

# **Southcote Mill Hydrology and Flood Risk Assessment FRA**



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## Southcote Mill Hydrology and Flood Risk Assessment FRA

### **Summary**

*This Hydrology Report and FRA has been written using available data from the C&RTrust, the CEH & HR Wallingford, the EA, Thames Water and Reading Borough Council and personal observations and calculations. The assistance of officers, staff and use of the data bases of the aforementioned organisations is gratefully acknowledged.*

*Development works as currently outlined in the Planning Application will have **no** adverse effects on the flood risk in the area or transfer the risk further downstream to Reading. Increased river flow, even without climate change, is fundamentally dependent on controlling the runoff from development elsewhere in the Kennet River catchment area.*

*The Wire Mill is a derelict Victorian industrial heritage structure well worthy of a modern usage rather than progressing into further decay. A well managed leisure facility on the old Wire Mill / Waterworks site would be beneficial to the local economy with no tangible downsides. The main beneficiaries would be the walkers, cyclists, naturalists, and the boating fraternity on the canal and its towpath. It would create a potential for additional employment opportunities during the reconstruction phase and seasonally when the Cafe is open.*

*Analysis of the annual maximum flood data since 1961-2015 has shown that only twice in the 54 years has a flood occurred in the March-October period. Operation of a Cafe on the Wire Mill site during the winter season could reflect EA flood warnings and close accordingly. This could be covered by a "Condition" covering activities which the Planning Authority may wish to impose for reasons of public safety.*

*In the Main Report it has been shown that in flood periods access to the Southcote Mill site (RG30 3DZ) will be made slightly more difficult under Climate Change flow conditions. Increasing maximum flood discharges measured at Theale Gauging Station by 20% from **76.9 m<sup>3</sup>/s** to **92.2 m<sup>3</sup>/s** results in a rise in water levels of less than **90 mm** (3.5 inches) over the flood plain north and east of Southcote Mill. Using CEH estimated discharges of **69.8m<sup>3</sup>/s** in February 2014 and adding 20% for climate change to **83.8m<sup>3</sup>/s** would result in a rise in water levels of less than **80 mm** (3.3inches) than higher than the observed flood in 2014 . The flood level in this area is fixed and hydraulically determined by the discharge and by the 39.600m aod crest level at Fobney Duckbill Weir some 500 metres downstream from Lock 104 at Southcote.*

*Assuming a staff gauge zero level of 35.89m at Lock 104 the water levels downstream are estimated to be lower than 40.05m when flood plain storage is allowed for, compared to a controlled level in the canal above the lock of 40.98m. The planned ground floor level in the proposed development would be 41.75 m, some 300mm above the level of the tow path at 41.45 m aod.*

*The access road to Southcote Mill and the lockside Wire Mill site crosses the “Functional Flood Plain” in EA Zones 2 and 3 which have a Medium or High probability >1/100 risk of flooding . The Wire Mill site is in Zone 1 on land with a lower flood probability< 1/1000.*

*The applicants have offered to maintain the shared gravelled access road from Circuit Lane without increasing the level of the surface, so that the overland flow of water from the north and west is not impeded. They are also prepared to maintain the existing four pipe drains under the road and to add any additional under drains that may found to be necessary.*

*Extreme flood events tend to occur after prolonged winter rainfall such as that in late 2013 and early spring of 2014 which had a return period of once in 54 years. While inconvenient, to those living at Southcote Mill and any working at the proposed Wire Mill development would have several days warning of rising flood plain inundation enabling them to evacuate the area using the canal tow path to the main road at Burghfield Bridge. The Canal and River*

*Trust would endeavour to keep this access route open to enable staff to service their canal bank assets and structures.*

*It should be noted that in 2017 the EA revised their advice to developers linked to the NPPF. Bearing in mind that the Wire Mill site is in the less vulnerable Flood Zone 1 and that the Sequential Option does not apply to this application, the Local Authority - Reading Borough Council are requested to treat this Application on an Exception Test basis. Only the access route (Southcote Farm Lane) falls within Flood Zones 2 and 3a.*

*On this basis, it is recommended that Planning Permission be **Granted** with conditions that the Planning Authority may wish to impose.*

*GBMayes August 2017.*

# **Southcote Mill Hydrology and Flood Risk Assessment FRA**

## **1. Introduction**

I have been asked to study and report upon the flood risk in the area around Southcote Mill (RG30 3DZ) and the Lock 104 on the Kennet and Avon Canal (K&A) prior to the resubmission of a Change of Use Planning Application to Reading Borough Council (RBC) for the development of the derelict Wire Mill site. In carrying out this exercise I have reviewed background correspondence, studied aerial photography and Warner Land Survey data 2015/2017, Ordnance Survey mapping, and mapping of the K&A by British Waterways. This has been augmented by hydrologic data from the Centre for Ecology and Hydrology (CEH) and Hydraulics Research (HR) both at Wallingford UK, the Canal and Rivers Trust, the Environment Agency and Reading Borough Council. I have personally walked the canal from the Tyle Mill, to the Burghfield Road bridge and downstream to Fobney Lock 105, noting salient hydraulic and environmental features along the route. The assistance of officers, staff and use of the data bases of the aforementioned organisations is gratefully acknowledged.

## **2. Consultancy Experience**

I have over fifty years experience investigating, designing and managing Irrigation and Drainage Projects worldwide for British and European Consulting companies funded by agencies such as the UKs ODA/ DfID, FAO, the World and Asian Development Banks and European Aid Agencies. These studies have involved hydrologic measurement, data collection and analysis, flood estimation and the design of hydraulic structures such as dams, weirs and sluices. I am a Chartered Civil Engineer, Water and Environmental Manager and member of the British Hydrological Society.

## **3. Initial Visit Report Updated**

My first site visit to acquaint myself with the conditions at Southcote Mill on the River Kennet in South Reading was on the 15<sup>th</sup> March 2017. The weather conditions were sunny and dry. Access was via the unmade gated roadway from Circuit Lane, past the Thames Water Southcote works, under the arched bridge on the Southcote Junction to Newbury railway line and over Holy Brook to Southcote Mill and the Lock (No 104) of that name on the Kennet and Avon Canal. (K&A)

The land south of the Southcote escarpment to the Kennet and Avon Canal is drained by the Holy Brook and is traversed east to west by the railway line to Newbury. Potential blockage of the culverts under the railway embankment complicates the prediction of the flow pattern for surface waters over and throughout the area. The Holy Brook passes under the railway embankment on the Basingstoke line and appears to bypass Fobney Weir/Lock (No.105) before joining the Kennet and Avon Canal (K&A) just upstream of County Lock. (No.106).

Upstream of Southcote Lock 104 the canal is on embankment to the Cunning Man public house at Burghfield Bridge on the Burghfield Road 1.5 km to the west.

