

# **HONG KONG RAINFALL AND LANDSLIDES IN 1991**

**GEO REPORT No. 20**

**N. C. Evans**

**GEOTECHNICAL ENGINEERING OFFICE  
CIVIL ENGINEERING DEPARTMENT  
HONG KONG**

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**This report was originally produced as GEO Special Project Report No. SPR 5/92**

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First published, September 1992  
First Reprint, April 1995

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Hong Kong.

This publication is available from:

Government Publications Centre,  
Ground Floor, Low Block,  
Queensway Government Offices,  
66 Queensway,  
Hong Kong.

Overseas orders should be placed with:

Publications (Sales) Office,  
Information Services Department,  
28th Floor, Siu On Centre,  
188 Lockhart Road, Wan Chai,  
Hong Kong.

Price in Hong Kong: HK\$111

Price overseas: US\$16.5 (including surface postage)

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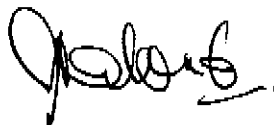
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## **PREFACE**

In keeping with our policy of releasing information of general technical interest, we make available some of our internal reports in a series of publications termed the GEO Report series. The reports in this series, of which this is one, are selected from a wide range of reports produced by the staff of the Office and our consultants.

Copies of GEO Reports have previously been made available free of charge in limited numbers. The demand for the reports in this series has increased greatly, necessitating new arrangements for supply. In future a charge will be made to cover the cost of printing.


The Geotechnical Engineering Office also publishes guidance documents and presents the results of research work of general interest in GEO Publications. These publications and the GEO Reports are disseminated through the Government's Information Services Department. Information on how to purchase them is given on the last page of this report.

A handwritten signature in black ink, appearing to read 'A. W. Malone', with a stylized flourish at the end.

A. W. Malone  
Principal Government Geotechnical Engineer  
April 1995

#### FOREWORD

This report presents a general review of rainfall and landslides in Hong Kong in 1991. Geotechnical engineers of the Geotechnical Engineering Office District Divisions provided details of the notable landslides. Supplementary landslide data were provided by the Agriculture and Fisheries Department, Architectural Services Department, Civil Engineering Office, Fire Services Department, Highways Department, Housing Department and Water Supplies Department. The Royal Observatory provided rainfall information. All contributions are gratefully acknowledged.



(Y C Chan)

Chief Geotechnical Engineer/Special Projects

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## 1. INTRODUCTION

This report reviews rainfall and landslide occurrence in Hong Kong throughout 1991. Rainfall information has been obtained from the Geotechnical Engineering Office (GEO) automatic raingauge system and from the Royal Observatory (RO). Most of the landslide data have been taken from the records of incidents reported to the GEO during the year. Supplementary data have been obtained from other Government departments.

In this report, a landslide is defined as the collapse of a soil or rock mass, and includes the failure of fill slopes, cut slopes, retaining structures, natural slopes and rock or boulder falls. A major landslide is defined as a failure in which the volume of the collapsed mass exceeds 50 cu m.

The GEO received a total of 95 incident reports in 1991. Of these, 85 were classified as genuine landslides and three of them were major. The remaining incidents were minor ground or structural movements or of no geotechnical concern. One major basement excavation failure also occurred. It is notable that fifteen incidents occurred between 8 and 10 June, while thirteen incidents occurred between 14 and 16 October. This report is based on landslides reported to the GEO, since these were inspected by the GEO's geotechnical engineers and detailed information is available.

The arrangement of this report is similar to the previous annual rainfall-landslide reports (Premchitt, 1985-1989, Siu, 1990 and Tang, 1991). The report reviews rainfall and landslide occurrence throughout the whole year rather than emphasising any one specific rainstorm. Information has been compiled from many sources throughout the government.

## 2. RAINFALL

### 2.1 The Raingauge System

In the rugged terrain of Hong Kong, the distribution and intensity of rainfall during a storm can vary dramatically with respect to both geography and time. In order to provide sufficient coverage for a meaningful analysis of rainfall distribution the Royal Observatory has installed a network of raingauges which, during 1991, comprised 21 automatic and 116 manual gauges at a total of 97 locations. These raingauges range from a detailed automatic and instantaneous rate-of-rainfall recorder to raingauges which are read manually once every month. The "principal" gauge is located at the Royal Observatory's headquarters in Tsim Sha Tsui, and a continuous rainfall record has been kept at this location since 1884. Weather summaries and rainfall statistics are normally based on the measurements made at this principal location.

Since 1978 the GEO, in cooperation with the RO, has installed a number of automatic raingauges which transmit current rainfall data via telephone lines to the GEO's Emergency Control headquarters. Improvements have been made regularly and at the end of 1991 there were 48 GEO gauges and 21 RO gauges in this system, which provide up-to-date rainfall data every five minutes to the operation rooms of the GEO and RO. These data are also stored on computer tape and diskettes for future reference. The locations of these automatic raingauges (Figure 1) were selected to supplement the network of



other types of raingauge and to provide specific information in areas of particular geotechnical interest. The latest major upgrading of this system was completed in January 1989.

In this report, where a comparison is being made for "daily" rainfalls, the 24-hour maximum rainfall will be used instead of daily rainfall, since the latter is based on an arbitrary fixed period of midnight to midnight which does not necessarily represent the true rainstorm intensity. In addition, when a rainfall amount is quoted without reference to the location of the measurement, this will be the amount measured at the RO headquarters.

## 2.2 Royal Observatory Records

The year's weather for 1991 was summarised by the Royal Observatory in the Monthly Weather Summary for December 1991. Their comments on rainfall are as follows:

"1991 was the tenth driest year in Hong Kong on record. Rainfall at the Royal Observatory was only 1639.1 mm compared to a normal of 2214.3 mm. All months but January and October were drier than normal. In 1991, altogether thirteen tropical cyclones occurred over the South China Sea. Six of them required the hoisting of tropical cyclone signals in Hong Kong. The No. 8 Gale or Storm Signal was hoisted during the approach of Severe Tropical Storm Brendan for the first time since Typhoon Gordon in 1989.

January 1991 was warmer than normal. The weather was generally cloudy and humid. The monthly rainfall of 28.7 mm was 23% above the January normal of 23.4 mm.

February was on the whole warmer and sunnier than normal. The rain that fell during the month was mostly light and patchy. The monthly total rainfall of 8.2 mm was 83% below the February normal of 48.0 mm.

March was warmer and more humid. Rain that fell was mostly associated with late-season surges of the winter monsoon. The first major downpour and thunderstorm of the year occurred on 22 March. However, the monthly total rainfall of 51.5 mm was 23% below the March normal of 66.9 mm.

The weather in April was sunnier and drier. It was the seventh driest April on record. The monthly total rainfall of 34.7 mm was 79% below the April normal of 161.1 mm. Most of the rain fell on the last day of the month and could be attributed to a dissipating tropical cyclone over western Guangdong.

May 1991 was one of the driest and warmest Mays on record. The monthly rainfall of 60.9 mm, the eighth lowest ever, was only about 20% of the May normal.

June 1991 was the seventh warmest June on record. The

monthly total rainfall of 371.1 mm represented about 99% of the June normal of 376.0 mm.

Although three tropical cyclones affected Hong Kong in July, the monthly rainfall of 293.6 mm still fell short of the July normal of 323.5 mm by 9%. Between 23 and 24 July, Severe Tropical Storm Brendan prompted the hoisting of the No. 8 Gale or Storm Signal. At the end of the month, torrential rain associated with an active southwest monsoon resulted in extensive flooding in the Yuen Long area where the floodwater in several villages exceeded one metre in depth.

August was characterised by the passage of Typhoon Fred in the middle of the month. Fred necessitated the hoisting of the Strong Wind Signal No. 3 for nearly 34 hours. The monthly rainfall of 302.3 mm was 23% below the August normal of 391.4 mm.

September was relatively warm and dry. The monthly rainfall of 178.7 mm fell short of the September normal of 299.7 mm by 40%. Over half of the month's rain occurred on the night of 14 September in association with the arrival of a fresh easterly airstream. In contrast, the two passing cyclones, Joel and Nat, were most disappointing, bringing relatively little rain.

In spite of long hours of sunshine and below-normal humidity, October 1991 was a month of abundant rain. The monthly rainfall of 294.3 mm was more than double the October normal of 144.8 mm and was the tenth highest on record for the month of October. With the arrival of an easterly airstream on 14 October, nearly all the rain for this month fell within the 4-day period of 14 to 17 October. Several incidents of flooding were reported over the territory but no serious damage was incurred.

November was on the whole cooler and drier than normal. The monthly rainfall of 2.7 mm was a mere 8% of the November normal of 35.1 mm.

It was comparatively warm in December until the arrival of an exceptionally intense surge of the winter monsoon in the afternoon of 27 December. The monthly total rainfall of 11.8 mm was 57% below the December normal of 27.3 mm."

A summary of heavy rainstorms and resulting landslides in 1991 is given in Table 1. This table shows all periods (mutually exclusive) in which 24-hour rainfall at the RO exceeded 50 mm, and shows in addition the four-day and fifteen-day antecedent rainfalls which occurred prior to these 24-hour periods. For rainfall events not listed in Table 1 no more than two landslides were reported to the GEO during any one day. The five highest 24-hour rainfalls of 1991 were 206 mm on 14 to 15 October, 111.1 mm on 9 June, 93.2 mm on 14 to 15 September, 77.5 mm on 14 to 15 August and 70.6 mm on 23 to 24 July. Other detailed information in Table 1 will be discussed in subsequent sections.

The rainfall data as recorded at the RO, Tsim Sha Tsui, are presented in Figures 2 to 5. Cumulative rainfall since 1 January is shown in Figure 2. Daily and monthly rainfalls are shown in Figures 3 and 4 respectively. Figure 5 shows the hourly rainfall for the highest 24-hour rainfall of 1991.

### 2.3 Geotechnical Engineering Office Records

Rainfall data are also available from the GEO's 48 automatic raingauges. Current rainfall data can be found in the GEO's Rainfall Data Acquisition Centre and past data are kept in the Civil Engineering Library. A location map of the gauges is given in Figure 1.

In addition to the general RO rainstorm summary, data from some of the GEO raingauges are also given for the rainfall events in Table 1. Data are given for the maximum 24-hour, five-hour and one-hour rainfalls recorded anywhere in the Territory on these occasions.

The maximum 24-hour and one-hour rainfalls recorded during 1991 at the RO and at the GEO raingauges during these events were 206 mm and 65 mm respectively.

Appendix B shows hourly rainfall data obtained from GEO's raingauges for the heaviest 24-hour rainstorm during 14 to 15 October.

### 2.4 Rainfall Distribution

Rainfall distribution with time and location can be assessed by referring to detailed GEO and RO records.

Rainfall maps for 24-hour periods, taken from RO records, are shown in Figures 6 and 7 for two heavy rainstorms during 1991. In the storm of 14-15 October the rainfall was concentrated in Kwai Chung, West Kowloon and northwest Hong Kong Island. In the storm of 9 June the rainfall was concentrated in a belt extending from southeast Hong Kong Island to Tsing Yi and Kwai Chung, with subsidiary peaks over Lantau, Junk Bay and Long Harbour.

### 2.5 Warnings Issued by the Royal Observatory

Relevant warnings issued by the RO, and the Landslip Warning jointly issued by the GEO and the RO, are summarised in Table 2.

In 1991 there were 45 days on which Thunderstorm Warnings were issued and sixteen days on which Flood Warnings were issued. Six Tropical Storm Warnings were also issued. The highest Tropical Storm Warning signal number hoisted during the year was No. 8, which was issued on 23 and 24 July during the passage of Severe Tropical Storm Brendan. The No. 3 signal was issued on five occasions during July, August and September. All Tropical Storm Warnings were issued in the period between July and September.

One Landslip Warning was issued on the basis of predetermined rainfall criteria, after consultation between the GEO and the RO, at 2145 hrs on 15 October. A comparison of rainstorm damage in the events of 14 to 16 October with those on all other notable rainfall-landslide days is shown in Table 1.

Of the thirteen reported incidents on 15 and 16 October, the times of occurrence are known for six. Of these six incidents two occurred before the Landslip Warning was issued and four occurred afterwards.

## 2.6 Comparison with Past Rainstorms

Maximum rainfall amounts, of various durations, recorded at the GEO and RO raingauges for heavy rainstorms in 1991 are shown in Table 1 and are compared with the three major rainstorms (May 1982, July 1987 and May 1989) recorded since 1982. The highest 24-hour rainfall recorded at the RO in 1991 was 206 mm, which is slightly higher than the recorded rainfall for the storm of July 1987 but only about 50% of the values recorded in the storms of May 1982 and May 1989. It should be noted that rainfall recorded elsewhere in the Territory in the event of July 1987 was considerably higher than for the event of October 1991. The highest one-hour rainfall for 1991 recorded anywhere in the Territory during one of the events listed in Table 1 was 65 mm.

The return periods of heavy rainstorms in 1991 were estimated for rainfall durations of one hour to fifteen days, and are shown in Table 3. The return periods are generally less than two years. The highest return period is three years, for the two-day rainfall during the event of 14 to 16 October.

In Figure 2, cumulative rainfall for 1991 is shown in comparison with the average (1951-1980), the wettest year (1982) and the driest year (1963) since records began in 1884. The annual cumulative rainfall was 1639.1 mm, which is 74% of the average annual amount of 2214.3 mm. The cumulative rainfall remained below the mean cumulative rainfall for the whole year. Figure 4 shows monthly rainfalls in 1991 in comparison with the recorded maximum (since 1884) and mean (1961-1990) monthly rainfalls. Monthly rainfalls were below the mean monthly rainfalls for all months except January and October. The monthly rainfall in January was slightly above the mean value, whereas in October it was significantly above (double) the mean value.

