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Geological & Geotechnical Consultants

32 Willoughby Road

Basement Impact Assessment (October 2023)

Planning Reference Number ……

Prepared for Mr Jimeet Patel

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Contents

Non-Technical Summary **4**
1 Introduction **6**
1.1 Purpose of the BIA 6
1.2 Authors 7
1.3 Sources of Information 7
1.4 Existing and Proposed Development 7
1.5 Scope of Work 7
1.6 Limitations 8
1.7 Revision History 8
2 Desk Study **9**
2.1 Site History 9
2.2 Geology 9
2.3 Hydrogeology 10
2.4 Hydrology, Draining and Flood Risk 11
2.5 Other Information 12
3 Screening **14**
3.1 Screening Process 14
3.2 Non-Technical Summary of Screening Process 18
4 Scoping **19**
5 Site Investigation / Additional Assessments **20**
5.1 Site Investigation 20
6 Construction Methodology / Engineering Statements **25**
6.1 Outline Geotechnical Design Parameters 25
6.2 Outline Temporary and Permanent Works Proposals 25
6.3 Ground Movement and Damage Impacts Assessment 26
6.4 Movement Assessment 28
6.5 Damage Category 29
6.6 Monitoring 30
6.7 Control of Construction Works 31
6.8 Construction Programme 31
6.9 Construction Sequence 31
6.10 Construction Management 33
7 Basement Impact Assessment **35**
8 References **36**

Tables

Table 2.1-1: Summary of Historic Land Use 9
Table 3.1-1: Groundwater Screening 14
Table 3.1-2: Slope Stability Screening 15
Table 3.1-3: Surface Flow and Flooding Screening 17
Table 5.1-1: Results of Water Level Monitoring 24
Table 6.1-1: Outline Geotechnical Design Parameters 25
Table 6.4-1: Summary of Anticipated Ground Movement 29
Table 6.5-1: Summary of Building Damage Assessment 29
Table 6.5-1: Action Levels for Ground Monitoring 31

Figures

Figure 1.1-1: Site Location Plan 6
Figure 2.2-1: Extract from BGS Geological Map 10
Figure 2.3-1: Extract from Camden Aquifer Designation Map 11
Figure 2.4-1: Extract from Camden Watercourses Map 12
Figure 2.5-1: Extract from Slope Gradients Map 13
Figure 5.1-1: Cross-Section Through Site 20
Figure 5.1-2: SPT Plotted Against Depth 21
Figure 5.1-3: HSV Results Plotted Against Depth 22
Figure 5.1-4: Plasticity Chart 23
Figure 6.3-1: Extent of Proposed Basement 26
Figure 6.3-2: Proposals for Underpinning Existing Walls 27
Figure 6.3-3: Planning Details for Basement at No 34 Willoughby Road 27
Figure 6.9-1: First Stages of Underpinning 32
Figure 6.9-2: Construction of Box 32
Figure 6.9-3: Long Section Through Basement 33

Appendices

Appendix 1: Drawings Existing & Proposed Details
Appendix 2: Movement Calculation
Appendix 3: Embedded Retaining Wall Assessment
Appendix 4: XDisp Assessment

Non-Technical Summary

The site location is 32 Willoughby Road, Hamstead, N3 1RU.

The existing building is a three-storey, four-bedroom semi-detached house, built in the Victorian period. The house sits on the east side of Willoughby Road opposite the end of Rudall Crescent.

The proposed development comprises the following elements:

- Basement extension to run under the footprint of the house, into the rear side return and rear garden. The new basement level will house an open plan family living area to the rear, with a utility/ plant rooms and gym / cinema room towards the front.
- Replacement of the existing rear extension of the house with a new extension of a similar size.
- The house would be fully refurbished, with improved glazing and insulation, and building services updated to technologies with low energy and water. The remaining original Victorian internal features to the main part of the house would be retained and refurbished.

The following assessments are presented:

- Desk study
- Screening
- Scoping
- Additional evidence / assessments
- Impact Assessment

The authors of the report are David Halifax and Brian Duthie. David holds a BEng in Civil Engineering, a postgraduate qualification in Geotechnical Engineering and is a Chartered Civil Engineer (CEng, MICE) with 25 years' experience in geotechnical engineering. Brian holds a BEng in Engineering Geology and Geotechnics, is a Chartered Geologist and Fellow of the Geological Society and a UK Registered Ground Engineering Advisor with 30 years' experience in geotechnical engineering.

The ground conditions below the site are firm to stiff clays the London Clay Formation to a depth of at least 30m.

The construction methods proposed are two stage underpinning and embedded retaining walls.

A structural monitoring strategy to control the works and impacts to neighbouring structures will comprise the following.

- Visual inspection of the properties at No 34 and No 30 and recording any pre-existing cracking
- Visual inspection of the party wall between No 32 and No 30 and recording any pre-existing cracking
- Attachment of tell tales to accurately record movement of any pre-existing cracks

- Installation of levelling targets to monitor settlement of the party walls and the public highway, to be monitored by standard optical equipment.

The BIA has assessed land stability and the impacts of the proposed development on neighbouring structures will be Category 0 or 1, with the degree of severity being negligible to very slight, as defined CIRIA C580 Table 2.5.

The BIA has identified the following.

1. The ground investigation confirmed the findings of the desk study by demonstrating that the London Clay Formation has a high swell-shrink potential. The proposed foundations for the basement will be significantly lower than the depth of ground likely to be affected by swelling and shrinkage.

2. The front of the property is approximately 3m from the footpath along Willoughby Road. The ground movement assessment will determine the extent of anticipated ground movement at the footpath. The construction works will be managed so as not to disrupt access to the footpath.

3. A party wall is present between No 32 and No 30. The underside of the proposed basement will be approximately 3.5m lower than the underside of the existing foundation. The proposed works will support the existing foundation in the long-term and the ground movement assessment will demonstrate that anticipated ground movements are within acceptable limits.

   Monitoring during construction will be undertaken to ensure that measured settlements are in accordance with the estimated values.

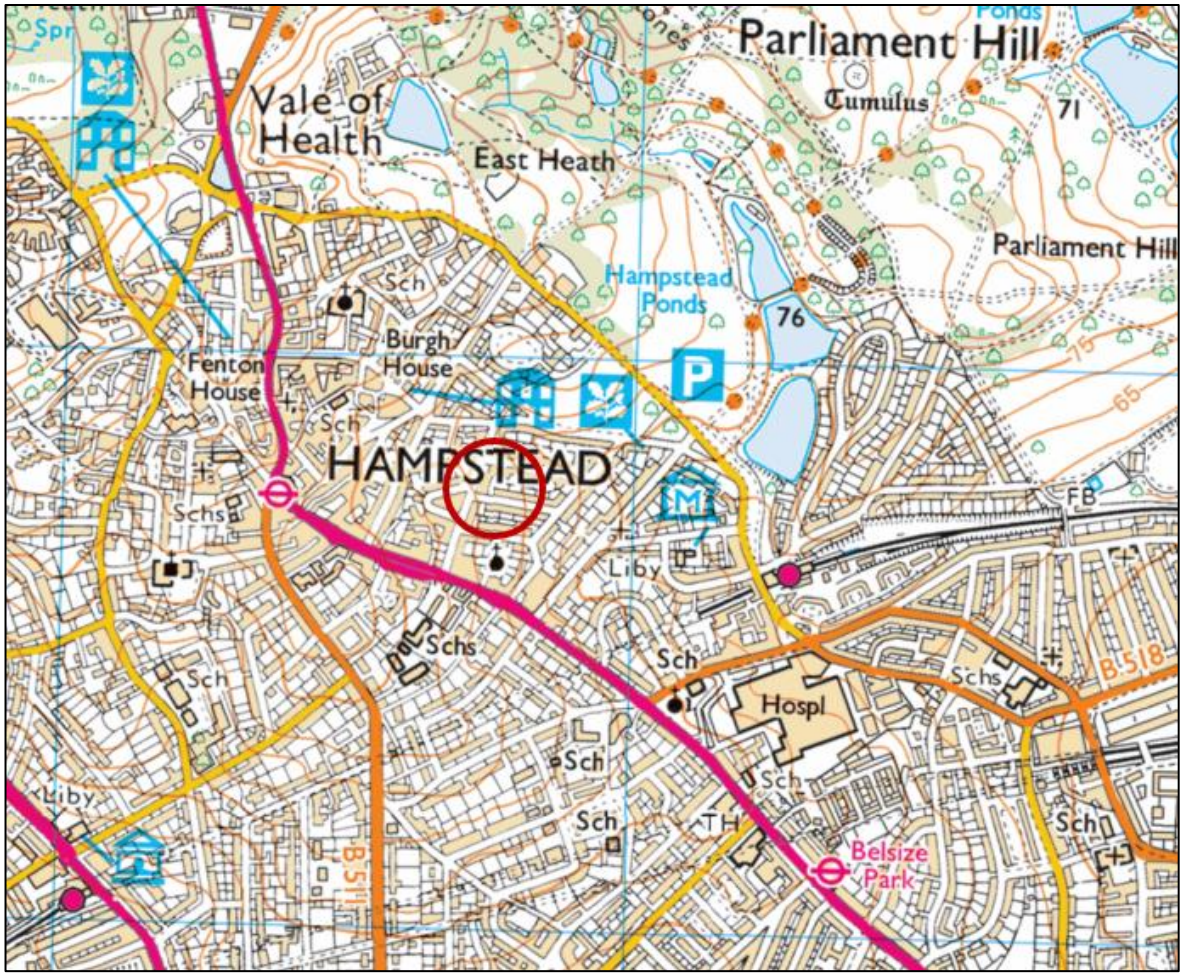
The BIA has identified a low flood risk for the proposed development with no proposed mitigation measures required.

1 Introduction

1.1 Purpose of the BIA

The purpose of this assessment is to consider the effects of a proposed basement development at 32 Willoughby Road, London NW3 1RU on the local hydrology, geology and hydrogeology and potential impacts to neighbours and the wider environment. The site location is presented in Figure 1.1-1 below. The National Grid co-ordinates for the site are E 526757m, N 185834m.

Figure 1.1-1: Site Location Plan



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The BIA approach follows the current planning procedure for basements and lightwells adopted by LB Camden and comprises the following elements (CPG Basements):

- Desk study;
- Screening;
- Scoping;
- Site investigation, monitoring, interpretation and ground movement assessment;
- Impact Assessment.

1.2 Authors

This BIA has been undertaken by David Halifax and Brian Duthie. David holds a BEng in Civil Engineering, a postgraduate qualification in Geotechnical Engineering and is a Chartered Civil Engineer (CEng, MICE) with 25 years' experience in geotechnical engineering. Brian holds a BEng in Engineering Geology and Geotechnics, is a Chartered Geologist and Fellow of the Geological Society and a UK Registered Ground Engineering Advisor with 30 years' experience in geotechnical engineering. Both assessors satisfy the qualification requirements given in the Camden Planning Guidance 4.

1.3 Sources of Information

- BGS Superficial Deposits Map for North London (2006)
- Camden geological, hydrogeological and hydrological study. Guidance for subterranean development, Issue 01, November 2010, Arup
- Ground Investigation Report, Key GeoSolutions, October 2023

1.4 Existing and Proposed Development

The existing building is a three-storey, four-bedroom semi-detached house, built in the Victorian period. The house sits on the east side of Willoughby Road opposite the end of Rudall Crescent. The property is situated in the London Borough of Camden.

The scope of the proposed project comprises the following elements:

- Basement extension to run under the footprint of the house, into the rear side return and rear garden. The new basement level will house an open plan family living area to the rear, with a utility/ plant rooms and gym / cinema room towards the front.
- Replacement of the existing rear extension of the house with a new extension of a similar size.
- The house would be fully refurbished, with improved glazing and insulation, and building services updated to technologies with low energy and water. The remaining original Victorian internal features to the main part of the house would be retained and refurbished.

The rear extension extends 10m from the rear of the original property. The basement extension covers the full length of the original property and the proposed extension.

The width of the extension at ground level is 4.82m. The finished floor level of the completed basement will be 3.6m below the current ground floor level.

1.5 Scope of Work

The aim of this work is to assess if the proposed basement can be constructed without having a detrimental impact on the surroundings with respect to land stability and in particular whether the development will affect the stability of neighbouring properties. The assessment conforms to the

requirements of guidance set out by The London Borough of Camden which provides comprehensive guidance on planning applications for basement extensions.

1.6 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the research carried out. The results of the research should be viewed in the context of the work that has been carried out and no liability can be accepted for matters outside the stated scope of the research. The assessment does not constitute a detailed structural design for the basement structure, as would be required to allow construction to take place.

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1.7 Revision History

Revision 4 – The report has been updated to address comments received from Campbell Reith following their assessment of the previous version of this document. The changes to the text are highlighted with a grey background.

2 Desk Study

2.1 Site History

The following table provides a summary of historic plans reviewed as part of the desk study. The historic plans for the site are provided in the Ground Investigation Report.

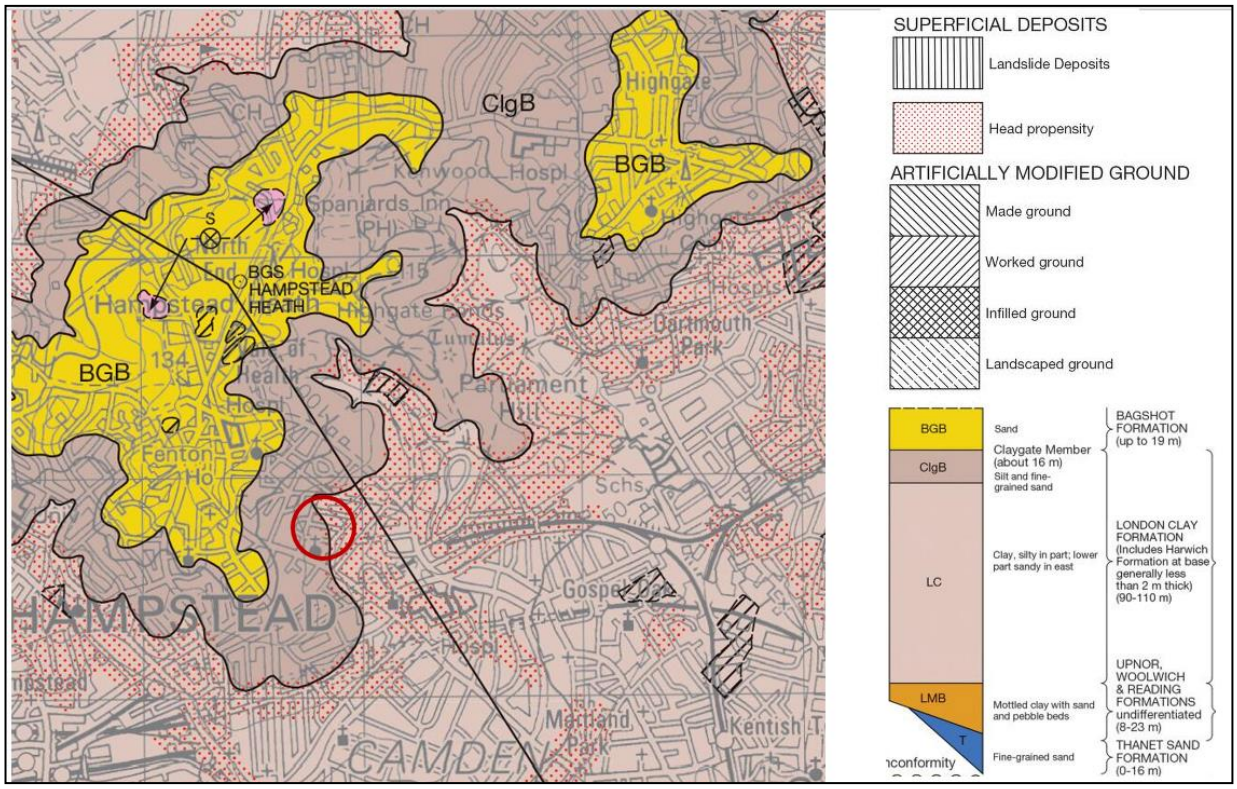
Table 2.1-1: Summary of Historic Land Use

Mapping Date	Scale	Site Use	Surrounding Site Use
1879	1:2500	Parkland	Two large water features are present to the south of the site
1896	1:2500	The site is developed with housing	The surrounding area is developed with housing
1915	1:2500	No change	No change
1934	1:2500	No change	No change
1952 - 1954	1:1250	No change	No change
1970	1:2500	No change	No change
1991	1:1250	No change	No change

2.2 Geology

The BGS Superficial Deposits Map for North London (2006) shows the site to be at the boundary of the Claygate Member of the London Clay Formation and the clays of the London Clay Formation. Areas of Head Deposits are mapped above the London Clay Formation. An extract from the BGS map is presented in Figure 2.2-1.

Figure 2.2-1: Extract from BGS Geological Map

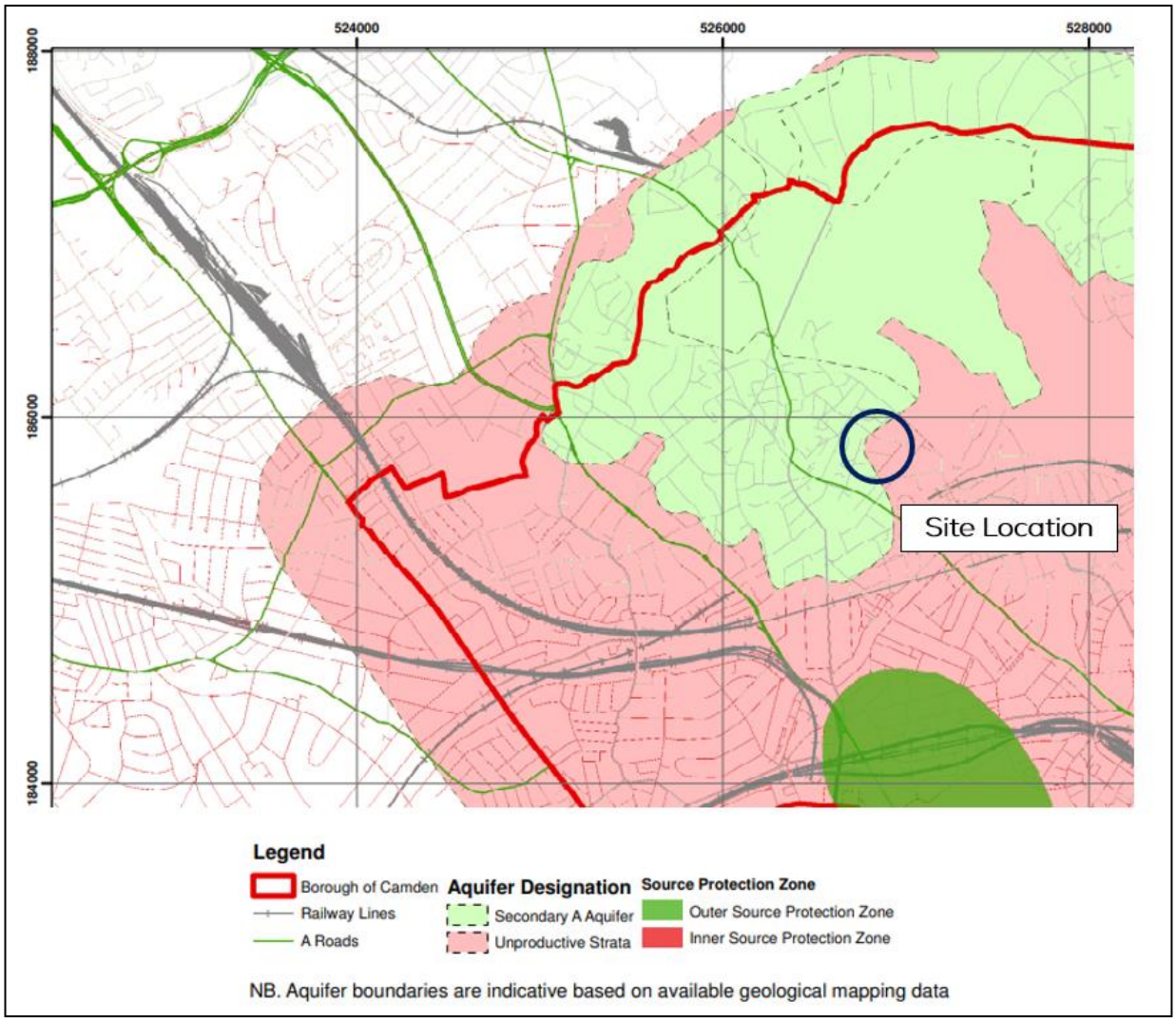


An intrusive ground investigation was undertaken at the site. Details of the ground investigation are provided in Section 5.

2.3 Hydrogeology

An extract from the Aquifer Designation Map shown on Figure 8 (Arup 2010) is presented in Figure 2.3-1. This indicates that the site is on the boundary between a Secondary A Aquifer and Unproductive Strata. The Secondary A Aquifer corresponds with the mapped extent of the Claygate Member shown in Figure 2.2-1.

