

BAE Systems

BAE Waterlooville

Flood Risk Assessment

Project Ref: 26365/002

Doc Ref: V3

June 2012

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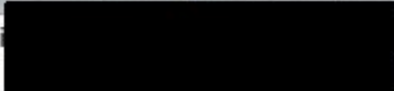
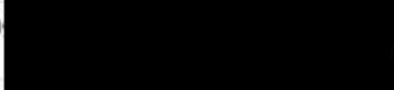
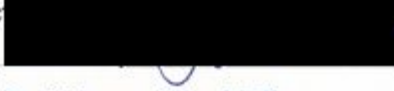


BAE Waterlooville
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Contents

1	Executive Summary.....	1
2	Introduction.....	2
3	Proposed Development Site.....	2
3.1	Site Location.....	2
3.2	Proposals.....	2
3.3	Vulnerability	3
3.4	Existing Site Levels.....	3
3.5	Existing Site Surface Water Drainage and Watercourses.....	3
3.6	Flooding History.....	3
4	Assessment of Flood Risk.....	5
4.1	Strategic Flood Risk Assessment.....	5
4.2	Flood Zone.....	5
4.3	The Sequential Test.....	6
4.4	The Exception Test.....	6
4.5	Mitigation Measures.....	6
4.6	Surface Water Management.....	7
4.7	Residual Risk.....	8
4.8	Emergency Access & Egress	9
5	Conclusions	9

Appendices

Appendix A: Figures
Appendix B: Flood Alleviation Capacity Checks
Appendix C: Proposed Storage Calculations

1 Executive Summary

- 1.1. BAE Systems is seeking planning permission to redevelop part of the BAE Systems Technology Park at Elettra Avenue, Waterlooville. In its current form the site comprises offices buildings and a staff restaurant in the eastern half of the site with car parking to the west. The proposals are for Class B uses, a 60-bedroom hotel, a car showroom and two restaurants (one with drive-in facility).
- 1.2. The site lies within Flood Zone 1, the zone of least probability, according to the Environment Agency flood maps. There is a 1800mm diameter public surface water sewer crossing the site from north-east to south-west. The sewer discharges into a short section of open watercourse within the site curtilage and this is classed as 'Main River'. There are twin 1200mm diameter culverts beneath Silverthorne Way and Tyak House to the south before the watercourse flows through an open channel away to the west. The watercourse becomes the River Wallington.
- 1.3. Flooding of the car park in the south-west area of the site occurred following heavy rainfall events in September 1999 and October 2001. Investigations into the causes of flooding revealed that the combined capacity of the 1200mm culverts is less than the upstream 1800mm culvert by up to 3 cumecs.
- 1.4. In 2003, with the approval of the Environment Agency and Southern Water, BAE constructed a flood alleviation scheme to cater for the shortfall in capacity in the twin 1200mm culverts. The scheme comprised a collector drain in the south-west corner of the car park discharging into a 1050mm diameter culvert beneath Elettra Avenue with a new outfall into Southern Water's attenuation pond immediately to the west. The scheme made use of the existing car park surface as an overland flow route. No repeat flooding has been reported since completion of the scheme.
- 1.5. It is proposed as part of the redevelopment to redefine the overflow flood route within a new swale constructed between the open section of watercourse and the existing collector drain. The swale will have a capacity no less than 3 cumecs so as to contain overflows within the defined channel.
- 1.6. The existing site surface water drainage systems discharge into the public surface water sewer network within Silverthorne Way at the south of the site. It is proposed to retain these existing connections to serve the redeveloped site.
- 1.7. The proposals do not increase the area of impermeable surfacing at the site. Therefore, there will be no increase in volume of runoff and no change is required to the existing attenuation provided by the Southern Water pond for rainfall events up to the 30-year return period. Discharges will be limited to the existing 30-year rates for rainfall events above this up to the 100-year return period including a 20% allowance for climate change. Storage to cater for this will be provided in the form of permeable pavements within parking areas.

2 Introduction

- 2.1. Government policy with respect to development in flood risk areas is contained within the National Planning Policy Framework (NPPF) and the Technical Guidance to the NPPF, both published in March 2012 by the Department for Communities and Local Government (DCLG).
- 2.2. The NPPF and the Technical Guidance replace Planning Policy Statement 25 (PPS25) 'Development and Flood Risk' along with the PPS25 Practice Guide. However, the Technical Guidance to the NPPF retains key elements of PPS25 as *"an interim measure pending a wider review of guidance to support planning policy"*.
- 2.3. The Local Planning Authority will make decisions with regard to any planning application within any floodplain or flood risk area, although the Environment Agency (EA) is a designated statutory consultee and plays a key role in providing advice on development and flood risk issues.
- 2.4. Peter Brett Associates LLP (PBA) has prepared this study in accordance with the NPPF and the Technical Guidance. PBA has many years of experience in, amongst other areas, the assessment of flood risk, hydrology, flood defence and river engineering.
- 2.5. PBA has been one of the EA's National Framework Consultants for flood risk mapping, a Term Consultant to the South West Region of the Agency and continues to provide engineering services through the NEECA2 Framework Agreement. PBA has been involved in the assessment of both tidal and fluvial flooding and the design and implementation of flood defences on behalf of the Agency as well as undertaking numerous Flood Risk Assessments to support planning application submissions.

3 Proposed Development Site

3.1 Site Location

- 3.1.1. The BAE Systems Technology Park is located at Elettra Avenue within the Brambles Farm Industrial Estate on the western edge of Waterlooville. The Park is surrounded by Elettra Avenue to the north and west, Silverthorne Way to the south and the B2150 Hambledon Road to the east. The whole complex covers 5.6 hectares (ha); however, the site red line boundary encompasses only 4.4 ha.
- 3.1.2. The site currently comprises office buildings and a restaurant building in the eastern half while the western half of the site comprises car parking. There is a short section of open watercourse within the site boundary in the southern part of the site. This watercourse is discussed later in this report.
- 3.1.3. A location plan is included in Appendix A.

3.2 Proposals

- 3.2.1. BAE Systems is seeking outline planning permission to redevelop the site with the following mix of uses:
 - Buildings for Class B uses in the western part of the site (around 8,500m² of floor area).
 - A 60-bedroom hotel at the east of the site.

- A restaurant in the south-east of the site.
- A restaurant with drive-through facility in the north-east of the development.
- A car showroom and forecourt to the east of the access from Elettra Avenue from the north.
- Associated access and parking provisions.

3.2.2. The proposed Masterplan is included in Appendix A.

3.3 Vulnerability

3.3.1. The Technical Guidance to the NPPF, Table 2, provides classifications of flood risk vulnerability. The proposed land uses are classified as follows:

- **More Vulnerable:** Buildings used for hotels.
- **Less Vulnerable:** Buildings used for restaurants, offices and general industry.

3.3.2. From these classifications, it is evident that the vulnerability of the development increases from the existing situation due to the introduction of the hotel building.

3.4 Existing Site Levels

3.4.1. The land falls very gently at around 1 in 75 towards the south-west. Levels alongside Hambledon Road are around 38m AOD falling to 34m AOD in the south-west corner.

3.4.2. Topographical survey information is included in Appendix A.

3.5 Existing Site Surface Water Drainage and Watercourses

3.5.1. The Technology Park is served by a private gravity drainage system comprising gravel strip drains, gullies, linear channel drains and sewers. There are three separate outfall connections into the public surface water sewer network within Silverthorne Way to the south. The public sewers discharge into an attenuation pond on the opposite side of Elettra Avenue south-west of the site. The pond is owned and operated by Southern Water and has a pumped outfall into the adjacent watercourse, a tributary of the River Wallington.

