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GEOMORPHIC EFFECTS OF CYCLONE BOLA 1988
A NOTE

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INTRODUCTION

Cyclone Bola caused widespread landsliding and flooding in the Gisborne-East Coast region of the North Island between March 6 and 9, 1988 (Trotter 1988). Its effects were more widespread than those of two previous cyclonic storms in 1980 and in 1982 (Cyclone Bernie) (Revell & Ward 1982; Phillips 1988), although rainfall totals and intensities were similar for many areas.

Phillips (1988) explained the response of a landscape to these two previous large storms in terms of a slope-forming event (1980) and a channel-forming event (1982). To further test the idea that large events are major contributors to landform evolution, the study area of the earlier investigation was re-examined after Cyclone Bola. This note outlines the results of that investigation.

METHODS

Following the December 1980 storm, Phillips (1988) surveyed 116 landslides in catchments of the mid-upper Waitahaia River, a tributary of the Mata River, and established 12 cross-sections on the Waitahaia River and its tributaries to record changes in sediment storage. Measurements of these cross-sections were made quarterly until 1983, then annually. After the April 1982 storm, four sub-regions within the original study area were selected for detailed aerial photo study of landslides resulting from both storms.

Because post-Bola aerial photography did not completely cover the previous study area, a complete landslide inventory could not be made. Where coincident photographic coverage did exist, areas in the earlier study were re-examined to determine the number of new landslides. A reconnaissance-level field inspection was carried out for the remainder of the study area not covered by post-Bola photographs to determine landslide frequency and location. Stream cross-sections were re-measured. However, the number of sections with one or both end-points missing meant that only five of the original 12 cross-sections could be re-surveyed. Explanation of sediment movement is thus based entirely on the few cross-sections that survived, on field observation, and from aerial photograph interpretation. Rainfall totals were estimated from isohyetal information as the recording rain gauge reported in Phillips (1988) had been removed. Intensities were taken from a recording gauge located at Mangatu Forest, 20 km to the south; an area which received comparable total rainfall.

RESULTS

Maximum rainfall during Cyclone Bola occurred several tens of kilometres to the east of the study area in a north-south trending band (Fig. 1). The study

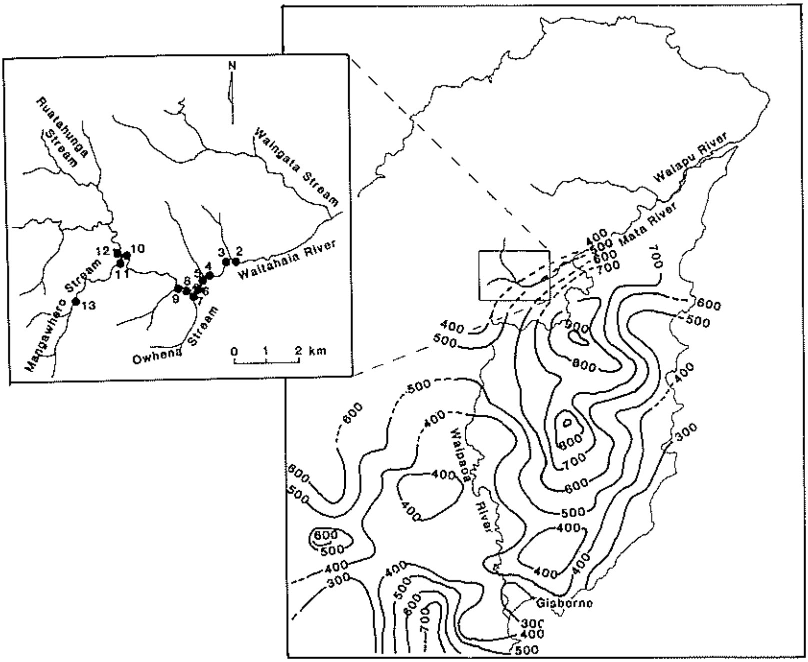

FIG. 1—Study area with Cylone Bola total rainfall isohyets (5–9 March 1988) superimposed (Courtesy of Mr B. Turnpenny, Gisborne Regional Council). Numbers refer to stream cross-sections reported in Phillips (1988).

area received an estimated 400–600 mm of rain during the 80-hour storm. This was similar to the total for the December 1980 storm (580 mm over 8 days) and significantly more than in the April 1982 event (220 mm over 3 days) (Phillips 1980). Hourly intensities may not have been as high, although the maximum 24-hour totals were comparable (190 mm Cyclone Bola; 265 mm December 1980; 188 mm Cyclone Bernie).

In the sub-regions examined after the previous two storms, new landslides were limited both in number and in extent. The largest number of new landslides (11) was recorded for sub-region 2 (Table 1), though the total number could have been higher as aerial photographs covered only about 45% of this sub-region. Most new landslides, as seen on aerial photographs, were either extensions of pre-existing failures (caused by the two earlier storms) or riparian failures. Field inspection of part of the study area indicated that new landslides were formed by stream undercutting of toe-slopes, or were headwall or lateral extensions of landslides caused by the previous two storms.

Valley infilling in all reaches of the major streams and rivers was more marked after Cyclone Bola than in the two previous storms. This is clearly shown by the cross-sectional data shown in Fig. 2, from aerial photographs and field evidence. Small terraces, banks, low-lying areas, and 'islands' were buried, and

TABLE 1—Comparison of landslide frequencies of 1980 plus 1982 storms and Cyclone Bola for the sub-regions described in Phillips (Table 2 1988).

