

**REVIEW OF THE
3 AUGUST 2006
LANDSLIDE INCIDENT ON
SLOPE NO. 11SW-C/FR319,
NO. 131 POK FU LAM ROAD**

GEO REPORT No. 279

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
No. LSR 2/2008 produced in March 2008**

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First published, May 2013

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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 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
May 2013

FOREWORD

This report presents the findings of a review of a landslide incident (Incident No. 2006/08/0694) that occurred on 3 August 2006 on slope No. 11SW-C/FR319, below the Ebenezer School and Home for the Visually Impaired at No. 131 Pok Fu Lam Road, Pok Fu Lam. The landslide involved the detachment of a mature tree and parts of the masonry wall near the crest of the feature. Debris, with an estimated volume of about 4 m³, and the detached tree were deposited on the slope portion of the feature located at the toe of the masonry wall. No casualties were reported as a result of the incident.

The key objectives of the review were to document the facts about the incident, the site history and pertinent post-failure 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 (LIC) for Hong Kong Island and Outlying Islands, for the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD), 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 (FSW).



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

On 3 August 2006, a landslide incident (Incident No. 2006/08/0694), occurred on the masonry wall near the crest of slope No. 11SW-C/FR319, located below an open carpark of the Ebenezer School and Home for the Visually Impaired (Ebenezer facility) at No. 131 Pok Fu Lam Road, Pok Fu Lam (Figure 1 and Plate 1). The exact time of failure is not known. Debris from the failure, with an estimated volume of about 4 m³, together with a detached mature tree, was deposited on the soil-nailed slope portion of the feature below the crest masonry wall. No casualties were reported as a result of the failure.

Following the incident, Fugro Scott Wilson Joint Venture (FSW), the 2006 and 2007 Landslide Investigation Consultants, carried out a review of the incident for the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD), under Agreement No. CE 49/2005 (GE).

This review report documents the facts about the incident, the site history and pertinent observations made by FSW in respect of the subject area. 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 general landform in the vicinity of the 3 August 2006 incident comprises a southwesterly-facing hillside extending below Pok Fu Lam Road at about 138 mPD, to Victoria Road at about 65 mPD with an overall inclination of around 30° (Figure 1). The hillside is incised by a number of drainage lines. The Ebenezer facility is sited on a cut-and-fill building platform adjacent to Pok Fu Lam Road at an elevation of about 128.5 mPD. The Ebenezer facility comprises a 6-storey high main building and a number of smaller structures of two to three storeys high, which are mostly surrounded by a concrete paved driveway and carparking areas. The building platform is accessed from Pok Fu Lam Road via a concrete paved ramp situated at the southeastern end of the complex.

Slope No. 11SW-C/FR319 extends along the southwestern edge of the building platform (Figure 2 and Plate 1), with a short return along the northwestern edge, below the concrete paved open carpark and driveway area, and between 5 m and 15 m from the main building of the Ebenezer facility. A swimming pool is located at the northwestern corner of the platform. Slope No. 11SW-C/FR319 comprises a 140 m long, 2 m to 12 m high masonry retaining wall extending directly below the platform level, which has been upgraded with soil nails and a reinforced concrete skin wall (see Section 5.3), and a 12 m high soil-nailed slope (Plate 2) with a surface cover of reinforced shotcrete, which is unevenly inclined at between 35° and 40° extending below the toe of the masonry wall. The sections of the retaining wall below the swimming pool do not have soil nails installed, but were instead upgraded with a mass concrete gravity retaining wall behind the original masonry construction.

A 0.45 m high parapet wall and a 2 m high chain-linked security fence run along the crest of the masonry wall (Plate 3), and two mature trees, excluding the one involved in the August 2006 incident, are established high on the wall face at roughly 22 m and 48 m from

the southeastern end of the wall respectively (Plate 1). A 1.2 m wide concrete paved pedestrian footway incorporating mature trees is situated immediately behind the parapet wall, and is separated from the adjacent driveway by a 100 mm high kerb and a 300 mm wide half-round channel (Plate 3). A 200 mm wide U-channel with concrete covers extends across the pedestrian footway from the half-round channel, and passes beneath the parapet wall about 2 m to the northeast of the August 2006 landslide, extending a further 0.5 m beyond the crest of the retaining wall portion of slope No. 11SW-C/FR319 to discharge onto the sloping ground below (Plate 1).

The ground below slope No. 11SW-C/FR319 (Plate 2) is incised by three drainage lines and falls away to the southwest at an inclination of about 40°. Vegetation cover below the toe of the shotcreted slope portion is heavy, and comprises mainly a natural cover of mature trees and undergrowth.

2.2 Water-carrying Services

Records of the Water Supplies Department (WSD) indicate that there are no buried water mains in the immediate vicinity of slope No. 11SW-C/FR319.

Records of the Drainage Services Department (DSD) indicate that there are no buried drainage works or foulwater sewers in the immediate vicinity of slope No. 11SW-C/FR319.

3. MAINTENANCE RESPONSIBILITY

According to the Slope Maintenance Responsibility Information System of the Lands Department, the maintenance responsibility of slope No. 11SW-C/FR319 rests with the owners of Lot No. RBL136.

4. SITE DEVELOPMENT AND PREVIOUS INSTABILITIES

4.1 Site Development

The site development history has been established from a review of file records in the GEO, which include an LPM Stage 2 Study Report incorporating an aerial photograph interpretation (API) for slope No. 11SW-C/FR319 prepared by Ove Arup and Partners (Hong Kong) Ltd. (OAP), the LPM consultants, in 1998. A review of aerial photographs has been carried out as part of the present study to verify the information from the previous API and provide observations on site development up to the present day (see Appendix A). Salient information relevant to the history of the site is presented in Figure 3.

Pok Fu Lam Road and Victoria Road were constructed some time prior to the 1924 aerial photographs, and have generally maintained the same respective alignments up to the present day. Pok Fu Lam Road in the vicinity of the Ebenezer facility underwent road widening works in the late 1970's, and the section of Victoria Road below the facility underwent widening and associated slope works in the late 1980's, which were completed at the time of the 1991 aerial photographs.

The building platform at No. 131 Pok Fu Lam Road currently occupied by the main building of the Ebenezer facility was also constructed prior to the 1924 aerial photographs, and a retaining structure extending along the southwestern edge, conforming to the alignment of slope No. 11SW-C/FR319, is visible at this time. Below the retaining wall was a body of fill, extending downslope by about 10 m to 20 m on plan for most of the feature length, and about 30 m at the southeastern end, which showed signs of erosion. Clear views of the fill mound in the 1949 aerial photographs indicate that it has a rough texture, suggesting that it was formed mostly of boulders, and signs of end-tipping of fill from the building platform were also evident.

A building structure pre-dating the present-day construction on the platform is visible at the southeastern end in the 1924 aerial photographs, and two additional buildings are visible at the northwestern end in the 1945 aerial photographs. The building at the southeastern end of the platform was demolished at some time between 1949 and 1963, and was replaced by the present-day southeastern wing of the Ebenezer facility, which is first visible in a completed form in the 1963 aerial photographs. A building structure added between this building and the two structures occupying the northwestern portion of the platform, and the present-day old age home associated with the Ebenezer facility and located further to the southeast of the main structure, are also visible at this time.

The northernmost of the three buildings located at the northwestern end of the platform was demolished at some time prior to 1967.

Between 1924 and 1993, relatively little change is observed in respect of the retaining wall portion of slope No. 11SW-C/FR319 or the fill body below, with the exception of the addition of two concrete chambers/tanks and a U-channel below the central portion of the retaining wall, visible in the 1963 aerial photographs. The concrete chambers have been identified as septic tanks associated with the sewage treatment system for the Ebenezer facility. Three trees, including the one involved in the August 2006 landslide, are visible growing from the retaining wall portion of slope No. 11SW-C/FR319 in the 1963 photographs, and are observed to grow in size through to the 2003 aerial photographs.

The hillside below the Ebenezer facility extending to Victoria Road gains a progressively heavier cover of vegetation during this time in general. Distinct areas of vegetation clearance are visible in the 1963, 1967, 1976 and 1980 aerial photographs, which became gradually re-vegetated over the succeeding years. These included a body of agricultural terraces, which is first visible below the southeastern portion of the Ebenezer facility in the 1976 aerial photographs and appears to have been abandoned in the 1989 aerial photographs.

Between 1992 and 1995, the Ebenezer facility underwent re-development, which included the demolition of the two existing building structures on the northwestern portion of the building platform and construction of the present-day northwestern wing and a swimming pool at the northwestern corner of the platform. Slope No. 11SW-C/FR319 was also upgraded at this time (see Section 5.3), which included the provision of a reinforced concrete skin wall and soil nailing of the masonry wall portion of the feature, as well as the construction of the mass concrete gravity wall at the northwestern end, removal of the fill mound below the retaining wall, soil nailing of the sloping ground and provision of a surface shotcrete cover. The 1993 aerial photographs show the majority of the fill mound footprint

below the retaining wall portion of slope No. 11SW-C/FR319 to have a shotcrete cover applied, with the exception of an area at the southeastern end, which is subsequently seen to be shotcreted in the 1995 aerial photographs.

The re-development works also included connection of the on-site sewerage system into the DSD sewer mains beneath Pok Fu Lam Road and abandonment of the original septic system. The concrete chambers located on the sloping ground within the boundary of slope No. 11SW-C/FR319 and first visible in the 1963 aerial photographs were left in place on completion of the works.

Following the re-development of the Ebenezer facility, no obvious change is observed in the vicinity of slope No. 11SW-C/FR319 up to the present day, except that the vegetation cover on the sloping ground becomes progressively heavier.

4.2 Previous Instabilities

According to the GEO's landslide database, two previous landslides (incident Nos. HK 83/1/2 and 2005/06/0230) have been recorded in the vicinity of slope No. 11SW-C/FR319 (Figure 2) but none was recorded at the subject slope feature.

No information could be located in relation to incident No. HK 83/1/2.

Incident No. 2005/06/0230 occurred on 24 June 2005. It involved a 10 m³ to 15 m³ failure on the natural hillside immediately below the Ebenezer Training Centre building platform, which is situated to the south of the Ebenezer facility main building, and affected a pedestrian pavement located at the platform edge. Debris from the incident travelled about 20 m downslope. Infiltration and washout were reported as possible contributing causes of the failure.

Although no previous landslides were identified in the vicinity of the August 2006 landslide from the API, an area of erosion on the fill body below the southeastern end of slope No. 11SW-C/FR319 was identified in the 1924 aerial photographs (Figure 3).

No previous landslides are shown in the GEO's Enhanced Natural Terrain Landslide Inventory (ENTLI) in the vicinity of the August 2006 incident. No relevant landslide data in the vicinity of the failure are shown in the GEO's Large Landslide Database.

5. PREVIOUS ASSESSMENTS AND SLOPE UPGRADING WORKS

5.1 Study by Binnie & Partners in 1977/78

In January 1978, the masonry wall portion of slope No. 11SW-C/FR319 was inspected by Binnie & Partners (B&P) under the "Phase 1 Re-appraisal of Cut & Natural Slopes & Retaining Walls Study" and was subsequently registered as slope No. 11SW-C/R20 in the 1977/78 Catalogue of Slopes. The field sheet for this feature recorded that the wall was 2 m to 5 m in height, and was in good condition with no signs of seepage, distress or previous instability.

The slope portion of slope No. 11SW-C/FR319 was not registered in the 1977/78 Catalogue of Slopes.

5.2 SIFT Study

Slope No. 11SW-C/R20 was identified through API study carried out under GEO's "Systematic Inspection of Features in the Territory" (SIFT) project in 1992. The associated SIFT report (No. PFL 285) recorded that large amount of fill existed downslope of the retaining wall. The report estimated that between 2 m and 6 m thickness of fill had been placed behind the wall to form the building platform, with an overall volume of about 1,500 m³.

A site inspection carried out under the SIFT Study confirmed the wall to be of dry-packed rubble construction with a masonry facing that was in poor condition, with missing blocks and plaster pointing. The inspection also identified the presence of loose angular rockfill standing at an angle of 40° in front of the wall, with "signs of movement" observed in the rockfill.

5.3 Re-development at No. 131 Pok Fu Lam Road

An 'Additions and Alterations' (A&A) project to the Ebenezer facility, which included upgrading works to slope No. 11SW-C/FR319, commenced at the time of the SIFT Study (Section 5.2). An Authorised Person (AP) and a Registered Structural Engineer (RSE) were appointed by the management of the Ebenezer facility for the project. Information on the slope upgrading works is obtained from the records in the relevant Buildings Department (BD) files (ref. BD 6/2084/92) and GEO files (ref. GCI 3/4/2084/92 and ref. GCI 2/E1/11SW-C/FR319).

Records in the BD/GEO files indicate that the site formation plans and the subsequent amendment plans for the A&A project were checked by the GEO and approved by the Buildings and Lands Department (renamed BD in 1993) between August 1992 and December 1992. According to the approved plans (Figures 4 and 5), the site formation works included, inter alia, the upgrading of the retaining wall portion of slope No. 11SW-C/FR319 with the use of soil nails. The proposed soil nails were to be embedded into "bedrock" by a minimum of 1.5 m and the corresponding estimated soil nail lengths based on the design geological model, as indicated on the approved plans, ranged from 9.5 m to 23.5 m. The nails were to be installed on a staggered grid with a horizontal spacing of 2.5 m and a vertical spacing of 4 m. Also, a 150 mm thick reinforced concrete "screen" wall was to be provided to the masonry wall face over a length of some 110 m from the southeastern end. A mass concrete gravity wall was proposed to be constructed behind the masonry wall over the remaining length of the feature.

It is noteworthy that the locations of the soil nail pull-out tests were not proposed in the first approved plan (dated 10 September 1992) and Drawing No. SF05 stipulates that "SOIL NAILS SUBJECTED TO PULL-OUT TESTS SHALL NOT FORM PART OF THE PERMANENT WORKS". The subsequent amendment plan (Drawing No. SF02B), which was approved by BD on 29 October 1992, indicates that pull-out tests were to be carried out

at the locations of six working nails scheduled to be installed on the retaining wall. The associated amendment Drawing No. SF05B has retained the above statement, namely "SOIL NAILS SUBJECTED TO PULL-OUT TESTS SHALL NOT FORM PART OF THE PERMANENT WORKS".

The approved plans (Figure 4) also indicate that the soil nail heads were to be constructed prior to the construction of the "screen" wall around them (i.e. a cold joint between nail head and "screen" wall) and that there was no tie-in of reinforcement between the two elements. No details relating to the arrangement of the "screen" wall at the locations of trees growing from the face of the masonry retaining wall are shown in the approved site formation plans.