3.5.2. A large 1800mm diameter public surface water sewer crosses through the site from north-east to south-west. This pipe issues into the short length of open channel within the site before being culverted beneath Silverthorne Way and Tyak House to the south within twin 1200mm diameter pipes. These culverts issue into open channel again to the west of Tyak House and the watercourse continues west past the Southern Water attenuation pond and onwards across open country.

3.5.3. No part of the site drainage network connects into the culverted watercourse.

3.5.4. The watercourse is classed as a public sewer as far as the downstream end of the 1800mm diameter culvert. From this point onwards, the watercourse is designated by the Environment Agency as a Main River.

3.6 Flooding History

3.6.1. The urbanisation of the upstream area in Waterlooville led to the incorporation of smaller watercourses into the sewerage infrastructure. The route of the 1800mm sewer was

originally the tributary of the River Wallington which was culverted when the Technology Park was constructed in around 1984.

- 3.6.2. The culvert issues into a man-made channel around 8m inside the site's downstream boundary. The construction of Silverthorne Way and, later, Tyak House just to the south led to a further length of the watercourse being culverted within twin 1200mm diameter pipes.
- 3.6.3. Flooding of the car park in the south-west area of the site occurred following heavy rainfall events in September 1999 and again in October 2001. BAE Systems commissioned a consultant to investigate the cause of these incidents. The investigation concluded that the flooding was caused by two problems concurrently.
- 3.6.4. Firstly, the number of grilles on the culvert inlets and outlets as well as inadequate maintenance had led to blockage. One of the upstream manholes within the site blew its cover on one occasion with some damage to paving surfaces locally. Secondly, the capacity of the twin 1200mm diameter culverts (calculated to be 4 cumecs) is less than that of the 1800mm diameter culvert directly upstream (calculated to be 7 cumecs).
- 3.6.5. The combination of these causes led to the open channel overflowing its banks and flooding the south-western corner of the car park to a depth of around 300 to 500mm. Many parked vehicles in this area were written off.
- 3.6.6. Lengthy dialogue took place between BAE Systems, Southern Water and the Environment Agency in order to seek remedial works. A programme of short-term and long-term improvements were made as follows:
- Manholes fitted with sealed covers.
 - Grilles on outlets removed.
 - Improved maintenance and inspection regime established on site.
 - An alarm fitted by BAE Systems to the open channel within the site to provide early warning of high water level.
 - A flood alleviation scheme constructed in 2003 by BAE Systems at its own expense.
- 3.6.7. The 2003 scheme was designed to compensate for the lack of capacity in the twin 1200mm diameter culverts and comprised the following elements:
- A new bunded surround to the open channel to direct overflow water west along the car park.
 - An area of the car park to serve passively as an overland flow route.
 - A large collector drain at the western end of the car park.
 - A 1050mm diameter culvert to convey flows directly into the Southern Water attenuation pond.
- 3.6.8. Since implementing these improvements, no similar flooding has been experienced at the site. However, on 30th November 2003, very soon after the above scheme was completed, intense rainfall combined with pump failure caused the attenuation pond to fill up. The capacity of the pond overflow weir may also have been impaired by debris. The reduced storage and outflow from the pond resulted in the local drainage systems backing up and causing localised flooding. Some flooding occurred in BAE's car park and neighbouring

premises to the south were affected. Southern Water subsequently installed telemetry and improved the maintenance regime to prevent re-occurrence.

- 3.6.9. According to Havant Borough Council's (HBC) website, an area of concern within the Wallington Catchment is at Aston Road which is beyond Hambledon Road to the east of the site. There is some historic spring activity which was particularly evident when the new Wellington Retail Park was built in 2000.

4 Assessment of Flood Risk

4.1 Strategic Flood Risk Assessment

- 4.1.1. The Partnership for Urban South Hampshire (PUSH) commissioned a Strategic Flood Risk Assessment (SFRA) Final Report in December 2007. The report and map sets are available to view online at <http://maps.hants.gov.uk/push/Map.aspx>.

- 4.1.2. The SFRA maps show the following information:

- The site lies entirely within Flood Zone 1 (as defined by the Technical Guidance to the NPPF, Table 1).
- Flood Zones associated with the tributary of the Wallington are shown beginning downstream of Tyak House to the south of the site.
- The flood extent does not reach the site when climate change allowances are added.
- The site lies within an area of low bedrock permeability.
- The site lies within an area where land use change is deemed to have a low impact on surface water runoff.
- In common with the whole urban area, the site is mapped as being a high or very high source of potential overland flow.
- Southern Water holds no records of observed sewer flooding in the vicinity of the site.

4.2 Flood Zone

- 4.2.1. In accord with the SFRA mapping, the Environment Agency's flood maps show the site to lie entirely within Flood Zone 1 as defined by the Technical Guidance to the NPPF, Table 1. Flood Zones 2 and 3 are present on land on the far side of Elettra Avenue and Silverthorne Way.
- 4.2.2. Flow in the open channel of the tributary will be governed by the capacity of the upstream culvert. It is therefore unlikely that the watercourse beyond Tyak House will overflow its banks.
- 4.2.3. Although not mapped, the historic flooding problem associated with the lack of capacity in the twin 1200mm diameter culverts actually demonstrates that the south-western end of the site is in a flood risk area. A plan illustrating the estimated extent of the affected area is included in Appendix A.

4.3 The Sequential Test

- 4.3.1. The site is designated as Flood Zone 1 and according to the Technical Guidance to the NPPF, Table 3, all forms of development are compatible with this Zone. The requirements of the Sequential Test have therefore been met.
- 4.3.2. No buildings will be located within the flood risk area associated with the south-west corner of the site and only buildings classed as 'Less vulnerable' will be located in the vicinity. Land in the corner will be reserved for roads, parking and landscaping. The hotel, as 'More vulnerable' development is to be located at the eastern end of the site on higher ground.
- 4.3.3. The proposed development is therefore in accord with the sequential approach set out in the NPPF and the Technical Guidance.

4.4 The Exception Test

- 4.4.1. The Exception Test is not required for development within Flood Zone 1. The mitigation required in the south-west corner of the site is discussed in the following section.

4.5 Mitigation Measures

- 4.5.1. The scheme constructed in 2003 to convey surcharge flows to the attenuation pond utilises the car park surface as a flow path. In such an event, flooding likely occurs in shallow depths across a moderately wide portion of the car park at this end of the site. With no further mitigation, this land would effectively be 'sterilised' as part of the redevelopment proposals.
- 4.5.2. It is proposed to formalise the flow route within a new swale constructed between the open watercourse and the existing collector drain at the western boundary of the site. The swale would be formed at a profile and gradient so as to accommodate the overflow design capacity of 3 cumecs established as part of the 2003 scheme.
- 4.5.3. A check has been made using pipe tables to verify capacities of the existing culverts. The calculations and methodology, included in Appendix B, indicate the lack of capacity in the twin 1200mm culverts to be less than 3 cumecs. Therefore, the proposed swale will sensibly include some spare capacity.
- 4.5.4. The 2003 scheme included the raising of ground levels around the open channel of the watercourse with the low point formed by a dropped kerb to direct overflow water to the west along the car park. This will be formalised as a 'weir inlet' to collect flows into the new swale.
- 4.5.5. The design levels of the swale will need to be balanced against existing constraints such as the presence of underground pipes and services along the route as well as the proximity of the boundary for tying in bank gradients. An outline swale design is included along with flow capacity calculations within Appendix B.
- 4.5.6. The amended scheme will be more effective in that site runoff will be directed into the site drainage network rather than entering the overflow culvert via the collector drain, thus preserving the full capacity of the culvert. Further, the risk of flooding to land at this corner of the site will be significantly reduced.
- 4.5.7. The proposed route of the new overflow swale is illustrated on the Proposed Surface Water Management Strategy plan. It is recommended that no buildings are constructed within 5m of the swale and this is reflected in the layout of the Masterplan.
- 4.5.8. As mentioned in Section 3.6, there are some concerns regarding localised spring activity at Aston Road to the east of the site. From reviewing the geology mapping available at the

British Geological Society's (BGS) website and the groundwater vulnerability mapping available at the Environment Agency's website, there are no clear indications of why this might occur. It is possible that a local variation in the near-surface geology may contribute to rising groundwater.

