The Cubic Mile Project: Policy summary and overview

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The City of London 'Square Mile' (Figure 1) is the historic centre of London and the financial and commercial heart of the UK. It is a very high-density urban environment.

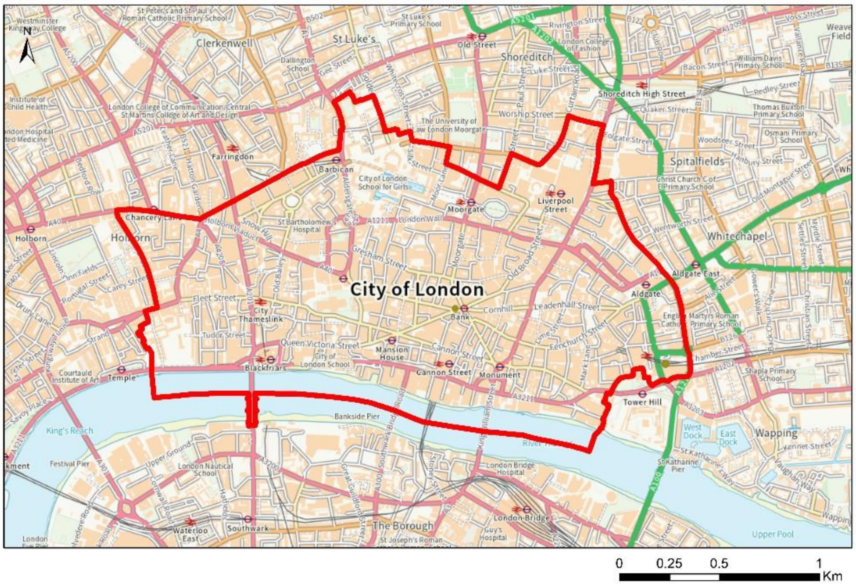

Figure 1 The City of London, also known as the Square Mile.

Specific modelling carried out by the Met Office (UKCP18) for London indicates that overall, winters will be 20% wetter and summers 30% drier, combined with more extreme weather events and sea level rise. Increased rainfall and surface water run-off present a key issue for the City, where the presence of many hard, impermeable surfaces significantly increases the risk of flooding of high-profile commercial premises. The projected increase in temperatures and heatwaves will also lead to overheating and increased mortality for the City's people and services, which, given its central urban location, is vulnerable to the urban heat island effect. The future resilience of the City to climate change is high on the City of London Corporation's agenda. The collaborative 'Cubic Mile' project with the British Geological Survey under the UK Climate Resilience Programme Embedded Researcher scheme was designed to support the delivery of the City of London's Climate Action Strategy, by understanding to what extent subsurface space could support climate resilience and adaptation. This policy review forms part of an exercise to determine policy barriers and enablers to urban subsurface climate resilience.

Overview of policy framework

Climate change is a global challenge. More than 130 countries have now made, or are setting, net zero commitments in legislation or policy. The [Climate Change Act 2008](#) is the legal basis for the UK's approach to respond to climate change and commits the UK Government to reduce greenhouse gas emissions by 100% by 2050 compared to 1990 levels. It requires the Government to identify proposals and policies for meeting these objectives, as well as to regularly assess risks of current and predicted impacts of climate change via the UK Climate Change Risk Assessment (CCRA). In response to the CCRA, the Government must also produce a National Adaptation Plan (NAP), outlining the programmes and policies required to adapt to the predicted impacts of climate change. Devolved administrations in Scotland, Wales and Northern Ireland are responsible for implementing UK-wide policies, as well as creating their own climate change policies.

The provisions of the Climate Change Act are also accompanied by a range of climate change mitigation and adaptation drivers at other levels, including (see Figure 2):

- International policies and agreements, e.g. UN Sustainable Development Goals; EU Water Frame Work Directive
- Regional government, e.g., the Mayor of London's London Environment Strategy
- Local government, e.g., the City of London Corporation's Climate Action Strategy and the Transport Strategy

Local Plans are prepared by Local Planning Authorities to guide planning decisions in their area, and are required to address climate change and sustainable development, guided by National Planning Policy Framework. These include the requirements for local authorities to adopt proactive strategies to mitigate and adapt to climate change. However, these plans do not address the **strategic planning of subsurface space to support climate adaptation**.

