

**REVIEW OF THE  
3 JUNE 2007 FAILURE OF A  
MASONRY RETAINING WALL  
ON HILLSIDE ADJACENT TO  
NO. 84 PEAK ROAD**

**GEO REPORT No. 250**

**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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## 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. These include guidance documents and results of comprehensive reviews. These 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.



R.K.S. Chan

Head, Geotechnical Engineering Office

July 2010

## FOREWORD

This report presents the findings of a review of a masonry retaining wall failure (Incident No. 2007/06/0020) that occurred on 3 June 2007 on the hillside adjacent to No. 84 Peak Road. The failure involved the detachment of six large stone masonry blocks (with maximum dimensions of 0.47 m by 0.3 m by 0.3 m), and about 10 small stone masonry blocks (with dimensions of <0.1 m by 0.1 m by 0.1 m) from the northwest portion of the retaining wall. Some of the detached stone masonry blocks were deposited on the hillside and some came to rest on Peak Road, resulting in the temporary closure of one lane of Peak Road. No casualties were reported as a result of the failure.

The key objectives of the review were to document the facts about the failure, the site history and pertinent observations. The scope of the review does not include any ground investigation or detailed diagnosis of the causes of the incident. Recommendations for follow-up actions are reported separately.

The report was prepared as part of the 2006/2007 Landslide Investigation Consultancy for landslides occurring in Hong Kong Island and Outlying Islands, for the Geotechnical Engineering Office, Civil Engineering and Development Department, under Agreement No. CE 49/2005 (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 49/2005 (GE)  
Study of Landslides Occurring in  
Hong Kong Island and Outlying  
Islands in 2006 and 2007

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## 1. INTRODUCTION

At about 4:30 a.m. on 3 June 2007, a failure (Incident No. 2007/06/0020) occurred at a masonry retaining wall<sup>1</sup>, which is located on the hillside adjacent to No. 84 Peak Road (Figure 1, and Plates 1 and 2). The failure involved the detachment of six large stone masonry blocks (with maximum dimensions of 0.47 m by 0.3 m by 0.3 m), and about ten smaller stone masonry blocks (with dimensions of <0.1 m by 0.1 m by 0.1 m) from the northwest portion of the wall. Some of the detached stone masonry blocks were deposited on the hillside and some came to rest on Peak Road. One lane of Peak Road was closed temporarily and no casualties were reported as a result of the failure.

Following the incident, Fugro Scott Wilson Joint Venture (FSW) carried out a review of the failure for the Geotechnical Engineering Office (GEO), Civil Engineering and Development Department (CEDD), under Agreement No. CE 49/2005 (GE).

The key objectives of the review were to document the facts about the incident, the site history and pertinent observations made by FSW. The scope of the review does not include any ground investigation or detailed diagnosis of the causes of the incident. Recommendations for follow-up actions are reported separately.

## 2. THE SITE

### 2.1 Site Description

The masonry retaining wall that failed on 3 June 2007 is located on a hillside between an access road to No. 84 Peak Road and slope No. 11SW-D/C258 above Peak Road (Figure 2 and Plate 3). The wall is a northeast-facing, partially pointed (at the south-eastern portion, i.e. the unfailed portion) squared stone masonry retaining wall, and is about 14 m long, up to 2.2 m high, and inclined at about 75°. Weepholes of 75 mm diameter are provided on the wall at approximately 2 m spacing. The top of the wall is located at about 2.5 m vertical and horizontal distance from the edge of the access road (Figures 2 and 3).

Above the masonry retaining wall is a 1 m high slope (probably comprising fill) inclined at about 22°. Above this slope is a small unregistered concrete wall, which has a maximum height of 1.4 m (Figures 2 and 3, and Plate 4) supporting the downslope edge of the access road.

A 200 mm high concrete upstand, with approximately 95 mm wide by 50 mm high drainage outlets at about 1.1 m spacing, is present along the downslope edge of the access road (Plate 3). A small, flat channel runs along the upslope edge of the access road (Plate 3), and is connected to a 150 mm diameter cross-road drain (Plate 3) through a 460 mm by 310 mm open catchpit, which discharges directly onto the hillside below the access road.

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<sup>1</sup> Subsequent to the June 2007 landslide, the masonry retaining wall that failed in the incident, together with the sloping ground at its crest, was registered as slope No. 11SW-D/CR2239 in the Government's New Catalogue of Slopes in July 2007.



An ephemeral drainage line, about 1 m wide by 0.6 m deep, is located on the upslope side of the access road (Plates 5 and 6). The drainage line discharges directly onto the access road at a location approximately opposite the masonry retaining wall that failed in the June 2007 incident (Figure 2). Surface water then appears to flow along the access road and onto Craigmin Road towards the northwest. Two cut slopes are located above the access road to No. 84 Peak Road on either side of the ephemeral drainage line (Plate 6). Slope No. 11SW-D/C1655 is a soil cut slope located to the north of the drainage line. The slope to the south of the drainage line is a 2.9 m high cut slope (i.e. does not satisfy the slope registration criteria), which is supported by a 2.94 m high and 3 m long concrete buttress in front. (Figure 2). Surface runoff enters the drainage line from the access road of the Peak Police Station at No. 92 Peak Road, which is situated at the top of a small hill above the June 2007 landslide site (Figure 2 and Plate 7). The drainage line is located on a hillside covered with trees and shrubs. At the upper part of the hillside, the surface is covered with loose fill materials, some scattered refuse and a small (about 1m high and 4 m long) masonry wall. The catchment area for the drainage line above the access road is about 1,200 m<sup>2</sup>.

Slope No. 11SW-D/C258 is a northeast- and east-facing cut slope above Peak Road (Figures 1 and 2, and Plate 2), and is located below the failed masonry retaining wall. It is about 104 m long, up to 14 m high and 65° (on average) steep (Figure 3). Overlying slope No. 11SW-D/C258 is an 18 m high, 35° steep hillside, which is covered with dense vegetation comprising grass, shrubs and mature trees (Plate 2). The toe of the failed masonry retaining wall is located at about 18 m horizontal distance and 12 m height above the crest of slope No. 11SW-D/C258. Peak Road is a single two-lane carriageway with a minimum width of 6 m.

## 2.2 Water-carrying Services

Records from the Water Supplies Department (WSD) and Drainage Services Department (DSD) indicate that water-carrying services are present along the access road above the masonry retaining wall that failed in June 2007 (see Figure 2).

Based on WSD's records, a buried 100 mm diameter Medium Density Polyethylene (MDPE) fresh water main is located below the upslope side of the access road. In addition, a fire hydrant is connected to the MDPE water main and located on the upslope side of the access road opposite the failed masonry retaining wall (Figure 2 and Plate 5). There were no reports of any leakages at the time of failure.

DSD's records indicate that a buried 150 mm diameter sewer runs below the outside edge of the access road above the failed masonry retaining wall (Figure 2), the majority of which falls within a private access road and is outside DSD's maintenance jurisdiction. DSD did not have any complaint or maintenance records on the drain between 2002 and 2007.

## 2.3 Regional Geology

According to the Hong Kong Geological Survey (HKGS) 1:20,000 map (Sheet 11) (GCO, 1986), the June 2007 landslide site is underlain by fine ash vitric tuff with bands of eutaxite of the Ap Lei Chau Formation (part of the Repulse Bay Volcanic Group).

## 2.4 Land Status and Maintenance Responsibility

A land status plan obtained from the Lands Department (Lands D) indicates that the subject masonry retaining wall is located on unleased and unallocated Government land (Figure 4).

As the failed masonry retaining wall was not registered in the GEO's New Catalogue of Slopes, its maintenance responsibility had not been assigned at the time of the June 2007 incident.

## 3. SITE HISTORY AND PAST INSTABILITY

### 3.1 General

The history of site development has been determined from an interpretation of the available aerial photographs, together with a review of relevant documentary information and site observations. The site development history and past instability are shown in Figure 5. Detailed observations from the API are given in Appendix A.

### 3.2 Site History

In the earliest available aerial photographs (taken in 1924), a road is evident in a similar position as the present-day access road (Figure 5). The wall involved in the June 2007 failure is not evident but may have been obscured by the vegetation, which covers most of the hillsides in the area. The access road leads to a platform with a single structure, which was previously the location of No. 2 Gough Hill Road (now known as No. 84 Peak Road). The platform is located near to the present-day House A at No. 84 Peak Road. Peak Road and slope No. 11SW-D/C258 are evident in the 1924 photographs in more or less their current alignment and layout (Figure 5).

In the 1949 photographs, the access road can be seen in more detail and appears to have been formed by cutting into the hillside and filling across a small depression and ephemeral drainage line immediately above the masonry wall that failed in June 2007. At the time, the Peak Police Station buildings and an access road were evident on the platform at the top of the hill above the access road and ephemeral drainage line.

In the 1963 aerial photographs, a small wall and possible hand-rail are evident along the downslope edge of the access road and the platform (Figure 5). Given that the alignment of the access road does not appear to have changed since 1924, the wall may have been constructed at the same time as the road. The location of the masonry wall affected by the June 2007 failure is obscured by vegetation. Above the access road, vegetation has been trimmed across a strip of hillside below the Peak Police Station platform. Some cutting may also have occurred on the hillside along this strip, which is currently registered as slope No. 11SW-D/CR1618. Below the strip, the hillsides remain covered with dense vegetation.

Between 1991 and 1992, a small area of anthropogenic activity, possibly representing the construction of a platform/structure and/or scaffolding, was evident on the slope between the access road and the southern portion of the masonry wall affected by the June 2007 failure (Figure 5). The reason for the activity is uncertain.

Between 1992 and 1994, all the structures located at No. 2 Gough Hill Road, i.e. on the platform to the south of the June 2007 landslide site, were demolished. Between 1994 and 1999, earthworks were undertaken on the platform and, between 1996 and 1999, a retaining wall was constructed along the northwestern side of the platform (Figure 5). Between 1996 and 1999, the platform was extended to southwest and the houses of No. 84 Peak Road were constructed on the podium (Figure 5).

### 3.3 Past Instability

According to GEO's Natural Terrain Landslide Inventory (NTLI) (King, 1999), the Enhanced Natural Terrain Landslide Inventory (ENTLI), and the large landslide study (Scott Wilson, 1999), there are no records of natural terrain landslides at the site. There are also no records of any reported landslide incidents at or in the vicinity of the site from the GEO's landslide database. No landslides were identified from the API in the vicinity of the masonry retaining wall involved in the June 2007 failure.

"Surface erosion" and a "slip scar on top of slope" on slope No. 11SW-D/C258 were described by Binnie & Partners (HK) (B&P) in 1978. A "Minor surface failure" on slope No. 11SW-D/C258 was observed by the Design Division (renamed LPM Division 2 in July 2004) of the GEO in 1994. FMR Consultants (FMR) described a "recent slope failure" at the northern part of slope No. 11SW-D/C258 (Figure 5), which was located downslope of the masonry retaining wall involved in the June 2007 failure and observed "Recent slope erosion – the upper soil/rock mix on the western end of the slope is continually eroding/raveling" in 1995. The failures and erosion as observed in 1978, 1994 and 1995 could not be seen during the API due to very dense vegetation cover. It is likely that the above observations relating to slope No. 11SW-D/C258 are of no relevance to the instability of the unregistered masonry wall in 2007.

## 4. PREVIOUS ASSESSMENTS AND SLOPE WORKS

### 4.1 Previous Ground Investigation

According to the information held at the GEO, there are no records of any previous ground investigation at or in the vicinity of the unregistered masonry retaining wall that failed in June 2007. Ground investigation works were carried out more than 35 m to the southeast of the masonry retaining wall during the redevelopment at No. 84 Peak Road in 1993 and the Landslip Preventive Measures (LPM) works for slope No. 11SW-D/C258 in 1999 (see Figure 2).

#### 4.2 Private Redevelopment at No. 84 Peak Road

Redevelopment at No. 84 Peak Road took place between 1992 and 1999. The access road and the masonry retaining wall affected by the June 2007 failure were not included in any of the plans for the redevelopment. The slope stabilisation plan (Drawing No. SSW-1) approved by the Buildings Department on 24 May 1999 for the redevelopment indicates that surface water runoff from the platform is discharged to the southeastern side of the site, which is away from the access road and the June 2007 failure.

#### 4.3 SIFT and SIRST Studies

In 1992, the GEO initiated a project entitled ‘Systematic Inspection of Features in the Territory’ (SIFT). This project aimed to search systematically for slopes not included in the 1977/78 Slope Catalogue and to update information on previously registered features by studying aerial photographs, together with limited site inspections. In January 1994, the GEO commenced a project entitled ‘Systematic Identification and Registration of Slopes in the Territory’ (SIRST), to update the 1977/78 Slope Catalogue. The subject masonry retaining wall was not included in the above studies and was not previously registered in the 1977/78 Slope Catalogue.

