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Date: 24 August 2012
Your Ref:
Our Ref : SMB/557/2383
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Dear David

**Flood Compensation Scheme for Development at Accrington Road,
Whalley**

Following the submission of the recent Flood Risk Assessment (FRA) compiled by PSA Design for the above development, I am pleased to enclose the results of the flood compensation scheme that you requested Herrington Consulting to undertake to accompany the Flood Risk Assessment; with the intention of satisfying the concerns raised by the Environment Agency (EA) in relation to the potential displacement of flood water from the site.

Herrington Consulting Limited

Compensatory Flood Storage Scheme Overview

From the topographic survey previously undertaken for the initial flood risk assessment a three dimensional elevation model (DEM) has been constructed and using the EA modelled flood level data detailed within the FRA the volume of displaced floodwater for the existing site, and for the proposed development, has been calculated. Consequently, this has enabled the required volume of compensatory flood storage to be calculated for the proposed development.

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The scheme that has been designed is in accordance with the criteria set out in the EA's guidance for Flood Plain Compensatory Storage. In this guidance it states that any flood storage that is lost as a result of a new development must be compensated for by the reduction in the level of nearby ground, such that the same volume is available at every flood level, before and after the works - in addition, it must drain freely. In other words, for any particular flood event the new site and storage scheme must mirror the existing flood characteristics of the existing site on a level for level basis.

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As such, the compensation scheme that has been designed by Herrington Consulting compares the volume of displaced flood water from the existing site, with the volume of floodwater displaced by the proposed scheme at 100mm depth intervals. Based on this information the areas of the site that are required to be regraded, in order to provide the sufficient compensatory flood storage required during an extreme flood event at each 100mm level, have been clearly identified. Below is the detailed methodology which demonstrates how this has been achieved.

Methodology

The georeferenced topographic survey of the site and the neighbouring land (which is under the same ownership as the development site) was used to create a three dimensional elevation model (DEM). Using this DEM the site was divided up into 8 discrete 'slices' of 100mm, based upon the upper and lower contours; the lower contour represents the 1 in 100 year extreme water level (45.2m AODN) and the upper contour represents the 1 in 100 year extreme water level including an allowance for climate change (45.98m AODN as defined in the FRA).

These 8 contours/slices were plotted using the elevation model and overlaid onto the proposed development scheme. Figure 1a and 1b below delineate each contour within the 1 in 100 year (plus climate change) flood extent. The black dotted line shows the proposed area of land raising, which will ensure that any new development is located sufficiently above the design flood level, (as described in the FRA).

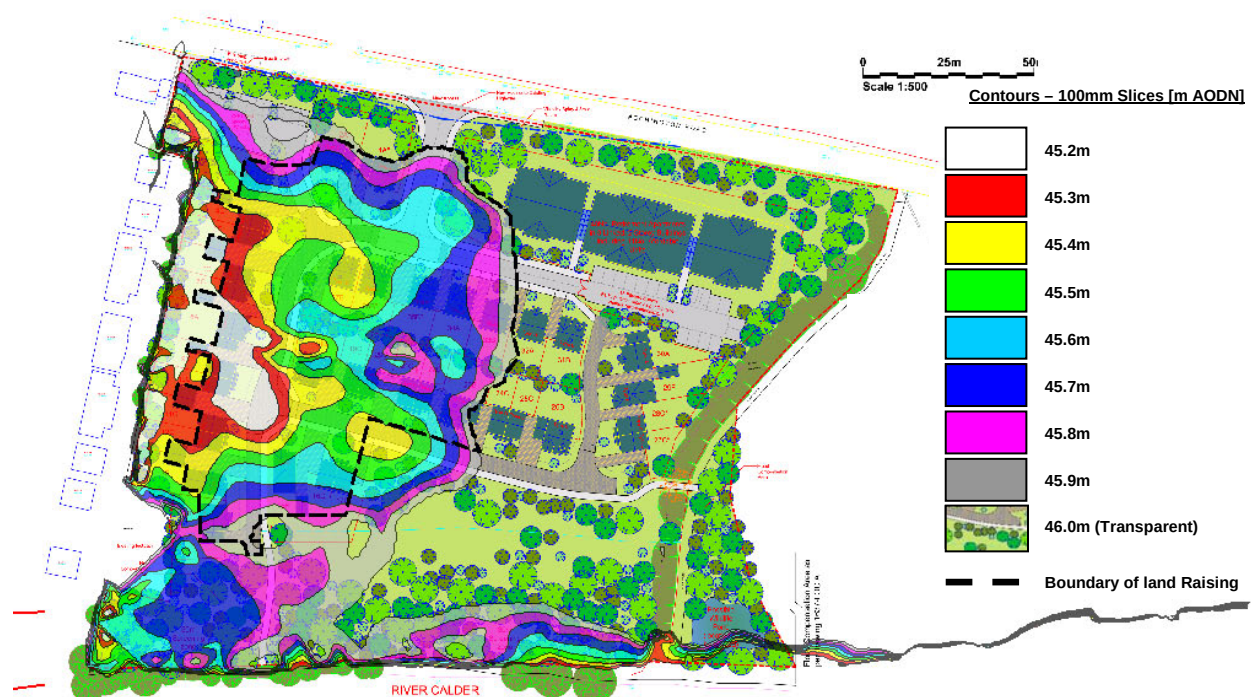


Figure 1a: Schematic View of Proposed scheme, delineating 100mm slices created using the DEM from the topographic survey. The dotted line represents the boundary of the land which is to be raised above the flood level and consequently, the area of compensatory flood storage required.

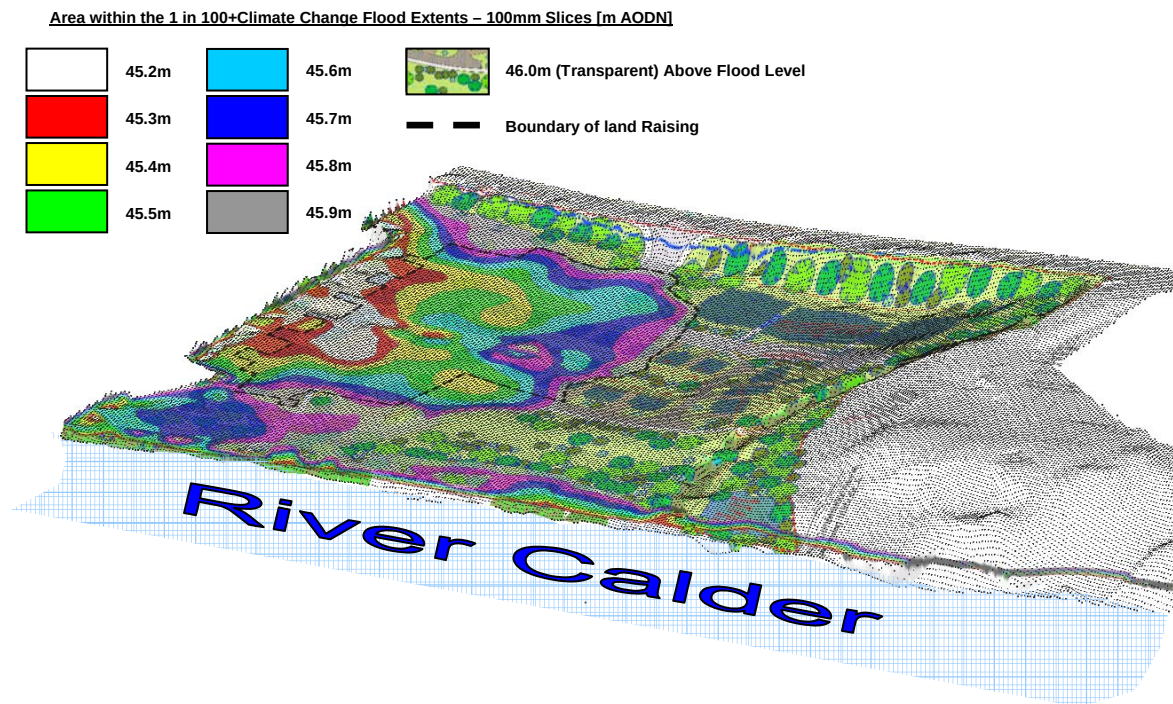


Figure 1b: Oblique View of 3D Digital Elevation model, delineating the 1 in 100 (plus Climate Change) flood extent divided into 100mm slices. The dotted line represents the boundary of the land which is to be raised above the flood level and consequently, the area of compensatory flood storage required.

