Geoguide 2 – Guide to Site Investigation

First Edition

AMENDMENT NO.: GG2/01/2017

BACKGROUND

This amendment sheet incorporates the recommendations given in the following GEO Technical Guidance Notes:

1. GEO Technical Guidance Note No. 3 (TGN 3) – Use of Downhole Geophysical Methods in Identification of Weak Layers in the Ground

2. GEO Technical Guidance Note No. 4 (TGN 4) – Guidelines on Recognition of Geological Features Hosting, and Associated with, Silt- and Clay-rich Layers Affecting the Stability of Cut Slopes in Volcanic and Granitic Rocks

3. GEO Technical Guidance Note No. 5 (TGN 5) – Geoguide 2 – Guide to Site Investigation Updated Appendix B: Sources of Information

4. GEO Technical Guidance Note No. 6 (TGN 6) – Application of Back Analysis Approach to the Design of Slope Preventive or Remedial Works

5. GEO Technical Guidance Note No. 10 (TGN 10) – Enhancement of Rock Slope Engineering Practice Based on Findings of Landslide Studies

6. GEO Technical Guidance Note No. 24 (TGN 24) – Site Investigation for Tunnel Works

7. GEO Technical Guidance Note No. 41 (TGN 41) – Amendments to British Standards References in Technical Guidance Documents for Migration to Eurocodes

The amendments are given below.

AMENDMENTS

SECTION 1 SCOPE

(a) Section 1

In paragraph 3, line 1, delete ‘, as in BSI (1981a),’**.**

In paragraph 3, line 5, delete ‘BSI (1981b)’ **and substitute** ‘BSI (2009)’**.**

SECTION 4 GENERAL PROCEDURE

(a) Section 4.2

Delete paragraph 1 and substitute the following new paragraph 1.

As a first stage in a site investigation, a desk study is necessary and Appendix A indicates the types of information that may be required. Much information about a site may already be available in existing records. A summary of the important sources of information is given in Appendix B.

Readers are advised to take note of any warning messages on the data, check with the relevant data owners on the reliability, accuracy and completeness of the data they require where necessary, taking into account the needs of their project. Readers are also invited to provide feedback to the GEO should the need to update this Geoguide 2 be identified.

(b) Section 4.6 **Add Section 4.6 as follows:**

4.6 Site Investigation for Tunnel Works

Pre-tender site investigation should be as comprehensive as possible to provide adequate information for the design of tunnel works and contract preparation. In addition to the geological and hydrogeological conditions, the site investigation should identify utilities and buried installations to ascertain whether they will interfere with or be affected by the tunnel works (see ETWB TC(W) No. 17/2004 for government projects).

There are inherent uncertainties in the subsurface geology and hydrogeology, regardless of the extent of site investigation. Also, physical constraints, e.g. existing buildings and subsurface installations could limit the pre-tender site investigation for particular sections of tunnel works. Therefore, it is essential to make provision for additional ground investigation in the works contract to check and monitor continuously the actual conditions against those assumed, and to take measures to deal with conditions not anticipated but having significant impact on the design, construction, or on life and property.

The US Army Corps of Engineers Manual (USACE, 1997) includes a practical guide to the relative cost of site investigation as a proportion of the estimated construction cost. Based on this guide, the typical cost of site investigation for a deep tunnel located in difficult ground conditions and in a dense urban area is about 3-4% of the estimated construction cost. Notwithstanding, the cost of site investigation for a particular project depends greatly on the quality, suitability and adequacy of available information, and the data needed for the design and risk management of the types of tunnel works involved. The client should include adequate funding for site investigation in the project cost estimate.

Site investigation for projects involving tunnel works should be phased. This approach is necessary as different phases of the project have different requirements. Also, the tunnel alignment and design requirements can change during route planning or design.

Using the data obtained at each phase, the impact of the proposed excavation method on the sensitive receivers identified and the geotechnical risks at each tunnel section should be assessed. The risk assessment should be reviewed when the tunnel alignment is fixed and as more information becomes available.

Some simple guidelines on site investigation for tunnelling are given in ITA (2009). An outline of the engineering considerations and site investigation techniques for rock tunnels, based on IMMM (2003), is given in Table 13. Supplementary information on ground investigation techniques is given in Appendix F.

For sources of information and expertise, reference should be made to Appendix B of this Geoguide and GEO (2016) for general guidance on, and sources of information for site investigation and tunnels in Hong Kong. Reference should also be made to Geoguide 4 (GEO, 1992), which contains guidance on site investigation for cavern schemes, much of which is also applicable to tunnels and shaft construction.

Information on the pre-Quaternary geology of Hong Kong is given in Sewell et al (2000). The Hong Kong Geological Survey (HKGS) section of GEO/CEDD has the most detailed information on the geology of Hong Kong and offers an advisory service. HKGS should be consulted, especially at the planning stage of new projects involving tunnel works, in the formulation of geological models, anticipation of difficult areas, and the verification of significant geological features (faults, dykes, contact zones between geological units, etc.). This consultation process in actual projects also allows feedback of important geological information from the project to existing geological archives maintained by HKGS.

SECTION 6 AERIAL PHOTOGRAPHS

(a) Section 6.1 **In paragraph 2, line 9, delete** 'Appendix B 1.3' **and substitute** 'Appendix B 3.3'**.**

(b) Section 6.2.1 **In paragraph 1, line 3, delete** 'Appendix B 1.1' **and substitute** 'Appendix B 3.1'**.**

(c) Section 6.3.1 **In paragraph 4, line 2, add** 'Ho et al. (2006), ' **after** 'API techniques are provided by'**.**

SECTION 7 INTRODUCTION TO GROUND INVESTIGATION

(a) Section 7.2 **Add the following after paragraph 12:**

In the project planning stage for tunnel works, alternative tunnel routes and potential shaft locations are typically considered. It is sufficient to have only a general picture of the subsurface geology and hydrogeology, to define the preferred route corridor and to estimate the order of project cost. The site investigation should largely comprise desk studies and site reconnaissance, and include only limited ground investigation, if any is needed. Reference should be made to information available from nearby tunnel projects (see, for example, the references given in GEO (2016)).

SECTION 8 TYPES OF GROUND INVESTIGATION

(a) Section 8.2 **In paragraph 3, line 5, delete** 'in BSI (1981b) and '**.**

SECTION 9 GEOLOGICAL MAPPING FOR GROUND INVESTIGATION

(a) Section 9 **Add the following after paragraph 6:**

General principles and key considerations relating to the development of engineering geological models are given in Section 3 of the Engineering Geological Practice in Hong Kong (GEO, 2007).

SECTION 10 EXTEND OF THE GROUND INVESTIGATION

(a) Section 10.7.6 **In title, replace the font from** '*Pipelines*' **to** 'Pipelines'**.**

(b) Section 10.7.8 **Delete Section 10.7.8**

(c) Section 10.8 **Add Section 10.8 as follows:**

10.8 Specific Guidance for Silt- and Clay-rich Layers of Rock Cut Slopes

In assessing the stability of a cut slope in volcanic or granitic rock, attention should be given to establishing whether any of the following geological features are present, and if so, whether they may adversely affect slope stability:

(i) laterally persistent (e.g. > 4 m) weak silt- and clay-rich layers (which predominantly comprise white to buff kaolin, but may contain other materials, most notably dark brown manganiferous and iron oxides), within the rock mass, regardless of thickness,

(ii) completely and highly decomposed rock (Grades V and IV) forming planar layers that sit on slightly and moderately decomposed rock (Grades II and III), and which dip directly, or obliquely outwards from slope faces (At the Fei Tsui Road landslide site, the rock type was a eutaxitic fine-ash crystal tuff. The investigation of the Fei Tsui Road landslide (GEO, 1996a) highlighted various geological features in this rock type that influence the stability of cut slopes. The recognition of these geological features during site investigation at other cut slopes in similar rock types should raise awareness of the potential for a slope failure in similar circumstances to those pertaining at the Fei Tsui Road site.), and

(iii) persistent (e.g. > 4 m), planar, steep joint sets and other geological contacts (e.g. dykes, faults etc.) that could form release surfaces.

The following additional ground conditions are often indicative of the presence of geological features listed in previous paragraph and should also be checked:

(i) stratification dipping out of the slope (e.g. as indicated by eutaxitic foliation in some fine ash tuffs),

(ii) zones of continuous seepage, and

(iii) clusters of previous slope failures.

In site investigation, the following items are recommended to facilitate the identification of geological features that may be adverse to slope stability:

(i) The desk study should establish the history of any past failures (including the mechanism and type of failure) and continuous seepage, and, where site formation photographs are available, the presence of significant geological features.

(ii) The engineering geological mapping should establish whether the

orientation of bedding, bedding-parallel fabrics (e.g. eutaxitic foliation, which could provide an indication of the orientation of potential bedding plane structures in volcanic rocks.) or laterally continuous discontinuities (e.g. sheeting joints) are adversely oriented, and identify any weak silt- and clay-rich layers, especially within adversely-oriented persistent discontinuities or along the weathering front (i.e. the boundary below which rock predominates in a partially weathered rock mass profile). Such adversely oriented weak layers may also occur in local depressions in the weathering front, caused for example by zones of faulting, discontinuities with close spacing, and subvertical eutaxitic foliation. Evidence of previous movement, especially that associated with any weak layers, should be noted, and could include:

(a) slickensiding, particularly within silt and clay-rich layers,

(b) brecciation and shear deformation of silt and clay-rich layers, and

(c) tension cracks and infilled tension cracks, possibly controlled by subvertical joints and particularly where associated with adversely oriented weak layers.

Zones of continuous seepage, especially where associated with silt- and clay-rich layers, should also be mapped.

(iii) During the initial phase of ground investigation, emphasis should be directed to developing a representative geological and hydrogeological model rather than testing. The ground investigation should focus on examining and logging the saprolite profile in detail, with emphasis placed on identifying the presence of adversely-oriented, weak silt- and clay-rich layers, especially in the vicinity of the weathering front, regardless or not whether these layers daylight in the slope under investigation. The ground investigation should also identify any such features within the rock mass where they may influence slope stability.

Suitable techniques for detailed examination of the saprolite profile should include:

(a) full-face mapping and logging of cut slopes, after stripping of surface cover, and adjacent exposures,

(b) excavation and logging of trial pits, and

(c) logging of drillholes.

Suitable techniques for detailed examination of the saprolite profile may also include:

(d) excavation of trenches or adits,

(e) continuous sampling in drillholes using triple tube core barrels with air-foam as the flushing medium, and

(f) downhole geophysical logging and other downhole techniques, including borehole televiewer and impression packer. (Technical guidelines on the use of downhole geophysical investigation techniques in the identification

of weak layers are given in Section 33.)

(d) Section 10.9 **Add Section 10.9 as follows:**

10.9 Specific Guidance for Tunnel Works

10.9.1 Preliminary Design Stage

In the preliminary design stage, recommendations are made on a preferred tunnel alignment and the scope of works, including risk mitigation measures based on assumed methods of excavation. Ground investigation with a geophysical survey could be undertaken to refine the geological model, to gain additional information on significant geological features, identify sensitive receivers and to establish baseline conditions.

Boreholes should extend well below the anticipated depth of the tunnel and shafts to allow for any subsequent changes in the vertical alignment of the tunnel in the detailed design stage, and because the zone of influence of the tunnel may be extended by the nature of the ground at a greater depth.

Long horizontal boreholes parallel to the proposed tunnel alignment are extremely useful, particularly where the location of the proposed tunnel is overlain by thick layers of deeply weathered rock (McFeat-Smith, 1987).

Soil permeability tests and Lugeon tests at close spacings should be undertaken in the boreholes to assess the soil mass and rock mass permeability, respectively. It is important not to overlook areas of apparently strong bedrock, as the mass permeability of these areas may be high and may affect significantly construction of the tunnel works. The test results should be used for development of the hydrogeological model, defining the hydraulic boundary conditions for the design and for assessing the need to control groundwater inflow/drawdown during construction.

10.9.2 Detailed Design Stage

In the detailed design stage, when the tunnel alignment has been fixed, the main aim of the ground investigation should be to obtain information for the reference design or detailed design of the tunnel works and the associated temporary works. The ground investigation should also identify conditions at likely problematic areas along the chosen alignment. The ground investigation data should be adequate for preparing the design of the ground support, ground treatment, groundwater control works and the risk mitigation measures. It should also be adequate for planning the inspection, testing and monitoring works during construction.

Where existing boreholes are found close to or intercepting the tunnel, the risk of these boreholes not properly grouted should be assessed and mitigation measures, where necessary, should be carried out to ensure that these boreholes would not form preferential flow paths that could jeopardize the tunnel construction.

New boreholes along the chosen tunnel alignment and shaft locations should generally extend to a sufficient depth below the invert of the

tunnel/shafts to obtain information for the assessment of possible failure mechanisms/limit states, and/or construction of the tunnel/shafts. For tunnels in rock, this should be a least 2.5 times the tunnel diameter (or the crown to invert dimension) below the invert.

Directional coring along the tunnel alignment should be considered. If this is to be carried out, it should preferably be done immediately on commencement of the detailed design stage, in order to yield early data to maximise its benefit for the design. Despite the cost, the directional coring together with pumped down packer tests could provide useful information on the geology and hydrogeology along the tunnel alignment which could not be obtained from vertical or inclined boreholes. The information along the tunnel alignment would help to enhance the management of ground risks in tunnel excavation.

