Land at Dalefield Way (West) Gravesend

Flood Risk Assessment Note & Preliminary Drainage Strategy

O'Halloran & O'Brien Ltd

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1.0 Introduction

Manhire Associates have been appointed by O'Halloran & O'Brien Ltd to prepare a Flood Risk Assessment (FRA) and Surface Water Drainage Strategy in support of a Planning Application for the redevelopment proposals for open storage (Use Class B8) for the western plot within the larger existing industrial land plot.

The existing site on Dalefield Way, Gravesend, Kent DA12 2JH is known as Dalefield Way Industrial Estate, which includes the offices, workshops and storage areas used by B&T plant hire, O'Halloran & O'Brien & Keady Construction.

Figure 1 - Arial Image of site.

Proposals are to construct 2969m2 of asphalt surfacing and associated drainage that will connect into the overall SuDS system already constructed and provide 9576m2 of permeable hardstanding for storage.

The purpose of this report is to provide a review of existing Flood Risk Assessments and to demonstrate to the planning authority and consultees that the industrial element has been assessed and is considered to be safe throughout its design life. It also confirms how surface water run off from the development can be dealt with within the existing sites sustainable drainage network previously constructed for the original development.

2.0 Review of previous Flood Risk Assessments

A site-specific Flood Risk Assessment was prepared by Ardent Consulting Engineers in January 2011 to support the planning application for consent to implement the Phase 2 industrial development scheme which was submitted in May 2010 (Planning reference

GR/2010/0436) directly north of the Phase 1 residential development and subject of a combined Environmental Impact Assessment covering both sites.

A site-specific Flood Risk Assessment was prepared by Ardent Consulting Engineers in July 2007 to support the planning application for consent to implement what is known as the Phase 3A industrial development scheme which was previously granted consent in 2002 which expired in 2006 and was re submitted in 2007 (Planning reference GR/2007/0678).

The site-specific Flood Risk Assessments prepared by Ardent Consulting Engineers in January 2011 and 2007 has been provided in Appendix A & D respectively.

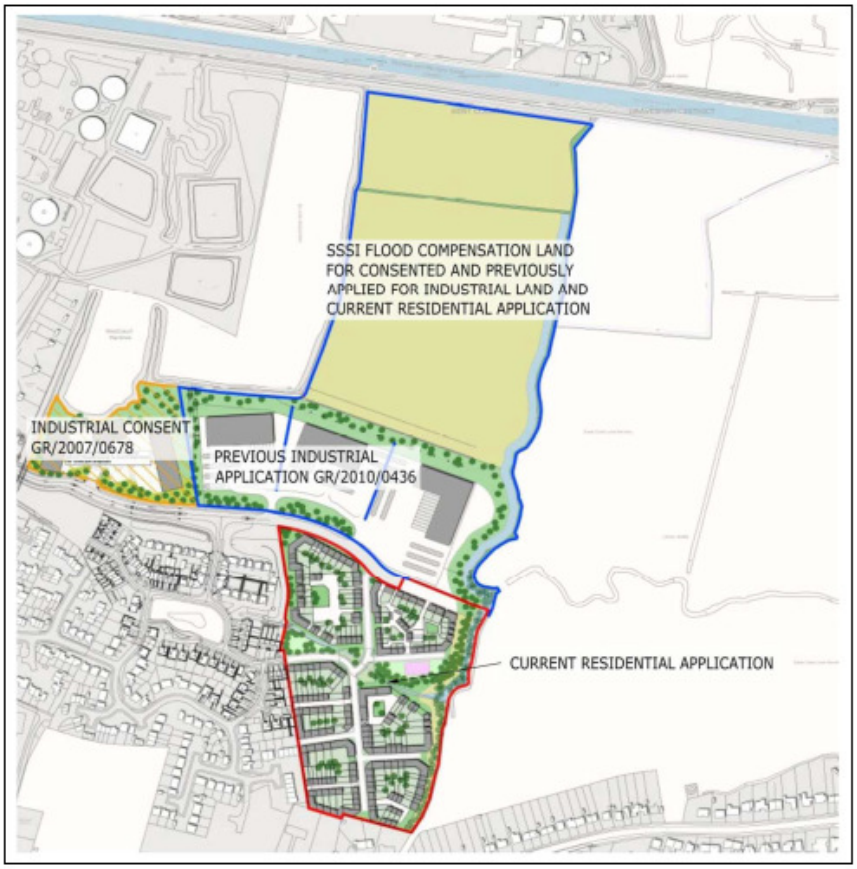

Figure 2 - Extant Planning Applications

An addendum to the Site-Specific Flood Risk Assessment was prepared by Ardent Consulting Engineers in November 2011 and reissued again in May 2016 following the receipt of new data from the Environment Agency on the existing flood defence crest heights.

During the determination of planning applications 2010/0436 (Industrial) and 2010/0197 (residential) Gravesham Borough Council (BC) identified that portions of the tidal flood defences around Gravesend may be at a lower level than that stated in the HR Wallingford Technical Note MCM57553/01 published in 2007.

This Flood Risk Addendum was used to support the Planning Applications and the Hydraulic Modelling, with the latter having been previously approved by the Environment Agency. At that time the proposals were confirmed as being safe.

On receipt of the information from Gravesham BC a joint meeting was held with senior representatives of the Council, the Environment Agency and Ardent Consulting Engineers. The meeting was held at the Environment Agency's offices on the 12 October 2011. During this meeting the impact of the lowered defence levels was discussed, and it was agreed that:

- Gravesham Borough Council, would benefit from further evidence to support the Sequential Test for the Site from the Applicant; and,

- The impact of the lowered defences needs to be agreed with the Environment Agency.

The Flood Risk Assessment Addendum concluded that the existing flood defence infrastructure and alignment of the railway line provide an adequate level of flood defence for the residential and industrial proposals up to 2055. Consequently, the industrial element is considered to be safe throughout its design life.

The site-specific Flood Risk Assessment Addendum prepared by Ardent Consulting Engineers in November 2011 has been provided in Appendix B with the May 2016 reissued Addendum provided in Appendix C

3.0 Review of previous Surface Water Drainage Strategy

As part of the Flood Risk Assessment prepared by Ardent Consulting Engineers in January 2011 to support the planning application for consent to implement the Phase 2 industrial development scheme which was submitted in May 2010 (Planning reference GR/2010/0436) a surface water drainage strategy was prepared based upon the parameters and flow conditions previously established and agreed by Ardent and Buchanan Consulting Engineers, HR Wallingford, the Environment Agency and English Nature/Natural England on the Heronsfield Development (GR/99/168) and the adjacent industrial consented scheme known as Phase 3A (GR/2007/0678).

In view of the requirements of PPS25, the design parameters and constraints associated with developing this particular site, a surface water drainage strategy has been devised to demonstrate that the scheme can be suitably implemented without increasing the level of flood risk when the drainage system experiences a 1:100 year rainfall event (including an additional 30% for any potential climate change impact). The adopted design principles are as follows:

- The ambient water level in the open watercourse channel is 1.70m AOD.

- Post-development 1:100-year floodwater level within the watercourses shall not exceed 2.04m AOD.

- Attenuation provision has been assessed based on the previously agreed total greenfield discharge rate of 32.20 litres/sec, although the run-off will freely discharge into the receiving open channel watercourses and the flows controlled to agreed Greenfield rates downstream by the existing devices that have previously been installed to the north of the application site (adjacent to the railway line);

- Sufficient on-line attenuation shall be provided in accordance with the previously agreed strategy by excavating on-line flood levees to accommodate the volume of surface water run-off generated by the development scheme when subjected to a 1:100 year event (including climate change) to provide a maximum volume of 1,905m3 (effective storage depth of 0.34m);

- Flood levees shall be excavated from a level of 1.65m AOD (i.e. below the ambient water level) to provide regular wetting, but the effective volume of attenuation has only been considered above the ambient water level of 1.70m AOD.

- The development's total impermeable catchment area is anticipated to be in the region of 3.0 hectares.

Details illustrating the extent of the intended watercourse provision and flood levee excavation works are presented below.

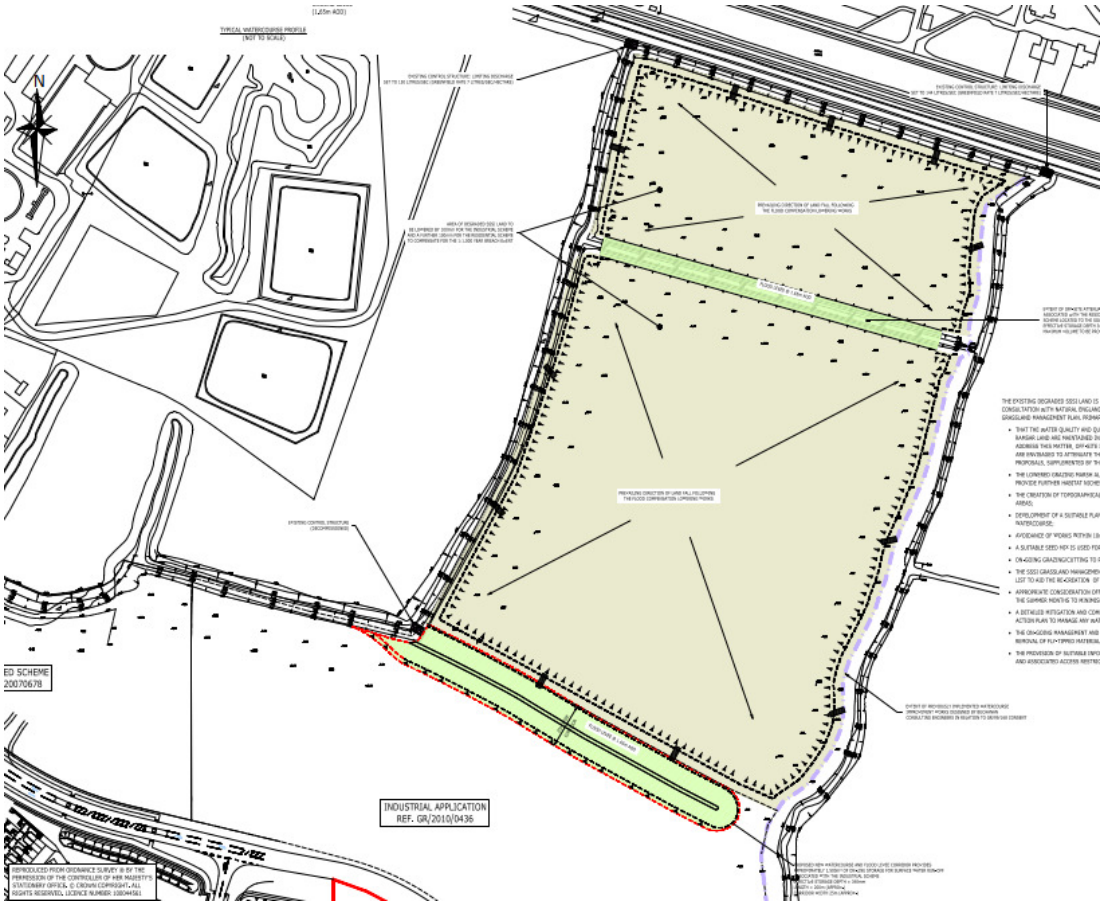

Figure 3 - Watercourse provision and flood levee excavation work.

4.0 Review of existing underground drainage layouts

In 2016 Stephen Wilson Partnership Ltd. prepared a drainage layout for the current offices, workshops and storage areas used for B&T plant hire, O'Halloran & O'Brien & Keady Construction. A copy of the drawings is provided in Appendix E.

The drainage network comprises a number of separate surface water drainage systems. Surface water collected from roads and storage areas in the yard are routed through full retention fuel /oil separators before discharging into the watercourse and flood levee corridors as described in section 3.0. Rainwater collected from the roofs of the buildings is relatively uncontaminated and is discharged through a separate system which discharges to the watercourses without going through the separators.

Foul water from the site is collected separately and routed to a private package pumping station to the south of the site adjacent to the site access road. From here it is pumped to a private chamber before discharging via gravity into a Southern Water Foul Manhole.

5.0 Proposed Drainage Strategy

As described in section 4.0 the existing site drainage networks currently discharges into the watercourses and flood levee corridors that were designed and implemented as part of the previous industrial development planning applications.

The introduction of 2969m2 of asphalt surfacing and 9576m2 of permeable hardstanding will have no adverse impact on the existing watercourses and flood levee corridors.

Run-off from the new asphalt areas will connect into the existing drainage ditches currently installed and discharge into the flood levee corridors as originally proposed.

Surface water collected from the impermeable road / storage areas will be routed through full retention fuel /oil separators before discharging into the watercourse and flood levee corridors as described in section 3.0.

A copy of the Proposed Drainage Layout in Provided in Appendix G.

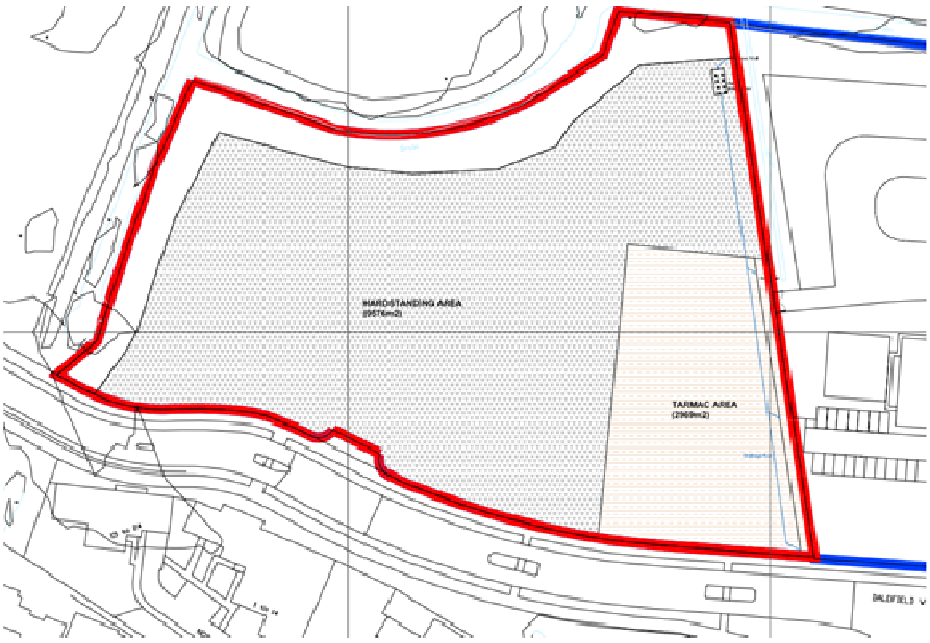

Figure 4 – Proposed Architectural Site Plan – (West)

6.0 Conclusions

A review of the existing Flood Risk Assessments for the site from 2007, 2011 and Addendums from 2011 and 2016 concluded that that the existing flood defence infrastructure and alignment of the railway line provide an adequate level of flood defence for the residential and industrial proposals up to 2055. Consequently, the industrial element is considered to be safe throughout its design life.

