

**DETAILED STUDY OF THE  
7 JUNE 2008 LANDSLIDE  
BEHIND ROCKWIN COURT,  
FUNG FAI TERRACE,  
HAPPY VALLEY**

**GEO REPORT No. 285**

**Fugro Scott Wilson Joint Venture**

**GEOTECHNICAL ENGINEERING OFFICE  
CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT  
THE GOVERNMENT OF THE HONG KONG  
SPECIAL ADMINISTRATIVE REGION**

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**This report is largely based on GEO Landslide Study Report  
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Prepared by:

Geotechnical Engineering Office,  
Civil Engineering and Development Department,  
Civil Engineering and Development Building,  
101 Princess Margaret Road,  
Homantin, Kowloon,  
Hong Kong.

## PREFACE

In keeping with our policy of releasing information which may be of general interest to the geotechnical profession and the public, we make available selected internal reports in a series of publications termed the GEO Report series. The GEO Reports can be downloaded from the website of the Civil Engineering and Development Department (<http://www.cedd.gov.hk>) on the Internet. Printed copies are also available for some GEO Reports. For printed copies, a charge is made to cover the cost of printing.

The Geotechnical Engineering Office also produces documents specifically for publication in print. These include guidance documents and results of comprehensive reviews. They can also be downloaded from the above website.

The publications and the printed GEO Reports may be obtained from the Government's Information Services Department. Information on how to purchase these documents is given on the second last page of this report.



H.N. Wong  
Head, Geotechnical Engineering Office  
September 2013



## FOREWORD

This report presents the findings of a detailed study of a landslide (Incident No. 2008/06/0156) that occurred on 7 June 2008 on the natural hillside behind Rockwin Court, Fung Fai Terrace, Happy Valley. Both Landslip Warning and Black Rainstorm Warning were in effect at the time of the failure. The landslide involved a failure volume of about 500 m<sup>3</sup> with a runout distance of about 55 m. The landslide debris was mainly deposited on the cut slopes at the toe of the hillside. Some debris came to rest at the rear of Rockwin Court, as well as at the rear alleyway of the adjacent Celeste Court. No casualties were reported as a result of the landslide, however residents in nine flats of Rockwin Court were temporarily evacuated.

The report was prepared as part of the Landslide Investigation Consultancy for landslides occurring in Hong Kong Island and Outlying Islands in 2008 and 2009, for the Geotechnical Engineering Office of the Civil Engineering and Development Department, under Agreement No. CE 40/2007 (GE). This is one of a series of reports produced during the consultancy by Fugro Scott Wilson Joint Venture.



Y.C. Koo  
Project Director  
Fugro Scott Wilson Joint Venture

Agreement No. CE 40/2007 (GE)  
Study of Landslides Occurring in  
Hong Kong Island and Outlying  
Islands in 2008 and 2009 –  
Feasibility Study

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## 1. INTRODUCTION

Between 8:45 a.m. and 9:30 a.m. on 7 June 2008, when both Landslip Warning and Black Rainstorm Warning were in effect, a major landslide (Incident No. 2008/06/0156) occurred on the east-facing natural hillside overlooking Rockwin Court and Celeste Court at Fung Fai Terrace, Happy Valley (Figure 1 and Plate 1).

Fugro Scott Wilson Joint Venture (FSW) has been engaged by the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD) to establish the probable causes of the landslide. This report documents the findings.

## 2. DESCRIPTION OF THE SITE

The east-facing natural hillside where the 7 June 2008 landslide occurred is steeply inclined at about 40° and densely vegetated. The concerned hillside catchment has a plan area of about 1,100 m<sup>2</sup>, and measures about 35 m wide and 30 m long (Figure 2). The sloping ground above the natural hillside is also inclined at about 40° and largely covered with a hard surface (Plate 2). An ephemeral drainage line is present to the north of the 7 June 2008 landslide scar.

Stubbs Road and residential blocks of Fung Fai Terrace are located at the crest and toe of the hillside at about 92 mPD and 36 mPD respectively. A concrete stairway leading from Stubbs Road traverses the sloping ground above the natural hillside and terminates at the northern flank of the 7 June 2008 landslide (Figure 2 and Plate 3). Based on the records provided by Water Supplies Department and Drainage Services Department, there are no water-carrying services buried in the hillside or in its immediate vicinity.

The hillside is surrounded by a number of registered man-made slopes (Figure 2 and Plate 4). Cut slopes Nos. 11SW-D/C14 and 11SW-D/C2237 are located behind Fung Fai Terrace, which are about 30 m and 24 m high respectively, sloping at about 50° and covered with a hard surface. Located immediately downhill of Stubbs Road is fill slope No. 11SW-D/F69, which is about 13 m high with a slope angle of about 35° and partly covered with a hard surface. The fill slope is located about 20 m to the southwest of the 7 June 2008 landslide site.

## 3. THE 7 JUNE 2008 LANDSLIDE

The 7 June 2008 landslide is an open hillslope failure with an estimated volume of about 500 m<sup>3</sup> (Plate 5). The landslide debris travelled down the natural hillside with a runout distance of about 55 m and was deposited mainly on the cut slopes (Nos. 11SW-D/C14 and 11SW-D/C2237) at the toe of the hillside (Figures 2 and 3, Plate 6). Some debris came to rest at the rear of Rockwin Court resulting in damage to the walls and windows (Plates 7 to 9), whilst some piled up at the rear alleyway of the adjacent Celeste Court (Plate 10). Muddy water also entered a flat of Rockwin Court probably through the broken windows (Plate 9). No casualties were reported as a result of the landslide, however residents in nine flats of Rockwin Court were temporarily evacuated.

#### 4. MAINTENANCE RESPONSIBILITY

Based on the information obtained from Lands Department, the 7 June 2008 landslide occurred on unleased and unallocated government land.

#### 5. SITE HISTORY AND PAST INSTABILITY

##### 5.1 General

The development history and past instability of the landslide site has been established from an interpretation of the available aerial photographs, together with a review of relevant documentary information and field observations (Figure 4). Detailed observations from the aerial photograph interpretation (API) are summarized in Appendix A. Salient points are presented as follows.

##### 5.2 Site History

Based on the earliest aerial photographs taken in 1945, the landslide site was a sparsely vegetated natural hillside that comprised an east-trending steep valley. A Y-shaped ephemeral natural drainage line was present within the valley. Most of the present-day developments in the vicinity of the landslide site and Stubbs Road, as well as the cut slopes to the west of Fung Fai Terrace, including slope No. 11SW-D/C14, had been formed. By 1949, a system of surface drainage channels was constructed generally along the ephemeral drainage line immediately above the 7 June 2008 landslide scar.

To the southwest of the 7 June 2008 landslide, a fill slope and the associated crest platform (subsequently modified and registered as slope No. 11SW-D/F69) were formed in 1963, which appeared to have been covered with a hard surface. Between 1981 and 1982, slope works were carried out on fill slope No. 11SW-D/F69 (see Section 6.2).

Rockwin Court and Celeste Court were built by 1988 and 1990 respectively. In association with the construction of Celeste Court, the cut slope to the west of No. 12 Fung Fai Terrace was modified to form slope No. 11SW-D/C2237 between 1990 and 1991.

The landslide site gradually became densely vegetated and there were no observable adverse changes to the site setting since 1992 based on the aerial photographs reviewed.

##### 5.3 Past Instability

According to the GEO's Landslide Database and Enhanced Natural Terrain Landslide Inventory (ENTLI), there are no records of previous landslides on the natural hillside that failed on 7 June 2008. In May 1987, a minor washout failure (Incident No. HK87/5/12) with a failure volume of about 0.5 m<sup>3</sup> occurred on slope No. 11SW-D/C14 located some 60 m to the northeast of the 7 June 2008 landslide (Figure 4). The washout failure affected the building at No. 15 Fung Fai Terrace.

Binnie & Partners (B&P) (1978) recorded two landslides in June 1960 and August 1971 respectively, which might have affected the building at No. 12 Fung Fai Terrace. However, no further details of these incidents (e.g. failure volumes and approximate locations) are available.

## 6. PREVIOUS ASSESSMENTS AND PREVENTIVE WORKS

### 6.1 General

The natural hillside that failed in the 7 June 2008 rainstorm had not been subjected to any site-specific detailed assessment or hazard study. A number of geotechnical assessments had been conducted for the surrounding registered man-made features. Relevant observations and the related issues pertaining to the landslide site are summarised below.

### 6.2 Phase IIC Landslide Study

The stability of slopes in the Happy Valley and Tung Shan Terrace areas had been generally assessed under the Phase IIC Landslide Study by B&P between 1975 and 1978 (B&P, 1978). The study area covered the subject natural hillside to the west of Rockwin Court. The study concluded that “many steep natural slopes are potentially unstable if excessive infiltration takes place” and recommended that “large areas of steep hillsides be covered by chunam to prevent infiltration”. The recommended preventive works relevant to man-made cut slopes to the west of houses 10-12 at Fung Fai Terrace comprised, inter alia, the provision of surface drainage system and the provision of hard surface cover to the trimmed slope. However, no preventive works in regard to the concerned natural hillside were recommended (Figure 5).

### 6.3 Special Investigation into Fill Slopes

Between 1979 and 1980, fill slope No. 11SW-D/F69 located below Stubbs Road was subjected to a detailed study under the Special Investigation into Fill Slopes by B&P (1979; 1980). The study noted that a large portion of the fill slope had been covered with chunam probably by the then Highways Office in 1978 (Figure 6). However, no drainage channels were provided at the periphery of the chunam cover to collect surface runoff from the hillside above. The study also pointed out that the steep and loose fill slope, if saturated, was liable to fail. Preventive works, mainly comprising the construction of an L-shaped retaining wall, the formation of a compacted fill slope above the retaining wall and the provision of a surface drainage system, were recommended and subsequently carried out (B&P, 1982). An extract of the as-built record plan is reproduced in Figure 7, which shows the general topography of the hillside. The stability of the natural hillside, where the 7 June 2008 landslide occurred, was not assessed in the study.

## 7. ACCOUNTS OF WITNESSES

Relevant observations relating to the timing of the 7 June 2008 landslide and the process of the landslide were collated from accounts given by witnesses.

A resident of Rockwin Court, who witnessed the process of the landslide and heard the loud noise of snapping trees, recalled that the natural hillside failed in a 'brittle' manner in one go and resulted in fast-moving debris. The landslide debris cascaded down the hillside very quickly and came to rest at the rear of Rockwin Court. According to the witness, the entire process of the landslide was over in less than a minute.

In consideration of the witness accounts and the incident log provided by Hong Kong Police Force, the landslide likely occurred between 8:45 a.m. and 9:30 a.m. on 7 June 2008.

## 8. ANALYSIS OF RAINFALL RECORDS

Rainfall data were obtained from GEO automatic raingauge No. H06, which is located at approximately 900 m to the northwest of the 7 June 2008 landslide site (Figure 1). The raingauge records and transmits rainfall data at 5-minute intervals to Hong Kong Observatory (HKO) and GEO. Another GEO raingauge No. H08, which is the nearest raingauge at about 470 m southeast to the landslide site, was not properly functioning during the 7 June 2008 rainstorm and therefore the rainfall analysis is based on rainfall data from raingauge H06 instead.

For the purposes of the rainfall analysis, the landslide was assumed to have occurred at 9:00 a.m. on 7 June 2008. The daily rainfall recorded by raingauge No. H06 from 4 May to 10 June 2008, together with the hourly rainfall for the period between 6 and 7 June 2008, are presented in Figure 8. The maximum 12-hour and 24-hour rolling rainfall preceding the landslide were 256 mm and 386.5 mm respectively.

Table 1 presents the estimated return periods for the maximum rolling rainfall for various durations recorded by raingauge No. H06 with reference to the historical rainfall data at HKO in Tsim Sha Tsui (Lam & Leung, 1994) and the local rainfall data of raingauge No. H06 (Evans & Yu, 2001). The results show that the 4-hour rolling rainfall of 224.5 mm was the most severe, with a corresponding return period of about 25 years.

The maximum rolling rainfall for the rainstorm on 7 June 2008 has been compared with the past major rainstorms between 1983 and 2007 as recorded at raingauge No. H06 (Figure 9). The results indicate that the rolling rainfalls for short durations of less than about 4 hours preceding the 7 June 2008 landslide are amongst the most severe in the history of raingauge No. H06, which came into operation in 1983.

