FLOODING OF COASTAL RIVERS IN SOUTH EAST QUEENSLAND IN FEBRUARY 1992

Queensland Regional Office
Bureau of Meteorology

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FLOODING OF COASTAL RIVERS

IN SOUTH EAST QUEENSLAND

IN FEBRUARY 1992

INTRODUCTION

Background

Major flooding occurred in the coastal catchments, shown in Figure 1, from Gladstone to Caloundra during the period 21 February to 24 February 1992.

Very heavy rainfalls in the coastal area between Bundaberg and Maryborough overnight on Thursday 21 February resulted in severe flooding along the Cherwell River in the Burrum River basin with several houses inundated.

The heavy rainfalls continued in the Mary River and along the Sunshine Coast for the next 36 hours and resulted in major flooding of urban areas and extensive flooding of rural areas.

In the Mary River, rainfall totals in the 48 hours to 9am on Saturday 22 February ranged from 150 mm in the lower reaches of the system to over 700 mm in the upper reaches above Gympie. A major flood peak of 21.40 metres at Gympie on Saturday night 22 February resulted in extensive inundation of the commercial area of the city and flood damages estimated at several million dollars.

Further downstream at Maryborough, the river reached a major flood peak of 9.50 metres on Monday afternoon. Over 100 commerical and residential premises were inundated by floodwaters.

Record rainfalls ranging from 300 to over 700 millimetres along the Sunshine Coast in the 24 hours to 9am on Saturday 22 February resulted in major flooding along the Noosa, Maroochy and Mooloolah Rivers with several hundred premises being inundated.

Major flooding in headwaters of the Brisbane River along the Stanley River occurred during Saturday 22 February and one motorist was drowned attempting to drive across a flooded river crossing.

During this period, the Regional Forecasting Centre (RFC) and the Flood Warning Centre (FWC) of the Bureau of Meteorology (BOM) in Queensland were particularly active in issuing weather forecasts and warnings, and flood warnings.

Aim

The purpose of this report is to document the meteorological and hydrological aspects of the flooding in the Burrum, Mary, Sunshine Coast and Stanley River basins in South East Queensland during the period 21 to 24 February 1992.

The performance of the flood forecasting system operated by BOM in these catchments is also examined and analysed.

Sources of Data

The primary source of data for this report is the log of rainfall and river height data collected by the FWC during the event. This data is received in the FWC via radio telemetry, telephone telemetry and from manual reporting stations via the Remote Observer Collection System (ROCS).

Additional rainfall data was collected following the event from non-realtime stations from several organisations. Supplementary river height data was compiled from the Queensland Water Resources Commission and local sources.

ANTECEDENT CONDITIONS

Meteorological Conditions

The drought which affected most of Queensland during 1991 and early 1992 was one of the most severe to have occurred in the State. The initial onset of dry conditions commenced in July 1990. Partial failure of the 1990/91 summer rains in the southern half of the State resulted in serious rainfall deficiencies in some areas but particularly in the south east corner. From March 1991 rainfalls declined markedly across the whole State and by the end of November southern Queensland was in the grip of a 18 month drought with the worst affected areas extending from Bundaberg to the NSW border and west to Charleville.

December rainfall totals up to 400mm removed the rainfall deficiencies, that is ended the drought, in substantial areas of the Moreton rainfall district including the middle and upper reaches of the Mary River catchment.

The drought of 1991/92 is linked to an El Nino event which affected the entire Pacific Basin. Previous droughts over eastern Australia, for example 1972 and 1982/3, were also associated with El Nino episodes.

El Nino episodes and negative phases of the Southern Oscillation are closely linked oceanic and atmospheric circulations which influence Queensland's broadscale weather. Whilst the El Nino can delay the onset of Queensland's wet season, resulting in below average rainfall in general across the State, it will not suppress or remove all rainmaking processes. The Mary River, February 1992, floods occurred whilst the Southern Oscillation Index was strongly negative and much of Queensland was experiencing an extensive concurrent drought.

Hydrological Conditions

From the beginning of February up to the onset of the heavy rain on 21 February, rainfall had fallen on about 10 days in the Moreton District. Totals for the period were generally 50 to 100 millimetres, although Tewantin had received over 250 millimetres during the same period.

As a result of these rainfalls, the Antecedent Precipitation Index for the Mary River to Gympie had risen from 15 mm at the beginning of February to 31 mm at 20 February. However, there was only a slight reduction in the Initial Loss which at 0900 on 20 February was estimated at about 50 mm.

River levels in the Mary River had shown little response to rainfalls and did not commence to rise until the onset of the heavy rainfall on 21 February.

METEOROLOGICAL ANALYSIS

Clearly, due to the many long standing records broken during this event, an attempt must be made to comprehend what meteorological conditions can produce such devastating rainfall. The aim of this section of the report is to reach that level of understanding and to compare the event with others which have generated exceptional rain over southeast Queensland.

The Larger Scale Environment

Mean Sea Level

The mean sea level (MSL) sequence (Figure 2) begins with tropical cyclone Daman moving away from southeast Queensland while another tropical low was developing in the Coral Sea. This low moved onto the Central Queensland coast and developed a trough along the coast to its south. The low moved west and became absorbed into the inland heat trough. The coastal trough evolved into a small low which then moved overland by 2300 UTC 21 February 1992.

Notice how ridging increased southeast of Brisbane in the wake of Daman. This helped form a large scale confluence (and undoubtably convergent) area into the coastal trough. The confluence zone was between the northwestly monsoon winds flowing around the tropical low and east-northeasterly winds circulating around the developing oceanic ridge. Dewpoints in southeast Queensland during the event were around 25^{o}C reflecting the tropical origin of the airmass.

Observe how the confluence zone moved onto the coast north of Fraser Island around 2300 UTC 19 February 1992 and developed in extent over the ensuing 24 hours. This was also the period during which the heavy rains developed and highlights the importance of this large scale confluence area in the development of the rain.

200 hPa and 700 hPa

From the sequences at these levels (Figure 3) the following features are worth noting:-

(i) A 200 hPa trough, which was retrogressing westward, amplified by 2300 UTC 19 February 1992 (prior to the onset of heavy rain) resulting in strong northwesterly winds over inland Queensland;

(ii) The tropical MSL low intensified as it moved to within a distance of 8 latitude degrees from this northwesterly jetstream which is quite similar to the situation when tropical cyclones intensify while approaching the coast;

(iii) At the same time a developing 700 hPa sub-tropical

ridge (STR) was broken by a weak trough over southeast Queensland;

(iv) By 2300 UTC 20 February 1992 (24 hours later) this 700 hPa trough had developed into a marked low over southeast Queensland and combined with the strengthening 700 hPa STR to the east to direct a north-northeasterly flow onto the coast at this level;

(v) Despite the formation of this low on the coast 700 hPa height rises were evident south from Gladstone during the whole period, giving an indication of the strengthening of this STR and its contribution to a steering current for the tropical low towards the coast;

(vi) The 700 hPa low developed in the entrance region of an anticyclonically curved 200 hPa jetstream, an area, using vorticity advection arguments, often associated with strong upper divergence.

500 hPa

At 500 hPa (Figure 4) a trough along the coast moved overland and deepened bringing a north-northeasterly flow onto the south coast as the rains developed. The northern section of this trough lay well to the west of the the MSL tropical low. A trough in the westerlies merged with the trough and passed through Brisbane by 2300 UTC 21 February 1992. Notice also the developing STR east of Brisbane. Height rises were also evident at 500 hPa across Southern Queensland and northern NSW during the whole period.

The structure of the STR was such as to provide a steering current onto the coast at 500 hPa. In fact the environment was quite similar to that associated with most severe tropical cyclones which intensify near the Queensland east coast and make landfall. In this scenario tropical cyclones intensify after moving to a distance of between 6 to 8 latitude degrees from an area of northwesterly winds greater than 50 knots located over inland Queensland. These winds are found east of an upper trough which had been amplifyfing but begins to slowly relax as the cyclone intensifies. During this period a 500 hPa STR builds up on the coast polewards of the cyclone and 500 hPa rises are still evident there 24 hours before landfall.

Upper Winds and Rainfall at Gladstone

From Figure 5 the rain commenced after the middle level winds turned northeasterly and strengthened. The northeasterly flow was associated with the evolving overland middle level trough. The heavier rain began as these northeasterlies progressively extended to lower levels as this overland trough developed downwards. Around the time of the heaviest rainfall the winds backed with height from low

level easterlies to middle level northerlies. From the thermal wind equation backing winds with height indicate warm air advection. Further, assuming the validity of quasi-geostrophic theory, warm air advection is associated with rising air motion where this warm air advection is maximised.

The coastal trough referred to above became evident soon after 2300 UTC 19 February when the warm air advection and rain developed. This followed the development of the upper northwesterly jetstream west of the area. A closer examination of this coastal trough in the Bundaberg area (Figure 6) shows the winds at coastal stations flowing into the trough and obviously forming a convergent zone with the strong oceanic easterly flow. There was even a slight westerly component to the winds at Bundaberg which was where the heaviest rain was reported from synoptic weather stations (139 mm in 3 hours). Precipitatin was mostly rain from stratiform cloud with thunderstorm cells embedded in it.

Upper Winds and Rainfall at Brisbane

The heavier rain and warm air advection began at Brisbane (Figure 7) not long after Gladstone. It commenced after the 700 hPa winds there turned northeasterly. The heavier rain ceased at Brisbane as westerly winds developed down to 600 hPa at 1700 UTC 21 February 1992. This followed the passage through Brisbane of the trough shown in Figure 4. This trough was through Gladstone by 0500 UTC 22 February 1992 around the time the heavier rain had ceased at Tewantin. It is probable that this 500 hPa trough passed through Gladstone and Tewantin about the same time. The way this clearing trough was retarded overland north of Brisbane created a major forecasting problem which was compounded by the fact that this area is located in the largest gap in the coastal upper wind network between Nowra and Cairns. This gap is destined to become larger with the planned movement of the Gladstone upper wind station to Rockhampton.

The only observation received from Tewantin in the midst of the heavy rain is shown in the MSL analysis in Figure 8. The station then reported offshore winds with heavy rain falling (316 mm in 6 hours). This airflow was obviously converging with onshore flow to the east.

Static Stability

Table 1 is a summary of the change in stability indicators leading into the rainfall event at Brisbane and Gladstone.

Table 1
Static Stability Indices & Dewpoints
at Gladstone & Brisbane
from 2200 UTC 18 February 1992
to 2200 UTC 21 Febraury 1992

(a) Gladstone	182200 UTC	192200 UTC	202200 UTC
Total totals	41.4	43.2	45.4
Showalter	3.4	0.3	-2.2
Whiting	28.7	36.1	36.5
Surface Dewpoint	20.8°C	24.3°C	23.6°C
700 hPa Dewpoint	2.8°C	6.8°C	7.0°C

(b) Brisbane	182200 UTC	192200 UTC	202200 UTC
Total totals	41.7	43.1	----
Showalter	2.3	0.8	----
Whiting	34.5	30.2	----
Surface Dewpoint	18.9°C	22.7°C	22.4°C
700 hPa Dewpoint	6.7°C	2.4°C	6.4°C

An increase in the total totals and Whiting indices and a decrease in the Showalter index indicate a reduction in atmospheric static stability. All the stability indices at Gladstone indicated a progressive destabilisation of the airmass. Note also the increase in the surface and 700 hPa dewpoints before the heavy rain. Unfortunately icing prevented the collection of data above 630 hPa at Brisbane from the radiosonde flight at 2200 UTC 20 February 1992. However the general trend at Brisbane was for a reduction in stability. The decrease in the Whiting index was due to a temporary intrusion of dry air around the 700 hPa level.

Summary of Event

A MSL tropical low intensified apparently as it moved closer towards a northwesterly jetstream east of an amplifying upper trough. At the same time a deep ridge developed to the south of the low creating an area of confluent flow onto the coast and helped create a steering current onto the coast. This directed a strong moist tropical airstream into the entrance zone of the anticyclonically curved jetstream, a zone usually associated with forced ascent. A middle level trough developed in this zone directing 700 hPa northeast winds and 500 hPa northerly winds into the rain area. The resulting vertical wind structure in the rain area during the period of heaviest rainfall was low level easterly winds backing with height through middle level northerlies.

Six other exceptional rainfall events (Jul 1965, Jun 1967, Jan 1974, Jun 1983, Apr 1989, Dec 1991) which have inundated southeast Queensland over the last thirty years were studied for comparison. The heavy rain in this event commenced as a wind structure developed common to these six events. This structure consisted of the winds backing with height up to 500 hPa and remaining mostly in the northeast quadrant. In addition, surface winds in the region clearly show strong low level convergence (Figure 8). Possible clues to the potential of such an exceptional event at 2300 UTC 19 February 1992 (before the onset of heavy rain) were :-

(i) The development of a tropical low as it advanced towards the coast and towards a strengthening anticyclonically curved upper jetstream;

(ii) Rising MSL pressures on the coast south of the low forming a low level confluent zone into the entrance area of the jetstream;

(iii) Low to middle level height rises south of the low was an indication (from past studies) it would be steered onto the coast; and

(iv) The development of middle level northeasterly winds at Gladstone.

RAINFALLS

Rainfall Totals

A list of daily rainfall totals in millimetres (mm) between 20 and 22 February appears in Table 2. Note that some totals are for periods of 48 or 72 hours as indicated in the Table by arrows from the previous observation.

Isohyetal maps of rainfall over SE Queensland during the period of heavy rainfall appear in Figures 9,10 and 11. These maps indicate two rainfall maxima.

In the 24 hours to 0900 on 21 February (Figure 9), more than 200 mm rain fell over the Burrum River catchment, with more than 300 mm over coastal areas. A second maximum with falls of over 250 mm was located near the Sunshine Coast.

In the following 24 hours (Figure 10), the rain had eased in the Burrum River catchment with falls of less than 20 mm. The Sunshine Coast and hinterland received very heavy rain, with falls in excess of 200 mm over much of the Mary, Sunshine Coast streams and Stanley River catchments. Tewantin in the lower Noosa catchment received 732 mm which followed 181 mm the previous day.

An isohyetal map for total rainfall over the 48 hours to 0900 on 21 February appears in Figure 11.

Rainfall Temporal Patterns

Pluviograph records for a number of stations in the area were analysed and rainfall mass curves derived. These curves appear in Figures 12 to 15.

An initial period of heavy rain occurred in the Burrum River catchment between 1700 on 20 February and 0300 on 21 February. Figure 12 shows the mass curves for Bundaberg and Childers. During this 10 hour period, 241 mm or 88% of the 3 day total rainfall fell at Bundaberg and 213 mm or 85% fell at Childers.

Rainfall mass curves for 11 stations in the Mary River catchment appear in Figures 13 and 14. Differing temporal patterns in the rainfall are evident between the north and the south sections of the Mary River and adjacent catchments.

DAILY RAINFALL (mm) – FEBRUARY 1992 (24hr to 0900)

No	Name	Latitude	Longitude	21st	22nd	23rd	24th
39135	Bagara	2449	15228	327	2	8.4	1.2
40013	Bauple	2550	15238	195.4	99.6	9	12.6
40284	Beerburrum For	2657	15258	130	323.8	12.2	0
40062	Beerwah	2649	15251	157.6	360	--->	201
40017	Beerwah Forest	2650	15300	131.6	339	--->	23.6
40021	Biggenden	2503	15203	122			
39186	Bingera	2456	15212	228			
39009	Boona–Choppa	2541	15217	224.8	106	14	6.4
39159	Booyal	2513	15202	134.6	10.9	16	13.4
40028	Brooweena PO	2536	15216	188	14.8	6.2	8.2
40031	Buderim PO	2641	15303	131	------->		425.6
39265	Bullyard	2457	15202	154	5	6	3
39128	Bundaberg	2454	15219	258	6	3	2
39174	Bundaberg Sugar	2451	15223	230 +	------->		11.6
39198	Burrum Heads	2511	15237	356	5	1.4	12
40038	Caboolture	2705	15257	121	------->		163
40040	Caloundra	2649	15318	93	342	16	
40759	Caloundra	2648	15305	94	388	--->	25
40043	Cape Moreton	2702	15328	106	93	14	
39207	Childers	2515	15213	181	25.4	17	10
39303	Childers	2516	15217	212	14.4	12.2	8.4
39025	Childers PO	2514	15217	248.4	------->		73.4
40047	Cleveland	2731	15316	73	44	0	0
40800	Cooroy TM	2625	15255	224	426	43	
40063	Dayboro	2712	15249	97	144		
40637	Dayboro	2706	15242	145.4	101.4	0	0
40069	Duckinwilla Ck	2524	15226	265.2 +	20.8	--->	46.2
39221	Elliot Heads	2455	15229	300	65	0	0
39210	Elliott R For	2501	15213	197.4	32	--->	114
40075	Esk	2714	15225	61			
	Eumundi TM	2629	15258	186	600	36	
40122	Gallangowan	2626	15218	234.4	---->	35	2
40083	Gatton	2733	15217	18			
39040	Gin Gin	2500	15158	123	------->		22
40089	Goomboorian	2604	15246	287	132	9	
40090	Goomeri	2611	15204	102			
40003	Gympie	2621	15238	283.6	389.4	76	2.6
40093	Gympie	2610	15239	200	336	16	
40686	Gympie (Kiah)	2612	15249	500 +	450 +	154	86
40765	Hervey Bay	2518	15249	173	41	24	
40098	Howard	2520	15234	245 +	---->	3	
40100	Imbil Forestry	2628	15240	215	281		108
40099	Imbil PO	2627	15240	244.4	251.6	836	1.6
40777	Imbil TM	2627	15241	224	260	74	
40481	Imbil (Borumba)	2630	15235	27.4	187.4	172.2	9.6
40102	Jimna Composite	2640	15228	139	100	58	1
40492	Jimna (Yielo)	2640	15231	170.4	112.9	0	0
40105	Kandanga PO	2623	15241	256	300	81.4	2
40801	Kandanga TM	2636	15244	253	216		
40106	Kenilworth	2636	15244	211	254	31	
40802	Kenilworth TM	2636	15244	216	227	31	

-------> Cumulative Total + Gauge Overflowed

DAILY RAINFALL (mm) – FEBRUARY 1992 (24hr to 0900)

No	Name	Latitude	Longitude	21st	22nd	23rd	24th
40110	Kilcoy	2656	15234	115	------>		124
40635	Kilcoy	2650	15229	101	87.8	23	3
40438	Kin Kin PO	2616	15252	275	305	35.4	17
40112	Kingaroy	2633	15150	55	64		
40117	Landsborough	2648	15208	134	370		
40247	Lindfield	2651	15235	131	126	13	
40698	Maleny	2648	15244	195	270	26.4	9.8
40121	Maleny PO	2645	15201	183	490	24	
40803	Maleny TM	2645	15251	199	485	23	
40123	Mapleton	2637	15252	211	513	23	
40804	Mapleton TM	2645	15251	211	493	22	
40126	Maryborough	2533	15241	245	35	4	
40680	Maryborough	2521	15236	250 +	------>		17
40134	Montville	2642	15254	133.2	494 +	18	2.4
40136	Mooloolah PO	2646	15258	129	423	44	2
40774	Morayfield	2707	15256	100	161		
40308	Mt Glorius	2720	15246	92	173	9	
40144	Mt Joseph	2545	15214	131	16	12	
40145	Mt Mee	2705	15247	113	214		
40152	Murgon	2614	15157	80	------>		14
40282	Nambour DPI	2639	15256	160			
40157	Nambour (Bowl)	2637	15258	155.4	503	25.2	1.8
40547	Nambour (Mill)	2638	15258	142	526		26
40158	Nanango	2629	15203	67	------>		11
40695	Palmwoods	2642	15257	148	480	29	
40805	Peachester TM	2650	15253	62	273	11	
40170	Pechey	2729	15203	27	------>		29
40171	Petrie	2716	15259	125	------>		183
40175	Point Lookout PO	2726	15332	79			
40057	Pomona	2611	15255	240	340	48	10.6
40806	Pomona TM	2622	15251	224	341	26	
40176	Pomona (Como)	2622	15251	244	382	24	
40697	Redcliffe	2714	15306	130	130	2	0
40189	Somerset Dam	2707	15233	82			
40390	Teddinton	2539	15240	254	45.8	3	28.2
40264	Tewantin PO	2624	15302	180	732	80	
40203	Tiaro	2544	15235	173	49	7	
40205	Toogoolawah	2705	15223	76	------>		67
40451	Toolara Forest	2600	15250	265	135		18.4
40207	Tuan	2541	15248	211			
40430	Urangan PO	2517	15254	122	71.8	9.4	0
39093	Wallaville	2505	15200	139	------>		37
40343	Wamuran	2703	15252	134	203	4.4	0
39168	Woodgate PO	2506	15223	363	13	0	4
40365	Woolgooga	2604	15223	151	140		
40257	Yandina PO	2634	15257	201	668	--->	50
40258	Yarraman	2650	15159	53	16	1	1

-------> Cumulative Total + Gauge Overflowed

Table 2 (cont)

Patterns for Maryborough and Kilkivan are similar and are chosen as representative of temporal patterns in the north. Rain fell in the 43 hours between 1200 on 20th and 0700 on 22nd February, with the heaviest rain in the 7 hours between 2200 on the 20th and 0500 on the 21st. During this time, 196 mm or 65% of the 3 day total rain fell at Maryborough and 115 mm or 62% of fell at Kilkivan. The heaviest rain fell in this region as it eased further north.

The temporal patterns for the stations in the southern section of the Mary River, the Sunshine Coast streams and the Stanley River catchment are similar. The representative stations are Mapleton, Maleny, Cooroy, Pomona, Imbil, Kandanga, Kenilworth, Jimna, Eumundi, Beerwah, Caloundra and Peachester and the rainfall mass curves are shown in Figures 14 and 15. The rain occurred during the 52 hours between 1400 on the 20th and 1800 on the 22nd.

The bulk of the rain fell in the 30 hours between 0300 on the 21st and 1200 on the 22nd. Again, the heavy rain occurred in this region as it eased further north.

The temporal pattern of the rainfall at Gympie is similar to that at Maryborough and Kilkivan between 1200 on the 20th and 2300 on the 21st. This included about 24 hours of heavy rain followed by 12 hours with little rain. By 1200 on the 20th, the rain had effectively cleared in the north. However, very intense rainfall was recorded at Gympie with 257 mm falling in the 6 hour period between 0000 and 0600 on 22 February before easing again.

Rainfall mass curves for stations in the Sunshine Coast are given in Figure 15. Throughout the area, rainfall patterns were reasonably uniform with rain commencing at 0900 21 February and the bulk of the rainfall having fallen by about 0000 22 February.

Radar Imagery

Imagery from the Mt Kanighan radar indicated that widespread rain from stratiform cloud was firmly established by 1100 on 20 February. The rain moved onto the coast in the north-easterly flow.

From 1400 on 20 February, a band of heavier rain moved onto the Burrum coast and moved south-west into the catchment. Shortly afterwards heavier falls began in the Hervey Bay area. Over the following 6 hours the rain areas moved very slowly south and intensified. By 0320 on the 21st the heaviest falls were detected within a radius of 50km of Mt Kanighan, and continued to move south.

By 1200 convergence between north-easterly and north-westerly flow onto the coast south of Fraser Island was evident. This area and inland to the south and

south-east of Mt Kanighan continued to receive the heaviest falls over the next 8 hours. By 2100 the heavy rain feeding onto the coast began to move westwards overland, and evidence of a cyclonic circulation was apparent. Between 1800 on the 21st and 0900 on the 22nd, local heavier rain would have occurred with a number of slow moving embedded thunderstorms evident. It was during this period that Gympie, for example had received a second burst of heavy rain. By 1100 on the 22nd the rain was easing as the low moved south-south-east off the coast.

From analysis of Mt Kanighan and Brisbane radar imagery, it is difficult to determine a distinct centre for the small low which developed. Continuity between apparent circulation centres in animated loops was poor at times, possibly reflecting tilting with height in the system.

An approximate track of the low derived from radar imagery appears in Figure 16. Note that the band of heaviest rain was to the south and south-east of the centre, with more isolated thunderstorms the main source of rain to the north.

Figure 17 is a sample of the digitised radar imagery from Mt Kanighan.

Record Rainfalls

Rainfall records were established at several locations throughout the flood affected areas and appear in Table 3.

Table 3
Record 24 Hour Rainfall Totals

Station Name	Total mm	Date	Previous Record mm	Date	Records Commenced
Goomboorian	287	21	269	Dec 1926	1913
Tewantin	732	22	448	Jan 1974	1895
Yandina	668	22	510	Feb 1893	1892
Mapleton	513	22	399	Dec 1909	1903
Maleny	490	22	394	Apr 1928	1915
Palmwoods	480	22	290	Feb 1972	1930
Eumundi	467	22	356	Jan 1974	1898
Cooroy	421	22	362	Mar 1955	1893
Pomona	381	22	340	Mar 1955	1919
Gympie	336	22	296	Mar 1901	1870
Kandanga	300	22	235	Feb 1947	1917

Rainfall Frequencies

Intensity-Frequency-Duration (IFD) curves were compiled for several rainfall pluviograph stations in the areas affected by floods. It should be noted that, in most cases, raw telemetered rainfall data, which was not adjusted to the official manually recorded total, was used to compile the actual rainfall pattern shown on the curves. As such, the IFD information shown is only approximate but is sufficient for the purpose of this report.

IFD curves for Childers and Bundaberg appear in Figures 18 and 19 and rainfall intensities recorded during this event are plotted on the curves. The rainfall total of 210 mm at Bundaberg in the 6 hour period between 1700 and 2300 on the 20th corresponds to an Average Recurrence Interval (ARI) of about 100 years, and totals recorded at Childers correspond to an ARI of about 50 years.

IFD curves for Eumundi and Maleny appear in Figures 20 and 21. The rainfall which occurred during the 12 to 48 hour period exceed the ARI of 100 years at Eumundi and the 24 hour rainfall recorded at Maleny corresponds to an ARI of 100 years. The rainfall intensities for durations of a few hours correspond to an ARI of less than 20 years at both stations. This reflects the sustained heavy rainfall over a 48 hour period, with an absence of significantly intense brief bursts of rain.

The IFD curves for Gympie, Figure 22, shows the actual recorded rainfall plotted on the curves. The rainfall intensities over the 2 to 15 hour durations and the 24 to 72 hour durations exceed the ARI of 100 years.

The IFD curves and rainfall intensities for available durations for Tewantin appear in Figure 23, indicating the ARI for these durations is in excess of 100 years.

FLOODS

Table 4 indicates the class and nature of flooding in the Noosa, Mary and Brisbane basins over the period 21 to 24 February 1992. Similar data is not available in this form for the Burrum, Maroochy and Mooloolah River basins.

Burrum River

The heavy rain in the Bundaberg to Maryborough area overnight on Thursday 21 February caused widespread flooding.