For ground investigation to support the design of shafts, particular attention should be given to identifying poor ground conditions, which could lead to collapse, excessive ground deformation/vibration or excessive groundwater inflow/drawdown. For deep shafts with a significant length in rock, the ground investigation should assess the hydrogeology and inflow into the unlined sections of the rock mass, and the need for ground treatment and groundwater control works to prevent excessive drawdown of piezometric pressures in the rock and the soil overburden.

For significant temporary works to be designed by the contractor, e.g. major ground treatment, groundwater control and ground support works, the pre-tender site investigation should provide sufficient geological and hydrogeological data for the pre-tender reference designs of such works, which should be carried out to adequately define the scope of the works required to meet the safety standards and the performance criteria specified.

SECTION 13 AGGRESSIVE GROUND AND GROUNDWATER

(a) Section 13.2 **In paragraph 1, line 3, delete** '(BSI, 1975b)' **and substitute** '(GEO, 2017a)'**.**

(b) Section 13.3 **In paragraph 1, lines 5 and 6, delete** 'the Model Specification for Reinforced Fill Structures (Brian-Boys et al, 1986)' **and substitute** 'Geoguide 6 (GEO, 2017b)'**.**

In paragraph 1, line 9, delete 'BSI (1973)' **and substitute** 'BSI (1990)'**.**

SECTION 16 REVIEW DURING CONSTRUCTION

(a) Section 16.5 **Add Section 16.5 as follows:**

16.5 Tunnel Works

In the construction stage, further site investigation should be undertaken to obtain information to support the design review of the tunnels, caverns and shafts, in order to ensure that there is adequate safety margin and performance.

For the exposed faces in tunnel works, the site investigation should

include geological and engineering geological mapping, and an assessment of the tunnel sections/shafts using a soil/rock mass classification scheme on which the design may be based. A proforma for recording the rock mass mapping and classification data in rock tunnels is available from the Hong Kong Slope Safety Website under the downloading area at http://hkss.cedd.gov.hk.

Depending on the tunnel excavation method and the risk assessment, probing ahead of the tunnel excavation may be carried out. The penetration rate, the quantity of water inflows, and the colour and nature of cuttings and flushing water returns should be recorded. This information should be used to assess the ground conditions ahead, in particular the soil/rock interfaces and sections with potentially high water inflow, and the need for implementation of robust mitigation measures before further tunnel excavation. In addition to probing, use of non-invasive techniques and coring during construction may be considered where cost effectiveness can be demonstrated. For TBM works, further ground investigation may be necessary prior to or during the TBM drive to confirm the locations of permeable soils and soil/rock interfaces and the variations in groundwater pressures for design.

Sufficient time should be allowed in the construction programme for the results of additional ground investigation and site inspection and monitoring to be fed back into the design and risk management processes, in order that modifications to the design can be implemented or other contingency measures undertaken in a timely manner.

SECTION 18 EXCAVATIONS AND BOREHOLES

(a) Section 18.3 **In line 4, delete** 'BSI (1981a)' **and substitute** 'BSI (2010)'**.**

(b) Section 18.6 **In line 5, delete** 'BSI (1981a)' **and substitute** 'BSI (2010)'**.**

SECTION 19 SAMPLING THE GROUND

(a) Section 19.2 **In paragraph 4, line 1, delete** 'BSI (1975b, 1975c)' **and substitute** 'GEO (2017a) and BSI (1990)'**.**

In paragraph 4, line 7, delete 'BSI (1975a)' **and substitute** 'CS3:2013 (2016)'**.**

(b) Section 19.4.5 **In line 2, delete** 'Test 19 of BSI (1975b)' **and substitute** 'BSI (2011b)'**.**

(c) Section 19.8 **In paragraph 1, line 3, delete** '(BSI, 1974a)'**.**

SECTION 21 TESTS IN BOREHOLES

(a) Section 21.2.1 **In paragraph 1, line 2, delete** 'Test 19 of BSI (1975b)' **and substitute** 'BSI (2011b)'**.**

In paragraph 2, line 4, delete 'Test 19 of BSI (1975b)' **and substitute** 'BSI (2011b)'**.**

In paragraph 2, delete items (a) and (b).

In paragraph 2, re-number items (c) and (d) to items (a) and (b) respectively.

In paragraph 2, add the following new item (c).
'(c) The results of standard penetration tests should be included in borehole records without the application of corrections.'

Delete paragraph 3.

(b) Section 21.2.3 **In paragraph 2, line 3, delete** 'BSI (1975b)' **and substitute** 'BSI (2011b)'**.**

(c) Section 21.3.1 **In paragraph 1, line 4, delete** 'Test 18 of BSI (1975b)' **and substitute** 'BSI (1990)'**.**

(d) Section 21.3.2 **In paragraph 2, lines 1 and 2, delete** 'Test 18 of BSI (1975b)' **and substitute** 'BSI (1990)'**.**

SECTION 23 PROBING AND PENETRATION TESTING

(a) Section 23.4 **In lines 4 and 5, delete** '; this technique is further discussed in BSI (1981a)'**.**

SECTION 25 PUMPING TESTS

(a) Section 25.2 **In paragraph 3, line 2, delete** 'BSI (1981a)' **and substitute** 'BSI (2010)'**.**

(b) Section 25.7 **In paragraph 2, line 5, delete** 'BSI (1981a)' **and substitute** 'BSI (2012c)'**.**

SECTION 26 DISCONTINUITY SURVEYS

(a) Section 26.2 **Replace Section 26.2 by the following:**

In the mapping of discontinuities, special emphasis should be given to identifying adverse geological features and dilated rock joints or open joints with infill or sediment, which could indicate progressive slope deterioration and/or adverse groundwater conditions. The key characteristics of these adverse geological features should be adequately mapped. In addition, care must be taken to ensure that apparently minor, but kinematically significant joint sets or individual joints are not overlooked (Evans & Irfan, 1991). However, sample of joint measurements should be representative of the overall picture, in order to avoid collection of large quantities of measurements that may have little relevance to stability assessment.

Large-scale rock slope failures have occurred involving laterally persistent discontinuities such as sheeting joints. The waviness of a sheeting joint could involve local steepening of the joint dip angle behind the slope face, which can be difficult to detect in practice (HCL, 2001).

Site-specific laboratory tests may be carried out to characterise the operational joint shear strength where considered necessary, with consideration given to the roughness and persistence of the joint, influence of any weak infill, etc. (Hencher, 1981).

(b) Section 26.3 **Move the original Section 26.2 to a new Section 26.3.**

SECTION 27 FIELD DENSITY TESTS

(a) Section 27.1 **In paragraph 4, line 5, delete** 'BSI (1975b, Test 1A)' **and substitute** 'GEO (2017a)'**.**

In paragraph 4, lines 8 and 9, delete 'BSI (1975b), Test 1' **and substitute** 'BSI (1990)'**.**

In paragraph 5, lines 2 and 3, delete 'Test 15 of BSI (1975b)' **and substitute** 'Geospec 3 (GEO, 2017a) and BSI (1990).'**.**

(b) Section 27.2 **In paragraph 1, line 1, delete** 'BSI (1975b) describes three variations' **and substitute** 'GEO (2001) describes two variations'**.**

In paragraph 1, line 3, delete ', as defined in BSI (1975b)'**.**

In paragraph 1, lines 4 to 7, delete the last sentence.

(c) Section 27.3 **In line 1, delete** 'BSI (1975b)' **and substitute** 'BSI (1990)'**.**

(d) Section 27.4 **In the title, delete** 'WEIGHT' **and substitute** 'IMMERSION'**.**

In line 1, delete 'weight' **and substitute** 'immersion'**.**

In line 1, delete 'BSI (1975b)' **and substitute** 'BSI (1990)'**.**

(e) Section 27.5 **In line 1, delete** 'BSI (1975b)' **and substitute** 'BSI (1990)'**.**

In line 2, delete 'weight' **and substitute** 'immersion'**.**

SECTION 28 INSITU STRESS MEASUREMENTS

(a) Section 28.2 **In paragraph 5, line 2, delete** 'BSI (1981a)' **and substitute** 'BSI (2010)'**.**

SECTION 29 BEARING TESTS

(a) Section 29.1.4 **In paragraph 5, line 2, delete** 'BSI (1981a)' **and substitute** 'BSI (2010)'**.**

(b) Section 29.4.2 **In lines 1 to 3, delete** 'Test 16 of BSI (1975b) excluding the compaction, and subject only to those alterations necessary to enable it to be carried out in the field' **and substitute** 'BSI (1990)'**.**

In lines 7 to 14, delete the third sentence to the last sentence.

SECTION 31 LARGE-SCALE FIELD TRIALS

(a) Section 31.2 **In paragraph 1, line 4, delete** 'BSI, 1981b' **and substitute** 'BSI, 2009'**.**

(b) Section 31.3 **In paragraph 2, line 7, delete** '(BSI, 1981b)' **and substitute** '(BSI, 2009)'**.**

SECTION 32 BACK ANALYSIS

(a) Section 32.2 **Delete title** 'Failures' **and substitute** 'Failures and Design of Slope Preventive or Remedial Works'**.**

Add new paragraphs after paragraph 1.

Whilst the back analysis approach serves as a useful yardstick for assessing the mass shear strength, this approach should not be used in isolation. The application of the back analysis approach for the design of slope preventive or remedial works should be accompanied by rigorous geotechnical investigation, including ground investigation, laboratory testing and engineering geological mapping in order to provide a more reasonable basis for making judgement on suitable mass shear strength parameters.

Extreme care must be taken to avoid the adoption of unduly high shear strength parameters derived from back analysis which may have incorporated the effect of suction. Where the ground mass is relatively homogeneous with no corestones or boulders, binding effect of tree roots, three-dimensional effects of the slope geometry, etc., back-analysed shear strength parameters which are higher than those determined from laboratory tests on saturated specimens should not be used.

The notion that the continued stability of an existing slope may be proven by past rainstorms should be treated with caution. Factors such as deterioration of the slope condition, progressive slope deformation and possible changes in environmental conditions (e.g. enhanced infiltration through a dilapidated hard surface cover, leakage from water-carrying services, etc.) should be carefully considered before one can confidently count on past performance in the use of the back analysis approach. In particular, the use of the back analysis approach to derive mass shear strength parameters for designing upgrading works should be done with extreme caution where the proposed works involve the replacement of a hard surface cover with a vegetated cover.

When back analysis is used, it should be for deriving the possible range of strength parameters. If more than one predominant soil type (e.g. fill and CDG) is involved, the back analysis approach, if used, should be applied to assess the strength parameters for the particular soil type with greater uncertainty (e.g. high spatial variability, difficulty in retrieving representative samples for laboratory testing, etc.), whilst the strength parameters for the other soil type(s) should be determined by other means such as conventional laboratory tests.

The back-analysed shear strength parameters for a certain slope section should not be applied to other sections of the slope in the case of a sizeable slope with highly varied characteristics (e.g. in terms of slope geometry, geology, catchment characteristics, etc.) along its length. Different sets of strength parameters may need to be obtained by back-analysing suitably selected sections.

Back analysis of a landslide or a slope with signs of distress can be useful where there is sufficient and reliable information on the ground conditions and the geometry of the rupture surface. This can assist in the diagnosis of failure mechanisms and examination of the likely combinations of soil shear strength and groundwater conditions at the time of failure. For the design of remedial works, however, the back-analysed groundwater conditions prevailing at the time of the landslide should not necessarily be taken as the design groundwater conditions. This is because the groundwater response for

rainstorms with differing characteristics in terms of intensity, duration and return period may be different, and because the hydrogeological setting of the failed slope may be altered by the landslide and/or the proposed remedial works.

The above guidance on the use of the back analysis approach is also generally applicable to the design of preventive or remedial works for retaining walls.

SECTION 33 GEOPHYSICAL SURVEYING

(a) Section 33.2.1 **In line 3, delete** '(BSI, 1965)' **and substitute** '(BSI, 1990)'**.**

(b) Section 33.2.5 **Add Section 33.2.5 as follows:**

33.2.5 The Gamma Density Method

The principle of the Gamma Density method is to irradiate the target material with medium-high energy collimated gamma rays and to measure their attenuation between the tool source and the detectors. The attenuation is a function of the electron density of the target material, which in turn is closely related to its mass density.

Based on the relative density contrast between target materials, the technique can be used, within a drillhole, to identify weak layers in the ground at a practical logging speed of 1 m/min. Such weak layers include clay-rich layers, weathered seams and disturbed zones that are of comparatively lower mass density. The resolution of the method increases with the increase in relative density contrast between the target and the adjacent materials. The resolution decreases if casing is used and as the dip angle of the weak layer becomes aligned with the drillhole axis (i.e. sub-vertical in a vertical drillhole).

Two examples are shown in Figures 45 and 46. Figure 45 shows strong signatures for the weak clay-rich layers at locations A to D where the density contrast is high between the weak layers and the adjacent materials. In this case the method was able to identify weak layers as thin as in the centimeter range. The clay-rich layers at E to I as a whole give a strong signature in the log, but the individual layers cannot be clearly distinguished. Figure 46 shows poor correlation for those weak clay-rich layers at locations A to H where the density contrast between the weak layers and the adjacent materials is low.

