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A Holistic Methodology for the Mapping of Landslides in the Bath Area

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A Holistic Methodology for the Mapping of Landslides in the Bath Area

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Summary

This report describes the currently available data in the Bath area and a field reconnaissance visit, with reference to the remapping of the Foundered Strata on the Bath sheet 265. This was carried out in order to assess the best methods to use to differentiate between ground affected by cambering and landsliding from ground unaffected by either process.

The report provides an assessment of field and remote mapping techniques in order to provide a more accurate demarcation of the Foundered Strata on the Sheet as part of the BGS research programme; Integrated Geoscience Surveys, Southwest region.

The first part of the report introduces the project and gives a brief history of earlier geological reserch in the Bath area and the importance of geohazard mapping for the user community. The second part of the report assesses the amount of data currently held within NGRC, and the BGS Library and its usefulness in aiding the remapping of Foundered Strata.

The third and final part of the report outlines suggested methods for the remapping Foundered Strata, taking into account the inherent difficulties in mapping areas where the current landscape has been affected by a complex mixture of post-depositional processes.

1 Introduction

Understanding the evolution of complex landscapes, particularly where a complicated mix of cambering and landsliding have occurred, is crucial if we are to provide usable information on ground instability and hazard potential. The city of Bath is Britain's only World Heritage City and the countryside to the north and east is designated as an Area of Outstanding Natural Beauty (AONB). The distinctive landscape created, in part, by the geomorphology that the cambering and landslides define, juxtaposes conservation, heritage and geohazard issues. The area therefore warrants a significant effort to understand better the continuing evolution of this complex landscape.

On the current BGS 1:63 360-scale geological map of Bath (sheet 265) the term "Foundered Strata" was used over a large portion of the map face, due to the difficulty in differentiating landslipped ground from cambered ground and from ground unaffected by either slope process. Hawkins, (1971) explained the significance of the term "Foundered Strata" as originally being a response to the cartographic requirement of indicating solid formational boundaries below landslip. The apparent impracticability of showing such boundaries with any confidence beneath highly disturbed valley slopes led to the use of the term " Foundered Strata" symbolised by horizontal lines and a uniform colour. The term emphasised that the intensity of superficial disturbances on the slopes around Bath but precluded a distinction between landslipped and cambered ground and indicated that the mixture of deposits from the various rock formations could not be resolved into distinct units. Currently no information about the lithology or structural characteristics in areas currently classified as "Foundered Strata" are given on the map face which in areas of highly variable engineering and foundation conditions significantly reduces the use of the geological map to the end user community.

Difficulties exist because of a number of heavily wooded areas that obscure the true profile of the slopes and non-wooded areas that have been subjected to agricultural processes that have obscured the original geological features. Wooded areas represent about 15% of the total Foundered area. They typically have thick undergrowth, and mainly occupy the steeper slopes and escarpments. Hedgerows and wood boundaries often follow the edges of landslide features and geological boundaries, some being displaced by the landslide and or replanted by the farmer (Privett, 1980). A hedgerow for example often marks a landslide's backscar.

During the summer I visited the Bath area along with two Engineering geologists Pete Hobbs and Gareth Jenkins to examine the area categorised as "Foundered Strata" and to assess the possibilities of re-mapping the area in order to more accurately reflect the underlying geology and landslide deposits. This report outlines the results of this fieldwork, assesses the amount and quality of previous work carried out in the area and finally looks at other remote techniques not so far carried out in the Bath area. This will finally provide a methodology for the mapping of landslides in the Bath area.

2 Outline of the History of Earlier Geological Research

It is beyond the scope of this report to review the vast and varied literature that over several centuries has touched upon the geology of the Bath district. Significant contributions go back over four and a half centuries. The early years of the nineteenth century saw William Smith, develop his work on the Carboniferous, Triassic and Jurassic rocks that was to lay the foundations of modern stratigraphy and earn him the name of the "father of English geology".

Among the earliest recorded local geological observations were those by Leland between 1535 and 1545. He saw Lower Lias ammonites at Keynsham, which he described as "stones figured like serpents". John Aubrey (1625-1697), born at Easton Peirs near Malmesbury, made numerous observations on the geology of the country in and around Wiltshire. He also speculated on the origin of the Avon Gorge and recognised that fossils are the remains of extinct animals, he described the occurrence of the grey weathered sandstone boulders or sarsens which are scattered widely over west Wiltshire and the eastern Mendips. Glanvil, (1669) made the first description of the White and Blue Lias as well as gaining information on the Bath "Hot Springs"

William Smith was reported to have discovered the fundamental principles of stratigraphy whilst surveying the Somerset coal canal in 1792-95. He published the first geological map of the area in 1799, which extended for five miles around Bath, including the eastern side of Bristol and Somerset coalfield, the area around Corston and Newton St Loe in the Avon valley between Bath and Saltford.

In the same year heavy persistent rainfall resulted in landslides and mudflows on steep slopes in the Bath area (Phillips, 1844; Kellaway, 1968). Possibly one of Williams Smith's greatest achievements was to stabilise these landslides, which were threatening to destroy Combe Grove house in 1799 and 1800. Smith did this by driving a tunnel into the hillside and tapping the water issuing from the base of the Great Oolitic Limestone overlying Fullers Earth Clay. In this way he drained the slipped mass of limestone and clay on the steep slope below Combe Down, bring the slips to rest (Phillips, 1844). Many other investigations in the Bath area have highlighted the importance of landslides in the district (Cook, 1973, Chandler, 1976, Hawkins, 1977, Privett 1980, Forster, 1985).

In 1801, William Smith published his first geological map of England and Wales on which the geology of the Bath district is represented. This was followed by a five miles to one-inch map in 1815. The original one-inch geological survey published on old series sheets 14,19, 34 and 35 appeared in 1845, and show the main outlines of the stratigraphy and structure of the district as described in Volume 1 of the Memoirs of the Geological Survey (De La Beche, 1846). These were substantially revised and new editions published: sheet 35 in 1866 and 1872 and sheet 19 in 1873. A third edition of the sheet was published in 1899, incorporating information collected during the preparation of Prestwich's report to the Royal Coal Commission of 1871. An explanatory memoir by H. B. Woodward, entitled "The geology of the east Somerset and Bristol Coalfields" appeared in 1876.

The first edition of the Bristol and Gloucester regional guide was produced in 1935 which was the first official geological guide to the region (subsequently republished in 1948 and then again more recently in by Green, (1992). The Bath district was surveyed on six inch scale in 1944-8 and 1957-9 by Pensford D R A, Kellaway G A, Cave R, Welch F B A, Bullerwell W, and Green G W, the final 1:63 350-scale map published in 1965. Detailed work on the Bathonian strata of the Bath and Frome area was undertaken by Penn et al (1979) which provides a type description of the Fullers Earth sequence in the area. Wyatt re-mapped some of the "Foundered Strata" in 1985 as part of a Department of Environment study (Forster et al., 1987). This identified areas of cambered and landslipped strata and attempted to map the strata although this was not attempted beneath landslipped or cambered strata. In 1977 Bath city council prompted by the discovery of pathogenic Naegleria amoebae in its thermal water commissioned an intensive scientific and medical investigation of the hot springs the results of which were published in the “Hot Springs of Bath” edited by Kellaway, (1991).

Table 1. Middle and Lower Jurassic geological strata in the Bath area.

FORMATION	GROUP	SYSTEM
Forest Marble Formation	Great Oolite Group	Middle Jurassic
Chalfield Oolite Formation		
Fullers Earth Formation		
	Inferior Oolite Group	
Bridport Sand Formation	Lias Group	Lower Jurassic
Dyrham Formation		
Charmouth Mudstone Formation		
Blue Lias Formation		

The geology of the Bristol district by Kellaway G A and Welch R J published in 1993 covers the Bristol district special sheet, which includes the western part of the Bath sheet. In 1996 to 1997 part of the Western part of the Bath sheet was redrafted as digital maps at 1:10 000-scale as part of the Address Linked Geological Inventory (ALGI) project for Bristol and Bath. These maps were produced with minor amendments to the artificial geology and by incorporating Wyatt’s revised landslip line-work for ST76. The work was carried out by Farrant A and Strange P in 1995-1997.

3 Data currently available and its suitability for landslide Mapping

There is a large amount of data available for the Bath area. This includes Site Investigation reports (SI's), geotechnical surveys, borehole data and hydogeological reports etc. In this section I have attempted to highlight all the major data sets available and give recommendations as to the quality and suitability of this data to the mapping of landslides in the Bath area.

3.1 SITE INVESTIGATION REPORTS

There are 146 SI reports in the Bath area. These are all listed in Appendix 1. Of these there are several which have been commissioned to look at landslide stability:

16119	A4/A46 BATHEASTON/SWAINSWICK BYPASS	DEPARTMENT OF TRANSPORT	EXPLORATION ASSOCIATES LTD	ST76NE	1994
16132	A4/A46 BATHEASTON/SWAINSWICK BYPASS	DEPARTMENT OF TRANSPORT	SIR ALEXANDER GIBB AND PARTNERS	ST76NE	1983
16169	A4 BATHEASTON BYPASS	MINISTRY OF TRANSPORT	LE GRAND SUTCLIFF AND GELL LTD	ST76NE	1970
16323	A46 SLIPROAD NEAR SWAINWICK	SOMERSET COUNTY COUNCIL	FOUNDATION ENGINEERING LTD	ST76NE	1969
16324	A46 SLOPE STABILITY AT ASHCOOMBE WOOD, SWAINSWICK	SOMERSET COUNTY COUNCIL	FOUNDATION ENGINEERING LTD	ST76NE	1969
16336	SLIP AT HINTON HILL, HINTON CHARTERHOUSE	AVON COUNTY COUNCIL	SOMERSET COUNTY COUNCIL	ST75NE	1978
16389	A46 UPPER SWAINSWICK TO A420/A46 SWAINSWICK HILL	DEPARTMENT OF TRANSPORT/COUNTY OF AVON	EXPLORATION ASSOCIATES LTD	ST77SW	1983
16786	A363 SLIP ON TRUNK ROAD, SALLY-IN-THE-WOODS	SOMERSET COUNTY SURVEYOR	G.K.N. REINFORCEMENTS LTD	ST76SE	1959
16787	A363 STABILITY OF THE BATH TO TROWBRIDGE ROAD AT SALLY-IN-THE-WOODS	COUNTY OF AVON	SWIRL	ST76SE	1980
16873	LAND SLIP NEAR THE DRY ARCH, BATHAMPTON	SOMERSET COUNTY COUNCIL	STRUCTURAL SOILS LTD	ST76NE	1966
16907	COMBE HAY SLIP, BATH	AVON COUNTY COUNCIL	DR W.J. LARNACH	ST76SW	1981
21498	A46 SWAINSWICK HILL	COUNTY OF AVON	EXPLORATION ASSOCIATES (WARWICK) LIMITED	ST76NE	1977

Having read through these reports I would suggest that their use to mapping of landslides in the Bath area is variable.

The reports give a good indication of the type of sliding that is currently active at the moment. For example in SI 16324 it states that deep seated circular slides which could effect the full height of the slopes are not likely in the area due to the fact that the Lias clays have a greater shear strength that those of the drift deposits. SI 16324 goes on to state that shallow seated slides are possible if weather conditions were server enough to result in a rise in the groundwater table or if excavation into the hillside were to take place as the current slope angle is at 13^{o}, which is considered to be close to the angle of failure.

Nearly all of the reports cite the cause of landslip as the increase in pore pressure in the Fullers Earth Formation. In SI 16336 the increase in pore water pressure was caused by ground water seeping through the Great Oolite Formation, other reports site an increase in water seepage due to heavy rainfall as the most common cause of landsliding in the district e.g. SI 16323. It is also possible to use the reports to gauge the frequency of active sliding in the Bath area for example SI 16907 where it records the dates and severity of slipping on the A367.

An important set of SI investigations on the siting/construction of the A46 does contain valuable information, particularly SI 16120 that contains the geological interpretation. This includes groundwater studies and limits of landslides of direct importance to road construction. The work is of a detailed nature and is extremely informative as to the mechanism of landsliding in the area and to the composition of slope material.

However as with all SI reports they are limited to the area for which the report was commissioned. So in conclusion these reports offer a valuable insight into the history of landsliding in the Bath area. They contain a large amount of detailed information as to the mechanism of subsidence in the area and on its cause, but they cover only a limited part of the whole study area.

3.2 THE DEPARTMENT OF THE ENVIRONMENT'S THEMATIC PROJECT

In March 1984 the British Geological Survey commenced an environmental geological study of parts of west Wiltshire and southeast Avon for the Department of the Environment. The objective of this study was to collect the available geological data relevant to the area and to present them as a series of thematic maps accompanied by a descriptive report and a database/ archive of the data used. Wyatt carried out the remapping of part of the foundered strata area as part of this study.

The mapping managed to identify and differentiate between areas of cambered and landslipped ground but Wyatt did not identify stratigraphic boundaries through the landslide areas. This mapping took place over 6 weeks and was done by conventional feature mapping with auguring. The available aerial photography was poor and consequently was not used.

The project produced 14 themed maps. Those of relevance to the study of ground stability were: 1. solid lithostratigraphy, 2. drift deposits, 4. inferred distribution of Great Oolite limestone, 5. inferred distribution of Fullers Earth Formation 6. Ground water 7. Ground conditions in relation to groundwater 10. distribution of landslipped and cambered strata and 11. distribution of slope angles. The published report by Forster *et al.* 1985 goes through each of these maps in detail outlining the data sources used and their value to the planner or geotechnical engineer.

The original data is currently archived in NGRC in the miscellaneous report section. There are 4 box files containing information on water supply boreholes, photocopies of 1:10, 000-scale maps with corrections to some landslides, copies of correspondence to various geotechnical companies, SI reports, reports on the palaeontology and finally a whole box file contain mine planes from the Bath area.

This material should provide a valuable resource to work on the Bath area but it will require time to sort through the material.

3.3 BOREHOLE DATA BASE

Currently the BGS SOBI database contains 2922 borehole records within the Bath area. Most of the Boreholes are related to road improvements along the A4, A36 and A46 (Fig 1). There is a sporadic distribution of boreholes over the Foundered Strata see Fig 1, which will be valuable for deciphering the statagraphic sequence in the area. A list of boreholes greater than 20m for the Bath are listed in Appendix 2

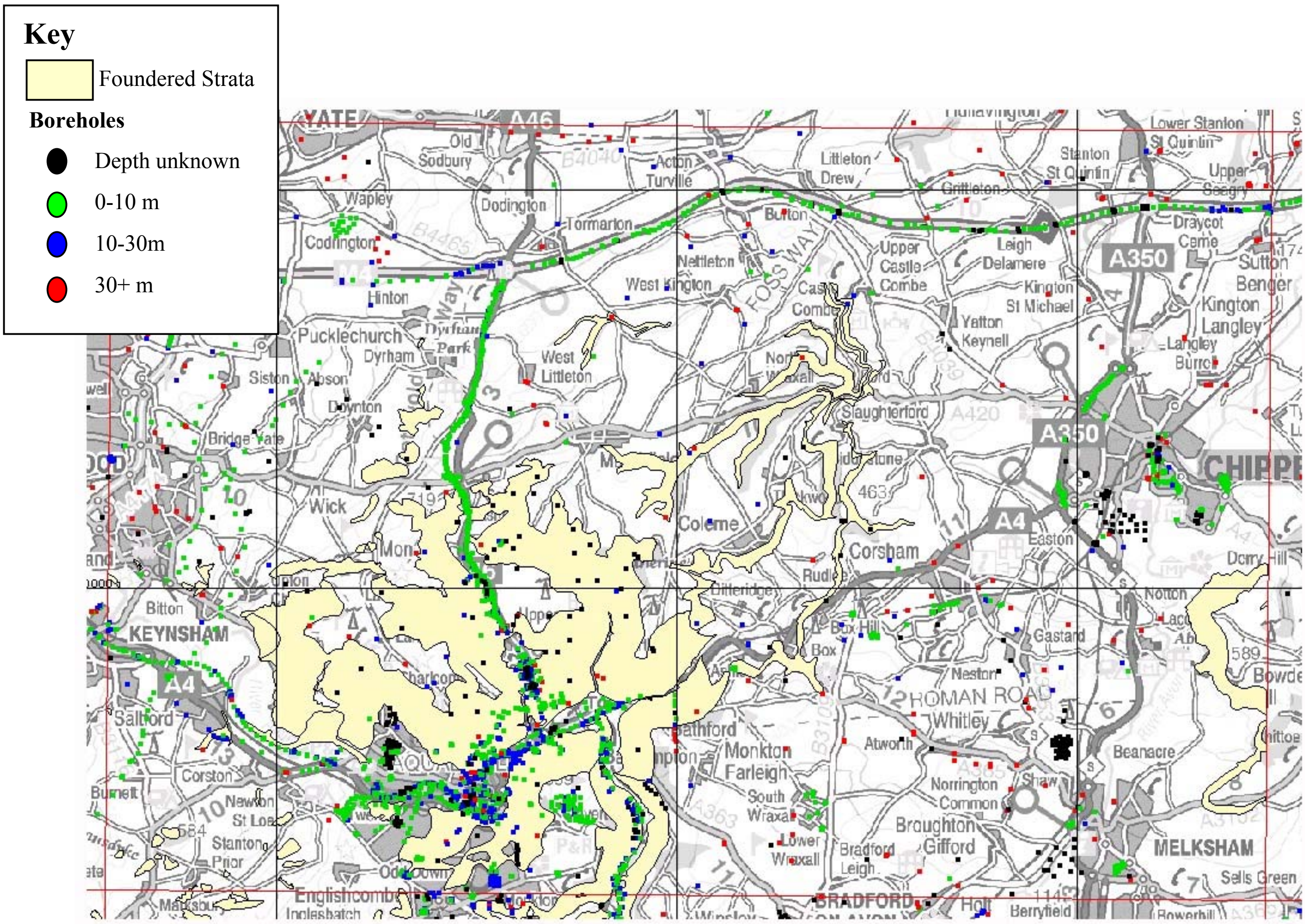

Figure 1: Diagram depicting the distribution of Boreholes in relation to Foundered ground in the Bath District

3.4 AERIAL PHOTOS

Currently there are 3 sets of aerial-photographs available for the Bath area. The first set is in black and white, at 1:10,000-scale flown in April/May 1975, the quality of these was reported as poor in Hobbs and Jenkins, 2002. There is also a colour set of photos that was flown in October 1997 at 1:25000-scale, these photos are of reasonable quality but the scale is not large enough to give the required detail. A final set of photographs were provided to the survey by Bath and Northeast Somerset council, these photos are in a digital format only and consequently apart from giving a good overview of the area within Bath and Northeast Somerset's domain are of limited use.

