SECTION 2: DETAILED STUDY OF THE LANDSLIDES BELOW VTC POKFULAM SKILLS CENTRE, POKFULAM ROAD ON 23 AUGUST 1999

Fugro Maunsell Scott Wilson Joint Venture

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FOREWORD

This report presents the findings of a detailed study of two landslides (GEO Incident No. HK 99/8/11) which occurred on 23 August 1999 in the hillside below the Vocational Training Council (VTC) Pokfulam Skills Centre on Pokfulam Road. Debris from the landslides, estimated at 100 m^3 and 200 m^3 respectively, was channelised in an ephemeral drainage line and reached Victoria Road, approximately 200 m west of the VTC facility on plan. No casualties were reported as a result of the incident.

The key objectives of the detailed study were to document the facts about the landslides, present relevant background information and establish the probable causes of the failures. The scope of the study comprised site reconnaissance, limited ground investigation and laboratory testing, desk study and engineering analysis. Recommendations for follow-up actions are reported separately.

The report was prepared as part of the 1999 Landslide Investigation Consultancy (LIC), for the Geotechnical Engineering Office (GEO), under Agreement No. CE 101/98. This is one of a series of reports produced during the consultancy by Fugro Maunsell Scott Wilson Joint Venture (FMSW).

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1. INTRODUCTION

In the early morning of 23 August 1999, two landslides (GEO Incident No. HK 1999/8/11) occurred in the hillside below the Vocational Training Council (VTC) Pokfulam Skills Centre (VTC facility) on Pokfulam Road during a rainstorm (Figure 1 and Plate 1). Debris from the landslides became channelised in ephemeral drainage lines and reached Victoria Road, approximately 200 m west of the VTC facility on plan. Victoria Road was closed to traffic following the incident. No casualties were reported as a result of the landslides.

Following the landslides, Fugro Maunsell Scott Wilson Joint Venture (FMSW), the 1999 Landslide Investigation Consultants, carried out a detailed study of the failures for the Geotechnical Engineering Office (GEO), Civil Engineering Department (CED), under Agreement No. CE 101/98.

The key objectives of the study were to document the facts about the landslides, present relevant background information and establish the probable causes of the failures. The scope of the study comprised site reconnaissance, limited ground investigation and laboratory testing, desk study and engineering analysis. Recommendations for follow-up actions are reported separately.

This report presents the findings of the detailed study, which comprised the following key tasks:

(a) a review of relevant documents relating to the history of the landslide site,

(b) topographical survey, geological mapping, and detailed observations and measurements at the landslide sites,

(c) limited ground investigation and laboratory testing,

(d) analysis of rainfall records,

(e) engineering analysis of the hillside, and

(f) diagnosis of the probable causes of the landslides.

2. THE SITE

2.1 Site Description

The local catchment containing the landslide scars is located on the southern margins of a broad, west-trending valley (Plate 2) extending from Victoria Peak to Telegraph Bay. The catchment comprises a portion of west-trending hillside, which falls from a north-south aligned ridge to the original coastline approximately 300 m to the west. The ridge line has been levelled predominantly by cutting to form a building platform (145 mPD) currently occupied by the VTC facility and Pokfulam Road to the east (Figure 1). The platform is

about 400 m long and 100 m wide. Victoria Road traverses the hillside at about 58 mPD and defines the western extent of the catchment.

The catchment (Plate 3) ranges from 90 m to 180 m in width and is defined to the north by a prominent spur ridge that extends south-west from the northern end of the VTC facility. It is defined to the south by a broad spur ridge extending west from the southern end of the VTC facility. The hillside typically slopes at angles of between 20° and 30°. The southern flanks of the northern spur are comparatively steeper and trend south to south-west at angles of 25° to 35°. The nose of the southern spur above Victoria Road slopes at angles ranging up to 40°.

Within the local catchment, four prominent natural drainage lines extend from the VTC facility to Victoria Road (Figure 2). Drainage line No. 1 is located along the southern flanks of the northern spur ridge and follows a continuous line south-west from the VTC facility to Victoria Road over a distance of about 200 m on plan. Drainage lines Nos. 2 and 3 extend from points along the edge of the VTC facility and converge with drainage line No. 1 approximately 90 m downslope. Drainage line No. 4 is located on the northern flanks of the southern spur ridge and converges with drainage line No. 1 immediately above Victoria Road. A south-trending gully is present in the southern flanks of the northern spur approximately 40 m west of the VTC facility. The building platform occupied by the VTC facility cuts across drainage lines Nos. 2 and 3.

Vegetation within the local catchment (Plate 4) predominantly comprises a broad-leaf succulent, which tends to proliferate in ephemeral stream courses within the drainage lines, and a tall grass species. Tree cover becomes more prevalent in the lower portion of the catchment. The predominant species are not characteristic of the hillside, which typically supports a dense cover of bushy trees.

Victoria Road was formed predominantly in cut and was undergoing widening at the time of the landslides (Section 3.2), which involved extensive slope works (Plate 1). A construction site of the road widening work is located at the toe of the local catchment. Slope registration numbers for features existing prior to slope works associated with the road widening are shown on Figure 1.

The 1999 landslides occurred immediately below the VTC facility at the head of drainage line No. 2 (Landslide A on Figure 1), and in the southern flank of the northern spur ridge (Landslide B on Figure 1) approximately 70 m on plan west of the VTC facility. The debris trails converged at the intersection point of drainage lines Nos. 1 and 2, and followed the alignment of drainage line No.1 to Victoria Road.

2.2 Water-carrying Services and Utilities

The locations of existing services and utilities in the vicinity of the landslide sites are shown in Figure 1. The only water-carrying services comprise the surface drainage system for the VTC facility. These include a 250 mm U-channel located along the western perimeter of a small platform at the northwestern end of the VTC building and drains southwards into the local surface drainage system within the VTC facility.

The local surface drainage system within the fence line of the VTC facility also includes a 250 mm U-channel, which discharges into a buried pipe at the junction with the U-channel described above. Details of the discharge point of the pipe could not be located.

2.3 Maintenance Responsibility

According to the Lands Department, the hillside in which the 1999 landslides occurred is Unallocated Government Land.

3. SITE HISTORY AND PREVIOUS STUDIES

3.1 General

The development history of the landslide site and details of previous studies have been compiled from a review of available aerial photographs and relevant documentation. Details of observations from aerial photographs are given in Appendix A and the salient points are presented in the following section.

3.2 Site History

The main observations in relation to the history of the landslide site are presented in Figure 2. The earliest available aerial photograph dates from 1924 and shows a Dairy Farm complex occupying the present VTC site. The farm began operations in the 1880's (Chan et al, 1996) and continued until the mid-1980's, when the land was returned to Government (Section 3.3). The farm property (Figure 2) included the hillside to the west of the levelled platform about mid-way downslope to Victoria Road, and incorporated the upper portion of the local catchment. The 1924 aerial photograph shows the southern portion of the local catchment to be traversed by a cleared track, which descends in a south-westerly direction to Telegraph Bay. The track is abandoned in the 1949 aerial photographs.

Throughout the period of operation of the Dairy Farm, the hillside in the local catchment had a low cover of vegetation, which was periodically cleared within the farm boundary to various extents. None of the aerial photographs studied indicate cattle or farm equipment on the hillside. The reason for the vegetation clearance is not known, but might have been related to crop cultivation for livestock feed.

Shallow landslides within drainage lines (Section 2.2) are observed in the 1963 and 1967 aerial photographs. A gully feature appears on the southern flanks of the northern spur ridge immediately east of the 1999 landslide scar (Landslide B on Figure 1) and a possible break in slope angle at the scar location is visible in the 1972 aerial photographs. The gully is enlarged in the 1979 aerial photographs and appears to have experienced further instability. Ephemeral stream courses within drainage lines appear to have been sharply incised in the 1976 aerial photographs and a possible landslide scar is present on the southern flanks of the northern spur further downslope towards Victoria Road at this time.

Aerial photographs do not indicate the presence of any substantial fill bodies within the local catchment during this period. However, a number of small areas of fill, apparently end-tipped, are visible along the edge of the farm platform in 1963, 1967, 1972 and 1976. The 1979 aerial photographs also show what appears to be a shallow covering of fill on the upper portion of the hillside within drainage line No. 2 and below the southern portion of the farm complex (Figure 2).

Following the abandonment of the farm complex in the mid-1980's, no further clearance of vegetation is observed on the hillside below and the vegetation became heavier with time. Narrow erosion channels are visible below the farm platform in the 1987 aerial photographs and appear to be located below areas of disturbed ground at the platform edge.

Re-development of the Dairy Farm site is first visible as site clearance works in the 1988 aerial photographs. The Pokfulam Temporary Housing Area (PTHA) is complete by 1990 and occupies the northern portion of the platform. Construction of the VTC facility appears to be complete in 1992. End-tipped fill and construction debris are visible along the western edge of the building platform. From this time, a small platform is also visible at the north-western end of the VTC facility on the northern edge of drainage line No. 2. It is not clear whether this has been formed in cut or fill, as the definition of the platform along the western edge is obscured by vegetation.

The 8 May 1992 Baguio Villa landslide scar (Chan et al, 1996) is visible in the 1992 aerial photographs and affected the northern portion of the platform occupied by the PTHA. The debris trail extends down a drainage line following the northern flanks of the northern spur, to the north of the concerned local catchment.

The 1994 aerial photographs show the housing blocks from the PTHA to have been demolished. A shotcreted landslide scar is present in drainage line No. 4 and extends from about 30 m below the VTC facility to Victoria Road. The main scarp and southern flank of this scar appear to be sub-vertical. It is unclear whether this failure involved fill or natural material within the drainage line. Areas of exposed ground within and to the south of the local catchment suggest that other incidences of instability/erosion occurred in the area at this time. The platform visible in the 1992 aerial photographs has a low cover of vegetation and appears to have a small scar at its northern end.

Further development within the Dairy Farm site occurred between 1996 and 1998, comprising the addition of a building east of the VTC facility and the establishment of construction site offices to the north. The small platform visible from 1992 aerial photographs has been concreted in the 1996 aerial photographs. This small platform again becomes overgrown with vegetation by the following year.

A possible erosion feature indicated by a change in vegetation is visible in drainage line No. 1 below the source area for landslide B (Figure 2) in the 1996 aerial photographs and the break in slope located within the landslide B source area first observed in the 1972 aerial photographs is again visible. These features remain visible through to the 1998 aerial photographs, in which a number of curvilinear features, possibly indicative of tension cracking, can also be seen below the break in slope. The ephemeral stream course in the upper portion of drainage line No. 2 appears to be sharply incised at this time, which may indicate ongoing erosion.

Slope works associated with the Victoria Road Improvement Phase II Stage 2 contract (Section 3.3) commenced in early to mid-1999.

There is no evidence of the local catchment having been affected by hillfires during the period covered by the API.

3.3 Previous Studies

The local catchment in which the 1999 landslides occurred was included in the study area for the "Landslide Study Programme – Phase IIC" completed by Binnie and Partners in the mid-1970's. The boundary of the study area incorporating the local catchment follows the southern boundary of the Dairy Farm and extends west to the coastline below Victoria Road. To the north, the study area boundary describes a broad are passing along the causeway of the Pokfulam Reservoir before turning west and extending to the coastline north of Baguio Villa. The assessment of the study area incorporating the local catchment was presented in the "Report on the Stability of Slopes in the Pokfulam Area, Volume 1, Slopes in the Region of Baguio Villa, Victoria Road" (Binnie & Partners, 1977).

The study included limited ground investigation and described the local geology as comprising pyroclastic volcanic bedrock with a shallow (up to 10 m) weathered zone overlain in the southeast (the local catchment of the 1999 landslide sites) by residual soil and colluvium.

A total of five cross-sections through the hillside above Victoria Road were considered in the stability analyses presented in the report. All of these lie to the north of the local catchment, the closest two sections taken below the Dairy Farm platform on the northern flanks of the northern spur ridge (Figure 2). The first of the two sections (Section 4-4 on Figure 2) extended from the northern end of the Dairy Farm platform to Lower Baguio Villa below Victoria Road. The ground profile appears to have been inferred from a single drillhole at the crest and comprised Grades II to III bedrock overlain on the upper two-thirds of the hillside above Victoria Road by Grades IV to V material, slopewash and fill (i.e. Grades II to III material at ground surface on the lower third). Shear strength parameters of $c' = 17$ kPa, $\phi' = 30°$ and $c' = 6$ kPa, $\phi' = 32°$ were assigned to the weathered volcanics and slopewash material respectively.

The minimum factor of safety for deep-seated failures under the highest observed groundwater conditions was found to be 0.95. Shallow failures were not considered. Analysis of the 1 in 10-year groundwater conditions indicated that an effective cohesion of 22 kPa in the weathered volcanics and a soil suction of 120 kPa were required to achieve a factor of safety of 1.4. The report concluded that there was reason for concern regarding the stability of the slope and a recommendation was made for design of remedial measures based on a more detailed investigation. Interim measures comprised lining the natural drainage path within the drainage line to the west of the analysed section and construction of a surface drainage system over an 18 m wide section of hillside adjacent to Upper Baguio Villa.

The second cross-section (Section 5–5 on Figure 2) was taken through the nose of the northern spur and only the lower third of the hillside above Victoria Road was considered. The ground profile was inferred from a drillhole at the toe and was similar to that adopted for

the section to the north, with a 6.5 m thick layer of colluvium between slopewash and fill. As with the first section, only deep-seated shear surfaces were analysed. There is inconsistency between the report text and drawings regarding the shear strength parameters assigned to colluvium (c' = 17 kPa , ϕ' = 30° and c' = 0 kPa , ϕ' = 38.6° respectively). The minimum factor of safety, assuming no positive pore water pressure, was found to be 1.02 and a pore suction of 20 kPa was required to achieve a factor of safety of 1.4. The report recommended the installation of psychrometers and concluded that the hillside was "… in a limiting state of stability and that any disturbance of the natural state of the hillside can result in instability".

Various items of correspondence indicate that an Advisory Letter was issued to the Dairy Farm owners in September 1981 in relation to the 18 m wide portion of hillside within the Dairy Farm lot boundary north of the northern spur (Figure 2).

Correspondence from the Geotechnical Control Office (GCO, re-named GEO in 1991), dated February 1983, indicates that "problems" had arisen as a result of the Advisory Letter based on the recommendation of Binnie and Partners. The GCO had subsequently made a separate appraisal of the Binnie and Partners' assessment and considered that the lot owners could be considered as satisfying the requirements of the Advisory Letter if they were advised to "… examine that portion of slope as indicated in the advisory letter for drainage lines and where present ensure that they are in good working order or repair as necessary. They should be adequately maintained to ensure they effectively function at all times. The vegetation cover to the slope is to be maintained at all times to ensure that it provides an effective cover". The area covered by the Advisory Letter is shown in Figure 2.

Correspondence from the District Lands Office (DLO) in mid-1986 indicated that the lease on the farm property was not to be renewed and that a temporary housing area was proposed on the levelled platform. The GCO indicated no geotechnical objections to the proposed land allocation. However, the GCO recommended that housing blocks should be sited as far from the edge of the platform as possible on the basis of the low margin of safety against instability of the natural hillside to the west.

Further correspondence from the DLO to the GEO in early 1990 indicated a proposed grant of the farm platform above the local catchment to the VTC for the development of a training facility and requested comments on the proposed grant document. Additional DLO correspondence in June 1990 proposed that the western boundary of the allocated area should be revised to extend only to the edge of the levelled platform and that the hillside below should revert to Unallocated Government Land status.

The fatal Baguio Villa landslide occurred on 8 May 1992, details of which are presented in Chan et al (1996). The failure involved the collapse of a masonry retaining wall at the northern end of the temporary housing area, which released about 1000 m^3 of debris into the drainage line in the northern flanks of the northern spur to the presently concerned local catchment.

3.4 Past Landslides

The GEO's Natural Terrain Landslide Inventory (NTLI) indicates that a past landslide occurred within the local catchment. The location of the landslide is consistent with the scar

present in drainage line No. 4 in the 1994 aerial photographs reviewed by FMSW (Section 3.2 and Appendix A). A number of other scars have also been identified by FMSW from a review of low-level aerial photographs (Figure 2).

The GEO landslide database indicates two previous landslide incidents adjacent to Victoria Road at the base of the local catchment (Incidents Nos. HK 86/8/9 and HK 94/7/59, see Figure 1). The GEO Incident Report for Incident No. HK 86/8/9 indicates that the landslide occurred on 24 August 1986 and involved a shallow failure adjacent to the road with a volume estimated at 15 m^3. It is not clear from the report whether the failure occurred in a cut slope or the natural hillside.

Incident No. HK 94/7/59 occurred on 24 July 1994 and comprises the landslide observed in drainage line No.4 in the 1994 aerial photographs and included in the NTLI. The GEO Incident Report describes the incident as a "mudslide" involving more than 40 m^3 of debris which blocked one lane of Victoria Road. Urgent repair works recommended to the Highways Department (HyD) by the GEO comprised removal of loose material, trimming of the failure surface to insitu soil, construction of a buttress to support local boulders on the slope and shotcreting of the failed area.

The 8 May 1992 Baguio Villa landslide is recorded as incident No. HK 92/5/8.

4. THE LANDSLIDES

4.1 Description of the Landslides

The landslides involved two separate source areas located on the hillside below the VTC facility. The source area for landslide A (Figure 1) was located at the head of drainage line No. 2 below the VTC facility and measured about 9 m in width. The main scarp was sub-vertical and between 1 m and 2 m in height (Plate 5). The source area was defined by steep, well-defined flanks extending about 20 m downslope from the main scarp. The maximum depth of failure measured normal to the surface of rupture was about 2 m and the volume of failure at the source area was estimated to be about 100 m^3.

The scarp and flanks (Plates 6 and 7) exposed heterogeneous fill material comprising cobbles, boulders and assorted construction waste and refuse (e.g. tyres, pottery shards and domestic rubbish) in a soil matrix. The surface of rupture was roughly planar and inclined at about 30° to 40° to the horizontal, exposing fill, colluvium and Grades IV and V tuff. Corestones and rock outcrops were also observed. The exposure of insitu material along the surface of rupture and fill in the main scarp and flanks indicates that the surface of rupture was located at or near the fill/natural ground interface.

Debris from landslide A comprised predominantly fill material, which travelled down drainage line No. 2 (Plates 8 and 9) and converged with drainage line No. 1, where it became channelised within the drainage line. Witnesses' accounts suggest that the debris was subsequently transported (over the following 24 hours, see Section 4.2), together with debris from landslide B, along the drainage line by ephemeral stream flow to Victoria Road (Plates 10 and 11), about 130 m downslope of the source area, blocking both lanes of the carriageway. The travel angle (Wong & Ho, 1996) of debris from landslide A is about 25°.

The source area for landslide B (Figure 1) was located on the southern flanks of the northern spur ridge approximately 70 m downslope of the VTC building and measured approximately 16 m in width (Plates 12 and 13). The main scarp was located about 15 m on plan south of the spur ridgeline.

The volume of failure at the landslide B source area is estimated at about 200 m^3. The maximum depth of the landslide scar occurred at the main scarp, which was steeply dipping (60° to 70°) and overhanging in places, and was of the order of 2 m. The source area was bowl-shaped and about 23 m long, the flanks becoming less defined with distance from the scarp. The surface of rupture was inclined at about 25° to 40° to the horizontal and appeared to daylight about 7 m upslope of the ephemeral stream course in drainage line No. 1 (Plate 14). Material exposed in the source area comprised colluvium and Grades IV and V tuff.

Debris from landslide B comprised predominantly sandy silt deposited in drainage line No. 1 and was channelised with debris from landslide A in the drainage line. Photographs taken by FMSW on 25 August 1999 show rafts of semi-intact material remaining within the source area of landslide A. The travel angle of the landslide debris (Wong & Ho, 1996) was 25° to the final extent of debris runout on Victoria Road.

Based on the results of the post-failure topographical survey of the landslide site, the general topography and profiles of the landslides are presented in Figures 3 to 6.

The manner in which the debris from each landslide moved down drainage line No. 1 to reach Victoria Road is unknown. However, it is likely the movement involved a series of pulses given the length of time between the first observation of the landslides from the VTC and the observation of debris on Victoria Road.

4.2 Observations Made Following the Landslides

The landslide scars were first observed by a security guard from the VTC facility at about 7:00 a.m. on 23 August 1999. The witness advised that both landslide scars were present and were not significantly different in extent to that observed on 26 August 1999 by FMSW (Plate 13).

The observation of landslide debris on Victoria Road was first reported to the GEO on the morning of 24 August 1999. The landslide site was inspected from Victoria Road by representatives of the GEO and the HyD at about 2:00 p.m. on 24 August 1999. The FMSW inspection team first visited the site on 25 August 1999. However, continued flow from drainage line No. 1 prevented access to the scar until 26 August 1999. At this time, urgent repair works, comprising shotcreting of the landslide scars, were being carried out.

The pertinent observations during the FMSW inspection are presented below:

(a) Water continued to flow down drainage line No. 1 from above the location of landslide B, eroding channels in the debris deposited within the scar (Plate 15).

(b) By comparison with drainage line No. 1, there was no significant flow of water from drainage line No. 2 (Plate 5), although seepage from rock outcrops within the debris trail of landslide A was observed (Plates 9 and 16). The source area of landslide A was also largely devoid of surface water.

(c) The debris trail of landslide A below the source area was largely devoid of deposited debris (Plate 9), the rock outcrops and boulders having been washed clean by subsequent rainfall.

(d) The surface drainage channel maintained by the VTC located along the edge of the small platform adjacent to the VTC building and above the scar of landslide A (Section 2.2) was heavily overgrown with vegetation and blocked at some locations (Plate 17).

(e) There were no obvious deposits of fill debris from landslide A evident in the debris trail below the point of intersection of drainage lines Nos. 1 and 2, the debris present being of the same appearance as that for landslide B (Plate 1). This may give some indication as to the relative timing of the landslides.

(f) The ephemeral stream course within drainage line No. 1 comprises a narrow, irregular channel, sharply incised in places, exposing bouldery colluvium and insitu weathered rock of Grades V to III along its length (Plate 4).

4.3 Urgent Repair Works

Urgent repair works recommended by the GEO and carried out by the HyD comprised trimming of loose material from the source area of both landslides and the application of shotcrete with weepholes over the full extent of the landslide scars. These works were completed within the week following the failures.

5. SUBSURFACE CONDITIONS

5.1 General

The subsurface conditions within the landslide site have been assessed on the basis of information obtained from the desk study, limited post-failure ground investigation and field mapping.

5.2 Previous Ground Investigations

A number of previous ground investigations have been undertaken in close proximity to the landslide site. The locations of previous investigation stations are shown in Figure 7.

5.3 Current Ground Investigation

The ground investigation comprised two vegetation strips adjacent to the landslide source areas, two surface strips within the shotcreted areas, eight trial pits to a depth of 3 m and the retrieval of disturbed and undisturbed soil samples. The locations of the ground investigation stations are indicated on Figure 7. GEO probing was carried out at each trial pit location and insitu density tests were carried out within the pits and adjacent to the landslide A scar. The results of this work are reported separately (Soils & Materials Engineering Co. Ltd, 1999 a, b & c). Insitu density test results are summarised in Table 1. Trial pit logs are presented in Appendix B. Photographs showing the various observations made during the investigation are presented in Plates 18 to 28.

Additional GEO probing was carried out during May 2000 on a 10 m to 20 m grid pattern along a 20 m wide strip of the hillside below the VTC platform to investigate the density of the near-surface ground profile and the approximate depth of fill bodies present.

Laboratory testing on recovered samples included classification, moisture content determination and compaction tests as well as triaxial and direct shear box testing. A summary of the laboratory test results is presented in Tables 1 to 3.

5.4 Ground Conditions

5.4.1 Geology and Geomorphology

Sheet 11 of the Hong Kong Geological Survey 1:20 000 scale map series HGM20 (GCO 1986) indicates that the solid geology of the landslide sites and their surroundings is fine ash vitric tuff from the Ap Lei Chau Formation of the Repulse Bay Volcanic Group (Figure 8) with units of eutaxite indicated approximately 150 m to the south-east. According to the geological map, the landslide sites are located on the western limb of a syncline, with a flow fabric dipping gently eastwards towards the axis of the syncline. A geological boundary with fine-grained granite is indicated approximately 100 m north-west of the landslide sites. Some degree of alteration to the tuff in the vicinity of the landslide sites might be anticipated, given the close proximity of this boundary. Quaternary debris flow deposits are shown on the hillside to the north of the main ridgeline.

The geology and geomorphology of the local catchment mapped by FMSW during the current investigation are shown on Figure 7. The hillside to the south of drainage line No. 1 below the VTC facility is characterised by gently undulating and occasionally hummocky ground (suggesting the presence of colluvial deposits) with several shallow landslide and erosion scars, and ephemeral drainage lines. The lower and middle portions of the hillside in this area are traversed by NNE-SSW trending rock outcrops. In contrast, the hillside to the north of drainage line No. 1, with the exception of the 1972/79 gully and 1999 landslide B

scar, is relatively planar below a line of small rock outcrops defining the main NE-SW trending spur ridgeline. This suggests that the slope north of drainage line No. 1 is not covered with significant colluvium.

