

# **HONG KONG RAINFALL AND LANDSLIDES IN 1990**

**GEO REPORT No. 14**

**K.Y. Tang**

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

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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'.

A. W. Malone  
Principal Government Geotechnical Engineer  
April 1995

#### FOREWORD

This report presents a general review of rainfall and landslides in Hong Kong in 1990. 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 1990. 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 exceeded 50 cu m.

The GEO received a total of 105 incident reports in 1990. Of these, 77 were classified as genuine landslides and six of them were major. The remaining incidents were minor ground or structural movements or of no geotechnical concern. It is notable that sixteen and ten incidents out of the whole year's total occurred during two severe rainstorms on 30 June to 1 July and 10 to 11 September respectively. This report will emphasize the cases of 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-landslides reports (Premchitt, 1985-1989 and Siu, 1990). The report reviews rainfall and landslide occurrence throughout the whole year rather than emphasizing any one specific rainstorm. Information has been compiled from many sources throughout the government and the report also documents the work done by GEO in dealing with the landslide incidents.

## 2. RAINFALL

### 2.1 The Raingauge System

In the rugged terrain of Hong Kong, rainfall distribution over different geographical areas, as well as over different time periods, can vary dramatically during a rainstorm. The Royal Observatory has installed 122 raingauges at 91 locations around the Territory in order to provide sufficient coverage for a meaningful analysis of rainfall distribution. These raingauges range from a detailed automatic and instantaneous rate-of-rainfall recorder to raingauges which are read manually once every day. 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 co-operation with the RO, has installed a number of automatic raingauges which transmit the current rainfall data via telephone lines to the GEO's Emergency Control headquarters. Improvements have been made regularly and at the end of 1990 there were 46 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. A 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 measurement, this will be the amount measured at the RO headquarters.

## 2.2 Royal Observatory Records

The year's weather for 1990 was summarised by the Royal Observatory in the Monthly Weather Summary for December 1990. Their comments on rainfall are as follows:

In 1990, six of the thirteen tropical cyclones which occurred over the South China Sea required the hoisting of tropical cyclone signals in Hong Kong. However, none of them necessitated the hoisting of the Gale or Storm Signal.... The total rainfall in 1990 was 2046.9 millimetres, 8 per cent below the normal of 2224.7 millimetres.

January 1990 was generally cloudy, humid and wet. There were only seven days in the month with no rain recorded at the Royal Observatory. The total rainfall for the month amounted to 47.5 millimetres, which was 77 per cent above normal.

February was even wetter and more humid. The monthly total rainfall of 195.7 millimetres was more than four and a half times the normal....

The weather in March turned drier and brighter. The monthly total rainfall of 29.9 millimetres was 45 per cent below normal....

April was gloomy and wet.... There was only three days in the month when no rainfall was recorded at the Royal Observatory. The monthly total rainfall amounted to 257.6 millimetres which was 85 percent above normal....

May was relatively dry with a monthly total rainfall of 102.4 millimetres which was just over one-third of the normal. Tropical cyclone signals were hoisted for the first time in the year on 17 May for Typhoon Marian, but Marian failed to come close enough to bring any significant rain to the territory.

In June, tropical cyclone warning signals were hoisted during the passage of Severe Tropical Storm Nathan and Typhoon Percy but the monthly rainfall total of 448.1 millimetres was only slightly above normal. On 30 June, an unstable southwesterly airstream in the wake of Percy brought about periods of heavy rain and thunderstorms ....

July was hotter and drier than normal. The weather was basically fine except for showers and periods of rain brought by an unstable southwesterly airstream in mid-July and by Severe Tropical Storm Tasha which necessitated the hoisting of the Strong Wind Signal No. 3 towards the end of the month. The monthly rainfall total was 268.0 millimetres, 15 per cent below the normal figures of 316.8 millimetres.

August 1990 was the hottest month and the driest August ever experienced in Hong Kong.... Its monthly mean relative humidity of 75 per cent was also the lowest for August. The monthly total rainfall of 150.1 millimetres was 64 per cent below normal.

September was relatively cloudy and wet. The monthly rainfall of 409.9 millimetres was 28 per cent above normal. Over half of the month's rainfall could be attributed to the passage of Typhoon Dot over southern China. During the 5-day period from 8 to 12 September, 230 millimetres of rainfall were recorded at the Royal Observatory. The heaviest downpour occurred on 10 September ...

[In October,] the monthly rainfall of 100.7 millimetres was 17 per cent below normal.

[In November,] the monthly rainfall of 36.9 millimetres was 6 per cent above the normal of 34.7 millimetres.

[In December,] only 0.1 millimetre of rain was recorded during the whole month.

A summary of heavy rainstorms in 1990 is given in Table 1. This table shows all periods (mutually exclusive) in which 24-hour rainfall at the RO exceeded 50 mm. It also shows the fifteen-day antecedent rainfalls which occurred prior to the 24-hour periods. The highest 24-hour rainfall was 182 mm on 10 to 11 September. 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 1990.

### 2.3 Geotechnical Engineering Office Records

Rainfall data are also available from the GEO's 46 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. The maximum rainfall recorded anywhere in the Territory on these occasions are given for three arbitrary durations of 24 hours, five hours and one hour.

The maximum 24-hour and one-hour rainfalls within the Territory during the year were 276 mm on 10 to 11 September and 91 mm on 1 June respectively.

Appendix B shows hourly rainfall data obtained from GEO's raingauges for the heaviest 24-hour rainstorm during 10 to 11 September.

#### 2.4 Rainfall Distribution

Rainfall maps, for 24-hour duration taken from RO records, are shown in Figures 6 and 7 for the two heaviest rainstorms of the year. These two rainstorms were discussed in the annual RO weather summary quoted in section 2.2. In the storm of 30 June to 1 July, the rainfall was concentrated in a belt extending from the northern part of Kowloon to Sai Kung (Figure 6). In the storm of 10 to 11 September, the rainfall was spread over Hong Kong but heavier rainfall were recorded in Kwai Chung, western part of Hong Kong Island, southern part of Tuen Mun and southern part of Lantau Island (Figure 7). These areas are all in southwestern part of the territory of Hong Kong.

#### 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 1990, there were 78 days in which Thunderstorm Warnings were issued, fifteen days in 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. 3, which was issued on four occasions in May, June, July and August. All tropical storm warnings were issued in the period from May to September.

Three Landslip Warnings were also issued after consultation between the GEO and the RO on the basis of predetermined rainfall criteria. A comparison of rainstorm damage in these events with those on all other notable rainfall-landslide days is shown in Table 1. Of all the reported incidents, sixteen are known to have occurred during 30 June to 1 July, ten during 10 to 11 September and five during 1 July, while there were less than four incidents on any one day for the rest of the year. In these three periods, of all incidents for which the time of landslide occurrence is known to within one hour, eight occurred after the warnings were issued and two occurred before the warnings were issued. Those events not shown in Table 1 had rainfall of less than 50 mm in 24 hours and less than two landslides on any one day.

#### 2.6 Comparison with Past Rainstorms

Maximum rainfall amounts of various durations recorded at the GEO and RO raingauges for heavy rainstorms in 1990 are shown in comparison with the three major rainstorms (May 1982, July 1987 and May 1989) recorded since 1982 in Table 1. The highest 24-hour rainfall recorded at the RO in 1990 was almost the same as that for the July 1987 rainstorm, but less than half of those for May, 1982 and May, 1989. The highest one-hour rainfall

recorded anywhere in 1990 was 91 mm.

The return periods of heavy rainstorms in 1990 were estimated, and are shown in Table 3, for rainfall durations of one hour to fifteen days. The estimated return periods were two years or even less. The highest return period is only two years, demonstrating that rainstorms in 1990 were not exceptional.

In Figure 2, cumulative rainfall for 1990 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 2046.9 mm, which is comparable with the average amount 2225 mm. Figure 4 shows monthly rainfalls in 1990 in comparison with the recorded maximum (since 1884) and mean (1951-1980) monthly rainfalls. In the early part of the year, up to August the cumulative rainfall was greater than the mean rainfall. After that it was below the mean. In May and August, the monthly rainfalls were significantly less than the mean. Only in February, April and September were the monthly rainfall above the mean.

### 3. LANDSLIDES

#### 3.1 Landslide Occurrence in 1990

The numbers of incidents reported to various Government departments during 1990 are shown in Table 4. The numbers of incidents affecting various types of area (building, road etc.) in Hong Kong, Kowloon and the New Territories are shown in Table 5. The number of major failures are also given in this Table. There were six major landslides in 1990.

A list containing details of all 105 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 analyses below. One incident had a slip in a cut slope and another slip in the natural slope above and was therefore counted as two. In total 99 incidents were considered of geotechnical concern. A location map for all these incidents is shown in Drawing No. GCSP 8/7. Selected incidents are illustrated in Plates 1 to 24. 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, particularly those which occurred in the New Territories. Therefore, it was difficult to determine the exact times of occurrence for these incidents. Out of 99 incidents, times of occurrence were known to within one day for 74 incidents. The daily numbers of these incidents are plotted in Figure 3. Of these 74 incidents, times of occurrence were determined to within one hour for 30 incidents.

The highest number of incidents in a rainstorm was 16 on 30 June to 1 July and the next highest was 10 to 11 September. These occasions 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 less than

two incidents on any one day of the year.

It is likely that there were other failures which were 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 in reading the following landslide statistics.

### 3.2 Areas Affected by Incidents

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

#### 3.2.1 Squatter Areas

A total of 44 incidents affected squatter areas. Of these, four occurred on Hong Kong Island, 26 in Kowloon and fourteen in the New Territories. Most of those occurring in Kowloon were in the Kowloon East region, and the majority of those occurring in the New Territories were in Kwai Chung, Tsuen Wan, Sha Tin, Tuen Mun and Tai Po.

All failures affecting squatter areas were not major. They led to the permanent evacuation of 60 huts and temporary evacuation of eighteen huts. Most of these evacuations resulted from failure of soil slopes and rock/boulder falls. Two incidents, K 90/4/2 and K 90/6/9, are discussed in Section 4.5 and Section 4.7 respectively.

#### 3.2.2 Buildings

There were fifteen incidents affecting buildings of which one was major failure. In incident MW 90/12/1 (Section 4.11), a multistorey building was affected. In incident HK 90/10/1 (Section 4.10) two adjacent buildings were temporarily evacuated.

#### 3.2.3 Roads and Access

A total of 43 incidents affected roads and access including footpath, of which four were major failures. There were sixteen sections of road and access blocked and temporarily closed after the failures. Most of these failures involved landslides in soil and fill slopes. The roads blocked included parts of South Lantau Road, Bowrington Road, Repulse Bay Road and Ching Chau Road. A typical failure (incident MW 90/9/2) is discussed in Section 4.8. An example of slope failures blocking footpaths is given in Plate 15 (ME 90/6/11).

#### 3.2.4 Construction Sites

There were five incidents relating to construction sites of which two were major. Both of the major incidents, ME 90/1/1 (Section 4.2) and HK

90/4/3 (Section 4.3), were probably caused by construction.

### 3.2.5 Catchwaters and Reservoirs

There was one reported incident which affected the periphery of a service reservoir and none of the incidents reported to GEO affected catchwaters. The incident reported, MW 90/6/1, was major and is discussed in Section 4.6.

### 3.2.6 Country Parks and Open Areas

There were four incidents reported affecting open spaces of which one was major. The major incident, MW 90/9/5, is discussed in Section 4.10.

## 3.3 Types of Incidents

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

### 3.3.1 Fill Slopes

There were twelve fill slope failures, forming 12% of all incidents reported. Two of them were major, forming 33% of all major incidents reported. The majority of the fill slope failures reported were due to infiltration but 33%, including the two major failures, were due to rupture of water mains or drains. An example of this type of failure, MW 90/12/1 is discussed in Section 4.11.

### 3.3.2 Cut Slopes

There were 41 cut slope failures, forming 42% of all incidents reported. Of these, 34% were in soil, 5% in soil/rock and 3% in rock.

There were 33 reported failures in soil cut slopes. The only major incident reported was ME 90/1/1 (Section 4.2) which was caused by oversteeping of a slope during construction. A typical example of cut slope failure is shown in Plate 14 (ME 90/6/8).

There were five soil/rock slopes failures reported.

Three failures in rock slopes were reported. An example is shown in Plates 17 and 18 (MW 90/9/4). The main causes of the failures were reported to be infiltration and disturbance of rock joints by tree roots.

### 3.3.3 Retaining Walls

There were five reported incidents related to retaining walls or walls having earth materials piled up behind them, forming 5% of all incident reported. None of them were major. A failure case, incident no. HK 9/4/1,

is discussed in Section 4.4.

#### 3.3.4 Natural Slopes

Eight natural slope failures were reported, forming 8% of all incidents reported. Two of them were major, MW 90/6/1 and MW 90/9/5, and are discussed in Sections 4.6 and Section 4.9 respectively.

#### 3.3.5 Rock and Boulder Falls

There were nine cases of rock and boulder falls, forming 9% of all incidents reported. An example is given in Plates 2 and 3 (HK 90/2/1).

#### 3.3.6 Basement Excavations

There were two cases of ground failure during basement excavation, incidents HK 90/4/3 and HK 90/10/1. They are discussed in Sections 4.3 and 4.10 respectively. Incident HK 90/4/3 was major.

#### 3.3.7 Other Failures

There are incidents which cannot be classified according to the above categories. They included cases of ground settlement and washout. There were 22 failures of this type, forming 22% of all incidents reported.