Figure 2.3-1: Extract from Camden Aquifer Designation Map



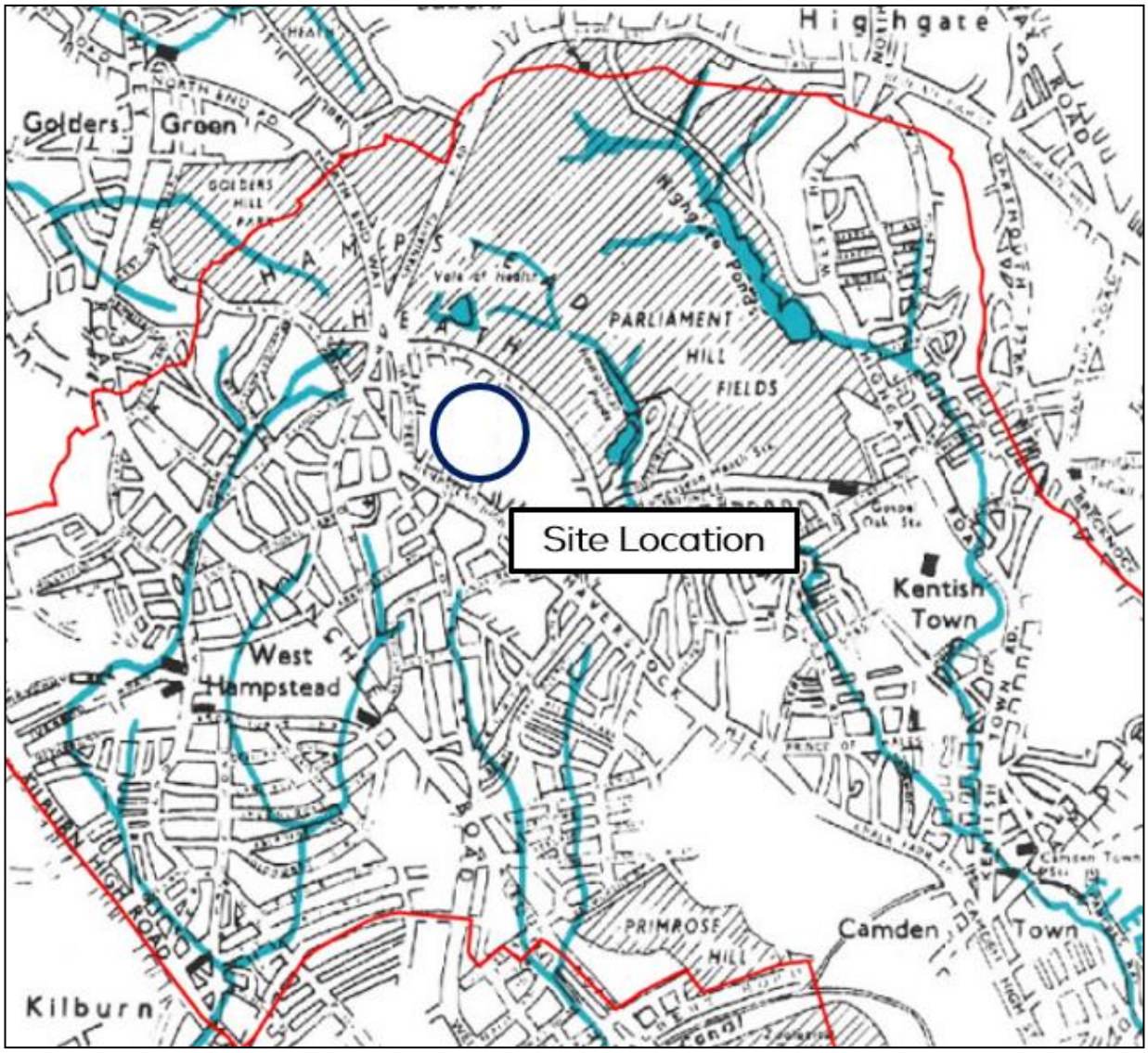
The Claygate Member is considered to be permeable in parts and may contain groundwater. The groundwater may be mobile if the unit is particularly sandy.

LB Camden data indicates the site is not within a groundwater source protection zone.

2.4 Hydrology, Draining and Flood Risk

An extract from the Watercourses Map provided in the Arup study is presented below. This shows no recorded watercourses near the project site.

Figure 2.4-1: Extract from Camden Watercourses Map

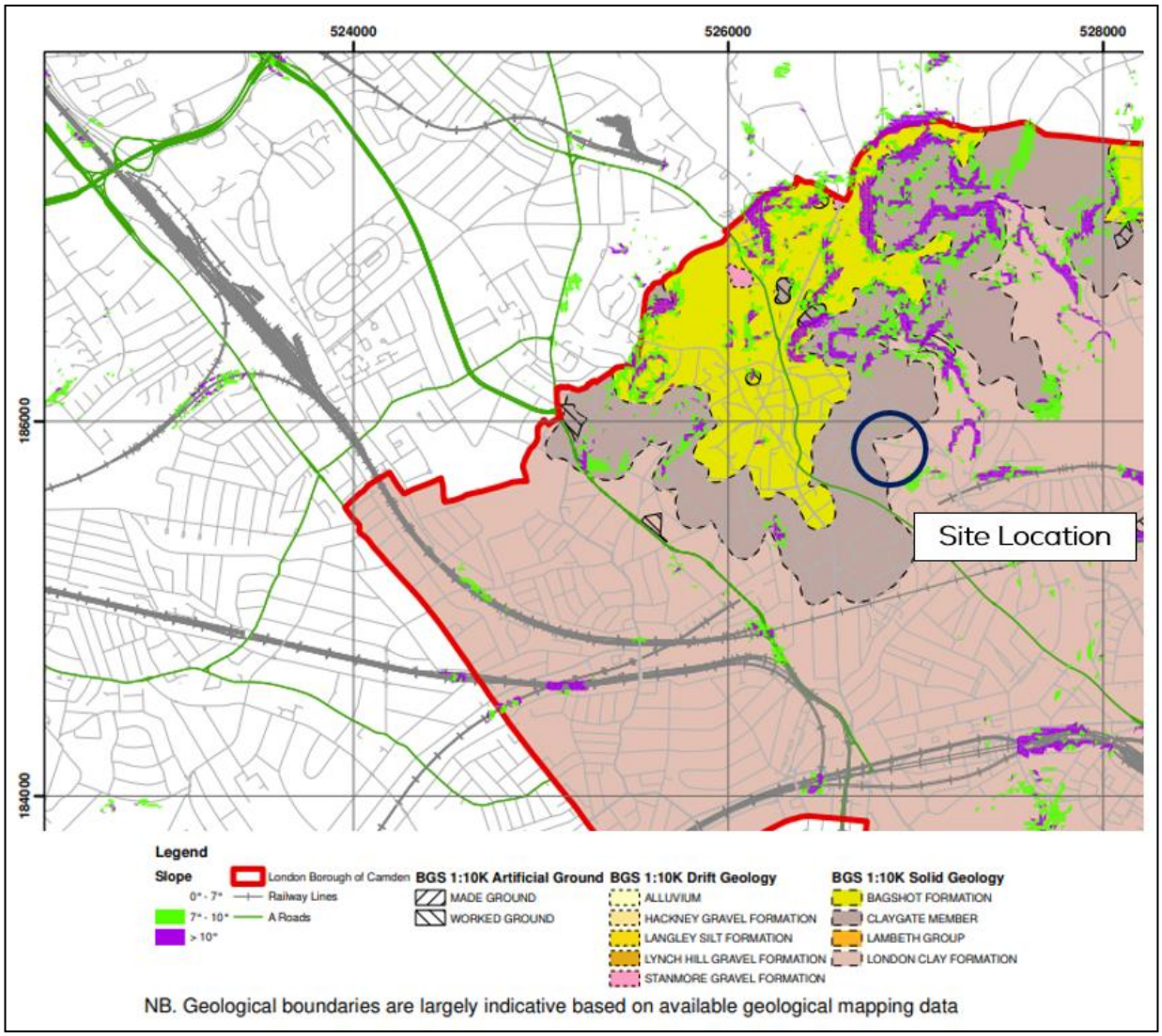


The flood risk classification for the site on the government flood risk mapping site is defined as **very low risk** for both surface water flooding and flooding from rivers or the sea. It is not within an area designated as being at risk from flooding from reservoirs.

2.5 Other Information

The general topography of the area is gently sloping towards the west at a gradient of less than 7°. Slope gradients in the Camden Borough are show in Figure 2.5-1.

Figure 2.5-1: Extract from Slope Gradients Map



The site is within an area mapped has potentially having **high** landslide potential.

3 Screening

3.1 Screening Process

A screening process has been undertaken and the findings are described below.

Table 3.1-1: Groundwater Screening

Subterranean (groundwater) (Figure 12, Camden Planning Guidance: Basements – Jan 2021)			
Impact question	**Answer**	**Justification**	**Reference**
1a) Is the site located directly above an aquifer?	**No**	The site is located on the London Clay Formation, which is classified as Unproductive Strata.	BGS, 2021
1b) Will the proposed basement extend beneath the water table surface?	**No**	Boreholes drilled at the site did not encounter groundwater other than some perched water in a shallow trial pit. The London Clay Formation is an aquiclude.	Appendix 1
2) Is the site within 100m of a watercourse, well (used/disused) or potential spring line?	**No**	The site is not within 100m of a watercourse (refer to Figure 2.4-1,)	Ove Arup, 2010 Appendix 2
3) Is the site within the catchment of the pond chains on Hampstead Heath?	**No**	The site is approximately 0.5km from Hampstead Heath No 1 Pond. It is outside of the catchment areas of the ponds.	CGHH4 Hampstead Heath Map Figure 14
4) Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	**No**	Although the proposed rear extension is slightly larger that the current rear extension at the property, the area of net increase is over an existing paved external area which currently collects surface water and discharges it into the surface water drainage system.	Drawings of proposed development
5) As part of the site drainage, will more surface water than at present be discharged to the ground?	**No**	There will be no increase of water transfer from surface to ground as a result of this development. Due to the underlying geology, there are no plans for the installation of a soakaway.	Drawings of proposed development

6) Is the lowest point of the proposed excavation close to, or lower than, the mean water level in any local pond or spring line?	**No**	No ponds or springs are present within 100m of the site (refer to Figure 2.4-1,).	Ove Arup, 2010 Appendix 2

Table 3.1-2: Slope Stability Screening

Slope stability screening flowchart (Figure 13, Camden Planning Guidance: Basements – Jan 2021)			
Impact question	**Answer**	**Justification**	**Reference**
1) Does the existing site include slopes, natural or manmade, greater than 7°?	**No**	Figure 2.5-1 indicates that the site area is very flat with slope angle of less than 7 degrees.	Ove Arup, 2010. Appendix 2
2) Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7°?	**No**	No re-profiling of the site is proposed.	
3) Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	**No**	There is no neighbouring land with a slope gradient greater than 7 degrees.	
4) Is the site within a wider hillside setting in which the general slope is greater than 7°?	**No**	Figure 2.5-1 indicates that the site area is very flat with slope angle of less than 7 degrees.	Ove Arup, 2010. Appendix 2 and 3
5) Is the London Clay the shallowest strata at the site?	**No**	Some Made Ground was encountered during the intrusive ground investigation and potentially a shallow layer of the Claygate Member was encountered at the front of the property	KeyGS Ground Investigation Factual Report
6) Will any trees be felled as part of the proposed development and / or any works proposed within any tree protection zones where trees are to be retained?	**No**	No trees are proposed to be felled as part of the development. The proposed foundation is below the depth of the tree protection zones.	

7) Is there any history of seasonal shrink-swell subsidence in the local area, and / or evidence of such effects at the site?	**Yes**	The boundary wall is leaning. The Ground Investigation Factual Report indicates the foundation soil has a high volume change potential.	KeyGS Ground Investigation Factual Report
8) Is the site within 100m of a watercourse or potential spring line?	**No**	No watercourses or spring lines are present within 100m of the site (refer to Figure 2.4-1,).	Ove Arup, 2010 Appendix 2
9) Is the site within an area of previously worked ground?	**No**	No evidence of previously worked ground was found during the desk study.	KeyGS Ground Investigation Factual Report
10) Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	**Yes**	The proposed basement will generally be constructed within the London Clay Formation which is a very low permeability strata and an unproductive aquifer. The front of the development is on the edge of the Claygate Member	KeyGS Ground Investigation Factual Report
11) Is the site within 50m of Hampstead Heath ponds?	**No**	Refer to Figure 2.4-1,	Ove Arup, 2010 Appendix 2
12) Is the site within 5m of a highway or pedestrian right of way?	**Yes**	The front of the property is within 5m of the public highway.	Appendix 3 Figure B Google Map
13) Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	**Yes**	The proposed basement will mean the is a differential depth of foundation relative to the neighbouring property.	Appendix 3 Figure B Google Map
14) Is the site over (or within the exclusion zone of) any tunnels e.g. railway lines?	**No**	There are no underground tunnels within the site area.	Appendix 3 Figure C Underground Map

Table 3.1-3: Surface Flow and Flooding Screening

Surface Flow and Flooding (Figure 14, Camden Planning Guidance: Basements – Jan 2021)			
Impact question	**Answer**	**Justification**	**Reference**
1) Is the site within the catchment of the pond chains on Hampstead Heath?	**No**	The site is approximately 0.5km from Hampstead Heath No 1 Pond. It is outside of the catchment areas of the ponds.	CGHH4 Hampstead Heath Map Figure 14
2) As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	**No**	The footprint of the proposed extension is similar to the existing rear extension but slightly larger. The location of the extension is above existing hard surfacing so the peak run-off will not vary significantly.	Drawings of proposed development
3) Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	**No**	The net area of the basement extension is currently a paved area.	Drawings of proposed development
4) Will the proposed basement result in changes to the profile of inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	**No**	The proposed basement will not affect the inflow of surface water. The existing site is currently paved.	Drawings of proposed development
5) Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	**No**	The proposed basement will not affect the quality of surface water. Surface water will be collected and channelled into the existing surface water drainage system.	Ordnance Survey Mapping.
5) Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk from flooding for example because the proposed basement is below the static water level of a nearby surface water feature?	**No**	The Site lies within Flood Zone 1 with very low risk of flooding according to the Environment Agency.	KeyGS Ground Investigation Factual Report

3.2 Non-Technical Summary of Screening Process

The screening process identifies the following issues to be carried forward to scoping for further assessment:

- Is there any history of seasonal shrink-swell subsidence in the local area, and / or evidence of such effects at the site?
- Is the site within 5m of a highway or pedestrian right of way?
- Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?
- Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?

The other potential concerns considered within the screening process have been demonstrated to not be applicable or not significant when applied to the proposed development.

4 Scoping

The following issues have been brought forward from the Screening process for further assessment:

Is there any history of seasonal shrink-swell subsidence in the local area, and / or evidence of such effects at the site?

The ground investigation confirmed the findings of the desk study by demonstrating that the London Clay Formation has a high volume change potential. The proposed foundations for the basement will be significantly lower than the depth of ground likely to be affected by volume change.

Is the site within 5m of a highway or pedestrian right of way?

The front of the property is approximately 3m from the footpath along Willoughby Road. The ground movement assessment will determine the extent of anticipated ground movement at the footpath. The construction works will be managed so as not to disrupt access to the footpath.

Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?

A party wall is present between No 32 and No 30. The underside of the proposed basement will be approximately 3.5m lower than the underside of the existing foundation. The proposed works will support the existing foundation in the long-term and the ground movement assessment will demonstrate that anticipated ground movements are within acceptable limits.

Monitoring during construction will be undertaken to ensure that measured settlements are in accordance with the estimated values.

Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?

The borehole at the front of the property encountered approximately 2m of slightly sandy, silty clay. This was interpreted as the Claygate Member. This soil is a similar low permeability clay soil to the London Clay Formation. No groundwater was encountered in this layer. Therefore, the development is not considered to present a risk to the Claygate Member as it is unlikely to affect any groundwater within the wider Claygate Member.

5 Site Investigation / Additional Assessments

A ground investigation was undertaken to determine the ground and groundwater conditions at the site and to identify any geotechnical hazards.

5.1 Site Investigation

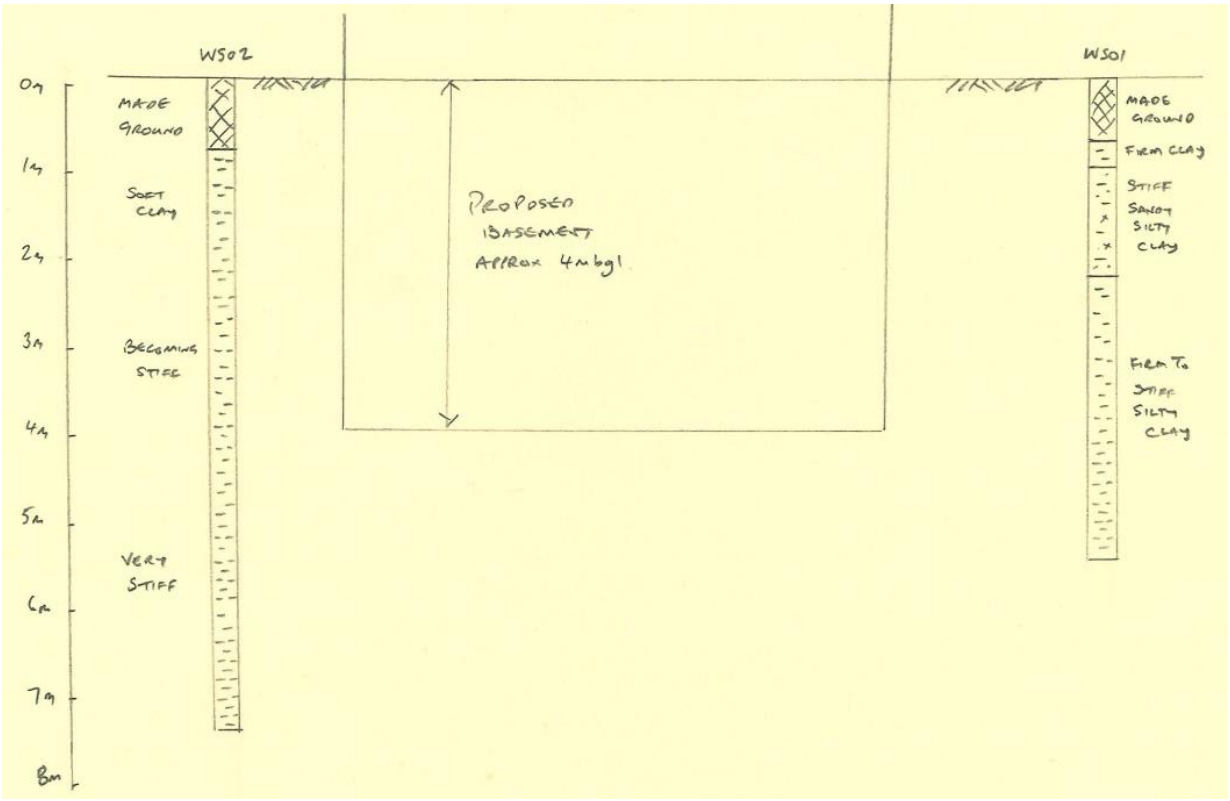
Two dynamic windowless sampling boreholes were undertaken at the property. WS01 was undertaken to a depth of 5.45mbgl at the front of the property and WS02 was undertaken to a depth of 7.45m at the rear of the property.

WS02 encountered Made Ground to a depth of 0.8mbgl and then London Clay to a depth of 7.45mbgl where the borehole was terminated. The consistency of the London Clay was soft near the surface becoming firm at 2.1mbgl and then stiff at 3mbgl and very stiff at 5.6mbgl.

WS01 encountered Made Ground to a depth of 0.7mbgl. Below this was 2.05m of slightly sandy silty stiff clay which is interpreted as the Claygate Member. The London Clay Formation was encountered below this strata to a depth of 5.45mbgl. The London Clay was firm to stiff.

No groundwater was encountered in the boreholes. A small amount of perched water was found in one of the trial pits.

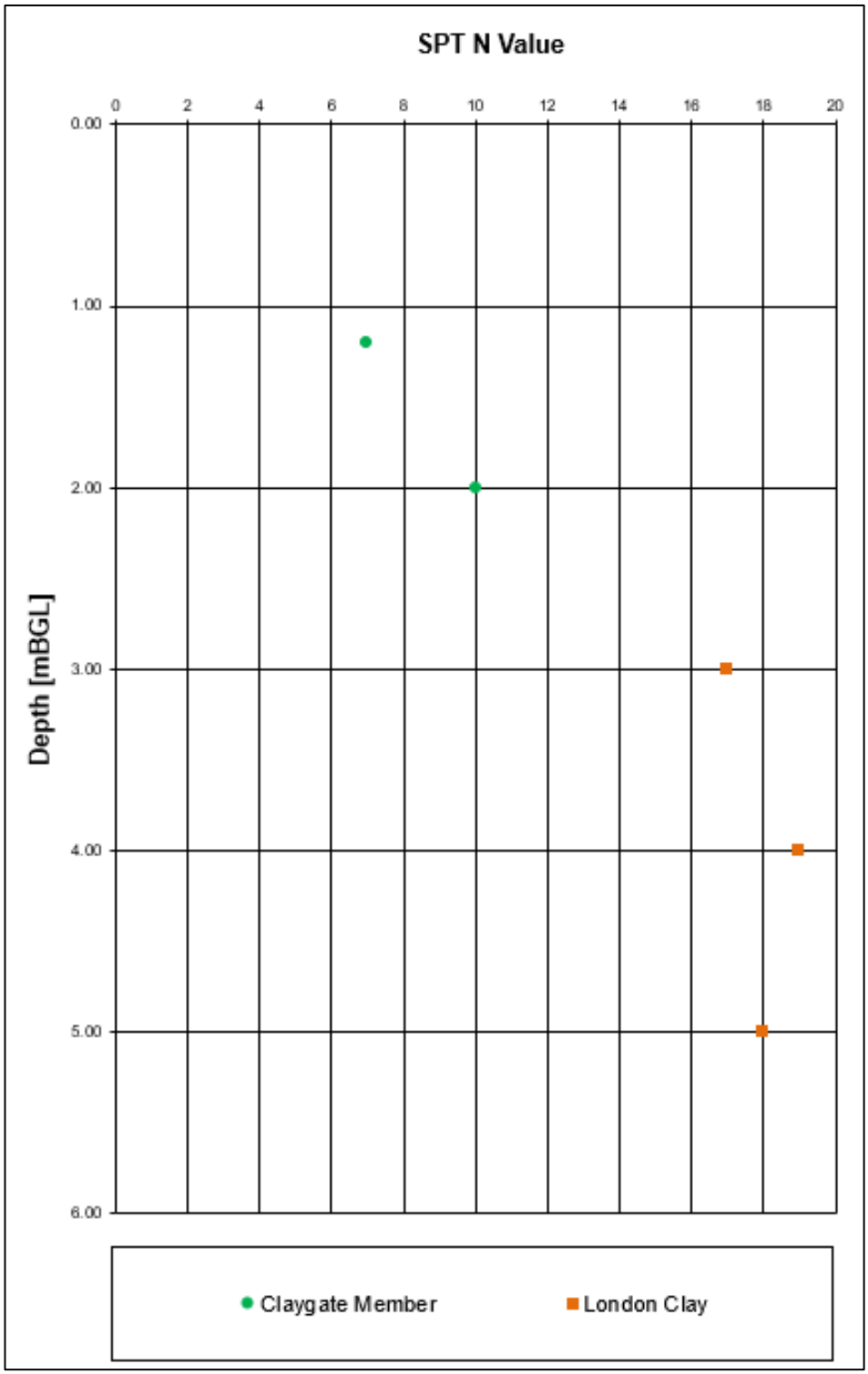
Figure 5.1-1: Cross-Section Through Site



5.1.1 In-Situ Testing

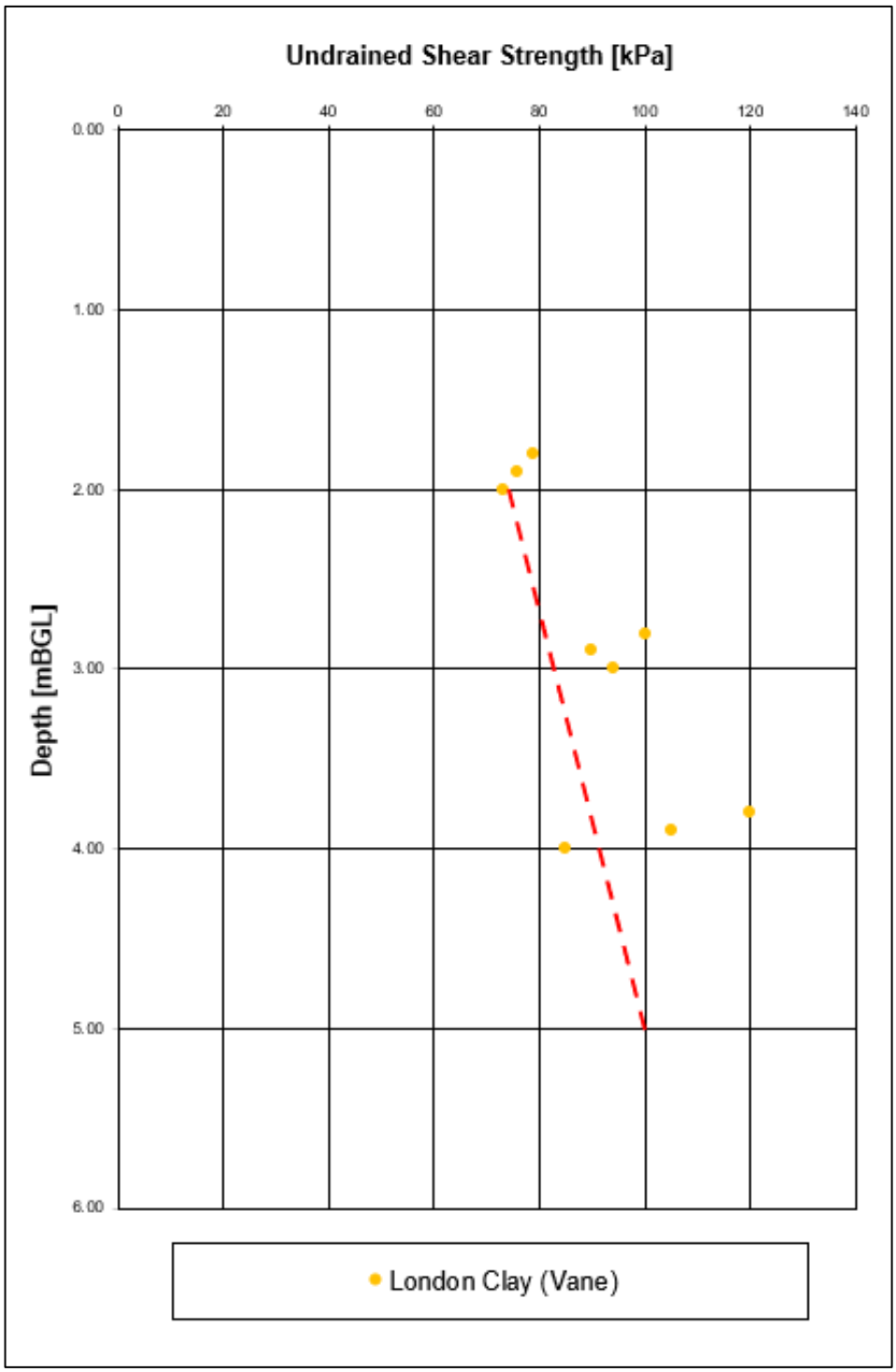
Standard penetration tests were undertaken within WS01 and WS02. The results for WS02 were not available at the time of writing the report. The results from WS01 are presented in Figure 5.1-2 below.