The water level downstream of Southcote Lock (No.104) on 15<sup>th</sup> March 2017 was approximately 40m AOD and the towpath level at a TBM alongside the lock some 41.487m AOD. This TBM was established by WLS in January 2017. The maximum water level during the December 2013-March 2014 floods was said to be approximately level with the top of wing wall / landing stage on the right bank just downstream of the lock gates near the staff gauge. The water level on the upstream reach of the canal (103-104) was approximately 41m AOD on 15/03/2017 and quoted as 40.98 m in the WLS survey in December 2015 and 41.06 m on 5<sup>th</sup> January 2017. An Ordinance Survey Bench Mark on the railway bridge abutment near Fobney Weir (132.29 ft or 40.322m) could not be found and no OS bench mark was located in the lock area. I have therefore referenced all water levels downstream of Southcote Lock (104) to the lock wall Staff Gauge although it needs cleaning, repair and/or replacement. From this, and other site readings, I have calculated that the zero level of the Staff Gauge to be approximately 35.89m AOD. See Annex 3. There is an old but unreadable water level gauge imbedded in the upstream left bank wing wall of Lock 104 which from the top to water level measured 0.254m on 5<sup>th</sup> August 2017.

The Canal and old River Kennet streams then flow under the two “Milkmaids” footbridges (bridges 12&13) and eastwards under the Southcote Junction to Basingstoke railway embankment, passed Fobney Weir, and a small fish pass to Fobney Lock( No 105). I now understand that the WLS survey traverse started and closed on a brass plate Bench Mark on the concrete deck of Fobney Weir (E30611108) at 40.651m. The survey traverse from Fobney Weir and Southcote Lock followed the towpath at levels of between 39.77m and

40.15m. Downstream and east of Fobney Lock (105) and the overflow weir from the old waterworks buildings is the confluence with Foudry Brook which flows from the catchment to the south.

#### **4. Subsequent Inspection of the Canal and Hydraulic Structures**

On 25<sup>th</sup> May 2017, I had the opportunity to walk the canal from the Cunning Man to Fobney Weir. At the Cunning Man the canal is at ground level and from personal experience the area has flooded several times in recent years. The water levels in the canal and round the Burghfield Island on the left bank are controlled by the right bank Sluice (6 gates)  $Q = f h^{1/2}$  and the adjacent EA fish ladder  $Q = f h^{3/2}$ . In December 2013 Green Lane flooded to a depth of some 300mm (1ft) from the canal sluice to the Burghfield Lakes which affected the industrial properties in the area. A whirlpool has formed on the right bank where the land to the south is more than 3 m lower than the canal embankment at the head of an old River Kennet channel. From here eastwards the canal towpath is on embankment seldom more than 15-20cm above water level at the date of the visit. The areas to the north of the canal to the railway line are low lying flood meadows and reed beds.

Working downstream, the next water level and flow control is on the right bank at the EA Southcote 1.2m wide fish ladder ( $Q = f h^{3/2}$ ) and a sluice structure (2 gates)  $Q = f h^{1/2}$  with a 3m drop to the lands to the south. On the opposite (left) bank nearby there is a sluice feeding the Southcote Mill race just upstream Lock 104. The fall in water level in the lock was some 1.6-1.8 m (5-6 feet), when the downstream staff gauge reading was 3.47m. The top level of the landing stage wing wall was noted at 4.04m on the staff gauge.

The reach below the Lock 104 to Fobney Weir receives return flows from Southcote Mill, the old River Kennet channel and from the water meadows on the right bank just below the “Milkmaids” foot bridge (bridge 12). On 23<sup>rd</sup> June 2017 at Southcote Lock 104, the downstream water level was 3.45m on the staff gauge. This compares to a maximum reading of approximately 4.02m during the 2013/14 flood.

## **5. Fobney Duckbill Weir**

Fobney Weir built in the 1980s is an 8 duckbill design with fall of some 2m. The flow ( $Q$ ) over this weir is not controlled by gates and is dependent solely on the head  $h$  (level) of the water in the upstream reach. ( $Q = f h^{3/2}$ ). In a flood situation, the flow to the River Kennet towards Reading cannot be reduced by management rules or operational means at Fobney weir. There may however be some scope for flood control at the Fobney Lock No 105 and on the Holy Brook.

At the present time, I understand from the C&R Trust and the Environment Agency (EA) that the weir is owned by Reading Borough Council, although the EA maintain the structure under their Permissive Rights & Safety Control arrangements. In mid June 2017 the structure was in need of weed and dead tree clearance from the weir crest. This vegetation debris would have the effect of increasing upstream water levels for any given flood flow. I have sought hydraulic design information for the weir and the topographic level data for the weir crest. These facts are relevant when considering the effect of future climate change on the upstream flood levels and especially in the area surrounding Southcote Mill.

Maintenance on the 8 duckbill weirs and removal of tree debris and weed clearing is difficult and would probably need the use of a long reach grab loader. Information from the EA information office states a weir width (22m), wing wall lengths (5m) and a fall (2m). Survey access was not possible, but my own supplementary measurements for duckbill length (5m) and 0.5m end width made it possible to calculate a preliminary rating curve for the weir. It initially appeared that the ownership was obscure and that the “As Constructed” detailed drawings were buried deep within the archived files of the EA, K&A, C&R Trust, RBC or with the Consulting Engineering Company involved in the design. Copies of the Thames Water design drawings dated 1982/3 were received from the EA on 2<sup>nd</sup> August 2017 which has enabled my early estimates to be refined. See Annex 1 for Tables 5.1A/i, 5.1A/ii & 5.1A/iii which show my calculations of a rating curve for Fobney Weir. These calculations are subject to change if the designer’s original assumptions and calculations are made available.

I am not aware of any other duckbill weirs in the UK but I believe that they were popular in Europe and French speaking northern Africa and also in South Africa at the time Fobney Weir was built. I have used the concept on irrigation canal schemes for water level and flow control in Tanzania and in Kosovo between 2000 and 2005. See Ref 2 . Kraatz and Mahajan (1975).

These calculations are based on the peak estimated flood on 7<sup>th</sup> February 2014 of **69.8 m<sup>3</sup>/s** as reported by the CEH. With the added 20% for climate change gives **83.76 m<sup>3</sup>/s** and indicates that water levels below Lock No104 and in the area surrounding Southcote Mill would rise by less than 80mm in the future. The water level at Southcote Mill is now thought to have been 39.91 m on that date. Table 5.1A/i in Annex 1 shows that without a climate change percentage increase the peak flood on December 24<sup>th</sup> 2013 could have been 40mm higher at Lock 104 or some 39.95m aod but this was not observed. That 39.95m value does allow for the hydraulic gradient between Fobney Weir and Lock 104 at Southcote Mill.

## **6. The Canal downstream to Fobney Waterworks and Fobney Lock No 105**

Downstream of Fobney weir, the overflow channel discharges through the conservation area, south of the K&A canal to Fobney Lock No 105. An EA fish pass is located at NGR SU 69851 71228 on the right bank of the canal just downstream of Fobney “duckbill” Weir and discharges a compensation flow of water into the conservation area south of the K&A canal.

On the left bank of the K&A canal between the Fobney Weir and Fobney Lock No 105 there is a Thames Water facility and Intake Sluice but there was no apparent offtake from or discharge into the canal at this point. Just upstream of the Fobney Lock No 105, is an intake to the Environment Agency fish farm also on the northern (left) bank.

