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THE THAMES - COROMANDEL FLOODS OF APRIL 1981

B. Collen and J.W.D. Hessell

J.S. Hickman
Director

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THE THAMES - COROMANDEL FLOODS OF APRIL 1981

ABSTRACT

The meteorological situation leading to the flood-producing rains between the 12th and 14th April 1981 is described. Analyses of the observed rainfalls are presented and these are discussed with reference to the rainfall climatology of the region. It is deduced that in most respects this was the most damaging flood recorded in the area, exceeding that of May 1954.

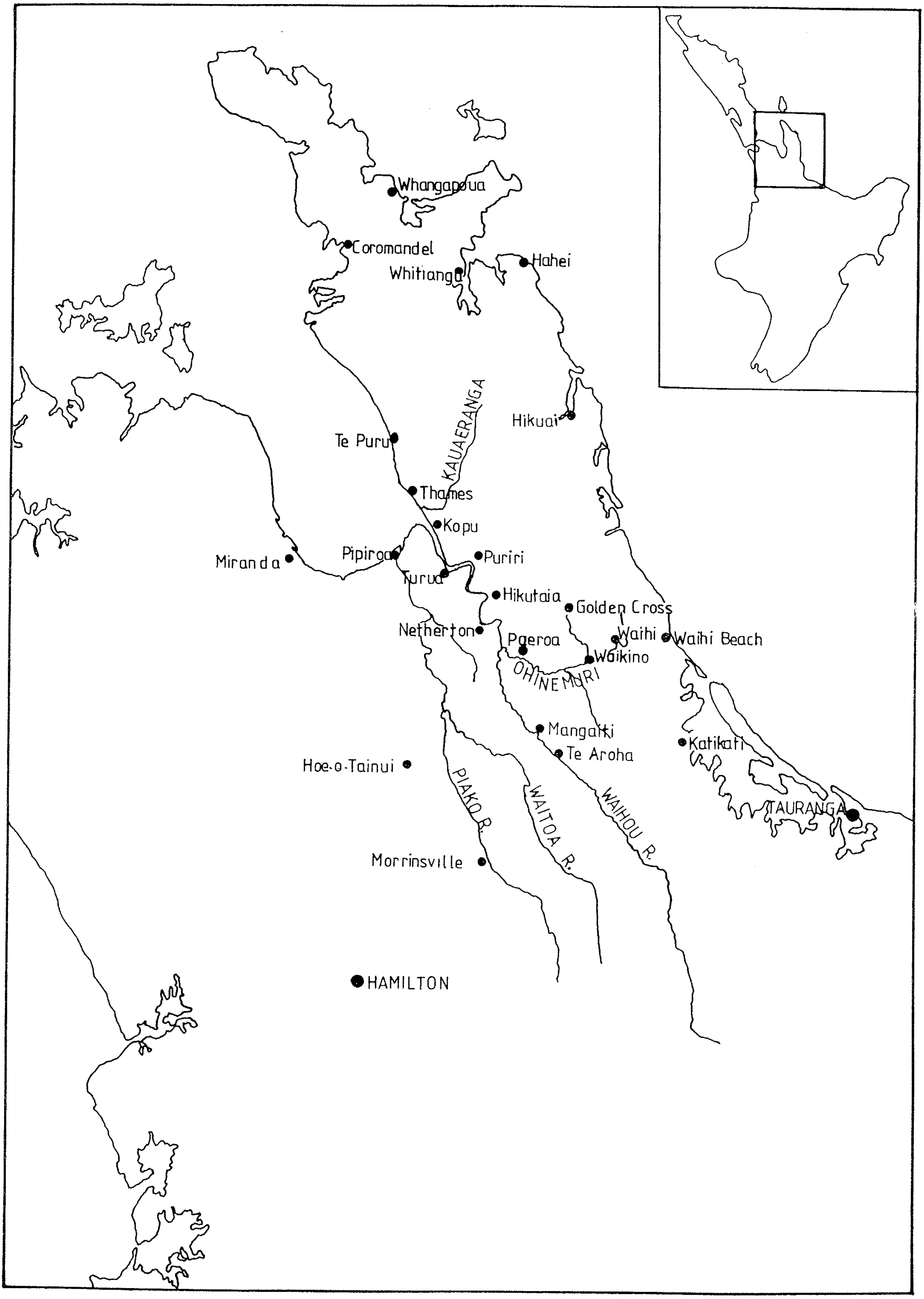


Fig. 1 : Locations referred to in the text.

1. Introduction

Rain began falling over the Coromandel Peninsula and Hauraki Plains areas between midnight and 1 am on the 12th of April 1981. Moderate to heavy rain continued to fall for the next 60 hours and widespread and severe flooding resulted.

Although many rivers and streams overflowed, the Ohinemuri River (see Fig. 1, location map) probably caused most damage. Five buildings were completely swept away in the small town of Waikino at about 6.30 pm on the 12th after the river reportedly rose 4 metres in 30 minutes at the Karangahake Gorge. Paeroa was already extensively flooded when the Ohinemuri River breached its stopbanks at 10 pm causing floodwaters to rise at the rate of 1 metre per hour. Many homes were flooded to roof level. About 750 people had been evacuated earlier after a state of civil emergency had been declared at about 5.45 pm. Two hundred people were evacuated from Thames when the Kauaeranga River and other streams within the town over-flowed their banks. Other small outlying settlements, including Waikino, Hikutaia and Te Puru were also evacuated, some by helicopter, after access roads were closed by slips, washouts or floodwaters. Paeroa became completely isolated when it became necessary to sandbag the Criterion Bridge, which at that stage was the last open access road to the town.

Apart from immediate difficulties caused by the floodwaters, secondary problems were created by loss of power and water supply in both Thames and Paeroa and pollution from over-flowing sewage systems in Paeroa.

Gale force winds affected many coastal areas, particularly around Whitianga. Houses in Hahei, Otama Beach and Simpsons Beach lost roofs and power lines were blown down.

2. The Synoptic Situation

As frequently occurs with extreme rainfall events cyclonic development resulting in heavy rain is favoured initially by the large scale dynamics of a synoptic situation. The thermodynamics of these situations become linked with the dynamics through conversion of the latent heat of condensation to kinetic energy. This process, under favourable circumstances, becomes self-perpetuating through the entrainment of air with a very high moisture content into a circular cyclonic system, and it is not until the supply of latent heat becomes insufficient to replace the kinetic energy lost in various ways, notably by friction, that such a system will dissipate. Further small scale dynamic processes such as orographic uplift may result in extreme local falls. (Hessell and Renwick, 1980).

During the period 9 - 13 April, a dynamically unstable mid-tropospheric trough which was passing eastwards in the hemispheric wave train sharpened in the vicinity of New Zealand. This event was favoured by the presence of strong upper air westerlies in high latitudes and pronounced ridges in the lower latitudes over eastern Australia and near New Zealand (Fig. 2). The cold front associated with the upper trough was approaching New Zealand at 0600 NZST 10 April (Fig. 3). At this stage a strong ridge southwest of Tasmania was injecting cold air into the western Tasman Sea while an anticyclone north of the country was bringing warm, moist air into the northern Tasman. There was a strong gradient of dewpoint (about 10°C/550 km) across the front. Contrasts between high and low latitude mid tropospheric zonal flows and in temperatures on each side of the front, together with the presence of air with a high moisture content in the region of ascent ahead of the upper air trough, appeared to be crucial factors for the development of a cyclonic circulation.

By 0600 NZST 12 April (Fig. 4) the depression at sea level had reached full maturity. At the same time, a strong ridge of high pressure had developed south of the depression, blocking any movement southwards. Also, the anticyclone east of New Zealand had intensified and developed a long north - south axis causing air originating in the tropics to become entrained into the cyclonic system. The cyclonic circulation had become extensive at 500mb by 0000 NZST on 13 April (Fig. 5) and lay immediately above the sea level position of the low - also a characteristic of blocked depressions.