## 3. LANDSLIDES

### 3.1 Landslide Occurrence in 1991

The numbers of incidents reported to various Government departments during 1991 are shown in Table 4. The numbers of incidents affecting various types of area (building lot, road etc) in Hong Kong, Kowloon and the New Territories are shown in Table 5. The number of major failures affecting different types of areas is also given in this Table. There were, in total, three major landslides and one major subsidence failure in 1991.

A list containing details of all 95 incidents reported to the GEO is provided in Appendix A. Seven of them were of no geotechnical concern as they were caused by flooding, tree fall etc. and were therefore ignored in the statistical analysis below. In total 88 incidents were considered to be of geotechnical concern. A location map for all the reported incidents is shown in drawing No. GCSP 8/8. Selected incidents are illustrated in Plates 1 to 21. More details of these incidents are contained in the incident files of the GEO District Divisions and the 1:5,000 incident location maps housed in the Civil Engineering Library.

Wherever possible, the dates and times of the landslides were ascertained by the geotechnical engineers during site inspection. Some incidents were not reported for several days or weeks and for these it was difficult to determine the exact time of occurrence. Out of 88 incidents, times of occurrence were known to within one day for 65. The daily numbers of these incidents are plotted in Figure 3. Of these 65 incidents, times of occurrence were determined to within one hour for 34.

The highest numbers of reported incidents in a single 24-hour period were nine on 9 June and eight on 15-16 August. However, heavy rain during the three days from 8 to 10 June resulted in a total of fifteen landslides being reported over this period. Likewise, if the events of 14-15 October and 16 October are considered together, the reported landslide total for this period is found to be thirteen. These events are included in Table 1, where the number of incidents reported in the newspapers and by the Fire Services Department are also shown for comparison. For those events not shown in Table 1, there were no more than two reported incidents on any one day of the year.

It is probable that there were other failures which are not known to the GEO, including minor failures of no consequence, such as failures in remote areas, open spaces and construction sites. This should be borne in mind when reading the following landslide statistics.

### 3.2 Areas Affected by Incidents

The numbers of incidents affecting various categories of area, as reported to the GEO, are given in Table 5. It should be noted that one incident may affect more than one area category. Landslide consequences, classified according to failure type, are shown in Table 6.

#### 3.2.1 Squatter Areas

A total of nineteen incidents affected squatter areas. Of these, four occurred on Hong Kong Island, eleven in Kowloon and four in the New Territories. Most of those occurring in Kowloon were in the Kowloon East region.

No failures affecting squatter areas were major. Failures led to the permanent evacuation of 26 huts and the temporary evacuation of seven huts. Most of these evacuations resulted from failures of fill and soil cut slopes and retaining walls. Examples of this type of failure are shown in Plates 7 and 20, and incident MW 10/3 (Plate 20) is discussed in Section 4.12.

Failures tend to occur in squatter areas due to indiscriminate cutting and filling on steep hillsides. Uncontrolled leakage and discharge from water supply, sewage and storm water pipes can also adversely affect slope stability in these areas.

#### 3.2.2 Building Lots

There were nineteen incidents affecting building lots, one of which (K 6/5, a basement excavation and subsidence failure) was major. Four incidents, HK 3/2, K 6/5, ME 7/1 and HK 8/3 are discussed in Sections 4.4,

4.7, 4.8 and 4.10 respectively (Plates 3 and 13). Incidents in this category resulted in the temporary evacuation of eleven buildings in part or in total.

### 3.2.3 Roads and Access

A total of 42 incidents affected roads and access, including footpaths and pedestrian pavements and walkways. Three of these incidents were major. Six incidents, MW 1/1, HK 3/2, HK 6/3, MW 8/3, HK 8/3 and HK 10/5 are discussed in Sections 4.2, 4.4, 4.5, 4.9, 4.10 and 4.11 respectively (Plates 3, 5, 6, 15, 16, 18 and 19).

### 3.2.4 Construction Sites

There was one incident (HK 2/2) affecting a construction site and it was major, resulting in one injury. This incident is discussed in Section 4.3 (Plates 1 and 2).

### 3.2.5 Catchwaters and Reservoirs

Incidents affecting catchwaters and reservoirs were dealt with separately by the Water Supplies Department. There were fifteen reported cases of slope failure, twelve affecting catchwaters and three affecting access roads. Of these fifteen cases, seven reportedly occurred on 24 July.

### 3.2.6 Country Parks and Open Areas

Fifteen incidents affecting Country Parks and open areas were reported directly to the GEO, none of which were major. The Agriculture and Fisheries Department recorded no additional incidents in the Country Parks.

## 3.3 Types of Incidents

The incidents inspected by the GEO have been classified into six types of failure and the number of each type is shown in Table 7. Damage resulting from these types of failure is summarised in Table 6.

### 3.3.1 Fill Slopes

There were nine fill slope failures, forming 10% of all incidents reported. One of these failures was major: incident HK 3/2 (Section 4.4, Plate 3) occurred when a water main within a fill slope ruptured.

### 3.3.2 Cut Slopes

There were 49 cut slope failures, forming 56% of all incidents reported. These failures were classified further according to types of material, ie: soil, soil/rock and rock cut slope failures.

There were 31 reported incidents in soil cut slopes, none of which were

major. Examples are shown in Plates 4, 7, 11, 14, 17, 18 and 19.

There were six soil/rock cut slope failures reported, one of which was major: incident ME 6/1 (Section 4.6, Plates 9 and 10). Other failures of this type are shown in Plates 12, 15 and 16.

Twelve failures in rock cut slopes were reported, one of which was major: incident HK 2/2 (Section 4.3, Plates 1 and 2). Another example of a failure of this type is shown in Plates 5 and 6 (Incident HK 6/3, Section 4.5).

### 3.3.3 Retaining Walls

There were five reported incidents related to retaining walls or walls having earth materials piled up behind them, forming 6% of all incidents reported. None of these failures were major. Examples are shown in Plates 8, 13 and 20.

### 3.3.4 Natural Slopes

Nine natural slope failures were reported, forming 10% of all incidents. None of these failures were major. Plate 21 (Incident HK 10/12) shows a failure of this type.

### 3.3.5 Rock and Boulder Falls

There were thirteen cases of rock and boulder falls, forming 15% of all incidents reported. None of these failures were major.

### 3.3.6 Other Failures

There are incidents which cannot be classified according to the above categories. Three subsidence failures were reported, forming 3% of all incidents. One of these incidents was major (Incident K 6/5, Section 4.7).

## 3.4 Rainfall-Landslide Relationships

A simple relationship between rainfall and landslides is demonstrated by the plot of daily rainfall and daily number of landslide occurrences through 1991 (Figure 3). The majority of recorded landslides occurred at times of heavy rainfall. The geographical distribution of rainfall in the heavy storms also had a considerable influence on the occurrence of landslides in various areas. Figures 6 and 7 show the location of landslides for which dates of occurrence are known (see Section 3.1), imposed on the 24-hour rainfall maps for the corresponding time period for the events on 9 June and 14 to 15 October. These Figures indicate that all the landslides that could be related to one of these events occurred in areas where 50 mm or more of rainfall were recorded in 24 hours, with over 50% of these incidents occurring in areas where the 24 hour rainfall was 100 mm or more.

More detailed and comprehensive discussions on rainfall-landslide

relationships and failure mechanisms can be found in Brand et al (1984) and Premchitt (1991), where extensive data from the past twenty years have been analysed.

#### 4. NOTABLE INCIDENTS

##### 4.1 Introduction

Out of the 95 incidents reported to the GEO, eleven are discussed in more detail in this section and are presented in chronological order. The nature of the incident is referenced under the caption for each incident. These incidents have been selected mainly on the basis of size, consequence and technical interest.

##### 4.2 Incident MW 1/1, Milestone 6, Castle Peak Road

(Date: 18 January 1991. Failure of a rock cut slope resulting in the partial blockage and subsequent closure of one lane of the road.)

The rock cut slope adjoining Castle Peak Road here is about 5 m high with a slope of over 70°, and comprises slightly to moderately decomposed granite with weathered joints. The failure involved a rock wedge of about 1.5 cu m, and is thought to have been caused by groundwater movement and subsequent weathering of unfavourably oriented rock joints. The failure resulted in the partial blockage of one lane of Castle Peak Road. Inspection revealed two similar potentially unstable rock wedges close to the failure scar.

##### 4.3 Incident HK 2/2, Shau Kei Wan East Housing Development Site

(Date: 28 February 1991. Major failure of a disused rock quarry face overlooking Hoi Ching Street, Plates 1 and 2.)

The landslide occurred at the crest of a 50 m high disused quarry face. Approximately 2,000 cu m of rock was dislodged and fell onto Housing Department Works Area 3CY situated in the base of the quarry. Six container offices and four vehicles were damaged and one man was slightly injured by a rebounding rock fragment. At the time of the failure blasting was taking place at the crest of the quarry as part of the site preparation works for the Shau Kei Wan East Housing Development Site, and the landslide is reported to have occurred within one minute of a blast that was situated within 3 m of the failure plane. GEO Report SPR 5/91 (Evans and Irfan, 1991) describes this landslide in detail and concludes that the failure was a planar slide on an unfavourably oriented discontinuity and was triggered by the blasting at the quarry crest. Rainfall was not a factor in this landslide.

##### 4.4 Incident HK 3/2, Stanley Gap Road

(Date: 27 March 1991. Major failure of a fill slope resulting in road blockage, Plate 3.)

The rupture of a water main in a fill slope caused a major failure involving approximately 150 cu m of silt and rock fill. An 8 m by 3 m section of Stanley Gap Road at the crest of the slope collapsed, while a further section of road about 6 m by 3 m subsided. At the toe of the failure, the playground of a residential building was affected. Rainfall was not



considered to be a factor in this incident.

4.5 Incident HK 6/3, Harlech Road

(Date: 9 June 1991. Failure of a rock cut slope resulting in the blockage of one lane of the road, Plates 5 and 6.)

Failure of a rock cut slope during rain led to approximately 1.5 cu m of weathered rock collapsing onto Harlech Road, blocking one lane. The failure was probably caused by the erosion of weathered unfavourably oriented rock joints.

4.6 Incident ME 6/1, Bride's Pool Road, North District, the NT.

(Date: 12 June 1991. Major failure of a soil and rock cut slope, Plates 9 and 10.)

Erosion and infiltration caused a major failure (approximately 70 cu m) in a soil and rock cut slope. A pedestrian pavement and a rural road were affected.

4.7 Incident K 6/5, Mau Lam Street, Jordan

(Date: 12 June 1991. Major subsidence failure resulting in the temporary closure of Mau Lam Street and the temporary evacuation of two buildings.)

Local failures in temporarily exposed ground in a basement excavation are thought to have formed voids behind the basement lateral support, with migration of the voids to the ground surface causing subsidence. GEO Technical Note TN 1/92 (Chan, 1992) describes this incident in detail.

4.8 Incident ME 7/1, Ha Wo Che Village, Shatin

(Date: 23 July 1991. Failure of a retaining wall and loose fill, Plate 13.)

Infiltration during heavy rain associated with Typhoon Brendan led to the failure of a brick retaining wall, concrete paving and associated loose backfill. Typhoon Signal No 8 was hoisted at the time. Approximately 20 cu m of material was involved and the retaining wall was displaced about 1 m downslope and was left overhanging a steep slope. A closure order was subsequently placed on parts of two village houses at the toe of the slope while emergency works were carried out under BO Section 27 A(4).

4.9 Incident MW 8/3, Milestone 6, Castle Peak Road

(Date: 15 August 1991. Failure of a soil and rock cut slope, resulting in the blockage and closure of Castle Peak Road, Plates 15 and 16.)

Infiltration during heavy rain associated with Typhoon Fred, and subsequent seepage, caused curvi-linear/planar failure of a rock cut slope comprising granite with moderately to highly decomposed joints. The cut slope adjoining Castle Peak Road here is about 15 m high with a slope greater than 70° and with a thin capping of residual soil. The failure involved approximately 30 cu m of soil and rock which collapsed onto Castle Peak Road,

blocking two lanes and the adjoining footpath. In addition, the failure crest came within one metre of an electricity power pole. A boulder estimated to weigh over 5 tonnes was left overhanging the upper part of the slip.

4.10 Incident HK 8/3, Repulse Bay Road

(Date: 16 August 1991. Failure of a natural slope resulting in the closure of one lane of the road and the serving of a Type 1 D-Notice on the owner.)

A considerable storm-water discharge from a broken connection to a manhole at the slope crest led to a washout in a natural slope in residual soil and completely decomposed volcanics. Some of the material may have been loose fill resulting from previous construction activities. Approximately 40 cu m of soil collapsed, resulting in the closure of one lane of Repulse Bay Road at the slope toe. A column footing supporting the podium of No. 5 Repulse Bay Road was exposed and a Type 1 D-Notice was served on the owner.

4.11 Incident HK 10/5, Chai Wan Road

(Date: unknown. Failure of a soil cut slope, blocking a pedestrian pavement, Plates 18 and 19.)

Approximately 10 cu m of highly to completely weathered granite failed and blocked the pedestrian pavement. Seepage of water was observed from a natural pipehole in the upper part of the slip scar. It is probable that the failure was induced by groundwater movement.

4.12 Incident MW 10/3, Lei Uk Tsuen, Shatin

(Date: 15 October 1991. Failure of a masonry rubble retaining wall, affecting squatters, Plate 20.)

Infiltration of rainwater caused the failure of a 1.5 m length of a 3.5 m high by 7.5 m long masonry rubble retaining wall and associated loose soil backfill. The failure involved about 3 cu m of material which collapsed into the back lane of two huts, which were temporarily evacuated as inspection showed that the remaining parts of the wall were also showing signs of distress.

