

**FOUR ASHES ENERGY FROM WASTE
PLANT
FLOOD RISK ASSESSMENT**

STAFFORDSHIRE COUNTY COUNCIL

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EXECUTIVE SUMMARY

This Flood Risk Assessment (FRA) was carried out prior to the planning application area being finalised. Originally the southwest corner of the site extended to Saredon brook and was therefore within Flood Zone 3. The planning application area was finalised later on in the assessment to reflect the fact that no development was proposed within this corner. As such the site is no longer within the flood zone. The FRA, therefore, presents a worst case scenario with regard to flooding, but concludes there will be no risk to the development from flooding.

Enviros Consulting was commissioned by Staffordshire County Council to undertake a flood risk and storm water management assessment for the proposed Energy from Waste (EfW) plant site at Four Ashes in November 2007.

Flood Risk

The majority of the site is located in flood zone 1 indicating that the risk of flooding from major sources is low. As such the sequential test, used by planning authorities to direct development away from areas of high flood risk, indicates that industrial development of this area is potentially appropriate. However, the south western corner is located in flood zone 3, where flooding is predicted to occur in a 1 in 100 year event (1% probability). Topographic data for the site indicated that this is likely to be correct.

Although the southwest corner of the site is included within the site boundary, no development is scheduled to be undertaken there. The area will be fenced off and access and egress routes are to the north, well away from this zone. Thus, the risk from this source to the development is considered to be low.

Other possible sources, not considered on the Environment Agency (EA) flood map, included the Staffordshire and Worcestershire Canal, a number of small ponds and drains and water and sewer services. An examination of each of these sources determined that the likelihood and impact of flooding from these sources was low or below, thus the overall risk was also low.

Thus, no further mitigation or management is required with regards to the site under the current development options.

Storm Water Management

The EA has stated that on-site infiltration is preferable to attenuation and storage of runoff water. Infiltration testing should be undertaken at the site to confirm the feasibility of this, and if so, infiltration could be achieved using a variety of Sustainable Drainage System (SuDS) design options. The area required for the infiltration of runoff from the site will depend on the results of the infiltration tests and the final design of the development. It is suggested that the runoff from roofing at the development could enter a system located in the northeast and southeast corners of the site, which are currently designated for landscaping. Runoff from the on-site roads and smaller buildings could be dealt with adjacent to those areas.

If infiltration proves impossible, it is recommended that runoff is attenuated using an appropriate SuDS method. Calculations indicate that approximately 2663m³ of attenuation storage would be required to manage up to a 1-in-100 year rainfall event (including provision for climate change) if runoff control were to be completely managed using this method. Discharge at greenfield rates (calculated as 14.4l/s) could then be made to Saredon Brook (following permission from the EA).

1. INTRODUCTION

This Flood Risk Assessment (FRA) was carried out prior to the planning application area being finalised. Originally the southwest corner of the site extended to Saredon brook and was therefore within Flood Zone 3. The planning application area was finalised later on in the assessment to reflect the fact that no development was proposed within this corner. As such the site is no longer within the flood zone. The FRA, therefore, presents a worst case scenario with regard to flooding, but concludes there will be no risk to the development from flooding.

This report was commissioned in November 2007 by Staffordshire County Council. The work concerns the provision of advice on the hydrological constraints to the development of an Energy from Waste (EfW) plant. This includes the flood risk to the development and storm water management of the increased runoff likely to result from the development.

1.1 Background

1.1.1 Sequential Assessment

The Environment Agency (EA) flood map (Figure 1) indicates that the majority of the site is located in flood zone 1, indicating that flooding from major fluvial or tidal sources is not likely. The southwest corner, however, is within flood zone 3, indicating that flooding is predicted to occur during a 1 in 100 year event (1% probability). Although the site boundary includes this area, none of the proposed development is located here (see Section 2.3, Development Plans).

The sequential test as set out in Planning Policy Statement 25: Development and Flood Risk (PPS25₂), states that industrial development is potentially appropriate in flood zone 1.

1.1.2 Requirement for Flood Risk Assessment

As a section of the site is within flood zone 3 (albeit a small area of approximately 60m x 30m which is not to be developed), and the site is approximately 4.4 hectares (ha) in area, a flood risk assessment is required. The latter is important as for any site larger than one hectare the EA's standing policy, in accordance with PPS25, states that an assessment must be undertaken.

In addition to assessing the external risk of flooding to the site, an assessment must demonstrate that the proposed development would not exacerbate flooding elsewhere. On brownfield sites it is also necessary to demonstrate that peak rates of flow would be reduced back towards the levels that would be expected from a greenfield site.

¹ The EA flood map was produced as part of a nationwide project to provide a visual representation of the extent and risk of flooding throughout England and Wales. This was undertaken for all tidal sources and fluvial sources where catchments are greater than 3km². The flood map classifies land as being in one of three zones (flood zones 1, 2 or 3). In areas defined as flood zone 3, the EA estimate that the annual risk of flooding exceeds 1% or 0.5%, for fluvial or tidal sources respectively. In flood zone 2 the annual risk is estimated to be between 0.1 and 1% for fluvial or between 0.1 and 0.5%, for tidal sources. In flood zone 1 the annual risk is assessed to be less than 0.1%.

² Planning Policy Statement 25: Development and Flood Risk, Department for Communities and Local Government, 2006

In addition PPS25 requires that localised sources of flooding such as sewers, drains and smaller streams that may not be represented on the EA flood map are also considered.

1.2 Objectives

The objectives of this assessment are to:

- ◆ Identify mechanisms by which the site could flood;
- ◆ Undertake a formal assessment of the risk posed to the development from all identified flood sources and mechanisms;
- ◆ Assess the storm water runoff potential for the site and the requirements for its attenuation and disposal;
- ◆ Produce a baseline flood risk assessment compliant with the guidance contained within PPS25; and,
- ◆ Identify any other key hydrological constraints to development in any areas of the site.

1.3 Consultees

The local water utility company (South Staffordshire Water) provided water mains records, and the local drainage company (Severn Trent Water) provided sewer plans. A Development Control Officer (John Folds) from the EA was also consulted and provided advice on the EA flood map, other flooding sources and EA requirements for storm water management systems. British Waterways were also contacted and provided information on local canals.

All data from external sources in this assessment have been accepted *de facto* and we assume their completeness and accuracy.

