REVIEW OF THE 21 AUGUST 2005 LANDSLIDE ON SLOPE NO. 3SW-C/C234 AT POLICE TACTICAL UNIT DEPOT FANLING

GEO REPORT No. 286

Halcrow China Limited

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 2/2010 produced in February 2010

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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
September 2013

FOREWORD

This report presents the findings of a review of a landslide (Incident No. 2005/08/0396) which occurred on slope No. 3SW-C/C234 at Police Tactical Unit Depot, Fanling on 21 August 2005. The incident involved a failure volume of about 40 m^3. The landslide debris reached an open area at the slope toe and damaged a 120 mm diameter water pipe running along the slope toe. No casualties were reported as a result of the landslide.

The key objectives of this review were to document the facts about the incident and to present relevant background information and pertinent site observations made under this review. 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 Landslide Investigation Consultancy for landslides occurring in Kowloon and the New Territories, for the Geotechnical Engineering Office, Civil Engineering and Development Department, under Agreement No. CE 53/2006 (GE). This is one of a series of reports produced during the consultancy by Halcrow China Limited.

Gerry Daughton
Project Director
Halcrow China Limited

Agreement No. CE 53/2006 (GE)
Study of Landslides Occurring in Kowloon and the New Territories in 2007 – Feasibility Study

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1. INTRODUCTION

A landslide (Incident No. 2005/08/0396) occurred on a soil cut slope No. 3SW-C/C234 at the Police Tactical Unit Depot, Fanling at about noon on 21 August 2005 when a Landslip Warning was in force.

Halcrow China Limited (HCL), the Landslide Investigation Consultants for Kowloon and the New Territories, carried out a review of the failure for the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD) under Agreement No. CE 53/2006 (GE).

2. DESCRIPTION OF THE SITE

Slope No. 3SW-C/C234 is a northeast-facing soil cut slope of about 45 m long with a maximum height of 11 m and inclined at a maximum angle of 40^{o} to the horizontal. The slope comprises two batters with an intervening 1.5 m wide berm and is generally vegetated, except for a 7 m wide strip at the northwestern end, which is covered with stone-pitching. Adjoining the southeastern boundary of the subject slope is another registered cut slope No. 3SW-C/C260, which is about 30 m long and 7.5 m high with an inclination of 30^{o} (Figure 1).

The subject slope is located at the foot of a natural, vegetated northeast-facing hillside. A two-storey building and a single-storey structure are located about 5 m and 3 m, respectively, from the toe of the slope.

A natural streamcourse runs in a northeasterly direction and discharges into a culvert about 20 m to the south-east of the slope. A site layout plan showing the registered boundary of the slope, together with the approximate location of the August 2005 landslide, is presented in Figure 2.

The surface drainage provisions at the subject slope comprise 300 mm U-channels along the crest and berm. These U-channels connect to 300 mm stepped channels at both ends of the slope, which discharge into the 1.5 m wide by 1.2 m deep covered rectangular drainage channel at the slope toe.

Based on the information provided by the Water Supplies Department and the Drainage Services Department, no recorded water-carrying services were present at, and in the vicinity of, the subject slope.

However, a water pipe (120 mm in diameter) was found emerging from the lower batter of the slope at its eastern end and running along the toe of slope No. 3SW-C/C234, and another water pipe (100 mm in diameter) was found along the crest of the subject slope (Figure 2 and Plates 7 and 8). No sign of leakage was observed during the site inspections after the August 2005 landslide.

3. THE 21 AUGUST 2005 LANDSLIDE

The landslide occurred on slope No. 3SW-C/C234 at the Police Tactical Unit, Fanling on 21 August 2005 at about noon when a Landslip Warning Signal was in force (Plates 1 and 2).

In response to a report from the PTU Depot, an initial inspection of the landslide site was carried out by the GEO at 2:40 p.m. on 22 August 2005. The landslide debris, with a failure volume of about 40 m^3, was deposited at the slope toe (Plate 3). A 120 mm diameter cast iron water pipe running along the slope toe was damaged by the landslide debris. No casualties were reported as a result of the incident.

4. MAINTENANCE RESPONSIBILITY

According to the Slope Maintenance Responsibility Information System (SMRIS) of the Lands Department, the subject cut slope is under the maintenance responsibility of the Government Property Agency (GPA) with Architectural Services Department (Arch SD) as the maintenance agent.

5. SITE HISTORY AND PAST SLOPE INSTABILITIES

5.1 Site History

The development history of the site has been established from an interpretation of aerial photographs taken between 1963 and 2006 and a review of available relevant documentary records (Figure 3). A detailed account of the aerial photograph interpretation (API) is presented in Appendix A. Salient aspects of the key observations are summarised below.

The earliest available aerial photographs taken in 1963 show that the slope was located at the toe of a northeast-facing natural hillside, which was covered with a thin veneer of vegetation, including grass and occasional shrubs. Agricultural terraces were present in front of the subject slope.

By 1973, denser vegetation could be observed on the hillside in the vicinity of the subject area. A faint lineament in the vegetation cover, probably a footpath, was observed traversing across the hillside. A rectangular platform associated with a small bare slope surface (which was later modified into slope No. 3SW-C/C260) was visible. However, it was uncertain as to whether the bare slope surface was formed by a cutting, or the result of a small failure.

By 1976, a footpath had been formed above the subject area. The rectangular platform observed in the 1973 photographs appeared to have been modified in association with the construction of the nearby slope No. 3SW-C/C241 at its present day location. By 1979, a darker toned area, which suggested agricultural activities, was observed on the rectangular platform.

Between 1987 and 1989, construction of the Police Tactical Unit Depot to the northeast of the subject area had been completed.

In the 1990 aerial photographs, formation of the subject slope No. 3SW-C/C234 in association with construction of the firing range in front of the slope was in progress. The slope appeared to have comprised two cut batters separated by a berm. A rectangular feature, likely to be a culvert, was observed on the platform immediately to the southeast of the slope. A

drainage channel was visible extending from the culvert, running along the toe of the slope, and draining to the northeast.

By 1992, the surface of the subject slope appeared to have been covered with dense grass. Surface drainage channels were visible at the crest and berm of the slope. Site formation works were ongoing at a platform immediately to the east of the slope. A building structure had been constructed on the platform immediately in front of the subject slope.

By 1993, the firing range and associated access roads had been constructed to the present-day layout. The site formation works on the platform immediately to the east of the subject slope were completed. Adjacent slope No. 3SW-C/C260 had been modified to the present-day layout.

The 1995 aerial photographs showed that clearance of vegetation on slope No. 3SW-C/C234 and the adjoining slope No. 3SW-C/C260 had been carried out and a fence had been erected along the crest of the slopes. A small rectangular structure had been constructed in front of the subject slope.

In 2002, it appeared that the north-western end of the subject slope had been modified to the present day layout and a reflective surface indicated that this portion was covered with hard surfacing.

In the 2006 aerial photographs, the slope face was seen to have been generally vegetated with grass and shrubs.

5.2 Past Slope Instability

According to the GEO's landslide database, there are no records of any previous reported landslides on the subject slope. There were, however, many relict landslides in the natural hillside above the subject slope, based on the information from the ENTLI database (Figure 4).

As indicated in the 2001 Engineer Inspection (EI) report prepared by Maunsell Geotechnical Services Limited (MGSL), a failure occurred at the toe of the north-western portion of the subject slope which was involved in the 2005 landslide (Figure 2). The failure area measured about 9 m by 3 m on plan but no failure volume was given in the EI report. According to the EI report, the incident was probably caused by surface infiltration and the scale of failure was "considered to be minor and the overall stability of the slope is unlikely to be affected".

6. PREVIOUS ASSESSMENTS AND SLOPE WORKS

6.1 Development of New Depot for Police Tactical Unit

A Phase II Development of Police Tactical Unit Depot, comprising a 2-storey Indoor Range Building (Site A), together with a 2-storey Close Quarters Battle (CQB) House and an outdoor 100 m firing range (Site B), to the west of the Phase I Development was proposed in

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1987. A preliminary geotechnical report, prepared by ArchSD for the proposed development, indicated that Site B was located on an old agricultural field with colluvial/alluvial deposits and at a natural drainage concentration where significant subsurface flow might be expected. The preliminary report recommended that ground investigation (GI) on the slope to the south of Site B (i.e. the location of the present-day slope No. 3SW-C/C234) and a stability analysis should be carried out. It also recommended that particular attention be paid to the drainage provision for Site B, as high groundwater level was anticipated in this area. The report concluded that the proposed development was feasible from a geotechnical point of view.

On 30 August 1989, ArchSD submitted to the then Geotechnical Control Office (re-named Geotechnical Engineering Office in 1991) for comment a geotechnical report on the Phase II Development under project “New Depot for Police Tactical Unit, Remaining Works, Fanling”. The geotechnical report indicated that the present-day slope No. 3SW-C/C234 was proposed to be formed by cutting into the hillside at a maximum angle of 40^o to the horizontal. According to the GI records, colluvium up to 0.6 m thick was present at the subject slope, below which is a layer of residual soil up to 4.5 m thick underlain by decomposed volcanic rock (CDV) of varying degrees of weathering.

In the geotechnical report, the slope stability analysis assumed a homogenous ground model comprising CDV. The strength parameters of CDV were derived from a single p'-q' plot, which incorporated the triaxial test results obtained from different soil materials including alluvium, colluvium, residual soil, CDV and HDV. Based on the p'-q plot the overall shear strength parameters were: c'=8 kPa and $\phi'=34^o$ (Figure 6).

Limited groundwater monitoring was undertaken daily for 7 consecutive working days following installation of the piezometers and at weekly intervals from 31 March 1989 to 14 April 1989 in six piezometers installed in 6 drillholes (B2, B5, B7 to B10). The piezometer tips were located near the interface of HDV and H/MDV (i.e. 36.5 m below ground level) in drillhole No. B9 and near the rockhead level (i.e. 14.2 m below ground level) in drillhole No. B10. The limited monitoring records indicated that the highest groundwater levels in drillhole Nos. B9 and B10 were 26.67 mPD and 26.42 mPD (i.e. 0.2 m above and 0.08 m below the slope toe) respectively (Figure 8). For design purposes, a groundwater level with a 1 in 10 year return period was assumed which was taken as 1 m above the highest measured level, i.e. at about 1.2 m above the slope toe level. A Factor of Safety (FOS) of 1.46, greater than the required value of 1.4, was calculated for cut slope No. 3SW-C/C234 (Figure 7).

The then GCO notified ArchSD on 14 November 1989 that they had no adverse comment on the proposed site formation works. It was also recommended that the groundwater level should be continuously monitored over one wet season, and the slope design be reviewed in the light of the results and that DSD should be consulted on the drainage aspect, particularly the effect of the proposal on the existing streamcourse nearby. However, no other groundwater monitoring records or evidence of the submission of drainage plans to DSD could be located.

6.2 SIFT and SIRST Studies

In April 1997, under the study entitled "Systematic Inspection of Features in the Territory" (SIFT) initiated by the GEO, the subject slope was categorized as SIFT Class 'C2' (i.e. a cut slope that have been formed or substantially modified after 30 June 78).

In June 1997, the subject slope was inspected as part of the study entitled "Systematic Identification and Registration of Slopes in the Territory" (SIRST). According to the inspection records, the slope surface was covered with vegetation and the surface condition was assessed as "fair". Its consequence-to-life category was classified as "1". It also recorded that signs of seepage were noted on the slope surface and signs of distress described as “reasonable” were observed at the middle portion and toe of the slope.

6.3 EI by MGSL

MGSL carried out EI for the slope in October 2001. The EI identified a failure at the toe of the slope. Trimming back of the failure surface and provision of surface protection had been carried out. There is no record of any detailed review of the stability of the slope following the failure. No stability assessment, preventive maintenance works or upgrading works were recommended.

6.4 Routine Maintenance

Based on ArchSD’s records, Routine Maintenance Inspections (RMI) were carried out for the subject slope annually from 2001 to 2005 prior to the failure. The failure recorded in the 2001 EI was also noted in the RMI reports in October and November 2002. Repair works comprising re-grading the eroded areas with compacted cement soil had been completed at the time of the RMI inspections.

The last RMW before the failure was carried out in February 2005, comprising clearance of debris along drainage channels, repair and fix erosion control mat and unblocked weepholes etc.

7. POST-LANDSLIDE OBSERVATIONS AND URGENT REPAIR

An inspection of the landslide site was undertaken by MGSL, another Landslide Investigation Consultants, on 14 November 2005 (Plates 3 to 6). According to the MGSL inspection records, the landslide scar measured about 8.6 m wide by 7.5 m high with a depth of about 1.5 m. The failure volume was about 40 m^3. MGSL recorded that the back scrap of the landslide site was near sub-vertical, and the debris deposited at slope toe had an average angle of 30^o (Plates 3 and 4). The slope was covered with trees, shrubs and grass at the time of failure. The failed material mainly comprised residual soil with some stones and cobbles and some completely decomposed tuff (Plate 9). MGSL did not observe tension crack or water seepage on the slope during their inspection. A cross-section through the landslide site is presented in Figure 8.

HCL subsequently inspected the landslide site on 18 December 2007, by which time the urgent repair works had already been completed. The landslide area had been backfilled with compacted cement soil and covered with vegetation (Plate 10). The affected water pipe along the slope toe had been re-aligned (Plate 8). A patch of bare surface was observed at the upper portion of the backfilled area (Plate 11), where the growth of vegetation may have been hindered by the cement soil.

Some soil staining was observed on the hard surface apron at the slope toe. This possibly indicated minor surface erosion or washout at the slope (Plate 12). Minor bulging was also visible at the slope toe (Plate 12). The bulging could have been a result of overfilling of the cement soil during the slope repair works following the August 2005 landslide. No other signs of distress or movement, or signs of seepage were noted at the subject slope at the time of inspection.

Residual soil was exposed at the western portion of the upper batter, comprising stiff, dry, brown and slightly sandy SILT. Colluvium, about 400 mm in thickness, was exposed in the middle of the upper batter comprising loose, dry, light yellowish brown, sandy SILT with some sub-angular fine to coarse gravel with occasional cobbles. Decomposed tuff was exposed below the residual soil and comprised extremely weak to very weak, dry, yellowish brown, dappled white and red, completely to highly decomposed metamorphosed coarse ash crystal TUFF with some quartz up to 50 mm in size.

A small rock outcrop was seen in the upper batter of the eastern portion of the slope and comprised moderately strong to strong, light grey to yellowish brown, moderately decomposed, coarse ash crystal TUFF. Close examination of the rock material revealed some schistocity and that the matrix of the tuff appeared to have a very high quartz content and silicified (Plate 13). Immediately to the east of the subject slope was another smaller isolated rock outcrop (Plate 14) with similar schistocity and silicification. Some small rock outcrops were also found on both sides of a paved footpath leading to the southwest of the subject slope (Plates 15 and 16), but these were limited in extent.

Following the 2005 landslide, urgent repair works including benching of the failed area to facilitate the subsequent filling with compacted cement soil, provision of 75 mm diameter perforated PVC pipes and hydroseeding with provision of wire mesh. The works were completed in February 2006. A 150 mm U-channel was also constructed at the toe of the repaired portion, which discharges water into an adjacent 1.5 m wide covered rectangular drainage channel (Plate 17).

8. SUBSURFACE CONDITIONS

8.1 General

The geology of the site was determined using information from desk study and field mapping. The desk study comprised a review of available data including previous Ground Investigation (GI) data, API and geological maps. According to Sheet 3 of the Hong Kong Geological Survey (HKGS) 1:20 000 scale map series HGM20 (GCO, 1986), the solid geology at the subject slope comprises slightly metamorphosed tuff. A northeast-trending strip of schist is located some 5 m above the slope and is shown to pass through the southeast side of the slope (Figures 4 and 5). No GI was carried out for this study.

8.2 Ground Conditions

Between November 1988 and January 1989, Lam Geotechnics Limited carried out a GI comprising eleven boreholes and two trial pits for the Phase II Development of the PTU depot

under Contract No. GC/87/05. Two boreholes (i.e. drillhole Nos. B9 and B10) were sunk within the boundary of present-day slope No. 3SW-C/C234. The locations of these drillholes are shown in Figure 2.

According to the GI findings, drillhole No. B9 encountered 0.5 m thick colluvium overlying 4.5 m thick residual soil which was underlain by completely decomposed volcanics (CDV). Below the CDV is a layer of highly decomposed volcanics (HDV), which was underlain by moderately decomposed volcanic rock (MDV) at about 38 m below ground surface (i.e. -0.05 mPD). Drillhole No. B10 recorded a layer of 0.6 m thick colluvium overlying HDV. Highly to moderately decomposed volcanic rock was encountered between 2.6 m and 7.5 m depth, with quartz seams between 2.6 m to 2.8 m and 5.35 m to 5.45 m below ground level. MDV was recorded at a depth of about 14 m below ground surface in drillhole No. B10 (i.e. 17.2 mPD). Drillhole records of B9 and B10 are included in Appendix B. Based on the limited GI information, it appears that the rockhead at the southeastern slope portion was significantly higher than that at the northwestern portion. This is consistent with the location of the observed rock outcrop in the eastern slope portion where a possible silicified hard band may be present. Based on the limited information available, it is uncertain that the silicified band would have affected the subsurface flow, if present, in the area in the vicinity of the August 2005 landslide.

8.3 Groundwater Conditions

As part of the previous GI works carried out for the Phase II Development between 1988 and 1989, piezometers were installed in the drillhole Nos. B2, B5, B7, B8, B9 and B10. The groundwater monitoring results are detailed in Section 6.1.

8.4 Soil Strength Parameters and Stability Analysis

As noted at Section 6.1 above, the geotechnical report prepared by ArchSD in 1989 for the Phase II Development of the Police Tactical Unit Depot included the results of triaxial compression tests carried out on samples of alluvium, colluvium, residual soil, CDV and HDV, on single p'-q plot (Figure 6). Under the present study, the test results have been plotted on separate p'-q plots for colluvium, residual soil and CDV (Figures 9, 10 and 11) for clarity. It is noted that most of the tests were performed in residual soil and CDV with a few in colluvium. Based on the limited test results, the estimated shear strength parameters for the materials are: $c'=4$ kPa and $\phi'=35^o$ for colluvium, $c'=0$ kPa and $\phi'=38^o$ for residual soil, and $c'=8$ kPa and $\phi'=34^o$ for CDV.

Based on these shear strength parameters, stability analysis indicates that the FOS of the slope is about unity even if no pore water pressure is assumed. This shows that the slope could fail upon loss of suction. The incident is thus theoretically admissible (Figure 12).

9. ANALYSIS OF RAINFALL RECORDS

Rainfall data were obtained from the nearest GEO automatic raingauge (No. N05), which is located at the Cheung Chi House, Cheung Wah Estate, Fanling, about 1.3 km to the

northeast of the subject slope (Figure 1). This raingauge records and transmits rainfall data at 5-minute intervals via a telephone line to the Hong Kong Observatory and the GEO.

According to the GEO landslide incident report, the incident occurred on 21 August 2005 at about noon. The daily rainfall for the period of 31 days before the incident and the hourly rainfall between 20 and 21 August 2005 are presented in Figure 13. The records show that the maximum rolling rainfalls for 24-hour and 2-day periods are 250.5 mm and 355.5 mm respectively. The maximum 1-hour rolling rainfall was recorded as 32.5 mm between 8:35 a.m. and 9:35 a.m. on 20 August 2005 (Table 1).

