APPENDIX E

Natural Terrain Hazard Study

Natural Terrain Hazard Study

Application for Permission under Section 16 of The Town Planning Ordinance (Cap. 131)
for
Minor Relaxation of Building Height Restriction
from 2 Storeys to 4 Storeys for
Proposed 4-Storey Columbarium
at Part of Inland Lot No. 7755 RP and
Government Land sandwiched between
Inland Lot No. 7755 RP and Inland Lot No. 7713,
Cape Collinson Road, Chai Wan

Philip So & Associates Limited

In association with: CALVINT GEO-SERVICES LIMITED
THE BEST SOLUTION FOR YOU

April 2024

Contents

1 INTRODUCTION

A 4-Storey Columbarium is proposed to be constructed at part of Inland Lot No. 7755 RP and government land sandwiched between Inland Lot No. 7755 RP and Inland Lot No. 7713, Cape Collinson Road, Chai Wan (842101E 813128N). A natural terrain hazard study was carried out with respect to the natural hillside located to the southeast of the proposed development site. This report documented the findings of the natural terrain hazards aroused from the natural hillside and the necessary mitigation measures to be carried out.

2 THE SITE AND THE NTSA DESCRIPTION

2.1 Site Location

The Site which is located at a very gentle slope (<20°) above Cape Collinson Road is defined as the area for the proposed 4-Storey Columbarium development. Several small rubble walls (<1.5m high) and footbridges are present within the Site (**Plate 1 to Plate 4**). These features appears to have been abandoned for a long period of time. They will be removed during site formation in the later stage of the project. The Site is overlooking by natural terrains at its southeastern side.

2.2 NTSA Location

The NTSA is generally a relatively planar open hillslope with two minor local depression areas at its middle portion. A catchwater channel traverses the NTSA at about +152 mPD. The Hong Kong Trial path is also traversing the upper portion of the NTSA at about +193 mpD. The hillslopes within the NTSA are generally facing northwest. The extent of the natural terrain hazard study area (NTSA) overlooking the proposed development is delineated in **Figure 1 and Plate 5**.

2.3 Initial Screening

An initial screening exercise has been carried out to assess whether the proposed development falls within the "In-principle Objection Criteria" or the "Alert Criteria" with respect to the concerned natural terrain according to the guideline given in GEO Report No. 138 2nd Edition. The potential hillside catchments that may affect the proposed development has been delineated based on the 1:1000 topographic map and is presented in **Figure 2**. The angular elevation projected from the hillside catchment to the location of the proposed 4-Storey Columbarium was measured with angular elevation of 25.6°. Graphical presentations of the angular elevation are presented in **Figure 2** and the values are summarised below:

Table 2.1 Summary of Angular Elevation for Initial Screening

Lot No.	Angular Elevation (°)
Part of Inland Lot No. 7755 RP and government land sandwiched between Inland Lot No. 7755 RP and Inland Lot No. 7713 (The Site)	25.6

The measured angular elevation from the NTSA to the Site is higher than 20° and lies within 50m of ground sloping, therefore it satisfied the "Alert Criteria" and further study of the natural terrain hazards posing to the development is required for hillside.

3 DESK STUDY

3.1 Topography

The general topography of the NTSA was reviewed based on the latest 1:1000 scale topographical map. The maximum altitude of the NTSA is about +214 mPD and its toe is at about +122 mPD. The elevation different between the toe and the crest of the NTSA is about 92m. A slope angle map has been generated for the NTSA based on the 1:1000 topographic map with the aid of the software ArcGIS **(Figure 3)**. As shown in the slope angle map, the upper portion of the NTSA is relatively gentle which generally lies below 20°, locally 25°; whilst the middle and the lower portions of the NTSA comprises of relatively steeper hillslope with slope angle range from 25° to 35°. Minor man-made cut slopes above the catchwater and the Hong Kong Trail lie between 55-65°.

3.2 Geological Maps

The geology of the NTSA is shown on the Hong Kong Geological Survey (HKGS) Map Sheet 11 (Hong Kong & Kowloon), 1:20,000-scale HGM20 series, 2012 Edition II. The local geology of the NTSA is presented in **Figure 4**.

3.2.1 Solid Geology

The 1:20,000 scale geological map sheet 11 shows that the NTSA is underlain by eutaxitic fine ash vitric Tuff (Krc_fvt) of Che Kwu Shan Formation under the Repulse Bay Volcanic Group in Early Cretaceous.

3.2.2 Superficial Geology

No superficial deposit is indicated within the NTSA which implies the superficial deposits (colluvium) could be less than 2m thick.

3.2.3 Structural Geology

No faults or any photolineament has been recorded within the NTSA. However, a NW-SE trending photo-lineament is record approximately 36m to the west of the NTSA, another

NE-SW photo-lineament is record approximately 10m below the Site.

3.3 GASP Report

The Geotechnical Area Studies Programme (GASP) comprised a systematic geotechnical information and assessment for land management and development planning of the Territory of Hong Kong. The findings were based on terrain classification techniques using aerial photographs, examination of geotechnical data collected from existing site investigation records and available literature and field reconnaissance. The study was based on the bedrock geology given on the 1:50,000 scale geological map produced by Allen & Stephens (1971) 'Report on the Geological Survey of Hong Kong', which has subsequently been superseded. The following are extracts from the relevant GASP report (GASP Report I, Hong Kong and Kowloon, 1987 Edition II):

a) Physical Constraints Map – This map indicates that the NTSA is mostly classified as slopes on insitu terrain which are generally steeper than 30 degrees, except the upper most small portion of the NTSA has no record of physical constraints.

b) Engineering Geology Map – This map indicates that the entire NTSA is covered by dominantly pyroclastics under the Repulse Bay Formation. Two approximate geological photo-lineaments are recorded along the toe of the NTSA and to the west of the NTSA.

c) Geotechnical Land Use Map – This map indicates that most of the NTSA is designated as Class III, which has high geotechnical limitations and has high engineering cost for development. A small portion of the western toe of the NTSA is classified as Class IV, which has extreme geotechnical limitations and has very high engineering cost for development. The upper most small portion of the NTSA is classified as Class II, which has moderately geotechnical limitations and normal engineering cost for development.

d) Generalised Limitations and Engineering Appraisal Map –This map indicates that the NTSA is mostly classified as zone of constraints for development which assessed principally in geotechnical terms, except the upper most small portion of the NTSA is classified as zone of potential for development. A country park boundary is present at the middle level of the NTSA which indicates the upper half of the NTSA is designated as Country Park.

3.4 Enhanced Natural Terrain Landslide Inventory

In 1995, the GEO compiled the Natural Terrain Landslide Inventory (NTLI) from an interpretation of high-altitude (8,000ft and above) aerial photographs dated from 1945 to 1994 (King, 1999). In 2007, the GEO produced an Enhanced Natural Terrain Landslide Inventory (ENTLI) using low-altitude (8,000ft and below) aerial photographs to update the NTLI.

In accordance with **GEO Report No. 138 2nd Edition** (GEO, 2016), landslides are classed as either "Relict" or "Recent", depending on their appearance in aerial photographs. "Relict" landslides are defined as those where the main scarp is well-defined but vegetation has re-established on the scar on the earliest set of available aerial photographs. "Recent" landslides are defined as having occurred within the timespan of the aerial photograph coverage. These are typically identified as having a light tone on the aerial photographs and are bare of vegetation.

Two relict landslides (11SED0090E and 11SED0091E) have been recorded within the NTSA **(Figure 5)**. The ENTLI recorded within the NTSA were summarised below in **Table 3.1**.

Table 3.1 Summary of Natural Terrain Landslide Events Recorded in ENTLI

ENTLI No.	Location	Recent / Relict	ENTLI Relict Landslide Class	Year of Photo	Landslide Type	Source Gradient (°)	Width (m)	Source Length (m)	Head Elevation (mPD)
11SED0090E	Within NTSA	Relict	Rounded Scarp (50% certain)	1963	R	32.5	19	17.5	169
11SED0091E	Within NTSA	Relict	Broad Depression (10% certain)	1963	R	23.5	19	48.5	184

3.5 Historical Landslide Catchment (HLC) Inventory

Historical Landslide Catchments (HLCs) have been defined by GEO based on the results of the ENTLI. One HLC has been delineated within the NTSA, namely 11SE-D/OH18 **(Figure 5)**.

3.6 Hillside Pockets

Hillside pockets are form of natural hillside catchment which have been affected by human disturbance to varying degree (e.g. construction of roads or building platforms). GEO has compiled an inventory of Hillside Pockets for the whole Hong Kong (GEO Report No. 138, Second Edition).

Under the Hillside Pockets Inventory, there is no registered Hillside Pockets within or in the vicinity of the NTSA.

3.7 Reported Landslide Incidents

The GEO landslide incident database has recorded one small scale failure within the NTSA. Incident no. 2017/04/1005WS was recorded in the middle portion of the NTSA on the man-made cut slope Feature No. 11SE-D/CR350 (**Figure 5**). It is a minor soil cut washout with failure volume of $0.8m^3$.

3.8 Boulder Field Inventory

The Boulder Field Inventory is a boulder study of the whole territory of Hong Kong including a series of study reports and 1:20,000 maps. The study was based on the use of the 1963 low altitude aerial photographs.

Four main attributes (Percentage Area Covered, Boulder Type, Boulder Size and Boulder Shape) and additional attributes are defined for the boulder study. Multiple Attribute Mapping was adopted to define areas of land having a relatively uniform pattern of boulder deposits and the results were mapped on 1:20,000 topographic maps of Hong Kong.

The Boulder Field Inventory was compiled by MGSL. The inventory contains referenced polygons encompassing individual boulder fields. Most of the NTSA is located within polygon no. S11_83 which representing land surface obscured by vegetation, only a tiny portion of the slope toe of the NTSA lies within polygon no. S11_E which representing cemetery. Therefore, not much information of boulder can be retrieved from the inventory within the NTSA (**Figure 6**).

3.9 Previous Ground Investigation

According to the GIU record, no ground investigation has been carried out within the NTSA. However, 7 boreholes were carried out in the close vicinity of the Site. The locations of these previous ground investigation stations are present in **Figure 7** and corresponding logs are given in **Appendix A**. All these boreholes are considered not relevant to the current NTSA as they were located at the Cemetery where the original land has been significantly modified during construction.

Details of the thickness of each stratum revealed in each ground investigation stations are summarised below in **Table 3.2**.

Table 3.2 Summary of Key Material Encountered at Previous GI

GIU Report No.	GI No.	Thickness of Strata (m)				
		Fill	Colluvium	Saprolite (Grade IV/V)	Grade III or above	Soil/Rock Type
22620	BH1	1.00	-		4.13	Tuff
	BH2	5.30	-		3.00	Tuff
	BH3	1.90	-	4.70	3.40	Tuff
	BH4	1.25	-		5.55	Tuff
	HH7	1.60	-	0.40		Volcanic
	HH8	2.20	-	0.40		Volcanic
22623	VH1	2.00	-	4.00	4.65	Volcanic

3.10 Existing Facilities

A catchwater and the Hong Kong Trail (Section 8) traverse the middle and upper portions of the NTSA respectively.

3.11 Registered Man-made Slopes

Two registered man-made cut slopes, Feature Nos. 11SE-D/CR350 and 11SE-D/CR351 are located within the NTSA above the Catchwater. While Feature No. 11SE-D/C356 is located within the NTSA above the Hong Kong Trail. Another man-made cut slope No. 11SE-D/C69 are registered adjacent to the northwest of the Site **(Figure 8.1 & 8.2)**.

Table 3.5 Summary of the Registered Man-made Slopes

Feature No.	**Location**	**Registered Date (dd/mm/yy)**	**Average Angle (degree)**	**S2/S3 Study**	**Slope Upgrading Works**
11SE-D/CR350	Within NTSA above Catchwater	14/11/1997	Slope:65 Wall:70	Nil	Nil
11SE-D/CR351	Within NTSA above Catchwater	14/11/1997	Slope:55 Wall:70	Nil	Nil
11SE-D/C356	Within NTSA above the Hong Kong Trail	14/11/1997	60	Nil	Nil
11SE-D/C69	Adjacent to the Northwest of the Site	14/11/1997	50	Nil	Nil

4 AERIAL PHOTOGRAPH INTERPRETATIONS

4.1 General

In order to study the landslide history, geomorphology and engineering geology of the NTSA and its adjacent area, an aerial photograph interpretation (API) has been carried out using a total of 106 relevant aerial photographs taken between 1945 and 2022. Site development and geomorphology obtained from API are summarised below and list of aerial photographs being examined is provided in **Appendix B**.

4.2 Landslides

4.2.1 Natural Terrain Landslide History

The landslide history for the NTSA was obtained from a series of aerial photographs between 1945 and 2022.

Landslides have been classified as “relict” and “recent”, in accordance with **GEO Report No. 138 2nd Edition** (GEO, 2016). “Relict” landslides are defined as the landslides first observed on the earliest set of available aerial photographs where vegetation has re-established and the scarp is not well defined due to degradation. While “recent” landslides are defined as the landslides first observed on the earliest set of aerial photographs where vegetation has not re-established. The volumes of the landslides are assessed base on the observation from API and calculation using the formula 1/6πD.W.L, which assumes that the failure was “spoon-shaped”.

Based on the findings from API, two relict landslide scars have been identified within the NTSA from year 1963 aerial photographs.

Two minor concave depressions appear as darker tone which are located at the middle portion of the NTSA, they are probably represent as two relict landslide scars (RL1 and RL2). The landslide scarp of RL1 appeared as a concave depression with a relatively distinctive change of slope. The landslide scarp of RL2 appears as rounded and broad depression. This degraded feature indicates the landslide could be happened a very long time ago before 1945. The failure of RL1 and RL2 probably due to the transient build-up of perched water table between the thin colluvium and the insitu materials. RL1 and RL2 have an estimated landslide volume of $33m^3$and $40m^3$respectively (need to verify during the field mapping, please refer to Section 5.2.4). These locations were probably registered in the ENTLI as the record nos. 11SED0090E and 11SED0091E respectively.

4.3 Geomorphological Conditions

The geomorphological map of the NTSA was developed based on API and cross-checked with field mapping. Details of the geomorphological features, including the morphology based on the system of Savigear (1965) and the regolith types based on the regolith guideline (TGN 22) are presented in **Figure 9** and described below:

4.3.1 Morphology

The NTSA is generally a small planar hillslope emerging from a north trending spur bounded by two subordinate indistinct northwest trending spurs. The hillslope is generally a northwest facing hillslope.

Morphologically, a convex change of slope is discerned at about +190 mPD. The convex change of slope demarcates the upper and the middle slope terrain. The NTSA comprises a relatively gentle slope at the upper portion whilst the middle and lower portion of the NTSA is comprises of relatively steeper slope which formed the transportational environment.

4.3.2 Regolith Types and Distribution

The surface of the NTSA appears as smooth morphology without distinctive hummocky terrain. Locally two minor depressions are discerned within the middle portion of the NTSA above the catchwater. Based on the morphology, the NTSA is probably covered by in-situ materials and may be covered by a thin veneer of colluvium.

4.3.3 Rock Outcrops

No prominent rock outcrop or boulder can be identified within or in the vicinity of the NTSA from the aerial photographs.

4.3.4 Drainage Lines

Neither ephemeral nor perennial drainage line can be discerned within the NTSA.

4.3.5 Erosion and sign of distress

No signs of erosion or other signs of distress were identified within the NTSA.

4.4 Anthropogenic Features

Before 1945, Cape Collinson Road was already constructed below the Site, a catchwater and the Hong Kong Trail were traversed at the middle and upper portion of the NTSA respectively. Man-made features Nos. 11SE-D/CR350 and 11SE-D/CR351 were probably formed in association the alignment of the catchwater, whilst feature No. 11SE-D/CR356 was probably formed in association with the alignment of the Hong Kong Trail. A strip of vegetation clearance is obvious above the Hong Kong Trail. It could probably be served as a fire break.

In between 1963 and 1972, Feature No. 11SE-D/C69 was formed in association with the access road to the Holy Cross Catholic Cemetery at the northern toe of the NTSA. The Hong Kong Buddhist Cemetery was constructed to the western side of the Site.

In 1976, construction of culvert appeared to have been carried out at the Site area.

Some small structures were constructed at the Site Area in 1984 and 2000.

The construction of the triangular shape building of the Hong Kong Buddhist Cemetery at the western side of the Site was completed in 1991.

In 1980s, small terraces (for placement of urns, verified during field mapping) were apparent at the toe of the NTSA. These terraces appeared to have been left abandoned since the completion of the Cemetery building which was completed in 1991.

Based on the aerial photographs, apart from the construction of the catchwater, the Hong Kong Trail and the small terraces, there is no other significant human disturbance has been occurred within the NTSA. Also there is no observable significant fill body can be discerned within the NTSA.

5 FIELDWORK

5.1 General

Fieldwork included detailed geological and geomorphological mapping, which was cross checked with the API and existing geological data. Field mapping traverses is illustrated in **Figure 13**.

5.2 Field Mapping

5.2.1 General

In general, the findings from field mapping were consistent with the aerial photography interpretations.

5.2.2 Regolith Mapping and Boulders

Figure 9 illustrates the mapped regolith types within the NTSA which generally include saprolite and open hillslope colluvium.

Inspection pit IP1 was excavated near the spur at the crest of the NTSA (**Figure 9)**. According to the findings at IP1, 0.1m thick top soil (TS) overlying completely decomposed fine ash vitric Tuff (CDT). CDT encountered at 0.1m BGL and can be described as extremely weak, reddish brown, mottled white, pink and orange, completely decomposed fine ash vitric Tuff which comprises stiff, sandy silt with many angular fine to medium gravel. Highly decomposed tuff encountered at 1.10m below ground and it can be described as weak, brown, mottled white and pink, highly decomposed fine ash vitric Tuff (**Plate 6**).

Inspection pit IP2, IP3 and IP5 were excavated at the upper, middle and lower portions of the NTSA respectively. The results shown that IP2, IP3 and IP5 has similar findings. IP2, IP3 and IP5 retrieved 0.8m to 1.0m thick of colluvium. Colluvium generally can be described as firm, brown, dappled grey, sandy silt with some subangular fine to coarse gravel sized rock fragment. Completely decomposed fine ash vitric Tuff (CDT) was discovered below the colluvium and can be described as extremely weak, reddish brown to yellowish brown, mottled white and pink, stiff, slightly sandy silt with some angular to subangular fine to medium gravel **(Plate 7 to Plate 9**).

Inspection pit IP4 was excavated at the abandoned small terraces (for urns placement) located at the toe of the NTSA. 1.10m thick of colluvium was retrieved from IP4 and can be described as firm, dark brownish grey, sandy silt with many subangular fine to coarse gravel sized rock fragments. CDT below the colluvium can be described as extremely weak, light brown, mottled white, completely decomposed fine ash vitric Tuff which comprises stiff, sandy silt with some angular to subangular fine to medium gravel **(Plate 10)**.

In general, a thin veneer of open hillslope colluvium (<1.50m) blanketed the NTSA and overlying saprolitic materials. Detail of the logs for IP1 to IP5 was provided in **Appendix C**.

Based on the field mapping, no prominent boulders can be identified within the NTSA, this observation is consistent with the observation from the 1963 aerial photographs. General view of the upper, middle and lower portions of the NTSA are given in **Plate 11 to 13.**

5.2.3 Rock Exposures

No rock outcrop was identified within the NTSA.

5.2.4 Natural Terrain Landslides

During API stage, a total of 2 relict potential landslide scars (RL1 & RL2) were identified within the NTSA. Key features from API were targeted during mapping for field verification and the dimensions of these features were revised during field mapping. The relict landslide scars were not clearly defined due to overgrown shrub. The dimension of the relict landslide scars were measured by the discernible topographic depressions and break of slopes.

Relict landslide, RL1 (ENTLI No. 11SED0090E) was identified at about +171 mPD near the southern spur within the NTSA. RL1 appears to be a distinctive concave depression with a rounded scarp of discernable change of slopes **(Plate 14)**. Overall slope gradient at the landslide location is about 35°. No noticeable debris lobe can be recognised below the landslide scar, probably the landslide could be occurred for a long time ago and most of the landslide debris had been eroded leaving a shallow depression with depth of about 0.7m. The measured width and length of landslide source is about 11.7m and 8.7m respectively. The total estimated landslide source volume is approximately 37.3m^3. A thin layer of colluvium overlying completely to highly decomposed rock is prevalent at this area, the failure could probably due to the transient build-up of perched water table between the boundary of colluvium and the decomposed rock.

Another relict landslide (RL2) was registered as ENTLI record no. 11SED0091E which is located at about +186 mPD below the convex change of slope between the upper slope terrain and middle slope terrain **(Plate 15).** It appears to be a broad, subtle and shallow depression with a rounded scarp, probably older than the RL1. This failure probably part of the hillside retreat process. The estimated failure volume of RL2 is 31.4m^3 with measured width, length and depth of the landslide source as 10.6m^3, 11.3m^3 and 0.5m respectively.

A landslide inventory was developed for this NTSA. Details of the landslides verified during field mapping were summarised in **Table 5.1** below.

Table 5.1 Landslide Inventory for the NTSA Based on Field Mapping

Landslide Reference No.	ENTLI No.	Location	Recent / Relict	Year of Photo	Landslide Type	Estimated Width (m)	Estimated Source Length (m)	Estimated Depth (m)	Estimated Source Volume (m^3)
RL1	11SED0090E	Within NTSA	Relict	1963	Relict	11.7	8.7	0.7	37.3
RL2	11SED0091E	Within NTSA	Relict	1963	Relict	10.6	11.3	0.5	31.4

5.2.5 Drainage Line Characteristics

No perennial or ephemeral drainage line has been identified within the NTSA.

5.2.6 Erosion and sign of distress

No sign of erosion or distress have been identified within the NTSA.

5.2.7 Water Seepage

No water seepage could be observed within or in the vicinity of the NTSA.

5.2.8 Soil Pipes

No obvious soil pipe was identified within the NTSA during the field mapping.

5.2.9 Vegetation

The NTSA is well vegetated with ferns, shrubs, rattans and small trees.

5.2.10 Anthropogenic Features

The major anthropogenic activities within the NTSA include the formation of the Hong Kong Trail (Section 8) and the catchwater which are traversed across the upper and middle portions of the NTSA respectively. Man-made cut slope Feature No. 11SE-D/C356 was formed as a small the upper cut slope along the Hong Kong Trail (Section 8) (**Plate 16**). Another two man-made cut slopes Feature Nos. 11SE-D/CR351 and 11SE-D/CR350 are existed along the upslope adjoining the catchwater which lies at the middle level of the NTSA (**Plate 17** and **Plate 18**).

Minor anthropogenic features also include abandoned terraces located at the toe of the NTSA (**Plate 19**). The height of the terraces are generally less than 0.7m with rubble facings and about 1.2m wide within an overall hillslope gradient less than 25 degrees. The terraces were probably used for placement of urns in the 1980s (observed from aerial photographs) and left abandoned since the completion of the Hong Kong Buddhist Cemetery which was located at the western side adjacent to the Site in 1991. No obvious significant fill bodies and no sign of distress or failure can be discerned within and in the vicinity of the terraces both from aerial photographs and during field mapping. These small terraces are considered to have no significant impact to the proposed development.

6 ENGINEERING GEOLOGICAL/GEOMORPHOLOGICAL MODEL

6.1 General

Geomorphological and engineering geological models were formulated for the NTSA based on information obtained from the desk study, API, field mapping and current GIs. An Engineering Geological Model and Geomorphological model of the NTSA were developed and presented below:

6.2 Solid Geology

The solid geology within the NTSA was underlain by eutaxitic fine ash vitric Tuff (Krc_fvt) of Che Kwu Shan Formation under the Repulse Bay Volcanic Group formed in Early Cretaceous.

6.3 Superficial Geology

The 1:20,000 scale geological map sheet 11 indicated that no superficial deposit within the NTSA which implies the superficial deposits could be less than 2m. This interpretation is confirmed by the current findings from the inspection pit nos. IP2, IP3, IP4 and IP5 which show that a thin layer of colluvium (0.8m – 1.1m) blanketing most of the hillslopes within the NTSA. The colluvium typically comprises firm, dark brownish grey, sandy SILT with some subangular fine to coarse gravel sized rock fragments.

6.4 Hillside Catchment Classification

Following the guideline given in GEO Report No. 138 2nd Edition (GEO, 2016), the NTHS area can be classified into three types of catchment, including Channelised Catchment, Topographic Depression Catchment and Open Hillslope Catchment, according to the type of hazard defined by the failure mechanism and mobility of debris movement. The catchment classification of the NTSA is given below:

Based on the LIC 1:1000 scale topographic map, the site specific aerial photograph interpretation and site mapping, the NTSA is classified as Open Hillslope (OH) Catchment. It is generally planar without drainage concentration although there are two subtle depressions present at the middle level of the NTSA. Debris would not converge due to the absence of topographic confinement at the lower portion of the NTSA.

6.5 Geomorphological Model

6.5.1 General

To appreciate the geomorphological process within the NTSA, it is better to look at a wider picture within the Study Region. Terrain Units within the Study Region are divided into three main units developed based on the simplified land surface model (Dalrymple, et al., 1968) according to their geomorphological characteristics. The terrain units identified within the NTSA are described below and presented in **Figure 10**.

6.5.2 Upper Slope Terrain Unit

The upper slope terrain comprises the gentle slopes along the ridges and spurlines at the upper most portion of the NTSA and along the upper boundaries of the NTSA. The slope gradient is generally less than 20 degrees. The upper slope terrain appears to be the oldest terrain unit in the NTSA. The terrain comprises predominately residual and saprolitic soil. The predominant geomorphic processes are likely to be pedogenic process, eluviation and soil creeping. This terrain appears currently stable with no evidence of recent or relict slope instabilities identified.

6.5.3 Middle Slope Terrain Unit

The transportational Middle Slope Terrain Unit is present at about +120 mPD to +190 mPD at the middle and lower portions of the NTSA. This Terrain Unit is demarcated by the convex break of slope immediately below the Upper Slope Terrain Unit. General slope gradient within this terrain is 25-35°, locally about 40°. The Terrain mainly comprises completely decomposed eutaxitic fine ash vitric Tuff overlain by a thin layer of colluvium with thickness of less than 1.1m. Two relict landslide scars, RL1 and RL2 have been identified at the upper portion of this terrain and based on the site observations, they could have been occurred for a long period of time (over 100 years ago). The mass wasting process within this terrain is relatively infrequent and therefore this terrain is considered to be low to moderately susceptible to landslides.

6.5.4 Incising Terrain Unit

The comparatively young and active Incising Terrain is characterized by the presence of ephemeral or perennial drainage lines which formed relatively incised valley slopes by fluvial incision, retrogressive erosion and undercutting of the adjacent soil by surface water. The terrain units are largely covered with clast-supported valley colluvium overlying saprolite or bedrocks at the stream beds. Some relict landslide scars were identified from aerial photographs near the head of the drainage lines in the study region. The mass wasting process within this terrain is relatively frequent than the Middle Slope Terrain Unit and the terrain is considered to be moderately susceptible to landslides. However, the current NTSA does not contain this Incising Terrain Unit.

7 HAZARD ASSESSMENT

7.1 General

Design Event Approach is adopted to assess the natural hazard based on the five generic hazard models defined in **GEO Report No. 138 2nd Edition** (GEO, 2016) as follows: open hillslope landslide, channelized debris flow, deep-seated landslide, rockfall / slide and boulder fall.

Based on the findings from detailed desk study, GI and Field work as well as the geological and geomorphological model established in section 6, hazard assessment with respect to the five generic hazard models are discussed below.

7.2 Hazard Identification

7.2.1 Open Hillslope Landslide (OHL)

The NTSA comprises stable upper slope terrain and transportational middle slope terrain. The upper slope terrain is considered to be of very low susceptible to landslide as the slope gradient generally less than 25° and has no evidence of landslide. Mass wasting process within these terrain units are observed to be inactive, with no signs of erosions or past instability. Therefore, open hillslope landslide is not envisaged in the upper slope terrain.

The NTSA also contain transportational middle slope terrain. The middle slope terrain lies between +120 mPD and +190 mPD where slope gradients range between 25-35°. Although, there is no significant water concentrate towards the NTSA, evidence of previous landslides are discerned on the relatively steeper hillslopes within the transportational middle slope terrain. Failure mechanism of the landslides are likely due to the development of transient perched water table at the interfaces between hillslope colluvium and decomposed rock materials during prolong of heavy rainfall. OHL is considered a viable hazard within the middle slope terrain unit. The potential landslide area within the NTSA is shown in the natural terrain hazard map (**Figure 11**).

7.2.2 Channelised Debris Flow (CDF)

As there is no perennial or ephemeral natural drainage line within the NTSA, therefore it is considered that CDF is a not viable hazard model within the NTSA.

7.2.3 Deep-seated Landslide

Deep-seated, intact sliding is not common in Hong Kong and in some cases the displaced material has not moved from the source area (slump) or where tension cracks and bulging are the sole surface expression of movement (Irfan, 1989; Ho & Evans, 1993). Based on the existing GI information and the field mapping results, neither tension cracks, surface bulging nor persistent thick layers of kaolin/weak seam within saprolite have been identified within the NTSA that could indicate the potential for deep-seated landslides. There is no clear evidence from historical records that suggests a deep-seated landslide could have occurred, or is likely to occur, within the NTSA. Therefore, the susceptibility for deep-seated landslide occurring within the NTSA is considered to be low.

7.2.4 Rock Fall

No rock outcrops are presences within the NTSA, therefore RF is not considered a viable hazard within the NTSA.

7.2.5 Boulder Fall

According to GEO Report No. 138 (2nd Edition), boulder fall is considered as significant risk if there is ‘presence of potentially unstable boulders, as evidenced by known signs of potential boulder falls from API or field inspection. Based on the site-specific API and field mapping, no prominent boulders was identified within the NTSA. No boulder fall incident has been recorded within or in the vicinity of the NTSA, therefore boulder fall is not considered a natural terrain hazard for this NTSA.

7.2.6 Hillside Pocket Type Setting

Although the NTSA does not fall into any hillside pocket boundary, ground information associated with hillside pocket type setting has been collected from aerial photographs and field mapping which revealed no fill body presence within the NTSA. Therefore, it is considered that the NTSA is not associated with landslide hazard with respect to the Hillside Pocket setting.

7.3 Design Event

According to GEO Report No. 138 2nd Edition (GEO, 2016), a design event should refer to the magnitude of the hazard type selected for mitigation and requires the understanding of the geological and geomorphological model and the consideration of historical landslide records.

7.3.1 Landslide Susceptibility

The landslide susceptibility of the NTSA has been reviewed to aid the derivation of the design event magnitude. This was based on the geological and geomorphological model as well as the landslide history of the NTSA. Details of the landslide susceptibility of each terrain unit are discussed in Table 7.1 below:

Table 7.1 Summary of Hazard Types and Landslide Susceptibility

Hazard Type	Terrain Unit Present Within NTSA	Description of Hazard and the Landslide Susceptibility

Hazard Type	Terrain Unit Present Within NTSA	Description of Hazard and the Landslide Susceptibility
OHL	Upper Slope Terrain	The terrain comprises mainly residual and saprolitic soil. The predominant geomorphic processes are likely to be pedogenic process, eluviation and soil creeping. This terrain appears currently stable with no evidence of recent or relict slope instabilities identified and therefore considered to have very low susceptibility to open hillslope failure.
OHL	Middle Slope Terrain	General slope gradient within this terrain is 25-35°, locally about 40°. The terrain is generally covered with less than 1.10m thick colluvium overlying completely decomposed fine ash vitric Tuff. The geomorphic process within this terrain unit could be by mass wasting process in the form of shallow debris slides. Evidence of two relict landslide scars, RL1 and RL2 were identified during the field mapping in the middle slope terrain. The landslides were probably due to the transient build-up of perched water table between the saprolite and hillslope colluvium during prolonged heavy rainfall. No significant water concentration is connected to the NTSA. Neither perennial nor ephemeral drainage line presents within this terrain. Therefore, the terrain is considered to be moderately susceptible to open hillslope landslides.

7.3.2 Design Event Requirement

According to the latest guideline given in GEO Report No. 138 2nd Edition (GEO, 2016), the design event principle is aimed at dealing with a realistic estimation of credible failure volume (e.g. Based on recent landslides as well as relict landslides with a high degree of certainty) that may be encountered during the design life of the affected facilities. A combination of desk study, API and detailed field mapping should provide basis for developing a realistic geological/geomorphological model of the NTSA by defining the magnitude of the design event.

Based on the detailed review on the above factors, as the Middle Slope Terrain unit present within the NTSA is moderately susceptible to landslide. The Design Event Requirement for the NTSA is summarized in **Table 7.2** below.

Table 7.2 Design event Requirement for the NTSA

Hazard	Terrain Unit	Landslide History and Geomorphological Setting	Design Event Requirement
OHL	Upper Slope Terrain	• No evidence of relict and recent landslide almost in the past 100 year • Slope gradient generally lies below 20° • Predominantly covered with insitu saprolitic soil • Convex landform (spurs) without water concentration	Not required
OHL	Middle Slope Terrain	• Mainly open planar hillslopes • Slope gradient generally lies between 25-35°, locally 40° • No ephemeral or perennial drainage line present within the NTSA • Moderately susceptible to landslide • Taking account to degraded relict landslides RL1 (37.3m^3) and RL2 (31.4m^3) probably occurred over 100 years ago • Thin colluvium cover (<1.10m)	40m^3

Based on the assessment of the design event requirements of middle slope terrain units within the NTSA, adoption of 40m^3 as a credible design event for the NTSA is considered appropriate. The potential landslide source area within the NTSA is shown in the natural terrain hazard map (**Figure 11**).

7.3.3 Debris Mobility Modelling

A notional landslide source volume of 40m^3 is adopted as the source volume from the NTSA for the debris mobility modelling. The assumed landslide source volume is made reference to the relict landslides RL1 and RL2.

In order to estimate the run out distance for debris flow within the NTSA, dynamic debris mobility modelling has been carried out using the programme 'DAN/W'. The input parameters and results of this modelling are discussed below and presented in **Appendix D**.

Potential landslide events have been modelled by adopting the Friction Rheology Model for Open Hillslope Landslide. The result of the debris mobility modelling is summarized in **Table 7.3** below:

Table 7.3 Summary of Debris Mobility Modelling Results

Terrain Unit	Runout Path No.	Modelled Source Volume (m^3)	Analytical Model	Apparent Friction Angle, φ_a	Travel Distance (m)	Landslide Debris Reaching the Site	Max. Debris velocity at the Site Boundary
Middle slope	RP1 (Case 1)	40.62	Friction	25° (OHL)	30.97	No	-
	RP1 (Case 2) (Below Catchwater)	40.47	Friction	25° (OHL)	63.74	Yes	3.90
	RP2 (Case 1)	40.47	Friction	25° (OHL)	57.18	No	-
	RP2 (Case 2) (Below Catchwater)	40.61	Friction	25° (OHL)	66.13	Yes	5.40

The result indicated that the debris on credible flow paths RP1 (Case 1) and RP2 (Case 1) would not reach the Site boundary, but Case 2 for both credible flow paths RP1 and RP2 modelled below the Catchwater will reach the Site boundary although most of the debris will deposit at the lower portion of the NTSA. Debris of the RP1 (Case 2) could reach the Site boundary at a maximum velocity of 3.90 m/s whilst debris of the RP2 (Case 2) could reach the Site boundary at a maximum velocity of 5.40 m/s.