At Fobney Lock No105 there is a intake channel on the left bank of the canal to the brick Waterworks building, the overflow from which discharges just below the downstream pair of lock mitre gates, over an overflow ogee weir some 3m wide with a fall of approximately 2.1m (7ft) at the date of the visit 23/6/2017. The return flow from the conservation area south of the K&A Navigation rejoins the canal just below the road bridges at the lock.

At this longitude, east of the Lock 105 and east of the Reading to Basingstoke railway line the total surface water flow of the Kennet Basin is conveyed in the Holy Brook and in the K&A canal. Here the canal and its confluence with Foudry Brook from the south adds to the flow and to the flood risk to the south of Reading.

## **7. Flood Flow Data Analysis and Interpretation**

A study of the aerial photography and flow data for the most recent major flooding in the area between late December 2013 to March 2014 and the long term record from 1961 has been undertaken. River Kennet flow data is measured at Theale gauging station (No 39016) which was finally located at SU 64959 70828 some 600m east of the Sheffield Bottom to Theale Road at the eastern end of Arrowhead Road, Theale. It is on the Holy Brook, which currently starts at a left bank canal sluice, fish pass and major weir structure on the canal 1km downstream of Tyle Mill Lock (99), Sulhamstead and some 3km upstream of the gauging station. Holy Brook carries most of the surface water flow in the River Kennet other than the controlled flow in the K&A canal. The HR Wallingford report (Ref 1) dated February 2016 shows a peak discharge of approximately 50 m<sup>3</sup>/s (cumecs) on the hydrograph (Figure 3.4) but that is a truncated value and rather lower than the peak quoted by the Centre for Ecology and Hydrology (CEH) data for the same period. The peak on 24<sup>th</sup> December 2013 was estimated by the CEH to be 76.85 m<sup>3</sup>/s and a 'suspect' 55.9 m<sup>3</sup>/s in February 2014, but see the comments below.

As far as I am aware the Theale gauging station (No39016) is the only and most representative station for the flows at Southcote Mill.

There was initially some doubt about the quoted location and reference number for the station. It is now operated by the Environment Agency under the ID 2290TH and was located on 15<sup>th</sup> July 2017 and inspected by the writer. At this site the Gauging Station on the Holy Brook utilises a shallow concrete Crump type weir (15.9m wide) to create the control section between vertical concrete walls 1.99m high and a bank full stage of 1.83m. The catchment area is quoted as 1033.4 km<sup>2</sup> and weir level 43.4m AOD. To the south is open grassed flood plain and to the north a kerbed tarmac roadway in front of industrial warehouse buildings at similar ground levels as the flood plain. The crest height to bank top is less than

two metres at which stage spillage on to the flood plain would occur. There were signs of erosion damage just upstream of the weir on the right (south) bank and scour on the left bank downstream of the apron where gravel materials have been tipped for protection. Upstream, the Holy Brook makes a left turn with a reed bed on the south bank and trees just before the weir. Elevated water levels and higher flows were obvious on the southern half of the weir crest, which is on the outside of the bend. The CEH text states that the weir has subsided and is 41mm lower on the left bank than on the right bank and would be drowned at stages higher than 0.5m.

The gauging station would be relatively reliable as a control up to bank top, but above this level the discharge data in times of flood would be uncertain as much of the flow would be over the fields to the south. All flows above bank top have been estimated by the operating agency or the CEH.

Flow data is held by the CEH at Wallingford for the whole country. (<http://nrfa.ceh.ac.uk/data/search>). The reference number for Theale GS is 39016 and from this data set the peak flow on 7<sup>th</sup> Feb 2014 was quoted as 55.9 m<sup>3</sup>/s (cumecs) but that data is marked as *Suspect*, and stated to have been *Estimated* at 69.8 m<sup>3</sup>/s by CEH. My interpretation of the caveat *Suspect* is probably due to it being an exceptional flood for which no rating curve would be reliable due to over bank flows bypassing the weir, and vegetative debris affecting the flood flow conditions. I have adopted the *Estimated* **69.8 m<sup>3</sup>/s** for the purposes of this Flood Risk Report as it is a pessimistic or worst case scenario for which the water levels at Southcote Mill are known. Adding 20% to this estimated maximum flood, gives a post Climate Change Design Flood of **83.76 m<sup>3</sup>/s**. The possible effects of this volume of water downstream are discussed in Sections 11 and 12 below. Similar results are presented for the CEH Peak flood on 24th December 2013 of **76.85 m<sup>3</sup>/s** which increased by 20% for climate change gives **92.22 m<sup>3</sup>/s** for which the downstream Southcote Mill water level was not observed and recorded. Using Table 5.1A/i (Annex 1) suggests that on the 24th December 2013 the flood level was some 40mm higher than in February 2014. With Climate Change the water level corresponding to the **92.22 m<sup>3</sup>/s** flood would be 40.05m aod downstream of Lock 104 at Southcote.

I have also analysed the annual peak flow records for the Kennet at Theale GS from 1961-2014. Table 7.1 in Annex 3 shows that the December 2013 peak flood had a return period of once in 54 years.

The table also shows that of the 15 highest annual floods over **45 m<sup>3</sup>/s** , 13 occurred between the end of October and early March and only two in June 1971 and July 2007. At this flow (**45 m<sup>3</sup>/s**) the water level below Southcote Mill would be 39.67m and some 240mm lower than that in February 2014 and the access lane dry and passable.

## **8. Kennet and Avon Canal Water Level Control**

The Kennet Navigation east of Newbury conveys the flow in the River Kennet, the River Lambourn and the River Enborne (a major and flashy tributary at the foot of the southern escarpment), and drainage from local streams as it flows eastwards towards the Thames at Reading. The navigable canal receives surface runoff and discharges excess water to the old River Kennet channels via sluices at the mills and locks along this length. Reaches vulnerable to damage at increased climate change flows are those where the total flow is concentrated on the navigable canal and where sluices may need enlarging and improving to safely pass the higher flows expected in the future.

The Environment Agency and the Canal & River Trust have provided information (June 2017) on the location and fall at the locks in the area from which the river gradients have been computed. From Sulhamstead (Lock100) (*Penlock on old OS mapping*) and Southcote Mill (Lock 104) there are 3 other locks (see Ref 3) with a total fall of 6.7 metres between the reach above Sheffield Lock (101) and the reach below Lock 104 (Southcote) over a distance of approximately 6 canal kilometres. This translates to an average hydraulic gradient of 1/896 in the Holy Brook which parallels the canal in this reach.

