COASTAL RIVERS FLOODS
NORTHERN QUEENSLAND
FEBRUARY 1994

Queensland Regional Office
Bureau of Meteorology

February 1994

Contents

List of Figures

List of Tables

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INTRODUCTION

During the period 30 January to 1 February 1994, very heavy rainfalls were recorded in coastal areas from Cairns to Ingham, shown in Figure 1. As a result, significant flooding occurred in the main river systems of the Johnstone, Tully and Herbert Rivers and smaller adjacent coastal streams.

The purpose of this brief report is to record the meteorological and hydrological aspects of the flooding during the period and to examine the performance of the flood warning system.

METEOROLOGICAL ANALYSIS

Mean Sea Level Analysis

At 9am 29 January the Monsoon trough extended across the far north of Cape York Peninsula linking a low pressure centre of approximately 1006 hpa southwest of the Solomon Islands to a 1002 hpa low to the north of Gove. In the mid latitudes a high pressure system over the central Tasman Sea extended a firm ridge along Queensland's east coast.

Over the next 12 to 24 hours the system to the north of Gove developed rapidly and moved southeast at about 20 kilometres per hour to be located in the eastern Gulf of Carpentaria by 9am 30 January. The system was named tropical cyclone "Sadie" with a central pressure of 992 hpa. "Sadie" continued to move in a southeast direction crossing the coast north of Normanton by 9am 31 January. "Sadie" then moved further southeast, degenerating to a tropical low, to be near Winton by 9am 1 February. During this period the high in the Tasman Sea remained stationary and maintained intensity, extending a firm ridge along Queensland's east coast. This pressure pattern produced broadscale confluence over the north coast region of Queensland extending from Cooktown to Townsville and gradually moving southward with the movement of the degenerating tropical cyclone "Sadie", as indicated on Figure 2.

Tropospheric Analysis

The low to mid levels were generally dominated by cyclonic flow over the Gulf of Carpentaria and anticyclonic flow over the Coral Sea generating a zone of convergence on the north tropical coast. The onshore airstream persisted along the coast for several days providing moisture through a deep layer of the atmosphere. The wind profiles at Cairns and Townsville between 9am 29 January and 9am 1 February indicate significant warm air advection to at least 300 hpa.

Topographical Influences

As is evident from the 72 hour rainfall totals to 9am 1 February (Refer to Figure 3 and Table 1) the higher rainfalls were recorded on and east of the ranges. This suggests orographic uplift played an important role in this heavy rainfall event.

Conclusion

The factors seen as most important in the development of this heavy rainfall event are:

1. High moisture content through a deep layer of the troposphere;
2. Marked convergence in the low to mid levels;
3. Orographic lifting; and
4. Significant warm air advection.

RAINFALLS

Rainfall Totals

A list of rainfall totals recorded in the 72 hours to 9am 1 February 1994 appears in Table 1. Note that some totals are for periods greater than 24 hours, shown by notation signifying the number of days over which the rainfall was recorded.

The isohyetal map of rainfall of the region during the 72 hour period, Figure 3, shows that the heaviest rainfalls were recorded in the coastal fringes and that rainfall totals decreased markedly away from the coast.

In the Johnstone River, the heaviest rainfalls were recorded in the middle reaches of the catchment around Crawfords Lookout where nearly 700 mm was recorded in the 72 hours. Totals in the tablelands area above Crawfords Lookout were generally below 250 mm for the same period while totals downstream of Crawfords Lookout were mostly around 500 mm.

The spatial pattern of rainfalls in the Tully and Herbert River systems was similar with the heaviest falls being recorded in the coastal fringe and decreasing markedly with distance from the coast.

In the Herbert River, the heaviest falls were recorded in the Stone River sub-catchment where totals exceeded 500 mm while in the upper Herbert above Gleneagle, totals for the 72 hour period were below 100 mm, again decreasing with distance from the coast.

Table 1
Daily Rainfalls
(millimetres)

Station	30 January	31 January	1 February	72 Hour Total
Malanda ALERT	..	165/2D	44	209
McKell Road ALERT	35	97	38	170
Topaz	87	297	26	410
Topaz ALERT	87	302	24	413
Millaa Millaa	65	146	40	251
Millaa Millaa ALERT	60	128	32	220
Bartle View	111	294	30	435
Greenhaven	89	135	38	262
Greenhaven ALERT	84	133	32	249
Sutties Creek ALERT	84	211	22	317
Crawfords Lookout	123	472	41	636
Crawfords Lkt ALERT	127	529	36	692
Nerada ALERT	118	436	39	593
Mena Vale ALERT	161	323	74	558
Corsis ALERT	157	464	68	689
Tung Oil ALERT	138	329	71	538
Central Mill TM	84	287	125	496
Innisfail ALERT	153	250	93	496
Ravenshoe	..	103/2D	17	120
Silver Valley TM	15	41	3	59
Mt Garnet	12	19	5	36
Murray Springs ALERT	14	80	4	98
Gleneagle	13	60	4	76
Gleneagle ALERT	12	59	9	80
Wallaman ALERT	49	170	67	286
Zattas TM	45	165	66	276
Abergowrie ALERT	52	204	153	409
Abergowrie Bridge	52	271	227	550
Upper Stone	..	337/2D	183	520
Peacock Siding ALERT	22	310	225	557
Ingham	21	309	216	546
Ingham ALERT	23	293	179	495
Koombooloomba Dam	58	180	34	272
Cardstone TM	85	193	37	315
Kareeya	..	230/2D	27	257
Tully	159	394	88	641
Tully TM	146	304	157	607
Euramo TM	..	563/2D	139	702
Cardwell	48	400	251	699

Rainfall Temporal Patterns

Rainfall mass curves and hyetographs were plotted for selected representative stations in each of the three catchments of main interest. These graphs appear in Figures 4 to 7.

The rainfall mass curves, Figure 4, show clearly the onset of the heaviest rainfall at each of the three stations and the movement of the rain bearing system down the coast from the Innisfail area around 6am Monday 31 January morning, through the Tully area around 9am and onto the Stone River area early Monday afternoon 31 January.

From 9am Saturday 30 January to around midnight Sunday, the rainfall in the Johnstone system, represented by Crawfords Lookout ALERT station, was reasonably steady. By this time a total of 263 mm or 40% of the storm total had been recorded. The period of heaviest rain in the catchment was recorded after this time when 394 mm or 55% of the storm total was recorded in the 9 hours up to 9am 31 January 1994.

Due to equipment failure, indicated in Figure 5 by the block of rainfall between 1am and 7am, it is not possible to accurately determine the maximum rainfall intensity but it is estimated that it may have been as high as 75 mm per hour.

Figure 6 shows that the heavier rainfall did not begin in the Tully River, represented by Tully TM station, until late Sunday 30 January. In the 18 hours to 9.30am 31 January, over 300 mm was recorded, with the maximum intensity estimated at 40 mm per hour.

In the Herbert River, the heavy rainfall commenced about noon on Sunday 30 January and continued for 27 hours until 3pm on Monday 31 January. During this period over 450 mm, 85% of the storm total, was recorded at Peacock Siding ALERT station. This station, the hyetograph for which is shown in Figure 7, is considered to be typical of the rainfall pattern in the lower Herbert system. The most intense period of rain at Peacock Siding occurred in the 3.75 hours to 12.45pm Monday 31 January when over 150 mm was recorded. The average intensity during this period was nearly 45 mm per hour.

FLOODS

Table 2 shows the peak heights recorded and the nature of flooding in the northern Queensland coastal rivers over the period 29 January to 2 February 1994.

Table 2
Peak Flood Heights
(metres)

Stream	Station	Peak		
		Height	Time	Date
Nth Johnstone R	Nerada	8.50	0820	31/01/94
	Tung Oil	9.80	0900	31/01/94
Sth Johnstone R	Corsis	8.68	0820	31/01/94
	Central Mill	10.68	1055	31/01/94
Johnstone R	Innisfail Wharf	5.70	1240	31/01/94
Tully R	Euramo	8.91	0400	01/02/94
Herbert R	Abergowrie	9.25	1900	31/01/94
	Abergowrie Br	8.05	1510	31/01/94
Stone R	Peacock Siding	13.45	1630	31/01/94
Herbert R	Ingham	12.80	2355	31/01/94
	Gairloch	11.10	0000	01/02/94
	Halifax	5.25	0600	01/02/94

Johnstone Rivers

While river rises had been monitored in the Johnstone system as early as Sunday afternoon, the observed rainfalls had not been sufficient to cause significant flooding. However, the onset of the early morning heavy rain caused very rapid rises in the lower reaches of both the North and South Johnstone Rivers. At Tung Oil, the North Johnstone River rose from 3.9 metres at 2.40am to 9.8 metres at 9am, an average rise of nearly 1 metre per hour. Similarly, the South Johnstone River at Central Mill rose from 5.3 metres at midnight Sunday to 10.7 metres at 10am Monday, an average rise of 0.5 metres per hour.

