

Storm Event 18 September 2005

Magnitude of the Storm Surge Recorded



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



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Cover Photo: Whakatane Heads

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Chapter 1: Introduction

On 18 September 2005, a storm passed through the Bay of Plenty, this storm generated a storm surge that affected some coastal areas of the region.

- Four houses in Port Ohope were flooded due to the height of the storm surge; having a level of 1.68 m (Moturiki Datum), minimum basement floor level was 1.64 m (Moturiki Datum).
- Some areas were inundated with the storm deposited debris; these include the Whakatane Heads Boat ramp car park, Port Ohope, Ohiwa Harbour and Kutarere Wharf.
- Scour depth reports at Ohope Beach ranged from <0.5 m (West End) to 2.5 – 3.0 m along the spit.
- Most access ways including sand ladders, steps and sand fencing were inundated, with some left impassable due to a vertical scarp.
- At Pukehina Beach the storm event caused fore dune erosion, in several areas up to 7 m of erosion was measured.

This report summarises details concerning the magnitude of the 18 September 2005 storm surges and documents relevant meteorological factors involved. This data is of considerable value for future re-estimates of coastal hazards including design maximum sea levels.

Chapter 2: Storm surge components

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, see 2.4 for further detail.

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

The synoptic charts show that a depression with central pressure of 976 mb travelled in a southerly direction towards the south eastern side of the North Island. Full details of the synoptic situation are presented in Appendix A.

Minimum pressures recorded at the Omokoroa and Whakatane Wharf sites and the general time of peak levels recorded are shown in Table 1.

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

Table 1 Meteorological Recording (18 September 2005)

	Omokoroa	Whakatane Wharf
Minimum pressure	976.6 mb at 1715 hrs NZST	976.9 mb at 2000 hrs NZST
Pressure at time of peak water levels	978.4 mb at 1945 hrs NZST	977.0 mb at 1945 hrs NZST

An associated easterly wind produced peak wind gusts of 53.6 km/hr (14.89 m/s) at 0840 hrs NZST and a secondary peak of 47.6 km/hr (13.22 m/s) at 1310 hrs NZST recorded at Edgecumbe. These wind gusts are considered to be relatively low in magnitude.

Chapter 4: Recorded Sea Levels

Peak sea levels were recorded at a number of gauged sites along the coast; measurements of peak level at other sites were made by examining debris levels on the following day. Details of actual peak sea levels recorded including storm surge levels are presented in Tables 2 and 3. The location and maximum recorded sea level at some sites are shown on Figures 1-4. 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 level was 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 metre and East of Omaio by 0.2 m. Levels for Tauranga, Whakatane and Ohiwa Harbour are set out below.

Tauranga	1.14 m at 1919 hrs
Whakatane	1.24 m at 1839 hrs
Ohiwa Harbour	1.30 m at 1933 hrs

These values have been translated into Moturiki Datum for this analysis.

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 and Opotiki Wharf recorders, the Thornton and Fords Cut (Kaituna) recorders. 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 Recorded sea levels and storm surge (18 September 2005)

Location	Peak Time High Tide	Floating Astronomical Tide (m RL)	Peak Sea Level (m RL)	Storm Surge (m)	Storm Surge + Wave dynamics (m)
Moturiki at Mt. Maunganui	1840	1.14	1.341	0.201	
Hairini (Tauranga Harbour)	1940	1.14	1.507	0.367	
Oruamatua (Tauranga Harbour)	1945	1.14	1.439	0.299	
Omokoroa (Tauranga Harbour)	2005	1.14	1.238	0.098	
Tug Berth	1920	1.14	1.157	0.017	
Sulphur Point	1920	1.14	1.377	0.237	
Fords Cut (Kaituna)	1845	1.14	1.644	0.504	
ORC (Tarawera)	1845	1.24	1.706	0.466	
Thornton (Rangitaiki)	1845	1.24	1.858	0.618	
Whakatane Wharf	1945	1.24	1.838	0.598	
Whakatane Heads Road*	-	1.24	3.970		2.730

Whakatane Boat Ramp Carpark*	-	1.24	1.92 - 2.24		0.78 - 1.10
Ohiwa Recorder	1945	1.30	1.750	0.450	
Sites around the Ohiwa Harbour*	-	1.30	-	See Table 3	
Otara at Wharf	1930	1.27	1.901	0.631	
Note: * Levels for the asterisked sites were obtained from the position of debris.					
Note: 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.					

Table 3 Recorded sea levels and storm surge around Ohiwa Harbour (18 September 2005)

Surge Levels at Ohiwa Harbour (m RL)			
Location	Floating Astronomical Tide (m RL)	Peak Sea Level (m RL)	Storm Surge (m)
1 Near end of Ohiwa Harbour Road*	1.3	1.76	0.46
2 Adjacent Port Ohope Store*	1.3	1.57	0.27
3 Ohiwa Parade*	1.3	1.69	0.39
4 Claydon Place, Port Ohope*	1.3	1.60	0.30
5 Ohiwa Harbour Sediment Site 2*	1.3	1.74	0.44
6 Ohiwa Harbour Sediment Site 4 (west BM)*	1.3	1.85	0.55
7 Kutarere Wharf*	1.3	2.08	0.78
8 Kutarere Road. adjacent east of junction w/Hiwarau Road*	1.3	2.21	0.91
9 Ohiwa Harbour Sediment Site 9, Reeves Road*	1.3	1.75	0.45
10 Ohiwa Harbour Sediment Site 10, Ohiwa Harbour Road*	1.3	1.82	0.52
11 Ohiwa Holiday Park, Ohiwa Harbour Road*	1.3	1.95	0.65
Note: Wave Runup may have had a small effect on the values of Storm Surge recorded here.			
Note: *Levels for the asterisked sites were obtained from the position of debris.			