3.5 REPORTS AND ARTICLES

3.5.1 BGS Publications and Open File Reports

There are 17 survey articles currently listed on the library database relating to Bath, a complete list is placed in appendix 3. There are 9 reports that are considered to be of prime importance are listed below with the most significant listed first.

1. Reconnaissance survey of slope instability in the Bath area, Internal Report No. IR/02/146, P Hobbs and G Jenkins
2. Slope stability studies in the Avon Valley (Bath to Limpley Stoke), Institute of Geological Sciences, Engineering Geology Unit, Report 80/10, 1980 [3],55,6,[41] : ill,maps,5folded maps, P.R. Hobbs/ Hobbs, P.R.N.; Institute of Geological Sciences. Engineering Geology Unit. - (Unit Reports, Engineering Geology Series; WN/EG/80/10). - [504] Includes bibliography.
3. Geophysical survey to investigate the internal structure of gulls and cambered strata in the north Cotswolds: *British Geological Survey, Regional Geophysics Series, Technical Report* WK/99/13 Raines, M.G. Greenwood, P.G. and Morgan, D.J.R., 1999
4. Environmental geology maps of Bath and the surrounding area for engineers and planners, In: Planning and Engineering Geology, Geological Society Engineering Geology Special Publication No.4. Eds: Culshaw MG, Bell FG et al. 1987 pp 221-235, A. Forster, P.R.N. Hobbs, R.J Wyatt and D.C. Entwisle/ Forster, A.; Hobbs, P.R.N.; Wyatt, R.J.; Entwisle, D.C.
5. .A Brief Review of Remote Sensing and 3D Surface Modelling Applied to Urban Geoscience, *British Geological Survey Internal Report* IR/01/076. Jordan, C. J. 2001
6. Thermal imaging techniques to map ground disturbances in a former Nottinghamshire coal mining area. *British Geological Survey Internal Report, IR/02/007.* Ager, G. J., Gibson, A. D., Raines. M. G., Gunn, D. A., Marsh, S. H., Farrant. A R., Lowe. D. J. & Forster. A. 2002.
7. The Great Oolite of the Bath area, by G.W. Green and D.T. Donovan with a contribution on the fauna of the Corsham cutting by H.C. Ivimey-Cook/ Green, G.W.; Donovan, D.T.; Ivimey-Cook, H.C.. - London : HMSO, [1969]. - ; 63p,vileaves of plates, ill(2col.), map, 25cm. - [503] Reprinted from: Bulletin of the Geological Survey of Great Britain, no.30, 1969, p1-63 [514] Cover title.
8. Data review leading to a conceptual model of the hydrogeology of the Combe Down area, Bath, British Geological Survey, Hydrogeology Series, Technical Report WD/00/35, D.M.J.Macdonald, E.J.Whitehead & A.S.Butcher/ MacDonald, D.M.J.; Whitehead, E.J.; Butcher, A.S.; British Geological Survey. Hydrogeology Research Group; Bath & North East Somerset Council. - 2001. - iv,52p; ill.(col). - Report for Bath & North East Somerset Council
9. The Bathonian strata of the Bath-Frome area 2 The stratigraphy and correlation of the Bathonian strata in the Bath-Frome area, Report of the Institute of Geological Sciences no.78/22, 1978 - p.23-88, I.E.Penn & R.J.Wyatt/ Penn, I.E.; Wyatt, R.J.; Bate, R.H.; Coleman, B.E.; Medd, A.W.; Merriman, R.J.; Morgan, D.J.; Institute of Geological Sciences. - [508] Contributors: B.E.Coleman, R.H.Bate, A.W.Medd, R.J.Merriman and D.J.Morgan.

These reports give a good overview of the current work done on landslide research and Stratigraphy in the Bath area. They also give a good indication of the expertise within BGS that could be brought together to work on the project.

3.5.2 Books held at the BGS Keyworth Library

There are 22 books currently held in the BGS library on various aspects of the Geology of the Bath area these are listed in Appendix 3. In general the books although of interest are of limited use to landslide mapping. However, the two books listed below will provide useful information on the behaviour of the Fullers Earth Formation and the stratigraphy of the Great Oolite.

1. Clay mineralogy and plasticity of the Fuller's Earth formation Bath, U.K., Clay Minerals 21(3)1986 p293-310, A.B.Hawkins, M.S.Lawrence and K.D.Privett/ Hawkins, A.B.; Lawrence, M.S.; Privett, K.D.. - ISBN X780135376
2. The Great Oolite of the Bath area, by G.W. Green and D.T. Donovan with a contribution on the fauna of the Corsham cutting by H.C. Ivimey-Cook/ Green, G.W.; Donovan, D.T.; Ivimey-Cook, H.C.. - London : HMSO, [1969]. - ; 63p,vileaves of plates, ill(2col.), map, 25cm. - [503] Reprinted from: Bulletin of the Geological Survey of Great Britain, no.30, 1969, p1-63 [514] Cover title. - ISBN X78004818X

3.6 RECENT PUBLICATIONS

Below are listed 16 publications on landslide mapping that are of vital importance, not only do they indicate the current thinking on landslides they suggest the people most interested in collaboration with the Survey on the Bath project.

1. Anson, R. 1996**.** The study of an active landslide in the Swainswick Valley, North of Bath. P*hD Thesis, Bristol University, 46-14573*
2. Chandler, R. J., Kellaway, G. A., Skempton, A. W. and Wyatt, R. J. 1976**.** Valley slope sections in Jurassic strata near Bath, Somerset. *Philosophical Transactions of the Royal Society, London* A283, 527-556
3. Cook, D. A. 1973. Investigation of a landslip in the fullers earth clay, Lansdown, Bath. *Quaternary Journal of Engineering Geology*. 6, 233:240.
4. Jordan, C. J. 2001**.** A Brief Review of Remote Sensing and 3D Surface Modelling Applied to Urban Geoscience, *British Geological Survey Internal Report* IR/01/076. 16pp
5. Marsh, S. H. 2000. Remote mapping technologies for temperate, vegetated terrain. *Proceedings of the 14th International Conference on Applied Geological Remote Sensing*. .11-18
6. Petley, D.N., 2001. The use of terrain evaluation for hazard assessment in Eastern Taiwan. In Griffiths, J. (ed.) Land Surface Evaluation for Engineering Practice. Geological Society London, Engineering Geology Special Publications, 18, 209-213.
7. Petley, D.N., Bulmer, M.H. and Murphy, W. 2002 in press. Movement patterns in rotational and translational landslides. Geology 2002.
8. Privett, K.D. 1980. The engineering geology of slopes in the south Cotswolds, - *Thesis: University of Bristol, 1980*
9. Ramli, F., Petley, D.N., Murphy, W., and. Inkpen, R. 2000. The detection of relict landslides using Airborne Thematic Mapper Imagery. In Bromhead, E., Dixon, N. and Ibsen, M-L. Landslides In Research, Theory and Practice. Thomas Telford, London, 1269-1274.
10. Ramli, M. F., Petley, D.N., Murphy, W., and. Inkpen, R. 2002. Integration of high resolution thematic mapper and digital elevation model for landslide mapping. Proceedings of the Regional Symposium on Environmental and Natural Resources, Kuala Lumpur, 647-653.

11. Smith, G. M. & Milton, E. J. 1999. The use of the empirical line method to calibrate remotely sensed data to reflectance. *International Journal of Remote Sensing,* 20, 2653-2662.

12. Thomas, C. W., Gillespie, M. R., Golledge, N. R., Jordan, C. J. & Kirkbride, V. 2002. Understanding and communicating the landscape history of the Cairngorm Mountains in Scotland. *Proceedings of the RIA conference, Natural and Cultural Landscapes: The Geological Foundation*. Dublin, September 2002.

13. Tragheim, D. et al. 1999. Investigating internal structures in Jurassic Limestone of Southern England using digital photogrammetry ground probing radar, electrical resistivity imaging and multispectral ATM data. *Abstract 13th International Conference of Applied Remote Sensing.*

14. Whitworth, M., Murphy, W., Giles, D.P., and Petley, D.N., 2000. Archaeological evidence for recent slope movements, Broadway, UK. Geographical Journal, 166, 139-155.

15. Whitworth, M.C.Z., Giles, D.P., Murphy, W, and Petley, D.N. 2000. Spectral properties of active, suspended and relict landslides derived from Airborne Thematic Mapper imagery. In Bromhead, E., Dixon, N. and Ibsen, M-L. Landslides In Research, Theory and Practice. Thomas Telford, London, 1569-1574.

4 Recent Site Visits and Assessment of previous mapping

During the reconnaissance field visit no active landslides were observed. However, the visit took place during summer during a period of dry weather. It should be noted that on previous visits Pete Hobbs informed me that he had observed small-scale landsliding after heavy rainfall. The literature also suggests that the majority of reactivation has occurred during periods of high rainfall. The majority of the Landslides in the Bath area fall within 3 main areas:

- In the SE in the Avon valley between Limpley Stoke and Bathford
- In the NW in the region of Freezing Hill and Tog Hill
- In the NE and E in the Doncombe Brook valley and at Colerne and Box.

The site visit showed that there were discrepancies between what is observed on the ground and what Wyatt had recorded in 1985. In the Swainswick valley an area recorded as containing cambered strata was found to contain a variety of structures that could be identified by differing morphologies. These included non-rotational failures and solifluction lobes. However, the cambered nature of the ground was not immediately apparent and its delineation and determination would probably require detailed field surveying and section mapping.

Landslides in other areas such as Kelston Park [711 665] and west of North Stoke village [698 689] were wood covered leading to difficulties in demarcation of the landslides even if detailed field survey techniques were used. A typical view of both landslides and cambering in the Bath area is shown in fig 2. The photograph depicts clearly the typical problems found within the Foundered Strata, the slope is partially wooded obscuring much of the morphological detail, and further detail is lost due to land cultivation.

Figure 2: View of West Side of the Swainwick valley (Soper's Wood). Note shallow landslides upper left and middle right, camber uper far left. Photograph from IR/02/146

North of Lansdown Hill almost no landslide deposits are recorded. Where landslides had been recorded it was evident that the deposits extended far below the current mapped boundary, this was particularly evident on Tog Hill. It was also clear that in many locations, modern methods of cultivation had removed or partially covered features caused by post-depositional processes making them very difficult to record.

Beyond to the east of the main escarpment, to areas where the Fullers Earth outcrops in small valleys within the oolitic limestones plateau the valleys tend to be narrow and steep sided and there was an abundant evidence of instability in the form of lobes and hummocks. It should be possible to identify many of these from aerial photographs, as these valleys are often open grazing lands with limited tree cover.

Adrian Humpage in 2001 was asked to select sites for trial pitting in the Bath area. In written communication he suggests two sites on Tog Hill [725 730; 729 732] where the farmer had expressed a willingness to allow a JCB onto his land. He suggested that these sites would be suitable for detailed morphological mapping. Other areas such as Kelston Park were too steep for trial pitting. Adrian also looked at areas within the Fullers earth outcrops beyond the Jurassic escarpment between Tormarton [769 788] and Marshfield [780 740], and in the Blue Lias outcrop between Upton Cheyney [691 698] and Tracey Park [714 718]. He found that in the Fullers Earth outcrops trial pitting would not be possible as the spring line occurs at the boundary between the Fullers Earth beds and the overlying oolitic limestone, resulting in very wet and mechanically unstable slopes. One location was found in the Blue Lias outcrop at [699 705], however the site is not ideally situated, as there is a small limestone quarry at the downslope end of the field. This would suggest that the deposits at this location are likely to be thin and won't yield much useful information.

Table 2: Summary description of slope features

Cambering	Landslide	Condition
Great Oolite on Fullers earth clays. Discrete and limited extents, associated with rock fall and slide	Translational slides (rock and soil), topples, debris flows within Fullers Earth clays	Cambering and landsliding moderately well distinguish but often detail is lost due to tree cover. Erosion by springs
Inferior Oolite on Lias Clays. Extensive drapping and thinning downslope	Debris flows, mudflows, solidfluction, and head deposits thickening downslope, rotational slumps within the Inferior Oolite and Lias clays. Occasional large rotational slides in Lais caused by river erosion	Cambering and Landsliding poorly distinguished. Erosion by rivers and springs. Many surface features obscured by farming

In conclusion from my Site visit and from discussions with other colleagues there are major problems in a purely field mapping approach to the remapping of the foundered Strata in the Bath region. Even mapping carried out in the 1980's has not correctly identified nor differentiated between cambered and landslipped strata in the area. It is unlikely therefore with the limited time available for resurvey that remapping alone would provide the results required and that a more integrated approach is needed.

5 Methodology for Landslide mapping in Bath

Clearly there are and have been major difficulties in geological mapping mass movement deposits in the Bath area. Given the problems with conventional mapping techniques and the likelihood that there will not be the resources to solve this comprehensively i.e. by extensive sub-surface investigation a new approach is therefore required. It is also clear that the relationship between cambering and landsliding of the sub-stratum requires further research, which although beyond the scope of the mapping programme itself is a necessary part of the project if any attempt is to be made to differentiate between landslide and cambered ground.

5.1 SUMMARY OF REMAPPING OPTIONS

5.1.1 On the Ground Techniques

Approach	**Conventional field mapping techniques**
Method	Using standard Feature mapping methods predominantly using the differing morphologies and features to discriminate between cambered strata or landslide deposits. Hand augering to help with lithological interpretation.
Advantages	First hand observations taken
Disadvantages	Slow as requires detailed field-mapping, a suggested figure would be a maximum of $2Km^2$ mapped a day. The wooded nature of much of the area will make feature mapping difficult if not impossible in some areas. Access problems to some parts of the district is likely. Finally this technique requires a high level of expertise in mapping landslides and cambered ground. This is a relatively complex area therefore some level of training would be necessary for some of the team members, as it is unlikely that we would be able to compile a team of experience geologist this would add significantly to the time required to complete the exercise. Finally senior field geologists have previously struggled to differentiate between these deposits, it is therefore unlikely that this approach alone, even if a significant time in the field were budgeted for, could provide a better result that what has already been attempted.

Approach	**Slope Profiling**
Method	Walking over selected traverses with hand instruments
Advantages	Less time required than to completely re-map the Foundered Strata. First hand observations taken.
Disadvantages	The technique will again be slow to complete. If there is a continuum and interplay between the processes of landsliding and cambering it is unlikely that this technique would be able to consistently separate the two processes. Profiling across some of the more recent landslipped areas would require two people to conform to BGS health and safety procedures already in place. Access problems are likely to hamper

progress as discussed above, as will heavily wooded areas. Training will again be essential for non-experienced staff.

Approach	**Terrestrial Surveying**
Method 1	Global Positioning System (GPS)
Method 2	Total Station
Advantages	Provides a more accurate profile of the slopes. First hand observations taken
Disadvantages	The technique will be slow to complete as with all field techniques. Tree cover will make using GPS difficult but this will depend on how thick the tree canopy is at the time of profiling. Winter would be the best time to carry out this work when the tree canopy has fallen. If using the Total station technique would require a target, which may be difficult to set up. Interplay between the two processes will make interpretation of the profiles difficult.