Available land

Figures 1a and 1b clearly delineate the extent of flooding across the site under the design flood event, i.e. the 1 in 100 year flood contour (*with a 30% allowance for climate change*) and highlight the areas of the site which are located above this level. Inspection of the contour plot within figure 1a also identifies that the site remains unaffected under the 1 in 100 year extreme event (without climate change) and consequently, it can be inferred that the eight 100mm slices used within the Flood Compensation Scheme calculations simply represent how flood water would encroach as a result of the impact of climate change.

Any land located above the design flood level (45.98m AODN) has not been represented by a filled contour in the diagrams above (Figure 1a & 1b) and therefore delineates the area of land that could potentially be lowered in order to provide the required compensatory flood storage under the design event. It is also evident from the contour plots that only a limited area of the site is actually affected under the design event, (mainly to the west of the site) and consequently there is a significant area to the east, within the site boundary, which can be used to provide the required compensatory flood storage.

Notwithstanding this, to enable the development to work with the natural constraints of the landscape, for example preventing the creation of large stepped areas within the site, it would be more beneficial to use the neighbouring section of land to the east as additional flood storage. This would have the added benefit of ensuring floodwater is kept within the river corridor.

This neighbouring section of land to the east of the development is under the same ownership as the western section of land and has therefore been included as part of the topographic survey (and the subsequent modelling process). The survey and model both identify that this land is located above the design flood contour and therefore remains unaffected under the design event. Consequently, this area of

land to the east provides an ideal opportunity to contribute towards the compensatory flood storage required for the existing site. Furthermore, any material that is required to be removed from this area to create the compensatory flood storage, can subsequently be used to raise the platform on the western section of the site, on which the new development will be located.

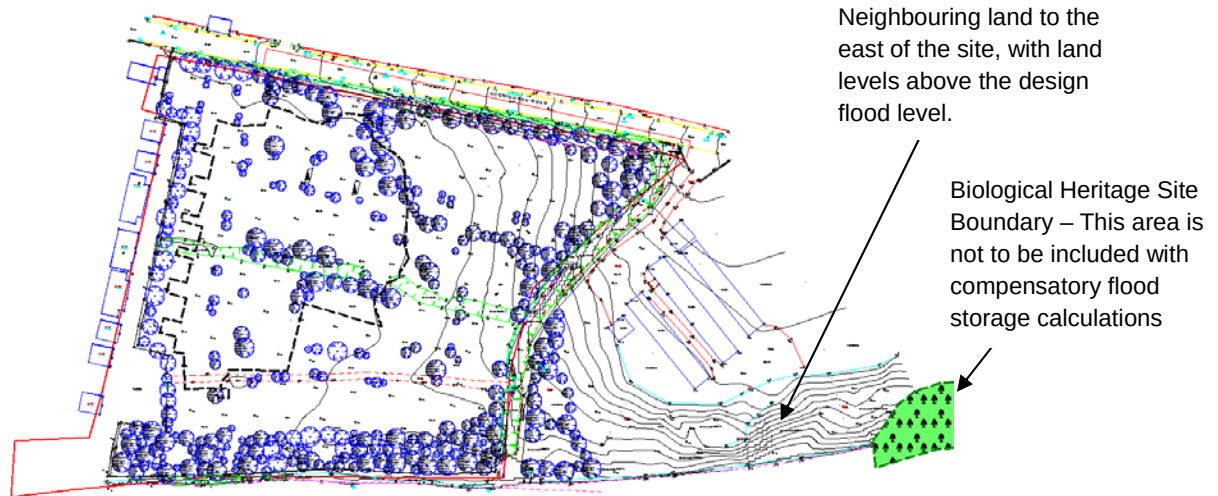


Figure 2: Topographic survey of the site and the neighbouring high ground to the east (under the same ownership) and the boundary of the Biological Heritage Site (an area where development will not be permitted)

General observations and assumptions

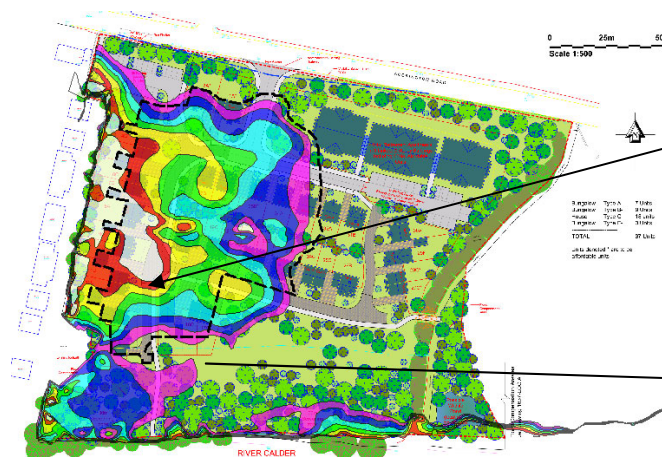
The area highlighted by the dotted black line in figure 2 represents the area of land to be raised as part of the flood mitigation measures. By raising the land at this location it will invariably displace flood water that would naturally pond here and therefore, to enable the required compensatory storage to be calculated accurately, the volume of displacement within each 100mm slice within this area has been examined in more detail.

The first observation that can be made when interrogating the model (based on the current land levels), is that up until the point at which the floodwater reaches a level of 45.7m AODN floodwater is actually prevented from encroaching into the proposed development area due to a raised section of land. It is only when the water level increases to 45.8m AODN that floodwater is able to weir over this high ground and flow into the lower areas to the west of the site. Consequently, it can be inferred that as the land raising proposals are not affected by floodwater under the 45.7m contour level, there is no requirement to provide compensatory flood storage for any slice below this level. This is demonstrated in the following two figures.

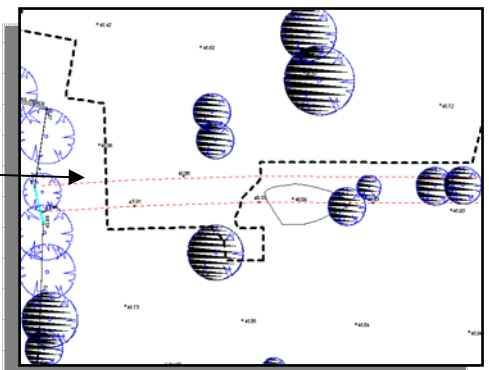


Extent of floodwater up to the 45.7m AODN contour. Note that the floodwater is prevented from moving further across the site due to a naturally high section of ground, which can be seen on the detailed topographic survey.

Figure 3: Delineating the 45.7m AODN contour. Floodwater is prevented from flowing further northwards due to a naturally high section of ground.



As water exceeds the height of the naturally high ground, water weirs over and into the low areas.