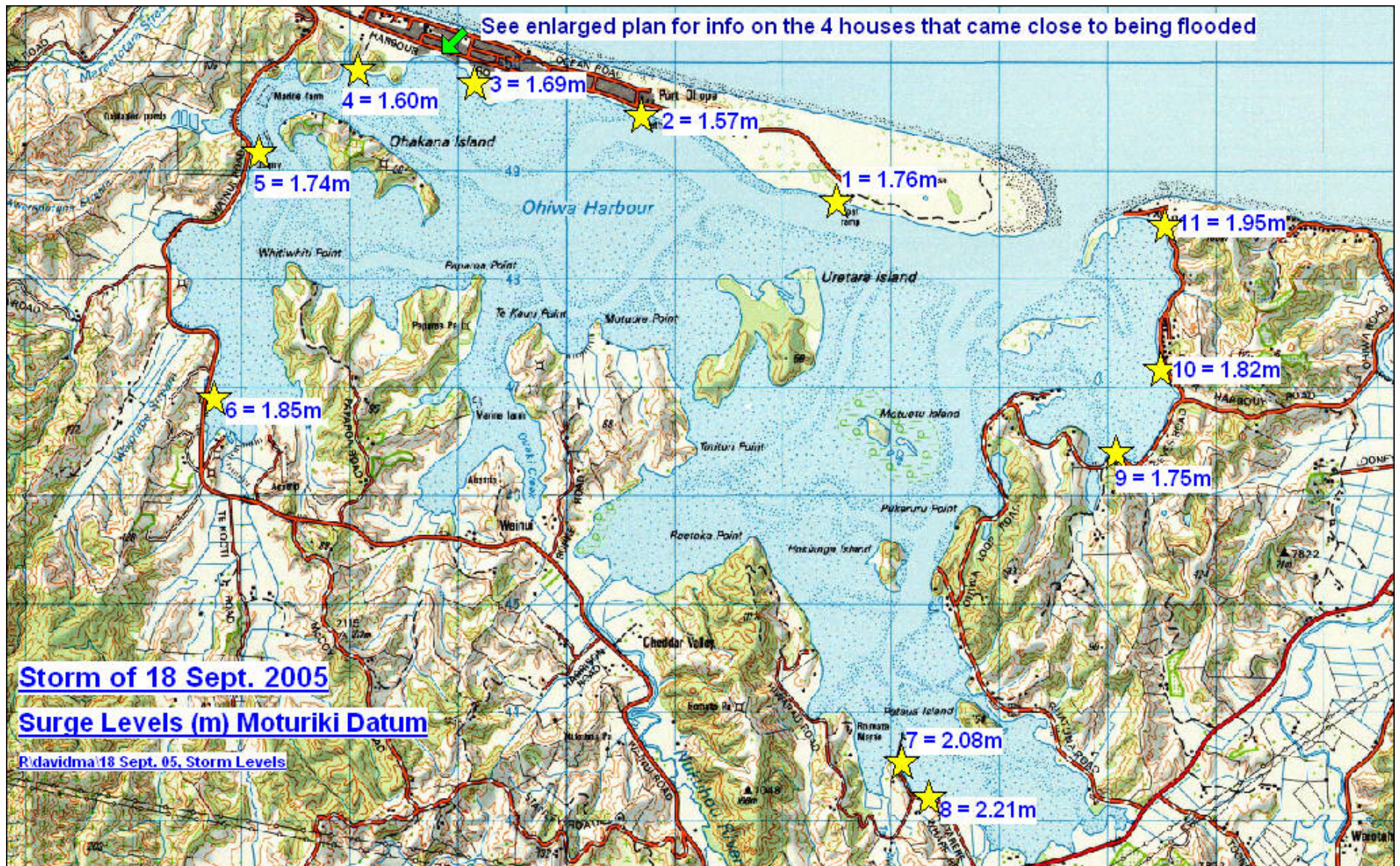


Figure 1 Storm surge levels recorded around the Ohiwa Harbour.



Figure 2 Debris levels reached in the Whakatane River Boat Ramp car park.



Figure 3 Debris levels reached in the Whakatane River entrance.