#### 4.4 Slope Maintenance Inspections

There are no records of any slope maintenance inspections on the subject masonry retaining wall by Government departments, as it was not registered in the Catalogue of Slopes and its presence was not known.

### 5. THE 3 JUNE 2007 FAILURE

The 3 June 2007 masonry wall failure incident was referred to the GEO by the HyD at about 5:10 a.m. on 3 June 2007. According to the incident report prepared by the GEO, the GEO carried out an inspection of the site at 6:59 a.m. and classified the failure as a boulder fall. The report records that six large pieces (with maximum dimensions of 0.47 m by 0.3 m by 0.3 m) and about ten smaller pieces (with dimensions of <0.1 m by 0.1 m by 0.1 m) were deposited on Peak Road. The incident report notes that there were no signs of groundwater seepage and that “Washout” and “Rainfall” were the possible causes of failure. One lane of Peak Road was closed to traffic until 11:15 a.m., and no casualties were reported as a result of the failure. Some loose boulders (about 10 pieces) were removed from slope No. 11SW-D/C258 by the HyD before the road was re-opened, according to the incident report.

Subsequent site inspections by FSW between 4 June and 11 June 2007 revealed a fresh scar (Plates 1 and 8) on an old masonry retaining wall, which had partially collapsed and showed signs of distress. The scar was located on the hillside at about 12 m above the crest of the northwest portion of slope No. 11SW-D/C258. The field evidence suggested that the ‘boulders’ deposited on Peak Road comprised cut stone blocks and some angular rock fragments, which had originated from the masonry wall and also possibly from the hillside

below the wall. Some of the detached blocks were deposited on the hillside and some at the crest of the cut slope, whilst some came to rest on Peak Road.

#### 6. FIELD OBSERVATIONS FOLLOWING THE 3 JUNE 2007 FAILURE

The landslide debris deposited on Peak Road had been removed by the HyD before the site was first visited by FSW on 4 June 2007. Imprints resulting from the impacts by the fallen blocks were observed on the sprayed concrete surface of slope No. 11SW-D/C258 and on the road pavement (Plate 9).

Site inspections carried out by FSW in June, September and November 2007 respectively on the hillside in the vicinity of the failed masonry retaining wall were limited in extent given the steep nature (40°) of the terrain, the presence of loose materials on slope surface and the close proximity to the traffic on Peak Road below. The failure scar was observed near the northwest end of the masonry retaining wall, i.e. the portion without pointing, and measured about 2.2 m wide, 1.6 m high and 0.5 m deep, exposing a wall thickness of about 0.3 m (Plates 1 and 8). Stone blocks, loose fill and some tree roots (about 30 mm in diameter) were exposed in the failure scar.

A 4.7 m wide section of the masonry retaining wall immediately to the southeast of the failure scar was found to be in an advanced state of severe distress (Figure 6 and Plate 10). A mature tree is present on this section of the wall with tree roots growing on the wall face and through the wall (Plate 10). Signs of bulging, together with major dislocation of stone blocks and numerous voids (e.g. a 1.2 m wide by 1.5 m high by 0.5 m deep void was located on the wall face), were observed near the wall toe.

A section of a 150 mm diameter broken ceramic pipe is partly exposed along the crest of the masonry retaining wall (Plate 8). The function of the pipe is not clear. The pipe was dry at the time of FSW's inspections, suggesting that it had been abandoned.

No signs of seepage at or in the vicinity of the June 2007 landslide scar and no flow through the disconnected 150 mm diameter ceramic pipe were evident during the inspections by FSW between June 2007 and November 2007.

The hillside directly below the scar was strewn with construction debris (including brick fragments, boulder-sized concrete blocks, a section of concrete U-channel, squared stone blocks, and sections of ceramic pipes) and some refuse (including aluminium cans, plastic bottles, foam boxes and a car tyre), see Figure 6 and Plate 11.

No signs of settlement or significant cracking were observed on the pavement of the access road above the masonry wall. However, two linear cracks were observed across the road (Figure 6, and Plates 12 and 13) located on either side of the landslide site. Both cracks were about 1 mm to 3 mm wide. The crack at the northern part of the site extends to the concrete upstand on the downslope edge of the road (Plate 12), and connects to the side of a WSD manhole cover, which suggests that the crack may possibly be associated with previous construction work related to the water main. The crack to the south of the failure could be associated with cable laying activities related to an old street lamp on the upslope edge of the road (Plate 13). The cracks did not exhibit any obvious vertical displacement.

There is a small flat channel running along the upslope edge of the access road connecting to a 150 mm diameter cross-road drain through a 460 mm by 310 mm catchpit, which discharges directly onto the hillside below the access road. The cross-road drain is located at the lowest point of the access road and was completely blocked at the time of the June 2007 inspections (see Plate 3). The ephemeral drainage line located on the upslope side of the access road would appear to discharge directly onto the access road, which has a cross-fall in either direction. Surface water would then flow partly along the flat channel (at the upslope edge) and partly against the 200 mm high concrete upstand (at the downslope edge) towards the northwest to the location of the cross-road drain (see Figure 6).

A 6 m long section of the concrete wall, which is located immediately below the access road and approximately above the northwest section of the masonry retaining wall, shows evidence of slight tilting. A 20 mm to 30 mm wide void between the road and wall was present during the post-landslide site inspection by FSW on 13 June 2007 (Figure 6, and Plates 4 and 14).

A small excavation pit, with dimensions of about 1.3 m wide by 0.6 m long by 0.5 m deep, was observed at the crest of the hillside below the entrance to No. 84 Peak Road (Figure 6 and Plate 15). A cable was located through the middle of the pit, which suggests that it was man-made.

Above the access road, slope No. 11SW-D/C1655 is composed of completely to highly decomposed fine ash tuff (C/HDT). The slope is covered with grass and shrubs. To the south of the ephemeral drainage line, the small cut slope comprises highly to moderately decomposed fine ash tuff (H/MDT), which is exposed on either side of a 3 m long by 2.94 m high concrete buttress (Figures 2 and 6, and Plate 6). A 0.5 m wide by 0.5 m deep, unlined crest channel is located at the crest of the small cut slope. The lower part of the ephemeral drainage line is composed of thin (<0.3 m thick) hillwash materials overlying H/MDT. There is no obvious evidence of any significant erosion within the channel or within the hillside further upslope towards the platform for the Peak Road Police Station. At the upper part of the drainage line, the hillside is covered with some loose fill materials, some scattered refuse and a small (about 1m high and 4 m long) masonry wall.

During the inspections by FSW, the road, surface drainage channels and the ephemeral drainage line were dry.

## 7. ANALYSIS OF RAINFALL RECORDS

Rainfall data were obtained from GEO automatic raingauge No. H16, which is the nearest raingauge to the June 2007 failure and located at The Peak, approximately 0.5 km to the west of the site (Figure 1). The raingauge records and transmits rainfall data at 5-minute intervals to the Hong Kong Observatory (HKO) and the GEO.

According to the incident report prepared by the GEO, the failure occurred at 4:30 a.m. on 3 June 2007. The daily rainfall recorded by raingauge No. H16 over the month preceding and one day following the incident, together with the hourly rainfall readings for the period between 1 June 2007 and 3 June 2007, are presented in Figure 7. The rainfall before the

failure of the masonry wall was not heavy. It is noted that there was no rainfall within the 24-hour period preceding the landslide incident.

Table 1 presents the estimated return periods for the maximum rolling rainfall for various durations recorded by raingauge No. H16 with reference to historical rainfall data at the HKO in Tsim Sha Tsui (Lam & Leung, 1994) and the local rainfall data of automatic raingauge No. H16 compiled by Evans & Yu (2001). The results show that for all the durations considered, the return period is within two years.

The maximum rolling rainfall for the rainstorm on 3 June 2007 has been compared with the past major rainstorms between 1983 and 2006 recorded by raingauge No. H16, which came into operation in 1983 (Figure 8). The maximum rolling rainfall for the rainstorm on 3 June 2007 is very light as compared to the previous significant rainstorms.

## 8. DISCUSSION

The 3 June 2007 failure involves primarily the detachment of some stone blocks from an unregistered old masonry retaining wall. The incident was not expected from rainfall-landslide correlations given that there was no rainfall recorded for the 24-hour period prior to the failure, and only light rainfall (10.5 mm) was recorded for the 48-hour period prior to failure. At the time of failure, there were no known road works or reported leakages from the buried pipelines located along the access road, and no leakages were observed after the failure.

The existing surface drainage provisions on the access road above the subject masonry retaining wall was probably inadequate at the time of the incident, in that the ephemeral drainage line located on the upslope of the access road discharged directly onto the access road. However, given the presence of a 200 mm high concrete upstand at the downslope side of the access road and the light antecedent rainfall at the time, it is highly unlikely that significant surface water could have overtopped from the access road onto the hillside below, thus contributing to the masonry wall failure. However there is a slight chance that overtopping could have occurred during periods of heavy rainfall in the past.

The catchment for the ephemeral drainage line above the subject retaining wall is relatively small (about 1,200 m<sup>2</sup>). It is possible for sub-surface water to be directed through the ephemeral drainage line towards the fill and masonry retaining wall. However, this is unlikely to have been a major contributory factor to the June 2007 failure given the light antecedent rainfall prior to failure.

Part of the unfailed portion of the retaining wall shows significant signs of distress in the form of bulging of the wall face, and there are numerous tree roots covering parts of the wall and in between some of the masonry blocks. In addition, some of the masonry blocks are absent from the wall face along the unfailed portion. The missing blocks could have been dislodged by previous wall movements. Some roots have penetrated behind the front face and between the masonry blocks, probably giving rise to wedging actions from the roots.

The June 2007 incident does not appear to have involved a common mode of failure of retaining wall (such as sliding or overturning), since only the outer-most layer of masonry blocks were detached from the body of the retaining wall. Given the presence of tree roots

exposed in the failure scar and the condition of the unfailed portion of the wall, root wedging action could have been a contributory factor to the dislodgement of the masonry blocks.

It is possible that there was intermittent and uneven settlement of the ground underneath the masonry retaining wall as a result of past heavy rainstorms, resulting in major dislocation of the masonry blocks prior to the June 2007 incident. The loosened masonry blocks might have been in a metastable condition prior to the detachment (as observed in the adjacent unfailed portion of the wall) that any further minor settlement of the ground (which may or may not be related to the antecedent rainfall) could have triggered the detachment of blocks. According to the API, the failed portion of the retaining wall was built across an ephemeral drainage line. It is likely that some filling up of the ephemeral drainage line was carried out (probably in a loose state), prior to construction of the masonry wall. Settlement of the fill that may underlie the wall appears to be a possibility.

The concrete wall located directly below the access road and above the northwestern portion of the masonry retaining wall (close to the failed portion of the wall) shows signs of distress in the form of tilting. It is not clear if this distress is associated with, or related to, the June 2007 incident. The tilting of the concrete wall is indicative of overturning wall movements. This could be caused by settlement of the ground below the concrete wall. Again, this wall was probably formed across the same ephemeral drainage line where the masonry wall below was built. Minor filling up of the drainage line (in a loose state) for the construction of this concrete wall is a possibility, where ground settlement is plausible.

Below the retaining wall that failed in June 2007, a slope failure and surface erosion were reported at the crest of the northern part of slope No. 11SW-D/C258 during slope inspections in 1994 and 1995. It is not certain whether the instability and erosion were caused by concentrated sub-surface or surface water flow, part of which may have been discharged from the cross-road drainage pipe below the access road. However, this should have had no effect on the failed masonry retaining wall, which is located some 7 m from the cross-road drain.

The subject retaining wall was not registered prior to the landslide as it did not satisfy the slope registration criteria (WBTC, 2000). As a result, it was not maintained regularly prior to the June 2007 landslide incident. The old masonry wall, which was in a poor condition, was probably substandard. Insufficient maintenance leading to progressive deterioration of the wall was probably a contributory factor to the failure. The situation may also have been aggravated by the inadequate and poor maintenance state of the surface drainage provisions on the access road above the wall.

The overall setting comprising an old, 2.2 m high substandard masonry wall, together with an old 1.4 m high concrete wall which exhibit signs of distress, with sloping ground probably comprising fill in between the walls, on a steep hillside at some distance above a 14 m high steep cutting is liable to pose a hazard to the road users below. The presence of loose construction debris and refuse on the steep hillside is also a potential hazard to the road users below.



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- Scott Wilson (Hong Kong) Ltd. (1999). Specialist API Services for the Natural Terrain Landslide Study – Task B Factual Report. Report submitted to the Geotechnical Engineering Office, Civil Engineering Department, Hong Kong, 9 p plus 4 Appendices.
- WBTC (2000). Registration and Updating of the Catalogue of Slopes (Works Bureau Technical Circular No. 9/2000). Works Bureau, Hong Kong, 3 p plus 4 Appendices.

