

# Cyclone Ivy – magnitude of storm surge recorded

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Environment Bay of Plenty  
Operations Publication 2008/07  
May 2008

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NEW ZEALAND

*Working with our communities for a better environment  
E mahi ngatahi e pai ake ai te taiao*

ISSN: 1176 5550



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## Chapter 1: Introduction

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Cyclone Ivy passed through the Bay of Plenty on 28-29 February 2004 and generated a sizeable storm surge (the elevation of sea levels above the predicted level). This report summarises details of the magnitude of the storm surge and documents relevant meteorological measurements. This data is of considerable value for future re-estimates of coastal hazards including design maximum sea levels.



## Chapter 2: Storm surge components

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Storm surge occurs as a result of coastal storms and super elevates of sea level along the coast. There are many factors involved in generating a storm surge. The three principal components are:

- Astronomical tidal height
- Barometric setup
- Wind setup

Within an estuary there is often an additional set up or set down, this is known as the Estuary effect.

### 2.1 **Astronomical tidal height**

The astronomical tidal height is the height that the tide has been forecast to reach under normal weather conditions. Tidal forecasts are provided in the Nautical Almanac and are the height that storm specific weather components build upon.

The tidal heights in the Almanac are given in Chart Datum and are converted into Moturiki Datum by subtracting 0.963 m from the Almanac height. This level then needs to be raised by 0.1 m at locations east of Matata to make account for the earth's geoid.

### 2.2 **Barometric setup**

As barometric pressure falls below the level of 1014 mb (which is defined as standard pressure) sea level rises above normal. The relationship is that for every millibar drop in pressure sea level rises by 1 cm.

### 2.3 **Wind setup**

The surface shear stress of the wind (called the geostrophic wind) travelling over the sea surface drives water in the prevailing wind direction. An onshore wind thus drives a wedge of water against the land. The magnitude of the height of this wedge is called the wind setup.

The size of the wind setup is complex to calculate and is dependent on several factors including:

- Intensity, duration and direction of high winds
- Coastline bathymetry
- Coastline geometry. The concave shape of the Bay of Plenty coast is likely to enhance setup levels.

## 2.4 **Estuary effects**

There are two components involved in estuary effects:

- Hydraulic effects relating to influx of freshwater, outlet controls, depth and channelling of water.
- Spatial differences in water levels due to the differential effect of wind stress.

## Chapter 3: Synoptic situation

Full details of the synoptic situation including synoptic charts, special weather bulletins and the track of the cyclone are presented in Appendix I.

Cyclone Ivy battered the small Pacific nation of Vanuatu on 26 February, with winds of 130-150 km/h in Vanuatu's northern and central islands. On 27 February, Cyclone Ivy left the tropics heading in a southerly direction towards the eastern side of the North Island. At this time, the Tropical Cyclone was breaking up and was downgraded to a deep depression with central pressures of 991 mb and associated high winds. It passed to the east of Northland and Coromandel and then tracked out to the east of East Cape.

An associated easterly wind produced peak wind gusts of 22.14 m per second (79.7 km/hr) at Whakatane Airport.

A summary of the relevant meteorological data in the Bay of Plenty is given in Table 1 below.

In comparison the 1% AEP barometric pressure is 981 mb, with extreme coverage and central pressures expected to be even lower. 1% AEP winds speeds are 34-36 m/s.

Table 1 Cyclone Ivy meteorological recordings (28-29 February 2004)

Site	Peak Wind Gust		Peak Average Wind Speed		Minimum Barometric Pressure (hPa)
	(m/s)	(km/h)	(m/s)	(km/h)	
Whakatane Airport	22.14	79.7 @ 2100	14.95	53.7 @ 2100	989.6 @ 1200
Tauranga Airport	20.08	72.3 @ 2200 (28 <sup>th</sup> )	9.78	35.2 @ 1300	992.4 @ 1200
Whakatane @ Warf					985.6 @ 1145
Tauranga @ Omokoroa					992.1 @ 1215
Edgecumbe	16.5	59.4 @ 1930 (28 <sup>th</sup> )	10.75	38.7 @ 1930 (28 <sup>th</sup> )	-

**Notes:** (1) Peak average wind speed for Whakatane and Tauranga Airports is based on a one hour duration. For Edgecumbe it is based on ten minute duration.





## Chapter 4: Recorded Sea Levels

Peak sea levels were recorded at a number of gauges for the event. Measurements of peak level at other sites were made by examining debris levels on the following day. Photos of debris locations are shown in Appendix III. Storm surge is calculated as peak sea level recorded minus predicted tide level for that location, where the peak level is influenced by open coast wave run-up and set-up we cannot make a definite calculation of storm surge, at these locations we get a value for combined storm surge and wave dynamics.

The predicted high tide levels were obtained from the tide tables produced in the New Zealand Nautical Almanac. Values are then altered to account for the earth's spherical shape on mean sea level; east of Matata levels are raised by roughly 0.1 m and east of Omaio by 0.2 m. Levels for Tauranga, Whakatane and Ohiwa Harbour are set out below.

Tauranga 0.64 m at 1340 hours

Whakatane 0.74 m at 1300 hours

Omaio 1.04 m at 1307 hours

Details of peak sea levels and estimated storm surge at some sites are presented in Table 2, see Appendix II for more detailed graphs at recorder locations.

At this stage it is not 100 percent clear to what extent the rivers influence the storm surge levels recorded within their mouths. Affected sites include the Whakatane Wharf recorder. This site was also affected by the river having elevated flood flows at the time of the surge, see graph and Appendix II. The flow in the relevant rivers at the time of a storm surge and the distance the recorder is from the open coast are factors that will influence our data collection at these locations.

*Table 2 Cyclone Ivy Recorded Sea Levels and Storm Surge (28-29 February 2004)*

Location	Peak Time High Tide	Floating Astronomical Tide (m RL)	Peak Sea Level (m RL)	Storm Surge (m)	Storm Surge + Wave Dynamics (m)
Ohiwa Wharf recorder	1445 hrs	0.768	1.149	0.381	
Whakatane Warf	1400 hrs	0.737	1.622	0.885	
Moturiki	1400 hrs	0.637	0.9	0.263	
Hairini	0140 hrs	0.637	1.03	0.393	
Oruamatua	1500 hrs	0.637	0.955	0.318	
Omokoroa	0200 hrs	0.637	0.871	0.234	
Waihi Beach*		0.637	5.618		4.981
Dead End Rd CCS 45*		0.637	2.697		2.060
Matakana Is Centre CCS 44*		0.637	2.455		1.818

Tank Rd CCS 43*		0.637	3.113		2.476
Bird Sanctuary CCS 42*		0.637	2.946		2.309
Fire Break Rd CCS 41*		0.637	3.092		2.455
Te Maunga CCS38*		0.637	2.541		1.904
Papamoa CCS 36*		0.637	2.984		2.347
Papamoa Beach CCS 35*		0.637	2.235		1.598
Taylor St Papamoa CCS 34*		0.637	2.771		2.134
Papamoa*		0.637	5.72		5.083
Banks Ave*		0.637	4		3.363
Kaituna River West CCS 33*		0.637	4.769		4.132
Kaituna River mouth*		0.637	5.671		5.034
Coastlands (near sand stockpile)*		0.737	5.53		4.793
Coastlands (500 m west of CCS #12)*		0.737	5.54		4.803
Ohope, 63 West End*		0.768	3.12		2.352
Ohope, 42 West End*		0.768	3.17		2.402
Ohope, 33 West End*		0.768	2.94		2.172
Ohiwa Harbour, End of Claydon Place*		0.768	1.18	**	0.412
Ohiwa Harbour, Kutarere SG at old causeway*		0.768	1.37	**	0.602
Ohiwa Harbour Holiday Park*		0.768	1.48	**	0.712
Waiwhakatoitoi (Waiotahi beach) CCS6*		0.806	4.668		3.862
Hawai Beach, eastern end*		0.806	5.73		4.924
Omaio Beach at store*		1.037	5.32		4.283
Eddie Patterson's house*		1.037	3.62		2.583
Raukokere School / Marae area*		1.037	4.2		3.163
Wharekura Bay*		1.037	4.761		3.724
<b>Note:</b> * Levels for the asterisked sites were obtained from the position of debris.					
<b>Note:</b> **Levels within Ohiwa Harbour have not got a large wave influence, however this influence can not be totally ruled out.					
<b>Note:</b> The storm surge wave run-up column relates to locations where the wave components could not be factored out, this measurement is not to be taken as the wave run-up level.					

## Chapter 5: Discussion

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### 5.1 Frequency of these events

The meteorological measurements (barometric pressure and wind speed) for Cyclone Ivy indicate that it was of significantly less intensity than a 100 year return period event. Whilst exact statistics are not available, it is likely that Cyclone Ivy was around a 10 year return period magnitude.

### 5.2 Recorded storm surge levels

Cyclone Ivy raised water levels to approximately 0.71 m above the expected tide level at Ohiwa Harbour Holiday Park.

Unfortunately due to the coincidence of the flood peak with the peak in storm surge levels at both the Whakatane and Opotiki Wharfs (see graphs in Appendix II) these levels are unable to be considered.

In Tauranga Harbour, storm surge levels have been calculated for sites at Hairini, Oruamatua and Omokoroa. Table 1 shows the storm surge levels at these sites to range from 0.23 m to 0.39 m.

### 5.3 Storm surge component for Cyclone Ivy

Examination of Table 2 suggests that for Cyclone Ivy, the estuary effects component in Ohiwa Harbour was relatively minor. The following appear to be the storm surge components for the Ohiwa Harbour recorder at time of high tide;

Astronomical Tidal Height	0.768 m RL	
Barometric Set-up	0.237 m	(based on 990.3 mb at 1445 hrs Whakatane Wharf)
Wind Set-up	0.144 m	
<b>Total</b>	<b>1.149 m RL</b>	

From the information above we are able to calculate the static storm surge level, this is the sum of the barometric setup and wind set up components. The static storm surge level is considered to have two levels for the Bay of Plenty, one level for the Western Bay of Plenty through to Matata and another level from Matata through to the Cape.

The “static” storm surge component is thus the sum of the barometric setup and wind setup and is 0.381 m for Ohiwa Harbour.

For Tauranga Harbour, the “static” storm surge component was calculated to be 0.263 m, based on the peak level of 0.900 m at the Moturiki gauge and astronomical tide of 0.637 m and a barometric pressure of 995.2 mb at Omokoroa measure at the time of peak water levels.

Thus the “static storm surge” was 0.12 m greater at Ohiwa than Tauranga, reflecting the storm direction and concave geometry in the Eastern Bay of Plenty. This reinforces the conclusions reached with data recorded from Cyclone Fergus (30-31 December 1996) and Cyclone Drena (16-11 January 1997).

## 5.4 Wind setup

Wind set-up is the vertical rise in the still-water level on the leeward side of a body of water caused by wind stresses on the surface of the water.

The wind set up of 0.144 m does not exceed the 100 year return period estimate used in the Regional Coastal Plan of 0.54 m.

Cyclone Ivy peak gust	22.14 m/s	
100 year wind gust	34 m/s	(based on Tauranga data in NZ 4203)
Cyclone Ivy wind setup	0.144 m	(max)
100 year wind setup	0.54 m	(Regional Coastal Plan for Ohiwa)

## 5.5 Estuary effects

Different estuary effects are principally caused by the wind stress across the body of water, causing an “estuary” wind setup and wave run-up (also perhaps a wave setup). The variances in the value of estuary effect felt around an estuary can be caused by bathymetry, different wind fetch lengths and sheltering.

The quantum of these in Cyclone Ivy can be determined from comparing different levels recorded at sites within the Tauranga and Ohiwa Harbours to the respective Moturiki and Ohiwa recorders (it is possible that the Ohiwa recorder has a minor wind “set-down”), as the Moturiki and Ohiwa recorders do not experience any estuary effects. The effects are presented in Table 3.

*Table 3 Cyclone Ivy recorded estuary effects*

Location	Peak Level (m RL)	Estuary Effect (m RL)
Ohiwa Harbour, End of Claydon Place*	1.18	0.031
Ohiwa Harbour, Kutarere SG at old causeway*	1.37	0.221
Ohiwa Harbour Holiday Park*	1.48	0.331
TGA Hairini	1.03	0.130
TGA Omokoroa	0.871	-0.029
TGA Oruamatua	0.955	0.055

**Note:** \* Levels for the asterisked sites were obtained from the position of debris.

## 5.6 Wave run-up and coastal erosion

Whilst the focus of this report is on storm surge, some comment is warranted on the impact of the waves generated by these storms.

Wave run-up is essentially the maximum height on land reached by the breaking waves and varies with breaking wave characteristics, beach and backshore slope. Wave run-up is defined as the peak water level reached on land minus the still water level. During a storm surge event the still water level can be described as the predicted high tide level plus the static storm surge level. Table 4 below shows the wave run-up values recorded in Cyclone Ivy, values are based on recorded debris levels, these values varied across the Bay. Highest wave run-up levels were recorded in the Western Bay with 4.82 m recorded at Papamoa and 4.7 at Waihi Beach and the Kaituna River mouth. Kaituna River recorder is likely affected by the river being in a flood state. At Coastlands, the maximum wave run-up component recorded from deposited driftwood by Cyclone Ivy was 4.42 m and at Ohope Beach the maximum component recorded was 2.02 m. Erosion of the foredune at both these sites was significant however the dunes were not over topped. Further up the East Cape at areas such as Omaio and Hawaii, wave run-up reached heights of 3.90 m and 4.54 m respectively.

Table 4 Cyclone Ivy recorded wave run-up elevations

Site	Floating Astronomical Tide (m RL)	Peak Level (m RL)	Static Storm Surge Level (m)	Wave Runup (m)
Waihi Beach	0.637	5.618	0.263	4.718
Dead End Rd CCS 45	0.637	2.697	0.263	1.797
Matakana Is Centre CCS 44	0.637	2.455	0.263	1.555
Tank Rd CCS 43	0.637	3.113	0.263	2.213
Bird Sanctuary CCS 42	0.637	2.946	0.263	2.046
Fire Break Rd CCS 41	0.637	3.092	0.263	2.192
Te Maunga CCS38	0.637	2.541	0.263	1.641
Papamoa CCS 36	0.637	2.984	0.263	2.084
Papamoa Beach CCS 35	0.637	2.235	0.263	1.335
Taylor St Papamoa CCS 34	0.637	2.771	0.263	1.871
Papamoa	0.637	5.720	0.263	4.820
Banks Ave	0.637	4.000	0.263	3.100
Kaituna River West CCS 33	0.637	4.769	0.263	3.869
Kaituna River mouth	0.637	5.671	0.263	4.771
Coastlands (near sand stockpile)	0.737	5.530	0.381	4.412
Coastlands (500 m west of CCS #12)	0.737	5.540	0.381	4.422
Ohope, 63 West End	0.768	3.120	0.381	1.971
Ohope, 42 West End	0.768	3.170	0.381	2.021
Ohope, 33 West End	0.768	2.940	0.381	1.791
Ohiwa Harbour, End of Claydon Place	0.768	1.180	0.381	0.031
Ohiwa Harbour, Kutarere SG at old causeway	0.768	1.370	0.381	0.221
Ohiwa Harbour Holiday Park	0.768	1.480	0.381	0.331
Waiwhakatoitoi (Waiotahi beach) CCS6	0.806	4.668	0.381	3.481
Hawaii Beach, eastern end	0.806	5.730	0.381	4.543
Omaio Beach at store	1.037	5.320	0.381	3.902
Eddie Patterson's house	1.037	3.620	0.381	2.202
Raukokere School / Marae area	1.037	4.200	0.381	2.782
Wharekura Bay	1.037	4.761	0.381	3.343



## Chapter 6: Conclusion

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The Cyclone Ivy storm of 28-29 February 2004 produced a significant storm surge event. It is likely that Cyclone Ivy was around a 10 year return period magnitude.

The maximum storm surge elevations reached during Cyclone Ivy were within the Ohiwa Harbour, with likely enhancement from various estuarine effects. Slightly lower than these were the values recorded within the Tauranga Harbour.

Maximum wave run-up levels varied within the Bay with maximum heights recorded at Waihi Beach, Coastlands Beach and Hawaii, all being in excess of 4.4 m RL.

Data collected in this report and others like it create a valuable record of past storm events, they are used when analysing coastal processes and when making predictions and calibrating models showing coastal inundation. They also help us develop a picture of what happens within our harbours with different coastal conditions.





## Chapter 7: References

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Arts, V, 2005, Cyclone Ivy: Magnitude of Storm Surges Recorded and Implications for Design Maximum Sea Levels. Environment Bay of Plenty Operations Report No 2005/04.

Blackwood, PL, March 1997; Cyclone Fergus and Drena Storm Surge: Report on the Magnitude of Storm Surges Recorded and Implications for Design Maximum Sea Levels. Environment Bay of Plenty Operations Report No 97/1.



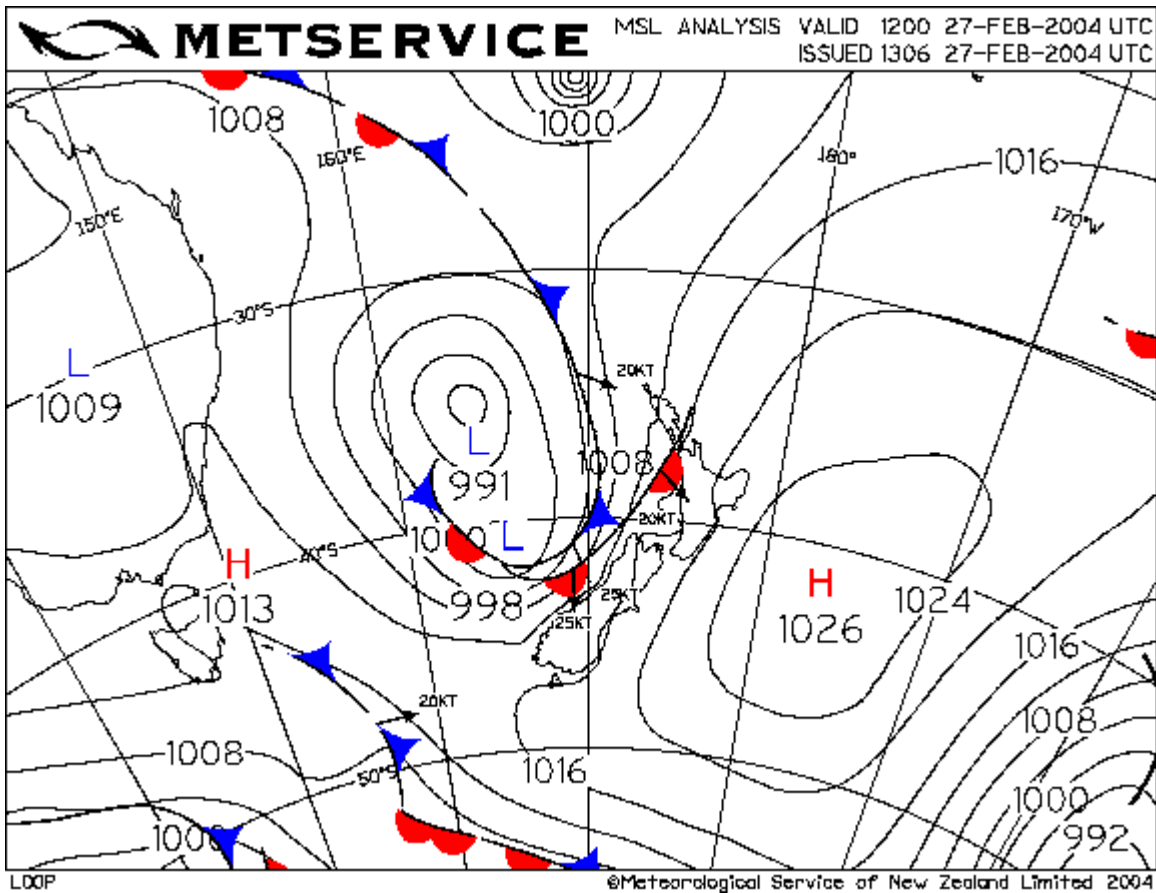
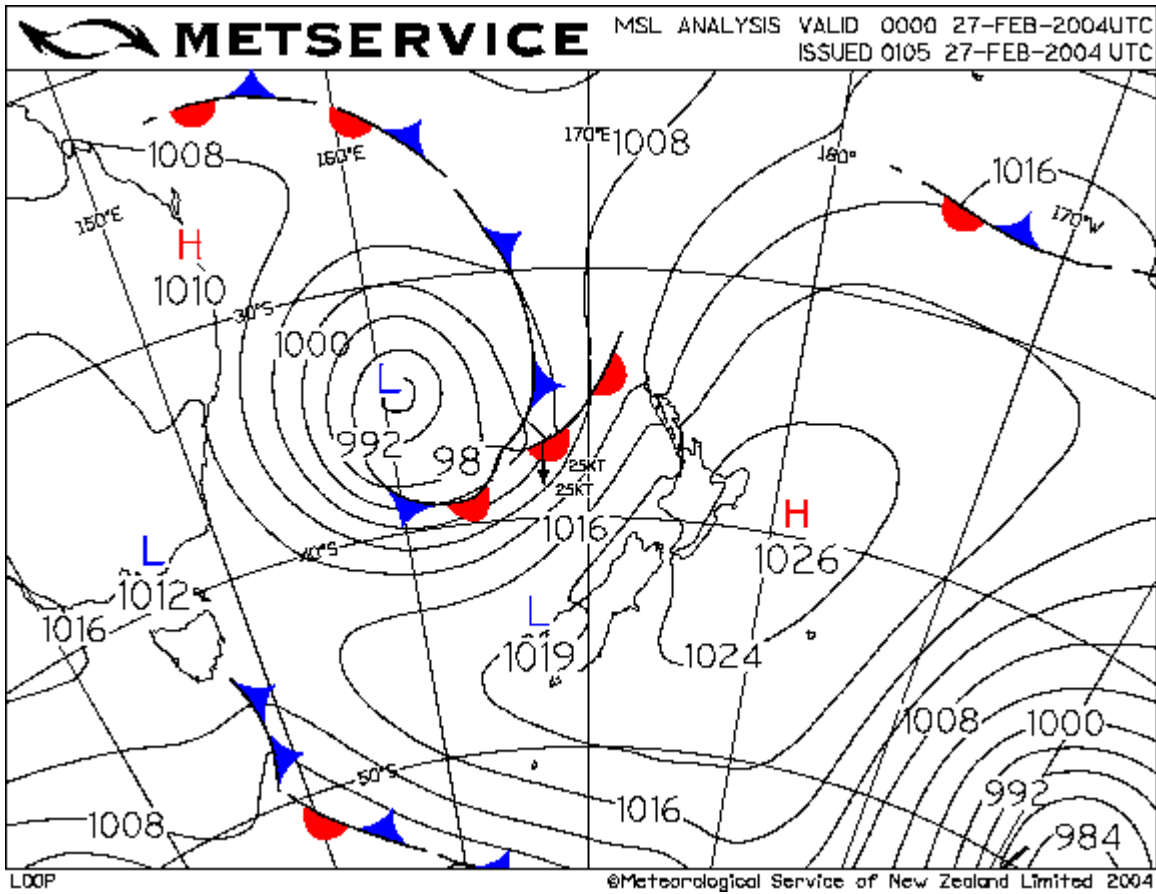
## Appendices