The southeast quadrant of the low, dynamically favoured for upward motion, lay at this stage over the North Island with widespread rain. The satellite picture for about 0600 NZST 12 April (Fig. 6) shows that the cloud sheet associated with the ascending motion was very large. As can be seen from the Auckland thermodynamic sounding (Tephigram) at 1200 NZST 12 April (Fig. 7) there were layers of moist air to 600mb (4,000 metres) with saturated air to about 2,500 metres at this stage. It may be assumed that the kinetic energy being created by the conversion of latent heat energy, largely resulted, through the gradient wind relationship, in the pressure at the centre of the depression dropping to near 990 mb - as observed by ships in the area (Fig. 4).

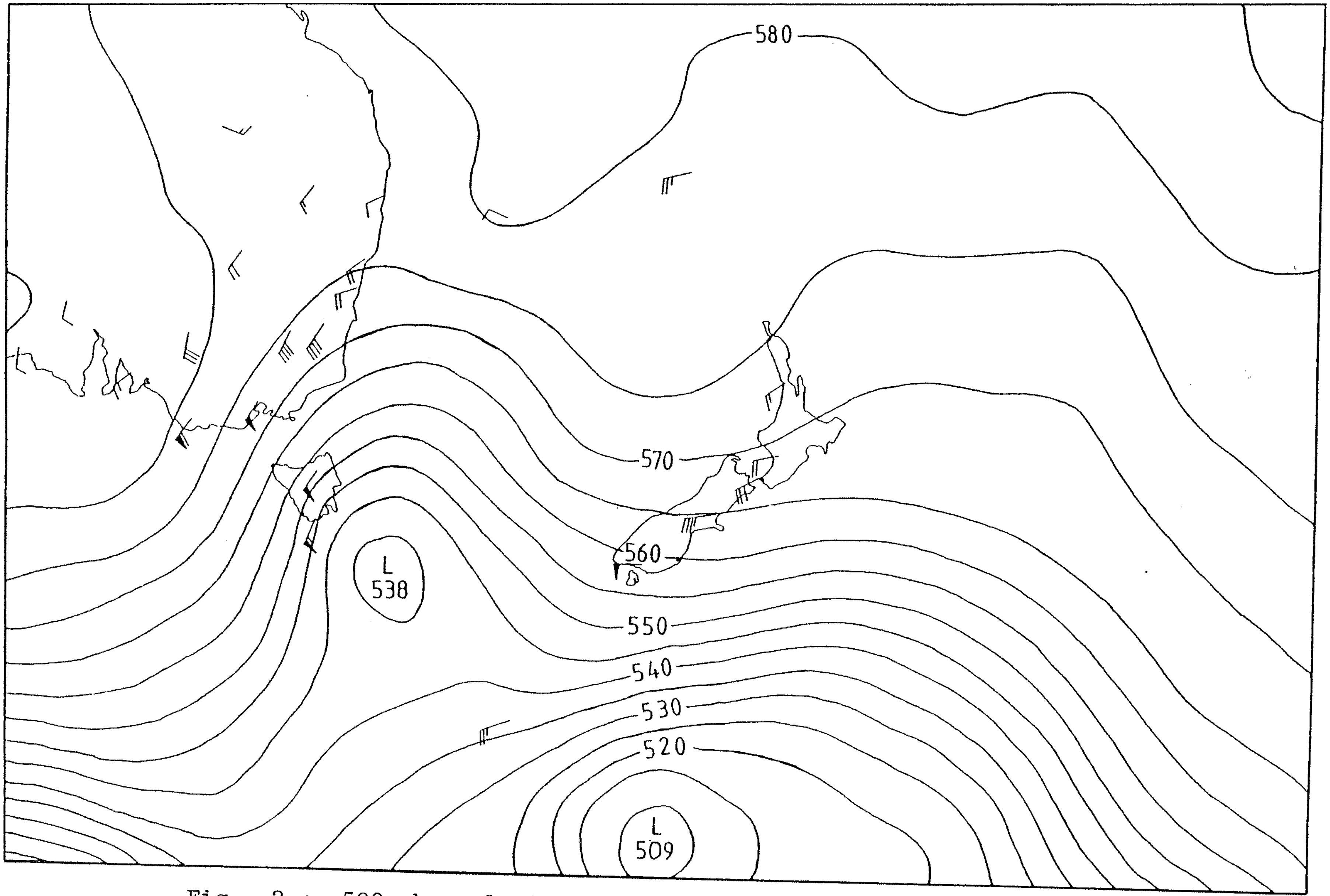


Fig. 2 : 500 mb analysis at 0000 NZST 10 April 1981. Flags indicate wind direction and speed, each half barb represents 5 knots, full barb represents 10 knots and each triangle 50 knots. Heights are in metres. (G.P.M.)

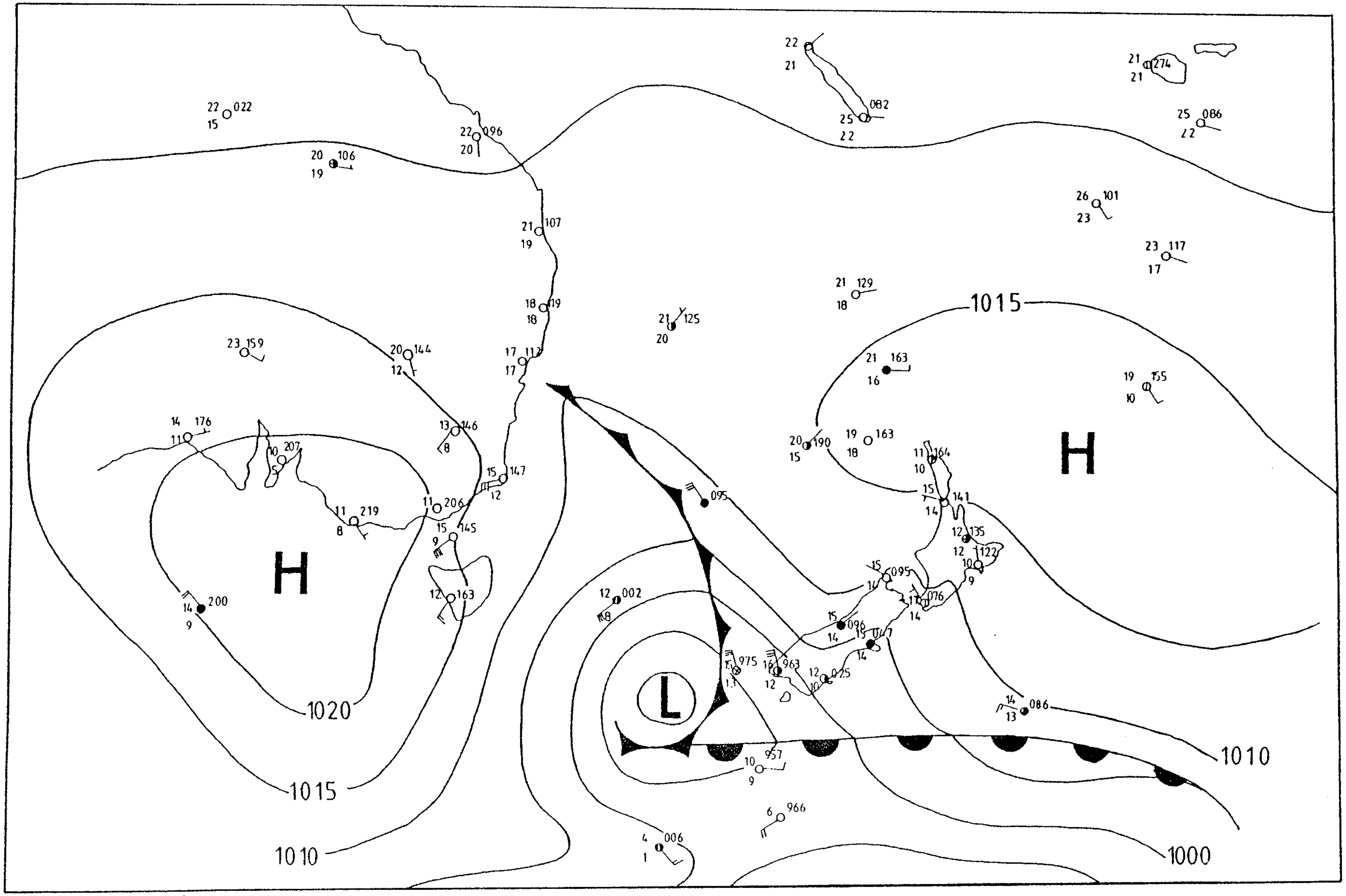


Fig. 3 : Mean sea level analysis 0600 NZST 10 April 1981. Pressures are plotted (last 3 digits only) to the right of the station circle, dry bulb and dew point temperatures to the left. Wind strength as for Fig. 2.