8 HAZARD MITIGATION STRATEGY

8.1 Requirement of Mitigation Action

Following the review of the landslide hazards on the NTSA, debris mobility model for the NTSA have been simulated to assess whether a failure volume of 40m³ from the NTSA could pose hazard to the Site. The results revealed that the debris for Cases on both critical flow paths RP1 and RP2 at the upper portion of the NTSA will not reach the site boundary. However, debris for both cases on the flow paths RP1 and RP2 below the Catchwater will reach the Site boundary. Therefore, mitigation measure is considered necessary. To mitigate the landslide hazards, erection of a rigid debris-resisting barrier at the toe of the NTSA is recommended. It will be more cost-effective to integrate the debris-resisting barrier with the ELS/Site formation designs. An elevated retaining walls/bored-pile walls can be acted as a debris-resisting barrier. The detailed design of the mitigation measures will be under separate submission in the later stage, i.e. site formation design. The location of the recommended rigid debris barrier is illustrated in **Figure 12**.

9 CONCLUSIONS

A natural terrain hazard assessment was carried out based on guidelines given in GEO Report No.138 2nd edition (GEO, 2016), by reviewing the topography, geomorphology, landslide susceptibility and landslide history of the NTSA. Results of the assessment showed that there is potential OHL hazard from the NTSA.

Debris mobility modelling has been carried out to simulate the potential design event of $40m^3$. The results revealed that the debris will reach the Site boundary. Following the result from the assessment, mitigation works for the potential natural terrain hazard is considered necessary for the proposed development. A rigid debris-resisting barrier integrated with the ELS/Site Formation designs is recommended to be constructed along the toe of the NTSA.

10 REFERENCES

Dalrymple, J.B., Blong, R.J. and Conacher, A.J. (1968). A Hypothetical Nine-Unit Land Surface Nodel, Zeiscrift fur Geomorphologie, Vol. 12, pp. 60-76.

Geotechnical Engineering Office (2016). Guidelines for Natural Terrain Hazard Studies. Geotechnical Engineering Office, Hong Kong. GEO Report No. 138 2nd Edition.

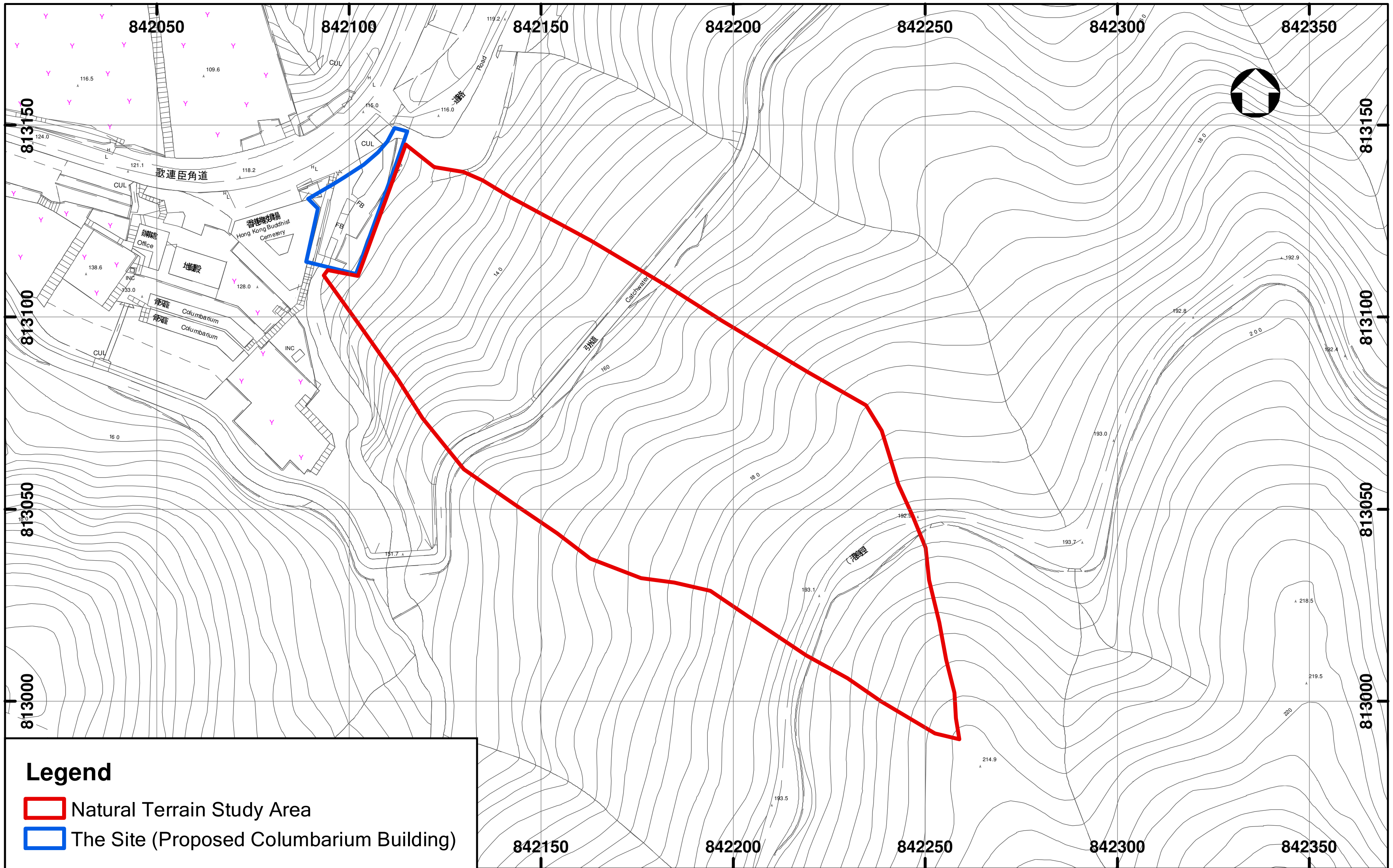
Geotechnical Engineering Office (1987). Geotechnical Area Studies Programme – Hong Kong and Kowloon. Geotechnical Control Office, Hong Kong, GASP Report No. I (Edition II).

Geotechnical Engineering Office (2004). Technical Guidance Note 22: Guidelines on Geomorphological Mapping for Natural Terrain Hazard Studies. Geotechnical Engineering Office, Hong Kong.

King, J.P. (1999). Natural Terrain Landslide Study. The Natural Terrain Landslide Inventory. GEO Report No. 74, Geotechnical Engineering Office, Hong Kong.

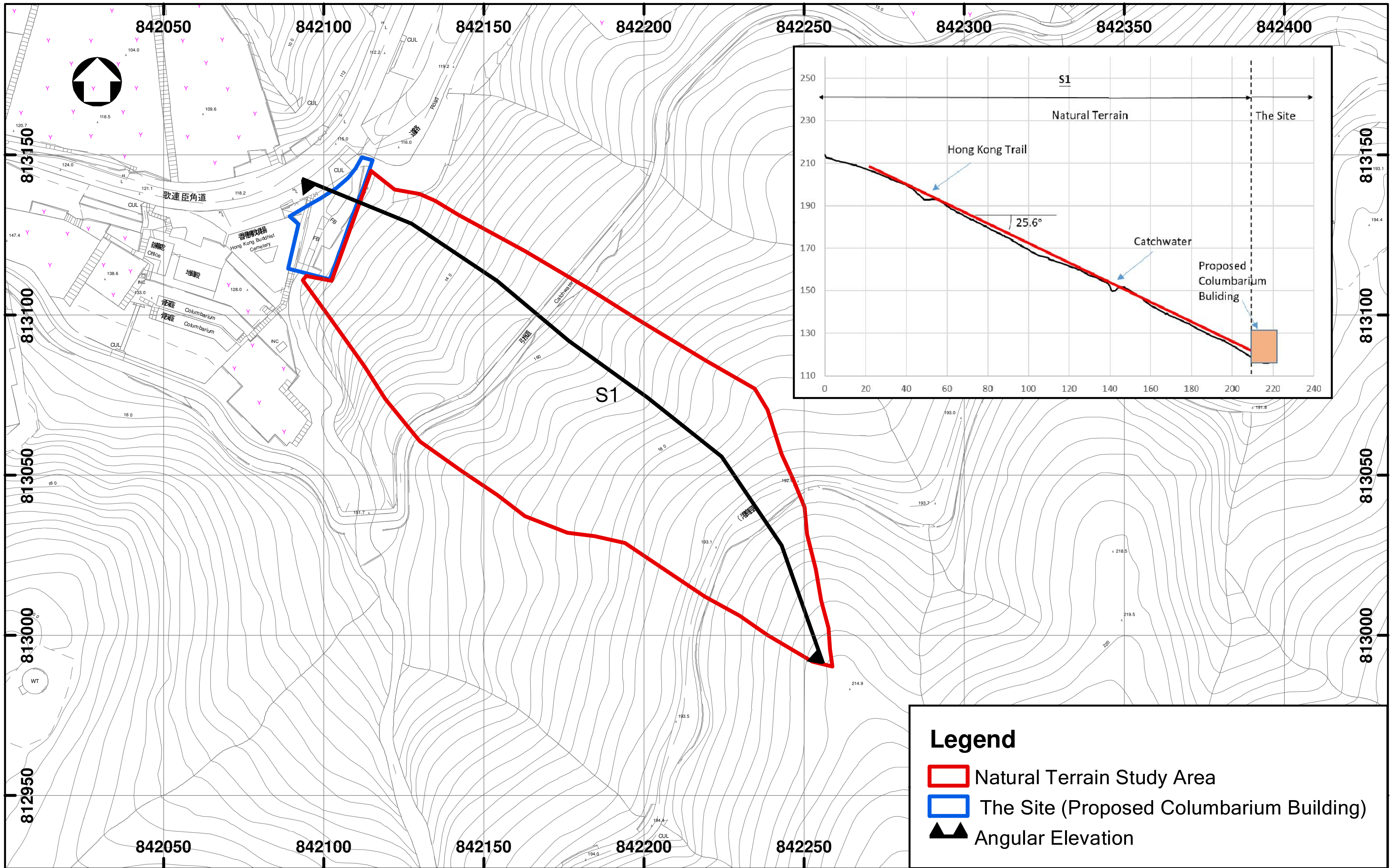
Savigear, R.A.G. (1965). A technique of morphological mapping, Annals of the Association of American geographers, Vol 53, p514-538.

LIST OF FIGURES



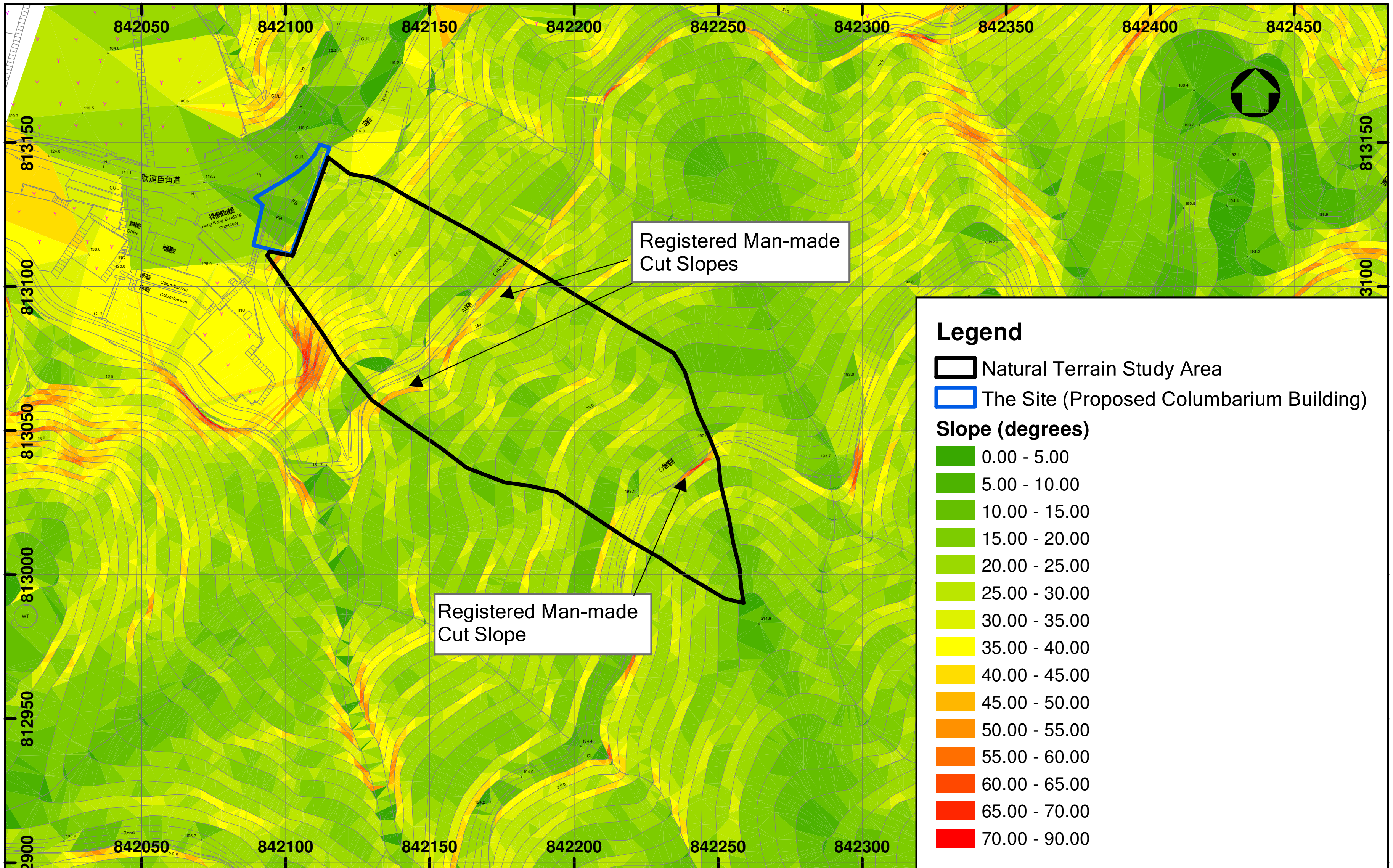
PROJECT:	**Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan**

TITLE: **Location Plan of the Site and Natural Terrain Study Area**	**SCALE:** **1 : 1500**	**Philip So & Associates Limited** In associaton with CALVINT GEO-SERVICES LIMITED	**FIGURE NO :** **FIGURE 1**



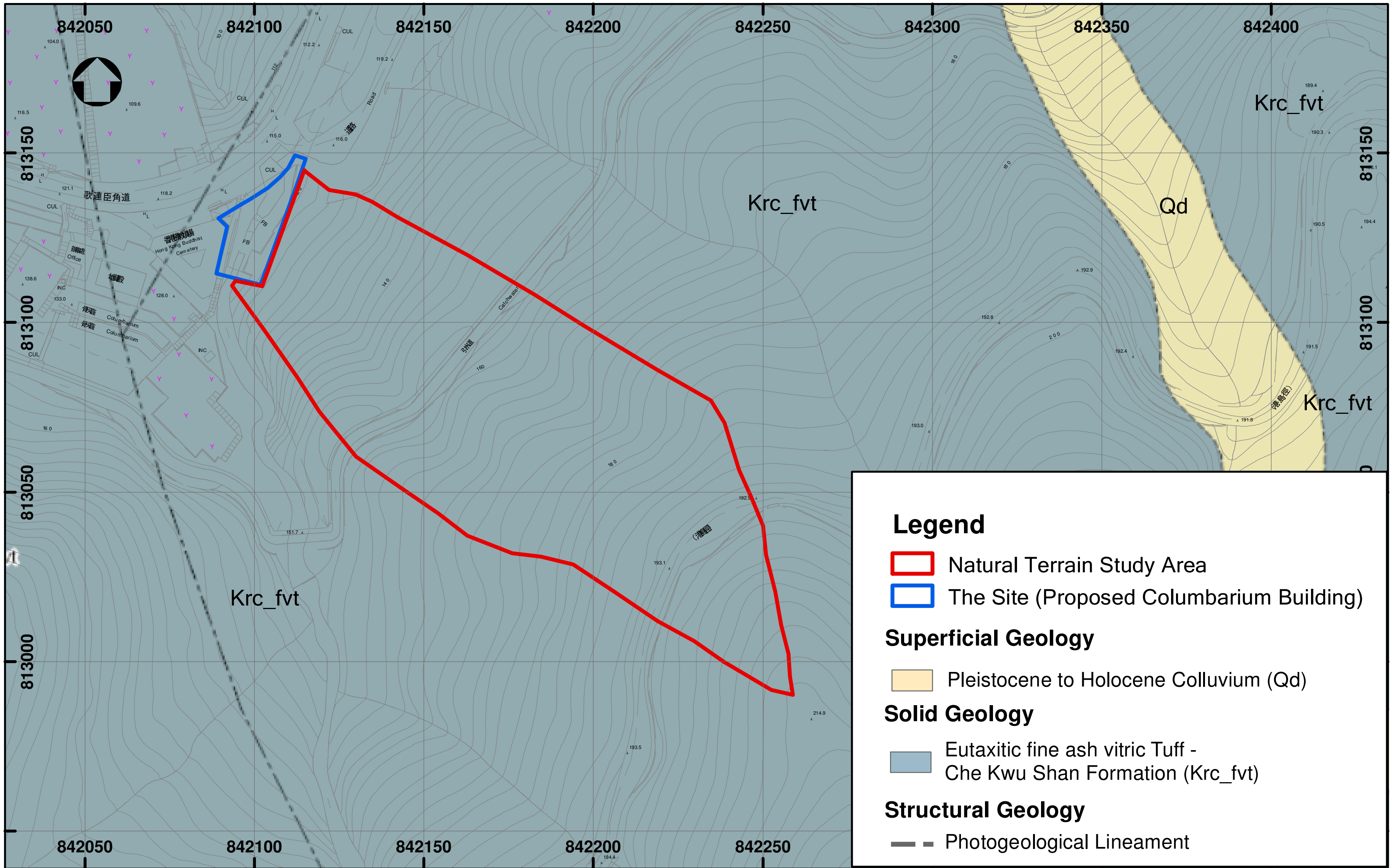
PROJECT: Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan

TITLE: Angular Elevation	**SCALE:** 1 : 1800	**Philip So & Associates Limited** In associaton with Calvint Geo-Services Limited	**FIGURE NO :** FIGURE 2



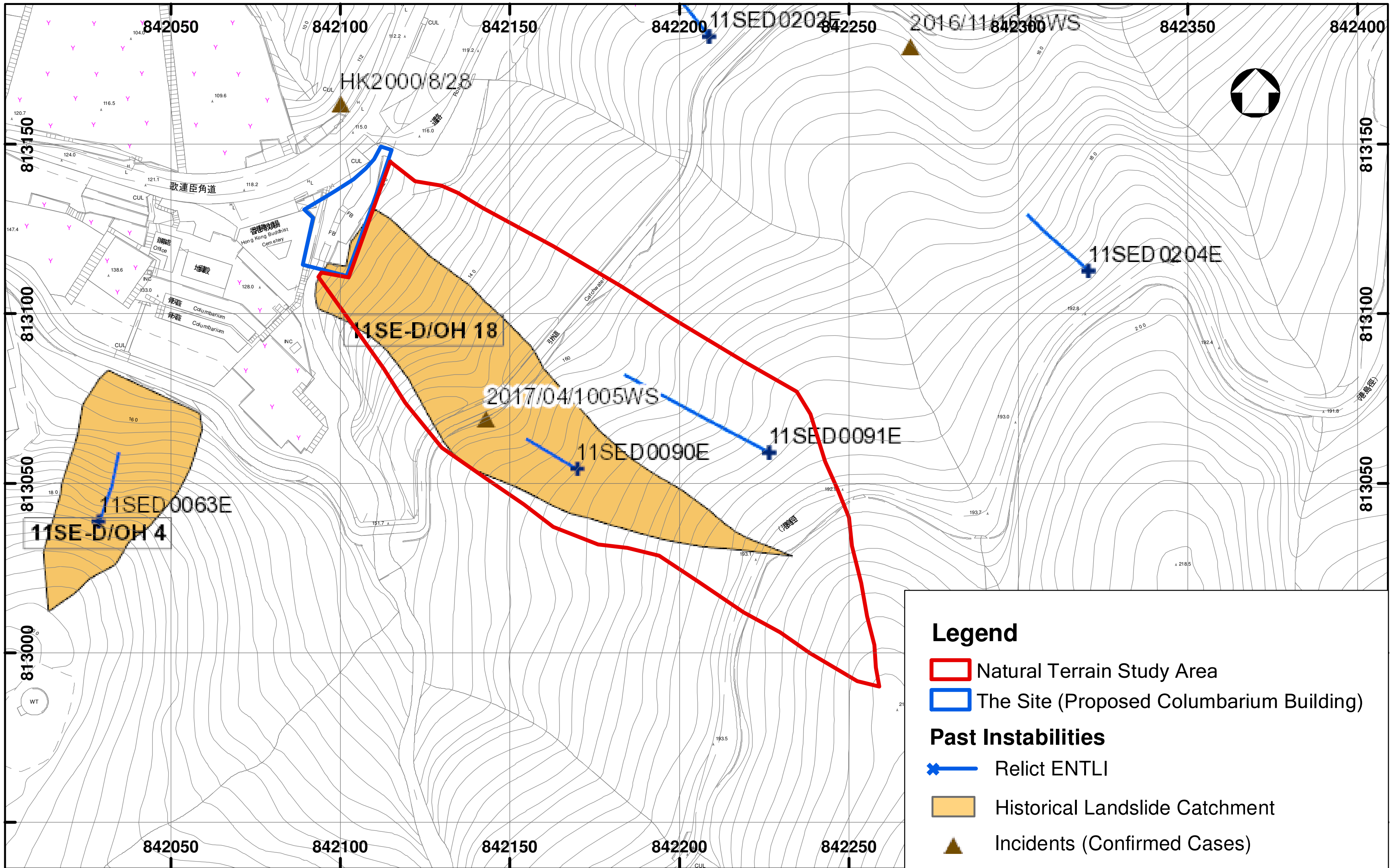
PROJECT:	**Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan**

TITLE: Slope Angle Map	**SCALE:** **1 : 2000**	**Philip So & Associates Limited** In associaton with Calvint Geo-Services Limited	**FIGURE NO :** **FIGURE 3**

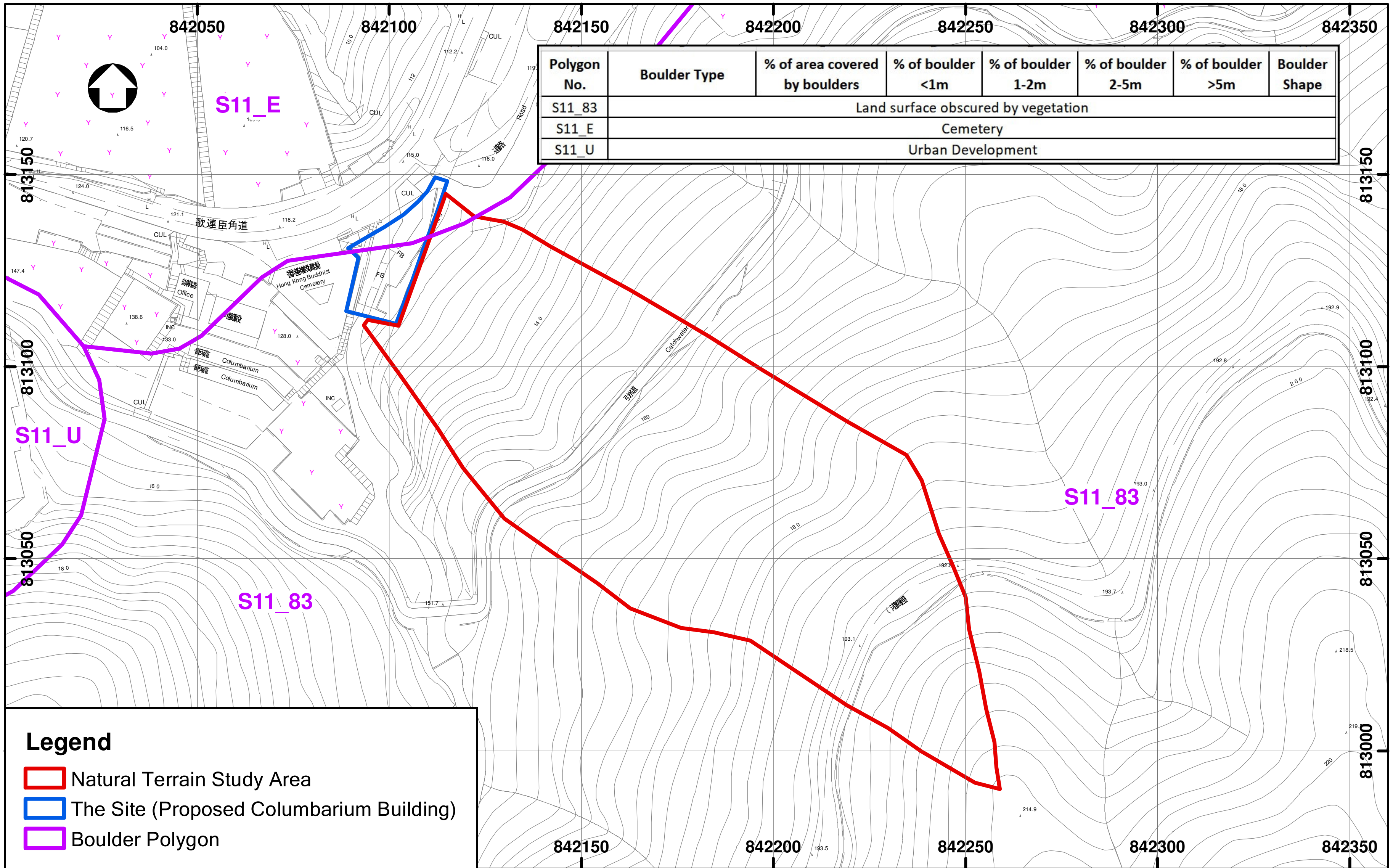


PROJECT:	**Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan**

TITLE: **Geological Map**	**SCALE:** **1 : 1700**	**Philip So & Associates Limited** In associaton with Calvint Geo-Services Limited	**FIGURE NO :** **FIGURE 4**



PROJECT:	**Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan**		
TITLE: **Recorded Past Instabilities**	**SCALE:** **1 : 1700**	**Philip So & Associates Limited** In associaton with CALVINT GEO-SERVICES LIMITED	**FIGURE NO :** **FIGURE 5**



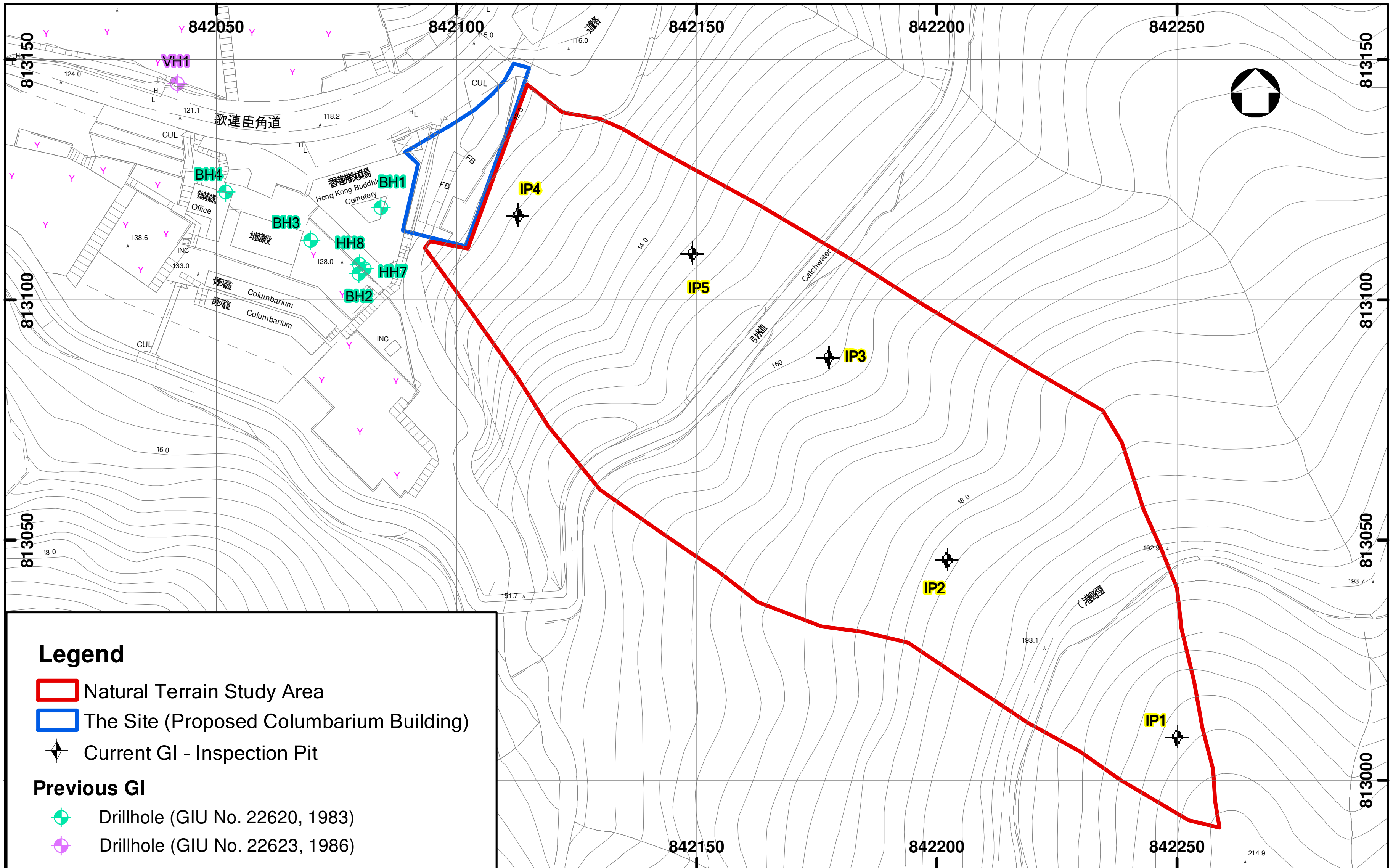
Polygon No.	Boulder Type	% of area covered by boulders	% of boulder <1m	% of boulder 1-2m	% of boulder 2-5m	% of boulder >5m	Boulder Shape
S11_83	Land surface obscured by vegetation						
S11_E	Cemetery						
S11_U	Urban Development						

Legend

- Natural Terrain Study Area
- The Site (Proposed Columbarium Building)
- Boulder Polygon

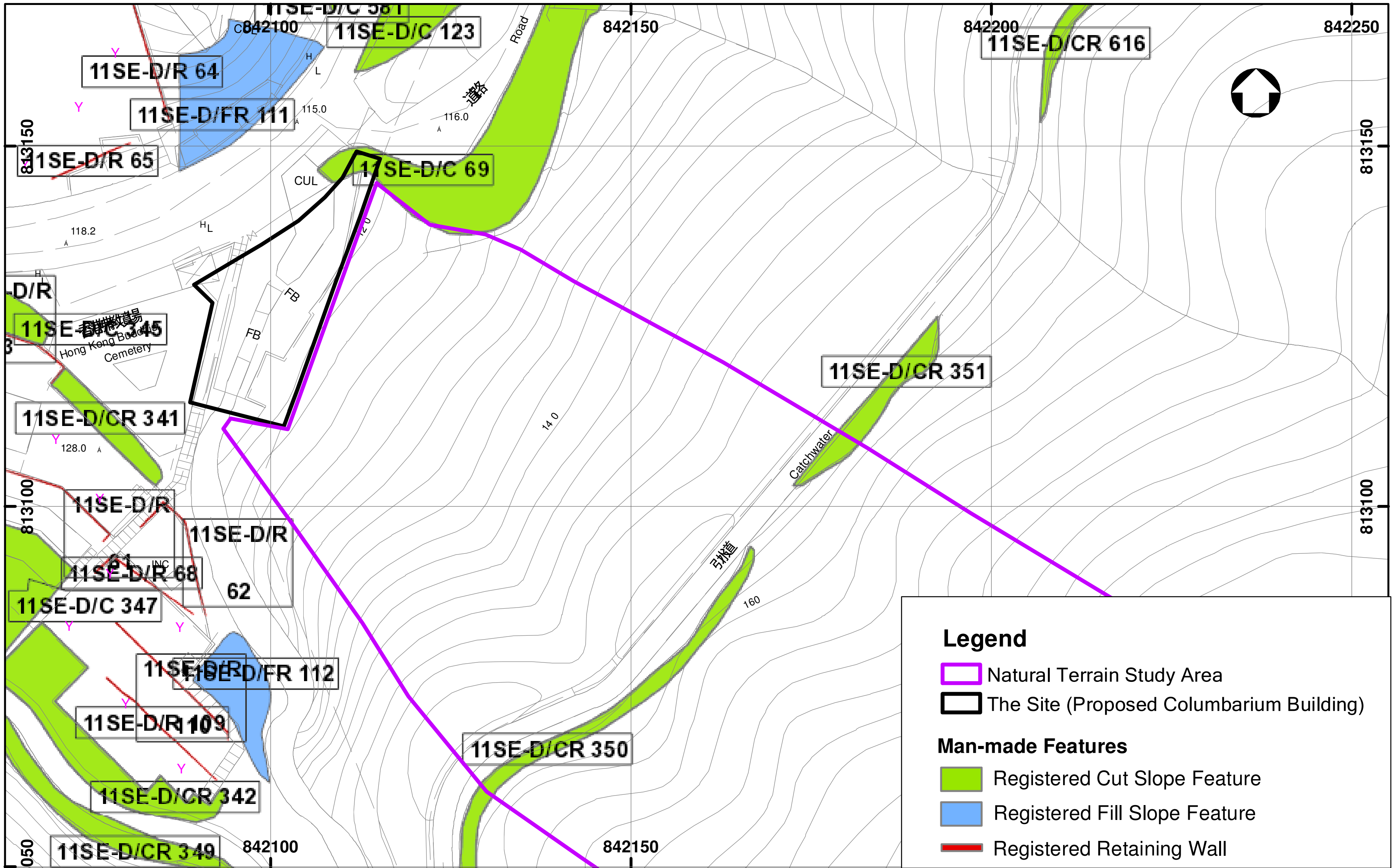
PROJECT: Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan

TITLE: Boulder Inventory	**SCALE:** 1 : 1500	**Philip So & Associates Limited** In associaton with Calvint Geo-Services Limited	**FIGURE NO :** FIGURE 6



