1936
Great Cyclone

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13 Factsheet 2: Coastal inundation (storms)

Storm inundation is an acute natural event arising from extreme weather events (storms), in which normally dry, but low-lying coastal land is flooded occasionally. Storm-related coastal inundation is caused by high tides (normally during spring or perigean tides), combining with:

- storm surge – the temporary (hours to days) increase in sea level over and above the predicted tide height due to a combination of strong winds and low barometric pressure
- waves, through a combination of wave set-up (an increase in the water levels landward of where waves are breaking) and wave run-up over the upper beach, which can overtop low coastal barriers.

'Storm tide' is used to describe the total sea level formed from the combination of tide and storm surge during storm conditions. During storm events, the likelihood and magnitude of coastal inundation is highly dependent on the occurrence or timing of high tides, storm surge and wave conditions. For example, the peak of the storm surge will not always coincide with the highest wave conditions and the time of a high spring tide. Around New Zealand, they will be correlated in some way, owing to the following:

- certain weather conditions, such as the tracking of extra-tropical cyclones or low-pressure systems close to New Zealand's coast, could produce both high wave conditions and high storm surge. However, as storm surge in New Zealand is relatively modest compared to the astronomical tide (which is completely independent of meteorological conditions), any correlation with extreme wave conditions may not be that high (particularly on the west coast where the tide range is higher)
- wave heights that are limited by water depth in shallow water. In such a case there may well be a high correlation between high water level and higher wave conditions.

An aerial photograph of the flooding over the lower Hauraki Plains over the fourth to fifth of May nineteen thirty eight.

The biggest storm-tide events last century occurred close together in 1936 and 1938. The Great Cyclone of 1–2 February 1936, with barometric pressures down to 970 hPa and ferocious winds and waves, came on the back of a very high perigean-spring tide and caused widespread coastal inundation damage along the east coast of the North Island. Coastal roads were washed away, a house fell into the sea at Te Kaha, while the sea swamped houses 100 m inland at Castlepoint (the sea broached the coastal dunes). A month later, on 25–26 March 1936, an easterly gale produced by a low depression combined with extremely high 100-year high tides and together they caused damage and sea flooding in the Auckland region.

Two years later, on 4–5 May 1938, 35,000 ha of the lower Hauraki Plains (pictured) were flooded through a combination of spring tides and northeast gales that caused a large storm surge and accompanying waves. There were several breaches of the shoreline stopbank from Waitakarau to Kopu. The inundation was exacerbated by heavy rainfall.

Source: Brenstrum E. 1998. The New Zealand Weather Book. Craig Potton Publishing: Nelson.

The extent and magnitude of inundation also depends on how the high storm tide and wave conditions actually inundate an area (ie, their flow path). This depends on the physical characteristics and topography of the upper parts of the beach or estuarine shoreline and immediate coastal hinterland. Typical flow pathways include:

- direct inundation, where the storm-tide level exceeds the level of the land. This typically occurs where waves have not built up a coastal barrier, such as along estuarine and sheltered coastlines or along the margins of rivers and streams
- inundation due to the breaching of a barrier. This may be related to the breaching of a natural barrier such as a gravel ridge or narrow dune field (with low-lying land behind it) or a human-made defence such as a stopbank. Coastal flooding due to breaching of a barrier is more likely to occur on open sections of coast exposed to larger waves
- overtopping of a barrier. Again this may be either a natural barrier such as a gravel ridge or narrow dune field or a human-made defence such as a stopbank. Overtopping typically occurs due to wave or swell conditions during a high tide or storm tide on more exposed open sections of coast.

Photographs showing the gravel barrier being overwashed at East Clive on the 16 August 1974. The photograph on the left is taken from landward of the barrier and shows wave overtopping and flooding of land behind the barrier. The photograph on the right is taken from the air and shows waves also overtopping the barrier and the flooded land behind.

