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The Importance of Construction Stage Geo-Data on Infrastructure Projects

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Geotechnical Engineering and Design Practices for Sustainable Infrastructure Development

Wednesday 15th May 2024

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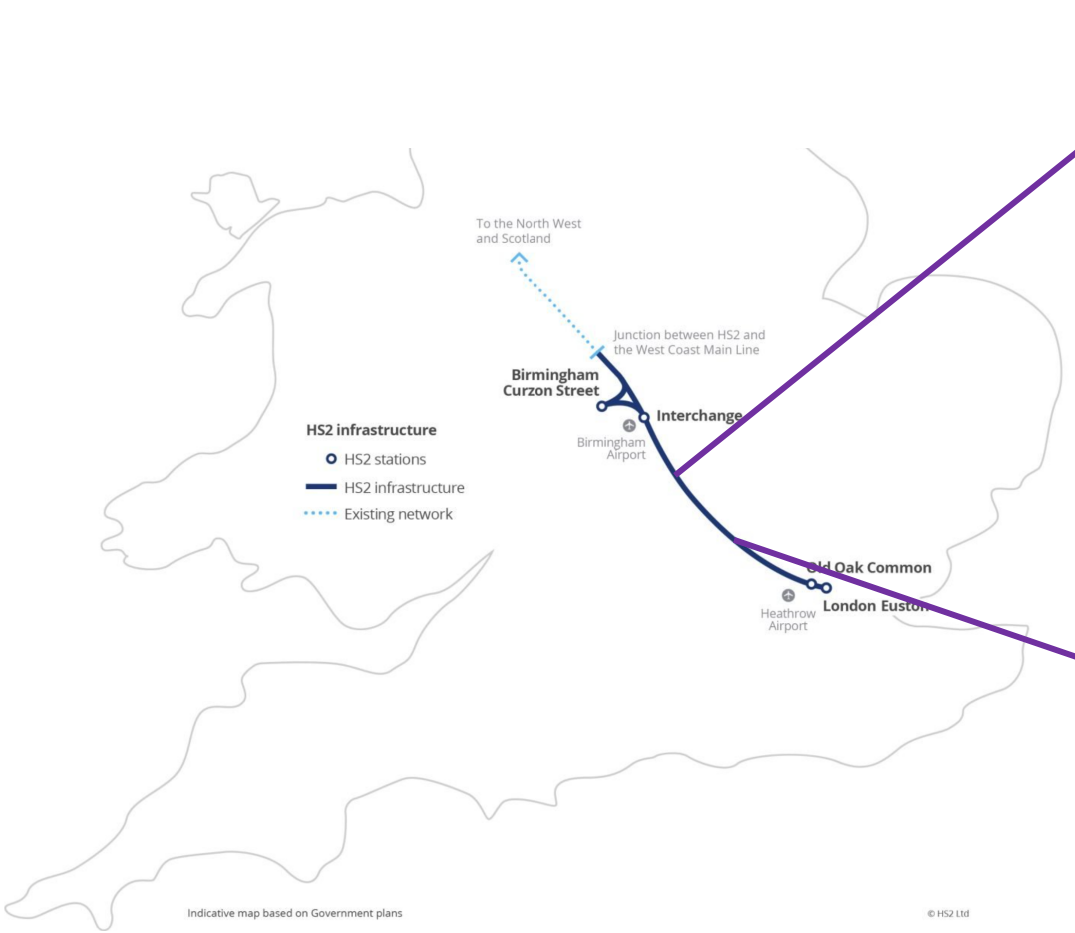
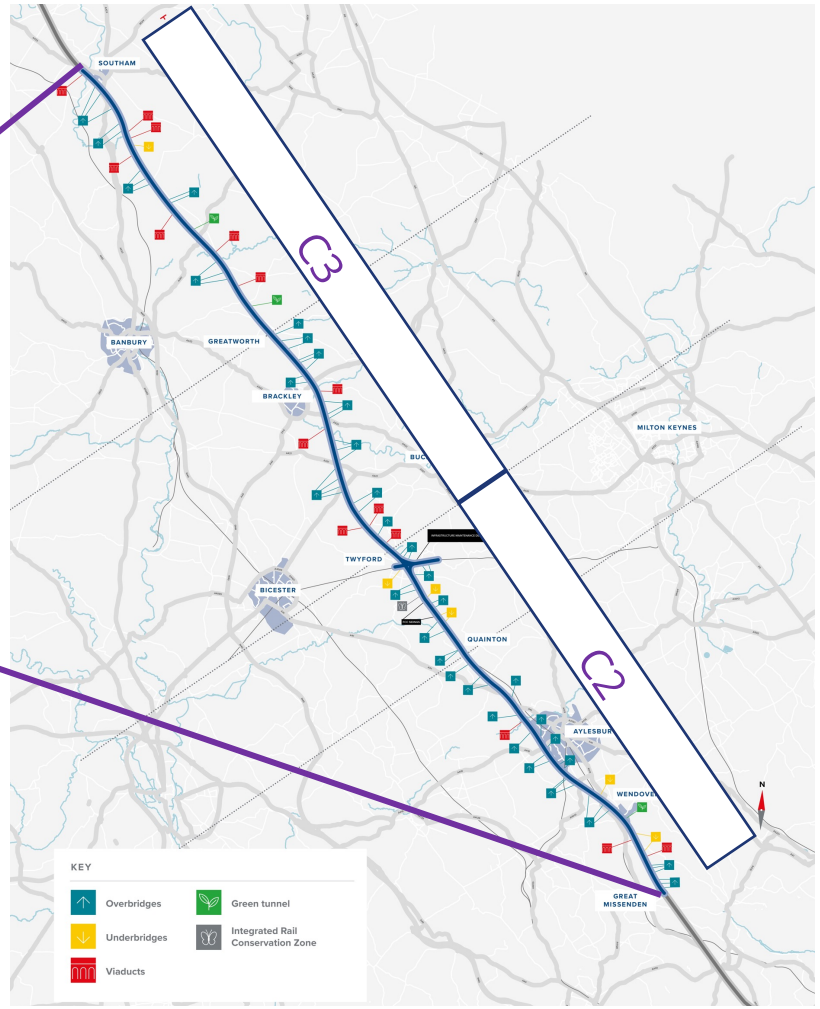
HS2 C23 Introduction



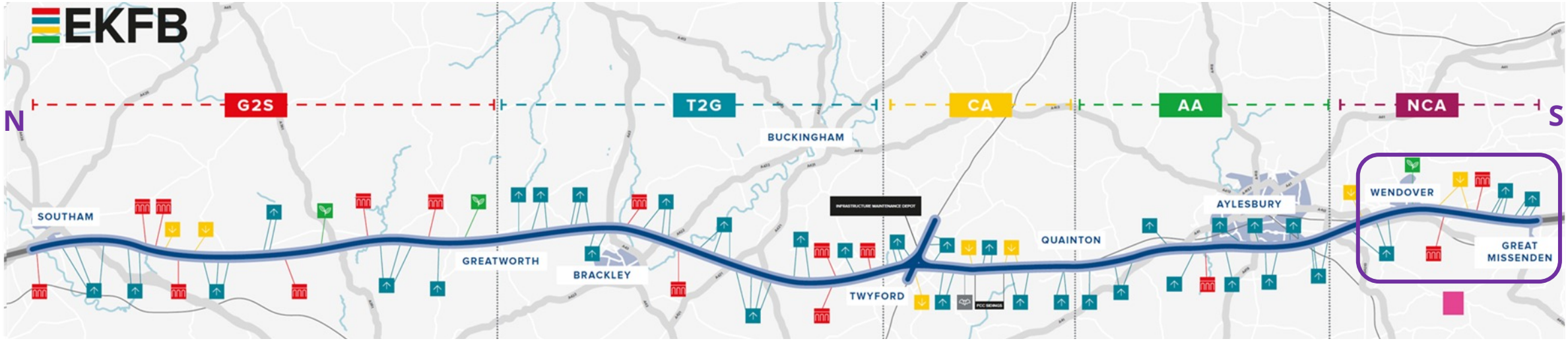
HS2 Phase One route



C23 sectors

Eiffage, Kier, Ferrovial, and Bam (EKFB), is building the Central 2 & 3 (C23) contracts for HS2 Phase One.