5. CONCLUSIONS

Rainfall during 1991 was very low, the year being the tenth driest on record. The total rainfall in 1991 was 74% of the yearly average of 2214.3 mm.

One Landslide Warning was issued in 1991, during the heavy rainstorm of 15 to 16 October. There were 88 landslides and related incidents reported to the GEO District Divisions during the year and the damage resulting from these incidents may be summarised as follows: 33 squatter huts were evacuated (seven temporarily and 26 permanently), eleven buildings were temporarily evacuated, and 21 sections of road/access were blocked.

The relatively low number of landslides in 1991, and the lack of serious landslide damage, can be directly related to the exceptionally low rainfall.

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Table 1 - Rainfall-Landslide Events in 1991 with 24-hour Rainfall Greater than 50 mm

Date <sup>(1)</sup> of Event	Maximum Rainfall (mm)								Landslide Consequences				
	Royal Observatory					GEO Raingauges <sup>(2)</sup>			Number of Landslides			Persons Killed or Injured	Number Huts Evacuated Permanently
	24-hr	5-hr	1-hr	Antecedent		24-hr	5-hr	1-hr	GEO <sup>(3)</sup>	Newspaper <sup>(4)</sup>	FSD		
				4-day	15-day								
14-15/10/91 <sup>(5)</sup>	206.0	71.3	30.5	15.7	15.7	195.5	70.0	39.5	8	-	-	-	1
9/6/91	111.1	64.6	23.5	50.5	56.9	180.5	88.0	52.5	9	-	-	-	2
14-15/9/91	93.2	64.9	29.2	13.7	40.3	195.0	113.5	65.0	1	-	-	-	-
14-15/8/91	77.5	41.7	27.3	31.6	102.2	92.5	48.0	31.0	5	-	1	-	-
23-24/7/91	70.6	31.1	10.4	69.7	130.4	148.0	64.5	18.0	5	1	-	-	2
10/6/91	66.8	33.9	17.5	161.6	167.8	106.0	46.0	30.0	2	-	-	-	-
16/10/91 <sup>(5)</sup>	66.5	34.6	14.3	222.5	222.5	185.0	90.0	42.0	5	-	-	-	1
15-16/8/91	62.2	41.2	18.1	106.7	127.9	94.0	53.5	28.5	7	-	-	-	-
31/7/91	59.3	50.9	23.0	13.5	154.2	96.0	70.0	40.5	1	-	-	-	-
8/6/91	50.5	46.9	31.4	NIL	6.5	72.5	67.5	47.5	4	-	-	-	4
Recent Major Rainstorms (For Comparison Only)													
29/5/82	394	153	44	1	11	430	237	111	551	498	15	48	1153
29-30/7/87	183	71	38	147	343	314	169	73	111	36	3	3	49
20-21/5/89	388	149	37	28	42	566	224	51	340	100	3	5	199
Notes : (1) The events are arranged in order of magnitude of 24-hour rainfall at the Royal Observatory, Tsim Sha Tsui. (2) The maxima are selected from the 48 GEO Raingauges for the same rainstorm period. (3) For the rest of 1991, no more than 2 incidents were reported to GEO on any one day. (4) Newspapers searched are South China Morning Post and Hong Kong Standard. (5) Landslip warnings were issued for these events.													
Abbreviation : GEO = Geotechnical Engineering Office; FSD = Fire Services Department; RO = Royal Observatory													

Table 2 - Type and Date of Warnings Issued by the Royal Observatory in 1991

Month	Monthly Rainfall (mm)	Dates of Warnings			
		Thunderstorm	Flood	*Landslip	Tropical Storm
January	28.7	-	-	-	-
February	8.2	-	-	-	-
March	51.5	22,31	-	-	-
April	34.7	30	-	-	-
May	60.9	1,15,16,27,29	15	-	-
June	371.7	8-11,18-23	8,9,20,22	-	-
July	293.6	3,13,14,19-21,25,29-31	31	-	12(signals no. 1-3 Zeke), 18-19(signals no. 1-3 Amy), 22-24(signals no. 1-8 Brendan)
August	302.3	9-14,19-22,24-26	11,12,15,21,25	-	13-14(signals no. 1-3 Fred)
September	178.7	4,12,14,15	12,14,15	-	3-4(signals no. 1-3 Joel), 16,23,29(signal no.1 Nat)
October	294.3	-	15,16	15-16	-
November	2.7	-	-	-	-
December	11.8	-	-	-	-
Total	1639.1	45	16	1	6
Legend : * Landslip warnings were issued after consultation between GEO & RO					

Table 3 - Maximum Rainfalls During 1991 and Estimated Return Periods

Duration	* Rainfall (mm)	Ending Time		† Estimated Return Period (Year)
		Date	Hours	
1 hour	31.4	8/6	1300	< 2
5 hours	71.3	15/10	0700	< 2
12 hours	125.8	15/10	1000	< 2
24 hours	206	15/10	2300	2
2 days	283.6	16/10	2100	3
4 days	293.3	17/10	2200	< 2
7 days	293.9	20/10	0100	< 2
15 days	327.8	22/6	1600	< 2
Legend : * Rainfall at Royal Observatory, Tsim Sha Tsui † Gumbel equation, Peterson & Kwong (1981)				

Table 4 - Number of Incidents Reported to Various Offices/Departments During 1991

Office/Department	Total Number	Types of Incident		
		Landslide	Flooding	Others
Agriculture & Fisheries Department	-	-	-	-
Architectural Services Department	2	1	-	1
Drainage Services Department	9	-	9	-
Fire Services Department	4	2	1	1
Geotechnical Engineering Office, CED	95	85	2	8
Highways Department	37	29*	-	8
Housing Department	4	4	-	-
Water Supplies Department	15	15	-	-
Legend : * Landslides reported to HyD were referred to GEO and are included in the GEO incidents				



Table 5 - Number of Incidents Reported to GEO Affecting Different Areas in 1991

Affected Area	Hong Kong	Kowloon	New Territories	All Districts
Squatters	4	11	4	19
Building Lots	9	1(1)	9	19(1)
Roads / Access	25(1)	3(1)	14(1)	42(3)
Construction Sites	1(1)	0	0	1(1)
Country Park	2	0	0	2
Open Areas	6	3	4	13
TOTAL	47(2)	18(2)	31(1)	96(5)
Legend :				
( )      Number of major failures				
Notes :				
(1)    One incident may affect more than one type of area.				
(2)    Incidents of no geotechnical concerned (e.g. tree falling, flooding) were ignored.				

Table 6 - Consequence Related to Type of Failure in 1991

Type of Failure		No. of Huts Evacuated		Closure of Part of Building	Road / Access Blocked	Injury
		Permanent	Temporary			
Fill Slope		14	0	0	1	0
Cut Slope	Soil	7	2	3	4	0
	Soil/Rock	0	0	0	2	0
	Rock	0	0	1	7	1
Natural Slope		4	0	2	1	0
Retaining Wall		0	3	3	2	0
Rock / Boulder Fall		1	0	0	4	0
Others (Subsidence etc.)		0	2	2	1	0
TOTAL		26	7	11	22	1

Table 7 - Number of Incidents Reported to GEO During 1991 Classified by Type of Failure

Type of Failure		Number	Percentage
Fill Slope		9(1)	10
Cut Slope	Soil	31	35
	Soil / Rock	6(1)	7
	Rock	12(1)	14
Retaining Wall		5	6
Natural Slope		9	10
Rock / Boulder Fall		13	15
Others (Subsidence etc.)		3(1)	3
TOTAL		88(4)	100
<b>Legend :</b> ( )      Number of major failures			
<b>Note :</b> Incidents of no geotechnical concern (e.g. tree falling, flooding) were ignored.			

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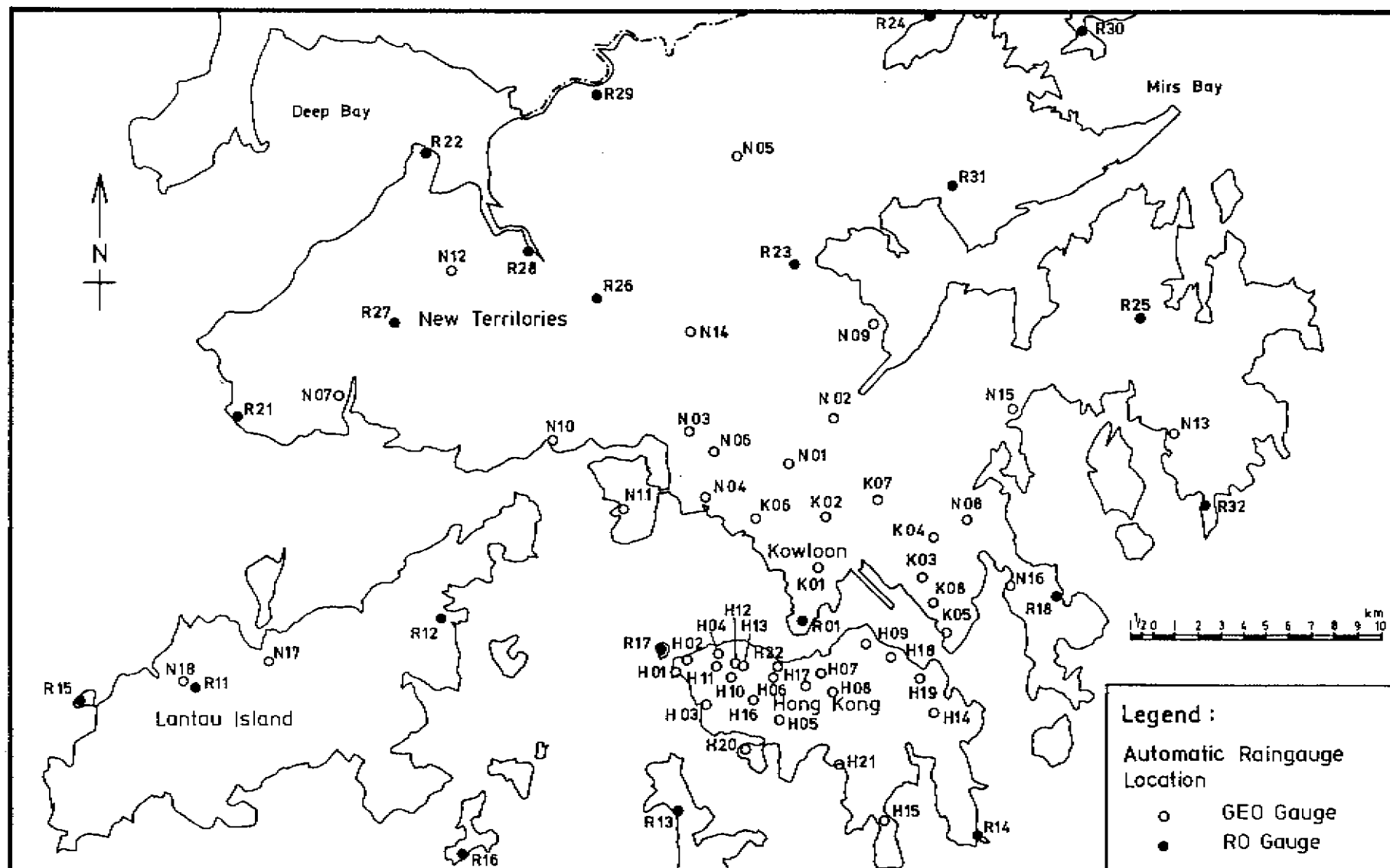


Figure 1 - Location of GEO and RO Automatic Raingauges

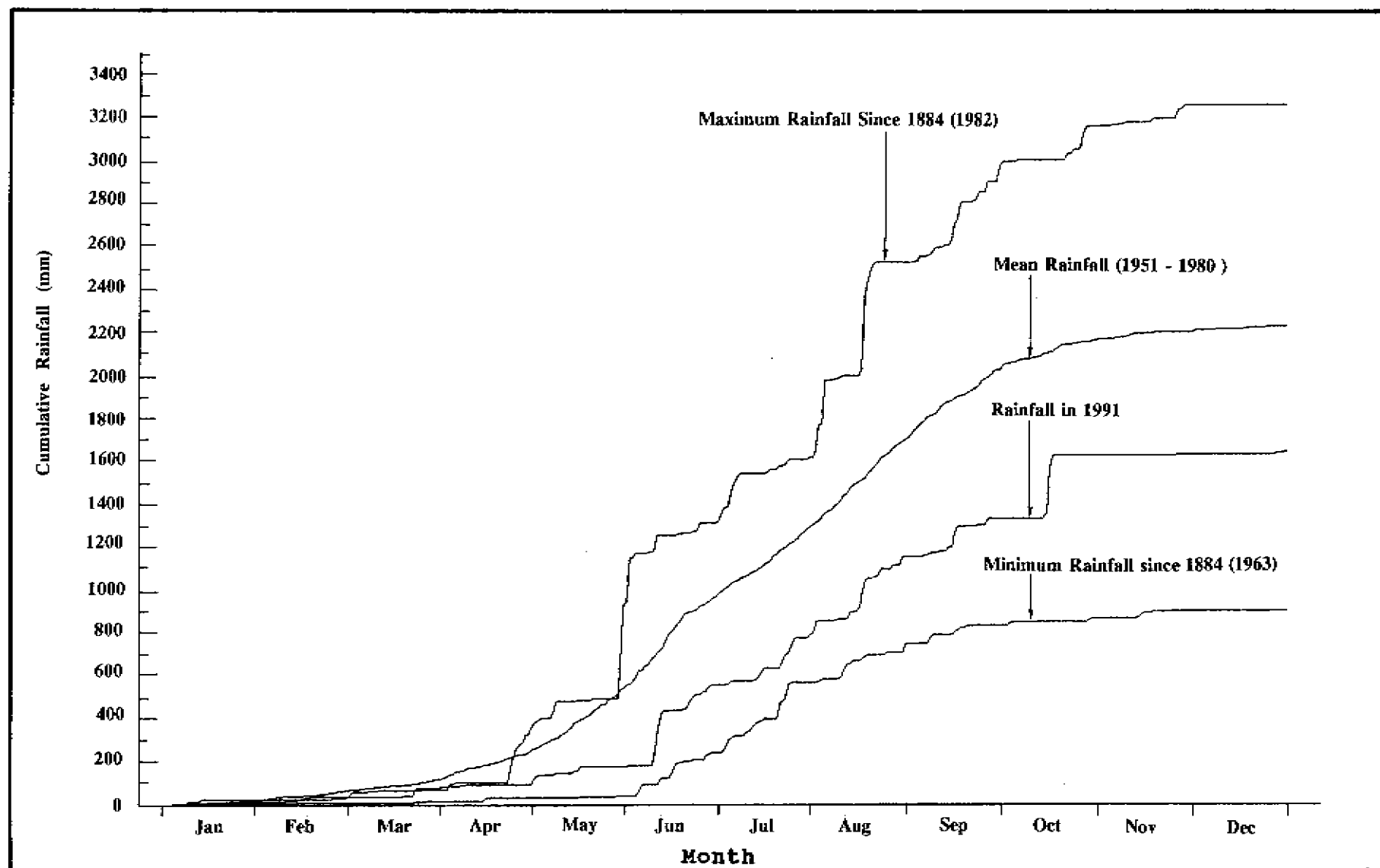


Figure 2 - Cumulative Rainfall for 1991 and the Recorded Maximum, Mean and Minimum Cumulative Rainfalls