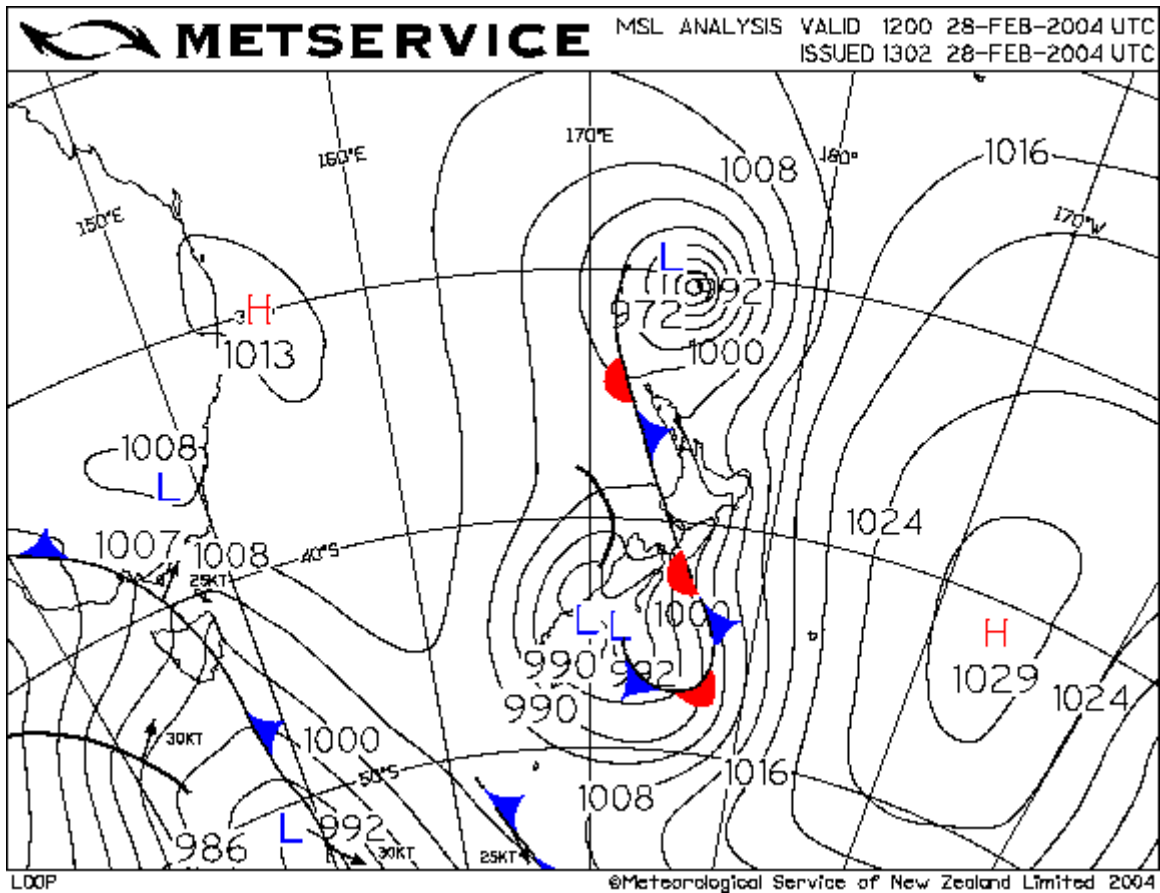
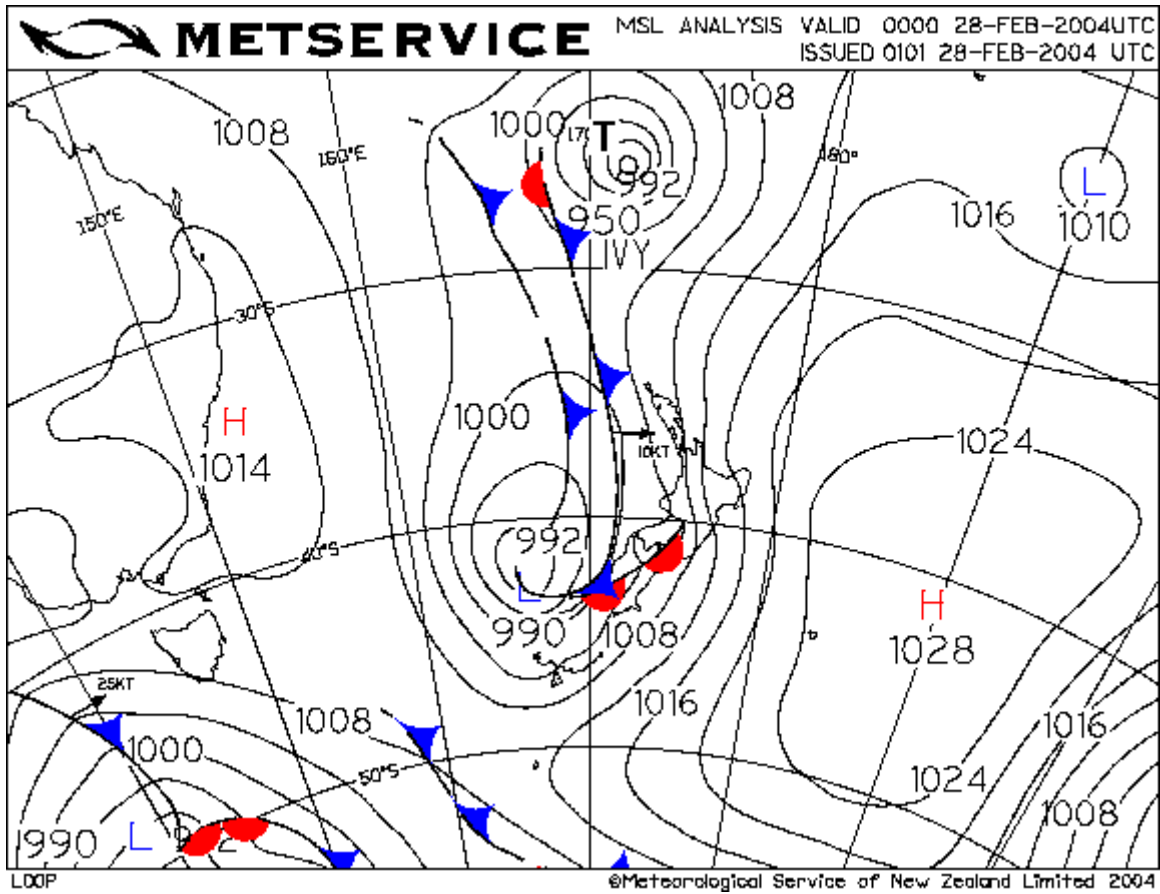
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<i>Appendix I</i> .....	<i>Synoptic situation</i>
<i>Appendix II</i> .....	<i>Graphs</i>
<i>Appendix III</i> .....	<i>Photos</i>

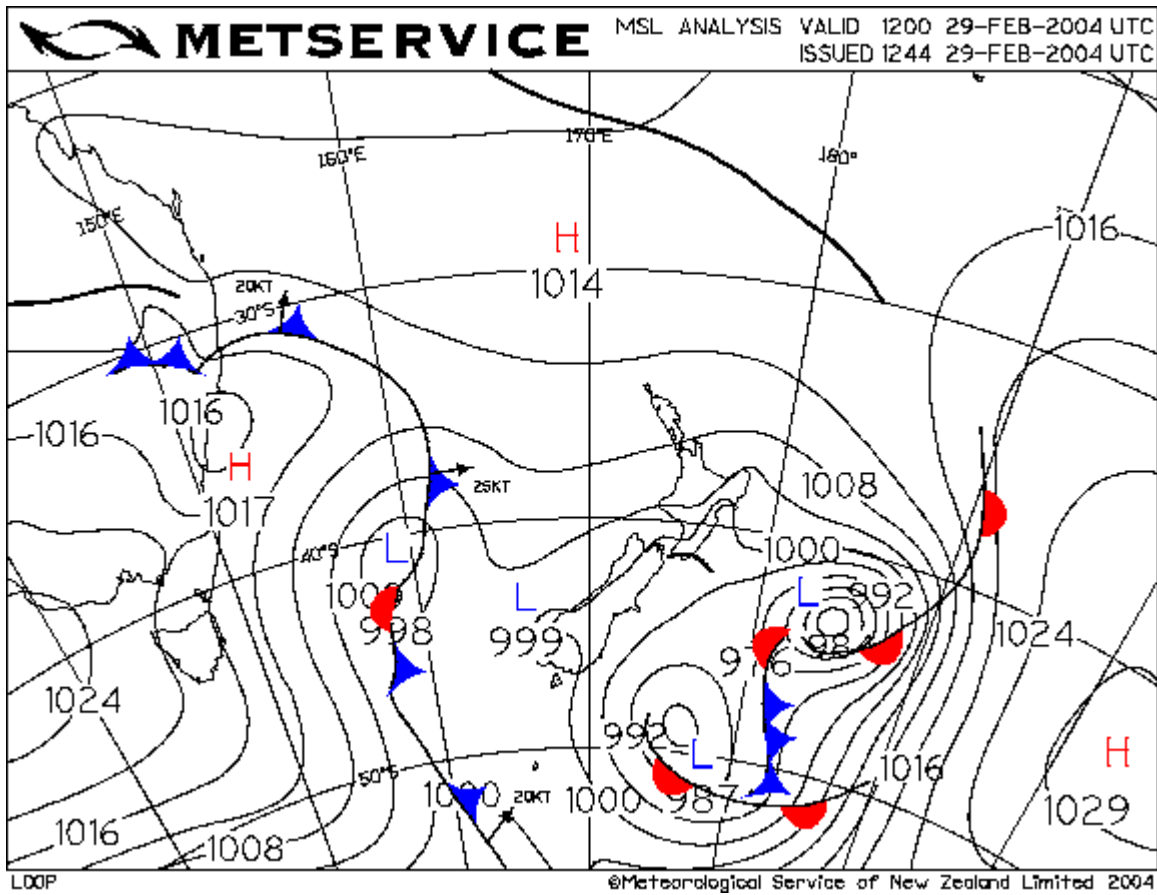
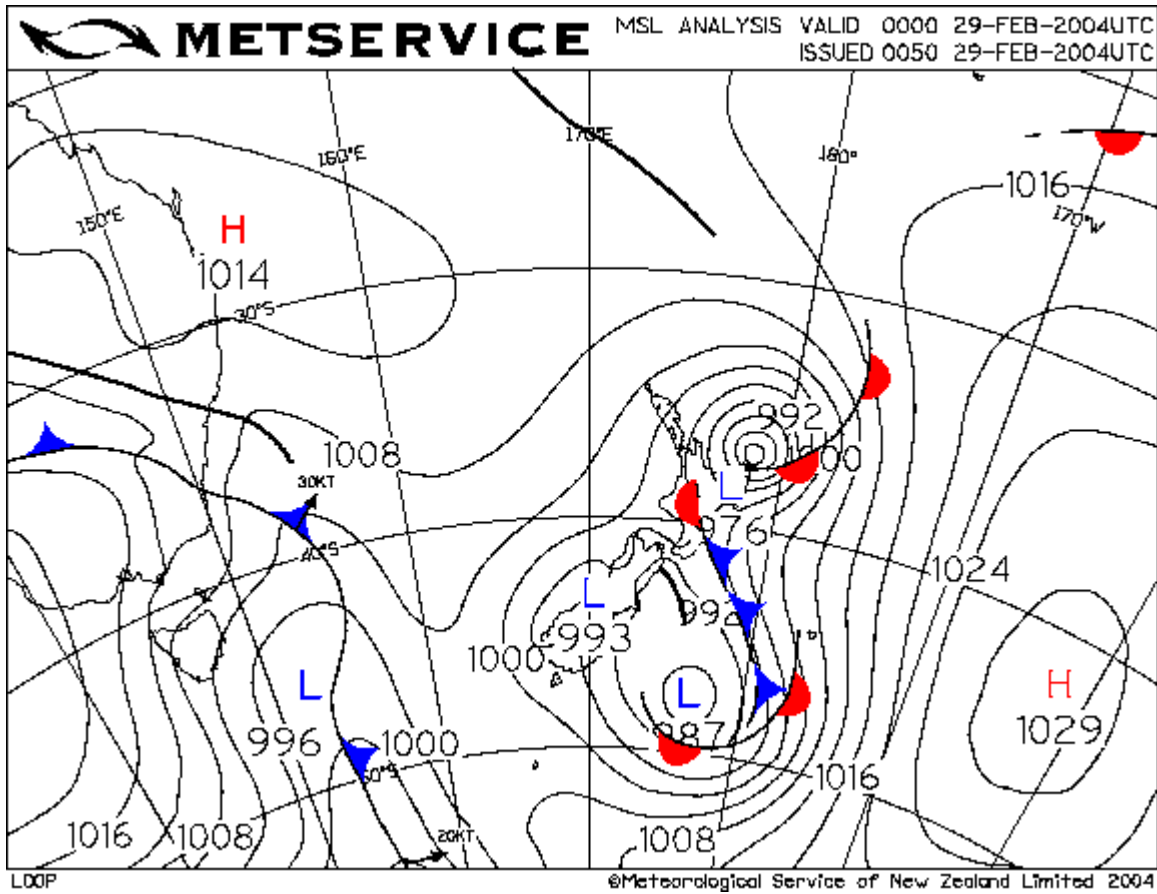


## Appendix I – Synoptic situation









MetService – Weather Maps

## **Heavy rain and flood sin northern and central North Island 28-29 February 2004**

A strong, moist north to northeast flow affected the North Island at the end of February, bringing heavy rain and floods to northern and central parts of the North Island.

Many roads were closed by floods and slips, including State Highway 1 in at least 3 places. Worst affected was the central North Island town of Turangi where homes were evacuated after the Tongariro River burst its banks overnight 28-29<sup>th</sup>.

Levels of the Wanganui, Rangitikei and Manawatu rivers caused concern on the 29<sup>th</sup> (some properties were flooded in Wanganui), and the Waikato River flooded low lying areas downstream in following days as Lake Taupo emptied.

The heavy rain moved slowly in from the Tasman Sea on the 28<sup>th</sup> ahead of an active front and low pressure system. Falls exceeding 100mm in 24 hours were felt in northwest Nelson and Taranaki before northern and central North Island districts received similar amounts, peaking there during the night of the 28-29<sup>th</sup>.

Many MetService weather stations exceeded their normal February monthly rainfall total in one day. For example, Farewell Spit (northwest Nelson) recorded 131.4mm in the 24 hours to 6pm on the 28<sup>th</sup>, including two consecutive one hour deluges of 33.2mm and 26.6mm (hours ending 1pm and 2pm) respectively. New Plymouth recorded 117.8mm in the 24 hours to 10pm on the 28<sup>th</sup>, while falls on Mt Taranaki exceeded 200mm in the same period.

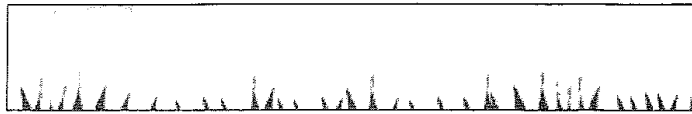
Around 50-70mm fell in 24 hours in Nelson City, Marlborough (including a previously drought-stricken Blenheim), also in an already soaking Wellington and Kapiti/Horowhenua.

Auckland Airport measured 97.2mm in the 24 hours to 1am on the 29<sup>th</sup>, while Hamilton got 94.6mm in the 24 hours to midnight on the 28<sup>th</sup>. Other large totals (in the 24 hours to 9am on the 29<sup>th</sup>) included 120.8mm at Whitianga, 116.4mm at Te Puke, 103.8mm at Taharoa, and 120.0mm at Rotorua.

The rain impacted on various weekend events on the 28<sup>th</sup>, such as the NZ vs SA one-day cricket match in Auckland (washed out), and the Cuba Street Carnival in Wellington. A wet, cold southerly developed in the south on the 28<sup>th</sup> producing unusually low 'summer' temperatures. For example, Dunedin reached just 13°C, while Queenstown and Oamaru only managed 14°C.

The strength of the northeast flow ahead of the front also caused problems, with winds reaching gale force in exposed northern parts on the 28<sup>th</sup>. In Auckland there were power cuts, trees downed, and boats blown off moorings. Winds gusted to 124 km/hr in the Hauraki Gulf.

On the 29<sup>th</sup> a deep depression, former tropical cyclone Ivy passed quickly southeast over the seas just northeast of the North Island. This had little effect on New Zealand, except for producing heavy swells on North Island east coast beaches. Ivy had caused concern however, as at least one computer model prediction a few days earlier indicated it was to move directly south over the North Island, which would have been 'interesting' to say the least. This was a close call.



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**MetService Press Release:  
More Wet-and-Windy Yo-Yo Weather**

*Issued at 12:37pm 26-Feb-2004*

MetService meteorologists have issued a special weather advisory as they monitor two storms which are expected to bring further heavy rain and strong winds to New Zealand over the weekend.

"It looks like we are in for a tempestuous ending to a tempestuous month", commented MetService Weather Ambassador, Bob McDavitt. "Our Yo-Yo summer is turning into a Yo-Yo autumn".

By late Saturday a deepening low in the Tasman Sea is expected to cross the South Island. This low and its associated front are likely to bring a period of heavy rain on Saturday to the west of the South Island, Nelson, Marlborough, Wellington and the Tararua Ranges, and also that part of the North Island north of a line from Taranaki to East Cape. Heaviest falls of around 150 mm are being forecast for the hills and ranges from Mount Taranaki to Ruapehu to East Cape, and this includes the headwaters of the Whanganui and the Rangitikei rivers. At this stage forecasters are predicting less rain over the lower lying areas of Wanganui and Manawatu where 20-30mm of rain is possible. Northerly gales are also forecast for many parts of northern and central New Zealand ahead of the front.

On Sunday morning this low should move away. Later on Sunday or early on Monday another depression, formed from the spread-out remnants of tropical cyclone Ivy, should pass over or just east of the North Island. Another period of heavy rain and damaging winds is possible, particularly over the north and east of the North Island. The actual track of this storm is uncertain at this stage and people are advised to keep up to date with the latest forecasts.