- 4.5.9. It is known that the year 2000 was marked by high groundwater conditions across the south and east of England following prolonged wet weather. Groundwater flooding problems were heightened at known hotspots and identified at new locations where previously no flooding occurred.
- 4.5.10. The land around Aston Road generally falls away in a southerly direction and, as the nature of the springing activity is localised, it is unlikely that any flooding from this source would have any significant impact on the site. Nonetheless, the geology and groundwater patterns at the site will need to be understood to inform the detailed design of the development.

4.6 Surface Water Management

- 4.6.1. The preferred method for disposal of surface water is by means of infiltration before discharge to a watercourse or a sewer is considered. However, the site lies on the London Clay formation which has very low permeability. Therefore, infiltration techniques will not be suitable at this location.
- 4.6.2. The proposed solution will be to discharge to the public sewer network in Silverthorne Way via the existing connections from the site drainage network. The existing site drainage systems will need to be modified / replaced to suit the revised layout of the redevelopment proposals. Particularly, the drainage serving the retained property (outside the red line but within the overall complex) will need to be preserved albeit with some diversions / modifications.
- 4.6.3. The existing impermeable surfaces coverage at the site is approximately 80% with some peripheral areas of soft landscaping. The proposed layout includes similar peripheral landscaping and the impermeable coverage will remain around 80%. Thus, the volume of runoff leaving the site during a rainfall event will not be increased by the development.
- 4.6.4. The site drains into the Southern Water attenuation pond west of Elettra Avenue which was constructed along with the industrial estate in the early 1980's. No information on the design standard of the pond could be obtained; however, it is likely that the pond was designed to attenuate flows up to the 30-year or perhaps the 50-year return period. Therefore, there is no requirement to attenuate runoff further for events up to the 30-year return period.
- 4.6.5. It is proposed to restrict runoff rates to the existing 30-year rates for all events above the 30-year return period up to the 100-year +20% return period. This will require attenuation storage with outfall controls and it is proposed to provide this in the form of lined permeable paving cells within parking areas. Runoff from roofs and road areas will be directed into the sub-base of the permeable paving. The parking areas will be designed to accommodate shallow above-ground storage in the more extreme events.
- 4.6.6. A plan showing the proposed storage locations is included in Appendix A. Calculations are included in Appendix C to demonstrate the proposal.
- 4.6.7. The permeable paving sub-base provides the added benefit of filtration for runoff treatment. This will be augmented by the use of trapped gullies as well as petrol interceptors where required.
- 4.6.8. The proposed layout will require the modification / diversion of drainage serving the retained property at the complex. This will need to be considered during the detailed design stage; however, the potential routes are indicated on the plan in Appendix A.

4.7 Residual Risk

- 4.7.1. The perceived residual flood risks are associated with the following three scenarios:
- Pump failure on Southern Water attenuation pond outfall.
 - The capacity of the drainage systems being exceeded by a rainfall event of greater magnitude than the design conditions.
 - Blockage of the drainage systems.
- 4.7.2. Shortly after the site flood alleviation scheme was constructed in 2003, a flooding incident occurred off site due to the failure of both pumps in the attenuation pond. Southern Water responded to the incident by improving the maintenance regime and installing telemetry gauging. No re-occurrence has since been observed.
- 4.7.3. The risk of pump failure is considered to be low given that an improved maintenance regime has been established but a repeat occurrence cannot be absolutely discounted. The potential effect of pump failure would be overspilling of the pond and backing up of the local drainage systems including the site drainage systems.
- 4.7.4. The crest level of the pond overflow weir was surveyed as 33.51m AOD above the pumped outfall, with bank levels around 33.9m AOD either side of this. Water overspilling the weir will flow directly into the River Wallington. The existing car park levels at the site are all above 34m AOD. Existing road levels between the development and the pond are in the region of 34.3m to 34.6m AOD. In the existing scenario therefore, although the site is above the pond weir levels, any backing up of the drainage system due to a restricted outfall could cause some shallow ponding at the bottom corner of the site.
- 4.7.5. The proposed swale at the south-west corner of the site will help to contain this problem as any surface water prevented from entering the drainage network will run into the swale. Further mitigation will be provided as follows:
- All proposed building thresholds should be set at least 300mm above surrounding road levels in Elettra Avenue and Silverthorne Way and at least 300mm above the proposed swale crest levels.
 - All proposed road, parking and pedestrian area finished levels should be set no lower than the surrounding road levels in Elettra Avenue and Silverthorne Way and no lower than the proposed swale crest levels.
- 4.7.6. These measures will help to ensure that any water backing up from the pond will still be able to escape south-west towards the pond and the river. As a further precaution, buildings at the south-west corner of the site should incorporate flood resilience techniques such as solid floors, raised electrics, sealed ducts, resilient finishes etc.
- 4.7.7. The site drainage system will be designed to accommodate at least the 30-year return period event with designated shallow above-ground storage in parking areas to cater for the 100-year return period event on site (including a 20% allowance for predicted climate change).
- 4.7.8. Safe routes for exceedance flows will need to be defined as part of the detailed design stage. However, as a general approach building thresholds should be set at least 150mm above surrounding finished ground levels with localised grading to achieve level access criteria as required. Exceedance flows will then naturally be directed around the buildings towards the lower parts of the site. The mitigation arrangements already described for the south-west corner of the site will help to protect the buildings there.

- 4.7.9. The risk of blockage will be minimised by establishing a suitable inspection and maintenance regime for the site drainage infrastructure. The regime will need to be defined in accordance with industry and manufacturer guidelines and recommendations and agreed by the developer in conjunction with adopting authorities prior to construction. Permeable paving components in particular require very little maintenance to continue functioning as designed. Again, the mitigation arrangements already described will help to protect the buildings from flooding caused by blockage of the drainage system.

4.8 Emergency Access & Egress

- 4.8.1. An emergency access and egress route will be available via the Elettra Avenue entrance to the north at all times.

