

CHAPTER 10

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HONG KONG SPECIAL ADMINISTRATIVE REGION**

CAPITAL WORKS RESERVE FUND

GOVERNMENT SECRETARIAT

Works Bureau

GOVERNMENT DEPARTMENT

Civil Engineering Department

Slope safety and landslip preventive measures

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SLOPE SAFETY AND LANDSLIP PREVENTIVE MEASURES

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SLOPE SAFETY AND LANDSLIP PREVENTIVE MEASURES

Summary and key findings

A. **Introduction.** Hong Kong has a hilly terrain. Over the years, urban development close to hillsides has resulted in the formation of a large number of man-made slopes adjacent to buildings and infrastructure. Following a number of disastrous landslips in the 1970s, the Geotechnical Engineering Office (GEO) was established in July 1977. The GEO tackles the problem of slope failure by implementing a slope safety programme under the policy responsibility of the Works Bureau. The slopes formed before July 1977 are classified as old slopes, and those formed after July 1977 are classified as new slopes. The GEO has been checking the design and construction of all new slopes to ensure that they comply with the current safety standards. The GEO has also been upgrading substandard old government slopes on an ongoing basis through a Landslip Preventive Measures (LPM) Programme (paras. 1.1 to 1.3 and 1.5).

B. **Audit review.** Audit has recently conducted a review of the economy, efficiency and effectiveness with which the Government implemented the slope safety programme (para. 1.16). The findings are summarised in paragraphs C to G below.

C. **Need to improve compilation of landslip statistics and reporting of landslips.** Landslips bring about human casualties and economic losses. Since the establishment of the GEO in 1977, landslip-related fatalities have been reduced considerably. From 1997 onwards, the GEO has been conducting systematic studies of landslips to identify measures for improving slope safety. However, the GEO has not conducted systematic studies on the landslips reported to other government departments and has not included these landslips in the landslip figures published in the GEO's reports. Moreover, since 1999, the GEO has discontinued the compilation of the detailed reports on economic losses. To facilitate a comprehensive evaluation of slope safety, Audit considers that there is a need for the GEO to compile failure rates for all reported landslips and for all slopes (paras. 2.3, 2.6, 2.10, 2.11 and 2.13 to 2.19).

D. **Incomplete coverage of the Catalogues of Slopes.** The GEO registers all man-made slopes in Hong Kong that meet the stipulated criteria for registration. In 1978, the GEO compiled the Old Catalogue of Slopes. However, the coverage of the Old Catalogue was incomplete. In September 1998, the GEO compiled the New Catalogue of Slopes. However, the coverage of the New Catalogue is also incomplete. Investigations of landslips which occurred from 1998 to 2000 revealed that 62 failed slopes had not been included in the New Catalogue. These unregistered slopes were discovered because landslips had occurred. There might be other unregistered slopes which had not yet been found because no landslips had occurred. The existence of unregistered slopes may pose a

threat to public safety. Audit also noted that the GEO had not yet completed the registration of most of the unregistered slopes identified by the landslip investigations (paras. 3.2 to 3.7 and 3.11 to 3.13).

E. Need to improve monitoring of the upgrading of old government slopes. Many of the old slopes formed before 1977 were largely substandard and required upgrading works to bring them to current safety standards. Since 1977, the GEO has been carrying out upgrading works of the old government slopes through the LPM Programme. In February 1995, the then Governor-in-Council ordered that the LPM Programme should be accelerated with a view to substantial completion by 2000 of the upgrading of the slopes in the Old Catalogue. However, Audit noted that the target of this 5-year Accelerated LPM Programme was not clearly stated and had been presented in different ways subsequently. In September 1997, the Government formulated a 10-year Extended LPM Programme for commencement in April 2000. The target of the 10-year Extended LPM Programme is to complete the upgrading works for another 2,500 substandard old government slopes by the year 2010. In formulating the 10-year Extended LPM Programme, the Government had pledged to deal with the substandard old government slopes by three additional slope safety measures, namely, integrated development, enhanced maintenance and clearance of squatters. Overall, a total of 10,000 high consequence slopes are expected to be dealt with by March 2010. However, Audit noted that 34% of the slopes upgraded under the LPM Programme were not high consequence slopes. The Works Bureau has not yet formulated any detailed work plan for achieving the targets under integrated development and enhanced maintenance. The Works Bureau and the GEO have not yet formulated a long-term plan for dealing with the remaining substandard old government slopes (paras. 4.2, 4.3, 4.8, 4.13, 4.14, 4.18, 4.26, 4.29, 4.31, 4.36 and 4.37).

F. Omissions to exercise geotechnical control over the formation of new slopes. The GEO exercises geotechnical control over the formation of new slopes. In principle, the GEO should have checked all the new slopes formed after 1977 to ensure that their design and construction were up to the required safety standards. The GEO's investigations of landslips, which occurred from 1997 to 2000, revealed that a number of new slopes had not been subject to GEO's geotechnical control over their formation. The majority of these slopes were government slopes. In August 2001, the Works Bureau introduced the checking certificate system to prevent the recurrence of similar cases in future. Audit notes that works departments have the discretion of not making geotechnical submissions. However, the Works Bureau has not specified the criteria and circumstances under which the works departments can exercise such discretion. Audit considers that there is a need for the GEO to conduct a special review to identify new slopes which have not been subject to proper geotechnical control (paras. 5.2, 5.10, 5.12, 5.15, 5.17, 5.18 and 5.21 to 5.23).

G. Need to improve management of LPM works. Under the LPM Programme, the GEO carries out detailed studies and upgrading works of the substandard government slopes. Audit selected 502 slope-works items of the upgrading works completed in 1999-2000 and 2000-01 for detailed analysis. Audit noted that the GEO did not compile management reports for monitoring the progress and the cost of the individual slope-works items. Among the 502 slope-works items completed, there were many cases of delay in completion and increases in cost. 384 slope-works items (or 76%) were

not completed within the original time for completion. There was an increase in cost for 220 slope-works items (or 44%). Taking into account the cost saving of \$62 million for other items, the net increase in cost was \$32 million. Audit considers that there is scope for the GEO to improve the management of the LPM works to minimise delays in completion and increases in cost (paras. 6.2, 6.8, 6.10, 6.11, 6.13 and 6.15).

H. **Audit recommendations.** Audit has made the following main recommendations that:

(a) the Director of Civil Engineering should:

Landslip statistics and reporting of landslips

- (i) in conjunction with the Secretary for Works, require other government departments to report all landslips to the GEO. This would enable the GEO to conduct systematic studies of landslips and compile comprehensive landslip statistics (para. 2.22(a));
- (ii) compile detailed statistics of the consequences of all landslips (including fatalities, injuries and economic losses) for trend analysis and monitoring purposes (para. 2.22(d));

Registration of slopes

- (iii) take action to identify and register other unregistered man-made slopes which should be registered (para. 3.15(b));

Progress of upgrading old government slopes

- (iv) in conjunction with the Secretary for Works, ensure that the target of a government programme, such as the 5-year Accelerated LPM Programme, is stated clearly in the papers submitted to the relevant authority in future (para. 4.16(a));
- (v) monitor the progress of the 10-year Extended LPM Programme by comparing the actual number of old government slopes upgraded with the GEO's pledged target, and report separately the number of new government slopes and mixed responsibility slopes upgraded (para. 4.24(a));
- (vi) in reporting the progress of upgrading old government slopes under the 10-year Extended LPM Programme:
 - report accurately the actual number of high consequence old government slopes upgraded (para. 4.40(a)(i)); and

- report separately the number of slopes dealt with under the other slope safety measures, such as those dealt with by clearance of squatters (para. 4.40(a)(ii));
- (vii) in consultation with the Secretary for Works, formulate a long-term plan for upgrading the remaining substandard old government slopes (para. 4.40(b));

Geotechnical control of new slopes

- (viii) critically review the relevant Works Bureau technical circulars and issue clear guidelines on the circumstances under which geotechnical submissions to the GEO by the works departments are not required (para. 5.24(c));
- (ix) consider carrying out a special review to identify new slopes which have not been subject to proper geotechnical control (para. 5.24(d));

Management of LPM works for upgrading old slopes

- (x) critically review the current procedures for the management of the LPM works and implement effective control measures so as to ensure that the works are completed on time and within the tender sums (para. 6.18(a)); and
- (xi) compile regular management reports to monitor closely the progress and the cost of the LPM works and to identify those slope-works items which require early management action (para. 6.18(b)); and

- (b) the Secretary for Works should:

Progress of upgrading old government slopes

- (i) coordinate with the slope maintenance departments and the relevant works departments to formulate work plans for the implementation of the slope upgrading/improvement works (para. 4.41(a)); and
- (ii) explore ways to speed up the upgrading/improvement of old government slopes (para. 4.41(b)).

I. **Response from the Administration.** The Administration has generally agreed with the audit recommendations (paras. 2.23, 3.16, 4.42, 4.43, 5.25 and 6.19).

PART 1: INTRODUCTION

Slopes and landslips

1.1 Hong Kong has a hilly terrain. Natural hillsides cover over 60% of the land area of Hong Kong. Over the years, urban development has resulted in the formation of a large number of man-made slopes. The density of man-made slopes in Hong Kong is one of the highest in the world. There are now about 54,000 man-made slopes in Hong Kong. These man-made slopes can be classified into three main types, namely cut slopes, fill slopes and retaining walls. Figure 1 on the centre pages is a schematic diagram of different types of slopes. (For a glossary of terms relating to slopes in this audit report, see Appendix I).

1.2 Both natural slopes and man-made slopes are prone to landslips, particularly at times of torrential rain during the rainy season from May to September each year. A landslide is defined as the detachment or excessive lateral displacement of a soil or rock mass on a natural or a man-made slope. On average, there are about 300 reported landslips a year in Hong Kong. Most of these landslips are minor. However, in the past years, there were a number of disastrous landslips, resulting in casualties and economic losses.

Implementation of the slope safety programme

Establishment of the Geotechnical Engineering Office

1.3 The Geotechnical Engineering Office (GEO — Note 1) of the Civil Engineering Department has the overall responsibility for slope safety in Hong Kong. The GEO was established in July 1977 to improve slope safety, after a number of disastrous landslips had occurred in the 1970s (Photograph 1 on the centre pages shows a disastrous landslide in 1972). It implements a slope safety programme under the policy responsibility of the Works Bureau. Before the establishment of the GEO, there was very limited geotechnical control on slope formation both in the private and public sectors. **The slopes formed before the establishment of the GEO (in July 1977) are classified as “old slopes”.** They are largely substandard. **The slopes formed after the establishment of the GEO are subject to the GEO’s checking, and are classified as “new slopes”.**

1.4 The Government’s basic strategy for slope safety includes:

- (a) upgrading of substandard slopes to bring them to current safety standards;
- (b) checking of the design and construction of all new slopes so as to contain the number of substandard slopes; and
- (c) proper maintenance of all slopes to prevent their deterioration.

Note 1: *The GEO was originally known as the Geotechnical Control Office. It was renamed as the GEO in 1991.*

1.5 Since 1977, the GEO has been checking all new slopes to ensure that they comply with the current safety standards. New slopes normally do not require upgrading but maintenance is needed to prevent their deterioration. The slopes formed before 1977 are largely substandard and require upgrading to bring them to current standards. Photograph 2 on the centre pages shows a site with slope upgrading works in progress. The Government's slope upgrading efforts are focused on old slopes, although maintenance is needed for all man-made slopes. The GEO has been carrying out the upgrading of substandard old government slopes on an ongoing basis through the Landslip Preventive Measures (LPM) Programme. The LPM Programme also includes the task of conducting safety screening of private old slopes. Under the Buildings Ordinance (Cap. 123), when a slope on privately-owned land or under private responsibility requires ground investigation or upgrading, the GEO may ask the Buildings Department to issue a Dangerous Hillside Order which requires the owner to investigate the stability of the slope and undertake any necessary landslip preventive measures. If the owner does not respond to the Order, the Government is empowered to carry out the works at the owner's expense.

1.6 Seven government departments (hereinafter collectively referred to as slope maintenance departments) are responsible for the maintenance of the government slopes. They are the Highways Department, the Architectural Services Department, the Agriculture, Fisheries and Conservation Department, the Drainage Services Department, the Lands Department, the Water Supplies Department and the Housing Department.

1.7 As mentioned in paragraph 1.3 above, the GEO has the overall responsibility for slope safety in Hong Kong. The GEO upgrades the more risky and complex substandard slopes, while it also assumes an overall coordination role in the maintenance of slopes. It maintains close contact with the slope maintenance departments, and assists them by providing maintenance standards and guidance, developing cost-effective engineering techniques for maintenance, providing technical assistance on difficult cases, and carrying out reviews of the maintenance operations.

Works Bureau's slope safety review

1.8 In late 1994, the Works Bureau carried out a major review of the slope safety programme in Hong Kong and issued a Slope Safety Review Report. In February 1995, the Executive Council (ExCo) endorsed the Slope Safety Review Report and the GEO was allocated additional resources to accelerate the LPM Programme (see para. 4.8 below for details).

1.9 In May 1995, the Director of Civil Engineering appointed a Slope Safety Technical Review Board (SSTRB) to advise the Government on the technical aspects of slope safety. The Board is made up of three renowned international experts on geotechnical engineering. The Board meets every year in Hong Kong and issues a report after the meeting.

1.10 In 1996, a Standing Committee on Slope Safety (Note 2) was set up to monitor the implementation of measures to improve slope safety. The Committee is also responsible for

Note 2: *The Standing Committee on Slope Safety is chaired by a Deputy Secretary for Works and includes representatives from bureaux and departments involved in slope safety.*

reviewing the existing legislation for the control of slope safety, and for considering matters of slope safety referred to it by the Secretary for Works.

Government expenditure on slope safety

1.11 The Government has committed significant resources to improving slope safety. GEO has an establishment of 520 staff deployed to carry out slope safety tasks. Funding is provided for the LPM Programme for the upgrading of substandard old government slopes. Funding is also provided to the seven slope maintenance departments for slope maintenance. According to the 2001-02 Annual Estimates, the total government expenditure for upgrading and maintenance of slopes is as follows:

	(\$ million)
Recurrent expenditure of the GEO	271
Expenditure for the LPM Programme	883
Expenditure for slope maintenance	600
Total	<u>1,754</u>

Improvement in slope safety

1.12 Slope safety has always been a subject of public concern and is one of the key policy initiatives of the Government. The Government has been taking both proactive and reactive measures to improve slope safety.