After a brief clearance in the weather on Monday there may well be another low developing in the Tasman Sea on Tuesday.

Updated details of this incoming wind and rain are available from the www.metservice.co.nz website.

**For further information please contact:  
Bob McDavitt Weather Ambassador (09)377 4831**

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Met Service – Press Release

Met Service – Severe Weather Warnings

Verna Arts

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From: email-lists@metSERVICE.CO.NZ  
 Sent: Friday, 27 February 2004 12:09  
 To: WARNING@lists.metSERVICE.CO.NZ  
 Subject: : SEVERE WEATHER WARNING. : 061822

{SWW Event 2004/16.1}  
 URGENT - IMMEDIATE BROADCAST IN:  
 FIORDLAND WESTLAND BULLER NELSON MARLBOROUGH WELLINGTON MANAWATU  
 WAIRARAPA TARANAKI TAUMARUNUI TAUPO BAY OF PLENTY GISBORNE WAITOMO  
 WAIKATO AUCKLAND COROMANDEL PENINSULA NORTHLAND

NOT TO BE BROADCAST AFTER 9:00pm Friday 27-Feb-2004

<b SEVERE WEATHER WARNING. </b  
 <b ISSUED BY MetService AT 12:08 pm 27-Feb-2004</b  
 {MEDIA}  
 STORMS EXPECTED TO BRING HEAVY RAIN TO MANY PARTS OF NEW ZEALAND THIS WEEKEND  
 A deep depression over the Tasman Sea is expected to move southeast and cross Fiordland and Otago late Saturday. The low and its associated front should bring a period of heavy rain to the north and west of both islands. Worst affected will be the high country from Mt Taranaki across Ruapehu to the ranges between Gisborne and Bay of Plenty where between 150 and 200mm of rain is possible. This area includes the headwaters of the Whanganui and Rangitikei Rivers.

During Sunday another deep depression, formed from the remains of tropical cyclone Ivy, should pass just to the east of Northland and Coromandel and then pass close to East Cape. A further burst of heavy rain is likely about the ranges between Gisborne and Bay of Plenty possibly bringing total rainfall of 270mm there for the whole event.

Strong or gale northerly winds are likely with the rain on Saturday. Gales associated with the ex-tropical cyclone on Sunday should be out over the sea to the east of the North Island but a small change in the direction of movement of this low could bring damaging winds over parts of the east coast from Northland to Gisborne.

People in these areas should beware of rising river levels and hazardous driving conditions and keep up to date with the latest forecasts.

FOR THE LATEST WEATHER AND FORECAST CHARTS PLEASE GO TO  
<http://www.metSERVICE.CO.NZ/maps/index.asp>

MORE DETAILED INFORMATION FOR EMERGENCY MANAGERS AND TECHNICAL USERS FOLLOWS:

===== <b HEAVY RAIN WARNING.</b =====

AREA/S AFFECTED: WEST COAST OF THE SOUTH ISLAND, NELSON, MARLBOROUGH THE TARARUA RANGES, THE RANGES FROM MT TARANAKI ACROSS TO EAST CAPE, WAIKATO, BAY OF PLENTY, AUCKLAND, COROMANDEL PENINSULA, NORTHLAND <b FORECAST:</b

WEST COAST RANGES FROM MILFORD TO OTIRA  
 In the 24 hours from midnight Friday to midnight Saturday about 100mm

of rain is likely but 150 mm from Franz Josef to Otira.

**RANGES OF NORTHWEST NELSON**

In the 18 hours from midnight Friday to 6pm Saturday 80 to 100mm of rain is likely.

**MARLBOROUGH SOUNDS AND RICHMOND RANGES**

In the 18 hours from 3am to 9pm Saturday 80 to 100mm of rain is likely.

**THE TARARUA RANGE**

In the 18 hours from 3am to 9pm Saturday 120 to 140 mm of rain is likely about the higher slopes with 80 to 100 mm lower down.

**Mt TARANAKI**

In the 18 hours from midnight Friday to 6pm Saturday 150 to 180mm of rain is likely about the higher slopes and 100 mm lower down. Heaviest falls of 30mm per hour are possible.

**HILL COUNTRY FROM MT TARANAKI ACROSS TO RUAPEHU ALSO WAITOMO AND WAIKATO**

In the 18 hours from 6am to midnight Saturday 80 to 100mm are likely but up to 200mm may fall on the mountains. Heaviest falls of 30mm per hour are possible.

**AUCKLAND**

In the 18 hours from noon Saturday to 6am Sunday 80 to 100mm is likely about the Hunua and Waitakare Ranges and 60 to 80 mm elsewhere.

**NORTHLAND**

In the 15 hours from noon Saturday to 3am Sunday 100 to 140mm of rain is likely. The heaviest rain should be between 5pm and 1am with falls of 25-30mm per hour.

**BAY OF PLENTY AND COROMANDEL PENINSULA**

In the 24 hours from noon Saturday to noon Sunday 130 to 150 mm of rain is likely in the ranges and 100mm elsewhere. However, about the eastern ranges of Bay of Plenty, a further 140 mm is possible in the 12 hours from noon to midnight Sunday. Heaviest falls of 30mm per hour are possible.

**GISBORNE NORTH OF TOLAGA BAY**

In 24 hours from 6pm Saturday to 6pm Sunday 180mm of rain possible in the ranges and 100mm elsewhere.

**FREEZING LEVEL/SNOW CONDITIONS: 3400 metres**

<b NEXT SEVERE WEATHER WARNING WILL BE ISSUED AT OR BEFORE</b  
<b 9:00pm Friday 27-Feb-2004</b

<b Forecast prepared by: Erick Brenstrum</b

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1209 27 February 2004

## Severe Weather Warning

SEVERE WEATHER WARNING.  
ISSUED BY MetService AT 9:00 pm 27-Feb-2004

STORMS EXPECTED TO BRING HEAVY RAIN TO MANY PARTS OF NEW ZEALAND THIS WEEKEND

A deep depression over the Tasman Sea is expected to move southeast and cross Fiordland and Otago late Saturday. The low and its associated front should bring a period of heavy rain to the north and west of both islands. Worst affected areas will be the Nelson ranges, also the high country from Mt Taranaki across to Mt Ruapehu and the ranges of Bay of Plenty and northern Gisborne where between 150 and 250mm of rain is possible. This area includes the headwaters of the Whanganui and Rangitikei Rivers.

During Sunday another deep depression, formed from the remains of tropical cyclone "Ivy", should pass just to the east of Northland and Coromandel and then pass close to East Cape. A further burst of heavy rain is likely about the ranges between Gisborne and Bay of Plenty with total rainfalls of 250mm possible there for the whole event.

Strong or gale northerly winds are likely with the rain on Saturday. Gales associated with the ex-tropical cyclone on Sunday should be out over the sea to the east of the North Island, but a small change in the direction of movement of this low could bring damaging winds over parts of the east coast from Northland to Gisborne.

People in these areas should be on the alert for rising river levels and hazardous driving conditions and keep up to date with the latest forecasts.

FOR THE LATEST WEATHER AND FORECAST CHARTS PLEASE GO TO  
<http://www.metservice.co.nz/maps/index.asp>

MORE DETAILED INFORMATION FOR EMERGENCY MANAGERS AND TECHNICAL USERS FOLLOWS:

### HEAVY RAIN WARNING.

AREA/S AFFECTED: THE SOUTH ISLAND WEST COAST, NELSON, MARLBOROUGH, WELLINGTON, THE TARARUA RANGES, THE RANGES FROM MT TARANAKI ACROSS TO NORTHERN GISBORNE, WAIKATO, WAITOMO, TAUMARUNUI, TAUPO, BAY OF PLENTY, COROMANDEL PENINSULA, AUCKLAND, NORTHLAND

#### FORECAST:

SOUTH ISLAND WEST COAST FROM MILFORD SOUND TO OTIRA  
In the 24 hours from midnight Friday to midnight Saturday about 100mm of rain is likely, especially north of Franz Josef.

#### NELSON

In the 18 hours from 10pm Friday to 4pm Saturday, 200mm of rain is likely about the ranges, with 80 to 100mm possible elsewhere. Peak intensities of 30 to 40mm per hour are possible about the ranges in

the morning.

#### MARLBOROUGH SOUNDS AND RICHMOND RANGES

In the 18 hours from 1am to 7pm Saturday, 100 to 150mm of rain is likely, with peak intensities of 25 to 30mm per hour late morning.

#### WELLINGTON

In the 9 hours from 8am to 5pm Saturday, 60mm of rain likely, especially about the northern hills.

#### THE TARARUA RANGES

In the 18 hours from 9am Saturday to 3am Sunday, 120 to 150mm of rain is likely about higher slopes with 80mm about lower slopes.

#### MT TARANAKI

In the 18 hours from 6am to midnight Saturday 150 to 200mm of rain is likely about the higher slopes and up to 100mm lower down. Peak intensities of 25 to 35mm per hour are possible about higher slopes Saturday afternoon or evening.

#### HILL COUNTRY FROM INLAND TARANAKI ACROSS TO MT RUAPEHU, ALSO TAUMARUNUI, WAITOMO WAIKATO AND TAUPO, INCLUDING THE HEADWATERS OF THE WHANGANUI AND RANGITIKEI RIVERS

In the 18 hours from 9am Saturday to 3am Sunday, 100mm of rain is likely, but up to 250mm is possible on the mountains, especially Mt Ruapehu. Peak intensities of 30mm per hour are possible about higher slopes from Saturday evening.

#### BAY OF PLENTY AND COROMANDEL PENINSULA

In the 24 hours from 6pm Saturday to 6pm Sunday, 120 to 150mm of rain is likely in the ranges and up to 100mm elsewhere. However, about the eastern ranges of Bay of Plenty, a further 100mm is possible in the 6 hours from 6pm to midnight Sunday. Heaviest falls of 30mm per hour are possible.

#### AUCKLAND

In the 18 hours from 3pm Saturday to 9am Sunday, 80 to 100mm is likely about the Hunua and Waitakare Ranges and 60 to 80mm is possible elsewhere.

#### NORTHLAND

In the 18 hours from 3pm Saturday to 9am Sunday, 100 to 150mm of rain is likely. Peak intensities of 25 to 35mm per hour are possible overnight Saturday.

#### GISBORNE NORTH OF TOLAGA BAY

In 24 hours from 3am Sunday to 3am Monday, 180mm of rain is possible in the ranges and up to 100mm elsewhere.

**FREEZING LEVEL:** Above 3000 metres.

**NEXT SEVERE WEATHER WARNING WILL BE ISSUED AT OR BEFORE  
9:00am Saturday 28-Feb-2004**

Forecast prepared by: Andy Downs

For further information after 9pm contact Duty Forecaster  
Allister Gorman

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2100 27 February 2004

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## Severe Weather Warning

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SEVERE WEATHER WARNING.  
ISSUED BY MetService AT 8:51 am 28-Feb-2004

### HEAVY RAIN FOR MANY PARTS OF NEW ZEALAND THIS WEEKEND

A deep depression over the Tasman Sea is expected to move southeast and cross Fiordland and Otago tonight. The low and its associated front should bring a period of heavy rain to the north and west of both islands. Worst affected areas will be the Nelson ranges, also the high country from Mt Taranaki across to Mt Ruapehu and the ranges of Bay of Plenty and northern Gisborne where between 150 and 250mm of rain is possible. This area includes the headwaters of the Whanganui and Rangitikei Rivers.

During Sunday another deep depression, formed from the remains of tropical cyclone "Ivy", should pass just to the east of Northland and Coromandel and then pass close to East Cape. A further burst of heavy rain is likely about the ranges between Gisborne and Bay of Plenty with total rainfalls of 250mm possible there for the whole event.

Strong or gale northerly winds are likely with the rain today. The worst of the gales associated with the ex-tropical cyclone on Sunday should be out over the sea to the east of the North Island, but a small change in the track of this low could bring damaging winds over parts of the east coast from Northland to Gisborne.

People in these areas should be on the alert for rising river levels and hazardous driving conditions and keep up to date with the latest forecasts.

FOR THE LATEST WEATHER AND FORECAST CHARTS PLEASE GO TO  
<http://www.metservice.co.nz/maps/index.asp>

MORE DETAILED INFORMATION FOR EMERGENCY MANAGERS AND TECHNICAL USERS FOLLOWS:

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### HEAVY RAIN WARNING.

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AREA/S AFFECTED: THE RANGES OF WESTLAND AND FIORDLAND, NELSON, MARLBOROUGH, WELLINGTON, THE TARARUA RANGES, THE RANGES FROM MT TARANAKI ACROSS TO NORTHERN GISBORNE, INCLUDING TAIHAPE, TAUMARUNUI, WAITOMO, WAIKATO, TAUPO, THE BAY OF PLENTY, COROMANDEL PENINSULA, AUCKLAND, NORTHLAND

#### FORECAST:

THE WEST COAST RANGES FROM MILFORD SOUND TO OTIRA  
In the 18 hours from midday Saturday to 6am Sunday, 80mm of rain is possible, especially north of Franz Josef.

#### NELSON

In the 16 hours from 8am to midnight Saturday, 150 to 200mm of rain is likely about the ranges and parts of Golden Bay, with 80 to 100mm possible elsewhere. Peak intensities of 30 to 40mm per hour are possible from late morning.



**MARLBOROUGH SOUNDS AND RICHMOND RANGES**

In the 18 hours from 8am Saturday to 2am Sunday, 100 to 150mm of rain is likely, with peak intensities of 25 to 30mm per hour from midday.

**WELLINGTON**

In the 21 hours from 9am Saturday to 6am Sunday, 90mm of rain likely, especially about the northern hills.

**THE TARARUA RANGES**

In the 24 hours from 9am Saturday to 9am Sunday, 150mm of rain is likely about higher slopes with 80mm about lower slopes.

**MT TARANAKI**

In the 24 hours from 9am Saturday to 9am Sunday, 200mm of rain is likely about the higher slopes and up to 100mm lower down. Peak intensities of 25 to 35mm per hour are possible about higher slopes.

**HILL COUNTRY FROM INLAND TARANAKI ACROSS TO MT RUAPEHU, INCLUDING TAIHAPE, TAUMARUNUI, WAITOMO, WAIKATO AND TAUPO, ALSO THE HEADWATERS OF THE WHANGANUI AND RANGITIKEI RIVERS**

In the 27 hours from 9am Saturday to midday Sunday, 100mm of rain is likely, but up to 250mm is possible on the mountains, especially Mt Ruapehu. Peak intensities of 30mm per hour are possible about higher slopes from Saturday evening.

**BAY OF PLENTY AND COROMANDEL PENINSULA**

In the 24 hours from 6pm Saturday to 6pm Sunday, 120 to 150mm of rain is likely in the ranges and up to 100mm elsewhere. However, about the eastern ranges of Bay of Plenty, a further 100mm is possible in the 6 hours from 6pm to midnight Sunday. Heaviest falls of 30mm per hour are possible.

**AUCKLAND**

In the 21 hours from 3pm Saturday to midday Sunday, 80 to 100mm is likely about the Hunua and Waitakare Ranges and 60 to 80mm is possible elsewhere.

**NORTHLAND**

In the 21 hours from midday Saturday to 9am Sunday, 100 to 150mm of rain is likely. Peak intensities of 25 to 35mm per hour are possible overnight.

**GISBORNE NORTH OF TOLAGA BAY**

In 24 hours from 2am Sunday to 2am Monday, 200mm of rain is possible in the ranges and up to 100mm elsewhere.

**FREEZING LEVEL:** Above 3000 metres.

**NEXT SEVERE WEATHER WARNING WILL BE ISSUED AT OR BEFORE  
9:00pm Saturday 28-Feb-2004**

Forecast prepared by: Andy Downs

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0851 28 February 2004

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## Severe Weather Warning

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SEVERE WEATHER WARNING.  
ISSUED BY MetService AT 8:32 pm 28-Feb-2004

### MORE RAIN FOR MANY AREAS

A deep depression over the Tasman Sea is expected to move southeast and cross the South Island overnight Saturday/Sunday. Heavy rain has been affecting most of the North Island, also the north and west of the South Island. In many places, the rain should ease off Sunday morning. However, over the northern half of the North Island, the night and morning should see some further very heavy falls during this period.

During Sunday, another deep depression, the remains of tropical cyclone "Ivy" should pass just to the east of Northland and Coromandel Peninsula, and then pass close to East Cape. This should bring a further burst of heavy rain to the ranges of Gisborne and eastern Bay of Plenty.

The worst of the gales associated with ex-tropical cyclone "Ivy" on Sunday should be out to sea, but a small change in the track of this low could bring damaging winds over parts of the east coast from Northland to Gisborne.

People in these areas should be alert for surface flooding, rising river levels, and hazardous driving conditions, and keep up to date with the latest forecasts.

FOR THE LATEST WEATHER AND FORECAST CHARTS PLEASE GO TO  
<http://www.metservice.co.nz/maps/index.asp>

MORE DETAILED INFORMATION FOR EMERGENCY MANAGERS AND TECHNICAL USERS  
FOLLOWS:

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### HEAVY RAIN WARNING.

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AREA/S AFFECTED: THE RANGES OF WESTLAND AND FIORDLAND, NELSON, MARLBOROUGH, WELLINGTON, THE TARARUA RANGES, THE RANGES FROM MT TARANAKI ACROSS TO NORTHERN GISBORNE, INCLUDING TAIHAPE, TAUMARUNUI, WAITOMO, WAIKATO, TAUPO, THE BAY OF PLENTY, COROMANDEL PENINSULA, AUCKLAND, AND NORTHLAND

#### FORECAST:

THE WEST COAST RANGES FROM MILFORD SOUND TO OTIRA

In the 9 hours from 9pm Saturday to 6am Sunday, another 70-90mm is possible.

#### NELSON

In the 6 hours from 9pm Saturday to 3am Sunday, expect another 30-40mm.

MARLBOROUGH SOUNDS AND RICHMOND RANGES

In the 9 hours from 9pm Saturday to 6am Sunday, another 30-50mm is likely.

**WELLINGTON**

In the 12 hours from 9pm Saturday to 9am Sunday, another 30-50mm is possible, more especially about the northern hills.

**TARARUAS**

In the 12 hours from 9pm Saturday to 9am Sunday, expect another 90-100mm about higher slopes, with 50-60mm about lower slopes.

**MT TARANAKI**

In the 12 hours from 9pm Saturday to 9am Sunday, another 100-120mm is likely about higher slopes with 50-70mm about lower slopes. Intensities reaching 20-30mm per hour about higher slopes.

**THE HILL COUNTRY FROM INLAND TARANAKI ACROSS TO MT RUAPEHU, INCLUDING TAIHAPE, TAUMARUNUI, WAITOMO, WAIKATO AND TAUPO, ALSO THE HEADWATERS OF THE WHANGANUI AND RANGITIKEI RIVERS**

In the 12 hours from 9am Saturday to 9am Sunday, up to 150mm is expected on Mt Ruapehu, and 70-90mm elsewhere.

**BAY OF PLENTY AND COROMANDEL PENINSULA**

In the 15 hours from 9pm Saturday to noon Sunday, expect a further 120-150mm in the ranges, and 100mm elsewhere. However, about the eastern ranges of Bay of Plenty, a further 100mm is possible in the 6 hours from 6pm to midnight Sunday. Intensities of 30mm per hour are possible.

**AUCKLAND**

In the 15 hours from 9pm Saturday to noon Sunday, expect a further 80-100mm in the ranges, and 60-80mm elsewhere.

**NORTHLAND**

In the 12 hours from 9pm Saturday to 9am Sunday, expect another 120-150mm. Intensities reaching 25 to 35mm an hour overnight.

**GISBORNE**

In the 24 hours from 2am Sunday to 2am Monday, 200mm is possible north of Tolaga Bay, and up to 100mm further south.

**FREEZING LEVEL:** Above 3000 metres.

**NEXT SEVERE WEATHER WARNING WILL BE ISSUED AT OR BEFORE  
9:00am Sunday 29-Feb-2004**

**Forecast prepared by: Mark Pascoe**

**For further information after 8.50pm Sat contact Duty Forecaster  
Geoff Sanders**

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*2032 28 February 2004*

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29-Feb-04 8:27 AM Page 1 of 2

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## Severe Weather Warning

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SEVERE WEATHER WARNING.  
ISSUED BY MetService AT 8:18 am 29-Feb-2004

REMAINS OF CYCLONE "IVY" EXPECTED TO PASS JUST EAST OF THE NORTH ISLAND TODAY

The heavy rain has eased over the South Island as well as southern and western parts of the North Island and the warnings for these areas are lifted. However, the remains of tropical cyclone "IVY" are set to pass just east of the North Island this afternoon, with further heavy rain likely in Coromandel Peninsula, Bay of Plenty and Gisborne. Also, southeast gales are likely in these areas for a time today, and may rise to severe gale about northern Gisborne from late morning to late afternoon, with possible gusts of 120 km/h north of Tolaga Bay. The winds will turn southwest and ease later in the day.