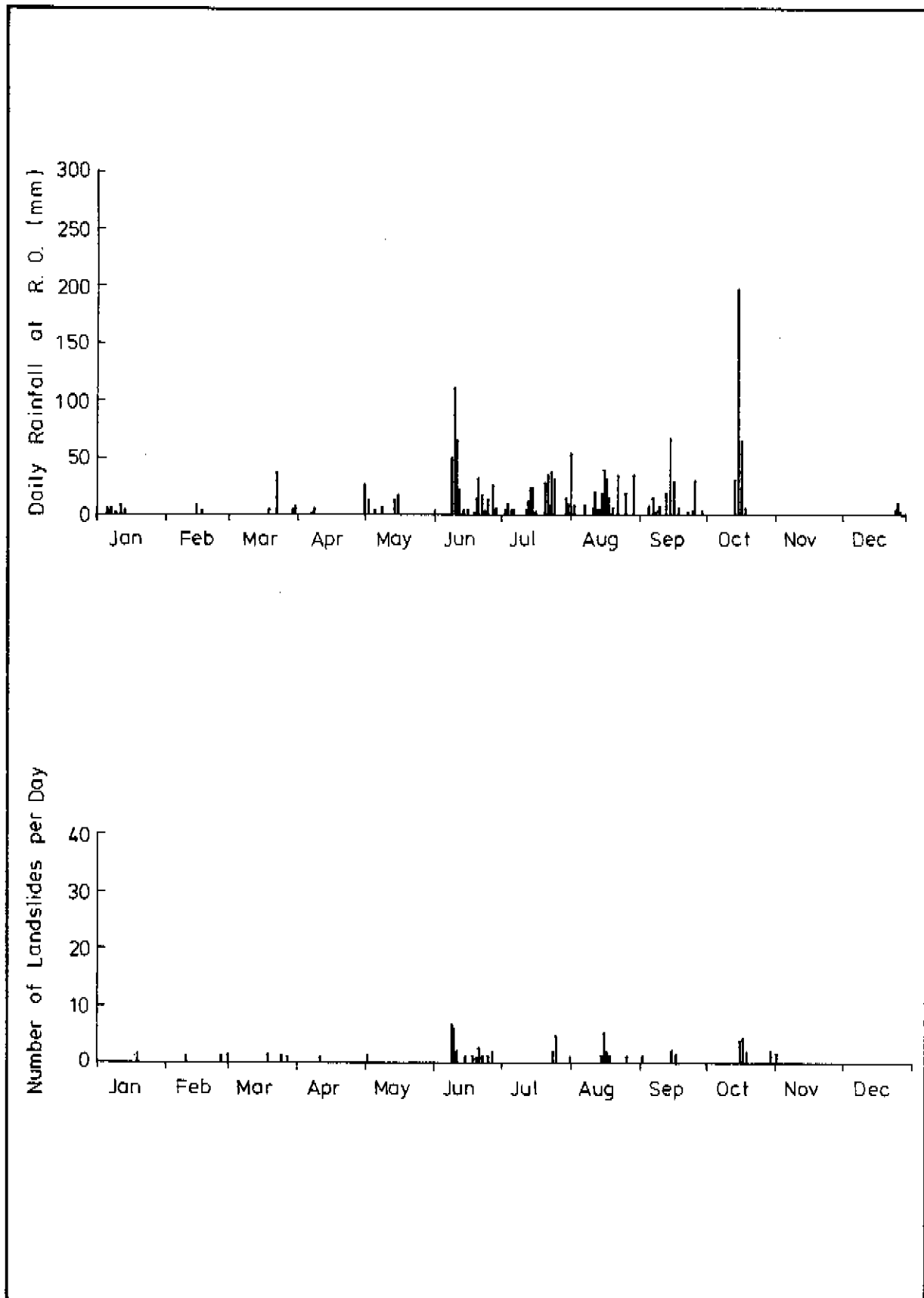


Figure 3 - Daily Rainfall and Distribution of Number of Landslides During 1991

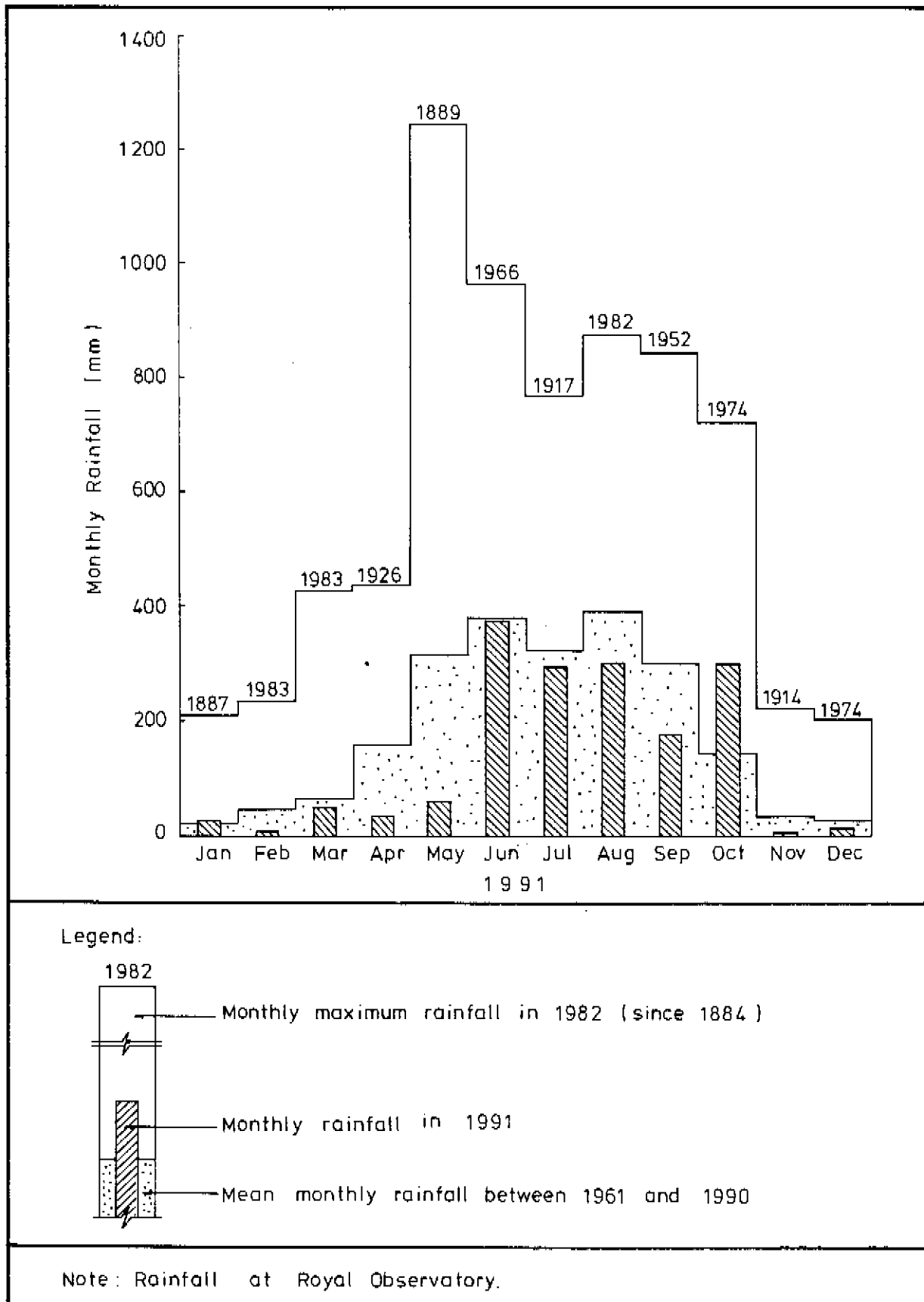


Figure 4 - Monthly Rainfalls in 1991 in Comparison with Recorded Maximum and Mean Monthly Rainfalls



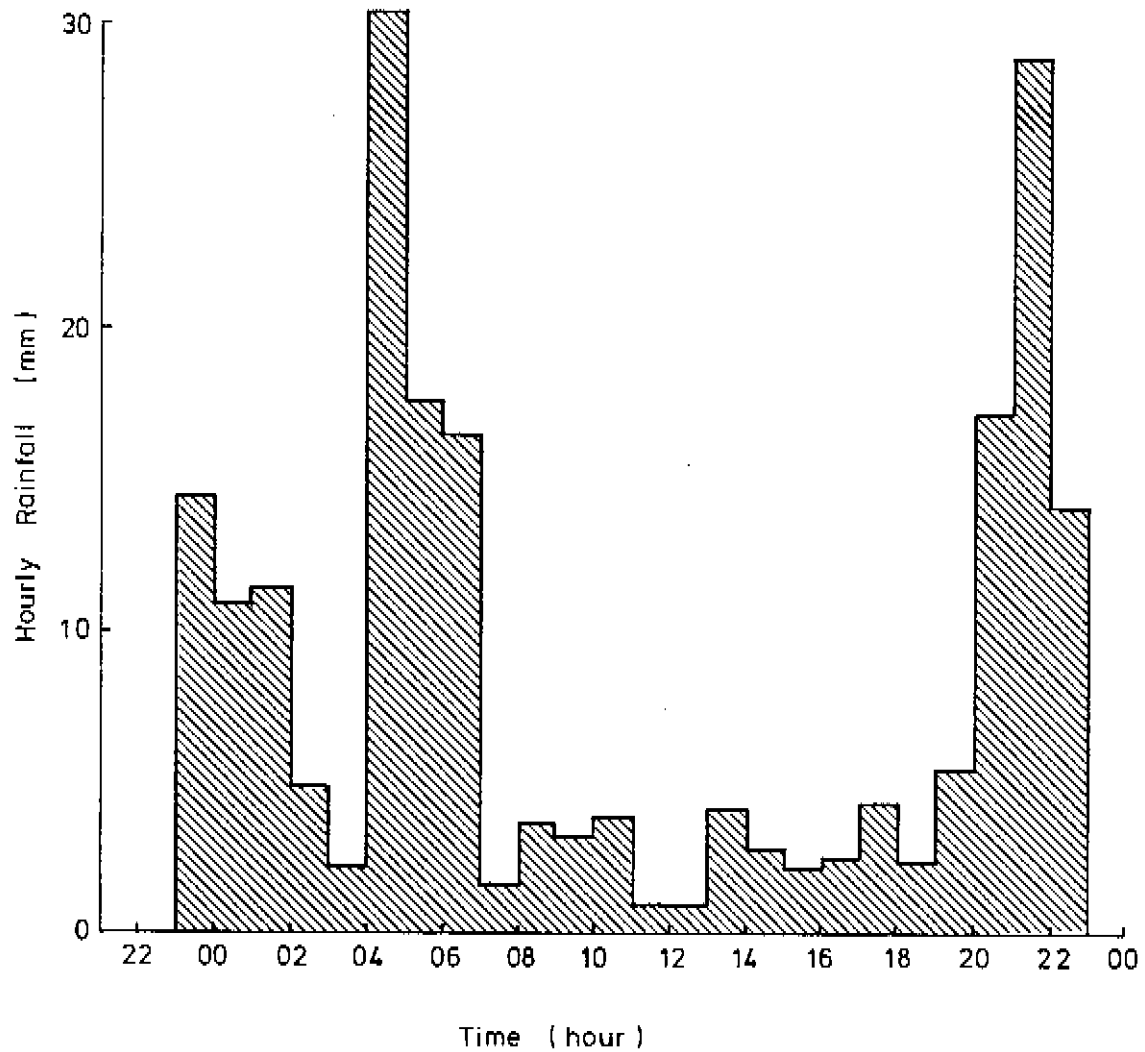


Figure 5 - Histogram of Hourly Rainfall at the Royal Observatory for the Highest 24-hour Rainfall in 1991 (14 to 15 October)