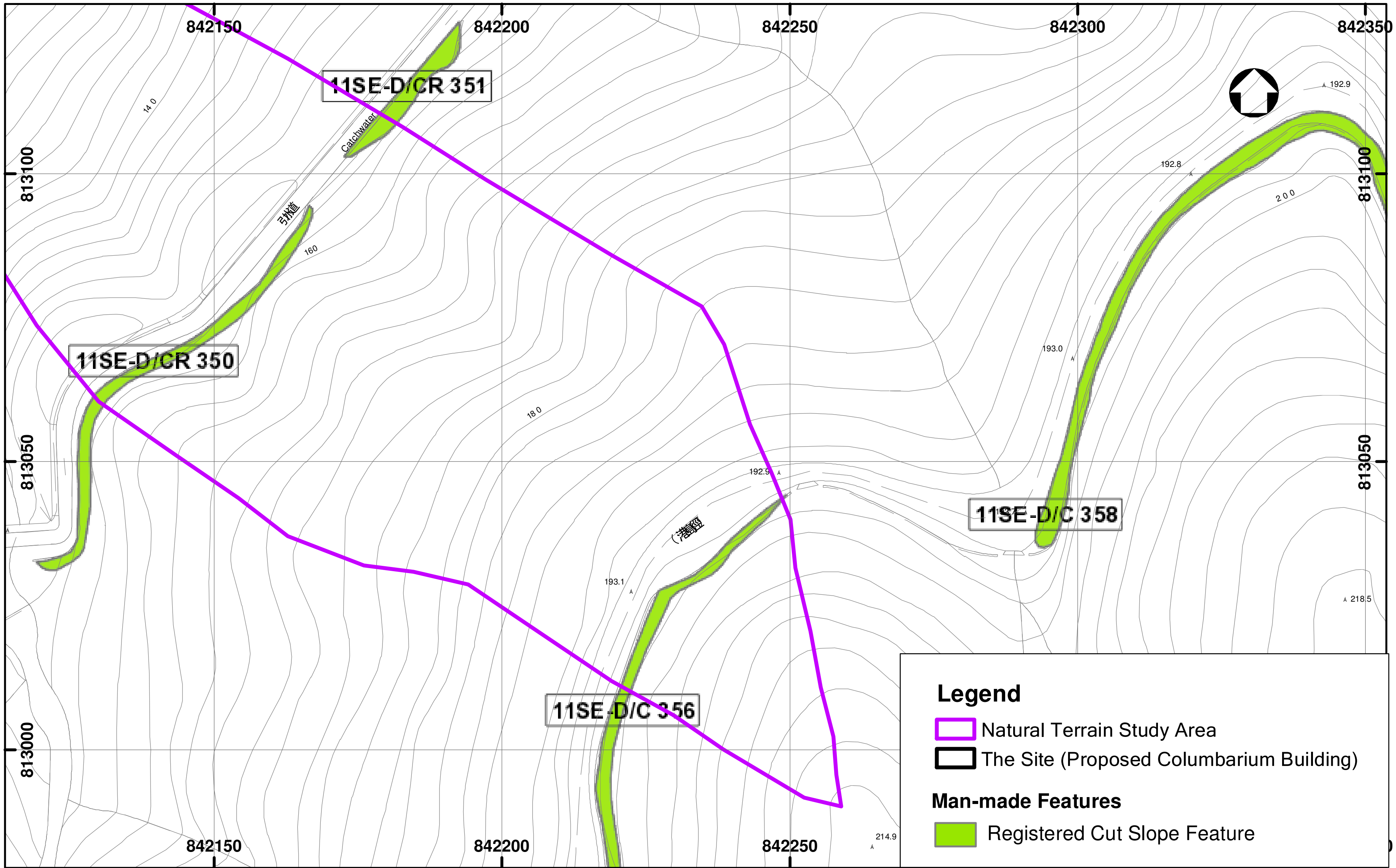
PROJECT: Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan

TITLE: Location Plan of Ground Investigations	**SCALE:** 1 : 1200	**Philip So & Associates Limited** In associaton with Calvint Geo-Services Limited	**FIGURE NO :** FIGURE 7



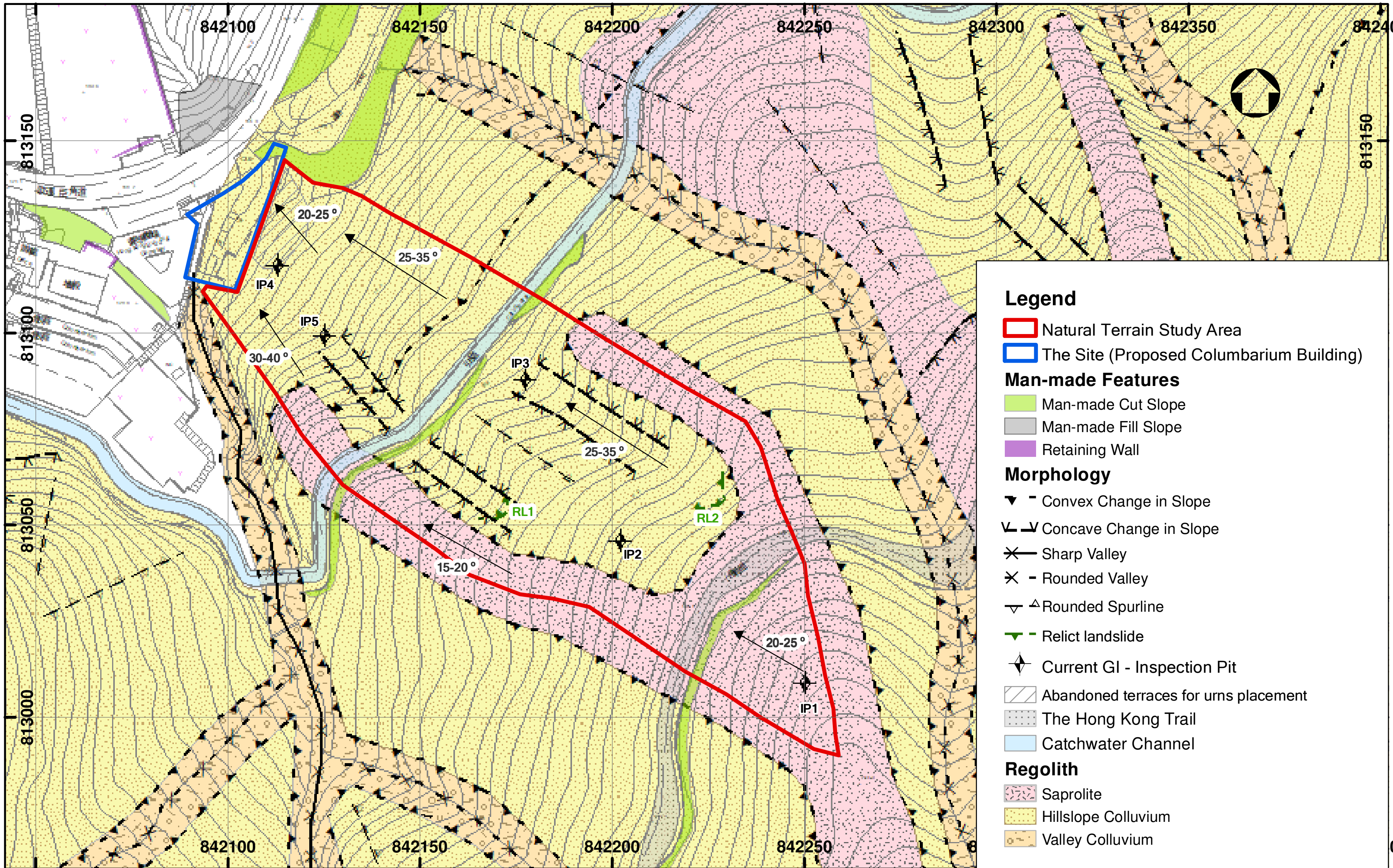
PROJECT: Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan

TITLE: Registered Man-made Features (Lower Portion)	**SCALE:** 1 : 800	**Philip So & Associates Limited** In associaton with Calvint Geo-Services Limited	**FIGURE NO :** FIGURE 8.1



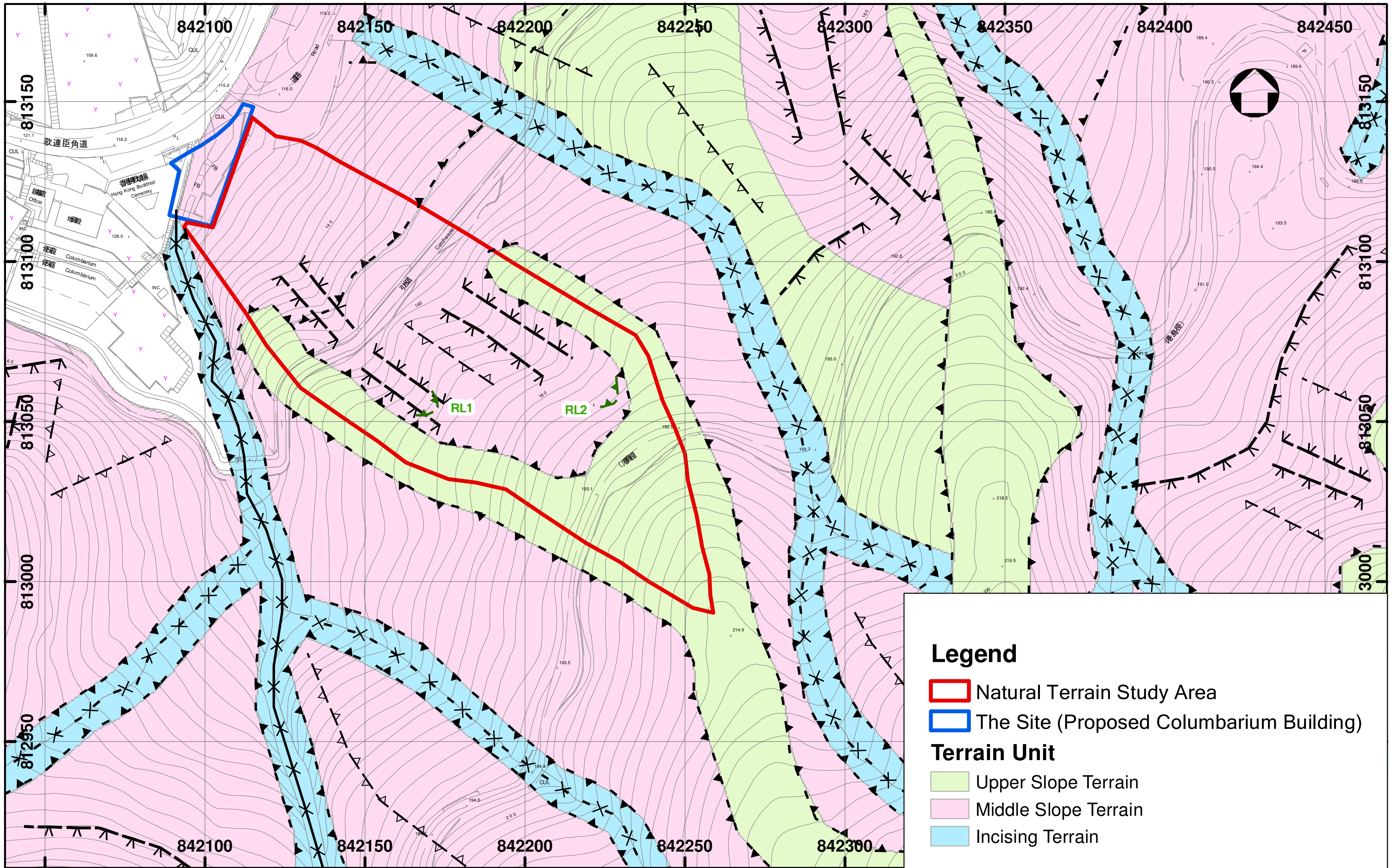
PROJECT: Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan

TITLE: Registered Man-made Features (Upper Portion)	**SCALE:** 1 : 1000	**Philip So & Associates Limited** In associaton with CALVINT GEO-SERVICES LIMITED	**FIGURE NO :** **FIGURE 8.2**



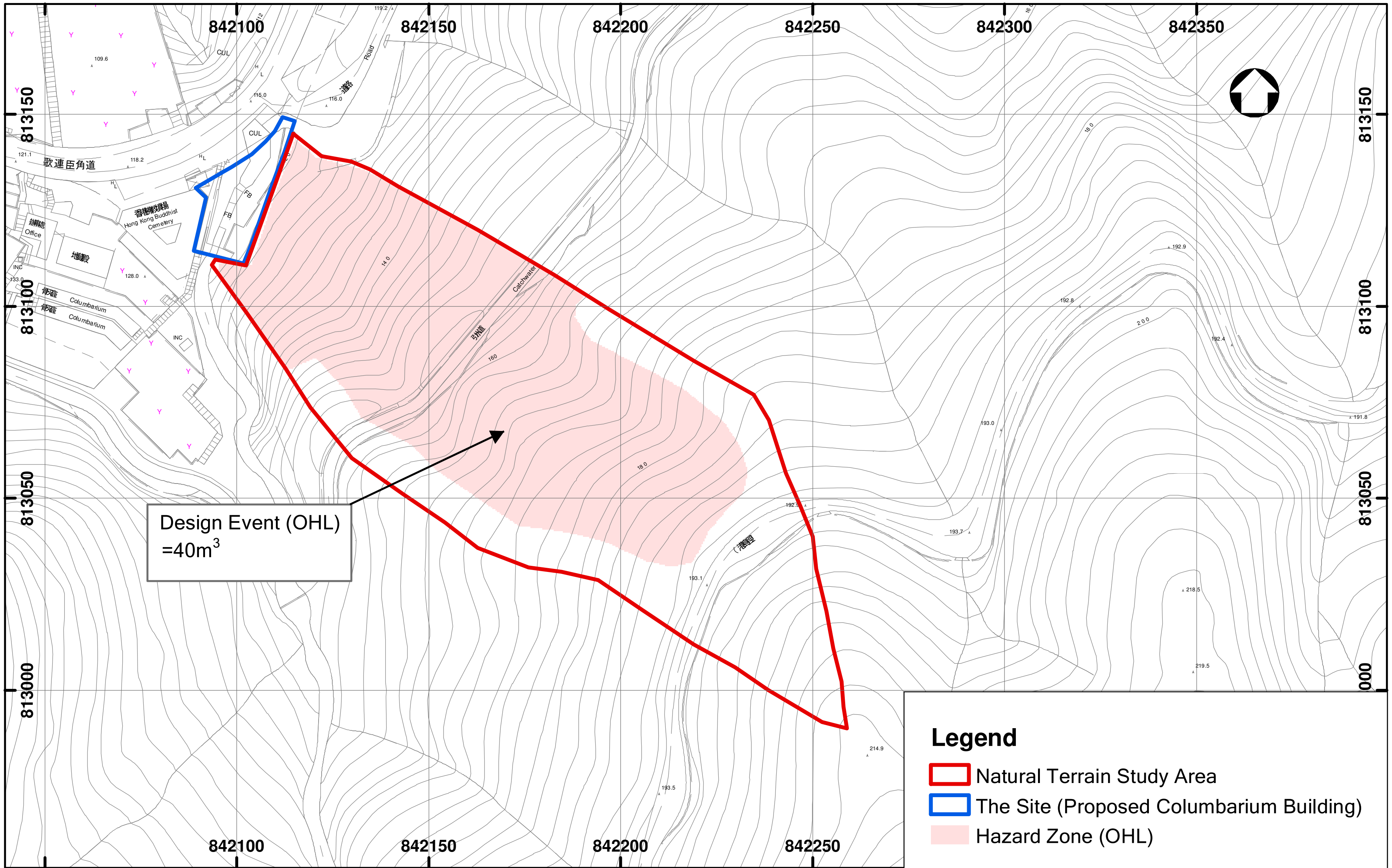
PROJECT: Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan

TITLE: Engineering Geomorphological Map	**SCALE:** 1 : 1500	**Philip So & Associates Limited** In associaton with CALVINT GEO-SERVICES LIMITED	**FIGURE NO :** FIGURE 9



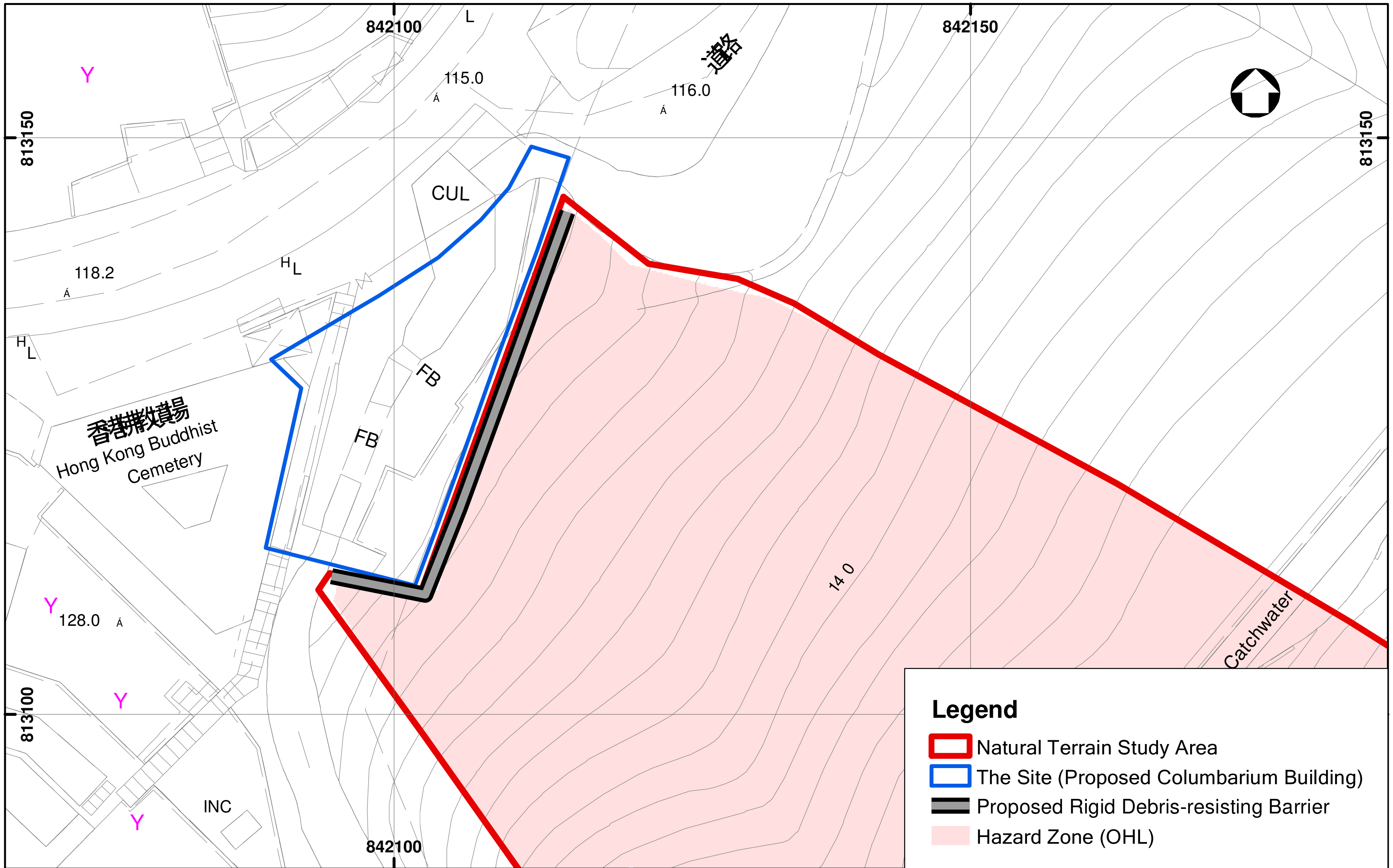
PROJECT: Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan

TITLE: Terrain Unit Map	**SCALE:** 1 : 1800	**Philip So & Associates Limited** In associaton with Calvint Geo-Services Limited	**FIGURE NO :** FIGURE 10



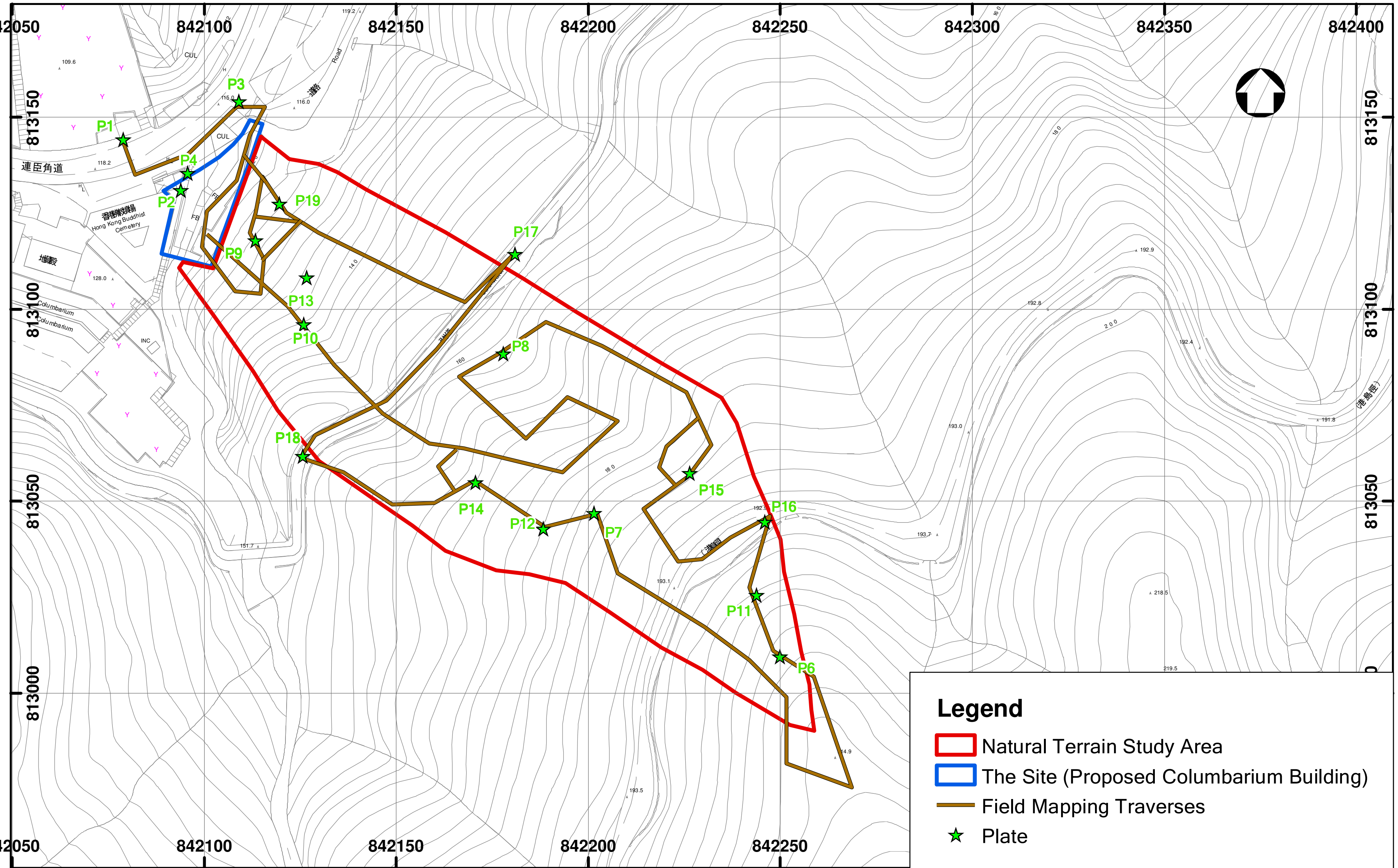
PROJECT: Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan

TITLE: Natural Terrain Hazard Map	SCALE: 1 : 1500	Philip So & Associates Limited In associaton with Calvint Geo-Services Limited	FIGURE NO : FIGURE 11



PROJECT: Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan

TITLE: Natural Terrain Hazard Mitigation Measures	**SCALE:** 1 : 500	**Philip So & Associates Limited** In associaton with Calvint Geo-Services Limited	**FIGURE NO :** FIGURE 12



PROJECT:	**Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan**

TITLE: **Field Mapping Traverses**	**SCALE:** **1 : 1500**	**Philip So & Associates Limited** In associaton with CALVINT GEO-SERVICES LIMITED	**FIGURE NO :** **FIGURE 13**

LIST OF PLATES

Plate 17 Catchwater and man-made cut slope Feature No. 11SE-D/CR351 located at the middle level of the NTSA

Plate 18 Catchwater and man-made cut slope Feature No. 11SE-D/CR350 located at the middle level within the NTSA

Plate 19 Abandoned small terraces (probably for urns placement during 1980s) near the northern toe of the NTSA

r

Plate 1 General View of the Natural Terrain Hazard Study Area (NTSA) overlooking the Site

Plate 2 Close up view of the Southern Portion of the Site (looking south)

Plate 3 Close up view of the Northern Portion of the Site (looking west)

Plate 4 Close up view of the Northern Portion of the Site (looking east)

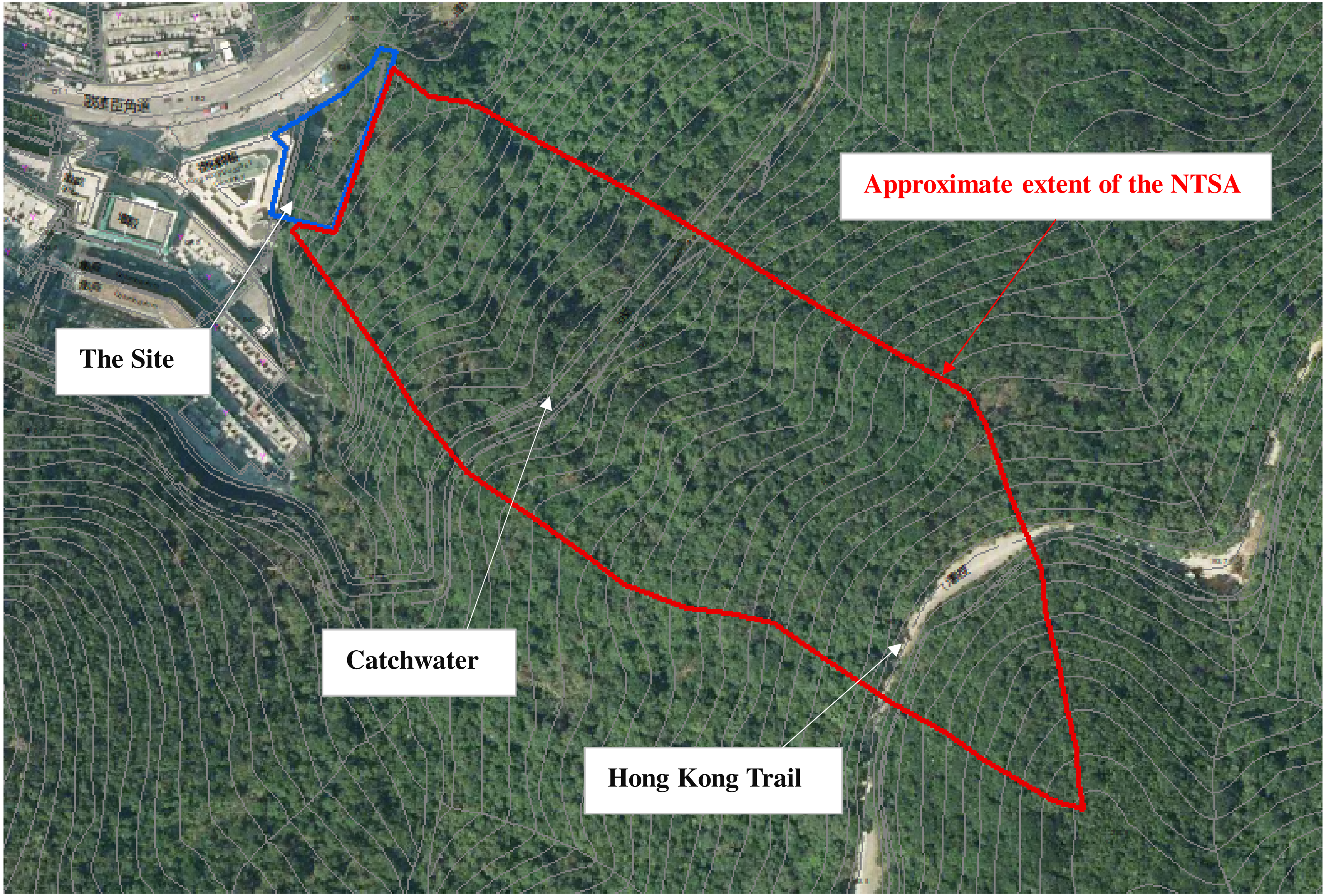
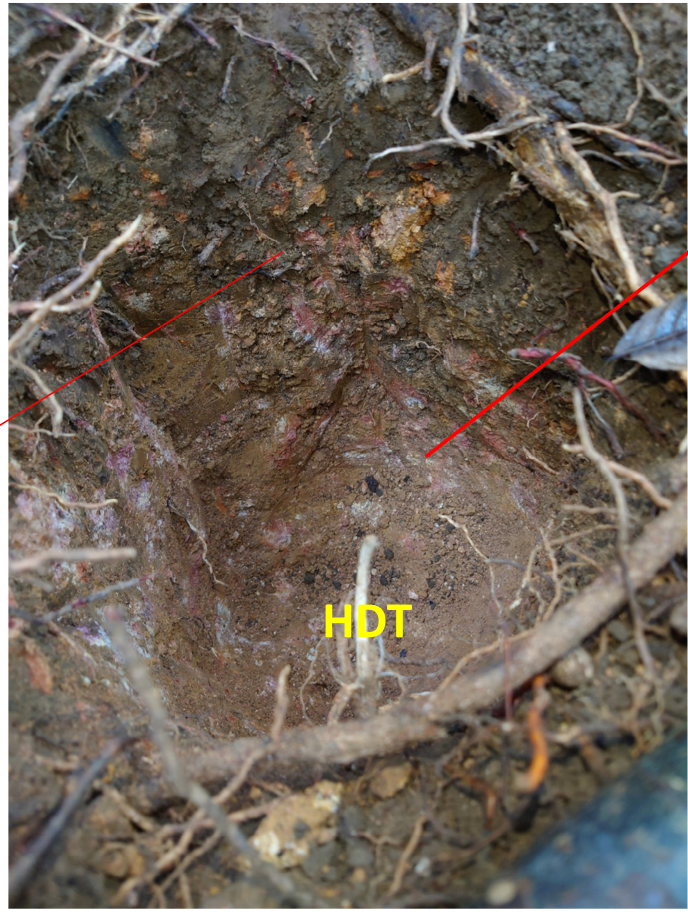


Plate 5 Aerial View of the NTSA and the Site

0.1m thick top soil (TS) overlying completely decomposed fine ash vitric TUFF (CDT). CDT encountered at 0.1m BGL and can be described as extremely weak, reddish brown, mottled white, pink and orange, completely decomposed fine ash vitric TUFF which comprises stiff, sandy SILT with many angular fine to medium gravel.

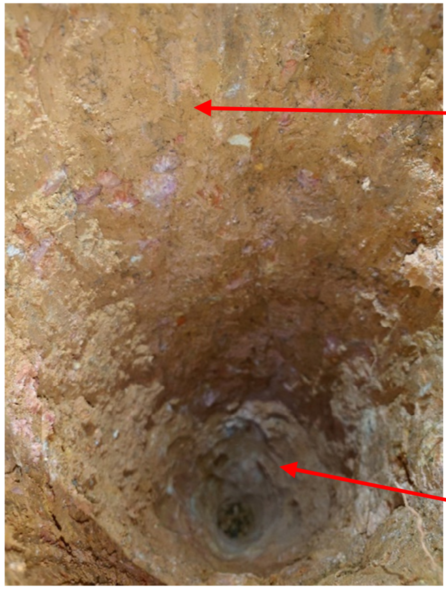
IP1 at the upper spur of the NTSA

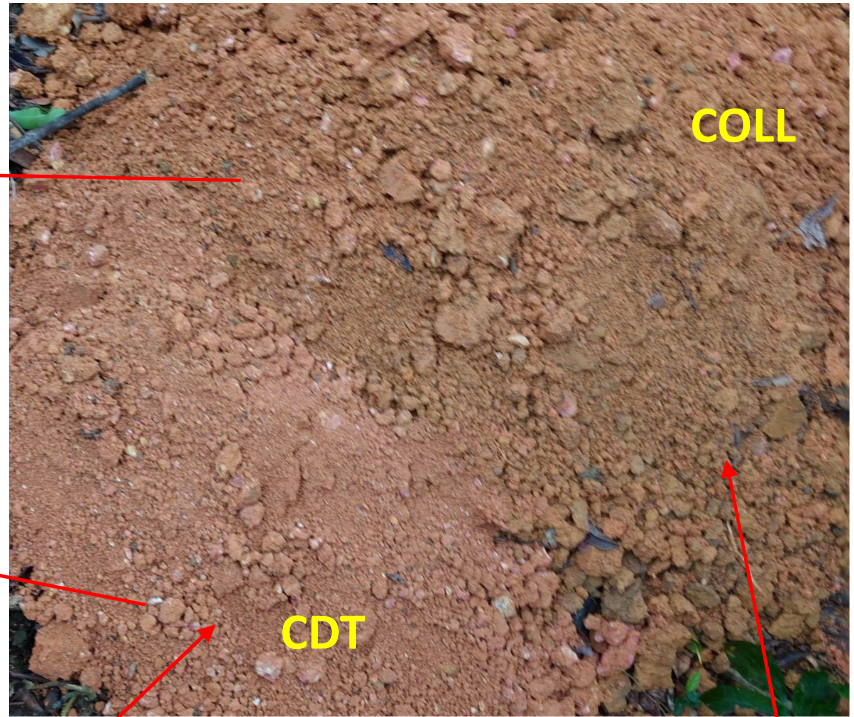


HDT encountered at 1.10m below ground of IP1 which can be described as weak, brown, mottled white and pink, highly to moderately decomposed fine ash vitric TUFF.

Plate 6 Saprolitic soil cover the spurs of the NTSA (IP1)

IP2 at the upper portion of the NTSA

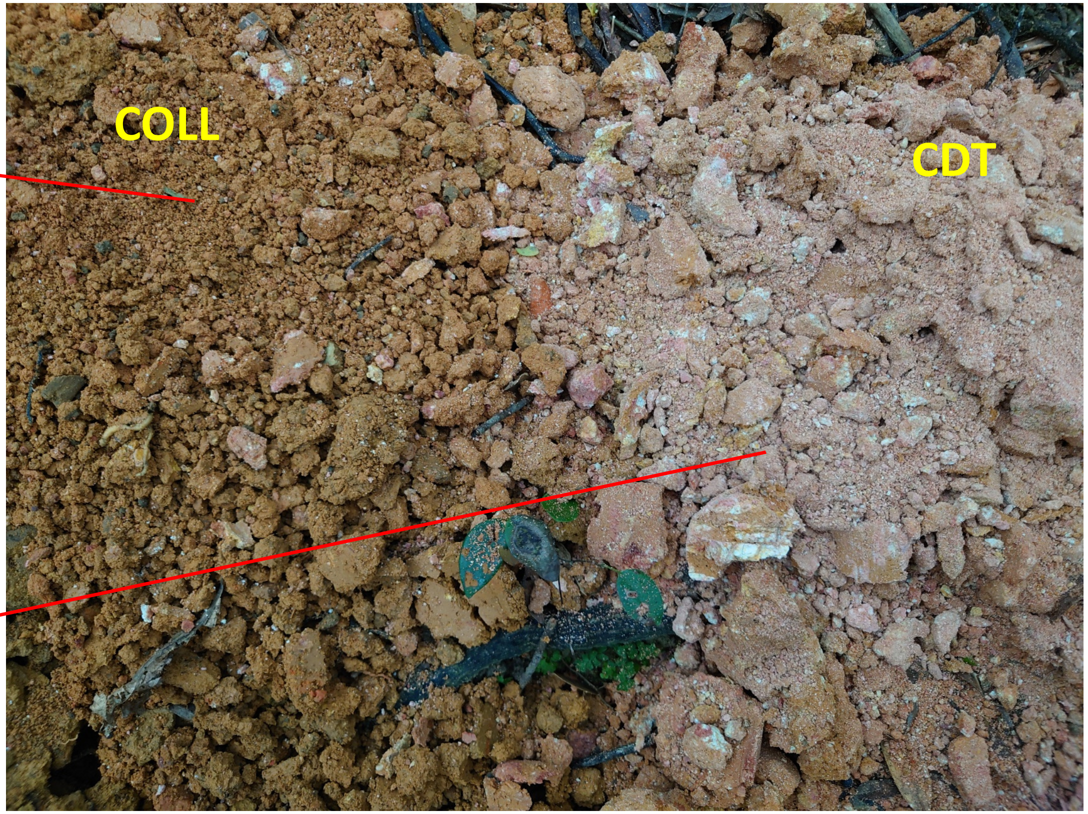




From 0 to 0.8m below ground level, colluvium was retrieved from IP2 which can be described as firm, brown, sandy SILT with some subangular fine to coarse gravel sized rock fragments.