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Table 1 - Maximum Rolling Rainfall at GEO Raingauge No. H16 for Selected Durations Preceding the Landslide on 3 June 2007 and the Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period (Hours) (see Note 3)	Estimated Return Period (Years) (See Note 2)	
			By Lam & Leung (1994)	By Evans & Yu (2001)
5 Minutes	2.5	3:20 a.m. on 2 June 2007	< 2	< 2
15 Minutes	2.5	3:20 a.m. on 2 June 2007	< 2	< 2
1 Hour	3	4:40 a.m. on 2 June 2007	< 2	< 2
2 Hours	5.5	4:40 a.m. on 2 June 2007	< 2	< 2
4 Hours	8	4:40 a.m. on 2 June 2007	< 2	< 2
12 Hours	8	4:40 a.m. on 2 June 2007	< 2	< 2
24 Hours	10.5	4:40 a.m. on 2 June 2007	< 2	< 2
48 Hours	17	4:40 a.m. on 2 June 2007	< 2	< 2
4 Days	20	7:15 a.m. on 1 June 2007	< 2	< 2
7 Days	108	4:40 a.m. on 2 June 2007	< 2	< 2
15 Days	304.5	4:40 a.m. on 2 June 2007	< 2	< 2
31 Days	319	4:40 a.m. on 2 June 2007	< 2	< 2
Notes: (1) Maximum rolling rainfall was calculated from 5-minute rainfall data. (2) Return periods were derived from Table 3 of Lam & Leung (1994) and Evans & Yu (2001). (3) The landslide was assumed to have occurred at 4:30 a.m. on 3 June 2007 for the purpose of rainfall analysis. (4) The nearest GEO raingauge to the landslide site is raingauge No. H16 which is situated at about 0.5 km to the northwest of the landslide site.				

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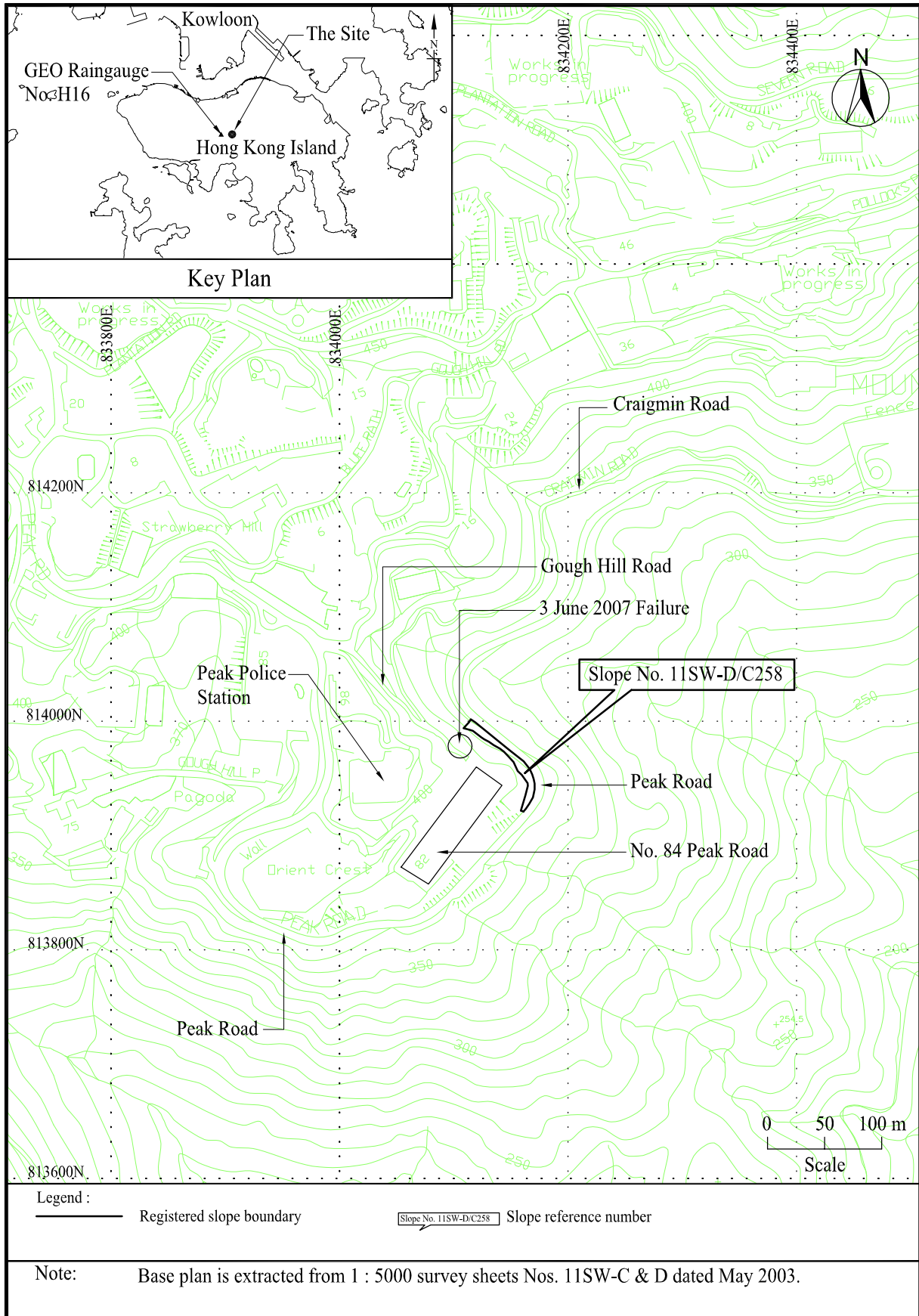


