

City of York Council
Castle Piccadilly
Engineering Constraints Study

Issue | 15 September 2015

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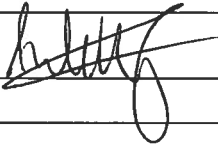

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Executive Summary

Ove Arup & Partners Ltd have been appointed by City of York Council (CYC) to provide a high level engineering constraints study for two sites. The sites are both currently surface level public car parks, located in the south of York city centre.

Castle Car Park

The Castle Car Park site is being considered as the location for a one or two storey underground car park, with associated above ground structure (maximum three storeys on the eastern half of the site only) and a pedestrian bridge across the River Foss.

The conclusion of this study is that construction of a 1 or 2 level basement is feasible. A number of constraints have been identified but it is considered that these can be overcome as part of the design process.

From a ground engineering perspective the key issues relate to:

- soft ground conditions, from both made ground and natural ground;
- obstructions, principally within the made ground from previous developments;
- groundwater in relation to both excavation and uplift pressures;
- unbalanced propping load relating to the retaining wall along the River Foss and loading from Cliffords Tower; and
- the impact of movements from excavation on sensitive structures, particularly Cliffords Tower.

The site elevation is typically above 11mOD, located in Flood Zone 1, compatible with any land use. However, part of the north east corner of the car park is within Flood Zone 3a. Any proposal to raise this part of the site would need to be accompanied by compensatory flood storage provision.

Based on the expected ground conditions it is anticipated that the basement will be constructed using a rotary bored in situ, hard firm secant piled wall. The size of piles will be affected by the basement depth. The basement structure would predominantly be formed of insitu concrete walls, slabs and columns. The anticipated ground conditions and construction methodology will potentially require significant temporary propping during excavation.

The initial assumptions for basement design indicate that approximately 190 car parking spaces would be provided on each level of basement.

Construction of a development over part of the basement is also considered feasible, though the potential incompatibility of structural grids will require a transfer zone between the structures at ground level.

St George's Field Car Park

The St George's Field Car Park site encompasses both the car park and the Foss Basin (the section of the River Foss immediately to the east of the car park). The site is located at the confluence of the River Foss and the River Ouse. The site is being explored for potential development options.

Flooding is the principal control on development of this site, which is located within the 1 in 25 year floodplain and is designated as Flood Zone 3b, functional floodplain. This limits development to water-compatible land uses unless it is re-designated. It is possible that at least part of this site could be developed without increasing flood risk, using a precautionary approach. Development options could include a platform on stilts above the flood level and creation of a marina facility. Arup has held initial discussions with the Environment Agency (EA). It was agreed that the next steps would include further discussions with the EA and a modelling study to assess the potential for modification of the existing flood defence infrastructure and creation of a new development. It is important that dialogue is continued to ensure all stakeholders are satisfied with the work being undertaken.

1 Introduction

Ove Arup & Partners Ltd have been appointed by City of York Council (CYC) to provide a high level engineering constraints study for two sites in central York City. The two sites discussed in the following sections are currently operational surface level carparks, located on the southern side of the City of York. A location plan of the two sites is provided on Appendix A, Sketch 1, an excerpt of which is shown in Figure 1.

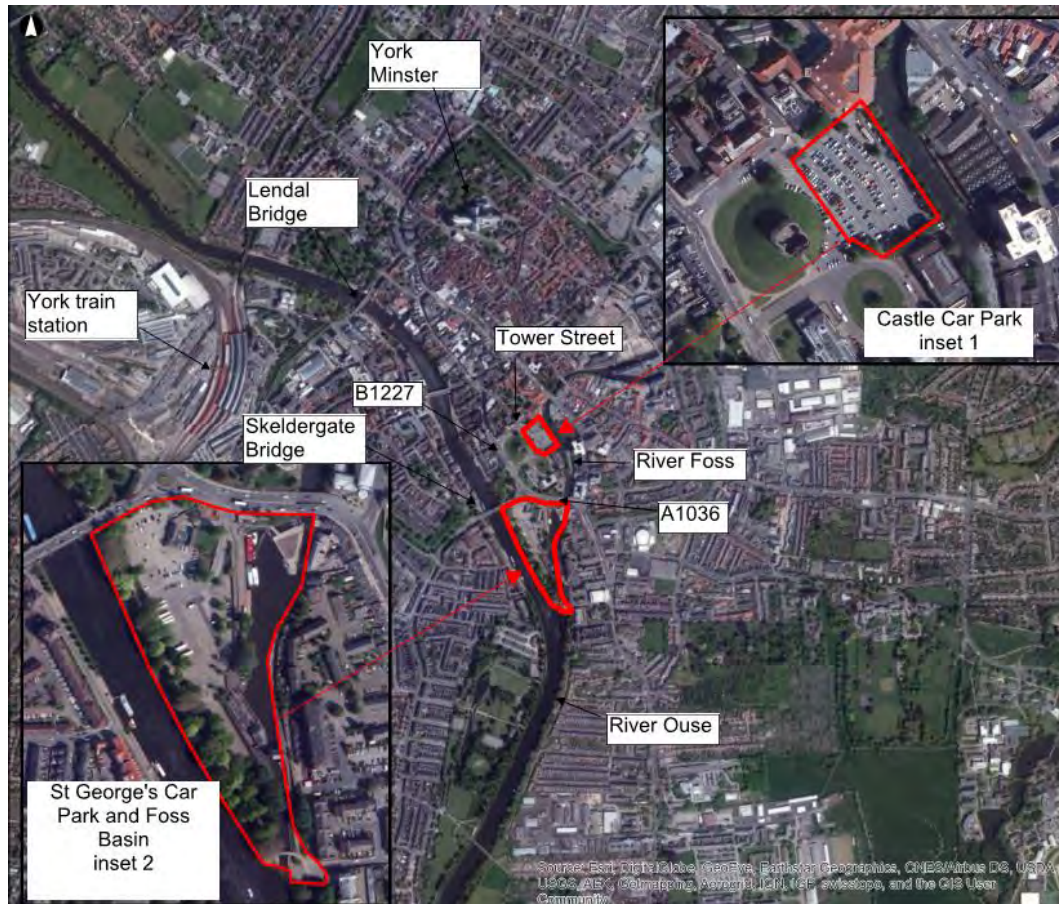


Figure 1: Location plan of Castle Car Park and St George's Car Park

The Castle Car Park site, located on the western bank of the River Foss, to the east of Cliffords Tower is being considered as the location for a possible underground car park, with associated above ground structure and a pedestrian bridge across the River Foss. The scope of works includes consideration of key engineering issues related to implementation of a one or two storey basement, access routes and the pedestrian bridge. A high level feasibility cost estimate for construction of the basement and pedestrian bridge has been prepared in Appendix B.