### 3.4 Rainfall-Landslide Relationships

A simple relationship between rainfall and landslide is demonstrated by the plot of daily rainfall and daily number of landslide occurrences through 1990 in Figure 3. The great majority of the 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 the 30 June to 1 July and 10 to 11 September. These Figures indicate that most of the landslides occurred in those areas which had the highest concentration of rainfall and in squatter areas (particularly East Kowloon).

More detailed and comprehensive discussions on rainfall-landslide relationships and failure mechanisms can be found in Brand et al (1984) and Premchitt et al (1985), where extensive data from the past twenty years have been analysed.

### 3.5 Other Causes of Failure

The primary cause of the majority of the landslides in 1990 was rainfall. Other failures were mostly isolated incidents caused by such factors as construction work, leakage of services and indiscriminate

activities relating to earthworks and drainage alterations in squatter areas. Some of these factors were found to play important roles in causing major ground failures in 1990. Two out of the six major failures in 1990 were probably caused by construction activities and two other major failures by leakage from water mains. In total, eleven incidents in 1990 were caused by construction or rupture of water mains or pipes.

#### 4. NOTABLE INCIDENTS

##### 4.1 Introduction

Out of the 99 incidents, ten are discussed in more details in this section. These 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 interest and are considered to be representative of the landslides discussed in Section 3. For brevity and convenience, not all major failures are included in this section.

##### 4.2 Incident ME 90/1/1, Po Lo Che Service Reservoir, Sai Kung

(Date : 10 January, 1990. Failure of a temporary cut slope affecting a village access road, Plate 1.)

The contractor for the site formation and construction of the service reservoir formed a temporary cut slope up to 15 m high at 60° in completely weathered volcanic and then undercut the slope toe to 75° for construction of the reservoir walls and manholes. Work continued despite GEO's concern over the safety of the temporary steep slope cutting. Although the work was carried out in the dry season, about 400 m<sup>3</sup> of this temporary cut slope failed. There was no rainfall during the 24 hours before the failure (Plate 1). Part of a village access road at the crest of the slope was undermined and half of the road was closed.

##### 4.3 HK 90/4/3, Bowrington Road

(Date : 6 April, 1990. Collapse of soil into an excavation resulting in the formation of a deep hole in the road, Plates 4 and 5.)

Sheet piling was used to support a basement excavation. Some sheet piles terminated at a level above the approved level, allegedly due to obstruction by boulders. Steel plates were welded to the sheet piles to support the excavated face below the sheet piles. At failure, the height of this excavated face was about 3 m. Marine sand behind the sheet wall moved into the excavation site and a water main ruptured. A hole, 6 m by 10 m in plan and 6 m deep was subsequently found on the adjacent Bowrington Road, completely sealing it off from traffic (Plates 4 and 5).

##### 4.4 HK 90/4/1, No. 17 MacDonnell Road (Brick Wall at Eastern Boundary)

(Date : 10 April, 1990. Structural failure of a boundary wall affecting a private backyard, Plates 6 and 7.)

No 17 MacDonnell Road was an abandoned building site (Plate 6). Building debris had built up behind a 2 m high brick boundary wall. After a heavy rainfall in the evening of 9 April, the wall failed structurally



and the building debris spilled over to the adjacent private backyard. (Plate 7).

4.5 K 90/4/2, Cha Kwo Ling Village Behind Fan Wah Street

(Date : 12 April, 1990. Failure of a rock cut slope affecting squatters, Plates 8 and 9.)

About 10 m<sup>3</sup> of rock mass was dislodged from the rock face. The causes of the failure were infiltration and weakening of a rock joint by root growth (Plate 8). There were squatter huts below the rock slope (Plate 9) but no evacuation was required as a rock fence separating the huts from the rock slope was constructed under the 1984/85 Landslip Preventive Measures Programme.

4.6 MW 90/6/1, Natural Slope Below Cheung Chau Service Reservoir, Cheung Chau

(Date : 8 June, 1990. Failure of a natural slope damaging part of the drainage channel system at the edge of the platform for the service reservoir, Plates 10 and 11.)

The average gradient of the natural slope below the service reservoir is about 33°. The gradient of the failed section is about 40°. About 700 m<sup>3</sup> of soil and rock slid, leaving a long scar on the natural slope immediately below the service reservoir (Plate 10). Most of the slip located within an area of rhyolite, with only part of the head scarp located in coarse-grained granite. A few days before the failure, the service reservoir was rinsed and the rinsing water was discharged onto the hillside through a discharge channel that was damaged in the failure (Plate 11). The rainfall preceding the failure was modest. After the failure, CGE/A carried out a study on the slope for WSD. Results of the study and his recommended remedial works are given in Advisory Report ADR 13/91 (Yip, 1991).

4.7 K 90/6/9, Nam Shan Mei Village, Hut Nos. USD/NSM/46,47,55,56,57

(Date : 20 June, 1990. Failure of a soil cut slope affecting squatters, Plates 12 and 13.)

Infiltration of rainfall caused failure of a 3 m high soil slope which was abutted by a squatter hut. The platform at the crest of the slope subsided (Plate 12) and soil slumped into the abutting hut (Plate 13). Five squatter huts were permanently evacuated.

4.8 MW 90/9/2, MS 1, Lai Chi Yuen, Below Water Treatment Works, South Lantau Road, Lantau Island

(Date : 11 September, 1990. Failure a soil slope blocking part of South Lantau Road, Plate 16.)

The slope before the failure was about 9 m high and the averaged slope angle was about 55°. The slope material was bouldery colluvium. The bottom half of the slope was covered by stone pitching while the top part was probably covered by a thin layer of sprayed concrete. Failure was in the top half of the slope (Plate 16). The failure was probably caused by a

perched water table built up in the colluvium by heavy rain. One lane of the road was blocked.

4.9 MW 90/9/5, Above Area 19, off Lung Mun Road, Tuen Mun

(Date : 11 September, 1990. Failure of a natural slope affecting a stocking piling area below, Plates 19 and 20.)

This is among the biggest landslides in natural slopes in the history of Hong Kong (Plate 19). The length of the landslide was 1,025 m in plan. The main scarp was up to 10 m wide and the debris fan was 120 m at its widest. The depth of the landslide varied and the maximum was about 5 m. The quantity of materials involved was of the order of 22,000 m<sup>3</sup>. Gradient of the natural slope before the failure varied from about 40° at the crown of the landslide to a gentle 10° at the toe. The depleted material was mostly bouldery colluvium (Plate 20). Some insitu weathered granite and mata-andesite was also involved. The landslide developed into a debris flow spreading a large debris fan into a stockpiling area below. Chan et al (1991) had compiled a factual report on the landslide.

4.10 HK 90/10/1, Nos. 40-42 Yun Ping road & Nos. 17-19 Jardine's Crescent

(Date : 24 October, 1990. Failure of a basement excavation affecting building and road, Plates 21 and 22.)

Basement excavation in Nos. 2 - 38 Yun Ping Road was down to 4 m below ground level when failure occurred. The sheet pile wall supporting the excavation deformed excessively (Plate 21). A 100 mm diameter water main along Jardine's Crescent ruptured. The party wall of an adjacent building fell down (Plate 22). A cavity was formed on Jardine's Crescent. Two adjacent buildings were temporarily evacuated.

4.11 MW 90/12/1, Kwe Yang House, Tsuen Wan Centre, No. 9 Tsuen King Circuit, Tsuen Wan

(Date : 30 November, 1990. Failure of a fill slope beneath a building affecting pedestrian pavements at Tsuen King Circuit and beneath, Plates 23 and 24)

The fill slope is located beneath Tsuen Wan Centre which is a multistorey building. Some of the building caissons passed through the fill slope. Rupture of three water mains (one 200 mm and two 100 mm in diameter) at the crest of the fill slope caused failure of the slope between two groups of caissons. The failure was about 3.5 m in width and 2.5 m in depth. The side faces of the caps of the caisson groups were exposed at some locations. The failure debris moved onto a pavement below (Plate 23) and then spilled over to a nullah. Steep soil faces were formed at isolated locations in the fill (Plate 24). An advisory letter was issued to the owners of the building advising them to reinstate the failed portion of the fill slope.

## 5. CONCLUSIONS

In general, rainfall during 1990 can be considered as normal. The total rainfall in 1990 was eight percent below the average amount. The

wettest month in 1990 was June, followed by September. The rainfall in June was slightly higher than the average. The rainfall in September was 28 percentage above average. The rainfall in the rest of the months in the wet season (May to September) were all slightly below average.

Over the whole year, three Landslide Warnings were issued. There were 105 landslides and related incidents reported to the GEO District Divisions and the damage resulting from these incidents may be summarized as follows: 78 squatter huts were evacuated, two buildings were temporarily evacuated and sixteen sections of road/access were blocked. Many of these incidents occurred during the two heaviest storms of the year on 30 June to 1 July and 10 to 11 September and Landslide Warnings were issued on both occasions.

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Table 1 - Rainfall-Landslide Events in 1990 with 24-hour Rainfall Greater than 50 mm

Date of Event <sup>(1)</sup>	Maximum Rainfall (mm)								Landslide Consequences				
	Royal Observatory					GCO 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	GCO <sup>(3)</sup>	Newspaper <sup>(4)</sup>	FSD		
				4-day	15-day								
10-11/9/90 <sup>(5)</sup>	182	65	27	65	95	276	104	55	10	5	1(flooding)	-	9
1/6/90 <sup>(5)</sup>	145	115	57	2	46	160	123	91	5	0	1(house collapse)	-	0
16-17/6/90	106	45	23	3	137	137	61	33	3	0	-	-	0
19/9/90	98	74	39	7	260	124	106	36	3	0	-	-	2
3-4/4/90	91	91	57	1	28	63	63	27	-	0	-	-	0
4-5/10/90	87	65	24	8	149	65	53	28	-	0	-	-	0
30/6-1/7/90 <sup>(5)</sup>	83	63	20	13	162	182	170	53	16	1	-	-	5
1-2/8/90	77	73	42	89	162	79	70	36	2	0	-	-	1
11-12/4/90	73	38	32	46	165	85	31	24	4	0	-	-	6
30-31/7/90	63	36	14	37	101	161	128	41	0	0	-	-	0
22-23/2/90	57	41	32	21	61	73	42	31	2	0	-	-	2
13-14/7/90	57	24	11	24	130	75	45	32	0	0	-	-	0
Recent Major Rainstorms (For Comparison Only)													
29/5/82	394	153	44	1	11	430	111	237	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	421	429	552	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 46 GEO Raingauges for the same rainstorm period. (3) For the rest of 1990, there were less than 2 landslips reported to GEO on any one day. (4) Newspapers searched are South China Morning Post and Hong Kong Standard. (5) Landslip warnings are 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 1990

Month	Monthly Rainfall (mm)	Dates of Warnings			
		Thunderstorm	Flood	* Landslip	Tropical Storm
January	47.5	—	—	—	—
February	195.7	16, 17, 18, 21, 22, 23, 24	—	—	—
March	29.9	29, 30, 31	—	—	—
April	257.6	1-4, 9-11, 16, 19, 23, 26	4	—	—
May	102.4	3-4, 9, 12-13	—	—	17-18 (signals No. 1-3 Marian)
June	448.1	1, 6-11, 17, 26, 28-30	1, 8, 16, 30	1(04:10-21:30) & 30(15:15-07:00)	17-18 (signals No. 1-3 Nathan) 28-29 (signal No. 1 Percy)
July	268.0	3-4, 12-15, 17-18, 20-21 23, 27-29, 31	13, 14, 31	—	28-31 (signals No. 1-3 Tasha)
August	150.1	2, 3, 4, 5, 11, 13, 16, 18, 26	2, 3	—	27-28 (signals No. 1-3 Becky)
September	409.9	5-12, 19-20, 24-25, 28	8, 10-11, 19	11(07:10-09:00)	14-17 (signal No. 1 Ed)
October	100.7	4, 5	5	—	—
November	36.9	9	—	—	—
December	0.1	—	—	—	—
TOTAL NUMBER	2046.9	78 days	15 days	3 warnings	6 warnings
Legend:					
* Landslip warnings were issued after consultation between GEO & RO					

Table 3 - Maximum Rainfalls During 1990 and Estimated Return Periods

Duration	* Rainfall (mm)	Ending Time		† Estimated Return Period (Year)
		Date	Hours	
1 hour	57.4	1/6	1200	2
5 hours	114.7	1/6	1400	2
12 hours	143.3	1/6	2100	< 2
24 hours	182	11/9	0900	< 2
2 days	189.7	12/9	0100	< 2
4 days	230.3	12/9	1500	< 2
7 days	253.0	12/9	1500	< 2
15 days	358.3	20/9	1200	< 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 1990

Office / Department	Total Number	Types of Incident		
		Landslide	Flooding	Others
Agriculture & Fisheries Department	2	-	2	-
Architectural Services Department	1	1	-	-
Drainage Services Department	-	-	-	-
Fire Services Department	6	1	1	4 (House Collapse)
Geotechnical Engineering Office, CED	105	87	2	16
Highways Department	90	85 *	1	4 (Boulder fall & Fallen tree)
Housing Department	2	-	2	-
Water Supplies Department	11	8	-	3
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 1990

Affected Area	Hong Kong	Kowloon	New Territories	All Districts
Squatters	4	26	14	44
Buildings	5	0	10(1)	15(1)
Roads / Access	12(2)	4	27(2)	43(4)
Construction Sites	4(1)	0	1(1)	5(2)
Service Reservoir	0	0	1(1)	1(1)
Open Areas	0	1	3(1)	4(1)
TOTAL NO. OF FAILURE	20(2)	29	50(4)	99(6)
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 1990

Type of Failure		No. of Huts Evacuated		Closure of Part of Building	Road / Access Blocked	Injury
		Permanent	Temporary			
Fill Slope		4	0	0	4	0
Cut Slope	Soil	14	1	0	6	0
	Soil/Rock	9	3	0	1	0
	Rock	0	0	0	0	0
Natural Slope		4	0	0	0	0
Retaining Wall		2	0	0	1	0
Rock / Boulder Fall		14	0	0	2	0
Basement Excavation		0	0	1	2	0
Others (Subsidence, washout etc.)		13	14	0	0	0
TOTAL		60	18	1	16	0

Table 7 - Number of Incidents Reported to GEO during 1990 Classified by Type of Failure

Type of Failure		Number	Percentage
Fill Slope		12(2)	12
Cut Slope	Soil	33(1)	34
	Soil / Rock	5	5
	Rock	3	3
Retaining Wall		5	5
Natural Slope		8(2)	8
Rock / Boulder Fall		9	9
Basement Excavation		2(1)	2
Others (Subsidence, washout etc.)		22	22
TOTAL		99(6)	100
<b>Legend :</b> ( )      Number of major failures			
<b>Note :</b> Incidents of no geotechnical concerned (e.g. tree falling, flooding) were ignored.			