The return period for the rainfall recorded at raingauge No. N05 preceding the incident was estimated based on historical rainfall data at the Hong Kong Observatory (Lam & Leung, 1994). The maximum rolling rainfall for various durations was derived and is given in Table 1. The result shows that the return periods of the rainfall were relatively short, generally less than 5 years. The return periods were comparable with that based on the statistical parameters derived by Evans & Yu (2001) (Table 1).

A comparison of the maximum rolling rainfall for the 21 August 2005 incident with that of the past major rainstorms recorded by Raingauge No. N05 is presented in Figure 14. The results indicate that the rainfall on 21 August 2005 is less severe than the previous major rainstorms.

10. DISCUSSION

The 21 August 2005 landslide, which involved a failure volume of about 40 m^3, occurred on an engineered, unsupported soil cut slope following a prolonged period of rainfall. The timing of the August 2005 landslide suggests that the landslide was triggered by rainfall.

An over-simplified ground model was adopted in the previous stability analysis for the subject slope, which was assumed to comprise a single stratum of CDV with a single set of soil strength parameters. No account was taken of the overlying colluvium and residual soil, which have a lower shear strength based on the laboratory test results. The FOS of the slope would have been overestimated.

A small-scale failure occurred at the slope toe in 2001. This indicated that the unsupported cut slope was of marginal stability and might have been subject to deterioration. The incident was identified in the 2001 EI, but the need for a thorough review of the stability of the slope was not fully appreciated at the time.

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LIST OF TABLES

Table 1 - Maximum Rolling Rainfall at GEO Raingauge No. N05 for Selected Durations Preceding the Landslide on 21 August 2005 and Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period (Hours) (see Note 4)	Estimated Return Period (Years) (see Note 3)	
			A	B
5 minutes	5.0	16:00 hours on 20 Aug 2005	1	< 2
15 minutes	11.5	09:20 hours on 20 Aug 2005	1	< 2
1 hour	32.5	09:35 hours on 20 Aug 2005	< 2	< 2
2 hours	50.0	09:35 hours on 20 Aug 2005	< 2	< 2
4 hours	80.0	10:50 hours on 20 Aug 2005	< 2	< 2
12 hours	167.0	19:50 hours on 20 Aug 2005	< 2	2
24 hours	250.5	20:10 hours on 20 Aug 2005	3	3
2 days	355.5	12:00 hours on 21 Aug 2005	5	4
4 days	435.0	07:10 hours on 21 Aug 2005	5	4
7 days	489.0	12:00 hours on 21 Aug 2005	5	5
15 days	604.5	12:00 hours on 21 Aug 2005	4	4
31 days	847.5	12:00 hours on 21 Aug 2005	5	3

Notes:

(1) Maximum rolling rainfall was calculated from 5-minute rainfall data.

(2) The nearest GEO raingauge to the landslide site is Raingauge No. N05 located at Cheung Chi House, Cheung Wah Estate, about 1300 m to the northeast of the landslide site.

(3) Return periods were derived from Table 3 of Lam & Leung (1994) (Column A refers) and using data of Raingauge No. N05 from Evans & Yu (2001) (Column B refers). The return periods obtained by data of Lam & Leung (1994) and Evans & Yu (2001) show a sligh difference.

(4) The landslide occurred at about noon on 21 August 2005.

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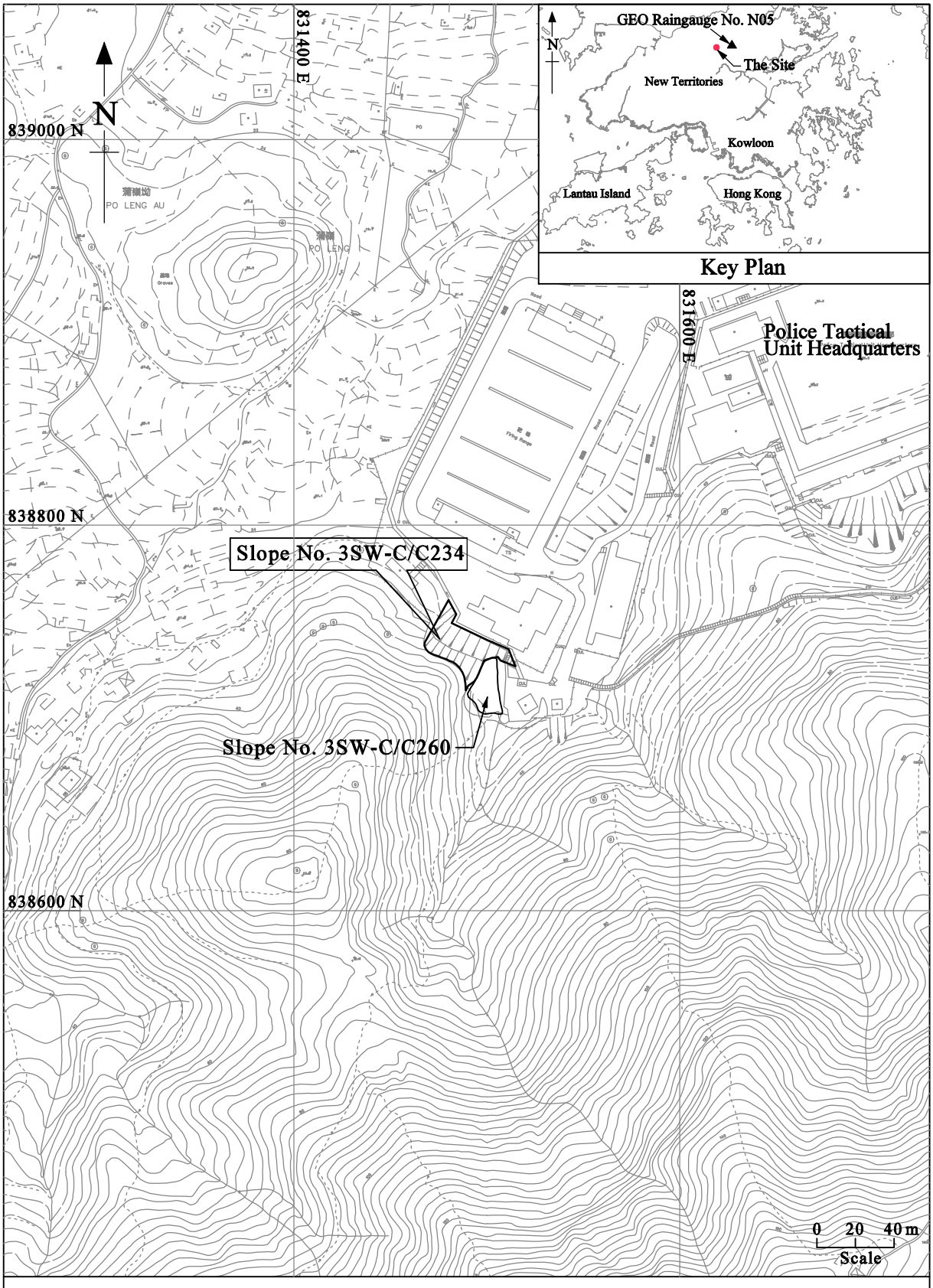

Figure 1 - Site Location Plan

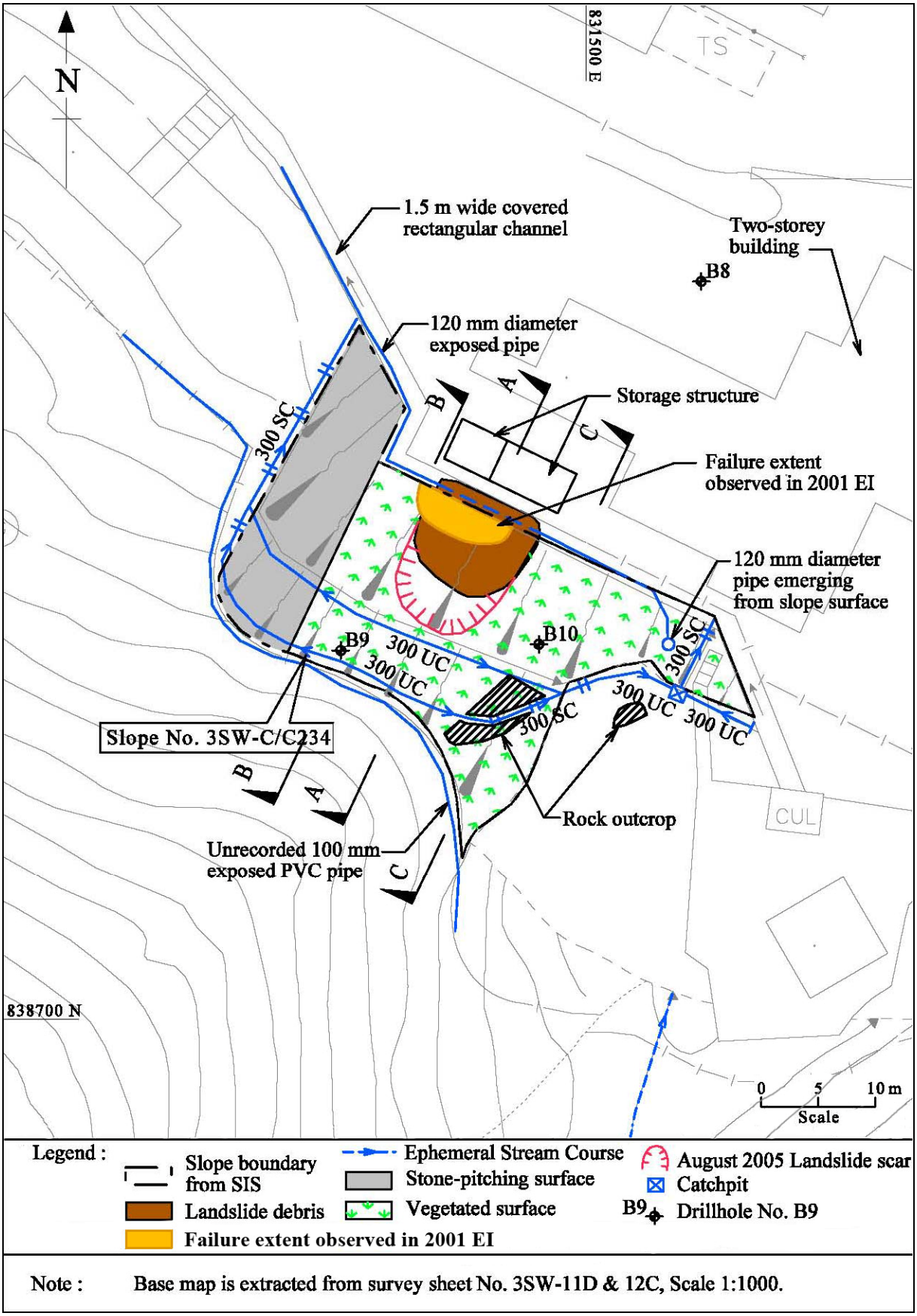

Figure 2 - Site Observations

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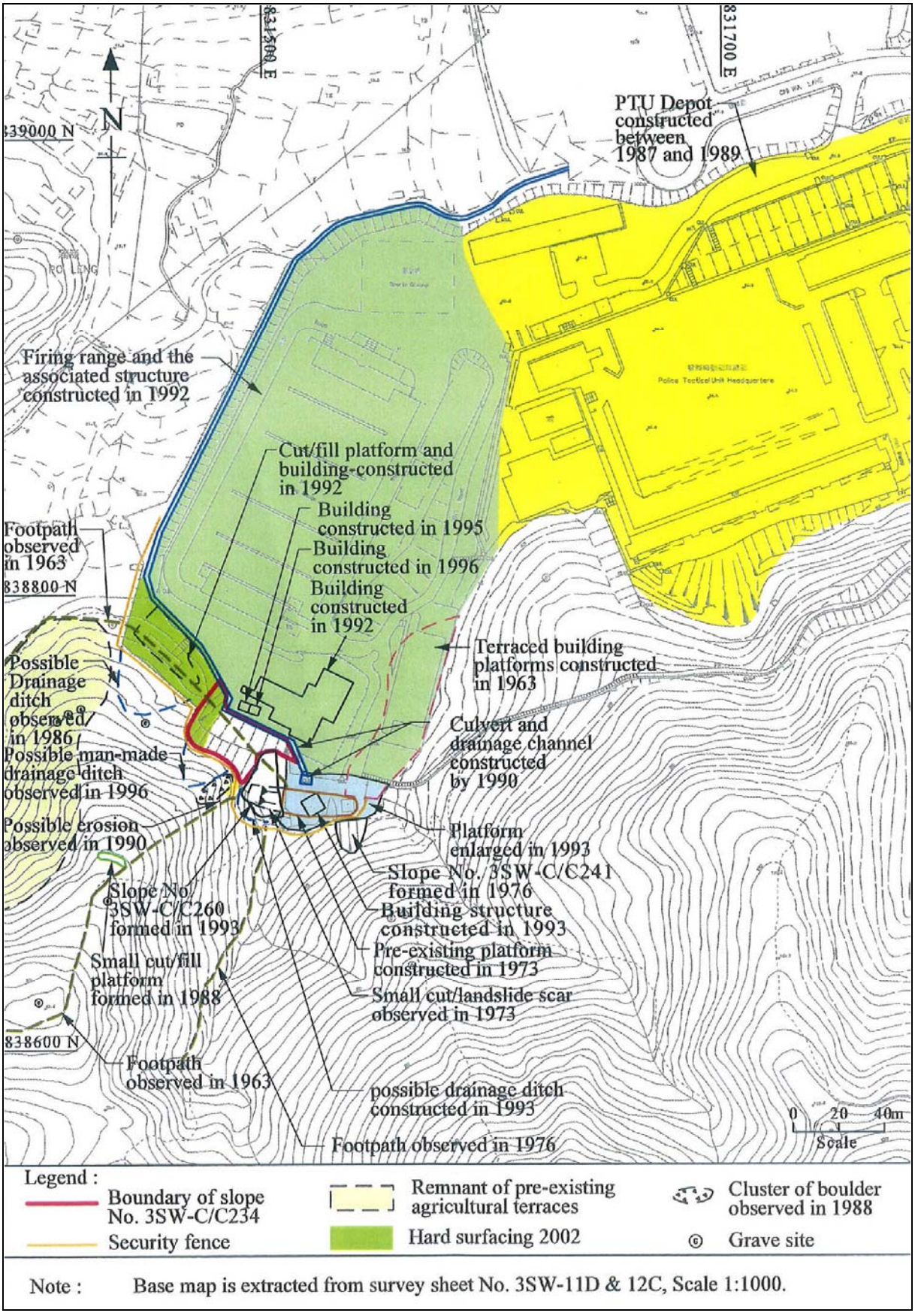


Figure 3 - Site Development History

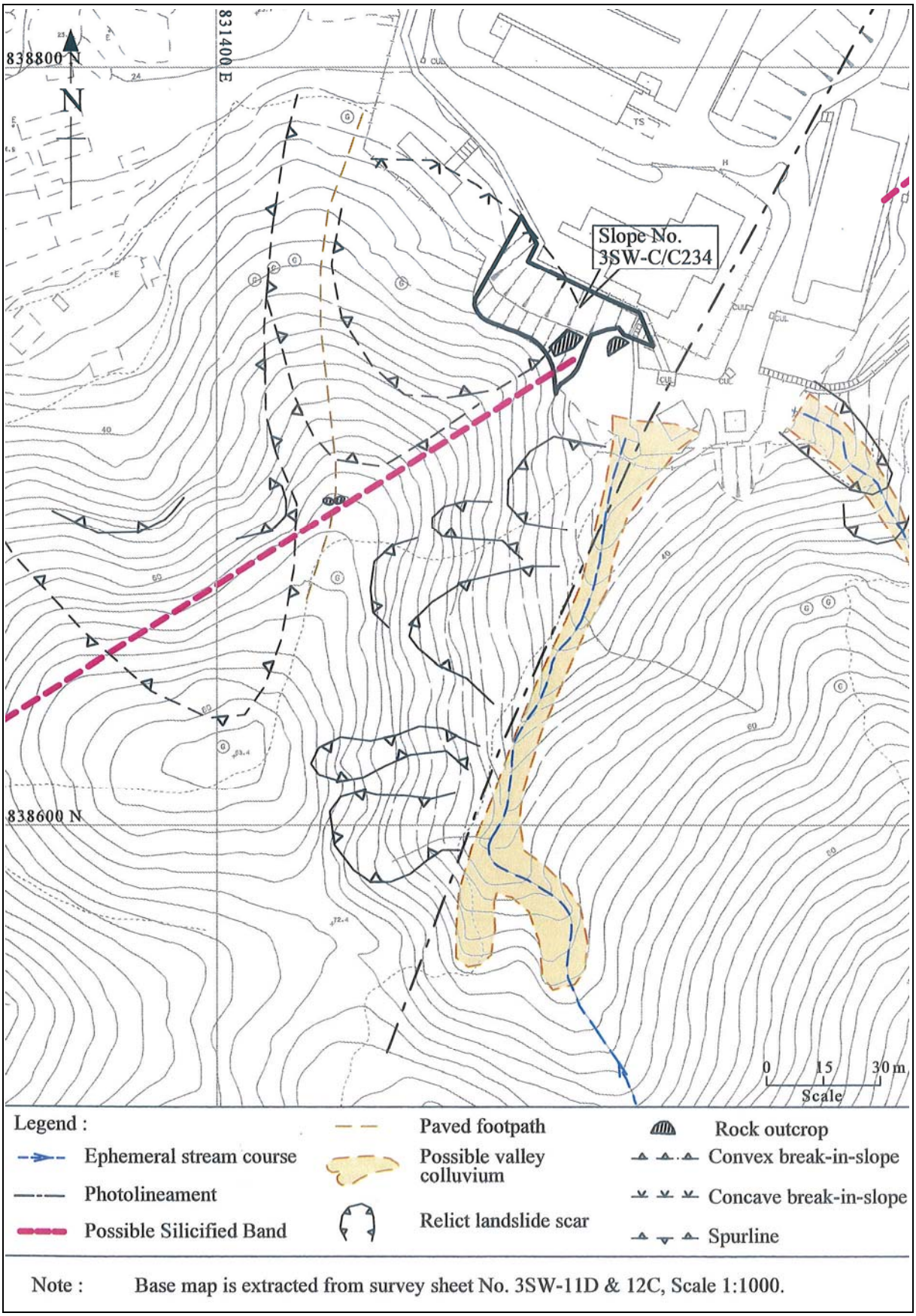
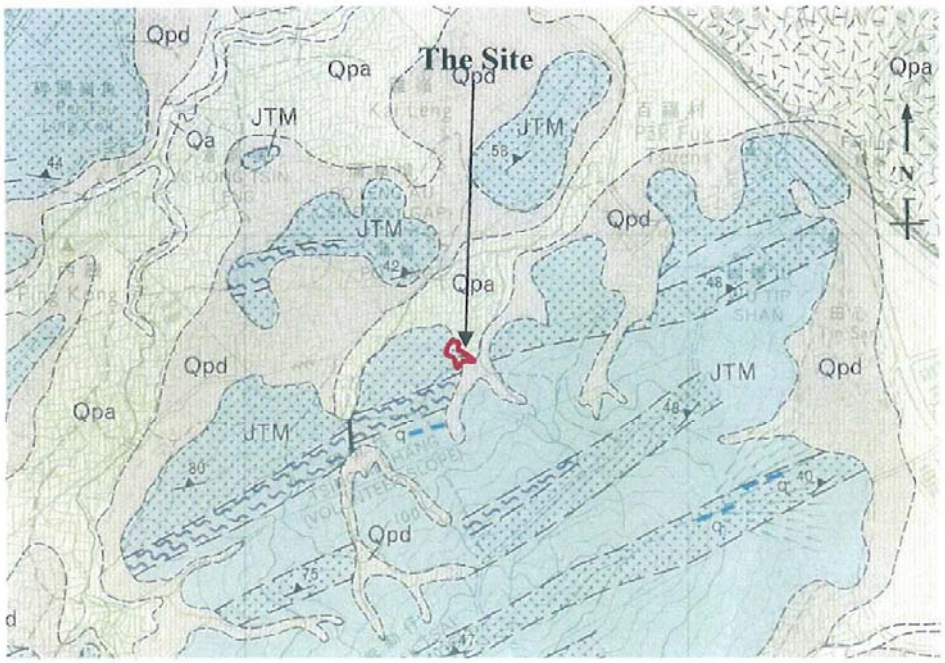


