Telford & Wrekin Co-operative Council

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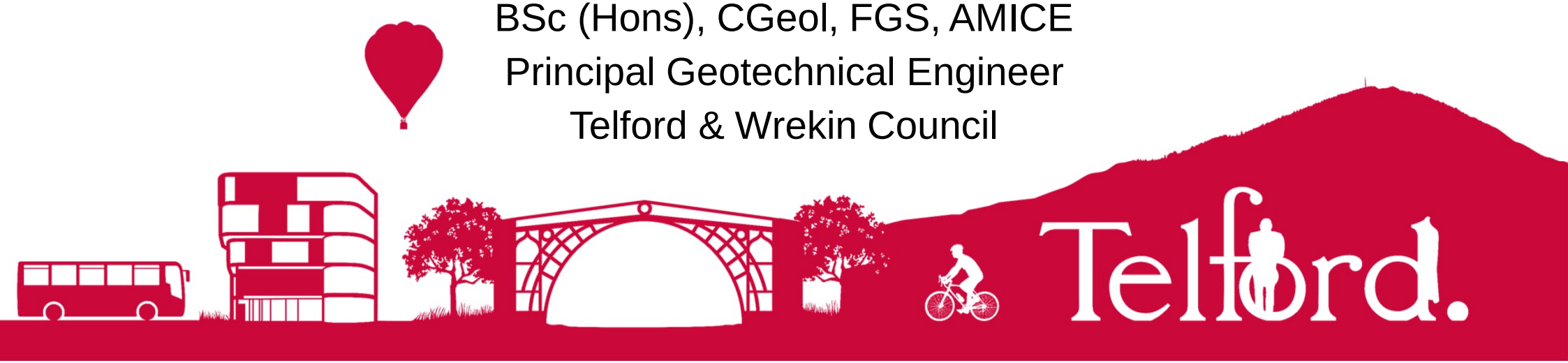
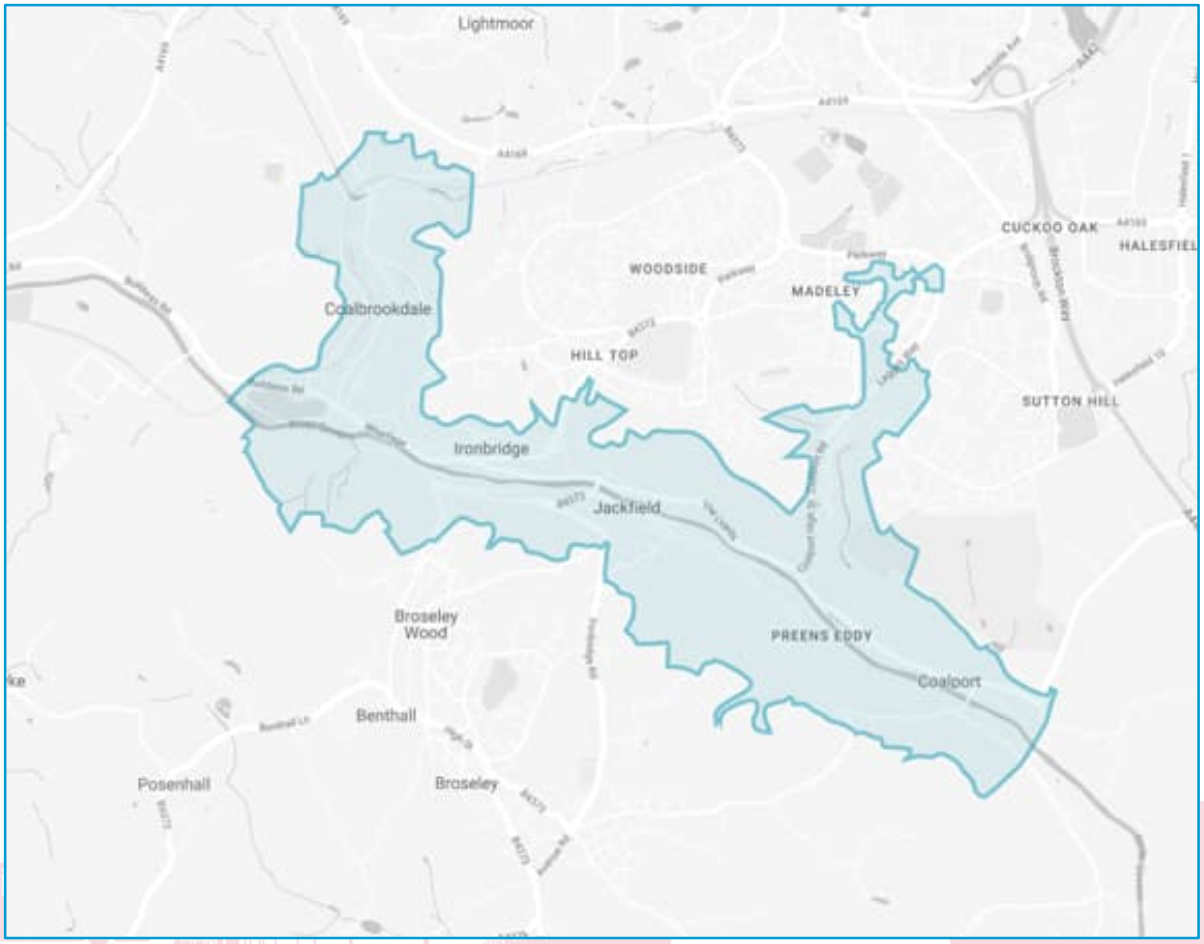
Land Instability in the Ironbridge Gorge

Chris Bullas
BSc (Hons), CGeol, FGS, AMICE
Principal Geotechnical Engineer
Telford & Wrekin Council

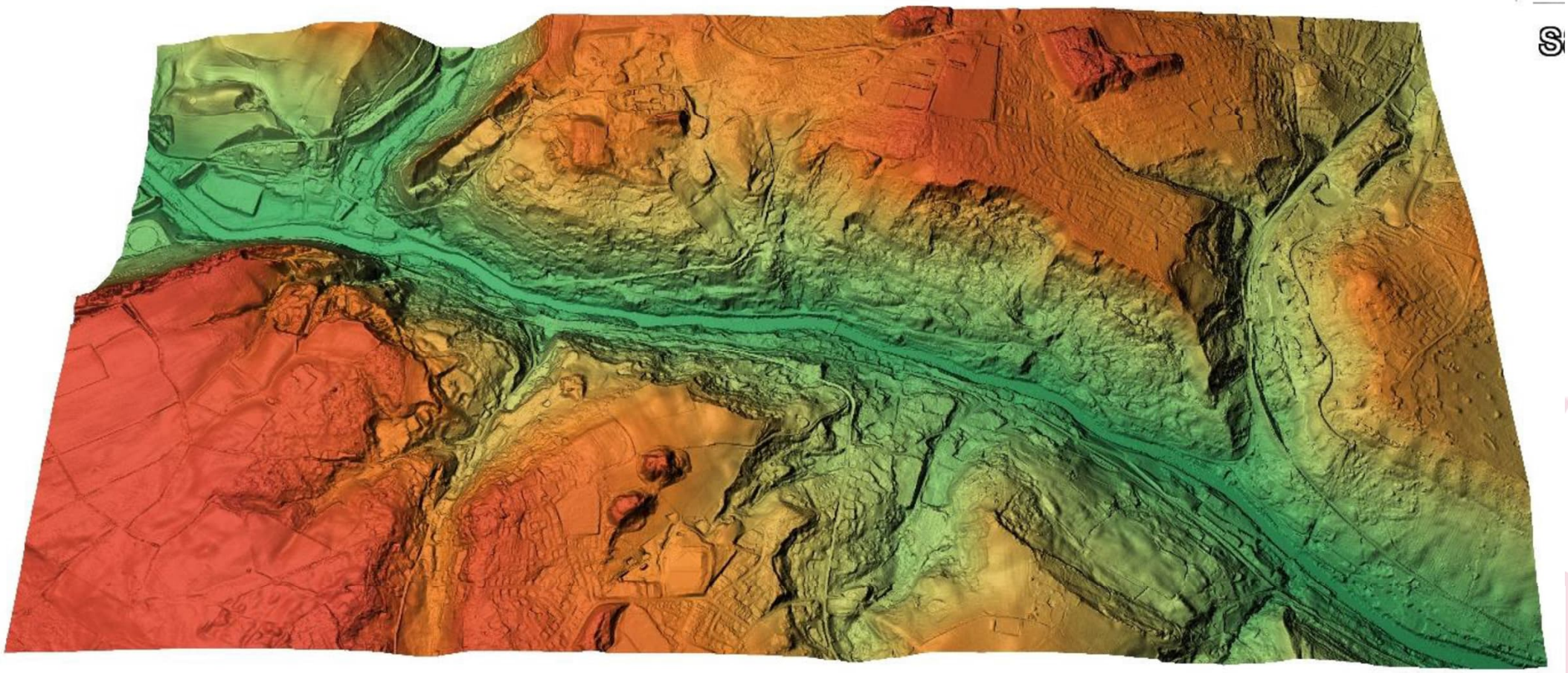


Location & Topography



The Ironbridge Gorge World Heritage Site (IGWHS) spreads over 550ha. Approximately three quarters of the area falls within the Borough of Telford & Wrekin Council.

Coalbrookdale
THE GORGE CP
River Severn
Severn Way
Ironbridge Gorge
Ironbridge
Woodside
Madeley
MADELEY CP
Sutton Hill
Jackfield
Coalport
Coalford
Benthall
Benthall Edge Wood
Lloyd's Coppice
Tweedale
Timber Wood
Birches Coppice
The Lodge
Westminster Farm
Marnwood Hall
Strethill
Captain's Coppice
Workings
Power Station (dis)
Albert Edward Bridge
The Meadow
Vane Coppice
Cherry Tree
Oilhouse Coppice
Woodside
Rough Park
Dale Coppice
Castle Green
Cemy
Lightmoor Junction
Balancing Lakes
Playing Field
Madeley Court
DRY SKI SLOPE
Works
A 4169
School
Acad
Resr
Playing Field
Sutton Wood
Monarch's Way
Blists Hill
Lee Dingle
The Villas
Hotel
Sutton Hill Farm
Suttonhill House
Telford Golf Club
Dogkennel
Sutton Wood Farm
Coalport Bridge
Sweyney Cliff
China Works
Tar Tunnel
Silkin Way
Preenshead
Corbett's Dingle
The Tuckies Farmhouse
Woodhouse Farm
Salthouses
The Lloyds
Cross Britain Way
Shropshire Way
FURNACES
Ladywood
Broadacres Farm
Workhouse Coppice
Benthall Edge
Banghams Wood
Hungerdale Farm
Benthall Hall Farm
Benthall Hall
The Vineyards
The Avenue
Barnetts Leasow Mound
Stocking Mound
Cockshot Mound
Barratshill Farm
Ironbridge Road
Wyke



