

APPENDIX A – SUPPLEMENTARY INFORMATION FOR THE GIS ASSESSMENT

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Table A.1 – Criteria used to interpret BGS ROCK codes to indicate source material availability.

Score	Criteria
10	<ul style="list-style-type: none"> Granular superficial material – sand, gravel, boulders including silt and clay if they are minor components. Diamicton is assumed to be granular and capable of being mobilised. Loose material such as talus. Material that might reasonably be assumed to be so on a worst-case scenario such as made ground and fill If dense lodgement till could be distinguished from the above materials it could be assigned a lower rating, perhaps 5 might be appropriate on the basis that material in the near surface zone would be sufficiently weathered to become mobilised in the same way as a less dense melt out till would be mobilised.
9	<ul style="list-style-type: none"> Materials at the finer end of the coarse materials with some silt and clay but not enough to stabilise the material if copious water were present.
8	<ul style="list-style-type: none"> Materials with clay and silt listed as the major component. Probably sufficient fine material to stop debris flow mobilisation unless the components are present as discrete bodies that could be mobilised and the finer components then incorporated. Their potential for being mobilised may be overestimated at this score and subdivision and rescoring on geomorphological grounds may improve this. Possibly raised deposits go to score of 7 or 6 and the flat lying deposits go to a score of 1. Materials in the highest class of the accumulation model are assigned this score as described in Section 4.2.2
7	<ul style="list-style-type: none"> Landslip and worked ground are included in this group on the basis that they are probably loose and at residual strength but may be fine-grained.
6	<ul style="list-style-type: none"> No mapped materials are assigned to this score but accumulation materials as identified by the methodology described in Section 4.2.2 are assigned this value.
5	<ul style="list-style-type: none"> This score has been assigned to bedrock lithologies that were considered the most likely to develop a significant regolith that could be mobilised by flowing water. Thus the regolith would be predominantly the result of physical weathering and comprise coarse material either through the induced fracturing along incipient discontinuities (schists, pelites semipelite etc) under the influence of freeze/thaw activity or lesser thermal effects or the break up of inter-mineral bonds by the break down of some of the mineral components (coarse grained igneous rocks, granites, migmatites etc). The working party report noted that schist and granite were associated with debris flows, an observation that supports this classification.
4	<ul style="list-style-type: none"> This score has been assigned to bedrock lithologies that appear less likely to generate a granular regolith because: <ul style="list-style-type: none"> They comprise mixed sedimentary rock with lithologies that contain some clay rich components that may soften and bind the regolith together e.g. undivided cyclic sedimentary rocks, ‘sandstone, siltstone, mudstone’, greywacke. Are mainly stronger and have a lesser propensity for breaking along discontinuities than the pelite/semipelite lithologies. These lithologies are the more gneissose semipelites. Also included here are fine grained igneous rocks such as basaltic and andesitic lavas that are assumed to have large numbers of discontinuities due to cooling joints or a rubbly fabric that would assist their weathering, along with tuffs which are all known, in some instances to weather to a granular regolith.
3	<ul style="list-style-type: none"> Sedimentary conglomerates are included on the basis that the individual components might weather out of a weaker matrix.
2	<ul style="list-style-type: none"> These materials are assumed to have relatively few discontinuities that would allow them to form an extensive granular regolith and to be relatively resistant to chemical weathering. Although some of the basic igneous intrusions would be more likely to form clay-rich weathering products than the other lithologies in this group. These materials include sandstones, psammites, and minor igneous intrusions (both basic and acidic).
1	<ul style="list-style-type: none"> These materials are those which are considered unlikely to be mobilised as a debris flow because <ul style="list-style-type: none"> They are too silty or clayey. They are limestones that would dissolve rather than form a regolith. They are high-grade metamorphic psammite/gneiss and would be unlikely to form a regolith due to their strength and chemical stability.

Table A.2 – Criteria used to determine the rating of available debris material score from the deceleration data.

