Planning Policy Guidance 14: Development on Unstable Land - Annex 1: Landslides and Planning

On 5th May 2006 the responsibilities of the Office of the Deputy Prime Minister (ODPM) transferred to the Department for Communities and Local Government.

Department for Communities and Local Government
Eland House
Bressenden Place
London SW1E 5DU
Telephone: 020 7944 4400
Website: www.communities.gov.uk

This publication is only available online via the Communities and Local Government website: www.communities.gov.uk

Alternative formats under Disability Discrimination Act (DDA):if you require this publication in an alternative format please email alternativeformats@communities.gsi.gov.uk

Publication title: Planning Policy Guidance 14: Development on Unstable Land - Annex 1: Landslides and Planning
Date published: March 1996
ISBN: 0 11 753259 2
Price: £6 (available to view below)

Summary

This Annex develops Planning Policy Guidance 14 (PPG14) in relation to landslides and unstable slopes.

Order

This is a priced publication available from TSO (The Stationery Office), PO Box 29, Norwich NR3 1GN. Order through the Parliamentary Hotline (Lo-call): 08457 023 474, fax: 0870 600 5533, textphone 0870 240 3701, email: book.orders@tso.co.uk or visit www.tsoshop.co.uk to buy online.

Alternative formats under Disability Discrimination Act (DDA): if you require this publication in an alternative format (eg Braille or audio) please email alternativeformats@communities.gsi.gov.uk quoting the title and product code/ISBN of the publication, and your address and telephone number.

Contents

Foreword

Planning Policy Guidance Note 14 set out the broad planning and technical issues in respect of development on unstable land. This annex to PPG 14 aims to take that guidance forward with particular reference to problems caused by landslides and unstable slopes and should be read in conjunction with it.

This guidance advises:

- how local planning authorities can identify areas where landsliding is taking or has taken place or is a potential problem; and that
- within these areas, policies should seek to minimise the impact of landslides on development by controlling or restricting development where appropriate;
- policies should outline the consideration which will be given to landsliding, including the criteria and information requirements which will be used in determining planning applications; and
- where appropriate, planning applications should be accompanied by a slope stability report which demonstrates that the site is stable or can be made so and will not be affected by or trigger landsliding beyond the boundaries of the site.

Appendices outline

- an incremental method of landslide hazard assessment with two examples developed in specific areas which may be more widely applicable; and
- guidance on the preparation, content and format of slope stability reports to accompany planning applications.

Introduction

1. The full and effective use of land may be difficult to achieve because of the problems caused by unstable slopes. Such instability may include slips and flows of material and falls of rock or soil. It affects slopes ranging from gently sloping to vertical or even overhanging. Landslides and rock falls may damage or destroy existing buildings and structures and threaten public safety. In coastal areas, landsliding may lead to physical loss of land as well as risks to coastal assets. Landslides occurring during construction result in increased costs or even the abandonment of development. It is also the case that, due to their unstable nature, landslide areas are often undeveloped or uncultivated and may thus represent a significant opportunity to retain and increase the ecological resources of the wider area.

2. Identification of the problems in advance allows appropriate strategies to be adopted for dealing with them, helping to maintain a physically safe environment. Land which is potentially unstable can thus be put to a suitable use, contributing to the Government's broad objectives for economy and efficiency in the use of land and the protection of the environment.

Go to table of contents

Purpose Of The Guidelines

3. The purpose of these guidelines is to advise local authorities, landowners and developers on the exercise of planning controls over land use and development on or adjacent to slopes which are actually or potentially unstable. They are intended to help to ensure that:-

- the occurrence of and potential for slope instability is recognised at the earliest possible stage;
- appropriate strategies are adopted for dealing with the problems arising thus preventing the unnecessary sterilisation of land;
- due account is taken of the constraints imposed by slope instability at all stages of the planning process;
- development does not proceed in certain areas of instability or where treatment proposed is ineffectual;
- development is suitable and will not be threatened by landslides or cause instability of surrounding slopes;
- expensive protection or remedial works, which may be publicly funded, are not needed after a site has been developed;
- the environmental value of unstable land is assessed and due account taken of managing the resource in terms of sustainability requirements; and
- any necessary protection or remedial works will not lead to significant adverse environmental effects at the site or elsewhere.

4. These guidelines form an Annex to and should be read in conjunction with Planning Policy Guidance Note 14: Development on unstable land, which sets out the wider planning and administrative issues, and with PPG 20 which deals with the issues specifically relevant to Coastal Planning. Separate Mineral Planning Guidance on "Stability in quarrying" is being prepared which will also have wider relevance in terms of significant earth moving developments such as excavation of slopes and deposition of tips and related structures.

Problems Due To Unstable Slopes

5. Landsliding is a common but largely unrecognised occurrence in Britain. PPG 14 Appendix A (A43-A48, Fig. A5 and Table A1) illustrates the different types of landslides and the processes involved. Loss of life is infrequent (probably 2 or 3 per year due to cliff falls along the coast or to falls of ground from quarry faces or other excavations) but damage to and destruction of property and economic loss due to disruption of transport and other activities are common, as well as delays to development. Some examples of developments which have been affected by landslides both during and after construction are shown in Table 1.

6. The impact of such events varies enormously and is difficult to quantify in total. Table 2 illustrates the range of effects which contribute to the costs which may arise due to landsliding in Britain. It also illustrates the benefits which may result. In most cases, the potential for landsliding can be identified by appropriate investigations. Many of these costs are, therefore, avoidable. Generally, the costs of investigation and precautionary or remedial measures are greatly offset by the savings in terms of construction costs, damage, disruption or destruction that would otherwise arise.

Causes And Distribution Of Landslides

7. Landslides occur when the gravitational forces acting on the material comprising a slope exceed the resisting strength of those materials. Movement may be initiated by natural or human-induced changes in either of these controls. Once movement has occurred, the slope geometry may change to a more stable configuration but the resisting strength is reduced permanently. Further movement may be more likely if there is any adverse change in conditions. Water is particularly important since it increases the weight, and therefore the forces tending towards failure. Since the strength which is effective in resisting landsliding is reduced by water pressure, water is also important from this point of view. As might be expected, the rapidity of landsliding and the mobility of debris is increased by the presence of water.