Flash flooding and surcharge of urban drainage system appears to have been a major problem in Bundaberg with highways and roads into the city and coastal communities covered by floodwaters up to 1 metre in depth. Several homes in the low lying area of Bundaberg were also inundated.

The worst of the flooding occurred in the Pacific Haven area near Howard where the Cherwell River, a tributary of the Burrum River, reportedly rose very rapidly and burst its banks early on Friday morning. It was estimated that up to 60 houses and caravans were inundated and about 20 people required evacuation.

Mary River

Flooding in the Mary River basin impacted on several sectors of the rural and urban communities.

During the early stages of the event on Friday morning, very steep river rises were recorded throughout the catchment. As shown on Figure 24, river rises at stations in the Kenilworth to Gympie reach were particularly fast.

By Friday evening, rainfalls had begun to ease and the rates of river rises were starting to decrease. However, as indicated in Figure 25, the recurrence of very heavy rainfall in the 6 hours to 0600 Saturday 22 February caused localised areas of flash flooding and increases in the rate of river rises throughout the catchment, particularly in the area immediately around Gympie. During this period, stormwater systems in the Gympie commercial centre surcharged causing flood inundation of areas which were not affected by the main flood waters which peaked at 21.4 metres gauge height at 2100 on Saturday evening February 22.

At Gympie, the Mary River rose rapidly from 0.3 metres at 0300 to 11.9 metres at 1200 on Friday 21 February. After this time, the rate of rise slowed until about 0000 Saturday 22 February when it started to rise rapidly again.

Table 4. Flood Level Classifications and Peak Heights

Catchment	River/Stream	Station	Station Type	Minor Flood Level (m)	Moderate Flood Level (m)	Major Flood Level (m)	Bridge Level (m)	February 1992 Flooding Peak (m)	Time	Date	Comments
Noosa River	Noosa River	Boreen Point	Manual	1.5	2.0	2.5	---	3.30	2400	22/2/92	
		Lakeway Drive	Manual	1.0	1.5	2.0	---	2.55	2400	22/2/92	
		Tewantin	Manual	1.0	1.5	2.0	---	1.81	300	23/2/92	
Mary River	Mary River	Bellbird Creek	Telemeter	---	---	---	---	---	---	---	Failed -- Last report 4.61 m, 0900, 21/2/92
		Kenilworth Bridge	Manual	5.0	8.0	11.0	5.8	9.80	300	22/2/92	Bridge washed away -- telephone lines down
		Kenilworth Homestead	Telemeter	---	---	---	---	9.20	---	---	Failed -- Last report 6.16 m, 1200, 21/2/92
		Moy Pocket	Telemeter	---	---	---	---	14.42	530	22/2/92	
	Yabba Creek	Imbil	Manual/Telemeter	5.0	5.0	8.0		8.90	1645	22/2/92	
	Kandanga Creek	Hygait	Telemeter	---	---	---	---	8.54	1100	22/2/92	
	Mary River	Dagun Pocket	Telemeter	---	---	---	---	17.39	1500	22/2/92	
	Amamoor Creek	Zachariah	Telemeter	---	---	---	---	10.20	1300	22/2/92	
	Six Mile Creek	Cooran	Manual	5.0	7.0	9.0	7.2	10.20	600	22/2/92	
		Cooran	Telemeter	6.5	8.5	11.0		11.96	400	22/2/92	
	Mary River	Gympie	Manual/Telemeter	6.0	12.0	17.0	9.9	21.44	2100	22/2/92	
		Fishermans Pocket	Telemeter	---	---	---	---	23.15	2100	22/2/92	
	Wide Bay Creek	Kilkivan	Telemeter	---	---	---	---	2.57	900	21/2/92	Failed -- Last report 1.39 m, 1700, 22/2/92
		Woolooga	Manual	8.0	10.0	11.0	2.4	5.28	1000	22/2/92	
		Brooyar	Telemeter	---	---	---	---	---	---	---	Failed -- No reports for this event
	Mary River	Miva	Manual/Telemeter	7.5	9.5	15.5	12.5	20.45	900	23/2/92	
	Munna Creek	Lone Pine	Manual	8.0	8.0	12.0	3.5	---	---	---	Stopped reporting at 5.88 m, 1500, 21/2/92
		Marodian	Telemeter	---	---	---	---	9.31	1020	22/2/92	
	Mary River	Home Park	Telemeter	---	---	---	---	20.57	1930	23/2/92	
		Tiaro	Manual	6.0	6.0	12.0	6.1	18.65	300	24/2/92	
	Tinana Creek	Bauple East	Telemeter	9.0	11.0	12.3	3.0	---	---	---	Failed -- Last report 12.33 m, 1800, 22/2/92
	Mary River	Maryborough	Manual	5.0	8.0	9.0	5.5	9.50	1500	24/2/92	
		Churchill Street	Telemeter	---	---	---	---	8.91	1500	24/2/92	
Brisbane	Stanley River	Peachester	Telemeter	---	---	---	---	8.62	2400	21/2/92	
		Woodford	Telemeter	5.6	6.1	7	---	7.16	2400	21/2/92	
		Somerset Dam	Radio Telemetry	---	---	---	---	8.27	900	24/2/92	

Similar shaped hydrographs, shown in Figure 26, were experienced between Gympie and Tiaro with initial sharp rises, then an easing in the rate of rise and finally a steady rise to a peak.

At Marybrough, the river did not commence to rise significantly until late Saturday evening 22 February but then rose steadily to a peak of 7.5 metres late on Monday afternoon 24 February.

At Maryborough, the Mary River commenced to rise at 0000 Sunday 23 February and continue to rise to a peak of 9.47 metres at 1500 on Monday 24 February.

In Gympie, flood damage was incurred in all sectors of the community. Approximately 30 to 40 houses were inundated along with about 110 business premises in the commerical centre of the town. Both bridges between Gympie and the southern suburbs were overtopped, limiting access between the areas. Community facilities such as bowls clubs, swimming pool and recreation ovals were also inundated in Gympie.

In the rural areas of the catchment, significant damages were sustained in farming sector with major soil erosion, land slides and failure of farm dams. In addition, stock and crop losses were considerable. Several road bridges, including the bridge at Kenilworth, were destroyed and transport routes were cut at several locations causing major disruption.

A small number of houses were inundated in the township of Kandanga, upstream of Gympie and numerous farm houses throughout the catchment were isolated.

Early estimates of damage were put at several million dollars.

Despite record rainfalls at several locations throughout the catchment, flood levels in the Mary River were generally below record levels.

The Mary River at Gympie peaked at 21.40 metres at 2100 on Saturday 22 February. As shown in Table 5, this flood is ranked 6th in the record of floods dating from 1870 and was very similar to the March 1955 flood.

Table 5 shows that this flood peak at Maryborough is ranked 6th in the record of floods dating from 1870.

The effect of tides on flooding at Maryborough is very small once the river level exceeds about 7 metres.

Table 5
Record of Peak Flood Heights

Mary River at Gympie		
Month	Year	Gauge Height (metres)
Feb	1893	25.45
Feb	1898	22.00
Mar	1870	21.59
Mar	1898	21.49
Mar	1955	21.44
Feb	**1992**	**21.40**
Feb	1893	21.08
Jan	1974	20.73
Apr	1989	19.65
Jul	1973	19.61

Mary River at Maryborough		
Month	Year	Gauge Height (metres)
Feb	1893	12.27
Mar	1955	11.23
Jan	1974	10.95
Jan	1890	10.06
Jan	1898	9.70
Feb	**1992**	**9.50**
Jan	1968	9.25
Feb	1875	8.99
	1870	8.39
Jul	1973	7.70

Sunshine Coast

Flooding occurred in several rivers and streams throughout the Sunshine Coast.

In the Noosa River, the main flood waters did not reach Tewantin in the lower reaches until early Sunday morning 23 February. This effect was primarily due to the attentuating capacity of Lake Cootharaba (Boreen Point) and Lake Cooroibah (Lakeway Drive). Figure 27 shows the hydrographs for the flood warning river height stations in the Noosa system.

No loss of life was reported in the Noosa catchment although many properties were inundated and there was extensive above-ground flooding of the Noosaville-Tewantin district.

River levels in the Maroochy system upstream of the Bruce Highway peaked generally late Friday afternoon 21 February. At this stage the main impact of the floods was the closure of several low level roads. However, by late Saturday approximately 225 homes throughout the Maroochy system were inundated by depths up to 800mm. The worst affected area was Pacific Paradise, adjacent to the mouth of the Maroochy River.

Little information on river levels or flood damages is available for the Mooloolah River although there were media reports of severe structual damage of at least one house.

Overall, there were only isolated instances of major structural damage to houses and roads throughout the Sunshine Coast. The main flood impact seems to be above

ground inundation of several hundred residential properties and disruption to road transport. Inundation of floor levels appears to be limited to far fewer than the number of properties affected.

As the Maroochy and Mooloolah Rivers do not have flood warning networks, there were no river heights collected by the FWC during the event.

Stanley River

River levels in the upper Stanley River commenced to rise during Friday morning 21 February. The Stanley River at Woodford reached a peak of 7.16 metres at midnight on Friday 21 February, just over major flood level, as shown in Figure 28.

The only loss of life during these floods occurred in the Stanley catchment when a motorist was drowned when he attempted to drive across a barricaded river crossing.

Although major flood level was exceeded at Woodford, there were few reports of flood damage to property in the catchment and the main impact of the flooding appears to be limited to cutting of roads.

FLOOD WARNING

Warning Requirements

With the exception of the Mary River at Gympie and Maryborough, specific warning requirements have not been defined for the Burrum River, Sunshine Coast and Stanley Rivers. Warning requirements for the Noosa River and Stanley River are only based on the flood classsifications which define the river heights at which minor, moderate and major flooding commences.

Table 6
Warning Requirements

Basin	Station	Warning Requirements	
		Height (m)	Time (Hrs)
Mary	Gympie Maryborough	12.0 6.0	21-27 18-24

Warning requirements for the Mary River in Table 6 have been developed from objectives of the warning system, rather than specifically defined user requirements.

Flood Warning Networks and Performance

BOM operates and maintains a network of rainfall and river height stations in the Mary River, Noosa River and Stanley River catchment areas for the purpose of flood forecasting and warning.

The flood warning data observation networks in the rivers between Bundaberg and Caboolture are shown in Figure 1.

There is no specific flood warning network in the Burrum River catchment with only two daily rainfall stations in the area.

There is a far more comprehensive network in the Mary River catchment.

The rainfall component of the network for the Mary River consists of 34 rainfall stations, 11 of which are daily stations and 23 are heavy rainfall stations.

The daily rainfall stations report 24 hourly totals to the Bureau at 9AM each day. This information is used to compute mean catchment rainfall, catchment wetness and assess flood

potential. During the period of heavy rainfall from 21-22 February, more frequent reports (usually at 3 hourly intervals) were sent by the 23 heavy rainfall stations allowing early qualitative warnings to be issued.

From 21 to 23 February, over 450 rainfall observations were received from this network at the FWC. This was made up of 150 9AM daily reports, 55 heavy rainfall manual reports and 250 3 hourly telemetry reports.

During the flood period, more than 775 river height reports were processed in the FWC.

Most of these river height and rainfall observations sent into the FWC were received within half an hour of their nominated reporting time, and nearly 95 per cent of the total observations were received within one hour of their nominated report time.

The river height component of the network for the Mary River consists of 29 stations, 11 of which are manual stations and 17 are telemetered.

The river height stations are strategically located to monitor the inflow from the significant tributaries and follow the flood wave down the Mary River. The time interval between reports varies with the size of the flood, becoming more frequent with increasing depth.

During most of the flood, observations were received in the FWC at 3 hourly intervals with more frequent hourly observations near the peaks of the flood at Gympie and Maryborough.

The Sunshine Coast streams consist of the Mooloola, Maroochy and Noosa Rivers. Only the Noosa River has official river height stations. These are located at Lake Cootharaba, Lake Cooriabah and at Tewantin. Regular reports were received from these stations during the flood. However a lack of flood history at these stations made it difficult to interpret the rising flood levels into areas and depths of inundation in the Noosaville and Tewantin areas.

Overall the floodwarning data networks performed exceptionally well. Of the 34 rainfall stations in the area only 4 missing observations, and two equipment failures were recorded, corresponding to a data loss rate of less than 5%.

Of the river height observations, loss of observations from 4 river height stations, about 10% of total expected observations, did not affect the warning service as backup readings from adjacent stations filled any missing gaps.

Telephone telemetry equipment was extremely reliable with only slight TELECOM delays recorded, for example between 0900 and 1200 during peaks at Gympie and Maryborough.

Forecasting Models

(i) Burrum River

There are no forecasting aids or techniques for the Burrum River.

(ii) Mary River

The Flood Warning Directive for the Mary River contains details of several flood forecast techniques including:

* Peak stage correlations between upstream and downstream river height stations from Kenilworth to Maryborough, including effects of local area inflows where required.

* Unit Hydrograph to Gympie

For the prediction of flood heights at Gympie, traditional peak stage relationships (using an observed upstream height to predict a downstream peak height) were not effective during this flood due to the widespread nature of the heavy rainfall. Forecasts based upon these techniques did not provide adequate lead time at Gympie.

The use of the Mary River to Gympie unit hydrograph model partially overcame this problem since it used average catchment rainfalls over the whole catchment to calculate Gympie heights, and also could be run at any time during the rising limb of the hydrograph.

All forecasts for Gympie prior to the observed peak at Dagun Pocket were based on the integrated unit hydrograph model. Forecasts for Gympie issued after 1500 Saturday 22 February were based upon the observed peak at Dagun Pocket.

Actual river height predictions provided for Gympie in the flood warnings relied on significant interpretation and judgement by the Engineer Hydrologists in the FWC.

Average catchment rainfalls were calculated hourly from a network of seven rainfall telemeters which were interrogated at least every three hours. The rainfall averaging routine uses rain weighting factors derived from a statistical isohyetal analysis of historical storm events.

The unit hydrograph model also includes four forecast rainfall scenarios; no further rain, light rain, medium rain and heavy rain , each for a further 6 hours. This provides an estimate of the sensitivity of flood predictions given various rainfall rates in the future.

Results of the Gympie unit hydrograph model predictions are given in Table 7 which shows the results of the actual runs carried out during the flood prediction phase.

Table 7
Gympie Flood Height Model Predictions

Date Time (Height)	Forecast Rain	Forecast Lead Times					
		6 Hour		12 Hour		24 Hour	
		F'cast	Actual	F'cast	Actual	F'cast	Actual
21/2 0800 (8.1m)	L M H	11.1 11.6 12.1	12.8	12.7 13.6 14.5	13.8	15.8 17.2 18.3	19.3
21/2 1300 (12.4m)	L M H	14.5 14.9 15.4	13.7	16.7 17.5 18.1	14.9	19.2 19.8 20.2	20.8
21/2 1500 (13.1m)	L M H	16.0 16.3 16.6	13.9	18.1 18.5 18.9	14.9	19.9 20.3 20.6	21.1
21/2 2300 (14.2m)	L M H	18.9 19.1 19.2	17.1	20.0 20.2 20.4	20.2	20.2 20.5 20.9	21.4
22/2 0800 (19.3m)	L M H	20.9 21.0 21.1	21.0	21.1 21.1 21.2	21.4	After peak	

Notes:
1. For the Forecast Rain, L,M,H refers to low, medium an high rainfall predictions as follows:
   L - 5 mm/hr for next 6 hours
   M - 10 mm/hr for next 6 hours
   H - 15 mm/hr for next 6 hours
2. Height - Height at date and time of forecast.
   F'cast - Forecast height at lead time shown.
   Actual - Actual height reached at lead time shown.

The model was first run at 0800 on Friday 21 February. Initial runs indicated that an initial loss of 50mm closely matched the observed rising limb of the Gympie hydrograph. This initial loss agreed with the API catchment wetness analysis which suggested an initial loss for this part of the catchment of 48mm. Subsequent runs of the model during Friday 21 and Saturday 22, confirmed 50mm as the best estimate of the initial loss.

To match the early part of the hydrograph a baseflow of 5 cumecs was also used but this had a negligible effect on the predicted hydrographs from the model.

As show on Figure 29, the initial model run at 0800 on Friday 21 February underestimated the actual hydrograph by about 1 - 2 metres for about the first 12 hours. This was due to the very heavy localised rain that fell in the the Gympie area, which caused rapid partial catchment runoff and resulted in higher than average rates of rise at Gympie between 0300 and 1200 on Friday 21.

Subsequent runs at 1300, 1500 and 2300 on 21 February showed the model was overestimating the rate of rise at Gympie significantly.

From about midnight on Friday 21, subsequent model runs provided reasonably accurate forecasts of Gympie heights, despite overestimating the rising limb at the time. The model run at 2300 on Friday 21 provided a 12 hour forecast for Gympie within 0.2 metres, and a 24 hour forecast for Gympie within 0.8 metres of the actual heights. Considering that heavy rains continued for a further 6 - 12 hours from midnight to 1200 on Saturday 22, the unit hydrograph modelled the actual heights very well.

During the flood forecast period from 0600 on Friday 21 to 1200 on Saturday 22, rainfall forecasts grossly underestimated the rainfall which eventually fell.

Towards the end of the heavy rainfall, the unit hydrograph model generally provided very good guidance for flood forecasters as to the magnitude and timing of the flood peak. However, initial model runs tended to underestimate the rising limb and then subsequent runs overestimated the rising limb. This inability to match the rising limb of the hydrograph gave rise to concerns of the peak predicted by the model late Friday 21.

In the Mary River below Gympie, qualitative flood forecasts are based on relatively simple peak height correlations between upstream and downstream stations.

The technique may be applied using predicted or observed river heights. In the former case, longer term predictions can be made at the expense of lead time while in the latter case lead time is much longer but accuracy is much reduced.

An additional complication in the application of this technique is the effect of local rainfalls. Local rainfalls in the area below the upstream station may affect the height at the downstream station by several metres. The forecaster makes subjective allowance for local rainfalls in applying the technique.

During the flood, public flood warnings only contained qualitative forecasts for Miva and Tiaro.

Initial predictions for Maryborough were based on the forecast peak at Gympie, which provided about 36 hours lead time of the Maryborough peak. As heights at Maryborough can be significantly affected by tributary inflows from the many creeks which enter the Mary River between Gympie and Maryborough, this method provides only an approximate peak.

Only after a peak had been recorded at Tiaro can a reasonably accurate estimate of the Maryborough peak be forecast. This technique provides about 12 hours lead time to the peak at Maryborough but has limited accuracy to within 0.5 metres, as there are still significant local effects which can affect the final peak height. These include local rainfall, the volume of the flood runoff, the timing of inflows from local tributaries and, to a lesser extent, the timing of the tides at Maryborough.

It should be noted that because of the relatively flat hydrograph at Maryborough, the flood peak straddles at least one high tide. This effect is taken into account in the forecast of the peak height, as it can slightly affect the timing of the peak.

Current forecasting techniques for Maryborough do not allow for the provision of any better predictions than were provided during this flood. However, several consultations held with local agencies early during the event (on Saturday 22 February morning) indicated that a flood peak in the vicinity of 10.0 metres should be used for planning purposes. This provided about 48 hours advance notice. These consultations provided far more detail and longer lead time than contained in the publically issued flood warnings.

(iii) Sunshine Coast

There are no forecasting aids or techniques for the Sunshine Coast Rivers. However, there is some data available for the 1968 flood in the Noosa which assisted the subjective judgments required to be made by the Engineer Hydrologists.

(iv) Stanley River

There are no forecasting aids or techniques for the Stanley River.

Warning Services

Warning policy and details of warning services provided by the Bureau of Meteorology throughout Queensland are detailed in Appendix A. Basically, the warning services consist of:

(a) River Height Bulletins

Table 8
Schedule of River Height Reports

(Figures are reporting height in metres)

Station	Reporting Time							
	00	03	06	09	12	15	18	21
Boreen Point			1.0		1.5		1.0	
Lakeway Drive			1.0		1.5		1.0	
Tewantin			0.9		1.5		0.9	
Kenilworth			6.0	3.0		6.0		3.0
Imbil				3.0				
Cooran			4.0	3.0		4.0		3.0
Gympie			9.0	4.0		9.0		4.0
Woolooga			6.0	2.0		6.0		2.0
Miva	14.0		8.0	5.0		8.0		5.0
Lone Pine			6.0	3.0		6.0		3.0
Tiaro	12.0		7.0	3.0		7.0		3.0
Maryborough		6.0	5.0	4.0		4.0		4.0

River Height Bulletins for the stations in Table 8 were issued up to six times per day throughout the flood event at approximately 45 minutes after the reporting time. River height observations are made by the observer whenever the river is above the reporting height shown in Table 8.

The Bulletins are prepared automatically using data received via the Bureau of Meteorology's Remote Observer Collection System. The FWC also collected a significant proportion of the river height data from telephone telemetry stations. These were generally not included in the River Height Bulletins, however facilities will be provided to enable these to be included in the Bulletins within the next six months.

(b) Flood Warnings

(i) Burrum River

Most of the smaller coastal rivers and streams in the flood

effected area are only covered by generalised flooding warning services.

No specific warnings were issued for the flooding that occurred in the Howard area on Friday morning 21 February but an advice of significant rises in coastal streams from Gladstone to the Sunshine Coast was included in the South Coast District Forecast issued at 1600 on Thursday 20 February.

(ii) Mary River

The initial flood warning for the Mary River and tributaries was issued at 0645 on Friday 21 February when the Mary River at Gympie was rising rapidly but still below minor flood level.

Thereafter, with the exception of early mornings, flood warnings were issued at about three hourly intervals until the flood peak had reached Maryborough at 1200 on Monday 24 February. The interval between warnings then increased to approximately 9 hourly until the final warning was issued at 1000 on Wednesday 26 February when the river at Maryborough had fallen below minor flood level.

Flood warnings containing the latest predictions, and rainfall and river height observations were usually issued within 1.5 hours of the receipt of the data in the Flood Warning Centre.

Of the total of the 27 warnings issued for the Mary River, 11 contained quantitative height predictions for Gympie and 12 contained quantitative predictions for Maryborough. The schedule of warnings issued and forecast summaries for the Mary River are in Appendix B.

The performance of the flood forecasting and warning system for Gympie is summarised diagramatically in Figure 30.

Obviously, while the rain was continuing to fall, the early flood warnings could only provide interim river height predictions as the prediction of the peak at Gympie depended on the amount and distribution of rainfall. These are known as "rising limb" predictions. The warnings issued up to 1900 on 21 February contained reasonably accurate indications of rising limb river heights at Gympie and gave early estimates that the flood would be similar in magnitude to that of early April 1989.

These warnings generally gave at least 15 hours lead time of the onset of major flood level and further river rises.

By 2100 on Friday 21 February, rainfalls had begun to ease in the western part of the catchment and were forecast to continue to ease overnight. At the same time the rate of

river rises in streams in the upper catchment had slowed. Accordingly, the warning issued at 2230 on 21 February indicated that, while major flood level of 17.0 metres would be reached the next morning, that the peak might be below the April 1989 peak.

However, further very heavy overnight rain to Saturday morning resulted in a resurgence of rapid river rises. Subsequent warnings, issued from early Saturday morning predicted that flood levels greater than 1989 were expected with a peak flood height at Gympie in the 21 to 22 metre range.

The warnings issued just a few hours prior to the peak overestimated the actual height by about 0.5 metres.

The first quantitative public forecast for Maryborough was issued at 1640 on Saturday 22 February when the river was still below minor flood level.

As shown in Figure 31, this prediction advising of 8.0 metres (moderate flood level) early Sunday afternoon with major flooding overnight Sunday proved very accurate. The forecast was issued some 26 hours prior to this height actually being attained. The subsequent three warnings reinforced this prediction.

The first prediction of a peak at Maryborough was in the warning issued at 1000 on Sunday morning when the river was 6.5 metres. This warning gave nearly 21 hours lead time to an expected peak of 9.0 metres on Monday morning.

Subsequent warnings issued up to 0600 on Monday underestimated the peak by about 0.5 metres.

(iii) Sunshine Coast

Similar to the Burrum River flooding, advice of stream rises along the Sunshine Coast was initially included in the South Coast District Forecast issued at 1600 on Thursday 20 February. Subsequent flood warnings for the Sunshine Coast streams apart from the Noosa River were primarily based on rainfall information in the absence of flood warning river height networks.

Further advice of Sunshine Coast flooding was included in the Mary River warning issued at 1230 Friday 21 February.

The warnings for the Mary River and adjacent coastal streams were updated and re-issued at three hourly intervals (with exception of 0300 Saturday 22 February) up to 1000 Saturday 22 February.

Floods levels in the upper reaches of the Maroochy and Mooloolah Rivers peaked period between 1200 and 2200 on

Friday 21 February.

From 1015 Saturday 22 February, flood warnings were issued specifically for the Noosa, Maroochy and Mooloolah Rivers and updated and re-issued at three hourly intervals.

Flood levels in the lower Noosa River peaked early on Sunday morning 22 February.

Warnings contained advice of latest observed rainfallsin the area with river heights in the Noosa system and qualitative forecasts for flooding on Noosa River only.

(iv) Stanley River

No specific flood warnings were issued for the Stanley River although major flood level was reached at Woodford.

(c) Professional Advice

FWC staff were in constant telephone contact with SES State Headquarters and local agencies throughout the period of the flood.

Most of the professional advice provided concerned flood height predictions for Gympie, and then for Maryborough.

Staff at Gympie City Council were contacted several times throughout the event to provide specialist flood warning advice.

The Maryborough City Engineer frequently contacted the FWC for early Maryborough height predictions. As a result, during the morning on Saturday 22 February, FWC staff advised Council to plan for a maximum peak of about 10 metres at Maryborough late Monday morning.

Regular contact was also maintained with the Shire Engineer at Noosa until late Saturday 22 February when telephone service to the area became difficult.

(d) Media Briefings

FWC staff provide regular updates to media services, in particular radio, throughout the event. The services ranged from general enquires regarding flood information to short interviews for broadcasting.

COMMENTS AND CONCLUSIONS

The following comments and conclusions are restricted to the internal Bureau operations of the flood warning networks and flood forecast models and to the flood warning services provided by the Bureau of Meteorology during the event.

Bureau officers have been involved in other forum such as the disaster debriefs where issues were explored which related to wider aspects of the warning-response system.

Flood Warning Networks

Flood warning networks have not been established in the Burrum, Maroochy and Mooloolah Rivers. Additionally, there are an inadequate number of rainfall and river height stations in the Noosa River, especially in the upper reaches.

The coverage provided by the flood warning network in the Mary River is generally adequate although rainfall observations from the western sections of the catchment above Gympie and downstream of Gympie are sparse.

With a few exceptions, both the manual and automatic components of the established flood warning networks worked well. However, there were failures associated with some of the telephone telemetry stations in the Mary River system including :

* Access to Kenilworth Homestead TM ceased from 1200 on 21 February due to telephone line failure caused by the collapse of the Kenilworth Bridge.