Approach	**Sub-Surface**
Method 1	Drilling
Advantages	Provides first hand observations and would allow stratigraphic detail to be gained from beneath the landslides
Disadvantages	This is an extremely slow process and is also very expensive. Access is very likely to be a problem. It will also be difficult to find suitable sites to drill as the ground is very steep in parts, often water logged and unstable.
Method 2	Trail Pitting
Advantages	Large and small-scale features can be determined by first hand observation. Details such as, what each deposit is made up of, what are their textures and fabrics, what are their significant physical properties, how may they be distinguished from each other can be easily determined.
Disadvantages	Can often be slow, difficult to get permission to access land. Too expensive to get extensive coverage over all landslipped deposits, specific sites would have to be identified. Safety will be a problem as the slopes are steep and often water logged. Trial pitting would require a minim of two geologists and a JCB driver to do the work. Boarding up of the pits may also be necessary in this type of ground.

Method 3	Window sampling
Advantages	The equipment is towable and samples are obtained
Disadvantages	As with other techniques above the process is very slow. There is likely to be access problems as the technique is very noisy and motorised. Waterlogged soils and steep slopes will probably mean that access to some areas will be prohibitive.

Method 4	Geophysics
Advantages	A major advantage compared to the techniques above is that the process is non invasive and the equipment is largely portable.
Disadvantages	It is extremely slow and there is no guarantee that the technique will provide useful results. Access to farmland may again prove to be problematic and there is no ground truthing or sampling done.

5.1.2 Remote (field) techniques

Approach	**Terrestrial surveying**

Method 1	Laser scanning
Advantages	This technique will produce slope profiles very rapidly and with few access problems are likely
Disadvantages	Laser scanning does have range limitations this may reduce its effectiveness in some areas. Tree cover of many of the steepest slopes will mean that there will be areas where laser scanning could not be used. Ground truthing is not done as routine.

Method 2	Reflectorless total station
Advantages	Very accurate and again produce slope profiles with few access problems.
Disadvantages	The technique is very slow and will have range limitations as with Laser scanning. Its major limitation is its unsuitability in tree covered areas.

5.1.3 Remote (aerial) techniques

Approach	**Remote sensing**

Method 1	Stereo aerial photos
Advantages	Aerial photographs taken at the 1:2000-scale with a resolution of 10cm will provide detail necessary to aide in the delineation of landslide deposits. This type of resolution has been used successfully by the

highways Agency (Pers. comm. Matthew Willis, ARUP). The interpretation of the data is likely to be quick.

Disadvantages Current aerial photographs held by BGS does not provide the resolution required to pick out anything other than the larger morphological features. The cost of obtaining photographs at the required resolution is currently prohibitive. Trees cover a significant proportion of the district and therefore aerial photographs are of no us in these areas.

Method 2 LiDAR, ATM, IR

Advantages The high x, y and z resolution of LiDAR data can be used to distinguish landforms which lie within the range 10cm to 500m in scale. Ground height data measured by the Optech instrument enables penetration of the forestry that covers part of the study area for the first time, providing a clear advance over aerial photography and the derivative products such as DEMs that can be produced using digital photogrammetry. Because the LiDAR data are digital, we can apply the visualisation techniques which are being developed in house to model and understand geology and landform (Jordan, 2001; Marsh et al., 2000; Thomas et al., 2002).

Using The Airborne Thematic Mapper (ATM), by applying the thermal band it is possible to understand the distribution of the sediments and soils based on their likely variation in thermal properties. The thermal band should enable related characteristics of the sediments such as moisture content to be inferred via their thermal properties, even below a cover of grass. This would make it possible to link morphology to texture in the landform analysis and therefore to define for the first time a direct correlation between, for example, the clay content and cambering. This could potentially illuminate where and why cambering occurs, enabling a classification of the landforms and their effects on the landscape both locally and throughout the region.

Using ATM daytime acquisition of the visible, near and short-wave infrared channels of the ATM sensor to characterise the surface materials in two ways. These data will help geologists to gauge the ‘texture’ of the deposits either when directly exposed through ploughing or via their effects on surface vegetation. They could also be used to attempt to differentiate clay and carbonate minerals where they are exposed based on spectral contrasts and thus supplement the information provided by the thermal band. These are the only methods that would provide this type of data to the geologist.

Disadvantages Unless LiDAR and ATM data can be obtained through the NERC Airborne Remote Sensing facility (ARSF). This type of data is not financially viable without the use of NERC-ARSF, for example the EA’s own LiDAR data costs around £250 per $1km^2$. There is also no first hand observation of the landform.

Approach **3D-modelling**

Method Digital Elevation Model

Advantages Subtle changes in the slope morphology across the area of study will provide us with clues to the evolution of the landscape in the Bath area. This will be very fast and accurate.

Disadvantages In order to get an accurate detailed DTM of the Bath area it will be necessary to use LiDAR with its ability to "see through trees" and to produce the fine scale DTM necessary to show up some of the very subtle changes in slope.

5.1.4 Recommendations

It is clear that no single option above used in isolation would provide all the answers to the problem of landslide mapping in the Bath area. An integrated approach would therefore have distinct advantages. Moreover this is the only way to provide an answer to the longstanding problems with the Bath 1:50 000-scale sheet.

The availability of aircraft-borne sensors such as Light Detection and Ranging LiDAR, Airborne Thematic Mapper (ATM) infrared photography may be applicable if accessed through NERC. With this in mind an application to NERC-ARSF has been made a copy of the full application is in Appendix 4 (see fig 3 for proposed area of study). This application has successfully qualified for flight time and we are now awaiting further information from the ARSF board. Negotiations are also underway to secure a quid-pro-quo agreement with the EA agency for use of their LiDAR data. The EA LiDAR data will give us will give us coverage of the Northern part of the Jurassic escarpment.

The project will benefit from collaboration with the Urban Geoscience and Hazards Programme. This Programme has been tasked with developing a method of assessing and classifying land instability. They will need to test their proposed field recording system currently being developed, Bath would be an ideal location to do this (Appendix 5 contains a copy of the landslide data base field Notebook Pro-forma).

It is also recommended that the project look into collaboration with Leeds and Plymouth Universities who could be tasked with collecting some samples or conducting site investigations. This will provide the project with a way of gaining geoscientists with relevant expertise at a low overall cost to the project. Plymouth University for example have currently been working in the Broadway area just to the north of the current study area in collaboration with Andy Gibbson.

Finally it will not be possible to fully or successfully differentiate between landslipped ground from cambered ground and from ground unaffected by either slope process without first being able to understand the relationships between these two slope processes and to appreciate how these complex landscapes evolved. It is therefore strongly recommended that no detailed fieldwork is carried out until a full assessment is made of all the remote sensing data to be collected and all information contained with SI reports and the borehole records is assessed.

5.2 SUGGESTED METHODOLOGY

5.2.1 Aims and Objectives of the Study

The overall aim of this project is to provide a means of mapping more comprehensively the Foundered Strata in the Bath area for the new 1:50 000-scale geological map sheet. In order to do this effectively we must also aim to increase our understanding of landscape evolution in this geologically and geomorphologically complex area by developing an improved method of mapping and assessing hazard potential based on a 3D-landscape model.

This can be achieved through four main objectives; by understanding the relationship between cambering and landsliding using LiDAR and ATM remote sensing techniques in combination with on the ground field checking, by Analysing soil composition and distribution using spectral and thermal approaches, by developing a 3D landscape model of the Bath area and finally by developing an automated system of feature mapping techniques for areas which have undergone a complex history of landscape evolution.

Figure 3: Proposed area for LiDAR data collection

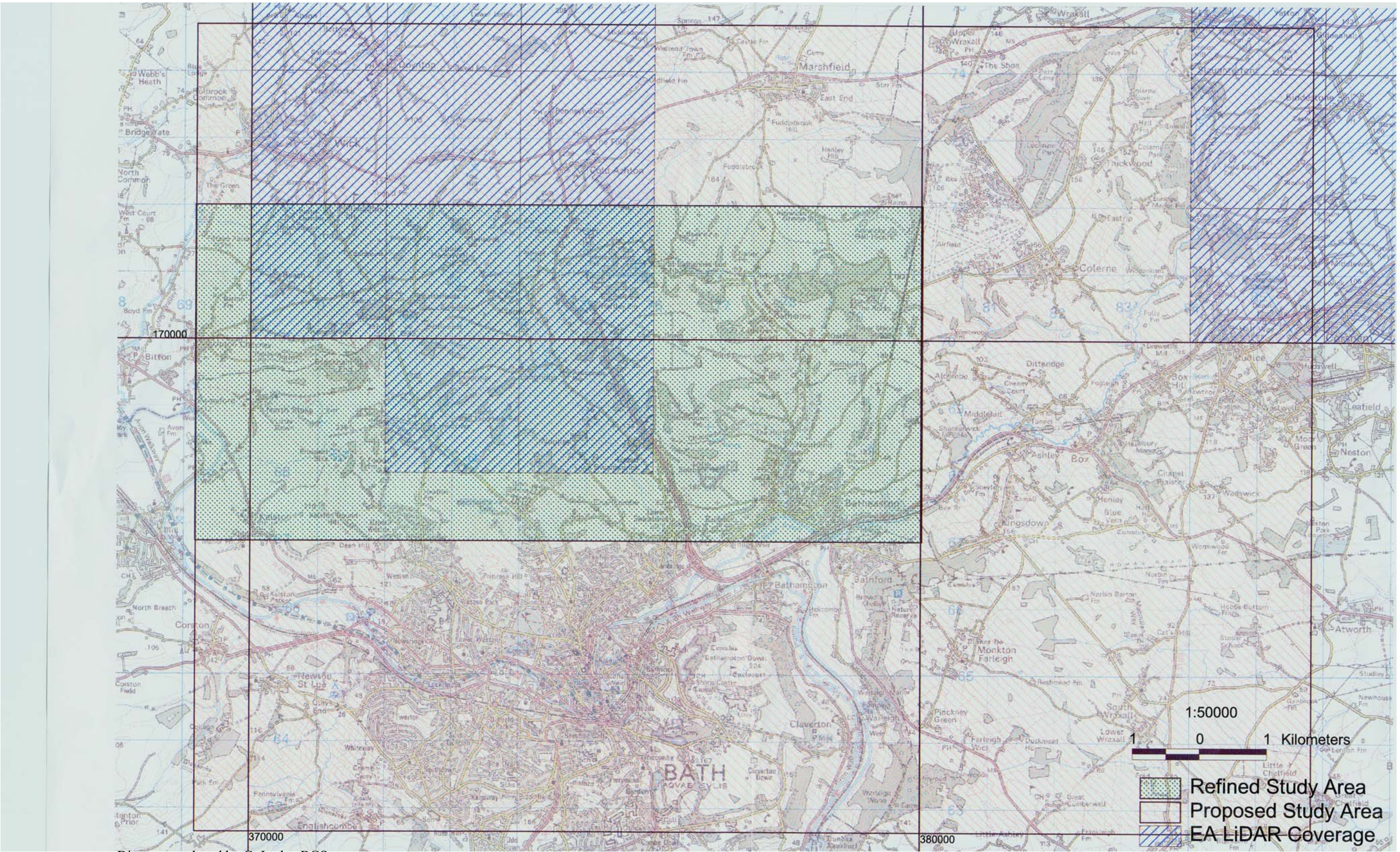

Diagram produced by C. Jordan BGS

5.2.2 Understanding the relationship between cambering and landsliding

Using LiDAR and ATM we will be able to delineate areas of landsliding and cambering (fig 3). Using their morphologies, textures and orientations, we will be able to classify and date the processes chronologically as they occurred. This will allow us to understand the temporal relationship between cambering and landsliding and hence the evolution of the landscape in the Bath area.

The combination of the ATM and LiDAR data is critical in helping develop our understanding of these landforms and thus in assessing their impact on society. The integrated analysis of these data sets would help to answer key science questions through:

- Slope analyses – to determine if the clays, known to be associated with cambering, occur within a certain range of slope angles. If this is so it would lead to a new understanding of their interrelationship and help predict the geotechnical properties associated with certain landforms.
- Anaglyph visualisations and stereo interpretations of the ATM data (developed using the LiDAR DEM) would help the geoscientists understand the landscape evolution and provide an arresting way to convey that knowledge to the wider community.

Cambering within the limestones must be closely associated with landsliding in the Bath area however neither tension cracks nor gullying have been observed in the field (Hobbs and Jenkins, 2002). These features are likely to have produced significant underground voids. Previous remote sensing work by Tragheim et al, (1999) and Rains *et al.* (1999) has shown that gulls and cambering can be picked out using aerial photographs and airborne thematic mapper multispectral data at 2m ground resolution because of topographical, mineralogical and moisture contrasts associated with them.

This should then be backed up with a full assessment of the various SI reports and boreholes followed by field visits to key locations highlighted in the remote sensing work. This should focus the ground truthing techniques to areas where there are specific problems that can only be resolved using this methodology. This should therefore reduce the staff time and cost to the project. It is hoped that this will also make it possible to use highly qualified staff which it is felt are essential if this complex relationship is to be understood.

5.2.3 Analysing soil composition and distribution using spectral and thermal approaches

To obtain maximum benefit from the remote sensing imagery, it will be useful to carry out a calibration of the radiance data provided with absolute reflectance value. This will ensure that any image analysis methodologies derived during this research are useable elsewhere in space and time and will enable the direct comparison of the results with similarly converted results. A number of spectrally stable targets have been identified, with a variety of surfaces including tarmac, building stone and relatively stable golf course bunkers. Field measurements of these properties will be taken using an appropriate field spectrometer. This will not allow for the perfect calibration of the airborne data but it will transform the data from a single, one-off flight into a more useful 'baseline' data set. It will also assist in the spectral and thermal analysis of clay and carbonate minerals and moisture contrasts in the soils associated with the cambered strata.

It is envisaged that this work could be completed through University Collaboration with Plymouth University. This will allow the project to be able to undertake a detailed analysis which otherwise it would not have time to carry out.

5.2.4 A 3D landscape model of the Bath area.

Subtle changes in the slope morphology across the area of study will provide us with clues to the evolution of the landscape. The use of LiDAR with its ability to “see through trees” will provide us with the first ever-accurate DTM of the Bath area so that they can be accurately surveyed. Together with the ATM data on soil moisture and mineral content this will allow a detailed, 3D-landscape model of the area to be produced. We will also use the new-accurate DTM to drape the aerial photographs of the area over. This will aid interpretation and give the geologists a better overall assessment of the geomorphology within the context of the geology and soils. This will ultimately allow the geologist to pick a hand full of locations that require fieldwork

5.2.5 Automating feature mapping techniques in areas of complex landscape evolution

It is becoming increasingly necessary to develop a methodology for the understanding of landscapes in areas where the original morphology has been obscured by post-depositional processes. Bath is not unique in the British Isles there are many other areas where complex histories of post-depositional processes have taken place. For example there are several areas on the Wellington Sheet 311 (currently being resurveyed) which would warrant a similar study as accurate delineation of landslides whilst in the field is prevented due to tree cover and recent agriculture processes, which have obscured the original geological and geomorphological features.

The landscape model created for Bath can be used to understand landform and then develop automated geomorphological feature extraction by applying image analysis and GIS tools to the 3D model. This can then be combined with traditional field surveying techniques to give an holistic approach to mapping post-depositional deposits.

5.3 OUTPUTS AND RESULTS

If this methodology is adopted not only will we be able to improve the mapping of landslide deposits in the Bath 1:50 000-scale geological map sheet 265 but also develop a methodology for the mapping of areas that have undergone a complex history of post-depositional processes.

I believe that in consultation with Leeds and Plymouth University we will be able to help set-up a national classification of mass-movement / landslide morphology and hence contribute to wider geohazard surveying within the UK.

We will also be able to contribute significantly to landslide research particularly with the proposed innovative approach to using LiDAR and ATM data.

Finally we will be able to contribute significantly to the population of the national landslide database with data that will not be obtainable using conventional field mapping techniques.