In general, the geology of the landslide site comprises thin colluvium and fill (below the VTC platform) overlying an insitu weathering profile of fine ash vitric tuff. The rock outcrops mapped across the site were generally composed of moderately weak to moderately strong, light brownish grey Grade III fine ash tuff.

Bedding was observed within some of the rock outcrops dipping gently towards the northwest (dip direction/dip of 300°-351°/5°-16°), and flow banding was measured dipping WNW at moderately steep (52° to 65°) to steep (70° to 85°) angles. A medium-spaced and persistent joint set has developed parallel to the orientation of the flow banding. This set partly controls the pattern of rock outcrops across the slope.

Other significant joint sets were mapped within the rock outcrops along the main ridgeline, dipping ENE (075°/80°) and north-east (024°-048°/45°-70°). In addition, an undulating and persistent sheeting joint (Figure 7) was mapped within an outcrop located in the landslide A debris trail dipping gently towards the south-west (207°/8°-24°). This orientation is adverse with respect to the general hillside.

5.4.2 General Ground Profile

The available ground investigation information from previous studies is concentrated in three areas, comprising the levelled platform occupied by the VTC facility, the northern flanks of the northern spur ridge extending to Victoria Road, and above and below Victoria Road on the nose of the northern spur.

The typical sequence indicated for the VTC platform comprises up to 1 m of fill material overlying an insitu weathering profile of fine ash vitric tuff comprising Grades V to II/III material. Fill material comprises a loose to dense granular material including gravel, cobbles and construction waste, and a reddish-brown silty clay at one location.

The decomposed tuff is typically described as a loose to very dense light brown and light grey fine-grained sandy silt and silty sand. Grades IV and V material extended to depths of about 20 m below platform level before Grade II/III material was encountered. SPT 'N' values obtained in this material ranged from less than 10 to 200.

The ground profile extending down the northern flanks of the spur ridge comprises up to 3 m of colluvium underlain by Grades V to II/III tuff. Colluvium is described as a firm reddish and orangish brown, slightly sandy clayey silt containing sub-rounded cobbles and boulders.

The thickness of Grades IV and V tuff is greatest near the VTC platform (20 m to 30 m) and reduces downslope to less than 5 m above Victoria Road. A limited number of SPT results are available from stations located on the sloping ground and indicate an 'N' value in the range of 16 to 18.

Ground investigation data from stations above Victoria Road indicate a natural ground profile comprising up to 2 m of colluvium overlying Grades II to V tuff. The colluvium is described as a yellowish-brown, fine-grained sandy silt containing cobbles and boulders. The Grades IV and V tuff is described as a medium dense yellowish-brown, silty fine- to medium-grained sand. The weathering profile ranges up to 8 m in thickness, below which Grade II/III material was encountered.

5.4.3 Ground Profile at Landslide A

The landslide scar exposed predominantly Grades IV and V tuff containing corestones of Grades II and III material, overlain by between 1 m and 2 m of heterogeneous fill, comprising sub-angular to sub-rounded cobbles and boulders, construction waste and refuse, including tyres, pottery shards and domestic rubbish in a dark grey-brown clayey sandy silt matrix.

The landslide debris was almost entirely comprised of heterogeneous fill material, with little evidence that the surface of rupture had penetrated the natural ground. Debris deposited in drainage line No. 2 below the source area was loose, highly disturbed and largely unsaturated.

The results of insitu density testing and laboratory compaction tests indicate that the fill in the vicinity of the landslide A source area is in a very loose to dense state, with relative compaction generally in the range of 74% to 98%, with five out of seven results less than 90%. GEO probe results within the fill at trial pits TP3 and TP4 located adjacent to the scar were generally less than 10 blows/100 mm, indicating a loose to medium dense state.

The GEO probing carried out within the 20 m wide strip along the western edge of the VTC platform encountered loose to medium dense material (blow count less than 10 blows/100 mm) to varying depths, followed by a sudden increase in the blow count to in excess of 20 blows to 30 blows/100 mm at the majority of locations. The depth at which the blow count increased has been interpreted as the interface between fill material and the natural ground below. On this basis, the depth of fill material within the area tested is typically in the range of 0.5 m to 1.5 m. Local accumulations of fill in excess of 2 m deep are indicated along the western edge of the VTC platform and are generally in agreement with the discrete areas of fill interpreted from API (Figure 2).

The natural ground profile beneath the fill encountered in trial pits TP1 to TP4 (Plates 18 and 19) comprised decomposed tuff of Grades IV and V to the depth of investigation. The decomposed tuff typically comprised a firm to stiff, light greyish-brown sandy silt. Fill material overlying the natural ground adjacent to the scar was less than 1 m thick (Plate 20).

The Grade IV tuff became more prevalent from depths of between 1 m and 2 m below the ground surface and displayed an open, blocky structure (Plate 21), with the relic joints being open and infilled with grade V material (Plates 21 and 22). Joint orientations show considerable scatter although there appear to be general groupings around the typical sets identified during the mapping exercise (Section 5.4.1).

The results of triaxial testing on samples of Grades IV and V tuff show a degree of scatter, reflecting the variability in strength of this material. Considering data points in the appropriate stress range indicates 'best-fit' shear strength parameters of the order of c' = 3 kPa and ϕ' = 36°. Direct shear box tests on similar material produced a greater consistency in results and indicate c' in the range of 0 kPa to 6 kPa and ϕ' = 33°.

5.4.4 Ground Profile at Landslide B

The source area for landslide B exposed decomposed tuff of Grades IV and V, overlain in the main scarp and flanks by about 0.6 m of topsoil/colluvium. The Grades IV and V material is typically described as a firm to stiff, brown and grey slightly clayey, sandy silt. The overlying topsoil/colluvium comprises a soft to firm, dark brown slightly sandy silt. Landslide debris deposited below the source area comprised a brown sandy silt and was wet.

Trial pits excavated adjacent to the source area generally confirmed the ground profile described above (Plates 23 and 24), with Grade III/IV tuff also encountered in TP5. Trial pits excavated within the source area (Plates 25 and 26) exposed Grades IV and V tuff to the depth of investigation, indicating that the surface of rupture was not defined by a marked change in material.

The Grade IV and V tuff exposed in trial pits TP5 to TP8 was observed to contain noticeable mica content in the form of transparent off-square flakes approximately 0.5 mm to 1 mm in size, which were generally absent in similar material exposed at the landslide A site. The Grade III tuff encountered in trial pit TP5 was heavily jointed/fractured and blocky in appearance (Plate 27). Joint orientations again show considerable scatter although there appear to be similar groupings around the typical sets identified during the mapping exercise (Section 5.4.1), as for landslide A.

An infilled tension crack was observed in the western face of trial pit TP5, extending approximately 1 m below ground surface (Plate 28). The maximum aperture of the crack was about 30 mm to 40 mm. Infill material comprised the topsoil/colluvial layer. Cracking was also noted to develop in the eastern and southern faces of trial pit TP7 during the investigation (Plate 24). The cracks were a maximum of 5 mm in width and extended about 0.8 m below ground surface. It is noted that this trial pit was located a short distance from the flanks of a gully in the adjacent hillside (Section 3.2) and that the cracks may have formed as a result of reduced lateral support to the trial pit faces closest to the gully.

Shear strength parameters indicated by laboratory tests on the Grades IV and V tuff are as reported for landslide A in Section 5.4.3.

5.4.5 Groundwater

Available groundwater monitoring data for the local catchment are limited. Piezometer and standpipe installations, and groundwater levels, where recorded, are presented in Figures 4 to 6.

Three piezometer and standpipe installations from the October/November 1987 ground investigation for the Victoria Road Improvement Phase II Stage 2 project located in the vicinity of the local catchment indicated a 'dry' result. The installations extended to depths of between 5 m and 7 m below ground level.

Two out of five piezometer installations from the January 1988 ground investigation associated with the Pokfulam Temporary Housing Area, and located on the VTC platform north of the facility, indicated groundwater at elevations of between 119 mPD and 139 mPD (i.e. 12 m to 27 m below ground level) from 26 January to 8 February 1988. The remaining three installations were 'dry'. Tip elevations for installations recording a groundwater table were 114.6 mPD and 136.3 mPD respectively. Tip elevations for the remaining three installations ranged from 142.4 mPD to 146.9 mPD.

Two piezometer installations (tip elevations of 122 mPD and 118 mPD respectively) associated with the June/July 1992 investigation of the Baguio Villa landslide indicated groundwater elevations of between 134 mPD and 139 mPD during the period from 17 June to 8 July 1992 at the platform north of the VTC facility. A piezometer installation (tip located 14 m below ground level) approximately mid-way down the slope towards Victoria Road indicated a 'dry' result during the period from 4 July to 7 July 1992.

No groundwater or seepage was observed in the trial pits during the post-failure ground investigation carried out during November and December 1999.

Based on the above, the main groundwater table is below the surface of rupture for both landslides A and B.

6. ANALYSIS OF RAINFALL RECORDS

The nearest GEO automatic raingauge to the landslide is No. H03, which is located at Block No. 44, Baguio Villa, about 200 m north-west of the landslide site.

For the purposes of rainfall analysis, it is assumed that the landslide occurred at 7:00 a.m. on 23 August 1999 (Section 4.2).

Daily rainfall for one month preceding, and seven days following the landslides, together with hourly rainfall for 48 hours before and 12 hours following the landslides, are given in Figure 9. The daily rainfall records show that the storm was concentrated around 22 to 24 August 1999, with the hourly data indicating a peak intensity of 42 mm/hour from 6:00 a.m. to 7.00 a.m. on 23 August 1999.

Table 4 presents the estimated return period for the maximum rolling rainfall for various durations based on historical rainfall data at the Hong Kong Observatory (Lam & Leung, 1994). A return period of less than 2 years is indicated for rainfall durations between 5 minutes and 31 days. A comparison of the severity of the August 1999 rainstorm and selected previous major rainstorms is presented in Figure 10. This shows that a number of substantially more severe rainstorms in the past 10 years have been experienced at the site.

7. THEORETICAL STABILITY ANALYSES

Theoretical stability analyses using the rigorous solution of Morgenstern & Price (1965) were carried out to assist in the diagnosis of the probable causes of the landslides. The analyses examined the likely operative range of shear strength parameters along the surface of rupture for different groundwater conditions at the time of failure.

Cross-sections through each of the landslide source areas were included in the stability analyses. The pre-failure slope profile was based on topographical survey plans, photographic records and engineering judgement. The geometry of the surface of rupture is based on site measurements by FMSW and post-failure topographical survey. The idealised sections used in the analyses are presented in Figures 11 and 12 respectively.

The stability analyses were carried out using the generalised range of shear strength parameters given for decomposed volcanics in Table 8 of Geoguide 1 (GEO, 1993) and the results of laboratory tests carried out as part of the post-failure ground investigation (Tables 1 to 3). Various levels of elevated groundwater pressures above the surface of rupture were assumed for the purposes of the stability analyses.

The results of the analyses are presented in Figures 11 and 12 respectively. The results for Section A-A presented on Figure 11 indicate that elevated groundwater pressures of between 0.25 m to 0.5 m above the surface of rupture (fill/natural ground interface) would be required to initiate failure when effective cohesion corresponds to 1 kPa to 2 kPa. The fill was probably in a loose to medium dense state based on the interpretation of the available test results and site observations. This suggests that cohesion would be low.

The results for Section B-B, presented in Figure 12, are similar to those obtained for Section A-A, indicating that the development of elevated groundwater pressures of between 0.25 m and 0.5 m above the surface of rupture would be required to initiate failure in the hillside when the effective cohesion at the surface of rupture is 1 kPa to 2 kPa.

8. DIAGNOSIS OF PROBABLE CAUSES OF THE LANDSLIDES

8.1 Mode and Sequence of Failures

The first observation of the landslides by an eyewitness on the morning of 23 August 1999 provides little insight to the mode and sequence of each landslide. Reconstruction of the failure scenario is based primarily on observations made at the landslide source areas and debris trails in the days following the failures.

The geometry of the source area of landslide A and location of the surface of rupture near the interface between the fill and natural ground suggest that the failure involved a sliding failure mainly in the fill. Given the uncertainty about travel angle with the initial failure, it is not certain whether a liquefaction-type failure involving collapse of the meta-stable soil structure upon water ingress occurred locally along the surface of rupture. The runout was likely to have been influenced by channelisation of the debris within the drainage line. The largely unsaturated state of debris deposited along drainage line No. 2 points to a sliding type failure rather than overall liquefaction or washout failure.

The geometry of the source area of landslide B, together with the location of the surface of rupture (which daylights several metres above the ephemeral stream course in drainage line No. 1), the location of the main scarp being close to the spur ridge line (insignificant catchment above), is indicative of a shallow sliding failure. The detachment of the failure mass probably occurred mainly as a single event, although some retrogression may have occurred at the main scarp and flanks, as evidenced by the small rafts of intact material observed in the source area by FMSW on 26 August 1999.

Based on the apparent absence of the darker, fill-derived debris as discrete deposits within the ephemeral stream course of drainage line No. 1, and the continuous trail of debris downslope from the source area of landslide B, landslide A probably occurred prior to landslide B. However, there is no evidence to suggest that the two failures are related in terms of one triggering the occurrence of the other.

Debris from both landslides deposited in the ephemeral stream course of drainage line No. 1 became channelised and was transported to Victoria Road over the 24-hour period, probably in pulses, by ephemeral stream flow in the stream course. It is not certain whether the mobility of the debris was further increased by shotcreting of the lower 20 m to 30 m of the drainage line following a previous landslide incident in 1994.

8.2 Probable Causes of Failures

The landslides occurred in a steep hillside sloping at angles of up to 35°. The close correlation between the rainstorms of 23 and 24 August 1999 and the first sighting of the landslides suggest that the failures were triggered by rainfall.

The landslides were probably caused by the development of transient elevated water pressures within fill and insitu material respectively as a result of water ingress. There is no evidence to suggest that either of the landslides contributed to triggering the other.

The location of the surface of rupture at the interface between the loose fill and the insitu profile below at the source area of landslide A suggest that transient elevated water pressures, probably in the form of a perched water table, may have developed along the interface to initiate failure. Seepage flows along the interface between the natural ground and the overlying fill would also tend to concentrate within the drainage line, producing locally more adverse groundwater conditions.

Two possible sources of water at the landslide A site have been identified. These are:

(a) direct infiltration of rainfall into the unprotected fill material, and

(b) overflow of runoff from the cut platform above the loose fill as a result of blocked surface drainage channels (Plate 17 and Section 4.2).

Given the relatively light rainfall preceding the failure, overflow from the blocked

channels behind the fill was likely to have been an important source of water at the landslide site. The fill was in a loose state and was vulnerable to failure due to water ingress.

With respect to landslide B, API has indicated a break in slope angle roughly parallel to the spur ridge line at the approximate location of the 1999 main scarp since 1972 and possible tension cracking towards the western flank of the present scar (subsequently confirmed by the post-failure ground investigation) observed in the 1998 aerial photographs. This suggests previous local instability and ground movements, which may have led to weakening of the materials, local over-steepening of the terrain and possibly preferential drainage paths in the near-surface soil profile. The postulated failure mechanism involves direct infiltration and subsurface seepage along the preferential flow paths in the soil profile and possible cleft water pressures in tension cracks causing wetting up of the soil mass and build-up of water pressure due to seepage pressure caused by subsurface flow in a downslope direction.

Other possible factors that may have contributed to the landslide B are:

(a) The predominant joint orientations controlling the development of the northern spur and producing locally steeper southern flanks, where the failure occurred.

(b) The atypical vegetation on the local catchment within the lot boundary of the original Dairy Farm development, which comprises grasses and succulents having a shallow and superficial root structure by comparison with the low scrub prevalent on the adjacent hillsides.

8.3 Discussion

Landslide A involved end-tipped fill which accumulated over the years that the Dairy Farm was in operation from the 1880's to the mid-1980's. Some construction waste from the development of the VTC site was further dumped in the early 1990's. The depression in the hillside at drainage line No. 2 probably resulted in a greater thickness of fill accumulating at the landslide site. The depth of fill interpreted from GEO probe results along the western edge of the VTC platform and the overall extent of fill below the platform level indicate that the body of fill is registerable as a fill slope.

The historical records indicate that the local hillside has been prone to periodic incidence of shallow landslides, particularly along drainage lines, in the past 40 years. The local geomorphology is controlled by predominant joint orientations which give rise to relatively steep flanks to the south of the spur ridge (Section 5.4.1) and an adversely orientated sheeting joint has been mapped on the local hillside. In this context and in the light of the recent (1972) formation of a gully feature immediately upslope of the present landslide B site (Section 3.2), the occurrence of landslide B is probably part of the natural development of the local catchment. Vegetation clearance on the hillside within the Dairy Farm boundary during the years that the farm was in operation has changed the predominating surface vegetation to species with shallow root growth. Although its effect on slope stability is difficult to quantify, vegetation clearance has probably had a negative impact on the

near-surface stability of the hillside.

The main uncertainty in relation to the present failures is the particular timing of the incidents (i.e "why this year"), particularly since the rainstorm event preceding the failures was not as severe as events experienced previously. In the case of landslide A, lack of maintenance to the surface drainage system within the VTC development probably permitted overflow at the slope crest which was an important source of water ingress into the fill.

With respect to landslide B, there is evidence to suggest that the failure was influenced by progressive deterioration of the ground conditions (in the form of tension cracking and ground movement), which was possibly exacerbated by previous, more severe rainstorm events. This rendered the affected terrain more vulnerable to failure.

The occurrence of two landslides within the same local catchment of the hillside during the same rainstorm, which involved different materials, may have been coincidental in this instance, but the possibility that one landslide may have influenced the other cannot be totally ruled out (e.g. toe erosion caused by debris leading to retrogressive failure, ground shaking caused by the first failure, etc.). However, based on the geometry of the landslide scars and the topographical relationship between the two, the scenario involving the erosion by debris leading to retrogressive failure is considered unlikely.

The topography of the local catchment, comprising a steep hillside incorporating a number of drainage lines containing ephemeral stream courses with a history of failure, is predisposed to local shallow rainfall-induced failures. The possible effect of ground shaking associated with the initial failure in triggering the other failure, if any, may not be significant.

The local presence of an unregistered loose fill on the hillside presents an additional hazard and this can be exacerbated by concentrated discharge of surface water overflowing from blocked drainage channels due to inadequate maintenance. Also, it is possible that shotcreting of part of the drainage lines as part of the urgent repair works may have contributed to increasing the mobility of landslide debris by creating a relatively planar and smooth path along which the channelised debris will travel.

9. CONCLUSIONS

It is concluded that the two landslides that occurred in the disturbed hillside below the VTC Pokfulam Skill Centre on 23 August 1999 were triggered by rainfall. The failures affected a local catchment comprising relatively steep topography incorporating a number of drainage lines containing ephemeral stream courses, which has experienced a history of instability. The local catchment has been altered by human action through the deposition of loose fill on the hillside and periodic clearance of vegetation, which has resulted in a change in the dominating species locally.

The landslides were probably caused by transient elevated water pressures in the soil mass following the rainfall that preceded the failures. The rainfall that triggered the failures was not as severe as previous rainstorms in the past 10 years which did not cause any major instability of comparable scales and with similar debris runout. Blockage of surface drainage above one of the landslides and the previous local instability resulting in change in slope

gradient and possible deterioration of ground conditions (i.e. development of tension cracks) at the second probably promoted the failures at this particular time. The two landslides, involving different materials, probably did not have any connection in that one was not triggered by the other.

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LIST OF TABLES

Table 1 – Summary of Test Results for Soil Samples (Sheet 1 of 3)

Material Type	Sample Location	Depth (m)	Sample Type	Particle Size Distribution				LL (%)	PL (%)	PI (%)	Moisture Content (%)	Maximum Dry Density (Mg/m^3)	Insitu Dry Density (Mg/m^3)
				Gravel (%)	Sand (%)	Silt (%)	Clay (%)						
FILL	TP1	0.0-0.2	LDS	27	38	25	10	60	44	16	30	1.25	1.46
C/HDT		0.5-1.0	LDS	2	50	41	7	30	NP	*	12	1.72	1.62
C/HDT		1.01-1.49	U76	3	51	40	6	NP	NP	-	8.8	-	-
C/HDT		1.0-1.5	HCB	4	61	32	3	NP	NP	-	10	1.65	-
C/HDT		1.5-2.0	LDS	1	48	48	3	35	NP	*	9.4	1.72	1.64
C/HDT		2.13-2.49	U76	1	55	41	3	NP	NP	-	9.2	-	-
C/HDT		2.0-2.5	HCB	4	56	37	3	NP	NP	-	11	1.61	-
C/HDT		2.0-2.5	HCB	1	43	52	4	-	-	-	-	-	-
CDT	TP2	0.5-1.0	LDS	3	49	40	8	30	NP	*	13	1.72	1.64
CDT		1.01-1.49	U76	5	55	34	6	NP	NP	-	15	-	-
C/HDT		1.0-1.5	HCB	6	59	31	4	NP	NP	-	15	1.63	-
C/HDT		1.5-2.0	LDS	1	52	38	9	31	NP	*	16	1.72	1.57
C/HDT		2.02-2.49	U76	3	63	28	6	NP	NP	-	16	-	-
C/HDT		2.0-2.5	HCB	2	58	33	7	NP	NP	-	16	1.79	-
FILL	TP3	0.0-0.2	-	-	-	-	-	-	-	-	-	-	1.46
CDT		0.5-1.0	LDS	1	35	51	13	30	23	7	16	1.69	1.56
CDT		1.06-1.49	U76	7	53	34	6	NP	NP	-	15	-	-
C/HDT		1.0-1.5	HCB	7	50	35	8	NP	NP	-	16	1.68	-
C/HDT		1.5-2.0	LDS	1	44	47	8	28	18	10	15	1.69	1.60
C/HDT		2.08-2.48	U76	6	57	32	5	NP	NP	-	14	-	-
C/HDT		2.0-2.5	HCB	12	51	32	5	NP	NP	-	15	1.70	-
CDT	TP4	0.5-1.0	LDS	1	37	42	20	35	NP	*	11	1.82	1.68
C/HDT		1.01-1.49	U76	12	39	39	10	NP	NP	-	12	-	-
C/HDT		1.0-1.5	HCB	1	39	41	19	NP	NP	-	12	1.82	-
C/HDT		1.0-1.5	HCB	1	38	44	17	-	-	-	-	-	-
C/HDT		1.5-2.0	LDS	1	37	50	12	33	27	6	16	1.71	1.62
H/MDT		2.02-2.48	U76	2	48	42	8	NP	NP	-	14	-	-
H/MDT		2.0-2.5	HCB	6	44	40	10	NP	NP	-	15	1.74	-

Table 1 – Summary of Test Results for Soil Samples (Sheet 2 of 3)

Material Type	Sample Location	Depth (m)	Sample Type	Particle Size Distribution				LL (%)	PL (%)	PI (%)	Moisture Content (%)	Maximum Dry Density (Mg/m^3)	Insitu Dry Density (Mg/m^3)
				Gravel (%)	Sand (%)	Silt (%)	Clay (%)						
FILL	TP5	0.0-0.2	LDS	5	55	23	17	34	22	12	13	1.55	1.45
CDT		0.5-1.0	LDS	2	50	27	21	33	22	11	15	1.71	-
CDT		1.15-1.49	U76	7	58	23	12	NP	NP	-	15	-	-
RS		1.0-1.5	HCB	3	42	26	29	38	20	18	19	1.71	-
HDT		1.0-1.5	HCB	13	57	22	8	-	-	-	-	-	-
CDT		1.5-2.0	LDS	1	48	31	20	31	22	9	16	1.71	1.52
CDT		2.01-2.49	U76	13	56	21	10	NP	NP	-	16	-	-
CDT		2.0-2.5	HCB	0	12	62	26	35	20	15	17	1.71	-
Top Soil	TP6	0.0-0.2	-	-	-	-	-	-	-	-	-	-	1.54
CDT		0.5-1.0	LDS	1	50	33	16	33	22	11	17	1.78	-
CDT		1.01-1.29	U76	2	52	38	8	NP	NP	-	15	-	-
CDT		1.0-1.5	HCB	5	48	37	10	NP	NP	-	15	1.78	-
CDT		1.5-2.0	LDS	2	48	40	10	31	22	9	14	1.78	1.56
CDT		2.02-2.29	U76	3	53	36	8	NP	NP	-	14	-	-
CDT		2.0-2.5	HCB	2	58	33	7	NP	NP	-	16	1.73	-
CDT		2.0-2.5	HCB	2	53	36	9	-	-	-	-	-	-
FILL	TP7	0.0-0.2	LDS	7	49	22	22	52	32	20	18	1.48	1.54
CDT		0.5-1.0	LDS	3	39	32	26	37	21	16	16	1.79	-
CDT		1.33-1.48	U76	1	47	36	16	30	21	9	14	-	-
CDT		1.0-1.5	HCB	0	45	35	20	NP	NP	-	13	1.84	-
CDT		1.5-2.0	LDS	1	48	38	13	31	20	11	14	1.79	1.54
CDT		2.21-2.48	U76	2	46	40	12	NP	NP	-	14	-	-
CDT		2.0-2.5	HCB	1	50	37	12	NP	NP	-	14	1.81	-

Table 1 – Summary of Test Results for Soil Samples (Sheet 3 of 3)

Material Type	Sample Location	Depth (m)	Sample Type	Particle Size Distribution				LL (%)	PL (%)	PI (%)	Moisture Content (%)	Maximum Dry Density (Mg/m^3)	Insitu Dry Density (Mg/m^3)
				Gravel (%)	Sand (%)	Silt (%)	Clay (%)						
Top Soil	TP8	0.0-0.2	-	-	-	-	-	-	-	-	-	-	1.45
CDT		0.5-1.0	LDS	0	49	33	18	33	23	10	18	1.72	-
CDT		1.01-1.34	U76	1	59	30	10	NP	NP	-	19	-	-
CDT		1.0-1.5	HCB	2	54	31	13	NP	NP	-	18	1.71	-
CDT		1.5-2.0	LDS	0	50	35	15	32	24	8	18	1.72	1.57
CDT		2.08-2.49	U76	1	64	28	7	NP	NP	-	17	-	-
CDT		2.0-2.5	HCB	3	56	30	11	NP	NP	-	18	1.75	-
Fill	ID1	0.0-0.2	LDS	-	-	-	-	-	-	-	37	1.33	1.04
Fill	ID2	0.0-0.2	LDS	-	-	-	-	-	-	-	29	1.43	1.29
Fill	ID3	0.0-0.2	LDS	-	-	-	-	-	-	-	31	1.57	1.17
Fill	ID4	0.0-0.2	LDS	-	-	-	-	-	-	-	24	1.55	1.52
Fill	ID5	0.0-0.2	LDS	-	-	-	-	-	-	-	28	1.63	1.30
Fill	ID6	0.0-0.2	LDS	-	-	-	-	-	-	-	30	1.37	1.22

Legend:

LL	Liquid Limit	RS	Residual Soil	TP2	Trial Pit 2
PL	Plastic Limit	C/HDT	Completely/Highly Decomposed Tuff	LDS	Large Disturbed Samples
PI	Plasticity Index	H/MDT	Highly/Moderately Decomposed Tuff	HCB	Hand-Cut Block Sample
NP	Non-plastic	*	Cannot be determined	U76	76 mm Dia. Undisturbed Tube Sample

ID1 Insitu Density Test Identification Number

Note: See Figure 7 for samples locations.

