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FLOOD RISK ASSESSMENT

ON

Land at
Cellars Clough,
Nr Marsden,
Huddersfield,
West Yorkshire
HD7 6NB

FOR

Cellars Clough Properties Ltd

E15/6518/FRA001A

April 2016
REVISED September 2017

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1.0 INTRODUCTION

1.1 This report is commissioned to investigate and report on the Flood Risk for this site in accordance Planning Practise Guidance- Flood Risk and Coastal Change April 2015 (PPG-FRCC) and the proposals for drainage of this site when redeveloped as residential land. The report is based on information supplied by the client and from relevant authorities in both written and verbal format. Some of this information is in verbal form only. No liability can be accepted for information supplied by third parties which is subsequently found to be inaccurate or incorrect.

1.2 The report has been updated following revisions to the layout requested by Kirklees MDC.

2.0 THE SITE

2.1 The site is located of an access road off the A62 between Slaithwaite and Marsden approx. 5 miles west of Huddersfield town centre. It is situated around Ordnance Survey grid reference SE 405834 412511. A site location plan is shown on Figure 1 in Appendix A.

2.2 The site is roughly trapezoidal in nature and situated on the site of a former mill. There are a few residential properties to the north and south of the site. The site was originally 90% covered with industrial properties except for land to the east of the site which is open pasture land. Only the main mill buildings now remain on site. The surrounding area is generally open pasture land. The site area is approximately 1ha.

2.3 To the west of the site is the former mill pond which now acts as a fishing pond. This is spilt into two distinct areas: the main pond sits to the west before passing through a former sluice gate to form a smaller pond immediately adjacent to the site. This part of the pond is to be infilled as part of the proposed development. To the south of the pond and adjacent to the site runs the River

Colne; to the north runs the Huddersfield Narrow Canal. To the north of the canal is Sparth reservoir which is owned by the canal Trust and acts as a feeder reservoir for the canal. The access to the site is from the A62 and down a steep access road before crossing a steel bridge over the River Colne which provides access to the site and to the fishing pond. The River Colne forms the southern boundary to the site and normal water levels are 3-4m below the bank levels. The river is further contained by an existing stone wall 350mm wide by 900mm high on the bank top. The northern boundary is formed by the towpath to the Canal and whilst the canal water levels are some 2.5 metres above the general site levels there is a former buildings external wall on the boundary that stands 2.5m above the towpath level and is 600mm thick. Beyond the main buildings this reduces to a 1.2m high stone wall 450mm thick. The area of land to the north of the canal is generally level or slightly lower than the canal towpath.

There is a second bridge from the site that originally served the land on the south side of the river which has been partially utilised for residential use. The bridge is closed off for access and should be removed as part of the redevelopment.

2.4 The site is generally flat with a high point of 160.8m AOD in the north west corner of the site and a lower point of 159.9 m on the middle of the eastern boundary to the development site. The site to the east falls away from the site at a slight gradient. The millpond has a 2m thick stone retaining wall to its perimeter which thickens out to 4m thick at the mill end of the pond. The mill pond is approx. 2.4m deep at the mill end which has now been partially drained. and the top of this stands at a level of 165.3m AOD. Water level was maintained at 164.50m AOD. On the northern boundary the towpath level is around 162.7m whilst the site side of this wall currently stands at 2m below this at 160.70m AOD. The top of the boundary wall between the site and the towpath is over 2.5m above the towpath level.

2.5 The mill pond is supplied by a simple goit adjacent to a weir on the River Colne some 400m upstream of the site. This is controlled by a simple penstock to adjust in flows into the pond. The top of this some 1.5m above the weir level. The mill pond itself has a number of flow control and over flows. The first control is adjacent to the mill building and was a sluice controlled inlet to the water turbine that provided power to the site. The outlet from this runs through the site and into the River Colne. The proposals will include infilling or removal of this outlet for its full length beneath the site. It would include sealing the void with cementitious grout to prevent water flows.