## 9. POST-LANDSLIDE OBSERVATIONS

A number of inspections of the 7 June 2008 landslide site and its immediate vicinity were carried out between June 2008 and September 2009. Immediately following the landslide, emergency works, comprising the removal of landslide debris and the provision of hard surface protection to the landslide scar, were carried out by Highways Department. At the time of the first landslide inspection on 10 June 2008, the main scarp and the source area of the 7 June 2008 landslide had been covered with hard surface.

The landslide source area was about 30 m wide by 20 m long on plan, and was relatively shallow with a maximum depth of about 1.5 m (Plate 5). The volume of the landslide was about 500 m<sup>3</sup>. The failure surface comprised a steeply inclined main scarp and an undulating basal slip surface (Figure 3). No obvious signs of subsurface seepage and concentrated surface runoff were observed on the landslide scar. There was no significant entrainment of material along the landslide trail, as the lower part of the hillside is largely covered with hard surface (Figure 2).

The landslide debris deposited at the rear of Rockwin Court and at the rear alleyway of Celeste Court was about 4 m and 0.5 m thick respectively, which comprised mainly a soil matrix of light reddish brown mottled yellow clayey sandy silt with some gravel- or cobble-sized and occasional boulder-sized rock fragments. The debris contained considerable amount of vegetation including many broken tree trunks (Plates 6, 7 and 10).

Above the landslide scar is a 40° steep sloping ground, which was sparsely vegetated with some mature trees and generally covered with a hard surface (Figure 2). The pre-existing hard surface cover that is in a reasonably good condition marked the main scarp of the 7 June 2008 landslide (Plate 2). No topographic depressions or drainage features and no signs of distress in the form of tension cracks were observed on the area above the 7 June 2008 landslide.

Site inspection carried out on 10 June 2008 observed that the stepped channels connected to a catchpit at the northern flank of the 7 June 2008 landslide were blocked by leaf debris (Figure 2 and Plate 11). During subsequent inspections, fairly significant surface erosion was also noted at the sides of catchpit and surface drainage channels of cut slope No. 11SW-D/C12 to the south of the landslide scar (Figure 2 and Plate 12).

A small unpaved platform with a plan area of about 130 m<sup>2</sup> is present at the crest of fill slope No. 11SW-D/F69 alongside the uphill lane of Stubbs Road (Plate 13), at about 25 m to the southwest of the subject landslide site. An approximately 38 m long, 0.3 m high concrete upstand is provided along the elevated section of Stubbs Road above the concerned hillside (Figure 2 and Plate 14). Moreover, two roadside gullies along the uphill lane of Stubbs Road (Figure 2), which collect surface runoff from a portion of Stubbs Road, are connected to the surface drainage system at the northern end of slope No. 11SW-D/F69 through a 150 mm diameter drain pipe.

## 10. SUBSURFACE CONDITIONS

The solid geology underlying the site was mapped by the Hong Kong Geological Survey (GCO, 1986) at a scale of 1:20,000 as medium-grained granite of Jurassic-Cretaceous age with debris flow deposits generally to the east (Figure 10).

The subsurface geological conditions at the 7 June 2008 landslide site were determined from a review of pre-failure and post-failure ground investigation (GI) information and field mapping of the landslide scar. The post-failure GI works, comprising 3 vertical drillholes, 8 trial pits, 7 coreholes, 13 inspection pits and 1 slope surface strip, were carried out on the landslide scar and its vicinity by Gold Ram Engineering and Development Limited between March 2009 and April 2009. The locations of relevant GI stations are shown in Figure 11.



An interpreted geological section through the 7 June 2008 landslide is shown in Figure 3, which indicates that the site comprises a mantle of residual soil of up to about 1.8 m thick, overlying completely decomposed granite (CDG) and bedrock comprising slightly to moderately decomposed granite (S/MDG). The post-failure GI revealed that the 7 June 2008 landslide appeared to have taken place within the residual soil or CDG. No adversely orientated relict joints in the residual soil and CDG were noted in the post-failure GI stations. Other pertinent observations from individual GI stations are summarised as follows.

Two inspection pits (Nos. IP9 and IP10) were excavated above the main scarp of the landslide, which encountered a layer of residual soil of up to about 1.8 m thick, overlying CDG. The layer of residual soil comprises mainly stiff to very stiff dark reddish brown sandy to clayey silt and gradually thins out in the downslope direction as evidenced by inspection pits (Nos. IP8, IP12 and IP13) excavated at about the mid-slope of the hillside, which only exposed CDG with a thin veneer of topsoil layer.

At the lower part of the landslide scar, remnants of the 7 June 2008 landslide debris of up to about 1.5 m thick were found overlying a thin layer of fill up to about 1.1 m thick and CDG in inspection pits Nos. IP2, IP4 and IP11, as well as trial pit No. TP5. This observation also correlates with the findings of the surface strip No. SS1. The landslide debris comprises loose yellowish brown clayey silty sand with a few fresh granite fragments, which is consistent with the materials in the landslide debris deposited at the rear of Rockwin Court. The thin veneer of fill at the lower part of the hillside was probably associated with the previous works for the adjacent surface drainage above slope No. 11SW-D/C2237.

As part of the post-failure GI, monitoring of piezometers/standpipes installed in drillholes Nos. BH1 to BH3 was carried out between March and April 2009. The monitoring data indicate that the base groundwater table was about 25 m to 40 m below ground surface. The base groundwater table probably did not contribute to the shallow failure on 7 June 2008.

## 11. DIAGNOSIS OF THE 7 JUNE 2008 LANDSLIDE

### 11.1 Mode and Nature of the Failure

The 7 June 2008 landslide was a shallow failure, involving a thin mantle of residual soil and possibly part of the underlying CDG, on a steeply inclined natural hillside. The incident probably occurred between 8:45 a.m. and 9:30 a.m. during heavy rainfall. Although the exact sequence of the landslide event is not known, the landslide took place suddenly and was over within a short space of time. It is likely that the hillside might have failed in one go according to the witness accounts.

### 11.2 Diagnosis of Causes and Mechanism of Failure

The close correlation between the rainfall and the timing of the failure suggests that the landslide was triggered by the heavy rainfall preceding the landslide. The 7 June 2008 rainstorm was an intense rainstorm and the rolling rainfalls for short durations of less than about 4 hours were amongst the most severe that the hillside had experienced. This is consistent with the observed shallow depth of failure, which was probably triggered by

saturation of the near-surface groundmass and the build-up of transient groundwater pressure perching above the residual soil/weathered rock interface as a result of infiltration.

Prior to the 7 June 2008 landslide, soil suction probably developed in the groundmass, which contributed to maintaining the stability of the hillside. Water ingress through infiltration during heavy rainfall would have wetted up the groundmass and led to a reduction of the soil suction and a gradual reduction of the shear strength of the groundmass. In addition, transient groundwater pressure could have built up locally within the residual soil above the residual soil/weathered rock interface, which further contributed to destabilising the hillside.

The natural hillside where the 7 June 2008 landslide occurred and the sloping ground above the landslide scar are relatively steep with an average slope angle of about 40°. The sloping ground is largely covered with a hard surface. This would have enhanced surface runoff towards the hillside below and promoted additional water ingress into the groundmass. Surface erosion at the sides of the catchpit and surface drainage channels of the adjacent slope No. 11SW-D/C12 immediately to the south of the 7 June 2008 landslide site indicate that enhanced surface runoff might have taken place on the subject hillside.

Another factor that might have contributed to the failure could be the blocked stepped channels (Figure 2 and Plate 11), which were located immediately above the northern flank of the 7 June 2008 landslide. The channels collect surface water from the hillside above and any blockage would have resulted in overspilling onto the northern flank of the hillside that failed on 7 June 2008. This is, however, considered to have a relatively minor contribution to the failure, as the extent of the area affected by the overspilling would likely have been limited.

Water ingress through a small unpaved platform above fill slope No. 11SW-D/C69 could be another possible source of water, which might have led to subsurface seepage flow towards the 7 June 2008 landslide site. However, the identification of any notable subsurface drainage features, such as soil pipes, was not possible as the scar had been covered by shotcrete before the landslide site was first inspected.

The above factors, including the severity of the 7 June 2008 rainstorm and the adverse site setting, could have contributed to the lateral extensiveness of the failure.

This incident also highlighted the potential landslide risk arising from natural hillsides close to developments within urban areas, as well as the adverse impact of the surrounding man-made features, such as the surface drainage system, on the stability of the hillside.

## 12. CONCLUSIONS

The 7 June 2008 landslide involved the failure of a relatively small pocket of steeply inclined natural hillside below Stubbs Road. The failure was triggered by rainfall, leading to saturation of the near-surface groundmass and possible build-up of transient groundwater pressure. The sloping ground immediately above the landslide site is covered with a hard surface, which might have contributed to enhanced surface runoff towards the landslide site and hence promoted water ingress into the ground. In addition, the blockage of stepped

channels at the northern flank of the landslide might have resulted in overspilling and additional water ingress into the groundmass, although the effect is considered to be relatively minor and localised.

### 13. REFERENCES

- Binnie & Partners (1978). Landslide Study Phase IIC – Report on the Stability of Slopes in the Happy Valley and Tung Shan Terrace Areas (2 Volumes). Geotechnical Control Office, Hong Kong, 205 p. plus 44 drawings.
- Binnie & Partners (1979). Special Investigation into Fill Slopes – Detailed Studies: Slope No. 11SW-D/F69, Stubbs Road above Village Terrace. Geotechnical Control Office, Hong Kong, 43 p.
- Binnie & Partners (1980). Detailed Investigation and Design of Preventive Works to Fill Slopes: Slope No. 11SW-D/F69, Stubbs Road above Village Terrace. Geotechnical Control Office, Hong Kong, 144 p. plus 4 drawings.
- Binnie & Partners (1982). Slope No. 11SW-D/F69, Stubbs Road. Record Drawings Nos. 44-49, PWD Contract No. 439/80, Landslide Preventive Measures 1980/81 Fill Slopes, Geotechnical Control Office, Hong Kong, 6 drawings.
- Evans, N.C. & Yu, Y.F. (2001). Regional Variation in Extreme Rainfall Values. GEO Report No. 115, Geotechnical Engineering Office, Hong Kong, 81 p.
- Geotechnical Control Office (1986). Hong Kong and Kowloon: Solid and Superficial Geology. Map Sheet No. 11, Map Series HGM20, Hong Kong Geological Survey, Geotechnical Control Office, Hong Kong, 1 map.
- Lam, C.C. & Leung, Y.K. (1994). Extreme Rainfall Statistics and Design Rainstorm Profiles at Selected Locations in Hong Kong. Technical Note No. 86, Royal Observatory, Hong Kong, 89 p.