Table 2 - Summary of Triaxial Compression Test Results for Soil Samples (Sheet 1 of 2)

Sample Location	Depth (m)	Material Type	Sample Type	Moisture Content before Testing (%)	Dry Density before Testing (Mg/m^3)	Specific Gravity (Mg/m^3)	Type of Test	p' (kPa)	q (kPa)
TP1	1.0 - 1.5	C/HDT	Block	12.3	1.670	2.64	CUM	106.2 151.2 494.6	93.7 119.2 302.4
TP1	2.0 - 2.5	C/HDT	Block	11.4	1.642	2.63	CUM	72.7 108.3 514.1	61.4 78.5 324.4
TP2	1.0 - 1.5	C/HDT	Block	16.0	1.685	2.62	CUM	136.2 204.8 753.5	129.9 187.6 545.2
TP2	2.0 - 2.5	C/HDT	Block	18.0	1.469	2.62	CUM	19.3 39.5 130.2	11 22.8 75.6
TP4	1.0 - 1.5	C/HDT	Block	12.8	1.511	2.62	CUM	33.7 46.7 61.7	20.2 20.7 24.5
TP4	2.0 - 2.5	H/MDT	Block	15.0	1.375	2.62	CUM	14.3 33.7 52.9	8.7 12.1 20.8
TP5	2.0 - 2.5	CDT	Block	15.9	1.704	2.60	CUM	409.4 702.8 1202.1	394.6 670.9 1053.8
TP6	1.29 - 1.49	CDT	U76	15.8	1.525	2.64	CUM	40.9 99.8 215.5	24.8 61.2 122.1
TP6	1.0 - 1.5	CDT	Block	15.6	1.480	2.65	CUM	38.8 61.3 99.2	25.6 34.7 55
TP6	2.29 - 2.49	CDT	U76	15.2	1.556	2.64	CUM	49.3 103 209.8	31 62.1 118.9
TP6	2.0 - 2.5	CDT	Block	15.5	1.466	2.63	CUM	56.4 95.8 162.2	42.7 61 95.4
TP7	1.18 - 1.33	CDT	U76	13.2	1.684	2.64	CUM	49.2 84.8 122	30.5 47.3 63.3

Table 2 - Summary of Triaxial Compression Test Results for Soil Samples (Sheet 2 of 2)

Sample Location	Depth (m)	Material Type	Sample Type	Moisture Content before Testing (%)	Dry Density before Testing (Mg/m^3)	Specific Gravity (Mg/m^3)	Type of Test	p' (kPa)	q (kPa)
TP7	1.0 - 1.5	CDT	Block	13.7	1.682	2.63	CUM	53.9 74.5 104.2	33.5 40 49.1
TP7	2.01 - 2.21	CDT	U76	14.6	1.497	2.63	CUM	45.9 70.4 112.9	27.6 38.8 61.8
TP7	2.0 - 2.5	CDT	Block	15.1	1.434	2.66	CUM	40.6 55.3 84.8	24.3 25.9 38.4
TP8	1.34 - 1.49	CDT	U76	19.6	1.462	2.62	CUM	61.8 99.5 174.8	42.4 63.3 104.7
TP8	1.0 - 1.5	CDT	Block	17.5	1.397	2.63	CUM	41.4 60.5 94.5	27.4 34.1 51.5
TP8	2.0 - 2.5	CDT	Block	17.1	1.479	2.64	CUM	29.1 40.4 67.9	17.6 21.4 33.1

Legend: C/HDT Completely/Highly decomposed tuff CUM Consolidated undrained multi-stage triaxial compression test TP1 Tril Pit No. TP1

$p' = \frac{1}{2}(\sigma_1' + \sigma_3')$

$q = \frac{1}{2}(\sigma_1' - \sigma_3')$, where σ_1' and σ_3' are the major and minor principal effective stresses respectively

Notes: (1) See Figure 6 for the locations of samples.

(2) All samples of CDG extracted for the triaxial compression tests were outside the distressed zone of the slope.

Table 3 - Summary of Direct Shear Box Test Results for Soil Samples (Sheet 1 of 2)

Sample Location	Depth (m)	Material Type	Sample Type	Direction of Shearing	Vertical Stress at the Beginning of Test (kPa)	Maximum Shear Stress (kPa)	Horizontal Displacement at Maximum Shear Stress (mm)	Vertical Displacement at Maximum Shear Stress (mm)	Vertical Stress at Maximum Shear Stress (kPa)
TP1	2.0 - 2.5	C/HDT	Block	Horizontal	25	49.2	2.23	0.271	25
					50	41.8	5.38	-0.240	50
					100	63.2	10.53	-1.370	100
TP3	1.0 - 1.5	C/HDT	Block	Horizontal	25	15.9	8.35	-1.370	25
					50	33.7	9.95	-0.870	50
					100	66.2	8.69	-0.690	100
TP4	1.0 - 1.5	C/HDT	Block	Horizontal	25	18.6	5.72	-0.741	25
					50	37.5	10.67	-0.940	50
					100	72.5	9.16	-0.780	100
TP4	2.0 - 2.5	C/HDT	Block	Horizontal	25	17.1	5.78	-1.008	25
					50	35.5	5.75	-0.730	50
					100	68.9	6.23	-0.640	100
TP6	1.0 - 1.5	CDT	Block	Horizontal	25	19.7	2.63	-0.237	25
					50	36.1	7.87	-0.610	50
					100	69.0	8.21	-0.650	100
TP6	2.0 - 2.5	CDT	Block	Horizontal	25	23.7	3.76	-0.185	25
					50	35.5	11.38	-0.580	50
					100	69.4	7.90	-0.500	10
TP7	1.0 - 1.5	CDT	Block	Horizontal	25	17.5	3.29	-0.300	25
					50	32.6	10.95	-0.830	50
					100	64.1	9.60	-0.790	100

Table 3 - Summary of Direct Shear Box Test Results for Soil Samples (Sheet 2 of 2)

Sample Location	Depth (m)	Material Type	Sample Type	Direction of Shearing	Vertical Stress at the Beginning of Test (kPa)	Maximum Shear Stress (kPa)	Horizontal Displacement at Maximum Shear Stress (mm)	Vertical Displacement at Maximum Shear Stress (mm)	Vertical Stress at Maximum Shear Stress (kPa)
TP7	2.0 - 2.5	CDT	Block	Horizontal	25	17.0	11.80	-0.956	25
					50	37.5	8.95	-0.810	50
					100	71.3	8.29	-0.750	100
TP8	1.0 - 1.5	CDT	Block	Horizontal	25	18.3	10.02	-0.660	25
					50	35.3	10.76	-0.780	50
					100	67.5	9.27	-0.660	100
TP8	2.0 - 2.5	CDT	Block	Horizontal	25	47.5	5.22	0.552	25
					50	58.9	11.37	-0.090	50
					100	90.2	10.86	-0.480	100

Legend: C/HDT Completely/Highly decomposed tuff
TP3 Trial Pit No. TP3

Notes:
(1) See Figure 7 for the locations of trial pits.
(2) The rate of shearing was 0.08 mm/min.
(3) The positive vertical displacement denotes dilation and a negative vertical displacement denotes compression.

Table 4 - Maximum Rolling Rainfall at GEO Raingauge No. H03 for Selected Durations Preceding the 23 August 1999 Landslides and the Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period	Estimated Return Period (Years)
5 Minutes	8.0	05:10 on 23 August 1999	<2
15 Minutes	21.0	05:15 on 23 August 1999	<2
1 Hour	41.5	05:35 on 23 August 1999	<2
2 Hours	55.0	06:00 on 23 August 1999	<2
4 Hours	76.0	06:50 on 23 August 1999	<2
12 Hours	108.0	06:30 on 23 August 1999	<2
24 Hours	166.5	07:00 on 23 August 1999	<2
2 Days	177.0	07:00 on 23 August 1999	<2
4 Days	177.0	07:00 on 23 August 1999	<2
7 Days	178.0	07:00 on 23 August 1999	<2
15 Days	322.0	07:00 on 23 August 1999	<2
31 Days	419.5	07:00 on 23 August 1999	<2

Notes: (1) Return periods were derived from Table 3 of Lam and Leung (1994).

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

(3) The use of 5-minute data for durations between 4 hours and 31 days results in better data resolution, but may slightly over-estimate the return periods using Lam and Leung (1994)'s data, which are based on hourly rainfall for these durations.

LIST OF FIGURES

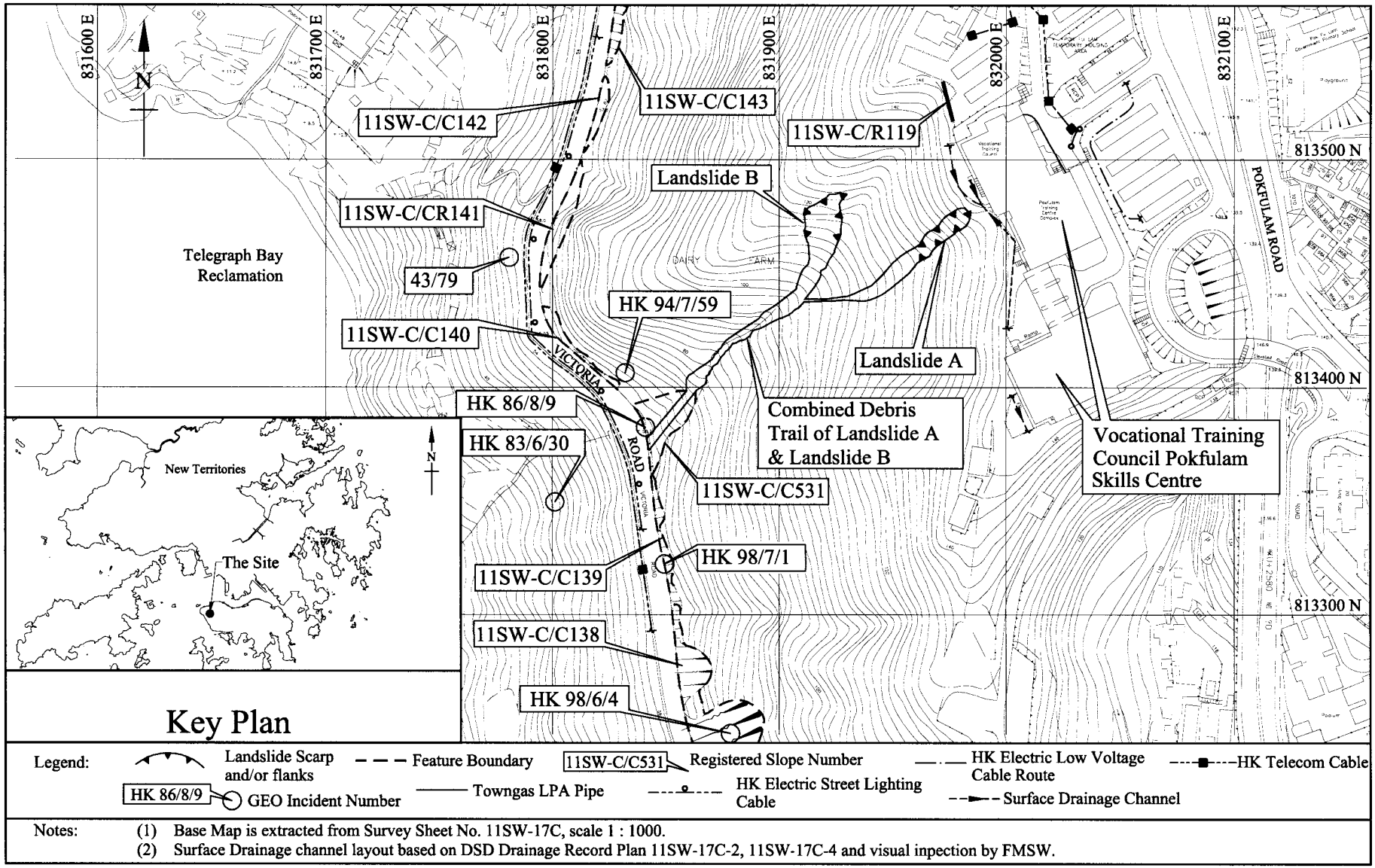


Figure 1 - Site Location and Utility Plan

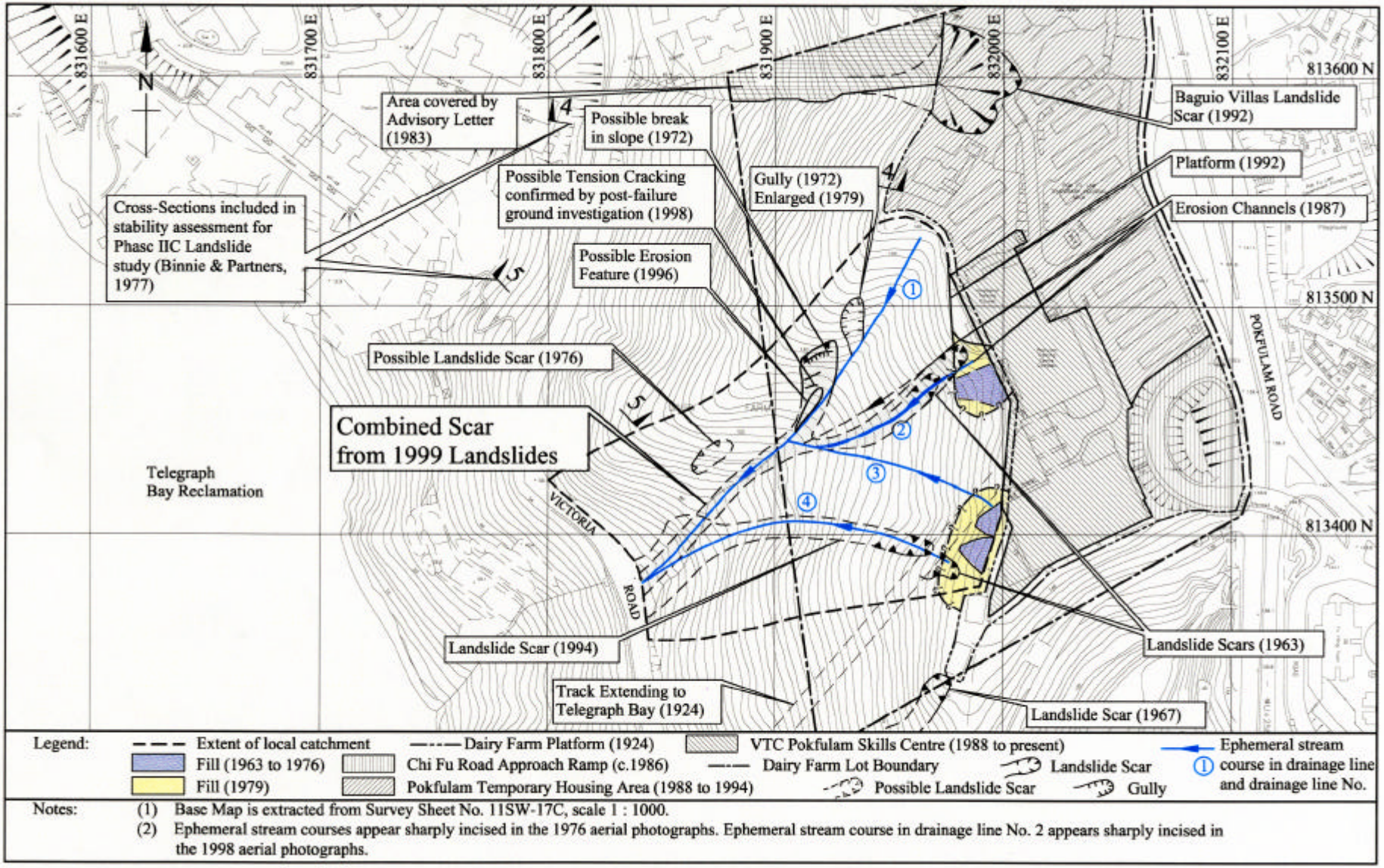


Figure 2 - Site History

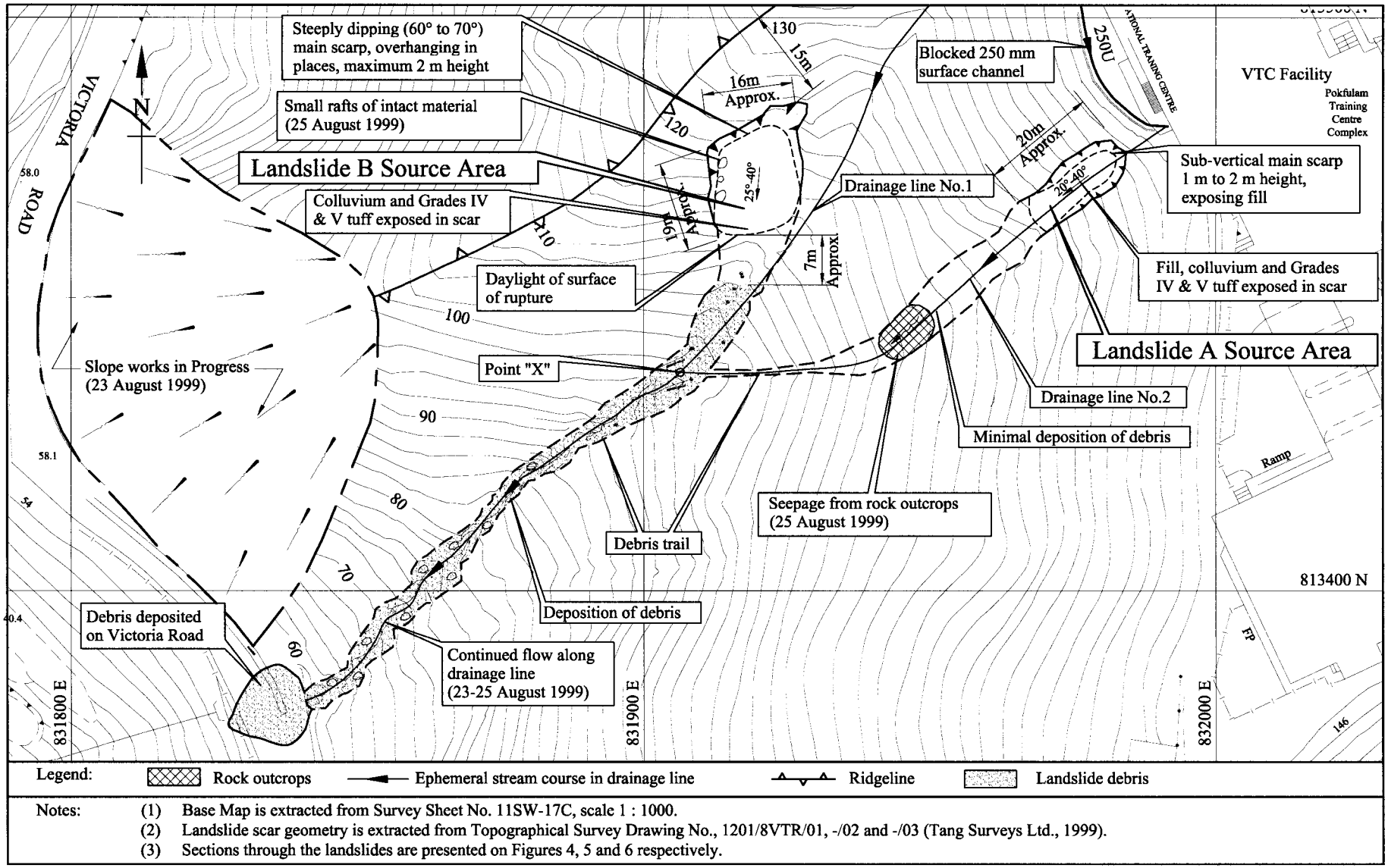
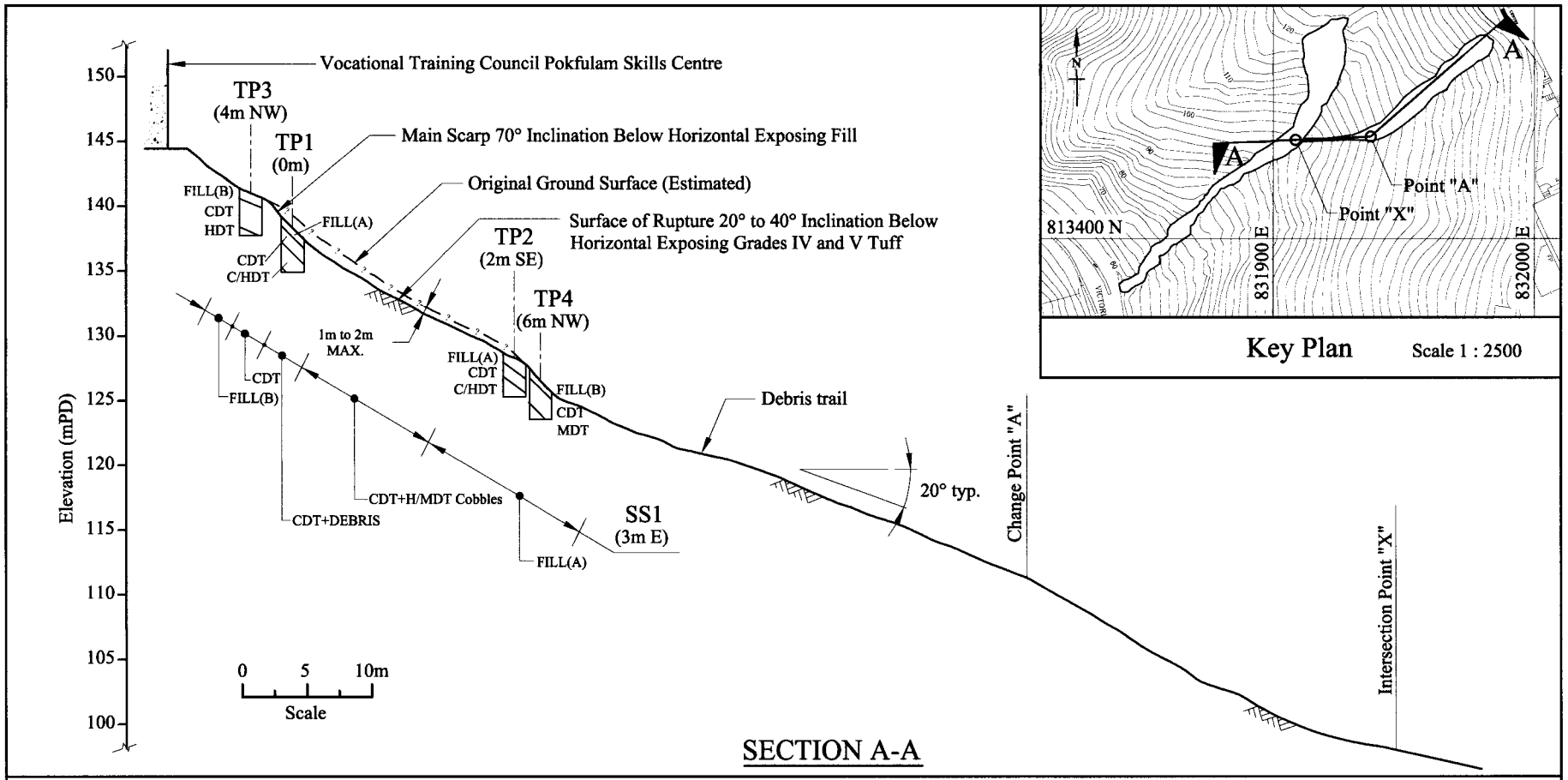