FOR THE LATEST WEATHER AND FORECAST CHARTS PLEASE GO TO  
<http://www.metservice.co.nz/maps/index.asp>

MORE DETAILED INFORMATION FOR EMERGENCY MANAGERS AND TECHNICAL USERS FOLLOWS:

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### HEAVY RAIN WARNING.

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AREA/S AFFECTED: COROMANDEL PENINSULA BAY OF PLENTY GISBORNE  
FORECAST:

#### COROMANDEL PENINSULA

In the 4 hours from 8am to midday today (Sunday), expect a further 50mm in the ranges and 20mm elsewhere.

#### BAY OF PLENTY

In the 6 hours from 8am to 2pm today (Sunday), expect a further 80mm in the ranges, especially east of Whakatane and 30 to 50mm elsewhere.

#### GISBORNE

In the 9 hours from 8am to 5pm today (Sunday), expect 120mm in the ranges, especially north of Tokomaru Bay, where intensities may reach 35mm per hour. 30 to 50mm are possible for lower lying areas during this time.

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### STRONG WIND WARNING.

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AREA/S AFFECTED: GISBORNE NORTH OF TOLAGA BAY  
FORECAST:

#### GISBORNE NORTH OF TOLAGA BAY

East to southeast gales developing this morning and may rise to severe gale between 10am and 5pm today (Sunday), especially north of Ruatoria. The winds turning southwest towards evening and then easing.

**WARNINGS NO LONGER IN FORCE**

HEAVY RAIN WARNINGS HAVE BEEN LIFTED FOR: THE RANGES OF WESTLAND AND FIORDLAND, NELSON, MARLBOROUGH, WELLINGTON, THE TARARUA RANGES, THE RANGES FROM MT TARANAKI ACROSS TO TAUPO, INCLUDING TAIHAPE, TAUMARUNUI, WAITOMO, WAIKATO, AUCKLAND, AND NORTHLAND. The rain has eased. NO FURTHER WARNINGS WILL BE ISSUED FOR THIS EVENT FOR THE ABOVE AREAS.

NEXT SEVERE WEATHER WARNING WILL BE ISSUED AT OR BEFORE 9:00pm Sunday 29-Feb-2004

Forecast prepared by: Andy Downs

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**HEAVY RAIN WARNING**

AREAS AFFECTED: COROMANDEL PENINSULA BAY OF PLENTY DISTRICT

FORECAST:

COROMANDEL PENINSULA

In the 4 hours from 8am to midday today (Sunday), expect a further 50mm in the ranges and 20mm elsewhere.

DAY OF PLENTY

In the 6 hours from 8am to 2pm today (Sunday), expect a further 50mm in the ranges, especially east of Westlake and 20 to 50mm elsewhere.

DISTRICT

In the 3 hours from 8am to 2pm today (Sunday), expect 150mm in the ranges, especially north of Lake Taupo, where 100mm may reach the sea. In the 6 hours from 2pm to 8pm today (Sunday), expect 50mm in the ranges, especially north of Lake Taupo, where 20mm may reach the sea. In the 6 hours from 8pm to 2am today (Sunday), expect 20mm in the ranges, especially north of Lake Taupo, where 10mm may reach the sea.

**STRONG WIND WARNING**

AREAS AFFECTED: DISTRICTS NORTH OF TOLAGA BAY

FORECAST:

DISTRICTS NORTH OF TOLAGA BAY

Fast to southeast gales developed this morning and will rise to

0818 29 February 2004

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## Severe Weather Warning

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SEVERE WEATHER WARNING.  
ISSUED BY MetService AT 4:52 pm 29-Feb-2004

ALL WARNINGS LIFTED

The remains of Tropical Cyclone Ivy are moving away to the east of Gisborne. All warnings are now lifted.

FOR THE LATEST WEATHER AND FORECAST CHARTS PLEASE GO TO  
<http://www.metservice.co.nz/maps/index.asp>

MORE DETAILED INFORMATION FOR EMERGENCY MANAGERS AND TECHNICAL USERS  
FOLLOWS:

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WARNINGS NO LONGER IN FORCE

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HEAVY RAIN WARNINGS. HAVE BEEN LIFTED FOR: COROMANDEL  
PENINSULA, BAY OF PLENTY, AND GISBORNE  
NO FURTHER WARNINGS WILL BE ISSUED FOR THIS EVENT FOR THE ABOVE AREAS.

STRONG WIND WARNINGS. HAVE BEEN LIFTED FOR: GISBORNE NORTH OF  
TOLAGA BAY  
NO FURTHER WARNINGS WILL BE ISSUED FOR THIS EVENT FOR THE ABOVE AREAS.

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1652 29 February 2004

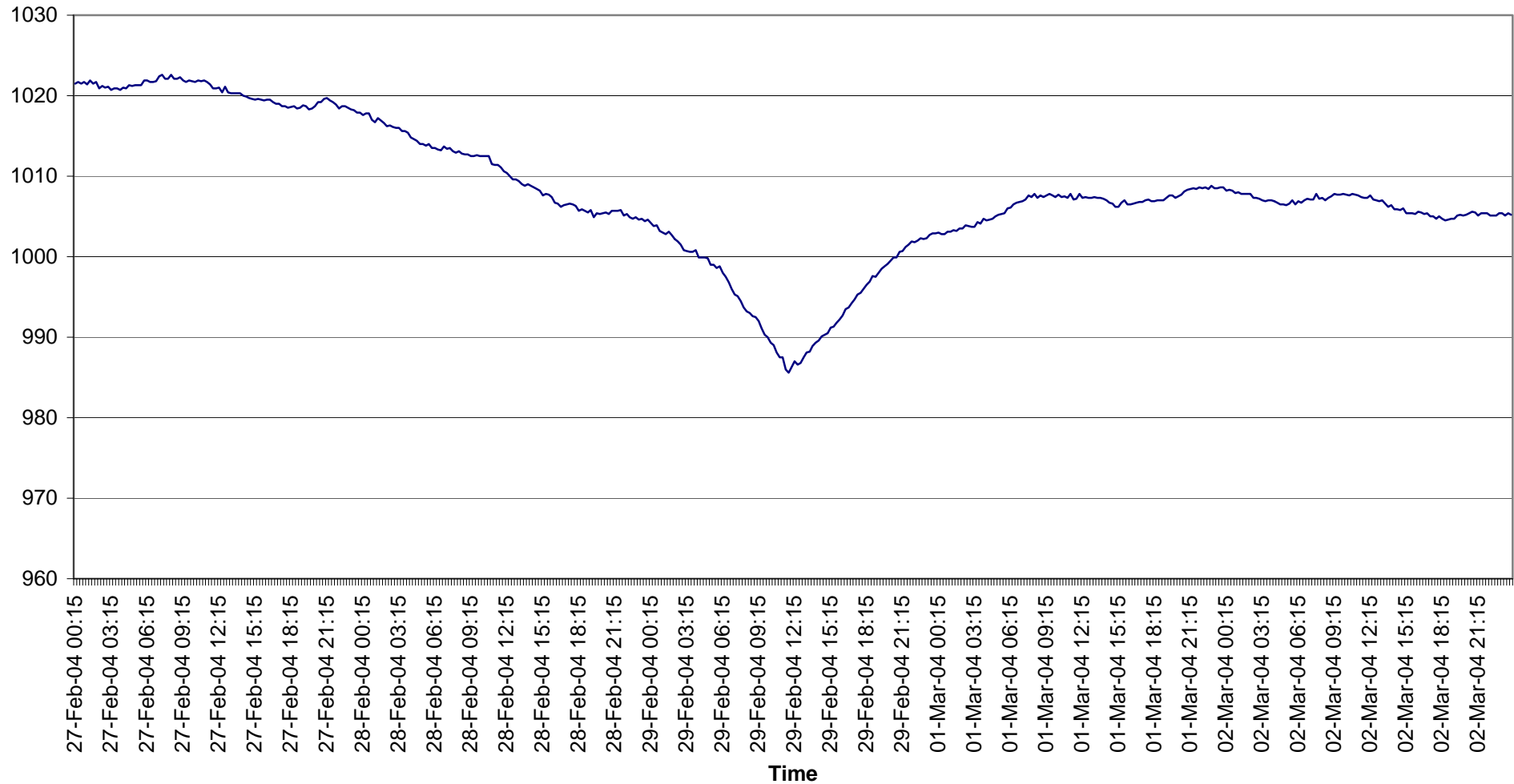


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## Appendix II – Graphs

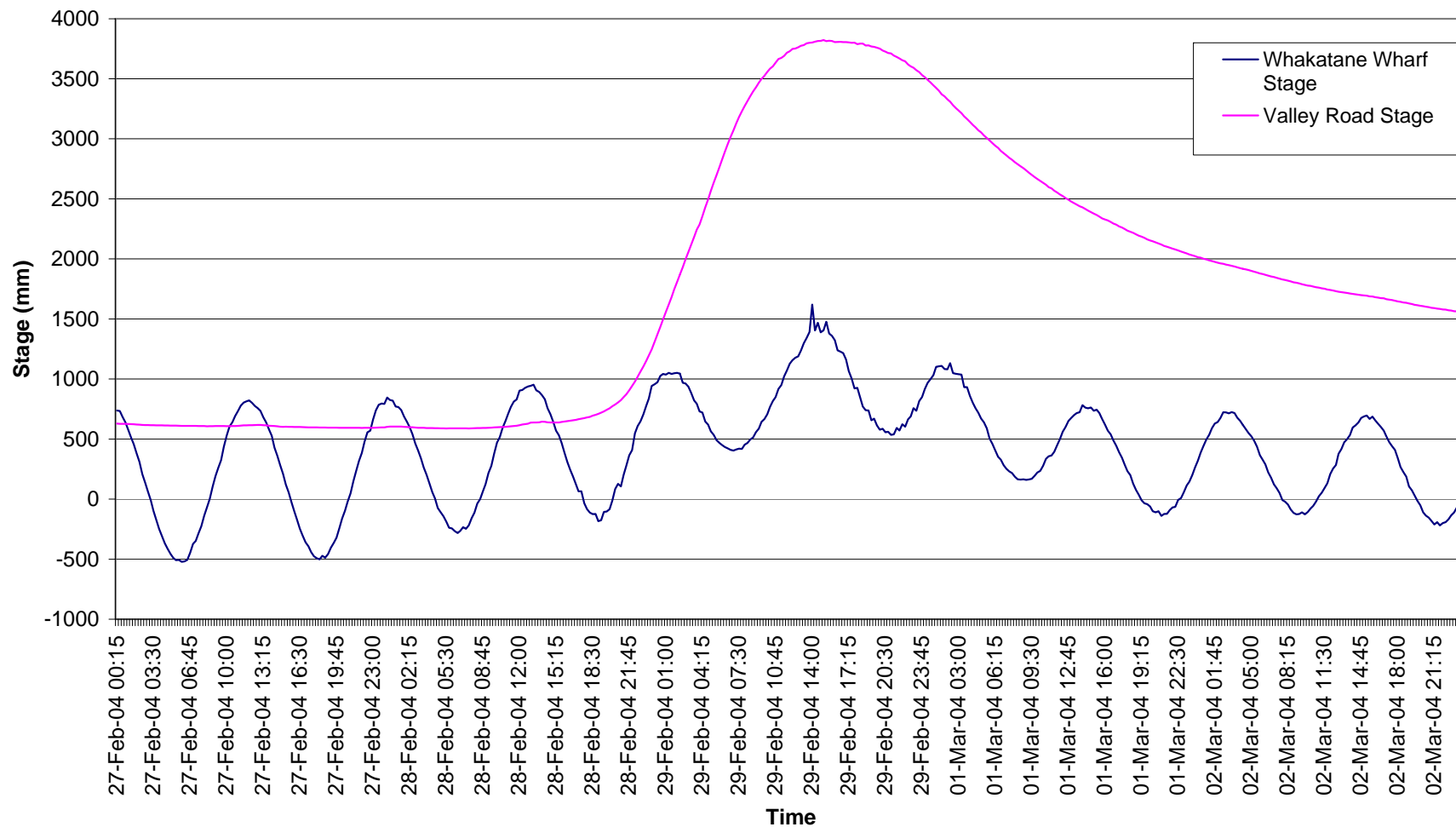


### Cyclone Ivy: Storm Surge Event 29 February 2004: Whakatane Wharf Barometric Pressure



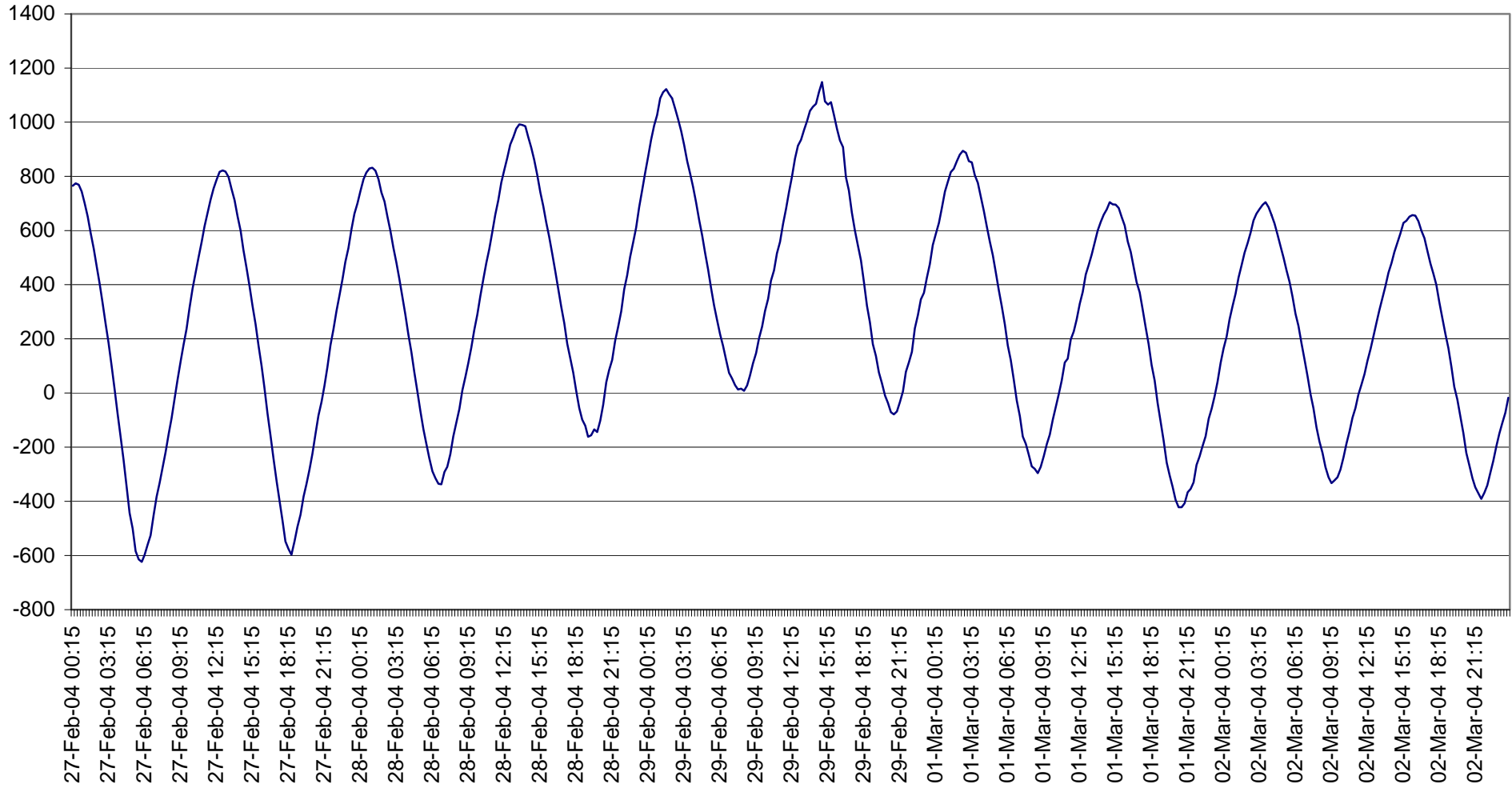
*Whakatane Wharf Barometric Pressure*

### Cyclone Ivy: Storm Surge Event 29 February 2004: Whakatane Wharf and Valley Road Stage



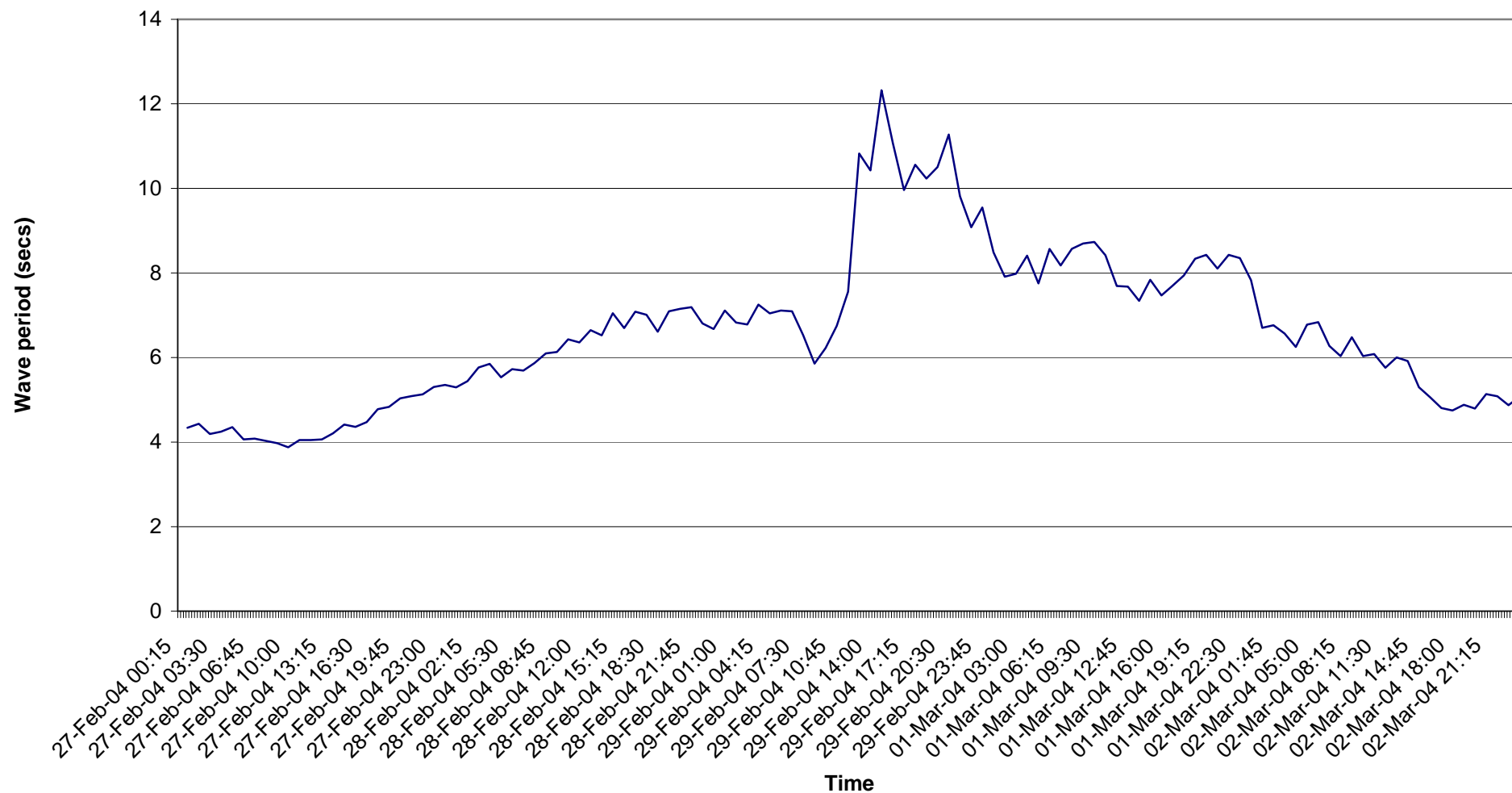
Whakatane Wharf Stage / Valley Road Stage

