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The impact of groundwater on the Middlewich Eastern Bypass project

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Engineering Geologist, Jacobs

10th Jan 2023 – West Midlands Regional Group

Introduction

- BSc Geological Sciences – University of Leeds
- MSc Engineering Geology – University of Leeds

- Soil Engineering Geoservices Ltd (2016-17)
- Jacobs (2019-Present)

- Glossop Award Winner 2021
- Engineering Group of Geological Society – Early Careers Lead (2022)

Introduction

- The Romans called Middlewich "*Salinae*"
- According to Collins English Dictionary, "wich" refers to a salt producing town
- The four Cheshire "wiches" (Northwich, Leftwich, Middlewich and Nantwich) are known as the Domesday wiches, recorded as salt producing towns in the Domesday Book of 1086
- 57% of the salt used in British cooking is produced by British Salt in Middlewich (Saxa brand)

Agenda

1. Project Background
2. Ground Model and Groundwater
   i. Stratigraphy
   ii. Halite dissolution and mechanisms
   iii. Geohazards
3. Groundwater Impact
   i. Anthropogenic
   ii. Glaciation
4. Ground Investigation
   i. Strategy
   ii. Results and Interpretation
5. Potential Future Impact on the Site
6. Conclusions

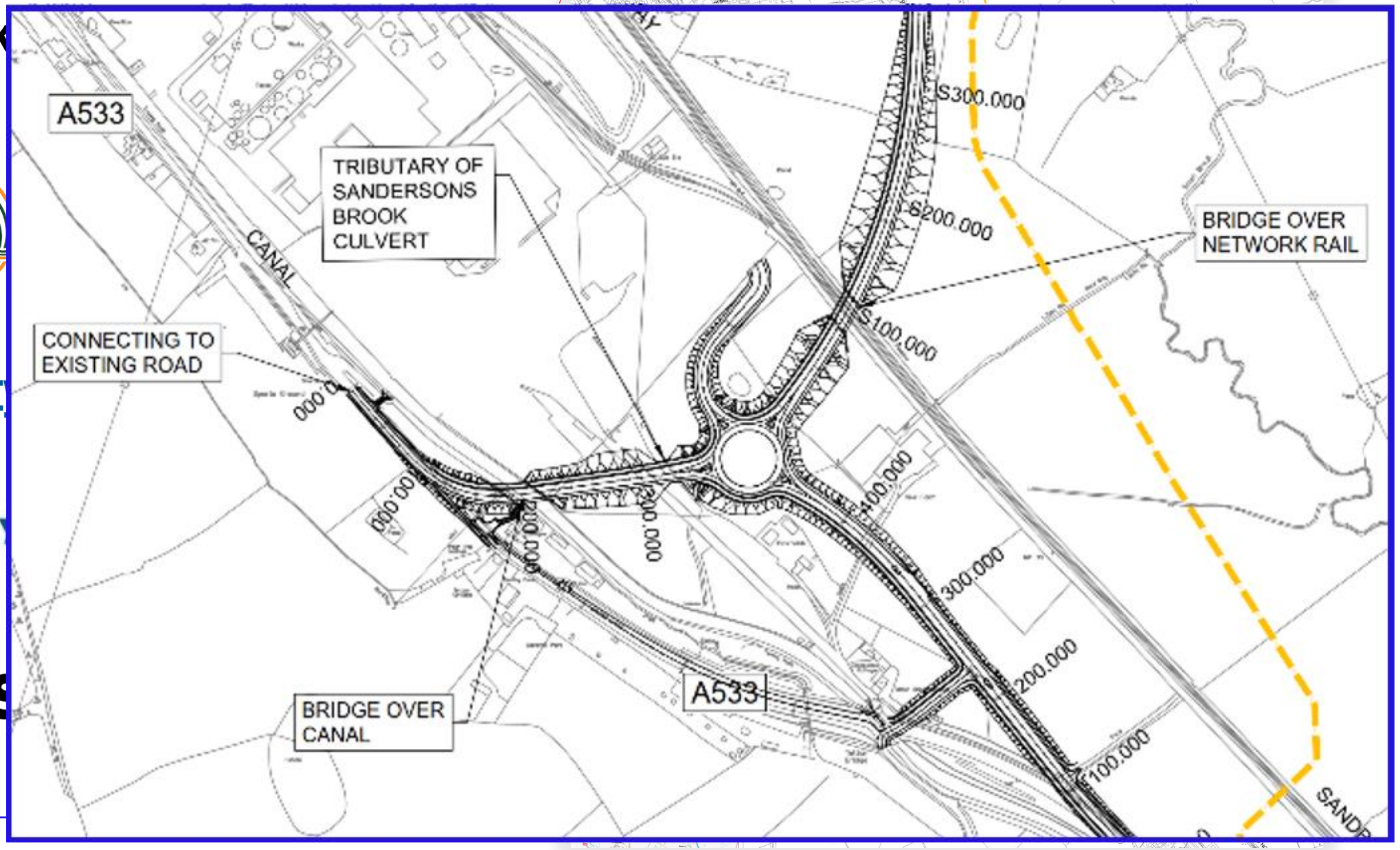
Project Back

Cheshire East Council

Balfour Beatty

RINGWAY JACOBS

Jacobs



Stratigraphy

- Triassic evaporite and mudstones
- Wet rockhead
- Dissolution geohazard - voids

