Figure 13 - Layers of London Bomb damage map from the London Metropolitan Archives webmap (https://www.layersoflondon.org/ accessed 17/01/2023)

2.10 Flood risk assessment

A flood risk assessment (FRA) has been carried out by Arup relating to this application. The document assesses the flood risk at the site from various sources and presents the proposed drainage strategy for the redevelopment. For the detailed assessment please refer to the Flood Risk Assessment report (Arup, 2023, Report ref.: 281835-ARP-XX-XX-RP-CD-0001).

The key findings of the FRA are outlined as follows:

- The site is located within Flood Zone 1, an area of low probability of flooding.
- Flood risks from tidal/ fluvial sources, pluvial sources, groundwater, artificial sources, and infrastructure failure are all considered to be low.
- Considerations have been given to both risk to the site, and potential offsite risk as a result of the proposed redevelopment, in accordance with the requirements of Chapter 14 of the National Planning Policy Framework (NPPF).
- Based on current understanding of site setting and the proposals, it is considered that the redevelopment can be carried out and operated safely and would not increase flood risk elsewhere.
- The existing drainage network will be retained as there is no change to the site footprint.
- It is assumed that there is no infiltration due to the presence of basement beneath the building footprint.
- Attenuation will be provided within a combination of blue roof systems and storage within the basement. It is proposed where possible, the inclusion of tanked permeable paving and provision of urban vegetation and green roofs to increase water cleansing; and
- Foul water flows are expected to increase due to the proposed alterations and increased floorplate, so it is likely that these flows will be pumped within the building to the existing point of connection.

3. Ground conditions and ground model

3.1 Regional geology

Published British Geological Society (BGS) 1:50,000 series solid and drift geological mapping is presented in Figure 1 of Appendix C. The superficial geology at the location of the site consists of Lynch Hill Gravel (part of the River Terrace Deposits). The outcrop of the boundary between Lynch Hill Gravel and Langley Silt ('Brickearth') is located approximately 200m to the north of the site. No indication of faults, drift-filled hollows ('scour hollows') or other distinct geological features are identified on the available mapping in the immediate vicinity of the site.

The BGS 1920s edition of the solid and drift geological map is shown in Figure 2 of Appendix C. This map does not show the outcrop of Langley Silt but shows a direct transition between the River Terrace Deposits and London Clay approximately 300m to the north of the site. Approximately 150m to the east of the site a stream or watercourse is indicated. The Lost Rivers of London by Barton (1992) was reviewed to determine the presence of former river features in proximity to the site.

Figure 3 of Appendix C presents an indicative section of the London basin from 1994 BGS 1: 50,000 series geological map, consisting of River Terrace Deposits overlying London Clay, Lambeth Group, Thanet Sand and Chalk.

Contour maps from the more recent BGS 1:50,000 series geological maps presented in Figure 4 of Appendix C indicate that the base of London Clay is expected to be between 0mOD and -5mOD and the top of the Upper Chalk is at around -30mOD.

3.2 Site investigations

Previous project site investigations researched and availible in the vicinity of Euston Tower include:

- 12 no. boreholes (BH1 to BH12) and 9 no. trial pits (TP1 to TP9) – Regents Place and Triton Square Geotechnical Investigation Report, Laing Technology Group Limited (LTG), dated April 1995. The site location plan and two closest logs (BH12 and TP8) are included in Appendix D.
- 1 no. borehole (BH1) at 1 Triton Square- Related to the recent refurbishment and foundation strengthening project undertaken by British Land, dated 2017; and,
- 6 no. boreholes (BH1 to BH 6) – Tolmers Square Geotechnical Investigation Report, dated 1977. The site location plan and borehole logs have been included in Appendix D.

In relation to the proposed development at Euston Tower, an initial intrusive foundation and geotechnical investigation has been undertaken between February and July 2022.

- The aim of the investigation was to determine the suitability of a foundation re-use scheme and to investigate the existing piled foundations, ground, and groundwater conditions local to the Euston Tower.
- Excavations were carried out to the toe level of several existing piles to confirm the length and soil stratigraphy and properties, and to obtain samples for laboratory testing.
- Samples of the substructure steel and concrete were taken for examination and testing.

3.3 Stratigraphy

Figure 14 presents a west to east geological cross-section, summarising existing previous local borehole information from Regents Place, Tolmers Square together with stratigraphy encountered from the 2022 foundation investigation.