The method is most suitable for use in uncased or plastic-cased drillholes and where the relative density contrast between the target (weak layers) and adjacent materials is high. However, caution needs to be exercised in interpreting the data as the absence of a strong signature does not necessarily confirm the absence of weak layers in the ground.

(c) Section 33.2.6 **Add Section 33.2.6 as follows:**

33.2.6 The Spectral Gamma Ray Method

The Spectral Gamma Ray method is based on the principle that decomposition of potassium-bearing minerals leads to a progressive loss of potassium ions (K). Naturally occurring potassium contains radiogenic K.

Thus the amount of radiogenic K present in the material is related to the degree of decomposition of potassium-bearing minerals in the parent rock and hence the degree of weathering of the rock mass. The Spectral Gamma Ray method produces a log of the potassium count rate along the drillhole.

The location along the drillhole where the count rate shows a significant reduction compared to the adjacent materials can be interpreted as a more weathered, weak layer. However, interpretation of the data is dependent on the origin of the target material, which may significantly affect the potassium count rate. For instance, where a clay layer does not originate directly from the decomposition of the adjacent materials, the potassium count rate of the layer may not necessarily be lower than those of the adjacent materials. Also, if thin layers are to be identified, a slow logging speed will be required, e.g. 0.05 m/min for a resolution of 50 mm.

This method does not require the use of any radioactive source and it can be used in drillholes lined with different types of casing. Also it is much cheaper than the Gamma Density method (about half the price based on term contract rates in 1999/2000). The Spectral Gamma Ray method, when applied to materials of the same origin and preferably backed up by site-specific calibration, can give an indication of the degree of weathering. Although the method is not as good as the Gamma Density method in identifying thin weak clay-rich layers, there is potential for it to be used in verifying ground conditions, especially in the case of a large number of drillholes without the need for sampling, e.g. drillholes for installing soil nails, raking drains, observation wells and piezometers, etc.

The example in Figure 45 shows that the potassium count rate log gives signatures for the weak clay-rich layers at locations A, B and C. The potassium count rate log in Figure 46 is unable to identify any of the weak layers (A to H). However, the trend of increasing potassium count rate in less weathered material is evident.

(d) Section 33.2.7 **Add Section 33.2.7 as follows:**

33.2.7 The Neutron Porosity Method

The principle of the Neutron Porosity method is to irradiate the target materials with fast neutrons. The neutrons collide with particles having similar mass as the neutrons in the target material, reducing their speed and becoming thermal neutrons. Within the ground, those particles that would normally have similar mass as the neutrons are mainly hydrogen nuclei. If the ground is saturated, the hydrogen content equates with water content and that in turn is related to porosity. So the neutron porosity log gives an indication of porosity if the target material is saturated.

Based on the relative moisture content contrast between the target materials, the technique can be used in open and steel-cased drillholes to identify weak layers in saturated ground at a practical logging speed of 1 m/min. However, in unsaturated ground, the relative moisture content between target materials does not truly reflect the porosity and misleading results will be given by the method.

The method does not work where plastic casing is used because the hydrogen molecules in the plastic absorb the neutrons and affect the results.

(e) Section 33.6 **Add Section 33.6 as follows:**

33.6 Identification of Weak Layers in the Ground

The Gamma Density and Spectral Gamma Ray methods (see Sections 33.2.5 and 33.2.6 for further elaboration) are recommended for use as supplementary ground investigation techniques to help to identify weak layers in the ground. These methods have been included in CEDD's ground investigation term contracts to facilitate their use in government projects.

Useful results may be obtained from the Neutron Porosity method (see Section 33.2.7) in identifying weak layers in ground that is saturated with water. However, in unsaturated ground, the method can give misleading results.

The Self Potential method, Acoustic Borehole Televiewer method, 4-arm Dipmeter method, 3-arm Caliper method and Electrical Cylinder method did not give consistent and reliable results in the identification of weak layers.

SECTION 34 PRINCIPLES OF LABORATORY TESTING

(a) Section 34 **In paragraph 2, line 6, delete** 'BSI (1975b)' **and substitute** 'BSI (1990) and GEO (2017a)'**.**

SECTION 38 TESTS ON ROCK

(a) Section 38 **In paragraph 2, line 6, delete** 'BSI (1981a)' **and substitute** 'BSI (2010)'**.**

SECTION 39 FIELD REPORTS

(a) Section 39 **In paragraph 1, lines 7 and 8, delete** 'BSI (1981a)' **and substitute** 'BSI (1990a) and the appropriate Parts of BSI (2011a, 2011b, 2012a, 2012b, 2012c, 2012d, 2012e, 2012f).'**.**

SECTION 40 SITE INVESTATION REPORT

(a) Section 40.3.1 **In line 4, delete** 'BSI, 1965; 1973; 1974b; 1975a; 1977; 1981b; 1986' **and substitute** 'BSI, 1974; 1986, 1991; 2004; 2007; 2009'**.**

(b) Section 40.4 **Add Section 40.4 as follows:**

40.4 Documentation for Site Investigation of Tunnel Works

Factual engineering geological and hydrogeological data relating to the tunnel project should be fully documented including any field data obtained from the excavation faces or inferred from the equipment/processes adopted for the tunnel works.

Survey and monitoring reports should include factual data, details of the survey and monitoring methods, and equipment/system calibration.

Interpretative engineering geological and inspection and monitoring reports should be prepared using the data obtained during the various phases of

the site investigation and from construction records. These reports should update any previous relevant interpretative reports and be presented in a form that will meet the needs of the professional users. They should incorporate information on the cavern/tunnel/shaft excavation method and working sequence, trends of key performance indicators and records of actual impacts observed during construction.

TABLES

(a) Table 2

Replace Table 2 by the new one as enclosed in Appendix I of this amendment sheet.

(b) Table 5

In Note (2), delete 'BS 4019: Part 1 (BSI 1974a) on rotary core drilling equipment and Figure 29 of BS 5930 (BSI, 1981a)' **and substitute** 'BS EN ISO 22475-1:2006 (BSI, 2006)'**.**

(c) Table 7

In Note, delete '(BSI, 1981a)' **and substitute** '(BSI, 2010)'**.**

(d) Table 9

In Note (3), delete 'taken from BS 5930 (BSI, 1981a)' **and substitute** 'adapted from BS EN 1997-2:2007 (BSI, 2007)'**.**

(e) Table 12

In row 1, under the column 'Recommended References', delete 'BS 1377 (BSI, 1975b) Test 1 (A)' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 5'**.**

In row 2, under the column 'Recommended References', delete 'BSI (1975b) Test 2 (A) or 2(B) and Test 3' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 6'**.**

In row 3, under the column 'Recommended References', delete 'BSI (1975b) Test 5' **and substitute** 'BS 1377-2 (BSI, 1990a) Clause 6.5'**.**

In row 4, under the column 'Recommended References', delete 'BSI (1975b) Test 6' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 7'**.**

In row 5, under the column 'Recommended References', item (a), delete 'BSI (1975b) Test 7(A)' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 8'**.**

In row 5, under the column 'Recommended References', item (b), delete 'BSI (1975b) Test 7(C) or 7(D)' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 8'**.**

In row 5, under the column 'Remarks', item (a), delete 'The standard method of dry sieving (BSI, 1975b Test 7(B)) is not recommended for general use in Hong Kong. As a variation to the standard method of wet sieving (BSI, 1975 b Test 7(A)), it will be appropriate to exclude the use of dispersant' **and substitute** 'Dispersant should be excluded'**.**

In row 7, under the column 'Recommended References', delete 'BSI (1975b) Test 8' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 9.1'**.**

In row 8, under the column 'Recommended References', item (a), delete 'BSI (1975b) Test 9' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 9.3'**.**

In row 8, under the column 'Recommended References', item (b), delete 'BSI (1975b) Test 10' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 9.3'**.**

In row 8, under the column 'Remarks', lines 2 and 3, delete 'Test 9 of BSI (1975b)' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 9.3.'**.**

In row 10, under the column 'Recommended References', delete 'BSI (1975b) Test 11(A)' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 9.5'**.**

In row 13, under the column 'Recommended References', delete 'Brian-Boys et al (1986) Clause 5.4' **and substitute** 'BS 1377-9 (BSI, 1990) Section 5.1'**.**

In row 14, under the column 'Recommended References', delete 'Brian-Boys et al (1986) Clause 5.5' **and substitute** 'BS 1377-9 (BSI, 1990) Section 5.2'**.**

In row 14, under the column 'Remarks', line 3, delete 'CP1021 (BSI, 1973)' **and substitute** 'BS 1377-9 (BSI, 1990)'**.**

Delete row 15.

In row 16, under the column 'Recommended References', item (a), delete 'BSI (1975b) Test 21' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 15'**.**

In row 18, under the column 'Recommended References', item (a), delete 'BSI (1975b) Test 17' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 14'**.**

In row 21, under the column 'Recommended References', delete 'BSI (1975b) Tests 12, 13, 14' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 10'**.**

In row 21, under the column 'Remarks', delete 'Test 12 is commonly used in Hong Kong', **and delete** 'BSI, 1975b Test 15' **and substitute** 'Geospec 3 (GEO, 2017a) Clause 11'**.**

In row 22, under the column 'Recommended References', delete 'BSI (1975b) Test 16' **and substitute** 'GEO (2017a) Clause 12'**.**

(f) Table 13 **Add a new Table 13 (enclosed in Appendix I of this amendment sheet).**

FIGURES

(a) Figure 20 **In Note, delete** 'BS 5930 (BSI, 1981a)' **and substitute** 'BS 5930 (BSI, 2010)'**.**

(b) Figure 25 **In Note (1), delete** 'BS 1377 (BSI, 1975 b)' **and substitute** 'BS EN ISO 22476-3 (BSI, 2011b)'**.**

(c) Figure 26 **In Note, delete** 'BS 1377 (BSI, 1975 b)' **and substitute** 'BS 1377-9 (BSI, 1990)'**.**

(d) Figure 28 **In Note (1), delete** 'BS 5930 (BSI, 1981a)' **and substitute** 'BS 5930 (BSI, 2010)'**.**

(e) Figure 39 **In Note (1), delete** 'BS 5930 (BSI, 1981a)' **and substitute** 'BS EN ISO 22476-1 (BSI, 2012f)'**.**

(f) Figure 43 **In Note, delete** 'BS 5930 (BSI, 1981a)' **and substitute** 'BS 5930 (BSI, 2010)'**.**

(g) Figure 45 **Add Figure 45 (enclosed in Appendix I of this amendment sheet).**

(h) Figure 46 **Add Figure 46 (enclosed in Appendix I of this amendment sheet).**

APPENDIX B SOURCES OF INFORMATION

(a) **Delete the original Appendix B and substitute by a new Appendix B (enclosed in Appendix II of this amendment sheet).**

APPENDIX E SAFETY PRECAUTIONS

(a) Section E.2 **In paragraph 4, item (c), lines 1 to 3, delete** 'BSI 5573: Code of Practice for Safety Precautions in the Construction of Large Diameter Boreholes for Piling and Other Purposes (BSI, 1978)' **and substitute** 'BS 8008: Safety Precautions and Procedures for the Construction and Descent of Machine -bored Shafts for Piling and Other Purposes (BSI, 2008)'**.**

(b) Section E.5 **Add the following new reference:**

BSI (2008). *Safety Precautions and Procedures for the Construction and Descent of Machine-bored Shafts for Piling and Other Purposes (BS 8008:1996+A1:2008).* British Standards Institution, London, 20 p.

(c) Section E.5 **Delete the following reference:**

BSI (1978). *Code of Practice for Safety Precautions in the Construction of Large Diameter Boreholes for Piling and Other Purposes (BS 5573:1978).* British Standards Institution, London, 8 p.

APPENDIX F SUPPLEMENTARY INFORMATION ON GROUND INVESTIGATION TECHNIQUES

(a) **Add a new Appendix F (enclosed in Appendix III of this amendment sheet).**

REFERENCES

(a) **Add the following new references:**

BSI (1990). *Methods of Test for Soils for Civil Engineering Purposes - Parts 1 to 9: (BS1377, Parts 1 to 9:1990).* British Standards Institution, London, 406 p.

BSI (1991). *Cathodic Protection - Part 1: Code of Practice for Land and Marine Applications - (formerly CP 1021) (BS 7361-1:1991).* British Standards Institution, London, 122 p.

BSI (2004). *Eurocode 7: Geotechnical Design - Part1: General Rules (BS*

EN 1997-1:2004). British Standards Institution, London, 174 p.

BSI (2006). *Geotechnical Investigation and Testing - Sampling Methods and Groundwater Measurements - Part 1: Technical Principles for Execution (BS EN ISO 22475-1:2006)*. British Standards Institution, London, 134 p.

BSI (2007). *Eurocode 7 - Geotechnical Design - Part 2: Ground Investigation and Testing (BS EN 1997-2:2007)*. British Standards Institution, London, 202 p.

BSI (2008). *Safety Precautions and Procedures for the Construction and Descent of Machine-bored Shafts for Piling and Other Purposes (BS 8008:1996+A1:2008)*. British Standards Institution, London, 20 p.

BSI (2009). *Code of Practice for Earthworks (BS 6031:2009)*. British Standards Institution, London, 128 p.

BSI (2010). *Code of Practice for Site Investigations (BS 5930:1999+A2:2010)*. British Standards Institution, London, 206 p.

BSI (2011a). *Geotechnical Investigation and Testing - Field Testing - Part 2: Dynamic Probing (BS EN ISO 22476-2:2005+A1:2011)*. British Standards Institution, London, 40 p.