1.13 According to the records of the GEO, there has been a significant reduction in the number of landslide fatalities in recent years. This demonstrates that the risk of landslide in Hong Kong has been significantly reduced as compared with that which existed before the GEO was established in 1977. Slope safety in Hong Kong is now broadly comparable to that in countries such as Canada, Japan and the United States of America. In January 2001, the SSTRB (see para. 1.9 above) commended the achievements of the GEO in its Report No. 10, and recommended that the GEO should start considering the possibility of exporting its competence internationally to assist other countries in their efforts to mitigate landslide hazard, as the expertise and experience of the GEO was of international calibre. Nonetheless, the Government considers that the landslide risk has not yet been reduced to a level acceptable to the community. The Government intends to exercise constant vigilance on slope safety.

1.14 To address public concern on the visual appearance of slopes, the GEO has promulgated guidelines on the landscape treatment and bio-engineering for slopes. The GEO has been landscaping every slope upgraded under the LPM Programme since 2001. The slope maintenance departments are also going to progressively improve the appearance of slopes in the course of their maintenance works.

1.15 The GEO investigates significant landslips, and undertakes research and development projects with the objective of improving geotechnical practices. The GEO promulgates a Geotechnical Manual for Slopes and a series of “Geoguides” to give guidance on methods of investigation and stability analysis, and the minimum acceptable safety standards. The geotechnical engineering profession regards these documents as standard guidelines for slope works.

Audit review

1.16 Audit recently conducted a review of the economy, efficiency and effectiveness with which the Government implemented the slope safety programme. The review focused on the GEO’s efforts in the upgrading of substandard old slopes under the LPM Programme, and the exercising of geotechnical control of new slopes.

1.17 The audit focused on the following areas:

- (a) landslip statistics and reporting of landslips (see PART 2 below);
- (b) registration of slopes (see PART 3 below);
- (c) progress of upgrading old government slopes (see PART 4 below);
- (d) geotechnical control of new slopes (see PART 5 below); and
- (e) management of LPM works for upgrading old slopes (see PART 6 below).

The audit has revealed that there is scope for improvement in the above areas. Audit has made a number of recommendations to address issues in these areas.

General response from the Administration

1.18 The **Director of Civil Engineering** welcomes the recommendations in the audit report to further enhance slope safety. He is pleased to note that the audit report has made reference to the commendations by the SSTRB that the expertise and experience of the GEO is of international calibre. In addition, he notes Audit’s view that the substantial reduction in landslip fatalities over the past 20 years or so is an indication of the effectiveness of the GEO’s efforts in improving slope safety in Hong Kong.

1.19 The **Secretary for Works** welcomes the recommendations in the audit report.

PART 2: LANDSLIP STATISTICS AND REPORTING OF LANDSLIPS

2.1 This PART examines the compilation and reporting of statistics relating to landslips. The audit has revealed that there is room for improvement in the way the GEO gathers and presents information about landslips.

Statistics on landslips and consequences of landslips

2.2 Slopes in Hong Kong are prone to landslips, particularly at times of torrential rain. The GEO classifies landslips by their scale of failure, as follows:

- (a) *Major landslips.* These are landslips with a failure volume (Note 3) of 50 cubic metres or more; and
- (b) *Minor landslips.* These are landslips with a failure volume of less than 50 cubic metres.

2.3 On average, about 300 landslips are reported to the GEO a year. Figure 2 on the centre pages shows the number of landslips reported to the GEO from 1984 to 2000. Landslips can result in human casualties (i.e. fatalities and injuries) and economic losses (facilities affected, disruption to traffic and public services, etc.). Appendix A shows the number of landslips and the consequences of landslips from 1984 to 2000.

Investigations of landslips

2.4 Since the early 1980s, the GEO has been collecting data and conducting annual reviews of rainfall and landslips in Hong Kong. The GEO:

- (a) has selected serious landslips for investigations and published separate reports on such cases;
- (b) has conducted research and development studies with a view to improving the understanding of the characteristics and mechanisms of landslips in Hong Kong;
- (c) from 1984 up to 1998, published the “Hong Kong Rainfall and Landslides” annual reports. These reports presented an overview of rainfall and landslips in Hong Kong; and

Note 3: *The failure volume refers to the sum of the volume of detached material and the volume of any deformed material (which has not been displaced significantly and remains on the slope).*

- (d) from 1997 onwards, publishes the “Review of Landslides” annual reports (see para. 2.7 below).

2.5 On 23 July 1994, a slope and a retaining wall outside Kwun Lung Lau, Kennedy Town collapsed, killing five people and seriously injuring three others. After this landslide, the Government engaged an internationally renowned landslide expert, Professor N. R. Morgenstern of Canada, to carry out an independent review of this landslide. Professor Morgenstern recommended, among other things, that the GEO should introduce a more integrated approach into the slope stability assessment process. He recommended that a means of doing this was as follows:

- (a) all landslide occurrences were to be reported to the GEO as an incident report;
- (b) based on the incident report, a senior geotechnical engineer of the GEO should confirm that subsequent slope evaluation could continue as guided by the Catalogue of Slopes. If not, a more integrated approach would be called for; and
- (c) a more integrated approach would normally be based on the scale of a project or development. It would require:
 - (i) identification of what was known and what was assumed;
 - (ii) identification of whether site-specific soil properties and special geological features should be determined; and
 - (iii) an accounting of all water flow pathways that might affect the site.

Systematic studies of landslips

2.6 In December 1994, the Government accepted Professor Morgenstern’s recommendations. The Government provided the GEO with additional resources for the systematic studies of landslips in order to adopt an integrated approach. Since 1997, the GEO has carried out systematic studies of landslips:

- (a) to identify those slopes that are affected by inherent stability problems so that appropriate follow-up actions can be taken for integrated slope assessment and upgrading works; and
- (b) to review the performance of the Government’s slope safety system so that the current slope engineering practices can be improved.

2.7 These systematic studies of landslips provided useful information on the types and causes of landslips. The GEO conducted a diagnostic review of the landslide data and information from

landslip studies to assess the overall performance of the slope safety system and to identify areas requiring attention. The GEO compiled landslip statistics and maintained a landslip database. In 1997, the GEO introduced a new series of reports entitled “Review of Landslides”. Up to December 2001, the GEO has issued the following three reports:

- (a) Review of 1997 and 1998 Landslides (published in October 1999);
- (b) Review of 1999 Landslides (published in December 2000); and
- (c) Review of Landslides in 2000 (published in December 2001).

2.8 Based on the result of the systematic studies of landslips, the GEO introduced a number of technical and administrative improvement measures, which included:

- amendments to Geoguide 5 (Guide to Slope Maintenance);
- guidelines for the GEO Emergency Manual on landslide inspections; and
- input to the drafting of a new Highway Slope Manual.

The GEO also acquired more technical knowledge concerning landslips, such as that relating to slope deformation prior to landsliding, mobility of landslide debris and the causes of natural terrain landslides.

Audit observations on landslip statistics and reporting of landslips

Findings of GEO’s systematic studies of landslips

2.9 The GEO’s systematic studies of landslips have improved the understanding of slope failures and provided the basis for formulating new initiatives for improving slope safety. The systematic studies of landslips have resulted in a number of improvements (see para. 2.8 above). Audit notes that most of the proposals have been or are being actively followed up by the GEO. Audit considers that the systematic studies of landslips contribute considerably to the improvement of slope safety in Hong Kong and the GEO should keep up its efforts in conducting such studies and taking necessary follow-up actions. However, Audit considers that the following two issues require special attention:

- (a) the existence of unregistered slopes (see PART 3 below); and
- (b) the effectiveness of geotechnical control of new slopes (see PART 5 below).

Reporting landslips to the GEO for systematic studies

2.10 Appendix A shows the number of landslips in Hong Kong from 1984 to 2000. The GEO released these landslip figures in the “Hong Kong Rainfall and Landslides” reports (1984 to 1998) and the “Review of Landslides” reports (1997 to 2000). Audit noted that the landslip figures reported by the GEO were based on the landslips reported to the GEO for geotechnical advice. However, these landslip figures did not include landslips reported to other departments, for which the GEO’s geotechnical advice had not been sought (see Table 1 below).

Table 1

**Number of landslips not included in the GEO’s published landslip figures
1994 to 1998
(Figures for 1999 and 2000 are not available — Note 1)**

	1994	1995	1996	1997	1998
	(No.)	(No.)	(No.)	(No.)	(No.)
(A) Landslip figures released by the GEO based on landslips reported to it for geotechnical advice	436	295	153	559	228
(B) Landslips reported to other departments (Note 2) but not reported to the GEO for geotechnical advice and not included in GEO’s reported figures in (A) above	244	134	17	122	54

Source: GEO’s records

Note 1: Up to 1998, the GEO collected landslip data from other departments. Information for 1999 and 2000 is not available because the GEO has stopped collecting the data from departments since 1999.

Note 2: These departments are the Highways Department, Water Supplies Department, Architectural Services Department, Fire Services Department, Housing Department and Agriculture, Fisheries and Conservation Department. According to the GEO, there might have been duplication in the number of landslips reported to other departments as some landslips might have been reported to more than one department.

2.11 Upon Audit’s enquiry, in December 2001, the GEO said that not all landslips were reported to the GEO for geotechnical advice. Some landslips (such as minor landslips in remote areas and construction sites) were reported to other departments and were dealt with without involving the GEO. The GEO did not have detailed information on these minor landslips. As a result, the total number of landslips known to the Government as a whole has not been ascertained.

2.12 In January 2002, Audit referred the GEO to Professor Morgenstern's recommendation that all landslide occurrences should be reported to the GEO as an incident report (see para. 2.5 above). Audit suggested that, based on his recommendation, the GEO should request other departments to report all landslide occurrences to the GEO so that it could update the landslide database and perform comprehensive diagnostic reviews of landslips. In January 2002, the GEO informed Audit that, in order to obtain better quality data, the GEO was designing a return with a suitable format for use by departments in reporting landslide incidents to the GEO. The GEO would give guidance on the reporting of pertinent information for identifying genuine landslips. The GEO would, in future, examine in detail the information provided by other departments in its systematic studies of landslips and in the compilation of landslide statistics.

Analysis of consequences of landslips

2.13 Appendix A shows the consequences of landslips including human casualties and economic losses from 1984 to 2000. Audit noted that, up to 1998, information on the economic losses in terms of facilities affected and road closures was included in the "Hong Kong Rainfall and Landslides" reports. However, since 1999, the GEO has discontinued the compilation of such reports. In January 2002, Audit suggested to the GEO that there was a need to compile relevant statistics in order to assess the economic losses of landslips. In response, the GEO compiled the figures on economic losses of landslips for the years 1999 and 2000 (now incorporated in Appendix A). The GEO has advised Audit that the GEO will include figures on consequences of landslips in the "Review of Landslides" reports in future.

2.14 Landslip-related fatalities have decreased since the establishment of the GEO in 1977. A detailed analysis of the data and the locations of the landslips involving fatalities from 1972 to 2000 is at Appendix B. The 5-year rolling total figures and the 5-year rolling average figures of fatalities have dropped considerably during the last 29 years. This is an indication of the effectiveness of the GEO's efforts in improving slope safety in Hong Kong.

Calculation of failure rates

2.15 To assess the performance of the Government's slope safety system, the GEO calculated two sets of failure rates for the registered slopes (see glossary of terms at Appendix I). One set of failure rates was for those slopes which had been processed by the slope safety system (i.e. slopes which had been assessed, designed or upgraded to meet the required geotechnical safety standards). Another set of failure rates was for those slopes which had not been processed by the slope safety system. Table 2 below shows the annual failure rates of registered slopes calculated by the GEO from the landslide statistics from 1997 to 2000.

Table 2

Annual failure rates of registered slopes

	1997	1998	1999	2000	Target
(A) Slopes processed by the slope safety system:					
(i) All landslips (major and minor)	0.16%	0.11%	0.11%	0.11%	*
(ii) Major landslips only	0.04%	0.03%	0.03%	0.02%	0.2%
					(i.e. 2 in 1,000; see also para. 2.16 below)
(B) Slopes not processed by the slope safety system:					
(iii) All landslips (major and minor)	0.88%	0.33%	0.71%	0.40%	*
(iv) Major landslips only	0.10%	0.03%	0.09%	0.02%	*
(C) All slopes (i.e. all slopes in (A) and (B) above):					
(v) All landslips (major and minor)	0.65%	0.26%	0.51%	0.30%	*
(vi) Major landslips only	0.08%	0.03%	0.07%	0.02%	*

Source: GEO's records and Audit's analysis

Note: * denotes that a target has not been set.

2.16 For registered slopes processed by the slope safety system, the GEO has set a target success rate of 99.8% in preventing major landslips. This target success rate is translated into a target failure rate of 0.2% (i.e. 2 in every 1,000 slopes) in Table 2 above for comparison purposes. **In reporting the overall performance of slope safety for each year, the GEO only quoted this success rate and conclude that the system was performing satisfactorily in preventing major landslips.**

2.17 **Table 2 above shows that the failure rates for all landslips are significantly higher than those for major landslips alone.** In this connection, Audit noted that minor landslips with a failure volume of less than 50 cubic metres had also resulted in serious consequences in the past in terms of casualties and economic losses. Examples are shown at Appendix C.

2.18 **Audit considers that all landslips (both major and minor) should be taken into account in the evaluation of overall slope safety. Audit noted that the SSTRB (see para. 1.9 above) commented in its Report No. 9 of January 2000 that the success rate of 99.9% for the reliability of the Government’s slope safety system, as reported in the report “Review of 1997 and 1998 Landslides” (see para. 2.7 above), was too optimistic. The SSTRB suggested that appropriate adjustments should be made.**

2.19 **Audit considers that failure rates for all landslips (major and minor), and for all slopes (whether or not processed by the slope safety system) should also be compiled for trend analysis and reporting purposes. While the GEO has set a target success rate for major landslips on slopes processed by the slope safety system, a target success rate has not been set for all landslips on slopes processed by the slope safety system.**

Timely disclosure of landslide statistics

2.20 Landslip statistics and consequences of landslips are useful management information for evaluating slope safety and for policy formulation. It is important for the management information to be available in a timely manner. Audit noted that the annual “Review of Landslides” reports (published since 1997, see para. 2.4 above) had been issued with a time lag of about one year (see para. 2.7 above). Moreover, the landslide statistics were not incorporated in the Controlling Officer’s Report of the Annual Estimates of the Civil Engineering Department to give the Legislative Council (LegCo) and other stakeholders an overall assessment of slope safety.