Figure 3 - Plan View of the Landslides



Legend:									
TP3 (4m NW)	Trial Pit Reference No., offset and direction	SS1 (3m E)	Surface Strip Reference No., offset and direction	C/H/MDT	Completely/Highly /Moderately Decomposed TUFF	FILL(A)	Landslide debris and trimmed material remaining in scar	FILL(B)	Intact fill material adjacent to landslide scar

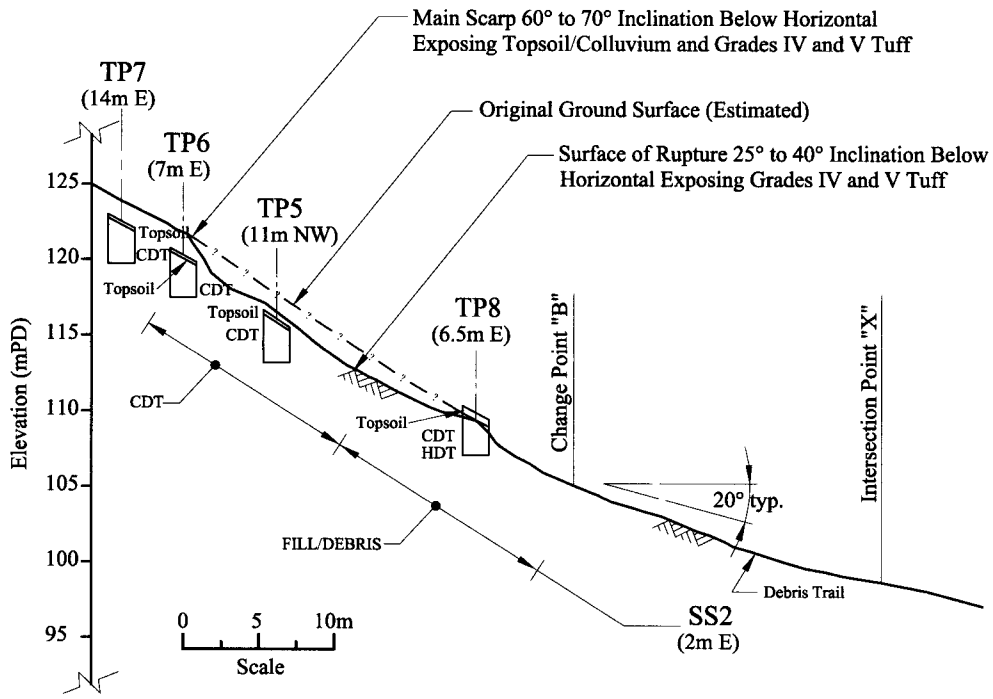
Notes:

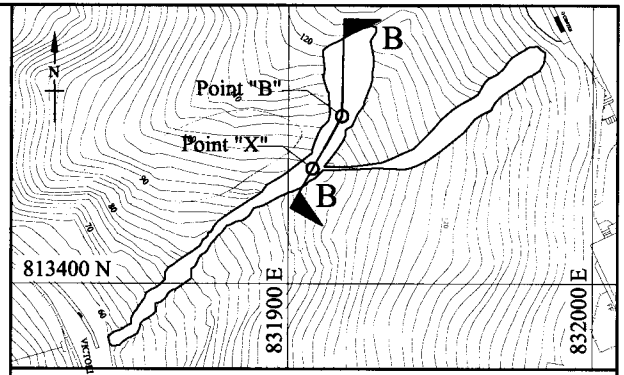
(1) Section geometry is based on Topographical Survey Drawings Nos. 1201/8VTR/01, -/02 and -/03 (Tang Surveys Ltd., 1999).

(2) Refer to Key Plan for location of section.

(3) Trial pit and surface strip information indicated on section are based on the ground investigation carried out in 1999/2000. Refer to Figure 7 for locations of trial pits and surface strips.

Figure 4 - Section A-A through Landslide A



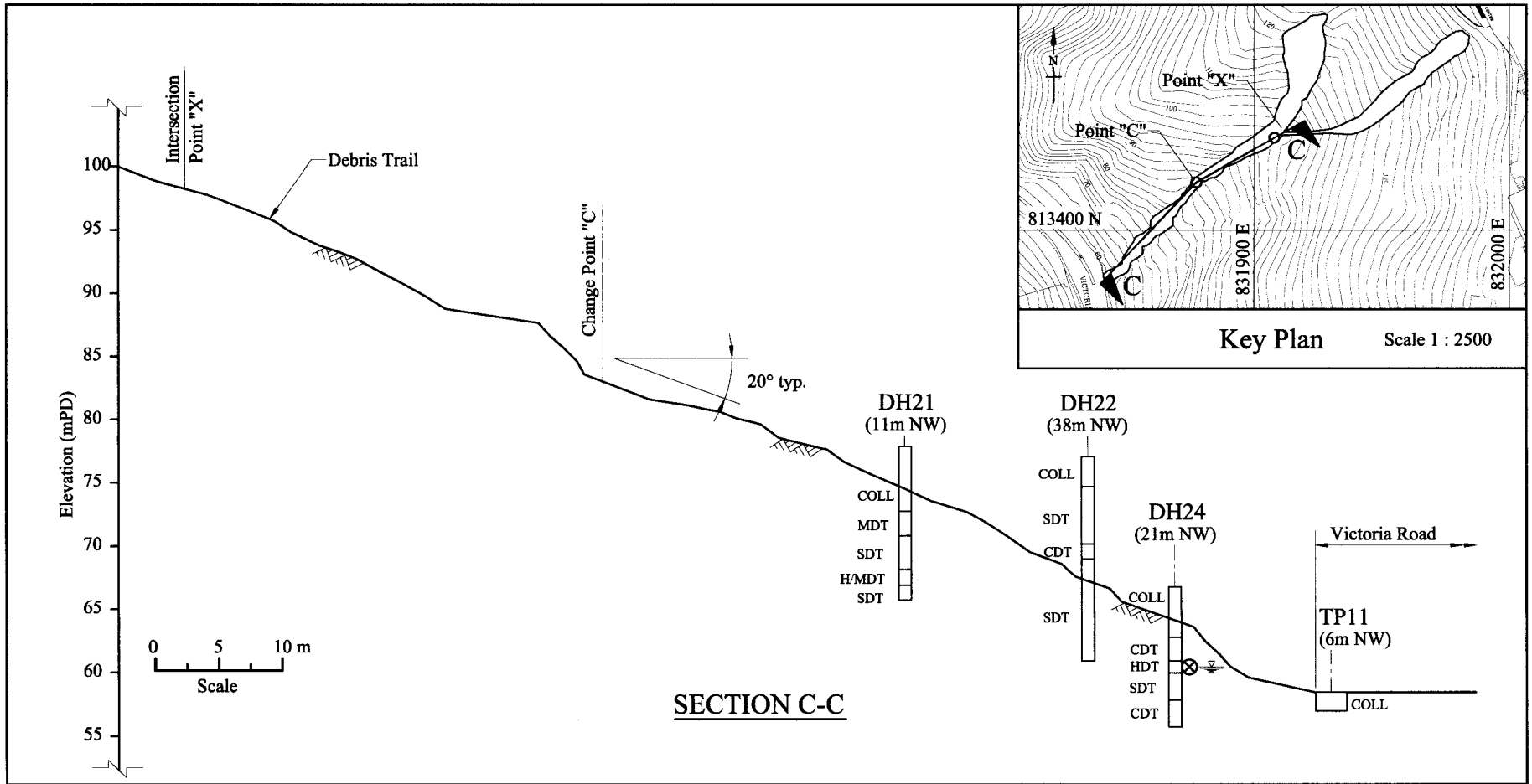


SECTION B-B

Legend:	TP6 (7m E)	Trial Pit Reference No., offset and direction	SS2 (2m E)	Surface Stripping Reference No., offset and direction	C/H/MDT	Completely/Highly/Moderately Decomposed TUFF	

Notes:
(1) Section geometry is based on Topographical Survey Drawings Nos. 1201/8VTR/01, -/02 and -/03 (Tang Surveys Ltd., 1999).
(2) Refer to Key Plan for location of section.
(3) Trial pit and surface strip information indicated on section are based on the ground investigation carried out in 1999/2000. Refer to Figure 7 for locations of trial pits and surface strips.

Figure 5 - Section B-B through Landslide B



Legend: DH21 (11m NW) Drillhole Reference No., offset and direction; TP11 (6m NW) Trial Pit Reference No., offset and direction; C/H/M/SDT Completely/Highly/Moderately/Slightly Decomposed TUFF; COLL Colluvium; ⊗ Piezometer Tip; ▽ Observed groundwater level (maximum)

Notes:
(1) Section geometry is based on Topographical Survey Drawings Nos. 1201/8VTR/01, -/02 and -/03 (Tang Surveys Ltd. 1999).
(2) Refer to Key Plan for location of section.
(3) Drillhole and trial pit information on are based on the ground investigation by Bachy Soletanche in 1987. Refer to Figure 7 for the locations of drillholes and trail pits.

Figure 6 - Section C-C through the Combined Debris Trail

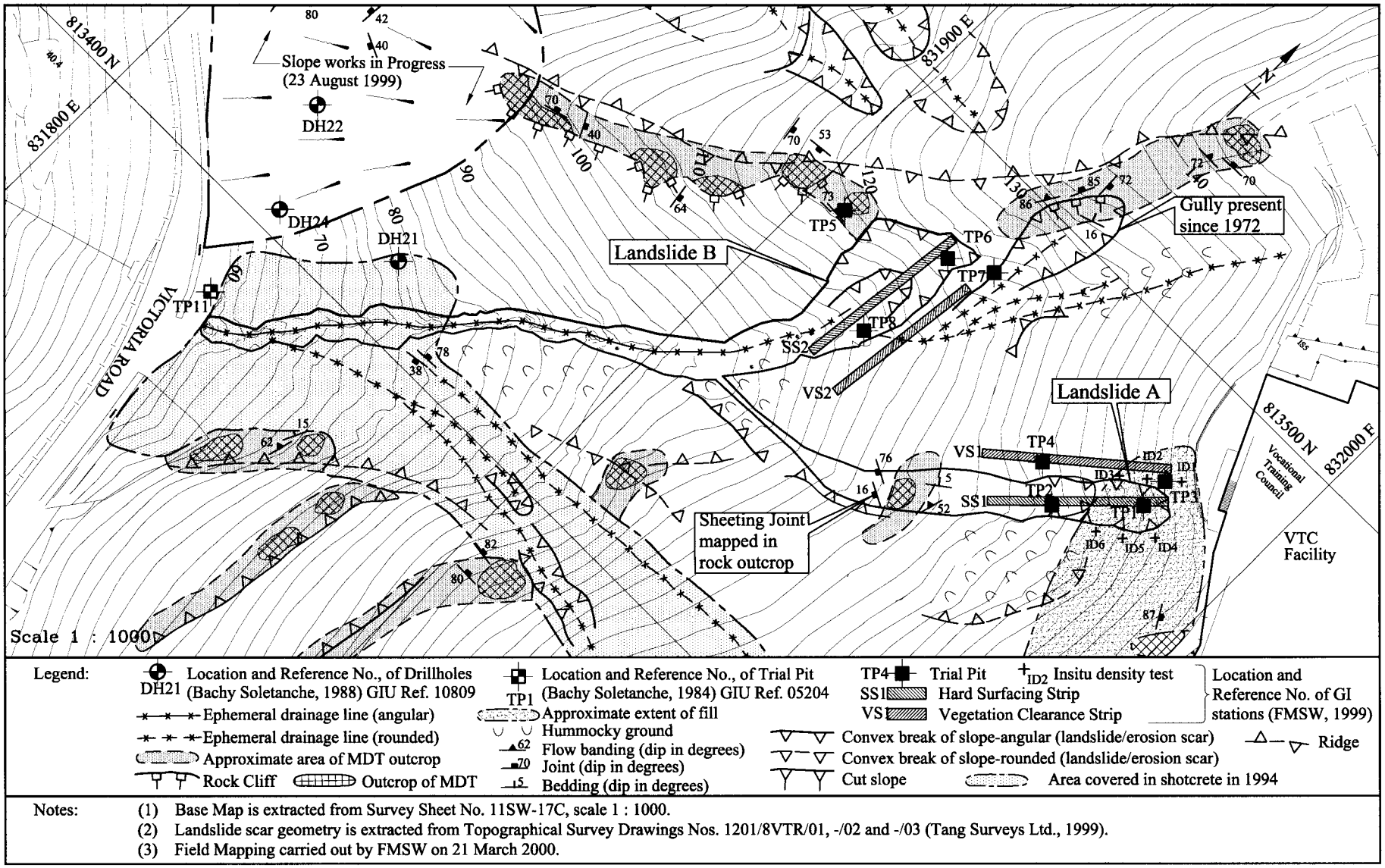
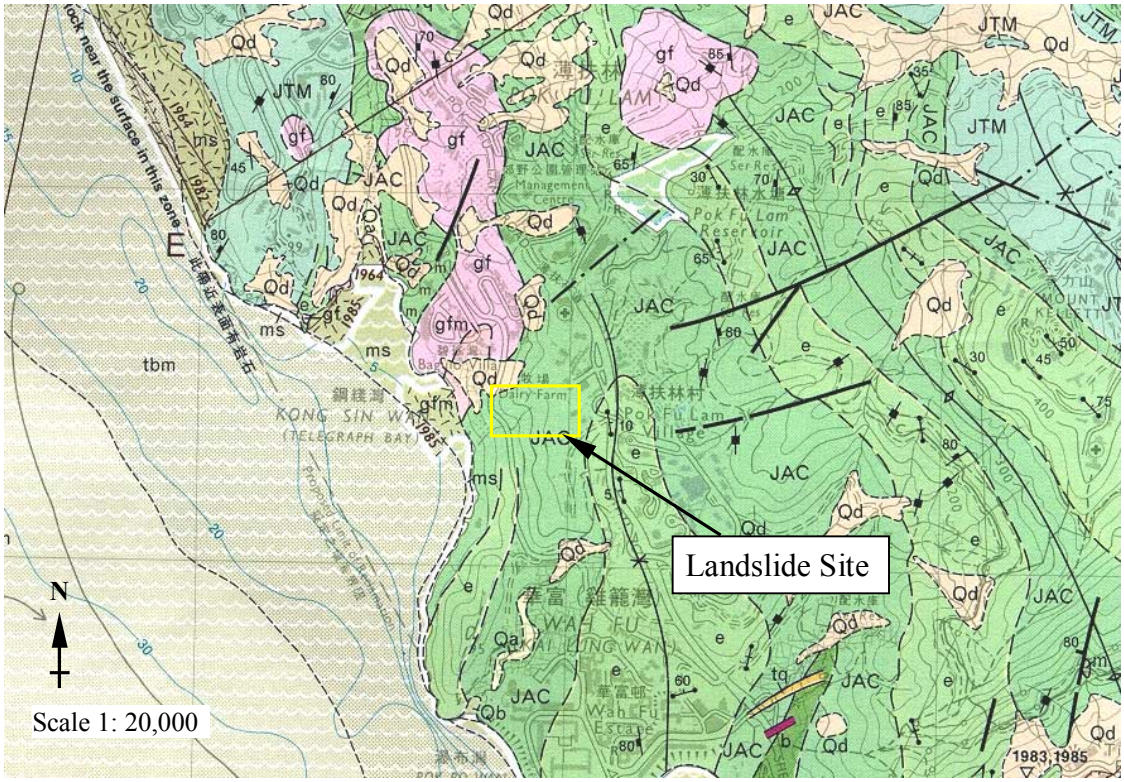


Figure 7 - Mapping of the Landslide Scars and Local Catchment



LEGEND :

SUPERFICIAL DEPOSIT (ONSHORE)

- Fill, sanitary fill (Qfs)
- Qa — Alluvium
- Qd — Debris flow deposits

SUPERFICIAL DEPOSIT (OFFSHORE)

- tbm — Marine mud
- ms — Marine sand, part silty

SOLID GEOLOGY

- JTM — Coarse ash crystal tuff
- JAC — **Fine ash vitric tuff**
- e — Eutaxite
- gf — Fine-grained granite; <2 mm
- gfm — Fine to medium-grained granite

GEOLOGICAL LINES

- Geological boundary, superficial deposit
- Geological Boundary, solid rock
- Fault (crossmark indicates downthrow side)
- Photogeological lineament

(* Broken lines on map face denote uncertainty)

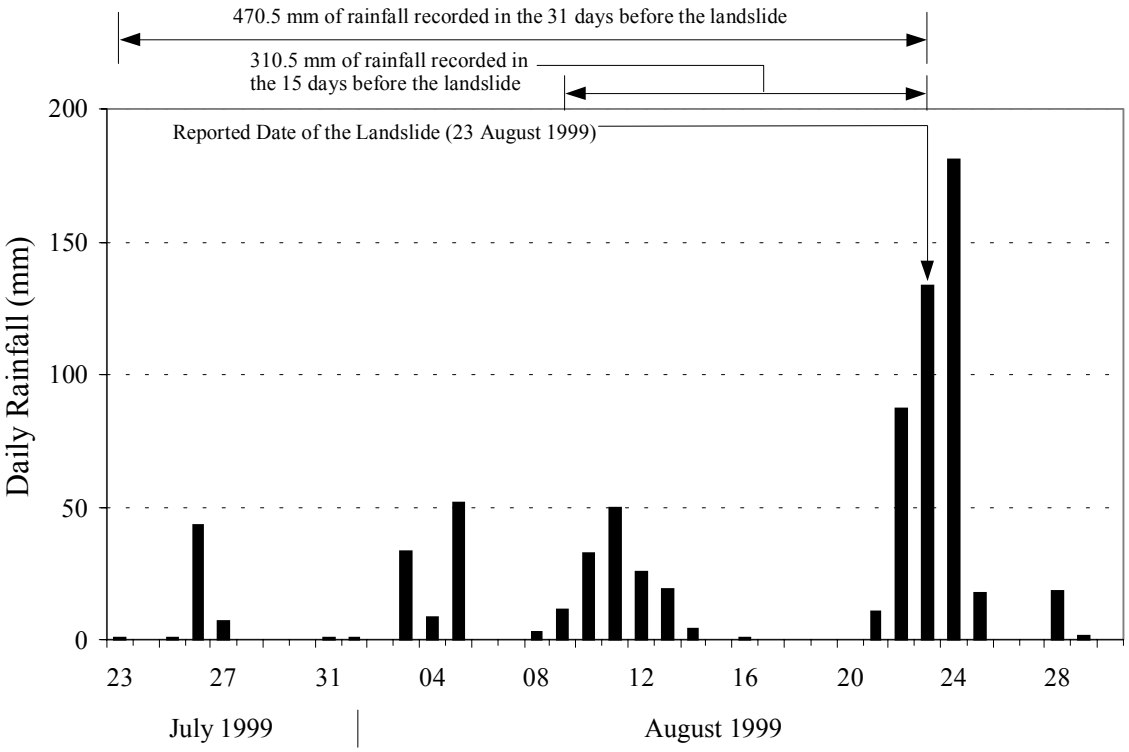
STRUCTURAL SYMBOLS

- Anticline axial trace (major)
- Syncline axial trace (major)
- 20 — Inclined flow fabric
- Vertical flow fabric
- 20 — Inclined jointing
- Vertical jointing

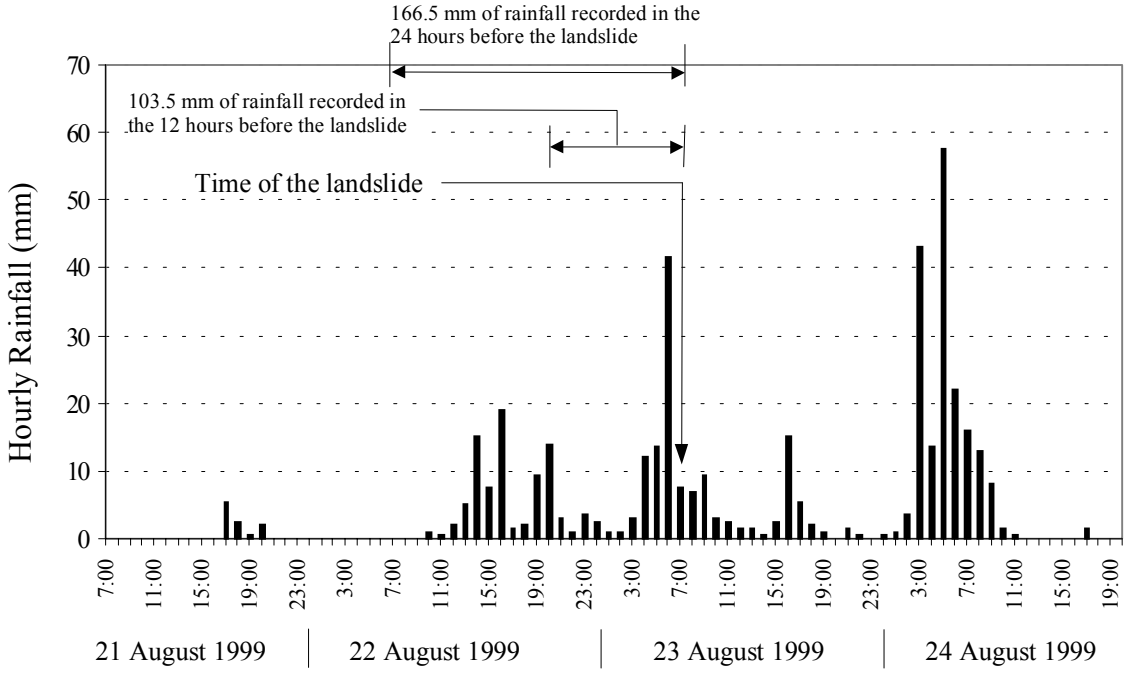
Notes: (1) Geology relevant to study area shown bold.

(2) Extract from Sheet 11 of the Hong Kong Geological Survey 1 : 20,000 Scale Map Series HGM20 (GCO, 1986).