As part of the Flood Risk Assessment prepared by Ardent Consulting Engineers in January 2007 & 2011 to support the planning application for consent to implement the Phase 2 industrial development scheme a surface water drainage strategy was devised to demonstrate that the scheme can be suitably implemented without increasing the level of flood risk when the drainage system experiences a 1:100 year rainfall event (including an additional 30% for any potential climate change impact).

Surface Water run-off from the site will freely discharge into the receiving open channel watercourses and the flows controlled to an agreed Greenfield rate of 32.20 litres/sec by the existing devices that were previously installed to the north of the application site (adjacent to the railway line).

Sufficient on-line attenuation has been provided in accordance with the previously agreed strategy by excavating on-line flood levees to accommodate the volume of surface water run-off generated by the development scheme when subjected to a 1:100 year event (including climate change) to provide a maximum volume of 1,905m3.

The site adjacent site is presently drained by a series of surface water networks which discharge into the watercourse and flood levee corridors.

The introduction of 2969m2 of asphalt surfacing and 9576m2 of permeable hardstanding will have no adverse impact on the existing watercourses and flood levee corridors.

Run-off from the new asphalt areas will connect into the existing drainage ditches currently installed and discharge into the flood levee corridors as originally proposed.

The overall conclusion of the initial FRA`s remain applicable to overall flood risk within the terms and requirements of National Planning Policy Framework.

Appendix A – Phase 2 Flood Risk Assessment - January 2011

FORT KNIGHT GROUP, SUNRAY DEVELOPMENT LTD
AND KENT COUNTY COUNCIL

LAND AT PM9, NORTH-EAST GRAVESEND: PROPOSED RESIDENTIAL DEVELOPMENT

FLOOD RISK AND DRAINAGE ASSESSMENT

PROJECT NO. B142
REPORT REF. B142-03
JANUARY 2011

LAND AT PM9, NORTH-EAST GRAVESEND: PROPOSED RESIDENTIAL DEVELOPMENT

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H. Southern Water's Foul Water Capacity Assessment Letter Report (1st July 2010)

I. HR Wallingford's Report – Hydraulic Assessment of the Existing Drainage Channels (13th September 2001)

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B142-009 Preliminary Foul and Surface Water Drainage Strategy
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U481-002D Off-site Channel Improvements: Cross Sections

DOCUMENT CONTROL SHEET

REV	ISSUE PURPOSE	AUTHOR	CHECKED	REVIEWED	APPROVED	DATE
-	Draft for comment	SJB	SJB	ARF	CBP	09.11.10
-	Planning Issue	SJB	SJB	CBP	CBP	25.01.11

1.0 INTRODUCTION

1.1 Ardent Consulting Engineers has been appointed by a consortium comprising Fort Knight Group, Sunray Development Ltd and Kent County Council to prepare a formal Flood Risk Assessment (FRA) and identify a strategy for the disposal of the foul water flows and surface water run-off arising from the proposed residential development scheme.

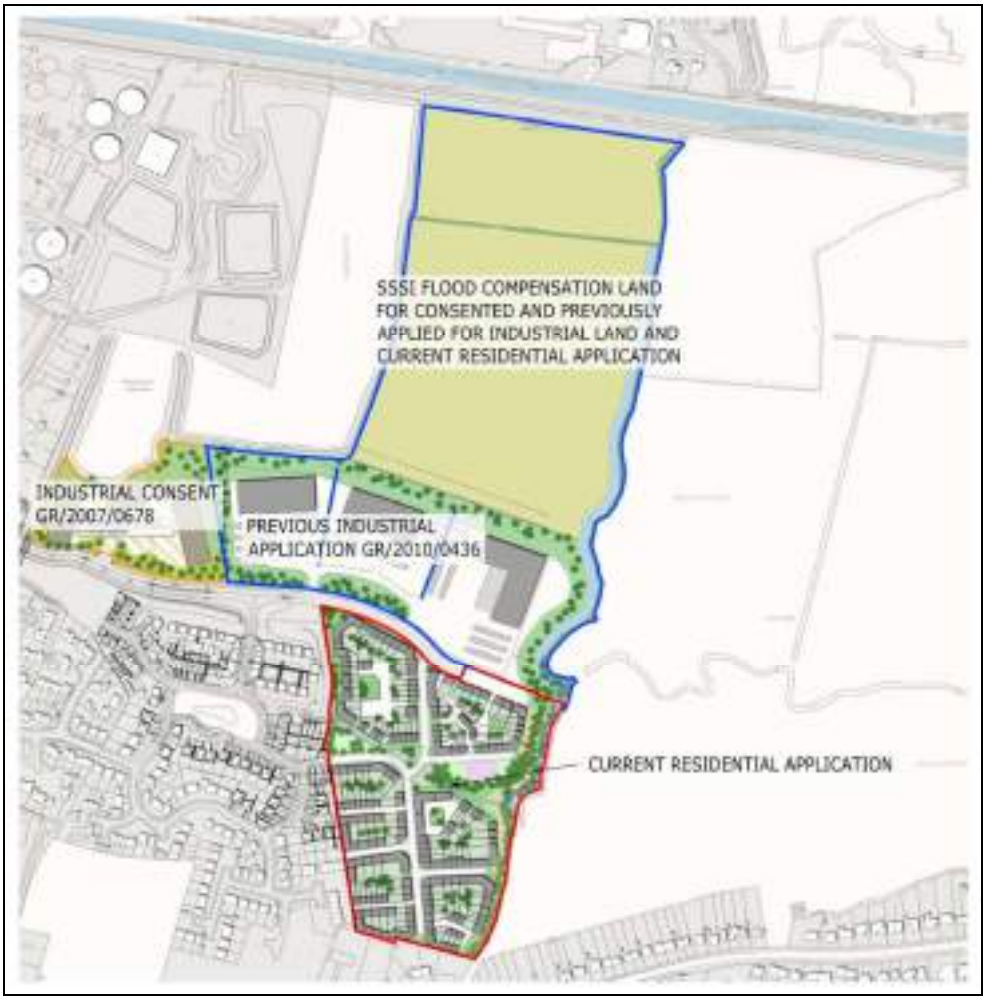
1.2 The following report has been prepared to support a planning application for permission to provide up to 130 residential dwellings with associated supporting infrastructure comprising internal access roads, car parking courtyards and a suitable landscaping scheme. The extent of the application and adjoining sites previously consented or submitted for the planning approval, as shown over the page.

1.3 The site is deemed to partially lie within the indicative undefended floodplain associated with the River Thames (albeit appropriately defended) and, to comply with the requirements of 'Planning Policy Statement 25: Development and Flood Risk' (PPS25), a site-specific FRA has been prepared to accompany the planning application.

1.4 The adjacent site to the north-west was granted outline planning consent in June 2001 for a scheme comprising a total of 3,333m^2 gross floor area (GFA) for employment use (Classes B2 - industrial and B8 - distribution warehousing). This consent was subsequently renewed in August 2004. Expiry of that outline consent necessitated the resubmission of this application for an identical scheme in July 2007. This application was approved in October 2007 by Gravesham Borough Council (GBC) under the reference GR/2007/0678 but has not yet been built out. However a Reserved Matter application was submitted in October 2010 and is currently under consideration by Gravesham Borough Council

1.5 A site-specific Flood Risk Assessment has also been prepared by Ardent Consulting Engineers to support the planning application for consent to implement an industrial development scheme which was submitted in May 2010 (Planning reference GR/2010/0436), directly north of this proposal and subject of a combined Environmental Impact Assessment covering both sites.

1.6 The drainage proposals outlined within this report follows the methodology adopted for previous phases of both residential and industrial development granted planning permission by the Local Planning Authority.



1.7 The development, drainage and flood mitigation proposals have been devised in accordance with the position reached with the Environment Agency at the meeting held on 19th October 2009 and

subsequent meetings with Natural England. A copy of the minutes of the meeting has been included within **Appendix F** of this report for further reference. Furthermore, meetings have also been held with Natural England on 20th November 2009 and 27th April 2010 to discuss the principle of development and the surrounding SSSI area.

1.8 It is anticipated that where additional and/or further detailed information is required, the Authorities will recommend standard conditions to be assigned to any planning decision for future consideration and determination.

1.9 This report is to be submitted to the Local Planning Authority (Gravesham Borough Council) and its Statutory Consultees to obtain an approval to the drainage strategy and associated flood risk matters. The objective of the report is to allow the planning application to progress without objection from the Authorities.

1.10 It is anticipated that where additional and/or further detailed information is required, the Authorities will recommend standard conditions to be assigned to any planning decision for future consideration and determination.

2.0 BASELINE PARAMETERS

Existing Site

2.1 The land which forms the basis of this particular planning application is situated approximately 500m north of the A226 Rochester Road, 700m south of the disused Thames and Medway Canal which lies adjacent to the London to Medway Towns North Kent railway line.

2.2 The site is centred on an Ordnance Survey grid reference of 567100mE, 173300mN, as illustrated in the site location plan below and as outlined in red in the key plan within the introduction:

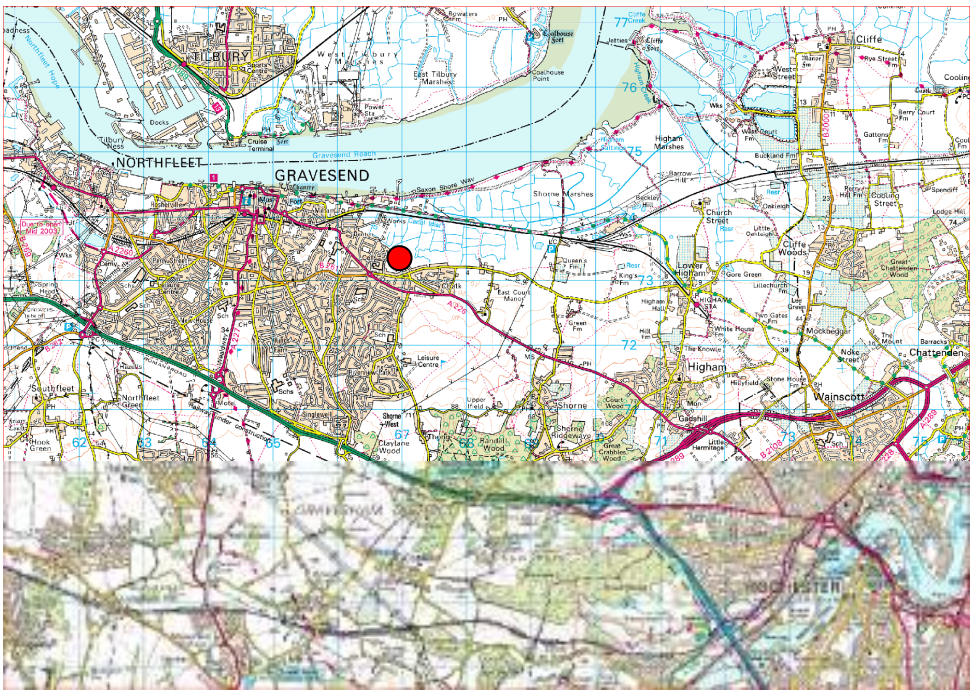


Figure 1 - Site Location Plan

2.3 The site lies within an area known as Westcourt which is situated to the north-east of Gravesend and occupies a portion of land allocated as PM9 within Gravesham Borough Council's Local Plan.

2.4 The PM9 area is currently allocated in Gravesham Borough Council's Adopted Local Plan First Review of 1994 for industrial and residential development, open space and further education facilities, and also

allocated in the Review Local Plan of 2000 (Policy MDS5) for a similar range of uses.

Figure 2 - Aerial Photograph

2.5 A topographical survey that was prepared by Randall Surveys in June 2005, establishes the ground levels for the existing site to be between 2.1m to 8.0m AOD (as illustrated in **Figure 3** below):

Figure 3 - Extract of the Topographical Survey

2.6 To enable a breach analysis to be modelled, Light Detection and Ranging (LiDAR) data was also obtained from the Environment Agency to establish the existing ground topography across the associated embayment.