Table 1: Some examples of damage caused by landslides

- in 1966, work on the A21 Sevenoaks Bypass was halted and the road realigned when construction works reactivated an ancient landslide system.
- in 1969-70, completion of the M4 motorway near Swindon was delayed when construction works reactivated an ancient landslide system.
- in 1978, a £350,000 service reservoir in the Malverns was abandoned at a cost of £250,000 when excavations reactivated an ancient landslide.
- in 1979, the A625 cross-Pennine road was permanently closed following continuing instability at Mam Tor.
- in 1988, 4 houses were lost at Luccombe Village in the Isle of Wight following reactivation of an ancient landslide at this cliff top site; the village had been constructed at this site in the 1930s following the destruction of the earlier fishing village of Luccombe by landsliding.
- during 1993, several houses in Bolsover were damaged and subsequently demolished following reactivation of an old landslide after a prolonged period of rainfall.
- in June 1993, part of the four star Holbeck Hall Hotel collapsed and the remainder was demolished after the cliff top receded by over 60m in a new first-time landslide after a period of prolonged rainfall.
- in January 1994, excessive rainfall after a particularly wet year led to widespread cliff falls and landslides on the Ventnor undercliff, Isle of Wight; at Blackgang Chine two houses were destroyed, a road cut and a caravan/chalet site had to be abandoned; elsewhere a number of houses were threatened, their gardens lost and footpaths blocked or destroyed.

Table 2: Range of costs and benefits commonly associated with landslides in Great Britain

Personal Costs	Fatal Accidents; Injuries; Psychiatric problems.

Immediate Costs	Mobilisation of relief workers and emergency services; Evacuation and provision of temporary or replacement housing and other buildings; Loss of land and property; Loss of industrial or agricultural production; Transport delays; Construction delays; Costs of investigation to determine appropriate response; Cost of repair to damaged buildings and structures.
Indirect Costs	Increased insurance premiums or withdrawal of cover; Depreciated property or land values; Costs of legal actions; Costs of public inquiries into causes and responsibilities.
Costs Of Prevention	Research into nature and extent of landslide problems; Formulation of planning policies related to development on unstable land; Coastal protection schemes; Design and construction of preventive measures including drainage and regrading; Costs of monitoring potentially and actually unstable slopes.
Benefits	Sites of Special Scientific Interest for their national or international importance for research, training and education; Regionally Important Geomorphological Sites for their educational, research, historical and aesthetic importance; Maintenance of exposure of faces of geological interest and importance; Large areas of environmentally valuable and diverse habitats not formally designated by English Nature; Provision of material directly to beaches and to longshore drift supplying beach material to other areas, thus inhibiting coastal erosion and enhancing protection against flooding; Improved stability and security of property and land if stabilisation is carried out.

Figure 1: Distribution of the 8835 recorded landslides in the National Landslides Database (after Jones and Lee, 1994)

8. Figure 1 shows the distribution of the 8835 landslides recorded in the national landslide database resulting from research for the Department of the Environment. An interpretation of this data is presented in PPG 14 Appendix A (A49 and Fig. A6). Together these give a broad general picture of the widespread nature of landsliding in Great Britain and of some of the areas where landslides are more likely to cause problems. The picture is not complete, however, since it only features landslides which have been recorded in the published literature. It is likely, for example, that more landslides have been recorded where they have been encountered by or caused by development. Thus there are generally, but not always, fewer records in areas of low population density. In addition, some areas have been investigated thoroughly but others have not. There are undoubtedly many more landslides than are recorded in the database.

9. Landslides involve the movement of large volumes of material in a relatively short time. Once movement has occurred, the normal erosion processes are slow and ineffective in

removing the evidence. As a result, landslides accumulate in the landscape. The survival time of landslide form and deposits and the shear surface on which movement took place is very long. They thus remain in the landscape as a hazard for perhaps thousands of years. The majority of inland landslides are a legacy of the past. New landslides do occur but, fortunately, they are rare. On the coast, a mixture of repeated first-time failures and pre-existing landslides occur.

10. Even landslides which occurred a long time ago, when environmental conditions may have been different than now, are still present as a potential hazard to development. Over time, the surface form may have all but disappeared due to erosion but the shear surface remains beneath the surface as a weak zone which may be reactivated easily by both natural and human interference.

11. Some present-day processes (eg weathering, coastal or river erosion, change in drainage patterns or change in groundwater regime due to abnormal or prolonged rainfall) can cause or contribute to landsliding, as they have done in the past. However, the main cause of slope instability over the last 100 years or so, especially in inland areas, has undoubtedly been the disturbance of ancient landslide areas by various human activities such as mining, highway construction and topographic reprofiling as a consequence of industrial and urban development.

12. Figure 2 illustrates the range of human influences on slope instability in the valleys of the South Wales coalfield. Whilst this example is specific to that area, many of the activities shown or similar ones take place elsewhere in Britain. The range of activities which may contribute to slope instability includes:-

- the placing of fills and other superimposed loads for construction purposes or the disposal of wastes;
- excavation, especially into old landslides, but also into slopes previously unaffected by landsliding;
- mineral extraction beneath slopes;
- leakage of water-retaining structures, including canals, reservoirs, ponds, swimming pools, water supply pipelines and sewers;
- uncontrolled disposal of water, including soakaways and the diversion of natural drainage courses; and
- changes in land use, such as deforestation or ploughing of grassland.

The effects of changing the distribution of loading on a slope and, especially, of changing the water regime are evident.

Strategies For Dealing With The Problems

13. A number of possible responses to the problems of slope instability, which have been used variously in other countries, are shown in Table 3. Whilst all may be appropriate in different circumstances, a strategy of controls on development and land use through the Building Regulations and the operation of the planning system is probably the most effective in Britain.