Figure 8 – Solid and Superficial Geology of the Landslide Site

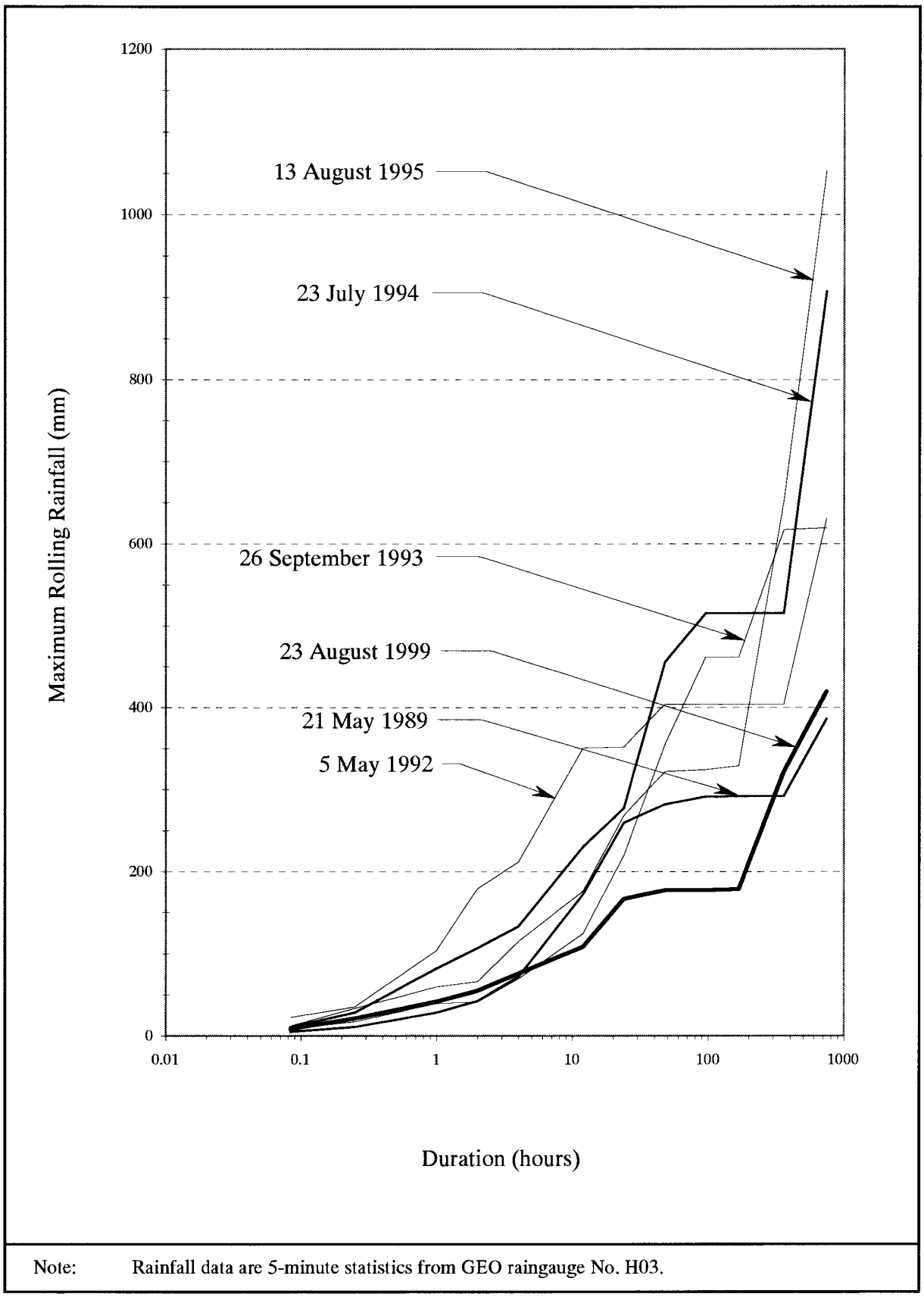


(a) Daily Rainfall Recorded between 23 July and 30 August 1999



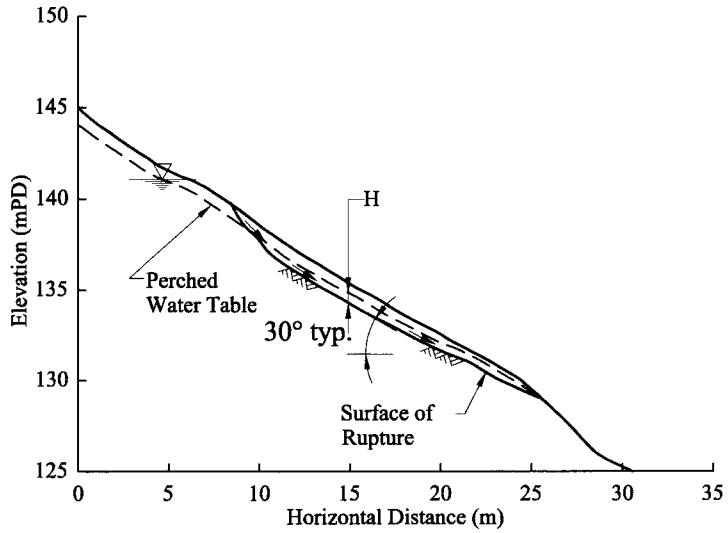
(b) Hourly Rainfall Recorded between 07:00 hours on 21 August and 19:00 hours on 24 August 1999

Figure 9 - Rainfall Recorded at GEO Raingauge No. H03

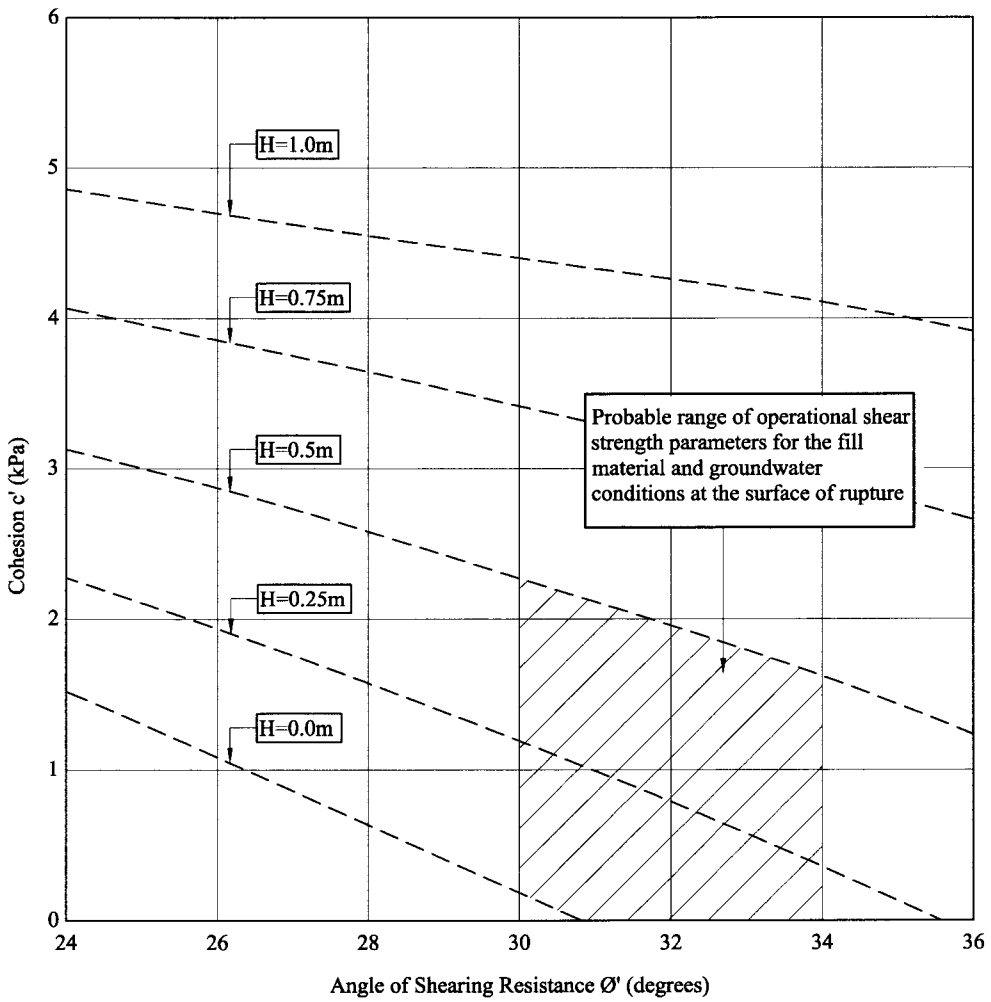


Note: Rainfall data are 5-minute statistics from GEO raingauge No. H03.

Figure 10 - Maximum Rolling Rainfall Preceding the Landslides of 23 August 1999 and Selected Previous Major Rainstorms Recorded at GEO Raingauge No. H03

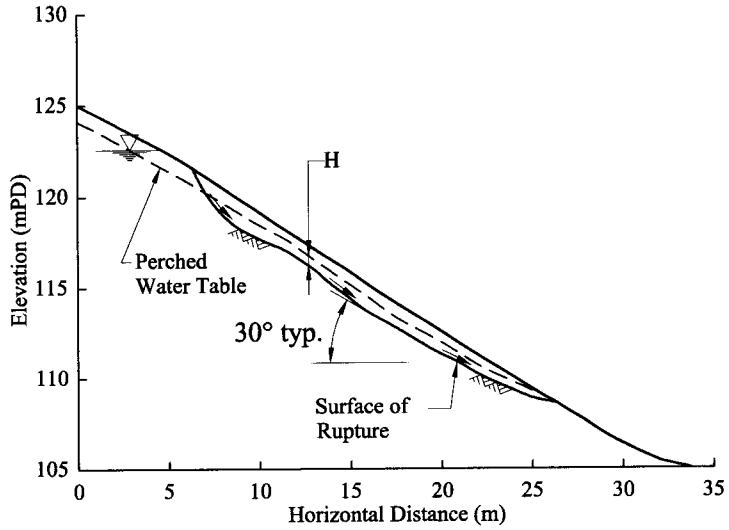


Idealised Section A-A

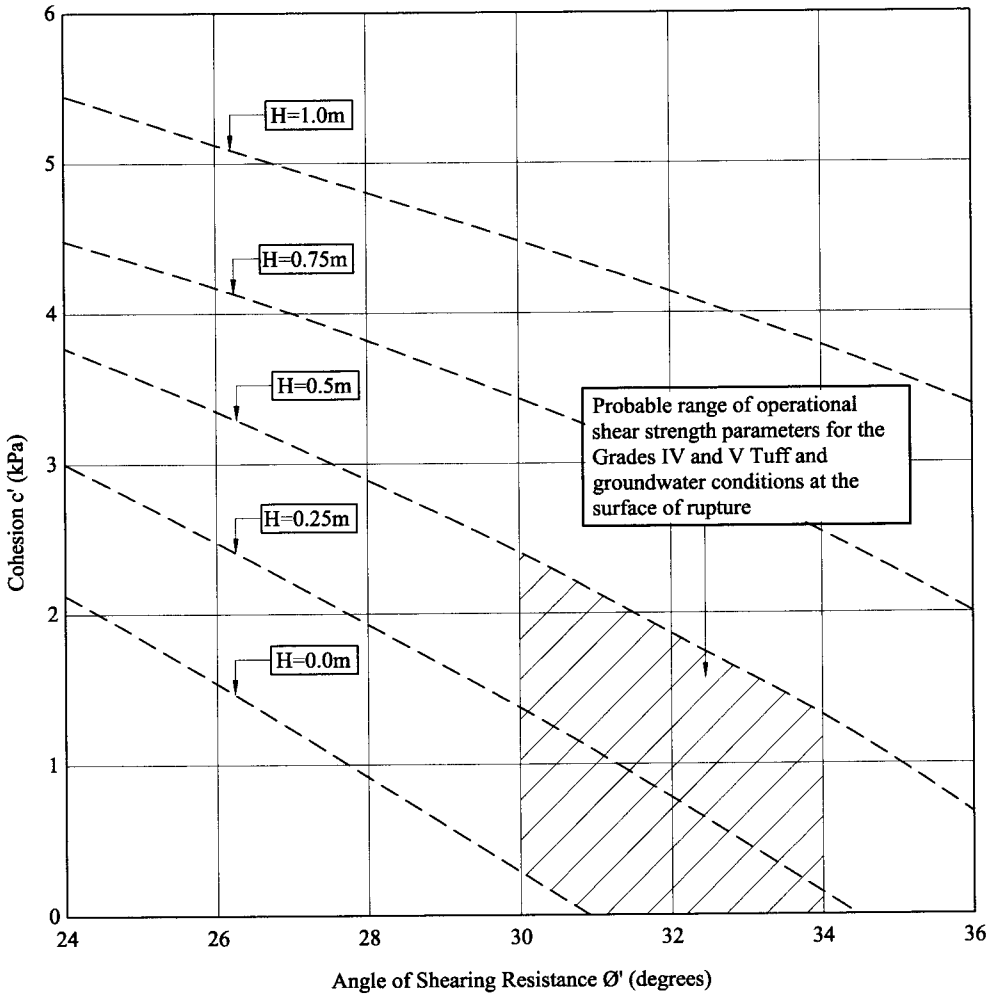


Notes: (1) – – – – Factor of Safety Equal to Unity (i.e. Limiting Equilibrium).
(2) Refer to Figure 4 for details of Section A-A.

Figure 11 - Summary of Sensitivity Analyses (Landslide A)



Idealised Section B-B



Notes: (1) – – – – Factor of Safety Equal to Unity (i.e. Limiting Equilibrium).
(2) Refer to Figure 5 for details of Section B-B.

Figure 12 - Summary of Sensitivity Analyses (Landslide B)

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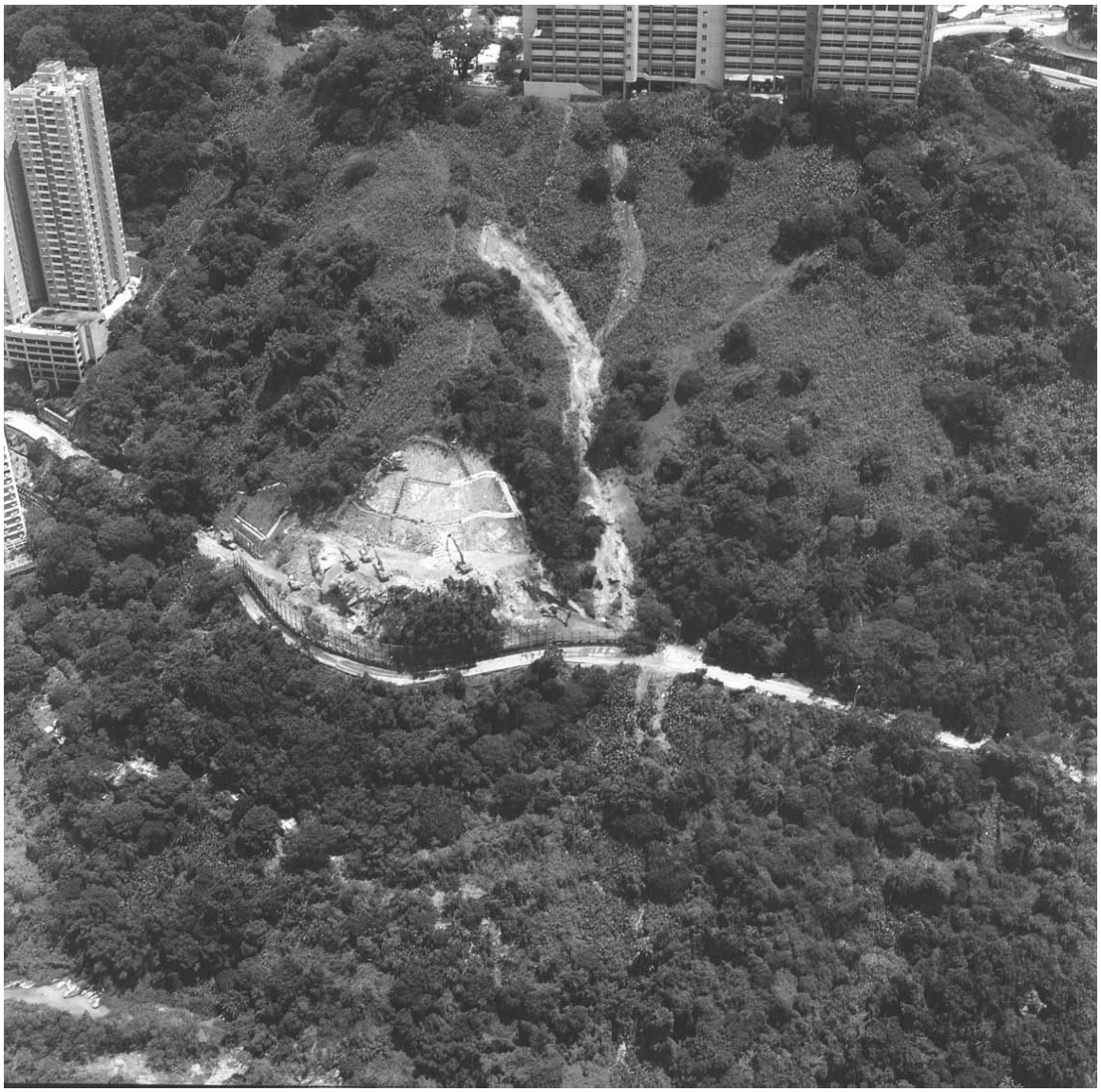


Plate 1 – Oblique View of the Landslide Site Indicating Convergent Debris Trails and Subsequent Runout to Victoria Road. VTC Pokfulam Skills Centre Visible in Upper Portion of Frame. Upper Baguio Villas (Block 26) and Lower Baguio Villas (Block 44) Separated by Victoria Road Visible on Left of Frame. Slope Works in Progress above Victoria Road Associated with Victoria Road Improvement Stage 2 Phase II Project (Photograph Taken on 2 September 1999)

Plate 2 – Oblique View East towards the Landslide Site Showing General Landform. Telegraph Bay Reclamation in Foreground Abutting Original Coast Line. Baguio Villa Estate in Lower Portion of Westerly Trending Valley Extending to Victoria Road. Pokfulam Reservoir Visible to East. Note also Change in Vegetation in Valley of Adjacent Hillside (Photograph Taken on 2 September 1999)

Plate 3 – Oblique View East towards Local Catchment Defined by Prominent Spur Ridge to the North and Broad Spur Ridge to the South (Indicated) (Photograph Taken by GEO on 15 July 1999)

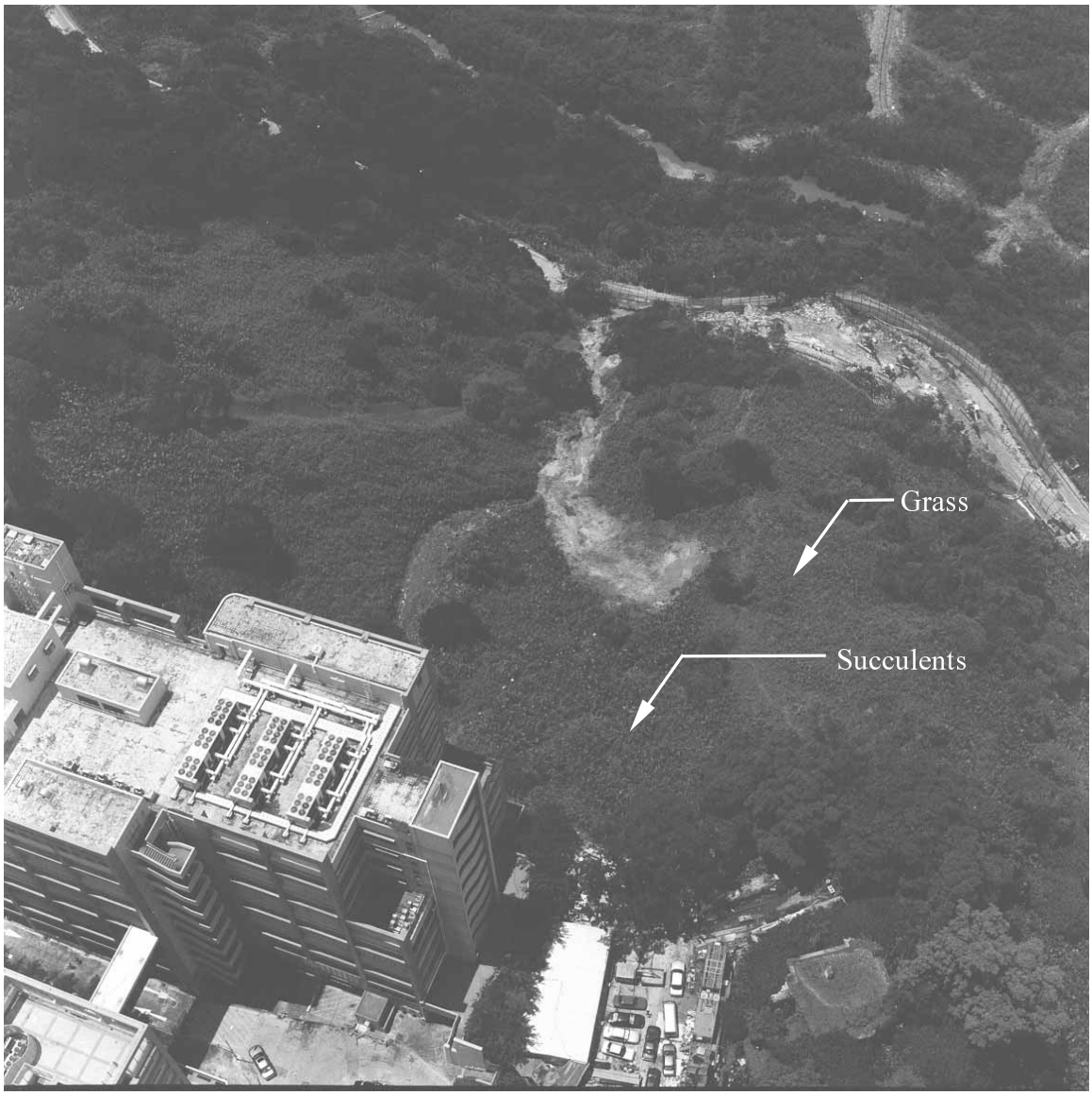


Plate 4 – Oblique View West down Debris Trail towards Victoria Road Indicating Predominant Vegetation Species (Photograph Taken on 2 September 1999)

Plate 5 – View East across Main Scarp and Southern Flank of Landslide A. Note Definition of Scarp and Flank, Exposed Fill in Flanks and Clear Line of Interface with Natural Ground Below. Note also Refuse Content of Fill (Photograph Taken on 26 August 1999)

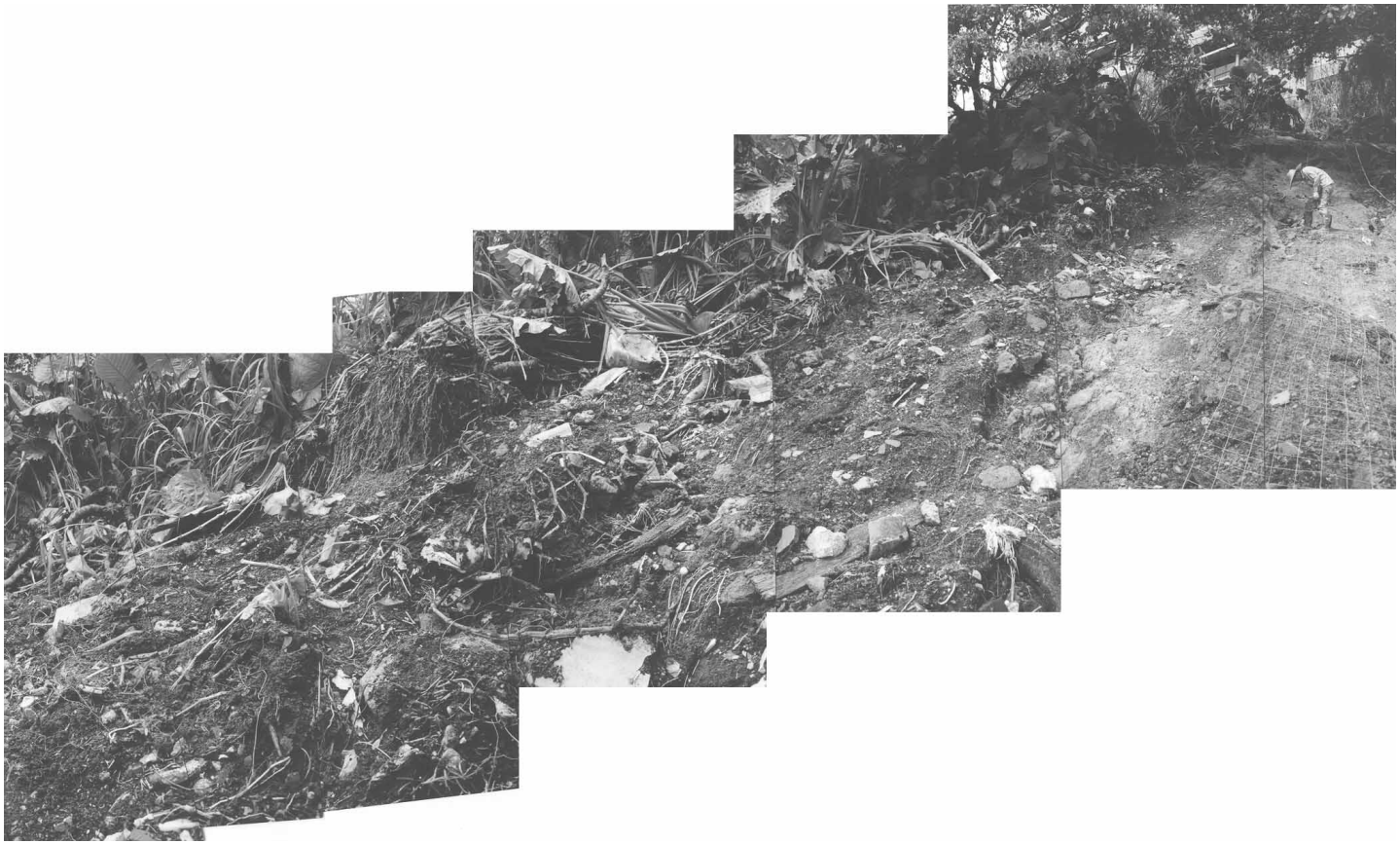


Plate 6 – View North-East along Northern Flank of Landslide A. Note Shallow Depth of Fill Overlying Natural Ground and Refuse Content of Fill (Photograph Taken on 26 August 1999)