Qualified Supervision under the Buildings Ordinance (BO) section 17 was not imposed by the BD for the approved site formation works (viz. proposed upgrading works to the retaining wall portion of slope No. 11SW-C/FR319).

At the request of the GEO following a joint site visit with a representative from the RSE on 14 December 1992, the AP submitted to BD on 28 December 1992 a proposal to deal with the loose rockfill immediately downslope of the subject masonry wall as identified by the SIFT Study (see Section 5.2). The proposed works involved removal of surface vegetation and excavation of the "top loose soil until compact sub-soil was reached", with the slope surface protected by shotcrete.

The proposal was accepted by the GEO on 18 January 1993. Class (A) (now referred to as Category (I)) Qualified Supervision was recommended by the GEO on the "slope remedial works". This comprised weekly inspections by an approved qualified geotechnical engineer from the firm that prepared the geotechnical content of the submission to check that the design assumptions were valid and that the works were being carried out as specified. Monthly reports on the findings and recommendations were submitted to the AP/RSE and copied to the BD and the GEO.

The AP submitted in February 1993 another set of amended site formation plans, which incorporated the above proposed "slope remedial works", to BD for approval. The GEO confirmed that they had no geotechnical objection to the approval of the amendment plans and re-iterated the requirements of the Class (A) Qualified Supervision on 15 March 1993.

According to the monthly reports prepared by the Class (A) Qualified Supervision personnel during construction, the soil nailing works commenced in March 1993. The reports indicated that no major geotechnical problems were encountered during soil nail construction. The soil nailing works were completed in April 1993.

The Island Division of the GEO carried out a site visit on 24 March 1993 to verify the qualified supervision for the "slope remedial works". It was noted that there was no site record of visits made by the Class (A) Qualified Supervision personnel and that removal of the loose fill was yet to commence.

The record plan of the as-constructed site formation works (Figure 6) indicates the arrangement of the soil nails installed on the masonry wall portion of slope

No. 11SW-C/FR319 is, in general, the same as that shown on the approved plans, except that an additional soil nail has been installed in the uppermost row about 30 m to the northwest of the August 2006 landslide. The plan also records that the rock socket lengths of installed soil nails are 1.5 m (as per the approved plans), with the overall lengths ranging from 5.3 m to 12.1 m. These as-built lengths are much shorter than as compared to that indicated in the approved plans (ranging from 9.5 m to 23.5 m) based on the design geological model at the time of submission. The differences in the soil nail lengths are likely to be a result of a revised geological model adopted by the designer during construction whereby the "bedrock" was deemed to be much higher than that assumed previously based on the ground investigation. There are no records of any construction reviews or additional ground investigation carried out to validate the geological model.

The record plan indicates that pull-out tests were carried out at the same locations of six working nails as scheduled in the approved amendment plans. The lengths of the reinforcing bars ranged from 5.1 m to 11.1 m, with the 1.5 m long grouted sections embedded into "bedrock". The geotechnical report submitted to BD by the RSE in July 1993 following completion of the Stage 1 site formation works (see Figure 7) states that the pull-out test results had been checked to have satisfactorily complied with the appropriate acceptance criteria and notes the following: "we consider that these nails (test nails) are still in working condition and can be used as working soil nails". The acceptance criteria for the pull-out tests were not elaborated. Pull-out test records presented in the report indicate that the termination of the test nail installation was based on the penetration rate of the drilling plant, which noticeably reduced beyond the inferred rockhead location.

A general view of slope No. 11SW-C/FR319 in 1995 after the completion of the slope works is shown in Plate 4.

5.4 SIRST Study

In June 1996, slope No. 11SW-C/FR319 was inspected under the "Systematic Identification and Registration of Slopes in the Territory" (SIRST) project initiated by the GEO. At this time, the masonry wall (i.e. slope No. 11SW-C/R20) had been combined with the soil-nailed slope below it and re-registered as slope No. 11SW-C/FR319. The SIRST field sheet notes that the retaining wall portion of the feature showed no signs of distress or past instability, and seepage was observed on the face of the wall, which was attributed to a 'horizontal sewer' associated with the masonry wall with a 40 mm wide crack, allowing infiltration to the slope below. The slope portion of the feature was recorded as showing minor signs of distress, comprising the 40 mm wide crack in the sewer described above, and minor past instability. No signs of seepage were observed on the slope face. Weepholes in both the wall and slope portions of the feature were recorded as being clear. The consequence-to-life category of the subject slope was rated as '1'.

The SIRST records indicate that slope No. 11SW-C/FR319 had been categorised as a Class 'B2' feature (i.e. a slope "assumed to have been checked by GEO (assumed formed post 1977)") in November 1996.

5.5 LPM Stage 2 Study

Slope No. 11SW-C/FR319 was included in the LPM Programme in 1998. An LPM Stage 2 Study was completed for the slope by the LPM consultant, OAP, under Agreement No. CE 45/94 SA2 in June 1998. Stability analyses carried out for the study (OAP, 1998) were limited to the "area of unsupported fill below the Stage II works", given that the "old masonry wall at the crest of the slope" had been stabilised with soil nails and the construction of a 150 mm thick reinforced concrete "screen" wall facing. The critical section analysed (Figure 8) comprises about 1 m of fill overlying between 3 m and 6 m of completely to highly decomposed volcanics (C/HDV).

No site-specific ground investigation was carried out for the LPM Stage 2 Study. Reference was made to the data from previous ground investigations carried out along Pok Fu Lam Road in the local vicinity. Account was also taken of observations made during site inspection, which indicated that rockhead was exposed in adjacent streamcourses and therefore relatively close to the ground surface.

The stability analyses indicated that "the slope possesses adequate factors of safety as required by the current geotechnical standard". Additionally, the fill material was considered to be of low risk liquefaction failure for the following reasons:

- (a) the fill is bouldery and free draining;
- (b) the slope has a well established covering of vegetation which is beneficial to the stability of the slope; and
- (c) water ingress from above the slope is limited to the hardstanding of the school playground combined with efficient and well maintained drainage.

The study concluded that no further action was required in respect of slope No. 11SW-C/FR319.

6. THE 3 AUGUST 2006 INCIDENT AND POST-FAILURE OBSERVATIONS

6.1 Description of the 3 August 2006 Incident

The August 2006 landslide incident occurred at the crest of the soil-nailed retaining wall portion of slope No. 11SW-C/FR319, immediately below the parapet wall. The staff at the Ebenezer facility reported the incident to the GEO on 4 August 2006. Based on the incident report prepared by the Island Division of the GEO, the failure occurred on 3 August 2006. The exact time of failure is not known. No casualties were reported as a result of the failure.

A plan view of the failure is presented in Figure 2. An elevation and a section are presented in Figure 9.

The source area of the failure (Plate 5) was located about 38 m from the southeastern end of the feature. The failure involved the detachment of a mature tree protruding from the

wall face, which carried with it sections of the masonry wall facing and the adjacent concrete skin wall. It resulted in the exposure of rubble and soil backfill, and partial detachment of the masonry facing blocks over an area about 4 m wide and 2 m high, undermining the concrete pavement slab and parapet wall by about 0.4 m. The detachment also affected a soil nail head located at the lower margin of the affected area, which displaced outwards from the face of the retaining wall by about 0.5 m, and was suspended by the soil nail reinforcing bar (Plate 6). The affected soil nail was subsequently exhumed from the retaining wall face during the urgent repair works on 4 September 2006 and detailed description of the affected soil nail is presented in Section 6.2.

Debris from the failure, with an estimated volume of about 4 m³ and comprising the detached tree and portions of the root system, small sections of concrete skin wall, masonry blocks and soil and rubble backfill, was mostly deposited on the shotcreted sloping ground at the toe of the retaining wall, travelling a maximum distance of about 10 m on plan downslope (Plate 2).

6.2 Post-failure Observations by FSW

FSW inspected the site on 30 August and 4 September 2006, during which time the urgent repair works were underway. The failure scar (Plate 7) exposed light brown clayey silty sand fill containing gravel- and cobble-sized rock fragments in the upper portion and masonry blocks in the lower portion. Many tree rootlets were also exposed in the fill (Plate 8), as well as the more developed portions of the tree root system growing in the interstices between the masonry blocks. The masonry blocks disturbed by the failure had been removed to provide a stable base for the repair works on the undisturbed blocks below. No signs of seepage were observed on the scar, based on the GEO incident report and during the post-failure inspection by FSW.

Inspection of the adjacent portions of the retaining wall face and sloping ground at the toe of the wall (Plate 9) identified no obvious signs of distress. Similarly, inspection of the concrete paved driveway and carpark area behind the failure location as well as the parapet wall indicated no obvious signs of distress attributable to the failure.

Inspection of trees growing on the wall face to the northwest and southeast of the failure scar revealed that the concrete skin wall constructed over the original masonry facing between 1992 and 1995 at these locations had been curtailed locally around the extensive exposed root systems. The extent of the concrete skin wall within the failure scar prior to the failure could not be determined. Based on the observations at the adjacent trees, it is probable that it was similarly curtailed. This is supported by the small proportion of skin wall fragments observed in the debris and the presence of construction joints in the skin wall at the edge of the failure scar (Plate 5). The curtailment details are not shown on the record plan.

The dimensions of the displaced soil nail head (Plate 10) measured about 0.7 m by 0.7 m by 0.2 m. The corresponding exposed soil nail reinforcing bar, which was inclined at an angle of about 10° below horizontal into the retaining wall face, had been bent downwards locally to an angle of about 15° at about 250 mm behind the soil nail head. The connection between the reinforcing bar and the soil nail head appeared to be intact. No signs of grout surrounding the reinforcing bar were observed over the exposed length or in the soil nail

drillhole. Inspection of the soil nail head and skin wall construction in the general vicinity of the failure scar indicated that the heads had been constructed separately to the skin wall, i.e. a cold joint was present between the perimeter of the nail head and the skin wall.

The affected soil nail was exhumed from the retaining wall face by Wanson Construction Company Limited (WCC), BD's Term Contractor, during the inspection on 4 September 2006 at the request of the Island Division of the GEO. The soil nail head was first cradled in a sling and the exposed portion of reinforcing bar was cut at about 0.3 m behind the nail head (Plate 11). The remainder of the reinforcing bar was subsequently removed manually from the soil nail drillhole without difficulty (Plate 12).

The measured length of the exhumed bar (Plate 13) was 2.94 m (i.e. a total length of 3.24 m including the 0.3 m attached to the nail head). No trace of grout was evident over the entire length of the exhumed bar, which was generally clean. A section of the grout tube exhumed from the soil nail drillhole was also clear of grout (Plate 14). No centralisers were provided to fix the reinforcing bar centrally within the drillhole. The soil nail drillhole was probed to the full extent of 5 m.

The location of the affected soil nail as observed on site is not consistent with the record plan, on which no soil nail is shown to have been installed at that location. According to the record plan, the nearest soil nail to the affected soil nail is the one with reference No. 'W29', which is approximately 2 m above the affected soil nail. It is noted that the mature tree that was involved in the 3 August 2006 incident was located at the recorded location of soil nail No. 'W29' on the record plan. It is postulated that the affected soil nail is the one with reference No. 'W29', which was likely to have been relocated due to the presence of the mature tree at the originally proposed nail location. The drilled length of the soil nail hole for soil nail No. 'W29', as recorded on the record plan, is 6.4 m, including a rock socket length of 1.5 m.

Identification of the locations of the other soil nail heads (i.e. soil nails Nos. 'W1' to 'W28', 'W30' to 'W43', 'W43a', 'W44', 'W44a' and 'W45' as shown on the record plan) was carried out through visual inspection on the retaining wall face as far as available access would permit. A total of 56 nail heads on the retaining wall face have been identified (see Figure 10). A number of the nail heads were noted to be out of position by a small distance (mostly less than 1 m except soil nail No. 'W20' which is out of position by approximately 2 m) from the standard pattern. As compared with the approved drawing dated 24 March 1993 (see Figure 5) and the record plan (Drawing No. FSF02) submitted by the AP to BD on 17 June 1993 (see Figure 6), ten additional nail heads were also found. Nine of the additional nail heads are located at the southern end of the wall (about 35 m to the south of the August 2006 incident) where the actual interface between the retaining wall and the shotcreted fill slope below is lower (about 5 m) than the elevation shown on the record plan. The other additional nail head is located between soil nail Nos. 'W36' and 'W38' at the base of the retaining wall (about 15 m to the north of the August 2006 incident).

7. METEOROLOGICAL RECORDS

7.1 Wind Records

Based on Hong Kong Observatory (HKO) records, the weather system associated with Typhoon 'Prapiroon' affected Hong Kong between 2 and 3 August 2006, bringing strong winds and rainfall to the territory. The HKO's Typhoon Signal No. 3 was in force between 4:20 p.m. on 2 August 2006 and 5:40 a.m. on 4 August 2006, which anticipated sustained wind speeds of between 41 km/h and 62 km/h, and gusts possibly exceeding 110 km/h. Mean wind speeds during these two days, as measured at Waglan Island, were 60.5 km/h and 64.8 km/h respectively, compared to a mean wind speed of 19.6 km/h for the month of August 2006 and a normal wind speed of 18.5 km/h for the month of August.

The HKO's nearest monitoring station to the failure site, located at Wong Chuk Hang, about 480 m to the southeast of the failure, recorded mean wind speeds of 28 km/h and 38 km/h for 2 and 3 August 2006 respectively (Figure 11), with peak wind gusts reaching 83 km/h and 116 km/h respectively.

7.2 Rainfall Records

Rainfall data were obtained from GEO automatic raingauge No. H03, which is the nearest raingauge to the failure site and located at Block 44 of Baguio Villa, about 650 m to the south of the failure (Figure 1). The raingauge records and transmits rainfall data at 5-minute intervals to the HKO and the GEO.

The exact time of the failure is not known. For the purpose of rainfall analysis, the time of the failure was assumed to be at midnight on 3 August 2006, given that staff from the Ebenezer facility reported the incident to the GEO in the morning of 4 August 2006.

The daily rainfall recorded by raingauge No. H03 over the month preceding the failure, together with the hourly rainfall readings for the period between 4:00 p.m. on 2 August 2006 and 2:00 p.m. on 4 August 2006, are presented in Figure 12. The maximum 24-hour and 12-hour rolling rainfall before the failure was 90 mm and 54 mm respectively.