BSI (2011b). *Geotechnical Investigation and Testing - Field Testing - Part 3: Standard Penetration Test (BS EN ISO 22476-3:2005+A1:2011)*. British Standards Institution, London, 26 p.

BSI (2012a). *Geotechnical Investigation and Testing - Geohydraulic Testing - Part 2: Water Permeability Tests in a Borehole using Open Systems (BS EN ISO 22282-2:2012)*. British Standards Institution, London, 36 p.

BSI (2012b). *Geotechnical Investigation and Testing - Geohydraulic Testing - Part 3: Water Pressure Tests in Rock (BS EN ISO 22282-3:2012)*. British Standards Institution, London, 36 p.

BSI (2012c). *Geotechnical Investigation and Testing - Geohydraulic Testing - Part 4: Pumping Tests (BS EN ISO 22282-4:2012)*. British Standards Institution, London, 34 p.

BSI (2012d). *Geotechnical Investigation and Testing - Geohydraulic Testing - Part 5: InfiltrometerTests (BS EN ISO 22282-5:2012)*. British Standards Institution, London, 30 p.

BSI (2012e). *Geotechnical Investigation and Testing - Geohydraulic Testing - Part 6: Water Permeability Tests in a Borehole using Closed Systems (BS EN ISO 22282-6:2012)*. British Standards Institution, London, 24 p.

BSI (2012f). *Geotechnical Investigation and Testing - Field Testing, Part 1: Electrical Cone and Piezocone Penetration Test (BS EN ISO 22476-1:2012)*. British Standards Institution, London, 46 p.

CS3:2013 (2016). *Aggregates for Concrete (Construction Standard CS3:2013)*. Civil Engineering and Development Department, Hong Kong, 140 p.

ETWB (2004). *Impossibility/Unforeseen Ground Conditions/Utility Interference (Environment, Transport and Works Bureau Technical Circular (Works) No. 17/2004)*. Environment, Transport and Works Bureau, Government Secretariat, Hong Kong.

Evans, N.C. & Irfan, T.Y. (1991). *Landslide Studies 1991 : Blast-induced Rock Slide at Shau Kei Wan, November 1991*. Special Project Report No. SPR 6/91, Geotechnical Engineering Office, Hong Kong, 115 p.

GEO (1992). *Guide to Cavern Engineering, Geoguide 4*. Geotechnical Engineering Office, Hong Kong, 156 p.

GEO (2007). *Engineering Geological Practice in Hong Kong*. Geotechnical Engineering Office, Hong Kong, 278 p.

GEO (2016). *Catalogue of Hong Kong Tunnels (up to February 2016)*. Geotechnical Engineering Office, Hong Kong. (http://www.cedd.gov.hk/eng/publications/reference/doc/HK%20Tunnel%20Cat.pdf)

GEO (2017a). *Model Specification for Soil Testing (Geospec 3)*. Geotechnical Engineering Office, Hong Kong, 340 p.

GEO (2017b). *Guide to Reinforced Fill Structure and Slope Design (Geoguide 6)*. Geotechnical Engineering Office, Hong Kong, 236 p.

HCL (2001). *Detailed Study of Selected Landslides on Slope No. 11NE-D/C45, Hiu Ming Street, Kwun Tong*. Landslide Study Report No. LSR 7/2001, Geotechnical Engineering Office, Hong Kong, 96 p.

Hencher, S.R. (1981). *Report on Slope Failure at Yip Kan Street (11SW-D/C86) Aberdeen on 12th July 1981*. Geotechnical Control Office Report No. GCO 16/81, Geotechnical Control Office, Hong Kong, 26 p.

HKSARG (2013). *Construction Standard, Aggregates for Concrete (CS3:2013)*. The Government of the Hong Kong Special Administrative Region, Hong Kong, 140 p.

Ho, H.Y., King, J.P. & Wallace, M.I. (2006). *A Basic Guide to Air Photo Interpretation in Hong Kong*. Applied Geoscience Centre, Department of Earth Sciences, University of Hong Kong, 115 p.

IMMM (2003). *Ground Investigation Working Party - Final Report*. Institute of Materials, Minerals and Mining, Hong Kong Branch, 46 p.

ITA (2009). *General Report on Conventional Tunnelling Method*. International Tunnelling and Underground Space Association. (http://www.ita-aites.org/cms/ita-aites-home/latest-news-detail/datum/2009/05/13/ita-report-online-copie-1.html)

Sewell, R.J., Campbell, S.D.G., Fletcher, C.J.N., Lai, K.W. & Kirk, P.A. (2000). *The Pre-Quaternary Geology of Hong Kong*. Geotechnical Engineering Office, Hong Kong, 181 p.

USACE (1997). *Engineer Manual 1110-2-2901 Engineering and Design - Tunnels and Shafts in Rock.* US Army Corps of Engineers. (http://140.194.76.129/publications/eng-manuals/em1110-2-2901/toc.htm)

(b) **Delete the following references:**

Brian-Boys, K.C., Howells, D.J., Pang, P.L.R. & Koirala, N.P. (1986). *Second Draft Model Specification for Reinforced Fill Structures*. Geotechnical Control Office, Hong Kong, 83 p.

BSI (1965). *Earthing (CP 1013:1965)*. British Standards Institution, London, 132 p.

BSI (1973). *Cathodic Protection (CP 1021:1973)*. British Standards Institution, London, 104 p.

BSI (1974a). *Specification for Core Drilling Equipment (BS 4019:1974). Part I - Basic Equipment*. British Standards Institution, London, 152 p.

BSI (1975a). *Methods for Sampling and Testing of Mineral Aggregates, Sand and Filters (BS 812:1975). Part I - Sampling, Size, Shape and Classification*. British Standards Institution, London, 24 p.

BSI (1975b). *Methods of Test for Soil for Civil Engineering Purposes (BS 1377:1975)*. British Standards Institution, London, 144 p.

BSI (1975c). *Methods of Test for Stabilized Soils (BS 1924:1975)*. British Standards Institution, London, 96 p.

BSI (1977). *Code of Practice for Protective Coating of Iron and Steel Structures against Corrosion (BS 5493:1977)*. British Standards Institution, London, 112 p.

BSI (1981a). *Code of Practice for Site Investigations (BS 5930:1981)*. British Standards Institution, London, 148 p.

BSI (1981b). *Code of Practice for Earthworks (BS 6031:1981)*. British Standards Institution, London, 88 p.

APPENDIX I
NEW TABLES & FIGURES

Table 2 - Aerial Photographs Available from the Lands Department
(Sheet 1 of 2, low altitude photographs)

[Amd GG2/01/2017]

Year	Scale(s)	Approximate Coverage (%)			Remarks
		HKI	K	NT	
1924	Approx. 1:14 000	60	10	30	Medium to low resolution, single frames with incidental stereo overlap.
1945	1:12 000	95	60	95	Medium to good resolution. Almost all areas except east-west strip from Tuen Mun to Sai Kung.
1949	1:4 800 1:11 600	100	95	30	Good resolution. Excellent coverage of north-west New Territories. Good coverage of lowland areas.
1956 1959	1:10 000 1:13 300	10	50	5	Good resolution; some stereo overlap.
1961-1962	1:10 000	100	100	10	Good resolution; small relief exaggeration.
1963	NT = 1:7 800 HKI + K = 1:5 400	100	100	95	Excellent resolution, full stereo coverage. Coverage of all areas except Mai Po to Sha Tau Kok.
1964	1:3 600	5	5	10	Coverage of trunk roads.
1967	1:7 800 - 1:12 500	90	90	20	Coverage of main Urban Area only.
1968-1970	1:5 000 - 1:10 000	40	100	20	Coverage of Urban Areas.
1972	1:6 000 - 1:13 000	40	80	20	Coverage of trunk road.
1973	1:3 000 1:10 000 - 1:12 000	70 70	100 100	5 90	Urban Areas only. Most of HKSAR.
1974	1:5 000	10	70	30	Coverage of north-west and west New Territories.
1975	1:4 600 - 1:10 000	5	40	30	Coverage of north-west and west New Territories.
1976	1:2 000 - 1:8000	100	100	40	Coverage of Urban Areas and New Towns.
1977	1:2 800 - 1:8 000	100	100	50	Detailed coverage of north-west and north New Territories plus New Towns.
1978-1987	1:4 000 - 1:8 000	100	100	60	Annual coverage of Urban Areas including New Towns and lowland areas.
1988 to present	1:2 000 - 1:12 000	100	100	45-90	Annual coverage of New Territories varies from year to year.

Note: Colour aerial photographs have also been taken routinely since 1993.

Table 2 - Aerial Photographs Available from the Lands Department
(Sheet 2 of 2, high altitude photographs)

[Amd GG2/01/2017]

Year	Scale(s)	Approximate Coverage (%)			Remarks
		HKI	K	NT	
1954	1:60 000	2	80	90	Good resolution.
1964	1:25 000	100	100	100	Excellent resolution. Mosaic of aerial photographs available. East to west flight lines, 4 to 5 km apart.
1973	1:25 000	100	100	90	Good resolution. East to west flight lines 3 to 5 km apart.
1974-1976	1:25 000	100	100	100	Good resolution. Annual coverage. East to west flight lines, 1 to 4 km apart.
1977	1:25 000	20		20	Obliques only of Urban Area. Coverage of Lantau, west New Territories and Sha Tin.
1978	1:25 000	100	100	100	Complete coverage.
1979	1:20 000	100	100	100	Complete coverage.
1980	1:20 000	100	80	20	Southern half of HKSAR only.
1981	1:20 000 1:50 000	100 80	100 80	100 10	Complete coverage. Urban Area and Lantau only.
1982	1:20 000	100	100	100	Complete coverage
1983	1:20 000 1:40 000	100 100	100 100	100 95	Complete coverage. Almost complete coverage.
1984	1:20 000	30	40	15	Coverage of Urban Area, Clearwater Bay and Sai Kung Peninsula.
1985	1:20000 1:30 000	100	100	100	Complete coverage
1986	1:20 000	100	100	100	Complete coverage.
1987	1:40 000	100	100	100	Complete coverage.
1988 – 1997*	1:20 000 - 1:40 000	100	100	100	Complete coverage.
1998 to present	1:16 000 - 1:40000	100	100	100	Complete coverage.

Note: Colour aerial photographs have also been taken routinely since 1993.
*Year 1996: only 1:20 000 available

Table 13 – Outline of Engineering Consideration and SI Techniques for Rock Tunnels (based on IMMM, 2003)

[Amd GG2/01/2017]

MAJOR ENGINEERING CONSIDERATIONS	KEY POINTS FOR SI	APPROACH TO INVESTIGATION **Investigation Methods**	TESTING **Insitu Testing**	SURVEY / MONITORING **Instrument Types**
Blasting design Machineability (suitability for TBM) Soil and rock mass excavation and support design (possibility of presence of mixed face conditions, fractured ground, and weak, compressible and/or permeable zones) Water pressures acting on lining /retaining structures for their design Potential water inflow into the shafts and along the tunnels. Assessment of tunnels/shafts drainage and pumping requirements Effects of the tunnel works on land stability, e.g. ground collapse/landslide due to inadequate support, hydraulic failure, blow-out failure, etc. Ground settlement, heave and lateral movement and distortion of sensitive receivers as a result of construction-induced ground loss, ground deformation/vibration and groundwater inflow/drawdown Design of tunnel portal slopes Lining/retaining structure durability design Effects of blasting on surface/subsurface facilities and slopes	Nature of soil and/or rock at tunnel level (invert and crown) and around the tunnels, and around/within the shafts Rock mass weathering (including presence of corestones and mixed ground) and strength Distribution, orientation and characteristics of discontinuities Rock mass permeability Insitu stress Presence of fault zones, dykes, contact zones between geological units, etc. Hydrogeology, including permanent groundwater table, perched water tables, permeable zones feeding water to the tunnels, etc. Potential recharge in response to rainfall and the sea, and hydraulic boundary conditions Dewatering effects of the tunnels, and the tunnel works damming subsurface groundwater flow Nature of surface materials, in particular, strength, permeability, compressibility and consolidation and creep characteristics As-built records and site history, in particular, effects of past and on-going construction activities that could affect the tunnels/shafts and the sensitive receivers Ground and groundwater chemistry	Geological mapping of surface rock exposures Aerial photograph interpretation to identify photolineaments Geophysical surveys to identify anomalies and low seismic velocity zones Boreholes – vertical holes needed for sampling and downhole tests. Unless surface materials need to be characterised for assessment of effects of the tunnel works, boreholes can be wash-bored down to the zone of interest Sub-horizontal/inclined holes from the tunnel portal and/or shaft locations to examine variations of ground conditions along the tunnel drive Inclined holes to intercept faults, dykes and contact zones at tunnel level Probing ahead during tunnelling operation Directional coring (for deep tunnels) **Sampling** Rock coring through proposed tunnel levels (including all alternative alignments) and covering sufficient ground above crown and below invert Undisturbed soil samples for near-surface materials, potentially affected by the tunnel and shaft construction	Impression packer test, televiewer Packer permeability test and possibly pumping test Insitu stress measurement (e.g. by hydrofracturing) Soil permeability test and response test in piezometer **Laboratory Testing/Analysis** Unconfined Compressive Strength Young's Modulus Poisson's Ratio Point Load Strength Rock joint characteristics Abrasivity Hardness Geological thin sections Classification and consolidation creep tests for settlement-susceptible near-surface materials Salinity testing to assess the effects of groundwater on tunnelling equipment and lining	Piezometers for monitoring pore water pressures at various hydrogeological response zones Settlement gauges **Survey / Monitoring** Location survey of physical constraints and sensitive receivers Complete annual cycle needs to be monitored to indicate groundwater pressure response to rainfall and seasonal fluctuation, and to recharge from the sea Baseline ground movement and vibration survey and condition survey of sensitive receivers (e.g. cracks on existing structures) over a sufficiently long period to establish trends

NB: Reference should also be made to the ground investigation guidelines for deep excavations and rock tunnels produced by AGS (HK) (2004a & b; 2005).