Building Regulations

14. Engineering controls tend to be specific to particular structures. They are designed to make them better able to withstand the effects of hazards. The Building Regulations 1991 specify in Requirement A2 of Schedule 1 that:-

> "The building shall be constructed so that ground movement caused by - ... landslip ... in so far as the risk can be reasonably foreseen, will not impair the stability of any part of the building."

15. However, these Regulations relate only to buildings and controlled services or fittings and some buildings are exempt. In addition, a wide range of development activities which may affect the stability of slopes, particularly by increasing the passage of water into the ground, may not require approval under the Building Regulations. Examples include the removal of trees, creation of hard-standing, terracing a site, creation of sports fields and facilities or swimming pools and storage of materials. It is also generally accepted that the regulations cannot be used to enforce maintenance of a property, however essential that may be for slope stability.

Figure 2. Some human influences on slope stability in the South Wales coalfield (after Halcrow, 1993)

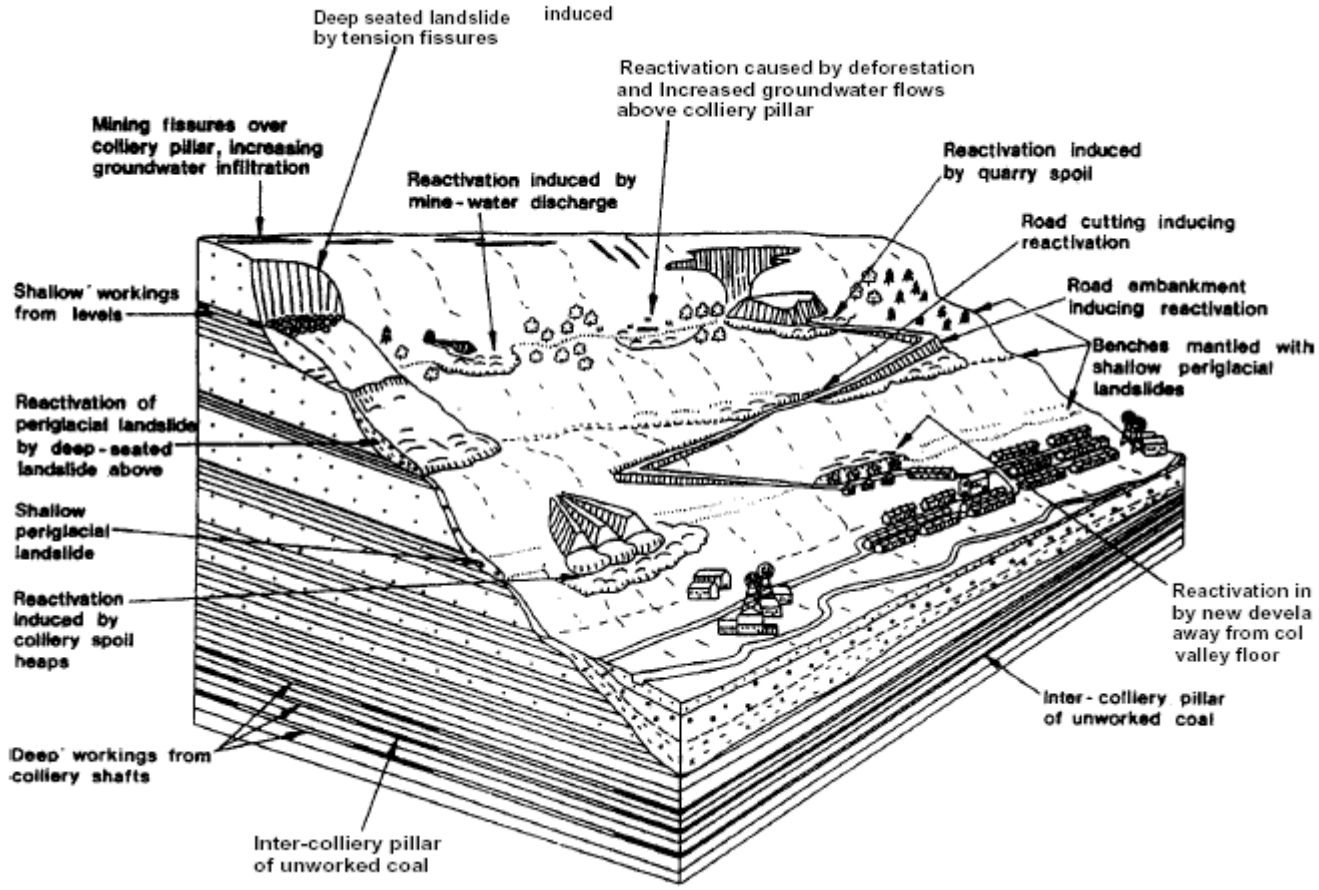

Table 3: Responses to problems of slope instability

Emergency Response And Crisis Management	*dealing with the problems only after they arise* - Planning for emergency procedures may be needed where development has already taken place without reference to the stability of slopes; this response involves avoidable costs and may be unacceptable where public safety is at risk.
Planning For Losses	*spreading the losses by insurance, statutory compensation or fiscal measures* - the risk of losses may need to be accepted where development has already occurred on unstable slopes; this response involves avoidable costs and may be unacceptable where public safety is at risk.
Modify The Hazard	*by prevention or correction* - slope stabilisation measures, rock fall protection structures, good practice in property maintenance and restrictions on certain engineering activities may help to prevent or reduce the losses arising from landsliding; this response may be justified where there is significant risk to public safety or buildings and structures; implementation may be constrained by economic or land ownership considerations.

Control The Effects	*by avoidance*: - the identification of landslides and the use of hazard assessment in planning control may enable the effects to be avoided altogether by not developing in landslide areas; *by engineering controls* - planning and building controls may enable losses to be avoided or reduced through design and construction measures.