1.4 Report Synopsis

Chapter 2 describes the site and the surrounding area. Chapter 3 covers the risk from flooding to the site and the consequences to the proposed development, should flooding occur. The management of site runoff within the site and possible strategies for complying with guidance are then discussed in Chapter 4. The report is then concluded in Chapter 5.

2. SITE DESCRIPTION AND BACKGROUND

This Flood Risk Assessment has been produced in conjunction with an Environmental Statement for the proposed EfW plant. More detailed information on other aspects of the development (such as landscape, transport and noise) are available in that document. The following description relates only to those aspects of the development relevant to flood risk and stormwater management.

In addition to desk-based information sources, a site visit was undertaken on 11 December 2007. The weather was fine, although heavy rain had occurred in the week prior to the visit.

2.1 The Current Site

The site covers approximately 4.4 hectares. It is brownfield and was previously used for sand and gravel extraction but is currently vacant. It is located off the east end of Enterprise Road, in Four Ashes (Figure 1).

2.1.1 Land Cover

The site entry is from the northwest, via a gravel driveway. The majority of the site is covered in rough grassland, apart from a large area of bare made ground (outlined in black on Figure 1). The surface of this area is composed of small gravel and fragments of brick through to full bricks. Some evidence of this material can be seen across the rest of the site, although rabbit activity has also exposed significant areas of sand.

An area in the centre of the site is marshy, with significant cover of reeds (up to 1.5m in height) and a number of small (~2m high) willows. This has standing water of up to 10cm depth. Small pools of standing water were also present across the majority of the site during the site visit, probably due to slow infiltration after the recent rainfall.

The eastern and western edges of the site are wooded with thick bramble undergrowth. The west and southwest corner is also wooded, with brambles and nettles in the drier parts and reeds in the lower, damper areas.

2.1.2 Topography

The site is at an elevation of between 96 and 103 metres above Ordnance Datum (m aOD), as shown in the detailed topographic data in Figure 4. The marshy area in the south west bordering the Saredon Brook (discussed in section 2.2.3) coincides with the lowest elevations on site, varying between 96 and 99m aOD. This rises gently along the western border up to the concrete works, but more abruptly up to the site proper, after which there is a bund of approximately 1m in height. Moving along the southern and eastern borders of the site, this bund becomes part of a steep bank of 3m height which separates the site from the drain and farmland below (discussed in sections to follow).

The main site area is relatively uniform, sloping gently upwards to the north from 99.5 and 102.5m aOD. The only interruption to this is a slightly higher spoil heap area just above the bank in the centre south of site, of up to 102.5m aOD. There is another spoil heap on the western boundary that rises to 101.8m aOD.

2.1.3 Water Bodies & Services

There are a number of small water sources on site, as listed below.

Pond & Drains

The Ordnance Survey maps indicate an elongated ephemeral pond is present in the east of the site, stretching approximately 100m in length from north to south. This was not observed during the site visit, although there were several small isolated pools in the marked location. Given that considerable recent rainfall had fallen, it seems unlikely that this is a significant water feature.

The 'pond' is drained at the southern end by a small waterway which flows south to the southeast corner of the site, where it is confluent with another drain entering from the east. This tributary was observed as contributing a very noticeable orange discharge which coated the bed and sides of the drain. While the drain formerly had an exit to the Saredon Brook directly to the south, this has been blocked with a concrete iron structure, and instead the drain flows along the border of the site to the Saredon Brook. At the point of discharge, the drain is approximately 1m in width within a well defined channel with consistent banks of at least 1m in height. During the site visit the water depth was approximately 10cm.

There is also a sunken pool of approximately 2m diameter on the western border of the site, within the wooded area. The inflow to this is from under a concrete slab and appears to originate in the concrete works. Another small pond is located down-gradient of this, close to the Saredon Brook.

In addition, as mentioned above in section 2.1.1., there is an area of standing water in the centre of the site. This was a maximum of 30m x 30m in size at the time of the site visit, but may vary with rainfall.

Mains Supply and Drainage

There are currently no mains supply pipes or surface, stormwater or foul drains on site.

2.1.4 Geology

The solid geology of the site consists of Wildmoor Sandstone. Overlying this sedimentary rock is silty sand and glacial till (boulder clay), which is further overlain by sands and gravels. These sedimentary deposits can be considered made ground as the site was worked over as a sand and gravel extraction quarry for concrete aggregates. Once the extraction of marketable material was completed the resulting depression was backfilled with inert waste materials up to the level of the adjacent land. It is not known if the site is contaminated but this is considered unlikely given the inert nature of the fill.

2.1.5 Hydrogeology

The EA's groundwater vulnerability map indicates that the site is underlain by low permeability drift deposits of glacial till overlying a major aquifer of the Sherwood Sandstone group. The soils on the site are shown on the map to be of high infiltration potential, as they are deep, permeable, coarse textured soils which rapidly drain and have low attenuation potential.

The major aquifer is highly productive and of regional importance for large public water supply abstractions. The regional groundwater flow direction is likely to be

south easterly towards the River Penk but this may be impacted locally by the presence of the Staffordshire and Worcestershire Canal to the north of the site and the Saredon Brook to the south.

The site is located within a designated Nitrate Vulnerable Zone (NVZ) under the Nitrates Directive, due to the groundwater containing or potentially containing (without preventative action) nitrate concentrations of greater than 50mg/l.

In addition, the site is located in an outer groundwater source protection zone, as defined by the EA. This is for an abstraction source (likely to be for public supply) located approximately 1.2km to the southwest. The zones of protection for a groundwater abstraction are defined by the area identified as the source of water (i.e. the catchment area) and the time taken for the water to reach the borehole. The outer zone is that which is defined by a 400-day travel time from any point below the water table.

2.1.6 Surface Drainage

At the time of the site visit significant previous rainfall had given rise to localised ponding as already described and it was anticipated that this was followed by infiltration into the ground. There is no developed surface water drainage system. Any significant overland flow would enter the pond and drains on the east and south of site before flowing to the Saredon Brook, or would enter the standing water in the centre of the site before slowly infiltrating.

2.2 The Surrounding Area

2.2.1 Land Use

To the immediate north of the site is vacant land. This has planning permission to be developed with industrial / warehousing units. Beyond this is the Staffordshire and Worcestershire Canal (discussed below), agricultural land and Station Road.

To the east is derelict land for approximately 300m, beyond which is a minor road followed by a Severn Trent Water sewage sludge treatment works and agricultural land. Southwards, across Saredon Brook, is also agricultural land.

