

**Evidence to demonstrate that trees of any size grow healthily to full size
on top of garden basements**

Introduction

This report demonstrates that trees grow healthily to full size on top of garden basements when designed appropriately.

The report includes:

- Two examples of private gardens where good design has improved or maintained the quality of the garden on top of a garden basement.
- Pictures from the commercial tree industry that demonstrates that healthy trees are routinely grown in soil volumes that are far more restricted than those that will be in place in the one metre of soil on top of a basement that extends beyond the footprint of the existing building.

1. Improvement of rear garden due to basement development – 54 Bedford Gardens W8 7EH

Basement construction took place during 2012. The garden area has gone from being a paved area with no planting to a small but well planted area with a mature tree on top of the basement roof and a significant increase in greenery and planting.

Garden before development

Prior to development the rear areas of the property were:

- Fully paved courtyards
- With no planting in the ground
- Poor drainage as the ground was London clay with no top soil and a thin layer of man-made ground (worked ground from previous building works including old bricks etc). The London clay is effectively impermeable meaning that nearly all rainwater was lost and flowed immediately into the drain system.
- All surface water falling onto the area was fed by gravity directly into the main drainage / sewer system.
- No surface water from the roof or garden were collected, re-used or attenuated to avoid sewer flooding during storms.



Rear garden before development - facing to rear (towards Campden Street, facing roughly north)



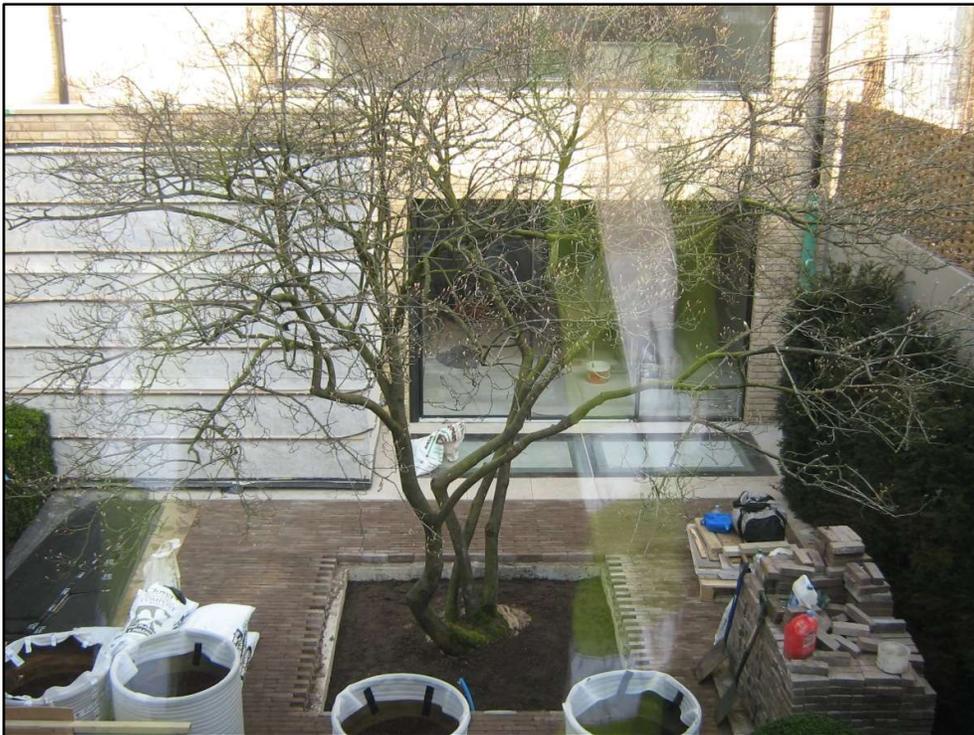
Rear garden before development – facing to front (towards Bedford Gardens, facing roughly south)

Garden after development

After basement development:

- Surface is soil or permeable paving / decking.
- Planting into the soil comprises:
 - One 50 year old mature multi-stem tree.
 - Mature hedges on both sides of the garden.
 - Living plant greenwall to the rear mews house.
- There is one metre of soil under the full area - this is a marked improvement on water retention capacity.
- Rainwater from the garden area drains into the ground and does not flow into the gravity drainage / sewer system.
- Rainwater from the roof of the house is collected for reuse.

We have pictures from 2013 of the garden after construction but before the completion of the landscaping and recent publicly available aerial pictures showing the garden and mature tree 12 years after planting



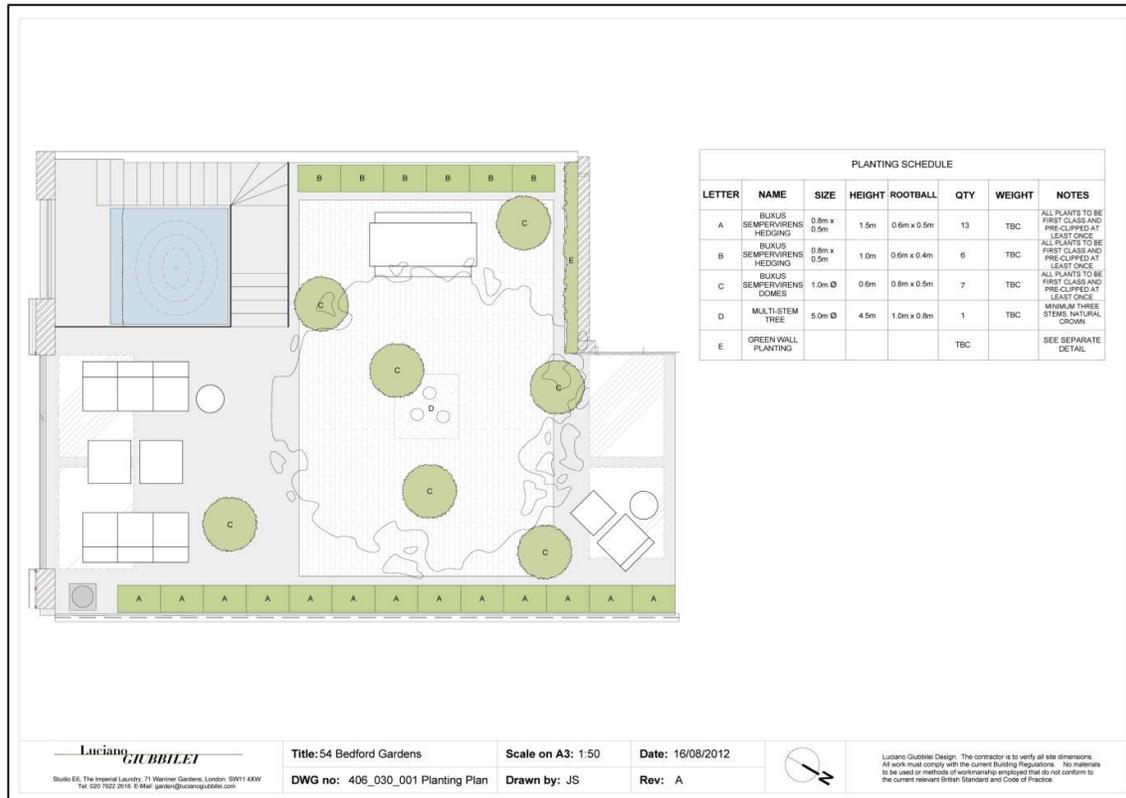
50 year old mature multi-stem tree planted in the one metre of soil over the basement roof - green wall to be introduced in the area of white wall on the left of the picture – picture before completion of landscaping works in 2013



Mature tree and hedges planted in the one metre of soil over the basement roof– picture before completion of landscaping works in 2013



Opposite view of mature tree and hedges - living green wall to be planted on the white wall on the left of the picture– picture before completion of landscaping works in 2013



Planting plan

The garden has now had 12 years to mature.

There is no direct access to the property however the garden area can be seen from recent public aerial mapping.

This shows the garden over the basement that extends beyond the footprint of the existing building to be in good health and with the mature tree growing well and covering most of the rear garden in healthy tree canopy.



Aerial view of whole property – rear garden highlighted in red



Rear garden after development - 2025 - facing to rear (towards Campden Street, facing roughly north) – close to the same aspect as the first picture on page 2 from before development



Rear garden after development - 2025 – facing to front (towards Bedford Gardens, facing roughly south) - close to the same aspect as the second picture on page 2 from before development



Rear garden after development - 2025 – oblique view towards rear right (towards Campden Street, facing roughly north east) – showing mature tree on top of roof of garden basement approximately 12 years after planting

2. Planting of bucolic artisan garden in Chelsea Park Gardens – 32 Chelsea Park Gardens SW3 6AB

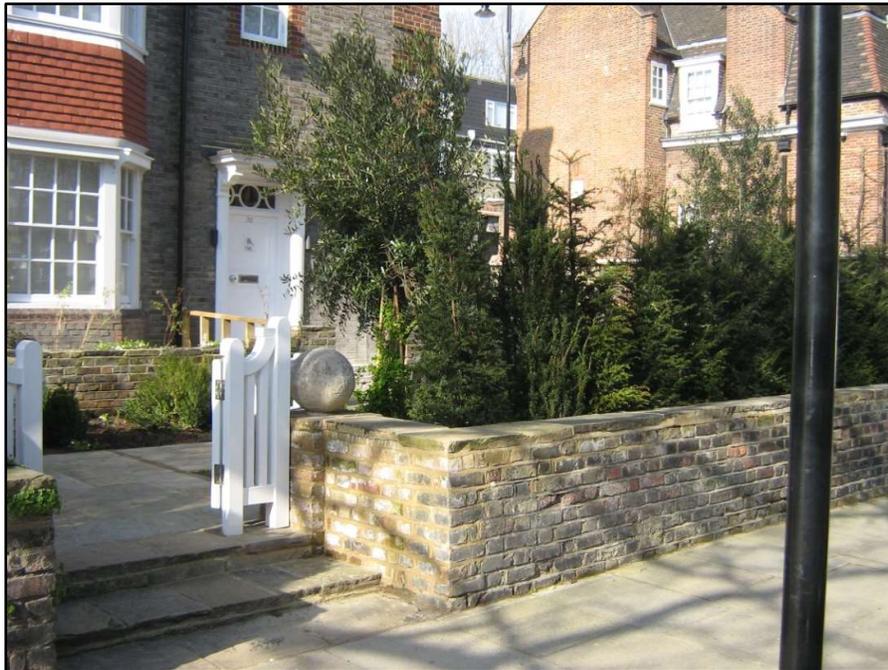
The front gardens of Chelsea Park Gardens are notable for their bucolic character.

A basement development that extends beyond the footprint of the host building for 85% of the front garden was completed in 2011. Landscaping on top of the basement in the front garden was completed in 2012. We do not have pictures from before the work however we have pictures from shortly after completion of the landscaping in 2012 and current pictures, from June 2025.

The basement development extended for the full width of the garden and from the house to one metre from the boundary with the pavement at the front. All of the planting, including the trees, are directly above the garden basement except for the hedge by the front garden wall immediately beside the public footpath.



Front garden over basement - one month after planting – 2012



View from road- one month after planting - 2012



Aerial view of whole property – front garden highlighted in red - 2025



Front garden after development - 2025 - facing towards house (roughly west) from Beaufort Street – all trees and other planting are directly above the basement under the front garden except for the hedge at the front next to the public footpath (opposite the red car)

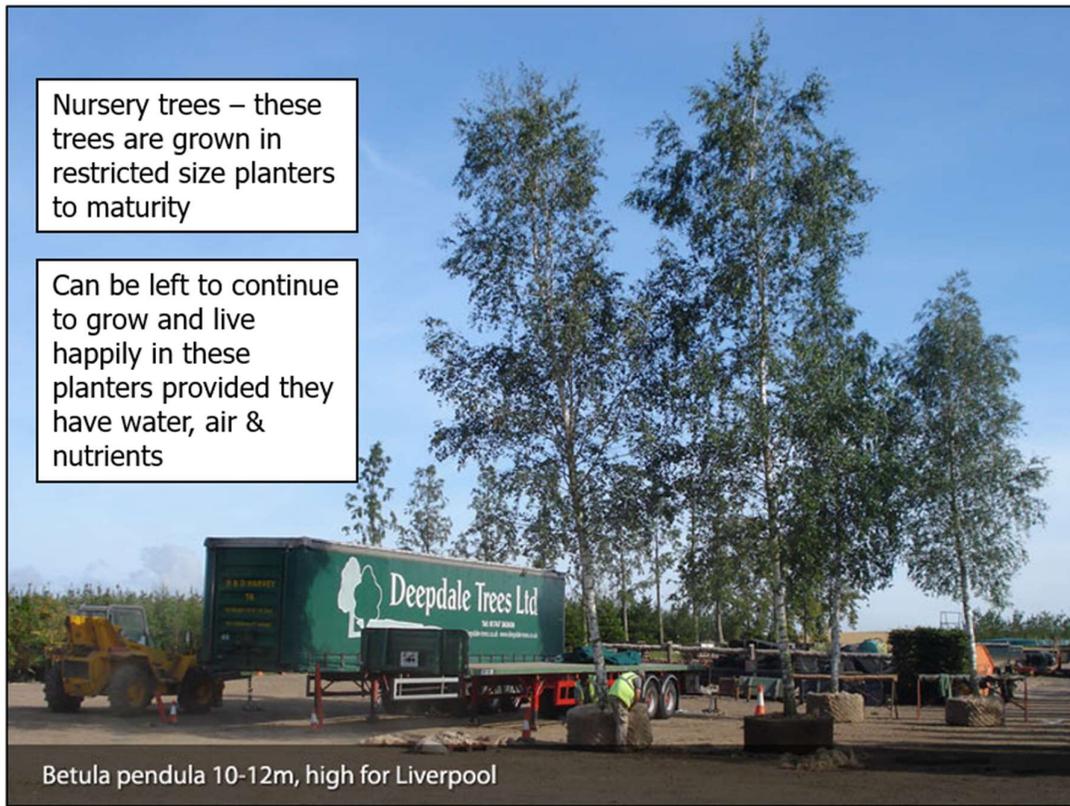


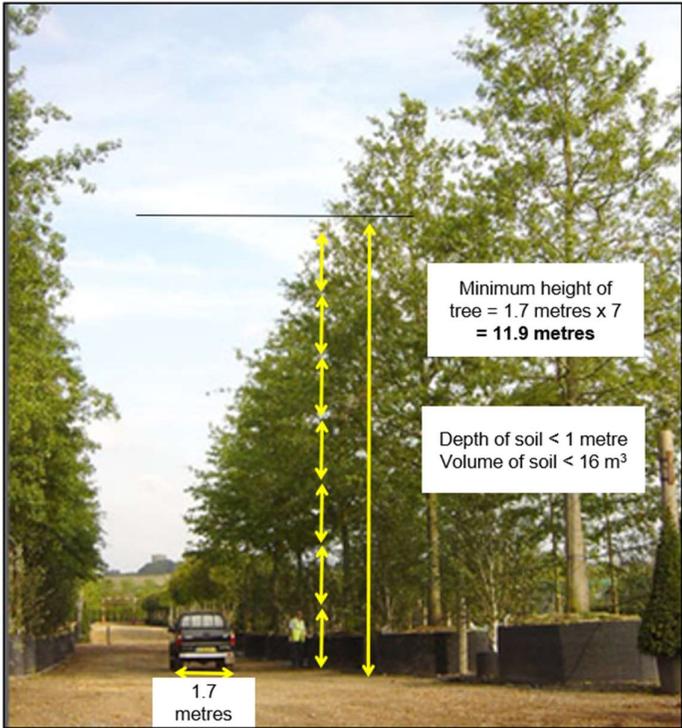
Front garden after development - 2025 - facing across front of garden (roughly north east)– all trees and other planting in the picture are directly above the basement under the front garden except for the hedge on the very left of the picture, beyond the white gate

3. Evidence that healthy and sizeable trees are routinely grown by the commercial tree industry in soil volumes that are significantly more restricted than those on top of a basement with one metre of soil depth that extends beyond the footprint of the existing building

The following pictures show trees that are grown to semi-maturity and full maturity by commercial tree companies in planters with restricted soil volumes.

These soil volumes are significantly less than are afforded where a basement that extends beyond the footprint of the host building has one metre of soil placed on top of the basement.





Minimum height of tree = 1.7 metres x 7 = 11.9 metres

Depth of soil < 1 metre
Volume of soil < 16 m³

1.7 metres

Nursery trees – these trees are grown in restricted size planters to maturity

Grow to:

- Full size
- Full lifespan
- Healthy

Trees need:

- Sufficient 'good' soil
- Water
- Air
- Nutrients





Force Foundations Ltd.
(Basement Force)

**Royal Borough of Kensington and
Chelsea Basements Policy**

Hydrologic Review of Second Draft
Policy for Public Consultation

Issue | 29 April 2013



This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.



ARUP

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Background of Policy Development

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Summary of Proposed Policy

1 Introduction

The report documents a review of the Royal Borough of Kensington and Chelsea's (RBKC's) 2nd draft Basement Policy by Ove Arup and Partners Ltd. (Arup). The report focuses only on the potential hydrological and hydrogeological impacts of the proposed policy and therefore should not be considered to be a comprehensive review of the proposed policy. In particular, structural impacts related to the proposed policy are outside the scope of this project.

This report was funded by a commission from Force Foundations Ltd. (Basement Force) As part of the defined scope of work and agreement between Arup and Force Foundation Ltd, Arup has performed an impartial and unbiased assessment of the proposed RBKC policy and supporting documentation.

The purpose of the report is as follows:

- Review the proposed policy and supporting documents with respect to potential hydrological and hydrogeological impacts both locally and across the Borough;
- Review the technical appropriateness of the proposed policy in order to evaluate if proposed policies are technically reasonable; and
- Provide recommendations to improve the policy such that the policy is more protective of environmental resources.

This report is organized in the following sections:

- Section 2: Description of RBKC including geology and hydrogeology;
- Section 4: Review of the Draft Policy;
- Section 5: Hydrological assessment of Draft Policy; and
- Section 6: Conclusions and recommendations.

2 Royal Borough of Kensington and Chelsea

2.1 General information

The RBKC extends from the River Thames at Chelsea Embankment in the south, past Hyde Park which lies to the east, up to Kensal Green in the north. RBKC is busy and densely populated, and is home to a wide spectrum of socio-economic groups. The following statistics summarise key facts and figures (Arup, 2008):

- Land area: 12.13 square kilometres
- Population: 196,000
- Population density: 16,175 per square kilometre (*densest in the UK*)
- Average size of household: 2 per property
- Proportion of private households: 78%
- Proportion of social housing tenants on housing benefit: 66%

- Proportion of incomes above £60k: 16.6% (*highest in the UK*)
- Proportion of school children eligible for free school meals: 40%
- Number of listed buildings: more than 4,000
- Proportion of land designated as Conservation Areas: 70%

The building stock within the Borough is as diverse as its population. Across the Borough are areas occupied by terraced properties, semi-detached properties, detached properties, garden squares, and blocks of flats. In some parts of the Borough, buildings are close to their neighbours, and in other areas individual properties are set within larger grounds. Some districts include a greater proportion of commercial buildings, including office blocks. Much of the older building stock in the Borough is of traditional masonry-type construction, although the newer, multi-storey structures and apartment blocks are typically built of reinforced concrete.

2.2 Soil and Geology

The sequence of soil and rock layers that lie beneath the topsoil in the Borough are, shallowest first:

- Superficial geology:
 - Made Ground, including archaeological remnants in places
 - River Terrace Deposits, Alluvium, Brickearth (*largely absent in the northern portion of the Borough*)
- Solid geology:
 - London Clay
 - Lambeth Group (comprising mixed layers of clays and sands)
 - Thanet Formation (a dense sand)
 - Chalk rock.

Of most relevance to basement developments in the Borough are the soil layers that lie nearest to the ground surface. Figure 1 provides a distribution of shallow soils. The near-surface geology across the Borough can generally be separated into two distinct zones:

- In the north, the near-surface outcropping strata is the **London Clay**;
- In the south, the near-surface outcropping strata is mainly the **River Terrace Deposits (RTDs)**. This gravelly soil is underlain by London Clay.

There is much local natural variation in the details of the geology across the Borough, however the north/south divide between the clay and gravel is the key geological feature most relevant to the discussion of subterranean development in the Borough (Figure 1). This is because the majority of basement applications are for locations either in the Notting Hill area dominated by London Clay or RTDs or the Chelsea area dominated by RTDs (Arup, 2008).

Below the London Clay, the deeper geological strata that lie beneath the Borough are essentially similar across the whole district, albeit with some local variations in elevation. Due to the thickness of the London Clay (50m to 70m) and its

relative impermeability, deeper strata are of little relevance to residential basement developments in the Borough and are not considered further.

Appendix A provides greater detail of the geological conditions in the Borough.

2.3 Hydrogeology

The groundwater regime across the Borough is generally characterised by two distinct aquifers (“water tables”), which are separated by the essentially impermeable London Clay:

- The Upper Aquifer is perched water sitting in gravelly soils that overlie the London Clay; and
- The Lower Aquifer is found within the sandy soils and chalk located deep below the London Clay. In the Borough, the Lower Aquifer is confined by the London Clay.