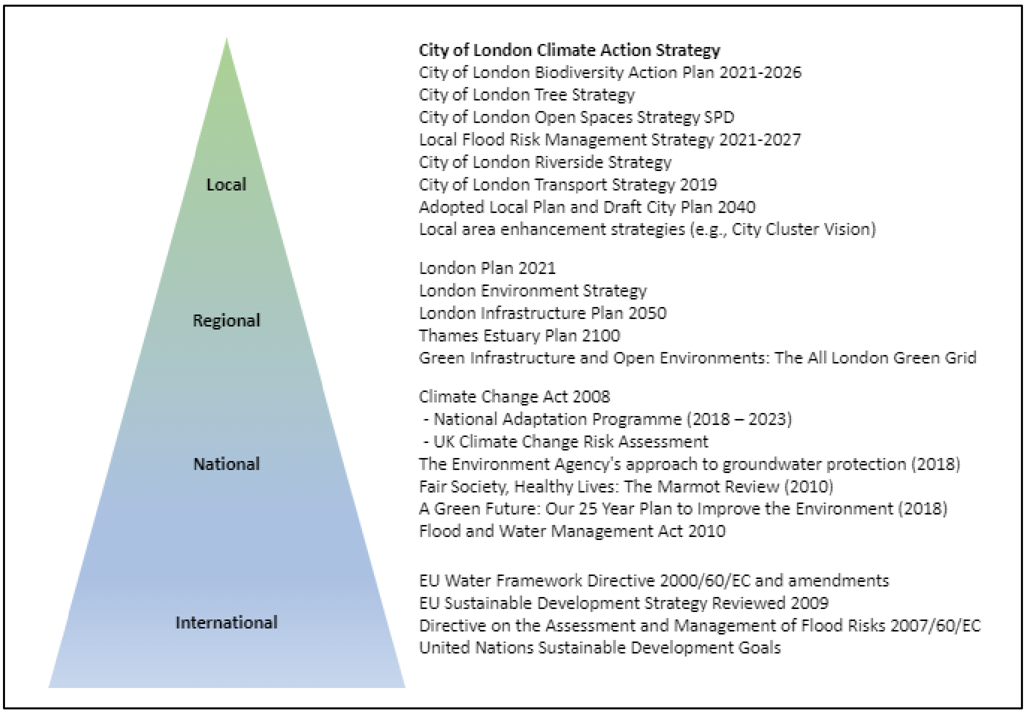

Figure 2 Examples of climate related policies applicable to the City of London Corporation

Subsurface development and governing policy

Knowledge and understanding of the ground that urban spaces are built on is key for continued development. Increasingly as cities expand, they are doing so upwards and downwards and, as a result, subsurface space is becoming more crowded. Agendas are addressing the challenges of sustainability in urban growth, embracing technological advances in digital data, sensors and SMART city initiatives. Urban blue-green solutions and renewable or decarbonized energy systems are being promoted as key visions. Focus on the congested subsurface primarily centres on reducing the cost of construction and infrastructure and protecting cultural heritage. Subsurface space is increasingly seen as a potential resource that could be utilised to support the resilience of society to climate change.

The value of the subsurface is high both in social and economic terms, yet underground space is only **regulated to a degree** through development management policy (e.g. conversion and subterranean expansion of residential property) and environmental licensing (e.g. water abstraction, mineral extraction, discharge and mining) and on a case-by-case basis. Without any lead governing polices at the local level, the variety of different laws and regulations governing specific aspects of the subsurface **can result in conflicts of interest** and even the potential for long term environmental damage (e.g., groundwater flow issues from abstraction and basement development, heat transfer from discharges). There is currently **no formal policy within the planning framework for integrating urban underground space and above ground city services** and **no one organisation with a mandate to take ownership**.

Localised subsurface considerations may also be addressed on a specific development basis, e.g. the City of London (St Paul' s Cathedral Preservation) Act 1935. This Act defines the area close to St Paul's Cathedral where development proposals that may include excavation or extraction of water at depth must be submitted to the City of London Corporation for approval in order to protect the stability of the Cathedral. This specific case is due to registered shallow foundation depths; since its construction, damage has occurred to the Cathedral due to ground movements arising from consolidation of settlements, 19th century deep utility excavations and changes in upper aquifer groundwater levels.