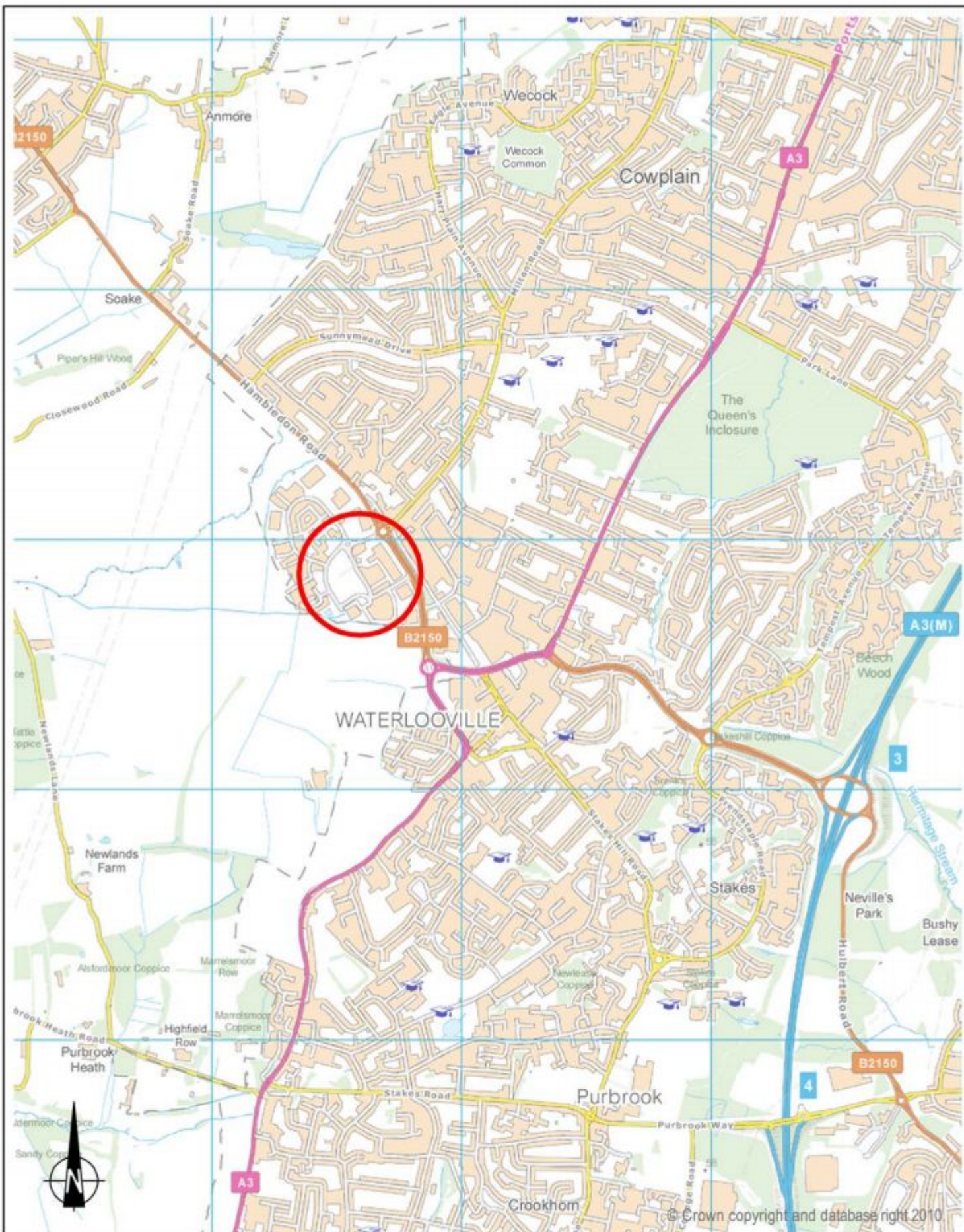
5 Conclusions

- 5.1. The site lies within Flood Zone 1.
- 5.2. The combined capacity of the twin culverts under Tyak House is less than the upstream sewer culvert. The flood alleviation scheme constructed by BAE in 2003 compensates for this lack by routing surcharged flows across the existing car park into the Southern Water attenuation pond.
- 5.3. A proposed swale between the sewer culverts and the collector drain will contain any overflows within a defined channel. It will thereby reduce the area of land subject to overland flow.
- 5.4. The proposed development does not increase the existing area of impermeable surfaces at the site. The existing drainage connections into the public sewer network in Silverthorne Way will be retained to serve the proposed development. The existing systems are assumed to cater for rainfall events up to the 30-year return period.
- 5.5. Permeable pavements in car parking areas will include sub-base storage and shallow above-ground storage capacity. These measures will be used to manage surface water sustainably for rainfall events up to the 100-year return period including a 20% allowance for climate change.

Appendix A: Figures

- Figure 1: Location Plan
- Figure 2: Proposed Masterplan
- Figure 3: Topographical Survey
- Figure 4: Existing Site Constraints
- Figure 5: Proposed Strategy

BAE Waterlooville
Flood Risk Assessment



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Proposed Redevelopment at
Elettra Avenue
Waterlooville

Location Plan

Date 22.05.2012

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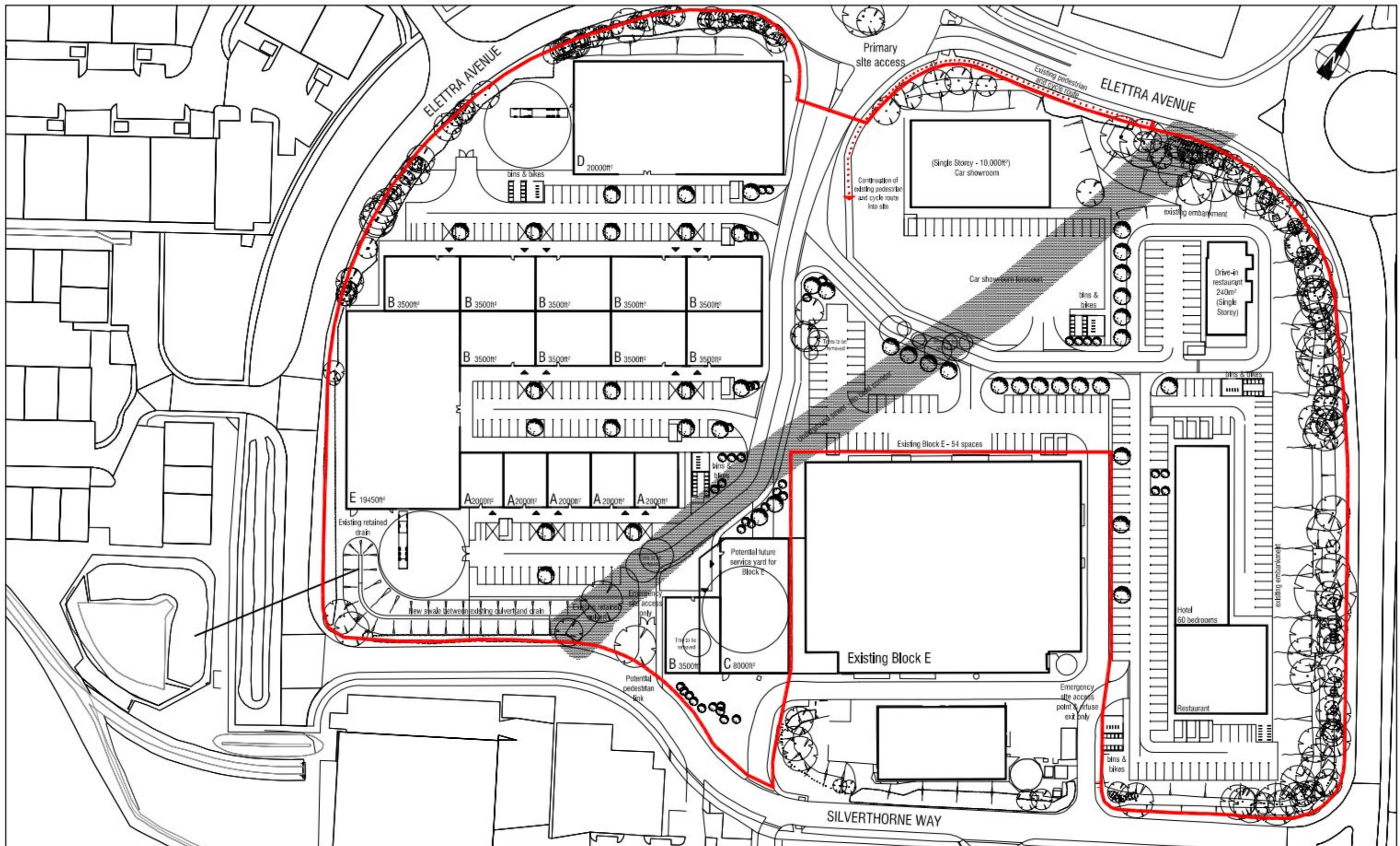
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Figure 1