Table 1 presents the estimated return periods for the maximum rolling rainfall for various durations recorded by raingauge No. H03 with reference to historical rainfall data at the HKO in Tsim Sha Tsui (Lam & Leung, 1994). The estimated return periods for all rainfall durations were less than 2 years.

The return periods were also assessed based on the statistical parameters derived by Evans & Yu (2001) for rainfall data recorded by local raingauge No. H03 between 1984 and 1997 (Table 1). The results show that the 31-day rolling rainfall of 634.5 mm before the failure was the most severe, with a corresponding return period of about 2 years. For rainfall durations less than 31 days, the corresponding return periods were less than 2 years. It is noted that the estimated return periods of the August 2006 rainstorm based on rainfall data at the local raingauge are similar to those estimated by the historical rainfall data at the HKO.

The maximum rolling rainfall for the rainstorm on 3 August 2006 has been compared with the past major rainstorms as recorded by raingauge No. H03 between 1994 and 2005,

which came into operation in the mid-1980's (Figure 13). The maximum rolling rainfall for the rainstorm on 3 August 2006 is less severe than the previous significant rainstorms.

8. DISCUSSION

The small-scale failure (4 m^3) in August 2006 was a minor incident with negligible consequence, which principally involved the detachment of a tree on a masonry wall during a typhoon when there was light rainfall. Although the incident occurred on an engineered feature that had been upgraded to the required safety standards using robust measures (viz. soil nails and skin wall), the landslide itself is of no special technical interest in terms of the nature of the failure.

The site observations made following the August 2006 landslide revealed some discrepancies with regard to the record plan as submitted by the AP to BD. According to the record plan, there should have been no soil nail at the location of the nail that was disturbed by the August 2006 landslide, whereas the nearest soil nail (i.e. No. 'W29') should have been about 2 m away at the location of the mature tree (which was involved in the August 2006 landslide). On this basis, it is postulated that the soil nail that was disturbed by the August 2006 landslide is likely to be nail No. 'W29', which was probably re-located because of the presence of the mature tree at the originally proposed nail location. If the disturbed soil nail were actually a sacrificial or an abandoned nail instead, then there would effectively be one working nail short as compared with that shown on the BD approved plans and the record plan submitted by the AP (i.e. a major non-compliance) in the middle portion of the retaining wall where the August 2006 landslide occurred.

Based on the postulation that the disturbed soil nail is nail No. 'W29', the August 2006 landslide revealed two major non-compliances in respect of the construction of this soil nail, namely:

- (a) the measured length of the reinforcement bar as exhumed from the disturbed soil nail is less than 3 m (evidently not bonded into bedrock), which is less than that shown on the record plan (viz. a total length of 6.4 m, including 1.5 m embedment in bedrock); and
- (b) the lack of a grouted annulus around the reinforcement bar of the disturbed soil nail.

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- Geotechnical Engineering Office (1993). Guide to Retaining Wall Design (Geoguide 1) (Second Edition). Geotechnical Engineering Office, Hong Kong SAR Government, 268 p.

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Table 1 - Maximum Rolling Rainfall at GEO Raingauge No. H03 for Selected Durations Preceding the Landslide Incident on 3 August 2006 and the Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period (See Notes 3)	Estimated Return Period (Years) (See Notes 2)	
			Lam & Leung (1994)	Evans & Yu (2001)
5 Minutes	8.5	17:10 hours on 3 August 2006	< 2	< 2
15 Minutes	13.5	17:10 hours on 3 August 2006	< 2	< 2
1 Hour	19	05:00 hours on 3 August 2006	< 2	< 2
2 Hours	23.5	17:15 hours on 3 August 2006	< 2	< 2
4 Hours	28.5	17:15 hours on 3 August 2006	< 2	< 2
12 Hours	54	16:10 hours on 3 August 2006	< 2	< 2
24 Hours	90	18:10 hours on 3 August 2006	< 2	< 2
48 Hours	113.5	23:50 hours on 3 August 2006	< 2	< 2
4 Days	113.5	23:50 hours on 3 August 2006	< 2	< 2
7 Days	313	01:45 hours on 3 August 2006	< 2	< 2
15 Days	388.5	23:50 hours on 3 August 2006	< 2	< 2
31 Days	634.5	23:50 hours on 3 August 2006	< 2	2
<p>Notes: (1) Maximum rolling rainfall was calculated from 5-minute rainfall data.</p> <p>(2) Return periods were derived from Table 3 of Lam & Leung (1994) and Evans & Yu (2001).</p> <p>(3) The landslide is assumed to have occurred at 00:00 hours on 4 August 2006 for the purpose of rainfall analysis.</p> <p>(4) The nearest GEO raingauge to the landslide site is raingauge No. H03, which is located about 650 m to the south of the 3 August 2006 landslide site and is operational since 22 March 1983.</p>				

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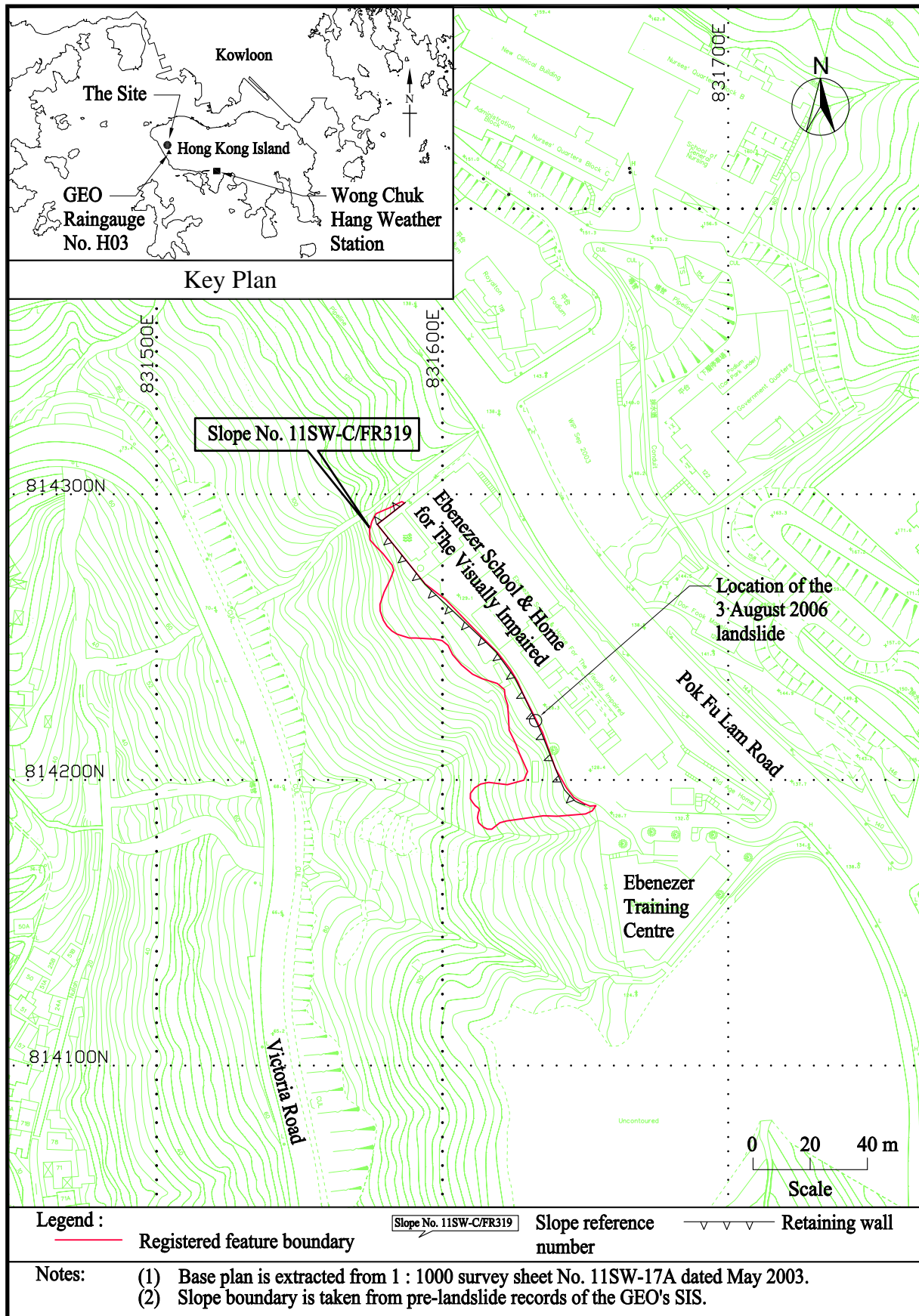


Figure 1 - Site Location Plan

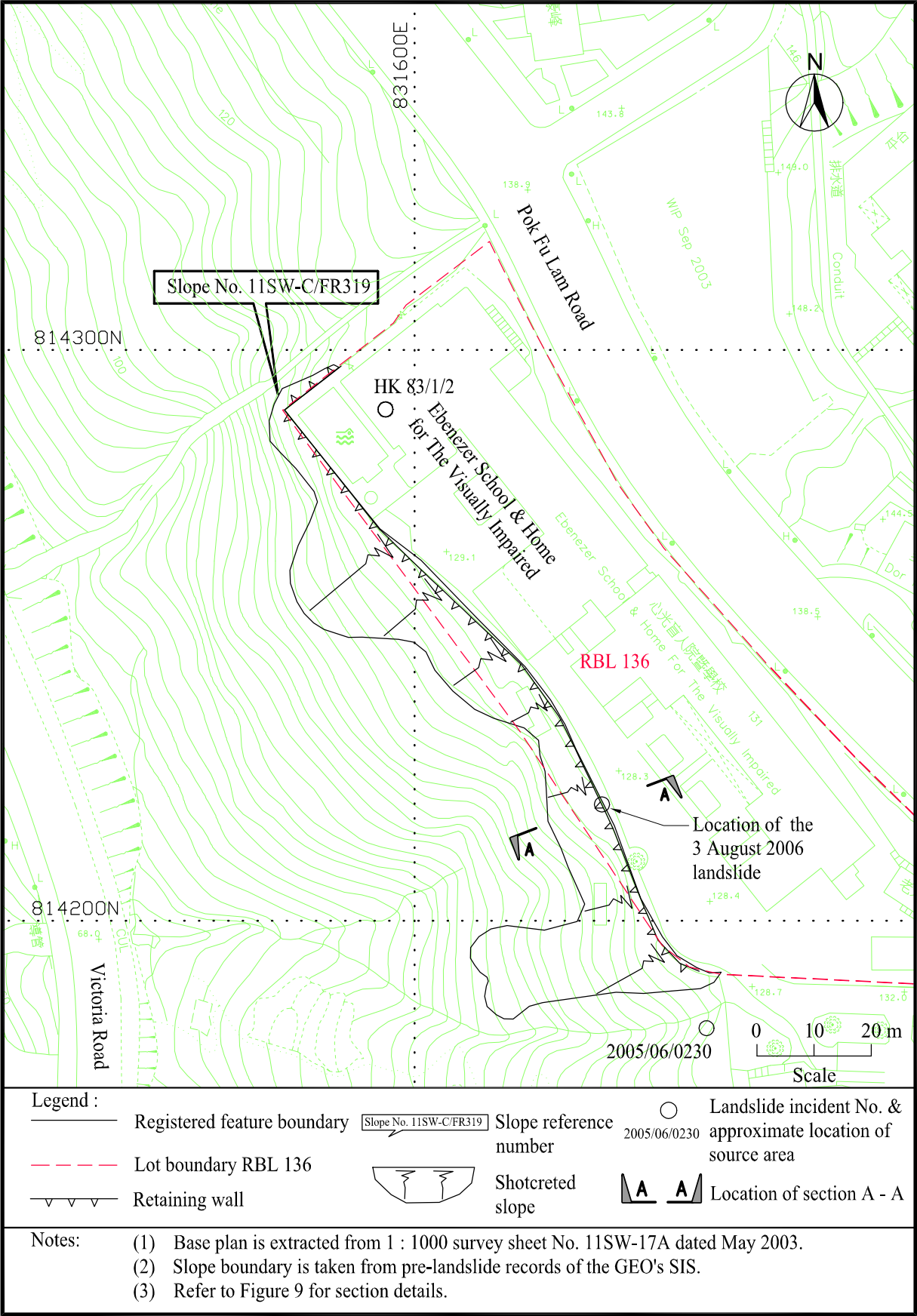


Figure 2 - Site Plan

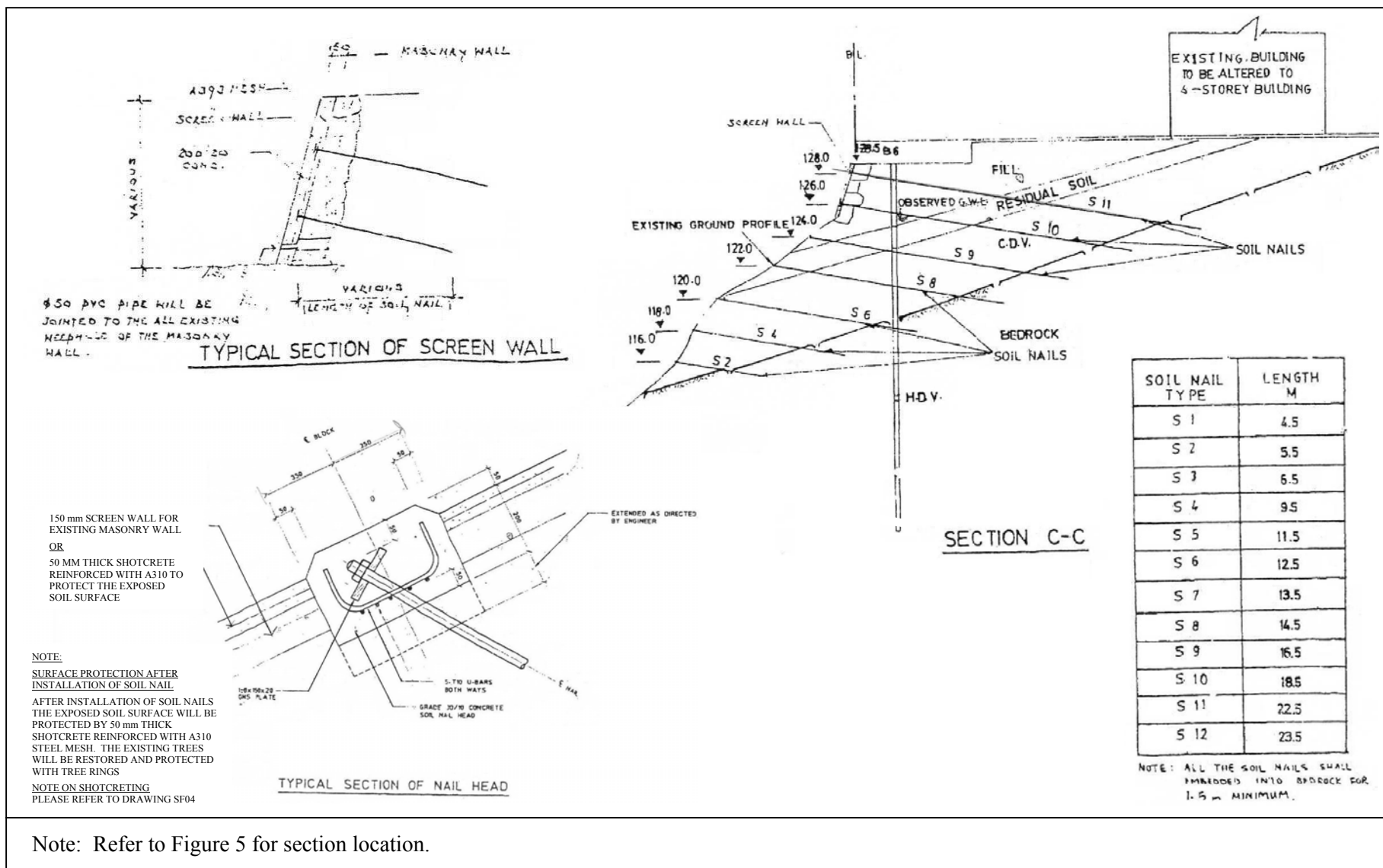


Figure 4 – Approved Slope Upgrading Works for Slope No. 11SW-C/FR319
(Extracted from BD Approved Plan Nos. SF03 and SF05 dated 29 October 1992)