* The river height telemeter at Imbil read about 1 metre higher than the manual observer at the same site. This caused some confusion because of conflicting river height reports from the same site. The probable cause of this difference was a river bank collapse over the sensing equipment at the site.

* The Tinana Creek at Bauple East telemeter equipment failed on 22 February as floodwaters reached 12.5 metres and submerged the sensing equipment.

* Telemetry equipment at Brooyar and Kilkivan did not work at any time during the event.

* Rainfall telemetry equipment at Kandanga failed on 22 February as rising floodwaters submerged the rain gauge. Alternative readings were provided by the manual observer at 3 hour intervals.

* River height telemetry equipment at Bellbird Creek failed on 21 February.

Meteorological Forecasting

The general prediction of the onset of rain, and some heavy rain, in the general Gympie area was provided 12 - 24 hours prior to the onset of the event. However Quantitative Precipitation Forecasts(QPF) for the region failed to realise the potential intensity and duration of the rain. Initial guidance given to the FWC indicated 24 hour rainfall totals up to 100mm.

As mentioned in the Meteorological Summary the situation was analogous to a tropical cyclone crossing the coast and the resulting rainfall totals were consistent with such an event. Although the magnitude of the rainfall totals was certainly beyond prediction, a better estimate of the "ball-park" figure should have been provided. However comprehensive techniques for QPF are not well developed and it is hoped that future work will improve skills in this area.

The use of updated radar data in the next few years offers the best hope for the accurate detection of intense precipitation over small catchments.

A detailed evaluation of the computer model predictions has yet to be undertaken but initial analysis shows that the numerical models generally performed poorly or did not have the resolution to adequately resolve the event.

There has been some criticism of Bureau performance in the prediction of the rainfall experienced late on Friday night and Saturday morning. The Meteorological Analysis demonstrated the mesoscale nature of the phenomena associated with this second wave of heavy precipitation. Even with hindsight it is extremely difficult to see how the development of the mesoscale low centre, and the continued precipitation into Saturday morning, could have been accurately forecast.

Hydrological Modelling

With the exception of the Mary River, Flood Warning Directives and systems for the Burrum, Sunshine Coast and Stanley Rivers are largely undeveloped and provide little advice or guidance to flood forecasters.

The unit hydrograph to Gympie is the only forecasting model which is integrated with the data collection system and provides firm guidance to flood forecasters. This is reflected in the relative accuracy of the unit hydrograph to model the observed response of the river at Gympie. However, advice on the model accuracy should be included in the Flood Warning Directive.

Predictions for Maryborough were based upon Gympie forecasts

with subjective allowances for local area rainfall. In this event, local area rainfall did not significantly contribute to the rise at Maryborough and, as result, height predictions for Maryborough were reasonably accurate and gave long lead time.

Warnings

No generalised flood warnings were issued for the Burrum River area, apart from a note on the District Forecast of the afternoon prior to the floods in the Cherwell River.

The initial flood warning for the Mary River was issued just after the onset of minor flooding at Gympie. At this stage the heavy rainfall had only just commenced and it is doubtful that any longer lead time could have been provided.

While the unit hydrograph for Gympie modelled the actual response with reasonable accuracy, these predictions were not always mirrored in the warnings, primarily due to an expectation of clearing rainfall, varying accuarcy of the model over a number of events and little documentation on the model accuracy in the Flood Warning Directive. Rainfall forecasts were inaccurate, particular in relation to the prediction of likely rainfall amounts.

In general, the nature of the event in terms of the continuing heavy rain in the middle and lower catchment areas around Gympie resulted in the warning system not achieving the objective of 21 to 27 hours lead time of the flood peak at Gympie.

With a lead time of nearly 48 hours of the peak at Maryborough, the warning system clearly succeeded in providing adequate lead time.

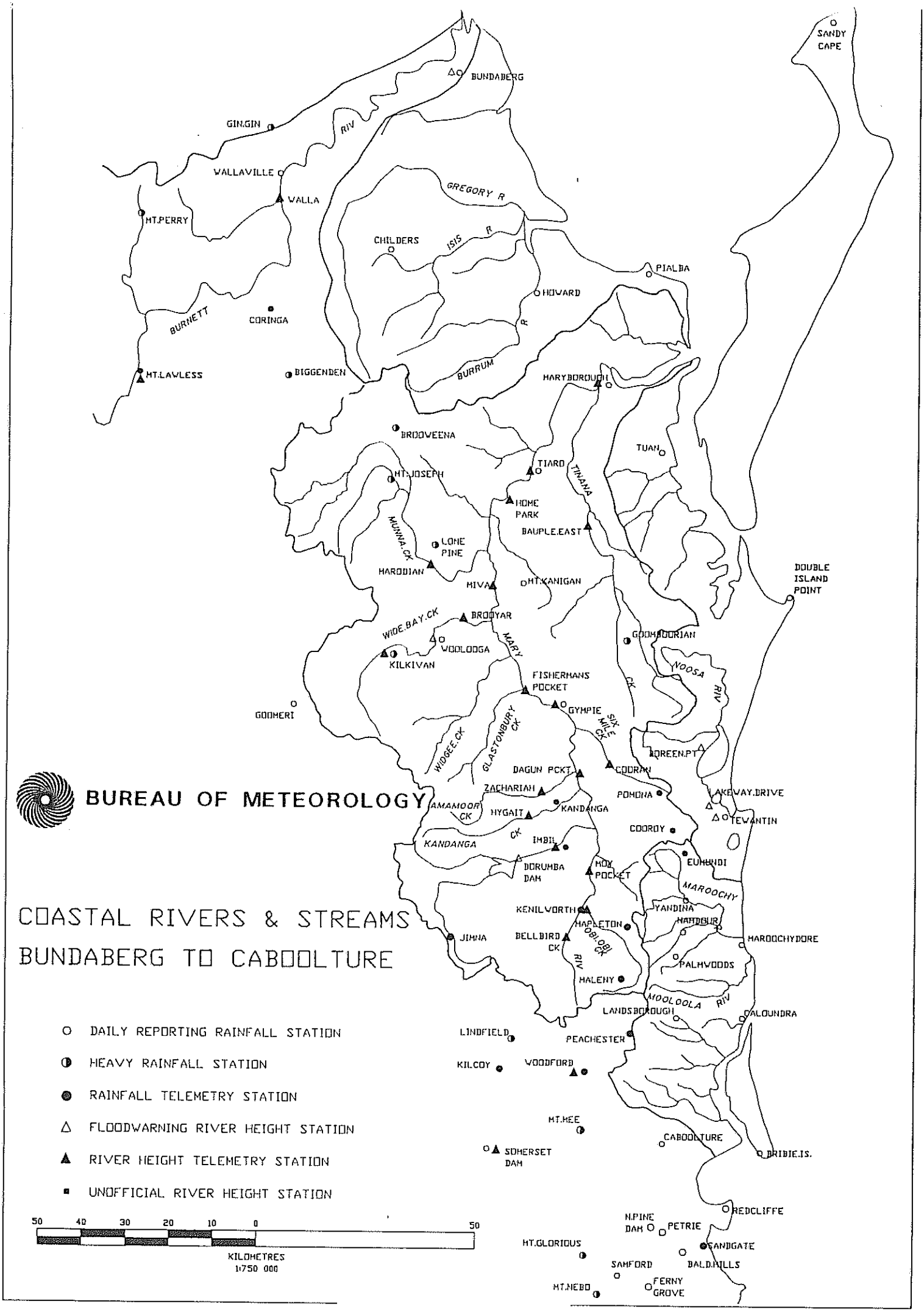
Overall, the performance of the warning system for the Mary River enabled appropriate pre-flood response actions at Gympie, although some shortcomings in the Gympie flood prediction system were identified.

Clearly, this event demonstrated the need for flood warning systems to be developed for the Burrum River system and for the Sunshine Coast rivers and streams.

Flood warnings were issued regularly at three hourly intervals during the heavy rainfall periods for both the Mary River and Sunshine Coast streams. The process time for these warnings from the time of receipt of the data to the issue time was usually about one hour. Both the frequency and process time for flood warnings is considered adequate and, given existing systems, there appears little room for improvement.

Although major flood level was reached at Woodford, no

specific flood warnings were issued for the Stanley River. However, there were few, if any, reports of major flood consequences or damage from the area. The flood level classifications and warning requirements for the Stanley River need to be reviewed.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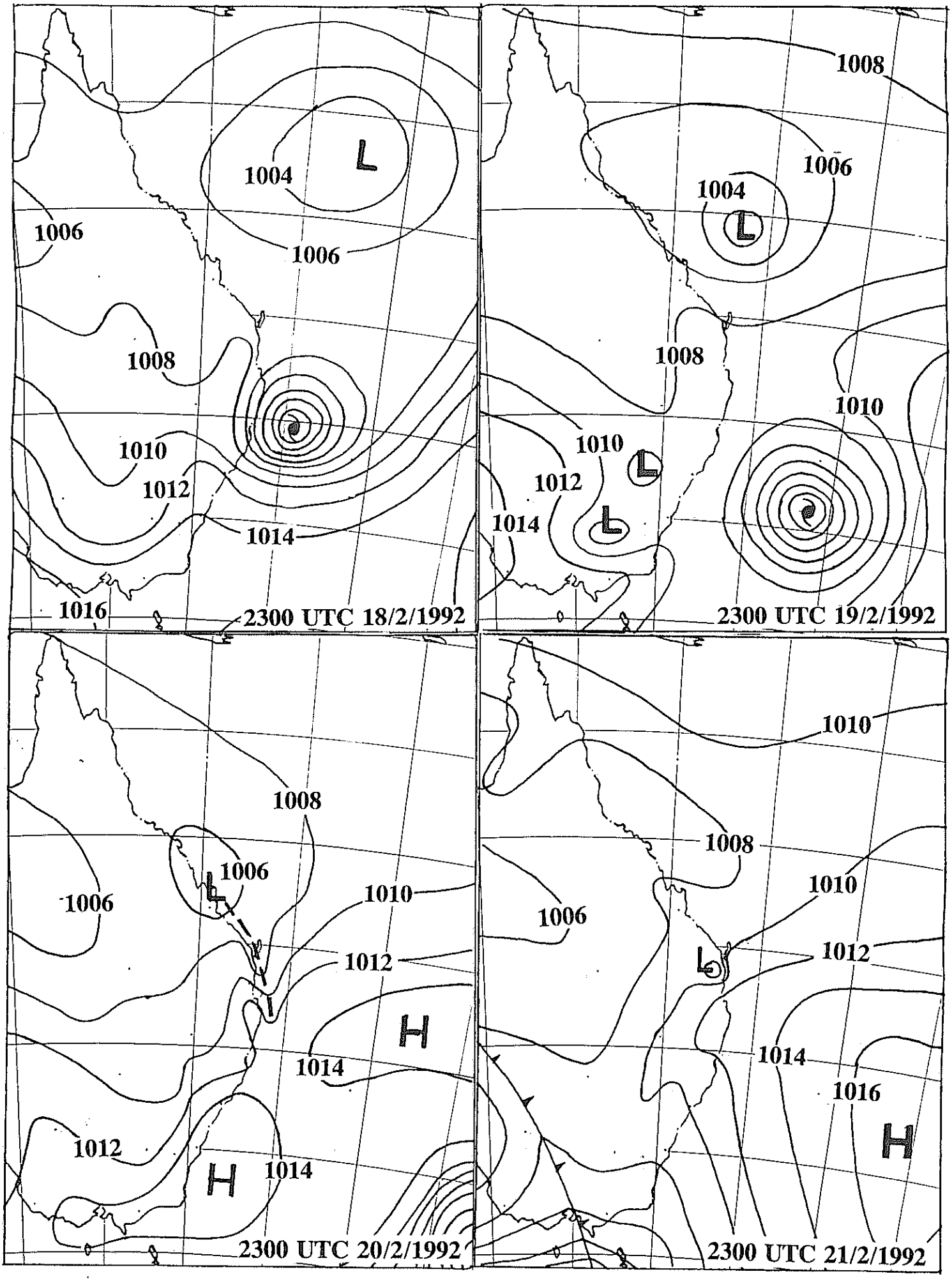
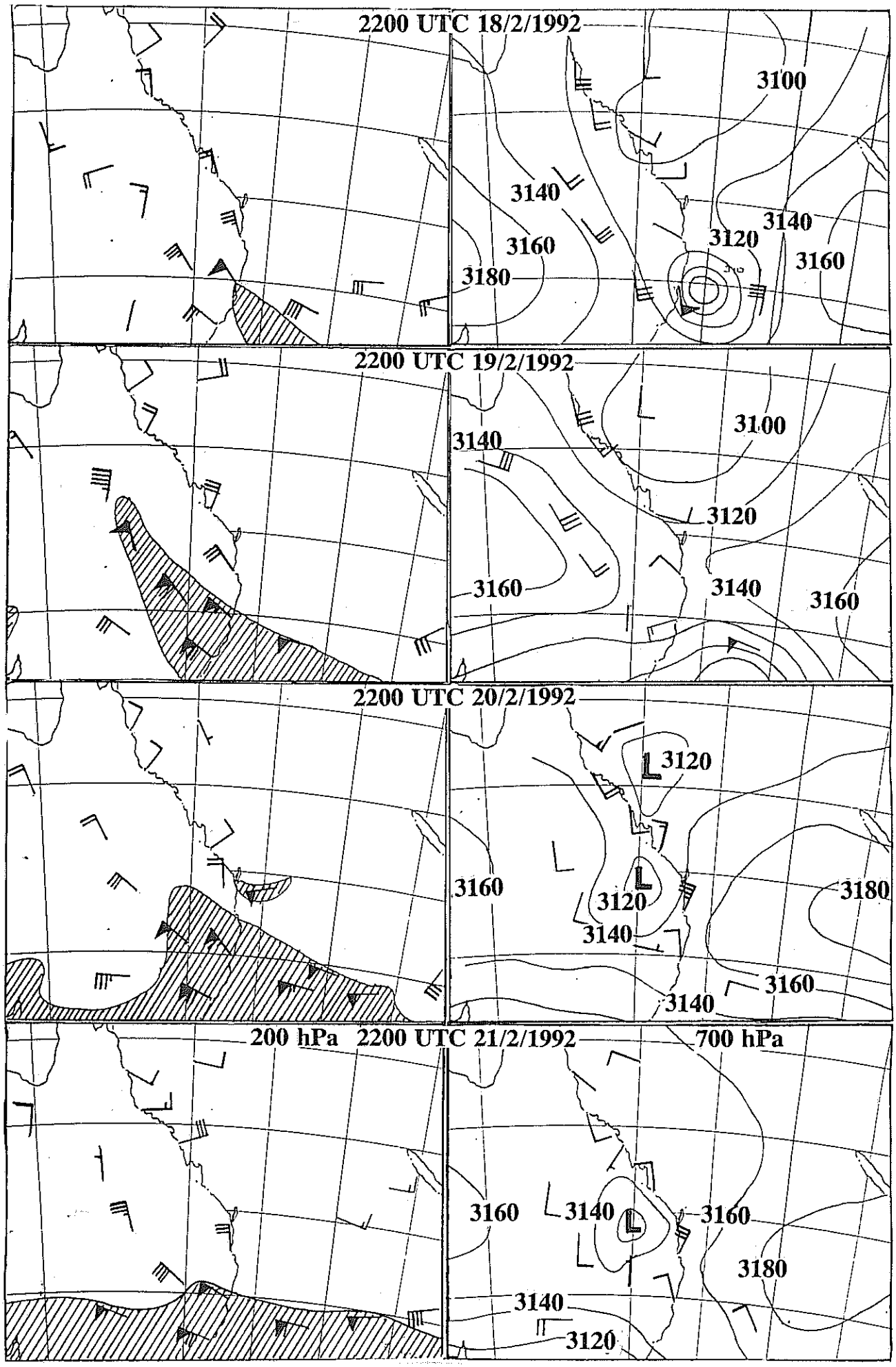
COASTAL RIVERS & STREAMS
BUNDABERG TO CABOOLTURE
DAILY REPORTING RAINFALL STATION
HEAVY RAINFALL STATION
RAINFALL TELEMETRY STATION
FLOODWARNING RIVER HEIGHT STATION
RIVER HEIGHT TELEMETRY STATION
UNOFFICIAL RIVER HEIGHT STATION
50 40 30 20 10 0 50
KILOMETRES
1:750 000
SANDY CAPE
BUNDABERG
GIN.GIN
RIV
WALLAVILLE
WALLA
MT.PERRY
GREGORY R
CHILDERS
ISIS R
PIALBA
HOWARD
BURNETT
CORINGA
R
BURRUM
MT.LAWLESS
BIGGENDEN
HARYBOROUGH
BROOVEENA
TUAN
TIARO
TINANA
MT.JOSEPH
HOME PARK
BAUPLE.EAST
MUNNA.CK
LONE PINE
HARODIAN
MIVA
MT.KANIGAN
DOUBLE ISLAND POINT
WIDE.BAY.CK
BROOYAR
MARY
GOOMBOORIAN
WOOLOOGA
KILKIVAN
YOOSA
RIV
CK
FISHERMANS POCKET
GOOMERI
GYMPIE
SIX MILE CK
WIDGEE.CK
GLASTONBURY CK
QREEN.PT
DAGUN PCKT
COORAN
ZACHARIAH
POMONA
LAKEWAY.DRIVE
AMAMOOR CK
HYGAIT
KANDANGA
TEWANTIN
COOROY
KANDANGA
CK
IMBIL
EUMUNDI
DORUMBA DAM
MOY POCKET
MAROOCHY
KENILWORTH
YANDINA
HAPPLETON
HARDBUR
JIMNA
BELLBIRD CK
MOOLOOLA CK
RIV
HAROOCHYDORE
PALMWOODS
HALENY
MOOLOOLA
RIV
LANDSBOROUGH
CALOUNDRA
LINDFIELD
PEACHESTER
KILCOY
WOODFORD
MT.MEE
CABOOLTURE
SOMERSET DAM
BRIBIE.IS.
REDCLIFFE
N.PINE DAM
PETRIE
MT.GLORIOUS
SANDGATE
SAMFORD
BALD.HILLS
MT.NEBO
FERNY GROVE

Figure 1



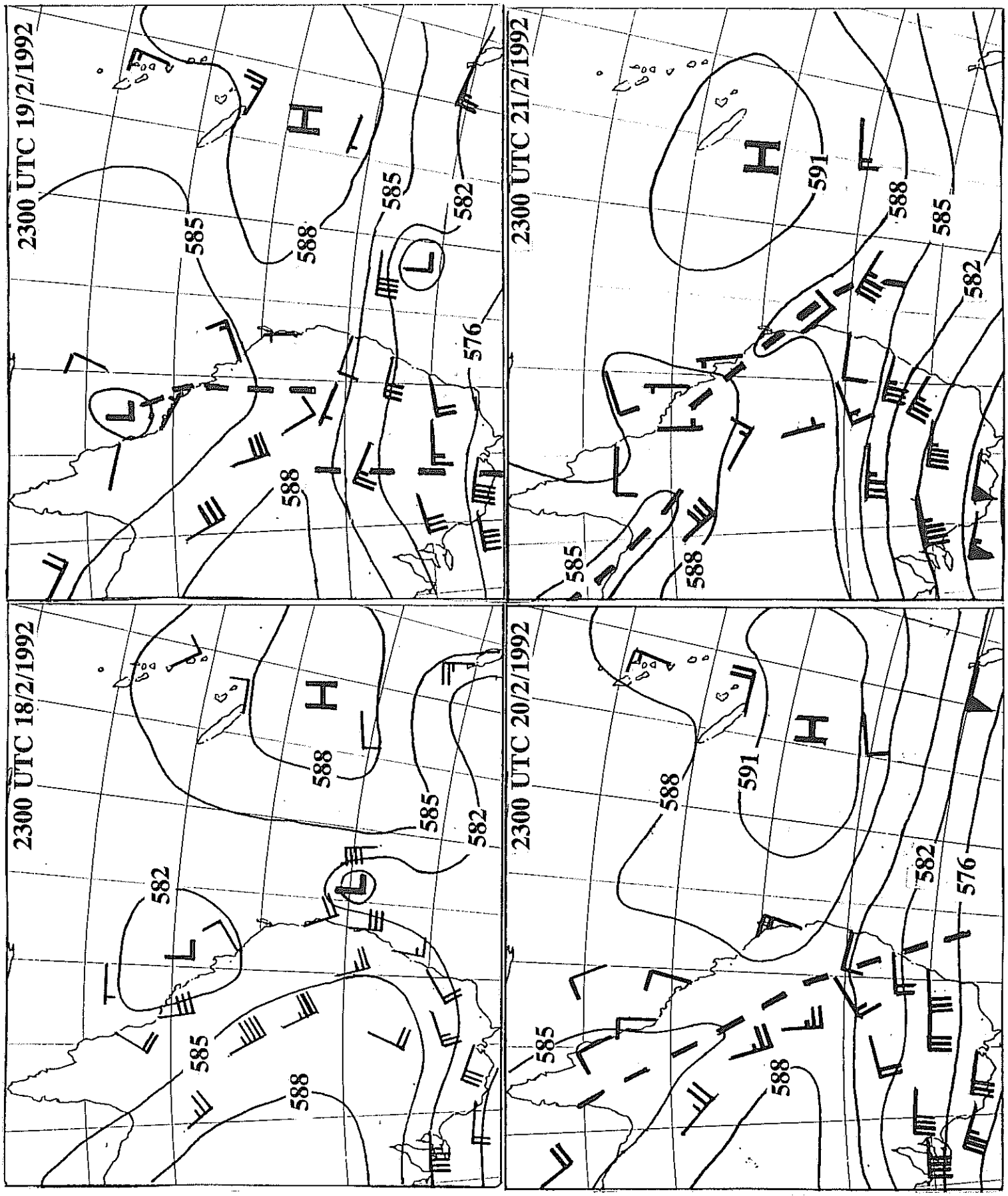
Mean sea level pressure (hPa) distribution sequence

Figure 2



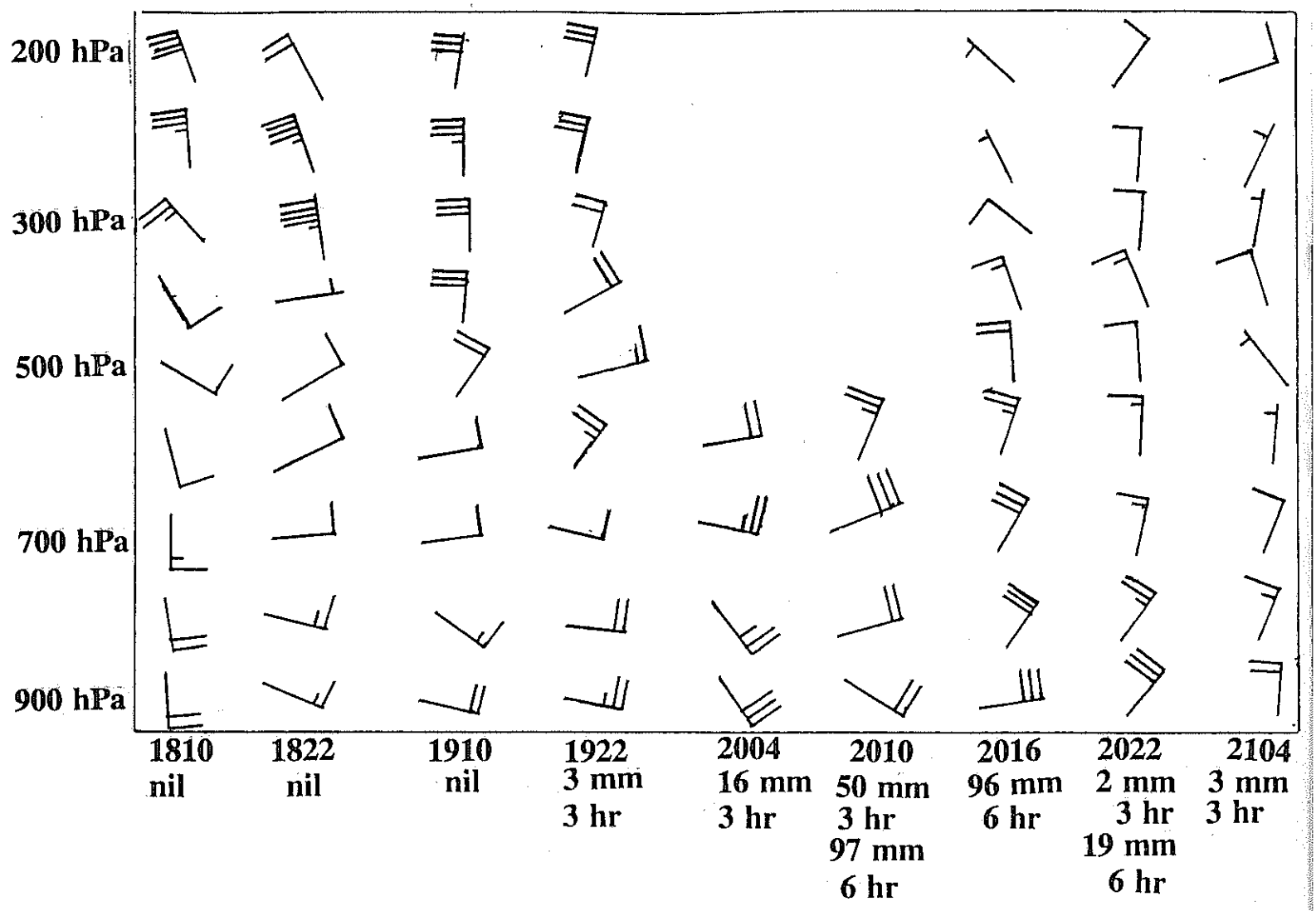
200 hPa wind and 700 hPa height contour (gpm) sequences

