SECTION 2 : DETAILED STUDY OF THE LANDSLIDE NEAR KOWLOON-CANTON RAILWAY CORPORATION FO TAN STATION ON 2 JULY 1997

Halcrow Asia Partnership Ltd

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FOREWORD

This report presents the findings of a detailed study of a landslide (GEO Incident No. ME97/7/30) which occurred on 2 July 1997, about 250 m southwest of the Kowloon-Canton Railway Corporation (KCRC) Fo Tan Station. Debris from the landslide obstructed the north-bound KCRC rail track. The first north-bound train of the day was partly derailed by the landslide debris, causing significant disruption to rail services. No fatalities or injuries were reported.

The key objectives of the detailed study were to document the facts about the landslide, present relevant background information and establish the probable causes of the landslide. The scope of the study was generally limited to site reconnaissance, desk study and analysis. Recommendations for follow-up actions are reported separately.

The report was prepared as part of the 1997 Landslip Investigation Consultancy (LIC), for the Geotechnical Engineering Office (GEO), Civil Engineering Department (CED), under Agreement No. CE 68/96. This is one of a series of reports produced during the consultancy by Halcrow Asia Partnership Ltd (HAP). The report was written by Mr M Riley and reviewed by Dr R Moore and Mr H Siddle. The assistance of the GEO in the preparation of the report is gratefully acknowledged.

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CONTENTS

1. INTRODUCTION

On the morning of 2 July 1997, a landslide (GEO Incident No. ME97/7/30) occurred on a slope about 250 m southwest of the Kowloon-Canton Railway Corporation (KCRC) Fo Tan Station, Sha Tin (Figure 1). Debris from the landslide obstructed the north-bound KCRC rail track. The first north-bound train of the day was partly derailed by the landslide debris, causing significant disruption to rail services throughout the morning. No fatalities or injuries were reported.

Following the landslide, Halcrow Asia Partnership Ltd (the 1997 Landslip Investigation Consultants) carried out a detailed study of the failure for the Geotechnical Engineering Office (GEO), Civil Engineering Department (CED) under Agreement No. CE 68/96. This is one of a series of reports prepared during the consultancy by Halcrow Asia Partnership Ltd (HAP).

The key objectives of the study were to document the facts about the landslide, present relevant background information and establish the probable causes of the failure. The scope of the study was limited to site reconnaissance, desk study and 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 site,

(b) analysis of rainfall records,

(c) discussions with KCRC staff and other parties who inspected the incident,

(d) detailed site observations and measurements at the landslide, and

(e) diagnosis of the probable causes of failure.

2. THE SITE

2.1 Site Description

A plan of the landslide location is shown in Figure 2. The slope that failed was a 26 m high, densely vegetated, partly modified natural hillside (Plate 1). At the crest of the slope there was a 3 m wide concrete footpath, which provides access to Sui Wo Court, uphill and northwest of the landslide. The footpath was positioned on the southern edge of a cut platform, which extends a further 20 m to the north. A network of surface drains has been installed on the platform (Figure 2).

At the location of the landslide the slope faces southeast and was inclined generally at 45°. The inclination of the lowest 8 m of the slope was about 55° to the horizontal and near the crest, the slope angle reduces to 25°. The area between the toe of the slope and the KCRC track was approximately level.

An abandoned squatter platform exists mid-way up the slope which was accessed down a concrete stairway from the main footpath at the crest of the slope (Plate 3). A squatter village is located southwest of the landslide.

The landslide affected land within the KCRC boundary, but also extended into unallocated Government land and Sha Tin Town Lot (STTL) No. 43sA (Figure 2). STTL No. 43sA is currently under the responsibility of the Housing Department.

2.2 Site History

The history of development of the site was determined from a review of aerial photographs, available documentary records and information contained in GEO's Landslide Incident Report database. Key findings are summarised in Table 1 and shown on Figure 3.

Shallow excavations were evident at the toe of adjacent slopes in 1963 (Table 1). It is possible that the lower, steep section of slope at the landslide location had been modified by similar excavations.

A linear body of fill was observed on the 1980 aerial photographs immediately adjacent to the footpath at the crest of the slope, which was probably placed during the construction of the footpath and platform at about that time.

The GEO's Landslide Incident Report database indicates that three minor failures occurred nearby in July 1987 (Incident Nos. ME87/7/18, 18A and 18B, Figure 3). Information available in the database indicates that the volume of each of the failures was about 3 m^3 and that a nearby squatter hut was affected. The incidents were reportedly caused by infiltration. A failure (Incident No. ME93/5/2) also occurred near a footpath in the same village in May 1993 (Figure 3). The volume of failure was reported as 6 m^3 and the failure was attributed to infiltration and an oversteep slope profile.

A squatter hut (No. XRCSW/13), previously located on the platform affected by the landslide on 2 July 1997, was permanently evacuated following a failure on 11 June 1993 (Incident No. ME93/6/7, Figure 3). According to the GEO Incident Report, the failure was about 2 m^3 in volume and occurred on a minor cut slope formed behind the squatter hut. The failure involved weathered rock and was attributed to infiltration.

Two small landslides (GEO Incident Nos. ME97/7/98 and ME97/7/110), located immediately southwest of the July 1987 failures (Figure 3), were reported to the GEO on 16 July 1997 and 24 July 1997 respectively. Shotcrete was applied to the slopes soon after the failures and this prevented detailed inspection by HAP. According to the GEO Incident Reports, the failures each involved about 2 m^3 of residual soil and were caused by infiltration. The KCRC rail tracks were not affected.

2.3 Previous Studies

The slope that failed was a substantially unmodified natural slope in the late 1970's, and was not registered in the 1977/78 Catalogue of Slopes by the consultants engaged by the Government to prepare the Catalogue.

In 1984, KCRC began a comprehensive geotechnical investigation of existing man-made slopes adjacent to their rail tracks (Ove Arup & Partners (OAP), 1987). The project included preliminary (Stage 1) cataloguing and assessment of all "cutting and embankment slopes along the railway between Hung Hom and Lo Wu" (OAP, 1987). The Stage 1 assessment involved field inspection and stability analysis based on assumed soil parameters and was intended to identify potentially unstable features for further (Stage 2) study. The findings of the assessment were presented in a report prepared in 1984, but this could not be found in KCRC's records. It has not been possible, therefore, to establish whether the slope affected by Incident No. ME97/7/30 was specifically included in the Stage 1 assessment. The Stage 2 Studies were based on a programme of site specific ground investigation and laboratory testing and the results were presented in a report prepared in April 1987 (OAP, 1987). An assessment of the affected slope was not included in the Stage 2 investigation report.

In 1992, the GEO initiated a consultancy agreement entitled "Systematic Inspection of Features in the Territory" (SIFT) which aims, inter alia, to systematically search for slopes not presently included in the 1977/78 Catalogue of Slopes for inclusion in the New Catalogue of Slopes. The SIFT records for the area indicate that the part of the slope affected by Incident No. ME97/7/30 was not identified for registration in the New Catalogue.

KCRC carry out annual inspections of slopes adjacent to their rail tracks (KCRC, 1997a). The part of the slope affected by Incident No. ME97/7/30 forms the southern part of Slope No. U11.6(6.2) in KCRC's system. According to KCRC's records, Slope No. U11.6(6.2) was last inspected on 23 June 1997 shortly before the landslide. A number of observations and recommendations were made, but most notably "slumping and erosion" at locations to the north and south of the landslide site were reported (Figure 3). The date and time of the slumping and erosion, however, was not known. Following the inspection it was recommended to "invite geotechnical specialists to assess the stability of the slope" (KCRC, 1997b). After the 2 July 1997 failure, KCRC instigated a geotechnical review of existing slopes within their boundaries and adjacent to the railway tracks. Slope No. U11.6 (6.2) was included for assessment in the review.

3. THE LANDSLIDE

3.1 Time of Failure

A report prepared by KCRC following the landslide incident (KCRC, 1997c) noted that the derailment of the train was confirmed at 05:54 hours on 2 July 1997. The last north-bound train passed unobstructed through Fo Tan Station at about 00:40 hours on 2 July 1997. The time of failure, therefore, may reliably be constrained to between 00:40 hours and 05:54 hours on 2 July 1997. A landslide warning was raised at 06:25 hours on 2 July 1997.

3.2 Description of the Landslide

Details and observations of the landslide made during site inspections are given in Figures 4 and 5. Cross-sections of the landslide are presented in Figures 6 and 7 and photographs are shown in Plates 1 to 6.