2.21 **Audit considers that the GEO should expedite the compilation of the landslide statistics and release the relevant information in a timely manner.** According to Policy Address 2001, the Government intends to publish the first “Annual Report on Government Slope Safety Works for the Year 2001” by April 2002. **Audit considers that it is useful to incorporate the latest landslide statistics and the consequences of landslips in this annual report so as to give an updated comprehensive view of slope safety in Hong Kong.**

Audit recommendations on landslide statistics and reporting of landslips

2.22 **Audit has *recommended* that the Director of Civil Engineering should:**

- (a) **in conjunction with the Secretary for Works, require other government departments to report all landslips to the GEO. This would enable the GEO to conduct systematic studies of landslips and compile comprehensive landslip statistics;**
- (b) **calculate failure rates for all landslips and for all slopes in order to provide meaningful and full landslip information;**
- (c) **set target rates for all landslips for slopes processed by the slope safety system to facilitate the performance evaluation of the system;**
- (d) **compile detailed statistics of the consequences of all landslips (including fatalities, injuries and economic losses) for trend analysis and monitoring purposes; and**
- (e) **incorporate detailed landslip statistics and consequences of landslips in a timely manner in the forthcoming Annual Report on Government Slope Safety Works, and consider providing relevant information in the Controlling Officer's Report of the Annual Estimates of the Civil Engineering Department.**

Response from the Administration

2.23 The **Director of Civil Engineering** agrees with the audit recommendations on landslip statistics and investigations of landslips as mentioned in paragraph 2.22 above.

PART 3: REGISTRATION OF SLOPES

3.1 This PART examines the coverage of the Catalogues of Slopes of the GEO. The audit has revealed that there is scope for improvement in compiling the Catalogues of Slopes.

Criteria for registration of slopes

3.2 To implement the slope safety programme, the first step is to catalogue the location and other details of the slopes. The GEO registers all man-made slopes in Hong Kong that meet the criteria for registration, as listed in Appendix D.

3.3 The GEO gives each slope a unique slope registration number. It records relevant details (including the location, type, size, and other parameters) of each slope and uses the information to formulate the programmes on slope safety. Since 1977, the GEO has compiled two catalogues of slopes, namely:

- (a) the Old Catalogue of Slopes of 1978; and
- (b) the New Catalogue of Slopes of September 1998.

Old Catalogue of Slopes

3.4 In 1977, the GEO started to compile a catalogue of man-made slopes in Hong Kong. The purpose was to provide an inventory of “sizeable man-made slopes” which existed at that time. The main focus was on slopes in the main urban areas of Hong Kong Island and Kowloon, and the larger slopes in the New Territories. **In 1978, the compilation of the Old Catalogue of Slopes (hereinafter referred to as the Old Catalogue) was completed.** It contained details of about 10,000 old slopes (about 70% of which were government slopes). Since its compilation, the GEO used the Old Catalogue as an information database for the systematic investigation and upgrading of slopes under the LPM Programme.

3.5 However, the Old Catalogue compiled in 1978 did not include all the old slopes (i.e. those formed before July 1977 — see para. 1.3 above). In 1992, investigations of landslips revealed that a number of failures involved slopes which had not been registered in the Old Catalogue. Among these cases was the slope failure at Baguio Villa on 8 May 1992 involving an unregistered retaining wall, which resulted in two fatalities.

New Catalogue of Slopes

3.6 In mid-1992, the GEO initiated the project “Systematic Inspection of Slopes in the Territory” to search for slopes not registered in the Old Catalogue, and to update information on the slopes which had been registered in the Old Catalogue. In July 1994, in order to accelerate the process, the GEO employed a consultant to undertake the project “Systematic Identification and Registration of Slopes in the Territory”. The project included the following tasks:

- (a) a systematic search for and identification of all registrable man-made slopes in Hong Kong using aerial photograph interpretation techniques and existing topographic maps;
- (b) recording and updating of pertinent information;
- (c) inspection of each slope to be registered;
- (d) making recommendations for follow-up actions; and
- (e) establishment of a computer database containing all the information in the Catalogue of Slopes.

3.7 In September 1998, the GEO completed the compilation of the New Catalogue of Slopes (hereinafter referred to as the New Catalogue) at the cost of \$110 million. The New Catalogue has registered a total of about 54,000 slopes, comprising 37,000 old slopes and 17,000 new slopes:

Table 3
Number of slopes in the New Catalogue
as at September 1998

	Government	Private	Total
	(a)	(b)	(c) = (a) + (b)
	(No.)	(No.)	(No.)
Old slopes	26,000	11,000	37,000
New slopes	11,000	6,000	17,000
Total	<u>37,000</u>	<u>17,000</u>	<u>54,000</u>

Source: GEO's records

Note: The GEO published these figures in thousands. According to GEO's records, the number of slopes registered in the New Catalogue as at November 2001 remained unchanged.

3.8 **The GEO's intention was that the New Catalogue would supersede the Old Catalogue.** During the cataloguing exercise, the GEO also conducted preliminary studies of the old slopes registered in the New Catalogue. As part of the project, the GEO developed a Slope Information System (SIS) which contained pertinent information on the slopes registered in the New Catalogue. The SIS is accessible by the public through designated computer terminals located at the GEO's office or on the Hong Kong Slope Safety Website. See Figure 3 on the centre pages. Figure 4, also on the centre pages, is an example of a slope location plan in the SIS.

Audit observations on registration of slopes

3.9 The identification and recording of the details of the slopes for the compilation of a database is the first and a very important step in the slope safety programme. The GEO relies on the Catalogues of Slopes for planning geotechnical control works, prioritising geotechnical studies and carrying out upgrading works under the LPM Programme. The Catalogues of Slopes also provide useful information for the planning of public works projects and private developments. They provide pertinent information for use by the slope maintenance departments, the engineering profession and the public. **It is, therefore, essential for the Catalogues of Slopes to contain comprehensive, accurate and up-to-date information on all the registrable man-made slopes in the territory. However, Audit notes that both the Old Catalogue and the New Catalogue do not have a full coverage of all the slopes in Hong Kong.**

Incomplete coverage of the Old Catalogue

3.10 As mentioned in paragraph 3.4 above, the Old Catalogue compiled in 1978 contained details of about 10,000 old slopes. However, the Old Catalogue did not have a full coverage of all the old slopes in the territory. The New Catalogue compiled in 1998 showed that there were about 37,000 old slopes which existed at the time when the GEO was established (i.e. in July 1977). Therefore, the Old Catalogue had a shortfall of about 27,000 (37,000 – 10,000) slopes. The incomplete coverage of the Old Catalogue could have affected the formulation and implementation of the programme on the upgrading of old slopes. In this connection, Audit noted that the 5-year Accelerated LPM Programme launched in 1995 (see para. 4.8 below for details) was formulated on the basis of the incomplete information contained in the Old Catalogue.

Incomplete coverage of the New Catalogue

3.11 As mentioned in paragraphs 3.6 to 3.7 above, from 1992 to 1998, the GEO spent considerable resources to compile the New Catalogue. The main objective of the exercise was to register all registrable man-made slopes in Hong Kong (see para. 3.6 above). After this exercise, it was generally considered that all registrable man-made slopes had been registered in the New Catalogue. However, the coverage of the New Catalogue was also found to be incomplete. According to the GEO, about 4% of the registrable man-made slopes might not have been identified and registered due to technical difficulties in locating them. Audit noted that in the GEO's systematic studies of landslips, it was revealed that there were a number of failed slopes which had not been registered in the New Catalogue. Table 4 below is an analysis of the unregistered slopes revealed by the systematic studies of landslip from 1998 to 2000.

Table 4

Number of unregistered slopes
revealed by the systematic studies of landslip

Year	Number of landslips in the year	Number of unregistered slopes			
		Total	Non-registrable (Note)	Registration required	
	(a)	(b)	(c)	(d) = (b) - (c)	(e) = $\frac{(d)}{(a)} \cdot 100\%$
	(No.)	(No.)	(No.)	(No.)	
1998	228	88	71	17	7.5%
1999	402	126	107	19	4.7%
2000	322	160	134	26	8.1%
Total	<u>952</u>	<u>374</u>	<u>312</u>	<u>62</u>	6.5%

Source: GEO's records

Note: These slopes were not registrable because they were either natural slopes or small man-made slopes that did not meet the criteria for registration in Appendix D.

3.12 As shown in Table 4 above, the number of slopes which should have been registered but which had not been registered in the New Catalogue, as revealed by the systematic studies of landslips from 1998 to 2000, was 62, or 6.5% of the total number of landslips. These 62 unregistered slopes were discovered because landslips had occurred. It is conceivable that there might be other registrable slopes which had not yet been found. **These unregistered slopes may pose a threat to public safety as there is little information about their number, location, stability and maintenance conditions. Audit considers that there is a need to conduct a further exercise to identify and register these slopes (which are unregistered but are registrable) so that proper follow-up actions can be taken.**

Unregistered slopes discovered during systematic studies of landslip

3.13 For those unregistered slopes discovered during the systematic studies of landslips, Audit notes that there is a mechanism in place for the subsequent registration of these slopes. In this connection, Audit reviewed the information in the SIS about the progress of the registration of these slopes, and found that the registration of most of these slopes had not yet been completed. For all of these slopes, the GEO had assigned a slope reference number and had drawn up a location plan. However, for many of these 62 slopes, as at the end of November 2001, the following essential information had not yet been fully recorded in the SIS:

- (a) **Classification of the slope.** The classification of the slope as an old slope or a new slope would determine the follow-up actions required;
- (b) **Ownership.** The ownership of a slope would determine whether the Government or a private owner should be responsible for its maintenance; and
- (c) **Consequence classification.** This is an assessment of what the consequences could be if the slope fails (Note 4).

3.14 Of the 62 unregistered slopes (see Table 4 in para. 3.11 above), up to the end of November 2001, Audit could only find 10 (about 16%) for which all the essential information for registration had been fully recorded in the SIS. **From the information recorded, Audit noted that the GEO had classified a number of the slopes as high consequence slopes. In view of the slow progress and the potential risk of the unregistered slopes, Audit considers that the GEO should expedite action to complete the registration of these slopes.**

Audit recommendations on registration of slopes

3.15 **Audit has recommended that the Director of Civil Engineering should:**

- (a) **expedite action to complete the registration of all unregistered slopes found in the investigations of landslips;**
- (b) **take action to identify and register other unregistered man-made slopes which should be registered; and**
- (c) **take necessary follow-up actions to ensure the safety of the unregistered slopes which have been identified.**

Response from the Administration

3.16 The **Director of Civil Engineering** agrees with the audit recommendations on the registration of slopes as mentioned in paragraph 3.15 above.

Note 4: *The consequence classification of a slope gives an indication of the likely consequence to the public if the slope fails. The descriptive terms “high”, “low” and “negligible” were originally used in the consequence classification system and were intended to reflect the likely relative severity of the consequence of a slope failure in terms of loss of human lives. Since March 1996, the three categories of consequence have been revised to Categories 1, 2 and 3, with Category 1 representing the most severe consequence.*

PART 4: PROGRESS OF UPGRADING OLD GOVERNMENT SLOPES

4.1 This PART examines the progress of the Government's efforts to upgrade the 26,000 old government slopes in the New Catalogue of Slopes through the LPM Programme and other slope safety improvement measures. The audit has revealed that there is room for improvement in the planning and the monitoring of the upgrading of old government slopes.

The LPM Programme

4.2 Prior to the establishment of the GEO in 1977, there was very limited geotechnical control over the formation of slopes on private land and by public works projects. Many of the old slopes formed before 1977 are largely substandard and they constitute the main source of landslide risk in Hong Kong. Substandard slopes require upgrading to bring them to the current safety standards. The upgrading of a slope involves ground investigation, stability assessment, and design and construction works. It can take years to complete the upgrading of a slope. The cost involved can be significant.

4.3 Of the 37,000 old slopes in the New Catalogue, 26,000 (about 70%) are government slopes. Since 1977, the GEO has been conducting the upgrading works of the government slopes through the LPM Programme, which is an ongoing programme for the systematic investigation and the upgrading of the substandard slopes. Prior to 1995, there was no specific plan for completing the upgrading works of all substandard government slopes. From 1977-78 to 1994-95, a total of 631 slopes (about 35 slopes a year) were upgraded under the LPM Programme (see Table 5 in para. 4.11 below).

4.4 Substandard slopes can become unstable as a result of the deterioration in their condition, severe rainfall or the lack of maintenance. To determine whether a slope is stable, the GEO has to carry out a detailed study. The study may confirm that the slope does not require upgrading works. However, according to the results of the detailed studies completed by the GEO, such cases were rare. Over 90% of the old slopes, which had been selected for detailed studies from 1995-96 to 2000-01, required upgrading works to bring them to the current safety standards (see para. 6.4 below).

The 5-year Accelerated LPM Programme

4.5 *The Kwun Lung Lau landslide.* Following the Kwun Lung Lau landslide in July 1994 (see para. 2.5 above), there were calls on the Government to strengthen its programme on slope safety. In particular, the Government was urged to increase the resources allocated to the investigation and the upgrading of old slopes, and to reinforce the control of the inspection and the maintenance of government and private slopes.

4.6 In December 1994, at a meeting of the LegCo Panel on Planning, Lands and Works, Members of the Panel expressed their concern about the long period of time (estimated to be about 15 years at that time) required to upgrade the substandard old slopes in the Old Catalogue. They were also concerned about whether adequate resources were being deployed for slope maintenance. In April 1995, at another meeting of the Panel, Members asked again whether it would be possible to further accelerate the LPM Programme by allocating more funds for its implementation.

4.7 *Slope Safety Review.* In late 1994, the Secretary for Works carried out a review of the policy, legislation, and resources in respect of landslip prevention. In February 1995, the Secretary for Works issued the Slope Safety Review Report. The Report stated that:

- (a) despite the commitment of significant public resources, at the rate of progress of the LPM Programme at that time, it would take about 15 years (i.e. by 2009) to complete the upgrading works on the substandard slopes in the Old Catalogue;
- (b) public opinion as reflected by LegCo Members, District Board Members and the media demanded faster action; and
- (c) an accelerated LPM programme was required in the interests of public safety, and it was recommended that the LPM works on the substandard slopes in the Old Catalogue should be completed by the year 2000.

4.8 *Endorsement of ExCo.* In February 1995, the Administration informed ExCo that at the rate of progress at that time, the upgrading of all substandard slopes in the Old Catalogue would not be completed before 2009. Recognising the importance of slope safety, the Administration recommended acceleration of the LPM Programme with a view to completing work on the slopes in the Old Catalogue by 2000. **In February 1995, ExCo advised and the then Governor ordered that:**

- (a) **the LPM Programme should be accelerated, by some ten years, with a view to substantial completion by 2000 of the upgrading of the slopes in the Old Catalogue; and**
- (b) **more low consequence slopes (see Note 4 in para. 3.13 above) adjacent to roads and footpaths should be considered under the LPM Programme.**

To implement the 5-year Accelerated LPM Programme endorsed by ExCo in February 1995, additional funding of some \$1.3 billion for capital works and \$400 million for creating 160 posts (in the GEO and the Buildings Department) was allocated over the 5-year period from April 1995 to March 2000.