Figure 4 - Geomorphology Plan



LEGEND:

0 m — 1000 m
Scale

SUPERFICIAL DEPOSITS

- Fill
- Qpa — Terraced alluvium
- Qa — Alluvium
- Qpd — Debris flow deposits

SOLID GEOLOGY

- JTM — Undivided, coarse ash crystal tuff
- Schist
- Quartz vein
- Slightly metamorphosed tuff

GEOLOGICAL LINES

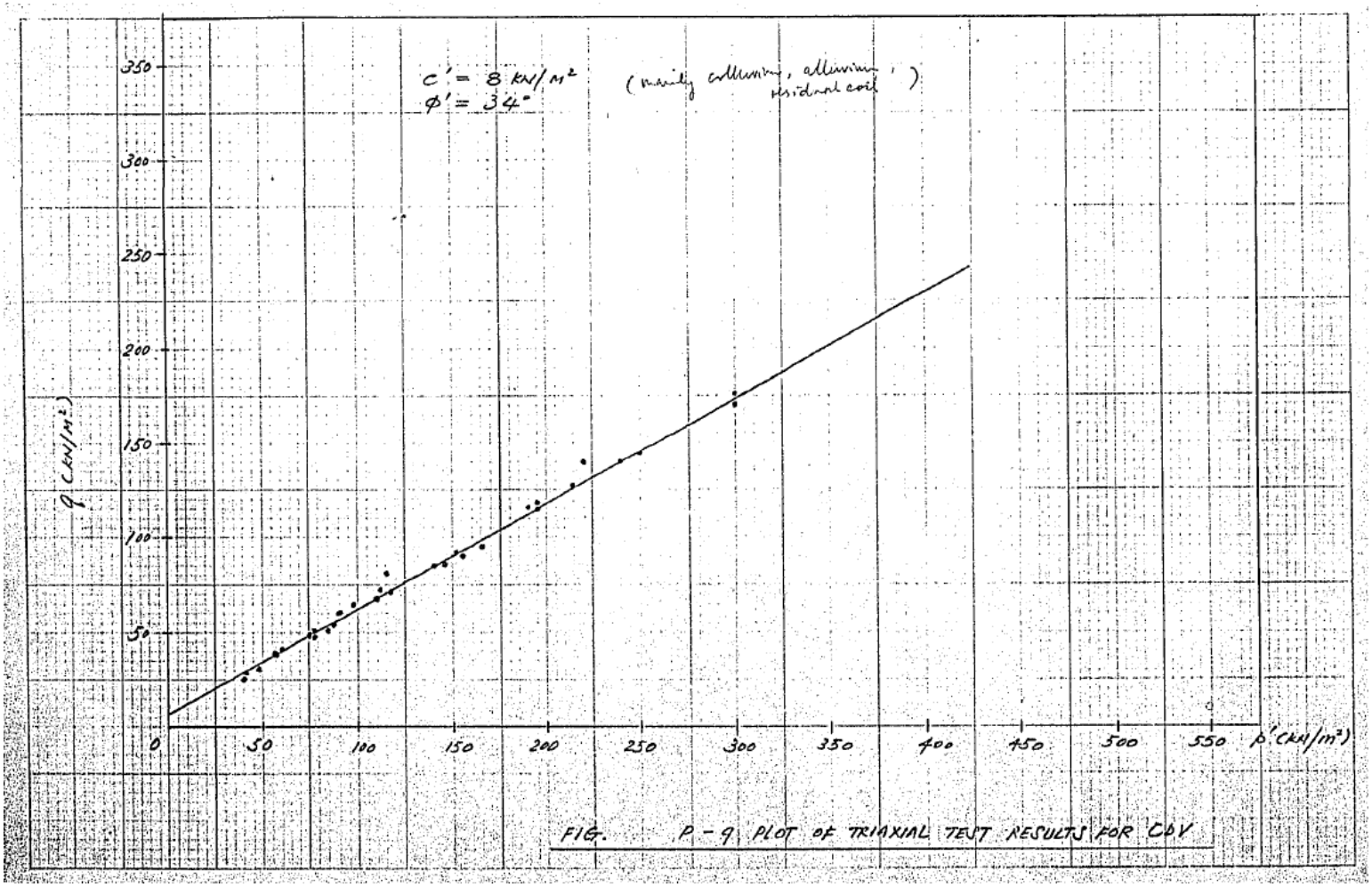
- Geological boundary, superficial deposit
- 1982 — Fill boundary, with limit of reclamation at date shown
- Geological boundary, solid rock (* Broken line denote uncertainty)
- Fault (crossmark indicated downthrow side)
- Thrust, teeth pointing to upper plate
- Photogeological lineament
- Mineral vein

STRUCTURAL SYMBOLS

- 40 — Foliation

Note : Extracted from Hong Kong Geological Survey Map Series HGM20, Sheet No. 3, 1:20,000 scale (GCO, 1986).

Figure 5 - Regional Geology



Legend : Plan extracted from GEO File No. GCMW 3/1/575.

Figure 6 - Previous p'- q Plot for Slope Stability Analysis for Slope No. 3SW-C/C234

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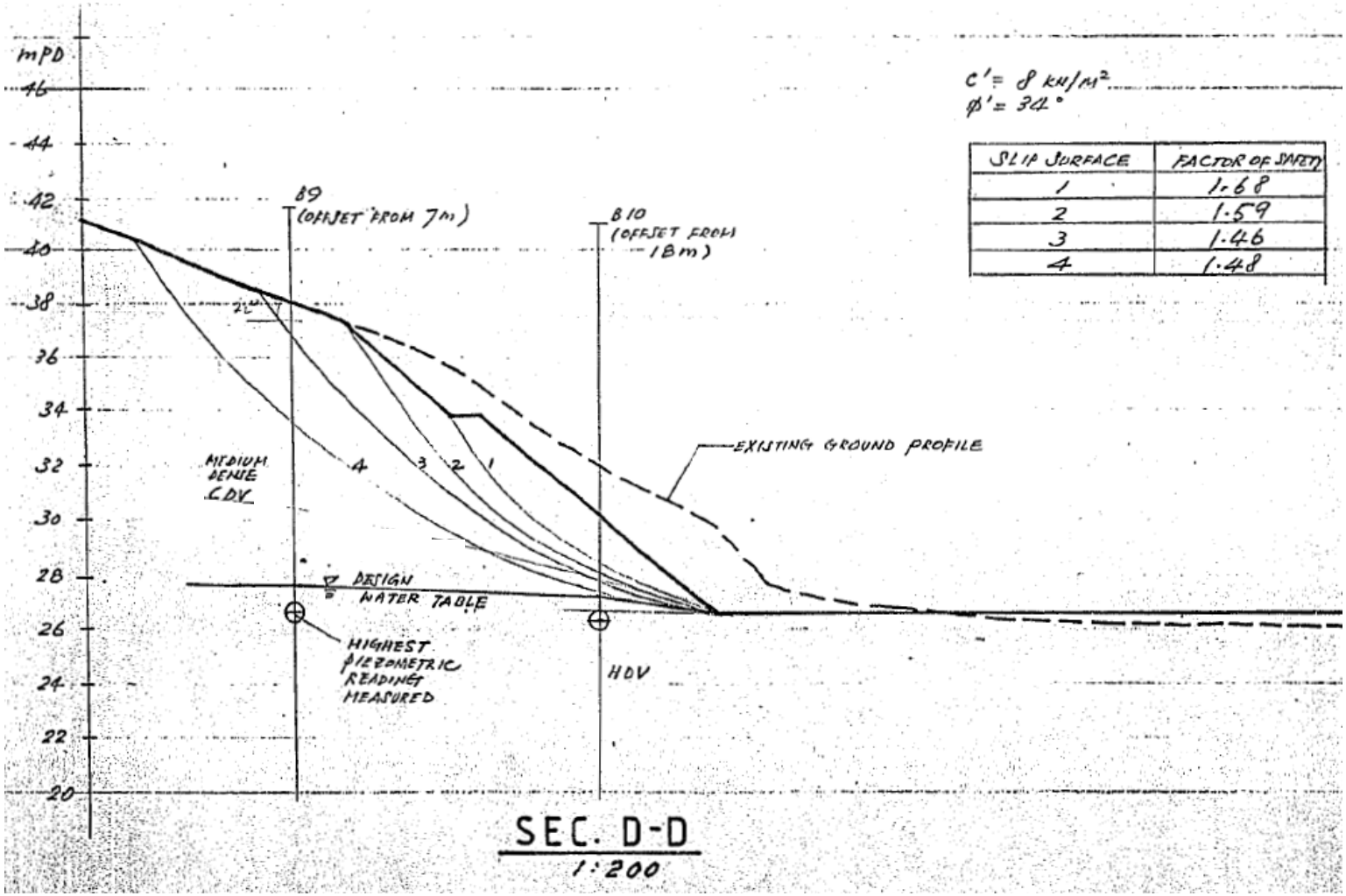

Legend : Plan extracted from GEO File No. GCMW 3/1/575.