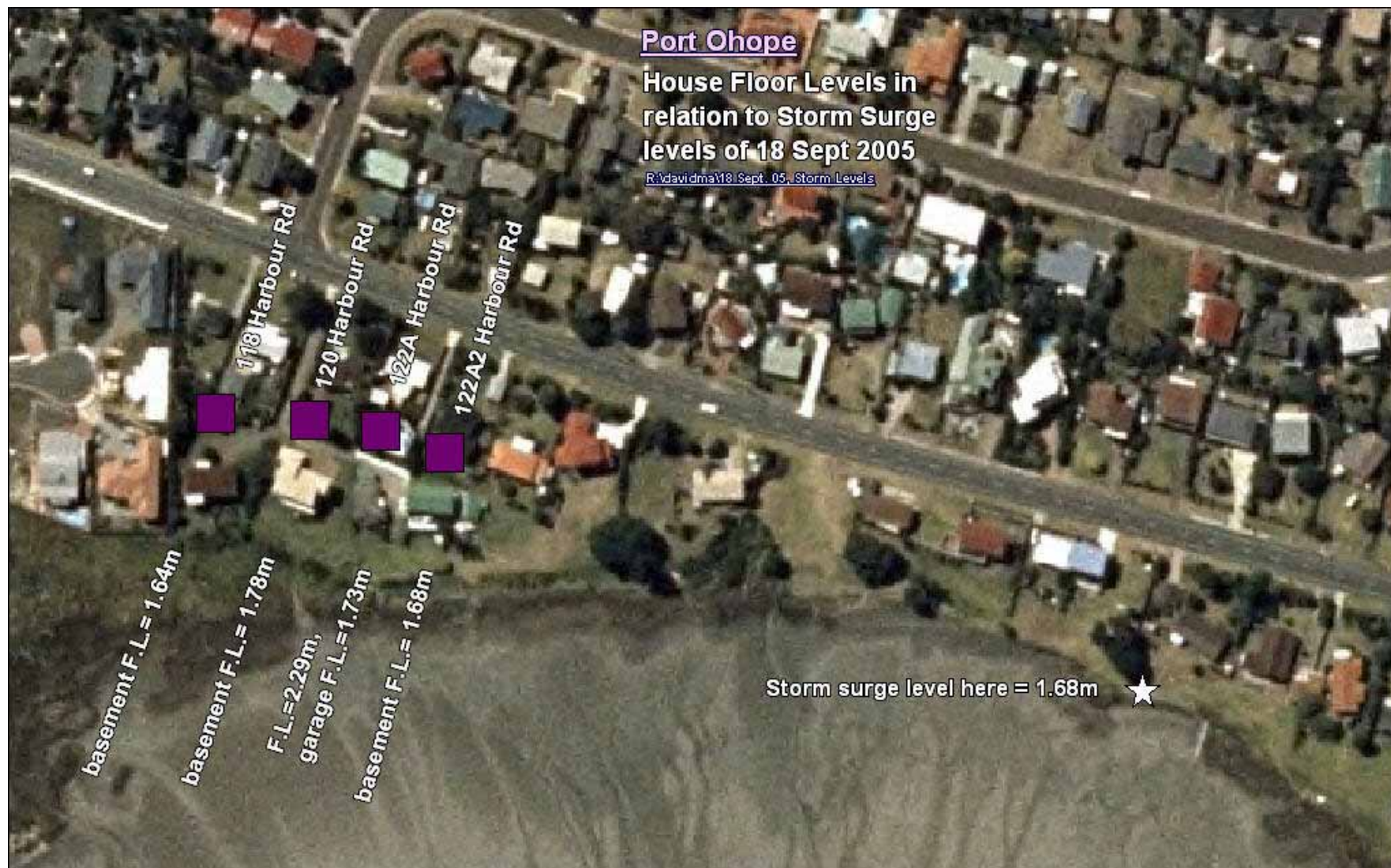


Figure 4 Debris levels reached in the Whakatane River entrance.

Chapter 5: Discussion

5.1 Frequency of these events

Due to the unusually low barometric pressure component, this storm is of interest to us.

The minimum barometric pressure of 976.6 mb was lower than the 100 year design estimate of 981 mb. The latter figure is the 1% AEP and covers a larger area with central pressures expected to be lower.

The other contributing meteorological factors were of a more frequent nature.

The peak wind gust of 53.6 km/hr (14.89 m/s) was far below the 100 year estimate of 111.96 km/hr (31.1 m/s).

In comparison to other storms, this storm was a more frequent sized event and had a comparatively small return period. However the low barometric pressure makes it of much benefit to future analysis.

5.2 Recorded storm surge levels

The 18 September 2005 storm surge event raised water levels to approximately 0.45 m above the expected tide level at the Ohiwa Harbour Recorder.

In Tauranga Harbour, storm surge levels have been calculated for sites at Hairini, Oruamatua and Omokoroa, these show the storm surge levels at these sites to range from 0.1 m to 0.37 m.

5.3 Storm surge component for 18 September 2005

The static sea levels for the 18 September 2005 storm event were higher than Cyclone Fergus and Drena, partly due to a King Tide (1.14 Moturiki Datum) at Whakatane and Ohiwa.

The following appear to be the storm surge components for 18 September 2005 at Ohiwa Harbour;

Astronomical Tidal Height	1.3 m RL
Barometric Set-up	0.37 m
Wind Set-up	0.08 m
Total	1.75 m

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 for Ohiwa Harbour during this event was 0.45 m Moturiki Datum.

For Tauranga Harbour, the “static” storm surge component is 0.2 m, based on the peak level of 1.34 m at the Moturiki gauge and astronomical tide of 1.14 m.

Thus the “static storm surge” was 0.25 m greater at Ohiwa than Tauranga, reflecting the storm direction and concave geometry in the Eastern Bay of Plenty.

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 0.08 m is well under the 100 year return period estimate used in the Regional Coastal Plan of 0.54 m, reflecting that the majority of this storm surge component was due to the very low barometric pressures.

Cyclone Ivy peak gust	14.89 m/s	
100 year wind gust	34 m/s	(based on Tauranga data in NZ 4203)
Cyclone Ivy wind setup	0.08 m	
100 year wind setup	0.54 m	(Regional Coastal Plan for Ohiwa)

5.5 Estuary effects

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 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 on 18 September 2005 can be determined from the different levels recorded at the various sites, as compared to their respective Moturiki or 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 results are presented in Table 4.

Table 4 Recorded estuary effects

Location	Peak Level (m RL)	Estuary Effect (m)
1 Near end of Ohiwa Harbour Road*	1.76	0.010
2 Adjacent Port Ohope Store*	1.57	-0.180
3 Ohiwa Parade*	1.69	-0.060
4 Claydon Place, Port Ohope*	1.60	-0.150
5 Ohiwa Harbour Sediment Site 2*	1.74	-0.010
6 Ohiwa Harbour Sediment Site 4 (west BM)*	1.85	0.100
7 Kutarere Wharf*	2.08	0.330

8 Kutarere Road. adjacent east of junction w/ Hiwarau Road*	2.21	0.460
9 Ohiwa Harbour Sediment Site 9, Reeves Road*	1.75	0.000
10 Ohiwa Harbour Sediment Site 10, Ohiwa Harbour Road*	1.82	0.070
11 Ohiwa Holiday Park, Ohiwa Harbour Road*	1.95	0.200
Hairini (Tauranga Harbour)	1.507	0.166
Oruamatua (Tauranga Harbour)	1.439	0.098
Omokoroa (Tauranga Harbour)	1.238	-0.103
Note: * Levels for the asterisked sites were obtained from the position of debris.		
Note: The minor effect of wave action at these locations cannot be completely ignored.		