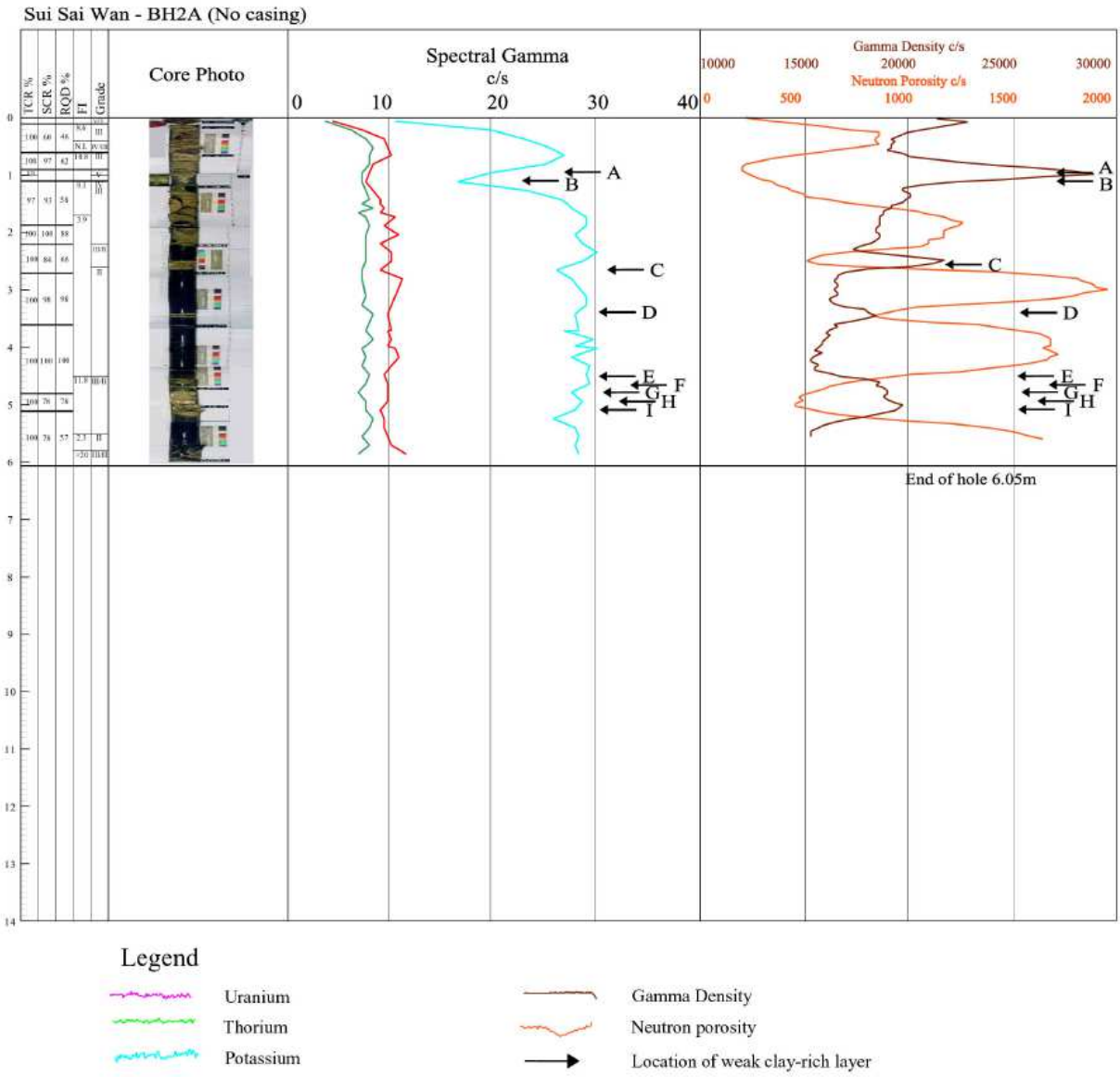

Figure 45 – Geophysical Logs – Siu Sai Wan – BH2A

[Amd GG2/01/2017]

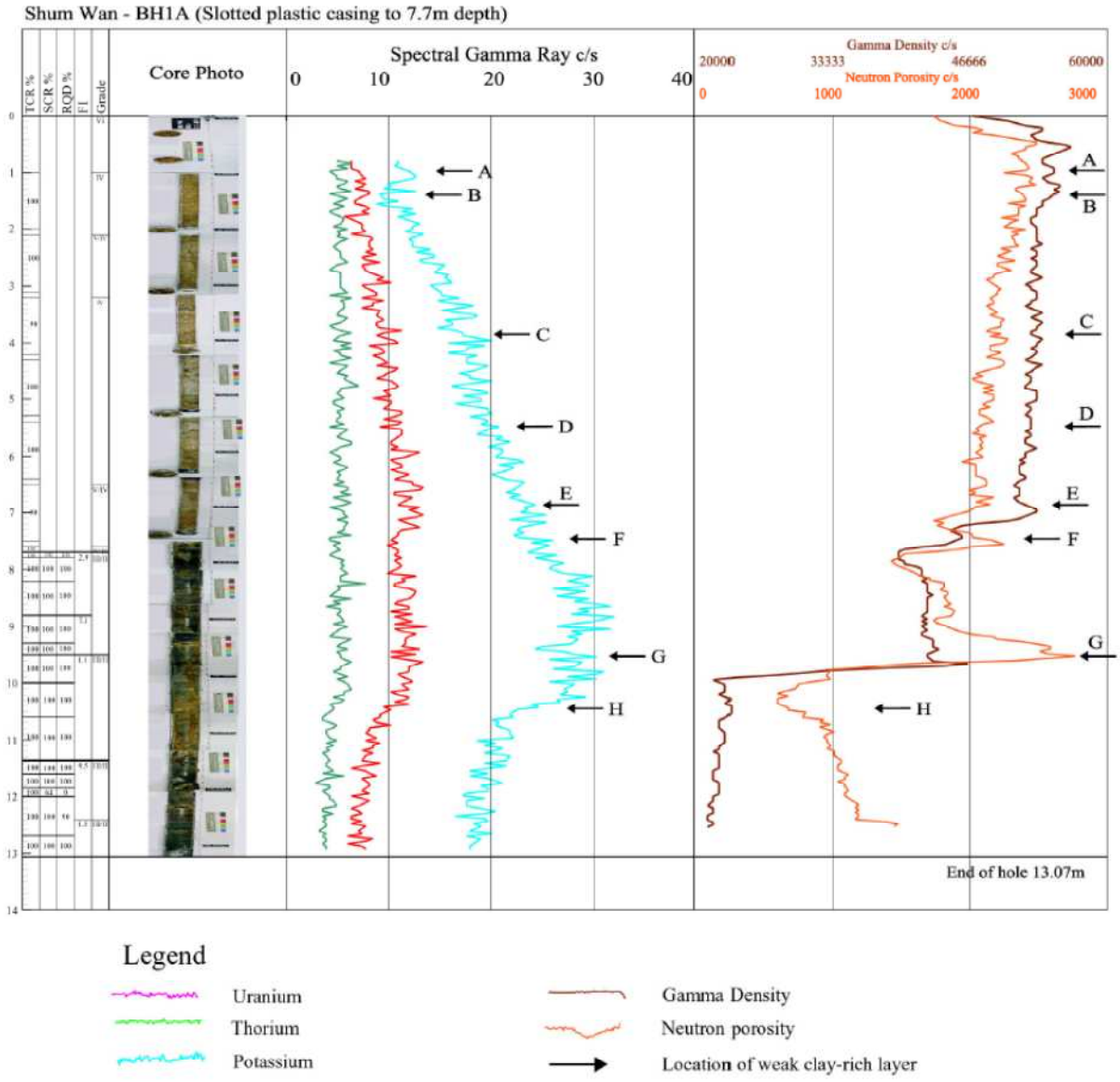

Figure 46 – Geophysical Logs – Shum Wan – BH1A

[Amd GG2/01/2017]

APPENDIX II
NEW APPENDIX B OF GEOGUIDE 2

Appendix B

Sources of Information

[Amd GG2/01/2017]

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B.1 Generals

This document gives important sources of information for the planning of site investigation in Hong Kong, in addition to the publications and guidance documents prepared by the GEO. A complete list of GEO publications and a list of TGNs, which are continually updated, can be found at the website http://www.cedd.gov.hk. Other information that could be useful for planning, design, construction and maintenance of geotechnical works can be found at the Hong Kong Slope Safety Website http://hkss.cedd.gov.hk.

B.2 Slope-related Information Systems and Databases

B.2.1 Slope Information System (SIS)

The SIS is a geographical information system developed by the GEO to enable on-line examination and analysis of information on slopes and the surrounding ground. It contains computerised information including the catalogue of slopes (see Section B.2.2 below), slope maps, locations of previous landslide incidents reported to GEO and ground investigation stations, geology, natural terrain landslides and selected geotechnical information for the various districts in Hong Kong. The SIS can be accessed through the SIS terminals in the Civil Engineering and Development Building and also via the Hong Kong Slope Safety Website (http://hkss.cedd.gov.hk). The GEO Slope Safety Division can be contacted for up-to-date information on the development of the SIS.

B.2.2 Catalogue of Slopes

The Catalogue of Slopes contains information on physical properties, conditions and histories of over 57,000 sizeable man-made slopes in Hong Kong (e.g. slope type, slope geometry, type of surface protection, signs of seepage, movements and previous failures). Information on slopes in the Catalogue can be retrieved from SIS terminals in the Civil Engineering and Development Building, via the Hong Kong Slope Safety Website (http://hkss.cedd.gov.hk), or by application in writing to the GEO Slope Safety Division.

B.2.3 Slope Maintenance Responsibility Information System (SMRIS) Maintained by the Lands Department

The SMRIS, which is maintained by the Lands Department, systematically identifies the maintenance responsibility of all man-made slopes registered in the Catalogue of Slopes. The most up-to-date information of maintenance responsibility can be accessed via the Lands Department or at the Lands Department's Website (http://www.landsd.gov.hk). Where the land status of a slope is not available in SMRIS, the Systematic Identification of Maintenance Responsibility of Slopes (SIMAR) Unit or the respective DLO of Lands Department should be consulted.

B.2.4 Rainfall Database

The GEO in collaboration with the Hong Kong Observatory (HKO) has established and maintains a network of automatic raingauges throughout Hong Kong. Rainfall data have been recorded at 5-minute intervals at these raingauges since 1984. In 1999, the GEO automatic raingauge system was upgraded and expanded to include 86 GEO raingauges (Pang et al, 2000). Verified rainfall data are available either from the HKO or the GEO Standards and Testing Division.

B.2.5 Landslide Database

An Incident Report contains information on the date, time (where known) and location of the incident, the type, size, possible causes contributing to and consequence of the failure, the advice given, evidence of past instabilities, photographs taken of the failure, etc. If the failure mass exceeds 50 m^3 or where a fatality is involved, a Landslip Card, which contains more detailed information, is also prepared and is available for inspection in the Public Section of the Civil Engineering Library (CEL) (Section B.12.1). A computerised landslide database containing data from the Incident Reports and Landslip Cards is available and is accessible via the SIS. The database is maintained and updated by the GEO Landslip Preventive Measures Division 1.

B.2.6 Enhanced Natural Terrain Landslide Inventory (ENTLI)

The ENTLI contains information on over 105,000 landslides occurred on natural terrain. Comprehensive information is recorded in Geographical Information System for each landslide record including the dates of the aerial photographs when the landslide was first observed, width and length of the landslide scar, slope gradient, and nature of vegetation cover across the landslide source. The ENTLI is available for inspection as 1:5 000 scale map sheet paper copies in the CEL and the digital copy of the data is held in the GEO Planning Division.

B.2.7 Boulder Field Inventory

A series of fifteen 1:20 000 scale boulder field inventory maps covering the Hong Kong Special Administrative Region (HKSAR) is available for viewing in GEO Planning Division and the CEL and a digitised version is available in the SIS. A multiple attribute mapping technique was adopted to present the results. Four attributes were mapped-percentage area covered by boulders, boulder type, boulder size and boulder shape.

B.2.8 Large Landslide Study

In this study, covering the whole of Hong Kong, a geomorphological interpretation was conducted to identify features thought to be landslides with sources areas greater than 20 m wide (Scott Wilson (Hong Kong) Ltd., 1999a, 1999b). The 1:5 000 scale maps containing the features are available for viewing in the GEO Planning Division.

B.3 Topographical Maps, Plans and Aerial Photographs

B.3.1 Maps and Plans Produced by the Survey & Mapping Office

The Survey & Mapping Office (SMO) of the Lands Department provides maps and plans in various scales and for various purposes in both digital and paper forms. A list of the currently available plans and maps, and their coverage, is given in Table B1.