Telford & Wrekin Co-operative Council

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Roads and Retaining Walls

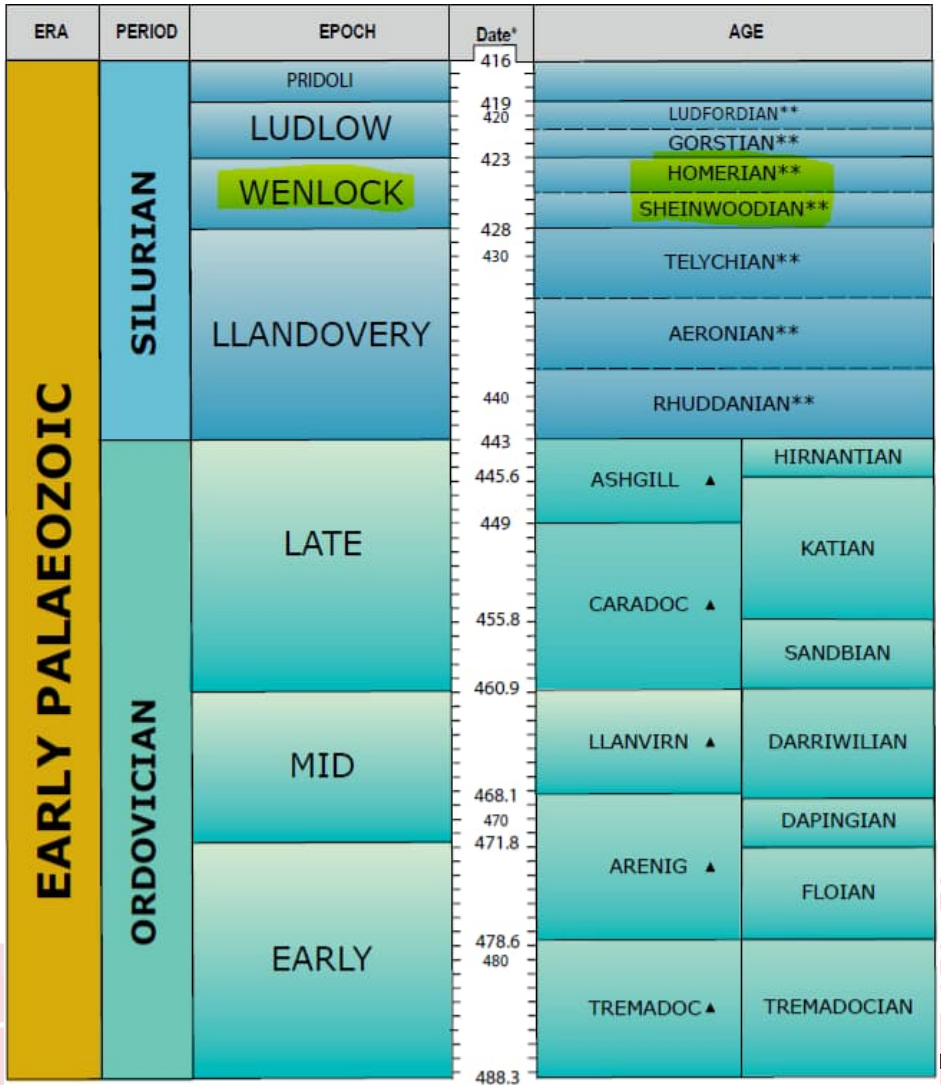
Prehistory

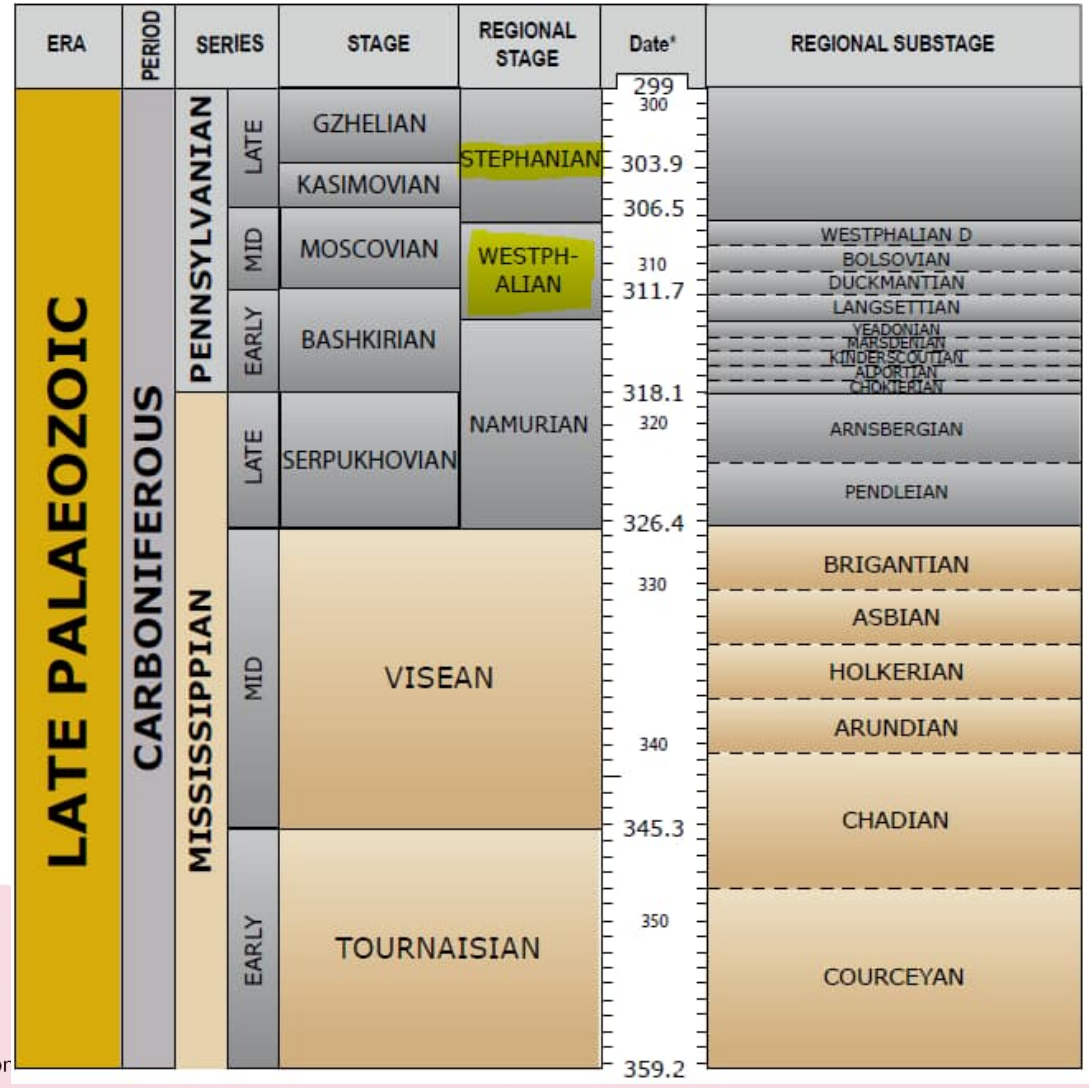
- Silurian
- Carboniferous
- Ice Ages

Telford & Wrekin Co-operative Council

Protect, care and invest to create a better borough

Solid Geology





Telford & Wrekin Co-operative Council

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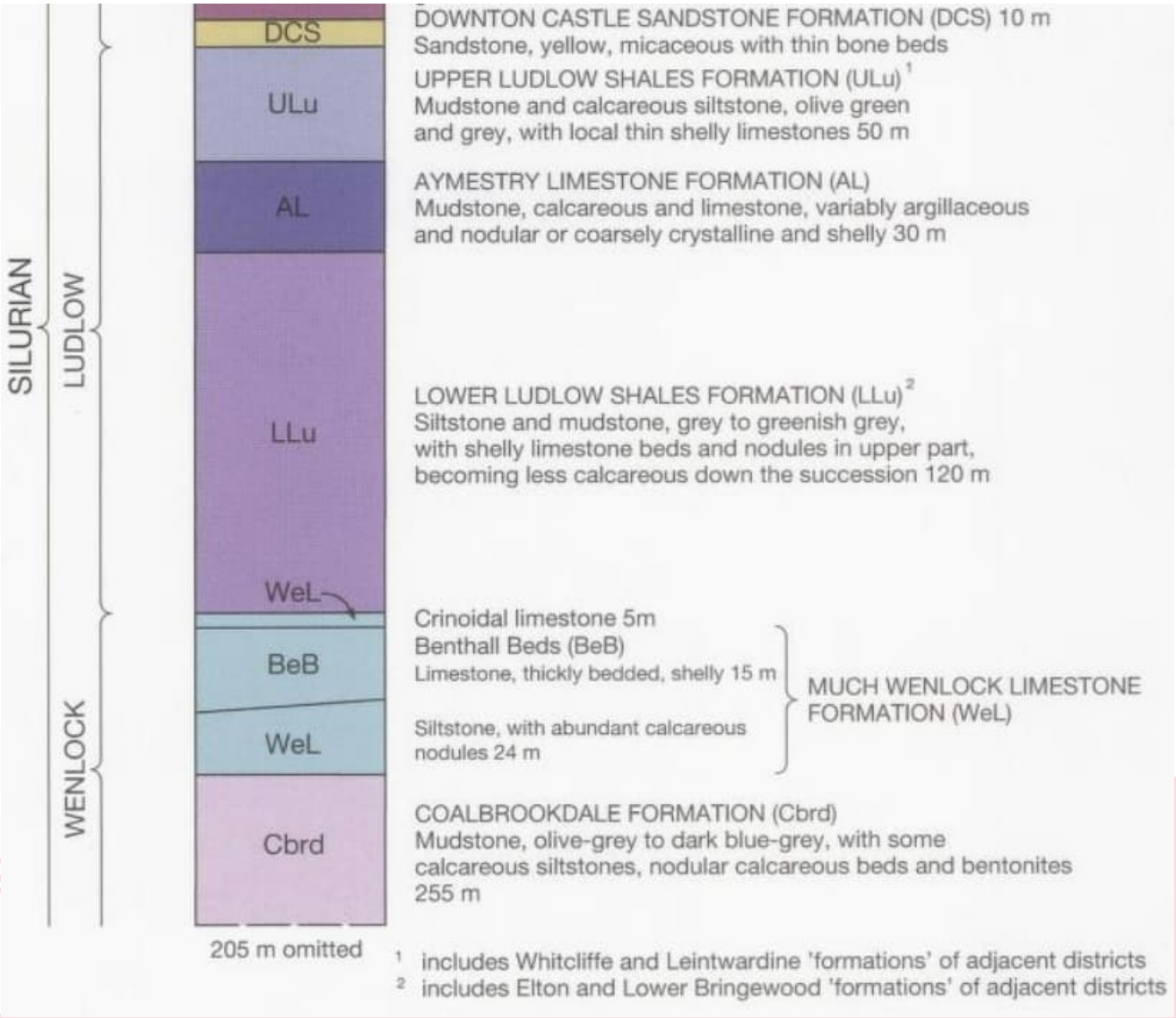
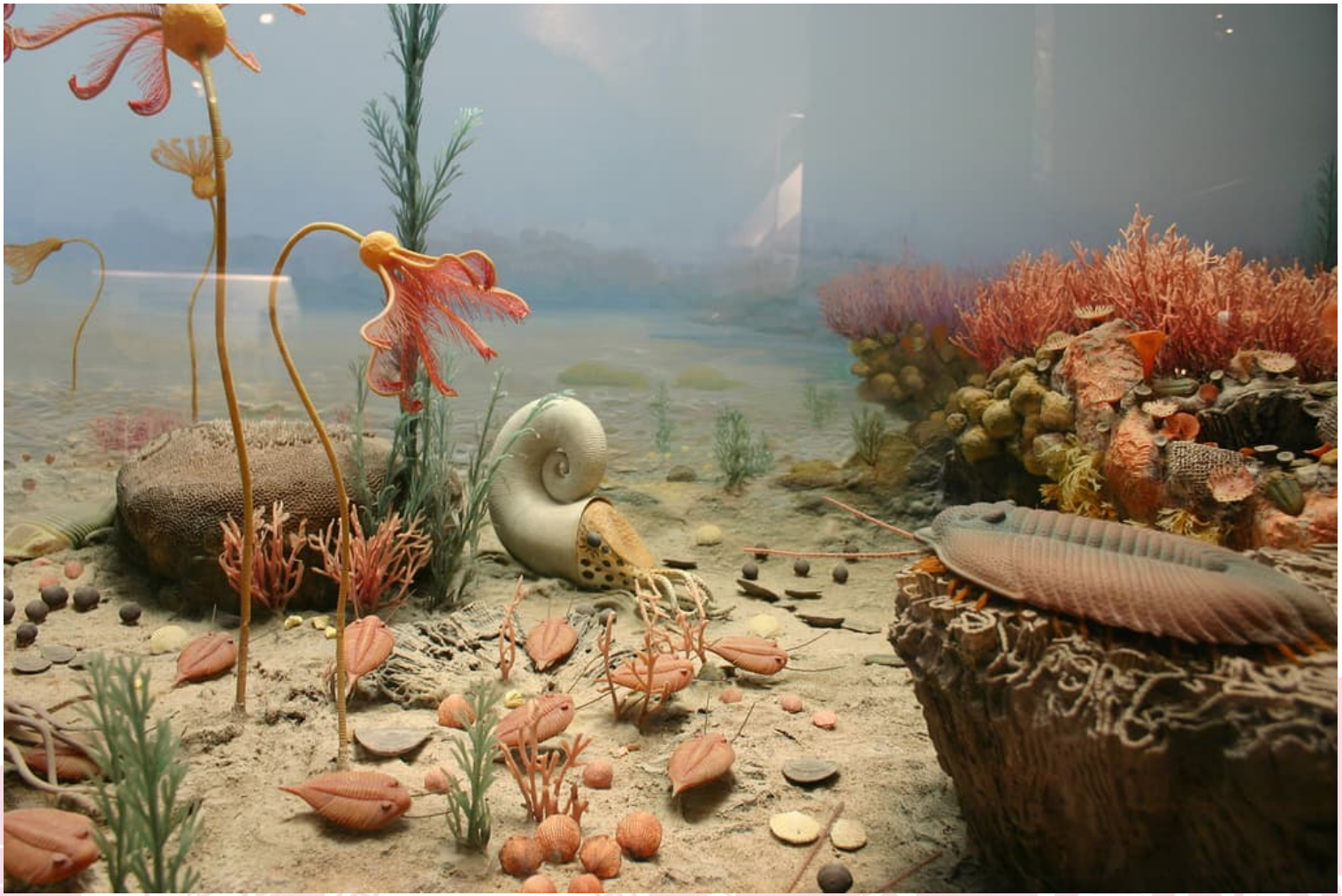
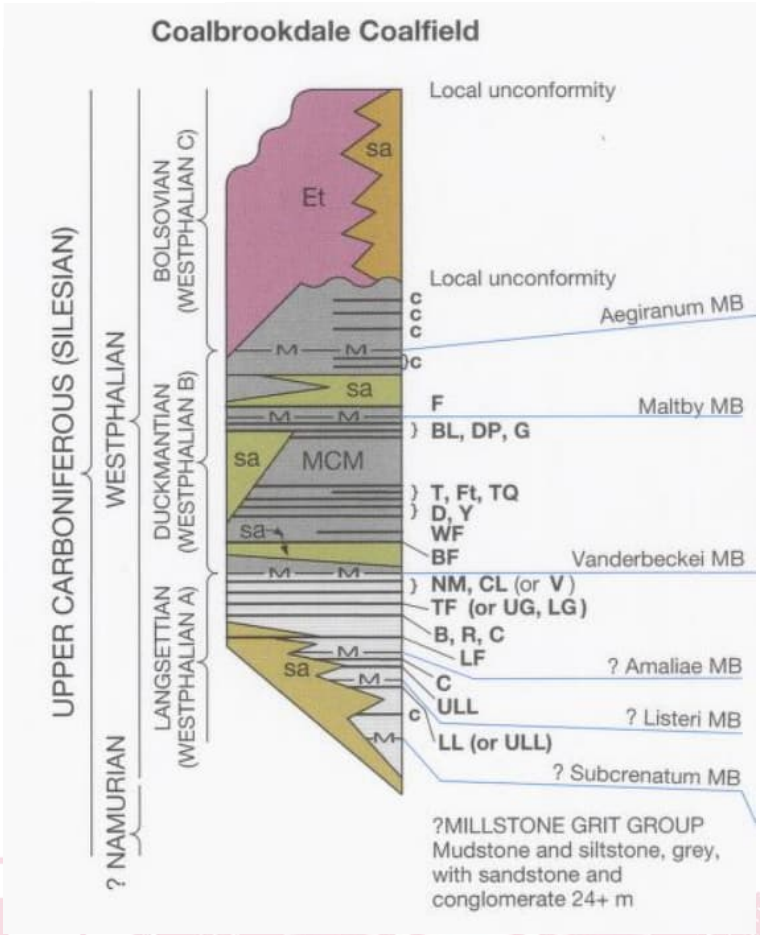
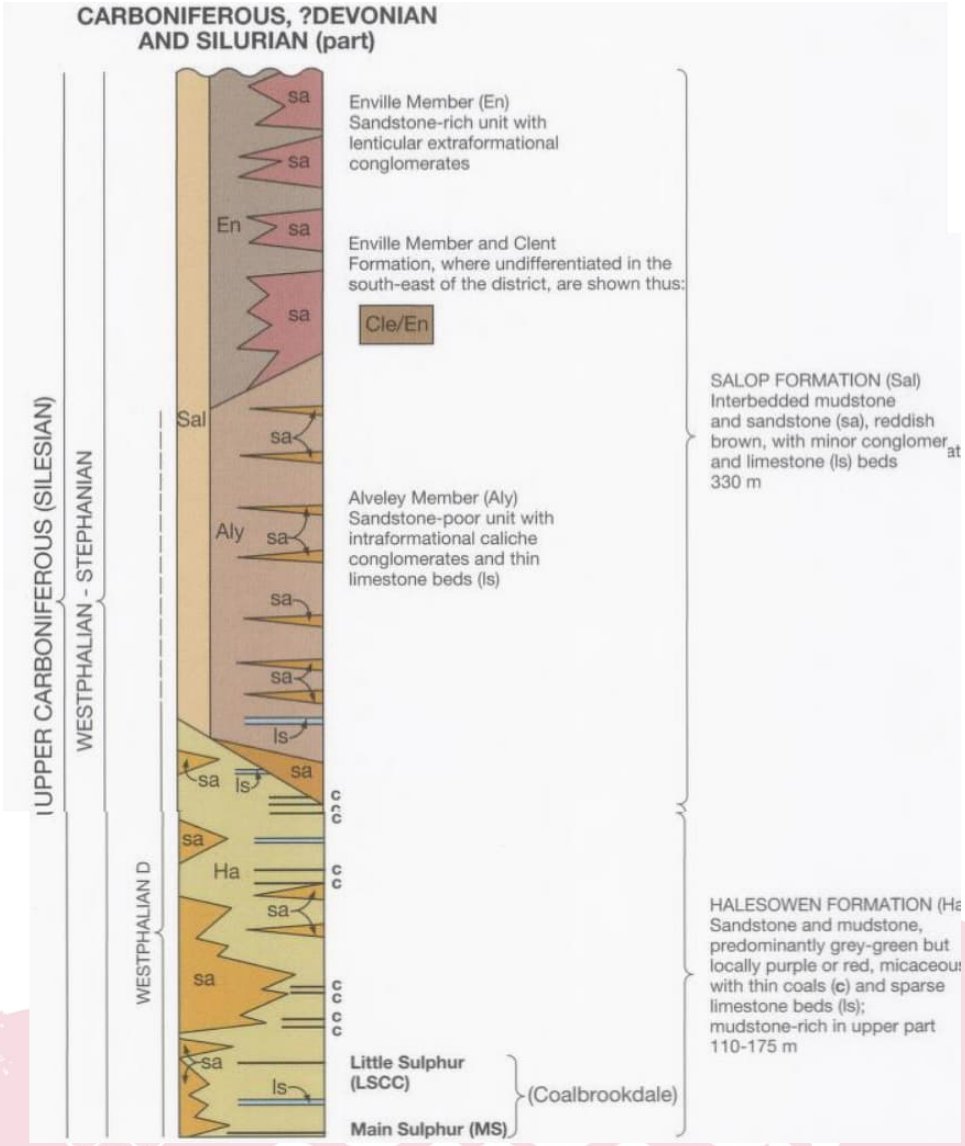
Silurian Rocks



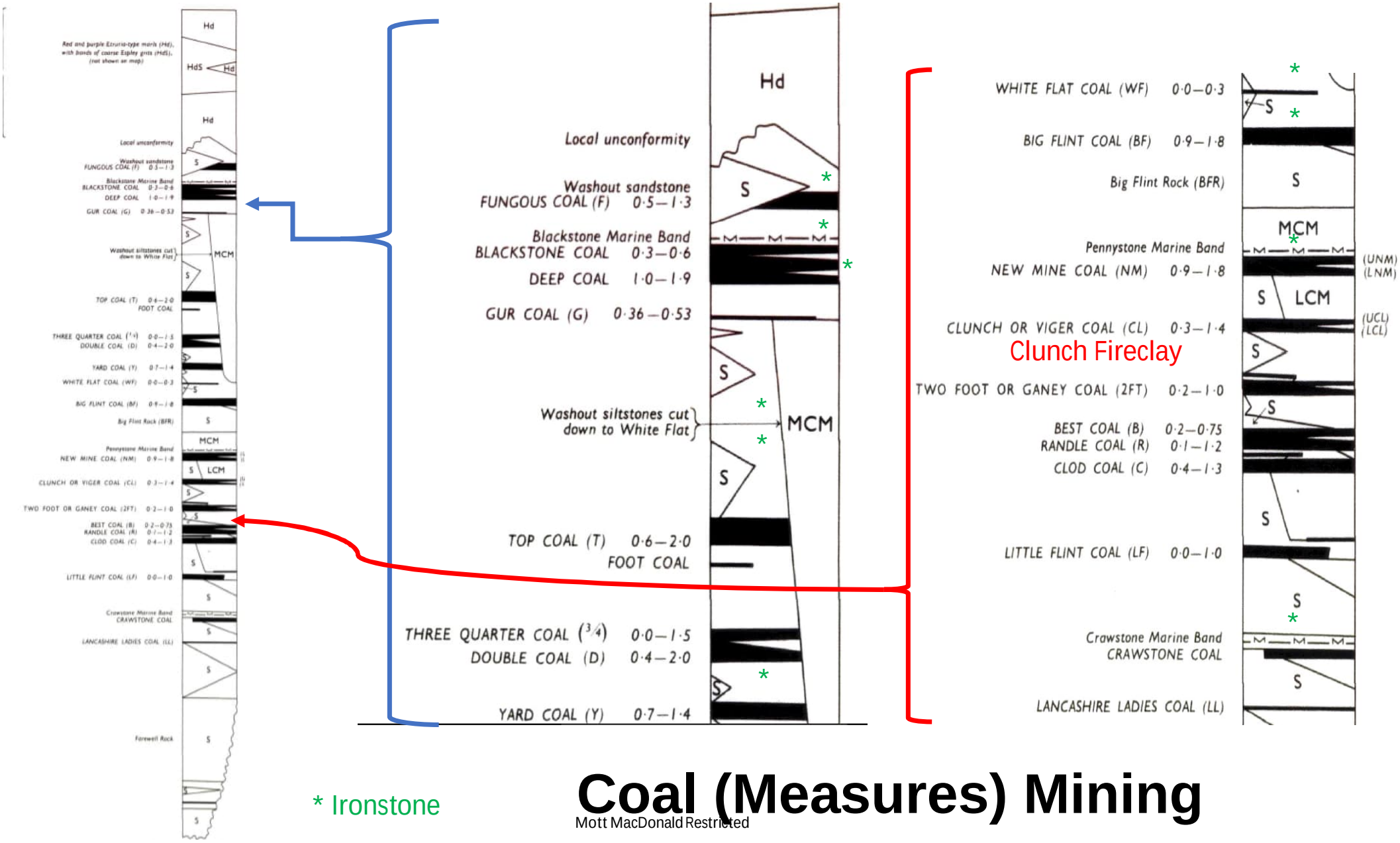






Carboniferous Rocks

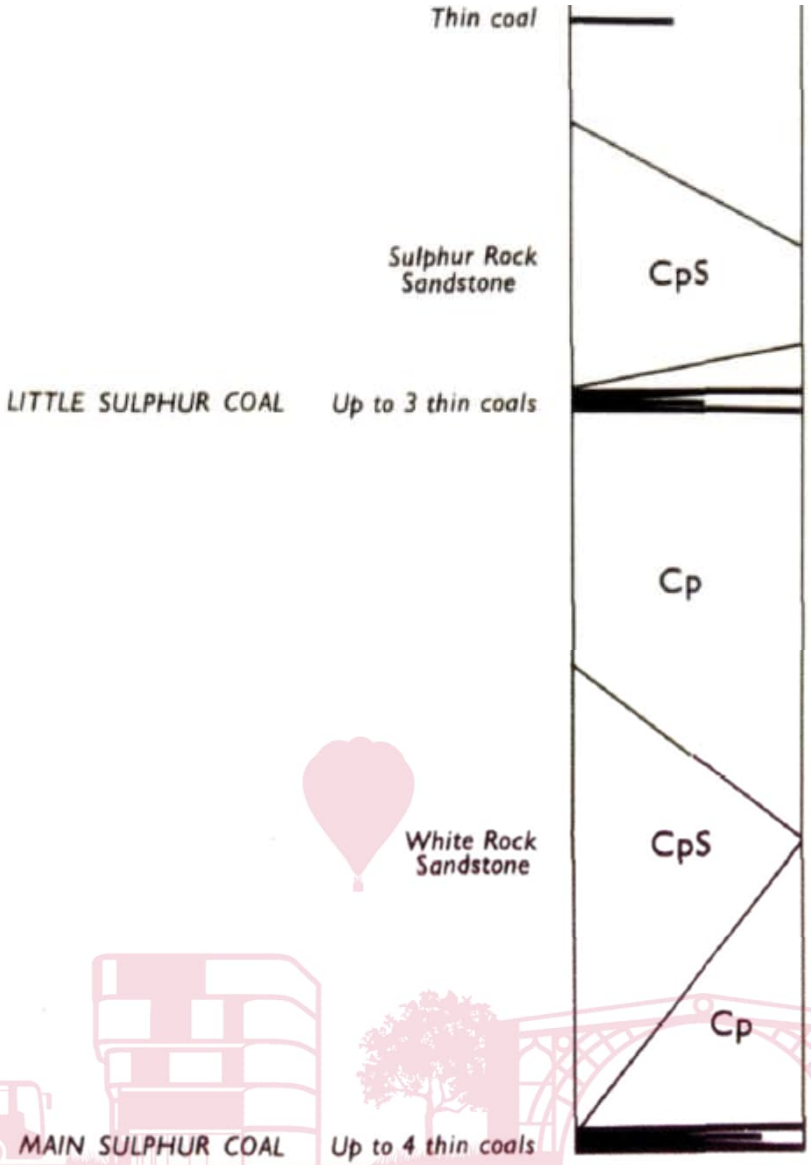

SPL

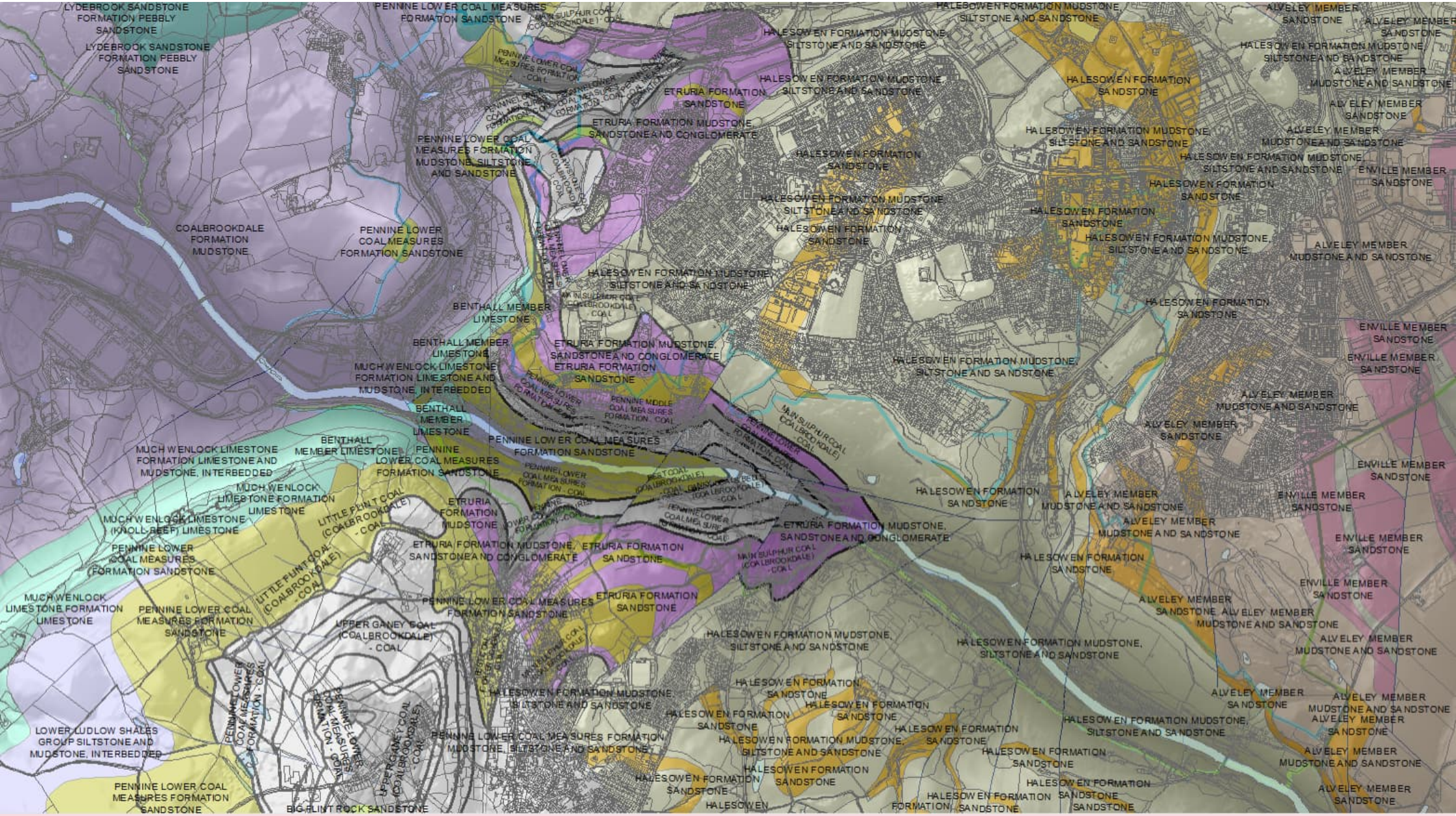


* Ironstone

Coal (Measures) Mining

Coal (Measures) Mining




LYDEBROOK SANDSTONE FORMATION PEBBLY SANDSTONE
PENNINE LOWER COAL MEASURES FORMATION SANDSTONE
HALESOWEN FORMATION MUDSTONE, SILTSTONE AND SANDSTONE
ALVELEY MEMBER SANDSTONE
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ETRURIA FORMATION SANDSTONE
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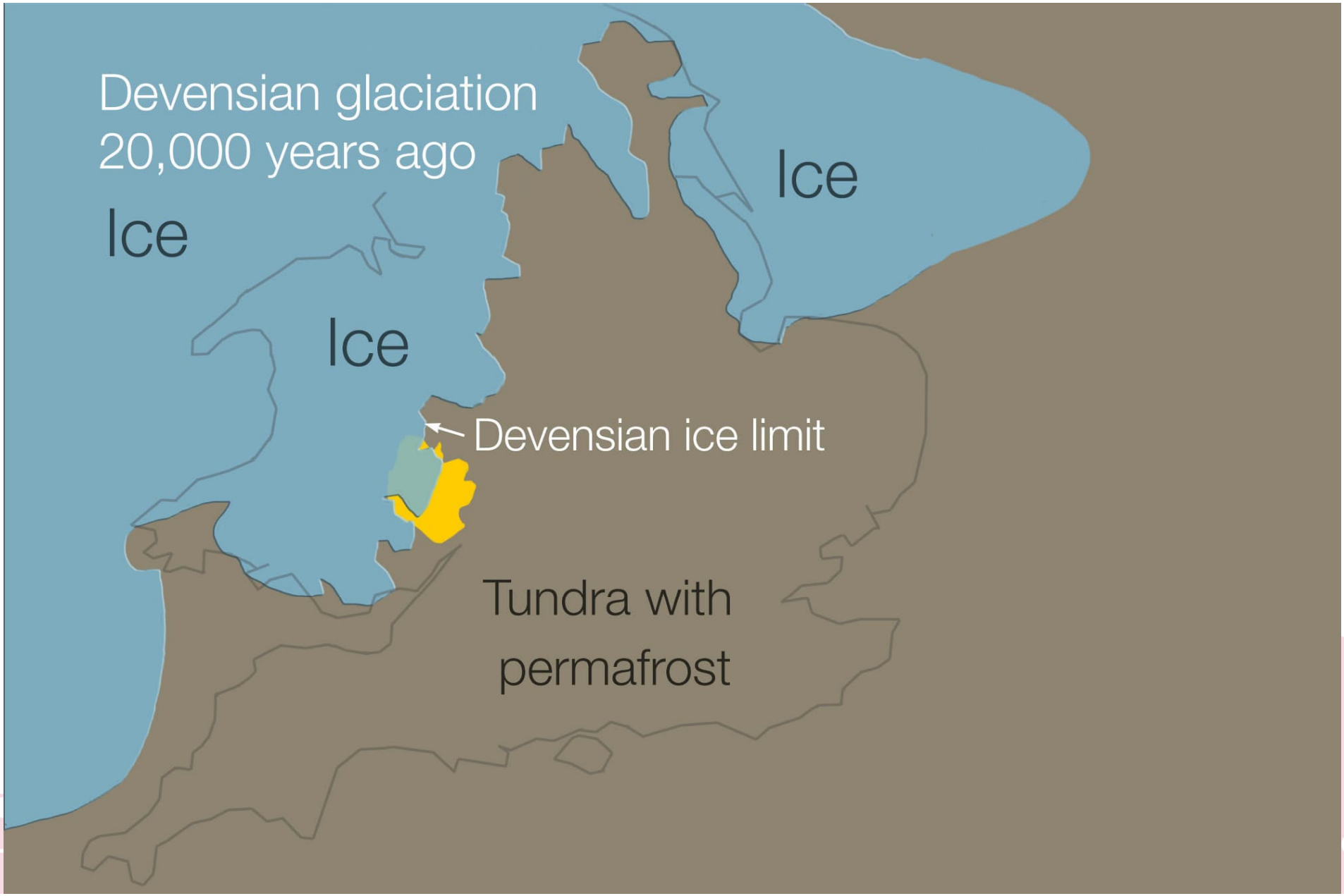
LOWER LUDLOW SHALES GROUP SILTSTONE AND MUDSTONE, INTERBEDDED
BIG FLINT ROCK SANDSTONE