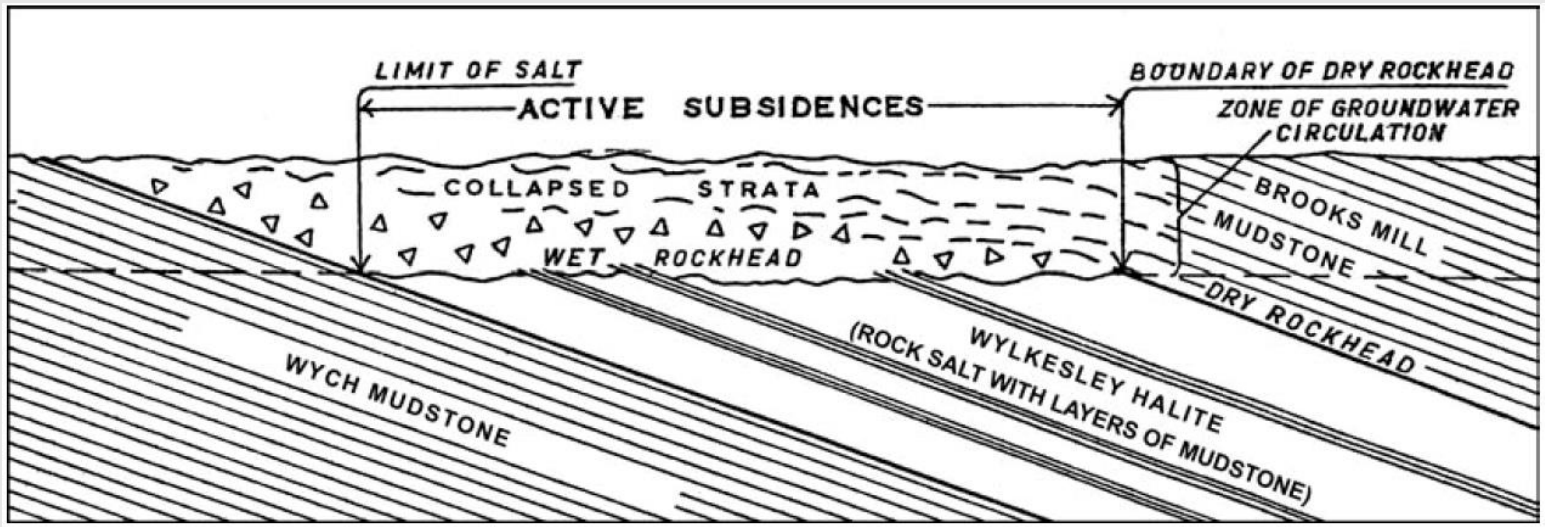


Figure from Worsley, 2008

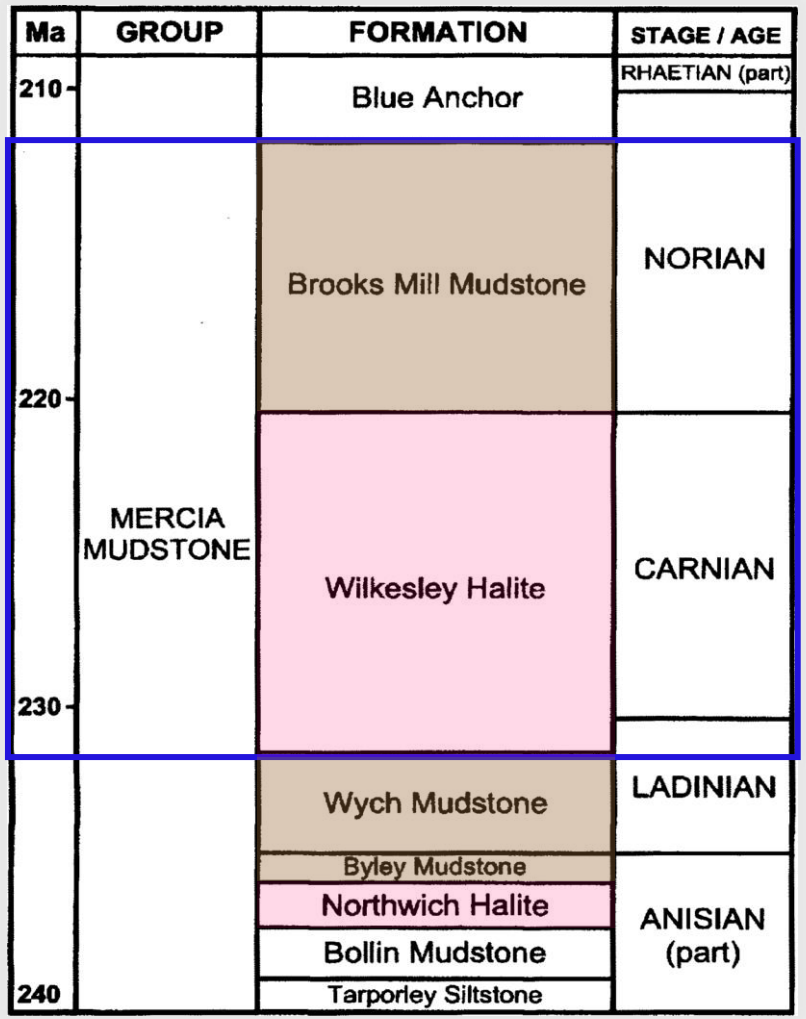


Figure adapted from Wilson, 2003

Dissolution Mechanism

- Five main karstic rocks in the UK; dolomite, limestone, chalk, gypsum and salt

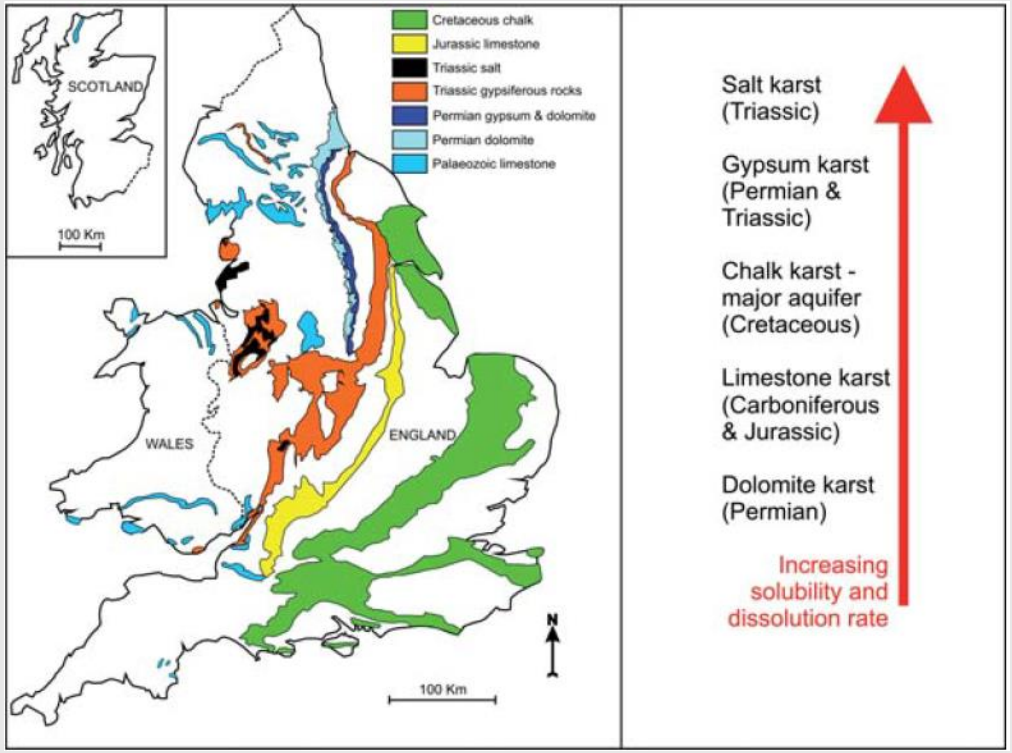
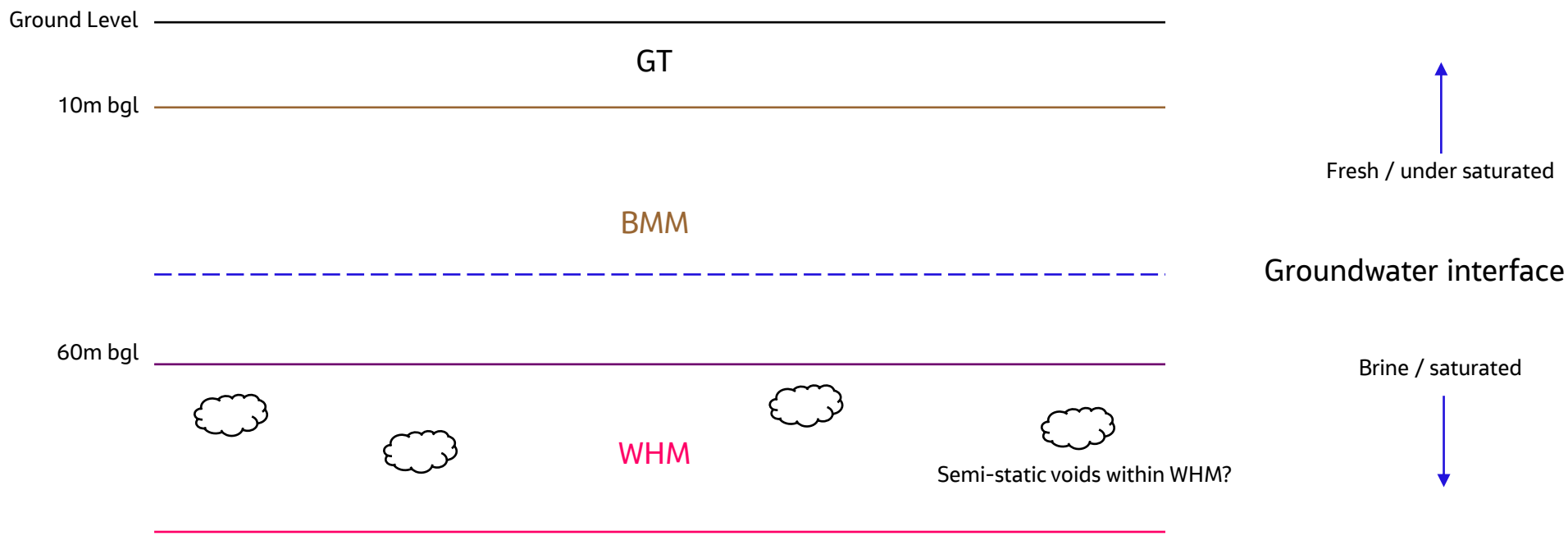