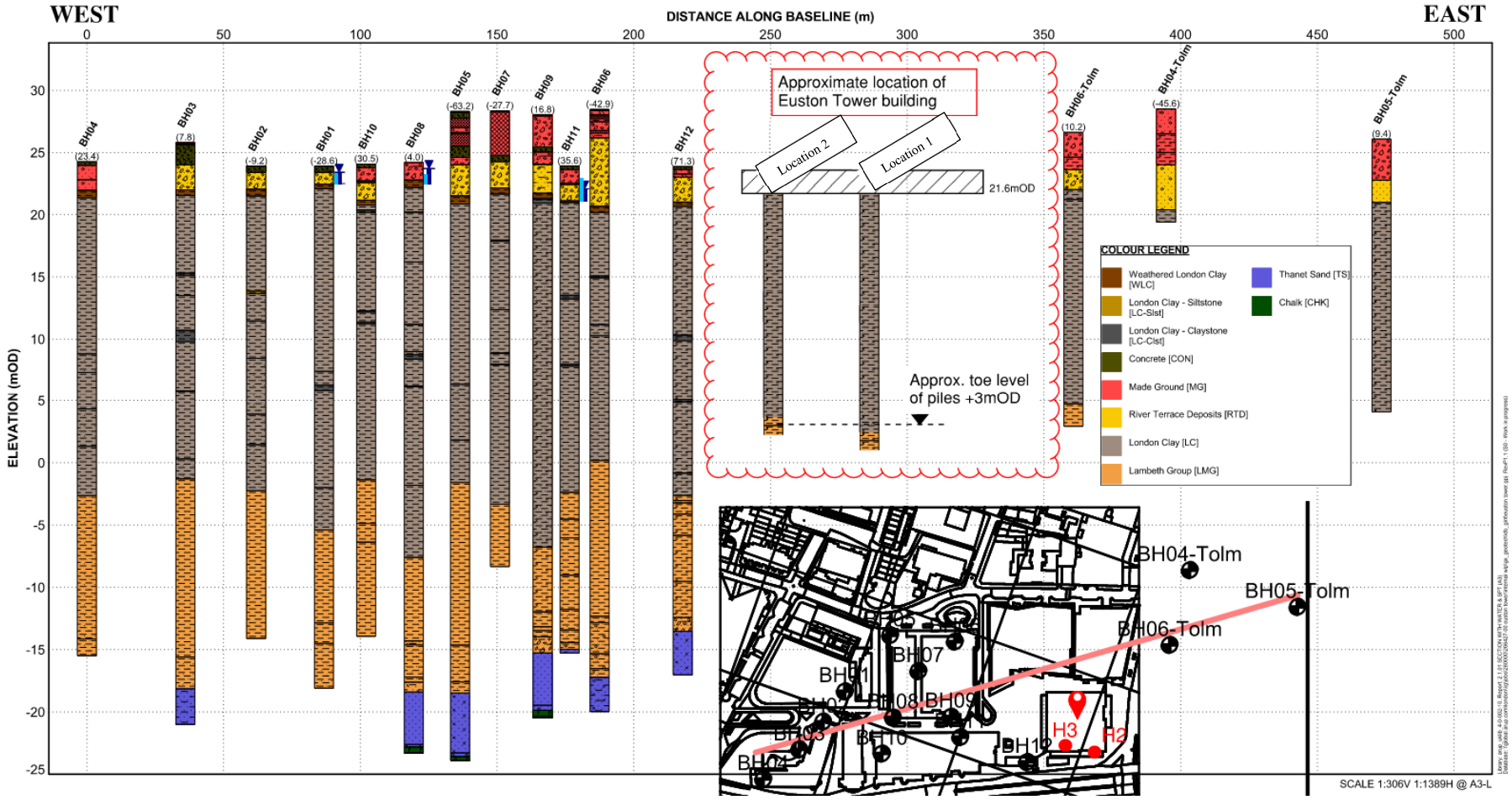


Figure 14 - West-east geological cross-section

Table 3 shows the stratigraphy encountered at the nearest investigation locations. The anticipated stratigraphy adopted for design and assessment is presented in Table 4.

Table 3: Summary of encountered stratigraphy from nearby site investigations.

Stratum	Euston Tower foundation investigation Locations 1 & 2[1]			BH12[2]			BH6[3]		
	Depth (mbgl)	Top of stratum level (mOD)	Thickness (m)	Depth (mbgl)	Top of stratum level (mOD)	Thickness (m)	Depth(mbgl)	Top of stratum level (mOD)	Thickness (m)
Fill / Made Ground	0	+28.0	4.4	0.25	+23.62	0.6	0	+26.62	3
River Terrace Gravel	4.4	+23.6	1.6	0.85	+23.02	2	3	+23.62	1.6
London Clay (weathered)	6	+22.0	0.5	2.85	+21.02	0.35	4.6	+22.02	0.8
London Clay	6.5	+21.5	16.9	3.2	+20.67	23.3	5.4	+21.22	16.5
Lambeth Group Formation	23.4	+4.6	*	26.5	-2.63	10.9	21.9	+4.72	>1.8*
Thanet Sand	-	-	-	37.4	-13.53	>3.5*			
End of hole	-	-	-	40.9	-17.03	n/a	23.7	+2.92	n/a

Notes:

* Borehole/Trial pit terminated within stratum. Thickness not determined.

1. Euston Tower Foundation Investigation Locations 1 & 2 undertaken in December 2022 in relation to the proposed development.

2. Regents Place and Triton Square Geotechnical Investigation Report, Laing Technology Group Limited (LTG), dated April 1995.