North Chilterns Area (NCA) Case Study



Case study area

Case Study: NCA section – Engineering Geology Model (EGM) refinement and dissolution feature mitigation

1. Development of an Engineering Geology Model (EGM/Model).
2. Targeted ground investigations.
3. Digital geo-data collection, reporting and visualisation during the construction stage.

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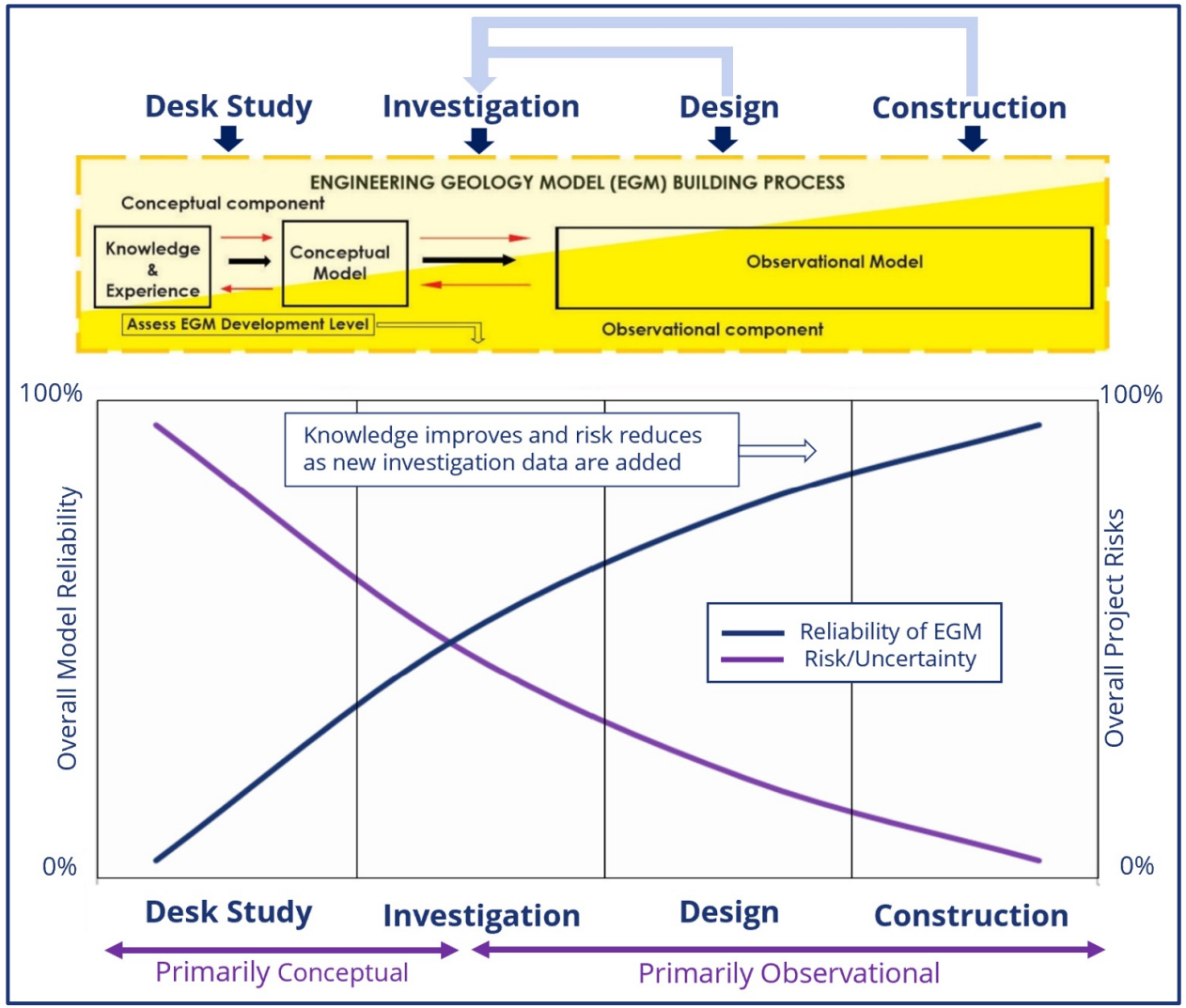
Engineering Geology Model Development



Modified from IAEG Commission 25 Publication, 2022

Stage	Data Source	Output
Desk Study	Published docs Local knowledge	Desk Study Report Geotechnical Risk Register (GRR)
Ground Investigation (GI)	LiDAR Geophysics Boreholes Lab testing	Ground Investigation Report (GIR) GRR
Design	Interpretation of GI Technical spec.	Geotechnical Design Report (GDR) GRR
Construction	Observations 3D Laser Scanning	Geotechnical Feedback Report (GFR) GRR

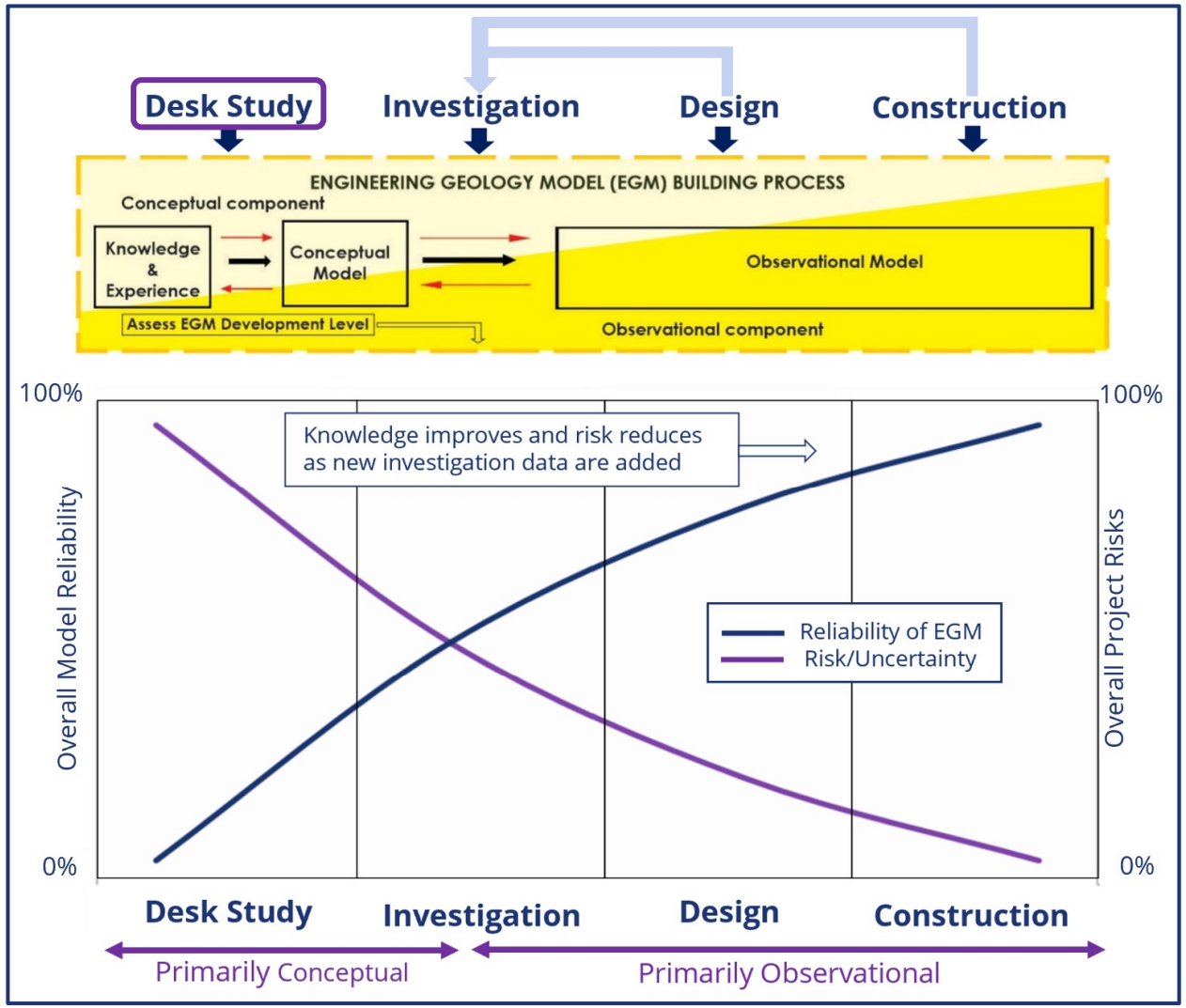
An EGM is crucial to effectively identify and mitigate potential geohazards.