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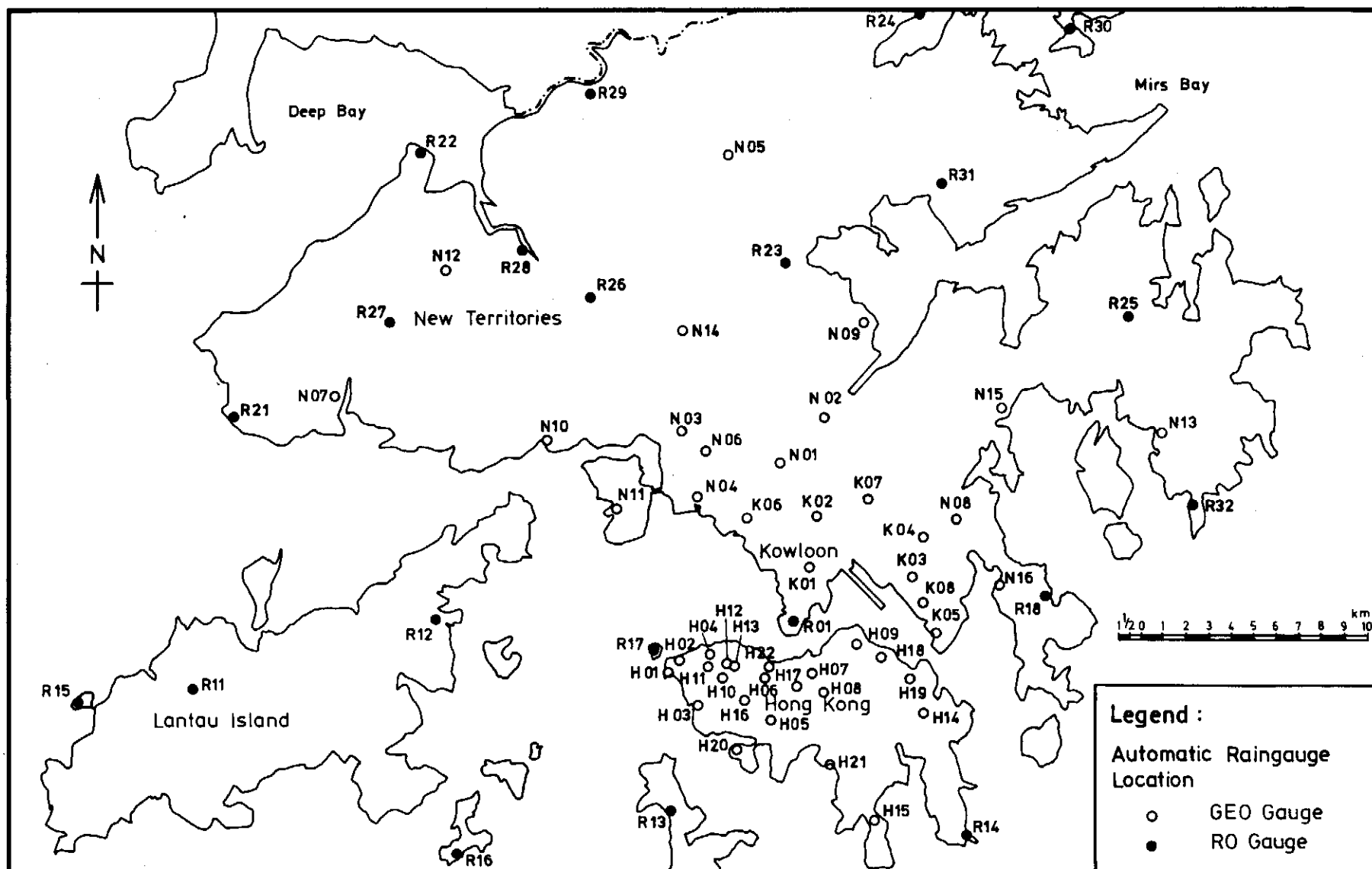


Figure 1 - Location of GEO and RO Automatic Raingauges

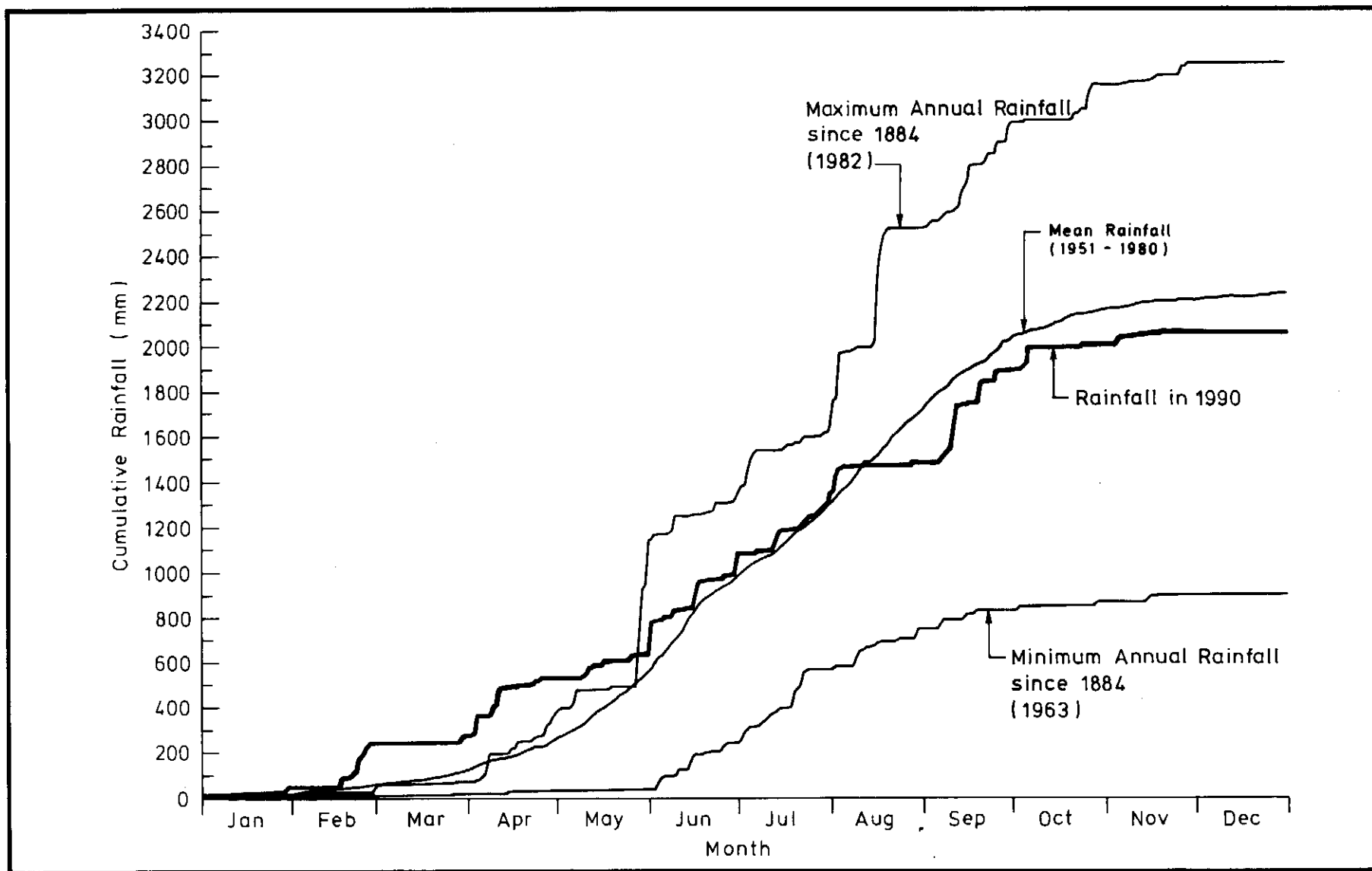


Figure 2 - Cumulative Rainfall for 1990 and the Recorded Maximum, Mean and Minimum Cumulative Rainfalls