For basements in the Borough, the **Upper Aquifer** is more relevant. This is the water table that would be encountered when digging a basement, and against which the basement has to be designed structurally, and waterproofed for. It is also the groundwater table in which, potentially, flow patterns could be interrupted or altered by the presence of basements. In general, the “natural” trend in groundwater flow directions within the Upper Aquifer would originally have tended to be towards the historic waterways (Counter’s Creek and the Westbourne) that previously formed the main tributaries of the Thames in this part of London. In the southern part of the Borough, groundwater flow is directly to the River Thames. While, the urbanisation of London has likely altered these natural trends, the alluvial deposits associated with the historic waterways still act to draw groundwater. The Westbourne is now contained within the Ranelagh sewer, and the Creek is carried within the Counter’s Creek sewer (Arup, 2008).

In the northern portion of the Borough, where the RTDs are not present, the Upper Aquifer is not present, as the shallow London Clay is relatively impermeable. In this part of the Borough, groundwater is initially found much deeper and is associated with the confined Lower Aquifer.

An important element of the hydrogeologic cycle is the interaction between rainfall and urban leakage (from sewers and water mains) and the underlying aquifers. This interaction is known as recharge when aquifers are replenished from surface waters. Generally rainfall is deposited on the ground surface where it either infiltrates into the soil or runs-off as a surface flow. Once rainwater infiltrates it can either be evaporated, be transpired by plants or recharge underlying aquifers. If no aquifer is present, or if the soil is too impermeable to allow hydraulic communication to the aquifer then there is no significant recharge.

With respect to drainage conditions, the RTDs are relatively permeable materials and will allow water movement. Thus rain water and urban leakage will move vertically and horizontally through the RTDs and perch on the underlying London Clay. The London Clay is relatively impermeable and will only allow limited water movement. Thus water does not move vertically through the clay to deeper strata or aquifers.

2.4 Typical residential basement projects

Basement projects are highly variable and can range in size, depth, percentage of garden coverage, and location. Basements can be constructed beneath the building, front garden, back garden, or some combination of all three. The majority of residential basement projects are located within the Notting Hill and Chelsea areas (Arup, 2008).

3 Review of Draft Policy

3.1 Policy Background

The RBKC Council (Council) as part of a review of its 2010 Core Strategy is developing a bespoke policy on basements. The policy is currently in its second draft and the draft document is currently in a six week public consultation period. The public consultation period is scheduled to end on 2 May 2013.

As a result of an increase in basement construction projects in the Borough, a Supplementary Planning Document (SPD) was enacted in 2009. In December 2010, the Council adopted its Core Strategy. This Core Strategy, which included elements of the earlier Borough policy, also included the following:

- Policy on “New Buildings, Extensions, and Modifications to Existing Buildings” (Part (g) of Policy CL2);
- Policy on “Climate Change” (Part (c) of Policy CE1;
- Policy on “Flooding” (Part a) of Policy CE2); and
- Policy on “Heritage Assets – Conservation Areas and Historic Spaces” (Policy CL3).

The SPD, while predating the Core Strategy is still considered to be a relevant policy document (ABA, 2013). However the SPD is also under review and amendments are planned for later in 2013.

Appendix B provides a review of the London Plan as well as summaries of the review reports by Arup in 2008 and Alan Baxter and Associates (ABA) in 2013. Both review reports were prepared on behalf of the Borough. The Arup 2008 report was an initial scoping study which highlighted key issues relevant to subterranean developments. The ABA 2013 report provided an evaluation of the key issues documented in Arup’s 2008 report in addition to other issues raised between 2008 and 2013. The London Plan and review reports provide context and background for the current draft version of the basement policy.

The draft policy is separated into two sections: 1) Reasoned Justification and 2) Proposed Policy. The Reasoned Justification section provides supporting text to the actual policy. The following provides Arup’s review and comment of sections relevant to potential hydrological and hydrogeological impacts. Appendix C provides a brief summary of the draft policy.

3.2 Proposed policy

The proposed policy provides specific criteria to be adhered to (with some exceptions for large, comprehensively planned developments). From a

hydrological and hydrogeological perspective, most of the criteria are reasonable. However, of note, is the following criterion “a” of the policy:

“Basement development should not exceed 50% of each garden of the property”

Arup Comment: After reviewing the supporting documentation provided in the proposed policy and the ABA 2013 report, it is unclear what the technical basis for the 50% limitation is. The only information which provides any quantitative limitation of basement size is the rules of thumb provided in the ABA 2013 report. However, as indicated in Appendix B, Section B4.5, no technical basis has been provided for the ABA’s rules of thumb.

From a planning perspective, it is understandable that the Borough would want to create a policy which ensures that the soil infiltration capacity throughout the Borough is not reduced beyond a critical level. Any specified limitation in basement size should take into account cumulative impacts and not just the impacts to the project site area. However, a policy which is not grounded with sound scientific reasoning may be easily challenged. This would undermine the effect of putting such a policy into place. In addition, instituting such a limitation may further preclude engineering designs which improve local hydrologic conditions. An example is described in Section 4.2 below.

3.3 Reasoned justification

Section 34.3.59 states that at least half of a garden should remain basement-free to enable flexibility in planting, including major trees. This will also allow water to drain through to the Upper Aquifer. This section references the ABA 2013 report.

Arup Comment: The ABA report provides only “rules of thumb” on percentage of garden to be retained to allow sufficient drainage. No data from a detailed technical evaluation or source of the “rules of thumb” have been provided. Thus it is unclear how technically relevant the 50% limitation is. Under certain conditions, this limitation may be overly conservative, and in some conditions this limitation may not be conservative enough.

Section 34.3.60 states that the unexcavated garden area needs to be in a single area. If to the rear, it should normally be at the end of garden where it will be adjacent to similar areas in other plots allowing for better drainage.

Arup Comment: Policy related to basements should be based on technically appropriate requirements (such as surface water storage and drainage requirements) and should require assessment to include neighbouring conditions in addition to site-specific conditions. While Section 34.3.60 may generally be reasonable, it does not address the need to evaluate proposals with respect to conditions at adjacent plots, groundwater flow, and surface water storage and drainage.

Section 34.3.71 states that Policy CE 2 of the Core Strategy requires surface water run-off to be managed as close to its source as possible. Sustainable Urban Drainage Schemes (SUDs) related to basement developments should include a minimum of one metre of a suitably drained permeable soil above any basement. Other measures may also be required.

Arup Comment: Run-off and sewer discharge volumes can be significantly impacted by basement projects. However engineering designs can be used to improve drainage conditions thereby reducing run-off and sewer impacts. Therefore, this is an area where the Borough has an opportunity to put into place policies which serve to improve overall conditions. This would be of particular benefit in the northern portion of the Borough where the outcropped London Clay creates poor drainage conditions which are subject to significant discharges to the combined sewer system.

Section 34.3.74 states that ground and hydrological conditions must be thoroughly investigated. The developer must demonstrate that the works can be carried out whilst safeguarding structural integrity.

Arup Comment: This is an important requirement for any successful development plan. Further, the policy should explicitly state that competent professionals be employed to perform these evaluations and investigations.

4 Hydrologic Evaluation of Potential Impacts

4.1 Potential groundwater impacts

The potential impact of subterranean developments on groundwater levels and groundwater flows is a subject of concern for many people in the Borough. The scale and extent of such impacts will be specific to a particular site and its immediate surroundings, and will depend on a combination of factors acting together such as soil types, the nature of existing and proposed development and the existing ground water flow patterns in and around the area of the site.

In general, where the Upper Aquifer is present (such as in the southern portion of the Borough) groundwater will usually find an alternative route when it meets an underground obstruction and static groundwater will re-distribute itself. It is therefore likely that, in general, the effect of a new basement on groundwater levels will be relatively small. However both groundwater levels and groundwater flows are factors that basement design engineers and contractors should take into account in their work, as each affects the technical design and practical construction of a basement. In addition, the impacts of temporary works must be assessed including how the project transitions from temporary to permanent works (i.e. what temporary alterations are left in place).

Excavations in the RTDs which do not completely penetrate the RTDs are not likely to adversely affect groundwater flow. Since the RTDs are dominated by gravels, the material has a relatively large capacity for flow due to its high relative permeability. Thus groundwater will have the ability to move around and below the remaining RTD volume. Figure 2 is adapted from an evaluation performed by Arup in 2010 for the Borough of Camden. Figure 2 illustrates conceptual impacts of basements on groundwater flow (Arup, 2010). In the extreme case where successive basements cut off the RTDs (such as in a line of houses) groundwater migration will likely move through the surrounding network of RTDs located beneath streets (Arup, 2008). Clearly cumulative impacts of multiple developments can increase the risk of adversely altering hydrogeologic conditions.

In the northern portion of the Borough where the Upper Aquifer is not present, groundwater flow and mounding impacts will not be an issue. However

basements founded in clay should consider potential issue of hydraulic uplift due to pore pressure within the London Clay. Also hydrological impacts related to soil infiltration capacity will be an issue and is discussed in Section 4.2.

Groundwater can potentially flow out of RTDs over the top of the London Clay causing local flooding. This condition is generally constrained to the Notting Hill area where outcropped RTDs are adjacent to outcropped London Clay. There is the potential that basement developments could exacerbate this flooding risk. Thus basement developments in this area should evaluate potential impacts of this phenomenon.

Regardless of the anticipated low impacts of groundwater, an assessment of potential impacts should be performed by competent and experienced professionals as part of the planning application. The assessment should conform to guidance provided by the Borough. Potential risks found in the assessment should be properly mitigated and managed.

At a minimum, a detailed assessment should evaluate the following:

- Existing groundwater and hydrogeologic conditions (“baseline” condition);
- Potential post-development groundwater and hydrogeologic conditions;
- Risk to nearby and adjacent structures due to groundwater level and pore pressure increases;
- Risk of flooding and/or water ingress to the basement structure and nearby/adjacent structures;
- Impacts of pore pressures on the basement structure; and
- Impacts of local conditions such as sloped topography, flood risks associated with the River Thames, and site-specific geology and hydrogeology.

Further details on an approach to properly assess the hydrogeologic environment are beyond the scope of this review. The ABA 2013 report provides a discussion of assessment methodologies. In addition, Arup developed a Basement Impact Assessment methodology for the Borough of Camden which could be adapted to the RBKC (Arup, 2010).

4.2 Qualitative hydrological assessment of proposed policy

The main hydrological issue related to basement developments is the potential impact to storm water management and drainage. This section evaluates whether there is a relationship between storm water management and the proposed policy to limit residential basements to ‘*not exceed 50% of each garden of the property*’

It is understood that the ‘50% rule’ has been proposed by RBKC based on a wide range of factors including advice given by ABA. The advice given has been extracted below from their Residential Basement Study Report, dated March 2013.

Where the near surface subsoil is gravel, water that falls on gardens will be held in the topsoil and by the vegetation and then drain through to the gravel and into the Upper Aquifer. When a basement is built, water falling on the topsoil above it needs to be channelled or directed to an unbuilt area

of the garden, so that it can enter the ground and find its way into the gravel and down into the Upper Aquifer. As a rule of thumb, 25% of the garden area is likely to be sufficient to enable this to happen. On this basis a new basement should not occupy more than 75% of the area of a garden.

Where the near surface subsoil is clay, water that falls on gardens will be held in the topsoil and by the vegetation. It will drain through the topsoil until it reaches the clay, which will act as a barrier to the vertical flow of water. Some water will be absorbed by the clay surface. On sites with falls, water will gradually flow down any slope within the topsoil. The topsoil and ground will be waterlogged until the water evaporates or is absorbed by the underlying clay and dries out. To enable the clay subsoil to absorb some of the rainwater, a proportion of the garden should not be built under and on clay sites this might be between 25% and 50%. On this basis a new basement should not occupy more than between 50% and 75% of the area of a garden on clay sites.

For the purposes of this report, we are not considering basements in Flood Zone 2 and 3 as defined by the Environment Agency. Basements in these locations within RBKC are subject to Policy CE2.

4.2.1 Description of a Typical Site

For the purposes of this qualitative hydrological evaluation, a typical site will be used as the basis of assessment and discussion. Figure 3 illustrates the typical layout and section of a site being considered under Policy CL7. This can be described as follows:

- Narrow plot with the residential house at the front and a back garden.
- The boundary of the site follows the extent of the back garden.
- The proposal to be considered would typically involve a basement extension to the property below the garden area.
- The garden is considered to be a lawn or landscaped area that enables natural infiltration of surface water.
- Projects are located either on London Clay or on RTDs. These are the main geotechnical conditions for the Borough as described in Section 2.2.
- Neighbouring properties have similar scale gardens to the side of the site and there is a garden backing onto the site.
- Neighbouring properties have sufficient drainage typical to the area.
- The back garden of the site does not drain to the local public surface water sewer. The only means of discharge is through natural infiltration.

4.2.2 Storm Water Management Objectives

In order to frame the discussion on storm water management, a set of objectives have been defined that generally summarise the current policy on how storm water should be managed.

- Surface water shall be managed to ensure that it is managed on site in line with building regulations and so neighbouring properties are not adversely affected.
- The natural groundwater regime should not be adversely affected. Groundwater shall be managed so that it is retained within the site and so neighbouring properties are not adversely affected by an increase in sub surface or surface flows of groundwater.
- Sustainable Urban Drainage Systems (SUDS) should be implemented where appropriate.

For the purposes of this report, we are assuming that off-site discharges to the public storm sewer are not acceptable because water authorities do not tend to accept land drainage into the combined sewer. Hence, we have not defined an objective for an off-site discharge rate. In reality however, some gardens will be connected to the surface water sewer system (likely to be old combined storm and foul sewers). Properties that do have a positive drainage connection will benefit because they will not have to rely solely on infiltration to discharge surface water.

4.2.3 Storm water Management Discussion

There are a wide range of factors that clearly support a limitation on the extent of basement construction across the Borough. However, when storm water management is considered in isolation, there are engineering solutions that can be considered to create the situation where a basement could be extended beyond the 50% rule and still comply with the objectives mentioned above in section 4.2.2. Large sites that are positioned in the RTDs for example, may be able to facilitate a larger basement extent and still manage to adequately infiltrate surface water. Whereas small sites located on London Clay will find it more difficult to encroach beyond the 50% rule and manage storm water through infiltration alone. Sites located on London Clay will likely discharge to the public sewer system. Therefore, engineering solutions will need to regulate storm water flows from the site such that the combined sewers are not overburdened during storm events.

To demonstrate this, we have illustrated three scenarios on Figure 4. The scenarios are as follows:

Scenario 1 – No basement – this is a typical small site as defined above in Section 3, the garden allows natural infiltration of surface water into the ground.

Scenario 2 – 50% rule – a typical small site where Policy CL7 is implemented. A permeable soil storage zone is provided above the basement slab to provide attenuation and a soakaway is provided in the garden area connected to the storage zone to enable a discharge to ground.

Scenario 3 – Maximum Basement Extents – This scenario illustrates a basement extension where the constraints imposed by storm drainage are at the limits of design. Again attenuation is provided in a permeable soil zone above the basement slab and a soakaway is provided in the garden space. However, there is only enough space to position a soakaway within the setback required by building control for properties and the site boundary.

Note that the three generalised scenarios (i.e. are not specific to where the Upper Aquifer is present or where the London Clay outcrops to the surface). Thus these

scenarios assume that engineering measures are appropriate and suitable for the conditions in and around the site.

The above scenarios help to illustrate the following:

- Engineering methods are available which can be used to maintain or improve storm water storage and infiltration capacity within the site curtilage.
- A simple limitation of 50% may preclude innovative methods which improve overall drainage conditions within the Borough.
- There is a limit to the amount of garden which can be developed into a basement. To establish this limit, site specific assessment will be needed, a general rule cannot be applied.

4.2.4 Design Approach

Regardless of the basement size an applicant should undertake a site specific assessment to demonstrate that storm water can be managed appropriately. The following points describe the design methodology that should typically be followed in order to generate a storm water management strategy that meets the objectives described in Section 4.2.2. Please note that this methodology would be modified if the site is in Flood Zone 2 and 3 as defined by the Environment Agency. In this case, a formal Flood Risk Assessment (FRA) would be required in line with National Planning Policy Framework (2012).

Data collection

- Assess the existing site to obtain information on the existing storm water drainage system.
- Identify the local ground conditions in order to evaluate potential infiltration rates. This is likely to require physical site investigation work.
- Understand the ground levels to be in a position to look at overland flow routes.
- Obtain rainfall data for the site and make allowances for climate change in line with best practice guidance.
- If there is evidence of an offsite discharge route into a public sewer, consult with the local water authority on the allowable discharge rate.

Design

- Assess the performance of the existing drainage system and the potential to infiltrate on site. Identify existing infiltration rates and if appropriate, existing discharge rates to the local storm sewer. Then undertake a water balance across the site.
- Develop a drainage strategy that mimics the above discharge rates using appropriate form of SUDS where possible.
- Undertake an assessment of extreme rainfall events up to the 1 in 100 year annual probability event plus a factor for climate change to ensure surface water is managed on site and does not adversely affect neighbouring properties.

- If appropriate, gain agreement from the local water authority on the drainage strategy.

5 Conclusions and Recommendations

The Royal Borough of Kensington and Chelsea (RBKC) have produced a 2nd draft Basement Policy which is currently in its public consultation period (until 2 May 2013). Arup has performed a review of this policy focussing only on the potential hydrological and hydrogeological impacts of the proposed policy. This report was funded by a commission from Basement Force. As part of the defined scope of work and agreement between Arup and Force Foundation Ltd, Arup has performed an impartial and unbiased assessment of the proposed RBKC policy and supporting documentation.

There is only one significant groundwater system of relevance to the proposed policy, the perched water known as the Upper Aquifer. The Upper Aquifer is located within the RTDs and is perched on top of the underlying London Clay. The Upper Aquifer is only present in the southern portion of the Borough where the River Terrace Deposits are also present. The northern portion of the Borough is dominated by outcropping and largely impermeable London Clay. There is no Upper Aquifer in areas where the London Clay outcrops at the ground surface. There are other soil types present to a lesser extent within the Borough such as Alluvium and Brickearth. The near-surface geology across the Borough can generally be separated into two distinct zones:

- In the north, the near-surface soil layer is the **London Clay**;
- In the south, the near-surface soil layer is mainly the **River Terrace Deposits (RTDs)**. This gravelly soil is underlain by London Clay.

The current policy on basements is part of the Borough's Core Strategy and includes the 2009 Supplementary Planning Document (SPD). The SPD will likely be revised later in 2013 and will include guidance on performing Basement Impact Assessments. The 2nd draft of the revised Basement Policy will eventually be included within the Borough's Core Strategy. The basis for the policy is derived from reviews performed by Arup in 2008 and ABA in 2013. The policy contains two sections: 1) reasoned justification; and 2) policy criteria.

Generally the 2nd draft of the policy provides a reasonable policy to be implemented with respect to potential hydrological and hydrogeological impacts both locally and across the Borough. The most significant comments are related to the criterion which limits basement size to 50% of the garden plot where the remaining garden area is continuous. Based on our review, we have drawn the following conclusions:

- It is difficult to define a direct relationship between the 50% rule and the constraints posed from a hydrological perspective. Each site will have unique characteristics which would need thorough investigation if there is a desire to implement a bespoke drainage solution.
- Policy requirements should be tied to technically appropriate requirements which directly allow adequate groundwater flow, surface water, and drainage at the site and neighbouring areas. Generalised requirements may be useful,

but should not limit good engineering practices to improve hydrologic and hydrogeologic conditions in the Borough.

- From a planning perspective, we can see merit in applying a standard rule that takes a conservative approach which ensures that the soil infiltration capacity throughout the Borough is not reduced beyond a critical level. However, it needs to be soundly based and technically justifiable.
- A policy which is not grounded with sound scientific reasoning may be easily challenged. This would undermine the effect of putting such a policy into place.
- Instituting such limitations may further preclude engineering designs which improve local hydrologic conditions.
- If there is a desire to extend beyond the 50% rule, the size of the site and the existing ground conditions have will a significant impact on the potential to implement engineering solutions.
- There may be some sites where the 50% rule is not conservative enough or where existing/adjacent developments could be impacted detrimentally. For example, a site where existing conditions do not provide adequate surface water storage, such as sites in outcropped London Clay areas. In these areas, engineering designs will be required to satisfy storage and discharge requirements for any basement proposals.
- In order to improve the sensitivity of existing policy with regards to hydrological performance of basement extensions, specific objectives such as those included in Section 4.2.2 could be adopted into the policy that require engineering solutions which are overall more effective and allow greater design flexibility. These engineering solutions should be subject to detailed assessment when discussed with statutory bodies such as Thames Water or the Environment Agency depending on location and details of proposal prior to planning approval.