3. Tolmers Square Geotechnical Investigation Report, dated 1977.

Table 4: Anticipated site stratigraphy

Stratum	Description	Thickness (m)	Top of stratum level (mOD)
Ground level	-	-	+28.0
Fill / Made Ground	SAND and GRAVEL with demolition and building waste (brick and mortar cobbles)	0.3	+28.0
River Terrace Gravel	Medium dense, yellow-brown, fine to coarse SAND and sub-angular to rounded, fine to coarse flint GRAVEL. Medium to coarse orange-brown sand and fine to medium gravel	1.6	+23.6
London Clay (weathered)	Firm, brown and yellow-brown mottled Silty CLAY	0.5	+22.0
London Clay	Stiff to very stiff dark grey, brown Silty CLAY. Occasional grey green silt veins/pockets and shell debris. Clay is very to extremely closely fissured. Interbedded claystone's. Becoming very stiff from 10.8m below top of London clay. Becoming very sandy from 22.3m below top of London Clay.	17.5	+21.6
Lambeth Group Formation (formerly known as Woolwich and Reading Beds)	Very stiff, grey mottled red and brown Silty CLAY with occasional bands of fine to medium grained sand. Becoming very stiff to hard. Becoming hard Sandy CLAY 6.9m below top of layer.	17.5	+4.0
Thanet Sand	Very dense, grey, fine to medium grained sand. Occasional interbedded pockets of silt/clay	3.5*	-13.5
Note: * Borehole terminated at 40.9mbgl within Thanet Sand. Layer thickness and underlying strata not proven within available investigations.			

3.4 Ground model

For the purposes of the Basement Impact Assessment presented in this report, a preliminary ground model has been adopted for ground movement assessment, as shown in Table 5. The formation level of existing basement was taken at +21.6mOD, based on the 2022 foundation investigation findings is taken as the upper ground surface.

Table 5: Preliminary ground model adopted for ground movement assessment.

Stratum	Top of stratum level	Undrained shear strength	Vertical undrained Young's modulus	Vertical drained Young's modulus
	(mOD)	(kPa)	(MPa)	(MPa)
London Clay Formation	+21.6 (Underside level of existing basement)	$80 + 5z^1$	$E_{u,v} = 40 + 2.5z^1$ $(E_{u,v} = 500\ c_u)$	$E'_v = 25.6 + 1.6z^1$ $(E'_v = 320\ c_u)$
Lambeth Group	+4.0	$168 + 5z^2$	$E_{u,v} = 84 + 2.5z^2$ $(E_{u,v} = 500\ c_u)$	$E'_v = 53.8 + 1.6z^2$ $(E'_v = 320\ c_u)$
Thanet Sand	-13.5	-	-	$E'_v = 200$
Chalk	-20.0	Assumed to be rigid boundary		

Notes:

1. z^1 denotes depth in metres below London Clay Formation surface.
2. z^2 denotes depth in metres below Lambeth Group surface.
3. The undrained shear strength and stiffness profiles for Lambeth Group (Clay) are assumed to be a continuation from the respective overlying London Clay Formation profiles.

Figure 15 shows the supporting undrained shear strength results from UT100 unconsolidated undrained (UU) triaxial tests.