The Land Information Centre of the SMO operates a Computerised Land Information System (CLIS) and maintains the topographic mapping database covering the whole territory of Hong Kong. Many utility companies, engineering consultants, computing system consultants and education institutes have established their own automated mapping, facilities management, customer support and geographic information systems using the digital maps provided by the SMO as their common reference. The digital map data are available in four different formats, namely E00, DGN, DXF and DWG, to suit applications in different platforms.

Services offered by the SMO include the supply of photographic copies of available maps, plans and aerial photographs, as well as producing enlargements and reductions. Updated information on map products and related publications, data map products and map price catalogue, etc., can also be found at the Lands Department Website (http://www.landsd.gov.hk/mapping/ en/pro&ser/products.htm).

B.3.2 Other Maps

Other map sources include the following:

(a) Early maps of Hong Kong are held for reference by the Survey & Mapping Office and the Government Records Service (GRS).

(b) The Antiquities and Monuments Office (AMO) of Leisure and Cultural Services Department (LCSD) holds research files covering declared monuments, historic buildings, structures and boundaries of archaeological sites. Most of these research materials can be accessed by the public in AMO by appointment. Declared monuments, historic buildings, structures and boundaries of archaeological sites may also be indicated in non-statutory plans which are available for sale in the Map Publications Centres of the Survey & Mapping Office of the Lands Department (Section B.3.1).

B.3.3 Aerial Photographs

The availability of vertical aerial photographs is summarised in Tables B.2a and B.2b. In general the aerial photograph scales range from 1:2 500 down to 1:50 000. The low altitude aerial photographs, mainly in the range of 1:6 000 to 1:10 000, are the most useful scale for the majority of aerial photograph interpretation undertaken.

The GEO Aerial Photograph Library contains over 280,000 aerial photographs including oblique aerial photographs. They can be borrowed by GEO staff as well as consultants working on Government projects. A GIS-based computerised aerial photograph retrieval system is now available for users to identify the photograph collection at a workstation in the Library. The Library, which is housed in the GEO Planning Division on the 11th Floor of the Civil Engineering and Development Building, is accessible by staff of the HKSAR Government and also non-Government staff engaged in Government projects.

A similar system for searching aerial photographs is also available in the SIS.

Aerial photographs can be purchased directly from the Map Publications Centres of the Lands Department.

B.4 Geological and Related Maps and Memoirs

B.4.1 Geological Maps and Memoirs

Geological surveying in Hong Kong is carried out by the Hong Kong Geological Survey (HKGS) of the GEO. Thirty-four maps and six sheet reports have been published to date and the Sheet Reports are available (free of charge) either from the GEO Planning Division or downloaded from the CEDD Website (http://www.cedd.gov.hk). In 2003, the HKGS embarked on a programme to update the 1:20 000 scale geological maps and to release them in digital form. The coverage of the maps, memoirs and reports is shown in Figure B1. The maps and memoirs (except those which are free of charge) can be obtained from the Map Publications Centres of the Survey and Mapping Office while the memoirs are also available from the online Government Bookstore at http://www.bookstore.gov.hk.

B.4.2 Terrain Classification and Engineering Geology Maps

A series of eleven 1:20 000 scale terrain classification maps (TCM) covering the whole of the HKSAR was produced by the GEO in the 1980s. Each map covers an irregular area based on catchment boundaries. Derivative maps and accompanying reports have been published for each area as the Geotechnical Area Studies Programme (GASP) series. The series contains 12 volumes, of which Volume XII is a summary report for the whole of the HKSAR. They are available for viewing in the Geotechnical Information Unit (GIU) of the CEL. Limited copies are available for sale at the Map Publications Centres of the Survey and Mapping Office, and online Government Bookstore.

Nine catchments with extensive colluvial deposits were also identified for GAS mapping at 1:2 500 scale. These maps contain details of old landslide scars. In 1990, a 1:5 000 scale

terrain classification mapping exercise was carried out for eleven 1:5 000 scale map sheets in North Lantau. These are available for viewing in the CEL and have been incorporated into three Engineering Geology Reports on the North Lantau Area (Franks, 1991, 1992; Woods, 1992).

B.4.3 Other Geological Records and Information

The GEO Planning Division is the repository for geological records for the HKSAR. These include the field observations embodied in the geological maps and memoirs, manuscript geological maps, and offshore data. Requests for information should be directed to the Chief Geotechnical Engineer of the Planning Division. The GEO also holds a collection of representative rock types and thin sections. These are available for inspection by arrangement. An on-line version of the geology of Hong Kong, based on the two memoirs but with additions from the current map updating programme now underway, has been published on the internet (Lee & Sewell, 2007). The on-line geological memoir of Hong Kong can be accessed at http://www.cedd.gov.hk/eng/about/organisation/ org_geo_pln_map.htm. A summary of the nature and occurrence of Hong Kong rocks and superficial deposits is also given in Appendix A of Geoguide 3 (GEO, 2017).

B.5 Nautical Charts and Marine Department Notices

The Hydrographic Office of the Marine Department complies and publishes paper charts and electronic navigational charts. Further information on the products and services of the Hydrographic Office can be found at the website http://www.mardep.gov.hk.

Marine Department Notices are issued as and when required concerning information relating to navigational safety and other marine activities in Hong Kong waters. Copies of the Notices can be downloaded from the website http://www.mardep.gov.hk.

B.6 Meteorological, Seismological and Tidal Information

The Hong Kong Observatory (HKO) collects and publishes meteorological information in Hong Kong. It issues daily weather reports and forecasts as well as warnings on tropical cyclone, thunderstorm, rainstorm, landslip, strong monsoon, fire danger, frost, tsunami, cold and very hot weather. Rainfall records are published monthly and annually. The HKO also maintains a local seismological network to monitor earthquakes near Hong Kong.

Predicted tide levels at selected locations are published annually in ‘Tide Tables for Hong Kong’ which are available at the online Government Bookstore.

Further information on the services of the HKO can be found at the website http://www.hko.gov.hk.

B.7 Hydrological Information

The Drainage Services Department and Water Supplies Department operate and maintain separate systems of stream/river gauging stations in the main catchment areas of the HKSAR.

B.8 Past Records

B.8.1 Records from Previous Investigations

The GIU of the GEO holds reports of previous ground investigation, which usually include borehole logs and sometimes results from geophysical surveys and laboratory testing of soils, rocks and sediments. Digital Geotechnical Information Unit (DGIU) system is also available for fast retrieval of these reports in the CEL.

The GIU also contains a large amount of other information of direct relevance to site investigation, and this is described in Section B.12.1.

B.8.2 Design and Construction Records

Several Government Departments possess information that is of value to the planning and execution of site investigation in Hong Kong, but this is often not readily accessible. However, arrangements can usually be made for specific information to be made available to bona fide users.

For example, each Government Department retains its own files on projects that are carried out under its control. Copies of design reports and record drawings of completed projects are also kept.

A brief summary of information possessed by some of the Government Departments is given below:

Department	Record/Information
Architectural Services Department	Records of Government buildings
Buildings Department	Building plans and related documents of existing buildings in Hong Kong (except for pre-war buildings and New Territories Exempted Houses). These documents may be available for viewing by the public in the Buildings Department upon application.
Environmental Infrastructure Division of the Environmental Protection Department	Records of known landfills
Civil Engineering Library	Plans showing the locations of disused tunnels
Drainage Services Department	Records of sewerage tunnels (see also Section B.10.4)
Geotechnical Engineering Office of the Civil and Engineering and Development Department	Landslip Preventive Measures study reports, information on slopes and records of all known disused tunnels and quarries. Catalogue of Hong Kong Tunnels and Catalogue of Notable Tunnel Failure Case Histories. The Catalogues can be accessed at the CEDD Website http://www.cedd.gov.hk/eng/publications/reference/doc/HK%20Tunnel%20Cat.pdf and http://www.cedd.gov.hk/eng/publications/reference/doc/HK%20NotableTunnel%20Cat.pdf (Designers should obtain the design and construction details of such tunnels from the relevant owners and maintenance agents.)
Water Supplies Department	Record of water tunnels, water mains, catchwaters, impounding reservoirs, service reservoirs, water treatment works, pumping stations, and ancillary structures.

B.8.3 Hong Kong Rainfall and Landslide Studies

Since 1984, the GEO has compiled annual reports to document information on rainfall and landslides occurring in the HKSAR. GEO has also prepared detailed/forensic investigation reports on some selected major landslide incidents and incidents involving casualties. Since 1997, GEO has started engaging consultants to carry out investigation of some selected landslides and to prepare landslide study reports. The annual reports, detailed/forensic investigation reports and landslide study reports are either published as GEO Reports or produced as GEO internal reports. GEO Reports can be purchased from the online Government Bookstore or downloaded from the CEDD Website http://www.cedd.gov.hk.

GEO internal reports can be viewed in the CEL. Summary of findings of selected landslide studies are also uploaded onto the Hong Kong Slope Safety Website http://hkss.cedd.gov.hk for viewing.

B.8.4 Slope Maintenance Records

Slope maintenance records (e.g. maintenance manuals, records of slope upgrading, records of routine maintenance and Engineer Inspections, records of monitoring of special measures such as permanent prestressed ground anchors and designed horizontal drains) are kept by the slope owners or their maintenance agents (GEO, 2003).

B.8.5 Other Public Records

The GRS is the central repository for the permanent archives and selected official publications of the HKSAR Government. It maintains catalogued collections of maps and photographs dating from 1860, together with almost complete collections of the Hong Kong Government Gazette, Blue Books, Sessional Papers, Administrative Reports, Historical & Statistical Abstracts of Hong Kong, Legislative Council Minutes, Annual Departmental Reports, Ordinances and Regulations, Hong Kong Hansard and a comprehensive newspaper collection. In November 2002, GRS introduced an integrated information access system to facilitate online searching of all catalogues and access to selected visual images via the Internet. (http://www.grs.gov.hk/ws/english/es_online_cata.htm)

The Photo Library of the Information Services Department has in place some old photographs which may be reproduced for use by members of the public.

Lists of declared monuments and deemed monuments as well as archaeological sites are maintained by the Antiquities & Monuments Office (AMO) of the Leisure and Cultural Services Department (see also Section B.3.2).

B.9 Notes and Circulars Related to Ground Investigation Works

For private development, the general requirements for carrying out ground investigation works, including the site supervision requirements, are given in PNAP APP-49 which can be downloaded from Buildings Department Website http://www.bd.gov.hk. For public development, the requirements are given in WBTC No. 13/90. Ground Investigation Note No. 1/2008, which can be downloaded from CEDD Website http://www.cedd.gov.hk gives the details of procurement of ground investigation and laboratory testing services provided by CEDD for Government projects. Guidance on specific aspects of site investigation for tunnel works in Hong Kong are given in Sections 10.9, 16.5 and 40.4 of this Geoguide.

B.10 Scheduled and Designated Areas and Other Concerned Areas

B.10.1 Mid-levels Scheduled Area

Ground investigation works in scheduled areas, including the Mid-levels Scheduled Area, are subject to special geotechnical control under the Buildings Ordinance. The Mid-levels Scheduled Area is specified as Area Number 1 of the Scheduled Areas in the Fifth Schedule of the Buildings Ordinance. A plan showing the boundary of the Mid-levels Scheduled Area is on display in Buildings Department and in the GIU of the CEL.

The Mid-levels Consultants' study was summarised in a report entitled "Mid-levels Study: Report on Geology, Hydrology and Soil Properties" (GCO, 1982). The report is available for sale at the online Government Bookstore. All factual data on geology, hydrology and soil properties collected in the course of the Mid-levels Study between 1979 and 1981 are available for inspection in the GIU.

For private development, the requirements on the special geotechnical control for ground investigation works in the Mid-levels Scheduled Area are given in PNAP APP-30. For public development, the requirements are specified in ETWB TC (Works) No. 29/2002A.

B.10.2 North-western New Territories and Ma On Shan Areas

The designated areas in North-western New Territories and Ma On Shan are specified as Area Numbers 2 and 4 respectively of the Scheduled Areas in the Fifth Schedule of the Buildings Ordinance. The plans illustrating the exact extent of these Areas are on display in the Buildings Department and in the GIU.

Considerable information exists on the geology of the Scheduled Areas. Twenty 1:5 000 Geological Map sheets, together with the Hong Kong Geological Survey Sheet Report No. 1 - Geology of Yuen Long, covers Area Number 2. Scheduled Area 4 is covered by 1:5 000 Geological Map Sheets 7-NE-C and 7-NE-D, together with a report on the geology. These can be obtained from the GEO Planning Division.

For private development, the requirements on the special geotechnical control for ground investigation works in these Scheduled Areas are given in PNAP APP-61. For public development, the requirements are specified in ETWB TC (Works) No. 4/2004.

B.10.3 Mass Transit Railway Areas

To safeguard the safety and stability of the Mass Transit Railway (MTR) structures operated and maintained by the MTR Corporation Limited (MTRCL), a "protection boundary" for the railways has been drawn on plans or determined by a figure and a set of building/engineering guidelines produced. The areas within the "protection boundary" are commonly known as the railway protection areas.