Figure 3



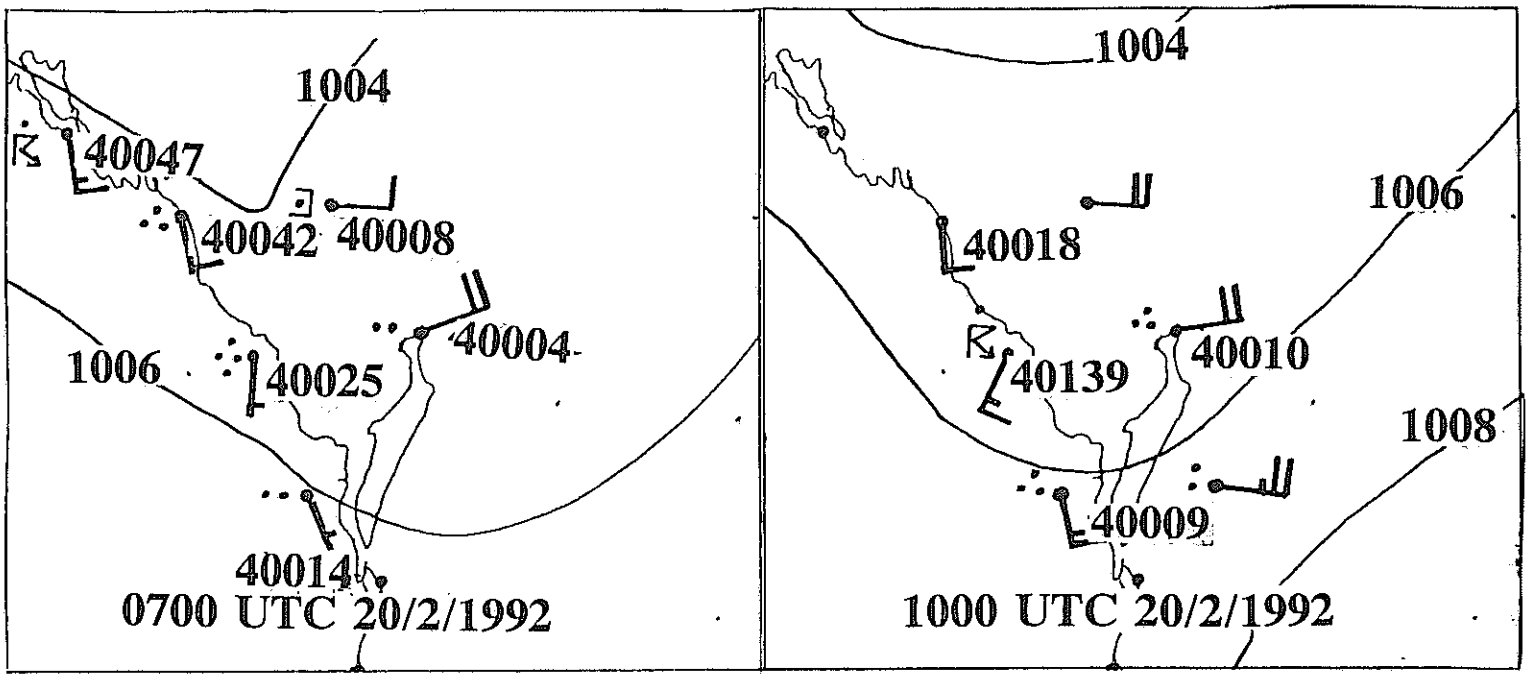
500 hPa height contour (gpm) sequence

Figure 4



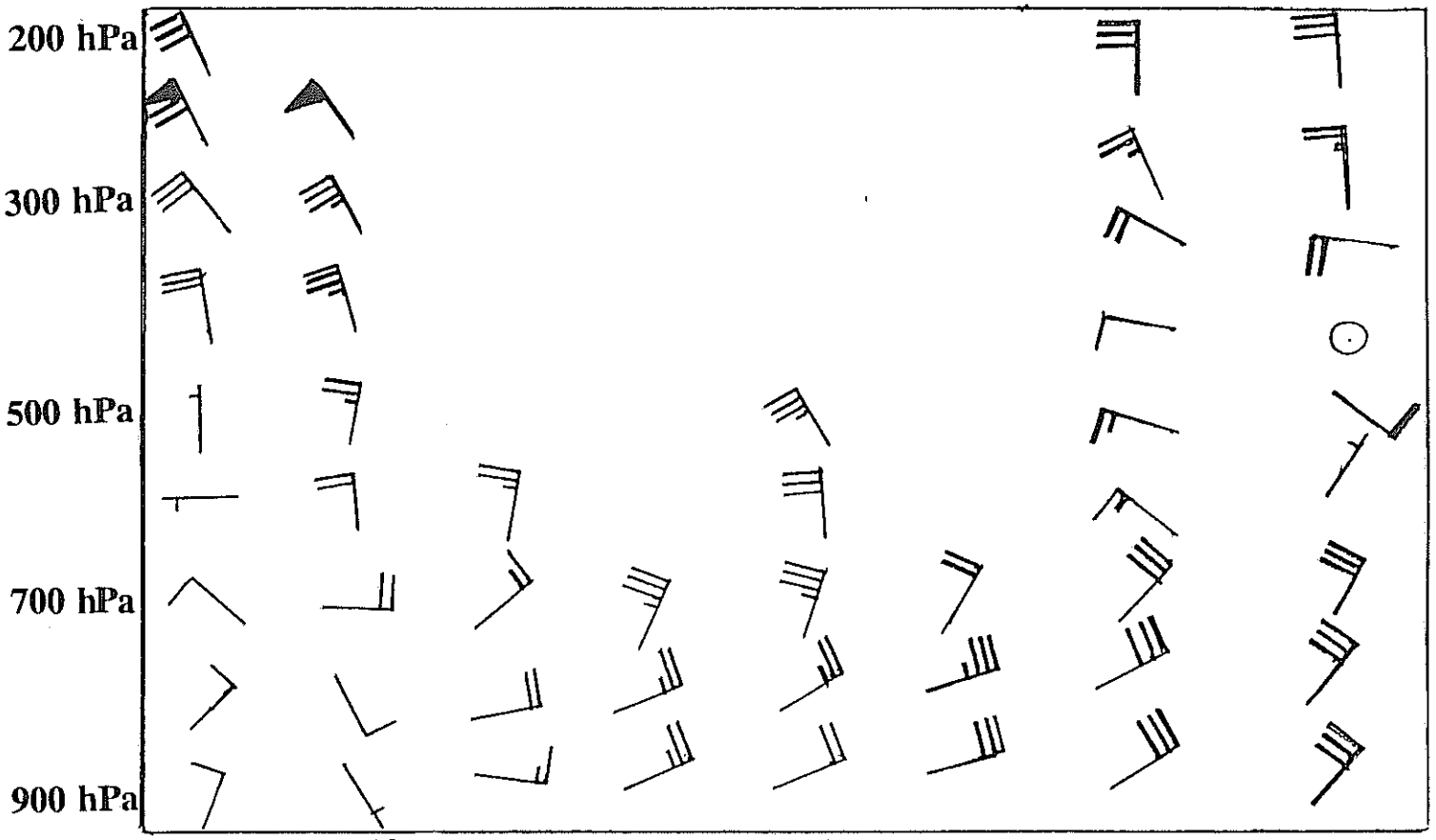
Gladstone upper wind time section with 3 hour and 6 hour rainfall totals 1000 UTC 18/2/1992 (1810) to 0400 UTC 21/2/1992 (2104)

Figure 5



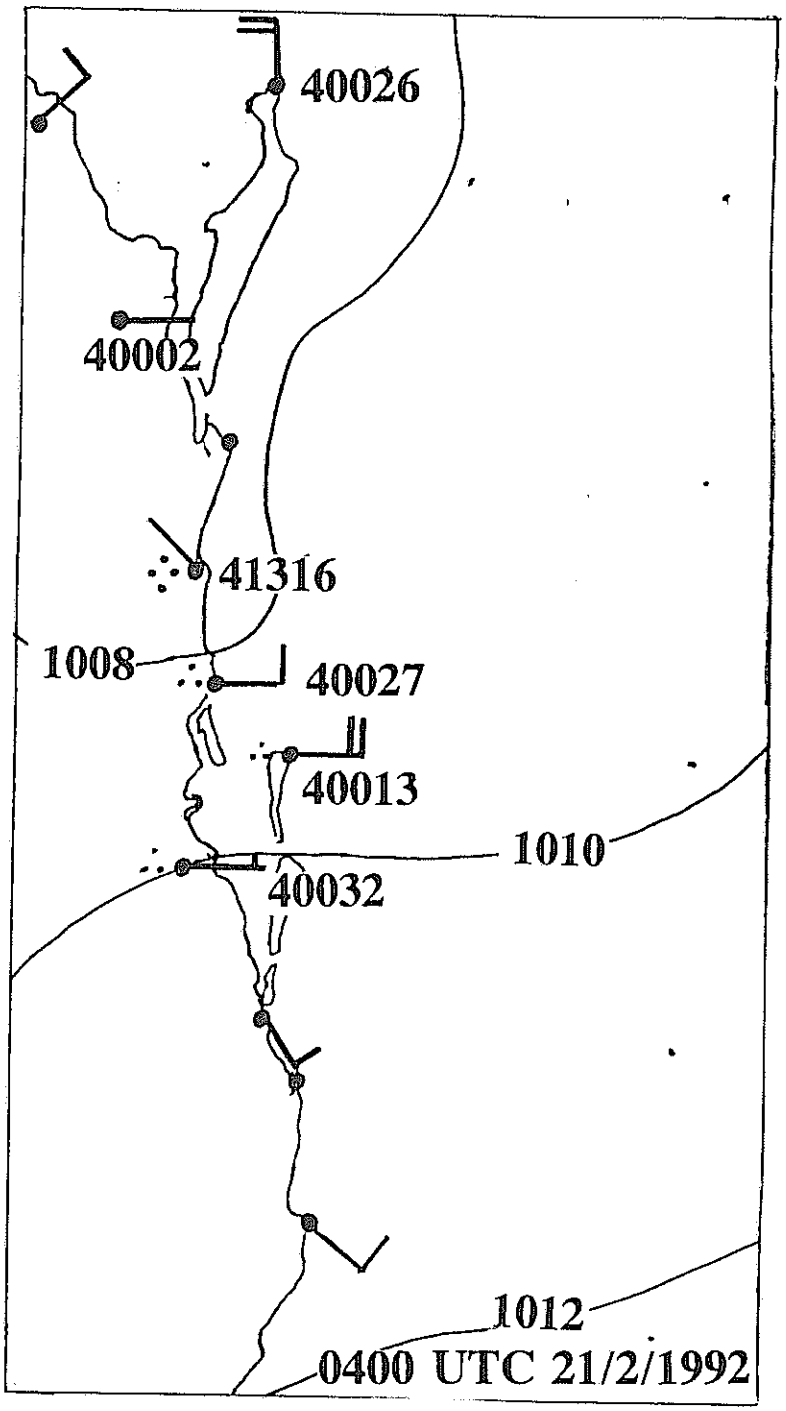
Local mean sea level pressure (hPa) distribution sequence

Figure 6



Brisbane upper wind time section with 3 hour and 6 hour rainfall totals 2200 UTC 19/2/1992 (1922) to 2200 UTC 21/2/1992 (2122)

Figure 7



Local mean sea level pressure (hPa) distribution sequence

Figure 8

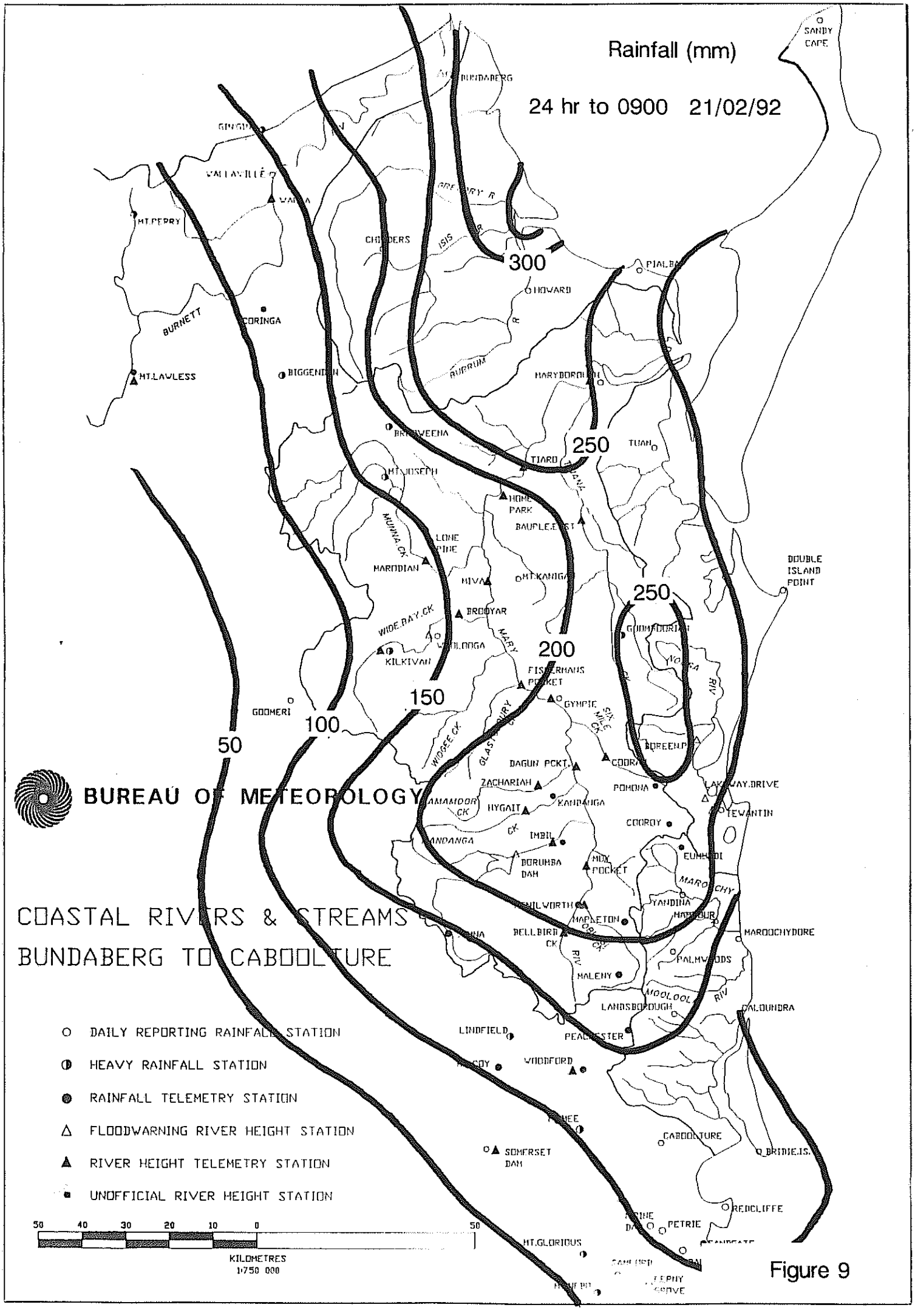

Rainfall (mm)
24 hr to 0900 21/02/92
300
250
250
200
150
100
50
BUREAU OF METEOROLOGY
COASTAL RIVERS & STREAMS
BUNDABERG TO CABOOLTURE
DAILY REPORTING RAINFALL STATION
HEAVY RAINFALL STATION
RAINFALL TELEMETRY STATION
FLOODWARNING RIVER HEIGHT STATION
RIVER HEIGHT TELEMETRY STATION
UNOFFICIAL RIVER HEIGHT STATION
50 40 30 20 10 0 50
KILOMETRES
1:750 000
SANDY CAPE
BUNDABERG
MT PERRY
CHILDERS
ISIS
HOWARD
BURNETT
CORINGA
MT LAWLESS
BIGGENDEN
BURRUM
MARYBOROUGH
TUAN
TIARO
MT JOSEPH
HOME PARK
BAUPLE EAST
MUNNA CK
LONE PINE
MARODIAN
MIVA
MT KANIGA
DOUBLE ISLAND POINT
BROOYAR
WIDE BAY CK
KILKIVAN
MARY
FISHERMANS POCKET
GYMPIE
GOOMERI
WIDGEE CK
GLASTONBURY
SIX MILE CK
DAGUN PCKT
ZACHARIAH
AMAMOOR CK
HYGAIT
KANDANGA
IMBIL
BORUMBA DAM
NUX POCKET
POMONA
COOROY
TEWANTIN
EUMUNDI
MARO CHY
YANDINA
NILWORTH
MAPLETON
BELLBIRD CK
MALENY
MAROOCHYDORE
PALMWOODS
LANDSBOROUGH
CALOUNDRA
LINDFIELD
WOODFORD
PEACHESTER
SOMERSET DAM
CABOOLTURE
BRIDIE IS.
REDCLIFFE
PETRIE
MT GLORIOUS

Figure 9

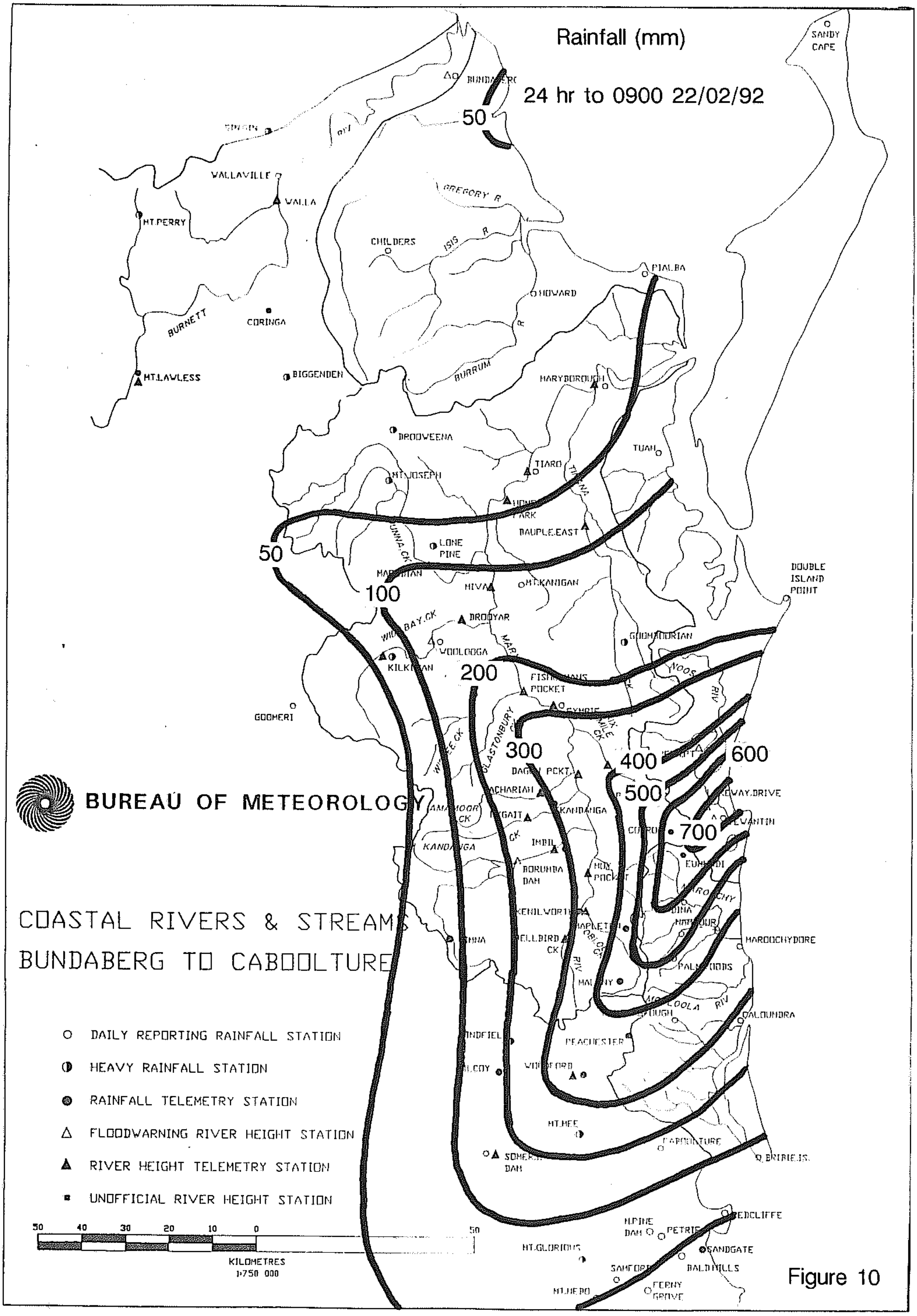
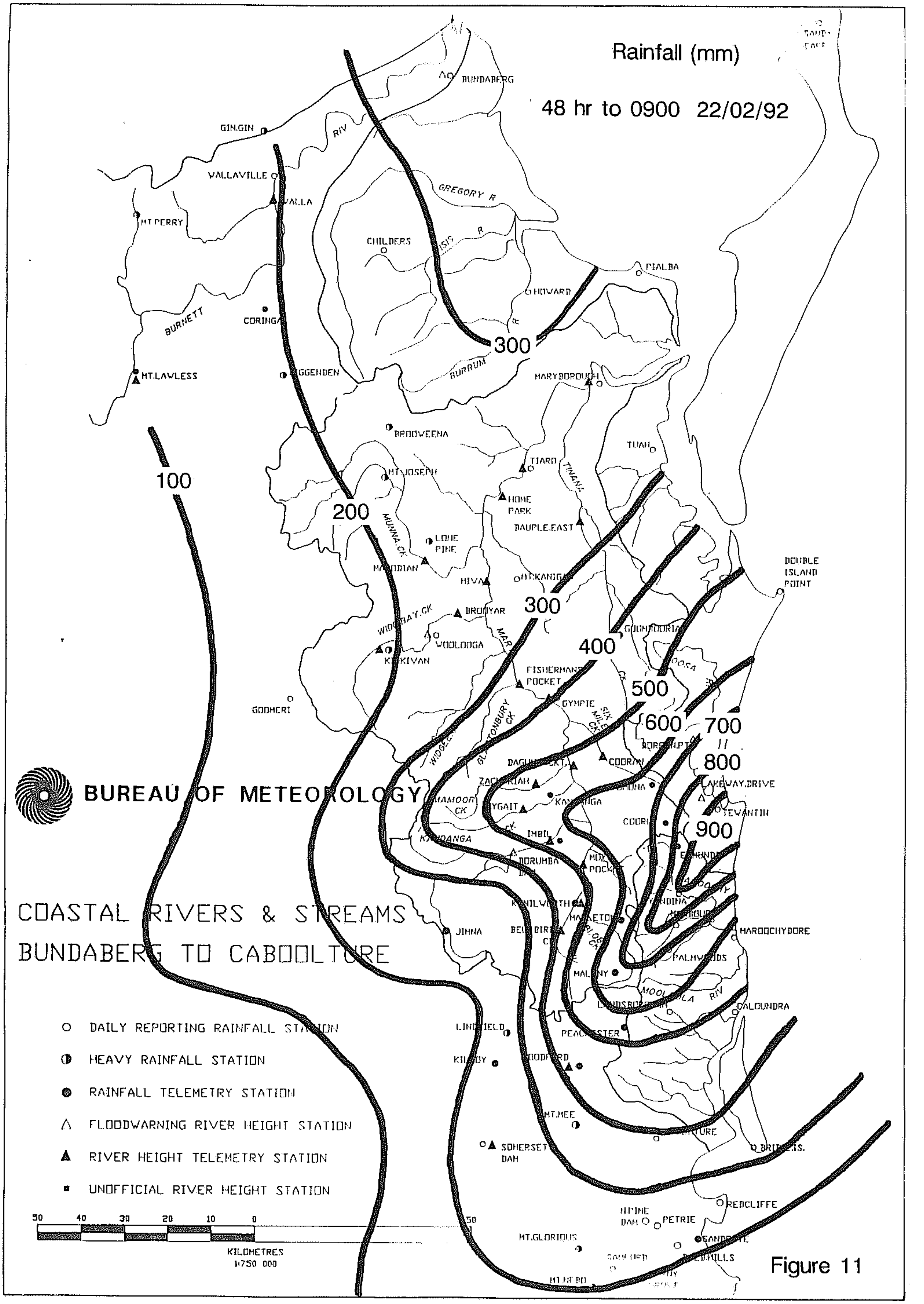

Rainfall (mm)
24 hr to 0900 22/02/92
BUREAU OF METEOROLOGY
COASTAL RIVERS & STREAMS
BUNDABERG TO CABOOLTURE
DAILY REPORTING RAINFALL STATION
HEAVY RAINFALL STATION
RAINFALL TELEMETRY STATION
FLOODWARNING RIVER HEIGHT STATION
RIVER HEIGHT TELEMETRY STATION
UNOFFICIAL RIVER HEIGHT STATION
KILOMETRES
1:750 000
50
100
200
300
400
500
600
700
SANDY CAPE
CHILDERS
HOWARD
PIALBA
MARYBOROUGH
TIARO
TUAN
GOOMBURIAN
DOUBLE ISLAND POINT
TEWANTIN
EUMUNDI
MAROOCHYDORE
CALOUNDRA
CABOOLTURE
BRIBIE IS.
REDCLIFFE
SANDGATE
GOOMERI
KILKIVAN
WOOLOOGA
IMBIL
KENILWORTH
WOODFORD
MT.MEE
SOMERSET DAM
MT.GLORIOUS
CORINGA
BIGGENDEN
MT.LAWLESS
MT.PERRY
WALLAVILLE
WALLA

Figure 10



Rainfall (mm)
48 hr to 0900 22/02/92
BUNDABERG
GIN.GIN
RIV
VALLAVILLE
VALLA
MT.PERRY
GREGORY R
CHILDERS
ISIS R
PIALBA
HOWARD
BURNETT
CORINGA
300
BURRUM
MT.LAWLESS
MARYBOROUGH
BROOWEENA
TUAN
100
MT.JOSEPH
TIARO
TINANA
HOME PARK
200
MUNNA CK
LONE PINE
DAUPLE.EAST
MERIDIAN
HIVA
MT.KANIGAN
DOUBLE ISLAND POINT
BROOYAR
WIDGEE
WOOLOOGA
KILKIVAN
400
GOOMBOORIAN
FISHERMANS POCKET
500
GOOMERI
GYMPIE
SIX MILE CK
600
700
GLASTONBURY CK
BOREEN PT
800
COORAN
BUREAU OF METEOROLOGY
LAKEWAY DRIVE
ZACHARIAH
KANDANGA
TEWANTIN
AMAMOOR CK
POMONA
900
COORAN
IMBIL
KANDANGA
BORUMBA DAM
EUMUNDI
KENILWORTH
YANDINA
NAMBOUR
COASTAL RIVERS & STREAMS
BUNDABERG TO CABOOLTURE
JIMNA
MAROOCHYDORE
PALMWOODS
MALENY
MOOLOOLAH RIV
CALOUNDRA
LANDSBOROUGH
DAILY REPORTING RAINFALL STATION
HEAVY RAINFALL STATION
RAINFALL TELEMETRY STATION
FLOODWARNING RIVER HEIGHT STATION
RIVER HEIGHT TELEMETRY STATION
UNOFFICIAL RIVER HEIGHT STATION
LINDFIELD
PEACHESTER
KILCOY
WOODFORD
MT.MEE
CABOOLTURE
BRIBIE IS.
SOMERSET DAM
REDCLIFFE
N.PINE DAM
PETRIE
50 40 30 20 10 0 50
KILOMETRES
1:750 000
MT.GLORIOUS
SANDGATE
REDHILLS
MT.NEBO