The peak discharge of the North Johnstone River at Tung Oil was approximately 3900 m3 per sec while the estimated peak at Central Mill was 1800 m3 per sec.

At Innisfail Wharf ALERT site, the Johnstone River reached the minor flood level of 5.0 metres at 10am and peaked at 5.70 metres at 12.40pm, causing moderate

flooding. This flood is the highest height recorded at Innisfail since the February 1986 flood when the river reached 6.4 metres.

Information from Johnstone Shire Council advises that flood damage to infrastructure was of the order of $300 000 and that losses to the private sector was limited to uninsurable crops losses and damage to farm machinery. While flood waters inundated residential areas, there were no significant reports of over-floor flooding.

However, topsoil erosion and damage to stream banks was significant.

Tully River

In the Tully basin, the River at Euramo commenced a steady climb from 9am Sunday when it was approximately 3 metres until 2pm Monday by which time it had reached 8.1 metres, at which it commences to cover the Bruce Highway approaches to the Tully River bridge.

Thereafter, the rate of rise slowed appreciably until the peak was attained at 8.91 metres at 4am Tuesday, just below major flood level.

Herbert River

River rises were first generally recorded in the lower Herbert River system late Sunday night. However, the Stone River at Peacock Siding rose quickly from 1.00 metres at 6pm on Sunday to 13.45 metres at 4.30pm on Monday, an average rate of rise of about 0.5 metres per hour.

At Abergowrie ALERT where rainfalls were significantly less intense than in the Stone River, the Herbert River rose steadily from 1.5 metres at 6pm Sunday up to a peak of 8.05 metres at 3pm Monday, an average rate of rise of only 0.3 metres per hour.

The estimated peak discharge at Ingham was 3500 cubic metres per second, with approximately 60% of the total storm runoff from the catchment area below Abergowrie. The estimated peak flow at Abergowrie and Peacock Siding was 1900 and 2170 cubic metres per second respectively.

The rise in the Herbert River at Ingham occurred about 4 hours after that observed at Peacock Siding.

FLOOD WARNING

River Height Prediction Objectives

Quantitative prediction and warnings are given for the Johnstone, Tully and Herbert Rivers at Innisfail, Euramo and Gairloch respectively.

In the Johnstone system, the Bureau's objective is to provide 6 hours lead time of heights of 5.0 metres or greater at Innisfail.

Warning lead times of 6 to 12 hours are given by the Bureau for the Tully River at Euramo for heights greater than 7.0 metres.

In the Herbert River, the Bureau attempts to provide 6 to 12 hours lead time for predicted heights of 9.0 metres or greater at Gairloch. However, this lead time varies greatly with the location of the heavy rainfall within the catchment.

Flood Warning Networks

The flood warning networks for the Johnstone, Tully and Herbert Rivers are shown in Figure 1.

1. Johnstone Rivers

The main source of data in the Johnstone system is the ALERT radio telemetry system which reports directly to the base station at Johnstone Shire Council. This is supplemented by two Department of Primary Industry,Water Resources, telephone telemetry stations at Central Mill and Tung Oil. Additional data is supplied from manual rainfall readers at several stations.

Overall, the flood warning network performed quite well, with a couple of exceptions :-

a. Power at the ALERT base station was lost from about 1am to 8am. Unfortunately, this was a critical period with the most intense rainfalls and, whilst the rainfall accumulators at each rainfall station continued to work, the detail of the temporal pattern of the rainfall was lost for this period.

b. While all 14 ALERT rainfall stations appeared to have functioned correctly, there were malfunction at two of the five river height stations. At Tung Oil ALERT, it appears that the station malfunctioned well before the power loss while at Central Mill ALERT, the station appears to have lost calibration during the power outage. Fortunately, the loss of data from these two ALERT sites was covered by backup readings available from the telemeters at these respective sites, until loss of communications at the Tung Oil station just after the peak had been recorded.

c. Delays were experienced in contacting the telephone telemeters and base stations via the public telephone system. Several times during the event, the availability and quality of telephones into the Johnstone area was poor.

2. Tully River

The flood warning network in the Tully River relies mainly on telephone telemetered stations, supplemented with a few manual observers. Similarly to the Johnstone, problems encountered with the delays in retrieving data because of the congested public telephone network, otherwise the network performed well.

3. Herbert River

The flood warning network for the lower Herbert River consists mainly of an ALERT radio telemetry system reporting to the base station at Hinchinbrook Shire Council, supplemented by a few telephone telemeters and manual rainfall/river height stations. All 6 ALERT stations appeared to have reported well throughout this event.

However, similarly to the other catchments, delays were experienced in downloading data to the Bureau's computer system through the public telephone network.

Forecasting Models

Rainfall-based flood forecasting models were used in all three catchments as the basis for quantitative predictions.

1. Johnstone River

The predictive model for the Johnstone River to Innisfail consists of two unit hydrographs, at Tung Oil and Central Mill, the results of which are combined and routed to Innisfail Wharf. This model is supplemented by an empirical "addition of flows" technique.

The model depends upon the ALERT system for rainfall and river height data as input. Due to poor temporal definition of rainfalls in the period of the power loss, the unit hydrograph models did not accurately reproduce the observed peaks at Tung Oil and Central Mill but satisfactorily predicted the peak at Innisfail Wharf. Figure 8 shows the model results at Innisfail Wharf. Note that the model was run well after the flood using the recommended average loss parameters.

However, the ALERT data filtering process meant that the model was not able to be used until about 30 minutes after the restoration of power at the base station. The prediction for Innisfail, given in the Flood Warning issued at 9.30am on Monday, was therefore based upon simple addition of the peak flows at Tung Oil and Central Mill, a technique which proved sufficiently accurate.

2. Tully River

Quantitative predictions for the Tully River at Euramo are based upon a unit hydrograph model. As seen from Figure 9, the model only approximates the response of the River at Euramo but is sufficiently accurate for flood forecasting.

3. Herbert River

The lower Herbert River from Gleneagle to Halifax is modelled using an URBS rainfall routing model, linked directly to the ALERT data base.

During the early stages of the Herbert River flood, it became obvious that this flood with its heavy localised rainfall in the lower areas was very different to the events used to calibrate the model. Adjustments were made to the calibration factors at the start of the event and the resulting outcome, Figure 10, shows that the URBS model reproduces the hydrograph at Ingham reasonably well.

Warning Services

Flood warning services provided by the Bureau of Meteorology include regular Flood Warnings and River Height Bulletins, local agency consultations and media briefings. In these floods, all four services were provided.

River Height Bulletins were issued to media and response agencies regularly throughout the duration of the flood, generally being updated every three hours with the latest available data from manual and automatic river height stations.

The Flood Warning Centre (FWC) became operational on Sunday afternoon 30 January 1994 following advice from the Regional Forecasting Centre of observed heavy rainfalls and forecasts of further heavy rainfall. The FWC remained staffed almost continuous for the next 3 days, apart from the early morning hours.

1. Johnstone River

The first Flood Warning for the Johnstone River was issued at 7.30am on 31 January 1994. This warning, based on the limited available data, did not reflect the severity of the impending flood. By 9am when it became obvious that a significant flood in Innisfail was imminent, the Works Manager at Johnstone Shire was advised by telephone of the Innisfail flood height prediction. Top priority public Flood Warnings were issued shortly thereafter.

The flood performance diagram for Innisfail, Figure 11, shows that, while the warning issued at 9.30am did not satisfy the warning objectives and overestimated the flood peak, it was nevertheless a useful alert to the severity of the flooding expected at Innisfail.

The Johnstone River flood highlighted the necessity for simple techniques for flood forecasting based on limited data and the importance of direct contact between the FWC and the local response agency.

2. Tully River

Figure 12 shows the flood performance diagram for the Tully River at Euramo and indicates that the warning objectives were fully satisfied by public flood warnings.

3. Herbert River

Services in the Herbert consisted mainly of public Flood Warnings and direct consultations with Hinchinbrook Shire Council.