Figure 7 - Previous Stability Analysis for the Slope No. 3SW-C/C234

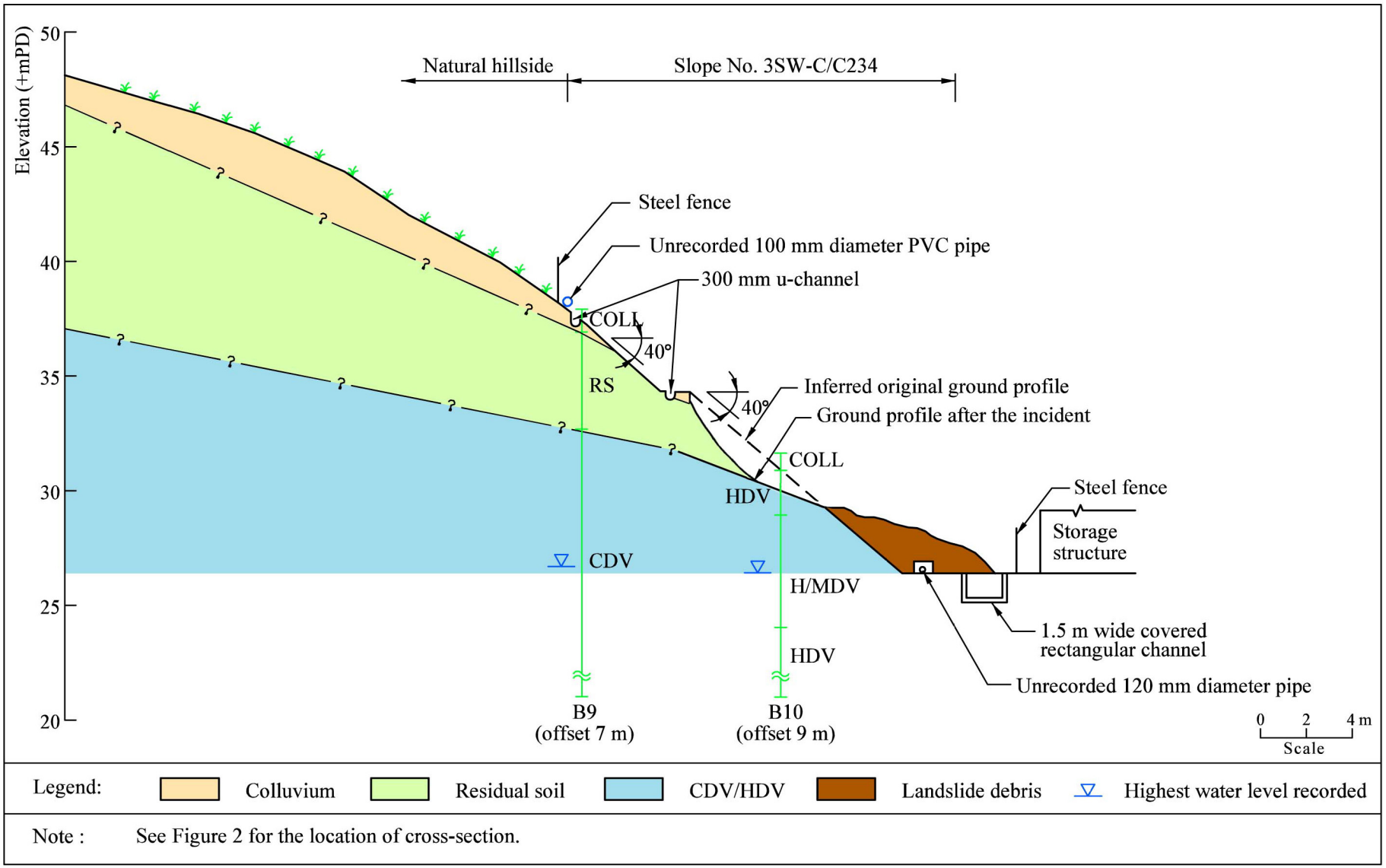

Figure 8 - Section A-A through the 21 August 2005 Landslide

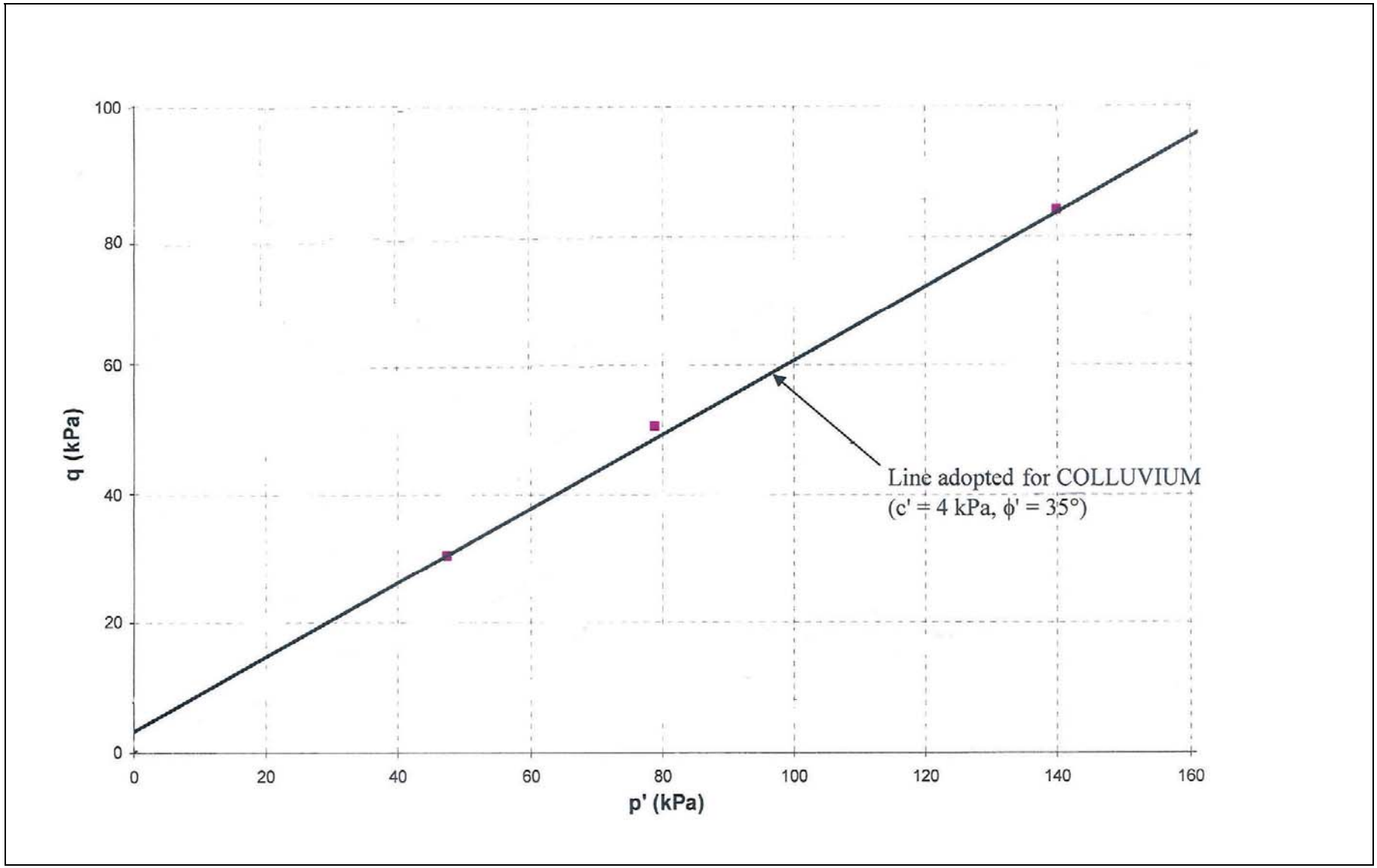

Figure 9 - p'-q Plot for Colluvium

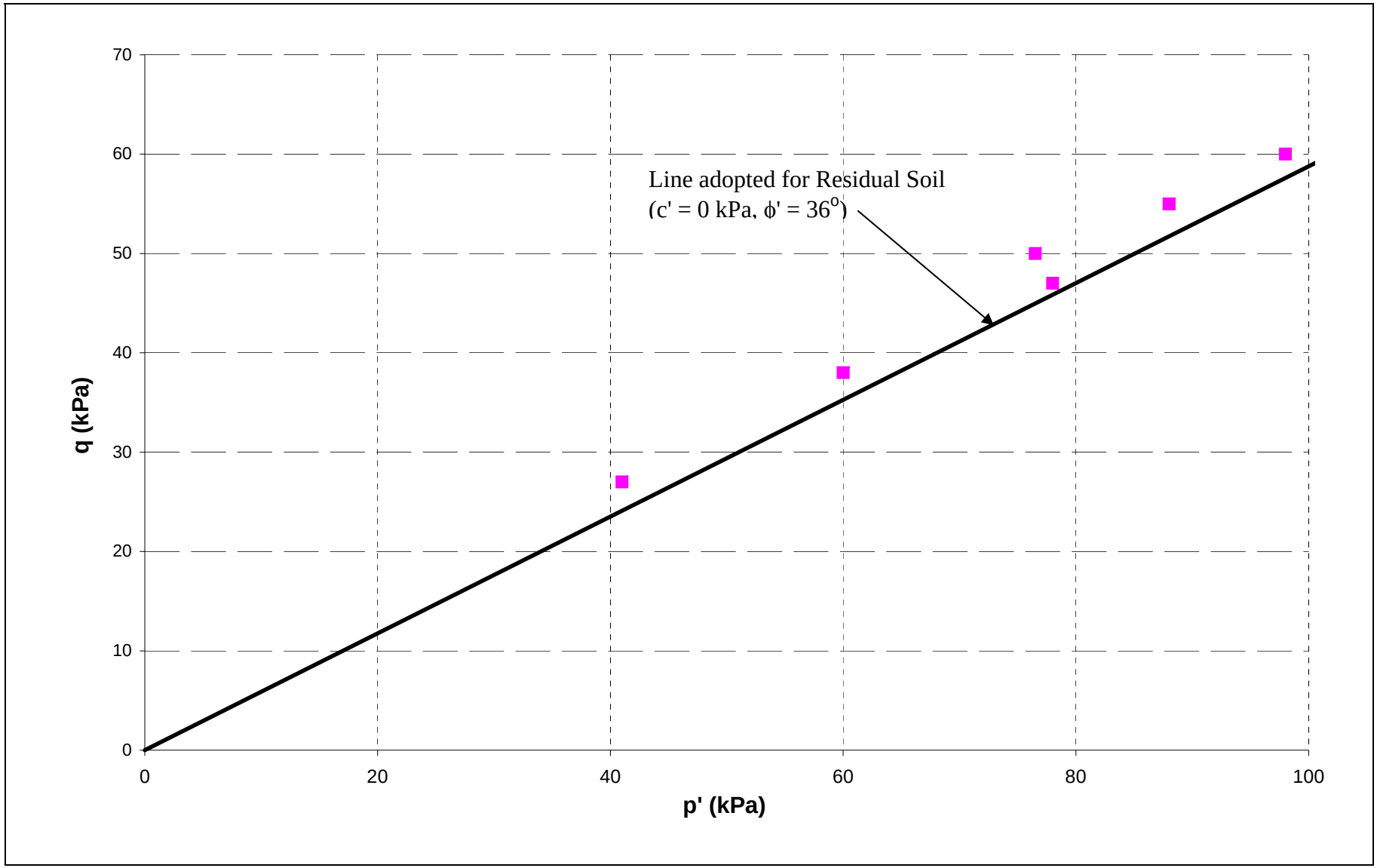

Figure 10 - p'-q Plot for Residual Soil

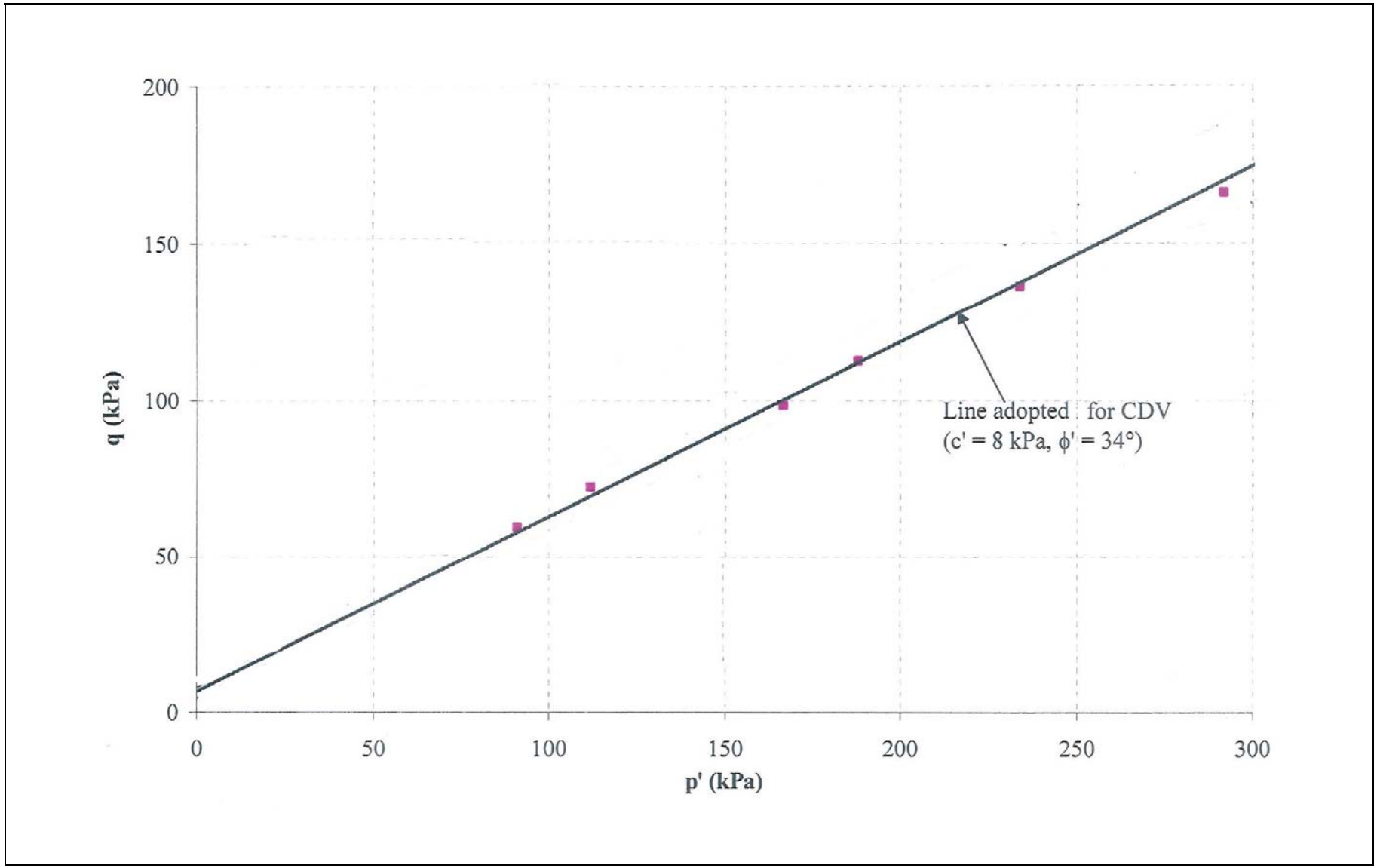

Figure 11 - p'-q Plot for CDV

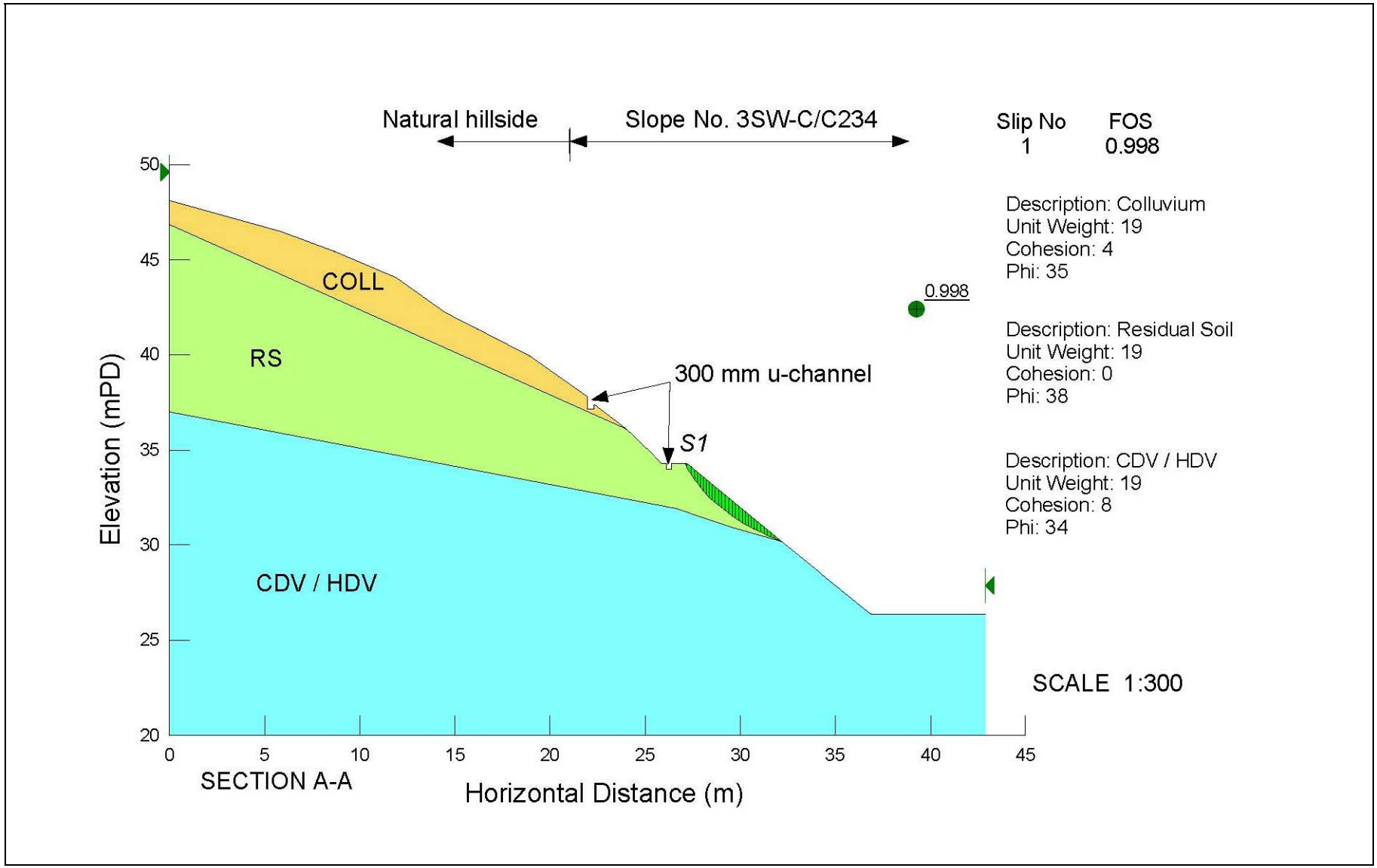

Figure 12 - Summary of Theoretical Stability Analysis of the August 2005 Slip Surface

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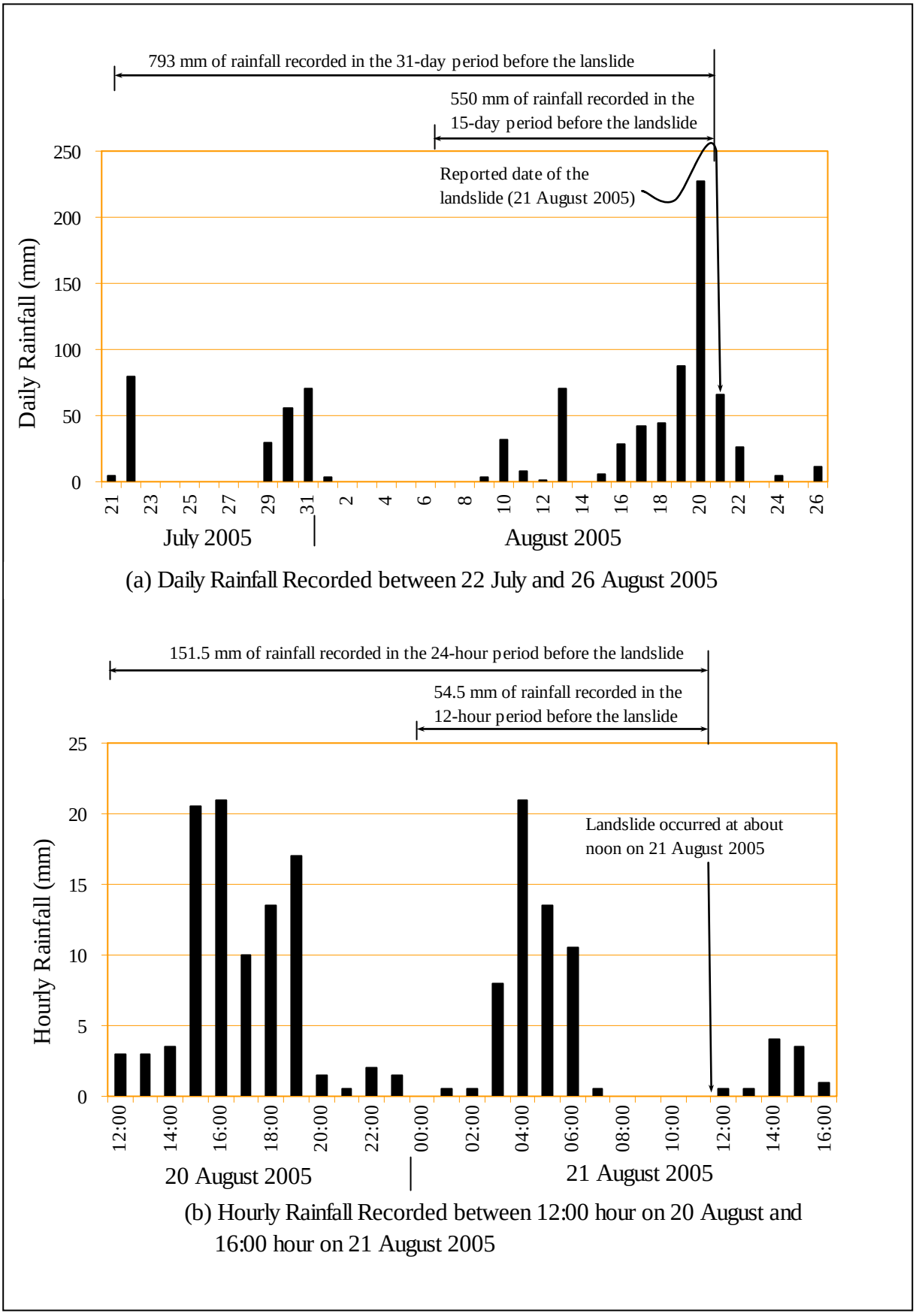

Figure 13 - Daily and Hourly Rainfall Recorded at GEO Raingauge No. N05

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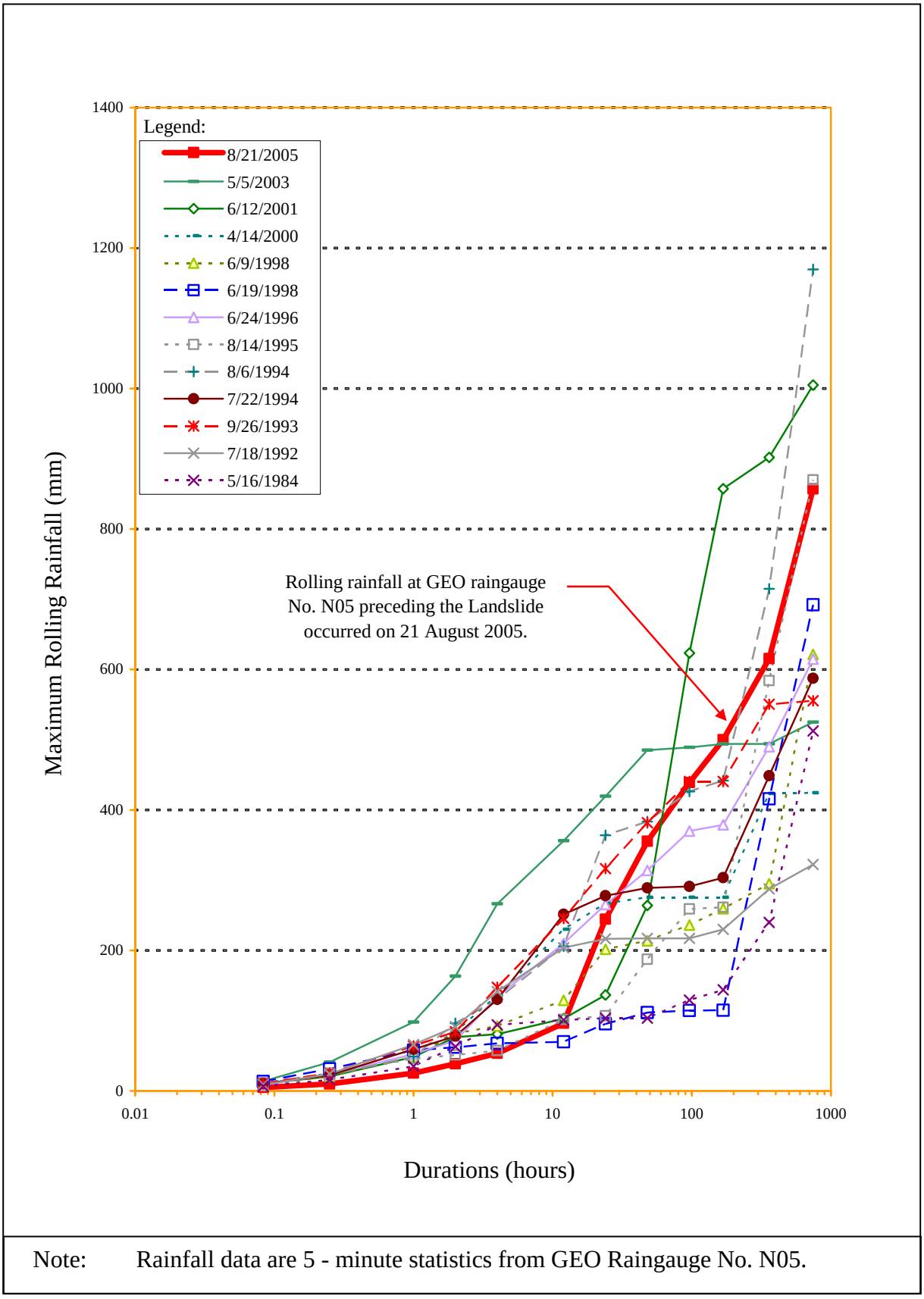

Note: Rainfall data are 5 - minute statistics from GEO Raingauge No. N05.