To the west and north-west lies the Four Ashes Industrial Estate, consisting of mixed industrial and commercial buildings and associated roads. The Industrial Estate is bounded by a railway line approximately 750m to the west.

2.2.2 Topography

The site is located in a generally level area which extends to the north and northwest. To the west, there is a brief dip followed by a continuation of the north-south slope down to the Saredon Brook as seen on site. To the east, there is a lower area for approximately 200m before the land gradually begins to rise up in to the Saredon catchment.

To the south and southwest the land drops away to the Saredon Brook (which had a water level at the time of surveying of 96.1m aOD - see Figure 4), after which it begins to rise gently again to the south.

The only significant topographic feature within the vicinity of the site is the railway line to the west, which is embanked above the surrounding area.

2.2.3 Saredon Brook

The Saredon Brook borders the site to the south. It is confluent with the River Penk approximately 3km downstream of the site and these form part of the River Trent catchment.

The brook originates as Ridings Brook in the northeast of Cannock, which then flows southwest. This tributary is 6.2km long and drains an area of 18km², the majority of which is urban. The brook's tributaries include Pye Green Brook, County Brook, Hawkes Green Brook and Golly Brook North. Saredon Brook is known to be susceptible to flooding with notable flood events in September 1994, July 1999 and November 2000. In December 2006 a new flood alleviation scheme was completed for the brook, which is designed to provide protection for most properties against a 1:100 year event (1% probability), although some of the most vulnerable properties will still only be protected against a 1:50 year event (2% annual probability).

In the southwest of Cannock, Ridings Brook is joined by Golly Brook and Wryley Brook. Both of these are only approximately 500m in length and are contained within the south western suburbs of Cannock. There is a disused lock on the lower section of Golly Brook.

Saredon Brook initiates upon the confluence of Ridings, Golly and Wryly Brooks. From here it winds 5km west to the site through agricultural land. During this distance the brook drops approximately 10m in elevation. There is only one other significant tributary, that joins from the south 300m upstream of the site. There are a number of bridges over Saredon Brook before it reaches the site, but it does not appear to be culverted at any stage. Just before reaching the site, the brook splits into two sections of channel for approximately 200m.

In the vicinity of the site, the flowing brook is approximately 3m wide and varies between 0.2 - 0.6m deep. At the time of the site visit the water level in the brook was approximately 1m below the banks.

Flood warnings for Saredon Brook are available on the EA website (<http://www.environment-agency.gov.uk>) from Deepmore Farm (200m upstream of the site) to Coven where the brook is confluent with the Penk River. These are updated at 15 minute intervals. The last flood warnings for the brook were on the 15th and 25th of June, 2007.

2.2.4 Other Hydrological Features

As well as the Saredon Brook there are a number of man-made hydrological features within the surrounding area, as outlined below.

Staffordshire and Worcestershire Canal

The canal is located at its closest point 150m north of the site. In this area it runs east – west, although approximately 1km east of the site it splits in two, with the main canal running to the south and the now disused Hatherton Canal continuing east. At this junction there is also the Calf Heath marina.

The Staffordshire & Worcestershire Canal is 74km in length from the River Severn at Stourport Basins to the Trent and Mersey Canal at the Great Haywood Junction. It was constructed in 1772 and has 45 locks although there are none within 1km of the site.

Ponds

There is a series of man-made ponds located 500m to the west of the site, parallel to the railway line. Their use is unknown, but they lead via a channel back to Saredon Brook 550m downstream of the site.

In addition, there is a pond of approximately 50m x 30m located 250m east of the site, just west of the sewage works. There are no obvious inlets or outlets to the pond.

Drains

There are three land drainage systems within the vicinity of the site. The easternmost initiates from a spring 650m to the east, before running west and discharging into the Saredon Brook approximately 400m east of the site. This drain has one small tributary (only 20m in length) which is confluent approximately 500m east of site.

The second system arises from the farmland to the south and south east of the site and drains two areas of fields to the Saredon Brook through a network of small channels. None of these drains are large or carry significant flow.

The last drain is located approximately 150m south west of site and is only 20m in length. It is supplied by surface runoff from the Four Ashes Industrial Estate (as discussed below) and also discharges to the Saredon Brook.

Mains Supply

Currently, a 180mm feeder for mains supply runs along the south of Enterprise Drive, finishing where the tarmac ends approximately 100m west of site, at a similar elevation to the upper areas of the site. Another branch runs down Latherford Close to the west, and is a smaller 125mm pipe. This is down-gradient of the site.

Surface Water Drains and Sewers

The only surface water drainage system in the area follows a similar path to the mains supply, initiating 100m west of the site and flowing west down Enterprise Drive. However, on combining with flow coming from the opposite direction it turns down Aspley Close approximately 200m west of the site. A second section initiates in Latherford Close, 150m west of the site, and flows south then west, where it joins with the first section to discharge to Saredon Brook.

Foul Sewers

The foul sewers in the area run past (but not through) the sewage treatment works located 300m east of the site before a pressurised sewer runs up-gradient to approximately 200m from the north west corner of the site. From here they run down Enterprise Drive and Latherford Close (where there is a pumping station). This is the current situation; however, the proposed development located to the north of the site (which has been granted planning permission) will relocate the pressurised sewer to beneath a roadway constructed along the boundary fence between the two properties. The ground height above this sewer will be between 102 and 103m aOD.

2.3 Development Plans

The final design of the Energy from Waste plant has not yet been issued (see the current options in Figure 3). However, the two current options are fairly similar in



their floor plan, both resulting in approximately 80% of the site area being converted to impermeable surface (roofing or hardstanding). This would form an approximate oval in the centre of the site. The Finished Floor Levels (FFL) vary between 87m aOD for a bunker and up to 109m aOD for the Tipping Hall. It is presumed that the bunker, which is expected to be in the centre of the building, will be adequately protected from intrusion of groundwater.

Areas not utilized for the development would include the trees to the west and southwest of the site, the banks and drain to the south of the site, the northeast and southeast corners and the banks, drain and pond to the east. A fence is proposed to exclude all but the northeast and southeast corners, which would be landscaped.

3. EXTERNAL FLOOD SOURCES

Current guidance³ recommends that a Flood Risk Assessment should consider all possible sources of flooding for a given site. A large number of specific mechanisms exist; however, many of these can be easily discounted. Table 1 summarises a range of potential risks and the possibility that these may be relevant to this site.