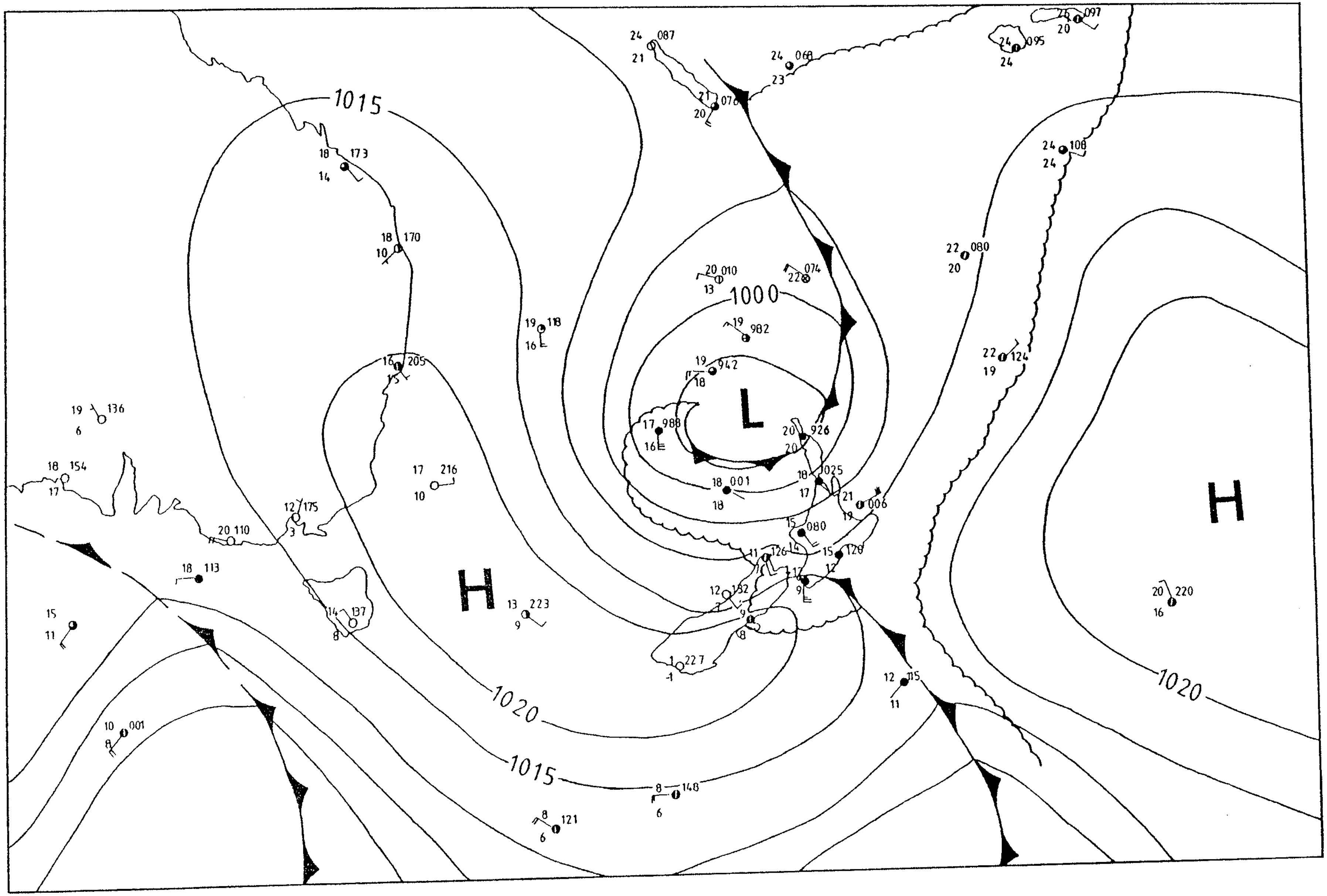


Fig. 4 : Mean sea level analysis 0600 NZST 12 April 1981.
Symbols as for Fig. 3.

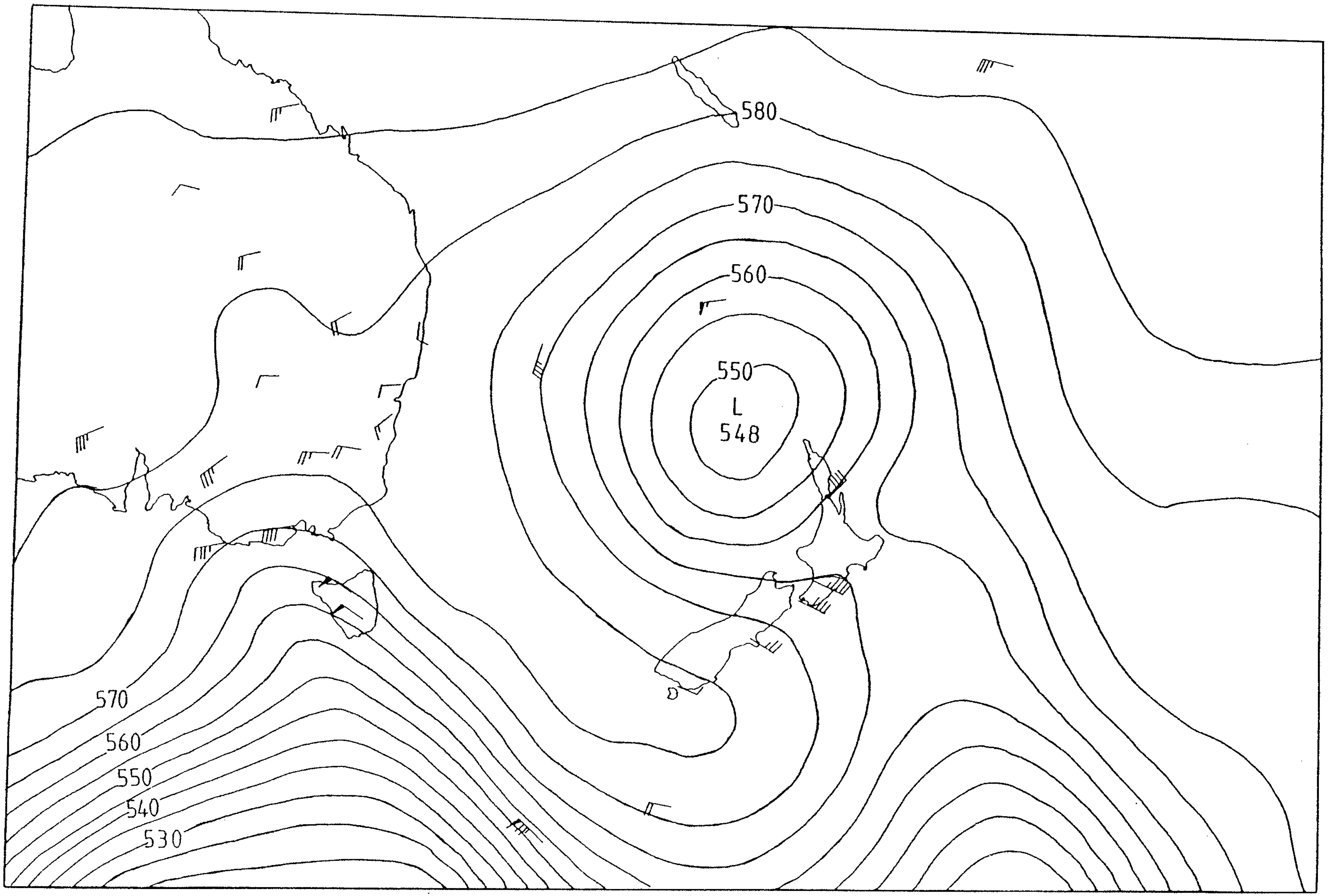


Fig. 5 : 500 mb analysis 0000 NZST 13 April 1981.
Symbols as for Fig. 2.