Figure 14 - Maximum Rolling Rainfall for Previous Major Rainstorms at GEO Raingauge No. N05 between 1984 and 2005

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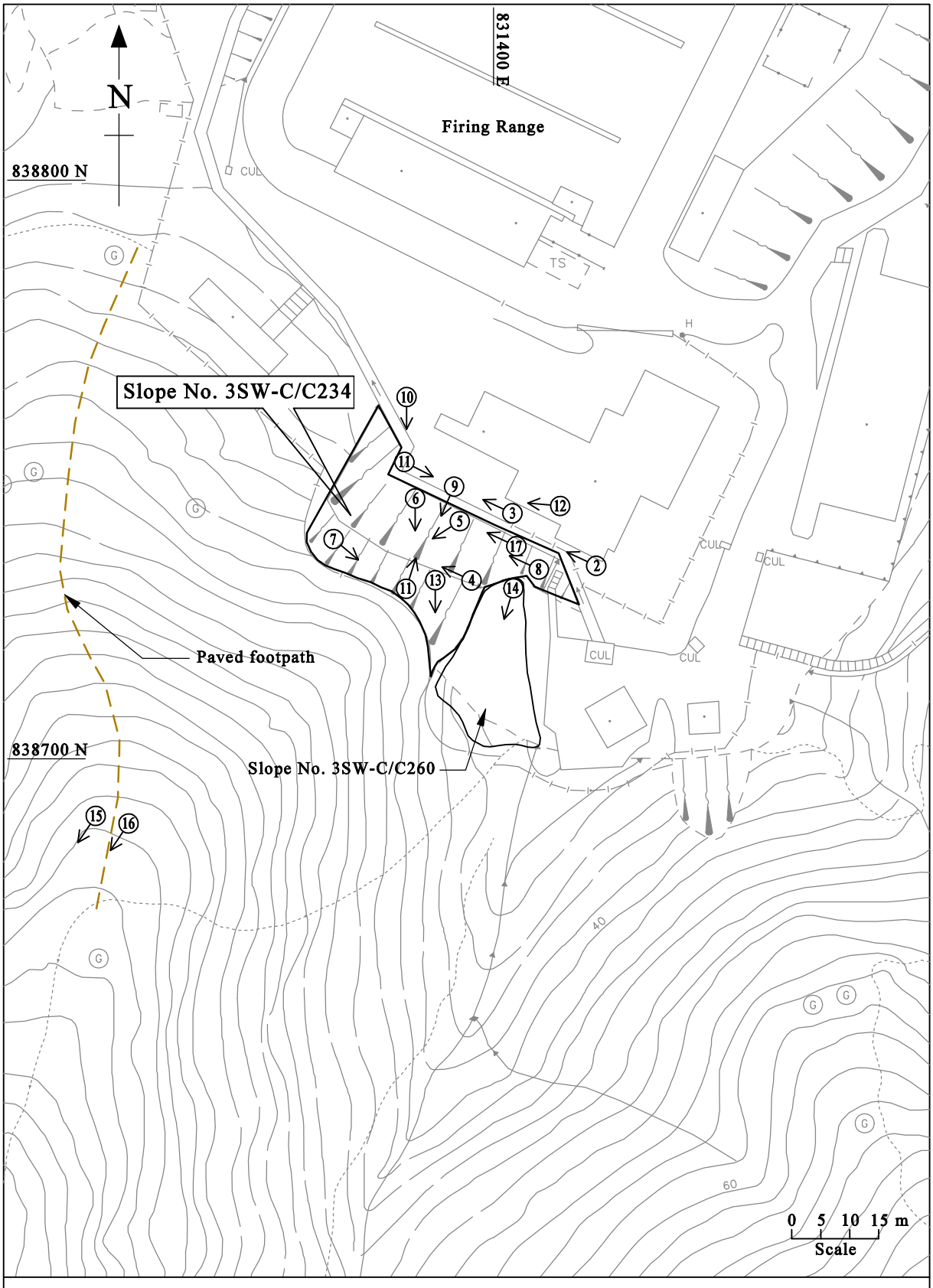

Note : Base map is extracted from survey sheet No. 3SW-11D & 12C, Scale 1:1000.

Figure 15 - Location and Directions of Photographs Taken

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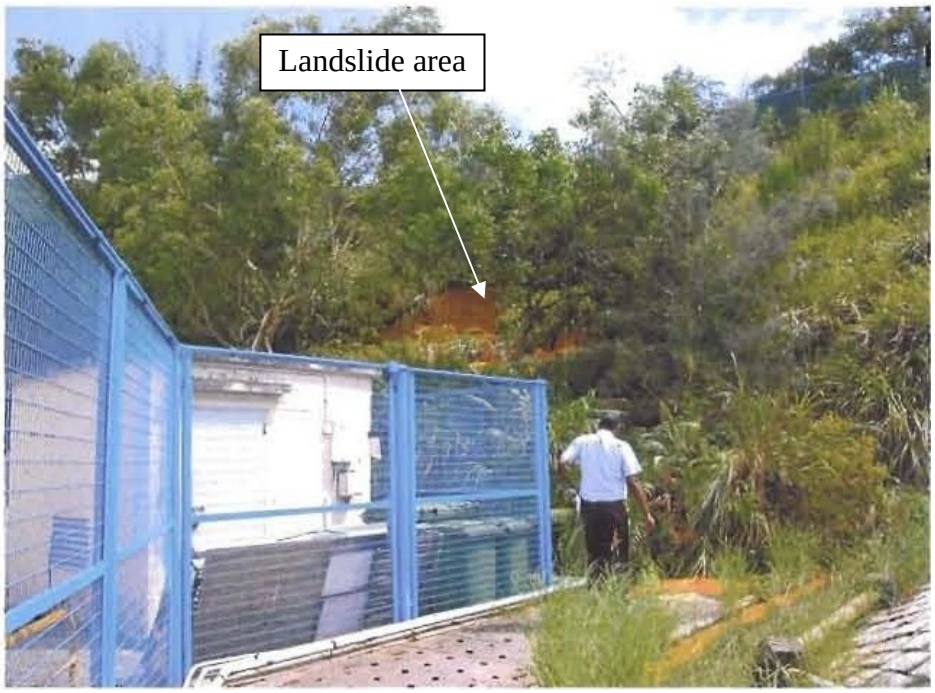

Plate 1 - General View of the Landslide Site
(Photograph taken by GEO on 22 August 2005)

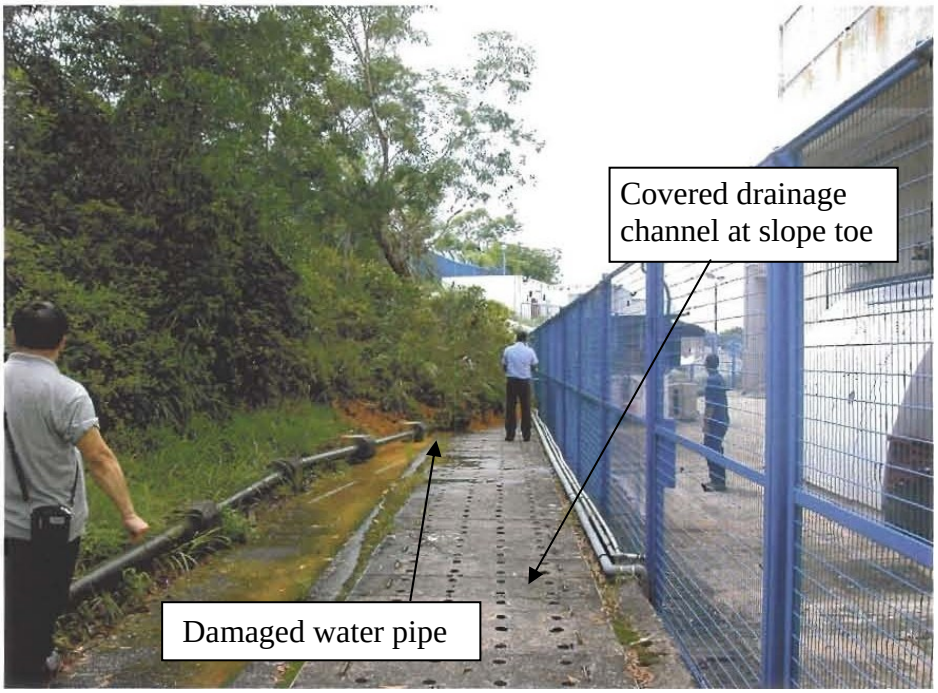

Plate 2 - Landslide Debris Damaged a Water Pipe along the Slope Toe
(Photograph taken by GEO on 22 August 2005)

Note : See Figure 15 for locations and directions of photographs.

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Plate 3 - Side View of the Landslide Site
(Photograph taken by MGSL on 14 November 2005)

Plate 4 - General View of the Crest of the Landslide Site
(Photograph taken by MGSL on 14 November 2005)

Note : See Figure 15 for locations and directions of photographs.

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Plate 5 - General View of the Back Scarp of the Landslide Site
(Photograph taken by MGSL on 14 November 2005)

Plate 6 - Soil Materials Exposed on the Back Scarp of the Landslide Site
(Photograph taken by MGSL on 14 November 2005)

Note : See Figure 15 for locations and directions of photographs.

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Plate 7 - A 100 mm Diameter PVC Pipe Running along the Crest of Slope No. 3SW-C/C234
(Photograph taken by HCL on 18 December 2007)

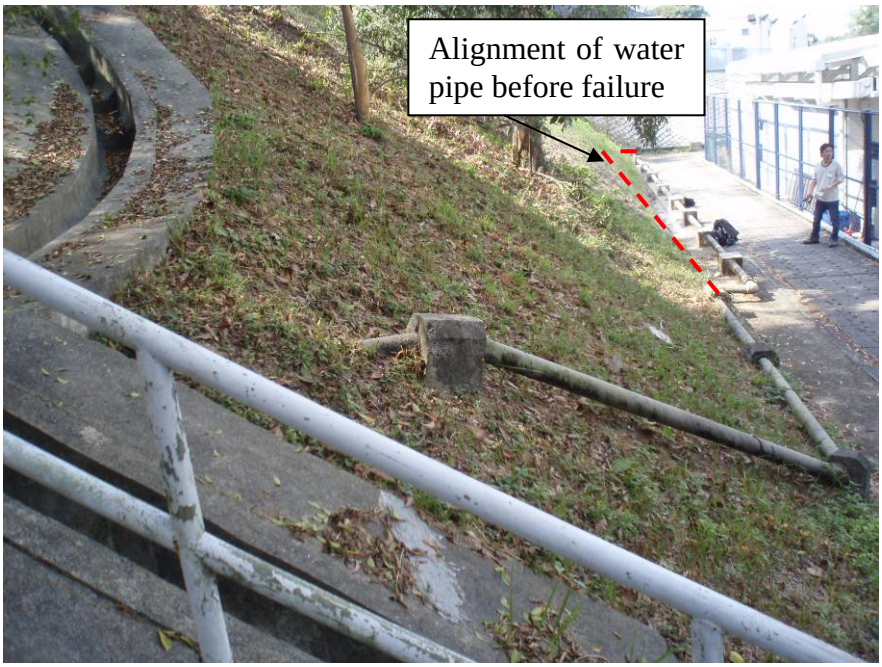

Plate 8 - A 120 mm Diameter Pipe Emerging from the Lower Batter of Slope No. 3SW-C/C234
(Photograph taken by HCL on 18 December 2007)

Note : See Figure 15 for locations and directions of photographs.

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Plate 9 - Completely Decomposed Tuff Exposed on the Landslide Debris
(Photograph taken by MGSL on 14 November 2005)

Plate 10 - General View of Slope No. 3SW-C/C234 after
Completion of Urgent Repair Works
(Photograph taken by HCL on 18 December 2007)

Note : See Figure 15 for locations and directions of photographs.

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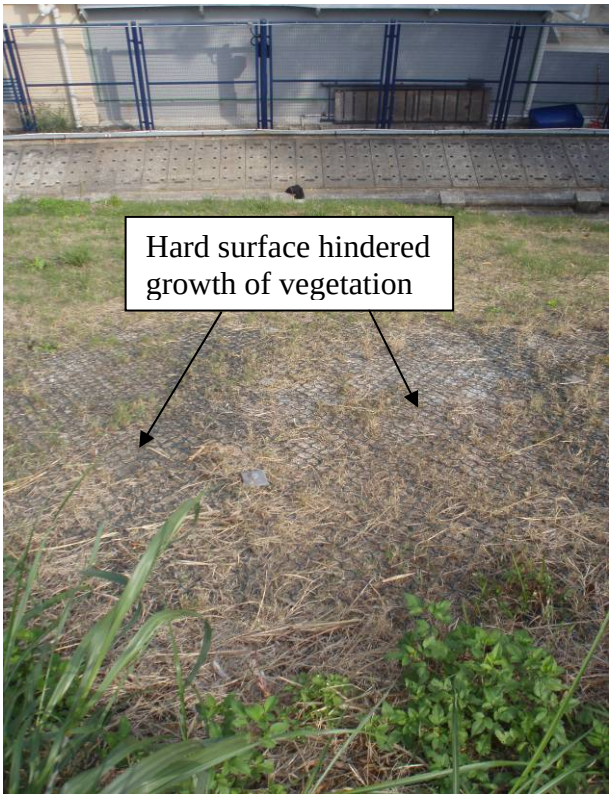

Plate 11 - Close-up View of Bare Surface from Slope Berm
(Photograph taken by HCL on 18 December 2007)

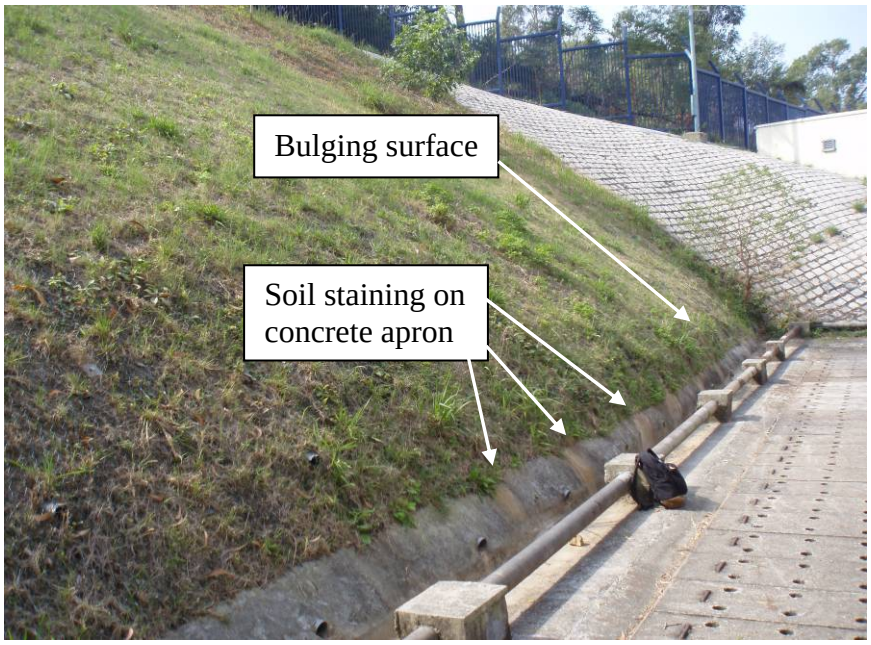

Plate 12 - Soil Staining and Bulging Observed at the Toe of Slope No. 3SW-C/C234
(Photograph taken by HCL on 18 December 2007)

Note : See Figure 15 for locations and directions of photographs.

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Plate 13 - Rock Outcrop Exposed on the Upper Batter of the Slope No. 3SW-C/C234
(Photograph taken by HCL on 18 December 2007)

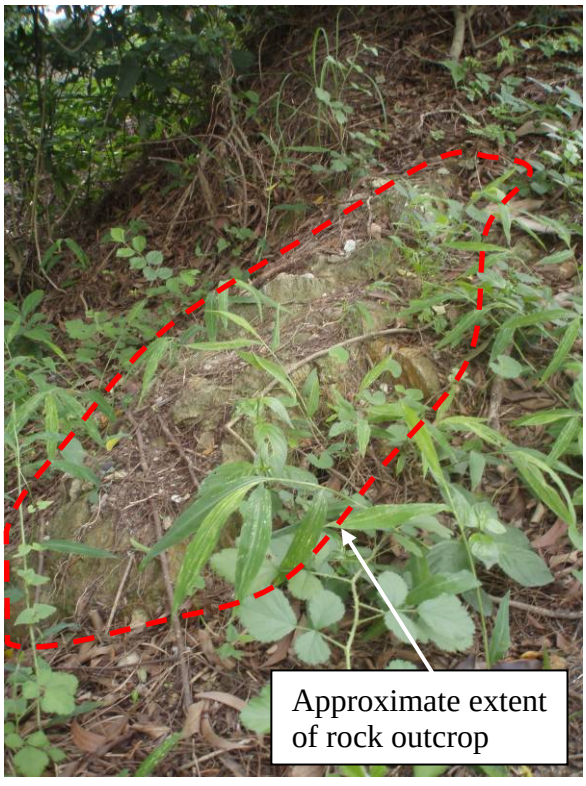

Plate 14 - Rock Outcrop Exposed Immediately to the East of Slope No. 3SW-C/C234
(Photograph taken by HCL on 18 December 2007)

Note : See Figure 15 for locations and directions of photographs.

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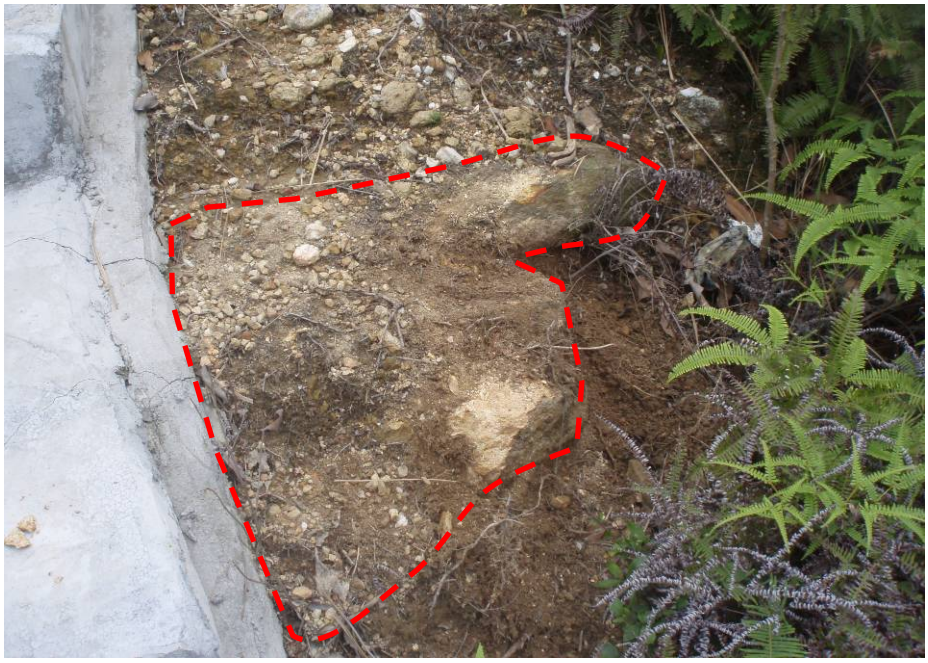

Plate 15 - Possible Rock Outcrop Exposed at the Right Hand Side of the Paved Footpath to the Southwest of Slope No. 3SW-C/C234
(Photograph taken by HCL on 30 April 2008)

Plate 16 - Possible Rock Outcrop Exposed at the Left Hand Side of the Paved Footpath to the Southwest of Slope No. 3SW-C/C234
(Photograph taken by HCL on 30 April 2008)

Note : See Figure 15 for locations and directions of photographs.