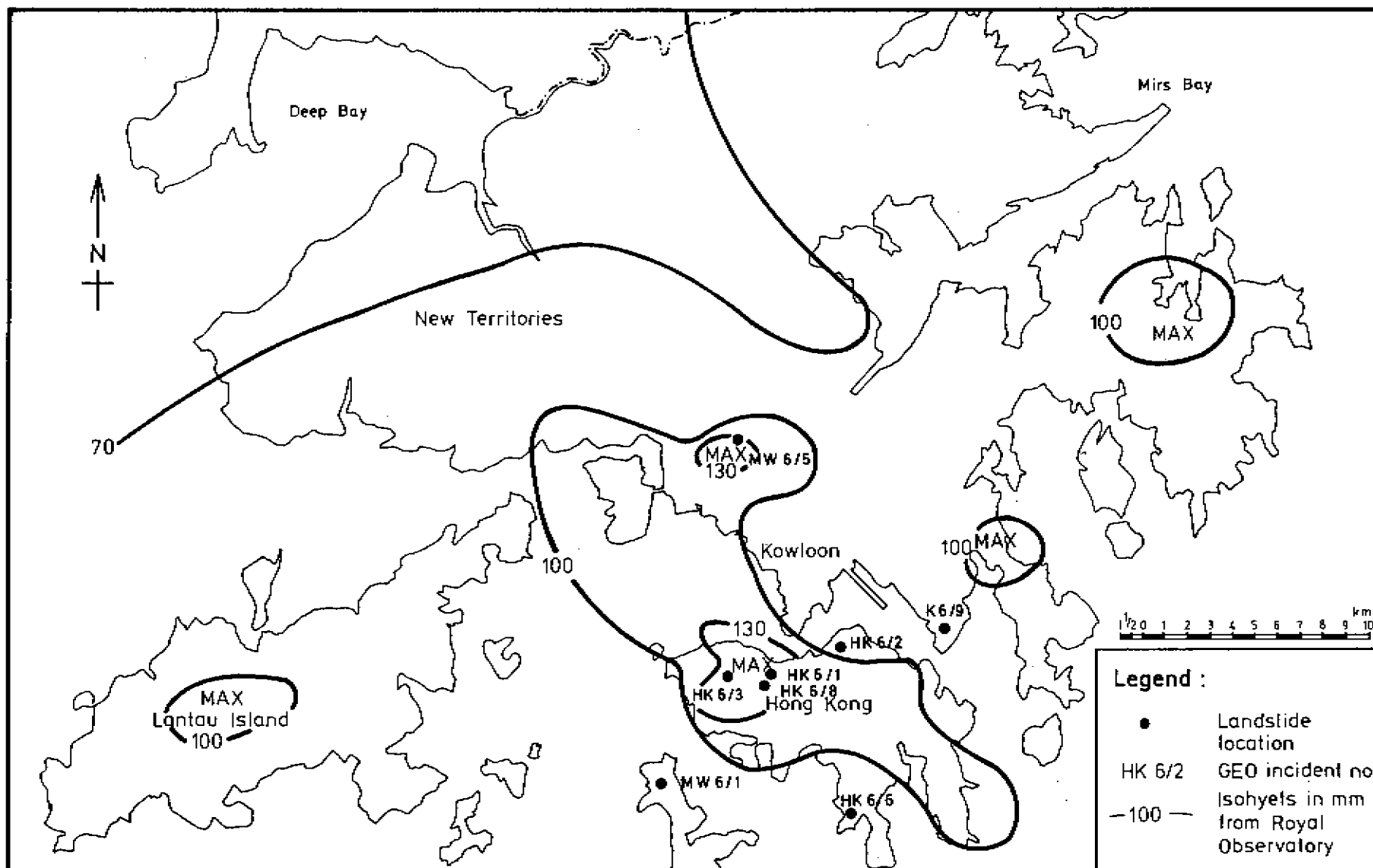


Figure 6 - 24-hour Rainfall Distribution Ending at 2400 hrs on 9th June 1991 and Locations of GEO Incidents

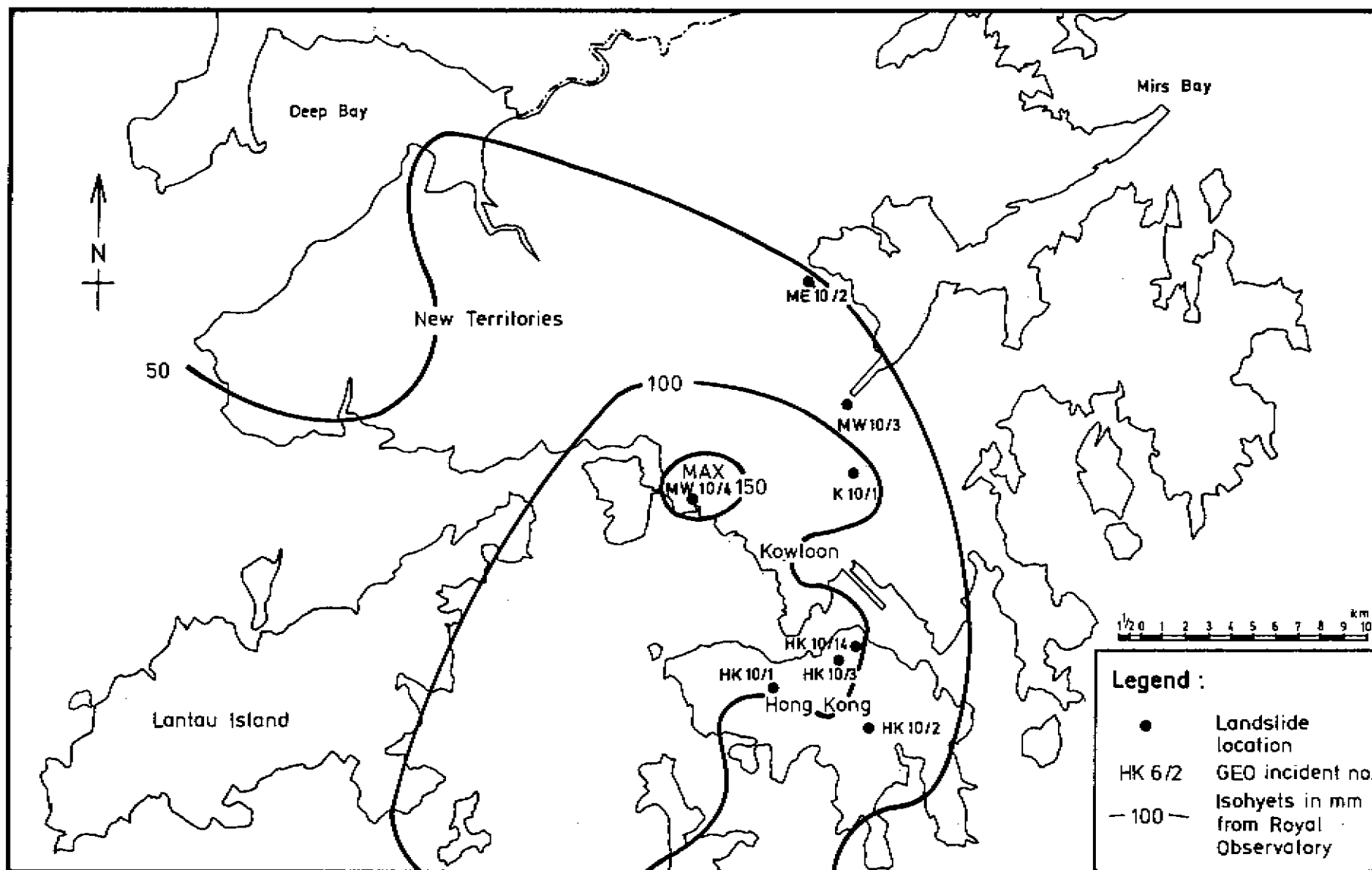


Figure 7 - 24-hour Rainfall Distribution Ending at 2300 hrs on 15th October 1991 and Locations of GEO Incidents

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Plate 1 : Negative No. I 9100614

Taken on : 5-3-91



Plate 2 : Negative No. I 9100615

Taken on : 5-3-91

Description : Major failure of a disused rock quarry face overlooking Hoi Ching Street on 28 February 1991 (about 2,000 cu m).

Plates 1 & 2 - Shau Kei Wan East Housing Development Site (Incident HK 2/2)





Plate 3 : Negative No. I 9103008

Taken on : 27-3-91

Description : Major failure of a fill slope on 27 March 1991 blocking both road lanes (about 150 cu m).

Plate 3 - Stanley Gap Road (Incident HK 3/2)



Plate 4 : Negative No. MW 9111105

Taken on : 8-6-91

Description : Failure of chunam on a soil cut slope on 8 June 1991.

Plate 4 - No. 14 Yung Shue Long New Village, Lamma Island (Incident MW 6/6)





Plate 5 : Negative No. I 9112104

Taken on : 10-6-91



Plate 6 : Negative No. I 9112105

Taken on : 10-6-91

Description : Failure of a rock cut slope on 9 June 1991, blocking one road lane.

Plates 5 & 6 - Harlech Road, Victoria Gap (Incident HK 6/3)



Plate 7 : Negative No. ME 9116808

Taken on : 10-6-91

Description : Failure of a soil cut slope on 9 June 1991 leading to the permanent evacuation of two squatter huts.

Plate 7 - Ling Nam San Tsuen, Kwun Tong, hut RKT/12A/W/243 (Incident K 6/1)





Plate 8 : Negative No. MW 9110202

Taken on : 10-6-91

Description : Failure of a masonry retaining wall on 10 June 1991, affecting squatter huts and a public footpath.

Plate 8 - No. 16, Ka Loon Tsuen, MS 14½ Castle Peak Road (Incident MW 6/3)



Plate 9 : Negative No. ME 9117803

Taken on : 14-6-91



Plate 10 : Negative No. ME 9117804

Taken on : 14-6-91

Description : Major failure of a soil and rock cut slope on 12 June 1991 affecting a rural road.

Plates 9 & 10 - Bride's Pool Road, North District, the New Territories  
(Incident ME 6/1)





Plate 11 : Negative No. MW 9111901

Taken on : Unknown

Description : Failure of a soil cut slope on 20 June 1991 resulting in the partial blockage of a back lane.

Plate 11 - 72 Po Wah Yuen, Lamma Island (Incident MW 6/10)



Plate 12 : Negative No. MW 9111904

Taken on : Unknown

Description : Failure of a soil and rock cut slope on 20 June 1991 resulting in the blockage of a back lane.

Plate 12 - 84A Tai Peng New Village, Lamma Island (Incident MW 6/11)



Plate 13 : Negative No. ME 9120804

Taken on : 23-7-91

Description : Failure of a retaining wall on 23 July 1991 resulting in the temporary evacuation of two village houses.

Plate 13 - No. 143, Ha Wo Che Village, Shatin (Incident ME 7/1)





Plate 14 : Negative No. MW 9113312

Taken on : 26-7-91

Description : Failure of a soil cut slope (date unknown) resulting in the closure of a pedestrian pavement.

Plate 14 - Shek Li Street, Kwai Chung (Incident MW 7/4)





Plate 15 : Negative No. MW 9114107

Taken on : 15-8-91



Plate 16 : Negative No. MW 9114108

Taken on : 15-8-91

Description : Failure of a soil and rock cut slope on 15 August 1991 resulting in the blockage of two road lanes.

Plates 15 & 16 - MS 6, Castle Peak Road (Incident MW 8/3)



Plate 17 : Negative No. ME 9126207

Taken on : 24-9-91

Description : Failure of a soil cut slope on 15 September 1991 affecting an access road.

Plate 17 - Slope in front of Lot 161, Sheung Sze Wan (Incident ME 9/1)





Plate 18 : Negative No. I 9127601

Taken on : 17-10-91



Plate 19 : Negative No. I 9127608

Taken on : 17-10-91

Description : Failure of a soil cut slope (date unknown) blocking a pedestrian pavement.

Plates 18 & 19 - Chai Wan Road, Shau Kei Wan (Incident HK 10/5)



Plate 20 : Negative No. MW 9119002

Taken on : 15-10-91

Description : Failure of a masonry retaining wall on 15 October 1991 resulting in the temporary evacuation of two huts.

Plate 20 - House 1A, Lei Uk Tsuen, Shatin (Incident MW 10/3)





Plate 21 : Negative No. I 9130023

Taken on : 8-11-91

Description : Failure of a natural slope on 28 October 1991, affecting a pedestrian pavement.