An iterative process that informs and guides engineering decisions from start to finish.

As the quantity of collected data increase, the risk and uncertainty is reduced, and the reliability enhanced.

A robust model enhances safety, performance, and cost-effectiveness = **Sustainable Infrastructure Development**.

Desk Study



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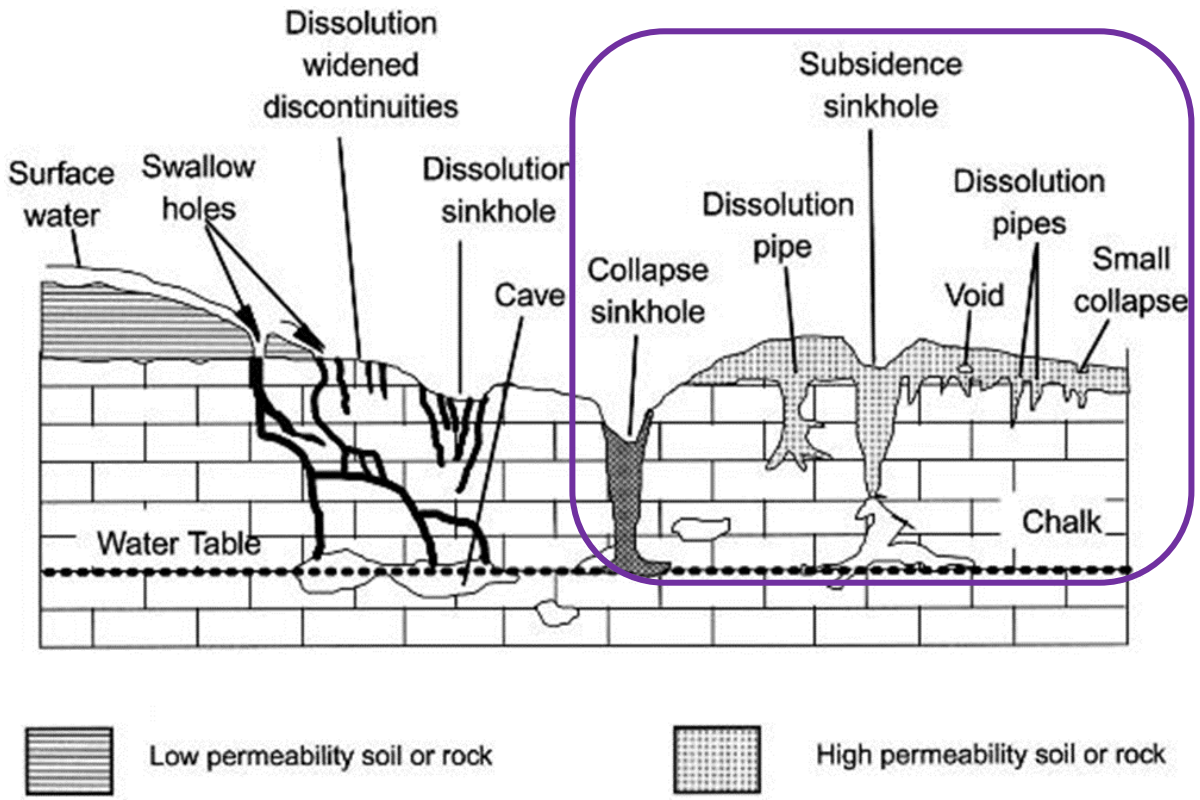
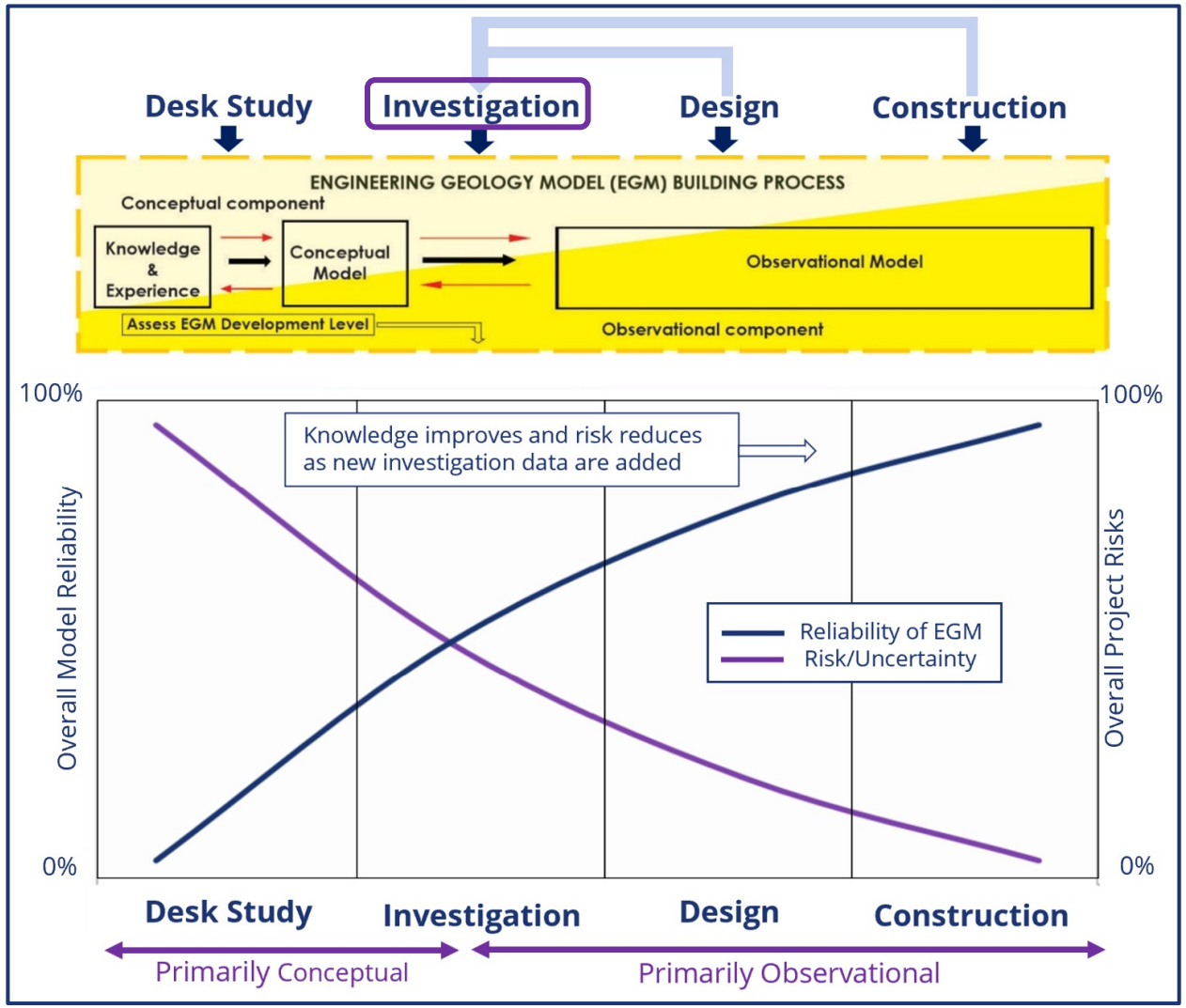


Schematic cross-section of common dissolution feature types (Applied Geology, 1993)

Ground Investigation



Modified from IAEG Commission 25 Publication, 2022

Stage	Data Source	Output
Ground Investigation (GI)	LiDAR Geophysics Boreholes Lab testing	Ground Investigation Report (GIR) Geotechnical Risk Register (GRR)

This data collection phase is crucial for refining the initial conceptual model by adding real data points and measurements.