Permission for **larger subsurface infrastructure projects** is granted at Government level. Hybrid bills often propose works of **national importance but in a geographically specific part of the UK.** Such bills have been used for major subsurface development projects, such as the Channel Tunnel, the Dartford Tunnel and most recently the Crossrail project, which delivered the Elizabeth Line in central London. This project began as a hybrid bill, introduced to Parliament in 2005 and enacted in 2008 as The Crossrail Act 2008. It contained within it a description and location of the works and identified the land needed temporarily or permanently, including below ground.

Documentation and sharing of subsurface information remains a key issue. Subsurface information is often gathered on a localised or site-by-site basis addressing the needs of a specific development or works. The secrecy of the location of many underground assets (due to security concerns), and the lack of central information depositories for gathered subsurface information, means accessing subsurface data is a commonly identified gap for Local Authorities and planners specifically addressing climate change adaptation. While there appears to be an increasing focus on policy to deliver climate change considerations through a design-led approach, there remain shortcomings in record-keeping that mean the necessary information is not available at a wider scale to those trying to progress climate change adaptation.

Subsurface space for climate adaptations

The UK Climate Resilience Programme 'Cubic Mile' project has focused research on five main climate adaptation strategies:

- Urban greening and tree planting
- Sustainable Urban Drainage Systems (SuDS)
- Below ground cool spaces
- Ground source energy

- Resilience of buried utility networks

Local and national policies, planning policy, urban design guidance and open spaces strategies are all relevant to the implementation and increased uptake of the five outlined climate adaptation measures.

Urban greening and tree planting

Many of the policy documents accessed at regional and local level include reference to **tree planting for urban climate resilience**: providing shade to people, buildings, and surfaces during periods of higher temperature; cooling the air through evapotranspiration; and other environmental co-benefits, such as improving air quality and carbon sequestration.

Tree planting is actively promoted in many new urban planning policies. For example, the National Model Design Code, which provides detailed guidance on the production of design codes for planning purposes, includes detailed recommendations to promote successful green infrastructure and street tree design. At the national level, policies also exist to protect the environment; for example, the Environment Act 2021 now requires local highway authorities in England to consult before felling street trees. For development proposals that include extensive refurbishment or demolition and reconstruction, the promotion of green infrastructure and biodiversity networks is supported by both planning policies and a more holistic ability to design these features in.

	PRINCIPLES FOR PLANTING
	Planting opportunities within the City are to be informed by the following key principles as illustrated
1	Appropriate space for root and canopy growth to be ensured around existing heritage trees retained or newly planted feature trees
2	Street tree planting at 8 m centres between avenue trees to also consider below ground archealogical and utility constraints, proximity to buildings and carriageway movement
3	Clear stem to street trees to be minimum 2.5-2.75m
4	Planting beds within natural ground are preferred to allow for successful planting and less intensive maintenance
5	Introduction of above ground planters (fixed or moveable) where protection is desired or below ground constraints determine

Figure 3 Principles of planting – City of London Public Realm Technical Manual ©City of London Corporation 2023

However, in many instances, urban greening and tree planting presents a retrospective design issue, managing congested surface and subsurface spaces and greening the public realm can more complex issue. In areas of established urban development such as the City of London**, a key barrier to tree**

planting for climate resilience is the (lack of) detailed knowledge and understanding of subsurface congestion by decision makers. Accessing overview data at earlier levels of project planning could assist longer term climate resilience adaptation planning and reduce costs of exploratory investigations. The City of London Public Realm Technical Manual, the reference document for designers and developers operating within the public realm and private spaces of the City of London, does include direct mention of surface constraints as a key consideration for planting opportunities (see **Error! Reference source not found.**). The City of London Tree Strategy also refers to subsurface c onstraints, including the densely populated nature of the roads and pavement, and the concern of tree roots potential damage to the public sewerage system. However, there is no mention of limitations that may arise from lack of information or mapping on subsurface uses.

Historical activity and the build up of archaeological remains over two thousand years, basement construction and presence of services mean that there is little if any natural soil occurring in the City of London. Whilst policy is pushing for more trees to support urban climate resilience, understanding of the subsurface has a role to play in this. The England Trees Action Plan 2021-2024 identifies that a key aspect to delivering more trees and greening in urban areas is to develop skills, education, and technical knowledge to ensure the correct trees are planted in the correct place, space and remain well maintained. This will be a key to support climate adaptation, ensuring urban greening is resilient to increases in temperatures and changes in rainfall patterns.