Figure from Cooper, Farrant and Price, 2010

Video from BGS YouTube Channel, 2013

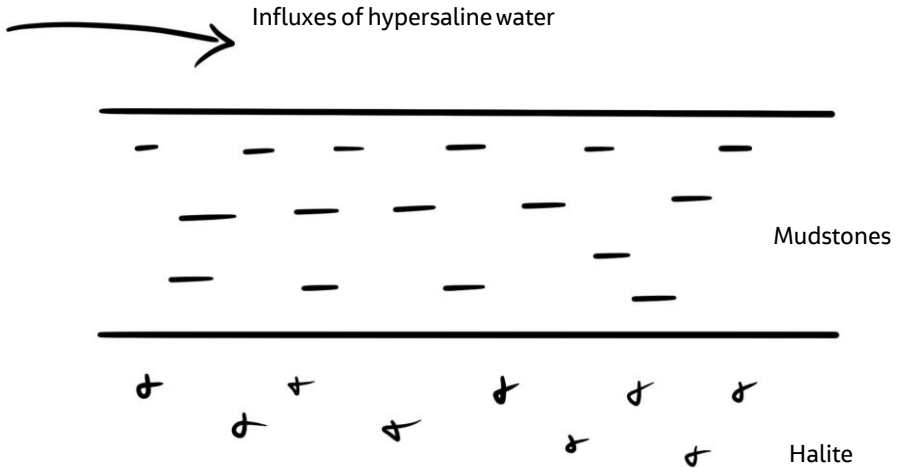
Dissolution Mechanism

- The relative density of fully saturated brine is 1.2 → freshwater floats on top of it
- Interface forms a “protective blanket”

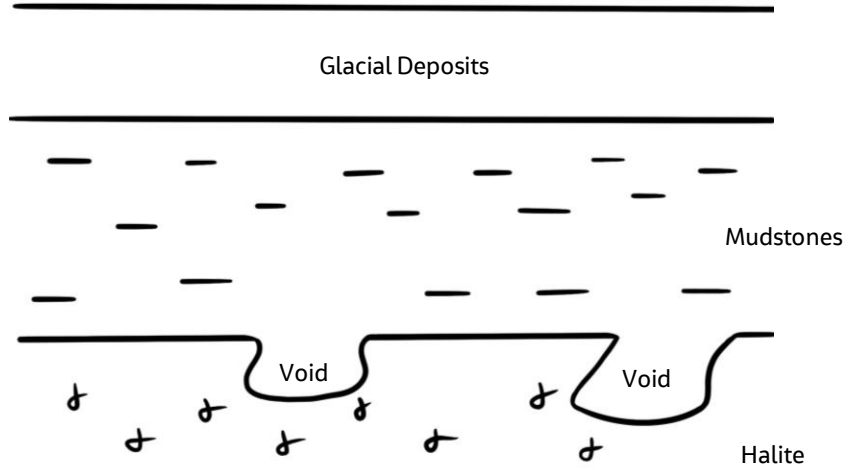


Geohazards

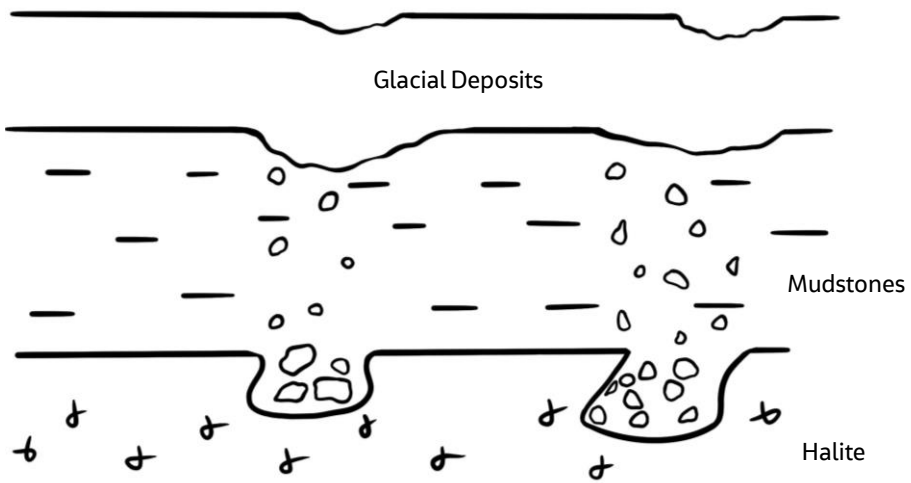
- Geological processes associated with previous dissolution