Right: Extract from topographic survey showing naturally high ground levels preventing water from reaching the lower contours

Figure 3: Once the water reaches the 45.8m AODN contour floodwater can flow into the low areas shown above. Consequently, the accumulative volume of each of these low 100mm slices forms part of the calculations for the required storage at this level.

The above figures show that there is not a requirement for the lower slices (45.7m AODN and below) to be compensated for initially. However, as the water level exceeds 45.8m AODN and floodwater begins to weir over the high ground, a large area of low ground becomes flooded. The volume of storage provided by this area of low ground will therefore be required to be compensated for if this is to be removed by the land raising proposals. Consequently, the volume of storage at the 45.8m AODN contour is required to include the overall volume displaced at the lower slices as well. The following calculations demonstrate this.

Calculations:

The following calculations show (a) the area and the volume (area x 100mm) of floodwater displaced by the proposed raised development platform at each 100mm slice and (b) the proposed compensatory flood storage required at that level.

Slice No.	Upper Contour (m AODN)	Additional Contours within Slice (m AODN)	Area displaced by New Proposals (m ²)	Volume Displace by Proposed Dev. Platform (m ³) (Storage Required) Area x 100mm	Mitigation required to achieve required compensatory storage
1	45.2	None	No Change	0	None
2	45.3	None	No Change	0	None
3	45.4	None	No Change	0	None
4	45.5	None	No Change	0	None
5	45.6	None	No Change	0	None
6	45.7	None	No Change	0	None
7	45.8	As below	Weirs into lower area	Total = 766	Lower land above slice contour to 45.8m AODN. Required area = volume m ³ / 0.1 = 7668m ²
7	45.8	45.2	569	57	
7	45.8	45.3	632	63	
7	45.8	45.4	1194	119	
7	45.8	45.5	1475	148	
7	45.8	45.6	1524	152	
7	45.8	45.7	1362	136	
7	45.8	45.8	912	91	
8	45.9	Already compensated for in Slice 7	8240	824	Land above flood contour lowered to 45.9m AODN – Lower contours already mitigated for (see above) Area = 8240m ²
9	46	ABOVE FLOOD CONTOUR			

Table 1: Compensatory Flood Storage Scheme calculation results on a level per level basis *for raised development platform only – (Depth calculations simplified for purposes of reporting)*

From Table 1 above it can be seen that there is no requirement to compensate for the displacement of flood water at the lower levels (Slices 1-6), as the new development platform does not displace any floodwater at these levels.

However, as flood levels increase to 45.8m AODN (and above) floodwater begins to fill the lower sections of the site. The volume of water displaced at each slice has been calculated on a level per level basis, by multiplying the area of land raising at each slice by the thickness of the slice (100mm). This provides the

volume that is required to be compensated for at that level. Usually each slice would be compensated for adjacent to the river, at each corresponding level. However, in this instance because the lower slices are located in a depression of land and this area is separated by a band of high ground, these slices do not get wet until the water has exceeded the height of the raised section of land (45.8m AODN). This is shown in Figure 3 and therefore these slices are only required to be compensated for as one combined volume, at this higher level/slice.

Potential Additional Land Raising

Notwithstanding the above findings, in order to make the construction process more manageable it has been assumed that additional land raising may be required in order to provide level ground on which to locate the raised land platform and to prevent water from ponding in isolated areas. This new area of land raising is shown in figure 4 below and comprises raising the lower land on the eastern side of the site to 45.8m AODN. This will in turn increase the area of compensatory flood storage that is required at this level.

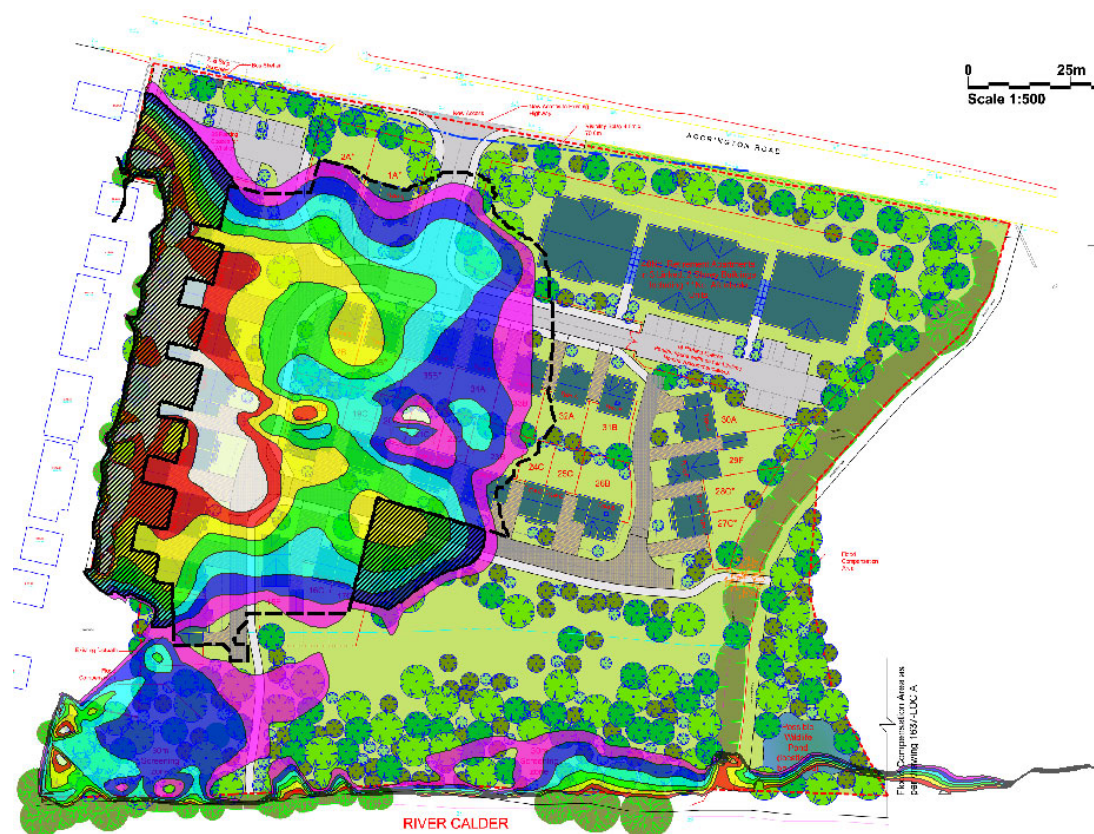


Figure 4: Black hatched areas denote potential areas of additional land raising to make a level construction platform on which to build the raised development platform and prevent water from ponding at these locations.

Revised Calculations:

The following table shows the calculations undertaken to account for the additional land raising identified in Figure 4. The same methodology as previously described has been used to derive the new values.

Slice No.	Upper Contour (m AODN)	Additional Contours within Slice (m AODN)	Area displaced by New Proposals (m ²)	Area displaced by Additional Land raising (m ²)	Total Volume Displace by combined land raising (m ³) (Storage Required) Area x 100mm	Mitigation required to achieve required compensatory storage
1	45.2	None	No Change	0	0	None
2	45.3	None	No Change	0	0	None
3	45.4	None	No Change	0	0	None
4	45.5	None	No Change	0	0	None
5	45.6	None	No Change	0	0	None
6	45.7	None	No Change	0	0	None
7	45.8	As below	Weirs into lower area	Total = 2636	Total = 1010	Lower land above slice contour to 45.8m AODN. Required volume m ³ = $766.8 + 241 = 1007.8\text{m}^3$ $= 10,078\text{m}^2$ Area
7	45.8	45.2	569	687	69	
7	45.8	45.3	632	437	44	
7	45.8	45.4	1194	423	42	
7	45.8	45.5	1475	344	34	
7	45.8	45.6	1524	267	27	
7	45.8	45.7	1362	249	25	
7	45.8	45.8	912	0	0	
8	45.9	Already compensated for in Slice 7	8240	Not affected, land levels below slice	824	Land above flood contour lowered to 45.9m AODN – Lower contours already mitigated for (see above) Area = 8240m ²
9	46	ABOVE FLOOD CONTOUR				

Table 2: Compensatory Flood Storage Scheme calculation results on a level per level basis *for raised development platform and additional land raising – (Depth calculations simplified for purposes of reporting)*

The figures provided above in Table 2 identify how the increase in the volume of water displaced by this additional land raising has been achieved as part of the calculations.