The MTR operates a network of railways. Amongst the railway protection areas, some areas are designated as Scheduled Area No. 3 in the Fifth Schedule of the Buildings Ordinance

(Scheduled Area No. 3). The areas within the "protection boundary" have been designated as Scheduled Area No. 3. The plans illustrating the extent of these areas are available for inspection in the Buildings Department (BD) and the MTRCL. Information on the "alignment of the railways as constructed" may be obtained direct from MTRCL. For private development, the additional requirements for ground investigation works within Scheduled Area No. 3 are given in PNAP APP-24 and PNAP APP-131. WB Technical Circular No. 19/2002, ETWB Technical Circular (Works) Nos. 33/2003 and 2/2005 shall be referred to for guidance on ground investigation works near the MTR and liaison with the Railway Protection & Land Survey Manager of the MTRCL.

The Survey and Mapping Office of Lands Department maintains a set of digital land records covering the whole territory of Hong Kong. Useful information, e.g. lot boundaries, the railway reserves and others, is recorded in this database.

B.10.4 Sewage Tunnel Protection Areas

The sewage tunnel protection areas are designated as Area Number 5 of the Scheduled Areas in the Fifth Schedule of the Buildings Ordinance (Scheduled Area No. 5). The plans illustrating the extent of these areas are available for inspection in the Buildings Department and the Drainage Services Department. For private development, the additional requirements for ground investigation work within Scheduled Area No. 5 are given in PNAP APP-62. For ground investigation works proposals of Government Departments in the vicinity of the sewage tunnels, the project proponents shall refer to ETWB Technical Circular (Works) No. 28/2003 for the procedures for forwarding proposals to Drainage Services Department and GEO for comment/agreement.

B.10.5 Designated Area of Northshore Lantau

The Designated Area is underlain by locally complex geological conditions that require due attention to be given to the potential problems associated with high-rise buildings and other structures involving deep foundations. Technical recommendations and the plan illustrating the exact extent of the area are given in GEO TGN No. 12.

For private development, administrative procedures and general guidance for ground investigation work in the Designated Area are given in PNAP APP-134. For public development, the requirements are specified in ETWB TC(W) No. 4/2004.

B.10.6 Water Gathering Grounds (WGG)

Information on the limits of the WGG and the required conditions for protection of the WGG against pollution should be obtained from the relevant regional office of the Water Supplies Department. Maps showing WGG are also held by the relevant District Lands Offices of the Lands Department.

B.10.7 Marine Ground Investigation in Difficult Ground Areas

Difficult ground conditions generally refer to the existence of unfavourable subsoil strata on site. Technical guidelines on the areas and the plan illustrating the extent of the areas are given in Port Works Design Manual issued by CEDD.

B.11 Services and Utilities

Information on gas, electricity, telephone, cable television and similar services, including both the locations and details of existing facilities and the provision of further services, should be sought from the private companies supplying these services (see local telephone directories or the Yellow Pages for their latest addresses and telephone numbers).

Information on the locations of water mains, water tunnels, reservoirs and other waterwork facilities maintained by the Water Supplies Department (WSD) should be sought from the Department. Application forms and further information on the customer services of the WSD can be found at the website http://www.wsd.gov.hk.

As-built records of public stormwater drains and foul sewers should be sought from the Drainage Services Department (DSD). Similar records for private lots can be obtained from the Buildings Department. As-built records of exclusive road drainage should be sought from the Highways Department.

Tentative limits of allowable settlement, groundwater drawdown and vibration may be obtained from DSD, WSD, public corporations and private utility undertakers.

B.12 Local Libraries

B.12.1 The Civil Engineering Library and the Geotechnical Information Unit

The CEL is the central reference library of the Civil Engineering and Development Department. The CEL contains over 150,000 documents, including periodicals, books, conference proceedings, manuals, standards, codes of practice, geotechnical reports, maps, documents submitted to GEO in support of private developments, and documents produced by or for Government Departments.

The GIU forms part of the CEL and comprises a collection of geotechnical data from ground investigations throughout the HKSAR. The following GIU materials are among those available for inspection within the Public Section of the CEL.

(a) ground investigation and geophysical survey reports;

(b) reports on the laboratory testing of soil and rock;

(c) Landslip Cards;

(d) piezometer monitoring data; and

(e) an inventory of natural terrain landslides.

The Bibliography on the Geology and Geotechnical Engineering of Hong Kong, produced by the GEO, lists more than 4,600 items that are known to have been published specifically on aspects of the geology and geotechnical engineering of Hong Kong. The Bibliography can be found under the Publications Section of the CEDD Website http://www.cedd.gov.hk/eng/publications/reference/index.htm.

Members of the public are free to view documents held within the Public Section of the CEL and search for library materials using the Online Public Access Catalogue (OPAC) – V Lib computer terminals. Retrieval of ground investigation and laboratory testing reports can be accessed by the Digital Geotechnical Information Unit (DGIU) system. A user's manual for DGIU is provided in the CEL. Photocopying and printing facilities are available.

Further information on the services of the CEL and GIU can be found under the Public Services Section of the CEDD Website http://www.cedd.gov.hk/eng/services/library/ index.htm.

B.12.2 Other Libraries

The City Hall Public Library, the Hong Kong Central Library and the Kowloon Public Library each houses a reference section which contains a number of published documents on the geology and geotechnical engineering of Hong Kong, together with some unpublished reports. They also house Hong Kong Collections of considerable interest. Direct access is permitted to the shelved items, and bibliographic information of the items can be accessed through the Online Public Access Catalogue. Photocopying facilities are available for public use.

The University of Hong Kong, the Chinese University of Hong Kong, the Hong Kong Polytechnic University, the Hong Kong University of Science and Technology and the City University of Hong Kong each has a large library which contains a collection of general geological and geotechnical information. The first three, however, can only be accessed by special permission, although for bona fide visitors this is usually not difficult to obtain. The University of Hong Kong maintains the Hong Kong Collection, which contains considerable unpublished information, as well as master and doctoral degree theses on geological and geotechnical topics.

B.13 Addresses of Local Organizations

Antiquities and Monuments Office,
Leisure and Cultural Services Department,
136 Nathan Road, Tsim Sha Tsui, Kowloon.
(Tel.: 2721 2326)
(Website: http://www.amo.gov.hk)

Architectural Services Department,
Queensway Government Offices,
66 Queensway, Hong Kong.
(Tel.: 2867 3628)
(Website: http://www.archsd.gov.hk)

Buildings Department,
12th-18th Floors and 21st to 22nd Floors
Pioneer Centre, 750 Nathan Road, Kowloon.
(Tel.: 2626 1616)
(Website: http://www.bd.gov.hk)

City Hall Public Library,
City Hall High Block,
Edinburgh Place, Hong Kong.
(Tel.: 2921 2672)
(Website: http://www.hkpl.gov.hk)

Chinese University of Hong Kong Library,
122 Milestone, Tai Po Road,
Sha Tin, New Territories.
(Tel.: 2609 7301)
(Website: http://www.lib.cuhk.edu.hk)

City University of Hong Kong,
Run Run Shaw Library,
Tat Chee Avenue, Kowloon.
(Tel.: 2788 8311)
(Website: http://www.cityu.edu.hk)

Civil Engineering Office,
Civil Engineering and Development
Department,
Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon.
(Tel.: 2762 5111)
(Website: http://www.cedd.gov.hk)

District Lands Office,
Lands Department,
20th Floor, North Point Government
Offices,
333 Java Road, North Point,
Hong Kong
(Tel: 2525 6694)
(Website: http://www.landsd.gov.hk)

Drainage Services Department,
43rd Floor, Revenue Tower,
5 Gloucester Road,
Wan Chai, Hong Kong.
(Tel.: 2877 0660)
(Website: http://www.dsd.gov.hk)

Environmental Infrastructure Division,
Environmental Protection Department,
4/F, East Wing, Island West Transfer
Station,
88, Victoria Road,
Kennedy Town, Hong Kong
(Tel: 2872 1807)
(Website: http://www.epd.gov.hk)

Government Record Service,
Hong Kong Public Record Building,
13 Tsui Ping Road,
Kwun Tong, Kowloon,
(Tel: 2195 7801)
(Website: http://www.grs.gov.hk)

Geotechnical Engineering Office,
Civil Engineering and Development
Department,
Civil Engineering and Department
Building,
101 Princess Margaret Road,
Homantin, Kowloon.
(Tel.: 2762 5111)
(Website: http://www.cedd.gov.hk)

Geotechnical Information Unit,
Civil Engineering Library,LG1, Civil
Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon.
(Tel.: 2762 5148)
(Email: librarian@cedd.gov.hk)

Geotechnical Projects Division, GEO,
23rd Floor, 410 Kwun Tong Road,
Kwun Tong, Kowloon,
(Tel: 2716 8612)
(Email: anthonylam@cedd.gov.hk)

Highways Department,
5th Floor, Homantin Government Offices,
88 Chung Hau Street,
Homantin, Kowloon.
(Tel.: 2926 4111)
(Website: http://www.hyd.gov.hk)

Hong Kong Observatory,
134A Nathan Road,
Tsim Sha Tsui,
Kowloon.
(Tel: 2926 8200)
(Website: http://www.hko.gov.hk)

Hong Kong Central Library,
55 Causeway Road, Hong Kong,
(Tel: 2921 0222)
(Website: http://www.hkpl.gov.hk)

Hong Kong Geological Survey,
Geotechnical Engineering Office,
11th Floor, Civil Engineering and
Development Building,
101 Princess Margaret Road,
Homantin, Kowloon,
(Tel: 2762 5380)
(Email: jsewell@cedd.gov.hk)

Hong Kong Polytechnic University Library,
Pao Yue-kong Library,
Yuk Choi Road,
Hung Hom, Kowloon.
(Tel.: 2766 6863)
(Website: http://www.lib.polyu.edu.hk)

Hong Kong University of Science &
Technology Library,
Clear Water Bay,
Kowloon.
(Tel.: 2358 6762)
(Website: http://library.ust.hk)

Kowloon Public Library,
5 Pui Ching Road,
Homantin,
Kowloon.
(Tel.: 2926 4062)
(Website: http://www.hkp1.gov.hk)

Lands Department,
1st, 2nd, 6th, 18th to 24th Floors,
North Point Government Offices,
333 Java Road, North Point, Hong Kong.
(Tel.: 2231 3294)
(Website: http://www.landsd.gov.hk)

Lands Information Centre,
Survey and Mapping Office,
Lands Department,
23rd Floor, North Point Government Offices,
333 Java Road,
North Point, Hong Kong,
(Tel: 2231 3452)
(Website: http://www.landsd.gov.hk)

Landslip Preventive Measures Division 1,
GEO, 1st Floor, Civil Engineering and
Development Building,
101 Princess Margaret Road,
Homantin, Kowloon.
(Tel.: 2760 5778)
(E-mail: dominiclo@cedd.gov.hk)

Leisure and Cultural Services Department,
1-3 Pai Tau Street,
Sha Tin,
New Territories.
(Tel.: 2603 4567)
(Website: http://www.lcsd.gov.hk)

Map Publications Centre (Hong Kong),
Survey and Mapping Office
Lands Department
23rd Floor, North Point Government Offices,
333 Java Road, North Point, Hong Kong.
(Tel.: 2231 3187)
(E-mail: smosale1@landsd.gov.hk)

Map Publications Centre (Kowloon),
Survey and Mapping Office,
Lands Department
382 Nathan Road,
Yau Ma Tei, Kowloon.
(Tel.: 2780 0981)
(E-mail:smosale2@landsd.gov.hk)

Marine Department,
Harbour Building,
38 Pier Road, Hong Kong.
(Tel.: 2542 3711)
(Website: http://www.mardep.gov.hk)

Mines Division, GEO,
25th Floor, 410 Kwun Tong Road,
Kwun Tong, Kowloon.
(Tel.: 2716 8666)
(E-mail:mines@cedd.gov.hk)

MTR Corporation Limited
MTR Tower Telford Plaza,
Kowloon Bay, Kowloon.
(Tel.: 2993 2111)
(Website:http://www.mtr.com.hk/engtxt/railway/protection_index.html)

Online Geological Memoir
(Website:http://www.cedd.gov.hk/eng/about/organisation/org_geo_pln_map.htm)

Online Government Bookstore,
(Website: http://www.bookstore.gov.hk)

Planning Division, GEO,
11th Floor, Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon.
(Tel.: 2762 5400)
(E-mail: tonyykho@cedd.gov.hk)

Publications Sales Unit,
Information Services Department,
Room 402, 4th Floor, Murray Building,
Garden Road, Central, Hong Kong.
(Tel.: 2537 1910)
(Website: http://www.isd.gov.hk)

Slope Maintenance Responsibility Information Centre,
Lands Department,
1st Floor, North Point Government Offices,
333, Java Road, North Point, Hong Kong.
(Tel.: 2231 3333)
(Website: http://www.landsd.gov.hk)

Slope Safety Division, GEO,
7th Floor, Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon.
(Tel.: 2760 5760)
(Hong Kong Slope Safety Website:
http://hkss.cedd.gov.hk)
(E-mail: hkss@cedd.gov.hk)

Standards and Testing Division, GEO,
12th Floor, Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon.
(Tel.: 2762 5345)
(E-mail: juliankwan@cedd.gov.hk)

The University of Hong Kong Library,
Pokfulam Road,
Hong Kong.
(Tel.: 2859 2203)
(Website: http://lib.hku.hk)