We recommend that the policy be revised such that applications which improve the overall hydrology and hydrogeology and satisfy all other planning constraints be considered for approval regardless of project size limitations. In addition, there should be an onus on the owner/developer that the development does not have an adverse impact on surface infiltration or groundwater conditions. Assessments should always consider the cumulative impacts to neighbouring areas.

6 References

- [1] Alan Baxter and Associates (ABA), (2013). Royal Borough of Kensington and Chelsea, Residential Basement Study Report. Dated March 2013.
- [2] Arup (2008). Royal Borough of Kensington & Chelsea, RBCK Town Planning Policy on Subterranean Development, Phase 1 – Scoping Study. Dated 13 November 2008.
- [3] Arup (2010). Camden geological, hydrogeological and hydrological study, Guidance for subterranean development. Dated 18 November 2010.
- [4] The Royal Borough of Kensington and Chelsea (RBKC), (2013). Basements, Second Draft Policy for Public Consultation, Partial Review of the Core Strategy. Dated March 2013.

Appendix A

Geology and Hydrogeology

Appendix A provides further information on the geology and hydrogeology of the RBKC. Figure 1 illustrates the distribution of shallow strata across the Borough

A1 Southern part of the Borough: River Terrace Deposits

The geology of the south is dominated by prehistoric flood plains of the ‘ancestral’ River Thames. It is blanketed by the River Terrace Deposits (RTDs) which comprise a complex mixture of sands, silts, gravels and clayey soils. These deposits were deposited during major flood events and would be partly eroded by the river before being buried by the next flood event. The RTDs in the borough are comprised by several different types of gravels known as the Boyne Hill Gravel, Hackney Gravel, Kempton Park Gravel, Lynch Hill Gravel, and Taplow Gravel (Figure 1). In engineering terms, the River Terrace Deposits comprise a large-grained non-cohesive soil. This unit is permeable to water and groundwater located within the RTDs is known as the upper-aquifer. Groundwater tends to remain and migrate through the RTDs without percolating deeper through the largely impermeable London Clay.

A2 Northern part of the Borough: London Clay

Only in the northern portion of the Borough, does the London Clay outcrop at the surface, however the London Clay underlies the full footprint of the Borough. In the southern area, the London Clay is covered over by a blanket of River Terrace Deposits that is sufficiently thick in places such that excavations for basements would not encounter the London Clay.

London Clay is a brown or grey, firm, silty clay. The London Clay developed from a fine sediment that was gradually deposited on the seabed of a tropical sea that covered much of southeastern England between 55 and 52 million years ago. Although nowadays it is present at or near the ground surface, the London Clay has, during its geological history, been buried hundreds of metres below the ground surface. This overmantle material has since been completely eroded. However, its great weight acted to compress and stiffen the London Clay (it is termed an “overconsolidated clay”). In engineering terms, the London Clay is a fine-grained, cohesive soil. The design of foundations in the London Clay is governed by its cohesive, rather than frictional, properties.

The London Clay has a relatively low permeability to ground water. In essence, the London Clay presents an almost complete barrier to groundwater. In practice, this barrier is not complete: groundwater can permeate slowly through intact London Clay, and it can move more quickly along any fissures and cracks in the clay, and through localised zones that contain a higher proportion of silts or sands. However, even in the presence of fissures or silty zones, ground water flow rates in the London Clay are significantly slower than in the River Terrace Deposits.

The clayey minerals in the London Clay make it responsive chemically to water. Moisture present within the clay can bond chemically with particles of clay minerals, and cause the particles to swell. The well-known phenomenon of the seasonal swelling (in wet winters) and shrinkage (in dry summers) of London Clay is caused by this chemical bonding.

A3 Local shallow variations: Alluvium and Brickearth

Alluvium is very recently-formed soil (recent in geological time) made from sediments deposited by a river and is typically made up of a variety of materials, including fine particles of silt and clay and larger particles of sand and gravel. Alluvium is present in a narrow strip along the eastern edge of the Borough, corresponding to the course of the old river Westbourne. Alluvium is also present at Chelsea Creek, at the confluence of the old Counter's Creek with the Thames.

Brickearth was formed from a wind-blown dust that was deposited across Europe under extremely cold, dry conditions. It comprises very fine sand, silt and clay particles that are small enough to be carried on the wind. In RBKC, the brickearth is a River Brickearth ("Langley Silt"): the soil particles were picked up and carried by a river from wherever the wind originally deposited them, and then re-deposited by the river at their current location. The thickness of the brickearth layer in the Borough varies from 2m to 4 m. As its name suggests, brickearth was traditionally used to make bricks. It is not unusual to find that this commercially useful soil has been quarried and replaced with backfill.

A4 Upper Aquifer Groundwater Boundaries

Groundwater flow within the upper aquifer historically would have been bounded by the Counter Creek and Westbourne waterways on the west and east, respectively, and the River Thames in the South. The northern boundary is generally defined by the topographic rise in the area of Kensal Green. With the urbanisation of London, Counter's Creek is now carried within the Counter's Creek sewer and the Westbourne is now contained within the Ranelagh sewer (Arup, 2008). Thus groundwater boundaries between the eastern and western catchments are not as clearly defined.

A5 The Lower Aquifer

The Lower Aquifer of the London basin is now mainly present at depth within the Thanet Sand and Chalk. It is an important water resource for London and it is a protected aquifer. From the early C18th, abstraction from deep wells for drinking water and industrial uses caused the groundwater level in the Lower Aquifer to be artificially depressed. This trend continued until the mid-C20th, when industrial demand for water started to dwindle. From the mid-1960s, as the rate of abstraction of water needed by industry in London continued to fall, the groundwater level in the Lower Aquifer began to rise. In principle, if left unchecked, the rising groundwater could regain its natural, pre-industrial levels. In some parts of London, the pre-industrial water level was above ground surface (that is, artesian conditions). In the late 1990s, a long-term programme of dewatering called the "GARDIT" scheme was established by Thames Water Ltd in association with the Environment Agency in order to remedy the problem. This has started to arrest and reverse the trend of increasing groundwater levels in the Lower Aquifer. Environment Agency (EA) data issued in June 2007 indicates that the groundwater level in the Lower Aquifer across the Borough is being controlled by the ongoing de-watering scheme.

Appendix B

Background of Policy Development

B1 Borough Policy

The RBKC Council (Council) as part of a review of its 2010 Core Strategy is developing a bespoke policy on basements. The policy is currently in its second draft and the draft document is currently in a six week public consultation period. The public consultation period is scheduled to end on 2 May 2013.

The RBKC has previously had in place a Unitary Development Policy (UDP), which includes several policies related to subterranean development. As a result of an increase in basement construction projects in the Borough, a Supplementary Planning Document (SPD) was enacted in 2009. In December 2010, the Council adopted its Core Strategy. This Core Strategy, which included elements of the UDP, also included the following:

- Policy on “New Buildings, Extensions, and Modifications to Existing Buildings” (Part (g) of Policy CL2);
- Policy on “Climate Change” (Part (c) of Policy CE1);
- Policy on “Flooding” (Part a) of Policy CE2); and
- Policy on “Heritage Assets – Conservation Areas and Historic Spaces” (Policy CL3).

The SPD, while predating the Core Strategy is still considered to be a relevant policy document (ABA, 2013).

B2 The London Plan

The London Plan¹ updated in July 2011 has relevant policies related to basement construction as the design potentially impacts urban drainage and hydrogeology as summarised below:

Policy 3.5: Quality and design of housing developments

Developments should be of the highest quality and should enhance the quality of local places. The Plan supports development plan-led presumptions against development on back-gardens where locally justified by a sound local evidence base. Local approaches to the surfacing of front gardens should include the need for surfaces to be permeable, subject to permitted land development rights²

Policy 5.11: Green roofs and development site environs

Major development³ proposals should be designed to include roof, wall and site planting, especially green roofs and walls where feasible, to deliver as many of the following objectives as possible:

¹ The London Plan refers to PPS25, which has now been superseded by the NPPF. However, technical guidance contained within PPS25 has been carried through to the NPPF.

² Environment Agency, Communities and Local Government (CLG) (2009). Guidance on Permeable Surfacing of Front Gardens.

³ Major developments are defined as: where 10 or more dwellings are to be constructed (or if number not given, area is more than 0.5hectares); where the floor space will be 1,000sq m or more for all other uses

- Sustainable urban drainage;
- Adaptation to climate change (i.e. aiding cooling); and
- Mitigation of climate change (i.e. aiding energy efficiency).

Policy 5.12: Flood risk management

The Mayor will work with all relevant agencies including the Environment Agency (EA) to address current and future flood issues and minimise risks in a sustainable and cost effective way.

Development proposals must comply with a Flood Risk Assessment (FRA) and management requirements set out in PPS25 over the lifetime of the development and have regard to measures proposed in Thames Estuary 2100 and Catchment Flood Management Plans.

Developments which are required to pass the PPS25 Exception Test will need to address flood resilient design and emergency planning by demonstrating that:

- The development will remain safe and operational under flood conditions;
- A strategy of either safe evacuation and/ or safely remaining in the building is followed under flood conditions;
- Key services including electricity, water etc. will continue to be provided under flood conditions; and
- Buildings are designed for quick recovery following a flood.

Developments adjacent to flood defences will be required to protect the integrity of existing flood defences and wherever possible should aim to be set back from the banks of watercourses and those defences to allow their management, maintenance and upgrading to be undertaken in a sustainable and cost effective way.

Policy 5.13: Sustainable drainage

A Development should utilise sustainable drainage systems (SUDS) unless there are practical reasons for not doing so, and should aim to achieve Greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy:

- Store rainwater for later use;
- Use infiltration techniques, such as porous surfaces in non-clay areas;
- Attenuate rainwater in ponds or open water features for gradual release;
- Attenuate rainwater by storing in tanks or sealed water features for gradual release;
- Discharge rainwater direct to a watercourse;
- Discharge rainwater to a surface water sewer/drain; and
- Discharge rainwater to the combined sewer.

Drainage should be designed and implemented in ways that deliver other policy objectives of this Plan, including water use efficiency and quality, biodiversity, amenity and recreation.

Policy 5.14: Water quality and wastewater infrastructure

The Mayor will work in partnership with the boroughs, appropriate agencies within London and adjoining local planning authorities to:

- Ensure that London has adequate and appropriate wastewater infrastructure to meet the requirements placed upon it by population growth and climate change
- Protect and improve water quality having regard to the Thames River Basin Management Plan.

Development proposals must ensure that adequate wastewater infrastructure capacity is available in tandem with development. Proposals that would benefit water quality, the delivery of the policies in this Plan and of the Thames River Basin Management Plan should be supported while those with adverse impacts should be refused.

Development proposals to upgrade London's sewage (including sludge) treatment capacity should be supported provided they utilise best available techniques and energy capture.

The development of the Thames Tideway Sewer Tunnels to address London's combined sewer overflows should be supported in principle.

B3 Arup 2008 scoping study

As part of the overall policy development, Arup provided a scoping study report in 2008 to the Council (Arup, 2008). The purpose of the scoping study was: *“to identify and assess the likely importance of factors and issues considered as being potentially relevant to policies on subterranean development in the Borough.”*

Arup's 2008 Scoping Study report provided eight conclusions summarised as follows:

1. Subterranean development in the Borough cannot be viewed in isolation from other planning issues, such as the protection of heritage structures, archaeology, and conservation areas; environmental protection; requirements for sustainable development; the need for provision of additional housing; the risk of flooding *etc.*
2. Previous policies dealt explicitly with subterranean developments in the Borough, but only in conservation areas (which occupy almost 70% of Borough). Thus revised policy should be comprehensive for the entire Borough.
3. The potential impact of subterranean developments on groundwater levels and groundwater flows is a subject of concern for many people in the Borough. The scale and extent of such impacts will be site-specific, and will depend on a combination of factors acting together such as soil types, and the existing ground water flow patterns. In general, where the sub-surface conditions are not unusually adverse, groundwater will usually find an alternative route when it meets an underground obstruction and static groundwater will re-distribute itself. It is therefore likely that, in general, the effect of a new basement on groundwater levels will be relatively small. However both groundwater levels and groundwater flows are factors that

basement design engineers and contractors should take into account in their work, as each affects the technical design and practical construction of a basement.

4. Concerns about the potential for structural damage if subterranean development works are not undertaken properly were also prominent in the public consultation. Subterranean development in a dense urban environment, especially basements built under existing structures, is significantly more challenging. In particular, there is a potential risk of damage to neighbouring structures and infrastructure if excessive ground movements occur around an ill-planned or poorly-implemented subterranean development. On the other hand, subterranean developments have been successfully achieved in London and elsewhere over many years. In general these successful projects have been undertaken by experienced, competent teams who recognised the potential hazards and mitigated against them.
5. Information gathered during the 2008 Arup study suggests that it is perhaps appropriate that different, stricter planning requirements and safeguards be considered for subterranean developments than for other types of building works in the Borough. If such a distinction were to be adopted, then the Borough should require that the “works” are performed by competent and experienced professionals. The “works” should be taken as encompassing the full spectrum of activities from project inception to completion. All stages in the works process are important and should be undertaken competently.
6. Design issues for subterranean developments under semi-detached or terraced properties that directly share a common party wall with neighbour(s) differ in several ways from fully-detached properties that are not close to other structures. There are engineering design issues specific to subterranean developments alongside such party walls; in addition to owner-occupiers’ natural concerns about noise, vibration and general inconvenience when their neighbours “have the builders in.” These engineering challenges can be successfully addressed and mitigated in practice, and would not necessarily preclude a subterranean development under a non-detached property, but it is appropriate for the Council to consider whether explicit additional policy provisions should be made.
7. The potential long-term impact of a subterranean development abutting a shared party wall tends to be more significant in clayey soils than in gravelly or sandy soils. The associated engineering challenges can be addressed and mitigated in practice, and should not necessarily preclude a subterranean development under these conditions, but it is appropriate for the Council to consider whether explicit additional provisions should be made in the planning requirements.
8. It should be understood that geologic maps are not necessarily definitive. Geologists have inferred mapped boundaries from available field data, and they gradually amend the boundary lines as more field data becomes available to them. If geologic maps are to be used for planning decisions, then it is recommended that decisions allow the latest available geological information to also be used.

B4 2013 ABA review study

In 2012, Alan Baxter and Associates (ABA) performed a review study on behalf of the Council (ABA, 2012). The ABA study built upon work initially performed by Arup in 2008 and included additional evaluations such as:

- The effect of subterranean developments on gardens, landscaped areas and trees, and the overall character and nature of the Borough green space; and
- Sustainability considerations and energy use.

Specifically relevant to this hydrologic review of the proposed RBKC policy, ABA provided a review and recommendations for, among other things:

- Groundwater issues;
- Flooding;
- Water ingress;
- Landscaping and trees; and
- Site coverage by basements built outside the footprint of a house.

The following summarises ABA's review and recommendations related to these relevant topics.

B4.1 Groundwater issues

Groundwater issues are only considered to be significant within the perched water of the Upper Aquifer where river terrace deposits (RTDs) consisting of gravels overlie the largely impermeable London Clay. ABA suggests that flow is significant only in sloped areas within the Borough such as in the Notting Hill area. Further, the presence of two historical water courses, Counter's Creek and River Westbourne, may create localised groundwater flow areas. Thus additional considerations should be given in these areas. In addition, houses located near the River Thames may need consideration with respect to tidal impacts from the River.

While groundwater levels are rising in the Lower Chalk Aquifer, groundwater levels within the Upper Aquifer are reasonably stable and only fluctuate as a result of season. In areas where the London Clay outcrops to the surface, there is generally no Upper Aquifer.

Basements constructed in clay should consider the potential for hydraulic uplift and should be designed to resist hydraulic forces.

Excavations in the RTDs which do not completely penetrate the RTDs are not likely to adversely affect groundwater flow. This is due to the ability of groundwater to move around and below the remaining RTD volume. In areas where the RTDs are completely penetrated or where successive numbers of basements are anticipated (such as in long terraces of houses) then an evaluation may be necessary to assess the impact to the Upper Aquifer. Engineering measures are available, such as engineered drainage, which can be used to mitigate potential issues.

Adding basements in areas where basements or lowered ground levels are present should be carefully evaluated. Basement constructions could increase local groundwater conditions causing nearby structures to become wet or impacting surface structures. Engineering solutions can be employed in the basement design to mitigate these issues.

In some areas within the Borough excessively perched groundwater can flow out of the soil onto the London Clay causing localised flooding. This condition is generally constrained to the Notting Hill area. Thus basement developments in this area should evaluate potential impacts of this phenomenon.

B4.2 Flooding

Flood risk areas in the Borough have been defined with respect to flooding from the River Thames, stormwater, and groundwater. Basements designed in these established areas should include assessments of flood risk. In addition, since the Borough sewer system is a combined storm water and sewer system, the potential exists for foul water to impact basements. Designs should include measures to reduce surface water discharges and methods to prevent water ingress.

B4.3 Water ingress

Basement construction projects should include designs to prohibit water ingress into the basement. Currently within the Borough there are a number of existing basements which experience flooding in the area of Counters Creek area due to overloaded drains.

B4.4 Landscaping and trees

All trees within conservation areas and trees with Tree Preservation Orders (TPOs) are protected and so must be considered during the design phase. In addition, British Standard 5837 (Trees in relation to design, demolition and construction) indicates that basements should not be constructed within a distance of twelve times the tree trunk diameter.

Arboriculturists should be consulted for projects where trees exist or will be planted to ensure that conditions are appropriate for tree health. The final ground level and permeability should be kept as close as feasible to the existing conditions.

Basements which extend under trees or Root Protection Areas (RPAs) should not be permitted, even if technically feasible.

RBKC policy states that all new basements should include a 1m minimum of soil cover over the slab. This soil cover should allow for adequate drainage as well as allow for normal garden cultivation.

A minimum portion of a garden should be retained to “ensure that trees can be planted to replace existing species that die and also to provide a hydraulic connection between the surface and the perched water table...to maintain the current status quo with the groundwater regime”.

B4.5 Site coverage by basements built outside the footprint of a house

The basement size has to be limited outside the building footprint to:

- a) Allow natural drainage from gardens by maintaining connectivity between the surface and Upper Aquifer or allowing rain water to infiltrate into the soil.
- b) Allow for large tree and shrub planting to maintain the character of Borough green space.

Policy CE2 of the Borough's Core Strategy requires the use of Sustainable Urban Drainage Systems (SUDS) or other methods to reduce the volume and intensity of run-off entering the combined sewer system. Thus water should be attenuated to less than or equivalent to existing conditions. Good practice in basement design should adopt these methods as a design principle.

In areas where the Upper Aquifer is present (i.e. where RTDs are present) water falling onto a property should find its way to the Upper Aquifer. ABA suggests a "rule of thumb" that a new basement should not occupy more than 75% of the garden area.

In areas where the London Clay outcrops at the ground surface, water falling onto the surface should be managed. ABA suggests that a new basement should occupy between 50 and 75% of the garden area. They reason that water which falls onto a site will be retained within the topsoil until it drains to the top of the clay where the clay will act as a vertical barrier. While some water will be absorbed by the clay, most will remain within the topsoil where it will either evaporate, be transpired, or flow to a drainage system (where a significant slope exists).

Groundwater conditions should be managed such that an increase in subsurface or surface water flows from groundwater does not adversely impact neighbouring properties.

Appendix C

Summary of Proposed Policy

C1 Summary of Proposed “Reasoned Justification”

The “Reasoned Justification” section provides supporting text to the actual policy and is intended to be included into the Core Strategy as Section 3 of Chapter 34. Section 3 within Chapter 34 includes the following:

- Section 34.3.56 provides a basement definition;
- Section 34.3.57 provides a rationale for needing a basement policy (i.e. the significant rise in basement applications between 2010 and 2012);
- Section 34.3.58 provides a rationale to restrict basement size to reduce construction impacts to neighbours;
- Section 34.3.59 states that at least half of a garden should remain basement-free to enable flexibility in planting, including major trees. This will also allow water to drain through to the Upper Aquifer.
- Section 34.3.60 states that the unexcavated area of the garden needs to be a single area, adjacent to similar areas in other plots, allowing for better drainage and planting. This section also provides a rationale that protection against inappropriate development is supported in the London Plan.
- Section 34.3.61 states that the depth of basement developments should not allow for future subdivisions of the basement.
- Section 34.3.62 states that basements should be limited to a single storey to avoid greater structural risks and complexities.
- Section 34.3.63 states that greater coverage and depth may be allowed for larger comprehensively planned sites.
- Section 34.3.64 states that trees must not be placed in long term risk and that works shall conform to BS 5837 2012 and the Council’s Trees and Development SPD. Full tree surveys and tree protection proposals must be included in applications for both construction and developed phases.
- Section 34.3.65 states that the significance of heritage assets must be identified. The significance may go beyond appearance and preclude the ability to further develop the property.
- Section 34.3.66 states that basements beneath the garden of a listed building or structure are not allowed except on larger sites where there is no harm to the building’s structure and the basement is substantially separated from the listed building.
- Section 34.3.67 states that basements should preserve or enhance the character of the conservation area. Externally visible elements such as light wells and railings have a bearing on the character.
- Section 34.3.68 states that archaeological remains must not be threatened by a development, either directly or indirectly.
- Section 34.3.69 states that impact of basements on non-designated heritage assets must be assessed on their merits to avoid any harm to their significance.