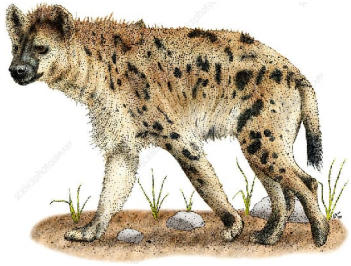

Devensian glaciation
20,000 years ago
Ice
Ice
Ice
Devensian ice limit
Tundra with
permafrost

Steppe Bison
Bison priscus

Woolly Rhinoceras
Coelodonta antiquitatis

Steppe Mammoth
Mammuthus primigenius

Wild horse
Equus ferus



Spotted Hyaena
Crocuta crocuta

Grey Wolf
Canis lupus

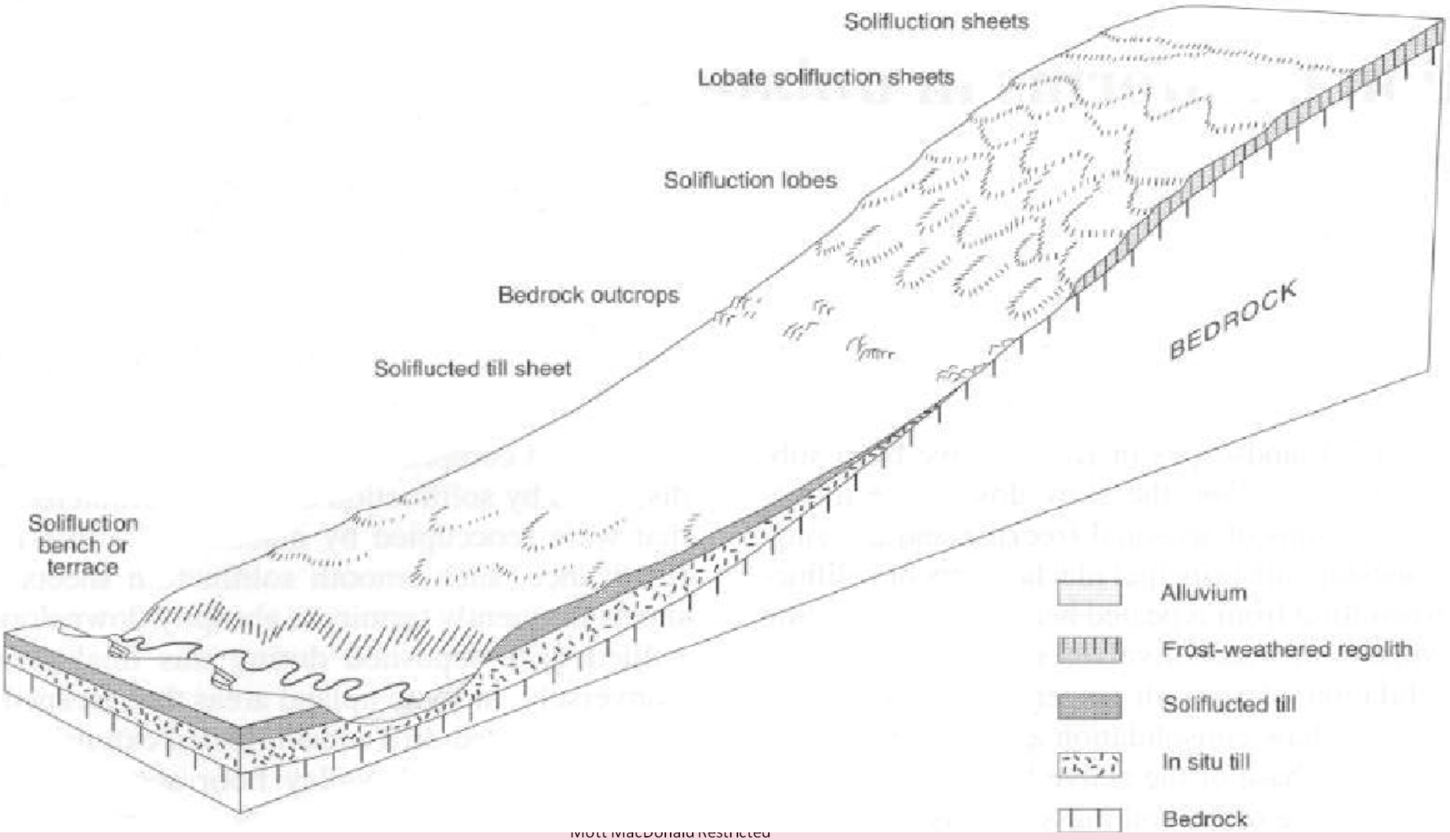
Land Instability - Processes

Solifluction is the slow viscous downslope flow of waterlogged soil and other unsorted and unsaturated superficial deposits".

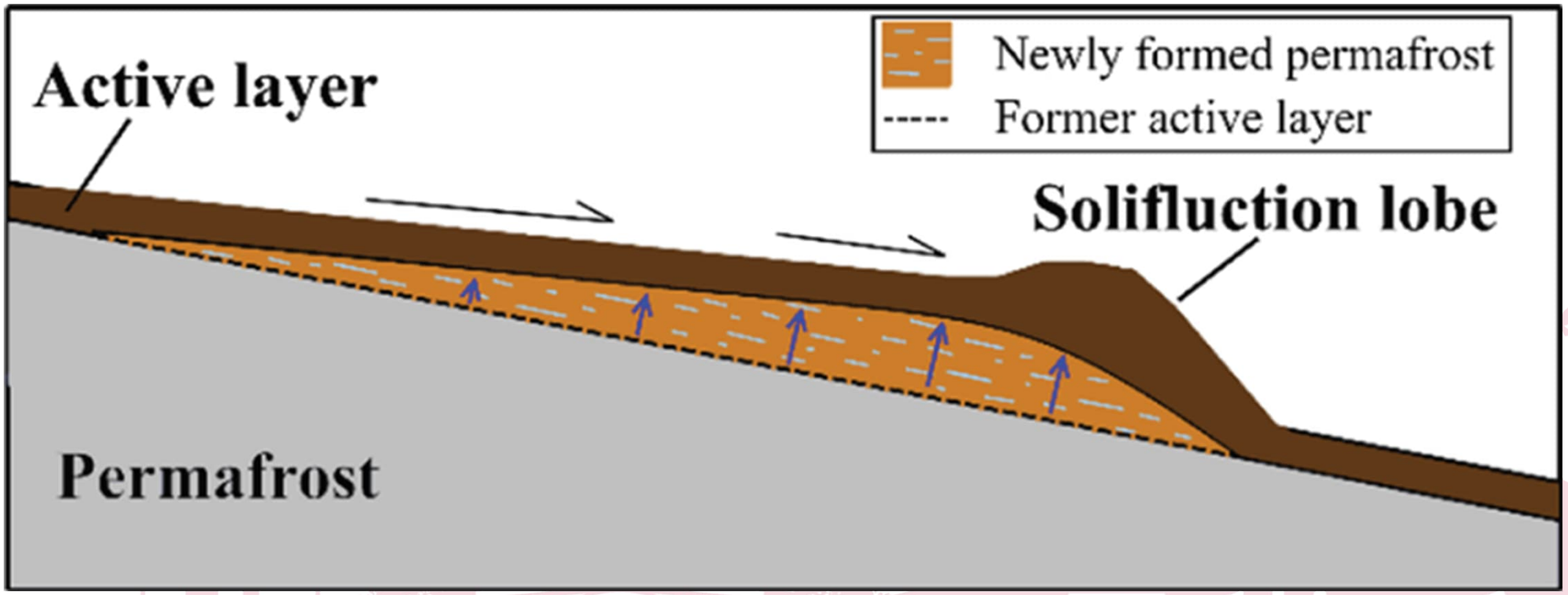
i.e. soils do not need to be fully saturated, the process is promoted by freeze/thaw activity.

Gelifluction is restricted to the slow flow of fluidized superficial deposits during the thawing of seasonally frozen ground. The flow is initiated by meltwater from thawing ice lenses".

i.e. soils need to be saturated


Solifluction sheets
Lobate solifluction sheets
Solifluction lobes
Bedrock outcrops
Soliflucted till sheet
BEDROCK
Solifluction bench or terrace
Alluvium
Frost-weathered regolith
Soliflucted till
In situ till
Bedrock

Land Instability - Deposits



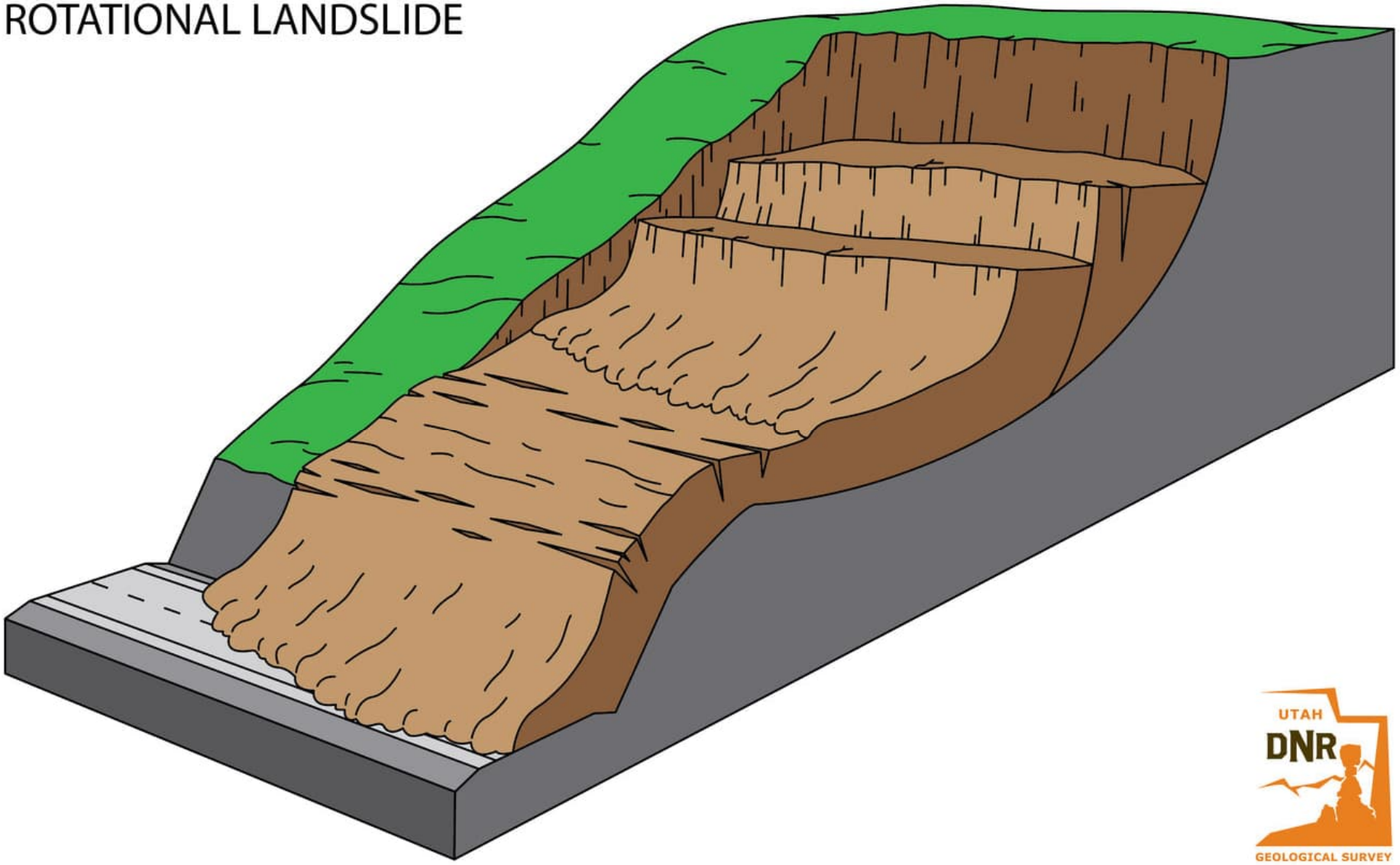
Land Instability - Processes

Land Instability - Deposits

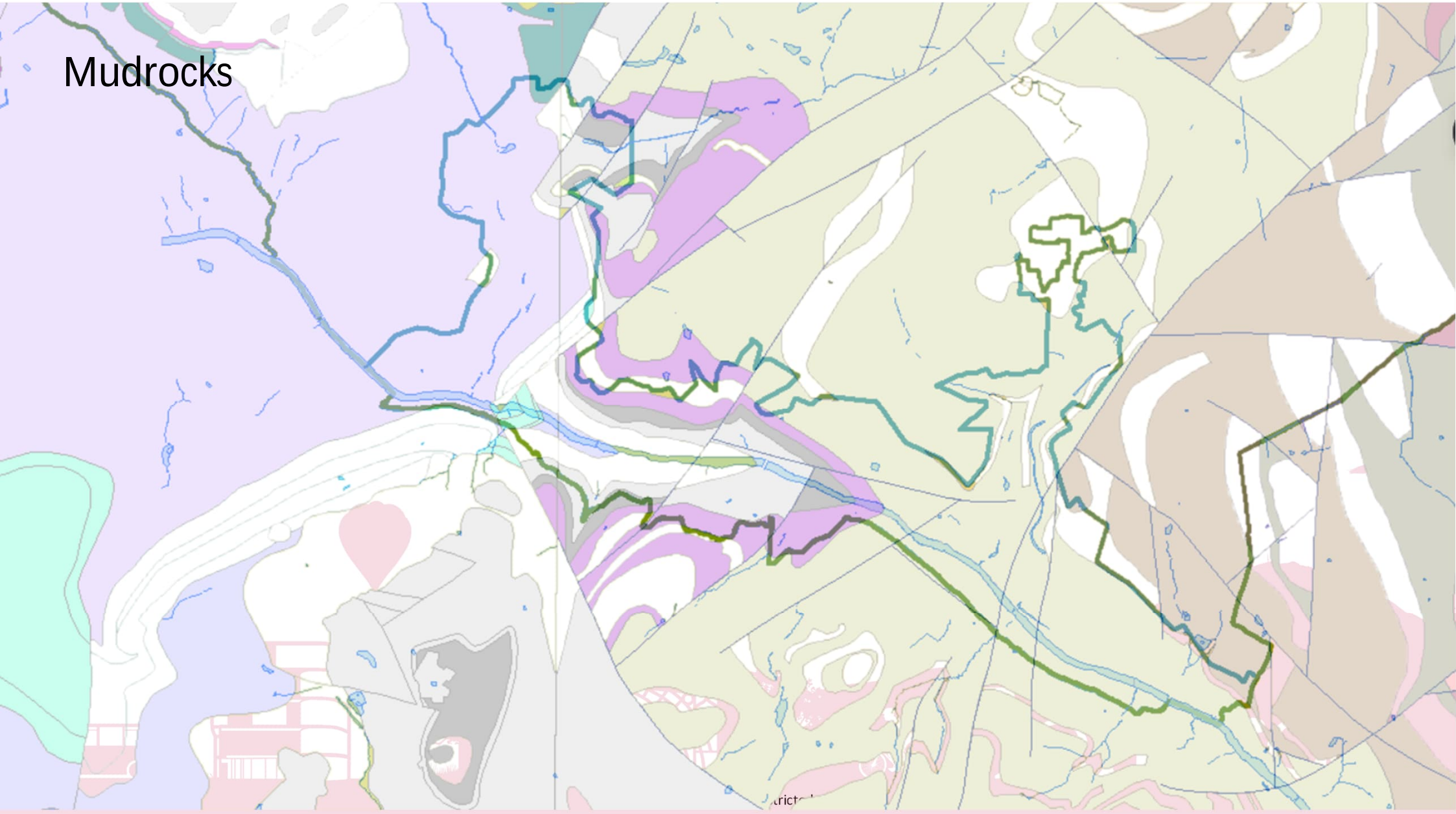
Colluvium (also colluvial material or colluvial soil) is a general name for loose, unconsolidated sediments that have been deposited at the base of hillslopes by either rainwash, sheetwash, slow continuous downslope creep, or a variable combination of these processes. Colluvium is typically composed of a heterogeneous range of rock types and sediments ranging from silt to rock fragments of various sizes.

Head is poorly sorted and poorly stratified, angular rock debris and/or clayey hillwash and soil creep, mantling a hillslope and deposited by solifluction and gelifluction processes".