Table 1 Summary of potential flood source

Flood Type	Source	Potential pathway	Consider further
Fluvial	Saredon Brook	Flows in excess of channel capacity	Yes
	Ponds and drains on site	Blockage and exceedance of channel/retention area	Yes
	Ponds and drains off site	None	No
Tidal	None	None	No
Drainage	Mains supplies	Pipe burst and overland flow	Yes
	Surface drains & sewers	Blockage and surcharge followed by overland flow	Yes
	Foul sewers	Blockage and surcharge followed by overland flow	Yes
Overland flow	None	None	No
Groundwater	Wildmoor Sandstone	High groundwater levels expressed at surface	No
	Underlying sands and gravels	High groundwater levels expressed at surface	Yes
Other / Artificial	Staffordshire and Worcestershire Canal	Blockage followed by overland flow	Yes
	Pond on site	None	No
	Pond 500m west of site	None	No

3.1 Risk Assessment

The risk assessment methodology used within this project is set out in Appendix 1 and is written based on guidance provided in PPS25. The guidance recommends that flood risk is assessed through consideration of both the magnitude of potential impacts and the probability of occurrence. The magnitude of impact is then dependent on two factors; these are the sensitivity of potential receptors and the

³ Planning Policy Statement 25: Development and Flood Risk, Department for Communities and Local Government, 2006

severity of the flooding. There are therefore three criteria on which flood risk is assessed. These are;

- Sensitivity of the receptor,
- Severity of flooding, and
- Probability of occurrence.

3.1.1 Sensitivity of Receptor

The proposed development is an industrial plant. Thus, under the sequential test defined within PPS25 the development would be classified as a '*less vulnerable development*'. Given this the sensitivity will be defined as **medium**. Those areas not being developed will be *water-compatible* and thus will have a **low** sensitivity.

Development in general has the potential to impact the flood risk posed to off site receptors. All off site development is considered to have a **very high** sensitivity to any increase in flood risk and therefore it is important that any adverse off site impacts to flood severity or frequency are avoided.

3.1.2 Severity and Probability of Flooding

The severity and probability of flooding are both fully defined within Appendix 1 and the classification of these criteria is discussed over the following sections.

3.2 Fluvial

Saredon Brook

The EA flood map (Figure 1) shows that the south western corner of the site is located within flood zone 3. This indicates that the annual risk of flooding to this area of the site from Saredon Brook is 1% or higher. The detailed topographic data provided for this assessment (Figure 4) indicates that the predicted flooding covers those areas below 98.5m aOD, which is up to 2.2m above the current river level. It is therefore considered that this zoning is probably accurate.

The proposed development design options exclude any areas below 100m aOD. They also provide fencing so that the flood risk area is not accessible for placing equipment or by personnel. Therefore, there is effectively a 3.7m difference in elevation between the normal river level and the development and a 1.5m difference between the maximum elevation of a 1-in-100 year flood event and the development.

In addition, whilst detailed topographic information for the opposite bank of the river is not available, the Ordnance Survey 1:25,000 map indicates that the ground is lower on the opposing bank, at approximately 99m aOD. This elevation continues for a significant distance over several fields. Thus, if floods exceeding the predicted 1:100 year event were to occur, flood waters would extend southwards onto the open lower land rather than onto the site.

Thus, while the probability of flooding from this source to the site is high, as long as the development design continues to exclude those areas below 100m aOD, it is considered that the probably of occurrence is very low. Any impacts on the site might be high, but on the development would also be very low and this conclusion

is not modified by allowing for possible climate change effects. The overall risk from the brook is therefore assessed as high to the site and very low to the development.

Drains and Ponds on Site

There are a number of small drains and ponds on site that have a medium possibility of becoming blocked and exceeding their channel or retention confines, particularly after a significant storm event. This could result in minor flooding of the area to the west of the site or around the eastern and southern borders. However, as the development area will be up-gradient of these water features it is considered that the impact of such flooding, if it were to occur, would be negligible and the overall risk would also be negligible.

3.3 Drainage & Mains Supply

Main Supply or Surface Water Drains/Sewers

A failure of one of the surface water drains/sewers or mains supply could potentially occur, for example due to very high system flows after a major storm event or a collapse within the system itself. There is a small possibility that such an event up-gradient of the site to the northwest could cause surface flooding. The position of the mains and sewers, however, is such that any such flood waters, if they were to occur, would not be likely to flow onto the site, but would flow directly south to the Saredon Brook.

Also, the mains supply and drainage systems around the site are not extensive and are not expected to convey significant rates of flow. In case of a system collapse the total volume of flood waters would not be large.

Whilst the likelihood of a flood event due to failure of the local drainage and main supply system cannot be easily quantified, it is conservatively assessed as of medium probability. The magnitude of impact should it occur is considered to be negligible, thus the overall flood risk is also negligible.

Foul Sewers

The location of the pressurised foul sewer directly up-gradient of the site, and the plans of the developers of the neighbouring industrial units to move it to very close to the site boundary, means that should a break down in the system occur, foul sewage could flow onto the site. However, as at this point the sewer is a relatively small 225mm pipe, it is unlikely to carry significant flow. Thus, should flooding occur it is not predicted to be above low magnitude. Again, the likelihood of such an event occurring is assessed as medium and so the overall risk is low.

3.4 Groundwater

The sands and gravels on site are underlain by low permeability glacial drift that is unlikely to transmit significant volumes of water. The site is on a gentle slope to the south and overlooks low lying land to the east and south. It is not at the base of any significant slope.

With consideration of these factors, it has been determined that the potential for flooding to occur from seepage is low. Should it occur, due to the small volume likely to be present, the impact would be very low and therefore so would the overall risk.

3.5 Artificial

The flood map does not consider man-made canals as they cut across catchments, do not usually have significant flow and do not generally flood as they can be managed through the use of locks. However, there is a possibility that vandalism, a blockage or structural failure of the Staffordshire and Worcestershire Canal could result in a build up of water and overland flow up and above the edge of the canal to the site.

However, the canal is not embanked, is located 150m north of the site on relatively level ground and is monitored and controlled by British Waterways (who can operate emergency sluices in the event of an accident). The probability of flooding from such an event reaching the site is considered to be very low, and the resulting impact, should it occur, is also considered to be very low. Combined, the overall risk of flooding from this source is very low.

3.6 Summary Table of Risks

The probability and severity of each type of flooding has been assessed in line with the methodology and guidance set out in Appendix 1. This is then combined with the assessment of receptor sensitivity to define the level of flood risk on a scale ranging from negligible to high. These are outlined in Table 2.

