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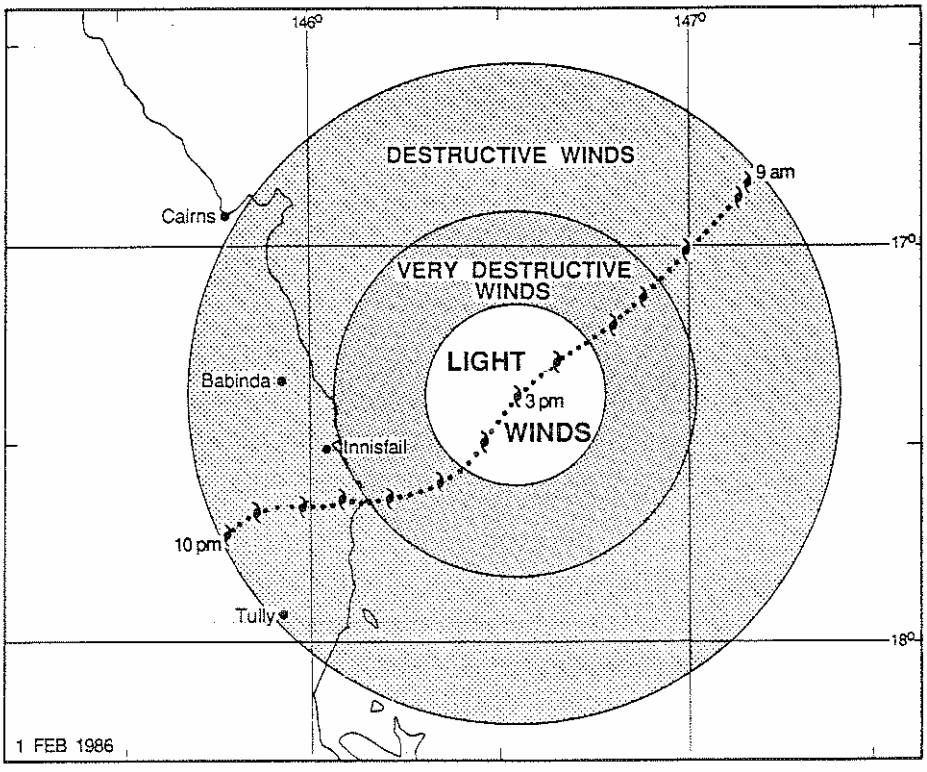
BUREAU OF METEOROLOGY
DEPARTMENT OF SCIENCE

REPORT ON CYCLONE WINIFRED

FEBRUARY 1986



October 1986

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Foreword

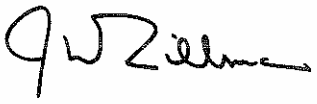
Tropical cyclone *Winifred* crossed the north Queensland coast just south of Innisfail during the late afternoon and evening of Saturday 1 February 1986, causing extensive damage from Cairns to Ingham and taking three lives.

Winifred was the first severe tropical cyclone to affect north Queensland for over fourteen years and was therefore a severe test of all aspects of the tropical cyclone warning system.

Although the area which suffered the full force of the cyclone was under cyclone warning for over two days before the destructive winds were experienced, there was public criticism of some aspects of the detailed operation of the Bureau's warning services.

This report summarises the meteorological aspects of *Winifred,* the warning services provided, the major criticisms of these services and the responses to them. It also addresses some of the problems highlighted by the cyclone, particularly the shortcomings of the current tropical cyclone surveillance system, and suggests some remedial action.

The report was prepared by Mr C. Pierrehumbert, Superintendent, Severe Weather Warning Services, in collaboration with Messrs R. Falls, G. Crane, B. Gordon, P. Fletcher and G. Heatherwick of the Queensland Regional Office.



J. W. Zillman
Director of Meteorology

15 August 1986

Corrigendum

Please note that the figures on pages 23 and 24 have been transposed. i.e. the enhanced infrared photograph is on page 23 and the unenhanced infrared photograph on page 24.

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Purpose and overview

The Commonwealth Meteorology Act 1955-1973 charges the Bureau of Meteorology with 'the issue of warnings of gales, storms and other weather conditions likely to endanger life and property, including weather conditions likely to give rise to floods...'

In any major meteorological disaster, the Bureau of Meteorology post analyses the event and reviews the manner in which its heavy responsibilities to the public were discharged. The Bureau also looks to ways of improving its procedures and systems in order to overcome any difficulties revealed by a detailed examination of its warning operations and by the public response.

Cyclone *Winifred* , which crossed the north Queensland coast between Cairns and Townsville on 1 February 1986, was the first tropical cyclone in 14 years to have a major impact on Australia's northeast tropical coast. *Winifred* was therefore a severe test of community preparedness and public understanding of cyclones, as well as of the total cyclone warning process.

Winifred's direct damages have been estimated at approximately $130 M. Three lives were lost. The damage caused by high winds, high seas, and wind-driven rain were compounded by major flooding of the Herbert and Tully Rivers. The economic and social implications are expected to be protracted because the primary impact area around Tully, Innisfail and Babinda is the heart of an economically-depressed sugar industry.

In the hierarchy of severe tropical cyclones, *Winifred* was of moderate intensity but relatively large in its area of impact. This report provides a record of *Winifred's* important meteorological characteristics.

Two days warning was provided to the area where *Winifred* finally made landfall, and despite some difficulties, the Bureau believes that the overall performance of the tropical cyclone warning system was good. However, public expectations are very high, and some aspects of the cyclone warnings attracted sharp public criticism. The Bureau has acknowledged that some of the criticism - mainly on points of detail which did not materially affect the warning strategy - were valid. However, there were some criticisms which reflected unrealistic expectations of what the current warning systems can deliver while others indicated a poor understanding of the physical nature of tropical cyclones. In contrast to the critical reaction, a number of people and organisations praised the warning services provided.

A number of senior officers from the Bureau visited north Queensland within two to three weeks of the event to consult with officials, the media and the public on the performance of the cyclone warning system. These visits enabled the Bureau to explain the operation of the cyclone warning system during *Winifred* and permitted a free exchange of views between the Bureau and relevant organisations. Important insights into the cyclone's impact and public reaction were also obtained.

The performance of the Bureau's cyclone tracking systems during *Winifred* has been critically appraised. Of particular concern was a delay of some nine hours in detecting *Winifred's* turn towards the coast. A requirement for further improvements to the cyclone tracking technology available to the Bureau is indicated.

As a result of the cyclone *Winifred* experience, important areas have been identified for attention. These include:

- the need for improved public understanding of the nature of tropical cyclones and the cyclone warning system;
- the need for improvements in the provision of cyclone warning information to the public through the media;
- the need to address problems of work overload in Tropical Cyclone Warning Centres;
- the need for the Bureau to look to advanced technology to further improve its cyclone surveillance capability.

Impact of *Winifred*

Winifred crossed the north Queensland coast near Silkwood during the early evening of Saturday 1 February. Winds reached destructive force on the coast during the mid-afternoon and then extended slowly inland. *Winifred* weakened rapidly after it and crossed the coast. By 11 pm destructive-force gusts were limited to a small area near the cyclone's centre and by early the following morning destructive-force gusts were no longer being experienced.

Winifred's primary impact resulted from high winds, heavy seas, wind-driven rain, and stream flooding. The main area of damage extended from Cairns in the north to Ingham in the south and inland to Millaa Millaa. The worst affected area was from Babinda to Tully. Figure 1 shows the locations of areas mentioned in this report. Photographs showing some of the damage are reproduced in the centre pages.

There were three deaths. A pensioner was blown to his death from his garage roof at Malanda at the height of the storm, and a male nurse was found drowned near Ingham after floodwaters had receded. A thirteen-year old Innisfail girl who was hit by a sheet of roofing iron subsequently died from her injuries. There were also numerous less serious injuries.

The total cost of damage caused by *Winifred* has been estimated at approximately $130 M. However, there are many other losses which cannot be accurately valued and these are not included in the above estimate.

The quantifiable losses can be separated into three components: agricultural ($87 M); insured assets such as buildings and contents, boats, vehicles etc. ($35 M); and restoration of public utilities such as electricity supplies, telephones, debris clearance, repairs to roads and bridges (between $5 M and $10 M).

The value of losses incurred by various sections of primary industry are set out in Table 1.

Table 1. Estimated agricultural losses ($ x 1000).

Sugar	1.5 M tonnes lost	40 000
Bananas	3.7 M cases lost	34 600
Pawpaws		4 900
Dairying	loss of production	2 000
Poultry	18 000 laying hens destroyed	600
Maize	crop loss of 15%	500
Others	(including avocadoes, lychees, custard apples, flowers and chokoes)	3 800
	Total	***86 400***

(Source: Commonwealth Department of Primary Industry)

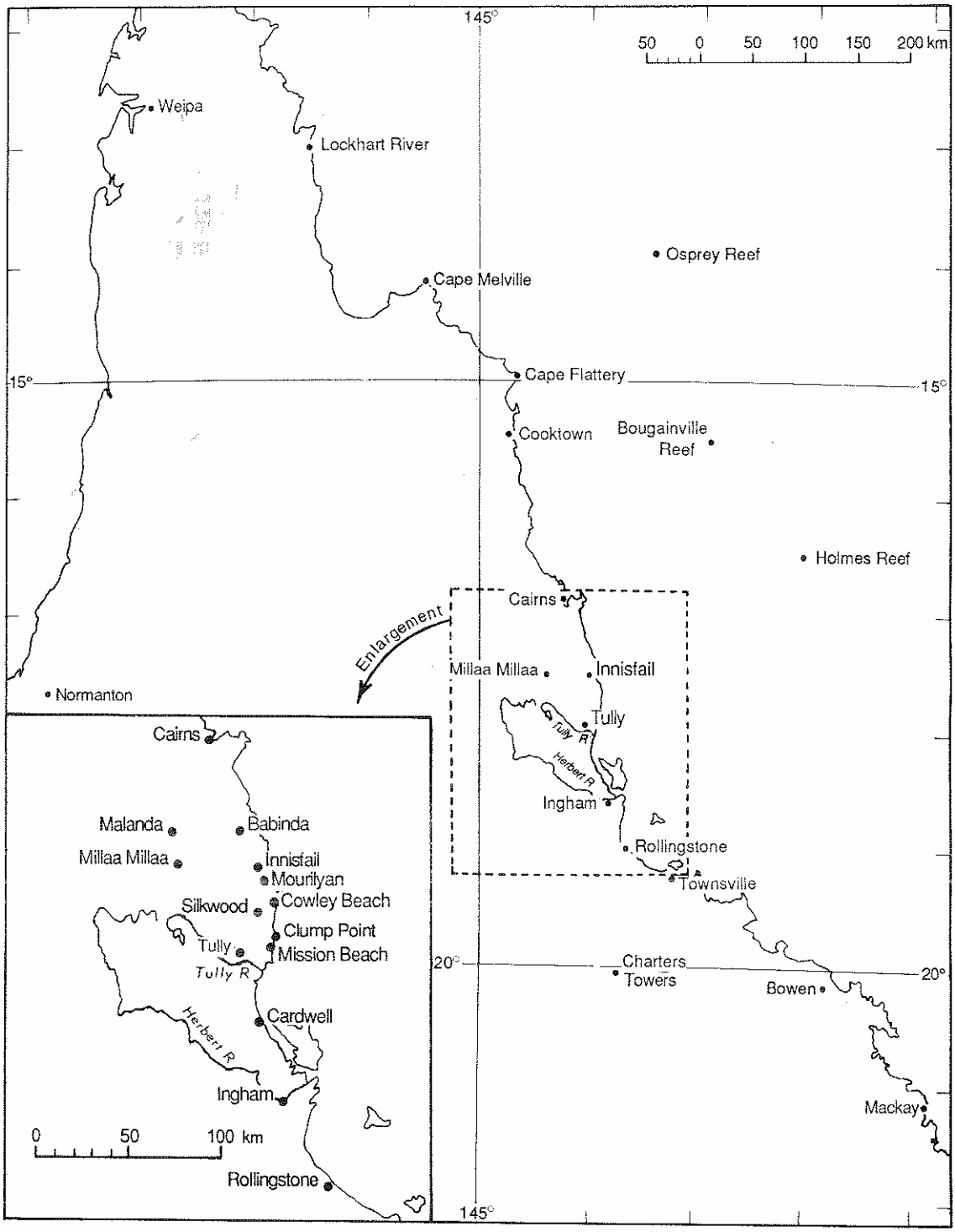


Fig. 1 Location map.

The major losses which cannot be costed include lost wages and profits in non-rural industries, uninsured and under-insured assets, the socio-economic impact of the disaster on an already depressed sugar industry ($40 M crop loss), years of work in restoring public and private parks and gardens, and very widespread damage to natural forests. Vast amounts of fallen timber quickly created a serious fire hazard. Some areas of the forests having been stripped of bark will die, and recovery will take many years. Extensive areas which suffered defoliation will recover sooner. The value of commercial timber losses are unknown, but about $1 M in restoration work was required in State forests.

Structural damage was light compared with the extent of the damage to vegetation. Comparatively few people had their homes destroyed although many houses suffered roofing and superficial damage. The self-reliance of the largely rural community enabled structural recovery to proceed rapidly.

The largest single impact of tropical cyclone *Winifred* is likely to be the socio-economic flow-on effects within the sugar industry. Since the industry was already depressed, some growers will be unable to finance continued operation of their farms. In addition, there will be less work in the crushing mills in the immediate future. As a result, it is likely that many mill employees will be put out of work. This, in turn, will lead to less trade in supply and service industries and result in financial hardship for many more people in the region.

An emotional impact was also evident during conversations with residents. There was great mental stress during the high winds caused mainly by a lack of understanding of what to expect.

West of the Great Dividing Range, the rainfall and stream flows caused by the remnants of *Winifred* were generally welcomed. *Winifred* was the only summer cyclonic system to water inland Queensland during the 1985/86 season.

Physical characteristics

Introduction

The physical characteristics of cyclone *Winifred* are described in the following section. It should be noted that some of the data used in this post-analysis were not available in real time, e.g. the barograph traces from Cowley Beach, Innisfail and South Johnstone (all of which experienced the eye of the cyclone), as well as the wind record from Cowley Beach. As a consequence there are differences between estimates of the various parameters of the cyclone derived from post-analysis and estimates made in real time. Additionally, interpretation of any particular radar or satellite photograph during post-analysis is simplified by reference to both preceding and succeeding photographs. This is not possible operationally.

Track

Cyclone *Winifred* developed from a tropical low which was first indentified on the afternoon of Monday 27 January approximately 450 km north of Cairns. The low pressure system moved initially in an easterly direction and very slowly intensified. Early on the morning of Wednesday 29 January, the system changed course and commenced moving on a southerly track. By 4 am on Thursday 30 January, the low had developed into tropical cyclone *Winifred* with a central pressure of 995 hPa.

Cyclone *Winifred* continued to intensify and underwent two major changes of direction before landfall, firstly from south to southeast on the evening of 30 January, and from southeast to southwest overnight on 31 January. The centre temporarily turned from southwest to west-southwest just prior to landfall at about 6.45 pm on Saturday 1 February. Throughout its life prior to landfall *Winifred* continued to intensify from its initial pressure of 995 hPa to an estimated central pressure of 957 hPa on landfall. The cyclone weakened as it moved inland but continued to exist as a weakening depression until 6 February. The track of the system is shown at Fig. 2.

Radar surveillance

Radar surveillance was maintained by the Cairns Weather Service Office throughout 31 January and 1 February. Photographs at half-hourly intervals of the plan position indicator (PPI) display which presents a plan view of the echoes from the rain associated with the cyclone were available from 5.30 pm on 31 January until 10 am on 1 February. From 10 am until 11 pm on 1 February, photographs were available at 15-minute intervals. A selection of these photographs are shown at Fig. 3.

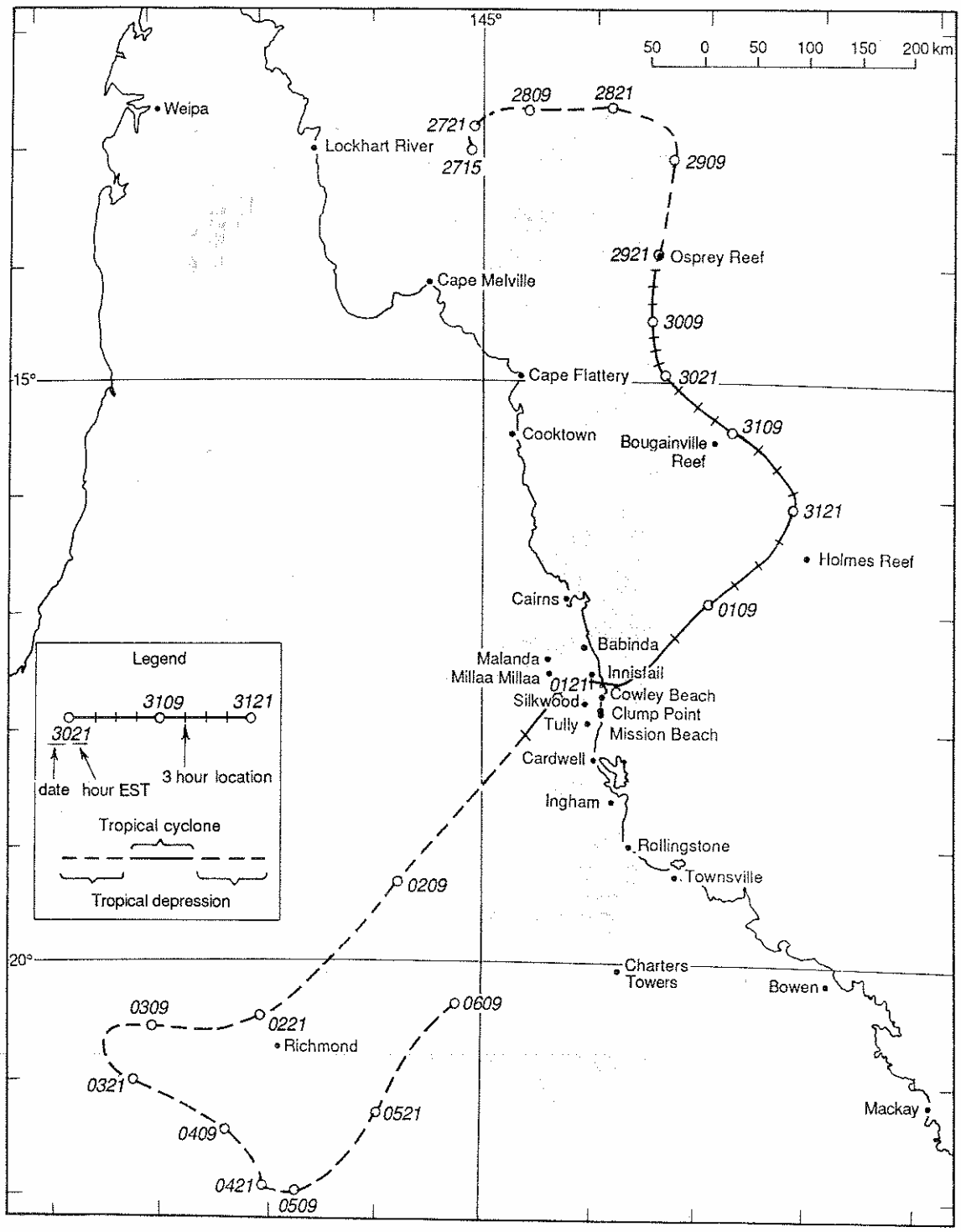


Fig. 2 Detailed track of cyclone *Winifred.*

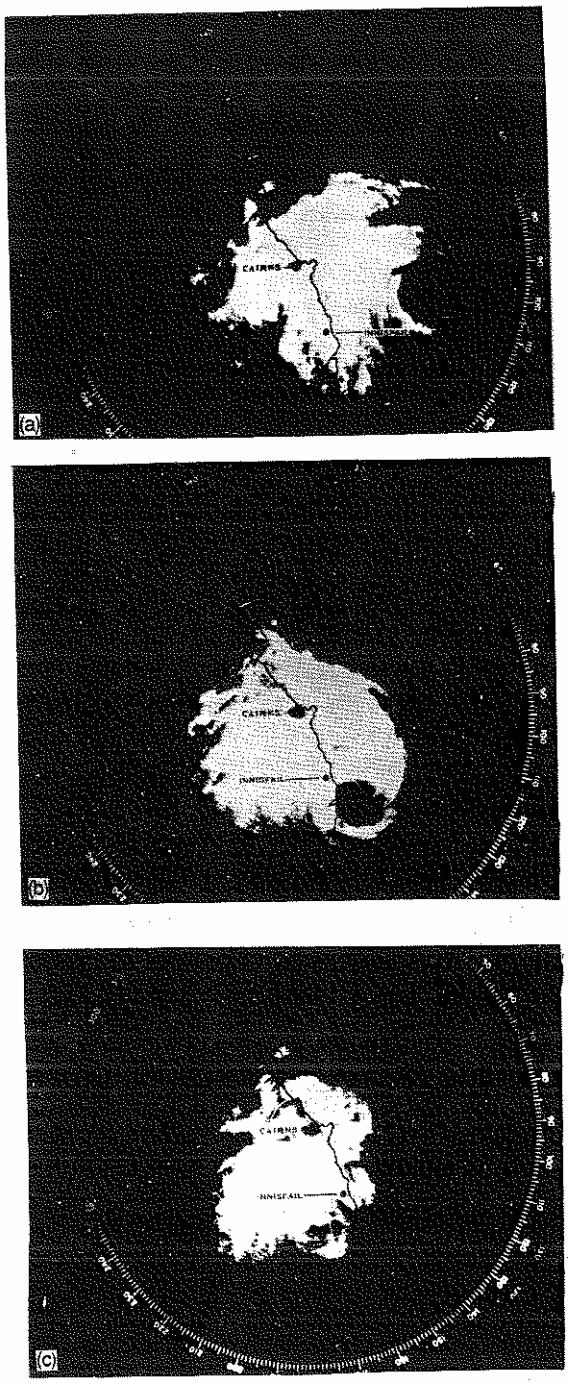


Fig. 3 Radar photographs of *Winifred* at:

(a) 11.30 am on 1 February showing part of the eye wall about 100 km east-southeast of Cairns;

(b) 6.30 pm on 1 February showing the full eye just off the coast south of Innisfail;

(c) 9.30 pm on 1 February showing the eye over land south of Innisfail beginning to lose intensity.