Appendix 1 Site Investigation reports available in the Bath area

SI No.	Report title	Commissioning Authority	Contractor	Quarter sheet	Year
8165	AVONCLIFF AQUEDUCT TO BRADFORD UPON AVON LOCK KENNET AND AVON CANAL	BRITISH WATERWAYS BOARD	NORWEST HOLST SOIL ENGINEERING	ST85NW	1990
16038	A36 CLAVERTON VILLAGE	COUNTY OF AVON	EXPLORATION ASSOCIATES LTD	ST76SE	1976
16077	BRISTOL ROAD, RADSTOCK	COUNTY OF AVON	EXPLORATION ASSOCIATES LTD	ST65NE	1977
16119	A4/A46 BATHEASTON/SWAINSWICK BYPASS	DEPARTMENT OF TRANSPORT	EXPLORATION ASSOCIATES LTD	ST76NE	1994
16132	A4/A46 BATHEASTON/SWAINSWICK BYPASS	DEPARTMENT OF TRANSPORT	SIR ALEXANDER GIBB AND PARTNERS	ST76NE	1983
16169	A4 BATHEASTON BYPASS	MINISTRY OF TRANSPORT	LE GRAND SUTCLIFF AND GELL LTD	ST76NE	1970
16170	BATH VEHICULAR TUNNEL APPROACH ROADS	CITY AND COUNTY BOROUGH OF BATH	FOUNDATION ENGINEERING LTD	ST76NW	1972
16199	SALTFORD BYPASS (SECTION 2 WORKS)	SOUTH WESTERN ROAD CONSTRUCTION UNIT	TARMAC CONSTRUCTION LTD	ST66NE	1972
16200	SALTFORD BYPASS FINAL SOIL SURVEY	SOUTH WESTERN ROAD CONSTRUCTION UNIT	TARMAC CONSTRUCTION LTD	ST66NE	1972
16201	SALTFORD BYPASS (PRELIMINARY SURVEY)	SOUTH WESTERN ROAD CONSTRUCTION UNIT	LE GRAND SUTCLIFF AND GELL LTD	ST66NE	1970
16211	A46 LINK BATHEASTON BYPASS	SOUTH WESTERN ROAD CONSTRUCTION UNIT	FOUNDATION ENGINEERING LTD	ST76NE	1974
16320	A363 BATHFORD - PROPOSED FOOTBRIDGE	AVON COUNTY COUNCIL	SOMERSET COUNTY COUNCIL	ST76NE	1977
16321	RETAINING WALL, MOUNT ROAD, BATH	AVON COUNTY COUNCIL	SOMERSET COUNTY COUNCIL	ST76NE	1977
16322	A36 WIDENING AT BATHAMPTON	SOMERSET COUNTY COUNCIL	COULSON	ST76NE	1971
16323	A46 SLIPROAD NEAR SWAINWICK	SOMERSET COUNTY COUNCIL	FOUNDATION ENGINEERING LTD	ST76NE	1969
16324	A46 SLOPE STABILITY AT ASHCOOMBE WOOD, SWAINSWICK	SOMERSET COUNTY COUNCIL	FOUNDATION ENGINEERING LTD	ST76NE	1969
16330	WINIFRED LANE, BATH		GEO-TESTING SERVICES LTD	ST76NW	1972
16333	WRITHLINGTON BRIDGE, NEAR RADSTOCK	AVON COUNTY COUNCIL	SOMERSET COUNTY COUNCIL	ST75NW	1978
16334	WINDSOR BRIDGE, BATH	COUNTY OF AVON	STRATA SURVEYS LTD	ST76NW	1975
16335	CAM VALLEY SEWAGE TREATMENT WORKS, PEASEDOWN ST. JOHN, AVON	WESSEX WATER AUTHORITY	C.J. ASSOCIATES	ST75NW	1977
16336	SLIP AT HINTON HILL, HINTON CHARTERHOUSE	AVON COUNTY COUNCIL	SOMERSET COUNTY COUNCIL	ST75NE	1978
16337	S.W. GAS PIPELINE, A36 ROAD CROSSING AND RAIL CROSSING AT WESTBURY	SOUTH WEST GAS	NORWEST HOLST SOIL ENGINEERING LTD	ST75NE	1986
16338	PROPOSED VEHICULAR UNDERPASS, BATH	CITY OF BATH	GEORGE WIMPEY AND CO. LTD	ST76NW	1968

16339	A4-A36 LINK AT WINDSOR BRIDGE, BATH	COUNTY OF AVON	SWIRL	ST76NW	1977
16340	FORMER CATTLE MARKET SITE, BATH ROAD, KEYNSHAM		MCCARTHY AND STONE DEVELOPMENTS	ST66NE	1985
16389	A46 UPPER SWAINSWICK TO A420/A46 SWAINSWICK HILL	DEPARTMENT OF TRANSPORT/COUNTY OF AVON	EXPLORATION ASSOCIATES LTD	ST77SW	1983
16393	CAMERTON BRIDGE, CAMERTON, AVON	COUNTY OF AVON	C.J. ASSOCIATES	ST65NE	1976
16394	STONEAGE BRIDGE, CARLINGCOTT	AVON COUNTY COUNCIL	SOMERSET COUNTY COUNCIL	ST65NE	1978
16395	RADSTOCK TELEPHONE EXCHANGE	DEPARTMENT OF THE ENVIRONMENT/PSA	FOUNDATION AND GROUND ENGINEERING SECTION	ST65NE	1973
16587	COLERNE AZIMGHUR BARRACKS	DEPARTMENT OF THE ENVIRONMENT/PROPERTY SERVICES AGENCY	BEAVER ENGINEERING LABORATORIES	ST87SW	1988
16647	GAGES ROAD, KINGSWOOD, BRISTOL - PROPOSED HOUSING DEVELOPMENT	BRYANT HOMES LTD	EDWARD J WILSON	ST67SE	1988
16761	KENNET AND AVON CANAL. CLAVERTON BRIDGE TO BATHAMPTON BRIDGE	BRITISH WATERWAYS CENTRAL ENGINEERING	NORWEST HOLST SOIL ENGINEERING LTD	ST76NE	1991
16780	KENNET AND AVON CANAL DUNDAS AQUEDUCT TO CLAVERTON BRIDGE NEAR BATH, AVON. VOLUME 1	BRITISH WATERWAYS	SOIL MECHANICS LTD	ST76SE	1991
16783	A36 LIMPLEY STOKE	COUNTY OF AVON	EXPLORATION ASSOCIATES LTD	ST76SE	1977
16784	A36 LIMPLEY STOKE HILL SUPPORT WORKS	THE COUNTY COUNCIL OF AVON	EXPLORATION ASSOCIATES LTD/C.J. ASSOCIATES	ST76SE	1983
16785	RALPH ALLEN DRIVE, BATH, AVON	COUNTY OF AVON	C.J. ASSOCIATES	ST76SE	1976
16786	A363 SLIP ON TRUNK ROAD, SALLY-IN-THE-WOODS	SOMERSET COUNTY SURVEYOR	G.K.N. REINFORCEMENTS LTD	ST76SE	1959
16787	A363 STABILITY OF THE BATH TO TROWBRIDGE ROAD AT SALLY-IN-THE-WOODS	COUNTY OF AVON	SWIRL	ST76SE	1980
16788	TUCKINGMILL OBSERVATION BOREHOLE	BATH CITY COUNCIL	BATH CITY COUNCIL/BRITISH GEOLOGICAL SURVEY	ST76SE	1988
16789	BATH MAGISTRATES COURT SITE	L.G. MOUCHEL AND PARTNERS	NORWEST HOLST SOIL ENGINEERING LTD	ST76SE	1981
16790	COMBE DOWN AREA DRAINAGE	CITY OF BATH	BATH CITY ENGINEER	ST76SE	1977
16791	BEECHEN CLIFF SCHOOL	BEECHEN CLIFF SCHOOL	EXPLORATION ASSOCIATES LTD	ST76SE	1991
16792	CLAVERTON PUMPING STATION	BRITISH WATERWAYS BOARD	EXPLORATION ASSOCIATES LTD	ST76SE	1980
16793	BATH UNIVERSITY	UNIVERSITY OF BATH	TERRESEARCH LTD	ST76SE	1992
16794	PROPOSED REMEDIAL WORKS, DUNDAS AQUEDUCT	BRITISH WATERWAYS BOARD	GEOTECHNICAL ENGINEERING LTD	ST76SE	1983
16818	LAND AT WELLSWAY, BATH	CITY OF BATH	GEOTECHNICAL ENGINEERING LTD	ST76SW	1973
16820	PROPOSED HOUSING ESTATE, KINGSWAY, BATH	BEEZER LTD	UNIVERSITY OF LONDON/UNIVERSITY OF BRISTOL	ST76SW	1961
16821	28 OOLITE ROAD, ODD DOWN, BATH	DENNIS JUBB AND PARTNERS	GEO-TESTING SERVICES LTD	ST76SW	1974
16822	PROPOSED HOUSING DEVELOPMENTS AT LANSDOWN VIEW 1 AND 2 AND THE CLOSE AT TWERTON, BATH, SOMERSET	CITY OF BATH	GEORGE WIMPEY AND CO. LTD	ST76SW	1969
16823	SOUTHDOWN AND SOUTH TWERTON DRAINAGE	CITY OF BATH	STRATA SURVEYS LTD	ST76SW	1975
16824	GREEN PARK STATION, BATH	ERNEST GREEN AND PARTNERS	PRE-FOUNDATION DESIGN LTD	ST76SW	1980
16825	TWERTON PUMPING STATION	CITY OF BATH	UNIVERSITY OF BRISTOL	ST76SW	1959
16827	SOUTH WRAXALL, BRADFORD-ON-AVON	WESSEX WATER PLC	STRUCTURAL SOILS LTD	ST86SW	1999
16828	RIVER AVON, BATH	AVON RIVER AUTHORITY	GEOTECHNICAL ENGINEERING LTD	ST76SW	1965

16829	RECONSTRUCTION OF MAIN INTERCEPTOR SEWER, BATH	CITY OF BATH	FOUNDATION ENGINEERING LTD	ST76SW	1973
16831	RECONSTRUCTION OF MAIN INTERCEPTOR SEWER ST. JOHNS ROAD TO CLEVELAND BRIDGE	CITY OF BATH	GEOTECHNICAL ENGINEERING LTD	ST76SW	1973
16833	PROPOSED NEW BRIDGE OVER THE RIVER AVON AT BATH, SOMERSET	CITY OF BATH	GEORGE WIMPEY AND CO. LTD	ST76SW	1962
16835	PROPOSED NEW BRIDGE OVER THE RIVER AVON AT BATH, SOMERSET	CITY OF BATH	GEORGE WIMPEY AND CO. LTD	ST76SW	1962
16837	RIVER AVON BATH FLOOD PROTECTION SCHEME	CITY OF BATH		ST76SW	1965
16838	PROPOSED FOOTBRIDGE ACROSS THE MAIN LINE RAILWAY AT BROOK ROAD, BATH	AVON COUNTY COUNCIL	SOMERSET COUNTY COUNCIL	ST76SW	1976
16839	KINGSMEAD CAR PARK BORING, BATH		G.A. KELLAWAY	ST76SW	1981
16840	PROPOSED DEVELOPMENT AT KINGSMEAD SQUARE, BATH, SOMERSET	STAR (GB) DEVELOPMENTS LTD	LOW AND PARSONS BROWN	ST76SW	1971
16841	LANSDOWN VIEW, THE HOLLOW AND WHITEWAY DRAINAGE	CITY OF BATH	GROUND ENGINEERING LTD	ST76SW	1974
16855	VEHICULAR TUNNEL, BATH	GEORGE WIMPEY AND CO. LTD	GEOTECHNICAL ENGINEERING LTD	ST76NE	1970
16856	HEDGEMEAD PARK DEVELOPMENT	C.H. BEAZER AND SONS LTD	SOIL MECHANICS LTD	ST76NE	1968
16857	WHITE WELLS NURSERIES ESTATE	BATH CITY PLANNING OFFICER	GEOTECHNICAL ENGINEERING LTD	ST76NE	1965
16858	PARTIAL FAILURE OF A RETAINING WALL, MOUNT ROAD, BATH	AVON COUNTY COUNCIL	UNIVERSITY OF BATH	ST76NE	1977
16860	MIDSUMMER ROAD, BATH	CLARKE NICHOLLS AND MARCEL	GEOTECHNICAL ENGINEERING LTD	ST76NE	1965
16861	TYNING LANE, BATH	BATH CORPORATION	GEOTECHNICAL ENGINEERING LTD	ST76NE	1972
16862	CAMDEN ROAD, BATH. PROPOSED TO FLAT	CITY OF BATH	GEOTECHNICAL ENGINEERING LTD	ST76NE	1976
16863	LONDON STREET, BATH	BATH CITY COUNCIL	GEOTECHNICAL ENGINEERING LTD	ST76NE	1981
16864	BANNER DOWN, BATH	AVON COUNTY	C.J. ASSOCIATES	ST76NE	1975
16865	SECOND SLIP ON TRUNK ROAD A363, SALLY IN THE WOODS	SOMERSET COUNTY SURVEYOR	G.K.N. REINFORCEMENTS LTD	ST76NE	1960
16866	PROPOSED NEW OFFICE BLOCK, THE TOWERS, BEACON HILL, BATH	M.P. KENT LTD	STRATA SURVEYS LTD	ST76NE	1973
16871	ONEGA GARAGE SITE, UPPER BRISTOL ROAD, BATH	HAMWOOD DEVELOPMENTS	C.J. ASSOCIATES	ST76NW	1981
16872	NEW RETAINING WALL, LANSDOWN ROAD, BATH	AVON COUNTY COUNCIL	SOMERSET COUNTY COUNCIL	ST76NW	1976
16873	LAND SLIP NEAR THE DRY ARCH, BATHAMPTON	SOMERSET COUNTY COUNCIL	STRUCTURAL SOILS LTD	ST76NE	1966
16878	ORMONDE HOUSE, BATH	BRISTOL COMMERCIAL DEVELOPMENTS LTD	GEO-TESTING SERVICES LTD	ST76NW	1974
16879	ONEGA CENTRE DEVELOPMENT, UPPER BRISTOL ROAD, BATH	HAMWOOD DEVELOPMENTS	C.J. ASSOCIATES	ST76NW	1981
16880	A4 - A36 LINK AT WINDSOR BRIDGE, BATH	COUNTY OF AVON	SOUTH WESTERN INDUSTRIAL RESEARCH LTD	ST76NW	1975
16881	PROPOSED DEVELOPMENT AT LANSDOWN GROVE, BATH, AVON	WIMPEY CONSTRUCTION UK LTD	WIMPEY LABORATORIES	ST76NW	1983
16882	NEWBRIDGE WORKS, BATH	HORSTMANN GEAR CO. LTD	GEOTECHNICAL ENGINERING LTD	ST76NW	1979

16883	RETAINING WALL FAILURE ALONGSIDE ST. STEPHENS ROAD, BATH	COUNTY OF AVON	SOUTH WESTERN INDUSTRIAL RESEARCH LTD	ST76NW	1979
16896	PULTENEY ROAD RAILWAY BRIDGE, BATH	BATH CITY ENGINEER	GEOTECHNICAL ENGINEERING LTD	ST76SE	1971
16898	BATH, NORWOOD	HARRIS AND SUTHERLAND	SOIL MECHANICS	ST76SE	1965
16900	HOUSING DEVELOPMENT ODD DOWN, BATH	MR K.J. HOLLOWAY	GEOSTRATA LTD	ST76SW	1974
16901	PROPOSED MULTI-STOREY DEVELOPMENTS AT 6 TO 9 NEW KING STREET AND 1 TO 5 ST. PAULS PLACE, BATH	ALAN GRANT AND PARTNERS	GEOSTRATA LTD	ST76SW	1974
16902	KINGSWAY ESTATE PHASE 4, BATH	C.H. BEAZER AND SONS LTD	GEOSTRATA LTD	ST76SW	1965
16903	TWERTON, BATH	M.P. KENT LTD	STRUCTURAL SOILS LTD	ST76SW	1970
16904	WELLS ROAD, BATH	HASTINGS CLEMENTS AND ASSOCIATES	C.J. ASSOCIATES	ST76SW	1980
16907	COMBE HAY SLIP, BATH	AVON COUNTY COUNCIL	DR W.J. LARNACH	ST76SW	1981
16908	NEWTON ROAD, BATH	BATH CITY COUNCIL	GEOTECHNICAL ENGINEERING LTD	ST76SW	1986
16984	AVON STREET CAR PARK, BATH	ERNEST IRELAND LTD	GEOSTRATA LTD	ST76SW	1967
16985	BATH SOUTHERN LOOP ROAD FEASIBILITY STUDY	CITY OF BATH	BATH CITY ENGINEER	ST76SE	1972
17000	DEVELOPMENT AT BROAD QUAY, BATH	C.H. BEAZER DEVELOPMENTS LTD	GEO-TESTING SERVICES LTD	ST76SE	
17001	SOUTHGATE STREET, BATH	CITY OF LONDON REAL PROPERTY CO. LTD	SOIL MECHANICS LTD	ST76SE	1969
17002	TRINITY ROAD DEVELOPMENT, BATH	CITY OF BATH	CRYER LIDDIARD PARTNERSHIP	ST76SE	1973
17003	BATH BRIDGE ROADWORKS	RICHARD COSTAIN (CONSTRUCTION) LTD	GEOSTRATA LTD	ST76SE	1965
17004	CLAVERTON STREET RELIEF SCHEME	CITY OF BATH	FOUNDATION ENGINEERING LTD	ST76SE	1970
17005	KENNET AND AVON CANAL - PROPOSED NEW SEWER SYPHON	CITY OF BATH	GEOTECHNICAL ENGINEERING LTD	ST76SE	1981
17006	NEW STORES AT BATH, SOMERSET	MARKS AND SPENCER LTD AND F.W. WOOLWORTH AND CO. LTD	SOIL MECHANICS LTD	ST76SE	1961
17007	CALTON ROAD, BATH	BATH CITY ENGINEER	GEOTECHNICAL ENGINEERING LTD	ST76SE	1974
17008	THE PRIORY, BATHWICK HILL, BATH	CONCEPT HOMES LTD	GEO-TESTING SERVICES LTD	ST76SE	1972
17009	COMBE ROAD, COMBE DOWN, BATH	C.H. BEAZER LTD	C.J. ASSOCIATES	ST76SE	1979
17010	PROPOSED DEVELOPMENT - HAM GARDENS, BATH	JOHN F FARQUHARSON AND PARTNERS	STRATA SURVEYS LTD	ST76SE	1974
17011	ABBEYGATE STREET, BATH	NORWEST HOLST LTD	C.J. ASSOCIATES	ST76SE	1981
17012	ABBEYGATE STREET, BATH	PACE LTD	C.J. ASSOCIATES	ST76SE	1982
17013	PROPOSED DEVELOPMENT, LONGWOOD HOUSE, CLAVERTON DOWN ROAD, CLAVERTON DOWN, BATH	MARPLES RIDGWAY PROPERTIES LTD	C.J. ASSOCIATES	ST76SE	1981
17014	P.O. SORTING OFFICE, MANVERS STREET, BATH		C.J. ASSOCIATES	ST76SE	1983
17015	PROPOSED RESIDENTIAL DEVELOPMENT AT GREENDOWN PLACE, COOMBE DOWN, BATH	CITY OF BATH	GEOSTRATA LTD	ST76SE	1976
17016	ROMAN RESERVOIR AT THE KINGS BATH	BATH CITY COUNCIL	GEOTECHNICAL ENGINEERING LTD	ST76SE	1980
17017	PUMP ROOM, BATH	L.G. MOUCHEL AND PARTNERS	GEOTECHNICAL ENGINEERING LTD	ST76SE	1972
17018	BATHWICK RAILWAY TUNNEL CULVERT	BATH CITY ENGINEER	GEOTECHNICAL ENGINEERING LTD	ST76SE	1971
17019	BATH PUMP ROOM/YORK STREET CORNER DEVELOPMENT	L.G. MOUCHEL AND PARTNERS	GEOTECHNICAL ENGINEERING LTD	ST76SE	1970

