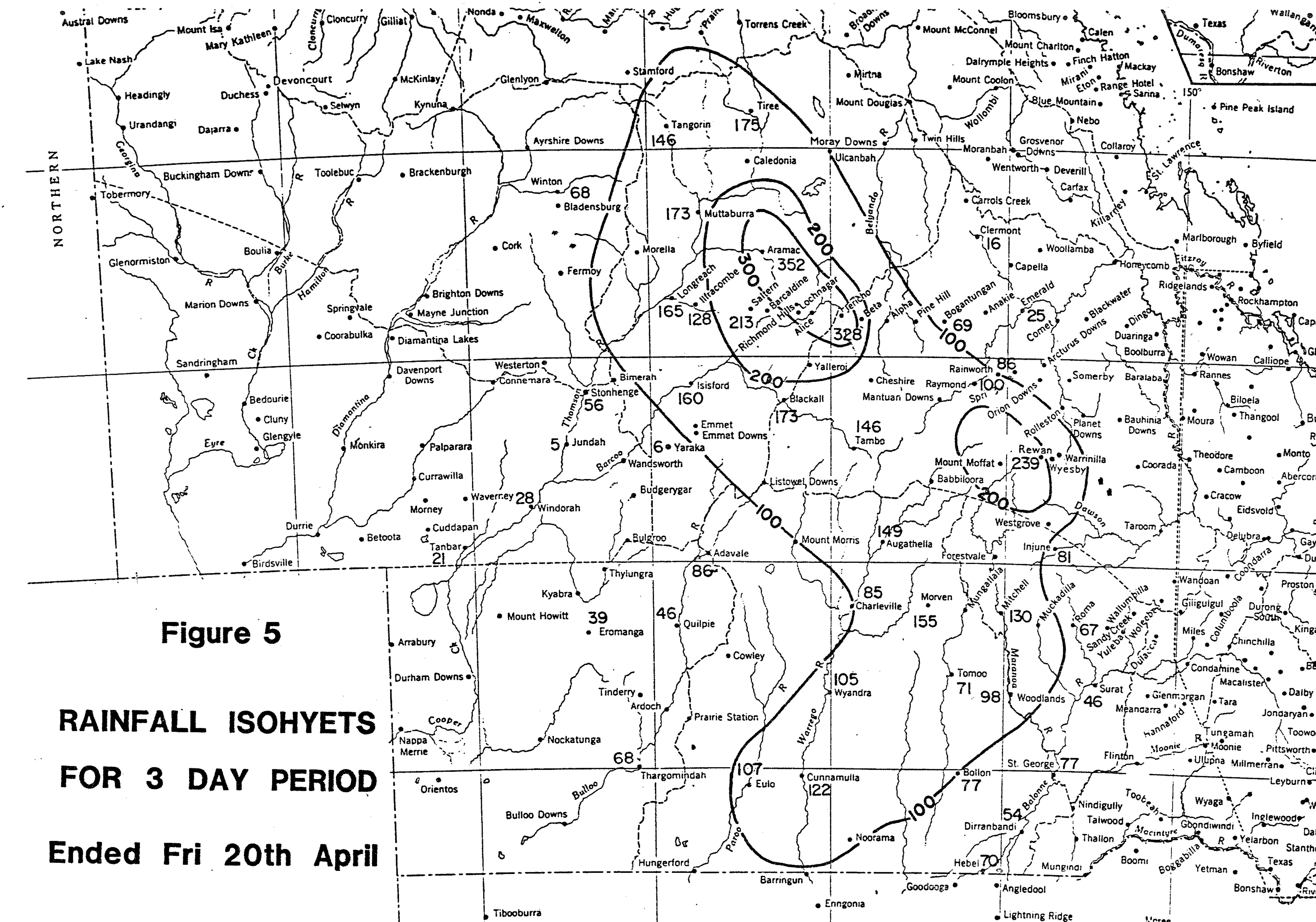


Figure 5

RAINFALL ISOHYETS

FOR 3 DAY PERIOD

Ended Fri 20th April

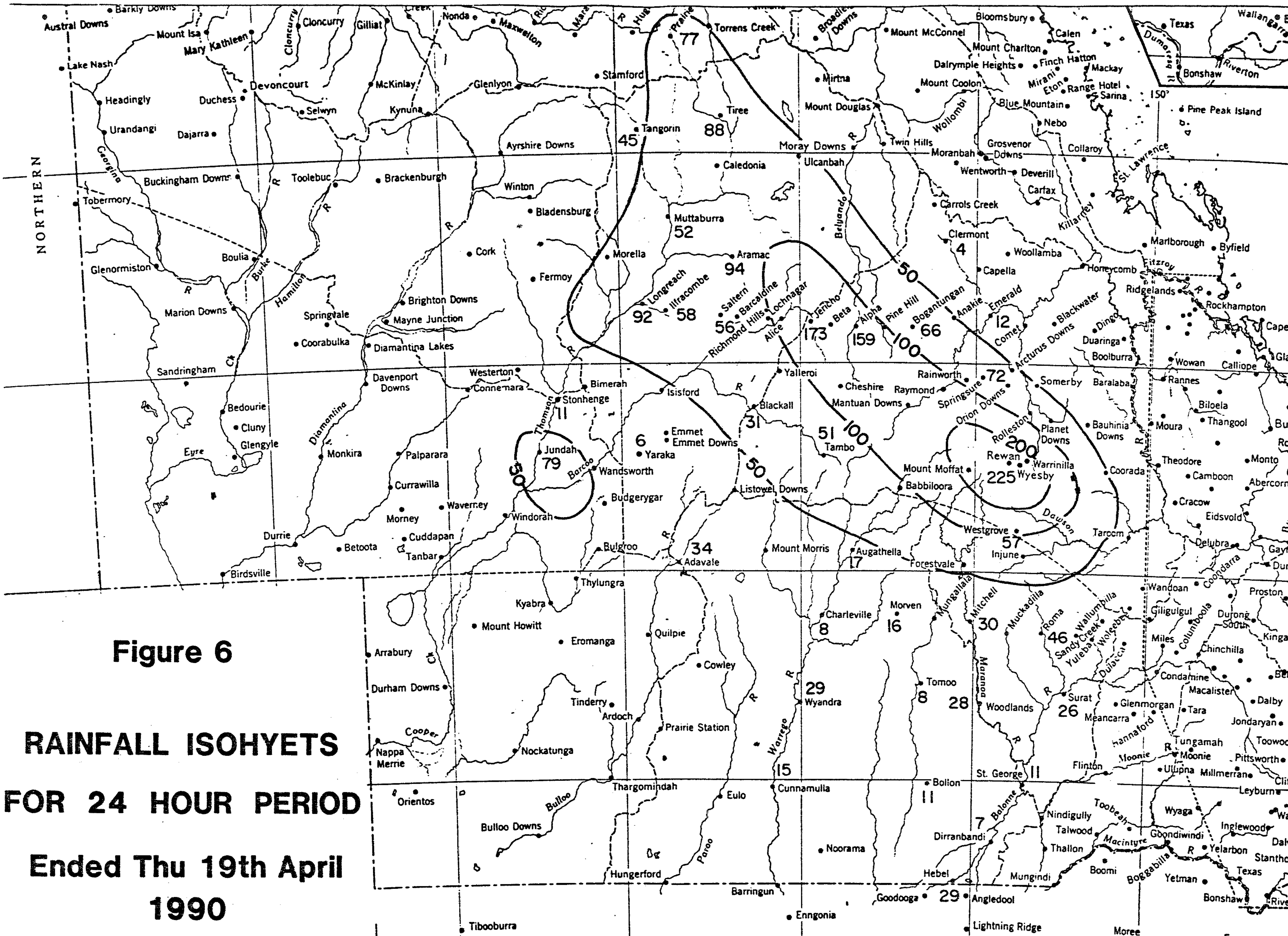


Figure 6

RAINFALL ISOHYETS

FOR 24 HOUR PERIOD