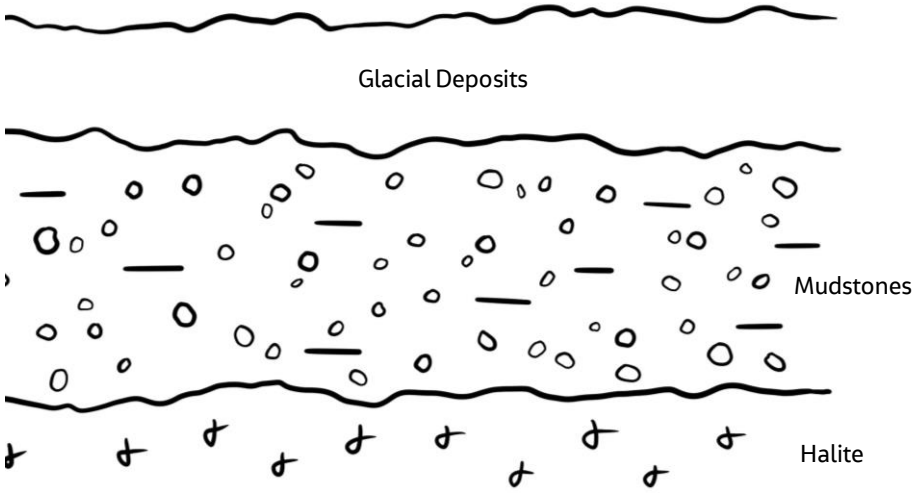
1. Initial Deposition (Triassic)



2. Formation of voids within halite

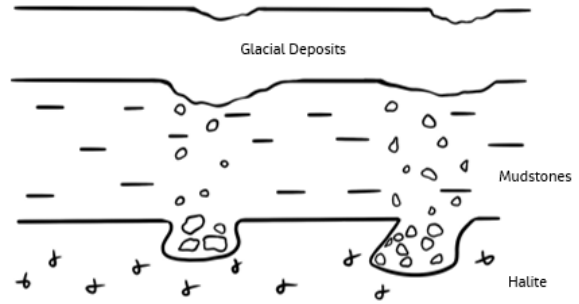


3. Localised dissolution and upward migration (Anthropogenic)



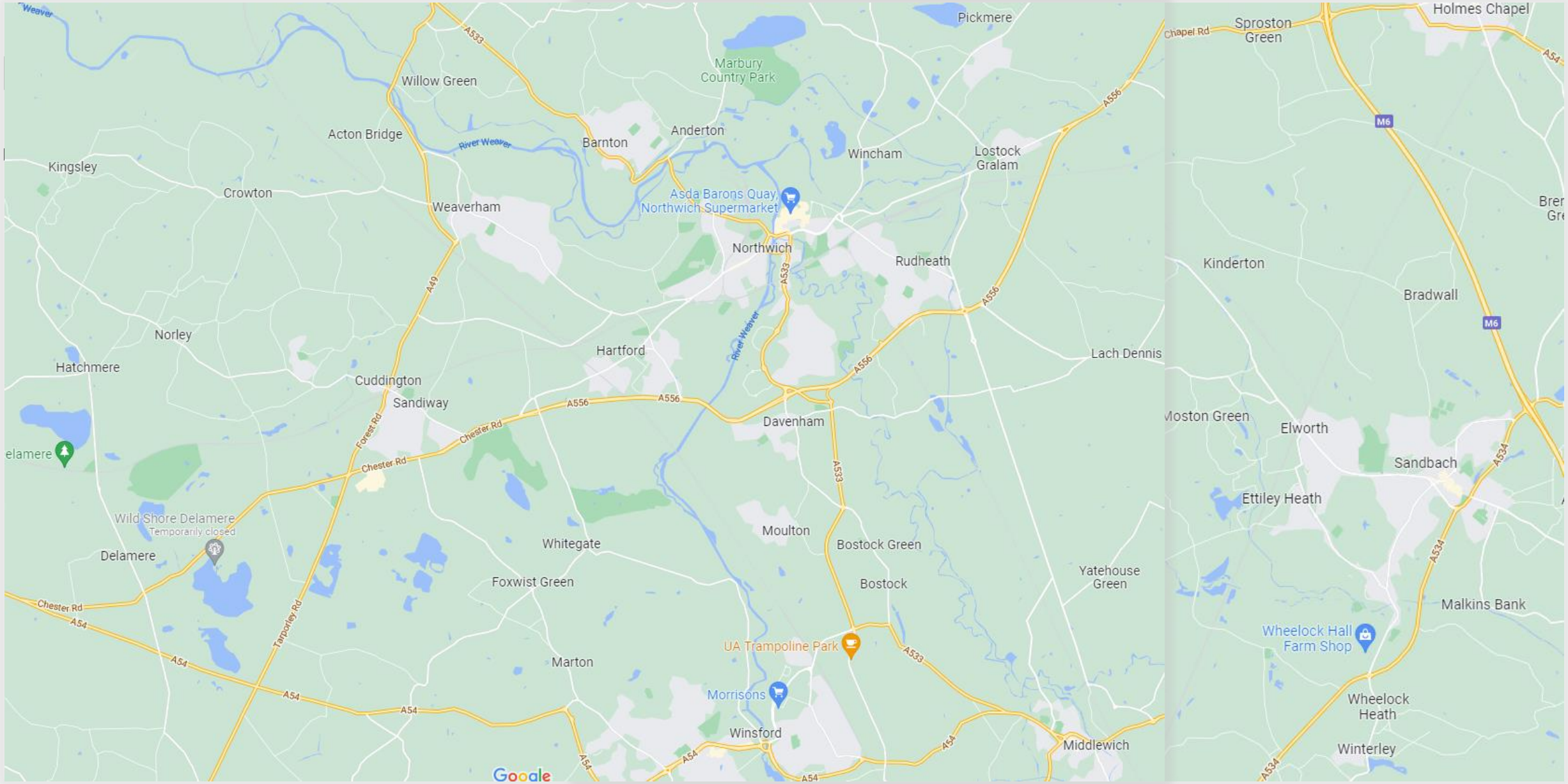
4. Regional subsidence with large drawdown of brine interface