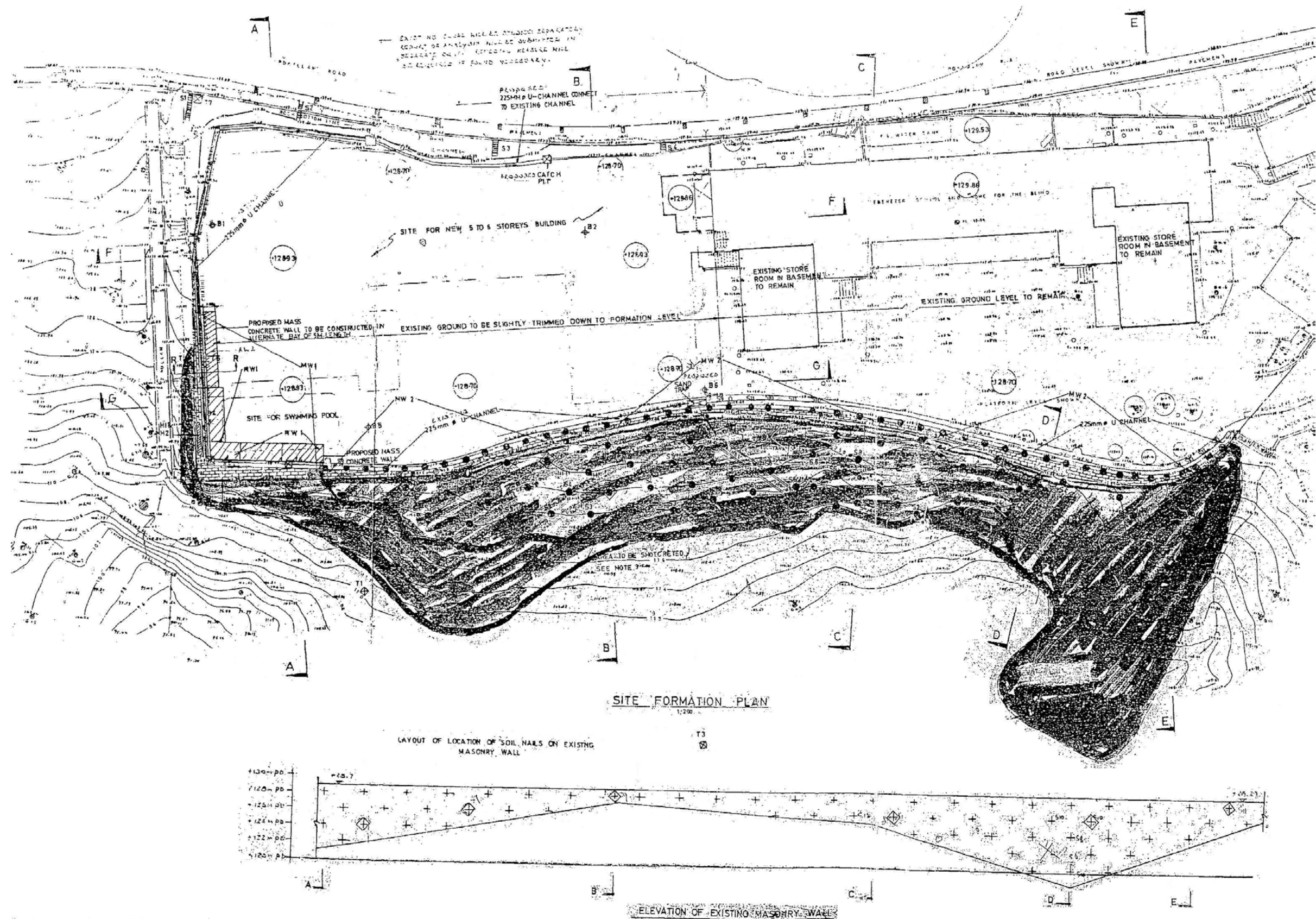


Figure 5 – Proposed Soil Nail Arrangement (Extracted from BD Approved Plan No. SF02 dated 24 March 1993)

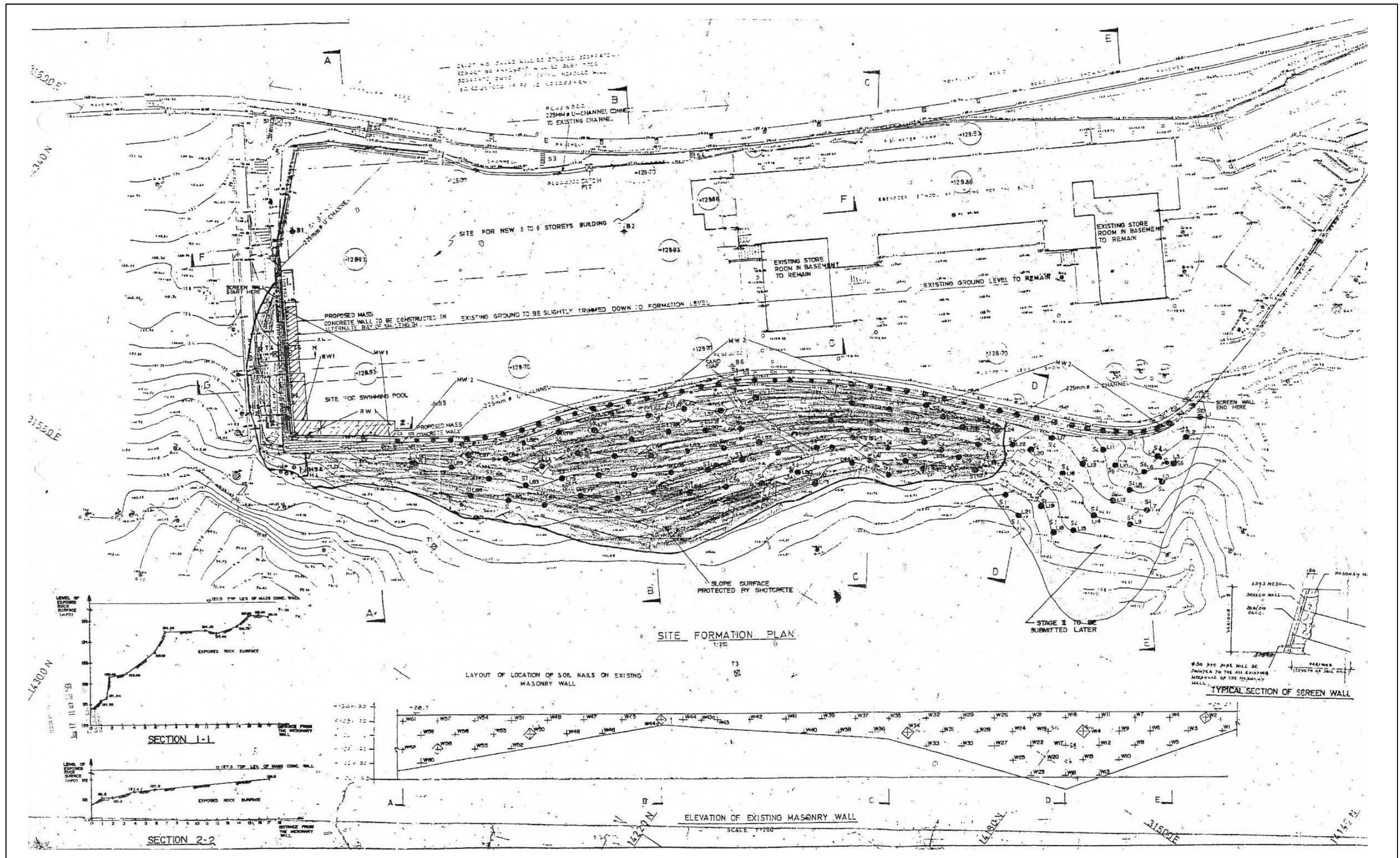


Figure 6 – As-constructed Soil Nail Arrangement (Extracted from Record Plan No. FSF02 dated 17 June 1993)

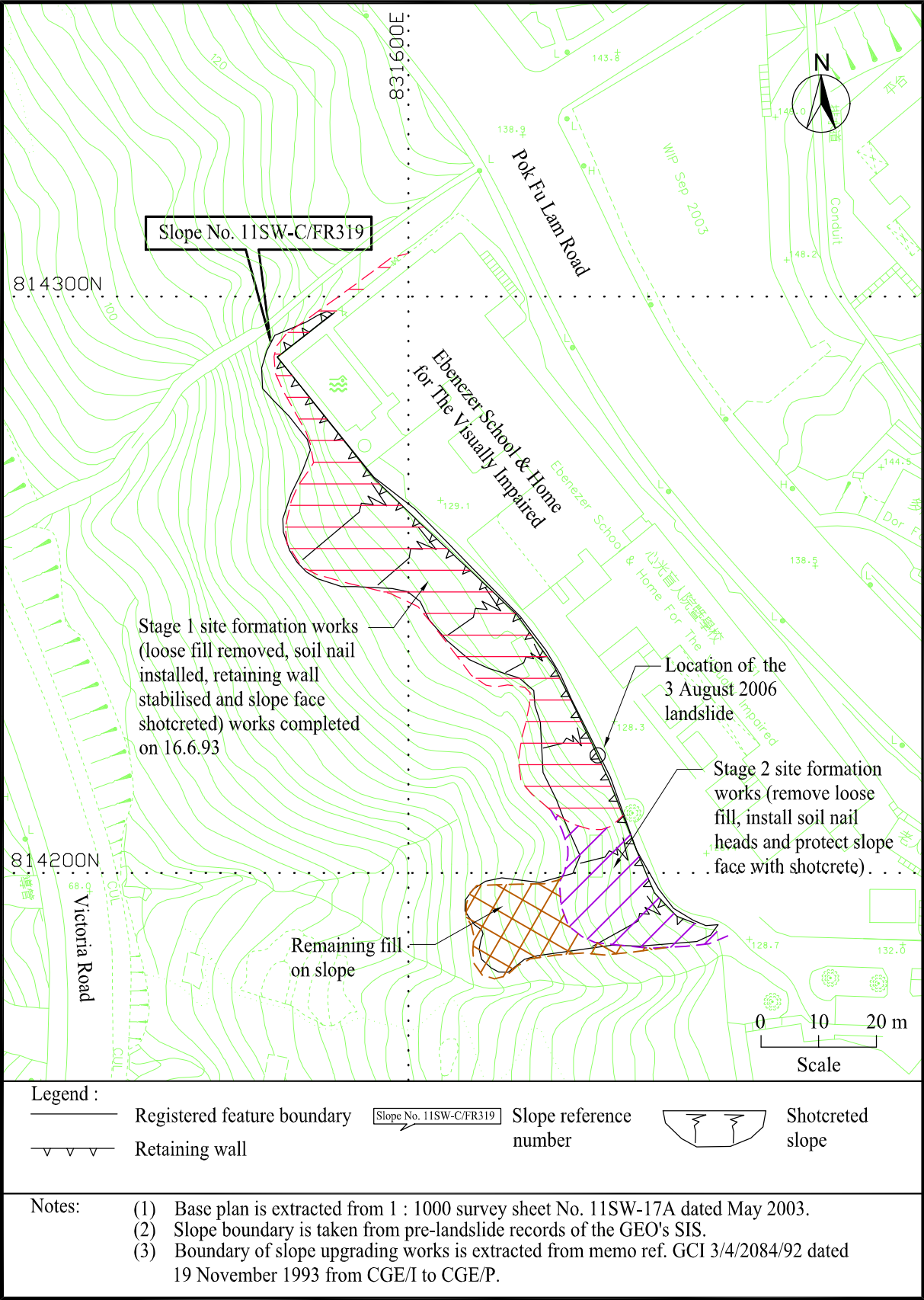


Figure 7 - Stage 1 and Stage 2 Slope Upgrading Works during Re-development of No. 131 Pok Fu Lam Road between 1992 and 1995