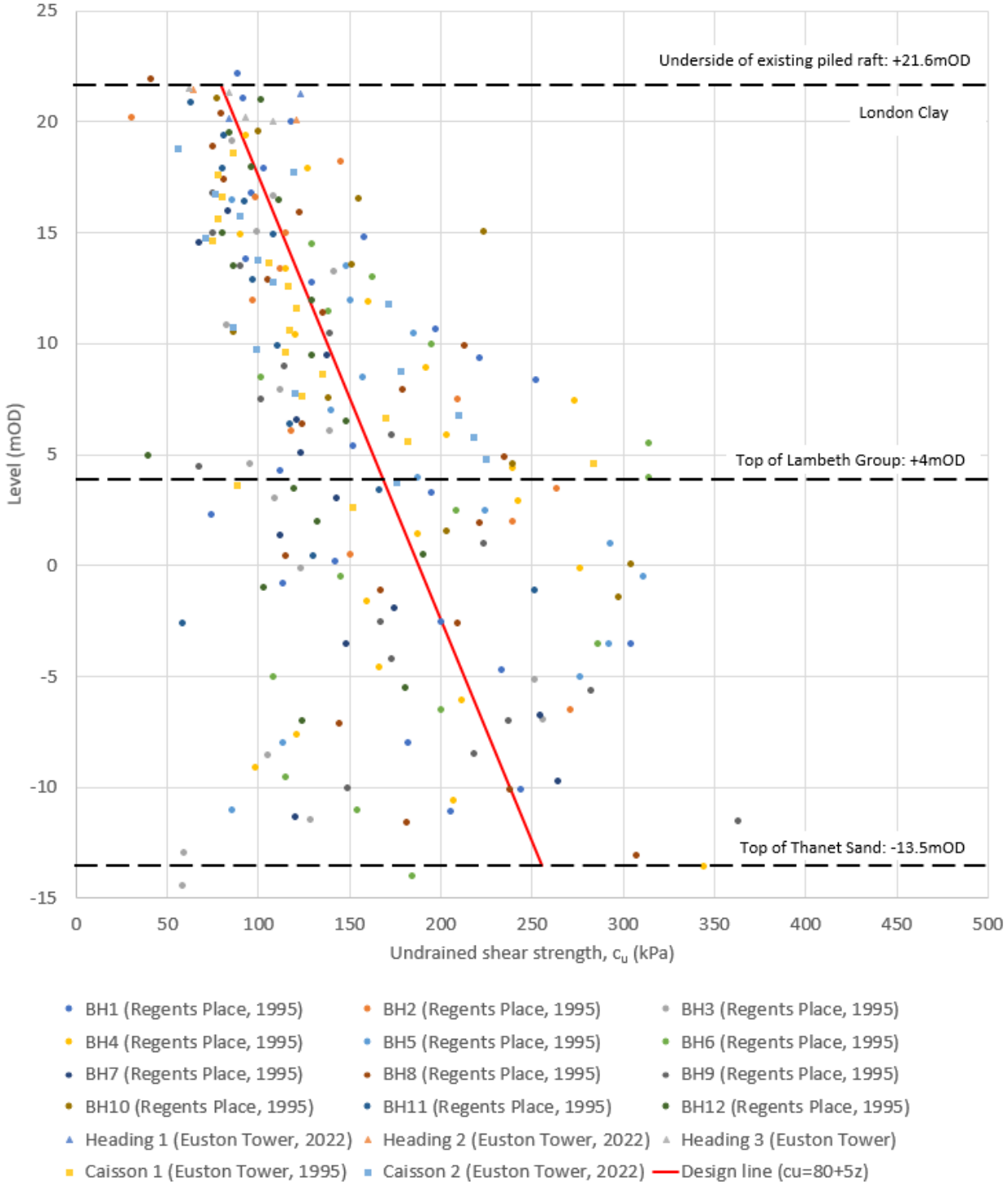


Figure 15: Undrained shear strength from Undrained Unconsolidated triaxial results on 100mm diameter samples.

3.5 Groundwater

A map of the Lost Rivers of London is shown in Figure 16. There are no lost rivers recorded within the site extent.

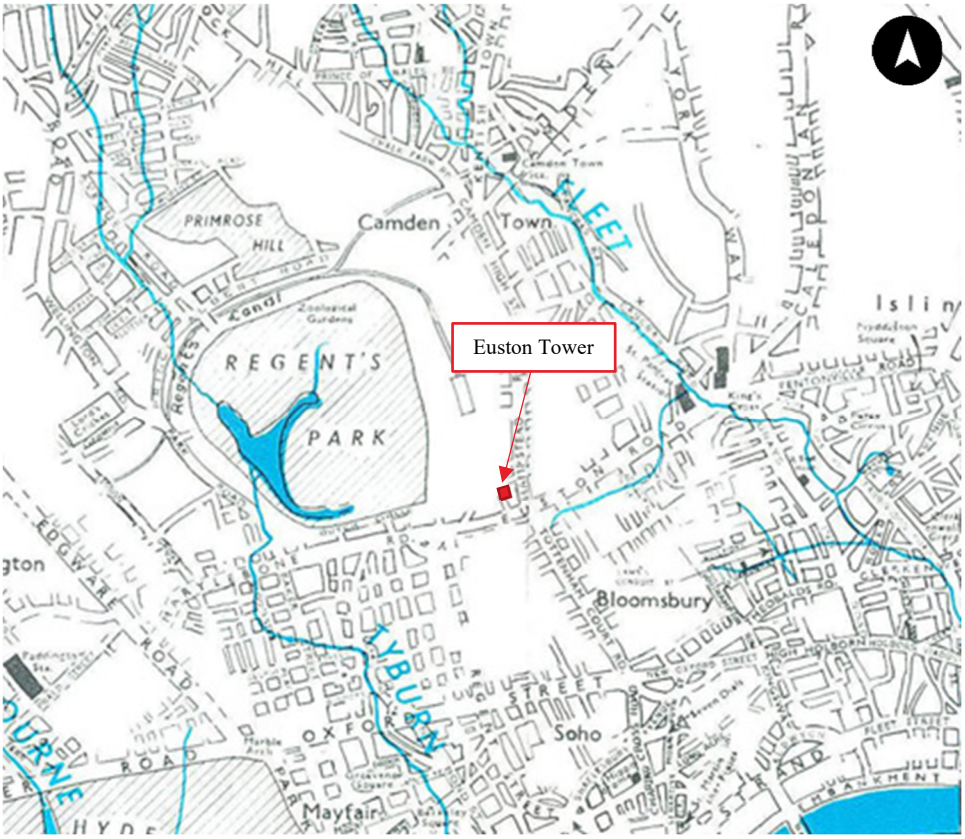


Figure 16 - Lost rivers of London (https://www.hiddenhydrology.org/, accessed 17/01/2023)

As relevant to the basement impact assessment, groundwater is anticipated in the shallow aquifer within the superficial deposits (principally the River Terrace Deposits). Groundwater is expected to be either in continuity within the aquifer or encountered as perched, due to variation in the surface of impermeable strata (clays and/or by the presence of buried man-made structures).