2.7 The existing surface water land drainage regime comprises a number of open channels which inter-connect with a wide network of watercourses within the north-east area of Gravesend i.e. Westcourt, East Shorne and beyond. Ultimately, the flows in the watercourse network drain in a northerly direction towards the River Thames, which is located approximately 850m to the north of the site, via culverts which pass under the North Kent railway line and disused canal. An extract of the original land drainage regime is shown in **Figure 4** below for reference:

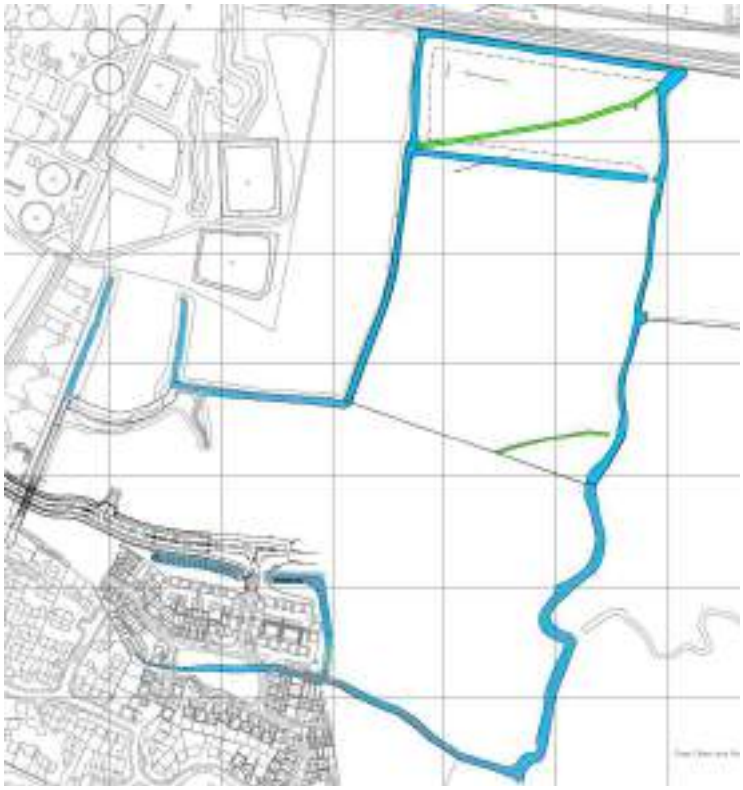


Figure 4 - Land Drainage Regime

2.8 Being part of an inter-connected network of watercourses, hydraulic continuity is evident across the catchment and any subsequent local rise in water level is naturally dissipated around the catchment until it reaches hydraulic equilibrium.

2.9 In March 1999, Buchanan Consulting Engineers prepared a surface water drainage strategy to support a planning application for the provision of 165 residential dwellings and the associated implementation of these initial phases of development associated with the Heronsfield scheme (Phases 1 and 2 of GR99/168). The surface water drainage strategy utilised a freely discharging outfall from the parcels of development which were controlled to greenfield rates for the catchment-wide area (off-site, adjacent to the railway line). This strategy identified the requirement for supplementary improvement works along a linear length of the existing watercourses present within the SSSI land for approximately 650m

to provide the necessary on-line attenuation required to facilitate the development proposals.

2.10 The storage provision essentially comprised excavation of flood levees marginally below the ambient water level of 1.70m AOD (at 1.65m AOD). This methodology has also been adopted for successive phases of development, namely in the area associated with the Phase 3A scheme which was also recently granted planning permission by Gravesham Borough Council in October 2007 under the planning reference GR/2007/0678, to provide a similar industrial development scheme on the adjacent site.

2.11 Also associated with the previously approved surface water drainage strategy were the provision of two outfall structures immediately south of the railway which limits the flows to a commensurate greenfield run-off rate.

2.12 Detailed design drawings for the off-site watercourse improvement works were subsequently produced and approved by both English Nature/Natural England and the Environment Agency. A copy of the consented drawings has been appended to this report for further reference (Drawing numbers U481-001 Rev. E and U481-002 Rev. D).

2.13 The surface water drainage strategy devised for this latest phase has also been based on the principles previously agreed with the Environment Agency and English Nature/Natural England and subsequently implemented in the area. In essence, the strategy seeks to provide appropriate mitigation measures above the ambient water level of 1.70m AOD to ensure the water level does not rise above the 1:100 year level of 2.04m AOD, as a result of implementing the development proposals (based on the hydraulic assessment of the existing land drainage regime prepared by HR Wallingford in September 2001 contained within **Appendix I** of this report). A copy of the relevant correspondence has been included within **Appendix G** of this report for further reference.

2.14 To dispose of the surface water run-off generated by the development site, it is anticipated that the existing watercourses located to the east of the site will accept run-off from the scheme, in accordance with the previously approved strategy for the area as a whole and as acknowledged by the Environment Agency on 6th July 2000.

2.15 The current development proposals for the area, allow for the vast majority of the existing watercourse to be retained, whilst providing a compensatory length of new watercourse, to ensure there is no net loss in watercourse length (culverted for access reasons only). To offer betterment, the scheme also seeks to implement additional watercourses to promote the aquatic biodiversity in the area.

2.16 A search of the Environment Agency's website confirms that the site does not lie within a groundwater source protection zone, as illustrated in **Figure 5** below:

Figure 5 - Extract of Groundwater Source Protection Zones

2.17 To the north-west of the site lies Southern Water's Sewage Treatment Works into which, the surrounding development schemes to the west, discharge foul water flows.

2.18 A copy of the public sewer record plans has been provided in **Appendix B** of this report to illustrate the location of the existing public sewers and Sewage Treatment Works mentioned above.

Development Proposals

2.19 The planning application for the proposed residential scheme is to comprise up to 130 dwellings with associated infrastructure comprising internal access roads, parking courtyards, amenity space and supporting landscaping scheme. Vehicular access will be achieved off an extension to the distributor road known as Dalefield Way, including inter-connectivity with the adjacent residential scheme.

2.20 A development masterplan layout has been prepared by Kember Loudon Williams Limited (see **Figure 6** below for an extract) which has also been included within **Appendix C** of this report for further reference.

Figure 6 - Extract of Development Masterplan

2.22 The overall developable area associated with this planning application is approximately 4.60 hectares (excluding the off-site flood mitigation works - refer to **Section 3.0** of this report for details), with an approximate impermeable area of 3.0 hectares which equates to 65% of the total area. The remainder of the land will be suitably landscaped, which will also include the provision of supporting buffer zones and proposed watercourse provisions.

2.23 In addition to the above, the works will also comprise locally raising lower lying areas of the site for development by up to 1.7m to 3.9m AOD, to mitigate the risk of floodwater inundation from the River Thames in the event of a breach to the existing defences.

3.0 FLOOD RISK ASSESSMENT

3.1 'Planning Policy Statement 25: Development and Flood Risk' (PPS25) was originally published in December 2006 (subsequently revised in March 2010) and is the acknowledged standard for conducting Flood Risk Assessments (FRA). This study is based on the guidance stated within PPS25.

3.2 Following an inspection of the Environment Agency's website, the development site is shown to partially lie within the indicative undefended floodplain of the River Thames which also benefits from the presence of existing flood defence systems - as illustrated in **Figure 7** below:

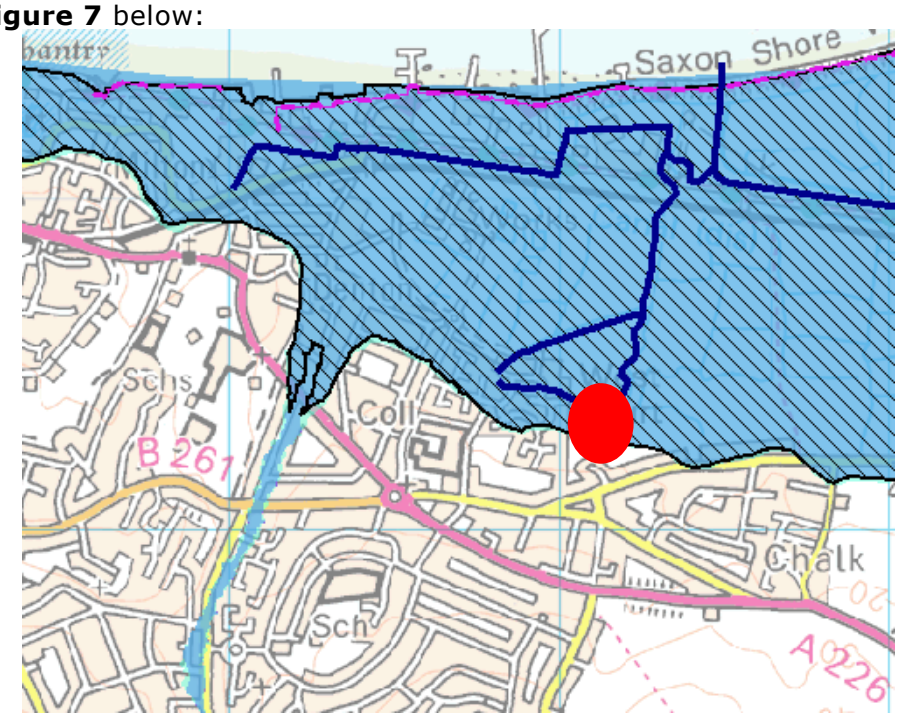


Figure 7 - Indicative Floodplain Mapping

3.3 As the site is classified by the criteria specified in PPS25 as being situated within a Flood Risk Zone 3 area (high probability), the planning application is required to be accompanied by a site-specific FRA, to comply with the requirements of paragraph E9 of PPS25.

3.4 PPS25 primarily places the onus upon Developers for:

- Providing a FRA which demonstrates:

  i) whether any proposed development is likely to be affected by current or future flooding from any source;

  ii) to the Local Planning Authority that the development is safe and where possible, reduces flood risk overall;

  iii) whether it will increase flood risk elsewhere; and

  iv) the measures proposed to deal with these effects and risks;

- Producing designs which reduce flood risk to the development and elsewhere by incorporating sustainable urban drainage systems (SUDS) and where necessary, flood resilience measures; and

- Identifying opportunities to reduce flood risk, enhance biodiversity and amenity, protect the historic environment and seek collective solutions to managing flood risk;

Sequential Test

3.5 The guidance uses the concept of sequential testing and the risk based approach to flood risk and development. Development priorities are based on the specific flood risk zones which are outlined in Table D.1 of PPS25 and briefly summarised below:

Zone 1 - Low probability. Land assessed as having a less than 1 in 1,000 year chance of river and sea flooding in any year (<0.1%);

Zone 2 – Medium probability. Land assessed as having between a 1 in 100 and 1 in 1,000 chance of river flooding (1%-0.1%) and between a 1 in 200 and 1 in 1,000 chance of sea flooding (0.5%-0.1%) in any year;

Zone 3a – High probability. Land assessed as having a 1 in 100 year or greater chance of river flooding (>1%) and a 1 in 200 year or greater chance of flooding from the sea (>0.5%) in any year;

Zone 3b – Functional floodplain. Land where water has to flow or be stored in times of flood;

3.6 Reviewing the content of Table D.2 of PPS25 classifies a residential development scheme as 'more vulnerable' in terms of flood risk. Reviewing Table D.3 of PPS25 considers the provision of a 'more vulnerable' land class usage in a Flood Risk Zone 3 area, will require the Sequential Test to be applied to ensure the Exception Test is satisfied, as illustrated in **Figure 8** below:

Flood Risk Vulnerability classification (see Table D2)		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table D.1)	Zone 1	✔	✔	✔	✔	✔
	Zone 2	✔	✔	Exception Test required	✔	✔
	Zone 3a	Exception Test required	✔	✗	Exception Test required	✔
	Zone 3b 'Functional Flood plain'	Exception Test required	✔	✗	✗	✗

Key:
✔ Development is appropriate
✗ Development should not be permitted

Figure 8 - Table D.3 of PPS25: Flood Risk Vulnerability and Flood Zone Compatibility

3.7 The document 'Development and Flood Risk: A Practice Guide Companion to PPS25' also confirms that the on-going regeneration of a particular area should be supported, considering the initial commitment to redevelop certain local areas and the implementation of major infrastructure to support this (i.e. Dalefield Way and its potential for ultimate extension to the A226 and Canal Basin).

3.8 A proportion of the PM9 land has already been successfully developed and regenerated for the North-East Gravesend area over

the last 15 years in accordance with the current Local Plan Policy its allocation and will require continued support if the longer term objectives and needs of the area are to be properly realised.

3.9 At present, eight hectares of land remaining under the PM9 allocation which is undeveloped to date and the significant infrastructure mentioned above, is in place to deliver these requirements locally, whilst also serving the wider aspirations for the North-East Gravesend area. The implementation of this development scheme would also allow the opportunity for the degraded SSSI land to the north of the application site to be suitably reinstated to a form and condition that would improve the habitat in accordance with a scheme agreed with Natural England.

3.10 As part of the development proposals, it is anticipated that the existing ground levels within the built area will be raised sufficiently (refer to the following sections for specific details) to remove the site from the Flood Risk Zone 3 area.

3.11 Taken as a whole, the wider development proposals are zoned sequentially, whereby the lower vulnerability flood risk land-class usage (industrial scheme) is located nearer to the River Thames, with the residential scheme sited further away to the south of the distributor road extension.

Exception Test

3.12 The Exception Test provides a method of flood risk management whilst permitting necessary development. For a proposed development to meet the Exception Test, three key criteria must be met. The criteria are as follows:

- It should be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared. This element of the test is applied by the Local Planning Authority;

- The development should be on developable previously developed land or, if it is not on previously-developed land, that there are no reasonable alternative sites on developable land; and
- A Flood Risk Assessment must demonstrate that the development will be safe, without increasing flood risk elsewhere and, where possible, will reduce risk overall;

Strategic Flood Risk Assessment

3.13 The Kent Thameside Strategic Flood Risk Assessment (SFRA) was produced by Entec UK Limited in 2005 and subsequently updated in December 2009. The SFRA was updated as a requirement of PPS25 and identifies the flood risk in the area.

3.14 The SFRA includes the assessment of flood risk due to breaches of the River Thames flood defences which have a design standard in excess of 1:1,000 years. A number of Tuflow breach models were developed based on a 1:1,000 year tidal/fluvial flood levels in the River Thames across the area. These breach models were determined from locations in the flood defences deemed most likely to fail.

3.15 An independent study of the SFRA was prepared by HR Wallingford in 2007 (refer to **Appendix D**) which concluded that the report did not provide quantitative information on the variation of flood risk across the embayment and in actual fact, flood risk is defined in flood risk management terms as 'probability x consequence'. As the SFRA is concerned with the implementation of new development, the consequence is a function of the development design.