The St George's Field Car Park is being reviewed for potential development. The scope of this study includes exploration of possible development options, and consideration of the key engineering issues, including the provision of examples of flood requirements that may need to be incorporated into any future schemes.

2 Castle Car Park

2.1 Site Context

The Castle Car Park site is located on the southern side of the city centre, immediately east of Clifford's Tower, on the western bank of the River Foss, as shown in Appendix A, Sketch 1. The site is currently a 318 space public surface car park.

Tower Street running along the northern boundary of the car park provides vehicular access to/from the car park via a priority controlled junction. The car park is accessed from the south via the A1036 inner ring road at the B1227 Tower Street/Skeldergate Bridge junction to the B1227 Tower Street. From the north access is also available through the city centre via B1227 Bridge Street and Clifford Street. A priority controlled junction provides access to/from B1227 from the north and south to/from Tower Street.

Egress from the car park is via Tower Street or Castlegate to access the B1227 for routes through the city centre or to the A1036 inner ring road.

Pedestrian access to/from the site is via the local highway. Pedestrian routes are also available through the Castle Museum and Clifford's Tower sites to the south and west of the site. It is noted that CYC are investigating options for the provision of a new pedestrian bridge across the River Foss as part of the development of the Ryedale House site. Options developed to date would provide a bridge to the south east corner of the Castle car park site.

The development proposal for the site considers the installation of a 1 or 2 storey basement. The area for development of the basement was defined by CYC and is shown in Appendix A, Sketch 2.

The basement development is principally intended as a car parking facility. However, the option of developing the space for retail is also discussed.

In conjunction with the development of the basement an above ground structure is also under consideration. There are some constraints on the above ground development. As shown in Appendix A, Sketch 2 only the north eastern side of the site is feasible for above ground development, due to the line of site requirements. The proposed structure for an as yet undefined purpose will be a maximum of three storeys.

There is an aspiration for a footbridge to improve pedestrian connectivity of the site across the River Foss to the east of the city. The proposed pedestrian footbridge is considered here on the basis of the Holder Mathias Architects design provided by CYC.

2.2 Engineering Site Constraints

2.2.1 Ground Conditions

2.2.1.1 Site History

The history of the site has been investigated through online searches. These show that the area occupied by the car park was developed as York Castle Prison around 1825 (<http://freespace.virgin.net/cade.york/castle/amenity.htm>). The prison building remained on site until approximately 1930. An image of the prison is shown on Figure 2.



Figure 2: York Castle Prison

In the 1930's the prison was demolished and there were plans to develop health clinics and municipal buildings on the site. A phased development was planned, although it is suggested that all the foundations were constructed together. In the end it appears that little development was actually undertaken. The photograph in Figure 3 appears to show some of the foundation/basement structures in place. Archaeological reports for previous proposals on the site suggest that over 400 driven piles were installed to form the foundations of the development.



Figure 3: Extract from the 1961 York Guidebook
(<http://www.yorkmix.com/life/history/six-things-that-have-disappeared-from-york-in-the-last-50-years/>)

The site was requisitioned during WWII, however, following derequisition, was never developed. It is suggested that the existing structures were buried beneath the carpark currently occupying the site (<http://freespace.virgin.net/cade.york/castle/clinic.htm>). Trench 2 of the York Archaeological Trust 1995 investigation (“Evaluation at York Castle Car Park, Report number 3”) encountered the reinforced concrete slab from the 1930’s development at a depth of 0.5m.

A buttressed masonry retaining wall appears to form the boundary between the site and the river Foss. It is possible that this wall comprises the footings of the 1825 prison wall.

2.2.1.2 Geological Setting

The image in Figure 4 is an extract from the Geological Survey of England and Wales 1:63,360/1:50,000 geological map series sheet 63, “York”. The map shows the site is underlain by Boulder Clay (renamed as Glacial Till) overlying Bunter and Keuper Sandstone (renamed as Sherwood Sandstone).

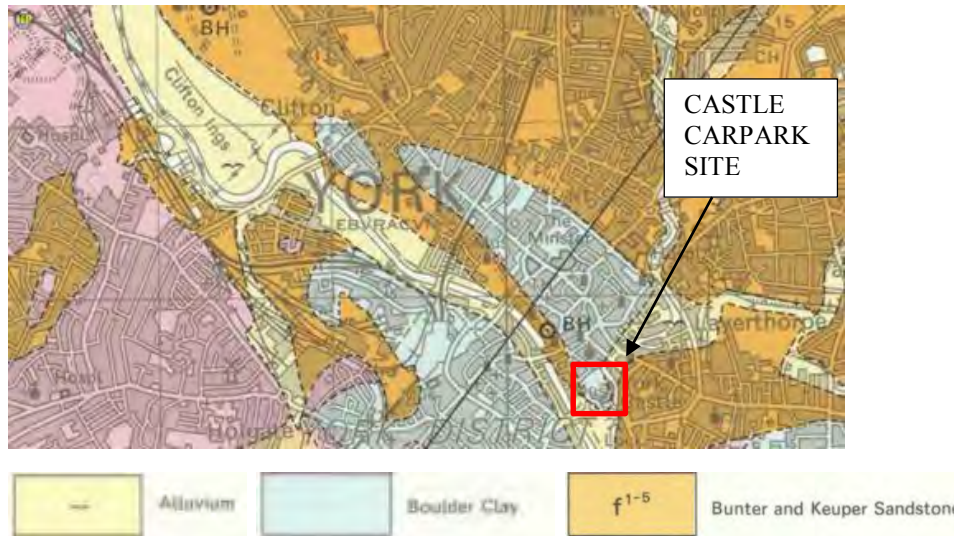


Figure 4: Extract from the Geological Survey of England and Wales 1:63,360/1:50,000 geological map series sheet 63, “York” (Solid and Drift), 1983.

2.2.1.3 Historical Boreholes

A number of historical boreholes located on the site are available from the BGS online Geindex catalogue. The available boreholes are primarily associated with the proposed development of municipal buildings in the 1930's. The boreholes shows the following typical sequence:

- Made Ground (4 to 5m thick)
- Soft silt/clay (3 to 4 m thick)
- Hard clay (8m thick)
- Sandstone (from a depth of 17m, thickness unproven)

The historical boreholes also record details of water strikes, with water typically being noted to enter the borehole at the interface of the Made Ground and underlying silt/clay. Whilst there is no record of standing water levels, the water strike levels are comparable with the water levels in the River Foss (approximately 4m below ground level).