Localised - Anthropogenic



- Brine extraction from 1800s to 1970s
- Frequent catastrophic collapse

Photographs from Worsley, 2008


Pickmere
Willow Green
Marbury Country Park
Acton Bridge
River Weaver
Barnton
Anderton
Wincham
Lostock Gralam
Kingsley
Crowton
Weaverham
Asda Barons Quay, Northwich Supermarket
Northwich
Rudheath
Norley
Hartford
Lach Dennis
Hatchmere
Cuddington
Sandiway
Davenham
Chester Rd
Forest Rd
Wild Shore Delamere
Temporarily closed
Delamere
Whitegate
Moulton
Bostock Green
Foxwist Green
Bostock
Yatehouse Green
Tarporley Rd
UA Trampoline Park
Marton
Morrisons
Winsford
Middlewich
Google
Holmes Chapel
Sproston Green
Chapel Rd
Kinderton
Bradwall
Elworth
Sandbach
Ettiley Heath
Malkins Bank
Wheelock Hall Farm Shop
Wheelock Heath
Winterley
A533
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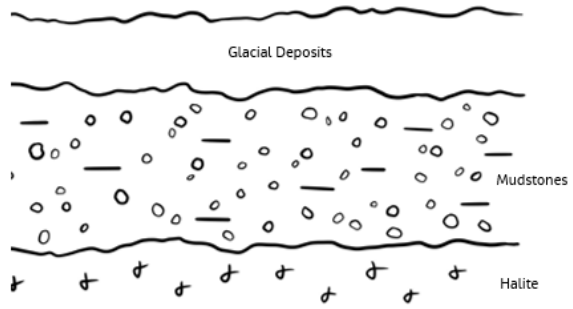
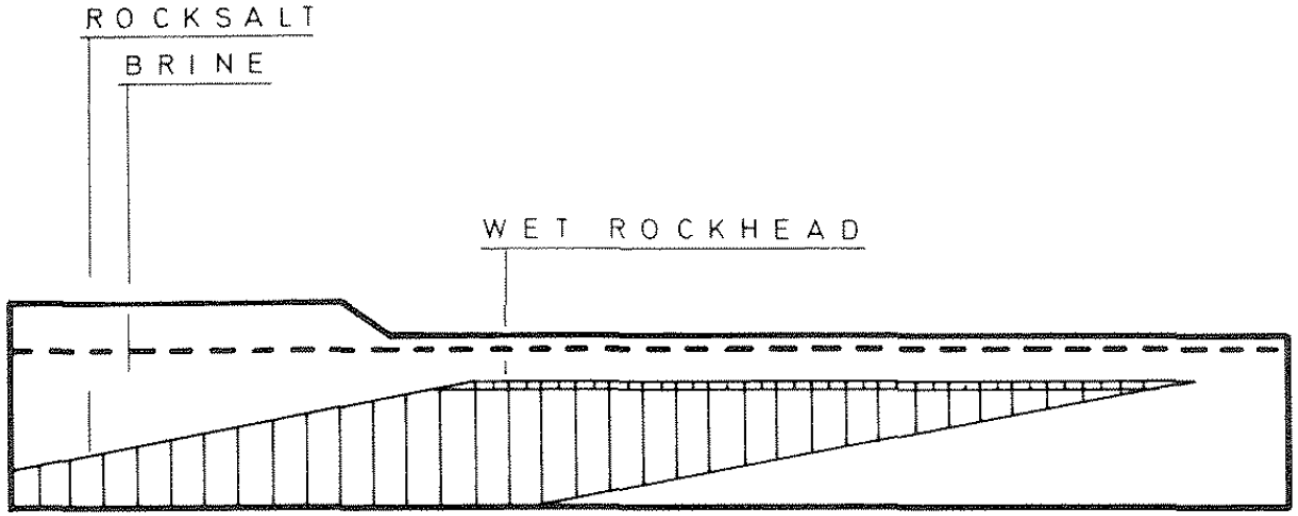
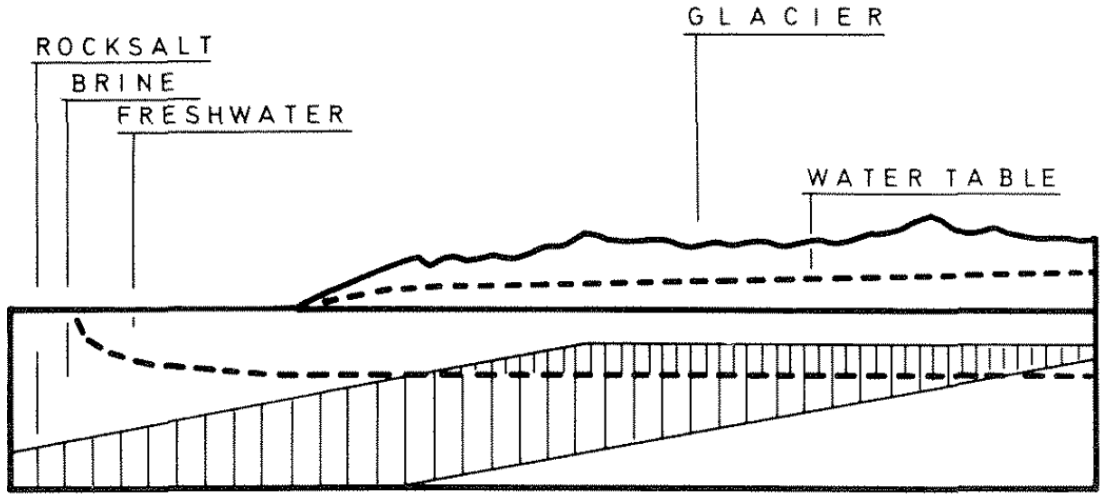
Regional - Glaciation



- Lowering of interface with major head of water during glacial retreat



Post-Glacial rebound of saline interface.



Emplacement of Glacial freshwater.

Figures from Howell and Jenkins, 1974

Ground Investigation Strategy

- There isn't masses of freely available literature or previous GI case studies
- Used multiple techniques for a "lines of evidence" approach
- Started at desk study – any movement shown on LiDAR data? Ponds appearing and disappearing on historical maps? Are any of these near the proposed bridges.
- Phases of GI scheduled to best determine where to locate boreholes
  - Phase 1 "Surface Geophysics"
  - Phase 2 "Deep intrusive and downhole geophysics"
  - Phase 3 "Shallow intrusive"
- Results from each phase informed the subsequent phases for a targeted GI