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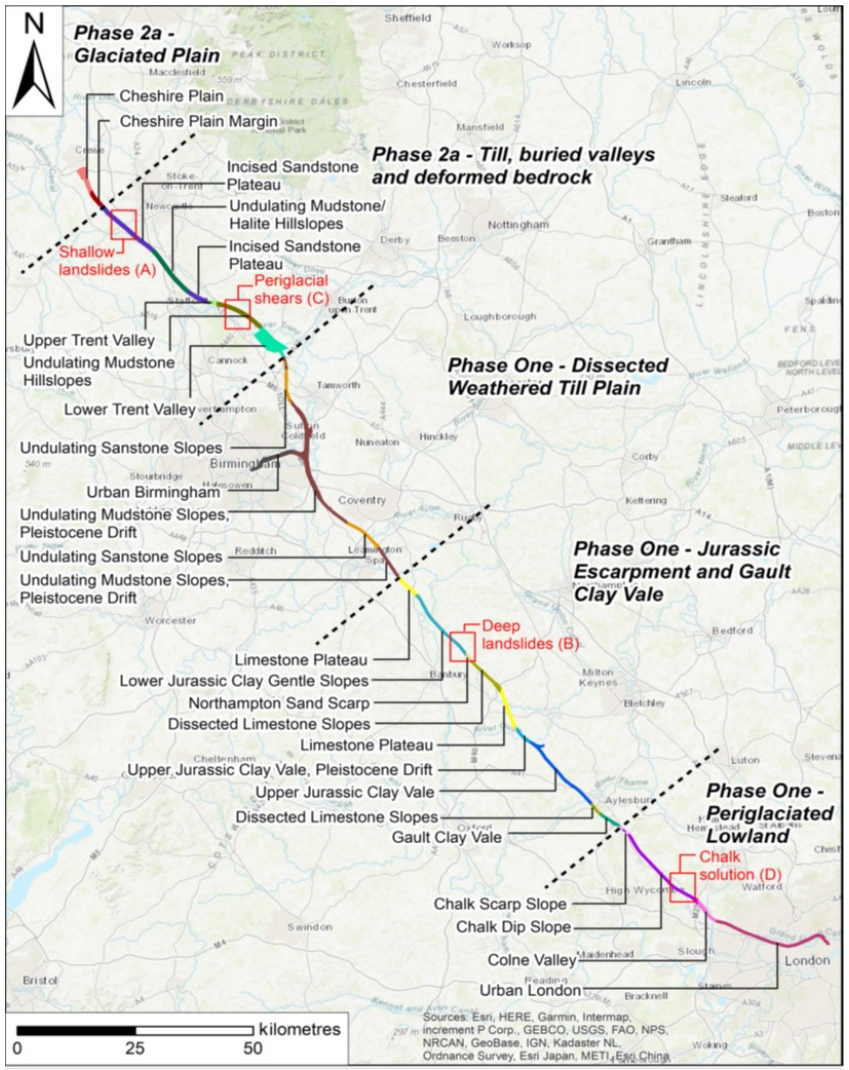
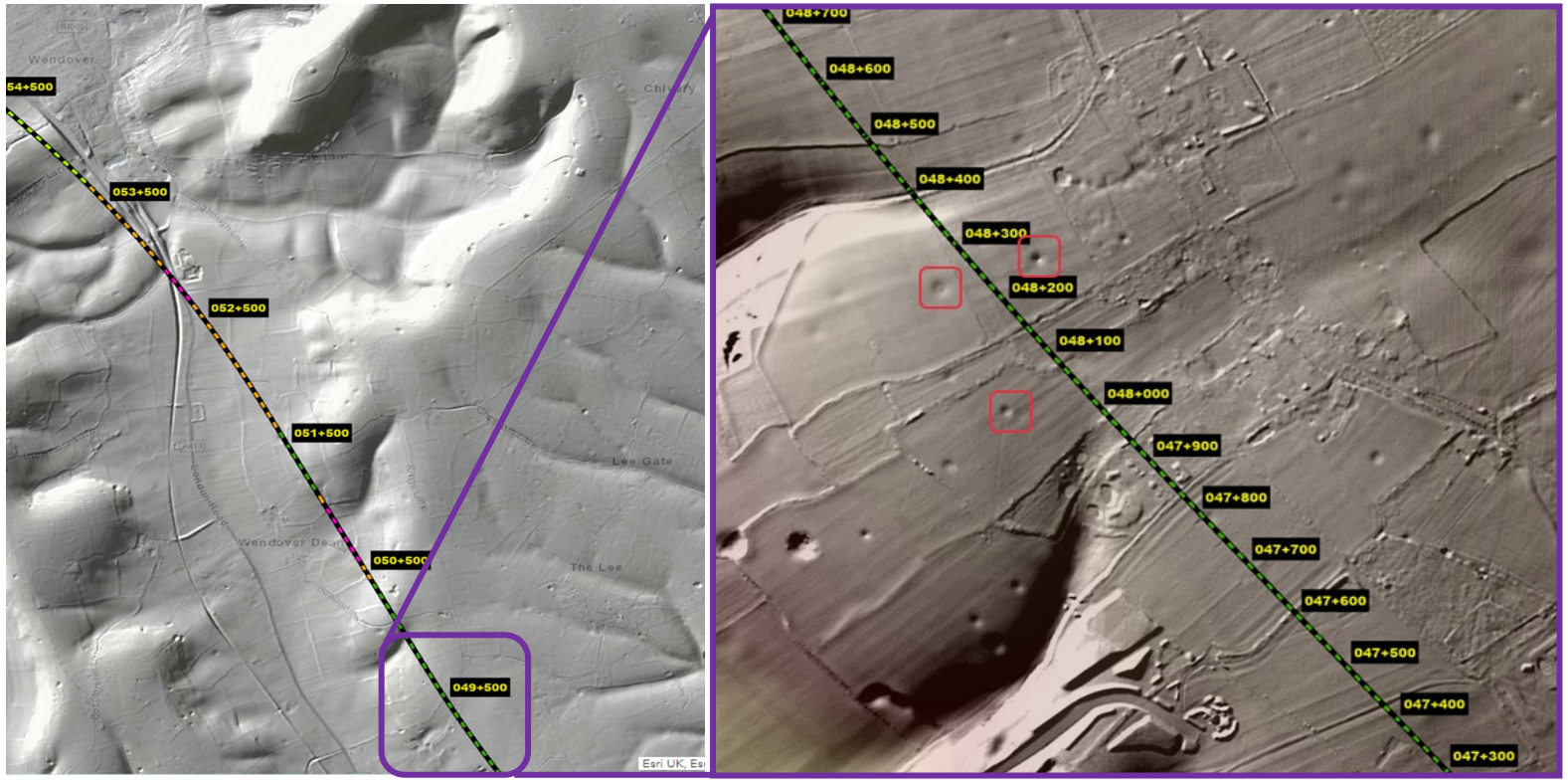
Ground Investigation