16. Thus, whilst the consideration of landslip has been introduced into the Building Regulations since the publication of PPG 14, they do not cover all aspects relevant to slope stability. The situation remains, therefore, that the Building Regulations cannot be used as a safety net to ensure that slope stability issues are taken into account before development takes place. Planning responses are required, therefore, to ensure that adequate consideration is given to the issues of slope stability and landslides in considering development and the use of land.

Planning

17. Planning responses may be specific to individual developments or to wider areas of land. In some circumstances the planning repsonse may be to seek to divert development away from areas of hazard, ie an avoidance strategy, as indicated for certain coastal areas in PPG 14 and PPG 20. Whilst often the most cost-effective strategy, avoidance will not always be possible. The planning response must seek, therefore, to take due account of the hazard presented by unstable slopes to ensure that adequate precautionary or remedial measures are undertaken in an environmentally acceptable manner. This requires an improved understanding of landslide hazards and their identification for forward planning and to enable them to be considered fully when planning applications are determined.

The developer's responsibility

18. It is the responsibility of developers to ensure that their developments will not initiate instability or will not be affected by instability originating outside the area of a development. Developers should therefore seek appropriate technical and environmental expert advice about the likely consequences of proposed developments on sites where landsliding is known or may be reasonably foreseen. They should also procure any necessary investigations to ascertain that their sites are and will remain stable or can be made so as part of the development works. As well as being in the developer's interests, this information may be required by a local planning authority in determining an application for planning permission and, if building work is involved, to meet the requirements of the Building Regulations.

19. It is important that investigations are not limited to the development site. A site needs to be assessed in the context of surrounding areas where landsliding could threaten the development within its anticipated life or damage neighbouring land or property. This is essential since the feasibility of development may be severely curtailed where a site is threatened by landslides originating in neighbouring areas to which the developer has no right of access to carry out investigations or remedial measures or for which there are no cost-

effective engineering solutions. For these reasons, at least a preliminary assessment of slope stability should be carried out at the earliest possible stage before a detailed design is prepared. Only on the basis of such a geomorphological and engineering geological assessment, comprising a desk study of available information, including aerial photographs, and a ground inspection, can the need for further investigations to ascertain the true extent of the hazard and any necessity for precautionary or remedial measures be determined.

Go to table of contents

Planning Control

20. The planning system acts to control development in the public interest. "This Common Inheritance" (Cm 1200, September 1990) identified the maintenance of a physically safe environment as one of the priorities, which should be weighed in the public interest in determining policies for land use. The planning system should assist in ensuring that proper precautions are taken against the risks which might be posed by physical hazards. Since landsliding may threaten public safety, the built environment and economic activities, it is a material planning consideration. It should be considered as one of the factors in drawing up development plans as well as in decisions on planning applications.

1. Development Plans

21. PPG 14 (Paragraphs 25-30) outlines the approach that local planning authorities should follow in dealing with land instability issues in their development plans. It may be appropriate, where the relevant information is available, to identify any specific areas where particular consideration of landsliding or the potential for landsliding will be needed. This may be done using a constraints map or by narrative description within the local plan or in supplementary planning guidance.

22. Appendix 1A describes a step-by-step approach to landslide identification and hazard assessment. Two examples of more detailed assessments which have been developed in specific areas but which are likely to be more generally applicable are described. An appraisal by survey of the environmental value of landslide areas may also be needed to provide an information base for policy formulation.

23. Policies may be needed to control or restrict development in specific areas. Where slope instability cannot be overcome satisfactorily or where it provides other environmental benefits a presumption against development may be appropriate. In other areas, built development may not be appropriate unless adequate and environmentally acceptable slope stabilisation measures are included in the development proposal. PPG 20 and PPG 14 recommend the avoidance of eroding cliff lines.

24. Since even apparently minor development can, in certain circumstances, be the final factor which initiates landsliding, **consideration may need to be given in some circumstances to the use of Directions under articles 4 or 7 of the Permitted Development Order 1995 to control permitted development.** In areas of active landsliding, this could usefully complement an avoidance strategy, though it is not likely to be needed in more than a few limited situations.

25. Local Plan development proposals should ensure that land use is appropriate in the light of any known landslide risk. As well as the consideration needed for new development, where there are risks to existing development, proposals may include specific action on land stabilisation or coast protection to reduce those risks or to enable appropriate beneficial use of unstable slopes.

26. As indicated in PPG 14 (paragraph 27), **local plans should set out the criteria and information requirements which will be used in determining planning applications in**

areas of actual or potentially unstable slopes. These might include the situations and types of development for which a slope stability report would or would not normally be required (eg small developments, see paragraph 29 below) and the form and content of a slope stability report (see Appendix 1B). Although most authorities will not need to do so, where slope stability considerations are likely to be common in an area, it may be appropriate to prepare supplementary guidance notes for applicants (eg as in the Rhondda landslip potential study - Halcrow, 1993) or to amend the application form to include specific questions on slope stability.

2. Development Control

27. General guidance for the handling of individual applications for development on land which is known or suspected to be unstable or potentially unstable is given in PPG 14. Figure 3, which derives from the Ventnor study described in Appendix 1A outlines the general procedure. Figure 4, from the Rhondda study also described in Appendix 1A, illustrates the planning responses which may be appropriate depending on the perception of landslide risk. Particular attention is given here to the requirements for reporting of information to enable decisions to be taken which take due account of the potential for slope instability and to the need for liaison with the Building Regulations authority.

The slope stability report

28. Where there are grounds for believing that there is active or potential landsliding which would affect a proposed development reservations can be overcome in an environmentally acceptable manner. This may require the application to be accompanied by a slope stability report prepared by a competent person, which demonstrates that the site is stable or can be made so and will not be affected by or trigger landsliding beyond the boundaries of the site. Guidance on the preparation, content and format of slope stability reports is contained in Appendix 1B. Failure to satisfy the local planning authority on slope instability considerations may be grounds for refusing an application. Where recommendations are made for any remedial, preventive or precautionary measures, it may be appropriate for conditions specifying such measures to be attached to the planning permission.