A summary cross section of the anticipated ground conditions is shown in Appendix A, Sketch 3.

2.2.1.4 Impact of Ground Conditions

Based on the information presented in this report the implications of the anticipated ground conditions are outlined below.

- **Obstructions:** The history of the site suggests that significant obstructions may be present in the form of the former prison foundations or the basement structure of the municipal development. These have been clearly identified in previous archaeological excavations, though it is not known whether the depth of the foundations has been proven. Whilst near-surface obstruction may be removed prior to construction, it may be necessary to deal with deeper obstructions as excavation proceeds. This means the basement wall

construction method may require flexibility to deal with encountering deeper obstructions. There is also the potential that the Glacial Till (formerly known as boulder clay) may present obstructions in the form of cobbles or boulders of rock within the clay matrix.

- **Soft ground:** Made Ground can be variable in nature, and the borehole data shows that beneath this is a layer of soft silt/clay. This material is likely to be unsuitable for supporting foundations or a retaining wall. It is therefore anticipated that some form of embedded retaining wall, extending into the Glacial Till, will be required. Piled foundations are also anticipated to support the building structure.
- **Ground Water:** The ground water appears to tie into the level of the River Foss, at approximately 4m depth, based on the historical data. The impact of water will therefore depend upon the depth of the basement. A single storey basement is likely to encounter ground water towards the base of the excavation. To control ground water ingress during construction it is expected that the basement perimeter wall would be designed as a cut-off into the Glacial Till. This is likely to be achieved through installation of a secant piled wall. Long term, water pressure acting on the underside of a single level basement will be balanced by the weight of the structure and so uplift will be prevented. In the case of a 2 level basement, a head of approximately 4m of water is anticipated on the underside of the base slab. Where there is no structure over the car park there is a risk of uplift, so tension piles may be required. The water pressures will also increase the forces in the base slab and may increase its thickness.
- **Unbalanced loads:** To the west of the site is the mound of Cliffords Tower, to the east is the River Foss. Typically in a basement the propping loads from one wall are transferred to the opposite wall via props or slabs. Where the ground is higher on one side than the other these prop loads are not balanced and there is a risk of sway. In order to mitigate this it is necessary to introduce additional stiffness in the basement structure to mitigate sway. However, there is also a problem in the temporary case, where temporary steel props are typically used to support the walls. Such systems do not have the stiffness to resist the sway loads. The sequence of temporary propping may need to be more complex to ensure temporary wall stability.
- **Sensitive structures:** Constructing a basement inevitably creates ground movement in the surrounding area. The presence of sensitive structures, in particular Cliffords Tower, means that limiting these movements is likely to be very important. This is best achieved through selection of a stiff basement wall and an appropriate construction sequence. A hard-firm secant pile wall provides suitable stiffness. For construction, the presence of the soft silt/clay may mean that excavating the wall as a cantilever is not possible, and temporary propping will be required.

2.2.2 Flood Risk

2.2.2.1 Flood Mechanisms at the Site

The Castle car park is at risk of flooding directly from the River Foss, and less directly, from the River Ouse. Surface water flooding is not a significant risk at

this site as any excess floodwater from the urban drainage systems can drain directly overland to the River Foss. However, groundwater does pose risks to the basement development during design, construction and operation from the perspective of both uplift pressures and water flow into the excavation/water proofing of the basement structure.

2.2.2.2 Flood Defence Infrastructure

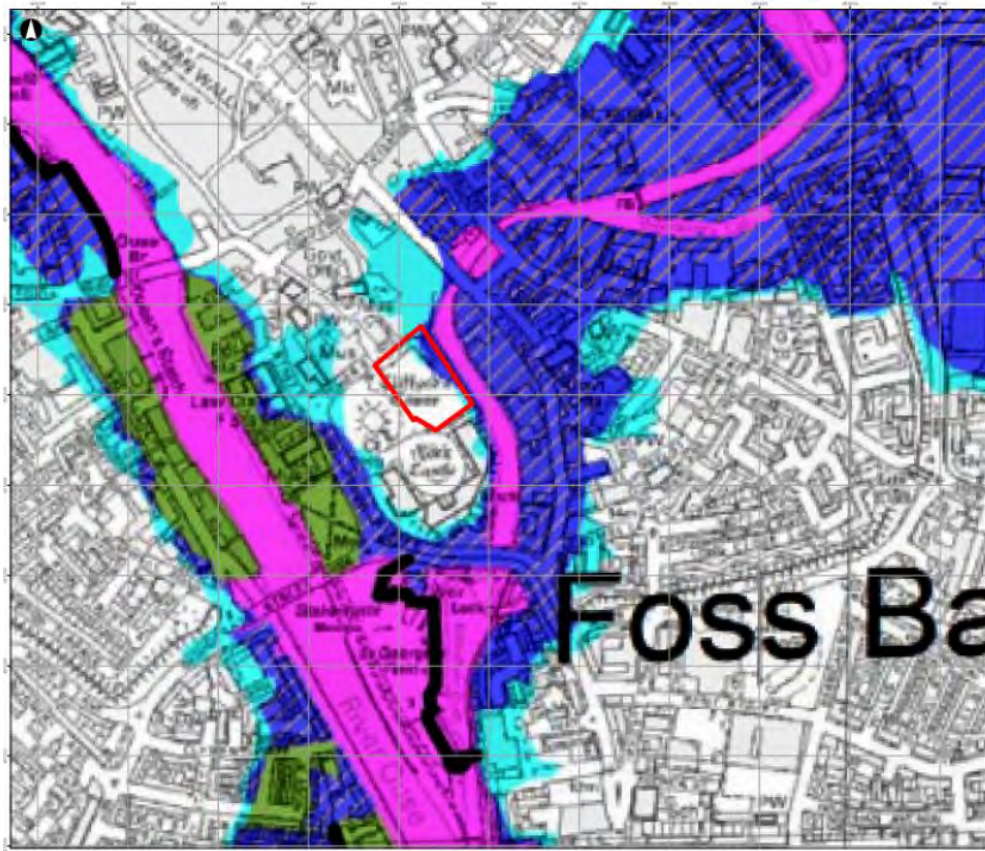
A ridge of high ground on which Clifford's Tower is located means that direct flooding from the River Ouse is very unlikely. The site is at risk from the River Ouse indirectly due to backing up of the River Foss from its confluence with the Ouse immediately to the south of the site. This mechanism places some 1,000 properties at risk in central York. Foss Barrier and its associated floodwalls and pumps are designed to prevent this flood mechanism from coming into action. As flood levels in the River Ouse rise, the Foss Barrier is lowered into position. When the River Foss is flood-locked in this way, flood levels in the Foss are controlled by a combination of the storage volumes available within the channel and pumping. There are currently eight pumps at Foss Barrier. Relevant normal and flood level data is summarised in Table 1:

Table 1: Relevant normal and flood level data.