CDT encountered at 0.8m BGL and can be described as extremely weak, reddish brown, mottled white and red, completely decomposed fine ash vitric TUFF which comprises of stiff, slightly sandy SILT with some subangular fine to medium gravel.

Plate 7 Open hillslop colluvium revealed at IP2 (about +183 mPD) in the vicinity of the upper portion of the NTSA



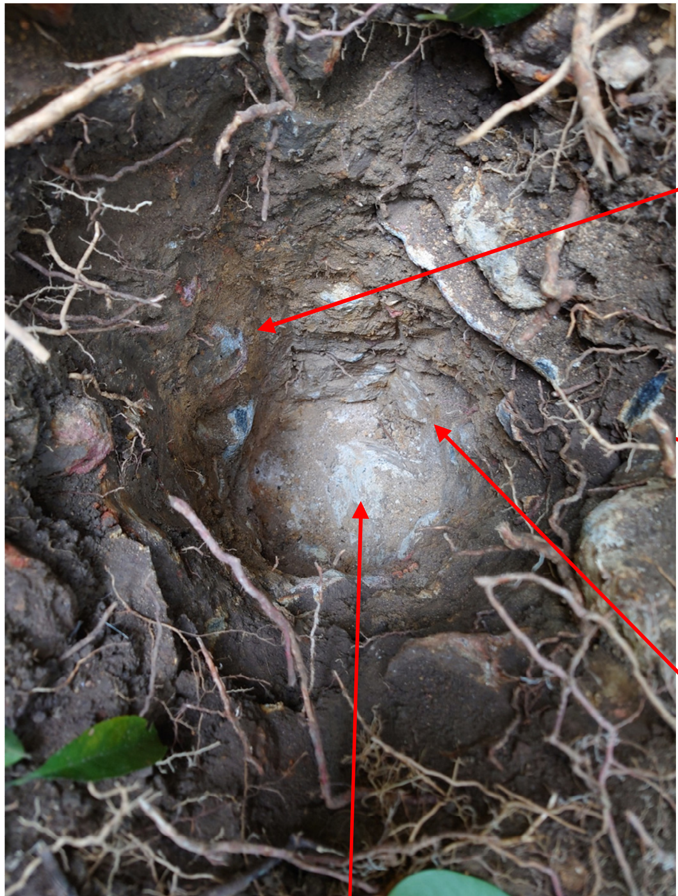
Colluvium was retrieved at IP3 from 0m to 1.0m BGL which can be described as firm, brown, sandy SILT with many subangular fine to coarse gravel sized rock fragments.

CDT encountered at 1.0m BGL and can be described as extremely weak, light pink, mottled white and brown, completely decomposed fine ash vitric TUFF which comprises of stiff, sandy SILT with some angular to subangular fine to medium gravel.

IP3 at the middle portion of the NTSA

Plate 8 Open hillslope colluvium revealed at IP3 (about +161 mPD) in the middle portion of the NTSA

IP4 at the toe of the NTSA



MDT encountered at the bottom of IP4 which can be described as weak, light brown, mottled white, highly to moderately decomposed fine ash vitric TUFF.

From 0 to 0.3m below ground level, colluvium was retrieved from IP4 which can be described as firm, dark brownish grey, sandy SILT with some subangular fine gravel sized rock fragments and occasional rootlets.

Colluvium was also retrieved at IP4 from 0.3m to 1.10m which can be described as firm, brown, dappled grey, sandy SILT with many subangular fine to coarse gravel sized rock fragments.

CDT encountered at 1.10m BGL and can be described as extremely weak, light brown, mottled white, completely decomposed fine ash vitric TUFF which comprises of stiff, sandy SILT with some angular to subangular fine to medium gravel.

Plate 9 Open hillslope colluvium revealed at IP4 (about +126 mPD) near the toe of the NTSA

IP5 at the lower portion of the NTSA

From 0 to 1.0m below ground level, colluvium was retrieved from IP5 which can be described as firm, brown, dappled grey, sandy SILT with some subangular fine to coarse gravel sized rock fragments.

CDT encountered at 1.0m BGL and can be described as extremely weak, yellowish brown, mottled white, completely decomposed fine ash vitric TUFF which comprises stiff, slightly sandy SILT with some subangular fine to medium gravel.

Plate 10 Open hillslope colluvium revealed at IP5 (about +136 mPD) near the lower portion of the NTSA

General slope gradient at the upper portion of the NTSA is about 15° and covered with dense vegetation and rattans.

Plate 11 General view of the natural terrain at the upper portion of the NTSA

General slope gradient at the upper portion of the NTSA is between 25° and 30°. It is also covered with dense vegetation and rattans.

Plate 12 General view of the natural terrain at the middle portion of the NTSA

General slope gradient at the upper portion of the NTSA is about 30°, locally 35 °. It is covered with denser vegetation than the upper and middle portions of the NTSA.

Plate 13 General view of the natural terrain at the lower portion of the NTSA

Relict landslide, RL1 (ENTLI No. 11SED0090E) was identified at about +171 mPD near the southern spur within the NTSA. RL1 appears to be a distinctive concave depression with a rounded scarp of discernable change of slopes. No noticeable debris lobe can be recognised below the landslide scar, probably the landslide could be occurred for a long time ago and most of the landslide debris had been eroded leaving a shallow depression with depth of about 0.7m. The measured width and length of landslide source is about 11.7m and 8.7m respectively.

Plate 14 Relict landslide scar, RL1 (ENTLI No. 11SED0090E) at about +171 mPD

Relict landslide (RL2) was registered as ENTLI record no. 11SED0091E which is located at about +186 mPD below the convex change of slope between the upper slope terrain and middle slope terrain **(Plate 15).** It appears to be a broad, subtle and shallow depression with a rounded scarp, probably older than the RL1.

The estimated failure volume of RL2 is 31.4m³ with measured width, length and depth of the landslide source as 10.6m^3, 11.3m^3 and 0.5m respectively.

Plate 15 Relict landslide scar, RL2 (ENTLI No. 11SED0091E) at about +186 mPD

Plate 16 Hong Kong Trail (Section 8) and man-made cut slope Feature No. 11SE-D/C356

Plate 17 Catchwater and man-made cut slope Feature No. 11SE-D/CR351 located at the middle level of the NTSA

Plate 18 Catchwater and man-made cut slope Feature No. 11SE-D/CR350 located at the middle level within the NTSA

The height of the terraces are generally less than 0.7m with rubble facings and about 1.2m wide within an overall hillslope gradient less than 25 degrees. The terraces were probably used for placement of urns in the 1980s (observed from aerial photographs) and left abandoned since the completion of the Hong Kong Buddhist Cemetery which was located at the western side adjacent to the Site in 1991.

Plate 19 Abandoned small terraces (probably for urns placement during 1980s) near the northern toe of the NTSA

Appendix A

Previous Ground Investigation Records

r

BACHY SOLETANCHE

BACHY SOLETANCHE GROUP

SOIL & FOUNDATIONS SPECIALISTS

DRILLHOLE RECORD (LAND INVESTIGATION)

CONTRACT – OF –

W. O. W-120

HOLE No. VH1

DATE from 23/12/85 to 28/12/85

SHEET 1 OF 1

PROJECT:

PROPOSED CARPARK FOR BUDDHIST CEMETERY CAPE COLLINSON ROAD. HONG KONG

METHOD ROTARY	CO-ORDINATES E 42041.72 N 13145.17	ROCK COREBIT T76 4.00m TO 10.65m
MACHINE & No. LONGYEAR 24 - 11		HOLE DIA 0.00m - 3.50m HX 3.5m - 4.00m NX.
FLUSHING MEDIUM WATER	ORIENTATION VERTICAL	GROUND-LEVEL +119.81 mPD

Drilling Progress	Casing depth/size	Water level time date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R Q D	Fracture Index /m	Tests	Samples	Reduced Level	Depth (m)	Grade	Zone	Description
				100		100					0.22		(WALL STRUCTURE)	CONCRETE SURFACING AT TOP 200mm. MASS CONCRETE WITH RUBBLES, COBBLES AND GRAVEL. (WALL STRUCTURE)
				92		0			HX		0.72			
1 23/12				34		21					1.30			
				60		0			T76		1.70			
2				43		0				+117.81	2.00			
				75					1		3.00	V	B	MEDIUM DENSE, YELLOWISH BROWN SPECKLED GREYISH WHITE GRAVELLY SILTY FINE TO MEDIUM SAND WITH VOLCANIC FRAGMENT. (C.W.V)
3 24/12	3.50							N=20	2		3.45			
4	4.00			90					3	+115.81	4.00			
				50	50	0	NI				5.00	IV/V	C	YELLOWISH GREY, FINE TO MEDIUM GRAINED CLOSELY SPACED JOINTS, HIGHLY TO MODERATELY WEATHERING VOLCANIC. WEAK TO VERY WEAK.
5			0	50	30	0	NI				5.70			
6										+113.81	6.00			
				100	95	24	NI				6.42	III	D	GREY, FINE GRAINED, CLOSELY SPACED JOINTS, MODERATELY WEATHERED VOLCANIC, MODERATELY STRONG TO STRONG. JOINTS DIPPING AT 75°-85°, HIGHLY FRACTURED (M.W.V.)
7				100	89	50	NI		T76		7.05			
				100	86	0	NI			+112.41	7.40			
27/12				100	100	100	0				7.81	II	D	GREY, FINE GRAINED, MEDIUM SPACED JOINTS, SLIGHTLY WEATHERED VOLCANIC, STRONG TO VERY STRONG. JOINTS DIPPING AT 0°-10°, 45°-60°, 75°-85°. (S.W.V.)
8				100	100	100	3				8.17			
				100	100	100	0				8.56			
9				100	100	100	2				9.01			
				100	100	100	3				9.34			
28/2				100	100	47	11				9.85			
10				100	95	31	9			+109.16	10.65			END OF DRILLHOLE AT 10.65m

- ● SMALL DISTURBED SAMPLE
- BULK DISTURBED SAMPLE
- S.P.T. LINER SAMPLE
- U 100 UNDISTURBED SAMPLE
- MAZIER SAMPLE (76mm)
- ▲ WATER SAMPLE
- ▼ WATER LEVEL
- ↓ STANDARD PENETRATION TEST
- PERMEABILITY TEST

LOGGED WAI DATE 4/1/86

CHECKED LUN DATE 6/1/86

REMARKS

PIEZOMETER INSTALLED AT 10.15m BELOW Ex. G.L.

CONTRACTOR

DRILLHOLE RECORD

Lam Construction Co., Ltd.

		WORKS ORDER OR JOB NUMBER 542
		SITE NAME [illegible]
		HOLE NO. [illegible]
RIG TYPE [illegible]	CO ORDINATES E [illegible]	DATE FROM 28.02 TO 3.3.[illegible]
RIG NUMBER [illegible]	N [illegible]	SHEET 1 OF 1
OPERATOR MR. S. M. CHEUNG	HOLE DIAMETER	GROUND LEVEL [illegible] M.P.D.
METHOD ROTARY	CASING DIAMETER NX	ORIENTATION VERTICAL

Drilling progress	Casing depth, size	Water Level	Water recovery %	Core recovery %	R.Q.D. %	Fracture index/m	Tests	Samples	Depth metres	Reduced Level	Legend	Description	Core bit	Core grade
28/2	NX			100					0 – 0.15			CONCRETE SLAB		
	NX								0.15 – 1.00			Yellowish brown, silty sand with gravel. (FILL)		
		0.50m at 18:00		70	0	*			1.00 – 2.05		V V V	Strong, pale green grey, fine to medium grained, slightly weathered volcanic tuff with closely spaced fractures sub-vertical clay mineral stained & occasional sub-horizontal limonite stained joints, core fractured	[illegible]	
28/2 – 2/3		0.80m at 8:00		93	60	>10			2.05 – 3.15		V V V			II
		0.62m at 18:00		100	0	*			3.15 – 3.90		V V V			
2/3 – 3/3		0.78m at 8:00		100	33	10			3.90 – 4.70		V V V			
3/3				95	95	2		Piezometer	4.70 – 5.15		V V V		[illegible]	
									5.15			END OF HOLE.		

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

- • Small disturbed sample
- Large disturbed sample (102mm)
- Undisturbed sample
- Water sample
- Field permeability test
- M Moisture content (%)
- Mazier sample
- Liner sample (40mm)
- ∇ Water table
- Standard penetration test
- V Vane shear test
- U 76 Undisturbed
- Piezometer

REMARKS

1. *: Cannot be determined.
2. Standard [illegible] piezometer was installed at [illegible]

CONTRACTOR	DRILLHOLE RECORD	WORKS ORDER OR JOB NUMBER [illegible]
Lam Construction Co., Ltd.		SITE NAME [illegible] HOLE NO. [illegible]

RIG TYPE Toho D2-6-?	CO ORDINATES E 42079.70	DATE FROM 19.3.?? TO 21.3.??
RIG NUMBER RC3	N 18105.49	SHEET 1 OF 1
OPERATOR MR. S. K. CHEUNG	HOLE DIAMETER	GROUND LEVEL 107.82 M.P.D.
METHOD ROTARY	CASING DIAMETER NX	ORIENTATION vertical

Drilling progress	Casing depth. size	Water Level	Water recovery %	Core recovery %	R.Q.D. %	Fracture index/m	Tests	Samples	Depth metres	Reduced Level	Legend	Description	Core bit	Core grade
19/3	NX		85	100					0.14			CONCRETE SLAB		
				80					0.80			yellowish brown, gravel & cobble embedded in fill soil. (FILL)		
			70	92					1.50			yellowish brown, fill soil (FILL)		
				88										
19/3		1.46 at 18:00	70	86								moderately strong, gravel & cobble sized rock fragment with occasional cement sand in between. (FILL)		
20/3		NIL at 8:00	0	100					3.40					
	NX			97					4.20			very strong, dark grey volcanic boulder. (FILL)		
				100					4.40				TNW	
				100					5.30			strong, mottled yellowish grey, cemented sand & gravel concrete from column for retaining wall concrete footing.	TNW	
20/3		5.90 at 18:00	0	100	0	*			5.60				TNW	
21/3		[illegible] at 8:00	85	98	11	*			6.60			strong to very strong grey, light yellowish grey, fine to medium grained, highly fractured, moderately weathered volcanic - tuff.		III
				92	0	*			7.60					
21/3		6.7? at 18:00	85	90	0	*			8.30			END OF HOLE.	TNW	

- • Small disturbed sample
- Large disturbed sample (102mm)
- Undisturbed sample
- Water sample
- Field permeability test
- M Moisture content (%)
- Mazier sample
- Liner sample (40mm)
- ∇ Water table
- Standard penetration test
- V Vane shear test
- U 76 Undisturbed
- Piezometer

REMARKS
1. * : cannot be determined.
2. standard single piezometer was installed at depth 8.?m
3. standard standpipe was installed at depth 5.?0m

CONTRACTOR

Lam Construction Co., Ltd.

DRILLHOLE RECORD

WORKS ORDER OR JOB NUMBER 542

SITE NAME [illegible] HOLE NO. [illegible]

RIG TYPE Toho DE-C-V8

RIG NUMBER RC 3

OPERATOR MR. S. M. CHEUNG

METHOD ROTARY

CO-ORDINATES E 42069.62 N 13113.49

HOLE DIAMETER

CASING DIAMETER NX

DATE FROM 12.3.88 TO 18.3.88

SHEET 1 OF 1

GROUND LEVEL 127.89 M.P.D.

ORIENTATION VERTICAL

Drilling progress	Casing depth, size	Water Level	Water recovery %	Core recovery %	R.Q.D. %	Fracture index/m	Tests	Samples	Depth metres	Reduced Level	Legend	Description	Core bit	Core grade
				1.00					0			CONCRETE SLAB		
12/3	NX								0.14			MEDIUM DENSE, BROWN, YELLOW, SILTY, FINE TO COARSE SAND WITH GRAVEL & ROCK FRAGMENTS. (FILL)		
							36 BLS 5.15.21	F.S. 1	1.45					
13/3		1.70m AT 18:00					N=18 5.7.10	2	1.90					
14/3		1.05m AT 8:00												
							43 BLS 11.17.26	F.S. 3	2.10			VERY DENSE, BROWN, YELLOWISH BROWN, SILTY FINE TO MEDIUM SAND WITH OCCASIONAL GRAVEL (C.W.V.)		
							N=132/0.05m	4	2.95					V
							83 BLS 19.31.52	F.S. 5	4.45					
14/3		3.65m AT 18:00					N=102 31.40.62	6	4.90					
15/3		2.80m AT 8:00					250/0.15m	F.S. 7	5.50					
							250/0.20m	8	5.65 / 5.85					
15/3	NX	5.25m AT 18:00					200/0.05m	9	6.60	1.29				
16/3		5.?m AT 8:00		100	0	*			6.60 / 6.80			STRONG TO VERY STRONG, GREY, MOTTLED BROWNISH GREY, FINE TO MEDIUM GRAINED, HIGHLY FRACTURED MODERATELY WEATHERED VOLCANIC - TUFF.	TNC	
16/3		6.53m AT 18:00		100	0	24			7.50					
17/3		5.20m AT 8:00		92	0	25								III
				98	0	*			8.35					
17/3		7.95m AT 18:00		100	0	*			8.50					
18/3		7.05m AT 8:00		88	0	*			8.70					
				86	0	*								
				92	0	*			9.20					
18/3		9.10m AT 18:00		92	0	*			10			END OF HOLE	TNC	

- • Small disturbed sample
- Large disturbed sample (102mm)
- Undisturbed sample
- Water sample
- Field permeability test
- M Moisture content (%)
- Mazier sample
- Liner sample (40mm)
- ▽ Water table
- Standard penetration test
- V Vane shear test
- U 76 Undisturbed
- Piezometer

REMARKS

1. * : CANNOT BE DETERMINED.
2. STANDARD SINGLE PIEZOMETER WAS INSTALLED AT DEPTH 10.00m
3. STANDPIPE PIEZOMETER WAS INSTALLED AT DEPTH 6.50m
4. F.S. : FRESH SAMPLE.

CONTRACTOR

DRILLHOLE RECORD

Lam Construction Co., Ltd.

RIG TYPE: Tone ?2-C-5?	CO-ORDINATES E 820??.86	WORKS ORDER OR JOB NUMBER: [illegible]	SITE NAME: [illegible] HOLE NO. [illegible]
RIG NUMBER: R03	N 1812?.?9	DATE FROM [illegible] TO [illegible]	SHEET 1 OF 1
OPERATOR: MR. S.M. CHEUNG	HOLE DIAMETER	GROUND LEVEL 12?.?9 M.P.D.	
METHOD: ROTARY	CASING DIAMETER NX	ORIENTATION VERTICAL	

Drilling progress	Casing depth. size	Water Level	Water recovery %	Core recovery %	R.Q.D. %	Fracture index/m	Tests	Samples	Depth metres	Reduced Level	Legend	Description	Core bit	Core grade
4/3	NX								0.07			Concrete slab.		
							12.5/0.02m	1	1.25			Very dense, brown yellow clayey sandy silt with gravel & rock fragments. (FILL)		
				31	0	*			1.65		v v v	Moderately strong to weak, yellowish grey, fine to medium grained, moderately weathered volcanic-type (highly weathered from 2.40-2.60m: gravelly sandy silt) with closely sub-vertical joints, highly fractured.	NX	III
				93	0	*	110/0.08m	2	2.40					IV
	NX								2.60					
4/3		0.20m at 18:00		24	0	*			3.40					III
5/3		0.40m at 8:00		50	0	*			3.80				NX	
				95	27	*			4.90		v v v	Strong, pale green grey, fine to medium grained, slightly weathered volcanic-type with closely sub-vertical partly limonite stained joints, core fractured.	NX	II
				100	18	>7			6.20					
5/3				97	58	13		Piezometer	6.60				NX	
												End of hole		

- • Small disturbed sample
- Large disturbed sample (102mm)
- Undisturbed sample
- Water sample
- Field permeability test
- M Moisture content (%)
- Mazier sample
- Liner sample (40mm)
- ∇ Water table
- ↓ Standard penetration test
- V Vane shear test
- U 76 Undisturbed
- Piezometer

REMARKS

1. * : cannot be determined
2. Standard single piezometer was installed at depth 6.?m.

CONTRACTOR

DRILLHOLE RECORD

Lam Construction Co., Ltd.

WORKS ORDER OR JOB NUMBER [illegible]

SITE NAME [illegible] HOLE NO. [illegible] 7

RIG TYPE [illegible]	CO ORDINATES E 42080.77
RIG NUMBER [illegible]	N 13106.59
OPERATOR MR. S. M. CHEUNG	HOLE DIAMETER
METHOD ROTARY	CASING DIAMETER NX

DATE FROM [illegible] 10 [illegible]

SHEET 1 OF 1

GROUND LEVEL 126.27 M.P.D.

ORIENTATION HORIZONTAL

Drilling progress	Casing depth. size	Water Level	Water recovery %	Core recovery %	R.Q.D.%	Fracture index/m	Tests	Samples	Depth metres	Reduced Level	Legend	Description	Core bit	Core grade
24/3			90	100					0			MODERATELY STRONG TO STRONG, MOTTLED YELLOWISH GREY, COMPACTED SAND & GRAVEL CONCRETE BOND COURSE FOR RETAINING WALL		
			80	100					1					
									1.60			VERY STRONG, DARK GREY, VOLCANIC BOULDER.		
				100					1.80					
24/3.							↡	• 1	2			MEDIUM DENSE TO DENSE, YELLOWISH BROWN. (C. D. V.)		E
									3					
									4					
									5					
									6					
									7					
									8					
									9					
									10					

- • Small disturbed sample
- ⁝ Large disturbed sample (102mm)
- ⊠ Undisturbed sample
- ▲ Water sample
- ⧫ Field permeability test
- M Moisture content (%)
- ▨ Mazier sample
- ▯ Liner sample (40mm)
- ∇ Water table
- ↡ Standard penetration test
- V Vane shear test
- ▮ U 76 Undisturbed
- ⍊ Piezometer

REMARKS

DRILLHOLE RECORD

CONTRACTOR

Lam Construction Co., Ltd.

WORKS ORDER OR JOB NUMBER 542

SITE NAME [illegible] HOLE NO. [illegible]

RIG TYPE [illegible]	CO ORDINATES E 42079.85	DATE FROM 22.3.[illegible] TO [illegible]
RIG NUMBER RC 3	N 18107.55	SHEET 1 OF 1
OPERATOR MR. S. M. CHEUNG	HOLE DIAMETER	GROUND LEVEL 124.39 M.P.D.
METHOD ROTARY	CASING DIAMETER NX	ORIENTATION Horizontal

Drilling progress	Casing depth. size	Water Level	Water recovery %	Core recovery %	R.Q.D. %	Fracture index/m	Tests	Samples	Depth metres	Reduced Level	Legend	Description	Core bit	Core grade
22/3	NX		85	100					0 – 1.50			Moderately strong to strong, mottled yellowish grey, cemented sand & gravel concrete being coarse for retaining wall		
				100					1.50 – 2.20			Medium dense to dense yellowish brown, completely weathered volcanic.		
				100			↓	1	2.20 – 2.30					
22/3	NX		85				↓	2	2.30 – 2.60					V
									2.60			End of hole.		

• Small disturbed sample	Liner sample (40mm)	REMARKS
Large disturbed sample (102mm)	Water table	
Undisturbed sample	Standard penetration test	
Water sample	V Vane shear test	
Field permeability test	U 76 Undisturbed	
M Moisture content (%)	Piezometer	
Mazier sample		

Appendix B

Aerial Photograph Interpretation

B.1 DETAILED AERIAL PHOTOGRAPH INTERPRETATION

The following report comprises the detailed observations made from the examination of aerial photographs taken between 1945 and 2022. A list of aerial photographs examined in this study is presented in Table B1. The interpretations on geomorphology and man-made features are shown in Figure B1 to B11.

YEAR	**OBSERVATIONS**
1945 (Figure B1)	High altitude and fair resolution stereo pairs. The NTSA is generally a small planar hillslope emerging from a north trending spur bounded by two subordinate indistinct northwest trending spurs. The hillslope is generally a northwest facing hillslope. The dark tone surface of the NTSA suggest the NTSA is covered by moderately dense vegetation. Cape Collinson Road was existed below the NTSA and the Site, a catchwater and the Hong Kong Trail were traversed at the middle and upper portion of the NTSA respectively. Man-made features Nos. 11SE-D/CR350 and 11SE-D/CR351 were probably formed in association the alignment of the catchwater, whilst feature No. 11SE-D/CR356 was probably formed in association with the alignment of the Hong Kong Trail. A strip of vegetation clearance appeared above the Hong Kong Trail. It probably served as a fire break. The crest of the NTSA is partially obscured by cloud.
1949	High altitude and high resolution stereo pairs. No substantial change to the NTSA since 1945. No sign of distress can be discerned within the NTSA.
1963 (Figure B2)	Low altitude and high resolution stereo pairs. The morphology of the hillside is a generally planar northwest facing hillslope. The NTSA comprises of a moderately steep hillslope. It is generally covered with medium dense small trees and grass. The surface of the NTSA appears as smooth morphology without distinctive hummocky terrain. Locally two minor depressions are discerned within the middle portion of the NTSA above the catchwater. Based on the morphology, the NTSA is probably covered by in-situ materials and may be covered by a thin veneer of colluvium.

YEAR	**OBSERVATIONS**
	Neither ephemeral nor perennial drainage line can be discerned within the NTSA. No significant of water concentration is envisaged towards the NTSA. No prominent rock outcrop or boulder is observed within the NTSA. Two minor concave depressions appear as darker tone which are located at the middle portion of the NTSA, they are probably represent as two relict landslide scars (RL1 and RL2). The landslide scarp of RL1 appeared as a rounded and relatively distinctive change of slope. The landslide scarp of RL2 appears as rounded and broad depression. This degraded feature indicates the landslide could be happened a very long time ago before 1945. The failure of RL1 and RL2 probably due to the transient build-up of perched water table between the thin colluvium and the insitu materials. RL1 and RL2 have an estimated landslide volume of $33m^3$ and $40m^3$ respectively (need to verify during the field mapping). These locations were probably registered in the ENTLI as the record nos. 11SED0090E and 11SED0091E respectively. A man-made cut slope was formed at the northern toe of the NTSA. This could be the registered man-made Feature No. 11SE-D/C69. It was formed in association with the access road to the Holy Cross Catholic Cemetery which was undergo construction. A fire break (a strip of vegetation clearance) above the Hong Kong Trail at the upper portion of the NTSA is clearly discerned in the aerial photographs. Morphologically, a convex change of slope is discerned at about +190 mPD. The convex change of slope demarcates the upper and the middle slope terrain. The NTSA comprises a relatively gentle slope at the upper portion whilst the middle and lower portion of the NTSA is comprises of relatively steeper slope which formed the transportational environment.
1964	High altitude and high resolution single photograph. No observable significant change to the NTSA since 1963. No sign of distress or landslide can be discerned within the NTSA.
1967 (Figure B3)	Low altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1964. No sign of distress or landslide can be identified within the NTSA. The Hong Kong Buddhist Cemetery was under construction. Feature Nos. 11SE-D/FR111, 11SE-D/R64, 11SE-D/R65 were formed probably in association with the site formation works for the Hong Kong Buddhist

YEAR	OBSERVATIONS
	Cemetery which located in the northwest direction of the Site and the NTSA.
1972 (Figure B4)	High altitude and fair resolution stereo pairs. No observable significant change to the NTSA since 1967. No sign of distress can be discerned within the NTSA. Several buildings of the Hong Kong Buddhist Cemetery were constructed adjacent to the west of the Site. Feature Nos. 11SE-D/C345, 11SE-D/R63 and 11SE-D/CR341 were formed probably in association with this construction.
1973	High altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1972. No sign of distress can be discerned within the NTSA.
1975	High altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1973. No sign of distress can be discerned within the NTSA.
1976 (Figure B5)	High altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1975. No sign of distress can be discerned within the NTSA. A general increase of vegetation density appears within the NTSA. A patch of high reflectance surface was discerned at the Site, probably due to vegetation clearance. Construction of culvert appears to have been taken place at the northern portion of the Site.
1977	Low altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1976. No sign of distress can be discerned within the NTSA. A general increase of vegetation density appears within the NTSA.
1978	Low altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1977. No sign of distress can be discerned within the NTSA.
1979	High altitude and high resolution stereo pairs.

YEAR	OBSERVATIONS
	No observable significant change to the NTSA since 1978. No sign of distress can be discerned within the NTSA.
1980	High altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1979. No sign of distress can be discerned within the NTSA.
1981	Low altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1980. No sign of distress can be discerned within the NTSA.
1982	High altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1981. No sign of distress can be discerned within the NTSA.
1984 (Figure B6)	Low altitude and high resolution stereo pairs. A patch of bare soil was discerned at the northern toe of the NTSA, probably vegetation clearance have been carried out. Several tiny structures can be discerned within the Site area. Another small structure was constructed adjacent to the lower portion of the NTSA.
1985	High altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1984. No sign of distress can be discerned within the NTSA.
1986	Low altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1985. No sign of distress can be discerned within the NTSA.
1987 (Figure B7)	Low altitude and high resolution stereo pairs. Small terraces (for placement of urns, verified during field mapping) were apparent at the lower portion of the NTSA. A footpath is discerned in the middle of the terraces.

YEAR	OBSERVATIONS
	No sign of distress can be discerned within the NTSA.
1988	Low altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1987. No sign of distress can be discerned within the NTSA.
1989	Low altitude and high resolution single colour photograph. No observable significant change to the NTSA since 1988. No sign of distress can be discerned within the NTSA.
1990	Low altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1989. No sign of distress can be discerned within the NTSA.
1991 (Figure B8)	Low altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1990. No sign of distress can be discerned within the NTSA. A building of the Hong Kong Buddhist Cemetery was constructed adjacent to the Site.
1992	Low altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1991. No sign of distress can be discerned within the NTSA.
1993	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 1992. No sign of distress can be discerned within the NTSA.
1994	Low altitude and high resolution stereo pairs. No observable significant change to the NTSA since 1993. No sign of distress can be discerned within the NTSA.
1995	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 1994. No sign of distress can be discerned within the NTSA.

YEAR	OBSERVATIONS
1996	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 1995. No sign of distress can be discerned within the NTSA.
1997	Low altitude and high resolution colour single photograph. No observable significant change to the NTSA since 1996. No sign of distress can be discerned within the NTSA.
1998	Low altitude and high resolution colour single photograph. No observable significant change to the NTSA since 1997. No sign of distress can be discerned within the NTSA.
1999	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 1998. No sign of distress can be discerned within the NTSA.
2000 (Figure B9)	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 1999. No sign of distress can be discerned within the NTSA. Entire NTSA was covered by dense vegetation.
2001	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2000. No sign of distress can be discerned within the NTSA.
2002	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2001. No sign of distress can be discerned within the NTSA.
2003	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2002. No sign of distress can be discerned within the NTSA.
2004	Low altitude and high resolution colour stereo photo. No observable significant change to the NTSA since 2003. No sign of distress

YEAR	OBSERVATIONS
	can be discerned within the NTSA.
2005	Low altitude and high resolution colour stereo photo. No observable significant change to the NTSA since 2004. No sign of distress can be discerned within the NTSA.
2006	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2005. No sign of distress can be discerned within the NTSA.
2007	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2006. No sign of distress can be discerned within the NTSA.
2008 (Figure B10)	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2007. No sign of distress can be discerned within the NTSA. Several new small structures are appeared at the Site.
2009	Low altitude and high resolution colour stereo pairs. No sign of distress can be discerned within the NTSA. No observable significant change to the NTSA since 2008.
2010	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2009. No sign of distress can be discerned within the NTSA.
2011	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2010. No sign of distress can be discerned within the NTSA.
2012	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2011. No sign of distress can be discerned within the NTSA.

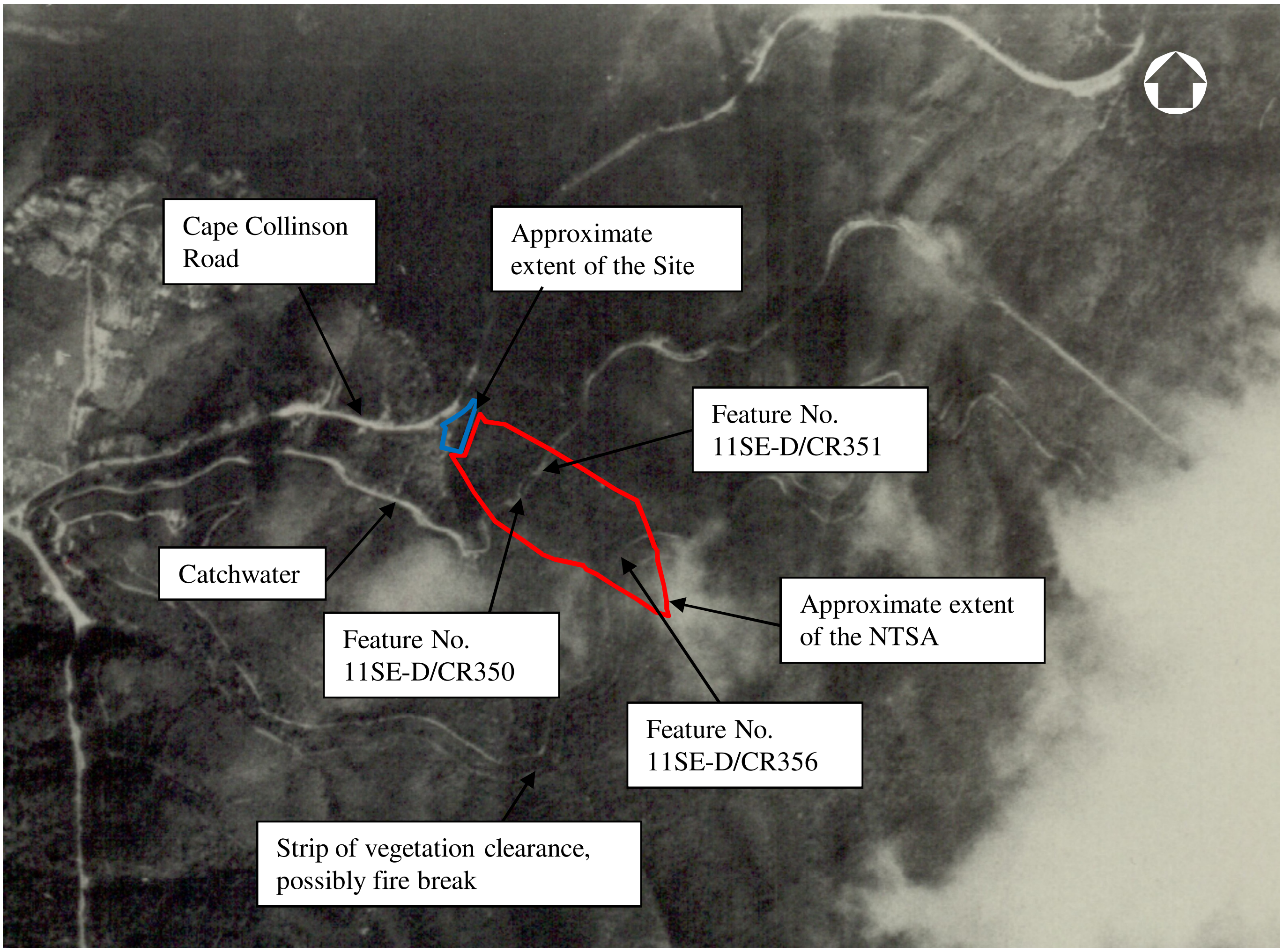
YEAR	OBSERVATIONS
2013	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2012. No sign of distress can be discerned within the NTSA.
2014	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2013. No sign of distress can be discerned within the NTSA.
2015	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2014. No sign of distress can be discerned within the NTSA.
2016	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2015. No sign of distress can be discerned within the NTSA.
2017	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2016. No sign of distress can be discerned within the NTSA.
2018	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2017. No sign of distress can be discerned within the NTSA.
2019	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2018. No sign of distress can be discerned within the NTSA.
2020 (Figure B13)	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2019. No sign of distress can be discerned within the NTSA.
2021	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2020. No sign of distress can be discerned within the NTSA.