Sustainable urban drainage systems (SuDS)

The design and implementation of SuDS to assist with urban future surface water management is already well controlled through planning policy. The National Planning Policy Framework (NPPF) focuses on flooding and managing flood risk, and is supported at a local level by Local Plan policies. As an example, the City of London Local Plan Policy DM 18.2 (Figure 4) sets out the City's requirements for SuDS to consider subsurface infrastructure and follow the London Plan drainage hierarchy:

- Rainwater used as a resource (harvesting and blue roofs for irrigation)
- Rainwater infiltration to ground or close to source in non-clay area (i.e., porous surfaces)
- Rainwater attenuation in green infrastructure features for gradual release (e.g., green roofs, rain garden, tanks/ sealed water features))
- Rainwater discharge direct to water courses (unless not appropriate)
- Controlled rainwater discharge to a surface water sewer or drain
- Controlled rainwater discharge to a combined sewer

Policy DM 18.2 Sustainable drainage systems (SuDS)

1. The design of the surface water drainage system should be integrated into the design of proposed buildings or landscaping, where feasible and practical, and should follow the SuDS management train and London Plan drainage hierarchy.

2. SuDS designs must take account of the City's archaeological heritage, complex underground utilities, transport infrastructure and other underground structures, incorporating suitable SuDS elements for the City's high density urban situation.

3. SuDS should be designed, where possible, to maximise contributions to water resource efficiency, biodiversity enhancement and the provision of multifunctional open spaces.

Figure 4 Policy DM 18.2 of the City of London Adopted Local Plan 2015 (with 2020 review) ©City of London Corporation 2023

Local Planning Authorities must also produce a Strategic Flood Risk Assessments (SFRA), considering the risk from all forms of flooding, the impact that may arise from development and the opportunities to reduce the causes and impacts of flooding. Local authorities then grant SuDS permissions as necessary, in line with the relevant technical standards that have been produced by Defra (or the Welsh Government and Scottish Government). The CIRIA C753 SuDS Manual documents construction and considerations of drainage design with consideration of the subsurface geology (Appendix B – infiltrations assessment checklist).

Regional, local and sector-specific policy and guidance may also be issued where appropriate, such as Transport for London's 'SuDS in London – a guide', which seeks to demonstrate how SuDS can be incorporated in streets and the public realm with a focus on the London context. In addition, the London Sustainable Drainage Action Plan outlines several key actions, including those in specific sectors such as transport, education, retail and recreation, that will be undertaken to improve surface water management through SuDS. However, it is noted that the primary aim of this plan is the effective management of surface water to mitigate flood risk, rather than specifically concerning the risks arising from climate change. **It is understood that there is no currently policy/ requirement to register and record SuDS after construction.** The GLA do maintain a Retrofit SuDS map to view locations of SuDS across London, however recording of information is voluntary. **There may be a knowledge gap on how schemes and subsurface infrastructure (e.g., basements affecting groundwater water flow) may affect future management of water other areas**.

Cool spaces (below ground)

In many areas of London, high property values combined with a lack of developable land for surface development has resulted in a **surge in the excavation of underground basements**, both in commercial and residential buildings. As an example, a recent study on London residential basement developments underneath existing houses indicated over 7,000 had been granted planning permission between 2008 and 2019 (Burrows *et al.*, 2021). At the time of the study (2021), twenty-five of the London boroughs had developed supplementary planning policies and guidance concerning basement development. Only two boroughs – Ealing and Havering – had these in place in 2008; the majority were developed after 2011 in line with the surge in applications. The Planning (Subterranean Development) Bill, introduced in 2015, was intended to '…make provision for the presumption against the granting of planning permission in respect of subterranean development where certain conditions apply'. It would have provided local authorities with the power to refuse permission in areas where, for example, flood risk was indicated. However, **the bill did not progress beyond its second reading**.

There are thus currently no national policies in place governing spatial planning of the subsurface, including therefore the issue of cool spaces below ground. In London, the urban heat island can cause temperatures to be up to 10 °C higher in central urban areas than surrounding rural areas. UKCP18 climate projections for London include an increase in average summers of 2-5 °C and increased frequency and duration of extreme summer temperatures and heatwaves.