- Section 34.3.70 states that the visual impact from visible elements must be minimised. Light pollution to neighbours should be avoided. Externally visible elements should not be allowed in areas where they are not already an acceptable feature of the local streetscape.
- Section 34.3.71 states that Policy CE 2 of the Core Strategy requires surface water run-off to be managed as close to its source as possible. SUDs related to basement developments should include a minimum of one metre of suitably drained permeable soil above any basement. Other measures may also be required.
- Section 34.3.72 provides carbon emission requirements to meet a “very good” rating using the BREEAM methodology.
- Section 34.3.73 states that construction related nuisances (traffic, noise, dust, and vibration) should be kept to acceptable levels.
- Section 34.3.74 states that the ground and hydrological conditions must be thoroughly investigated. The developer must demonstrate that the works can be carried out whilst safeguarding structural integrity.
- Section 34.3.75 states that all basements should be fitted with a ‘positive pumped device’ or technological equivalent. In addition, a ‘non-return valve’ is not acceptable.
- Section 34.3.76 states that applicants are strongly advised to discuss proposals with neighbours and others affected, commence party wall negotiations, and discuss with the Council before a planning application submittal. This includes discussion of traffic plans.

C2 Proposed Policy

The proposed basement policy will become Policy CL7 of the Core Strategy. The policy is stated exactly as follows:

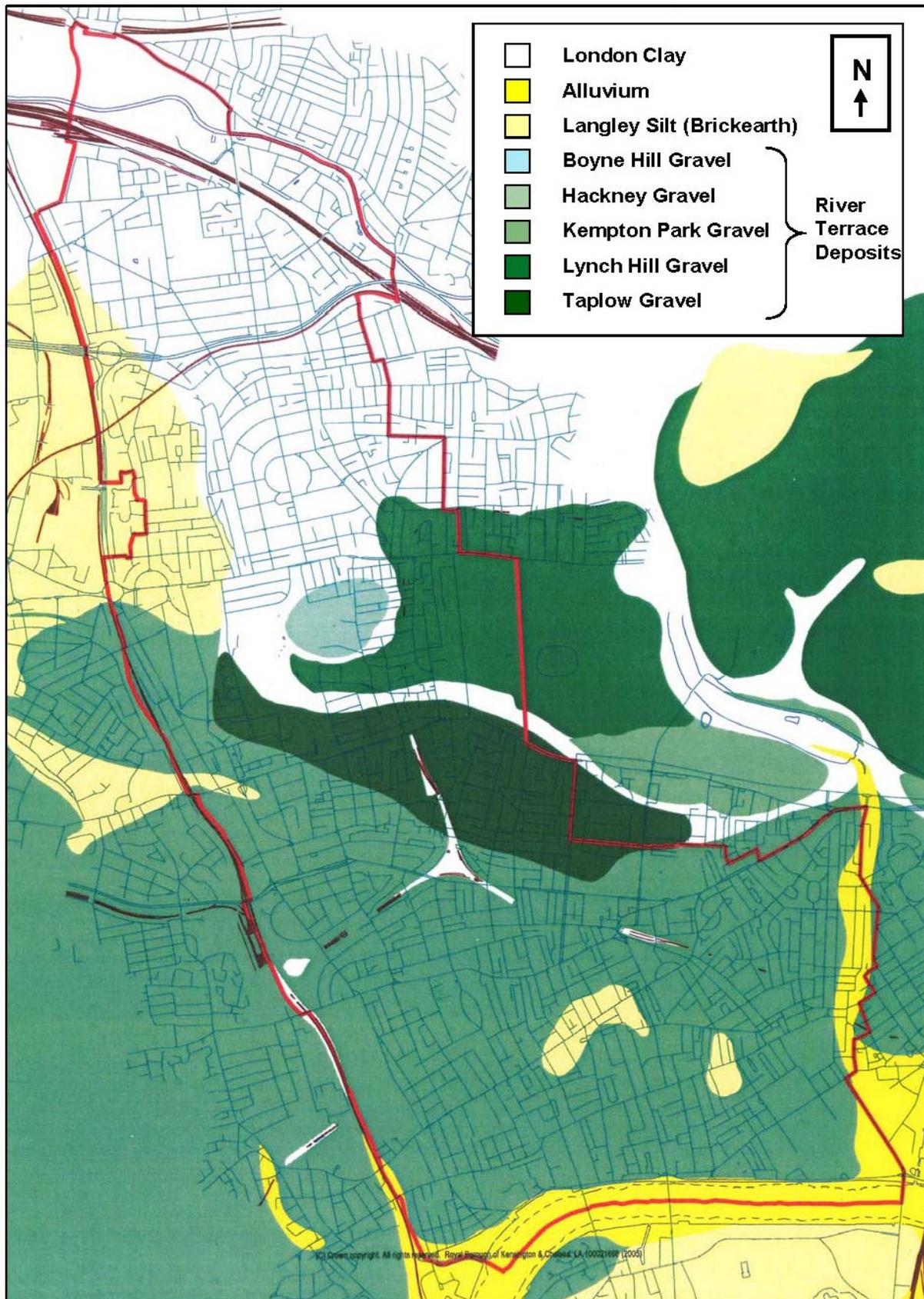
“All aspects of basement development must be designed, constructed and completed to the highest standard and quality. All basement development should meet the following criteria except that, on large comprehensively planned developments the requirements in a. and b. below may be varied depending on site circumstances. Basement development should:

- a. not exceed 50% of each garden of the property. The unaffected garden must be in a single area and where relevant should form a continuous area with other neighbouring gardens;
- b. not comprise more than one basement storey nor add a further basement floor to an existing basement;
- c. not cause loss, damage or long term threat to trees of townscape or amenity value;
- d. not cause harm to heritage assets⁴;

⁴ A building, monument, site, place, area or landscape identified as having a degree of significance meriting consideration in planning decisions, because of its heritage interest (as defined in the NPPF).

- e. not involve excavation underneath a listed building (including pavement vaults) or any garden of a listed building except for gardens on large sites where the basement would be substantially separate from the listed building and would not involve extensive modification to the foundation of the listed building;
- f. not introduce light wells and railings to the front or side of the property where these are not already an acceptable feature of the local streetscape;
- g. maintain and take opportunities to improve the character and appearance of the building, garden or wider area, with external elements such as light wells, roof lights, plant and means of escape being sensitively designed and discreetly sited;
- h. include a sustainable urban drainage scheme, including a minimum of one metre of permeable soil above any part of the basement beneath a garden;
- i. ensure that any new building which includes a basement, and any existing dwelling or commercial property associated with new basement development, is adapted to a high level of performance in respect of energy, waste and water to be verified at pre-assessment stage and after construction has been completed.
- j. ensure that traffic and construction activity do not harm road safety, significantly increase traffic congestion, nor place unreasonable inconvenience on the day to day life of those living and working nearby;
- k. ensure that construction impacts such as noise, vibration and dust are kept to a reasonable level for the duration of the works;
- l. be designed to safeguard the structural stability of the application building and nearby buildings;
- m. be protected from sewer flooding through the installation of a suitable pumped device.

A specific policy requirement for basements is also contained in Policy CE2, Flooding.”



Map produced by the Royal Borough of Kensington and Chelsea Planning Services Department using GGP 13/11/2006

NOT TO SCALE
ORIGINAL SCALE 1:25,000

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draft	250413	MC	GC	PM
Issue	Date	By	Chkd	Appd

Client
Force Foundations Ltd.

Job Title
Royal Borough of Kensington and Chelsea Basement Policy

Drawing Title
SHALLOW SOIL STRATA WHICH UNDERLIE GROUND SURFACE

Scale at A3		
Plot ID		
Drawing Status		
ISSUE		
Job No	Drawing No	Issue
230276	Figure 1	1

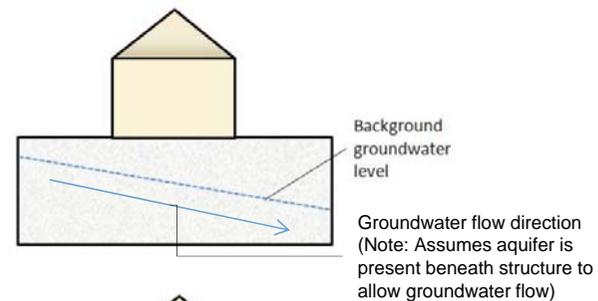
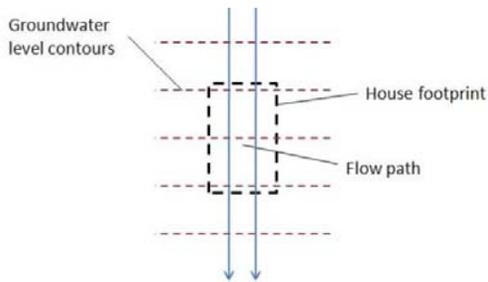
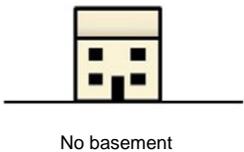
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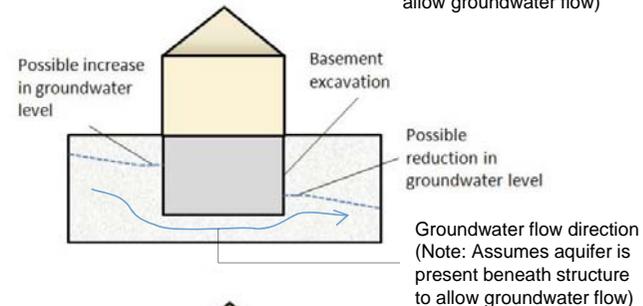
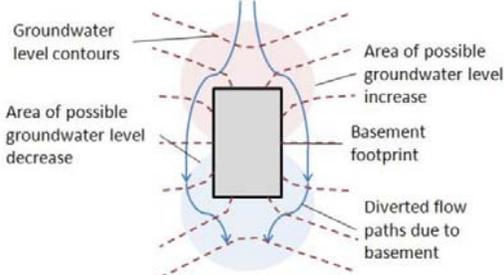
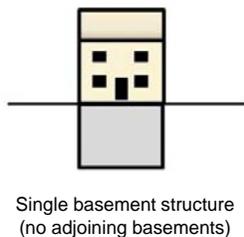
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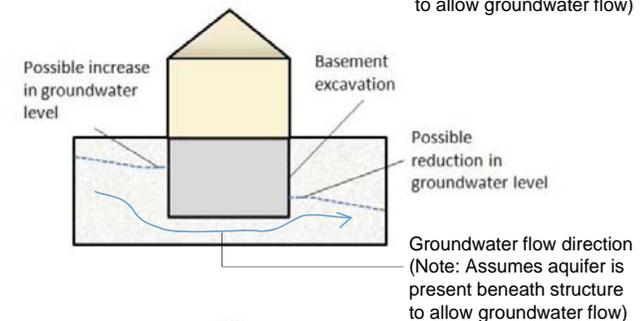
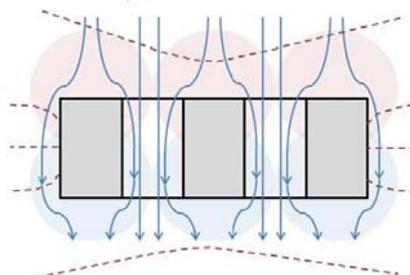
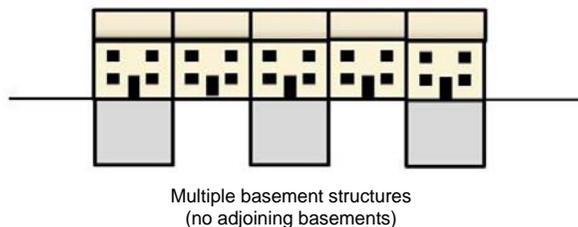
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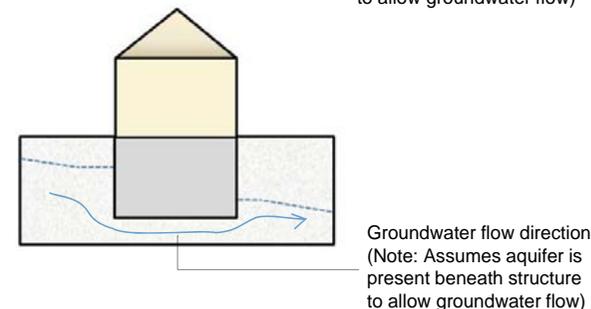
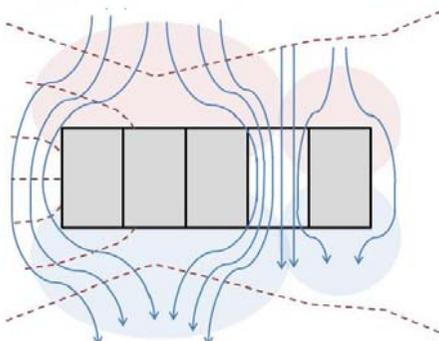
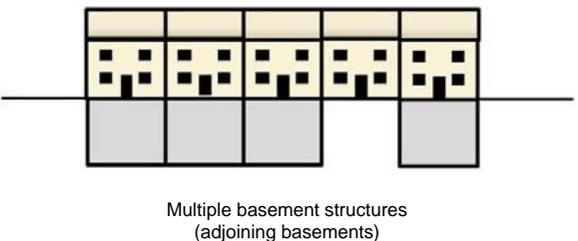
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Adapted from Figure 23, Arup (2008). Camden geological, hydrogeological and hydrological study, Guidance for Subterranean development. Dated 18 November 2010.

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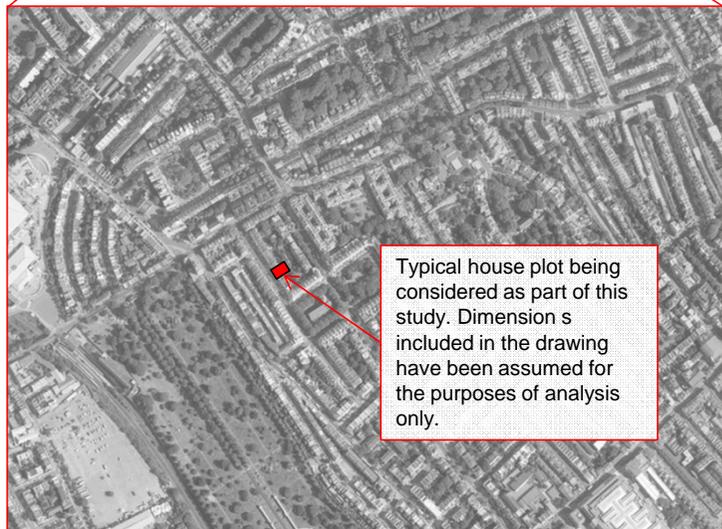
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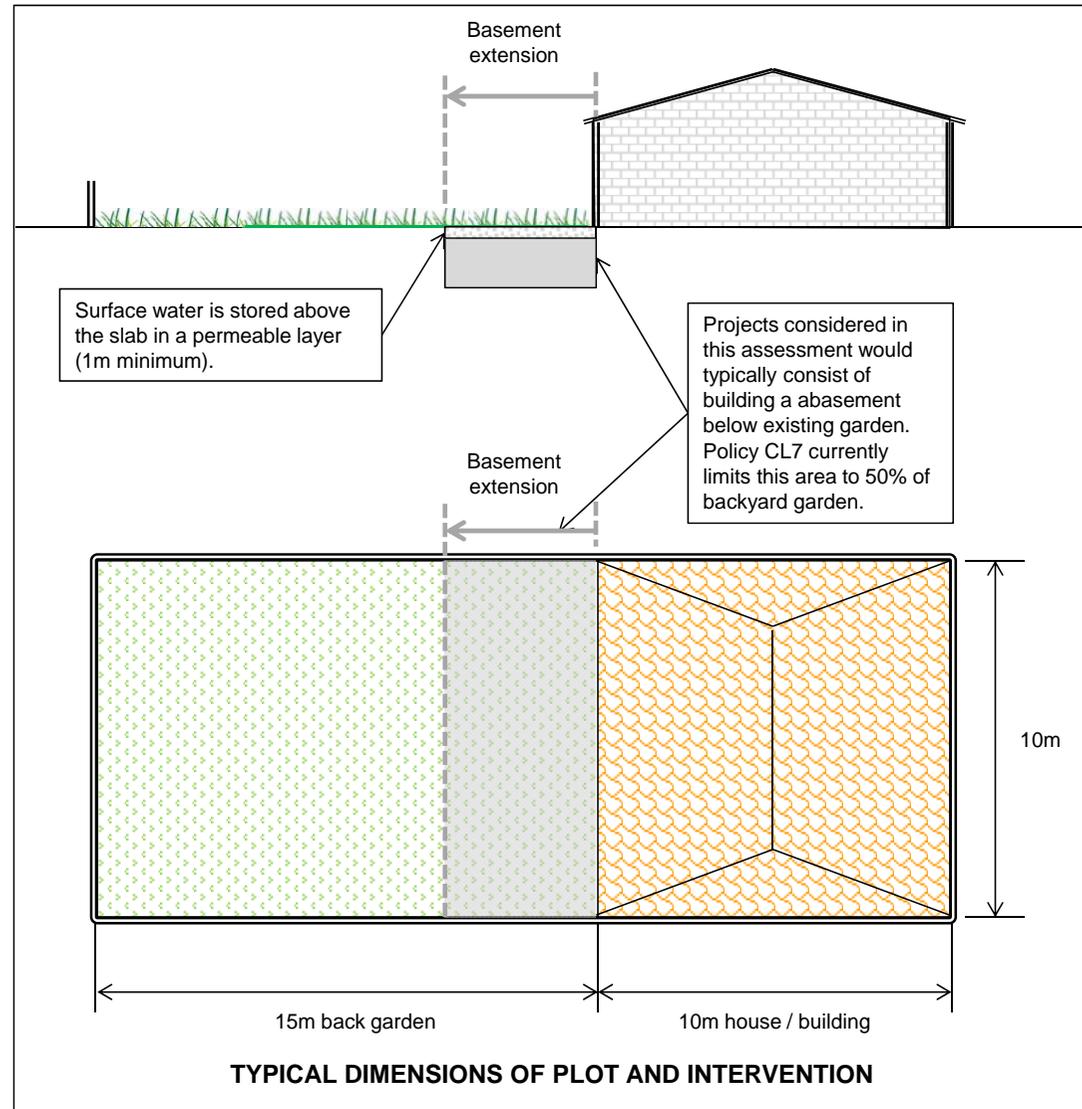
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215579	Figure 2	1



Typical house plot being considered as part of this study. Dimension s included in the drawing have been assumed for the purposes of analysis only.