Ended Thu 19th April 1990

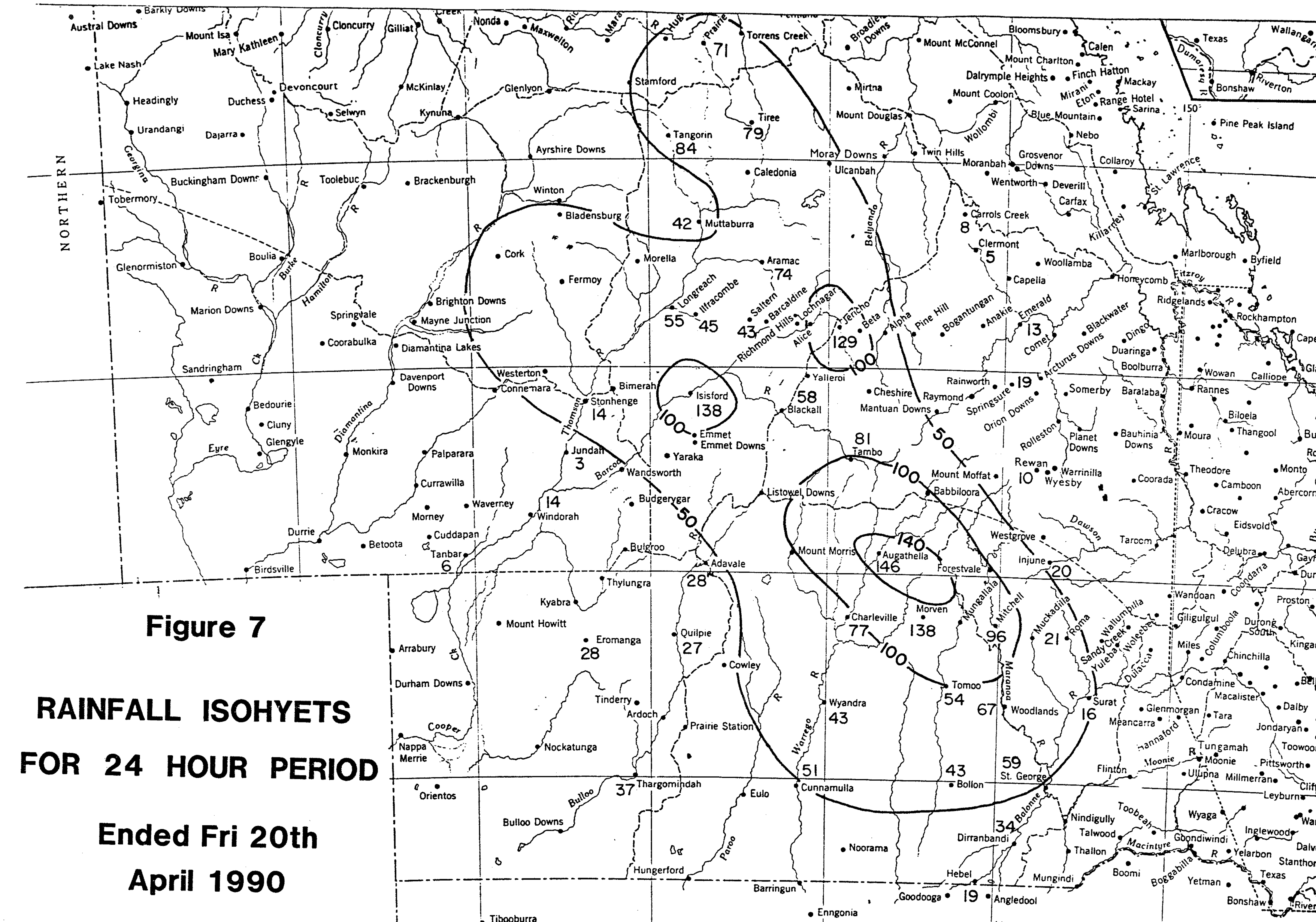


Figure 7

RAINFALL ISOHYETS FOR 24 HOUR PERIOD

Ended Fri 20th April 1990

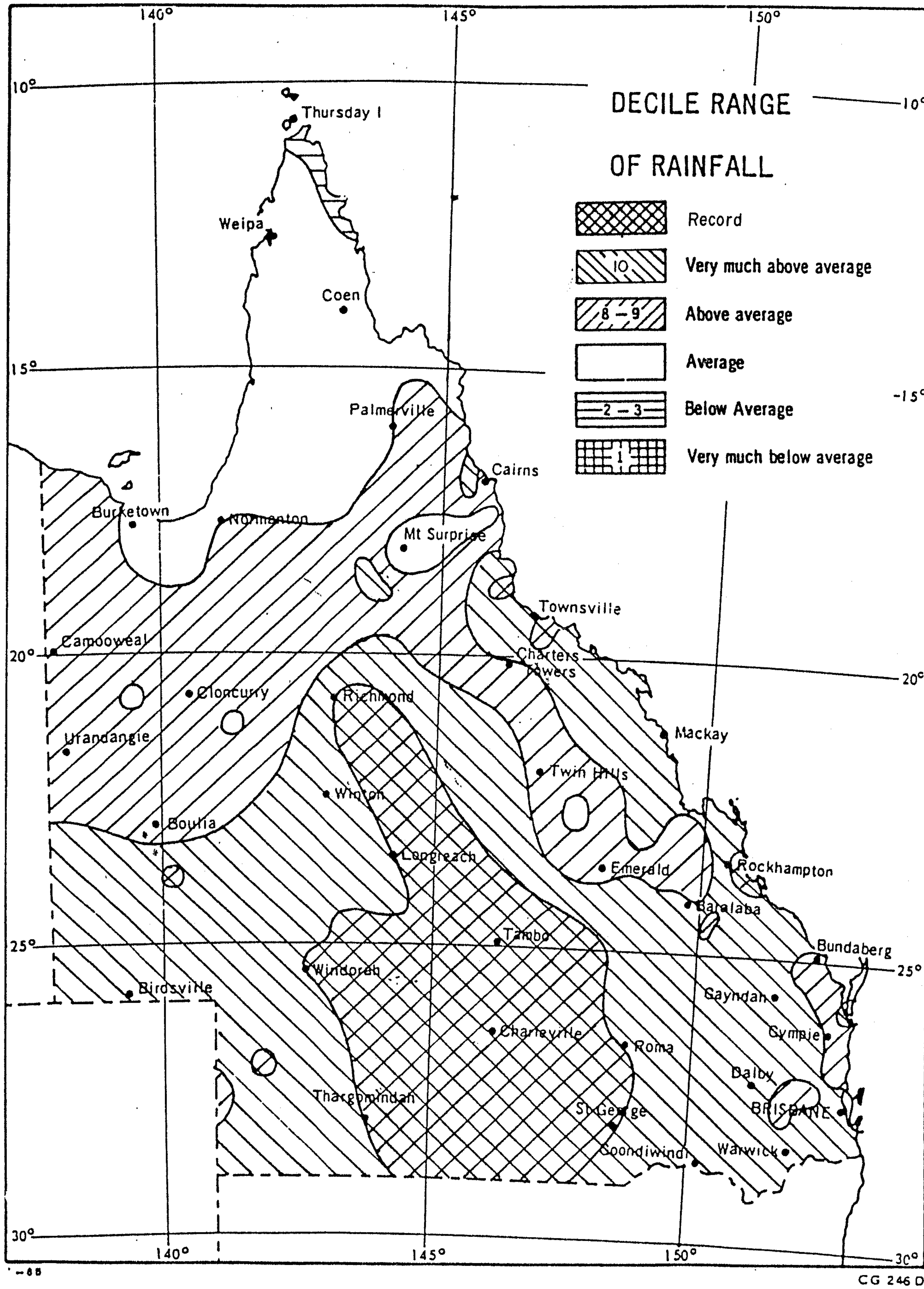


Figure 8
RAINFALL DECILES AND RECORD RAINFALL AREAS