The landslide originated from the upper part of the slope. It produced a failure scar typically about 15 m long and 8 m wide, with an average depth of about 1.5 m. The volume of failure was estimated to be about 100 m^3 (Plate 1).

The shape of the main scarp of the landslide suggests that there might have been two phases of movement. The initial failure, a translational debris slide, occurred immediately north of the squatter platform. It was the larger of the two phases, with an estimated volume of about 80 m^3. The debris travelled down the slope and crossed the north-bound tracks, a distance of about 15 m from the toe of the slope (Plate 2). The travel angle of the debris from this failure phase, measured from the crest of the failure to the distal end of the main body of the debris, was about 30° (Figure 6). This angle is within the typical range for rain-induced landslides in Hong Kong (Wong & Ho, 1996), indicating that the debris mobility from this failure is comparable to that commonly observed. The failed mass observed at the toe of the slope was almost totally disintegrated and comprised pale-orange, coarse-grained silty sand with occasional cobbles and boulders (Plate 2). The material was very wet and was deposited in a layer between 0.1 m and 0.3 m thick. The squatter platform part way up the slope was partly demolished by the initial failure (Plate 3). The failure also undermined the ground further up the slope, below the footpath to Sui Wo Court, which was involved in the subsequent failure phase. A plastic pipe, approximately 100 mm in diameter was observed immediately behind the main scarp of the initial failure (Figure 5, Plate 4). No water was seen issuing from the pipe during inspection by HAP on 4 July 1997.

The second phase failure was also a translational debris slide, involving about 20 m^3 of material near the crest of the slope below the footpath. The failed mass was less mobile, with most of the debris remaining as a disturbed raft within the rupture area (Figure 5). The travel angle of the debris from this failure phase was 38° (Figure 7), again within the typical range for rain-induced landslides in Hong Kong (Wong & Ho, 1996).

KCRC staff, when inspecting the landslide on the day of the failure, observed surface water flowing along the platform at the crest of the slope (Figure 4). Part of the surface flow was channelled into the landslide by the footpath and staircase leading to the squatter platform. The washout action of the surface flow eroded a gully below the rupture zone of the initial failure (Plate 4) and significantly reworked debris at the toe of the slope.

Following the landslide, loose debris was removed by KCRC and shotcrete applied to the surface of the slope at the recommendation of the GEO. Weepholes were installed at regular intervals to enable drainage of water from the slope. The GEO also advised Buildings Department that a Dangerous Hillside Order (DHO) be served with respect to the failed slope on private land, and that the Design Division of GEO investigate and, if necessary, upgrade adjacent areas on Government land.

3.3 Subsurface Conditions

Geological observations made on site are summarised in Figures 5 to 7.

The failure occurred principally in weathered, coarse-grained granite. The weathered rock, however, was overlain at the eastern part of the landslide by about 1 m of brown sandy soil material, which may be fill, and a thin veneer of topsoil. A thin layer of coarse gravel, cobble and boulder size fragments of highly decomposed granite, also probably fill, mantled weathered rock in much of the southwest side of the failed area. These materials may correspond to the fill body which is believed to have been formed during construction of the platform at the crest of the slope in 1980, or may be associated with construction of the squatter platform and access stairway.

The landslide exposed slightly to moderately decomposed granite in the lower part of the slope, and highly and completely decomposed materials higher up. Heavily stained surfaces dipping at between 45° and 55° were exposed locally in the base of the landslide scar, which were interpreted as sheeting joint surfaces (Figure 5).

A particularly pronounced surface, inclined at 45°, was exposed in the area associated with the initial failure. Two voids or erosion pipes, typically between 50 mm and 70 mm in diameter, extended into the slope at the interface between a similar exposed surface and overlying material near the central part of the rupture zone (Plate 6). Soil around the pipes and on the surface was heavily stained.

A prominent pervasive wavy joint surface observed in the face of the lower part of the slope below the landslide scar, was inclined out of the slope at between 26° and 46°. The wavelength of the undulation was typically between 4 m and 6 m, and the amplitude about 1 m. The surface was interpreted as a sheeting joint. Similar surfaces occur throughout the full height of the slope at spacings between about 0.1 m and 4 m. The surfaces exposed in the main landslide scar also appear to belong to the sheeting joint system. The joint surfaces lower in the slope are locally heavily stained, containing up to 100 mm of closely fractured, completely decomposed granite. Seepages from joints near the toe of the slope were observed after the failure (Figure 5). Flows of between about 2 l/min. and 3 l/min. were estimated during an inspection on 26 September 1997.

Two sub-vertical, planar joint sets dipping typically towards 070° and 320°, at spacings of between 0.5 m and 2 m were evident in the lower part of the slope and exposed locally in the main scarp. These surfaces interact in places with the sheeting joint set, and may have provided release surfaces in the rupture area.

Sheet 7 of the Hong Kong Geological Survey 1: 20 000 Scale Map (Geotechnical Control Office (GCO), 1986), and the 1987 Geotechnical Area Studies Programme (GASP) Engineering Geology Map for the Central New Territories (GCO, 1987), indicate that the site is underlain by coarse-grained granite. The GASP map also indicates a linear fill body orientated close to the alignment of the footpath at the crest of the slope. These findings are in general agreement with observations made on site.

4. RAINFALL

Analysis of rainfall records was carried out to assess the influence of rainfall on the landslide. The analysis was based on rainfall readings taken at 5-minute intervals by a network of automatic raingauges located throughout Hong Kong and transmitted to HAP by the Hong Kong Observatory.

The nearest GEO automatic raingauge No. N02 is located at Shun Wo House, Wo Che Estate, Sha Tin, about 650 m southwest of the landslide. Figure 8 shows the location of raingauge and presents isohyets of rainfall recorded between 18:00 hours on 1 July 1997 and 06:00 hours on 2 July 1997. Daily rainfall recorded at the raingauge from 2 June to 9 July 1997 and hourly rainfall between 30 June and 3 July 1997 are shown in Figures 9a and 9b respectively.

Rainfall on 2 July 1997 started at about 01:00 hours and intensified significantly between 05:00 hours and 06:00 hours. The maximum rolling hourly rainfall (92.5 mm) was recorded between 04:55 hours and 05:55 hours. The 12-hour and 24-hour rainfall totals recorded prior to 05:55 hours on 2 July 1997 were 68 mm and 138.5 mm respectively.

Table 2 presents estimated return periods of maximum rolling rainfall for selected durations based on historical rainfall at the Hong Kong Observatory (Lam & Leung, 1994). The maximum rolling 31-day rainfall was the most severe with a corresponding return period of about 8 years. The maximum rolling 1-hour rainfall intensity was also notable, having an estimated return period of about 6 years.

Historical maximum hourly rainfall totals recorded in each month at raingauge No. N02 since installation are presented in Figure 10. Figure 10 indicates that the maximum hourly rainfall for July 1997 (99 mm recorded between 05:00 hours and 06:00 hours on 2 July 1997), was associated with the landslide and may be among the highest recorded.

5. PROBABLE CAUSES OF FAILURE

The landslide comprised principally two phases of sliding, though significant secondary erosion by surface water flow also occurred. The sliding surface of the initial failure phase was controlled by an adversely oriented sheeting joint surface. Sub-vertical joint systems were also observed in the main scarp of the initial failure. The sub-vertical and sheeting joint surfaces were probably significant in causing the failure, by enabling detachment of the failure mass and preferential flow and accumulation of water.

The close correlation between the rainfall event of 2 July 1997 and the likely time of failure indicates that heavy rainfall most probably triggered the landslide. Four possible sources of water at the landslide site were considered, namely:

(a) leakage of water from the pipe observed in the main scarp of the failure,

(b) direct infiltration of rainfall into the slope,

(c) saturation of near surface materials by surface water originating from the platform and stairway, and

(d) subsurface seepage to the landslide area through the sheeting joint system.

There was no evidence to indicate that the plastic pipe observed near the main scarp of the initial failure was leaking before the failure and it seems unlikely that this was a significant source of water. Infiltration of rainfall and surface run-off from the footpath and stairway would both have enabled water to enter the slope, assisted by the absence of surface protection and the localised presence of fill and sub-vertical joints. However, rainfall before the failure, though heavy, was not exceptional with calculated maximum return periods between about 6 and 8 years. This may indicate that infiltration of surface run-off was more influential in causing the failure than direct infiltration of rainfall.

The heavily stained surfaces and localised erosion pipes observed in the main scarp also indicate that periodic subsurface water flow occurs along the sheeting joints. It is possible that subsurface water, transmitted through the sheeting joints, also reached the landslide site from the upslope area.