Typically risks assessed to be low or less are acceptable whereas risks assessed to be moderate or high require additional mitigation or management to enable development to proceed. All the risks to the development, based on the two development options provided, are assessed as being either low or very low. Thus, no further mitigation or management is required in respect of flood risk. However, as there is a low risk of flooding from foul sewers up-gradient of the site, it is recommended that Finished Floor Levels (FFLs) be at least 0.3m above the surrounding ground level, as is currently proposed in the design for the plant.

Table 2 Flood Risk summary table

Flood Source		Pathway	Receptor	Sensitivity	Severity of impact	Probability of impact*	Flood Risk
Fluvial	Saredon Brook	Flows in excess of channel capacity	Site	Low	High	High	High
		Flows in excess of channel capacity	Development	Moderate	Very low	Very low	Very low
	Pond and drains on site	Blockage and exceedance of channel/retention area	Development	Moderate	Negligible	Medium	Negligible
Drainage	Mains water	Pipe burst and overland flow	Development	Moderate	Negligible	Medium	Negligible
	Surface drains & sewers	Blockage and surcharge followed by overland flow	Development	Moderate	Negligible	Medium	Negligible
	Foul sewers	Blockage and surcharge followed by overland flow	Development	Moderate	Low	Medium	Low
Groundwater	Underlying sands and gravels	High groundwater levels expressed at surface	Development	Moderate	Very Low	Very Low	Very Low
Artificial Sources	Staffordshire and Worcestershire Canal	Blockage followed by overland flow	Development	Moderate	Very Low	Very Low	Very Low

* During life time of development

4. INTERNAL FLOOD SOURCES

Flood risk in any area is controlled by a number of contributing factors throughout the catchment. At the local scale, when developing or re-developing a site, it is usual to acknowledge the part that this will play in contributing, or potentially alleviating, flood risk to the immediate surrounding area.

4.1 Design Standards

The EA's standing policy for site redevelopments is that runoff from a site should not be increased and that a decrease of site runoff towards greenfield levels is desirable. Where possible, this should be done using **Sustainable Drainage Systems (SuDS)**.

Discussions with the EA concluded that the site drainage systems should be designed based on a 1% annual probability design event. In addition to this, potential increases in storm severity associated with climate change need to be considered (20% increase in rainfall depths).

Also, the EA proposed that if water is to be discharged, peak flow discharge rates should not exceed greenfield rates (as calculated in Appendix 2). Any water in excess of this will need to be infiltrated to the ground or stored on site and released slowly over time.

4.2 Storm Water Management Principles

Site drainage systems should be developed based on sustainable drainage principles as laid out in a number of guidance documents including PPS25.

4.2.1 Site Discharge

An order of preference exists for drainage receptors. Infiltration drainage should be used where possible. Where this is not possible, or does not provide sufficient capacity, attenuated discharge to watercourses should be sought. Only where neither of these two options is available should discharge to sewers be considered.

At this site infiltration may be feasible as previous infiltration testing undertaken directly to the north of the site determined that an infiltration rate of 7.57×10^{-6} metres per second (m/s) could be used, provided that the soakaways were positioned just above groundwater level, which would allow for drainage within the sands and gravels below this level. This testing was conducted as part of the design of a stormwater system for a similar-sized development that has been approved by South Staffordshire District Council and the EA.

However, the report also indicated that the area was used as the sediment lagoons for the sand and gravel extraction, so the superficial deposits may vary from those on the current site. Therefore, it is strongly recommended that site-specific and seasonally appropriate testing be undertaken to confirm the possibility of infiltration. If it is shown not to be possible, it is recommended that attenuation followed by discharge to Saredon Brook would be the next best option. It may be that a combination of the two could be developed.

4.2.2 Sustainable Drainage System

A **Sustainable Drainage System** aims to mimic natural systems whereby water is held close to the source, then released slowly over time. This acts to both reduce peak discharge and to promote the settlement of sediment thereby improving the water quality of any resulting discharge.

Whilst the provision of SuDS within development sites is not as yet a statutory requirement in England its inclusion is strongly recommended in all recent guidance documents. The failure to include such features within the development is also likely to result in the EA objecting to the development on the grounds that flood risk has not been adequately addressed.

Two broad categories of sustainable drainage techniques exist. These are those that discharge to the ground and those that discharge to a surface receptor such as a stream or sewer.

Infiltration

Discharge to the ground, or infiltration, is currently believed to be the preferred drainage solution for this site; however the effectiveness of infiltration is dependent on the ground conditions. Whilst in general terms it is understood that the geological deposits that underlie the site would be suitable for infiltration, site specific conditions may still prevent this. Potential obstacles include:

- ◆ Local variations in permeability preventing infiltration.

It is strongly recommended that infiltration testing at the site is undertaken at the earliest appropriate opportunity to determine the practical viability of infiltrating storm water to the ground. This testing should be undertaken in line with the guidance contained in BRE 365 or CIRIA R156 and the results used to firstly check feasibility and secondly to size the necessary infiltration features.

- ◆ Presence of leachable contamination at the site

Where ground contamination exists, the use of infiltration techniques can promote the leaching of contaminants into the aquifer beneath the site. This should be avoided wherever possible and therefore in such circumstances infiltration is not recommended. As the previous use of the site (sand and gravel extraction) is not considered to be contaminative and the site was backfilled with inert material, it is unlikely that the site has significant contamination. However, as the site is located within an outer groundwater protection zone, an intrusive investigation should be undertaken to confirm this.

- ◆ Source protection zones

As discussed in Section 2.1.5 and above, the site is located in the outer source protection zone of a groundwater public water supply located approximately 1.2km to the southwest. Due to the potential for surface contamination to impact the abstracted water it is required that if water from roads or parking surfaces are to be infiltrated, this water should first be directed via an oil interceptor.

Should these obstacles be overcome, there are a number of different infiltration methods that could be used. The different areas of the site, including the roadways and parking, the smaller buildings (e.g. substation and gatehouse) and the main plant building, could each use different systems, or could be combined into one system. This depends on the expected volume of runoff from each area during a

design event, which can be calculated once the design for the development is finalised, and the area(s) available for infiltration systems can be determined. It is worth noting that SuDS guidance recommends that runoff is dealt with as close to the source as possible.