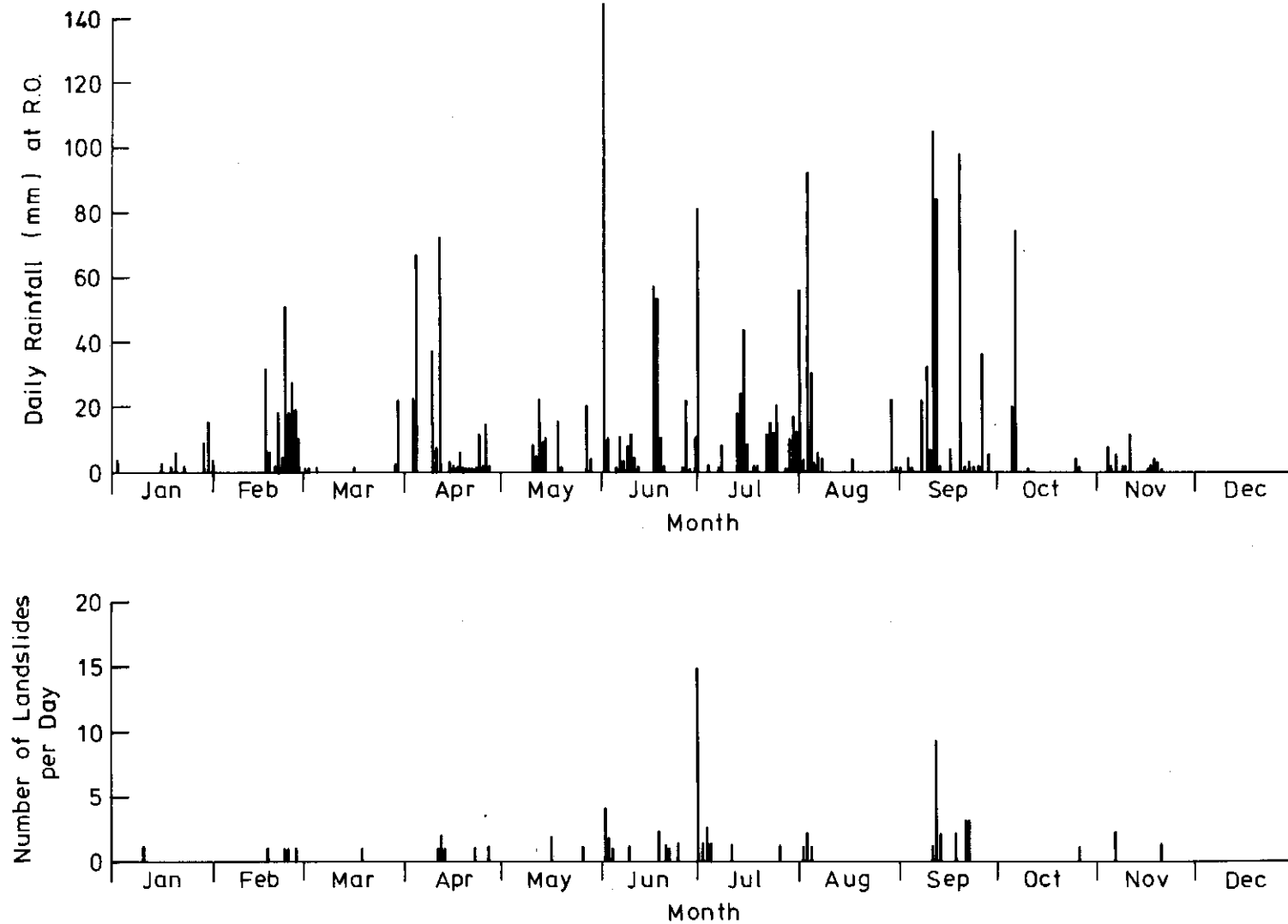


Figure 3 - Daily Rainfall and Distribution of Number of Landslides during 1990



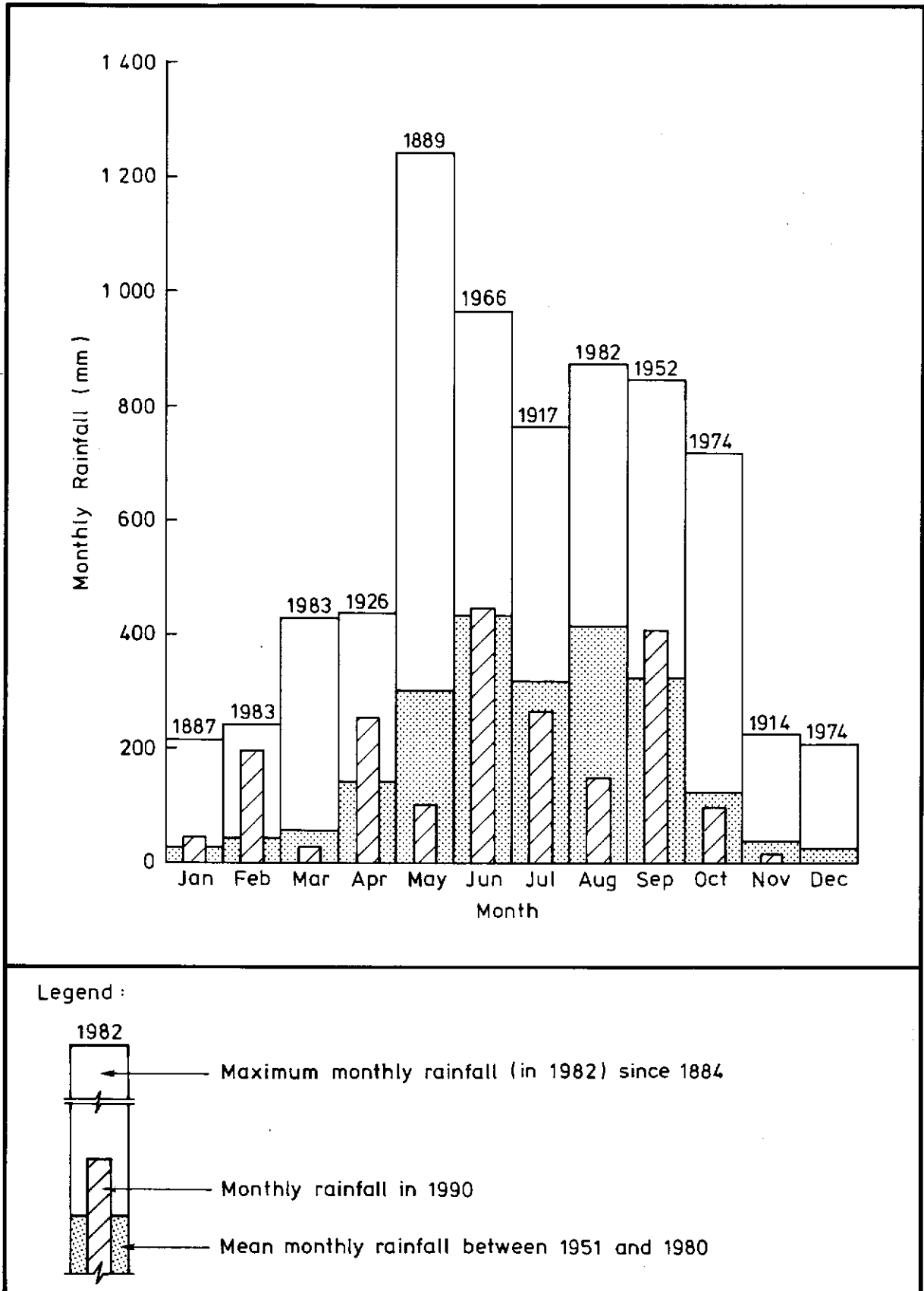


Figure 4 - Monthly Rainfalls in 1990 in Comparison with Recorded Maximum and Mean Monthly Rainfalls at the Royal Observatory

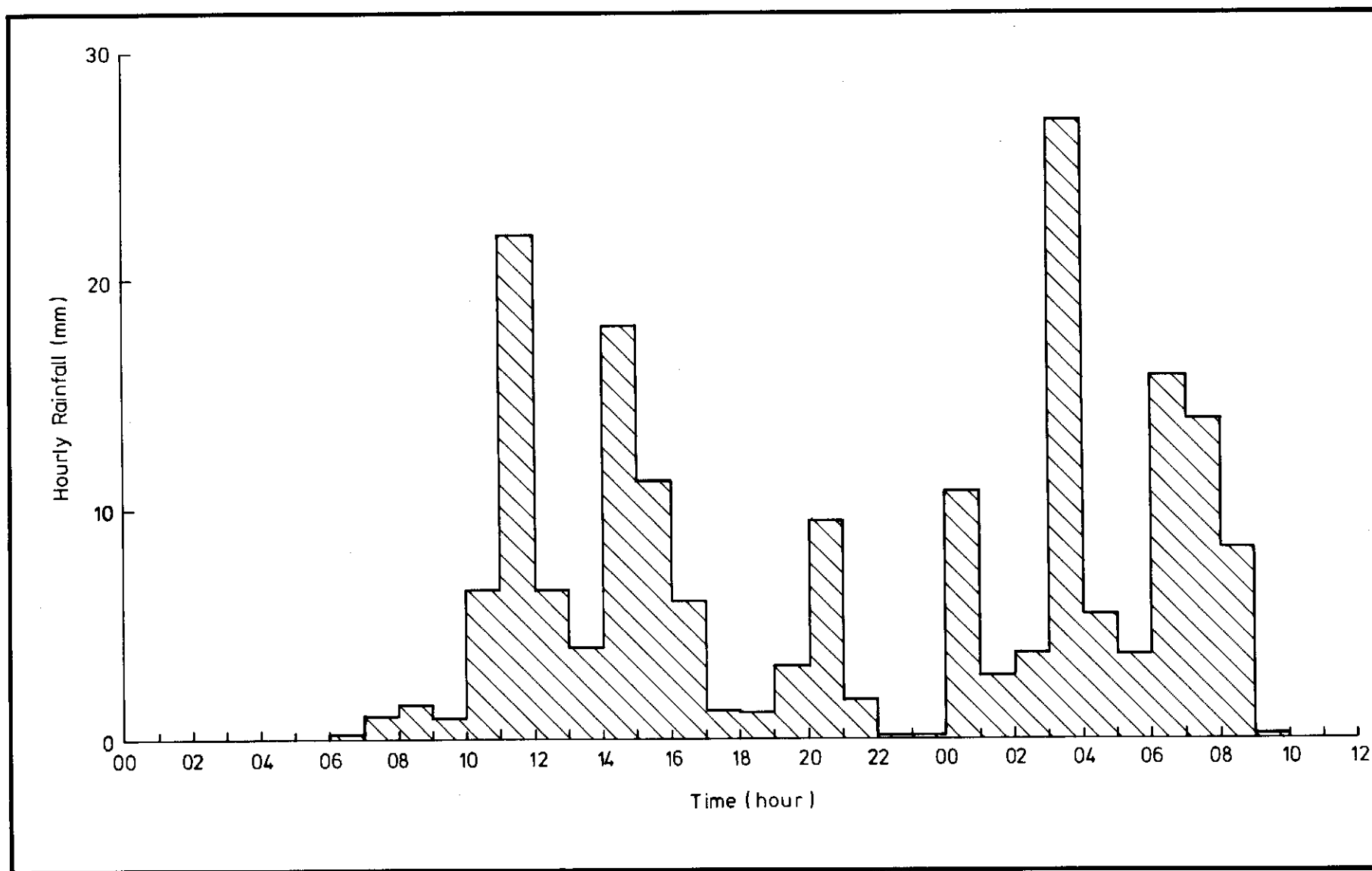


Figure 5 - Histograms of Hourly Rainfall at the Royal Observatory for the Highest 24-hour Rainfall in 1990 (between 10 & 11 September, 1990)

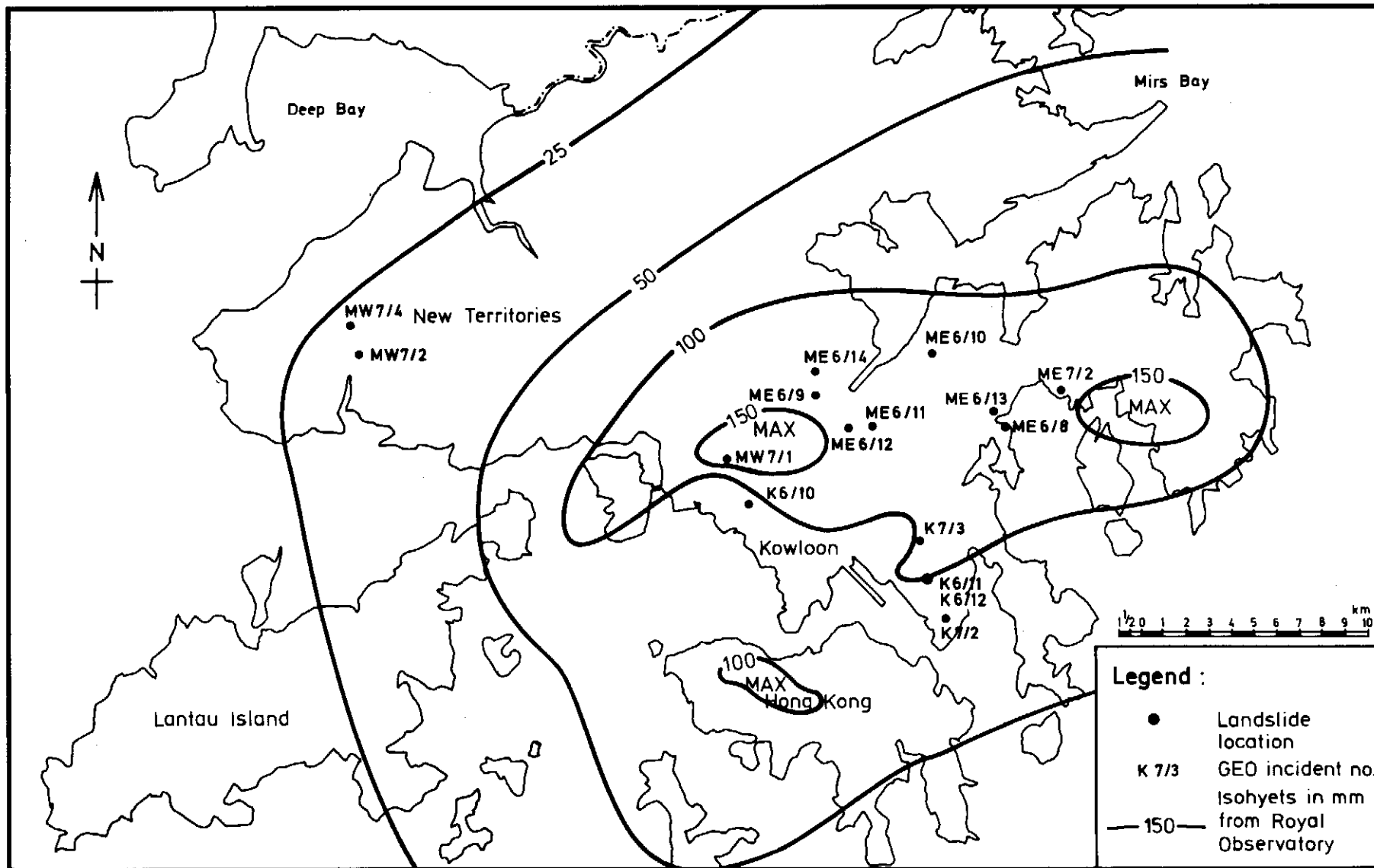


Figure 6 - 24-hour Rainfall Distribution Ending at 12 am on 1 July 1990 and Location of GEO Incidents

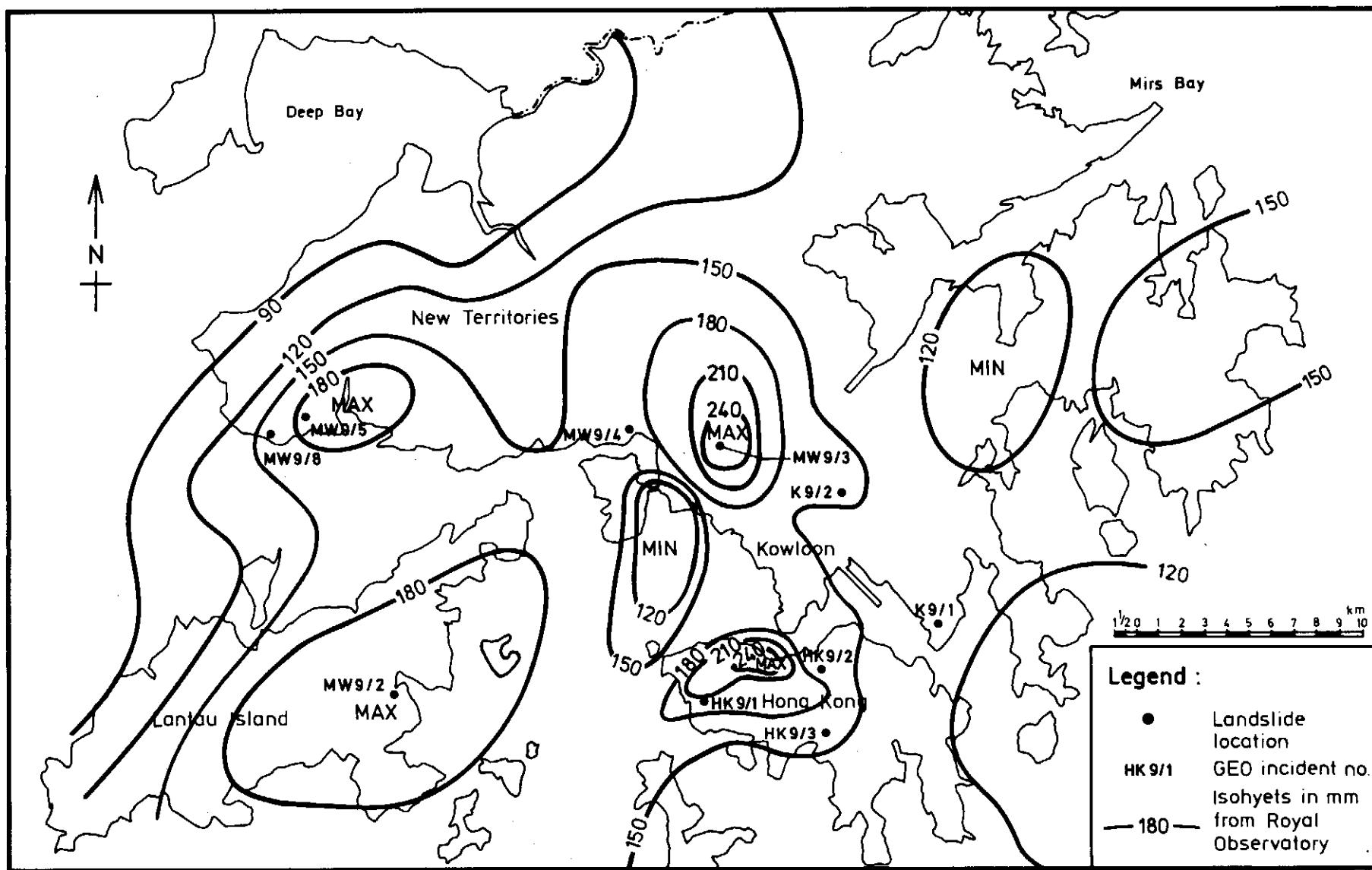


Figure 7 - 24-hour Rainfall Distribution Ending at 9 am on 11 September 1990 and Location of GEO Incidents