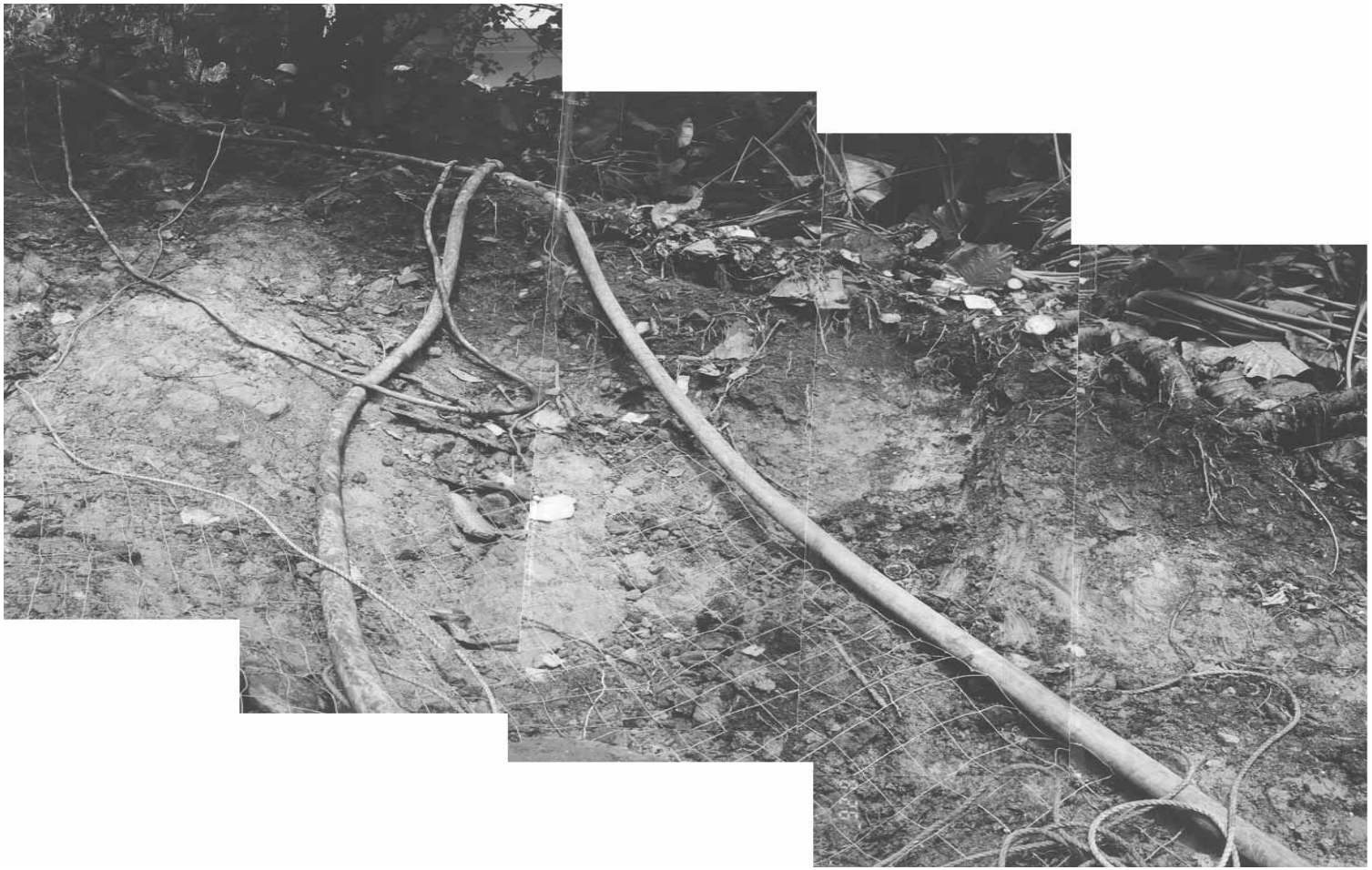


Plate 7 – View East across Southern Flank of Landslide A. Note Shallow Depth of Fill and Planar Exposure of Natural Ground in Scar. Note also Refuse Content of Fill (Photograph Taken on 26 August 1999)

Plate 8 – View South-West down Landslide A. Note Shallow Sectional Geometry of Scar and Exposure of Natural Ground on Left of Frame (Photograph Taken on 26 August 1999)

Plate 9 – View South-East up Landslide A from Point of Confluence of Drainage Lines Nos. 1 and 2 (Photograph Taken on 26 August 1999)

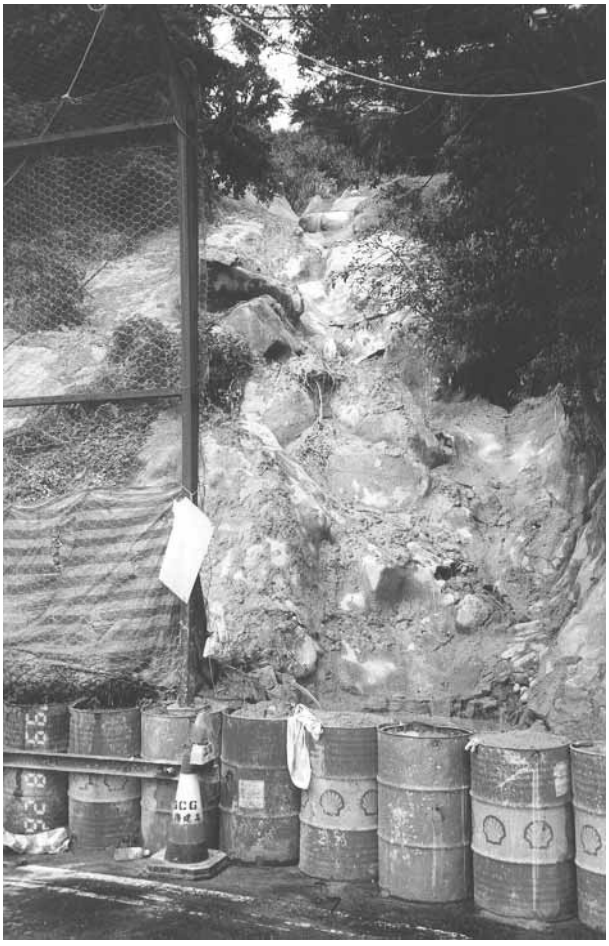


Plate 10 – View North–East up Landslide Scar from Victoria Road. Slope No. 11SW-C/C531 in Foreground. Note Random Orientation of Large Blocks in Slope to Suggest Previous Instability (Photograph Taken on 26 August 1999)

Plate 11 – View North-East up Landslide Scar from above Crest of Slope No. 11SW-C/C531 Exposing Previous Application of Shotcrete to Ephemeral Stream Course and Drainage Line No. 4 above Victoria Road (Photograph Taken on 25 August 1999)

Plate 12 – View North–West across Landslide B. Landslide A Visible at Extreme Left of Frame. Note Rafts of Semi-Intact Material Remaining in Landslide B. Note also Light Colour of Material Exposed in Landslide B Compared to Landslide A
(Photograph Taken by GEO on 24 August 1999)

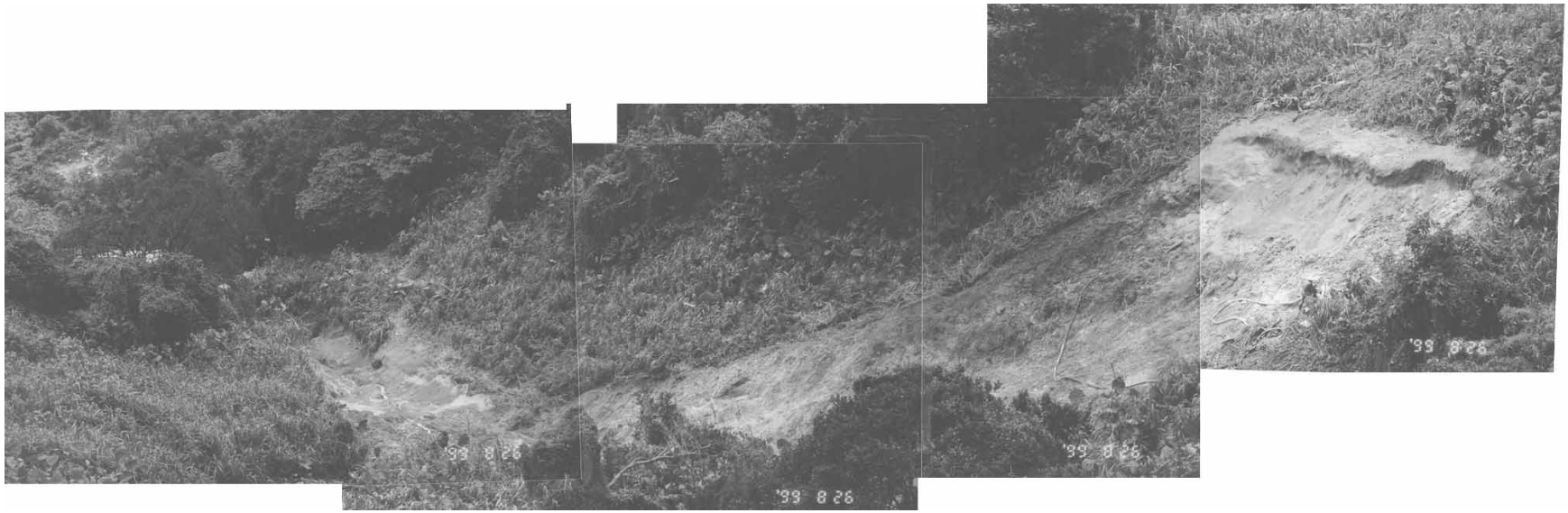


Plate 13 – View West across Landslide B from VTC Building. Shotcreting Works in Progress. Note Apparent Layer Separation in Main Scarp Producing Overhang. Note also Darker Superficial Material Remaining in Scar (Photograph Taken on 26 August 1999)

Plate 14 – View North up Landslide B from above Point of Confluence. Shotcreting Works Underway. Note Overhang of Main Scarp. Intact Vegetation in Scar in Foreground Suggests Source Area Largely Confined to Portion Already Shotcreted (Estimated Daylight Indicated). Note also Erosion Gully in Base of Drainage Line Traversing Scar in Foreground (Photograph Taken on 26 August 1999)

Plate 15 – Erosion Channels within Landslide Scar downslope of Point of Confluence (Photograph Taken on 26 August 1999)

Plate 16 – View West down Landslide B at Point of Confluence. Note Ponded Water from Continued Seepage along Drainage Line above (Photograph Taken on 26 August 1999)

Plate 17 – 250 mm U-Channel Located above Main Scarp of Landslide A Overgrown and Blocked by Vegetation (Photograph taken on 25 August 1999)

Plate 18 – Trial Pit TP1: General View Showing Insitu Weathering Profile of Fine Ash Vitric Tuff (Photograph Taken on 6 December 1999)

Plate 19 – Trial Pit TP2: General View Showing Insitu Weathering Profile of Fine Ash Vitric Tuff (Photograph Taken on 8 December 1999)

Plate 20 – Trial Pit TP3: South-East Face of Pit Exposing Fill Overlying Insitu Profile (Photograph Taken on 7 December 1999)

Plate 21 – Trial Pit TP2: General View Indicating Open, Blocky Structure of Grade IV Tuff (Photograph Taken on 8 December 1999)

Plate 22 – Trial Pit TP1: General View Showing Relic Joints in Grade IV Tuff Infilled with Grade V Material (Photograph Taken on 6 December 1999)

Plate 23 – Trial Pit TP5: General View of Pit Showing Exposure of Grades IV and V Tuff (Photograph Taken on 16 December 1999)

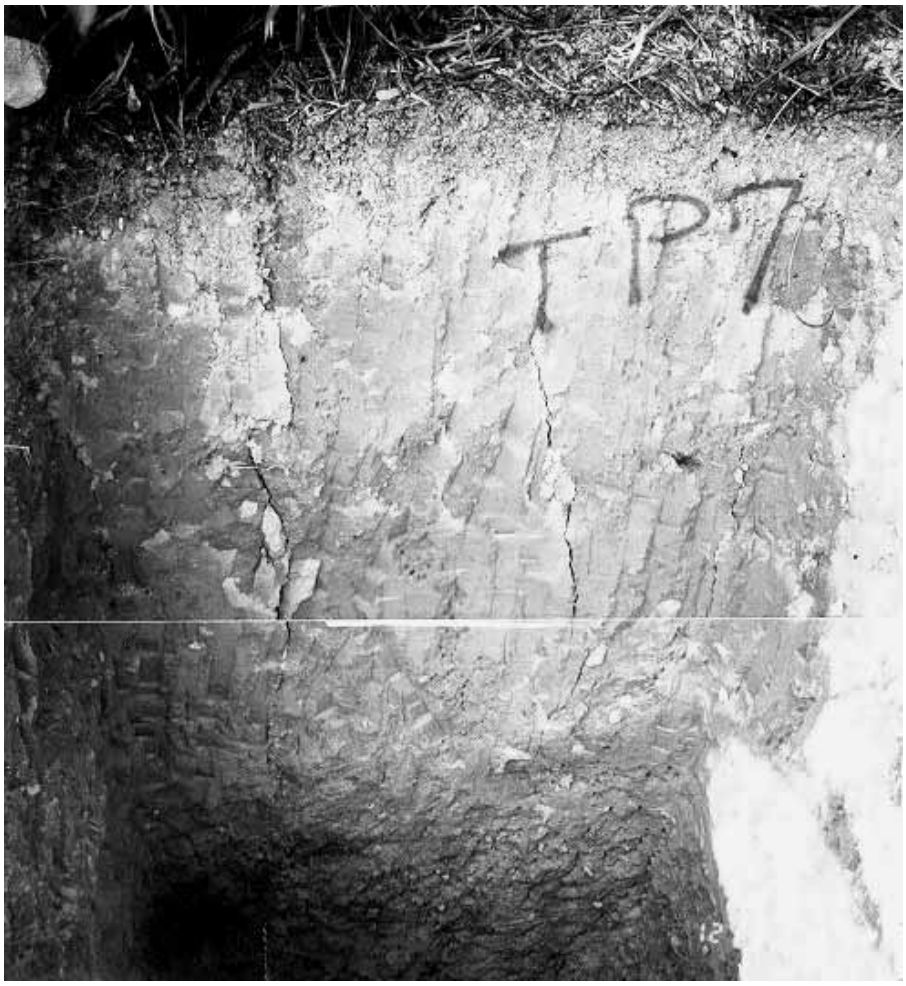


Plate 24 – Trial Pit TP7: General View of Pit Showing Exposure of Grade V Tuff. Note also Cracks in Face of Pit (Photograph Taken on 15 December 1999)

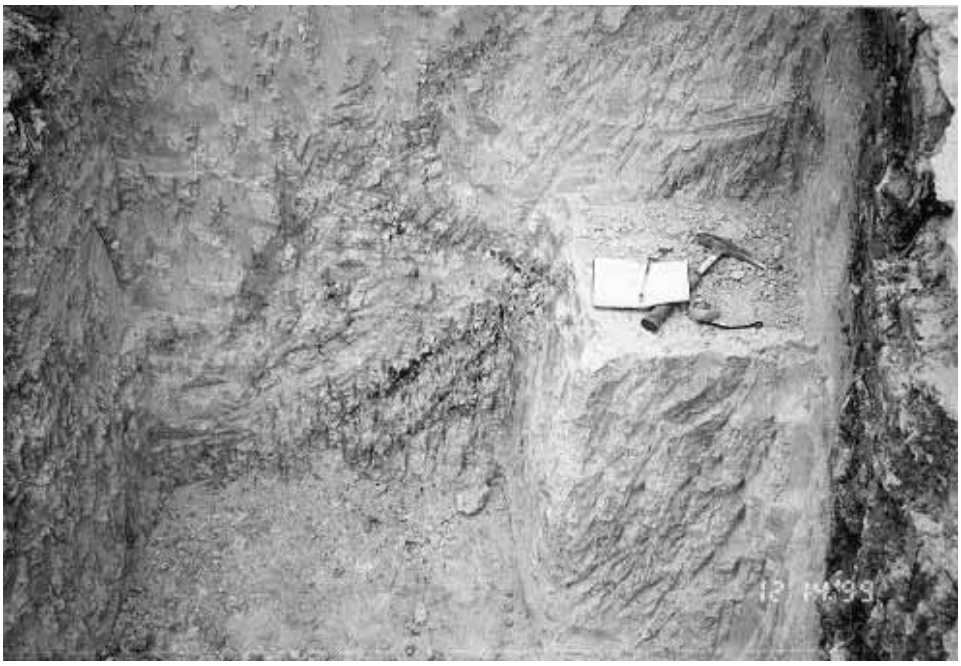


Plate 25 – Trial Pit TP6: General View of Pit Showing Exposure of Grades IV and V Tuff. Note Landslide Debris Remaining beneath Shotcrete on Right of Frame (Photograph Taken on 14 December 1999)

Plate 26 – Trial Pit TP8: General View of Pit Showing Exposure of Grades IV and V Tuff. Note Landslide Debris Remaining beneath Shotcrete at Top of Frame (Photograph Taken on 13 December 1999)

Plate 27 – Trial Pit TP5: Exposure of Grade III/IV Tuff in Western Face of Pit. (Photograph Taken on 16 December 1999)

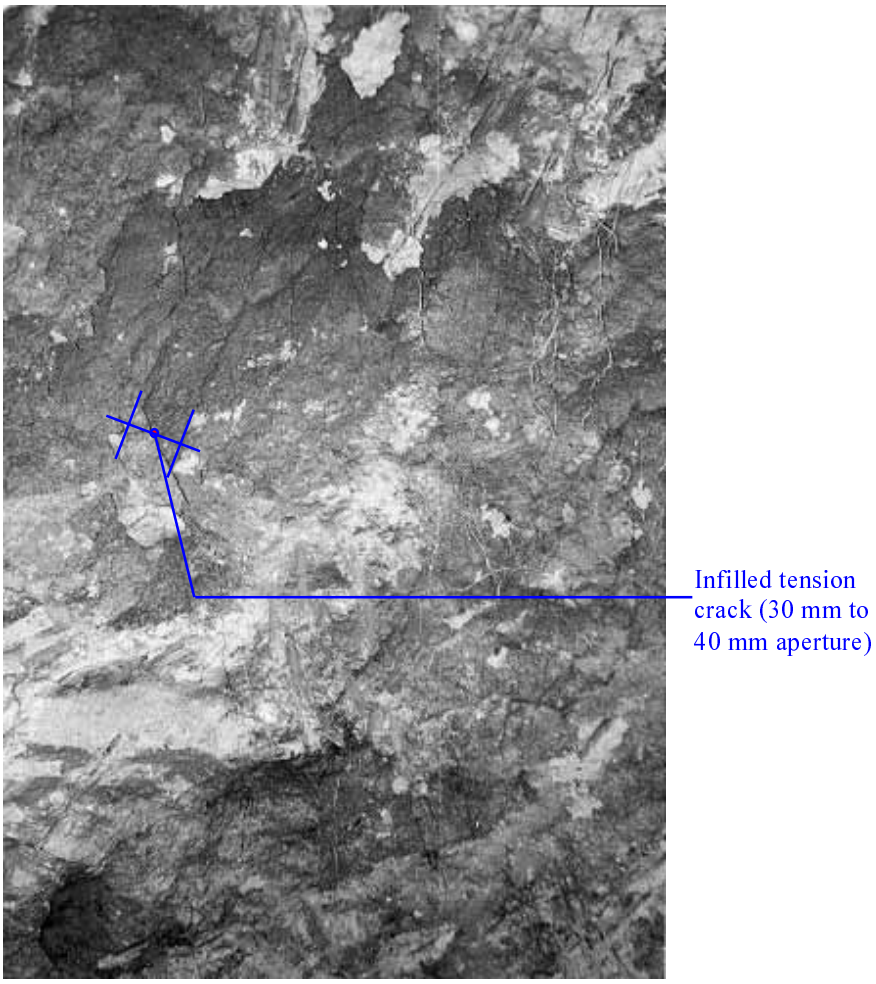


Plate 28 – Trial Pit TP5: Infilled Tension Crack Exposed in Western Face of Pit (Indicated) (Photograph Taken on 16 December 1999)

APPENDIX A

AERIAL PHOTOGRAPH INTERPRETATION

A.1 DETAILED OBSERVATIONS

Detailed observations made from the aerial photographs studied are given below. Relevant aerial photographs are referenced in Section A.2.

YEAR **OBSERVATIONS**

1924 No stereo pair available. High altitude photograph. Pokfulam Road, Victoria Road and the Dairy Farm complex are present (see 1963 observations for description). The hillside below (west of) the farm has a low cover of vegetation which may be grass. A linear track traverses the hillside from the southern end of the farm complex southwest across Victoria Road to Telegraph Bay.

1949 No stereo pair available. Photograph does not extend to Victoria Road. The hillside below the farm complex appears hummocky. The track (1924) is abandoned and locally destroyed by creep and shallow earth flow landsliding.

1963 Earliest available stereo pair. The Dairy Farm complex is constructed predominantly on cut platforms excavated along the crest of a north-south trending ridge. The northern boundary of the farm is common with the adjacent development "Bethany". The farm complex extends about 400 m to the south and is about 100 m wide, Pokfulam Road forming the eastern boundary. The complex comprises a number of fenced yards and outbuildings. A structure that appears to be the farm residence is located towards the northern end of the site and overlooks the hillside extending to the west. The ridge occupied by the farm complex forms the eastern margin of a long, west-facing hillside, which descends to Telegraph Bay (reclaimed after 1985). The local catchment containing the 1999 landslide scars is defined to the north by a prominent spur ridge that extends southwest from the northern end of the farm complex and to the south by a broad spur ridge extending west from the southern end of the farm complex.

The arrangement of the farm complex appears essentially unchanged since 1924. The cut platforms step down to Pokfulam Road. The yards north and south of the residence are formed on fill placed in the upper part of drainage lines to the north and south of the northern spur ridge and retained along the western extent by near-vertical walls. Other than these and very minor fill slopes along the western edge of the farm complex, no significant bodies of fill can be discerned on the hillside within the local catchment.

Within the local catchment, a number of drainage lines extend from the farm platform to Victoria Road. Drainage line No.1 is located along the southern flank of the spur ridge defining the northern extent of the catchment and follows a continuous line southwest from the farm platform to Victoria Road over a distance of approximately 200 m on plan. Drainage lines Nos. 2 and 3 extend from points along the edge of the farm platform and converge at drainage line No. 1 approximately 90 m downslope. Drainage line No. 4 is located on the northern flanks of the broad spur ridge defining the southern

YEAR	OBSERVATIONS

1963 cont'd extent of the local catchment and converges with drainage line No. 1 immediately above Victoria Road. The 1999 landslides occurred in the southern flanks of the spur ridge at the northern end of the catchment, approximately 70 m downslope of the platform, and at the head of drainage line No. 2 immediately below the farm platform.

The hillside is traversed by remnants of the track (1924), farm roads, and trails. In addition, there are a number of lineaments, some at right angles, which appear to define agricultural plots. Although farm-related features are present on the hillsides below the Dairy Farm complex, and portions of the hillsides are periodically cleared over the years, no cows or farm equipment (e.g. tractor) are present in any of the photographs studied. Two drainage channels discharge into drainage lines Nos. 2 and 3 from the farm platform. Several small fill bodies are present on the hillside.

Except for the southeast flank of the spur ridge, most of the hillside shows evidence of creep (hummocky ground), shallow landsliding, and surface erosion and gullying. The hillside is traversed by a number of northeast-southwest trending breaks. Some of these breaks, particularly lower on the hillsides, comprise rock outcrops. These may be controlled by more resistant layers within the fine ash vitric tuff of the Ap Lei Chau Formation which underlies the area (GCO, 1986). As shown on the geological map, the hillside below the farm complex is located on the flank of a syncline, and flow fabric in the tuff is indicated as dipping shallowly toward the east. Creep is common in the aprons of superficial deposits or more weathered rock below these slope breaks. Higher on the hillside to the south of the local catchment, the slope breaks are not visibly rock outcrops, and may be the scarps of shallow landslides.

Two small, shallow landslides are present in the 1963 photographs, one in the upper portion of drainage line No. 2 and the other in the upper portion of drainage line No. 4.

1967 No obvious changes to farm complex. A recent shallow debris flow landslide involves the edge of the farm platform near the head of drainage line No. 2 and extends at least 130 m downslope. The drainage line below this landslide is locally scoured, extending below Victoria Road to the coast. Another older, partially vegetated shallow debris flow landslide is present in a drainage line immediately south of the local catchment. This feature extends from the edge of the farm platform at the southern end of the complex and down the drainage line to the coast. A remnant of the track (1924) crossing the drainage line remains sparsely vegetated (partially cleared?). Five areas of recent erosion and/or gullying and two small landslides are present on the nose and northern flank of the broad spur ridge defining the southern extent of the local catchment. Five areas of recent fill and/or erosion are present along and below the edge of the farm platform and extend downslope over a distance of about 15m.