3.16 The SFRA only provides qualitative information on flood risk and it remains for the impact of the development to be evaluated. The standard of protection offered by the Thames Tidal Defences is unique compared to the rest of the UK (1:1,000 year) and is far

greater than elsewhere (compared with 1:100 year for non-tidal and 1:200 year for tidal flooding).

3.17 Fragility curves have been derived for the defence system along the Shorne Marshes by HR Wallingford which illustrate that the probability of failure when the water levels are below the defence crest level. The technical note assessed that the statistical return period of a breach at GR8 together with a 1 in 1,000 year tidal event is likely to occur less than once every 100,000 years. Overtopping of the flood defences would also occur less than once every 10,000 years.

3.18 The presence of the Thames Tidal Defence System means that the annual probability of flooding at the development site is significantly less than 0.1% and the result of any breach scenario occurring under these conditions would in actual fact, be a probability less than 0.0001% to 0.00001%.

Breach Analysis

3.19 A breach analysis has recently been undertaken by Ardent Consulting Engineers and is appended to this report (**Appendix E** - Report Ref. B142-01: Flood Risk Modelling Report). The breach analysis sought to determine the impacts of the development on flood levels during the event of the River Thames flood defences being breached. The breach assessment also considered the possible introduction of the proposed industrial scheme that may be constructed to the north of Dalefield Way, which is currently being considered for consent, and the previously consented industrial area Phase 3 to the west (GR/2007/0678).

3.20 The breach analysis was developed using Tuflow and was based upon the updated Kent Thameside SFRA which was revised in December 2009. Hydrology data was obtained from the Environment Agency which had been used within the SFRA for an event modelled in the Gravesend area at a location named "GR8",

which related to a breach in the flood defences, as identified in **Figure 9** below:

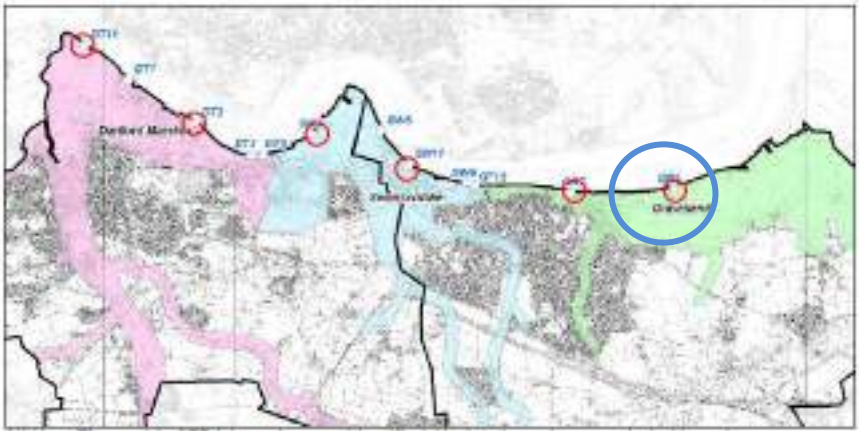


Figure 9 - SFRA Breach Location

3.21 LiDAR data was used to provide the geometry for the Tuflow model. The breach analysis included a model of the 1:1,000 year probability event, as provided by the Environment Agency.

3.22 The breach model analysis predicts a flood level at the development site of 3.38m AOD during the 1:1,000 year return period event during the existing scenario. With the proposed land raising to approximately 3.9m AOD at the development site, the Tuflow modelling predicted that the depth of flooding would marginally increase in the event of the River Thames flood defences failing. The standing advice generally offered by the Environment Agency however, only requires a 1:200 year breach event to be assessed and as such, the study of a 1:1,000 year event (due to the absence of any data relating to the 1:200 year tidal event), is an extremely conservative approach for a development scheme of this nature

3.23 The breach model was re-run to establish the impact of raising the ground levels in this particular area and identified that the water level would marginally rise by approximately 10mm at the development site (to a level of 3.39m AOD). Other areas away from the development site within the breach embayment showed

negligible changes (i.e. <5mm) and can therefore be considered unaffected by the development.

3.24 To accommodate the development proposals and maintain the pre-development floodwater levels in the event of a breach, a compensatory storage volume of approximately 7,200m^3 will need to be provided for the residential scheme. To deliver the compensatory flood mitigation measures, degraded SSSI land to the north of the site has been identified for land lowering and recent discussions with Natural England has established an agreement to the principle of this provision and the ultimate restoration of the SSSI land.

3.25 To offset this predicted marginal rise in water level, compensatory flood storage is proposed within the degraded SSSI land to the north of the development site. It is anticipated that this flood storage will be provided by lowering the land in these areas up to a maximum depth of 200mm, as illustrated in **Figure 10** below. This is an additional 100mm lower than the proposed reduction offered as compensation area for the proposed employment area located directly to the north of this proposed residential development.

Figure 10 - Extent of Flood Compensatory Works Area

3.26 The Tuflow model demonstrates that following the reduction in levels on the SSSI (i.e. <5mm), the additional increase of flood depths are negligible and there is no increase to the extent of the flood outline i.e. maintaining the status quo.

3.27 Meetings have been held with representatives of Natural England in both November 2009 and April 2010, to discuss the implications associated with lowering the existing ground levels in this area. It was acknowledged that the SSSI land identified is damaged and of poor condition in this particular location and the implementation of the development would provide the opportunity to improve the quality of the ecology and biodiversity. Having discussed these particular matters in detail, the Applicant's Ecology Consultant (Ecology Consultancy) has been continuing to liaise with each party to devise a suitable scheme which will allow the enhancement and improvement of the SSSI land to be achieved whilst addressing the future maintenance requirements of these areas.

3.28 Remodelling the breach analysis to include the proposed development and associated compensatory works confirmed that the predicted flood levels will be approximately the same as the predicted existing flood levels (i.e. pre-development level of 3.38m AOD).

3.29 The existing degraded SSSI land is to be rejuvenated to a favourable condition in consultation with Natural England and will be formally documented within a SSSI Grassland Management Plan, primarily comprising proposals to ensure:

- That the water quality and quantity in the existing ditches within the SSSI and Ramsar land is maintained, in accordance with the previously agreed strategy. To address this matter, off-site improvement/widening works to the existing ditches are proposed to attenuate the surface water run-off generated by the development proposals, supplemented by the introduction of a new watercourse;

- The lowered grazing marsh also provides specific lower areas of undulation to provide further habitat niches;
- The creation of topographical variety to maximise moisture variation and ecological areas;
- Development of a suitable planting plan to enhance the SSSI land and the new watercourse;
- Avoidance of works within 10m of the existing ditches (where possible);
- A suitable seed mix is used for grazing;
- On-going grazing/cutting to provide further ecological niches;
- The SSSI grassland management plan shall also include a post-construction planting list to aid the re-creation of typical grazing marsh flora;
- Appropriate consideration offered to undertaking the majority of the works during the summer months to minimise the potential for disturbance to wintering birds;
- A detailed mitigation and compensation strategy is prepared outlining a suitable action plan to manage any water voles, if encountered on-site;
- The on-going management and maintenance of the SSSI land (including the regular removal of fly-tipped material);
- The provision of suitable information boards outlining the restored SSSI character and associated access restrictions;
- To protect the water quality during the construction stage, a formal Construction Management Plan will be devised and agreed with the LPA to ensure that the construction operations are suitably controlled and managed;

3.30 Further details relating to the proposed flood compensatory works have been illustrated on drawing no. B142-010 appended to this report.

Access/Egress Routes

3.31 The adjacent access road known as Dalefield Way has previously been constructed to a level in the region of 3.5m AOD and will offer

occupants a means of dry and safe escape from the site, should a 1:1,000 year breach event occur in the Thames Tidal Defence System. Furthermore, the adjoining properties to the south of the site are located on higher land and will also offer a means of dry and safe escape from the site.

3.32 The residential development is located at a level approximately 500mm higher than the predicted flood level within the breach model undertaken as part of this assessment for the 1,000 year breach of the River Thames flood defences. Interrogation of the flood extents from the SFRA drawings and paired against the LiDAR suggests that the SFRA predicts a breach flood level of 3.45m AOD which again is well below the proposed level at the development of 3.9m AOD.

3.33 It is recommended that the units are registered with the Environment Agency's 'Floodline Warnings Direct Service' to receive advanced information regarding the flood risk status in the area, thus allowing appropriate evacuation measures to be implemented as necessary.

4.0 SURFACE WATER DRAINAGE STRATEGY

4.1 This drainage strategy has been prepared based upon the parameters and flow conditions previously established and agreed by Ardent and Buchanan Consulting Engineers, HR Wallingford, the Environment Agency and English Nature/Natural England on the Heronsfield Development (GR/99/168) and the adjacent industrial consented scheme known as Phase 3A (GR/2007/0678).

4.2 HR Wallingford previously constructed an ISIS model of the existing drainage watercourse regime to establish the post-development water level in the open channels for the over-arching drainage strategy. The analysis determined that the ambient water level in the open channels was approximately 1.70m AOD with levels rising to 2.04m AOD when subjected to a 1:100 year event. Refer to **Appendix I** of this report for confirmation of the methodology adopted and the results of the assessment.

4.3 As mentioned in the previous section of this report, the existing watercourse channels modelled by HR Wallingford are inter-connected around the application site and the wider area, thus providing hydraulic continuity. For the purposes of this strategy, the objective is to provide sufficient on-line attenuation to ensure that the water levels in the open channels do not rise above the post-development level of 2.04m AOD when the site is developed, thus maintaining the status quo.

Pre and Post-Development Run-off

4.4 The surface water drainage strategy for the scheme proposes to discharge freely into the adjacent watercourse with the necessary volume of attenuation provided on-line, with modification of the existing watercourse to implement the necessary flood levees. Off-site flows continue to be controlled to previously agreed rates in accordance with the consented drainage strategy implemented in 2001 (Ref. GR/99/168).

4.5 As the existing site is greenfield in nature, the surface water drainage proposals will be assessed adopting a commensurate discharge rate. Using the following design parameters and the rates previously agreed for the catchment area of 7 litres/sec per hectare (as agreed with the Environment Agency), the application site has been assessed using a dummy limiting flow of 32.20 litres/sec. Any significant lower rate will deviate from the strategy previously agreed for the site-wide area and may cause lower water levels to occur - thus, preventing the frequent wetting of the adjacent land/flood levees desired by Natural England. The Environment Agency has previously confirmed that the drainage strategy and run off rates previously implemented for the earlier phases of development will be suitable in this instance (refer to the letter dated 6th July 2000 appended to this report).

Attenuation Provision

4.6 To drain the development scheme in a sustainable manner, whilst complying with the requirements of PPS25, the strategy should seek to implement an appropriate sustainable urban drainage systems (SUDS).

4.7 Typically these forms of SUDS provision could comprise utilisation of either infiltration drainage devices to discharge surface water to the underlying soil stratum (where ground conditions permit), basins and ponds, on-line watercourses and flood levees, filter strips and swales, permeable surfaces, geo-cellular infiltration/attenuation units and over-sized pipes/culverts.

4.8 Adopting the design parameters outlined below, a preliminary attenuation assessment has been conducted using Micro Drainage's WinDES hydraulic modelling suite.

4.9 Within the simulations, we have also included an additional 30% provision as an allowance for any potential climate change impact,

in accordance with the requirements specified in Table B.2 of PPS25 for the scenario 2085 to 2115 associated with a residential scheme.

4.10 Refer to the summary tables below for the attenuation volume predicted for the proposed development scheme:

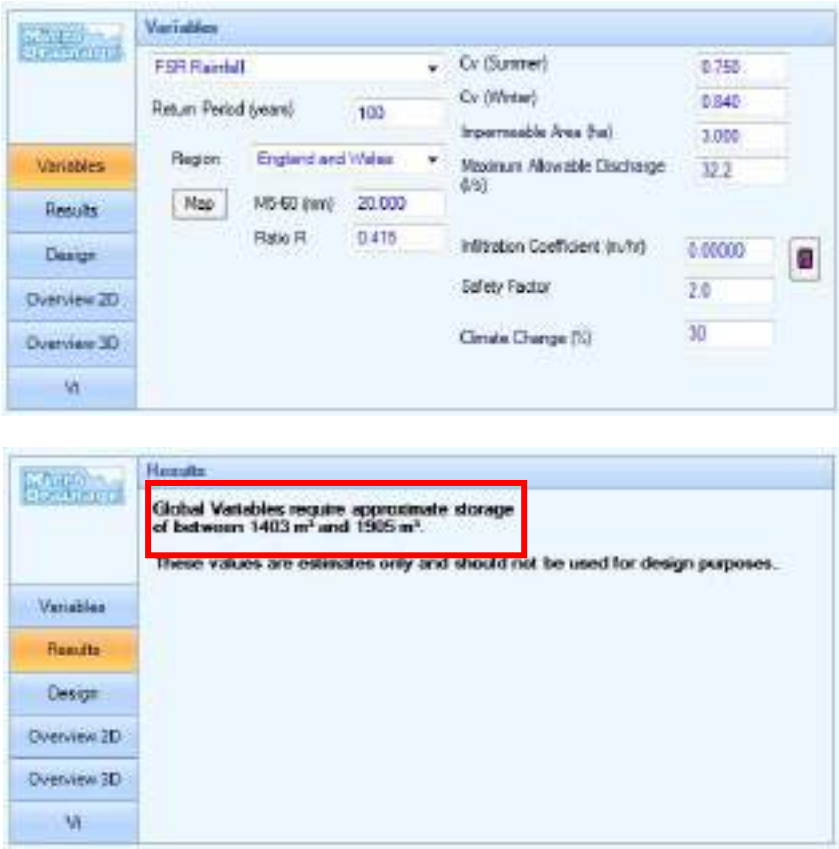


Figure 11 - Feasibility Attenuation Assessment

4.11 Based on the above-mentioned design parameters, the preliminary attenuation simulations predict that in the region of 1,403m^3 to 1,905m^3 will be required to maintain the existing water levels within the receiving watercourses.