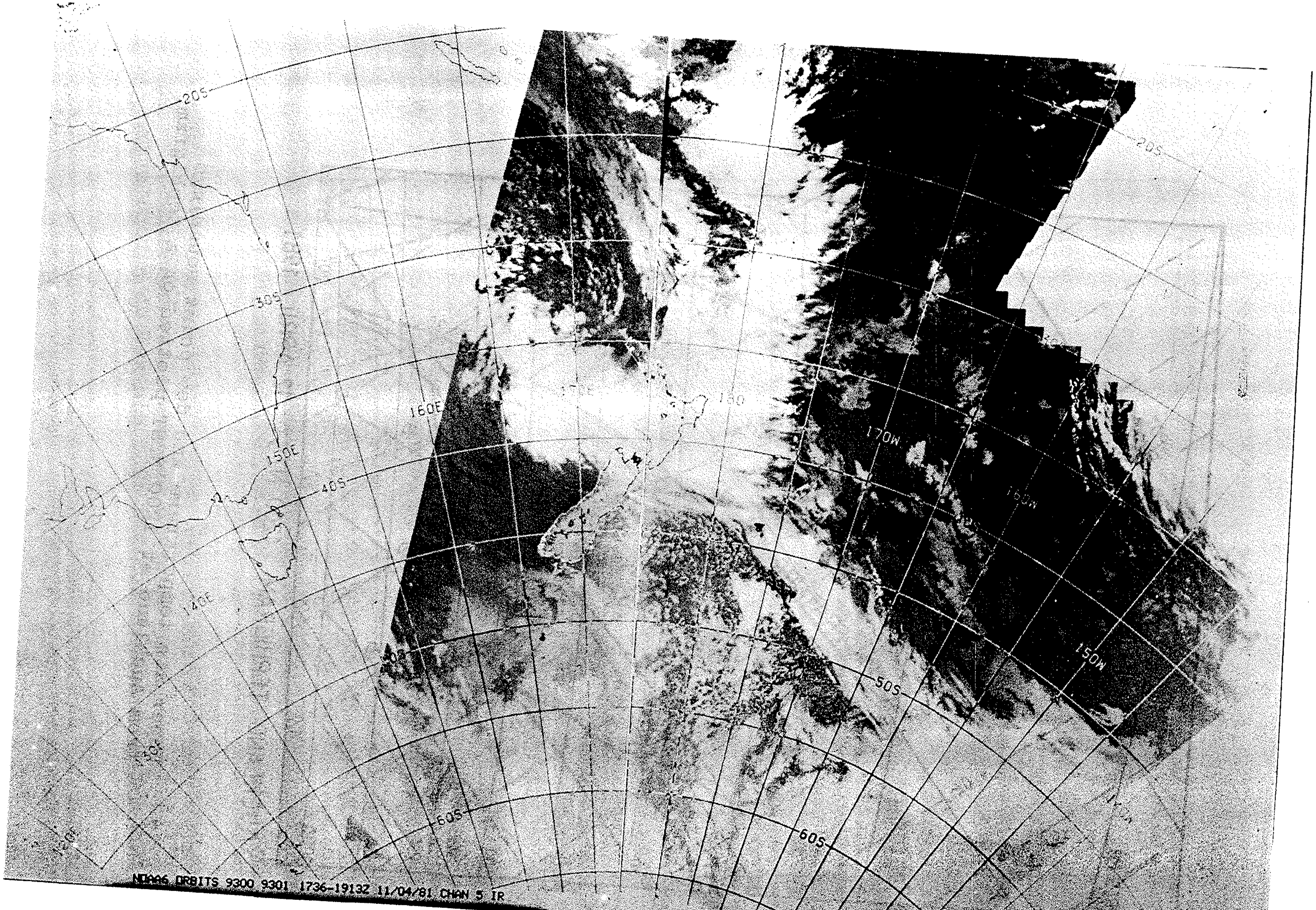
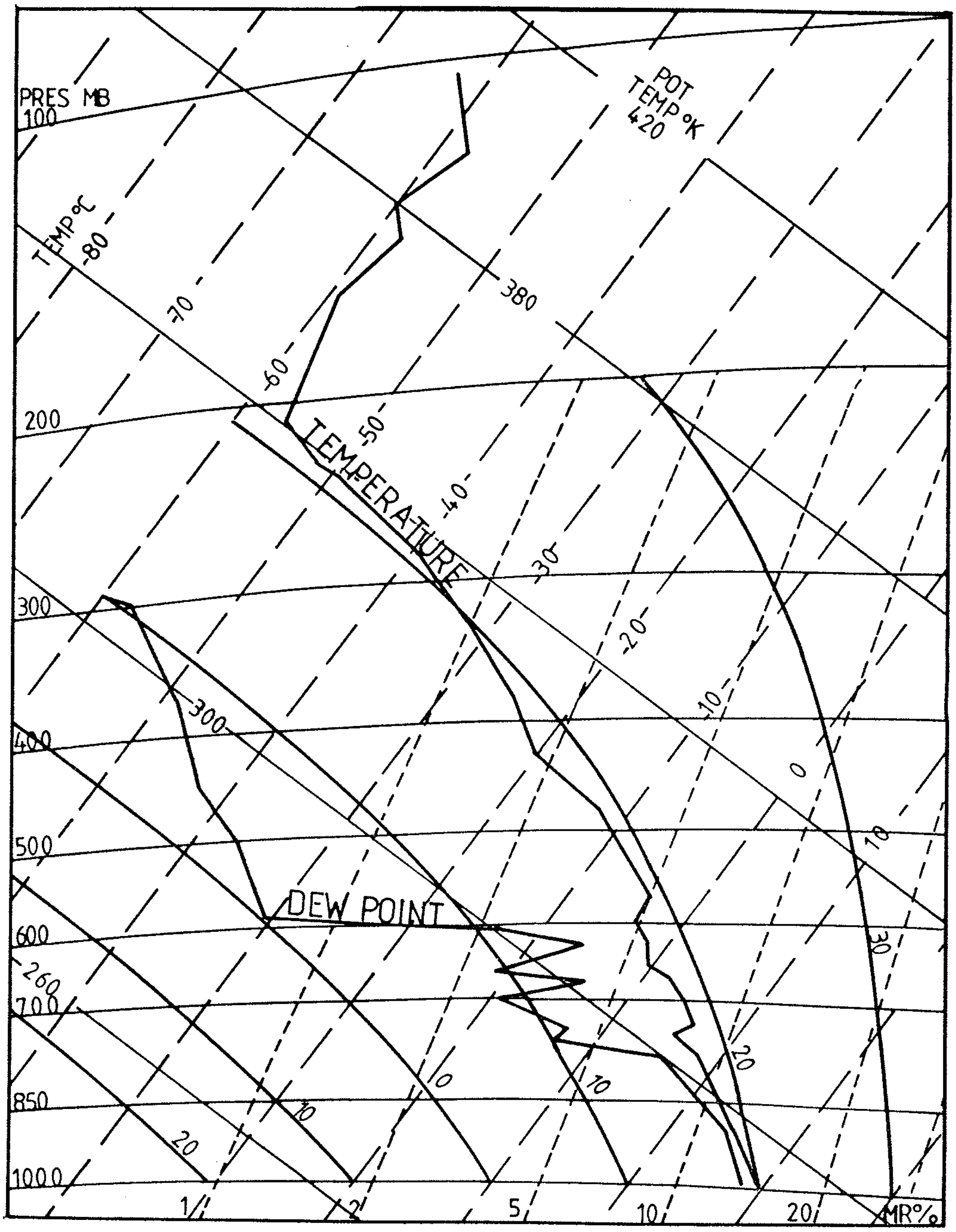


Fig. 6 : Infrared photograph from the satellite NOAA6 at approximately 0600 NZST 12 April 1981.