17020	PROPOSED DEVELOPMENT AT MANVERS STREET, BATH	STATURE INVESTMENTS LTD	CEMENTATION CO. LTD	ST76SE	1969
17021	PROPOSED THRUST BORE PIT AND RIVER INTAKE AT BRASS KNOCKR LANE, LIMPLEY STOKE, BATH, AVON	WESSEX WATER AUTHORITY	WIMPEY LABORATORIES LTD	ST76SE	1978
17022	CALTON ROAD, BATH	BATH CITY ENGINEER	GEOTECHNICAL ENGINEERING LTD	ST76SE	1974
17027	MIDFORD ROAD, COMBE DOWN, BATH	CROSS MANUFACTURING CO. LTD	OAKLEY SOILS AND CONCRETE ENGINEERING LTD	ST76SW	1980
17028	LAND AT WELLSWAY, BATH	CITY OF BATH	GEOTECHNICAL ENGINEERING LTD	ST76SW	1973
17029	BEREWYKE ESTATE, BATH	CITY OF BATH	GEOTECHNICAL ENGINEERING LTD	ST76SW	1975
17030	CUT ROUTE - BATH CONSERVATION STUDY	BATH LOCAL AUTHORITY	GEOSTRATA LTD	ST76SW	1967
17031	ENGLISHCOMBE LANE, BATH	BATH CITY COUNCIL	GEOTECHNICAL ENGINEERING LTD	ST76SW	1984
17032	BATH TECHNICAL COLLEGE, STAGE 3	OVE ARUP AND PARTNERS	THE BRITISH REINFORCED CONCRETE ENGINEERING CO. LTD	ST76SW	1970
17033	PROPOSED DEVELOPMENT AT MANVERS STREET, BATH	STATURE INVESTMENTS LTD	SOIL AND ROCK ENGINEERING LTD	ST76SE	1969
17034	GEORGES HOUSE, BATHWICK HILL, BATH	INDEPENDENT MOTORS LTD / B.S. ASSOCIATES	CONTRACT DRILLING LTD	ST76SE	1972
17035	BROAD QUAY DEVELOPMENT, BLOCK A, BATH	PARSONS BROWN	NOTT, BRODIE AND COMPANY LTD	ST76SE	1973
17036	PROPOSED RECREATION CENTRE AT NORTH PARADE ROAD, BATH	MODULE 2 LTD	G.K.N. FOUNDATIONS LTD	ST76SE	1972
17039	ODD DOWN LODGE, BATH	VICTOR TOOGOOD (PROPERTY) LTD	GEOTECHNICAL ENGINEERING LTD	ST76SW	1975
17040	BROAD QUAY DEVELOPMENT, BATH	ERNEST IRELAND (CONTRACTERS) LTD	NOTT BRODIE AND COMPANY LTD	ST76SW	1975
17067	CLAREMONT, BATH	BLENFORD PROPERTIES LTD	C.J. ASSOCIATES	ST76NE	1979
17103	LIMPLEY STOKE VIADUCT	COUNTY OF AVON	SWIRL	ST76SE	1978
17104	SALLY-IN-THE-WOODS	SOMERSET COUNTY COUNCIL	G.K.N. FOUNDATIONS LTD	ST76SE	1969
17258	RNSD COPENACRE (SPRING COURT) CRISP COMPUTER BUILDING	DEPARTMENT OF THE ENVIRONMENT/PROPERTY SERVICES AGENCY	DCES	ST86NW	1979
17259	COLLERNE RAF UKMSCS EARTH TERMINAL DIVERSIFICATION SR (SLA) 1595	DEPARTMENT OF THE ENVIRONMENT/PROPERTY SERVICES AGENCY	DCES	ST87SW	1987
17278	RNSD COPENACRE (SPRING QUARRY) MAC BUILDING ADDENUM NO.1	DEPARTMENT OF THE ENVIRONMENT/PROPERTY SERVICES AGENCY	DCES	ST86NW	1980
17527	LOCKBROOK ROAD, BATH	HORSTMAN LTD	TERRESEARCH LTD	ST76SW	1960
18657	CLAVERTON PUMPING STATION	BRITISH WATERWAYS BOARD	EXPLORATION ASSOCIATES LTD	ST76SE	1980
18659	A36 ROAD CROSSING, TROWBRIDGE	NORWEST HOLST PIPEWORKS	NORWEST HOLST SOIL ENGINEERING LTD	ST75NE	1985
18805	WELLOW S.T.W. WELLOW, NEAR BATH	WESSEX WATER	C.J. ASSOCIATES	ST75NW	1992
18830	KEYNSHAM STW	WESSEX WATER	STRUCTURAL SOILS LTD	ST66NE	1991
21076	NORTHEY ARMS GARAGE, BOX, WILTSHIRE	NORTHEY ARMS GARAGE	STRATA TEST LTD	ST86NW	1983
21083	WICK SEWAGE TREATMENT WORKS	WESSEX WATER AUTHORITY	OSIRIS-CESCO LIMITED	ST67SE	1982
21215	UPPER BRISTOL ROAD, BATH	WARRINGTONS PLC	NORWEST HOLST SOIL ENGINEERING LTD	ST76NW	1989
21497	BATH POLLUTION PREVENTION PHASE 1	WESSEX WATER SERVICES LTD	GEO TESTING SERVICES LTD	ST76NE	1995
21498	A46 SWAINSWICK HILL	COUNTY OF AVON	EXPLORATION ASSOCIATES (WARWICK) LIMITED	ST76NE	1977
21527	BATH POLLUTION PREVENTION SCHEME	WESSEX WATER SERVICES LTD	THYSSEN LTD	ST76SW	1998

Appendix 2 Boreholes from the SOBI database greater than 20m

BGS reference Number	Length	Borehole name	GR	Confidential
ST66NE18	127.1	WELL AT BITTON BITTON	ST 68130 69860	N
ST66NE25	127.1	BITTON GOLDEN VALLEY PAPER MILLS	ST 68140 69860	N
ST66NE26	60.96	NORTH BREACH CORSTON	ST 68150 65950	N
ST66NE36	24.41	SALTFORD BYPASS PRELIM R1	ST 68550 66270	N
ST66NE77	66.15	SALTFORD BYPASS PRELIM R133	ST 68880 67220	N
ST66NE81	22	SALTFORD BYPASS PRELIM R137	ST 69070 66850	N
ST66NE88	20	SALTFORD BYPASS PRELIM R201	ST 69020 66940	N
ST66NE89	25	SALTFORD BYPASS PRELIM R202	ST 69140 66780	N
ST67NE2	30.48	WALLSEND COLLIERY	ST 66460 76600	N
ST67NE3	69.79	BULLERS DEEP PIT	ST 66770 76410	N
ST67NE6	177.08	PARKGATE PIT	ST 68350 78760	N
ST67NE7	205.43	BRANDY BOTTOM	ST 68230 77150	N
ST67NE8	153.31	NEW ENGINE PIT	ST 67800 79390	N
ST67NE9	86.86	COOKS PIT PUCKLECHURCH	ST 69230 77500	N
ST67NE10	36.57	ANCIENT TRIAL HOLE & BORE	ST 69090 78220	N
ST67NE15	105.76	DUDLEY PIT PUCKLECHURCH	ST 69460 78170	N
ST67NE16	120.7	PUFFERS PIT PUCKLECHURCH	ST 69370 78000	N
ST67NE17	392.27	WHIMSEY OR BRYANTS PIT PUCKLECHURCH	ST 69320 77710	N
ST67NE56	25.36	CELESTITE 5	ST 69680 78760	N
ST67NE57	41.32	CELESTITE 6	ST 68670 76980	N
ST67NE58	28.74	CELESTITE 7	ST 67500 75230	N
ST67NE59	24.64	CELESTITE 13	ST 69040 77630	N
ST67NE60	29	CELESTITE 14	ST 69490 78270	N
ST67NE61	38.65	CELESTITE 15	ST 67690 75600	N
ST67NE62	26.21	CELESTITE 16	ST 68380 75950	N
ST67NE63	40.57	CELESTITE 17	ST 68670 75080	N
ST67NE90	20	AVON RING ROAD STAGE 1B R13	ST 66870 77780	N
ST67NE91	32	NUMBER NOT USED (RE-REGISTERED AS ST61NE/15)	ST 66290 76010	N
ST67SE1	155.44	SISTON COMMON PIT	ST 66940 73900	N
ST67SE2	118.87	WEST PIT SISTON	ST 67160 73540	N
ST67SE7	42.67	CORONATION PIT KINGSWOOD	ST 66550 72420	N
ST67SE8	79.24	GOLDNEY PIT KINGSWOOD	ST 67000 72580	N
ST67SE10	111.25	CALIFORNIA NO.2 PIT OLDLAND	ST 66380 71770	N
ST67SE11	121.92	CALIFORNIA NO.1 PIT OLDLAND	ST 66530 71400	N
ST67SE13	114.3	COWHORN HILL PIT OLDLAND	ST 66950 72040	N

ST67SE14	54.86	BULLHALL COLLIERY OLDLAND COMMON	ST 67500 71930	N
ST67SE15	201.16	HOLE LANE COLLIERY OLDLAND COMMON	ST 67790 71750	N
ST67SE16	277.97	GOLDEN VALLEY NEW PIT BILTON	ST 68590 71010	N
ST67SE17	43.89	OLDLAND	ST 66990 71940	N
ST67SE20	37.79	MOUNDS FARM BILTON	ST 67730 74070	N
ST67SE21	137.16	GOLDEN VALLEY OLD PIT BILTON	ST 69010 70800	N
ST67SE22	20.42	KINGSWOOD GRIMSBURY ROAD 1	ST 66180 73580	N
ST67SE27	21.33	WICK-ABSON WICK	ST 69800 70600	N
ST67SE48	30.15	KINGSWOOD C1	ST 65890 73230	N
ST67SE49	25.78	KINGSWOOD C2	ST 65840 73270	N
ST67SE51	30	KINGSWOOD P2	ST 65870 73270	N
ST67SE52	30	KINGSWOOD P3	ST 65850 73310	N
ST67SE54	30	KINGSWOOD P5	ST 65840 73220	N
ST67SE55	30	KINGSWOOD P6	ST 65890 73200	N
ST67SE57	30	KINGSWOOD P8	ST 65920 73230	N
ST67SE58	27.43	LODGE ROAD ABSON	ST 69850 74950	N
ST67SE79	37.76	MOUNDSCOURT FARM SISTON	ST 67700 74100	N
ST67SE80	117.04	COWHORN PIT BITTON	ST 66960 72050	N
ST68SE3	45.72	BURGESS PIT FRAMPTON COTTERILL	ST 66960 81770	N
ST68SE4	200	FROGLANE PIT FRAMPTON COTTERILL	ST 68700 81550	N
ST68SE5	88	OXBRIDGE PIT FRAMPTON COTTERILL	ST 68140 81510	N
ST68SE6	73	HALF MOON PIT FRAMPTON COTTERILL	ST 67960 81070	N
ST68SE7	64	UPPER WHIMSEY COALPIT HEATH	ST 67810 80700	N
ST68SE8	170	RAMHILL PIT WESTERLEIGH	ST 67910 80250	N
ST76NE14	21.33	BATH UNDERPASS B5	ST 75060 65410	N
ST76NE15	24.38	BATH UNDERPASS A5	ST 75000 65240	N
ST76NE19	24.68	A46 STABILITY INVESTIGATION F26	ST 75300 69990	N
ST76NE37	24.4	BATH UNDERPASS 106	ST 75040 65290	N
ST76NE39	106.88	SWAINSWICK 15	ST 75760 69070	N
ST76NE41	57.01	SWAINSWICK 30	ST 75450 69440	N
ST76NE44	29.26	SWAINSWICK 28	ST 75690 69020	N
ST76NE46	47.94	SWAINSWICK 37	ST 75590 68940	N
ST76NE47	25	SWAINSWICK 19	ST 75520 68900	N
ST76NE48	21.34	SWAINSWICK 27	ST 75760 68900	N
ST76NE53	37.28	SWAINSWICK 9	ST 76140 67740	N
ST76NE54	24.78	SWAINSWICK 36	ST 76380 67750	N
ST76NE55	47.89	SWAINSWICK 8	ST 76550 67450	N
ST76NE61	30.4	SWAINSWICK 17	ST 76240 67270	N
ST76NE63	30.44	SWAINSWICK 1	ST 76610 66760	N
ST76NE65	40.27	SWAINSWICK 14	ST 76020 69330	N
ST76NE99	24.38	LONDON-BRISTOL A4 B4	ST 78480 67040	N
ST76NE108	21.33	LONDON-BRISTOL A4 B17	ST 76770 66230	N
ST76NE115	20.19	LONDON-BRISTOL A4 B25	ST 76500 66360	N
ST76NE120	26.5	SWAINSWICK 51	ST 76470 67590	N
ST76NE121	45.6	SWAINSWICK 51A	ST 76610 67660	N