A summary of groundwater readings from nearby investigation locations are included below in Table 6. The groundwater readings are typically between 1m (+22.87mOD) and 1.8m (+22.07mOD) below top of the basement slab (+23.87mOD) at the location of BH12. These readings relate to the development of 1 Triton Square within the Regents Place estate.

Table 6: Monitored groundwater levels from nearby site investigations.

BH	Monitored Groundwater Level (mOD)	Source (refer notes)
BH12 (water strike)	+22.87	(1) – year 1995
TP08 (water strike & recharge)	+22.62	(1) – year 1995
CH03 (standpipe)	+22.5	(2) – year 2017
CH02 (standpipe)	+22.4	(2) – year 2017
BH101 (standpipe)	+22.25	(2) – year 2017
CH01 (standpipe)	+22.10	(2) – year 2017
BH11 (standpipe)	+22.07	(1) – year 1995
Notes:		

BH	Monitored Groundwater Level (mOD)	Source (refer notes)
(1) Regents Place and Triton Square Geotechnical Investigation Report, LTG, April 1995 (2) 1 Triton Square Geotechnical Report, Arup, 2017		

Groundwater was also encountered in the River Terrace Deposits during recent foundation strengthening works carried out at 1 Triton Square (2018-2019). Water levels were generally controlled for raft and pile cap construction works by localised temporary works and pumping.

During the 2022 foundation investigation at Euston Tower, water was encountered within the superficial deposits and was controlled by localised temporary works and pumping.

4. Screening assessment

4.1 Screening assessment methodology

The screening assessment criteria used to guide this Basement Impact Assessment is taken from London Borough of Camden guidance for subterranean development 'the Arup Report' (Camden, 2010). The screening assessment including potential impact and mitigation is set out in the tables under the following Sections 4.2 to 4.4. A summary of the key impacts and proposed mitigation is presented in Section 0.

4.2 Subterranean Screening Assessment

Question	Response	Proposal/ Mitigation
1a. Is the site located directly above an aquifer?	Yes. Made Ground and River Terrace Deposits are present outside and beneath the existing basement footprint.	The proposals do not include widening the plan extent of existing basement. Localised deepening within the River Terrace Deposits and London Clay underneath the existing basement is proposed to construct Basement 02 level plant/tank space.
1b. Will the proposed basement extend beneath the water table surface?	Yes. Groundwater is present within Made Ground and River Terrace Deposits.	Proposed local Basement 02 plant/tank level beneath the existing single level basement involve localised excavation within River Terrace Deposits and London Clay. Provision for temporary water control and retaining wall should be made.
2. Is the site within 100m of a watercourse, well (used/ disused) or potential spring line?	No.	N/A
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No.	N/A
4. Will the proposed basement development result in a change in the proportion of hard surfaced/ paved areas?	No.	N/A
5. As part of the site drainage, will more surface water (e.g., rainfall and run-off) than at present be discharged to the ground (e.g., via soakaways and/ or SUDS)?	No.	N/A Refer to Flood Risk Assessment report (Arup, 2023, Report ref.: 281835-ARP-XX-XX-RP-CD-0001).
6. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local point (not just the pond chains on Hampstead Heath) or spring line?	Yes	A portion of the local B02 basement proposed as part of the application will be below the water table. This will be waterproofed by design to resist water ingress to the space, tied in to the existing basement.

4.3 Stability Screening Assessment

Question	Response	Proposal/ Mitigation
1. Does the existing site include slopes, natural or manmade, greater than 7°?	No.	N/A
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No.	N/A

Question	Response	Proposal/ Mitigation
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No.	N/A
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No.	N/A
5. Is the London Clay the shallowest stratum at the site?	No. However, existing pile cap for tower building founded directly on London Clay.	N/A
6. Will any trees be felled as part of the proposed development and/ or are any works proposed within any tree protection zones where trees are to be retained?	Yes, the tree planting is to be adjusted as part of the development, however trees are located within engineered tree pits.	The existing and proposed trees are within engineered tree planting troughs and/or otherwise not expected to cause ground movement at the basement formation level due to depth.
7. Is there a history of seasonal shrink-swell subsidence in the local area and/ or evidence of such effects at the site?	London Clay stratum present is susceptible to shallow shrink swell effects generally, following established guidance.	The foundations/basements for the development are at greater than 5m depth below ground, and trees are located within engineered tree pits.
8. Is the site within 100m of a watercourse or potential spring line?	No.	N/A
9. Is the site within an area of previously worked ground?	Yes. Made Ground is present on site and has been modified over site's development history.	Existing basement has removed majority of Made Ground so extent remaining is limited. Further investigations are recommended if fill is to be considered as a bearing stratum in design.
10a. Is the site within an aquifer?	Yes. Made Ground and River Terrace Deposits are present outside existing basement footprint.	The existing basement within the site is directly underlain by London Clay. The proposals do not include widening the plan extent of existing basement.
10b. Will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Yes.	Temporary water control provisions are recommended for proposed Basement 02 excavation within the River Terrace Deposits and London Clay.
11. Is the site within 50m of Hampstead Heath ponds?	No.	N/A
12. Is the site within 5m of a highway or pedestrian right of way?	Yes. The edge of existing basement is located within 3m of existing pedestrian walkways.	Contractor to agree proposed hoarding line to minimise impact on public right of way and agree with Camden planning authority.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes. The proposed Basement 02 level will be deeper than the existing single level basement. However, 2-level basements are present at neighbouring 10-30 Brook Street, so this will be less deep than adjoining basements.	Ground movement assessment has been carried out in Section 6.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g., railway lines?	Yes. The site falls within the 2015 Crossrail 2 Safeguarding Directions (see Appendix E for correspondence from Crossrail 2). The site is located to the west of Northern and Victoria line	Third party consultation and engagement with Crossrail 2 will be carried out. A preliminary ground movement assessment will be carried out separately to assess the impact of proposed