Some methods which could be used close to sources of runoff on the site include:

- ◆ Filter strips - These are wide, gently sloping areas of grass or other dense vegetation that treat runoff from adjacent impermeable areas such as the on-site road and parking areas.
- ◆ Pervious surfaces - Porous surfaces or slabs/brick etc laid so that void space is provided between them to allow rainwater to infiltrate through the surface into an underlying storage layer, where water is stored before infiltration to the ground, used, or released to surface water. These could be incorporated under on-site roadways and parking areas.
- ◆ Swales – Composed of broad, shallow channels covered by grass or other suitable vegetation, swales are designed to convey and/or store runoff. They are not generally suitable for large volumes or flows so could be used for the runoff from the smaller buildings located around the central plant.

As the roof space of the proposed development is of a relatively large area, the appropriate method will probably involve conveyance to a retention/attenuation facility with infiltration capabilities. This could include one of the following designs:

- ◆ Filter drains and perforated pipes - Surface water from the edge of paved areas flows into trenches (which contain a permeable material such as gravel), is filtered and conveyed to other parts of the site. A slotted or perforated pipe may be built into the base of the trench to collect and convey the water. These could be used to transport runoff from one area of the site to another, if required.
- ◆ Infiltration basins - These are depressions that are designed to store runoff and infiltrate the water to the ground. They may also be landscaped to provide aesthetic and amenity value and could be included in the areas to the northeast and southeast of the site.
- ◆ Extended detention basins - Extended detention basins are normally dry, though they may have small permanent pools at the inlet and outlet. They are designed to detain a certain volume of runoff as well as providing water quality treatment.
- ◆ Wet ponds – Similar to an infiltration basin, but with a permanent pool of water for water quality treatment. They provide temporary storage for additional storm runoff above the permanent water level and may provide amenity and wildlife benefits.
- ◆ Soakaways – Gravel or geocellular / modular systems which can have a high void ratio and allow for significant storage.

It should be noted that the proposed development to the north of the site will have five soakaways. These have been designed to contain rubble of between 40-60mm (providing a void ratio of 0.3). They are proposed to be formed of pre-cast concrete rings or geo-cellular material.

It is worth bearing in mind that, as with surface features, these devices require occasional maintenance for continued effective infiltration and management arrangements should be considered prior to development.



Attenuation

If infiltration techniques prove not to be suitable at this site then attenuation storage of some kind should be used to achieve the requisite run-off rates. This method involves restricting site runoff to an agreed limit (normally those assigned to greenfield) and then storing any excess storm water on the site.

The way this water is stored and attenuated can vary depending on the context and nature of the development being proposed. The EA would however normally request that surface storage systems should be used as alternative 'tanked' systems are not considered sustainable. Potentially appropriate features for attenuating the runoff might include:

- ◆ Ponds – Designed correctly these can be habitats for many species as well as an attractive storage area. They should have waterside vegetation to discourage entry and gradual edges to allow ease of egress;
- ◆ Wetland areas – A system of small vegetated ponds through which water moves slowly. These will also provide some filtering effects if necessary; and
- ◆ Swales or soakaways – As above.

The best locations for these systems would be the areas of open landscaped ground proposed for the north east and south eastern corners of the site. Following attenuation, runoff could be directed to the Saredon Brook, possibly via the drainage channel flowing along the east and south of the site.

If it is assumed that no infiltration is possible and that 80% of the site is developed with impermeable surfaces, calculations (Appendix 3) indicate that 2663m³ of storm water would need to be stored within such features if uncontrolled flooding were to be prevented, i.e. that water from the site were to be released at a greenfield rate (14.4l/s).



5. CONCLUSIONS AND RECOMMENDATIONS

Following the completion of this Flood Risk Assessment, in line with the recommendations of PPS25, the following conclusions have been made:

1. The EA flood map indicates that a small area in the south west of the site is located in flood zone 3, whereas the rest of the site is within flood zone 1. Topographic information confirms this zoning is probably correct.
2. Whilst the site boundary includes the flood zone 3 area, this is excluded from the development plans. As such under the sequential test industrial development on the site is appropriate.
3. Consideration of smaller flood sources, not shown on the EA flood map, identifies the Staffordshire and Worcestershire Canal, ponds and drains, water mains and sewers. An assessment of these sources, potential pathways and impacts indicates that the risk from these sources is low or below.
4. It is recommended that any alterations to the proposed design continue to exclude those areas identified as at risk from flooding from Saredon Brook and maintain Finished Floor Levels (FFL) of at least 0.3m above the surrounding area.
5. Given the physical environment at the site it is strongly recommended that site specific infiltration testing be undertaken to determine if runoff from the development can be infiltrated on site.
6. Should infiltration be possible on site, a number of SuDS methods could be used, particularly in the northeast and southeast of the site.
7. If infiltration drainage is not possible, site flows could be attenuated to greenfield rates and discharged to Saredon Brook to the south of the site subject to relevant approvals.
8. Runoff from roads and parking areas should only be discharged to the ground after passing through an oil interceptor.



FIGURES



Figure 1 Site location map



Figure 2 Environment Agency flood map



Figure 3 Proposed development options



Figure 4 Topographic data

1. FLOOD RISK ASSESSMENT METHODOLOGY

It is recommended by both the Environment Agency (EA) and DEFRA that the primary assessment tool within a flood risk assessment should be the sequential test as set out in Tables D1 and D2 of the draft version of PPS25: Development and Flood Risk. Such an assessment however, deals almost exclusively with the risks associated with tidal and fluvial sources and not the full range of flooding sources identified in Annex C of PPS25. In addition to this, the sequential test does not provide guidance for assessing the impact of mitigation and residual risk subsequent to development, as required by Annex G of PPS25.

Therefore in order to allow for the wider assessment of flood risk this more generalised assessment methodology has been developed. It should be noted that where applied to fluvial and tidal sources the results of the assessment should be cross checked against the results of the sequential test.

Assessment Methodology

In line with guidance set out in the draft version of PPS25: Development and Flood Risk, the key to the classification is that the designation of significance (or risk) is based upon the consideration of:

- ◆ The sensitivity of the receptor – takes into account the nature of the development or receptor and its likely response to increased risk.
- ◆ The magnitude of the potential hazard (i.e. severity) – takes into account the potential severity and nature of the flooding.
- ◆ The probability of occurrence (i.e. likelihood) – takes into account both the presence of the hazard and receptor, and the integrity of the pathway.

Classification of Sensitivity of the Receptor

When considering new developments, the classification of sensitivity is based (where possible) directly on the sequential test as set out within Table D2 of the draft version of PPS25. When considering off site impacts there is a general assumption that all developments are highly sensitive. This assumption can however typically be relaxed when considering 'Water Compatible' development or undeveloped land. Given this the Sensitivity of the receptor is ranked as shown in Table 1.