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Proposed Redevelopment at Elettra Avenue
Waterlooville

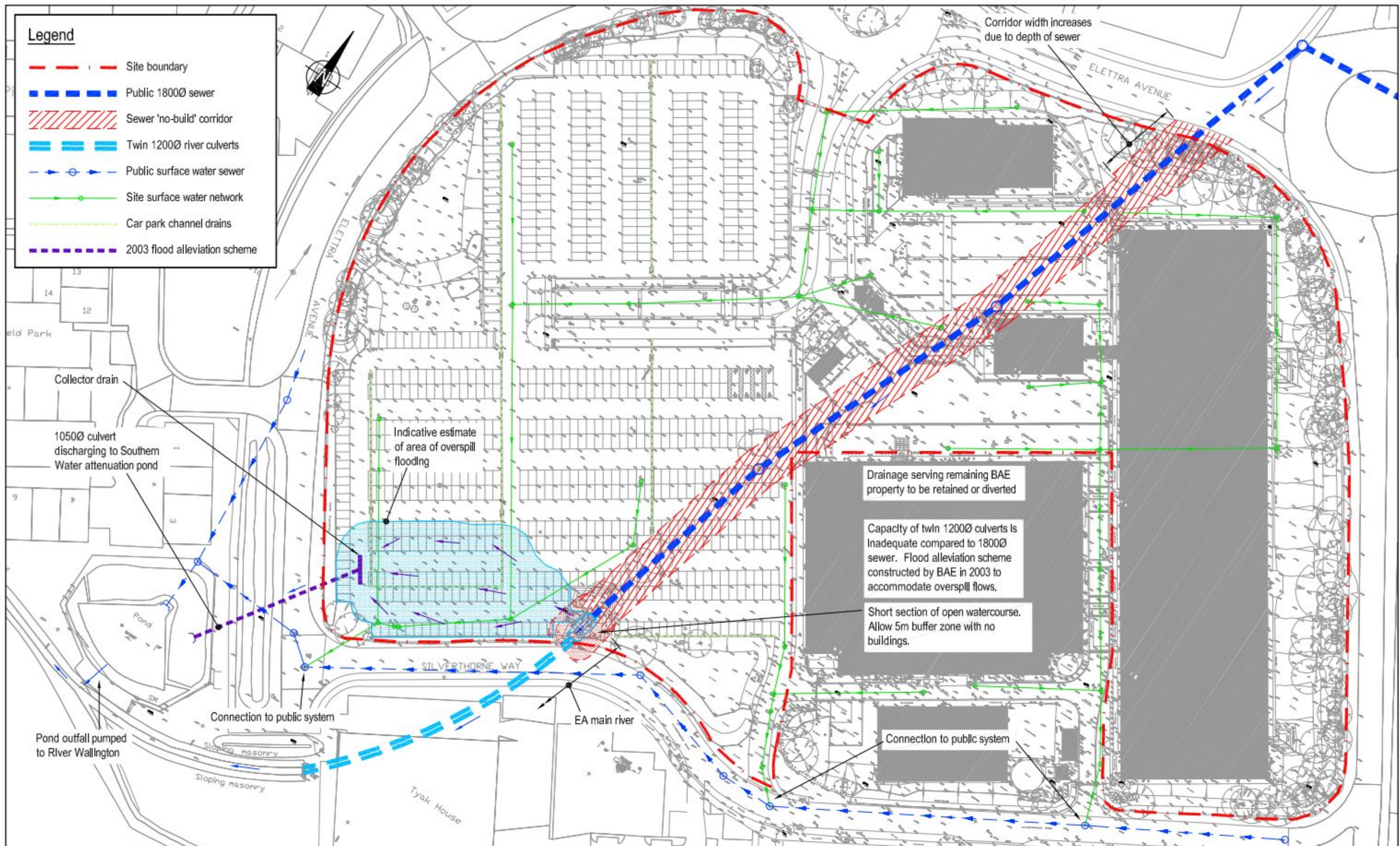
Proposed Masterplan
(From HGP Architects drawing 11.074.002)

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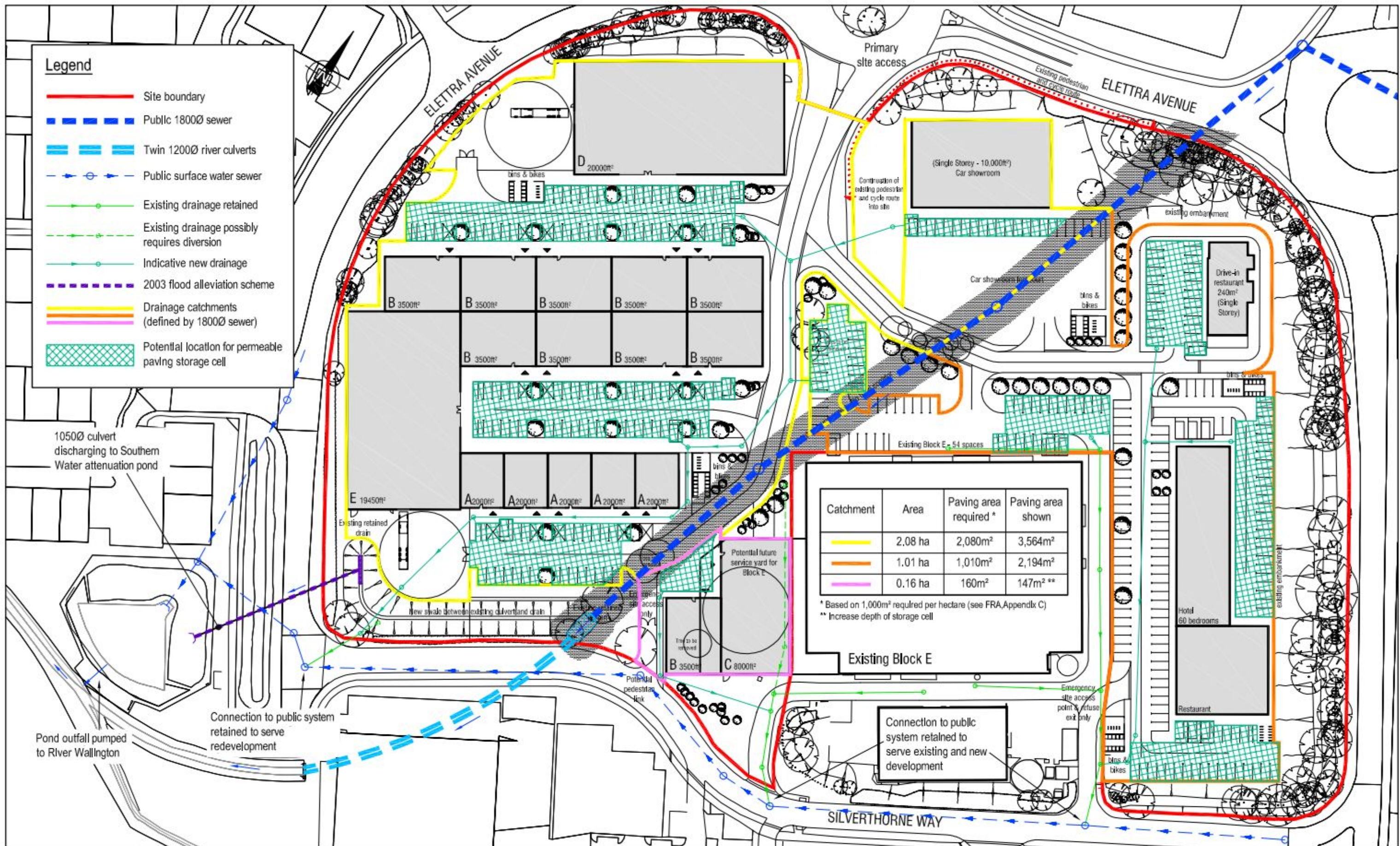
Proposed Redevelopment at Elettra Avenue
 Waterloo