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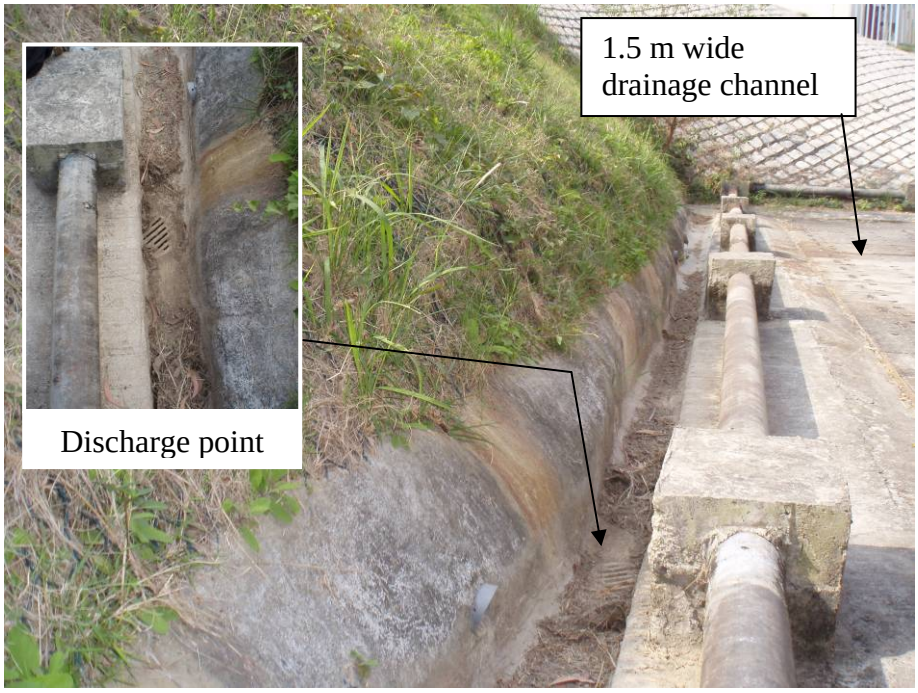

Plate 17 - The 100 mm U-channel at the Toe of Slope No. 3SW-C/C234 Discharges Water to the Adjacent 1.5 m Wide Covered Drainage Channel (Photograph taken by HCL on 18 December 2007)

Note : See Figure 15 for locations and directions of photographs.

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APPENDIX A

AERIAL PHOTOGRAPH INTERPRETATION

CONTENTS

A1. DETAILED OBSERVATIONS

The following report comprises the detailed observations made from the examination of aerial photographs taken between 1963 and 2006. A list of aerial photographs examined in this study is presented in Table A1 and the main observations of the API are shown in Figure A1 and Figure A2.

YEAR	**OBSERVATIONS**
1963	Excellent quality, low-flight aerial photographs. The subject slope No. 3SW-C/C234 had not yet been constructed. It was located at the toe of a north-facing natural hillside with a shallow slope gradient of approximately 30°. There were a number of discontinuous north-east trending ridges truncated by valleys in vicinity of the subject slope area. These ridges appeared to lie along the same axis and rock outcrops/boulders can be observed on these ridges. This possibly suggested that a band (could be a discontinuity including metamorphosed band, bedding planes or dyke) of high resistance to weathering may be underlying the ridges. A photolineament evidenced by an apparent linear topographic depression could be delineated along the valley located immediately to the east of the subject area running towards the north. This photolineament was believed to be underlain by material of relatively less resistance to weathering and could be associated with different geology or structural weakness. A convex change-in-slope was evidenced above the slope area. Concave break-in-slope was observed below this convex change-in-slope near to the toe of the hillside. A number relict landslide scars evidenced by convex break-in-slope area were also observed on the southeastern flank of the valley immediately to the east of the subject slope area. The hillside in vicinity of the subject slope area was generally undeveloped and covered with a thin veneer of vegetation including grass and occasional shrubs. Gravesites were visible near the upper mid-slope and the ridge to the west. The hillside to the west appeared to have been locally affected by anthropogenic modification with remnant of agricultural terraces evidenced. The alluvial toe slope immediate at the toe of the subject slope area demonstrated high reflectivity brought by the prevailing agricultural activities. Two northeast- and northwest- draining perennial stream courses could be observed emanating from the steep broad valleys to the east of the slope area. Some localised incisions and steeper section could be demarcated. Based on the geomorphology, valley colluvium possibly accumulated within these stream valleys. An access trail could be discerned above the subject slope area connecting bottom of the stream valley to the uphill area.

1964 High elevation stereo pairs of fair quality.

No observable significant change.

1973 High elevation high quality stereo pairs.

Denser vegetation could be observed on the hillside in vicinity of the subject slope area. A lineament on the vegetation cover, possibly a footpath, was observed traversing the mid portion of the subject slope area. The footpath led to the valley to the east of the subject slope area where a rectangular platform associated with a small bare slope surface had been created. This small bare slope surface (which was later modified into Slope No. 3SW-C/C260) could be a cut slope formed for the creation of the platform or alternatively could be a small failure occurred on the hillside.

1975 High elevation high quality stereo pairs.

There was no observable significant change to the subject area.

1976 Monograph only. Good quality and high altitude aerial photograph.

A footpath was created uphill of the subject area. The rectangular platform observed in 1973 appeared to have been renovated. Slope No. 3SW-C/C241 was constructed in associated with the renovation.

1978 High altitude fair quality stereo pairs.

No significant change since 1976.

1979 Monograph only. Good quality and high altitude aerial photograph.

No significant change observed on the subject slope area. Darker toned area possibly created by agricultural activities was observed on the renovated platform observed in 1976.

1981 Monograph only. Poor quality and high altitude aerial photograph.

No significant change since 1979.

1982 High elevation high quality stereo pairs.

No significant change observed apart from dense trees growing on the subject slope area.

1983 High elevation good quality stereo pairs.

No significant change.

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1985 High elevation stereo pairs.

No significant changes except some possible excavation works evident by high reflectivity was undertaken within Slope No. 3SW-C/C260.

1986 Low altitude good quality stereo pairs.

No significant change except a lineament, possibly a drainage line was discerned to the west of the study area.

1987 Low elevation monograph.

There was no observable significant change to the subject area. Large site clearance and formation of platform for the construction of Police Tactical Unit depot has commenced to the northeast of the subject area.

1988 Good quality stereo pairs.

The hillside in vicinity of the subject slope area appeared to be overlain by a thin veneer of short grass only. Clusters of rock outcrops/boulders were observed on the spur immediately above the subject slope area. A small cut/fill platform was constructed on the hillside above the subject slope area.

To the north-east, the site clearance works of Police Tactical Unit Depot was complete.

1989 High elevation stereo pairs.

No significant change could be observed except the construction of Police Tactical Unit Depot appeared to be substantially completed.

1990 Good quality stereo pairs.

The construction of Police Tactical Unit Depot was complete as the present-day configuration while the site clearance and excavation works for the construction of Firing Range was undertaken immediately in front of the subject slope. The subject slope No. 3SW-C/C234 was undergoing construction in association with the site formation work. It appeared as a cut slope with its surface apparently composed of material of soil texture. The subject slope appeared to be composed of two cut batters separated by a berm. An area of bared surface could be discerned on the hillside immediately above the crest of the subject slope which could be associated with surface erosion or could be surface clearance created during the construction of the slope.

A rectangular feature likely to be a culvert was observed on the platform immediate to the southeast of the subject slope. U-channels were visible extending from the culvert, through the toe of lower batter, to the northeast lower-lying sloping ground.

1991 Monograph only. Fair quality and high altitude aerial photograph.

Construction of the Firing Range was still in progress. No changes of significance could be identified around the subject slope.

1992 Good quality stereo pairs.

The surface of the subject slope appeared to be covered by dense grass. Surface drainage channels were constructed on the crest and between the batters of the subject slope.

Site formation work was on-going on the platform located immediately to the east of the subject slope. In association with this site formation work, fill material was being placed on the platform and the lower portion of the small cut slope (or landslide scar) observed in 1973. The filling material appeared to be soil based on its texture and tones.

A building structure had been constructed on the platform immediately in front of the subject slope.

Immediately to the west of the subject slope, a cut/fill platform with a building constructed on it had been created.

1993 Fair quality stereo pairs.

No observable significant change except the Firing Range and the associated access roads was constructed as the present-day extent.

The site formation works observed on the platform immediately to the east of the subject slope was likely to be completed. The small cut slope/landslide scar described in 1992 was evidenced to have been modified with its dimension similar to the present day 3SW-C/C260. Lineament, possibly a drainage channel, could be observed on the crest of this slope. A new building structure was constructed on this platform in front of Slope No. 3SW-C/C241.

1994 Good quality stereo pairs.

No significant changes except more scattered shrubs were grown within the lower and upper mid portions of the subject slope and Slope No. 3SW-C/C260.

1995 Good quality stereo pairs.

No significant changes except clearance of vegetation had been undertaken within the general area of the subject slope and adjacent Slope No. 3SW-C/C260. Lineament possibly a security fence was erected along the crest of the subject slope and slope no. 3SW-C/C260. A small rectangular structure was built in front of the subject slope.

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1996 Good quality stereo pairs.

No significant changes except a curvilinear feature possibly a man-made drainage channel was observed immediately above the subject slope. Another small rectangular structure was built adjacent to the small rectangular structure observed in 1995.

1997 Good quality stereo pairs.

No significant change apart from isolated small trees could be discerned on the lower portion of the Subject Slope.

1998 Good quality stereo pairs.

No significant change except more small shrubs and thin grass cover were visible at the toe portion of the subject slope.

1999 Good quality stereo pairs.

No significant change.

2000 High elevation stereo pairs.

No significant change observed owing to the high flight, fair quality aerial photographs.

2001 Good quality stereo pairs.

No significant change was apparent.

2002 Good quality stereo pairs.

An area in the western portion of the subject slope and the area around the cut/fill platform to the west (first observed in 1992) appeared to be covered with surfacing, evidenced by its lighter tone.

2003 Fair quality stereo pairs.

No significant change except vegetation density within the general area of the subject slope continued to increase.

2004 Fair resolution stereo pairs.

The central portion of the lower batter of subject slope was overgrown by dense vegetation.

2005	Fair resolution stereo pairs. No significant changes except clearance of vegetation was observed on the upper batter of the subject slope.
2006	Fair resolution stereo pairs. No significant changes could be observed. The slope face had been generally thinly vegetated with grass and shrubs.

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Table A1 - List of Aerial Photographs

Date taken	Altitude (ft)	Photograph Number
22 Feb 1963	3,900	Y09965 – Y09966
14 Dec 1964	12,500	Y13094 – Y13095
20 Dec 1973	12,500	7883 – 7884
24 December 1975	12,500	11919 – 11920
4 November 1976	12,500	16021
15 December 1978	12,500	24505, 24507
29 November 1979	10,000	28340
13 January 1981	10,000	35591
10 October 1982	10,000	44714 – 44715
22 December 1983	10,000	52300 – 52301
4 October 1985	15,000	A02770 – A02771
7 March 1986	4,000	A04681 – A04682
12 July 1987 10 October 1987	4,000 9,000	A09781 CN1175
8 January 1988	4,000	A11696 – A11697
30 November 1989	20,000	A19782 – A19783
3 December 1990	4,000	A24233 – A24234
24 October 1991	10,000	A28617
28 April 1992	4,000	A30610 – A30611
6 December 1993	10,000	CN5472 – CN5473
14 May 1994	4,000	A38286 – A38287
19 December 1995	3,500	CN12965 – CN12966
29 October 1996	3,500	A43609 – A43610
15 May 1997	3,500	CN16840 – CN16841
5 July 1998	3,000	CN19649 – CN19650
7 September 1999	3,500	CN23659 – CN23660
16 February 2000	20,000	CN26090R – CN26091R
29 March 2001	3,500	CW30335 – CW30336
8 October 2002	8,000	CW44527 – CW44528

Date taken	Altitude (ft)	Photograph Number
3 July 2003	3,000	CW48818 – CW48819
17 December 2004	7,000	CW63357 – CW63358
7 May 2005	2,500	CW64726 – CW64727
6 November 2006	8,000	CW73802 – CW73803
Note: All aerial photographs are in black and white except for those prefixed with CN or CW.		