Figure 5.1-2: SPT Plotted Against Depth



Hand shear vane test were conducted on samples of soil retrieved from the boreholes. The results are presented in the figure below.

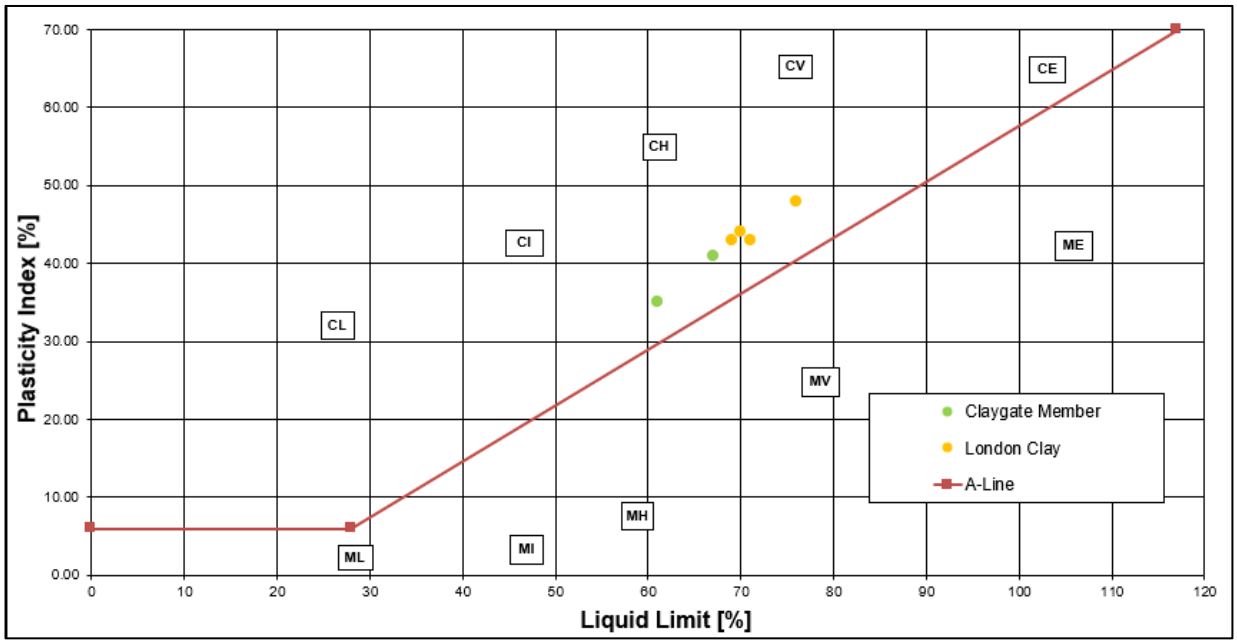
Figure 5.1-3: HSV Results Plotted Against Depth



5.1.2 Laboratory Testing

Atterberg limit testing was undertaken on samples taken from the Claygate Member and London Clay Formation. The results are presented below. The results show that the London Clay Formation is a high to very high plasticity clay. The Ground Investigation Report notes the London Clay Formation has a high volume change potential.

Figure 5.1-4: Plasticity Chart



5.1.3 Groundwater Monitoring

Slotted pipes were installed into the boreholes at the front and rear of the property to allow groundwater monitoring to be undertaken. No groundwater was encountered in either borehole during drilling. In London Clay there is generally no upper aquifer and no groundwater flow. Although pore water is present within the clay structure, it is not easy to determine the hydrostatic pressure without using advance pore pressure monitoring systems. It is possible that water is present within sand lenses within the London Clay Formation and this water could provide a source of water that imposes a water pressure on the basement.

The water levels in the standpipes were monitored on two occasions. Water was present in both boreholes. This water was bailed out and the level re-measured. There was no short-term change to the water level in the borehole after bailing. This would indicate that the water in the borehole is possibly surface water, or that the permeability of the soil is so low that re-establishment of a groundwater level would take a long time.

The ground levels at the front an rear of the property are approximately similar at the borehole positions but a 0.47m difference in the water level before bailing and a 1.34m difference in the water level after

bailing was noted. This would indicate that there is not a steady groundwater level at the property, as would be expected in coarser soils.

It was not possible to enter the rear of the property to monitor the level of the water in WS02 on the second visit.

Table 5.1-1: Results of Water Level Monitoring

Monitoring Date	Depth to Water Level from Initial Reading (m)		Depth to Water Level after Bailing Out Water (m)	
	WS01	WS02	WS01	WS02
21/06/23	1.33	1.80	4.91	6.25
10/07/23	3.94	N/A	4.92*	N/A

* water level rose to 4.90 after one hour

5.1.4 Presence of the Claygate Member

The borehole at the front of the property encountered approximately 2m of slightly sandy, silty clay. This was interpreted as the Claygate Member. However, this soil is a similar low permeability clay soil to the London Clay Formation and no groundwater was encountered in this layer.

The soils interpreted as the Claygate Member are at a shallow depth and did not contain any free water. A water table was not found to be present during the ground water monitoring i.e. no water was flowing into the borehole.

The suspected presence of the Claygate Member at the site is not considered to have any negative implications for the development due to the low permeability of the strata at this location and its shallow depth.

6 Construction Methodology / Engineering Statements

The proposed basement will be constructed within the footprint of the existing property. The excavation will be generally within the London Clay Formation. Approximately 2m of slightly sandy, silty clay was encountered at the front of the property which is interpreted as the Claygate Member. However, this soil is a similar low permeability clay soil and no groundwater was encountered in this layer. The basement will be used for habitable space.

Potential issues relating to excavation

- No groundwater was encountered in the boreholes during the ground investigation. A small amount of perched water was found in the Made Ground one of the trial pits. Perched groundwater within the Claygate Member or London Clay formation could be encountered during the excavation.
- The basement is not likely to have an impact on surface water so a hydrological assessment is not necessary.
- Since the basement is not within a flood risk area, a flood risk assessment is not necessary.

6.1 Outline Geotechnical Design Parameters

The following outline, reasonably conservative geotechnical parameters have been determined, based on the site investigation data presented in Section 5.1 and within the Ground Investigation Report. These values are provided for preliminary design only. The basement designer should make their own assessment of the ground conditions based on the information provided in the GIR.

Table 6.1-1: Outline Geotechnical Design Parameters

Strata	Bulk Density (kN/m^3)[1]	Undrained Shear Strength (kN/m^2)	Effective Cohesion (kN/m^2)	Drained Friction Angle (°)[2]
Claygate Member	20	40	0	22
London Clay Formation	20	75 - 100	0	22

[1] Estimated from Figure 2 BS8004:2015

[2] Estimated using Equation 8 BS8004:2015

6.2 Outline Temporary and Permanent Works Proposals

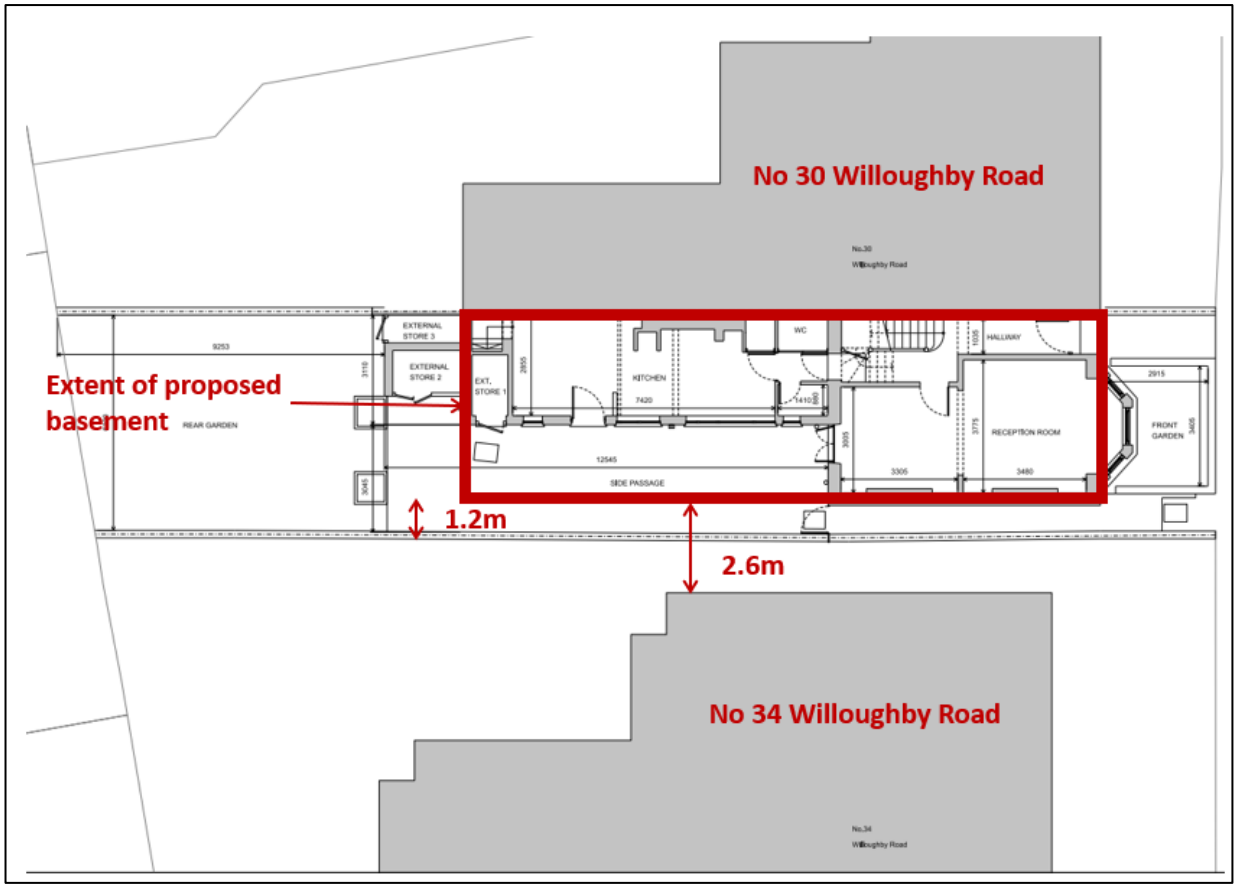
The proposed works include the creation of a new basement and the replacement of the rear extension with a new two and three storey extension. The foundations of the original Victorian property will be underpinned and a new box structure will be constructed to form the basement. A wine cellar will be constructed below the new basement.

A temporary embedded retaining wall could be used to support the excavation at the front and rear of the property. An assessment of the likely length of piles for a temporary excavation support has been undertaken. This indicates that a propped pile length of 9m would be suitable. This assessment is a preliminary assessment only and further detailed design calculations need to be undertaken to confirm the requirements for the temporary works. The results of the assessment are provided in Appendix 3.

6.3 Ground Movement and Damage Impacts Assessment

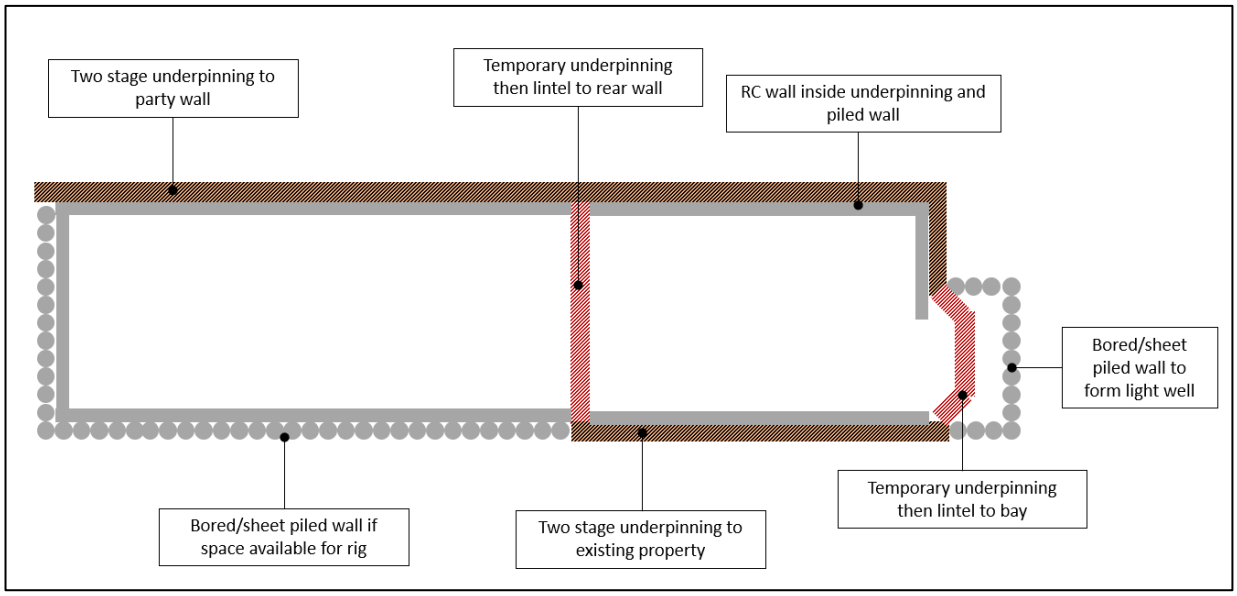
The proposed development is shown on the Joe Wright Architects drawings, which are provided in Appendix 1. In summary, it is proposed to construct an extension to the rear of the property and a basement below the full length of the extended property. The extent of the proposed basement is shown in Figure 6.3-1 below.

Figure 6.3-1: Extent of Proposed Basement



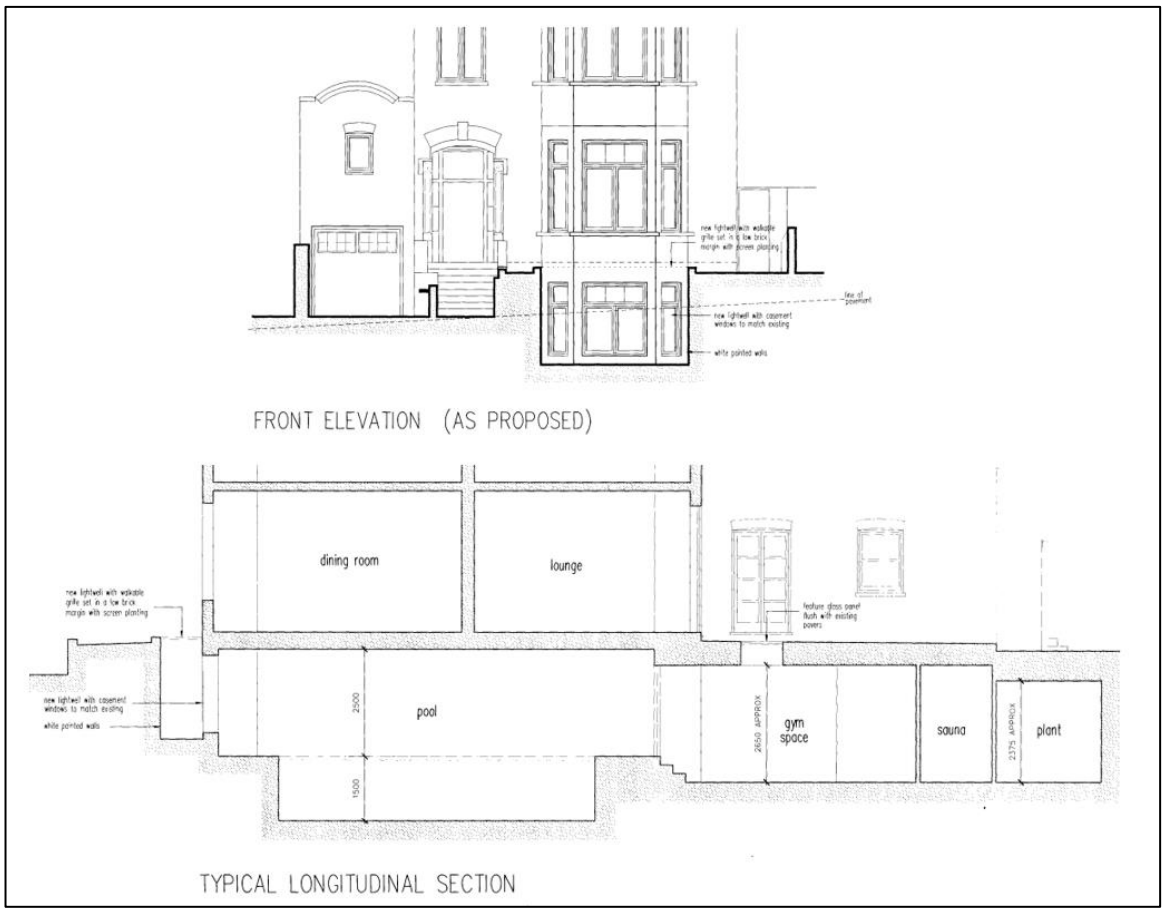
The proposed basement has a base level 4,055mm lower than the existing ground levels. The foundations of the existing property are approximately 500mm to 600mm below the existing ground level and will need to be underpinned. The sections of wall that will need to be underpinned are shown in Figure 6.3-2.

Figure 6.3-2: Proposals for Underpinning Existing Walls



Ground movements associated with the excavation works are anticipated to affect the party wall with No 30 Willoughby Road, the boundary wall between No 34 and No 32 and the property at No 34. The property at No 34 has a basement. The planning drawings for the basement show that it is approximately 4m below existing ground level at it's deepest part, which is similar to the basement proposed at No 32.

Figure 6.3-3: Planning Details for Basement at No 34 Willoughby Road



It is assumed that a suitably experienced specialist basement contractor will be appointed for the works, this contractor will be responsible for the design and implementation of the temporary works necessary to build the basement and ground floor.

Ground movements resulting from underpinning are not well documented and there is no specific method for assessing their magnitude. An assessment will be undertaken in accordance with CIRIA C760. Ground movement monitoring will be proposed to ensure the ground movements are in accordance with the estimated values.

The following aspects have been considered for the incorporation of the wine cellar below the basement.

- Change in strata of the foundation soil. The foundation soil is London Clay to a significant depth, so a deeper excavation would still be within the London Clay (+100m thick).
- Reduction in bearing capacity. The cellar is reasonably small and will not significantly affect the bearing resistance of the basement.
- Waterproofing. It is very important the waterproofing system for the basement also incorporates the wine cellar.
- Uplift. The additional volume of the cellar is relatively small and is unlikely to affect the stability with respect to buoyancy.

6.4 Movement Assessment

Assessment of the ground movement resulting from the excavation to form the basement has been undertaken with reference to CIRIA C760 Guidance on embedded retaining wall design (2017). To provide some basis for estimating likely movements and damage resulting from excavating the basement in front of the underpinning and in the absence of underpinning specific guidance, the underpinned sections have been treated as low stiffness retaining elements.

For the party wall the embedded length of the underpins will be wholly in firm to stiff London Clay, hence it is possible from C760 to estimate the horizontal and vertical movements that could be expected as a result of the underpinning construction and the excavation of the basements. It is assumed that a low stiffness support system will be applied to the underpins. This gives an approximate vertical and horizontal movement of approximately 15mm at the edge of the excavation. This aligns well with an estimate of 5mm to 10mm of vertical and horizontal movement for each stage of underpinning.

The calculations for movement are provided in Appendix 2.

The movements given by C760 are for excavations with long straight walls, corners tend to limit movements, such that horizontal deflections towards an excavation in the vicinity of a corner to the excavation are typically reduced to about half that predicted. Hence, given the limited dimensions of the proposed excavations and likely effect the corners will have, the predicted movements given in Table 6.4-1 are likely to be conservative.