ROTATIONAL LANDSLIDE

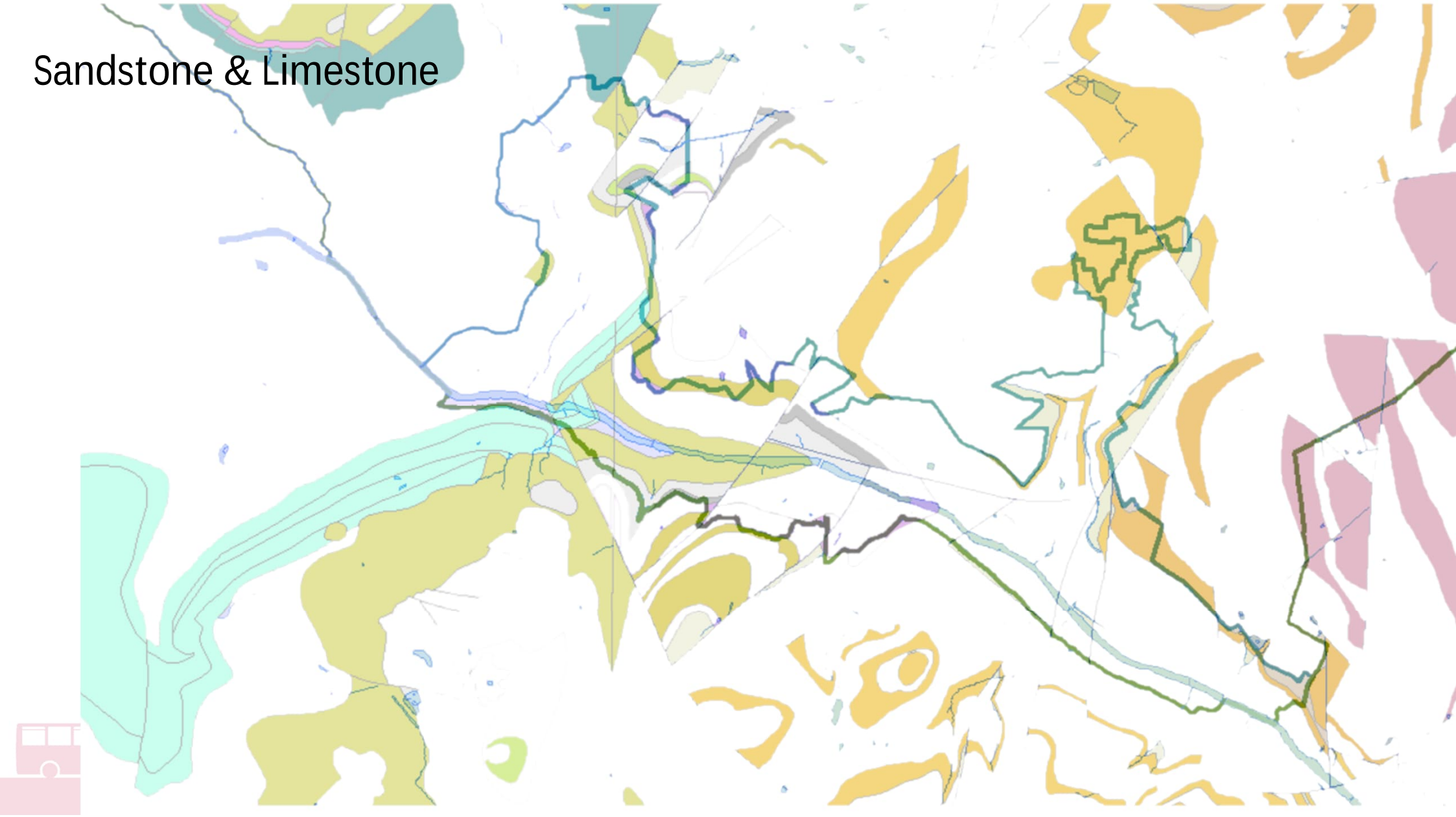


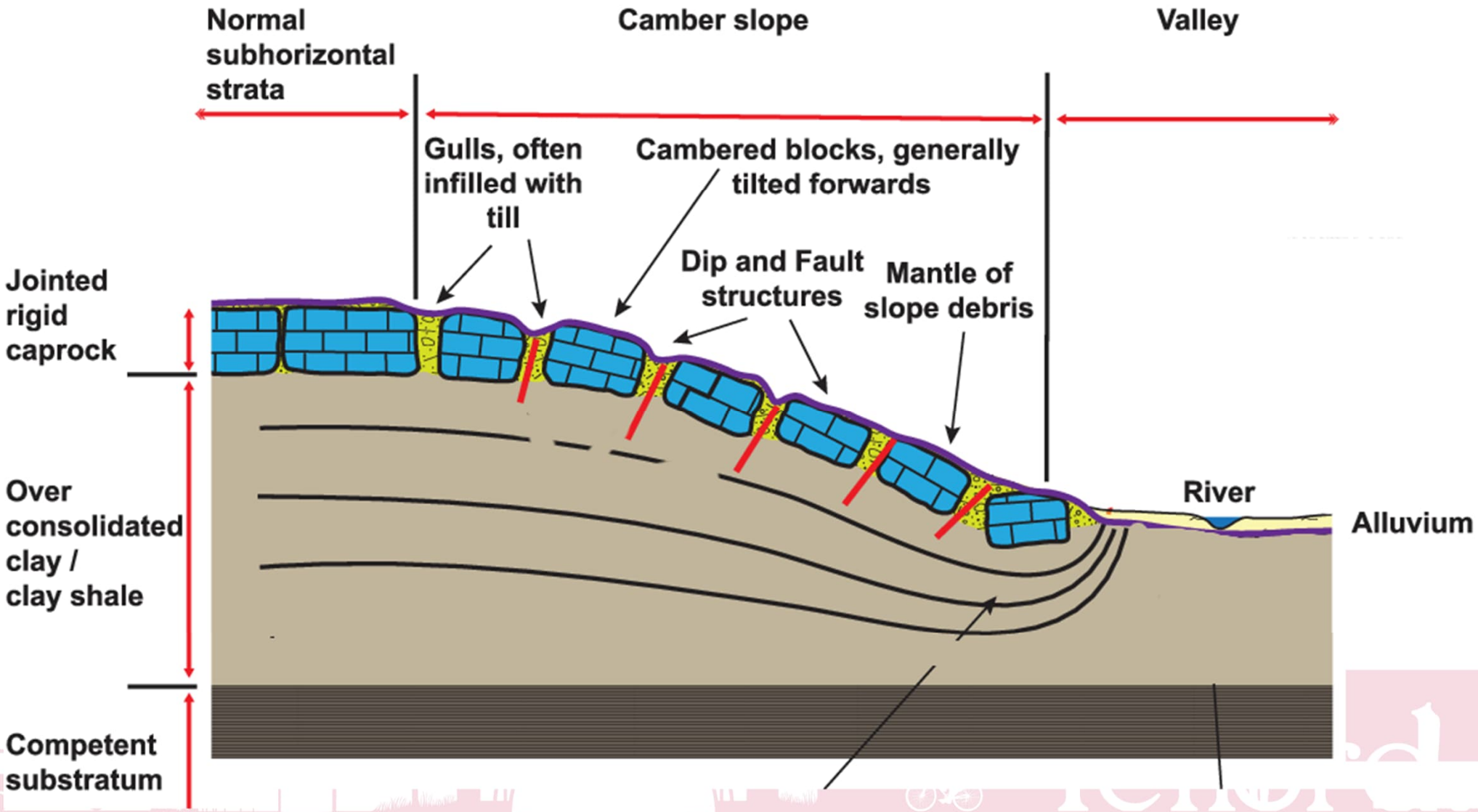
UTAH DNR GEOLOGICAL SURVEY


Mudrocks

Land Instability – Soil Type

Sandstone & Limestone

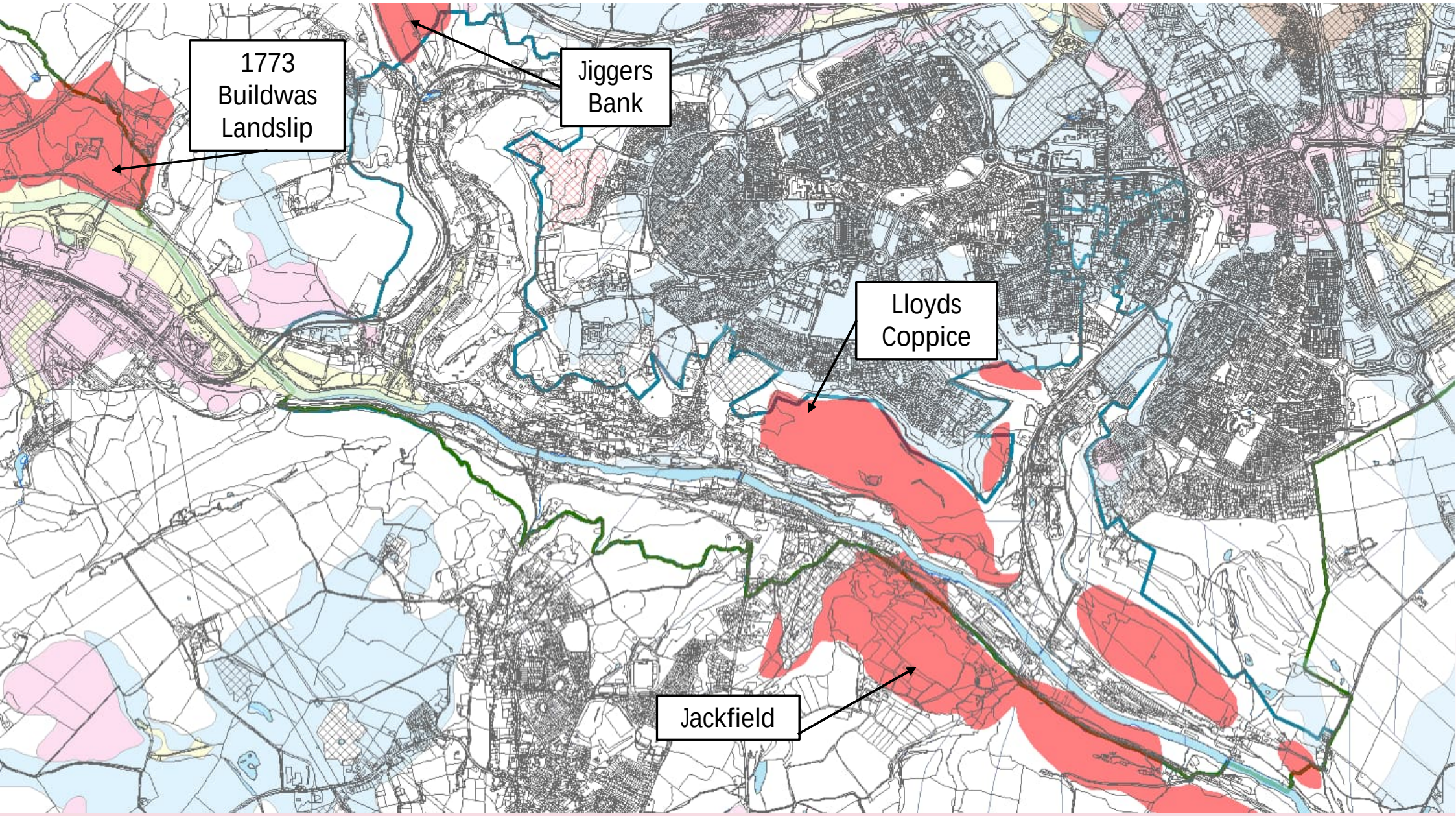



Normal subhorizontal strata
Camber slope
Valley
Gulls, often infilled with till
Cambered blocks, generally tilted forwards
Dip and Fault structures
Mantle of slope debris
Jointed rigid caprock
Over consolidated clay / clay shale
Competent substratum
River
Alluvium

Instability Hotspots

- 1773 Buildwas Landslide
- The Lloyds
- Jackfield
- Jiggers Bank

These are the worst culprits but the whole of the Gorge is on the move.


1773
Buildwas
Landslip
Jiggers
Bank
Lloyds
Coppice
Jackfield

1773 Buildwas Landslide

Between the parish of Buildwas and Colebrook Dale, there is a place called THE BIRCHES, probably from some large birch trees which formerly grew there. This place is remarkable for having been the scene of an extraordinary concussion of the earth, which in its effects perfectly agrees with those occasioned by the earthquakes in Calabria, in 1733 .

This singularly awful event took place early in the morning of the 27th of May, 1773. It has been described by the late most excellent and eminently pious Mr. Fletcher, vicar of Madeley,

Telford & Wrekin Co-operative Council

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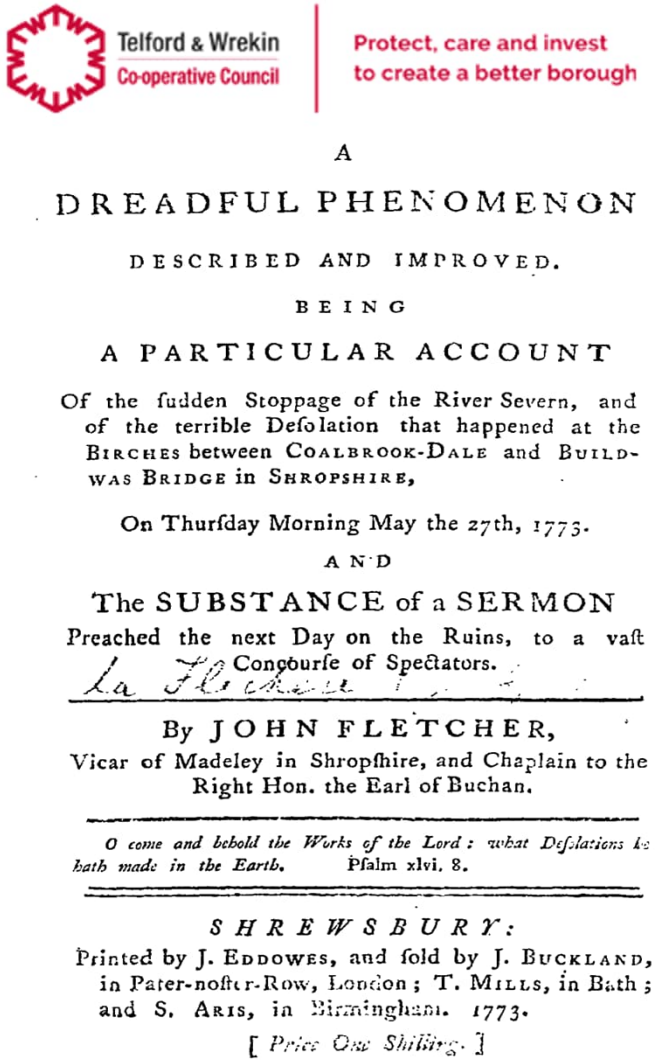
1773 Buildwas Landslide



A

DREADFUL PHENOMENON

DESCRIBED AND IMPROVED.

BEING

A PARTICULAR ACCOUNT

Of the ſudden Stoppage of the River Severn, and of the terrible Deſolation that happened at the BIRCHES between COALBROOK-DALE and BUILDWAS BRIDGE in SHROPSHIRE,

On Thurſday Morning May the 27th, 1773.

AND

The SUBSTANCE of a SERMON

Preached the next Day on the Ruins, to a vaſt Concourſe of Spectators.

By JOHN FLETCHER,

Vicar of Madeley in Shropſhire, and Chaplain to the Right Hon. the Earl of Buchan.

O come and behold the Works of the Lord: what Deſolations he hath made in the Earth. Pſalm xlvi. 8.

SHREWSBURY:

Printed by J. EDDOWES, and ſold by J. BUCKLAND, in Pater-noſter-Row, London; T. MILLS, in Bath; and S. ARIS, in Birmingham. 1773.

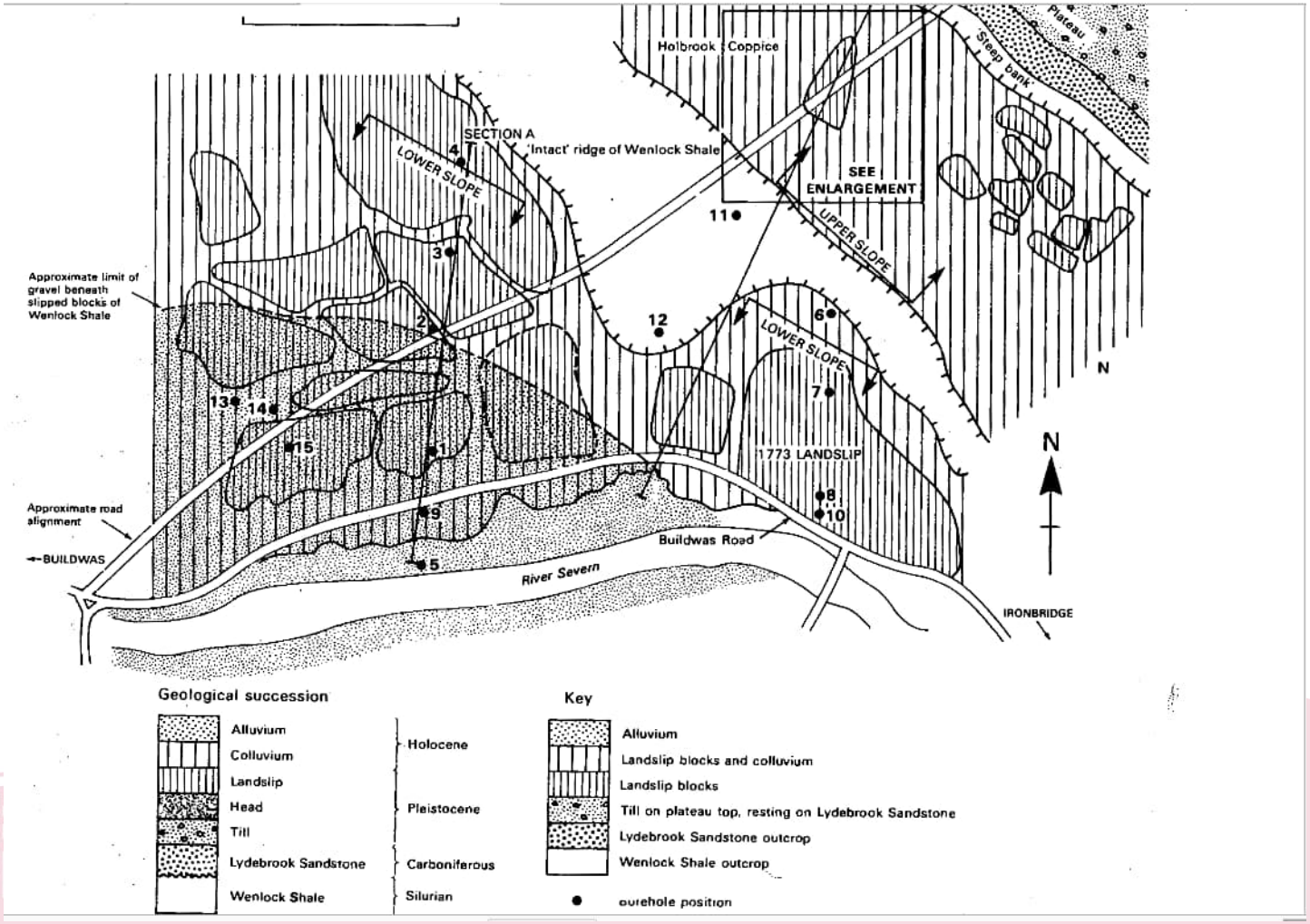
[*Price One Shilling.*]

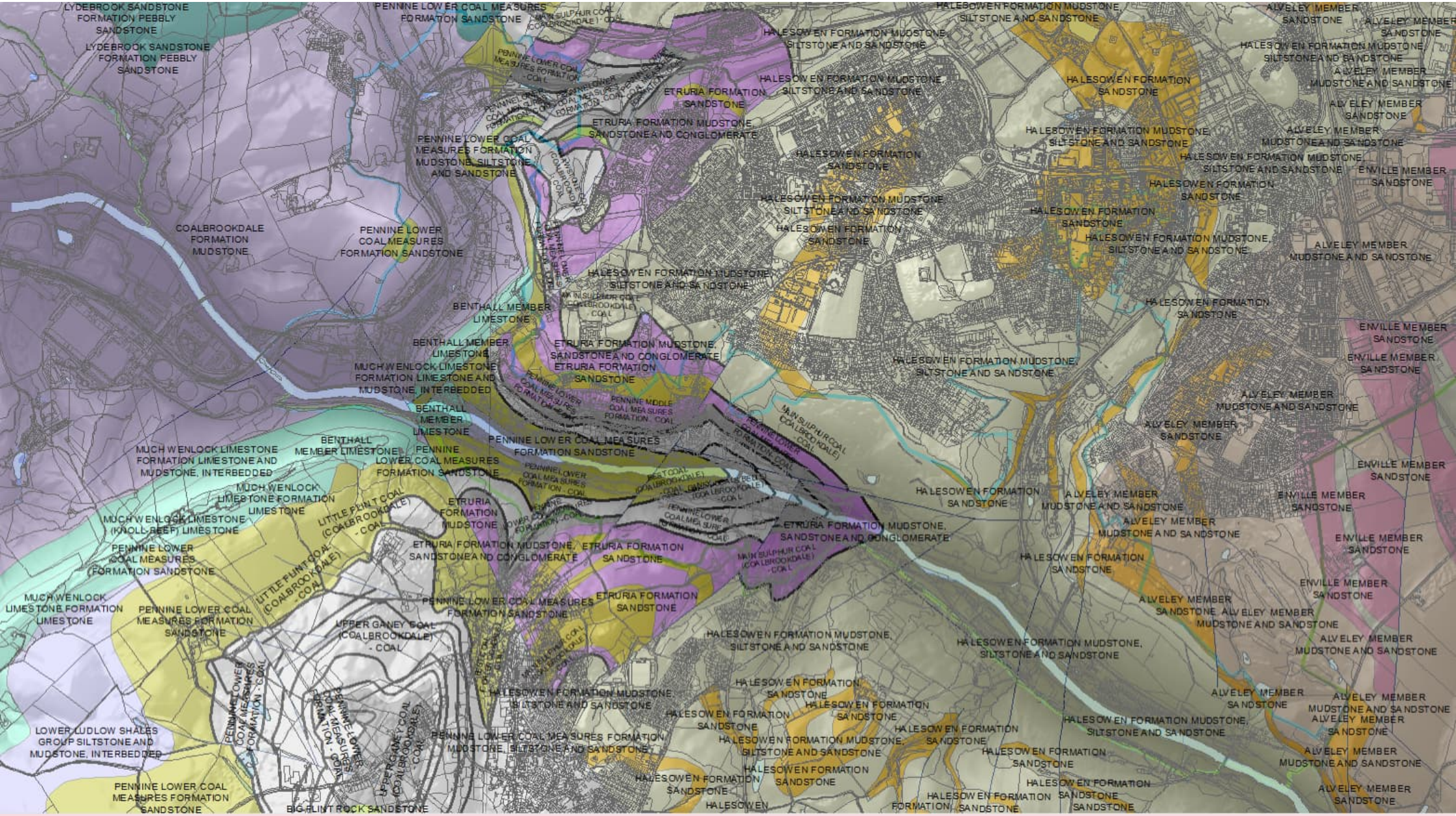
- From these observations we may conclude, that it was an earthquake, accompanied by a considerable eruption of air: and this appears from the sudden gust of wind that shook Samuel Cookson's windows
- The watermen affirmed that the water fell six feet in six minutes at Bridgenorth, which is twelve miles distant; and the shock was felt very severely at Newport, which is fourteen. It was also felt at the collieries in Coalbrook Dale

1773 Buildwas Landslide

"The Influence of Late and post glacial slope development on the engineering geology of Wenlock Shale near Ironbridge, Salop"

T.P Gostelow, R.J.O. Hamblin, D.I. Harris & D.W. Hight




LYDEBROOK SANDSTONE FORMATION PEBBLY SANDSTONE
PENNINE LOWER COAL MEASURES FORMATION SANDSTONE
HALESOWEN FORMATION MUDSTONE, SILTSTONE AND SANDSTONE
ALVELEY MEMBER SANDSTONE
ALVELEY MEMBER MUDSTONE AND SANDSTONE
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ETRURIA FORMATION MUDSTONE, SANDSTONE AND CONGLOMERATE
HALESOWEN FORMATION SANDSTONE
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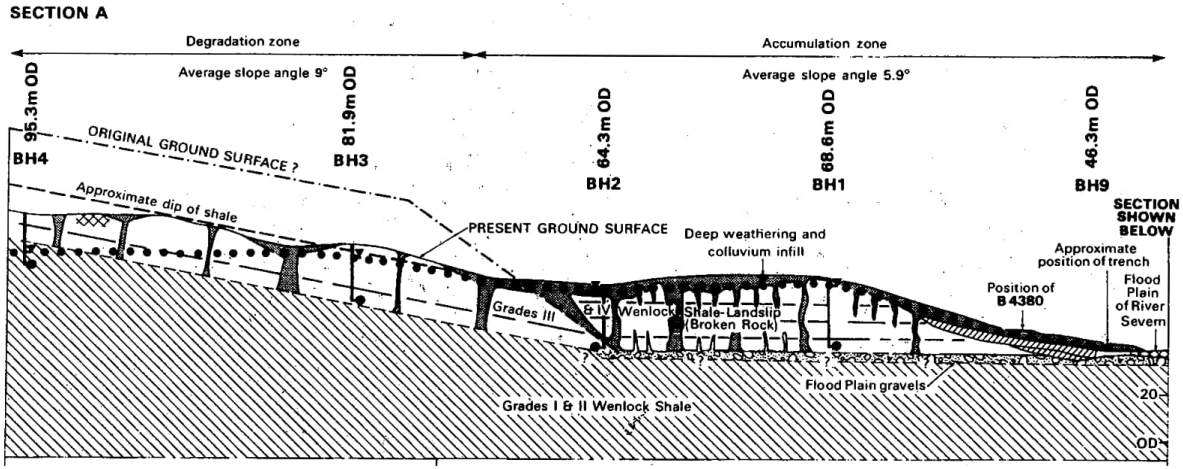
LOWER LUDLOW SHALES GROUP SILTSTONE AND MUDSTONE, INTERBEDDED
BIG FLINT ROCK SANDSTONE

1773 Buildwas Landslide

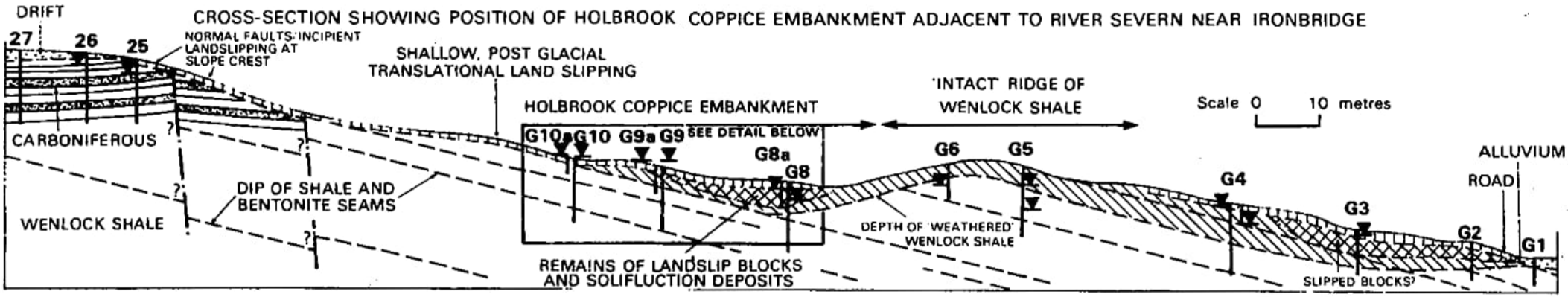


The influence of late and post glacial slope development on the engineering geology of Wenlock Shale near Ironbridge, Salop