Figure 1 - Site Location Plan

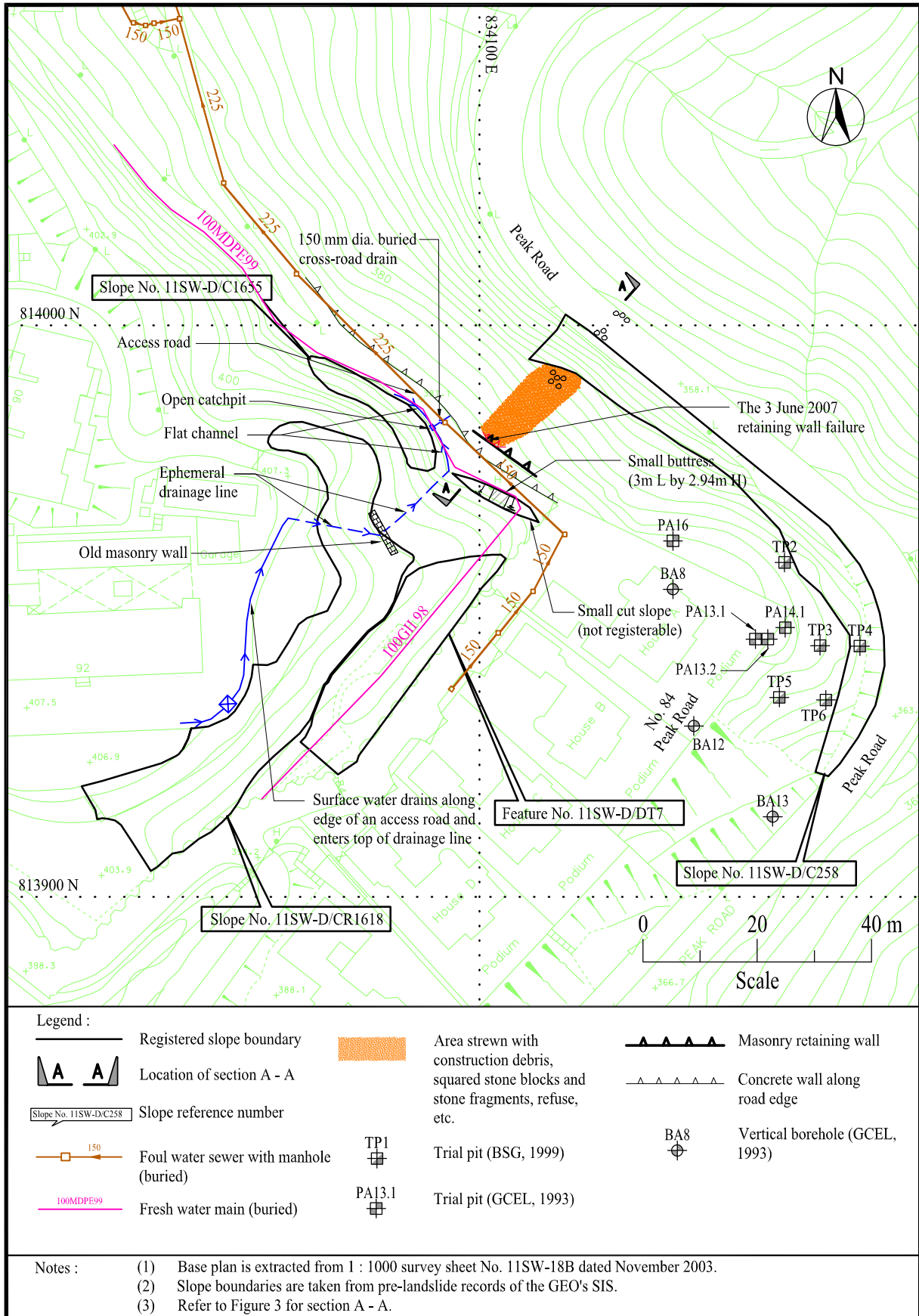


Figure 2 - Site Plan

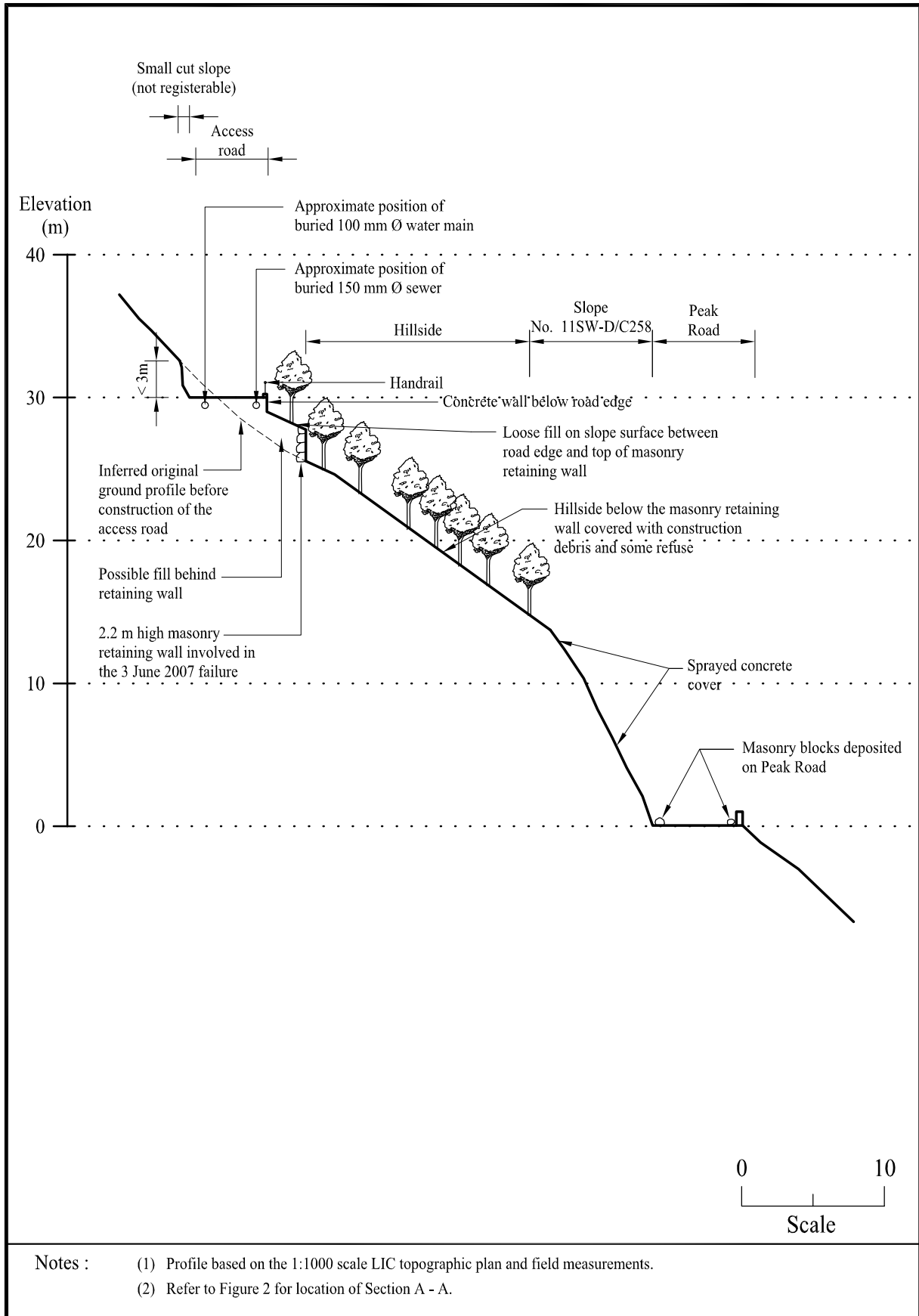
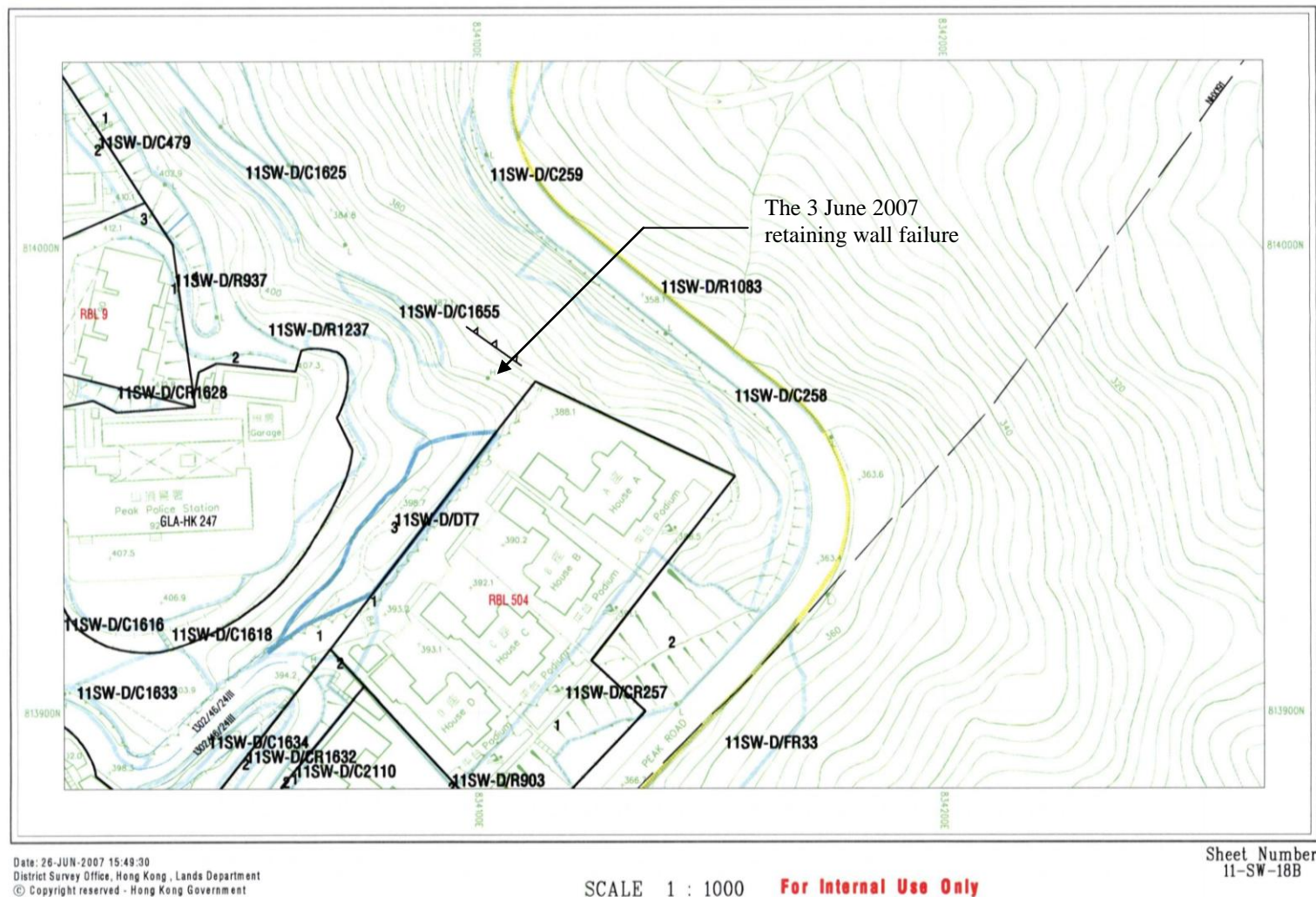


Figure 3 - Section A - A





Note: This figure on the land status within the study site is reproduced from District Survey Office Lot Index Plan - 1:1000 map sheet No. 11SW-18B dated June 2007 and superimposed with the registered slope boundaries.

Figure 4 – Land Status Plan



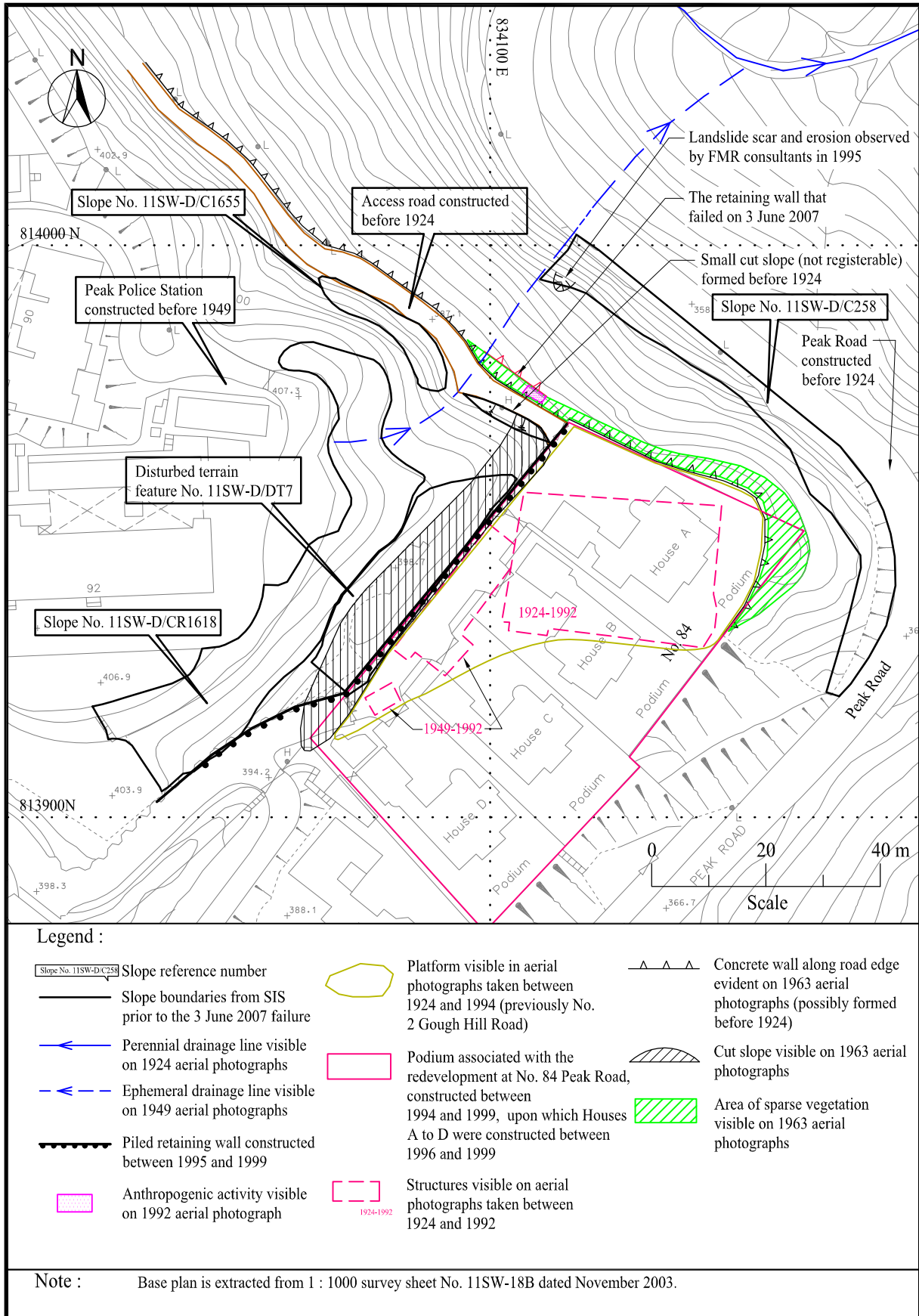


Figure 5 - Site Development History

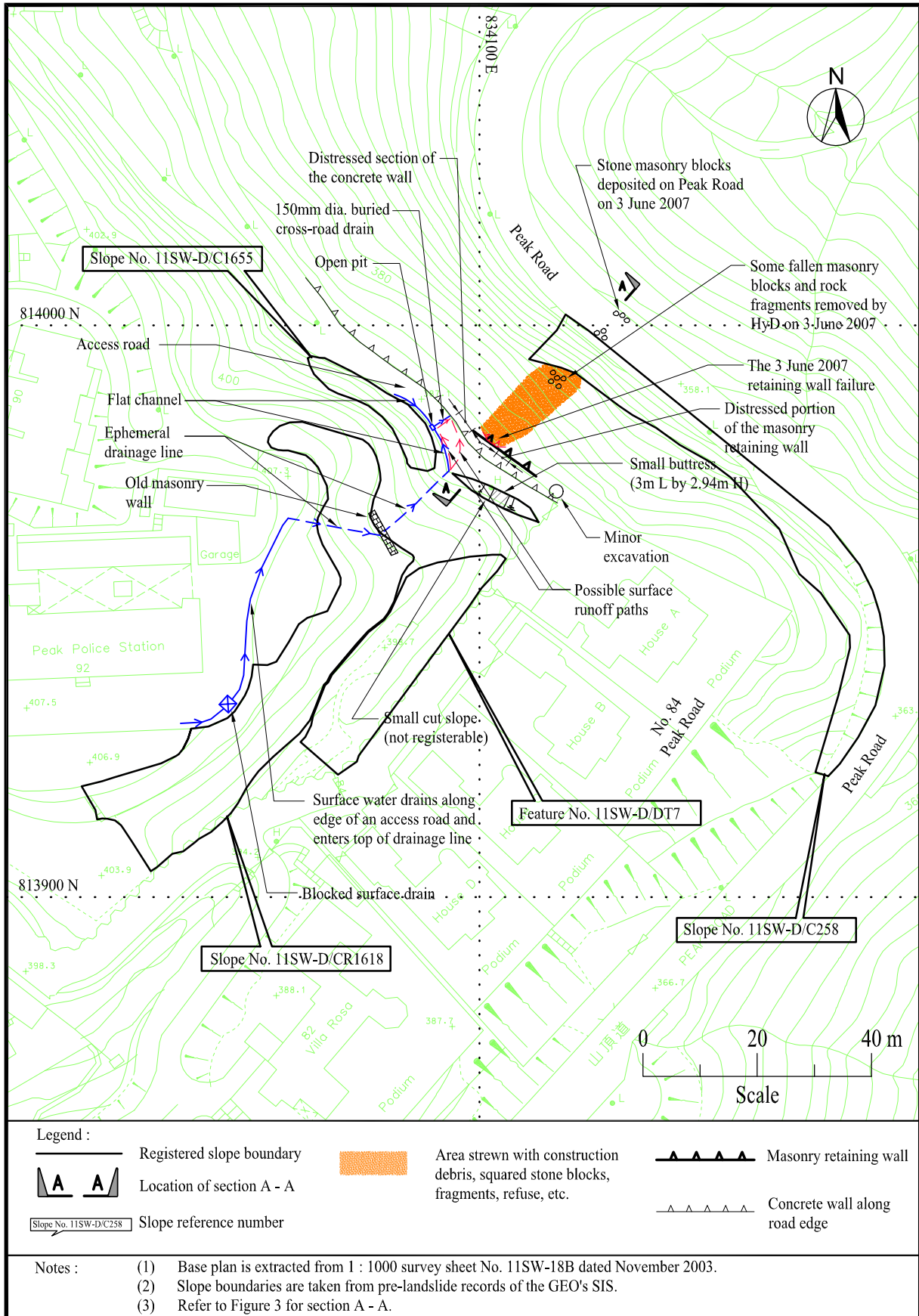
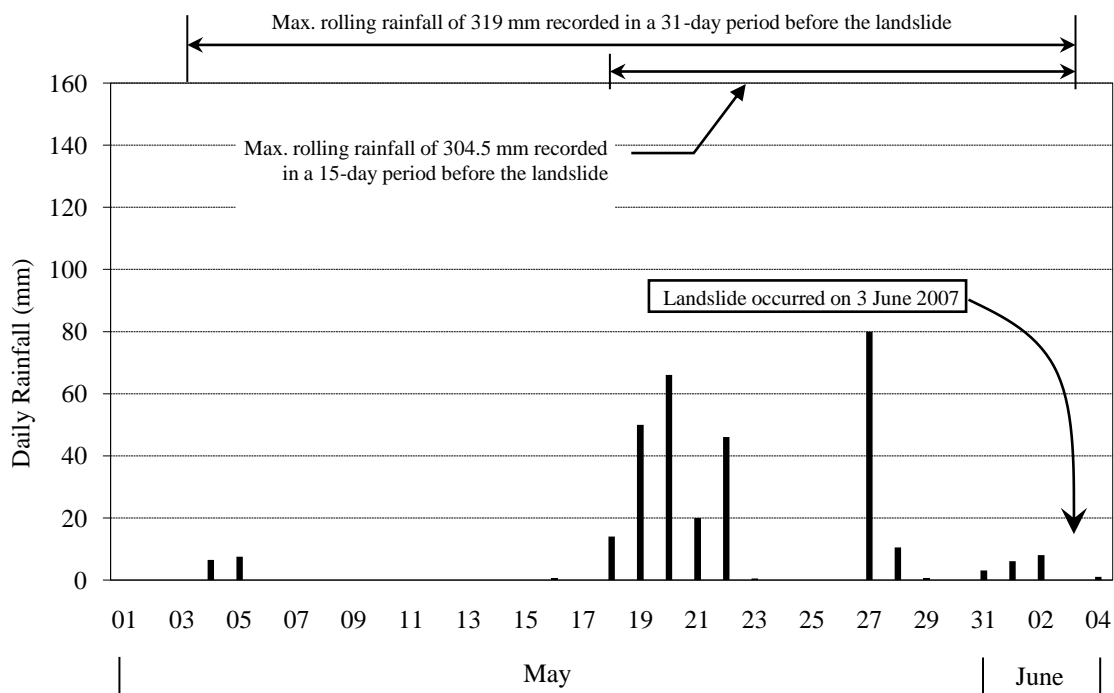
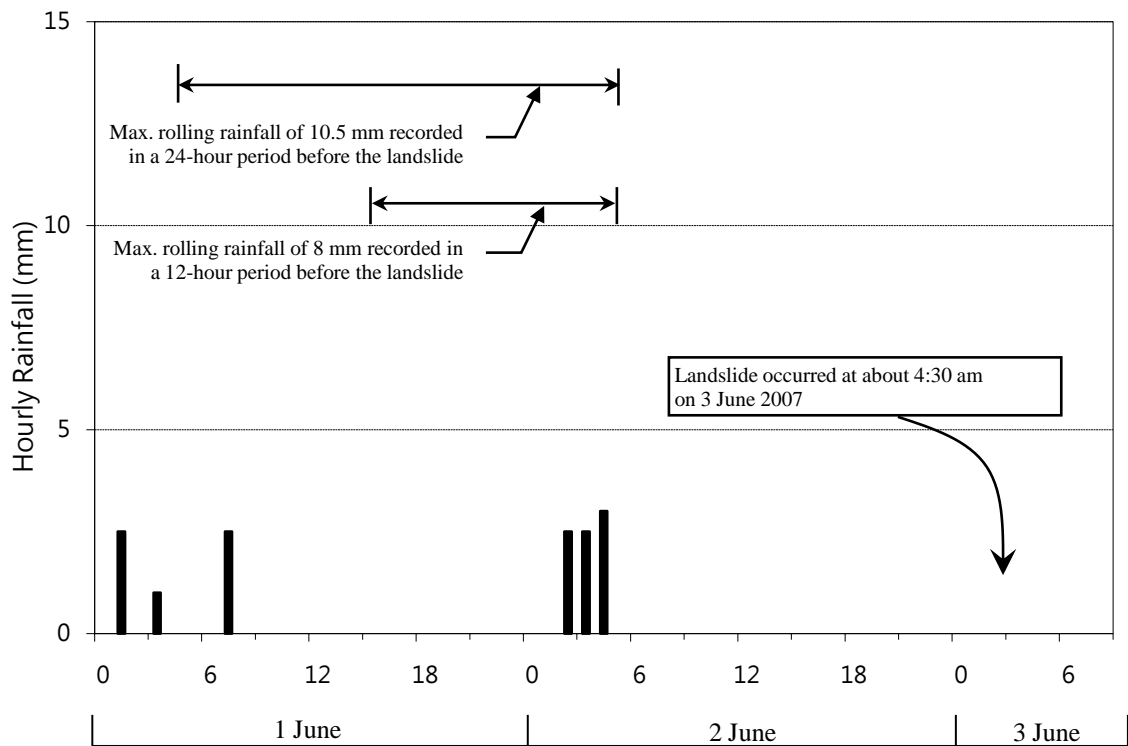