**Table 8.1 Lock Name Location and Fall Data**

| <u>Lock No</u> | <u>Location</u> | <u>OS GR</u> | <u>Fall m</u> | <u>Designer</u>   |
|----------------|-----------------|--------------|---------------|-------------------|
| 99             | Tyle Mill       | SU626691     | 1.93          |                   |
| 100            | Sulhamstead     | SU637698     | <u>1.24</u>   |                   |
| 101            | Sheffield       | SU648706     | 0.66          |                   |
| 102            | Garston         | SU655707     | 2.31          |                   |
| 103            | Burghfield      | SU674709     | 2.13          |                   |
| 104            | Southcote       | SU693712     | <u>1.60</u>   | John Hore Newbury |
| 105            | Fobney          | SU705710     | 2.24          | John Hore 1718-23 |
| 106            | County Lock     | SU713729     | 0.36          |                   |

Ref 3 Sulhamstead Lock (100), Sheffield Lock (101), Garston Lock (102) Burghfield Lock (103).

It is important to appreciate that the water levels in the canalised sections of the Kennet Navigation are controlled by C&RT staff to maintain the safety of the craft and to protect the canal asset from structural damage by leakage or overtopping of the embankments. In flood periods when craft movements are often restricted, sluice gates are opened (raised) and water is released to the adjacent drainage channels and old river alignments to ensure that water levels in the canalised and embanked sections do not rise to risk overbank erosion and embankment failure. Sluice gates and fish ladder gates will normally be discharging from the canal to the adjacent flood plain. The towpath is therefore permanently accessible along its full length apart from fallen trees or similar obstructions. This was the situation at Southcote Mill in 2013/14 to the Cunning Man at the Burghfield Road Bridge and is unlikely to be allowed to alter even with increased surface run off under climate change conditions. Every effort would then be taken by the Authorities to maintain the canal asset. Increased capacity at the sluices may be required if flood flows do increase to the discharges given in this FRA and extra storage capacity may be need to be secured to protect downstream communities. However, these measures are outside the scope of the current planning application and will not materially alter the decisions made at this time.

## **9. The Wire Mill Site**

The remains of the Wire Mill on the right bank (south) of the canal are the subject of the current planning application. This structure appears to be a substantial compartmented concrete box or tank once used as filter beds for potable water supplies to Reading. When drained of water and emptied of filter material and debris, the box tank is unlikely to be

buoyant during flooding of the adjacent fields. The tank is surrounded and topped by brick, block or rubble masonry walls up to 2.5 m above the brick walkways between the basins (compartments). These outer walls are ivy covered with a single doorway onto the canal towpath. The filter beds have many original cast iron sluice gates and valves in place, the residue of filter material and vegetation growing within and adjacent to the walls in the area which is unroofed and fully open to sunlight and precipitation. Without remedial action the structure could become derelict and unsafe to the public.

On the south side of the walled area, accessed through another doorway, there are lower level basins which were said to have been used in the past as a fish farm. Beyond this open basin area, the built structures drop way to the River Kennet flood plain, which regularly floods and is vegetated with grasses, reeds, hedges and trees.

The Architect's planned floor levels are understood to be 41.75 m. some 300mm above the level of the tow path 41.45 m as surveyed by WLS in 2015/16, to meet EA and NPPF regulations.

The logistics of moving construction materials to the Wire Mill site is challenging as road access is only possible to Southcote Mill by car and light vans south of the arched railway bridge and the narrow bridge over the Holy Brook. However the applicants are discussing numerous options with relevant stakeholders

## **10. Aerial Photograph Mapping**

Aerial photography of the flooding in early 2014 has been studied and compared with the Ordnance Survey mapping of the area.

Photo No 1 dated 26<sup>th</sup> February 2014. Clearly shows the area of flooding in Black and White from the Burghfield Road to Fobney weir with ~50% thin cloud. North of the Reading Newbury Line the Holy Brook valley shows flooding among the trees. South of the line the flooding appears to be relatively shallow. Upstream (west) of the Burghfield Road (Cunning Man) was also flooded but with dry areas east of the lake and near the electrical substation, while south of the K&A canal the darker presumably deeper flooded pits are surrounded by

tree and hedge lines which stand out. The scale of the photo was calculated to be 1/4,500.

Photo No 2 dated 9<sup>th</sup> March 2014. A colour print shows much the same detail as above (No1) with a higher percentage cloud cover at ~60%. It is however difficult to distinguish between permanently flooded gravel pits from flooded water meadows but it would appear that the meadow flooding had started to recede by this date. The scale was similar to Photo 1 calculated at 1/4,500.

## **11. Environment Agency Flood Mapping**

During this Flood Study, the Report by HR Wallingford dated February 2016 (Ref 1 commissioned by the Applicants), the Environment Agency (EA) website information and the EA letter (ref WA/2016/123025/01-l01) dated 28<sup>th</sup> October 2016 to Reading Borough Council Development Control Department, have all been reviewed.

Referring to the NPPF for new developments involving a Change of Use, it is clear that the proposed remodelling of the Wire Mill to a Cafe will **not** increase the risk of flooding in the area upstream or downstream of Southcote Lock 104. Neither can it be expected to reduce flooding. Only an increase in Fluvial, Pluvial and Groundwater Flooding due to climate change would cause increased flood runoff, always assuming that development by others elsewhere in the River Kennet catchment area does not result in reduced flood storage or increased run off. In the discussion in the paragraphs above the maximum recorded flood runoff at Theale in 2013/14 has been increased for Climate Change and the likely effects on the Southcote Mill access lane estimated. The December 2013 flood of **76.85 m<sup>3</sup>/s** is shown to have a return period of over 1 in 50 years (2%) and would cause the water levels below Lock 104 to increase by less than 90mm if climate change flows plus 20% occur.

Clauses 100 to 102 in the NPPF suggest that a “Sequential Test” approach should be adopted by developers to steer change away from flood prone areas. Clearly, there is no opportunity in the case of the Wire Mill plans to re-develop on an alternative site. The “Exception Test” procedure should therefore be adopted by the Planning Authority.

The EA mapping of the area presented in Reference 1 (Figure 3.2 on page 5) clearly shows that the access lane to Southcote Mill and to the development site passes through the 1% AEP (1 in 100years) Zone 3. However, Table 3.2 in the same reference states that the 1% AEP with a 20% flow increase for climate change would flood to a level of 40.98m, an increase of 70 mm compared to the level without Climate Change. The corresponding 1% AEP with a 20% flow increase for climate change on the west side of Southcote Mill is quoted to be flooded to a level of 40.34m, an increase of 110 mm on the pre climate change 1% AEP estimate.

These frequency/level predictions are suspect or the location imprecise in the text. The water level at Southcote Mill is now considered to have been 39.91m in February 2014 (2% AEP), compared to 40.18m interpolated from Table 3.2 (Ref 1) for the same frequency. This is an 270mm overestimate for the water level immediately downstream at Lock 104. Similarly the quoted level of 40.98m for the 1% AEP with 20% for climate change is suspicious as it represents exactly the water level in the canal upstream of Lock 104 at the time of the WLS Survey in December 2015. This implies that with climate change the flood plain water level would be the same as the C&RT controlled level in the canal upstream of Lock 104.

This EA level data is therefore subject to correction as the 2013/14 flood evidence shows the downstream water level at Lock 104 was below 39.91m estimated the using the WLS survey data of 5th January 2017 or some 220mm & 1.00m lower than the EA values of between 40.13m and 40.23m for the 5% AEP and 1% AEP levels respectively (Table 3.2 (Ref 1) .