Summary of Land Raising/Lowering & Schematics

In summary, by utilising both the eastern and western sites (which are under the same ownership) there is sufficient land available (which is located above the design flood contour) on which to provide the required compensatory flood storage. By increasing the low areas of the site to 45.8m AODN it will provide a level platform on which to construct the higher development platform, which will subsequently ensure that the buildings within the development are located above the flood level.

The following figures below identify the areas on the proposed site schematic that are required to be regraded in order to provide an adequate volume of compensatory flood storage at each respective level. The coloured polygons simply show the area in which the ground level must be lowered/raised to enable the appropriate storage requirements to be met. It should be noted that although the figures show polygons meeting with abrupt changes in ground level, in reality these levels can be graded where practical, with minimal effect on the compensatory storage volumes.



Figure 5: Areas of land to be lowered or raised as follows:

-  The red hatched area delineates the raised development platform (located above the design flood level at 46.45m AODN) – approximately 1m above the current ground levels.
-  *The pink area represents the current 45.8m AODN contour (which will remain unchanged).
-  *The grey area represents the current 45.9m AODN contour, (which will be lowered to 45.8m AODN).
-  *The green hatched area is the land currently located above the design flood level and is the area to be lowered to 45.8m AODN. This provides sufficient compensatory flood storage for both of the upper flood contours (45.8 and 45.9m AODN).
-  *The black hatched area is the potential, additional area to be raised to 45.8m AODN. By lowering the 45.9m AODN contour there is, however, sufficient volume to accommodate the additional storage required.

*The above pink, grey, green hatched and black hatched areas will all be lowered to 45.8m AODN.

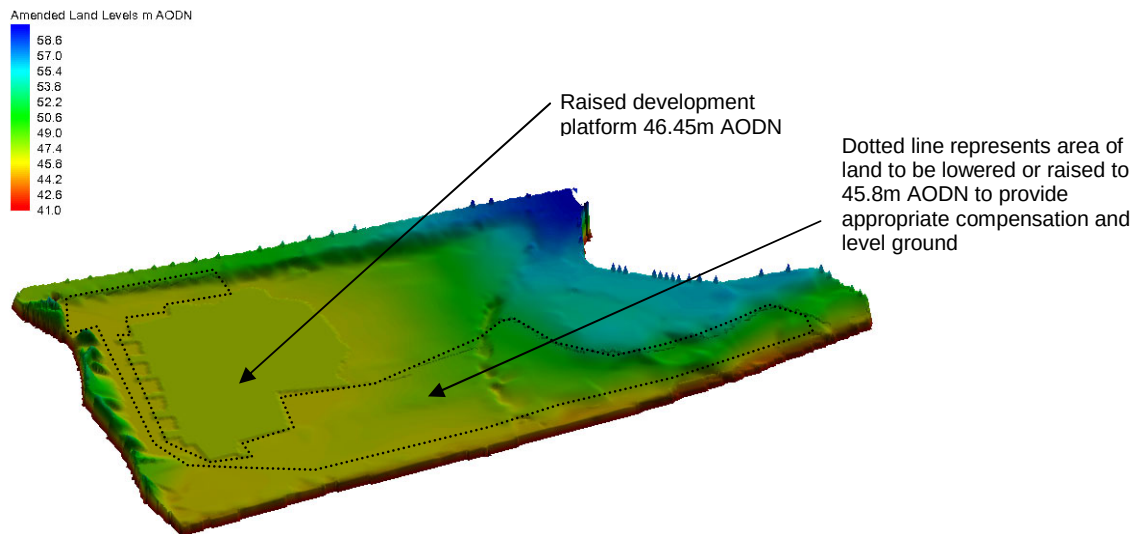


Figure 6a: Shows the raised development platform on the existing land levels – the dotted line represents the land to be lowered (or raised in some areas) to 45.8m AODN. The area within this dotted line will only flood under the 1 in 100 year (plus climate change scenario).

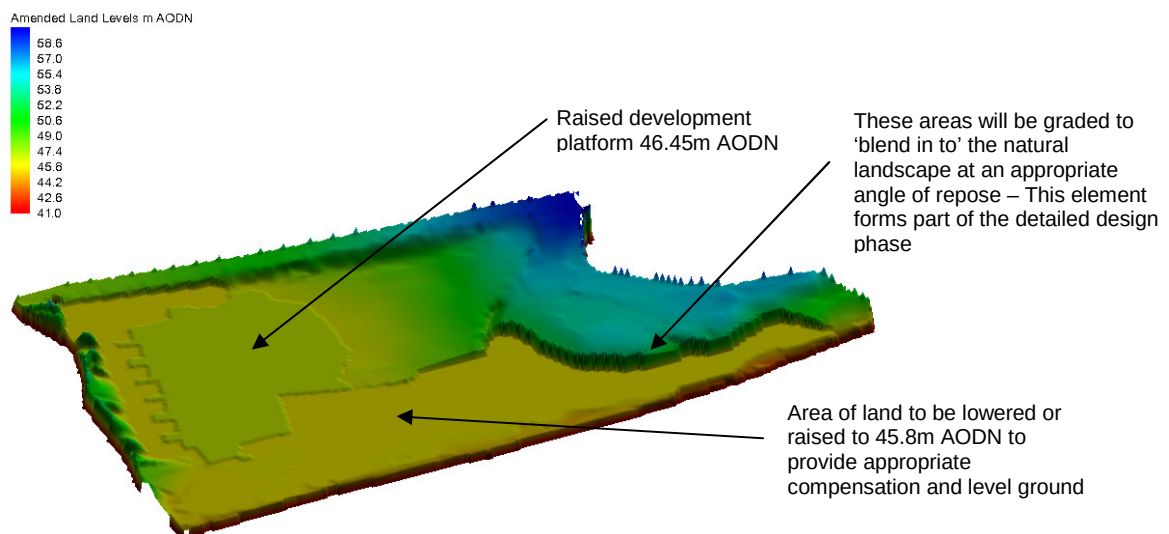


Figure 6b: Shows the raised development platform and the proposed regraded land levels (lowered or raised) to 45.8m AODN.

With regards to the excavated material removed during the regrading process, it is important that this material is either used in the areas defined to be raised, or alternatively deposited offsite, outside of the 1 in 100 year flood contour, so as not to displace any additional floodwater

Figure 7a and 7b below both delineate the maximum flood extent under the 1 in 100 year event (including a 30% allowance for climate change), with the appropriate compensatory flood storage provided.