Table 6.4-1: Summary of Anticipated Ground Movement

Structures/ Infrastructure	Distance from Excavation (m)	Horizontal Movement (mm)	Vertical Movement (mm)
Party Wall Between 32/30	0	16.2	14.2
Garden wall between 34/32	1.2	15.0	10.5
Nearest part of No 34	2.6	13.0	8.9
Public Highway	3.0	12.6	8.5

Oasys XDisp has also been used to calculate the ground movements around the excavation. The software can be used to determine the Burland Damage Category for adjacent structures. The results of the vertical and horizontal movements are presented in Appendix 4. These align closely with the values calculated in Table 6.4-1.

Other than a small amount of perched water, groundwater was not encountered during the 2022 ground investigation it is considered unlikely that large amount of groundwater will be encountered within the basement excavation, rather localised perched water, which should be dealt with as they are encountered.

The work should be carried out in accordance with the Party Wall Act 1996 and pre-condition surveys of the adjacent properties will be required.

All properties within the zone of influence have been assessed. Foundation depths have been confirmed during the ground investigation as approximately 500mm to 600mm below existing ground level.

6.5 Damage Category

Oasys XDisp has been used to assess the likely damage to adjacent buildings in accordance with the approach proposed by Burland and Wroth.

The results of building damage assessment are presented in Table 6.5-1.

Table 6.5-1: Summary of Building Damage Assessment

Structure	Elevation	Damage Category	Category of Damage	Typical Damage	Crack Width
30 Willoughby Road	Party wall	3	Moderate	Cracks require some opening up and can be repaired by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be	5 – 15mm

				replaced. Doors and windows sticking. Service pipes may fracture. Weather tightness often impaired	
30 Willoughby Road	Front elevation	1	Very Slight	Cracks easily filled. Redecorating probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weather tightness. Doors and windows may stick slightly	<5mm
34 Willoughby Road	Side elevation	0	Negligible	Hairline cracks	<0.1mm
34 Willoughby Road	Front elevation	0	Negligible	Hairline cracks	<0.1mm

6.6 Monitoring

It will be necessary to monitor the impact of the works on the adjoining properties and the public highway to ensure that movements are not excessive. The monitoring should comprise the following;

- Visual inspection of the properties at No 34 and No 30 and recording any pre-existing cracking
- Visual inspection of the party wall between No 32 and No 30 and recording any pre-existing cracking
- Attachment of tell tales to accurately record movement of any pre-existing cracks
- Installation of levelling targets to monitor settlement of the party walls and the public highway, to be monitored by standard optical equipment.

The levelling targets on the party wall should be no greater than 2m apart and located as close to the top of the existing foundations as possible. The maximum allowable movement should be no more than 3mm between adjacent levelling targets.

The limits on maximum movement and proposed actions are given in the table below:

Table 6.6-1: Action Levels for Daily Ground Monitoring

Movement	Category	Action
0 - 5 mm	Green	No action required
5 – 15 mm	Amber	Crack monitoring: Carry out local structural review; Preparation for the implementation of remedial measures should they be required
>15 mm	Red	Crack monitoring: Implement structural support as required; Cease works with exception of necessary works for the safety and stability of the structure and personnel; Review monitoring data and implement revised method of works

Monitoring should be undertaken at daily intervals during excavation works.

6.7 Control of Construction Works

The construction works will be monitored in accordance with the guidance provided in Section 6.5.

6.8 Construction Programme

A construction programme will be made available by the main contractor to Planning and Building Control.

6.9 Construction Sequence

The proposed layout of underpins is shown in Figure 6.3-2. The existing party wall, and the front, rear and side walls of the original property will be underpinned. The underpinning works will be carried out with the traditional 1, 3, 5, 2, 4 and 6 sequence of underpins to ensure that no more than 20% of the existing building wall is unsupported at any time. Underpinning shall be fully packed to the underside of existing wall foundation with dry pack mortar soon after the concrete has gone off.

The embedded retaining walls to the side and front of the property can be either bored pile retaining walls or driven sheet piles. The choice of method will probably be governed by the available access for construction equipment and materials. These should be designed by a competent person and installed by and appropriately experienced contractor. The design should include an assessment of the ground movement during excavation in front of the retaining walls to confirm that this is within acceptable limits.

Figure 6.9-1: First Stages of Underpinning

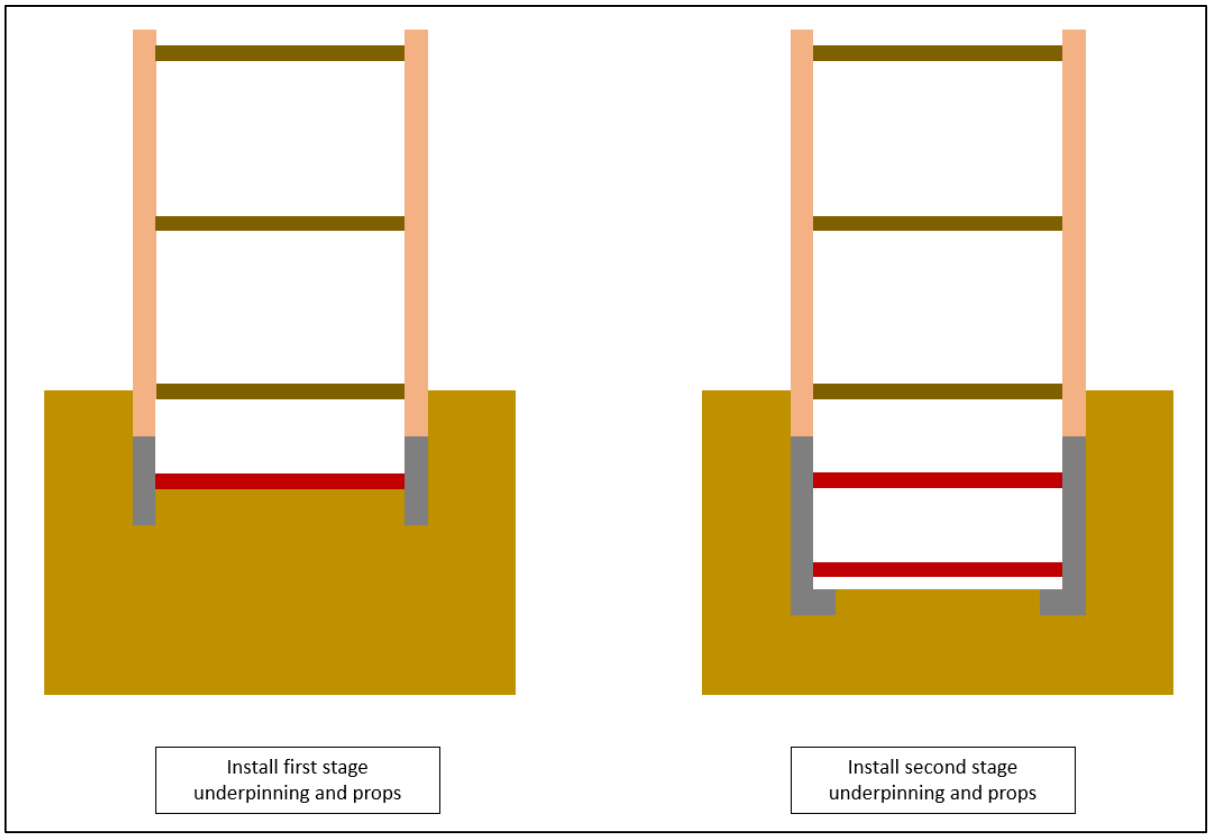


Figure 6.9-2: Construction of Box

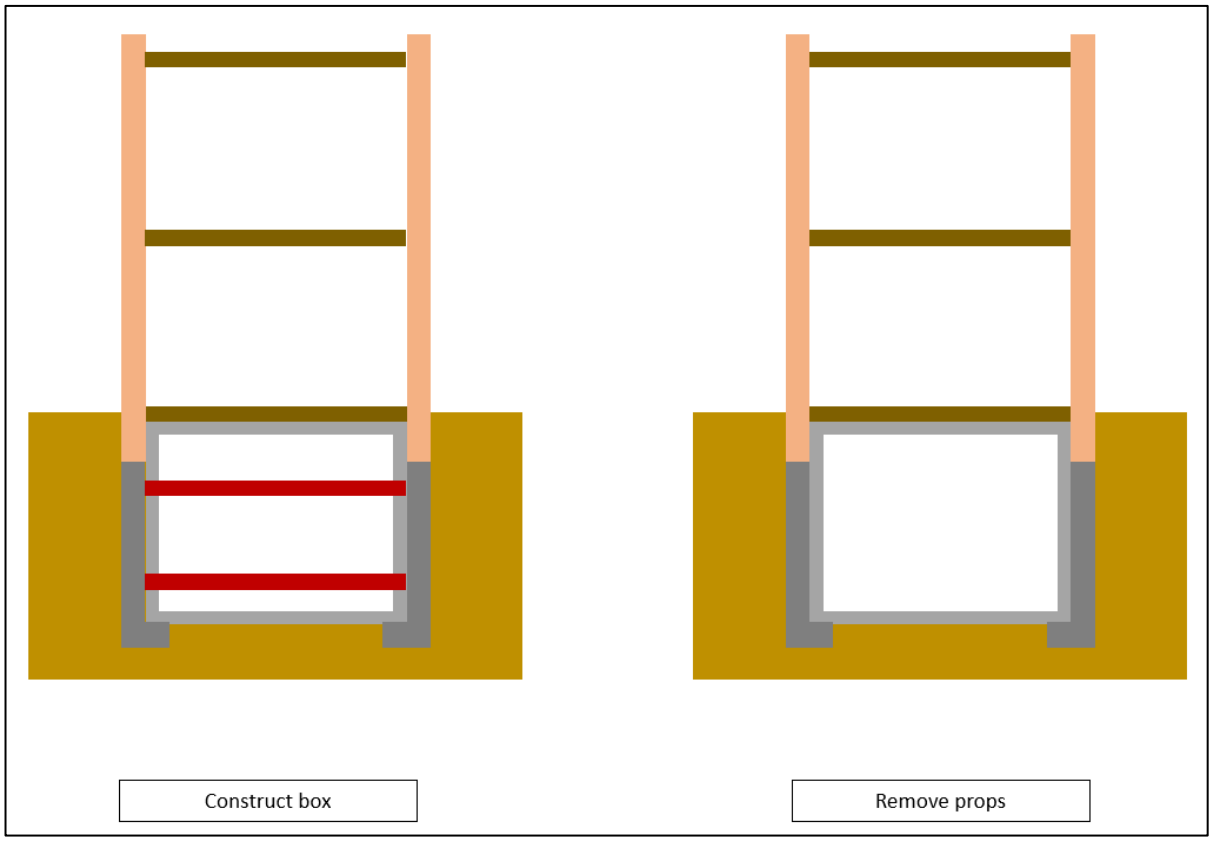
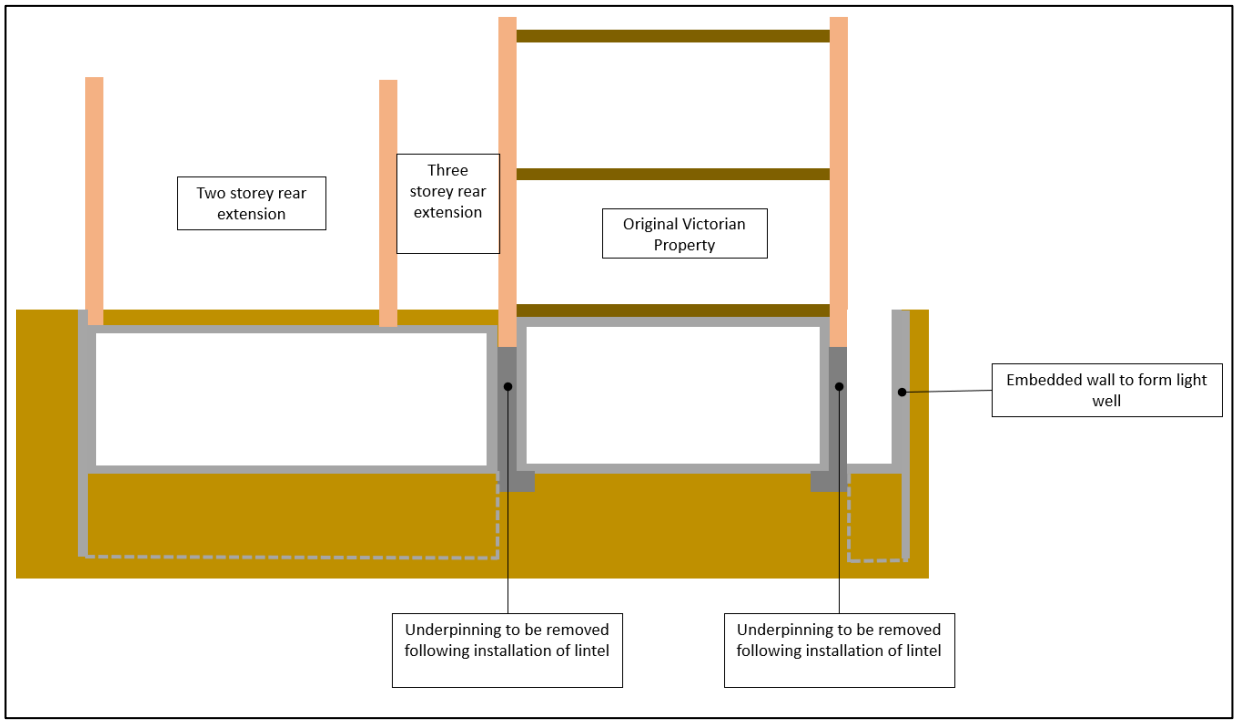


Figure 6.9-3: Long Section Through Basement



The proposals shown in the figures above are indicative only, the final design and implementation of the temporary works will be the design of the appointed contractor. Note: The appointed contractor may wish to vary the proposed sequence of works but this will be finalised prior to construction commencing on site.

A full structural design for the permanent and temporary works will need to be provided before any works commence on site.

6.10 Construction Management

6.10.1 Site Security and Access

All boundaries to the site will be protected with timber hoarding to ensure containment of the construction activities throughout the duration of the project. The hoarding will display the details of the main companies involved in the scheme and the emergency contact details. Any plant and vehicular movements through the construction phase will be scheduled to minimise the street congestion and the effects on immediate neighbours, so far as reasonably practical.

The parking of contractor's vehicles will be off site and on the local highways.

6.10.2 Site Personnel

The site workforce will be familiar with this type of work and supervised by competent personnel at all stages of the work.

6.10.3 Recycling and Disposal of Waste

A waste management plan will be prepared to address the re-use and recycling of the material arising from demolition, excavation and construction stages.

6.10.4 Contractor's Compound

The area at the front of the property will be used as the contractor's compound. Additional material storage may take place in the rear garden.

As far as reasonably possible the levels of noise and dust pollution will be kept to normal standards.

7 Basement Impact Assessment

An assessment has been made of the potential impacts of the proposed basement construction at No. 32 Willoughby with respect to groundwater, surface water, slope stability and ground movement. This assessment does not constitute a detailed structural design for the basement.

Given that the natural topography of the area is relatively flat it is considered that the proposed basement will not have an impact on the overall slope stability within the area.

From the screening process three questions returned ‘yes’ answers and will require particular attention to be paid during the construction process. These questions can be dealt with by the adoption of an appropriate structural design and appropriate construction techniques.

With regard to impact on the adjacent properties and the public highway, it is considered that the expected movement will not be excessive. It should be possible to ensure that degree of damage to these properties would fall into Category 0, 1 or 3, with the degree of severity being negligible to moderate, as defined CIRIA C580 Table 2.5 (after Burland, 1995), which in relation to damage to the buildings would equate to cracks require some opening up which can be repaired by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork may be required and possibly a small amount of brickwork to be replaced. Doors and window could stick and may require some adjustment. Service pipes could fracture. These would need to be monitored during construction. Weather tightness could be impaired.

Hence, it is concluded, based upon the information currently available, that the proposed basement could be constructed employing appropriate construction methods without significant impact on the surface water, groundwater or ground stability.

8 References

[1] CPG Basements, London Borough of Camden, January 2021

[2] Camden geological, hydrogeological and hydrological study, Guidance for subterranean development, Ove Arup & Partners, November 2010

[3] CIRIA C580 Embedded retaining walls, 2003

[4] CIRIA C760 Guidance on embedded retaining wall design, 2017

[5] Assessment of risk of damage to buildings due to tunnelling and excavation, Burland J B, 1995

[6] Ground movements resulting from urban tunnelling: predictions and effects, Rankin W J, 1988

[7] BS 5030: 2020 Code of practice for ground investigations, British Standards Institution

[8] BS 8004:2019 Code of practice for foundations, British Standards Institution

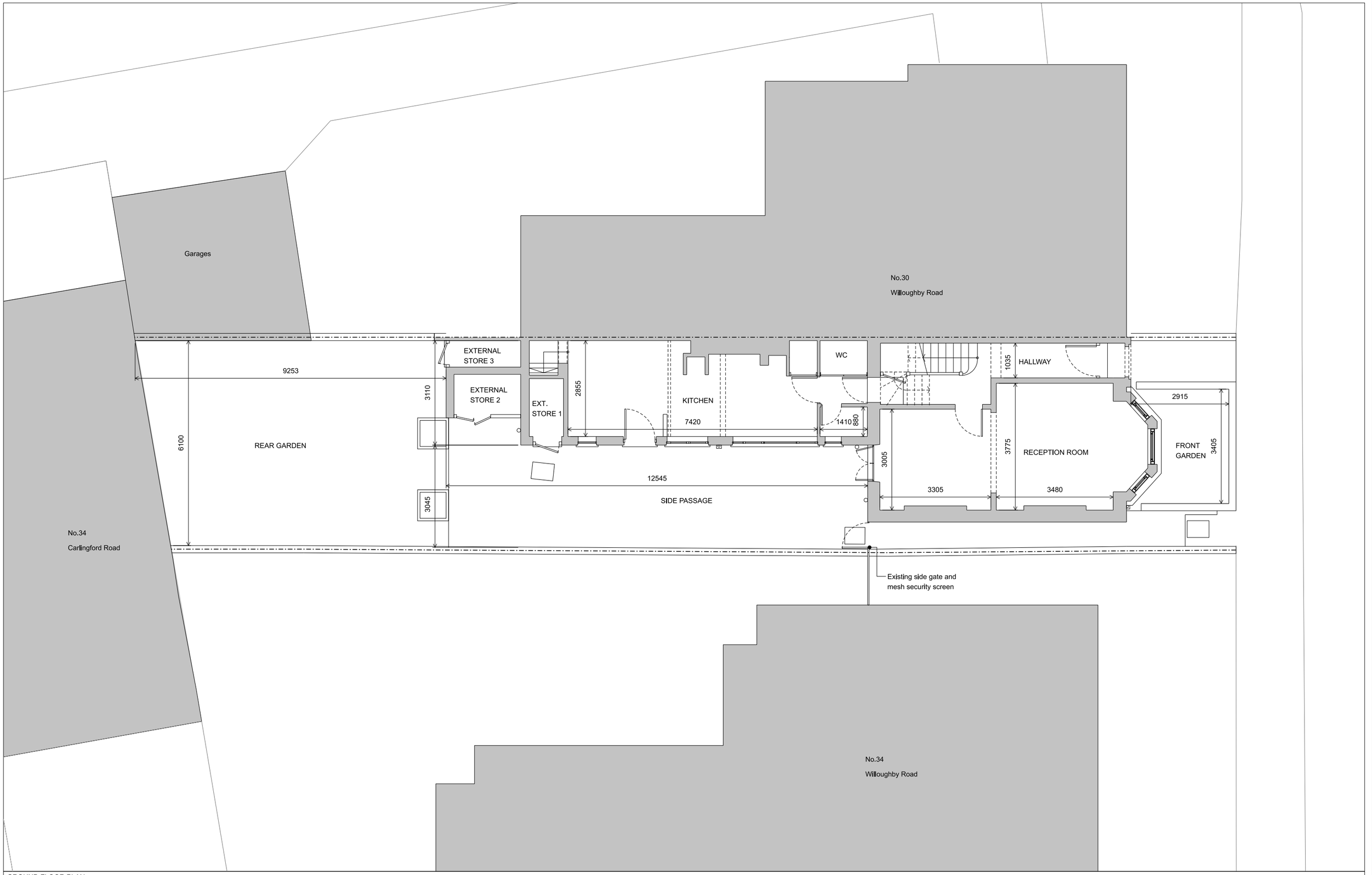
[9] BS 10175:2011+A2:2017, Investigation of potentially contaminated sites – Code of practice, British Standards Institution

[10] BS EN 1997-2:2007 Eurocode 7 — Geotechnical design — Part 1: Ground investigation and Testing Incorporating corrigendum June 2010

[11] BS EN 1997-2:2007 Eurocode 7 — Geotechnical design — Part 2: Ground investigation and Testing Incorporating corrigendum June 2010

[12] BRE Special Digest 1:2005, Concrete in Aggressive Ground, BRE

Appendix 1: Drawings Existing & Proposed Details



GROUND FLOOR PLAN

Rev:

0m 1 2 3 4 5

N

Notes: Unless stated otherwise, all dimensions are in millimetres. All dimensions to be checked and confirmed on site by contractor and as such are to be his responsibility. Any errors, omissions or discrepancies on this drawing are to be reported to the architect.