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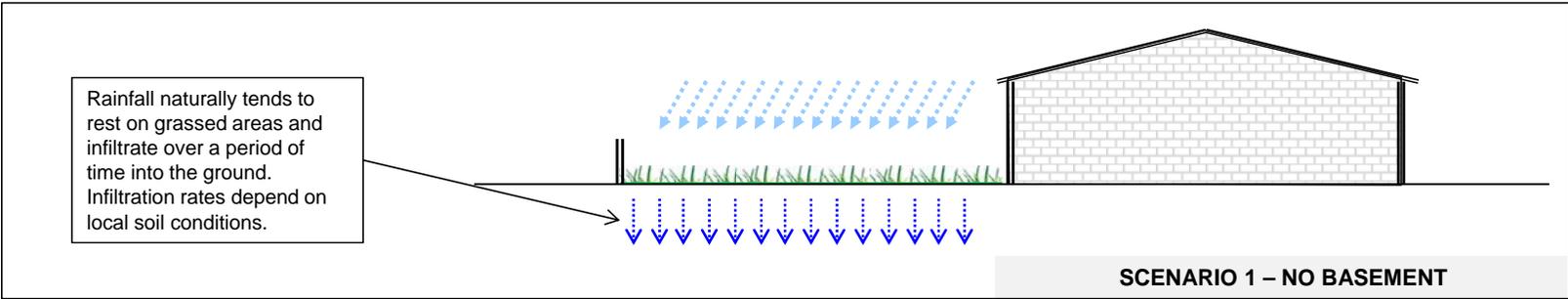
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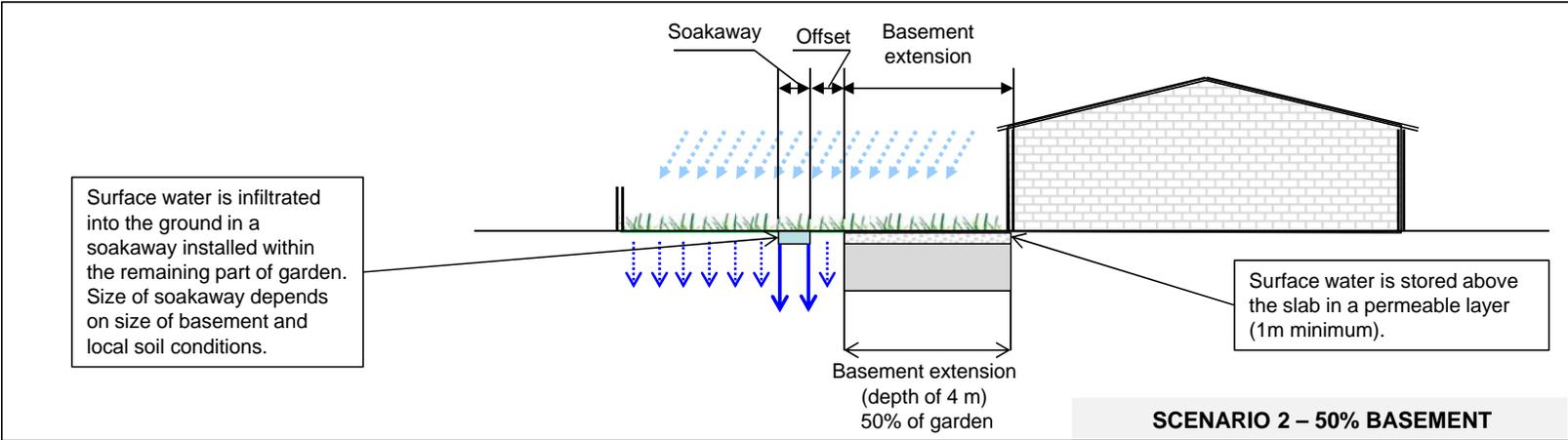
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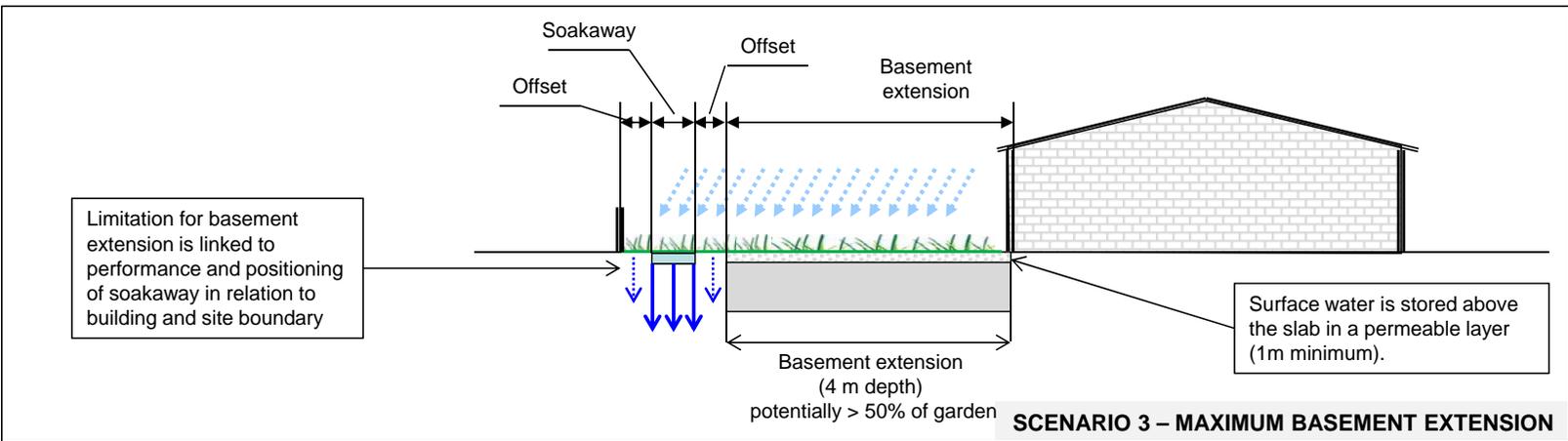


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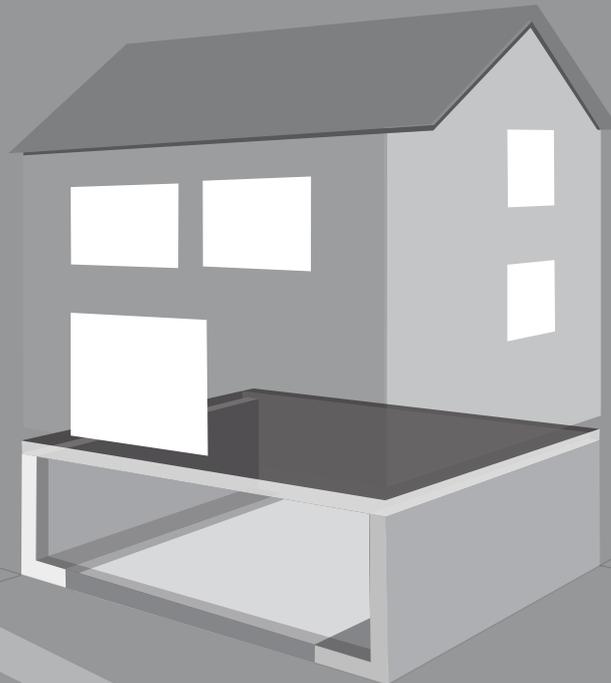
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Drawing Title
EXAMPLE STORMWATER MANAGEMENT STRATEGY

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ASUC | Guidelines on
SAFE AND EFFICIENT BASEMENT
CONSTRUCTION DIRECTLY BELOW
OR NEAR TO EXISTING STRUCTURES



ASUC

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ASUC

ASUC is an independent trade association formed by a number of leading contractors to promote professional and technical competence within the underpinning industry. Members offer a comprehensive range of subsidence repair techniques, engineered foundation and retrofit basement construction solutions. It publishes a number of useful documents on underpinning and related activities and a comprehensive directory of members all of which are freely available to download via the website. ASUC members offer 10 or 12 year, depending on the nature of the works, insurance backed latent defects guarantees.

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GUIDELINES ON SAFE AND EFFICIENT BASEMENT CONSTRUCTION DIRECTLY BELOW OR NEAR TO EXISTING STRUCTURES

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HEALTH AND SAFETY EXECUTIVE (HSE) FORWARD TO ASUC BASEMENT GUIDELINES 2ND EDITION

Building a basement directly below or next to an existing building has become a popular means to extend a house. However, compared to a conventional above ground extension, basement construction is more complicated both in the design and preparation work needed, and in how the work needs to be carried out. This creates significant safety risks for workers and the public.

Any failure to correctly plan or conduct the work can lead to ground movement in excavations and the collapse of existing buildings onto workers and people nearby. Costly repair work or demolition of the original building, and sometimes adjacent properties, may also result.

I welcome that the industry has recognised that management and control of the risks involved in basement construction has frequently been poor and has put significant effort into producing this advice to assist all of those involved.

The Health and Safety Executive was consulted in the production of the sensible and proportionate guidance covering health and safety issues that form a large part of this publication. I would like to thank everyone from industry who has contributed and ask that the advice it contains is now turned into action.

Peter Baker



1 EXECUTIVE SUMMARY

- 1.1 There has been a marked increase in the number of domestic basement construction projects undertaken below or near to existing structures. There has also been a significant rise in the number of health and safety incidents linked to basement construction including fatalities, injuries, and damage to buildings, as well as negative impact on people not involved in the works, notably local residents.
- 1.2 The Association of Specialist Underpinning Contractors (ASUC) is publishing these guidelines to improve the safety and efficiency of basement construction below or near to existing structures and to reduce negative impact on others, especially people living or working near to basement construction projects.
- 1.3 This document will consider basements which are built either directly below the footprint of an existing structure or where the basement will structurally undermine the foundations of an existing structure.
- 1.4 The objective of these guidelines is to enable clients, designers, engineers and others involved in basement construction projects below or near to existing structures to instruct safe and efficient work.
- 1.5 Basement construction is a complex form of building involving geotechnical, hydrological, structural and civil engineering, health and safety and waterproofing expertise that even those with significant construction experience may not have encountered previously.
- 1.6 The single leading principle throughout these guidelines is the absolute priority that health and safety has over all other aspects of a project.
- 1.7 Temporary works (support to existing buildings and to the ground around excavations) is critical and is often overlooked or addressed superficially.
- 1.8 Basement works can be classified as cellar extensions, single level basements or multi-level basements.
- 1.9 The main construction techniques used to build the supporting and retaining walls of basement structures are underpinning and piling.
 - 1.9.1 There are two main types of underpinning: mass concrete underpinning and reinforced concrete (RC) underpinning.
 - a. Mass concrete underpins provide vertical support underneath existing walls but usually require an inner RC retaining wall to provide additional horizontal strength as on their own they are usually unable to retain the ground outside the basement.
 - b. RC underpins can usually provide vertical support underneath existing walls and retain the ground outside the basement without an additional inner retaining wall.
 - 1.9.2 In basement construction two main types of piles are used to build retaining walls; reinforced concrete (RC) bored piles and steel sheet piles.
 - a. RC bored pile walls are constructed of either a series of side by side columns formed vertically in the ground (called contiguous piles)

with a small gap between each pile or by a series of overlapping soft and hard piles (called secant piles). For secant piles the soft piles are constructed first followed by the hard piles. The bores for the hard pile should penetrate the edges of the initial soft piles resulting in the piled structure being a continuous wall with no gaps between any of the piles.

- b. Steel sheet piles are constructed using thin interlocking sheets of steel which are driven into the ground. The edges of the steel sheets can be welded to limit water ingress.
- 1.10 Building below the groundwater level adds complication and cost to any basement construction project. There are several methods for building below the groundwater level. Careful consideration of the most appropriate method will be needed for each project where groundwater is encountered.
 - 1.11 Temporary works in basement construction are used to support excavations, existing structures, partially built new structures, equipment and plant, and site facilities. Support for excavations and existing structures are critical. Temporary works for excavations covers support for individual underpin excavations and for the whole site during the main bulk excavation after the basement walls have been built.
 - 1.12 Temporary works should be designed by a suitably qualified and experienced engineer called the Temporary Works Engineer (TWE). In addition to the TWE a named person must be appointed to coordinate temporary works. The person responsible for this function is often known as the Temporary Works Coordinator (TWC) and may be a dedicated person on larger sites or, on smaller sites, be the site manager or another manager. The TWC must be suitably qualified and experienced for that project.
 - 1.13 Basements are generally constructed from the ground level down (the existing floor at the lowest level is removed and the basement is built from the ground level downwards) or by tunnelling underneath the existing floor which remains in place.
 - 1.14 Ground level down construction can be completed from the bottom up (the ground is excavated and the ground slab is constructed before the upper level slabs) or from the top down (the upper level slab is constructed before the main excavation and construction of the ground slab).
 - 1.15 The most appropriate construction method must be assessed on a case by case basis.
 - 1.16 Basement construction can have a significant negative impact on people not involved with the work, especially local residents. The main negative impacts come from:
 - Damage to surrounding buildings and structures
 - Noise, vibration and dust
 - Traffic
 - 1.17 There will always be some negative impact but this should be minimised through early engagement, imaginative planning and considerate execution.
-

1.18 In addition to health and safety, which is the single most important priority, the other main factors to consider when choosing the construction technique and sequence are:

- Architectural design
- Occupier's desire to live in the existing building during the works
- Structure and condition of the existing building
- Party wall matters
- Soils and geology
- Hydrogeology especially groundwater which, if present, has a significant impact
- Surrounding structures
- Site access
- Impact on others

1.19 Basement construction under or near existing structures has a high level of construction hazard. Collapse of excavations, collapse of existing buildings and falls from height, including into excavations, are the three safety hazards most likely to lead to death or serious injury. Exposure to asbestos and to dust containing silica are the two health hazards most likely to cause death or serious injury.

1.20 Business clients, designers and contractors all have extensive duties under the Construction (Design and Management) Regulations 2015 (CDM 2015). Domestic clients also have duties under CDM 2015 but these are usually automatically transferred to the principal contractor or contractor or by arrangement to the principal designer.

1.21 Designers and contractors must manage risk by:

- Assessing hazards
- Avoiding risk where possible preferably by design
- Reducing risk throughout by selection of suitable control measures
- Developing safe methods and systems of work
- Managing and monitoring risk throughout
- Using only suitably trained and experienced personnel
- Having effective emergency plans and procedures

1.22 Only responsible, competent and experienced designers and contractors should be appointed.

- 1.23 Waterproofing ensures the usefulness of a basement and preserves the integrity of the structure. Waterproofing risk is assessed from low to high where a basement with any part below the permanent groundwater level is classified as high risk. All basements should be constructed to cope with groundwater levels up to the full retained height of the basement.
- 1.24 There are three types of basement waterproofing:
- Barrier protection using watertight membranes installed during or after construction
 - Structurally integral protection where the material that forms the structure is waterproof
 - Drained cavity protection where most of the water is held out by the structure but any water that penetrates is drained away and usually removed by pumps in a collection sump below the basement floor or, less commonly, flows away from the site by gravity
- 1.25 In high risk situations protection using more than one type of waterproofing can be considered. This is known as combined protection.
- 1.26 The basement structure and waterproofing should be considered as a whole rather than being considered separately.
- 1.27 Most problems with basement waterproofing are due to poor design or installation rather than with the failure of a waterproofing product. Manufacturers' warranties and guarantees for waterproofing are usually limited and will generally only cover a fault with the product and will not cover design or installation. In addition manufacturer's warranties and guarantees will usually only cover repair of the faulty product and will usually not cover the work needed to identify or uncover the repair or pay for any consequential losses such as the cost of repair of any damage caused by the water ingress.
- 1.28 Comprehensive first party indemnity latent defects insurance provides the best form of waterproofing guarantee cover. The waterproofing cover for the ASUC Basement Insurance Guarantee (BIG) is this type of guarantee.
- 1.29 The composition of the project team will vary by project. Apart from the Client the project team can include a Principal Designer (a health and safety requirement under CDM 2015), Architect, Structural or Design Engineer, Temporary Works Engineer, Temporary Works Coordinator, Principal Contractor, Party Wall Surveyor, Quantity Surveyor and others. A Structural or Design Engineer will always be needed in the design team. The Structural or Design Engineer can be an independent consultant or can be retained by a design and build contractor.
- 1.30 Basement construction work can be procured by any of the four main procurement methods: traditional design then tender, design and build, management or integrated. There is no single best method and they each have advantages and disadvantages. It is important to choose a form of procurement that incentivises safe and efficient construction.

- 1.31 The right insurances should be in place to protect all parties. The main insurances are: Professional Indemnity (PI), Employer's Liability (EL), Public Liability (PL), Contractors All Risks (CAR), non-negligent for third party property (JCT 21.2.1 / 6.2.4 / 6.5.1 insurance), existing buildings, and non-negligent damage to the client's property. Insurance cover for basement construction projects is complex and advice from experienced parties should usually be sought.
- 1.32 Guarantees for building work, like many guarantees, often promise much but deliver little. The detailed wording for each guarantee must be understood in order to know the true level of protection. The main types of guarantees are: company, product, insurance backed, latent defects insurance and indemnity latent defects insurance. The best protection is provided by a comprehensive indemnity latent defects insurance underwritten by a financially strong insurance company. The ASUC Basement Insurance Guarantee (BIG) is this type of indemnity latent defects insurance guarantee.
- 1.33 Basement developments will probably be the most complex structural work that a domestic property owner will undertake. The main areas for a domestic owner to consider at the outset are:
- Property rights and rights of access
 - Planning permission
 - Existing trees and their protection
 - Listed building consent if relevant
 - Building regulations particularly for fire safety and ventilation
 - Health and safety
 - Impact on neighbours
 - The economics of the project
 - The option of living in the building during the construction work
 - Party wall matters
 - Legal responsibilities and liabilities
 - Choosing whether to instruct an architect or other designers, or to move forward with a design and build contractor
- 1.34 Basement construction is complex and should only be undertaken by suitably qualified and experienced teams.
- 1.35 Instructing an ASUC member to undertake a project should increase confidence that the work will be completed safely and efficiently.

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2 INTRODUCTION

2.1 Outline

In the last decade there has been a significant increase in the number of domestic basement construction projects undertaken below or near to existing structures. This has been driven by increasing property prices especially in London and advances in waterproofing technology.

Alongside this increase in domestic basement construction activity there have been several health and safety problems including fatalities, injuries, building collapses, partial building collapses and other damage to structures. There has also been significant negative impact on people not involved in the works notably residents living near basement construction projects. The Association of Specialist Underpinning Contractors (ASUC) is publishing these guidelines in order to support efforts to:

- Improve the safety and efficiency of basement construction below or near to existing structures
- Reduce negative impact on others, especially people living or working near to basement construction projects

2.2 Scope

Basements vary greatly in size, construction, complexity and end use. This document will consider basements which are built either:

- Directly below the footprint of an existing structure, or
- Where the construction will structurally undermine the foundations of an existing structure

In general the document is written with domestic basements in mind but the techniques and issues considered are largely the same for commercial basements.

Standard construction methods can generally be used on open sites where the ground can be excavated back at a shallow angle without affecting the foundations of surrounding buildings. This type of open site basement will not be considered further.

2.3 Objective

The objective of these guidelines is to enable clients, designers, engineers and others involved in basement construction projects below or near to existing structures to instruct or oversee safe and efficient work.

2.4 Overview

Basement construction is a complex form of building and involves a combination of geotechnical, hydrological, structural and civil engineering, health and safety and waterproofing expertise. Even those with many years of above ground construction experience may not have faced the issues that are met when building a basement underneath or near to the foundations of existing structures.

This document is intended to be used as an outline guide by property owners, developers, architects, engineers, contractors, quantity surveyors, building surveyors and anyone else involved in basement construction. It should provide a basis of understanding of the techniques used in basement construction and assist the informed consideration of the many factors and issues faced when considering a basement construction project. A summary of these factors is given below.

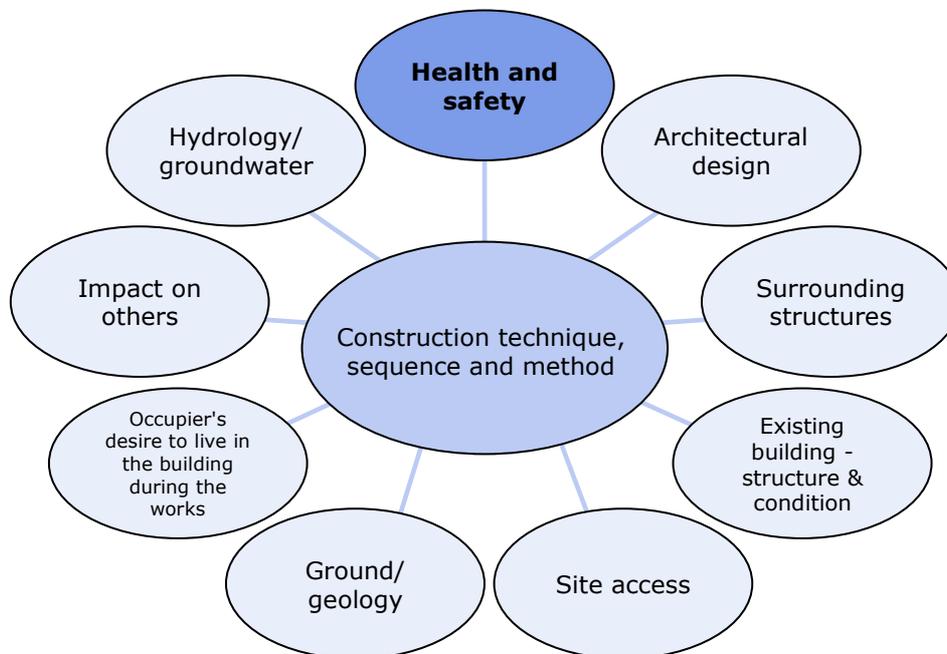


Fig 1. Main factors for consideration

The guide has been set out in a logical order however all of the areas covered are heavily interrelated so, to some extent, they cannot be viewed in isolation and need to be considered collectively.

This guideline is not intended as a code of practice, set of design rules, engineering specification or building code and does not provide a single answer for the complex question of what design or method is best for any individual project.

2.5 Health and safety

The single leading principle throughout these guidelines is the absolute priority that health and safety has over all other aspects of a project. Health and safety is covered in a dedicated section later in the document but at all times it is a fundamental consideration.