Coastal inundation at East Clive, south of Napier on 16 August 1974 was caused by persistent heavy swell coinciding with high tides. This resulted in the gravel barrier being overtopped and the low-lying land behind being inundated and 200 homes affected.

Source: Ministry of Works and Development collection, Napier.

River flooding of coastal and estuarine margins, and stormwater flooding of low-lying areas, can be exacerbated by high tides or storm tides. In relatively flat low-lying coastal margins (eg, Lower Heathcote at Christchurch, South Canterbury Plains, Hauraki Plains), land may stay flooded with seawater for several days after an extreme event. This type of inundation has a dramatic effect on vegetation and pasture production, and can sometimes curtail pasture growth for a year or more.

Human interventions can also exacerbate storm inundation hazards through:

- river training works (straightening, stopbanks) that increase river levels at the coast
- poorly designed coastal protection structures that exacerbate loss of the beach adjacent to the structure or increase wave run-up and overtopping potential
- coastal property development in inundation-prone areas (low-lying estuary margins or shore-front areas without an adequate buffer), or roads or other infrastructure that blocks overland flows
- physical removal, reduction or damage to natural coastal barriers such as sand dunes and gravel barriers (eg, lowering access ways, removing vegetation, trimming or removing dunes)
- permanent modification of coastal margins (eg, by constructing waterways, canals, marinas and boat ramps, and carrying out reclamation).

High tide 'red alert' days

www.niwascience.co.nz/rc/hazards/dates – Dates in the present year when high tides reach the highest levels. Hence storm surge or large wave conditions on top of such high tide levels during these dates will likely result in inundation of exposed low-lying coastal areas.

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Cyclone Bola 1988

Type of Event: Cyclone
When: 7 March, 1988
Where: East Coast, North Island

One of the most damaging cyclones to hit New Zealand, Cyclone Bola struck Hawke's Bay and the Gisborne/East Cape region in March 1988. Slowing as it moved over the area, it resulted in continuous torrential rain for three days.

What Happened?

- The East Coast of the North Island suffered devastating floods.
- Winds up to 100kph toppled trees and tore off roofs. Heavy rain resulted in landslides, cuts to power and sewage services and road closures.
- Three people died when their car was swept away by floodwaters. Two other occupants in the car were saved.
- Te Karaka was evacuated when the swollen Waipoa River came close to flooding the township of 500 people.
- State Highway 2 was closed in several places by slips and flooding. When people in one house couldn't be evacuated by helicopter, horses were brought in to get them out.
- States of emergency were declared in Wairoa, Gisborne and the East Cape. In Gisborne, the water pipeline from the supplying dams was lost.
- Cyclone Bola's force was also felt in Northland where torrential rain caused flooding and cut power and telephone services.
- A state of emergency was declared in Dargaville. The main water line was washed away with a bridge, disrupting supply to the township.

her Impacts And Outcomes

- A Disaster Relief Committee was set up to assess storm damage on the East Coast.
- A peak rainfall of 916 millimetres over the three days was recorded inland from Tolaga Bay.
- The most intense rainfall was on steep East Coast hill country. Areas where there had been little or no soil conservation work done or no flood control schemes suffered the worst damage.
- Flooding affected some 3600 hectares of farming and horticultural land, with the associated losses estimated at $90 million.
- 1765 farmers were affected by damage to their land and crops and stock losses. Cyclone Bola hit some areas just as harvesting was about to start.
- Repairs to Gisborne's water supply cost an estimated $6.6 million. Damage to East Coast forests was estimated at $8.6 million.
- An inquiry into flood management followed. Recommendations included soil conservation work, improved river control and management and better land use planning.

Statistics

Formed	February 24, 1988
Dissipated	March 4, 1988
Highest Winds	165 km/h (105 mph) (10-minute sustained) 195 km/h (120 mph) (1-minute sustained)
vest Pressure	940 hPa (mbar)
Fatalities	3 direct
Damage	$87 million (1988 USD)
Areas Affected	Fiji, Vanuatu, New Zealand

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