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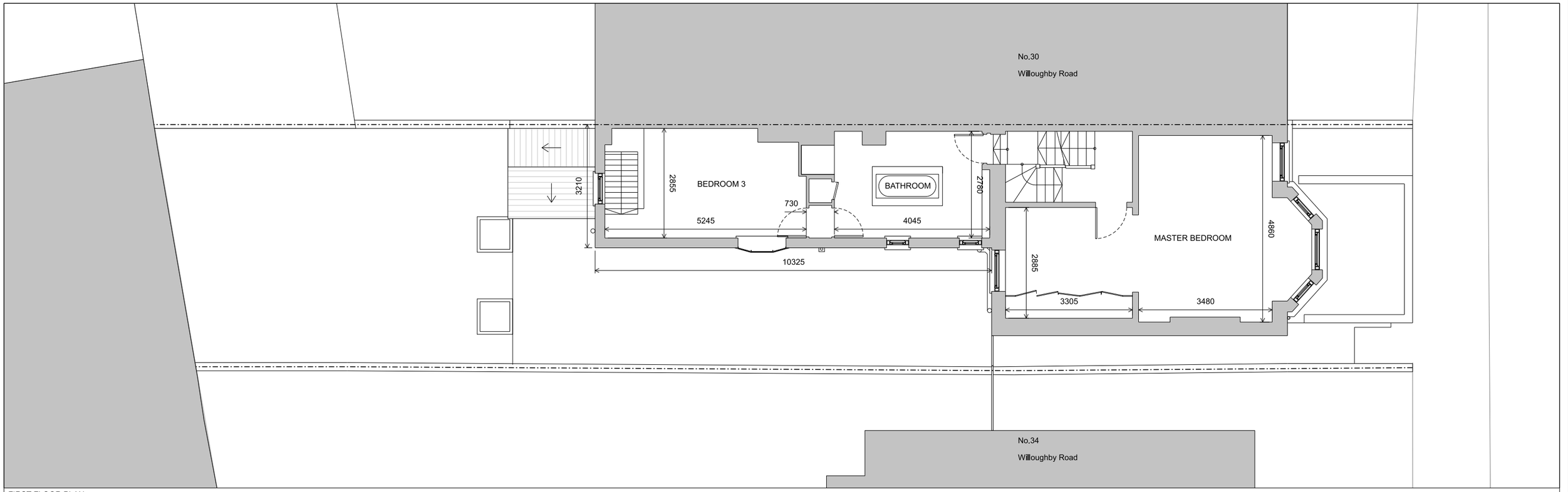
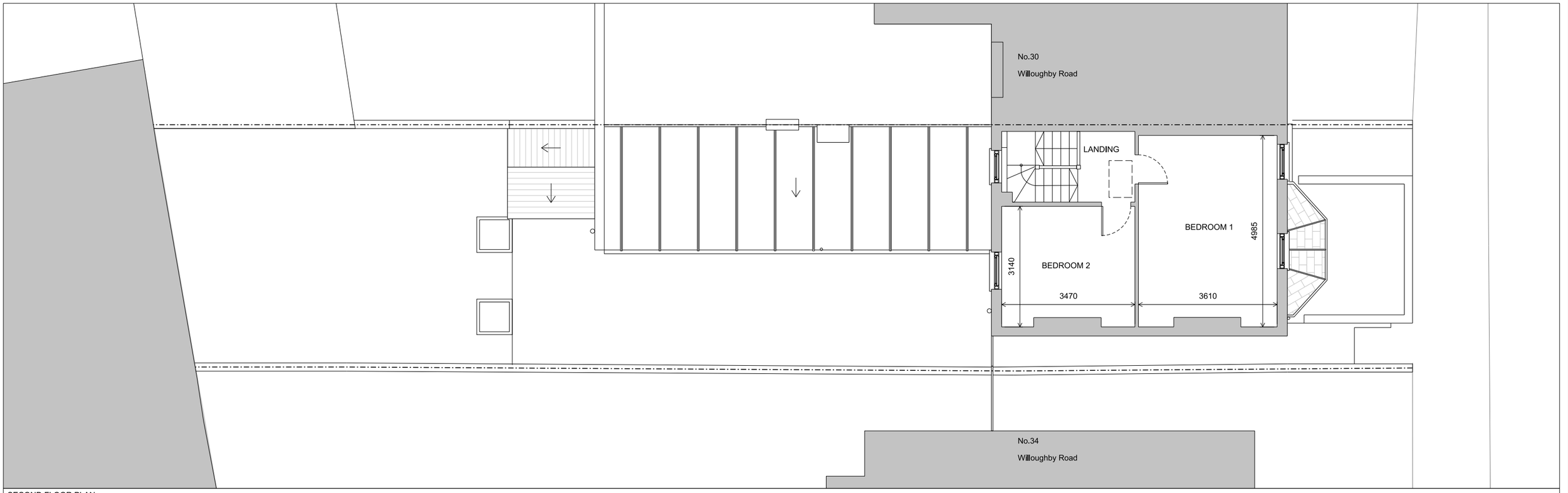
Project: 32 Willoughby Road, NW3 1RU		Scale: 1:100 @ A3	Date: 14.06.22
Drawing Title: Existing Drawing Plans		Drwg No: 2104-01_PL_001	Rev: E



FIRST FLOOR PLAN



SECOND FLOOR PLAN

Rev:

0m 1 2 3 4 5

N

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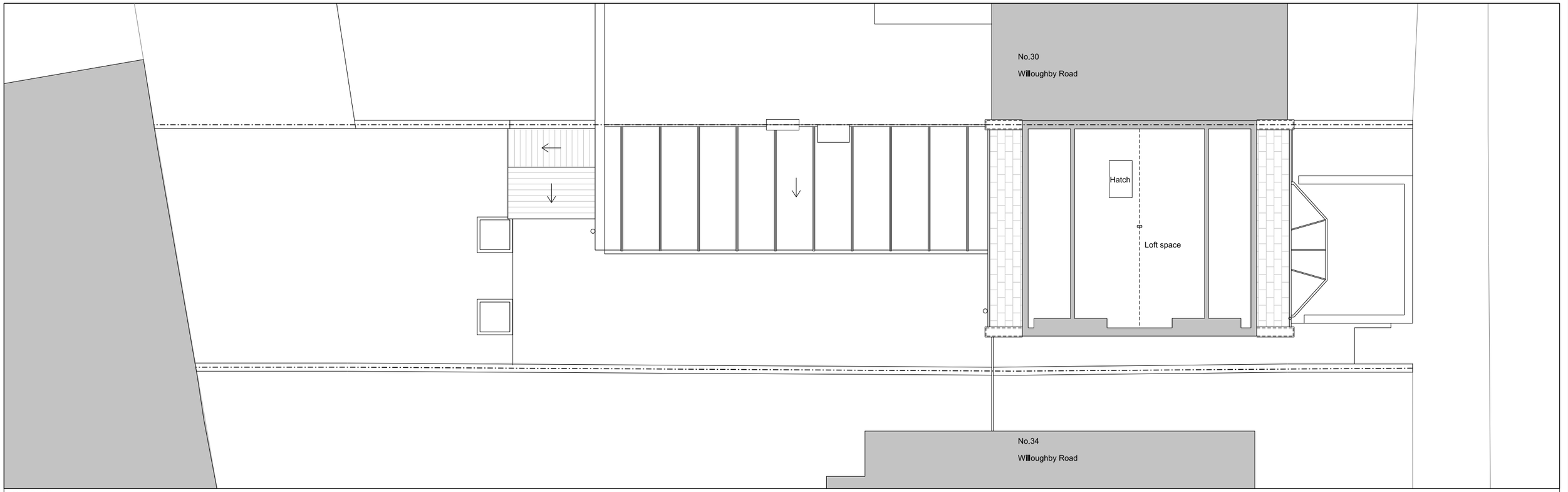

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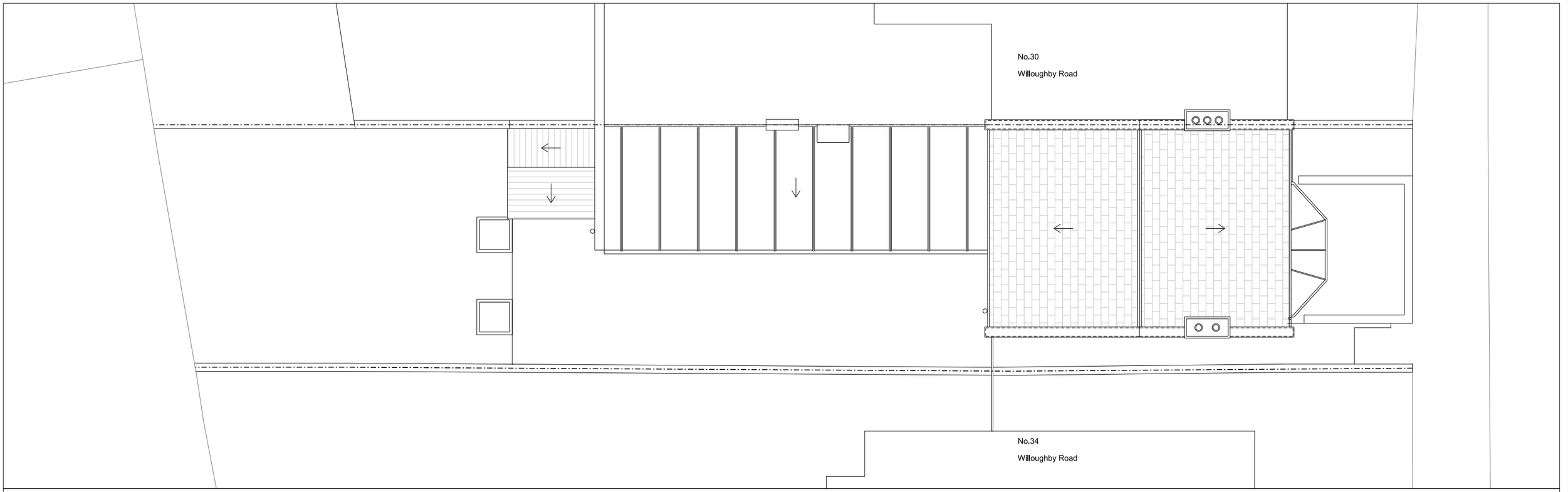

ROOF PLAN

Rev:

0m 1 2 3 4 5

N

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Drawing Title: Existing Drawing Plans

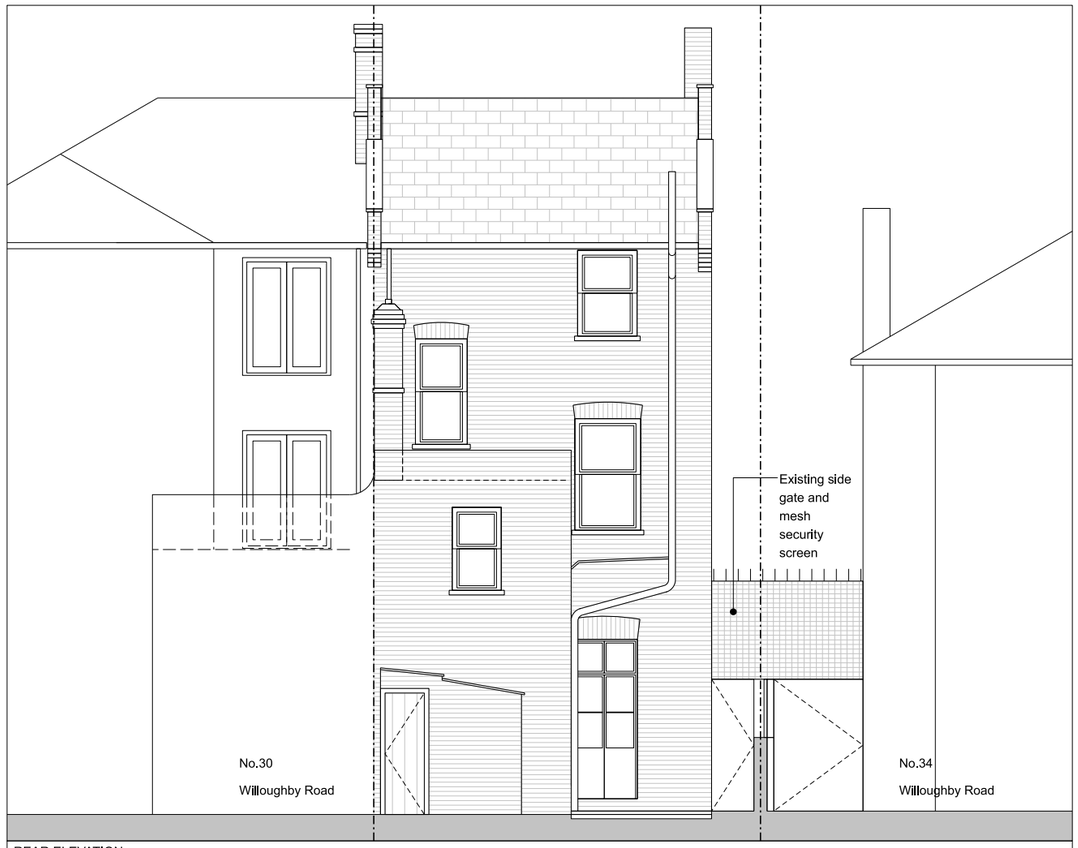
Scale: 1:100 @ A3

Drwg No: 2104-01_PL_003

Date: 14.06.22

Rev: E

FRONT ELEVATION



REAR ELEVATION

SIDE ELEVATION

Notes:

Unless stated otherwise, all dimensions are in millimetres.

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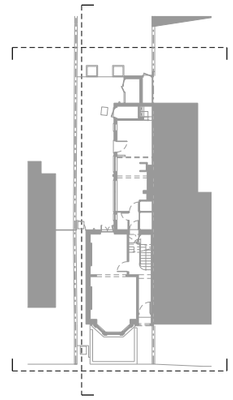

WILLOUGHBY ROAD

KEY PLAN

Rev:

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Project:	32 Willoughby Road, NW3 1RU
Drawing Title:	Existing Drawing Elevations
Scale: 1:100 @ A3	Date: 12.05.22
Drwg No: 2104-01_PL_004	Rev: D

SECTION AA

SECTION BB

Notes:

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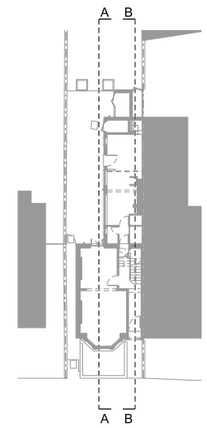

WILLOUGHBY ROAD

KEY PLAN

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Project: 32 Willoughby Road, NW3 1RU

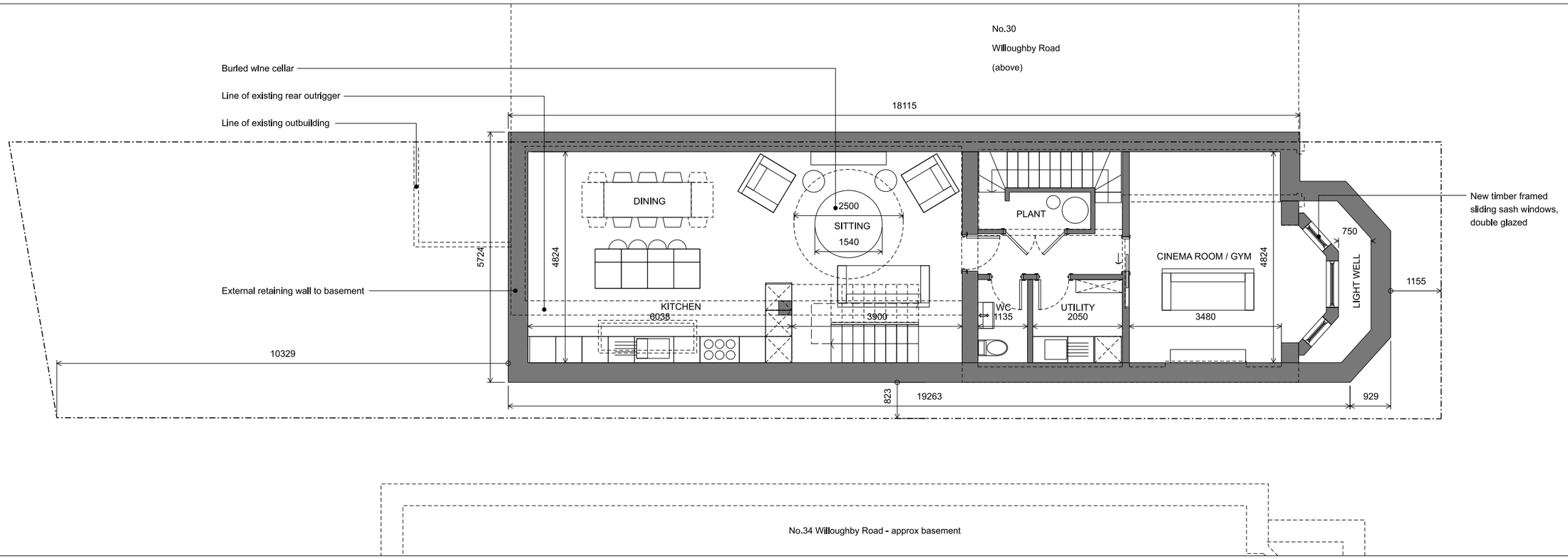
Drawing Title: Existing Drawing
Sections

Scale: 1:100 @ A3

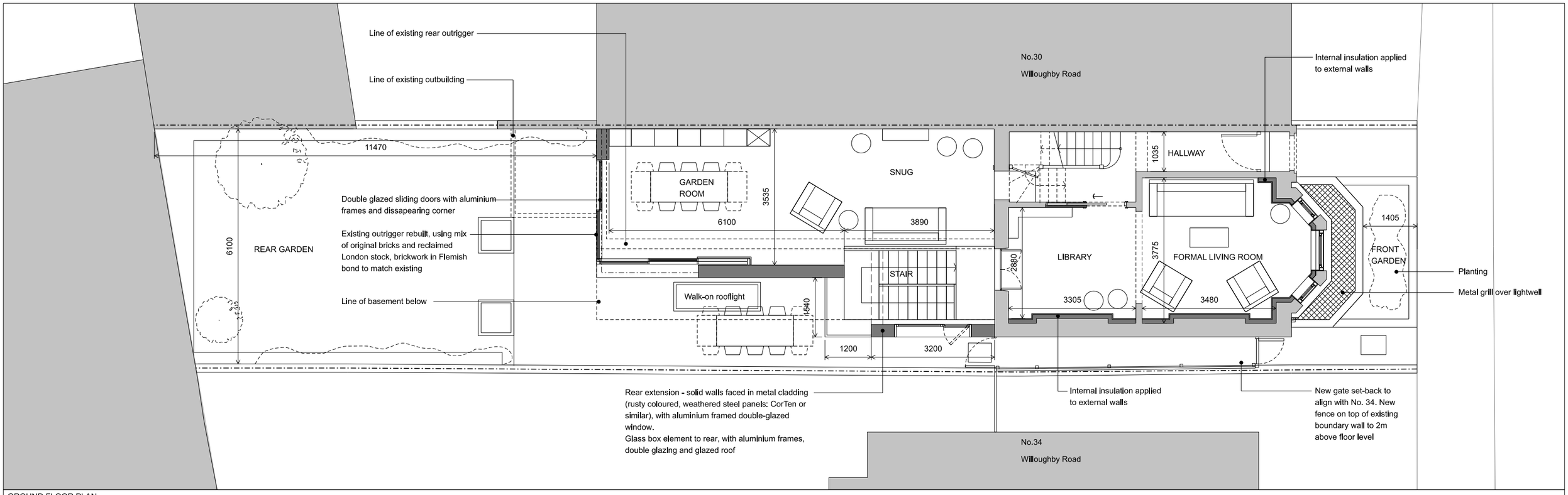
Date: 14.06.22

Drwg No: 2104-01_PL_005

Rev: E



BASEMENT PLAN



GROUND FLOOR PLAN

Rev:

0m 1 2 3 4 5

N

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Project: 32 Willoughby Road, NW3 1RU		Scale: 1:100 @ A3	Date: 29.03.2023
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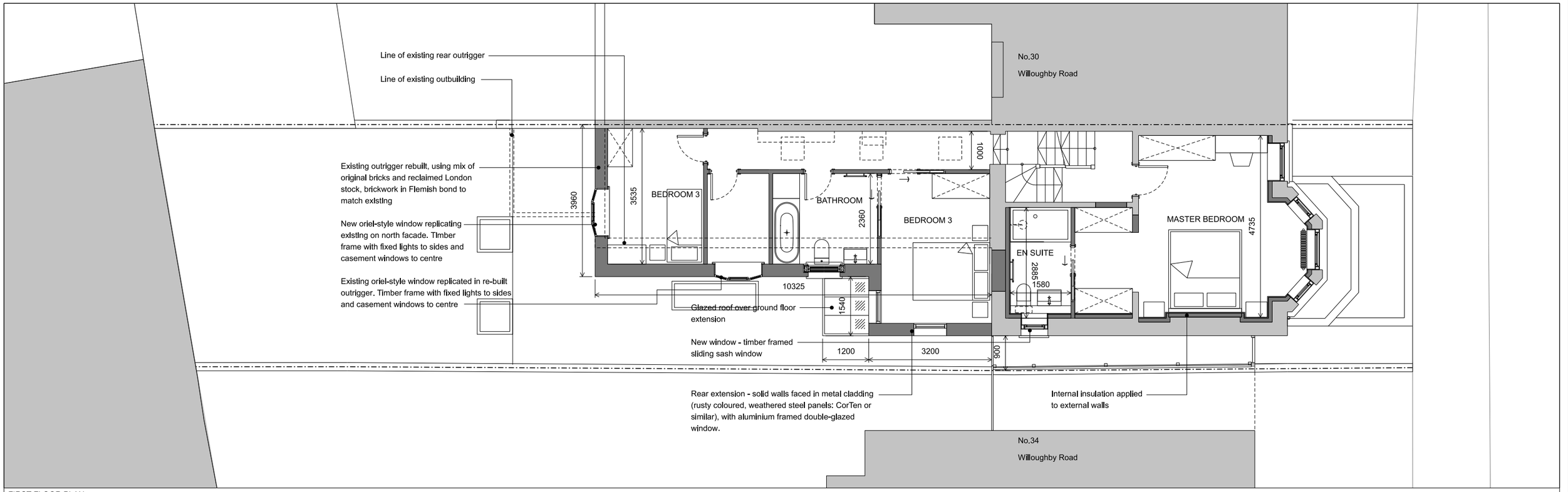
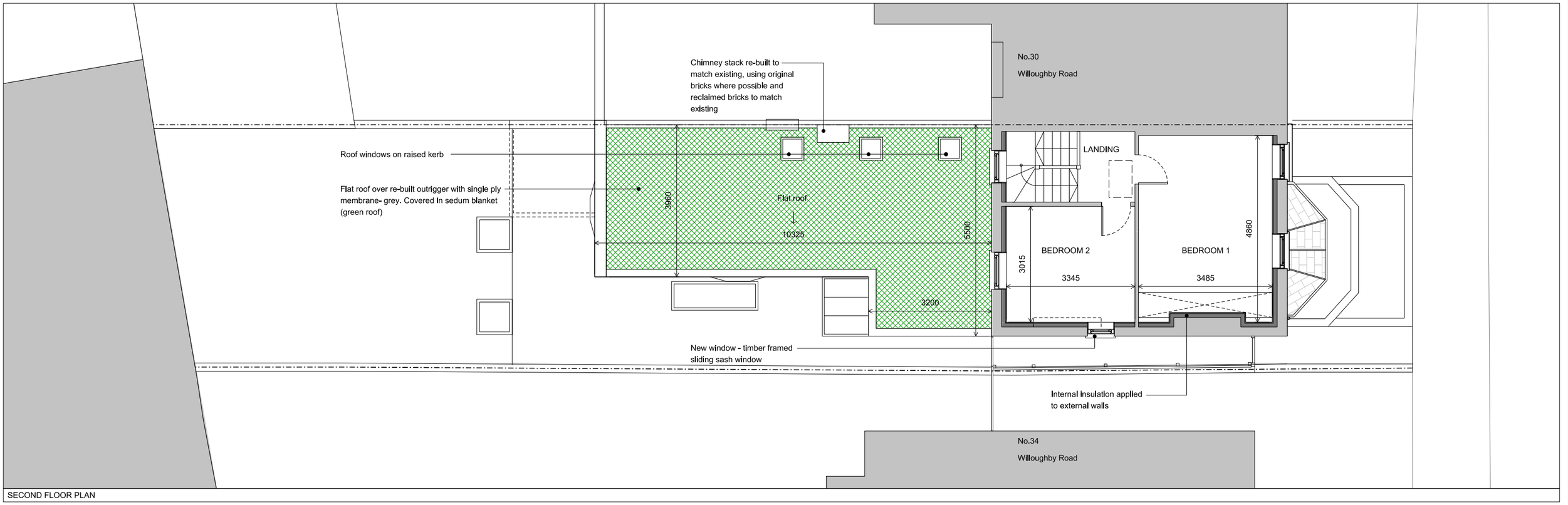