The main radar features of a tropical cyclone are the eye, which is essentially an echo-free area, and the eye wall echo which surrounds the eye and is approximately circular or slightly elliptical in shape. When discernible features of a cyclone are available on radar this provides the best available means of determining the location of the system. The radar track of *Winifred* is shown in Fig. 4. The centre of the system was taken to be the geometrical centre of the echo-free area within the eye wall. Previous radar observations of tropical cyclones have often shown that the centre appears to move in an irregular fashion of movement and in this regard *Winifred* was no exception.

Eye characteristics of *Winifred*

A partial eye wall echo was discernible on the Cairns radar at 7 am on 1 February when the centre was located about 185 km from the radar. By 1 pm, with the centre 130 km from Cairns, the complete eye was visible and remained so until 9 pm, from which time the cyclone began to lose its identifiable radar features.

The radar eye of *Winifred* was large and mostly elliptical, having a mean diameter of 51 km at 1 pm. However, as the cyclone approached the coast, the eye diameter gradually decreased to 49 km by 5 pm when the eye wall first touched the coast and to 41 km as the centre of the eye crossed the coast. This decrease in diameter was in agreement with other evidence indicating that the cyclone continued to intensify until landfall at 6.45 pm.

Pressure profile

Barograph traces are available from three localities which experienced the cyclone's eye. The centre of the eye passed within 15 km of Innisfail where a corrected lowest central pressure of 963 hPa was recorded. A copy of the trace is shown as Fig. 5(a). The barograph was checked in the week following the cyclone and was found to be reading 2 hPa high. At South Johnstone the lowest corrected pressure recorded was 958 hPa. A copy of the trace is shown at Fig. 5(b).

The centre of the eye passed within a few kilometres of the Joint Tropical Trials and Research Establishment (JTTRE) at Cowley Beach. This station was equipped with a barograph and a synchrotac anemometer. A copy of the barograph trace is shown at Fig. 5(c). The lowest central pressure recorded was 958 hPa just before 6 pm. It is of interest to note that the lowest central pressure occurred approximately one hour before the geometrical centre of the eye was closest to Cowley Beach, suggesting that the pressure centre and the geometrical centre of the eye did not coincide.

Winds

The synchrotac anemometer at Cowley Beach provided 10-minute wind run data in kilometres for each 10-minute period of the day. These data yield the most accurate and detailed description of the wind field associated with *Winifred* and 10-minute mean winds in kilometres per hour are plotted at Fig. 6

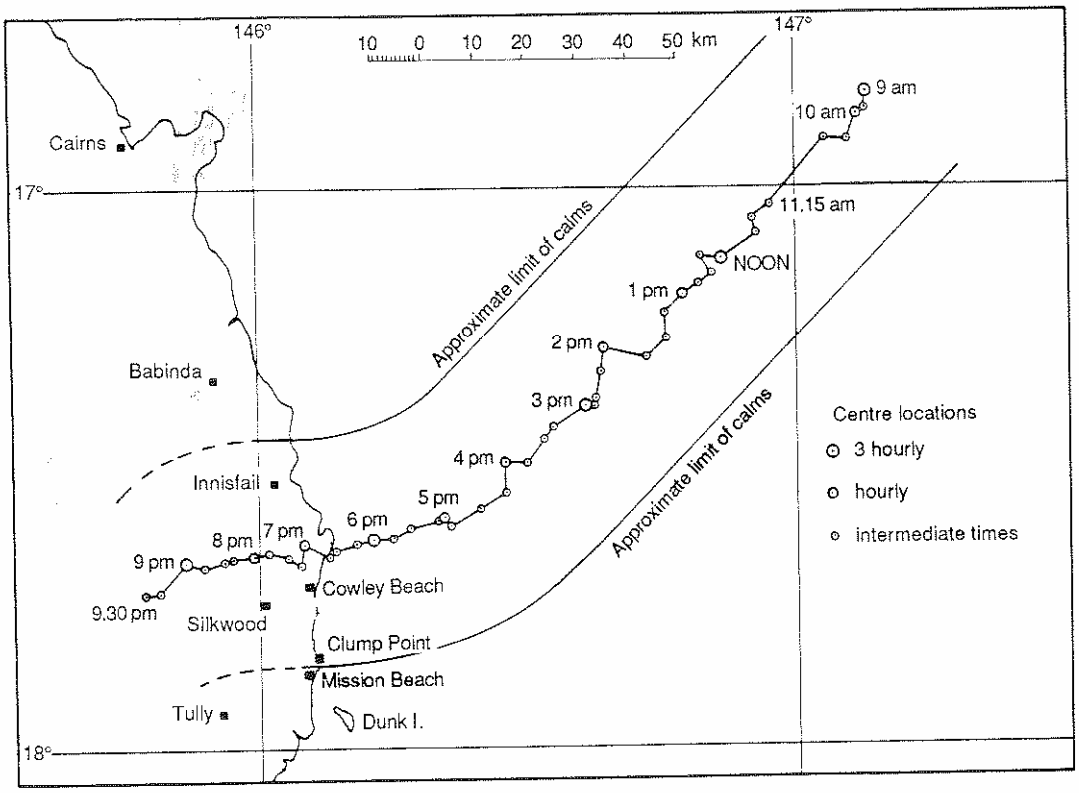


Fig. 4 Radar track of cyclone *Winifred* on 1 February showing path of the eye.

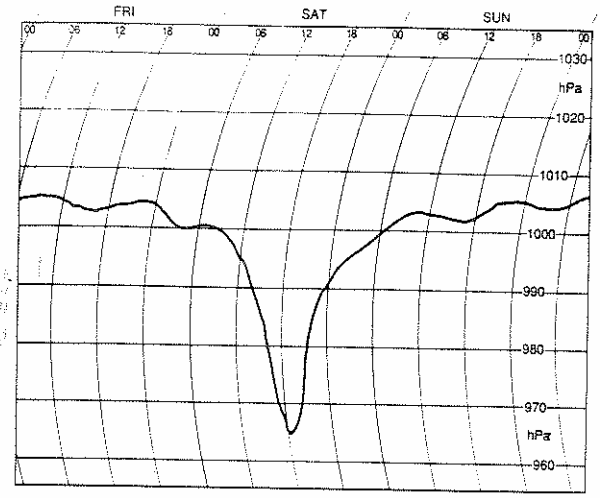


Fig. 5(a) Barograph trace - Innisfail.

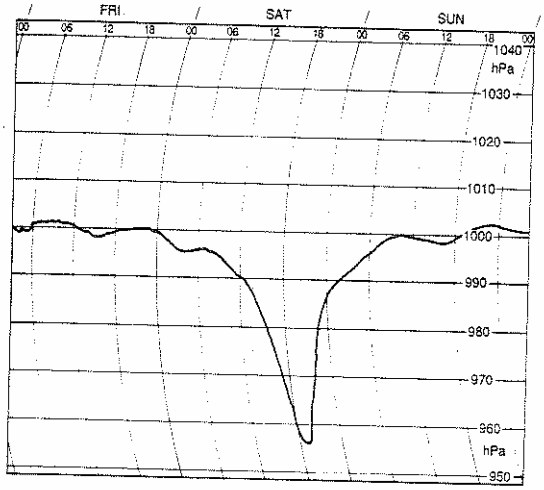


Fig. 5(b) Barograph trace - South Johnstone.

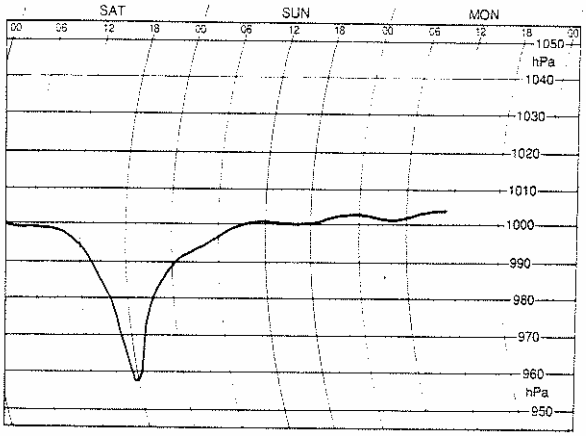


Fig. 5(c) Barograph trace - Cowley Beach.

along with the corresponding pressure values.

JTTRE has advised that the anemometer does not record 10-minute wind run values between 21 and 25.5 km, i.e. any value of 21 could be higher, but no higher than 25.5. The highest 10-minute wind run recorded was 21 km which converts to a mean wind of 126 km/h. Based on the mean wind speed profile shown in Fig. 6, it is considered unlikely that this value would have been higher and 126 km/h has been accepted as the maximum mean 10-minute wind.

To arrive at an estimate of the peak 3-second gust, it is necessary to apply an appropriate gust factor to the mean wind. The major consideration in selecting a gust factor is the surface roughness. The strongest mean winds at Cowley Beach occurred between 4 pm and 4.30 pm when the wind direction was south-southeasterly. This indicates that the mean wind was essentially an off-water wind and a gust factor of 1.4 would be appropriate. This gives a maximum gust of approximately 176 km/h.

Remarkably strong winds were recorded as far north as Cairns in the westerly wind regime north of the cyclone centre. The effect of mountainous terrain was clearly evident at Cairns Airport where northwesterly wind gusts to 119 km/h were recorded while the mean winds were averaging only 45 to 55 km/h. With such mountainous terrain along the far north tropical coast, large local variations in wind gusts would be expected.

Gradient wind profile

The availability of pressure data from the barograph at Cowley Beach and the accurate location of the cyclone centre from radar observations enable calculation of the gradient wind profile near the eye following the method outlined by the Bureau of Meteorology (1977). The results of these calculations are shown in Table 2 for the south-southeast wind regime before the passage of the cyclone centre. The gradient wind level is the level at which the wind is not affected by the frictional influence of the earth's surface and is usually about 1000 metres above the surface. In Table 2, ΔP represents the pressure drop during the time that the cyclone approached a distance ΔR, R is the distance of the cyclone centre from Cowley Beach and Vg is the gradient wind.

The values in Table 2 indicate that the radius of maximum winds was approximately 27 km. Estimates of the radius of maximum wind using the mean wind speed profile shown in Fig. 6 and the speed of the cyclone indicate that this is a realistic assessment. Table 2 also indicates that maximum winds should have been experienced at Cowley Beach at about 4 pm which is in close agreement with recorded data.

Storm surge

When a tropical cyclone crosses or closely approaches a coastline there is a resultant rise in mean water level above that expected from astronomical tides alone. This rise in water level is called a storm surge. The abnormal rise in

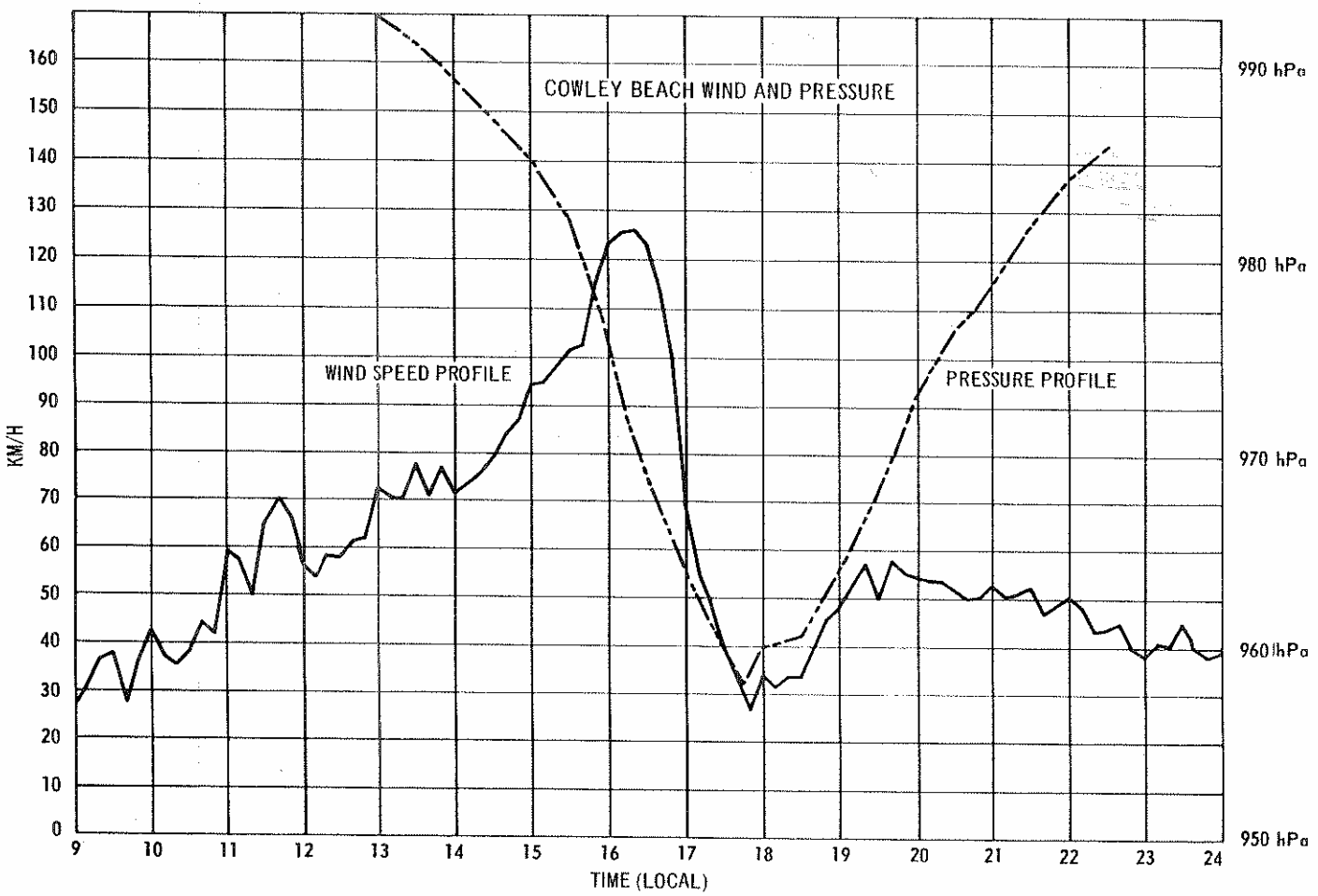


Fig. 6 Wind speed and pressure data - Cowley Beach.

Table 2. Gradient wind profiles.

Time (EST)	ΔP (hPa)	ΔR (km)	R (km)	Vg (km/h)
2.00 pm - 2.30 pm	2.0	8.3	56.9	120
2.15 pm - 2.45 pm	2.1	9.3	52.3	111
2.30 pm - 3.00 pm	2.0	8.3	47.6	110
2.45 pm - 3.15 pm	2.6	8.2	43.9	122
3.00 pm - 3.30 pm	3.1	8.7	39.5	123
3.15 pm - 3.45 pm	4.3	9.6	35.2	130
3.30 pm - 4.00 pm	6.2	8.7	29.8	152
3.45 pm - 4.15 pm	7.4	5.7	26.5	195
4.00 pm - 4.30 pm	7.0	6.1	23.1	175
4.15 pm - 4.45 pm	5.4	7.4	20.4	128
4.30 pm - 5.00 pm	5.0	7.4	16.7	111
4.45 pm - 5.15 pm	4.6	7.2	13.0	96
5.00 pm - 5.30 pm	4.0	6.9	9.5	78

level is caused principally by wind stress on the water surface and the effects of the reduction in atmospheric pressure. A storm tide is defined as the summation of the storm surge and the astronomical tide, i.e. storm tide is the absolute water level above a stated datum.

The Bureau of Meteorology has responsibility for the production and dissemination of quantitative storm tide warnings to the State Counter Disaster Organisation. Warnings are issued only if the predicted storm tide height exceeds the Highest Astronomical Tide (HAT) at the locations under threat. Qualitative advices of storm tide threat are included in tropical cyclone warnings which contain landfall or near landfall predictions.

Storm tide predictions were first made on the morning of Saturday 1 February for the stretch of coast from Innisfail to Clump Point and later extended southwards to Cardwell. For a landfall time of 4 pm, it was ascertained that the storm tide level would be near HAT but would not exceed it. A later landfall time would result in lower levels as astronomical tides would be falling. Consequently no quantitative storm tide warnings were issued, but advices that abnormally high tides could cause minor flooding were included in the public cyclone warnings from 11 am onwards.

Throughout Saturday storm tide gauges at Cairns, Mourilyan, Clump Point, Cardwell and Lucinda were interrogated at regular intervals to monitor tide levels.

Levels at all centres were above predicted astronomical tides throughout the day. With a radius to the region of maximum winds of 27 km at landfall, the peak storm surge would have occurred in the Clump Point-South Mission Beach area. The maximum storm surge recorded at Clump Point was 1.6 metres, approximately 0.2 metres below the highest astronomical tide. Cardwell recorded a maximum surge of 1.2 metres. Using tide data provided by the Beach Protection Authority, plots of actual tides, predicted astronomical

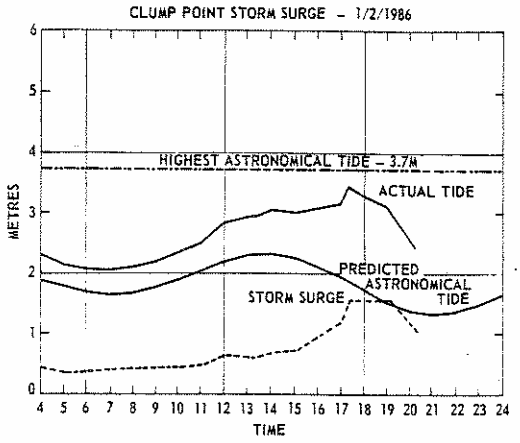


Fig. 7(a) Storm tide data - Clump Point.

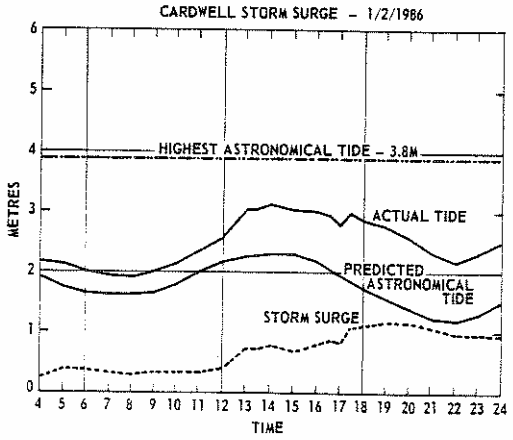


Fig. 7(b) Storm tide data - Cardwell.