Description	Defended (D) or Undefended (U)	Level (mOD)
River Foss Opposite Clifford's Tower (Model_FOSS08_014)		
Normal water level	n/a	c. 7.6
1 in 100 year flood level	Defended (ie Foss Barrier and its associated pumps work in conjunction with the main river flood defences to prevent floodwater backing up from the River Ouse).	to be established in consultation with the EA
1 in 100 year plus climate change		
1 in 1,000 year flood level		
1 in 100 year flood level	Undefended (Barrier fails)	9.97
1 in 100 year plus climate change		10.92
1 in 1,000 year flood level		11.18
River Ouse (Opposite Peckitt Street, 12213_MODEL_Ouse061, except where indicated)		
Normal water level (Ouse Bridge, Viking Recorder)	n/a	c. 5.1
1 in 100 year flood level	Defended	10.38
1 in 100 year plus climate change		10.76
1 in 1,000 year flood level		11.39
1 in 100 year flood level	Undefended	10.29
1 in 100 year plus climate change		10.77
1 in 1,000 year flood level		11.32

2.2.2.3 Flood Zones and Relevant Water Level Data

The Strategic Flood Risk Assessment (SFRA) for 2011 is shown in Figure 5.



SFRA 2011 Flood Risk Zones Legend:






<p>All Uncoloured Areas</p>     	<p>Zone 1: Less than 1 in 1000 annual probability of flooding in any year (<0.1Percent)</p> <p>Zone 2: Between 1 in 100 and 1 in 1000 annual probability of flooding in any year (1Percent to 0.1Percent)</p> <p>Zone 3a: Areas between 1 in a 100 and 1 in 25 annual probability of flooding in any year (1 to 4 Percent)</p> <p>3a - Defended up to 1 in 50, Flood Risk between 1 in 50 and 1 in 100 (2 to 1 Percent)</p> <p>3a - Defended up to 1 in 100 (1Percent)</p> <p>Zone 3a(i): Developed areas with up to a 1 in 25 or greater annual probability of flooding in any year (4 Percent or greater)</p> <p>Zone 3b: Areas with up to a 1 in 25 or greater annual probability of flooding in any year (4 Percent or greater)</p> <p>Flood Defences</p>
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Figure 5: Flood Zones in central York taken from Figure 10c of the York SFRA¹

¹

http://www.york.gov.uk/downloads/file/1988/figure_10c_flood_risk_areas_within_zones_1_2_and_3_-_city_centre

2.2.2.4 Implications for New Development

Flood zones and land use

All areas above a level of 10.92mAOD constitute Flood Zone 1 and as such could be used for any land use. Areas below 10.92mOD constitute Flood Zone 3a. Highly vulnerable uses, as defined in National Planning Policy Framework (NPPF)², should not be permitted in this zone. The more vulnerable uses and essential infrastructure should only be permitted in this zone if the Exception Test is passed. Any proposals that would prevent this area from flooding in the future would need to be developed in conjunction with measures to retain the overall flood storage volume within the River Foss system.

Basements

To prevent groundwater ingress and flooding from the rivers, the basement should be rendered as watertight as possible up to the level of the access ramp, with internal pumps provided to evacuate any minor water ingress that does occur.

The basement access should ideally be above the 1 in 1,000 year flood level in the Rivers Foss and Ouse, including an allowance for climate change and a safety margin (freeboard), assuming that Foss Barrier, or its associated pumping station, fails to operate. Assuming freeboard of 300mm, this would give a target minimum ramp level of 11.69, say 11.7mOD. If this was achievable, then the risk of the basement flooding directly from either river would be very low. It is likely that an access from Tower Street to the north, which is slightly elevated, could be configured to achieve this.

If the above is not achievable, the minimum measure for basement flood protection would be to incorporate an automatically rising barrier on the ramp that would defend to a 1 in 100 year plus climate change level with freeboard, assuming the site is protected by Foss Barrier. The top of the rising gate would need to be designed based on levels provided by the EA. The ramp itself could then be lower than this level. Under this latter scenario, a flood plan would be required that sets out what would be done to evacuate the basement and recover the situation after any flood that exceeded this design standard, if for example, the Barrier failed.

Footbridge

The soffit of the footbridge would need to satisfy navigation requirements as agreed with the navigation authority. From a flood risk perspective, freeboard of at least 600mm would be required beneath the soffit to allow floating debris to pass beneath the bridge during the peak of a 1 in 100 year plus climate change flood in the River Foss. This would give a soffit level of 11.52mOD, if no reliance was placed on Foss Barrier. Consultation with the EA is required to confirm the 'defenced' equivalent.

² <http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/flood-zone-and-flood-risk-tables/table-2-flood-risk-vulnerability-classification/>

2.2.3 Structural

2.2.3.1 Development Assumptions

This constraints assessment has been carried out based on the following broad assumptions:-

- The basement will be for car parking usage, with no specific operator requirements.
- The basement will extend to the maximum allowable footprint, with the superstructure building over remaining within the available development area created by the line of site requirements.
- The building development will be a maximum of 3 storeys and will have a predominantly retail use.

The car parking will be delivered to an efficient car parking grid, which will not be economic for retail use. An allowance has therefore been made for a transfer deck within the overall basement depth assessment as this will provide the required flexibility not to overly compromise the value of any development over the basement.

- Basement framing is assumed to be in-situ concrete.
- The basement will extend out under the adjacent public realm and this will require external build up to falls and will require access for vehicles such as fire appliances and refuse collection vehicles.

These assumptions are summarised in Appendix A, Sketches 4, 5, 6 and 7.