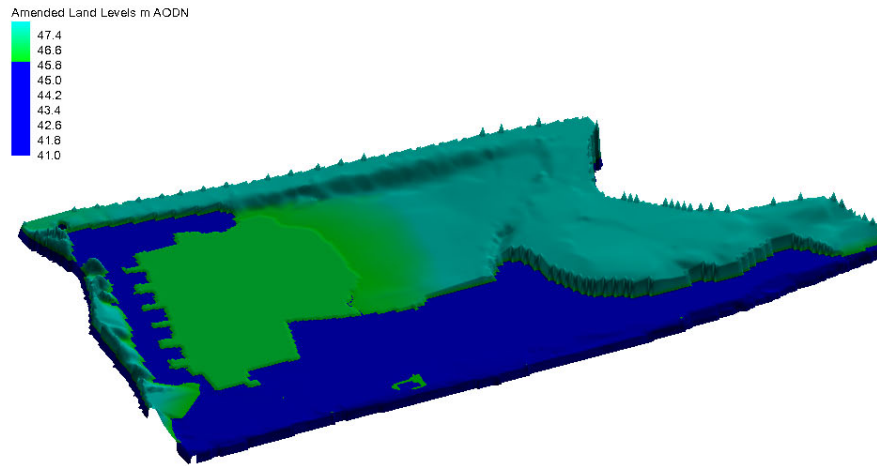


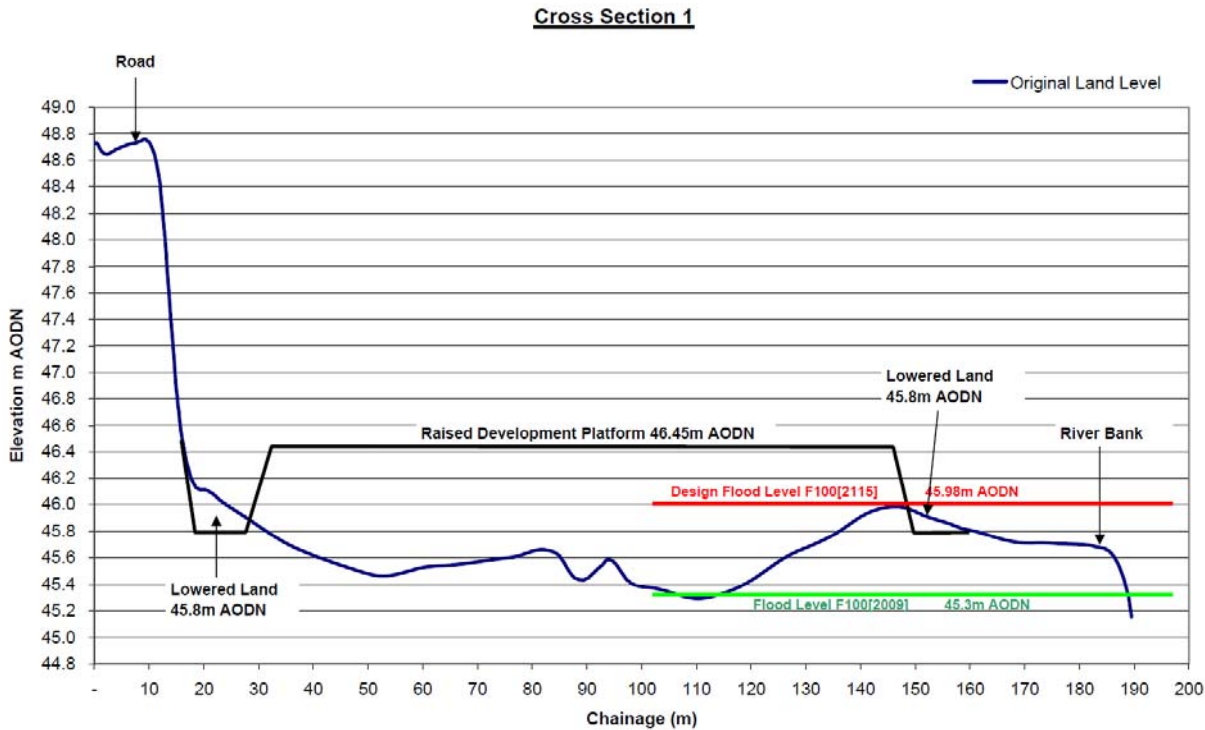
Figure 7a: Shows the raised development platform, the proposed regraded land levels (lowered or raised) to 45.8m AODN and the 1 in 100 year (plus climate change flood extent): the approximate depth of flooding under this event would be circa 200mm.



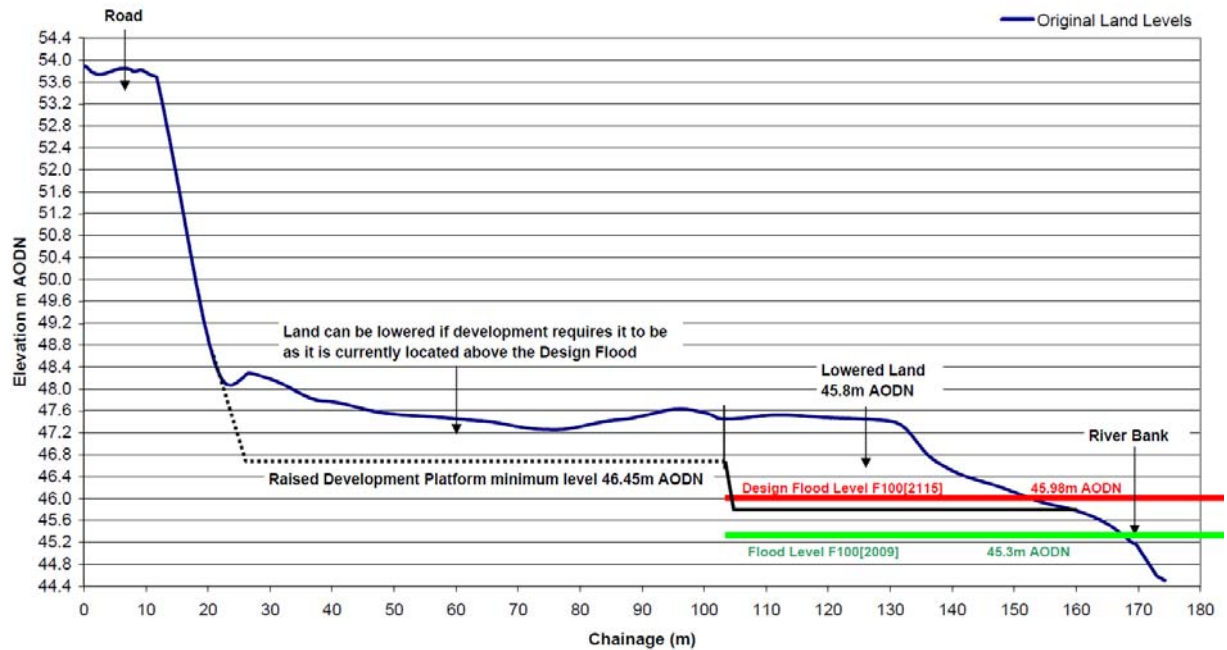
Figure 7b: Schematic: Maximum flood extent under the design event overlaid onto the proposed development scheme.

The majority of the compensatory flood storage is created by lowering the land levels to 45.8m AODN. Consequently, under the design event the estimated depth of flooding (based on the Environment Agency design flood level) is circa 200mm – which represents only shallow flooding. To provide an indication of how the land alterations may look when compared to the current site levels, two cross sections have been extracted through the models. These are shown in the figures below and indicate the depth of material that is required to be added/removed. In most instances the depth of land to be removed is typically in the region of 0.7 to 2.0m deep.

Figure 8 (below): Two cross sections taken through the proposed development site delineating the extent of land raising/lowering to provide the appropriate compensatory flood storage required.