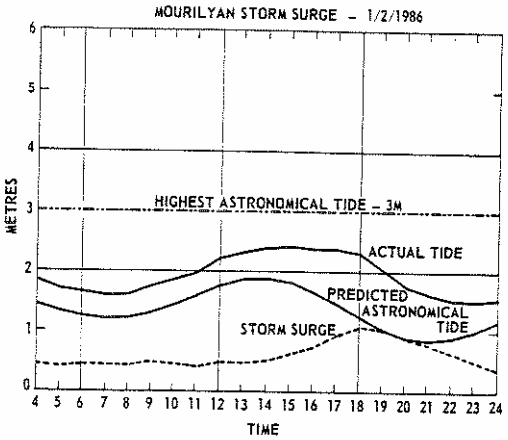


Fig. 7(c) Storm tide data - Mourilyan.

tides and storm surge for Mourilyan, Cardwell and Clump Point are shown as Fig. 7(a), (b), and (c).

Surveys of wave debris lines at Mission Beach by teams from James Cook University and the Bureau of Meteorology indicate waves ran up the beach to approximately 2 metres above the astronomical tide, agreeing well with the 1.6 metre surge measured at Clump Point.

Rainfall and associated flooding

Rainfall over the northern half of the State for the period 30 January to 5 February is shown as an isohyetal map in Fig. 8. Totals of over 100 mm were recorded over much of the far north tropical coast and in some inland areas. Totals exceeding 500 mm occurred in some coastal areas particularly over the Tully, Herbert and Johnstone catchments.

Coastal catchments on the far north tropical coast were generally saturated by heavy rainfall associated with the developing low, several days before landfall. Table 3 shows the rainfall for selected North Coast (Barron and Herbert) stations for the period.

Table 3. Selected rainfalls (mm) for North Coast (Barron-Herbert)

Station	*Week ended 9 am 29 Jan*	*24-hour rainfall ended 9 am*				
		30/1	*31/1*	*1/2*	*2/2*	*3/2*
Mossman	250	63	50			41 (three days)
Cairns Aero	93	94	54	40	24	3
Babinda	239	251	138	65	241	24
Topaz	126	304	165	54	224	1
Innisfail	188	221	111	74	203	26
Coondi	188	168	99	65	204	23
Greenhaven	172	176	120	31	383	8
Crawfords Lookout	86	205	122	30	250	5
Cardstone	150	159	88	28	389	1
Tully	204	170	91	45	212	3
Abergowrie Bridge	190	19	17	40	199	1
Ingham	230	10	10	24	10	
Paluma	197	8	8	15	206	52

Flood warnings commenced for the Tully River on Thursday 30 January, and, by the time of landfall on 1 February, flood warnings were current for a number of north coast streams.

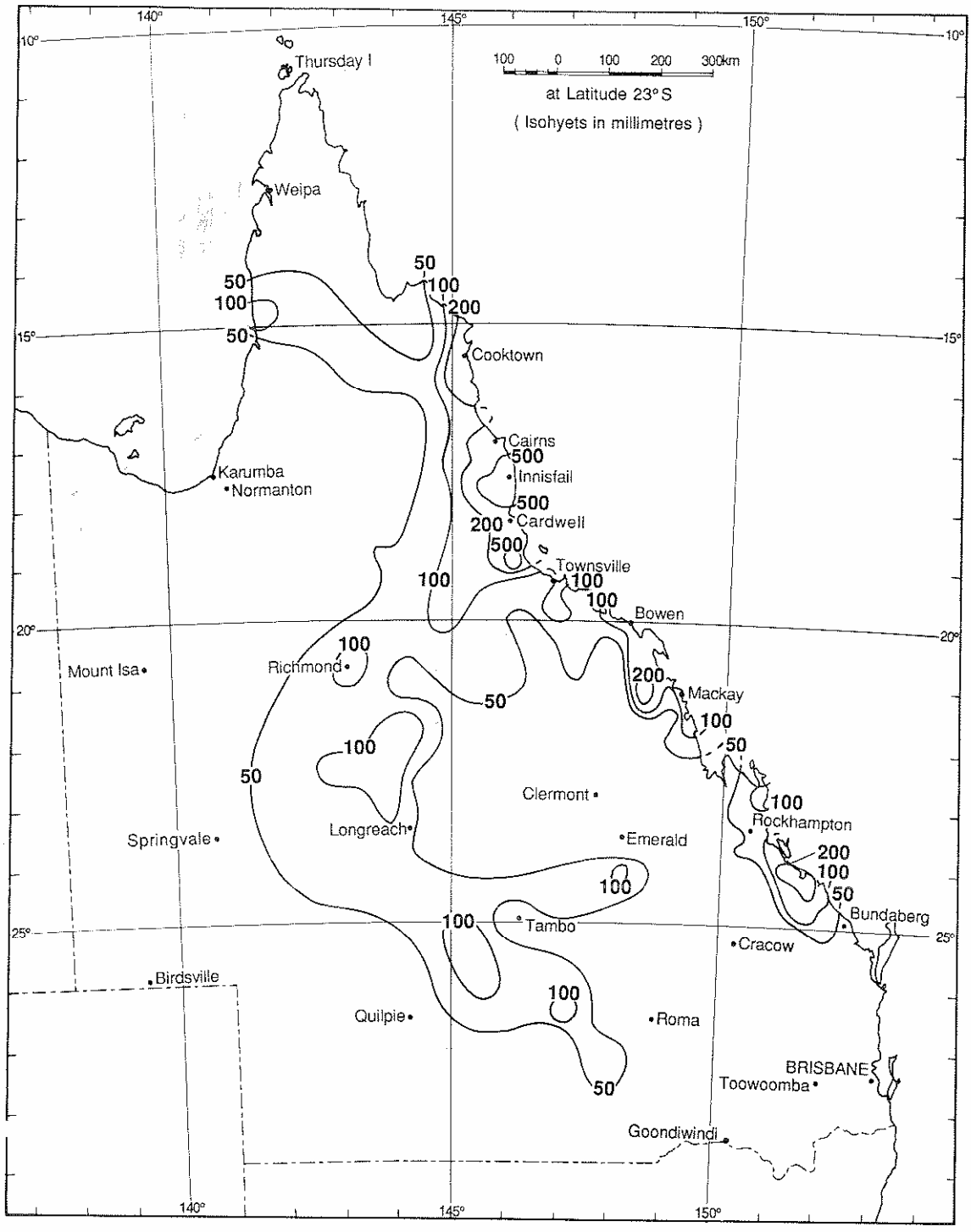


Fig. 8 Rainfall isohyets for the period 30 January - 5 February.

Major flooding occurred in the Tully and Herbert Rivers with river levels approaching record heights.

The southwestward movement of the low which was formerly cyclone *Winifred* brought flood-producing rainfall to the inland-flowing streams during early February. Selected rainfalls for the period 3 to 5 February are given in Table 4.

Table 4. Selected flood-producing rainfalls in Central Lowlands and Upper Western districts.

	24-hour rainfall (mm)		
Station	***3/2***	***4/2***	***5/2***
Richmond	116	4	5
Tangorin	131	21	4
Winton	64	82	6
Longreach	20	51	40
Blackall	1	80	18
Stonehenge	0	87	10
Mount Morris	0	137	23

Resultant flooding occurred in the Thomson River and Cooper Creek, and in the Warrego, Bulloo and Diamantina Rivers.

A more detailed description of the *Winifred* flooding, in particular for the Tully and Herbert Rivers, is given in Appendix 1.

Operation of the cyclone warning system

Introduction

Provision of a tropical cyclone warning service depends on a very complex system of information-gathering and processing, decision-making, warning distribution, and finally community response. The essential components of a meteorological warning system are outlined schematically in Fig. 9.

A modern tropical cyclone warning system comprises an advanced surveillance system - meteorological satellites, coastal radar stations, automatic weather stations, and manually recorded observations from weather observers, ships and aircraft.

Measurements of wind, temperature and humidity through the atmosphere to altitudes of about 20 km, provided by Bureau-staffed stations, are vital for recognising the conditions under which tropical cyclones are likely to develop or change in intensity, and for predicting the direction in which they are likely to move.

Efficient communications systems and data-processing procedures are necessary in order to receive, process and analyse the quantity and diversity of information needed by a tropical cyclone warning centre. The communications system is also the key to the efficient distribution of warning and information bulletins to the public via the media, and to counter-disaster organisations, police and other community bodies requiring direct advice from the warning centre.

In Queensland, observations are collected by telex, a computer-controlled telephone accessing system, radio teletype, radio voice circuits, the aviation teleprinter network, the Bureau's own computer message switching system and via the Telecom telegram system. Warnings are almost all distributed via telex using the Telecom automatic broadcast call facility to ensure that the very large number of messages are cleared rapidly.

Staffing

Operating the cyclone warning system requires considerable manpower resources, most of which are provided on an overtime basis. The balance is obtained by redeployment of staff from less urgent duties.

In the Queensland Regional Office staff are required to man both the Tropical Cyclone Warning Centre (TCWC) and the Flood Warning Centre. Additional communications staff are also required. During cyclone *Winifred* extra staff were also brought on duty at Cairns and Thursday Island to undertake additional surface observations and radar surveillance and to provide additional technical maintenance support.

Staff resources allocated to duties related to tropical cyclone *Winifred* are summarised in Table 5.

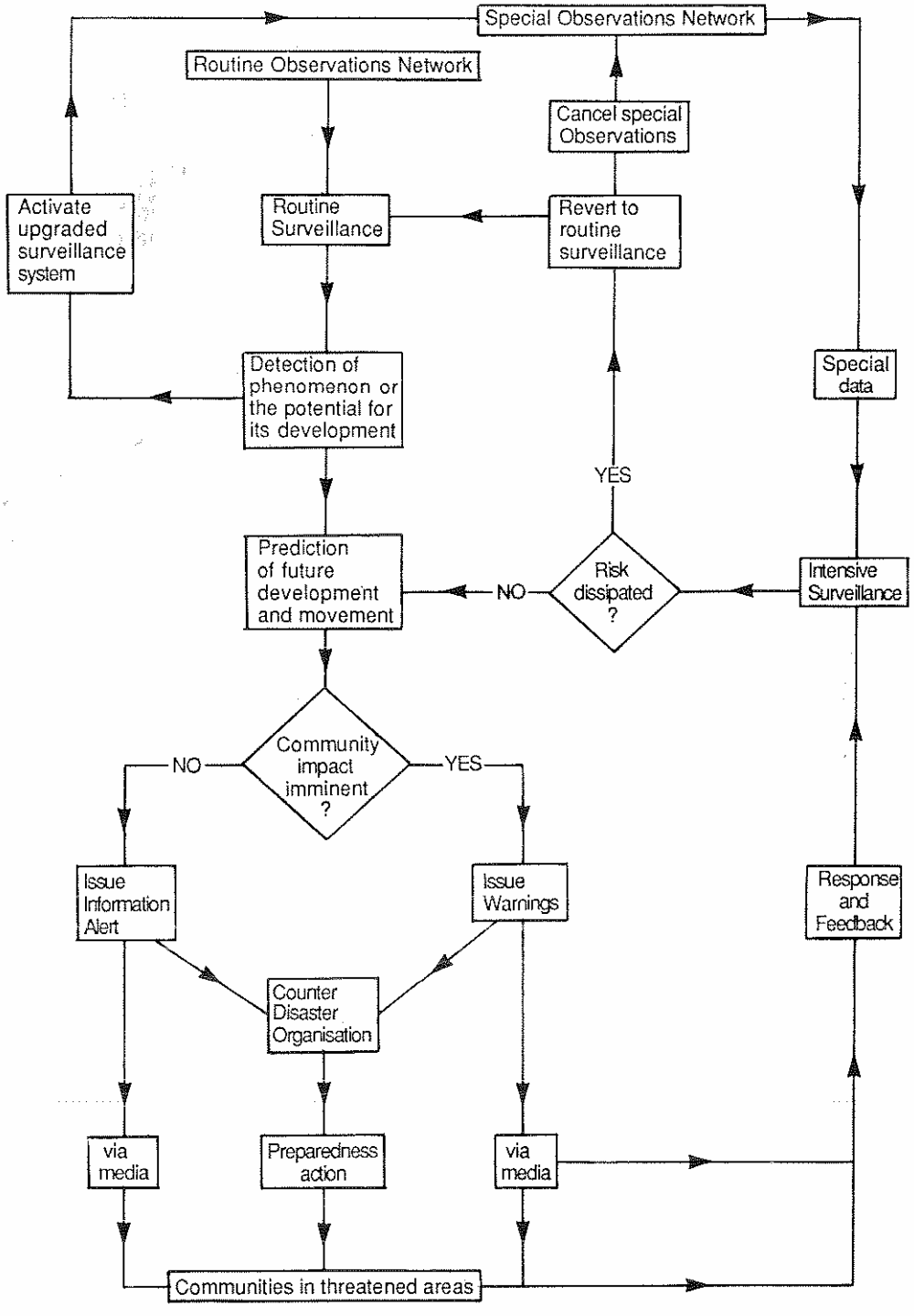


Fig. 9 The essential components of a meteorological surveillance and warning system.

Table 5. Additional staff resources used during cyclone Winifred.

	Number of staff involved	*Overtime (hours)*	*Redeployed from routine duties (hours)*	*Total*
TCWC				
Supervising Meteorologist RFC	1	20	15	35
Senior Meteorologist RFC	3	32	54	86
Senior Meteorologist Spec.Serv.	1	12	7.35	19.35
Technical support staff	3	35	36.75	71.75
Communicators	5	35.5	-	35.5
Totals	*13*	*134.5*	*113.1*	*247.6*
Field Stations				
Observers	5	39.5	-	39.5
Radio Technical Officer	1	13.5	-	13.5
Totals	*6*	*53.0*	-	*53.0*
TOTALS (all stations)	*19*	*187.5*	*113.1*	*300.6*

Total commitment of staff to cyclone-related duties (excluding flood warnings) was 41 man-days or an average of over 12 man-days per day for 3.33 days. This represents an average of four extra staff on duty around the clock throughout the warning period. Actual deployment was one additional staff on Wednesday evening increasing to eight extra on Saturday afternoon. Duty meteorologists in the Regional Forecasting Centre worked a total of 24.5 hours overtime and were redeployed for 7.35 hours. This was required to cover the shifts of senior meteorologists who had moved into the Tropical Cyclone Warning Centre.

Floods caused by the aftermath of cyclone *Winifred* required hydrometeorological staff to work a total of 75.75 hours overtime.

Staff committed to cyclone warning duties on an overtime and redeployment basis continued to attend to their routine duties whenever possible. Typical total hours worked for the week ended Saturday 1 February 1986 were:

Supervising Meteorologist RFC	56
Senior Meteorologist RFC	46
Duty Meteorologist RFC	44
Technical Support Officer	49

Observations

The most important observational data in the surveillance of *Winifred* were:

- information from GMS, the Japanese Geostationary Satellite;

- observations from the ship *Auriga Bay* which sheltered for a period near Bougainville Reef;
- observations from the automatic weather station on Holmes Reef;
- Cairns weather watch radar.

The information from GMS provided the initial alert to the possible development of *Winifred*. It also provided most of the data used in locating the cyclone's centre and estimating its intensity until it came within range of the Cairns radar during the morning of Saturday 1 February. Routine 3-hourly imagery was available throughout the period. An example is given in Fig. 10. Using 'enhancement' techniques, which highlight selected aspects (for example small differences in cloud top temperatures), greater detail can be obtained. An enhanced version of the satellite picture in Fig. 10 is shown in Fig. 11.

Under special arrangements with the Japanese Meteorological Agency hourly data was made available from 4 am to 7 pm on 1 February. Figure 12 shows the sequence of hourly pictures from 11 am to 6 pm.

During all of *Winifred's* existence as a tropical cyclone, a canopy of high-level cirrus cloud covered its eye and the spiral bands normally associated with a cyclone, making precise location of the eye from satellite data alone extremely difficult. During those periods when no other data were available to assist in accurately locating the cyclone's centre, post-analysis indicates that estimates of its position made in real time were up to 100 km in error. This figure is typical of the accuracy of cyclone location using satellite data alone when the eye is not detectable.

Of particular importance was the location of the centre of the cyclone on the morning of 1 February. The 8 am advice, which was based largely on satellite data, gave *Winifred's* position as approximately 200 km from the coast. By 11 am, when the eye of the cyclone was within range of the Cairns radar, the location of the centre was able to be much more accurately determined as 130 km from the coast.

Observations from the ship *Auriga Bay* which sheltered near Bougainville Reef during the period from 8 am on 30 January to 1.30 pm on 31 January were extremely valuable in confirming the location of the centre inferred from GMS data and in estimating the intensity and movement of *Winifred* during this period. Had these observations not been available the location and movement of the cyclone would have been much less precisely known.

Observations from the automatic weather station at Holmes Reef were received throughout the entire period but were of greatest value during the period from 3 am on 31 January until 6 am on the following day.

Cairns weather watch radar played a crucial role in monitoring the movement of the cyclone during the period from 9 am on 1 February until about 9.30 pm that evening when the cyclone had moved inland and had weakened to the extent that the eye was no longer discernible.

The weather watch radar at Cairns is almost 25 years old and is becoming increasingly prone to outages. During this cyclone season it has been out of operation on a number of occasions, including a period of two weeks in November and a further period of 24 hours just 10 days prior to *Winifred*. It again became unserviceable at

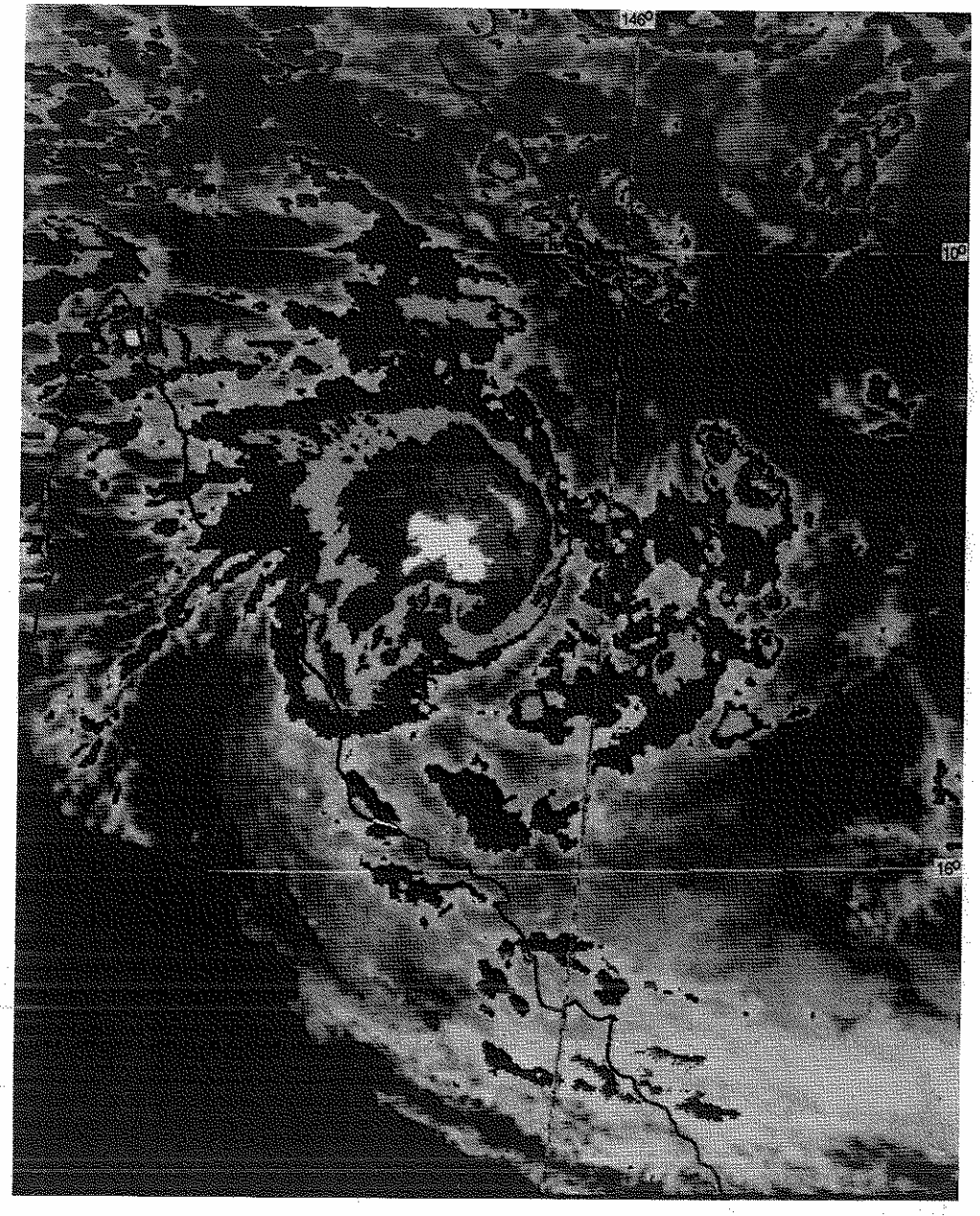


Fig. 10 High resolution infrared photograph from GMS at 4 pm on 31 January (unenhanced).