Flood Risk and Surface Water Management
 Existing Site Constraints

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Proposed Redevelopment at Elettra Avenue
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 (Masterplan from HGP Architect's drawing 11.074.002)

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Appendix B: Flood Alleviation Capacity Checks

- Pipe Capacity Checks
- Figure B.1: Outline Design of Proposed Swale
- Proposed Overflow Swale Capacity – ISIS outputs

BAE Waterlooville
Flood Risk Assessment

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FRA Appendix B - Pipe Capacity Checks

Public surface water sewer through the site

Pipe Name	Public sewer, MH 6050 - MH 6950		
Diameter (mm)	1800	Roughness (mm)	0.6
U/S IL (m AOD)	34.15	D/S IL (m AOD)	33.66
Length (m)	115.5	Gradient (1:x)	235.6
Capacity (m ³ /s)	7.9		

Pipe Name	Public sewer, MH 6950 - MH 5850		
Diameter (mm)	1800	Roughness (mm)	0.6
U/S IL (m AOD)	33.66	D/S IL (m AOD)	33.38
Length (m)	82.7	Gradient (1:x)	295.5
Capacity (m ³ /s)	7.1		

Pipe Name	Public sewer, MH 5850 - outfall 575x		
Diameter (mm)	1800	Roughness (mm)	0.6
U/S IL (m AOD)	33.38	D/S IL (m AOD)	33.2
Length (m)	63.7	Gradient (1:x)	353.9
Capacity (m ³ /s)	6.5		

Limiting Capacity (m³/s)	6.5
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Twin river culverts downstream of site

Pipe Name	River culvert, west (twin)		
Diameter (mm)	1200	Roughness (mm)	0.6
U/S IL (m AOD)	32.87	D/S IL (m AOD)	32.54
Length (m)	87.0	Gradient (1:x)	263.6
Capacity (m ³ /s)	2.6		

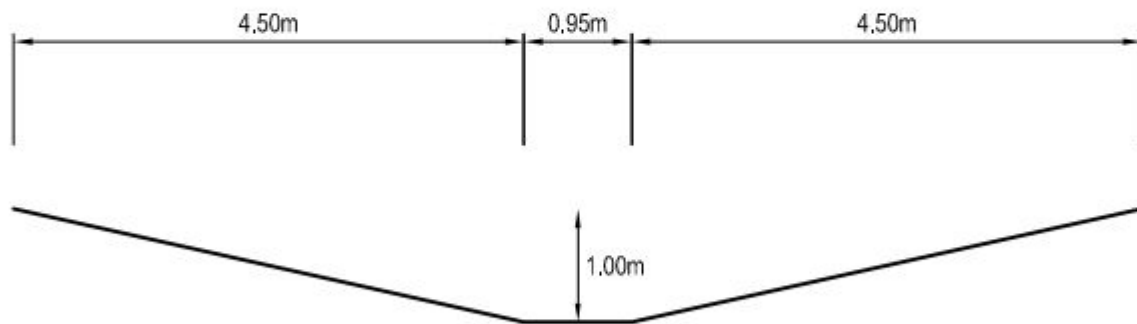
Pipe Name	River culvert, east (twin)		
Diameter (mm)	1200	Roughness (mm)	0.6
U/S IL (m AOD)	32.84	D/S IL (m AOD)	32.62
Length (m)	87.0	Gradient (1:x)	395.5
Capacity (m ³ /s)	2.1		

Combined Capacity (m³/s)	4.7
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Shortfall in Capacity (m³/s)	1.8
--	------------

2003 alleviation scheme

Pipe Name	Overflow culvert to attenuation pond		
Diameter (mm)	1050	Roughness (mm)	0.6
U/S IL (m AOD)	32.60	D/S IL (m AOD)	32.00
Length (m)	51.0	Gradient (1:x)	85.0
Capacity (m ³ /s)	3.2		



Length of proposed swale: 68m
 Gradient: 1 in 600
 Fall: 0.113m

Crest level of open channel overflow weir (upstream): 35.00m AOD

Cover level of existing collector drain (downstream): 34.19m AOD

Invert level of downstream 1050Ø culvert: 32.60m AOD

Soffit level of downstream 1050Ø culvert: 33.65m AOD

Possible swale levels:	Upstream bank:	34.80m AOD
	Upstream invert:	33.80m AOD
	Downstream bank:	34.69m AOD
	Downstream invert:	33.69m AOD

(collector grating lowered)