Cross Section 2



Conclusions

In conclusion, the Flood Risk Assessment for this site has identified that there is potential for the site to flood from the River Calder under the design flood conditions and consequently, the FRA has highlighted that a raised development platform is required to ensure the buildings are located above this design flood contour. This report has therefore considered these mitigation measures in greater detail, in turn quantifying the volume of flood water displaced by the land raising proposals and calculating the required volume of compensatory flood storage (on a level per level basis). It has been shown that there is sufficient land available within the site to contain any displaced floodwater and consequently there should be no negative impacts further downstream as a result of the proposed mitigation measures.

The calculations in this document have been based on the Environment Agency flood levels published in the FRA, and consequently the blue area shown in Figures 7a and b is only expected to be flooded following an extreme event with a return period of 1 in 100 years (including an allowance for 100 years of climate change). Furthermore, if this additional allowance for 100 years of climate change is *not* applied, the site remains unaffected and therefore it can be inferred that is only towards the latter years of the development design life that the site could experience flooding to this degree. Notwithstanding this, the development proposals do ensure that there is a safe means of access and egress to/from the development should an event of this magnitude occur.

The proposals include lowering a significant area of land between the River bank and the development, however, the current bank levels are to remain unaltered and the proposals are to ensure that the lowered land, which will provide the required compensatory flood storage, is not built upon. Instead this land will revert to green space, similar to the existing landscape. This provides the opportunity to maintain the biodiversity along the river bank corridor.

Despite the great level of detailed work undertaken to produce this report, at this stage it is understood that for planning purposes the above proposals are in outline form only and simply demonstrate that the proposals are achievable on site. It is therefore anticipated that following planning permission and before the construction of the development, a phase of detailed design will follow. This detailed design phase will ensure that all of the elements outlined in this document are in accordance with the Environment Agency guidance and recommendations.

I trust that the attached diagrams and above calculations and descriptions are sufficient to enable you to incorporate this document as an addendum to the original Flood Risk Assessment. However, if you would like any additional detail or clarification on any of the information above then I would be happy to discuss further.

Yours sincerely

A handwritten signature in black ink, appearing to be 'SB' with a stylized flourish.

Simon Maiden-Brooks Msc. Bsc. (Hons) MCIWEM

Technical Director & Partner

Figure 1: Proposed scheme, 100mm slices created using the DEM from the topographic survey.

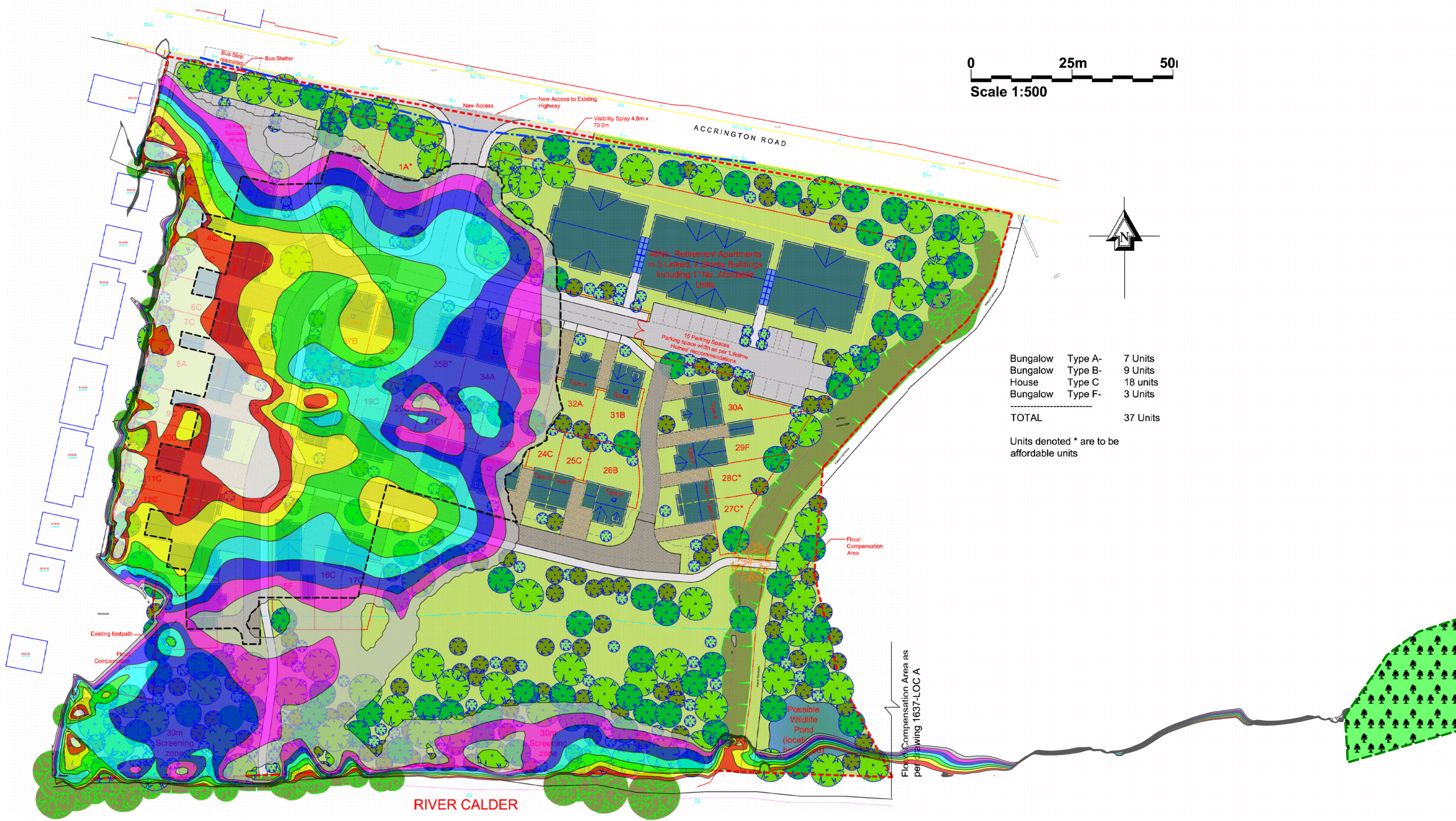


Figure 2: Topographic survey of the site and the neighbouring high ground to the east .