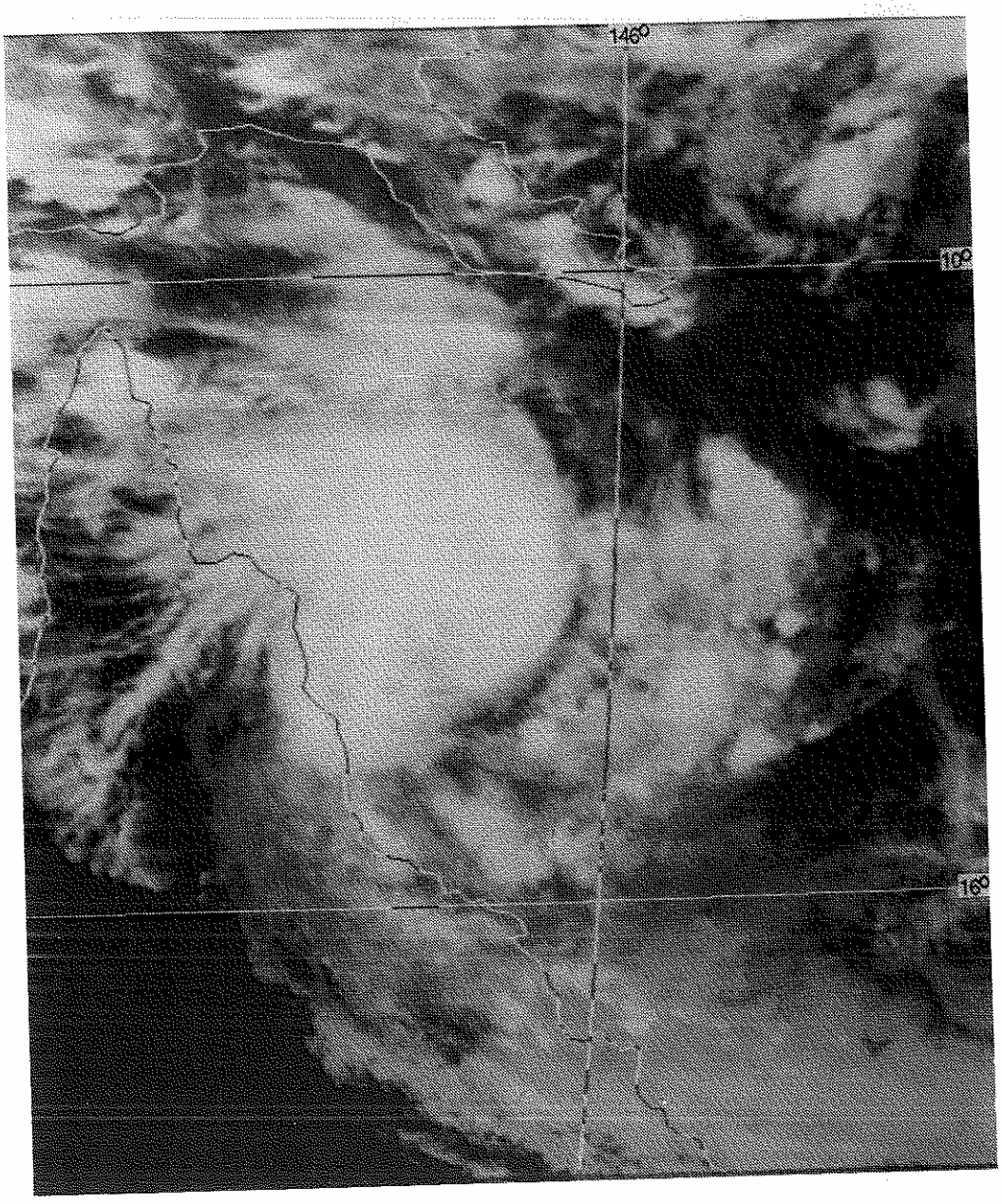


Fig. 11 High resolution infrared photograph from GMS at 4 pm on 31 January enhanced to highlight cloudtop features at heights between 10 and 16 km.

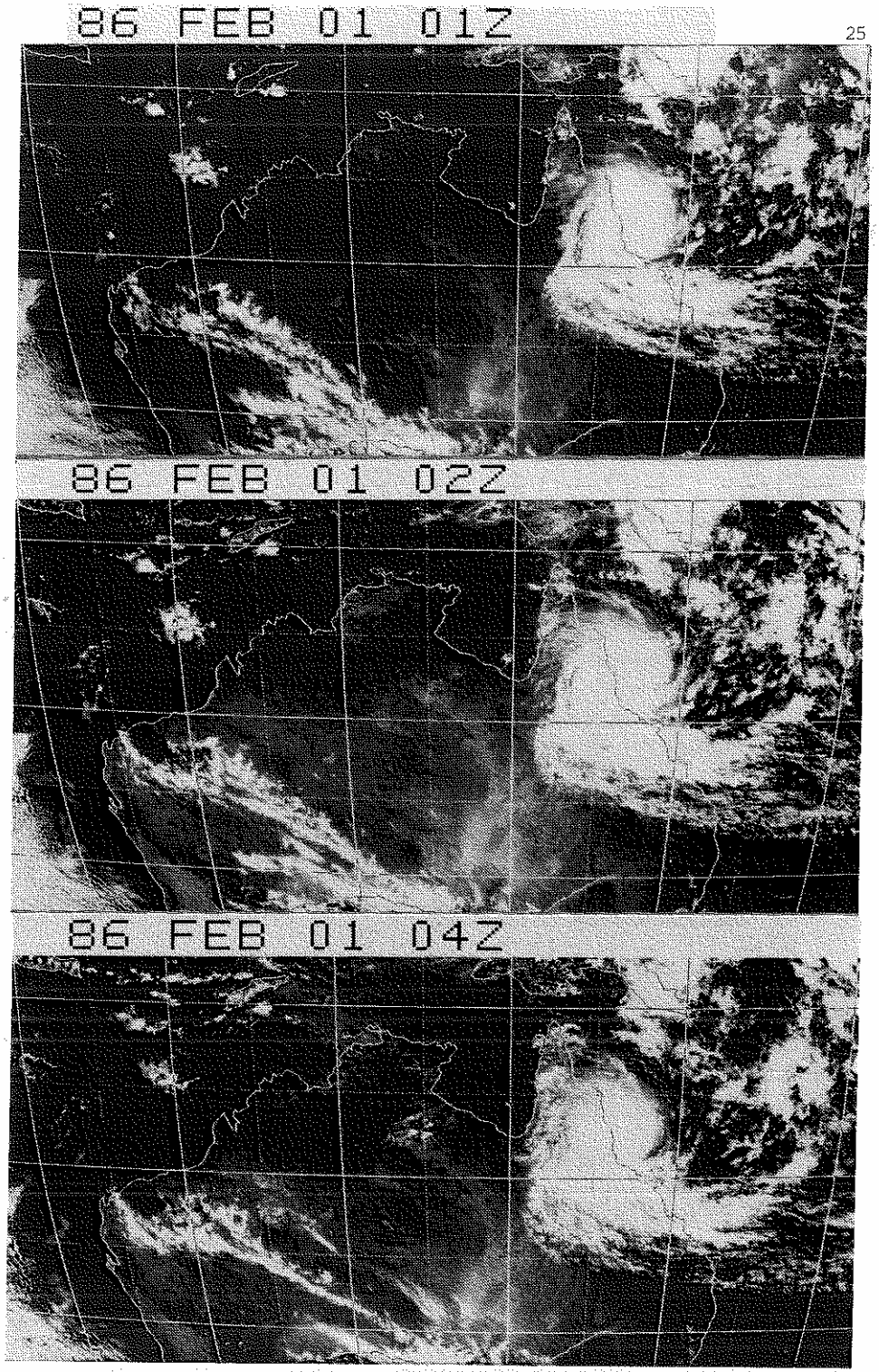
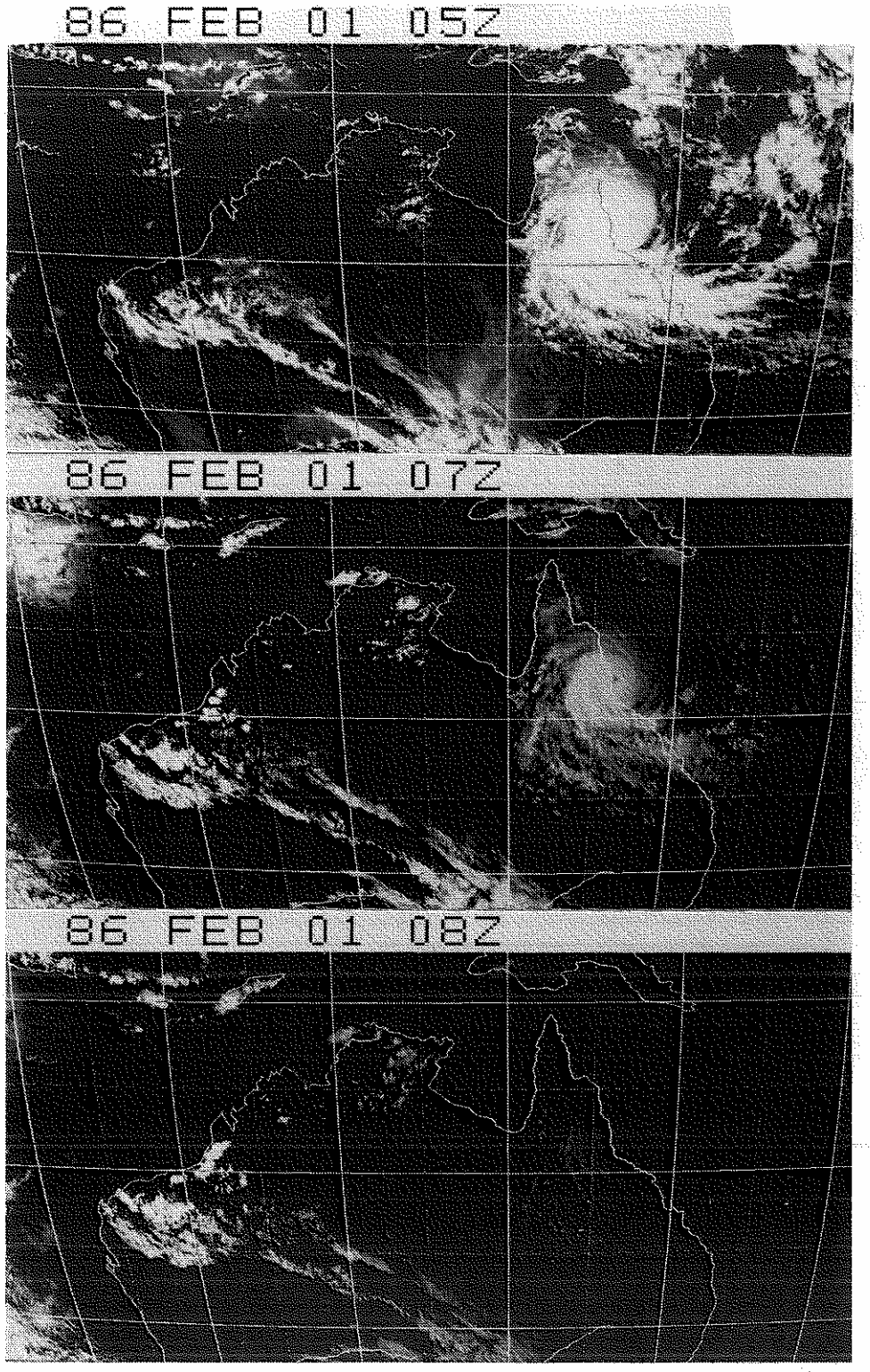


Fig. 12 Sequence of hourly photographs from GMS for the period 11 am to 6 pm on 1 February. Note - Times are in GMT.
- Routine full disc photographs for 03 and 06 GMT (1 pm and 4 pm) are not included.



Note - The last photograph in the series (08 GMT) was taken shortly before sunset and as a result, very little of the cloud formation over the Queensland coast can be seen.

10.15 pm on 30 January but repairs were able to be effected by 3 am the following day. Fortunately, *Winifred* was still some 200 km from Cairns during this period. The radar then operated satisfactorily until late 1 February by which time the eye of the cyclone was no longer identifiable.

Tracking and forecasting

The real-time plot of the track of a tropical cyclone made in a Tropical Cyclone Warning Centre under operational conditions is subject to errors from various sources. These cyclone location errors depend on the intensity of the cyclone itself and on the effectiveness of the available observational network. In general cyclone tracking becomes more accurate as a cyclone becomes more intense and as it moves closer to the coast.

There are invariably significant differences between the operational track as reported to the public in Tropical Cyclone Advices and the reconstructed best track prepared after the event with the benefit of hindsight and additional observational data unavailable to the Tropical Cyclone Warning Centre in the real time. A comparison between the cyclone positions provided in the public advices and the post-analysed track of the positions of cyclone *Winifred* is given in Fig. 13.

The average difference between the location of the centre of cyclone *Winifred* obtained in real time and the corresponding post-analysed position was 42 km. This compares closely with average cyclone positioning errors in Australia's northeastern region which have been gradually declining over the last decade and averaged 40 km in the 1984/85 season.

Another measure of performance is the average error in successive forecasts of the cyclone's central position 12 hours ahead. The average difference between these forecasts for *Winifred* and the corresponding post-analysed best track positions was 129 km. The long-term downward trend of this statistic has seen the average error decline to 113 kilometres by the 1984/85 season. Figure 14 shows the trend with time of both the initial position errors and the 12-hour forecast errors together with the values for cyclone *Winifred.*

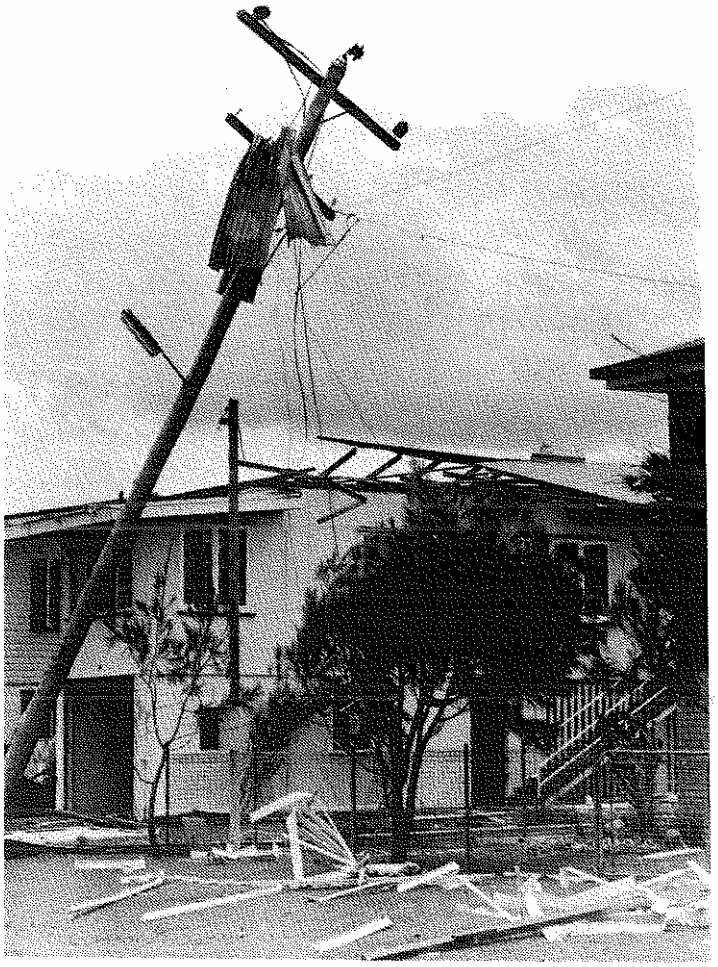
Errors in the forecast track for *Winifred* were a little above the average for recent seasons. This was due in part to the fact that the track contained two sharp turns, both of which occurred when the cyclone was outside radar range and while it was not sufficiently intense to be accurately positioned from satellite data.

Advices and warnings

The tropical low which developed into cyclone *Winifred* was first identified on the afternoon of Monday 27 January. The first Tropical Cyclone Advice was issued at 4 pm on 29 January when the low was located about 340 km northeast of Cooktown and showing little movement. The advice declared a cyclone watch for coastal areas between Thursday Island and Cooktown.

The area covered by the watch was extended further to the south in subsequent advices so that by 5 am on Thursday 30 January, when the first cyclone warning was declared, the area covered by the warning was from Cape Flattery to Townsville while

The Anglican church at Babinda after cyclone *Winifred.*



Damaged buildings at Kurrimine beach.

The South Johnstone River at Innisfail on Sunday morning.

A scene from Gordonvale on Sunday afternoon.
Gordonvale was outside the zone of strongest winds.