Water entering the slope by the above mechanisms probably caused an increase of water pressure in the soil mass and enabled build-up of local water pressure along pre-existing discontinuities in the weathered granite. The increase in water pressure would have resulted in reduction of the available shear strength, principally along the main sheeting joint surface, leading to the initial failure near the squatter platform. Infiltration of rainfall into the near-surface materials would also have increased their bulk density, and contributed further to the de-stabilising effect on the soil mass. Undermining of the upper parts of the slope by the initial failure was the principal cause of the second failure phase.

The hillside has been modified by the formation of a platform and placement of fill at its crest, construction of a squatter hut and access stairway and, possibly, by shallow excavations at its toe. These modifications probably only marginally reduced the overall factor of safety of the hillside. However, the footpath associated with the platform at the crest, together with the abandoned squatter hut and stairway, may have served to concentrate and discharge surface water flows into the landslide area. It is possible that the fill at the crest of the slope also contributed by locally promoting infiltration.

The significance of the slumping and erosion of the slope noted before the landslide during an inspection by KCRC on 23 June 1997 is unclear, but observation of these features may indicate that other parts of the slope are also subject to periodic surface water flows, presumably during times of heavy rainfall.

6. CONCLUSIONS

It is concluded that the landslide south of Fo Tan KCRC Station on 2 July 1997 was triggered by heavy rainfall. The probable cause of failure was build-up of transient water pressure within the soil mass and along an adversely oriented sheeting joint system. The increase in water pressure would have reduced the available shear strength and enabled failure to occur. Surface water flowing onto the slope from above the crest area, together with heavy rainfall on the slope surface, were probably the most significant sources of water. Subsurface flow along the sheeting joint in response to heavy rainfall, however, may have also contributed to the generation of transient water pressure on the joint surface. Saturation of the near-surface materials would also have increased their bulk density and contributed to the destabilising effect on the soil mass.

7. REFERENCES

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KCRC (1997a). Notes of Meeting for Preventive Measures – Landslide. KCRC Minutes of Meeting on 23 July 1997, 4 p.

KCRC (1997b). KCRC Slope Inspection Data Sheet: Slope No. U11.6 (6.2). KCRC Maintenance Inspection Record, dated 23 May 1997, 13 p.

KCRC (1997c). Derailment of H001 (T22) at south of Fo Tan on 2/7/1997. KCRC Internal Memorandum, dated 2 July 1997.

Lam, C.C. & Leung, Y.K. (1994). Extreme rainfall statistics and design rainstorm profiles at selected locations in Hong Kong. Royal Observatory, Hong Kong. Technical Note no. 86, 89 p.

Ove Arup & Partners (1987). Investigation of Existing Slopes. Report on Stage 2 Investigation - Executive Report. Technical Report, Ove Arup and Partners Limited, Consulting Engineers for Kowloon-Canton Railway Corporation.

Wong, H.N. & Ho, K.K.S. (1996). Travel distance of landslide debris. Proceedings of the Seventh International Symposium on Landslides, Trondheim, Norway, vol.1, pp 417-422.

LIST OF TABLES

Table 1 - Key Site Developments Identified from Aerial Photograph Interpretation and Documentary Review

Year	Key Development
1949	The hillside appears undisturbed, though areas of shallow excavation are evident on the lower parts of the slopes.
1963	Almost all of the lower slopes have been excavated, possibly to provide borrow for reclamation works nearby. Three squatter huts have been built near the current crest of the slope behind the landslide location.
1977	Squatter huts at crest demolished.
1980	Squatter platform formed mid-way up slope; formation of cut platform at the crest, associated with minor filling on upper part of slope. Construction of platform, footpath and drainage system at crest of slope.
1985	Surficial filling below squatter platform.
1987	Three minor failures (GCO Incident Nos. ME87/7/18, 18A and 18B) occurred near to the village southwest of the landslide site.
1993	Squatter hut (No. XRCSW/13) and platform affected by landslide on 2 July 1997 abandoned following failure of minor cut slope behind building.
1997	Minor failures (GEO Incident Nos. ME97/7/98 and ME97/7/110) reported to the GEO on 16 July 1997 and 24 July 1997.

Table 2 – Maximum Rolling Rainfall at GEO Raingauge No. N02 for Selected Durations Preceding the 2 July 1997 Landslide and The Corresponding Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period	Estimated Return Period (Years)
5 minutes	11	05:50 hours on 2 July 1997	1
15 minutes	31	05:50 hours on 2 July 1997	3
1 hour	92.5	05:55 hours on 2 July 1997	6
2 hours	116.5	06:00 hours on 2 July 1997	4
4 hours	144.5	06:00 hours on 2 July 1997	3
12 hours	150	06:00 hours on 2 July 1997	2
24 hours	179	06:00 hours on 2 July 1997	2
2 days	227	06:00 hours on 2 July 1997	2
4 days	233	06:00 hours on 2 July 1997	1
7 days	278.5	06:00 hours on 2 July 1997	1
15 days	406.5	06:00 hours on 2 July 1997	2
31 days	909.5	06:00 hours on 2 July 1997	8

Notes: (1) Return periods were derived from the Gumbel equation and data published in Table 3 of Lam & Leung (1994).

(2) Maximum rolling rainfall was calculated from 5-minute data for durations up to one hour and from hourly data for longer rainfall durations.

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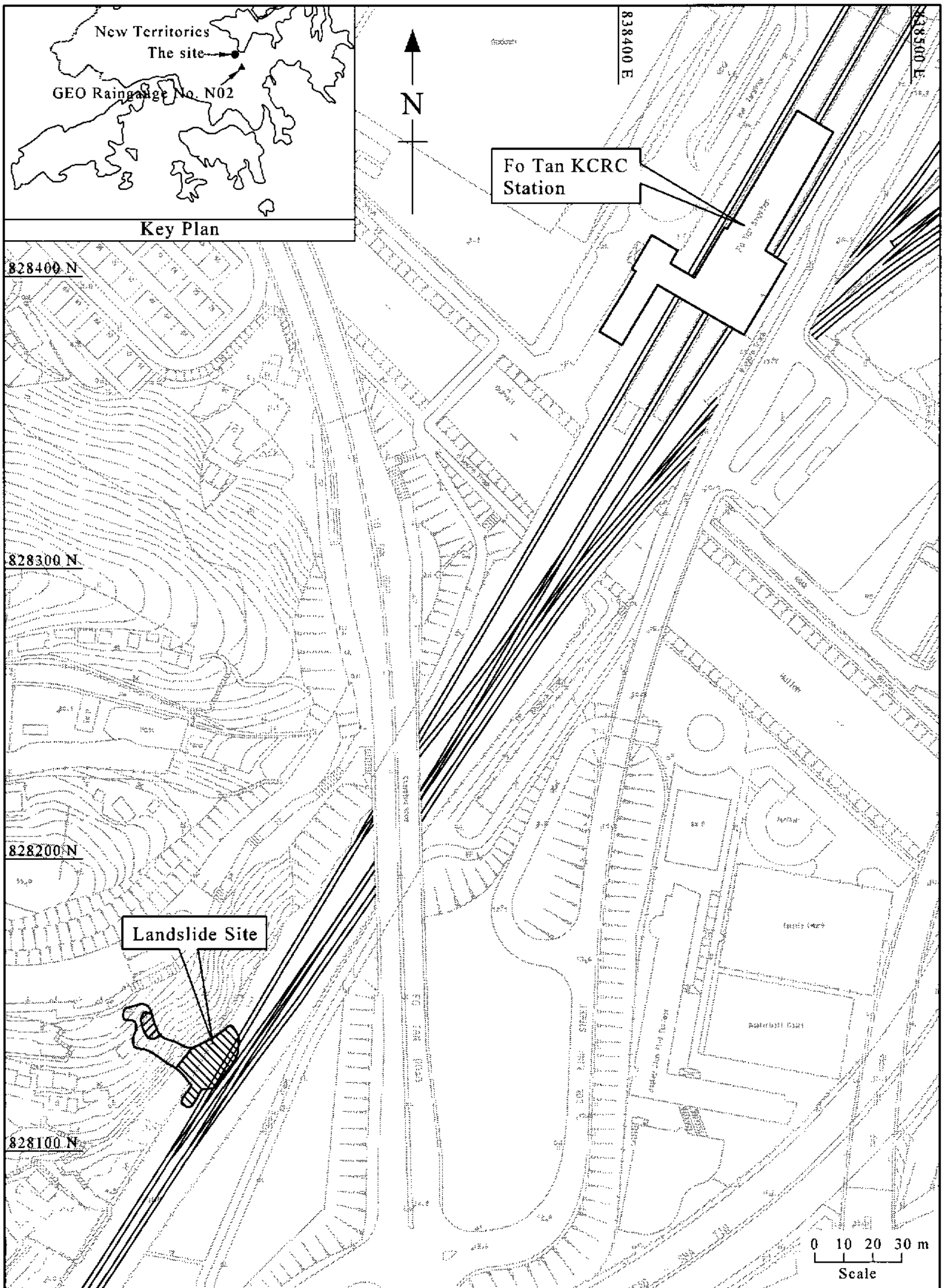


Note : Base map is extracted from Survey Sheet Nos. 7SE-6A, 7SE-6B, 7SE-6C and 7SE-6D dated October 1992 (Original scale 1:1 000).