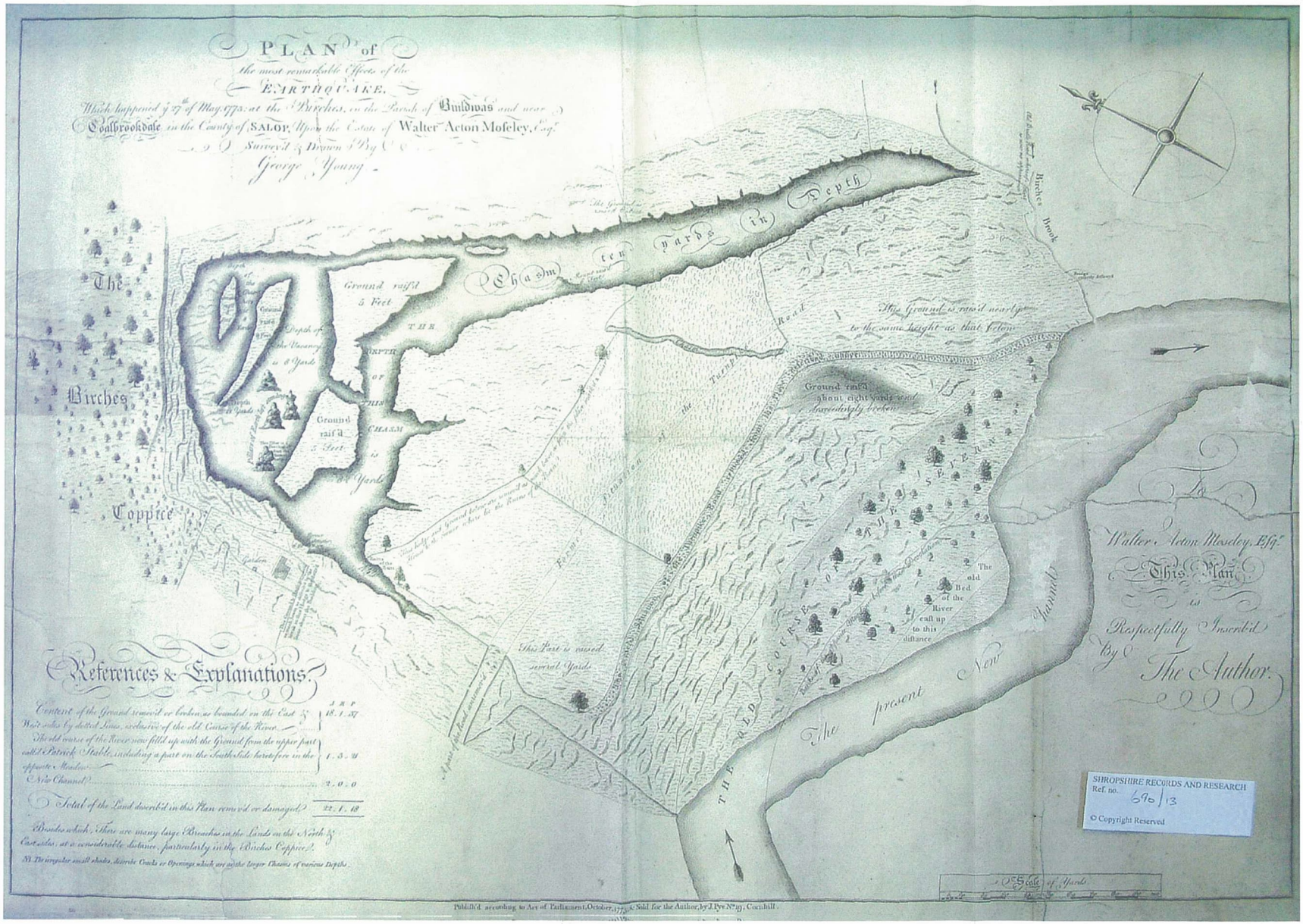
T. P. Gostelow[1], R. J. O. Hamblin[1], D. I. Harris[2] & D. W. Hight[2]

[1]British Geological Survey, Keyworth, Nottingham NG12 5GG, UK

[2]Geotechnical Consulting Group, 1a Queensbury Place, London SW7 2DL, UK



SECTION B

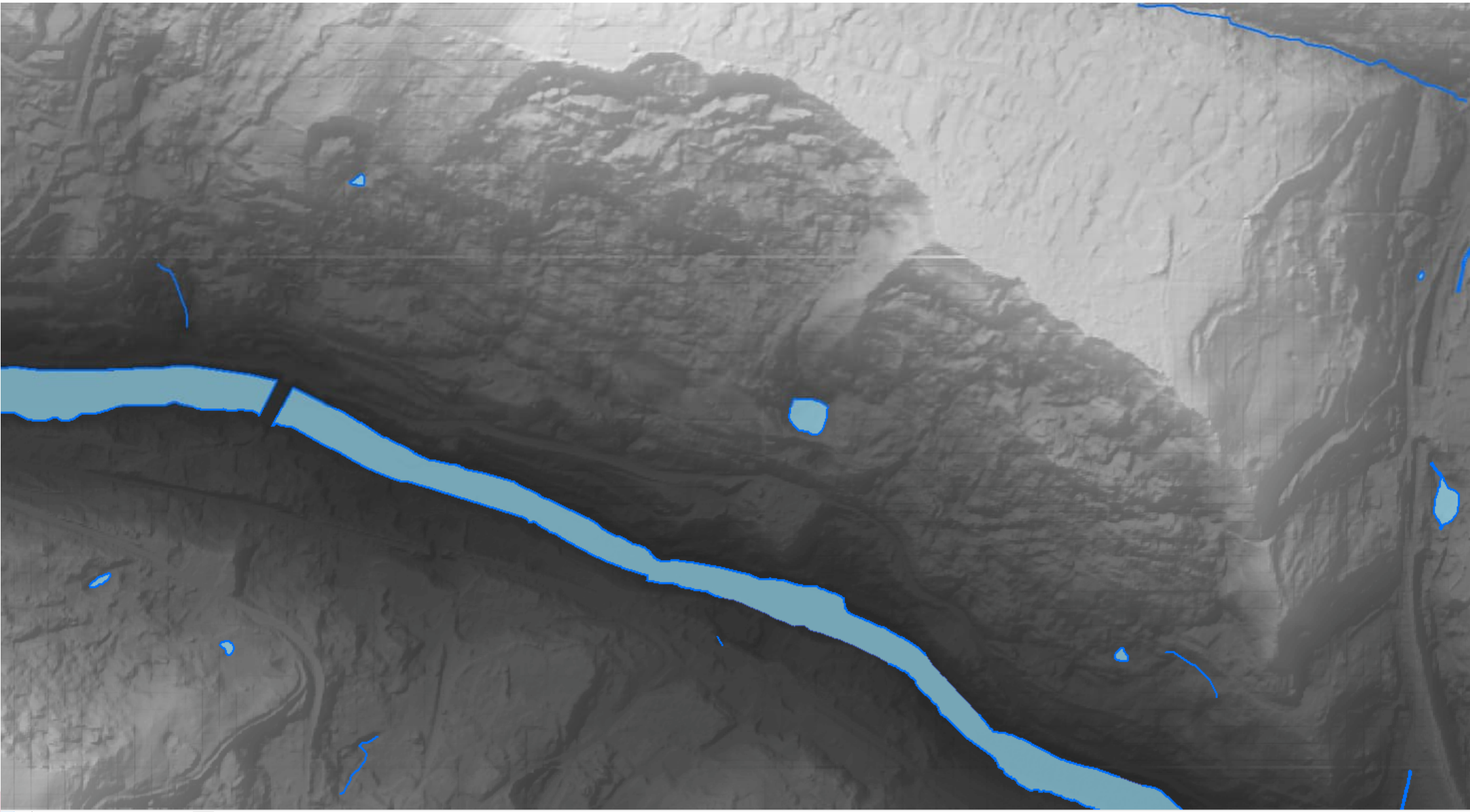


The Lloyds

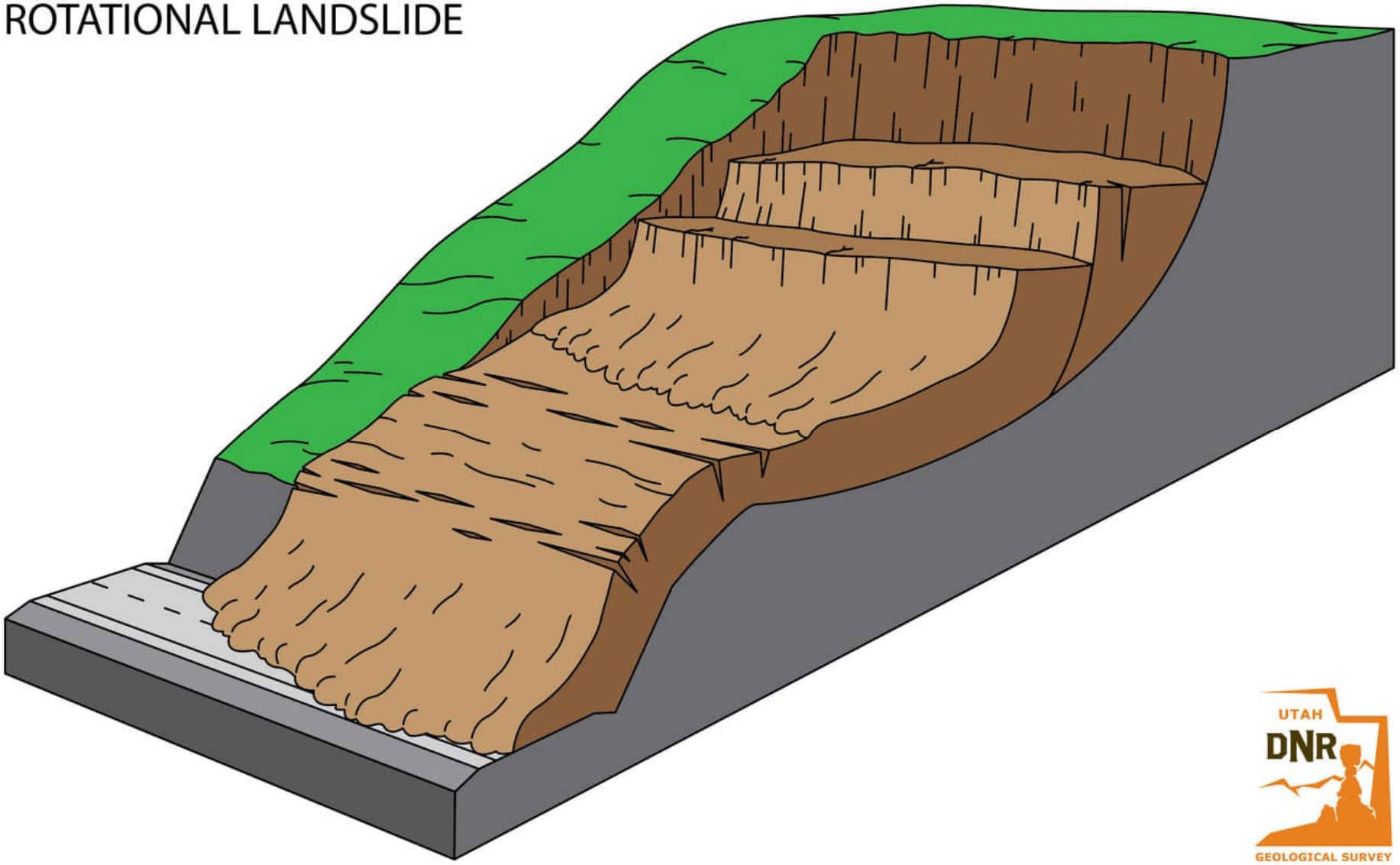
West of Ironbridge centre, The Lloyds is a two-way road on the northern bank of the River Severn

North of The Lloyds is an area of woodland known as Lloyds coppice.

- a series of rotational and translational slides.
- Sandstone units slid from their outcrop near the top of the hill, bringing with them the overlying thick till.



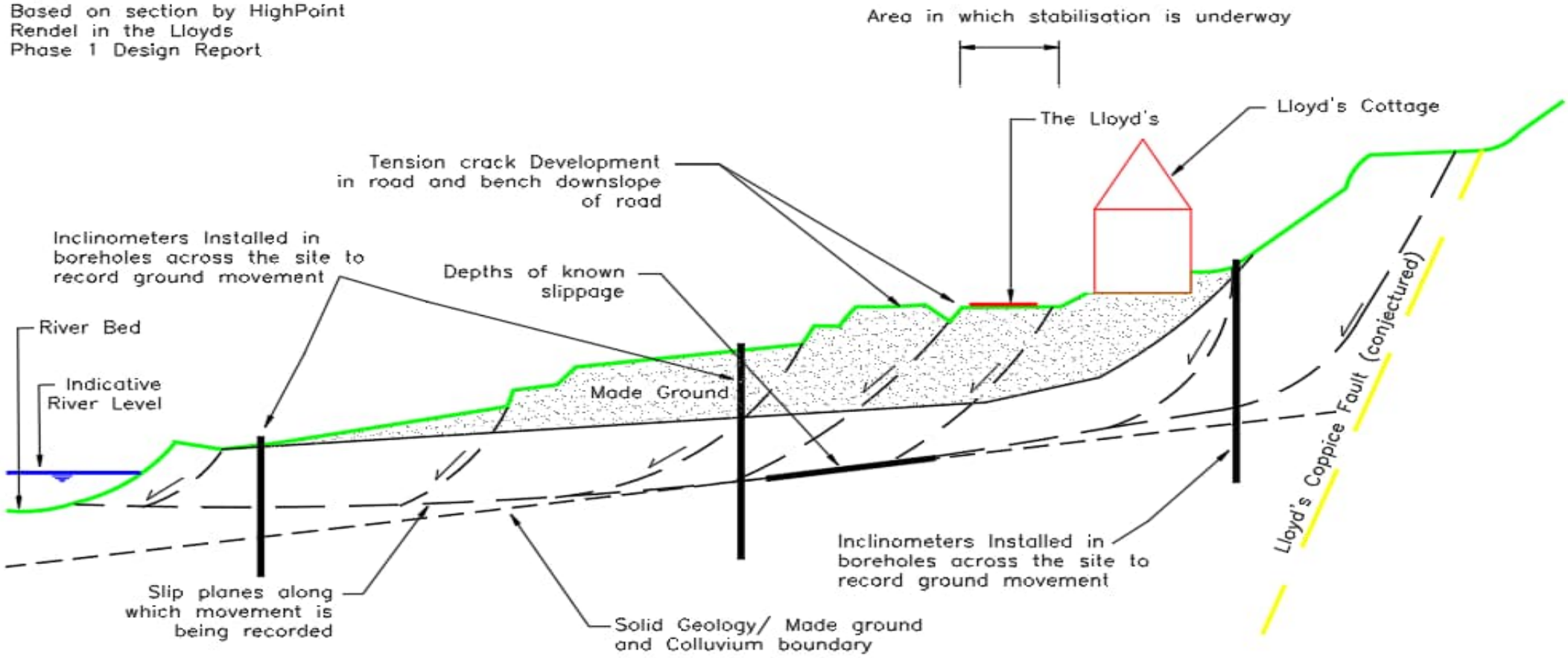
ROTATIONAL LANDSLIDE



UTAH DNR GEOLOGICAL SURVEY

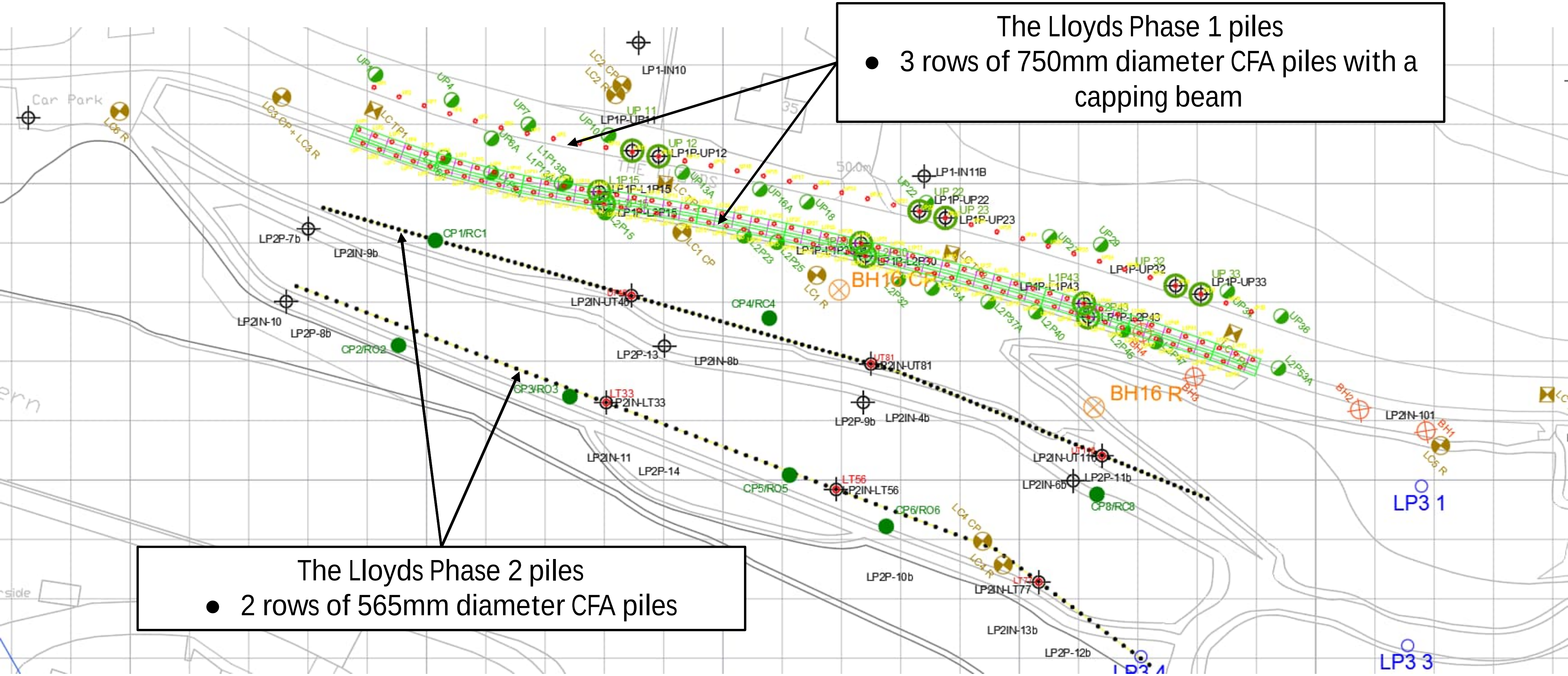
Photographs from 1924 of the Backscarp

Note:
Based on section by HighPoint Rendel in the Lloyds Phase 1 Design Report

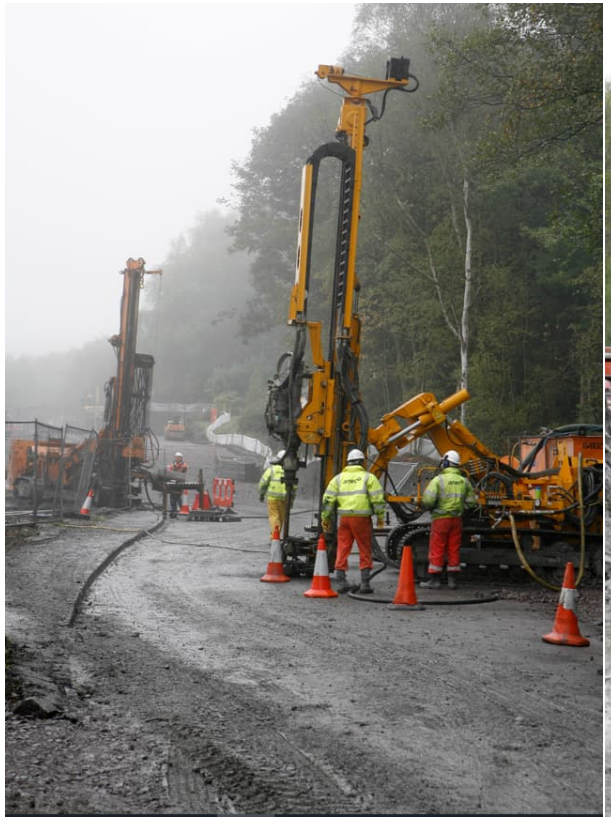


IRONBRIDGE GORGE WORLD HERITAGE SITE - LAND INSTABILITY
LOYDS PHASE 1
INDICATIVE CROSS SECTION THROUGH THE LLOYDS SHOWING INCLINOMETER LOCATIONS

L:\projects\E1\E099\E099A-General\Drawings\Indicative Cross Section with Inclinometers.dwg


The Lloyds Phase 1 piles
3 rows of 750mm diameter CFA piles with a capping beam
The Lloyds Phase 2 piles
2 rows of 565mm diameter CFA piles
BH16 CP
BH16 R
LP3 1
LP3 3
Car Park

Drilling & Pressure grouting (Main Sulphur Coal & Clay)



The Lloyds Phase 1 pile installation

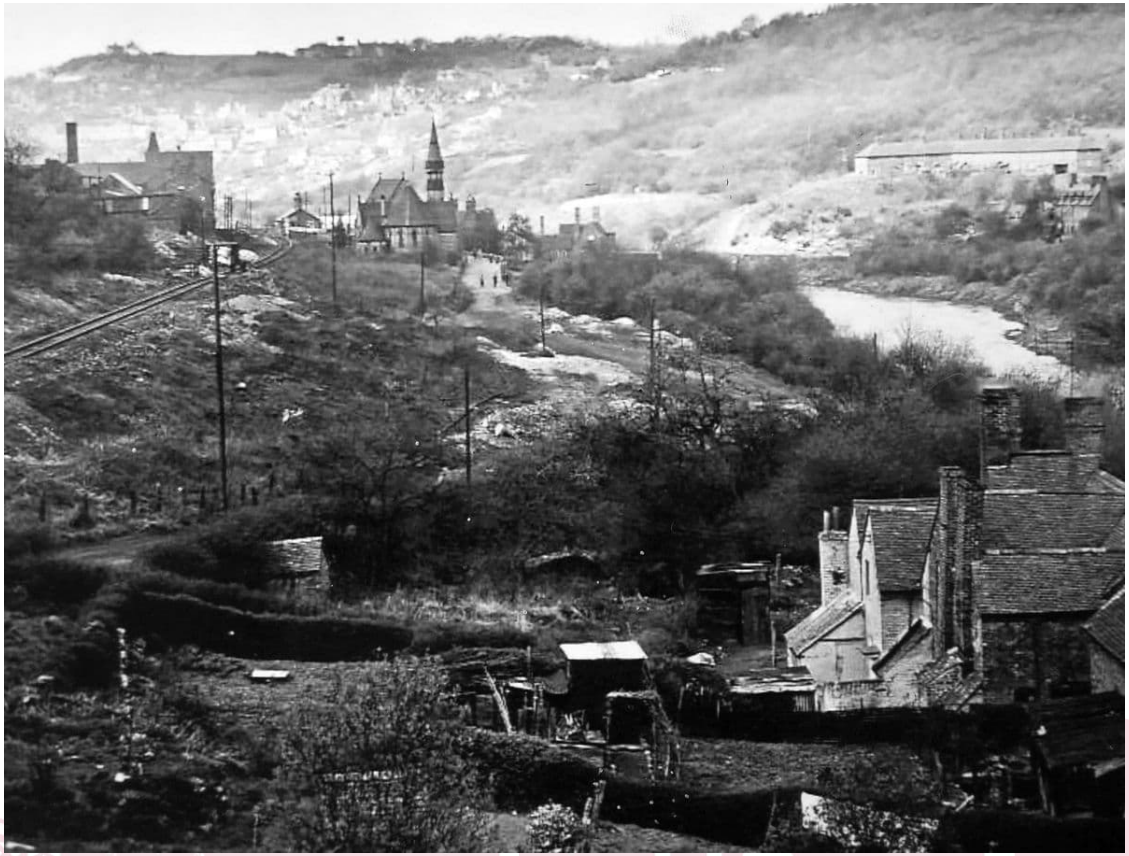
The Lloyds Phase 2 pile installation

The Lloyds Phase 2 2008 Completion

The Lloyds Phase 2 2009

The Lloyds Phase 2 2021

Jackfield Landslip – April 1952



Jackfield Landslip

Movement observed in 1951 followed by more catastrophic events in Spring 1952.