In the letter to Reading Borough Council dated 28<sup>th</sup> October 2016 it states that the EA OBJECT to the Planning Application and recommended refusal at that time without further flood risk analysis.

The EA website of 2017 revised the Pixellated Flood mapping in their advice to developers and those seeking planning approval. Clearly there is no opportunity to apply the Sequential Test. The Exception Test route should be used bearing in mind that the Wire Mill is above the Flood Zones 2 and 3 and the application is for a Change of Use to Planning Class A3 which includes Cafes. Only the access route (Southcote Farm Lane) falls within Zones 2 and 3.

Observations and the independent hydraulic calculations presented in this Annex 1 of this Flood Study Report generally support the expectation of a rise of less than 90mm with a 20% climate change peak flow increase. The water levels below Lock 104 of 40.05m aod for a flood of 92.22 m<sup>3</sup>/s is determined largely by the fixed crest level of 39.300m at Fobney Weir.

## **12. Flood Risk Assessment FRA for Southcote Mill**

It is apparent from the above data that the flood plain area around Southcote Mill will continue to flood following periods of prolonged heavy rainfall and high groundwater in the Kennet River basin. The Wire Mill site is unlikely to suffer damage as it is not in the Flood Zones FZ2 or FZ3. The canal bank top is at 41.45m AOD alongside Lock 104 and the upstream canal water level is controlled at approximately 41m by the C&R Trust.

Analysis of the Theale gauging data (See Section 7 & Table 7.1 Annex 2) the flood on 24<sup>th</sup> December 2013 was the worst recorded flood with a frequency of once in 54 years.

Using the same WLS survey data from 2<sup>nd</sup> December 2015 as that referred to in the Sections (3&9) above, the Architect's planned floor levels are 41.75 m. some 300mm above the level of the tow path at 41.45 m .

The calculations for the Fobney Duckbill Weir indicate that the water levels around the mill are likely to increase by less than 70mm (<3 inches) from a peak flow at Theale from **69.8 m<sup>3</sup>/s** in February 2014 to a post climate change design flood increased by 20% to **83.75 m<sup>3</sup>/s**. The staff gauge at Southcote Mill Lock 104 would then read less than 4.09m compared to 4.02 in February 2014. In fact, if all other hydraulic conditions in the river and drainage system remain unchanged, increased flood levels downstream of Lock 104 are certain to increase the downstream flows in the Holy Brook and at Fobney Lock 105. Increased channel and flood plain storage of 55,000 m<sup>3</sup> will further reduce the rise in water levels.

It is important to note from the aerial photography (See Section 10) that if the water levels along the Southcote Farm Lane increase due to climate change, the section of Burghfield Road between the Cuning Man and the Railway Bridge would also be subjected to increased

flooding compared to that in 2013/14, when the Electrical Substation was vulnerable and diversionary pumping was needed. For this reason the EA have indicated that the levels of the access track, 1.2km to the east should **not** be raised to ease access to the Wire Mill during periods of flood. No increase in the surface levels of the Lane are proposed in this current Planning Application.

The Applicants have indicated that since the 2013/14 floods they have added and maintained a number of small piped culverts under the access lane to reduce the areas of stagnant standing water to the west of the lane. They had been prevented from exiting to Circuit Lane for a prolonged period of time during the flooding by temporary pumps, pipes and equipment laid across the roadway by Network Rail, EA and Thames Water to reduce flooding in Southcote due to blocked culverts under the railway embankment. During that time the residents at Southcote Mill used the canal towpath to the Burghfield Road which was available throughout the flood period.

They would be prepared to add more small piped culverts on the gravelled access lane if necessary seeking advice from relevant bodies - EA and Reading Borough Council). They have always maintained the road surface used jointly with heavy lorries from Network Rail, EA , CRT and Thames Water plc.

The Wire Mill is a derelict Victorian Industrial structure well worthy of a modern usage rather than progressing into further decay. It could become a heritage structure in its own right. A well managed leisure facility on the old Wire Mill / Waterworks site would be beneficial to the local economy with no tangible downsides. The main beneficiaries would be the walkers, cyclists and the boating fraternity on the canal and using the towpath. There is also the potential for the creation of additional employment opportunities during the reconstruction and seasonally when the Cafe is open. Analysis of the annual maximum flood data since 1961-2015 has shown that only twice in the 54 years has a flood occurred in the March-October period. Operation of a Cafe on the Wire Mill site can made subject to a “Condition” covering seasonable activity should the Planning Authority wish to impose for the reason of public safety.

Planning Approval should be considered under the Exception Test procedures by the Officers and Councillors on the LA Planning Committee.

### **13. Findings and Recommendations**

The discussions above represent a pessimistic or the worst case scenario as far as runoff in the Kennet Valley under Climate change conditions is concerned. The Application does not make the flooding worse. Water levels of 40.05m which allows for a 20% flow increase for climate change to 92.22 m<sup>3</sup>/s downstream of Southcote Lock 104 are likely to be less than 90 mm higher than in 2013/14 which was the highest *estimated* flood in the 54 years of recorded flows in the Holy Brook at Theale.

The flood risk is not considered to be sufficient with the proposed actions to refuse the Application. In the Wire Mill, the ground floor levels proposed are 300mm above the towpath 41.45m . The level of the Southcote Farm Lane to the Mill will not be raised to impede the overland flow of surface water through FZ2 & FZ3 and extra drains will be provided if required.

The management of the Cafe in FZ1 will continue to take part in the Environment Agency's flood warning initiatives to those residing in flood prone areas. Subject to planning conditions, the Cafe would only open in non flood periods when the risk to walkers and the public in general would be no greater than if the Cafe did not exist.

From the flood risk prospective Planning Approval is recommended.

GBMayes 28<sup>th</sup> August 2017.

## References

1. HR Wallingford February 2016 Southcote Mill Redevelopment Level 1 Flood Risk Assessment.
2. Kraatz and Mahajan (1975). Duckbill Weirs and FAO Rome.
3. C&RTrust Website – Locks at Sulhamstead (100), Sheffield (101), Garston (102), Burghfield (103).
4. EA website and Drawings of Fobney Weir
5. WLS Levelling data and site plan for Z Puddephatt 2<sup>nd</sup> December 2015 and 5<sup>th</sup> January 2017 .
6. Centre for Ecology and Hydrology (CEH) Website data for Theale.