Figure 1 - Site Location Plan

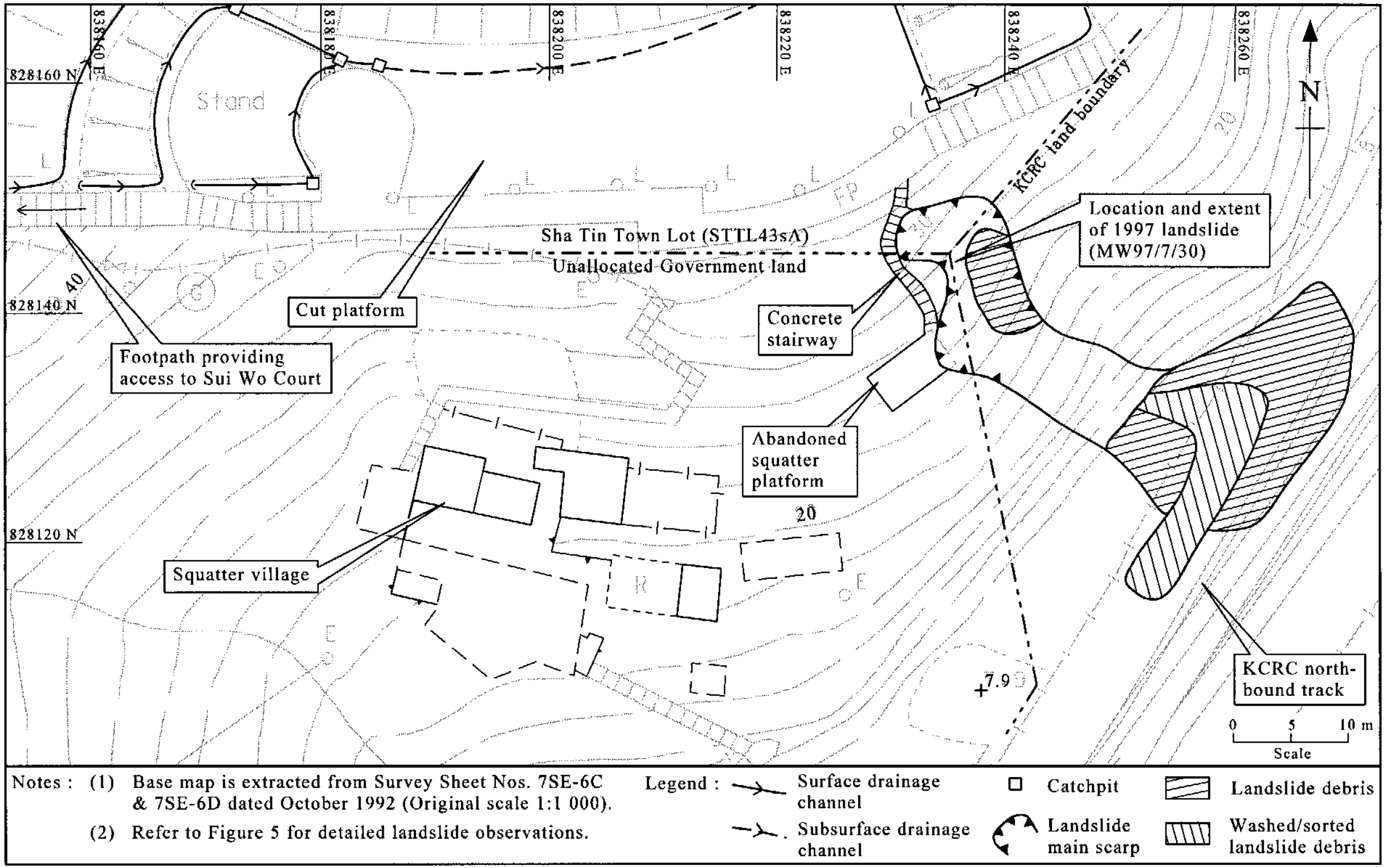


Figure 2 - Plan of the Landslide Site

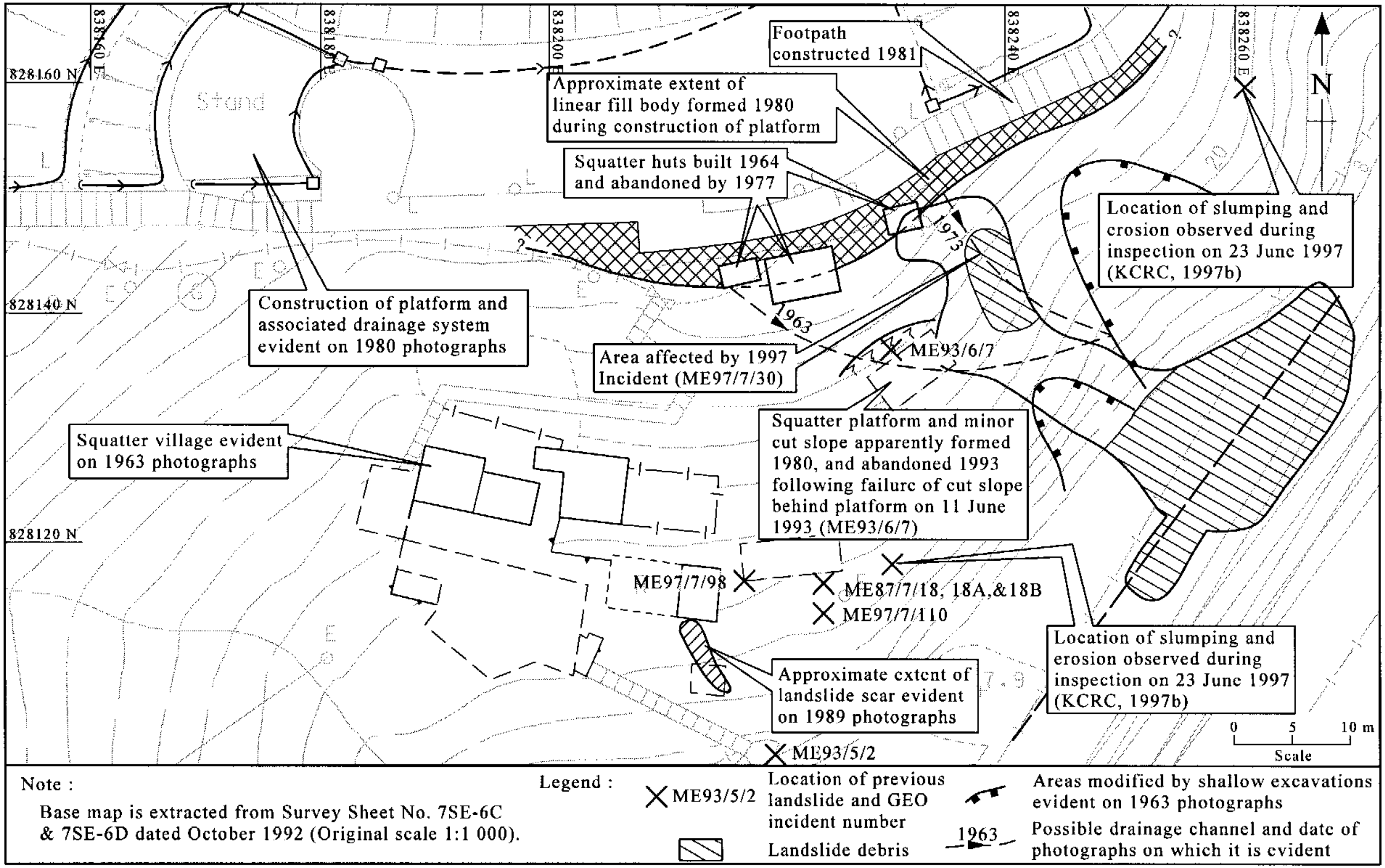
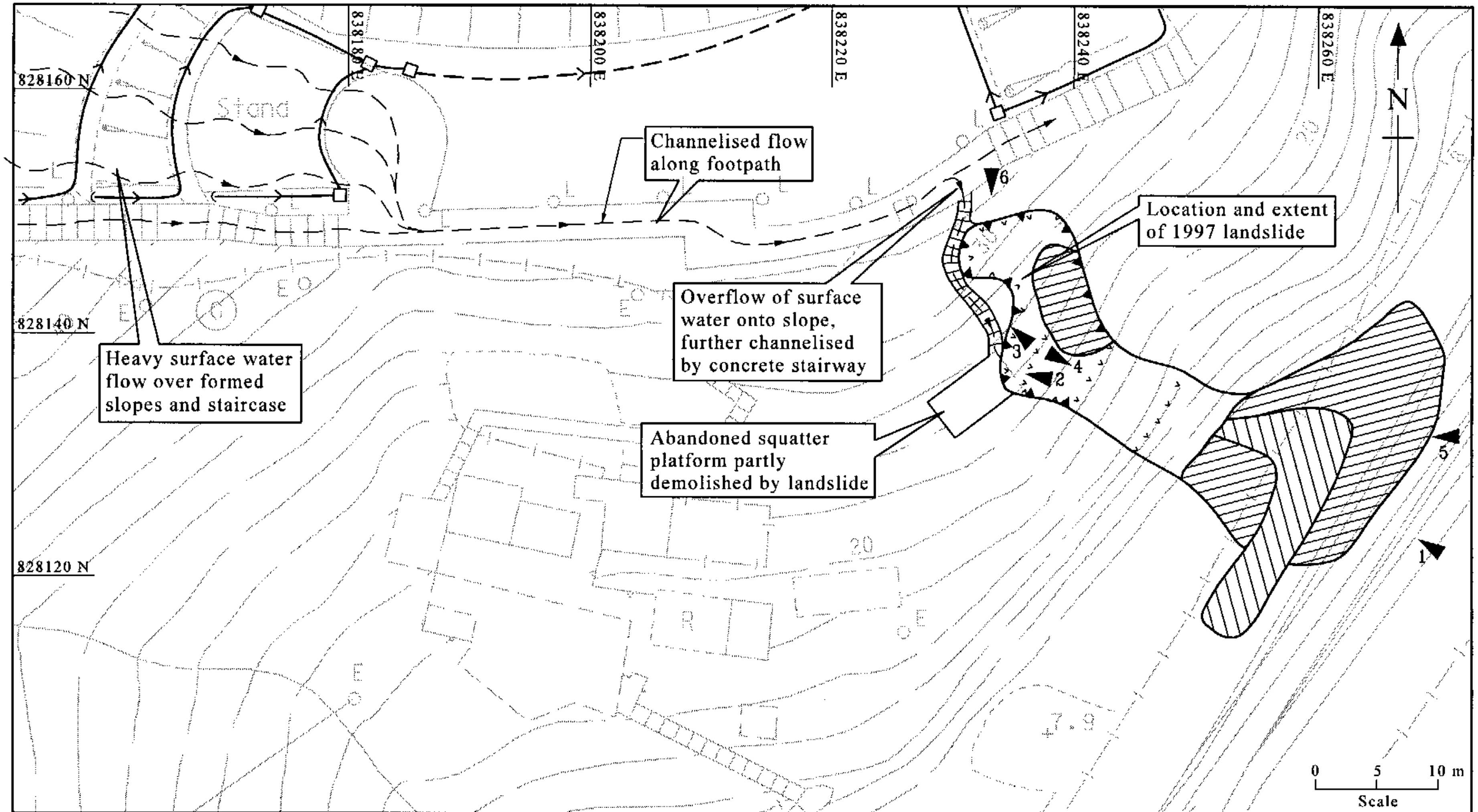


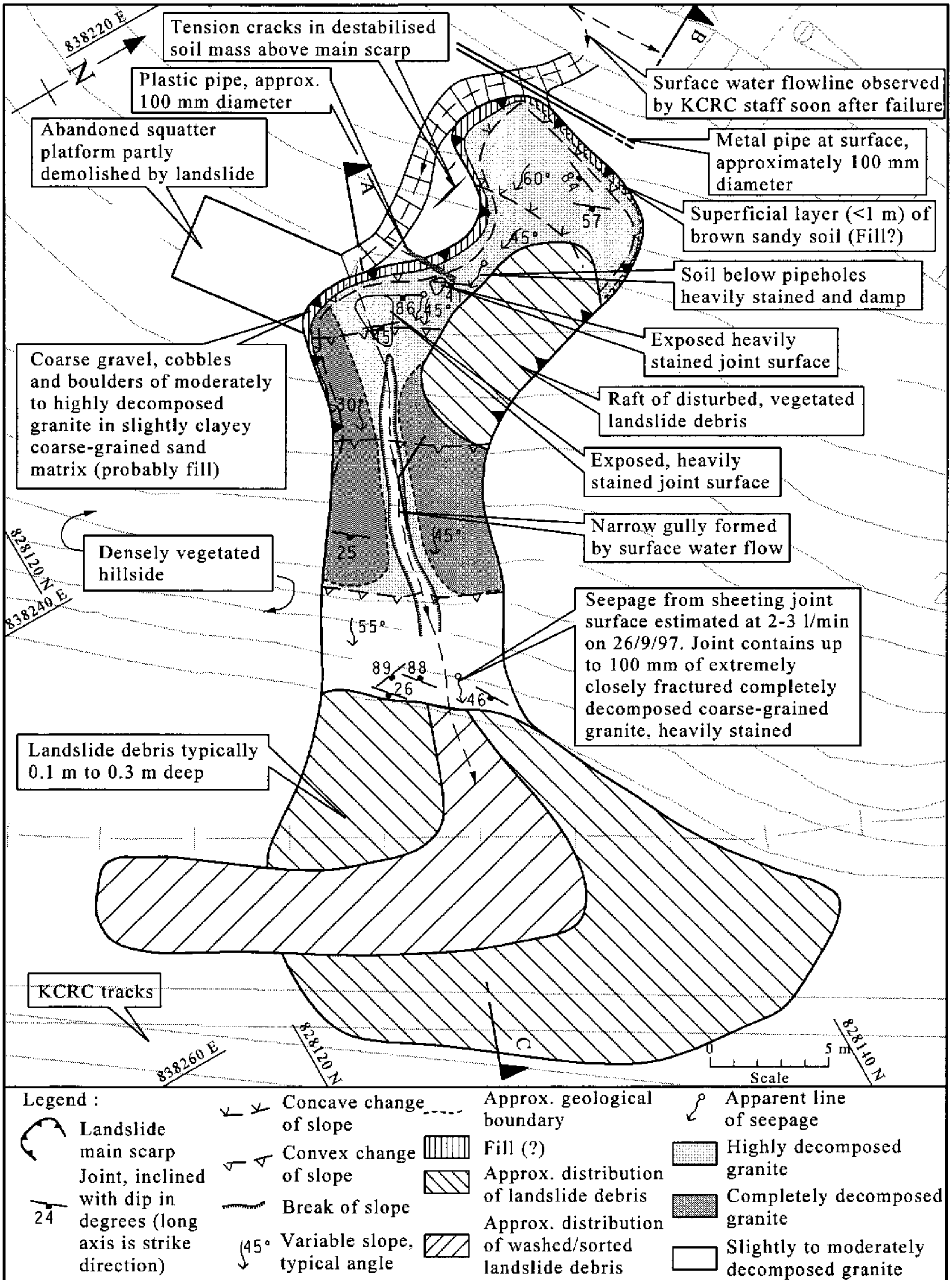
Figure 3 - Site History



Notes : (1) Base map is extracted from Survey Sheet Nos. 7SE-6C and 7SE-6D dated October 1992 (Original scale 1:1 000).
(2) Refer to Figure 5 for detailed observations of landslide scar.
(3) Observations of surface water flow made by KCRC staff soon after failure.