Figure 11

Rainfall Mass Curves

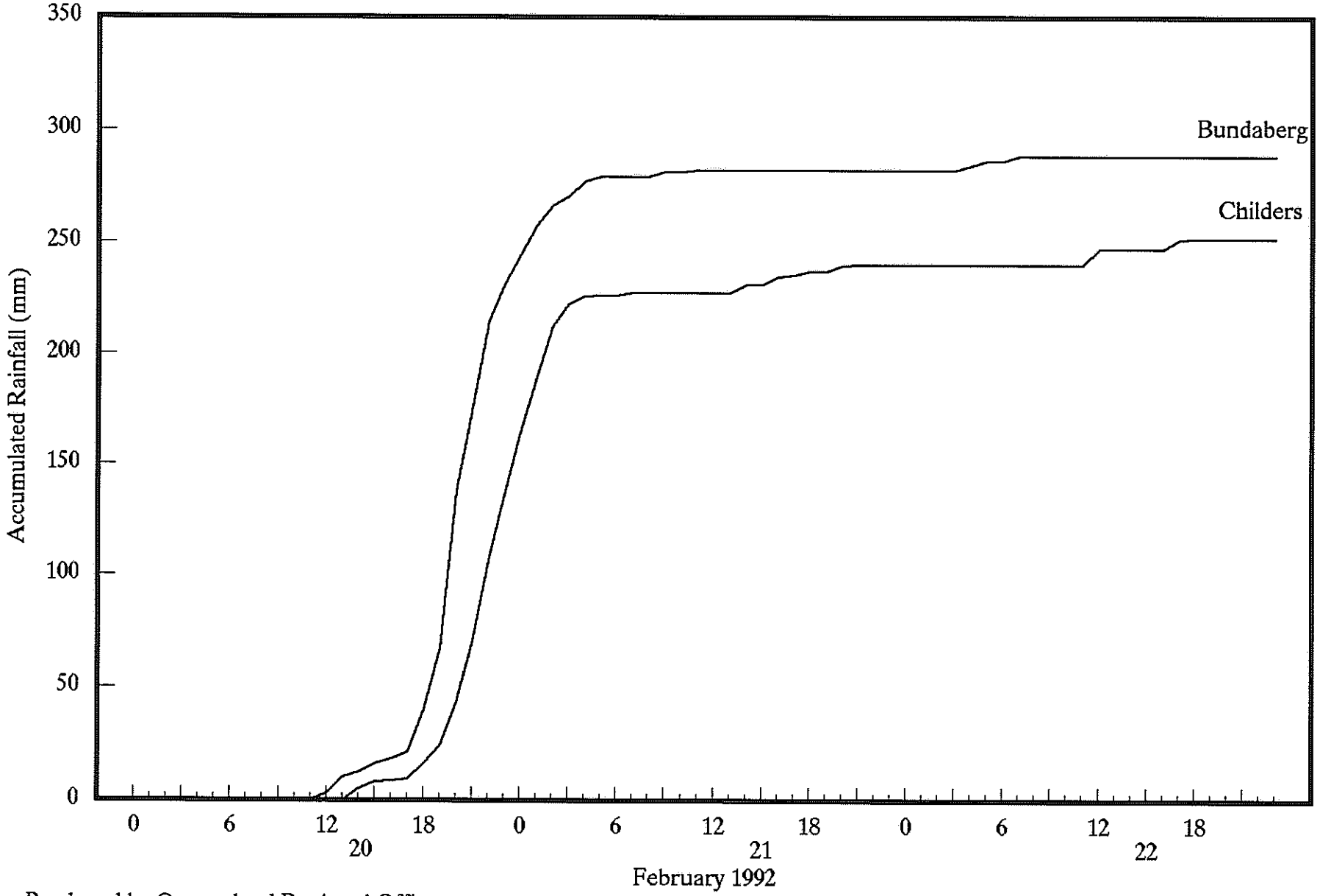


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Figure 12

Rainfall Mass Curves

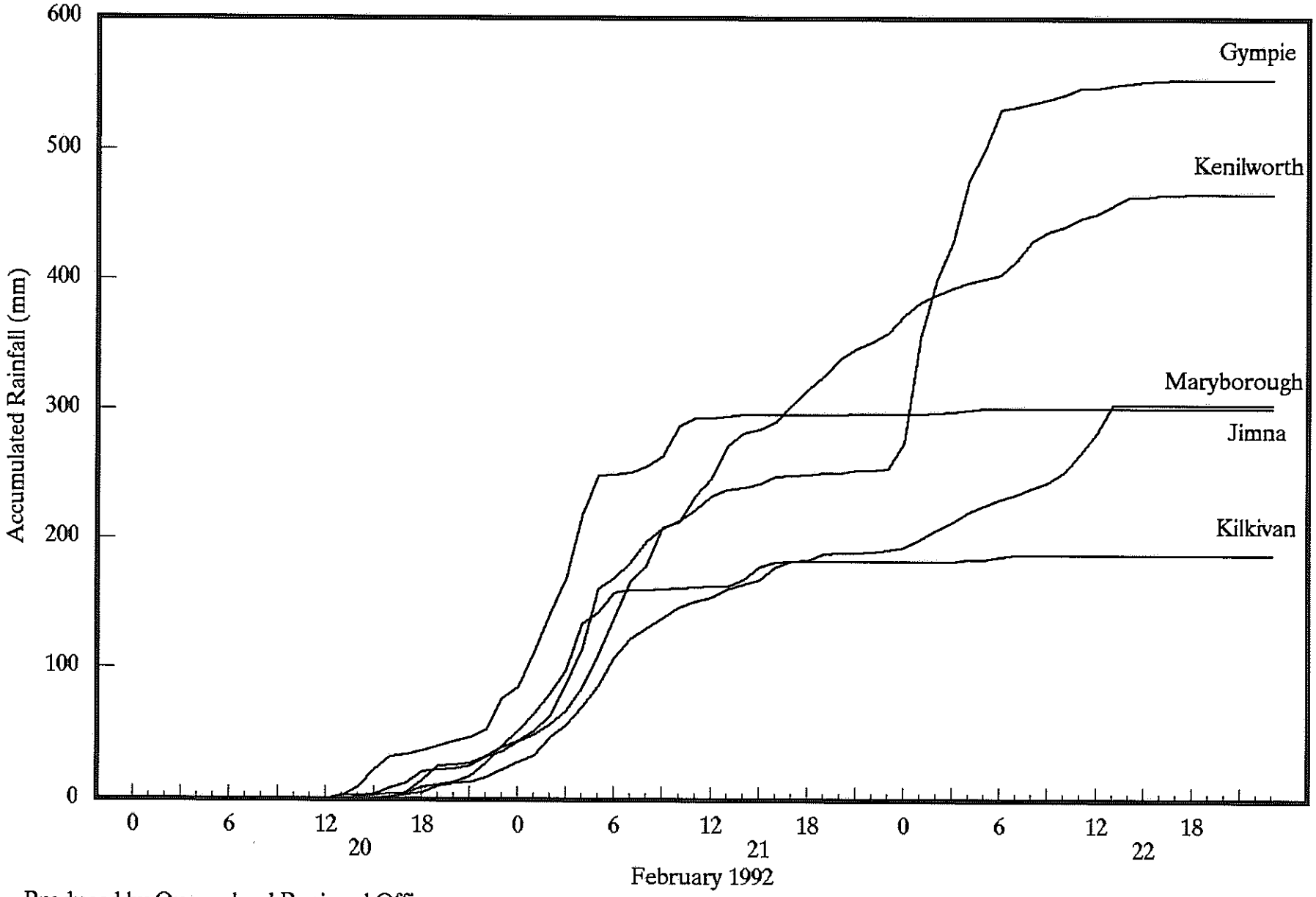

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Figure 13

Rainfall Mass Curves

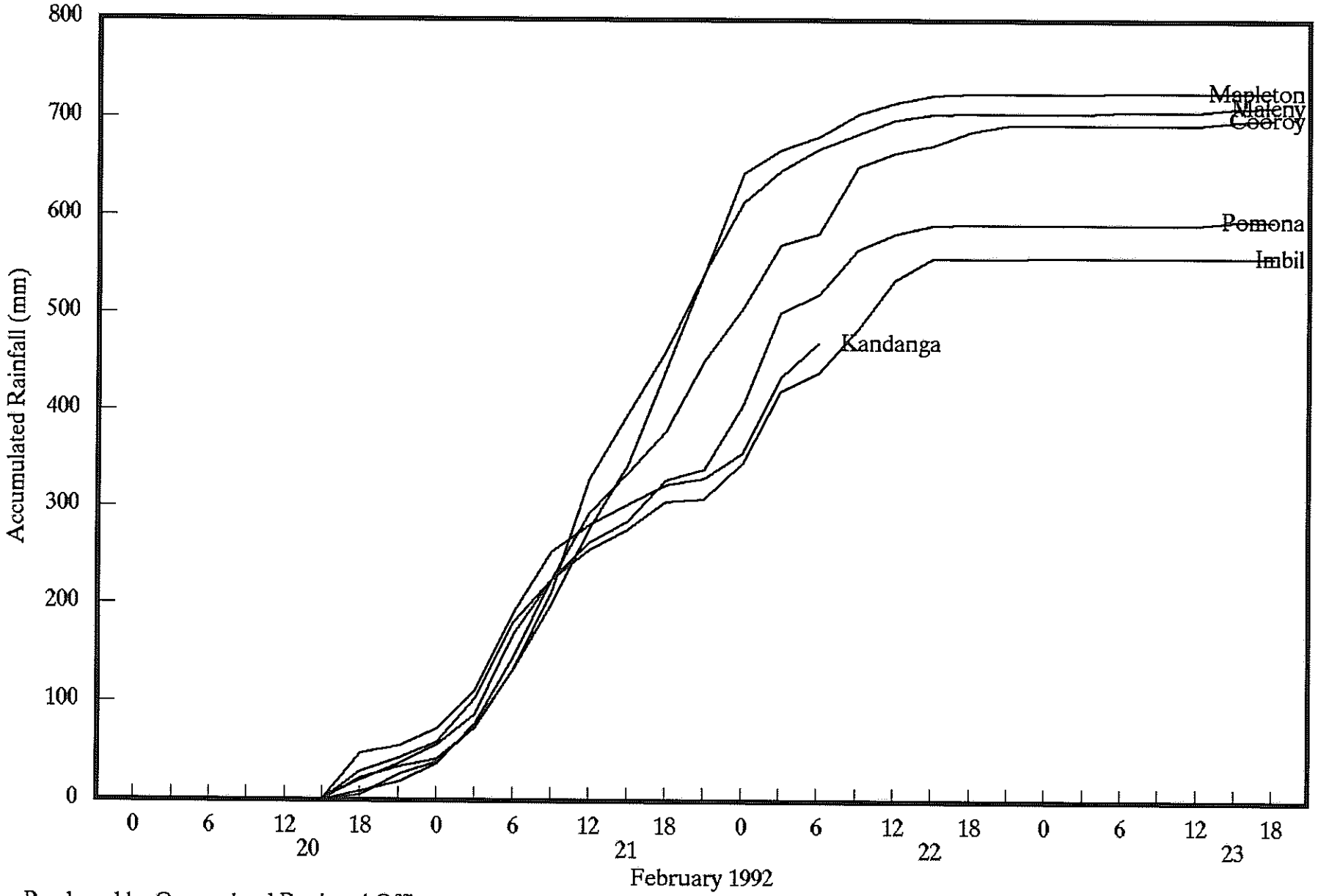

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Figure 14

Rainfall Mass Curves

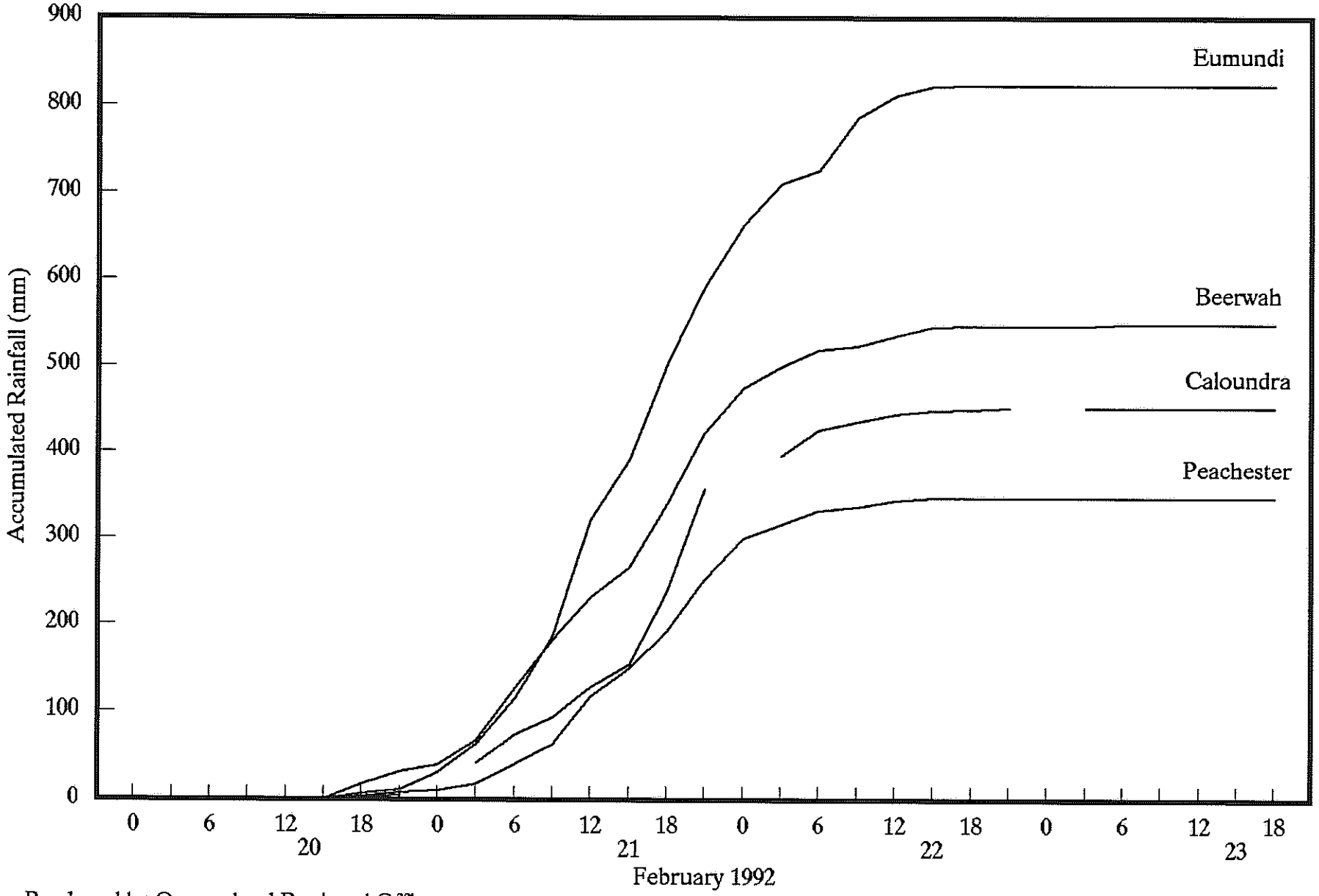

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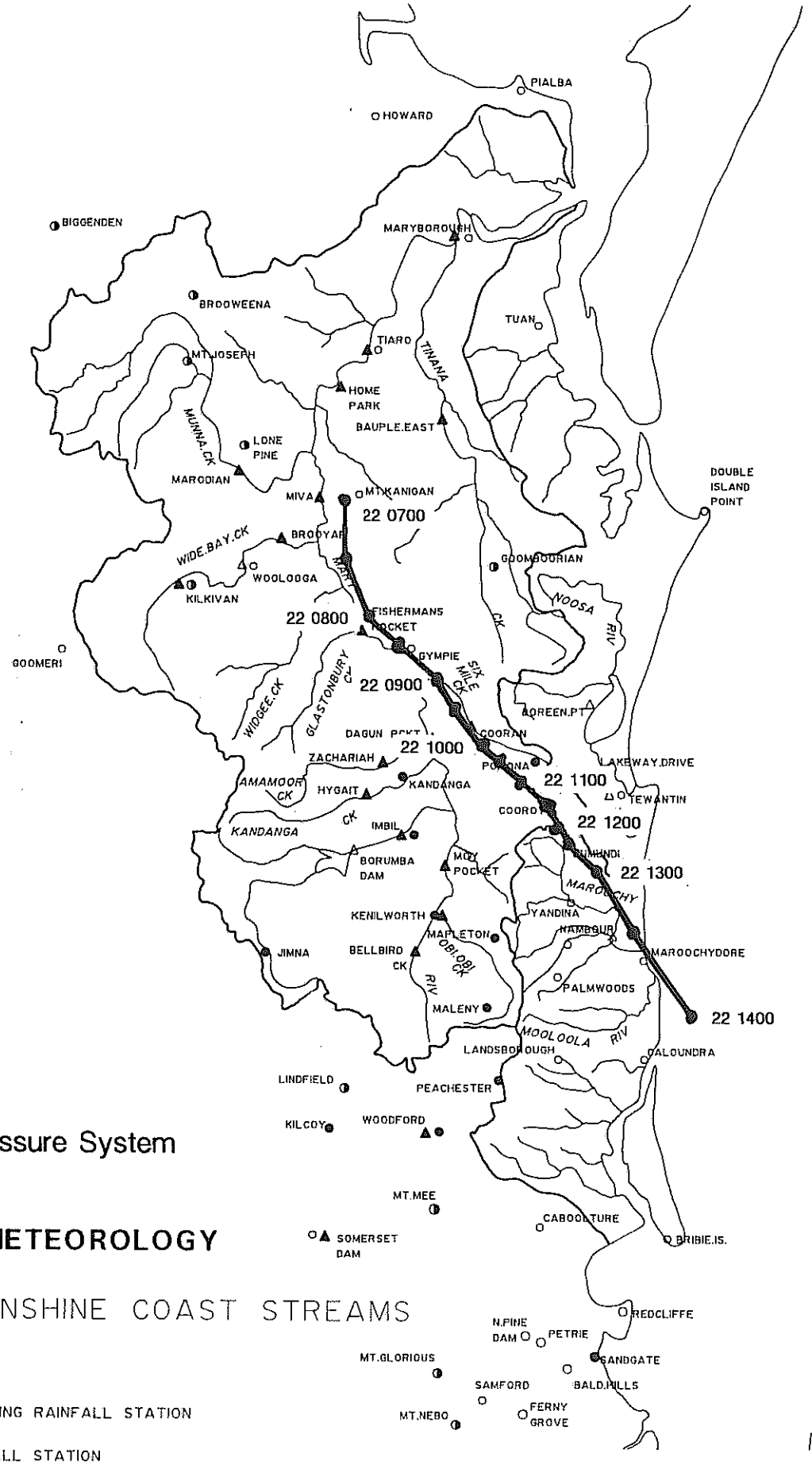
Figure 15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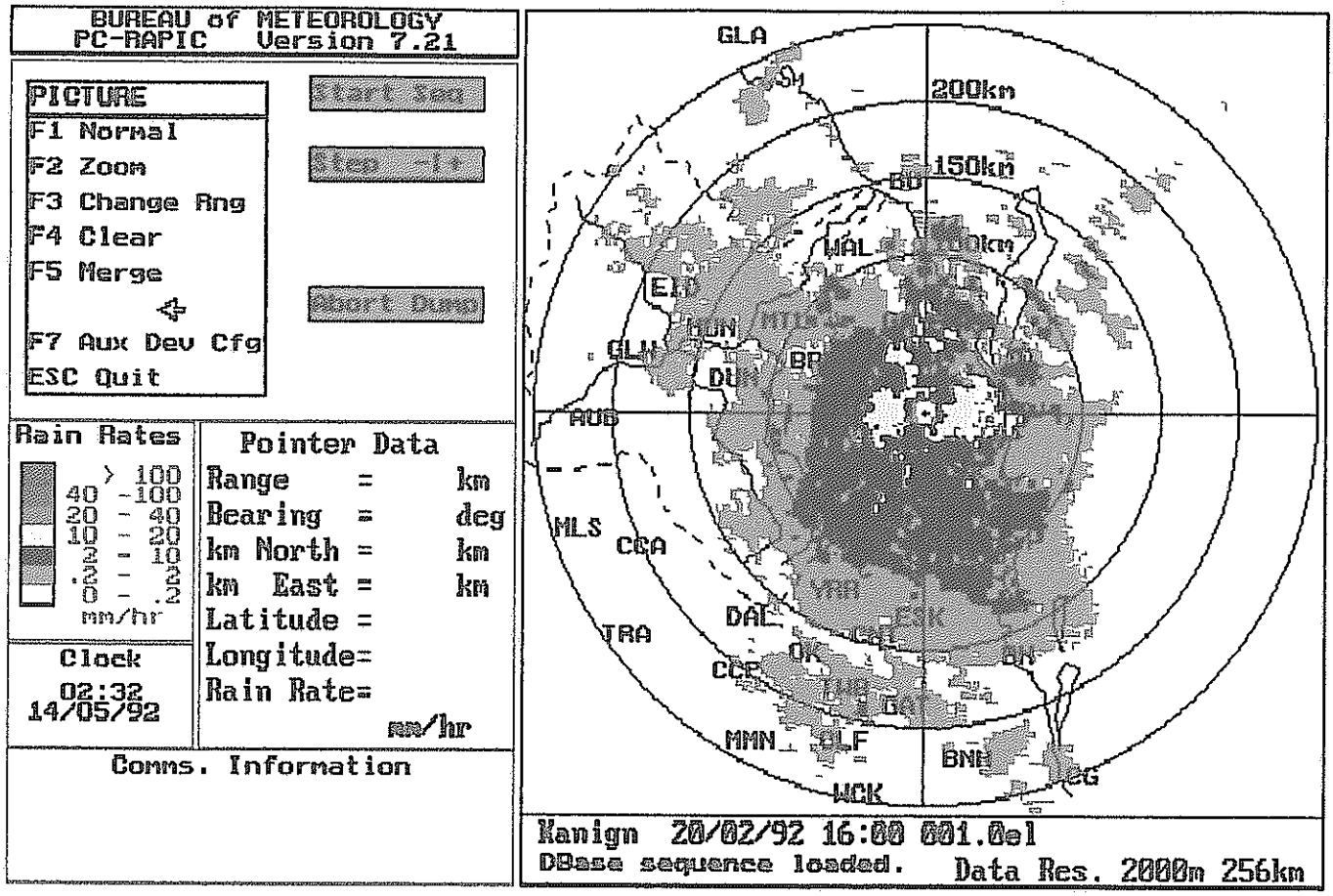
HOWARD
BIGGENDEN
MARYBOROUGH
BROOWEENA
TUAN
TIARO
MT.JOSEPH
TINANA
HOME PARK
BAUPLE.EAST
MUNNA.CK
LONE PINE
MARODIAN
MIVA
MT.KANIGAN
22 0700
DOUBLE ISLAND POINT
BROOYAR
WIDE.BAY.CK
WOOLOOGA
KILKIVAN
GOOMBOORIAN
NOOSA RIV
22 0800
FISHERMANS POCKET
GOOMERI
GYMPIE
SIX MILE CK
GLASTONBURY CK
WIDGEE.CK
22 0900
AOREEN.PT
DAGUN POCKET
COORAN
22 1000
ZACHARIAH
POMONA
LAKEWAY.DRIVE
AMAMOOR CK
HYGAIT
KANDANGA
22 1100
TEWANTIN
COOROY
KANDANGA CK
IMBIL
22 1200
BORUMBA DAM
MOY POCKET
22 1300
MAROOCHY
KENILWORTH
YANDINA
NAMBOUR
MAPLETON
JIMNA
BELLBIRD CK
OBI OBI CK
MAROOCHYDORE
PALMWOODS
MALENY
22 1400
MOOLOOLA RIV
LANDSBOROUGH
CALOUNDRA
LINDFIELD
PEACHESTER
KILCOY
WOODFORD
MT.MEE
CABOOLTURE
SOMERSET DAM
BRIBIE.IS.
REDCLIFFE
N.PINE DAM
PETRIE
MT.GLORIOUS
SANDGATE
SAMFORD
BALD.HILLS
MT.NEBO
FERNY GROVE
Track of Low Pressure System
BUREAU OF METEOROLOGY
MARY RIVER & SUNSHINE COAST STREAMS
DAILY REPORTING RAINFALL STATION
HEAVY RAINFALL STATION
RAINFALL TELEMETRY STATION
FLOODWARNING RIVER HEIGHT STATION
RIVER HEIGHT TELEMETRY STATION
UNOFFICIAL RIVER HEIGHT STATION
50 40 30 20 10 0 50
KILOMETRES
1:750 000