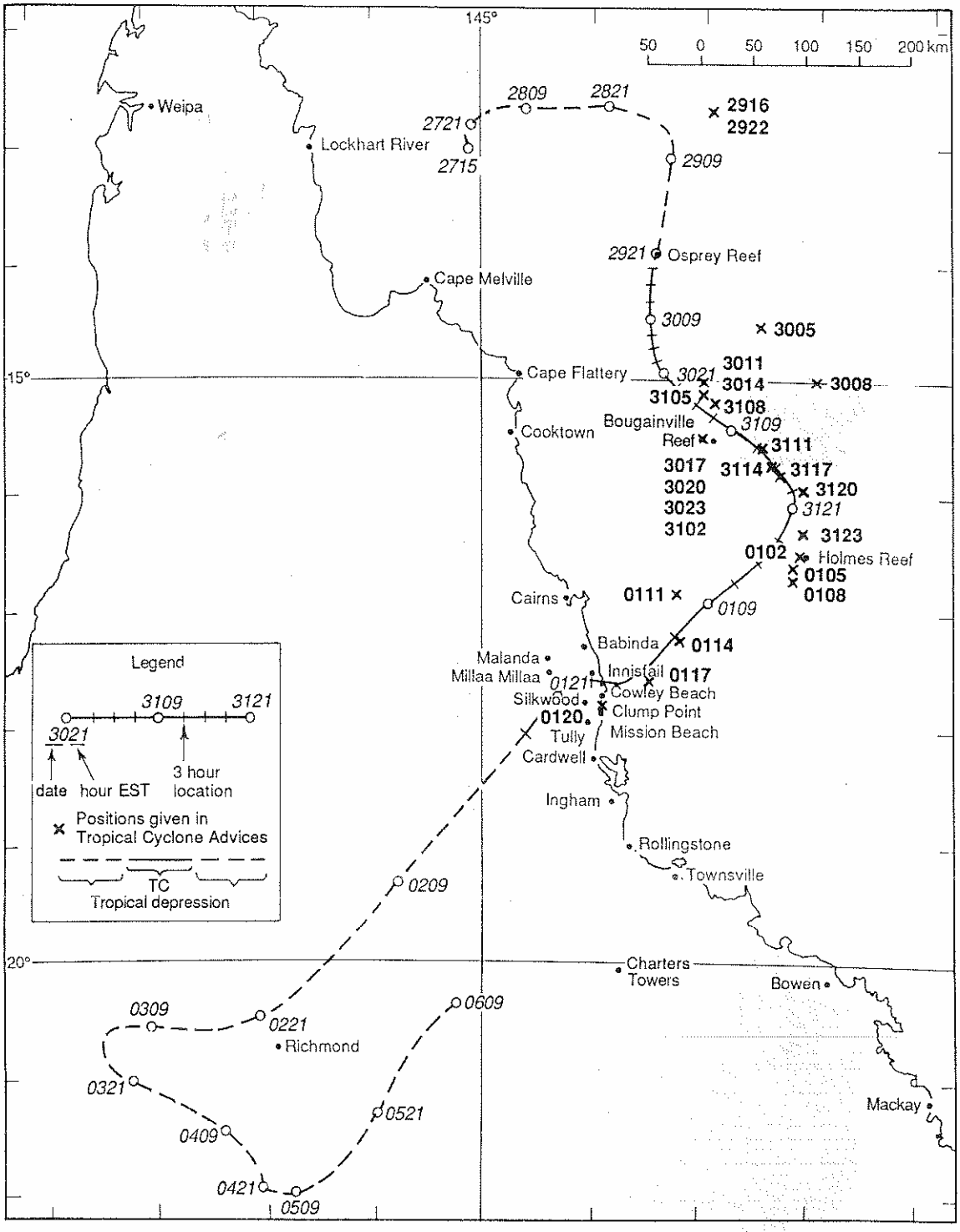


Fig. 13 Comparison of real time and post-analysis locations of cyclone *Winifred.*

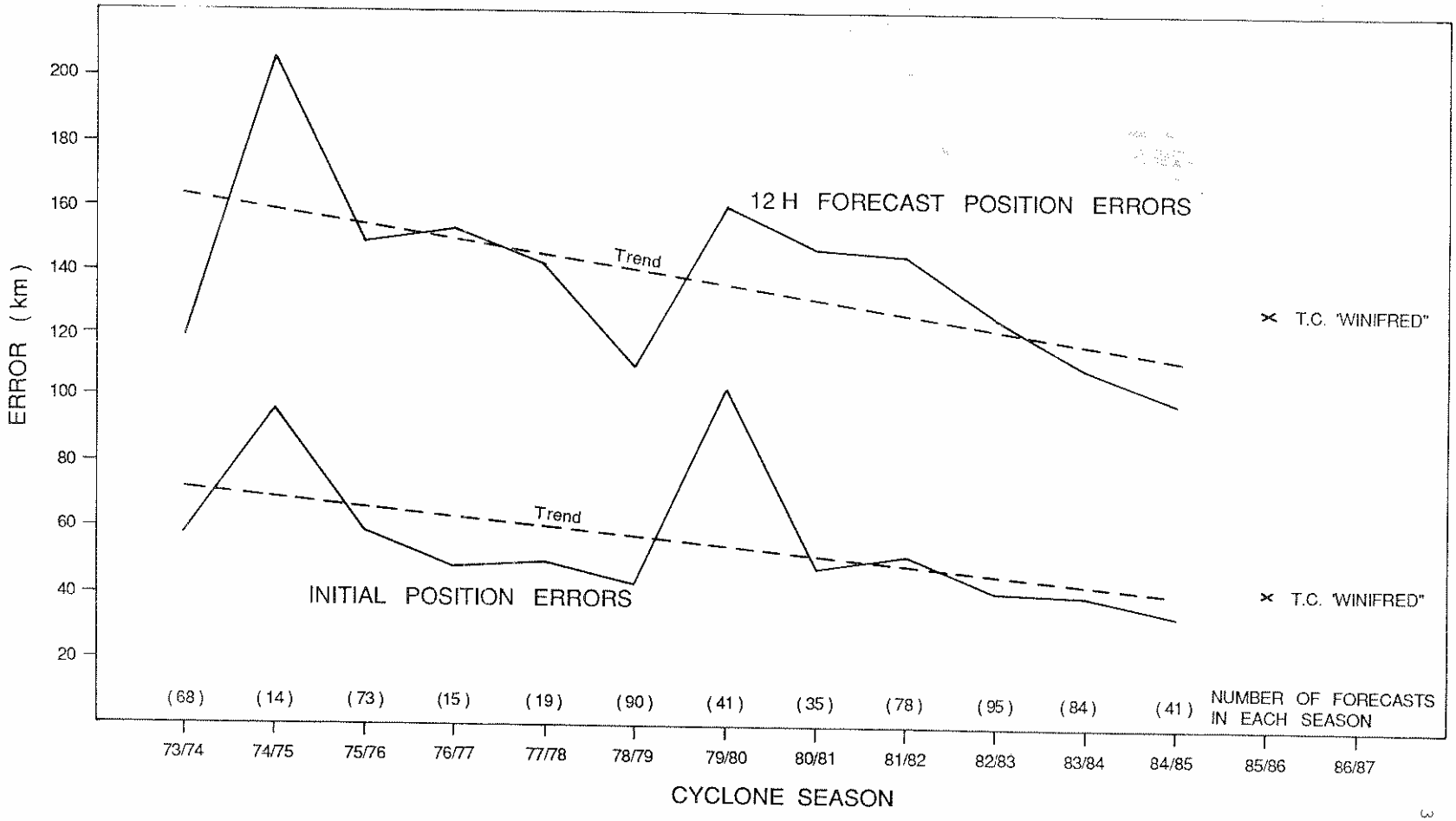


Fig. 14 Tropical cyclone position errors - eastern Australian region.

watch areas extended north to Lockhart River and south to St Lawrence.

Subsequent advices indicated that the area under threat continued to extend to the south and by 5 pm on 30 January the area under cyclone warning was from Cooktown to Bowen. This includes the entire stretch of coast that two days later experienced the full force of cyclone *Winifred.*

Throughout 31 January and into the morning of 1 February, the area between Cairns and Bowen remained under cyclone warning with the southern limit of the warning being extended to St Lawrence.

At about 10 am on 1 February it became clear from Cairns weather watch radar that *Winifred* had changed course some hours earlier. It was now heading in a southwesterly direction towards the coast. A Flash Tropical Cyclone Advice was issued at 11 am, warning of very destructive winds that afternoon between Fitzroy Island and Innisfail and destructive winds as far south as Cardwell. The forecast position of landfall was near Babinda. Maximum gusts were forecast to be 190 km/h.

For the remainder of the day messages indicating the latest position of the cyclone were issued every hour while full warnings were issued every three hours.

At 2 pm and again at 5 pm the forecast location of landfall and the stretch of coastline expected to experience destructive or very destructive winds were further refined. These are shown diagramatically in Fig. 15.

The 8 pm advice, issued after landfall which occurred near Silkwood at about 7 pm, indicated that *Winifred* would continue to move inland and weaken during the next few hours.

By 11 pm the cyclone had weakened to the extent that its major features were no longer discernible by radar and all available observations indicated that winds were rapidly decreasing. The 11 pm advice indicated that damaging gusts would be restricted to a small area close to the centre of the cyclone and should cease to occur overnight. This was the final advice issued. Copies of the more significant messages are given in Appendix 2.

In summary, all of the area which experienced destructive winds or destructive wind gusts (from Cairns to Ingham) was under cyclone watch from 5 am on Thursday 30 January. This was upgraded to a cyclone warning at 11 am on the same day.

Wind gusts to 130 km/h were first forecast for exposed coastal areas between Cairns and Cardwell at 11 am on Friday 31 January and very destructive winds (gusts to 180 km/h) were first forecast at 11 am on Saturday 1 February.

During the whole period a heavy workload was placed on the communication staff of the Tropical Cyclone Warning Centre and its telex facilities. The three-hourly tropical cyclone advices were telexed to up to 100 recipients while the brief hourly updates issued between midday and 10 pm on Saturday 1 February were telexed to 47 addresses.

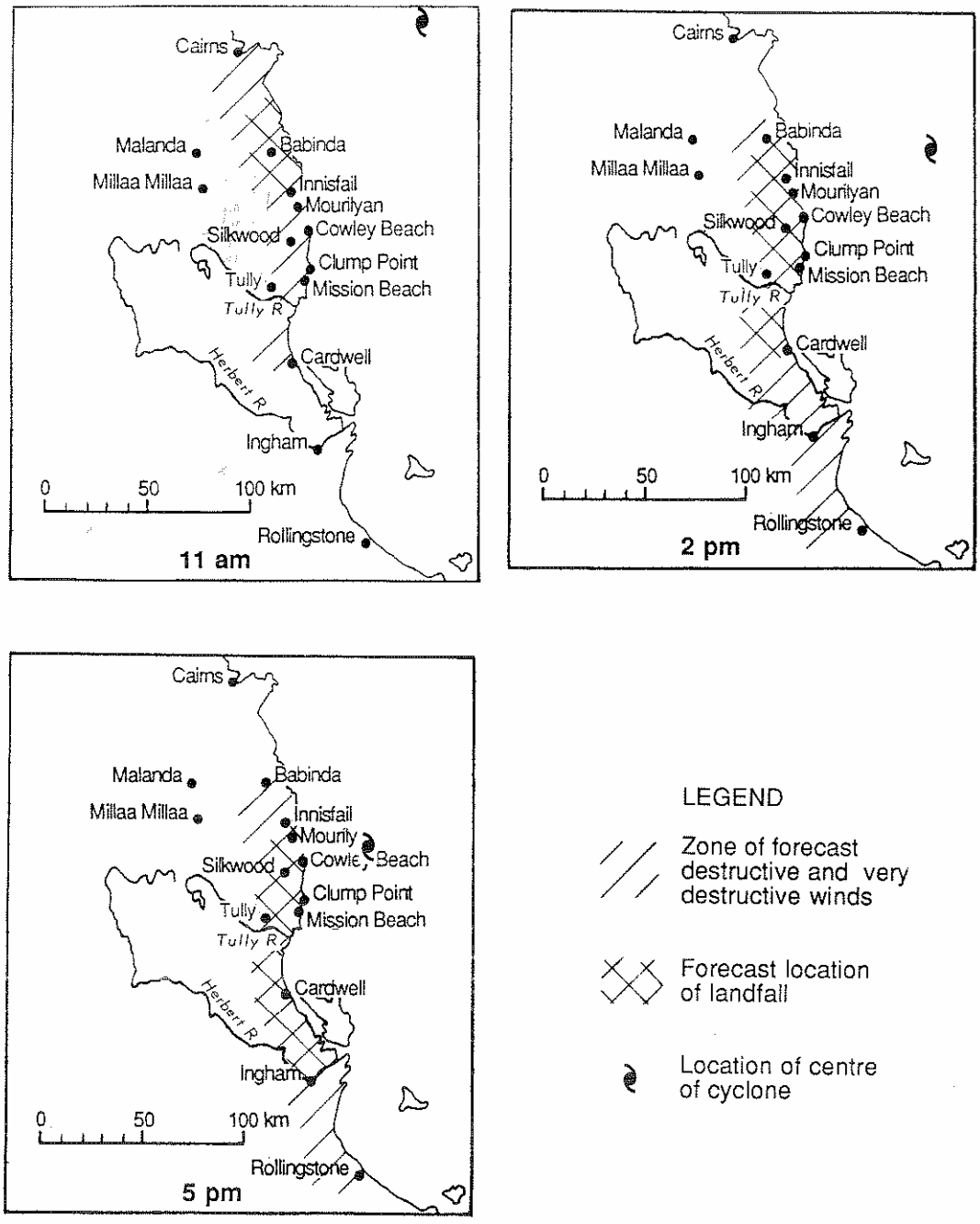


Fig. 15 Forecast locations of landfall and zones of destructive and very destructive winds on 1 February.

Public reaction

There was a mixed public reaction to the Bureau's performance during cyclone *Winifred.*

Critical comment appeared in editorials and in letters to the editor in regional papers, in media interviews and radio talk-back programs, in letters to the Regional Director and the Minister for Science, and at special meetings between Bureau staff and local representatives held in Cairns and Townsville during the second week of February.

The main areas of criticism, and comments on them, follow:

Receipt of advices by the media later than the nominated time of issue

Comment:

Apart from one occasion - the advice nominally issued at 8 pm on Saturday 1 February - all advices were transmitted to media outlets in the Cairns-Townsville area within 15 minutes, and the vast majority within 10 minutes, of the nominated issue time. Transmission of the 8 pm, 1 February advice was completed by 8.20 pm. The full 3-hourly warning messages were disseminated by telex to approximately 100 addresses, and the brief hourly updates to 47 addresses.

Meeting message deadlines has been a long-standing problem with the Tropical Cyclone Warning System, and is related to workload. However, to the media and the public, delays of even 10 minutes in the receipt of messages are considered intolerable during critical periods. Computerisation in the areas of text preparation and message dissemination should alleviate these problems in future.

Late notification of cyclone Winifred's turn towards the coast

Comment:

During the period commencing late on Friday 31 January and continuing into the morning of 1 February, *Winifred's* centre was being tracked by satellite, aided by reports from Holmes Reef automatic weather station. As the cyclone turned and accelerated towards the coast it was not possible from the data available to accurately track the centre and errors in cyclone location reached 44 km by 8 am 1 February.

The turn occurred while the cyclone centre was outside the effective range of the Cairns radar. Normally, the Bureau's radar network can detect cyclone centres at a range of 200 km or more. Using images transmitted from Cairns radar at 15-minute intervals by photo-facsimile, cyclone *Winifred's* centre was not confidently identified until about 9.30 am, at a range of approximately 130 km from the Cairns radar.

Between 9.30 am and 10.30 am on 1 February, meteorologists in the Tropical Cyclone Warning Centre worked to establish the cyclone's new direction and speed, forecast its characteristics and likely location of landfall, and compute the likely height

of the storm tide. These tasks were successfully completed and Flash Tropical Cyclone Advice No. 21 was despatched to reach media outlets by 11 am.

The Tropical Cyclone Warning Centre always recognised the possibility that *Winifred,* a slow moving cyclone, could turn towards the coast. For that reason, coastal areas, including the final impact area, were kept on a full cyclone warning from late Thursday until Saturday. People who heeded these warnings had ample time to prepare and would have been in a position to respond quickly when *Winifred's* turn towards the coast was notified.

Confusion created when the direction-distance of the cyclone centre from a coastal reference point did not closely coincide with the latitude - longitude reference

Comment:

Discrepancies that did occur were generally within the error tolerances of the cyclone tracking systems in use, and had no significant impact on the overall warning strategy. However, many people were using cyclone tracking maps to plot the path of the cyclone's centre, and some of the discrepancies could have been confusing.

Whereas the latitude-longitude reference enables accurate plotting of the estimated position of the cyclone centre on suitable charts, the bearing (to 16 compass points) and distance information, though inherently less accurate, can provide a meaningful guide to people without access to such charts. People plotting the cyclone's progress should recognise that central position estimates can be more than 20 km and, on occasions, up to 100 km in error if the position fix is based solely on satellite information, and up to 15 km in error based on a good radar-scope presentation. The Tropical Cyclone Warning Centre regularly re-appraises previous position estimates on the basis of new information, and simply joining the latest and previous position indicated in warnings will not necessarily provide the cyclone's current movement.

Omission of distance east of a coastal location

Comment:

There is a public demand for tropical cyclone advices to give the location of the cyclone centre in terms of a distance east of a town or geographical reference point on the coast. This information was contained in all advices up to and including 11 am on 1 February. Thereafter the cyclone was becoming too close to the coast to be located with sufficient accuracy in terms of distance east of a well-known location. Furthermore, Tropical Cyclone Warning Centre staff are aware of a belief held by many people that, once a cyclone having a southward component of motion has reached a bearing east of a town, it will almost certainly pass on by. This would have been a particularly dangerous misconception as *Winifred* approached landfall. From midday on 1 February, bearing-distance information was only provided in relation to threatened towns in the cyclone's path.

Dissatisfaction with brief hourly updates

From 11 am on 1 February, when *Winifred* was being tracked towards the coast by radar, the full 3-hourly warnings were supplemented by hourly updates of the cyclone position and the area under major threat. These updates were despatched to the

media with a request to also broadcast the last full 3-hourly warning, which contained additional information about winds and storm tide. These led to complaints from some people that the media were still broadcasting the full 2 pm warning after 4 pm, even though the 4 pm updated position would also have been broadcast.

Comment:

The workload and telex transmission time involved has prevented the provision of full warnings at hourly intervals. The form and content of all warnings will be reappraised in connection with the new AROS computer system in the Brisbane Regional Office, which will facilitate text preparation and automatically disseminate cyclone advices.

Notification of time of landfall

The Bureau was sharply criticised for delaying until 8 pm advice, which was received by media outlets at about 8.20 pm, that *Winifred's* centre had crossed the coast at 7 pm. According to one source this 'unbelieveable time delay could have in many cases increased property damage and it is fortunate it did not result in loss of life'.

Comment:

Tropical Cyclone Advice No. 21 issued at 11 am on 1 February warned of very destructive wind gusts above 180 km/h between Fitzroy Island and Innisfail, and destructive wind gusts above 130 km/h between Innisfail and Cardwell, during the afternoon. This advice further indicated that the cyclone centre was expected to make landfall near Babinda late that afternoon. Tropical Cyclone Advice No. 22 issued at 2 pm forecast landfall 'between Babinda and Cardwell late this afternoon' and turned out to be very accurate. Tropical Cyclone Advice No. 23 issued at 5 pm and updates issued at 6 pm and 7 pm, as well as subsequent advices, all specifically warned of conditions that would be experienced with the passage of the calm eye of the cyclone.

The advice provided in the 8 pm warning concerning the coastal crossing at 7 pm near Silkwood was simply an information item to help people identify the recent path of the cyclone's centre. The Bureau does not accept there was any lack of forewarning that the cyclone centre would cross the coast as implied by the criticisms.

Termination of Advices while heavy winds were still being experienced

Comment:

The last Tropical Cyclone Advice was transmitted at 11 pm on Saturday 1 February. By this time *Winifred* was estimated to be more than 50 km inland over mountainous country, and weakening rapidly. The cyclone was no longer discernible on radar. The advice referred to 'Cyclone *Winifred* - continuing to weaken - damaging gusts extending further inland and gradually easing overnight'. Criticism came from residents who were still experiencing winds too strong to move outdoors when the advice was broadcast, and still fearful of what the cyclone would do next. Although little information was being received from the immediate area at the time, Tropical Cyclone Warning Centre staff acknowledge it would have been psychologically preferable to have maintained warnings for another 3 hours.

Location of Tropical Cyclone Warning Centre

The call for the establishment of a new Tropical Cyclone Warning Centre in Townsville came from a number of quarters including editorials in north Queensland newspapers, and from John Moore, Australian Government Opposition Spokesman on Northern Development.

Comment:

The main argument forwarded to support this proposal is the elimination of the perceived time delay caused by the need to transmit information from north Queensland to Brisbane for analysis before Tropical Cyclone Advices are prepared for transmission back to north Queensland.

However, unless the Tropical Cyclone Warning Centre was very close to the cyclone, and the radar located at that office was actually tracking the cyclone, the communication delays would be identical to those experienced with the Tropical Cyclone Warning Centre located in Brisbane.

Facilities presently available permit transmission of radar-scope images to Brisbane by photo-facsimile in about 5 minutes. Planned improvements will provide a real-time continuous display from any of the six Queensland coastal radar stations on monitors in the Tropical Cyclone Warning Centre.

A second warning centre in Townsville would require a duplication of the expensive facilities and specialist meteorological staff, supporting staff, and infrastructure, now existing in Brisbane. Furthermore, a centre in Townsville would be vulnerable to communications losses or other disablement during a cyclone impact on Townsville itself.

Although a Tropical Cyclone Warning Centre in Townsville would provide moral reassurance for people in north Queensland, it is considered that resources would be more profitably deployed by improving the capabilities of the existing Brisbane - based centre, and in upgrading cyclone surveillance facilities along the Queensland coast.

Appreciative references to Bureau services

In contrast to the critical comment, several complimentary references to the services provided by the Bureau during *Winifred* were received. These were made through personal contacts with senior Bureau staff, a letter to the editor in a regional newspaper, and letters to the Bureau's Regional Director, Queenland from a local authority and other organisations. Tropical Cyclone Warning Centre staff were particularly grateful for a letter of appreciation received from Mr Vic McCristal, President of ANSA, the Australian National Sport Fishing Association, and have asked that this fact be recorded here.

Post-cyclone activities by Bureau staff

During the eleven days following the cyclone three groups of Bureau staff visited the cyclone-affected area. The first group, which included the Supervising Meteorologist from the Queensland Regional Office, visited Cairns, Innisfail and Tully on February 6 and 7. The major functions carried out by this group included:

- public opinion survey on the effectiveness of the tropical cyclone warning system;
- appearances on radio talk- back programs in Cairns and Innisfail;
- visits to selected cooperative and emergency observers;
- visits to selected citizens who had recorded pressure readings on their home barometers;
- general inspection of damage in the area.