In the short term, **cool space strategies are surface based** and have been developed to enable the public to better respond to heatwaves and high temperatures. For example, in response to the heatwaves of Summer 2022, the Greater London Authority released a map of cool and shaded places of refuge for Londoners when temperatures are high, to which local authorities, community groups and other organisations contribute. These include naturally cooler spaces, such as parks, water courses and tree canopy cover, as well as indoor cool spaces (that may include active cooling such as air conditioning) such as community centres, libraries and churches.

There is potential for the future **repurposing of subsurface structures** to meet this need (e.g., underground car parks or disused subway tunnels and public toilets), but there is currently no policy or supporting strategic overview on this as a climate adaptation/resilience focus. Accessible basement cool spaces could in the future be safeguarded through planning policy, but the lack of knowledge on locations means the potentially most useful spaces are not easily documented, and there is currently no policy or framework to enable the implementation of such ideas. In London, subsurface venues are frequently repurposed for commercial venues (e.g. vaults and basements converted to pubs or available to hire as venue spaces, toilet bars) but these are not identified as designated cool spaces for respite from heat.

Ground source energy

Heat networks, and heat pumps, are expected to become a major part of the government's plan to reduce the UK's reliance on fossil fuels for heating homes and businesses. The UK Parliament's POSTbrief 46 evidence review paper offers an overview of geothermal energy in the UK. There is currently no bespoke regulatory system for the licensing, ownership and management of geothermal energy in the UK, as it not yet recognised by law as a natural resource (like water or gas). POSTbrief 46 recognises that uncertainty of ownership of subsurface heat, the lack of enforced licensing in the UK, and potential effects from neighbouring subsurface schemes could present barriers for uptake.

No specific regulations for geothermal schemes are in place in the UK, although regulation is determined by devolved administrations. Local planning authorities currently lead on the planning consent, whilst environment regulations related to abstraction and discharge permitting permits are governed by devolved regulators. Licensing legislation for ground source heat pumps (GSHPs) **varies depending on whether the system is closed loop or open loop**. Schemes classified as **closed loop are exempt from licensing control** however it is **requested** (not enforced) that **installations are registered** with a network database to record uptake. Not enforcing the formal registration of closed loop systems could pose a future risk for developing subsurface climate adaptation measures (for example installation of local district heating network schemes).

The current requirement is for **open loop heat pump schemes to be licensed** and this is managed through the Environment Agency (EA). Policy requires **consideration of permitting and licensing** for groundwater investigation consent, abstraction licences, permit to discharge water and a permit for flood risk activities. There are schemes which may have the ability to swap their abstraction and discharge points around; this can assist in the longevity of a scheme or flexibility in the operation of the scheme.

Abstraction license and discharge permits are approved by the EA detailed in documents such as CAMS: London abstraction licensing strategy including instruction such as:

- *(p18) Licences issued for any ground source heat pump scheme (GSHP) will have attached conditions that will require licence holders to monitor and record water abstraction volume, water levels and temperature of the groundwater on a daily basis (water abstraction for GSHP is only considered non-consumptive, when total volume of the abstracted water is returned to the source of supply, i.e. the same aquifer which water is abstracted from). GSHP schemes will need to be installed in accordance with best practice. Schemes which consider discharging water to foul sewer and/or different source of supply are considered consumptive and will not be looked upon favourably.*
- *(p19) The assessment of an application for GSHP will need to consider the following:*
    - *Any impacts on nearby abstractors and the aquifer from the abstraction and reinjection of groundwater;*

- *The spacing and thermal performance of the system and how that may change over time;*
- *Any underground structures and services that could be impacted through the proposed re-injection.*

The complex and diverse development of the subsurface will affect water flow and temperatures in the urban subsurface. The lack of subsurface monitoring infrastructure, both in terms of legislation and physical technologies means that water and temperature fluctuations are not well understood or modelled at the current time.

Notable subsurface borehole schemes are already in place in the City of London, such as the Citigen hybrid district heating scheme (geothermal heat pump and recycled waste heat from power generation) and geothermal heating and cooling to the One New Change shopping centre. While GSHPs may provide a suitable source of low carbon heat and cooling in some parts of the City of London, the specific issue for the City is the limited residential population, and a likelihood that any scheme is likely to be larger in scale. Developers must liaise with the Environment Agency to ascertain the suitability of this option for their site(s) and obtain the necessary licences ensuring long term protection of underground resources (e.g., groundwater flow and quality, management of local temperature fluctuations). The City of London Local Area Energy Plan began in Summer 2022; this will comprise a whole energy system analysis and plan for the Square Mile in conjunction with Arup.