Deceleration Range	Material Score
0.0 to 0.025	8
0.025 to 1	6

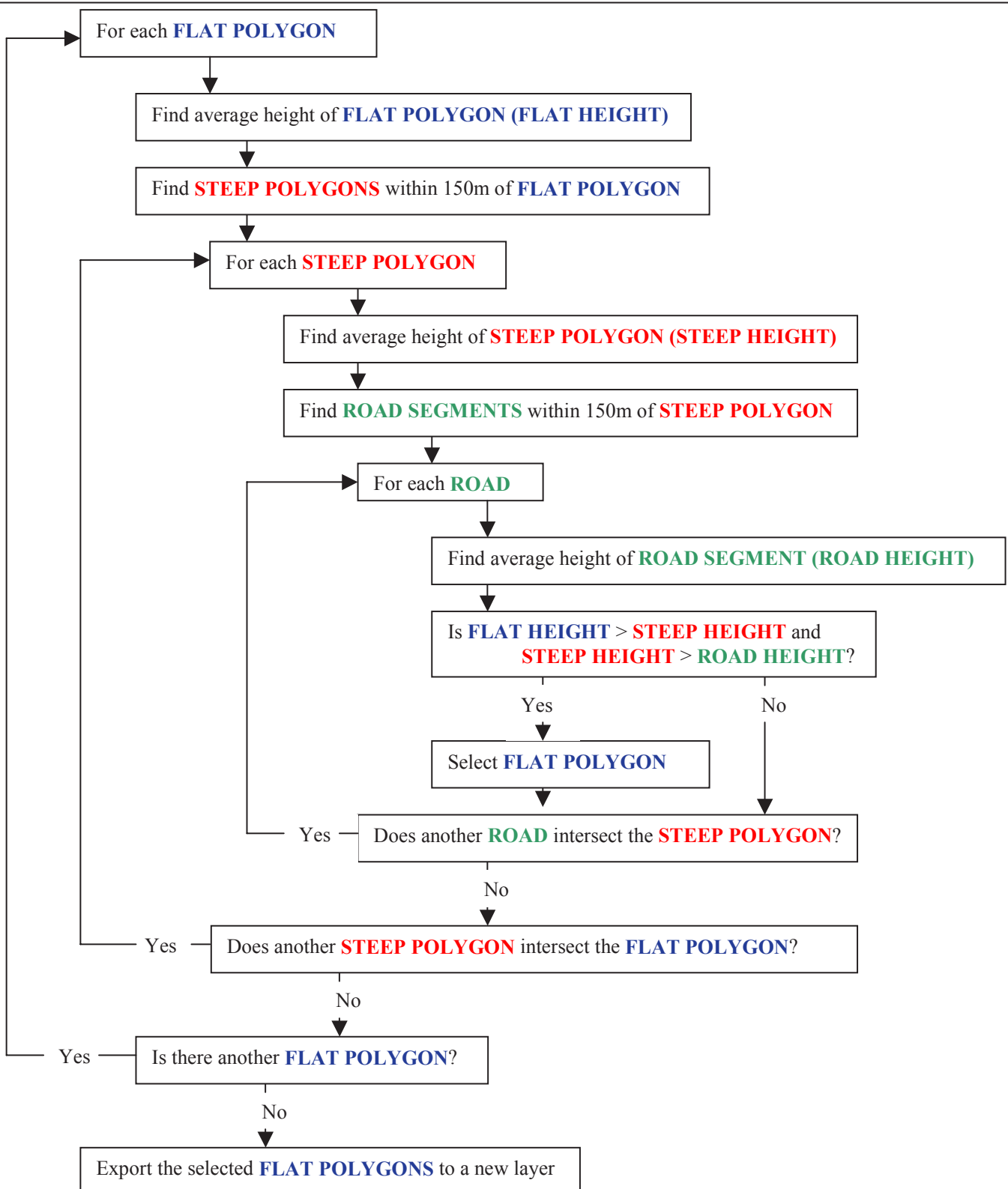
Table A.3 – Criteria used to interpret BGS ROCK_D codes to indicate hydrogeological influence upon debris flow formation.

Score	Criteria
10	<ul style="list-style-type: none"> Formations including superficial and bedrock deposits of silts and clays with little permeability due to their fine particle size and bedrock formations of gneissic or plutonic formations whose low porosity and very widely spaced discontinuity spacing results in a low permeability.
9	<ul style="list-style-type: none"> These formations comprise metamorphic rocks expected to have very low porosity and widely spaced, tight discontinuity spacing.
8	<ul style="list-style-type: none"> These formations comprise fine-grained metamorphic rocks (pelite), uniform sandstone (quartzite) and mixed sequences of mudstone/siltstone/sandstone that might be expected to have slightly more discontinuities than the previous class.
7	<ul style="list-style-type: none"> These formations comprise sandstone, minor igneous intrusions (i.e. not plutonic), limestone, conglomerate and lava which are likely to have moderately spaced discontinuities that might be expected to form a three dimensional pattern rather than a planar one and thus promote downward drainage.
6	<ul style="list-style-type: none"> These comprise clay or silt rich superficial deposits that may have a small under drainage capacity if they contain discrete units of coarse material and a small number of lithologies with properties that are not easily predicted such as landslip, fault crush and worked ground.
5	<ul style="list-style-type: none"> No materials are assigned to this score.
4	<ul style="list-style-type: none"> No materials are assigned to this score.
3	<ul style="list-style-type: none"> No materials are assigned to this score.
2	<ul style="list-style-type: none"> No materials are assigned to this score.
1	<ul style="list-style-type: none"> These materials are superficial deposits that are or may be expected to contain significant amounts of sand and/or gravel that would allow some under drainage of overlying material.
0.1	<ul style="list-style-type: none"> These are superficial deposits that comprise primarily sand and gravel which would offer significant under drainage possibly to the extent that the passage of a debris flow on low slope angles could be slowed and pore water from antecedent rainfall might be dissipated relatively quickly.