An excellent response was recieved to both the survey on the effectiveness of the tropical cyclone warning system and to the radio talk- back programs.

On 10 and 11 February, a second group including the Regional Director Queensland and the Assistant Director Services visited Cairns and Townsville. The main purpose of this visit was to address meetings of representatives of the media, local government, SES, police and other interested parties.

During the period from 10 to 14 February, senior staff from the Flood Warning Centre in Brisbane also visited the area. They held meetings with police, State Emergency Services and shire council officers in Ingham and Tully to discuss the performance of the flood warning system during the floods produced by *Winifred.*

All of these visits were very useful. They enabled discussion of the various criticisms of the Bureau's service including suggestions for future improvements.

Criticisms of the Bureau's services were published in the regional press, both as editorial comment and as letters to the editor. A response to these criticisms was provided by Regional Director Queensland, in a letter published in the 'Cairns Post' on 12 February.

Future needs

As a result of cyclone *Winifred* the Bureau has identified a number of areas where efforts and resources should be directed to improve the performance of the total cyclone warning process. These requirements will be further considered and implemented within the responsible program areas of the Bureau, and within the context of the Bureau's program planning and budgeting process.

Public education

It appears that during *Winifred,* many people had a poor idea of what to expect from a severe tropical cyclone. For example, many people apparently thought, because their homes were experiencing winds above gale force while the Bureau was saying *Winifred's* centre was still well off-shore, that the Bureau was hours behind with its tracking. They did not understand that the cyclone was such a big system, causing destruction 50 to 100 km ahead of the central point. Figure 16 shows the position of *Winifred* at 3 pm on Saturday 1 February together with the approximate extent of the belts of destructive and very destructive winds. It can be seen that, although the centre of the cyclone is still some 50 km from the coast, destructive winds have already affected the coast from just south of Cairns to near Tully and have extended up to 10 or 15 km inland.

Other people criticised the Bureau for apparent discrepancies of only several kilometres in locating the central point of the cyclone. Whilst some of these criticisms were valid, it is apparent people had unrealistic expectations in terms of the accuracy possible from the cyclone tracking systems available to the Bureau.

Intensified efforts are needed to help people better understand the nature of tropical cyclones (particularly the extent and sequence of the hazards), and to appreciate both the strengths, and limitations of accuracy of cyclone warnings. People must also have confidence that cyclone warnings are not issued unless there is a very real danger.

Provision of cyclone warning information to the public via the media

The cyclone tracking and forecasting efforts of the Tropical Cyclone Warning Centre are wasted if the message doesn't get across to the public. The Bureau considers improvements are possible in the wording of cyclone advices to provide the best description of the nature and the level of impending danger in a relatively concise and easily understood message.

It appears necessary to place more emphasis on the temporal sequence and areal extent of the hazardous phenomena. During *Winifred* it appears that too much emphasis was placed by those who heard the warnings on tracking the central point.

Television has great potential for communicating in pictorial form the progress and areal extent of the cyclone. A moving overlay, indicating the extent of destructive and very destructive winds, could be shown on a suitable map background. The meaning of destructive and very destructive winds could be recalled by showing film clips from past cyclones.

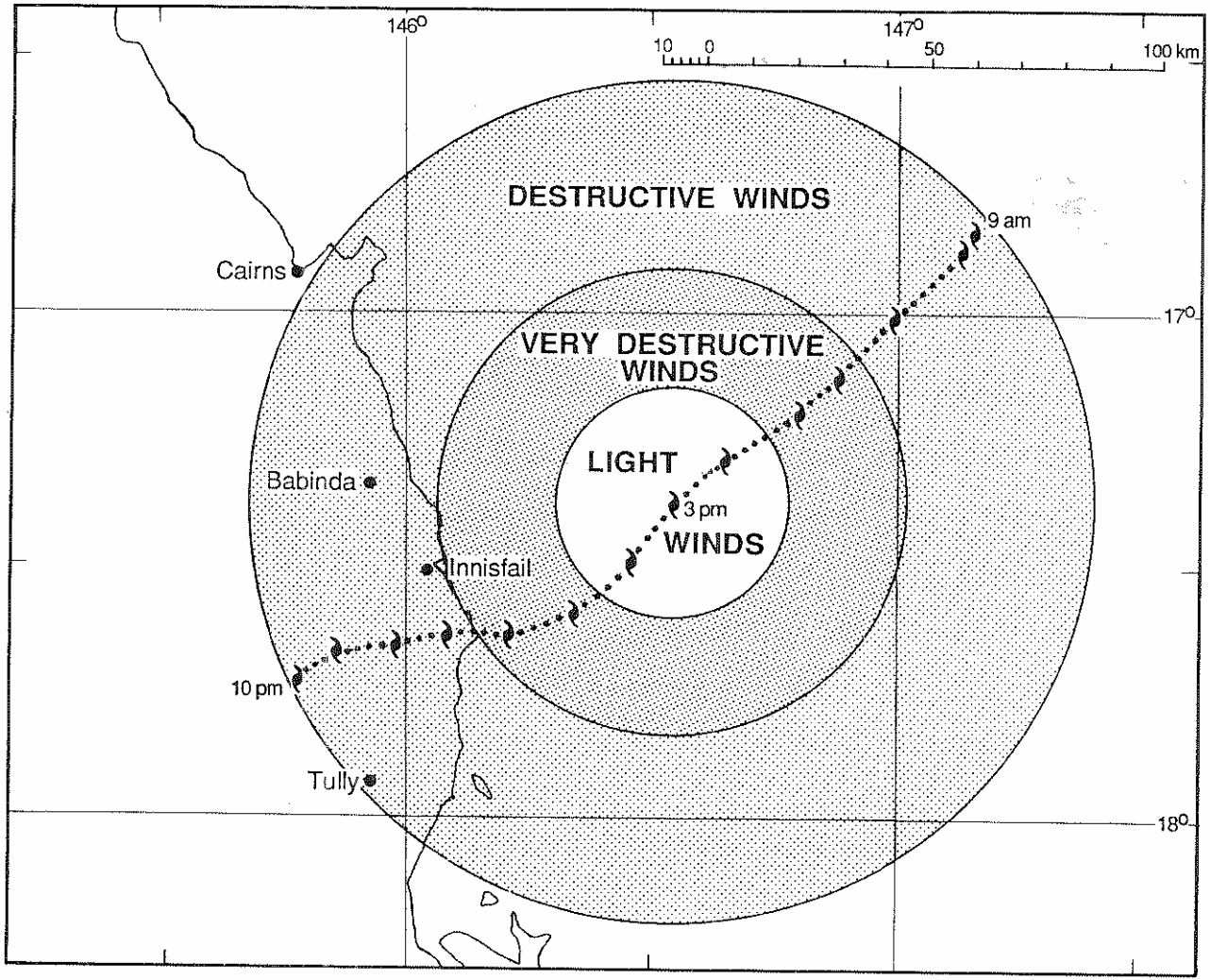


Fig. 16 Approximate wind fields for cyclone *Winifred* at 3 pm on 1 February.
Note - track shows hourly locations of the central position.

The Bureau is unable to provide tropical cyclone advices more frequently than hourly when a cyclone is approaching or impacting on the coast, nor would there be any significant counter-disaster benefit in doing so. However, people seek reassurance and confirmation during cyclone events. Senior Bureau staff make themselves available for live interviews at such times to explain and reinforce warnings. The media will be encouraged to use this facility.

The Bureau's Automated Regional Operations System (AROS) became operational in the Queensland Regional Office and Tropical Cyclone Warning Centre during June 1986. This system has a high-volume message dissemination capability through Telecom's telex network and will significantly impact on the timeliness of cyclone advices. AROS could also provide the capability to issue fully worded warnings in lieu of the brief intermediate hourly updates, after the workload problems in the cyclone warning centre have been satisfactorily resolved.

Cyclone tracking technology

The main difficulty encountered in tracking cyclone *Winifred* related to a major change in direction which occurred while *Winifred* was out of range of the coastal radar network. *Winifred's* turn towards the coast which commenced late on 31 January, was not clearly apparent to Tropical Cyclone Warning Centre staff until about 9 hours after the turn commenced.

The following systems would be capable of providing more precise information on cyclones outside of coastal radar range.

- Automatic weather stations

The Bureau's network of automatic weather stations (AWS) on the Great Barrier Reef, installed during the 1960s and early 1970s, is becoming unreliable and difficult to maintain. These stations will be replaced during 1986/87 with modern equipment which will transmit via the Japanese Geostationary Meteorological Satellite. *Winifred* indicated that AWS would be very valuable on Bougainville and Osprey reefs, in addition to existing locations.

- Aircraft reconnaissance

Reconnaissance flights into tropical cyclones have been undertaken by the United States Air Force in the Atlantic and North Pacific Oceans for many years. These flights provide precise information about cyclone locations and intensities, and en-route measurements of environmental winds that 'steer' the cyclone. Such flights are undertaken at 6-hourly intervals when cyclones threaten vulnerable areas or facilities.

An investigation by Curnow and Moll (1984) indicated that regular cyclone reconnaissance flights in Australia would prove very costly. However, the Bureau could pursue the possibility of 'one-off' flights to provide information during those infrequent situations in which the Tropical Cyclone Warning Centre assesses there is a critical requirement.

- Over The Horizon (OTH) radar

The Jindalee Skywave Radar, located near Alice Springs, reflects a narrow beam of

radio waves off the ionosphere in order to probe the ocean surface to the northwest of Australia. Wind and sea-state data can be produced over a large ocean area. These data, measured to a horizontal resolution of 1 km, have been verified against observations from the Bureau's AWS located on tropical islands and against observations from ships in the area. The aim of the second stage of Project Jindalee is to develop automatic procedures for the locating and tracking of tropical cyclones (Anderson 1984). The Bureau is maintaining a close interest in this technology.

- Meteorological satellites

Future improvements in satellite sensing and image processing techniques are expected to gradually improve satellite-based estimates of tropical cyclone positions and intensities.

The relatively high cost of equipment required for reception and processing of very high resolution data currently being transmitted by American weather satellites has so far prevented the Tropical Cyclone Warning Centres gaining access to this information.

A project is underway to provide all of the Bureau's Regional Offices with facilities for real-time interactive processing of satellite data. These facilities will eventually provide the Tropical Cyclone Warning Centres with the operational flexibility needed to obtain the best possible estimates of cyclone positions and intensities from the satellite data now available to them.

- Land-based radars

Land-based radars remain the most efficient system for tracking cyclones within about 200 to 300 km of the coast. The aging radar at Cairns will be replaced during 1986. The Bureau plans to provide remote colour television displays in the Tropical Cyclone Warning Centre linked to all coastal radar stations. This will replace the existing facsimile system which has served the Bureau well but is now outmoded. The new displays will provide immediate and more detailed information. Storage, time-lapse and zooming capability will permit more precise and detailed radar interpretations of tropical cyclones. Post - analysis of Cairns radar data indicates that had such a system been available during cyclone *Winifred,* the cyclone's turn toward the coast could have been detected about two hours earlier - in time to influence the Tropical Cyclone Advice issued at 8 am on Saturday 1 February.

Staffing of Tropical Cyclone Warning Centres

The Bureau has long recognised the benefits that it would obtain from the development of specialist groups dedicated to severe weather warning, particularly in the Tropical Cyclone Warning Centres. Tropical Cyclone Warning Centre operations provide a high-stress environment. High workloads and excessive hours of duty provide a precarious aspect of these operations, and this problem must be addressed.

The Bureau is developing a proposal to provide specialist staff in Cyclone Warning Centres. Two specialist meteorologists would considerably alleviate the operational staffing problems. They would also provide a much-improved capacity for developing and fine-tuning the warning system, and for important extension activities with the media, local authorities, emergency services, industry, and the public.

Conclusions

Tropical cyclone *Winifred* was the first severe tropical cyclone to affect the north Queensland coast since *Althea* in December 1971. It created a total damage bill estimated to be in excess of $130 M.

Winifred followed a somewhat erratic course with four major changes of direction before it finally made landfall late on Saturday 1 February. Despite this erratic track and some problems caused by the inability of the aging Cairns radar to locate the centre of the cyclone beyond a range of about 130 km, the Bureau's Tropical Cyclone Warning Centre performed creditably. The entire area which experienced significant damage from the violent winds (between Cairns and Ingham) was under cyclone warning from 11 am on Thursday 30 January. Landfall in the vicinity of Innisfail was first forecast at 11 am on Saturday, some eight hours before the cyclone crossed the coast near Silkwood.

Some criticism of the Bureau's warning service was received from the local media, local authorities and certain residents. Some of this criticism concerned minor points of detail which did not significantly affect the overall warning strategy. Other criticisms reflected unrealistically high expectations of the warning service and the public's misconceptions concerning the nature of tropical cyclones. Some of the criticism, however, particularly in relation to the delay in picking up the change in *Winifred's* track which occurred early on the morning of 1 February, was more serious and steps are being taken to overcome the problems which have been identified.

On the other hand, several complimentary references to the Bureau's services were also received.

The visits of senior Bureau personnel to the affected areas and the public meeting held in Cairns on 10 and 11 February were very valuable, both in discussing the criticisms raised and enabling the Bureau to explain the strengths and limitations of the warning services.

As a result of *Winifred* and as a part of a general upgrade of weather services, the Bureau has already commenced a number of initiatives and is planning others which will improve its capabilities in future cyclone events. These initiatives include the upgrading of the Cairns weather watch radar, the introduction of a computer-based forecast and warning preparation and dissemination system to speed up receipt of warnings, the introduction of remote colour television displays of all tropical cyclone surveillance radars in the Brisbane Tropical Cyclone Warning Centre and an expanded public education program.

References

Anderson, S.J. 1984. Remote sensing with the Jindalee Skywave Radar. *Proc. 1st Aust. Conf. on Physics of Remote Sensing of Atmosphere and Ocean.* Melbourne, February 1984.

Bureau of Meteorology. 1977. *Report on Cyclone Tracy, December 1974.* AGPS, Canberra.

Curnow, R.J. and Moll, J.W. 1974. Improvement of the Tropical Cyclone Warning Service in Queensland. *CSE Note 33, October 1974.*

Appendix 1

Cyclone Winifred flooding

Introduction

Heavy rain commenced along the far north tropical coast between Cairns and Townsville during the afternoon of Saturday 1 February, with peak rainfall intensities being recorded between noon and midnight. Some of the higher 12-hour rainfalls for this period included Ravenshoe 309 mm and Cardstone 375 mm.

Major flooding occurred in the Tully and Herbert Rivers with the Herbert River at the Gairloch gauge (near Ingham) rising to a peak of 12.22 m which is only 0.38 m lower than the record 1967 flood. Flood levels in parts of Halifax are reported to have been the highest in 60 years. There was also minor flooding in the North and South Johnstone Rivers and the Burdekin River.

As the low, formerly cyclone *Winifred,* moved further westward, general heavy rains were recorded over the headwaters of the Diamantina, Thomson, Barcoo, Bulloo and Warrego Rivers. Rainfalls for the 72 hours ended 5 February totalled up to 150 mm in the headwaters of the Diamantina and Thomson Rivers and 100 mm in the headwaters of the Bulloo and Warrego Rivers, but with isolated falls up to 140 mm. As a result, there was major flooding in the Thomson River and upper reaches of Cooper Creek, moderate flooding in the Diamantina and Bulloo Rivers and minor flooding in the Warrego River.

The most significant flooding was in the Tully and Herbert Rivers and this is discussed below together with a review of the performance of the flood warning system for these rivers.

Tully-Herbert River floods

Rainfall

Rainfalls for the 24-hour period to 9 am on Sunday 2 February are shown as an isohyetal map in Fig. A1. The heaviest rainfalls occurred in the headwaters of the South Johnstone, Tully and Murray Rivers and in the eastern tributaries of the Herbert River above the gorge. To the north and west of this area rainfall amounts decreased markedly.

For flood-forecasting purposes, the rainfall for Herbert River catchment is assessed in three regions - (i) the Herbert River above Gleneagle, (ii) the drainage area between Gleneagle and Abergowrie Bridge and (iii) the area below Abergowrie Bridge to Gairloch near Ingham. The temporal distribution of the rainfall for these subcatchments is shown in Fig. A2. The rainfalls are averaged using statistical weighting factors applied to the rainfall amounts reported by the floodwarning rainfall stations. Figure A2 illustrates the high rainfall intensities which occurred up to midnight on 1 February as cyclone *Winifred* was crossing the coast.

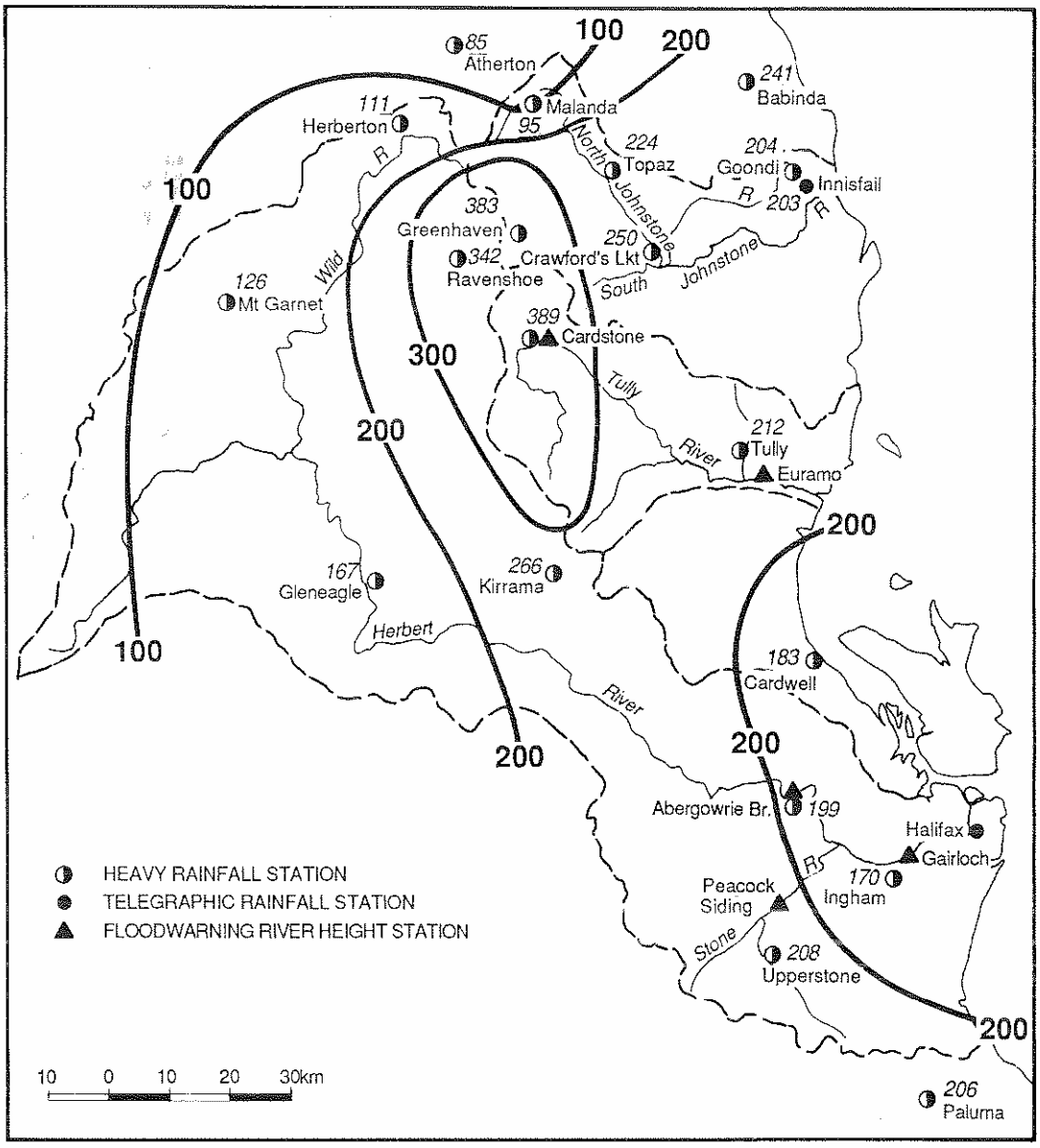


Fig. A1 Rainfall isohyets (mm) for the 24 hours ended 9 am on 2 February.