2.6 Key points

The key points in the guideline are:

- Health and Safety is paramount
- Temporary works (support to existing buildings and to the ground around excavations) are critical and is often overlooked or addressed superficially
- Environmental consequences and any negative impact on others should be minimised
- A well-managed safe project will be an efficient project - this applies both to the design and to the implementation of the works
- Basement design and construction is complex - all of the interdependent factors need to be considered at the design stage. Involving an experienced contractor as early as possible reduces the risk that early design choices will have subsequent negative safety and cost consequences
- The property owner will always bear some risk from third parties - involving an experienced team early will help to minimise these risks
- Proper risk management is not the same as wholesale risk transfer to the contractor - risks, both physical and commercial, should be considered early and each risk addressed appropriately
- Designers and contractors involved in the complicated business of basement construction should have relevant competence, qualifications and experience
- All parties involved in basement construction need to understand their own responsibilities and the responsibilities of the other parties
- Appointing suitably qualified and experienced parties early in the process is critical - once an inexperienced designer and/or an inexperienced contractor has started work it can be very difficult to bring a project back on track:
 - Once extensive structural work has started it is often too late to adopt a more durable design and usually too late to change to a more experienced contractor without considerable rectification cost
 - There have been several instances where the only way of stabilising the building has been to fill the new basement with foam concrete and either abandon the project or start again. In some instances demolition of the house has been the only safe solution to a poorly planned and executed basement project
- Members of the Association of Specialist Underpinning Contractors (ASUC) are committed to working in accordance with these guidelines

2.7 The Association of Specialist Underpinning Contractors (ASUC)

ASUC *plus* (The Association of Specialist Underpinning Contractors) is a trade association founded in 1992 by a group of specialist contractors whose main business was foundation repair by underpinning and piling. The association's intention was to raise standards of health, safety and quality across the sector. Domestic basement construction now faces similar challenges.

Standards in the foundation repair industry were improved by ASUC members being audited on health and safety, technical competence, financial strength and the completeness of their insurance cover. The increase in standards achieved by ASUC members enabled the association to introduce an insurance-backed latent defects guarantee scheme in 2002. This cover is provided by a major insurance company directly to the homeowner and covers any problem with the foundation repair work. An ASUC guarantee is now frequently demanded by insurers as a prerequisite for foundation repair work.

Basement construction uses underpinning, piling and other structural techniques that are similar to those used in traditional foundation repair. This has led to several ASUC members being at the forefront of the growing basement construction industry.

In 2013 ASUC introduced a new class of membership for basement contractors. This class of membership is open to existing ASUC members and to contractors who have not been involved in the foundation repair sector.

The new basement category of membership has more stringent levels of audit across all areas with only those showing excellent health and safety, technical ability, financial strength and appropriate insurances being admitted. In addition a new tailored insurance-backed defective works guarantee scheme has been introduced. The new guarantee scheme is called the Basement Insurance Guarantee (BIG).

2.8 Summary

It is hoped that these guidelines will assist those involved in basement construction to achieve the best possible outcome for their project with the work completed safely, efficiently and with the minimum negative impact on others.

In conclusion it is suggested that a property owner will increase the likelihood of achieving a safe and successful project by inviting an ASUC member, who will operate in line with the spirit of these guidelines, to be involved at the earliest opportunity.

3 TYPES OF BASEMENT

3.1 Introduction

Basement types can be classified in multiple ways. In these guidelines the following classification will be used:

- a. Cellar extensions.
- b. Single level basements.
- c. Multi-level basements.

3.2 Cellar extensions

This is the least complex form of retro-fit construction. Generally the existing walls are underpinned to extend the existing foundations downwards, increasing the head height of the existing cellar or vaults.

A new floor slab is constructed and an appropriate waterproofing system is installed to protect the new basement from water ingress through both the existing and new structures.

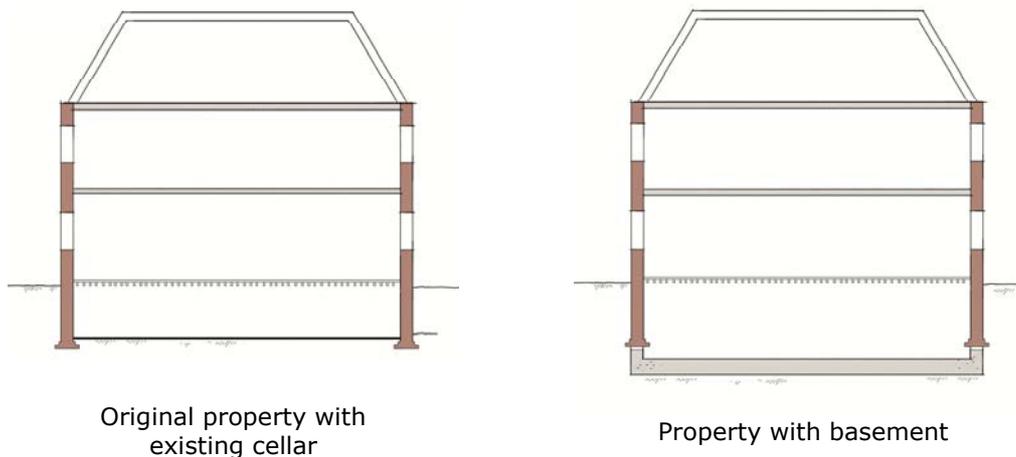


Figure 2. Cellar extension

3.3 Single level basements

Single level basements involve creating one new level of basement below the level of the lowest internal floor or below a garden.

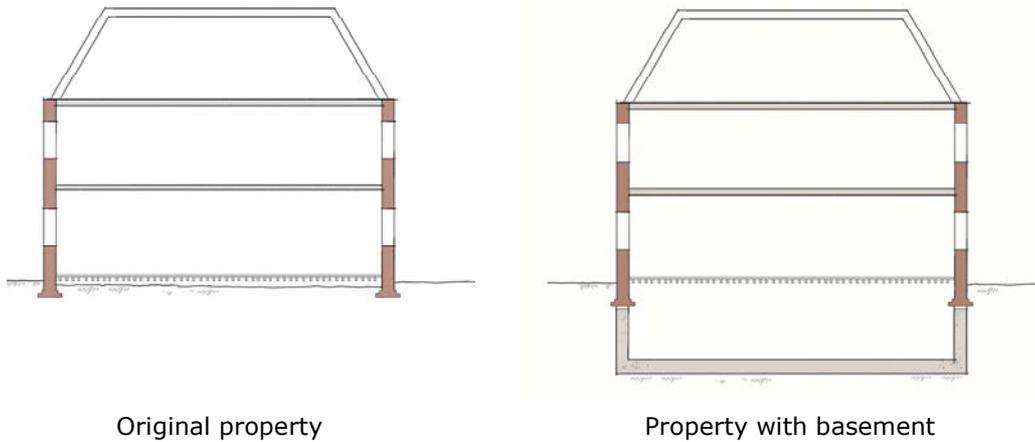


Figure 3. Single level basement

3.4 Multi-level basements

Multi-level basements involve creating more than one new level of basement below the existing lowest floor level of a building or below the garden.

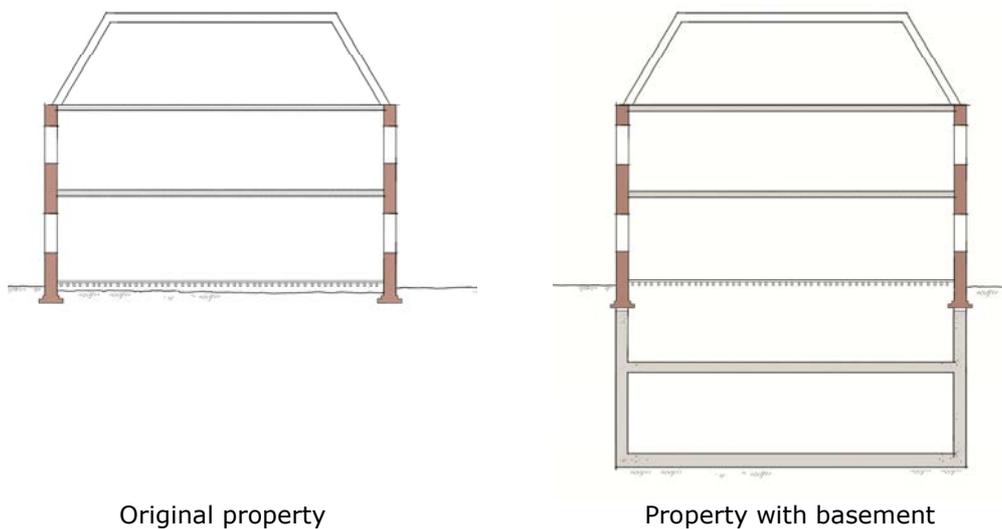


Figure 4. Multi-level basement

3.5 Summary

In these guidelines basements have been classified as cellar extensions, single level basements and multi-level basements.

4 TECHNIQUES USED IN BASEMENT CONSTRUCTION

4.1 Introduction

This section describes techniques used to build the main structural elements of a basement.

The main techniques covered are:

- a. Underpinning
- b. Piling

Underpinning and piling are by far the most common techniques used for basements built underneath or close to existing structures. King post retaining walls are occasionally used in certain situations but will not be considered further in these guidelines

An additional section outlining the challenges faced when building below the groundwater level is also included.

4.2 Underpinning

4.2.1 General

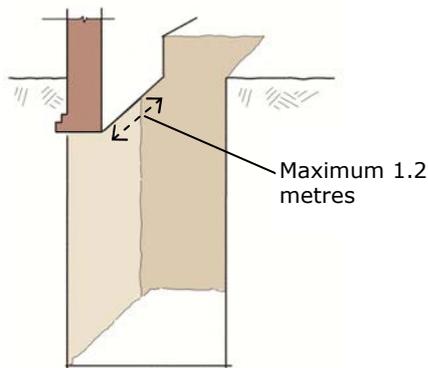
Underpinning is the technique by which an existing foundation is provided with increased depth. Historically this technique was used for foundation repair and strengthening.

Underpinning relies on the ability of a wall to span unsupported for a short length. This allows a section of wall to be undermined and a new structure to be built directly underneath. In this way new sections of lower level basement foundation and wall can be built in a sequence until the existing wall is supported for its full length.

There are several types of underpinning used in basement construction, each of which will be covered further in this section. At the broadest level they can be considered as either:

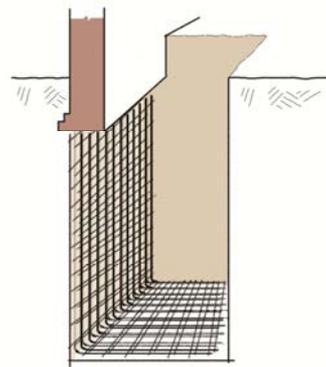
- a. Mass concrete underpins - they are constructed of concrete and do not contain significant steel reinforcement. Structurally they can be considered as being made only of concrete.
- b. Reinforced concrete (RC) underpins - these contain steel reinforcement that is designed to work structurally.

The general method for building all underpins is very similar. The construction stages for a reinforced concrete underpin are given on the next page.



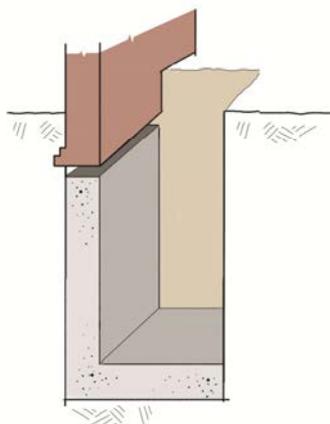
1. Excavation must be fully supported by props and shoring.
2. Edge protection to prevent falls into the excavation must be installed.
3. A temporary vertical prop or support may be placed under the wall to keep any loose bricks or masonry in place.
4. The main load from the existing wall will span onto the wall and foundations on either side of the excavation.

Stage 1. Excavation



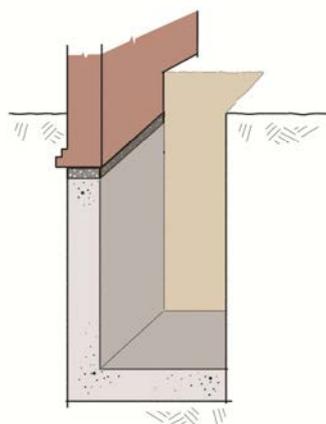
1. Reinforcement is fixed into position.
2. Reinforcement details are given in the engineering design. It is critical that the reinforcement is installed as detailed in the design.
3. The design will usually require a shear connection between adjacent underpins. This is generally achieved using dowel bars between adjacent pins or by building shear keys in the concrete underpin walls.

Stage 2. Reinforcement



1. Concrete is placed in the toe first.
2. Once the toe is sufficiently cured the concrete wall is poured.
3. Shuttering, usually timber, is used to hold the concrete for the wall in place while it is placed.
4. Gap of approximately 75mm left between the top of the concrete and the underside of the existing foundation.

Stage 3. Concrete placement



1. After a minimum of 24 hours dry-pack is rammed into the 75mm void that has been left above the new underpin.
2. Dry-pack is a mix of sharp sand and cement. It is easy to handle and has a low shrink volume, minimising settlement of the wall onto the new underpin foundation.
3. The completed underpin must be supported horizontally either by horizontal propping or by backfilling the excavation until the ground slab and possibly other permanent works are constructed.

Stage 4. Dry packing

Figure 5. Typical underpin construction sequence



Reinforcement bars - remaining upper reinforcement yet to be installed and tied

NB. The importance of good health and safety is evident from this picture

Figure 6. Underpinning - Access shaft used to construct a single underpin – note the small work area and the temptation to limit the amount of shoring materials. The foot of the pin has been cast and steel reinforcement for the pin is being installed. Contrast the less than ideal support arrangement with the standards shown in Fig 28 on page 37.

Underpinning is a tried and tested technique that has been used for many years for foundation repair. Historically for foundation repair the underpins were transferring vertical load from the existing foundations down to a lower level where the ground was stronger or more stable. The underpins were usually built of concrete with no reinforcement.

In basement construction there is a structural requirement to:

- Transfer the vertical load on the existing wall down to the new lower foundation level, and
- Hold back the horizontal load of the ground, hydrostatic pressure and any other surcharge loads acting on the outside walls of the basement.

The horizontal force from the ground or other surcharge from outside the basement must be considered in the permanent design of the final completed basement (the permanent condition) and at all stages during construction (the temporary condition). The horizontal force of ground is real and powerful.

The strength of the horizontal force from the ground is shown by the movement seen on the basement wall in the picture on the next page. The bottom of the basement wall was not restrained by temporary works during the basement excavation. The horizontal force of the ground caused the base of the wall to slide resulting in collapse of the building above.



Figure 7. Wandsworth, South London during construction of a basement - effect of horizontal force from the ground on unrestrained basement wall

The picture above was taken after the collapse of an existing building in Wandsworth, South London. The building had collapsed due to inward horizontal movement of the basement walls. At the time of the photograph the debris from the collapsed building above had largely been removed exposing the extent of the movement.

The subsequent investigation found that the bulk excavation had been completed to the full depth of the underpins without horizontal temporary works being installed. The horizontal force of the retained ground had caused the bottom section of the basement walls to move inwards leading to the collapse of the building above.

Source: Wandsworth Building Control.

4.2.2 Traditional mass concrete underpinning

Mass concrete underpins can sometimes be used to form the walls of basement structures. This will need to be determined by the structural engineer. Commonly, on their own, mass concrete underpins will not have sufficient horizontal strength to act as the basement walls and to retain the ground.

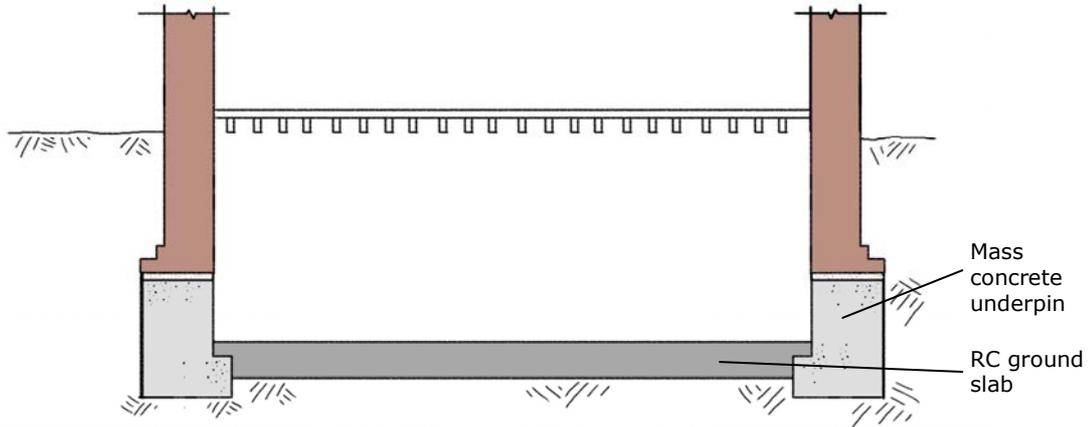


Figure 8. Mass concrete underpinning

Mass concrete underpins are quite often used to transfer vertical loads of various elements to deeper levels either temporarily or permanently.

4.2.3 Traditional mass concrete underpinning with inner reinforced concrete (RC) lining wall

Mass concrete underpinning can be used in conjunction with an inner reinforced concrete (RC) retaining wall as part of the permanent design. The inner RC wall can also be part of a strong complete inner RC box.

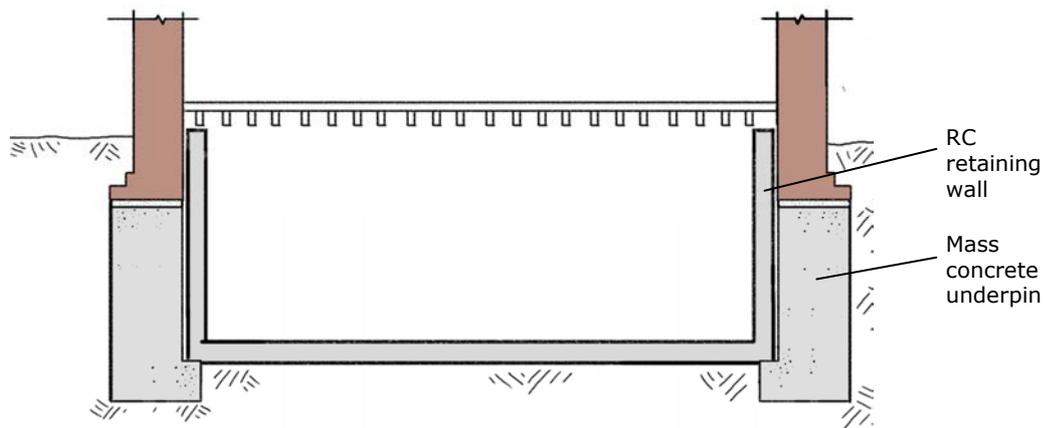
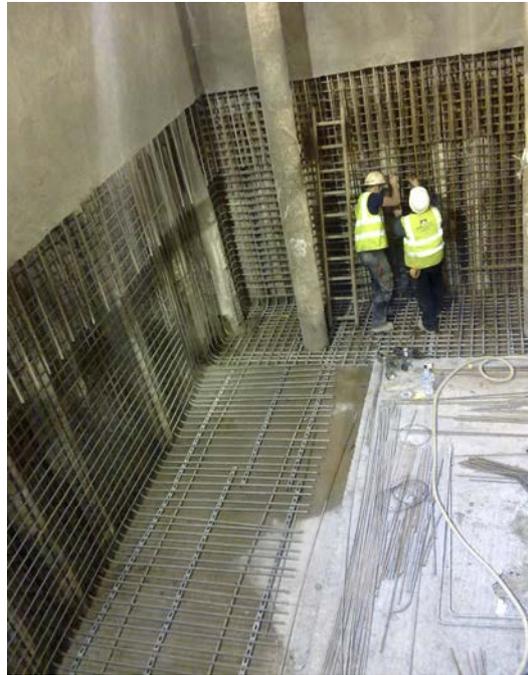


Figure 9. Mass concrete underpinning with RC lining wall

In this design the mass concrete underpin will not be sufficiently strong to act as a retaining wall in the temporary condition so horizontal temporary propping and a somewhat complicated construction sequence is usually needed to provide support until the inner RC retaining wall or box is built and has gained strength.



NB. In this instance a piled wall is retaining the ground allowing the inner RC wall construction to proceed unhindered by temporary works

Figure 10. RC retaining wall

This mass concrete underpin with an RC inner lining wall is generally not seen as an efficient design but does overcome one issue that can arise from the Party Wall Act.

Reinforced concrete underpinning, under the Party Wall Act, is called a 'Special Foundation'. Under the Party Wall Act the adjoining owner's agreement, 'Special Foundations Consent', is required in order to build reinforced concrete underpinning under a party wall.

Conversely the Party Wall Act allows a building owner to build a mass concrete underpin underneath the party wall without the consent of the adjoining owner. So a design with a mass concrete underpin and an inner RC retaining wall or box avoids the need for special foundations consent.

It is now fairly rare for Special Foundations Consent not to be given. There are several reasons why the Adjoining Owner can benefit from giving Special Foundations Consent. In the few cases where consent is not forthcoming a mass concrete underpin with an RC lining wall can be built anyway.

4.2.4 Reinforced Concrete Underpinning

As discussed basement walls need to support the vertical loads from the existing structure and resist the horizontal forces from the ground, hydrostatic pressure and from any other surcharge loads such as the foundations of nearby structures or vehicles on roads.