FIRST FLOOR PLAN



SECOND FLOOR PLAN

Rev:

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0m 1 2 3 4 5

N

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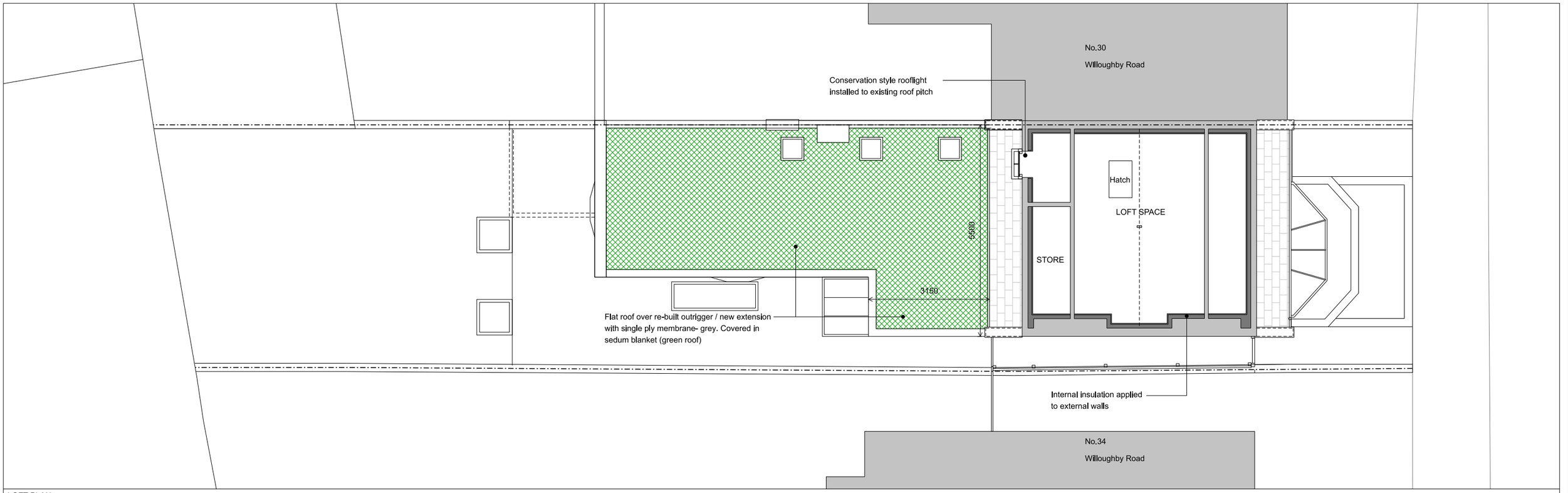
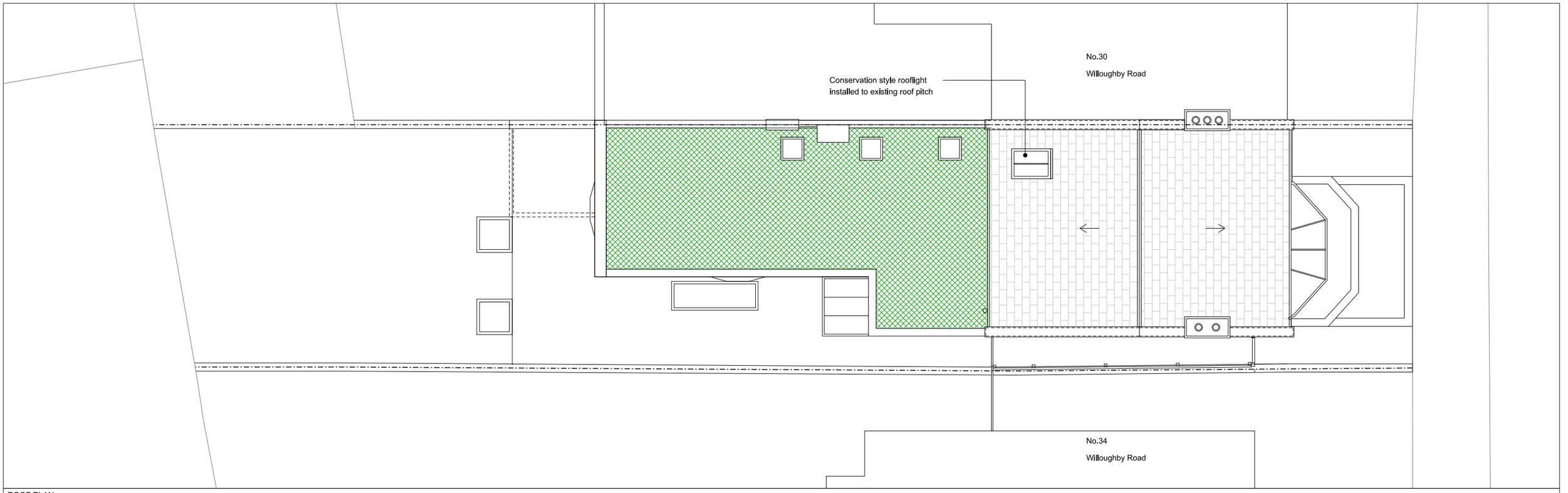
Project: 32 Willoughby Road, NW3 1RU		Scale: 1:100 @ A3	Date: 21.02.2023
Drawing Title: Proposed Drawing 1F & 2F Plans		Drwg No: 2104-01_PL_202	Rev: C



LOFT PLAN



ROOF PLAN

Rev:

0m 1 2 3 4 5

N

Notes: Unless stated otherwise, all dimensions are in millimetres. All dimensions to be checked and confirmed on site by contractor and as such are to be his responsibility. Any errors, omissions or discrepancies on this drawing are to be reported to the architect.

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Project: 32 Willoughby Road, NW3 1RU		Scale: 1:100 @ A3	Date: 21.02.2023
Drawing Title: Proposed Drawing 3F & Roof Plans		Drwg No: 2104-01_PL_203	Rev: -

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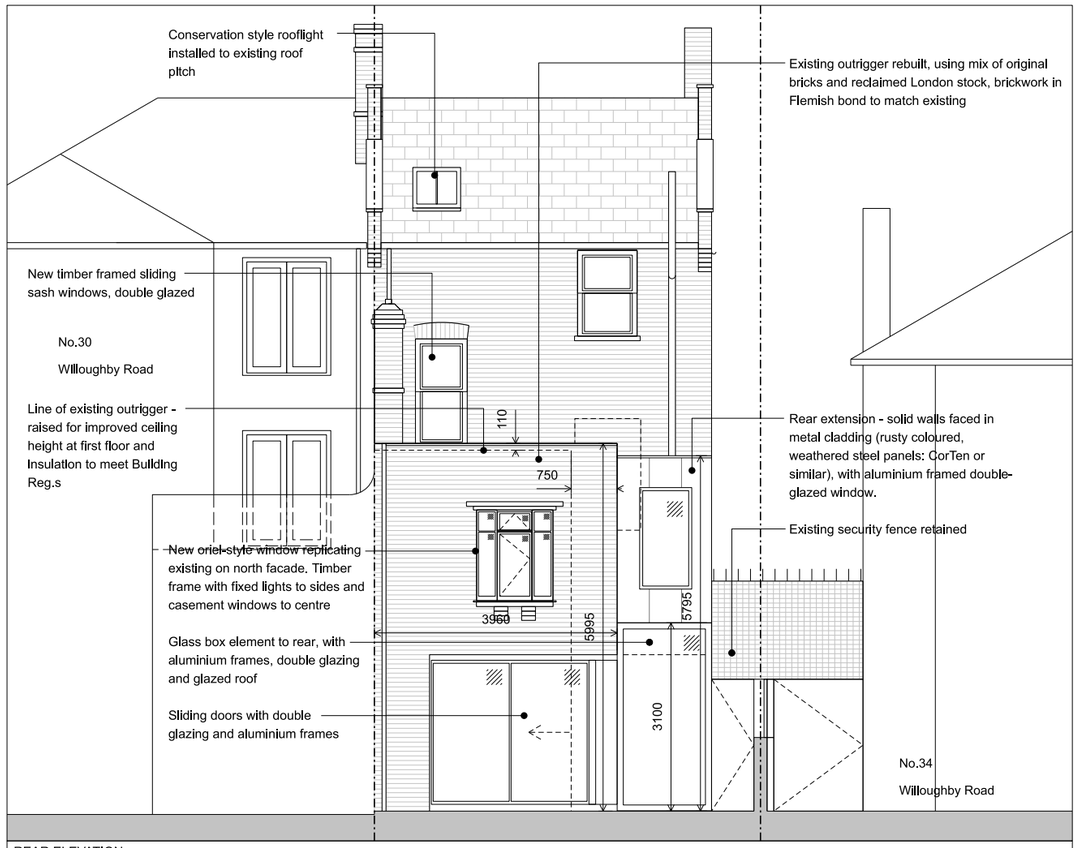
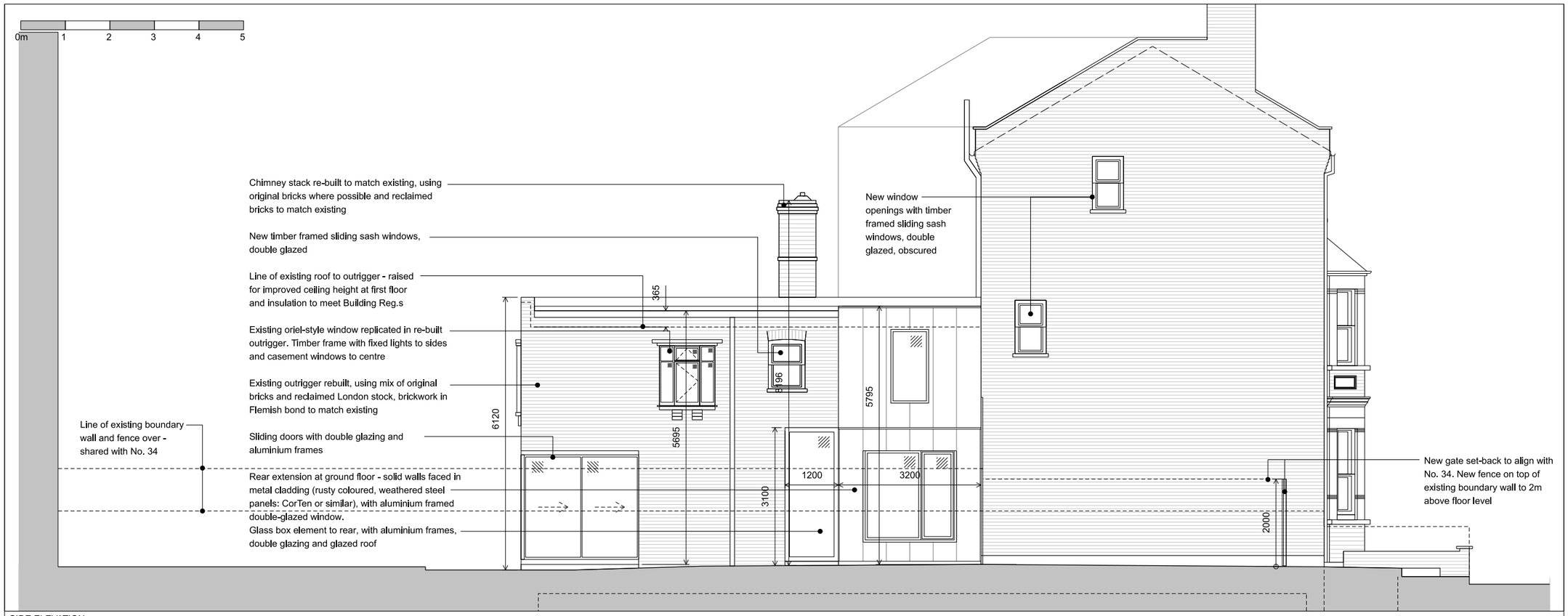


REAR ELEVATION



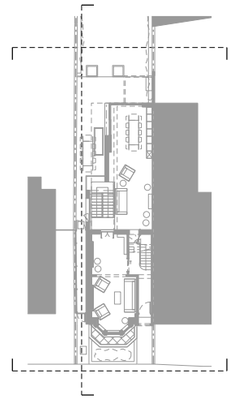
SIDE ELEVATION

Notes:

Unless stated otherwise, all dimensions are in millimetres.

All dimensions to be checked and confirmed on site by contractor and as such are to be his responsibility.

Any errors, omissions or discrepancies on this drawing are to be reported to the architect.



WILLOUGHBY ROAD

KEY PLAN

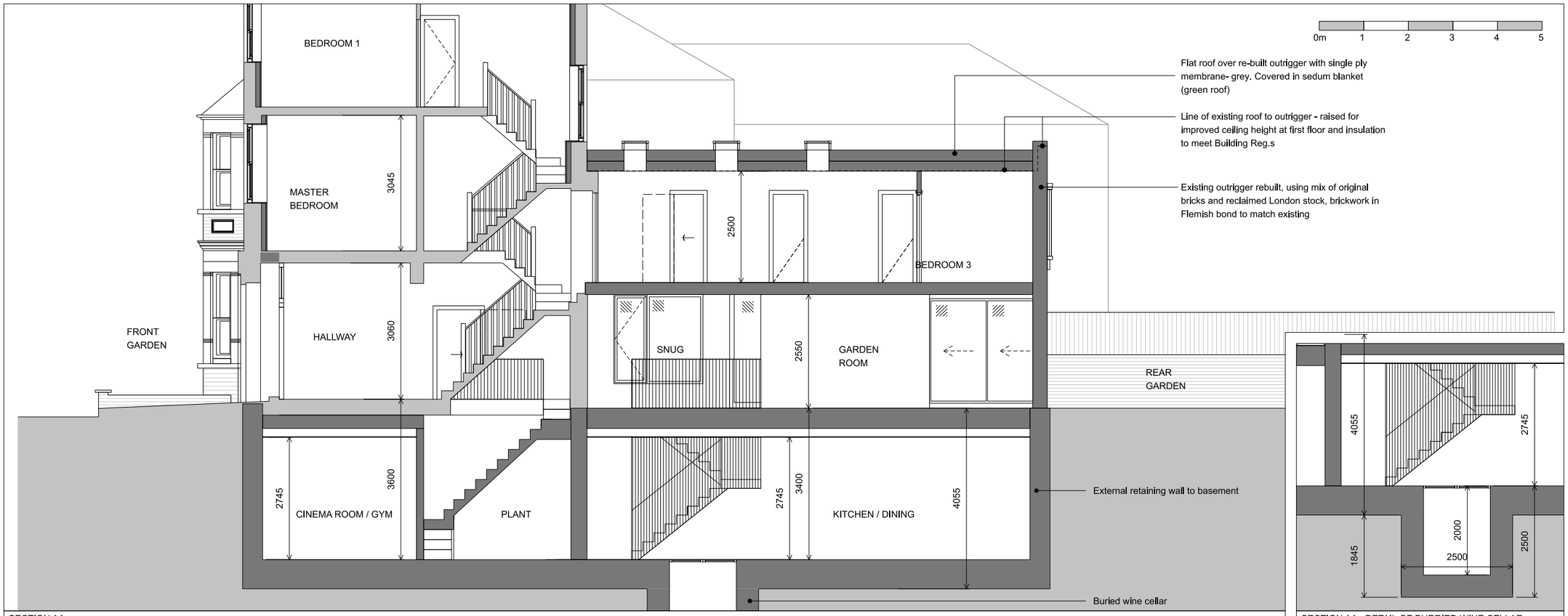
N

Rev:

JOE WRIGHT ARCHITECTS

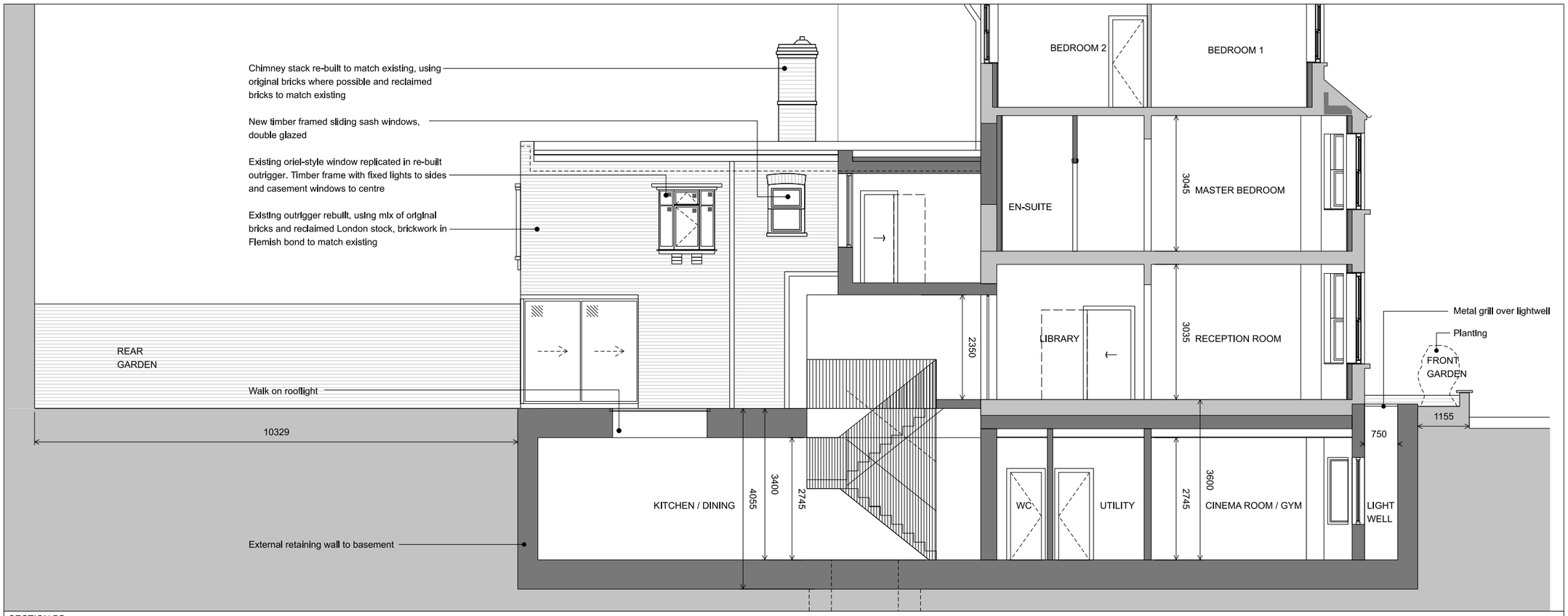
i: www.joewrightarchitects.co.uk e: info@joewrightarchitects.co.uk

Project:	32 Willoughby Road, NW3 1RU
Drawing Title:	Proposed Drawing Elevations
Scale: 1:100 @ A3	Date: 21.02.2023
Drwg No: 2104-01_PL_204	Rev: C



SECTION AA

SECTION AA - DETAIL OF BURRIED WINE CELLAR



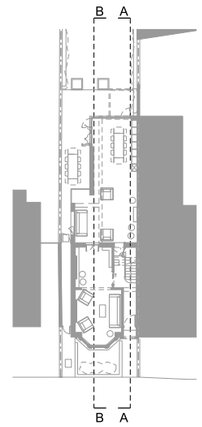
SECTION BB

Notes:

Unless stated otherwise, all dimensions are in millimetres.

All dimensions to be checked and confirmed on site by contractor and as such are to be his responsibility.

Any errors, omissions or discrepancies on this drawing are to be reported to the architect.



WILLOUGHBY ROAD

KEY PLAN

N

Rev:

JOE WRIGHT ARCHITECTS
t: www.joewrightarchitects.co.uk e: info@joewrightarchitects.co.uk

Project: 32 Willoughby Road, NW3 1RU

Drawing Title: Proposed Drawing
Sections

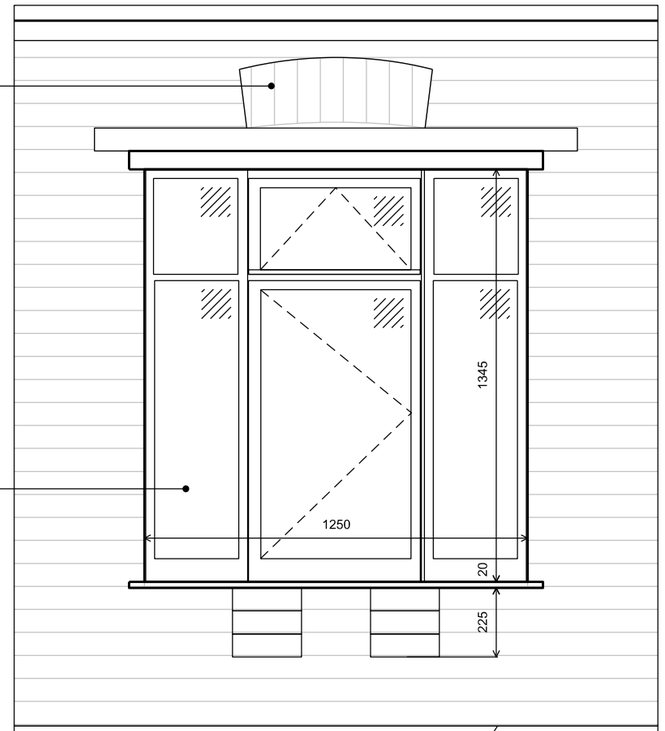
Scale: 1:100 @ A3

Date: 29.03.2023

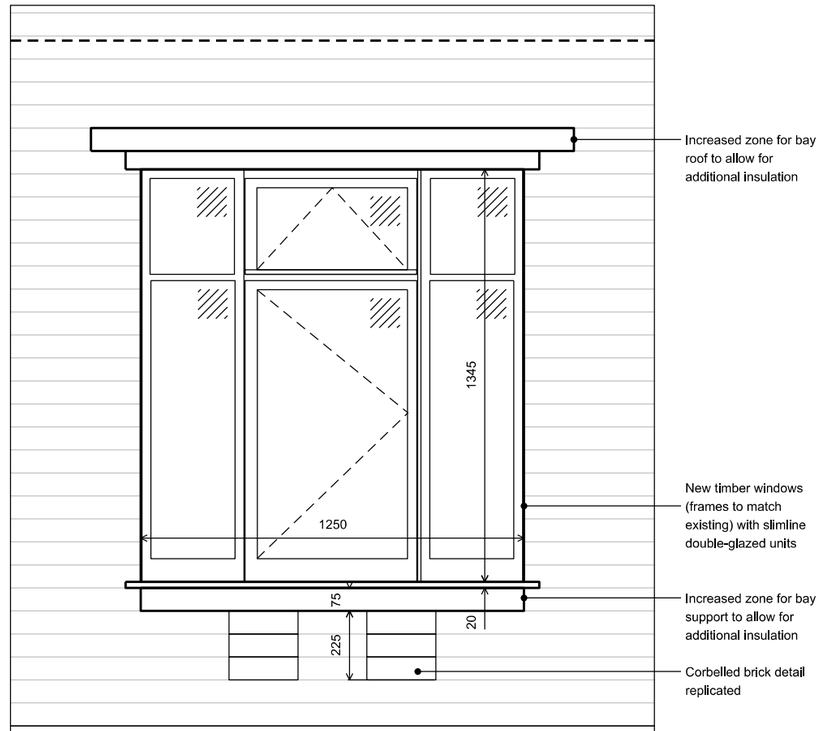
Drwg No: 2104-01_PL_205

Rev: D

0m 0.5m 1m



EXISTING ORIEL WINDOW



PROPOSED ORIEL WINDOW

Notes:

Unless stated otherwise, all dimensions are in millimetres.