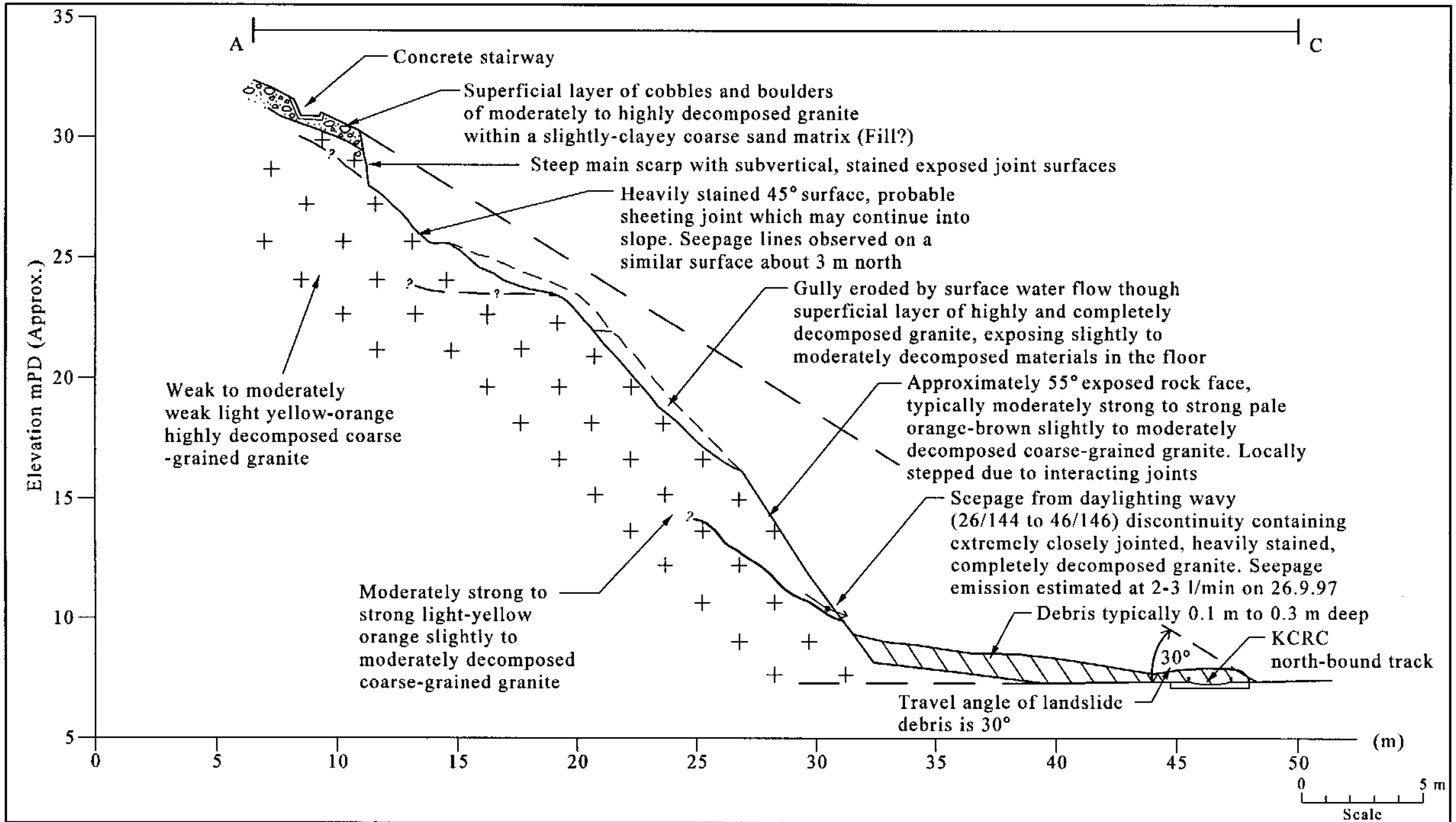
Legend :
Washed/sorted landslide debris
Landslide debris
Landslide main scarp
Orientation of photograph and Plate No.

Figure 4 - General Site Details and Landslide Observations



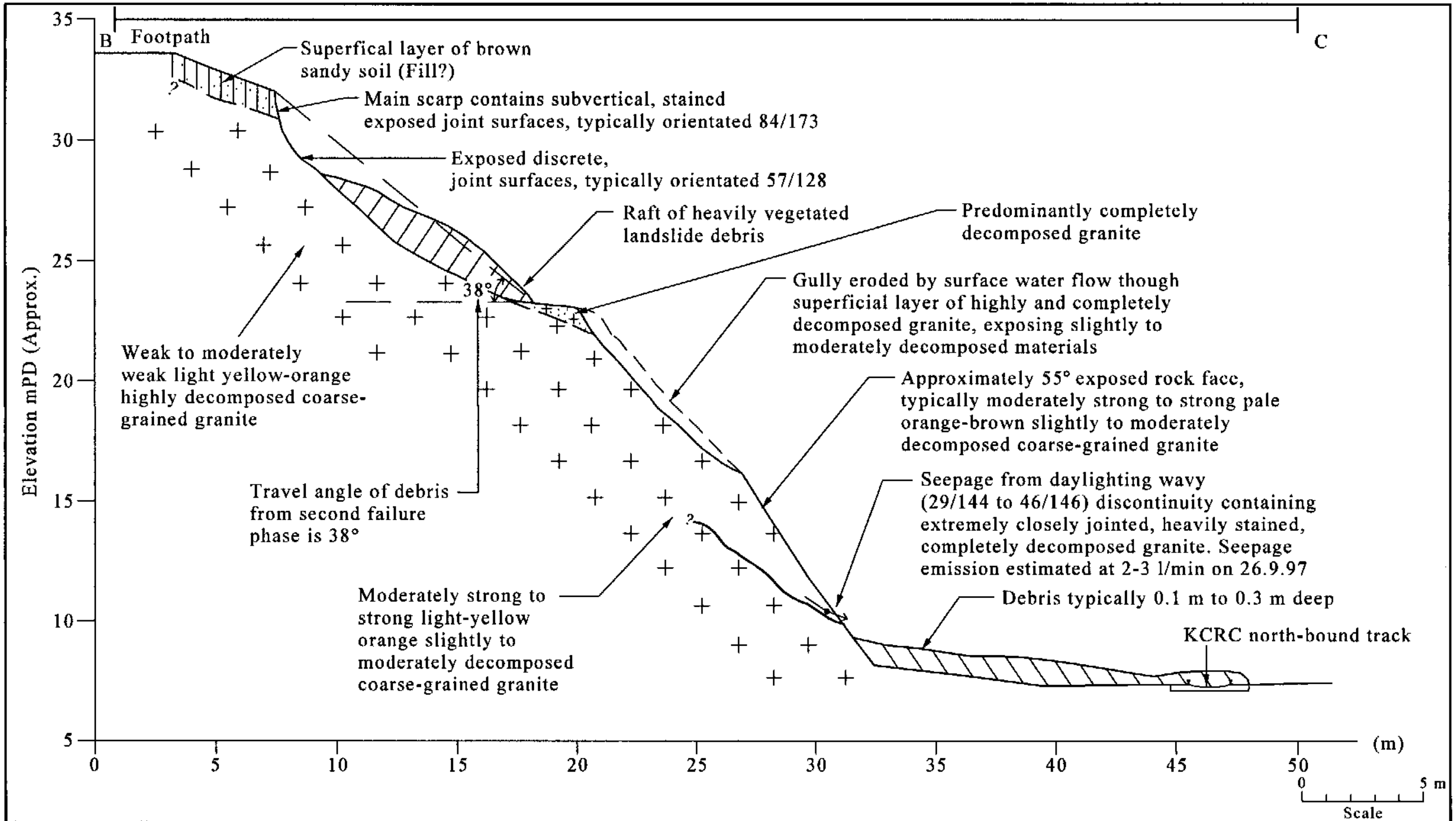
Notes : (1) Base map is extracted from Survey Sheet Nos. 7SE-6C & 7SE-6D dated October 1992 (Original scale 1:1 000).
(2) Refer to Figure 6 and Figure 7 for cross-sections A-C and B-C.

Figure 5 - Detailed Landslide Observations



Notes : (1) Refer to Figure 5 for location of cross-section.
(2) Section prepared by site measurement.
(3) 26/144 indicates a surface dipping at 26° towards 144°.