Plate 21 - 38 Cloud View Road, North Point (Incident HK 10/12)

APPENDIX A  
LIST OF INCIDENTS  
REPORTED TO GEO

APPENDIX A

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Table A1 – List of Incidents on Hong Kong Island Reported to GEO in 1991 (Sheet 1 of 5)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
HK 1/1	Underneath elevated road deck outside No.8 Broadwood Road, Happy Valley.	2/1	HyD		Soil/rock cut slope	Minor	Access		Washout
HK 2/1	J/O Peak Road and Guildford Road, Magazine Gap.	9/2	W.S.D.	9/2 am	Soil cut slope	Minor	Highway bridge		Washout
HK 2/2	Shau Kei Wan East Housing Development Site. Disused quarry face overlooking Hoi Ching Street	28/2	F.S.D.	28/2 13:15	Rock cut slope	Major	Construction site	Temporary evacuation of p.m. school. One person injured.	Failure induced by blasting.
HK 3/1	Tai Wan Sun Tsuen, Pokfulam Road, Pok Fu Lam	14/3	DO/HKS		Natural slope	Minor	Squatter	One hut permanently evacuated	Erosion and subsidence
HK 3/2	Stanley Gap Road near Stanley Village Road / Tai Tam Road Junction	27/3	H/HK	27/3 00:30	Fill slope	Major	Road, playground of a residential building	Two lanes of road blocked	
HK 5/1	Sai Wan Ho Ambulance Depot	1/5	F.S.D.	1/5 c.08:30	Rock/boulder fall	Minor	Open space		
HK 6/1	64 MacDonnell Road, Central, above R.Wall No. 11SW-B/R348	10/6	Resident	8/6-9/6	Fill slope	Minor	Building Lot		Washout
HK 6/2	22 Cloud View Road Islamic School, North Point	10/6	DO/E	8/6-9/6	Rock/boulder fall	Minor	Building Lot		
HK 6/3	Harlech Road, Victoria Gap	10/6	HyD/HK	9/6	Rock cut slope	Minor	Road	One lane of road blocked	
HK 6/4	54 Kong Sin Wan Village, Telegraph Bay	10/6	DO/HKS	8/6	Soil cut slope	Minor	Squatters		



Table A1 – List of Incidents on Hong Kong Island Reported to GEO in 1991 (Sheet 2 of 5)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
HK 6/5	272 Kung Man Village, Mt Davis	10/6	Resident	8/6	Soil cut slope	Minor	Squatters		Collapse of chunam
HK 6/6	Chung Hom Kok Road, Chung Hom Kok	12/6	HyD/HK	9/6 a.m.	Rock cut slope	Minor	Road	One lane of road blocked	
HK 6/7	86 Telegraph Bay, Pok Fu Lam	11/6	DO/HKS	8/6 24:00	Natural slope	Minor	Squatters	Three squatter huts permanently evacuated	Scouring stream course
HK 6/8	12 Severn Road, Mount Gough. (11SW-D/C 501)	10/6	HyD/HK	9/6 a.m.	Rock cut slope	Minor	Building Lot		
HK 6/9	Opposite 34 Island Road, Repulse Bay.	20/6	HyD/HKS	19/6 24:00	Soil/rock cut slope	Minor	Road		
HK 6/10	Yee King Road, North Point. (11SE-A/C 214)	25/6	HyD	24/6-25/6	Free-standing wall	Minor	Pedestrian pavement		No geotechnical concern
HK 6/11	Tai Hang Road, Jardine's Lookout, near 7H10 (11SE-C/C 54)	27/6	HyD	26/6-27/6	Rock/boulder fall	Minor	Road	One lane of road closed for repairs	
HK 7/1	Tai Tam Road, Chai Wan (between catchpit TT87 & TT88) (11SE-D/C 133)	3/7	HyD	End of June	Soil cut slope	Minor	Road	Partial blockage of the road side gully	
HK 7/2	4,7,& 19 Shek O Road, Shek O	17/7	Resident		Fill slope	Minor	Access		

Table A1 – List of Incidents on Hong Kong Island Reported to GEO in 1991 (Sheet 3 of 5)

Incident No.	Location	Call Received		Date (Time)	Failure		Area Affected	Consequence	Remarks
		Date	From		Type	Scale			
HK 7/3	9–31 Peacock Road Carpark, North Point, at the rear of Ming Yuen Mansion	24/7	BOO	24/7 08:00	Rock cut slope	Minor	Carpark	One taxi damaged	
HK 7/4	50 Kai Yuen Terrace, North Point	24/7	Police	23/7– 24/7	Fallen trees	Minor	Buildings		No geotechnical concern
HK 8/1	Access to 11 Repulse Bay Road	18/8	HyD/HK	15/8 09:00	Flooding of catchpit & road	Minor	Private access		No geotechnical concern
HK 8/2	19 Blue Pool Road, Happy Valley	18/8	Police	15/8	Soil cut slope	Minor	Building lot		Washout
HK 8/3	South of 5 Repulse Bay Road	16/8	HyD/HK	16/8 09:30	Natural slope	Minor	Building lot, access	One lane of road closed	Possible fill from building construction
HK 8/4	45 Repulse Bay Road (15NE–A/C22)	16/8	HyD/HK	16/8 12:30	Rock cut slope	Minor	Road	1/4 lane of road blocked	Minor plane failure
HK 8/5	10 Stanley Market Road, Stanley	16/8	Police	15/8	Soil cut slope	Minor	Building lot		
HK 8/6	Southeast of 129 Repulse Bay Road (15NE–A/C 110)	17/8	HyD/HK	17/8 14:30	Rock cut slope	Minor	Road	One lane of road blocked	
HK 8/7	Slope above Salesian School, Chai Wan Road, Shau Kei Wan (11SE–B/C99)	19/8	Education Dept.	14/8– 15/8	Natural slope	Minor	Open space		
HK 9/1	19 Village Terrace, Village Road, Happy Valley	1/9	HyD/HK	1/9 11:25	Rock cut slope	Minor	Private access, open space		

Table A1 – List of Incidents on Hong Kong Island Reported to GEO in 1991 (Sheet 4 of 5)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
HK 9/2	88 Broadwood Road, Happy Valley	2/9	W.S.D.		Fill slope	Minor	Open space		Washout
HK 9/3	25–27 Ventris Road, Happy Valley	17/9	Resident		Soil cut slope	Minor	Building lot, private access		Washout
HK 9/4	Tai Hang Road near Perkins Road, So Kon Po (11SE – C/C87)	20/9	HyD/HK		Soil cut slope	Minor	Road		
HK 10/1	26 Peak Road	16/10	Police		Rock/boulder fall	Minor	Walkway	Walkway partly blocked	
HK 10/2	Tai Tam Road near calpitch TT90	16/10	Police		Rock/boulder fall	Minor	Walkway	Road partly blocked	
HK 10/3	Yee King Road, North Point	16/10	Police		Rock/boulder fall	Minor	Pedestrian pavement		
HK 10/4	52–54 Mt. Davis Road, Pok Fu Lam (11SW – C/C 205)	16/10	HyD/HK	16/10 20:30	Soil cut slope	Minor	Road	Half lane of road blocked	
HK 10/5	Chai Wan Road, Shau Kei Wan (11SE – D/C4)	17/10	HyD/HK		Soil cut slope	Minor	Pedestrian pavement	Pedestrian pavement closed	
HK 10/6	200 Chai Wan Road, Chai Wan	16/10	Police		Flooding		Construction site		No geotechnical concern
HK 10/7	Building Contractors Association School, Tin Hau Temple Road, North Point	17/10	A.S.D.	16/10	Rock cut slope	Minor	Building lot		Fallen trees and broken chunam
HK 10/8	48 Kennedy Road, Central	19/10	Public	16/10 21:30	Rock/boulder fall	Minor	Private access		

Table A1 – List of Incidents on Hong Kong Island Reported to GEO in 1991 (Sheet 5 of 5)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
HK 10/9	27–31 Blue Pool Road, Happy Valley	19/10	Design/ GEO	18/10	Natural slope	Minor	Open space		
HK 10/10	Mt. Parker Road, Quarry Bay	19/10	A.F.D.	18/10	Soil cut slope	Minor	Country Park		
HK 10/11	116 Aberdeen Main Road, Aberdeen	22/10	HyD/HK	18/10	Rock/boulder fall	Minor	Private access		
HK 10/12	38 Cloud View Road, North Point	29/10	HyD/HK	28/10 am	Natural slope	Minor	Pedestrian pavement		
HK 10/13	J/O Kennedy Road and Queen's Road East, Wan Chai	30/10	W.S.D.	30/10 15:00	Rock cut slope	Minor	Pedestrian pavement, road	One lane of road blocked, pedestrian pavement closed	Washout in weathered rock
HK 10/14	Behind 60 Kai Yuen Street, North Point	25/10	B.O.O.	15/10–18/10	Rock cut slope	Minor	Lane	Back lane blocked	
HK 12/1	Tai Tam Reservoir Road	9/12	HyD		Soil cut slope	Minor	Country Park		

Table A2 – List of Incidents on Kowloon Reported to GEO in 1991 (Sheet 1 of 2)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 3/1	On Lok Village, Sau Mau Ping (Hut No. XKE/9/B/8/1150-53)	26/2	HyD	25/2	Fill slope	Minor	Squatter	Four huts permanently evacuated	
K 3/2	On Lok Village, Sau Mau Ping (Huts No. XKE/9/B/8/1183 - 67 & 1101- 05)	18/3	HyD	18/3	Fill slope	Minor	Squatter	Ten huts permanently evacuated	
K 3/3	Heung Yeung Village, Tsz Wan Shan (Hut No. RKT/5B/139)	27/3	DO/WTs	24/3	Soil cut slope	Minor	Pedestrian pavement, open space		
K 4/1	No. 49F, Ma Wan Village, Lei Yue Mun	10/4	Police	10/4 14:00	Retaining wall	Minor	Squatter	One hut temporarily evacuated	Masonry wall
K 6/1	Ling Nam San Tsuen, Ko Chiu Road, Kwun Tong, (Hut No. RKT/12A/W/243)	10/6	D.O.	8/6 09:45	Soil cut slope	Minor	Squatter	Two huts permanently evacuated	Rear wall of hut 243 collapsed
K 6/2	Heung Yeung Village, Tsz Wan Shan (Hut No. RKT/5B/257)	10/6	GEO		Soil cut slope	Minor	Squatter	One hut permanently evacuated	
K 6/3	Hong Ning Road, Kwun Tong (Hut No. RKT/2/D/164A)	17/6	DO/KT	17/6 10:00	Subsidence	Minor	Squatter	One hut temporarily evacuated	
K 6/4	Slope behind hut No. RKT/3AB/509 Ngau Chi Wan Village	26/6	Police	26/6 16:00	Soil cut slope	Minor	Squatter	One hut temporarily evacuated	

Table A2 – List of Incidents on Kowloon Reported to GEO in 1991 (Sheet 2 of 2)

Incident No.	Location	Call Received			Failure		Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 6/5	Mau Lam Street, Jordan	12/6	BOO	12/6	Subsidence, basement excavation	Major	Road, building lot	Road closed. Closure orders on two buildings	Failure of a basement excavation
K 7/1	Sze Shan Public School, Cha Kwo Ling, Kwun Tong	1/7	School		Soil cut slope	Minor	Open space		
K 7/2	Tai Shing Village, Sau Mau Ping	24/7	HyD	24/7 a.m.	Soil cut slope	Minor	Squatter	Two huts permanently evacuated	No geotechnical concern
K 8/1	Slope behind Kwun Tong Police Station	20/8	Police		Fallen trees	Minor	Dangerous goods store at toe, private access		
K 8/1	Behind Lam Tin Polyclinic, Kai Tin Road, Lam Tin (Hut No. RKT/2D/D/61)	5/9	DO/KT	26/8	Soil cut slope	Minor	Squatter	One hut temporarily evacuated	
K 10/1	Tung Yeung Village, Tsz Wan Shan, (Hut No. RKT/5/N/443)	15/10	DO/WTS	15/10 am	Soil cut slope	Minor	Squatter, footpath	One hut permanently evacuated	One hut permanently evacuated
K 10/2	Lei Yue Mun Village, (Hut No. RKT/12/C/503)	21/10	F.S.D.	18/10 19:30	Rock/boulder fall	Minor	Squatter	One hut permanently evacuated	
K 10/3	On Shiu Road, Fok Kin Association Primary School (11NE-C/C28)	29/10	DO/KT	28/10 11:00	Rock/boulder fall	Minor	School playground		

Table A3 – List of Incidents in Eastern New Territories Reported to GEO in 1991 (Sheet 1 of 1)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
ME 1/1	No. 21 Luk Hop Village, 8½ mile, Tai Po Road (Beside hut No. RTPR/21)	28/12	DO/ST		Subsidence	Minor	Squatter	One hut temporarily evacuated	
ME 3/1	Slope behind the school in Ap Chau, Crooked Harbour	17/10/90	DO/N		Soil cut slope	Minor	Church, school buildings		
ME 6/1	Bride's Pool Road North District, N.T. (3SE-B/C6)	14/6	HyD/NT	12/6	Soil/rock cut slope	Major	Rural road		
ME 7/1	Retaining Wall beside No.143, Ha Wo Che Village, Shatin	23/7	BOO	23/7 22:00	Retaining wall	Minor	Open area, building lot	Parts of two houses temporarily evacuated	
ME 7/2	Slope adjacent to footpath outside house no. 3, Kap Pin Long, Sai Kung	31/7	DO	31/7 03:00	Soil cut slope	Minor	Footpath		
ME 9/1	Slope in front of lot 161 in DD235 Sheung Sze Wan, Sai Kung	16/9	BOO/DB	15/9	Soil cut slope	Minor	Access road		
ME 10/1	Near 'Kin Garden' New Long Keng Village Sai Kung	4/10	Resident		Natural slope	Minor	Private access		Washout
ME 10/2	Tai Po Kau, KCRC (Slope No.9.16 KCRC)	17/10	HyD/ Railway	15/10 22:30	Soil/rock cut slope	Minor	Open area adjacent railway lines		

Table A4 – List of Incidents in Western New Territories Reported to GEO in 1991 (Sheet 1 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
MW 1/1	M.S.6 Castle Peak Road, Kwai Chung (11NW-A/C38)	18/1	HyD	18/1 17:30	Rock cut slope	Minor	Road	One lane of road partially blocked and closed	
MW 6/1	31 A Yung Shue Wan Main Street, Lamma Island	10/6	Police	9/6 15:30	Natural slope	Minor	Building lot		
MW 6/2	2A-3A, Yau Kwong Street, Peng Chau (10SW-B/C15)	10/6	HyD/NT	8/6 16:00	Soil cut slope	Minor	Back lane		Collapse of chunam
MW 6/3	No. 16, Ka Loon Tsuen, M.S.14½ Castle Peak Road	10/6	B.O.O.	10/6 09:30	Retaining wall	Minor	Squatter, public footpath	Public footpath blocked, one house temporarily evacuated	Masonry wall
MW 6/4	Boulder adjoining No.16 Ka Loon Tsuen, M.S.14½ Castle Peak Road	10/6	B.O.O.	10/6 09:30	Natural slope	Minor	Building lot	Two houses temporarily evacuated	Washout of infill material between two boulders
MW 6/5	Kam Shan Village, Kwai Chung	9/6	B.O.O.	9/6	Soil cut slope	Minor	Building lot		Cracking of chunam and washout of exposed slope
MW 6/6	No.14 Yung Shue Long New Village, Lamma Island	13/6	HyD/NT	8/6 15:00	Soil cut slope	Minor	Building lot		Collapse of chunam
MW 6/7	Lot 392 in DD453, Fu Yung Shan San Tsuen, Tsuen Wan	21/6	HyD/NT	21/6 15:30	Soil cut slope	Minor	Building lot	Three houses temporarily evacuated	