Note that in Table 3 the estuary effects are a part of the storm surge component at each of the relevant sites.

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.

There are three effects occurring as a result of wave action under storm conditions; wave setup, wave run-up and coastal erosion. Of these, wave setup is considered to be static whereas wave run-up is dynamic. Wave set-up is the super elevation of the water surface over normal surge elevation due to onshore mass transport of the water by wave action alone. Wave run-up is essentially the maximum height on land reached by the breaking waves, this varies with breaking wave characteristics, beach and backshore slope.

During 18 September 2005 storm significant erosion was recorded as a result of severe wave action. At Pukehina Beach, the storm event resulted in several areas where up to 7 m of fore dune erosion was measured. Photos are shown in Appendix 3.

Chapter 6: Conclusion

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 of and calibrating models showing coastal inundation. They also help us develop a picture of what happens within our harbours with different coastal conditions.

- The minimum recorded barometric pressure was below the 100 year return period estimate.
- The waves produced during this storm event caused significant erosion to some coastal communities, with up to 7 m dune erosion recorded at Pukehina Beach.

Most of the storm components were of a higher frequency however the very low barometric pressure component makes this storm of much interest for future investigations.

References

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.

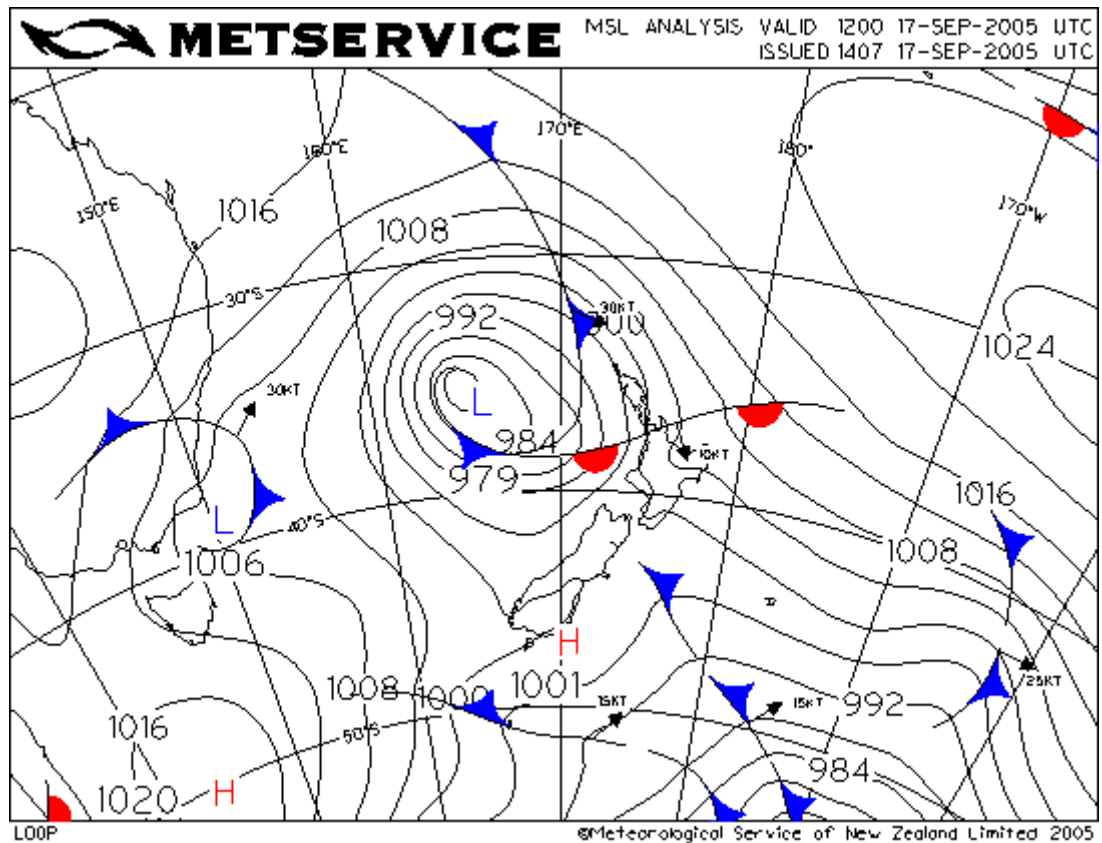
Blackwood, PL, March 1997; Cyclone Fergus and Drena Storm Surge: Report on the Magnitude of Storm Surges Recorded and Implications for Design Maximum Sea Levels. Environment Bay of Plenty Operations Report No 97/1.