Area of MGRAV survey and survey lines for ERT

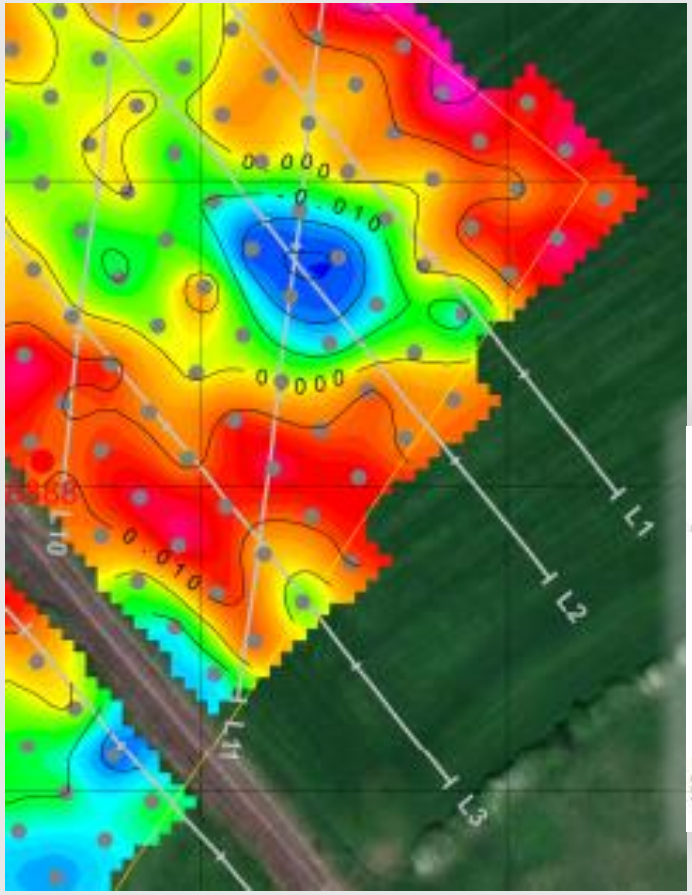
Seismic survey lines

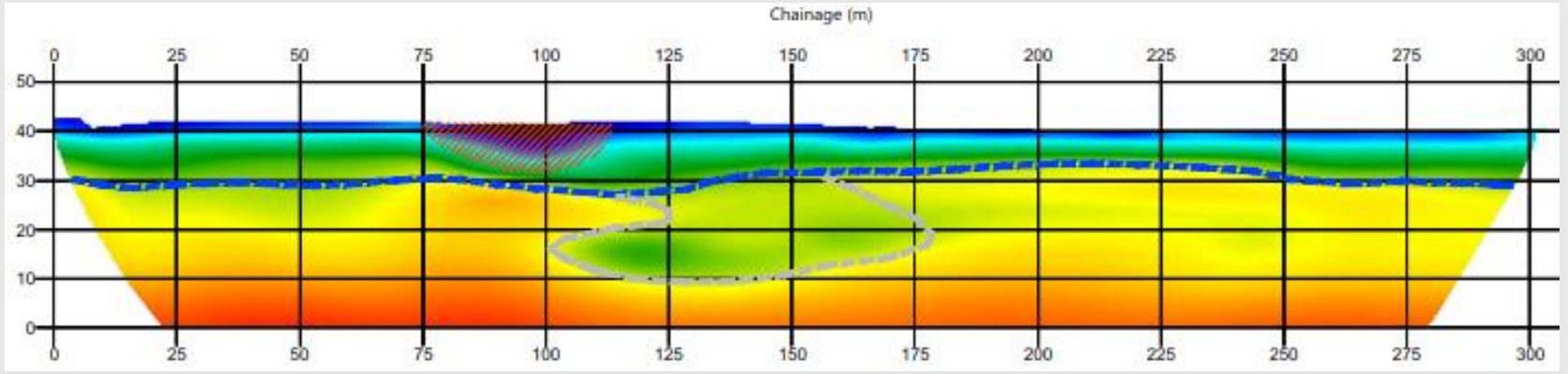
Intrusive boreholes

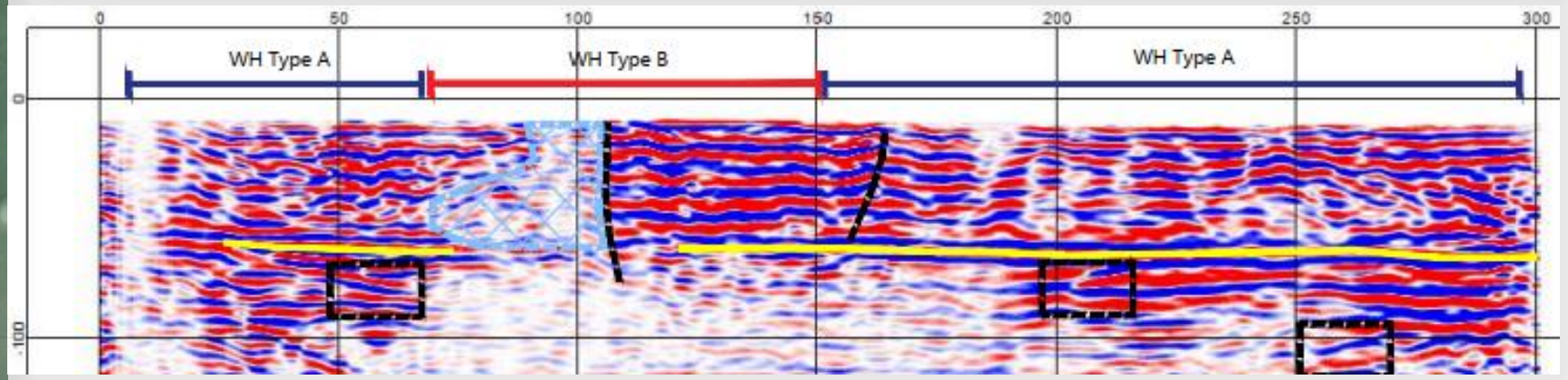
OS 25 Inch Series - 1914 | OS 1:25,000 - 1961 | Landmark Envirocheck Map - 1967 | Landmark Envirocheck Map - 2006 | Esri World Imagery Wayback - 2014