Audit observations on the 5-year Accelerated LPM Programme

The target of the 5-year Accelerated LPM Programme

4.9 As mentioned in paragraph 4.8 above, the target of the 5-year Accelerated LPM Programme was to achieve substantial completion by 2000 of the upgrading of the slopes in the Old Catalogue. On 3 March 1995, this target was announced in a press release. The press release said that the LPM Programme, which involved the inspection, and where necessary, upgrading of 10,000 man-made slopes listed in the Old Catalogue, should be accelerated by ten years for substantial completion by 2000. In April 1995, the 5-year Accelerated LPM Programme started and was scheduled for completion by March 2000. The GEO issued a quarterly report (hereinafter referred to as the Quarterly Report) to report on the progress of the studies and the slope upgrading works.

4.10 In January 1996 (in Quarterly Report No. 4/95), the GEO said that the target of the 5-year Accelerated LPM Programme was to complete the studies and the upgrading works on the substandard slopes in the Old Catalogue over five years commencing on 1 April 1995. However, Audit noted that, since July 1996, this target had been reported in different ways, as follows:

- (a) *Upgrading “high consequence” slopes.* On 9 July 1996, in a Note for ExCo, the Administration informed ExCo that the LPM Programme was being accelerated, **with a view to completing the study and the necessary upgrading works on the “high consequence” slopes** (see Note 4 in para. 3.13 above) **in the Old Catalogue by the year 2000.** However, ExCo was not informed of the definition and the number of high consequence slopes;
- (b) *Upgrading as many substandard slopes as reasonably practicable.* On 9 July 1996 (in Quarterly Report No. 2/96), the GEO said that **the target of the 5-year Accelerated LPM Programme was to complete the investigation and the necessary upgrading works on as many substandard slopes in the Old Catalogue over five years commencing on 1 April 1995 as was reasonably practicable; and**
- (c) *Upgrading of 850 government slopes.* In August 1997, in an Information Paper on Slopes Safety submitted to the then Provisional LegCo Panel on Planning, Lands and Works, the Administration said that **the target of the 5-year Accelerated LPM Programme was to upgrade about 850 government slopes by the year 2000.**

Actual output of the 5-year Accelerated LPM Programme

4.11 In March 2000, the 5-year Accelerated LPM Programme was completed, for which about \$2.9 billion of capital expenditure had been incurred. Table 5 below shows the number of slopes upgraded under the 5-year Accelerated LPM Programme from 1995-96 to 1999-2000, and the total number of slopes upgraded since 1977.

Table 5

**Number of slopes upgraded under
the 5-year Accelerated LPM Programme from 1995-96 to 1999-2000**

Year	Number of slopes upgraded under the		
	5-year Accelerated LPM Programme (No.)	Ongoing LPM Programme (No.)	
1977-78 to 1994-95 (18 years)	–	631	(i.e. about 35 slopes a year)
1995-96	51		
1996-97	72		
1997-98	150		
1998-99	240		
1999-2000	251		
	—		
Total for the 5-year Accelerated LPM Programme	<u>764</u>	764	(i.e. about 153 slopes a year)
		—	
(A) Total number of slopes upgraded since 1977 (i.e. 764 + 631)		<u>1,395</u>	
(B) Total number of slopes in the Old Catalogue (Note)		10,000	
(C) Percentage of slopes upgraded up to 1999-2000 ((C) = (A)/(B) × 100%)		14%	
(D) Total number of government slopes in the Old Catalogue		7,000	
(E) Percentage of government slopes upgraded up to 1999-2000 ((E) = (A)/(D) × 100%)		20%	

Source: GEO's records

Note: The 5-year Accelerated LPM Programme (from 1995-96 to 1999-2000) was based on the number of slopes in the Old Catalogue because the compilation of the New Catalogue was completed in 1998.

4.12 As shown in Table 5 above, under the 5-year Accelerated LPM Programme, the upgrading works of 764 slopes (about 153 slopes a year) had been completed. Taking into account the 631 slopes upgraded in the preceding 18 years from 1977 to 1994 under the ongoing LPM Programme, the total number of slopes upgraded was only 1,395, i.e. 14% of the 10,000 slopes or 20% of the 7,000 government slopes in the Old Catalogue.

4.13 Audit noted that in papers submitted to ExCo and LegCo as mentioned in paragraph 4.10 above, the target of the 5-year Accelerated LPM Programme, which had been endorsed by ExCo in February 1995, was stated in different ways. Audit was unable to trace any record which provided a reconciliation of the different ways of presenting the target. In February 2002, the GEO and the Works Bureau informed Audit that the real intention of the 5-year Accelerated LPM Programme was to fast-track, by some ten years, the upgrading works for the high consequence slopes in the Old Catalogue because these slopes were posing the highest risk. Based on the average rate of the upgrading works for government slopes at that time and an estimated period of 15 years needed to complete the necessary works, this would correspond to about 800 government slopes to be upgraded under the 5-year Accelerated LPM Programme. This intended target had not been as clearly spelt out in the February 1995 ExCo Memorandum (see para. 4.8 above). However, it was clear, in the subsequent submission to ExCo (see para. 4.10(a) above), that the target was to deal with the “high consequence” government slopes.

4.14 Audit notes that the target of the 5-year Accelerated LPM Programme had not been clearly stated when it was launched in 1995. Audit considers that the Administration should state clearly the targets of government programmes, such as the 5-year Accelerated LPM Programme, when making submission to the relevant authority.

Lack of post-implementation review

4.15 As stated in paragraph 4.9 above, the 5-year Accelerated LPM Programme was completed in March 2000. Audit notes that the GEO has not conducted a post-implementation review of the programme (Note 5). Audit considers that it is important for the GEO to carry out a post-implementation review of the 5-year Accelerated LPM Programme to assess whether there is any room for improvement in the implementation of the LPM Programme in future.

Audit recommendations on the 5-year Accelerated LPM Programme

4.16 Audit has *recommended* that the Secretary for Works and the Director of Civil Engineering should:

Note 5: *For example, in Chapter 4 of the Director of Audit’s Report No. 31 dated October 1998 on the Tolo Harbour Effluent Export Scheme, Audit recommended that the Administration should consider conducting post-completion reviews for improving the management of capital works projects. In response, the Administration agreed with the audit recommendation. The Drainage Services Department formed the Post Completion Review Group to review the various aspects of the Tolo Harbour Effluent Export Scheme.*

- (a) **ensure that the target of a government programme, such as the 5-year Accelerated LPM Programme, is stated clearly in the papers submitted to the relevant authority in future; and**
- (b) **conduct a post-implementation review of the 5-year Accelerated LPM Programme so as to ascertain whether the programme objectives have been achieved and whether there is any room for improvement in the implementation of the LPM Programme in future.**

The 10-year Extended LPM Programme

4.17 As mentioned in paragraph 3.7 above, the New Catalogue compiled in 1998 registered about 37,000 old slopes, of which 26,000 were government slopes. These old government slopes required studies and upgrading works in order to ensure that they meet the current safety standards.

4.18 In view of the significant number of old slopes registered in the New Catalogue, the GEO drew up a long-term strategy, under an expanded upgrading and maintenance programme, to upgrade those high consequence slopes not yet dealt with under the 5-year Accelerated LPM Programme. **In September 1997, the Government formulated a 10-year Extended LPM Programme for commencement in April 2000. The target of the 10-year Extended LPM Programme is to complete the upgrading works for another 2,500 substandard old government slopes by the year 2010 (i.e. to upgrade about 250 old slopes a year during the 10-year period from 2000-01 to 2009-10).** In July 1998, the Administration informed ExCo and LegCo of the target of the 10-year Extended LPM Programme.

Upgrading of slopes other than old government slopes

4.19 The target of the 10-year Extended LPM Programme is to upgrade annually 250 substandard old government slopes between 2000 to 2010. Therefore, the progress of the 10-year Extended LPM Programme should be measured against the number of old government slopes upgraded.

4.20 GEO Circular No. 19 specifies the criteria for the selection of slopes for upgrading. Besides the old government slopes, the following categories of slopes are eligible for selection under the LPM Programme:

- (a) ***Slopes related to New Territories Exempted House (NTEH) development*** (Note 6). Prior to the enactment of the Buildings Ordinance (Application to New Territories) Ordinance (Cap. 121) in October 1987, the Government had no statutory authority to require NTEH owners to submit designs of slope works to the GEO (via the Buildings Department) for checking. As a result, slopes formed in connection with NTEHs between 1977 and 1987 may not meet the required geotechnical safety standards. The GEO estimates that about 100 of these slopes may need to be included in the 10-year Extended LPM Programme;
- (b) ***Slopes dealt with in the late 1970s/early 1980s.*** These slopes were subject to stabilisation works arising from investigation studies conducted in the late 1970s and early 1980s. According to the records of the GEO, there are about 674 slopes in this category which will require further studies and upgrading works under the 10-year Extended LPM Programme. Up to the end of December 2001, detailed studies had been completed for 156 slopes in this category, of which 71 were found to require upgrading works;
- (c) ***Slopes requiring upgrading works due to landslips.*** Slopes in this category include both old slopes and new slopes. In February 2000, 56 slopes were included in the 10-year Extended LPM Programme following landslip studies. Of the 56 slopes, 19 were new slopes;
- (d) ***Mixed responsibility slopes.*** Mixed responsibility slopes are slopes classified as private slopes by the GEO but are in fact partly government-owned and partly privately owned. Slopes in this category have not been included in the 26,000 old government slopes in the New Catalogue. In February 2000, eleven slopes in this category were approved for inclusion in the 10-year Extended LPM Programme; and
- (e) ***New government slopes due to inadequate stability assessment.*** These are new government new slopes which have previously been checked. They are recommended for inclusion in the 10-year Extended LPM Programme due to inadequate assessment of stability in the past.

Note 6: *An NTEH is a building primarily used for habitation other than a guest house or a hotel in respect of which the Director of Lands, under the Buildings Ordinance (Application to the New Territories) Ordinance, has issued a certificate of exemption under the said Ordinance.*

Audit observations on the 10-year Extended LPM Programme

4.21 Audit noted that, in January and July 2001, the upgrading works for a total of 539 slopes were approved for inclusion in the 10-year Extended LPM Programme. Of the 539 slopes, 114 were new government slopes. To a certain extent, this may affect the achievement of the target of the 10-year Extended LPM Programme of upgrading 250 substandard old government slopes a year as resources have to be diverted to upgrade the 114 new government slopes.

4.22 For 1999-2000 and 2000-01, the GEO reported that 251 slopes were upgraded each year under the LPM Programme. Audit checked the classification of these 502 slopes (i.e. 251 slopes × 2 years). **Audit found that 40 slopes upgraded in 1999-2000 and 46 slopes upgraded in 2000-01 were either new government slopes or mixed responsibility slopes. These 86 (or 17% of 502) slopes were not old government slopes. However, in measuring the progress of the LPM Programme, the GEO included these slopes in the figure of the old government slopes upgraded, and reported that the upgrading of 251 slopes a year met the annual target of upgrading old government slopes under the LPM Programme.**

4.23 Audit noted the GEO's justifications that, in the interest of public safety, slopes other than old government slopes should also be included in the LPM Programme. **However, it is necessary to measure the progress of the Programme by the actual number of old government slopes upgraded. The number of new slopes and mixed responsibility slopes upgraded should be separately accounted for, and should not be included in the number of old government slopes upgraded. If the pledged target of the LPM Programme cannot be met, the GEO should consider whether it is necessary to make up for the shortfall by other means.**

Audit recommendations on the 10-year Extended LPM Programme

4.24 **Audit has recommended that the Director of Civil Engineering should:**

- (a) **monitor the progress of the 10-year Extended LPM Programme by comparing the actual number of old government slopes upgraded with the GEO's pledged target, and report separately the number of new government slopes and mixed responsibility slopes upgraded; and**
- (b) **explore other ways to make up for the shortfall in the actual number of old government slopes upgraded against the pledged target of upgrading 250 such slopes annually under the 10-year Extended LPM Programme. This will be necessary particularly if, owing to the urgent need to upgrade some government new slopes and mixed responsibility slopes, the attainment of the pledged target is affected.**

Overall progress of upgrading old government slopes

4.25 According to Table 6 in paragraph 4.27 below, under the 10-year Extended LPM Programme, the GEO intends to upgrade 2,500 old government slopes by 2010. Another 4,000 (900 + 2,400 + 700) old government slopes will be dealt with under other measures by 2010. As there are about 26,000 old government slopes in the New Catalogue, the Government will still need to deal with some 16,000 old government slopes (26,000 – 10,000) after 2010.

Additional slope safety measures

4.26 In formulating the 10-year Extended LPM Programme, the Government had pledged to implement the following additional slope safety measures from 2000-01 to 2009-10, **to deal with the substandard old government slopes not covered by the 10-year Extended LPM Programme:**

- (a) ***Integrated development.*** The Government would adopt an integrated approach for government road and development projects to ensure that slopes affected by the projects were upgraded to current safety standards as an integral part of the projects. The cost for the slope upgrading works would be charged to the respective project votes;
- (b) ***Enhanced maintenance.*** An “enhanced maintenance” approach would be adopted as far as practicable to improve the stability of substandard old government slopes. Resources would be made available under the slope maintenance votes of the slope maintenance departments for enhanced maintenance; and
- (c) ***Clearance of squatters.*** Since the early 1980s, the landslip risk to squatters had been dealt with by clearance of the squatter structures and re-housing of the occupants. The clearance of squatters on slope safety grounds by the departments concerned was based on the GEO’s inspections of the squatter areas.

4.27 In the selection of slopes for upgrading works, the GEO accorded higher priority to those slopes that had a lower degree of stability and the failure of which would affect the community more directly. In so doing, the Government could reduce the overall landslip risk by the greatest degree within the shortest possible time. In October 1999, the GEO estimated that by March 2010, all high consequence (see Note 4 in para. 3.13 above) government slopes would be dealt with. Table 6 below shows the estimated number of high consequence slopes dealt with, or to be dealt with, under different slope safety measures.