Figure 6 - Observations after the 3 June 2007 Failure



(a) Daily Rainfall Recorded at GEO Raingauge No. H16 between 1 May 2007 and 4 June 2007



(b) Hourly Rainfall Recorded at GEO Raingauge No. H16 between 1 June 2007 and 3 June 2007

Figure 7 - Daily and Hourly Rainfall Recorded at GEO Raingauge No. H16

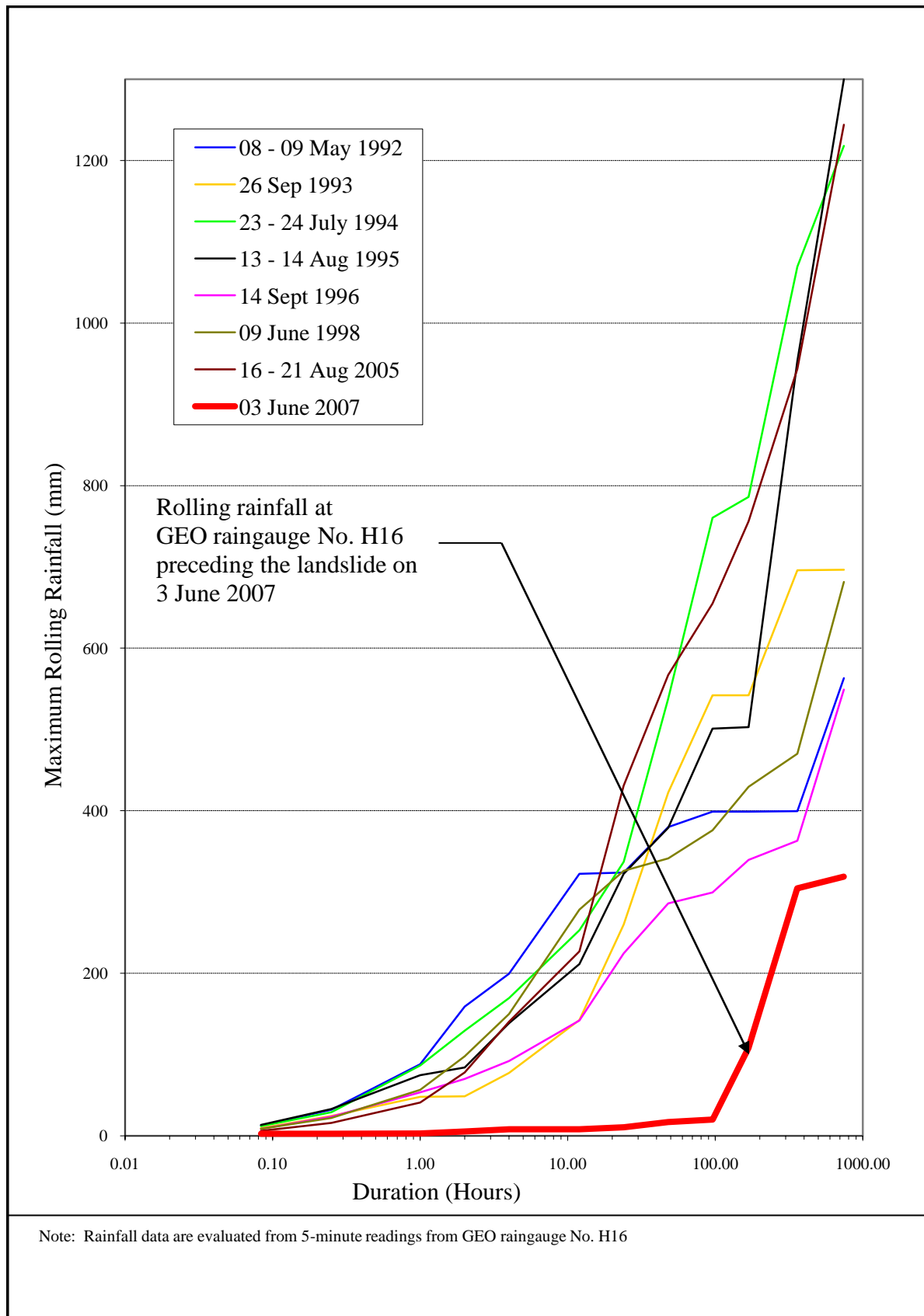


Figure 8 - Maximum Rolling Rainfall for the Rainstorm Preceding the Landslide and Selected Previous Major Rainstorms Recorded at GEO Raingauge No. H16

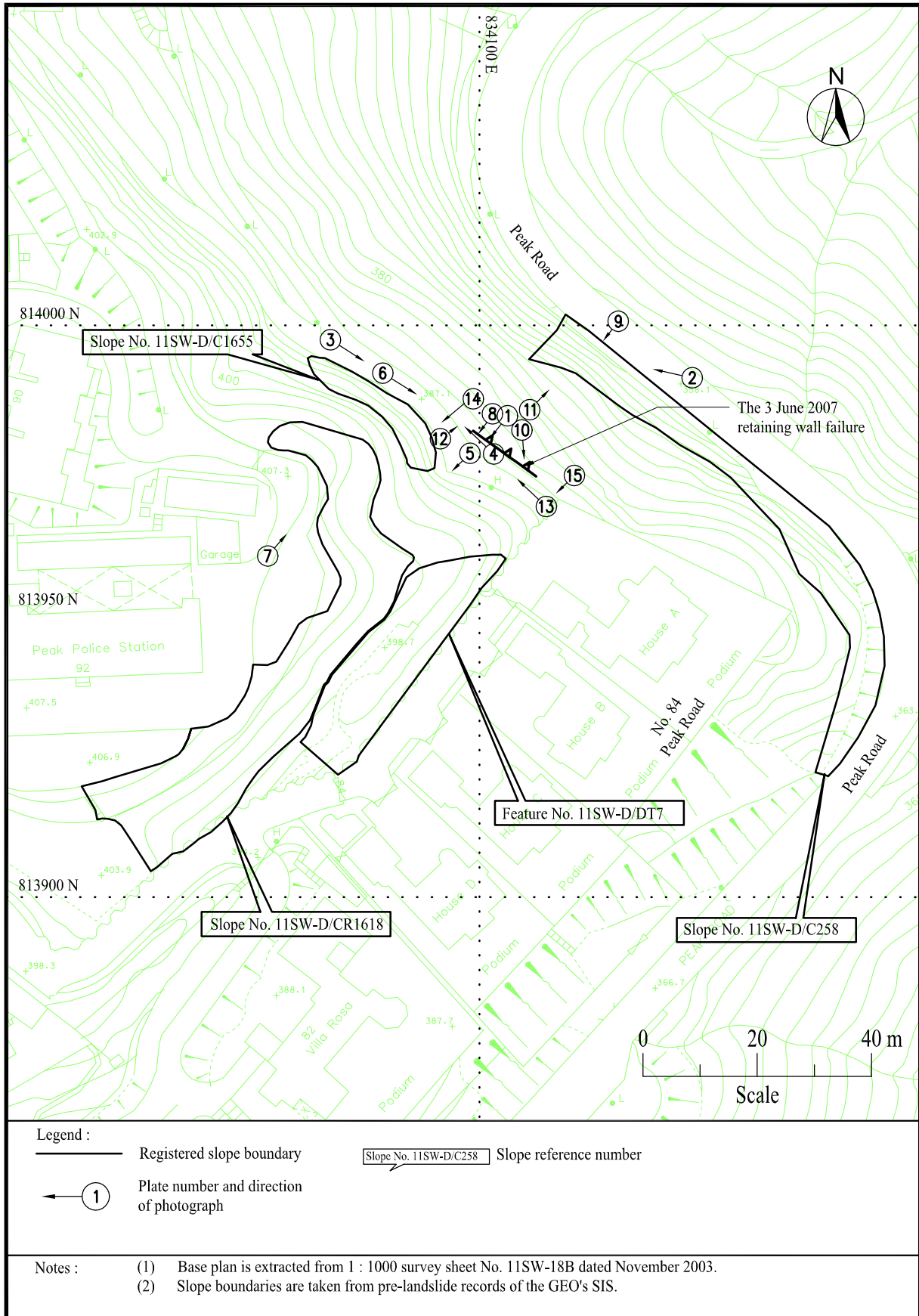


Figure 9 - Locations and Directions of Photographs

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12	Crack on the Access Road to the North of the Failure (Photograph taken on 7 November 2007)	42
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14	Tilted Concrete Retaining Wall Immediately below the Access Road (Photograph taken on 13 June 2007)	44
15	Small Excavation at the Crest of the Hillside below the Entrance to House A of No. 84 Peak Road (Photograph taken on 13 June 2007)	45





Plate 1 - The 3 June 2007 Retaining Wall Failure  
(Photograph taken on 11 June 2007)

Note: See Figure 9 for locations and directions of photographs.