Infiltration Drainage

4.12 The volume of attenuation stated above, assumes that all of the surface water run-off is conveyed to the receiving watercourse. This volume however, could potentially be reduced if the flows are also conveyed to the underlying soil stratum, should soil conditions

permit (but this could also affect the performance/levels of the levees).

4.13 An inspection of the British Geological Survey mapping for the area shows the site to be located on a geological drift boundary indicating the potential for alluvium drift deposits (comprising peaty silt and clay) to be underlying the land.

4.14 Furthermore, the Groundwater Vulnerability mapping for the area indicates that the site is also situated above a major aquifer, with high leaching potential.

4.15 An intrusive site investigation has been undertaken for the application site by Lustre Consulting. Reviewing the content of these reports, confirms that the site is underlain by silty sub soil, peat and alluvium over upper chalk and depth. Ground water was encountered in all intrusive test locations ranging from 0.7m to 1.7m, BGL.

4.16 In view of the findings outlined above and the intended future use for the land, it is considered that infiltration drainage techniques should be excluded from any further consideration due to the unsuitable ground conditions encountered on-site.

Surface Water Drainage Strategy

4.17 In view of the requirements of PPS25, the design parameters and constraints associated with developing this particular site, a surface water drainage strategy has been devised to demonstrate that the scheme can be suitably implemented without increasing the level of flood risk when the drainage system experiences a 1:100 year rainfall event (including an additional 30% for any potential climate change impact). The adopted design principles are as follows:

- The ambient water level in the open watercourse channel is 1.70m AOD;

- Post-development 1:100 year floodwater level within the watercourses shall not exceed 2.04m AOD;

- Attenuation provision has been assessed based on the previously agreed total greenfield discharge rate of 32.20 litres/sec, although the run-off will freely discharge into the receiving open channel watercourses and the flows controlled to agreed Greenfield rates downstream by the existing devices that have previously been installed to the north of the application site (adjacent to the railway line);

- Sufficient on-line attenuation shall be provided in accordance with the previously agreed strategy by excavating on-line flood levees to accommodate the volume of surface water run-off generated by the development scheme when subjected to a 1:100 year event (including climate change) to provide a maximum volume of 1,905m^3 (effective storage depth of 0.34m);

- Flood levees shall be excavated from a level of 1.65m AOD (i.e. below the ambient water level) to provide regular wetting, but the effective volume of attenuation has only been considered above the ambient water level of 1.70m AOD;

- The development's total impermeable catchment area is anticipated to be in the region of 3.0 hectares;

4.18 Details illustrating the surface water drainage strategy proposals have been provided on drawing no. B142-009, whereas the extent of the intended watercourse provision and flood levee excavation works are presented on drawing no. B142-010 for reference.

5.0 FOUL WATER DRAINAGE

5.1 The public sewer record plan provided by the Drainage Authority for the area (Southern Water), illustrates that there is an existing 300mm diameter foul water public sewer (increasing to 450mm in diameter further downstream) that crosses the site and continues through the adjacent Heronsfield development to the Sewage Treatment Works, as illustrated in **Figure 12** below:

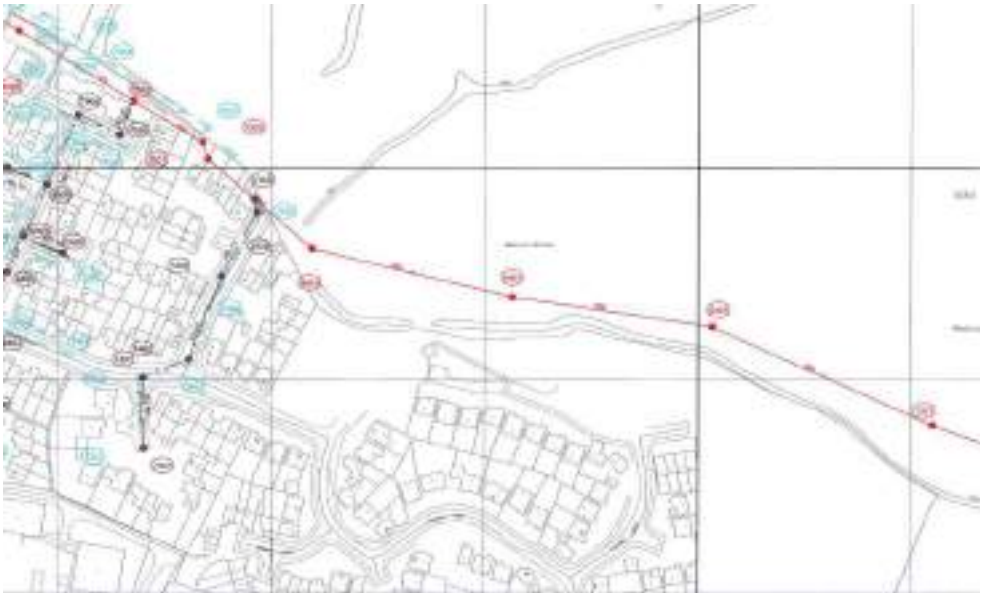


Figure 12 - Extract of Public Sewer Record Plan

5.2 The post-development peak foul water flows associated with this particular planning application for up to 130 residential dwellings is calculated to produce a peak flow of 6.1 litres/sec (based on 4,000 litres/unit dwelling per 24-hours, as per 'Sewers for Adoption').

5.3 A Level 1 capacity assessment (refer to **Appendix H**) has been prepared by Southern Water which confirms that the downstream sewer network will need to be locally upgraded to accommodate the foul water flows from the development. At present, the assessment has identified a potential connection location at the manhole referenced TQ66736502 which is situated within Dering Way and approximately 400m to the west of the site.

5.4 It is anticipated that the alignment of the existing 300mm diameter foul water public sewer will either be accommodated within the development layout (and the associated easement) or locally diverted under formal agreement with Southern Water's consent. In the event that the sewer is diverted, it could be upgraded to accept the development flows.

Strategy

5.5 To dispose of the foul water flows from the development, it is anticipated that a gravity draining system will be constructed on-site to direct flows into the public sewer network and utilise two points of connection.

5.6 As mentioned in the previous section of this report, the downstream section of the foul water public sewer will be locally upgraded in consultation with Southern Water to accept the additional flows generated by the development.

5.7 A foul water drainage strategy has been prepared and identifies the proposals to dispose of the foul water flows from the development scheme. These proposals are outlined on drawing no. B142-009.

5.8 The drainage strategy has been designed to demonstrate compliance with both Sewers for Adoption – 6th Edition and The Building Regulations 2000 - Part H: Drainage and Waste Disposal.

5.9 Based upon the design parameters and principles discussed previously in this report, it is concluded that following localised upgrading works (to be implemented by Southern Water under requisition) a suitable drainage system can be provided without having a significant material impact on the existing public sewer network.

6.0 SUMMARY

6.1 The land identified as PM9 in Gravesham Borough Council's adopted Local Plan is an allocated site identified for the potential implementation of a suitable industrial and residential development scheme.

6.2 Following an inspection of the Environment Agency's indicative floodplain mapping, the site is shown to partially lie within a Flood Risk Zone 3 area, albeit appropriately defended by the Thames Defence System for a 1:1,000 year event.

6.3 The level of flood risk associated with the site has virtually been eradicated due to the high standard of protection offered by the Thames Defence System. The fragility curves prepared by HR Wallingford confirm that the statistical return period of a breach occurring coinciding with a 1:1,000 year tidal event is likely to occur for a probability of less than 1:100,000.

6.4 The development proposals for the balance of the PM9 area have been sequentially zoned to locate less vulnerable flood risk properties (i.e. industrial units) nearer to the River Thames, with the residential houses being place on higher land outside of the flood inundation zone.

6.5 The Dalefield Way distributor road and its potential extension is of wider strategic importance for the future development of other areas of Gravesend, without which the successful delivery of these schemes cannot be easily foreseen.

6.6 The Environment Agency has confirmed that generally, the standard breach event to be considered relates to the 1:200 year scenario. However, in the absence of this event's base data, the breach assessment has been conducted using the 1:1,000 year hydrograph data (i.e. offering a precautionary approach to the modelling procedure).

6.7 Ardent Consulting Engineers has prepared a Tuflow model to assess the floodwater levels associated with a 1:1,000 year tidal breach event and established that the implementation of the development scheme without compensation would cause the water levels to marginally rise by 10mm to 3.39m AOD. Appropriate compensatory measures have therefore been proposed to mitigate this impact.

6.8 The Tuflow model previously prepared by Ardent for the 2009 industrial application has been re-run and established that the damaged SSSI land to the north of the site could be lowered by a further 100mm (approximately) to mitigate the impact of the residential development scheme (circa 200mm in total) and ensure the level of flood risk is not increased locally or to nearby properties. This 100mm reduction is in addition to the 100mm lowering proposed as part of the proposed employment site located to the north.

6.9 The proposed development is located within Flood Zone 3. A residential development would be subject to the Exception Test, however with the proposed land raising, the site would no longer be located within Flood Zone 3. With the proposed land raising, safe site access/egress is available from the site in the event of a breach of the River Thames's flood defences.

6.10 The proposal to undertake the compensatory mitigation measures also offers an opportunity to improve the quality of the SSSI land, particularly the ecology and biodiversity in the area.

6.11 To ensure the SSSI land is suitably reinstated, a suitable management plan will be formally produced and agreed with Natural England.

6.12 The water level within the watercourse networks will be controlled adopting the previously agreed site-wide strategy to ensure the existing conditions are maintained. Frequent wetting of the flood levees to promote the aquatic biodiversity of the reinstated SSSI

land, as desired by Natural England will be achieved by implementing the previously agreed reprofiling.

6.13 The site has been assessed adopting a greenfield discharge rate of 7 litres/sec per hectare (as previously agreed with the Environment Agency) and restricted by the slot weir devices previously installed downstream, adjacent to the railway line to control the flow for the catchment. The additional flows up to and including the 1:100 year event (plus an additional 30% as an allowance for any potential climate change impact) will be attenuated within the proposed open watercourse channel and flood levees to be constructed to the north of the application site.

6.14 The 8m wide buffer zone/easement associated with the existing watercourse is to be retained within the development layout.

6.15 It is considered that the requirements of PPS25 are satisfied as:

i. The development and its occupants are not at an increased risk of flooding;

ii. The development will not increase the level of flood risk to any existing development; and

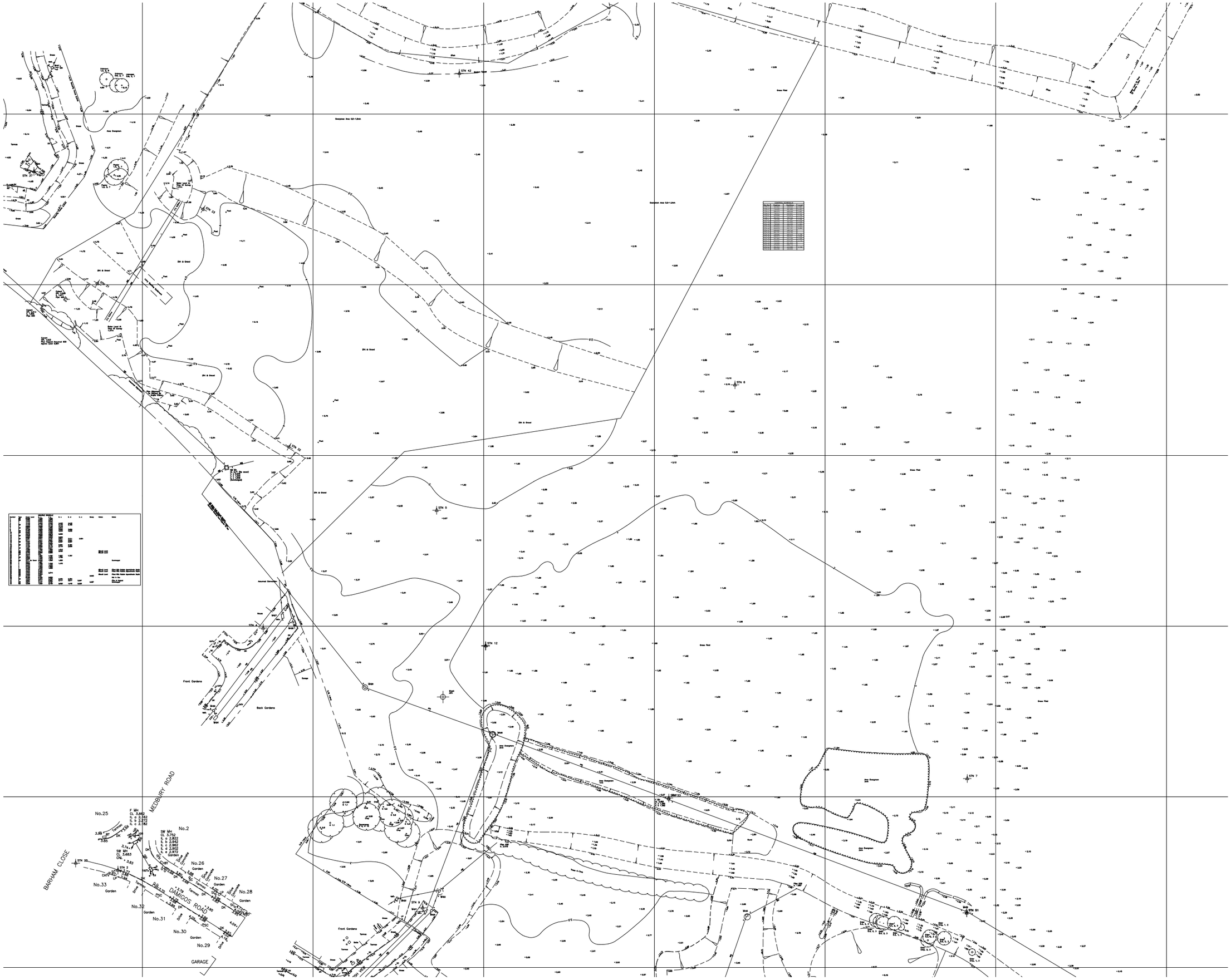
iii. The development can be drained in a sustainable manner;

6.16 Southern Water has advised that there will be adequate capacity within the existing downstream system to accommodate the predicted peak foul water design flows from the development scheme once the off-site improvement works are undertaken to the length of public sewer between the site and the manhole referenced 6502 within Dering Way.