YEAR	OBSERVATIONS
2022	Low altitude and high resolution colour stereo pairs. No observable significant change to the NTSA since 2021. No sign of distress can be discerned within the NTSA.

Table B1 – List of Photographs

Photo Year	Aerial Photo Reference No.	Flight Altitude (Feet)
1945	Y00384-5	20,000
1949	Y01337-8	8,600
1963	Y07136-7	2,700
1964	Y12833	12,500
1967	Y13244-5	6,250
1972	2290-1	13,000
1973	5459-60	12,500
1975	12073	12,500
1976	15840-1	12,500
1977	20495-6	4,000
1978	23753-4	4,000
1979	27768-9	10,000
1980	33423-4	10,000
1981	37458-9	4,000
1982	44449-50	10,000
1984	53753-4	4,000
1985	A02602-3	15,000
1986	A06055-6	4,000
1987	A10383-4	4,000
1988	A14523-4	4,000
1989	A17856-7	4,000
1990	A20777-8	4,000
1991	A27929-30	4,000
1992	A30993-4	4,000
1993	A35184-5	4,000
1994	CN8041-2	4,000
1995	CN12734-4	3,500
1996	CN15542-3	4,000
1997	CN17636-7	4,000
1998	CN21088-9	4,000
1999	CN24066-7	5,000
2000	CN28306-7	4,000
2001	CW31256-7	4,000
2002	CW39611-2	3,500
2003	CW47567-8	4,000
2004	CW60569-70	4,000
2005	CW69940-1	8,000

Photo Year	Aerial Photo Reference No.	Flight Altitude (Feet)
2006	CS02530-1	6,000
2007	CW77197-8	3,000
2008	CS11908-9	6,000
2009	CS22816-7	6,000
2010	CS30662-3	6,000
2011	CS32791-2	6,000
2012	CS36736-7	6,000
2013	CW99410-1	3,000
2014	CS47604-5	6,000
2015	CS54767-8	6,000
2016	CS62570-1	6,000
2017	E011947-8C	6,000
2018	E047734-5C	6,900
2019	E071325-6C	6,000
2020	E103699-700C	6,900
2021	E118365-6C	6,900
2022	E177955-6C	6,900



Photograph No.: Y00384 **Date of Photograph: 11 Nov 1945** **Altitude: 20,000'**

Legend: Approximate Boundary of the NTSA

The NTSA is generally a small planar hillslope emerging from a north trending spur bounded by two subordinate indistinct northwest trending spurs. The hillslope is generally a northwest facing hillslope.

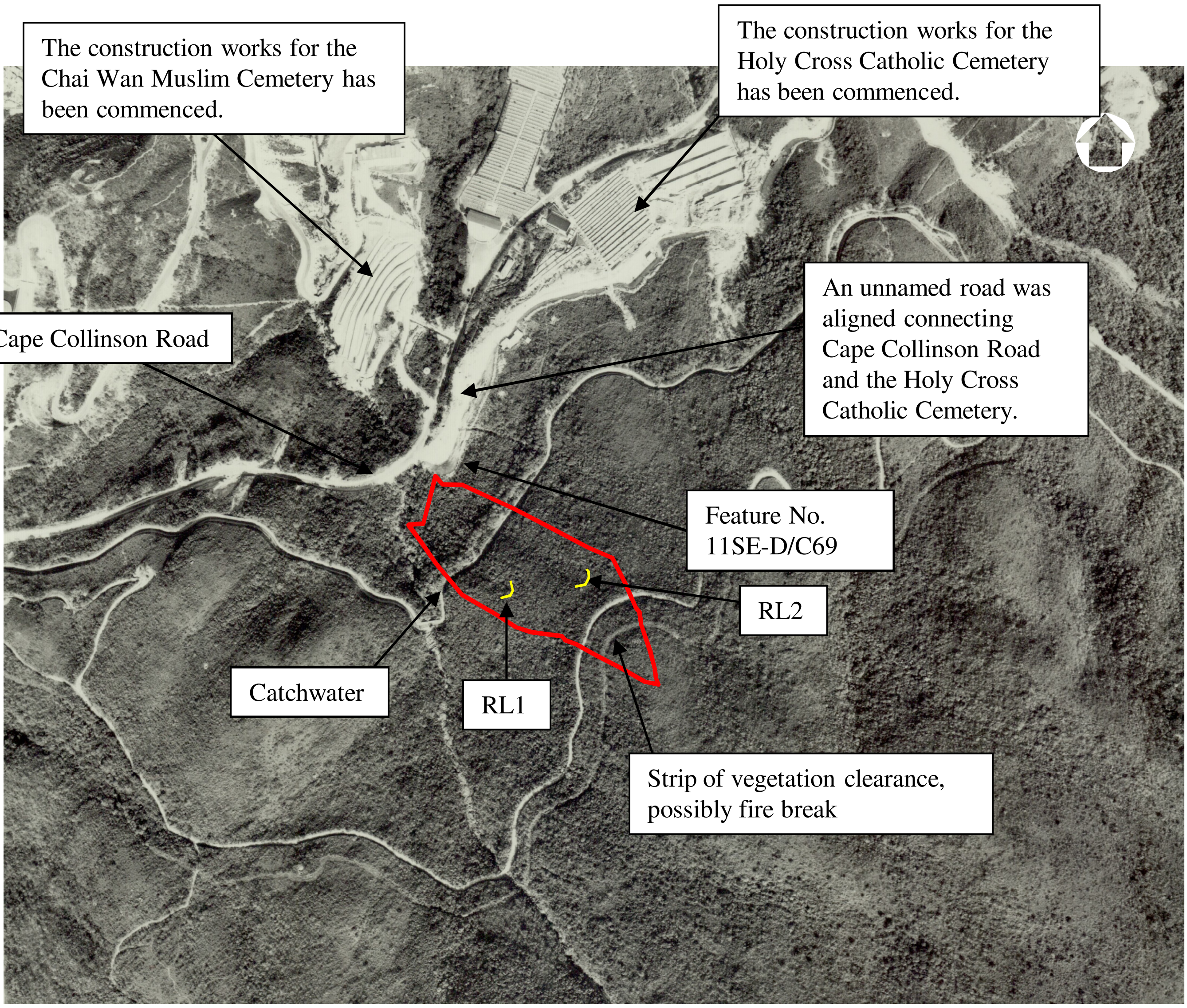
The dark tone surface of the NTSA suggest the NTSA is covered by moderately dense vegetation.

Cape Collinson Road was existed below the NTSA and the Site, a catchwater and the Hong Kong Trail were traversed at the middle and upper portion of the NTSA respectively. Man-made features Nos. 11SE-D/CR350 and 11SE-D/CR351 were probably formed in association the alignment of the catchwater, whilst feature No. 11SE-D/CR356 was probably formed in association with the alignment of the Hong Kong Trail.

A strip of vegetation clearance appeared above the Hong Kong Trail. It could probably be served as a fire break.

The crest of the NTSA is partially obscured by cloud.

Client:	Project:	FIGURE B1
Philip So & Associates Limited In association with CALVINT GEO-SERVICES LIMITED THE BEST SOLUTION FOR YOU	Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan	Location: Cape Collinson, Chai Wan Scale: NTS Date: 16 Feb 2024



Photograph No.: Y07137 **Date of Photograph: 1 Feb 1963** **Altitude: 2,700'**

Legend: Approximate Boundary of the NTSA

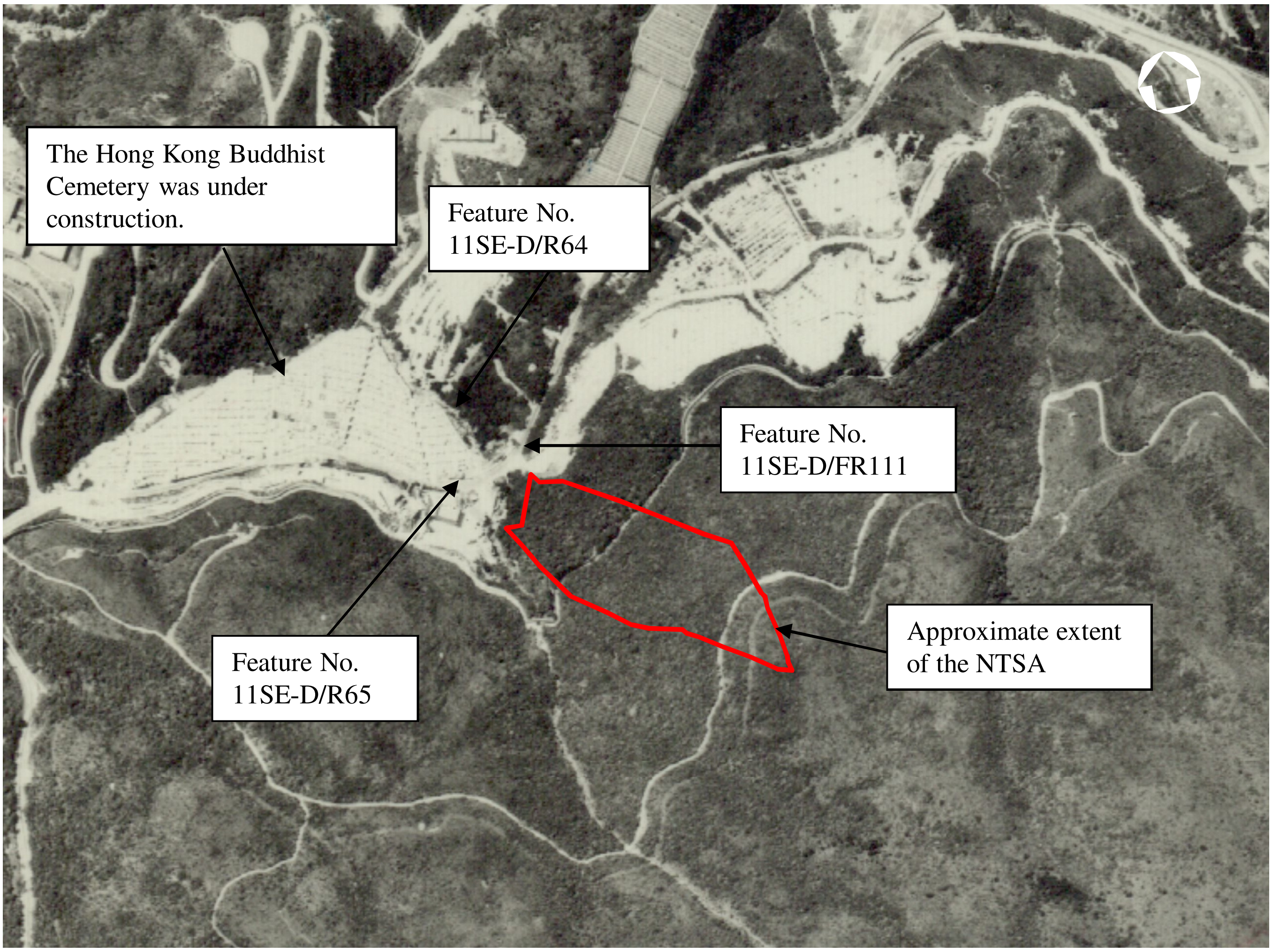
The morphology of the hillside is a generally planar northwest facing hillslope. The NTSA comprises of a moderately steep hillslope. It is generally covered with medium dense small trees and grass. The surface of the NTSA appears as smooth morphology without distinctive hummocky terrain. Locally two minor depressions are discerned within the middle portion of the NTSA above the catchwater. Based on the morphology, the NTSA is probably covered by in-situ materials and may be covered by a thin veneer of colluvium. Neither ephemeral nor perennial drainage line can be discerned within the NTSA. No significant of water concentration is envisaged towards the NTSA. No prominent rock outcrop or boulder is observed within the NTSA.

Two minor concave depressions appear as darker tone which are located at the middle portion of the NTSA, they are probably represent as two relict landslide scars (RL1 and RL2). The landslide scarp of RL1 appeared as a rounded and relatively distinctive change of slope. The landslide scarp of RL2 appears as rounded and broad depression. This degraded feature indicates the landslide could be happened a very long time ago before 1945. The failure of RL1 and RL2 probably due to the transient build-up of perched water table between the thin colluvium and the insitu materials. RL1 and RL2 have an estimated landslide volume of $33m^3$and $40m^3$respectively. These locations were probably registered in the ENTLI as the record nos. 11SED0090E and 11SED0091E respectively.

A man-made cut slope was formed at the northern toe of the NTSA. This could be the registered man-made Feature No. 11SE-D/C69. It was formed in association with the access road to the Holy Cross Catholic Cemetery which was undergo construction.

Morphologically, a convex change of slope is discerned at about +190 mPD. The convex change of slope demarcates the upper and the middle slope terrain. The NTSA comprises a relatively gentle slope at the upper portion whilst the middle and lower portion of the NTSA is comprises of relatively steeper slope which formed the transportational environment.

Client:	Project:	FIGURE B2
Philip So & Associates Limited In association with CALVINT GEO-SERVICES LIMITED THE BEST SOLUTION FOR YOU	Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan	Location Cape Collinson, Chai Wan Scale NTS Date 16 Feb 2024



Photograph No.: Y13244 **Date of Photograph: 16 May 1967** **Altitude: 6,250'**

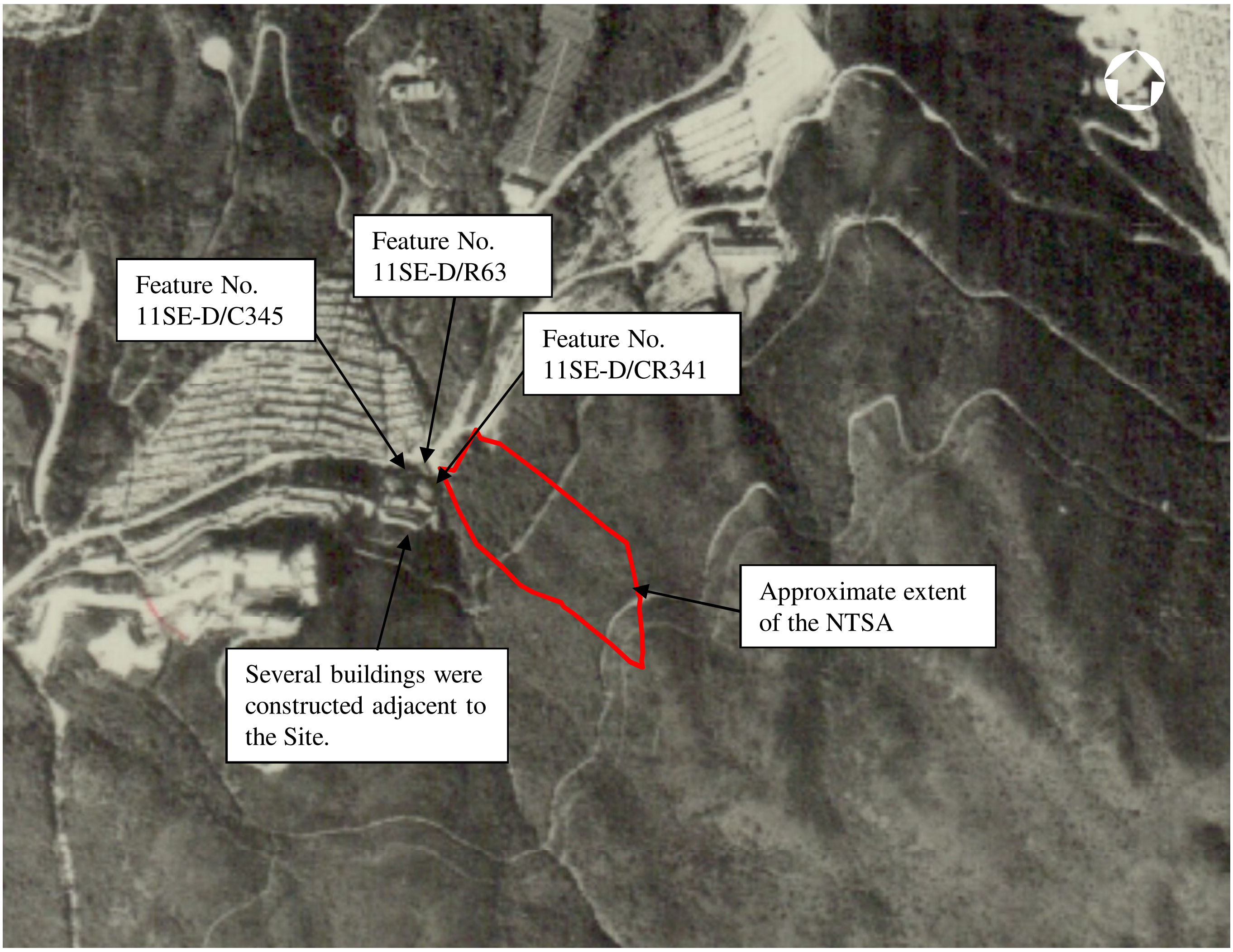
Legend: Approximate Boundary of the NTSA

No observable significant change to the NTSA since 1964.

No sign of distress or landslide can be identified within the NTSA.

The Hong Kong Buddhist Cemetery was under construction. Feature Nos. 11SE-D/FR111, 11SE-D/R64, 11SE-D/R65 were formed probably in association with the site formation works for the Hong Kong Buddhist Cemetery which located in the northwest direction of the Site and the NTSA.

Client:	Project:	FIGURE B3
Philip So & Associates Limited In association with CALVINT GEO-SERVICES LIMITED THE BEST SOLUTION FOR YOU	Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan	Location: Cape Collinson, Chai Wan Scale: NTS Date: 16 Feb 2024



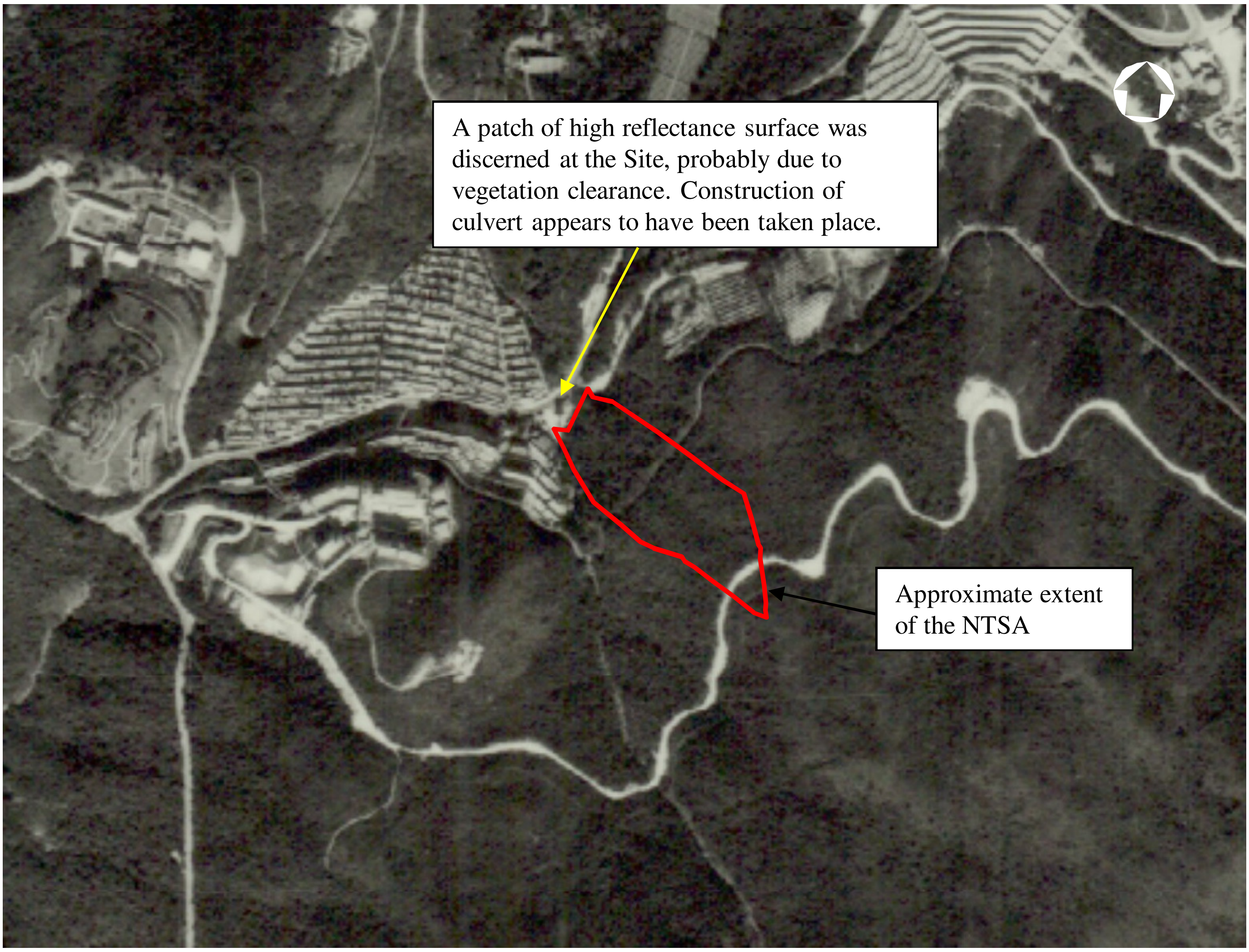
Photograph No.: 2291 **Date of Photograph: 3 Oct 1972** **Altitude: 13,000'**

Legend: Approximate Boundary of the NTSA

No observable significant change to the NTSA since 1967. No sign of distress can be discerned within the NTSA.

Several buildings of the Hong Kong Buddhist Cemetery were constructed adjacent to the west of the Site. Feature Nos. 11SE-D/C345, 11SE-D/R63 and 11SE-D/CR341 were formed probably in association with this construction.

Client:	Project:	FIGURE B4
Philip So & Associates Limited In association with Calvint Geo-Services Limited (The best solution for you)	Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan	Location: Cape Collinson, Chai Wan Scale: NTS Date: 16 Feb 2024



Photograph No.: 15841 **Date of Photograph: 4 Nov 1976** **Altitude: 12,500'**

Legend: Approximate Boundary of the NTSA

No observable significant change to the NTSA since 1975. No sign of distress can be discerned within the NTSA.

A general increase of vegetation density appears within the NTSA.

A patch of high reflectance surface was discerned at the Site, probably due to vegetation clearance. Construction of culvert appears to have been taken place at the northern portion of the Site.

Client: **Philip So & Associates Limited**

In association with CALVINT GEO-SERVICES LIMITED THE BEST SOLUTION FOR YOU

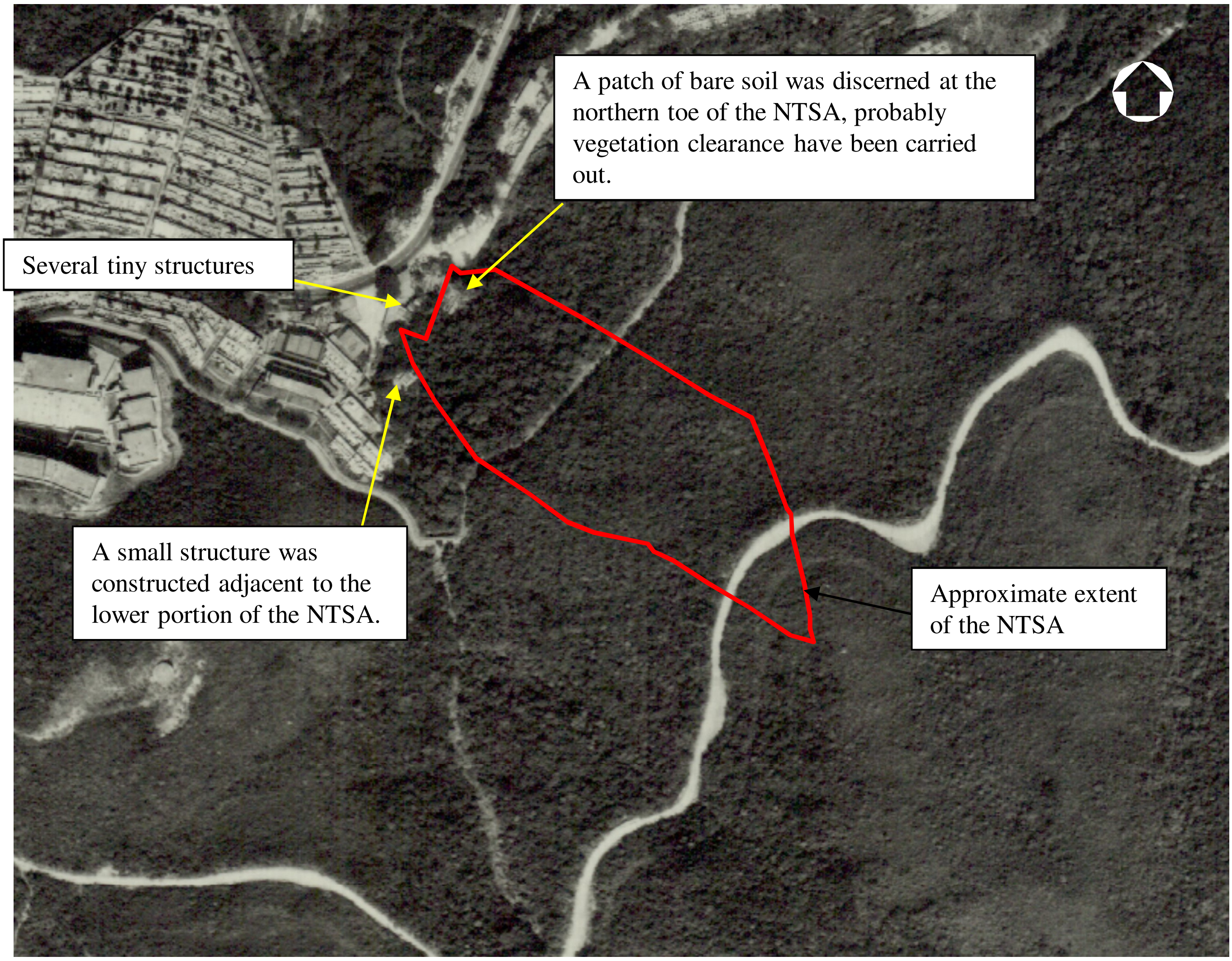
Project: Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan

FIGURE B5

Location: Cape Collinson, Chai Wan

Scale: NTS

Date: 16 Feb 2024



Photograph No.: 53753 **Date of Photograph: 2 Mar 1984** **Altitude: 4,000'**

Legend:

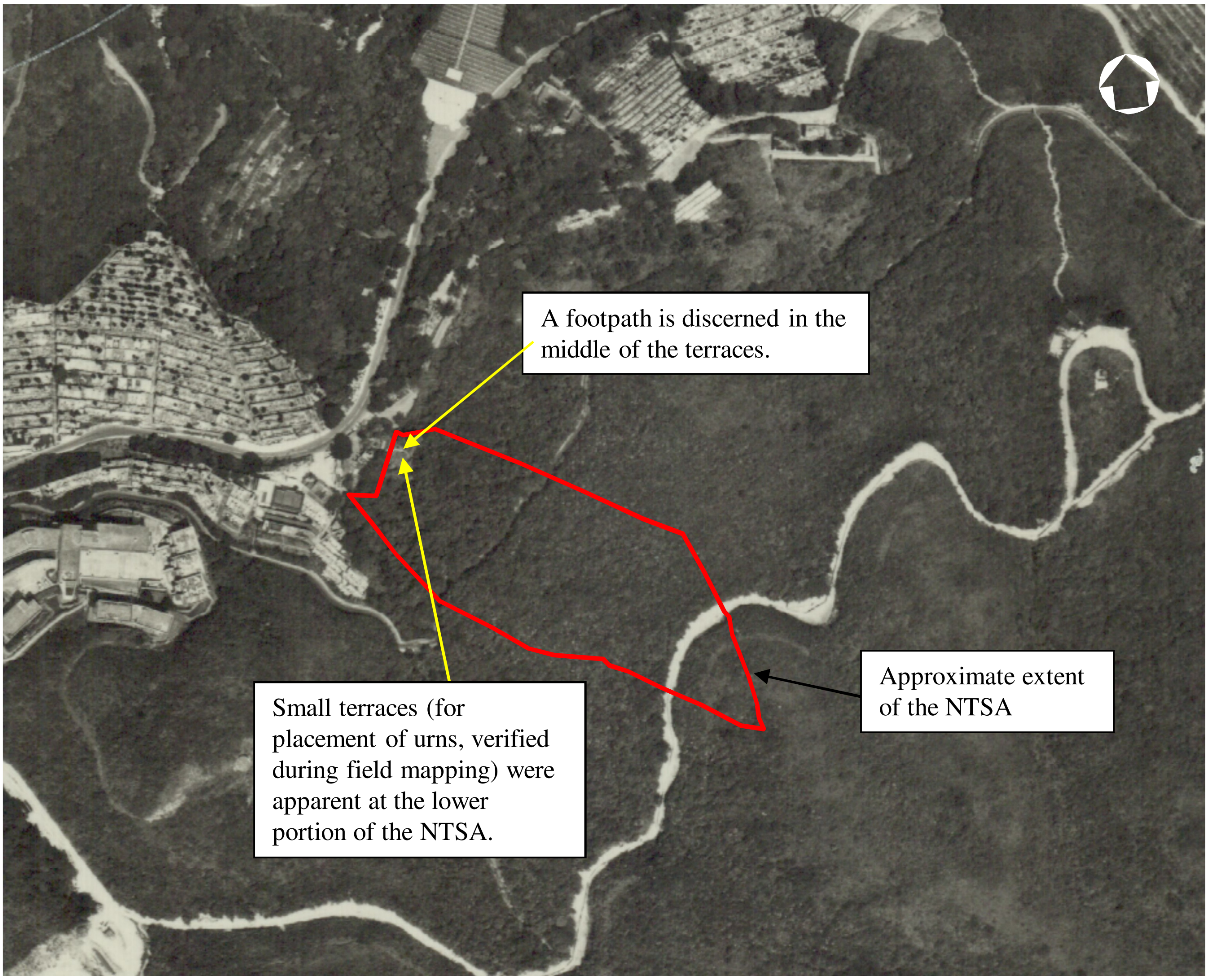
Approximate Boundary of the NTSA

A patch of bare soil was discerned at the northern toe of the NTSA, probably vegetation clearance and minor slope cutting works have been carried out.

Several tiny structures can be discerned within the Site area.

Another small structure was constructed adjacent to the lower portion of the NTSA.

Client: **Philip So & Associates Limited** In association with CALVINT GEO-SERVICES LIMITED THE BEST SOLUTION FOR YOU	Project: Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan	FIGURE B6 Location: Cape Collinson, Chai Wan Scale: NTS Date: 16 Feb 2024



Photograph No.: A10383 **Date of Photograph: 9 Sep 1987** **Altitude: 4,000'**

Legend:

Approximate Boundary of the NTSA

Small terraces (for placement of urns, verified during field mapping) were apparent at the lower portion of the NTSA.

A footpath is discerned in the middle of the terraces.

No sign of distress can be discerned within the NTSA.