## Annexures

### 1. Fobney Weir Rating Calculations

#### a. Table 5.1A/i

| Southcote Mill Hydraulic Calculations                       |        |            |                   | CEH Maximum Flows Dec2013 to February 2014 without Climate Change Allowances |     |    |                               |       |      |                 |                                             |
|-------------------------------------------------------------|--------|------------|-------------------|------------------------------------------------------------------------------|-----|----|-------------------------------|-------|------|-----------------|---------------------------------------------|
| Calculations based on New data.                             |        |            |                   | Table 5.1A/i<br>Revised Data for Fobney Duckbill Weir OSGR 469805 171202     |     |    |                               |       |      |                 |                                             |
| Crest Level OS                                              |        | 39.300     | m                 | Q                                                                            | Cd  | Le | H                             | H+1.6 | v    | DH              | Remarks                                     |
| Weir width w                                                | L      | 22         | m                 | m <sup>3</sup> /s                                                            |     | m  | m                             | m     | m/s  | m               |                                             |
| Length of Crest Le                                          | Le     | 95         | m                 |                                                                              |     |    |                               |       |      |                 |                                             |
| Head over weir H                                            | H      |            | m                 |                                                                              |     |    |                               |       |      |                 |                                             |
| Coeff Discharge Cd                                          |        | 1.5        |                   |                                                                              |     |    |                               |       |      |                 |                                             |
| Discharge Q                                                 | Q      |            | m <sup>3</sup> /s |                                                                              |     |    |                               |       |      |                 |                                             |
| Wing walls upstream                                         |        | 5          | m                 | Control Q                                                                    |     |    |                               |       |      |                 |                                             |
| Wing walls downstream                                       |        | 5          | m                 | 0                                                                            | 1.5 | 95 | 0.00                          | 1.60  | 0.00 | 0.00            |                                             |
| Approach Velocity v                                         | v      |            | m/s               | 10                                                                           | 1.5 | 95 | 0.17                          | 1.77  | 0.26 | 0.17            |                                             |
| Approach depth Apron at Weir                                |        | 1.6        | m                 | 20                                                                           | 1.5 | 95 | 0.27                          | 1.87  | 0.49 | 0.27            |                                             |
|                                                             |        |            |                   | 30                                                                           | 1.5 | 95 | 0.35                          | 1.95  | 0.70 | 0.35            |                                             |
|                                                             |        |            |                   | 40                                                                           | 1.5 | 95 | 0.43                          | 2.03  | 0.90 | 0.43            |                                             |
|                                                             |        |            |                   | 50                                                                           | 1.5 | 95 | 0.50                          | 2.10  | 1.08 | 0.50            | HR Wallingford Peak Q early Feb 2014        |
|                                                             |        |            |                   | 60                                                                           | 1.5 | 95 | 0.56                          | 2.16  | 1.26 | 0.56            |                                             |
| Revised following receipt of Thames Water's Design Drawings |        |            |                   | Flood Q at Theale                                                            |     |    |                               |       |      |                 |                                             |
|                                                             |        |            |                   | 69.80                                                                        | 1.5 | 95 | 0.62                          | 2.22  | 1.43 | 0.62            | Max Estimated flow at Theale GS 7/02/2014   |
|                                                             |        |            |                   | 76.85                                                                        | 1.5 | 95 | 0.66                          | 2.26  | 1.54 | 0.66            | Max Estimated flow at Theale GS 24/12/ 2013 |
| Staff gauge reading at Lock 104                             | 4.02m  | observed   |                   | Calculated fall in Water Level above Weir Dec2013 to Feb2014.                |     |    |                               |       |      |                 |                                             |
| Zero level for Staff Gauge                                  | 35.89m | estimated  |                   | 0.04 m                                                                       |     |    |                               |       |      |                 |                                             |
| OS Flood Level 7th Feb 2014                                 | 39.91m | calculated |                   |                                                                              |     |    |                               |       |      |                 |                                             |
|                                                             |        |            |                   | Q= Cd Le(H) <sup>1.5</sup>                                                   |     |    | H=(Q/(CdLe)) <sup>0.667</sup> |       |      | v=Q/((H+1.6)*L) |                                             |
| GBM rev 12th August 2017                                    |        |            |                   |                                                                              |     |    |                               |       |      |                 |                                             |

b. Table 5.1A/ii

|                                                             |    |        |      |                                                                           |     |         |        |            |          |         |         |                                                                         |                 |
|-------------------------------------------------------------|----|--------|------|---------------------------------------------------------------------------|-----|---------|--------|------------|----------|---------|---------|-------------------------------------------------------------------------|-----------------|
| Southcote Mill Hydraulic Calculations                       |    |        |      | CEH Maximum with Climate Change + 20%                                     |     |         |        |            |          |         |         |                                                                         |                 |
| Fobney Duckbill Weir OSGR469805 171202                      |    |        |      | Table 5.1A/ii<br>Revised Data for Fobney Duckbill Weir OSGR 469805 171202 |     |         |        |            |          |         |         |                                                                         |                 |
| Calculations based on New data.                             |    |        |      | Q<br>m3/s                                                                 | Cd  | Le<br>m | H<br>m | H+1.6<br>m | v<br>m/s | DH<br>m | Remarks |                                                                         |                 |
| Crest Level OS                                              |    | 39.300 | m    | Control Q                                                                 | 0   | 1.5     | 95     | 0.00       | 1.60     | 0.00    | 0.00    | HR Wallingford Peak Q early Feb 2014                                    |                 |
| Weir width w                                                | L  | 22     | m    |                                                                           | 10  | 1.5     | 95     | 0.17       | 1.77     | 0.26    | 0.17    |                                                                         |                 |
| Length of Crest Le                                          | Le | 95     | m    |                                                                           | 20  | 1.5     | 95     | 0.27       | 1.87     | 0.49    | 0.27    |                                                                         |                 |
| Head over weir H                                            | H  |        | m    |                                                                           | 30  | 1.5     | 95     | 0.35       | 1.95     | 0.70    | 0.35    |                                                                         |                 |
| Coeff Discharge Cd                                          |    | 1.5    |      |                                                                           | 40  | 1.5     | 95     | 0.43       | 2.03     | 0.90    | 0.43    |                                                                         |                 |
| Discharge Q                                                 | Q  |        | m3/s |                                                                           | 50  | 1.5     | 95     | 0.50       | 2.10     | 1.08    | 0.50    |                                                                         |                 |
| Wing walls upstream                                         |    | 5      | m    |                                                                           | 60  | 1.5     | 95     | 0.56       | 2.16     | 1.26    | 0.56    |                                                                         |                 |
| Wing walls downstream                                       |    | 5      | m    | Flood Q at Theale                                                         |     |         |        |            |          |         |         | Max Estimated flow at Theale GS Feb 2014<br>Plus 20% for Climate Change |                 |
| Approach Velocity v                                         | v  |        | m/s  | 69.8                                                                      | 1.5 | 95      | 0.62   | 2.22       | 1.43     | 0.62    |         |                                                                         |                 |
| Approach depth Apron at Weir                                |    | 1.6    | m    | 83.76                                                                     | 1.5 | 95      | 0.70   | 2.30       | 1.65     | 0.70    |         |                                                                         |                 |
| Duckbills                                                   |    | 8      | nr   | Increase Upstream Flood Levels since 2014                                 |     |         |        |            |          |         |         | 0.08 m                                                                  |                 |
| Revised following receipt of Thames Water's Design Drawings |    |        |      | Q= Cd Le(H)^1.5                                                           |     |         |        |            |          |         |         | H=(Q/(CdLe))^0.667                                                      | v=Q/((H+1.6)*L) |
| GBM rev 5th August 2017                                     |    |        |      |                                                                           |     |         |        |            |          |         |         |                                                                         |                 |