Geomorphological Terrains units after Moore et al., 2022



LIDAR Composite 1m DTM 2020 Hillshade

High : 255

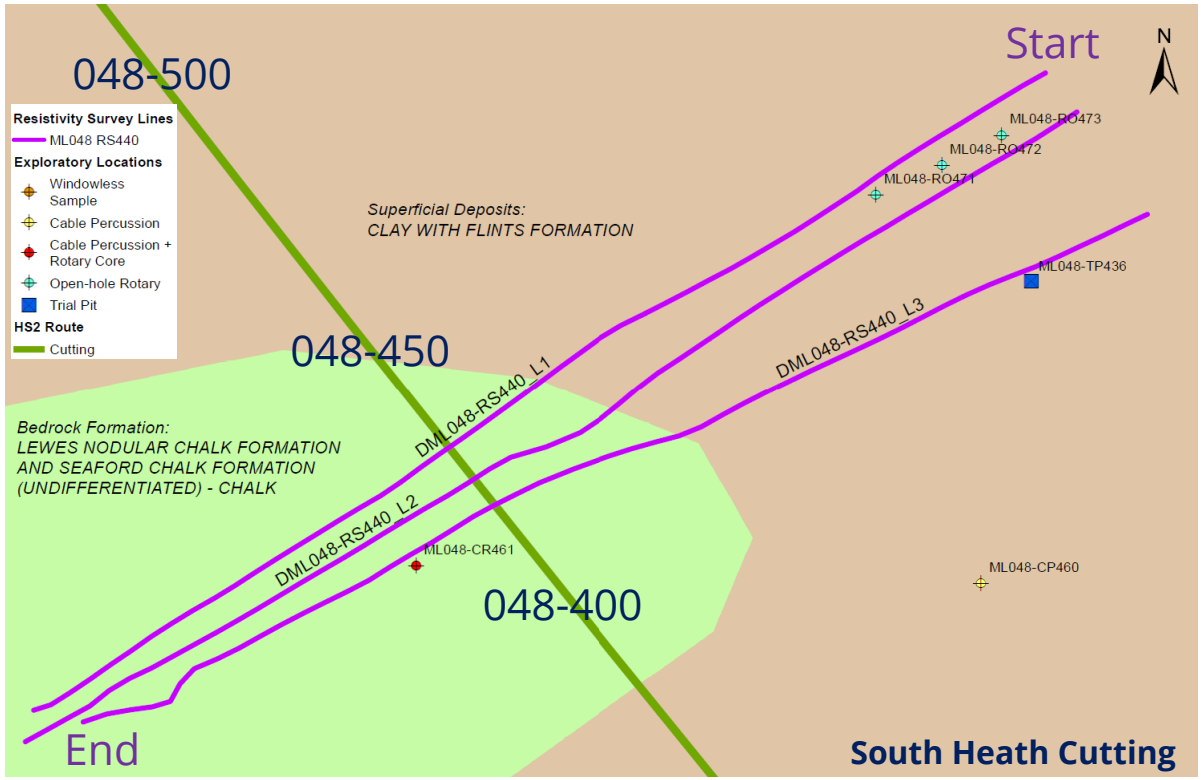
Low : 0

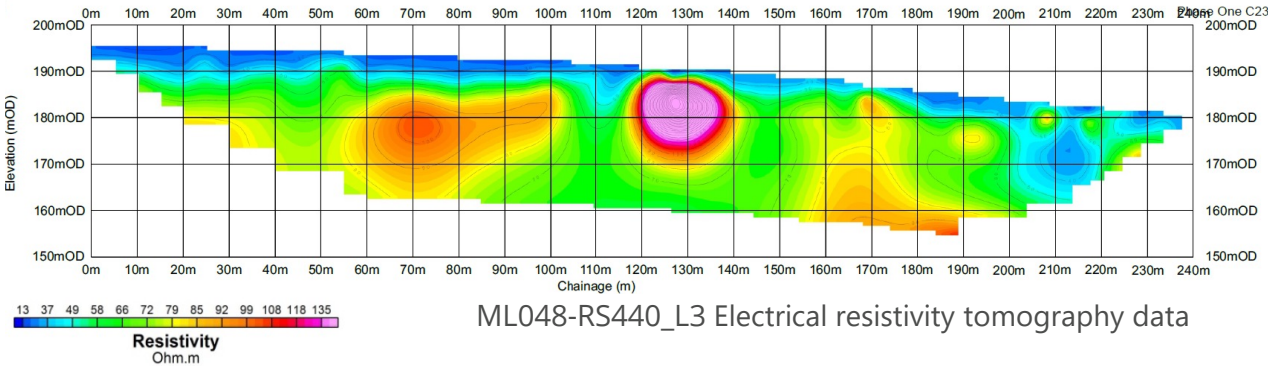
BGS LiDAR ©UKRI, 2022

BGS LiDAR ©UKRI, 2022

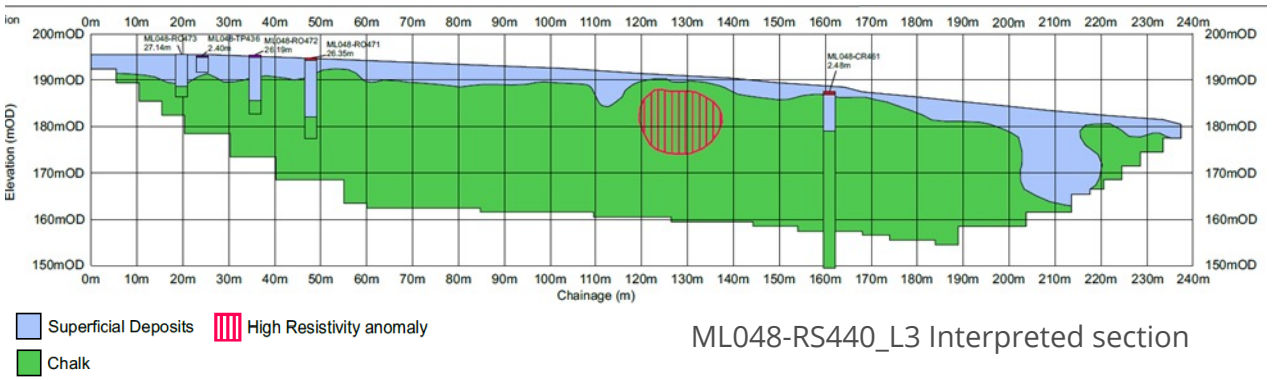
Stage	Data Source	Output
Ground Investigation (GI)	**LiDAR** Geophysics Boreholes Lab testing	Ground Investigation Report (GIR) Geotechnical Risk Register (GRR)

Ground Investigation





ML048-RS440_L3 Electrical resistivity tomography data



ML048-RS440_L3 Interpreted section

Thicker lower resistivity values and variation in profile are interpreted as dissolution features within the Chalk and/or the possible presence of Clay-with-Flints.