Client:
Philip So & Associates Limited
In association with CALVINT GEO-SERVICES LIMITED THE BEST SOLUTION FOR YOU

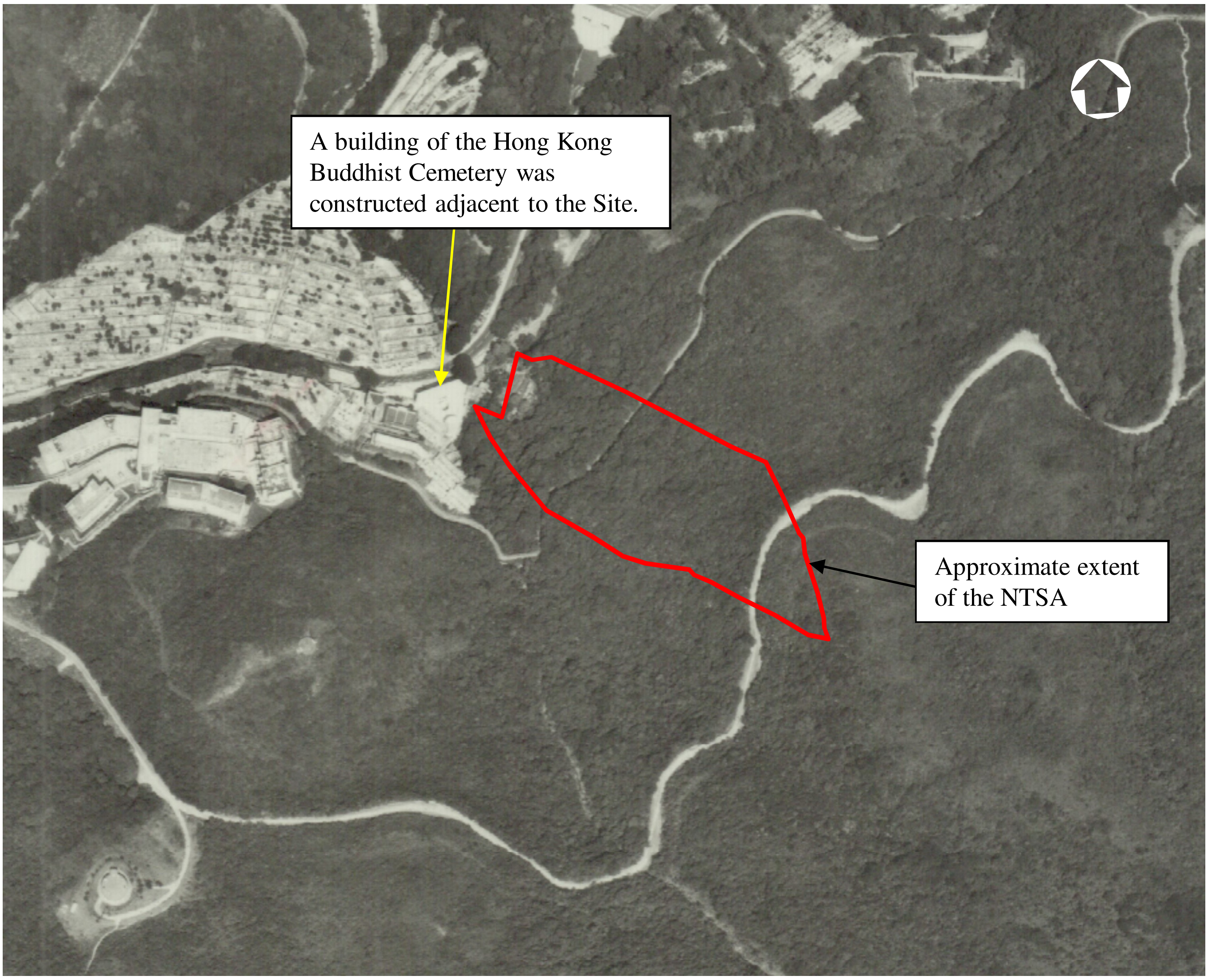
Project:
Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan

FIGURE B7

Location
Cape Collinson, Chai Wan

Scale NTS

Date 16 Feb 2024

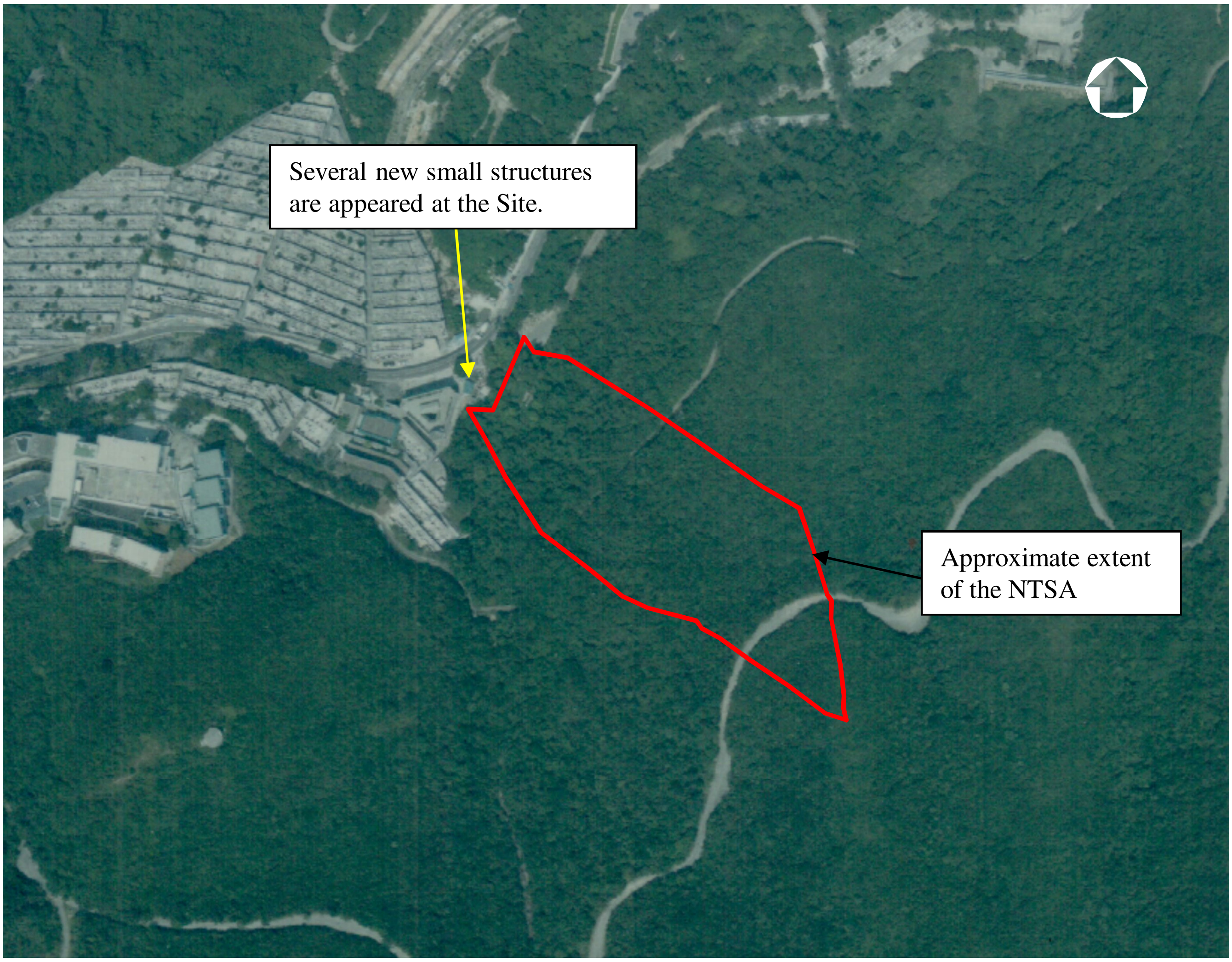


Photograph No.: A27930 **Date of Photograph: 4 Oct 1991** **Altitude: 4,000'**

Legend:

Approximate Boundary of the NTSA

Client: **Philip So & Associates Limited** In association with CALVINT GEO-SERVICES LIMITED THE BEST SOLUTION FOR YOU	Project: Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan	FIGURE B8 Location: Cape Collinson, Chai Wan Scale: NTS Date: 16 Feb 2024



Photograph No.: CN28307 **Date of Photograph: 16 Sep 2000** **Altitude: 4,000'**

Legend:

Approximate Boundary of the NTSA

Client:

Philip So & Associates Limited

In association with CALVINT GEO-SERVICES LIMITED THE BEST SOLUTION FOR YOU

Project:

Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan

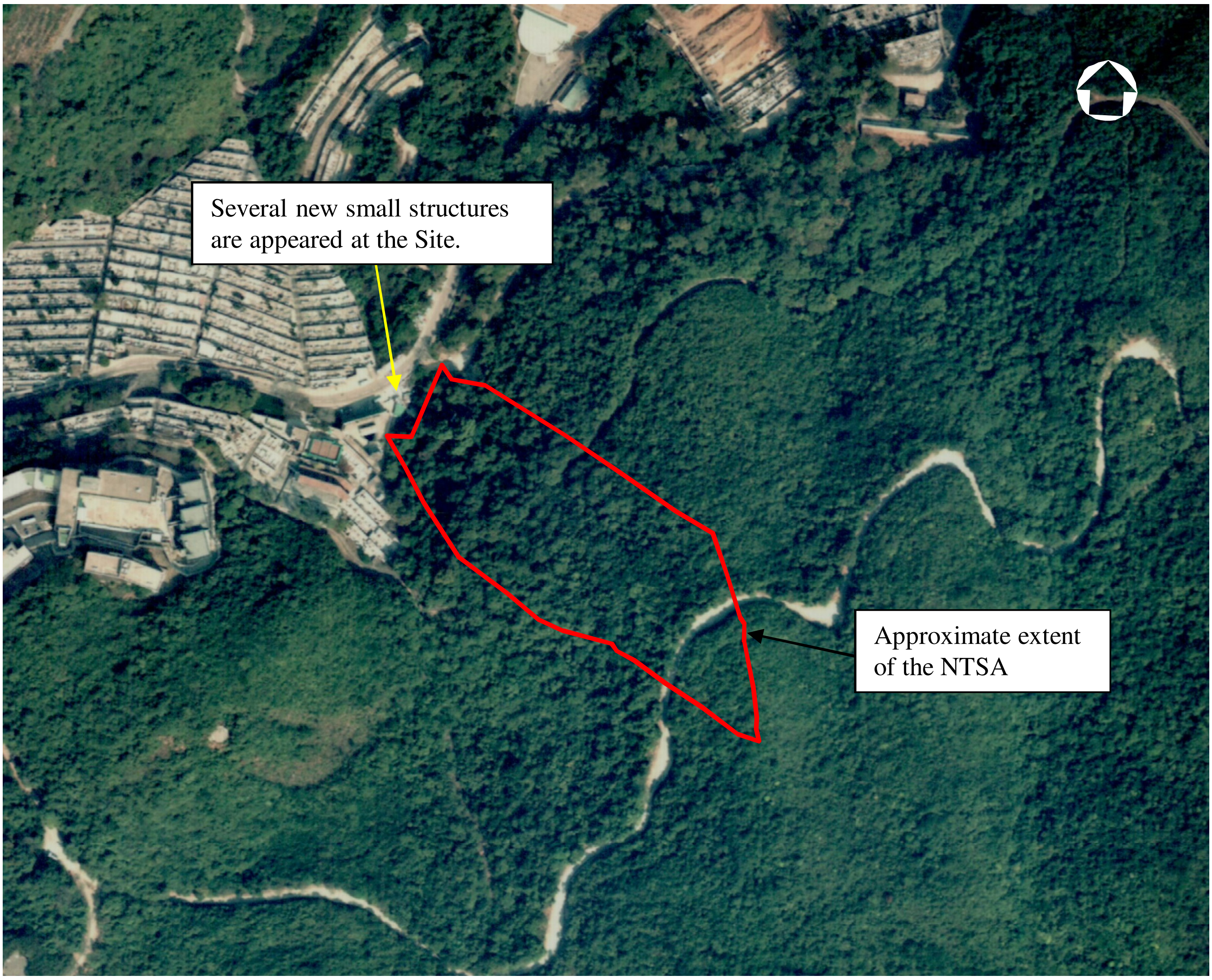
FIGURE B9

Location

Cape Collinson, Chai Wan

Scale NTS

Date 16 Feb 2024

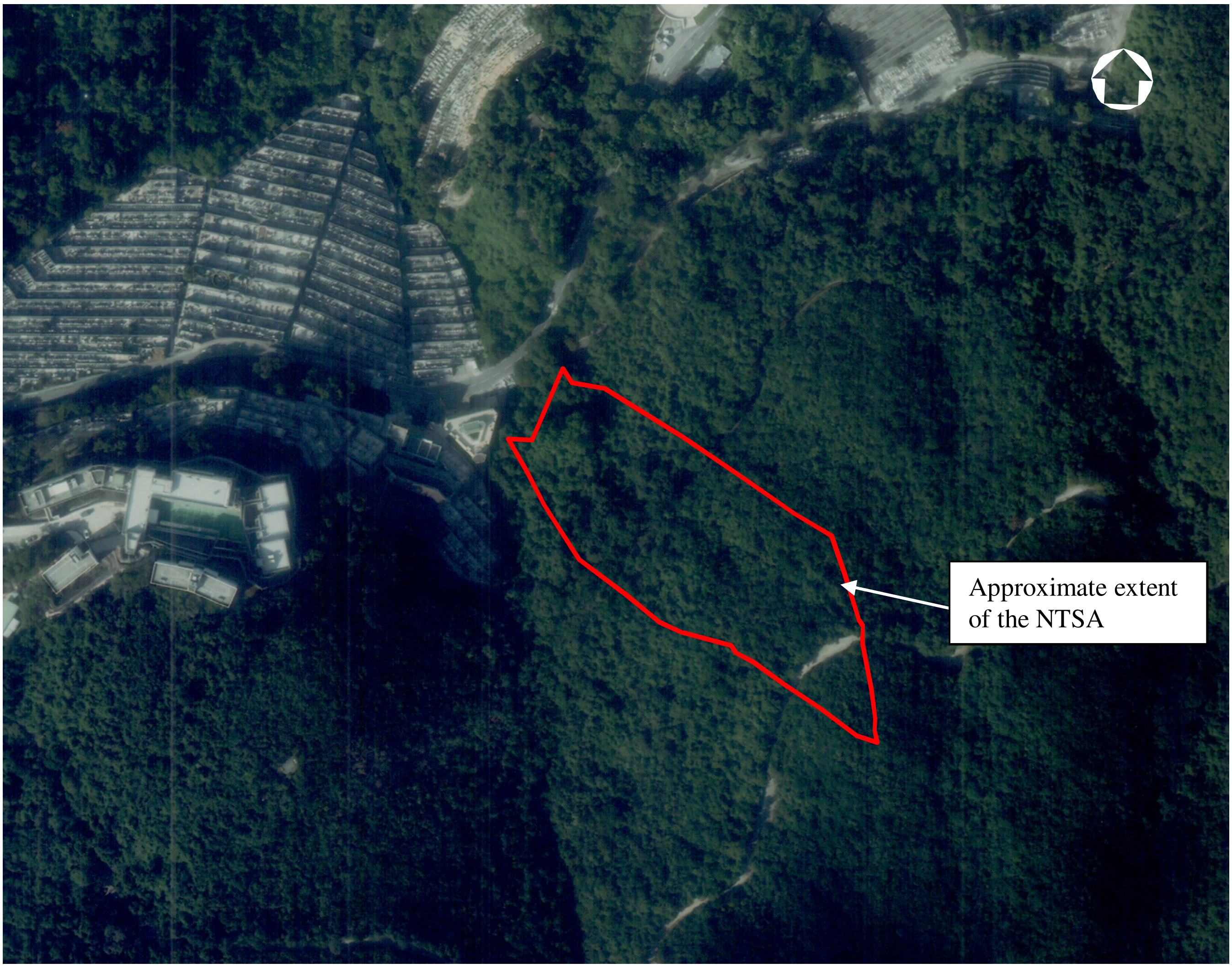


Photograph No.: CS11908 **Date of Photograph: 1 Mar 2008** **Altitude: 6,000'**

Legend:

Approximate Boundary of the NTSA

Client: **Philip So & Associates Limited** In association with CALVINT GEO-SERVICES LIMITED THE BEST SOLUTION FOR YOU	Project: Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan	FIGURE B10 Location: Cape Collinson, Chai Wan Scale: NTS Date: 16 Feb 2024



Photograph No.: E103700C **Date of Photograph: 27 Oct 2020** **Altitude: 6,900'**

Legend: Approximate Boundary of the NTSA

No observable significant change to the NTSA since 2008 until present.

Client:	Project:	FIGURE B11
Philip So & Associates Limited In association with CALVINT GEO-SERVICES LIMITED THE BEST SOLUTION FOR YOU	Natural Terrain Hazard Study for Proposed Columbarium Development for Extension to the Remaining Portion of Inland Lot No. 7755, Cape Collinson Road, Chai Wan	Location: Cape Collinson, Chai Wan Scale: NTS Date: 16 Feb 2024

Appendix C

Current Ground Investigation Records

r

Philip So & Associates Limited	PROJECT : **Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan**	LOGGED BY : **H.S.TSANG** DATE : **10/03/2024**	CO-ORDINATES : E **842250.30** N **813008.70**	GROUND LEVEL : **+208.90** m.P.D. EXCAVATION DATE : **10/03/2024** BACKFILL DATE : **10/03/2024**	TRIAL PIT NO : **IP1**
CONTRACT NO. :	WORKS ORDER NO. :				

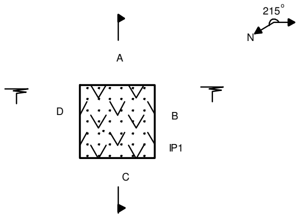
TRIAL PIT RECORD

Sketch: Face A : 0.5 m; Face B : 0.5 m; Face C : 0.5 m; Face D : 0.5 m

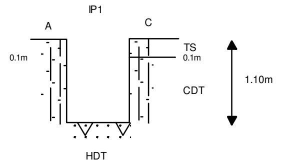
Samples & Tests	Depth (m)	Legend	Weathering Grade	Description
	0 – 0.10		-	Firm, dark grey, sandy SILT with some subangular fine to medium gravel sized rock fragments and occasional rootlets. (TOP SOIL)
	0.10 – 1.10		V	Extremely weak, reddish brown, mottled white, pink and orange, completely decomposed fine ash vitric TUFF. (Stiff, sandy SILT with many angular fine to medium gravel)
	1.10		IV	Weak, brown, mottled white and pink, highly decomposed fine ash vitric TUFF.
				End of Inspection Pit at 1.10m below existing ground.

Depth scale (m): 0, 1, 2, 3, 4, 5

PLAN



SECTION (NOT TO SCALE)



SYMBOL

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Sample Hori. ( )
- Undisturbed Sample Vert. ( )
- Block Sample
- Insitu Density Test
- Water Sample
- Schmidt Hammer Test
- Seepage

REMARKS

TRIAL PIT NO **IP1**

Philip So & Associates Limited	PROJECT : Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan	LOGGED BY : H.S.TSANG	CO-ORDINATES : E 842201.78 N 813046.16	GROUND LEVEL : +183.60 m.P.D.	TRIAL PIT NO : IP2
CONTRACT NO. :	WORKS ORDER NO. :	DATE : 10/03/2024		EXCAVATION DATE : 10/03/2024 BACKFILL DATE : 10/03/2024	

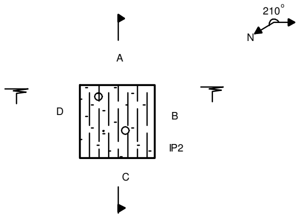
TRIAL PIT RECORD

Sketch: Face A : 0.5 m; Face B : 0.5 m; Face C : 0.5 m; Face D : 0.5 m

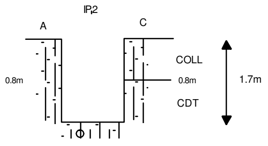
Samples & Tests	Depth (m)	Legend	Weathering Grade	Description
	0 – 0.80		-	Soft to firm, brown, sandy SILT with some subangular fine to coarse gravel sized rock fragments. (COLLUVIUM)
	0.80 – 1.70		V	Extremely weak, reddish brown, mottled white and red, completely decomposed fine ash vitric TUFF. (Stiff, slightly sandy SILT with some subangular fine to medium gravel)
	1.70			End of Inspection Pit at 1.70m below existing ground.

Depth scale: 0, 1, 2, 3, 4, 5

PLAN



SECTION (NOT TO SCALE)



SYMBOL

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Sample Hori. ( )
- Undisturbed Sample Vert. ( )
- Block Sample
- Insitu Density Test
- Water Sample
- Schmidt Hammer Test
- Seepage

REMARKS

TRIAL PIT NO IP2

Philip So & Associates Limited	PROJECT : **Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan**	LOGGED BY : **H.S.TSANG** DATE : **10/03/2024**	CO-ORDINATES : E **842177.52** N **813087.89**	GROUND LEVEL : **+161.00** m.P.D. EXCAVATION DATE : **10/03/2024** BACKFILL DATE : **10/03/2024**	TRIAL PIT NO : **IP3**
CONTRACT NO. :	WORKS ORDER NO. :				

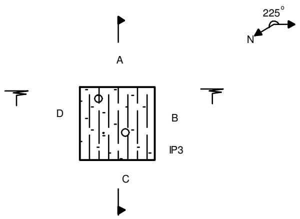
Sketch: Face A : 0.5 m; Face B : 0.5 m; Face C : 0.5 m; Face D : 0.5 m

Samples & Tests	Depth (m)	Legend	Weathering Grade	Description
	0 – 1		-	Firm, brown, sandy SILT with many subangular fine to coarse gravel sized rock fragments. (COLLUVIUM)
	1 – 1.80		V	Extremely weak, light pink, mottled white and brown, completely decomposed fine ash vitric TUFF. (Stiff, slightly sandy SILT with some angular to subangular fine to medium gravel)
	1.80			End of Inspection Pit at 1.80m below existing ground.

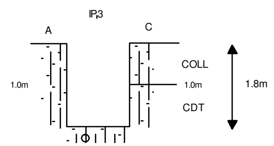
Depth scale (m): 0, 1, 1.80, 2, 3, 4, 5

TRIAL PIT RECORD

PLAN



SECTION (NOT TO SCALE)



SYMBOL

- ● Small Disturbed Sample
- Large Disturbed Sample
- ▭ Undisturbed Sample Hori. ( )
- ▯ Undisturbed Sample Vert. ( )
- ▨ Block Sample
- Insitu Density Test
- △ Water Sample
- ▼ Schmidt Hammer Test
- Seepage

REMARKS

TRIAL PIT NO IP3

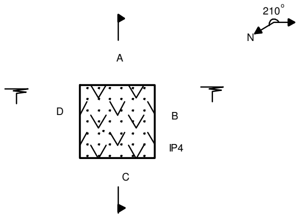
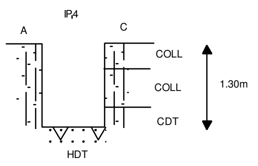
TRIAL PIT RECORD

Philip So & Associates Limited CONTRACT NO. :	PROJECT : **Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan** WORKS ORDER NO. :	LOGGED BY : **H.S.TSANG** DATE : **10/03/2024**	CO-ORDINATES : E **842112.78** N **813118.30**	GROUND LEVEL : **+126.20** m.P.D. EXCAVATION DATE : **10/03/2024** BACKFILL DATE : **10/03/2024**	TRIAL PIT NO : **IP4**

Sketch: Face A : 0.5 m; Face B : 0.5 m; Face C : 0.5 m; Face D : 0.5 m

Samples & Tests	Depth (m)	Legend	Weathering Grade	Description
	0 – 0.30		-	Firm, dark brownish grey, sandy SILT with some subangular fine gravel sized rock fragments and occasional rootlets. (COLLUVIUM-disturbed for terraces?)
	0.30 – 1.10		-	Firm, brown, dappled grey, sandy SILT with many subangular fine to coarse gravel sized rock fragments. (COLLUVIUM)
	1.10 – 1.30		V	Extremely weak, light brown, mottled white, completely decomposed fine ash vitric TUFF. (Stiff, slightly sandy SILT with some angular to subangular fine to medium gravel)
	1.30		IV	Weak, light brown, mottled white, highly decomposed fine ash vitric TUFF.
				End of Inspection Pit at 1.30m below existing ground.

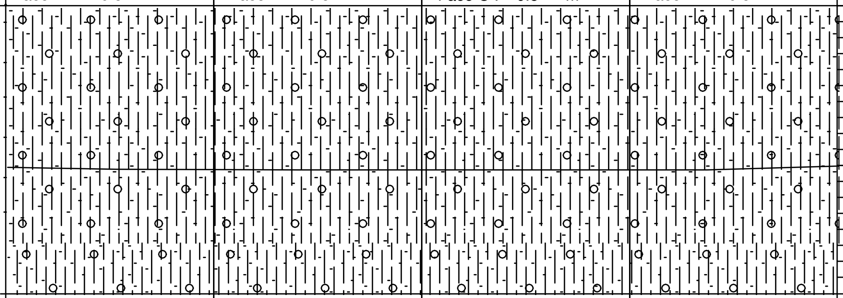
Depth scale: 0, 1, 2, 3, 4, 5

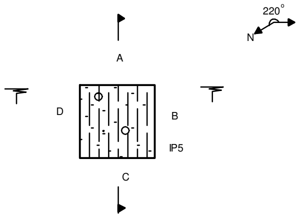
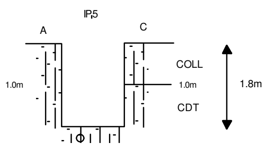
PLAN	SECTION (NOT TO SCALE)	SYMBOL	REMARKS
		● Small Disturbed Sample Large Disturbed Sample Undisturbed Sample Hori. ( ) Undisturbed Sample Vert. ( ) Block Sample Insitu Density Test △ Water Sample Schmidt Hammer Test Seepage	

TRIAL PIT NO **IP4**

Philip So & Associates Limited	PROJECT : Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan	LOGGED BY : H.S.TSANG DATE : 10/03/2024	CO-ORDINATES : E 842124.73 N 813099.61	GROUND LEVEL : +136.40 m.P.D. EXCAVATION DATE : 10/03/2024 BACKFILL DATE : 10/03/2024	TRIAL PIT NO : **IP5**
CONTRACT NO. :	WORKS ORDER NO. :				

TRIAL PIT RECORD

Samples & Tests	Depth (m)	Sketch: Face A : 0.5 m / Face B : 0.5 m / Face C : 0.5 m / Face D : 0.5 m	Depth (m)	Legend	Weathering Grade	Description
	0		0		-	Firm, brown, dappled grey, sandy SILT with some subangular fine to coarse gravel sized rock fragments. (COLLUVIUM)
	1		1		V	Extremely weak, yellowish brown, mottled white, completely decomposed fine ash vitric TUFF. (Stiff, slightly sandy SILT with some subangular fine to medium gravel)
	1.80		1.80			End of Inspection Pit at 1.80m below existing ground.
	2		2			
	3		3			
	4		4			
	5		5			

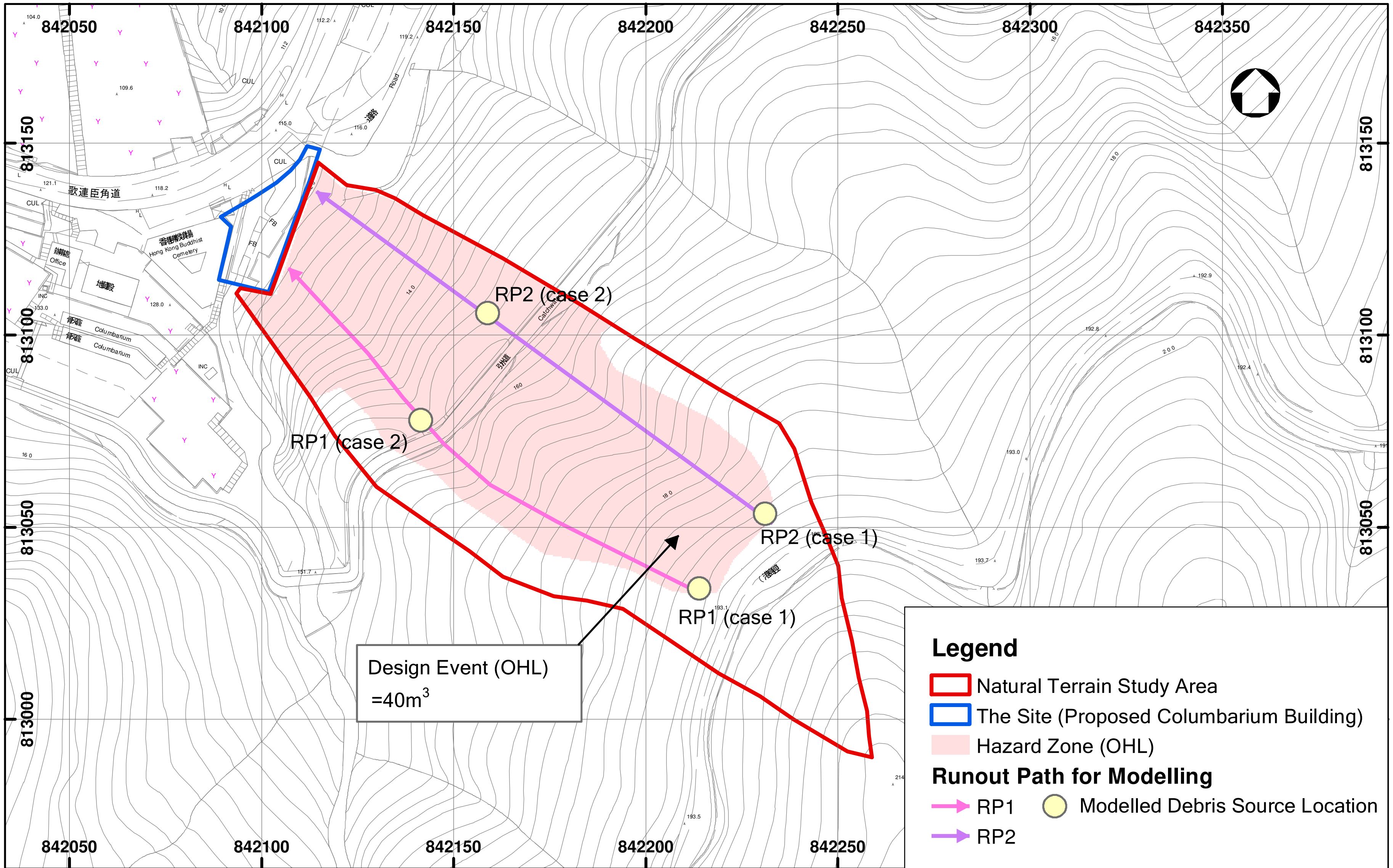
PLAN	SECTION (NOT TO SCALE)	SYMBOL	REMARKS
		● Small Disturbed Sample Large Disturbed Sample ▭ Undisturbed Sample Hori. ( ) ▯ Undisturbed Sample Vert. ( ) ▨ Block Sample Insitu Density Test △ Water Sample ▼ Schmidt Hammer Test Seepage	

TRIAL PIT NO **IP5**

Appendix D

Debris Mobility Analysis

r



PROJECT:	**Natural Terrain Hazard Study for Proposed Columbarium Development at Part of IL 7755 RP and Government Land sandwiched between IL 7755 RP and IL 7713, Cape Collinson Road, Chai Wan**

TITLE: Runout Paths for Debris Mobility Analysis	**SCALE:** 1 : 1500	**Philip So & Associates Limited** In associaton with Calvint Geo-Services Limited	**FIGURE NO :** FIGURE D1

D1. Introduction

The debris mobility assessment for the NTSA was performed by a computer programme, DAN-W developed by O. Hungr Geotechnical Research Inc.

D2. Debris mobility analysis for the NTSA

D2.1 Credible runout path

Based on the location of probable landslide source area, a steepest path (credible debris runout path) is generated from the topographic map using ArcGIS (Figure D1).

D2.2 Input parameters

The initial source volume is based on the Design Event Source Volume = 40m^3. The width of the modelled landslide mass is assumed to be 12m (RL1) and 10m (RL2) by reference to the landslide data obtained from the landslide records within the NTSA based on field mapping. The input parameters for the analysis are summarized below table:

Input parameters	Value	Remark & References
Rheological Model	Friction (For OHL)	GEO Report No.104, TGN 34
Apparent Angle of Friction	25° (For OHL)	TGN34
Turbulence Coefficient	-	-
Unit Weight of Debris	22kN/m^3	Based on DN 1/2012, assuming debris will comprise colluvium and residual soil

D3. Result of the analysis

Results of the analysis is shown in Figure D2 to D5 and summarized in below table:

Terrain Unit	Runout Path No.	Source Volume (m^3)	Analytical Model	Apparent Friction Angle, φ_a	Travel Distance (m)	Landslide Debris Reaching the Site boundary	Max. Debris Velocity at the Site Boundary (m/s)
Middle slope	RP1 (Case 1)	40.62	Friction	25° (OHL)	30.97	No	-
	RP1 (Case 2)	40.47	Friction	25° (OHL)	63.74	Yes	3.90
	RP2 (Case 1)	40.47	Friction	25° (OHL)	57.18	No	-
	RP2 (Case 2)	40.61	Friction	25° (OHL)	66.13	Yes	5.40

The result indicated that the debris on credible flow paths RP1 (Case 1) and RP2 (Case 1) would not reach the Site boundary, but Case 2 for both credible flow paths RP1 and RP2 modelled below the Catchwater would reach the Site boundary although most of the debris will deposit at the lower portion of the NTSA. Debris of the RP1 (Case 2) could reach the Site boundary at a maximum velocity of 3.90 m/s whilst debris of the RP2 (Case 2) could reach the Site boundary at a maximum velocity of 5.40 m/s.