2.6 The section of mill pond adjacent to the mill also has a drawdown shaft on its southern edge 10m away from the building which also discharges directly to the River Colne to the south. This has been used to drain the mill pond immediately adjacent to the old mill buildings. The upper section of the mill pond has been separated from the main pond by a narrow bank and a sluice gate that crossed the remaining opening and allowed the flows into the upper pond to be controlled. The sluice gate has been removed in the past but now has a temporary coffer dam to allow the upper mill pond to be drained. The draw down shaft would also be sealed off and grouted as part of these works. Alternatively it could be reconnected to the western pond with a new sluice valve to enable draw down of the western pond.

2.7 The water levels in the main or western pond are controlled by a simple overflow system. The control is a simple side weir structure that is some 150m away to the western end of the pond. It is built on the southern edge of the pond. This has a 8m wide, stone built, broad crested weir that acts as the overflow from the large pond. Any water leaving at this point flows via a simple cascade, directly under the towpath and down to the river some 4m below the path level. Adjacent to the main weir there is a steel penstock, or sluice, that

controls the water levels of the pond and will allow a further reduction in top water levels of 1m by adjusting the opening of this penstock.

2.8 There is a culverted watercourse that runs beneath the western pond and discharges via a small overflow weir within the southern edge of the western pond wall close to the separating walls between the two ponds. This is to remain unchanged as it carries the flows from the watercourse adjacent to Sparth reservoir.

2.9 The walls to the upper pond vary in height between 300mm at the western end of the pond to 2400mm in height at the north east corner. The depth of retained water in the larger pond is approximately 1.8m. The northern edge of the pond abuts the towpath to the canal. The towpath at the western end of the pond is 2-3m above the pond level and as the canal passes through the locks the tow path dips below the level of the pond. The canal has two locks along its length adjacent to the pond which form this change in level. This boundary between the pond and the tow path is formed by earth banks up to the towpath in the western section. At the eastern end of the large pond, the boundary is formed by dry stone-faced walls with possible rubble filling to give a minimum thickness of 2m thick above the towpath level. The internal face of these walls would appear to be graded back below the water level and this can be seen in the walls in the smaller eastern mill pond now the water has been drawn down in the eastern section.

2.10 A copy of a condition report by Kirklees MDC in October 2014 has been supplied by Kirklees MDC. A copy of that report is attached to this report in the appendices(appendix G). The report shows the some of the walls has minor issues with localised bulging and seepage through the walls. The walls where not considered as unstable and the seepage is of a low volume and discharge rate. The walls have all been re-inspected as part of a walkover survey for this repoint. There are still areas of slight seepage through the walls on both the north and south pond boundary walls. These areas and very localised and the

seepage is of a minor nature. The development proposals will include some cementitious grouting of the walls in these areas to prevent the seepage re-occurring. The walls would benefit from repointing works as a preventative measure to maintain their structural integrity but they have been generally found to be in reasonable condition. The bulging seen is minor in nature and symptomatic of dry stone walls construction. The thickness of the walls means that their structural stability is still adequate.

2.11 The report suggest that the western pond is emptied to allow inspection of the main walls to the pond but this would seem to be a drastic measure to prevent damage to the pond walls. The leakages are small and could be repaired using grouting systems. The walls do not show signs of immediate collapse or structural failure at the present time but do require minor remedial works. Emptying the pond would mean that there would be a significant environmental impact on the fish and environment within the pond. At worst a simple reduction in the water level by 0.6m would significantly reduce the pressures on the wall but would not impact so severely on the pond habitat.

2.12 At the time of inspection the eastern mill pond had been drained down and temporary dam between the eastern and western section of the ponds had been constructed. These allow a clearer understanding of the water flows through the ponds and the mills and its effect on the proposed scheme.

3.0 PROPOSED DEVELOPMENT

3.1 The proposed development is for two multi-storied apartment blocks adjacent to the canal with terraced dwellings and one detached dwelling adjacent to the River Colne with associated roads and parking areas. It is envisaged that the impermeable areas for the whole development would be close to that occupied by the former mill buildings and paved areas. The eastern mill pond is to be infilled. The total impermeable area of the eastern pond and the mills equates to 8510sq. m, of this the impermeable area of the mills equates to 6855sq. m. The

impermeable areas on the new development would be 7330sq.m. There is a proposed site plan in the appendices of this report Appendix J.