Figure 6 - Cross-section A-C through the Landslide

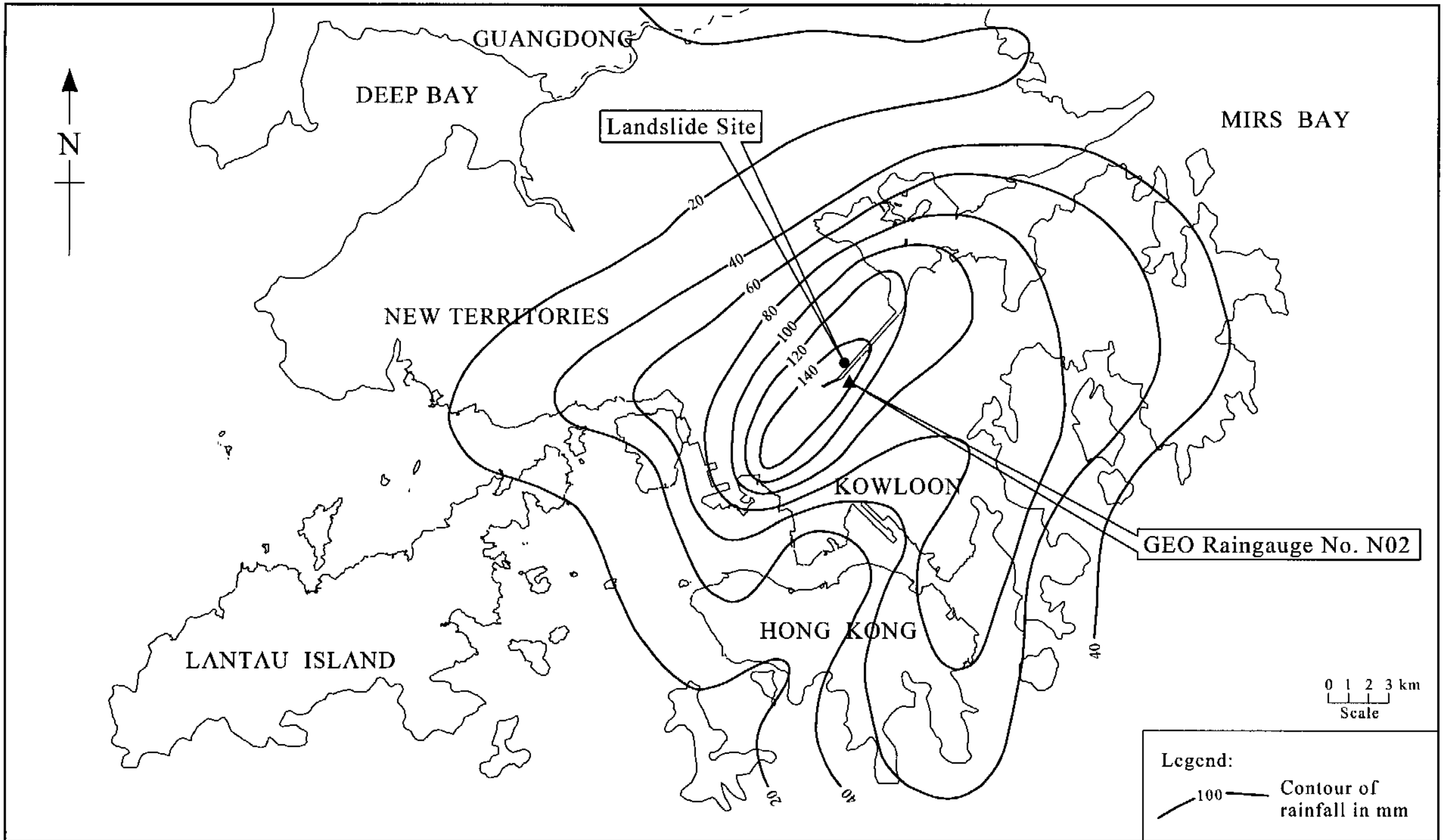


Notes : (1) Refer to Figure 5 for location of cross-section.

(2) Section prepared by site measurement.

(3) 84/173 indicates a surface dipping at 84° towards 173°.

Figure 7 - Cross-section B-C through the Landslide



Note : Isohyets prepared by the Hong Kong Observatory.

Figure 8 - Isohyets of Rainfall between 18:00 Hours on 1 July 1997 and 06:00 Hours on 2 July 1997