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Table 1 - Maximum Rolling Rainfall at GEO Raingauge No. H06 for Selected Durations Preceding the 7 June 2008 Landslide and the Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period	Estimated Return Period (Years)	
			Lam & Leung (1994)	Evans & Yu (2001)
5 Minutes	13.0	9:00 a.m. on 7 June 2008	2	3
15 Minutes	33.0	9:00 a.m. on 7 June 2008	4	7
1 Hour	102.0	9:00 a.m. on 7 June 2008	9	12
2 Hours	125.5	9:00 a.m. on 7 June 2008	5	6
4 Hours	224.5	9:00 a.m. on 7 June 2008	22	25
12 Hours	256.0	9:00 a.m. on 7 June 2008	6	7
24 Hours	386.5	9:00 a.m. on 7 June 2008	12	9
2 Days	392.5	9:00 a.m. on 7 June 2008	7	4
4 Days	446.0	9:00 a.m. on 7 June 2008	5	3
7 Days	539.0	9:00 a.m. on 7 June 2008	7	4
15 Days	657.5	9:00 a.m. on 7 June 2008	6	3
31 Days	738.5	9:00 a.m. on 7 June 2008	3	2
<p>Notes: (1) The landslide is assumed to have occurred at 9:00 a.m. on 7 June 2008 for the purposes of the rainfall analysis.</p> <p>(2) Maximum rolling rainfalls were calculated from 5-minute rainfall data recorded at GEO raingauge No. H06, which is located at about 900 m to the northwest of the landslide site and is operational since 22 March 1983.</p> <p>(3) Return periods were derived from the statistical parameters extracted from Table 3 of Lam &amp; Leung (1994) and the statistical parameters of raingauge No. H06 extracted from Appendix B of Evans &amp; Yu (2001).</p>				

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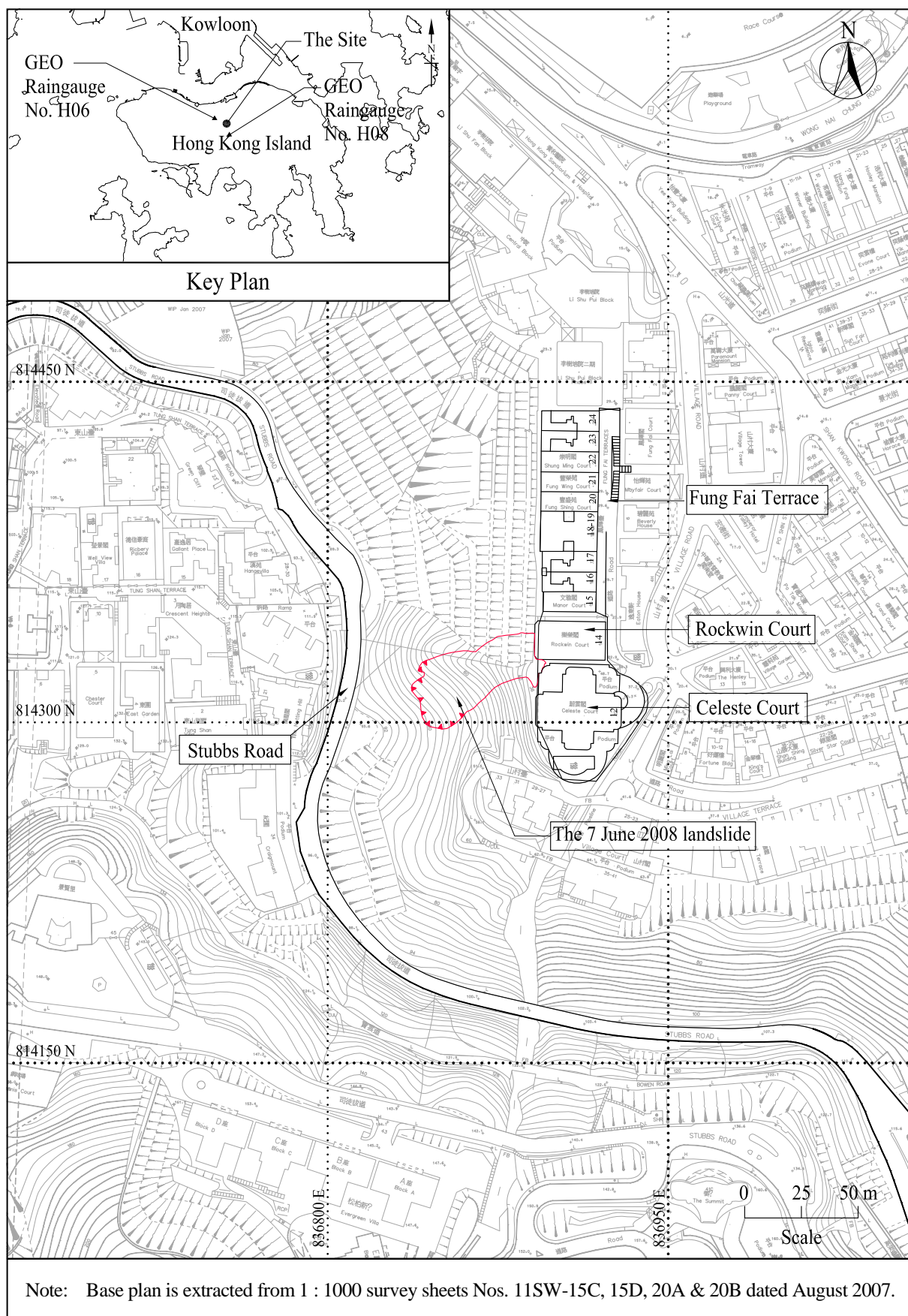