Utility networks

Underground space in the City of London is congested, not just with basements, but also with archaeology, transport tunnels, pipe subways, sewerage infrastructure and buried utility pipes and cables. Information on these subsurface assets is vitally important in the space of urban climate resilience and adaptation planning; however, there is no clear policy governing recording of the location of these assets, let alone the sharing of this information, other than on a 'need to know' basis, e.g. for strike avoidance purposes.

Historic utility network data **may not be recorded as accurately as required** and whilst suggested standards for the depth of installation are indicated, local conditions govern final installation. Old, abandoned pipes (not governed by newer regulations and policies) can remain unmapped and in-situ. The **existing regulations** guiding the recording, sharing and maintenance of underground asset data largely fall under two sets of regulations; New Roads and Street Works Act 1991 and The Street Works (Records) (England) Regulations 2002/2004, describing the format of records to be maintained and their accuracy level, and the use of electronic records. Records must be updated as soon as possible after an item is placed in the street or its position is altered, or if it is placed whilst doing any other works. More recently, data standards (PAS 128 and PAS 256) make provision for more consistent and accurate data capture of buried utilities, designed as a framework to improve accuracy, and collaborative sharing. PAS is not intended to be used retrospectively.

The UK Geospatial Commission is working with asset owners to build a digital map of underground pipes and cables as the National Underground Asset Register (NUAR). Participation in the trial platform is currently underway and whilst resilience and climate adaptation are included as potential long term future use cases, there are currently no drivers or agreements to make information accessible beyond addressing strike prevention.

Subsurface Data Standard Policy

The current variability of potentially useful information and data sources that could assist in climate adaptation planning results in difficulties accessing and practical limitations in using resources.

Information can range from quality controlled, georeferenced digital mapping layers (e.g. in GIS software), through to archived datasets, paper records and physical items. These are also accompanied by extremely useful but unverified citizen science.

Steps are being made towards rectifying this, with the UK Geospatial Commission pushing for the Q-FAIR (Quality - Findable, Accessible, Interoperable and Reusable) standard and the release of the UK Geospatial Data Standards Register in 2022. While initiatives with planning data (e.g. London Planning Data hub) are allowing development data to become more accessible, there remain issues with the recording of subsurface information (such as extent of basement excavations) within planning applications and this data is not easily searchable. The re-launch of the Construction Playbook means it is now a requirement for public sector projects that any ground investigation data collected must be shared as soon as reasonably practical with the British Geological Survey (BGS). This will mean the data collected will become part of the UK repository of subsurface data allowing for greater access and re-use.

The MUDDI standard (Model for the Underground Data Definition and Integration) is being developed by the Open Geospatial Consortium to create an international common language for holding information about underground assets in an interoperable manner. Again, the key focus for the working group has been data and information from excavation. In the UK, the National Underground Asset Register (NUAR) is implementing MUDDI to create a digital map of buried assets, such as underground pipes and cables, but is not yet accessible for wider uses beyond strike avoidance. Possible future additional use cases and benefits of access, (over-and-above strike avoidance), have been discussed including resilience planning (including flood risk) (Freeborough *et al.,* 2019; Freeborough & Bricker, 2021) however, these are not within the current scope of trial.

Key policies related to the subsurface that need considerations for climate change

- Increased use of underground space for climate adaptation and resilience planning requires wider discussions involving a wide range of participants, improved and accessible spatial mapping records.
- The focus of accessing utilities data is still for those working in the vicinity of buried assets and accessing this information for **research, resilience planning and climate adaptation is costly and spatially limited**.
- Development of new infrastructure is hampered by lack of understanding of old infrastructure and limited access to information.
- Define new forms of governance, creating a 'Land Registry' for the subsurface and defining a system-wide set of protocols for future use of the subsurface.
- Change from recommended / suggested recording of information (e.g. SuDS) to statutory deposits of data.
- **Not enough focus on the '3D understanding' of the subsurface, particularly depths**.

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