Table 6

Estimated number of high consequence government slopes to be dealt with from 2000-01 to 2009-10

Measures to deal with the slopes	Estimated number of slopes		
	Dealt with up to March 2000	To be dealt with from 2000-01 to 2009-10	Total
	(a)	(b)	(c) = (a) + (b)
	(No.)	(No.)	(No.)
(A) Upgrading under the LPM Programme	1,500 (Note)	2,500	4,000
(B) Upgrading through new development projects by works departments	100	900	1,000
(C) Improvement through enhanced maintenance by slope maintenance departments	100	2,400	2,500
(D) Clearance of squatters	1,800	700	2,500
Total	<u>3,500</u>	<u>6,500</u>	<u>10,000</u>

Source: GEO's records

Note: Up to March 2000, the actual number of slopes upgraded was 1,395 (see para. 4.12 above).

4.28 **Overall landslip risk.** The Government had estimated that, on completion of the 5-year Accelerated LPM Programme in March 2000, the Programme alone had reduced the overall landslip risk to the community by 50%, compared with that which existed in 1977. The implementation of the additional slope safety measures mentioned in paragraph 4.26 above would further reduce the risk of landslips arising from the old slopes. According to the GEO, by March 2010, on the completion of the 10-year Extended LPM Programme, the overall landslip risk of all old slopes to the community would be reduced to below 25% of that which existed in 1977.

4.29 According to Table 6 in paragraph 4.27 above, the Administration estimated that, up to March 2000, 3,500 old government slopes had been dealt with. The Administration plans to deal with another 6,500 old government slopes from 2000-01 to 2009-10. By March 2010, all the 10,000 old government slopes classified as high consequence slopes will be dealt with. **However, Audit found that some of the slopes dealt with were not part of the 26,000 old government slopes and were not classified by the GEO as high consequence slopes. Details are in paragraphs 4.30 to 4.34 below.**

Audit observations on overall progress of upgrading old government slopes

Upgrading of high consequence slopes

4.30 As mentioned in paragraph 4.27 above, the Government selected high consequence slopes for upgrading. By March 2000, a total of 3,500 high consequence slopes had been dealt with. **However, Audit noted that not all the slopes upgraded under the LPM Programme were high consequence slopes.**

4.31 According to Quarterly Report No. 1/2000, up to end of March 2000, the total number of slopes upgraded under the LPM Programme was 1,395. **Of the 1,395 slopes upgraded, only 927, or 66%, were classified as high consequence slopes. The remaining 468 slopes, or 34%, were not high consequence slopes. Audit considers that, in reporting the progress of the upgrading of old government slopes, there is a need for the GEO to report separately the number of high consequence slopes upgraded. Upgraded slopes belonging to other categories should not be included in the number of high consequence slopes upgraded.**

Slopes safety measures by clearance of squatters

4.32 As indicated in Table 6 in paragraph 4.27 above, the GEO estimated that, by March 2000, it had dealt with 1,800 slopes by the clearance of squatters. The GEO would deal with another 700 slopes by clearance of squatters from 2000-01 to 2009-10. However, there was no record to indicate how many of these 1,800 slopes were part of the 26,000 old government slopes requiring action.

4.33 In response to Audit's enquiry, in December 2001, the GEO said that its geotechnical inspections focused on identifying squatter huts to be cleared. Squatter areas were often built on natural hillsides, with the slopes formed by the squatters themselves. These slopes were often too small to be registered in the Catalogues of Slopes. The number of slopes to be dealt with by clearance of squatters was estimated from the number of squatters rehoused.

4.34 The clearance of squatters over the last decade had contributed significantly to reducing the landslip hazard to squatters. However, the clearance of squatters has only reduced the severity of the consequence of slope failures on the squatters, it has not upgraded the stability of the slopes concerned. Audit considers that these slopes should not be counted in the number of old government slopes dealt with.

Planning of enhanced maintenance and integrated project development

4.35 As shown in Table 6 in paragraph 4.27 above, by 2010, the slope maintenance departments are expected to improve 2,400 old government slopes through enhanced maintenance, and the works departments are expected to upgrade 900 old government slopes through integrated project development.

4.36 Up to the end of November 2001, the Works Bureau had not yet formulated any detailed work plan for the slope maintenance departments to achieve the target of improving 2,400 slopes by 2010, and for the works departments to achieve the target of upgrading 900 slopes by 2010. **As a number of works departments and slope maintenance departments are involved, Audit considers that there is a need to formulate, from the outset, a detailed work plan indicating how the targets are to be achieved.**

Slow progress of upgrading old government slopes

4.37 The overall progress of upgrading old government slopes has been outlined in Table 6 in paragraph 4.27 above. **Up to March 2000, the GEO's records showed that about 3,500 old government slopes had been dealt with. According to the present plan, by March 2010, a total of 10,000 old government slopes will be dealt with. Audit considers that the overall progress of upgrading old government slopes is slow. By March 2010, there will still be 16,000 old government slopes (26,000 slopes – 10,000 slopes) to be dealt with. However, the Works Bureau and the GEO have not yet formulated a long-term plan for dealing with the remaining 16,000 old government slopes.**

4.38 The current target of the LPM Programme is to upgrade 250 slopes a year. The GEO is of the view that the present level of output of the LPM Programme is appropriate. If the number of slopes to be upgraded is to be increased further, this may result in more temporary road closures and traffic diversions. There is also the need to balance the annual target output against the availability of contractors who are experienced in slope works in order to maintain a high quality of the works.

4.39 Audit recognises the constraints on the capacity of the LPM Programme as mentioned by the GEO in paragraph 4.38 above. However, in view of the present economic downturn, there may be some spare capacity in the local construction industry for undertaking slope upgrading works. In November 2001, the Works Bureau announced plans to expand the minor works programme and to streamline the procedures for public works programme in order to create job opportunities. This could be an opportunity to speed up the progress of upgrading/improving old government slopes.

Audit recommendations on overall progress of upgrading old government slopes

4.40 **Audit has recommended that the Director of Civil Engineering should:**

- (a) **in reporting the progress of upgrading old government slopes under the 10-year Extended LPM Programme:**
 - (i) **report accurately the actual number of high consequence old government slopes upgraded; and**

- (ii) **report separately the number of slopes dealt with under the other slope safety measures, such as those dealt with by clearance of squatters; and**
- (b) **in consultation with the Secretary for Works, formulate a long-term plan for upgrading the remaining substandard old government slopes.**

4.41 **Audit has recommended that the Secretary for Works should:**

- (a) **coordinate with all the slope maintenance departments and the relevant works departments to formulate work plans for the implementation of the slope upgrading/improvement works; and**
- (b) **explore ways to speed up the upgrading/improvement of old government slopes, having regard to the current spare capacity in the construction industry and the measures recently adopted by the Works Bureau for speeding up public works projects.**

Response from the Administration

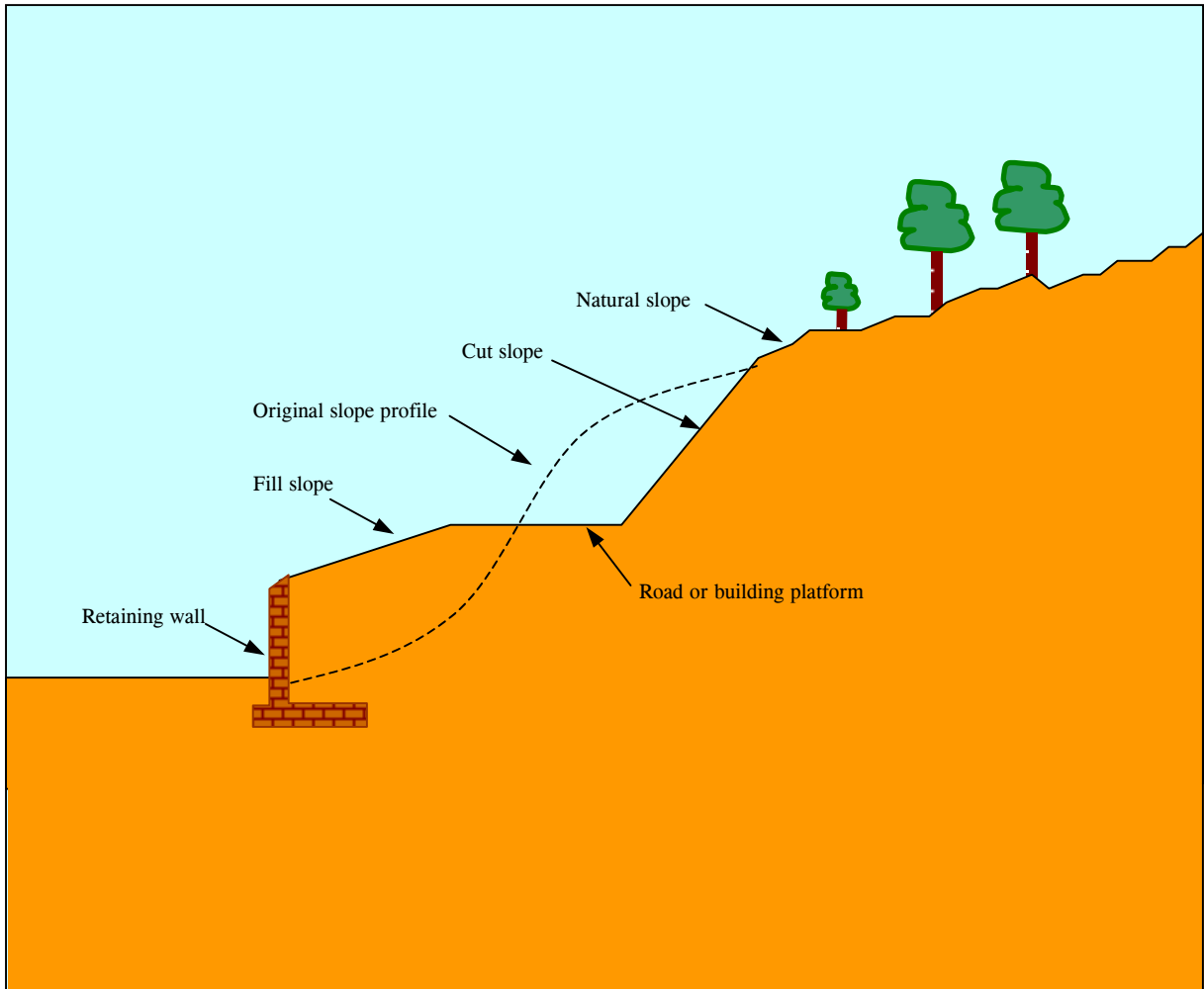
4.42 The **Director of Civil Engineering** agrees with the audit recommendations (on the 5-year Accelerated LPM Programme, the 10-year Extended LPM Programme and the overall progress of upgrading old government slopes) as mentioned in paragraphs 4.16, 4.24 and 4.40 above. He has said that:

- (a) a risk management approach is being adopted to tackle the acute slope safety problem in Hong Kong. In selecting slopes for investigation and upgrading, the GEO gives higher priority to slopes that have a higher risk in terms of both the probability and consequence of failure. Apart from upgrading the substandard old slopes by large-scale engineering works, there are other slope safety measures which are being taken to reduce the landslip risk. These measures include the removal of the affected facilities (e.g. clearance of squatters), improvement works as part of the slope maintenance programme, and public education and provision of warning notices on the slopes; and
- (b) a review of the long-term strategy for the upgrading of substandard old slopes will be carried out by 2005.

4.43 The **Secretary for Works** welcomes the audit recommendations on the 5-year Accelerated LPM Programme and the overall progress of upgrading old government slopes as mentioned in paragraphs 4.16 and 4.41 above.

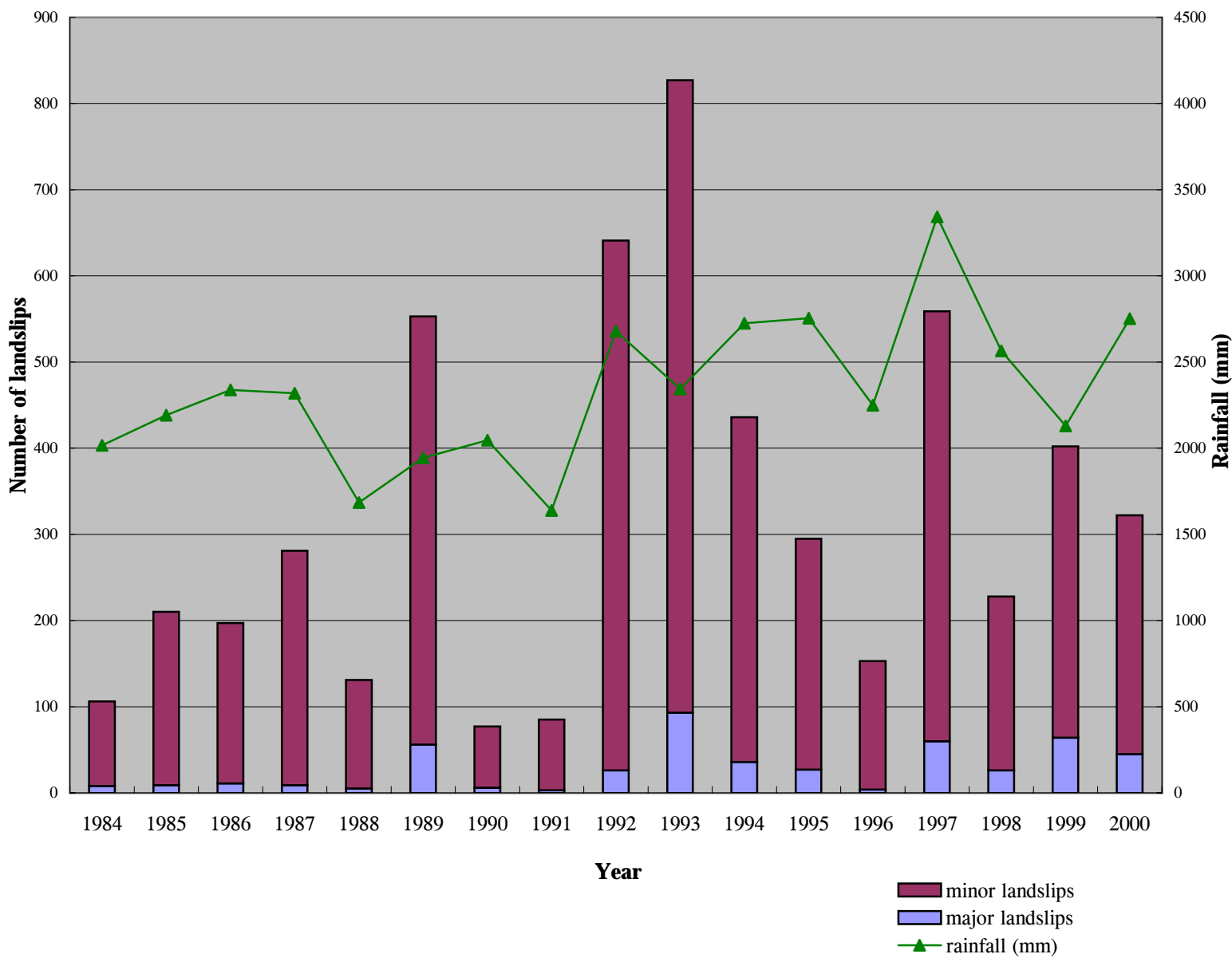
Figure 1

Schematic diagram showing different types of slopes
(para. 1.1 refers)