Figure 1 - Location Plan

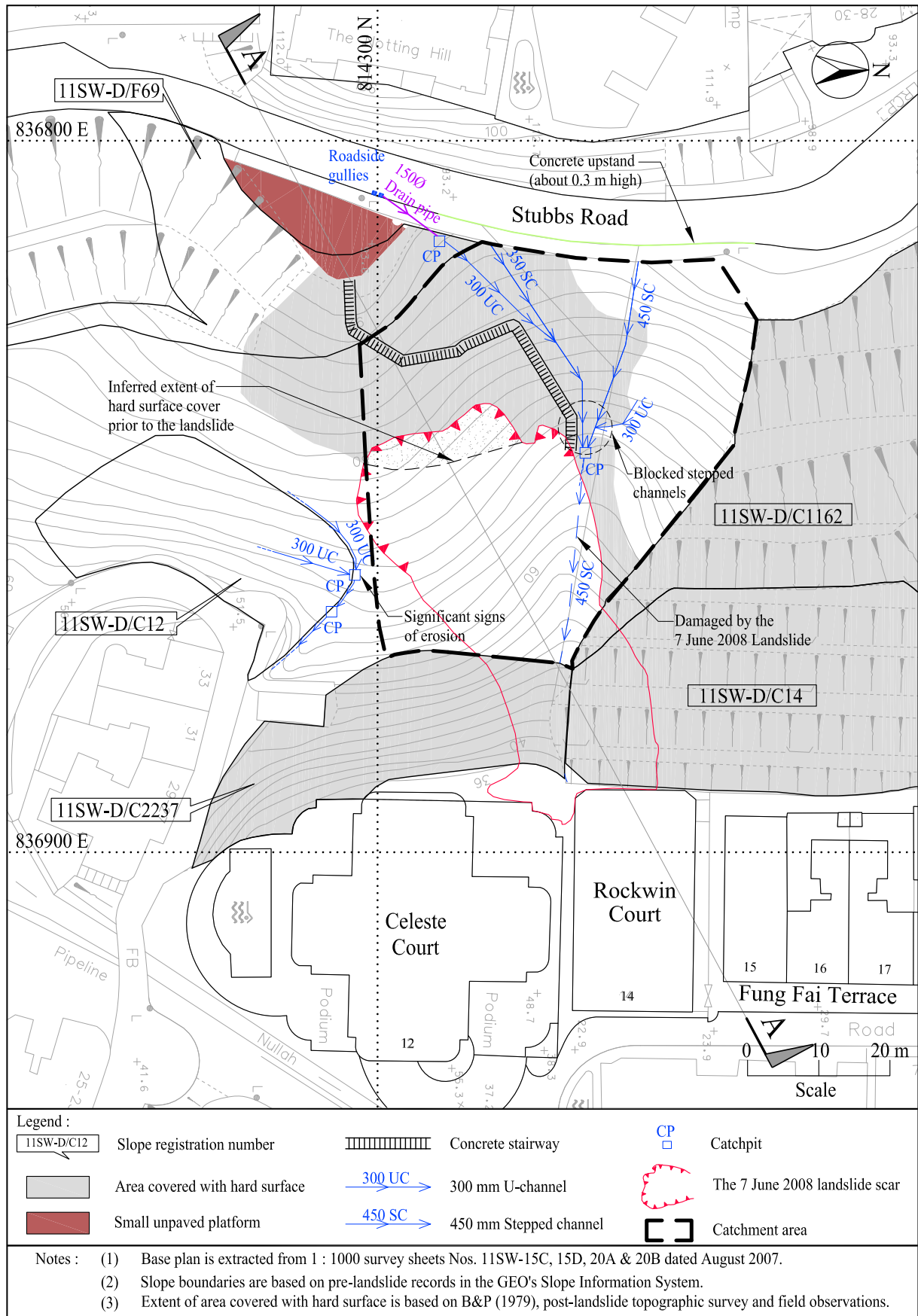


Figure 2 - Site Layout Plan and Field Observations



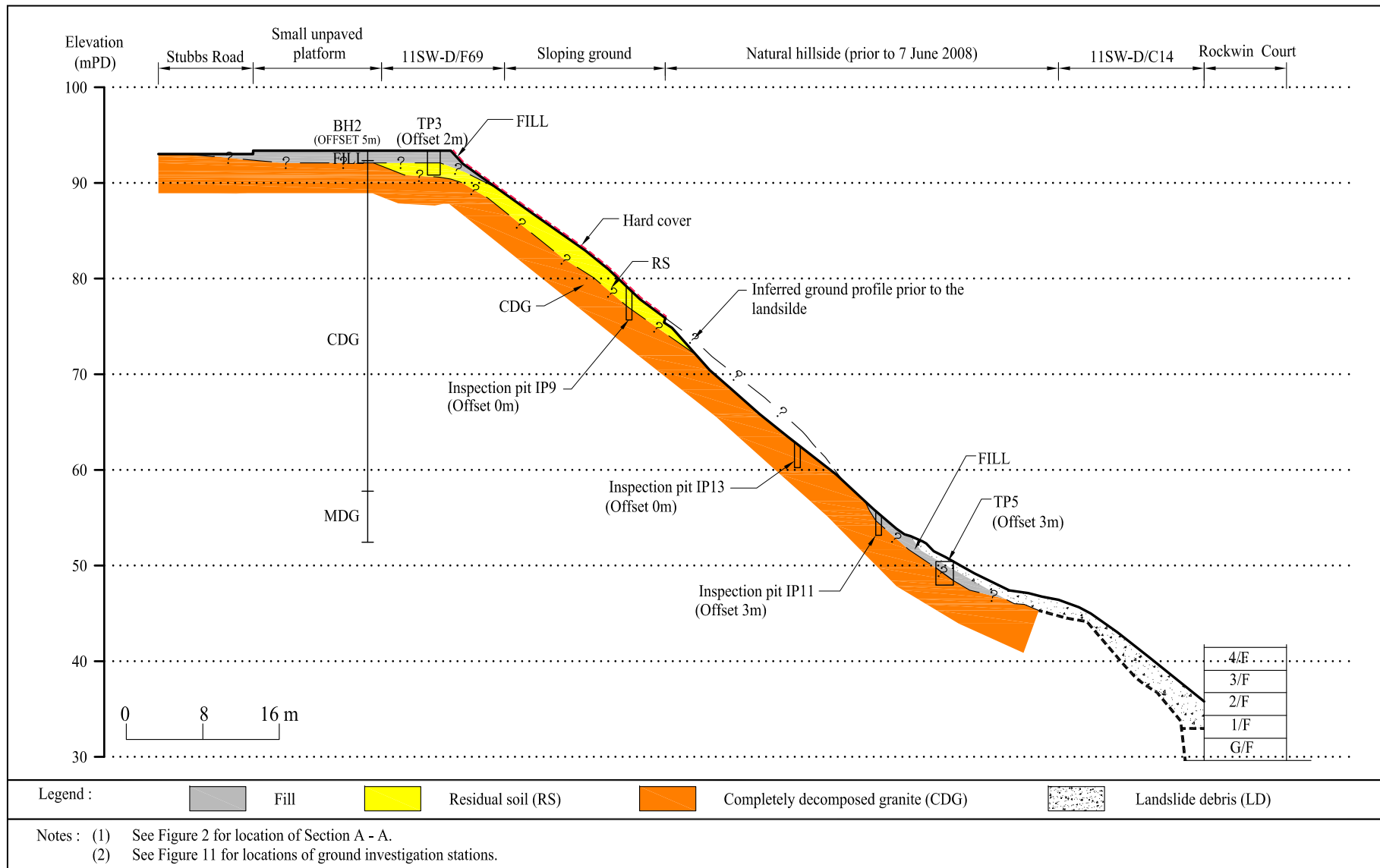


Figure 3 - Section A-A through the landslide

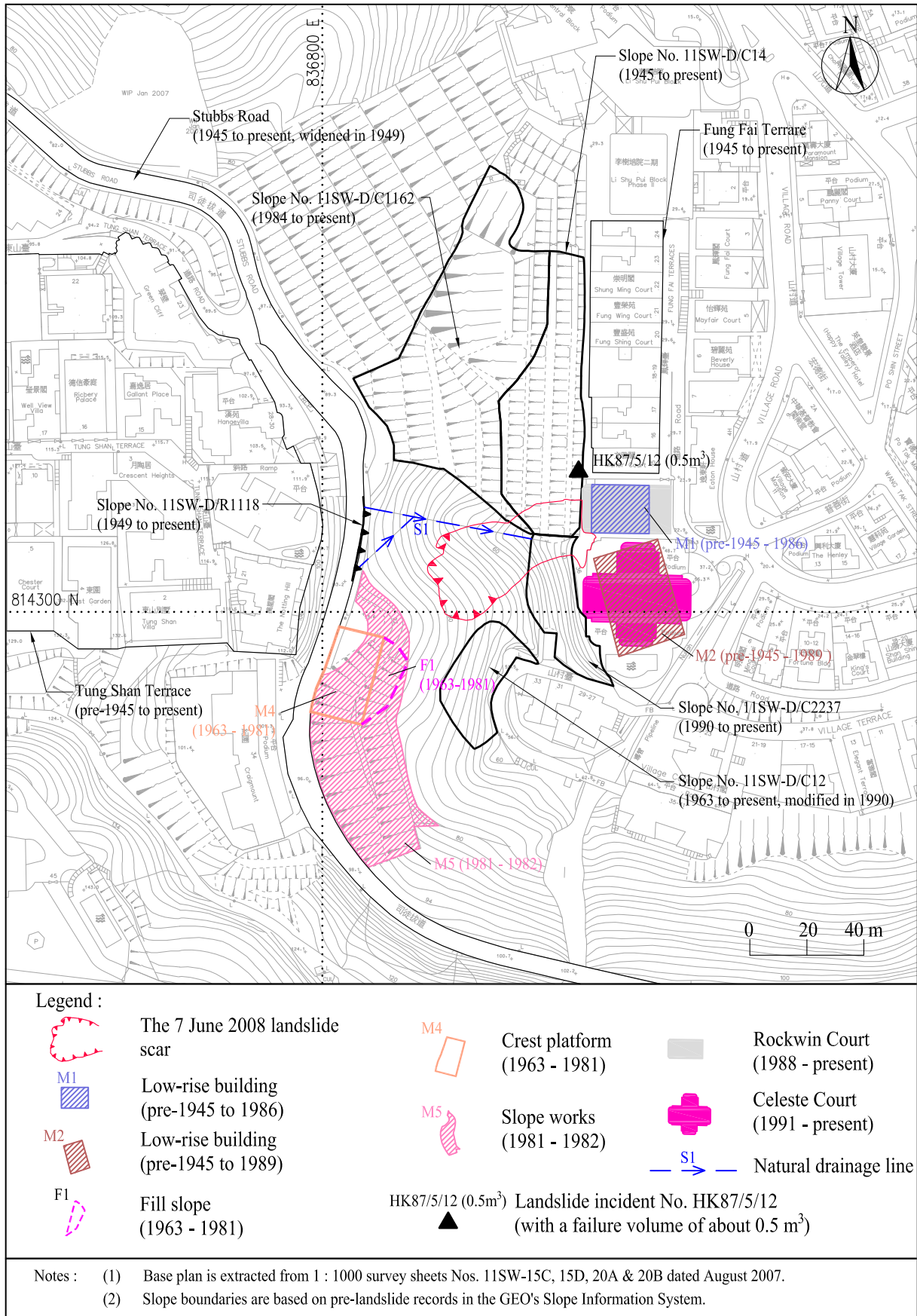


Figure 4 - Site Development History and Past Instability

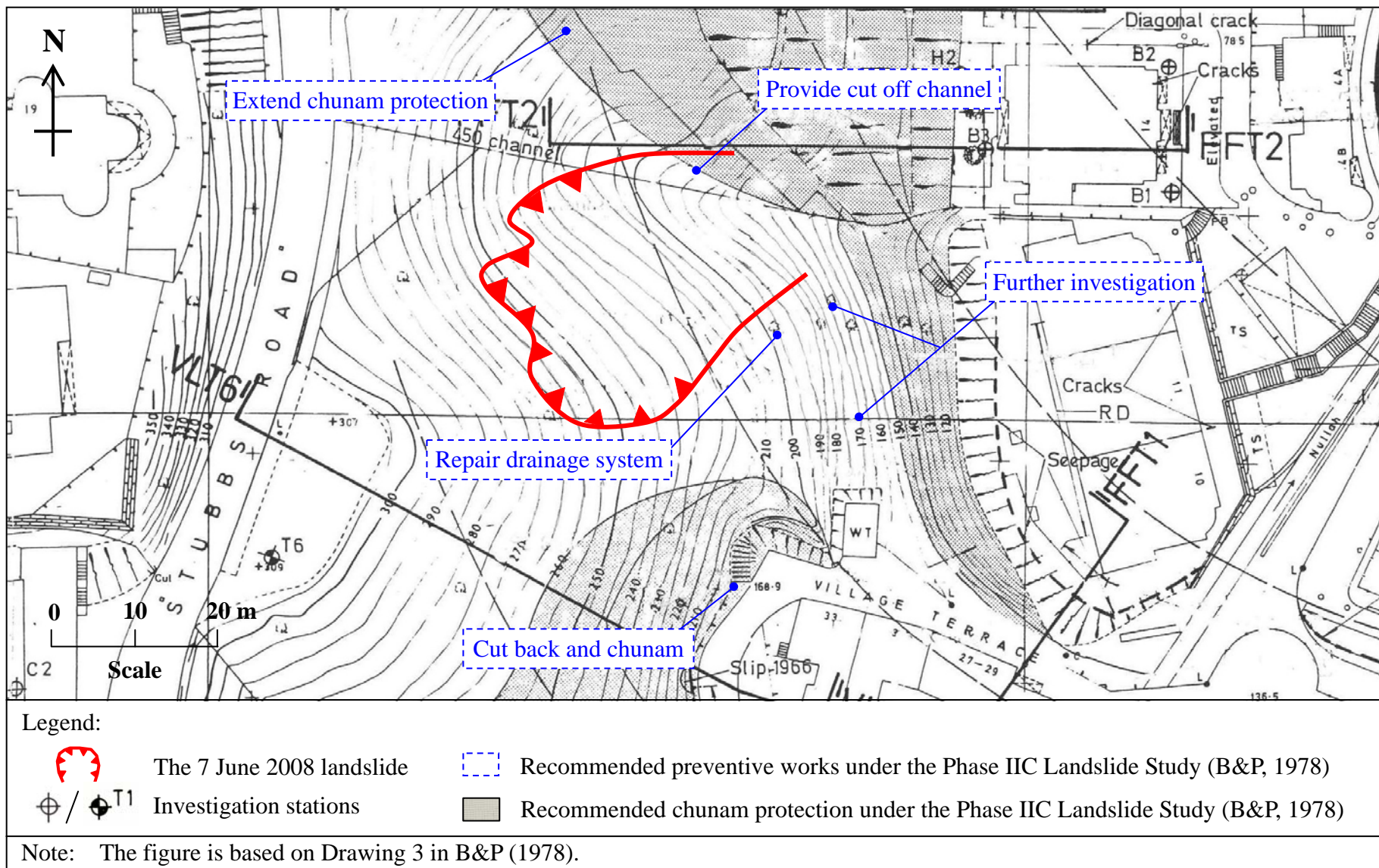


Figure 5 - Recommended Preventive Works under the Phase IIC Landslide Study



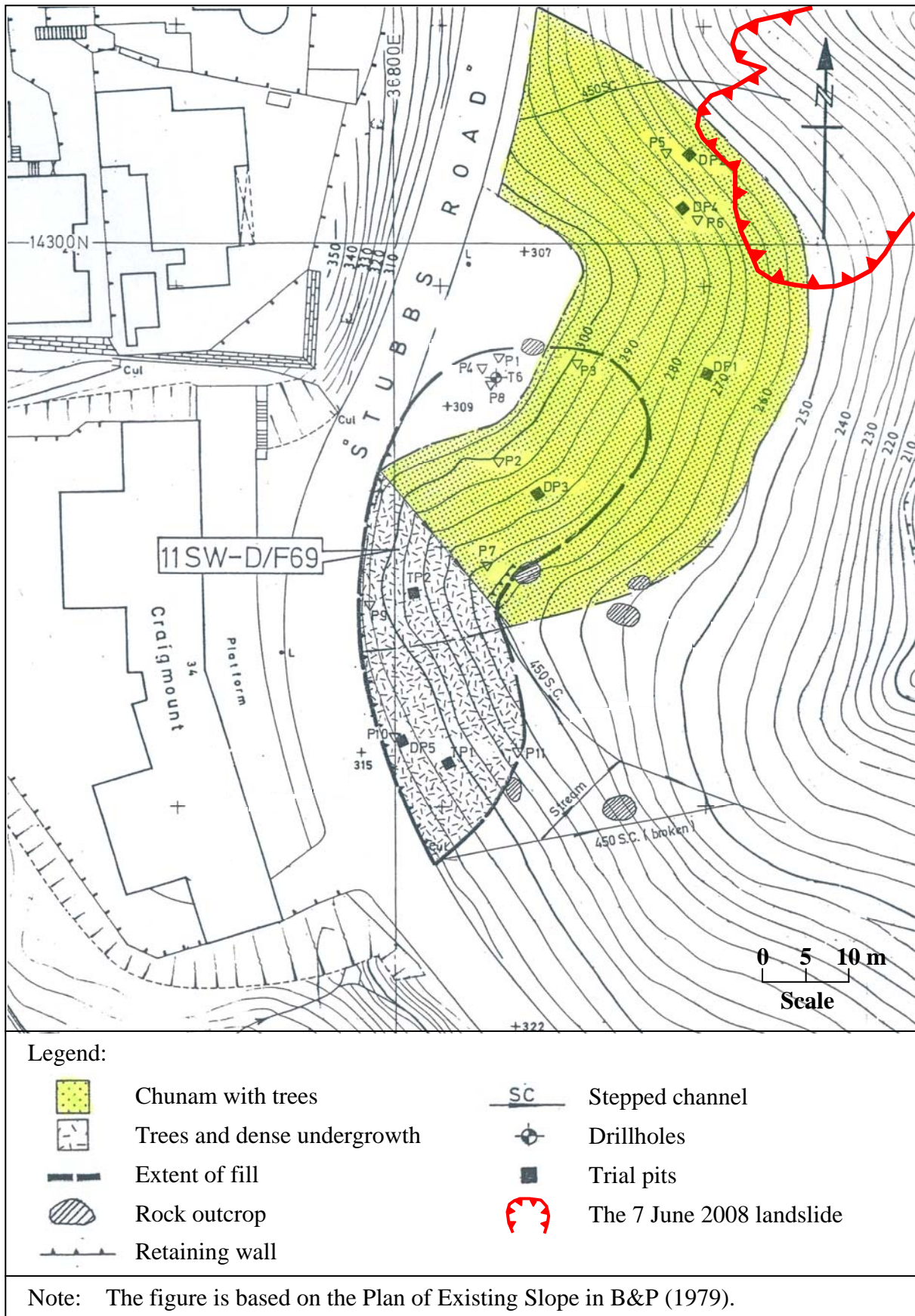


Figure 6 - Extent of Hard Surface Cover above the 7 June 2008 Landslide Site in 1979