ST76NE126	72.5	SWAINSWICK 55	ST 76460 67930	N
ST76NE127	64.6	SWAINSWICK 55B	ST 76510 67930	N
ST76NE128	33.57	SWAINSWICK 56	ST 76280 67810	N
ST76NE129	22.9	SWAINSWICK 57	ST 76100 67760	N
ST76NE130	37.5	SWAINSWICK 58	ST 76430 68070	N
ST76NE131	49.1	SWAINSWICK 58A	ST 76280 68000	N
ST76NE132	34.1	SWAINSWICK 59	ST 76180 68000	N
ST76NE134	36	SWAINSWICK 59B	ST 76170 67990	N
ST76NE135	36.2	SWAINSWICK 59C	ST 76190 68010	N
ST76NE136	32	SWAINSWICK 60	ST 76140 68250	N
ST76NE137	30	SWAINSWICK 61	ST 76150 67740	N
ST76NE149	30.3	BATH VEHICULAR TUNNEL APPROACH RD K5	ST 75330 65670	N
ST76NE150	32.95	BATH VEHICULAR TUNNEL APPROACH RD BH.K6	ST 75340 65700	N
ST76NE161	30	BATH VEHICULAR TUNNEL APPROACH RD K3	ST 75870 65870	N
ST76NE162	30	BATH VEHICULAR TUNNEL APPROACH RD K2	ST 75970 65840	N
ST76NE163	30	BATH VEHICULAR TUNNEL APP RD RCUB	ST 75990 65860	N
ST76NE164	233.62	BATHEASTON SHAFT & BOREHOLE	ST 78140 67760	N
ST76NE245	61	THE TOWERS-BEACON HILL 5	ST 75020 66280	N
ST76NE251	30	BATHEASTON/SWAINSWICK BY-PASS BB1	ST 76030 68480	N
ST76NE252	22.5	BATHEASTON/SWAINSWICK BY-PASS BB2	ST 76310 68040	N
ST76NE253	42	BATHEASTON/SWAINSWICK BY-PASS BB3	ST 76370 67870	N
ST76NE254	29.3	BATHEASTON/SWAINSWICK BY-PASS BB4	ST 77090 67370	N
ST76NE257	40.1	BATHEASTON/SWAINSWICK BY-PASS BB7	ST 77120 67280	N
ST76NE258	39.8	BATHEASTON/SWAINSWICK BY-PASS BB8	ST 77270 67110	N
ST76NE260	20	BATHEASTON/SWAINSWICK BY-PASS BB10	ST 78120 66260	N
ST76NE261	20.3	BATHEASTON/SWAINSWICK BY-PASS BB11	ST 78070 65870	N
ST76NE262	23.2	BATHEASTON/SWAINSWICK BY-PASS BB12	ST 76410 67900	N
ST76NE263	21.9	BATHEASTON/SWAINSWICK BY-PASS BB13	ST 76100 67840	N
ST76NE264	20.25	BATHEASTON/SWAINSWICK BY-PASS BB14	ST 76940 67040	N
ST76NE265	20.2	BATHEASTON/SWAINSWICK BY-PASS BB15	ST 78150 65410	N
ST76NE266	20.4	BATHEASTON/SWAINSWICK BY-PASS BB16	ST 78210 65650	N
ST76NE267	20	BATHEASTON/SWAINSWICK BY-PASS BB17	ST 76290 67530	N
ST76NE285	20.2	UPPER SWAINSWICK A46-A420 B62/6	ST 75600 69090	N
ST76NE286	20	UPPER SWAINSWICK A46-A420 B63/1	ST 75550 69180	N
ST76NE371	109.61	ALICE PARK BATH	ST 76500 66590	N
ST76NE380	20	BE/SWAINSWICK BYPASS SB33	ST 76410 67520	N
ST76NE381	20	A4/A46 BATHEASTON SWAINSWICK BYPASS SB34	ST 76357 67621	N
ST76NE385	20	BE/SWAINSWICK BYPASS SB38	ST 76440 67510	N
ST76NE392	22.45	BE/SWAINSWICK BYPASS SB45	ST 76260 67860	N
ST76NE394	20	BE/SWAINSWICK BYPASS SB47	ST 76210 67900	N
ST76NE395	25.1	BE/SWAINSWICK BYPASS SB48	ST 76250 67990	N
ST76NE408	34	BE/SWAINSWICK BYPASS BB60	ST 76360 67610	N
ST76NE409	22	BE/SWAINSWICK BYPASS BB63	ST 76420 67520	N
ST76NE410	33.6	BE/SWAINSWICK BYPASS BB64	ST 76420 67490	N
ST76NE411	34.9	BE/SWAINSWICK BYPASS BB67	ST 76400 67540	N

ST76NE412	21.7	BE/SWAINSWICK BYPASS BB68	ST 76440 67470	N
ST76NE413	26.2	BE/SWAINSWICK BYPASS BB80	ST 76340 67820	N
ST76NE414	26.2	BE/SWAINSWICK BYPASS BB81	ST 76290 67810	N
ST76NE416	30.2	BE/SWAINSWICK BYPASS BB85	ST 76340 67970	N
ST76NE418	20	BE/SWAINSWICK BYPASS BB89	ST 76210 67960	N
ST76NE421	25	BE/SWAINSWICK BYPASS BB92	ST 76170 67760	N
ST76NE422	20.8	BE/SWAINSWICK BYPASS BB96	ST 76280 67900	N
ST76NE424	23	BE/SWAINSWICK BYPASS BB98	ST 76290 67950	N
ST76NE481	20	KENNET/AVON CANAL STAGES 6 & 7 5	ST 78240 66060	N
ST76NE484	22	KENNET/AVON CANAL STAGES 6 & 7 8	ST 78190 65890	N
ST76NE486	24.85	KENNET/AVON CANAL STAGES 6 & 7 10	ST 78160 65730	N
ST76NE489	30.35	KENNET/AVON CANAL STAGES 6 & 7 13	ST 78080 65660	N
ST76NE490	27.05	KENNET/AVON CANAL STAGES 6 & 7 14	ST 78130 65330	N
ST76NE492	30.52	KENNET/AVON CANAL STAGES 6 & 7 15A	ST 78180 65350	N
ST76NE494	26.1	KENNET/AVON CANAL STAGES 6 & 7 17	ST 78260 65380	N
ST76NE496	22.45	KENNET/AVON CANAL STAGES 6 & 7 19	ST 78270 65270	N
ST76NE517	36.88	BOX TUNNEL NO 2	ST 79960 65940	N
ST76NE518	36.58	BOX TUNNEL NO 2A	ST 79960 66160	N
ST76NE519	39.62	BOX TUNNEL NO 3	ST 79940 66220	N
ST76NE520	45.72	BOX TUNNEL NO 4	ST 79930 66280	N
ST76NE521	44.2	BOX TUNNEL NO 5	ST 79930 66360	N
ST76NE522	38.1	BOX TUNNEL NO 6	ST 79940 66500	N
ST76NE523	22.86	BOX TUNNEL NO 7	ST 79940 66580	N
ST76NE531	34.14	SYDNEY GARDENS	ST 75680 65340	N
ST76NE532	102.81	BATHEASTON	ST 78000 67800	N
ST76NE584	40	BATH POLLUTION PREVENTION PHASE 1B 1	ST 75610 65870	N
ST76NW2	45.11	BATH UNDERPASS B1	ST 74610 65250	N
ST76NW3	30.48	BATH UNDERPASS B2	ST 74730 65360	N
ST76NW4	60.5	BATH UNDERPASS B3	ST 74850 65390	N
ST76NW5	38.1	BATH UNDERPASS B4	ST 74950 65400	N
ST76NW8	46.02	BATH UNDERPASS A2	ST 74700 65150	N
ST76NW9	24.38	BATH UNDERPASS A3	ST 74790 65180	N
ST76NW10	45.72	BATH UNDERPASS A4	ST 74870 65220	N
ST76NW11	24.25	BATH UNDERPASS 101	ST 74730 65130	N
ST76NW12	21.38	BATH UNDERPASS 102	ST 74800 65140	N
ST76NW13	23.03	BATH UNDERPASS 103	ST 74830 65180	N
ST76NW14	25.83	BATH UNDERPASS 104	ST 74940 65230	N
ST76NW15	28.87	BATH UNDERPASS 105	ST 74970 65270	N
ST76NW29	48.76	BATH RACECOURSE	ST 71790 68800	N
ST76NW31	67.66	BATH BREWERY CO	ST 72470 65080	N
ST76NW32	30.48	WESTERN MALTINGS	ST 72480 65010	N
ST76NW33	30.48	BECKFORDS TOWER WELL	ST 73730 67550	N
ST76NW34	28.98	CHANCOMBE GROVE FARM	ST 74210 68290	N
ST76NW37	71.62	FRYS WORKS SOMERDALE BHS17	ST 70820 69060	N
ST76NW46	172.97	GLEBE PIT (SHAFT)	ST 70230 65380	N

ST76NW139	41.6	BATH BRIDGE B1	ST 71120 65610	N
ST76NW141	34.29	BATH BRIDGE B3	ST 71180 65620	N
ST76NW178	173	GLOBE PIT	ST 70200 65400	N
ST76NW200	22.56	WESTON STATION	ST 72490 65000	N
ST76NW201	26.21	WESTON STATION	ST 72490 65090	N
ST76NW203	53.04	AMERICA BUILDINGS NR LANDSDOWNE	ST 73200 68100	N
ST76NW204	30	BATH POLLUTION SCHEME PHASE 3 4	ST 73440 65030	N
ST76SE4	30.48	BATHAMPTON DOWN 4	ST 77280 64570	N
ST76SE7	31.39	BATHAMPTON DOWN 7	ST 77030 64570	N
ST76SE10/A-E	30.48	BATHAMPTON H1-H5	ST 77400 64900	N
ST76SE22	20	HORSECOMBE VALE 13	ST 76290 62280	N
ST76SE24	72	HORSECOMBE VALE 15	ST 75550 62250	N
ST76SE27	57	D OF E BATH. NEW GOVERNMENT OFF.BH.JX012	ST 75400 62840	N
ST76SE37	20	D OF E BATH. NEW GOVERNMENT OFF.BH.021	ST 75530 62560	N
ST76SE46	23	A36 IMPROVEMENT BH1-7	ST 78850 64450	N
ST76SE54/A-L	30		ST 77430 64330	N
ST76SE54	30	BATH UNIVERSITY BH013	ST 77430 64330	N
ST76SE55	30.48	PRIOR PARK	ST 76310 62950	N
ST76SE70	90	PULTENEY 1	ST 75400 64800	N
ST76SE71	84	STALL STREET	ST 75030 64740	N
ST76SE129/A-G	27	ROMAN RESERVOIR BATH 1-7	ST 75100 64800	N
ST76SE183	22	CLAVERTON-KENNET & AVON BH1	ST 78380 62720	N
ST76SE184	20	CLAVERTON-KENNET & AVON BH2	ST 78460 62690	N
ST76SE188	25	CLAVERTON-KENNET & AVON BH6	ST 78570 62990	N
ST76SE191	23	CLAVERTON-KENNET & AVON BH9	ST 78630 63070	N
ST76SE197	22	CLAVERTON-KENNET & AVON BH15	ST 78900 63440	N
ST76SE200	23	CLAVERTON-KENNET & AVON BH18	ST 79010 63750	N
ST76SE203	20	CLAVERTON-KENNET & AVON BH21	ST 79050 64160	N
ST76SE206	20	BATHWICK HILL BATH BH1	ST 76600 64300	N
ST76SE208	22	BATHWICK HILL BATH BH3	ST 76600 64300	N
ST76SE210	20	WIDCOMBE PARADE BHS1235 TP1-5	ST 75400 64200	N
ST76SE211	27	WIDCOMBE PARADE BH4	ST 75370 64170	N
ST76SE248	21	DUNDAS AQUADUCT K+A CANAL BH 2	ST 78460 62530	N
ST76SE358	27.43	CAROLINE BUILDINGS	ST 75700 64300	N
ST76SE361	24.38	WIDCOMB LOCK PITS	ST 75500 64250	N
ST76SE362	53.04	MACAULAY BUILDINGS	ST 76500 63800	N
ST76SE363	24.38	WIDCOMB ROAD	ST 76000 64000	N
ST76SE367	24.38	CROWHALL	ST 75900 63900	N
ST76SE369	60.96	NEWARK ST	ST 75150 64420	N
ST76SW2	24.58	RUSH HILL 5 BATH	ST 73300 62770	N
ST76SW4	36.57	BATH UNDERPASS C1	ST 74810 64920	N
ST76SW23	30.12	BATH VEHICULAR TUNNEL APPROACH RD K9	ST 74390 64800	N
ST76SW27	262.43	TWERTON NO.1 COLLIERY	ST 71490 64560	N
ST76SW28	109.57	TWERTON NO.2 COLLIERY	ST 71280 64200	N
ST76SW32	112.2	KINGSMEAD CAR PARK 1	ST 74780 64800	N

ST76SW74	21.5	KINGSMEAD SQUARE 3	ST 74830 64720	N
ST76SW197	20	ARGYLE WORKS LOWER BRISTOL ROAD	ST 73300 64750	N
ST76SW238	35	ODD DOWN BATH 1	ST 74230 63660	N
ST76SW287	30.29	KINGSMEAD & MILK STREET BATH 2	ST 74680 64560	N
ST76SW305	109.22	CROSS BATH INCLINED BOREHOLE	ST 74940 64710	N
ST76SW309	63.09	BREWERY KINGSMEAD STREET	ST 74700 64800	N
ST76SW312	70.1	HOLLOWAY BREWERY	ST 74500 63900	N
ST76SW313	24.38	HOLLOWAY HILL	ST 74500 63900	N
ST76SW316	30	BATH POLLUTION PREVENTION PHASE 2 3	ST 74230 64970	N
ST77NE32	57	TORMARTON	ST 78340 76820	N
ST77NE33	85	WEST FARM WEST LITTLETON	ST 76250 75180	N
ST77NE34	31.39	TORMARTON	ST 76620 78580	N
ST77NE42	20	A46 COLD ASHTON M4 TORMARTON SECTION B2	ST 75537 77507	N
ST77NE49	20	A46 COLD ASHTON M4 TORMARTON SECTION B9	ST 75206 76657	N
ST77NE51	20	A46 COLD ASHTON M4 TORMARTON SECTION B11	ST 75123 76357	N
ST77NE91	27.65	DOWN FARM, WEST KINGTON	ST 78740 77300	N
ST77NE92	31.39	TORMARTON	ST 76620 78570	N
ST77NE93	84.73	WEST FARM, WEST LITTLETON	ST 76210 75200	N
ST77NE94	23.5	KINGSTONDOWN FARM	ST 79740 77540	N
ST77NW6	20.72	GLOUCS M4 PUCKLECHURCH NO.27 DYRHAM	ST 71620 77690	N
ST77NW16	24.38	GLOUCS M4 PUCKLECHURCH NO.5 DYRHAM	ST 74590 77930	N
ST77NW17	24.38	GLOUCS M4 PUCKLECHURCH NO.6 DYRHAM	ST 74600 77900	N
ST77NW22	29	CELESTITE 4	ST 70480 79320	N
ST77NW23	21.33	CODINGTON WELL CODINGTON	ST 72940 78850	N
ST77NW24	39	CODINGTON QUARRY	ST 72520 78800	N
ST77NW25	38	CODINGTON QUARRY	ST 72450 78510	N
ST77NW26	37	CODINGTON QUARRY	ST 72550 78220	N
ST77NW27	27	CODINGTON QUARRY	ST 72380 78180	N
ST77NW28	40	CODINGTON QUARRY	ST 72750 78430	N
ST77NW29	23	CODINGTON QUARRY	ST 72400 77620	N
ST77NW30	23	CODINGTON QUARRY	ST 72350 77120	N
ST77SE12	73.15	WESTEND TOWN FARM BH	ST 76700 74140	N
ST77SE22	164.59	MONKSWOOD	ST 75100 71100	N
ST77SE23	136.55	ASHWICKS HALL	ST 79700 71800	N
ST77SE33	58	SPRINGS FARM MARSHFIELD	ST 76400 74600	N
ST77SE58	58	SPRINGS FARM MARSHFIELD	ST 76400 74600	N
ST77SE63	73.15	WEST END TOWN FARM	ST 76720 74130	N
ST77SW1	305.1	HAMSWELL COLD ASHTON	ST 73480 70880	N
ST77SW13	44	SWAINSWICK 25	ST 74220 72430	N
ST77SW36	20	A46 COLD ASHTON M4 TORMARTON SECTION B18	ST 74708 74364	N
ST77SW58	20	A46 COLD ASHTON M4 TORMARTON SECTION B40/1	ST 74623 74256	N
ST78SE4	33.83	TORMARTON TRIAL SHAFTS 1	ST 78890 81240	N
ST78SE5	45.11	TORMARTON TRIAL SHAFTS 2	ST 78290 81290	N
ST78SE6	59.13	TORMARTON TRIAL SHAFTS 3	ST 77790 81220	N
ST78SE7	68.27	TORMARTON TRIAL SHAFTS 4	ST 77130 81360	N