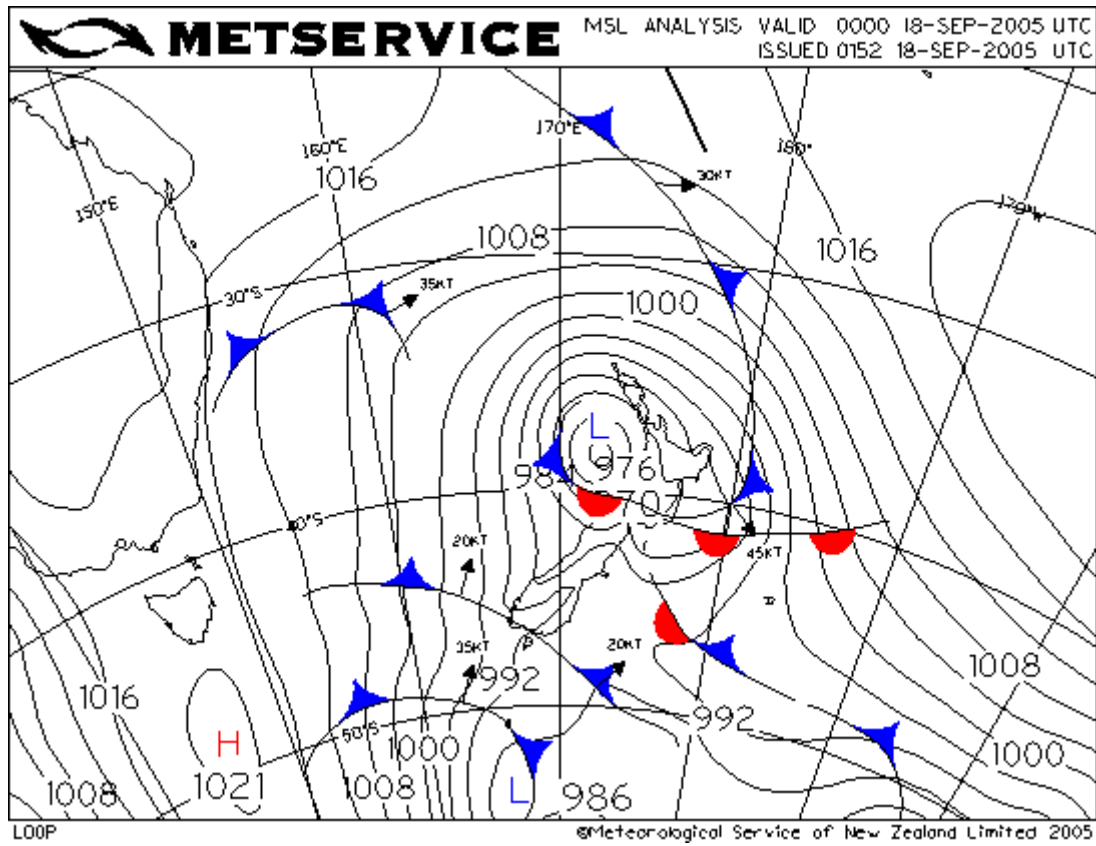
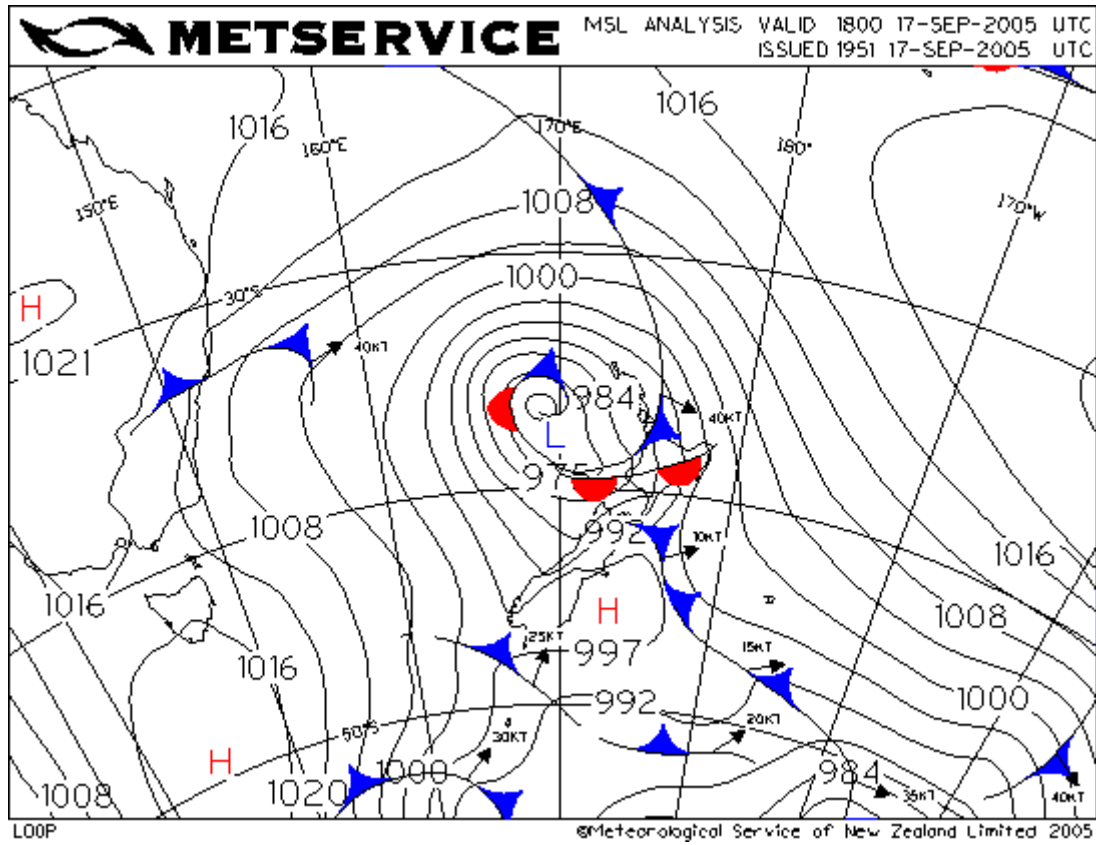
Appendices