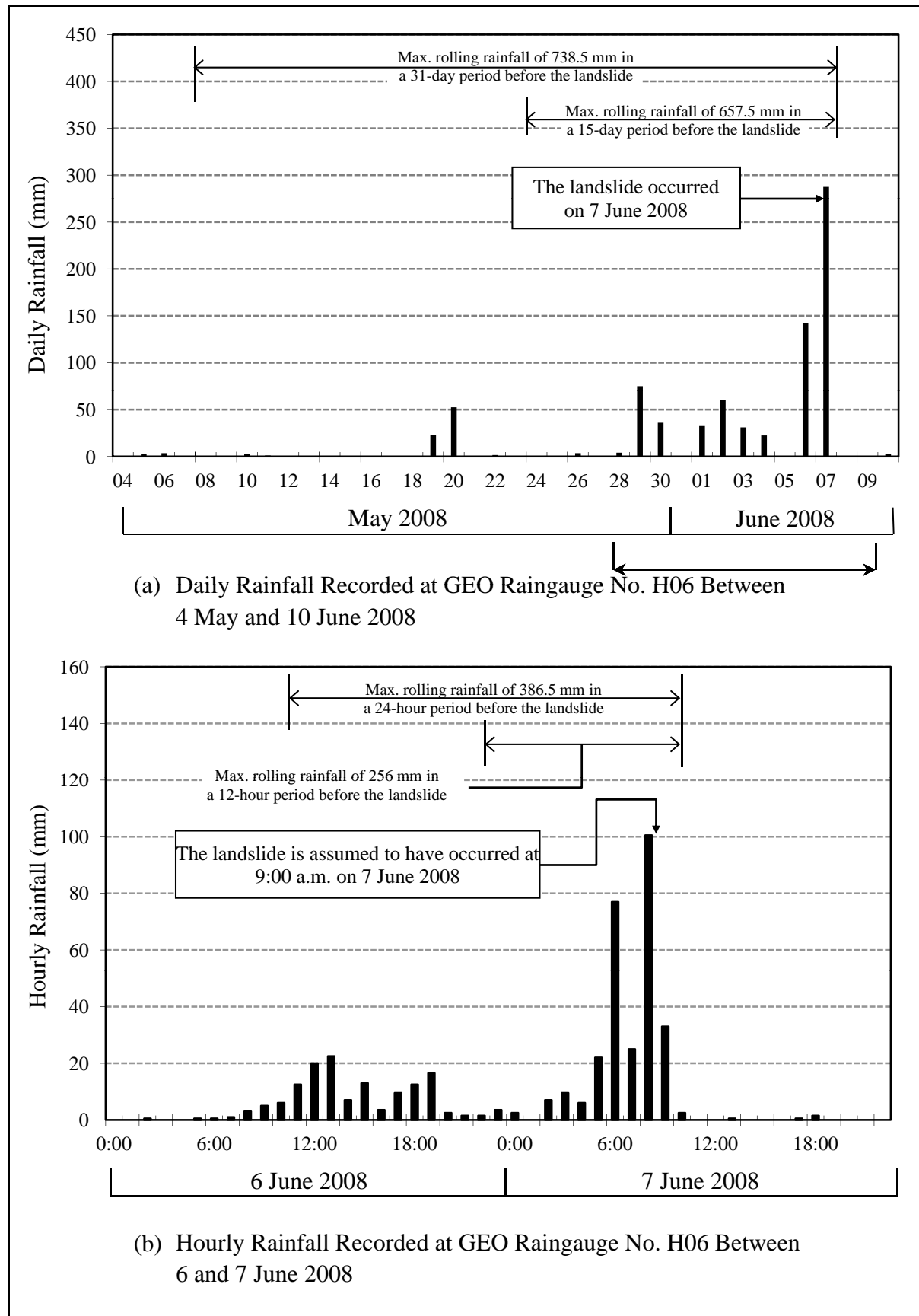


Figure 8 - Daily and Hourly Rainfall Recorded at GEO Raingauge No. H06



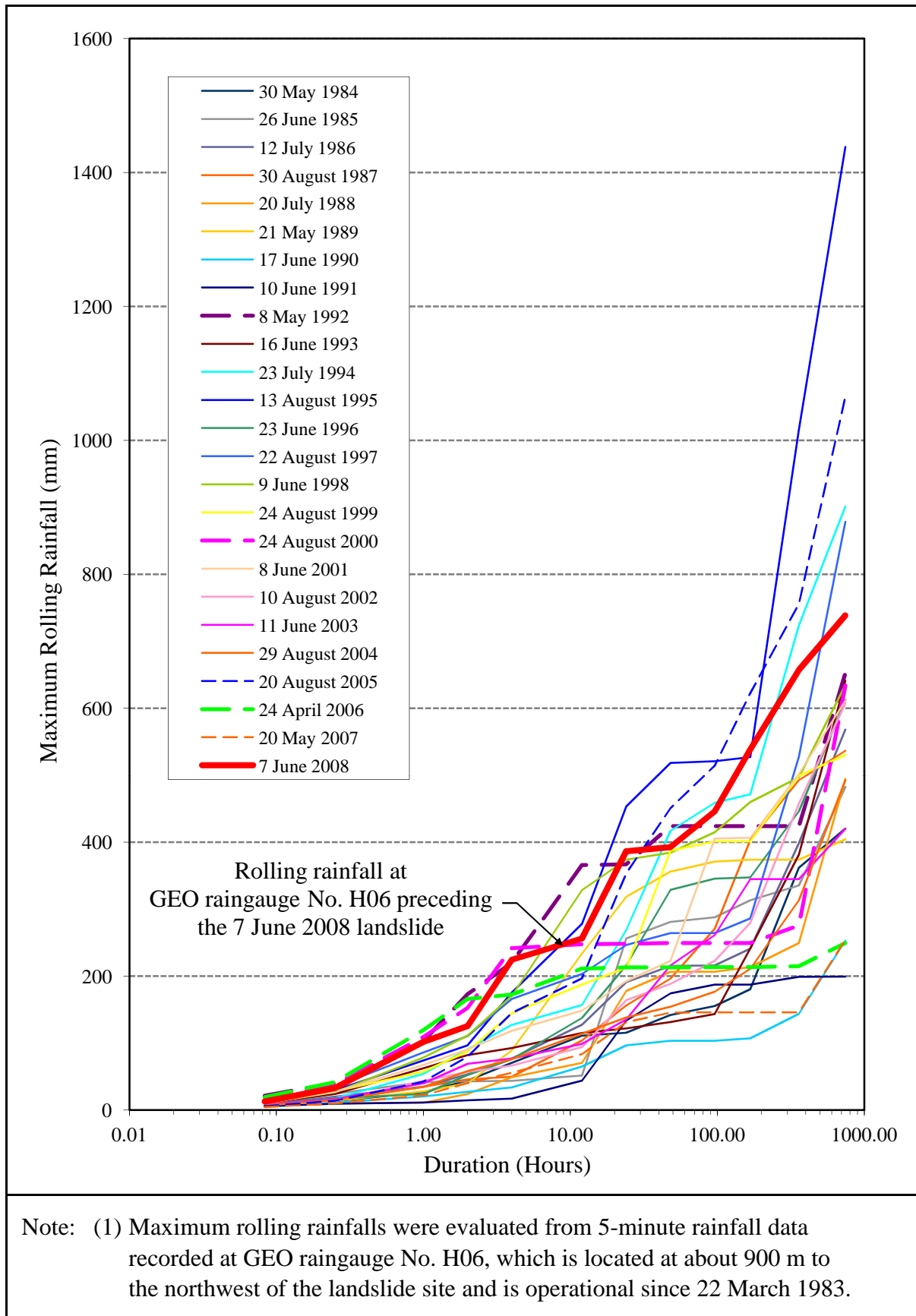


Figure 9 - Maximum Rolling Rainfalls for Major Rainstorms at GEO Raingauge No. H06