2.2.3.2 Superstructure Grid and Transfers

Structural grids in buildings vary depending on the usage of the building. Grids within retail units tend to work to the retailers' specific working modules and provide longer clear spans which maximise the retail floorplate. As a contrast, residential grids tend to be tighter and less flexible, as the spaces contained within the floors are more rigidly fixed and smaller. Car parking grids need to work efficiently with the layout of car parking spaces and vehicular circulation.

These different grids tend to be incompatible, particularly when different usages are stacked one above the other. To overcome this, either one space needs to compromise on the efficiency of its grid, or transfer beams are required to adjust the grid between floors. These transfer beams add structural depth, construction cost and complexity but often pay back in terms of the commercial value of the space generated. An assumption has been made that the additional depth for transfer beams at ground floor level will be required to maximise values of the development over.

2.2.3.3 Basement Construction Methodology

The basement is anticipated to be constructed using a rotary bored in situ hard firm secant wall. This construction will be required for either a single or double storey basement, with the pile size being larger for the increased depth of the two storey basement. The construction methodology will also require significant temporary propping during excavation. This typically takes the form of steel waling beams and either horizontal or raking props. It can be anticipated that if horizontal propping is used additional plunge piles and columns would be required to support the weight of the long spanning temporary props. If raking props were used, thrust blocks would need to be formed into competent material.

Basement waterproofing will be a key consideration. It is anticipated that a concrete liner wall construction will be required inside the secant wall and that this wall will need to be designed to water retaining standards. In addition allowance will need to be made for hydrophilic strips or water bars to all joints.

The basement ground bearing slab will be of reinforced concrete (RC) construction, where there is no above ground structure it will be sufficiently sized to account for the hydrostatic uplift pressure created by the high water table.

Intermediate slabs for car parking would be on in-situ RC construction onto RC columns.

The podium slab would also consist of RC construction, with additional downstand beams incorporated within a 'transfer zone' that would allow transferring of superstructure columns to maximise the space utilisation within the car park. Without this zone, superstructure columns would compromise the efficiency of the car parking layout.

2.2.3.4 Use for Retail

If the basement were to be used for retail provision rather than car parking either whole or in part, then those areas used would need the addition of a drained and insulated cavity wall liner in front of the concrete liner wall. This will act to control the internal environment to a more suitable level. The same provision would apply to storage areas within the basement or similar.

In addition, the structural grid would logically flow through from the superstructure retail spaces, reducing the need for transfer trusses. This is unlikely to realise any reduction in overall basement depth as it is anticipated that significantly greater floor to floor heights will be required for a retail space. In addition, retail space would require additional floor to floor height to allow for more intensive mechanical services. This would likely increase the overall depth of basement excavation for both single and double storey basements significantly.

2.2.4 Transport

The existing car park has provision for 318 spaces. It is anticipated that vehicular access proposals would not change from the existing provision. Primary access would likely be provided via Tower Street to/from the A1036 inner ring road. It

may be appropriate to consider measures to limit access / egress through the city centre.

The existing car park has a number of car trips to/from the site. Development of the site is proposed to include underground car parking, a single level of basement would be a reduction in the current parking provision and two levels would represent a slight increase. To assess the highway impact further detail of the proposed land use for trip generation and arrival/departure profiles would be required. Once the land use and arrival/departure profiles are understood they would need to be compared to the existing situation to make an assessment of the impact of changes. This would likely require some modelling of key adjacent junctions.

An initial sketch layout of the basement, as shown in Appendix A, Sketch 4 indicates that approx. 220 car parking spaces could be provided within each level of basement car park. In reality this would be nearer 190 to enable disabled parking provision and potential space for plant/storage/lift areas etc. A comparison of the number of spaces provided in existing and proposed car parking is provided in Table 2.

Table 2: Comparison of car parking provision numbers

Status	Number Car Parking Spaces
Existing	318
Proposed 1 level basement	190
Proposed 2 level basement	380

Pedestrian and cycle access to the site will need to be considered as part of the site design. The development of the Ryedale Bridge to provide a connection across the River Foss at the south east corner of the site will provide improved pedestrian connection. A feasibility cost estimate is provided in Appendix B. It is noted that previous concept study work in relation to Ryedale House and the bridge identify cycle routes along the eastern and southern boundaries of the Castle Car Park site as part of a cross city strategic cycle route. Design of the site will need to consider cycle connections to the wider cycle network and cycle parking.

The Piccadilly NCP, a 287 space multi storey car park, is located immediately north of the site. The main vehicular access to/from the car park is from Piccadilly to the north east of the site, however, an overflow basement exit ramp is provided rising in to the Castle Car Park to the north east corner of the site. CYC has stated that the exit ramp has been closed off for some time, however, it does provide access to Yorkshire Water equipment as well as a pedestrian fire exit route from the Fenwicks store to the river bank. Development of the Castle Car Park site will therefore need to consider the requirement for this in any design.

A service yard access / egress is located along the northern boundary of the site. Access proposals for the site will need to consider this, however CYC have

confirmed that the service yard does not necessarily have to be retained. Depending on land use the site will require access for emergency vehicles and service vehicles. Design of the building and surrounding area will need to allow for this.

2.3 Conclusions

Following this high level review of the engineering constraints it is considered that a one or two storey basement construction is feasible for use as either car parking or for retail purposes. The high level feasibility estimate gives a one level basement cost of £12,460,472, which equates to £65,581.43 per space. The total cost of a two storey basement is calculated to be £17,937,602, which equates to £47,204.21 per space.

There are constraints on the site from flooding risk and lines of sight. The ground conditions (particularly soft ground and obstructions) also pose constraints on development but that these constraints could be addressed during design. Considering the ground conditions, influence of ground water and temporary works requirements a two storey basement poses greater construction risks than a single storey basement.

A surface superstructure would affect design of the basement in terms of transfer of load between grids from surface to basement structure and combating uplift, particularly for a two storey basement.

Provision of a footbridge is feasible, subject to appropriate land acquisition and would improve pedestrian connectivity of the site.

An initial risk register for development of the site is provided in Appendix D.

2.4 Next Steps

The commercial viability of the site from a one or two storey basement perspective needs to be assessed.

If a decision to proceed with the development is made the use of the basement and the nature of the above ground superstructure would need to be defined in order to develop an appropriate design.

Access requirements to the underpass would also need to be more clearly defined.

Following these decisions a feasibility study should be undertaken incorporating a comprehensive desk study to assess ground conditions, historical records of the site (e.g. foundation and river wall records). The results of this study would be used to design an appropriate ground investigation. From which parameters for initial design of the basement and foundation requirements of the superstructure would be derived.