Figure 16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PC-RAPIC Version 7.21
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F2 Zoom
F3 Change Rng
F4 Clear
F5 Merge
F7 Aux Dev Cfg
ESC Quit
Rain Rates
> 100
40 - 100
20 - 40
10 - 20
2 - 10
.2 - 2
0 - .2
mm/hr
Pointer Data
Range = km
Bearing = deg
km North = km
km East = km
Latitude =
Longitude=
Rain Rate=
mm/hr
Clock
02:32
14/05/92
Comms. Information
GLA
200km
150km
BU
WAL
EIT
DUN
GLW
BP
DU
AUB
MLS
CCA
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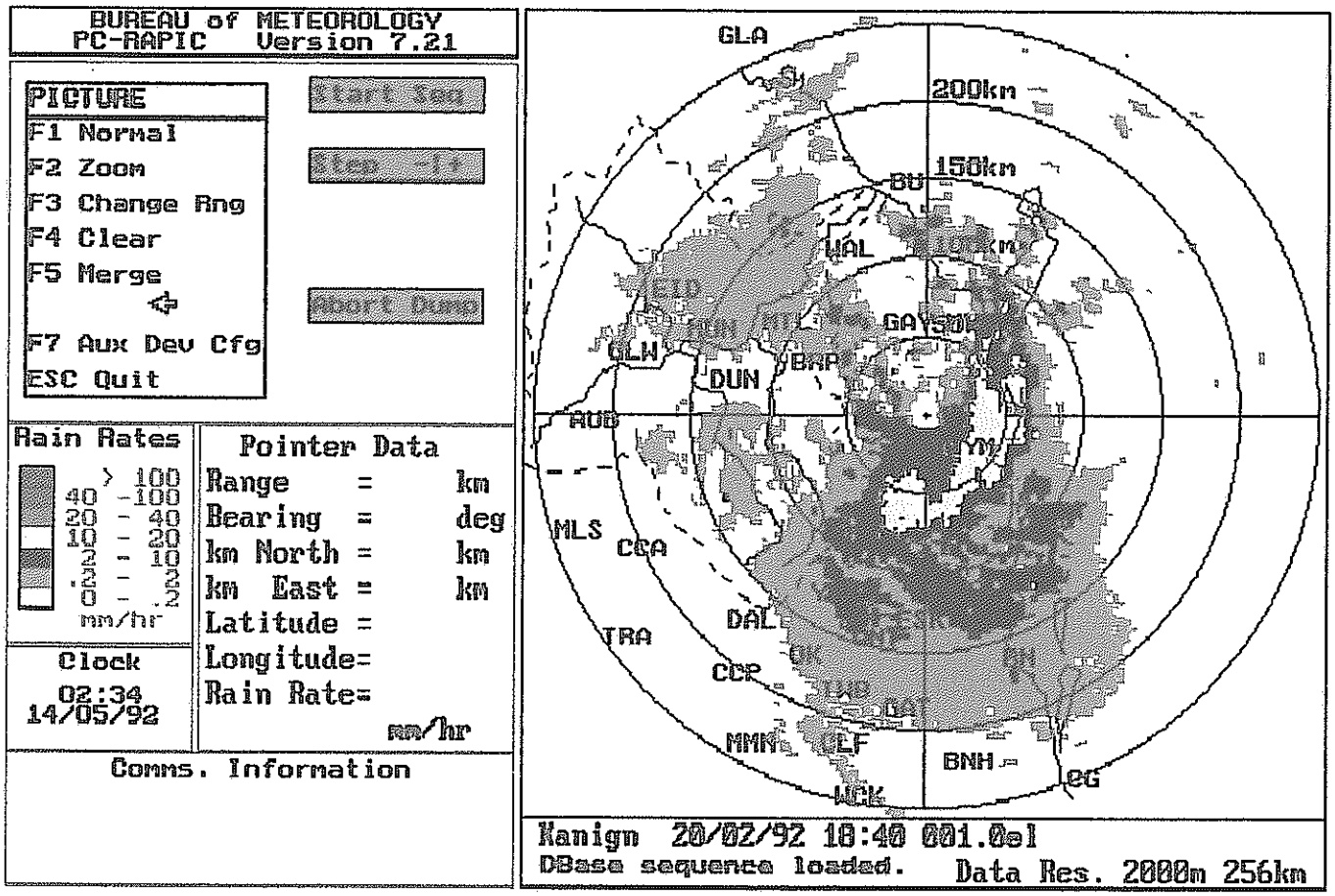
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PC-RAPIC Version 7.21
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F4 Clear
F5 Merge
F7 Aux Dev Cfg
ESC Quit
Rain Rates
> 100
40 - 100
20 - 40
10 - 20
2 - 10
.2 - 2
0 - .2
mm/hr
Pointer Data
Range = km
Bearing = deg
km North = km
km East = km
Latitude =
Longitude=
Rain Rate=
mm/hr
Clock
02:34
14/05/92
Comms. Information
GLA
200km
150km
BU
WAL
GLW
DUN
BNP
AUB
MLS
CCA
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WCK
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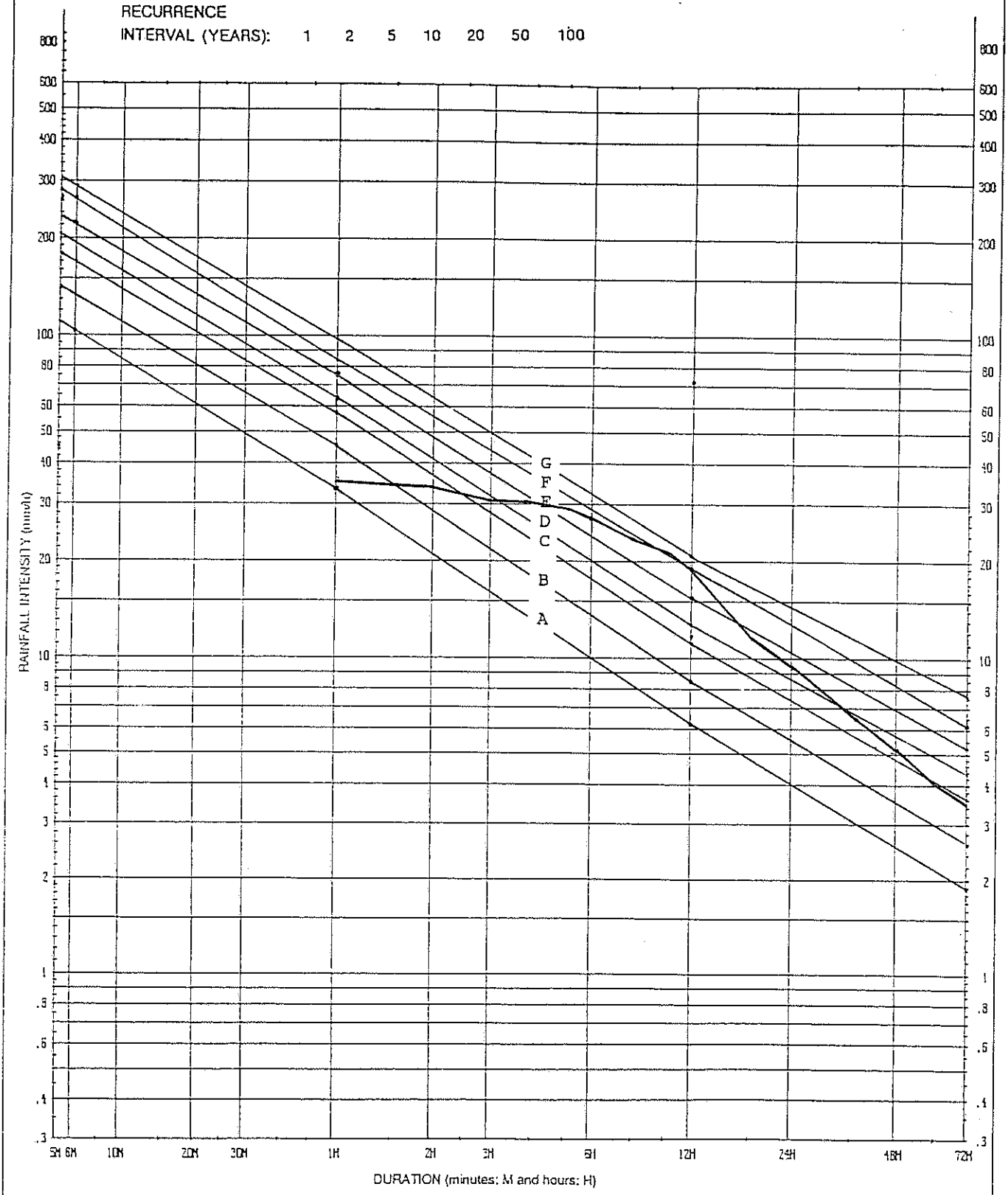
Figure 17