Table A4 – List of Incidents in Western New Territories Reported to GEO in 1991 (Sheet 2 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
MW 6/8	No.28-30 Butterfly Valley Cottages, Butterfly Valley	26/6	HyD/K	24/6	Fill slope	Minor	Building lot		Washout
MW 6/9	No.290 Mo Lo Shan, Tsing Shan Tsuen, Tuen Mun	21/6	HyD/NT		Fill slope	Minor	Open space		Washout
MW 6/10	72 Po Wah Yuen, Lamma Island	26/6	DLO/ Island	20/6	Soil cut slope	Minor	Back lane	Back lane partly blocked	
MW 6/11	84A Tai Peng New Village, Lamma Island	26/6	DO/ Island	20/6 03:00	Soil/rock cut slope	Minor	Back lane	Back lane blocked	
MW 7/1	Sha Tin Tau, Shatin (Hut No. XRSTT/11 No.18, Area 2)	24/7	HyD/NT	24/7 14:00	Soil cut slope	Minor	Squatter		
MW 7/2	Sha Tin Tau, Shatin (Hut No. RSTT/162 No.8A, Area 2)	25/7	HD	8/8 12:00	Soil cut slope	Minor	Squatter	Part of one hut permanently evacuated	
MW 7/3	Behind No.2A, Yau Kwong Street, Peng Chau (Slope No. 10 SW-B/G15)	30/7	DLO/ Island	24/7	Fallen tree	Minor	Back lane	Private lane blocked	No geotechnical concern
MW 7/4	Footpath east of Shek Li Street playground, Kwai Chung	25/7	DO/KC		Soil cut slope	Minor	Pedestrian pavement	Pedestrian pavement closed	
MW 8/1	10 Nam Kau Road, Kak Tin Village, Shatin	10/8	Resident		Rock/boulder fall	Minor	Building lot		

Table A4 – List of Incidents in Western New Territories Reported to GEO in 1991 (Sheet 3 of 3)

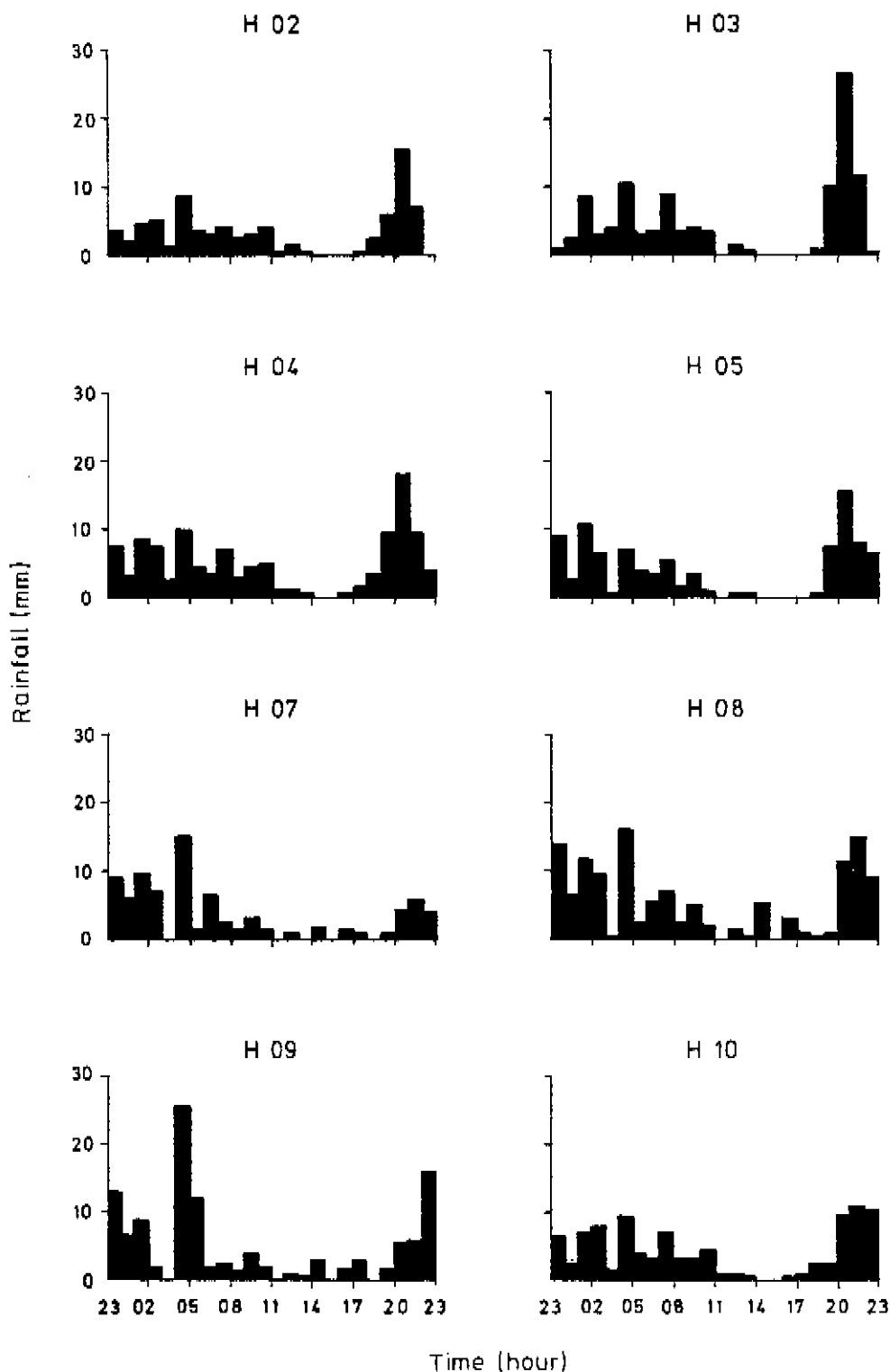
Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
MW 8/2	No. 72 Kau Wa Keng, San Tsuen	13/8	DO		Erosion	Minor	Open space		No geotechnical concern
MW 8/3	MS8, Castle Peak Road	15/8	HyD	15/8 13:30	Soil/rock cut slope	Minor	Road	2 lanes blocked	
MW 9/1	Public park adjacent to Lai King Catholic School, Kwai Chung	19/9	DO		Fill slope	Minor	Public park		Washout
MW 10/1	No.26 Yung Shue Long New Village, Lamma Island	2/10	DLO/ Island	mid-Sept	Retaining wall	Minor	Footpath	Footpath closed	
MW 10/2	Near Che Kung Temple, Shatin	7/10	DO/ST	15/8	Rock/boulder fall	Minor	Footpath	Footpath partly blocked	
MW 10/3	House No. 1A, Lei Uk Tsuen, Shatin (Hut Nos. RSTT/94 & 95)	15/10	DO/ST	15/10 02:00	Retaining wall	Minor	Squatter	Two huts temporarily evacuated	Masonry wall
MW 10/4	Lai Chi Kok Reception Centre, Butterfly Valley Road, Butterfly Valley	16/10	CSD	15/10	Rock/boulder fall	Minor	Footpath	Fence damaged	

APPENDIX B  
RECORDS FROM GEO RAINGAUGES DURING  
THE HEAVIEST 24-HOUR RAINSTORM  
OF 1991

APPENDIX B

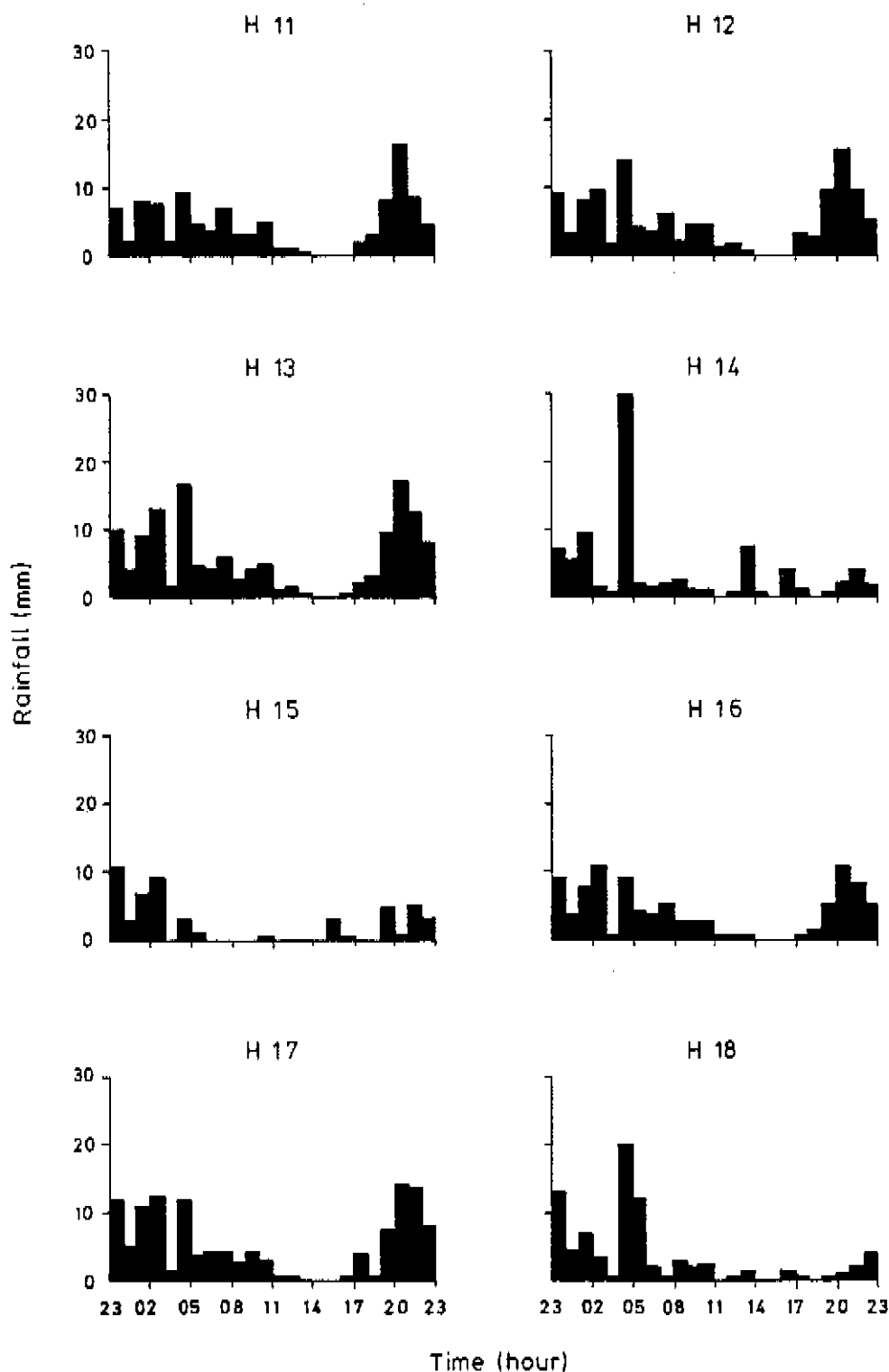
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Figure No.		Page No.
B1	Histograms of Hourly Rainfall Recorded by GEO Raingauges on 14 and 15 October 1991	68



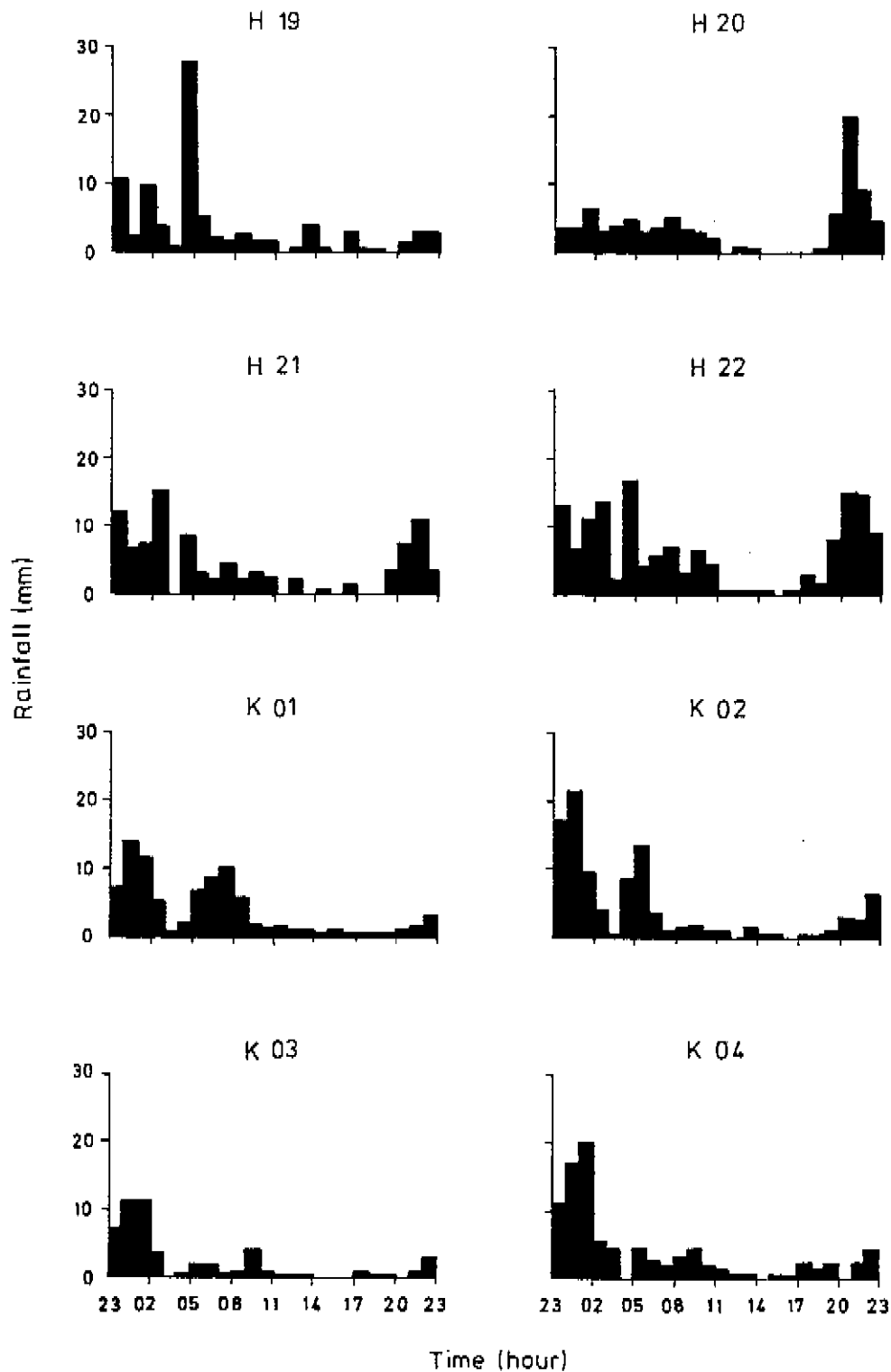
Note : Raingauge H01 was out of order during this event.