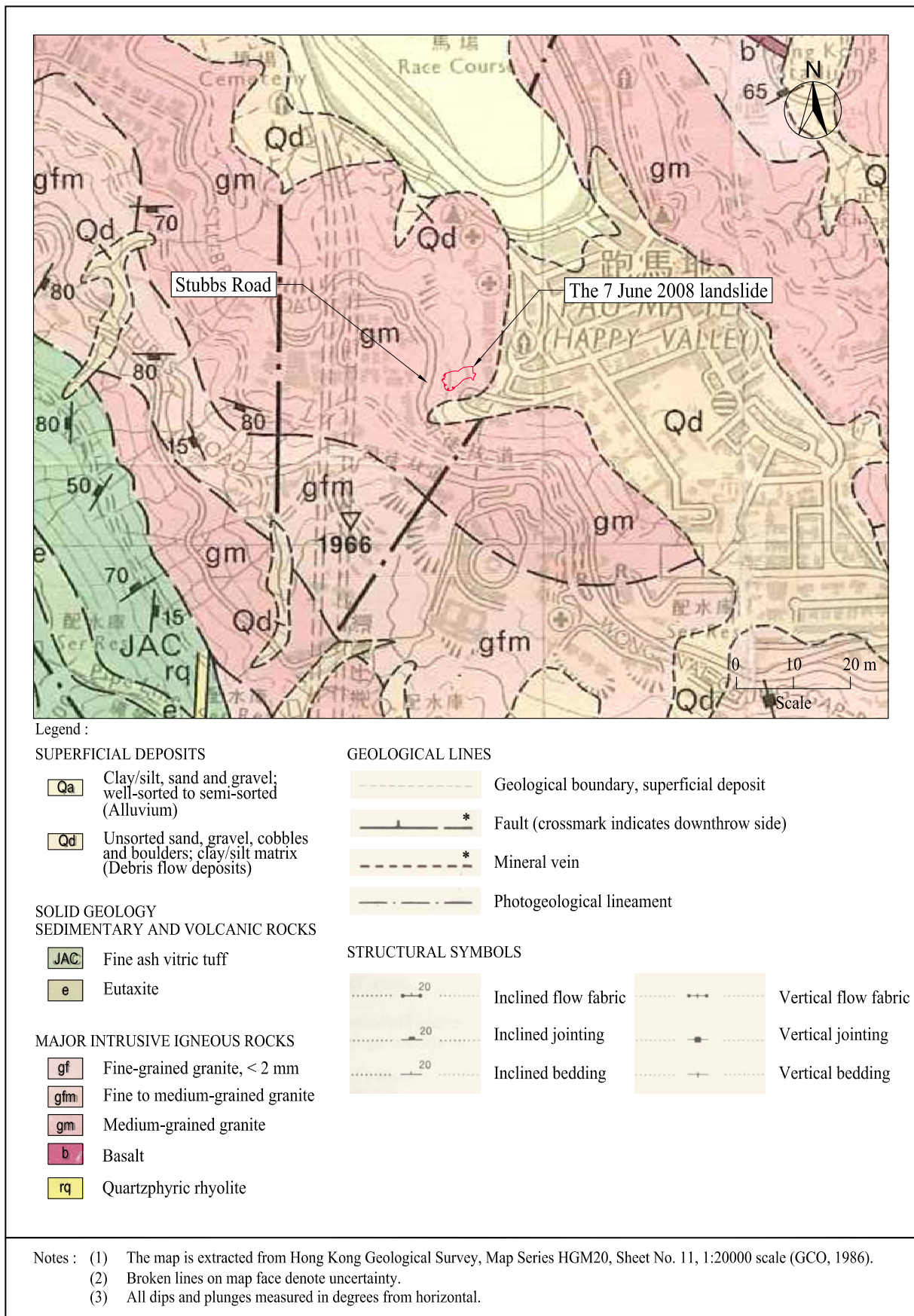


Figure 10 - Regional Geology



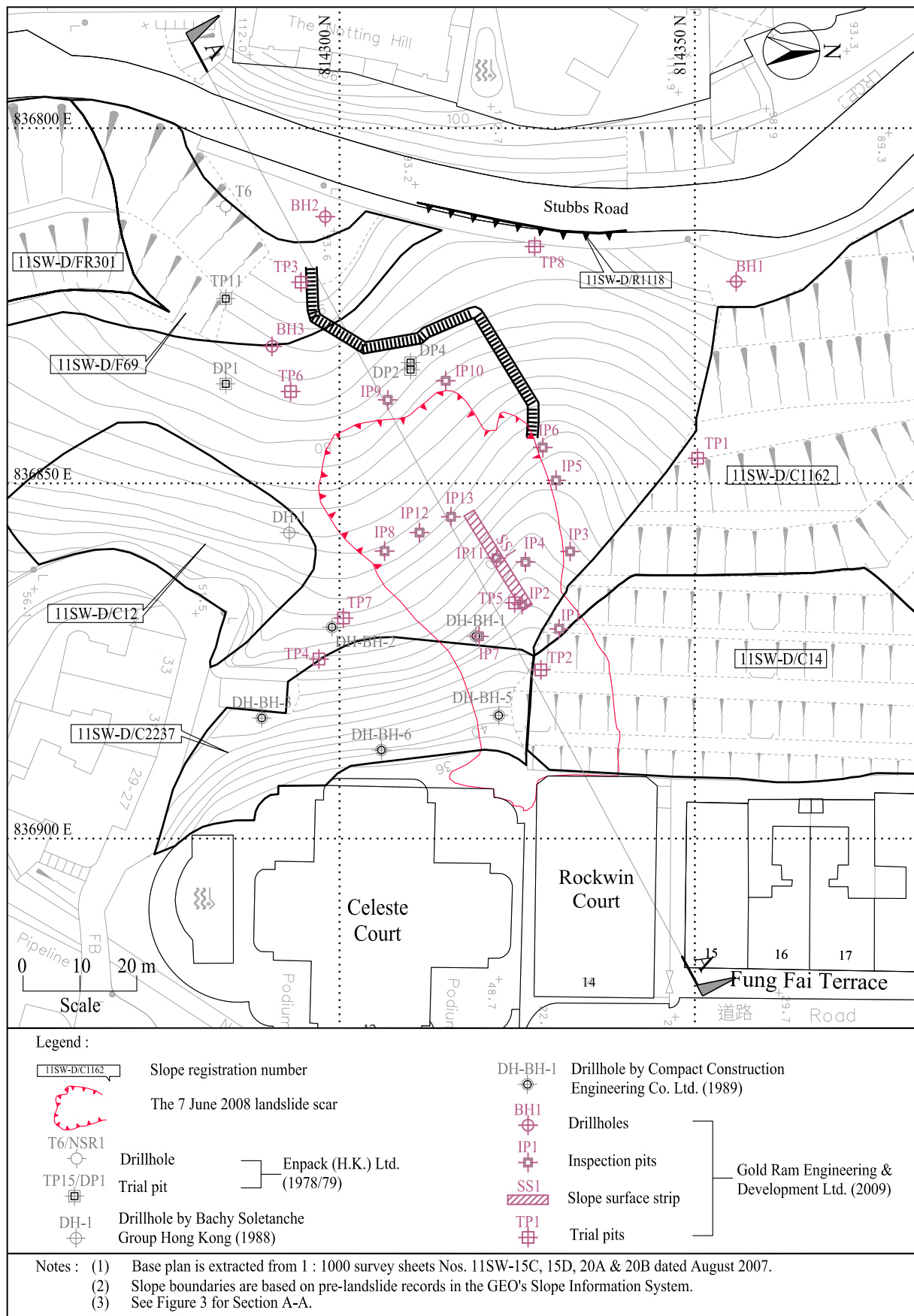


Figure 11 - Location Plan of Ground Investigation Stations

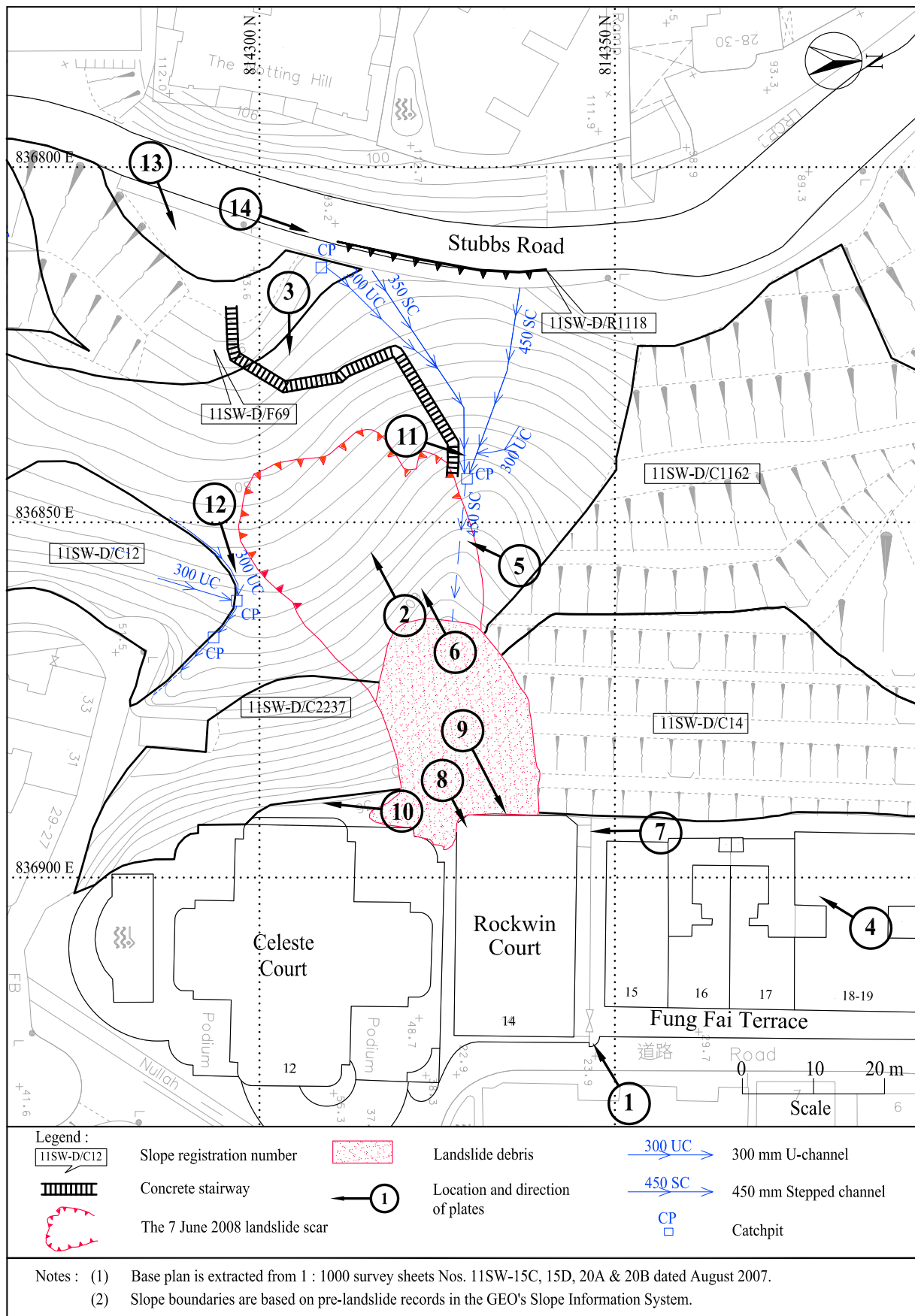


Figure 12 - Locations and Directions of Plates

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Plate 1 - General View of the 7 June 2008 Landslide  
(Photograph taken by a resident of Rockwin  
Court on 9 June 2008)

Note: See Figure 12 for location and direction of photograph.



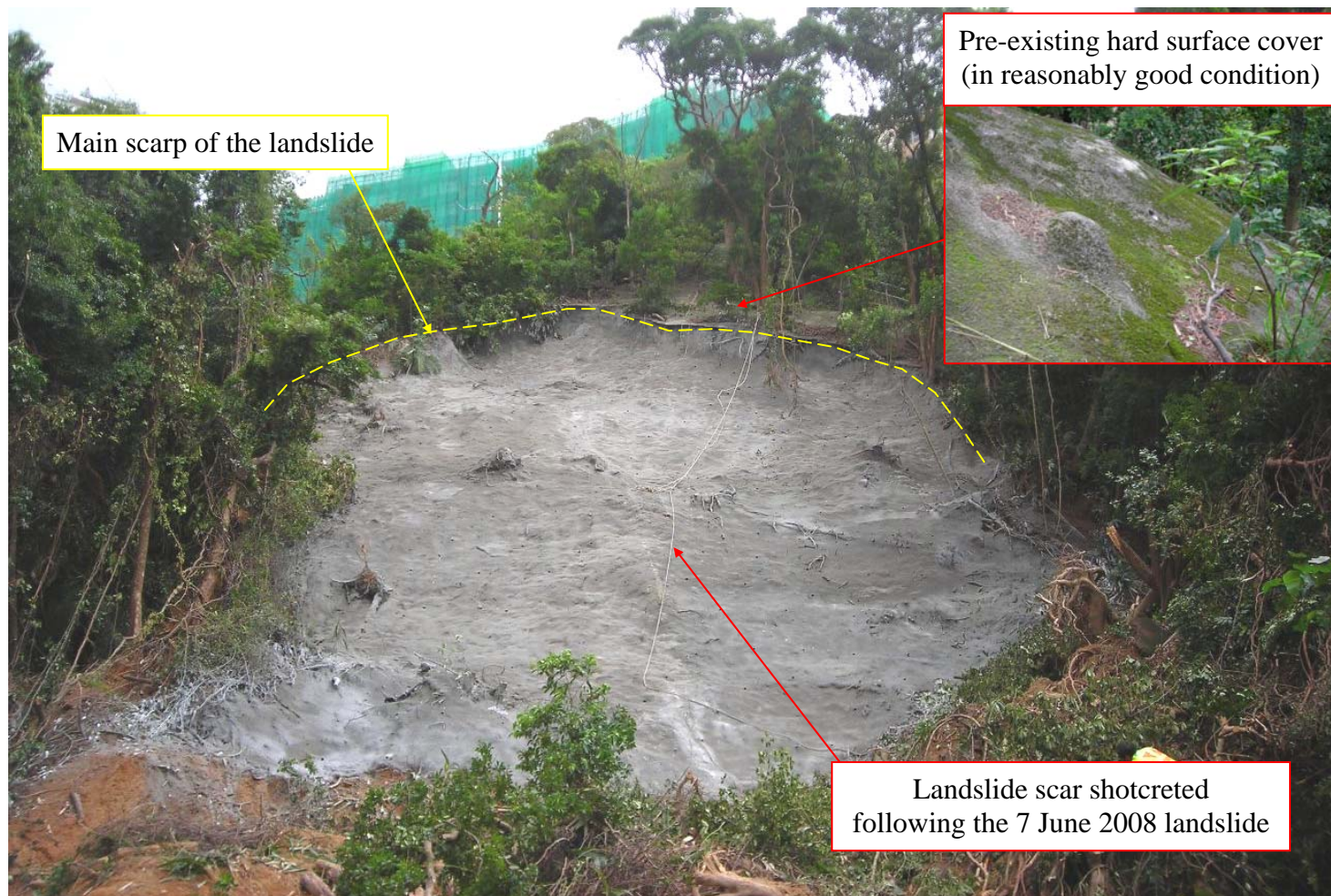


Plate 2 - Pre-existing Hard Surface Cover Marked the Main Scarp of the 7 June 2008 Landslide  
(Photograph taken on 10 June 2008)

Note: See Figure 12 for location and direction of photograph.





Pre-existing  
hard surface cover

To Stubbs Road

Plate 3 – Concrete Stairway above the 7 June 2008 Landslide Scar  
(Photograph taken on 10 June 2008)

Note: See Figure 12 for location and direction of photograph.





Plate 4 - Overall Setting of the Landslide Site  
(Photograph taken on 23 July 2008)

- Notes:
- (1) See Figure 12 for location and direction of photograph.
  - (2) Indicative slope boundaries are based on pre-landslide records in the GEO's Slope Information System.



Plate 5 - Source Area of the 7 June 2008 Landslide  
(Photograph taken by a resident of Rockwin  
Court on 8 June 2008)

Note: See Figure 12 for location and direction of photograph.





Plate 6 - Landslide Debris Deposited on the Cut Slopes at the Toe of Hillside  
(Photograph taken on 10 June 2008)

Note: See Figure 12 for location and direction of photograph.





Plate 7 - Landslide Debris Deposited at the Rear of Rockwin Court  
(Photograph taken on 10 June 2008)

Note: See Figure 12 for location and direction of photograph.