A reinforced concrete underpin can be designed to achieve both of these functions in one of two main ways, as either:

- A vertical cantilever with a turning moment acting around the end of the toe of the base, in other words the lower section of the underpin is held firmly in place and the vertical wall is sufficiently strong to prevent the soil outside the basement or any other outside horizontal forces from pushing the underpin foundation wall out of vertical, or as
- A vertical beam restrained at the bottom by the basement ground slab and restrained at the top by an RC basement roof slab or other structural arrangement.

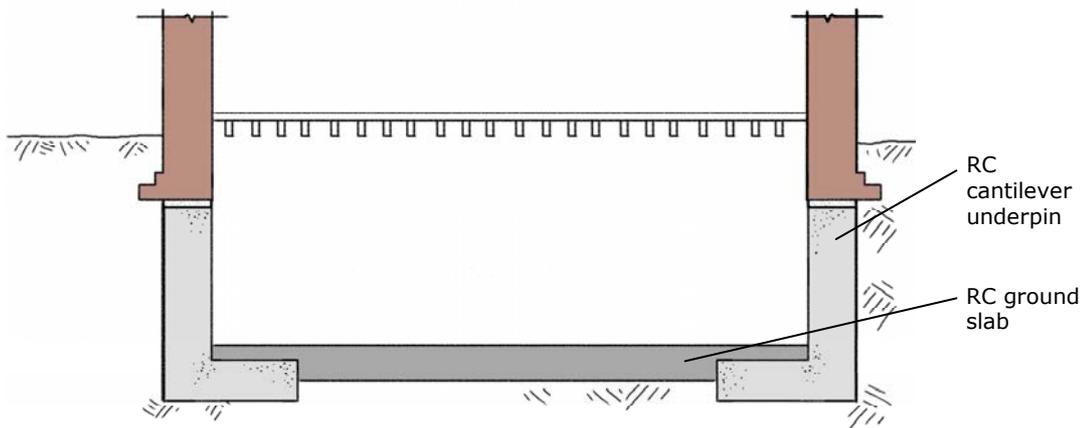


Figure 11. RC underpinning

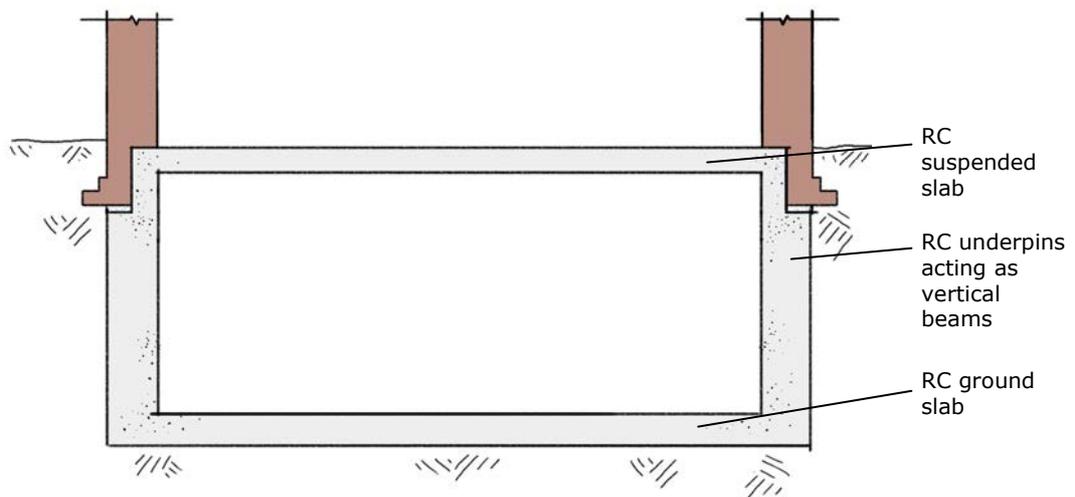


Figure 12. RC box

These sorts of RC underpin are generally viewed as efficient underneath a building as they maximise space, can be built in a low number of construction operations and, from a structural point of view, are low risk as they involve only one transfer of vertical loads.

4.2.5 Multi-stage underpinning

Multi-stage underpinning can be used to build deep RC walls either as part of a deep single level basement or when constructing multi-level basements.

Multi-stage underpins allow shallower individual underpin excavations which can be advantageous from a health and safety point of view especially in unstable soils.

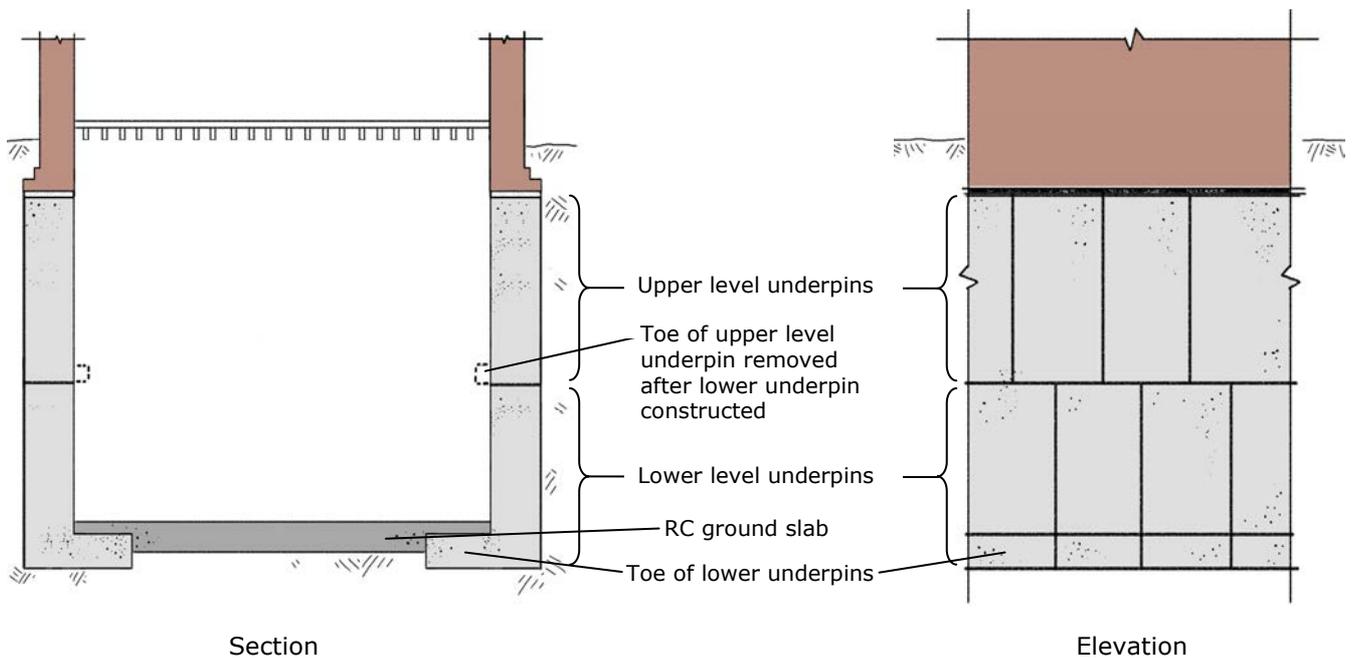


Figure 13. Multi-stage underpinning

There are several important points to note when undertaking multi-stage underpinning:

- Temporary propping - vertical and horizontal propping must be designed and in place at all times
- There must be reinforcement continuity between the different vertical stages of underpinning plus usually there will be, as a minimum, shear connections working horizontally between underpins
- The vertical load of the building must be supported by each stage of the underpinning - the base of each intermediate stage of underpinning will often need to be thickened in order to avoid increasing the temporary foundation's bearing pressure. Any intermediate stage base thickening will usually be trimmed off later to leave a flat vertical wall.
- The underpins at each stage should be offset horizontally to avoid a continuous bottom to top vertical construction joint

4.3 Piling

4.3.1 Outline

Piles are structural elements introduced into the ground from the surface.

In basement construction two main types of piles are used:

- Reinforced concrete (RC) bored piles - constructed by a hole being bored (drilled) into the ground then being filled with concrete and reinforcement.
- Steel sheet piles - constructed by thin interlocking sheets of steel being driven into the ground

They can be used to:

- Form the structural basement walls though they cannot usually be constructed below the walls of the existing building
- Support vertical loads in the temporary or permanent condition (RC piles only)
- Anchor the basement ground slab against uplift from hydrostatic pressure or clay heave (again RC piles only)

Piled retaining walls, both reinforced concrete bored piles and steel sheet piles, need an inner RC wall or box in the permanent condition to provide horizontal strength and for waterproofing.

Piling equipment needs space around the drilling head so there will always be a gap between the edge of the pile and the inner face of the existing wall. In terraced properties this results in the usable basement space being reduced when compared to the existing area immediately above.

The pile size can be limited by the size of the piling rig which can be used given the size of the site, available working height and access. In general faster and lower cost piling is achieved using larger piling rigs.

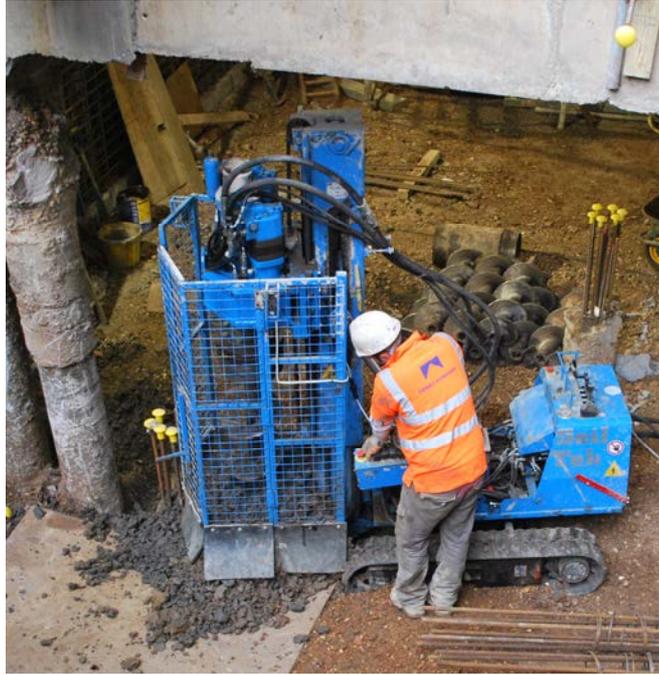


Figure 14. Restricted access mini piling rig



Figure 15. Piling rig in rear garden

The choice of which piling technique is used will be governed by the site layout, site restrictions, access, geology and hydrology. The possible and likely lateral loading

from earth pressure and adjacent building surcharges must also be taken into account in the design.

4.3.2 Reinforced concrete (RC) bored piles

There are two main types of RC bored pile retaining walls used in basement construction:

- Contiguous bored pile retaining wall
- Secant bored pile retaining wall

4.3.2.1 Contiguous bored pile retaining wall

A contiguous bored pile wall is formed by constructing a series of individual vertical RC piles. The diameter of each pile in a contiguous piled wall is usually not less than 300mm diameter.

A small space, usually around one hundred millimetres, is left between adjacent piles.

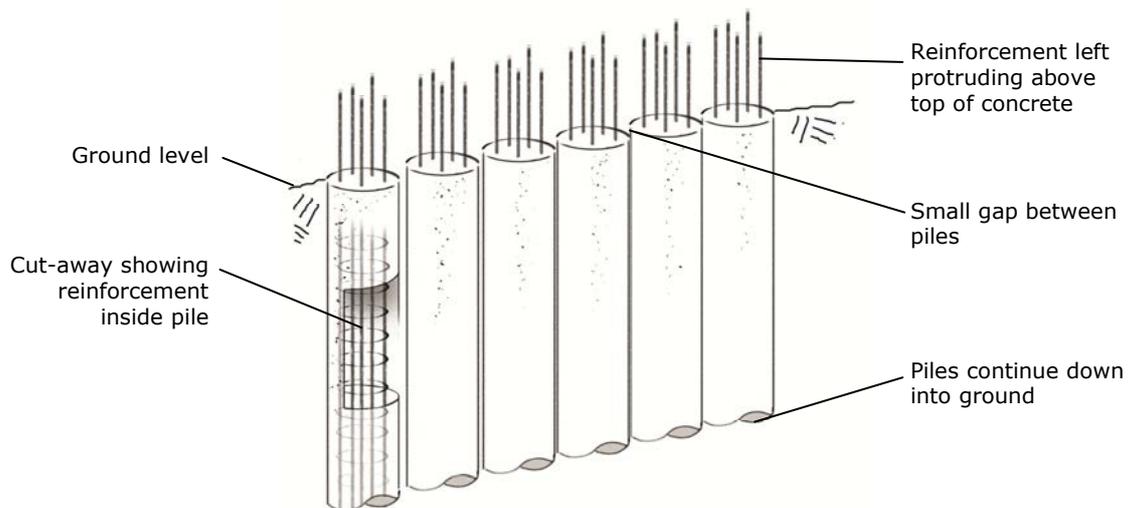


Figure 16. Contiguous bored piles

Once all of the piles have been constructed the top of the piles are usually joined together by an RC capping beam.

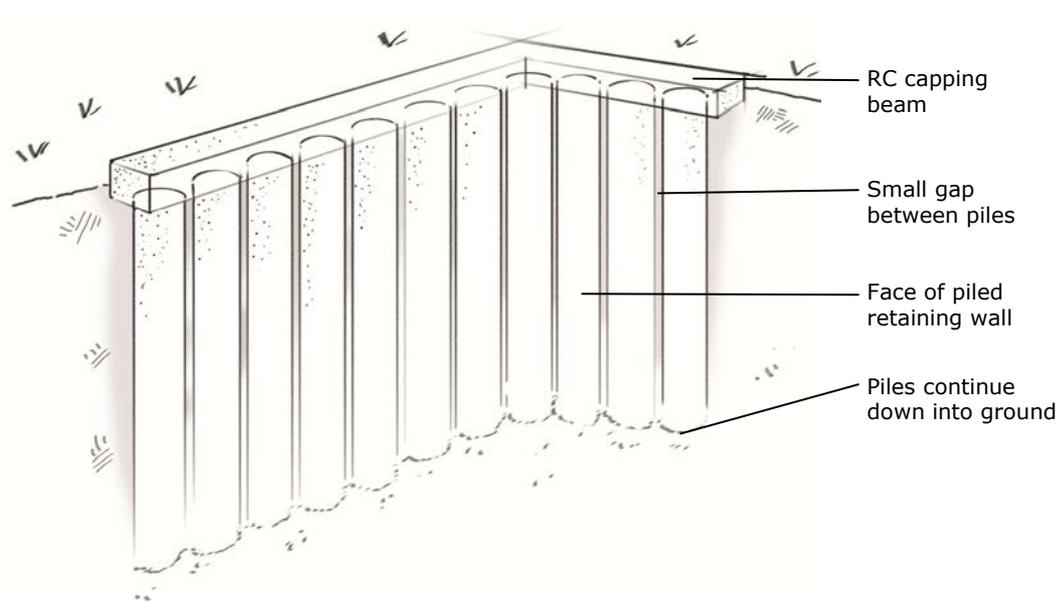


Figure 17. Contiguous bored piled wall with RC capping beam



Figure 18. Contiguous bored pile wall

In self-supporting soils such as stiff clays the sides of the holes will normally remain stable and can be concreted or grouted without the need for temporary casing. The ground between the completed piles will naturally span the gaps.

In non self-supporting ground, such as sands and gravels, the bored holes are generally temporarily cased. Where cased the effective diameter of the completed pile will be that of the casing. Therefore a nominal 450mm diameter pile with a

casing will have an effective diameter in the order of 510mm. This is an important consideration when determining the plan dimensions of a proposed new basement.

Hollow augers (drill bits) can be used as an alternative to casing. The ground is temporarily supported by the flight of the auger and spoil on it and concrete or grout is pumped to the base of the pile through the auger string. The auger should be withdrawn slowly enough to ensure the rate of flow of concrete or grout fills the drilled void. Unless carefully controlled there is potential for 'necking' of the pile or possible bulging in looser ground to occur. Once the drill string is fully withdrawn the reinforcing cage is then lowered into the concrete/grout.

4.3.2.2 Secant bored pile retaining wall

Secant bored pile walls are made using two types of piles: a soft unreinforced pile and a hard, strong reinforced concrete pile. The minimum diameter of each pile in a secant piled wall is usually 450mm.

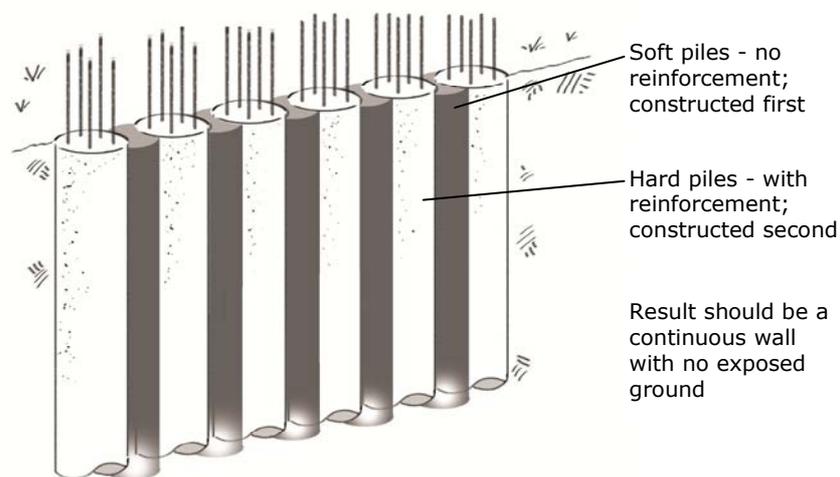


Figure 19. Secant bored piled wall



Figure 20. Secant piled wall

The construction sequence is:

- a. A line of unreinforced piles is constructed using low strength concrete. These are the soft piles.
- b. Then a second line of piles is constructed between and overlapping with the soft piles. The second line of piles is reinforced and uses high strength structural grade concrete. These are the hard piles.

The hard piles provide the structural strength. The soft piles act to fill the gap between the hard piles and hold back any ground or water that would otherwise be able to flow between the hard piles.

Secant piling is used where the ground has a perceived risk of becoming fluid, commonly due to the combination of non-cohesive deposits and water. This technique will reduce ground water ingress if designed and constructed correctly. Vertical pile tolerance needs to be considered as any gaps in the completed wall will allow water or ground ingress. The completed wall is rarely waterproof but water penetration is usually reduced to an extent which allows construction within the piled perimeter to continue safely.

4.3.3 Steel sheet piles

Sheet piled retaining walls are made using interlocking steel piles.

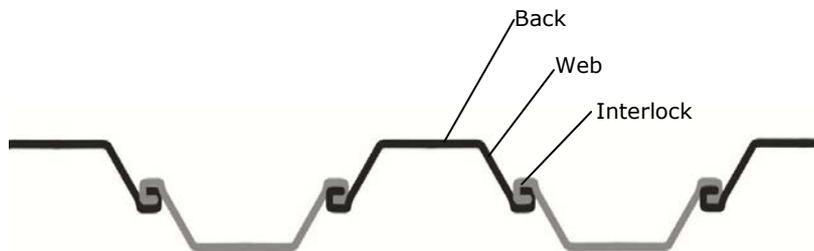


Figure 21. Section through steel sheet piles

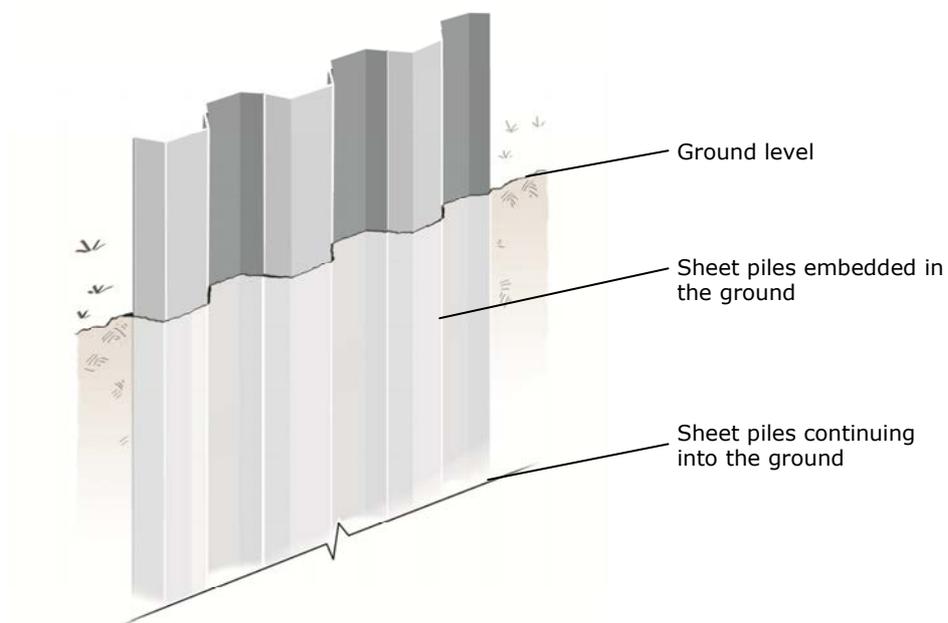


Figure 22. Steel sheet piles in the ground



Figure 23. Steel sheet piled wall

The steel sheet piles are generally driven or jacked into the ground using specialist plant. The plant is usually comparatively large which can be a limiting factor on their use. In addition head height clearance of at least the length of the steel sheet pile is required to allow installation.