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23 & 24	Kwe Yang House, Tsuen Wan Centre, No. 9, Tsuen King Circuit, Tsuen Wan (Incident MW 90/12/1)	50



Plate 1 : Negative No. ME 9001106

**Description:** Failure of a temporary cut slope on 10 January, 1990 (about 400 m<sup>3</sup>), closing half of a village road

Plate 1 - Po Lo Che Service Reservoir, Sai Kung (Incident ME 90/1/1)





**Plate 2 : Negative No. IE 9003909**



**Plate 3 : Negative No. IE 9003904**

**Description:** Typical example of a rock fall

Plate 2 & 3 - Skek O Road near Sand Trap No. 41 (Incident HK 90/2/1)





Plate 4 :

Negative No.

IE 9010208A



Plate 5 :

Negative No. IE 9010202A

Description : Failure of a basement excavation on 6 April, 1990 resulting in subsidence of part of Bowrington Road.

Plate 4 & 5 - Bowrington Road (Incident HK 90/4/3)





Plate 6 :  
Negative No.  
IW 9008414



Plate 7 :  
Negative No. IW 9008412

Description : Structural failure of a back wall on 10 April, 1990 affecting a private backyard

Plate 6 & 7 - No. 17 MacDonnell Road (Incident HK 90/4/1)





Plate 8 : Negative No.  
SP 9110625



Plate 9 : Negative No.  
ME 9011124

Description: Failure of a rock cut slope on 12 April, 1990 (Plate 8)  
above squatter area (Plate 9).

Plate 8 & 9-Cha Kwo Ling Village behind Fan Wah Street (Incident K 90/4/2)



Plate 10: Negative No. SP 91085 (B) Date: 8-6-90

**Description:** Failure of a natural slope (About 700 m<sup>3</sup>) on 8 June, 1990 (Plate 10) damaging part of the discharge channel system at the edge of the platform of the service reservoir (Plate 11)

Plate 10 - Natural Slope below Cheung Chau Service Reservoir, Cheung Chau (Incident MW 90/6/1)





Plate 11 : Negative No. SP 9110624

**Description :** Failure of a natural slope (About 700 m<sup>3</sup>) on 8 June, 1990 (Plate 10) damaging part of the discharge channel system at the edge of the platform of the service reservoir (Plate 11)

Plate 11 - Natural Slope below Cheung Chau Service Reservoir, Cheung Chau (Incident MW 90/6/1)



Plate 12 : Negative No. ME 9017619



Plate 13 : Negative No. ME 9017617

**Description:** Failure of a soil cut slope on 20 June, 1990 resulting in permanent evacuation of five squatter huts

Plate 12 & 13 - Nam Shan Mei Village, Hut Nos. USD/NSM/46,47,55,56,57.  
(Incident K 90/6/9)





**Plate 14 : Negative No. ME 9019401**

**Description:** Failure of a soil cut slope on 30 June, 1990 affecting an extension of a village house

Plate 14 - No. 29 Tui Hoi Village, Sai Kung (Incident ME 90/6/8)



**Plate 15 : Negative No. SP 9110626**

**Description:** Failure of a soil cut slope on 30 June, 1990 blocking a footpath.

Plate 15 - Near House No. 20, Ngan Pei Sha New Village Sha Tin (Incident ME 90/6/11)



Plate 16 : Negative No. MW 9017616

**Description :** Failure a soil slope on 11 September, 1990 blocking part of South Lantau Road.

Plate 16 - MS ½, Lai Chi Yuen, below Water Treatment Works,  
South Lantau Road, Lantau Island (Incident MW 90/9/2)





**Plate 17 : Negative No. MW 9016604 Date : 11-9-90**



**Plate 18 : Negative No. MW 9016601 Date : 11-9-90**

**Description :** Dislodging of a rock pieces from a rock face on 11 September, 1990.

Plate 17 & 18 - Tuen Mun Road/Tsuen Wan Road (Incident MW 90/9/4)





**Plate 19 : Negative No. PS 692/12**



**Plate 20: Negative No. SP 9109202**

**Description :** Failure of a natural slope on 11 September, 1990 (about 22,000 m<sup>3</sup>) affecting a stock piling area below. A bouldery colluvium debris is shown in Plate 20

Plate 19 & 20 - Above Area 19, off Lung Mun Road, Tuen Mun  
(Incident MW 90/9/5)



Plate 21 :

Negative No. IE 9031713

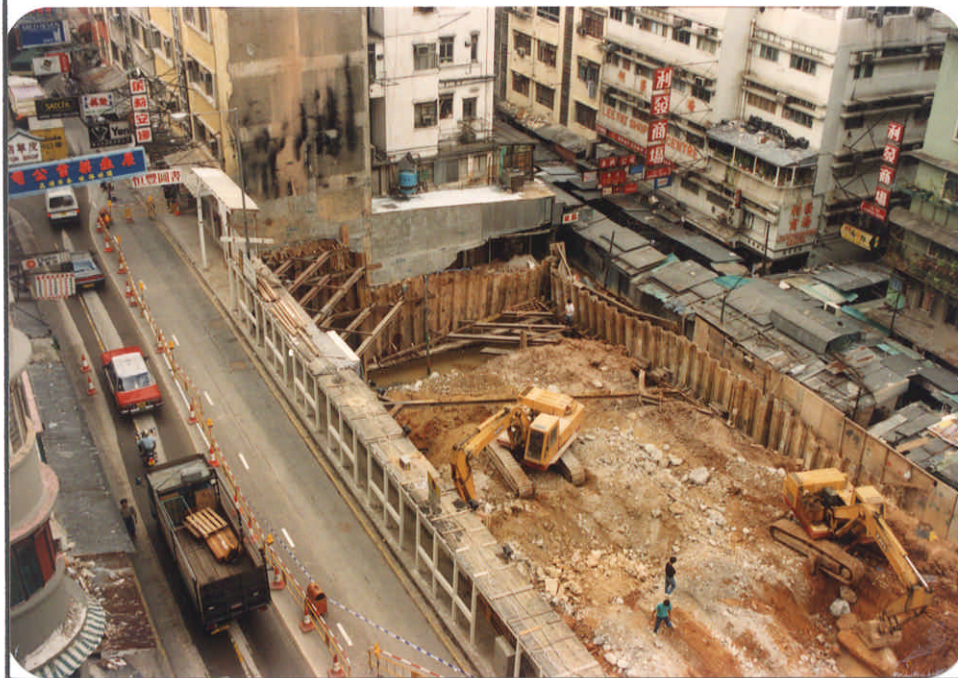


Plate 22 :

Negative No.  
IE 9031614

**Description :** Failure of a basement excavation on 24 October affecting building and road.

Plate 21 & 22 - Nos. 40-42 Yun Ping Road & Nos. 17-19 Jardine's Crescent  
(Incident HK 90/10/1)





**Plate 23 :**  
**Negative No.**  
MW 9024308



**Plate 24 :**  
**Negative No.** MW 9024408A

**Description:** Failure of a fill slope beneath a building block on 20 November, 1990 blocking a pedestrian pavement and a nullah below the building block.

Plate 23 & 24 - Kwe Yang House, Tsuen Wan Centre, No. 9, Tsuen King Circuit, Tsuen Wan (Incident MW 90/12/1)

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 on 1990 (Sheet 1 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
HK 2/1	Shek O Road near sand trap No. 41	6/2	HyD		Rock/boulder fall	Minor	Road		
HK 2/2	Ngar Choi Hang Village, at the J/O Cloud View Road/ Yee King Road, North Point	23/2	HyD	23/2 (2 am)	Wash out	Minor	Squatters Construction Site	1 hut temporarily evacuated	
HK 2/3	J/O Tai Hang Road/Broadwood Road	26/2	HyD	26/2	Soil/rock cut slope	Minor	Road		
HK 3/1	Behind Nos.4-12, Lin Shing Road, Chai Wan.	19/3	HyD		Soil cut slope	Minor	Lane		Broken chunam
HK 3/2	J/O Tin Wan Shan Road/ Shek Pai Wan Road	19/3	HyD	19/3	Rock/boulder fall	Minor	Pedestrian Pavement	Pedestrian pavement blocked	
HK 4/1	No.17 MacDonnell Road (Brick wall at eastern boundary)	10/4	BOO	10/4 (11 am)	Retaining wall	Minor	Building Lot	Private backyard blocked	
HK 4/2	Stubbs Road, below No.6 Shui Fai Terrace	9/4	HyD		Natural slope washout	Minor	Footpath	Shoulder of road slightly affected	
HK 4/3	Bowring Road	26/4	BOO	26/4 (13.40pm)	Basement excavation	Major	Road; Construction Site	2 lanes of road blocked	Rupture of water main
HK 6/1	Behind No.6, Leighton Lane LPM Site	1/6	BOO	1/6	Flooding		Building Lot		No geotechnical concern

Table A1 - List of Incidents on Hong Kong Island Reported to GEO on 1990 (Sheet 2 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
HK 6/2	Behind No.29 Conduit Road	4/6	Public	1/6	Flooding at ground floor, water coming from retaining walls (overflowing at top)		Building Lot		No geotechnical concern
HK 6/3	No.3 Eastern Hospital Road St Mary's Church College	13/6	BOO		Retaining wall	Minor	Building Lot	Backyard affected	Void in R.C. retaining wall
HK 6/4	Hut no. RH/18D/13 Wong Chuk Hang Path, Aberdeen	18/6	HyD	19/6 (9 am)	Soil cut slope	Minor	Squatters		Broken chunam
HK 6/5	Tai Hang Road near Mt. Butler Road (below Nos. 6-8)	19/6	HyD	17/6 (11 am)	Natural slope	Minor	Road		
HK 6/6	Nos. 1-11 Illumination Terrace	23/6	BOO	23/6	Retaining wall	Minor	Building Lot; Construction Site		
HK 7/1	South of No.12 Repulse Bay Road (opp. Slope 11 SE-C/C7)	23/7	HyD	23/7	Fill slope	Major	Road	Lane of road & footpath blocked	Leakage from water main
HK 8/1	Cut Slope 11SW-A/C151 behind abandoned filter beds and above Pokfulam Road	8/8	WSD	3/8	Rock/boulder fall	Minor	Footpath	Footpath blocked	
HK 9/1	Pokfulam Village	12/9	HyD	11/9	Soil cut slope	Minor	Squatters; Footpath	4 huts permanently evacuated	

Table A1 - List of Incidents on Hong Kong Island Reported to GEO on 1990 (Sheet 3 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
HK 9/2	Eastern Hospital Road (behind Buddhist Wong Fung Ling College)	13/9	DO	11/9	Wash out	Minor	Squatters		
HK 9/3	East of No.12 Repulse Bay Road	20/9	HyD	19/9	Soil cut slope	Minor	Road	Lane of road blocked	
HK 9/4	Findlay Path	20/9	Public	20/9	Rock/boulder fall	Minor			Peak Tram cable affected
HK 9/5	Below Nos. 26H-F Shouson Hill Road	20/9	HyD	20/9 (3 am)	Fallen trees	Minor	Road	Lane of road blocked	No geotechnical concern
HK 10/1	Nos.40-42 Yun Ping Road & Nos.17-19 Jardine's Crescent	25/10	BOO	24/10 (6 pm)	Basement excavation	Minor	Building Lot; Construction Site; Road	2 buildings temporarily evacuated, 1 lane closed	Rupture of water main
HK 11/1	Slope adjacent to SKH Stanley Village Primary School and below Carmel Road, Stanley	30/11	Police	30/11 (9:30 am)	Wash out	Minor	Building Lot	Playground fenced off	