FOR APRIL 1990

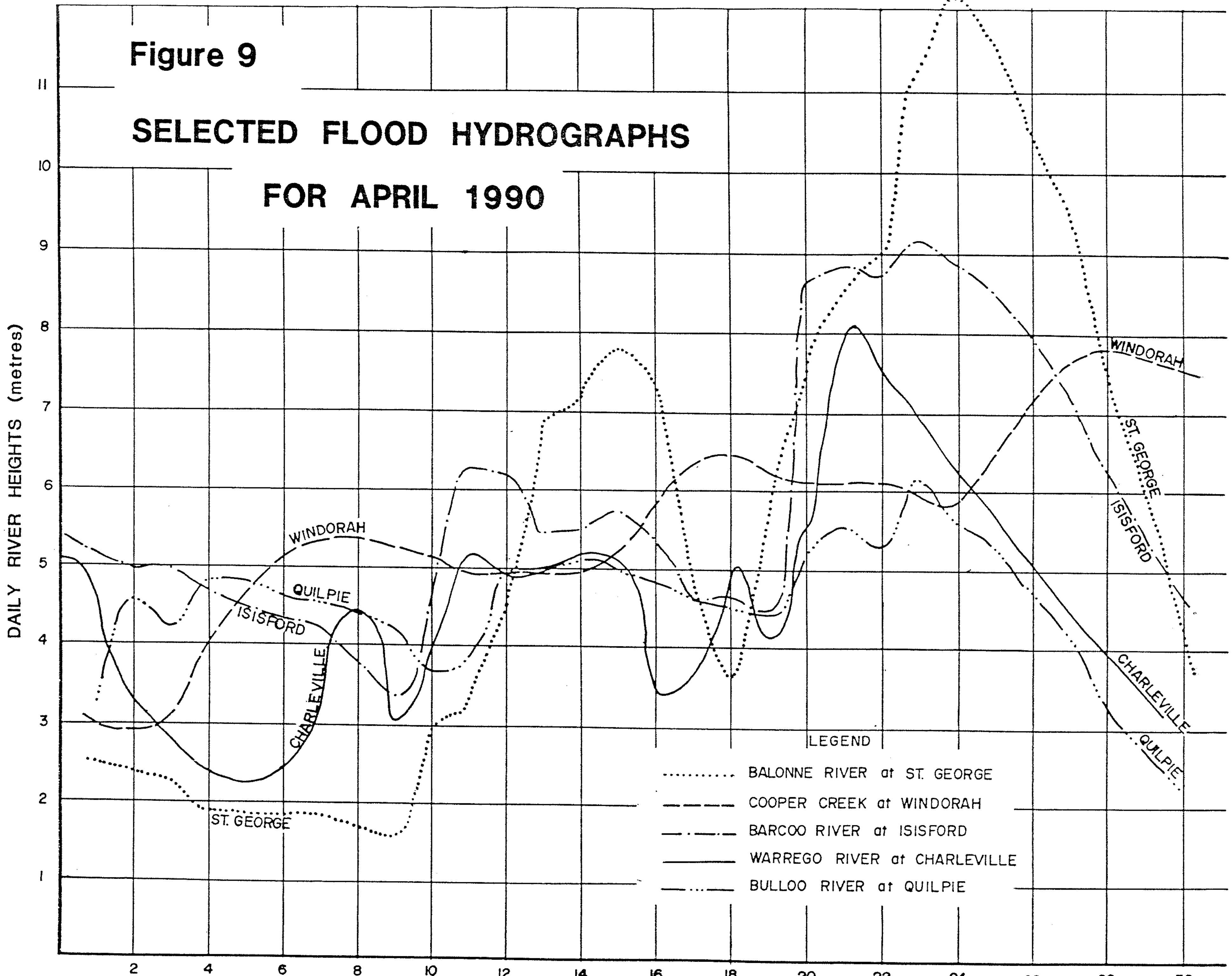


Figure 9
SELECTED FLOOD HYDROGRAPHS
FOR APRIL 1990
DAILY RIVER HEIGHTS (metres)
11
10
9
8
7
6
5
4
3
2
1
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
WINDORAH
QUILPIE
ISISFORD
CHARLEVILLE
ST. GEORGE
LEGEND
BALONNE RIVER at ST. GEORGE
COOPER CREEK at WINDORAH
BARCOO RIVER at ISISFORD
WARREGO RIVER at CHARLEVILLE
BULLOO RIVER at QUILPIE