Sample area	1	2	3	4
Area (km²)	3.8	6.8	2.0	4.1
Area of 1988 photo cover (estimated)	NA	40-45%	100%	80%
No. slips 1980 and 1982	82	61	49	110
No. of new slips from 1988 photos	NA	11	2	2

NA = not applicable due to lack of aerial photograph coverage

the width of the flood plain was increased in most localities by 2–10 m. In some places, the banks at the outside of river bends were extensively eroded. Since 1985, the true right banks at cross-sections 2 and 5 have retreated a minimum of 10 m and 5 m, respectively. Similar erosion has taken place at other localities and explains the loss of cross-section datum markers. Bank erosion was often the cause of new riparian failures.

Before Cyclone Bola, both the Owhena Stream tributary and the Waitahaia River were down-cutting. Measured sections showed renewed infilling after Cyclone Bola, and bed elevations were higher than those after the December 1980 storm (Fig. 2.)

DISCUSSION

Phillips (1988) explained the differences between the effects of two previous storms in terms of the susceptibility of sites to failure and transport, i.e., slope-forming and channel-forming events. Cyclone Bola had similar levels of rainfall to the 1980 storm but did not cause the same degree of landsliding in the study area. It did however, have a significant impact on the stream channels. A simple explanation, and one which is not new (e.g., Newson 1980), is that the earlier storms had exhausted sites where landsliding was imminent so that the potential for landsliding was significantly reduced for subsequent storms. Both the April 1982 event and Cyclone Bola were not slope-forming events but were channel-forming events, as indicated by the lack of new landslides and the major changes in stream-bed elevations.

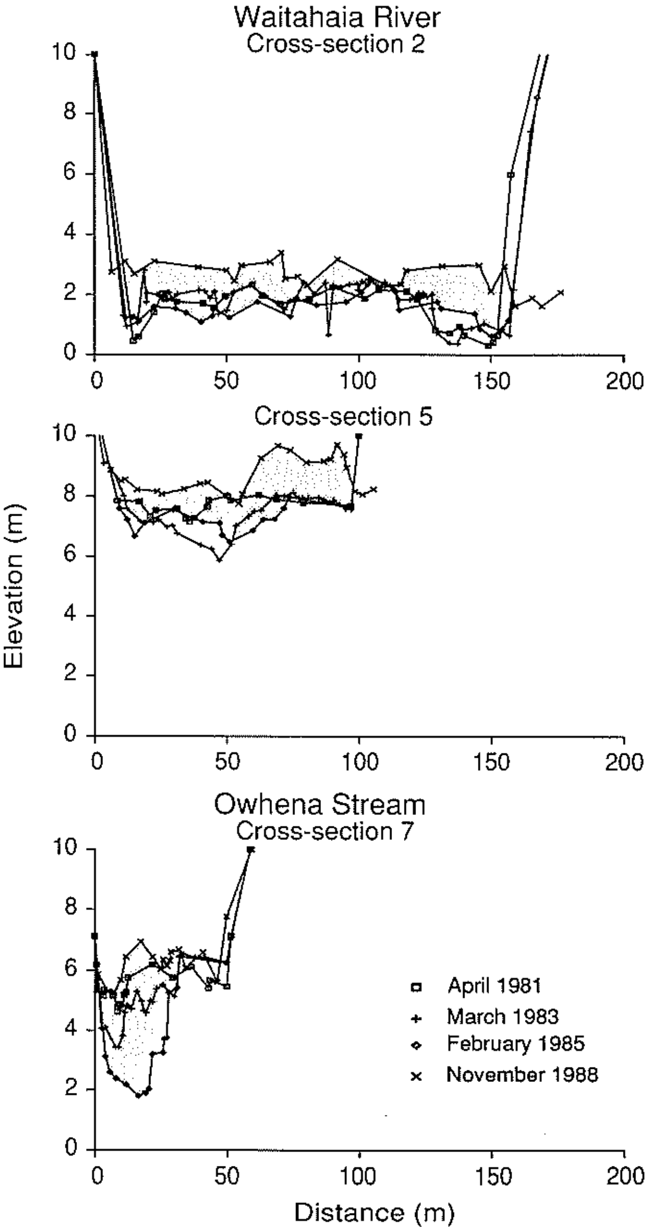

FIG. 2—Cross-sections of Waitahaia River and Owhena Stream showing profiles for 1981, 1983, 1985 and 1988. Shaded area is the amount of aggradation between 1985 and 1988.

The sediment delivered to the stream beds by the earlier events and held in storage in the upper reaches, was mobilised by the flows that occurred with Cyclone Bola and redistributed from upper to middle and lower reaches. The increases in bed level in the lower reaches (Fig. 2) were caused by the transfer of stored sediment from the upper-most reaches, not from the failure of adjacent slopes. Runoff flowing in the stream channels transported sediment and scoured some side streams down to bedrock. The stability of slopes in these upper reaches will tend to become marginal over time due to oversteepening and removal of toe-slope support. The next large storm will probably cause renewed landsliding in those areas adjacent to stream channels. The present data indicated that the majority of new landslides were, in fact, riparian failures. As regolith materials accumulate and weather on upper slopes, the potential for landsliding will increase as the regolith strength is reduced. Therefore, once potential landslide sites have failed, it takes either a significantly greater event or a longer time period between events before the potential for landslide failure is increased and the threshold conditions are lowered.

The approach to studying geomorphic effectiveness, adopted in this and the previous study may not be the best method, as the landslide inventory and stream cross-section monitoring do not provide enough information to fully assess geomorphic effectiveness. Longer term sediment budget studies of catchments to determine how catchments respond to, and recover from large events, are better methods in determining the role of these events in landscape evolution.

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