The issue of Flood Warnings commenced at 10am on Monday 31 January 1994 and regular issues throughout the day included rising limb predictions as shown in Figure 13. It was not until after the observed flood peak at Peacock Siding at 4.30pm that peak predictions were made for Gairloch.

The flood performance diagram for Gairloch shows that the warning objectives were adequately met.

RECOMMENDATIONS

As a results of these floods, several follow-up activities were identified to improve the performance of the flood warning system during the next event. Some of these activities may be dependent on the availabilty of funds.

1. Johnstone River

- Dry pressure transducers, to replace the existing unreliable shaft encoders, to be installed by the Bureau at Tung Oil and Central Mill.

- Johnstone Shire Council is considering the installation of additional river height stations in the Mourilyan and Goondi Mill areas.

- The Bureau to develop an URBS model for the catchment to backup and improve existing forecasting techniques.

2. Tully River

- Two additional telephone telemeters, planned for installation this financial year, to proceed.

3. Herbert River

- The calibration of the URBS model for the Herbert River to be reviewed.

- Installation of additional ALERT and telephone rainfall stations in the upper Herbert River, planned for this financial year, to proceed.

- Comments received from Hinchinbrook Shire re the inclusion of upper Herbert rainfalls and three hourly warning issue to be included in the Herbert River Flood Warning Directive and actioned next flood.

- Council and the Bureau to consider public education activities to inform the local community of the location and significance of the ALERT river height stations.

4. General

- The Bureau to continue to pursue more secure links for retrevial of data from ALERT base stations.

BUREAU OF METEOROLOGY
Queensland Regional Office

HERBERT, TULLY, JOHNSTONE AND BARRON RIVERS

FLOOD WARNING NETWORK

Figure 1

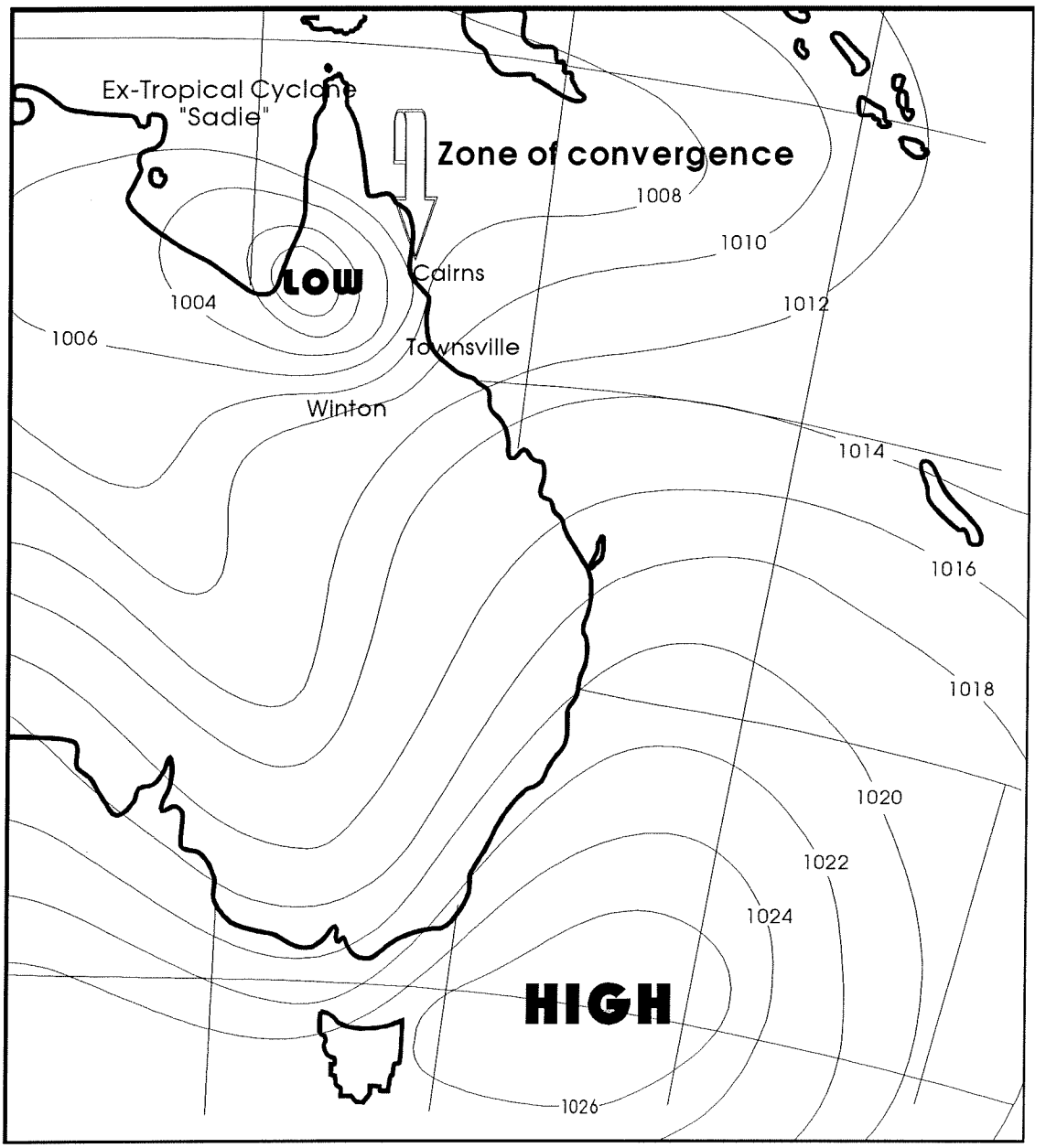
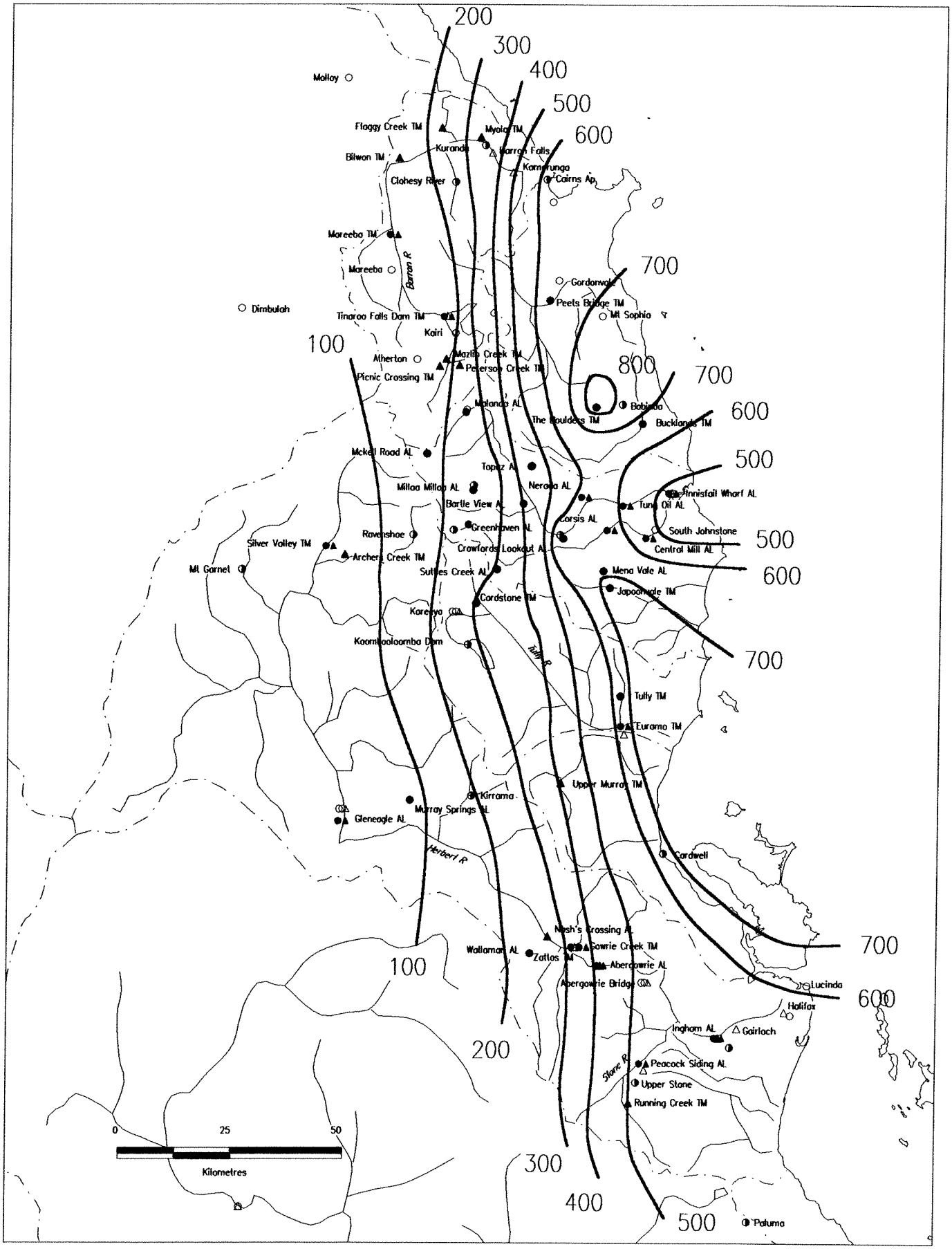


Figure 2. Mean Sea Level isobaric analysis at 9 am on the 31st of January 1994.