Plate 8 - Landslide Debris Piled against Rockwin Court  
(Photograph taken on 10 June 2008)

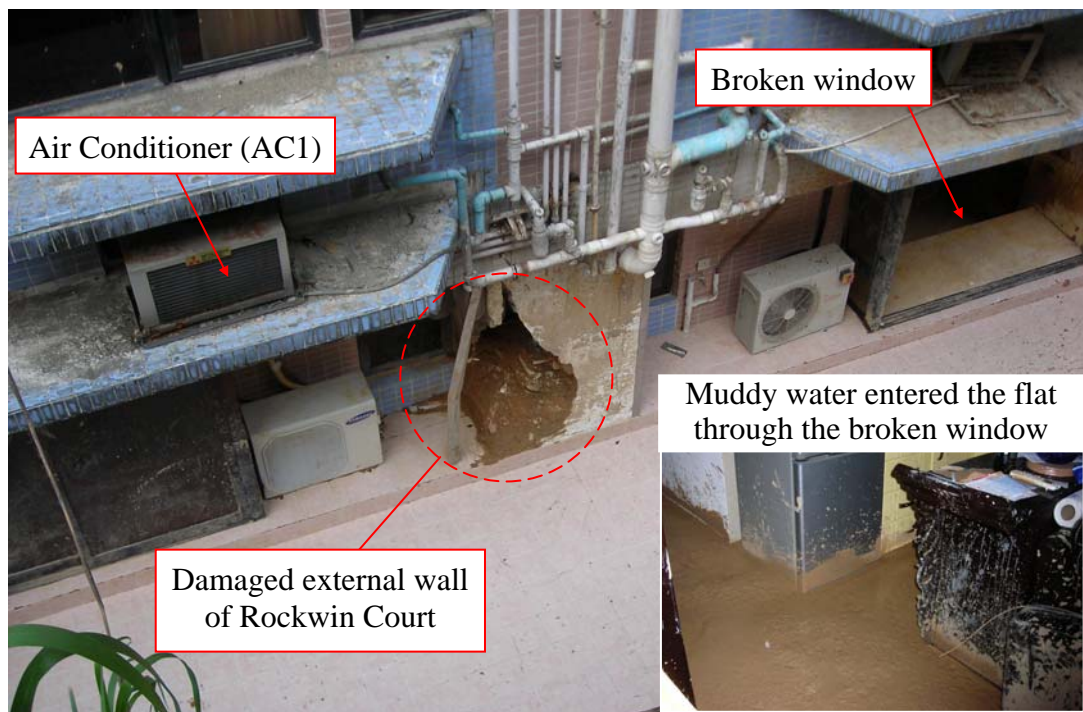


Plate 9 - Damage to Rockwin Court as a Result of the 7 June 2008 Landslide  
(Photograph taken on 14 July 2008 after removal of landslide debris)

Note: See Figure 12 for location and direction of photograph.





Plate 10 - Landslide Debris Deposited at the Rear Alleyway of Celeste Court  
(Photograph taken on 10 June 2008)

Note: See Figure 12 for location and direction of photograph.





Plate 11 - Blocked Stepped Channels at the Northern Flank of the 7 June 2008 Landslide  
(Photograph taken on 10 June 2008)

Note: See Figure 12 for location and direction of photograph.



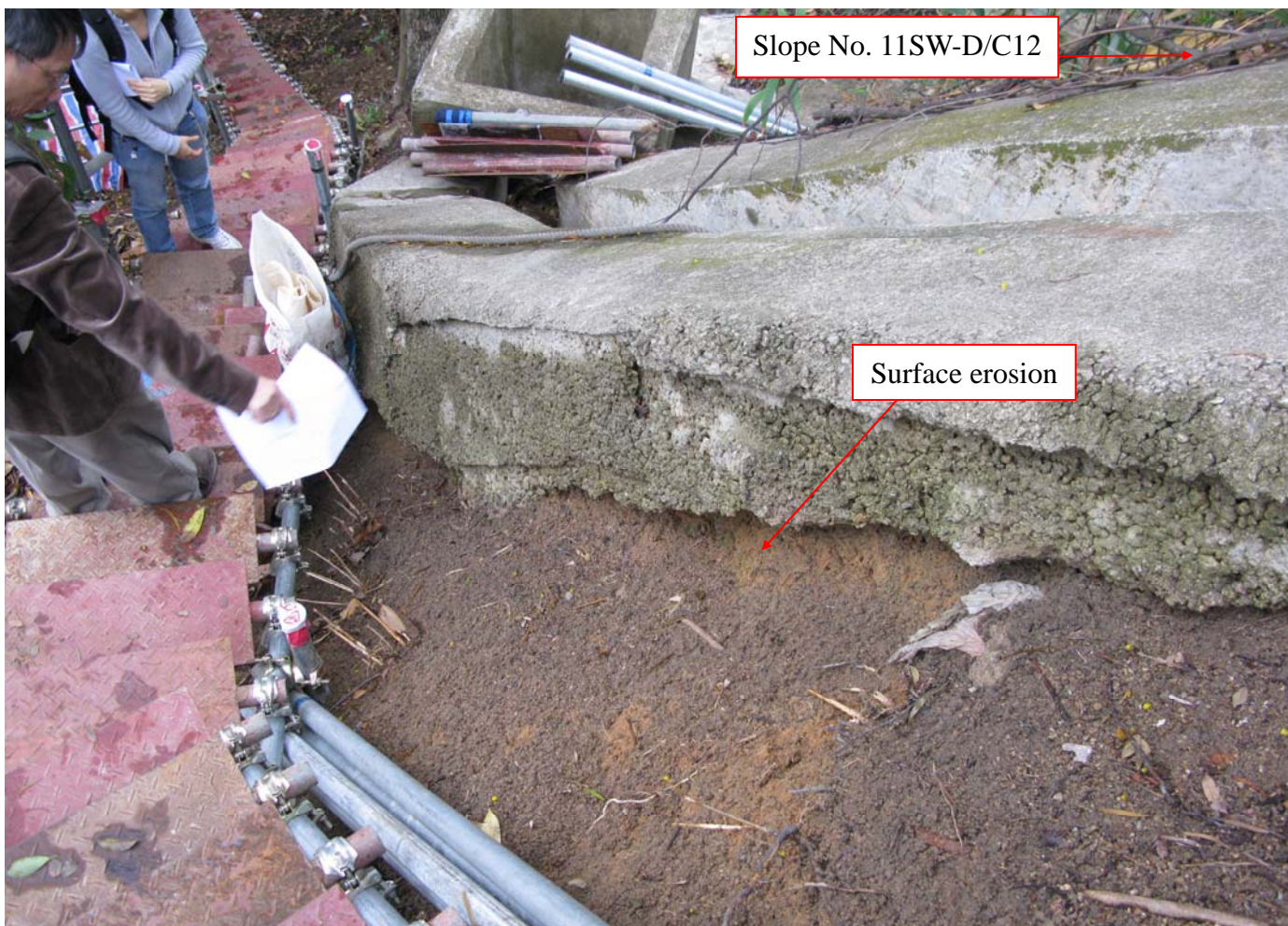


Plate 12 - Sign of Surface Erosion at the Sides of the Surface Drainage System of Slope No. 11SW-D/C12  
(Photograph taken on 24 March 2009)

Note: See Figure 12 for location and direction of photograph.





Plate 13 - Small Unpaved Platform at Crest of Slope No. 11SW-D/F69  
(Photograph taken on 23 September 2009)



Plate 14 - Concrete Upstand along Stubbs Road above the 7 June 2008 Landslide  
(Photograph taken on 23 September 2009)

Note: See Figure 12 for location and direction of photograph.

## APPENDIX A

### AERIAL PHOTOGRAPH INTERPRETATION



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## A1. DETAILED OBSERVATIONS

Detailed observations from a review of the available aerial photographs taken between 1945 and 2008 are presented below. A list of the aerial photographs reviewed is given in Table A1 and the major site development history is shown on Figure A1.

<u>YEAR</u>	<u>OBSERVATIONS</u>
-------------	---------------------

1945	High altitude aerial photographs of limited resolution.
------	---

The natural hillside, where the 7 June 2008 landslide occurred, comprises an east-trending steep valley. A Y-shaped ephemeral natural drainage line (S1) is visible within the valley immediately above the 7 June 2008 landslide scar. To the north of the Y-shaped natural drainage line (S1), extensive cutting into the lower hillside is evident and the present-day cut slope No. 11SW-D/C14 is being formed.

Stubbs Road has already been formed largely to its present-day configuration. Tung Shan Terrace is present above Stubbs Road largely in its present-day configuration. Two buildings (M1 and M2) are evident at the present-day footprints of Rockwin Court and Celeste Court respectively. Nos. 15-24 Fung Fai Terrace has been developed to their present-day extent.

1949	High altitude aerial photographs of limited resolution.
------	---

Vegetation on the hillside above the 7 June 2008 landslide appears to have become denser. A Y-shaped man-made surface drainage channel is visible within the valley, which in general follows the alignment of the Y-shaped natural drainage line (S1). Two areas of high reflectivity, possibly a cluster of boulders (B1) and anthropogenic disturbance (M3), are visible at the southern portion of the 7 June 2008 landslide scar and the hillside above the slope No. 11SW-D/C14 respectively.

Stubbs Road appears to have been widened. Retaining wall No. 11SW-D/R1118 has been constructed, possibly in association with the road widening works.

1963	Low altitude aerial photographs of good resolution.
------	---

Dense vegetation has been developed on the hillside, which has concealed the Y-shaped man-made surface drainage channel.

A fill slope (F1) and an associated crest platform (M4) has been constructed at the present-day location of slope No. 11SW-D/F69 to the southwest of the 7 June 2008 landslide. The fill slope (F1) appears to have been covered with a hard surface, possibly chunam. Slope No. 11SW-D/C12 and the road along its toe have been formed to the south of the hillside that failed on 7 June 2008.

1967	Low altitude aerial photographs of good resolution.
------	---

No changes of significance are observed on the hillside that failed on 7 June 2008.

<b><u>YEAR</u></b>	<b><u>OBSERVATIONS</u></b>
--------------------	----------------------------

	The fill slope (F1) first observed in 1963 has been covered with dense vegetation and only sparse vegetation has been developed on part of the platform (M4) above the fill slope (F1).
--	---

1972	Low altitude aerial photographs of good resolution.
------	---

	Vegetation in the valley has become denser. Vegetation on the platform (M4) appears to have been removed and excavation activities are evident on the southern portion of the platform (M4). An area of high reflectivity, possibly a local failure (LA1), is apparent on the fill slope below the northern portion of the platform (M4).
--	---

1973	High altitude aerial photographs of good resolution.
------	--

to

1975	No changes of significance are observed on the hillside that failed on 7 June 2008. Vegetation has been re-established on the platform (M4).
------	--

1976	Low altitude aerial photographs of good resolution.
------	---

	No changes of significance are observed on the hillside that failed on 7 June 2008. Vegetation clearance appears to have been carried out on parts of the platform (M4). Stubbs Road appears to have been re-paved.
--	---

1977	Single low altitude aerial photograph of good resolution.
------	---

	No changes of significance are observed on the hillside that failed on 7 June 2008.
--	---

1978	Single low altitude aerial photograph of good resolution.
------	---

	No changes of significance are observed on the hillside that failed on 7 June 2008. An area of high reflectivity, possibly anthropogenic disturbance, is apparent on the southern portion of the platform (M4).
--	---

1979	No changes of significance are observed on the hillside that failed on 7 June 2008.
------	---

to

1980

1981	High altitude aerial photographs of good resolution.
------	--

	No changes of significance are observed on the hillside that failed on 7 June 2008. Slope works (M5) are underway on the present-day locations of slopes Nos. 11SW-D/F69 and 11SW-D/FR301.
--	--

1982	Low altitude aerial photographs of good resolution.
------	---

	No changes of significance are observed on the hillside that failed on 7 June 2008. Slope works (M5) are still underway on slope No. 11SW-D/F69. Slope No. 11SW-D/FR301 and the associated surface drainage channels are being formed to
--	--

**YEAR**    **OBSERVATIONS**

its present-day configuration.

1984    Single low altitude aerial photograph of good resolution.

No changes of significance are observed on the hillside that failed on 7 June 2008. Slope works (M5) on slope No. 11SW-D/F69 appears to have been completed and slope No. 11SW-D/C1162 has been formed to its present-day configuration.

1985    High altitude aerial photographs of good resolution.

The valley and the surrounding areas are completely obscured by dense vegetation with many mature trees. Vegetation on the southern portion of slope No. 11SW-D/F69 is more prominent.

1986    Low altitude aerial photographs of good resolution.

No changes of significance are observed on the hillside that failed on 7 June 2008. The low-rise building (M1) has been demolished.