c. Table 5.1A/iii

|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|-------------------------------------------------------------|----|--------|-------------------|---------------------------------------------------------|--|--|--|--------------------|--|--|--|--|--|--|--|--|--|--|--|
| Southcote Mill Hydraulic Calculations                       |    |        |                   | CEH Maximum with Climate Change + 20%                   |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Fobney Duckbill Weir OSGR469805 171202                      |    |        |                   | Table 5.1A/iii<br>Revised Data for Fobney Duckbill Weir |  |  |  | OSGR 469805 171202 |  |  |  |  |  |  |  |  |  |  |  |
| Calculations based on New data.                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Crest Level OS                                              |    | 39.300 | m                 |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Weir width w                                                | L  | 22     | m                 |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Length of Crest Le                                          | Le | 95     | m                 |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Head over weir H                                            | H  |        | m                 |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Coeff Discharge Cd                                          |    | 1.5    |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Discharge Q                                                 | Q  |        | m <sup>3</sup> /s |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Wing walls upstream                                         |    | 5      | m                 |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Wing walls downstream                                       |    | 5      | m                 |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Approach Velocity v                                         | v  |        | m/s               |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Approach depth Apron at Weir                                |    | 1.6    | m                 |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Duckbills                                                   |    | 8      | nr                |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
| Revised following receipt of Thames Water's Design Drawings |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
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|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
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|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
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|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
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|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
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|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
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|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |
|                                                             |    |        |                   |                                                         |  |  |  |                    |  |  |  |  |  |  |  |  |  |  |  |

## 2. Table 7.1 Flood Frequency Data CEH and Analysis

| Annex 2 Flood Frequency Data CEH and Analysis                         |           |                                |        |                                                |                                     |                                                                                              |           |                                   |        |                                                |         |
|-----------------------------------------------------------------------|-----------|--------------------------------|--------|------------------------------------------------|-------------------------------------|----------------------------------------------------------------------------------------------|-----------|-----------------------------------|--------|------------------------------------------------|---------|
| Table 7.1 Gauging Records for Theale 1961-2015                        |           |                                |        |                                                |                                     | CEH Ref No 39016                                                                             |           |                                   |        |                                                |         |
| Base data from Centre for Ecology and Hydrology Wallingford July 2017 |           |                                |        |                                                |                                     | Theale Gauging Station EAID 2290TH OS GR 6495970828                                          |           |                                   |        |                                                |         |
| Water Year                                                            | Peak Date | Peak Flow<br>m <sup>3</sup> /s | Rank M | Return<br>Period<br>TR<br>=(n+1)/M<br>in years | Remarks                             | Water Year                                                                                   | Peak Date | Peak<br>Flow<br>m <sup>3</sup> /s | Rank M | Return<br>Period<br>TR<br>=(n+1)/M<br>in years | Remarks |
| 1st Oct                                                               | 30th Sept |                                |        |                                                |                                     | 1st Oct                                                                                      | 30th Sept |                                   |        |                                                |         |
| 2014                                                                  | 2015      | n/a                            | 30.2   | n/a                                            | Record not complete                 |                                                                                              |           |                                   |        |                                                |         |
| 2013                                                                  | 2014      | 24/12/2014                     | 76.847 | 1                                              | Digital after 1986/7                |                                                                                              |           |                                   |        |                                                |         |
| 2012                                                                  | 2013      | 21/12/2012                     | 32.511 | 35                                             |                                     |                                                                                              |           |                                   |        |                                                |         |
| 2011                                                                  | 2012      | 30/04/2012                     | 22.26  | 47                                             |                                     |                                                                                              |           |                                   |        |                                                |         |
| 2010                                                                  | 2011      | 18/01/2011                     | 31.0   | 39                                             |                                     |                                                                                              |           |                                   |        |                                                |         |
|                                                                       |           |                                |        |                                                |                                     | continued from bottom left                                                                   |           |                                   |        |                                                |         |
| 2009                                                                  | 2010      | 28/02/2010                     | 28.4   | 42                                             |                                     | 1979                                                                                         | 1980      | 28/12/1979                        | 38.6   | 24                                             | 2.25    |
| 2008                                                                  | 2009      | 11/02/2009                     | 55.0   | 5                                              |                                     | 1978                                                                                         | 1979      | 29/03/1979                        | 33.6   | 34                                             | 1.59    |
| 2007                                                                  | 2008      | 17/03/2008                     | 46.58  | 11                                             |                                     | 1977                                                                                         | 1978      | 28/01/1978                        | 38.0   | 27                                             | 2.00    |
| 2006                                                                  | 2007      | 21/07/2007                     | 55.6   | 4                                              |                                     | 1976                                                                                         | 1977      | 24/02/1977                        | 36.0   | 30                                             | 1.80    |
| 2005                                                                  | 2006      | 03/12/2005                     | 20.7   | 49                                             |                                     | 1975                                                                                         | 1976      | 01/12/1975                        | 19.1   | 53                                             | 1.02    |
| 2004                                                                  | 2005      | 19/12/2004                     | 19.3   | 52                                             |                                     | 1974                                                                                         | 1975      | 21/01/1975                        | 48.3   | 8                                              | 6.75    |
| 2003                                                                  | 2004      | 13/01/2004                     | 23.5   | 46                                             |                                     | 1973                                                                                         | 1974      | 11/02/1974                        | 44.8   | 17                                             | 3.18    |
| 2002                                                                  | 2003      | 02/01/2003                     | 52.948 | 6                                              |                                     | 1972                                                                                         | 1973      | 07/12/1972                        | 47.3   | 10                                             | 5.40    |
| 2001                                                                  | 2002      | 05/02/2002                     | 47.365 | 9                                              |                                     | 1971                                                                                         | 1972      | 07/03/1972                        | 34.2   | 32                                             | 1.69    |
| 2000                                                                  | 2001      | 31/10/2000                     | 63.465 | 3                                              |                                     | 1970                                                                                         | 1971      | 11/06/1971                        | 71.0   | 2                                              | 27.00   |
| 1999                                                                  | 2000      | 25/12/1999                     | 45.139 | 14                                             |                                     | 1969                                                                                         | 1970      | 25/01/1970                        | 27.9   | 43                                             | 1.26    |
| 1998                                                                  | 1999      | 27/12/1998                     | 45.632 | 12                                             |                                     | 1968                                                                                         | 1969      | 14/03/1969                        | 41.579 | 20                                             | 2.70    |
| 1997                                                                  | 1998      | 06/01/1998                     | 36.504 | 29                                             |                                     | 1967                                                                                         | 1968      | 17/09/1968                        | 37.247 | 28                                             | 1.93    |
| 1996                                                                  | 1997      | 18/02/1997                     | 17.381 | 54                                             |                                     | 1966                                                                                         | 1967      | 10/03/1967                        | 38.725 | 23                                             | 2.35    |
| 1995                                                                  | 1996      | 09/01/1996                     | 31.465 | 38                                             |                                     | 1965                                                                                         | 1966      | 26/02/1966                        | 42.091 | 19                                             | 2.84    |
| 1994                                                                  | 1995      | 02/02/1995                     | 45.657 | 13                                             |                                     | 1964                                                                                         | 1965      | 14/01/1965                        | 20.2   | 50                                             | 1.08    |
| 1993                                                                  | 1994      | 06/01/1994                     | 43.598 | 18                                             |                                     | 1963                                                                                         | 1964      | 19/11/1963                        | 40.9   | 22                                             | 2.45    |
| 1992                                                                  | 1993      | 11/01/1993                     | 41.286 | 21                                             |                                     | 1962                                                                                         | 1963      | 10/03/1963                        | 29.763 | 40                                             | 1.35    |
| 1991                                                                  | 1992      | 24/09/1992                     | 22.016 | 48                                             |                                     | 1961                                                                                         | 1962      | 22/01/1962                        | 38.394 | 26                                             | 2.08    |
| 1990                                                                  | 1991      | 10/01/1991                     | 27.892 | 44                                             |                                     | M=Ranking of the event                                                                       |           |                                   |        |                                                |         |
| 1989                                                                  | 1990      | 08/02/1990                     | 52.104 | 7                                              |                                     | n=number of years of record = 53                                                             |           |                                   |        |                                                |         |
| 1988                                                                  | 1989      | 21/03/1989                     | 25.051 | 45                                             |                                     | Peak Estimated Flow 76.8 m <sup>3</sup> /s in water year 2013/14 on 24/12/2013 at 21.15 hrs. |           |                                   |        |                                                |         |
| 1987                                                                  | 1988      | 30/01/1988                     | 45.001 | 16                                             |                                     | Median Flow 37.624m <sup>3</sup> /s                                                          |           |                                   |        |                                                |         |
| 1986                                                                  | 1987      | 20/11/1986                     | 45.13  | 15                                             |                                     | Max Gauged Flow 54.2 m <sup>3</sup> /s on 02/01/2003, Gauge level 1.65m 15/02/2014.          |           |                                   |        |                                                |         |
| 1985                                                                  | 1986      | 26/12/1985                     | 33.7   | 33                                             | Staff gauge readings before 1985/86 | GBM analysis correct at July 2017                                                            |           |                                   |        |                                                |         |
| 1984                                                                  | 1985      | 22/01/1985                     | 31.7   | 37                                             |                                     |                                                                                              |           |                                   |        |                                                |         |
| 1983                                                                  | 1984      | 24/03/1984                     | 32     | 36                                             |                                     |                                                                                              |           |                                   |        |                                                |         |
| 1982                                                                  | 1983      | 10/12/1982                     | 35     | 31                                             |                                     |                                                                                              |           |                                   |        |                                                |         |
| 1981                                                                  | 1982      | 16/03/1982                     | 38.6   | 24                                             |                                     |                                                                                              |           |                                   |        |                                                |         |
| 1980                                                                  | 1981      | 11/03/1981                     | 29.4   | 41                                             |                                     |                                                                                              |           |                                   |        |                                                |         |