YEAR	OBSERVATIONS
1968	No stereo pair available. Trees within the farm complex are becoming more mature. Most of the hillside below the Dairy Farm is more densely vegetated. Tracks/paths are visible along the ridge of the northern spur and across the hillside, parallel to contours, between drainage lines Nos. 1 and 2. The upper part of the scar in drainage line No. 2 (1967) remains unvegetated. The area west of drainage line No. 2 below the farm platform and extending downslope about 15 m, is partially vegetated and appears to have vehicle tracks in it (possibly material spread around by tractor). Parts of the areas of fill and/or erosion below the edge of the farm platform present in the 1967 photographs are still visible. The remnant of the track (1924) present in 1967 remains sparsely vegetated above Victoria Road. The hillside above the track and north of the drainage is sparsely vegetated, and the hillside above the track and south of the drainage is cleared.
1972	The site formation for Lower Baguio Villa is underway to the north-west of the site, below Victoria Road. The farm complex appears to have undergone some modification. One of the large outbuildings in the southern portion of the site has been replaced by two smaller buildings. Recent fill is present on the slope below this area. The hillside below the farm complex has a low cover of vegetation about halfway to Victoria Road, below which the vegetation becomes heavier. The track (1924) and slopes above the track have re-vegetated since 1968. A gully has formed on the southeast flank of the northern spur ridge (immediately upslope of the northern 1999 landslide scar) and extends into drainage line No. 1. A break in slope is visible to the west of the gully at the location of the 1999 scar.
1976	The site formation for Upper Baguio Villa is underway and housing blocks within the Lower Baguio Villa appear to be complete. One of the farm outbuildings constructed in 1972 is dismantled – only framing remains. Pokfulam Road east of the farm complex has been realigned further to the east and widened to four lanes; the old road remains. Three areas of recent fill and/or erosion are present below the edge of the farm platform, one in the scar of the 1967 landslide located in drainage line No. 2. Overall the vegetation on the hillside below is lusher. There are many lines in the vegetation radiating upslope from the points of convergence between drainage lines Nos. 1, 2 and 3; and drainage lines Nos. 3 and 4 respectively, suggesting ephemeral drainage/ erosion lines. The main drainage lines in each of the drainage lines appear to be sharply incised and the gully (1972) in the northern spur ridge is also visible in stark relief. The spur ridge above the gully is only partially vegetated. A possible scar is also visible on the flanks of the spur about 50 m above Victoria Road.

YEAR	OBSERVATIONS
1977	Residential towers in Upper Baguio Villa are under construction. No obvious change visible in farm complex. Vegetation on the hillside within the local catchment comprises a dense low cover immediately below the farm platform, below which is an extensive area of sparse vegetation, bordered to the west by a return to dense cover. Tracks/paths are again visible on the upper portions of the hillside. The gully (1972) in the north spur ridge remains in stark relief. Earthworks involving cutting have been carried out across the ridge of the spur above the gully.
1978	Little activity within the farm complex. Vegetation on the hillside below the farm platform is heavier, but a distinct change to much heavier cover occurs about one-third of the way downslope to Victoria Road. Vegetation obscures the 1967 scar in drainage line No. 2.
1979	Clear, low altitude photographs – excellent detail. Upper Baguio Villa development is complete. The upper hillside in the northern portion of the local catchment is again cleared. There appears to be a collection of fill/refuse in the upper portion of drainage line No. 2. The upper hillside in the southern portion of the catchment is sparsely vegetated. There are many interconnecting paths in this area which appear to have a covering of refuse. The gully (1972) appears in stark relief and is larger than previous. There appears to have been recent instability within the gully. A sharply incised track located along the ridge of the spur west of the gully appears to have a low wall along the northern edge.
16.4.1980	The upper hillside below the edge of the farm platform between drainage lines Nos. 1 and 2 is cleared of vegetation. An area further downslope spanning across drainage line No. 1 and a small area below the southern end of the platform are also cleared of vegetation. Refuse is still visible on the upper portion of the hillside between drainage lines Nos. 2 and 4.
4.11.1980	Additional cleared areas are present on the hillside below the farm platform extending beyond the ridge of the northern spur. Portions of the cleared areas visible in the April 1980 photographs have re-vegetated. Site formation works involving cutting are underway at the southern end of the farm complex adjacent to Pokfulam Road.
1986	Site formation works (1980) associated with road viaduct spanning Pokfulam Road (Chi Fu Road), are now complete. The farm complex appears to be abandoned. Several buildings have been removed and several others are in disrepair (missing or damaged roofs). The hillside below the farm platform is completely vegetated; no bare ground is visible. Telegraph Bay reclamation is underway.

YEAR	OBSERVATIONS
1987	The hillside is completely covered by vegetation. Two narrow linear erosion (?) channels extend downslope up to about 90 m from the edge of the farm platform, one located between drainage lines Nos. 1 and 2, the other within drainage line No. 2. These are immediately below an area of disturbed ground on the platform. Another erosion channel is present in the drainage line beyond the northern spur ridge and originates from an area of disturbed ground on the slope at the north end of the farm complex. The Telegraph Bay reclamation is mostly completed.
1988	Site clearance works are underway in the farm complex. A number of farm buildings remain. The hillside below the farm complex maintains a dense cover of vegetation. The three erosion channels (1987) are covered by vegetation.
1990	The Pokfulam Temporary Housing Area is completed and occupies the northern half of the previous Dairy Farm site. Two buildings from the farm complex remain and appear to have been incorporated into the facility. Construction of caisson/pier footings for the VTC facility is underway in the southern half of the site. Perimeter walls along the north-west and south-west sides of the VTC building have been constructed and fill is being placed in this area. Small areas of fill are present along western edge of the platform at the areas of construction activity. No significant changes in the hillside below.
1991	Construction of the VTC facility is well advanced. Fill and construction materials are present along the western edge of the construction area, and fill extends down the hillside about 10m. No significant changes in the hillside below. Vegetation on the hillside is heavier.
15.10. 92	The VTC facility is complete. A small platform is visible at the north-western end of the VTC building and the present fence line is visible. Fill below the VTC site (1991) is covered by vegetation. No changes to the hillside below. The 1992 Baguio Villa landslide scar is visible in the drainage line beyond the northern spur ridge. Repair works are underway.
20.10.92	No obvious changes.
9.7.1993	A strip of vegetation has been trimmed close to the ground below the cut platform (1992) at the north-western end of the VTC facility. No other significant changes to the hillside below. Vegetation appears heavier. The Baguio Villa landslide scar has been repaired. Repair works comprise slope formation in the source area and shotcreting of the debris trail.
8.10.1993	First colour photographs. No obvious changes from July 1993 photographs.

YEAR	OBSERVATIONS
1994	Structures associated with the Pokfulam Temporary Housing Area have been demolished; building pads remain. The shotcreted scar of a landslide is present in drainage line No. 4 and extends from about 30 m below the VTC platform (main scarp) to Victoria Road. The main scarp and southern flank of the scar appear to be near-vertical and the main scarp is approximately coincident with the location of the remnant (1963) of the track (1924), and just south of the landslide scar present in this area in the 1963 aerial photographs. The shotcrete surfacing extends beyond the scar in a broad swathe near Victoria Road. Areas of exposed ground, particularly beyond the southern extent of the local catchment suggest further landsliding and erosion in the general area.
1995	No significant changes in hillside. The small cut platform (1992) at the northwestern end of the VTC facility has a low cover of vegetation. There appears to have a small scar along the outside edge of the platform near the northwestern end.
1996	A construction site has been established in the southern portion of the previous temporary housing area (1990) to the east of the VTC facility. Footing construction is underway within the site. Additional construction works are underway on the roof of the VTC building. The small cut platform (1992) has been concreted. The shotcreted landslide scar in drainage line No.4 is partially overgrown by vegetation. There is a possible erosion feature in drainage line No. 1 indicated by a change in vegetation below the location of the 1999 landslide scar in the flanks of the northern spur ridge. There also appears to be a break in slope at the approximate location of the scarp of the 1999 landslide. However, there is no break in the vegetation cover at this location.
1997	Construction works on the building east of the VTC facility is well advanced. The small cut platform (1992) has a cover of low vegetation. No significant changes in the hillside within the local catchment. The possible erosion feature and break in slope (1996) above drainage line No. 1 are still visible. The shotcreted scar in drainage line No. 4 is almost completely covered by vegetation.
1998	Construction works for the building east of the VTC facility are complete. A site office has been constructed at the north-western end of the VTC building and a number of containers have been placed north of the site office structure. No significant changes in the hillside within the local catchment. The possible erosion feature and break in slope (1996) are still visible. There are also a number of curvilinear features present below the break in slope that may be tension cracks. The ephemeral stream course in the upper portion of drainage line No. 2 appears sharply incised.

A.2 LIST OF AERIAL PHOTOGRAPHS

A list of aerial photographs used in this API study is presented below.

YEAR	AERIAL PHOTOGRAPHS NOS.			
13.11.24	Y00052			
08.05.49	Y01306			
01.02.63	Y07153	Y07154	Y07155	
16.05.67	Y13274	Y13275	Y13276	
1968	Y14083	Y14089		
1972	108	109	110	
28.01.76	12694	12695		
21.12.77	20476	20477		
30.11.78	23803	23804	23805	
28.09.79	27061	27062	27063	
16.04.80	29881	29882		
04.11.80	32024	32025	32026	
20.08.86	A06021	A06022	A06023	
09.09.87	A10322	A10323	A10324	
27.09.88	A14436	A14437		
14.11.90	A23812	A23813	A23814	
04.10.91	A27886	A27887	A27888	A27889
15.10.92	A32553	A32554		
20.10.92	A32598	A32599		
09.07.93	A35199	A35200	A35201	
08.10.93	CN4730	CN4731	CN4733	
17.11.94	CN8047	CN8048	CN8049	
07.12.95	CN12770	CN12771	CN12772	
07.06.96	CN14168	CN14169	CN14170	
23.07.97	CN17613	CN17614		
23.10.98	CN21121	CN21122		

APPENDIX B

TRIAL PIT LOGS

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

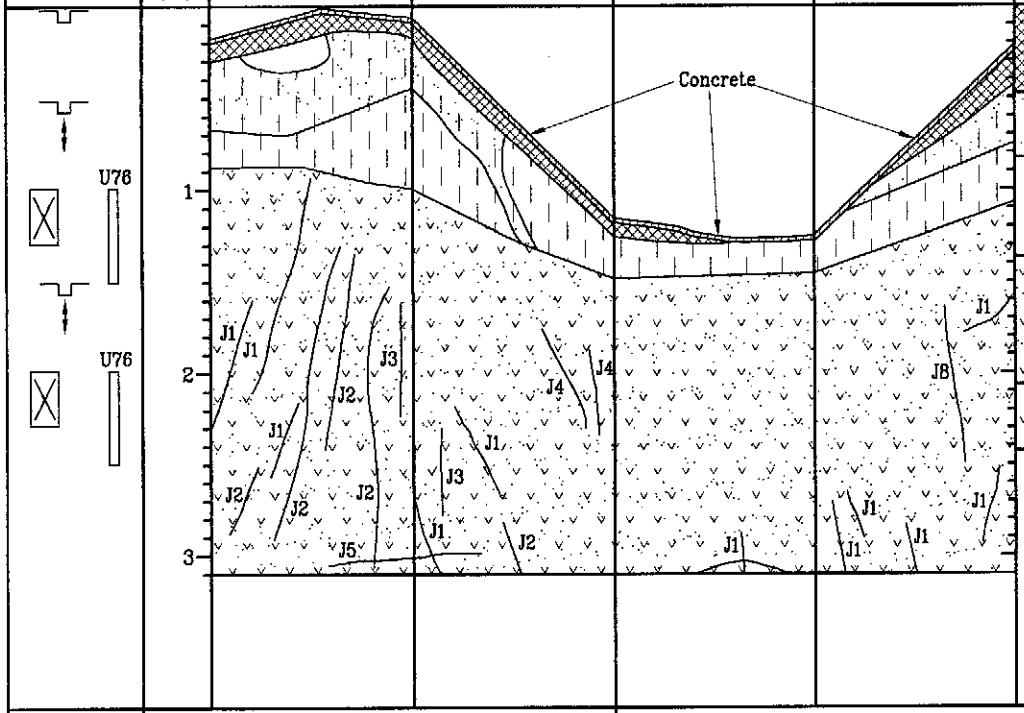
TRIAL PIT RECORD

TRIAL PIT No. 1

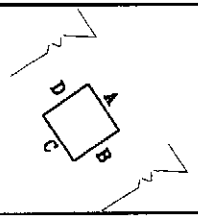
CO-ORDINATES 831982.112 E , 813475.829 N
GROUND LEVEL 140.34 mPD

Sheet 1 of 2

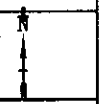
EXCAVATION DATE: from 26/11/1999
BACKFILL DATE: 8/12/1999
LOGGED BY: JLKS DATE: 6/12/1999
CHECKED BY: ICM DATE: 17/3/2000



Legend	Grade	Description
		Firm, slightly moist, dark blackish-grey, slightly clayey sandy SILT with refuse and tree roots. (Fill)
	V	Extremely weak, moist, brown, completely decomposed fine ash TUFF. (Firm to stiff, slightly sandy SILT)
	V	Extremely weak, slightly moist, light greyish-brown spotted with black and streaked with brown, completely decomposed fine ash TUFF. (Firm to stiff, slightly sandy SILT)
	V/IV	Extremely weak to weak, slightly moist, light brownish-grey spotted with black and streaked with brown, completely to highly decomposed fine ash TUFF. (Stiff, slightly sandy SILT) Locally mixed with grade V material (Firm, brown, SILT)
	IV	Weak, slightly moist, grey mottled with brown and light brown, highly decomposed fine ash TUFF. (Stiff, slightly sandy SILT)

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE		
▯	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U78)		
▯	UNDISTURBED SAMPLE VERT. (U100/U78)		
⊠	BLOCK SAMPLE		
⊓	IN-SITU DENSITY TEST		
▲	WATER SAMPLE		
∿	SEEPAGE		

KEY



NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

TRIAL PIT RECORD

TRIAL PIT No. 1

CO-ORDINATES 831982.112 E , 813475.829 N
GROUND LEVEL 140.34 mPD

Sheet 2 of 2

EXCAVATION DATE: from 26/11/1999
BACKFILL DATE: 8/12/1999
LOGGED BY: JLKS DATE: 6/12/1999
CHECKED BY: ICM DATE: 17/3/2000

Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
	3.1	J1, J2	J1, J2, J1	J7, J1, J1	J1, J1, J9			Trial pit complete at 3.0m depth (ave.)
	4							Joint Measurement: J1 : 323/75, 318/78, 320/75, 330/75, 328/75, 330/88, 350/79, 333/80, 322/82, 335/85, 320/86, 316/78, 318/80, 322/84 J2 : 340/85, 015/88, 347/86, 345/88 J3 : 146/89 J4 : 200/75, 193/74 J5 : 025/10 J6 : 104/20 J7 : 085/70, 070/62, 084/73, 095/74 J8 : 030/72 J9 : 095/85
	5							
	6							

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE	D A C B	
⊢	BULK DISTURBED SAMPLE		
‖	UNDISTURBED SAMPLE HORL. (U100/U78)		
⊠	UNDISTURBED SAMPLE VERT. (U100/U78)		
⊔	BLOCK SAMPLE		
▲	IN-SITU DENSITY TEST	KEY	
∿	WATER SAMPLE	N	
	SEEPAGE	NORTH ARROW	

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

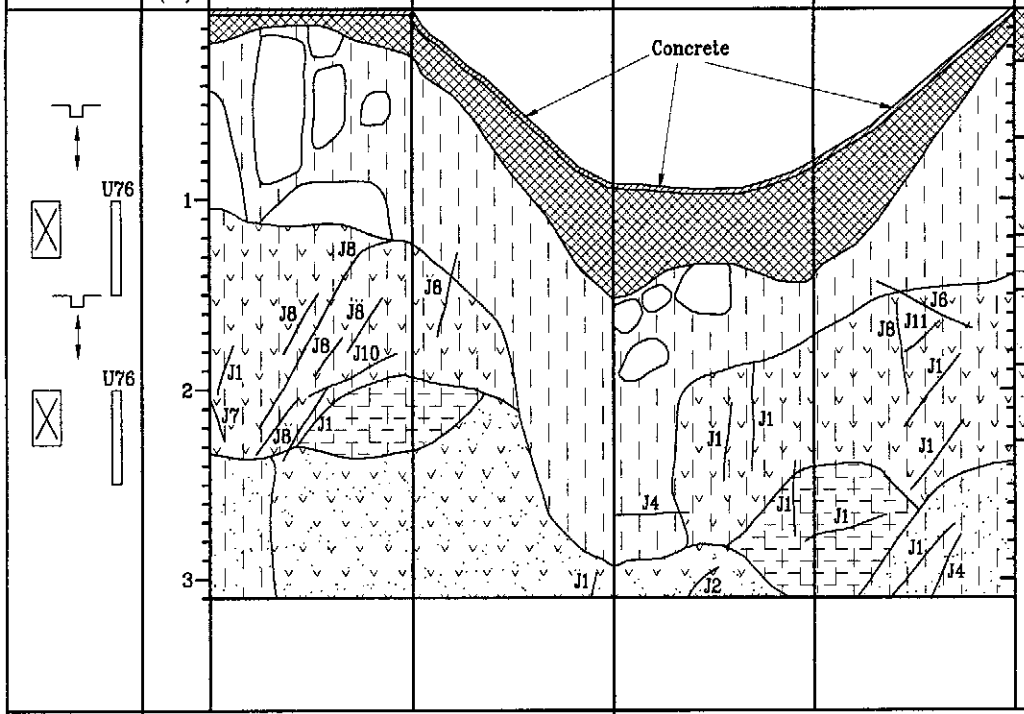
TRIAL PIT RECORD

TRIAL PIT No. TP2

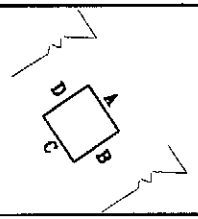
CO-ORDINATES 831968.919 E, 813463.625 N
GROUND LEVEL 128.65 mPD

Sheet 1 of 2

EXCAVATION DATE: from 27/11/1999
BACKFILL DATE: 9/12/1999
LOGGED BY: JLKS DATE: 7/12/1999
CHECKED BY: ICM DATE: 17/3/2000



Legend	Grade	Description
		Firm, slightly moist, dark grey/blackish-grey, sandy SILT with building debris and tree roots (Fill)
	V	Extremely weak, slightly moist, dark brown, completely decomposed fine ash TUFF with some gravels and cobbles. (Firm to stiff, slightly sandy SILT)
	V/IV	Extremely weak to weak, slightly moist, light brownish-grey mottled with light brown and white, streaked with brown, completely to highly decomposed fine ash TUFF. (Stiff, slightly sandy SILT)
	V	Extremely weak, moist, brown, completely decomposed fine ash TUFF with occasional tree roots. (Firm to stiff, slightly clayey SILT)
	V	Extremely weak, slightly moist, brown mottled with yellowish-brown and pink, completely decomposed fine ash TUFF. (Firm to stiff, slightly sandy SILT)
	V/IV	Extremely weak to weak, light orangish-brown mottled with pink and light grey, streaked with brown, completely to highly decomposed fine ash TUFF. (Stiff, slightly sandy SILT)

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE		
▮	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U78)		
▯	UNDISTURBED SAMPLE VERT. (U100/U78)		
⊠	BLOCK SAMPLE		
⊔	IN-SITU DENSITY TEST		
▲	WATER SAMPLE		
∿	SEEPAGE		

KEY

N

NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

TRIAL PIT RECORD

Sheet 2 of 2

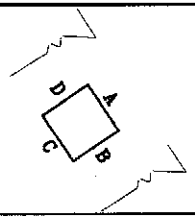
TRIAL PIT No. TP2

EXCAVATION DATE: from 27/11/1999
BACKFILL DATE: 9/12/1999

CO-ORDINATES 831968.919 E, 813463.625 N
GROUND LEVEL 128.65 mPD

LOGGED BY: JLKS DATE: 7/12/1999
CHECKED BY: ICM DATE: 17/3/2000

Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
	3.1	J9 J9	J1	J2	J1 J1			Trial pit complete at 3.0m depth (ave.)
	4							Joint measurement: J1 : 311/86, 332/70, 300/88, 301/81, 298/79, 306/80, 315/88, 310/85, 314/85, 315/86, 298/77, 298/72 J2 : 004/86 J4 : 198/73, 226/62 J6 : 115/22 J7 : 075/71 J8 : 018/74, 015/69, 038/88, 045/89, 019/78, 010/82, 030/84 J9 : 103/80, 104/85 J10 : 252/23 J11 : 293/46
	5							
	6							

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE		
▮	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U76)		
▯	UNDISTURBED SAMPLE VERT. (U100/U76)		
⊠	BLOCK SAMPLE		
⊔	IN-SITU DENSITY TEST		
▲	WATER SAMPLE		
∿	SEEPAGE		

KEY

N

NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

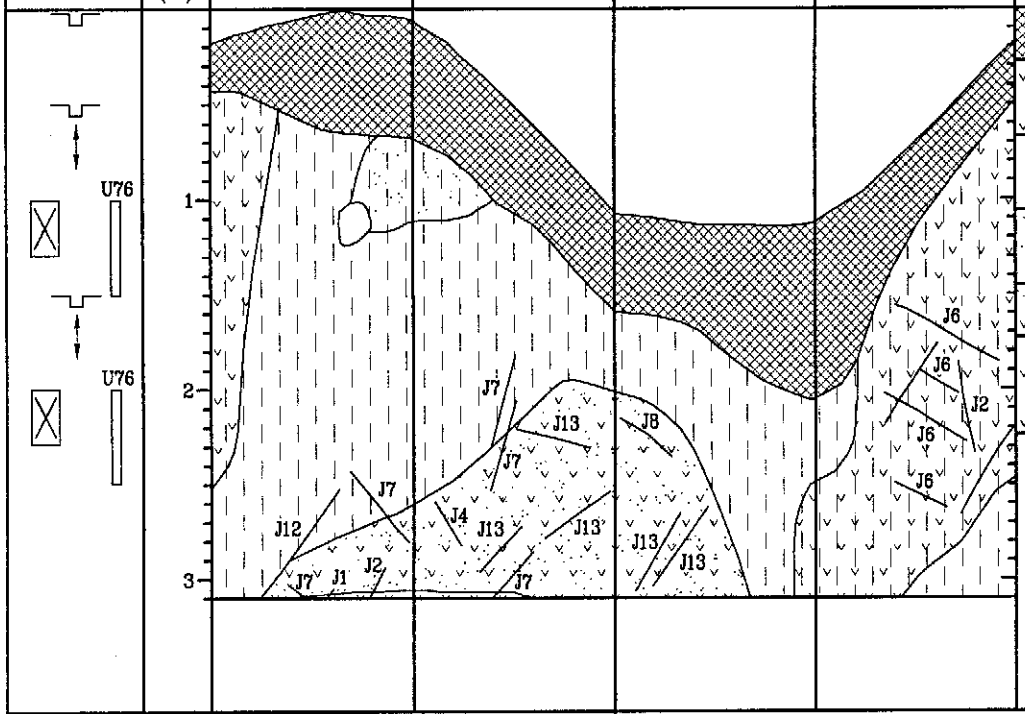
TRIAL PIT RECORD

TRIAL PIT No. TP3

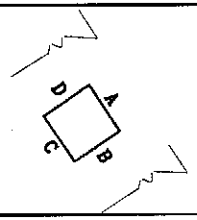
CO-ORDINATES 831980.223 E, 813481.426 N
GROUND LEVEL 142.21 mPD

Sheet 1 of 2

EXCAVATION DATE: from 26/11/1999
BACKFILL DATE: 8/12/1999
LOGGED BY: JLKS DATE: 7/12/1999
CHECKED BY: ICM DATE: 17/3/2000



Legend	Grade	Description
		Soft, slightly moist, dark grey, sandy SILT with building debris and tree roots. (Fill)
	V/IV	Extremely weak to weak, slightly moist, light brown mottled with light grey, streaked with brown, completely to highly decomposed fine ash TUFF. (Stiff, sandy SILT)
	V	Extremely weak, slightly moist, light greyish-brown mottled with brown, white and pink, completely decomposed fine ash TUFF with occasional tree roots. (Firm to stiff, slightly sandy SILT)
	V	Extremely weak, slightly moist, light greyish-brown spotted with brown and white, completely decomposed fine ash TUFF. (Firm to stiff, sandy SILT)
	IV	Weak, slightly moist, grey mottled with brown, white and pink, highly decomposed fine ash TUFF. (Stiff, sandy SILT)
	IV/III	Weak to moderately strong, slightly moist, grey mottled with white and pink, streaked with brown, highly to moderately decomposed fine ash TUFF. Quartz-rich zone is present at bottom of Face A. Manganese staining on joints. Some silt/clay infill.