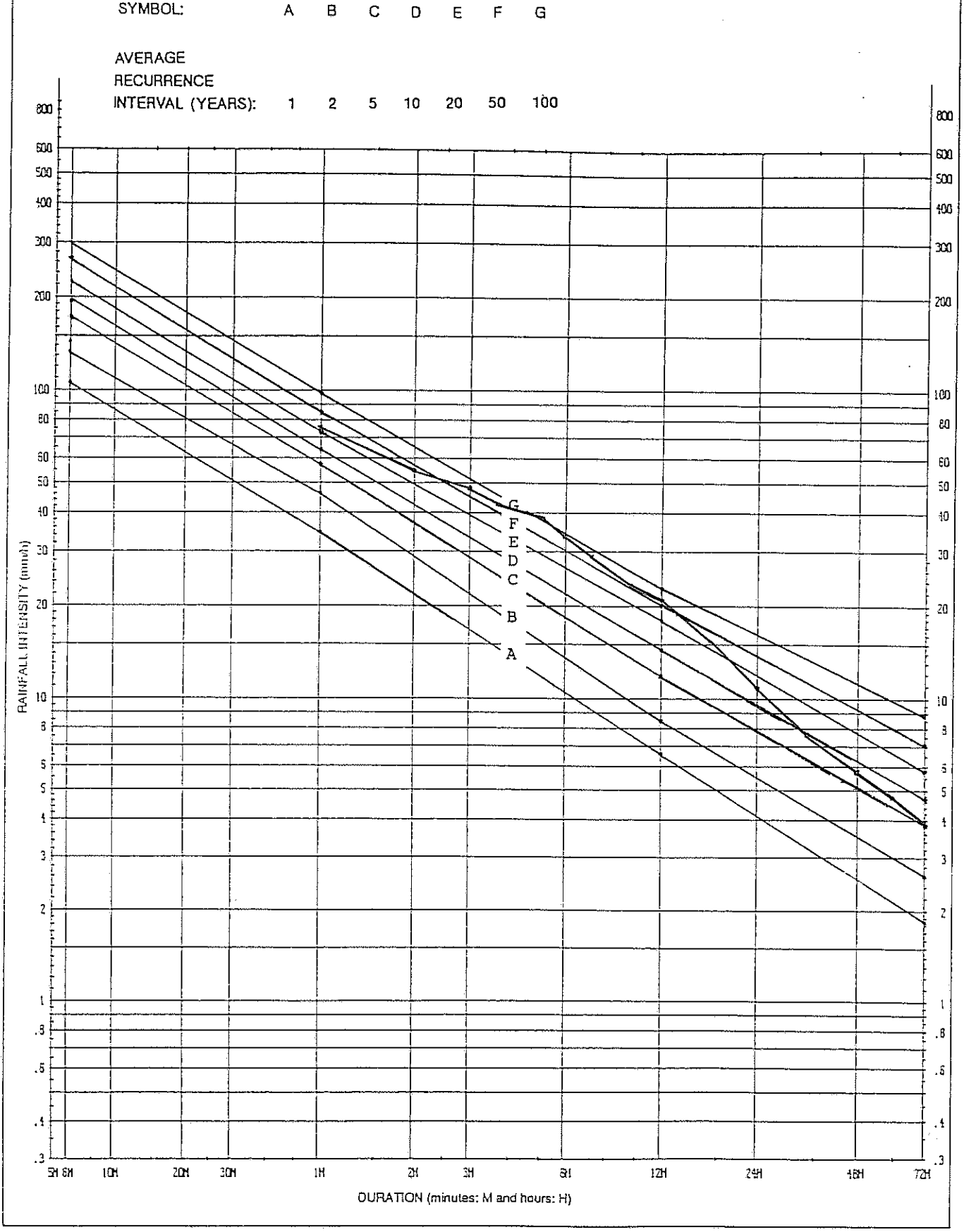


BUREAU OF METEOROLOGY

CHILDERS

INTENSITY-FREQUENCY-DURATION RAINFALL CURVES

Figure 18

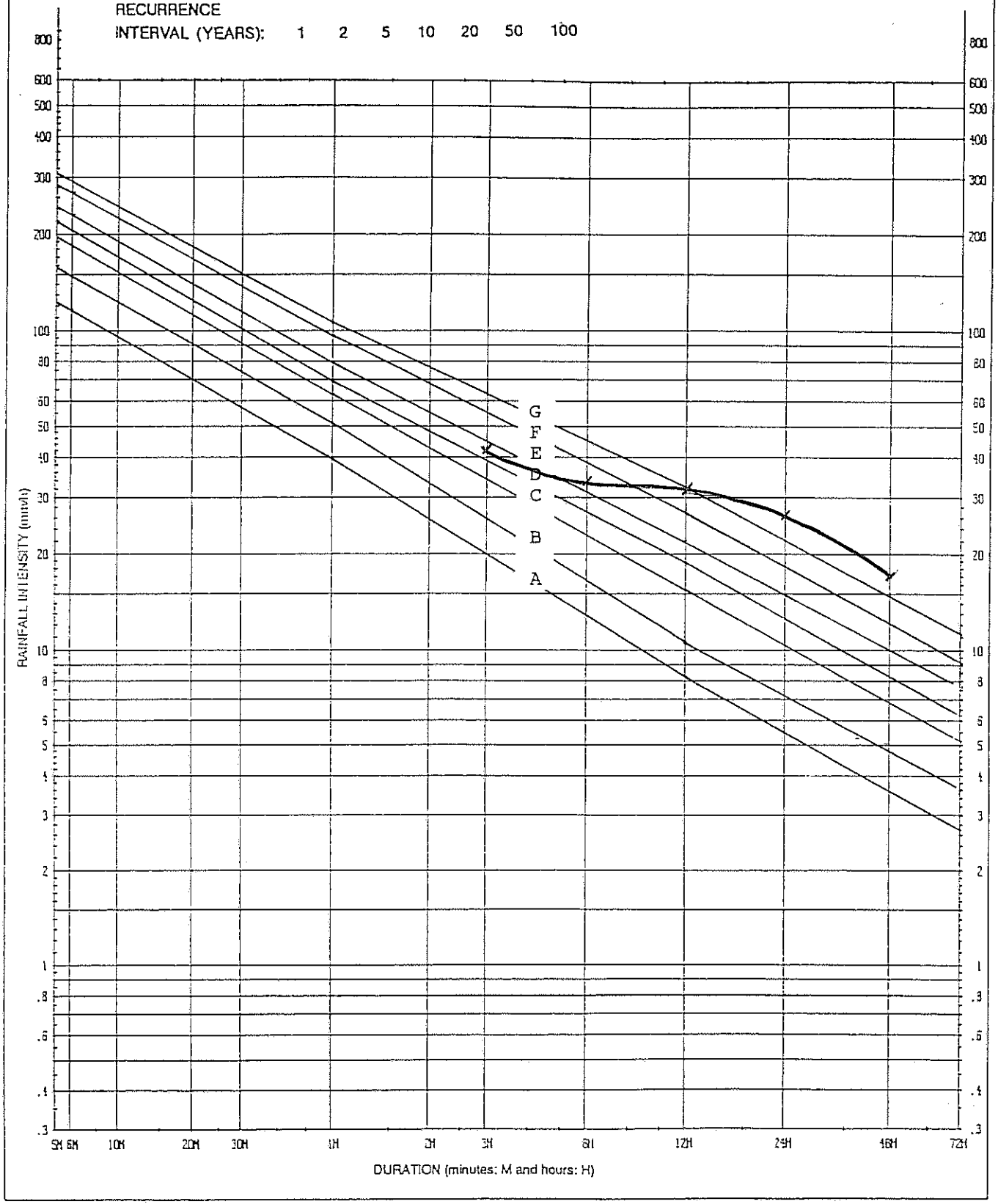


BUREAU OF METEOROLOGY

BUNDABERG

INTENSITY-FREQUENCY-DURATION RAINFALL CURVES

Figure 19

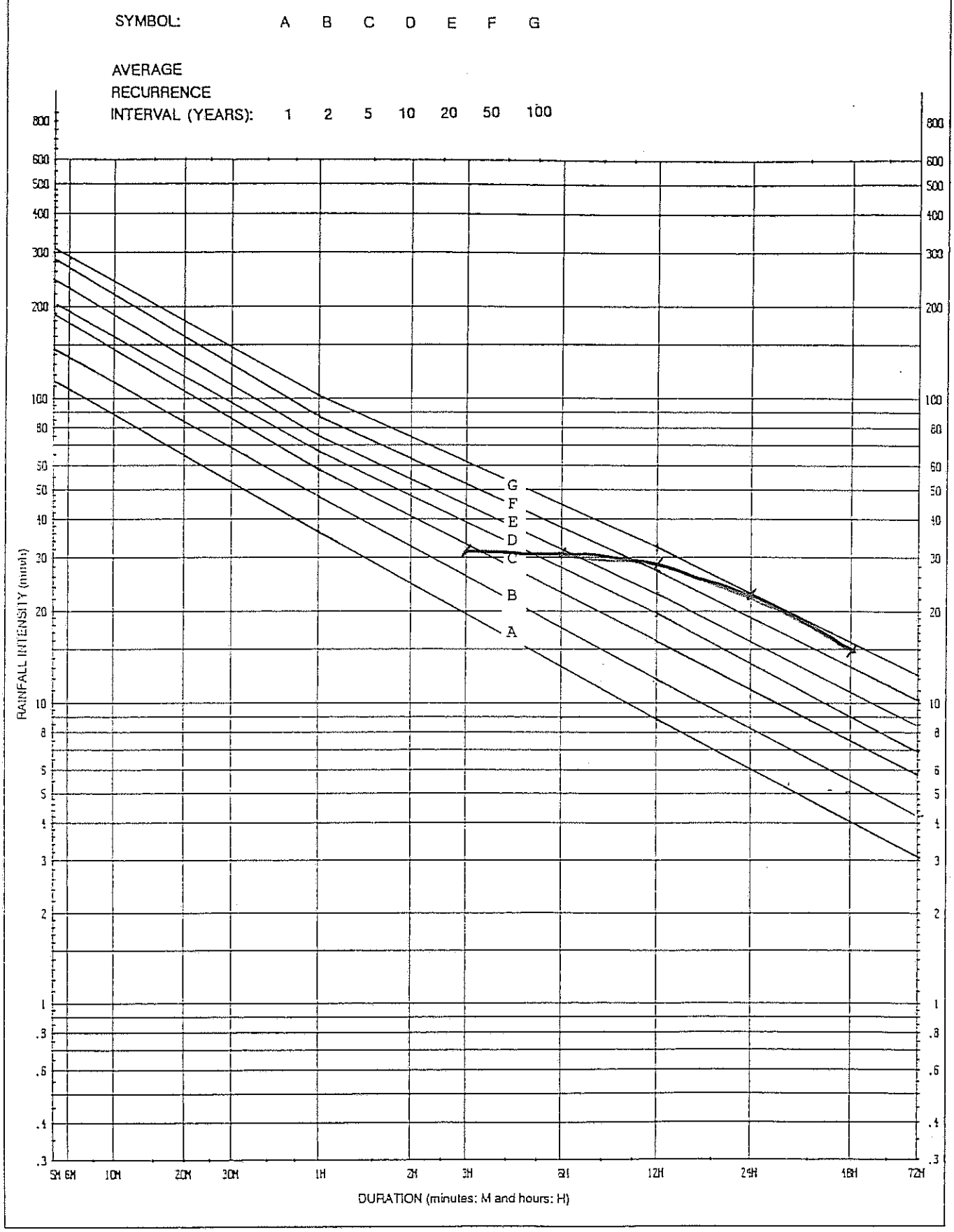


BUREAU OF METEOROLOGY

EUMUNDI

INTENSITY-FREQUENCY-DURATION RAINFALL CURVES

Figure 20

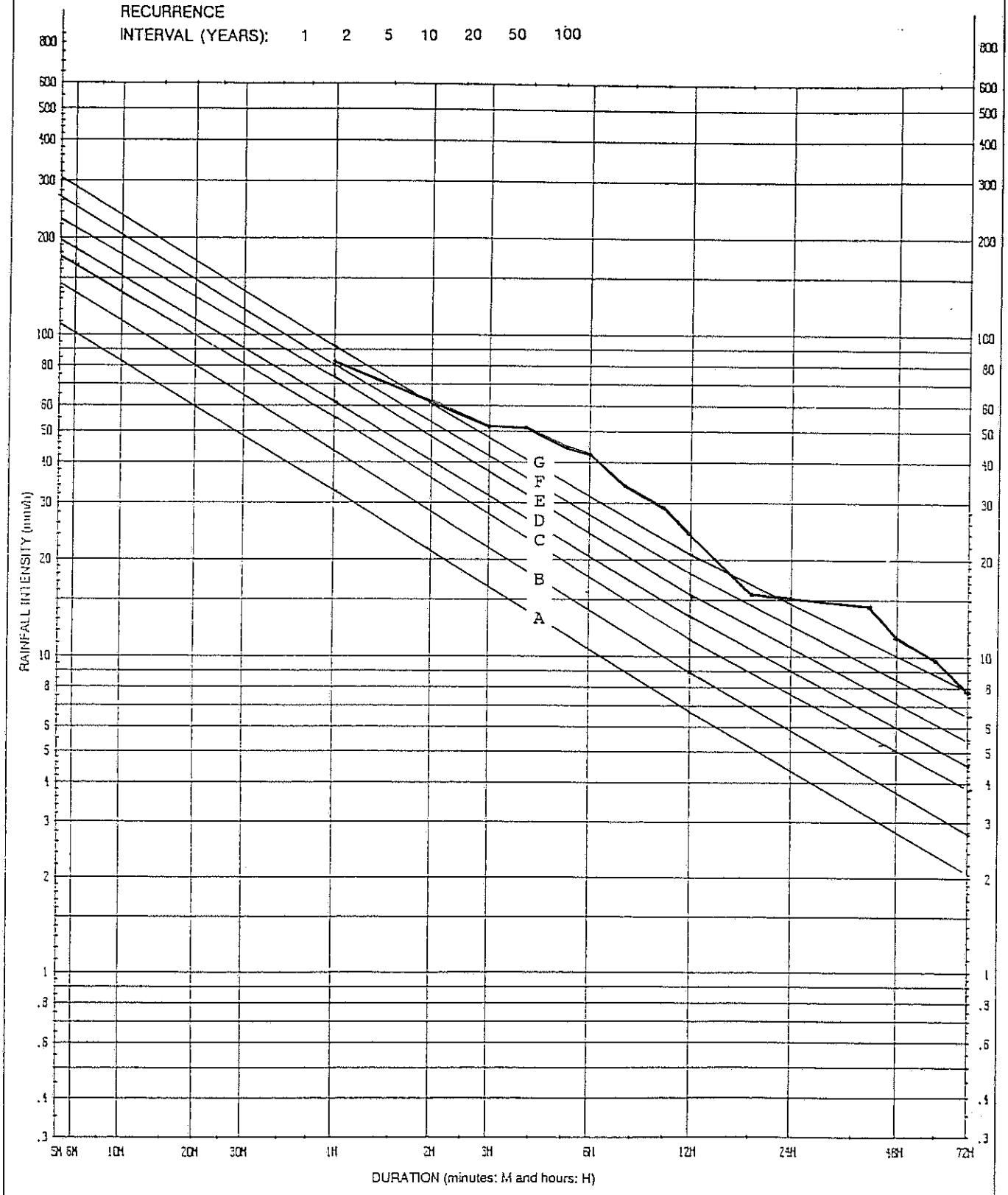


BUREAU OF METEOROLOGY

MALENY

INTENSITY-FREQUENCY-DURATION RAINFALL CURVES

Figure 21

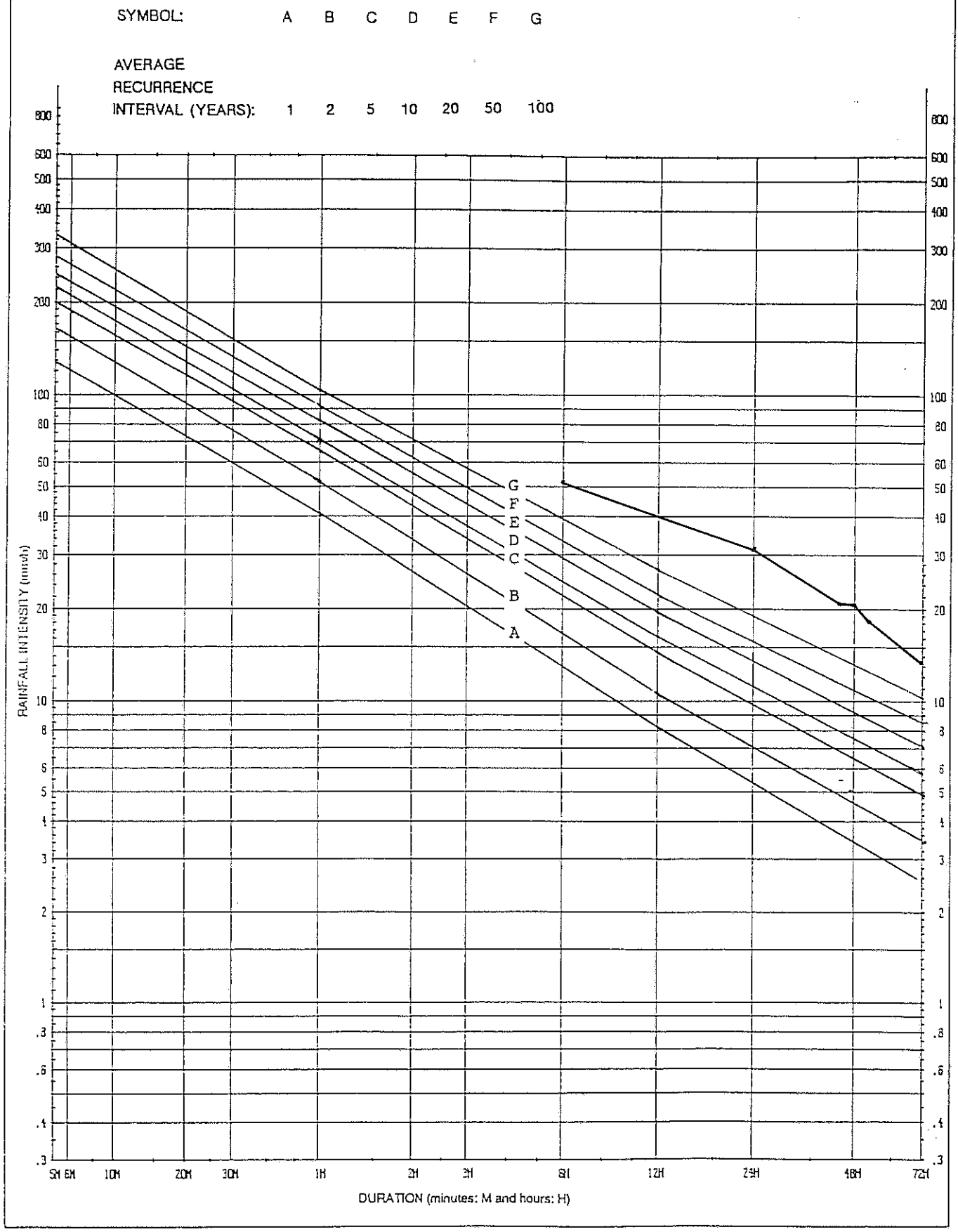


BUREAU OF METEOROLOGY

GYMPIE

INTENSITY-FREQUENCY-DURATION RAINFALL CURVES

Figure 22



BUREAU OF METEOROLOGY

TEWANTIN

INTENSITY-FREQUENCY-DURATION RAINFALL CURVES

Figure 23

Mary River

Kenilworth to Gympie

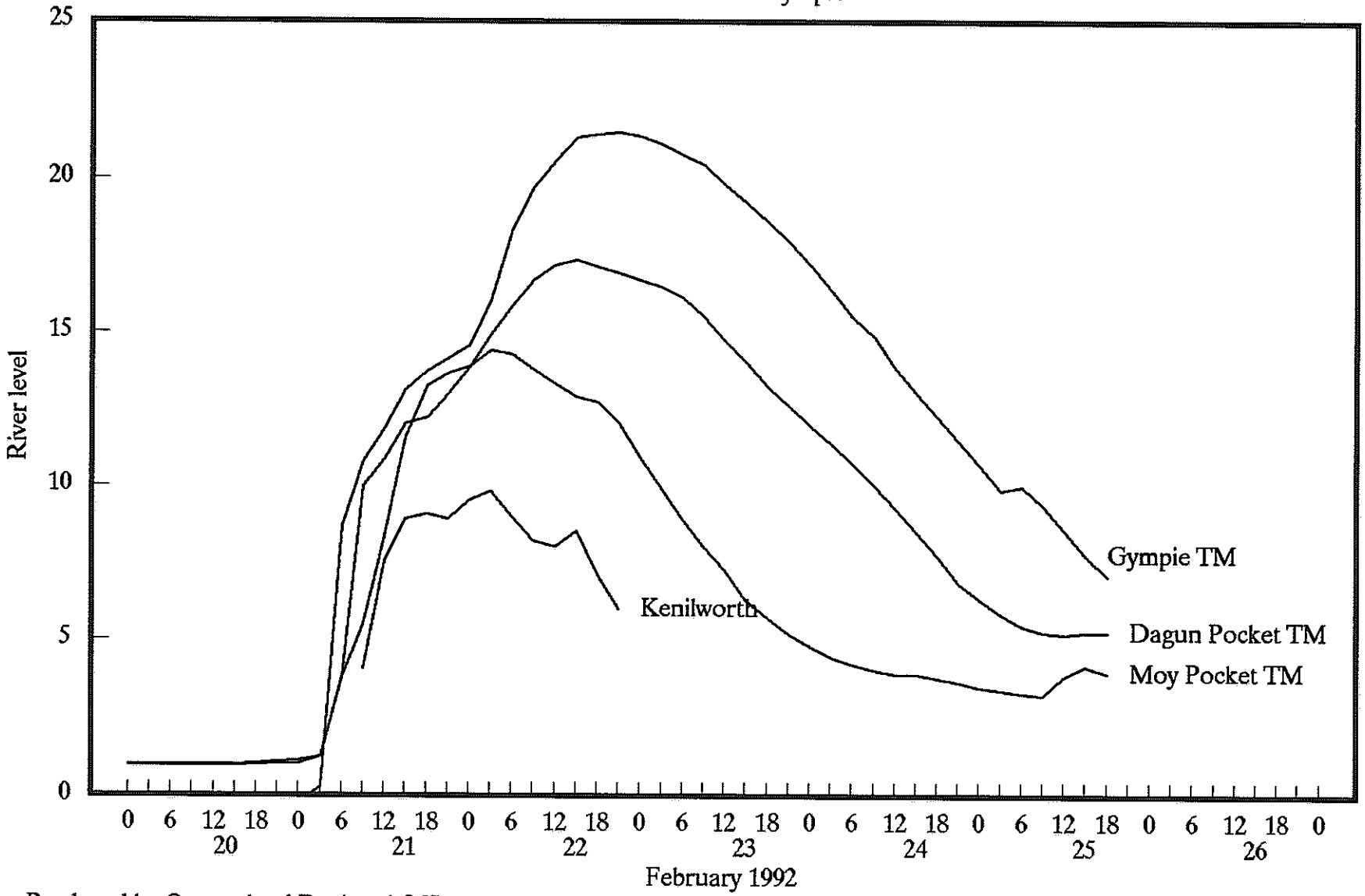


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Figure 24

Mary River

Catchment Rainfall & Gympie River Level

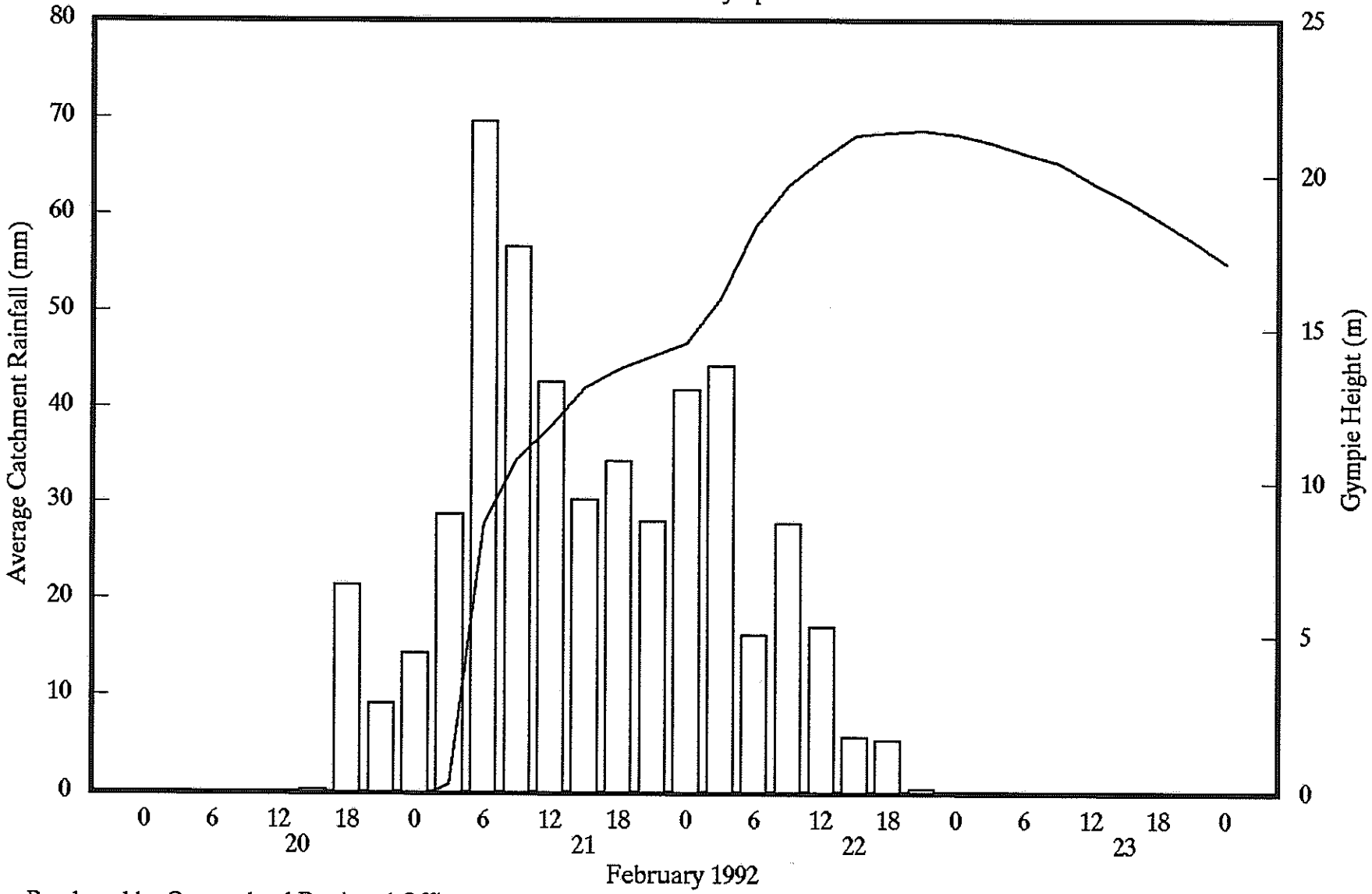

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Figure 25

Mary River

Gympie to Maryborough

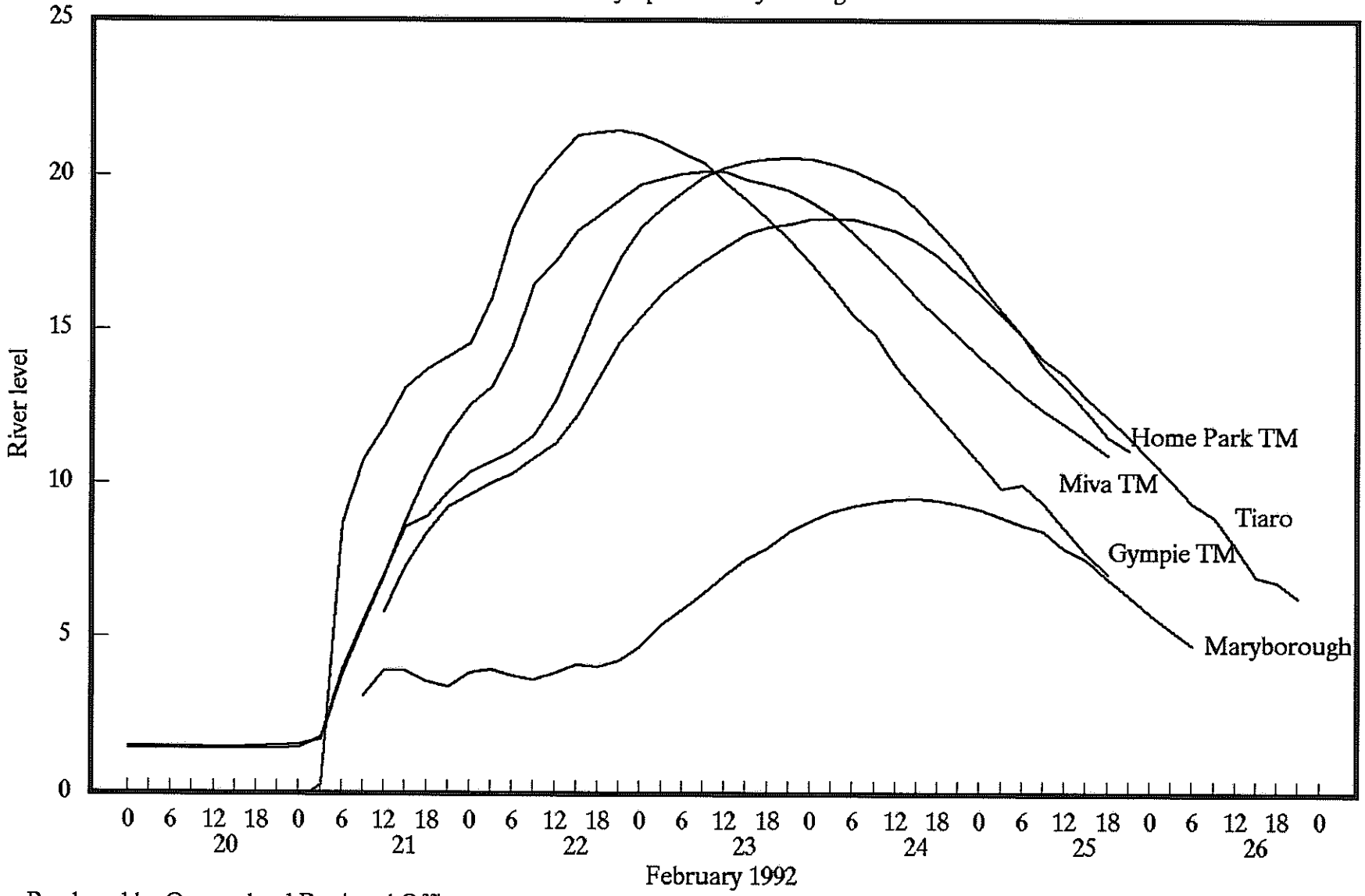

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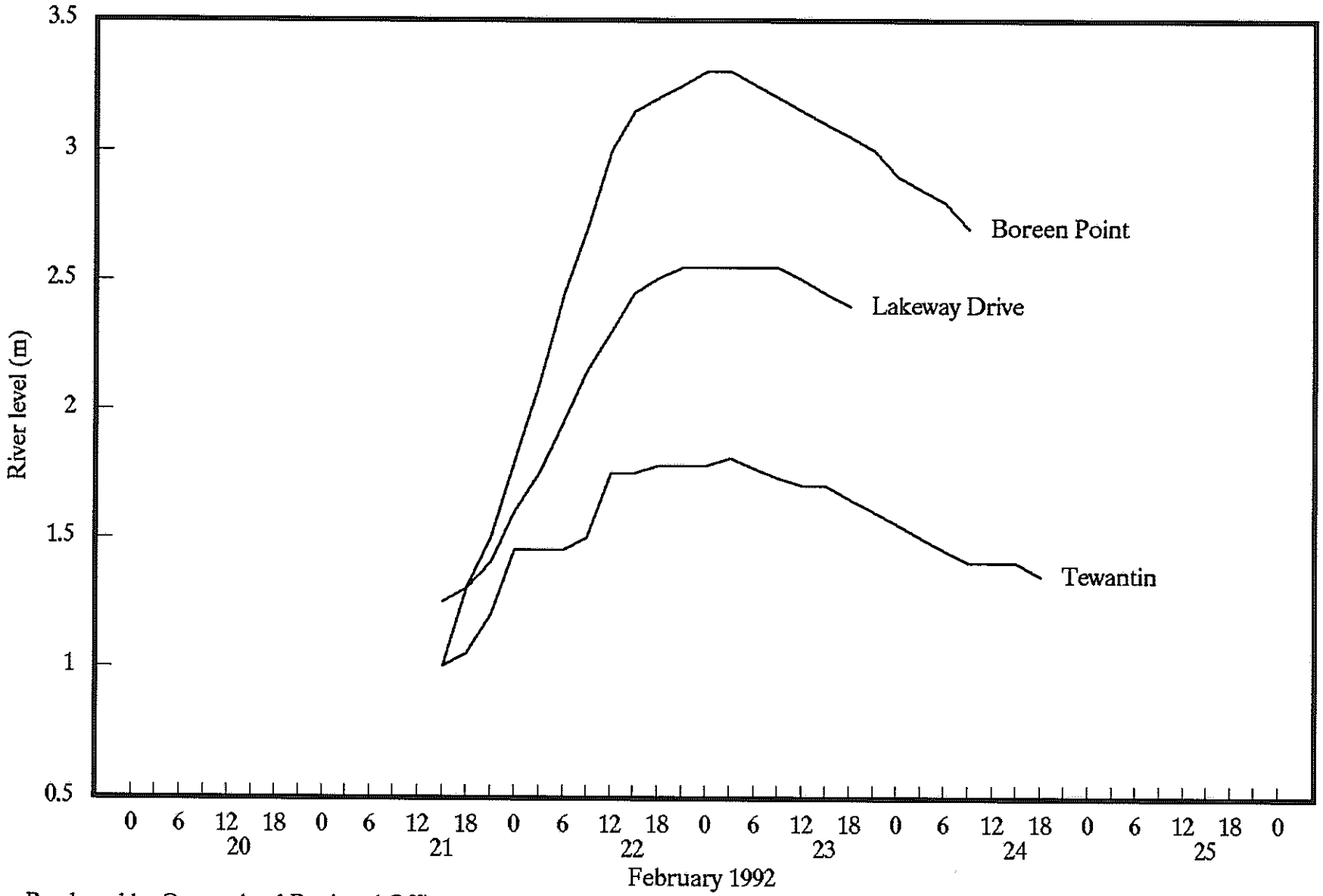
Figure 26

Noosa River



Produced by Queensland Regional Office
Bureau of Meteorology

Figure 27

Stanley River

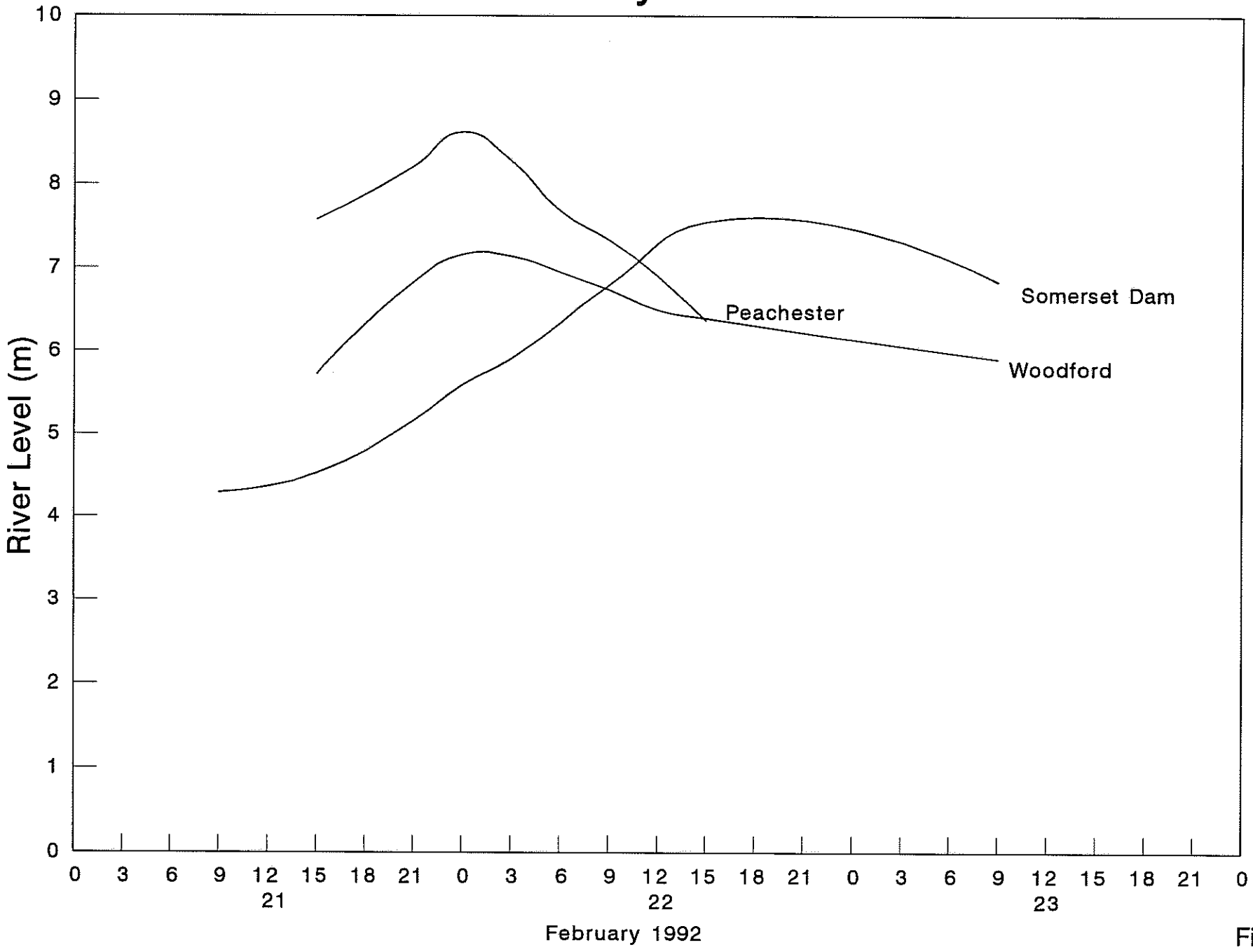
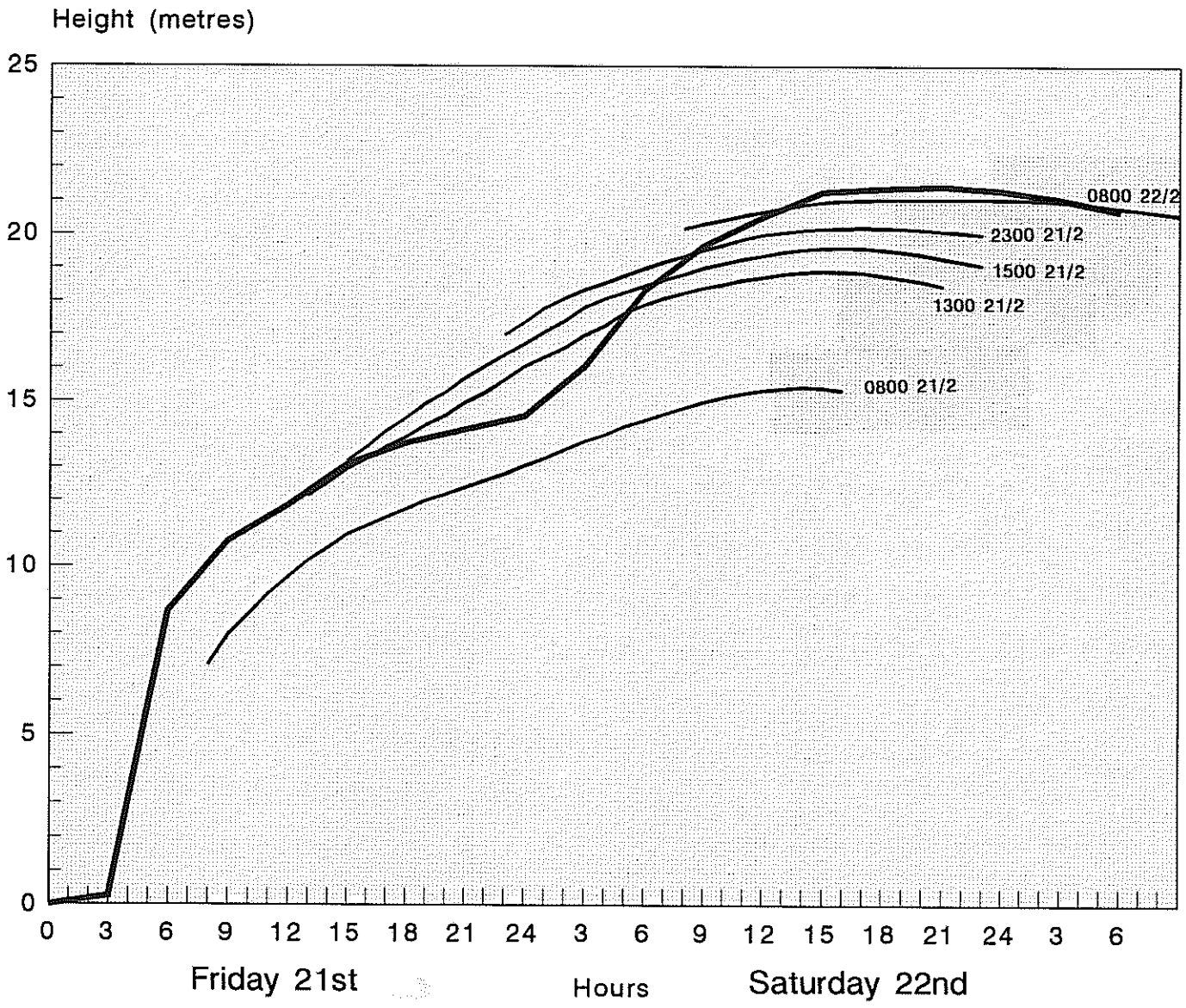


Figure 28

GYMPIE MODEL PREDICTIONS

February Flood 1992



Gympie Observed
0800 21/2 Prediction
1300 21/2 Prediction
1500 21/2 Prediction
2300 21/2 Prediction
0800 22/2 Prediction

Figure 29

Flood Performance Diagram

Gympie

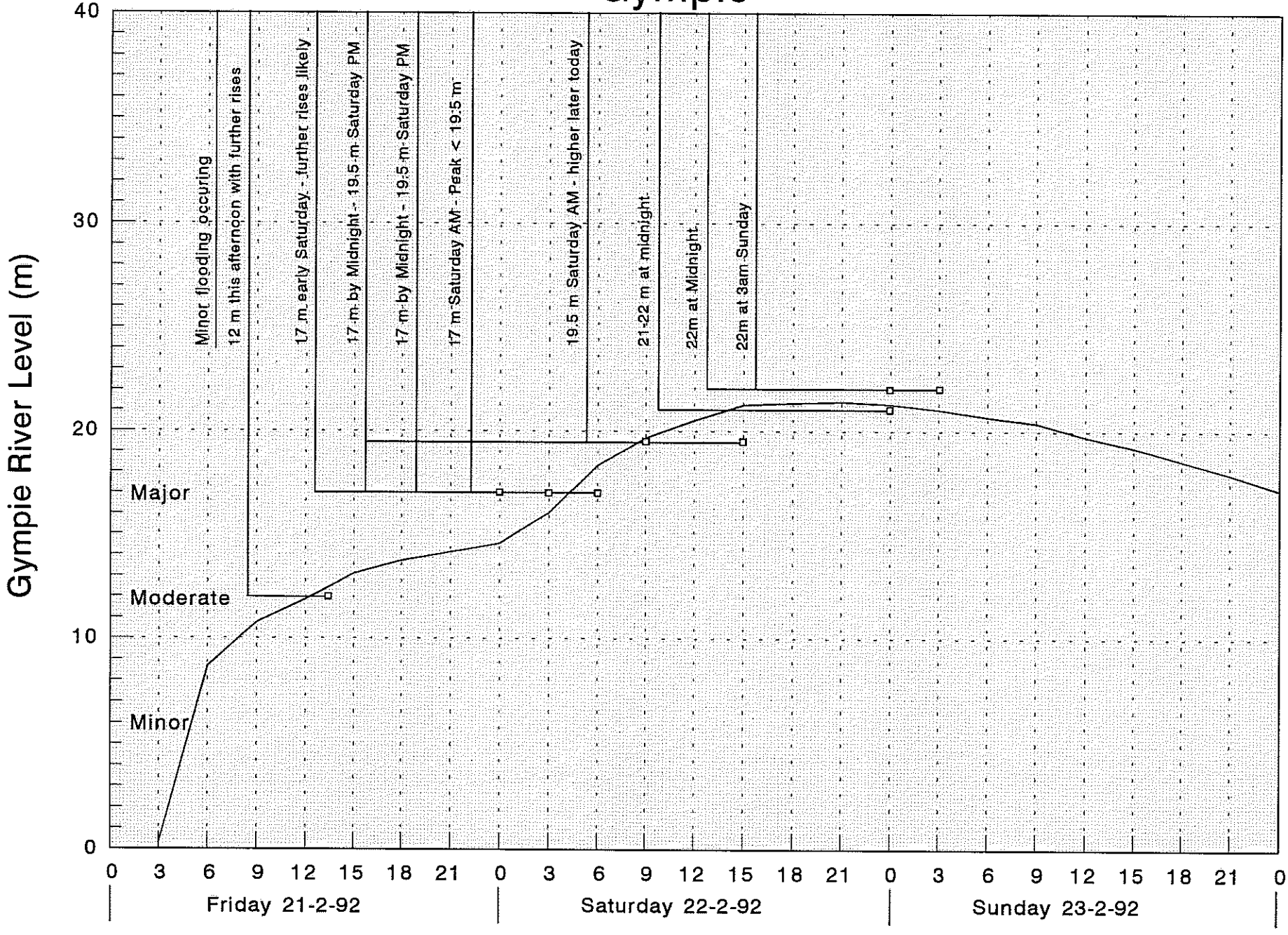


Figure 30

Flood Performance Diagram

Maryborough

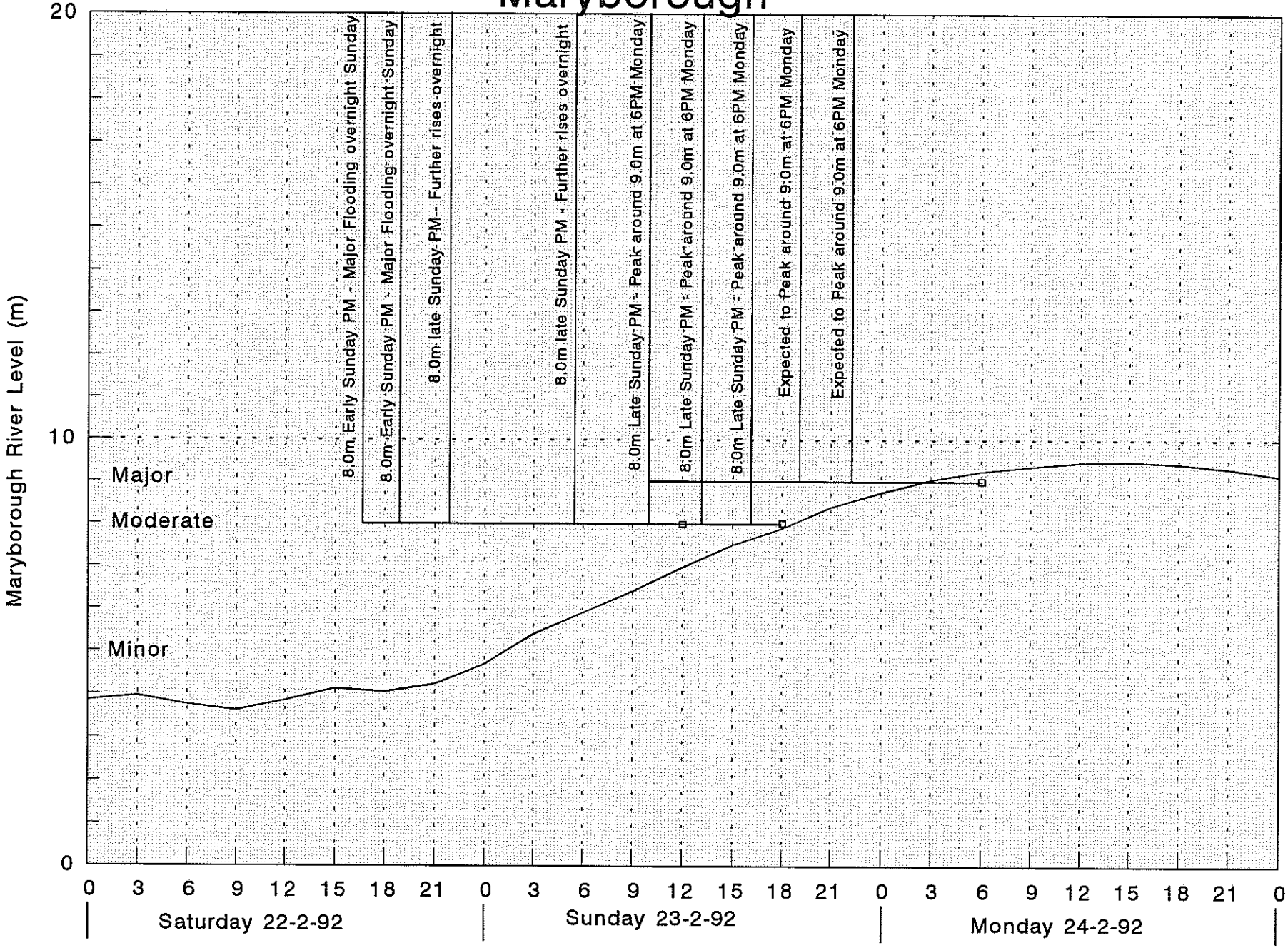


Figure 31

APPENDIX A

FLOOD WARNING SERVICES

Overview

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 of the Bureau of Meteorology based in Brisbane. The expertise and resources of other units in the Regional Office also contribute significantly to the operational flood warning service. In particular, the Regional Forecast Centre (RFC) provides continuous observed and forecast weather information and the Severe Weather Section (SWS) provides expert services during cyclones, thunderstorms and other severe weather. During operations, the focus of the Bureau's flood warning service is the Flood Warning Centre (FWC) which collates and analyses information from these sources and the special flood warning networks.