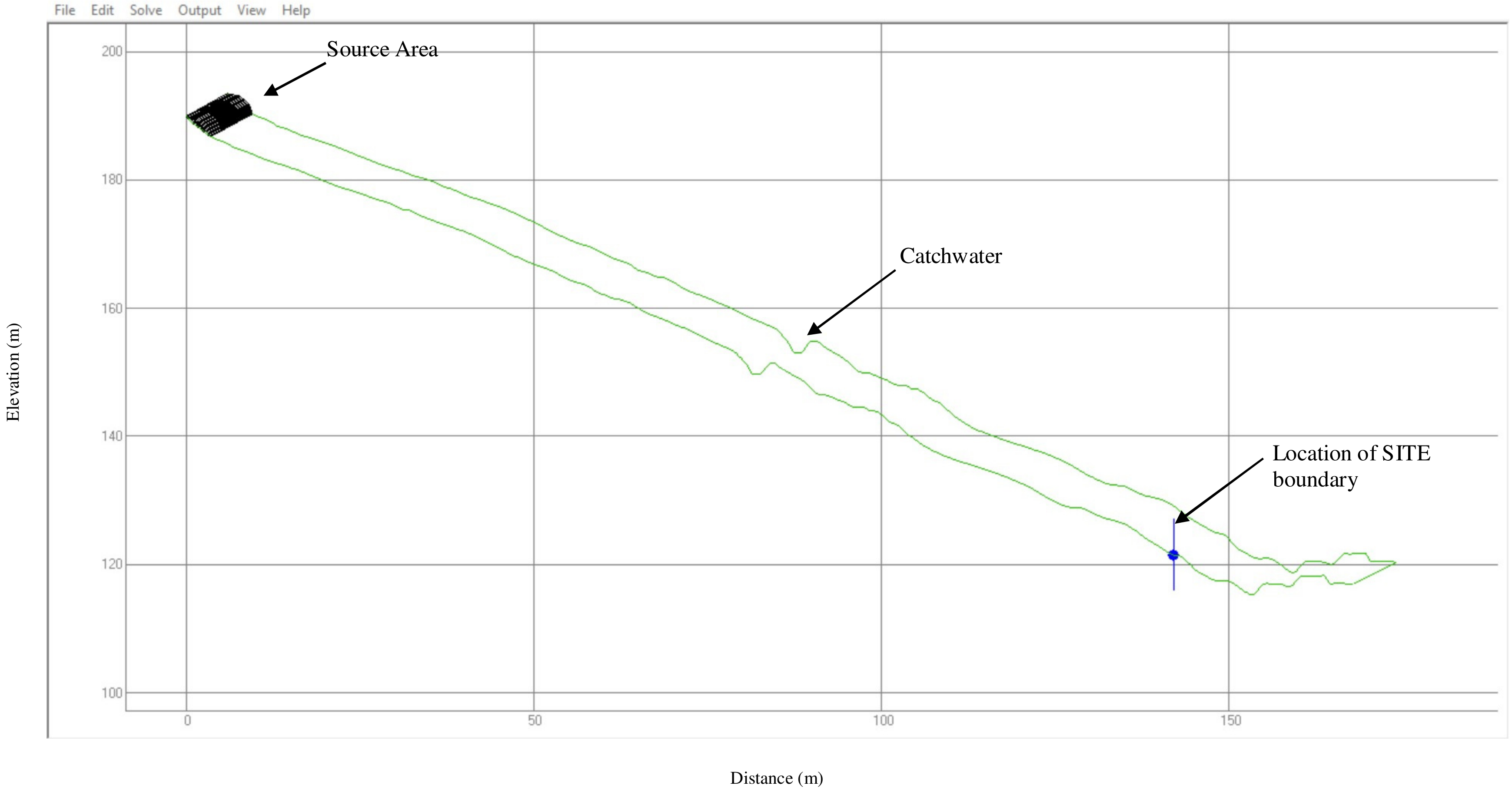
Debris Mobility Analysis for the Credible Runout Path RP1 (Case 1)

Landslide Type = OHL

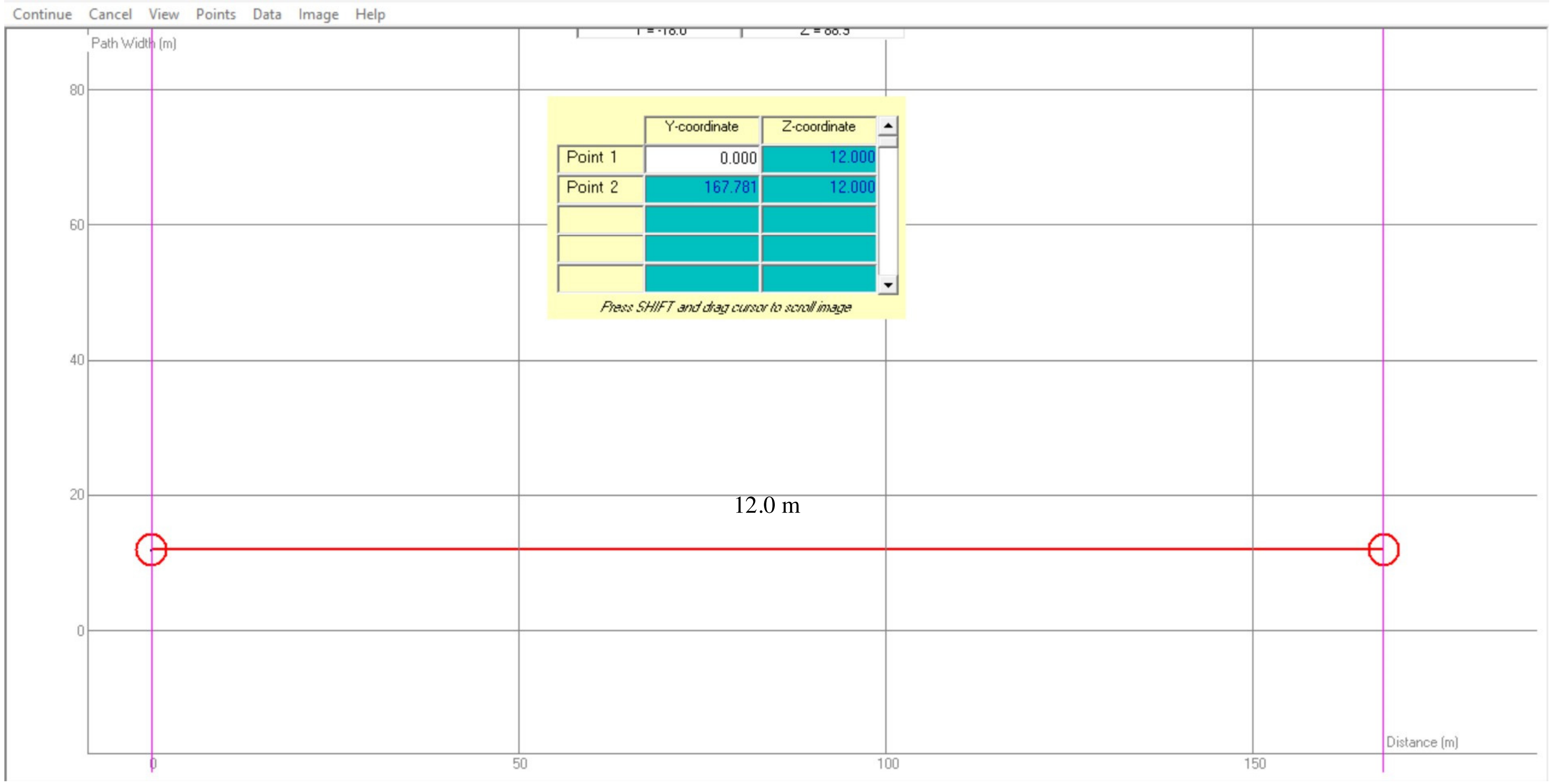
Design Source Volume = 40m^3

Figure D2

Section Profile – (pre-sliding)



Width Profile



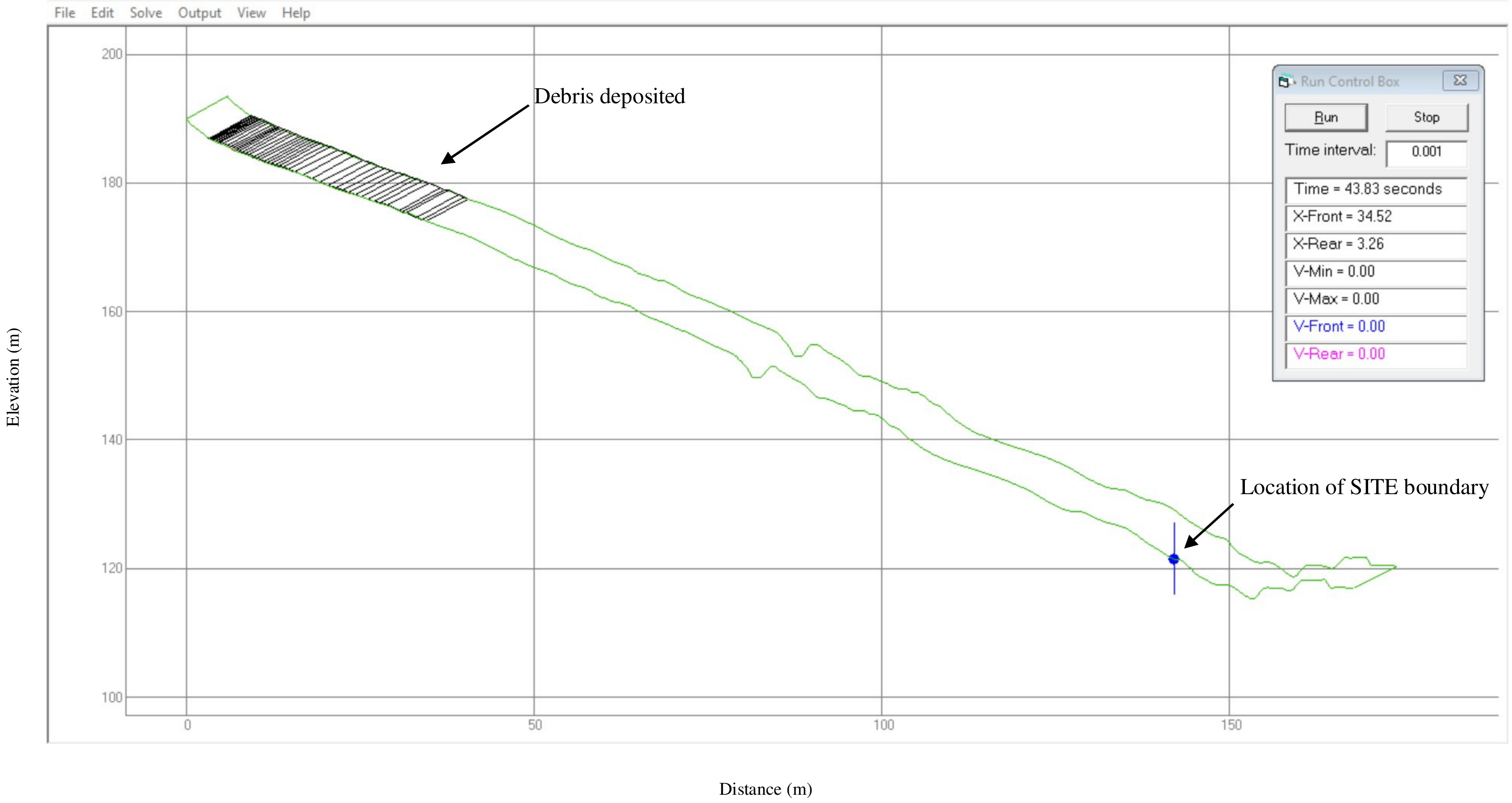
Path Width (m)

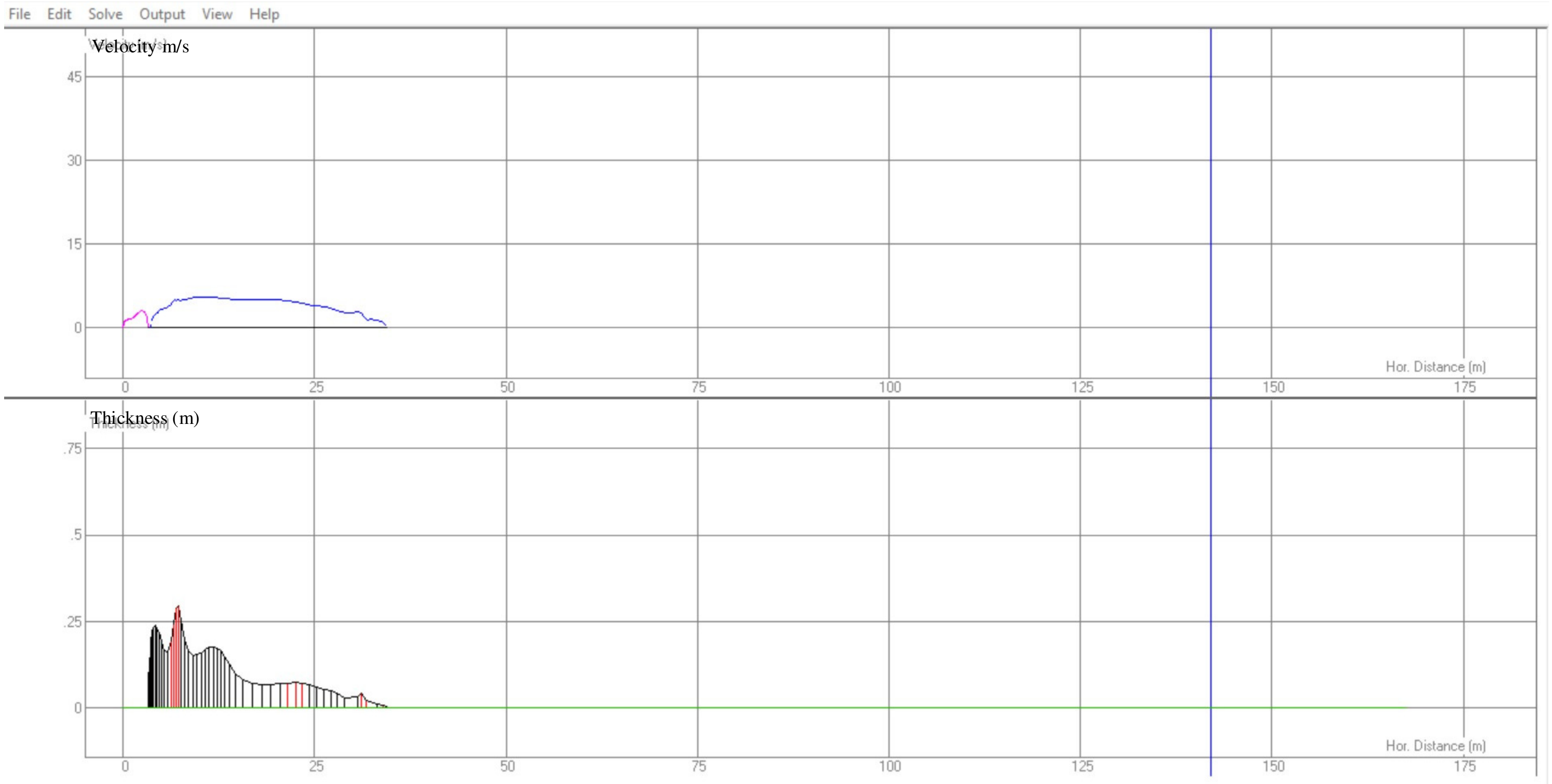
Distance (m)

Result of Debris Mobility Analysis

Source Volume (m^3)	Final Volume (m^3)	Travel Distance (m)	Debris Reached Proposed SITE Boundary
40.62	40.62	30.97	No

Section Profile – (post-sliding)





File Edit Solve Output View Help
Velocity m/s
45
30
15
0
Hor. Distance (m)
0
25
50
75
100
125
150
175
Thickness (m)
.75
.5
.25
0
Hor. Distance (m)
0
25
50
75
100
125
150
175

Distance (m)

No of Blocks = 50

Time step = 0.001 seconds

End at time = 0.00 seconds

Configuration = 3-dimensional

Boundary Block Geometry = Normal

Shape factor = 1.00

Maximum velocity = 5.56 at X = 10.56

Maximum front velocity = 5.56 at X =10.56

CENTRE OF GRAVITY: X-Source = 1.91

Z-Source = 188.67

X-Depos. = 13.10

Z-Depos. = 182.76

CG Ratio = 0.53

Travel angle = 27.85

FAHRBOSCHUNG = 24.74

FRONT DISPLACEMENT: X = 34.525 Z = 174.094

Curvilinear Displ.= 33.575

Horiz. Displ. = 30.97

REAR DISPLACEMENT: X = 3.26 Z = 186.99

Curvilinear Displ.= 4.46

Horiz. Displ. = 3.26

SLIDE VOLUME: Initial = 40.62

Final = 40.62

AREA IN PLAN: Initial = 42.70

Final = 375.15

Runout not completed, V-MAX = 0.00

Export Print Close Help

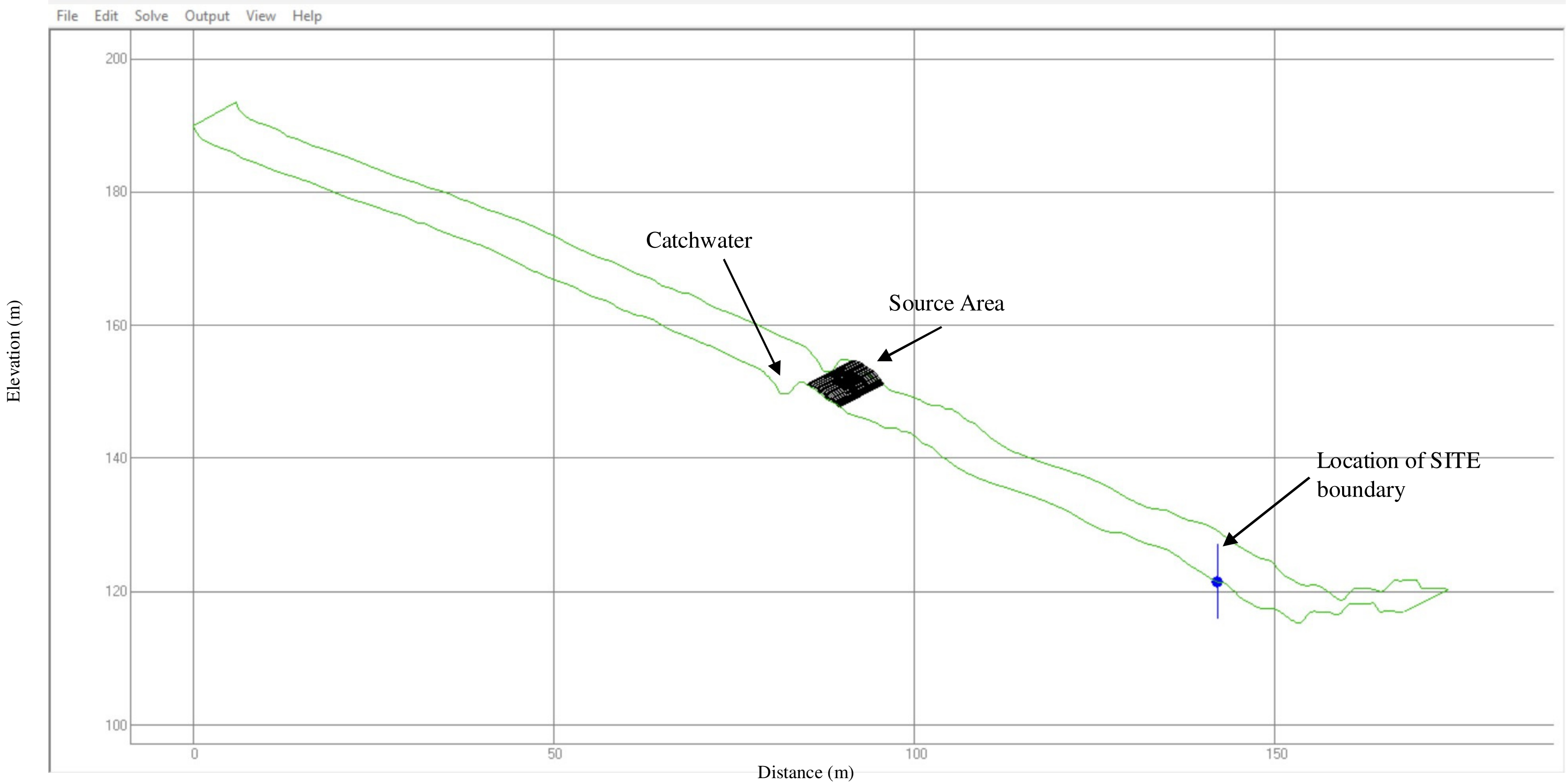
Debris Mobility Analysis for the Credible Runout Path RP1 (Case 2)

Landslide Type = OHL

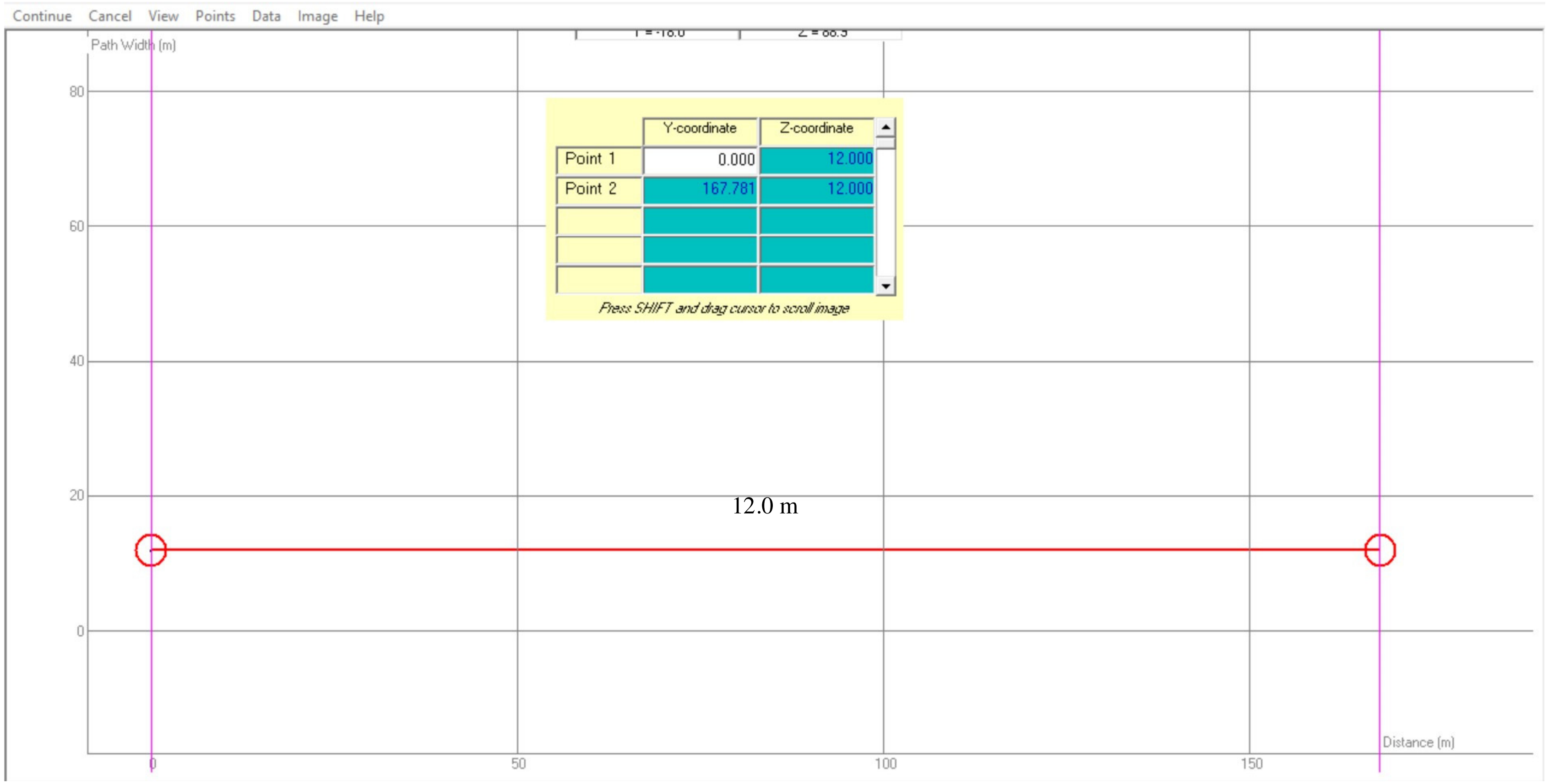
Design Source Volume = 40m^3

Figure D3

Section Profile – (pre-sliding)



Width Profile



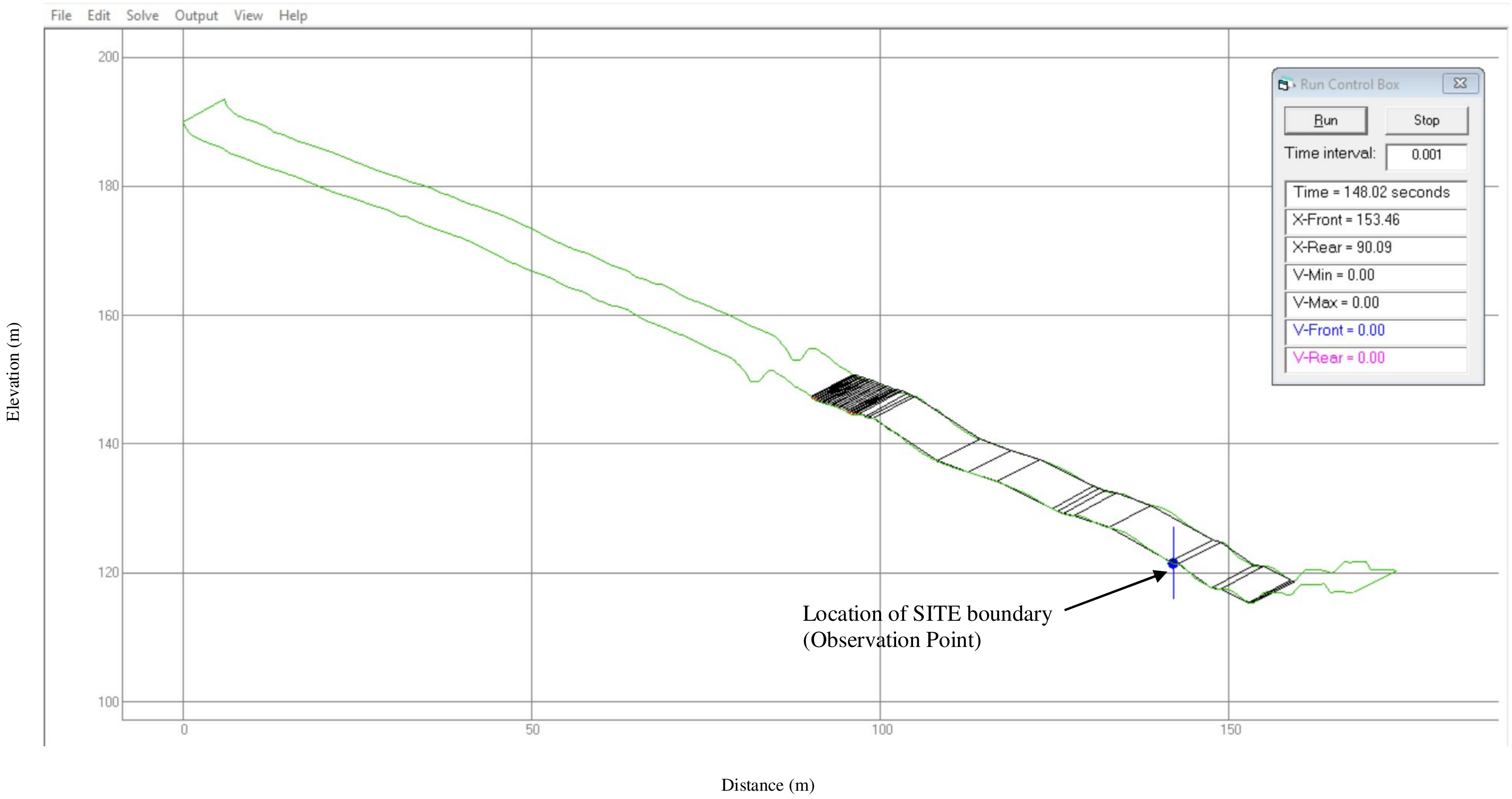
Path Width (m)

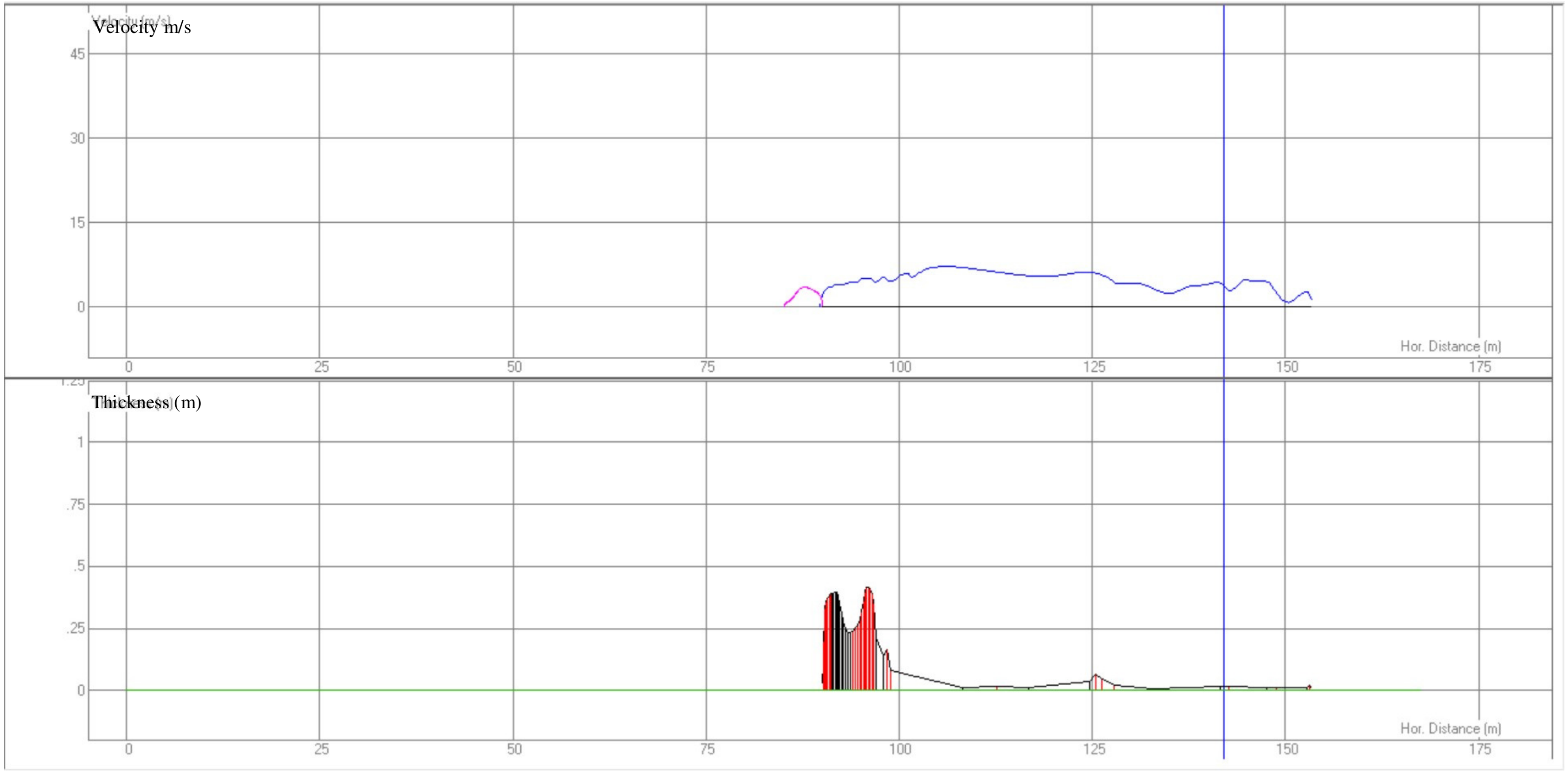
Distance (m)

Result of Debris Mobility Analysis

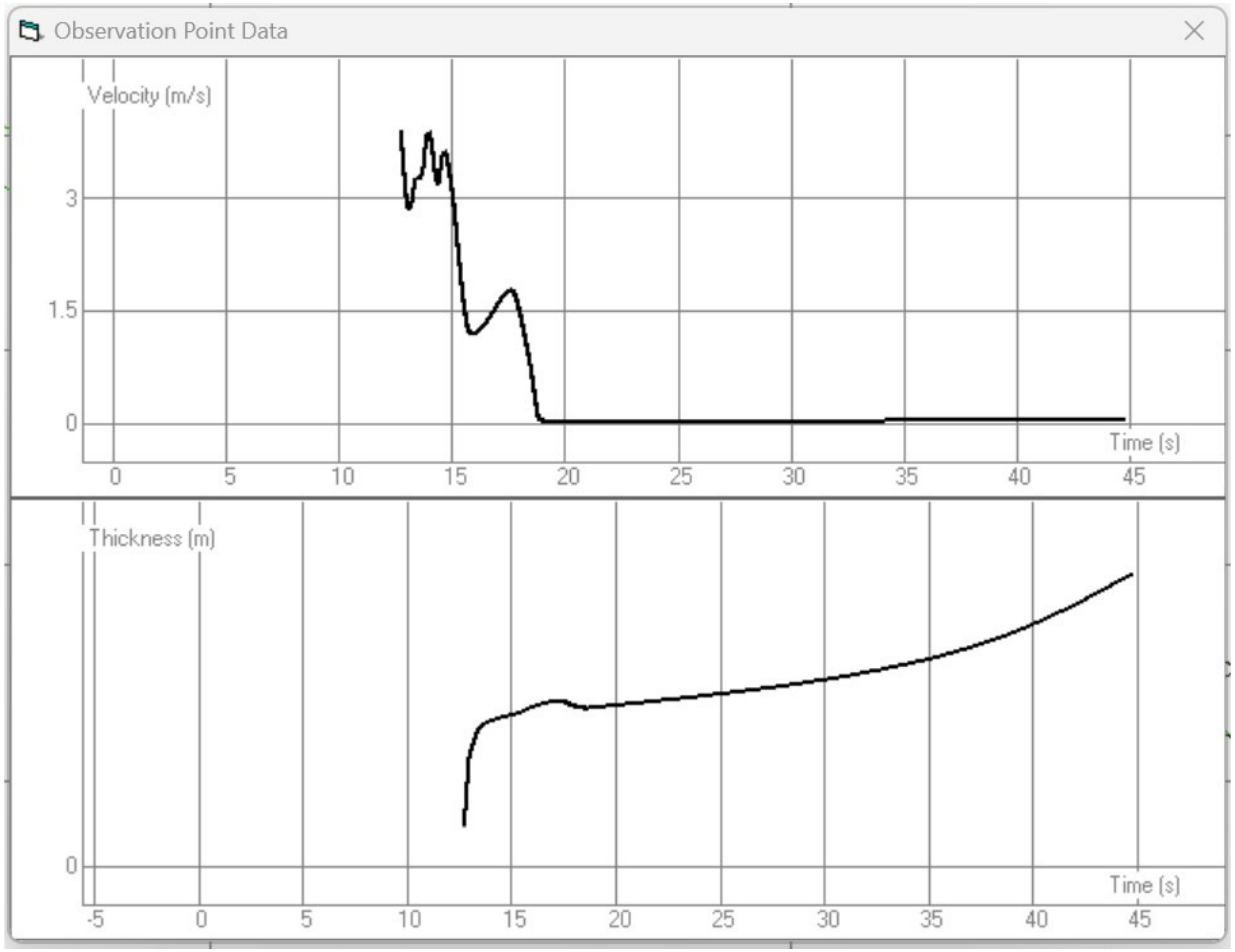
Source Volume (m^3)	Final Volume (m^3)	Travel Distance (m)	Debris Reached Proposed SITE Boundary	Max. Debris Velocity at the SITE Boundary (m/s)
40.47	40.47	63.74	Yes	3.90

Section Profile – (post-sliding)




Velocity m/s
45
30
15
0
Hor. Distance (m)
0
25
50
75
100
125
150
175
Thickness (m)
1
.75
.5
.25
0
Hor. Distance (m)
0
25
50
75
100
125
150
175

Distance (m)



Observation Point Data
Velocity (m/s)
3
1.5
0
Time (s)
0
5
10
15
20
25
30
35
40
45
Thickness (m)
0
Time (s)
-5
0
5
10
15
20
25
30
35
40
45

No of Blocks = 50

Time step = 0.001 seconds

End at time = 0.00 seconds

Configuration = 3-dimensional

Boundary Block Geometry = Normal

Shape factor = 1.00

Maximum velocity = 7.21 at X = 106.07

Maximum front velocity = 7.21 at X =106.07

CENTRE OF GRAVITY: X-Source = 87.47

Z-Source = 149.74

X-Depos. = 99.51

Z-Depos. = 142.91

CG Ratio = 0.57

Travel angle = 29.57

FAHRBOSCHUNG = 27.63

FRONT DISPLACEMENT: X = 153.465 Z = 115.315

Curvilinear Displ.= 72.960

Horiz. Displ. = 63.74

REAR DISPLACEMENT: X = 90.09 Z = 147.32

Curvilinear Displ.= 6.24

Horiz. Displ. = 4.95

SLIDE VOLUME: Initial = 40.47

Final = 40.47

AREA IN PLAN: Initial = 55.00

Final = 760.44

Runout not completed, V-MAX = 0.00

Export Print Close Help

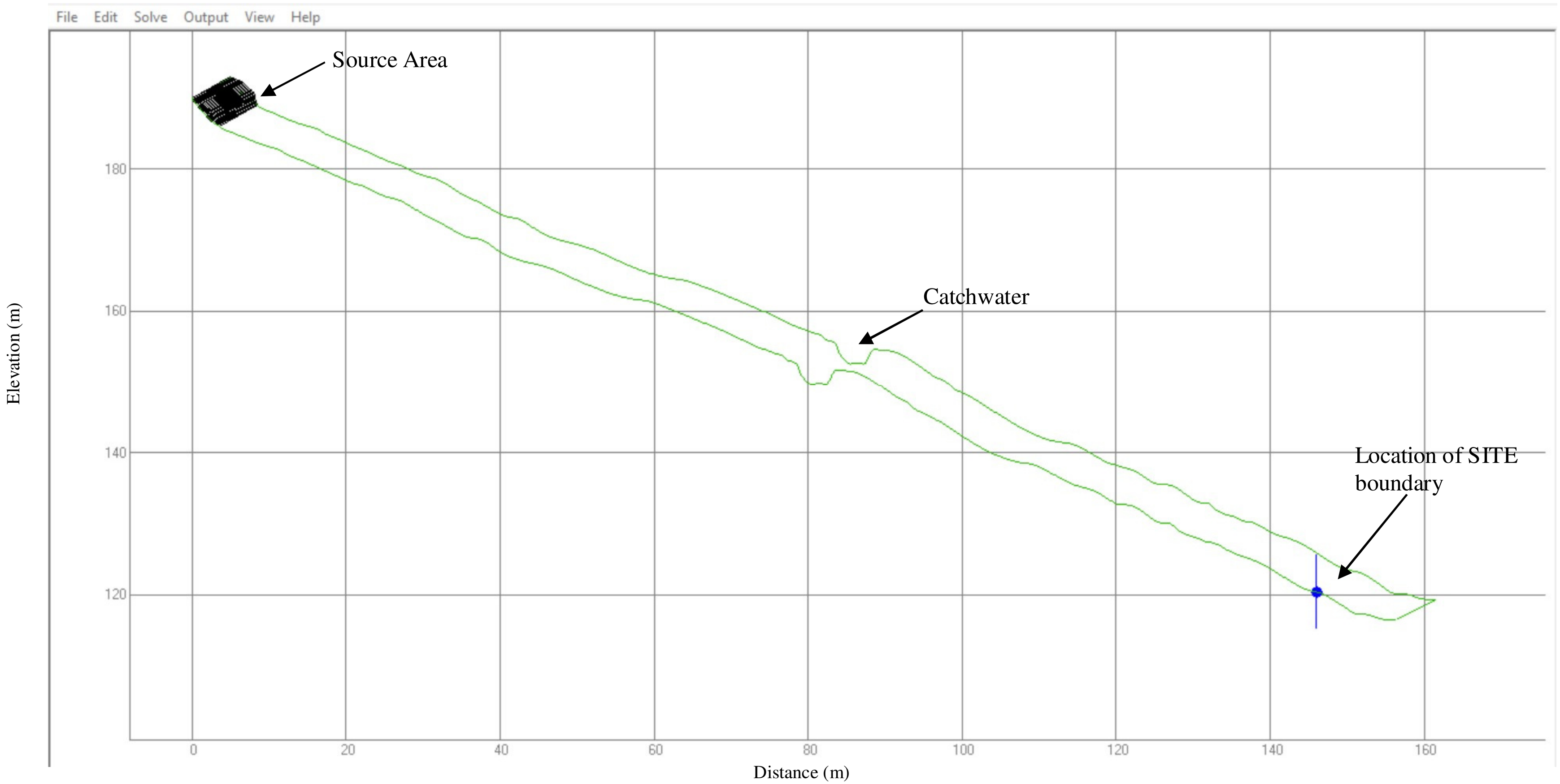
Debris Mobility Analysis for the Credible Runout Path RP2 (Case 1)