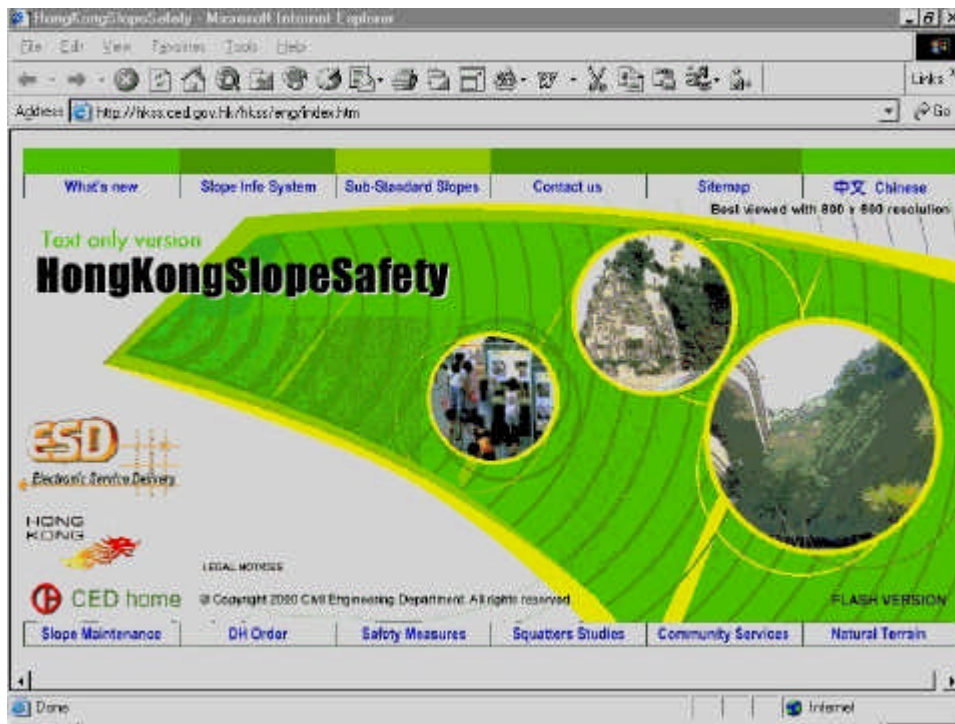
Source: GEO's records

Figure 2
Number of landslips reported to the GEO
1984 to 2000
 (para. 2.3 refers)



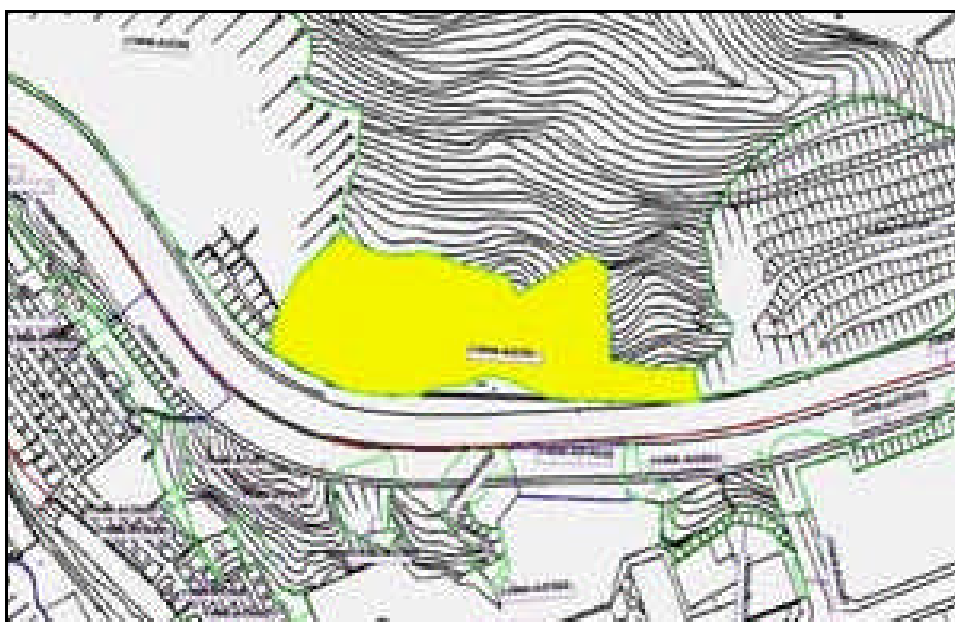
Source: GEO's records

Figure 3
The Hong Kong Slope Safety Website
(para. 3.8 refers)



Source: GEO's records

Figure 4
An example of a slope location plan in the Slope Information System
(para. 3.8 refers)



Source: GEO's records

Photograph 1
A disastrous landslip in Po Shan Road, Hong Kong in 1972
(para. 1.3 refers)



Source: GEO's records

Photograph 2
Slope upgrading works in progress
(para. 1.5 refers)



Source: GEO's records

PART 5: GEOTECHNICAL CONTROL OF NEW SLOPES

5.1 The GEO exercises geotechnical control over the formation of new slopes (see glossary of terms at Appendix I). This PART examines the effectiveness of GEO's geotechnical control over the formation of such slopes. The audit has revealed that landslips have occurred on some new slopes and that some slopes have not been subject to geotechnical control. The GEO needs to strengthen geotechnical control over the formation of new slopes.

Geotechnical control over the formation of new slopes

5.2 In Hong Kong, many new man-made slopes are formed each year in the course of building and infrastructure developments. The design and construction of these new slopes up to the required safety standards are key elements in ensuring their long-term safety. Since its establishment in 1977, the GEO has been checking the formation of all new slopes to ensure that they are designed and built to the required safety standards. Therefore, new slopes formed after 1977 normally do not require upgrading. Regular maintenance of the slopes is needed to prevent deterioration.

5.3 The GEO devotes a major part of its resources to the geotechnical control over the formation of new slopes by the government and the private sector. The GEO only approves designs which meet the required safety standards. Guidance on the technical standards to be met in the design and construction of slope works is given in the GEO's Geotechnical Manual for Slopes and the Geoguides.

5.4 *Geotechnical control of government slopes.* In January 1988, the then Lands and Works Branch issued Lands and Works Branch Technical Circular (LWBTC) No. 3/88 "Checking of Geotechnical Designs for Government Works". LWBTC No. 3/88 lays down the procedures to be followed by the works departments and their consultants for submission of geotechnical designs for public projects for checking by the GEO.

5.5 LWBTC No. 3/88 states that a works department should ensure that the proposed designs of all geotechnical works prepared by it are submitted to the GEO for checking where the checking is warranted in the interest of public safety. In case of doubt, the works departments should consult the GEO to determine whether GEO's checking is necessary. The circular also states that tenders should not be invited for any part of the geotechnical works which has not been agreed by the GEO, except when the GEO has given its written consent.

5.6 ***Geotechnical control of private slopes.*** The statutory authority for geotechnical control of private development is in the Buildings Ordinance. In exercising geotechnical control of private sector works projects, the GEO operates through the Buildings Department, which approves the developer's design submissions before construction proceeds. In 1995, the Government reviewed the effectiveness of the geotechnical control legislation, and made some amendments to enhance statutory geotechnical control.

Failures of new slopes which were not subject to geotechnical control

5.7 ***Pilot study on failures of new slopes.*** In 1997, the GEO conducted a pilot study on the failures of new slopes. The findings of the study were included in a draft Special Project Report of October 1997. The study revealed that, of the 156 major landslips (i.e. landslips with a failure volume of 50 cubic metres or more) reported to the GEO from 1993 to 1995, 12 cases were related to new slopes. The GEO tried to search for the design submissions and the stability assessment records. However, for half of the failure cases, the GEO could not find the design submissions. Therefore, it was difficult to assess whether the minimum safety standards recommended in the Geotechnical Manual for Slopes were adequate for the design of these new slopes.

5.8 The draft Special Project Report recommended that, in order to provide data for assessing the landslide risk of new slopes and for determining whether the minimum safety standards stated in the Geotechnical Manual for Slopes were adequate, the pilot study should be extended to include slope failures that occurred after 1995. Minor failures (i.e. landslips with a failure volume of less than 50 cubic metres), which had not been reviewed in the study, should also be included.

5.9 Various divisions inside the GEO commented on the draft Report. One notable comment was that it was not uncommon that the geotechnical designs of public works projects were not submitted to the GEO for checking. In October 1997, the Head of the GEO commented that the study on the failures of new slopes should be carried out annually.

5.10 ***Failures of new slopes from 1997 to 2000.*** The GEO's systematic studies of landslips (which occurred from 1997 to 2000 — see para. 2.9 above) again revealed a number of cases involving new slopes. The GEO's studies also revealed that a number of the failed new slopes had not been subject to proper geotechnical control over their formation. Table 7 below is an analysis of these cases.

Table 7

Analysis of landslips involving new slopes from 1997 to 2000

Year	Total number of landslips	Landslips involving new slopes	Failed new slopes without proper geotechnical control	Percentage of failed new slopes without proper geotechnical control
	(a)	(b)	(c)	$(d) = \frac{(c)}{(b)} \cdot 100\%$
	(No.)	(No.)	(No.)	
1997	559	35	11	31%
1998	228	20	7	35%
1999	402	38	24	63%
2000	322	19	4	21%
Total	1,511	112	46	41%

Source: GEO's records

5.11 As shown in Table 7 above, from 1997 to 2000, there were a total of 112 landslips involving new slopes. Of the 112 landslips, the GEO found that:

- in 41 cases, there were no indications that geotechnical designs had been submitted to the GEO for checking; and
- in 5 cases, there were major GEO comments outstanding that had not been addressed by the designers of the slopes.

5.12 Of the 46 (41+5) failed new slopes, 40 (87%) were government slopes, 3 (6.5%) were slopes classified as mixed responsibility slopes, and 3 (6.5%) were private slopes. Therefore, most of the failed new slopes without proper geotechnical control were new government slopes.

Implementation of the checking certificate system

5.13 In February 2000, the GEO informed the Works Bureau that there had been instances where geotechnical submissions, which should have been made to the GEO in accordance with LWBTC No. 3/88, had not been made.

5.14 The GEO considered that the likelihood of recurrence of such oversight could be greatly reduced or eliminated if a checking certificate system was introduced. The checking certificate system would give an assurance that all the necessary geotechnical submissions had been made, and that the GEO checking process was complete. The chances of the GEO not being informed of cases involving significant changes after its checking of a project would also be minimised.

5.15 In August 2001, the Works Bureau issued Works Bureau Technical Circular (WBTC) No. 16/2001 entitled “GEO Checking Certificate for Slopes and Retaining Walls” to implement the checking certificate system. According to WBTC No. 16/2001, the works departments responsible for the design and construction of public geotechnical works should:

- (a) institute a system to ensure that:
 - (i) all designs and amendments of design with geotechnical significance are properly checked internally and are submitted to the GEO for checking; and
 - (ii) all conditions imposed by the GEO are complied with;
- (b) keep proper records throughout the design and construction stages of the slope works; and
- (c) obtain a checking certificate from the GEO for all newly constructed slopes before they hand over the slopes to the parties responsible for maintenance. The GEO’s checking certificate certifies that the design and construction of a new slope have been checked as required by LWBTC No. 3/88. The checking certificate system is applicable to slope works for government contracts commencing after 30 September 2001.

**GEO’s response to Audit’s enquiry
on omissions to exercise geotechnical control**

5.16 In November 2001, in response to Audit’s enquiry, the GEO said that, apart from the cases mentioned in para. 5.10 above, it had also identified a number of omissions to exercise geotechnical control. In 1998, the GEO identified three completed government projects, involving the formation of 32 new slopes, for which no geotechnical submissions had been made to the GEO or there were actions outstanding on the GEO’s comments. The GEO was taking follow-up action with the works departments concerned to ensure that the design and construction of these slopes were up to the required safety standards.

5.17 The GEO considered that the introduction of the checking certificate system should be able to prevent the recurrence of similar cases in future. For other possible cases of new slopes without the GEO's geotechnical checking, the GEO considered that such cases would be detected by the inspections done by the slope maintenance departments. The slope maintenance departments would arrange all man-made slopes to be inspected in detail by professional geotechnical engineers once every five years. The first round of such inspections is scheduled to be completed by September 2002.

Audit observations on geotechnical control of new slopes

Failures of new slopes

5.18 As mentioned in paragraph 5.2 above, in 1977, the GEO introduced a system of geotechnical control. In principle, the GEO should have checked all the new slopes formed after 1977 to ensure that their design and construction were up to the required safety standards. Landslips occurring on these new slopes should be infrequent. However, the landslip investigations revealed that:

- among the landslips reported to the GEO from 1993 to 1995, there were 12 major landslips which involved new slopes (see para. 5.7 above); and
- there were 112 landslips, or about 7% of the total number of landslips reported to the GEO from 1997 to 2000, which involved new slopes (see para. 5.11 above).