AUCKLAND TEPHIGRAM 1200 NZST 12 APRIL 1981

Fig. 7 : Upper air temperature and dew point soundings from Auckland at 1200 NZST plotted on a tephigram.

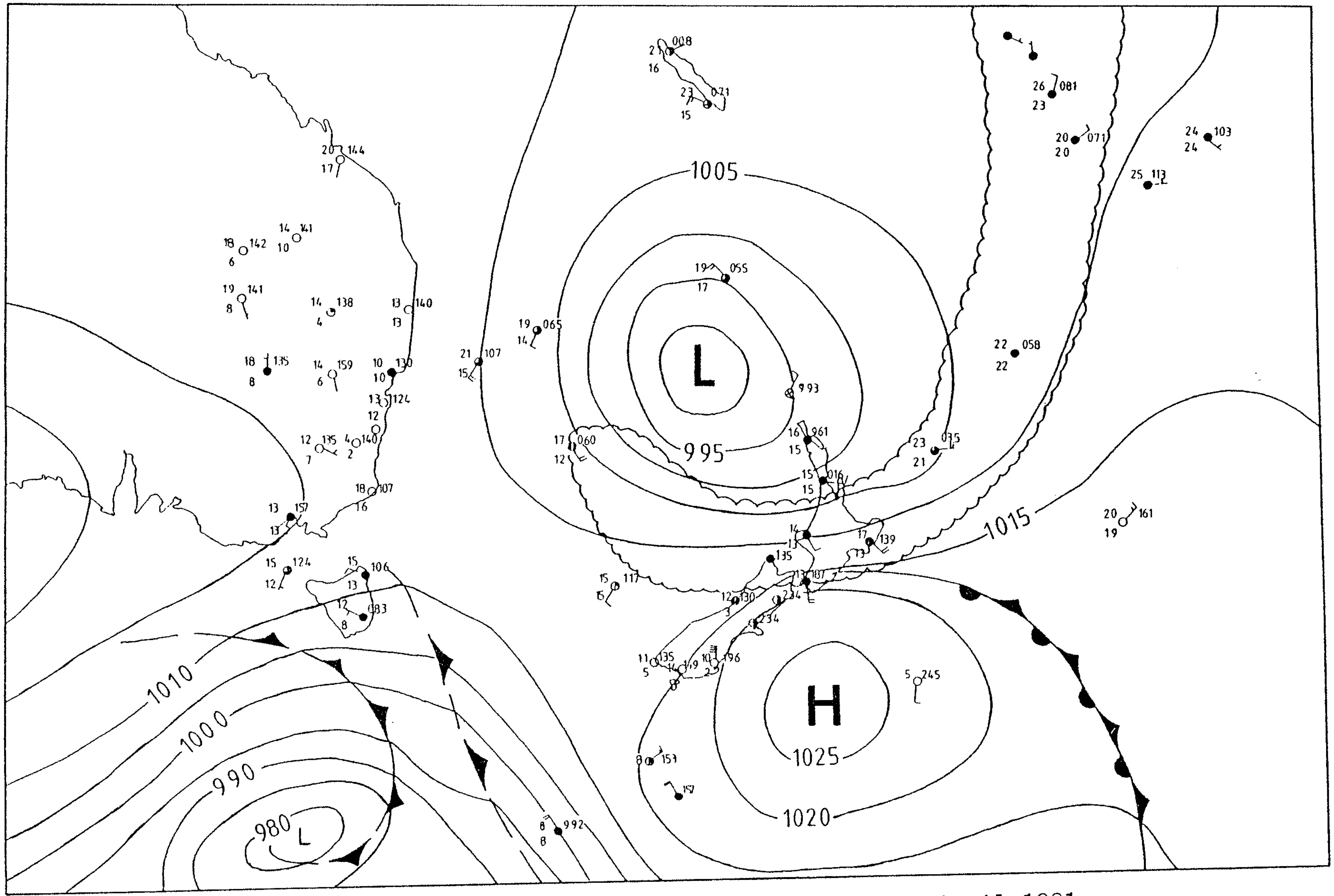


Fig. 8 : Mean sea level analysis 0600 NZST 13 April 1981.
Symbols as for Fig. 3.

The strong wind flow created was impinging almost perpendicularly onto the coast between Cape Reinga and Opotiki and the further uplift created orographically by the Coromandel/Kaimai Range caused falls to be particularly intense there, the rainfall rate being dependent to a large extent on wind speed under these circumstances.

Heavy rain continued to fall in this area due to continual entrainment of air of tropical origins though, with the collapse of the high pressure cell east of New Zealand by 0600 NZST on 13 April the entrainment of very moist air was decreasing, as indicated by the comparatively narrow cloudy band in Fig. 8 (shown by the scallopped boundary lines). This band still lay across the Coromandel/Kaimai area with heavy rain and the pressure gradient was still very strong (some 40mb in 1000 nautical miles) but it appears that the total supply of latent heat energy to the system at this stage was insufficient to maintain the kinetic energy required by this gradient for geostrophic balance as all winds over the North Island were showing marked ageostrophic directions, blowing almost directly towards the centre of low pressure (Fig. 8).

The system thereafter dissipated rapidly and due to the cutoff of the tropical air and the diminution of the wind component perpendicular to the ranges, the rain cleared rapidly from the north.

3. The Rainfall Observations

The New Zealand Meteorological Service maintains a network of rainguages throughout New Zealand. This network is largely manned by voluntary observers, who have contributed greatly to the knowledge of the rainfall regime in this area. The Ministry of Works and Development also has stations in the region and rainfall records from the two sources have been used in this study.

The gauges are mainly manual and are read at 9 am daily (NZST) with the rainfall credited to the previous day. There are five automatic gauges in the area and maximum totals from these have been used, with data from the manual gauges, to draw the 24 and 72 hour isohyetal maps (Figs 9 and 10). Totals for the manual gauges in these two figures cover the periods 0900hr/12th to 0900/13th and 0900/12th to 0900/15th respectively, with times of rainfalls given in NZST. It should be noted, however, that in most places the rain had stopped by 1800 hr on the 14th. Flooding prevented the automatic gauges at Paeroa and Waihi from functioning continuously and readings from the adjacent manual gauges have been incorporated where necessary.

4. Rainfall Intensity

Autographic charts from the automatic gauges at Paeroa, Coromandel, Te Aroha and Tauranga were used to determine the rate of rainfall accumulation (Fig. 11). At Paeroa, Coromandel and Te Aroha rainfall accumulated at a rate greater than 6mm/hour for most of the 48 hours between 0000hr (NZST) on the 12th and 0000hr on the 14th. Although initially of a similar rate to the other gauges, the rate of accumulation at Tauranga slowed after 1600hr on the 12th and the overall accumulation rate was, at an average 3.5mm/hour, very much lower than the more westerly sites.

Rainfall at Paeroa, Coromandel and Te Aroha was in the 'heavy' category (see inset, Fig. 11) and its persistence at this rate for close to 48 hours must account for the particularly severe flooding. Rainfall rates in excess of 12mm/hour were recorded at times at all three sites and it is probable that this rate was exceeded in areas of even heavier rainfall such as those at Golden Cross and Puriri. (See Appendix 1).

Distribution of the 24 and 72 hour rainfalls can be seen in Figs 9 and 10.

5. Calculation of Rainfall Intensities

The assessment of a return period in years, Ty, is made using a widely accepted statistical method developed by Gumbel (1958). Ty is assessed from the annual maxima of rainfall, X, of particular durations observed at specific sites. These maxima are assumed to fit a theoretical distribution, the extreme value distribution, given by:

$$P(X) = \exp(-e^{-y})$$

where y is a reduced variate of X. This method is explained fully by Coulter and Hessell (1980).