The basic data reporting network, upon which warning services are based, consists of the following in Queensland:

* River height reporting stations including telemetry stations	approx 400
* Special heavy rainfall stations including telemetry stations	approx 160
* Combined rainfall & river stations	approx 80
* Daily rainfall stations reporting at 0900, including the special heavy rainfall and synoptic stations	approx 500
* Synoptic stations reporting meteorological elements (pressure, temperatures, wind etc) as well as rainfall	approx 80

Types of Systems

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

Generalised warning systems describe the onset of flooding in general terms, based solely on meteorological considerations. These systems are usually in river basins where there is no special rainfall and river height networks.

Qualitative warning systems describe the severity of flooding at each location in terms of the broad descriptive terms of minor, moderate or major flooding. Special rainfall and river height network are established in these systems and flood forecasts are based upon established relationships between meteorological and hydrological relationships.

Flood warning river gauge stations have an established flood classification which details heights on gauges at which minor, moderate, and major flooding commences. These threshold levels are selected following consultation with observers, Police, State Emergency Service (SES) 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 lyinareas requiring the removal of livestock and the evacuation of isolated houses. Main traffic bridges may be closed.

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

Quantitative forecasting systems provide a higher level of service where a height is forecast for a key river gauge and disseminated to the public. Rainfall and river height data is collected from a more developed network and site specific forecasts are based upon modelling techniques which incorporate both meteorological and hydrological considerations.

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 required for the particular catchment.

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 FWC in Brisbane are grouped into bulletins based on geograhical and drainage areas of Queensland and are telexed or faxed to local authorities (Shire, Town and City Councils), local radio stations for broadcast, police headquarters in Brisbane for onforwarding to regional police stations by the police computer message switching system, State Emergency Service, and some additional organisations on a needs basis.

For each area in flood, a river height bulletin is issued up to six times per day (0645, 0945, 1245, 1545, 1845, 2145) when reports are available. This ensures that the data is available to the local Council, counter-disaster organisations and the public as soon as possible (within one hour) after the scheduled reporting time of the station. At each location, the bulletin indicates whether the 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.

During operational periods, the FWC 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") provides a tangible understanding of the flood threat and the appropriate evasive actions to local landholders and communities.

* *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 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 SES, Police, local Councils, other selected State Government Departments, radio and television stations and to other local 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 SES, 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 FWC 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.

APPENDIX B

TEXT OF FLOOD WARNINGS

MARY RIVER AND ADJACENT STREAMS

WARNING NO 1 - Initial issued at 0645 Friday 21/2/92

Heavy falls have been recorded in the Mary River and nearby catchments overnight. Some of the totals to 0600 today are: Kandanga 190mm, Pomona 181mm, Mapleton 133mm and Maleny 133mm.

River rises and minor flooding is occuring in the Mary River around Gympie and in adjacent streams. At 0600 this morning, the Mary River at Gympie was 5.8 metres and rising.

Heavy rain is continuing in the area which will maintain areas of minor flooding and traffic hazards.

Motorists are warned not to enter flooded crossings.

WARNING NO 2 - Renewal issued at 0830 Friday 21/2/92

Heavy falls are continuing in coastal and inland areas between Gympie and Brisbane. Some of the overnight totals to 0800 today are: Kandanga 245mm, Pomona 218mm, Mapleton 163mm and Maleny 171mm.

Fast river rises causing moderate flooding are expected to continue during today in the Mary River Catchment and adjacent coastal streams.

At 0800 today the Mary River at Gympie was 8.0 metres and rising fast with minor flooding. Gympie is expected to reach a moderate flood level of 12 metres during this afternoon with continued rises likely this evening.

Motorists are warned not to enter flooded crossings.

WARNING NO 3 - Priority Renewal issued at 1230 Friday 21/2/92

Heavy falls are continuing in coastal and inland areas between Maryborough and Brisbane. Totals since 0900 today include: Eumundi 134mm, Kandanga 36mm, Coory 69mm Maleny 99mm and Peachester 55mm.

The Mary river at Gympie is rising fast and is expected to reach about 17.0 metres by early tomorrow (Saturday) morning. Further rises are likely during Saturday.

This will cause major flooding in the Gympie area commencing later today and continuing over the weekend.

At noon today the Mary River at Gympie was 11.9 metres and rising fast with moderate flooding.

Moderate flooding is expected to develop downstream of Gympie to the Tiaro area during this afternoon and overnight.

Fast river rises and areas of moderate flooding are continuing in coastal streams between Gympie and Brisbane, causing areas of flooding and traffic hazards.

Motorists are warned not to enter flooded crossings.

WARNING NO 4 - Renewal issued at 1600 Friday 21/2/92

Heavy falls are continuing in coastal and inland areas between Maryborough and Brisbane.

Significant river rises should be expected to continue in coastal rivers and streams along the Sunshine Coast, causing areas of flooding and traffic hazards.

River levels above Gympie are still generally rising and major flooding will commence in the Gympie area later tonight and continue over the weekend.

The Mary River at Gympie is expected to reach 17 metres around midnight tonight. It is expected to continue to rise to a height similar to that experienced in April 1989 by Saturday afternoon.

Moderate flooding is expected to develop downstream in the Gympie to Tiaro area overnight and continue during the weekend.

Motorists are warned not to enter flooded crossings.

WARNING NO 5 - Renewal issued at 1900 Friday 21/2/92

Very heavy rainfalls from 50 to 100mm have been reported in coastal and inland areas between Maryborough and Brisbane in the last three hours.

Significant river rises should be expected to continue tonight in the Noosa River and other coastal rivers and streams along the Sunshine Coast, causing areas of flooding and traffic hazards.

River levels in streams above Gympie are still generally rising and major flooding will commence in the Gympie area later tonight and continue over the weekend.

The Mary River at Gympie is expected to reach 17 metres around midnight tonight. It is expected to continue to rise to about 19.5 metres by Saturday afternoon. This is similar height to that reached in early April 1989.

Moderate flooding will continue downstream in the Gympie to Tiaro area during the weekend.

Motorists are warned not to enter flooded crossings.

WARNING NO 6 - Renewal issued at 1030 Friday 21/2/92

Heavy rainfalls from 50 to 100mm have been reported in coastal areas between Gympie and Brisbane in the last three hours.

Significant river rises should be expected to continue tonight in the Noosa River and other coastal rivers and streams along the Sunshine Coast, causing areas of flooding and traffic hazards.

Major flooding will commence in the Gympie area tomorrow morning and continue over the weekend. The Mary River at Gympie is expected to reach 17 metres tomorrow morning and continue to rise slowly during Saturday.

The rates of rise in river levels in streams above Gympie are slowing more quickly than expected, indicating that the peak at Gympie may be lower than the April 1989 height.

Moderate flooding will continue downstream in the Gympie to Tiaro area during the weekend.

Motorists are warned not to enter flooded crossings.

WARNING NO 7 - Renewal issued at 0530 Saturday 22/2/92

Heavy rainfall has continued overnight in coastal areas between Gympie and Brisbane.

The Mary River at Gympie is continuing to rise and at 0500 was 17.1 metres and rising fast with major flooding in the Gympie area.

The river will continue rising and reach 1989 flood levels this morning (19.6 metres), with further rises expected today and overnight. Residents should prepare for flood levels higher than 1989 levels later today.

As the main flood waters travel downstream, moderate flooding will continue in the Tiaro to Maryborough areas.

Significant river rises are expected to continue today in the Noosa River and other coastal rivers and streams along the Sunshine Coast, causing areas of flooding and traffic hazards.

Motorists are warned not to enter flooded crossings.

WARNING NO 8 - Renewal issued at 1000 Saturday 22/2/92

Heavy rainfall is continuing in the Mary River headwaters and in the Sunshine Coast Streams.

Major flood levels at Gympie will continue rising today. At

1000, the Mary River at Gympie was 19.95 metres rising. The Gympie River level is predicted to reach about 21.0 metres by 1800 this evening which is 1.4 metres higher than the 1989 flood.

Based on upstream river rises, early indications are that Gympie should peak between the 21 to 22 metre level around midnight. Peak height predictions for Gympie will be updated as flood peaks are recorded upstream today. Flood levels have peaked in the Kenilworth area.

As the main flood waters travel downstream, fast river rises will occur along the Mary River downstream to the Tiaro area. Major flood levels will peak in the Miva to Tiaro reach during Sunday morning. Minor flood levels will be reached at Maryborough later today. Moderate flooding is expected to develop in the Maryborough area during Sunday.

Flooding is continuing in the Sunshine Coast area and Hinterland. River rises are expected to continue today in the Noosa River. Details will be provided in the flood warning for Sunshine Coast streams.

Motorists are warned not to enter flooded crossings.

WARNING NO 9 - Renewal issued at 1300 Saturday 22/2/92

Rainfall in the Mary River catchment has eased to about 20 millimetres in the 3 hours to 12 noon although heavy rainfall of 63 millimetres continued in the Kandanga area.

The main flood peak in the Mary River is located upstream from the Dagan Pocket area. Major flood levels at Gympie will continue rising today. At noon, the Mary River at Gympie was 20.5 metres rising. The Gympie River level is predicted to reach about 22.0 metres by midnight tonight which is about 2.5 metres higher than the 1989 flood.

Based on upstream river rises, indications are that Gympie should peak at about 22 metres between midnight and 0600 Sunday morning. Peak height predictions for Gympie will be updated as flood peaks are recorded upstream today.

As the main flood waters travel downstream, fast river rises will occur along the Mary River downstream to the Tiaro area. Major flood levels will peak in the Miva to Tiaro reach during Sunday. Minor flood levels will be reached at Maryborough later today. Moderate flooding is expected to develop in the Maryborough area during Sunday.

Flooding is continuing in the Sunshine Coast area and Hinterland. Details are been provided in the flood warning for Sunshine Coast streams.

Motorists are warned not to enter flooded crossings.

WARNING NO 10 - Renewal issued at 1610 Saturday 22/2/92

Rainfall in the Mary River catchment has eased with few stations reporting totals over 20 millimetres in the last three hours.

The Mary River at Dagan Pocket was 17.39 metres at 1500 and is expected to peak in the next few hours.

Major flood levels will continue to rise at Gympie for the next 12 hours and the peak height is expected to be about 22.0 metres, or slightly above, around 0300 Sunday morning. This is about 2.5 metres higher than the 1989 flood.

As the main flood waters travel downstream, fast river rises will occur along the Mary River downstream to the Tiaro area. Major flood levels will peak in the Miva to Tiaro reach during Sunday.

At Maryborough, the moderate flood level of 8 metres is expected to be reached by early Sunday afternoon. Major flood levels are expected overnight Sunday.

Flooding is continuing in the Sunshine Coast area and Hinterland. Details will be provided in the flood warning for Sunshine Coast streams.

Motorists are warned not to enter flooded crossings.

WARNING NO 11 - Renewal issued at 1845 Saturday 22/2/92

Only light rainfall was reported in the Mary River catchment in the last three hours.

Major flood levels will continue at Gympie tonight with a peak below 22.0 metres expected around midnight.

The main flood peak will travel downstream of Gympie overnight and river rises will occur along the Mary River downstream to the Tiaro area. Major flood levels will peak in the Miva to Tiaro reach during Sunday.

At Maryborough, the moderate flood level of 8 metres is expected to be reached by early Sunday afternoon. Major flood levels are expected overnight Sunday.

Motorists are warned not to enter flooded crossings.

WARNING NO 12 - Priority Renewal issued at 2200 Saturday 22/2/92

Only light rainfall was reported in the Mary River catchment in the last six hours.

Major flooding will continue at Gympie tonight. At 2100, the Mary River at Gympie was 21.44 rising very slowly and expected to peak below the 22.0 metres level around midnight.

The main flood crest will travel downstream of Gympie overnight and major flood peaks are expected in the Miva to Tiaro reach during Sunday.

At Maryborough, the river is expected to rise to the moderate flood level of 8 metres by late Sunday afternoon with further rises anticipated overnight on Sunday.

Motorists are warned not to enter flooded crossings.

WARNING NO 13 - Renewal issued at 0530 Sunday 23/2/92

Only light drizle was reported in the Mary River catchment overnight.

The Mary River at Gympie peaked at 21.5 metres at around 2200 last night and is now falling slowly. At 0300 this morning the river at Gympie was 21.1 metres and falling very slowly. Major flooding will ease very slowly at Gympie today.

The main flood crest will travel downstream of Gympie today with major flood peaks expected in the Miva to Tiaro reach during today.

At Maryborough, the river is expected to rise to the moderate flood level of 8 metres by late Sunday afternoon with further rises anticipated overnight on Sunday.

Motorists are warned not to enter flooded crossings.

WARNING NO 14 - Renewal issued at 1000 Sunday 23/2/92

Only light drizle was reported in the Mary River catchment overnight.

The Mary River at Gympie peaked at 21.5 metres at around 2200 last night and is now falling slowly. At 0900 this morning the river at Gympie was 20.4 metres and falling very slowly. Major flooding will ease very slowly at Gympie today.

The main flood waters are located in the Miva area. River levels downstream of Miva are rising slowly.

At Maryborough, the river is expected to reach 8 metres by this afternoon, with further steady rises to a peak around the major flood level of 9.0 metres by 0600 tomorrow (Monday) morning.

Motorists are warned not to enter flooded crossings.

WARNING NO 15 - Renewal issued at 1300 Sunday 23/2/92

At 1200 the Mary River at Gympie was 19.75 metres and falling very slowly. Major flooding will ease slowly at Gympie today.

At 1200 the Mary River at Miva was peaking at a level of 20.45 metres. Levels downstream of Miva are continuing to rise slowly. A major flood peak is expected at Tiaro this afternoon.

At Maryborough, the river is expected to reach 8 metres by later this afternoon, with further steady rises to a peak around the major flood level of 9.0 metres by 0600 tomorrow (Monday) morning.

Motorists are warned not to enter flooded crossings.

WARNING NO 16 - Renewal issued at 1600 Sunday 23/2/92

At 1500 the Mary River at Gympie was 19.2 metres and falling very slowly. Major flooding will ease slowly at Gympie today.

At 1500 the Mary River at Tiaro was 18.1 metres and rising slowly, causing major flooding and is expected to peak in the next few hours.

At Maryborough, the river is expected to reach 8 metres by later this afternoon, with further steady rises to a peak around the major flood level of 9.0 metres by 0600 tomorrow (Monday) morning.

WARNING NO 17 - Renewal issued at 1900 Sunday 23/2/92

At 1800 the Mary River at Gympie was 18.6 metres and falling slowly. Flooding will ease slowly at Gympie throughout tonight and tomorrow.

At 1800 the Mary River at Tiaro was 18.35 metres and rising slowly, nearing its peak and causing major flooding.

At 1800 the Mary River at Maryborough was 7.90 metres and rising slowly and is expected to peak around the major flood level of 9.0 metres around 0600 tomorrow (Monday) morning.

WARNING NO 18 - Renewal issued at 2200 Sunday 23/2/92

At 2100 the Mary River at Gympie was 17.9 metres and fallin slowly. Flooding will ease slowly at Gympie throughout tonight and tomorrow.

At 2100 the Mary River at Tiaro was 18.45 metres and rising very slowly and nearing its peak with major flooding.

At 2100 the Mary River at Maryborough was 8.40 metres and rising slowly and is expected to peak around the major flood

level of 9.0 metres around 0600 tomorrow (Monday) morning.

WARNING NO 19 - Renewal issued at 0545 Monday 24/2/92

At 0300 the Mary River at Gympie was 16.4 metres and falling slowly. Flooding will ease slowly at Gympie during the next few days.

At 0400 the Mary River at Maryborough was 9.1 metres and close to its peak. River levels will rise only very slowly in the next few hours before commencing to fall slowly today.

WARNING NO 20 - Renewal issued at 0815 Monday 24/2/92

River levels at Gympie have falling below major flood level overnight and will continue easing.

River levels have peaked in the Tiaro area upstream from Maryborough. Tiaro peaked at about 18.6 metres at around midnight.

At 0800 this morning the river at Maryborough was 9.35 metres and rising very slowly. The peak is expected within the next few hours. Only a slight rise of about 10 centimetres is expected in the next few hours. River levels at Maryborough will commence to fall slowly later today.

WARNING NO 21 - Renewal issued at 1230 Monday 24/2/92

River levels at Gympie have fallen below major flood level overnight and will continue falling.

River levels have peaked in the Tiaro area upstream from Maryborough. Tiaro peaked at about 18.6 metres at around midnight.

At noon today the river at Maryborough was 9.47 metres and rising very slowly. The river is now very close to its peak height. The river should commence to fall slowly later today.

WARNING NO 22 - Renewal issued at 1700 Monday 24/2/92

River levels at Gympie have fallen below major flood level and will continue falling.

At 1600 the river at Maryborough was 9.50 metres and steady. The river is now at its peak at Maryborough and will fall only very slowly during tonight. Areas of major flooding and traffic hazards will continue throughout the night.

WARNING NO 23 - Renewal issued at 2200 Monday 24/2/92

River levels at Gympie have fallen below moderate flood level and will continue falling.

The Mary River at Maryborough peaked at 9.50 metres at 1600 today causing major flooding. At 2000 the river at Maryborough was 9.35 metres and falling very slowly. Major flooding and traffic hazards will continue throughout the night.

WARNING NO 24 - Renewal issued at 1015 Tuesday 25/2/92

Although heavy rain of 73 millimetres has fallen at Gympie overnight, no significant rain has fallen in the upper catchment above Gympie. The effect on river levels in the Gympie area will be negligible.

River levels at Gympie have fallen below moderate flood level and will continue falling during today.

Further showers are expected in the Maryborough area today but these will not effect river levels.

At 0900 the river at Maryborough was 8.4 metres and falling. Moderate flooding and traffic hazards will continue throughout today.

WARNING NO 25 - Renewal issued at 1600 Tuesday 25/2/92

No significant rain has fallen in the upper catchment above Gympie since 0900.

River levels at Gympie have fallen below moderate flood level and will continue falling during tonight.

Some local heavy falls can be expected in the Maryborough area tonight but these will not effect river levels.

At 1400the river at Maryborough was 7.55 metres and falling. Moderate flooding and traffic hazards will continue throughout today.

WARNING NO 26 - Renewal issued at 2100 Tuesday 25/2/92

No significant rain has fallen in the upper catchment above Gympie today.

River levels at Gympie have fallen below moderate flood level and will continue falling during tonight.

Some local heavy falls can be expected in the Maryborough area tonight but these will not effect river levels.

At 2000 the river at Maryborough was 6.55 metres and falling. Minor flooding and traffic hazards will continue throughout tonight.

WARNING NO 27 - Final issued at 1000 Wednesday 26/2/92

River levels in the Mary River are below minor flood levels and continuing to fall. At 0600 this morning, the river at Maryborough was 4.75 metres and falling. No further heavy rainfalls are expected in the area today.

SUNSHINE COAST RIVERS AND STREAMS

WARNING NO 1 - Initial issued at 1015 Saturday 22/2/92

Heavy rainfalls in the catchments of the Noosa, Maroochy and Moolooba rivers overnight is causing fast river rises and flooding in downstream areas. (Tewantin has received 732mm, and Yandina 668mm in the past 24 hrs.)

Rainfall intensity has increased in the past 3 hours which will maintain current river rises. In the 6 hours from 0300 to 0900 this morning rainfalls were: Eumundi 56mm, Cooroy 75mm, and Pomona 65mm.

River levels on the Noosa River at Lake Cootharaba and Cooroibah are above major flood level and rising with major flooding. As this water travels downstream during today, major flooding is expected in the Tewantin area.

The river at Tewantin is likely to reach major flood levels (2.0 metres) during the high tide around noon today. Flood levels similar to 1968 flood levels are expected.

WARNING NO 2 - Renewal issued at 1245 Saturday 22/2/92

Heavy rainfalls in the catchments of the Noosa, Maroochy and Moolooba rivers overnight is causing fast river rises and flooding in downstream areas.

Rainfalls during the past 3 hours will maintain current river rises. In the 3 hours to noon this morning rainfalls were: Eumundi 24mm, Cooroy 20mm, and Pomona 17mm.

River levels on the Noosa River at Lake Cootharaba and Cooroibah are above major flood level and rising with major flooding. As this water travels downstream during today, major flooding is expected in the Tewantin and Noosaville areas.

The river at Tewantin is likely to reach major flood levels today and remain high overnight. Upstream river levels have exceeded 1968 flood levels.

WARNING NO 3 - Renewal issued at 1615 Saturday 22/2/92

Heavy rainfall has eased in the catchments of the Noosa, Maroochy and Moolooba rivers during the past 6 hours. Rainfalls are forecast to continue easing, although showers and light rain areas will continue overnight.

Flood levels in the Maroochy and Mooloolah River areas are expected to ease slowly overnight and Sunday.

River levels on the Noosa River at Lake Cootharaba and Cooroibah are above major flood level and rising. River levels downstream in the Tewantin and Noosaville areas will continue rising slowly this evening causing areas of major flooding.

WARNING NO 4 - Renewal issued at 1845 Saturday 22/2/92

Heavy rainfall has eased in the catchments of the Noosa, Maroochy and Moolooba rivers. Rainfalls are forecast to continue easing, although showers and light rain areas will continue overnight.

Flood levels in the Maroochy and Mooloolah River areas are expected to ease slowly overnight and Sunday.

The river level on the Noosa River at Lake Cooroibah is above major flood level and rising very slowly. River levels downstream in the Tewantin and Noosaville areas will continue rising slowly tonight with the tide causing areas of major flooding.

WARNING NO 5 - Renewal issued at 2145 Saturday 22/2/92

Heavy rainfall has eased in the catchments of the Noosa, Maroochy and Moolooba rivers and no significant reports have been received in the last 6 hours.

Showers, with some heavier falls, are possible overnight.

Flood levels in the Maroochy and Mooloolah River areas are expected to ease slowly overnight and Sunday.

River levels downstream in the Tewantin and Noosaville areas will continue rising slowly tonight with the tide causing areas of major flooding.

WARNING NO 6 - Renewal issued at 0545 Sunday 23/2/92

Heavy rainfall has eased in the catchments of the Noosa, Maroochy and Moolooba rivers and no significant reports have been received overnight. No further heavy rain is expected in these areas today.

Flood levels in the Maroochy and Mooloolah River areas are expected to ease slowly during today.

On the Noosa River, lake levels at Cootharaba and Cooroibah are still rising slowly. River levels downstream in the Tewantin and Noosaville areas will continue rising slowly today, causing areas of major flooding.

WARNING NO 6 - Renewal issued at 0945 Sunday 23/2/92

Flood levels in the Maroochy and Mooloolah River areas will continue to ease slowly today.

On the Noosa River, levels at Cootharaba and Cooroibah Lakes have peaked overnight and are now falling slowly. River levels downstream in the Tewantin and Noosaville areas will continue rising slowly with the tide this morning and reach a moderate flood peak around midday today. Flood levels are not expected to be as high as last night.

WARNING NO 7 - Final issued at 1300 Sunday 23/2/92

On the Noosa River, the level at Lake Cooroibah was 2.50 metres and falling at noon.

In the Tewantin and Noosaville areas, river heights will remain at current levels for the next few hours, and perhaps rise slightly due to tidal effects, but flood levels are not expected to be as high as last night.