All dimensions to be checked and confirmed on site by contractor and as such are to be his responsibility.

Any errors, omissions or discrepancies on this drawing are to be reported to the architect.

Rev:

JOE WRIGHT ARCHITECTS

i: www.joewrightarchitects.co.uk e: info@joewrightarchitects.co.uk

Project: 32 Willoughby Road, NW3 1RU

Drawing Title: Oriel Window
Comparison Existing and Proposed

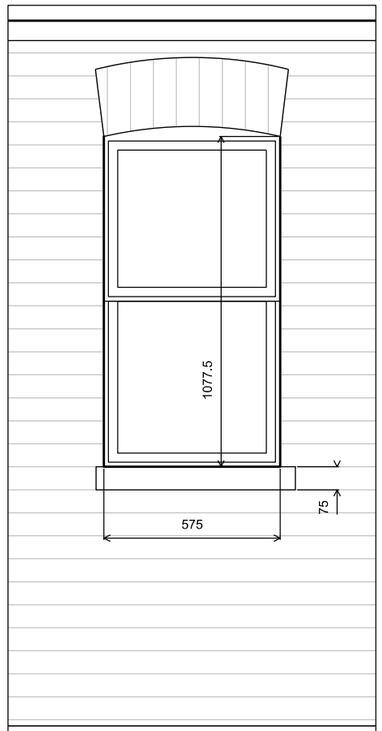
Scale: 1:20 @ A3

Date: 22.08.22

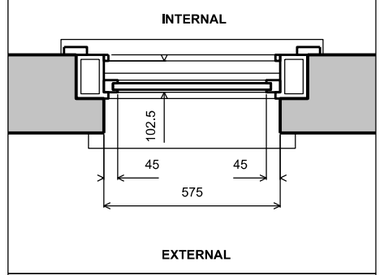
Drwg No: 2104-01_PL_110

Rev: B

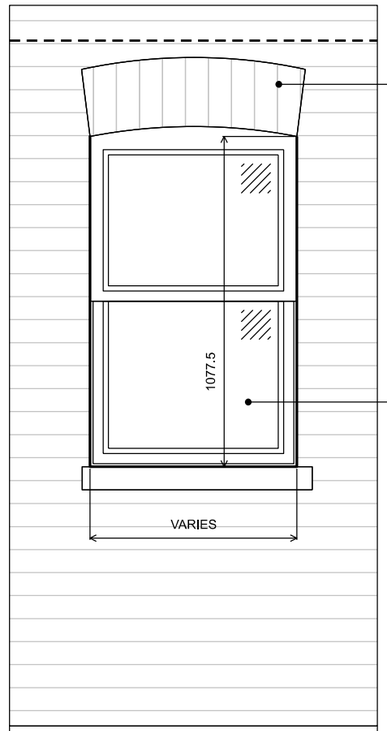
0m 0.5m 1m



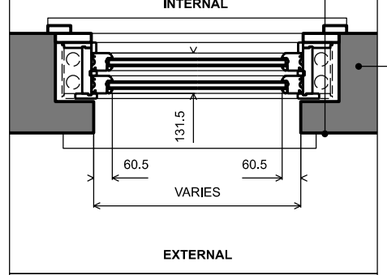
All dimensions of existing window approximate only, based on site survey infromation and visual assessment of thicknesses of elements



EXISTING TYPICAL SASH WINDOW



All dimensions of proposed window subject to final manufacturer's details



PROPOSED TYPICAL SASH WINDOW

Notes:

Unless stated otherwise, all dimensions are in millimetres.

All dimensions to be checked and confirmed on site by contractor and as such are to be his responsibility.

Any errors, omissions or discrepancies on this drawing are to be reported to the architect.

Rev:

JOE WRIGHT ARCHITECTS
i: www.joewrightarchitects.co.uk e: info@joewrightarchitects.co.uk

Project: 32 Willoughby Road, NW3 1RU

Drawing Title: Sash Window
Comparison Existing and Proposed

Scale: 1:20 @ A3

Date: 09.08.22

Drwg No: 2104-01_PL_111

Rev: A

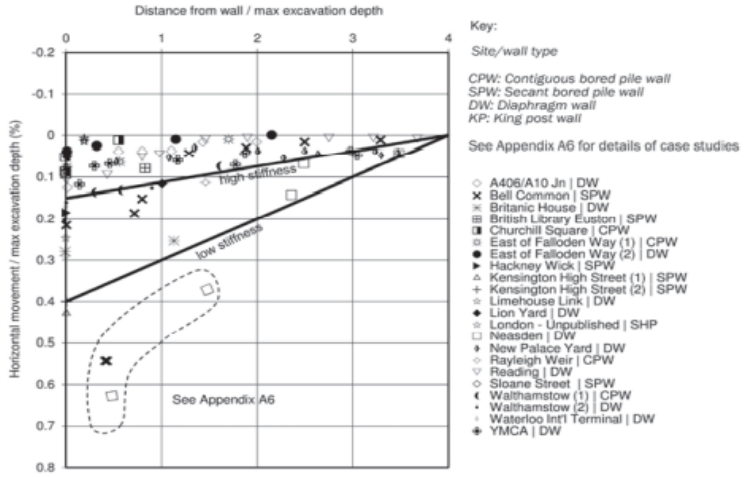
Appendix 2: Movement Calculation

1) Basement excavation

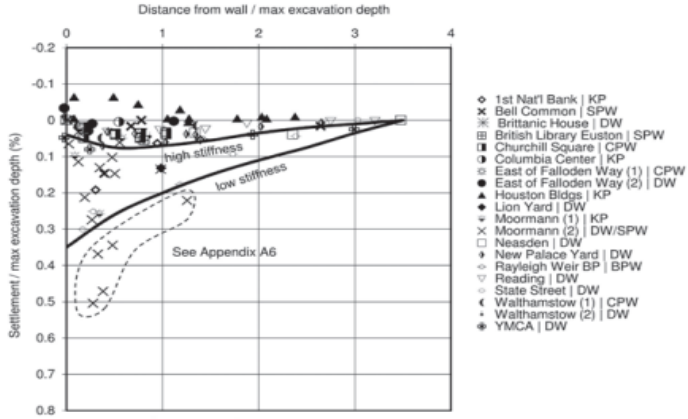
Max excvation depth 4.055 m

From Figure 6.15 P168 C760; assuming low support stiffness

Dist From Wall (m)	Dist From Wall / wall depth	Hor Mov/Wall Depth (%)	Hor Mov (mm)	Settlement / Wall Depth (%)	Vertical Settlement (mm)
0	0.0	0.4	16.2	0.35	14.2
0.7	0.2	0.38	15.4	0.3	12.2
1.2	0.3	0.37	15.0	0.26	10.5
2.6	0.6	0.32	13.0	0.22	8.9
3	0.7	0.31	12.6	0.21	8.5
4.4	1.1	0.28	11.4	0.18	7.3
5.6	1.4	0.25	10.1	0.12	4.9
6.3	1.6	0.21	8.5	0.11	4.5
7.4	1.8	0.18	7.3	0.1	4.1
11.1	2.7	0.05	2.0	0	0.0
14.8	3.6	0	0.0	0	0.0



a Horizontal movements



b Vertical movements

Appendix 3: Embedded Retaining Wall Assessment

Pile geometry

Pile top Level	0	m
Pile Length	9	m
Pile toe level	-9	m

Soils and ground water initial data (Soils data given for active and passive sides)

Initial Ground Water level 0

Top Level m	Description	Bulk Dens kN/m3	Sat' Dens kN/m3	Young Mod kN/m2	Young Inc. kN/m3	Cu C' kN/m2	C Inc. kN/m3	Phi Deg	Wall Shear Ratio	Ka Kp	Kac Kpc
.00	New Soil	18.00	20.00	30000	0	50				1.00 1.00	2.00

Water pressure profiles

	Active Actual Level	Active Water Level	Passive Actual Level	Passive Water Level
Water pressure profile 1	0.00	0.00	-4.00	-4.00

Construction sequence

Stage Ref		Stage Type	Level or Angle m/deg.	Load kN(/m)	Offset m	Width m	Length m
1	A	Passive side excavation	-2.00				
2		Insert prop	-0.50				
3	A	Passive side excavation	-4.00				
4	A	Water profile 1					
5	A	Active surcharge	0.00	15.0	.0		

Code of practice

Code of practice or reference document	Eurocode 7 ULS Design Approach 1 Combination 2
Application of pressures for stability	Not applicable for FOS=1 on moments
FOS on moments (stability check)	1.00
ULS factor on Tan(Phi) values	1.25
ULS fFactor on drained cohesion values	1.25
ULS factor on undrained cohesion values	1.40
ULS factor on active soil pressures	1.00
ULS factor on passive soil pressures	1.00
ULS factor on active water pressures	1.00
ULS factor on passive water pressures	1.00
ULS factor on loads applied to the soil	1.30
ULS factor on loads applied to the wall	1.30
FOS on embedment (stability check)	1.00
Correction factor on cantilever embedment	1.20

Wall analysis detail options

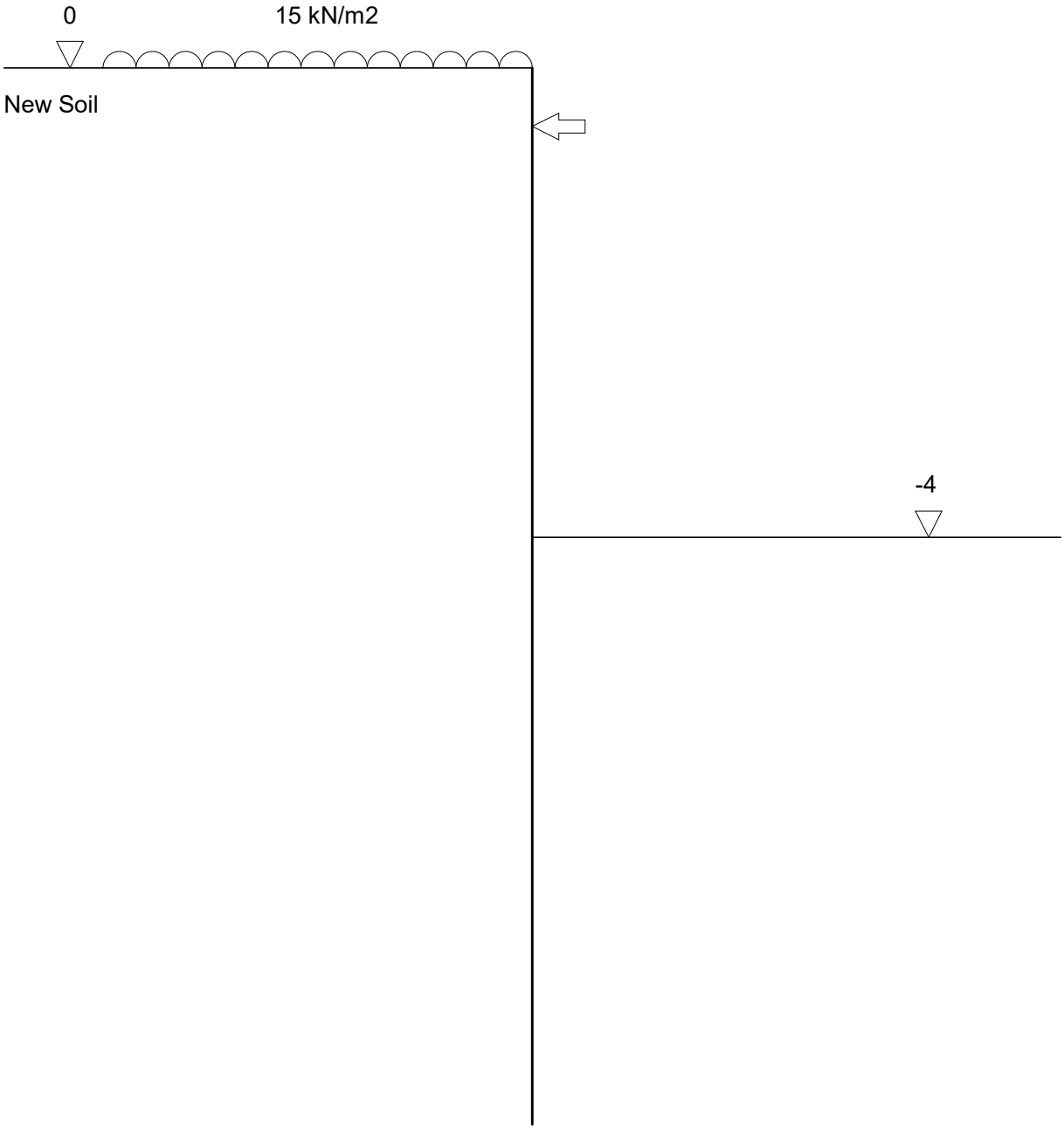
Nominal Phi for load distribution	30.0	Degrees
Depth of water filled tension cracks	.0	m
Density of water	10.0	kN/m3
Minimum equivalent fluid density	5.0	kN/m3
Depth of passive softened soil	1.0	m
Continuity model for wall analysis	Pins at second and lower props	

Deflection parameters

Wall moment of inertia	28662	cm4/m
Wall Youngs modulus	200000000	kN/m2

Properties for prop at -0.5		
Prop/Tie cross sectional area	200	cm2 each
Prop/Tie Youngs modulus	210000000	kN/m2
Prop/Tie length	10.0	m
Prop/Tie spacing	6.0	m
Waling moment of inertia	Waling deflection not included	
Waling Youngs modulus	Waling deflection not included	
Prop/Tie preload	0	kN
Initial lack of fit	0.0	mm

Stage ref. **5**
Stage type **Active surcharge**

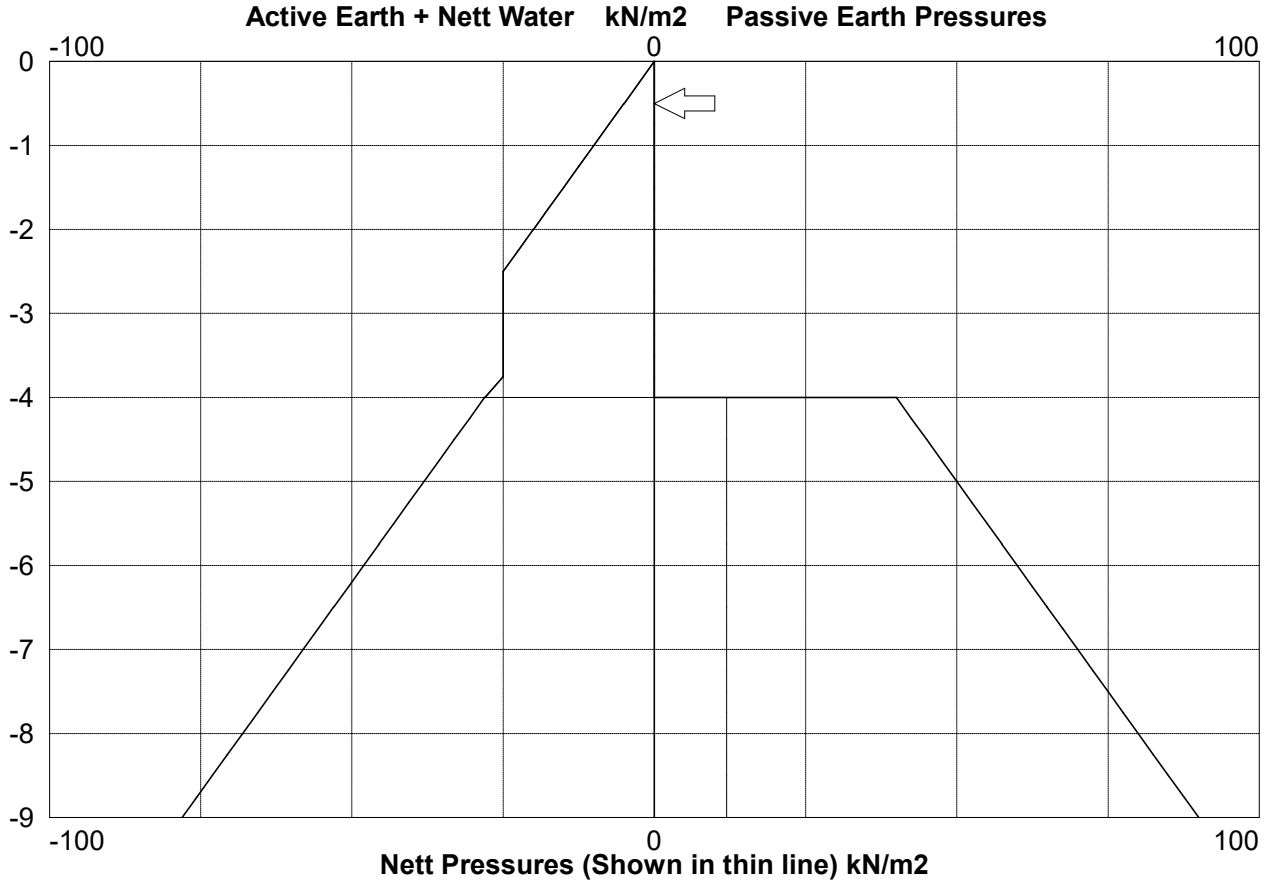


Tabular results from analysis of stage ref 5

strength.
analysis.

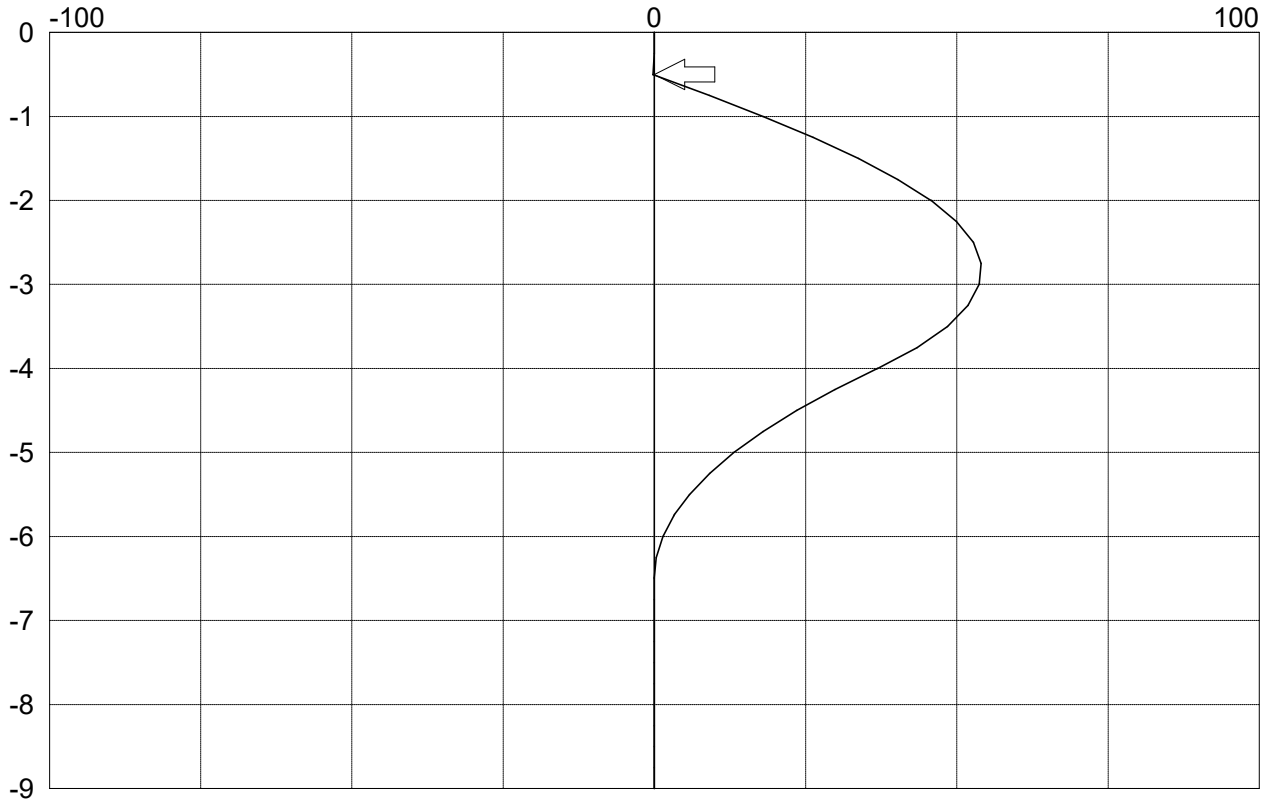
Calc Level m	Active Vert kN/m2	Active Earth kN/m2	Active Water kN/m2	Pas' Vert kN/m2	Pas' Earth kN/m2	Pas' Water kN/m2	Total Nett kN/m2	Bend. Moment kNm/m	Shear Force kN/m	Defl't mm	Prop Force kN/m	FOS
.00	19.5	.0	.0	.0	.0	.0	0	0	0			.00
t -.50	29.5	.0	5.0	.0	.0	.0	5.0	.2	-1.3		39.4	.00
t -.50	29.5	.0	5.0	.0	.0	.0	5.0	.2	38.2			.00
t -1.00	39.5	.0	10.0	.0	.0	.0	10.0	-18.0	34.4			.00
t -2.00	59.5	.0	20.0	.0	.0	.0	20.0	-45.7	19.5			.00
t -2.00	59.5	.0	20.0	.0	.0	.0	20.0	-45.7	19.4			.00
t -3.00	79.5	.0	25.0	.0	.0	.0	25.0	-53.7	-4.3			.00
-4.00	99.5	28.0	.0	.0	.0	.0	28.0	-36.9	-29.6			.00
-4.00	99.5	28.1	.0	40.0	40.0	.0	-11.9	-36.9	-29.7			.00
-4.01	99.7	28.2	.0	40.1	40.1	.1	-11.9	-36.6	-29.6			.01
-5.00	119.5	48.1	.0	50.0	50.0	10.0	-11.9	-13.2	-17.7			.66
-5.74	134.3	62.8	.0	57.4	57.4	17.4	-11.9	-3.3	-8.9			.88
-6.00	139.5	68.1	.0	60.0	60.0	20.0	-11.9	-1.4	-5.8			.93
-6.49	149.3	77.8	.0	64.9	64.9	24.9	-11.9	0	0			1.00
-7.00	159.5	88.1	.0	70.0	70.0	30.0	-11.9	0	0			1.05
-8.00	179.5	108.1	.0	80.0	80.0	40.0	-11.9	0	0			1.10
-9.00	199.5	128.1	.0	90.0	90.0	50.0	-11.9	0	0			1.12