Water Supplies Department,
48th, Floor, Immigration Tower,
7 Gloucester Road,
Wan Chai, Hong Kong.
(Tel.: 2829 4500)
(Website: http://www.wsd.gov.hk)

Waste Facilities Business Unit,
Environmental Protection Department,
4th Floor, West Wing, 88 Victoria Road,
Kennedy Town, Hong Kong.
(Tel.: 2872 1888)
(Website: http://www.epd.gov.hk)

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Table B1 - Selected Maps, Plans and Aerial Photographs Available from the Lands Department

Map/Plan	Coverage	Paper Map Products				Digital Map Products	
		Series No.	Size (mm)	No. of Sheets	Colour	Product Name	No. of Sheets
Topographic Maps							
1. 1:1 000	Full	HPIC	750 x 850	3254	B&W	B1000	3254
2. 1:5 000	Full	HP5C	750 x 850	166	B&W	B5000	189
3. 1:10 000 (Street Map)	Full	SM10C	685 x 980	59	B&W	B10000	57
4. 1:20 000	Full	HM20C	685 x 980	16	Colour	B20000	16
5. 1:50 000	Full	HM50CL	1010 x 690	2	Colour	N.A.	N.A.
6. 1:100 000	Full	HM100CL	655 x 850	1	Colour	N.A.	N.A.
7. 1:200 000	Full	HM200CL	327 x 425	1	Colour	N.A.	N.A.
8. 1:300 000 (Hong Kong in its regional setting)	As per title	HM300C	610 x 860	1	Colour	N.A.	N.A.
Digital Orthophotos / Orthophoto Maps							
1. 1:5 000	Full	N.A.	N.A.	N.A.	N.A.	DOP5000	189
2. 1:10 000	Full	N.A.	N.A.	N.A.	N.A.	DOP10000	55
3. 1:50 000	Full	OPM50	1080 x 1400	1	Colour	N.A.	N.A.
4. 1:100 000	Full	OPM100	600 x 770	1	Colour	N.A.	N.A.
Aerial Photos	Full#	N.A.	250 x 250	Numerous	B & W / Colour	DAP	numerous
Geological Maps							
1. 1:5 000*	Selective Areas	HGP5, 5A, 5B	760 x 1000	34	Colour	N.A.	N.A.
2. 1:20 000*	Full	HGM20 & 20S	775 x 1000	14 & 1	Colour	N.A.	N.A.
2a. 1:20 000	Full	HGM20	700 x 1000	1	Colour	N.A.	N.A.
3. 1:100 000	Full	HGM100	660 x 1000	1	Colour	N.A.	N.A.
Town Planning Plan by Planning Department	N.A.	471	Various	Various	B & W	N.A.	N.A.

Legend:

* See Figure B1 for area coverage

\# See Table B2 for further details

Table B2 - Aerial Photographs Available from the Lands Department (Low Attitude Photographs) (Sheet 1 of 2)

Year	Scale(s)	Approximate Coverage (%)			Remarks
		HKI	K	NT	
1924	Approx. 1:14 000	60	10	30	Medium to low resolution, single frames with incidental stereo overlap.
1945	1:12 000	95	60	95	Medium to good resolution. Almost all areas except east-west strip from Tuen Mun to Sai Kung.
1949	1:4 800 1:11 600	100	95	30	Good resolution. Excellent coverage of north-west New Territories. Good coverage of lowland areas.
1956 1959	1:10 000 1:13 300	10	50	5	Good resolution; some stereo overlap.
1961-1962	1:10 000	100	100	10	Good resolution; small relief exaggeration.
1963	NT = 1:7 800 HKI + K = 1:5 400	100	100	95	Excellent resolution, full stereo coverage. Coverage of all areas except Mai Po to Sha Tau Kok.
1964	1:3 600	5	5	10	Coverage of trunk roads.
1967	1:7 800 - 1:12 500	90	90	20	Coverage of main Urban Area only.
1968-1970	1:5 000 - 1:10 000	40	100	20	Coverage of Urban Areas.
1972	1:6 000 - 1:13 000	40	80	20	Coverage of trunk road.
1973	1:3 000 1:10 000 - 1:12 000	70 70	100 100	5 90	Urban Areas only. Most of HKSAR.
1974	1:5 000	10	70	30	Coverage of north-west and west New Territories.
1975	1:4 600 - 1:10 000	5	40	30	Coverage of north-west and west New Territories.
1976	1:2 000 - 1:8000	100	100	40	Coverage of Urban Areas and New Towns.
1977	1:2 800 - 1:8 000	100	100	50	Detailed coverage of north-west and north New Territories plus New Towns.
1978-1987	1:4 000 - 1:8 000	100	100	60	Annual coverage of Urban Areas including New Towns and lowland areas.
1988 to present	1:2 000 - 1:12 000	100	100	45-90	Annual coverage of New Territories varies from year to year.

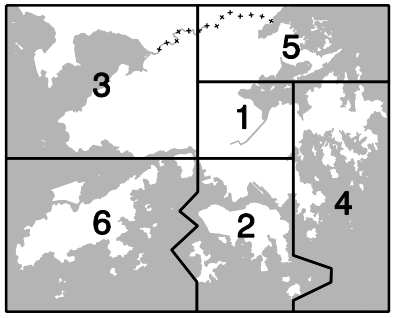
Note: Colour aerial photographs have also been taken routinely since 1993.

Table B2 - Aerial Photographs Available from the Lands Department (High Altitude Photographs) (Sheet 2 of 2)

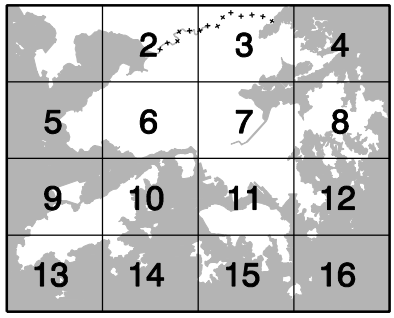
Year	Scale(s)	Approximate Coverage (%)			Remarks
		HKI	K	NT	
1954	1:60 000	2	80	90	Good resolution.
1964	1:25 000	100	100	100	Excellent resolution. Mosaic of aerial photographs available. East to west flight lines, 4 to 5 km apart.
1973	1:25 000	100	100	90	Good resolution. East to west flight lines 3 to 5 km apart.
1974-1976	1:25 000	100	100	100	Good resolution. Annual coverage. East to west flight lines, 1 to 4 km apart.
1977	1:25 000	20		20	Obliques only of Urban Area. Coverage of Lantau, west New Territories and Sha Tin.
1978	1:25 000	100	100	100	Complete coverage.
1979	1:20 000	100	100	100	Complete coverage.
1980	1:20 000	100	80	20	Southern half of HKSAR only.
1981	1:20 000 1:50 000	100 80	100 80	100 10	Complete coverage. Urban Area and Lantau only.
1982	1:20 000	100	100	100	Complete coverage
1983	1:20 000 1:40 000	100 100	100 100	100 95	Complete coverage. Almost complete coverage.
1984	1:20 000	30	40	15	Coverage of Urban Area, Clearwater Bay and Sai Kung Peninsula.
1985	1:20000 1:30 000	100	100	100	Complete coverage
1986	1:20 000	100	100	100	Complete coverage.
1987	1:40 000	100	100	100	Complete coverage.
1988 – 1997*	1:20 000 - 1:40 000	100	100	100	Complete coverage.
1998 to present	1:16 000 - 1:40000	100	100	100	Complete coverage.

Note: Colour aerial photographs have also been taken routinely since 1993.

*Year 1996: only 1:20 000 available

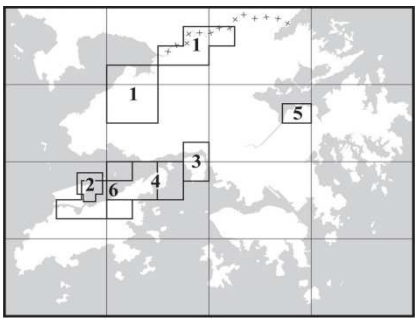


Geological Memoir Nos.

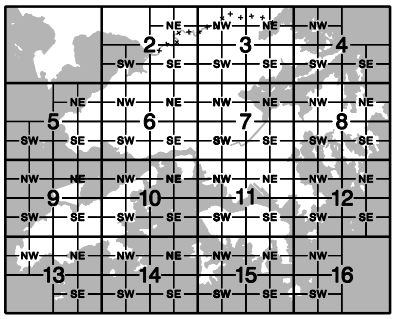


1:20 000 Map Sheet Nos.

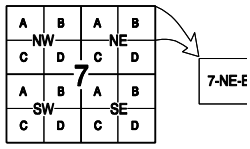
Geological Memoir Nos.	Area of Coverage	Map Coverage 1:20 000 Sheet Nos.
1	Sha Tin	7
2	Hong Kong Island and Kowloon	10, 11, 14, 15, 16
3	Western New Territories	2, 5, 6
4	Sai Kung and Clearwater Bay	8, 12, 16
5	Northeastern New Territories	3, 4
6	Lantau District	9, 10, 13, 14



Sheet Report Nos.



1:5 000 Map Sheet Nos.



Numbering System of 1:5 000 Series

Sheet Report Nos.	Area of Coverage	Map Coverage 1:5 000 Sheet Nos.
1	Yuen Long - Scheduled Area No. 2	14 map sheets
2	Chek Lap Kok	9-NE-C and 9-NE-D
3	Tsing Yi and surrounding offshore area	6-SE-B and 10-NE-B,D
4	North Lantau Island and Ma Wan	10-NE-A,C, 10-NW-B,C,D, and 10-SW-A
5	Ma On Shan - Scheduled Area No. 4	7-NE-D and 7-NE-C
6	Tung Chung and Northshore Lantau Island	9-SE-A, 9-SE-B and 5 offshore part map sheets

Figure B1 - Geological Maps, Memoirs and Sheet Reports

APPENDIX III
NEW APPENDIX F OF GEOGUIDE 2

Appendix F

Supplementary Information on Ground Investigation Techniques

[Amd GG2/01/2017]

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F.1 Geophysics

Non-invasive surveying methods using geophysics techniques are comparatively inexpensive compared with invasive ground investigation. Furthermore, they can often be completed within a short time, without major conflict over land use, and can cover large areas.

Magnetic surveys to identify faults have been successful in offshore areas in Hong Kong (Sewell et al, 2000 and references therein). Confirmatory boreholes and insitu testing should be carried out to verify the interpretation obtained from the survey.

Geophysical surveys do not provide direct measurement of engineering properties such as strength and permeability. They may not detect small-scale geological features. The interpretation and translation of the survey data into engineering geological information requires expertise and professional judgement.

F.2 Vertical and Inclined Boreholes

Although vertical boreholes are the most commonly used method of ground investigation, the samples and logging obtained may only indicate very localised characteristics of the ground along a tunnel alignment.

Inclined boreholes may give comparatively more information along the tunnel alignment than vertical boreholes. Where the orientation of suspected subvertical fault zones or other significant geological features is known, targeting an inclined borehole in a direction roughly perpendicular to the feature may give a useful indication of the location, overall thickness and engineering properties of the feature.

The relative inclinations of the borehole and the feature being investigated govern the success of the inclined borehole. Faults in Hong Kong are commonly discontinuous and typically have variable dip, dip direction, width and weathering characteristics. These factors may affect the effectiveness of inclined boreholes.

F.3 Horizontal Boreholes

Drilling of horizontal boreholes can be carried out either from the excavation face, an intermediate shaft or from the other end of the tunnel to investigate the ground conditions, in particular to check whether suspected features of poor ground are present and if so their nature and extent.

There are limitations to the maximum length that the horizontal borehole can be driven, depending on the ground conditions, the size of the hole and the power of the drilling rig. 'N' and 'H' size cores have been obtained from an 800 m long hole in Hong Kong.

Drilling of a horizontal borehole during the planning and design stage is often not feasible due to lack of access to the tunnel level; usually, for deep tunnels, the construction of vertical access shafts will not have commenced at this stage.

During the construction stage, drilling of horizontal boreholes from the tunnel face can affect the rate of progress of the excavation; hence alternative access points should be investigated and the cost-effectiveness of the operation needs to be carefully assessed in the light of the adequacy of ground data for the design and risk management.

F.4 Directional Coring Techniques

Directional coring techniques are now available to drill from ground level to great depth and then along a horizontal alignment. This method does not require provision of working space at the tunnel level and can be very useful for investigating deep tunnels.

These techniques could provide continuous information of the geological conditions along the alignment of a tunnel. Insitu tests could also be carried out for assessing the actual conditions of the ground to be excavated. The information along the alignment would minimize uncertainty of the tunnel works and enhance the management of risks for the project.

There may be limitations as to the maximum depth and length that a directional corehole can reach as well as the type of core samples that can be taken and the type of geotechnical tests that can be performed. These matters, as well as drilling location accuracy, cost, mobilisation considerations and drilling rate should be examined as early as possible in a tunnel project.

F.5 Other Aspects

To avoid creating preferential flow paths and obstructions in the ground that could pose hazards to the tunnel excavation, for boreholes that are close to or intercept the tunnel, the person supervising the ground investigation should ensure that all metal casings are removed and the boreholes are properly grouted after completion of sampling and testing.

For long boreholes, probe holes and core holes, the position of which could impact on the design and construction, the specification should require the orientation (dip and dip direction) and the position of the holes to be checked regularly as drilling progresses to ensure that they follow the intended alignment.