ST78SE8	80.16	TORMARTON TRIAL SHAFTS 5	ST 76510 81400	N
ST78SE9	85.64	TORMARTON TRIAL SHAFTS 6	ST 75830 81440	N
ST78SE11	21	LYEGROVE FARM	ST 77840 81630	N
ST78SE12	25.91	NEW HOUSE FARM, TORMARTON	ST 78600 81000	N
ST78SW1	436.47	WESTERLEIGH 1	ST 70610 81280	N
ST78SW12	36	CELESTITE 1	ST 71250 80290	N
ST78SW13	35	CELESTITE 2	ST 71670 80820	N
ST78SW14	39	CELESTITE 3	ST 71670 80350	N
ST78SW31	433.03	WESTERLEIGH BORING	ST 70600 81260	N
ST86NE22	112	ATWORTH 1	ST 85890 66850	N
ST86NE23	46	LACOCK 4 CORSHAM	ST 88310 69520	N
ST86NE24	49	LACOCK 3 CORSHAM	ST 89760 69090	N
ST86NE26	21.33	SPRING QUARRY CORSHAM	ST 85400 69320	N
ST86NE27	23.77	WADSWICK ROAD CORSHAM	ST 85490 67760	N
ST86NE31	35.66	GASTARD CORSHAM	ST 89140 67970	N
ST86NE32	22.25	GASTARD ESTATE CORSHAM	ST 88600 67840	N
ST86NE33	44.19	HAYES HOUSE ATWORTH	ST 87450 65590	N
ST86NE34	67.36	SHAW HILL HOUSE MELKSHAM	ST 89190 65050	N
ST86NE35	30.48	GASTARD ESTATE	ST 89370 67460	N
ST86NE36	59.13	NR MENDIP ENGINEERING CO ATWORTH	ST 87800 65600	N
ST86NE37	67.36	SHAWSHILL HOUSE MELKSHAM	ST 88470 65560	N
ST86NE38	39.92	CORSHAM	ST 86330 69820	N
ST86NE107	54.86	THE HAYES, ATWORTH	ST 87800 65530	N
ST86NE108	38.1	NEW MENDIP ENGINEERING CO., ATWORTH	ST 86900 65700	N
ST86NE109	112	DENLEYS FARM, ATWORTH 1	ST 85890 66350	N
ST86NE110	40	ATWORTH NO.3	ST 85900 66400	N
ST86NE111	60.96	GOODSHILL P.S.	ST 88700 67200	N
ST86NE113	96.01	TUNNEL QUARRY SITE, CORSHAM	ST 85730 69460	N
ST86NE114	91.44	TUNNEL QUARRY SITE, CORSHAM	ST 85230 69420	N
ST86NE115	59.44	TUNNEL QUARRY SITE, CORSHAM	ST 85230 69420	N
ST86NE116	56.69	CORSHAM	ST 88750 67010	N
ST86NE117	60.96	CORSHAM	ST 88750 67010	N
ST86NE119	40.84	ATWORTH	ST 86890 65860	N
ST86NW1	30.48	HULBERTS FARM MIDDLEHILL	ST 80480 69120	N
ST86NW5	20.72	DAPSTON LEASE FAIRLEIGH	ST 80320 65050	N
ST86NW6	53.03	HOBBS BOTTOM FARM ATWORTH	ST 84160 66180	N
ST86NW7	46.93	HOBBS BOTTOM FARM ATWORTH	ST 84150 66190	N
ST86NW8	79.24	KINGSDOWN ASYLUM BOX	ST 81760 67680	N
ST86NW20	25	LOWER KINGSDOWN ROAD LANDSLIP BOX BH 1	ST 81380 67990	N
ST86NW23	20	LOWER KINGSDOWN ROAD LANDSLIP BOX BH 4	ST 81390 67990	N
ST86NW25	25	LOWER KINGSDOWN ROAD LANDSLIP BOX BH 6	ST 81410 68010	N
ST86NW26	20	LOWER KINGSDOWN ROAD LANDSLIP BOX BH 7	ST 81400 67990	N
ST86NW36	60.96	NORBIN BARTON	ST 82700 66000	N
ST86NW37	46.21	WHIRLIGIG COTTAGE KINGSDOWN	ST 80480 66910	N
ST86NW38	52.91	WORMWOOD	ST 83610 67360	N

ST86SE1	82.29	HOLT 1	ST 87000 62550	N
ST86SE3	55	CHALFIELD 1A	ST 85230 63330	N
ST86SE4	55	CHALFIELD 2	ST 86030 62910	N
ST86SE5	88	NORRINGTON 1	ST 88220 64420	N
ST86SE16	64	NORRINGTON COMMON	ST 88310 64970	N
ST86SE17	158.49	CO-OPERATIVE WHOLESALE DEPOT	ST 89930 64420	N
ST86SE71	50	LITTLE CHALFIELD, NEAR BRADFORD LEIGH	ST 85200 63300	N
ST86SW4	57	CHALFIELD 3	ST 82860 63820	N
ST86SW5	46	FARLEIGH 1	ST 81170 63600	N
ST86SW11	33.52	DUCKMEAD CHERRY ORCHARD BRADFORD ON AVON	ST 82540 63620	N
ST86SW12	49.37	WOOLLEY GRANGE BRADFORD ON AVON	ST 83580 62280	N
ST86SW21	42	GREAT CUMBERWELL FARM	ST 82840 63180	N
ST86SW121	89.31	BRADFORD-ON-AVON	ST 80500 62540	N
ST86SW122	30.48	BRADFORD-ON-AVON	ST 80500 62540	N
ST86SW125	46.2	FARLEIGH NO.1	ST 81170 63610	N
ST86SW126	55	SOUTH WRAXALL	ST 82900 64300	N
ST87NE37	62	KINGTON ST MICHAEL	ST 89230 77380	N
ST87NE38	170	GRITTLETON ESTATE	ST 87190 79750	N
ST87NE39	34.74	FOSCOTE HOUSE GRITTLETON	ST 86210 79300	N
ST87NE40	44.9	LEIGH DELAMERE TIP BOREHOLE	ST 89880 78930	N
ST87NE43	137.46	LANHILL FARM, ALLINGTON	ST 88100 75100	N
ST87NW40	21	NETTLETON 1	ST 82350 78460	N
ST87NW41	51.2	MANOR FARM BH	ST 81480 77000	N
ST87NW42	110.03	NETTLETON 2	ST 82670 79460	N
ST87NW43	91.44	WESTFIELD FARM BH	ST 80240 78850	N
ST87NW45	110.03	GROVE BARN NETTLETON	ST 82670 79470	N
ST87NW47	61.56	STANTON COURT	ST 80770 79860	N
ST87NW48	43	KEEPERS COTTAGE NORTH WRAXALL	ST 83100 75800	N
ST87NW49	105	THE PIGGERIES BURTON	ST 81750 79150	N
ST87NW59	24.08	LOWER WICH COTTAGE, WEST KINGTON WICK	ST 81680 76630	N
ST87NW66	51.21	WEST KINGTON	ST 81470 77000	N
ST87NW67	42.6	KEEPERS COTTAGE, NORTH WRAXALL	ST 83100 75800	N
ST87NW68	105	THE PIGGERIES, BURTON	ST 81750 79150	N
ST87SE1	116	BIDDESTONE	ST 86090 72820	N
ST87SE2	28.65	HARTHAM PARK CORSHAM	ST 85300 70720	N
ST87SE3	32	CORSHAM COURT ESTATE	ST 86990 71070	N
ST87SE4	38.4	CORSHAM COURT ESTATE	ST 87510 70020	N
ST87SE5	45.11	CORSHAM COURT ESTATE	ST 87850 70210	N
ST87SE6	64	PICKWICK BREWERY	ST 86400 70640	N
ST87SE7	59	ALLINGTON 1	ST 89700 74790	N
ST87SW1	236	LUCKNAM BORE	ST 83380 70710	N
ST87SW2	43.28	DUNCOMBE HILL	ST 80420 73510	N
ST87SW3	22	COLERNE 1BH036	ST 82010 72130	N
ST87SW5	25	RAF COLERNE BH2	ST 80800 71700	N
ST87SW6	39	RAF COLERNE BH3	ST 80800 71700	N

ST88SE1	59	GRITTLETON 1	ST 85460 80770	N
ST88SE14	45.72	GRITTLETON	ST 86810 80400	N
ST88SE15	67.05	WOODBARN FARM	ST 89280 80210	N
ST88SE17	37	EAST DUNLEY FARM GRITTLETON	ST 85900 81700	N
ST88SE18	48	CLAPCOTE TIP BOREHOLE	ST 88090 80420	N
ST88SE21	37	EAST DUNLEY FARM	ST 85900 81700	N
ST88SE22	20.02	WOOD BARN FARM, STANTON ST QUINTON	ST 89220 80210	N
ST88SE23	37.67	CLAPCOTE FARM, GRITTLETON	ST 87520 81010	N
ST88SW21	22.4	CHESTNUT FARM	ST 81310 80830	N
ST88SW22	24.04	ALDERTON GROVE FARM	ST 83060 81430	N
ST96NW1	55	LACOCK 1	ST 90880 68710	N
ST96NW2	58	LACOCK 2	ST 92050 69260	N
ST96NW3	73	LACOCK (WHITEHALL FARM)	ST 91580 68950	N
ST96NW4	61.57	WHITEHALL FARM LACOCK	ST 91570 68950	N
ST96NW5	30.18	MARKET GARDENS LACOCK	ST 91090 68130	N
ST96SW1	133.35	MELKSHAM 1	ST 90880 64660	N
ST96SW11	76.5	MELKSHAM POWER STATION	ST 90400 63700	N
ST96SW12	107.28	MELKSHAM SPA	ST 91300 62700	N
ST96SW13	50.29	SPENCER & CO MELKSHAM	ST 90100 64810	N
ST96SW34	133.35	MELKSHAM NO 1	ST 90880 64650	N
ST97NW5	21.94	M4 SUTTON BENGER BH.R9	ST 93600 79560	N
ST97NW40	60.96	STANTON MANOR ST QUINTON	ST 90570 79780	N
ST97NW41	32	CLANVILLE FARM	ST 92210 79780	N
ST97NW44	79.24	WESSEX CHICKENS LTD	ST 94430 78720	N
ST97NW45	89.91	WESTERN POULTRY PACKERS LTD	ST 94540 78750	N
ST97NW46	88.39	KINGTON ST MICHAEL	ST 90270 77270	N
ST97NW47	83.51	STEINBROOK HOUSE KINGTON LANGLEY	ST 92650 76270	N
ST97NW48	83.51	STEINBROOK HOUSE KINGTON LANGLEY	ST 92640 76300	N
ST97NW49	91.44	LANGLEY BURNELL BREWERY	ST 93700 75100	N
ST97NW60	125	MANOR FARM LANGLEY BURRELL	ST 93430 75670	N
ST97NW61	137	ALLINGTON BOREHOLE	ST 90590 76070	N
ST97NW62	32.61	STANTON VICARAGE	ST 90600 79800	N
ST97NW64	91.44	LANGLEY BURRELL	ST 93300 75100	N
ST97NW65	63.4	LANGLEY BURRELL	ST 93200 75100	N
ST97NW66	35.8	CLANVILLE STANTON	ST 91800 79900	N
ST97SW1	61.26	IVYFIELDS 3	ST 91760 72790	N
ST97SW2	91	TYTHERTON 3	ST 94400 74450	N
ST97SW3	140.2	BACON CO LTD CHIPPENHAM	ST 92040 73770	N
ST97SW4	76.8	NESTLES MILK FACTORY	ST 91830 73380	N
ST97SW5	76.8	NESTLES & ANGLO SWISS CO	ST 91840 73360	N
ST97SW6	42.06	NEW TOWN WELL CHIPPENHAM	ST 91950 72880	N
ST97SW7	45.72	IVYFIELDS 2	ST 91770 72790	N
ST97SW8	66.14	WESTMEAD 4	ST 91960 72830	N
ST97SW9	46.32	IVYMEADS 4	ST 91730 72790	N
ST97SW10	60.96	CHIPPENHAM LAUNDRY	ST 91730 73350	N

ST97SW11	76.2	UNITED DAIRIES (WHOLESALE)	ST 92200 73680	N
ST97SW13	27.73	THINGLEY JUNCTION	ST 90350 70950	N
ST97SW14	89.61	PATTERDOWN FARM	ST 90770 71370	N
ST97SW15	30.48	GLENS NURSERIES PATTERDOWN	ST 91120 71030	N
ST97SW35	60	IVYFIELDS PUMPING STATION CHIPPENHAM BH	ST 91760 72760	N
ST97SW58	20	BOROUGH PARADE CHIPPENHAM BH 5	ST 91950 73190	N
ST97SW59	20	BOROUGH PARADE CHIPPENHAM BH 6	ST 91910 73170	N
ST97SW60	20	BOROUGH PARADE CHIPPENHAM BH 8	ST 91910 73150	N
ST97SW113	21	POLICE HEADQUARTERS CHIPPENHAM BH 1	ST 92190 72940	N
ST97SW253	60.96	CHIPPENHAM SANITARY LAUNDRY	ST 91740 73350	N
ST98SW8	64.61	SEALES FARM SEAGRY	ST 94670 80100	N
ST98SW9	54.86	SEAGRY HOUSE SEAGRY	ST 94400 80900	N
ST98SW10	50.29	HARDINGS FARM SUTTON BENGER	ST 94250 80180	N
ST98SW11	31.08	HARDINGS FARM SUTTON BENGER	ST 94220 80130	N
ST98SW12	30.48	LOWER STANTON NR CHIPPENHAM	ST 91680 80960	N
ST98SW13/A	98	LOWER STANTON	ST 92040 80990	N
ST98SW13/B	45	LOWER STANTON	ST 92040 80990	N
ST98SW16	98	LOWER STANTON P.S. NO 1	ST 92030 80970	N
ST98SW20	50.29	HARDINGS FARM UPPER SEAGRY	ST 94300 80100	N

Appendix 3 Published material on the Bath area

BGS Open File reports:

1. The geochemistry of Bath thermal waters, IN; Hot springs of Bath, investigations of the thermal waters of the Avon Valley edited by G.A. Kellaway; Bath City Council 1991; p143-156, W.M. Edmunds & D.L. Miles/ Edmunds, W.M.; Miles, D.L.. - [509] BGS Staff Paper at BGS01584. - ISBN X780683780

2. Data review leading to a conceptual model of the hydrogeology of the Combe Down area, Bath, British Geological Survey, Hydrogeology Series, Technical Report WD/00/35, D.M.J.Macdonald, E.J.Whitehead & A.S.Butcher/ MacDonald, D.M.J.; Whitehead, E.J.; Butcher, A.S.; British Geological Survey. Hydrogeology Research Group; Bath & North East Somerset Council. - 2001. - iv,52p; ill.(col). - Report for Bath & North East Somerset Council

3. .A Brief Review of Remote Sensing and 3D Surface Modelling Applied to Urban Geoscience, *British Geological Survey Internal Report* IR/01/076. Jordan, C. J. 2001

4. Petrography of a sand sample from a hot spring at the Kings Bath, Bath, Avon, Institute of Geological Sciences. Petrology Unit, Report 159, 1979 3, [3] : ill, G.E. Strong/ Strong, G.E.; Institute of Geological Sciences. Petrology Unit. - [504] Bibliography: p.2. - ISBN X780133020

5. Thermal imaging techniques to map ground disturbances in a former Nottinghamshire coal mining area. *British Geological Survey Internal Report, IR/02/007*. Ager, G. J., Gibson, A. D., Raines. M. G., Gunn, D. A., Marsh, S. H., Farrant. A R., Lowe. D. J. & Forster. A. 2002.

6. The Bathonian strata of the Bath-Frome area 2 The stratigraphy and correlation of the Bathonian strata in the Bath-Frome area, Report of the Institute of Geological Sciences no.78/22, 1978 - p.23-88, I.E.Penn & R.J.Wyatt/ Penn, I.E.; Wyatt, R.J.; Bate, R.H.; Coleman, B.E.; Medd, A.W.; Merriman, R.J.; Morgan, D.J.; Institute of Geological Sciences. - [508] Contributors: B.E.Coleman, R.H.Bate, A.W.Medd, R.J.Merriman and D.J.Morgan. - ISBN X780007599

7. The age and origin of the Bath thermal waters - new geochemical investigations as part of the Bath Spa Project, British Geological Survey Report CR/01/263N, W.M.Edmunds, W.G.Darling & others/ Edmunds, W.M.; Darling, W.G.; British Geological Survey. - 2002. - iii,19p; ill.

8. Slope stability studies in the Avon Valley (Bath to Limpley Stoke), Institute of Geological Sciences, Engineering Geology Unit, Report 80/10, 1980 [3],55,6,[41] : ill,maps,5folded maps, P.R. Hobbs/ Hobbs, P.R.N.; Institute of Geological Sciences. Engineering Geology Unit. - (Unit Reports, Engineering Geology Series; WN/EG/80/10). - [504] Includes bibliography. - ISBN X780132415
9. The Hydrogeology and hydrochemistry of the thermal water in the Bath-Bristol basin, Institute of Geological Sciences, Investigation of the Geothermal Potential of the UK, 1980 - [8],57p:ill,maps, W.G. Burgess ... [et al.]/ Burgess, W.G.; Andrews, J.N.; Lee, D.J.; Edmunds, W.M.; Kay, R.L.F.; Institute of Geological Sciences. - (Geothermal Energy Research Programme, Energy Resourcers; WJ/GE/80/2). - [508] Joint authors: W.M. Edmunds, J.N. Andrews, R.L.F. Kay and D.J. Lee. - ISBN X780053590
10. Wells and springs of Somerset (with a bibliography of the Bath thermal waters by W Whitaker)/ Richardson, L.; Whitaker, W.. - London : HMSO, 1928. - ; 279. - (Memoir (Water Supply) Geological Survey of GB; 1928). - ISBN X780014463
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Appendix 4 Copy of application to the NERC Airborne Remote Sensing Facility (ARSF)

The Use of Airborne Remote Sensing in Understanding the Evolution of Complex Landscapes

Kate Royse[1], Colm Jordan[1], Stuart Marsh[1], Andy Gibson[1] and Bill Murphy[2]

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INTRODUCTION

This proposal is designed to use an integrated package of advanced remote sensing and field data to generate a landscape model that will be used to understand processes of landscape evolution. The resulting knowledge will be applied to a range of landscape, heritage, conservation and geohazard issues. Understanding the evolution of complex landscapes, particularly where a complicated mix of cambering and landsliding have occurred, is crucial if we are to provide usable information on ground instability and hazard potential. In this study we will determine the evolution of the complex landscapes in the Bath area (Figure.1) by using a variety of remote sensing techniques, including LiDAR and ATM. The city of Bath is Britain's only World Heritage City and the countryside to the north and east is designated as an Area of Outstanding Natural Beauty (AONB). As well as surveying in the area, the BGS is advising English Partnerships on a number of issues related to ground instability in the city. The distinctive landscape created, in part, by the geomorphology that the cambering and landslides define, juxtaposes conservation, heritage and geohazard issues. The area therefore warrants a significant effort to understand better the continuing evolution of this complex landscape.