3.2 The northern boundary of the site will stay as existing with a 2m high wall 340 - 450mm thick running along the site boundary. The site area adjacent to this will be a communal amenity areas which will be some 3m above existing site levels at a similar level to the towpath. The existing boundary wall is to remain at a height of 2m above the tow path level. The lower levels buildings will be built at a level of 600 to 900mm above the existing ground levels with the road ways running from west to east. The proposals will include attenuation of flows from the site to 70% of original flows thereby giving a substantial reduction in flows off the site.

4.0 PROPOSED SURFACE WATER DRAINAGE

4.1 In the first instance the use of soakaways and infiltration systems should be investigated and if these appear to be unsuitable based on the infiltration tests then alternative systems can be investigated. Whilst the site has previously been developed, the un-attenuated surface water run off from this site would slightly decrease due to the development. However this is not fully in line with current re-development policies and normal practise for brown-field sites would be to reduce the run off by 30% rather than the 16% achieved by redevelopment. Therefore discharges should be managed by the use of surface water attenuation and storm water storage systems. The site currently does have a significant existing impermeable areas relating to roofs or hard paved areas. The current point of discharge of the surface water drainage systems on site would appear to be the River Colne on the southern boundary of the site. As the site has been previously developed any drainage system would have to be designed to reduce flows down to 70% of the original discharge rates. Further discussions with Yorkshire Water, and Kirklees MBC - Land Drainage Department, and the Environment Agency will be necessary to

formerly agree discharge rates but the estimated run off from the site for a 1 in 1 year storm would be 95lit/s. So the design flows from the site should be reduced to around 66lit/s. This assumes that the eastern section of the ponds acts as an impermeable surface which it would effectively be. Once it is infilled it can be considered to be a permeable surface thus there is a nett reduction in run off from the site. Checking this against the 6 hour volume test the discharge rate reduces to 33lit/s so this has been utilised for an estimate of the storage requirements for the site.

4.2 The flows would be controlled by a hydraulic flow device such as a Hydrobrake or similar. This would mean that storm-water storage would have to be provided on site. The existing mills and ponds previously discharged to the River Colne via a culvert that runs beneath the main mill buildings. This culvert is to be sealed and grouted as part of the development works. It would be proposed to reconnect the new surface water system from the site to point on this culvert downstream of the development, which will give a point of discharge to a surface water sewer or watercourse that is the same as the site currently discharges too. This would have to be agreed and approved by the Environment Agency, but it does provide the site with a right to discharge in perpetuity granted. The EA would /may also need to approve any such discharge rate and water quality.

4.3 Due to the small nature of the site and the land uptake required it is proposed to provide storage in above ground storage systems in the open fields to the east of the site. This area is within the developers site ownership and can be dedicated or passed over to either the water authority or to a management company with a covenant that this area of land cannot be developed or built on without allowing for the retention of the pond. This will be designed to cater for storms up to and including the 100year storm with due allowances for climate change. In accordance with NPPG this would mean an extra 30% based on the site usage and possible duration of development.

4.4 The sizes of the storm water storage facilities would need to determine accurately in the final designs. This is all in accordance with the PP**G-FRCC**. The volumes of storage for the 100 year and 100 year plus climate change can include flooding to roads and designated areas but must ensure that no buildings are flooded.

4.5 If infiltration systems or on-site balancing is utilised then the risk to downstream properties would be slightly reduced due to the development of the site.

5.0 FLOOD RISK

5.1 The site currently falls partially within flood zone 1 and partially in Zones 2 and 3 with the area to the east of the site, as shown on the Environment Agency Websites. It does not fall within an area shown to benefit from flood defences up to the 1 in 100 year flood event. The development is classified as More Vulnerable in Table 2 of the PP**G-FRCC**. The proposed area of development falls within Zone 2 and as such table 3 of that document also states that the proposed residential development is appropriate.

5.2 Due to the size of the development over 1Ha it will not be necessary to prepare a site Specific Flood risk Assessment for the site.

5.3 There are a number of potential flooding mechanisms that NPPF now requires are evaluated for each proposed development site. Each method of flooding requires an assessment to be made on its probability relative to the site development. The normal requirement of the document is for no flooding of properties for storms up to a 1% probability or a once in a 100 years storm. The risk assessment also includes for flooding both on site and off site, and the effects of the development on the downstream catchment or the flow regime of

the watercourse. NPPF also requires that the effects of severe storms above the normal 1% probability are reviewed together with the effects of climatic change relating to the design life of the development.