Errors in assessing Ty stem from many sources. The chief of these is inadequate sampling. A high probability of Ty being reliable is only achieved with sampling periods of the order of 30 years or greater. It must also be realised that annual maxima do not always belong uniquely to one distribution and that unusual meteorological phenomena can cause 'outliers' (values not fitting the theoretical distribution).

The maximum 24, 48 and 72 hour rainfall intensities and their frequencies (as return periods, Ty) for April 1981 are shown in Table 1.

TABLE 1

Automatic Gauge Maximum Rainfall Intensities and Frequencies for 24, 48 and 72 Hours, April 1981.

Duration	Date	WAIHI		PAEROA		TE AROHA		*COROMANDEL		TAURANGA	
		Amount (.1 mm)	Ty (years)	Amount	Ty	Amount	Ty	Amount	Ty	Amount	Ty
24 hours	12-13	2578	10	1979	70	2212	20	2057	5-10	1016+	2
48 hours	12-14	4445	80	3465	>100	3434	70	2882	20-50	1574	5-10
72 hours	11-14	5207	>100	3758	>100	3686	60	3076	20-50	1822	5

* Using return periods for Whangapoua Forest + 13-14th

Maximum intensities for 10, 20, 30, 60 minutes and 2, 6, and 12 hours were extracted for Paeroa, Coromandel and Te Aroha but because of the short duration of records from autographic gauges at Te Aroha (7 years) and Coromandel (2 years) no Ty could be calculated for periods less than 24 hours. At Paeroa the 10 minute to 2 hour rainfalls had a return period less than 2 years, and the 6 and 12 hour falls between 2 and 10 years. Details of 24, 48 and 72 hour falls and return periods are given in Table 1.

In Table 1 several return periods are shown as being greater than 100 years. Using the daily rainfalls available it appears that the return periods for the 48 hour maximum at Paeroa and the 72 hour maximum at Waihi are in the region of 500 years, but extrapolation of the depth frequency curves to such a period is questionable considering that the respective observations cover only 66 and 82 years.

The distribution of rainfall return periods in Table 1 with respect to the maxima of various durations seems not unusual for the biggest floods. It is similar to the pattern found during the great Southland-Otago flood of October 1978 (Hessell and Lopdell 1979). There, the return periods of maximum rainfalls of durations less than 2 hours were also unexceptional, but for durations greater than 12 hours the return periods exceeded 50 years.

6. The Distribution of Rainfall

The Coromandel and Kaimai Ranges form a chain extending from south of Te Aroha to the northern end of the Coromandel Peninsula. They rise to nearly 900 metres at the highest point, Mt. Moehau.

The heaviest rainfall was concentrated in a relatively narrow band along this range, decreasing rapidly both to the east and west (Figs 9 and 10). The western flanks of the range, on which are sited the towns of Te Aroha, Hikutaia and Paeroa, also had high rainfalls, indicating that distribution was at least partly orographically controlled.

The greatest falls recorded were in the Kauaeranga catchment area, which extends northwards from the Kopu - Hikuai Road. Among the 72 hour falls here were 870mm, recorded by the Ministry of Works at a site on the western side of the summit of the Kopu - Hikuai Road, 400m above sea level, and 850mm, again recorded by M.W.D. above Kauaeranga Falls, 460m above sea level. Golden Cross on the eastern side of the range, 300m above sea level, recorded 744mm while Waihi Beach, at sea level, recorded the relatively low total of 286mm in 72 hours. Rainfall on the Hauraki Plains ranged between 150 and 250mm for the 3 days.

7. Regional Flood History and Comparison with the May 1954 Flood

Historical information for the region is available in the form of newspaper clippings from 1919 onwards and in records from early rainfall stations at Omokoroa, Te Aroha, Turua, Waihi, Tauranga and Katikati, all of which began recording between 1890 and 1905. Reports of widespread flooding were made in June 1920, April 1923, May 1954 and June 1960.

It appears that the only comparable flood on record to that of April 1981 occurred between the 18th and 20th May 1954. (See Appendix 2). On this occasion the 48 hour rainfalls at Te Aroha and Paeroa were 390 and 297mm respectively, while the 24 hour rainfall at Thames (actually occurring in 20 hours) was 193mm. Flooding occurred in Paeroa and partial evacuation of the town was necessary but on this occasion the stopbanks along the Ohinemuri river remained intact even though the river rose 7 metres. Thames was flooded when the Waihou River backed up and rose over 9 metres and floodwaters covered low lying areas to a depth of 2 metres. It is fortunate that on this occasion the winds were easterly rather than northerly and did not impede the flow into the shallow Waihou estuary, though tidal effects in the Waihou River are important as far inland as Paeroa. At the time the May 1954 flood was reported as "the worst flood in 60 years" and checks of newspaper clippings and rainfall returns indicate that this was probably true.

Some stations recorded similar rainfalls for both floods and there were greater 24 and 48 hour falls in Coromandel and 24, 48 and 72 hour falls in Te Aroha in 1954. However all falls in Paeroa were greater in 1981. Comparative data from daily rain gauges can be found in the Appendices.

Flooding appears to have been far more widespread and severe in 1981. It is possible that this is at least partly due to increased urbanisation and rural development since 1954. Such development includes sealing and concreting roads, paths, yards etc. (There were only 14000 km of sealed or paved roads in New Zealand in 1954 compared with 47000 km in 1980). Flooding is also aggravated by an increase in roofed areas and increased drainage, both rural (field drains) and urban (stormwater drains). Open canals maintained by mechanical shovels are common in the Hauraki Plains and water in all artificial channels travels much more swiftly than by natural drainage. This can increase both surface water volume and flood levels of rivers (Hollis, 1975). Urbanisation also increases bank overflow from streams. The number of small floods can increase 4 times with the conversion of only 15% of the catchment to impervious surfaces (Waugh, 1978) and the several small streams within the Thames township may have contributed to flooding in this manner.

There were no stations operating in the Coromandel/Kaimai ranges in 1954 and it is possible that rainfall in the ranges was much lower on that occasion, a factor that would also contribute significantly to the disparity in the degree of flooding between the two storms.

The 1981 flood clearly exceeded the 1954 flood in both severity and areal distribution of heavy rainfalls, thus making this the worst flood on record for the Hauraki Plains and Coromandel Peninsula areas.