Audit considers that the number of slope failures involving new slopes is significant. **There is a need for the GEO to continue to review the landslips involving new slopes to assess whether the safety standards laid down for the design and construction of the new slopes are adequate.**

New government slopes without proper geotechnical control

5.19 Audit noted that the GEO had taken follow-up actions with the works departments concerned for the 32 new government slopes without proper geotechnical control (see para. 5.16 above). For the 46 failed new slopes which had not been subject to proper geotechnical control (see para. 5.11 above), Audit noted that emergency repairs had been carried out. **Audit considers that the GEO should also take follow-up action with the works departments concerned for these 46 slopes so as to ensure that they are up to the required safety standards.**

Effectiveness of the checking certificate system

5.20 The Works Bureau and the GEO have introduced the checking certificate system to ensure that geotechnical designs will be submitted to the GEO for checking. Audit appreciates the efforts of the Works Bureau and the GEO in tackling this problem. **According to the following circulars, the works departments are required to submit geotechnical designs of slope works to the GEO for checking where this is:**

- (a) **warranted in the interest of public safety (LWBTC No. 3/88, see para. 5.5 above); or**
- (b) **considered to be of geotechnical significance (WBTC No. 16/2001, see para. 5.15 above).**

5.21 In response to Audit's enquiry, in November 2001, the GEO said that the works departments had the discretion of not making a geotechnical submission if they considered that the above criteria were not met. **However, Audit considers that the practice of allowing the works departments the discretion of not making geotechnical submissions is at variance with the GEO's stated intention that all the new slopes are subject to geotechnical control by the GEO. Moreover, the circulars do not specify the criteria and circumstances under which the works departments can exercise the discretion. This may give rise to non-submissions of geotechnical designs even in warranted cases. Audit considers that there is a need to issue clear guidelines on the specific circumstances under which geotechnical submissions need not be made to the GEO.**

Identification of new slopes without proper geotechnical control

5.22 The detection of new slopes without proper geotechnical control indicates that there is scope for improvement in the geotechnical control system. As the cases were revealed after an investigation of the failed new slopes, there could be other cases not yet detected among the 17,000 new slopes (i.e. those registered as such by the GEO in 1998 — see para. 3.7 above). **Audit considers that there is a need for the GEO to conduct a special review to identify those new slopes which have not been subject to proper geotechnical control.**

5.23 Audit notes that the GEO relies on the slope maintenance departments' inspections to identify new slopes which have not been subject to proper geotechnical control. The GEO will review the information on geotechnical control provided by the slope maintenance departments when they complete the inspections of the slopes in September 2002. **In view of the significance of the issue, Audit considers that the GEO should, after examining the results of the**

inspections conducted by the slope maintenance departments, consider the need to conduct a special review to identify all new slopes which have not been subject to proper geotechnical control.

Audit recommendations on geotechnical control of new slopes

5.24 **Audit has *recommended* that the Director of Civil Engineering should:**

- (a) **critically review all landslips involving new slopes to assess whether the GEO's safety standards for the design and construction of new slopes are adequate and have been complied with;**
- (b) **take follow-up action with the works departments concerned on new slopes which have not been subject to proper geotechnical control to ensure that such slopes meet the GEO's safety standards;**
- (c) **critically review the relevant provisions in LWBTC No. 3/88 and WBTC No. 16/2001 and issue clear guidelines on the circumstances under which geotechnical submissions to the GEO by the works departments are not required; and**
- (d) **consider carrying out a special review to identify new slopes which have not been subject to proper geotechnical control.**

Response from the Administration

5.25 The **Director of Civil Engineering** agrees with the audit recommendations on the geotechnical control of new slopes as mentioned in paragraph 5.24 above.

PART 6: MANAGEMENT OF LPM WORKS FOR UPGRADING OLD SLOPES

6.1 This PART examines the GEO's management of the LPM works for upgrading substandard old slopes. The audit has revealed that there is room for improvement in the GEO's monitoring of the LPM works.

Studies and upgrading works under the LPM Programme

6.2 Since 1977, the Government has embarked on an ongoing LPM Programme to deal with substandard government slopes (see para. 1.5 above). Under the LPM Programme, batches of old slopes are selected for study in a priority order determined by a risk-based ranking system, which takes into account the relative landslide risk posed to the community.

6.3 There are two levels of study in the LPM Programme, namely a preliminary study and a detailed study. The preliminary study consists of the reconnaissance of a slope during which the consequence of failure is assessed, and a judgement made of the need for preventive measures. While the preliminary study aims to identify slopes requiring a detailed study, it also aims to identify dangerous slopes so that necessary works can be carried out. In March 1998, the GEO completed the preliminary studies of all the old slopes registered in the New Catalogue.

6.4 The detailed study is an assessment of the stability of an existing slope to decide whether upgrading works are necessary. In the detailed study, the GEO reviews the background information and examines the history and characteristics of a slope from a study of aerial photographs, site observations and assessments of geotechnical stability. If necessary, the GEO carries out a ground investigation. According to the records of the GEO, the majority of the old government slopes, for which detailed studies had been conducted, were found to be substandard. Upgrading works were necessary to bring them to the required safety standards. The results of the detailed studies conducted on government slopes from 1995-96 to 2000-01 are shown in Table 8 below.

Table 8

**Results of detailed studies conducted on government slopes
1995-96 to 2000-01**

Year	Slopes on which detailed studies were conducted	Slopes requiring upgrading	Percentage of slopes requiring upgrading
	(a)	(b)	(c) = $\frac{(b)}{(a)} \cdot 100\%$
	(No.)	(No.)	(%)
1995-96	134	129	96.3%
1996-97	186	174	93.5%
1997-98	233	219	94.0%
1998-99	205	193	94.1%
1999-2000	219	202	92.2%
2000-01	252	229	90.9%
Total	<u>1,229</u>	<u>1,146</u>	93.2%

Source: GEO's records

6.5 If an old government slope is found to be below the required safety standards, it is recommended for upgrading works. Large-scale engineering works may be needed to rectify substandard slopes. The upgrading process involves an assessment of the geological and groundwater conditions of the slope, likely modes of failure, detailed design and construction. The programme of government slopes selected for detailed studies and upgrading works is referred to an inter-departmental committee called the Landslip Preventive Measures Committee (LPMC — Note 7), for consideration, advice and agreement.

Funding of the LPM Programme

6.6 Before 1983, funding for slope upgrading works was provided within the individual projects of the Public Works Programme. In December 1983, for funding the LPM Programme, the Finance Committee (FC) of LegCo approved the creation of a block allocation Subhead

Note 7: *The LPMC is chaired by an Assistant Director of the GEO, and includes representatives of the Works Bureau, Architectural Services Department, Buildings Department, Lands Department, Water Supplies Department, Highways Department and Housing Department.*

5001BX — Landslip Preventive Measures under Head 705 (Engineering) of the Capital Works Reserve Fund. The scope of this block vote includes landslip preventive works, remedial works of an ad hoc nature, ground investigation works and geotechnical and engineering studies (including consultant fees). The FC has delegated to the Director of Civil Engineering the authority to approve individual items without limit, provided that the aggregate expenditure for the subhead does not exceed the annual allocation.

6.7 In 2001-02, the provision for the LPM Programme is \$883 million, with a target of upgrading 250 substandard government slopes (see para. 1.11 above). Appendix E below shows the expenditure and number of slopes upgraded under the LPM Programme from 1977-78 to 2000-01.

6.8 The GEO carries out the detailed studies and the design of upgrading works of old government slopes either by employing geotechnical consultants or by using its in-house staff. The consultants or GEO's staff manage the works contracts for the upgrading works. The upgrading works for a number of slopes are packaged in a works contract. Each works contract contains a number of sections, each of which is concerned with the upgrading works for a slope. A separate amount and works schedule are laid down for each section for contract management purpose. **In this audit report, the upgrading works for each slope is hereinafter referred to as a "slope-works" item. The amount tendered for the slope-works item is hereinafter referred to as the tender sum.**

6.9 The GEO holds meetings regularly to monitor the progress of the LPM works against the approved programme. The GEO focuses primarily on the timely delivery of the targets in terms of the number of slopes to be upgraded in the year. The GEO takes remedial actions if the pledged targets are not met.

Audit observations on management of LPM works for upgrading old slopes

Importance of good project management

6.10 The Government has committed substantial resources to the upgrading works of substandard government slopes under the LPM Programme. It is important that the LPM works are well managed so that the upgrading works are completed on schedule and within budget. In order to assess the performance of the GEO in the management of the upgrading works, Audit selected all the 502 slope-works items completed in 1999-2000 and 2000-01 for detailed analysis. In this regard, **Audit noted that the GEO did not compile management reports for monitoring the progress of individual slope-works items. For better management of the LPM works, Audit considers that the GEO should compile management reports regularly so as to monitor the progress and the cost of the slope-works items.**

6.11 In the absence of readily available management reports, Audit requested the GEO to compile ad hoc reports for the 502 slope-works items completed in 1999-2000 and 2000-01. Audit noted from the ad hoc reports that **there were delays in completion and increases in cost for many of the slope-works items.**

Delay in completion of the LPM works

6.12 For the 502 slope-works items completed, Audit compared the completion dates against the original target dates for completion. Audit noted that extension of time (EOT) had been granted to many slope-works items due to amendments in design and inclement weather. The EOT granted would determine the extended date for completion of the slope-works items. Table 9 below shows the delays in the completion of the slope-works items against the original and extended date for completion.

Table 9

Analysis of delay of slope-works items completed in 1999-2000 and 2000-2001

Extent of delay	Number of slope-works items			
	Delay when compared with the original target date for completion		Delay when compared with the extended date for completion	
	(No.)	(%)	(No.)	(%)
None	118	24%	337	67%
1 to 30 days	124	25%	48	10%
31 to 90 days	120	24%	61	12%
91 to 180 days	78	15%	26	5%
181 to 365 days	55	11%	9	2%
Over 365 days	7	1%	1	-
Extended date for completion not yet determined	-	-	20 (Note)	4%
Total	<u>502</u>	<u>100%</u>	<u>502</u>	<u>100%</u>

Source: GEO's records and Audit's analysis

Note: For these 20 slope-works items, the EOT had not yet been determined as at the end of November 2001.

6.13 As shown in Table 9 above, only 118 (or 24%) of the 502 slope-works items were completed within the original target date for completion. The other 384 (502 less 118) slope-works items (or 76%) suffered delays. **There were seven slope-works items which had a prolonged delay of over one year.** Details of these seven slope-works items are at Appendix F. If the EOT granted was taken into account, about 337 (or 67%) slope-works items were completed within the

extended date for completion. The other 145 (502 – 337 – 20) slope-works items (or 29%) suffered delays of various duration. Audit considers that there is scope for the GEO to improve the management of the LPM works to ensure that the slope-works items are completed on time.

Increases in cost of LPM works

6.14 Audit compared the final costs of the 502 slope-works items against their tender sums and analysed the extent of cost increase (as a percentage of the tender sum). Table 10 below shows the increases in cost of the 502 slope-works items.

Table 10

Increases in cost of the 502 slope-works items

Extent of cost increase	Number of slope-works items		Total cost of the slope-works items				
			Tender sum	Final cost	Cost increase		Cost saving
			(a)	(b)	(c) = (b) - (a)	(d) = $\frac{(c)}{(a)} \times 100\%$	
	(No.)	(%)	(\$ million)	(\$ million)	(\$ million)	(%)	(\$ million)
None	277	55%	498	436	-	-	(62)
1% to 15% of tender sum	110	22%	228	242	14	6%	-
16% to 50% of tender sum	80	16%	144	187	43	30%	-
51% to 100% of tender sum	18	4%	32	55	23	72%	-
Over 100% of tender sum	12	2%	10	24	14	140%	-
Final cost not yet determined (Note)	5	1%	8	8	-	-	-
Total	502	100%	920	952	94	-	(62)

Source: GEO's records and Audit's analysis

Note: For five slope-works items, the final costs had not yet been determined as at the end of November 2001. The increase in cost (or saving) could not be determined for these slope-works items.

6.15 As shown in Table 10 above, 277 (or 55%) of the 502 slope-works items were completed within the original tender sums for the slope-works items. There were cost increases for 220 (i.e. 502 – 277 – 5) slope-works items (or 44%), of which the costs of 12 slope-works items had increased by more than 100% over the tender sum for the individual slope-works items. Details of the 12 slope-works items are at Appendix G. The total cost increase for the 220 slope-works items amounted to \$94 million. For the 277 slope-works items completed within budget, there was a cost saving of \$62 million. **Taken into account the cost saving of \$62 million, there was a net cost increase of \$32 million (i.e. \$94 million less \$62 million).** Audit considers that there is scope for the GEO to improve the cost control of the slope-works items under the LPM Programme.

GEO's explanations for the delays and cost increases

6.16 In December 2001, upon Audit's enquiry, the GEO provided reasons for the delays in the completion of the LPM works and the increases in cost. According to the GEO, the delays and the increases in cost were mainly due to the additional works ordered arising from amendments to designs to cope with unforeseen ground conditions, and the slow progress of the contractors. The GEO said that there was room for improvement in tightening up the management and control of the LPM works. The GEO would periodically review the slope-works items with significant delays and increases in cost. From 2001-02 onwards, the GEO would also carry out an annual review of the slope-works items completed in each financial year. The review would aim to identify key lessons learnt so that improvements could be made in future.

6.17 Audit noted that the GEO had not completed the ground investigations for a number of slope-works items before finalising the design of works. In this connection, the GEO has prepared a guide for carrying out ground investigations. According to **Geoguide 2: Guide to Site Investigation**, ground investigations should be largely completed before the design of the works is finalised.

Audit recommendations on management of LPM works for upgrading old slopes

6.18 Audit has *recommended* that the Director of Civil Engineering should:

- (a) **critically review the current procedures for the management of the LPM works and implement effective control measures so as to ensure that the works are completed on time and within the tender sums;**

- (b) **compile regular management reports to monitor closely the progress and the cost of the LPM works and to identify those slope-works items which require early management action; and**

- (c) **ensure that GEO professional staff and consultants comply with the requirement of Geoguide 2 that adequate ground investigations are conducted before the design of the LPM works is finalised.**

Response from the Administration

6.19 The **Director of Civil Engineering** agrees with the audit recommendations on the management of the LPM works as mentioned in paragraph 6.18 above.