Figure B1 - Histograms of Hourly Rainfall Recorded by GEO Raingauges on 14th and 15th October 1991 (Sheet 1 of 5)



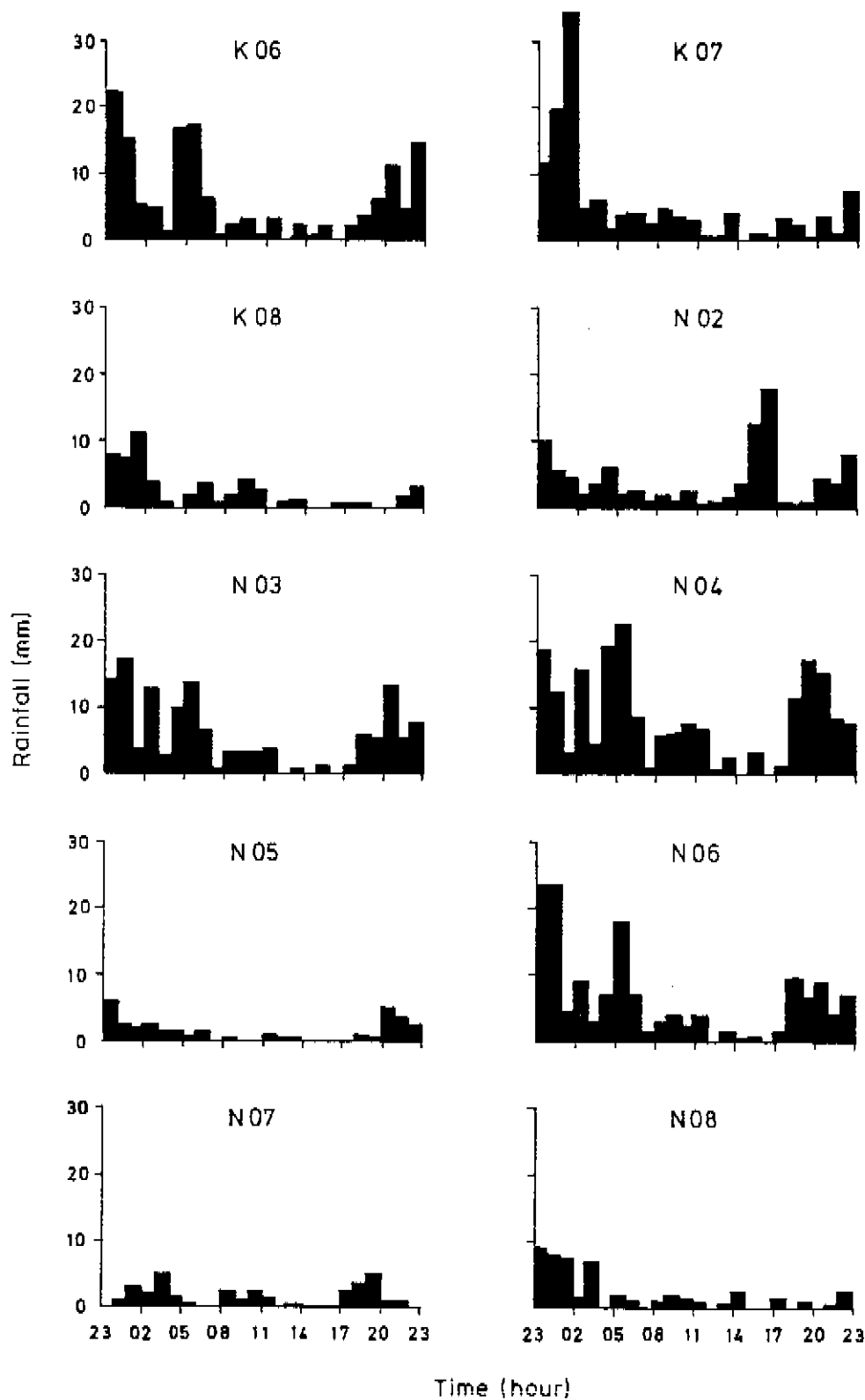
Note : Raingauge H01 was out of order during this event.

Figure B1 - Histograms of Hourly Rainfall Recorded by GEO Raingauges on 14th and 15th October 1991 (Sheet 2 of 5)



Note : Raingauge H01 was out of order during this event.

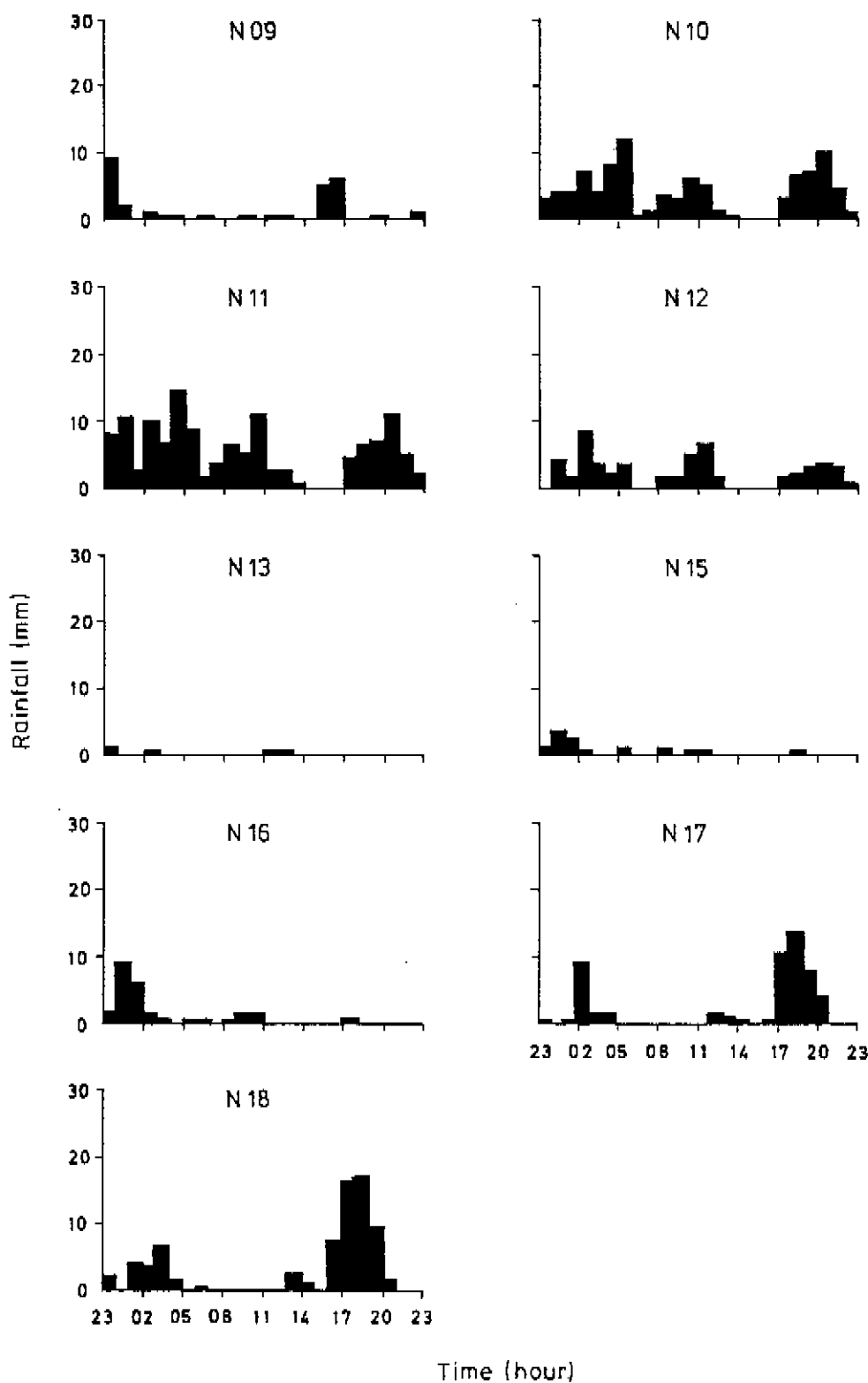
Figure B1 - Histograms of Hourly Rainfall Recorded by GEO Raingauges on 14th and 15th October 1991 (Sheet 3 of 5)



Note :      Raingauge H01 was out of order during this event.

Figure B1 - Histograms of Hourly Rainfall Recorded by GEO Raingauges  
on 14th and 15th October 1991 (Sheet 4 of 5)





Note : Rain gauge H01 was out of order during this event.

Figure B1 - Histograms of Hourly Rainfall Recorded by GEO Raingauges on 14th and 15th October 1991 (Sheet 5 of 5)

APPENDIX C

DAILY RAINFALL AT THE ROYAL OBSERVATORY IN 1991

APPENDIX C

LIST OF TABLES

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C1	Summary of Daily Rainfall at the Royal Observatory in 1991	75

Table C1 – Summary of Daily Rainfall at the Royal Observatory in 1991

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	–	–	Trace	–	11.8	–	–	5.2	–	Trace	–	Trace
2	–	–	0.4	–	Trace	–	4.4	0.9	Trace	–	–	Trace
3	–	–	0.8	–	1.4	–	11.5	–	–	–	–	Trace
4	Trace	–	0.1	–	2.8	–	2.2	–	3.2	–	–	–
5	5.1	–	–	Trace	0.8	Trace	1.5	Trace	2.8	–	–	–
6	2.2	–	–	1.3	Trace	Trace	Trace	0.6	11.0	Trace	–	–
7	7.6	–	–	Trace	7.1	Trace	Trace	6.9	0.4	–	–	–
8	2.5	–	–	5.3	Trace	50.5	Trace	Trace	0.2	–	Trace	–
9	–	–	–	Trace	Trace	111.1	–	Trace	8.8	–	0.3	–
10	–	–	Trace	Trace	Trace	66.8	–	5.2	–	–	–	Trace
11	8.4	Trace	–	–	–	22.3	3.0	25.6	–	Trace	–	–
12	1.9	Trace	Trace	–	–	0.2	12.1	4.3	19.4	–	–	Trace
13	Trace	Trace	Trace	–	12.7	2.5	21.8	1.7	Trace	–	–	Trace
14	0.5	6.4	Trace	–	–	3.4	22.8	20.9	64.1	30.1	–	–
15	0.5	0.1	–	–	17.7	Trace	1.0	65.2	29.1	192.4	–	Trace
16	–	1.1	Trace	–	0.1	0.3	–	56.0	–	66.5	–	–
17	–	0.4	Trace	–	–	–	Trace	12.2	–	4.3	–	–
18	–	Trace	2.5	–	Trace	2.3	–	–	4.2	Trace	–	–
19	–	Trace	Trace	Trace	Trace	14.6	0.2	4.4	–	0.4	Trace	–
20	–	0.2	Trace	Trace	–	33.2	27.5	Trace	Trace	0.2	0.2	–
21	–	–	–	0.5	–	16.9	34.6	34.7	1.6	–	Trace	–
22	–	Trace	36.6	–	Trace	3.4	7.2	–	0.8	Trace	–	–
23	Trace	–	1.2	–	Trace	2.7	37.1	–	–	Trace	Trace	Trace
24	Trace	–	Trace	–	0.1	12.8	33.5	0.6	3.0	0.4	Trace	–
25	–	–	Trace	–	0.2	0.6	0.4	19.3	28.0	Trace	1.8	–
26	Trace	–	–	Trace	Trace	25.4	–	–	–	–	0.4	0.6
27	–	Trace	–	Trace	–	2.7	Trace	–	–	–	–	0.4
28	–	Trace	Trace	Trace	Trace	Trace	Trace	38.4	Trace	–	–	7.6
29	–		Trace	0.1	0.7	–	13.5	Trace	2.1	–	–	1.3
30	Trace		3.8	27.5	0.7	–	7.5	0.2	–	–	Trace	1.4
31	Trace		6.1		4.8		51.8	–				0.5
TOTAL	28.7	8.2	51.5	34.7	60.9	371.7	293.6	302.3	178.7	294.3	2.7	11.8

The Total Rainfall in 1991 is 1639.1mm

LIST OF DRAWING

Drawing  
No.

GCSP 8/8      Location Map of Landslides and Related Incidents in 1991