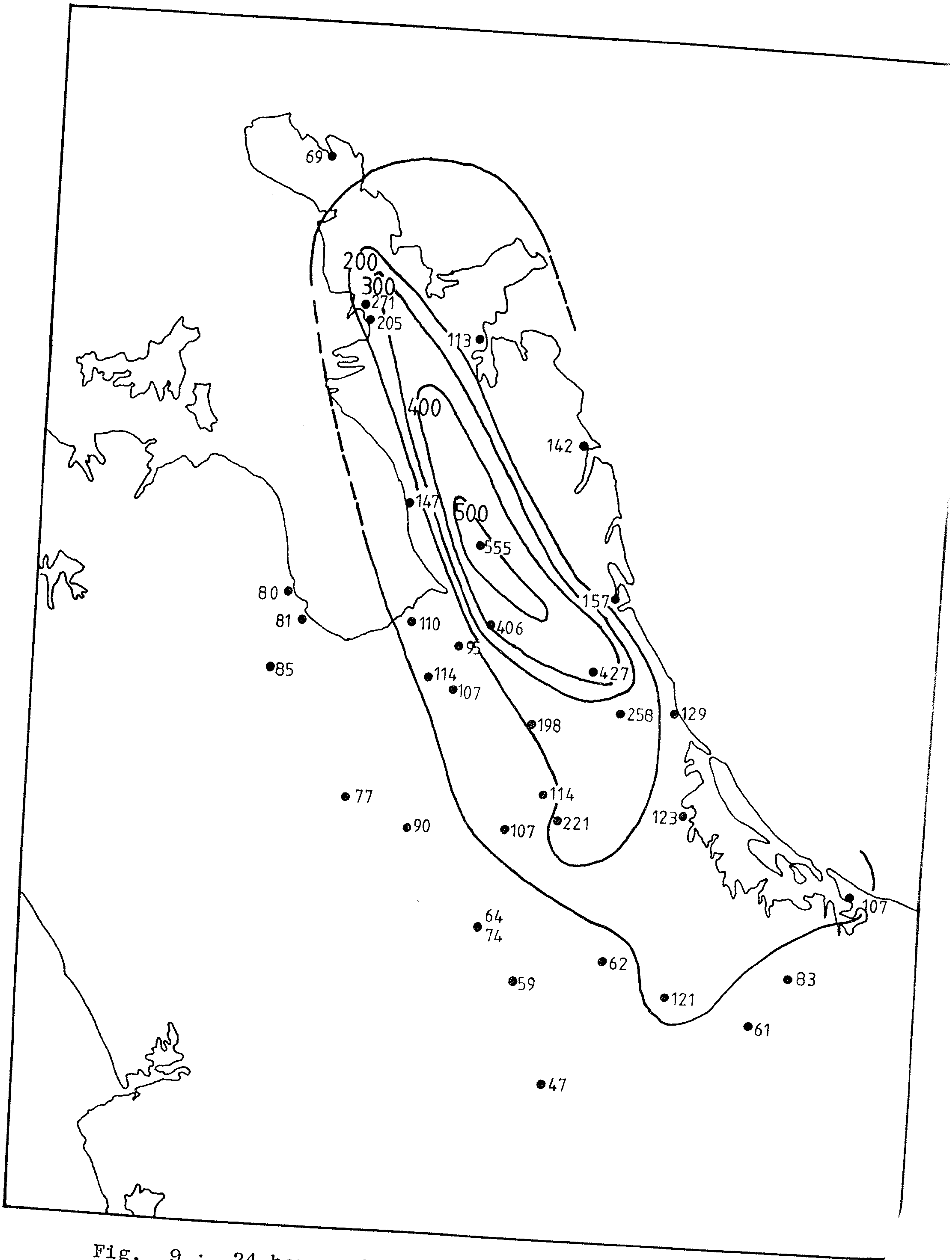


Fig. 9 : 24 hour rainfall isohyets (mm) from 0900 NZST 12 April to 0900 NZST 13 April.

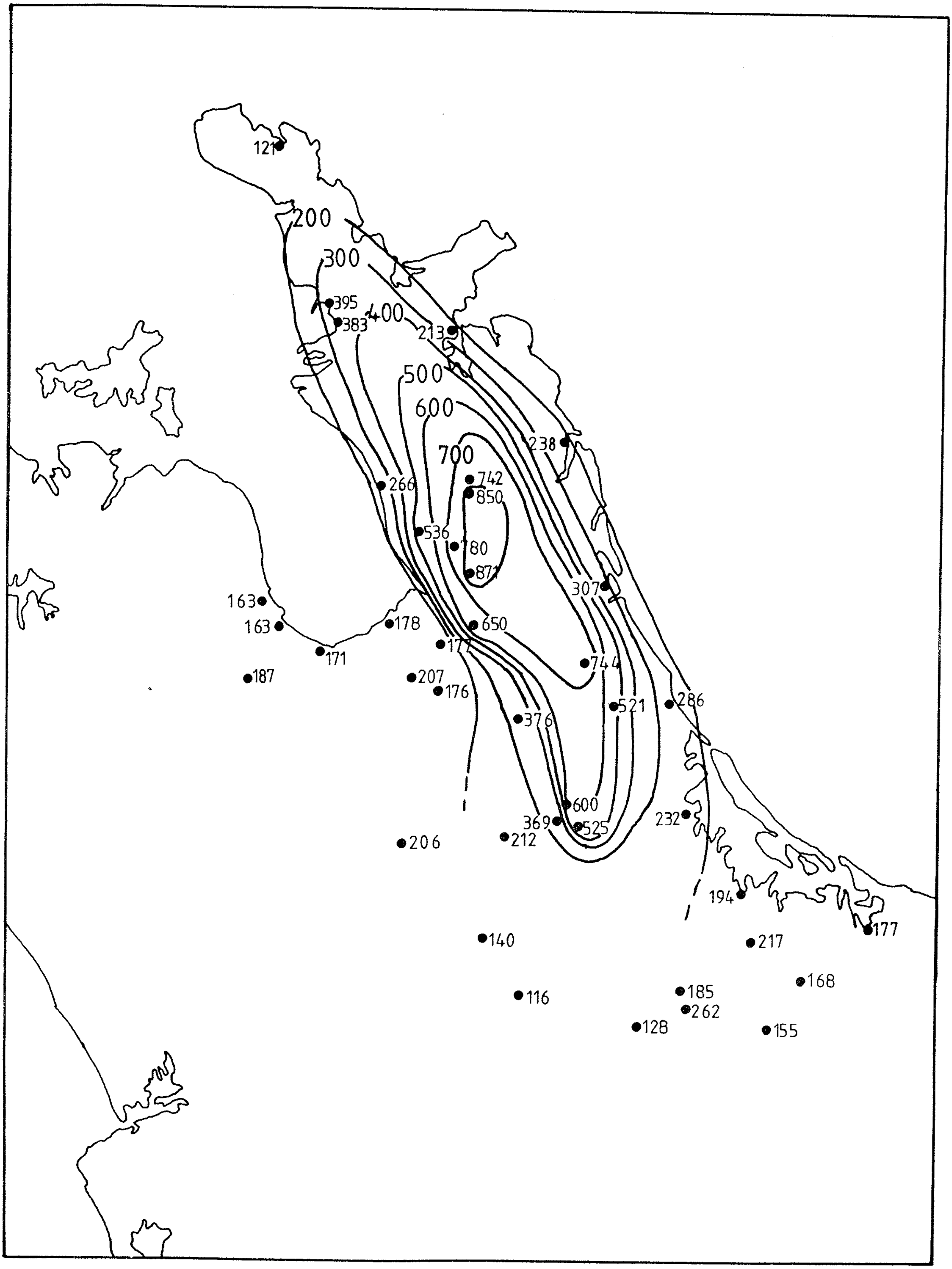


Fig. 10 : 72 hour rainfall isohyets (mm) from 0900 NZST 12 April to 0900 NZST 15 April.