### Cyclone Ivy: Storm Surge Event 29 February 2004: Ohiwa Harbour Stage



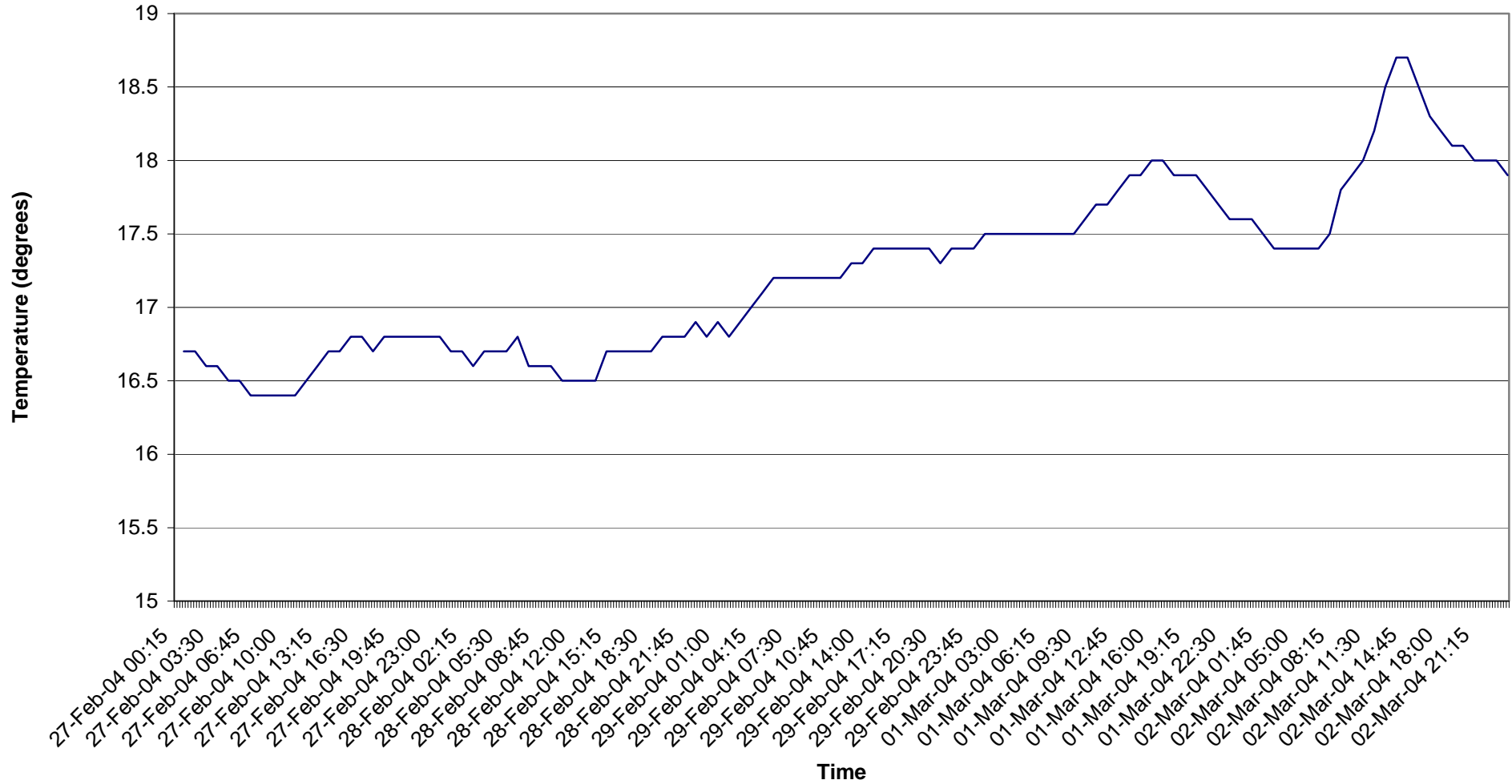
Ohiwa Harbour Stage

### Cyclone Ivy: Storm Surge Event 29 February 2004: Wave Buoy Mean Period



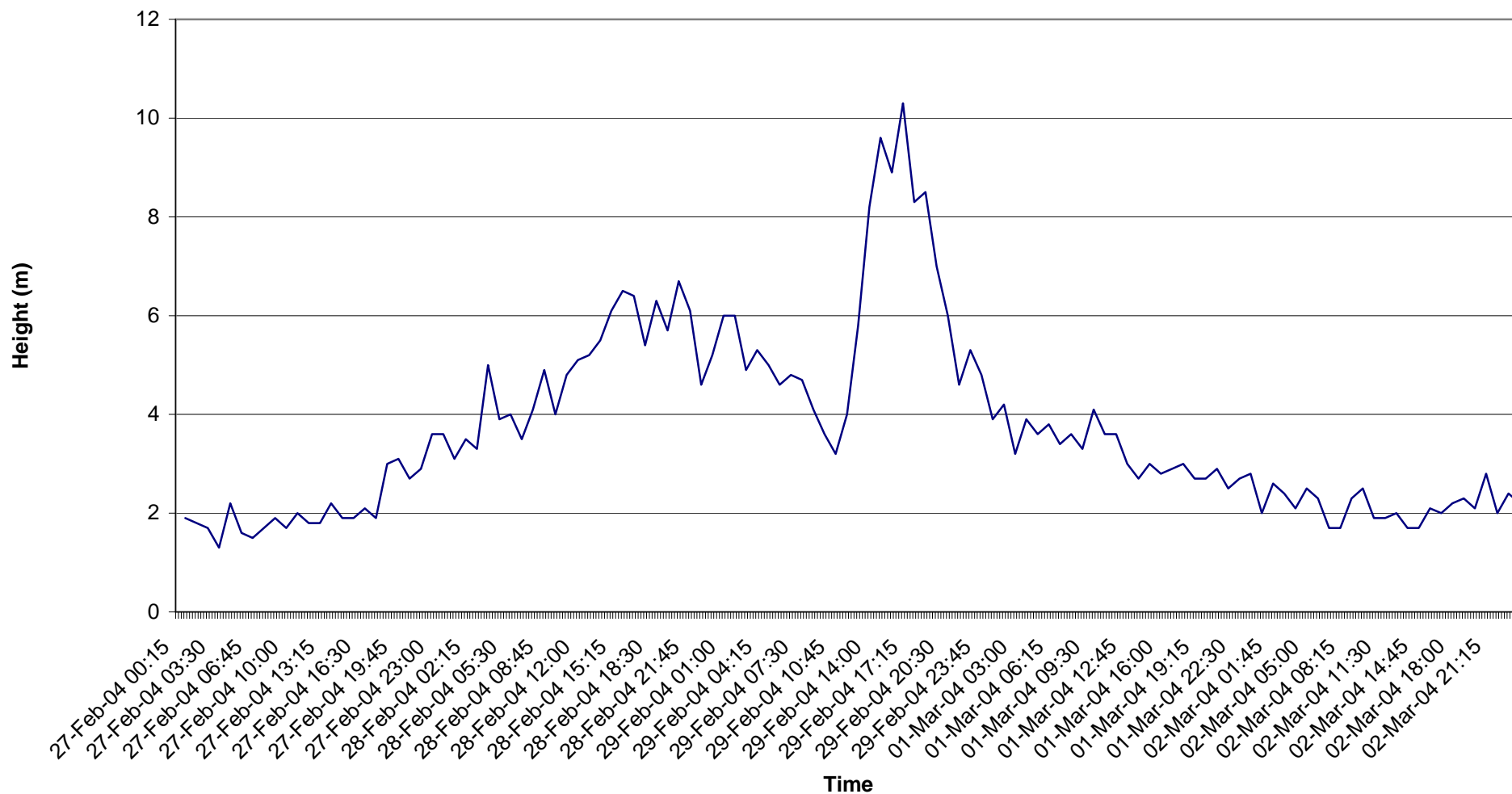
Wave Buoy Mean Period

### Cyclone Ivy: Storm Surge Event 29 February 2004: Wave Buoy Water Temperature



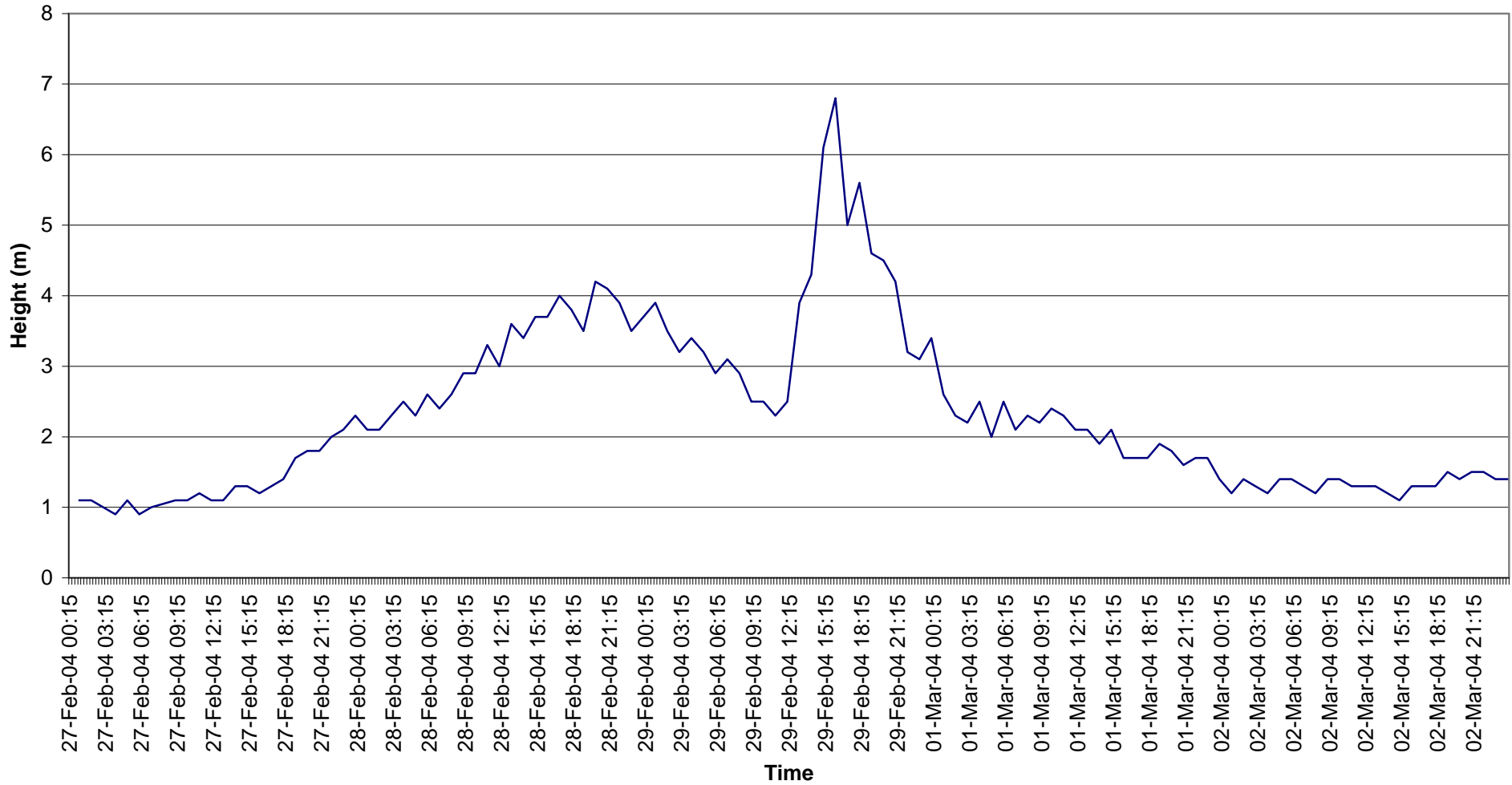
Wave Buoy Water Temperature

### Cyclone Ivy: Storm Surge Event 29 February 2004: Wave Buoy Maximum Wave Height



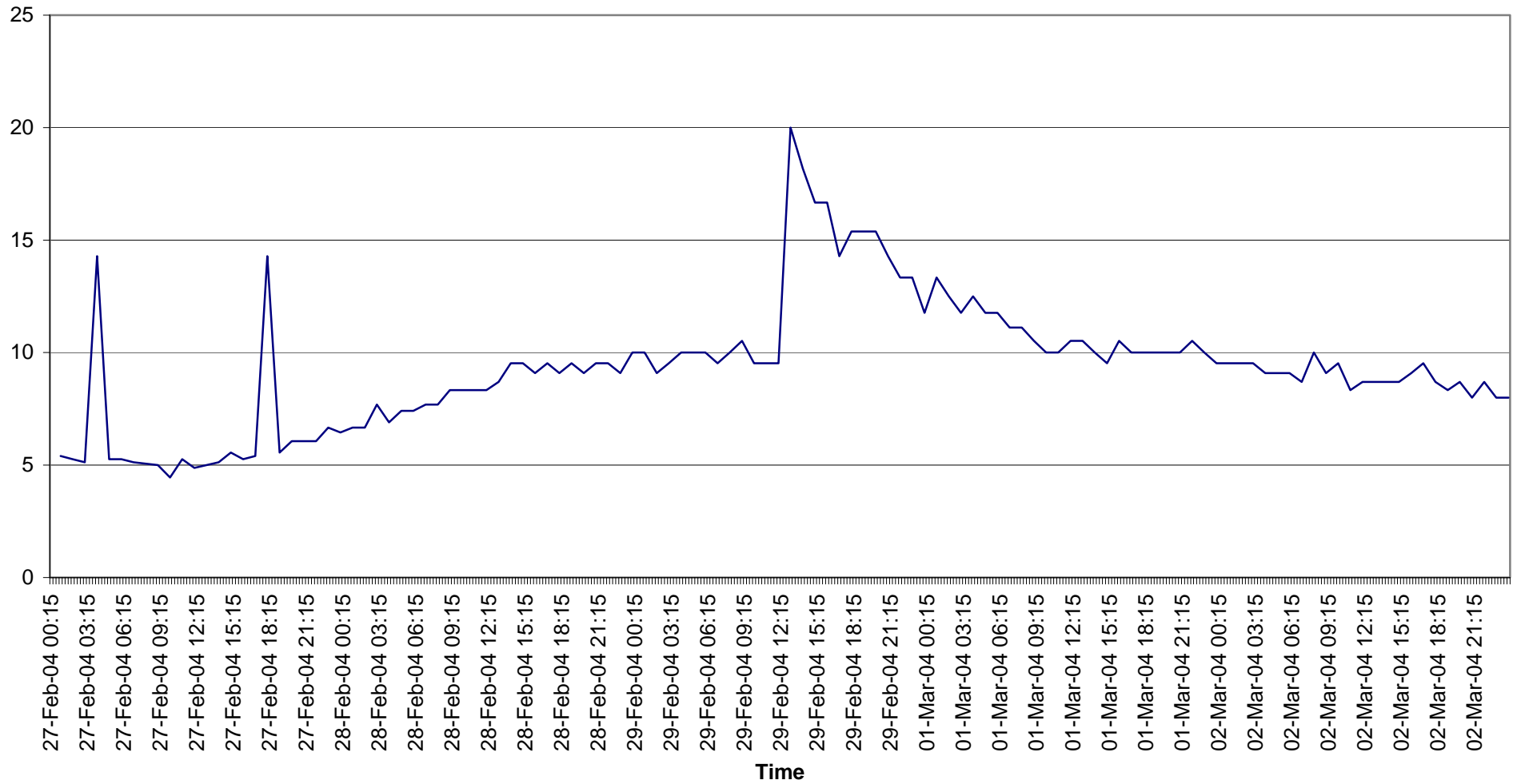
Wave Buoy Maximum Wave Height

### Cyclone Ivy: Storm Surge Event 29 February 2004: Wave Buoy Significant Wave Height



*Wave Buoy Significant Wave Height*

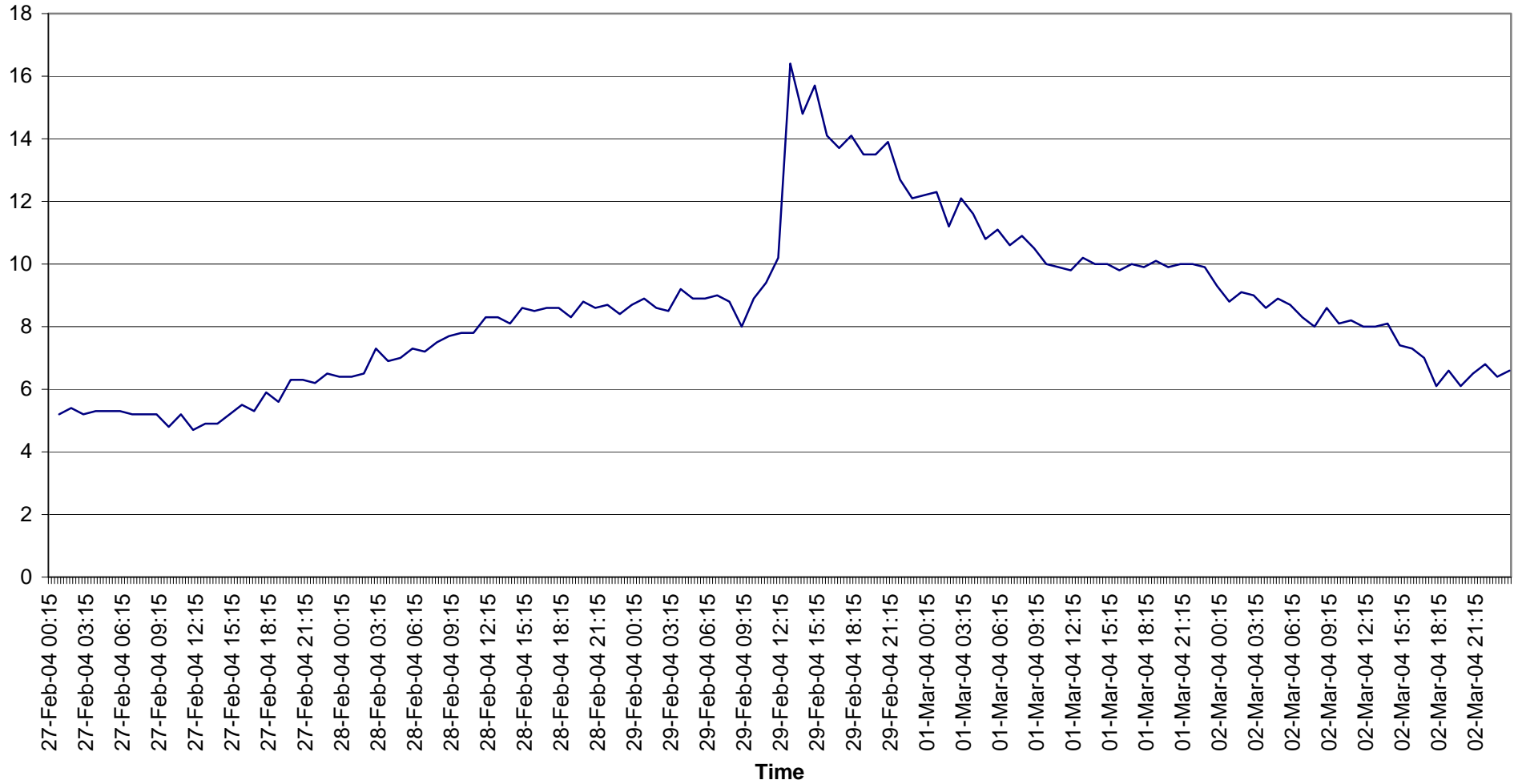
### Cyclone Ivy: Storm Surge Event 29 February 2004: Wave Buoy Peak Period