Table 3 Classification of sensitivity of receptor

<i>Sensitivity of receptor</i>	<i>New Development</i>	<i>Off site</i>
Very High	<i>Highly Vulnerable*</i> developments (e.g. emergency services, retirement housing)	All built developments unless mitigating circumstances exist. Key access routes
High	<i>More Vulnerable*</i> developments	Other access routes
Medium	<i>Less Vulnerable*</i> developments	Undeveloped Land

Low	<i>Water Compatible*</i> developments	-
Very Low	Flood attenuation features	-

* For definition of italicised terms please see Table D2 of PPS25

Classification of Magnitude of Potential Effect

To classify the magnitude of the potential effects it is necessary to look at the nature and scale of the individual impacts. These include, but are not confined to, the extent of flooding, the depth of flooding, the duration of flooding and the velocity of flood waters. For new developments the assessment is based on the likely post development situation, for off site receptors it is based solely on the likely deterioration resulting from the development.

Given this the magnitude of the potential effect is then ranked as shown below in Table 2.

Table 4 Classification of Magnitude of Potential Hazard

Magnitude of Hazard	New Development	Off site
High	Any one of the following criteria achieved: <ul style="list-style-type: none"> • flood depths greater than 1m, • flood flow velocities greater than 0.45m/s • likely flood duration in excess of 24 hours 	Any marked (>10%) increase in flood depth, flood flow velocity or flood duration. Any change in flood extent that impacts additional properties including access
Medium	Any one of the following criteria achieved: <ul style="list-style-type: none"> • flood depths between 0.3m and 1m, • flood flow velocity greater than 0.15m/s • likely flood duration in excess of one hour • Any restrictions to access and egress 	Any other measurable increase of flood depths, durations, flow velocities or extent.
Low	All of the following criteria achieved: <ul style="list-style-type: none"> • flood depths below 0.3m, • likely flood duration below one hour • flood proofing measures planned 	Likely, but unquantifiable small increases of flood depths, durations, flow velocities or extent
Very Low	Planned or permitted flooding that does not adversely impact the built development	-
Negligible	No potential for flooding, or no	No likely increase in flood severity

	identifiable impact of flooding	at any off site location
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Magnitude of Potential Effect

The magnitude of the hazard and the sensitivity of the receptor are combined using a matrix (shown below – Table 3) to determine the magnitude of the potential effect.

Table 5 Matrix for determining the Magnitude of the potential effect

		Sensitivity of Receptor				
		Very Low	Low	Medium	High	Very High
Magnitude of Potential Hazard	High	Low	Moderate	Moderate	High	High
	Medium	Very Low	Low	Moderate	Moderate	High
	Low	Very Low	Very Low	Low	Moderate	Moderate
	Very Low	Negligible	Very Low	Very Low	Low	Low
	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

Classification of Probability of Occurrence

To classify the probability of occurrence for a potential effect it is necessary to understand how regularly a given event or outcome will occur. This can be assessed in a number of ways including assessments based on historical data, quantitative analysis, or experience from other similar sites. Often this assessment will be based on standard guidance. The magnitude of the potential effect is then ranked as shown below in Table 6.

Table 6 Classification of Probability of Occurrence

Probability of Occurrence	Potential effect
High	Any consequence would appear likely in the medium term and inevitable in the long term (Life time of the development).
	Equivalent to an annual probability of flooding of greater than 1% (0.5% for tidal) or <i>Flood Zone 3*</i> .
Medium	Circumstances are such that an event is possible in the medium term and likely over the long term, although not necessarily inevitable.
	Equivalent to an annual probability between 0.1 and 1% (0.1 and 0.5% for tidal) or <i>Flood Zone 2*</i> .
Low	It is unlikely that any consequence would arise within the lifetime of the development.
	Equivalent to an annual probability of less than 0.1% or <i>Flood Zone 1*</i> .
Very Low	It is unlikely that any consequence will ever arise.

* For definition of italicised terms please see Table D1 of PPS25

It should be noted that in circumstances where sites are defended, determining an accurate assessment of probability of flood occurrence is complex and assumptions that

defences will not fail are unlikely to be acceptable. In such cases assessments cannot be prescriptive and site specific assessments should be undertaken. Factors that should be considered include construction, age, condition, maintenance, exposure and other external pressures.

Risk Assessment

Once the magnitude of the potential effect and likelihood of occurrence have been assessed these are then combined using a risk matrix (Table 5) to assess the flood risk of each potential effect.

Table 7 Risk Matrix

		Likelihood of Occurrence			
		Very Low	Low	Medium	High
Magnitude of Potential Effect	High	Low	Moderate	High	High
	Moderate	Low	Low	Moderate	High
	Low	Very Low	Low	Low	Moderate
	Very Low	Negligible	Very Low	Low	Low
	Negligible	Negligible	Negligible	Negligible	Negligible

Typically flood risks assessed as low, or less are considered acceptable. If the assessment results in moderate or high risk, additional mitigation measures will be required to facilitate development.

In some situations the risk assessment procedure will result in an artificially low assessment of risk. This is particularly the case in situations where consequences of very rare flooding (i.e. breach scenarios) are so extreme that any residual risk, however low, should not be allowed. In such instances the assessed risk should be elevated. Such decisions must always be accompanied by detailed justification.



2. GREENFIELD RUNOFF CALCULATION SHEET

Calculation Sheet (MAFF 1982, IH 1994)

Catchment Area (A) =	4.4	ha
Maximum Length of Catchment (L) =	200	m
Average Slope of Catchment (S) = $\left(S = \frac{\text{height}}{L} \right)$	0.02	
Annual Average Rainfall (AAR) =	679	mm

ADAS 345 (not advised for catchments > 30ha)

Catchment Characteristic (C) = $\left(C = 0.0001 \frac{L}{S} \right)$	1.33	
Dominant Crop Type =	grass	
Soil Type Factor (ST) =	0.5	
F Number = (Using graph, C, crop type and AAR)	4.76	
Peak Flow = $Q = S_T \times F$	2.4	l/s/ha
Peak Site Flow = $Q_s = Q \times A$	10.5	l/s
1 in 100 year Storm Event Peak Site Flow = $Q_s \times 2.57 =$	26.9	l/s

Institute of Hydrology Report 124 (not advised for catchments < 50ha)

Soil Index (SOIL, from FSR) =	0.4	
Peak Site Flow = $Q_s = 0.0108 \text{AREA}^{0.89} \text{SAAR}^{1.17} \text{SOIL}^{2.17}$	14.4	l/s

Where the catchment area is less than 50ha, the area (AREA) is set at 50ha then the resultant runoff is scaled by the ratio of the actual site area and 50ha.