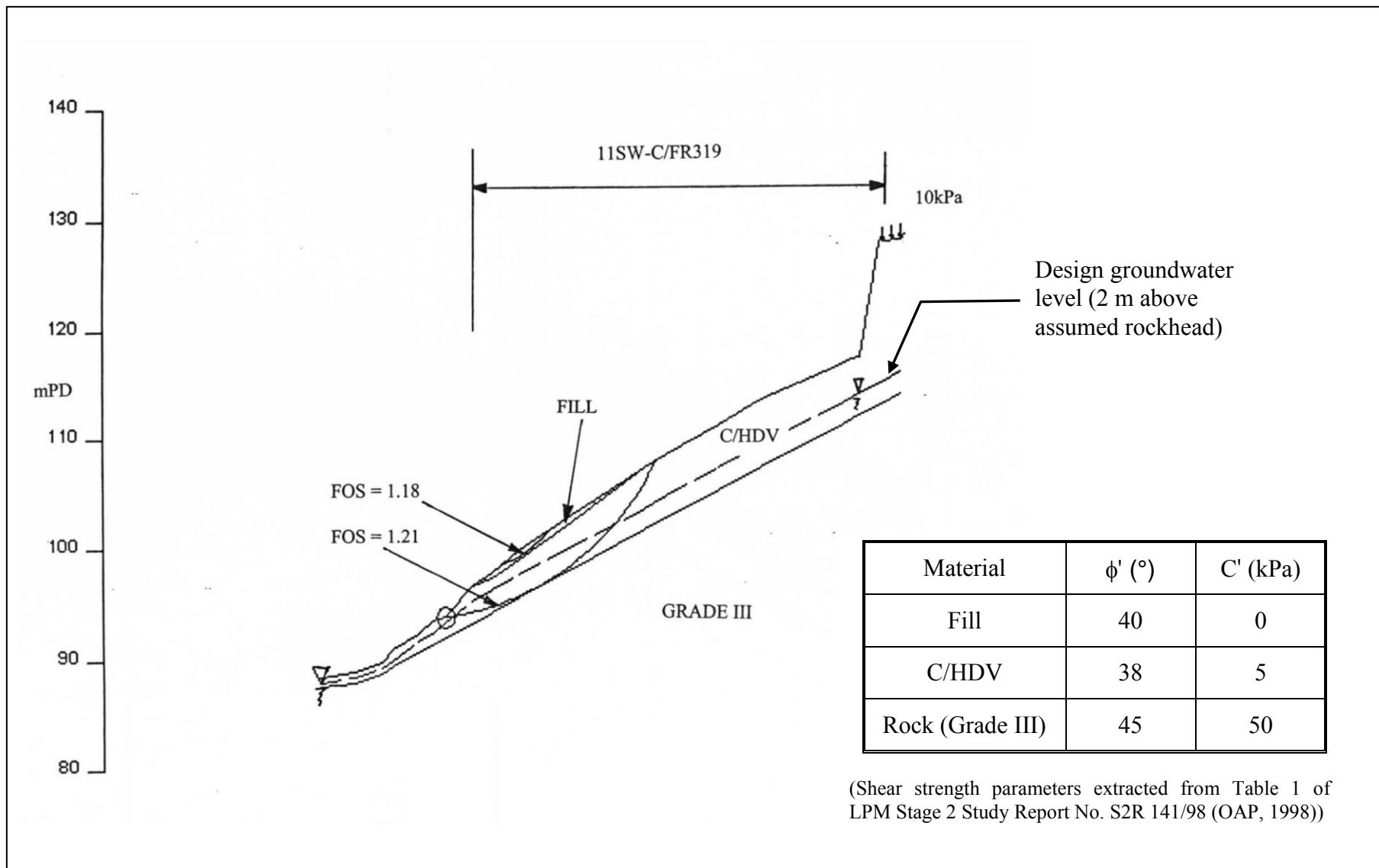


Figure 8 – Critical Section Analysed under LPM Stage 2 Study of Slope No. 11SW-C/FR319
(Extracted from Figure 6 of LPM Stage 2 Study Report No. S2R 141/98 (OAP, 1998))

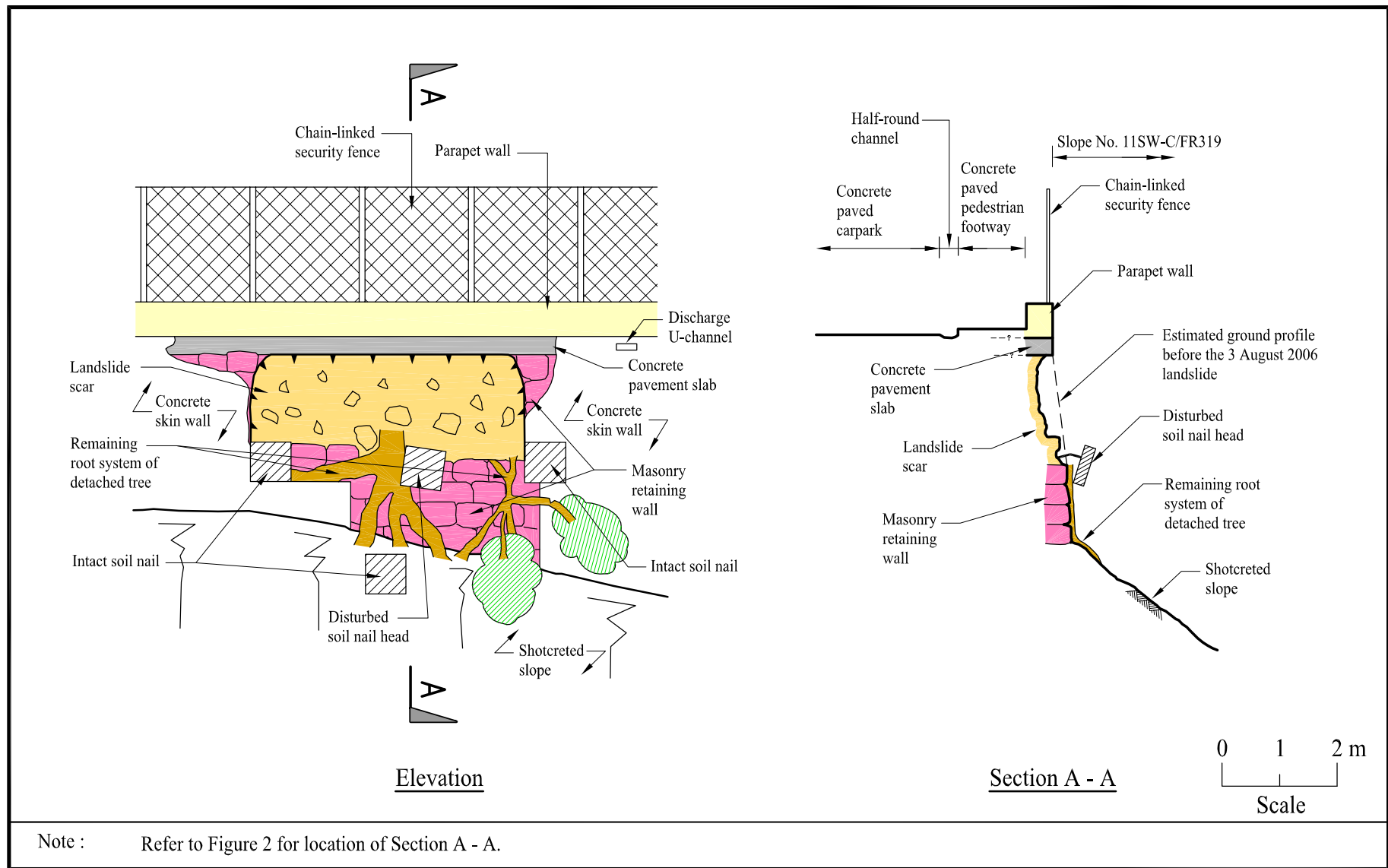


Figure 9 - Elevation View and Cross-section A - A Through the 3 August 2006 Landslide