Subject of the 1964 Rankine Lecture by Skempton:

- Towards the end of 1951 further movement was noted,
- February 1952 the road [Salthouse Road] was becoming dangerous. During the next month or two the landslide developed alarmingly. Six houses were completely broken up, gas mains had to be relaid above ground, the railway could be maintained only by daily adjustments to the track and a minor road along the river had to be closed to traffic.
- The maximum downhill displacement totalled 60 ft (~20m).
- The slide, however, was confined wholly within the zone of weathered, fissured clay extending to a depth of 20 ft to 25 ft (~6m to 7m) below the surface. The slip surface ran parallel to the slope (which is inclined at 10º).
- The length of the sliding mass, measured up the slope, amounted to about 170m and in the winter 1952–53 ground-water level reached the surface at a number of points, although on average it was located at a depth of 0.6m.

Jackfield Landslip

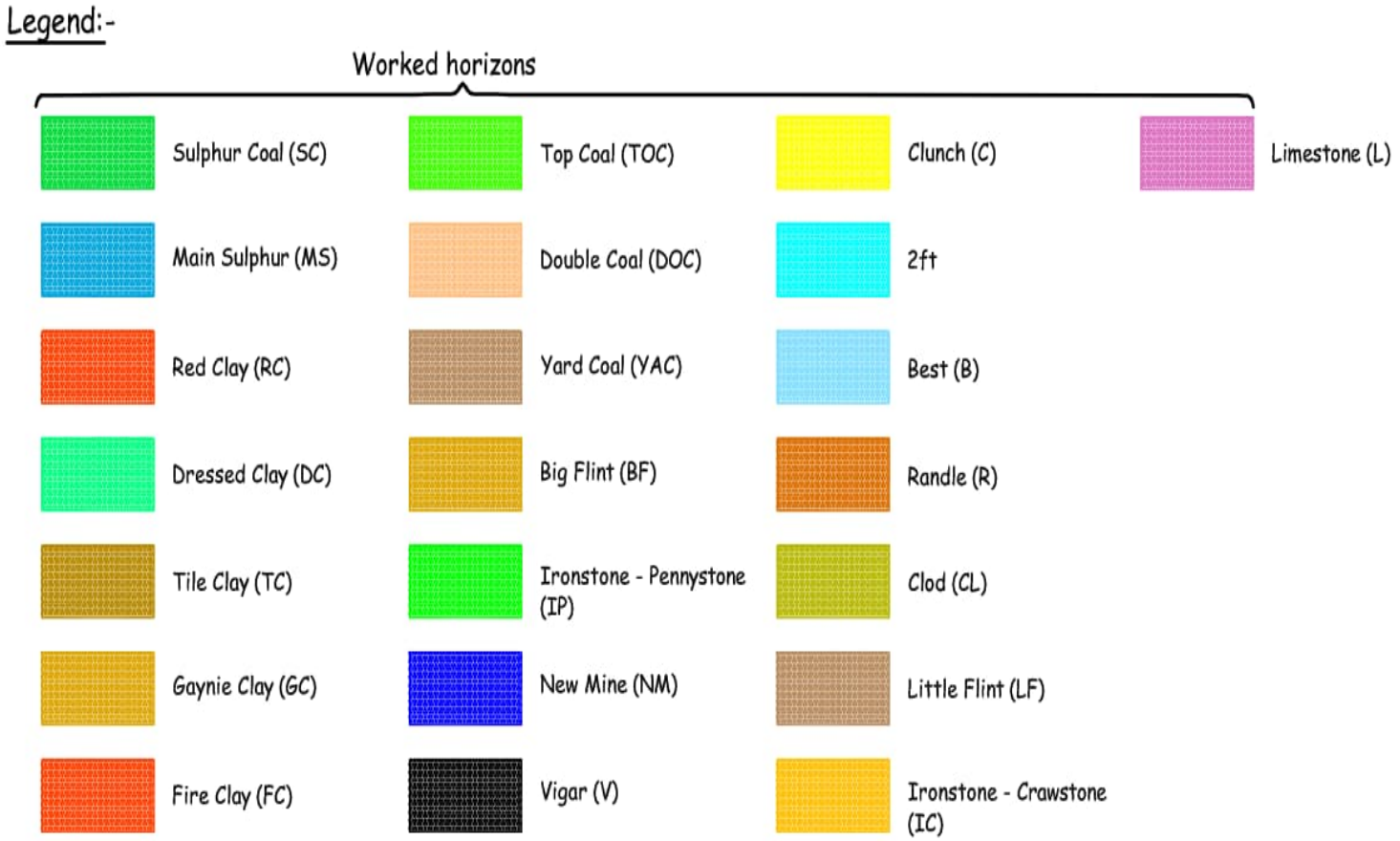
In 1984, further ground movement occurred to the west of the 1952 area of landslide.

Salthouse Road was carried into the river and was replaced by a temporary wooden roadway constructed along the line of the former railway.

Jackfield Landslip

Enabling works:

- Removal of trees
- Creation of piling platforms
- Shaft location and stabilisation
- Stabilisation of mine workings



Telford & Wrekin Co-operative Council

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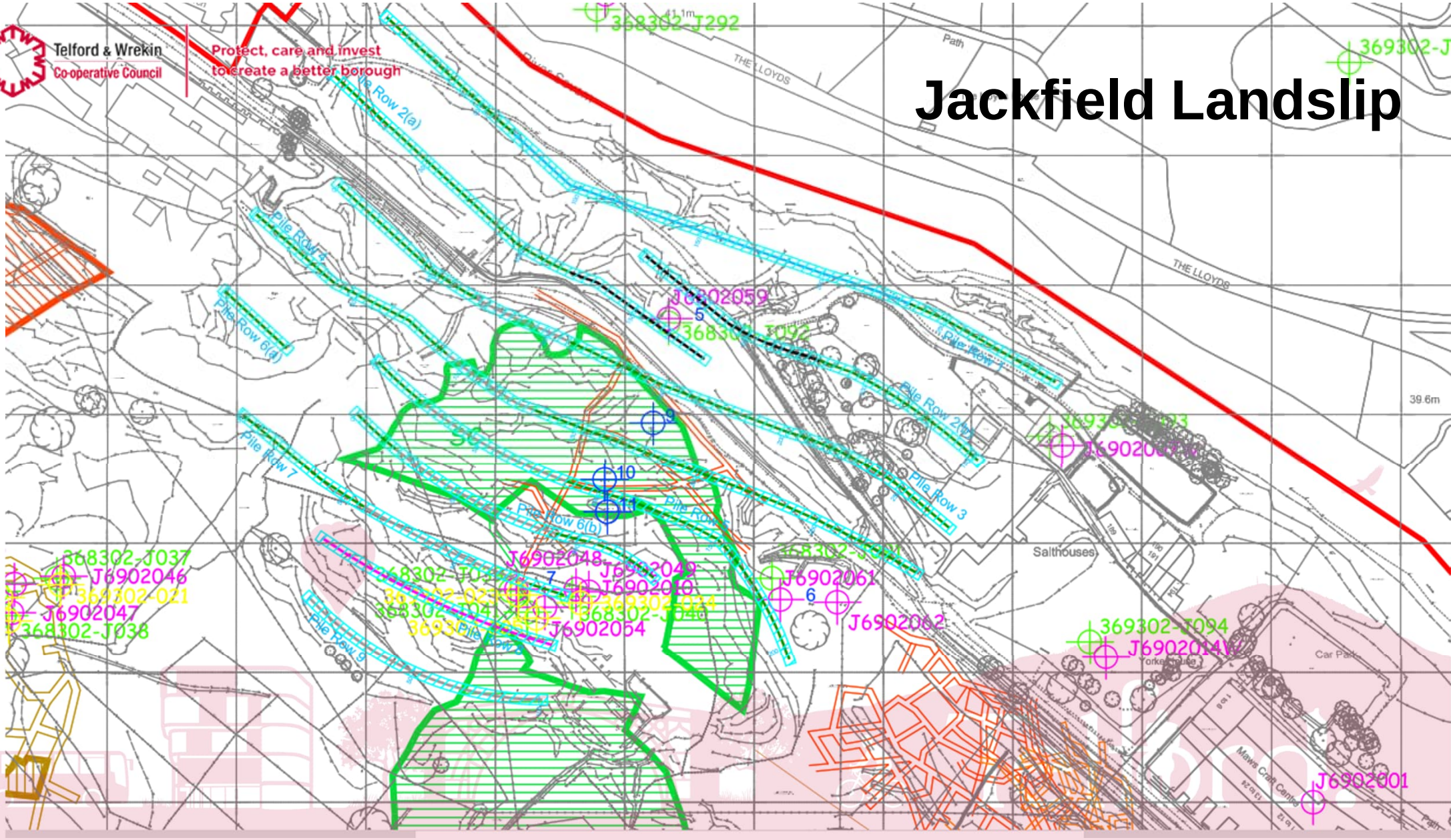
Jackfield Landslip



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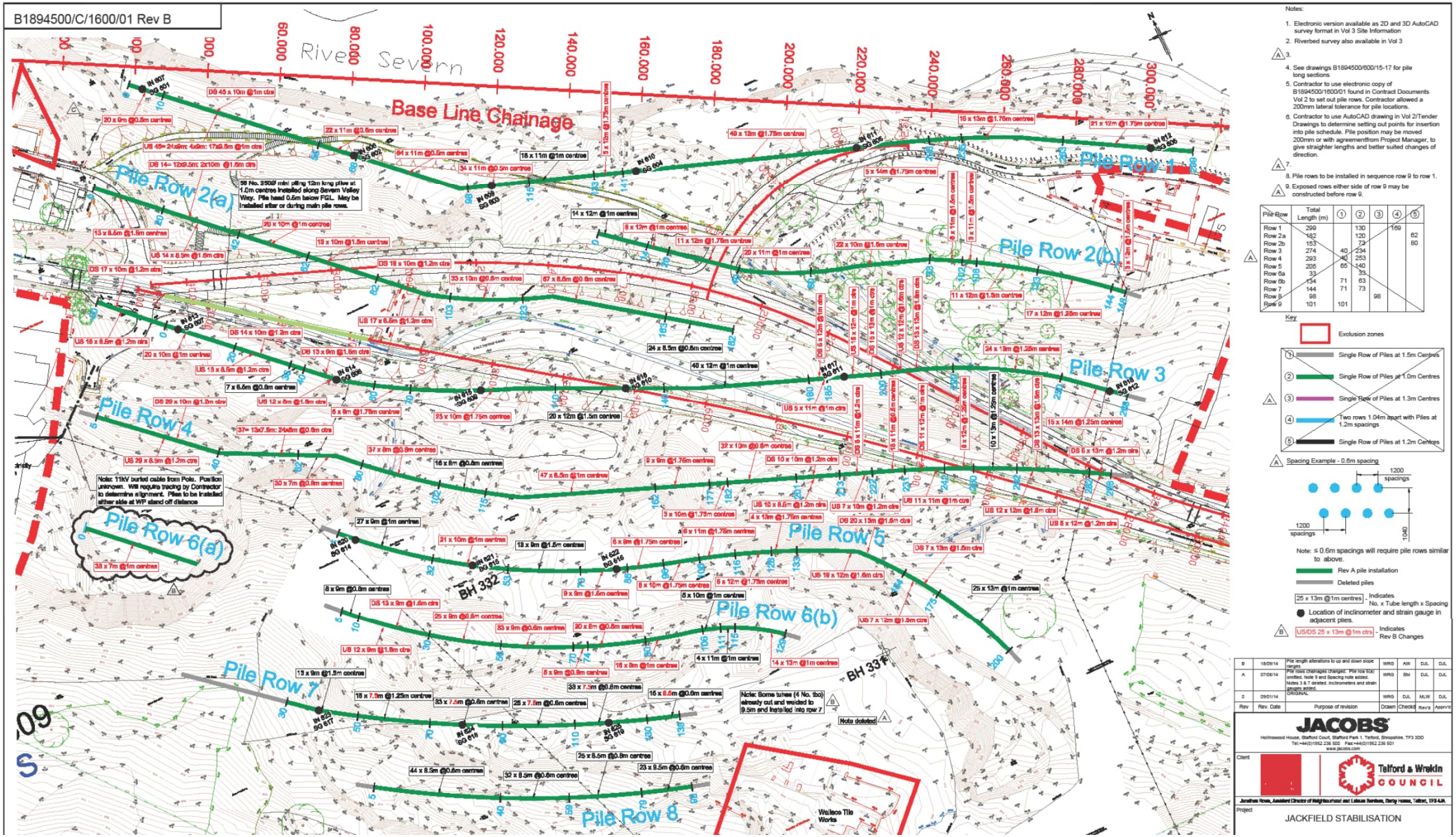
Jackfield Landslip

Enabling Works

Jackfield Landslip

The stabilisation works involved:

- Installation of over two thousand 600mm diameter piles, reinforced with 450mm diameter steel tubes up to 13m long.
- Installation of over five hundred 250mm diameter concrete piles reinforced with 139mm steel tubes, again up to 13m long.
- Installation of over five hundred rotary displacement concrete piles up to 9m long.
- Construction of swales, ditches, ponds, pipes and associated structures in order to drain the area effectively – groundwater being a major contributor to landslides.
- Construction of a stone revetment in the river bank along the entire frontage of the landslip zone.



Notes:

1. Electronic version available as 2D and 3D AutoCAD survey format in Vol 3 Site Information
2. Riverbed survey also available in Vol 3
3.
4. See drawings B1894500/600/15-17 for pile long sections
5. Contractor to use electronic copy of B1894500/1600/01 found in Contract Documents Vol 2 to set out pile rows. Contractor allowed a 200mm lateral tolerance for pile locations.
6. Contractor to use AutoCAD drawing in Vol 2/Tender Drawings to determine setting out points for insertion into pile schedule. Pile position may be moved 200mm or with agreementfrom Project Manager, to give straighter lengths and better suited changes of direction.
7.
8. Pile rows to be installed in sequence row 9 to row 1.
9. Exposed rows either side of row 9 may be constructed before row 9.

Pile Row	Total Length (m)	①	②	③	④	⑤
Row 1	299		130		169	
Row 2a	182		120			62
Row 2b	153		73			80
Row 3	274	40	234			
Row 4	293	40	253			
Row 5	205	65	140			
Row 6a	33		35			
Row 6b	134	71	63			
Row 7	144	71	73			
Row 8	98			98		
Row 9	101	101				

Key

Exclusion zones

① Single Row of Piles at 1.5m Centres

② Single Row of Piles at 1.0m Centres

③ Single Row of Piles at 1.3m Centres

④ Two rows 1.04m apart with Piles at 1.2m spacings

⑤ Single Row of Piles at 1.2m Centres

Spacing Example - 0.6m spacing

Note: ≤ 0.6m spacings will require pile rows similar to above.

Rev A pile installation

Deleted piles

25 x 13m @1m centres - Indicates No. x Tube length x Spacing

Location of inclinometer and strain gauge in adjacent piles.

US/DS 25 x 13m @1m ctrs - Indicates Rev B Changes

Rev	Rev. Date	Purpose of revision	Drawn	Checkd	Revd	Apprvd
B	18/09/14	Pile length alterations to up and down slope ranges	WRG	AW	DJL	DJL
A	07/08/14	Pile rows chainages changed. Pile row 6(a) omitted. Note 9 and Spacing note added. Notes 3 & 7 deleted. Inclinometers and strain gauges added.	WRG	BM	DJL	DJL
0	09/01/14	ORIGINAL	WRG	DJL	MLW	DJL

JACOBS

Hollinswood House, Stafford Court, Stafford Park 1, Telford, Shropshire, TF3 3DD
Tel:+44(0)1952 236 500 Fax:+44(0)1952 236 501
www.jacobs.com

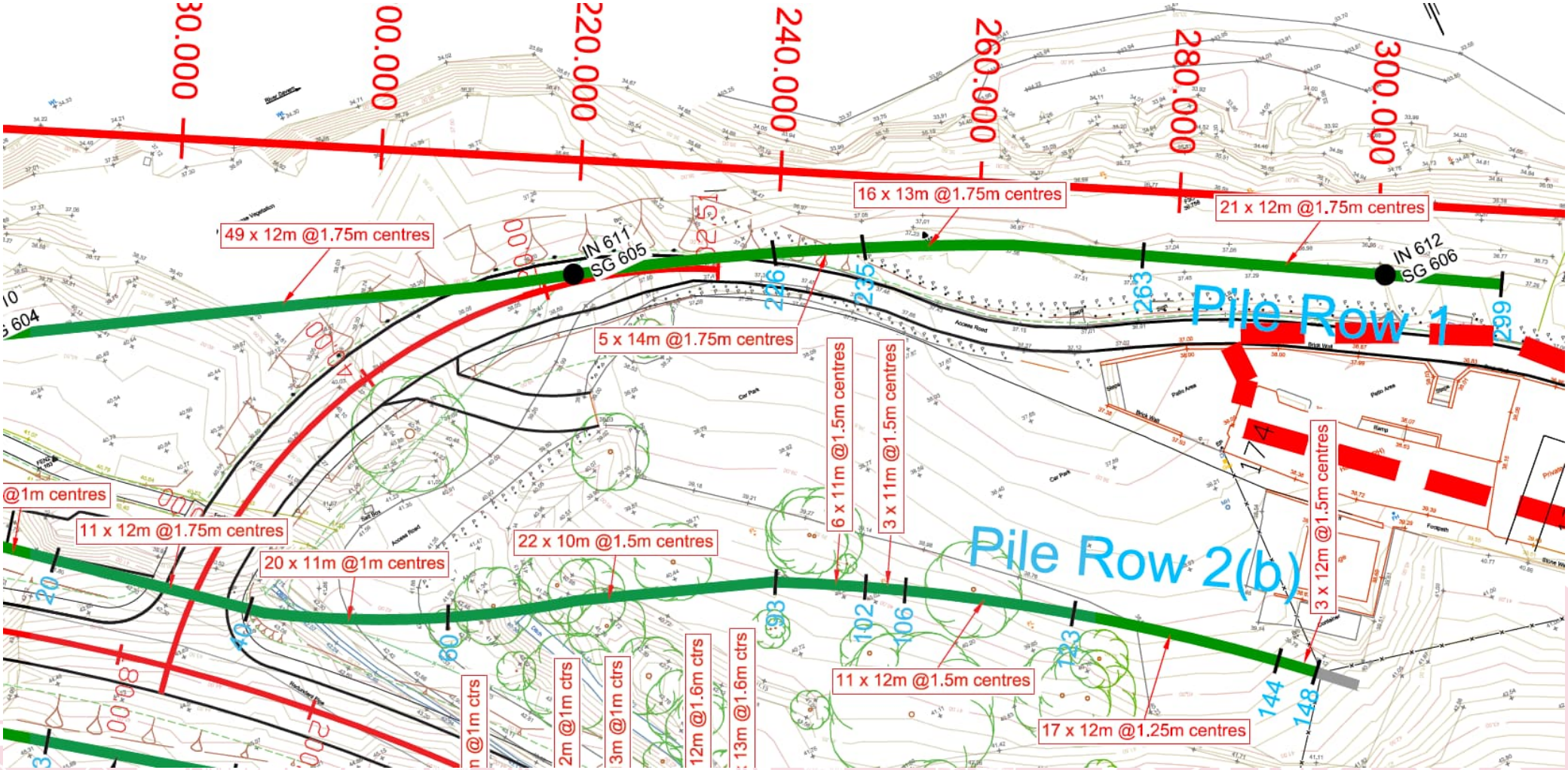
Client

Telford & Wrekin COUNCIL

Jonathan Rowe, Assistant Director of Neighbourhood and Leisure Services, Darby House, Telford, TF3 4JA.