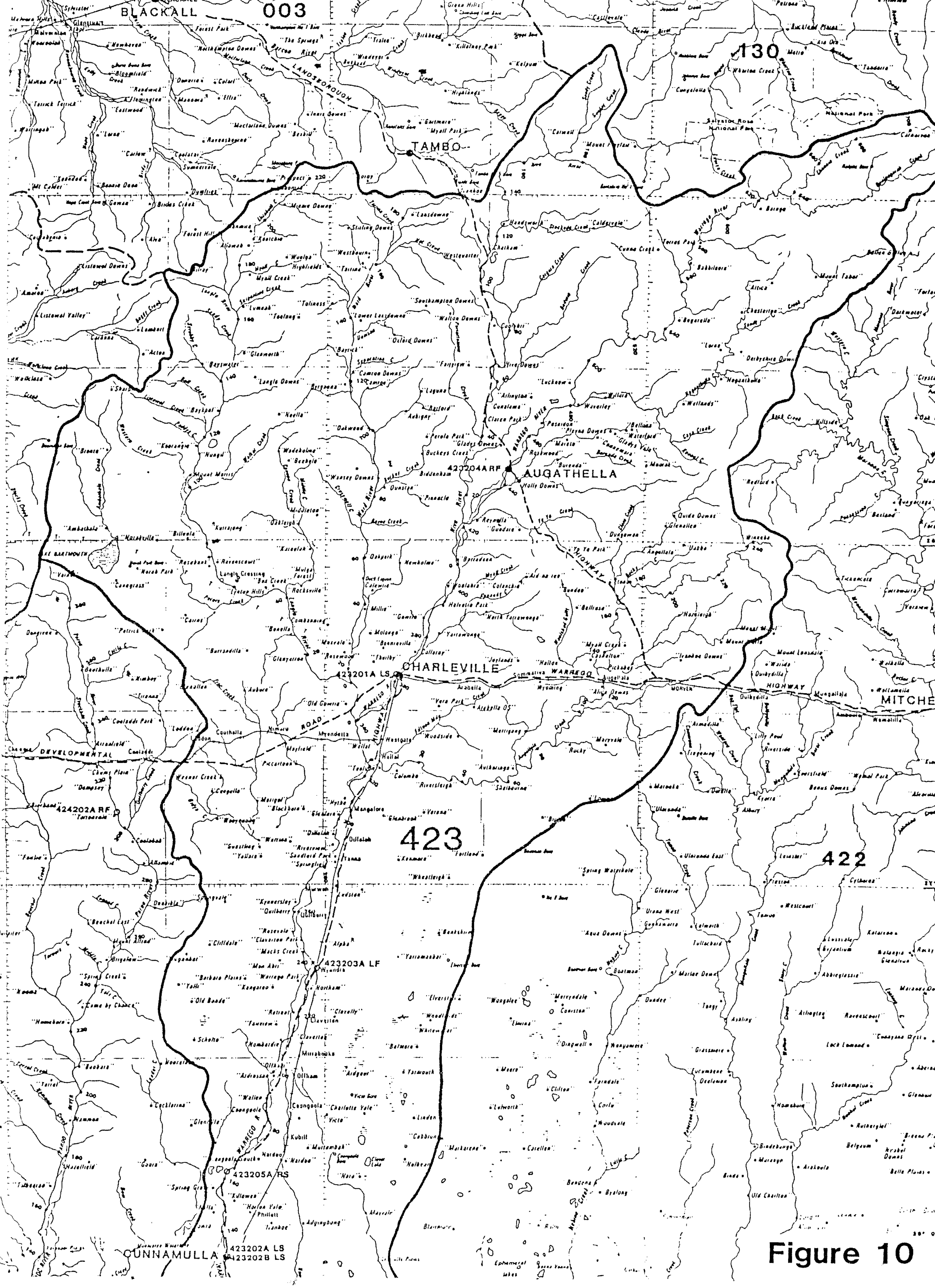


Figure 10

WARREGO RIVER CATCHMENT ABOVE CUNNAMULLA

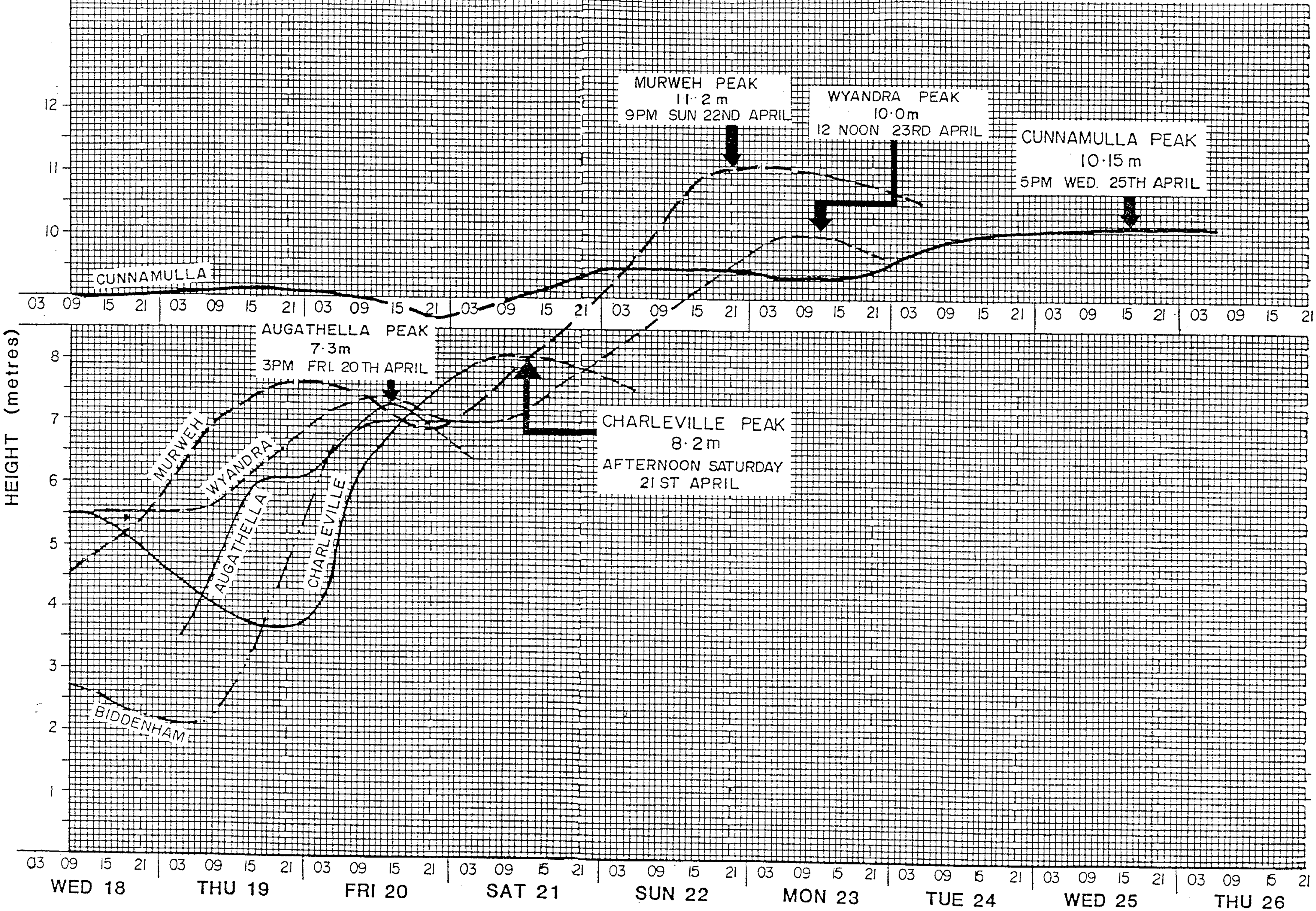