Ground Investigation – Localised Subsidence

- Non-intrusive investigation





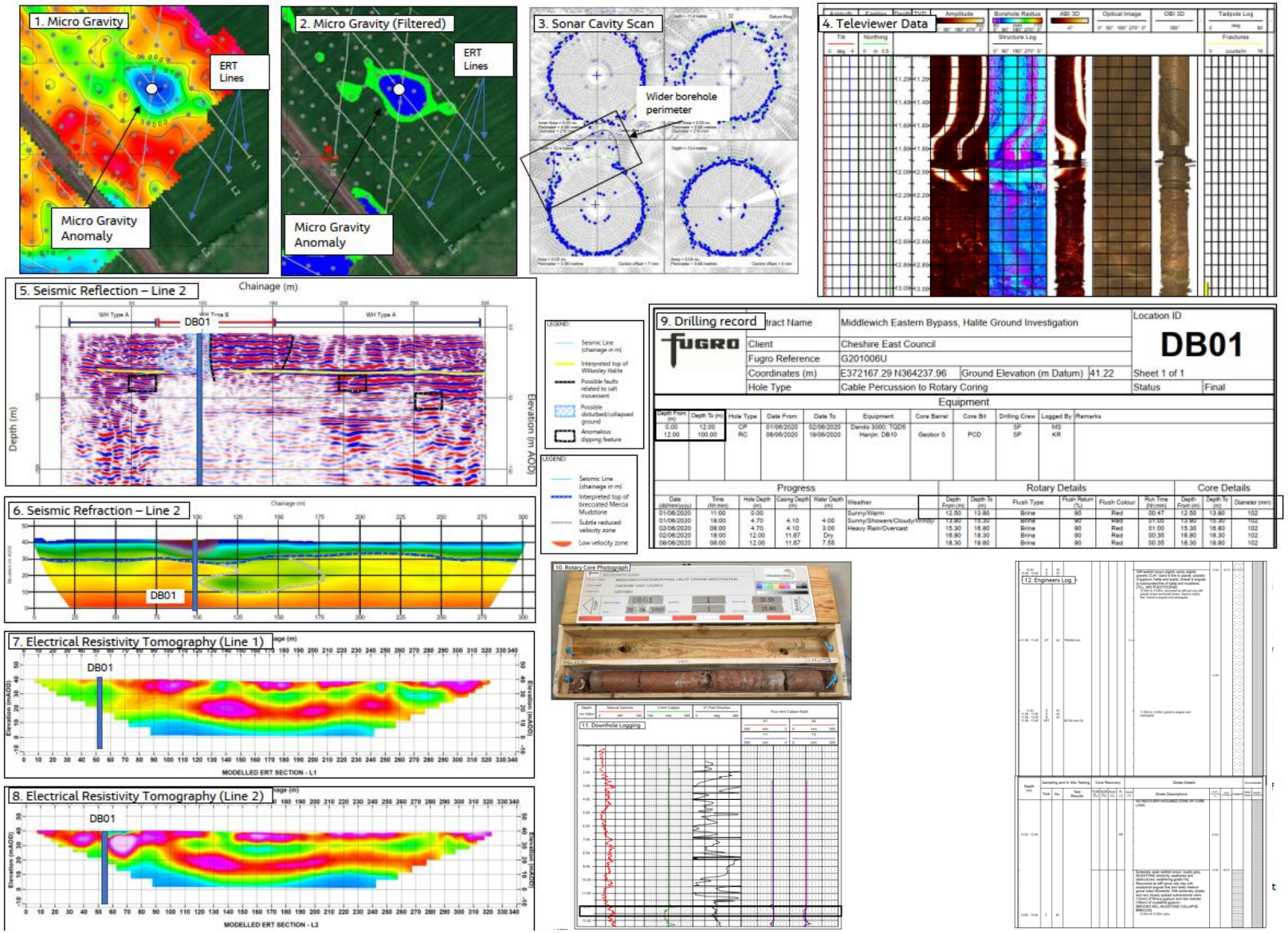


Ground Investigation – Regional Subsidence

- Intrusive investigation

Ground Investigation – Assessing Void Risk

- Zones of core loss >0.5m were assessed
- All the lines of evidence used to determine whether zones of core loss were possible voids or the result of drilling disturbance.
- Conclusions on void risk is currently confidential



Historical Groundwater Impact - Recap

- Regional dissolution has developed the collapse breccia
- Anthropogenically induced dissolution has developed local subsidence features

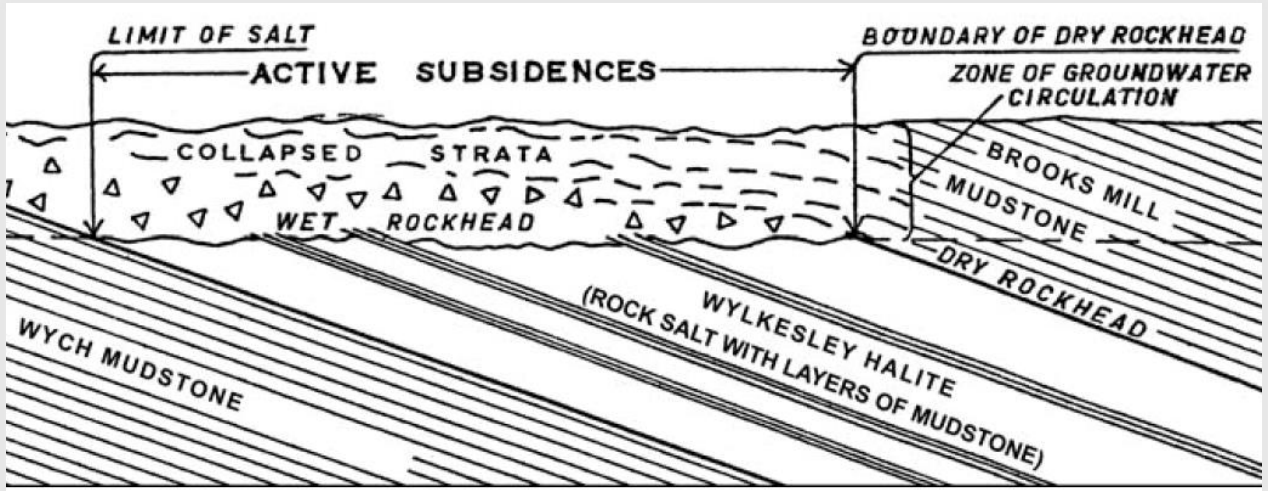


Figure from Worsley, 2008

Potential Future Groundwater Impact

- James Hutton's principle of uniformitarianism – "The present is the key to the past" (+ future)