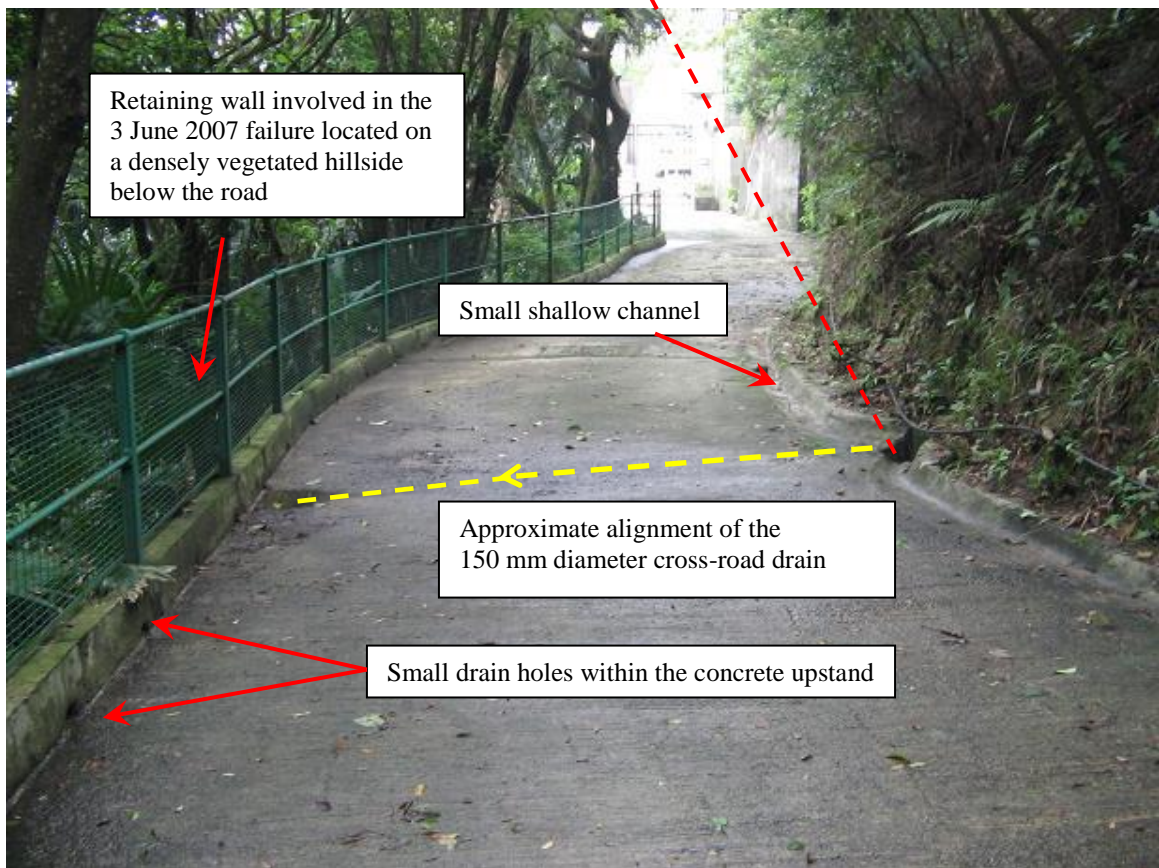


Plate 2 - Slope No. 11SW-D/C258 and the Hillside above  
(Photograph taken on 4 June 2007)

Note: See Figure 9 for locations and directions of photographs.



Blocked 150 mm diameter cross-road drain (viewed from inside the open catch pit)



Retaining wall involved in the 3 June 2007 failure located on a densely vegetated hillside below the road

Small shallow channel

Approximate alignment of the 150 mm diameter cross-road drain

Small drain holes within the concrete upstand

Plate 3 - Access Road above the Hillside on which the 3 June 2007 Retaining Wall Failure Occurred (Photograph taken on 11 June 2007)

Note: See Figure 9 for locations and directions of photographs.



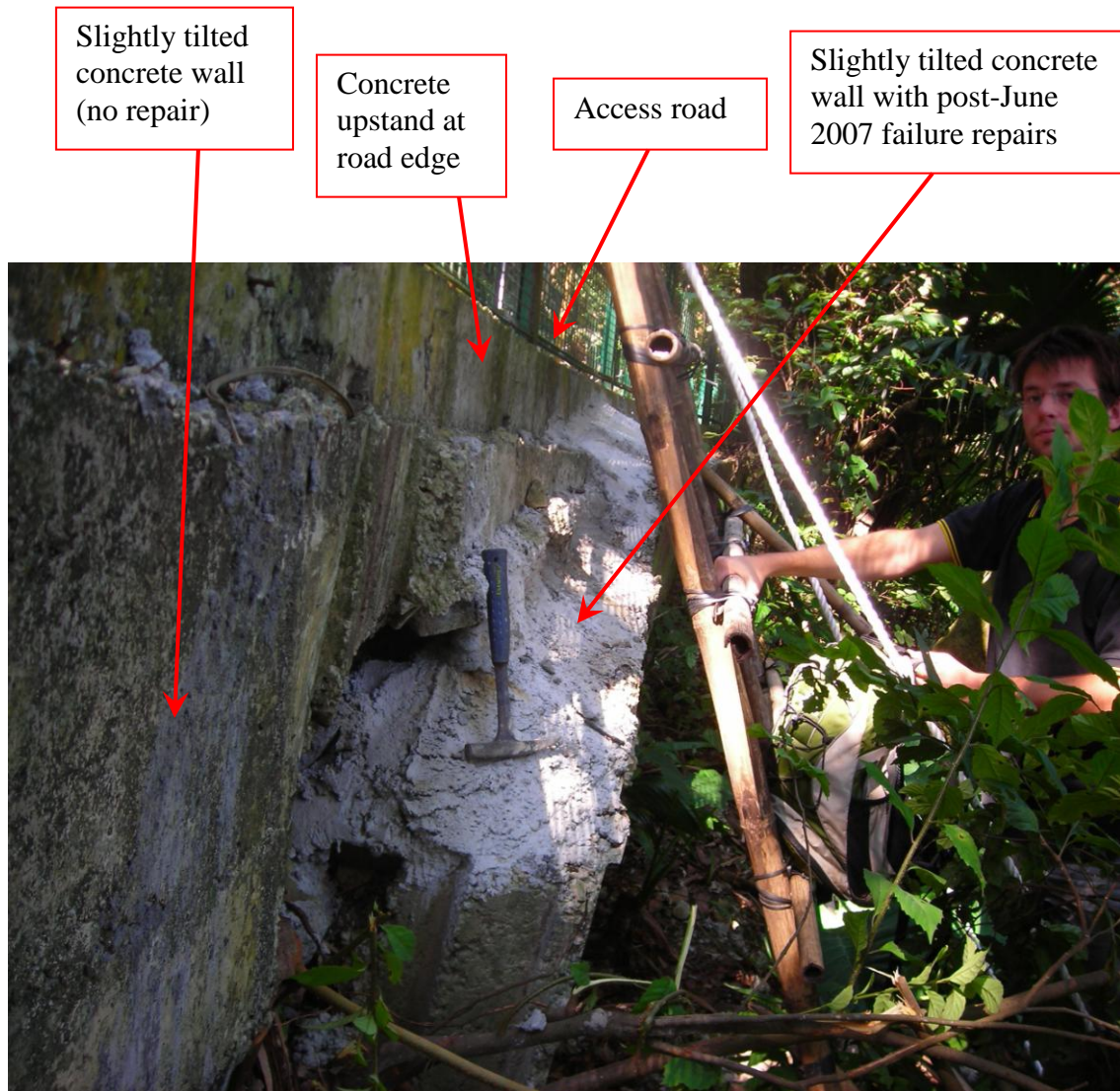


Plate 4 - Concrete Wall between the Access Road and Hillside below  
(Photograph taken on 7 November 2007)

Note: See Figure 9 for locations and directions of photographs.

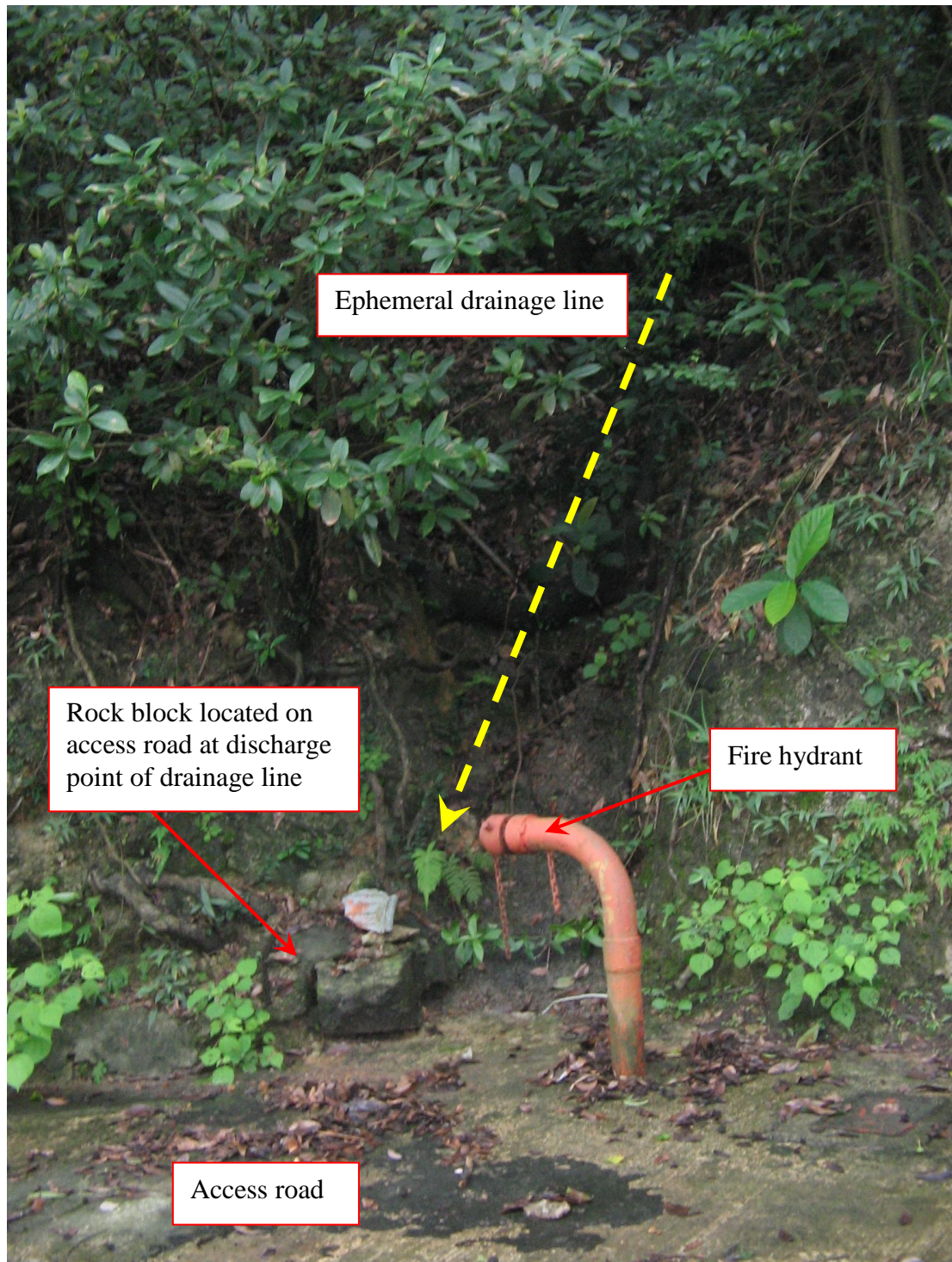


Plate 5 - Ephemeral Drainage Line which Discharges Directly onto the Access Road (Photograph taken on 11 June 2007)

Note: See Figure 9 for locations and directions of photographs.





Plate 6 - Cut Slopes above the Access Road  
(Photograph taken on 7 November 2007)



Plate 7 - Peak Police Station Access Road Surface Drainage Discharge Point  
(Photograph taken on 7 November 2007)

Note: See Figure 9 for locations and directions of photographs.





Plate 8 - Failure Scar on the Squared Masonry Retaining Wall  
(Photograph taken on 11 June 2007)

Note: See Figure 9 for locations and directions of photographs.