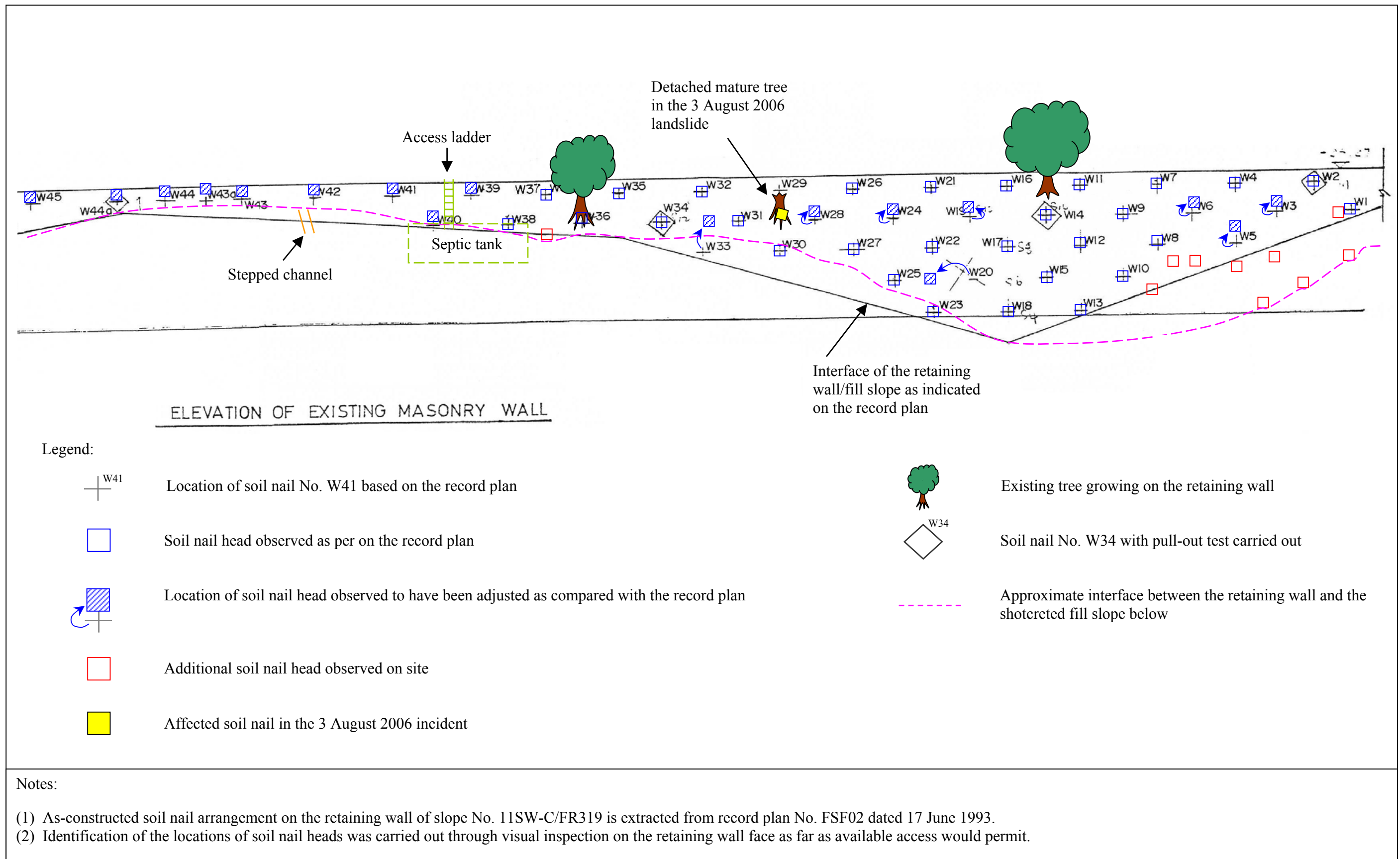


Figure 10 – Locations of Soil Nail Heads Observed on Site

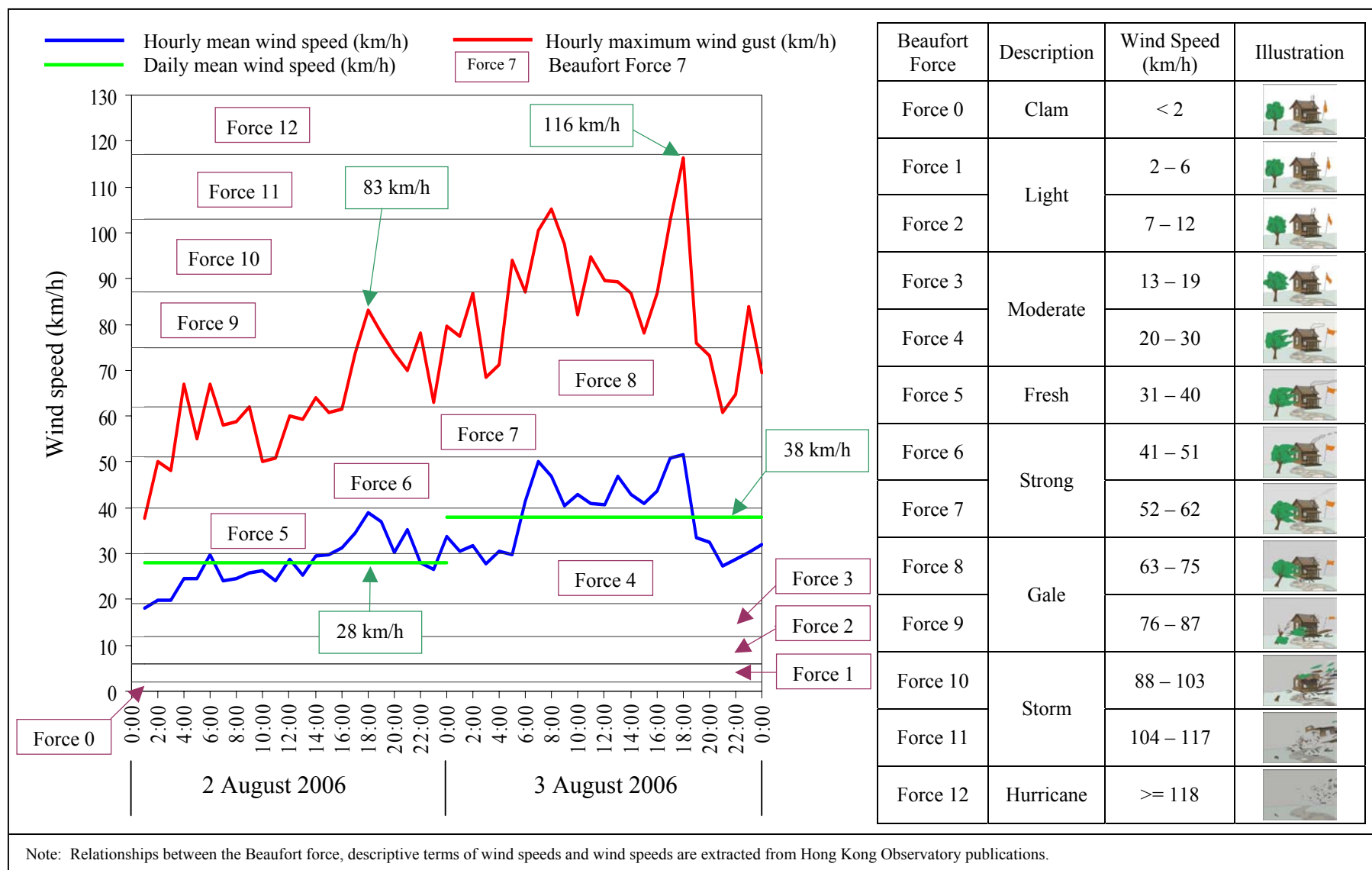
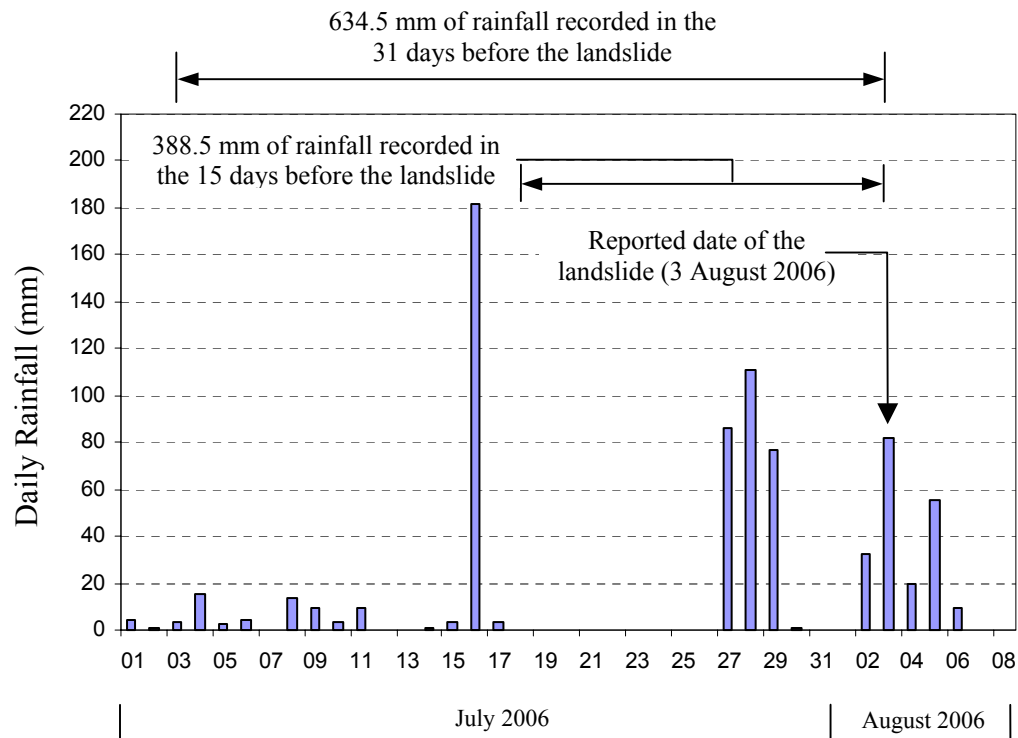
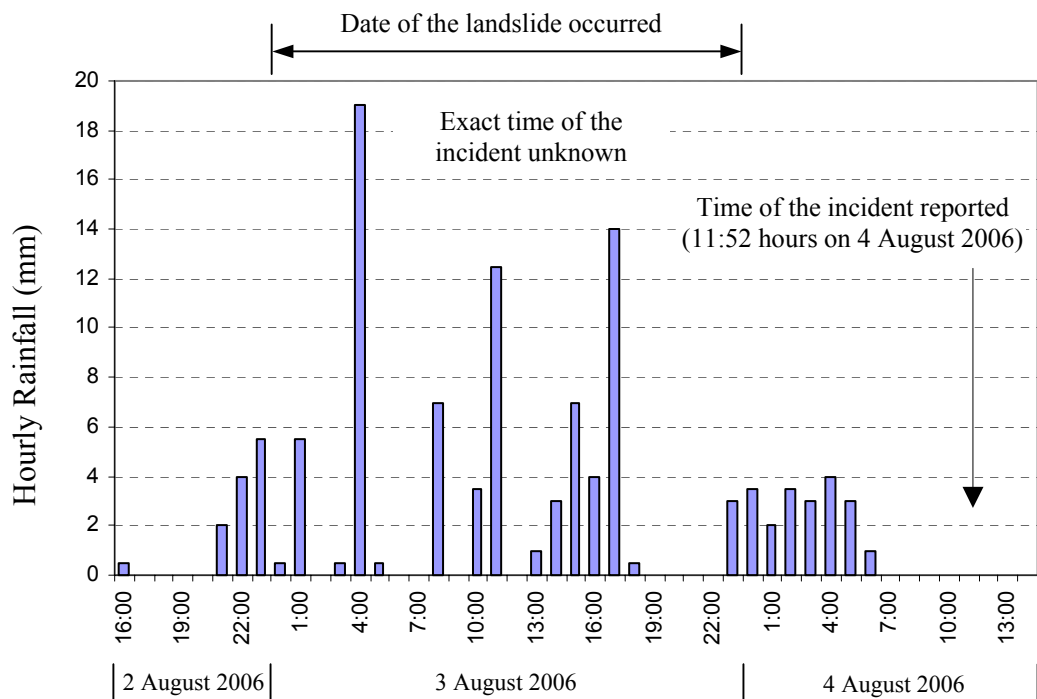


Figure 11 – Wind Speed Data Recorded at HKO Wong Chuk Hang Weather Station



(a) Daily Rainfall Recorded between 1 July and 8 August 2006



(b) Hourly Rainfall Recorded between 16:00 hours on 2 August 2006 and 14:00 hours on 4 August 2006

Figure 12 - Rainfall Recorded at GEO Raingauge No. H03

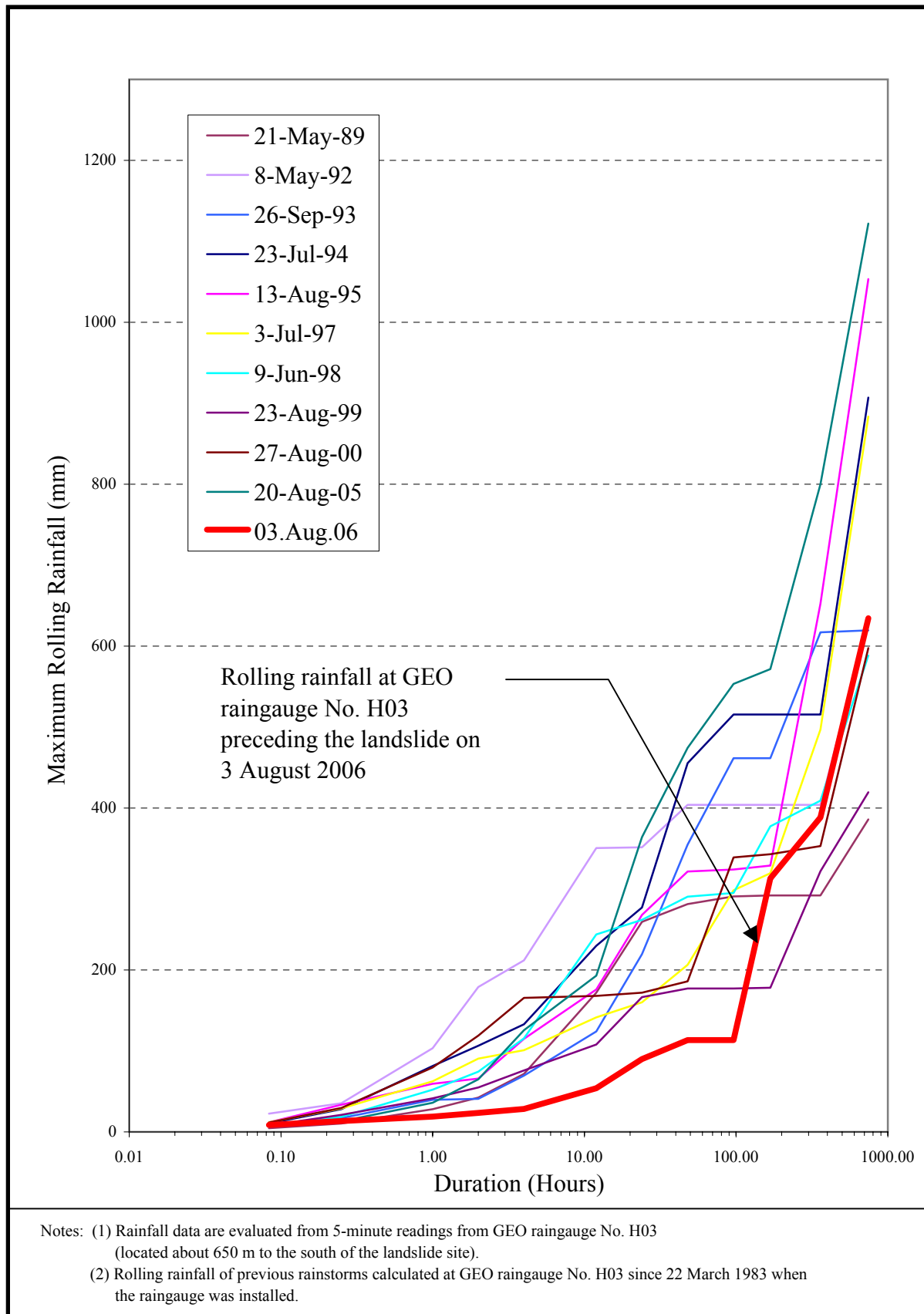


Figure 13 - Maximum Rolling Rainfall Preceding the 3 August 2006 Landslide Incident and Selected Previous Major Rainstorms Recorded at GEO Raingauge No. H03