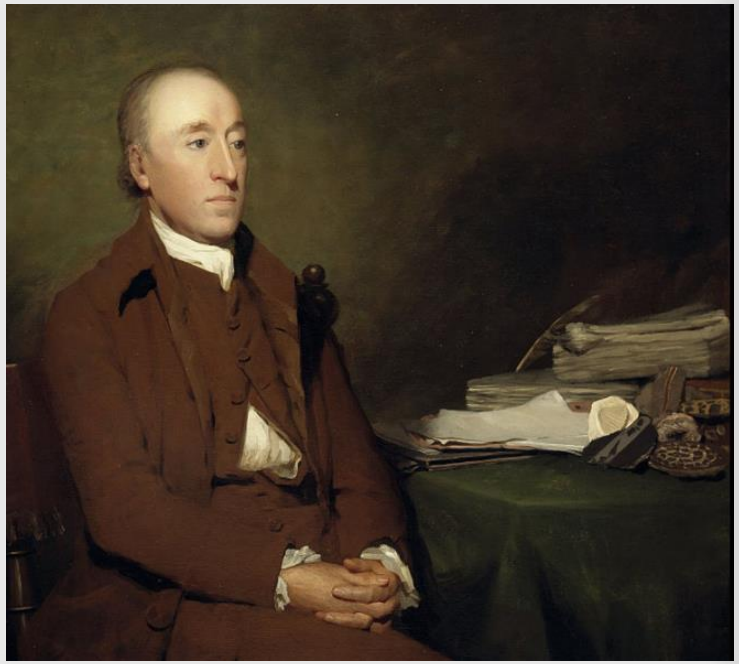


Figure from Wikipedia, 2021

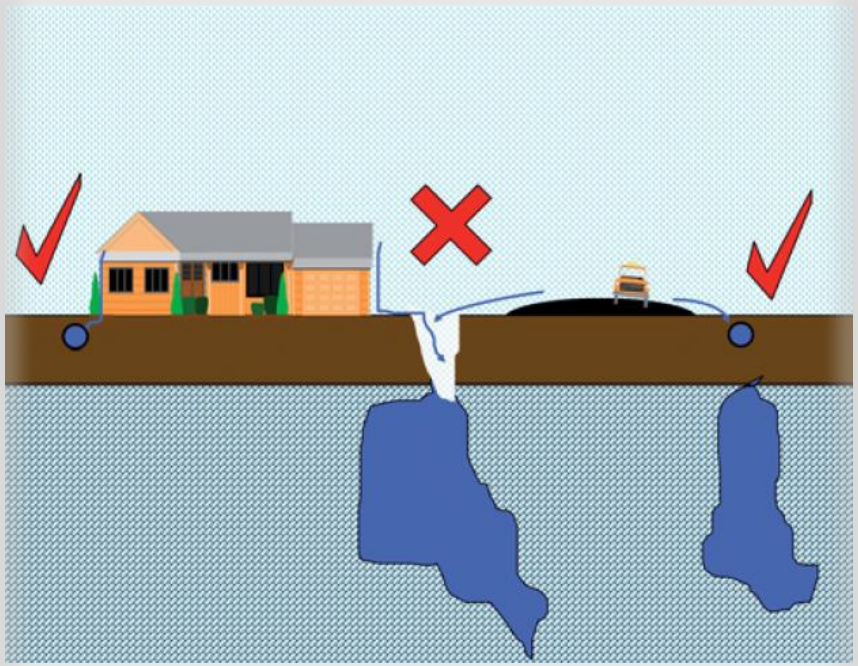


Figure from Cooper, Farrant and Price, 2010

Microsoft Stock Image, 2021

Summary

- The impact of groundwater has been profound on the Middlewich site
- Changes to the groundwater regime has led to dissolution of the Wilkesley Halite Member
- Dissolution has led to collapse in the overlying Brooks Mill Mudstone
- Ground investigation agrees with the hypothesis
- Latent background risk associated with soluble strata

Conclusions

Groundwater has had a profound impact on the surface geomorphology and subsurface characteristics of the stratigraphy beneath Middlewich

Understanding the geological and groundwater processes that have induced historical dissolution is fundamental in assessing the future risk of subsidence at Middlewich

CALL FOR VOLUNTEERS!

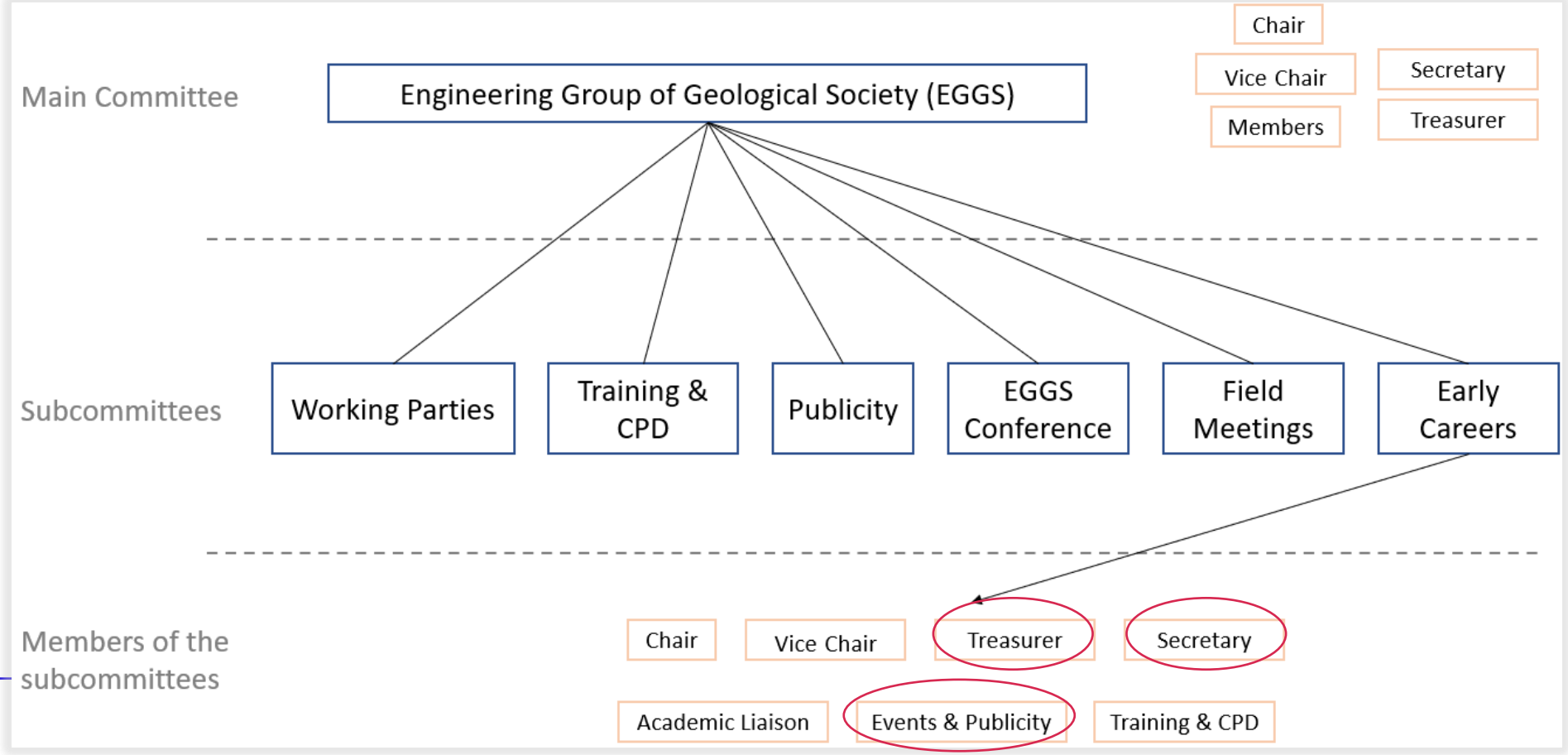
Engineering Group of the Geological Society - Early Career Subcommittee

Currently asking for volunteers to fill vacancies on the EGGS EC subcommittee.

4 people have expressed interest for the 7 roles (although none of the roles are confirmed).

Contact for info:

Josh.Dunlop@jacobs.com
or speak to me afterwards



Any Questions?