- Manual Heavy Rainfall Station
- Daily Reporting Rainfall Station
- Manual River Station
- Telemetry Rainfall Station
- Telemetry River Station

Herbert, Tully, Johnstone and Barron Rivers

Rainfall in Millimetres for the 72 Hours to 0900 1/2/94

Figure 3

Rainfall Mass Curves at Selected Stations

72 Hour Rainfalls to 0900 1/2/94

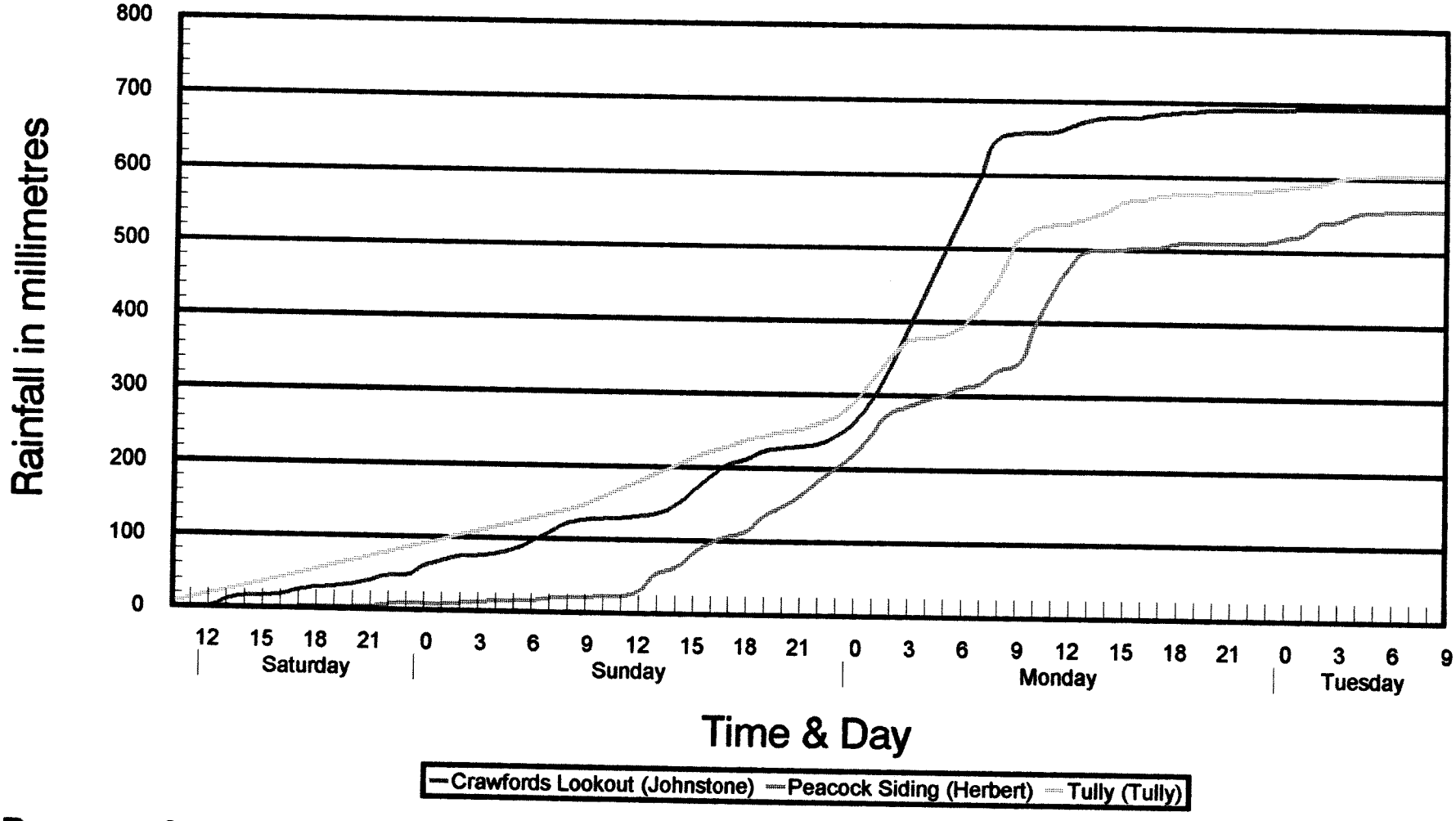


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Figure 4

Rainfall Hyetographs at Selected Stations

72 Hour Rainfalls to 0900 1/2/94

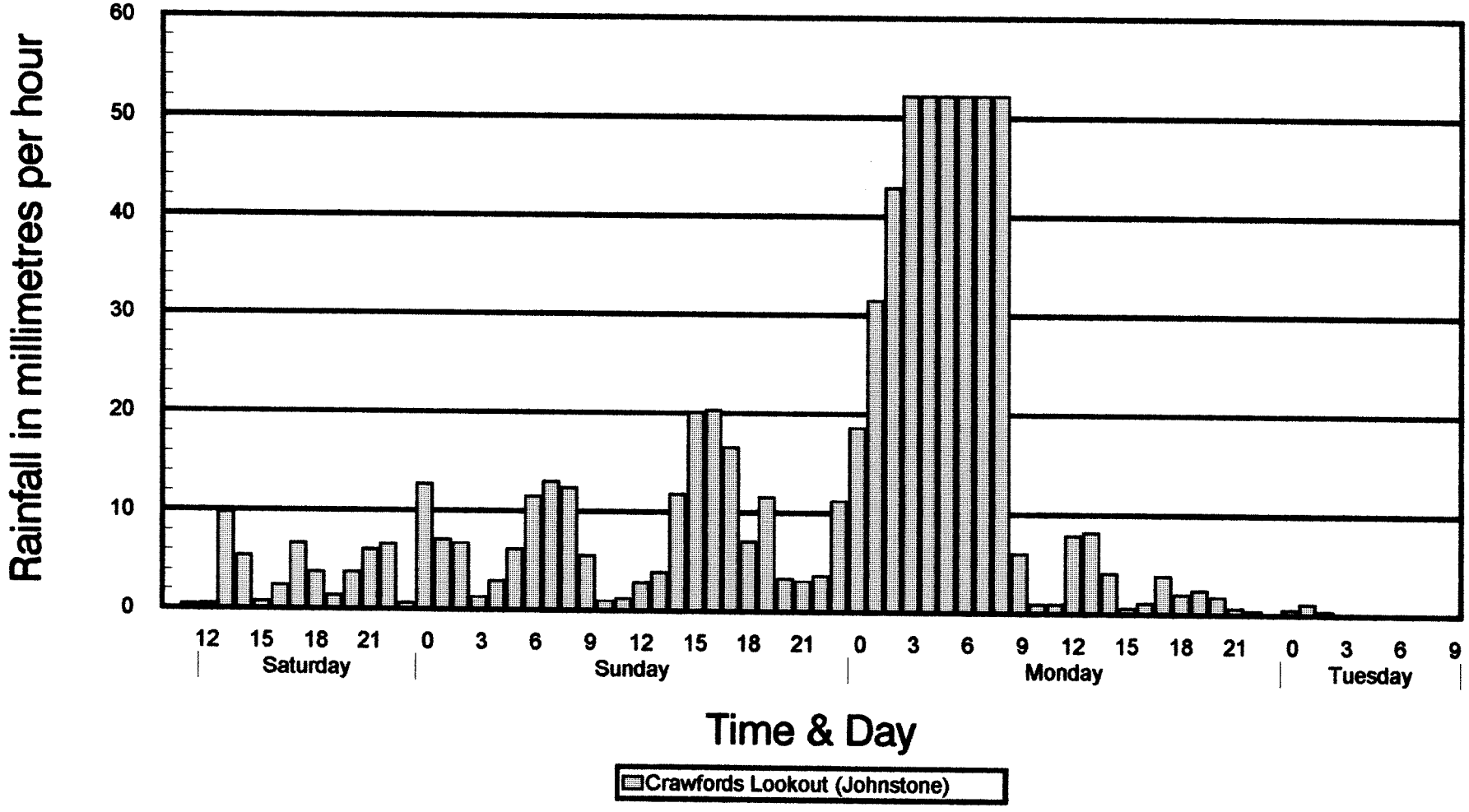