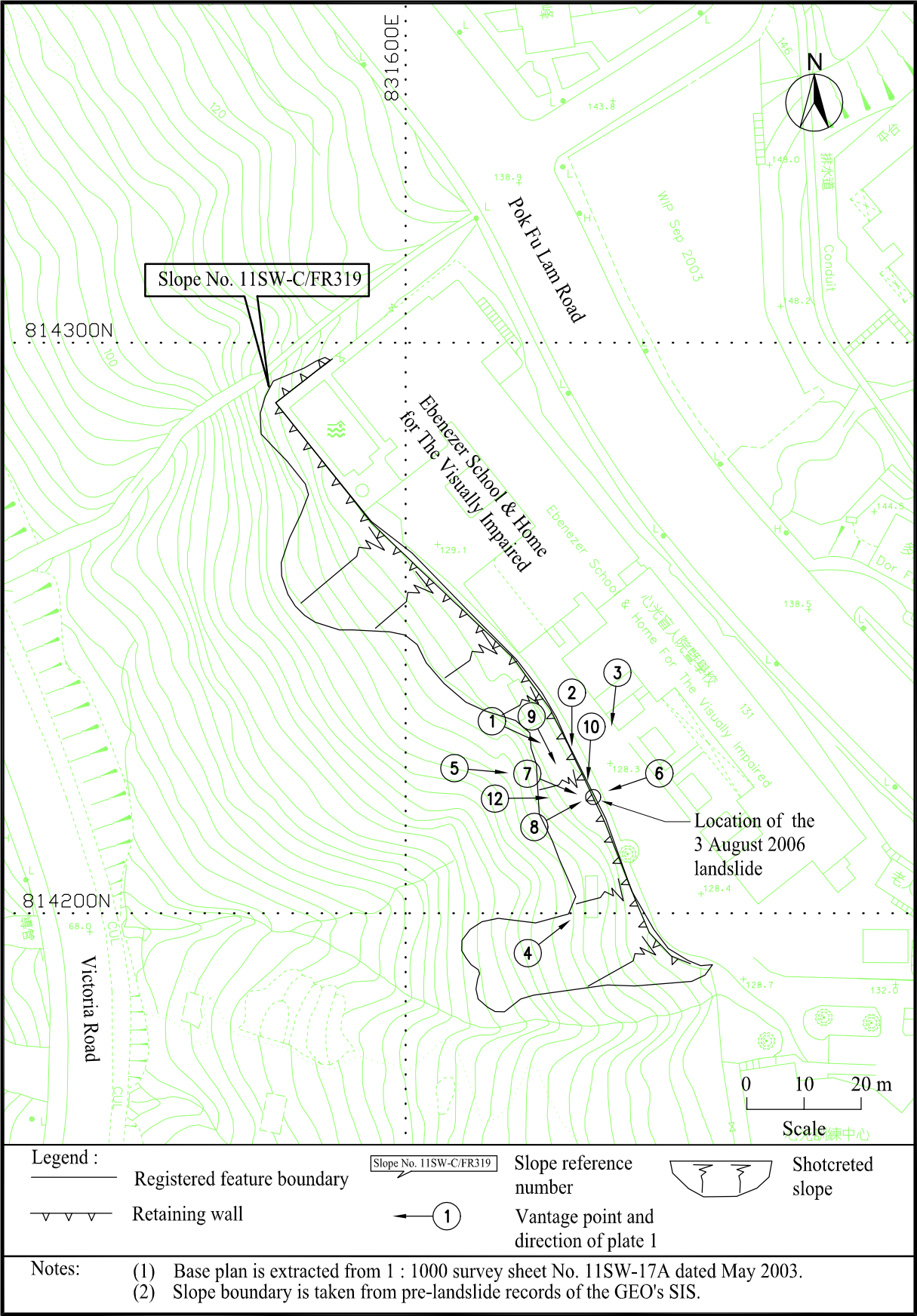


Figure 14 - Location and Direction of Photographs

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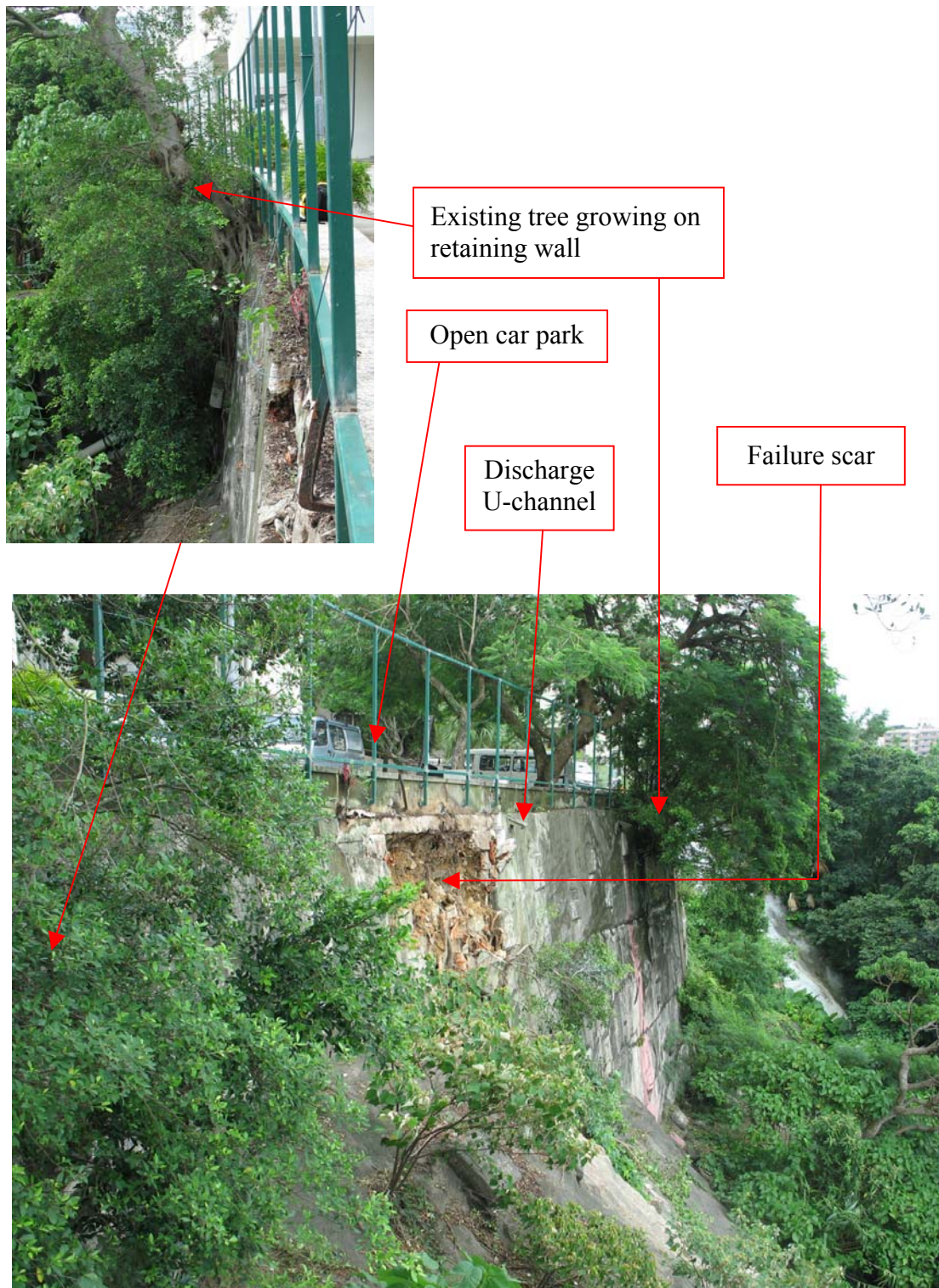


Plate 1 – General View of Retaining Wall Portion of Slope No. 11SW-C/FR319 Showing the 3 August 2006 Landslide Incident (Photographs taken by GEO on 4 August 2006)

Note: See Figure 14 for the location and direction of photograph.

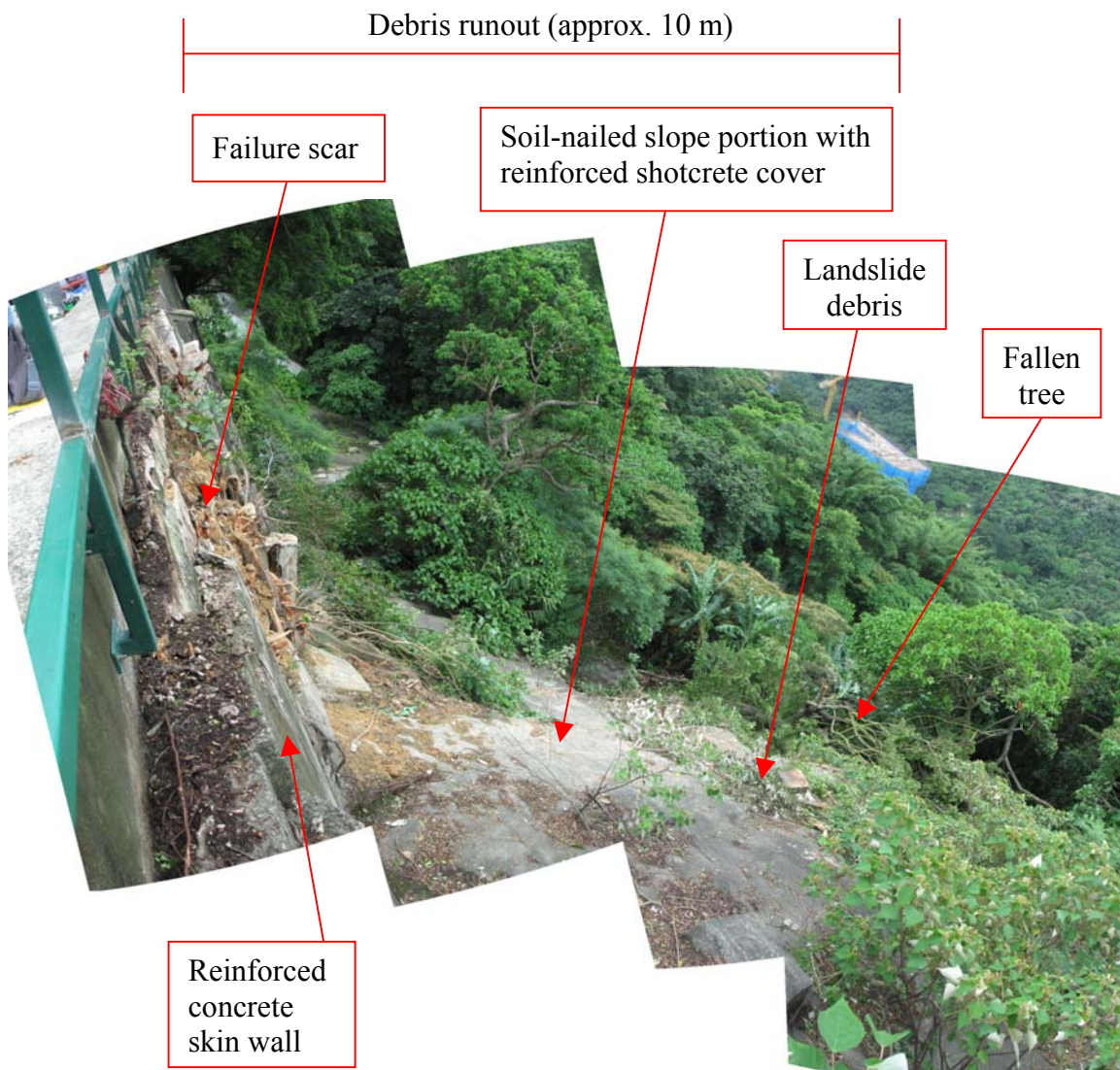


Plate 2 – General View of Slope Portion of Slope No. 11SW-C/FR319 Showing Debris Runout (Photograph taken by GEO on 4 August 2006)

Note: See Figure 14 for the location and direction of photograph.



Plate 3 – General View of Crest Area of Slope No. 11SW-C/FR319 above Location of the 3 August 2006 Landslide Incident (Photograph taken on 30 August 2006)

Note: See Figure 14 for the location and direction of photograph.

Tree involved in the 3 August 2006 incident



Septic tank

Plate 4 – General View of Slope No. 11SW-C/FR319 after Completion of Slope Upgrading Works in 1995
(Extracted from Photo 2 of Geotechnical Report for Stage 2 Site Formation)

Note: See Figure 14 for the location and direction of photograph



Plate 5 – Close View of Scar Associated with the 3 August 2006 Landslide Incident (Photograph taken by GEO on 4 August 2006)

Note: See Figure 14 for the location and direction of photograph.

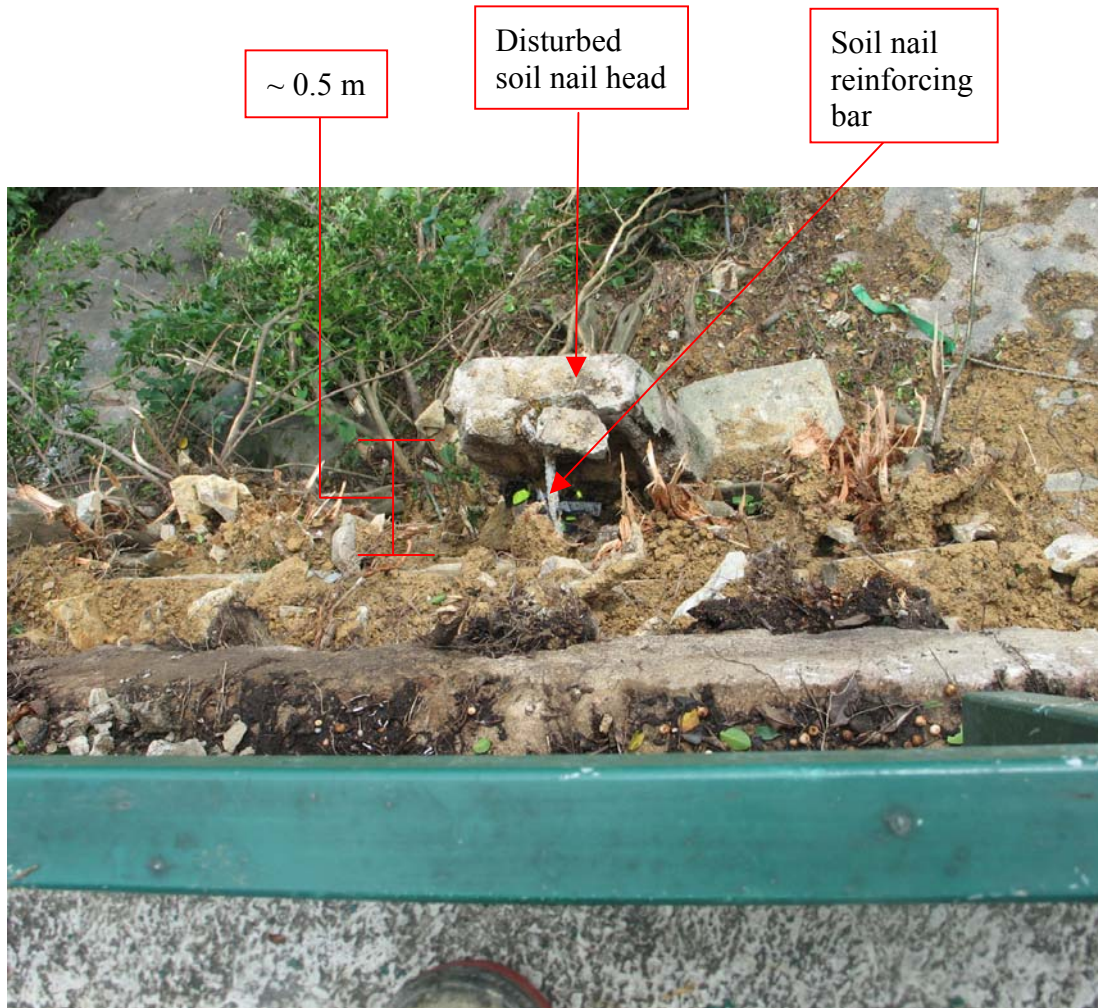


Plate 6 – Soil Nail Head Disturbed by Landslide Incident (View from Top of Retaining Wall) (Photograph taken by GEO on 4 August 2006)

Note: See Figure 14 for the location and direction of photograph.

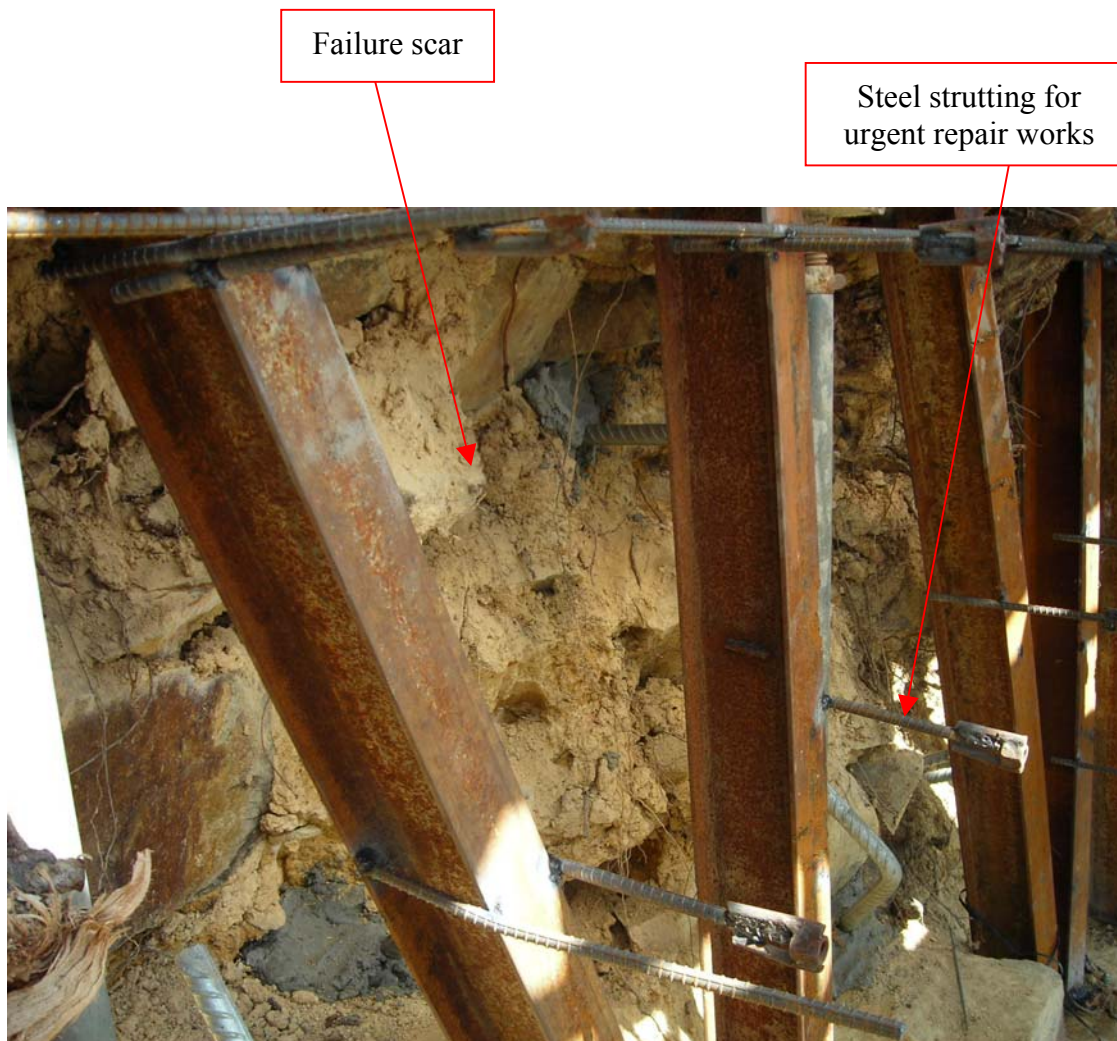


Plate 7 – Close View of Failure Scar (Photograph taken on 30 August 2006)

Note: See Figure 14 for the location and direction of photograph.