Recommended minimum threshold level: 35.00m AOD

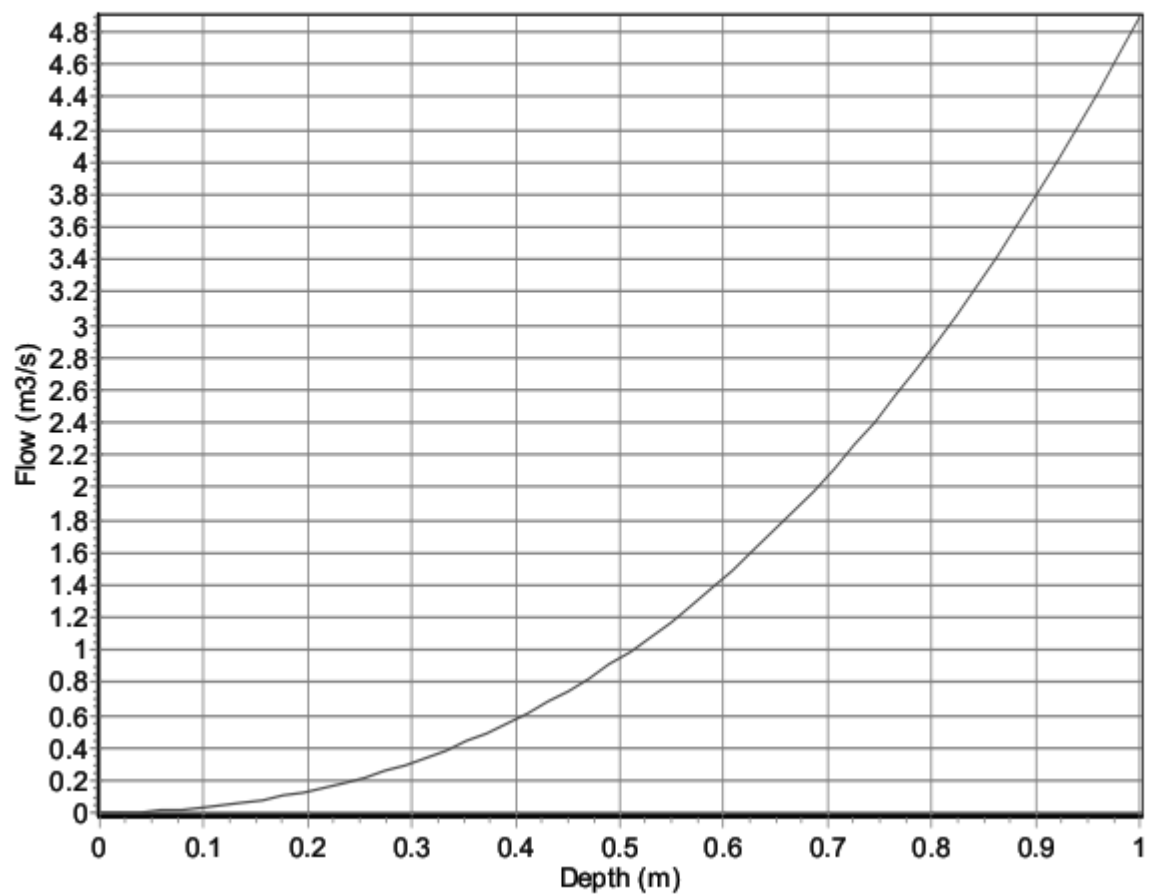
ALL SUBJECT TO DETAILED DESIGN.

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Proposed Overflow Swale Capacity - ISIS outputs

Node	Flow (m³/s)	Depth (m)	Velocity (m/s)	Width (m)	Slope
1	0.00	0.000	0.00	0.000	1 in 600
1	0.00	0.020	0.09	1.126	1 in 600
1	0.01	0.039	0.14	1.303	1 in 600
1	0.01	0.059	0.18	1.479	1 in 600
1	0.02	0.078	0.21	1.656	1 in 600
1	0.03	0.098	0.24	1.832	1 in 600
1	0.05	0.118	0.26	2.009	1 in 600
1	0.06	0.137	0.29	2.185	1 in 600
1	0.08	0.157	0.31	2.362	1 in 600
1	0.10	0.176	0.33	2.538	1 in 600
1	0.13	0.196	0.35	2.715	1 in 600
1	0.15	0.216	0.37	2.891	1 in 600
1	0.18	0.235	0.39	3.068	1 in 600
1	0.22	0.255	0.40	3.244	1 in 600
1	0.25	0.275	0.42	3.421	1 in 600
1	0.29	0.294	0.44	3.597	1 in 600
1	0.34	0.314	0.45	3.774	1 in 600
1	0.38	0.333	0.47	3.950	1 in 600
1	0.43	0.353	0.49	4.126	1 in 600
1	0.49	0.373	0.50	4.303	1 in 600
1	0.55	0.392	0.52	4.479	1 in 600
1	0.61	0.412	0.53	4.656	1 in 600
1	0.68	0.431	0.54	4.832	1 in 600
1	0.75	0.451	0.56	5.009	1 in 600
1	0.83	0.471	0.57	5.185	1 in 600
1	0.91	0.490	0.59	5.362	1 in 600
1	0.99	0.510	0.60	5.538	1 in 600
1	1.08	0.529	0.61	5.715	1 in 600
1	1.18	0.549	0.63	5.891	1 in 600
1	1.28	0.569	0.64	6.068	1 in 600
1	1.38	0.588	0.65	6.244	1 in 600
1	1.49	0.608	0.67	6.421	1 in 600
1	1.61	0.627	0.68	6.597	1 in 600
1	1.73	0.647	0.69	6.774	1 in 600
1	1.85	0.667	0.70	6.950	1 in 600
1	1.98	0.686	0.72	7.126	1 in 600
1	2.12	0.706	0.73	7.303	1 in 600
1	2.26	0.725	0.74	7.479	1 in 600
1	2.41	0.745	0.75	7.656	1 in 600
1	2.56	0.765	0.76	7.832	1 in 600
1	2.72	0.784	0.77	8.009	1 in 600
1	2.89	0.804	0.79	8.185	1 in 600
1	3.06	0.824	0.80	8.362	1 in 600
1	3.24	0.843	0.81	8.538	1 in 600
1	3.42	0.863	0.82	8.715	1 in 600
1	3.61	0.882	0.83	8.891	1 in 600
1	3.81	0.902	0.84	9.068	1 in 600
1	4.01	0.922	0.85	9.244	1 in 600
1	4.22	0.941	0.87	9.421	1 in 600
1	4.44	0.961	0.88	9.597	1 in 600
1	4.66	0.980	0.89	9.774	1 in 600
1	4.89	1.000	0.90	9.950	1 in 600
1	4.89	1.000	0.90	9.950	1 in 600

Depth (m) vs. Flow (m³/s)



Appendix C: Proposed Storage Calculations

- Existing 30-year Runoff Calcs
- MicroDrainage calculation sheets: "Typical permeable paving cell with above ground storage".
Results for 30-year and 100-year +20%.

BAE Waterlooville
Flood Risk Assessment

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Appendix C - Existing 30yr runoff calcs

Existing peak runoff calculation

30-year, 15 minute storm rainfall rate	70.5 mm per hour <i>(from MicroDrainage)</i>
Total storm rainfall	18 mm <i>(15 minute storm)</i>
Total volume of rainfall per hectare	180 m ³ per ha <i>(0.018m x 10,000m²)</i>
Percentage runoff	84 % <i>(winter runoff coefficient)</i>
Total rainfall runoff per hectare	151.2 m ³ per ha <i>(15 minute storm)</i>
Average runoff rate per minute per second	10.1 m ³ per ha 168 l/s/ha

This method is conservative in that the average is calculated rather than the peak. A reduction in peak runoff will therefore be achieved by limiting runoff to 168 l/s/ha.

The following MicroDrainage calculation sheets demonstrate that for each hectare of impermeable development around 1,000m² of permeable paving storage will be sufficient based on a sub-base depth of 250mm and above-ground storage of 100mm. Above-ground storage will be created by kerbs and finished levels surrounding the car park set 100mm above the car park level.

Refer to Figure 5 in Appendix A for indicative storage locations and catchments.