Table A2 - List of Incidents in Kowloon Reported to GEO in 1990 (Sheet 1 of 5)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 2/1	Behind No.51 Wing Lok Yuen, Ching Cheung Road	17/2	Police	17/2	Wash out	Minor	Squatters	12 huts temporarily evacuated	Incident No. Not used
K 2/2	On Lok Village (Hut No. XKE/9/B/8/465)	26/2	HyD	23/2 (9.30pm)	Fill slope	Minor	Squatters	1 hut permanently evacuated	
K 2/3	Incident No. Not used								
K 2/4	Diamond Hill New Village, behind the Deaf School	27/2	DO	24/2	Wash out	Minor	Squatters		
K 3/1	Heung Yeung Village (Hut No. RKT/5B/141)	16/3	DO		Wash out	Minor	Squatters	2 huts temporarily evacuated 1 hut permanently evacuated	
K 3/2	Road side slope at Chuk Yuen Road opp. to Tin Ma Court	17/3	HyD		Soil cut slope	Minor	Open area		
K 3/3	Diamond Hill New Village (Hut No. XK6/4BE/5/35)	28/3	DO	May 90	Wash out	Minor	Squatters		
K 4/1	Ngau Chi Wan East Village (Hut No. XKC/3AB/G1/470-471)	12/4	BOO	11/4 (8 pm)	Rock/boulder fall	Minor	Squatters	6 huts permanently evacuated	

Table A2 - List of Incidents in Kowloon Reported to GEO in 1990 (Sheet 2 of 5)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 4/2	Cha Kwo Ling Village behind Fan Wah Street	12/4	HyD	12/4 (2.30pm)	Rock cut slope	Minor	Squatters		No geotechnical concern
K 5/1	Access lane behind Nos. 8-10 Ho Man Tin Street	5/5	DSD	May 90	Rupture of Drain		Lane		
K 5/2	Sau On Village (Hut Nos. XKE/3E/G7/973, 974, 977 & 978)	15/5	DO	15/5 (9 am)	Rock/boulder fall	Minor	Squatters	4 huts permanently evacuated	
K 6/1	Fan Wah Squatter Area behind (Hut Nos. RKT/1A/C1-7, B308, B309)	4/6	DO	2/6 (5 am)	Soil & rock cut slope	Minor	Squatters	9 huts permanently evacuated 3 huts temporarily evacuated	No geotechnical concern
K 6/2	Tai Shing Village (Hut Nos. XKE/9B/6/3-4)	5/6	DO		Up-heaving of ground		Squatters		
K 6/3	Diamond Hill New Village (Hut Nos. XKC/4B-E/5/48 & 49)	5/6	DO		Wash out, Flooding		Squatters		
K 6/4	Diamond Hill New Village (Hut No. RKT/4B/E/126) off Po Kong Village Road	6/6	DO	6/6	Subsidence	Minor	Squatters	1 hut permanently evacuated	

Table A2 - List of Incidents in Kowloon Reported to GEO in 1990 (Sheet 3 of 5)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 6/5	Che Tang Village, Lei Yue Mun Squatter (Hut Nos. RKT/12E/220 & 222)	11/6	DO	9/6 (6 am)	Soil cut slope	Minor	Squatters	1 hut permanently evacuated	
K 6/6	Heung Yeung Village, Tsz Wan Shan (Hut No. RKT/5B/132)	12/6	DO	12/6	Wash out	Minor	Squatters		
K 6/7	Chun Wah Road, (Road side slope at Lok Wah North Estate), Ngau Tau Kok	12/6	Public	12/6	Wash out	Minor	Road		
K 6/8	Ling Nam Lower Village Lei Yue Mun, Hut Nos. RKT/12/B/39 and 40	8/6	DO		Natural slope	Minor	Squatters		
K 6/9	Nam Shan Mei Village, Hut Nos. USD/NSM/46,47,55,56,57 North of Diamond Hill Cemetery	20/6	Works Branch	20/6 (10 am)	Soil cut slope	Minor	Squatters	5 huts permanently evacuated	
K 6/10	Ching Cheung Road opposite Caritas Medical Centre	30/6	Police	30/6 (12.30pm)	Soil cut slope	Minor	Half lane of road blocked		
K 6/11	On Lok Village, Sau Mau Ping, Hut No. XKE/9/B/468	2/7	HyD	30/6	Fill slope	Minor	Squatters; Footpath	Footpath partially blocked	

Table A2 - List of Incidents in Kowloon Reported to GEO in 1990 (Sheet 4 of 5)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 6/12	On Lok Village, Sau Mau Ping, Hut No. XKE/9/B/6/1292	2/7	HyD	30/6	Soil cut slope	Minor	Squatters		
K 7/1	Heung Yeung Village, Hut No. XKC/5N/2/65-73	3/7	Police	2/7	Subsidence	Minor	Squatters	1 hut permanently evacuated	
K 7/2	Ling Nam New Upper Village, Hut No. RKT/12A/N/89	4/7	DO	30/6	Subsidence	Minor	Squatters	1 hut permanently evacuated	
K 7/3	Wo Ping Tsuen, Anderson Road (Hut No. RKT/9E/75)	9/7	DLO	30/6	Wash out	Minor	Squatters	1 hut permanently evacuated	
K 8/1	On Lok Village, Sau Mau Ping (Hut No. XKE/9/B/8/1161)	2/8	HyD	2/8 (4 am)	Fill slope	Minor	Squatters; Footpath	1 hut permanently evacuated Footpath blocked	
K 9/1	Nam Ling Upper Village, Hut No. XKE/12A/N/G3/185, 186 & 187, Ko Chiu Road	12/9	DO	11/9 (9 am)	Subsidence	Minor	Squatters	3 huts permanently evacuated	
K 9/2	Heung Yeung Village, Hut No. RKT/5/B 182, Heung Yueng 3rd Path, Tse Wan Shan	11/9	Police	11/9	Soil cut slope	Minor	Squatters	1 hut permanently evacuated	
K 9/3	Tai Shing Village, Sau Mau Ping, Hut Nos. XKE/9/C/G7/308A & 309	17/9	HyD	16/9	Foundation failure	Minor	Squatters	2 huts permanently evacuated	

Table A2 - List of Incidents in Kowloon Reported to GEO in 1990 (Sheet 5 of 5)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 9/4	Sau On Village, Sau Mau Ping, Hut Nos. XKE/3E/G7/410 & 411	20/9	HyD	19/9	Boulder	Minor	Squatters	2 huts permanently evacuated	
K 11/1	Nam Ling Upper Village Hut Nos. XKE/12A/N/G3/376 & 377 Ko Chiu Road	6/11	DO	5/11	Subsidence (foundation failure)	Minor	Squatters	2 huts permanently evacuated	

Table A3 - List of Incidents in Eastern New Territories Reported to GEO in 1990 (Sheet 1 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
ME 1/1	Po Lo Che Service Reservoir, Sai Kung.	10/1	WSD	10/1 (4 am)	Soil cut slope	Major	Road; Construction Site	Road undermined & blocked	Inside a construction site
ME 2/1	Erosion of fill slope opp. to slope 7 SW-D/C105 of Stage 3, Tai Po Road Improvement, near MS 50	31/1	Public	May 89	Fill slope	Minor	Road		
ME 4/1	Slope supporting a garden fronting lot No. 961 in DD 220, Nam Shan, Sai Kung.	11/4	Police		Flooding, subsidence	Minor	Building Lot		
ME 4/2	K.C.R.C., CH 13+448 below old Tai Po Road, Sha Tin (near Race Course)	24/4	HyD	22/4	Rock cut slope	Minor	Road		
ME 6/1	Wall below house No. 76, Ma Yau Tong.	11/6	HyD	2/6 (12 noon)	Retaining wall	Minor	Road	Road partly blocked	
ME 6/2	Access road in Mang Kung Uk Village	11/6	HyD	3/6	Soil cut slope	Minor	Road	Road partly blocked	
ME 6/3	Tai O Mun Road near Clear Water Bay First Beach	11/6	HyD	1/6	Soil/rock cut slope	Minor	Road		

Table A3 - List of Incidents in Eastern New Territories Reported to GEO in 1990 (Sheet 2 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
ME 6/4	Clear Water Bay Road West bound near Ta Ku Ling, San Tsuen	11/6	HyD	1/6	Wash out	Minor	Road		
ME 6/5	Near Ma On Shan Country Park Management Station	8/6	DO/ST	1/6	Fill slope	Minor	Road		
ME 6/6	Tin Lin Village, Sha Tin squatter Hut Nos. RTL/144 & 145	11/6	DO/ST		Soil cut slope	Minor	Squatters		
ME 6/7	Sha Tin Tau, Sha Tin Hut Nos. RSTT6/231-233	21/6	Works Branch	17/6 (3 am)	Soil cut slope	Minor	Squatters; Footpath		
ME 6/8	No.29 Tui Min Hoi Village, Sai Kung.	30/6	GCO	30/6 (2 pm)	Soil cut slope	Minor	Building Lot		
ME 6/9	Next to No.399, Pai Tau Village, Sha Tin.	2/7	DO/ST	30/6	Soil cut slope	Minor	Footpath		
ME 6/10	Access road to Ma On Shan near the road bridge by Country Park Management Station	2/7	DO/ST	30/6	Fill slope	Minor	Road		
ME 6/11	Near House No. 20 Ngan Pei Sha New Village Shatin.	4/7	HyD	30/6	Soil cut slope	Minor	Footpath	Footpath blocked	

Table A3 - List of Incidents in Eastern New Territories Reported to GEO in 1990 (Sheet 3 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
ME 6/12	No. 73 Sha Tin Wai Tsuen, Sha Tin.	4/7	Public	30/6	Soil cut slope	Minor	Village Houses		
ME 6/13	Slope in front of Lot 1833 in DD 221, Tan Cheung, Sai Kung.	30/6	Police	30/6	Soil cut slope	Minor	Road		
ME 6/14	Access road to Wong Chuk Yeung Village, Fo Tan, Sha Tin	1/7	HyD	30/6	Soil/rock cut slope	Minor	Road	Half lane closed	
ME 7/1	Slope near (>10 M) from Hut No. RYOT/B/X36 Yau Oil Village	9/7	DO/ST	7/7	Soil cut slope	Minor	Open Space		
ME 7/2	Slope opposite Lot 275 in DD 252 Fung Sau Road, Tai Mong Tsai, Sai Kung.	27/7	DLO/SK	1/7	Soil cut slope	Minor	Private access		
ME 7/3	House Nos. 119-121, Kam Sau Terrace, Kam Shan, Tai Po	16/8	DLO/TP	Jul 90	Soil cut slope Wash out	Minor	Building Lot		
ME 7/4	Behind House No. 27E, Po Lung Terrace, Kam Shan, Tai Po	16/8	DLO/TP	Jul 90	Rock/boulder fall	Minor	Squatters; Rear lane	2 huts permanently evacuated and Rear lane blocked	
ME 8/1	Pak Tin Area 4, (Hut No. RPAK/A/404 & 405)	1/8	DO/ST	1/8 (3 pm)	Soil cut slope	Minor	Squatters	1 hut temporarily evacuated	



Table A3 - List of Incidents in Eastern New Territories Reported to GEO in 1990 (Sheet 4 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
ME 9/1	Pak Shek Terrace Lot 1170 in DD253.	24/9	DLO/SK	20/9 (2.30pm)	Fill slope	Minor	Open Space		
ME 10/1	Behind No. 15, Chuk Hang Village, Tai Po.	12/10	DO/TP		Soil cut slope	Minor	Footpath; Building lot		
ME 10/2	Behind No. 17A, Chuk Hang Village, Tai Po.	12/10	DO/TP		Soil cut slope	Minor	Building Lot		
ME 10/3	Behind No. 16, Chuk Hang Village, Tai Po.	12/10	DO/TP		Soil cut slope	Minor	Building Lot; Footpath		

Table A4 - List of Incidents in Western New Territories Reported to GEO in 1990 (Sheet 1 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
MW 1/1	No. 32 Siu Lam Chuen, Tuen Mun	2/1	DO/TM	May 89	Soil cut slope	Minor	Squatters	Backyard blocked	2 landslips in one incident       No geotechnical concern
MW 1/2	Lot 1640 in DD 3(House No. 32), Yung Shue Long New Village, Lamma Island.	16/1	DLO	May 89	Soil cut slope	Minor	Building Lot	Backyard blocked	
MW 3/1	Behind No. 65, Kat Hing Back Street, Tai O, Lantau.	15/3	GCO		Natural slope/ soil cut slope	Minor	Footpath		
MW 4/1	Wo Yi Hop Road, near Ngong Hom Road, K. C.	17/4	HyD	11/4	Rock cut slope	Minor	Pavement	Footpath blocked	
MW 5/1	Gulf Oil Depot, Tsing Yi Island	25/5	BOO	25/5 (12 noon)	Fence wall				
MW 6/1	Slope below Cheung Chau Service Reservoir	8/6	WSD	8/6 (9 am)	Natural slope	Major	Service reservoir		
MW 6/2	Yau Kom Tau Area 28, Kin Yip Sun Tsuen.	19/6	HD	17/6	Soil cut slope	Minor	Squatters	1 hut permanently evacuated	
MW 6/3	Yau Kom Tau, Area 28 at Kin Yip Sun Tsuen (behind Hut No. R7W/2BB/76-78)	19/6	HD		Soil cut slope	Minor	Squatters	1 hut permanently evacuated	