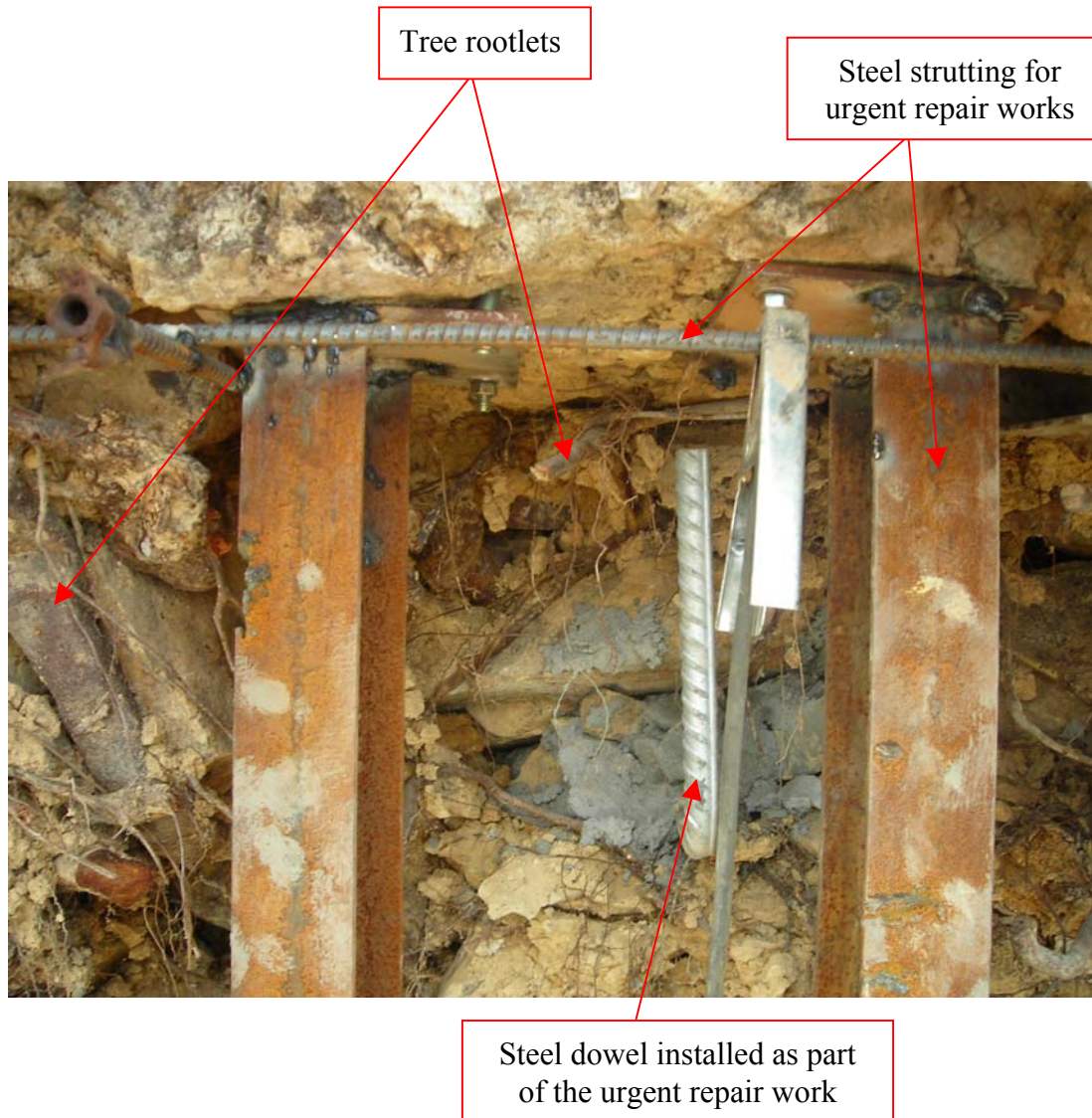


Plate 8 – Tree Rootlets Exposed in Failure Scar (Photograph taken on 30 August 2006)

Note: See Figure 14 for the location and direction of photograph.



Plate 9 – General View Across Retaining Wall Portion of Slope No. 11SW-C/FR319
(Photograph taken on 30 August 2006)

Note: See Figure 14 for the location and direction of photograph.



Plate 10 – Close View of Disturbed Soil Nail Head (Photograph taken on 4 September 2006)

Note: See Figure 14 for the location and direction of photograph.



Plate 11 – Soil Nail Head Following Detachment from Reinforcing Bar
(Photograph taken on 4 September 2006)



Plate 12 – Manual Removal of Soil Nail Reinforcing Bar (Photograph taken on 4 September 2006)

Note: See Figure 14 for the location and direction of photograph.



Plate 13 – Exhumed Soil Nail Reinforcing Bar (Photograph taken on 4 September 2006)



Plate 14 – Section of Grout Tube Recovered from Soil Nail Drillhole (Photograph taken on 4 September 2006)

APPENDIX A

AERIAL PHOTOGRAPH INTERPRETATION

A.1 DETAILED OBSERVATIONS

The following comprise the detailed observations made from the aerial photographs studied (see Figure A1). A list of aerial photographs used in this study is given in Section A.2.

<u>Year</u>	<u>Observations</u>
1924	<p>No stereo pair available. Pok Fu Lam Road and Victoria Road are present and generally conform to the respective present-day alignments. The building platform currently occupied by the Ebenezer School and Home for the Visually Impaired (Ebenezer facility) has been formed, with the present-day retaining wall portion of slope No. 11SW-C/FR319 extending along the southwestern edge. A building is present at the southeastern end of the platform.</p> <p>A body of fill is evident immediately downslope of the retaining wall portion of slope No. 11SW-C/FR319 and shows signs of erosion at the southeastern end.</p> <p>Three ephemeral drainage lines are visible on the hillside below the retaining wall. Rock outcrops are evident along the drainage lines extending below the northwestern and central portions of slope No. 11SW-C/FR319. The hillside below appears to have been disturbed.</p>
1945	<p>No major changes observed at slope No. 11SW-C/FR319.</p> <p>Two buildings have been constructed on the northwestern portion of the building platform. A small concrete structure is visible on the hillside immediately to the northwest of platform. The area of erosion identified at the southeastern end of the fill body below the retaining wall portion of slope No. 11SW-C/FR319 observed in the 1924 photographs has a cover of sparse vegetation.</p>
1949	<p>No major changes observed at slope No. 11SW-C/FR319 or the building platform above. The fill body below retaining wall portion of slope No. 11SW-C/FR319 appears to be rough in texture, suggesting it is mainly comprised of boulders, and signs of end-tipping are visible.</p> <p>A narrow track extends from the northwestern end of slope No. 11SW-C/FR319 to Victoria Road on a mostly north/south bearing. Vegetation on the hillside below slope No. 11SW-C/FR319 is heavier.</p>

<u>Year</u>	<u>Observations</u>
1963	<p>The building located at the southeastern end of the building platform behind slope No. 11SW-C/FR319 identified in the 1924 photographs has been demolished and the southeastern wing of the present-day Ebenezer facility has been constructed. Another building has been added between the southeastern wing and the two buildings occupying the northwestern portion of the platform, as well as the present-day Ebenezer Old Age Home to the southeast of the southeastern wing.</p> <p>Two concrete chambers/tanks are visible on the fill body below the central and southeastern portions of slope No. 11SW-C/FR319 respectively.</p> <p>A U-channel extending from the central portion of slope No. 11SW-C/FR319 to the drainage line below is visible. Three trees growing from the face of the retaining wall portion of slope No. 11SW-C/FR319, including the tree involved in the 3 August 2006 failure, are visible.</p> <p>The hillside below slope No. 11SW-C/FR319 indicates variable density in the vegetation cover, suggesting disturbance. Distinct vegetation clearance is apparent to the northwest and southwest of slope No. 11SW-C/FR319 respectively.</p>
1964	<p>High attitude photographs. No significant changes are apparent at slope No. 11SW-C/FR319 or the adjacent area. The vegetation in the general area is heavier.</p>
1967	<p>The northernmost building on the platform at No. 131 Pok Fu Lam Road has been demolished.</p> <p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area. An area of high reflectivity is apparent below the southeastern portion of slope No. 11SW-C/FR319, suggesting disturbance.</p> <p>A rock outcrop is evident on the hillside below the northwestern portion of slope No. 11SW-C/FR319 about mid-way to Victoria Road.</p>
1972	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p> <p>The areas of vegetation clearance identified in the 1963 photographs and the area of disturbance identified in the 1967 photographs have completely re-vegetated and the vegetation on the general hillside is heavier.</p>

<u>Year</u>	<u>Observations</u>
1974	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area. The building under construction in the 1972 photographs has been completed.</p> <p>Vegetation on the general hillside is heavier. Study area is almost completely covered by vegetation.</p>
1976	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p> <p>Agricultural terraces are visible on the hillside above Victoria Road to the south of the streamcourse extending below the southeastern end of slope No. 11SW-C/FR319.</p>
1978	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p> <p>Road works associated with the widening of Pok Fu Lam Road are in progress.</p>
1979	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p> <p>Vegetation on the hillside below slope No. 11SW-C/FR319 is generally heavier.</p> <p>Pok Fu Lam Road widening works have been completed.</p>
1980	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p> <p>Vegetation clearance is apparent on the hillside below slope No. 11SW-C/FR319 above the agricultural terraces identified in the 1976 photographs.</p>
1981	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p> <p>Area of vegetation clearance observed in 1980 photographs has re-vegetated.</p>
1984	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p>
1986	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p>

<u>Year</u>	<u>Observations</u>
1987	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area. Vegetation generally heavier on the hillside below.
1988	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.
1989	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p> <p>Victoria Road widening works and associated slope works to the northeast are in progress. Agricultural terraces observed in 1976 photographs appear to have been abandoned.</p>
1990	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p> <p>Victoria Road widening works and associated slope works are still underway.</p>
1991	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p> <p>Victoria Road widening works and associated slope works are completed.</p>
1992	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.
1993	<p>The two remaining buildings occupying the northwest portion of the platform above slope No. 11SW-C/FR319 first identified in the 1945 and 1963 photographs have been demolished.</p> <p>Vegetation over the footprint of the fill body below the retaining wall portion of slope No. 11SW-C/FR319 has mostly been cleared and the area shotcreted, with the exception of the fill extending further below the southeastern portion of slope No. 11SW-C/FR319.</p> <p>The trees growing from the face of the retaining wall portion of slope No. 11SW-C/FR319 have been left in place. The U-channel identified in the 1963 photographs has been re-constructed.</p>
1994	<p>No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.</p> <p>The present-day northwestern wing of the Ebenezer facility has been constructed on the platform above slope No. 11SW-C/FR319.</p> <p>A swimming pool has been constructed at the northwestern corner of the platform above slope No. 11SW-C/FR319.</p>

<u>Year</u>	<u>Observations</u>
1995	The remainder of the fill below the southeastern portion of slope No. 11SW-C/FR319 has been shotcreted. Vegetation within the study area is heavier.
1996	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.
1997	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.
1998	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area. Vegetation generally heavier.
1999	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area. Victoria Road widening works in progress.
2000	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area. Victoria Road widening works remain underway.
2001	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.
2002	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area.
2003	No major changes observed at slope No. 11SW-C/FR319 or the adjacent area. Study area almost completely masked by dense vegetation. Victoria Road widening works completed.

A.2 LIST OF PHOTOGRAPHS

Date	Reference No.	Altitude
1924	Y51	11,100'
11/11/1945	Y464, Y466	20,000'
8/5/1949	Y1359, Y1360	8,600'
6/2/1963	Y7297, Y7298	3,700'
13/12/1964	Y12826, Y12827	12,500
16/5/1967	Y13274, Y13275	6,250'
1972	108, 109	Not specified
21/11/1974	9691, 9692	12,500'
28/1/1976	12654, 12655	4,000'
30/11/1978	23836, 23837	4,000'
28/9/1979	27096, 27097	5,500'
16/4/1980	29826, 29827	4,000'
26/10/1981	39013, 39014	10,000'
2/3/1984	53677, 53678	4,000'
20/9/1986	A06016, A06017	4,000'
9/9/1987	A10363, A10364	4,000'
27/9/1988	A14503, A14504	4,000'
16/8/1989	A17779, A17780	4,000'
20/3/1990	A20830, A20831	4,000'
4/10/1991	A28048, A28049	4,000'
12/5/1992	A30952, A30953	4,000'
9/7/1993	A35414, A35415	4,000'
17/11/1994	CN8114, CN8115	4,000'
7/12/1995	CN12687, CN12688	3,500'
23/10/1996	CN15569, CN15570	4,000'
23/7/1997	CN17662, CN17663	4,000'
23/10/1998	CN21127, CN21178	4,000'
3/11/1999	CN24042, CN24043	5,000'
16/9/2000	CN28254, CN28255	4,000'
27/9/2001	CW34338, CN34339	4,000'
3/1/2002	CW38377, CW38378	2,500'
19/10/2003	CW50980, CW50981	8,000'

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

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:
Chief Geotechnical Engineer/Planning,
(Attn: Hong Kong Geological Survey Section)
Geotechnical Engineering Office,
Civil Engineering and Development Department,
Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon, Hong Kong.
Tel: (852) 2762 5380
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Tel: (852) 2762 5346
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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。

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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北角政府合署6樓626室
政府新聞處
刊物銷售組

或

- 致電政府新聞處刊物銷售小組訂購 (電話: (852) 2537 1910)
- 進入網上「政府書店」選購，網址為 <http://www.bookstore.gov.hk>
- 透過政府新聞處的網站 (<http://www.isd.gov.hk>) 於網上遞交訂購表格，或將表格傳真至刊物銷售小組 (傳真: (852) 2523 7195)
- 以電郵方式訂購 (電郵地址: puborder@isd.gov.hk)

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土木工程拓展署
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規劃部總土力工程師
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電話: (852) 2762 5346
傳真: (852) 2714 0275
電子郵件: 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 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. 1/2006 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.

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