GEOLOGICAL BACKGROUND

The area around Bath is characterised by distinctive plateaux incised by steep-sided valleys formed by the river Avon and its tributaries. With its geology consisting of intercalations of limestone and mudstone belonging to the Lower and Middle Jurassic system (Table 1), a complex mixture of cambering and landsliding occur. Cambering (sometimes called valley bulging) is the warping and sagging of relatively competent strata e.g. limestone which overlies less competent strata e.g. clay. Landsliding is defined as the rapid movement of mass downslope along a curved or planar failure surface, without deformation of the soil structure. These processes interact to affect slopes in the Bath area and one of the scientific aims of this project is to differentiate between them and hence understand their relationship in terms of processes.

FORMATION	**GROUP**	*SYSTEM*
Forest Marble Formation	Great Oolite Group	Middle Jurassic
Chalfield Oolite Formation		
Fullers Earth Formation		
	Inferior Oolite Group	

Bridport Sand Formation	Lias Group	Lower Jurassic
Dyrham Formation		
Charmouth Mudstone Formation		
Blue Lias Formation		

Table 1. Middle and Lower Jurassic geological strata in the Bath area.

This aim has proved to be to much for conventional ground-based methods. On the published geological map the term "Foundered Strata" was used over a large portion of the map face, due to the difficulty in differentiating landslipped ground from cambered ground and from ground unaffected by either slope process. Difficulties exist because of a number of heavily wooded areas, which obscure the true profile of the slopes, and non-wooded areas, which have been subjected to agricultural processes that have obscured the original geological features. Wooded areas represent about 15% of the total study area, they typically have thick undergrowth, and mainly occupy the steeper slopes and escarpments. Hedgerows and wood boundaries often follow the edges of landslide features and geological boundaries, either being displaced by the landslide or replanted by the farmer (Privett, 1980). A hedgerow for example often marks a landslide's backscar. A previous remote sensing study in another part of the Cotswolds (Tragheim et al, 1999) did not have access to LiDAR data and so could not overcome this constraint.

Many other investigations have highlighted the significance of landslides in the Bath area (Anson, 1996; Cook, 1973; Chandler *et al*. 1976; Hawkins, 1977; Privett 1980; and Forster *et al*, 1985) particularly those within the area of "Foundered Strata" (Figure 1). However delineation, classification and understanding of these landslides' evolution has not yet been achieved. The literature suggests that the slopes in the Bath area were formed by a two-layered process: the upper zone of landsliding consisting of cambering and landsliding of Chalfield Oolite on Fullers earth and the lower zone consisting of cambering and landsliding of the Inferior Oolite on Lias. During a field recognisance visit (Hobbs and Jenkins, 2002) it was found that differentiating this two-layered process was not possible, as large parts of the area were obstructed by woods or had been masked by agricultural processes.

Once this landscape has been understood, it will be possible to model its likely evolution under various climate change scenarios. The landscape in the Bath area has developed largely as a result of the climatic conditions that have prevailed since the end of the Devensian glaciation. However it is believed that much of the cambering activity, particularly of the Inferior Oolite, took place prior to this (Chandler *et al*., 1976). Landslides were probably most active in the wet conditions of early post-glacial times and it is likely that the larger landslides were formed at this time. Under current climatic conditions many slopes are only marginally stable (Forster et al., 1985, Chandler et al. 1976). This means that a small adverse change in climatic conditions or slope profile may initiate reactivation.

AIMS AND OBJECTIVES

The overall aim of this project is to increase our understanding of landscape evolution in geologically and geomorhologically complex areas by developing an improved method of mapping and assessing hazard potential based on a 3D landscape model. This will be achieved through four main objectives:

1. Understanding the relationship between cambering and landsliding

Using LiDAR and ATM we will be able to delineate areas of landsliding and cambering. Using their morphologies, textures and orientations, we will be able to classify and date the processes chronologically as they occurred. This will allow us to understand the temporal relationship between cambering and landsliding and hence the evolution of the landscape in the Bath area. Cambering within the limestones must be closely associated with landsliding in the Bath area however neither tension cracks nor gullying have been observed in the field (Hobbs and Jenkins, 2002). These features are likely to have produced significant underground voids. Previous remote sensing work by Tragheim *et al.* (1999) and Rains *et al.* (1999) has shown that gulls and cambering can be picked out using aerial photographs and airborne thematic mapper multispectral data at 2m ground resolution because of topographical, mineralogical and moisture contrasts associated with them.

2. Analysing soil composition and distribution using spectral and thermal approaches

To obtain maximum benefit from the NERC ARSF imagery, it will be useful to carry out a calibration of the radiance data provided to absolute reflectance. This will ensure that any image analysis methodologies derived during this research are useable elsewhere in space and time will enable the direct comparison of our results with similarly converted results gathered in the UK (Milton et al 2000). This will also make any subsequent comparison of the imagery with ground-based geochemical analysis a simpler process. Of the usual methods of performing a radiometric calibration, the most practical, bearing in mind the uncertainty of flight times and weather conditions would be the three-point calibration method whereby the reflectance of known targets is measured and used to carry out a relative calibration of the radiance data. (Emery *et al.*, 1998, Smith & Milton, 1999).

A number of spectrally stable targets have been identified within the proposed survey area, with a variety of surfaces including tarmac, building stone and relatively stable golf course bunkers. Field measurements of these properties will be taken using an appropriate field spectrometer. This will not allow for the perfect calibration of the airborne data (although calibration could be further improved if topography were to be taken into account by integrating the LiDAR survey) but it will transform the data from a single, one-off flight into a more useful 'baseline' data set. It will also assist in the spectral and thermal analysis of clay and carbonate minerals and moisture contrasts in the soils associated with the cambered strata.

3. Developing a 3D landscape model of the Bath area.

Subtle changes in the slope morphology across the area of study will provide us with clues to the evolution of the landscape. The use of LIDAR with its ability to “see through trees” will provide us with the first ever-accurate DTM of the Bath area so that they can be accurately surveyed. Together with the ATM data on soil moisture and mineral content this will allow a detailed, 3D landscape model of the area to be produced so that the overall geomorphology can be assessed and visualised within the context of the geology and soils.

4. Automating feature mapping techniques in areas of complex landscape evolution

With this study we will develop a methodology for the understanding of landscapes in other areas where the original morphology has been obscured by landslips and cambering. Bath is similar to many areas in the British Isles where a complex history of post-depositional processes have taken place. Their accurate delineation whilst in the field is prevented due to tree cover and recent agriculture processes, which have obscured the original geological and geomorphological features. The landscape model created here will be used to understand landform and then develop automated geomorphological feature extraction by applying image analysis and GIS tools to the 3D model.

Related BGS, Leeds University and Local Authority Studies

This project will form an essential part of a larger body of work within the Urban Geoscience and Hazards Programme and the Integrated Geoscience Survey of Southern Britain Programmes of BGS. BGS Science Budget funding will support the combination of the proposed NERC ARSF data analysis with additional fieldwork to be carried out in the summer of 2003. The project teams under these two BGS programmes have been tasked with developing a method of assessing and classifying land instability, and providing a methodology for improving the mapping of landslides and mass movement deposits in the area north of Bath, formally known as “Foundered Strata”.

The teams also work closely with members of the Combe Down Data review group who provide geoscientific advice with respect to the Combe Down Stone Mines remediation work on behalf of Bath and North East Somerset district councils. PhD students at the University of Leeds, working under Dr. W Murphy, will undertake some of this fieldwork by collecting and analysing samples as part of the University Collaboration scheme taking place between BGS and the university.

The data collected from LIDAR and ATM will not only provide a greater understanding of the evolution of this complex landscape, but will also be used to test a new landslide database and field recording system being developed within the British Geological Survey. It is expected that the study will provide some of the line-work on the new digital 1:50,000-scale geological map of the area. The final outcome will be a methodology for field geologists mapping landslipped terrain elsewhere in the UK to follow, combining remote sensing with both traditional and modern ground-based methods.

STUDY AREA

The proposed study area lying within ST692, 749 to ST858, 625 covers part of the area termed "Foundered Strata" on the current 1:50,000-scale geological map (Figure 1). This is the ideal research area, denoted by red crossed lines in Figure 2, but if this is considered to be too extensive an area then we believe we would be able to fulfil our scientific objectives if the 'refined study area' indicated in green were to be flown. It should be noted that while the EA has partial LiDAR coverage for the area (Figure 2), to our knowledge this only covers the northern tip of the 'Floundered Strata' and therefore does not cover a large enough region to increase our understanding of the geological processes involved. Moreover we expect to combine the LiDAR with ATM data which to the best of our knowledge does not exist for this study area and should in any case be acquired contemporaneously with the LiDAR.

REMOTE SENSING METHODOLOGY

The proposed research using the NERC Airborne Remote Sensing Facility is designed to answer scientific questions raised following BGS geological mapping of the Bath area (Hobbs & Jenkins, 2002). To map and differentiate the key features of the local geomorphology and investigate the associated heterogeneity of the surficial deposits, BGS is requesting the use of two sensors aboard the ARSF aircraft, **LiDAR** and **ATM**.

LiDAR is required for three reasons:

1. The high x, y and z resolution of LiDAR data is necessary in order to distinguish these landforms which lie within the range between 5m and 500m in scale. While the larger features can be seen on satellite imagery, the smaller features cannot be adequately mapped without using large-scale aerial photography.
2. Ground height data measured by the Optech instrument will enable penetration of the forestry that covers part of the study area for the first time, providing a clear advance over aerial photography and the derivative products such as DEMs that can be produced using digital photogrammetry.
3. Because the LiDAR data are digital, the BGS can apply the visualisation techniques we are developing to model and understand geology and landform and convey that understanding to the wider academic community and the public at large (Jordan, 2001; Marsh *et al.*, 2000; Thomas *et al.*, 2002).

ATM data are requested for two reasons:

1. To apply the thermal band in an attempt to understand the distribution of the sediments and soils based on their likely variation in thermal properties. The thermal band should enable related characteristics of the sediments such as moisture content to be inferred via their thermal properties, even below a cover of grass. This would make it possible to link morphology to texture in the landform analysis and therefore to define for the first time a direct correlation between, for example, the clay content and cambering. This could potentially illuminate where and why cambering occurs, enabling a classification of the landforms and their effects on the landscape both locally and throughout the region.
2. To use a daytime acquisition of the visible, near and short-wave infrared channels of the ATM sensor to characterise the surface materials in two ways. These data could help geologists to gauge the 'texture' of the deposits either when directly exposed through ploughing or via their effects on surface vegetation. They could also be used to attempt to differentiate clay and carbonate minerals where they are exposed based on spectral contrasts and thus supplement the information provided by the thermal band.

BGS has experience using both pre dawn NERC ATM thermal imagery to locate subsurface anomalies (disused mineshafts) despite masking by vegetation (Marsh 2000, Ager *et al.*, 2002) and using daytime NERC ATM optical imagery to map variations in soil composition (Tragheim *et al.*, 1999). Ideally, separate pre-dawn and daytime acquisitions would be made to support this research. If this were not possible, then a compromise strategy would be to acquire the ATM data shortly after sunrise, when solar heating effects are still at a relatively low level but there is sufficient incident radiation to record meaningful data in the optical bands. Either way, the combination of the ATM and LiDAR data would be critical in helping develop our understanding of these landforms and thus in assessing their impact on society. The integrated analysis of these data sets would help to answer key science questions through:

- Slope analyses – to determine if the clays, known to be associated with cambering, occur within a certain range of slope angles. If this is so it would lead to a new understanding of their interrelationship and help predict the geotechnical properties associated with certain landforms.
- Anaglyph visualisations and stereo interpretations of the ATM data (developed using the LiDAR DEM) would help the geoscientists understand the landscape evolution and provide an arresting way to convey that knowledge to the wider community.

ANTICIPATED OUTPUTS

This study will produce a range of outputs relating for the most part to our developing understanding of this complex landscape. We intend to contribute to peer-reviewed publications and conferences on both the methodology developed and the geoscience knowledge gained. The application of these techniques will also lead to new BGS maps based in part on the ARSF data and to the population of national landslide databases with data that cannot be obtained using conventional field methods. This project will provide a methodology for the study of complex landscapes which will be applied further in consultation with Leeds University to help set-up a national classification of mass-movement / landslide morphology and hence contribute to wider geohazard surveying within the UK.

Appendix 5 Current version of the New Landslide Database Field Notebook Pro-forma

BGS Landslide Pro-Forma Image Sheet No.

Attach and number further sheets as necessary

Landslide ID	Survey No	Original No	Total Number of Image Sheets
- - -			

Image Type	Image Identifier

Comments	

BGS 1835

Section F: Sketch map, diagrams, photo attachments, additional information.

Any locations and positions of landslide features, lithologies, springs, buildings, infrastructure and other features should be accompanied by a scale wherever possible to allow input into database system. *Use space also to add any further information sources or references.*

Designed by Ken Lawrie August 2002

BGS Landslide Pro-Forma P1

NGR Easting | Acc.

Landslide ID
Will be automatically allocated

Survey No

OS Sheet or 1:10 000 Sheet

NGR Northing | Prov.

Original Number

Surveyed By(BGS Code)

Survey Date

Pro Forma Geologist

Locality Name

Locale Details(county, district, distinctive landmarks nearby......)

Section B: Landslide Dimensions

Elevation of Crown | Prec.

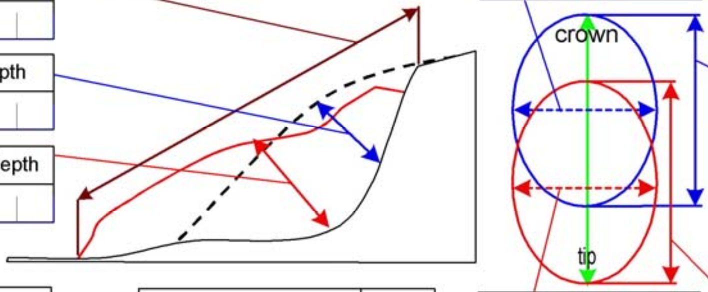
Rupture Max Width

Aspect
N
W E
S

Total Slide Length

Rupture Max Depth

Disp. Mass max Depth



Rupture Max Length

Length of Centre Line

Disp Mass Max Length

Dom. Source Material

Elevation of Tip | Prec.

Disp Mass Max Width

Section C: Landslide Detail

Slide Material

Stability Development

Stability Degree

Est Age

Slide H2O

Slide H2O Pos

Slide Veg.

Movement

Style

First Movement Date | Prec.

Last Movement Date | Prec.

Type	Order	Comments

Causal Factors

Cause	Nature	Comments

Designed by Ken Lawrie June 2002

BGS Landslide Pro-Forma P2

BGS 1835

Landslide ID	Survey No	Original No

Section D:Slope Detail

Profile	Slope Angle	Slope Height	Prec	Slope Veg	Slope H2O	Slope H2O Pos

Aspect

N

W E

S

Damage

Landuse Code	posn	Damage Y/N	Comments

Lithology

Fault control Y/N

Lithology	Strat / Formn.	Comments	Elev Top	Elev Base
Bed. Spacing	Bed.Dir.		Joint Spacing	Joint Dir.
Bed. Spacing	Bed.Dir.		Joint Spacing	Joint Dir.
Bed. Spacing	Bed.Dir.		Joint Spacing	Joint Dir.
Bed. Spacing	Bed.Dir.		Joint Spacing	Joint Dir.

Section E: Additional Comments

Springs, diverted streams, soft ground, antecedent weather, distorted trees, disruption of field patterns, disp' volume, dating evidence, access to land.....Cont' on Diagram Sheet if necessary

Information Sources

Source Type (e.g. media, survey, telephone call...), source (e.g. Newspaper, fieldslip, private individual...)
Full reference must be filled in. Continue on diagram sheet if necessary.

No	Src. Type	Source	Comments	Full Reference
1				
2				
3				
4				

Designed by Ken Lawrie July 2002

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