Figure 11 **WARREGO RIVER FLOOD HYDROGRAPHS APRIL 1990**

Figure 12 FLOOD WARNING NETWORK

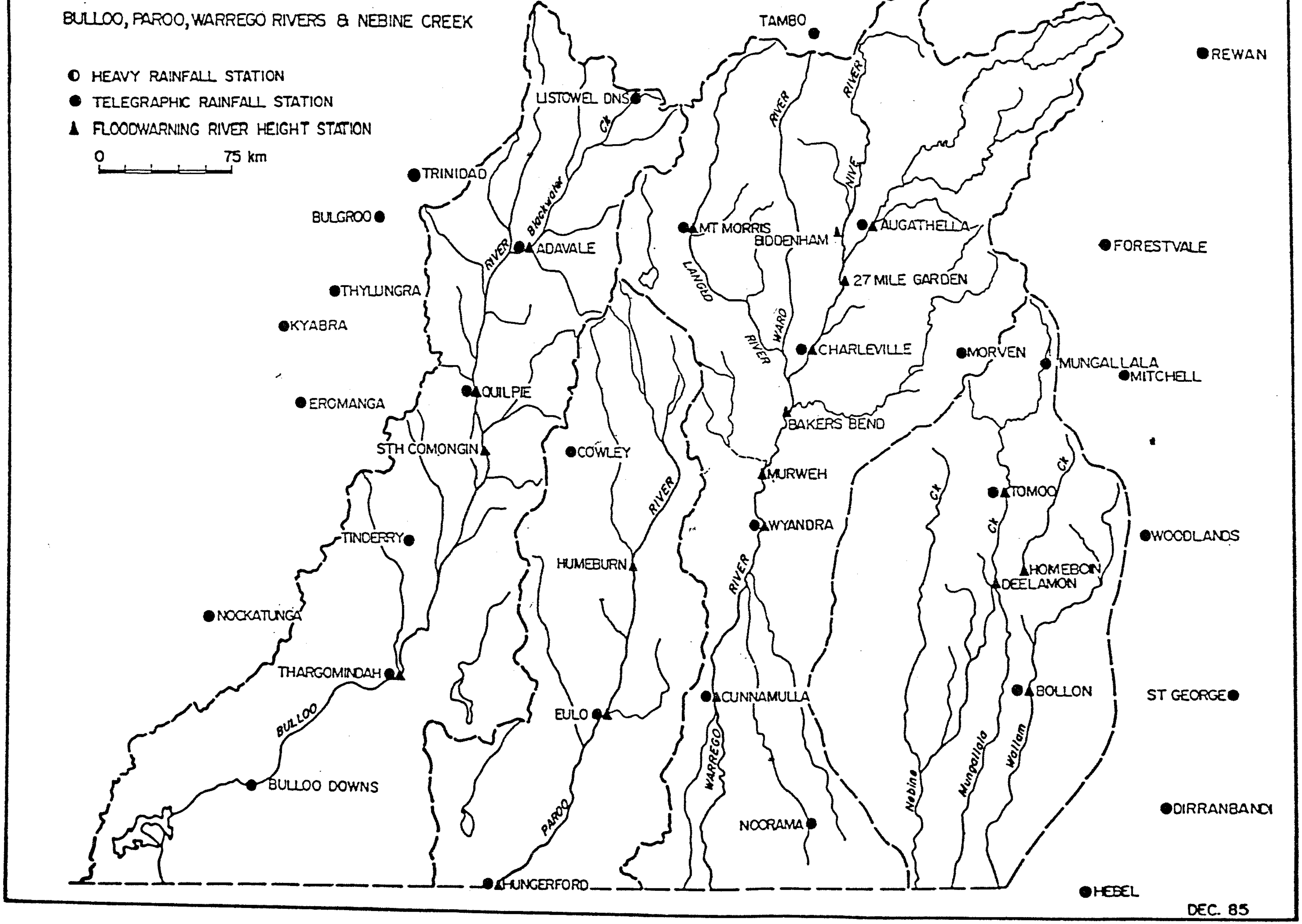
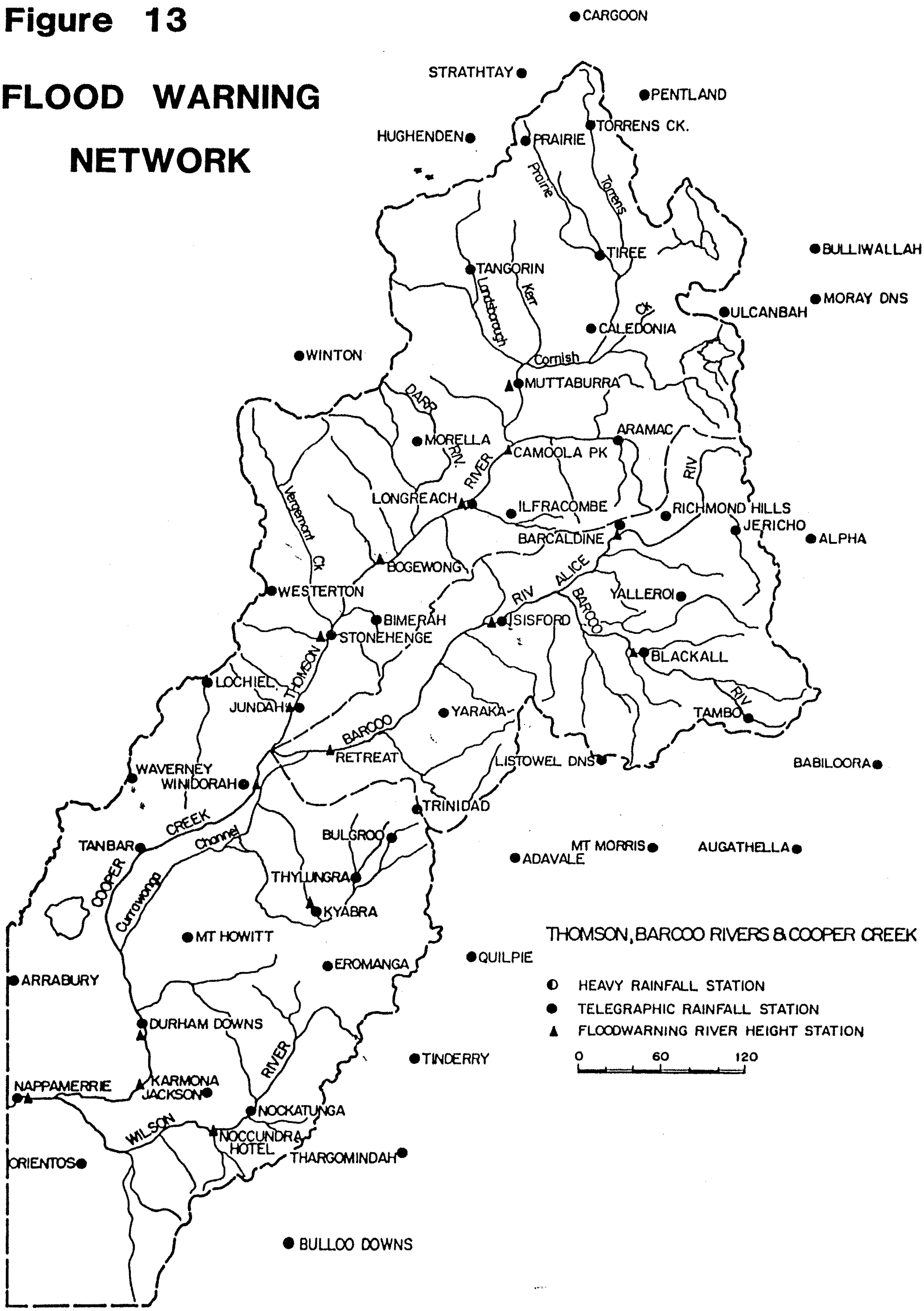
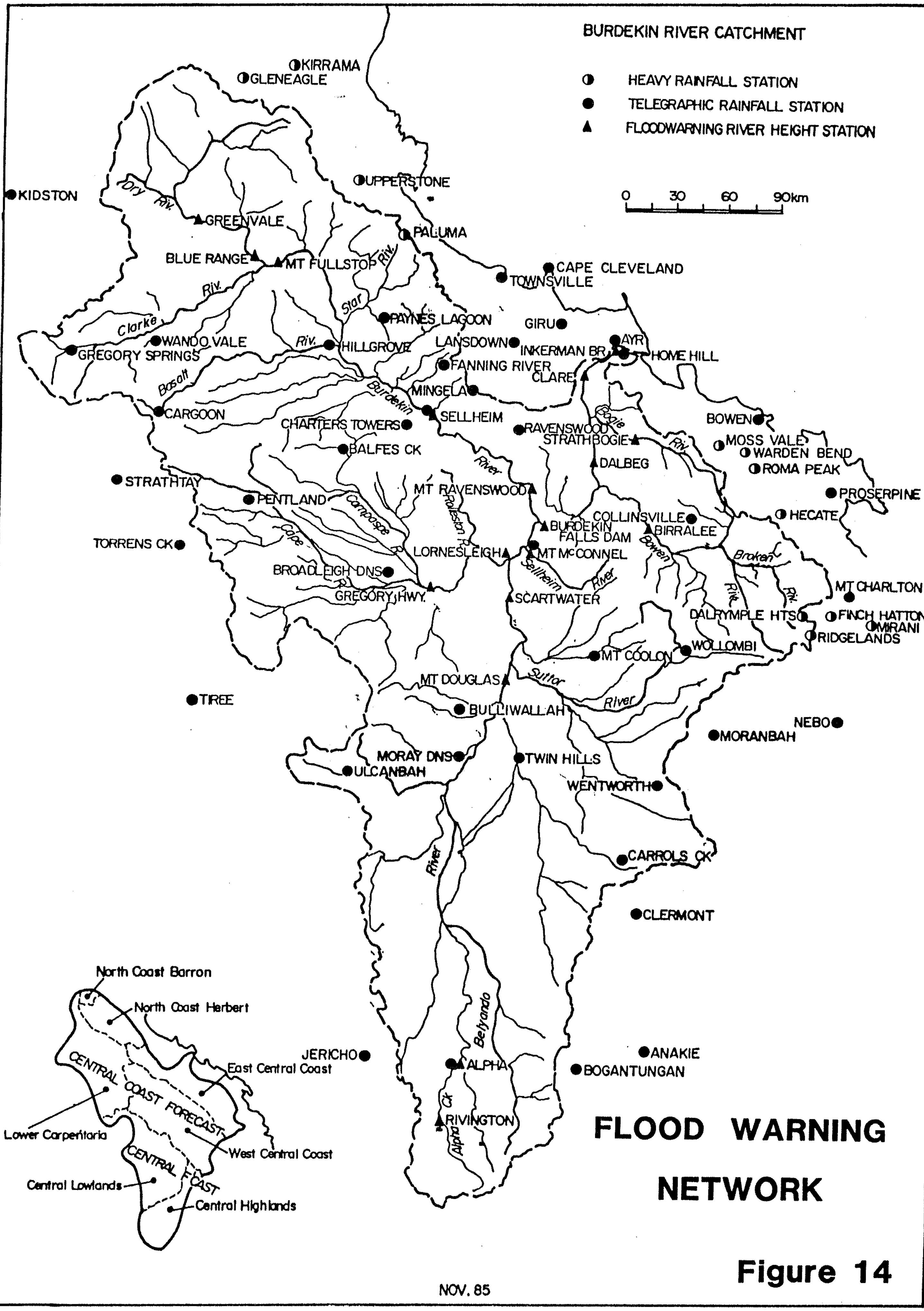


Figure 13

FLOOD WARNING NETWORK



DEC. 85



FLOOD WARNING NETWORK

Figure 14

Figure 15 FLOOD WARNING NETWORK