Table A4 - List of Incidents in Western New Territories Reported to GEO in 1990 (Sheet 2 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
MW 6/4	Mo Lo Shan, off Tsing Wun Road Tuen Mun (below squatter huts TM/MLS/435 & 436)	29/6	HyD		Natural slope	Minor	Squatters		
MW 7/1	Shek Lei Kam Shan Tsuen, off Lei Pui Street, Kwai Chung	2/7	HD	30/6	Natural slope	Minor	Squatters	3 huts permanently evacuated	
MW 7/2	No.81 Tsang Tau Chung Tsuen, Tuen Mun	4/7	Public	30/6	Fill slope	Minor	Footpath		
MW 7/3	Hon Man Tsuen, Yau Kom Tau, off Tuen Mun Road, Tsuen Wan.	4/7	BOO	3/7 (11 am)	Retaining wall	Minor	Squatters	2 hut permanently evacuated	
MW 7/4	No. 36 Tsz Tin Tsuen, Tuen Mun.	5/7	DO	30/6	Wash out	Minor	Building Lot		
MW 8/1	Near No. 376, 6½ Miles, Castle Peak Road Village, Kwai Chung.	6/8	HyD		Rubble fill	Minor	Footpath	Footpath subsided	
MW 9/1	Kau Wah Keng Village	11/9	Police	10/9	Fallen trees				No geotechnical concern
MW 9/2	MS ½, Lai Chi Yuen, below Water Treatment Works, South Lantau Road, Lantau Island	11/9	GCO	11/9 (7 am)	Soil cut slope	Minor	Road	Lane of road blocked	

Table A4 - List of Incidents in Western New Territories Reported to GEO in 1990 (Sheet 3 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
MW 9/3	Shei Lei Hang, hut XTW/SLH/25 off Shek Pai Street, Kwai Chung	11/9	HD	11/9 (10 am)	Soil cut slope	Minor	Squatters	1 hut permanently evacuated	
MW 9/4	Tuen Mun Road/Tsuen Wan Road	11/9	HyD	11/9	Rock/boulder fall	Minor	Road	Pedestrian Pavement blocked	
MW 9/5	Above Area 19, off Lung Mun Road, Tuen Mun.	11/9	PM/TM	11/9 (2.30am)	Natural slope	Major	Stockpiling Area		
MW 9/6	Kam Shan Village, hut RTW/9E/4 off Lei Pui Street, Kwai Chung	11/9	HD	12/9 (9.30 am)	Natural slope	Minor	Squatters	1 hut permanently evacuated	
MW 9/7	Castle Peak Road, 6½ miles village, Kwai Chung Hut RTW/9Q/158	11/9	HD	12/9 (11 am)	Fill slope	Minor	Squatters	2 huts permanently evacuated	
MW 9/8	Lung Mun Road, Tuen Mun.	12/9	HyD	11/9 (7.30pm)	Soil/rock cut slope	Minor	Pavement		
MW 9/9	No. 52A Tsz Tin Tsuen, Tuen Mun.	18/9	DO/TM	15/9	Soil cut slope	Minor	Squatters		
MW 12/1	Kwei Yang House, Tsuen Wan Centre, No. 9 Tsuen King Circuit, Tsuen Wan.	4/12	WSD	30/11 (4 pm)	Fill slope	Major	Building Lot; Pavement		Water mains ruptured

APPENDIX B  
RECORDS FROM GEO RAINGAUGES DURING  
THE HEAVIEST 24-HOUR RAINSTORM  
IN 1990

APPENDIX B

LIST OF FIGURES

Figure No.		Page No.
B1	Histograms of Hourly Rainfall Recorded by GEO Raingauges on 10 to 11 September 1990	70

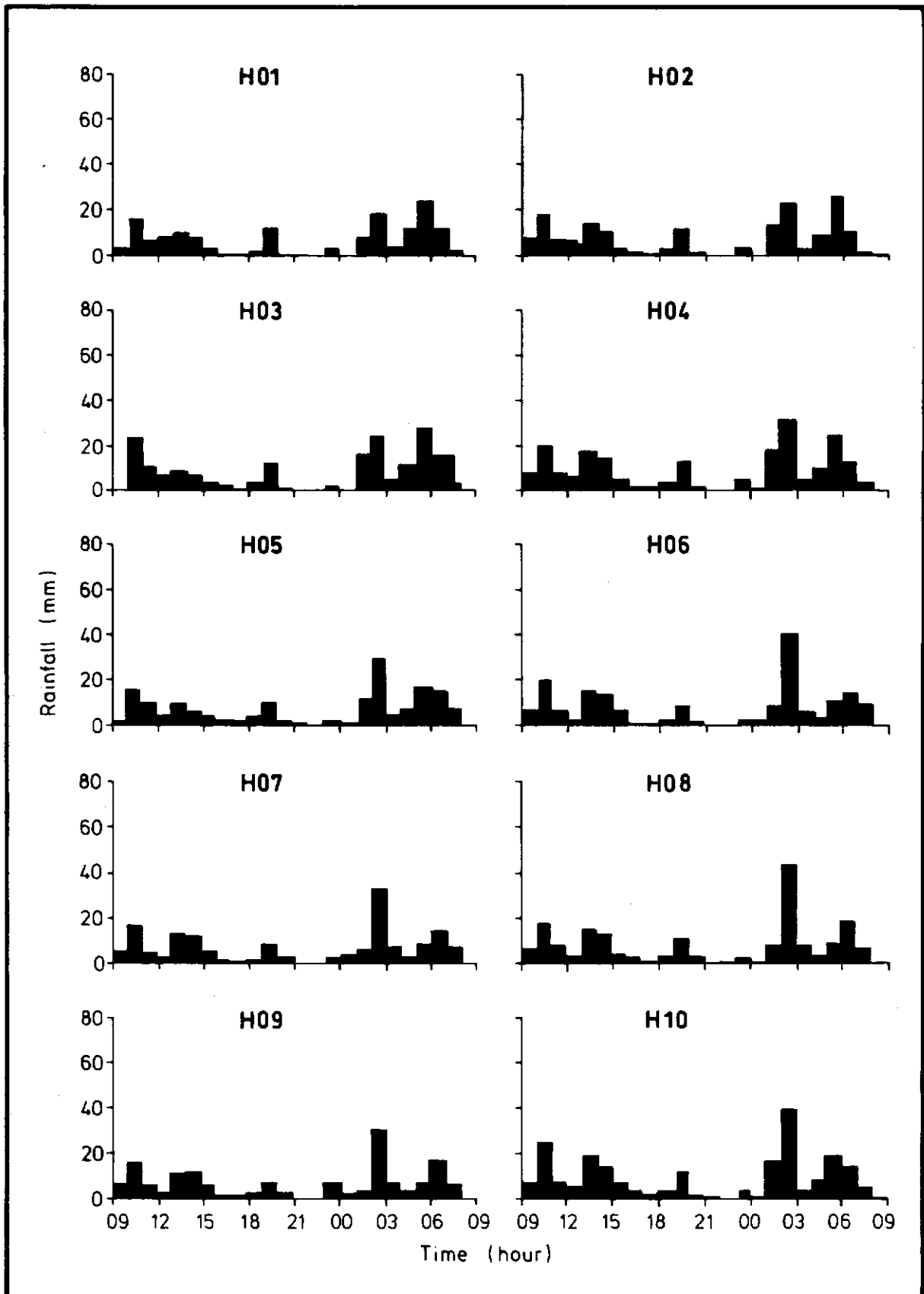


Figure B1 - Histograms of Hourly Rainfall Recorded by GEO Raingauges on 10th & 11th September 1990 (Sheet 1 of 5)

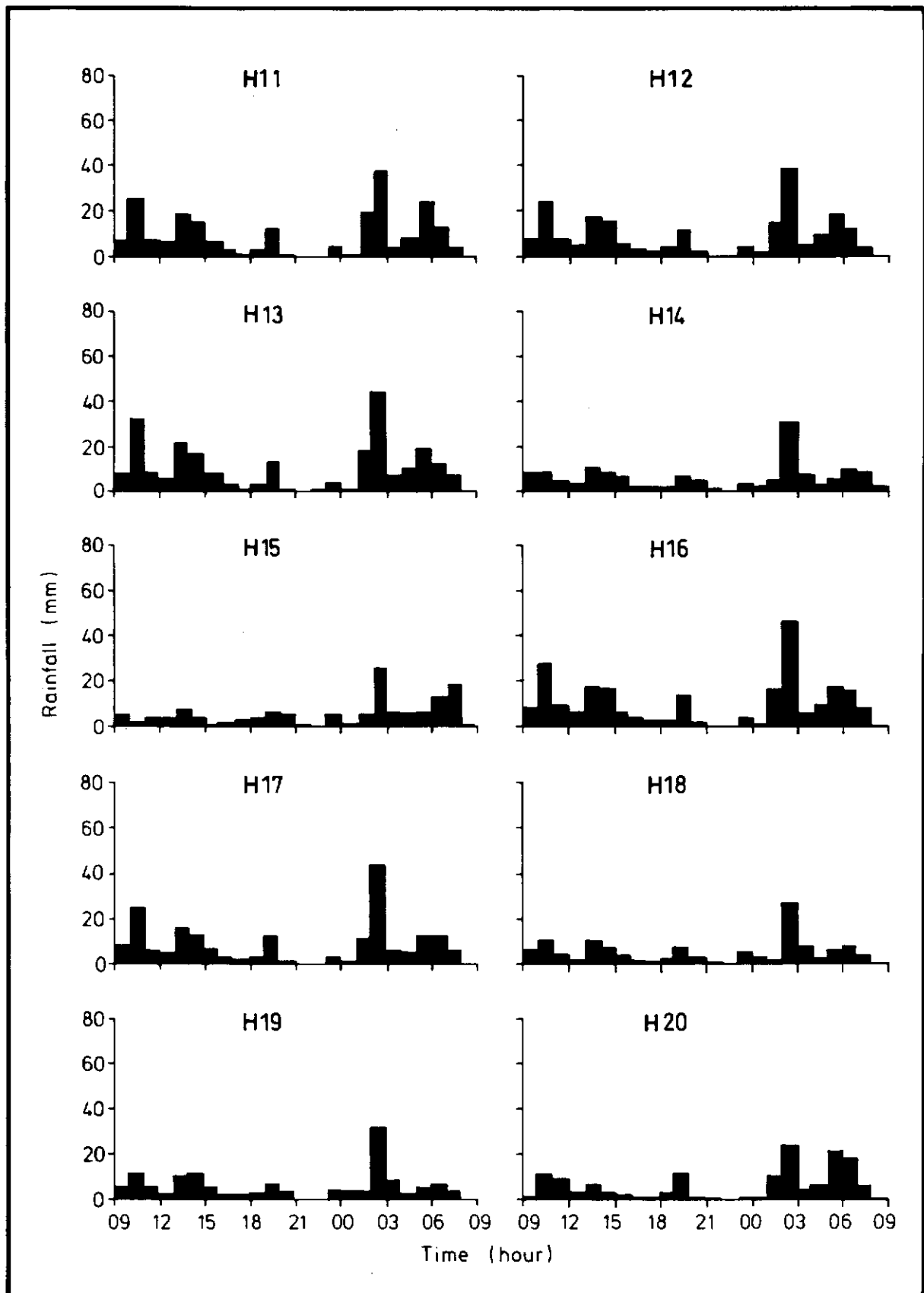


Figure B1 - Histograms of Hourly Rainfall Recorded by GEO Raingauges on 10th & 11th September 1990 (Sheet 2 of 5)



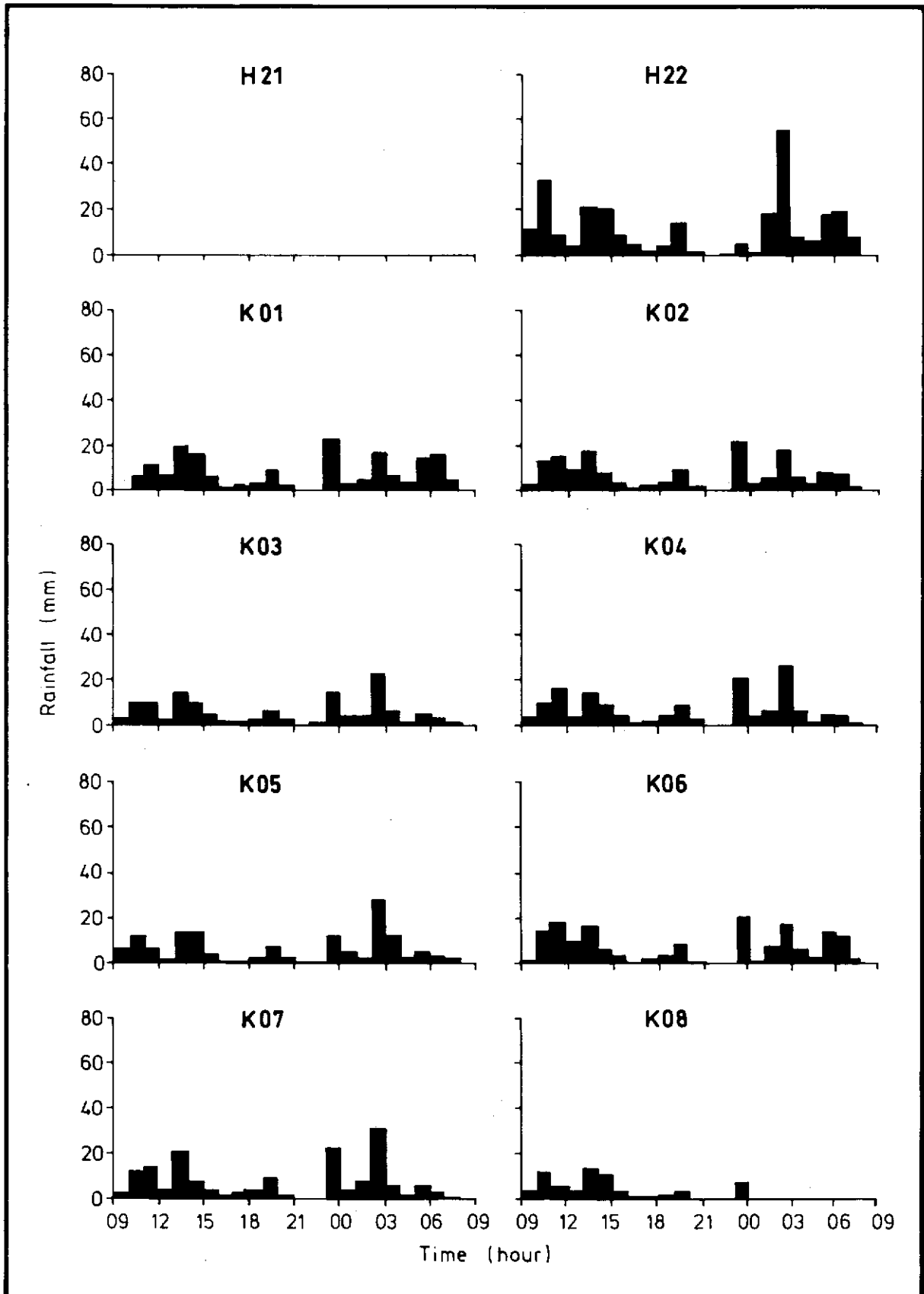


Figure B1 - Histograms of Hourly Rainfall Recorded by GEO Raingauges on 10th & 11th September 1990 (Sheet 3 of 5)