5.4 It also requires that the effects of climate change are taken into account together with the impacts of extreme events and flood defence failures.

5.5 Based on the published Environment Agency Flood Risk Maps the proposed development on site does fall within the 0.1% Flood Risk (i.e. Zone 2) and part of the site adjacent to the River Colne falls within the 1% Flood Risk (zone 3). The proposed residential development falls within the More Vulnerable Classification in Table 02 Technical Guidance to PP**G-FRCC**. The development is considered appropriate in accordance with Table 3. However it would be appropriate to consider the residual flood risks on this site because it stands within Zone 2 and what flood risk mitigation can be provided as part of this development.

5.6 PP**G-FRCC** requires that each flooding mechanism is addressed and levels of risk evaluated. We consider there are three main risks of flooding to the site the alternative mechanisms are not applicable to this site.

5.6.1 Inundation from floodwaters leaving watercourses or rivers entering the site. This can include the effects on culverted watercourses and where the risk of blockage can occur and from breach scenarios.

5.6.2 Rainwater falling on the site and not being able to leave the site at sufficient rate to prevent flooding on the site.

5.6.3 Risk of flooding from reservoirs coupled with flows from adjacent of sewerage systems or other watercourses.

5.6.4 The impact of the developed site on the existing drainage systems and off-site surface water systems must also be assessed as part of this flood risk assessment.

5.7 Discussion of Flood risks

5.7.1 Flood Risk from Watercourses, River & Tidal

5.7.2 The nearest watercourse shown on the O.S Survey is the River Colne that runs adjacent to the southern boundary of the site. River Colne is classed as main river and runs from west to east past the site. There are watercourses to the east that flow from north to south and outfall into the River Colne. There is an existing watercourse that is culverted beneath the larger western pond. The area of site immediately adjacent to the main river appears to fall within the 1% probability Flood Risk Maps as published by the Environment Agency. Flood modelling levels previously obtains for previous reports show the 1 in 100 year flood levels to be slightly above the existing bank levels adjacent to the beck for a short way. The flood zones shown on the plans ignore any flood protection so do not take into account the small 350mm thick 1m high solid wall on the southern edge of the site. The wall would prevent the 1 in 100 year flood water flows which would be only 100 -200mm above the base of the wall from actually entering the site. Whilst this is not a EA maintained flood defence its effect needs to be taken into account. The flood water levels for the 1000 year flood do however exceed the top levels of the wall for short sections but there would be no reason why the wall could not be reinforced or raised in height to prevent flood water entering the site. We have shown a details indicating a reinforcement of this boundary with an earth bank that would be above the 1 in 1000year flood water levels and thus prevent flood waters entering the site from this point. New house floor levels could be sited above the 1 in 1000year floodwater levels which would be above the 100 year plus allowances for climate change . The ground would be raised adjacent to the site boundary

accordingly without affecting any flood water displacement. The site is therefore considered to be at risk from fluvial flooding, but not for the 1 in 100 year flood.

5.7.3 The site is generally flat with slight falls towards the eastern area of the site. The bank height of the river adjacent to the development could be raised slightly to further protect the site from the 1 in 1000 year flood levels and a measure of compensatory flood water provided off site in the attenuation basin to the west. There are no reports of this site flooding in the past nor during the major flooding storms in the area at Christmas 2015.

5.7.4 The River Colne has been modelled and flood water levels for the 100 year and 1000 year flood have been obtained and previously submitted as part of the previous Flood \Risk assessments for this site. The results of this show that the access road into the site which has a level of 162.363m AOD would remain above the 1 in 100 year flood levels for the beck (160.630 m AOD) and also above the 1 in 1000 year flood level of 161.323. Thus the road would remain accessible at all times even for extreme events.

5.7.5 The modelled levels suggest that the floodwaters from the river stays within the banks upstream of the bridge but slight alterations in the access track levels could be made to ensure no flows travel down the access track towards the site even in exceedance events.

5.7.6 Immediately below the bridge the floodwater levels appear to be much closer to the site levels and it is proposed to ensure that flooding for the 100 year storm cannot enter the site by raising ground levels slightly so that house and garden levels are a minimum of 600mm above the 100 year flood levels or even above the 1 in 1000 year flood levels which would give due allowances for climatic change.