Stage	Data Source	Output
Ground Investigation (GI)	LiDAR **Geophysics** Boreholes Lab testing	Ground Investigation Report (GIR) Geotechnical Risk Register (GRR)

Ground Investigation

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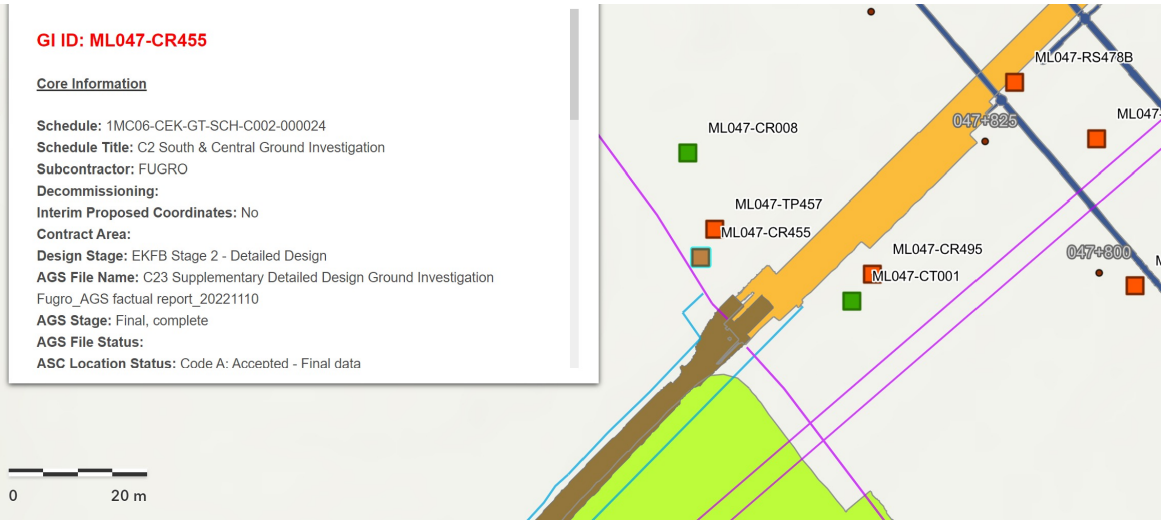
Cable Percussive Borehole Log

Final data ML047-CR455

Project	Project No.	Ground Level (mAOD)	GI Phase	Chainage (SG Grid)	Start Date	Scale
EKFB C2 & C3 Controlled Data	C2-C3-CONT-EKFB	192.38	ASC Detailed GI	47841.000	22/03/2021	1:50
Client	Easting (SnakeGrid)	Northing (SnakeGrid)	Asset Group	Offset	End Date	
	490035.86	202330.07	South Heath Cutting Group	-53	25/03/2021	Sheet 1 of 3

SAMPLES		TESTS		PROGRESS		STRATA				
Type + Depth	Type + Depth	Results	Water Depth	Date & Time	Casing & Water Depth	Description	Legend	Depth (Thickness)	Level	Install/ Backfill
(B1) 0.00-0.30				22/03/2021 10:00		TOPSOIL. Grass over brown slightly sandy slightly gravelly CLAY with frequent roots (<8mm x 10mm x 30mm) and rootlets (<3mm x 6mm x 8mm). Sand is fine to coarse. Gravel is angular and subangular medium and coarse of flint.		(0.30)		
(D2) 0.30 (B3) 0.40-0.80 (D4) 0.50-0.60	HV(1) 0.30 HV(2) 0.30 HV(3) 0.30	50(24)kPa 54(24)kPa 54(26)kPa				Stiff orangish brown mottled reddish brown and grey slightly sandy slightly gravelly CLAY with low cobble content and occasional pockets (<4mm x 10mm x 10mm) of possible black lignite. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of flint. Cobbles (<60mm x 100mm x 100mm) are angular of flint.		0.30 (0.90)	192.08	
(B5) 0.90-1.20 (D6) 1.00-1.10						1.10m to 1.20m; possibly soft.		1.20	191.18	
(UT#B7) 1.70-2.15		UT#B7 100 blows 7%rec.				Stiff orangish brown mottled reddish brown slightly sandy slightly gravelly silty CLAY with frequent to occasional pockets (<10mm x 15mm x 15mm) of white silt (possible degraded flint cortex) and occasional pockets (<10mm x 10mm x 10mm) of possible manganese. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of flint.				
(D8) 2.15-2.20						1.20m to 1.75m; driller noted soft brown clay.				

Borehole log ML047-CR455

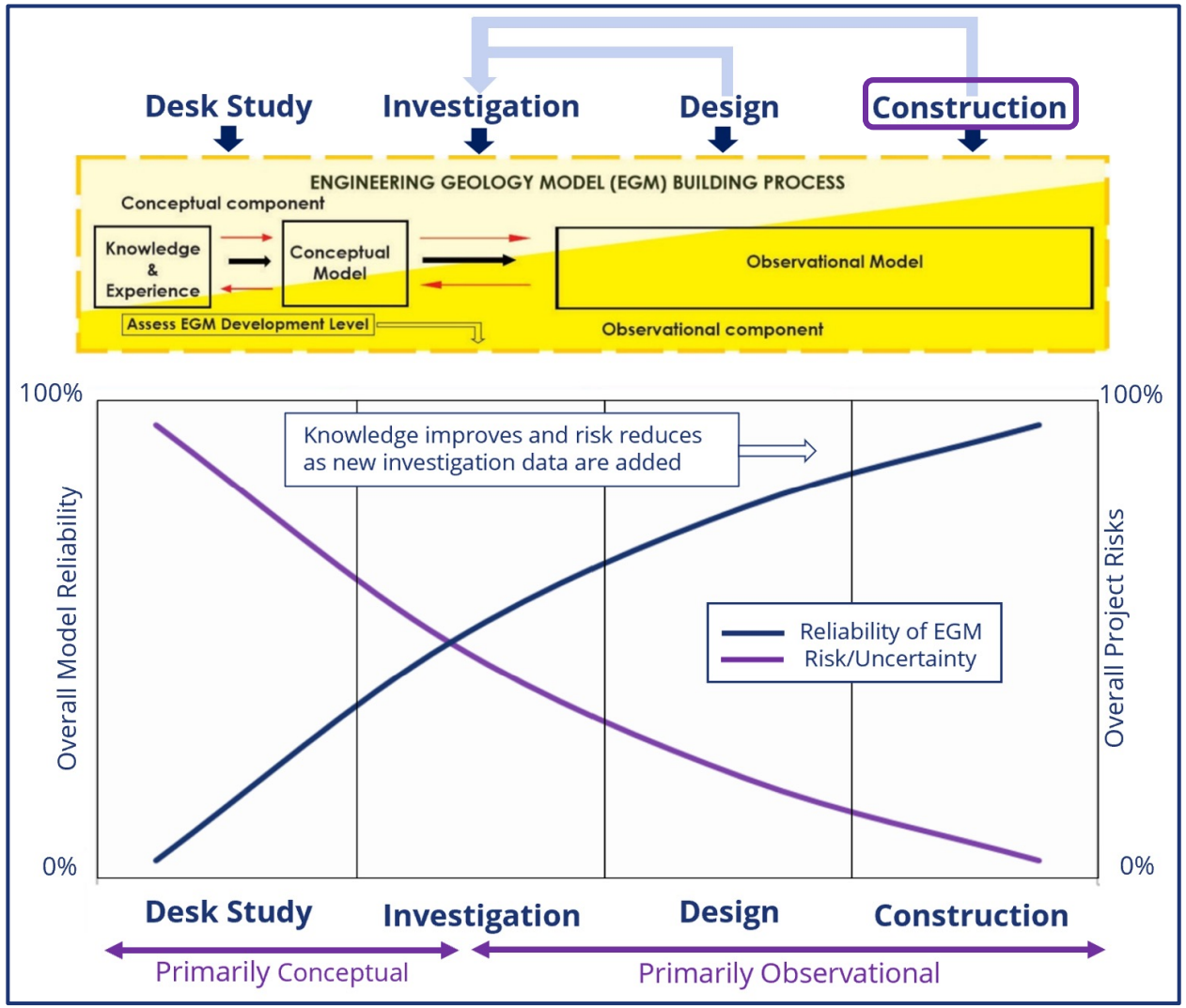


GI locations

ML048-CR455 Core loss between 14.7 - 20.4 m

Stage	Data Source	Output
Ground Investigation (GI)	LiDAR Geophysics **Boreholes** Lab testing	Ground Investigation Report (GIR) Geotechnical Risk Register (GRR)