Graphical results from analysis of stage ref 5

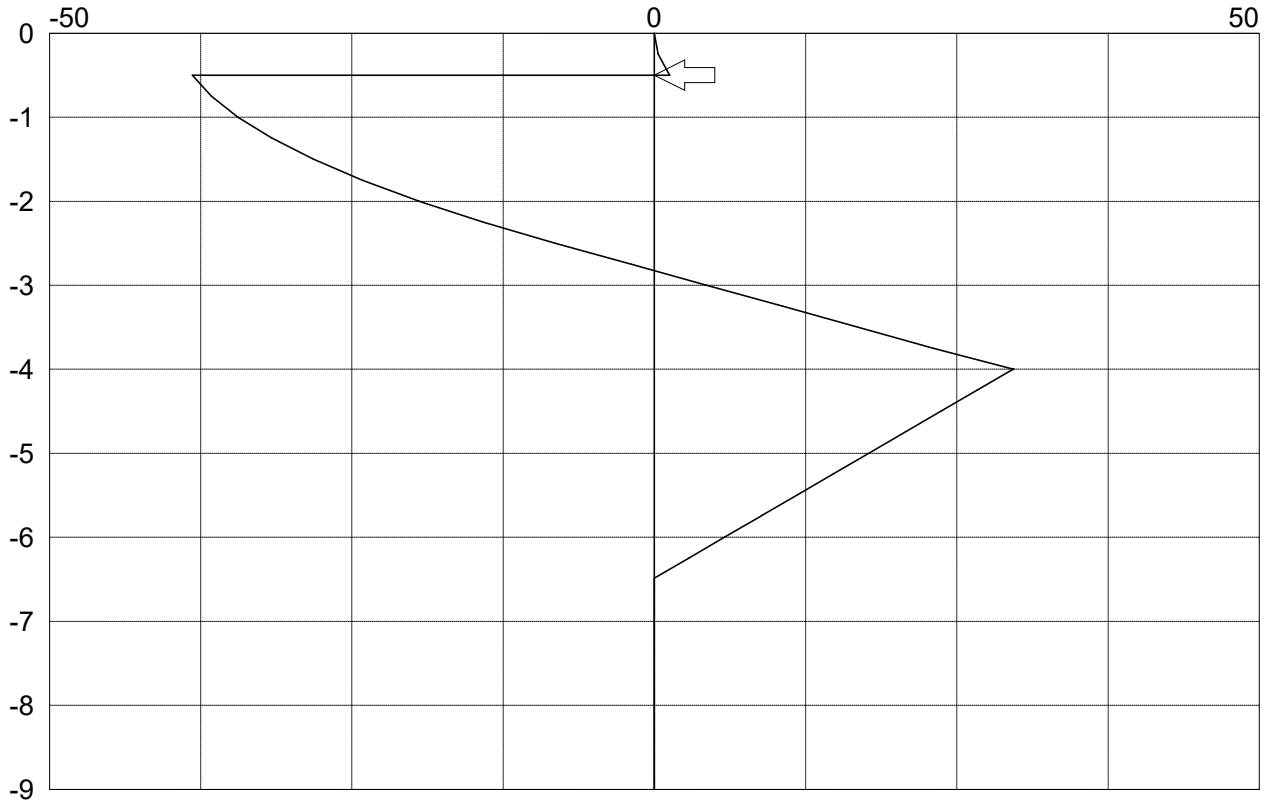


Deflection diagram not shown for analysis with partial factors applied

Graphical results from analysis of stage ref 5 continued

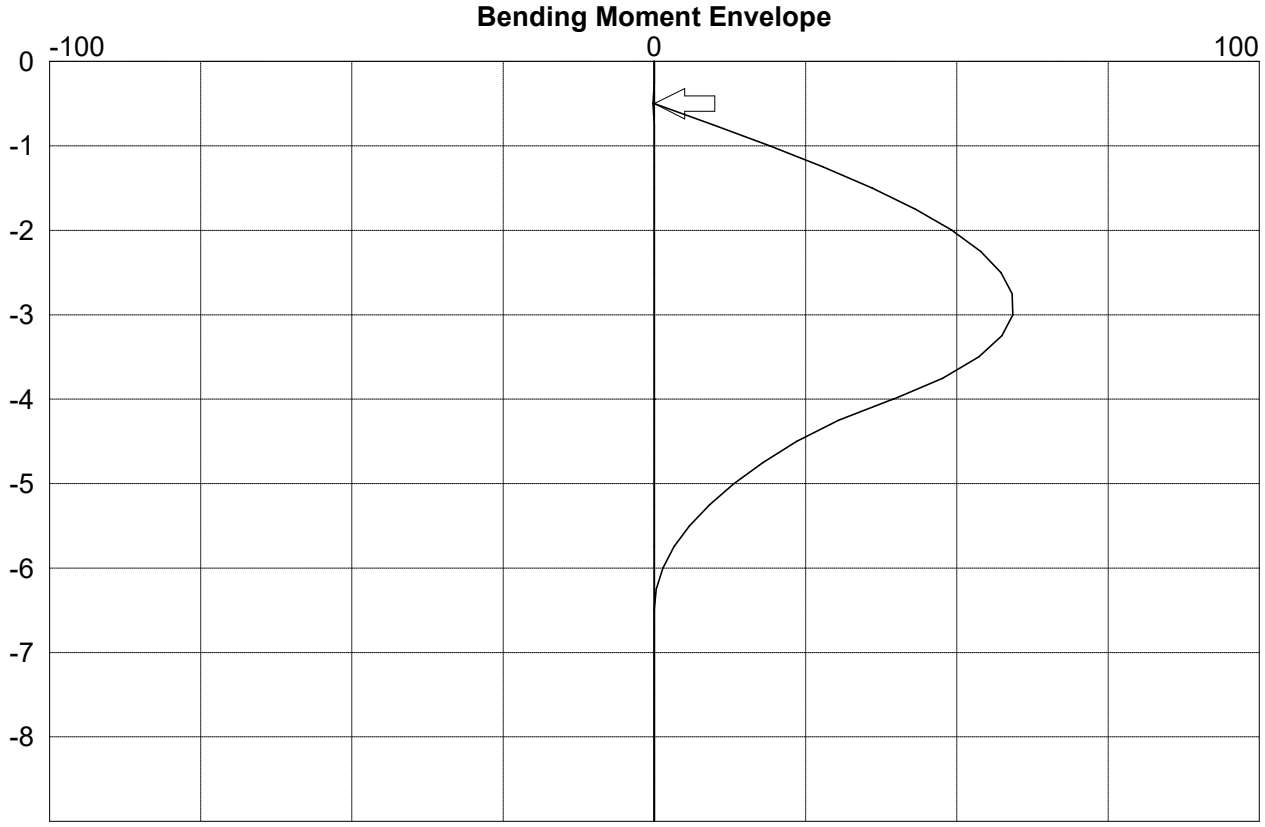


Bending Moment Diagram (kNm/m)



Shear Force Diagram (kN/m)

Graphical plot of envelope from selected construction stages



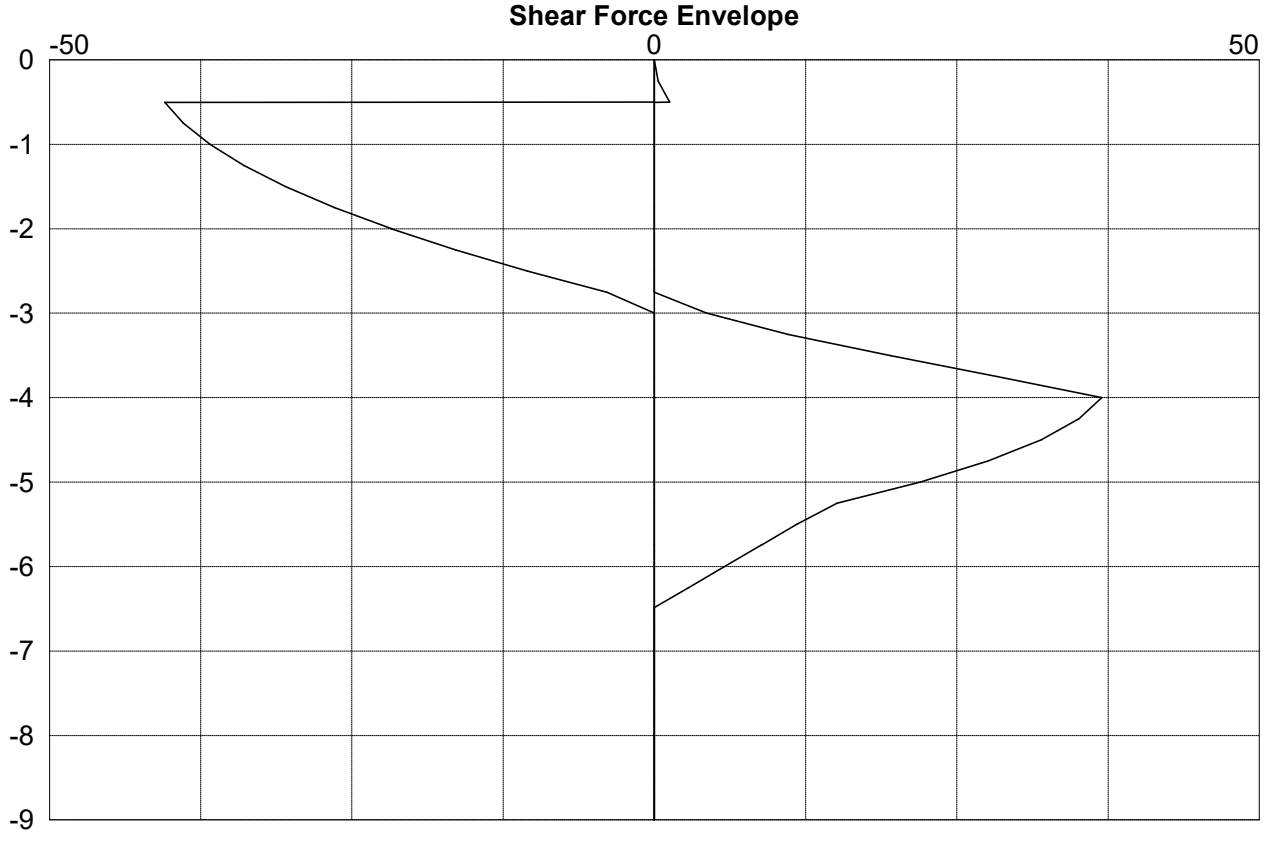


Table of envelope for wall forces

Calc Level m	Bending Minimum kNm/m	Bending Maximum kNm/m	Shear Minimum kN/m	Shear Maximum kN/m	Prop Force kN/m
.00	.0	.0	.0	.0	
-.50	.0	.2	-1.3	.0	41.7
-.50	.0	.2	.0	40.5	
-1.00	-19.1	.0	.0	36.7	
-2.00	-49.1	.0	.0	21.8	
-2.00	-49.2	.0	.0	21.7	
-3.00	-59.2	.0	-4.3	.0	
-4.00	-39.6	.0	-37.0	.0	
-4.00	-39.5	.0	-37.0	.0	
-4.01	-39.2	.0	-36.9	.0	
-5.00	-13.2	.0	-22.0	.0	
-5.74	-3.3	.0	-8.9	.0	
-6.00	-1.4	.0	-5.8	.0	
-6.49	.0	.0	.0	.0	
-7.00	.0	.0	.0	.0	
-8.00	.0	.0	.0	.0	
-9.00	.0	.0	.0	.0	

Structural design of wall

Wall section properties

Sheet pile section ref AU 14

Wall material properties

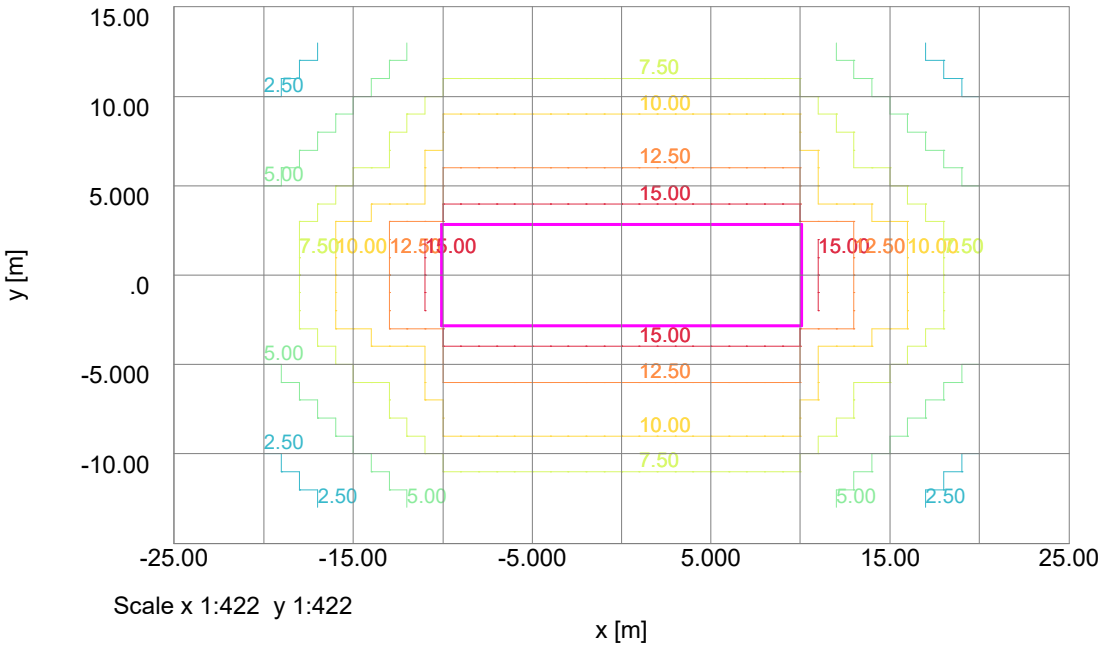
Yield stress of steel	355	N/mm2
Bending Stress Ratio	1.05	
Allowable bending stress	338	N/mm2
Allowable shear stress	202	N/mm2

Wall structural design checks

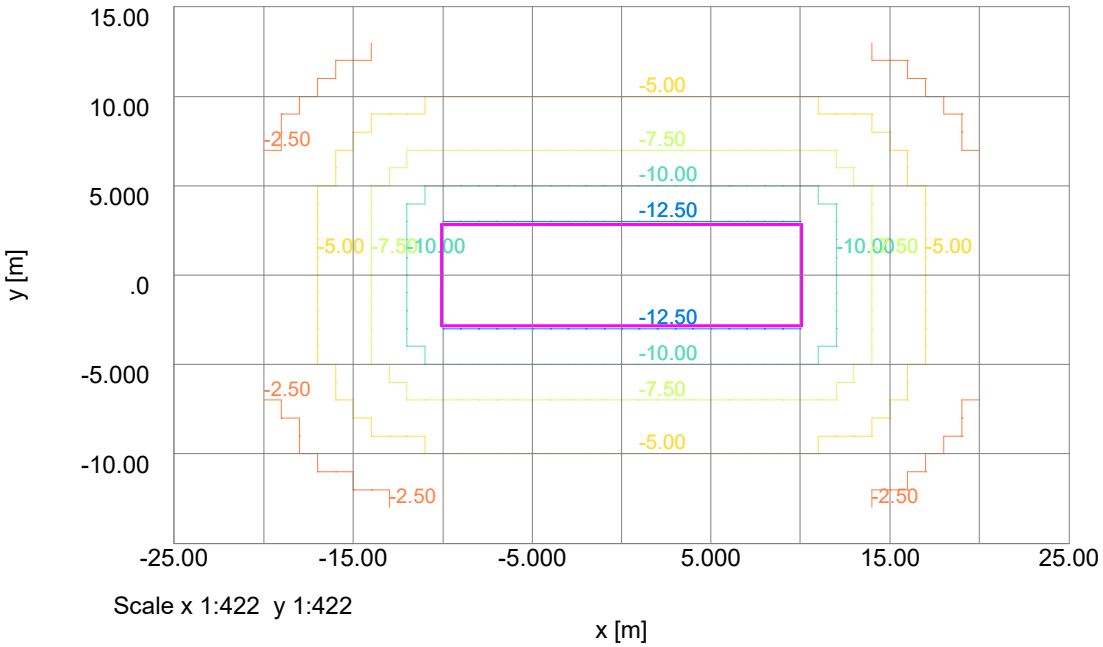
Check description	Required or Limit	Provided or Actual	Units
Section Class. EC3 Part 5, cl 5.2	3	3	Class
Bending resistance. EC3 Part 5, cl 5.2.2 elastic	59	499	kNm/m
Section modulus. EC3 Part 5, cl 5.2.2 elastic	167	1405	cm3/m
Shear resistance. EC3 Part 5, cl 5.2.2	40	903	kN/m
Shear induced web buckling. EC3 Part 5, cl 5.2.2	40	782	kN/m

Appendix 4: XDisp Assessment

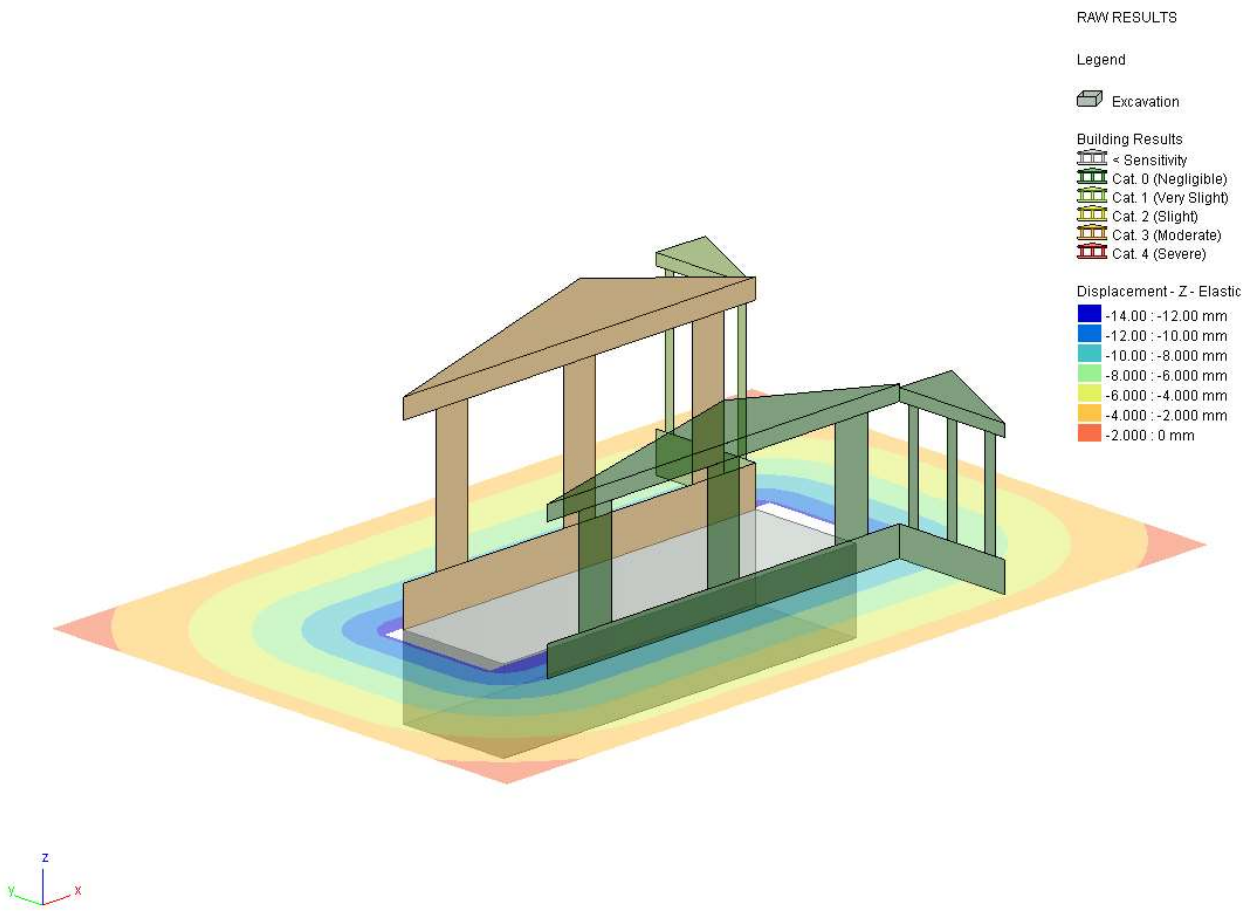
Horizontal Displacement Contours: Grid 1 (level 0.000m) Interval 2.5mm



Vertical Settlement Contours: Grid 1 (level 0.000m) (Interval 2.5mm)



Scale x 1:422 y 1:422


RAW RESULTS
Legend
Excavation
Building Results
< Sensitivity
Cat. 0 (Negligible)
Cat. 1 (Very Slight)
Cat. 2 (Slight)
Cat. 3 (Moderate)
Cat. 4 (Severe)
Displacement - Z - Elastic
-14.00 : -12.00 mm
-12.00 : -10.00 mm
-10.00 : -8.000 mm
-8.000 : -6.000 mm
-6.000 : -4.000 mm
-4.000 : -2.000 mm
-2.000 : 0 mm
Z
Y
X