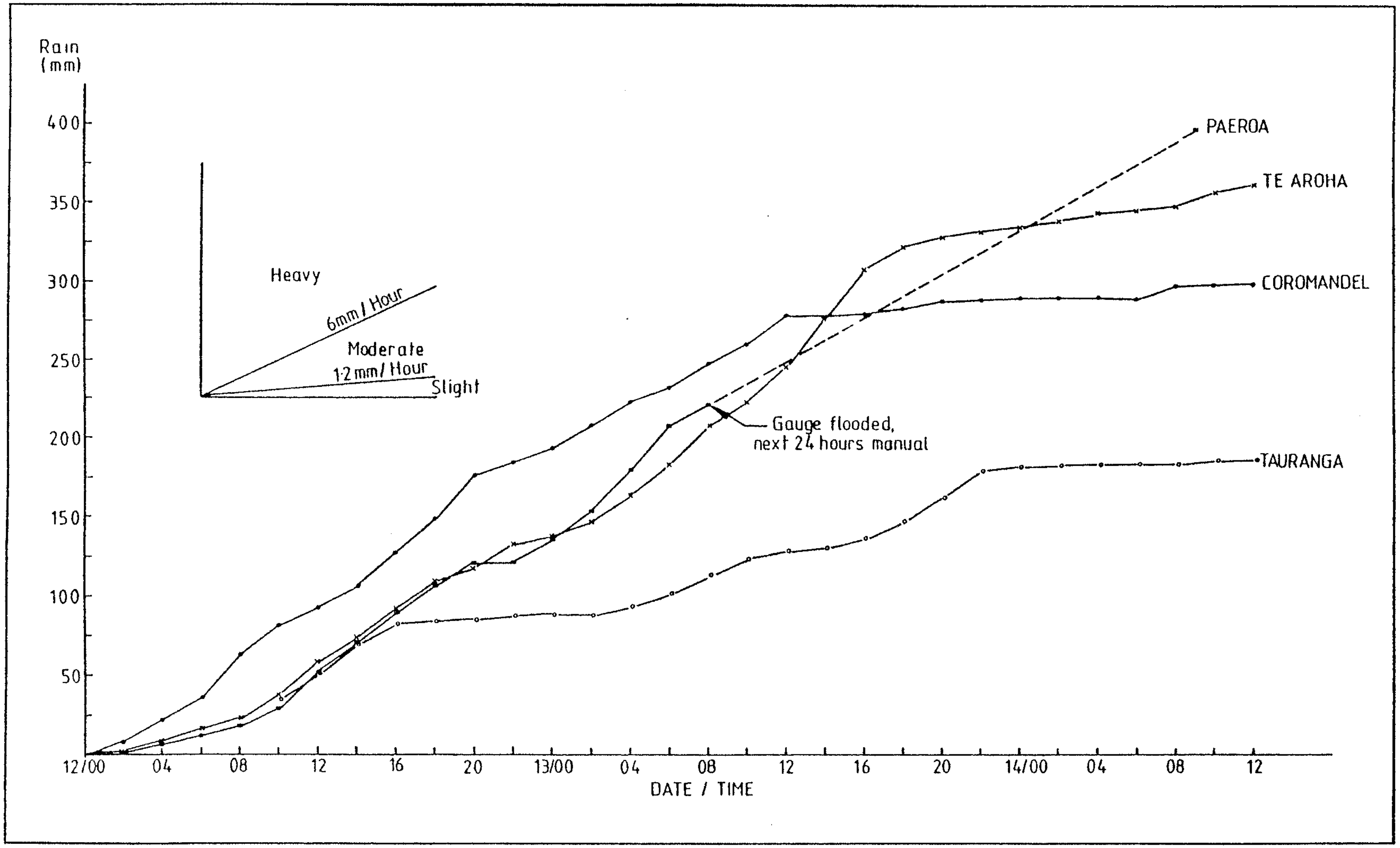


Fig. 11 : Rainfall accumulations at Paeroa, Te Aroha, Coromandel and Tauranga, from 0000 NZST 12 April to 1200 NZST 14 April 1981.

8. Conclusion

There were many factors contributing to the severe flooding which caused widespread serious damage in the Thames-Coromandel region in April 1981.

Initially the large scale dynamics of the hemispheric wave train were in an unstable mode requiring the development of a major trough in the New Zealand region for transformation to a more stable regime.

Pre-existing pressure patterns at sea level were favourable for the sudden development of the new regime in that they fed large amounts of moist air into the ascending region of the mid tropospheric trough thereby making available further energy for accelerated development. This process caused extensive rain to fall over the North Island.

A very strong sea level wind flow resulted from the transformation into kinetic energy of the latent heat energy originally fixed by evaporative processes in the tropics. This flow was perpendicular to the Coromandel/ Kaimai Range which forced strong local ascent within the broad scale ascending region, causing rainfalls to be especially intense in the vicinity.

The newly established stability of the hemispheric wave train, the formation of quasi-circular cyclonic flows at sea level and aloft together with the continual injection of new energy into the system by condensation of water vapour meant that the synoptic situation became, for a time, self perpetuating, the new energy being at least sufficient to overcome the dissipative forces present in any highly developed cyclonic circulation.

The extensive duration of the intense rainfalls near the region of strongest ascent resulted in the most intense flooding known in this region.

9. Acknowledgements

The authors wish to thank the many rainfall observers whose conscientious work in collecting data, often in particularly unpleasant weather, makes reports such as this possible. Thanks are also due to the Ministry of Works and Development for permission to use their data and to the staff of the National Weather Forecast Centre, Wellington, for analyses and comments on the meteorological situation.

10. References

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APPENDIX 1. Maximum 24, 48 and 72 hr Rainfalls (Units are 0.1 mm)

Station No.	Station Name	Record Starting Date	24 Hr	48 hr+	72 hr	Previous 24 hr Max.	Date
B65541	Sandy Bay	1956	699	1196 a	1264	2591	04/1971
B65542	Stony Bay	1967	617	1138 a	1213	2944	03/1972
B65741	Coromandel	1978	2057	2882 a	3076	-	-
B65751	Coromandel		....	2050 a	3850 o	2246	03/1975
B65761	Whangapoua Forest	1961	1182	1667 a	1886	2512	02/1966
B65851	Chiltern	1950	* 2707	* 3272 a	*3826	2007	03/1967
B65872	Whitianga	1941	1128	* 1923 a	*2126	1767	03/1947
B75051	Te Puru	1974	1465	2296 b	2661	1663	03/1975
B75082	Tairua	1913	1418	* 2023 a	*2378	2121	08/1916
B75182	Tairua Forest	1953	1675	2680 b	3266	1859	10/1960
B75251	Turua	1901	952	1696 a	1771	1892	04/1923
B75253	Ngatea	1968	1135	1815 b	*2065	1349	-
B75254	Pipiroa	1968	1100	1620 b	1780	-	-
B75261	Puriri	1970	* 4055	* 5632 b	*6495	2111	09/1976
B75281	Whangamata	1970	1570	2640 b	3065	2920	05/1975
B75351	Kerepehi	1912	1070	1536 b	1802	1778	04/1959
B75361	Paeroa	1914	* 1965	* 3465 b	*3758	1742	11/1950
B75372	Golden Cross	1968	* 4273	* 6319 b	*7441	2111	04/1968
B75381	Waihi	1898	2578	4445 b	5207	4191	02/1938
B75441	Hoe-o-Tainui	1956	898	1651 b	2062	1961	02/1967
B75491	Waihi Beach	1955	1293	2203 b	*2861	1684	02/1966
B75561	Elstow	1917	1074 ∞	* 1836 b	*2118	1511	04/1923
B75571	Te Aroha	1889	2212	3434 b	3686	2375	04/1954
B75581	Wharawhara Water Stn.	1969	1147	1871 b	2319	2084	03/1972
B75592	Katikati	1979	1234	1969 b	2401	2311∿	12/1966
B75654	Morrinsville	1978	744	1166 b	1399	1656∿	02/1966
B75782	Te Ariki Falls	1968	1206	1980 b	2627	1590	10/1970
B76611	Tauranga	1970	1074	1814 b	2125	1539	04/1974
B76621	Tauranga Airport	1896	1016	1574 b	1822	2390	04/1923
B75681	Shaftesbury	1951	1374	2300 b	2953	3091	03/1954

+ a = 48hrs covers 11-12, b = 48hrs covers 12-13th.

o Estimated from an accumulated fall. *New Record ∞ on 13th.

∿ Uses data from an earlier station, or more than one site.

APPENDIX 2 Maximum rainfalls recorded 18-20 May, 1954

Stn No.	Station Name	24 hrs	48hrs	72hrs
B65751	Coromandel	2405·	3424·	3551
B65851	Chiltern	1585	2151	2629
B65861	Whitianga	1077	1445	2098
B75081	Tairua	800	1184	1474
B75161	*Warahoe	1405	2797	3450
B75162	*Kauaeranga	1935	3835	4620
B75182	Tairua Forest	706	1288	1534
B75251	Turua	508	1016	1328
B75351	Kerepehi	559	1026	1280
B75361	Paeroa	1488	2969	3406
B75371	*Waitekauri	1974	3831	4519
B75381	Waihi	1461	2319	2593
B75471	*Waitawheta	1217	2159	2604
B75551	*Springvale	274	454	568
B75561	Elstow (Belle Vue)	965	1648	1859
B75569	*Waitoa	508	912	1179
B75571	Te Aroha	2375·	3899·	4671·
B75591	Katikati	808	1319	1438
B75671	*Ngarua	991	1809	2058
B75651	Morrinsville	371	694	890
B75681	Shaftesbury	2192	3698	4112

Units are 0.1 mm

* Closed station

· Fall greater than 04/1981