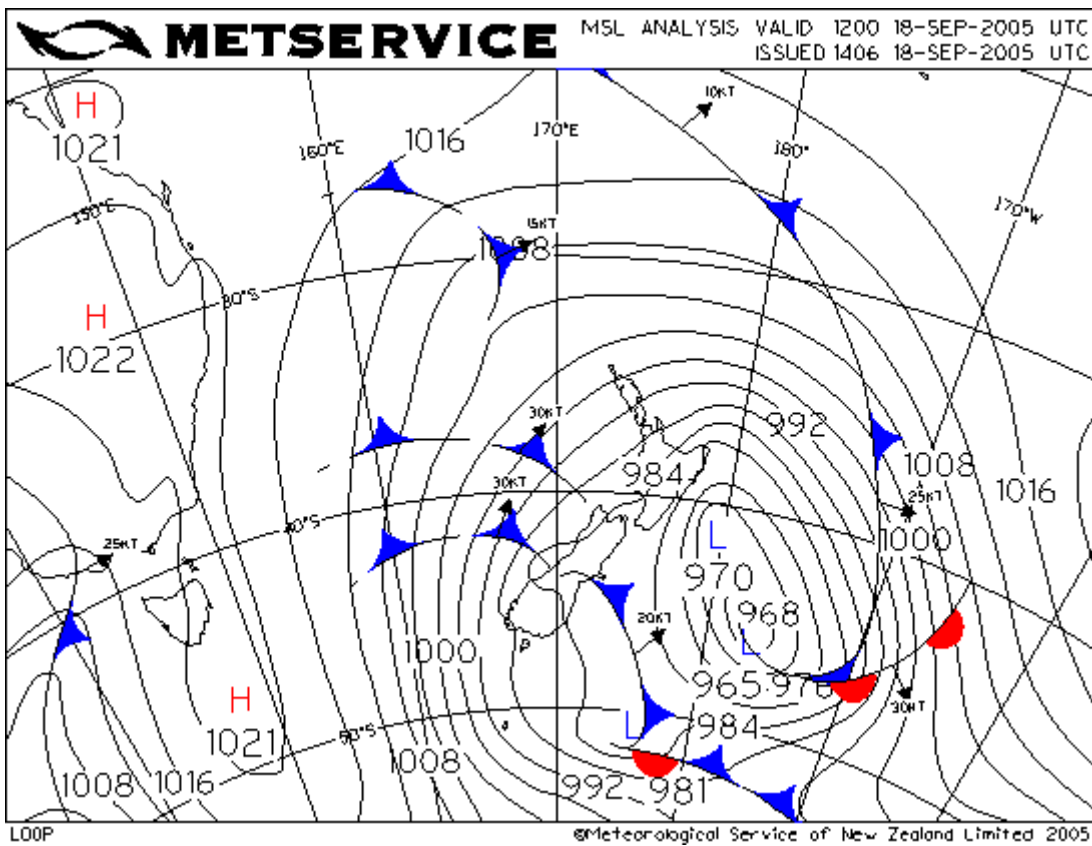
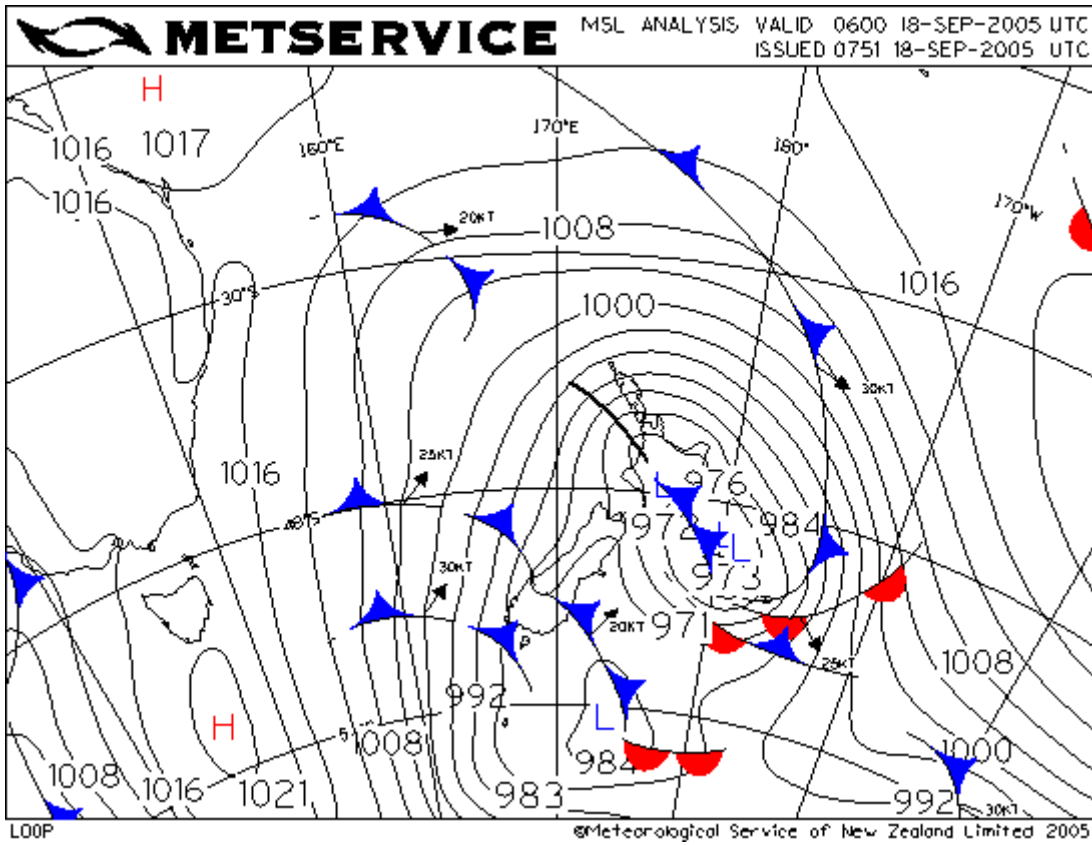
<i>Appendix I</i>	<i>Synoptic situation</i>
<i>Appendix II</i>	<i>Recorded sea level graphs</i>
<i>Appendix III</i>	<i>Photos</i>

Appendix I – Synoptic Situation

Storm event 18 September 2005.