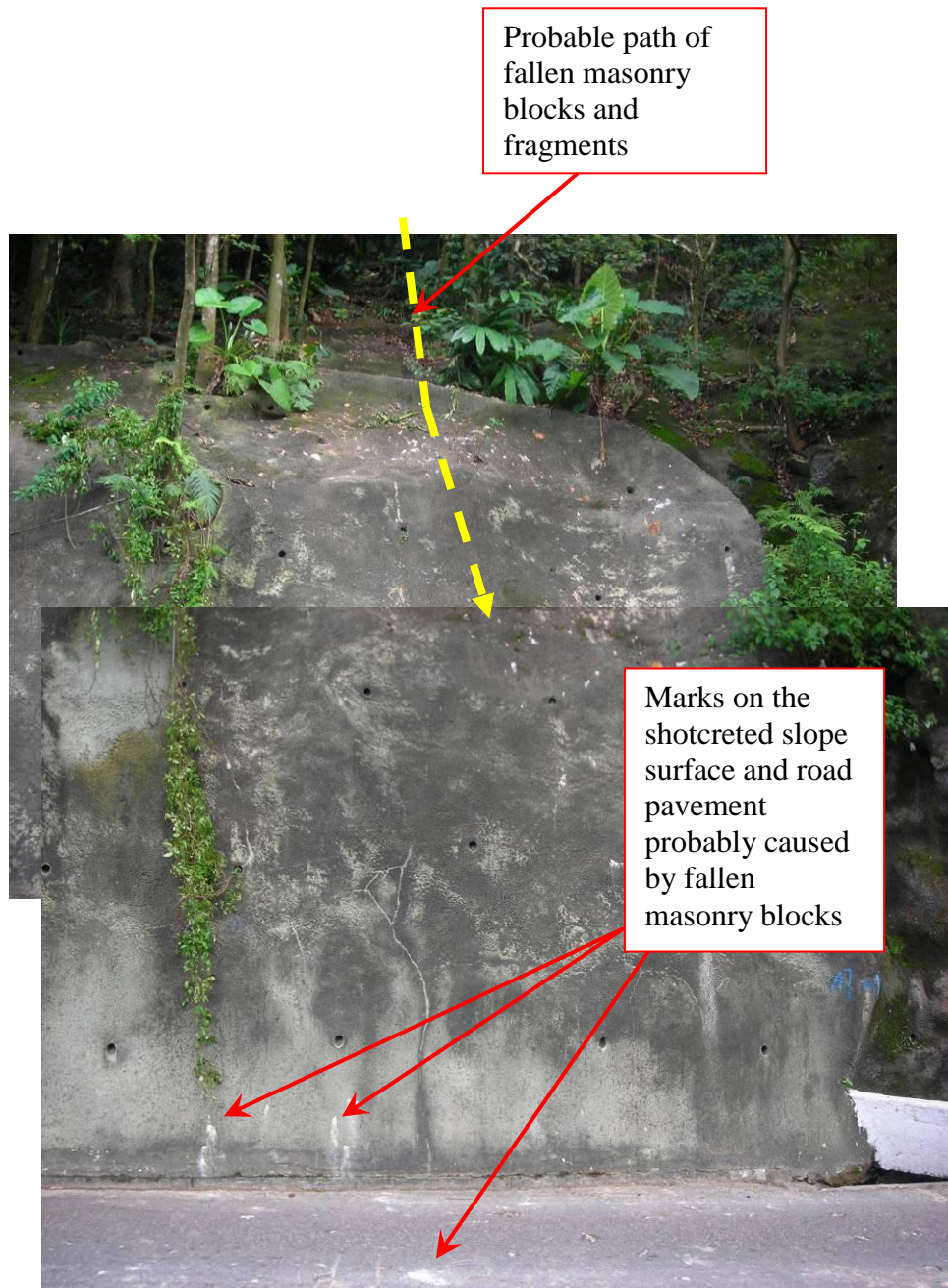


Plate 9 - View of the Marks on the Slope Surface and Road Pavement Probably Caused by the Impact of Fallen Masonry Blocks and Fragments  
(Photograph taken on 4 June 2007)

Note: See Figure 9 for locations and directions of photographs.





Large tree and  
extensive tree  
roots at crest and  
draped over the  
face of the wall



Plate 10 - Portion of the Masonry Retaining Wall  
in an Advanced State of Distress  
(Photograph taken on 13 June 2007)

Note: See Figure 9 for locations and directions of photographs.



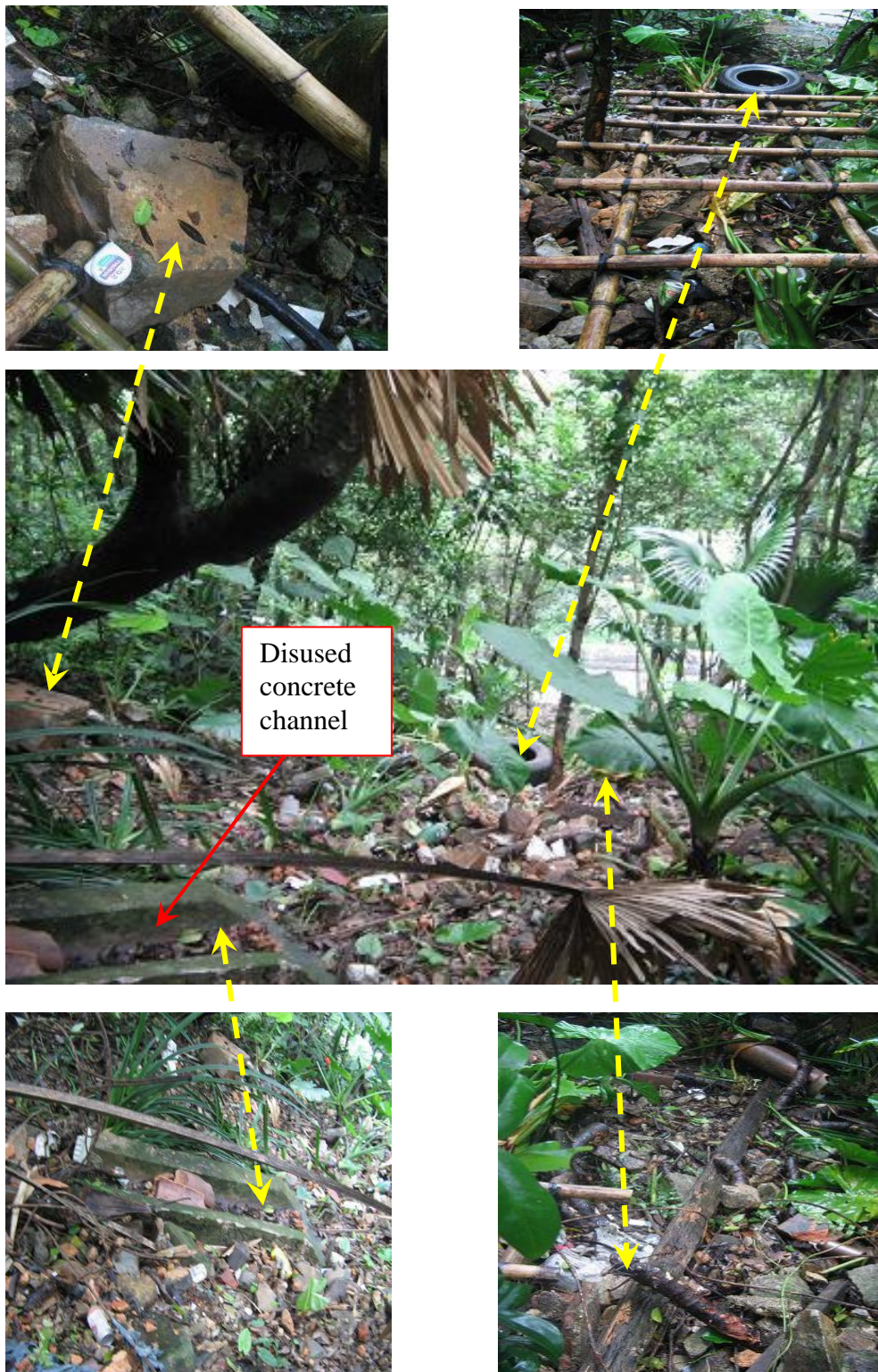


Plate 11 - Hillside below the Failure Scar Strewn with Construction Debris, Refuse and Rock Blocks  
(Photograph taken on 4 and 11 June 2007)

Note: See Figure 9 for locations and directions of photographs.





Note: See Figure 9 for locations and directions of photographs.

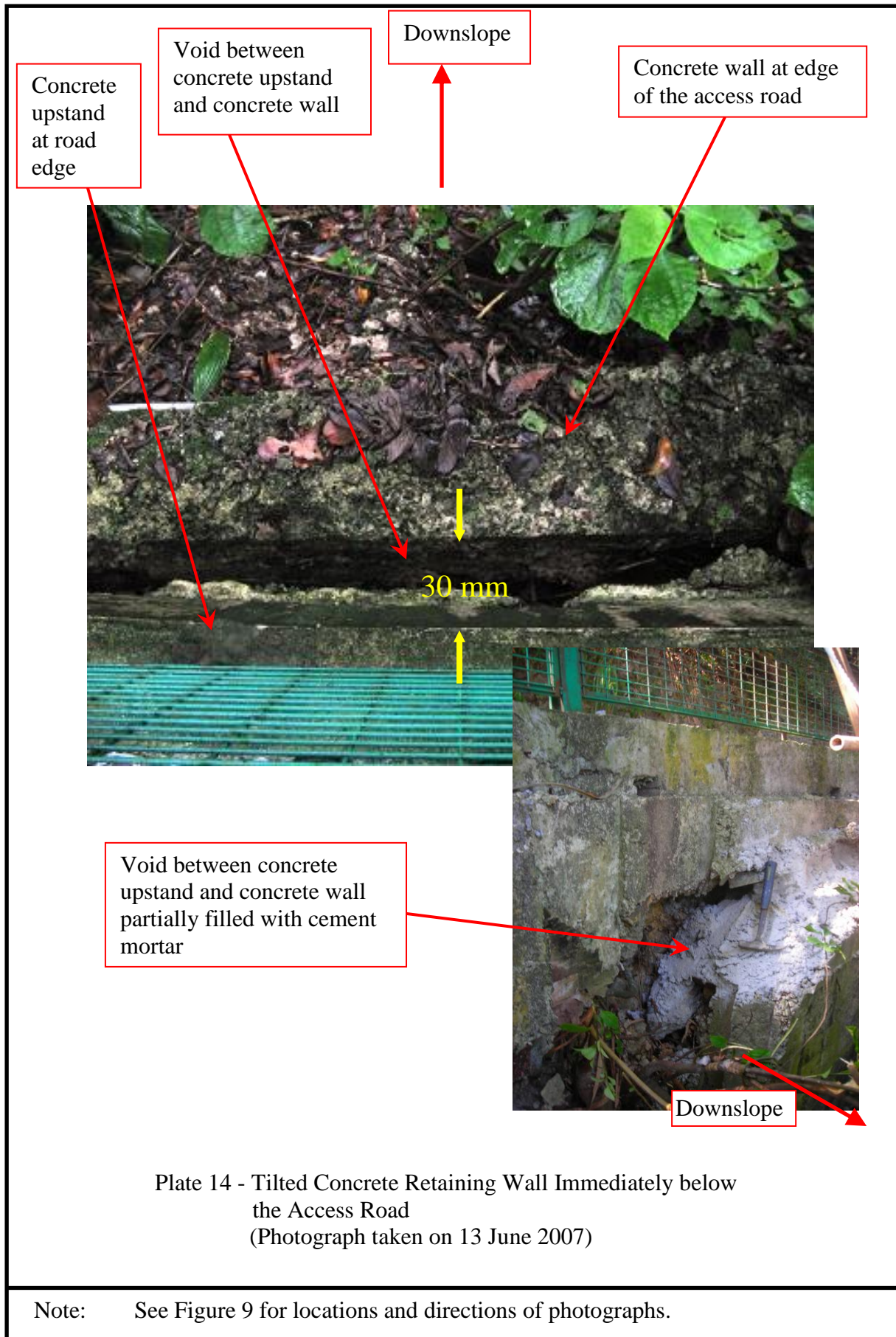


Narrow crack across  
the access road to the  
south of the failure



Plate 13 - Crack on the Access Road to the South of the Failure  
(Photograph taken on 7 November 2007)

Note: See Figure 9 for locations and directions of photographs.