Appendix A
(paras. 2.3, 2.10 and
2.13 refer)

**Number of landslips and consequences of landslips
1984 to 2000**

Year	Number of landslips		Casualties		Economic losses		
	Total (No.)	Major landslips (No.)	Fatalities (No.)	Injuries (No.)	Evacuation of buildings, houses and squatter huts		Blockage of roads, pedestrian pavements and access (Sections)
					Temporary (Units)	Permanent (Units)	
2000	322	45	0	1	18	0	86
1999	402	64	1	13	89	59	104
1998	228	26	0	0	38	11	68
1997	559	60	2	9	80	115	120
1996	153	4	0	1	61	4	87
1995	295	27	4	10	96	87	163
1994	436	36	6	21	118	117	225
1993	827	93	1	6	108	151	225
1992	641	26	3	6	106	210	181
1991	85	3	0	1	18	26	21
1990	77	6	0	0	20	60	16
1989	553	56	2	8	147	344	121
1988	131	5	0	1	30	106	39
1987	281	9	0	7	81	165	81
1986	197	11	0	1	47	127	58
1985	210	9	0	7	56	224	49
1984	106	8	0	1	64	109	22

Source: GEO's records

Appendix B
(para. 2.14 refers)

**Analysis of fatalities arising from landslips
1972 to 2000**

Year	Fatalities in the year	5-year rolling total	5-year rolling average	Locations of landslips involving fatalities (fatalities in brackets)
	(No.)	(No.)	(No.)	
1972	149	—	—	Po Shan Road (67); Sau Mau Ping Estate (71)
1973	0	—	—	
1974	1	—	—	
1975	2	—	—	
1976	26	178	35.6	Sau Mau Ping Estate (18)
1977	0	29	5.8	
1978	2	31	6.2	
1979	1	31	6.2	
1980	0	29	5.8	
1981	2	5	1.0	
1982	27	32	6.4	Many landslips affecting squatter areas in Kwun Tong, Tsing Yi, Tuen Mun and Shatin (27)
1983	4	34	6.8	Many landslips affecting squatter areas in Western District (4)
1984	0	33	6.6	
1985	0	33	6.6	
1986	0	31	6.2	
1987	0	4	0.8	
1988	0	0	0.0	
1989	2	2	0.4	Lion Rock Lower Village (2)
1990	0	2	0.4	
1991	0	2	0.4	
1992	3	5	1.0	Baguio Villa (2); Kennedy Road (1)
1993	1	6	1.2	Cheung Shan Estate (1)
1994	6	10	2.0	Kwun Lung Lau (5); Castle Peak Road (1)
1995	4	14	2.8	Tuen Mun Highway (1); Fei Tsui Road (1); Shum Wan Road (2)
1996	0	14	2.8	
1997	2	13	2.6	Ten Thousand Buddha Monastery (1); Kau Wah Keng Upper Village (1)
1998	0	12	2.4	
1999	1	7	1.4	Sham Tseng San Tsuen (1)
2000	0	3	0.6	

Source: GEO's records and Audit's analysis

Minor landslips with serious consequences

The following are examples of minor landslips (failure volume less than 50 cubic metres) with serious consequences:

- (a) in June 1981, a boulder fell from the natural slope above King's Road in Quarry Bay, resulting in the death of a pedestrian;
- (b) in June 1993, a landslip at a bus terminus at Cheung Shan Estate in Kwai Chung resulted in one fatality and injuries to five people;
- (c) in July 1997, two landslips affected the railway track at the Chinese University of Hong Kong and Fo Tan and caused temporary disruption to the railway service;
- (d) in April 2000, a boulder fell from the natural terrain above a cut slope disrupted traffic on Castle Peak Road and injured a motorcyclist; and
- (e) in June 2001, a rock fell from a cut slope, resulting in injury to two persons in a van travelling along Castle Peak Road.

Source: GEO's records

Criteria for registration of man-made slopes

The criteria for registration of man-made slopes are as follows:

- (a) cut slopes (including any associated retaining walls) and retaining walls greater than three metres high;
- (b) fill slopes (including any associated retaining walls) greater than five metres high;
- (c) fill slopes (including any associated retaining walls) less than five metres high which pose a direct risk to life; and
- (d) disturbed terrain features which (i) contain repairs to landslide scars; or (ii) comprise a series of composite cut and/or fill slopes where the ground surface has been disturbed (the natural slope gradient is greater than fifteen degrees) and the total height of which meet the criteria for registration.

Source: GEO's records

Appendix E
(para. 6.7 refers)

**Expenditure and number of slopes upgraded under the LPM Programme
1977-78 to 2000-01**

Year	Slopes upgraded (No.)	Expenditure under the LPM Programme (Note) (\$ million)
1977-78 to 1984-85 (8 years)	176	476
1985-86	41	56
1986-87	39	62
1987-88	32	63
1988-89	56	63
1989-90	27	75
1990-91	37	69
1991-92	34	62
1992-93	39	64
1993-94	77	69
1994-95	73	107
1995-96	51	195
1996-97	72	393
1997-98	150	681
1998-99	240	772
1999-2000	251	889
2000-01	251	921
Total	<u>1,646</u>	<u>5,017</u>

Source: GEO's records

Note: In addition to landslip preventive works, the LPM Programme also covers other categories of slope works, including remedial works of an ad hoc nature, ground investigation works and geotechnical and engineering studies.

**Particulars of 7 slope-works items completed
in 1999-2000 and 2000-01 with significant delays**

Case	Slope registration number and location	Start date	Original time for completion	Actual time taken for completion	Delay	Remarks
			(a) (Days)	(b) (Days)	(c) = (b) - (a) (Days)	
1	11SE-A/F14 Braemar Hill Road, North Point	01-Jul-98	239	832	593	Additional works ordered following design review during construction, and partly due to contractor's slow progress.
2	11NE-C/F87 Hong Ning Road, Kwun Tong	22-Nov-98	243	810	567	Slow progress of the contractor and design amendment during construction.
3	11NW-D/FR4 Sheung Lok Street, Ho Man Tin	1-Dec-98	303	793	490	Remedial works carried out as a result of a failure during construction.
4	11SW-B/C171 MacDonnell Road, Central District	18-May-98	138	589	451	Amendment in design to address the concerns raised by the adjacent private owners during construction, and partly due to contractor's slow progress.
5	6SE-C/C50 Emmanuel Primary School, Sham Tseng	11-Aug-98	164	592	428	Late possession of the works site due to unforeseen land matters.
6	11SW-D/F181 Tai Hang Road, Tai Hang	6-Oct-98	245	672	427	Time taken to resolve design problems after the contract was let.
7	11SW-B/F122 Bowen Drive, The Peak	20-May-98	206	589	383	Additional works ordered following design review during construction, and partly due to unexpected restriction on road closure during construction.

**Particulars of 12 slope-works items completed
in 1999-2000 and 2000-01 with significant cost increases**

Case	Slope registration number and location	Tender sum	Final cost	Cost increase	Percentage increase	Remarks
		(a)	(b)	(c) = (b) - (a)	(d) = $\frac{(c)}{(a)} \times 100\%$	
		(\$ million)	(\$ million)	(\$ million)	(%)	
1	7SW-B/C123 Shatin College, Shatin	2.10	5.72	3.62	172	Additional works due to the presence of loose fill at the crest of the slope, which was not originally envisaged.
2	11SE-A/F14 Braemar Hill Road, North Point	2.21	4.44	2.23	101	Additional works due to the increased extent of loose fill which was not identified during the investigation stage.
3	11SW-D/R216 Barker Road, The Peak	1.55	3.23	1.68	108	Additional works due to unforeseen ground condition.
4	11SE-C/C59 Junction of Mount Butler Road and Tai Hang Road, Tai Hang	0.60	2.40	1.80	300	Additional works due to unforeseen ground condition.
5	11SE-C/C531 Mount Parker Road, Sai Wan Ho	1.10	2.98	1.88	171	Additional works including soil nails and slope surface protection due to unforeseen ground condition.
6	6SE-C/C50 Emmanuel Primary School, Sham Tseng	1.01	2.23	1.22	121	Area of slope upgrading works had to be extended to cover another portion of the slope upon clarification of land matters during construction.

Case	Slope registration number and location	Tender sum	Final cost	Cost increase	Percentage increase	Remarks
		(a)	(b)	(c) = (b) - (a)	(d) = $\frac{(c)}{(a)} \times 100\%$	
		(\$ million)	(\$ million)	(\$ million)	(%)	
7	11SE-A/FR38 Belilios Public School, Causeway Bay	0.73	1.60	0.87	119	Additional works involving the removal of unexpected loose fill during construction.
8	11SW-D/C437 Stubbs Road, Happy Valley	0.34	0.71	0.37	109	Additional cost incurred due to the need to utilise a mobile working platform in order to mitigate the impact on traffic during construction.
9	7SW-C/C534 Tai Wo Hau Estate, Kwai Chung	0.39	0.80	0.41	105	Area of slope stabilisation works had to be extended to suit the actual ground condition.
10	11NE-D/R16 Ma Yau Tong, Tseung Kwan O	0.07	0.16	0.09	129	Amendment of design due to unforeseen ground condition.
11 & 12	6SE-A/C271 & 6SE-A/C272 (adjacent slopes) Tai Lam Country Park, Tuen Mun	0.01	0.03	0.02	200	Additional works to facilitate vegetation establishment on the slope surface due to the unexpected poor soil condition.

Source: GEO's records and Audit's analysis

Chronology of key events

Landslip statistics and reporting of landslips

July 1977	The GEO was established following a number of disastrous landslips in the 1970s. The GEO has an overall responsibility for slope safety in Hong Kong.
1984	The GEO published the first “Hong Kong Rainfall and Landslides” annual report.
July 1994	A slope and a retaining wall outside the Kwun Lung Lau, Kennedy Town collapsed. The Government engaged an internationally renowned landslip expert, Professor Morgenstern of Canada, to carry out an independent review.
December 1994	The Government accepted Professor Morgenstern’s recommendations.
Late 1994	The Works Bureau carried out a major review of the slope safety programme in Hong Kong.
February 1995	ExCo endorsed the recommendations of the Slope Safety Review Report prepared by the Works Bureau.
May 1995	The Director of Civil Engineering appointed a SSTRB to advise the Government on the technical aspects of slope safety.
1996	A Standing Committee on Slope Safety was set up to monitor and review the implementation of the recommendations of the Slope Safety Review Report.
1997	The GEO started to carry out systematic studies of landslips.
1999	The GEO ceased to publish the “Hong Kong Rainfall and Landslides” annual report.
October 1999	The GEO published the “Review of 1997 and 1998 Landslides”.

December 2000 The GEO published the “Review of 1999 Landslides”.

December 2001 The GEO published the “Review of Landslides in 2000”.

Registration of slopes

1977 The GEO started to compile the first catalogue of man-made slopes (Old Catalogue of Slopes) in Hong Kong.

1978 The compilation of the Old Catalogue of Slopes was completed. It contained details of about 10,000 old slopes.

1992 Investigations of landslips revealed that a number of slope failures involved slopes which had not been recorded in the Old Catalogue.

Mid-1992 The GEO initiated a project called “Systematic Inspection of Slopes in the Territory” to systematically search for slopes not registered in the Old Catalogue.

July 1994 The GEO employed a consultant to undertake the project “Systematic Identification and Registration of Slopes in the Territory” in order to accelerate the process of cataloguing slopes.

September 1998 The GEO completed the compilation of the New Catalogue of Slopes. The New Catalogue has registered a total of about 54,000 slopes.

Progress of upgrading old government slopes

1977 Since 1977, the GEO has been conducting upgrading works of the government slopes through the LPM Programme.

February 1995 The Administration informed ExCo that at the rate of progress at that time, the upgrading of all substandard slopes in the Old Catalogue would not be completed before 2009, and recommended acceleration of the LPM Programme with a view to completing work on slopes in the Old Catalogue by 2000.

February 1995	ExCo advised and the then Governor ordered that the LPM Programme should be accelerated, by some ten years, with a view to substantial completion by 2000 of the upgrading of the slopes in the Old Catalogue.
April 1995	The 5-year Accelerated LPM Programme commenced and was scheduled for completion by March 2000.
July 1996	The Administration informed ExCo that the LPM Programme was being accelerated, with a view to completing the studies and the necessary upgrading works on the “high consequence” slopes in the Old Catalogue by the year 2000.
July 1996	It was reported in the Quarterly Report No. 2/96 that the target of the 5-year Accelerated LPM Programme was to complete the investigation and the necessary upgrading works on as many substandard slopes in the Old Catalogue over five years commencing on 1 April 1995 as was reasonably practicable.
August 1997	The Administration informed the LegCo Panel on Planning, Lands and Works that the target of the 5-year Accelerated LPM Programme was to upgrade about 850 government slopes by the year 2000.
September 1997	The Government formulated a 10-year Extended LPM Programme for commencement in April 2000, with a view to completing the upgrading of another 2,500 substandard old government slopes during the 10-year period up to 2010.
July 1998	The Administration informed ExCo and LegCo of the target of the 10-year Extended LPM Programme.
July 1998	The Government pledged to implement additional slope safety measures from 2000-01 to 2009-10 to deal with the substandard old government slopes not covered by the 10-year Extended LPM Programme.
October 1999	The GEO estimated that, by March 2010, all high consequence government slopes, which might affect major developments, squatters or major roads, would have been dealt with.
March 2000	The 5-year Accelerated LPM Programme had completed the upgrading works of 764 slopes.

Geotechnical control of new slopes and management of LPM works for upgrading old slopes

1977	The Government embarked on the LPM Programme to deal with substandard government and private man-made slopes registered in the Catalogue of Slopes.
December 1983	The FC approved the creation of a block allocation Subhead 5001BX — Landslip preventive measures under Head 705 (Civil Engineering) of the Capital Works Reserve Fund for funding of LPM Programme.
January 1988	The Government issued LWBTC No. 3/88 “Checking of Geotechnical Designs for Government Works”.
1995	The Government conducted a review of the effectiveness of the geotechnical control legislation, and made some legislative amendments to enhance statutory geotechnical control.
1997	The GEO conducted a pilot study on the failures of new slopes, focusing on major landslips reported to the GEO during the years 1993 to 1995.
1998	The GEO identified a number of cases of omission of geotechnical checking.
August 2001	The Works Bureau issued WBTC No. 16/2001 “GEO Checking Certificate for Slopes and Retaining Walls”.

Glossary of terms relating to slopes in this Audit Report

Slopes	All slopes in Hong Kong, comprising natural slopes and man-made slopes.
Natural slopes	Slopes which are in their natural state (i.e. they have not been subject to modifications through civil engineering works or human activities).
Man-made slopes	Slopes which have been formed by civil engineering works or human activities. They are further classified into: <ul style="list-style-type: none">— cut slopes— fill slopes— retaining walls
	} see Figure 1 on the centre pages and Appendix D
Registered slopes	Government slopes or private slopes, which have been registered, in the “Old Catalogue of Slopes” compiled by the GEO in 1978 or the “New Catalogue of Slopes” compiled by the GEO in September 1998 — see PART 3.
Old slopes	Man-made slopes formed before the establishment of the GEO in July 1977.
New slopes	Man-made slopes formed after July 1977.
Government slopes	Man-made slopes on government land for which the Government is responsible for maintenance and repairs.
Private slopes	Man-made slopes on land assigned to private owners who are responsible for the maintenance and repairs of such slopes.
Mixed responsibility slopes	Slopes classified as private slopes by the GEO but in fact partly government-owned and partly owned by private owners.
Substandard slopes	Slopes which do not meet the current safety standards of the GEO.

Acronyms and abbreviations

EOT	Extension of time
ExCo	Executive Council
FC	Finance Committee
GEO	Geotechnical Engineering Office
LegCo	Legislative Council
LPM	Landslip Preventive Measures
LPMC	Landslip Preventive Measures Committee
LWBTC	Lands and Works Branch Technical Circular
NTEH	New Territories Exempted House
SIS	Slope Information System
SSTRB	Slope Safety Technical Review Board
WBTC	Works Bureau Technical Circular