LIST OF FIGURES

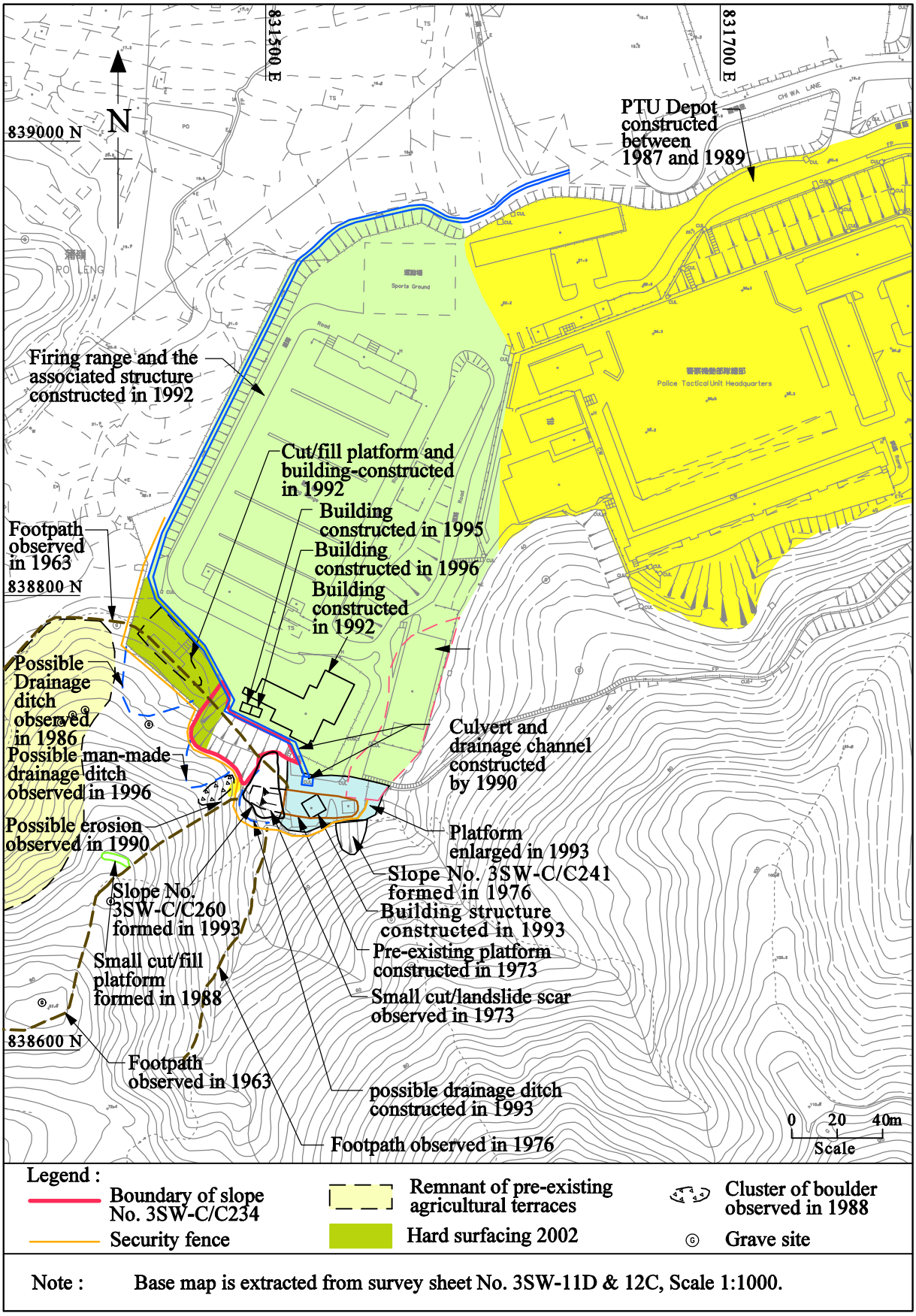

Figure A1- Site Development History

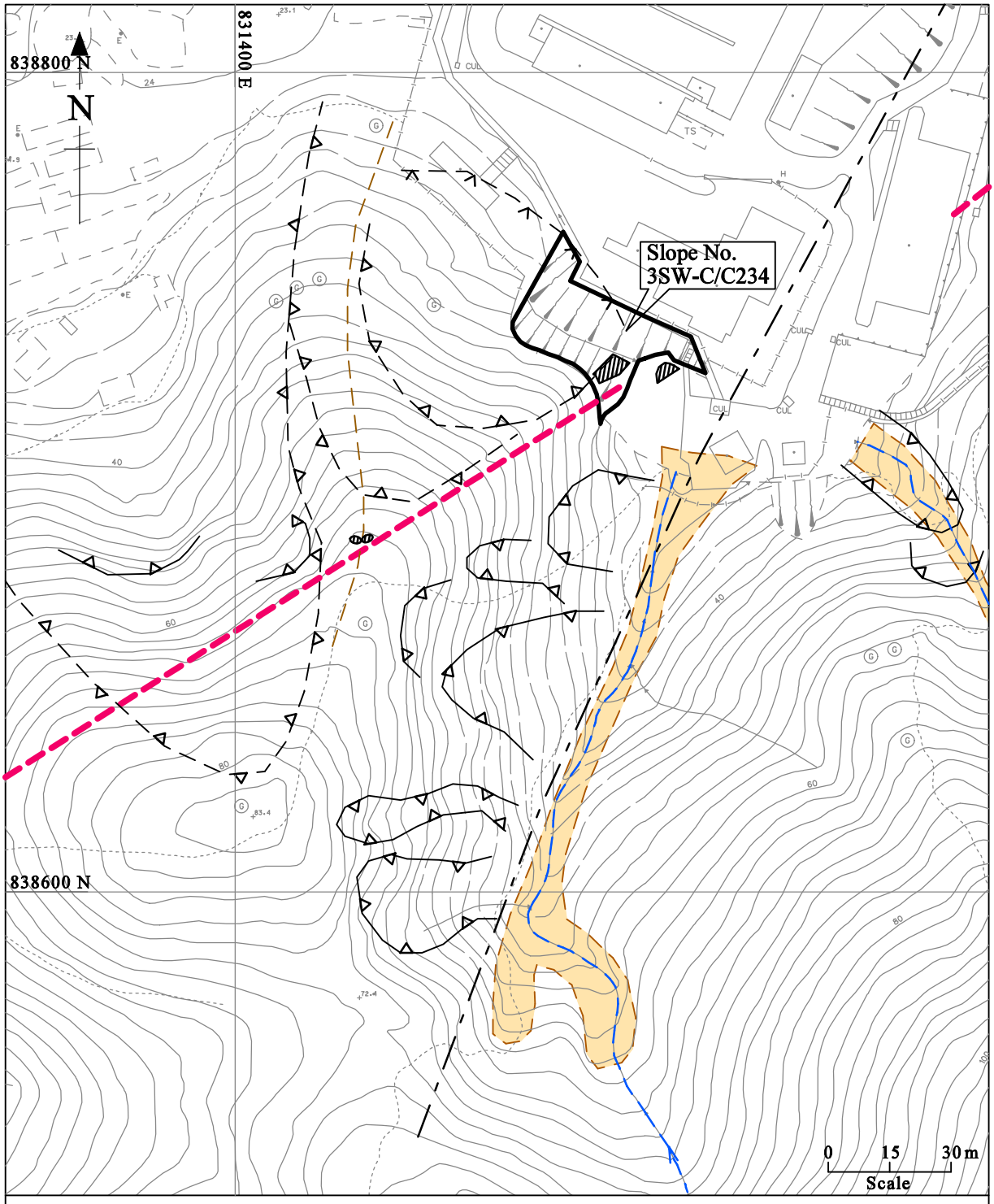

Figure A2 - Aerial Photograph Interpretation

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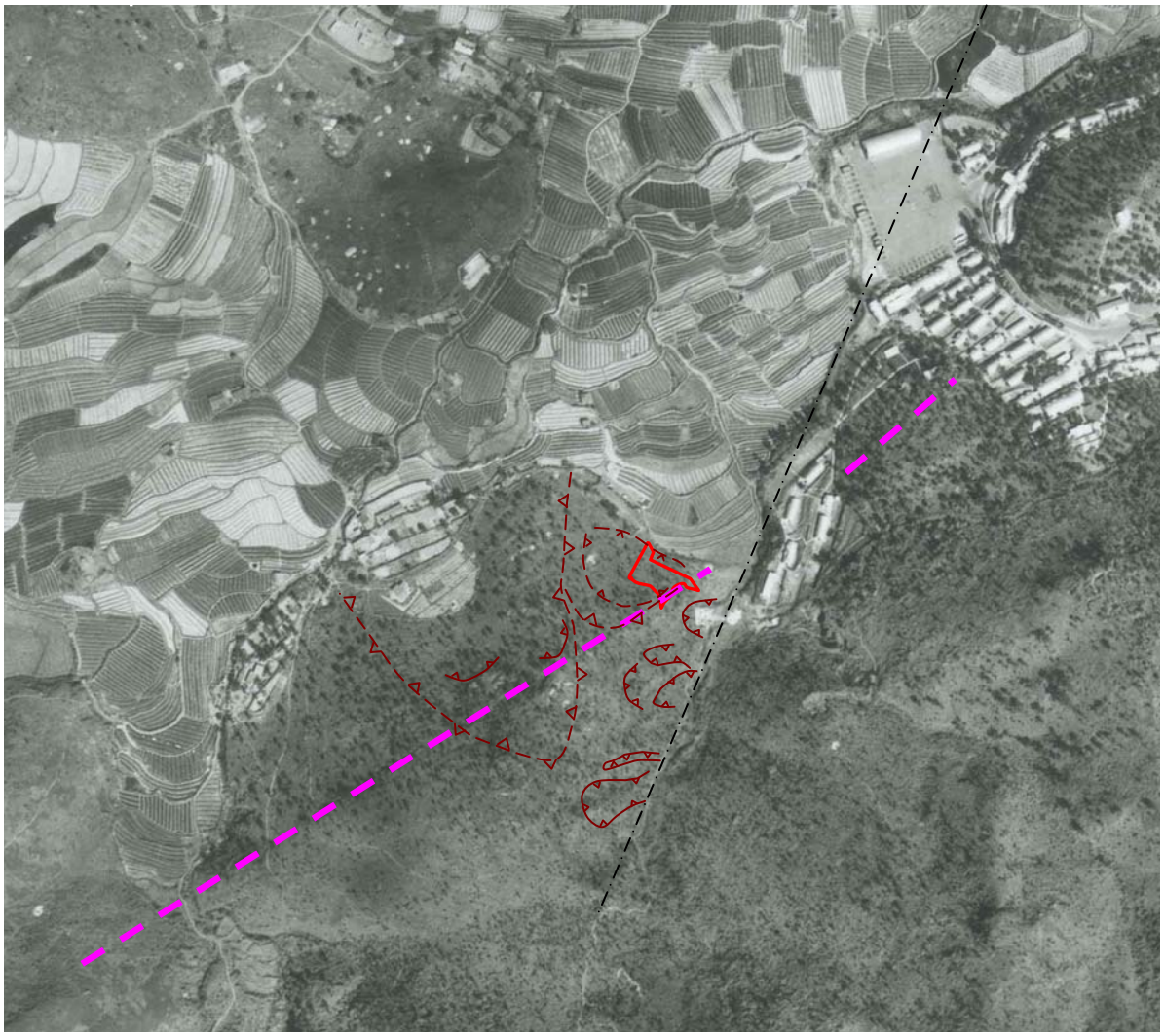

Legend:

- Location of Slope No. 3SW-C/C234
- Relict landslide scar
- Convex change-in-slope
- Concave break-in-slope
- Spurline
- Possible hard band (Silicified Band)
- Photolineament

Plate A1 - Interpretation of 1963 Aerial Photograph

Note : Aerial Photograph No. Y09965 taken on 22 February 1963.

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Legend:

Location of Slope No. 3SW-C/C234

Plate A2 - Interpretation of 1990 Aerial Photograph

Note : Aerial Photograph No. A24234 taken on 3 December 1990.

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APPENDIX B

RECORDS OF RELEVANT DRILLHOLES

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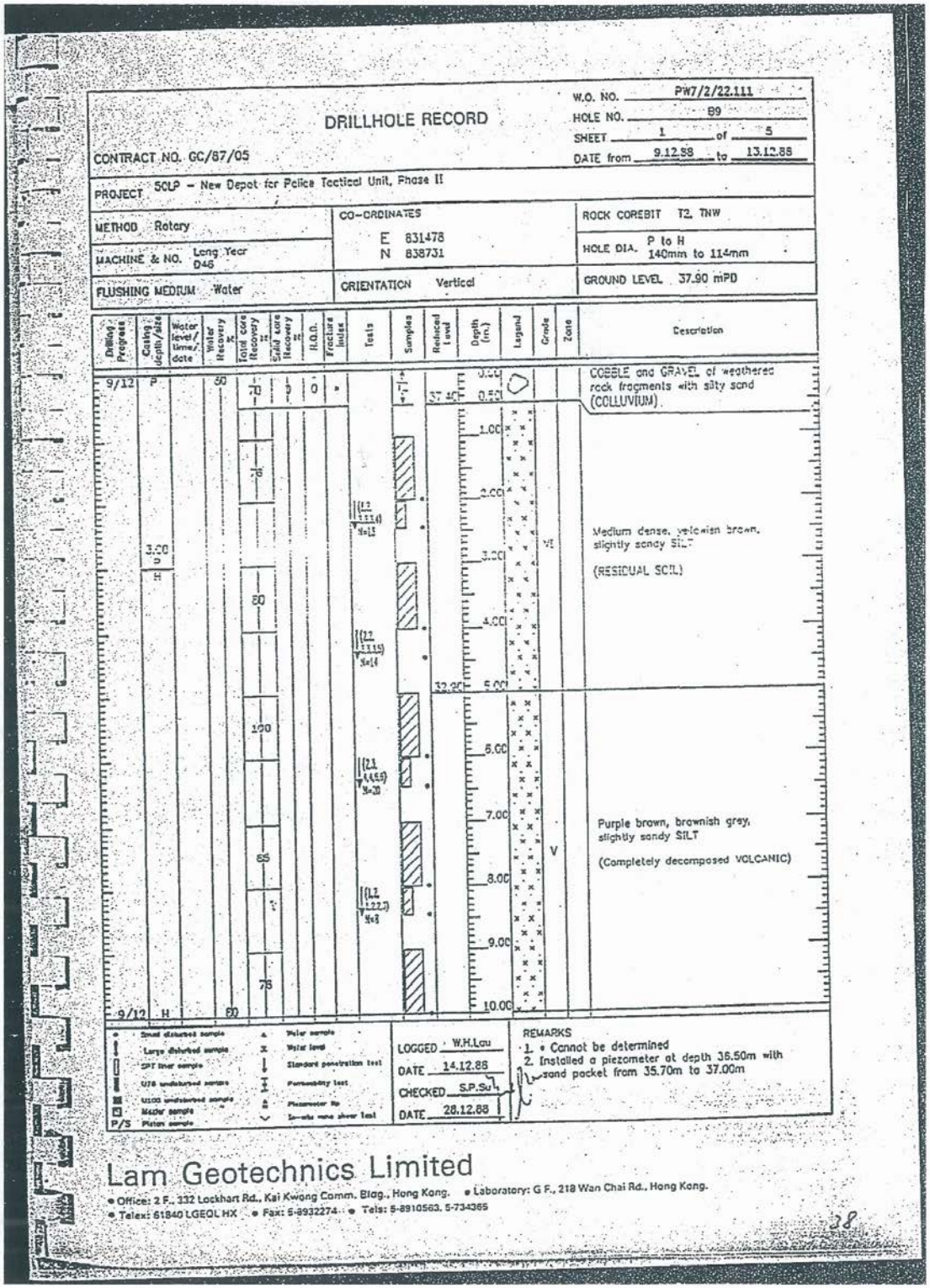

DRILLHOLE RECORD

W.O. NO. PW7/2/22.111
HOLE NO. B9
SHEET 1 of 5
DATE from 9.12.88 to 13.12.88

CONTRACT NO. GC/87/05

PROJECT SCLP – New Depot for Police Tactical Unit, Phase II

METHOD Rotary
MACHINE & NO. Long Year D45
FLUSHING MEDIUM Water

CO-ORDINATES
E 831478
N 838731

ORIENTATION Vertical

ROCK COREBIT T2, TNW
HOLE DIA. P to H 140mm to 114mm
GROUND LEVEL 37.90 mPD

Drilling Progress | Casing Depth/Size | Water level/ time/ date | Water Recovery % | Total core Recovery % | Solid core Recovery % | R.Q.D. % | Fracture Index | Tests | Samples | Reduced Level | Depth (m) | Legend | Grade | Zone | Description

9/12 P
3.00 U
H
9/12 H

0.00 CORBLE and GRAVEL of weathered rock fragments with silty sand (COLLUVIUM).
0.50
Medium dense, yellowish brown, slightly sandy SILT (RESIDUAL SOIL)
32.90 5.00
Purple brown, brownish grey, slightly sandy SILT (Completely decomposed VOLCANIC)
10.00

Small disturbed sample
Large disturbed sample
SPT liner sample
U76 undisturbed sample
U100 undisturbed sample
Water sample
P/S Piston sample
Water sample
Water level
Standard penetration test
Permeability test
Piezometer tip
In-situ vane shear test

LOGGED W.H.Lau
DATE 14.12.88
CHECKED S.P.Su
DATE 28.12.88

REMARKS
1. * Cannot be determined
2. Installed a piezometer at depth 36.50m with sand packet from 35.70m to 37.00m

Lam Geotechnics Limited
• Office: 2 F., 332 Lockhart Rd., Kai Kwong Comm. Bldg., Hong Kong. • Laboratory: G F., 218 Wan Chai Rd., Hong Kong.
• Telex: 61840 LGEOL HX • Fax: 5-8932274 • Tels: 5-8910563, 5-734365

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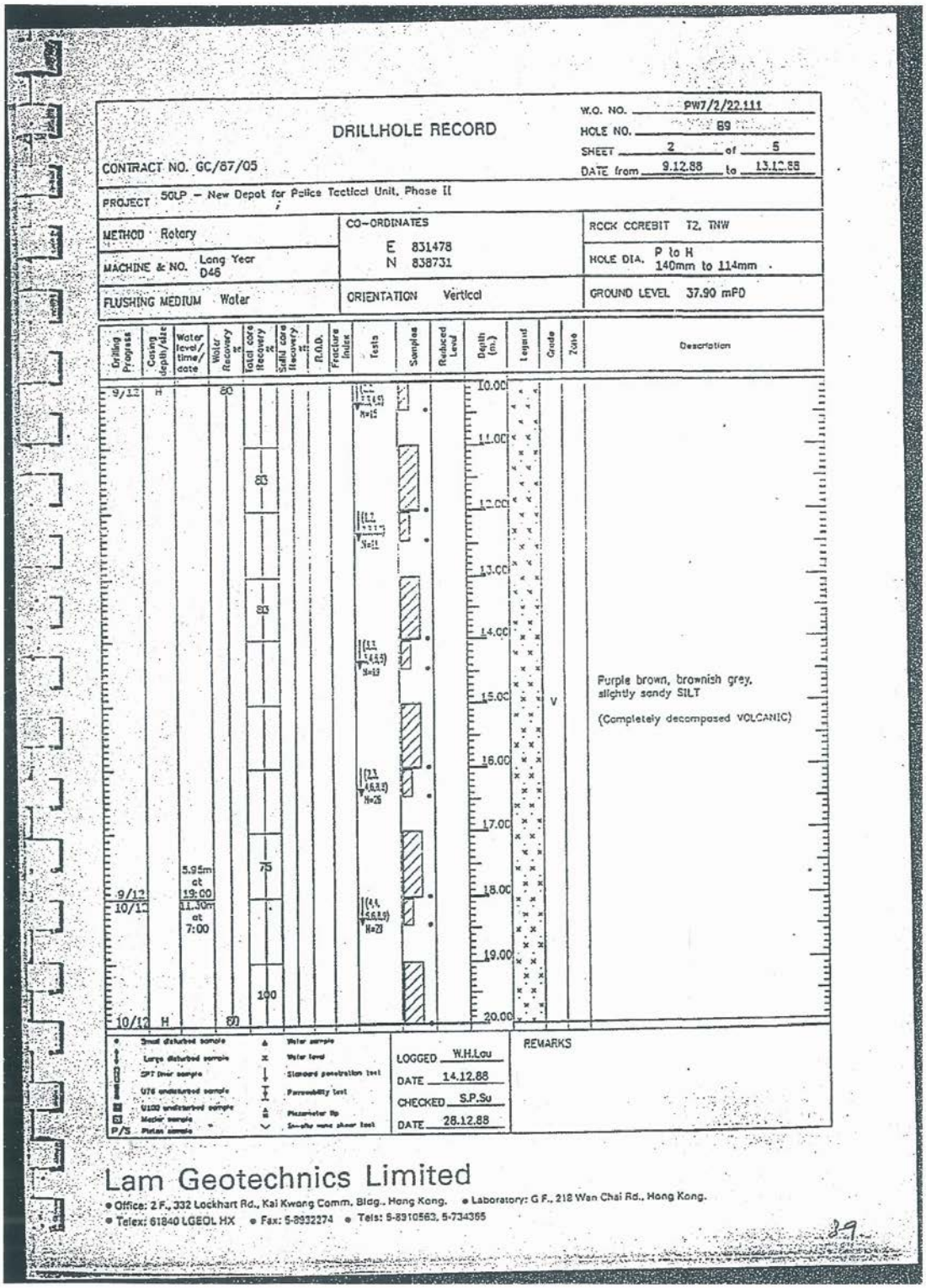
Figure B1 - Drillhole Record of B9 (Page 1 of 5)



DRILLHOLE RECORD

W.O. NO. PW7/2/22.111
HOLE NO. B9
SHEET 2 of 5
DATE from 9.12.88 to 13.12.88

CONTRACT NO. GC/87/05

PROJECT 50LP – New Depot for Police Tactical Unit, Phase II

METHOD Rotary
MACHINE & NO. Long Year D46
FLUSHING MEDIUM Water
CO-ORDINATES E 831478 N 838731
ORIENTATION Vertical
ROCK COREBIT T2, TNW
HOLE DIA. P to H 140mm to 114mm
GROUND LEVEL 37.90 mPD

Drilling Progress | Casing depth/size | Water level/time/date | Water Recovery % | Total core Recovery % | Solid core Recovery % | R.Q.D. % | Fracture Index | Tests | Samples | Reduced Level | Depth (m.) | Legend | Grade | Zone | Description

9/12 H 80
83
83
75
100
10/12 H 60

5.95m at 19:00 9/12
11.30m at 7:00 10/12

10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00

Purple brown, brownish grey, slightly sandy SILT
(Completely decomposed VOLCANIC)

Small disturbed sample
Large disturbed sample
SPT liner sample
U76 undisturbed sample
Ø100 undisturbed sample
Water sample
Water level
Standard penetration test
Permeability test
Piezometer tip
In-situ vane shear test

LOGGED W.H.Lau
DATE 14.12.88
CHECKED S.P.Su
DATE 28.12.88

REMARKS

Lam Geotechnics Limited
• Office: 2 F., 332 Lockhart Rd., Kai Kwong Comm. Bldg., Hong Kong. • Laboratory: G F., 218 Wan Chai Rd., Hong Kong.
• Telex: 61840 LGEOL HX • Fax: 5-8932274 • Tels: 5-8910563, 5-734365

B9

Figure B2 - Drillhole Record of B9 (Page 2 of 5)

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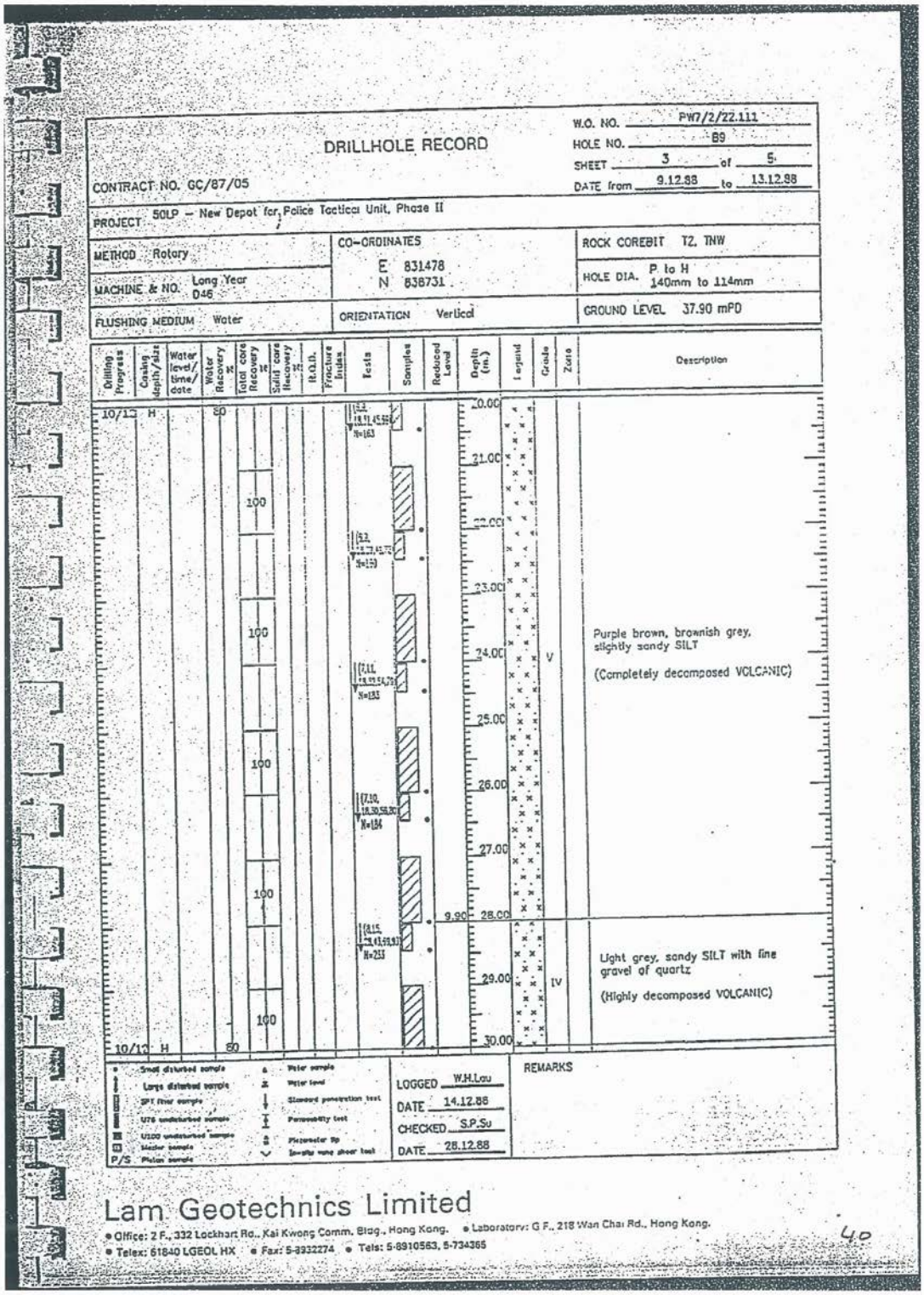