6.17 We therefore conclude that the scheme satisfies the requirements specified within 'Planning Policy Statement 25: Development and Flood Risk' and therefore planning consent should be granted on flood risk and drainage matters.

Appendix A

Topographical Survey



MEDBURY ROAD
BARHAM CLOSE
DAMIGOS ROAD
GARAGE
No.25
No.2
No.26
No.27
No.28
No.29
No.30
No.31
No.32
No.33
STN 42
STN 33
STN 31
STN 6
STN 5
STN 12
STN 7
STN 9
STN 51

Appendix B

Public Sewer Record Plans

Westcourt
Marshes
Caravan
Park
8751
8751
Drain
Drain
Drain
Drain
Drain
Drain
6552
6559
6558
6502
6501
7504
7503
7505
7551
7502
7501
7405
7453
7404
7403
7452
7401
7402
6406
6405
7406
6404
6401
6402
6403
9401
9401
0401
300
300
300
KENT WEST EURO CONS
Westcourt Marshes
Westcourt Marshes

Appendix C

Masterplan Development Layout

MASTERPLAN

Key

- Site Boundary
- Development Cells
- Hub
- Amenity Space
- Protected Route
- Protection zone adjacent to RAMSAR ditch
- Spine Street
- Minor Street
- Internal Access
- Emergency Access
- Key Frontage
- LEAP
- LAP
- Existing Trees
- Proposed tree planting within Cells
- Proposed tree planting outside Cells
- Proposed specimen tree planting
- Physical / visual links

Figure 12: Masterplan

Appendix D

HR Wallingford Report:
Review of Kent Thameside SFRA Technical Note MCM5753/01

Westcourt Marshes

Review of Kent Thameside SFRA

Technical Note MCM5753/01

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Appendix
Appendix A

1. Introduction:

Ardent Consulting Engineers, on behalf of Fort Knight Group Plc, commissioned HR Wallingford (HRW) to undertake the following tasks in relation to a proposed development in North East Gravesend:

- Initial Review of the Kent Thameside Strategic Flood Risk Assessment (SFRA);
- Response to the conclusions of SFRA and an objection raised by the Environment Agency (EA);
- Initial discussion of any potential mitigation measures necessary.

This Technical Note describes the findings of the review of the SFRA and assesses the implications on the proposed development.

1.1 PROPOSED DEVELOPMENT

The proposed development comprises a number of sites in North East Gravesend as detailed on the plan shown in Appendix A provided by Ardent Consulting Engineers. The proposed sites include *Site 3* for which previous planning consent for industrial development has been granted.

The intention of the client is to obtain planning consent for mixed use development (residential and commercial) for *Site 3* in the first instance, and to subsequently seek consent for the overall development shown in Appendix A. This study takes into account these two separate phases.

A large part of the proposed development, including *Site 3*, is within Flood Zone 3 (High Probability) as defined in PPS25. The flood zones are defined on the assumption that the flood defences are not in place although the sites are defended by the Thames Flood Defences as detailed in the SFRA.

2. Review of the Kent Thameside SFRA

The requirements for an SFRA are covered by Sections E5 to E7 of Planning Policy Statement 25 (PPS25).

An SFRA is intended to consider flood risk, identify suitable sites in priority order based on the Sequential Test in PPS25, and then allocate development sites. For the Kent Thameside SFRA, a general assessment of flood risk for the area has been undertaken, along with a more detailed level of assessment for a number of pre-determined development sites.

Paragraph E5 of PPS25 states that decision-makers should use the SFRA to inform their knowledge of flooding and determine the variations in flood risk across their area. Paragraph E6 indicates that flood outlines should be produced for different event probabilities, impact, speed of onset, depth and velocity, taking into account the presence of flood risk management infrastructure. In the case of the Kent Thameside SFRA, flood outlines have not been generated for different probability events, and the flood risk management infrastructure has not been accounted for in a probabilistic approach.

2.1 FLOOD SCENARIOS EVALUATED IN THE SFRA

The floodplains of the Shorne marshes and Gravesend are defended by the Thames Flood Defences. The Kent Thameside Strategic Flood Risk Assessment (SFRA) identifies the main pathways of flooding to be overtopping, breaching of flood defences and failure to close frontager gates. As an assessment of risk the Kent Thameside SFRA defines the following:

Source	Pathway	Likelihood	Consequence	Risk
Flooding due to tidal surge in excess of the 0.1% event	Overtopping	Very Remote	High	High
Flooding during the 0.1% event	Breach	Remote	High	High
Flooding during the 0.1% event	Failure to close flood gates	Likely	Medium	High

2.1.1 Overtopping of Defences

The SFRA modelling uses defence heights of around 6.7 m AOD in Gravesend, then lower elevations of 5.6 to 6 m AOD on the western Shorne marshes taken from LiDAR (Figure 2.4 and Appendix C in the SFRA vol.2 Report). The overtopping model is an ISIS model of the River Thames with spill units representing the defences in Gravesend and the Shorne Marshes. These are connected to a reservoir unit representing the whole of the Gravesend Embayment. The reservoir unit specifies a relationship between area and level, which is used to calculate the water level in the embayment for a given inflow volume of water. This model does not include the other floodplains/embayments of the Thames Estuary which would also be inundated in an extreme event.

The flood event on the River Thames is a tidal event, with a total tide level at Southend of 6.4 m AOD. This is derived from a 3 m astronomic tide with a surge of 3.1 m (2.7 m surge from 1953 with an additional 0.4 m for waves) and 0.3 m sea level rise from the DEFRA 2003 climate change scenario for 2050 (page 28 in the SFRA vol.2 Report). The Halcrow 2002 report calculates that the 1 in 10,000 year, or 0.01% probability event is approximately 5.53 m AOD. This is also the present day 0.01% event used in the TE2100 projects. The event used in the SFRA is greater than the 0.01% event (even if the climate change is taken into account and the wave component viewed as uncertainty).

The results of the SFRA model show flood depths of approximately 1 to 2 m over the entire Gravesend embayment (Figure 4.3 in the SFRA vol.2 Report). Because the relationship between storage area and level has been generated for the entire embayment (Figure 4.1 and Appendix B in the SFRA vol.2 Report) this does not include the impact of local floodplain topography (features which act as secondary defences) on the spatial distribution of flooding in the embayment. All areas with low topography are shown to be flooded whether there is a valid flow path or not.

2.1.2 Breaching of Defences (SFRA Breach GR_8)

The breach inflow is determined from the ISIS model. The breach dimensions are 50 m wide at the base with side slopes of 1 m in 0.5 m. The base of the breach is assumed to be at ground level (approximately 2m AOD). The discharge coefficient of the spill unit is 1.7. The flood extents and depths on the floodplain are modelled using JFLOW, which spreads the flow from the breach according to topography.

The SFRA dismisses the results of the HR Wallingford 1996 study (refer to Section 2.2 below) into the impact of breaching on flooding behind the flood defences, because it did not use the present day EA guidance on the size of breach and used a simplified method to calculate flood extents.

The SFRA does use current EA guidelines on breach dimensions and a 50 m wide breach in the flood defence for the Shorne Marshes is modelled. Due to the low ground levels in the vicinity of the breach, large flow volumes pass on to the floodplain. These are enough to overtop the railway embankment and flood the area to the south, including the development site, to depths of 2 to 2.5 m (Figure 5.11 in the SFRA vol.2 Report).

The volume of flow through the breach is such that the entire low lying area of the embayment is flooded to significant depths. However, the railway embankment is likely to delay the onset of flooding in the southern marshes from the breach in the main flood defence.

Analysis of the probability of the breach in addition to the probability of the event to determine the overall probability of flooding is not undertaken as part of the SFRA.

2.1.3 Failure to Close Flood Gates (Breach GR_7)

This breach is a failure of the flood gates of the canal basin in Gravesend. The breach dimensions are different to that used for breach GR_8. The breach is 7.3 m wide and the base depth is at -1.8 m AOD, the side slopes will be vertical. The SFRA results show extensive flooding throughout the embayment with greatest flood depths in low lying areas close to the breach location in Gravesend. On the marshes flood depths are up to a maximum of 1 m (Figure 5.10 in the SFRA vol.2 Report). The volume of water passing through the breach is approximately half that in Breach GR_8.

In the SFRA model it appears that the breach allows free flow into the storage area for the entire embayment. It may therefore over estimate the amount of flood water that can flow through the breach because of constraints caused by local topography. The topographic map (Figure 2.3 in the SFRA vol.2 Report) shows ground levels are generally between 3 and 5 m AOD in Gravesend, which limits the duration of and amount of water that can flow through the breach.

2.1.4 Overall Assessment of Risk

The Kent Thameside SFRA does not provide quantitative information on the variation of flood risk across the area. This statement is based on the following observations:

- Flood risk is defined in flood risk management as 'probability x consequence'.
- As the SFRA is concerned with new development, the consequence is a function of the development design. The key variable that must therefore be considered is the probability.
- No attempt has been made to assess the probability of flooding of the scenarios used in the SFRA. The SFRA provides the following:
    - Extent of the floodplain with an 0.5% (1 in 200-year) annual probability of flooding (Zone 3 in PPS25).
    - Extent of the floodplain with an 0.1% (1 in 1000-year) annual probability of flooding (Zones 2 and 3 in PPS25)
    - Area outside the floodplain with an 0.1% (1 in 1000-year) annual probability of flooding (Zone 1 in PPS25)
    - Extent of the defended floodplain and associated Standard of Protection (SoP). In the case of North East Gravesend, the area has tidal flood defences that

protect against a flood with an 0.1% (1 in 1000-year) annual probability of flooding.

- Within Zone 3, areas of High, Medium and Low residual risk are defined in the SFRA. However, these are subjective definitions that are unrelated to probability.

The SFRA only provides qualitative information on flood risk. This cannot be directly compared with results from SFRAs which cover defended areas elsewhere in the country as the Standard of Protection (SoP) on the Thames is higher.

The SoP provided by the Thames Tidal defences is unique in the UK, and much higher than the indicative standards adopted elsewhere (1% or 1 in 100-years for non-tidal flooding and 0.5% or 1 in 200-years for tidal flooding). The presence of the Thames Tidal defences means that the annual probability of flooding at the development site is less than 0.1%.

2.2 PREVIOUS STUDY - HR WALLINGFORD 1996 STUDY

The HR Wallingford 1996 study used historical breach sizes observed on the defences in the 1953 tidal flood on the Thames. The geometry of the modelled breach is as follows; 18.3 m wide and 2 m in depth below the defence crest (i.e. the crest level of the breach is about 4.2m AOD). The study also assumed that the breaches occurred at HW, which was what was observed in the 1953 event.

The weir equations used by HR Wallingford in 1996 are unlikely to be greatly different to those used in the spill unit of the ISIS model in the SFRA to calculate the flow through the breach. The study assumed that the ground level on the floodplain was 2 m AOD. Because the topography of the area is so flat and well defined the storage area relationships derived from OS maps are unlikely to be greatly different from those derived from LiDAR.

This produces smaller volumes of flow through the breach in a 1 in 1000 year event than the SFRA method, mainly because the breach width and depth are both less than the dimensions used in the SFRA. The results showed water depths of around 0.06 m for a single tide, and for a further two consecutive tides would raise it by another 0.14 m. The smaller volumes of flow through the breach calculated by HR Wallingford were not enough to overtop the railway embankment and flood the development site. The calculations tie in with the historical evidence that the railway embankment was not overtopped in the 1953 event.

2.3 INDEPENDENT ANALYSIS

As part of this study, simple checks of the results of the SFRA were undertaken using available models and data. It should be noted that these analyses do not include local survey detail and as such the results are not suitable for detailed design purposes.

2.3.1 Defence levels

Existing defence data shows that crest levels at Gravesend generally vary between 6.7 and 7.2 m AOD. There are a few low points at around 6 m AOD and also some higher points. On the Shorne Marshes the defence crest levels are generally between 6.5 and 6.7 m AOD with some lower spots at 6.33 m AOD.

2.3.2 Overtopping of Defences

The analysis undertaken as part of this study, using an ISIS flood cell model, indicates that the Shorne Marshes are not flooded in the 1,000 year or 10,000 year tidal events. The peak level for the present day 1,000 year event is 5.03 m AOD and for the 10,000 year event is around 5.51 m AOD at Southend. At the Shorne Marshes this level is approximately 5.75 m AOD in the 1,000 year event and 6.1 m AOD in the 10,000 year event. The defence crest levels tend to be 0.5 m to 1 m above the 0.1% water level. This is because of the freeboard built into the defences to account for uncertainty in the estimated water level and the impact of waves. The defence levels are also at least 0.2 m AOD above the 0.01% water level. The Shorne Marshes and the development sites are therefore not flooded in this event. The probability of inundation of the marshes from overtopping of the defences is therefore less than 0.01%, although this does not take account of freeboard on the flood defences. This is understood to be about 0.7m at Gravesend.

A test was carried out with the same boundary conditions for the River Thames as used in the SFRA study for overtopping. The ISIS flood cell model of the estuary used for the modelling included overtopping in other parts of the estuary, thus reducing tidal volume and water levels at Gravesend. This is more realistic than the assumption used in the SFRA that flooding would only occur in the vicinity of the development site (refer to Section 4.4 of the SFRA vol.2 Report) site. The results of this model show that there is little inundation south of the railway embankment. This model did not however include flow through culverts under the railway embankment, which may lead to greater flood depths if there are not tide flaps on the culverts.