Construction

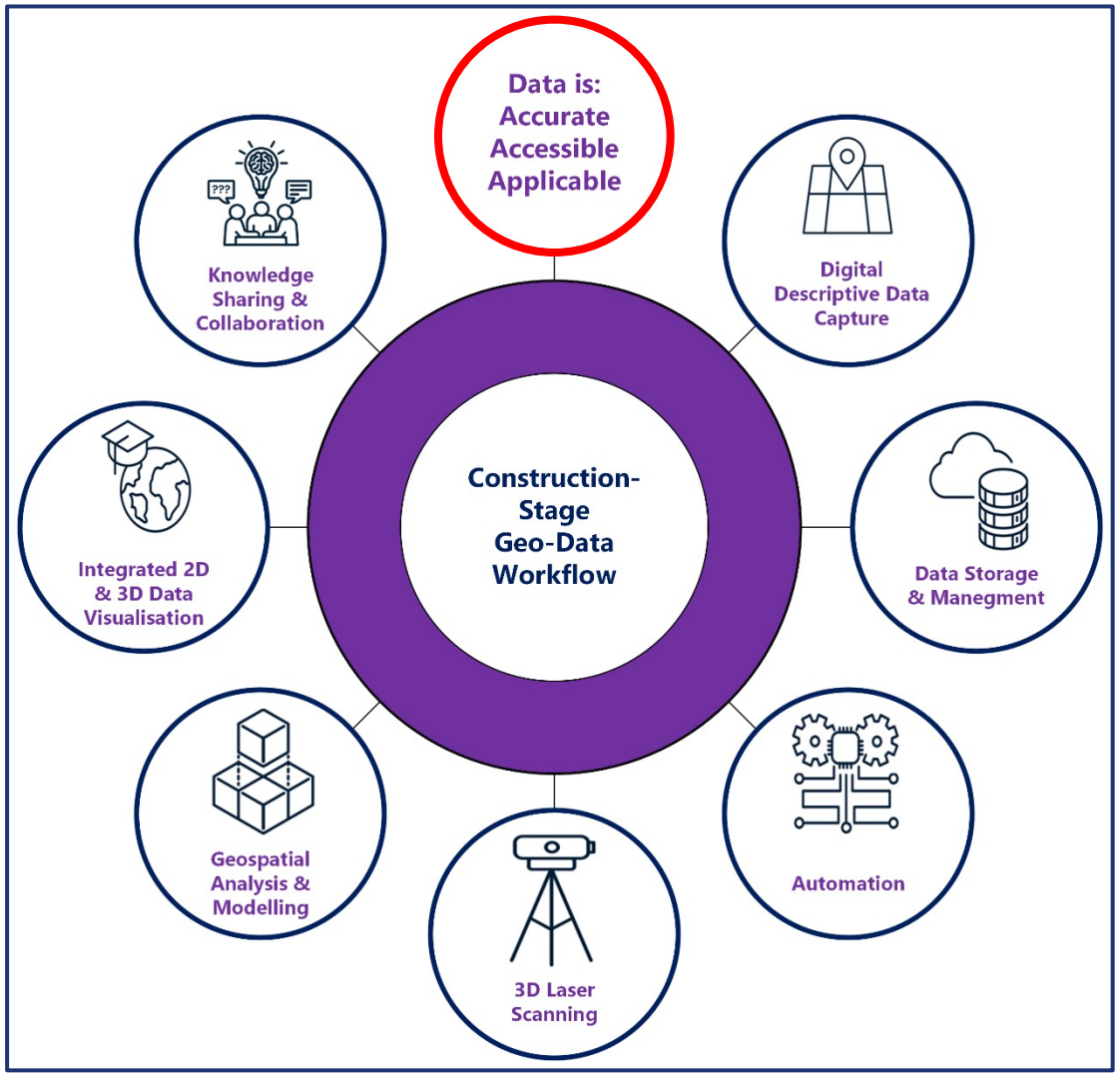


Modified from IAEG Commission 25 Publication, 2022

Stage	Data Source	Output
Construction	Observations 3D Laser Scanning	Geotechnical Feedback Report (GFR) GRR

Not just about execution but also a critical period for data collection.

Construction



Stage	Data Source	Output
Construction	Observations 3D Laser Scanning	Geotechnical Feedback Report (GFR) GRR

Construction stage geological mapping provides high-resolution geo-data, that can be incorporated into the model.

GNSS, **GIS**, and **3D Laser Scanning** tools have been incorporated into a digital workflow, which has streamlined the process of geo-data collection, reporting, and visualisation.

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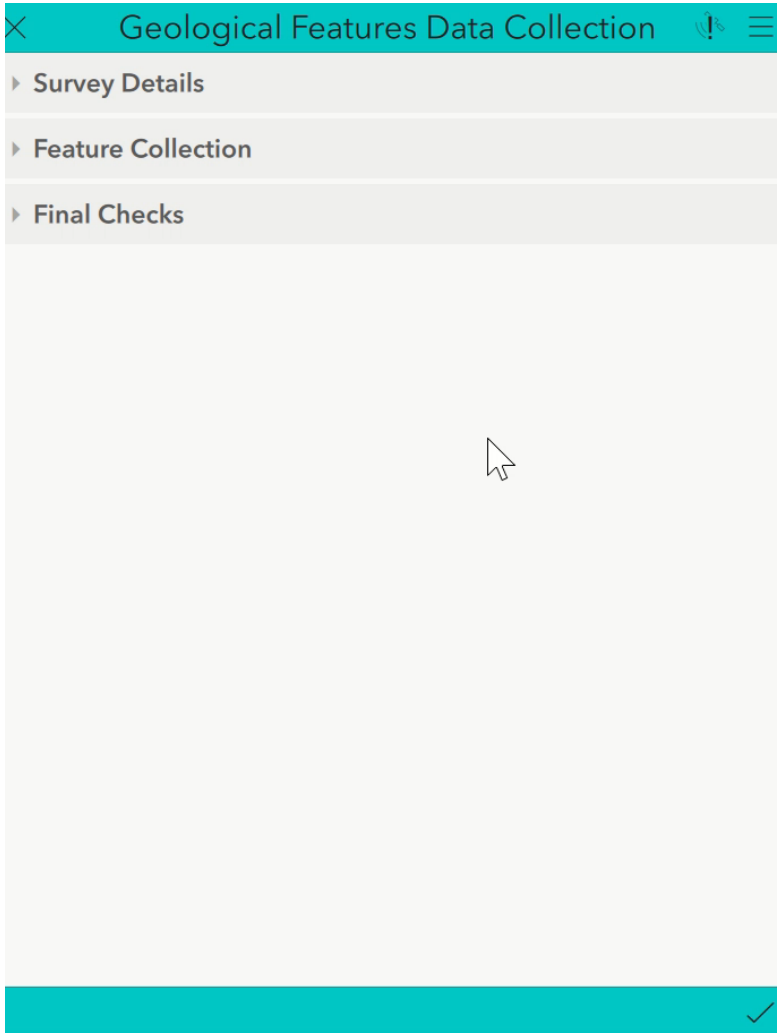
Construction Stage Geo-Data Collection

Stage	Data Source	Output
Construction	**Observations** 3D Laser Scanning	Geotechnical Feedback Report (GFR) GRR



ArcGIS Survey123:

Built for geo-data observations of different assets and features.

Following the BS5930 framework, this tool ensures precise geo-data collection with strong quality control measures for data integrity.

Once collected, the data is securely transferred to a cloud-based database, where it is processed for streamlined and efficient data management.

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Construction Stage Geo-Data Collection

Stage	Data Source	Output
Construction	Observations **3D Laser Scanning**	Geotechnical Feedback Report (GFR) GRR

Trimble X7:

To capture accurate geospatial data, a 3D laser scanner is used to collect detailed 3D point clouds of ground surfaces.

Its ability to quickly capture data from inaccessible or hazardous locations prioritises both worker safety and the quality of the data collected.