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Peter Brett Associates		Page 1
Caversham Bridge House Waterman Place Reading RG1 8DN	BAE Waterlooville Typical permeable paving cell with above ground storage	
Date 22 May 2012	Designed by PH	
File 120522 typical paving cell 30R...	Checked by	
Micro Drainage	Source Control W.12.6	

Summary of Results for 30 year Return Period

Half Drain Time : 4 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max E Outflow (l/s)	Max Volume (m³)	Status
15 min Winter	34.771	0.171	0.0	146.1	146.1	50.4	O K
30 min Winter	34.742	0.142	0.0	144.1	144.1	42.0	O K
60 min Winter	34.652	0.052	0.0	137.5	137.5	14.7	O K
120 min Winter	34.600	0.000	0.0	109.2	109.2	0.0	O K
180 min Winter	34.600	0.000	0.0	81.9	81.9	0.0	O K
240 min Winter	34.600	0.000	0.0	66.3	66.3	0.0	O K
360 min Winter	34.600	0.000	0.0	49.2	49.2	0.0	O K
480 min Winter	34.600	0.000	0.0	39.7	39.7	0.0	O K
600 min Winter	34.600	0.000	0.0	33.6	33.6	0.0	O K
720 min Winter	34.600	0.000	0.0	29.3	29.3	0.0	O K
960 min Winter	34.600	0.000	0.0	23.6	23.6	0.0	O K
1440 min Winter	34.600	0.000	0.0	17.4	17.4	0.0	O K
2160 min Winter	34.600	0.000	0.0	12.8	12.8	0.0	O K
2880 min Winter	34.600	0.000	0.0	10.3	10.3	0.0	O K
4320 min Winter	34.600	0.000	0.0	7.5	7.5	0.0	O K
5760 min Winter	34.600	0.000	0.0	6.0	6.0	0.0	O K
7200 min Winter	34.600	0.000	0.0	5.1	5.1	0.0	O K
8640 min Winter	34.600	0.000	0.0	4.4	4.4	0.0	O K
10080 min Winter	34.600	0.000	0.0	3.9	3.9	0.0	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Winter	70.483	13
30 min Winter	47.002	22
60 min Winter	30.026	38
120 min Winter	18.612	0
180 min Winter	13.906	0
240 min Winter	11.248	0
360 min Winter	8.340	0
480 min Winter	6.737	0
600 min Winter	5.705	0
720 min Winter	4.978	0
960 min Winter	4.012	0
1440 min Winter	2.957	0
2160 min Winter	2.176	0
2880 min Winter	1.748	0
4320 min Winter	1.283	0
5760 min Winter	1.030	0
7200 min Winter	0.868	0
8640 min Winter	0.755	0
10080 min Winter	0.672	0

Peter Brett Associates		Page 2
Caversham Bridge House Waterman Place Reading RG1 8DN	BAE Waterlooville Typical permeable paving cell with above ground storage	
Date 22 May 2012	Designed by PH	
File 120522 typical paving cell 30R...	Checked by	
Micro Drainage		Source Control W.12.6

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.500	Shortest Storm (mins)	15
Ratio R	0.346	Longest Storm (mins)	10080
Summer Storms	No	Climate Change %	+0

Time / Area Diagram

Total Area (ha) 1.000

Time (mins)	Area (ha)
----------------	--------------

0-4 1.000

Peter Brett Associates		Page 3
Caversham Bridge House Waterman Place Reading RG1 8DN	BAE Waterlooville Typical permeable paving cell with above ground storage	
Date 22 May 2012	Designed by PH	
File 120522 typical paving cell 30R...	Checked by	
Micro Drainage		Source Control W.12.6

Model Details

Storage is Online Cover Level (m) 35.100

Complex Structure

Porous Car Park

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	20.0
Membrane Percolation (mm/hr)	1000	Length (m)	50.0
Max Percolation (l/s)	277.8	Slope (1:X)	10000.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	34.600	Cap Volume Depth (m)	0.250

Tank or Pond

Invert Level (m) 35.000

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	1000.0	0.100	1000.0

Orifice Outflow Control

Diameter (m) 0.262 Discharge Coefficient 0.600 Invert Level (m) 33.600

Peter Brett Associates		Page 4
Caversham Bridge House Waterman Place Reading RG1 8DN	BAE Waterlooville Typical permeable paving cell with above ground storage	
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File 120522 typical paving cell.srcx	Checked by	
Micro Drainage	Source Control W.12.6	

Summary of Results for 100 year Return Period (+20%)

Half Drain Time : 7 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max E Outflow (l/s)	Max Volume (m³)	Status
15 min Winter	35.036	0.436	0.0	163.7	163.7	111.4	Flood Risk
30 min Winter	35.037	0.437	0.0	163.7	163.7	111.7	Flood Risk
60 min Winter	35.007	0.407	0.0	161.9	161.9	82.4	Flood Risk
120 min Winter	34.686	0.086	0.0	140.0	140.0	25.2	O K
180 min Winter	34.600	0.000	0.0	128.7	128.7	0.0	O K
240 min Winter	34.600	0.000	0.0	103.7	103.7	0.0	O K
360 min Winter	34.600	0.000	0.0	76.4	76.4	0.0	O K
480 min Winter	34.600	0.000	0.0	61.4	61.4	0.0	O K
600 min Winter	34.600	0.000	0.0	51.8	51.8	0.0	O K
720 min Winter	34.600	0.000	0.0	45.0	45.0	0.0	O K
960 min Winter	34.600	0.000	0.0	36.1	36.1	0.0	O K
1440 min Winter	34.600	0.000	0.0	26.4	26.4	0.0	O K
2160 min Winter	34.600	0.000	0.0	19.2	19.2	0.0	O K
2880 min Winter	34.600	0.000	0.0	15.3	15.3	0.0	O K
4320 min Winter	34.600	0.000	0.0	11.1	11.1	0.0	O K
5760 min Winter	34.600	0.000	0.0	8.8	8.8	0.0	O K
7200 min Winter	34.600	0.000	0.0	7.4	7.4	0.0	O K
8640 min Winter	34.600	0.000	0.0	6.4	6.4	0.0	O K
10080 min Winter	34.600	0.000	0.0	5.7	5.7	0.0	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Winter	109.477	14
30 min Winter	73.715	23
60 min Winter	47.357	40
120 min Winter	29.350	72
180 min Winter	21.840	0
240 min Winter	17.574	0
360 min Winter	12.947	0
480 min Winter	10.408	0
600 min Winter	8.780	0
720 min Winter	7.636	0
960 min Winter	6.120	0
1440 min Winter	4.472	0
2160 min Winter	3.260	0
2880 min Winter	2.602	0
4320 min Winter	1.890	0
5760 min Winter	1.505	0
7200 min Winter	1.261	0
8640 min Winter	1.092	0
10080 min Winter	0.967	0

Peter Brett Associates		Page 5
Caversham Bridge House Waterman Place Reading RG1 8DN	BAE Waterlooville Typical permeable paving cell with above ground storage	
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Micro Drainage		Source Control W.12.6

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.500	Shortest Storm (mins)	15
Ratio R	0.346	Longest Storm (mins)	10080
Summer Storms	No	Climate Change %	+20

Time / Area Diagram

Total Area (ha) 1.000

Time (mins)	Area (ha)
----------------	--------------

0-4 1.000

Peter Brett Associates		Page 6
Caversham Bridge House Waterman Place Reading RG1 8DN	BAE Waterlooville Typical permeable paving cell with above ground storage	
Date 22 May 2012	Designed by PH	
File 120522 typical paving cell.srcx	Checked by	
Micro Drainage		Source Control W.12.6

Model Details

Storage is Online Cover Level (m) 35.100

Complex Structure

Porous Car Park

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	20.0
Membrane Percolation (mm/hr)	1000	Length (m)	50.0
Max Percolation (l/s)	277.8	Slope (1:X)	10000.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	34.600	Cap Volume Depth (m)	0.250

Tank or Pond

Invert Level (m) 35.000

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	1000.0	0.100	1000.0

Orifice Outflow Control

Diameter (m) 0.262 Discharge Coefficient 0.600 Invert Level (m) 33.600