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Figure 5

Rainfall Hyetographs at Selected Stations

72 Hour Rainfalls to 0900 1/2/94

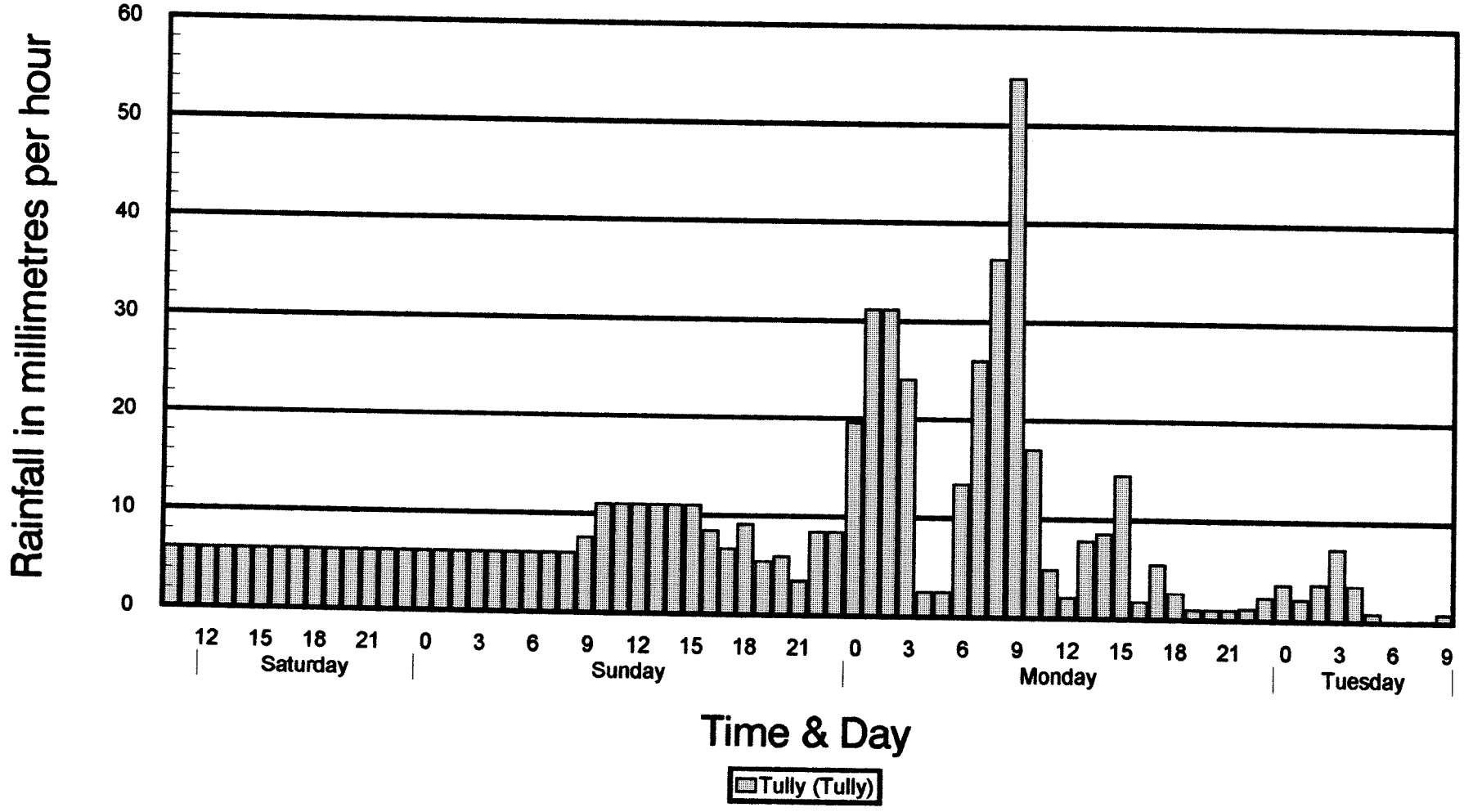

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Figure 6

Rainfall Hyetographs at Selected Stations

72 Hour Rainfalls to 0900 1/2/94

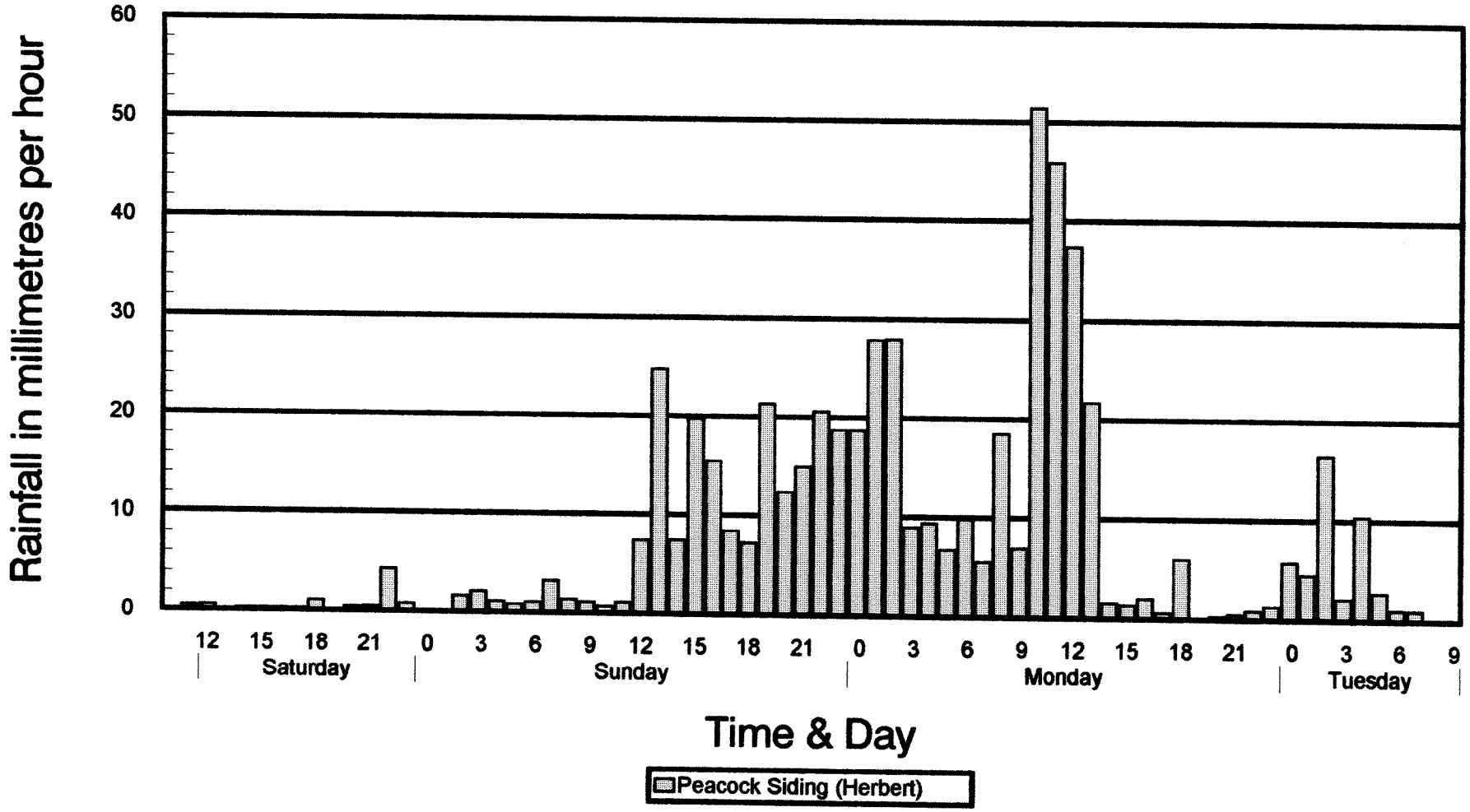

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Figure 7

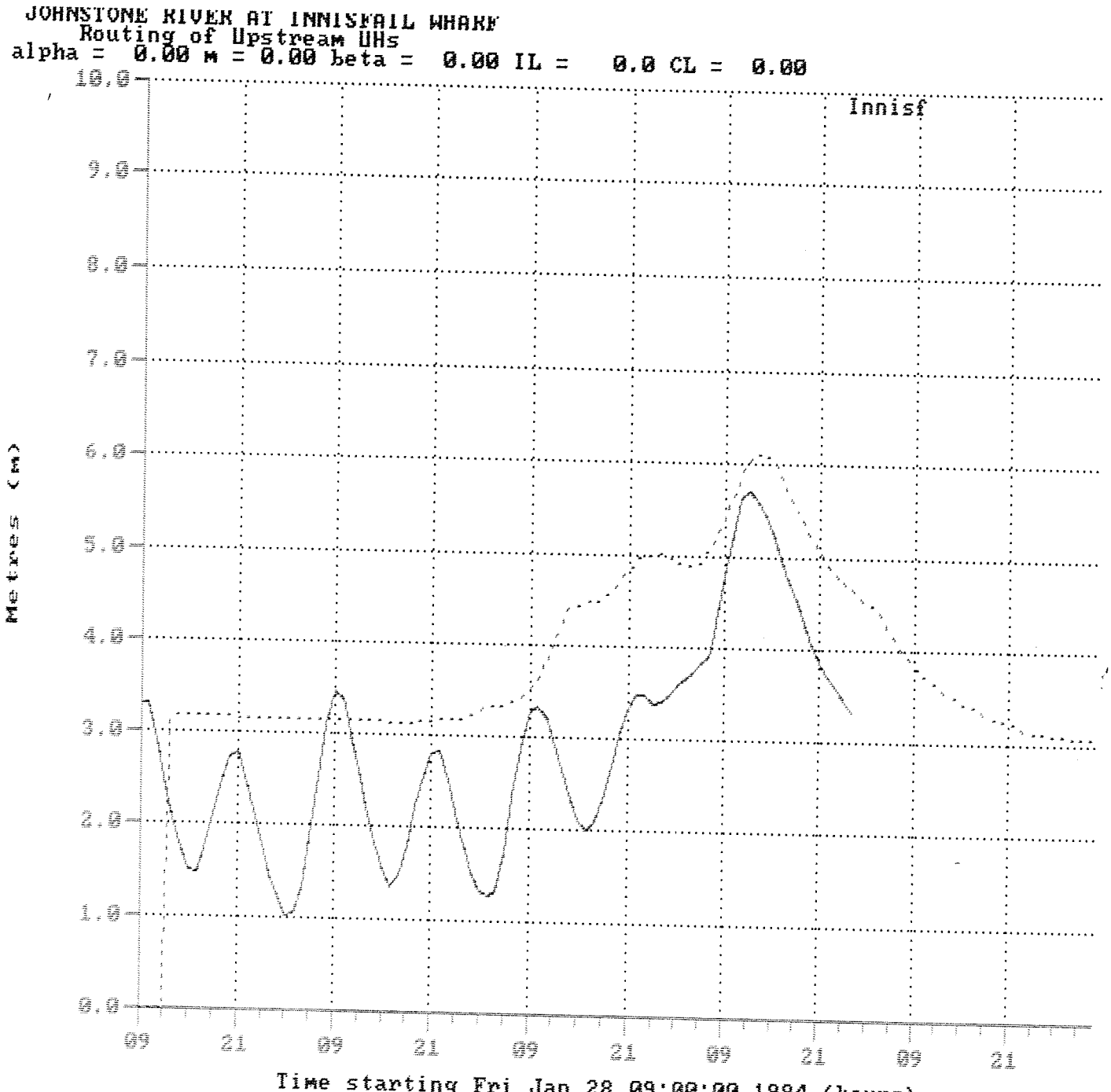

JOHNSTONE RIVER AT INNISFAIL WHARF
Routing of Upstream UHs
alpha = 0.00 m = 0.00 beta = 0.00 IL = 0.0 CL = 0.00