5.7.7 The existing perimeter wall to the site would actually prevent waters leaving the river for the 1 in 100 year event but these are not considered in production of

the E A Maps. If the wall retains the flood waters for the 100 year flows this would suggests that the site will not be flooded and that compensatory flood volumes would not be needed. However, if the modelled levels are considered and the boundary wall was assumed to have failed, then a small area between the river and the former building would be below the flood levels and may have flooded during the 100 year storm if the wall had collapsed or not been maintained. This would equate to an area of 700sq. m which would have been flooded to an average depth of 120mm for the 100 year flood. It is considered that a flood water compensation of 84cu.m would adequately compensate for that. This would be provided in the storm water lagoon or detention basin to the east of the site.

5.7.8 For the development to proceed on this site we would recommend floor levels are set a minimum of 600mm above the modelled 100 year flood water levels or even above the 1 in 1000 year flood level of the site. At the entrance bridge to the site the 1 in100year flood water levels are 160.43m AOD whilst the 1 in 1000year flows are 161.58m AOD but the flood water cannot enter the site at this point. At the downstream end of the development the 1 in100year flood water levels are 159.15m AOD whilst the 1 in 1000year flows are 159.9m AOD. Thus the lowest proposed floor levels of 160.45m are 1.3m above the in 100 year flood levels and 550mm above the in 100year flood water levels.

5.7.9 If development were to be approved then the residual flood risk would need to be considered. The ground floors of all the proposed dwellings are only entrance halls and garages and not residential rooms. Thus even in exceedance events the flood water would not affect residential rooms. The layout of the site with a flood route through it would allow any overland flows from exceedance events, to simply flow along the roads from west to east and thence back into the river downstream. If building levels are raised above the 1 in 100 year flood levels then the residual risk of flooding to the buildings would be low and therefore be acceptable. An area at the eastern end of the site could

be lowered as compensatory flood water volumes. If the area of buildings is considered this volume would be around 85 cu.m. as stated earlier.

5.7.10 The road level to the entrance to the site on the southern boundary of the site will be passable during the 100 year and the 1000 year flood event. The lower bridge may not be and as it is now disused, and not functional, we would suggest that it is removed as part of the site development. The site can therefore be accessed even during the 1 in 100 year flood event.

5.7.11 The site falls within the flood warning area designated by the E.A. The residents will need to subscribe to the flood warning system already operated by the EA to ensure they are aware of any risks to personnel and property due to flooding from the watercourse. Whilst it would not be necessary to evacuate the site up to the 100 year flood event, the risk of being isolated, which only occurs for exceedance events, remains and refuge areas should be provided within the buildings. The ground floors of all the proposed dwellings are only entrance halls and garages, not residential rooms. Thus even in exceedance events the flood water would not affect residential rooms.

5.8 Risk of Flooding from overland flows from adjacent land.

5.8.1 The site lies at the bottom of a valley with steep slopes down to open fields to three sides. To the south and west of the site the land is substantially higher than the site. To the north the adjacent land is higher than the site whilst the land to the east is lower than the site and falls away from the site. The risk of any overland flow is principally from the north and west.

5.8.2 The land to the west is higher but any flows will be intercepted by the existing pond and the river or canal to the south and north of the site respectively. The risk of overland flows is considered low, apart from reservoir breech events, which is discussed later in this section.

5.8.3 The risk of overland flows following reservoir breech scenarios needs to be considered. The site is shown to be within a zone subject to flooding from reservoirs should a breech occur. The plans do not show what the source would be for this site as there are a significant number of upstream reservoirs.

5.8.4 In close proximity to the site is Sparth Reservoir to the north west of the site. This is owned by the Rivers and Canal Trust and acts as a top up reservoir for the Huddersfield Narrow Canal which runs west to east between the site and the reservoir. The reservoir is fed by watercourses from the north that discharge into the reservoir. At its western end the water levels are only 1m above the canal and the canal water levels are approx. 1m above the western mill pond water levels. At its eastern end the reservoir has both its over-spillway and a drawdown channel to allow it to be emptied. At this point the water level is some 3m above the level of the canal. The dam is of earth construction with a concrete and stone spillway some 8m wide. The length of dam is limited to approx. 40m long due to the topography and the adjacent locks to the canal. It is assumed that this reservoir is maintained and inspected on a regular basis under the Reservoirs Act by the Rivers and Canal Trust.