Project

JACKFIELD STABILISATION


220.000
240.000
260.000
280.000
300.000
49 x 12m @1.75m centres
16 x 13m @1.75m centres
21 x 12m @1.75m centres
IN 611
SG 605
IN 612
SG 606
Pile Row 1
5 x 14m @1.75m centres
6 x 11m @1.5m centres
3 x 11m @1.5m centres
3 x 12m @1.5m centres
11 x 12m @1.75m centres
20 x 11m @1m centres
22 x 10m @1.5m centres
Pile Row 2(b)
11 x 12m @1.5m centres
17 x 12m @1.25m centres


ALL
ROOMS ENSUITE
Friday, 7 June 2024 11:28:32
Salthouse Road
Telford and Wrekin TF8 7LP

Telford & Wrekin Co-operative Council

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Jiggers Bank, Coalbrookdale

One of the three main routes into the Ironbridge Gorge, Jiggers Bank sites just north of the IGWHS.

Jiggers Bank, Coalbrookdale

- The road began as a horse drawn tramway that was first laid down in 1749.
- A road was constructed to replace the tramway in 1817; initially this was a toll road and has since become a public highway.
- To the west is Loamhole Dingle, the brook is a tributary of the Coal Brook
- Movement on the northern section of the road's western (uphill) lane forced a partial road closure in late 2020.
- It remained under two-way lights for three years.

Telford & Wrekin
Co-operative Council

Telford & Wrekin Co-operative Council

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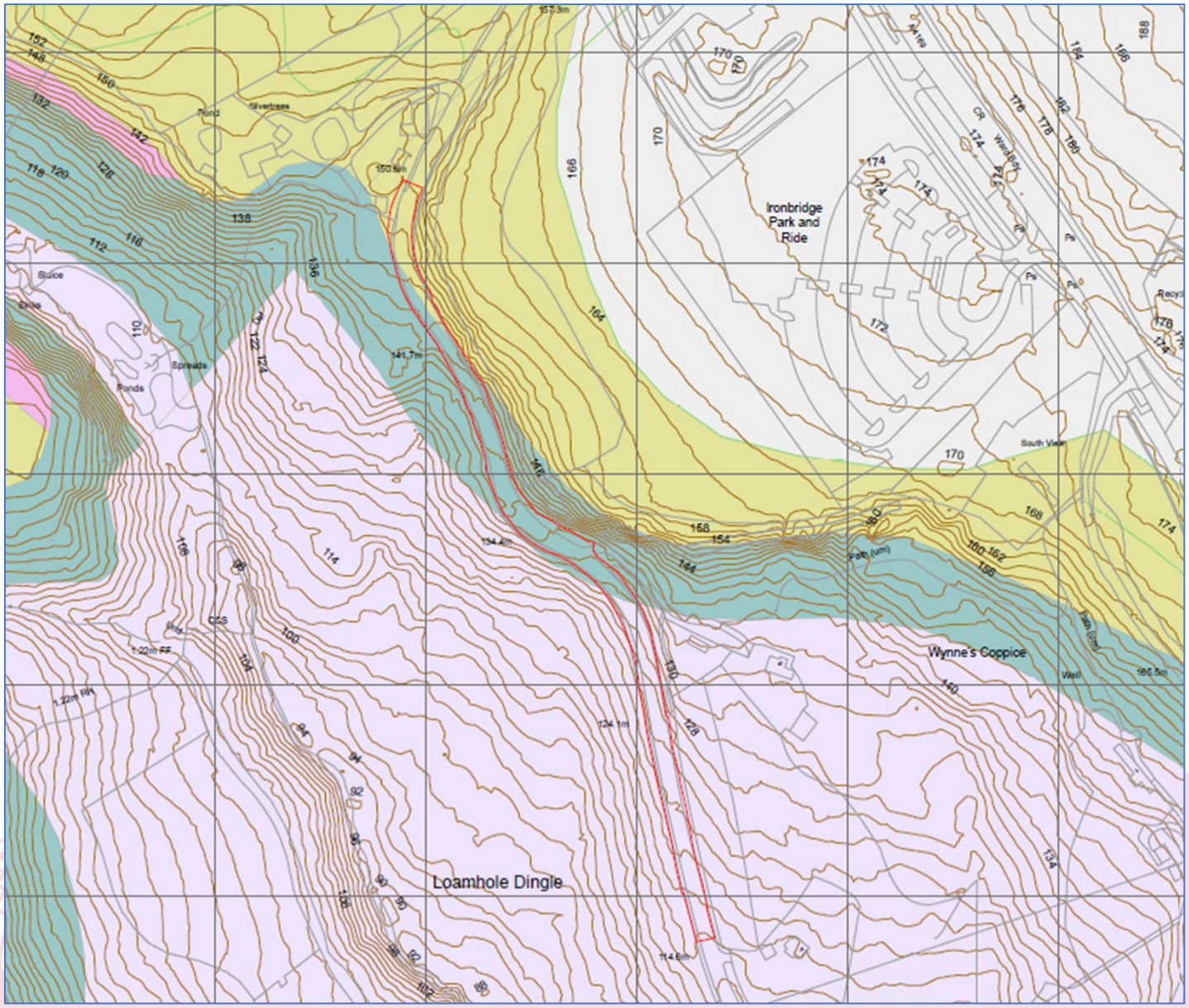
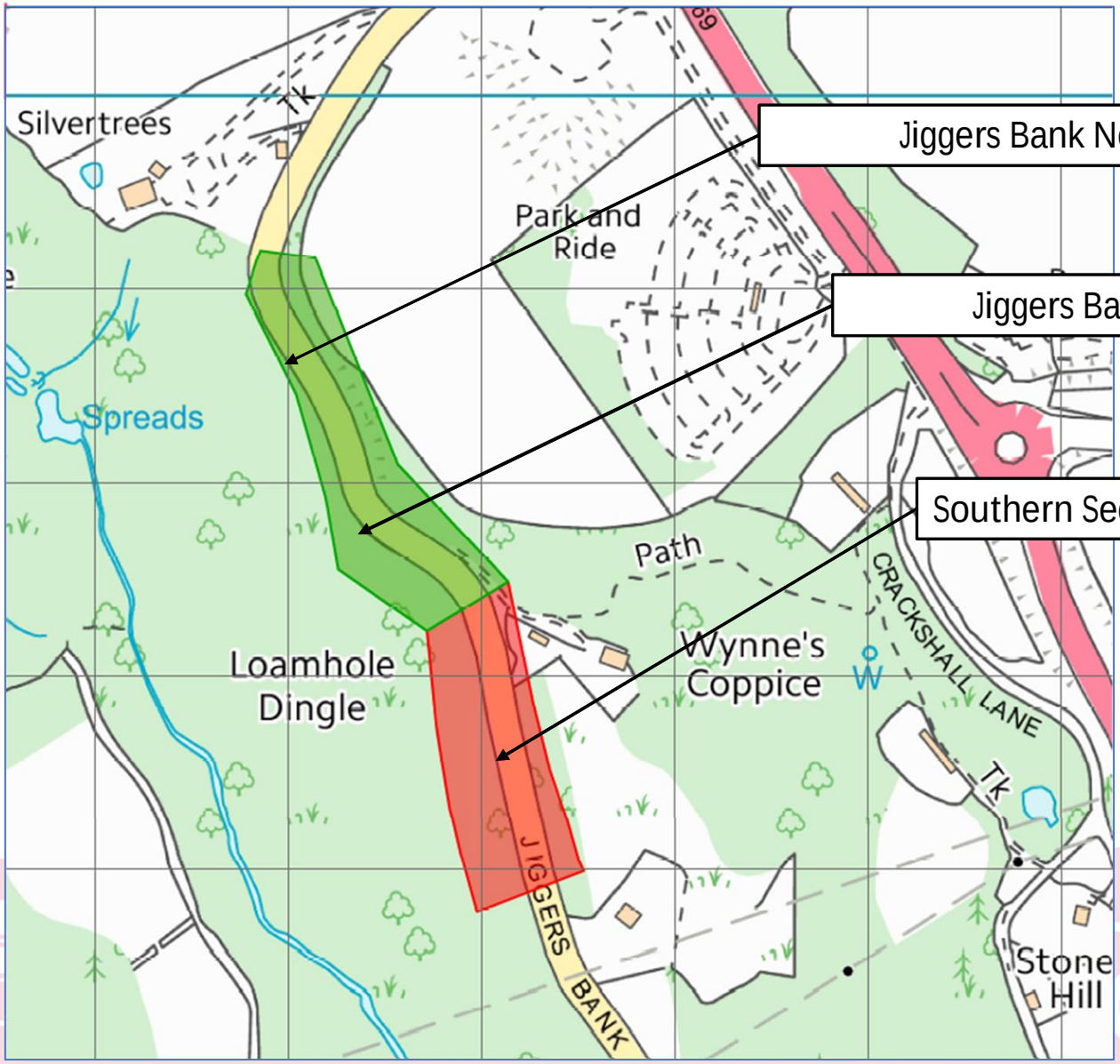
Jiggers Bank Geology

2m contours



Telford & Wrekin Co-operative Council



Jiggers Bank No.1 Retaining Wall

Jiggers Bank No.2 Retaining Wall

Southern Section - c2000 remedial works

Jiggers Bank

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Jiggers Bank - Existing Condition

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Jiggers Bank

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Jiggers Bank Retaining Wall

Southern part of Jiggers Bank 1988

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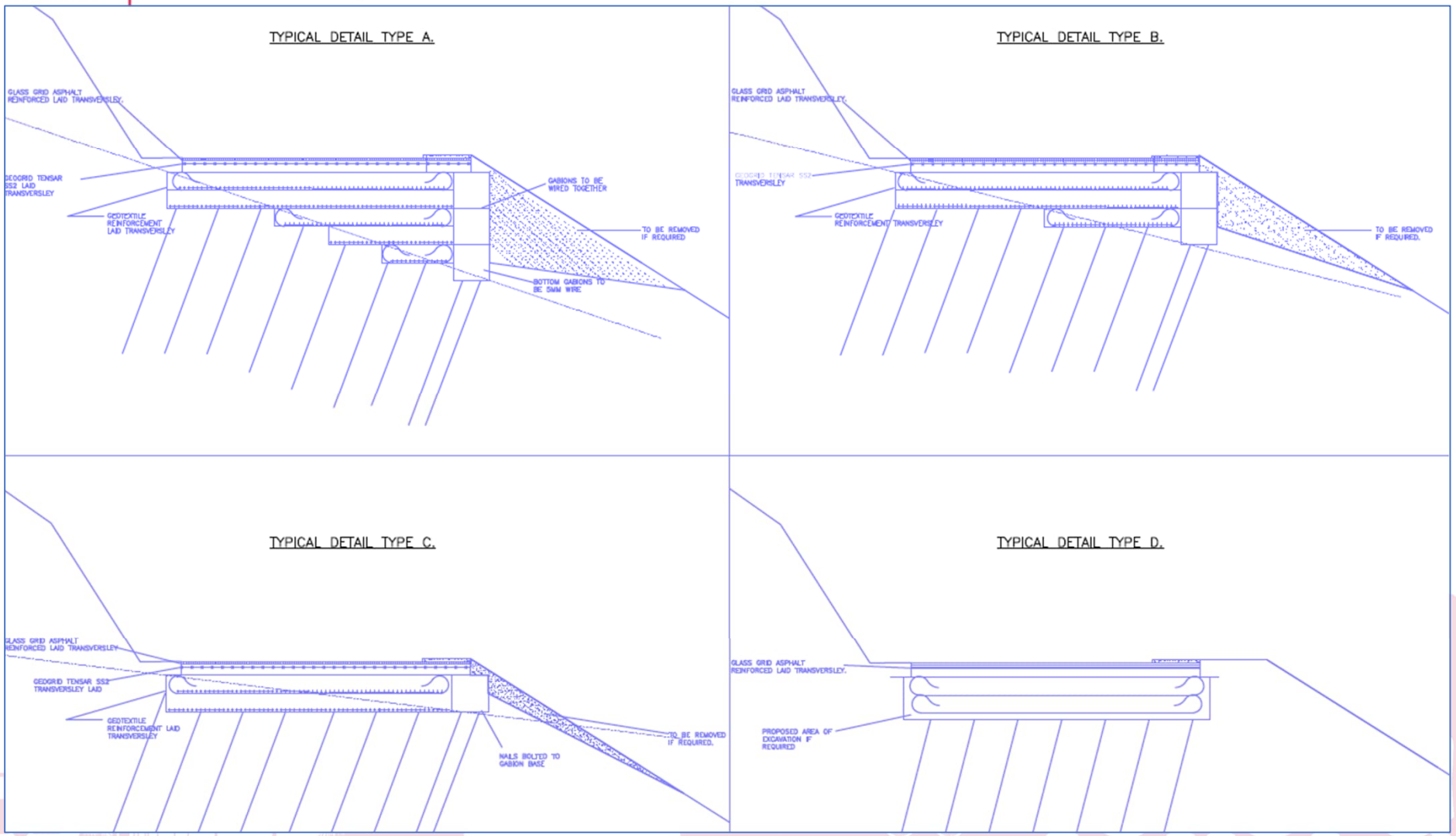
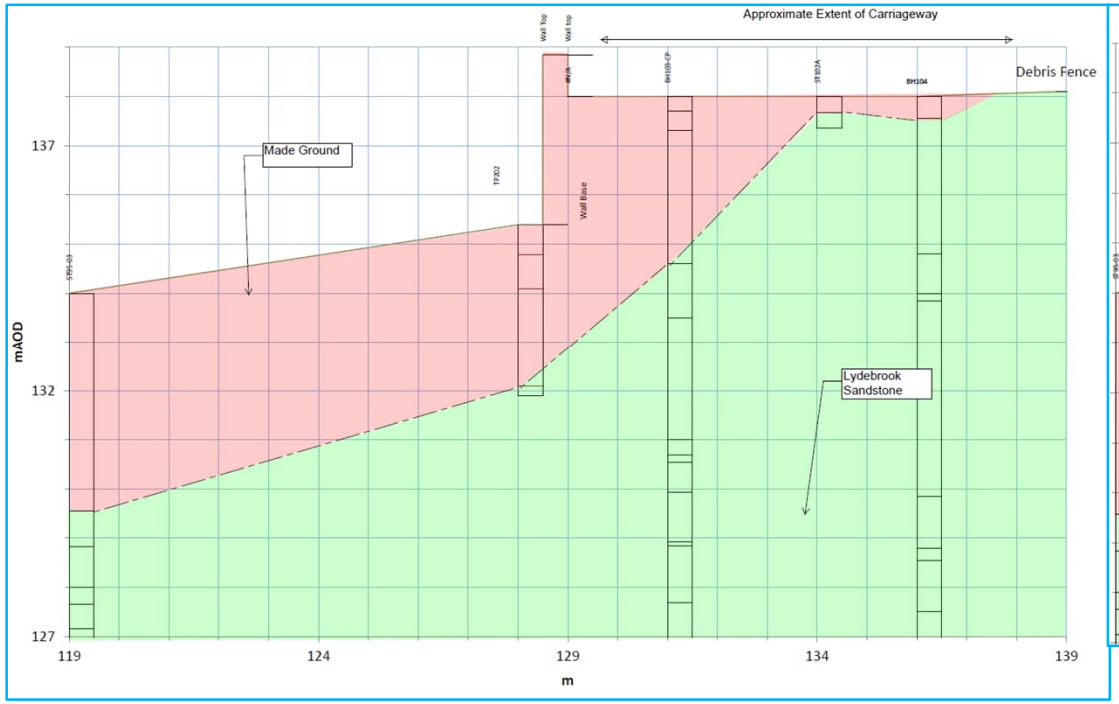
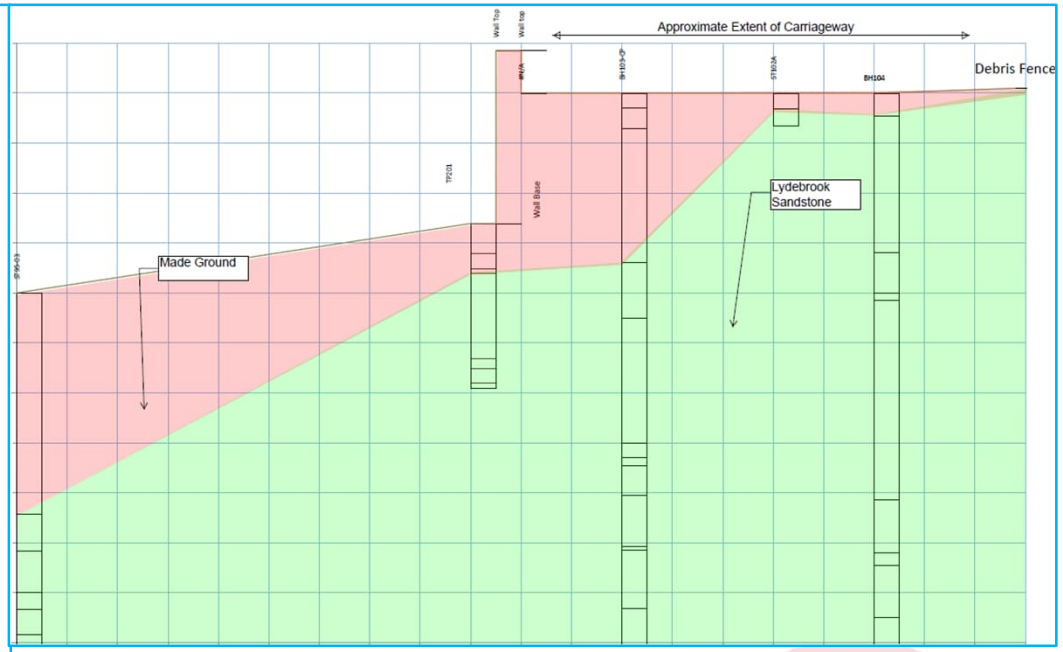
c2000 Remedial Works



2000 Remedial Works

2000 Remedial Works


Approximate Extent of Carriageway
Debris Fence
Made Ground
Lydebrook Sandstone
Wall Base
TP202
BH104
mAOD
137
132
127
119
124
129
134
139
m


Approximate Extent of Carriageway
Debris Fence
Made Ground
Lydebrook Sandstone
Wall Base
TP201
BH104

Telford & Wrekin Co-operative Council

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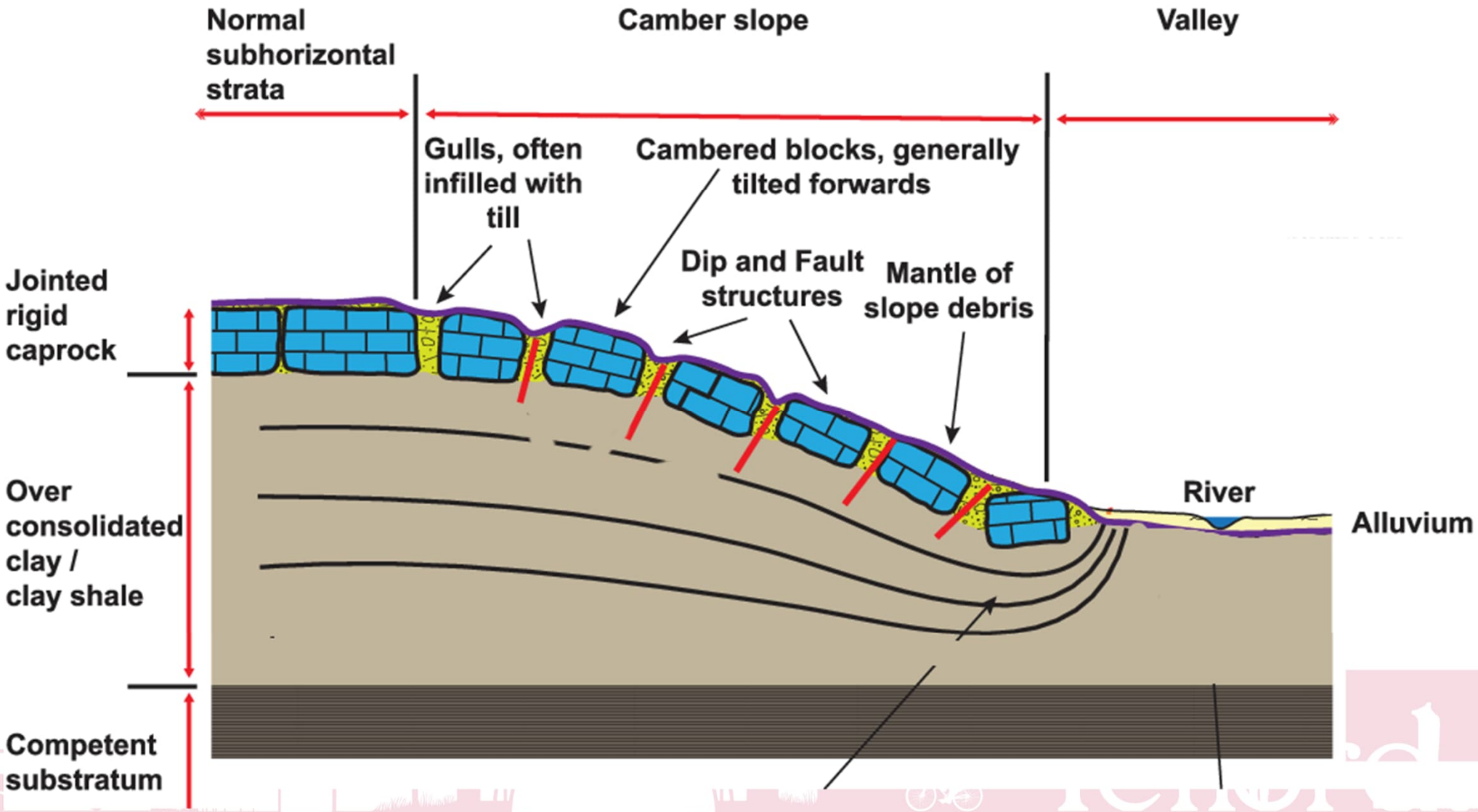
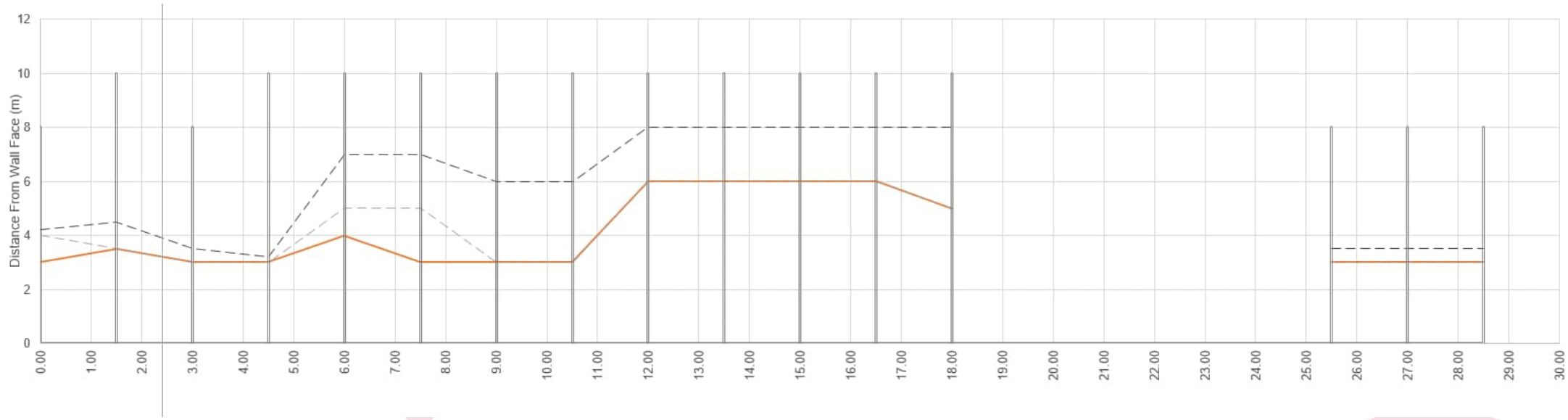