Question	Response	Proposal/ Mitigation
	tunnels, to the north of St Johns Wood to Back Hill deep cable tunnel and Hammersmith & City, Circle and Metropolitan line tunnel)	redevelopment on existing and future tunnels.

4.4 Surface Flow and Flooding Screening Assessment

Question	Response	Proposal/ Mitigation
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No.	N/A
2. As part of the proposed site drainage, will surface water flows (e.g., volume of rainfall and peak run-off) be materially changed from the existing route?	No.	N/A
3. Will the proposed basement development result in a change in the proportion of hard surfaced/ paved areas?	No.	N/A
4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	No.	N/A
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No.	N/A
6. Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk from flooding, for example because the proposed basement is below the static water level of nearby surface water feature.	No. The site is located in flood zone 1 – an area of low probability of flooding.	N/A

4.5 Summary of potential impacts and mitigations

The following key potential impacts have been identified from the screening assessment. Recommendations for further assessment are made:

Subterranean screening assessment:
An aquifer is present at the site location. The proposed local B02 basement would introduce local cut-off of the shallow aquifer to the London Clay aquiclude through the River Terrace Deposits (upper aquifer). However, the size of the local B02 basement is not significant in relation to the site footprint.
Refer to the Flood Risk Assessment report (Arup, 2023, Report ref.: 281835-ARP-XX-XX-RP-CD-0001) for assessment of surface water and SUDS.

Stability Screening Assessment:
Ground movement assessments for assets falling within the zone of influence associated with the proposed redevelopment are recommended. The zone of influence for ground movements refers to area with calculated vertical ground movements greater than +/-1mm.

The relative depth of the proposed Basement 02 is deeper than the existing single level basement for the Euston Tower building. Ground movements that will impact neighbouring buildings are to be assessed (presented in Section 6.)

The site falls within the 2015 Crossrail 2 Safeguarding Directions and therefore consultation is expected to be required. The site is located to the west of Northern and Victoria line tunnels, to the north of St Johns Wood to Back Hill deep cable tunnel and Hammersmith & City, Circle and Metropolitan line tunnel.

In relation to TfL and utility assets, third party consultation and engagement with the respective asset owners will be carried out. A preliminary ground movement assessment will be carried out separately to assess the impact of proposed redevelopment on existing and future assets.

Surface flow and flooding

Refer to Flood Risk Assessment report (Arup, 2023, Report ref.: 281835-ARP-XX-XX-RP-CD-0001).

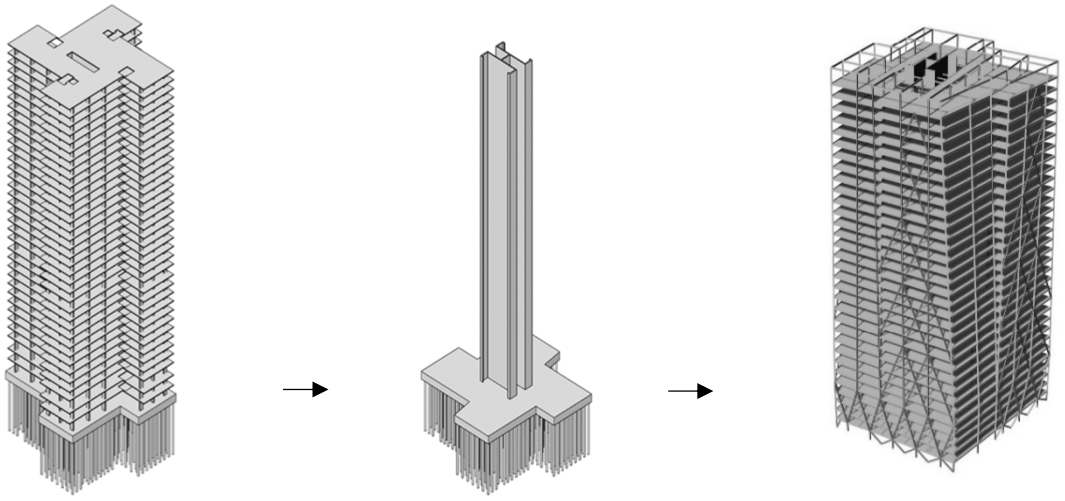
The cumulative effects of basement development are not considered to be significant or require assessment.