5.8.4 If a breech in the holding dam occurred, the flows would firstly enter the canal system and would flow away to the east. The flows could not enter the mill pond due to the 2.4m high stone faced retaining walls to the pond at this point. Thus any flows would be channelled along the canal route. The flows would therefore spill out to the northern side of the canal as this is a lower area than the site. Some flows may enter the existing watercourse that runs in a culvert beneath the western mill pond and would discharge to the River Colne to the south of the site. At some 50m from the dam, the water from any breech would overflow to land to the north rather than into the site due to the existing 600mm thick perimeter wall to the northern edge of the site. This wall is structurally capable of retaining flows up to 1.2 m deep in the short term. The height of retained water in Sparth Reservoir is not particularly high so any flows from a breech would probably not exceed 1m in depth along this route and would dissipate to

a depth of flow significantly less than that before meeting the lower boundary wall (approx. 1200mm high) some 280m away from the dam. This wall is 450mm thick an also capable of resisting a depth of flow up to 600mm deep. The floodwaters would also dissipate into the land to the north further reducing the depth of flow significantly.

5.8.5 The risk of flooding on the site from this source is further reduced by the proposal to infill the eastern mill pond which would provide a further strengthening of the wall at this point. The waters would not be able to enter the proposed development site due to the existing perimeter wall. Some 280m downstream the boundary wall reduces in height to 1200mm but the breech flow depth would be low by this point and again would not be able to enter the site. As such the level of risk of flooding from Sparth reservoir is considered to be very low. Any flows in the canal channel would remain there due to the site perimeter walls and the local topography until it is some way downstream of the development.

5.8.6 The risk of flooding from other reservoirs would still remain and the reservoirs that may influence this site are not detailed in the EA plans. These are however, all major reservoirs that have annual inspections and are covered by the requirements of the Reservoirs Act to be regularly maintained. The risk of flooding from this source is considered to be less than the 1% flood risk from rivers. It would however be prudent to ensure there is an overland flood route through the site to cater for extreme events and that the residents are subscribing to the EA Flood warnings system. We would suggest that external levels and the road levels are designed to provide such a route, and this will effectively reduce this risk to an acceptable level.

5.8.7 The risk of flooding from the mill ponds has been raised by the report carried out by Kirklees MDC on the ponds in October 2014. If the existing mill ponds were to be left then the site would be at risk of flooding if there was a breech scenario at the eastern end of the mill ponds where the culvert beneath the

mills begins. The dam which formerly held back a head of water approaching 3m, does appear to be in good condition at the present time, but would need regular inspection and maintenance to ensure its long term stability. Whilst the proposals would include a system to route flood waters, from such a scenario, along the highways, the risk of flooding to the dwellings could not be discounted.

5.8.8 The development proposals therefore include the infilling of the eastern mill pond with inert fill materials to remove the risk of a breech occurring at this point. This would also reinforce the existing walls to the canal to prevent breech waters from Sparth Reservoir entering the site from this point. The nearest point to the ponds would then be some 70m away from the new buildings.

5.8.9 The report also noted that there may be a significant risk of flood waters entering the site from a breech in the western ponds perimeter walls. On the northern side of the pond there is only a short section of wall that would retain approx. 1.2m depth of water once the eastern section is infilled. Once the wall construction has been consolidated by grouting works the risk of failure of this wall would be significantly reduced. In a similar way any flood water s from this breech would be channelled along the canal system as defined in the discussion regarding Sparth Reservoir earlier in this report.

5.8.10 The possible risk of flooding from a breech on the southern side of the western pond is also considered remote once the eastern section of the mill pond is infilled. In such a scenario the flood waters would flow directly into the River Colne adjacent to the wall. There is slight risk that some flood waters may reach the site entrance road crossing the River Colne but would then be channelled through the site via the highways flood water route.

5.8.11 The risk of flooding from this source is therefore considered to be acceptable for this development once the proposals are implemented fully.