Wave Buoy Peak Period

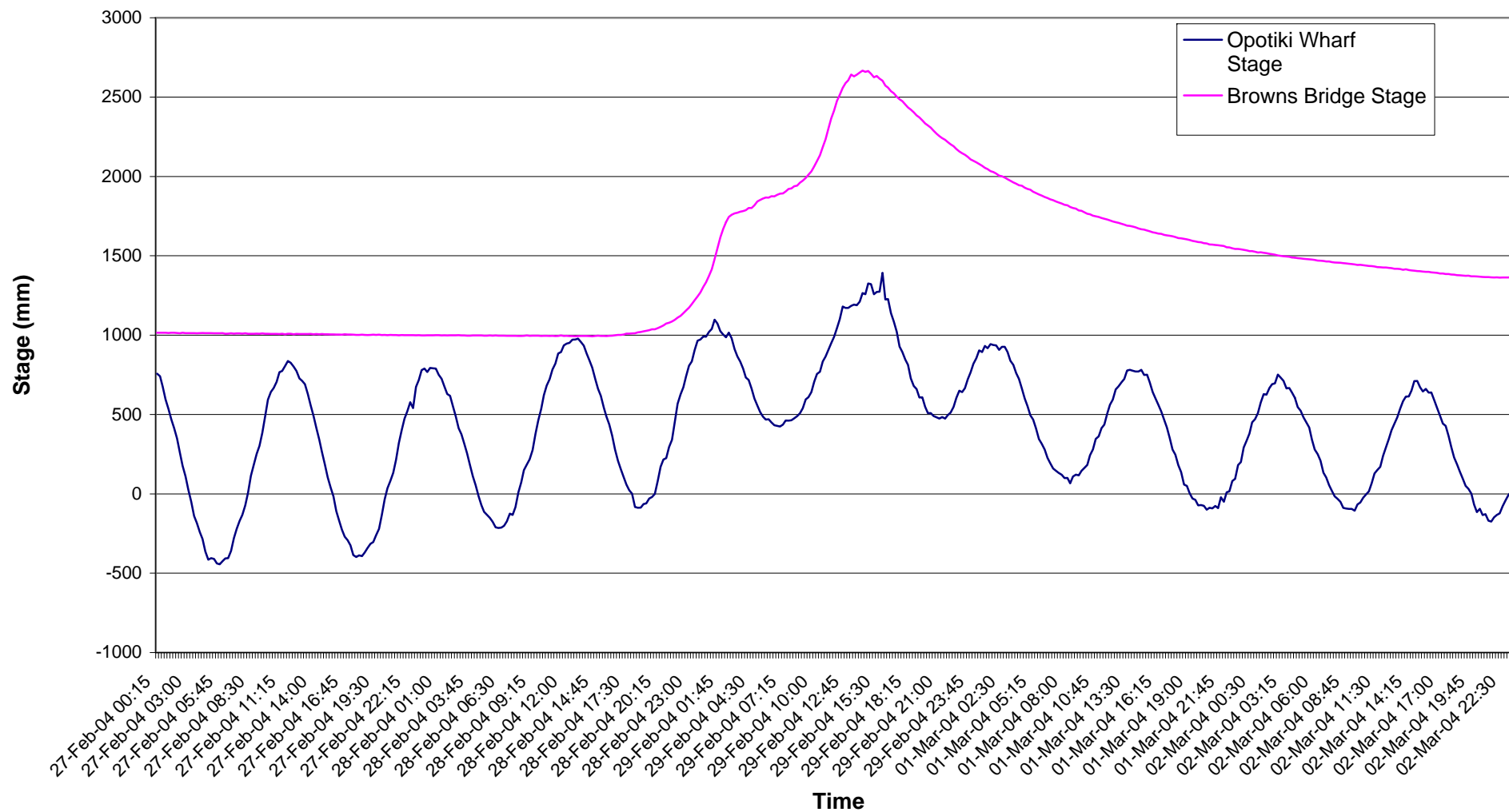


### Cyclone Ivy: Storm Surge Event 29 February 2004: Wave Buoy Significant Wave Period



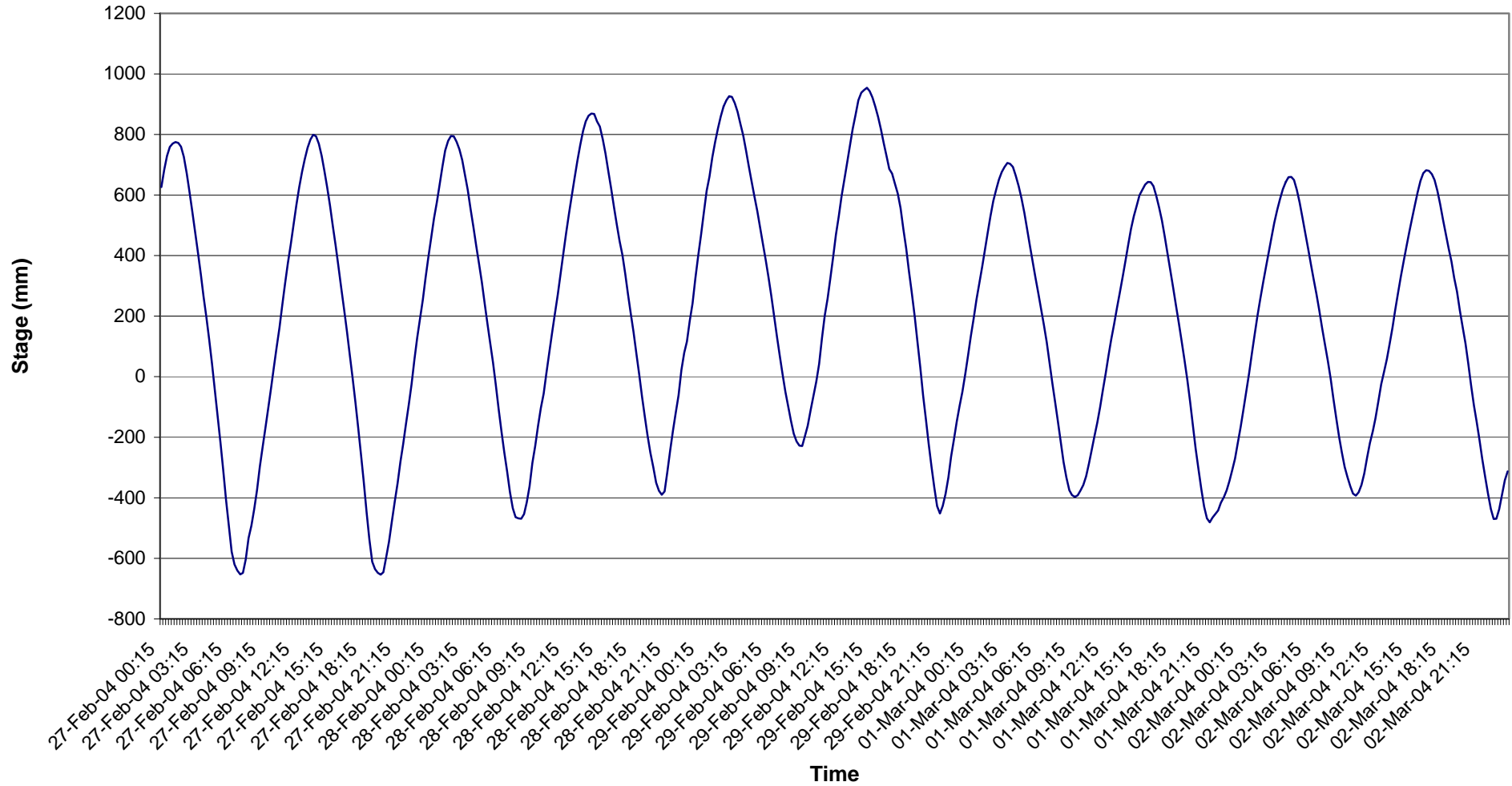
*Wave Buoy Significant Wave Period*

### Cyclone Ivy: Storm Surge Event 29 February 2004: Opotiki Wharf Stage



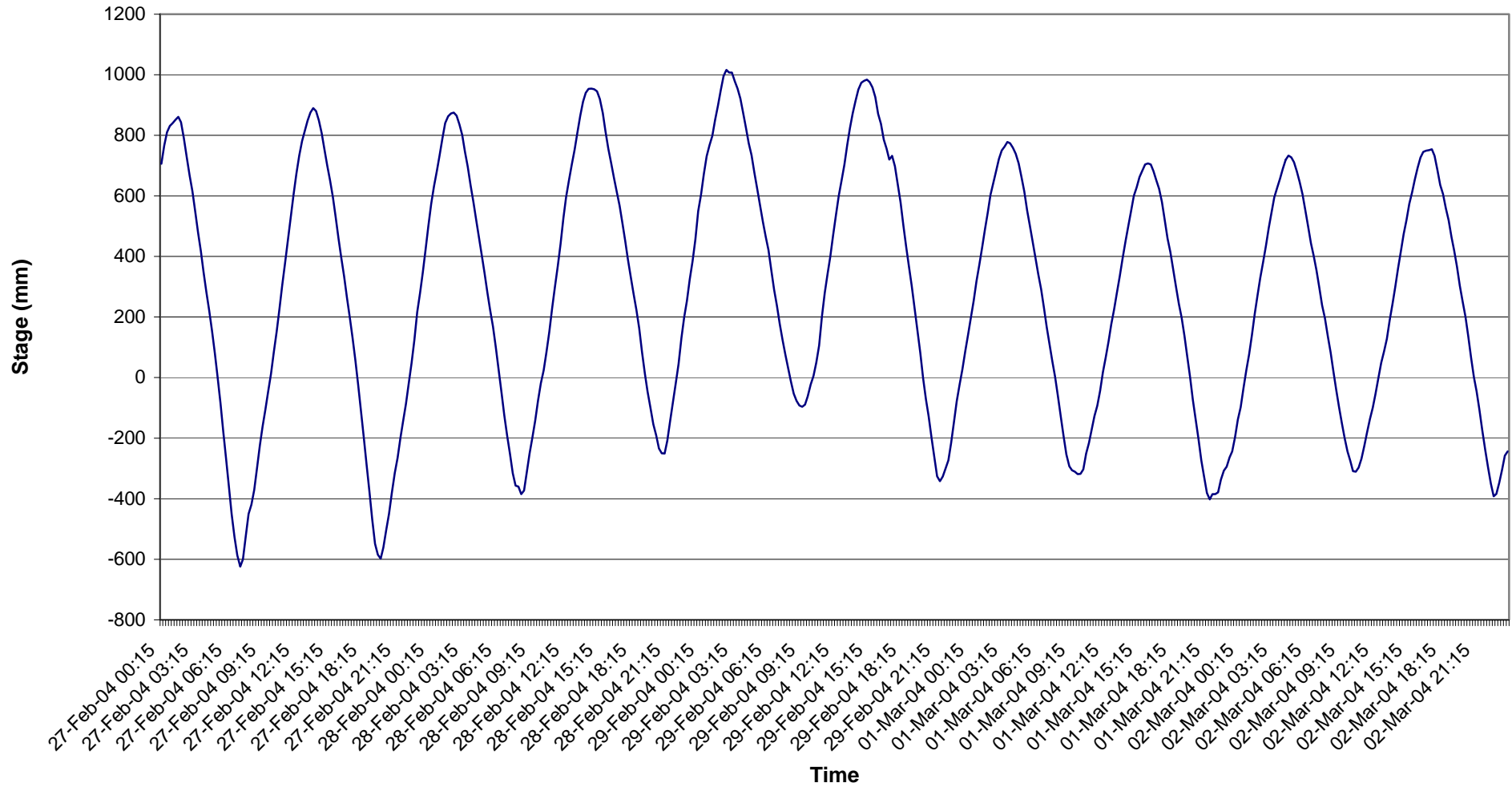
Opotiki Wharf Stage / Browns Bridge Stage