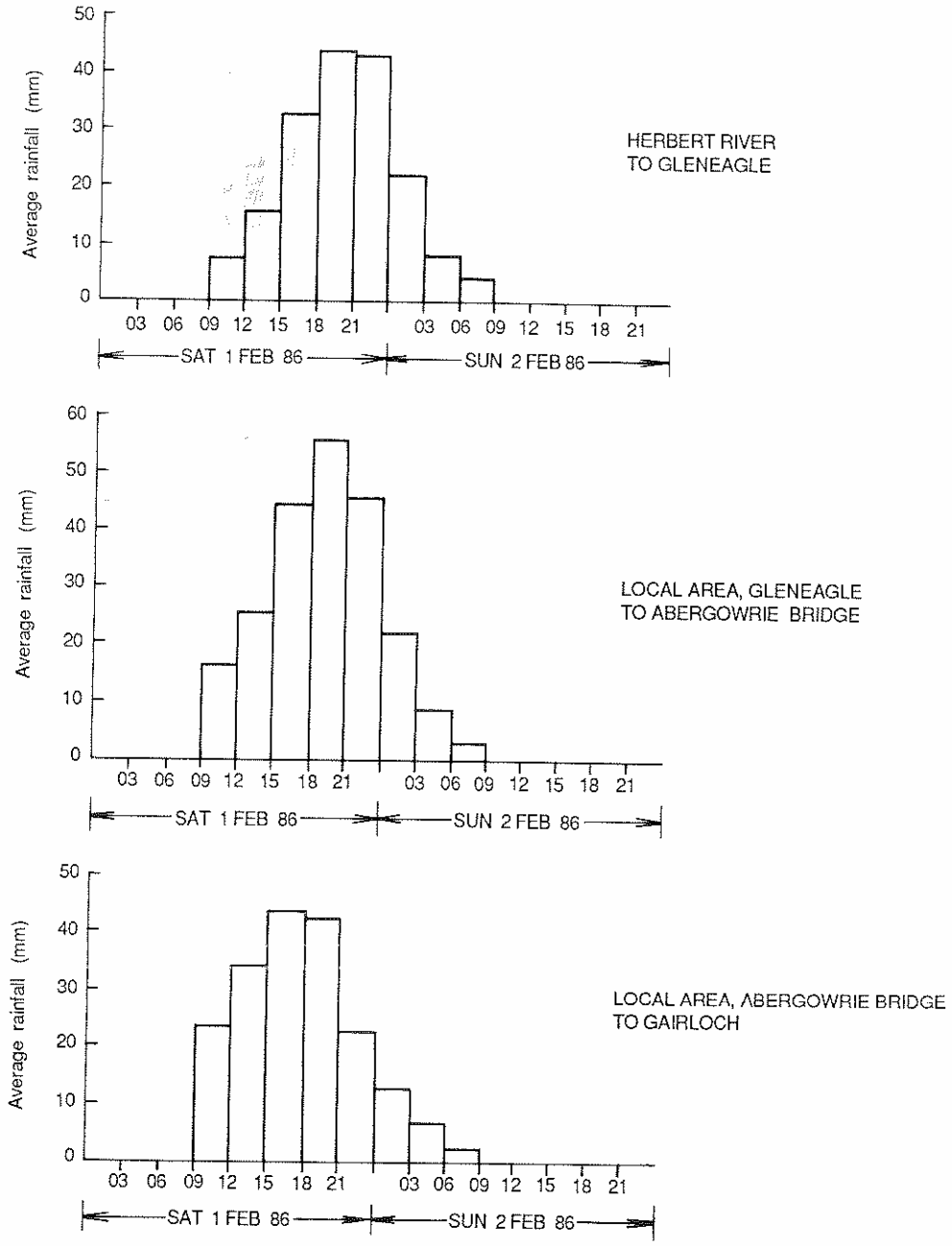


Fig. A2 Average sub-catchment rainfall (mm) over the Herbert River for the 24 hours ended 9 am on 2 February.

Flooding

Herbert River

Both the Herbert and Tully Rivers peaked at major flood levels during 2 February. The Herbert River at Gairloch peaked at 12.22 m at 3 pm on 2 February causing extensive inundation of Ingham and Halifax and adjacent agricultural (primarily sugar cane) areas. From the records of flood peaks held by the Bureau of Meteorology, the *Winifred* flood at Gairloch is the fourth highest flood since 1956. Flood heights for these floods are given in Table A1.

Table A1. Peak heights at Gairloch.

1.	14 March 1967	12.60 m
2.	7 March 1956	12.27 m
3.	7 March 1977	12.25 m
4.	2 February 1986	12.22 m

The 1967 flood is the highest flood on record. It can be seen from these heights that the Winifred flood is only 0.38 m lower than the record 1967 flood and almost the same as the 1956 and 1977 floods. However, this is not the case for further up- river at Abergowrie Bridge and Gleneagle where flood levels were much lower. The peak flood heights for these stations are given in Table A2.

Table A2. Peak heights at Gleneagle and Abergowrie Bridge.

Flood peaks for:	*March 1967*	*March 1977*	*February 1986*
Gleneagle	About 19.75 m	16.2 m	13.25 m
Abergowrie Bridge	20.0 m	18.6 m	16.5 m

The 1967 flood heigh for Gleneagle is estimated because the gauges were washed away by the floodwaters, but this flood was a remarkable 6.5 m higher than the peak of the *Winifred* flood.

Although the upstream peak flood heights for the Winifred flood were metres lower than for both the 1967 and 1977 floods, the high intensity rain below the Herbert River gorge caused the flood levels at Ingham to be similar. As shown in Fig. A2, an average of 184 mm fell in the lower reaches for the 24 hours to 9 am 2 February and most of this was in just 15 hours to midnight 1 February. In contrast, the 1967 rainfall over the same local area was less than 70 mm in the 24 hours prior to the Gairloch peak. The 1967 flood was mostly due to floodwater moving downstream from areas above Abergowrie Bridge and Gleneagle.

The high intensity rainfall in the lower Herbert River catchment resulted in a very rapid rise to the peak at Gairloch. This can be seen on Fig. A3 which shows the stage hydrographs (river height versus time) for the Herbert River floodwarning river height stations. During the early hours of 2 February, the river level at Gairloch was rising at over 0.5 metre per hour and was already 12 m at 9 am.

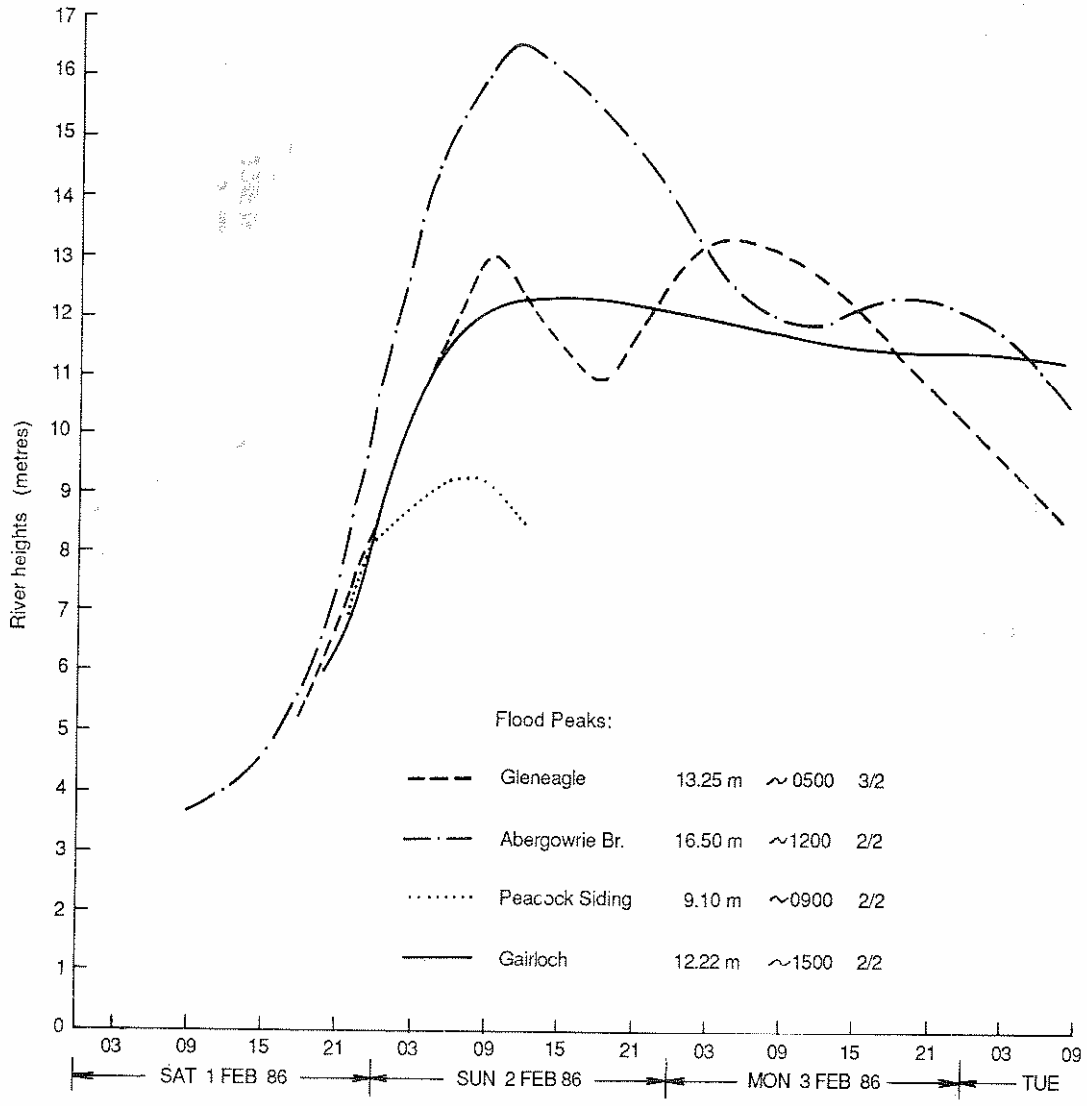


Fig. A3 Herbert River flood hydrographs for the period 1 to 4 February.

Herbert River levels had commenced falling by the afternoon of 2 February, although a second rise to 13.25 m was recorded at Gleneagle early on 3 February. This did not cause renewed rises at Ingham but did prolong the major flooding at Ingham and Halifax until 4 February.

Tully River

The Tully River at Euramo peaked at 9.09 m at about 4 pm on 2 February which is the highest level recorded since 1967. This height causes the Bruce Highway to be inundated to a depth of about 1 m in the vicinity of the main road bridge. The record flood of 1967 reached 9.37 m. Two other floods have exceeded 9 m in the past 20 years - these being 9.05 in March 1977 and 9.01 m in April 1982.

Performance of the flood warning system

Observations

The flood warning service is primarily based on special observations of rainfall and river heights provided by a network of volunteer observers, together with the routine meteorological observations used for general forecasting services. The dedication and public spirit of the floodwarn observers was again proven particularly through the night hours of Saturday and early Sunday morning when conditions were difficult and hazardous.

Unfortunately, some telephone communications were disrupted overnight Saturday 1 February which reduced the number of heavy rainfall observations at a critical time of flood prediction analysis. This problem is difficult to overcome and perhaps the only solutions would involve either emergency radio communications capability for manual observers or an automatic radio telemetry network.

The severity of the weather conditions demonstrated the value of the remote rainfall digital indicators (connected to a tipping bucket rain gauge) which have been provided by the Bureau at most floodwarn rain stations in far north Queensland. These allow rainfall readings to be safely taken indoors. Some data was lost from stations where remote indicators have not yet been installed because conditions were considered too dangerous to venture outside to the manual rain gauges.

Communications

This event highlighted the vulnerability of telephone communications in disaster areas. In addition to the disruption of some telephone services discussed above, some delays in both inward receipt of data and outward promulgation of flood warnings were caused by the congestion of the telephone network in the aftermath of the cyclone. A specific problem indentified after the event was that the Ingham Police did not receive two key flood warnings sent by phonogram because their telephone was continuously busy. To minimise future occurrences of this problem, the Bureau has requested the Police Department to implement a previously agreed procedure of promulgating floodwarnings to police stations using their internal message switching system.

Apart from these problems with the telephone network, the dissemination of flood warnings via telex proceeded without significant delays. The telex distribution of flood warnings is comprehensive and includes disaster authorities, shire councils, and television and radio stations.

Warning services

The Floodwarning Centre was manned continuously from the morning of 1 February when *Winifred* commenced its track towards the coast, until late on 2 February when it was certain that the forecast levels for Gairloch on 3 February would eventuate. During this period, engineer and technical support staff worked on shifts to receive and analyse incoming rainfall and river level data for the formulation and issue of flood warnings.

Herbert River

Floodwarnings issued by the Floodwarning Centre for the Herbert River were initially qualitative - that is the river level predictions were described in terms of minor, moderate and major flooding. To assist the community in interpreting this information, the Hinchinbrook Shire Council has provided landholders with a card titled 'Herbert River Flood Heights' (see Fig. A4) which details the extent of flooding in Ingham and Halifax for various heights on the Gairloch gauge.

Critical warnings issued during the morning of 2 February contained specific height forecasts for the Gairloch gauge and were formulated in close consultation with Hinchinbrook Shire Council.

Herbert River warnings commenced at 4 pm on 1 February with a prediction of significant stream rises causing local flooding and traffic disabilities for coastal streams between Innisfail and Ingham. Heavy rain continued in the catchment and qualitative warnings were renewed at 7.45 pm and 10.30 pm. A top priority warning was issued at 4.45 am on 2 February and predicted that the river level at Gairloch would reach 12 m that night with major flooding and levels similar to those in March 1977. Landholders and residents were warned to expect rapid river rises during Sunday morning between Abergowrie and Halifax.

The next warning at 10.15 am on 2 February predicted Gairloch to reach 12.3 m at noon and peak at about 12.5 m later in the afternoon. It also indicated that the rapid rises in the river levels in the Upper Herbert above the gorge would not increase the predicted heights at Gairloch.

The 3.45 pm warning reported that the Gairloch reading of 12.22 m at 3 pm was near the peak level. The Herbert River warning was again renewed at 10 pm and continued twice daily during the following week as river levels fell.

Tully River

Quantitative warnings containing predicted heights at Euramo are given for the Tully

HERBERT RIVER FLOOD HEIGHTS

Flood warnings issued by Hinchinbrook Shire Council are related to flood gauges at Abergowrie Bridge and Gairloch Bridge. Advance warnings of flood flows from the headwaters of the Herbert River are provided by river height readings from Glen Eagle Station.

In all cases river heights are given as depths of flow above the stream bed. At Abergowrie Bridge and Gairloch Bridge the river height when water is up to the bridge deck is:

Abergowrie Bridge: 10.0 m.

Gairloch Bridge: 4.1 m.

The following table shows significant heights at Gairloch Bridge and their probable effects in the area of Ingham and downstream.

Height at Gairloch in Metres.	Probable Effect
4.1	Water onto Gairloch Bridge
6.5	Water over Ingham Halifax Road at Halifax Washaway.
9.1	Water onto deck of Anabranch Bridge.
9.2	Water starts to flow through Palm Creek, Ingham.
9.4	Water over Bruce Highway at Gairloch Washaway.
9.6	Water 0.3 m deep on Anabranch Bridge.
10.7 - 11.0	Water starts to flow over Herbert Street, Ingham. Water starts to flow over Bruce Highway at Kingsbury Creek and over Halifax Road, Ingham. Water starts to flow over Townsville Road, Ingham.
12.6	1967 and 1977 type flooding.

The Bureau of Meteorology also issues flood warnings expressed in broad descriptive terms of minor, moderate or major flooding. The following table shows the river heights at Gairloch which correspond to these terms for each of the Ingham and Halifax areas.

Flood Description	River Height at Gairloch in Metres	
	Ingham	Halifax
Minor	9.5 to 10.5	6.5 to 9.0
Moderate	10.5 to 11.5	9.0 to 10.0
Major	11.5 and higher	10.0 and higher

The Council has available for free distribution a map indicating major flooding depths on properties in the town of Ingham. A.k for plan No. 2198.

Distributed by —

HINCHINBROOK SHIRE COUNCIL

November, 1980

Telephones:

Council Office 76 2211

S.E.S. Building 76 2056

Fig. A4 Flood information brochure issued by the Hinchenbrook Shire.

River when the river level at Euramo has reached 7 metres and is rising. The Euramo forecast is based on a technique which assesses the effect of the past 9 hours of rain on the existing height at Euramo.

Floodwarnings for the Tully River were current from Thursday 30 January. A priority warning was issued at 11 am on Saturday 1 February which forecast renewed rises as a result of cyclone *Winifred* changing direction towards the coast. The warning was updated at 4.15 pm, 6.45 pm and 10 pm. The 6.45 pm warning predicted Euramo to exceed 8.5 m by 3 am Sunday and the 10 pm warning predicted 8.70 m by 6 am Sunday.

At 4.30 am on Sunday 2 February the Tully River warning was renewed with a prediction of 8.9 m by noon with major flooding. The subsequent warning at 9.30 am indicated that this would be the peak height. Euramo peaked slightly higher than expected at 9.09 m at 4 pm. Flood warnings were continued on Sunday and during the next week until river levels fell below flood level.

Accuracy of river height forecasts

Comparison of the predicted and observed river heights for both the Herbert and Tully Rivers shows that the height predictions were very accurate, generally within about 0.2 m.

For the Herbert River, the top priority warning issued at 4.45 am on Sunday 2 February provided an excellent indication of the type of flooding that would be expected in that it predicted flood levels similar to those of March 1977. The forecast peak of about 12.5 m given in the 10.15 am Sunday warning was 0.28 m above the actual peak.

More importantly, this warning advised that the predicted peak at Gairloch would not be increased as a result of the rising river levels in the upper Herbert River. Despite this, incorrect reports of further 1 to 2 m rises were broadcast by the local media during Sunday afternoon and evening causing a great deal of needless concern amongst Ingham and Halifax residents.

Post-flood debriefing

During the period 10 to 14 February, senior staff from the Flood Warning Centre in Brisbane held meetings with police, State Emergency Service and shire council officers in Ingham and Tully to discuss the performance of the total flood warning system during the *Winifred* flood.

Problem areas were identified and follow-up action proposed to overcome these in future.

Appendix 2

Selected tropical cyclone advices

During the period from 4 pm on Wednesday 29 January 1986 until 11 pm on Saturday 1 February 1986, *Winifred* threatened and finally crossed the north Queensland coast. During this period the Tropical Cyclone Warning Centre in Brisbane issued a total of 25 Tropical Cyclone Advices. Copies of the more important of these are reproduced below. The advices included are:

Tropical Cyclone Advice No.				
	1 issued	4 pm	Wednesday	29 Jan
	3 issued	5 am	Thursday	30 Jan
	20 issued	8 am	Saturday	1 Feb
	21 issued	11 am	Saturday	1 Feb
	22 issued	2 pm	Saturday	1 Feb
	23 issued	5 pm	Saturday	1 Feb
	24 issued	8 pm	Saturday	1 Feb
	25 issued	11 pm	Saturday	1 Feb

METMA AA49924
METOK AA41380
METBN AA41023
METGL AA49497
METRK AA49177
METMK AA48104
WEATHER AA47015
METCS AA48416
METTI AA48829
METDR AA85088
86-01-29 1547 BT
CALL CONN GA

WARNING
PRIORITY
TROPICAL CYCLONE ADVICE NUMBER 1 ISSUED BY THE BUREAU OF METEOROLOGY BRISBANE AT 4PM WEDNESDAY 29TH JANUARY 1986.

A CYCLONE WATCH HAS BEEN DECLARED FOR COASTAL AREAS BETWEEN THURSDAY ISLAND AND COOKTOWN.

AT 4PM A TROPICAL LOW 998 MILLIBARS WAS ESTIMATED TO BE 400 KILOMETRES EAST OF LOCKHART RIVER AND 340 KILOMETRES NORTHEAST OF COOKTOWN AND ALMOST STATIONARY.

THERE IS THE POSSIBILITY OF A TROPICAL CYCLONE DEVELOPING BUT GALES ARE NOT EXPECTED ON THE COAST WITHIN 24 HOURS. GALES MAY OCCUR WITHIN 48 HOURS.

REPEATING A CYCLONE WATCH HAS BEEN DECLARED FOR COASTAL AREAS FROM THURSDAY ISLAND TO COOKTOWN.