2.3.3 Breaching of Defences/Failure of Flood Gates

The ISIS flood cell model of the estuary was used to calculate the flow through the breach and water levels on the floodplain. This method calculates the flow volumes in a similar way to the SFRA model but includes the impact of local topography to the breach. The floodplain inundation is a simplified method compared to the approach used in the SFRA because it does not account for flow times across the floodplain, but the peak water level should be similar. This model is used as a check that the railway embankment is overtopped and the area to the south, including the development site, would be flooded. The 1 in 1,000 year or 0.1% probability event on the Thames was used for the breach modelling, as in the SFRA (Page 38 and Section 3 in the SFRA vol.2 Report).

The model results for the Breach GR 8, a 50 m wide breach in the earth embankment defences on the Shorne Marshes, shows similar inflow volumes and flood extents as the SFRA modelling. This confirms that breach flow volumes are such that the railway embankment would be overtopped and the development site flooded to depths of 1 to 2 m. If the breach was located further away from the development site the depth of flooding at the site may be reduced.

The results for Breach GR 7, failure of flood gates, are significantly different from those of the SFRA model. The flow volume through the breach is significantly smaller, approximately 400,000 m^3 compared to 3,100,000 m^3. This is because the topography local to the breach in Gravesend constrains the volume of flow through the breach. This does not flood the development site to the south of the railway embankment. The breach was also re modelled using the storage area relationship for the entire embayment which gave similar inflow volumes as the SFRA model.

2.3.4 Fragility of Defences

The probability of the breach needs to be taken into account in addition to the probability of the source event. This can be expressed in the form of fragility curves which relate a defence

condition grade to probability of failure for different water levels. The generic fragility curve used for defences of condition grade 2, the condition of defences on the Shorne Marshes, is shown in Figure 1.

The fragility curve shows that the probability of defence failure when water levels are below the defence crest level is around 0.02%. The 1 in 1,000 year water level is considerably below the crest level and a breach is therefore unlikely. Once the water level becomes greater than the crest level the probability of a breach increases rapidly. However this would require an event of around 1 in 10,000 years.

It should be noted that these fragility curves are currently under review and that site specific data has not been used. However, these fragility curves provide an initial estimate of the likelihood of defence failure for a given event.

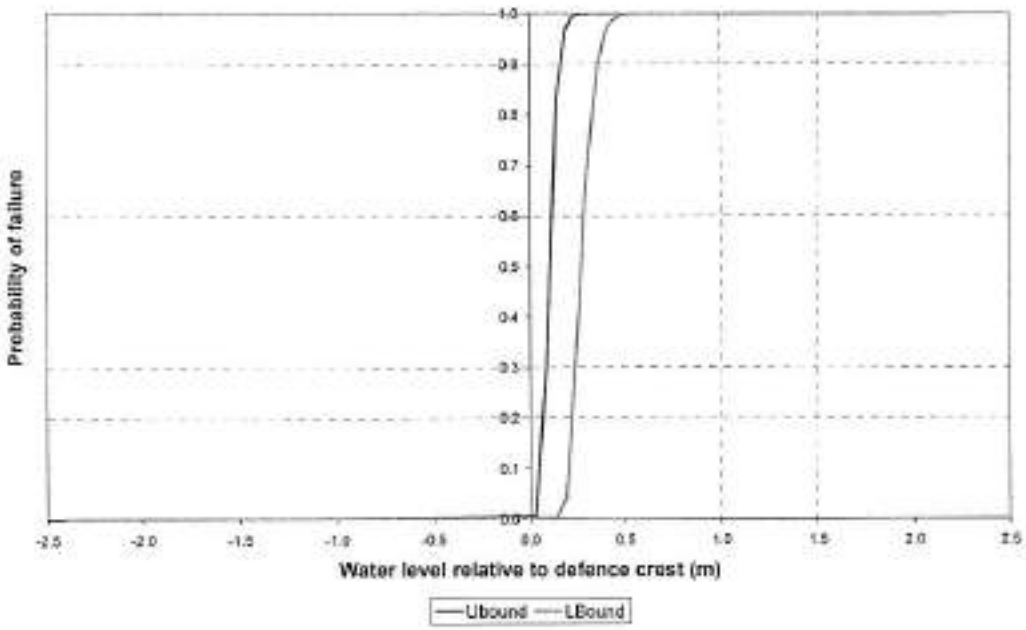


Figure 2 Generic fragility curve for condition grade 2 flood defences

2.4 CONCLUSIONS

With regards to the three pathways of flooding covered by the SFRA the following conclusions have been made.

2.4.1 Overtopping of Defences

- It would take an extraordinary overtopping event to cause flooding at the site (annual probability of occurrence far less than 0.1%). The following observations are made on the SFRA analysis:
    - The SFRA defence levels are about 0.5m to 1m lower than those obtained from existing records;
    - The SFRA flood levels are greater than an 0.01% (1 in 10,000-year) annual probability of flooding event;

  - The SFRA analysis treats the marshes as a single reservoir and does not appear to take account of the canal and railway embankment.
- An independent hydraulic analysis using the same tide as the SFRA indicates that there would be little inundation south of the railway embankment.
- It is concluded that the overtopping event used in the SFRA (which has an annual probability of <0.01%) would be unlikely to cause flooding at the site. Smaller events would not overtop the defences.

2.4.2 Breaching of Defences

- A 50m breach was modelled in the embankment protecting Shorne Marshes. This size is consistent with EA guidance.
- Flooding is predicted in the area south of the canal and railway, including the development site, to depths of 2 to 2.5 m.
- An independent hydraulic analysis shows that the SFRA model results for this scenario are reasonable.
- It is concluded that the breaching event would flood the site. However the annual probability of this event would be <0.1% (1 in 1000-years). This is because the SoP provided by the defences is about 0.1%, and the probability of failure is small (much less than 1).

2.4.3 Failure to Close Flood Gates

- The failure of the flood gates of the canal basin in Gravesend is represented by a breach 7.3 m wide with a base level at -1.8m AOD. The SFRA results show that this would flood the site.
- An independent hydraulic analysis indicates that flooding of the site would not occur. The SFRA analysis appears to over-estimate the flood volume. The independent analysis shows that flow into the embayment is restricted by ground levels in Gravesend.
- It is concluded that failure of the gates at the canal basin would be unlikely to cause flooding at the site.

2.4.4 Summary of Independent Analyses

Overall, it is concluded that only scenario 2 (breaching) would cause flooding at the site. However, the probability of this event is remote (<0.1% per annum).

3. PPS25 and Implications on Development

3.1 SEQUENTIAL TEST

The PPS25 sequential test aims to direct development towards low probability hazards identified by flood zone 1 or 2. The Thames embayments are in zone 3 which means they would be inundated by the 0.5% flood if the flood defences were not there. The policy in PPS25 is that, "only where there are no reasonably available sites in Flood Zones 1 or 2 should decision-

makers consider suitability of sites in Flood Zone 3, taking into account the flood vulnerability of land uses and applying the Exception Test if required".

Therefore, to satisfy the above policy, it needs to be demonstrated that no appropriate sites within Flood Zones 1 and 2 are available before development in Flood Zone 3 can be considered. In this case, the Exception Test is applied.

3.2 EXCEPTION TEST

Only where it is not possible to allocate development to sites in accordance with the Sequential Test is the Exception Test applied. The Exception Test is intended to make provision for sites where flood risk is outweighed by wider sustainability considerations and is designed to ensure that the flood risk is controlled and mitigated to an acceptable level.

The Exception Test includes three conditions, all of which must be fulfilled by all (other than minor developments) planning applications:

> a) it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk;
>
> b) the development should be on developable previously-developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously-developed land; and
>
> c) a FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Conditions a) and b) are planning issues and are therefore outside the scope of this study. However, the client will need to identify and prove that there are insufficient sites on developable previously-developed land and also demonstrate that wider sustainability benefits will be delivered to satisfy these conditions.

It is also worth noting that *Site 3* has previously been granted consent for industrial development and therefore the Local Planning Authority may consider treating this site differently to other greenfield sites, thus making condition b) less stringent for this specific application.

Condition c) has been considered as part of this study as outlined below.

4. Impacts of Proposed Development on Flood Risk

To ensure the proposed development is safe, one option would be to raise land levels above the design flood level. However, the impact of this loss of floodplain storage on surrounding areas would need to be mitigated. As part of this study a preliminary assessment of the impacts of this land raising on water levels has been undertaken for the *breaching of defence* scenario only.

This assessment has been undertaken for both the initial planning application (*Site 3*) and for the overall development.

4.1 SMALL APPLICATION (SITE 3 – PREVIOUSLY CONSENTED INDUSTRIAL LAND)

For the mall application it has been assumed that *Site 3* is entirely raised to 3.8m AOD. The relationship between area and level has been modified for this storage area to account for the land raising, as shown in Figure 3, with the areas of floodplain lost also tabulated in Table 1 on vertical intervals of 0.5m.

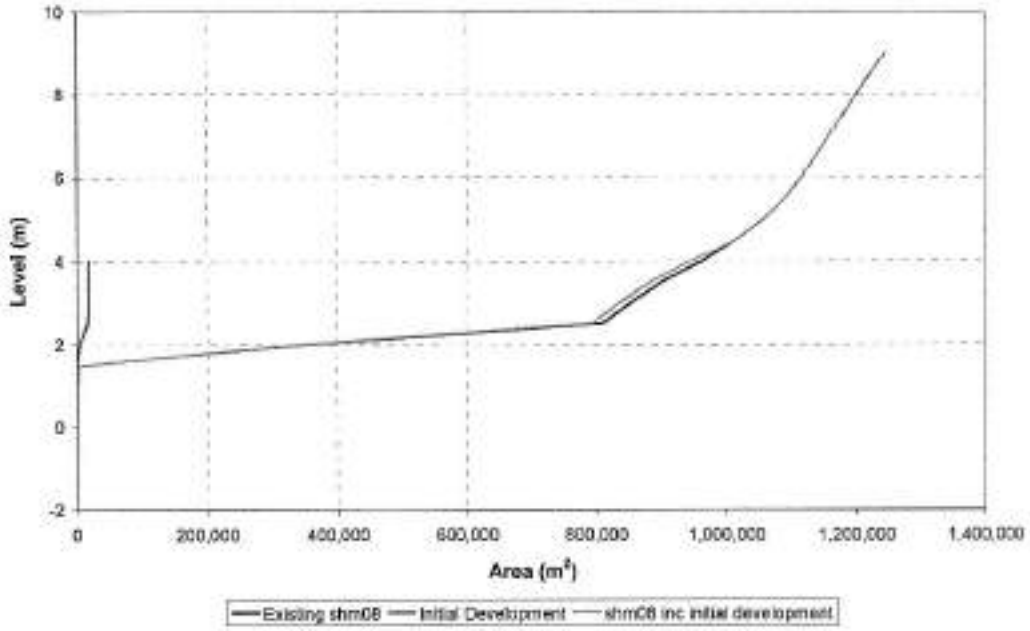


Figure 3 Relationship between storage area and level, including the impact of raised development

Table 1 Tabulation of the area lost due to development at different elevations

Elevation (m AOD)	Area (m^2)
1.5	0
2.0	4500
2.5	17000
3.0	17486
3.5	17486
4.0	17486

The breaching of defences scenario has been evaluated using this modified storage relationship to calculate the change in peak water level in the embayment. The results of this are shown in Table 2.

Table 2 Water level difference due to initial development

Location	Water level difference (mm) following raised development
North of railway, west of breach	0
North of railway, Breach	0
North of railway, east of Breach	0
North of railway, east of Breach	0
North of railway, east of Breach	0
North of railway, east of Breach	0
South of railway, west of Breach	0
South of railway, south of Breach	10
South of railway, east of Breach	10

These results show that there is little change in peak water levels due to the loss of storage area from the raised development. Flood levels are increased by 10 mm in the marshes south of the railway line where there is some existing development.

4.1.1 Proposed Mitigation

To satisfy condition c) of the Exception Test within PPS 25, adequate mitigation to ensure flood risk is not increased elsewhere would need to be demonstrated.

To provide adequate mitigation compensatory floodplain storage could be provided within the SSSI land area as part of an overall ecological enhancement project linked to the proposed development. Detailed analysis would be required to demonstrate that the compensation would mitigate the increase in flood levels and the environmental impacts of lowering levels within the SSSI site would need to be considered as part of a broader environmental assessment. Typically, compensation would need to be provided on a level for level basis although the Environment Agency may accept compensation at lower levels if this can be demonstrated as being effective in mitigating the increased flood levels resulting from the proposed development.

4.2 LARGE APPLICATION (OVERALL DEVELOPMENT)

This assessment has conservatively assumed that the entire development site, including the SSSI zone, of 458,555 m^2 is raised to a level of 3.8 m AOD. The relationship between area and level for this flood storage area has been modified to account for the land raising, as highlighted in Figure 4 below. Table 3 summarises the areas of flood plain storage lost in 0.5m horizontal slices.