As a result steel sheet piles usually cannot be used underneath buildings and are often restricted in their use close to structures. They are generally more suitable for open sites with good access. In these situations they are a credible alternative to RC bored piles

Steel sheet pile retaining walls are not generally used to support vertical loads.

Sheet piles are usually installed by either:

- Percussive methods - hammering the sheet piles into the ground. This is generally not acceptable in urban areas due to excessive noise and the vibration damaging adjacent structures.
- Jacking - forcing the sheet piles into the ground using heavy hydraulic drivers. The drivers often grip onto several neighbouring piles that are partially in the ground in order to force one pile further down. This sequence of gripping and forcing is alternated to steadily install a row of piles. This technique is often not acceptable in urban areas as water is required to assist the driving process and leads to heave and shrinkage in cohesive soils.

Ground conditions need to be considered when using sheet piling:

- Old foundations or natural obstructions such as boulders and stones within clays and silts can obstruct sheet piles and stop their penetration

- Sheet piles are large and heavy and will require either a crane or large excavator to handle them
- Good site access is needed
- A temporary piling mat will be needed to provide sufficiently level and firm ground
- Below the groundwater level welding of the sheets will usually be required to reduce water ingress

4.3.4 Piles to support vertical loads

RC piles can be used to support vertical loads and to resist uplift due to hydrostatic pressure or clay heave. Piles resisting uplift are known as tension piles with the pile effectively working as a ground anchor.

Positive vertical loads can be supported by load bearing piles particularly where there are high point loads. The piles will usually be installed prior to basement ground slab construction and the top of the piles will be tied into the RC basement ground slab.

Bearing piles may be used to support the building load including the new basement if there is low bearing capacity at the proposed formation level.

Piles can be designed to act in tension and bearing.

4.3.5 Bored pile tolerances

Bored piles have a construction tolerance that can be of significance for basement construction particularly in deep basements. Piles that are not vertical can end up straying inside the line of a proposed living area. Pile tolerances should be accounted for within the architectural design.

Pile tolerance should usually be specified in accordance with the Institute of Civil Engineers (ICE) Specification for Piling and Embedded Retaining Walls (SPERW)¹ given below.

	<u>Initial pile position without guide wall</u>	<u>Vertical tolerance</u>	<u>Horizontal radius offset due to vertical tolerance per metre depth</u>
Cast in situ pile	75mm	1 in 75	13.3mm

The table on the next page gives the radius of horizontal offsets from the planned centre of the pile at various depths based on the SPERW tolerances.

¹ ICE (Institution of Civil Engineers) Specification for piling and embedded retaining walls (SPERW) 2nd edition 2007

	<u>Radius of horizontal offset at differing pile depths</u>		
Depth:	<u>3 metres</u>	<u>6 metres</u>	<u>9 metres</u>
Cast in situ pile:	115mm	155mm	195mm

4.4 Building below the groundwater level

4.4.1 Outline

Building below ground water level adds considerable complication to the construction process.

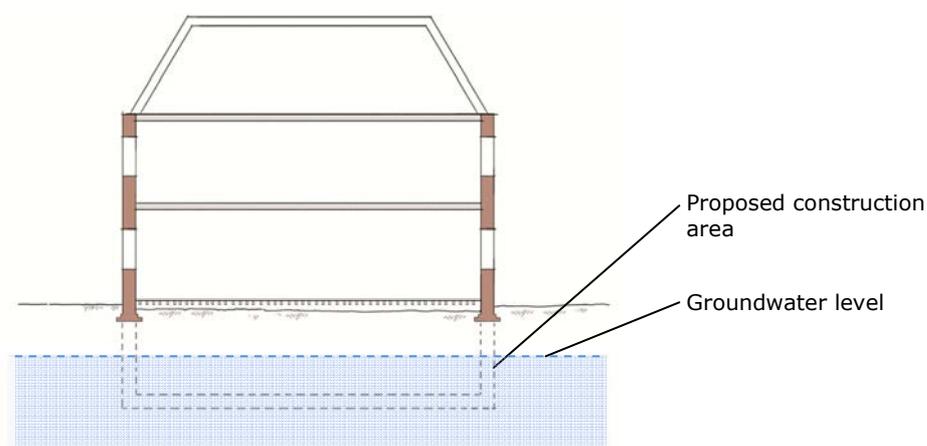


Figure 24. Proposed basement extending below groundwater level

The risk of ground movement and settlement is increased when working below the groundwater level. This is largely due to:

- A reduced bearing capacity of the ground at depth
- Cohesive soils' characteristics of shrinking when they dry and heaving (expanding) when wet
- Removal or migration of fine material from the ground during any dewatering process

The stability of the surrounding ground and existing structures must always be considered.

It is often not appropriate for water to be controlled by standard pumping methods when building below the groundwater level as these do not take account of the stability of the ground.

There are several techniques that have been developed specifically for construction of basements below the ground water level. Broadly these are:

- a. Local lowering of the groundwater level.
- b. Construction of a perimeter barrier to control water ingress.
- c. Soil stabilisation.

Ground freezing is also a recognised technique to enable construction below the water table. It has the disadvantages of causing ground heave due to the expansion of the water and of the frozen ground being difficult to dig through. It is usually limited to large scale commercial projects due to cost and size of plant required. This technique will not be considered further.

4.4.2 Local lowering of the groundwater level

Lowering the water table below the formation level of the basement allows construction within the dewatered area to be completed using standard construction methods. The principal technique for achieving safe local dewatering is to use a specialist well point dewatering system usually installed and operated by a specialist contractor.

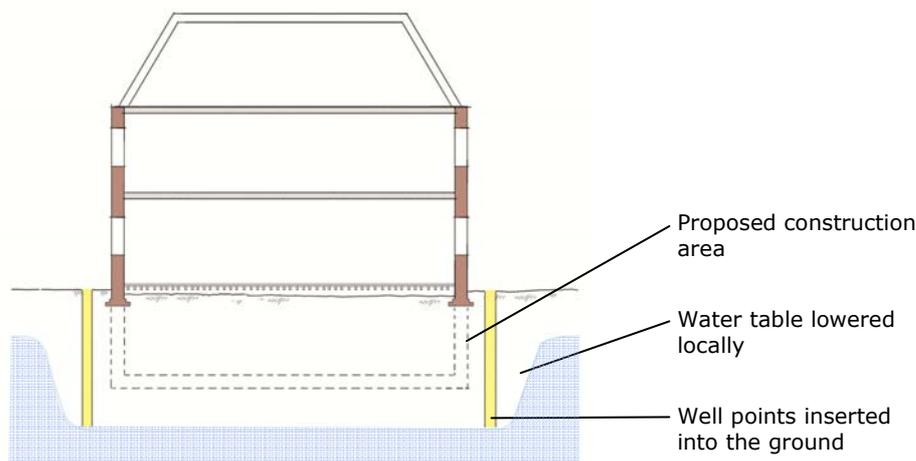


Figure 25. Dewatering for building below groundwater level

In these systems a series of submersible pumps is installed at below basement formation level down drilled well points around the perimeter of the site. The submersible pumps are each installed with a slotted pipe, wrapped in geotextile material and surrounded by a free draining material.

The geotextile material allows water to pass but blocks movement of any ground including fine material suspended in the groundwater. The pumps are usually left running continuously to keep the water table lowered during the work.

The water removed by the pumps should usually be passed through a settlement tank in order to monitor for removed ground and also to ensure that no material is discharged into the drains. A license is usually needed from the water utility company for discharge of groundwater into the drainage system.

Once the water table has been lowered construction work can continue in the now dry ground within the well points. After completion of the basement the dewatering system is removed and the water table will return to its original level.

These systems need to be correctly designed taking account of the specific ground conditions, water levels and proposed construction level. Detailed site investigation including information on the particle size of the ground and specialist geotechnical input will always be needed.

Local lowering of the water table is usually the least expensive of the three main methods though it is sometimes not the most appropriate geotechnical method.

4.4.3 Construction of a perimeter barrier to control water ingress

In this method a physical barrier is constructed into the ground around the perimeter and the water inside the perimeter is removed. The barrier walls block the horizontal flow of new water back into the site.

This method requires that there is a layer of impermeable ground under the site to prevent water flowing up inside the perimeter. This is largely the case in central and west London where a thick layer, in the order of seventy metres, of effectively impermeable London Clay underlies the upper layers of permeable sands and gravels.

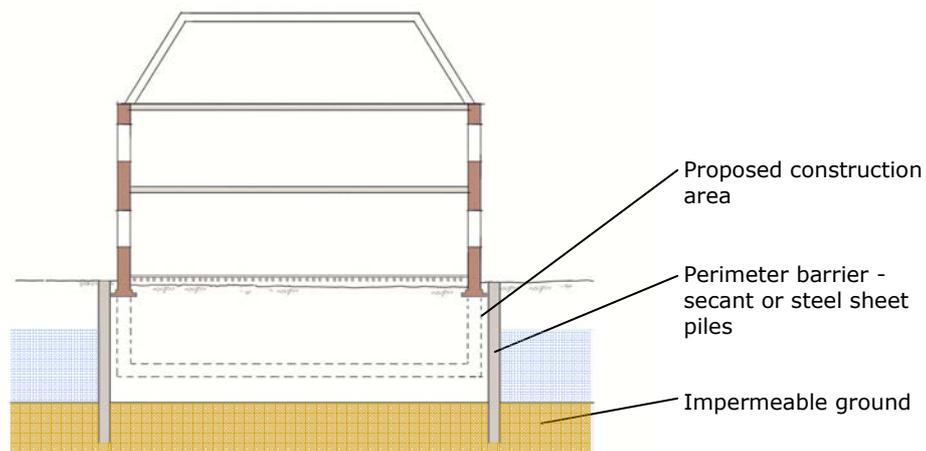


Figure 26. Perimeter barrier to control water ingress during construction

The perimeter barrier is constructed from the ground level and is usually constructed from either:

- a. Secant piles, or
- b. Steel sheet piles

Achieving a good seal in the barrier wall can be challenging. Misaligned or piles that are not sufficiently vertical will leave gaps in a secant piled wall that will need additional measures to create an effective barrier to water flow. Steel sheet piles will need to be welded at the joints and any leaks will need further post construction sealing.

The barrier walls must be embedded sufficiently into the underlying impermeable ground in order to prevent water flowing into the site.

Constructing a physical barrier to prevent water ingress is usually more expensive than dewatering but less expensive than soil stabilisation. Construction of a perimeter

barrier is not always the most appropriate method technically as it requires favourable geological conditions and, as it involves piling, has other construction factors that need to be considered.

4.4.4 Soil Stabilisation

Soil stabilisation involves changing the soil's natural properties by introducing material which mixes or binds the soil. The intention is both to block the flow of water and increase soil stability.

Soil stabilisation can be achieved in a number of ways from large scale compensation grouting to targeted lance injection.

Some soil stabilisation techniques that are widely used in conventional civil engineering can cause ground movement due to the pressure under which the stabilising material is introduced and can also require relatively large associated plant. Therefore these techniques are not usually suitable for basement construction projects directly below or near to existing structures or on restricted sites.

The main technique used in basement construction below or adjacent to existing structures is chemical grouting. Chemical grouting usually requires only small scale plant and low pump injection pressures.

The chemical grout is injected into the ground using lances driven into the ground at specified positions and depths. Each lance injection stabilises a section of ground local to the lance. These bulbs of stabilised ground overlap to form a homogenous zone of improved ground. Once all the chemical grout is placed the basement work can continue with the ground water retained and the soil sufficiently stable to resist hydrostatic collapse.

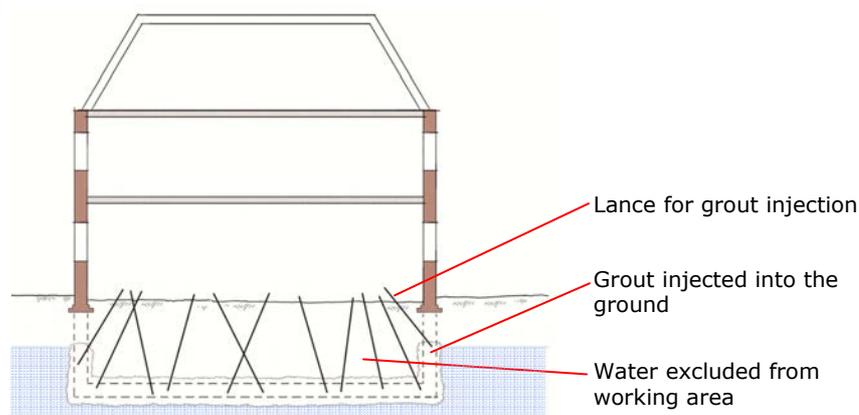


Figure 27. Grout injection for ground stabilisation

Chemical grouting needs to be correctly designed, usually by the specialist contractor, to ensure correct overlap of the bulbs of material. The designer will specify the type of grout to be used, usually a type of resin or acrylic, to give the right flow in the ground and to control any effect the material might have on the ground below adjacent structures.

In many instances stabilised soil does not entirely prevent the passage of water. The improved ground does however prevent the entrainment of fines and collapse of the

ground. Although not an impermeable barrier, stabilised soil should allow basement construction to progress.

Soil stabilisation is usually the most expensive of the three main techniques for building below the groundwater level and will only be used when the other main techniques are not appropriate technically. Soil stabilisation can have an added complication with regards to party wall agreements as consent from any adjoining owners will usually be needed if any introduced material is to be placed into the ground belonging to the adjoining owner.

4.4.5 Summary

Building below the groundwater level adds complication and cost to any basement construction project. There is added risk due to the effect of removing ground water and a reduction in ground stability.

There are several practical construction techniques though not all will be technically suitable in every case. The added cost varies by method with ground dewatering generally being the least expensive, followed by construction of a perimeter barrier, and with soil stabilisation being generally the most expensive.

Input from geotechnical, engineering and basement construction specialists should always be sought as early as possible if constructing a basement below or near to existing structures below the groundwater level.

4.5 **Summary**

Underpinning and piling are the main techniques used in basement construction.

5 TEMPORARY WORKS

5.1 Introduction

Temporary works are the parts of the works that allow or enable construction of, protect, support or provide access to the permanent works. They might or might not remain in place at the completion of the works. Temporary works include horizontal support to excavations and part built permanent works, and vertical support to existing structures. Temporary works will often consist of proprietary propping systems such as Slimshore Soldiers or Maybey Props, and smaller scale Acrow props or timber shoring.

All basement construction projects require temporary works. They are often complex with a mixture of horizontal and vertical temporary works in place at the same time and with different elements of the temporary works being installed, adjusted or removed concurrently.

A major cause of health and safety problems associated with basement construction is poor temporary works especially horizontal temporary works supporting excavations and part built basement structures. The temporary works on projects with problems are often:

- Missing
- Poorly or not designed
- Installed incorrectly
- Inadequate
- Not controlled
- Uncoordinated
- Removed prematurely or out of sequence

Possibly the most critical factor in avoiding serious health and safety problems on basement construction projects is the correct understanding of the function of the temporary works and how they should be installed.

Temporary works must be designed, installed, checked and supervised correctly. A sound process to ensure that nothing is missed must be in place.

Clients can be vulnerable to appointing a contractor who appears to offer a better price for the work when this is achieved by reducing use of temporary works to the point where the work cannot be conducted safely. This can place workers and the public at risk of injury and loss if the structure fails during construction. It is important that the client seeks confirmation at tender assessment stage that the submitted price is based on a sensible method of carrying out the work. Expert advice may be needed to help assess tenders.

5.2 Types

5.2.1 Outline

Temporary works in basement construction can be divided into the following main areas:

- Excavations - generally:
 - Individual underpin excavations
 - The main site excavation
- Structures - support to the existing building or adjoining buildings and to the permanent works in the temporary condition
- Equipment and plant - support to equipment and plant that has been brought onto site as part of the works
- Excavated soil - often stored on site temporarily
- Site facilities - hoarding and welfare facilities

5.2.2 Individual underpin excavations

The weight of the ground and of any loads surcharging the sides of an excavation make collapse or movement likely if adequate support is not provided.

Horizontal loads increase with depth so deeper excavations will need greater and more robust shoring than shallow excavations.

There are two aspects to be considered when shoring an underpin excavation.

- Safety of the personnel involved in the excavation
- The degree of relaxation of the ground that is permitted in relation to the potential for movement of effected structures

Excavations for individual underpins must be considered and the risk of collapse or movement assessed. There is no hard and fast rule over the depth at which underpin excavations should be shored but even shallow excavations should be shored if there is anything other than a minimal risk of ground movement.

The shoring must be designed by a suitably qualified and experienced engineer based upon site investigation information which is proven during initial site works. It is incorrect for site staff to decide the level of shoring that is needed. It is not possible to know the strength or stability of ground by visual inspection or experience and ground should always be assumed to be unstable. Site based measurements should usually be taken to prove the ground conditions.

The back face of the underpin excavation must also always be considered as unstable. Below party walls there will be a general requirement that the shoring material used in the back face and that will be left in the ground is non-biodegradable. Generally timber shoring should not be used for the back face of underpin excavations.



Figure 28. Temporary works - individual underpin

Underpin excavations should always have protection around the upper edge to prevent falls into the excavation and toe boards to minimise the risk of material or tools falling onto the people working in the excavations.

In addition a ladder or other means of access and egress must be permanently in place. There should be emergency exit and escape procedures from the excavation, including for an injured person, and these should be practised regularly. Harnesses and winches could be considered for this function.

Workmanship and quality control is vital when supporting underpin excavations. All site operatives must be suitably trained and experienced. In addition there must be continuous management supervision.

5.2.3 Main excavation

The walls of the basement will not be stable in the temporary condition once the main bulk is removed. Horizontal forces will act to cause:

- The basement walls to overturn or collapse
- The bottom of the walls to slide inwards.

A horizontal temporary propping scheme must be designed and installed in line with the construction sequence in order to prevent structural failure.

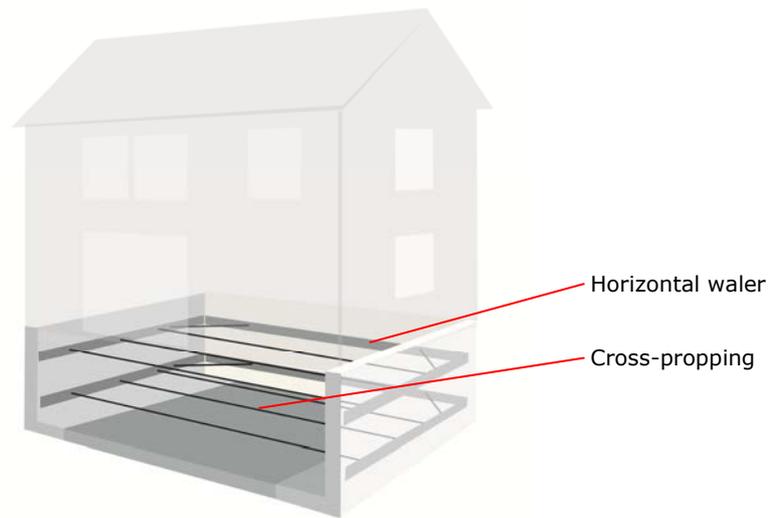


Figure 29. Temporary works to allow main excavation



Figure 30. Temporary works - main excavation

An accurate assessment of all loads that might affect the excavation must be made at an early stage. Loads that should be considered include those coming from:

- Any retained soils
- The existing foundations of the main building and any adjacent structures
- Other temporary works

- Vehicles on nearby roads and on site
- Any stored materials or plant
- Hydrostatic pressure

The main horizontal temporary works should only be removed once the main structural elements for which they are acting have gained adequate strength. Reinforced concrete will take some time, possibly several weeks, to achieve the required permanent strength. This should usually be assessed through sample concrete testing such as cube testing.

5.2.4 Existing structures

Existing structures must be correctly supported at all times. Generally this support will be vertical but can also be horizontal where side support is being removed or replaced, for example when a facade is to be retained or where a semi-detached house is being demolished.

Vertical temporary works will often be used in basement construction where structural steelwork is being installed into or under existing walls or columns.



Figure 31. Temporary works - support to existing structure

5.2.5 Equipment and plant

Large equipment and plant can be used in basement construction projects. Ground conditions should always be assessed to ensure plant is not vulnerable to overturn and will not overload adjacent structures.

Typical plant includes piling rigs, tower crane bases, crane outriggers, hoists and platforms, excavators, dumpers, lorry loader cranes, tipper lorries, concrete pumps