Normal subhorizontal strata
Camber slope
Valley
Gulls, often infilled with till
Cambered blocks, generally tilted forwards
Dip and Fault structures
Mantle of slope debris
Jointed rigid caprock
Over consolidated clay / clay shale
Competent substratum
River
Alluvium


Distance From Wall Face (m)
0
2
4
6
8
10
12
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
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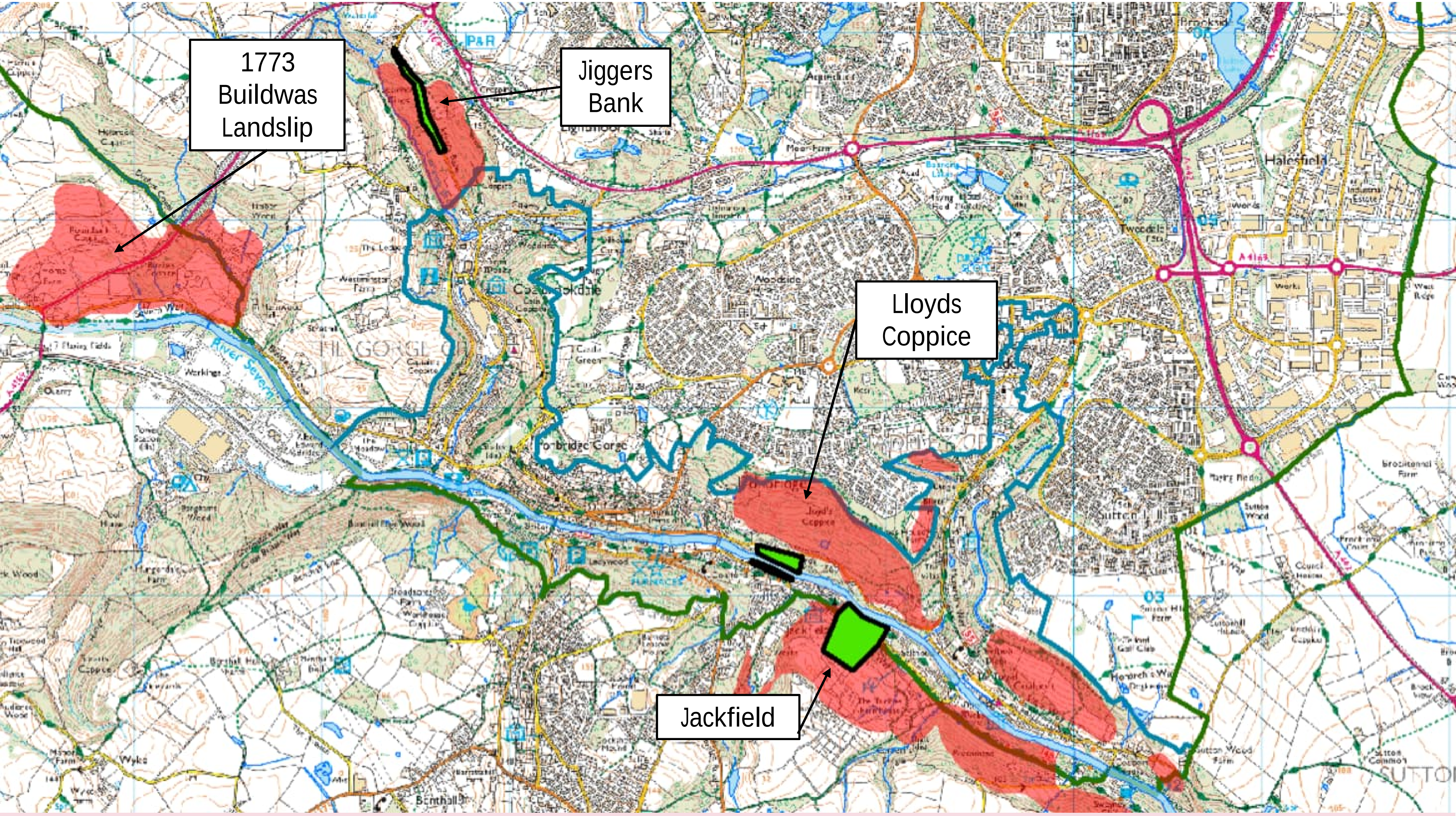
22.00
23.00
24.00
25.00
26.00
27.00
28.00
29.00
30.00


1773 Buildwas Landslip
Jiggers Bank
Lloyds Coppice
Jackfield

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Mine Entry Collapse – Severn Valley Way

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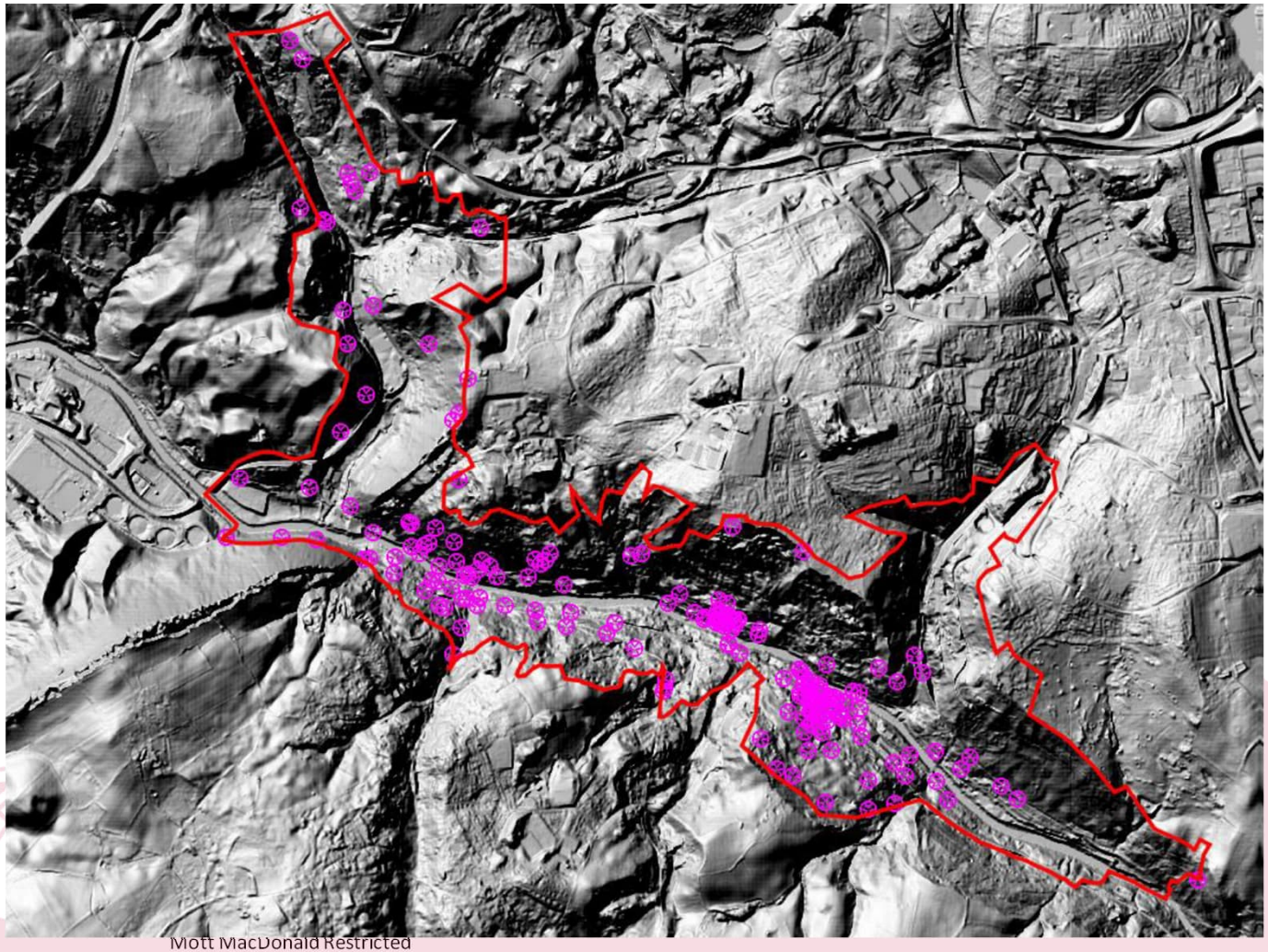
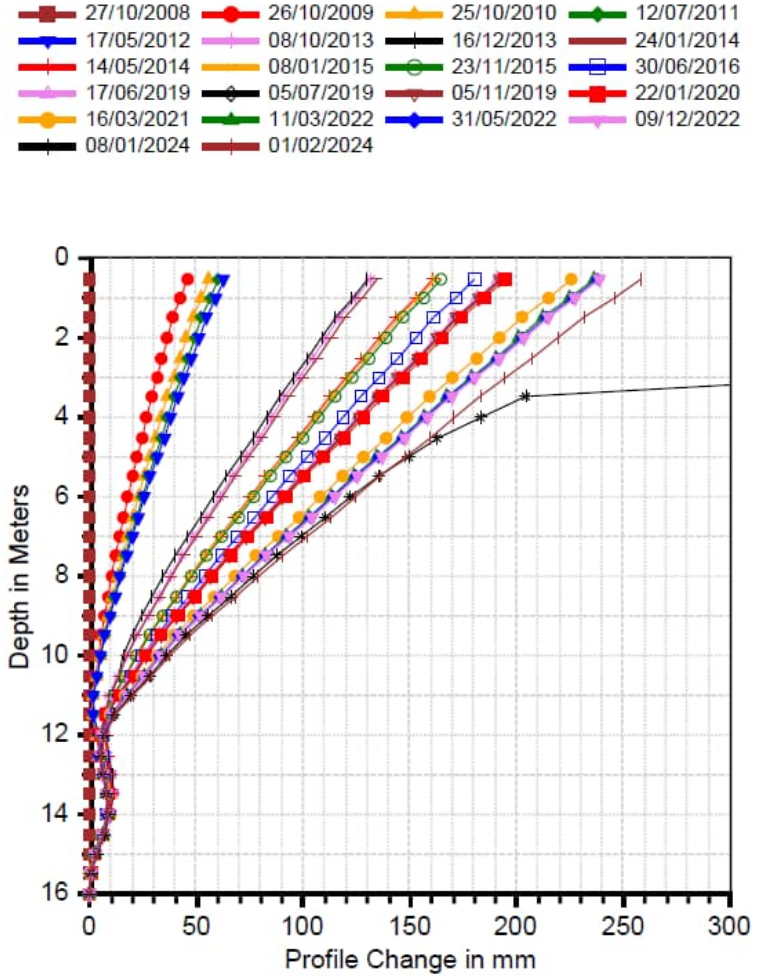
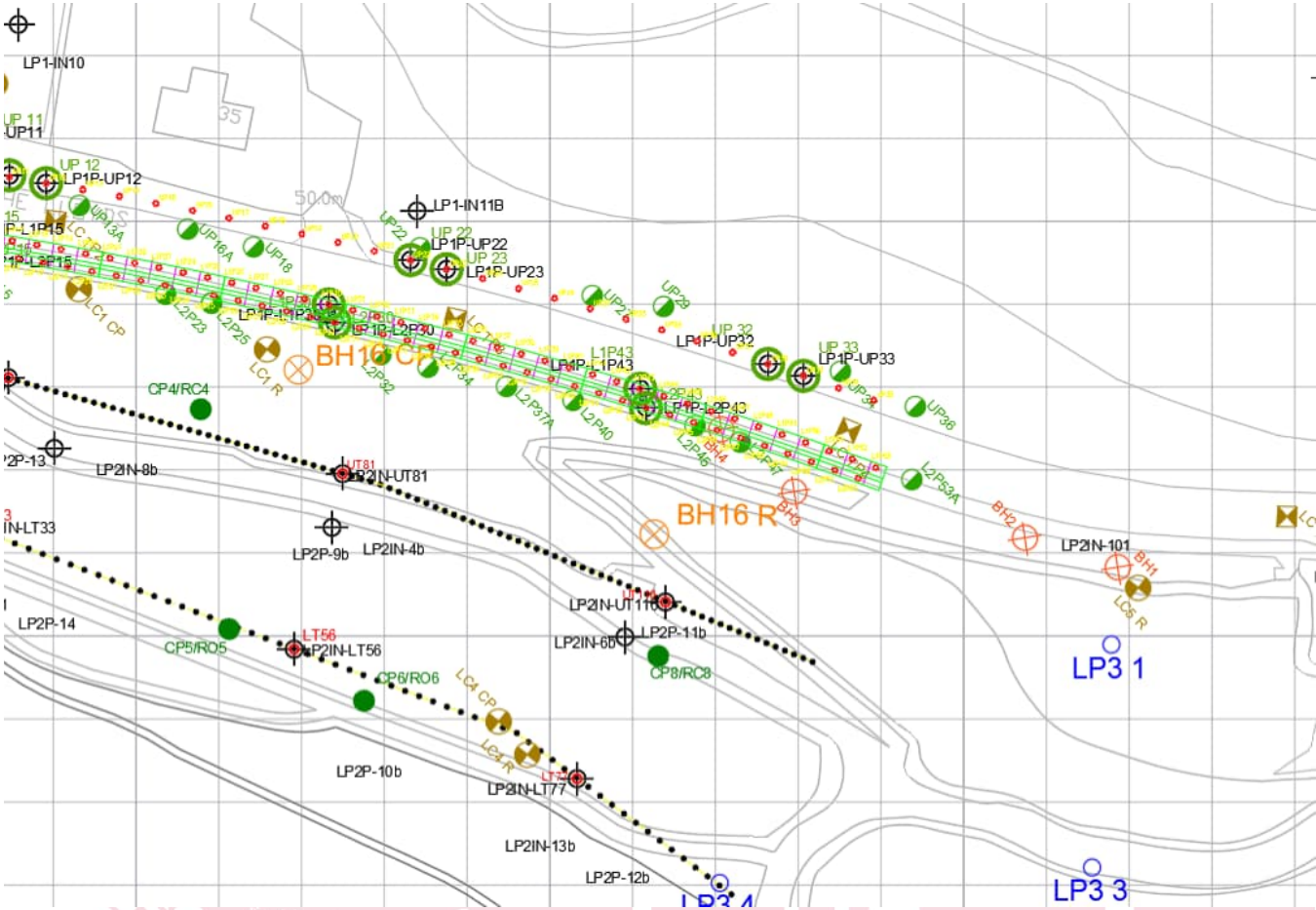
Monitoring

200+ inclinometer access tubes

200+ road pins




123 LT77 N A
27/10/2008
26/10/2009
25/10/2010
12/07/2011
17/05/2012
08/10/2013
16/12/2013
24/01/2014
14/05/2014
08/01/2015
23/11/2015
30/06/2016
17/06/2019
05/07/2019
05/11/2019
22/01/2020
16/03/2021
11/03/2022
31/05/2022
09/12/2022
08/01/2024
01/02/2024
Depth in Meters
Profile Change in mm
0
2
4
6
8
10
12
14
16
0
50
100
150
200
250
300


LP1-IN10
LP1P-UP12
LP1-IN11B
LP1P-UP22
LP1P-UP23
LP4P-UP32
LP1P-UP33
BH16 CP
BH16 R
CP4/RC4
LP2IN-8b
LP2IN-UT81
LP2P-9b
LP2IN-4b
LP2P-14
CP5/RO5
LP2IN-LT56
CP6/RO6
LP2P-10b
LP2IN-LT77
LP2IN-13b
LP2P-12b
LP2IN-101
LP2P-11b
CP8/RC8
LP3 1
LP3 3

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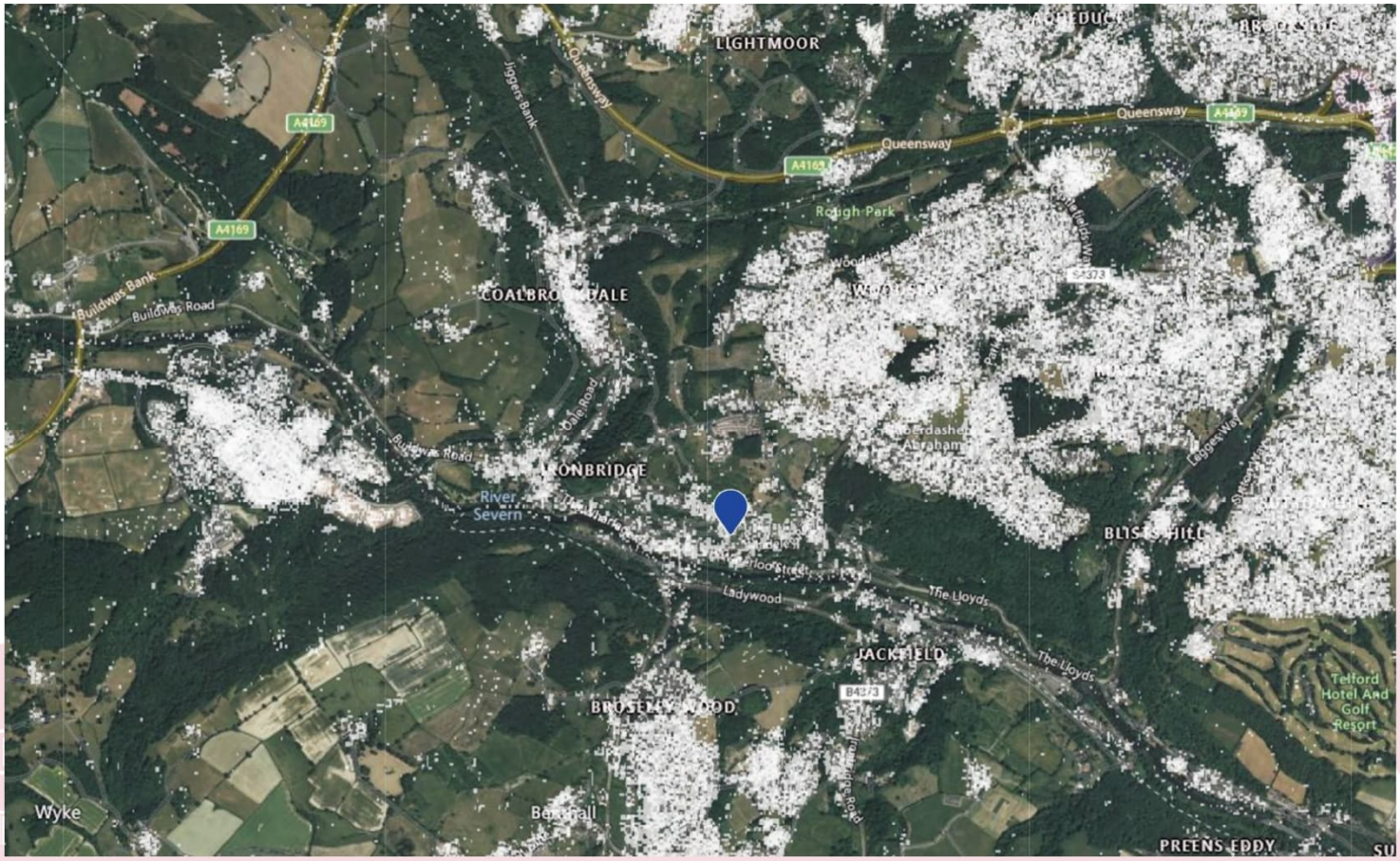
Future Monitoring: INSAR

Interferometric Synthetic Aperture Radar (InSAR) ground movement data



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Operation Tangent

Multi-agency response to a catastrophic slope failure in the Gorge

Armed forces, emergency services, utilities companies, local authorities, Environment Agenc

The geotechnical team have input into the proces by feeding the risks posed monitoring data to th coordinators.

Alert Level	General Alert Description	Situation	Agency Status
1 (Green)	Low – Business as Usual	Routine monitoring and natural background movement	General organisational preparedness
2 (Yellow)	Medium - Standby	Conditions (ground conditions, rainfall and river levels) indicate an increased possibility of landslide	Enhanced preparedness to respond Enhanced monitoring activity (TWC)
3 (Amber)	High – Response (Plan Activation)	Increased risk of landslide event, with increased risk of physical change and/or loss to life. Continuing pre-emptive conditions indicate further increased risk of landslide	Mobilisation and scaled response Assumptions: TCG stood-up
4 (Red)	Critical – Response (Evacuation)	Imminent risk of significant landslide event	Mobilisation and scaled response Assumptions: TCG stood-up and SCG likely to be stood-up
5 (Purple)	Catastrophic - Response	A significant landslide event has occurred or is occurring	Mobilisation and scaled response Assumptions: TCG and SCG stood-up

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Development in the Ironbridge Gorge

The geotechnical provide advise to Telford & Wrekin Planners.

Previous team drafted and implemented a one page stability declaration form to accompany planning applications in the Gorge.

Recently revised into a more comprehensive information pack and form.

It covers:

- Mining & its mitigation
- Slope stability & stabilising measures
- Permanent & temporary works

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Fin