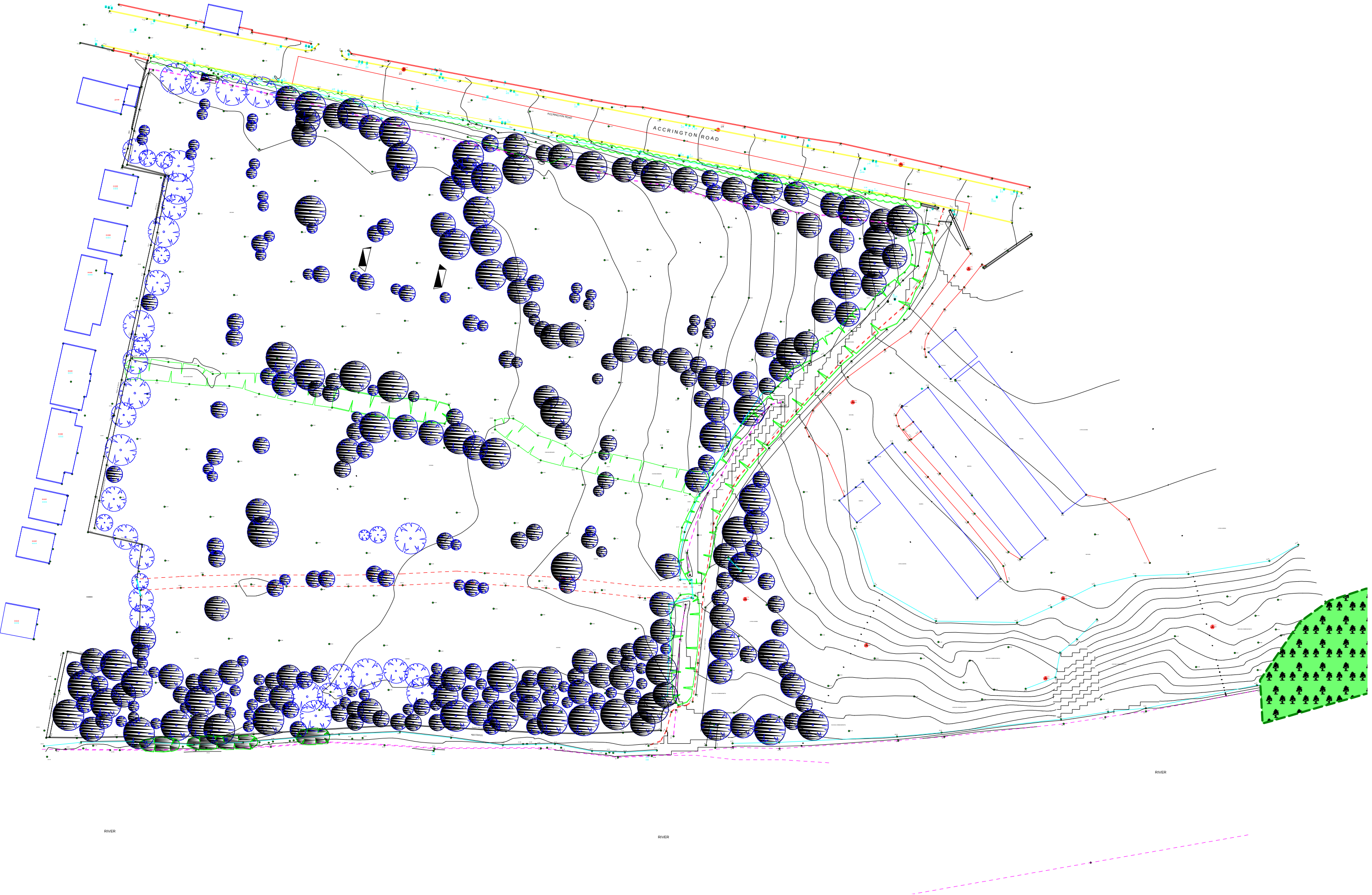
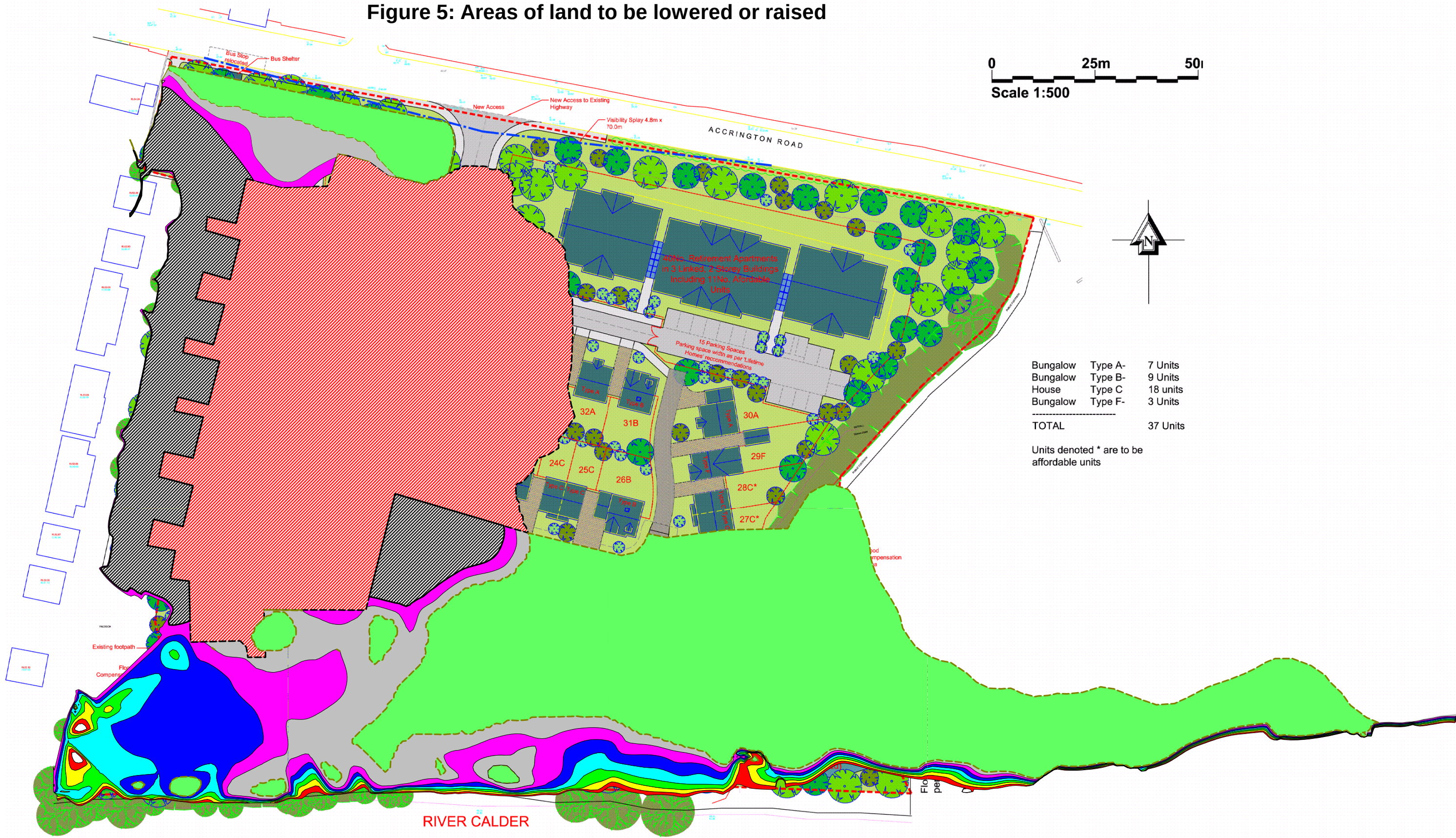


Figure 5: Areas of land to be lowered or raised



Bungalow	Type A-	7 Units
Bungalow	Type B-	9 Units
House	Type C	18 units
Bungalow	Type F-	3 Units
TOTAL		37 Units

Units denoted * are to be affordable units

Figure 6: Maximum flood extent under the design event overlaid onto the proposed development scheme.