1988    High altitude aerial photographs of good resolution.

No changes of significance are observed on the hillside that failed on 7 June 2008. Rockwin Court has been constructed.

1989    Single high altitude aerial photograph of good resolution.

No changes of significance are observed on the hillside that failed on 7 June 2008. The low-rise building (M2) has been demolished.

1990    Single low flight aerial photograph with good resolution.

No changes of significance are observed on the hillside that failed on 7 June 2008. Construction works for Celeste Court and the associated site formation works, viz. formation of slope No. 11SW-D/2237, are underway. A new surface drainage channel appears to have been constructed along the northern boundary of slope No. 11SW-D/C14. Vegetation on slope No. 11SW-D/C12 has been largely cleared, exposing a new cut face.

1991    High altitude aerial photographs of good resolution.

No changes of significance are observed on the hillside that failed on 7 June 2008. Celeste Court has been constructed and slope No. 11SW-D/C2237 has been formed to its present-day configuration.

1992    No changes of significance are observed on the hillside that failed on 7 June 2008.  
to  
2007

<b><u>YEAR</u></b>	<b><u>OBSERVATIONS</u></b>
--------------------	----------------------------

2008	The 7 June 2008 landslide scar is clearly visible, which has already been covered with shotcrete.
------	---

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Table A1 - List of Aerial Photographs Reviewed

Date Taken	Altitude (ft)	Photograph Number
11 November 1945	20,000	Y00469-70
8 May 1949	8,600	Y01375-76
1 February 1963	2,700	Y07363-64
16 May 1967	6,250	Y13280-81
24 June 1972	2,500	1832-33
24 October 1973	12,500	5462-63
21 November 1974	12,500	9693-94
24 December 1975	12,500	12071-72
28 January 1976	4,000	12644-45
21 December 1977	4,000	20460
5 December 1978	4,000	23870
28 September 1979	5,500	27144-45
16 April 1980	4,000	29836
18 May 1981	4,000	37402
26 October 1981	10,000	38969, 38971
28 July 1982	3,500	43055-56
2 March 1984	4,000	53670
4 October 1985	15,000	A02598-99
20 September 1986	4,000	A06007-08
3 June 1988	20,000	A13398-99
15 August 1989	10,000	A19299
14 November 1990	4,000	A23800
21 October 1991	10,000	A28533-34
15 October 1992	4,000	A32504-05
5 December 1993	4,000	A36992-93
17 November 1994	4,000	CN8102-03
12 February 1995	10,000	CN9720-21
21 November 1996	10,000	CN16295-96
22 August 2001	4,000	AW52271-72
25 October 2002	8,000	CW45607-08
19 October 2003	8,000	CW50975-76
5 October 2004	4,000	CW60211-12
24 October 2005	4,000	CW65371-72
9 November 2006	8,000	CW75242-43
12 July 2007	3,000	CW77103-04
25 November 2008	6,000	CS20135-36
Note: Aerial photographs are in black and white, except for those prefixed with CN, CW and CS.		

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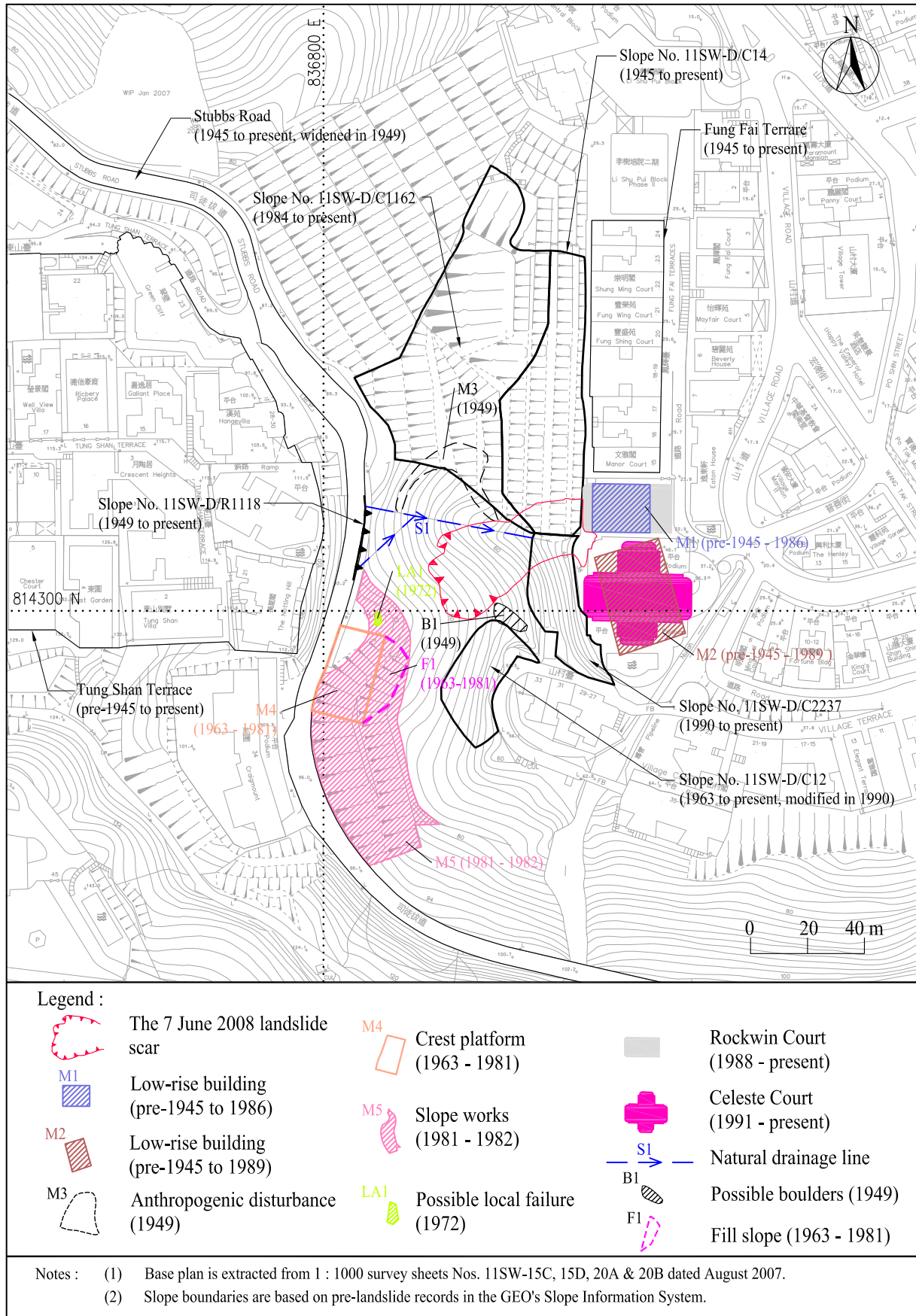


Figure A1 - Detailed API Observations

## GEO PUBLICATIONS AND ORDERING INFORMATION

### 土力工程處刊物及訂購資料

A selected list of major GEO publications is given in the next page. An up-to-date full list of GEO publications can be found at the CEDD Website <http://www.cedd.gov.hk> on the Internet under "Publications". Abstracts for the documents can also be found at the same website. Technical Guidance Notes are published on the CEDD Website from time to time to provide updates to GEO publications prior to their next revision.

**Copies of GEO publications (except geological maps and other publications which are free of charge) can be purchased either by:**

Writing to  
Publications Sales Unit,  
Information Services Department,  
Room 626, 6th Floor,  
North Point Government Offices,  
333 Java Road, North Point, Hong Kong.

or

- Calling the Publications Sales Section of Information Services Department (ISD) at (852) 2537 1910
- Visiting the online Government Bookstore at <http://www.bookstore.gov.hk>
- Downloading the order form from the ISD website at <http://www.isd.gov.hk> and submitting the order online or by fax to (852) 2523 7195
- Placing order with ISD by e-mail at [puborder@isd.gov.hk](mailto:puborder@isd.gov.hk)

**1:100 000, 1:20 000 and 1:5 000 geological maps can be purchased from:**

Map Publications Centre/HK,  
Survey & Mapping Office, Lands Department,  
23th Floor, North Point Government Offices,  
333 Java Road, North Point, Hong Kong.  
Tel: (852) 2231 3187  
Fax: (852) 2116 0774

**Requests for copies of Geological Survey Sheet Reports and other publications which are free of charge should be directed to:**

For Geological Survey Sheet Reports which are free of charge:  
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Civil Engineering and Development Building,  
101 Princess Margaret Road,  
Homantin, Kowloon, Hong Kong.  
Tel: (852) 2762 5380  
Fax: (852) 2714 0247  
E-mail: [jsewell@cedd.gov.hk](mailto:jsewell@cedd.gov.hk)

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Geotechnical Engineering Office,  
Civil Engineering and Development Department,  
Civil Engineering and Development Building,  
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Tel: (852) 2762 5346  
Fax: (852) 2714 0275  
E-mail: [florenceko@cedd.gov.hk](mailto:florenceko@cedd.gov.hk)

部份土力工程處的主要刊物目錄刊載於下頁。而詳盡及最新的土力工程處刊物目錄，則登載於土木工程拓展署的互聯網網頁 <http://www.cedd.gov.hk> 的“刊物”版面之內。刊物的摘要及更新刊物內容的工程技術指引，亦可在這個網址找到。

**讀者可採用以下方法購買土力工程處刊物(地質圖及免費刊物除外):**

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電子郵件: [florenceko@cedd.gov.hk](mailto:florenceko@cedd.gov.hk)

## **MAJOR GEOTECHNICAL ENGINEERING OFFICE PUBLICATIONS**

### **土力工程處之主要刊物**

#### **GEOTECHNICAL MANUALS**

Geotechnical Manual for Slopes, 2nd Edition (1984), 302 p. (English Version), (Reprinted, 2011).

斜坡岩土工程手冊(1998) , 308頁(1984年英文版的中文譯本)。

Highway Slope Manual (2000), 114 p.

#### **GEOGUIDES**

Geoguide 1            Guide to Retaining Wall Design, 2nd Edition (1993), 258 p. (Reprinted, 2007).

Geoguide 2            Guide to Site Investigation (1987), 359 p. (Reprinted, 2000).

Geoguide 3            Guide to Rock and Soil Descriptions (1988), 186 p. (Reprinted, 2000).

Geoguide 4            Guide to Cavern Engineering (1992), 148 p. (Reprinted, 1998).

Geoguide 5            Guide to Slope Maintenance, 3rd Edition (2003), 132 p. (English Version).

岩土指南第五冊      斜坡維修指南 , 第三版(2003) , 120頁(中文版)。

Geoguide 6            Guide to Reinforced Fill Structure and Slope Design (2002), 236 p.

Geoguide 7            Guide to Soil Nail Design and Construction (2008), 97 p.

#### **GEOSPECS**

Geospec 1            Model Specification for Prestressed Ground Anchors, 2nd Edition (1989), 164 p. (Reprinted, 1997).

Geospec 3            Model Specification for Soil Testing (2001), 340 p.

#### **GEO PUBLICATIONS**

GCO Publication      Review of Design Methods for Excavations (1990), 187 p. (Reprinted, 2002).  
No. 1/90

GEO Publication      Review of Granular and Geotextile Filters (1993), 141 p.  
No. 1/93

GEO Publication      Foundation Design and Construction (2006), 376 p.  
No. 1/2006

GEO Publication      Engineering Geological Practice in Hong Kong (2007), 278 p.  
No. 1/2007

GEO Publication      Prescriptive Measures for Man-Made Slopes and Retaining Walls (2009), 76 p.  
No. 1/2009

GEO Publication      Technical Guidelines on Landscape Treatment for Slopes (2011), 217 p.  
No. 1/2011

#### **GEOLOGICAL PUBLICATIONS**

The Quaternary Geology of Hong Kong, by J.A. Fyfe, R. Shaw, S.D.G. Campbell, K.W. Lai & P.A. Kirk (2000), 210 p. plus 6 maps.

The Pre-Quaternary Geology of Hong Kong, by R.J. Sewell, S.D.G. Campbell, C.J.N. Fletcher, K.W. Lai & P.A. Kirk (2000), 181 p. plus 4 maps.

#### **TECHNICAL GUIDANCE NOTES**

TGN 1                Technical Guidance Documents