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE		
▮	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U76)		
▯	UNDISTURBED SAMPLE VERT. (U100/U76)		
⊠	BLOCK SAMPLE		
⊓	IN-SITU DENSITY TEST		
▲	WATER SAMPLE		
∿	SEEPAGE		

KEY

N

NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

TRIAL PIT RECORD

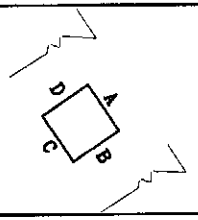
TRIAL PIT No. TP3

CO-ORDINATES 831980.223 E, 813481.426 N
GROUND LEVEL 142.21 mPD

Sheet 2 of 2

EXCAVATION DATE: from 26/11/1999
BACKFILL DATE: 8/12/1999
LOGGED BY: JLKS DATE: 7/12/1999
CHECKED BY: ICM DATE: 17/3/2000

Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
	3.1	J1, J2, J7, J7, J14	J7	J1, J7				Trial pit complete at 3.0m depth (ave.)
	4							Joint measurement: J1 : 337/72, 305/68 J2 : 008/75, 014/73 J4 : 176/63 J6 : 105/30, 125/41, 114/40, 095/41 J7 : 091/66, 080/72, 084/68, 083/68, 082/66, 073/73 082/66, 063/74 J8 : 053/80 J12 : 347/41 J13 : 121/66, 123/68, 115/67, 120/61 J14 : 182/44, 191/24
	5							
	6							

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE		
▮	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U78)		
▯	UNDISTURBED SAMPLE VERT. (U100/U78)		
⊠	BLOCK SAMPLE		
⊏⊐	IN-SITU DENSITY TEST		
▲	WATER SAMPLE		
∿	SEEPAGE		

KEY
N
NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

TRIAL PIT RECORD

TRIAL PIT No. TP4

CO-ORDINATES 831962.501 E, 813467.898 N
GROUND LEVEL 129.03 mPD

Sheet 1 of 2

EXCAVATION DATE: from 27/11/1999
BACKFILL DATE: 9/12/1999
LOGGED BY: JLKS DATE: 8/12/1999
CHECKED BY: ICM DATE: 17/3/2000

Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
U76 U76	1 2 3	J6 J10 J15 J15 J15 J15 J15 J15 J15 J15 J7 J7 J7 J15 J15	J4 J4 J4 J15 J15 J15 J4 J15 J15		J6 J6 J8 J11			Firm, slightly moist, dark grey, sandy SILT with building debris and tree roots. (Fill)
								Firm, moist, dark greyish-brown, sandy, slightly clayey SILT with tree roots. (Fill)
							V	Extremely weak, slightly moist, dark brown mottled with light grey, completely decomposed fine ash TUFF with tree roots. (Firm, slightly sandy SILT)
							V/IV	Extremely weak to weak, slightly moist, light greyish-brown mottled with brown, completely to highly decomposed fine ash TUFF with occasional tree roots. (Firm, slightly sandy SILT)
							III	Moderately strong, slightly moist, light brownish-grey spotted with black and white, moderately decomposed fine ash TUFF. Closely spaced manganese stained joints.
							IV	Weak, slightly moist, grey mottled with white and brown, highly decomposed fine ash TUFF. (Stiff, slightly sandy SILT) Locally mixed with medium soft, moist, brown, completely decomposed fine ash TUFF (Soft, slightly clayey SILT) penetrated by tree roots.
							IV/III	Weak to moderately strong, grey mottled with brown and white, highly to moderately decomposed fine ash TUFF.

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE	D A C B	
┃	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U78)		
▯	UNDISTURBED SAMPLE VERT. (U100/U78)		
⊠	BLOCK SAMPLE	KEY	
⊔	IN-SITU DENSITY TEST	N	
▲	WATER SAMPLE		
∿	SEEPAGE	NORTH ARROW	

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

TRIAL PIT RECORD

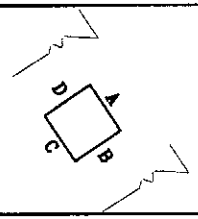
TRIAL PIT No. TP4

CO-ORDINATES 831962.501 E, 813467.898 N
GROUND LEVEL 129.03 mPD

Sheet 2 of 2

EXCAVATION DATE: from 27/11/1999
BACKFILL DATE: 9/12/1999
LOGGED BY: JLKS DATE: 8/12/1999
CHECKED BY: ICM DATE: 17/3/2000

Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
	3.1							Trial pit complete at 3.0m depth (ave.)
	4							Joint measurement: J2 : 020/78 J4 : 185/63, 189/50, 170/52, 152/65 J6 : 082/31, 070/35 J7 : 080/72, 098/74, 090/88 J8 : 010/60, 018/72 J10 : 235/30 J15 : 030/62, 024/49, 045/64, 038/72, 033/55, 038/64, 028/50, 024/45, 020/12, 018/58, 022/68 J16 : 275/60
	5							
	6							

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE		
▮	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U78)		
▯	UNDISTURBED SAMPLE VERT. (U100/U78)		
⊠	BLOCK SAMPLE		
⊔	IN-SITU DENSITY TEST		
▲	WATER SAMPLE		
∿	SEEPAGE		

KEY

NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

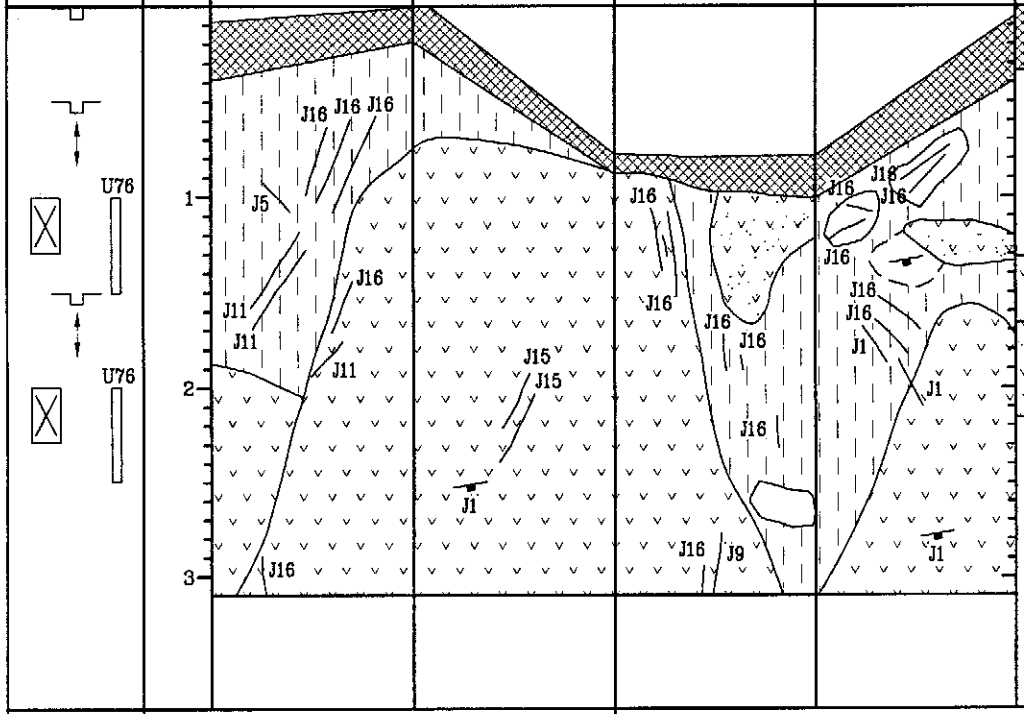
TRIAL PIT RECORD

TRIAL PIT No. TP5

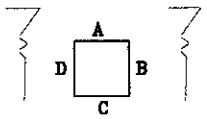
CO-ORDINATES 831915.529 E, 813483.219 N
GROUND LEVEL 122.78 mPD

Sheet 1 of 2

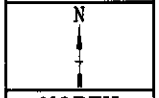
EXCAVATION DATE: from 10/12/1999
BACKFILL DATE: 20/12/1999
LOGGED BY: JLKS DATE: 16/12/1999
CHECKED BY: ICM DATE: 17/3/2000



Legend	Grade	Description
		Firm, slightly moist, dark grey, clayey sandy SILT with dead vegetation and many tree roots. (Fill)
	V	Extremely weak, slightly moist, dark brown spotted with white and black, completely decomposed fine ash TUFF (Firm to stiff, clayey slightly sandy SILT) with tree roots and gravel-sized grade IV/III materials. A presumed infilled tension crack orientated parallel to Face D contains many tree roots and infilled with soft, dark brown, clayey SILT.
	III	Moderately strong, slightly moist, light grey mottled with pink, white and yellowish-brown, moderately decomposed fine ash TUFF.
	IV/III	Weak to moderately strong, slightly moist, light grey mottled with pink and spotted with white, highly to moderately decomposed fine ash TUFF.

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE		
▮	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U78)		
▯	UNDISTURBED SAMPLE VERT. (U100/U78)		
▮	BLOCK SAMPLE		
⊔	IN-SITU DENSITY TEST		
▲	WATER SAMPLE		
∿	SEEPAGE		

KEY



NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

TRIAL PIT RECORD

Sheet 2 of 2

TRIAL PIT No. TP5

EXCAVATION DATE: from 10/12/1999
BACKFILL DATE: 20/12/1999

CO-ORDINATES 831915.529 E, 813483.219 N
GROUND LEVEL 122.78 mPD

LOGGED BY: JLKS DATE: 16/12/1999
CHECKED BY: ICM DATE: 17/3/2000

Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
	3.1	J16 J16		J9 J16 J16				Trial pit complete at 3.0m depth (ave.)
	4							Joint measurement: J1 : 305/70, 308/74, 306/82 J5 : 030/30 J9 : 089/85 J11 : 304/48, 308/53 J12 : 008/45 J15 : 030/64, 032/62 J16 : 272/62, 280/77, 289/60, 292/64, 240/73, 230/68, 262/82, 266/65, 260/68, 262/82, 256/54, 254/48, 294/56, 260/74, 285/62, 298/55
	5							
	6							

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)		REMARKS
●	SMALL DISTURBED SAMPLE	A D B C	KEY	
▮	BULK DISTURBED SAMPLE		N	
▯	UNDISTURBED SAMPLE HORL. (U100/U78)			
▯	UNDISTURBED SAMPLE VERT. (U100/U78)			
▣	BLOCK SAMPLE			
⊔	IN-SITU DENSITY TEST			
▲	WATER SAMPLE		NORTH ARROW	
∿	SEEPAGE			

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

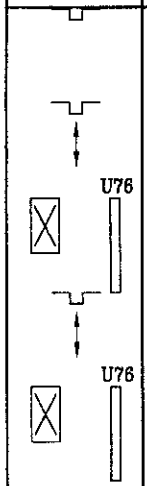
TRIAL PIT RECORD

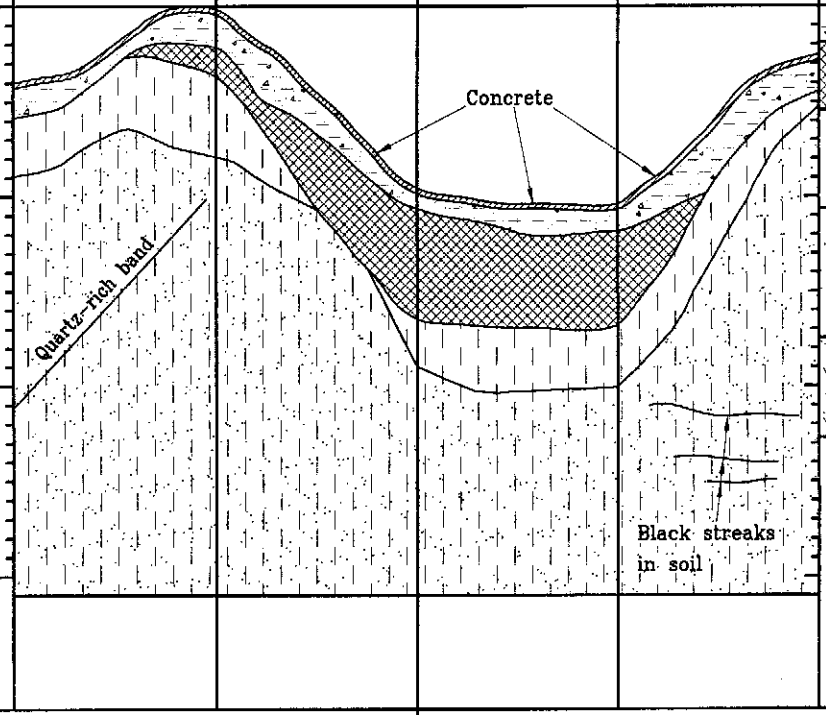
TRIAL PIT No. TP6

CO-ORDINATES E, N
GROUND LEVEL mPD

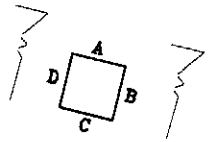
Sheet 1 of 2

EXCAVATION DATE: from 10/12/1999
BACKFILL DATE: 21/12/1999
LOGGED BY: JLKS DATE: 16/12/1999
CHECKED BY: ICM DATE: 17/3/2000





Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
								Firm, slightly moist, dark brown, slightly sandy SILT. (Debris)
								Firm, slightly moist, blackish-brown, clayey SILT with dead vegetation. (Fill)
							V	Extremely weak, slightly moist, brown, completely decomposed fine ash TUFF/Residual Soil (Firm to stiff, slightly sandy SILT) containing some mica/fine grained quartz.
							V	Extremely weak, slightly moist, light brown mottled with grey and white, streaked with black, completely decomposed fine ash TUFF (Firm to stiff, sandy SILT) containing some mica/fine grained quartz and with tree roots.
							V/IV	Extremely weak to weak, slightly moist, brown mottled with light brown, completely to highly decomposed fine ash TUFF (Stiff, sandy SILT) with trace of grade IV/III materials.

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE		
▬	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U78)		
⊠	UNDISTURBED SAMPLE VERT. (U100/U78)		
⊔	BLOCK SAMPLE		
▲	IN-SITU DENSITY TEST		
∿	WATER SAMPLE		
	SEEPAGE		

KEY

NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

TRIAL PIT RECORD

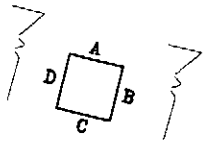
TRIAL PIT No. TP6

CO-ORDINATES E, N
GROUND LEVEL mPD

Sheet 2 of 2

EXCAVATION DATE: from 10/12/1999
BACKFILL DATE: 21/12/1999
LOGGED BY: JLKS DATE: 16/12/1999
CHECKED BY: ICM DATE: 17/3/2000

Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
	3.1							Trial pit complete at 3.0m depth (ave.)
	4			Black streaks in soil				
	5							
	6							

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)		REMARKS
●	SMALL DISTURBED SAMPLE		KEY	
▮	BULK DISTURBED SAMPLE			
▯	UNDISTURBED SAMPLE HORL. (U100/U78)			
▯	UNDISTURBED SAMPLE VERT. (U100/U78)			
▩	BLOCK SAMPLE			
⊔	IN-SITU DENSITY TEST			
▲	WATER SAMPLE			
∿	SEEPAGE			

N

NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

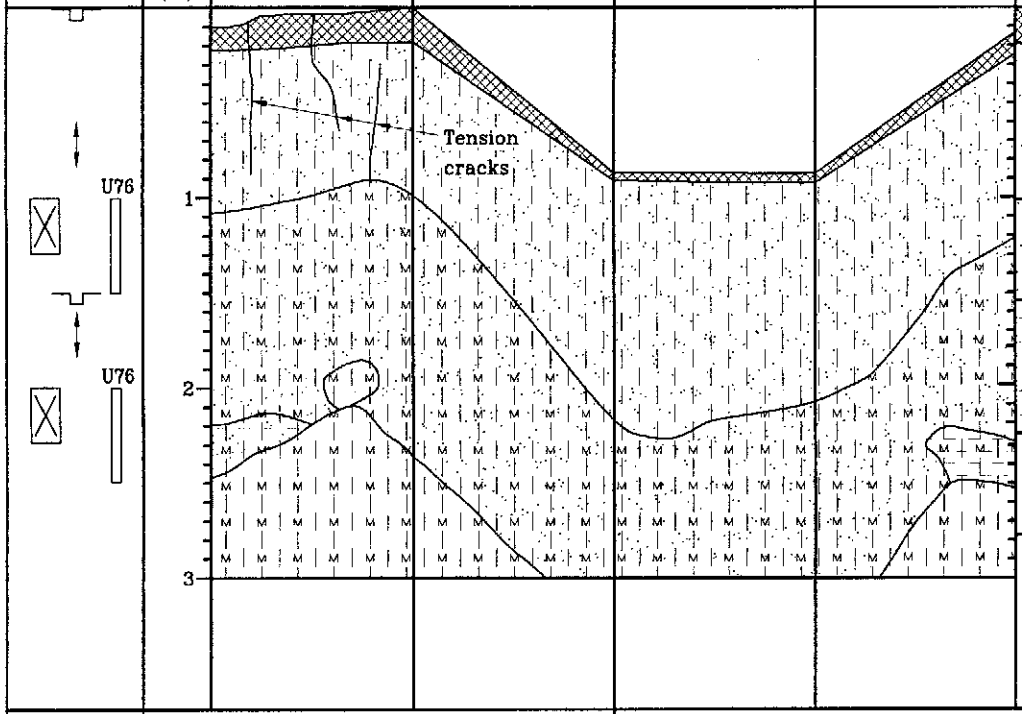
TRIAL PIT RECORD

TRIAL PIT No. TP7

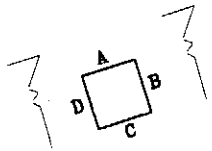
CO-ORDINATES 831932.268 E, 813485.513 N
GROUND LEVEL 123.10 mPD

Sheet 1 of 2

EXCAVATION DATE: from 10/12/1999
BACKFILL DATE: 21/12/1999
LOGGED BY: JLKS DATE: 15/12/1999
CHECKED BY: ICM DATE: 17/3/2000



Legend	Grade	Description
		Firm, slightly moist, dark grey, sandy SILT. (Fill)
	V	Extremely weak, moist, dark brown spotted with grey, completely decomposed fine ash TUFF (Firm to stiff, sandy SILT) containing much mica/fine grained quartz and tree rootss. Tension cracks observed on top of Face A. The longest one extends from ground surface to approximately 800mm depth within the layer of soil.
	V	Extremely weak, slightly moist, brown spotted with white and pink, completely decomposed fine ash TUFF (Firm to stiff, sandy SILT) containing mica/fine grained quartz and tree roots.
	V	Extremely weak, slightly moist, reddish-brown mottled with orangish-brown, completely decomposed fine ash TUFF (Firm to stiff, sandy SILT) containing mica/fine grained quartz and tree roots.
	V	Extremely weak, slightly moist, light grey mottled with brown and pink, completely decomposed fine ash TUFF (Firm to stiff, sandy SILT) containing much mica/fine grained quartz and tree roots.

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
	SMALL DISTURBED SAMPLE BULK DISTURBED SAMPLE UNDISTURBED SAMPLE HORL. (U100/U78) UNDISTURBED SAMPLE VERT. (U100/U78) BLOCK SAMPLE IN-SITU DENSITY TEST WATER SAMPLE SEEPAGE		KEY N NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

TRIAL PIT RECORD

Sheet 2 of 2

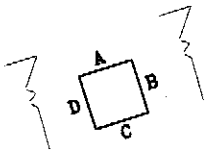
TRIAL PIT No. TP7

EXCAVATION DATE: from 10/12/1999
BACKFILL DATE: 21/12/1999

CO-ORDINATES 831932.288 E, 813485.513 N
GROUND LEVEL 123.10 mPD

LOGGED BY: JLKS DATE: 15/12/1999
CHECKED BY: ICM DATE: 17/3/2000

Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
	3							Trial pit complete at 3.0m depth (ave.)
	4							
	5							
	6							

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)		REMARKS
●	SMALL DISTURBED SAMPLE		KEY	
▮	BULK DISTURBED SAMPLE			
▯	UNDISTURBED SAMPLE HORL. (U100/U78)		N	
▯	UNDISTURBED SAMPLE VERT. (U100/U78)			
▣	BLOCK SAMPLE			
⌐	IN-SITU DENSITY TEST			
▲	WATER SAMPLE		NORTH ARROW	
∿	SEEPAGE			

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

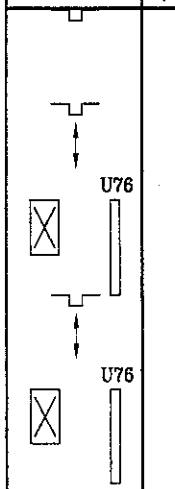
TRIAL PIT RECORD

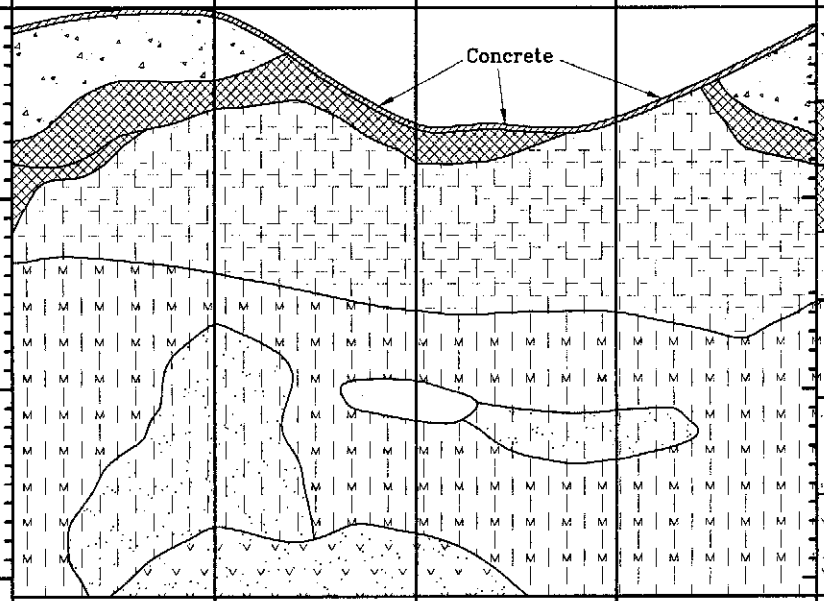
TRIAL PIT No. TP8

CO-ORDINATES 831924.818 E, 813462.533 N
GROUND LEVEL 110.34 mPD

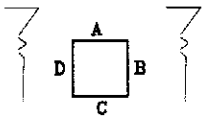
Sheet 1 of 2

EXCAVATION DATE: from 9/12/1999
BACKFILL DATE: 23/12/1999
LOGGED BY: JLKS DATE: 16/12/1999
CHECKED BY: ICM DATE: 17/3/2000





Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
								Firm, slightly moist with hair cracks, brown mottled with light brown and blackish-brown, gravelly, sandy SILT with some dead vegetation and sub-angular gravel of grade IV/III material. (Debris)
								Firm, slightly moist with hair cracks, blackish-brown, sandy SILT with dead vegetation and tree roots. (Fill)
								Soft, slightly moist, dark brown mottled with blackish-brown, slightly sandy SILT with dead vegetation. (Fill)
							V	Extremely weak, moist, brown, completely decomposed fine ash TUFF (Firm to stiff, slightly clayey sandy SILT) with occasional tree roots.
							V	Extremely weak, moist, light brown mottled with brown and orangish-pink, completely decomposed fine ash TUFF (Firm to stiff, slightly sandy SILT) containing some mica/fine grained quartz.
							V	Extremely weak, slightly moist, dark brown, completely decomposed fine ash TUFF (Stiff, slightly sandy SILT) containing some mica/fine grained quartz.
							IV	Weak, slightly moist, grey mottled with yellowish-brown and white, highly decomposed fine ash TUFF (Stiff, sandy SILT) containing some mica/fine grained quartz.

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE		
▮	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U78)		
▯	UNDISTURBED SAMPLE VERT. (U100/U78)		
▮	BLOCK SAMPLE		
⊔	IN-SITU DENSITY TEST		
▲	WATER SAMPLE		
∿	SEEPAGE		

KEY

NORTH ARROW

Fugro Maunsell Scott Wilson Joint Venture
Agreement No. CE 101/98
The 1999 Landslide Investigation Consultancy
Detailed Study No. 15
Victoria Road near VTC

TRIAL PIT RECORD

Sheet 2 of 2

TRIAL PIT No. TP8

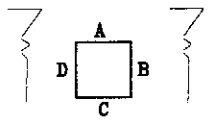
EXCAVATION DATE: from 9/12/1999
BACKFILL DATE: 23/12/1999

CO-ORDINATES 831924.818 E, 813462.533 N
GROUND LEVEL 110.34 mPD

LOGGED BY: JLKS DATE: 16/12/1999
CHECKED BY: ICM DATE: 17/3/2000

Samples & tests	Depth (m)	FACE A: 1.50 m	FACE B: 1.50 m	FACE C: 1.50 m	FACE D: 1.50 m	Legend	Grade	Description
	3.1							Trial pit complete at 3.0m depth (ave.)
	4							
	5							
	6							

SYMBOL	SAMPLES/TESTS/WATER	PLAN (NOT TO SCALE)	REMARKS
●	SMALL DISTURBED SAMPLE	KEY	
▮	BULK DISTURBED SAMPLE		
▯	UNDISTURBED SAMPLE HORL. (U100/U78)		
▯	UNDISTURBED SAMPLE VERT. (U100/U78)		
⊠	BLOCK SAMPLE		
⊔	IN-SITU DENSITY TEST		
▲	WATER SAMPLE		
∿	SEEPAGE		



NORTH ARROW