29. It is recognised that a large proportion of planning applications are for minor extensions to existing buildings and for garages and for changes of use. Where such "small developments" are situated on potentially unstable slopes, as identified in the landslide assessment, they would normally require a slope stability report. Since these are largely situated adjacent to existing property and generally unlikely to pose a significant threat to slope stability, it may be appropriate, in considering an application for planning permission, for them not to be subject to this requirement provided that there is no evidence of current instability and that the site is not to be significantly disturbed, ie that:

- cuts and fills are limited in depth and any deep temporary excavations for surface or foul drains or other services are limited to short lengths across the slope;
- provision is made for free drainage of groundwater within the slope and for inspection and facility for future works for maintenance of flows;
- surface drainage is not restricted or diverted;

- drainage from the proposed development is collected and conveyed in flexible piped systems; and
- any existing retaining walls are not removed or altered.

However, the need to satisfy the Building Regulations that landsliding, in so far as it can reasonably be foreseen, shall not threaten the security of a building may require the submission of a slope stability report to the building control authority.

30. Whilst a local planning authority is entitled to rely on the expert advice provided by a developer in relation to slope instability, it is recommended that a check development is that of the developer, the decision on the planning merits may not require the local planning authority to check design assumptions and calculations. However, there will remain a need for the local authority or an approved inspector to check designs submitted for approval under the Building Regulations and the highways authority will need to approve any retaining structures close to a highway.

Figure 3: Procedures for review of planning applications with respect to land stability issues (after Geomorphological Services Ltd, 1991)

Figure 4: An example of the planning response options to the potential for landsliding (after Halcrow, 1993)

31. There are clear benefits to local planning authorities in maintaining indexed central records of slope stability reports. Their existence should be noted and made known on request to subsequent enquirers, who should be directed to the commissioners of the report for specific information.

Liaison with building control authority

32. Since landsliding is now clearly recognised as a material consideration under both the planning system and the building regulations, there are advantages in attempting to achieve a coordinated response between the two controlling authorities whether they are different departments of the same local authority or different authorities, eg county/district councils and approved inspectors under the Building Regulations. A common recording system of applications allows easy cross-reference.

33. Where consideration is given independently to a development proposal under the Town and Country Planning Acts and the Building Regulations, any requests for slope stability reports should be communicated to ensure that consideration is on a common basis. Slope stability reports submitted to one authority should be provided to the other, together with any drawings showing proposed remedial, preventive or precautionary measures. Both controlling authorities can thus draw on their relevant expertise and enable any necessary checks on compliance during inspections of the works.

Conclusions

34. The considered assessment of landslides and their consideration when determining planning applications will help to reduce the impact of undesirable consequences such as risks to public safety, property damage, avoidable costs to development, personal distress to those affected, degradation of the physical environment and loss of environmental resources.

35. The investigation and evaluation of slope stability here recommended is consistent with current good practice. It will thus not lead to additional costs to responsible developers and is likely to enable savings in avoidable costs which might arise if the investigation falls short of this standard.

36. The specific policies and practices to be adopted by local planning authorities are for them to decide in the light of circumstances pertaining within their area. It is recognised, however, that the identification and assessment of landslides recommended to assist in the implementation of PPG 14 is more detailed than previous common practice. There will, therefore, be resource implications for some local planning authorities. However, the incremental method of assessment which is recommended will enable these costs to be spread over a period of time. There is also a possibility of some compensatory savings over the long term in respect of the costs of local authority developments and the implications for local authorities arising from unforeseen landslide events.

Appendix 1A - Landslide Recognition And Hazard Assessment

1A1. Local planning authorities wishing to assess landsliding within their areas should use a step-by-step approach, adding further information and refinement as time and resources permit.

1A2. Of primary importance is the need to establish the extent and distribution of actual landslides within the plan area. For many authorities such a landslide inventory will provide sufficient information to determine where specific consideration of landsliding is needed. In rural areas, initial costs could be reduced further by concentrating efforts on identifying landslides in areas where movements could threaten settlements and infrastructure.

1A3. In some cases, dependent on the extent and nature of landsliding, a more deterministic approach which considers the factors contributing towards slope instability may be appropriate. The method used in the Rhondda valleys of South Wales is described below. Alternatively, where substantial existing development is affected by landsliding, the ground behaviour approach adopted at Ventnor, Isle of Wight, may be used.

1A4. A first step in preparing a landslide inventory is through the information collected as part of the DOE's Review of research on landsliding in Great Britain which is summarised in Figure 1. The national landslides database contains details of 8835 landslides recorded in the published literature and these are shown on county maps at 1:250,000 scale together with interpreted "possible areas of extensive ancient landsliding". Whilst the coverage of this database is far from comprehensive and it is on a smaller scale than is usually appropriate for planning purposes, it does provide a useful starting point.

1A5. Consultation of the original records from which the database was compiled may allow mapping at a scale more appropriate for planning. The geological maps at 1:10,000 and 1:50,000 scale produced by the British Geological Survey are an important source of information since they show foundered strata and landslips. The Survey also operates a commercially available Ground Hazards Assessment Service, which is based on the geological maps and other geological information held by the Survey. Further searches of eg local authority, highways authority, British Rail and British Waterways records and local press reports will often provide additional information on the location of landslides and the situations in which they have occurred. In coastal areas the information held by the Coastal Defence Groups and providing the basis for shoreline Management Plans should also be consulted.

1A6. The use of aerial photographic interpretation, supplemented as necessary by field inspection and reconnaissance geomorphological mapping has proved to be a highly effective and relatively cheap means of identifying the presence and defining the extent of landslides. This provides a further refinement of the landslide inventory which would in most cases provide sufficient information for policy formulation and implementation.