### Cyclone Ivy: Storm Surge Event 29 February 2004: Oruamatua Stage



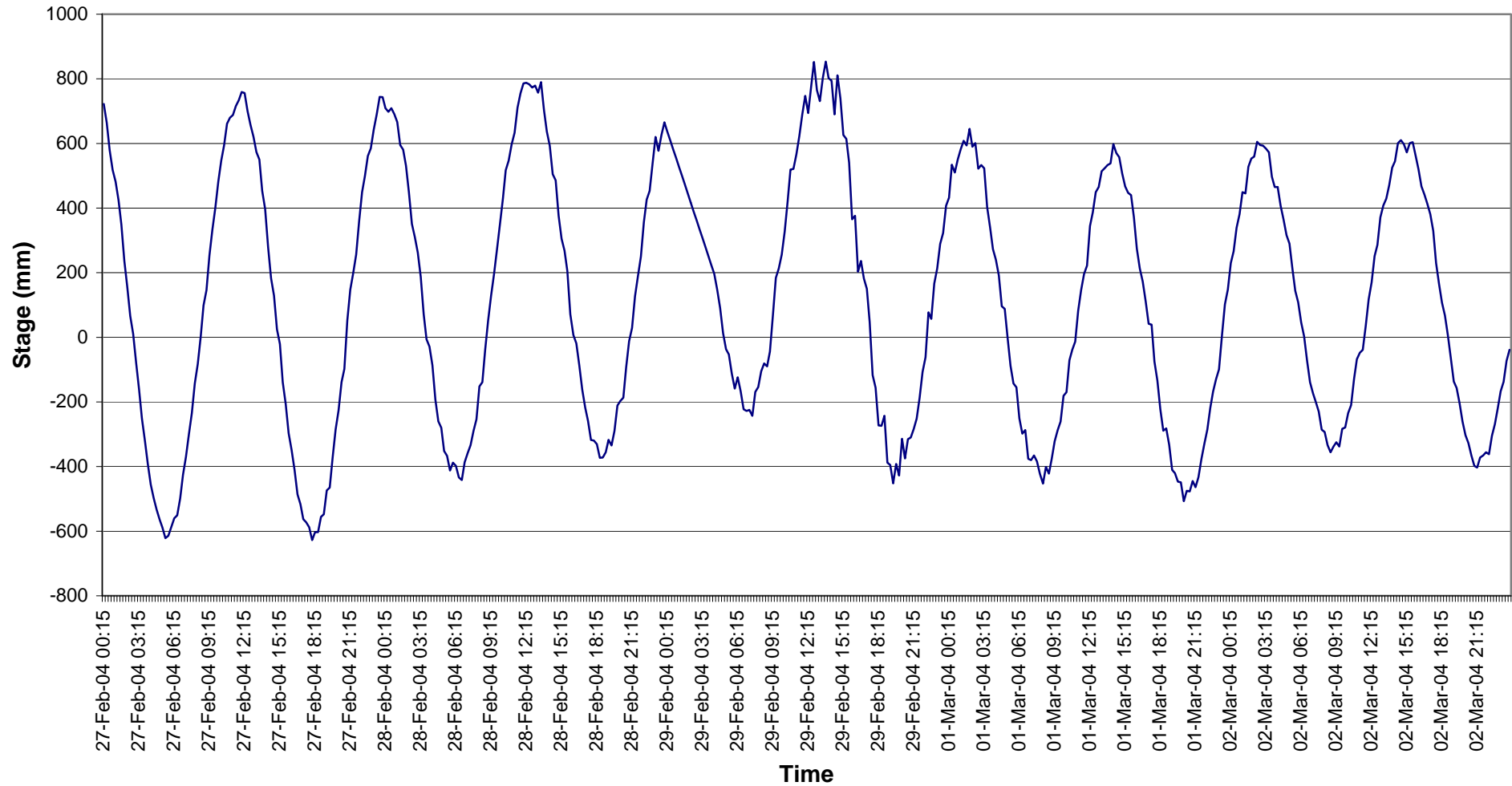
Oruamatua Stage

### Cyclone Ivy: Storm Surge Event 29 February 2004: Hairini Stage



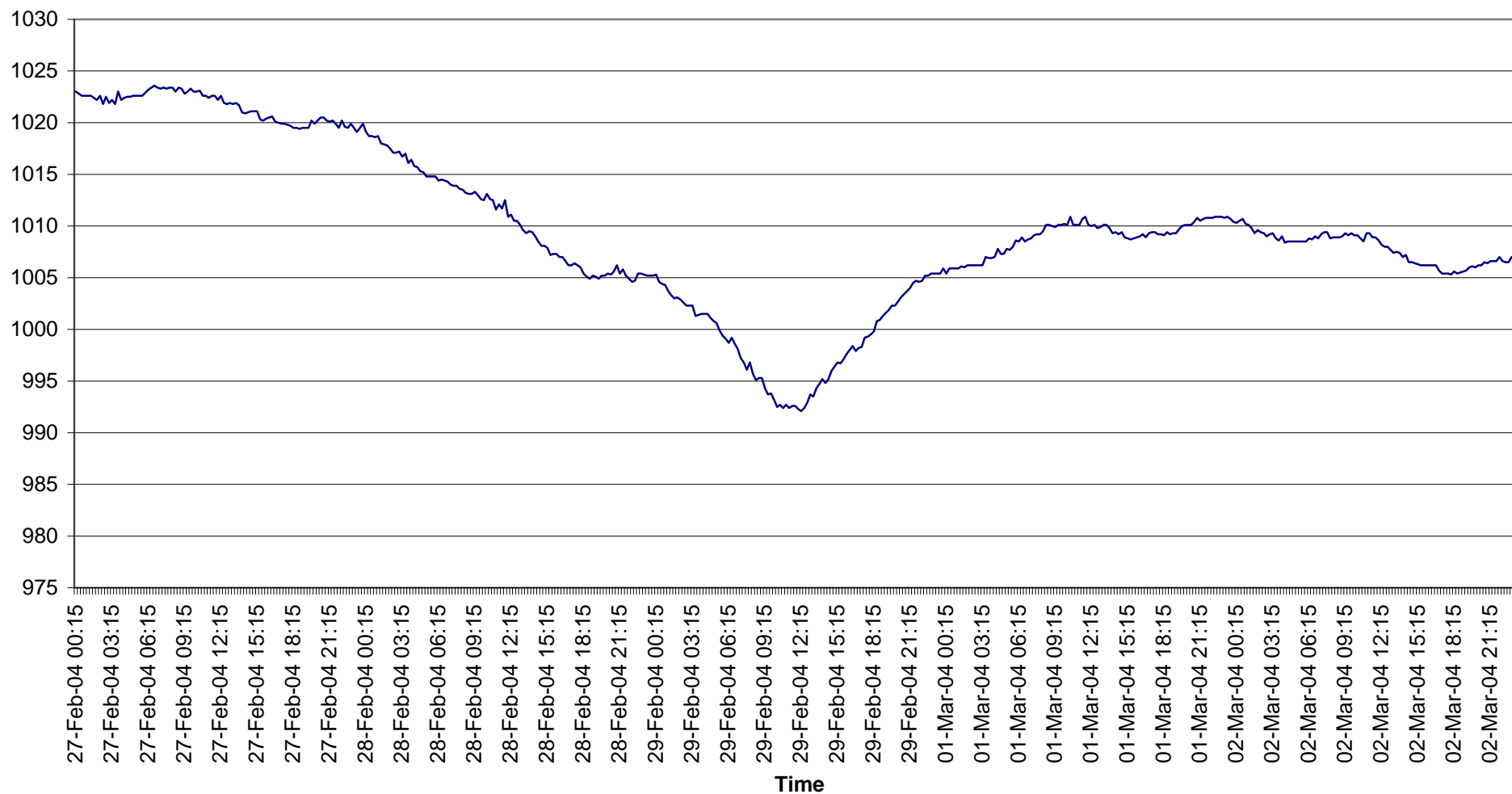
Hairini Stage

### Cyclone Ivy: Storm Surge Event 29 February 2004: Moturiki Stage



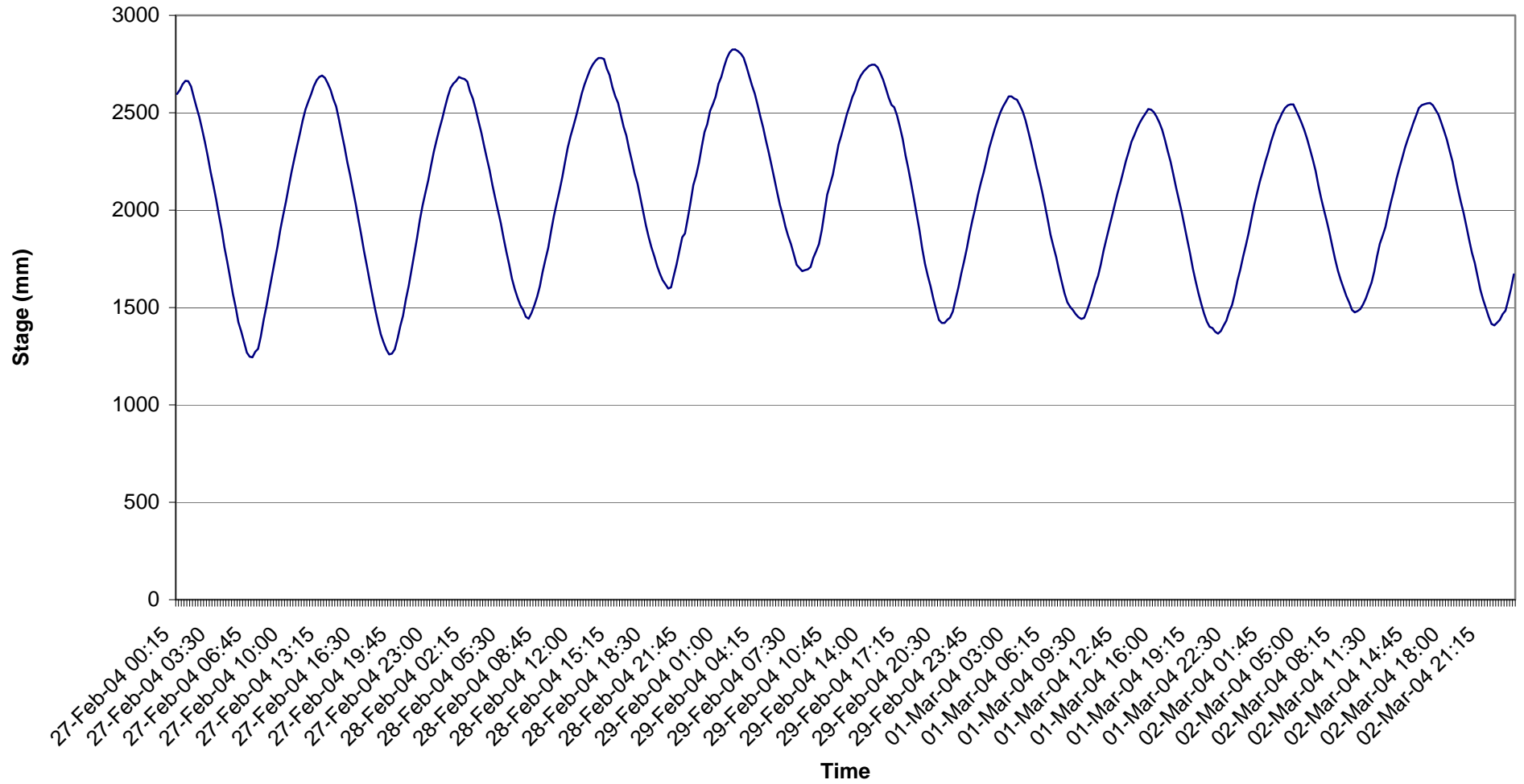
Moturiki Stage

### Cyclone Ivy: Storm Surge Event 29 February 2004: Omokoroa Barometric Pressure



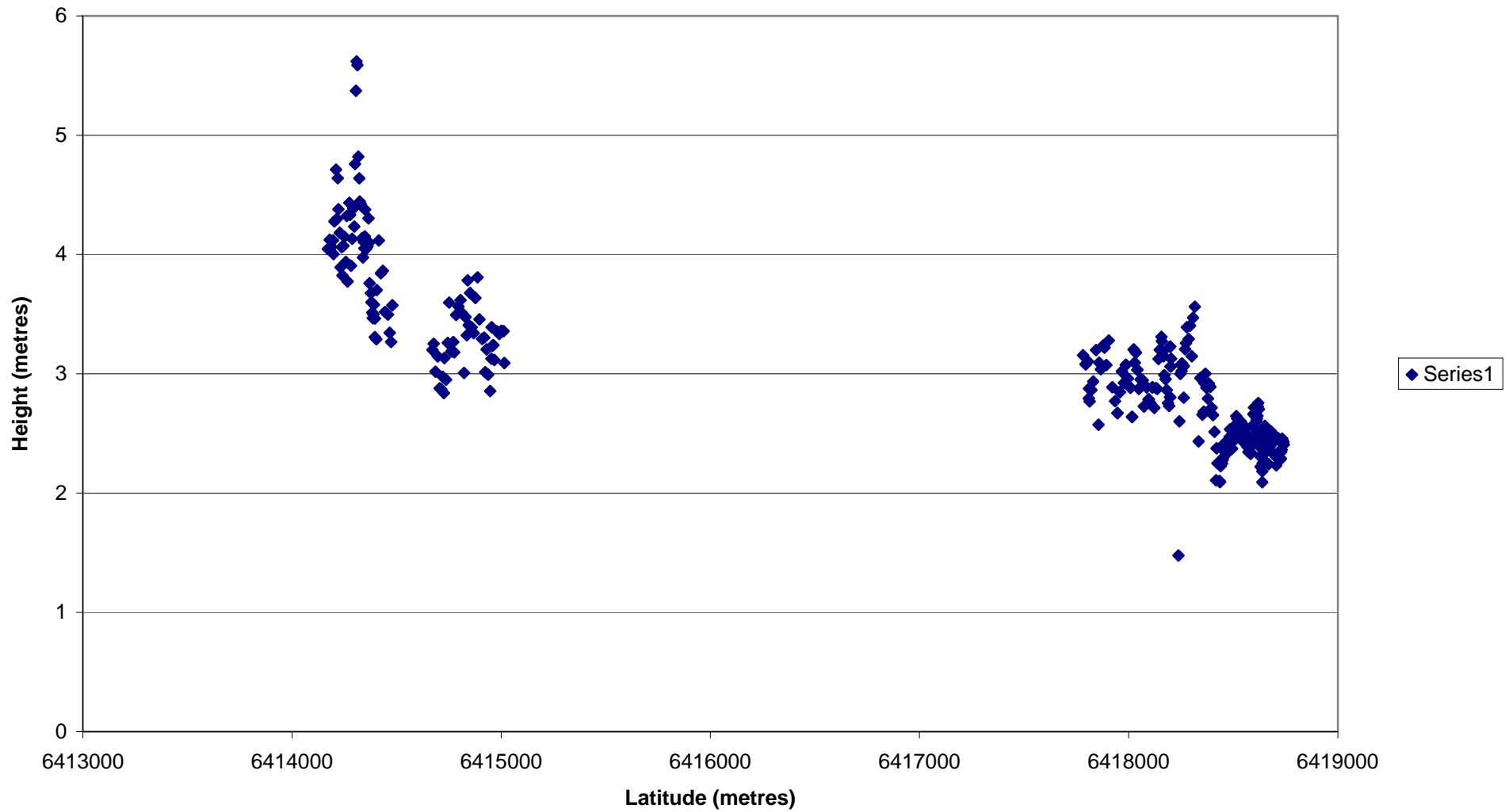
Omokoroa Barometric Pressure

### Cyclone Ivy: Storm Surge Event 29 February 2004: Omokoroa Stage



Omokoroa Stage

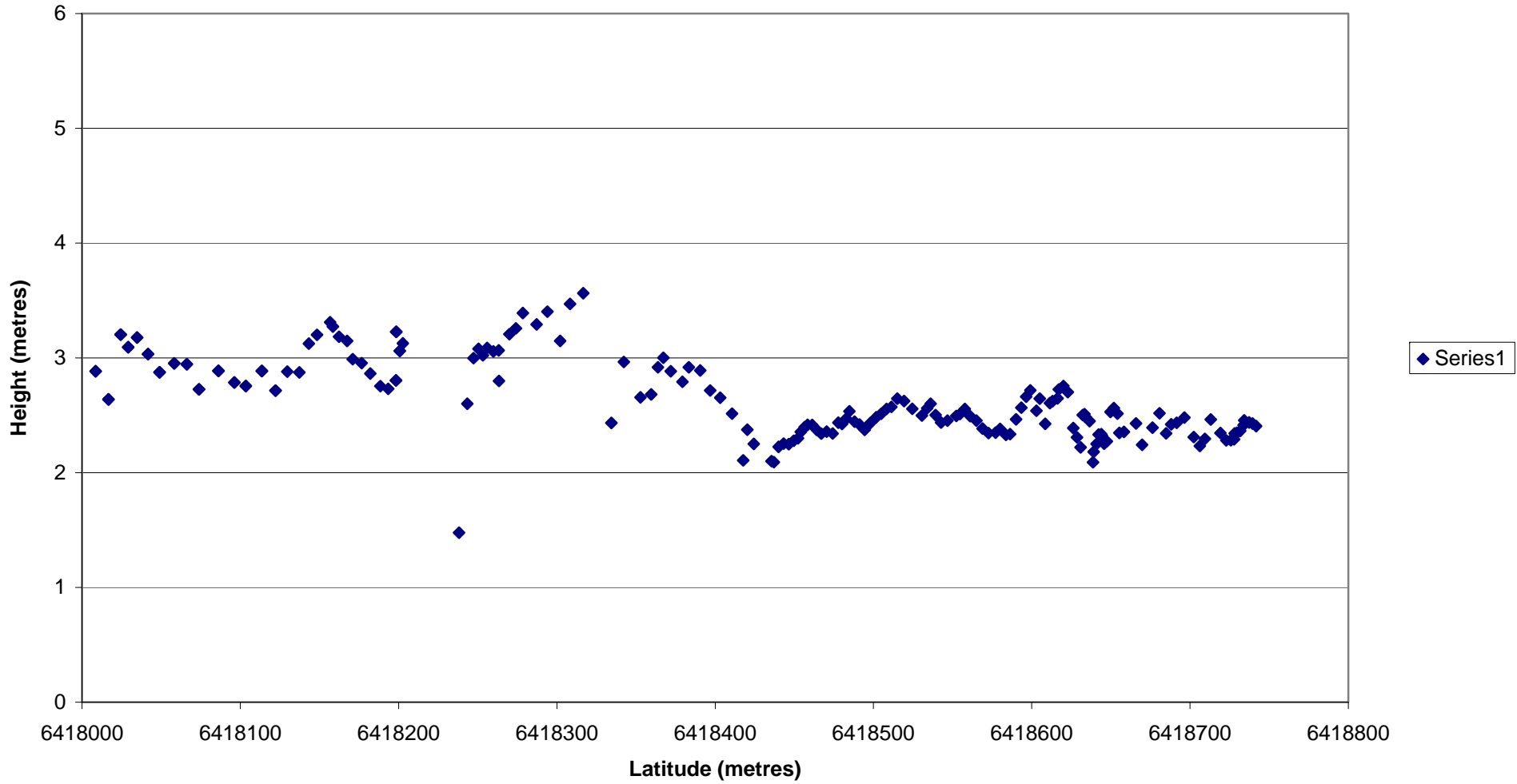
### Cyclone Ivy Peak Wave Runup at Waihi Beach



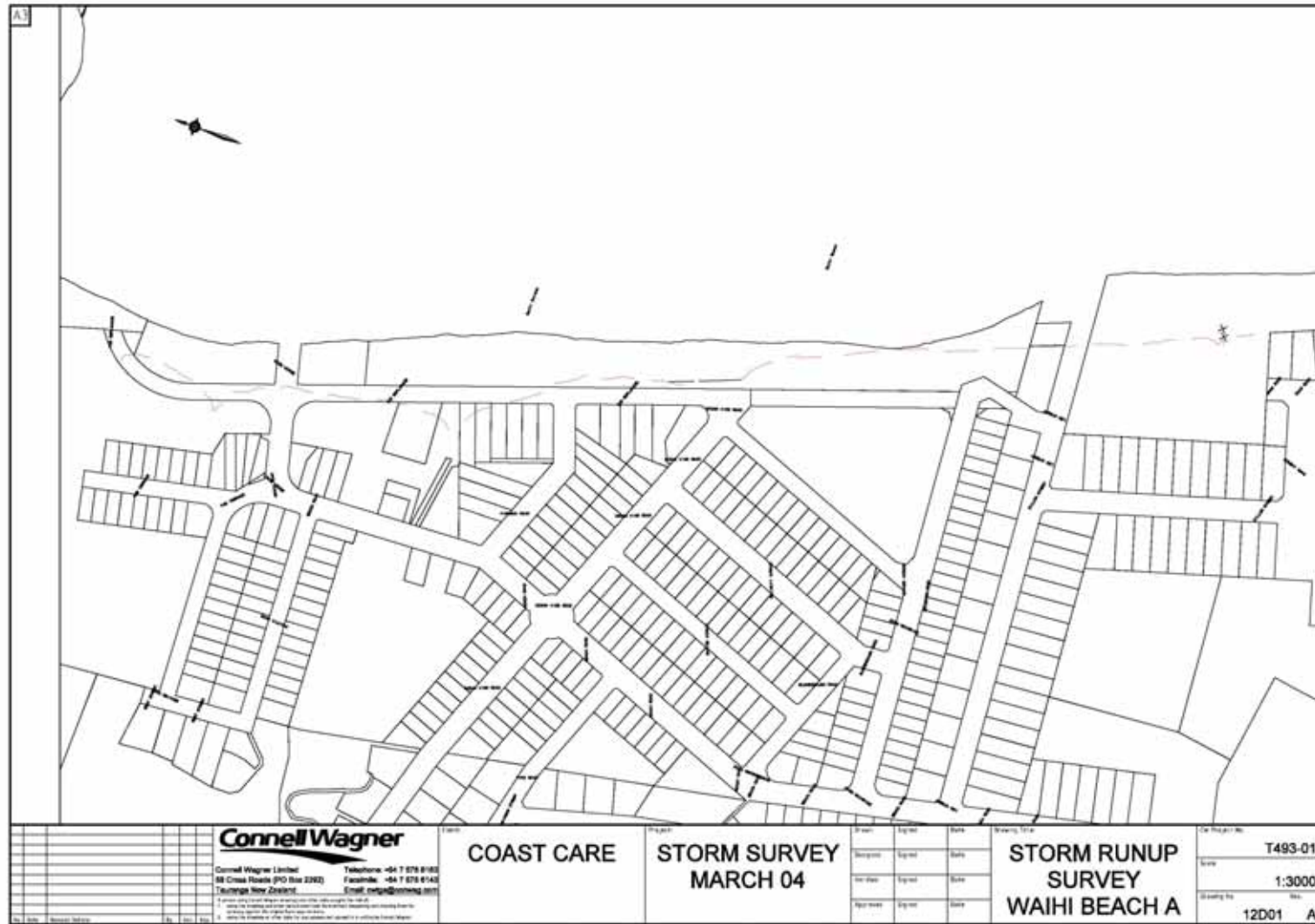
Cyclone Ivy Peak Wave Run-up at Waihi Beach – Chart 1



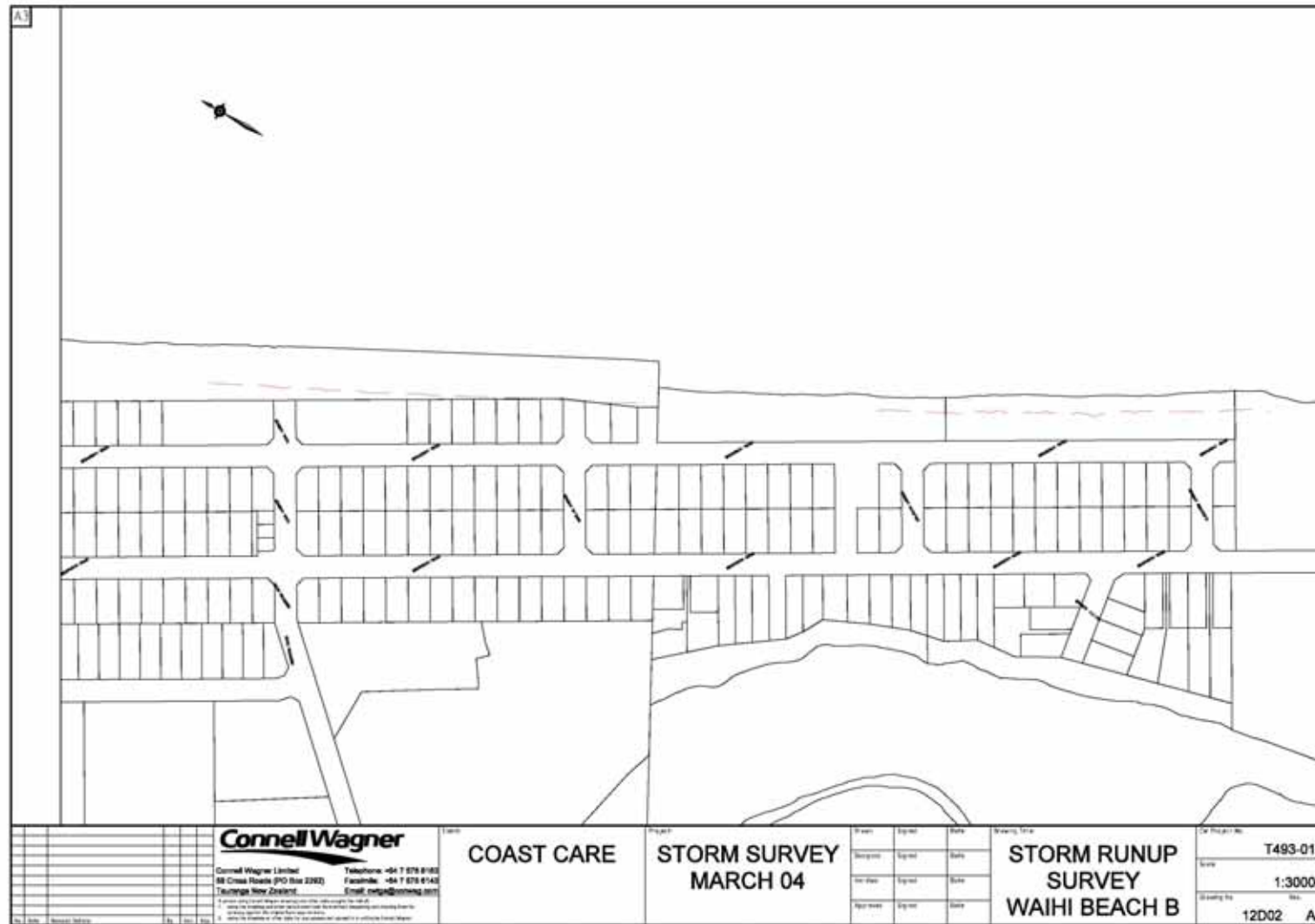
### Cyclone Ivy Peak Wave Runup Waihi Beach North



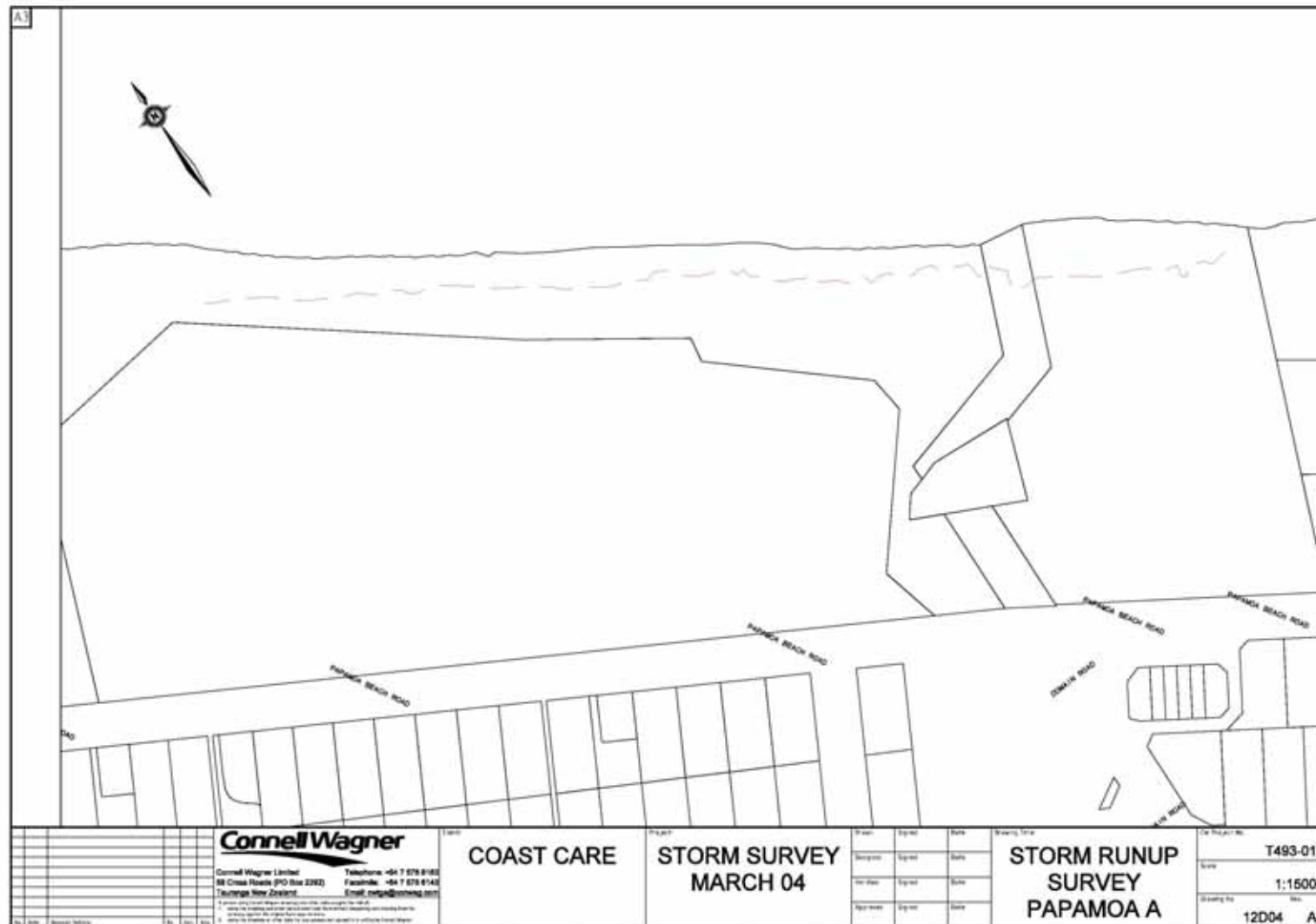
Cyclone Ivy Peak Wave Run-up Waihi Beach North – Chart 2