Trimble X7 3D laser scanner in cutting in mudrocks

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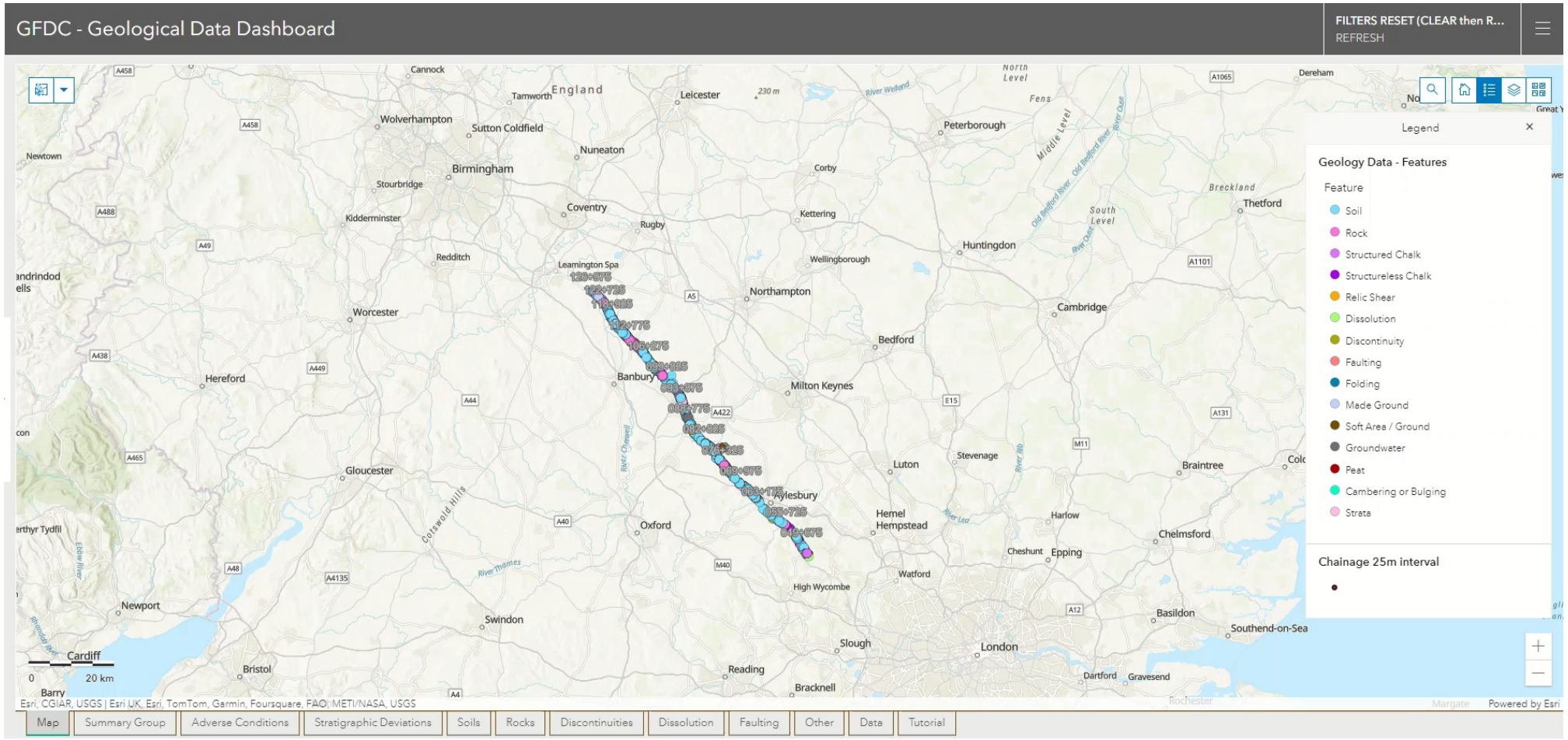
Construction Stage Geo-Data Visualisation



Data is:
Accurate
Accessible
Applicable

Integrated 2D & 3D Data Visualisation

Knowledge Sharing & Collaboration

An **ArcGIS Dashboard** serves as a central platform, enabling full access to real-time synchronised geo-data. It provides various visualisation options and analytical functionalities.

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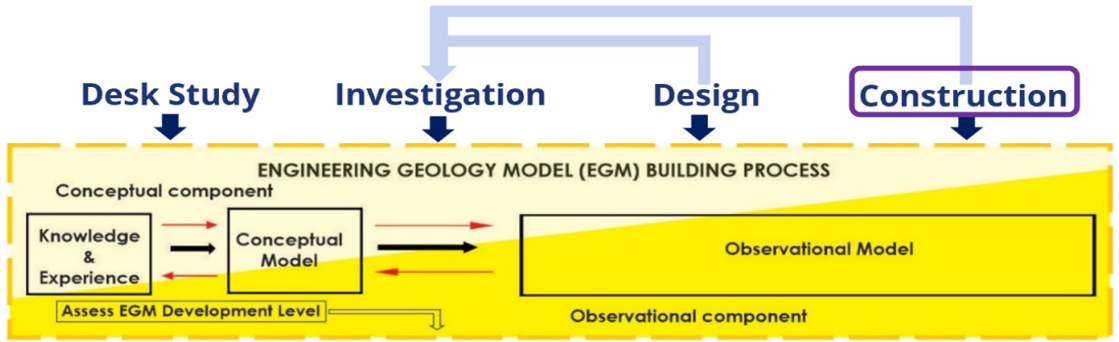
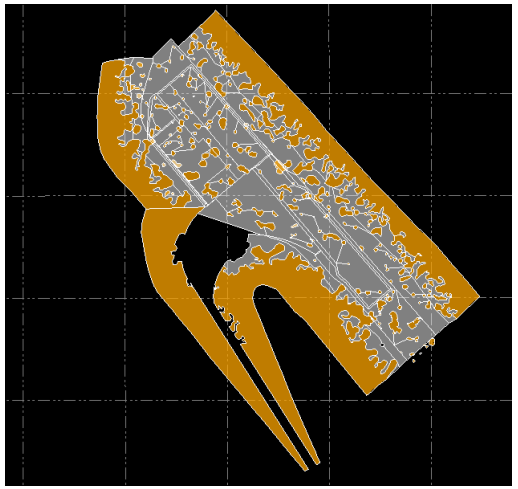
Construction Stage Geo-Data Visualisation

Stage	Data Source	Output
Construction	Observations **3D Laser Scanning**	Geotechnical Feedback Report (GFR) GRR

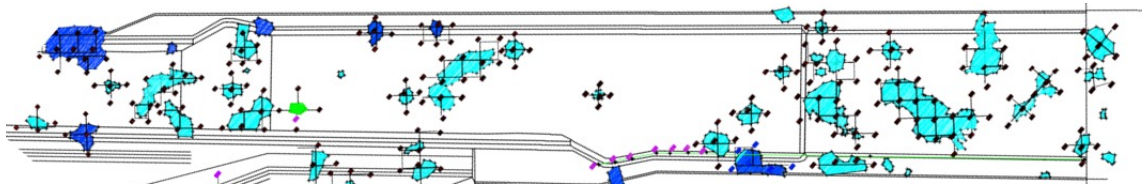
CWF mapped onto slopes after 3D laser scanning





CWF and dissolution feature surfaces to extract to GIS viewing platform

Construction stage mapping of dissolution features overlaid onto aerial photography



Further GI – surface geophysics and CPT probing - to delineate the extent of dissolution features

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Benefits of Construction Stage Geo-Data

Incorporating detailed construction stage geo-data into the model leads to:

- Increased reliability: More observations = greater accuracy
- Reduced risks: Early identification = fewer delays/costs increases
- Improved decision-making: data flow and knowledge sharing
- Increased safety: Immediate feedback = timely responses
- Cost efficiency: Designs to suit observed conditions

Sustainable Infrastructure Development