1A7. Slopes on stiff fissured clays which have been affected by periglacial solifluction (at around the end of the last glaciation some 10-13,000 years ago) are widespread in Britain, particularly in its southern parts. These are particularly hazardous as they are often smooth and featureless, thus revealing little under aerial photographic examination, and low-angled (typically between 12° and as little as 2-3°), hence suggesting an absence of stability

problems. However, because of the presence of numerous shear surfaces at residual strength and generally high groundwater levels, such slopes are easily reactivated by relatively modest cuts or fills and such failures in Britain lead to large unforeseen losses. The depths of such periglacial solifluction deposits are generally small (typically 1-3m) and any development brief on slopes where they are suspected should include provision for trial trenching. Relatively low angle slopes can also be subject to slow downhill creep of material and detailed mapping and/or trenching may be necessary to identify this hazard.

1A8. Consideration of the factors which contribute towards slope instability will also assist in refining the assessment of landslide hazard. Slope steepness is, perhaps, the most obvious and the easiest to determine and particular requirements according to the steepness of slopes may be appropriate in some circumstances, though this may not be straightforward, as indicated in paragraph 1A7. Other factors, such as the disposition and nature of both superficial and solid rock deposits and the importance of water in the slope may also need to be considered in particular circumstances.

1A9. The methods, described below were developed by DOE research to assess the potential for landsliding and to incorporate it in land use planning in the South Wales coalfield and at Ventnor, Isle of Wight. Whilst these methods were developed in the particular circumstances of the South Wales coalfield and a large coastal undercliff, they could be applied with suitable modification to other areas. However, most local planning authorities will not need to develop an assessment in this detail. 'The landslide inventory will be sufficient for their purposes, though a more detailed assessment could be considered when preparing a development brief for a particular site or area.

Landslip potential assessment: South Wales

1A10. A method of quantifying landslip potential for use by planners was developed initially in 60km^2 of the Rhondda valleys in the South Wales coalfield. It was subsequently extended to the whole of the administrative area of Rhondda Borough.

1Al l. The methodology involves the derivation of ratings which reflect the degree of association between landsliding and the physical attributes and composition of the landscape. Ratings for each attribute are then combined to define "landslip potential" as a number. Ranges of landslip potential are then portrayed on a map, at 1:10,000 scale, customised for use by the local planning authority. The basic mapping units used were regular 50m by 50m elements which permitted computerised methods of data storage, manipulation and plotting. The maps are based on a synthesis of geological, geomorphological geotechnical and hydrogeological data but are presented in a non-technical manner.

1A12. The initial step was to carry out a landslide inventory. Landslides were mapped from existing published sources of information and various archival sources. The main effort was concentrated on new mapping of landslides, both to confirm known boundaries and to locate previously unknown landslides. This was done using aerial photographic interpretation verified by field surveys. Landslides were classified according to their type and activity.

1A13. Factors which were considered to influence the location of landslides and for which existing data sources were capable of providing information are listed in Table 1A1. For each

factor, a map was produced showing variations in the attributes of that factor, by dividing the map into factor zones.

1A14. The analysis of the association between landslides and factors was based on a comparison of the relative areas of landsliding in factor zones and in the area as a whole. Analyses were carried out in two stages. Firstly, the location of known landslides in each factor zone was compared to their overall incidence in order to derive a rating for each factor zone. Secondly, the ratings were combined in various ways to define the landslip potential of each element.

1A15. Initially, the ratings for all the factors listed in Table 1A1 were used to derive an assessment of landslip potential. Further analysis indicated that factors with a small range of ratings could be omitted without adversely affecting the relative landslip potential of the elements. Various combinations of factors were then tried to promote an optimum correlation and it was found that a combination of slope angle, superficial deposit type, superficial deposit thickness and groundwater potential gave the best results for South Wales. Other factors may prove to be more important elsewhere according to the local conditions and landslide controls.

1A16. Four categories were defined initially by appropriate ranges of landslip potential, which represented the best fit between high values of landslip potential and landsliding whilst maintaining as large an area as possible in the lower two categories. Following testing of the likely impact of using the maps on existing procedures within the local planning authority, their final format portrays four zones:

- areas of active landsliding;
- areas of dormant landsliding;
- areas of some landslip potential corresponding to the two categories of greatest landslip potential initially defined; and
- areas of little or no landslip potential corresponding to the two categories of least landslip potential initially defined.

1A17. Prior to their use in the planning department of Rhondda Borough Council, a comprehensive legend was added which explains the methods used to prepare the maps and their limitations, explanations of each zone and the procedures for using the maps. A trial period in which the maps were used by the local planning authority has validated the procedures and presented few problems with their use. The maps continue to be in everyday use by the local planning authority.

Coastal landslip potential assessment - Ventnor, Isle of Wight

1A18. In the South Wales coalfield, the identification of landslides and potentially unstable areas enables them to be avoided by future development, or developed only if appropriate engineering measures are adopted. In contrast, the whole of the town of Ventnor lies within an ancient landslide complex. The problems relate to the control of the nature of development in parts of the town which may be susceptible to ground movement rather than being simply a

matter of identifying landslides. The Ventnor study aimed to develop a method of landslip potential assessment which was applicable to this situation and, more widely, to similar coastal problems.

1A19. The work undertaken involved a thorough review of available records, reports and documents followed by a programme of detailed field investigation comprising geomorphological and geological mapping, photogrammetric analysis, a survey of damage caused by ground movement, a land use survey and a review of local building practice.

1A20. A geomorphological map of Ventnor was produced which summarises the surface form of the landslide complex and the surrounding area. This map shows the relative positions of the main geomorphological units that occur in the area and identifies the nature and extent of individual landslide units.