Innisf
Metres (m)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
09
21
09
21
09
21
09
21
09
21
Time starting Fri Jan 28 09:00:00 1994 (hours)
NOTE :- Solid line is Observed & Dotted line is Modelled

Figure 8

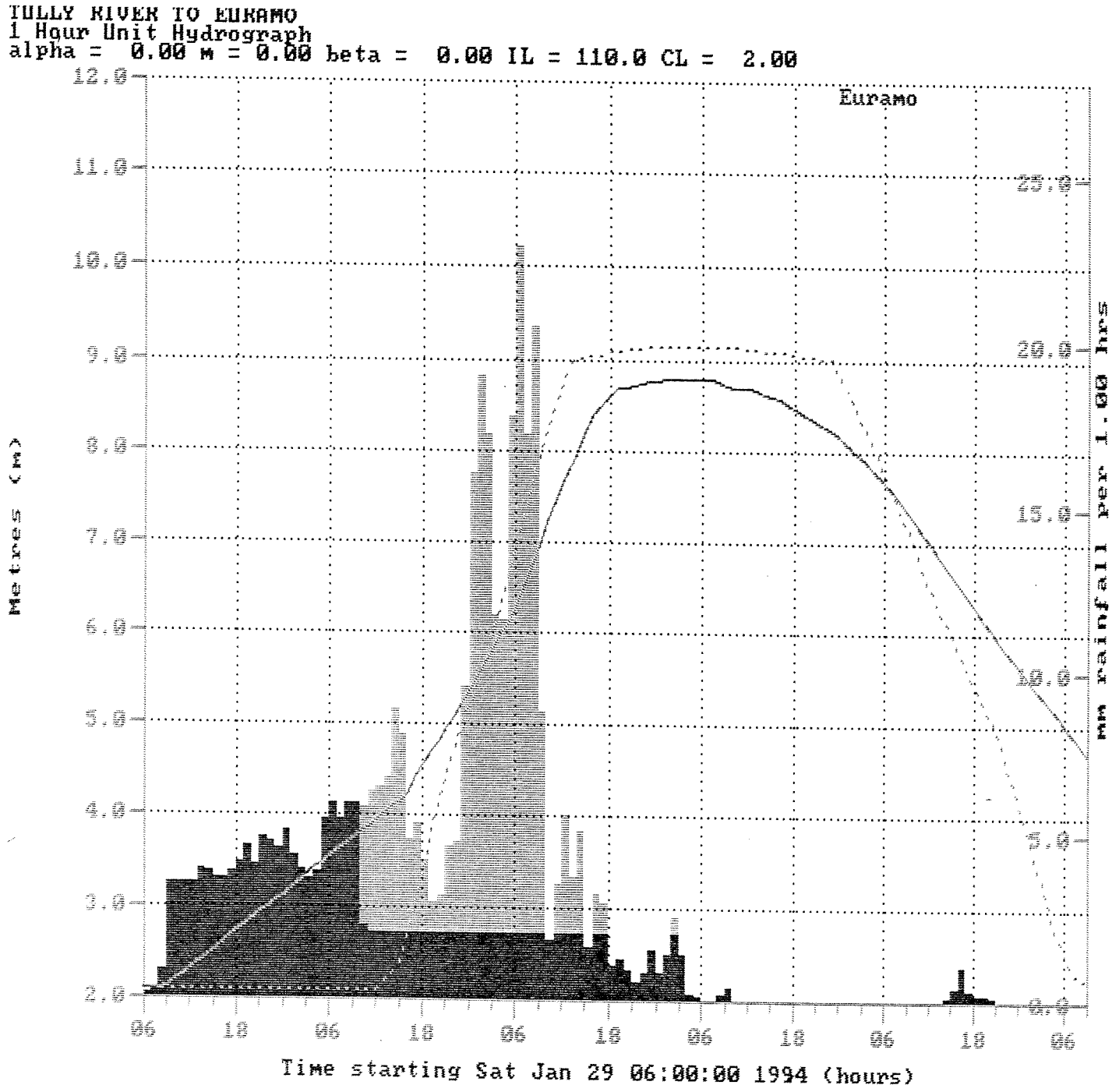

TULLY RIVER TO EURAMO
1 Hour Unit Hydrograph
alpha = 0.00 m = 0.00 beta = 0.00 IL = 110.0 CL = 2.00
Euramo
Metres (m)
mm rainfall per 1.00 hrs
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
25.0
20.0
15.0
10.0
5.0
0.0
06
18
06
18
06
18
06
18
06
18
06
Time starting Sat Jan 29 06:00:00 1994 (hours)