Cross Section 1

Cross Section 2

0 25m 50m
Scale 1:500

ACCINGTON ROAD

Bus Stop (relocated) Bus Shelter

New Access

New Access to Existing Highway

Visibility Splay 4.8m x 70.0m

25 Parking Spaces for Whalley

15 Parking Spaces (Home Office recommendations)

Parking space width as per Lifetime recommendations

30m Screening zone

30m Screening zone

Possible Wildlife Pond (location to be agreed)

Flood Compensation Area

Flood Compensation Area as per drawing 1637-LOC A

RIVER CALDER

Bungalow	Type A-	7 Units
Bungalow	Type B-	9 Units
House	Type C	18 units
Bungalow	Type F-	3 Units
TOTAL		37 Units

Units denoted * are to be affordable units

Cross Section 1

Cross Section 2

0 25m 50m
Scale 1:500

ACCINGTON ROAD

Bus Stop (relocated) Bus Shelter

New Access

New Access to Existing Highway

Visibility Splay 4.8m x 70.0m

25 Parking Spaces for Whalley

15 Parking Spaces (Homeowner's recommendations)

Parking spaces with as per Lifetime recommendations

30m Screening zone

30m Screening zone

Possible Wildlife Pond (location to be agreed)

Flood Compensation Area

Flood Compensation Area as per drawing 1637-LOC A

RIVER CALDER

Bungalow	Type A-	7 Units
Bungalow	Type B-	9 Units
House	Type C	18 units
Bungalow	Type F-	3 Units
TOTAL		37 Units

Units denoted * are to be affordable units



Cross Section 1

Cross Section 2

0 25m 50m
Scale 1:500

ACCINGTON ROAD

RIVER CALDER

Bus Stop (relocated) Bus Shelter

New Access New Access to Existing Highway

Visibility Splay 4.8m x 70.0m

25 Parking Spaces for Whalley

15 Parking Spaces Homeowner's recommendations

Parking space width as per Lifetime recommendations

Flood Compensation Area

30m Screening zone

Possible Wildlife Pond (location to be agreed)

Flood Compensation Area as per drawing 1637-LOC A

Bungalow	Type A-	7 Units
Bungalow	Type B-	9 Units
House	Type C	18 units
Bungalow	Type F-	3 Units
TOTAL		37 Units

Units denoted * are to be affordable units

Cross Section 1

Cross Section 2

0 25m 50m
Scale 1:500

ACCINGTON ROAD

Bus Stop (relocated) Bus Shelter

New Access

New Access to Existing Highway

Visibility Splay 4.8m x 70.0m

25 Parking Spaces for Whalley

100sqm Retirement Apartments in 2 Linked 2 Storey Buildings including 11sqm Gloriette Units

15 Parking Spaces Home Office recommendations

30m Screening zone

30m Screening zone

Possible Wildlife Pond (location to be agreed)

Flood Compensation Area

Flood Compensation Area

Existing footpath

30m Screening zone

RIVER CALDER

Unit Type	Count
Bungalow Type A-	7 Units
Bungalow Type B-	9 Units
House Type C	18 units
Bungalow Type F-	3 Units
TOTAL	37 Units

Units denoted * are to be affordable units

Flood Compensation Area as per drawing 1637-LOC A

Cross Section 1

Cross Section 2

0 25m 50m
Scale 1:500

ACCINGTON ROAD

Bus Stop (relocated) Bus Shelter

New Access

New Access to Existing Highway

Visibility Splay 4.8m x 70.0m

25 Parking Spaces for Whalley

1A*, 1A, 2A*, 2A, 3B*, 4C*, 5C, 6C, 7C, 8A, 9C, 10C, 11C, 12C, 13F, 14A, 15F, 16C, 17C, 18B, 19C, 20C, 21C, 22C, 23B, 24C, 25C, 26B, 27C*, 28C*, 29F, 30A, 31B, 32A, 33B, 34A, 35B*, 36B*, 37B, 38B

100sqm Retirement Apartments in 2 Linked 2 Storey Buildings including 11sqm Gloriette Units

15 Parking Spaces Home Office recommendations

30m Screening zone

30m Screening zone

Possible Wildlife Pond (location to be agreed)

Flood Compensation Area

Existing footpath

Flood Compensation Area

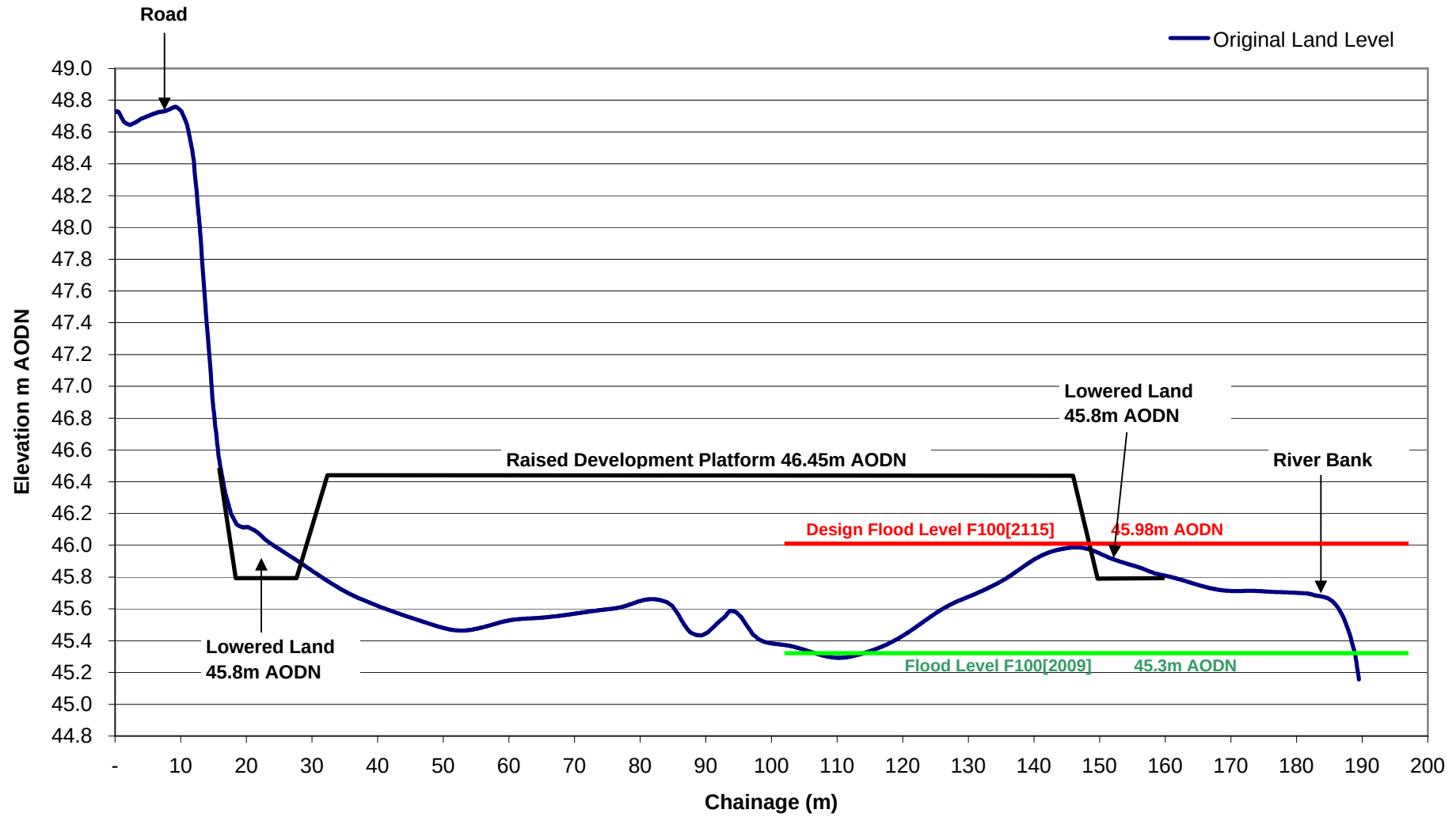
RIVER CALDER

Flood Compensation Area as per drawing 1637-LOC A

Bungalow	Type A-	7 Units
Bungalow	Type B-	9 Units
House	Type C	18 units
Bungalow	Type F-	3 Units
TOTAL		37 Units

Units denoted * are to be affordable units

Cross Section 1



Cross Section 2