Landslide Type = OHL

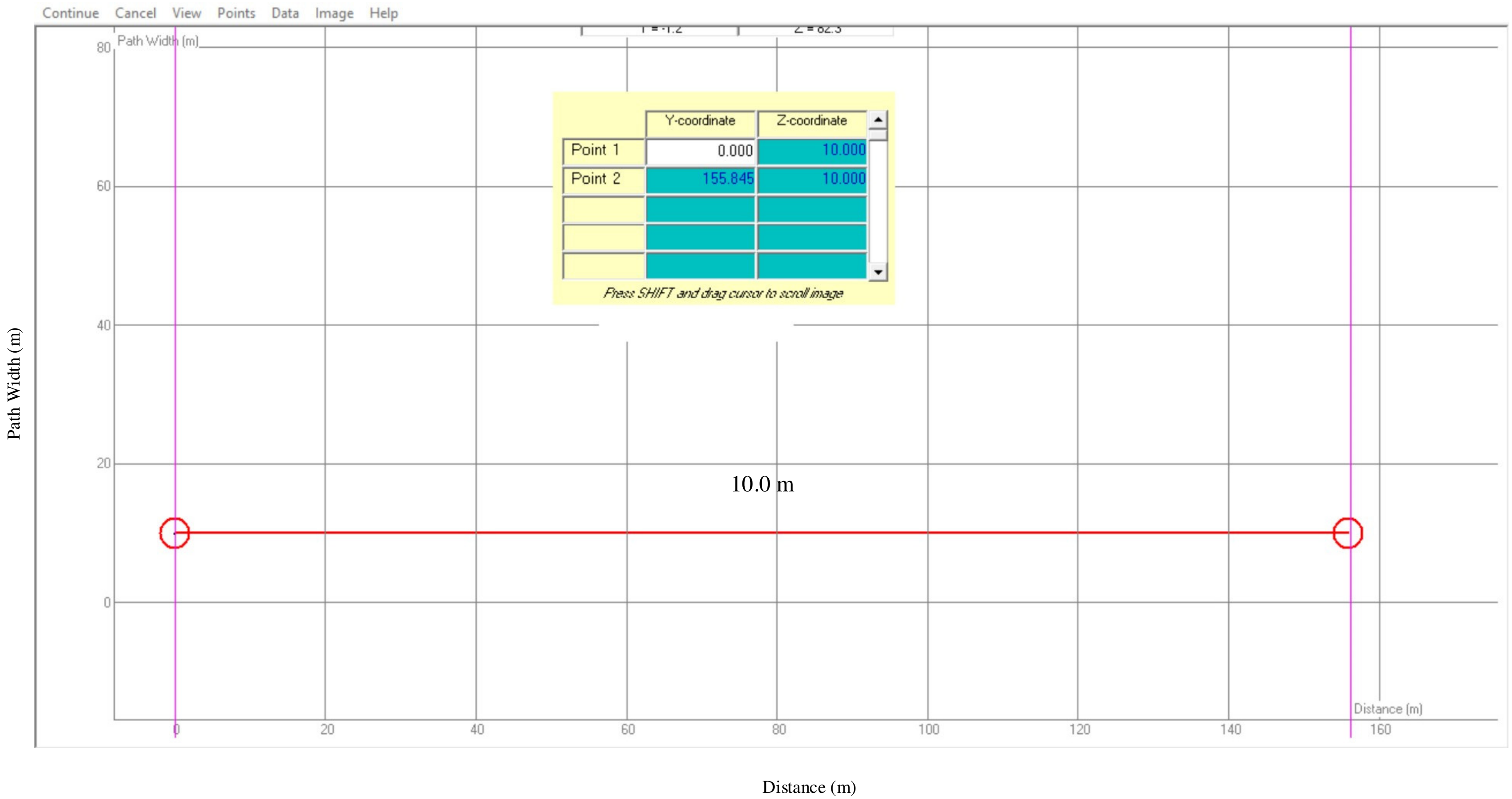
Design Source Volume = 40m^3

Figure D4

Section Profile – (pre-sliding)



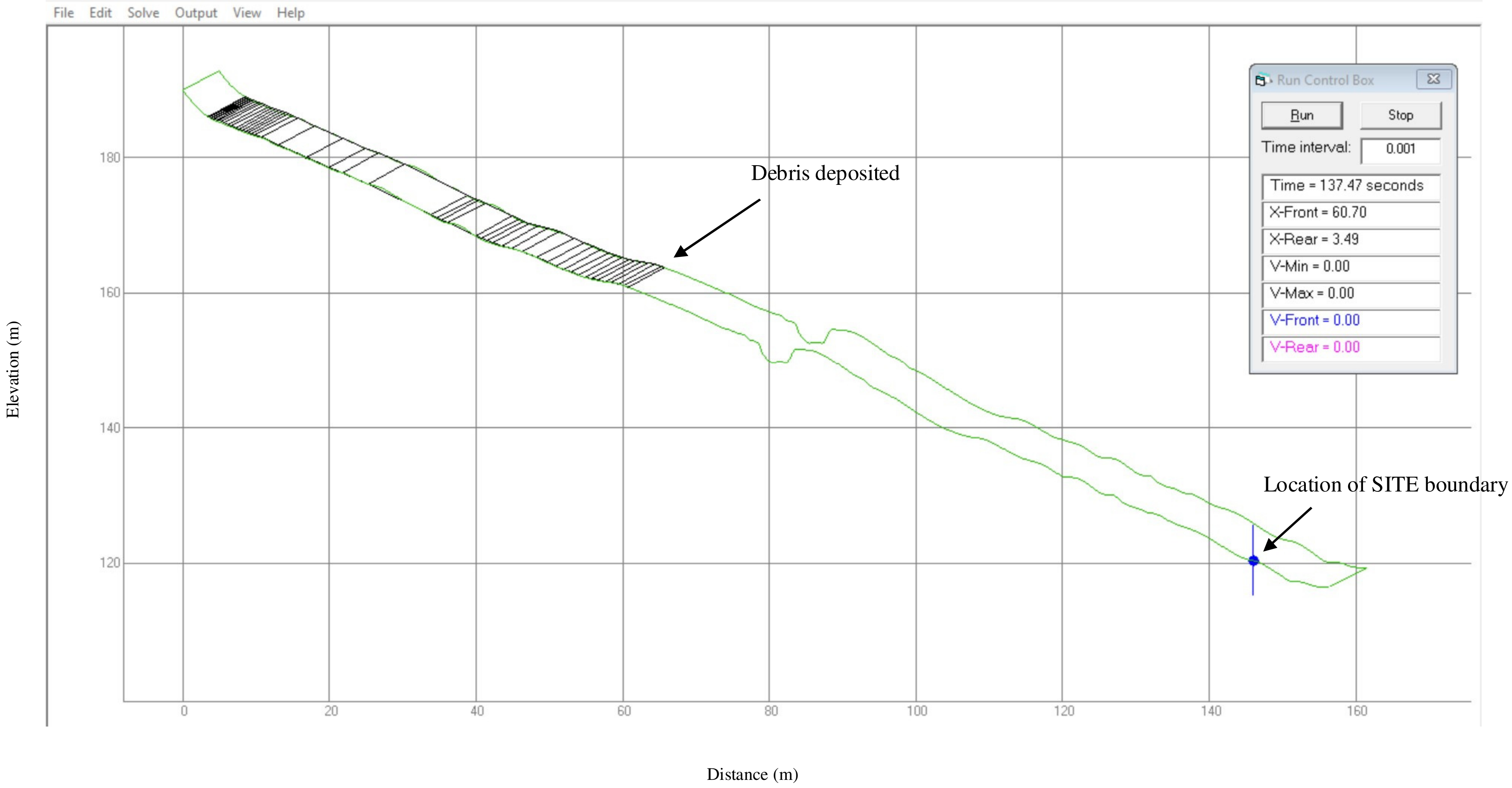
Width Profile

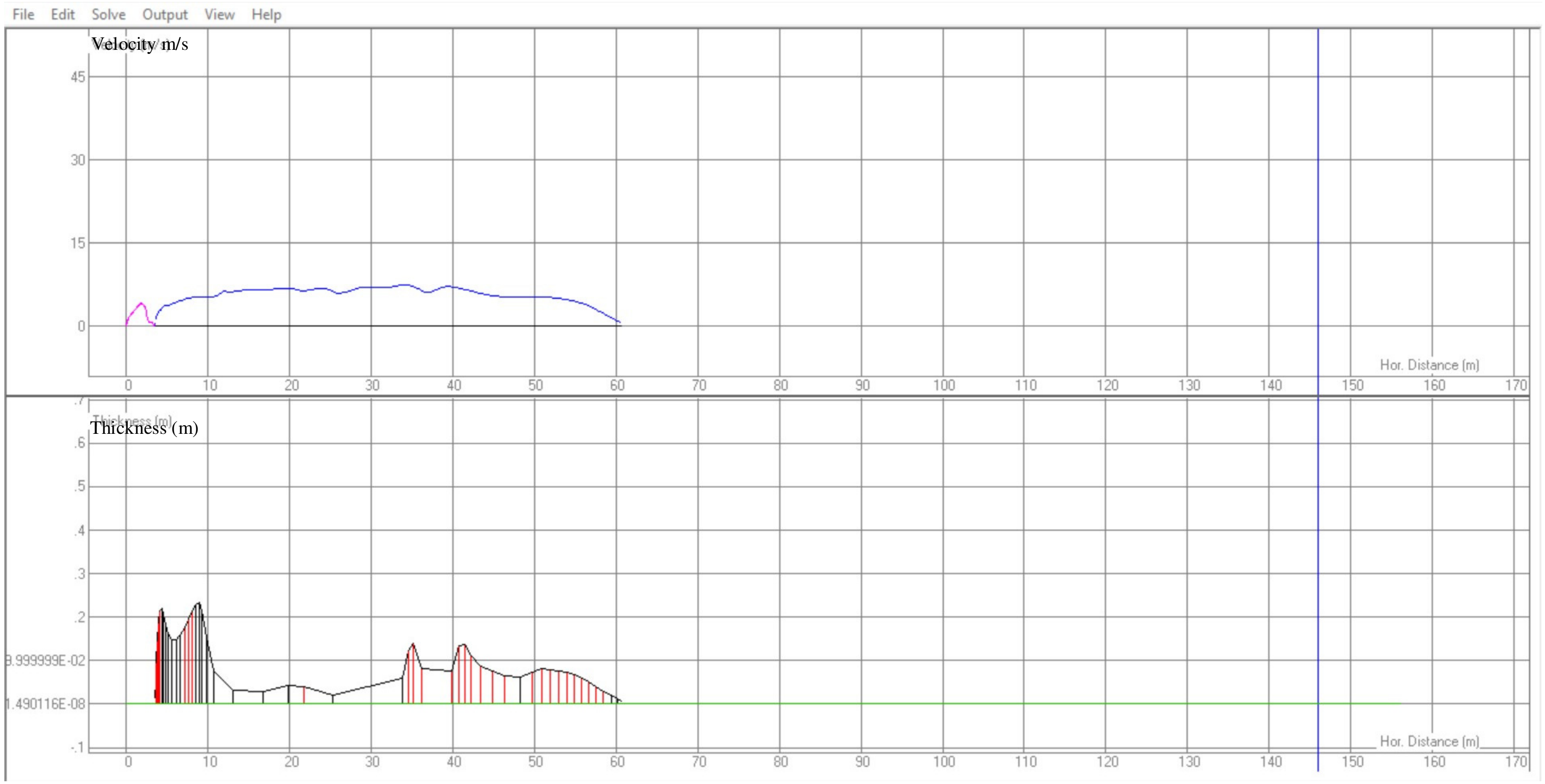


Result of Debris Mobility Analysis

Source Volume (m^3)	Final Volume (m^3)	Travel Distance (m)	Debris Reached Proposed SITE Boundary
40.47	40.47	57.18	No

Section Profile – (post-sliding)




File Edit Solve Output View Help
Velocity m/s
45
30
15
0
Hor. Distance (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
Thickness (m)
.7
.6
.5
.4
.3
.2
9.999999E-02
1.490116E-08
-.1
Hor. Distance (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170

Distance (m)

No of Blocks = 50

Time step = 0.001 seconds

End at time = 0.00 seconds

Configuration = 3-dimensional

Boundary Block Geometry = Normal

Shape factor = 1.00

Maximum velocity = 7.45 at X = 34.08

Maximum front velocity = 7.45 at X =34.08

CENTRE OF GRAVITY: X-Source = 1.97

Z-Source = 188.11

X-Depos. = 28.37

Z-Depos. = 174.39

CG Ratio = 0.52

Travel angle = 27.45

FAHRBOSCHUNG = 25.65

FRONT DISPLACEMENT: X = 60.697 Z = 160.859

Curvilinear Displ.= 62.913

Horiz. Displ. = 57.18

REAR DISPLACEMENT: X = 3.49 Z = 186.06

Curvilinear Displ.= 5.31

Horiz. Displ. = 3.49

SLIDE VOLUME: Initial = 40.47

Final = 40.47

AREA IN PLAN: Initial = 35.20

Final = 572.07

Runout not completed, V-MAX = 0.00

Export Print Close Help

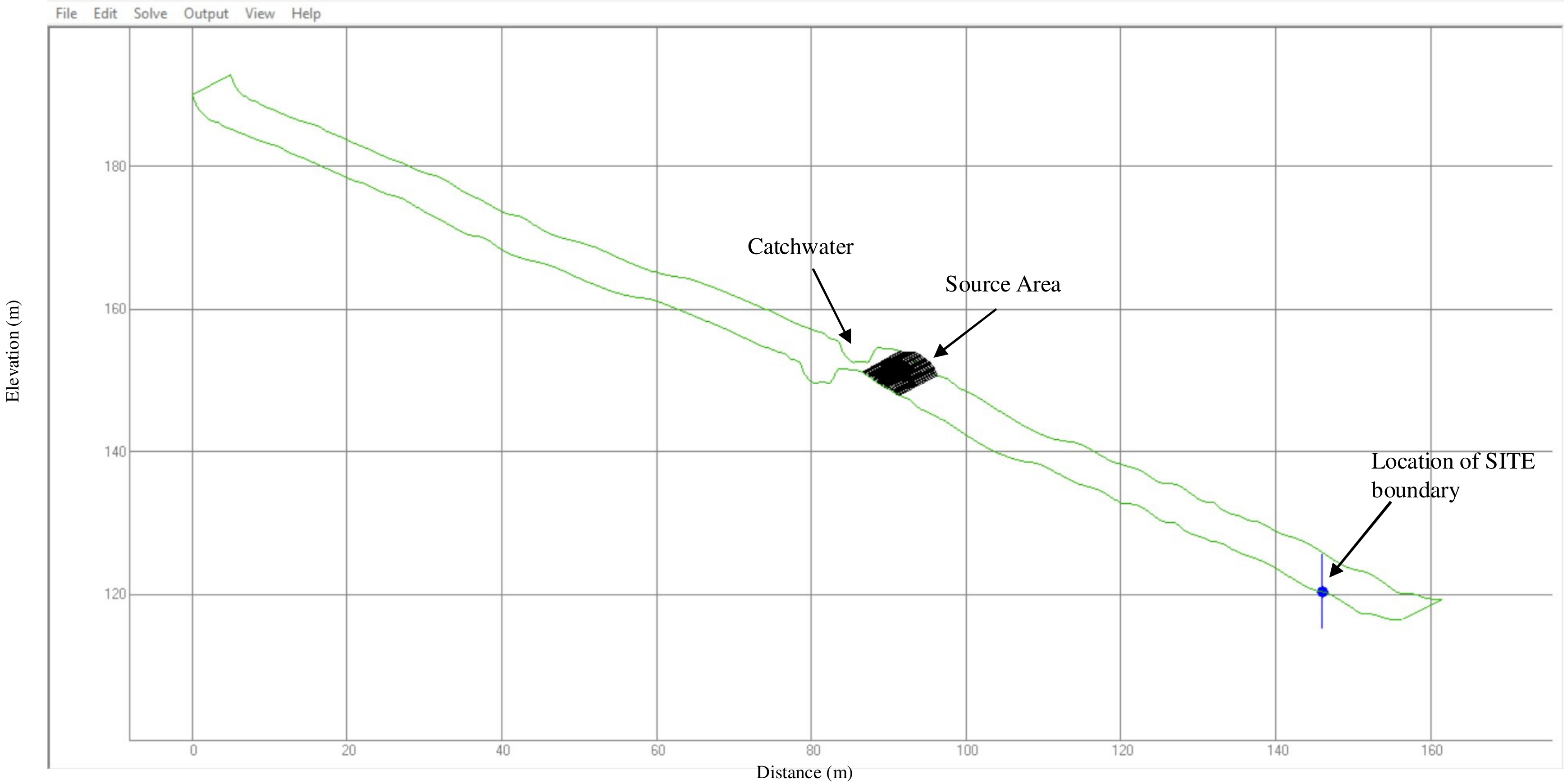
Debris Mobility Analysis for the Credible Runout Path RP2 (Case 2)

Landslide Type = OHL

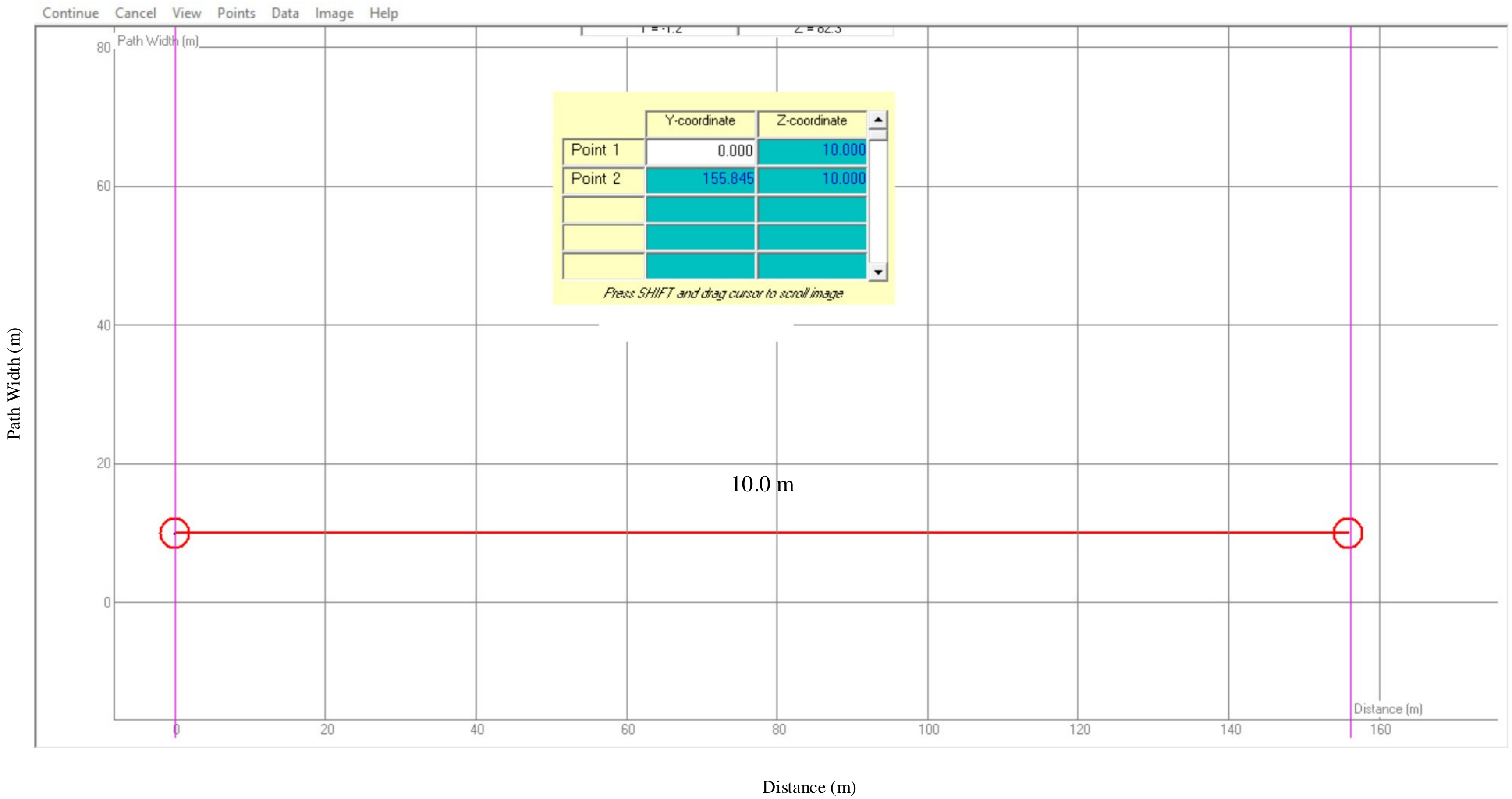
Design Source Volume = 40m^3

Figure D5

Section Profile – (pre-sliding)



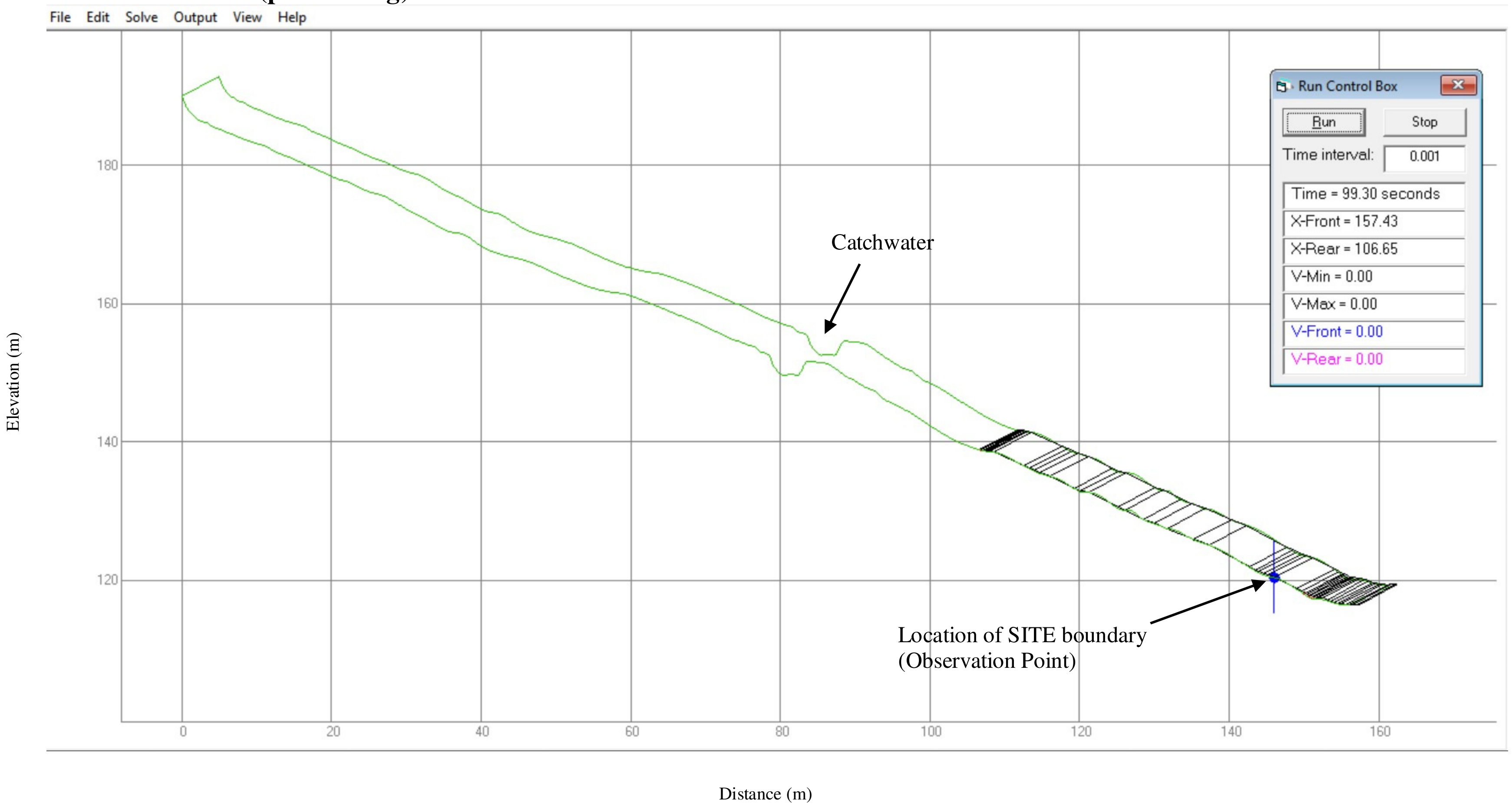
Width Profile

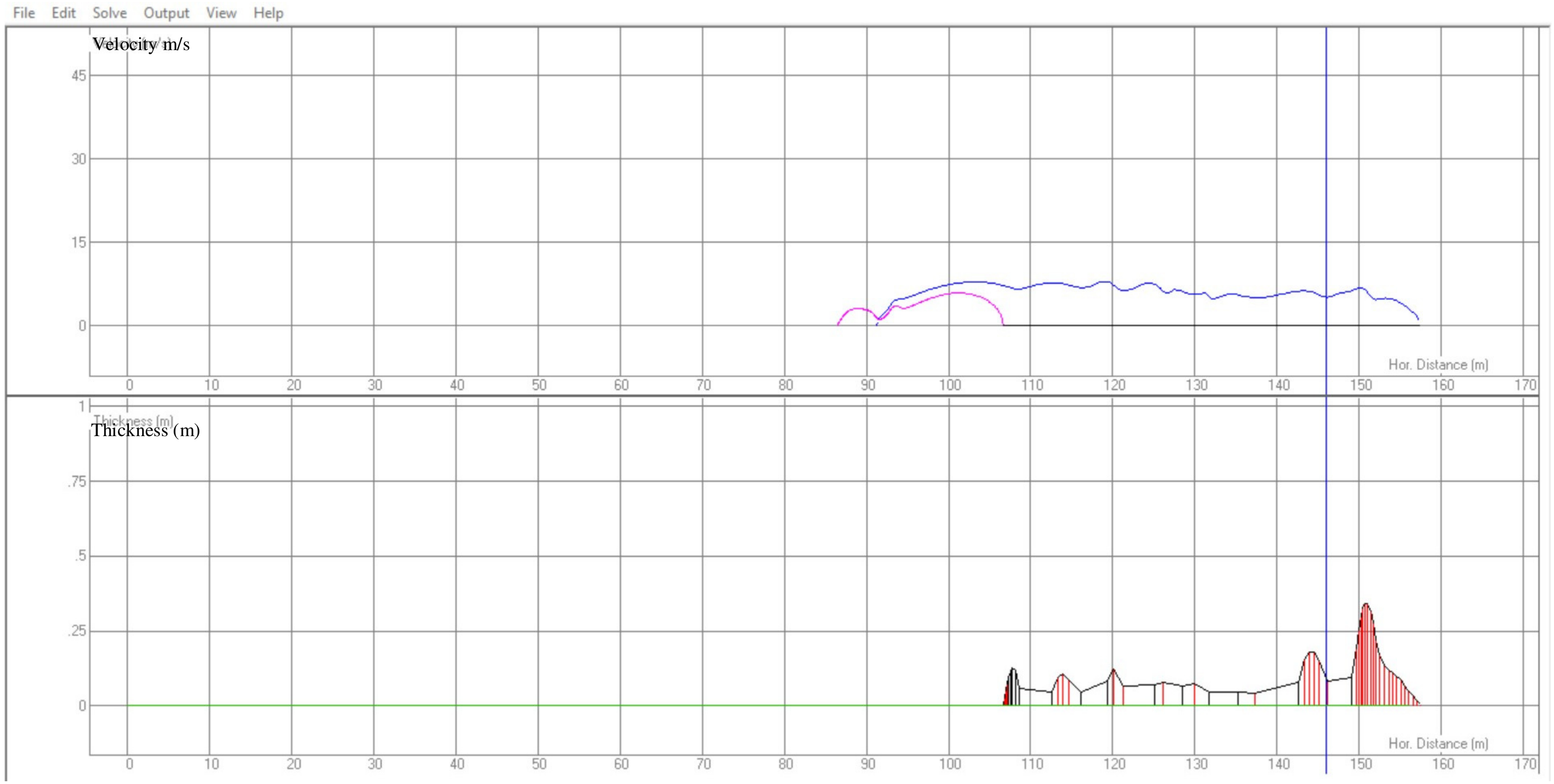


Result of Debris Mobility Analysis

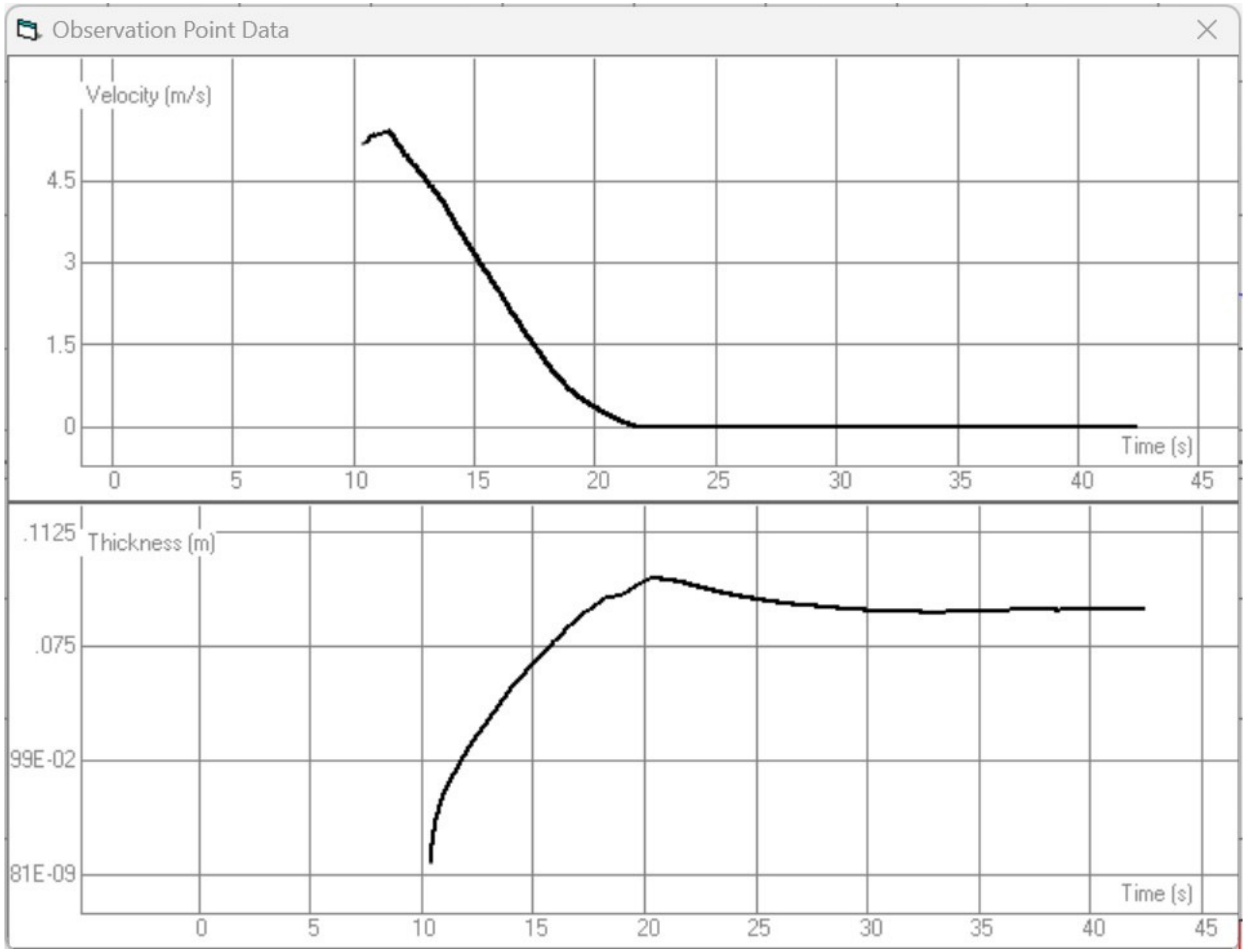
Source Volume (m^3)	Final Volume (m^3)	Travel Distance (m)	Debris Reached Proposed SITE Boundary	Max. Debris Velocity at the SITE Boundary (m/s)
40.61	40.61	66.13	Yes	5.40

Section Profile – (post-sliding)




File Edit Solve Output View Help
Velocity m/s
45
30
15
0
Hor. Distance (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
Thickness (m)
1
.75
.5
.25
0
Hor. Distance (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170

Distance (m)


Observation Point Data
Velocity (m/s)
4.5
3
1.5
0
Time (s)
0
5
10
15
20
25
30
35
40
45
.1125
Thickness (m)
.075
99E-02
81E-09
Time (s)
0
5
10
15
20
25
30
35
40
45

No of Blocks = 50

Time step = 0.001 seconds

End at time = 0.00 seconds

Configuration = 3-dimensional

Boundary Block Geometry = Normal

Shape factor = 1.00

Maximum velocity = 8.01 at X = 119.06

Maximum front velocity = 8.01 at X =119.06

CENTRE OF GRAVITY: X-Source = 89.18

Z-Source = 149.85

X-Depos. = 137.12

Z-Depos. = 124.65

CG Ratio = 0.53

Travel angle = 27.73

FAHRBOSCHUNG = 26.06

FRONT DISPLACEMENT: X = 157.433 Z = 116.544

Curvilinear Displ.= 74.496

Horiz. Displ. = 66.13

REAR DISPLACEMENT: X = 106.65 Z = 138.83

Curvilinear Displ.= 23.77

Horiz. Displ. = 20.14

SLIDE VOLUME: Initial = 40.61

Final = 40.61

AREA IN PLAN: Initial = 47.90

Final = 507.90

Runout not completed, V-MAX = 0.00

Export Print Close Help