1 in 100 year Storm Event Peak Site Flow = $Q_s \times 2.57 =$	37.1	l/s
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**3. POST DEVELOPMENT RUNOFF AND ATTENUATION
CALCULATION SHEETS**



Post-Development Modified Rational Method Calculation Sheet

Site Area (A) =	4.4	ha
Maximum Altitude =	103	m aOD
Minimum Altitude =	100	m aOD
Maximum flow path (L) =	200	m

These site descriptors can be used to calculate the time taken for water to travel from the furthest most point to the site outfall. After this period of time, known as the time of concentration, the entire site is contributing to site runoff. Maximum flow off the site should coincide with this.

This length of time can be calculated using the Bransby Williams formula shown below

$$T_c = \frac{58.5 L}{A^{0.1} S^{0.2}}$$

Time of Concentration (T_c) = 9.3 minutes

The depth of rainfall that will fall within this, and any other, period of time can be estimated using Depth Duration Frequency (DDF) modelling as outlined in the Flood Estimation Handbook (IH, 1999). A series of descriptors are available on a one kilometre grid across the UK on the FEH CD ROM. These are used to obtain a rainfall depth, which can then be easily converted to intensity.

Rainfall Intensity (I) = 211.0 mm/hr during the 9.3 minute, 100 year storm

This rainfall intensity is converted to a flow off the site using the Wallingford procedure (1981). A number of further descriptors that can be defined on either a regional, local or site level, are required. These are:

UCWI (Urban Catchment Wetness Index)	66	(non dimensional)
SOIL (Related to site permeability)	0.4	(non dimensional)
PIMP (Percentage of IMPervious Area)	80	%

These descriptors are used to calculate the percentage runoff (PR) from the site as follows.

$$PR = 0.829 PIMP + 25 SOIL + 0.078 UCWI - 20.7$$

Therefore;

Percentage Runoff (PR) = 60.8 %

Given this site runoff can be estimated using the following formula

$$Q = 2.78 C_v C_t I A$$

Where:

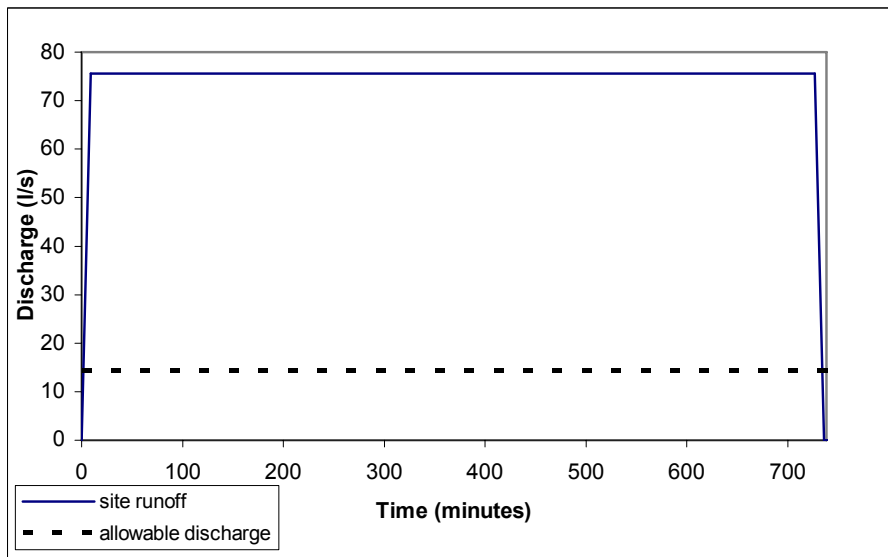
C_v (a routing coefficient) = 1.3, and

C_t = PR/100

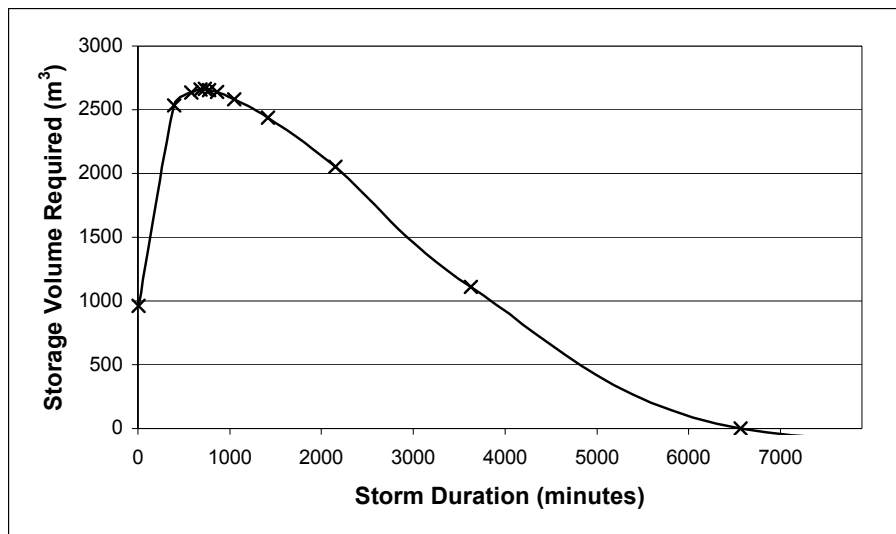
Given the above peak flow from the site is estimated at **2.129 m³/s**

Storage Requirement Estimation, Calculation Sheet

During intense rainfall events the volume of water arriving at the site outfall will exceed the rate at which it is either possible or allowable to discharge it. In this situation on site storage is required to prevent flooding. For very short events, whilst peak flows are often very high, total volumes are relatively low due to the short time period. For very long events the outflow will be similar to or exceed the flow generated by the site, so again required storage volumes will not be large. Between these two extremes are a series of events where significant storage is required. A range of events must be considered to ensure that the design event is captured.



The graph above plots both the water arriving at the site outflow and the maximum allowable discharge. The area above this second line (dashed) corresponds to the required storage. This area has been calculated for a range of storm durations and the required storages obtained are plotted against storm duration below.



This indicates that the design storm for storage is the 727 minute 100 year storm. To prevent flooding during this event 2663 m³ of storage would be required.