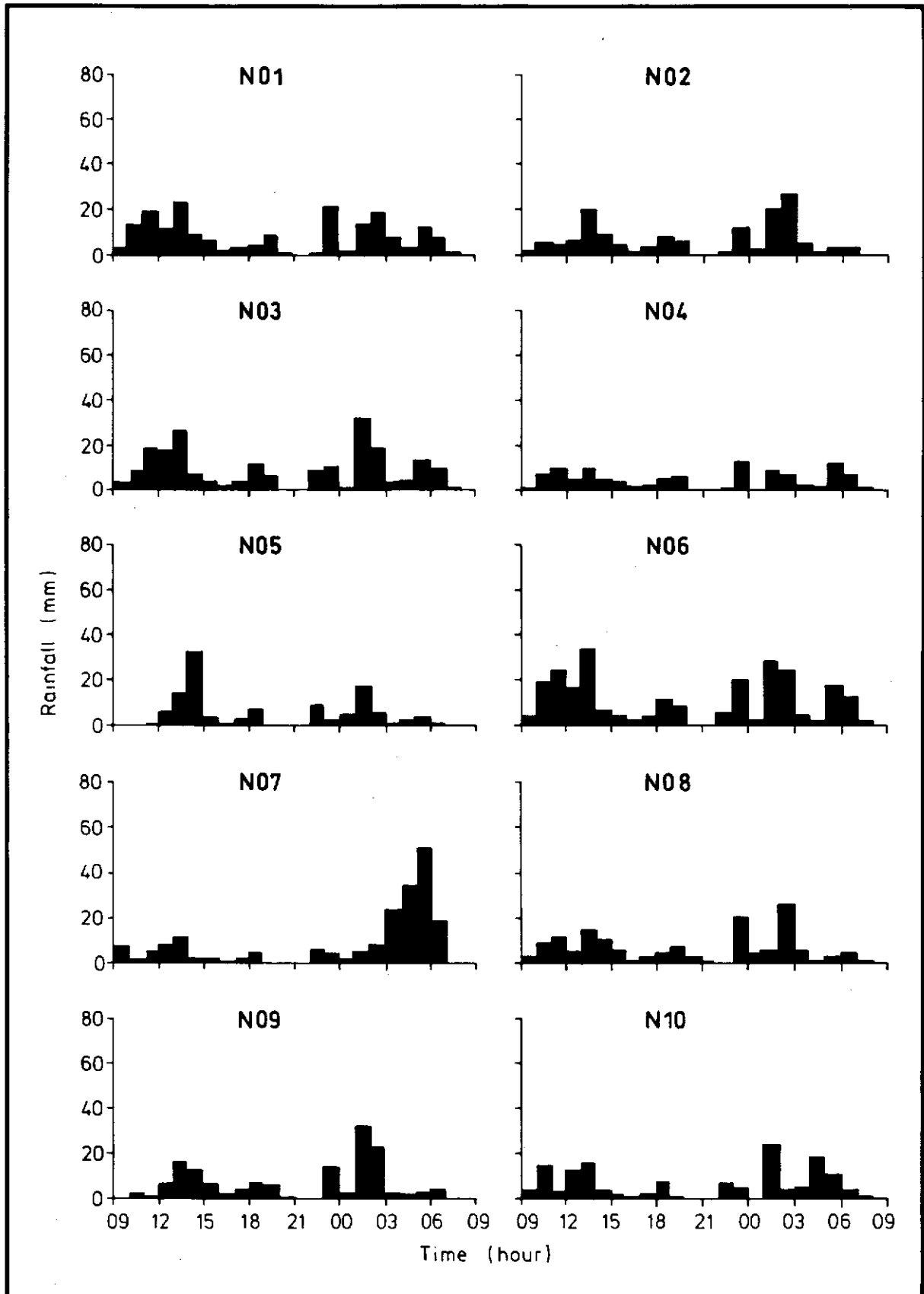


Figure B1 - Histograms of Hourly Rainfall Recorded by GEO Raingauges on 10th & 11th September 1990 (Sheet 4 of 5)

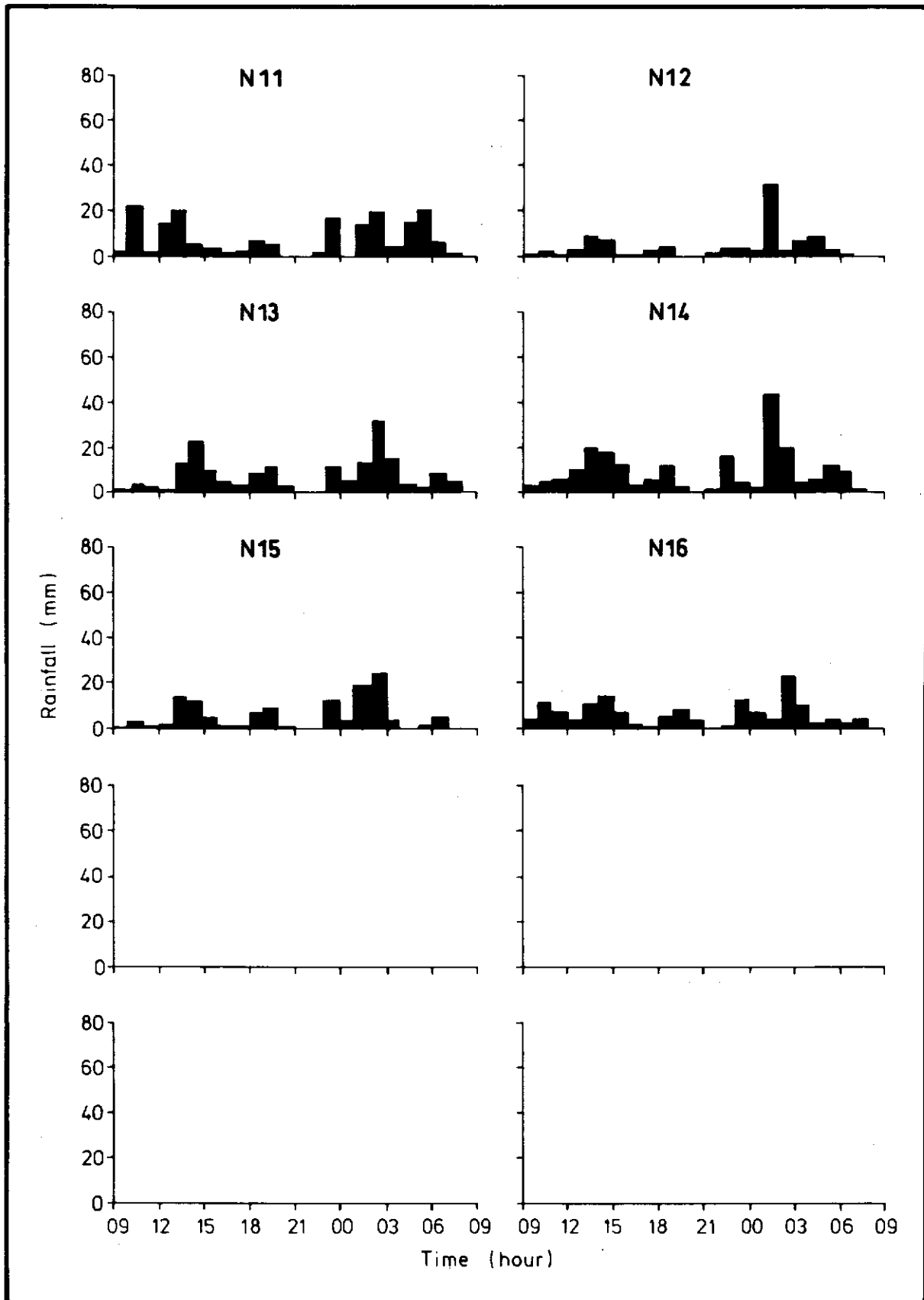


Figure B1 - Histograms of Hourly Rainfall Recorded by GEO Raingauges on 10th & 11th September 1990 (Sheet 5 of 5)

APPENDIX C

DAILY RAINFALL AT THE ROYAL OBSERVATORY IN 1990

APPENDIX C

LIST OF TABLE

Table No.		Page No.
C1	Summary of Daily Rainfall at the Royal Observatory in 1990	77

Table C1 - Summary of Daily Rainfall at the Royal Observatory in 1990

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.4	0.5	0.7	0.6	0.0	144.8	0.1	3.6	0.0	Trace	0.0	0.0
2	3.0	Trace	0.5	Trace	0.0	10.8	Trace	73.3	3.5	0.3	0.0	0.0
3	0.0	0.0	0.1	23.1	0.0	0.8	2.3	29.2	0.8	Trace	7.1	0.0
4	0.0	0.0	0.5	67.9	0.1	0.9	Trace	3.2	0.0	21.1	1.0	0.0
5	0.1	0.0	0.0	0.3	Trace	1.8	Trace	6.3	0.0	74.0	4.8	0.0
6	Trace	0.0	0.2	Trace	0.0	11.2	0.1	4.1	22.7	0.0	Trace	0.0
7	Trace	0.0	0.0	Trace	0.0	4.1	7.3	Trace	0.0	0.0	1.3	0.0
8	0.0	Trace	0.0	Trace	Trace	8.5	0.0	0.0	31.8	0.0	0.5	0.0
9	0.0	0.4	0.1	38.7	8.3	12.4	Trace	0.0	7.4	0.3	11.0	0.0
10	0.0	0.3	0.0	7.6	5.7	5.5	0.0	Trace	105.4	0.0	0.0	0.0
11	Trace	0.0	0.0	72.9	23.1	2.1	Trace	Trace	83.9	0.0	0.0	0.0
12	0.0	0.2	Trace	0.1	8.6	Trace	19.0	Trace	1.8	0.0	0.0	0.0
13	Trace	0.0	Trace	0.0	10.6	0.0	25.2	0.0	Trace	0.0	0.0	0.0
14	Trace	0.0	Trace	2.9	0.0	0.0	43.8	Trace	Trace	Trace	0.0	0.0
15	3.3	0.0	Trace	1.4	Trace	Trace	7.9	0.0	6.8	Trace	0.9	Trace
16	Trace	Trace	0.8	1.3	Trace	58.4	Trace	4.1	0.0	0.0	2.6	Trace
17	Trace	32.5	0.0	7.4	16.4	55.1	0.9	0.0	Trace	Trace	3.9	0.0
18	1.3	7.1	Trace	0.4	2.1	11.2	2.1	Trace	Trace	0.0	3.4	0.0
19	6.7	0.0	0.0	0.3	0.0	1.1	0.2	0.0	97.5	0.0	0.3	0.0
20	0.3	2.2	0.0	0.6	0.0	Trace	Trace	0.0	1.0	Trace	0.0	0.0
21	0.6	18.0	0.0	0.9	0.0	0.0	11.0	0.0	2.8	Trace	0.0	0.0
22	0.3	5.0	Trace	0.4	0.0	0.0	14.7	Trace	1.2	0.0	0.0	Trace
23	1.6	52.5	0.0	13.4	0.0	0.0	12.0	0.3	0.0	0.0	0.0	0.0
24	Trace	18.0	0.1	1.8	Trace	0.0	21.5	Trace	0.6	3.7	0.0	0.0
25	0.9	28.4	Trace	15.3	Trace	1.6	0.0	0.4	36.8	1.2	0.0	0.0
26	Trace	19.4	0.1	0.3	20.1	21.9	0.0	0.0	0.3	0.0	0.0	Trace
27	0.0	10.6	Trace	0.0	5.3	0.3	1.7	Trace	5.6	Trace	Trace	Trace
28	Trace	0.6	0.0	Trace	Trace	0.0	10.0	22.7	Trace	0.0	0.0	0.0
29	9.6		3.4	0.0	Trace	12.6	17.4	2.9	0.0	Trace	0.0	Trace
30	15.8		23.4	0.0	2.1	83.0	13.2	0.0	0.0	0.1	0.0	0.1
31	3.6		Trace		0.0		57.6	0.0		0.0		Trace
TOTAL	47.5	195.7	29.9	257.6	102.4	448.1	268.0	150.1	409.9	100.7	36.9	0.1

The Total Rainfall in 1990 is 2046.9mm

LIST OF DRAWING

Drawing  
No.

GCSP 8/7      Location Map of Landslides and Related Incidents  
in 1990