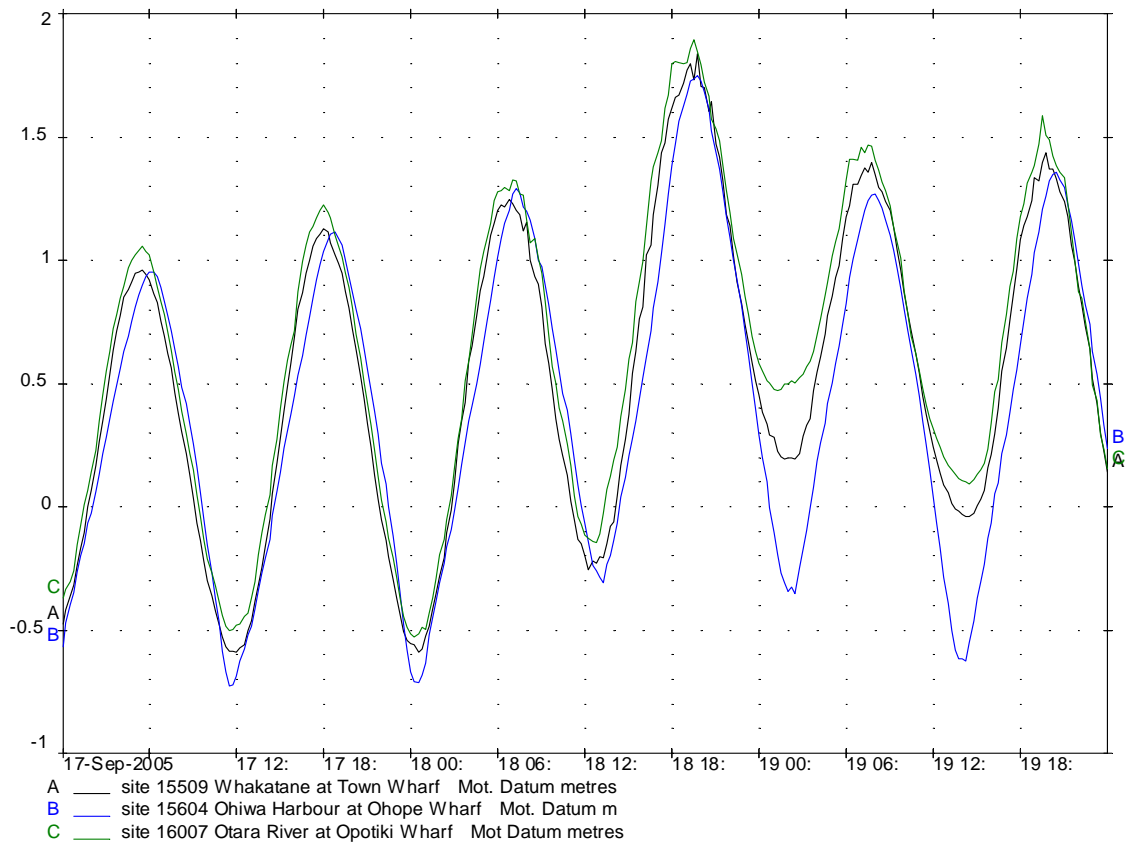




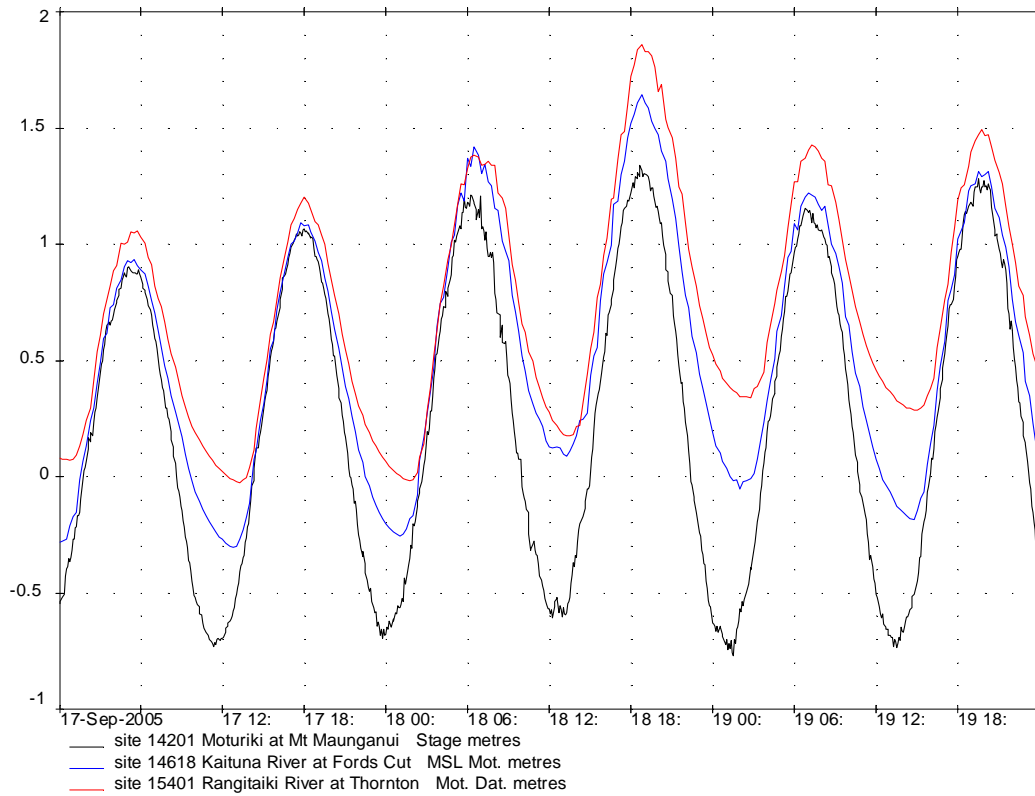
Appendix II – Recorded Sea Level Graphs

Graphs of sea level from Environment Bay of Plenty Data Recorders for storm surge event dated 18 September 2005.

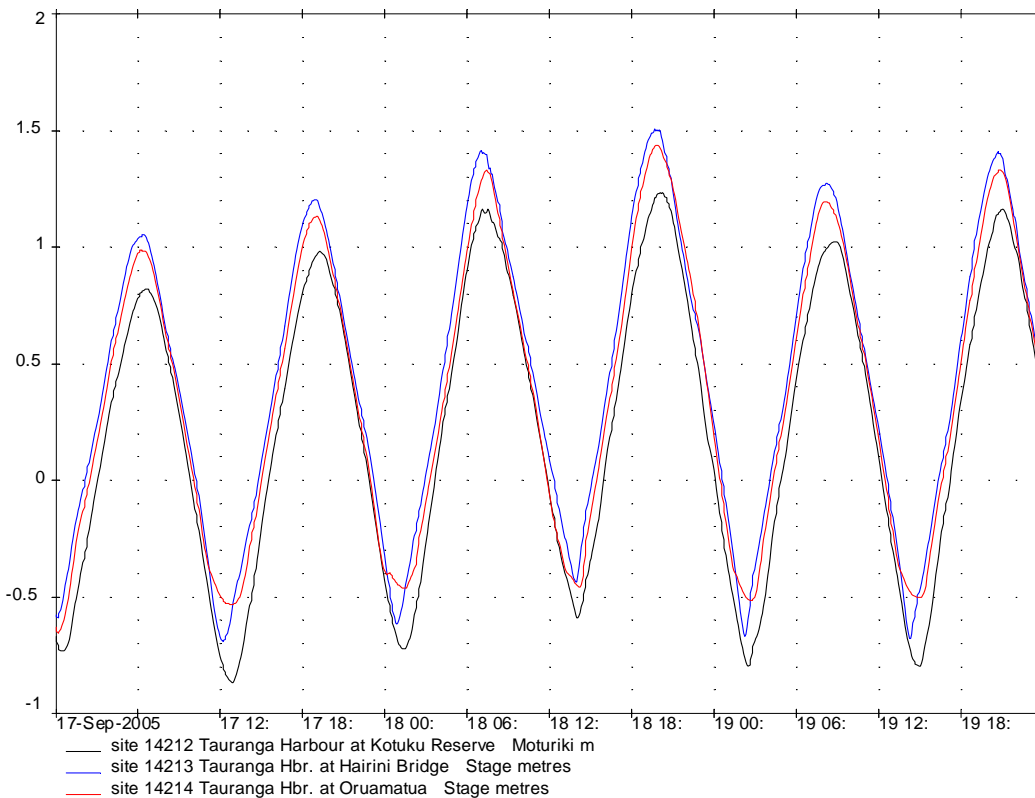
Sea level (Moturiki datum) for Whakatane at Town Wharf, Ohiwa Harbour at Ohope Wharf and Otara River at Opotiki Wharf.



Sea level (Moturiki datum) for Tauranga at Moturiki Island, Kaituna River at Fords Cut and Rangitaiki River at Thornton.



Sea level (Moturiki datum) for Tauranga Harbour at Kotuku Reserve (Omokoroa), Tauranga Harbour at Hairini Bridge and Tauranga Harbour at Oruamatua.



Appendix C – Storm of 18 September 2005 photos



Whakatane Heads boat ramp carpark



Whakatane Heads boat ramp carpark



Whakatane Heads boat ramp carpark



Whakatane Heads boat ramp Carpark



Whakatane Heads boat ramp carpark



Whakatane Heads boat ramp carpark



Whakatane Heads boat ramp carpark



Whakatane Heads



Whakatane Heads



Adjacent Port Ohope Store



Claydon Place, Port Ohope



Ohiwa Harbour Sediment Site 2 (south BM)



Ohiwa Harbour Sediment Site 4 (west BM)



Kutarere Wharf



Kutarere Wharf Road, just east of junction with Hiwarau Road



Kutarere Wharf Road, just east of junction with Hiwarau Road - inundated paddock



Ohiwa Harbour Sediment Site 8, Ruatuna Road



Ohiwa Harbour Sediment Site 9, Reeves Road



Ohiwa Harbour Sediment Site 10, Ohiwa Harbour Road



Boat Ramp, Ohiwa Loop Road



Ohiwa Holiday Park, Ohiwa Harbour Road



Toe of fore dune position at Pukehina Beach
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The storm event on the 17–18 September 2005 resulted in several areas where up to 7 m of foredune erosion was measured (see Map and Photos) at Pukehina Beach



209 Pukehina Parade (taken 27 September 2005).



215 Pukehina Parade (taken 27 September 2005).