DRILLHOLE RECORD

W.O. NO. PW7/2/22.111
HOLE NO. B9
SHEET 3 of 5
DATE from 9.12.88 to 13.12.88

CONTRACT NO. GC/87/05

PROJECT SOLP – New Depot for Police Tactical Unit, Phase II

METHOD Rotary
MACHINE & NO. Long Year 046
FLUSHING MEDIUM Water
CO-ORDINATES E 831478 N 838731
ORIENTATION Vertical
ROCK COREBIT TZ, TNW
HOLE DIA. P to H 140mm to 114mm
GROUND LEVEL 37.90 mPD

Drilling Progress | Casing depth/dia | Water level/ time/ date | Water Recovery % | Total core Recovery % | Solid core Recovery % | R.Q.D. % | Fracture Index | Tests | Samples | Reduced Level | Depth (m) | Legend | Grade | Zone | Description

10/12 H — 80

20.00
21.00
22.00
23.00
24.00
25.00
26.00
27.00
28.00
9.90
29.00
30.00

100
100
100
100
100

Purple brown, brownish grey, slightly sandy SILT
(Completely decomposed VOLCANIC)

V

Light grey, sandy SILT with fine gravel of quartz
(Highly decomposed VOLCANIC)

IV

10/12 H — 80

Small disturbed sample
Large disturbed sample
SPT liner sample
U76 undisturbed sample
U100 undisturbed sample
Block sample
P/S Piston sample
Water sample
Water level
Standard penetration test
Permeability test
Piezometer tip
Sample vane shear test

LOGGED W.H.Lau
DATE 14.12.88
CHECKED S.P.Su
DATE 28.12.88

REMARKS

Lam Geotechnics Limited
• Office: 2 F., 332 Lockhart Rd., Kai Kwong Comm. Bldg., Hong Kong. • Laboratory: G F., 218 Wan Chai Rd., Hong Kong.
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Figure B3 - Drillhole Record of B9 (Page 3 of 5)

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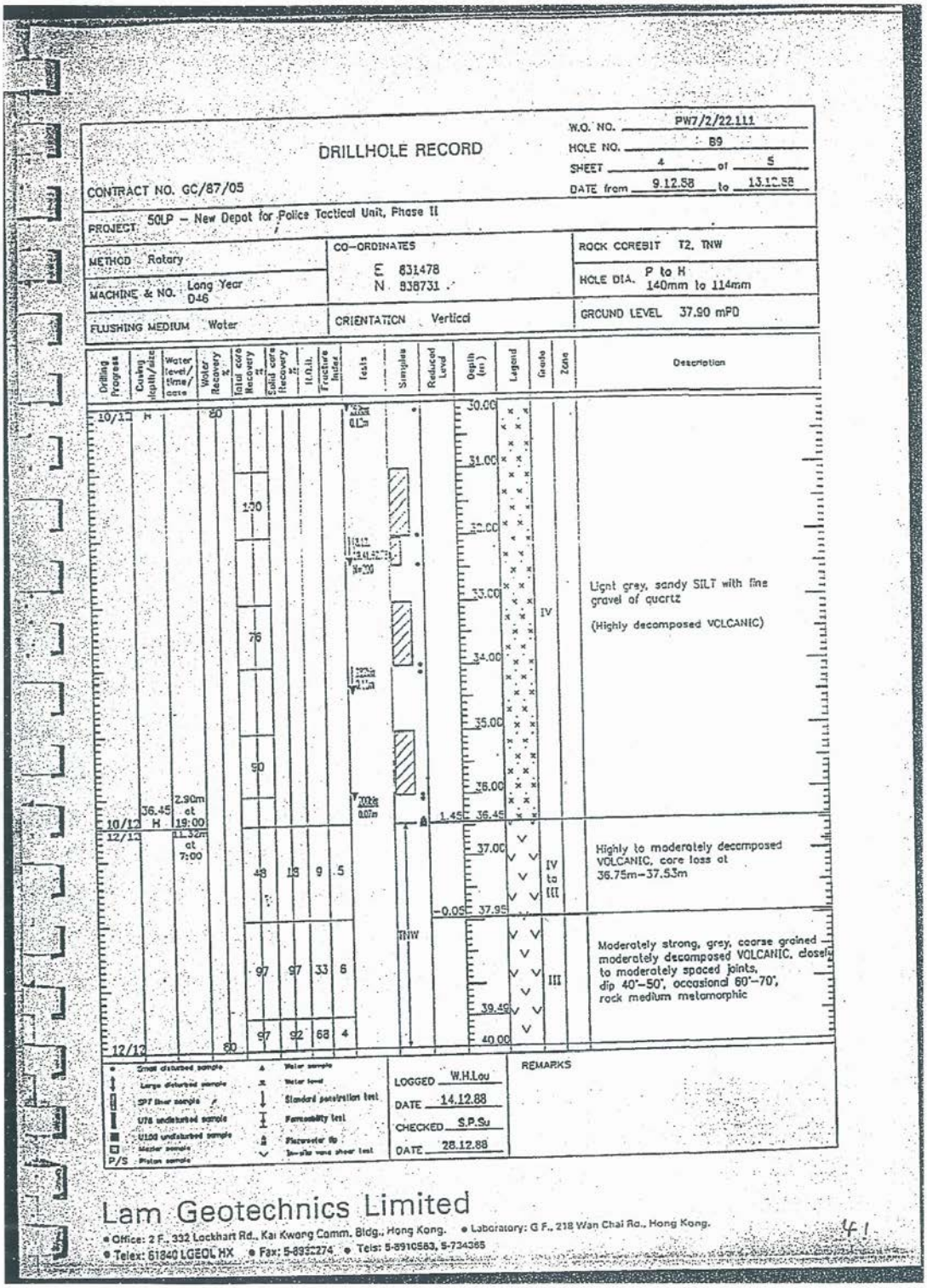
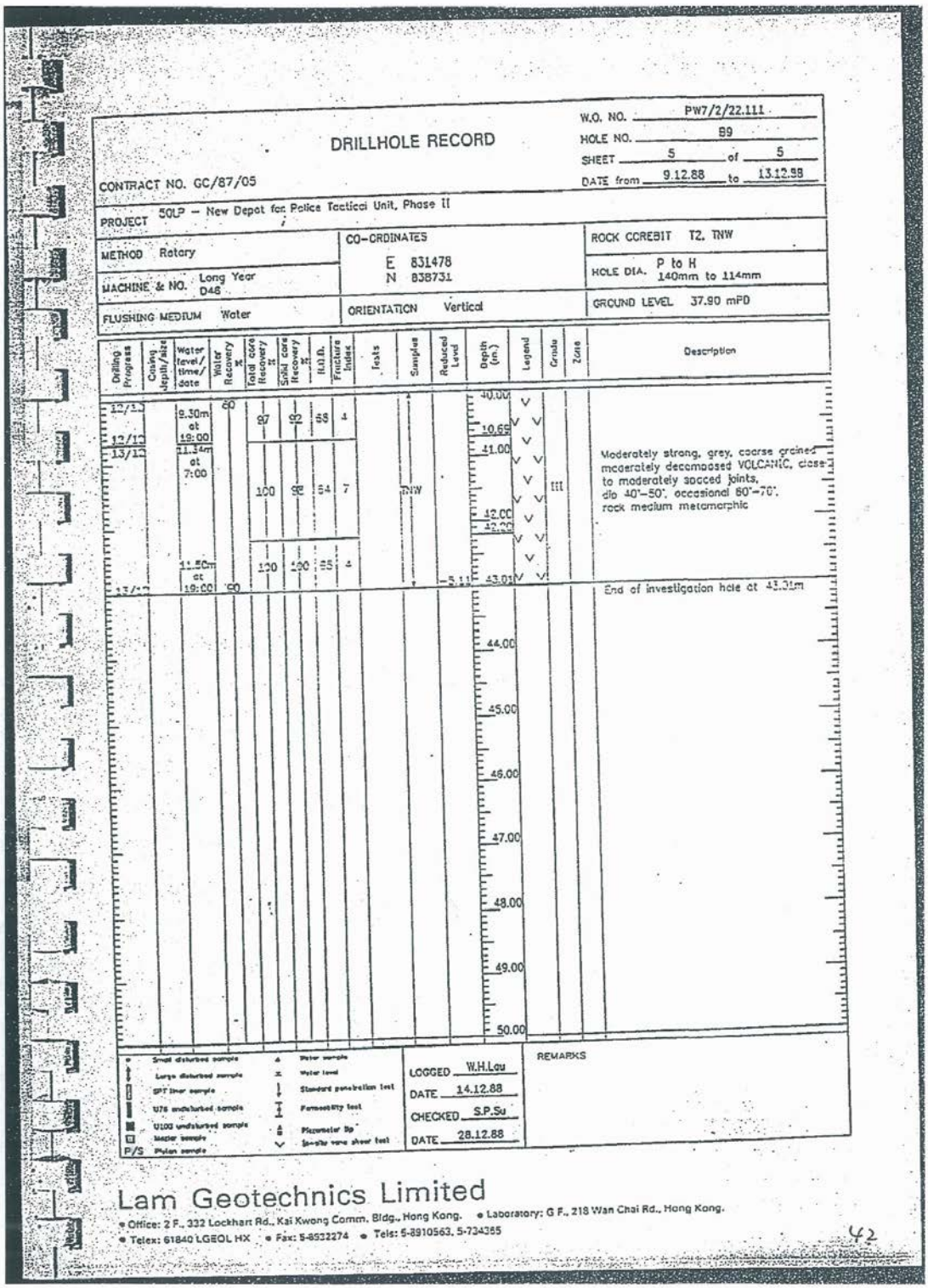


Figure B4 - Drillhole Record of B9 (Page 4 of 5)



DRILLHOLE RECORD

W.O. NO. PW7/2/22.111
HOLE NO. B9
SHEET 5 of 5
DATE from 9.12.88 to 13.12.88

CONTRACT NO. GC/87/05

PROJECT 50LP – New Depot for Police Tactical Unit, Phase II

METHOD Rotary
MACHINE & NO. Long Year D46
FLUSHING MEDIUM Water

CO-ORDINATES
E 831478
N 838731
ORIENTATION Vertical

ROCK CORE BIT T2, TNW
HOLE DIA. P to H 140mm to 114mm
GROUND LEVEL 37.90 mPD

Drilling Progress	Casing Depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D. %	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Zone	Description
12/12		9.30m at 19:00	60	97	93	88	4				40.00				
12/12		11.34m at 7:00									10.69				
13/12				100	98	84	7				41.00				Moderately strong, grey, coarse grained moderately decomposed VOLCANIC, close to moderately spaced joints, dip 40°–50°, occasional 80°–70°. rock medium metamorphic
											42.00				
		11.5Cm at 19:00	60	100	100	85	4			-5.11	43.01				End of investigation hole at 43.01m
											44.00				
											45.00				
											46.00				
											47.00				
											48.00				
											49.00				
											50.00				

Small disturbed sample
Large disturbed sample
SPT liner sample
U76 undisturbed sample
U100 undisturbed sample
Water sample
P/S Piston sample

Water sample
Water level
Standard penetration test
Permeability test
Piezometer tip
In-situ vane shear test

LOGGED W.H.Lau
DATE 14.12.88
CHECKED S.P.Su
DATE 28.12.88

REMARKS

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Figure B5 - Drillhole Record of B9 (Page 5 of 5)

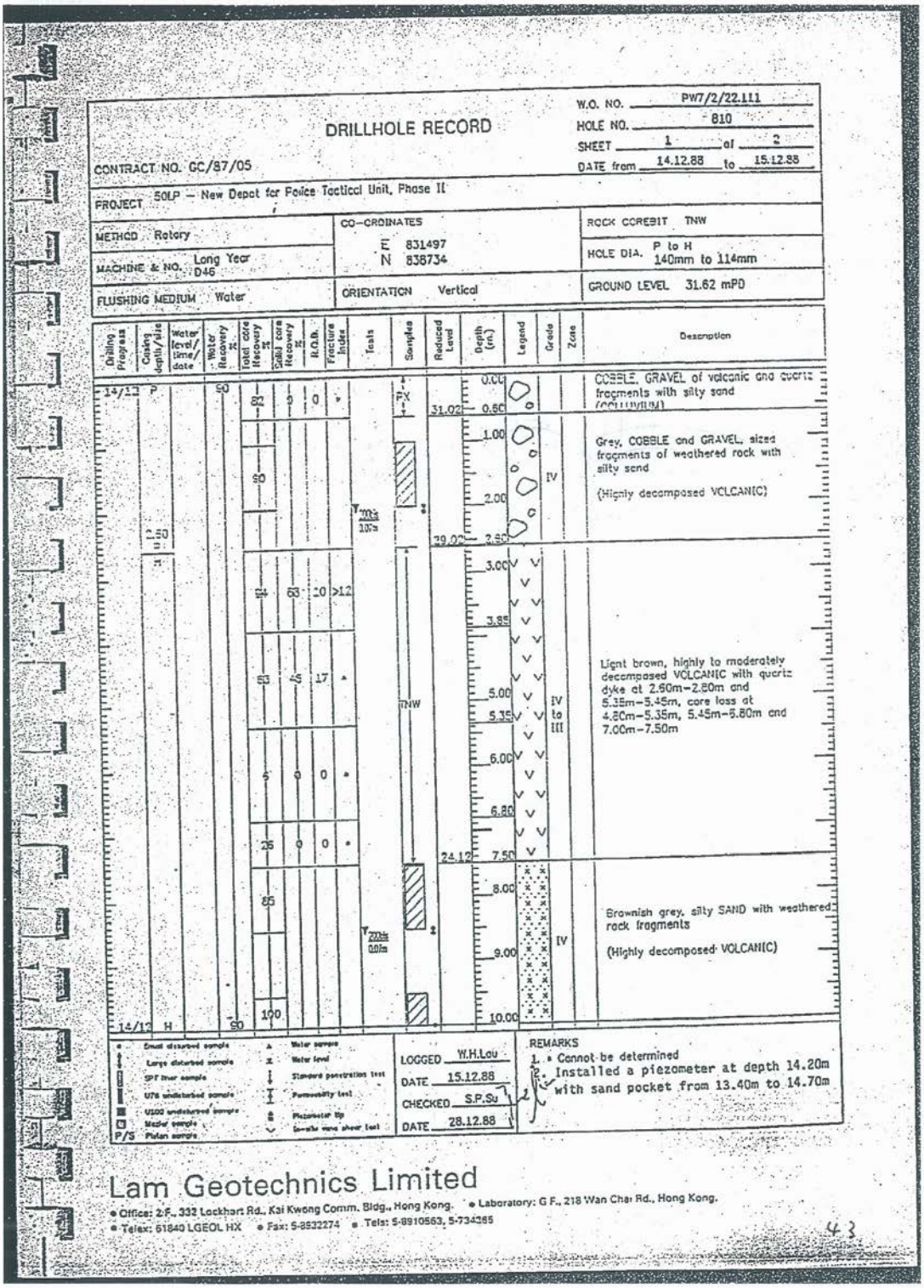

Figure B6 - Drillhole Record of B10 (Page 1 of 2)

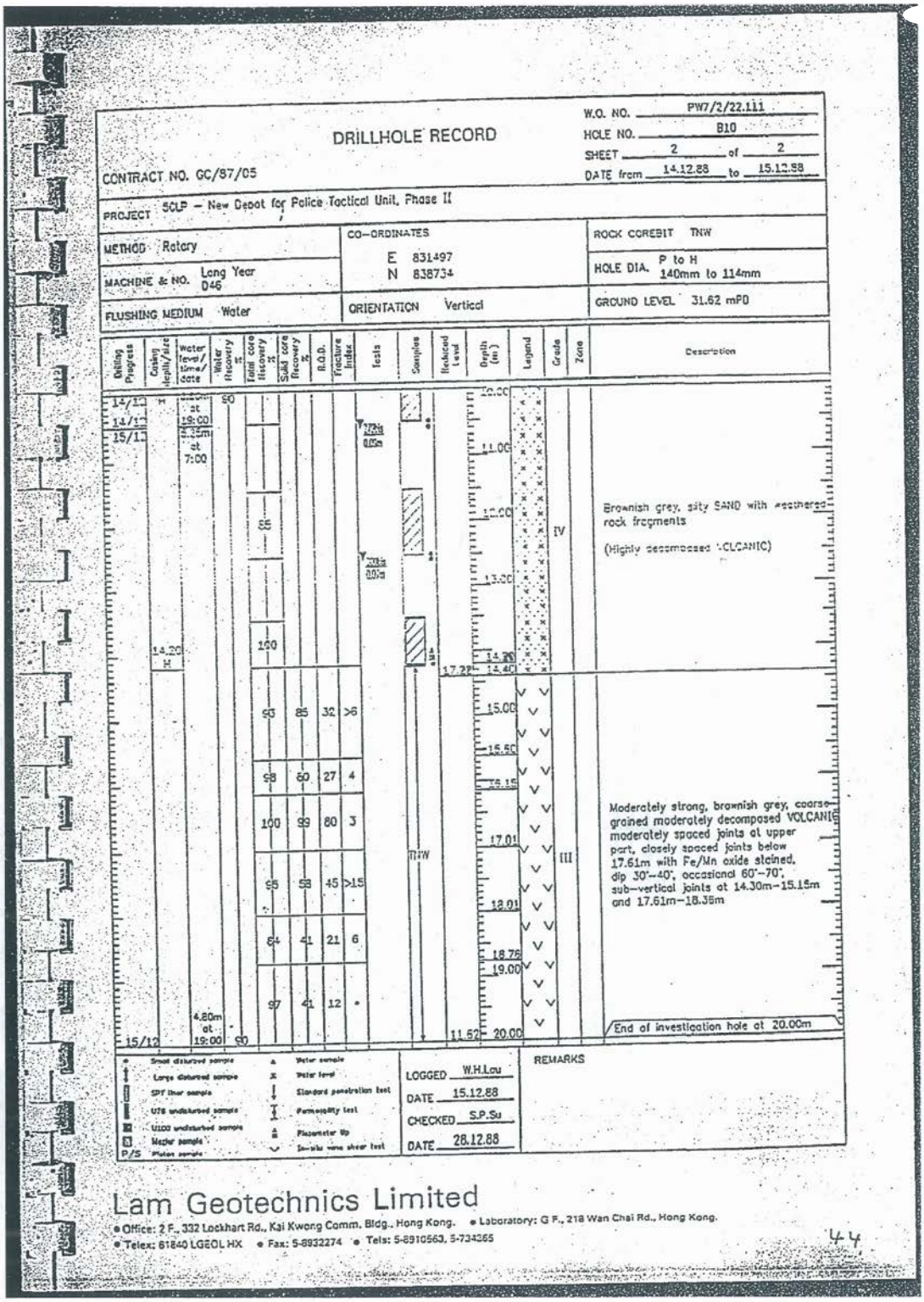

Figure B7 - Drillhole Record of B10 (Page 2 of 2)

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.

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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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
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或

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Tel: (852) 2762 5346
Fax: (852) 2714 0275
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MAJOR GEOTECHNICAL ENGINEERING OFFICE PUBLICATIONS
土力工程處之主要刊物

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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.

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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.

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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

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