5. Basement design

5.1 Proposed development

The proposed development of Euston Tower involves the deconstruction of the existing floorplates from roof to ground floor level, with the central core, foundations and basement retained. A new structural frame and new floorplates will be constructed, with the foundations and central core being reused. New supplementary foundations will be constructed to support the new superstructure where it extends beyond the extent of the existing pile cap.

Figure 17 illustrates the general proposed redevelopment stages for Euston Tower in outline.



a) Existing tower structural model

b) Retained core, basement, and foundation after partial deconstruction

c) New proposed structural model

Figure 17: Proposed redevelopment of Euston Tower building

5.2 Proposed basement geometry

The existing single level basement between the Euston Tower building and surrounding the building is to be retained. A local Basement 02 level is proposed underneath the existing single level basement to accommodate a water tank and plant room. The proposed Basement 02 level has a plan dimension of approximately 7.45m x 33m (246 sqm), located to the west of existing pinwheel piled raft as illustrated in Figure 18. The proposed FFL is +19.77mOD in relation to the general 1 level basement level of +23.9mOD.

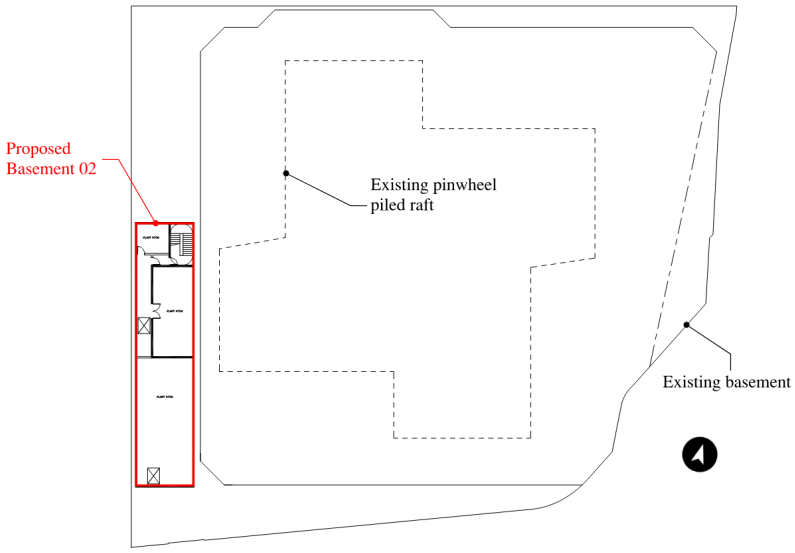


Figure 18: Proposed Basement 02 plan (extract from 3XN drawing no.: ET_DR-A_20098)

5.3 Foundations

5.3.1 Existing foundations

The 2022 foundation investigation demonstrated that piles are arranged in groups beneath the columns and structural cores. Figure 19 illustrates the understanding of pile arrangements under the tower. The reinforced concrete piles were discovered to be straight shafted with diameter of 2ft (610mm) and were approximately 19m long. Intrusive investigations have found the piles to be reinforced to full pile depth.

The pinwheel raft/ pile cap was found to be 2.8m thick, with a structural thickness of 2.4m. The raft extends over the entire footprint of the existing tower and is used to spread the load from individual columns into the pile groups. The piled raft was found to be in good condition given its age, despite being sparsely reinforced compared to current modern standards. No corrosion of reinforcing steel has been observed.