5.9 Risk of Flooding from Rainwater Falling on Site

5.9.1 The risk of flooding from water falling on site and not being able to leave is considered to be medium partly due to the topography of the site and its previous development. At present there are 6855sq.m of buildings and hard paved and positively drained areas on site. The new development would amount to 7330sq.m of hard paved areas. Although this suggests an increase in impermeable areas, the area of the infilled millpond would transform this into a net reduction in flows off site by approx. 15%. This is not sufficient to comply with current criteria and planning policies so these flows would however need to be attenuated to ensure no surcharging of systems downstream.

5.9.2 Storms up to the once in 100 year risk, and allowances to be made for climatic change, can be managed by the use of storm water storage systems. The design of these systems would be dependent on the agreed discharge for the site which is normally 70% of existing annual storm run off. The design can be detailed to cater for storms up to the 100 year return period with an allowance made for climatic change. This would currently suggest a 30% increase in storm intensities and additional flood water storage volume requirements. With this system in place the flows from the site into the surface water systems would be considered acceptable.

5.9.3 If the underlying ground is not suitable for infiltration then the system should be made to connect to the existing drainage system which discharges to the River Colne. The discharge from this system would be limited to agreed discharge rates. The storage system should be designed to cater for a 100 year storm and additional storage to cater for climatic change. This storage could be catered for above ground in designated flood areas such as car parks or shallow swales or public open spaces. The space for these is available in land to the east of the development site.

5.9.4 The storage volumes required are calculated as shown in the appendices and are defined as 110cum for the 30 year storm; 157cu.m for the hundred year storm and rising to 235cu.m when 30% climate change is taken into consideration. This can be provided in a shallow pond or swale to the east of the site. The flows would have to be controlled by a "Hydrobrake" or similar low maintenance flow control device. If these are provided the risk of onsite flooding from rainfall would be effectively controlled to acceptable levels.

6.0 CONCLUSIONS

6.1 In our opinion the site, is shown to be at risk of flooding, partially, from river or tidal water for a 1% return period and predominantly for storms in excess of the 0.1% risk level. The site is however defended by flood defences not maintained by the Environment agency and as such the residual flood risk should be evaluated. The development of the site would require the raising of floor levels but because the site was previously developed with building covering large areas of the site behind the flood defences mentioned earlier it does not form part of the flood plain. The provision of compensatory flood water storage for the site should be discounted but a notional volume can be provided to the east of the site. We would recommend that floor levels are raised to those indicated on drawing 6518_04 which area a minmum of 1300mm above the 1 in 100 year flood event levels and 550mm above the 1 in 1000 year flood level that could affect the site.

6.2 The development of the site with the use of soakaways or other infiltration methods is to be investigated but is thought to be unlikely due to the lack of infiltration capacity of the underlying strata.

6.3 It would be necessary to provide storm water attenuation systems on site to limit flows from the completed development to 70% of the existing flows from

the site. Discharges would have to be limited to agreed rates of discharge to ensure flood risks downstream are not increased.

6.4 The site is considered to be accessible even during the 1 in 1000 year event.

6.5 The residual flood risk to the properties from fluvial sources can be reduced to acceptable levels by raising garden levels on the southern side of the development to prevent flood waters leaving the river channel which is currently performed by the site perimeter wall. Public open space areas to the east could be left low or reduced to accommodate any flood waters displaced by the development.

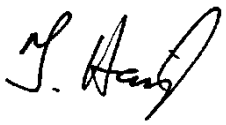
6.6 The risk of flooding from Sparth reservoir is considered to be low due to the site features and the local topography as is discussed in this report. It is important that the eastern section of the mill ponds is infilled and that the wall to the northern boundary is maintained at its existing height and width for the lifetime of the development. It is noted that there are minor problems with the existing pond retaining walls and these should be remedied as part of the development to reduce the risk of flooding from reservoir breech scenarios.

6.7 The provision of a flood route through the site will ensure that any residual flood risk exceedance events are catered for beyond the 1 in 100 year event. This can be achieved by simply ensuring that floor levels are a minimum of 450mm above the road levels.

6.8 The site is in an area covered by the EA flood waning scheme and residents should be made aware that they should subscribe to this system and respond to any warning given. It is our opinion however that the site will not be at risk when developed due to the items outlined above.

Haigh Huddleston & Associates

Civil Structural Engineering Consultants



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