Figure 9

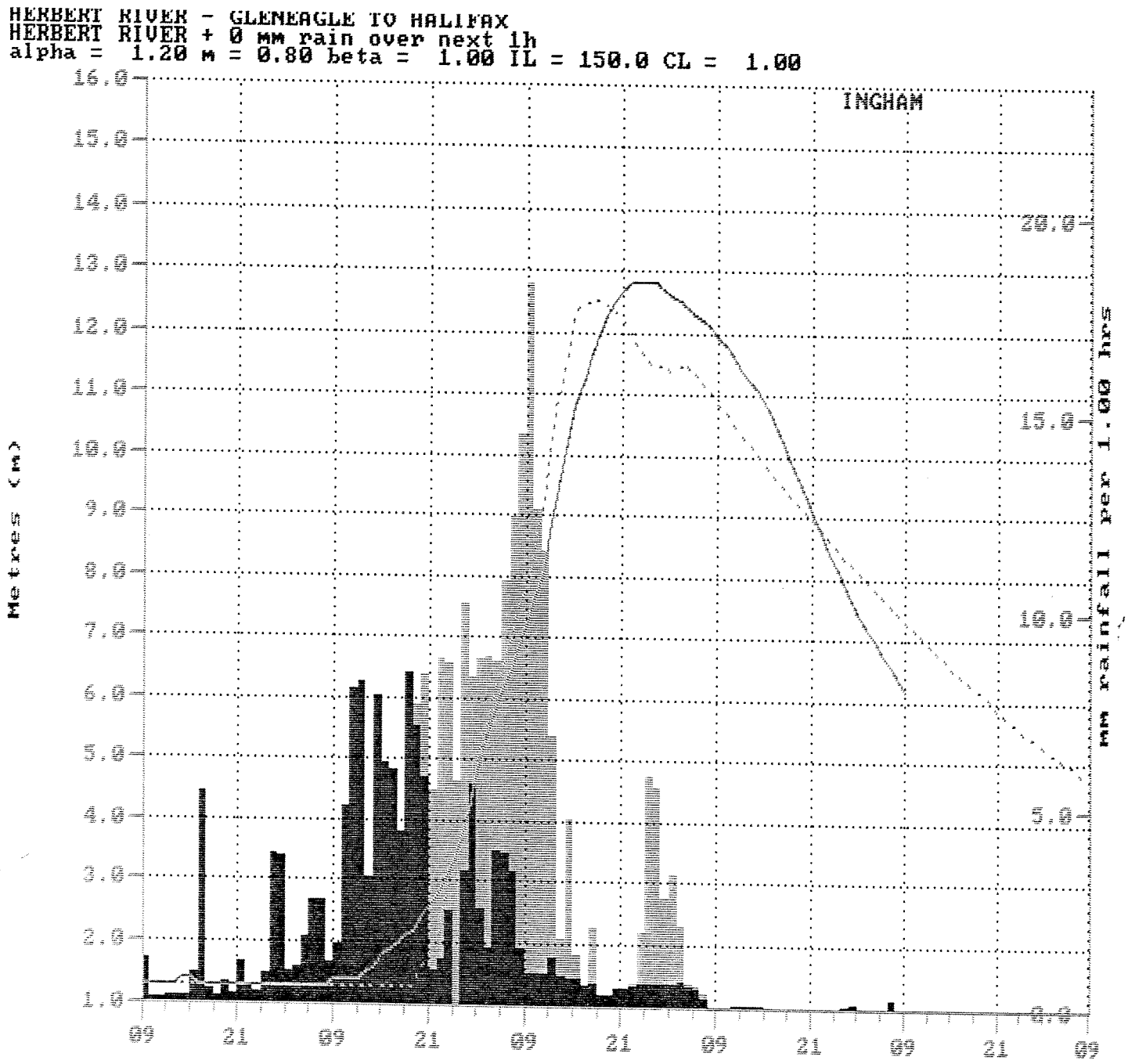
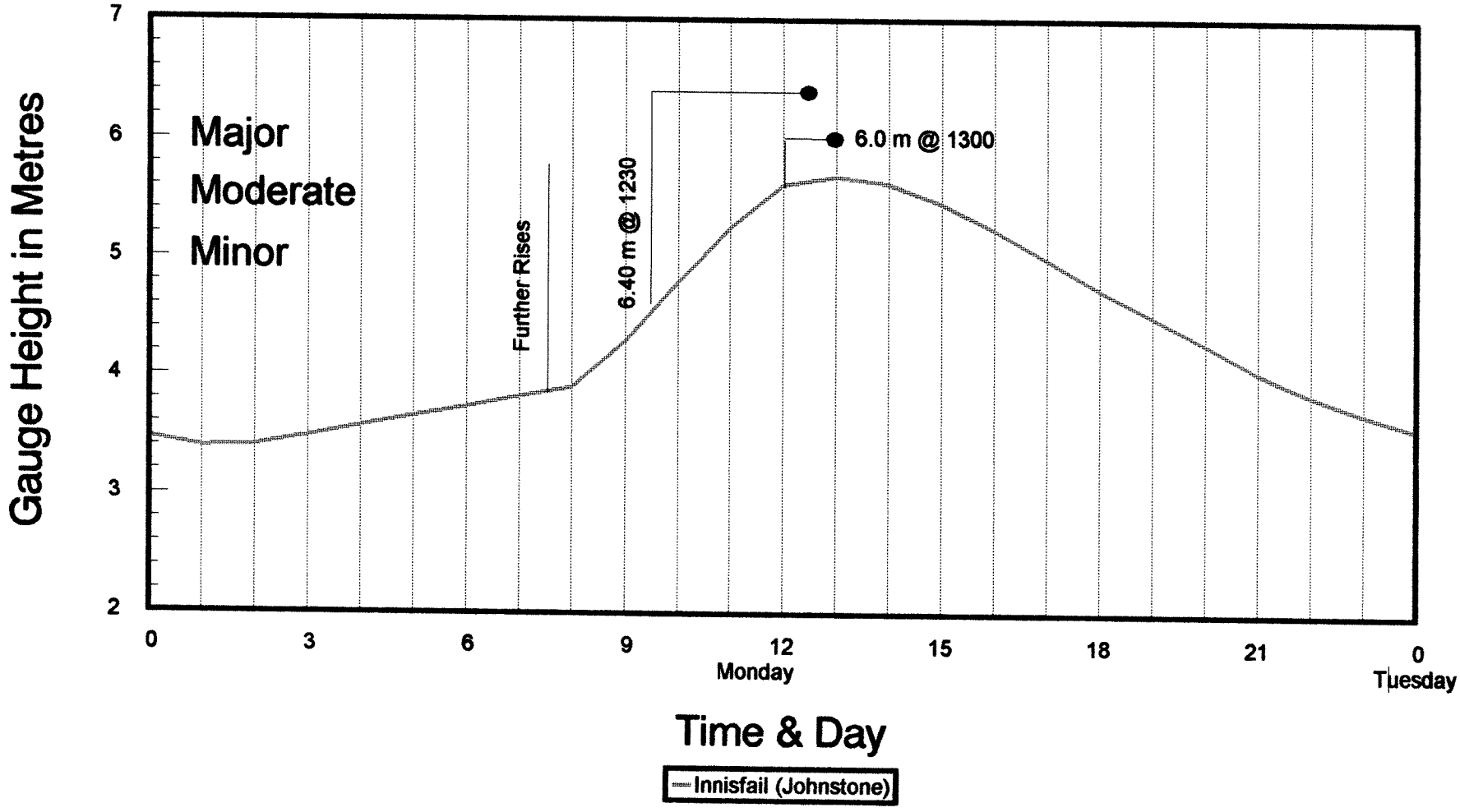