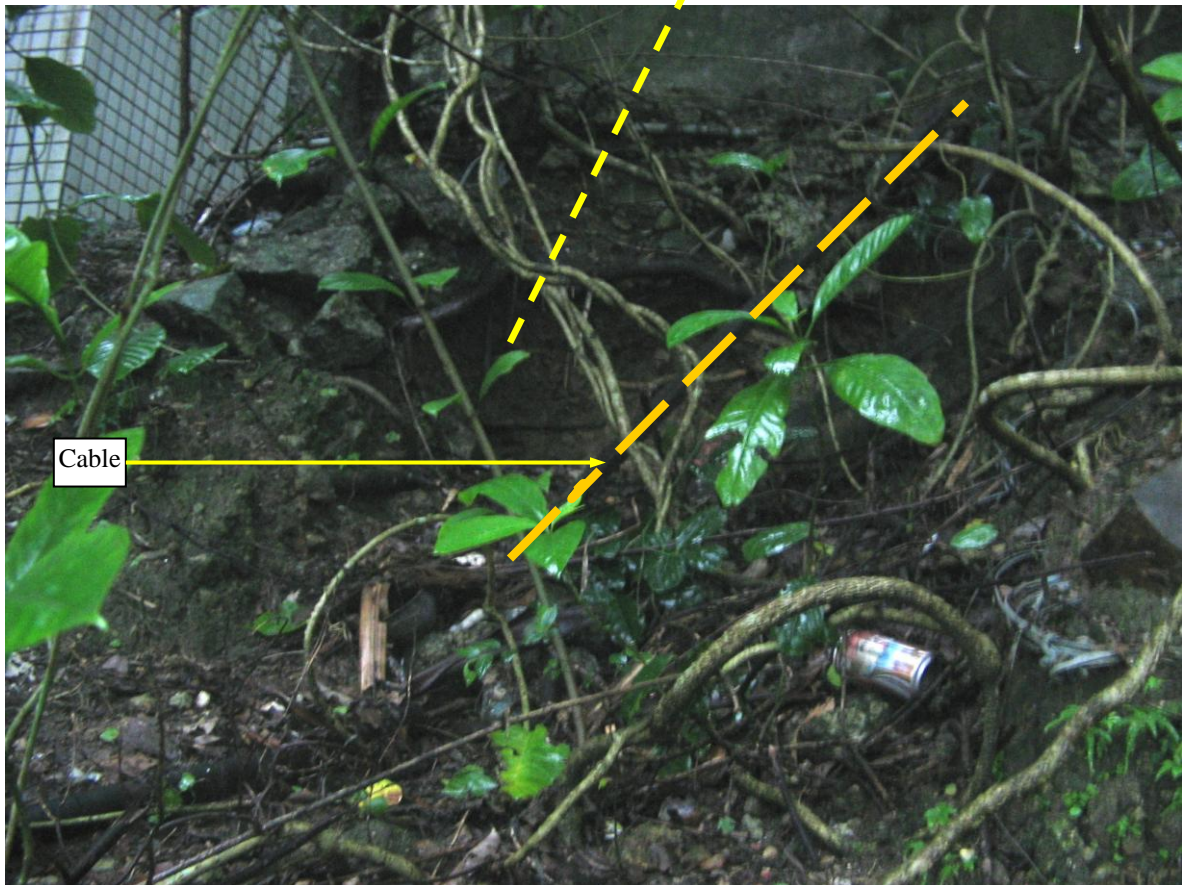


Plate 15 - Small Excavation at the Crest of the Hillside below the Entrance to House A of No. 84 Peak Road  
(Photograph taken on 13 June 2007)

Note: See Figure 9 for locations and directions of photographs.

## APPENDIX A

### AERIAL PHOTOGRAPH INTERPRETATION

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## A1. DETAILED OBSERVATIONS

This appendix sets out the detailed observations made from an interpretation of aerial photographs taken between 1924 and 2006. A list of the aerial photographs reviewed is presented in Table A1 and an annotated plan is shown in the main report (Figure 4).

### **YEAR    OBSERVATIONS**

1924    High flight, poor resolution aerial photographs.  
The subject landslide incident involved the failure of a retaining wall (the feature) located on a steep, northeast-facing hillside (the site) above slope No. 11SW-D/C258. The concerned retaining wall is not visible in the photograph. The site is located to the north of an east-west orientated spur, which forms the side slope of a deep, basin-shaped valley, containing a perennial drainage line. Much of the hillside is in shadow. A NW-SE orientated access road is apparent on the hillside above the northern portion of the site. The access road leads to a platform located above the southern portion of the site. The platform contains a structure. Slope No. 11SW-D/C258 has been constructed to accommodate Peak Road, both of which are located below the site. High reflectivity on and immediately below Peak Road suggests recent construction.

1949    Low flight, moderate to poor resolution aerial photographs.  
The feature is not visible on the photographs. The site is covered with dense vegetation. A SW-NE trending ephemeral drainage line flows through the northern portion of the site. The drainage line originates from above the access track and enters the perennial drainage line, initially observed in 1924, well below Peak Road. High reflectivity, probably representing road improvement work, is apparent along the access track. Two additional structures have been built on the western portion of the platform located above the eastern portion of the site. A small terraced garden has been formed on the hillside below the platform to the south of the site. High reflectivity, probably representing slope improvement works, is apparent on the central and southern portions of slope No. 11SW-D/C258.

At the time, the Peak Police Station buildings and an access road were evident on the platform at the top of the hill above the access road and ephemeral drainage line.

1963    A possible road edge retaining wall is apparent along the downslope side of the access road and the platform and was probably formed during the original construction of the access road. However, a strip of sparse vegetation, probably due to vegetation clearance, is apparent below this retaining wall, which could indicate more recent construction activities associated with the edge wall. A clear difference in gradient from the natural hillside below the strip, particularly in the central portion of the site where a shallow natural depression exists, suggests the strip has been formed from fill material. It is likely that the retaining wall of concern, although obscured by vegetation, has been constructed to retain this fill material.

**YEAR    OBSERVATIONS**

	A cut slope is evident along the northern boundary of the platform.
1967	Single aerial photograph. The site is covered with dense vegetation.
1973	No significant changes are noted.
1977	High reflectivity, representing an exposed rock face, is apparent in the southeastern portion of slope No. 11SW-D/C258.
1978	No significant changes are noted.
1980	No significant changes are noted.
1984	The area of high reflectivity, representing an exposed rock face, continues to be apparent in the southeastern portion of slope No. 11SW-D/C258.
1986	No significant changes are noted.
1988	No significant changes are noted.
1990	No significant changes are noted.
1991	High reflectivity remains apparent on the southeastern portion of slope No. 11SW-D/C258.
1992	A small area of anthropogenic activity, possibly representing a platform/structure and/or scaffolding, is apparent on the strip of fill material above the southern portion of the feature.
1994	All structures have been cleared from the platform to the south of the site.
1995	A hard surface cover is apparent on the upper part of the southeastern portion of slope No. 11SW-D/C258. Earthworks are apparent on the platform above the site.
1996	Earthworks continue on the platform above the site. A retaining wall is under construction along the northern boundary of the platform at the location of the cut slope, initially observed in 1963.
1999	The retaining wall has been completed and the platform, now better described as a podium, has been extended to the southwest. Four structures (Houses A to D), which together form No. 84 Peak Road, have been constructed on the podium. House A is located immediately above the site, which remains covered in dense vegetation.
2002	No significant changes are noted.

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

2004	No significant changes are noted.
------	-----------------------------------

2005	No significant changes are noted.
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2006	No significant changes are noted.
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Table A1 - List of Aerial Photographs Used in the Aerial Photograph Interpretation

Date	Altitude (ft)	Photograph Number
1924	11,100	Y45-46
08 May 1949	8,600	Y1367-1368
6 February 1963	3,700	Y7218-7219
16 May 1967	6,250	Y13277
20 December 1973	12,500	8058-8059
21 December 1977	4,000	20464-20465
30 November 1978	4,000	23799
4 November 1980	5,500	32045-32046
2 March 1984	4,000	53731-53732
20 September 1986	4,000	A6026, A6028
27 September 1988	4,000	A14497, A14499
14 November 1990	4,000	A23805-23806
2 October 1991	4,000	A27805-27806
15 October 1992	4,000	A32557-32558
17 November 1994	4,000	CN8051-8052
7 December 1995	3,500	CN12764-12765
7 June 1996	4,000	CN14163-14164
3 November 1999	5,000	CN24038
27 September 2001	4,000	CW34351-34353
3 January 2002	2,500	CW38388-38389
12 February 2004	16,000	RW3753-3754
8 March 2005	4,000	CW63745-63746
19 May 2006	4,000	CW71706-71707
<p>Notes: (1) Aerial photographs are in black and white except for those prefixed with CN, CW and RW.</p> <p>(2) Aerial photographs are of good quality, with the exception of the 1924 photographs which are of poor resolution.</p>		

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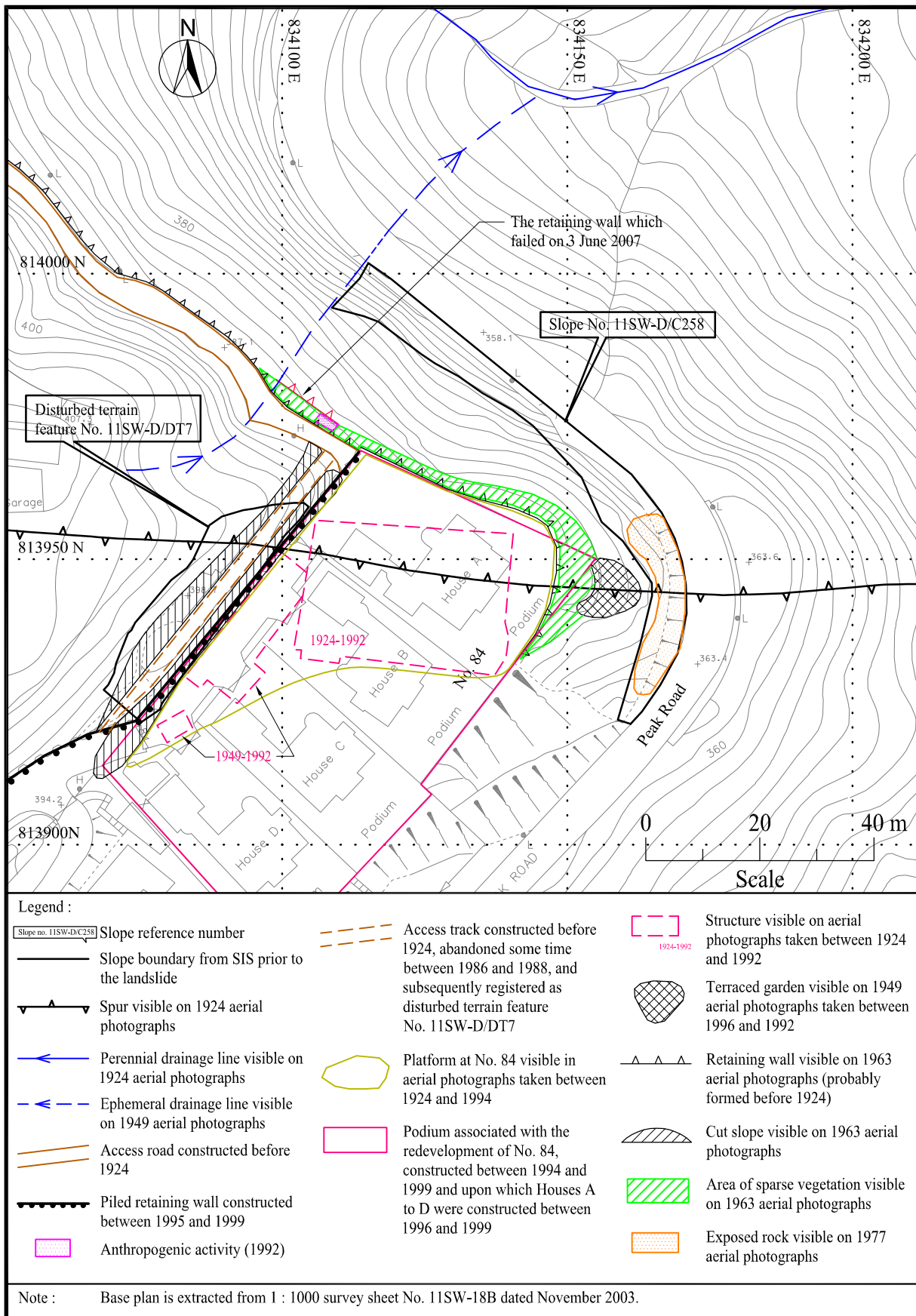


Figure A1 - API Plan

## 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 Section,  
Information Services Department,  
Room 402, 4th Floor, Murray Building,  
Garden Road, Central, Hong Kong.  
Fax: (852) 2598 7482

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:**

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23th Floor, North Point Government Offices,  
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Fax: (852) 2116 0774

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Civil Engineering and Development Building,  
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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。

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## **MAJOR GEOTECHNICAL ENGINEERING OFFICE PUBLICATIONS**

### **土力工程處之主要刊物**

#### **GEOTECHNICAL MANUALS**

Geotechnical Manual for Slopes, 2nd Edition (1984), 300 p. (English Version), (Reprinted, 2000).

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

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

GEO Publication No. 1/2000 Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls (2000), 146 p.

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

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

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

#### **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