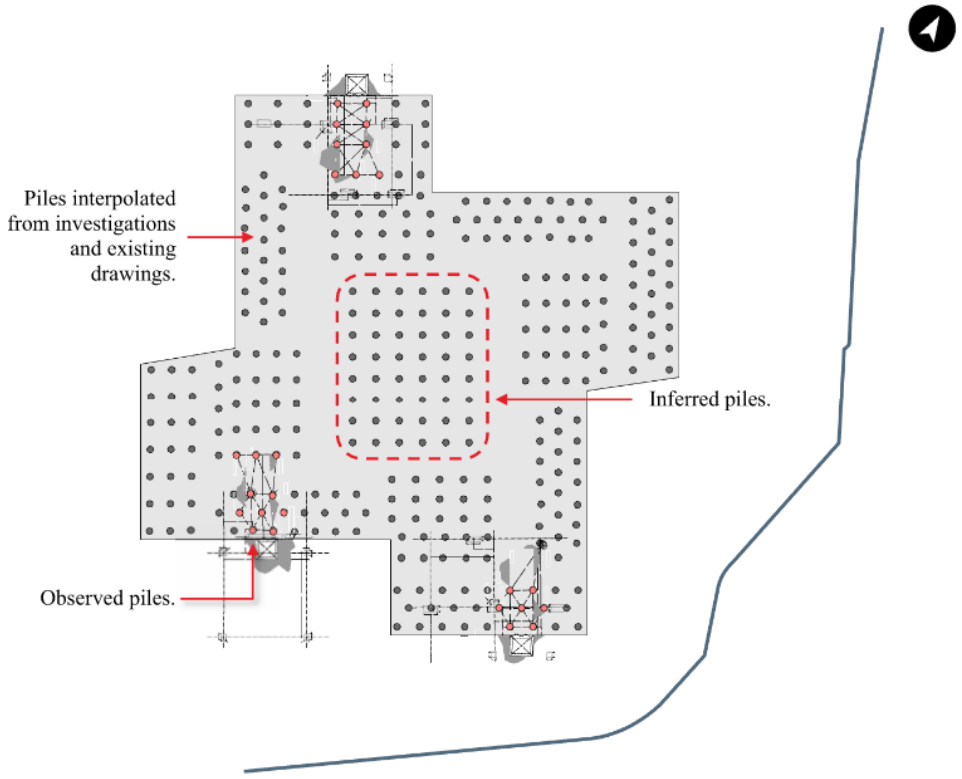


Figure 19: Plan showing anticipated existing foundations of Euston Tower

5.3.2 New foundations

Due to the limited knowledge of the existing foundations, a load balance approach is to be adopted where the new applied loading on the existing foundation is kept less than or equal to the existing loading regime. Basement load spreading structures are proposed to transfer loading from new column locations to the previous column locations in the basement. A new 1500mm thick piled raft with 900mm diameter piles is proposed to support new columns landing outside of the existing pinwheel piled raft, as shown in Figure 20.

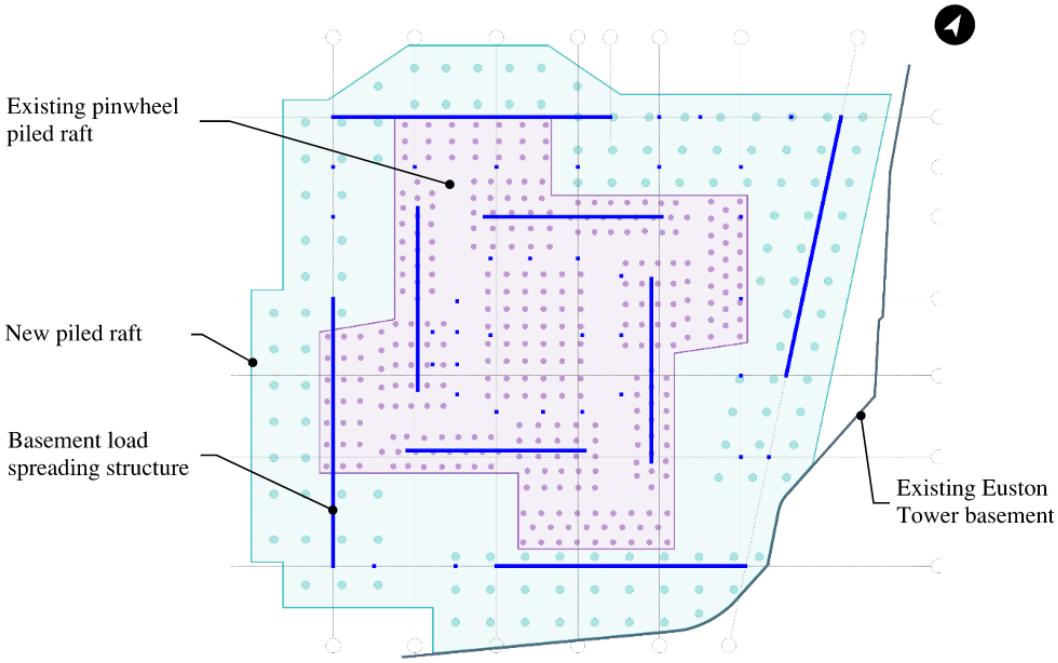


Figure 20: New foundations showing existing and new piled raft areas.

5.4 Construction sequence

For the purposes of the basement impact assessment presented in this report, the currently anticipated construction sequence for the proposed redevelopment is illustrated in Figure 21 and outlined below in summary:

- Site enabling works.
- Deconstruction of Euston Tower floorplates starting from roof level downwards
- Deconstruction of ground floor slab and installation of temporary props to support the existing retaining wall.
- Earthworks to provide piling platform level within basement for new foundations.
- Installation of foundation piles for new building superstructure and temporary retaining wall (contiguous piled wall or sheet pile wall) around proposed local Basement 02.
- Localised excavation to Basement 02 formation level with temporary propping as necessary
- Construction of new piled raft & substructure
- Construction of ground floor slab and new building floorplates above

A 'bottom-up' traditional construction of the proposed local Basement 02 and temporary retention of the existing basement using high support temporary propping is proposed. The temporary works and construction sequence will be further developed at later design stage and following engagement with specialist contractors and temporary works designers.

For further details refer to the Construction Management Plan included with the application.