The study should also incorporate a review of other influential factors for development on site, such as archaeology and utilities, which have not been included in this review.

3 St George's Car Park / Foss Basin

3.1 Site Context

The St George's Car Park is located on the southern site of the city centre, immediately south of the A1036 inner ring road, between the River Ouse and the River Foss, as shown in Appendix A, Sketch 1. The Foss Basin is the section of the River Foss immediately to the east of the car park. The basin is bounded to the north by the Castle Mills lock gates and to the south by the Foss Barrier.

St Georges Car Park is currently a public surface car park providing space for 276 cars and 27 coaches. The car park is accessed directly from the A1036 inner ring road immediately east of the Tower Street / Skeldergate Bridge junction. It has associated public conveniences at the northern end of the site adjacent to the access ramp.

The site is also occupied by two pumping stations, one at the north on the site adjacent to the access ramp and the other to the south east of the site associated with the Foss Barrier.

There is no specific development brief for the site, the engineering constraints study considers what options may be possible based on the specific site conditions.

3.2 Engineering Site Constraints

3.2.1 Ground Conditions

3.2.1.1 Site History

The English Heritage record a Scheduled Monument 120m south of York Castle, on the northern edge of the St George's Car Park. In the 12th century a chapel to York Castle was constructed, separated from the castle by a moat created by damming the River Foss. By the 1630's the chapel had been converted into a workhouse, the building was demolished in 1856. The monument consists of the buried remains of St George's medieval chapel. Limited excavations in 1991 indicate that significant remains of the structure survive below ground.

A review on online resources shows that the majority of the St Georges Fields site was undeveloped up to the late 19th century, at which time the York Public Baths were constructed on the east of the site (adjacent to the basin) and Skeldergate bridge to the north. Relatively little further development took place in the 20th century, with the formation of a surface car park, demolition of the public baths and construction of a Yorkshire Water pumping station.

3.2.1.2 Geological Setting

Figure 6 presents an extract from the Geological Survey of England and Wales 1:63,360/1:50,000 geological map series sheet 63, "York" (Solid and Drift). The

map shows the site is underlain by Alluvium, then Boulder Clay (renamed as Glacial Till) overlying Bunter and Keuper Sandstone (renamed as Sherwood Sandstone).

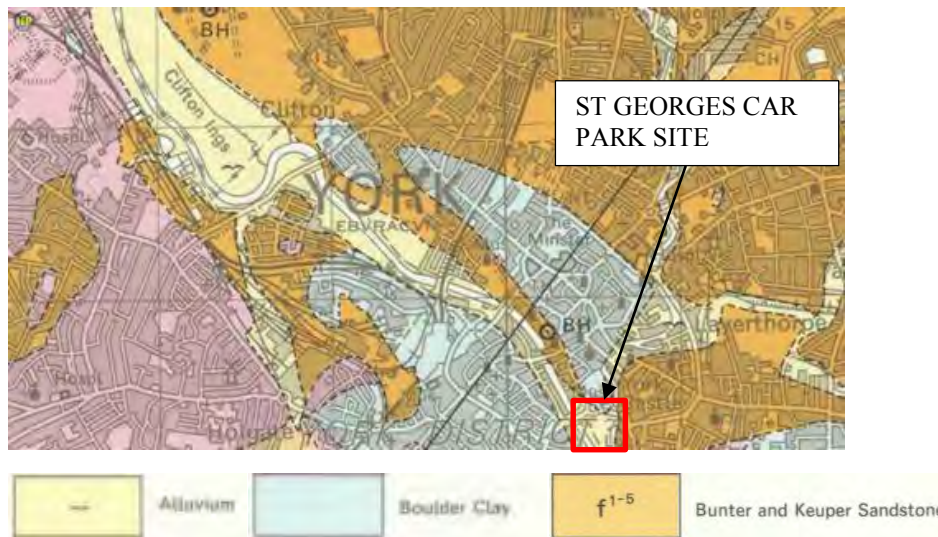


Figure 6: Geological Survey of England and Wales 1:63,360/1:50,000 geological map series sheet 63, “York” (Solid and Drift), 1983.

The geological map shows the site is underlain by Alluvium, overlying Glacial Till and Sherwood Sandstone.

3.2.1.3 Historical Boreholes

A number of historical boreholes located on the site are available from the BGS online Geindex catalogue. The boreholes shows the following typical sequence:

- Made Ground (typically up to 2m thick);
- Soft silt/clay, with sand and gravel towards the base (6m thick, base at approximately 0mOD);
- Firm to Stiff gravelly clay (2 to 3m thick);
- Sand over weathered sandstone (from a level of -2 to -3mOD thickness unproven).

The historical boreholes also record details of water strikes, with water typically noted to enter the borehole in granular layers below the silt/clay. Standing water levels were recorded at approximately 3 to 4m depth, estimated to be 5mOD.

3.2.2 Flood Risk Issues

3.2.2.1 Flood Mechanisms at the Site

The St Georges Fields Car Park is at risk of flooding directly from the River Ouse. Ground and surface water flooding is not a significant risk at this site as any excess floodwater from the urban drainage systems can drain overland to the river.

3.2.2.2 Flood Defence Infrastructure

The flood defence infrastructure as provided by CYC is shown on Figure 7.