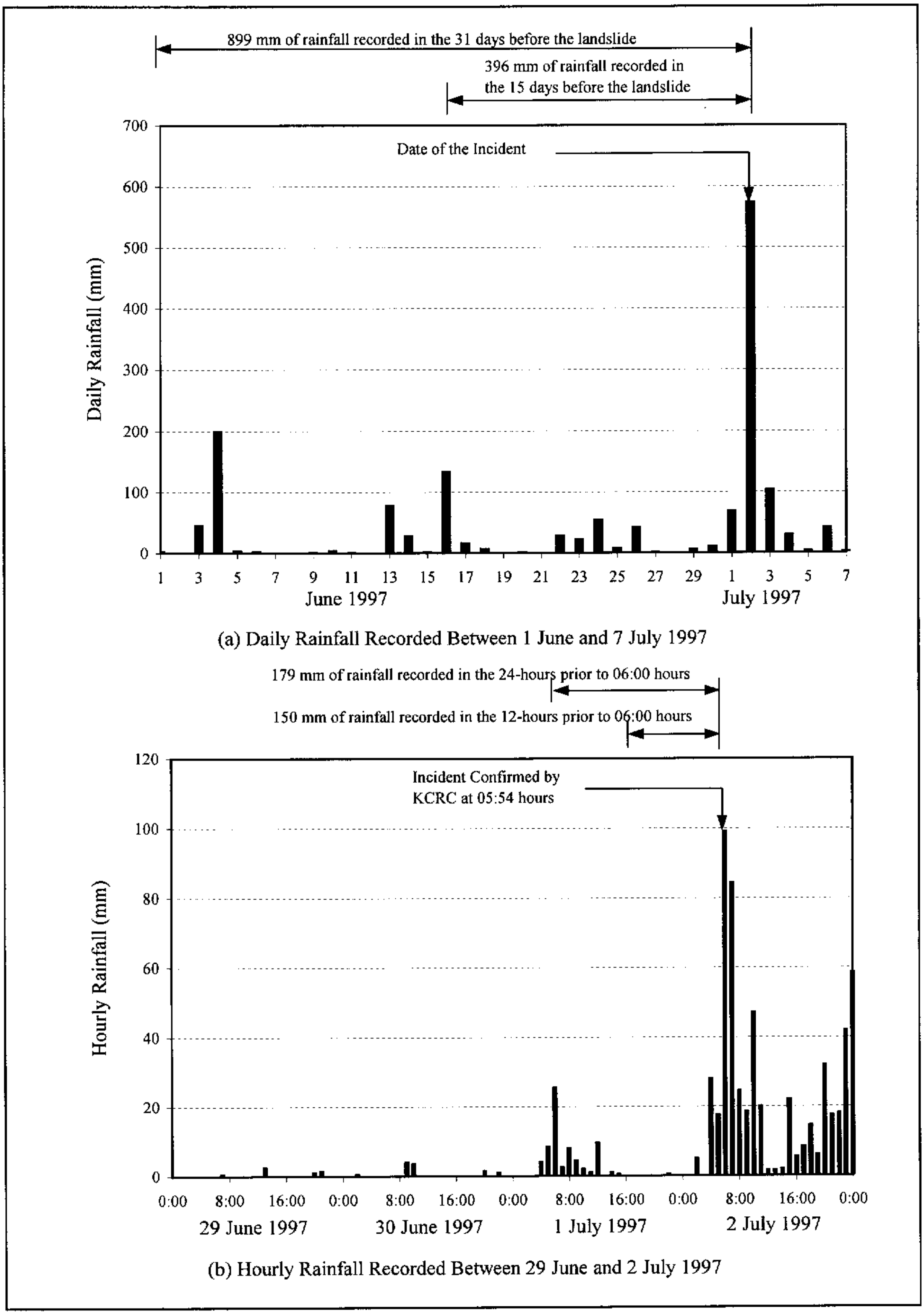


Figure 9 - Rainfall Records at GEO Raingauge No. N02

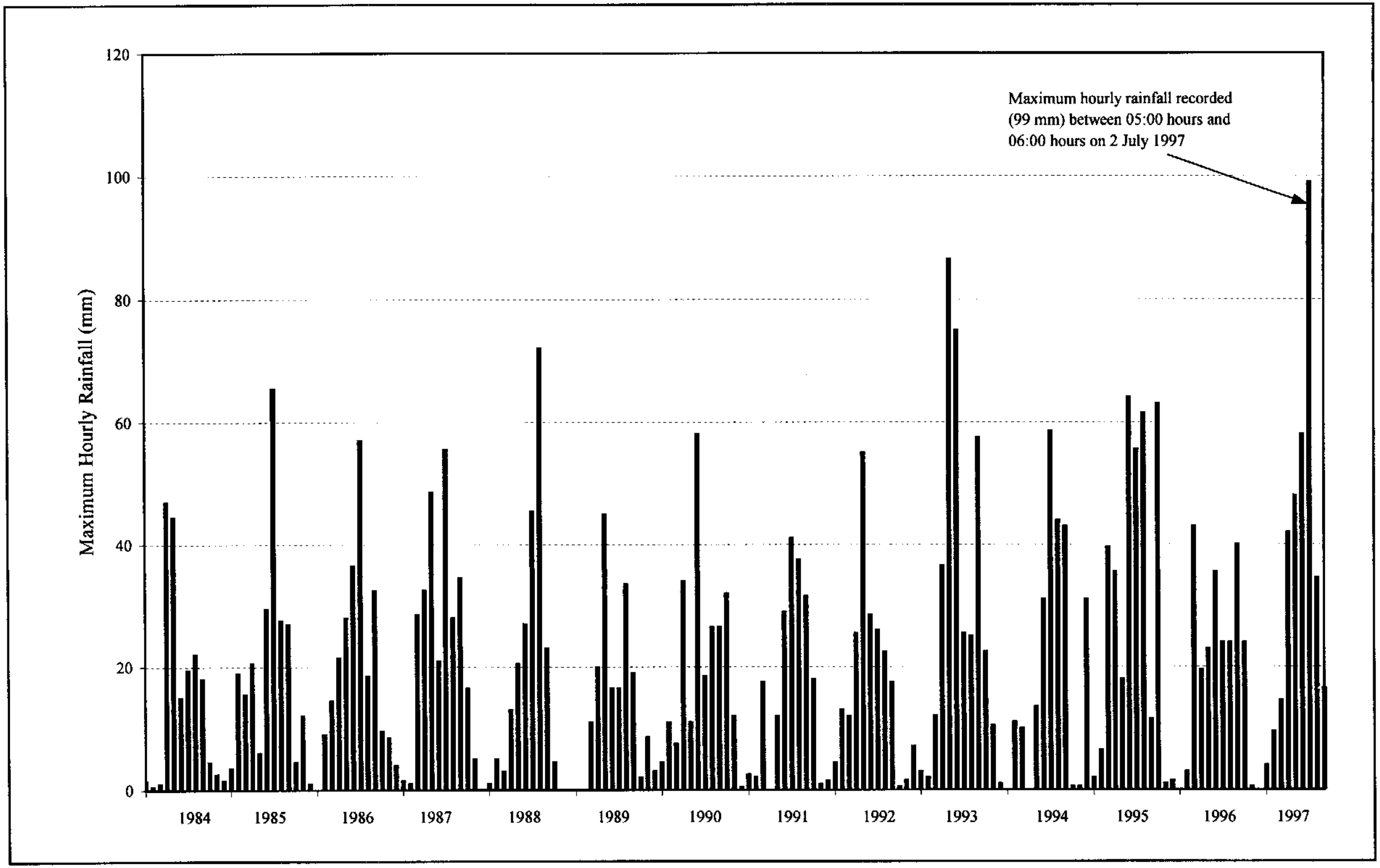


Figure 10 - Maximum Hourly Rainfall (mm) in Each Month at GEO Raingauge No. N02 from January 1984 to September 1997

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Plate 1 - General View of the Lower Part of the Landslide
(Photograph Taken on 4 July 1997)

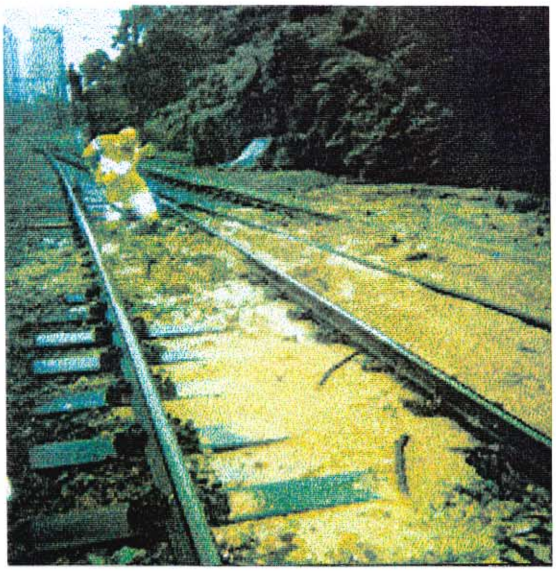

Plate 2 - General View of the Landslide Debris
(Photograph Taken on 2 July 1997)

Plate 3 - View from above the Main Scarp (Photograph Taken on 4 July 1997)

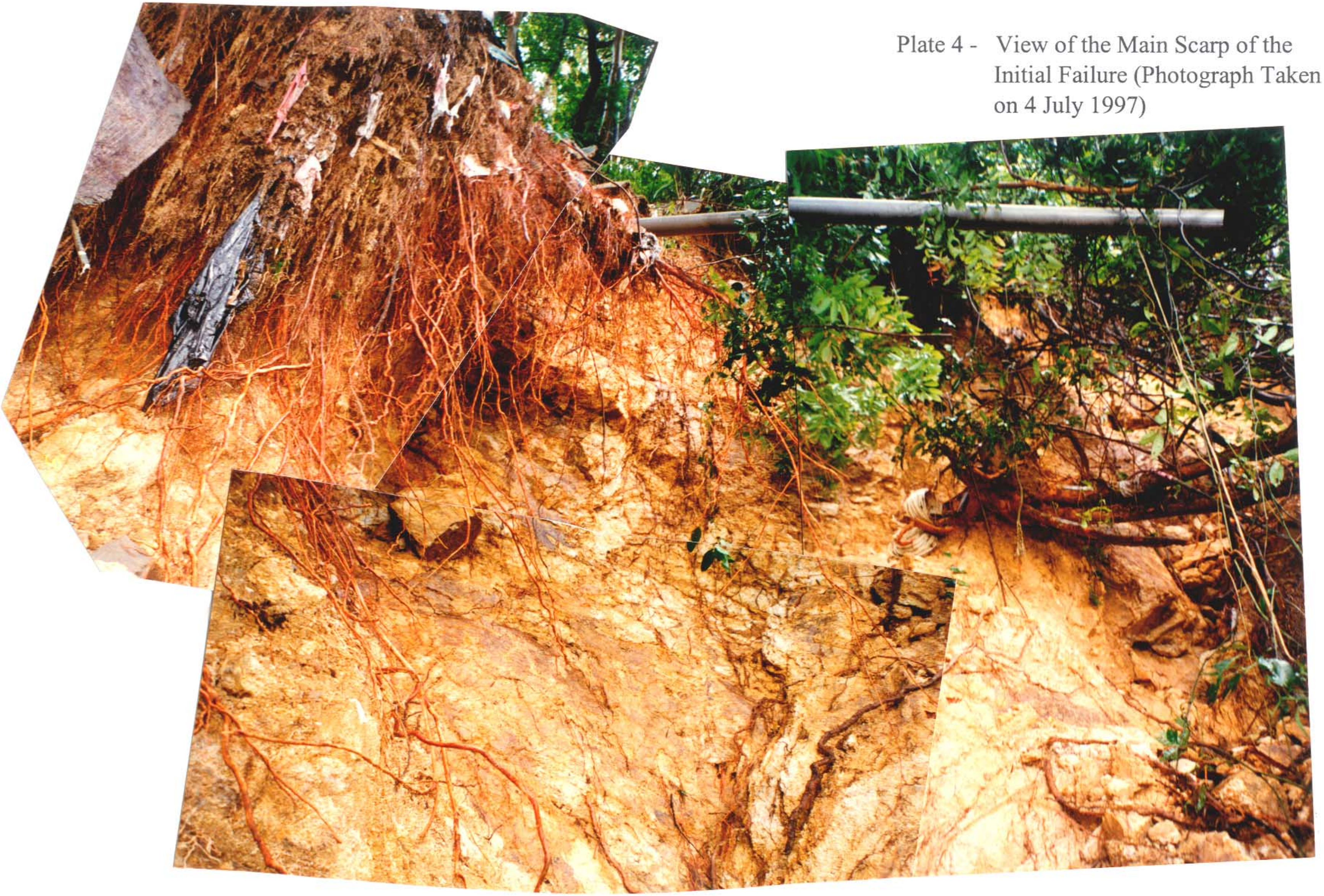

Plate 4 - View of the Main Scarp of the Initial Failure (Photograph Taken on 4 July 1997)

Plate 5 - Downslope View (Photograph Taken on 4 July 1997)

Plate 6 - Erosion Pipe Exposed in the Central Part of the Main Scarp
(Photograph Taken on 25 September 1997)