THE NEXT ADVICE WILL BE ISSUED AT ABOUT 10PM EST.

THIS ADVICE IS AVAILABLE ON THE RECORDED TELEPHONE SERVICE (07) 1190 BRISBANE, (077) 1196 TOWNSVILLE AND (070) 1196 CAIRNS.

ENDS WEATHER BRISBANE
TIME SENT ... 3.51PM

AAAAA

METBN AA41023 DURATION 2 : 57

METOK AA41380 DURATION 2 : 57

METGL AA49497 DURATION 2 : 57

PRIORITY

TROPICAL CYCLONE ADVICE NUMBER 3 ISSUED BY THE BUREAU OF METEOROLOGY BRISBANE AT 5AM THURSDAY 30/1/86.

A CYCLONE WARNING HAS BEEN DECLARED FOR COASTAL AREAS BETWEEN CAPE FLATTERY AND TOWNSVILLE.
A CYCLONE WATCH EXTENDS NORTH TO LOCKHART RIVER AND SOUTH TO ST LAWRENCE. THE WATCH HAS BEEN CANCELLED FOR AREAS THURSDAY ISLAND TO LOCKHART RIVER.

AT 4AM TROPICAL CYCLONE WINIFRED WAS ESTIMATED TO BE 320 KILOMETRES EAST OF CAPE MELVILLE AND 260 KILOMETRES EAST NORTH EAST OF COOKTOWN AND MOVING SOUTH SOUTH EAST PARALLEL TO THE COAST.

GALES IN COASTAL AREAS FROM CAPE MELVILLE TO CARDWELL WITH GALES EXTENDING TO TOWNSVILLE DURING THE DAY.
A STRONG WIND WARNING FOR SMALL CRAFT EXTENDS SOUTH TO GLADSTONE.

DETAILS OF TROPICAL CYCLONE WINIFRED AT 4AM 30/1/86
LOCATION OF CENTRE: LATITUDE 14.5 DEGREES SOUTH
LONGITUDE 147.5 DEGREES EAST
CURRENT MOVEMENT: SOUTH SOUTH EAST 25 KILOMETRES PER HOUR
CENTRAL PRESSURE: 995 MILLIBARS
MAXIMUM WIND GUSTS: 90 KILOMETRES PER HOUR NEAR CENTRE

REPEATING A CYCLONE WARNING HAS BEEN DECLARED FOR COASTAL AREAS FROM CAPE FLATTERY TO TOWNSVILLE.

THE NEXT ADVICE WILL BE ISSUED AT ABOUT 8AM.

THIS ADVICE IS AVAILABLE ON THE RECORDED TELEPHONE SERVICE (07) 1190 BRISBANE AND (079) 1196 ROCKHAMPTON AND (077) 1196 TOWNSVILLE AND (070) 1196 CAIRNS.

WHR BNE
TIME SENT...

TOP PRIORITY CYCLONE ADVICE NUMBER 20 ISSUED BY THE BUREAU OF METEOROLOGY BRISBANE AT 8AM EST SATURDAY 1ST FEBRUARY 1986

A CYCLONE WARNING IS CURRENT FOR COASTAL AREAS BETWEEN CAIRNS AND ST LAWRENCE. A CYCLONE WATCH CONTINUES SOUTH TO GLADSTONE.

AT 8AM SEVERE TROPICAL CYCLONE WINIFRED WAS ESTIMATED TO BE 210 KILOMETRES EAST OF CAIRNS AND 260 KILOMETRES NORTHEAST OF CARDWELL AND WAS MOVING SLOWLY SOUTHWARD, SLIGHTLY CLOSER TO THE COAST. THE CYCLONE IS CONTINUING TO SLOWLY INTENSIFY AND IS CAUSING WIND GUSTS TO 130 KILOMETRES PER HOUR IN EXPOSED COASTAL AREAS BETWEEN INNISFAIL AND AYR. GALES SHOULD CONTINUE ALONG THE EXPOSED COAST FROM CAIRNS TO BOWEN, AND MAY EXTEND TO ST LAWRENCE LATER TODAY.

A STRONG WIND WARNING FOR SMALL CRAFT EXTENDS NORTH TO COOKTOWN AND SOUTH TO GLADSTONE.

DETAILS OF SEVERE TROPICAL CYCLONE WINIFRED AT 8AM SATURDAY 1/2/86

LOCATION OF CENTRE:
LATITUDE 16.7 DEGRESS SOUTH
LONGITUDE 147.8 DEGREES EAST

CURRENT MOVEMENT: SOUTHWARD AT 7 KILOMETRES PER HOUR.

CENTRAL PRESSURE: 965 MILLIBARS

MAXIMUM WIND GUSTS: 190 KILOMETRES PER HOUR NEAR CENTRE.

REPEATING A CYCLONE WARNING IS CURRENT FOR COASTAL AREAS FROM CAIRNS TO ST LAWRENCE WITH WIND GUSTS TO 130 KILOMETRES PER HOUR ON THE EXPOSED COAST BETWEEN INNISFAIL AND AYR.

THE NEXT ADVICE WILL BE ISSUED AT ABOUT 11AM.

THIS ADVICE IS AVAILABLE ON THE RECORDED TELEPHONE SERVICE
(070) 1196 CAIRNS
(077) 1196 TOWNSVILLE
(07) 1190 BRISBANE

BNE RFC
TIME SENT...7.59AM
AAAAA

UTAHMK AA48149	DURATION 4 : 36
FOURHI AA46009	DURATION 4 : 36
HAYPT AA46483	DURATION 4 : 36
FNWKMK AA48521	DURATION 4 : 36
HAYPORT AA48174	DURATION 4 : 36
MKPORT AA46373	DURATION 4 : 36
HARMAC AA48100	DURATION 4 : 36
DALBAY AA46374	DURATION 4 : 36
MKYPOL AA48542	DURATION 4 : 36
ABCMKY AA48161	DURATION 4 : 36
MVQSIX AA48152	DURATION 4 : 36
FOURMK AA48512	DURATION 4 : 36

FOURRO AA49149
QEGBCB AA49842
QEGBRK AA49057
CAPELEC AA49014
HARROC AA49246
DDCRTN AA49122
RTQ AA49008
FOURHI AA46009
86-02-01 1054 BT
CALL CONN GA

WARNINGS

TOP PRIORITY

FLASH TROPICAL CYCLONE ADVICE NUMBER 21 ISSUED BY THE BUREAU OF METEOROLOGY BRISBANE AT 11AM EST SATURDAY 1/2/86

A CYCLONE WARNING IS CURRENT FOR COASTAL AREAS BETWEEN PORT DOUGLAS AND BOWEN. THE WARNING SOUTH TO ST LAWRENCE IS DOWNGRADED TO A CYCLONE WATCH. THE WATCH SOUTH OF ST LAWRENCE IS CANCELLED.

AT 11AM SEVERE TROPICAL CYCLONE WINIFRED WAS RELOCATED BY RADAR TO HAVE CHANGED DIRECTION TO NOW BE MOVING WEST SOUTHWEST TOWARDS THE COAST BETWEEN CAIRNS AND INNISFAIL.
THE CENTRE WAS ESTIMATED TO BE 130 KILOMETRES EAST OF CAIRNS AND 130 KILOMETRES NORTHEAST OF INNISFAIL.
VERY DESTRUCTIVE WINDS WITH GUSTS ABOVE 180 KILOMETRES PER HOUR ARE LIKELY IN EXPOSED AREAS BETWEEN FITZROY ISLAND AND INNISFAIL THIS AFTERNOON.
DESTRUCTIVE WINDS WITH GUSTS ABOVE 130 KILOMETRES PER HOUR IN EXPOSED COASTAL AREAS BETWEEN INNISFAIL AND CARDWELL.
GALES SHOULD CONTINUE ALONG THE EXPOSED COAST FROM PORT DOUGLAS TO BOWEN.

A STRONG WIND WARNING FOR SMALL CRAFT EXTENDS NORTH TO COOKTOWN AND SOUTH TO GLADSTONE.
ABNORMALLY HIGH TIDES COULD CAUSE MINOR FLOODING IN COASTAL AREAS FROM BABINDA TO MISSION BEACH.

DETAILS OF SEVERE TROPICAL CYCLONE WINIFRED
AT 11AM SATURDAY 1/2/86

LOCATION OF CENTRE:
LATITUDE 16.8 DEGREES SOUTH
LONGITUDE 146.8 DEGREES EAST

CURRENT MOVEMENT: WEST SOUTHWEST AT 15 KILOMETRES PER HOUR

CENTRAL PRESSURE: 965 MILLIBARS

MAXIMUM WIND GUSTS: 190 KILOMETRES PER HOUR NEAR CENTRE

EXPECTED LANDFALL: NEAR BABINDA LATE THIS AFTERNOON

REPEATING A CYCLONE WARNING IS CURRENT FOR COASTAL AREAS FROM CAIRNS TO BOWEN WITH VERY DESTRUCTIVE WIND GUSTS ABOVE 180 KILOMETRES PER HOUR ON THE EXPOSED COAST BETWEEN FITZROY ISLAND AND INNISFAIL.

A BRIEF UPDATE WILL BE ISSUED TO MEDIA OUTLETS SHORTLY AFTER NOON. THE NEXT FULL ADVICE WILL BE ISSUED AT ABOUT 2PM.

THIS ADVICE IS AVAILABLE ON THE RECORDED TELEPHONE SERVICE
(070) 1196 CAIRNS
(077) 1196 TOWNSVILLE
(07) 1190 BRISBANE

GA
48174
HAYPORT AA48174
METQR AA42073

WARNING.

TOP PRIORITY
TROPICAL CYCLONE ADVICE NUMBER 22 ISSUED BY THE BUREAU OF METEOROLOGY BRISBANE AT 2 PM EST SATURDAY 1/2/1986.

A CYCLONE WARNING IS CURRENT FOR COASTAL AREAS BETWEEN CAIRNS AND BOWEN. A CYCLONE WATCH EXTENDS SOUTH TO ST LAWRENCE. THE CYCLONE WARNING NORTH OF CAIRNS HAS BEEN CANCELLED.

AT 2 PM SEVERE TROPICAL CYCLONE WINIFRED WAS LOCATED BY RADAR 100 KILOMETRES NORTHEAST OF INNISFAIL MOVING SOUTHWEST TOWARDS THE COAST.
VERY DESTRUCTIVE WINDS WITH GUSTS ABOVE 180 KILOMETRES PER HOUR ARE LIKELY IN EXPOSED AREAS BETWEEN BABINDA AND LUCINDA THIS AFTERNOON AND THIS EVENING.
DESTRUCTIVE WINDS WITH GUSTS ABOVE 130 KILOMETRES PER HOUR IN EXPOSED COASTAL AREAS BETWEEN LUCINDA AND ROLLINGSTONE.
GALES SHOULD CONTINUE ALONG THE EXPOSED COAST NORTH OF CAIRNS AND SOUTH TO BOWEN.

A STRONG WIND WARNING FOR SMALL CRAFT EXTENDS NORTH TO COOKTOWN AND SOUTH TO GLADSTONE.
ABNORMALLY HIGH TIDES COULD CAUSE MINOR FLOODING IN COASTAL AREAS FROM INNISFAIL TO ROLLINGSTONE.

DETAILS OF SEVERE TROPICAL CYCLONE WINIFRED:
AT 2 PM SATURDAY 1/2/1986...

LOCATION OF CENTRE: LATITUDE 17.25 DEGREES SOUTH.
LONGITUDE 146.8 DEGREES EAST.
CURRENT MOVEMENT : SOUTHWEST AT 12 KILOMETRES PER HOUR.
CENTRAL PRESSURE : 960 MILLIBARS.
MAXIMUM WIND GUSTS: 220 KILOMETRES PER HOUR NEAR CENTRE.
EXPECTED LANDFALL : BETWEEN BABINDA AND CARDWELL LATE THIS AFTERNOON.

REPEATING A CYCLONE WARNING IS CURRENT FOR COASTAL AREAS FROM CAIRNS TO BOWEN WITH VERY DESTRUCTIVE WIND GUSTS ABOVE 180 KILOMETRES PER HOUR ON THE EXPOSED COAST BETWEEN BABINDA AND LUCINDA.

A BRIEF UPDATE WILL BE ISSUED TO MEDIA OUTLETS SHORTLY AFTER 3 PM.
THE NEXT FULL ADVICE WILL BE ISSUED AT ABOUT 5 PM.

THIS ADVICE IS AVAILABLE ON THE RECORDED TELEPHONE SERVICE (070) 1196 CAIRNS, (077) 1196 TOWNSVILLE AND (07) 1190 BRISBANE.

ENDS WHR BNE
SENT .. 01/
010205PM EST
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010256PM EST
HAYPORT AA48174

WARNINGS:

TOP PRIORITY
TROPICAL CYCLONE ADVICE NUMBER 23 ISSUED BY THE BUREAU OF METEOROLOGY,BRISBANE AT 5PM EST SATURDAY 1/2/1986.

A CYCLONE WARNING IS CURRENT FOR COASTAL AREAS BETWEEN CAIRNS AND TOWNSVILLE. A CYCLONE WATCH EXTENDS SOUTH TO BOWEN.

AT 5PM SEVERE TROPICAL CYCLONE WINIFRED WAS LOCATED BY RADAR 95 KILOMETRES NORTH EAST OF CARDWELL MOVING SOUTH WEST TOWARDS THE COAST.
VERY DESTRUCTIVE WINDS WITH GUSTS ABOVE 200 KILOMETRES PER HOUR ARE LIKELY IN EXPOSED AREAS BETWEEN BABINDA AND LUCINDA THIS EVENING.
DESTRUCTIVE WINDS WITH GUSTS ABOVE 130 KILOMETRES PER HOUR IN EXPOSED COASTAL AREAS BETWEEN LUCINDA AND ROLLINGSTONE.
GALES SHOULD CONTINUE ALONG THE EXPOSED COAST NORTH TO CAIRNS AND SOUTH TO TOWNSVILLE.

A STRONG WIND WARNING FOR SMALL CRAFT EXTENDS NORTH TO COOKTOWN AND SOUTH TO GLADSTONE.
ABNORMALLY HIGH TIDES COULD CAUSE MINOR FLOODING IN COASTAL AREAS FROM INNISFAIL TO ROLLINGSTONE.
FLOOD RAINS ARE LIKELY FROM BABINDA TO INGHAM.

DETAILS OF SEVERE TROPICAL CYCLONE WINIFRED
AT 5PM SATURDAY 1/2/1986

LOCATION OF CENTRE: LATITUDE 17.5 DEGREES SOUTH
LONGITUDE 146.5 DEGREES EAST
CURRENT MOVEMENT : SOUTHWEST AT 15 KILOMETRES PER HOUR
CENTRAL PRESSURE : 960 MILLIBARS
MAXIMUM WIND GUSTS : 220 KILOMETRES PER HOUR NEAR CENTRE
EXPECTED LANDFALL : BETWEEN INNISFAIL AND INGHAM THIS EVENING.

AS THE EYE OF THIS DANGEROUS CYCLONE CROSSES THE COAST IN THE VICINITY OF DUNK ISLAND AND CARDWELL THIS EVENING, CALM CONDITIONS MAY BE EXPERIENCED FOR UP TO TWO HOULRS. RESIDENTS ARE WARNED THAT THE WINDS WILL RESUME WITH SIMILAR STRENGTH FROM A DIFFERENT DIRECTION.

A BRIEF UPDATE WILL BE ISSUED TO MEDIA OUTLETS SHORTLY AFTER 6PM. THE NEXT FULL ADVICE WILL BE ISSUED AT ABOUT 8PM.

THIS ADVICE IS AVAILABLE ON THE RECORDED TELEPHONE SERVICE (070) 1196 CAIRNS, (077) 1196 TOWNSVILLE, AND (07) 1190 BRISBANE.

WEATHER BRISBANE
SENT: 1/5.06PM

GA
62053
ARMY AA62053
AA41591

TOP PRIORITY
WARNING

TROPICAL CYCLONE ADVICE NUMBER 24 ISSUED BY THE BUREAU OF METEOROLOGY, BRISBANE AT 8PM EST SATURDAY 1/2/86.

A CYCLONE WARNING IS CURRENT FOR COASTAL AREAS BETWEEN CAIRNS AND TOWNSVILLE.

AT 8PM SEVERE TROPICAL CYCLONE 'WINIFRED' WAS LOCATED BY RADAR 30 KILOMETRES NORTHEAST OF TULLY MOVING WEST SOUTHWEST. THE CYCLONE CENTRE CROSSED THE COAST AT 7PM NEAR SILKWOOD. VERY DESTRUCTIVE WINDS WITH GUSTS ABOVE 200 KILOMETRES PER HOUR CONTINUING IN EXPOSED AREAS BETWEEN BABINDA AND LUCINDA AND EXTENDING INLAND.

DESTRUCTIVE WINDS WITH GUSTS ABOVE 130 KILOMETRES PER HOUR IN EXPOSED COASTAL AREAS BETWEEN LUCINDA AND ROLLINGSTONE. GALES SHOULD CONTINUE ALONG THE EXPOSED COAST NORTH TO CAIRNS AND SOUTH TO TOWNSVILLE TONIGHT.

A STRONG WIND WARNING FOR SMALL CRAFT EXTENDS NORTH TO COOKTOWN AND SOUTH TO GLADSTONE.
ABNORMALLY HIGH TIDES COULD CAUSE MINOR FLOODING IN COASTAL AREAS FROM INNISFAIL TO ROLLINGSTONE.

FLOOD RAINS ARE LIKELY FROM BABINDA TO INGHAM.

DETAILS OF SEVERE TROPICAL CYCLONE WINIFRED AT 8PM SATURDAY 1/2/86:

LOCATION OF CENTRE: LATITUDE 17.7 DEGS SOUTH
LONGITUDE 146.1 DEGS EAST

CURRENT MOVEMENT: WEST SOUTHWEST AT 15 KILOMETRES PER HOUR
CENTRAL PRESSURE: 960 MILLIBARS
MAXIMUM WIND GUSTS: 220 KILOMETRES PER HOUR NEAR CENTRE
LANDFALL: NEAR SILKWOOD AT 7PM.

AS THE EYE OF THIS DANGEROUS CYCLONE MOVES INLAND PAST TULLY, CALM CONDITIONS MAY BE EXPERIENCED FOR UP TO TWO HOURS. RESIDENTS ARE WARNED THAT THE WINDS WILL RESUME WITH SIMILAR STRENGTH FROM A DIFFERENT DIRECTION.
THE CYCLONE SHOULD GRADUALLY WEAKEN AS IT MOVES FURTHER INLAND.

A BRIEF UPDATE WILL BE ISSUED TO MEDIA OUTLETS SHORTLY AFTER 9PM.
THE NEXT FULL ADVICE WILL BE ISSUED AT ABOUT 11PM.

THIS ADVICE IS AVAILABLE ON THE RECORDED TELEPHONE SERVICE (070) 1196 CAIRNS, (077) 1196 TOWNSVILLE, AND (07) 1190 BRISBANE.

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PRIORITY

TROPICAL CYCLONE ADVICE NUMBER 25 ISSUED BY THE BUREAU OF METEOROLOGY, BRISBANE AT 11PM SATURDAY 1/2/86 FOR COASTAL AREAS CAIRNS TO LUCINDA AND INLAND TO MOUNT SURPRISE.

AT 11PM CYCLONE WINIFRED WAS ESTIMATED TO BE CENTRED 20 KILOMETRES SOUTH OF RAVENSHOE MOVING WEST AT 15 KILOMETRES PER HOUR AND FURTHER INLAND.

CYCLONE WINIFRED IS CONTINUING TO WEAKEN.

SQUALLY WINDS WITH DAMAGING GUSTS EXTENDING FURTHER INLAND AND GRADUALLY EASING OVERNIGHT.

THIS IS THE FINAL ADVICE ON CYCLONE WINIFRED.

FLOOD WARNINGS CONTINUE FOR THE JOHNSTONE RIVERS, AND THE TULLY AND HERBERT RIVERS.

A SMALL CRAFT WARNING REMAINS CURRENT NORTH TO COOKTOWN AND SOUTH TO ST LAWRENCE.

THIS ADVICE IS AVAILABLE ON THE RECORDED TELEPHONE SERVICE (070) 1196 CAIRNS, (077) 1196 TOWNSVILLE AND (07) 1190 BRISBANE.

ENDS.
BNE TCWC
TIME SENT.....01/11.42PM
QUALUM AA49498