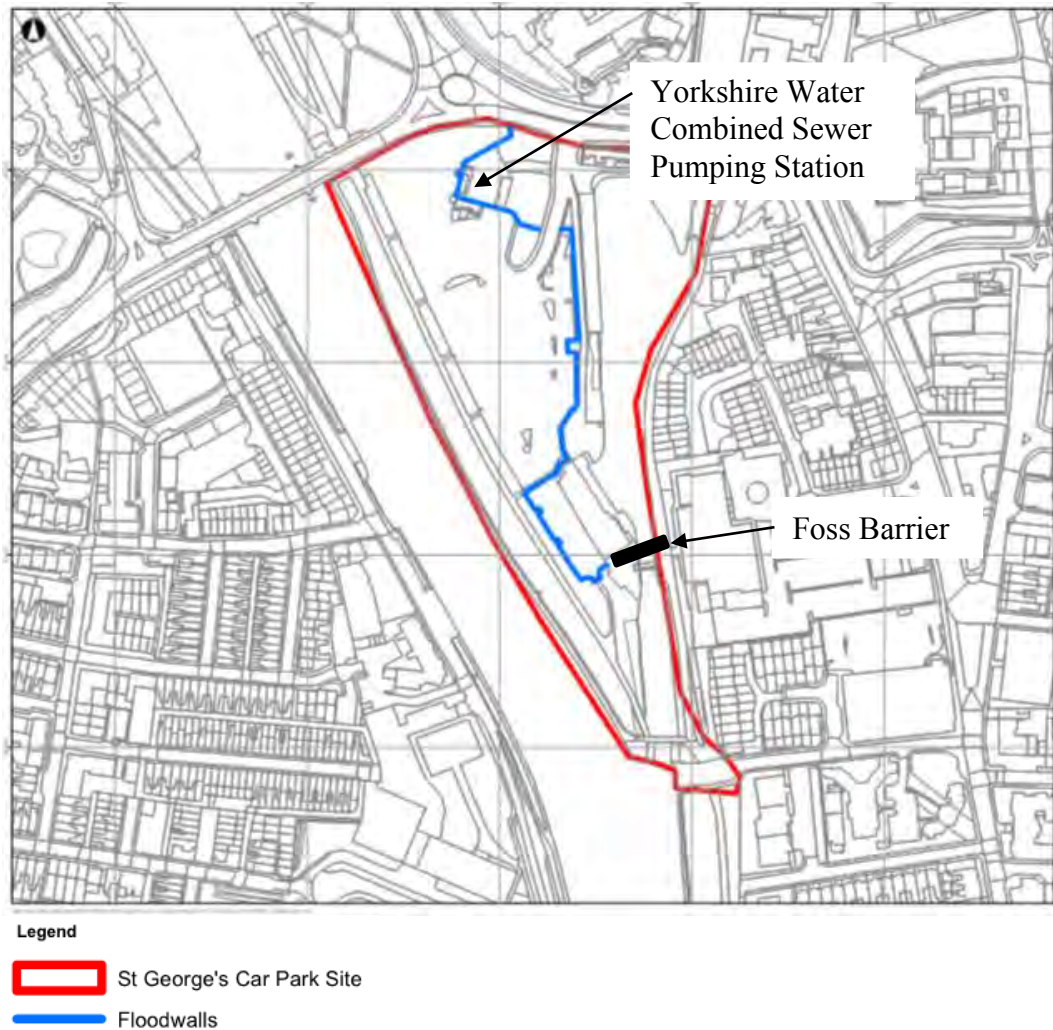
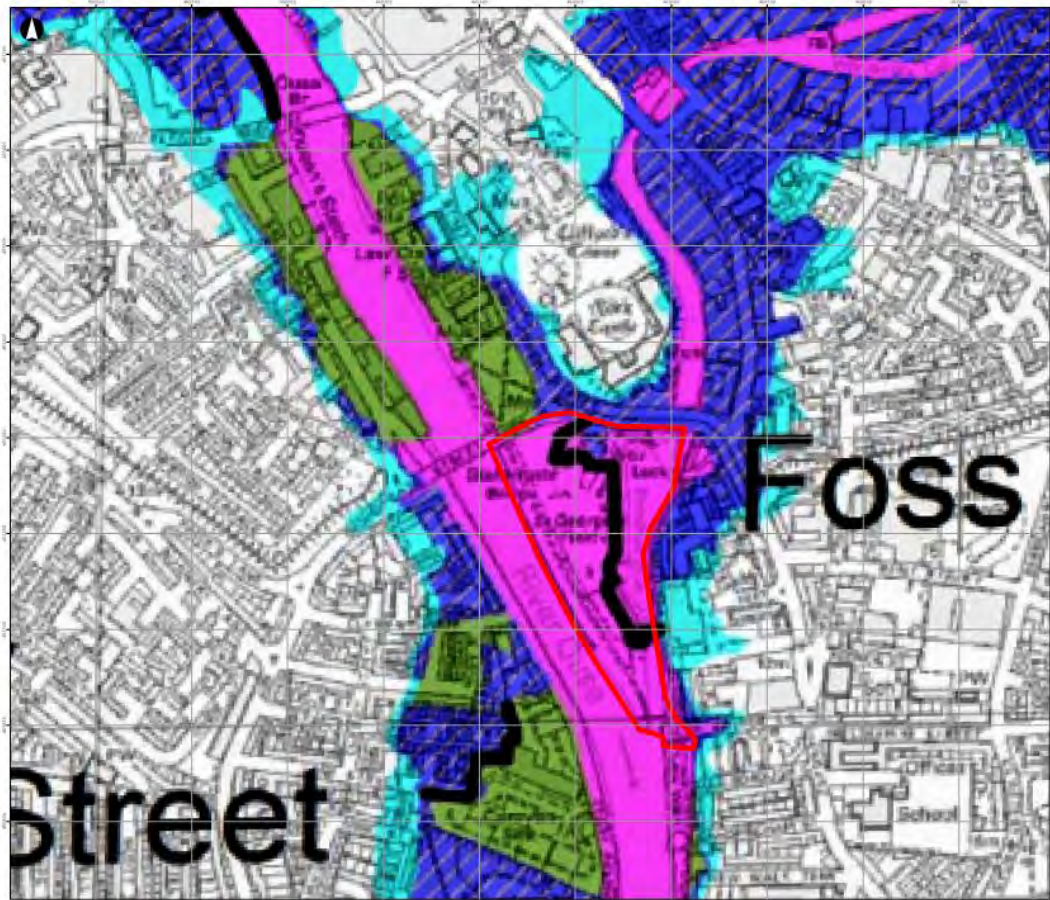


Figure 7: Showing alignment of flood walls and the location of Foss Barrier (adapted from the City of York Council Foss Basin Ownership sketch).

Landownership details, showing easements for operation and maintenance of this infrastructure are shown in Appendix A, Sketch 8.

3.2.2.3 Flood Zones and Water Level Data

The Strategic Flood Risk Assessment (SFRA) for 2011 is shown in Figure 8.



SFRA 2011 Flood Risk Zones Legend:







<p>All Uncoloured Areas</p>	<p>Zone 1: Less than 1 in 1000 annual probability of flooding in any year (<0.1Percent)</p>
	<p>Zone 2: Between 1 in 100 and 1 in 1000 annual probability of flooding in any year (1Percent to 0.1Percent)</p>
	<p>Zone 3a: Areas between 1 in a 100 and 1 in 25 annual probability of flooding in any year (1 to 4 Percent)</p>
	<p>3a - Defended up to 1 in 50, Flood Risk between 1 in 50 and 1 in 100 (2 to 1 Percent)</p>
	<p>3a - Defended up to 1 in 100 (1Percent)</p>
	<p>Zone 3a(i): Developed areas with up to a 1 in 25 or greater annual probability of flooding in any year (4 Percent or greater)</p>
	<p>Zone 3b: Areas with up to a 1 in 25 or greater annual probability of flooding in any year (4 Percent or greater)</p>
	<p>Flood Defences</p>

Figure 8: Flood Zones in central York taken from Figure 10c of the York SFRA

The relevant levels for normal and flood level data are provided in Table 3.