Table 1A1: Basis for zonation of factor maps in landslip potential assessment : South Wales (after Halcrow, 1993)

Factor Name	Number Of Factor Zones	Basis Of Zonation
Slope aspect	9	Slopes defined by compass beating in 45° sectors and areas of no slope.
Slope angle	11	Portrayed in increasing 5° increments.
Lithostratigraphic units	10	Argillaceous, arenaceous, mixed lithologies and stratigraphic units.
Superficial deposit type	8	Glacial soils, alluvium, peat; residual soils and colluvium types assessed from primary mapping; location on slope and underlying lithologies.
Superficial deposit thickness	3	Thickness contours prepared from geomorphological considerations and many data sources.
Dip of bedrock versus ground slope	6	Dip direction of solid rock strata (derived map) compared with slope aspect.
Faulting	3	Proximity to fault and size of fault.
Groundwater-potential	6	Location of points of groundwater emergence, together with an evaluation of potential groundwater- catchments.
Erosion potential	3	Presence or absence of erosion and rivet--trained areas.
Mining strains	6	Severity of tensile strains from a total extraction (derived) map.
Mining tilt	6	Relationship of tilt direction (from total extraction map) to ground slope direction.
Excavation and	5	Types of activity and location.

filling		

1A21. Detailed knowledge of the size and frequency of ground movement events over the last 200 years and an understanding of the geomorphology allowed the production of a 1:2,500 scale map of ground behaviour. This summarises the nature and extent of the different landslide processes that occur in the area and their impact on the community. This understanding of landslide behaviour, together with a knowledge of the vulnerability of different types of construction and the property risk in different areas was used to formulate a range of outline management strategies designed to reduce the impact of future movements.

These strategies include:

- effective planning control to avoid unsuitable areas and to control the nature of development;
- modifying the hazard to the community by means of environmentally appropriate engineering works, coastal protection, improved building practice etc;
- improving the understanding of landslide behaviour;
- mitigating the costs of landsliding through insurance etc; and
- coordinating community responses to the problems.

1A22. A planning guidance map was produced at 1:2,500 scale which relates categories of ground behaviour to forward planning and development control. This map indicates the need for different areas of the landslide system to be treated in different ways for both policy formulation and development control. Areas are recognised which are likely to be suitable for development, along with areas which are either subject to significant constraints or mostly unsuitable. Advice was also provided on the level of stability information which should be presented with planning applications in different areas.

1A23. Following the publication of the Ventnor study in 1991, the local authority involved, South Wight Borough Council, has developed and is implementing a landslide management strategy which takes account of the recommendations from the study. This has included the extension of the landslip potential assessment from the original DOE study area to the remainder of the built-up area within the Ventnor Undercliff landslide complex. Whilst this has not prevented all problems in Ventnor, it has undoubtedly reduced and will continue to reduce the impact of landsliding on land use and development in the area.

Appendix 1B - The Slope Stability Report

1B1. A slope stability report maybe required to be submitted to the local planning authority before determining an application or to the building control authority.

1B2. In order to satisfy a local planning authority, slope stability reports should demonstrate:

- an adequate appreciation of ground and groundwater conditions and any other relevant factors influencing stability based on desk studies, aerial photographic interpretation, geomorphological and engineering geological mapping of the site and appropriate subsurface investigation, laboratory testing and monitoring where necessary; this appreciation must include a statement on whether or not the site or surrounding areas are affected by earlier landsliding or periglacial deposits and, if so, a definition of their extent in plan and section;
- that the site is stable and has an adequate margin of stability, or can be made so as part of the development works, for the foreseeable conditions which will operate at the site;
- that the site is not likely to be threatened or affected by reasonably foreseeable slope instability originating outside the boundaries; and
- that the development is not likely to result in slope instability which will affect either the development or nearby property.

1B3. Slope stability reports should be prepared by a "competent person" able to demonstrate relevant specialist experience in the assessment and evaluation of slope stability. A competent person would normally be expected to be a Corporate Member of a relevant professional institution such as the Institution of Civil Engineers or the Geological Society. In this context, a competent person would be a geotechnical specialist as defined by the Site Investigation Steering Group of the Institution of Civil Engineers.

1B4. To assist prospective developers in identifying a relevant specialist, they should be advised to consult the British Geotechnical Society's Geotechnical Directory, which lists 125 firms and gives details of 700 geotechnical practitioners operating in the United Kingdom.

1B5. The competent person should undertake such inspections and investigations as are considered necessary to allow an opinion to be made on the stability of the development and its surrounding area. Investigations should be designed and executed in accordance with relevant British Standard Codes of Practice, including:

- BS5930:1981 Site investigations;
- BS1377:1991 Parts 1-9 Methods of test for soils for civil engineering purposes;
- BS8002:1994 Earth retaining structures;
- BS6031:1981 Earthworks; and
- BS8004:1986 Foundations.

1B6. A desk study examination of relevant published and any available unpublished information and a site reconnaissance should be carried out to obtain general information about the siting of the proposed development, its relation to existing structures and services and other relevant ground and surface features. Detailed information on ground conditions should be recorded, including:

- the morphology of the area;
- the geological sequence and structure, with particular emphasis on superficial deposits and rockhead, including the dip and dip direction of larger rock masses;
- landslide features such as back scars, tension fissures and lateral shears and evidence of soil creep;
- seepage lines and wet areas which might indicate groundwater emergence;
- vegetation types indicative of a high water table or changes in soil type and condition;
- evidence of movement in existing structures and trees;
- evidence of past movement indicated by discrepancies between locations of features and field boundaries and those on past editions of Ordnance Survey maps or aerial photographs;
- evidence of movement due to mining or natural underground cavities; and
- evidence of previous changes to the structure of the site by infilling, man-made embankments or tips and cuttings eg for canals, reservoirs, roads, railways, quarries, mines etc.

IB7. A comprehensive desk study and field reconnaissance represents the minimum investigation which should be carried out by a competent person in order to prepare a slope stability report. Where an adequate margin of stability can reasonably be assured, these two operations may be sufficient to support an opinion on the stability of a site. However, the competent person would normally be expected to carry out or to procure appropriate subsurface investigations.