Table A.4 – Criteria used to interpret CEH Landcover rating for debris flow hazard potential.

Score	Landcover 2000 Level 1	Landcover 2000 Level 2	Landcover 2000 Level 3	CEH Code	Comments
1	Sea/estuary	Sea/estuary	Sea, estuary	22.1	Not applicable - effect neutral
1	Water (inland)	Water (inland)	Water (inland)	13.1	Not applicable - effect neutral
1	Littoral rock and sediment	Littoral rock	Rock and rock with algae	20.1	Bare coastal slope may promote debris flows otherwise not
1	Supra-littoral rock and sediment	Littoral sediment	Mud, sand and sand with algae	21.1	Not applicable - effect neutral
1		Saltmarsh	Saltmarsh (Grazed/ungrazed)	21.2	Not applicable - effect neutral
1		Supra-littoral rock	Rock	18.1	Bare coastal slope may promote debris flows otherwise not
1		Supra littoral sediment	Shingle, vegetated shingle, dune, dune scrub	19.1	Bare coastal slope may promote debris flows otherwise not
1		Bog	Bog: shrub, grass/shrub, grass/herb Peat >0.5 m.	12.1	Not applicable separate assessment
0.85	Dwarf shrub heath	Dwarf shrub heath	Dwarf shrub heath (ericaceous/gorse) Peat <0.5 m thick	10.1	Some reinforcement by shrubs, better than grass.
0.9	Montane habitats	Open shrub heath	Open shrub heath (ericaceous/gorse)	10.2	Some reinforcement by shrubs, better than grass.
0.9	Broad-leaved/mixed woodland	Montane habitats	Montane vegetation	15.1	Mixed, reinforcement depends on vegetation type - better than
0.7	Coniferous woodland	Broad-leaved/mixed woodland	Scrub, open birch and deciduous mixed, broadleaved	1.1	Good stabilising effect through root reinforcement and soil
0.7	Arable and horticulture	Coniferous woodland	Conifers, new plantation and felled	2.1	Good stabilising effect through root reinforcement and soil
1.2	Improved grassland	Cereals	Barley, maize, oats % wheat	4.1	Bare ground - no root strengthening, loose condition
1.2	Neutral grassland	Arable horticulture	Bare, root crops, cropped legumes, linseed, rape, mustard,	4.2	Bare ground - no root strengthening, loose condition
0.9	Improved grassland	Non rotational horticulture	Orchard, ley, set aside	4.3	Mixed, orchards 0.75 but ley and set aside 0.9. Will be mostly ley
0.95	Neutral grassland	Improved grassland	Intensive grazing, hay/silage cut, grazing marsh	5.1	Slight reinforcement - better than bare ground.
0.9	Calcareous grassland	Setaside grass	Grass set aside	5.2	Some reinforcement - better than bare ground.
0.9	Acid grassland	Rough grass	Rough grass	6.1	Some reinforcement - better than bare ground.
0.9	Bracken	Managed neutral grass	Grass (neutral/improved)	6.2	Some reinforcement - better than bare ground.
0.9	Fen, marsh, swamp	Calcareous grass	Calcareous (managed, rough)	7.1	Some reinforcement - better than bare ground.
0.9	Built up areas, gardens	Acid grass	Acid	8.1	Some reinforcement - better than bare ground.
0.85	Inland bare ground	Bracken	Acid with <i>Juncus</i>	8.1	Some reinforcement - better than bare ground.
1		Fen, marsh, swamp	Acid <i>Nardus/Festuca/Molinia</i>	8.1	Some reinforcement - better than bare ground.
1.1		Suburban/rural developed	Bracken	9.1	Stoloniferous roots reinforce ground.
1.1		Continuous Urban	Swamp, fen/marsh, fen willow	11.1	Not applicable separate assessment
1.1		Inland bare ground	Suburban/rural developed	17.1	General infiltration impeded but potential for focused drainage
1.1			Urban residential/commercial	17.2	General infiltration impeded but potential for focused drainage
1.1			Despoiled/semi-natural	16.1	Bare ground - no root strengthening

Table A.5 – Algorithm for generation of flat areas above roads

**Key**

- **FLAT AREAS:** Areas with slopes less than 2 degrees. Intersected by catchments and roads. Clipped by a 3km buffer of the roads.
- **STEEP AREAS:** Areas with slopes greater than 5 degrees. Intersected by catchments and roads. Clipped by a 3km buffer of the roads.
- **ROADS:** Trunk roads only

Table A.6 – Criteria used to assess slope angle as part of debris flow hazard assessment.