Table 3: Relevant normal and flood level data.

Description	Defended (D) or Undefended (U)	Level (mAOD)
River Ouse downstream of Skeldergate Bridge (Model node 12213_MODEL_Ouse063)		
Normal water level	n/a	c. 5.2
1 in 5 year flood level	Defended	9.43
1 in 50 year flood level		10.14
1 in 75 year flood level		10.25
1 in 100 year flood level		10.3
1 in 100 year plus climate change		10.66
1 in 1,000 year flood level		11.26
1 in 100 year flood level		Undefended
1 in 100 year plus climate change	10.66	
1 in 1,000 year flood level	11.19	

3.2.2.4 Implications for development

The St Georges Fields site floods regularly. It is within the 1 in 25 year (4% annual chance) floodplain. In preparing their Strategic Flood Risk Assessment, CoYC has agreed with the Environment Agency that, in planning terms, this area should be designated as Flood Zone 3b, functional floodplain, as shown on Figure 8. Flood Zone 3b comprises land where water has to flow or be stored in times of flood.

The new/latest government guidance lists land uses that are compatible with functional floodplain. These primarily comprise water compatible land uses, such as marinas - retail and/or residential development does not feature on this list.

Proposals to develop this area would therefore test the National Planning Policy Framework (NPPF). In order to develop this site, CoYC and the Environment Agency (EA) will need to agree to the principles that would apply being mindful of potential conflicts with NPPF and undesirable precedents. Initial exploratory discussions were held with the EA on 22nd April, 2015, a copy of the minutes is provided in Appendix C. A proposal to develop part of the site may be viable if:

- CoYC revises their SFRA and, in consultation with the EA, re-classified part of the car park as Flood Zone 3a. This would make it potentially developable subject to satisfaction of the Sequential and (certainly for residential development) Exception Tests in NPPF;
- Those at risk of flooding nearby (e.g. Clementhorpe) and downstream of the site (e.g. Naburn) would need to be consulted/presented with a robust set of evidence-based proposals that demonstrate how the development will not increase flood risk, and will ideally reduce it;

- The process will be helped if this development is designed in line with latest guidance on Water Sensitive Urban Design.

There is the possibility of this development being promoted/developed in a manner which complements the EA's proposals to upgrade the York Main River flood defences. There are also potential funding synergies – and opportunities via European Social Fund (ESF) and the Local Enterprise Partnerships (LEP). If any development did proceed here, it will be very important for the proposals to be compatible with

- the constraints imposed by the physical presence of, and access requirements associated with, the flood defence infrastructure shown in Figure 7.
- the EA's programme of works to the flood defences at Foss Barrier and along the Ouse. The EA's modelling is currently being updated and should be complete by June 2015.

It is possible that at least part of this site could be developed without increasing flood risk, using a precautionary approach. There is an existing access over the flood defences into the site from the A1036. If a platform was constructed on stilts above the flood level in the area at the back of the car park, this would potentially be compatible with

- a) continuing to use the ground level as a car park and an 'area where floodwater is stored in times of flood', and
- b) with building an elevated high value riverside development at the southern gateway to the city centre.

The loss of storage associated with the stilts/pillars would need to be assessed and mitigated, but this volume would be small and this is likely to be possible and demonstrable using hydraulic modelling techniques. Examples of raised structures are shown on Sketch 9

Other options that could be considered would include creation of a marina facility. Under such a scenario it would be important not to compromise the main river flood defences. If entered from Foss Basin through the floodwalls, this access would need to be designed such that it could be fully closed off when floods occur in the River Ouse. This would result in the need for a gate of a similar size to the Foss Barrier. In principle, creation of such a gate would double the risk of a failure occurring in the main river flood defence system, so to obtain regulatory buy-in from the flood risk authority (EA) would be challenging.

Under any development proposal, there would be good scope to undertake complementary public realm improvements in this area that ensured flood storage volumes were retained/ enlarged and which helped to achieve Water Framework Directive objectives for the river.

3.2.3 Structural

As noted, any development of the site would require to be built from stilts / columns. These would need to be co-ordinated into the design of the individual buildings. It should also be noted that any construction at ground level would need to be resilient to periodic flooding, for instance lift shafts would need to not extend to ground floor, or would need to incorporate some degree of protection against flood water. If the structures are to be tanked and protected, buoyancy would need to be addressed in the design.

3.2.4 Transport

It is anticipated that the access proposals would remain unchanged from the existing provision.

The site is an existing car park therefore development at the site would likely provide less parking, therefore potentially result in less trips and highway impact. Further work regarding the proposed development land use is required to determine the trip generation, arrival / departure profiles and key impacts.

3.3 Conclusions

Development options for the site are primarily controlled by flooding. Principally this relates to the flood zone designation, and the potential for re-designation. Without re-designation the site can only be used for water compatible uses, such as a marina facility.

Following a conventional approach the site would not be developed due to these constraints. However, due to its prime location within the constrained city centre alternative approaches have been considered to explore the potential for development of the site.

There could be benefits from developing the site for both the EA and CYC, such as the potential to release funding for both the site and flood defence measures. Initial discussions with the EA did not highlight any fundamental reasons why assessment should not proceed to the next stage, as outlined in Section 3.4.

An initial risk register for development of the site has been provided in Appendix D.

3.4 Next Steps

The next step with regard to testing the flood risk constraints would be further discussions with other stakeholders within the EA who have not previously been consulted. We believe appropriate consultee's would be Neil Longden, Area Flood Risk Manager and Mark Scott, Area Manager at the Environment Agency.

If they are supportive in principle, then it is proposed that the next step would be to undertake a modelling study to assess how much flexibility there is to adjust the existing configuration of the flood defence infrastructure in this area. This would aim to maximise the development potential without increasing (and potentially

reducing) flood risk. Any such analysis would involve modification of the existing EA hydraulic models of the River Ouse and the River Foss in order to assess the options and impacts in detail.

Once this work has been undertaken options for feasible future land use of the site could be investigated.