1B8. Specific requirements for the scope and content of a ground investigation depend on the individual characteristics of each site and the development proposed. They should therefore be designed with regard to:

- the extent and nature of the development;
- the location of any features indicative of slope instability within the site boundary and in surrounding areas where relevant;
- the consequences of failure;
- the sequence, structure and depth of soils and of underlying strata which have a bearing on stability;
- understanding the ground water conditions, eg the depth and fluctuations of the water table and the possible presence of potential aquifers or confining layers; and
- the requirements for analysis and evaluation of remedial measures.

1B9. It will be necessary to establish:

- the location in plan and section of any existing or potential zones of movement;
- water pressures within the slope and likely fluctuations in adverse conditions;
- representative engineering parameters of the materials within the slope on which stability calculations can be based; and
- the configuration of critical slopes by survey for subsequent stability calculations.

1B10. In preparing the slope stability report, the competent person should consider all the factors which might influence the stability of the site and its surrounding area in relation to its suitability for the proposed development. The report should therefore contain:

- a factual record of all investigations carried out;
- a description and engineering interpretation of relevant ground and groundwater conditions;
- an account of any stability calculations;
- conclusions on the stability of the site and the influence of the proposed development; and
- any recommendations for remedial, preventive and precautionary measures, site inspections and monitoring.

1B11. For ease of assessment by the local planning authority, there are advantages in slope stability reports being prepared to a standard format. A suggested structure and content of a slope stability report are contained in Table 1B1.

1B12. An essential element of the slope stability report is the opinion of the competent person on the stability of the slope. Where recommendations are made for any remedial, preventive or precautionary measures, it is in the developer's interests for the development proposals to be made available to the competent person before submission to the local planning authority. The competent person should countersign the plans only if satisfied that the recommendations made in the slope stability report have been incorporated into the design.

Table1B1: Reporting Requirements For a Slope Stability Report in Support of a Planning Application

Introduction	Describe for whom the work was done, the nature and scope of the investigation, its general location, its purpose and the period over which it was carried out.
Description Of Site History	Describe the site in detail based on observations made during desk studies, aetrial photograp hic interppeetation and site reconnaissance, referenced to plan of site showing national grid coordinates at 1:2,500 scale or larger. Describe history of the site and its environs, previous uses, proximity to man-made structures such as highway, railway, canal embankments/cuttings and evidence of previous landslide events.
Investigations	Refer to information consulted during desk study and list as appendix. Describe fieldwork with full records of boreholes, trial

	pits or other exploratory methods as appendix and their locations shown on a plan. Describe site tests and laboratory tests and methods with their results included.
Ground Conditions	Describe ground and groundwater conditions based on desk studies, aerial photographic interpretation, geomorphological and engineering geological reconnaissance and mapping of the site and appropriate subsurface investigation monitoring and laboratory testing. Interpret their relevance to the stability of the site and the surrounding area, illustrated as necessary by plans and sections. Items discussed should include: • Whether or not the site is affected by earlier landslides and/or periglacial deposits; • Geological sequence and structure of soils and rocks within the relevant area of the site; • Mining and its effects with respect to collapse of workings and potential groundwater drainage paths and the relevance of pillars and colliery boundaries; • Hydrogeology including springs, issues and wet areas related to geology and main aquifers and aquicludes identified, any influence of mining and results of any monitoring of water pressures; • Material properties of relevant soils and rocks with reference to summary tables and charts of any laboratory tests, including an assessment of the reliability of data.
Evaluation Of Stability	Evaluate the stability of the site and relevant adjacent area with respect to proposed development and the assessment of ground conditions. State methods of analysis and parameters used for any stability calculations and illustrate on cross-sections. The stability calculations should evaluate the existing situation and the impact of the development and any proposed stabilisation measures with particular attention to gradients of cut slopes and tills, drainage measures, retaining structures and failure mechanisms and design criteria applied.
Conclusions And Recommendations	Summarise main conclusions of the investigation and list recommendations to ensure long-term stability of the site, taking account of the anticipated life of the development, and in the short term whilst construction proceeds.
Appendices	It is essential that all information consulted during the desk study is listed, together with full records of boreholes, trial pits and other exploratory methods.
Signature Of Competent Person	The Competent Person should sign and and date the Slope Stability Report and indicate his/her professional qualifications.

Appendix 1C - References

Jones, D.K.C. and E.M. Lee, 1994.
Landsliding in Great Britain.
London, HMSO, 361pp. (ISBN 0 11 7525661)

Halcrow, Sir William, And Partners, 1993.
Rhondda landslip potential assessment Summary report.
Cardiff, Sir Wm Halcrow & Ptnrs, 67pp. (Available from Halcrows Cardiff office at 31-33 Newport Road, Cardiff CF2 IAB)

Geomorphological Services Ltd, 1991.
Coastal landslip potential assessment: Isle of Wight undercliff, Ventnor: Technical report.
Milton Keynes, Geomorphological Services Ltd, x + 68pp. (out of print)

Geomorphological Services Ltd, 1991.
Coastal landslip potential assessment : Isle of Wight undercliff, Ventnor . Technical annexes.
Report to Department of the Environment, 312pp. (open-file publication, may be consulted at DOE, London, by arrangement)

Geomorphological Services Ltd, 1991.
Ground movement in Ventnor, Isle of Wight - a summary of the study of landslide problems in Ventnor carried out for the Department of the Environment.
Milton Keynes, Geomorphological Services Ltd, vi + 68pp. (out of print)

Rendel Geotechnics, 1995.
The undercliff of the Isle of Wight: a review of ground behaviour.
Cross Publishing, 68pp. (available from Engineering & Technical Services Dept, Isle of Wight Council, County Hall, Newport, IOW P030 IUD)

Geomorphological Services Ltd, 1986/1987.
Review of research into landsliding in Great Britain.
Reports to the Department of the Environment, 14 volumes + county maps at 1:250,000 scale. (open-file publication, may be consulted at DOE, London, by arrangement)

Site Investigation Steering Group, 1993.
Without site investigation, ground is a hazard.
London, Thomas Telford, 45pp.