## 3. Table 3.1 Estimated Staff Gauge Zero Level at Lock 104 Southcote Mill Lock

| Annex 3                                                                                            | Staff Gauge a Southcote Weir (104)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                  |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|----------------|---------------------------|-------|-------|--------------------|------|------|---------------------|------|------|--------------|------|------|-----------------------|------|------|-----------------------------|-------|-------|------------------------------------|-------|-------|
| Table 3.1                                                                                          | Estimated Staff Gauge Zero Level at Lock 104                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                  |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Gauge very dirty at lower readings-measured with steel tape below 4m mark.                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                  |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Description                                                                                        | <table><tr><th>01 December 2015</th><th>05 August 2017</th></tr><tr><td>Upstream Water Level OS m</td><td>40.98</td><td>41.00</td></tr><tr><td>Full Reading HWL m</td><td>0.45</td><td>0.45</td></tr><tr><td>Empty Reading LWL m</td><td>2.13</td><td>2.13</td></tr><tr><td>Difference m</td><td>1.68</td><td>1.68</td></tr><tr><td>Staff Gauge Reading m</td><td>3.43</td><td>3.43</td></tr><tr><td>Downstream Water Level OS m</td><td>39.30</td><td>39.32</td></tr><tr><td>Estimated Staff Gauge Zero Level m</td><td>35.87</td><td>35.89</td></tr></table> | 01 December 2015 | 05 August 2017 | Upstream Water Level OS m | 40.98 | 41.00 | Full Reading HWL m | 0.45 | 0.45 | Empty Reading LWL m | 2.13 | 2.13 | Difference m | 1.68 | 1.68 | Staff Gauge Reading m | 3.43 | 3.43 | Downstream Water Level OS m | 39.30 | 39.32 | Estimated Staff Gauge Zero Level m | 35.87 | 35.89 |
| 01 December 2015                                                                                   | 05 August 2017                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                  |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Upstream Water Level OS m                                                                          | 40.98                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 41.00            |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Full Reading HWL m                                                                                 | 0.45                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0.45             |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Empty Reading LWL m                                                                                | 2.13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2.13             |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Difference m                                                                                       | 1.68                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1.68             |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Staff Gauge Reading m                                                                              | 3.43                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 3.43             |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Downstream Water Level OS m                                                                        | 39.30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 39.32            |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Estimated Staff Gauge Zero Level m                                                                 | 35.87                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 35.89            |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| NB                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                  |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Upstream Water Level as surveyed December 2015. Average of surveyed levels assumed in August 2017. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                  |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| Upstream Water Level below top old Cast Iron Gauge on LB wing wall Lock 104 was 0.254m on 5/8/2017 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                  |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |
| GBM 20th August 2017                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                  |                |                           |       |       |                    |      |      |                     |      |      |              |      |      |                       |      |      |                             |       |       |                                    |       |       |

#### 4. Photos

##### a. Aerial photo 1 dated 26 February 2014



##### b. Aerial photo 2 dated 9 March 2014



c. K&A upstream of Southcote Lock 104



d. Sulhamstead Weir Head of Holy Brook



e. Theale Crump Gauging Weir



f. Milkmaids Towpath bridge



g. Milkmaids bridge at Lock 104



h. Fobney Duckbill Weir



- i. Southcote Lock 104 approach & Wire Mill left of towpath



- j. Staff Gauge at Southcote Lock 104



## ***Abbreviations***

- AOD or aod Above ordnance datum
- C&RT Canal And River Trust (formerly British Waterways Board)
- CEH Centre for Ecology and Hydrology
- EA Environment Agency
- FRA Flood Risk Assessment
- FZ Flood Zone
- HR Hydraulic Research Wallingford
- K&A Kennet and Avon Canal or Navigation
- NPPF National Planning Policy Framework
- OS GR Ordnance Survey Grid Reference
- RBC Reading Borough Council
- TBM Temporary Bench Mark
- TW Thames Water plc
- WLS Warner Land Survey Ltd