HERBERT RIVER - GLENEAGLE TO HALIFAX
HERBERT RIVER + 0 mm rain over next 1h
alpha = 1.20 m = 0.80 beta = 1.00 IL = 150.0 CL = 1.00
INGHAM
Metres (m)
mm rainfall per 1.00 hrs
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
20.0
15.0
10.0
5.0
0.0
09
21
09
21
09
21
09
21
09
21
09
Time starting Sat Jan 29 09:00:00 1994 (hours)

Figure 10

Flood Performance Diagram

Johnstone River at Innisfail Alert - Pk 5.70 Metres @ 1300 31/1/94



Bureau of Meteorology, Brisbane

Figure 11

Flood Performance Diagram

Tully River at Euramo - Pk 8.91 m @ 4am 1/2/94

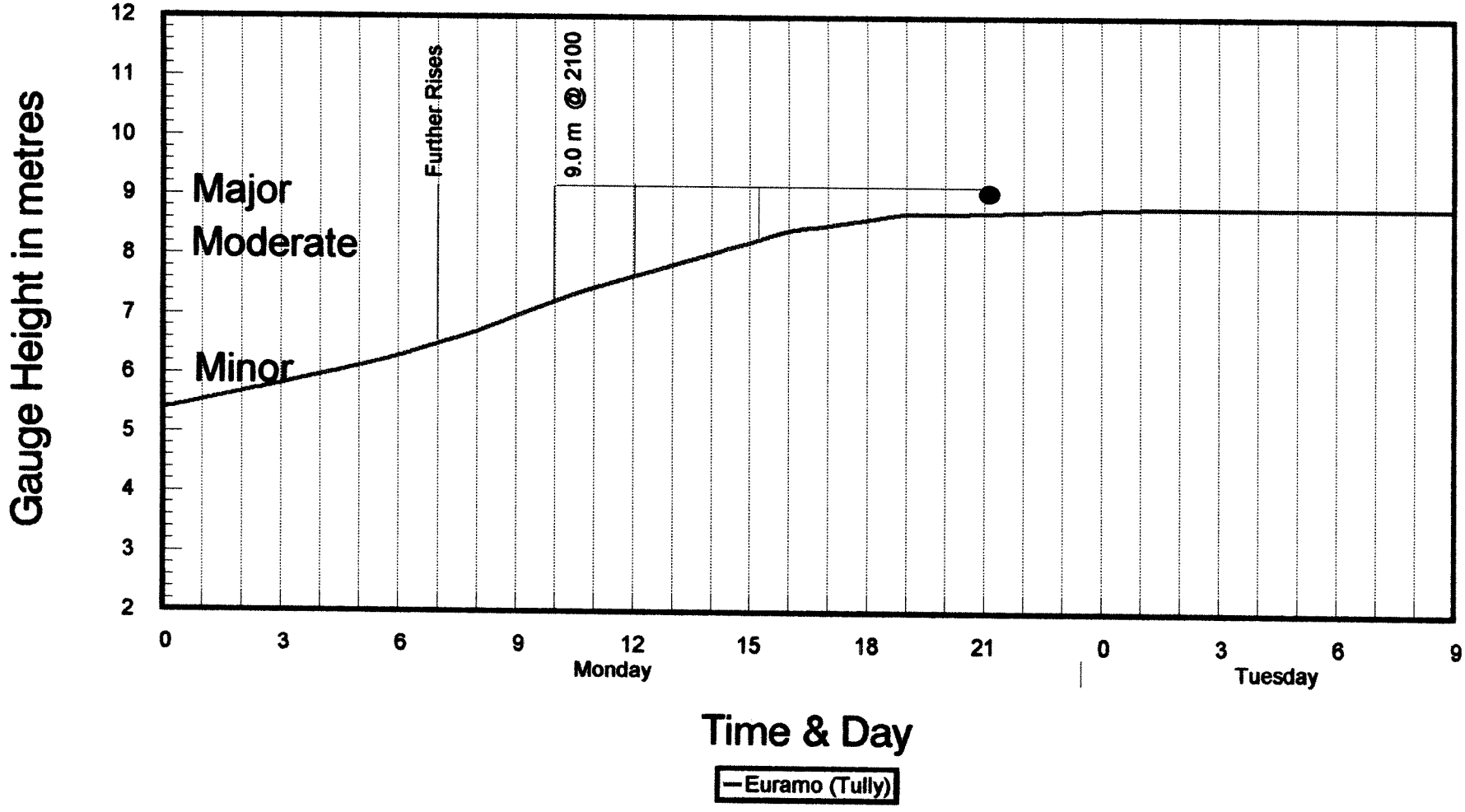


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Figure 12

Flood Performance Diagram

Herbert River at Gairloch - Pk 11.10 m @ 0000 1/2/94

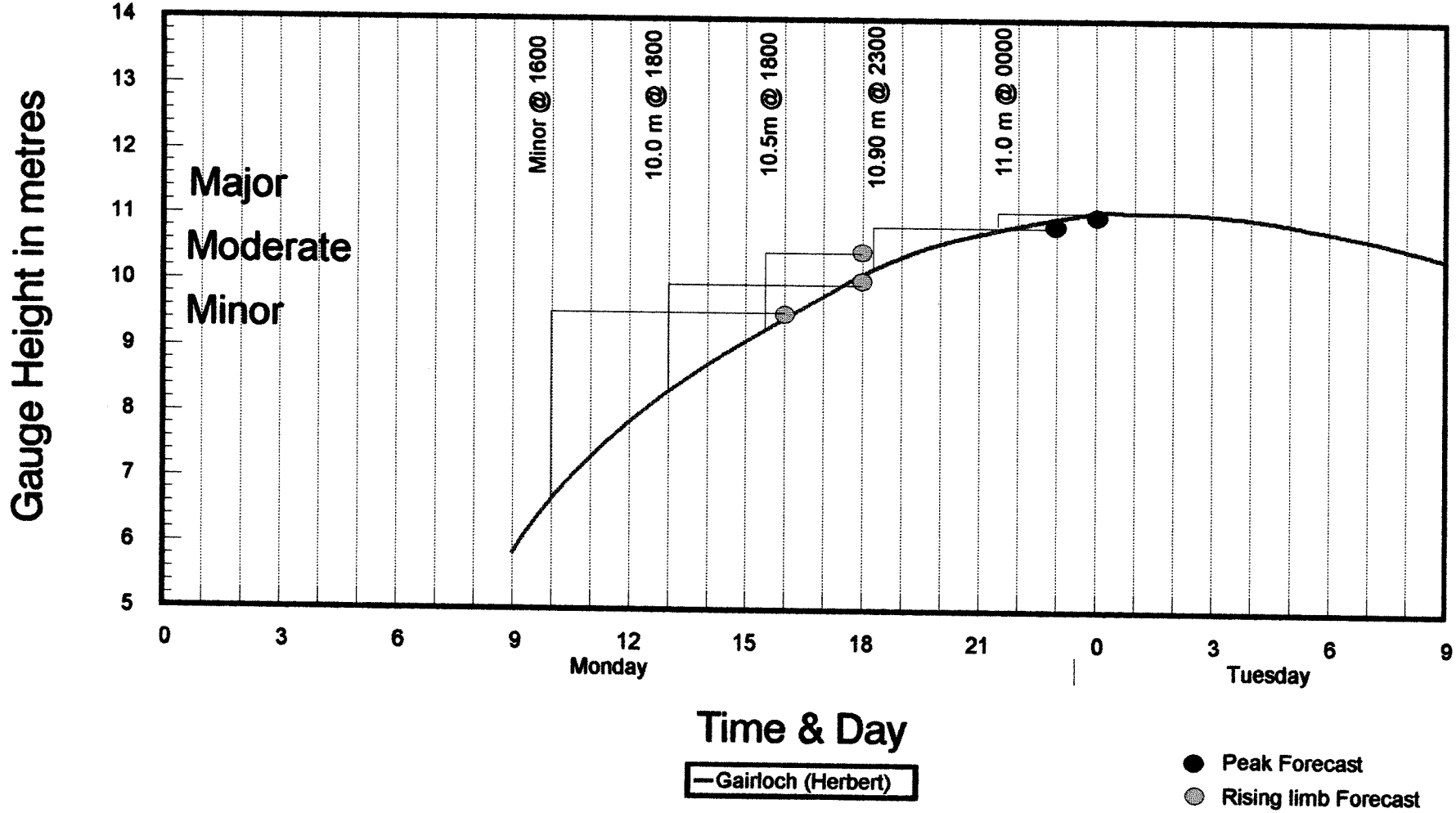

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Figure 13