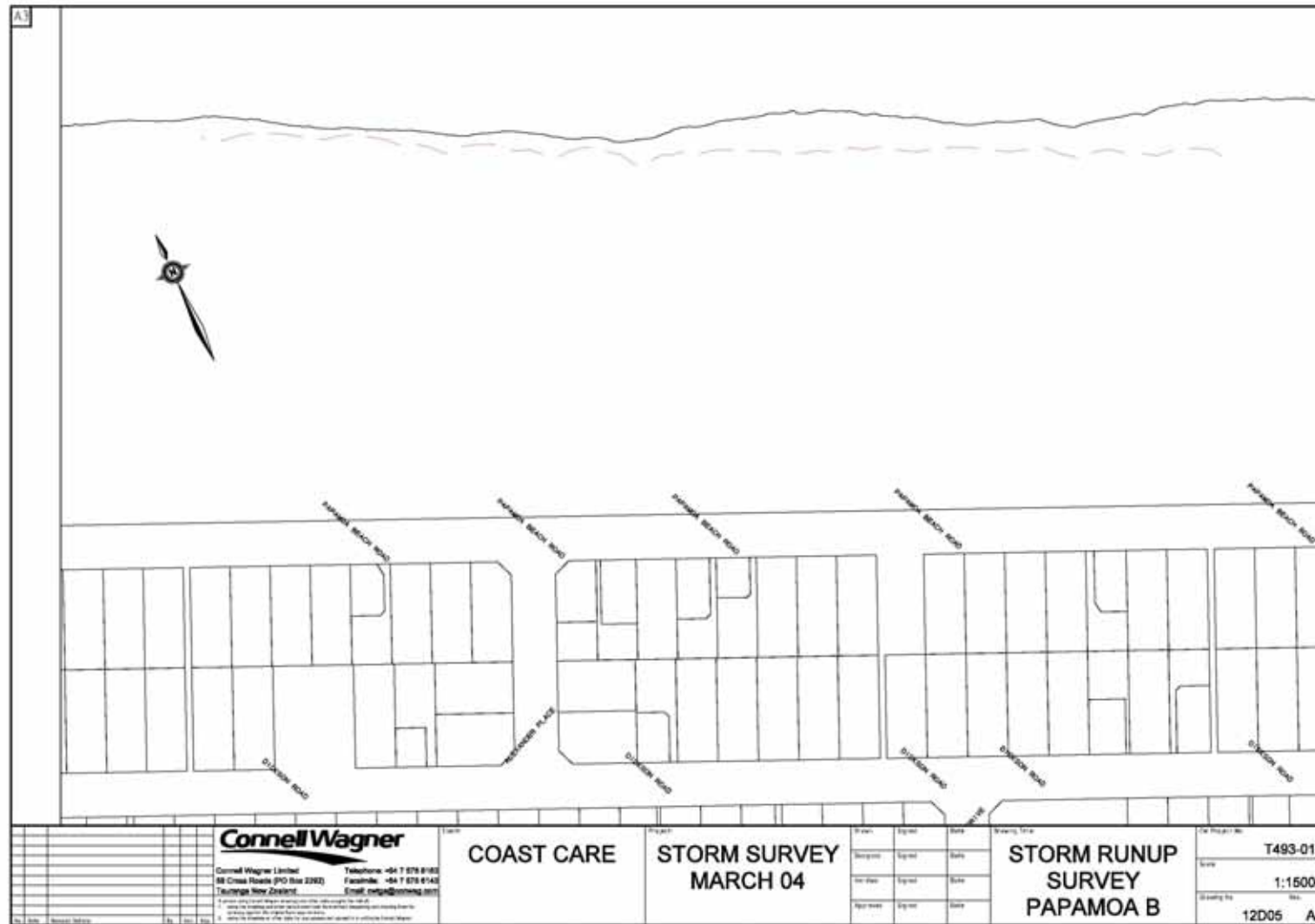
Storm Run-up Survey Waihi Beach A



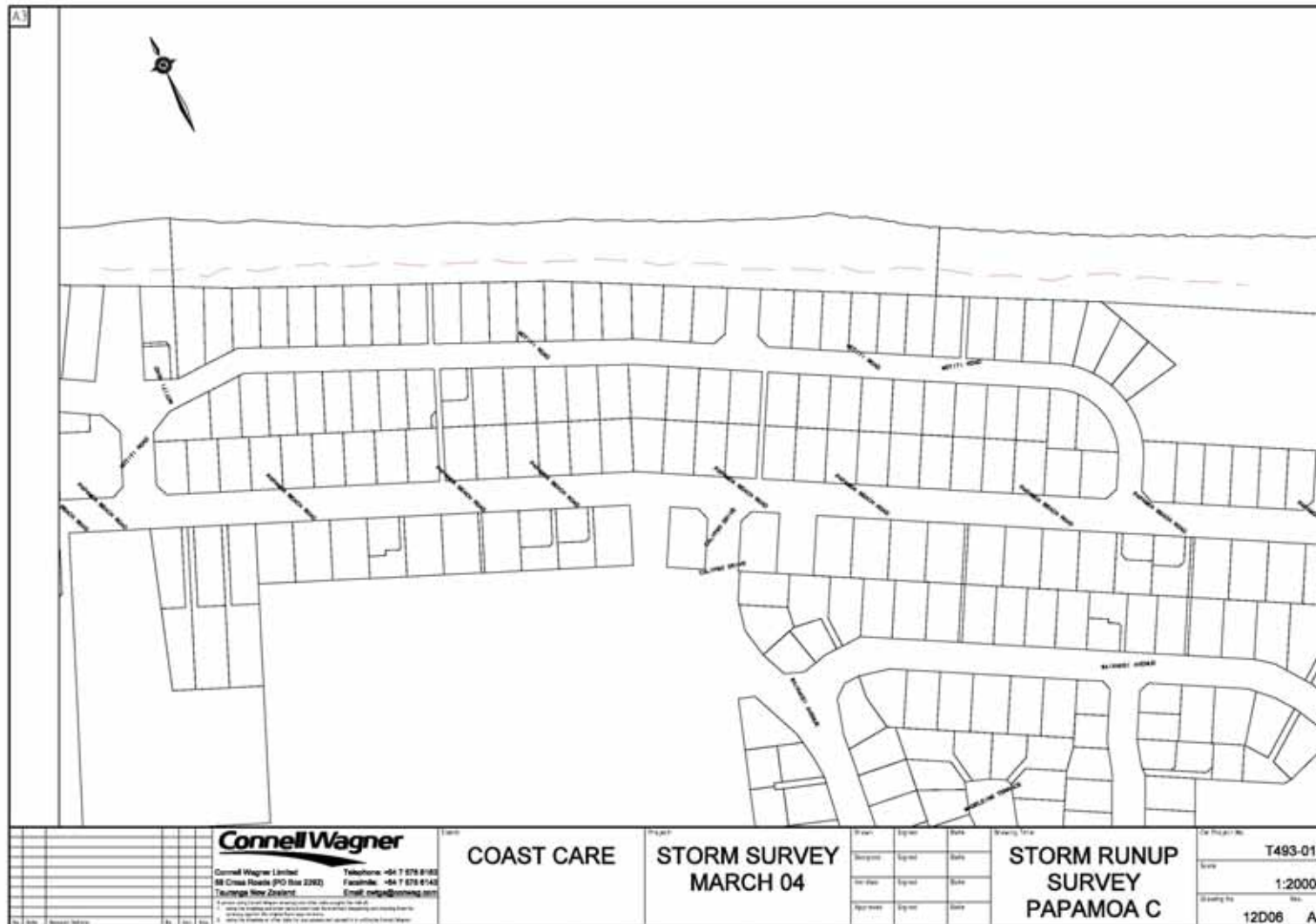
Storm Run-up Survey Waihi Beach B



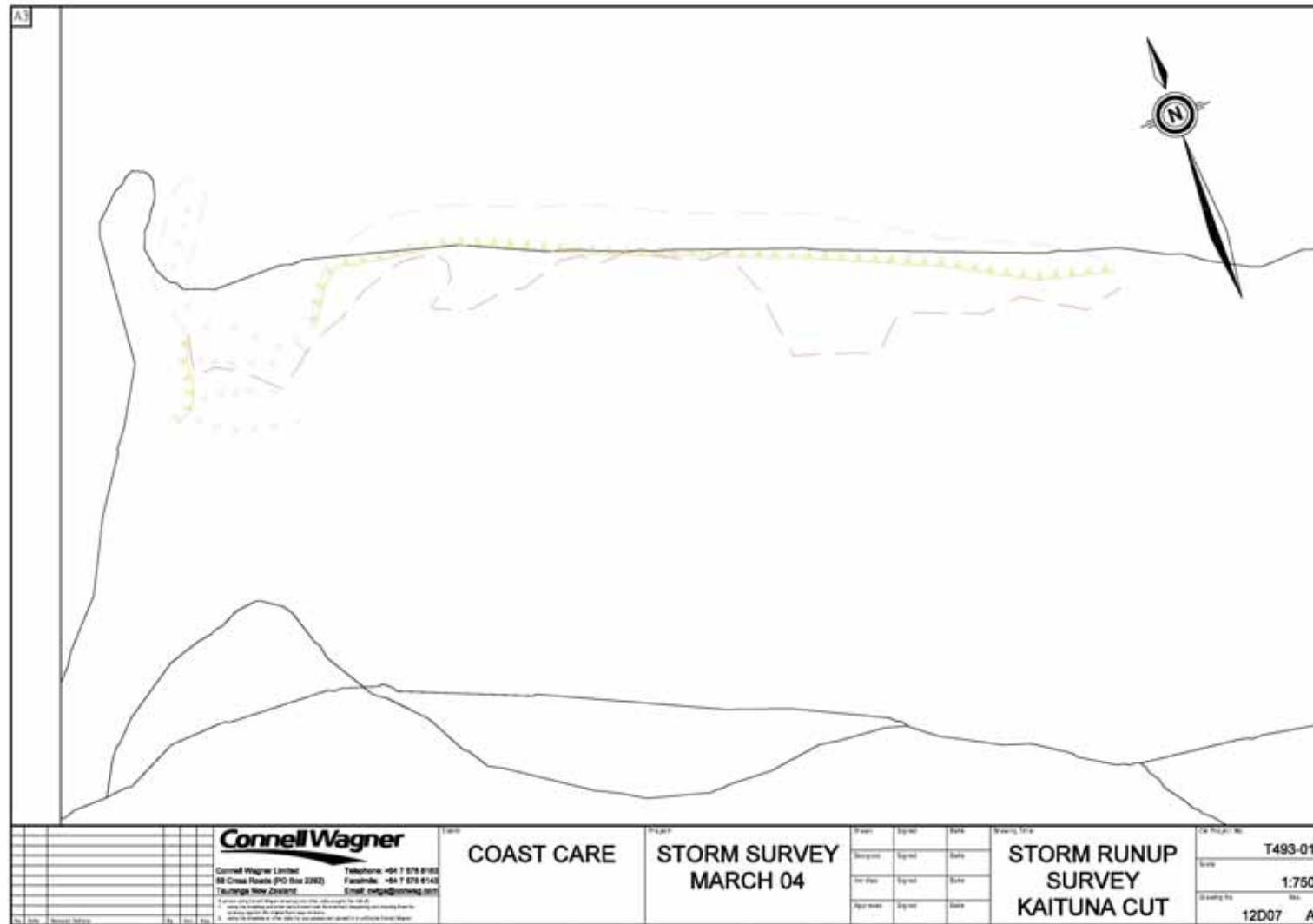
Storm Run-up Survey Papamoa A



Storm Run-up Survey Papamoa B



Storm Run-up Survey Papamoa C



Storm Run-up Survey Kaituna Cut

## Appendix III – Photos

- Connell Wagner aerial diagrams showing run-up levels.
- Photos of debris in Eastern Bay of Plenty.



## Cyclone Ivy – Sunday, 29 February 2004 (extent of wave surge)

Date of photography: 1 March 2004



COASTLANDS BEACH at end of Ohuirere Road/beach access.  
Storm surge reached to base of foredunes.



COASTLANDS BEACH approximately 500 m west of CCS 12.  
Storm surge spilled across low foredune area. RL = 5.54 m (BL 678, P.23)



COASTLANDS BEACH at beach access off Fisherman's Drive.

Storm surge reached to toe of dunes at bottom of stairs. Note: the surf had dropped in size considerably to 1.5-2.0 m by the following morning.



OHOPE BEACH – last carpark at 63 West End.

Storm surge just lapped into carpark area. RL = 3.12 m (LB 678, P.21)



OHOPE BEACH – 42 West End.

Storm surge reached across road here to guttering. RL = 3.17 m (LB 678, P.22)



OHOPE BEACH – CCS#1 at 33 West End.

Storm surge just short of BM, railway iron near flax bush. RL = 2.94 m (LB 678, P.22)



OHOPE BEACH – CCS#11 at 33 West End.  
Looking west to West End rocks.



OHOPE BEACH – CCS#11 at 33 West End.  
Looking east towards Ohope Surf Club.



#### OHOPE BEACH

Wave surge reached in behind toilet block opposite Villis Glade at bottom of Ohope Hill.



#### OHOPE BEACH – PORT OHOPE

Wave surge at top of walkway at end of Anne Street.



OHOPE BEACH – PORT OHOPE

Walkway at end of Anne Street looking west at new foredune erosion.



OHOPE BEACH – PORT OHOPE

Walkway at end of Anne Street looking east at new foredune erosion.



#### WAIOTAHİ BEACH

Storm surge level at first carpark/beach access just east of Waiotahi River mouth.



#### WAIOTAHİ BEACH

Storm surge level in low foredune area at CCS#6 just west of Waiotahi Surf Club.



#### HAWAI BEACH

Storm surge crossed State Highway 35 carrying with it many logs. The State Highway was closed during and after the storm peak while debris was removed. RL (centreline of highway approx) = 5.73 m see LB 649, P.30)



#### HAWAI BEACH





#### HAWAI BEACH

2 m storm surge following day, very intense shore break.



#### HAWAI BEACH

Storm surge inside #2810 driveway just south of Motor Camp.



HAWAI BEACH

Looking north from outside Motor Camp, storm debris is across State Highway 35.



HAWAI BEACH

Looking south from Motor Camp at storm debris across State Highway 35.



#### HAWAI BEACH

Storm debris came inside Motor Camp grounds. Most of the debris had been cleared but extent is still evident near parked caravans.



#### HAWAI BEACH

Storm debris seen outside the Motor Camp grounds. State Highway 35 was closed during the peak of the storm. There may have been up to 0.5 m deep of wave surge across State Highway to move this amount of debris.



HAWAI BEACH

Storm debris came through Waipae Urupa just north of Motor Camp.



HAWAI BEACH

Some debris came through Waipae Urupa just north of Motor Camp.



#### OMAIO BEACH

Extent of storm debris seen on knoll in front of Omaio Store. A search was in progress for two missing surfers missing in giant surf from the day before, still missing two weeks later. Storm surge RL = 5.97 m (see LB 678, P.26).



#### OMAIO BEACH

Extent of storm debris can be seen across low grassy foredune in front of Omaio Store.



OMAIO BEACH

Extent of storm debris came across grassy knoll in front of Omaio Store. Note debris line in front of helicopter.



OMAIO BEACH

Extent of storm debris 'behind' grassy knoll in front of Eddie Parkinson's house. Storm surge RL = 3.62 m (approx) LB 649, P.55.

Note – the large reef structure, in front of the knoll, would have absorbed most wave energy and would have reduced wave run-up in the lee of the knoll.



#### TE KAHA, SCHOOLHOUSE BAY

Extent of storm debris came across State Highway 35 100 m south of school. RL 3.78 m (see LB 678, P.41) road centreline = RL 4.14 m



#### TE KAHA – SCHOOLHOUSE BAY

Storm debris across State Highway 35 100 m south of school (see LB 678, P.41 for coastal profile at school)



**RAUKOKORE**

Storm debris surrounded abandoned bus.



**RAUKOKORE**

Storm debris came across State Highway 35 adjacent to abandoned bus.





### RAUKOKORE

Storm debris seen across State Highway 35 just north of abandoned bus. Note debris line in driveway



### RAUKOKORE

Storm debris came across State Highway 35. Roadside gabion protection suffered some erosion.



RAUKOKORE

Storm debris came across State Highway 35. Roadside gabion protection suffered some erosion.



RAUKOKORE

Looking north from eroded gabions, storm debris is across State Highway 35. State Highway 35 is very close to the ocean here but with a lot of reef structure evident to absorb wave energy and reduce run-up.



#### RAUKOKORE SCHOOL

Storm debris came across State Highway 35 and into school grounds. The school was closed for the day to allow heavy machines to remove debris and clear grounds.



#### RAUKOKORE MARAE

Storm debris came across State Highway 35 and into the marae grounds.



**RAUKOKORE MARAE**

Storm debris came across State Highway 35 and into the marae grounds.

## Additional photos of storm surge run-up taken on 24 March 2004



### OMAIO BEACH

Storm debris on knoll in front of Omaio Store (RL 5.974 m). See LB 678, P.26.



### OMAIO BEACH

Storm debris seen on knoll in front of Omaio Store. State Highway 35 = RL 6.44 m (see LB 678, P.26)



**WHAREKURA BAY**

Northern end of Maraetai (Schoolhouse) Bay, storm debris on knoll on the edge of reserve RL 4.761 m (see LB 678, P.26).



**WHAREKURA BAY – SITE MAP**

Northern end of Maraetai (Schoolhouse) Bay, storm debris on knoll on the edge of reserve RL 4.761 m (see LB 678, P.26).



#### WHAREKURA BAY

Northern end of Maraetai (Schoolhouse) Bay, looking south over LINZ BM GE 096.



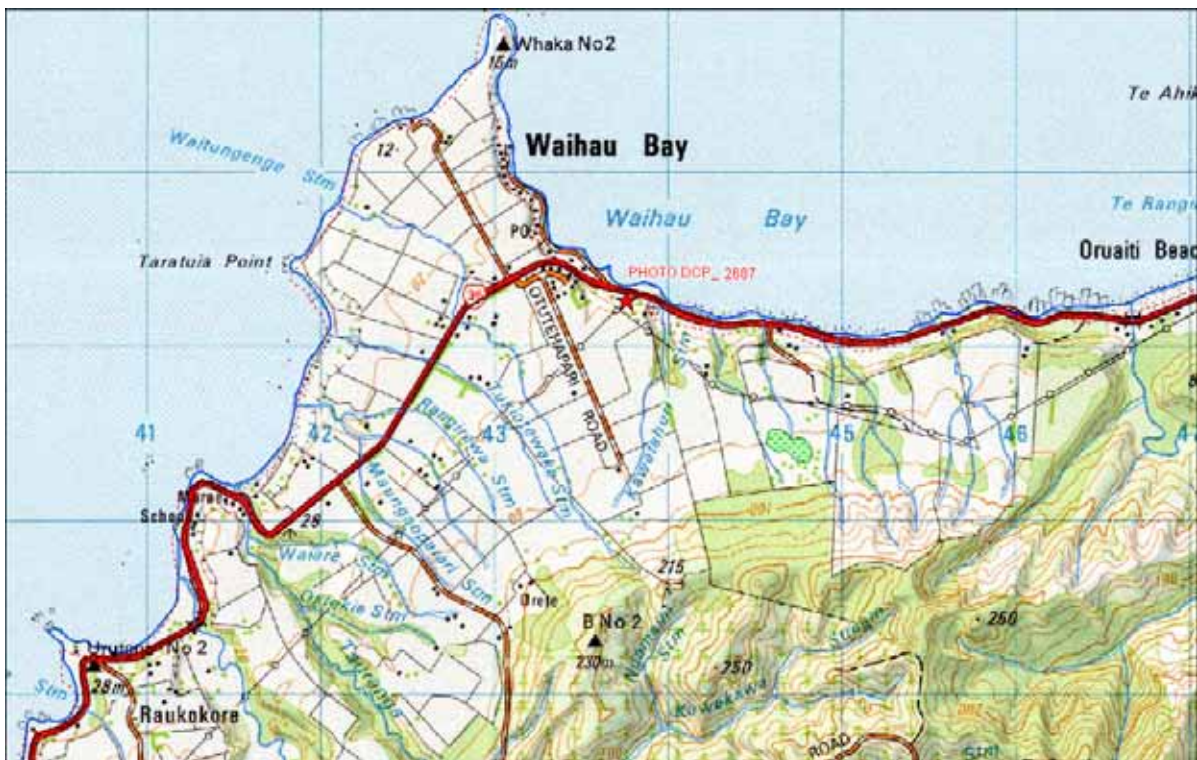
#### WAIHAU BAY

Storm surge level (RL 3.38 m) across State Highway 35 approximately 100 m north of Waihou Bay Lodge turn-off. See LB 678, P.27.



**WAIHAU BAY**

Storm surge level across State Highway 35 approximately 2 km north of Waihou Bay Lodge turn-off.



**WAIHAU BAY – SITE MAP**

Storm surge level across State Highway 35 approximately 100 m north of Waihou Bay Lodge turn-off.