Score	Slope Angle (degrees)	
0.5	0-7	Generally stable and only influencing the run-out characteristics of a debris flow.
1	8 - 15	Slopes within this range that occurred between a road and an area of debris flow hazard were likely to maintain the movement of the debris flow and facilitate its impact on the road although it was unlikely to be sufficiently steep to allow the initiation of a debris flow within it.
6	16 - 30	It appears that debris flows may be initiated on slopes within this range but it would be equally likely that additional material would be incorporated within this zone.
9	31 – 45	This slope range is considered the most likely to initiate debris flows based on the experience of the working group. This would appear to be sensible in that the peak angle of shearing resistance of dry granular material might be expected to be in this range (BS8002:1994).
10	Slope > 45	It is logical that slopes in the >45 ⁰ class should have a factor or weighting greater than the 31- 45 class in recognition of the increased driving force associated with the increase in the down slope component of shear stress.

Table A.7 – Weightings for the assessed factors. Min, Max, Range and Mean values given before weighting.

Factor	Weighting	Maximum Value	Minimum Value	Range	Mean
Lithology	x 1	10	1	9	6.68
Water conditions	x 1	10	0.1	9.9	4.33
Vegetation	x 0.75	1.2	0	1.2	0.92
Stream channel	x 0.75	10	0	10	0.88
Slope angle	x 1.25	10	0.1	9.9	2.08

Table A.8 – Class values for final data.

Class	Value
A	0-12.0
B	12.1-15.0
C	15.1-16.5
D	16.6-18.0
E	>18.1

Table A.9 – Shortened Field names for statistics calculated from the landslide data against the trunk road network.

Group of statistics calculated by road section	Number of points along section (only valid for trunk road network)	POINT_NO
	X-coordinate of start point of road section	START_X
	Y-coordinate of start point of road section	START_Y
	X-coordinate of end point of road section	END_X
	Y-coordinate of end point of road section	END_Y
	Length of section	S_LENGTH
	Highest point along section	S_HIGH
	Lowest point along section	S_LOW
	Average height along section	S_MEAN
Group of statistics calculated on catchments intersecting the road section. These are the areas that would be likely to yield material for a debris flow. (from intersection of NEXTMap DTM, NEXTMap slope model and catchments)	Number of catchments intersected	C_COUNT
	Total catchment area (m ²) intersected	C_AREA
	Highest point in catchment	C_HIGH
	Lowest point in catchment	C_LOW
	Average height in catchment	C_MEAN
	Maximum slope	C_MAX_SLOPE
	Minimum slope	C_MIN_SLOPE
	Average slope	C_AVE_SLOPE
Group of statistics calculated within the intersected catchments (from debris flow hazard grid and NEXTMap DTM)	Maximum debris flow hazard score	H_MAX
	Maximum debris flow hazard class	H_MAX_CLASS
	Minimum debris flow hazard score	H_MIN
	Minimum debris flow hazard class	H_MIN_CLASS
	Average debris flow hazard score	H_MEAN
	Average debris flow hazard class	H_MEAN_CLASS
Group of statistics calculated within the intersected catchments (from component hazard grids)	Maximum lithology score	H_LITH_MAX
	Minimum lithology score	H_LITH_MIN
	Average lithology score	H_LITH_MEAN
	Maximum water conditions score	H_WATER_MAX
	Minimum water conditions score	H_WATER_MIN
	Average water conditions score	H_WATER_MEAN
	Maximum vegetation score	H_VEG_MAX
	Minimum vegetation score	H_VEG_MIN
	Average vegetation score	H_VEG_MEAN
	Maximum stream channel score	H_STREAM_MAX
	Minimum stream channel score	H_STREAM_MIN
	Average stream channel score	H_STREAM_MEAN
	Maximum slope angle score	H_SLOPE_MAX
	Minimum slope angle score	H_SLOPE_MIN
	Average slope angle score	H_SLOPE_MEAN