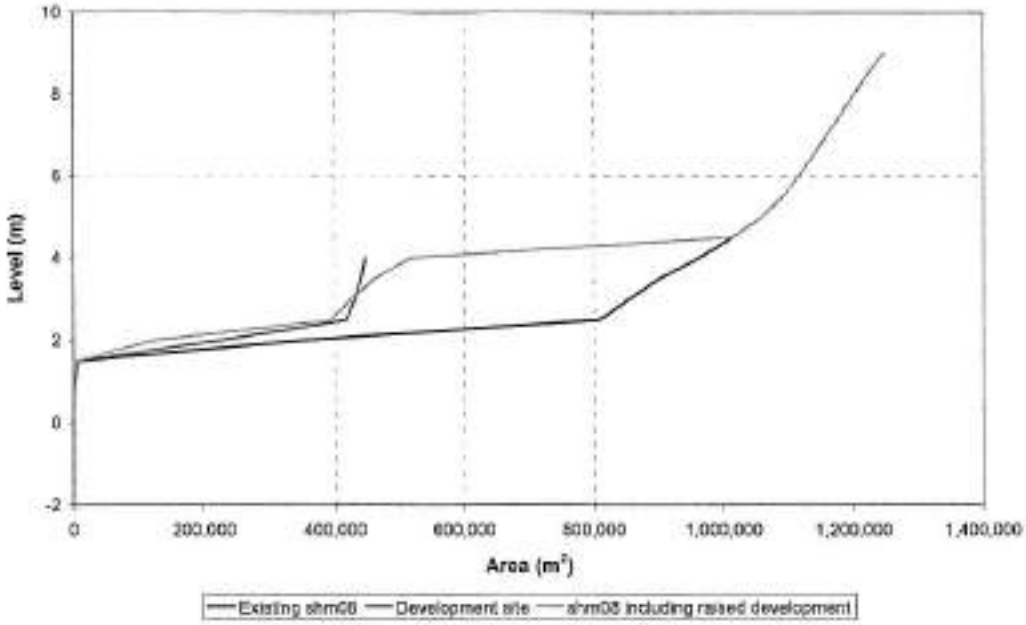


Figure 4 Relationship between storage area and level, including the impact of raised development

Table 3 Tabulation of the area lost due to development at different elevations

Elevation (m AOD)	Area (m2)
0.5	0
1.0	1300
1.5	3500
2.0	224032
2.5	417308
3.0	430392
3.5	440336
4.0	446460

The breaching of defence scenario has been run with this modified storage relationship to calculate the change in peak water level in the embayment. The results of this are shown in Table 4.

Table 4 Water levels with and without raised development

Location	Water level difference (mm) following raised development
North of railway, west of breach	0
North of railway, Breach	0
North of railway, east of Breach	30
North of railway, east of Breach	0
North of railway, east of Breach	0
North of railway, east of Breach	0
South of railway, west of Breach	280
South of railway, south of Breach	310
South of railway, east of Breach	310

Flood levels are increased by 30mm in the immediate vicinity of the breach. This land is undeveloped marsh. The small change in water level is due to the large storage volume in the embayment. It should be noted that the peak increase in water level is approximately 300 mm in storage areas south of the railway. This occurs for a short duration, after which the increase in water levels are 100 mm.

4.2.1 Proposed Mitigation

To satisfy condition c) of the Exception Test within PPS 25, adequate mitigation to ensure flood risk is not increased elsewhere would need to be demonstrated. Due to the increase in water levels, mitigation measures would need to be provided. These could include:

- Construction of new defences around existing development that would be affected by the increase. These should not affect existing land drainage. Areas where defences are required may include:

  - Existing development at West Court;
  - The sewage works and adjacent development;

  New defences will further raise water levels in the area, and will also require enhancement of the land drainage system to avoid increasing fluvial flood risk. If this increase in flood levels is limited to the marshes and away from developed areas then this may be acceptable to the Environment Agency.

- Improving flow paths across the marshes so that floodwater is diverted eastwards into the main marsh areas. This could of course worsen flooding elsewhere, and new local defences may be needed.

Any proposed mitigation measures would require detailed analysis to ensure that adequate mitigation could be provided and the environmental impacts of any such measures would also need to be considered. The location of any proposed mitigation measures would need to be a key consideration in the development design process and in determining the final layout of the development.

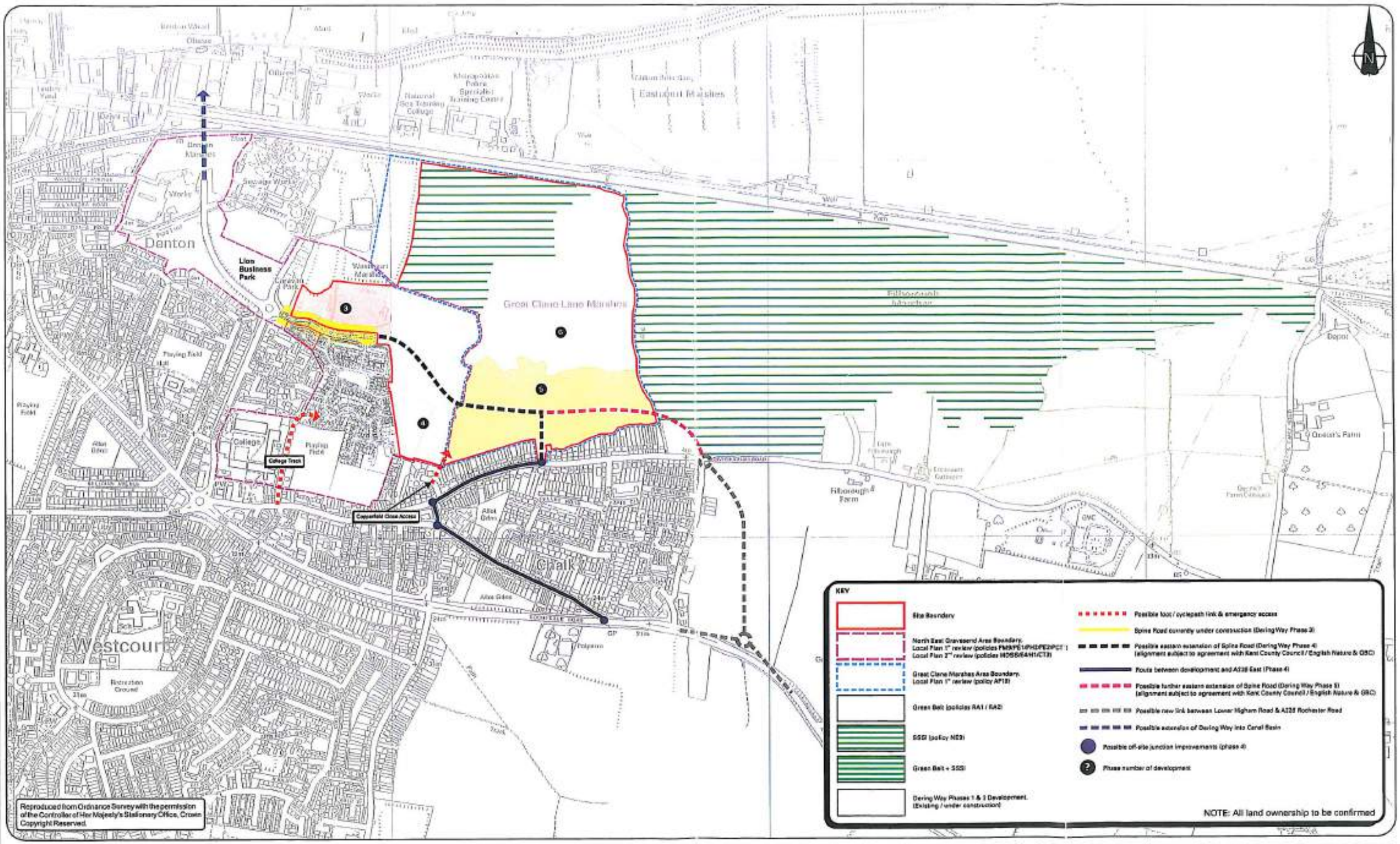
5. Conclusions

Following a review of the Kent Thameside SFRA, and consideration of the location of the proposed development sites, it is concluded that all the sites at North East Gravesend are well defended from inundation and that only the breaching of defences scenario identified in the SFRA would cause flooding at the site. However, the probability of this event is considered as remote and would be contingent upon a serious breach during a large (1 in 1,000 year return period) surge event. Further to this, it is highly probably that existing flood defences in this area will be maintained by the EA into the future, and therefore significant deterioration of these defences is unlikely.

However, the Local Planning Authority and the Environment Agency may still object on the basis of the policies defined in PPS25, and in particular the conditions relating to the Exception Test. If conditions a) and b) of the Exception Test can be satisfied on planning grounds then it is recommended that detailed investigation of potential mitigation measures for both the Small (*Site 3*) and Large applications is undertaken.

At this stage it is recommended that any further analysis or detailed modelling and investigation of mitigation measures awaits the resolution of the planning issues and confirmation that development of the sites is acceptable in principle by the local planning authority.

Appendix A



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Project Title	Client
Gravesend Masterplanning	Barratt Eastern Counties

Drawing Title: Opportunities for Additional Eastern Access & Potential Off-Site Highway Improvements

Scale	Date	Designed
NTS	02/03/06	ML
Drawn	**Checked**	**Approved**
AB	ML	CBP

Drawing No.: B330-04 (FIG. 5)

Rev

Appendix E

Flood Risk Modelling Report
(Ref. B142-01)

FORT KNIGHT GROUP, SUNRAY DEVELOPMENTS LIMITED AND KENT COUNTY COUNCIL

LAND AT PM9, NORTH-EAST GRAVESEND: PROPOSED RESIDENTIAL DEVELOPMENT

FLOOD RISK MODELLING REPORT

PROJECT NO. B142
REPORT REF. B142-01
JANUARY 2011

PROPOSED RESIDENTIAL DEVELOPMENT OF LAND AT PM9 NORTH-EAST GRAVESEND

FLOOD RISK MODELLING REPORT

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PROJECT NO. B142
REPORT REF. B142-01
JANUARY 2011

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Drawing B142-05: Tuflow Model Schematic

Drawing B142-06: Pre-Development Flood Outline

Drawing B142-07: Post-Development Flood Outline

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DOCUMENT CONTROL SHEET

REV	ISSUE PURPOSE	AUTHOR	CHECKED	REVIEWED	APPROVED	DATE
-	Planning Application	KW	SJB	ARF	CBP	25/01/11

1 INTRODUCTION

1.1 Ardent Consulting Engineers has been appointed by Fort Knight Group Limited, Sunray Developments Limited and Kent County Council to prepare a modelling report detailing the flood risk from a breach of the River Thames for a flood embayment at Gravesend. The report has been prepared in support of a residential development proposal in the north-east Gravesend area.

1.2 It is proposed by the Client to develop land located to the north-east of Gravesend for residential purposes. The site lies within an area known as Westcourt which is situated to the north-east of Gravesend and occupies a portion of land allocated as PM9 within Gravesham Borough Council's Local Plan.

1.3 This report summarises the two-dimensional modelling of a breach of the flood defences on the River Thames, based upon data obtained from the Kent Thameside Strategic Flood Risk Assessment (SFRA). The modelling assesses the impact of land raising within the embayment on flood levels and also assesses the mitigation provided to reduce the impact of land raising.

1.4 The report is submitted to support the planning application and to obtain an approval in principle that the proposed land raising and compensatory land lowering is acceptable. The objective of the report is to outline the extent of land filling and cutting and outline the modelling methodology and results.

2 BACKGROUND

Site Setting

2.1 The proposed development scheme is situated in the north-east of Gravesend, Kent as shown on the site location plan of Figure 1, below). The site is centred on the Ordnance Survey grid reference of 567100mE, 173300mN.

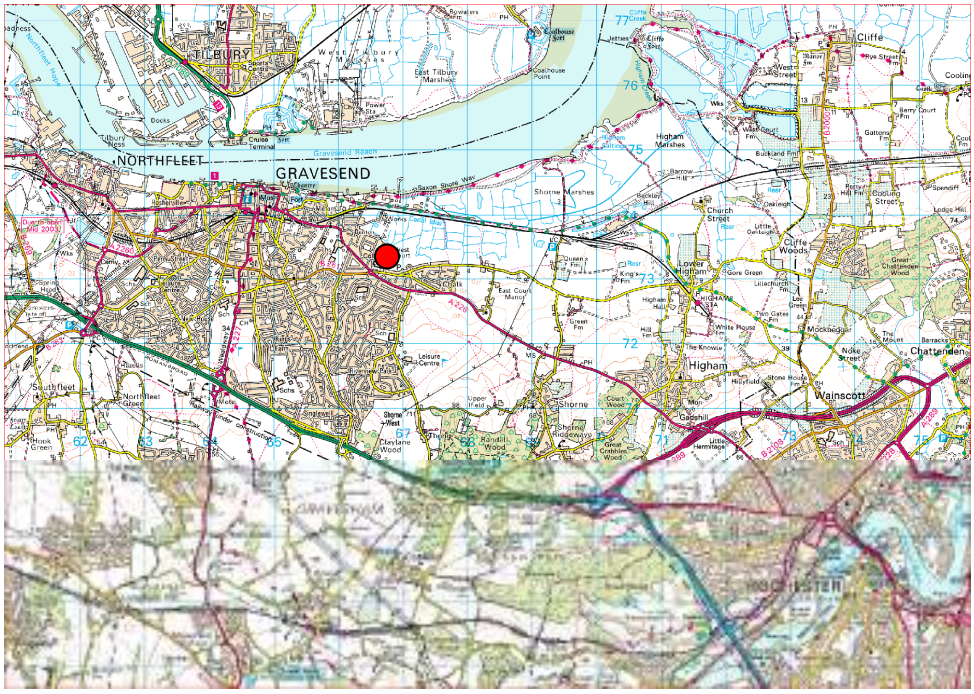

Figure 1 – Site Location Plan

2.2 The area of land set aside for land raising (herein referred to as the development site) lies within an area known as Westcourt which is situated to the north-east of Gravesend and occupies a portion of land allocated as PM9 within Gravesham Borough Council's Local Plan. The existing landform of the larger area west of the marshes is generally at a level of between 3.0m – 8.0m AOD and comprises top soil above alluvium, underlain by clay and chalk material.

2.3 The larger strategic development area is located within the defended floodplain of the River Thames and is classified as Flood Zone 3 (greater than 1 in 100 year and 1 in 200 year chance of flooding

from fluvial and tidal sources respectively). This places the site within an area of "high" risk of flooding, although the area benefits from well-maintained flood defences on the River Thames.

2.4 The development site and the proposed industrial area lie within an area known as Westcourt, which is bound to the north by the railway embankment. Within the north-west portion of the land lies a damaged SSSI site (see **Drawing No. B142-04 Development Area**). Whilst the SSSI is low lying and flat, the proposed mitigation works would improve the quality of the damaged SSSI land. The results of discussions with Natural England suggest that lowering of the land in the damaged SSSI area would promote enhancement and aid restoration of the SSSI.

2.5 The total area of the development site is approximately 4.6 ha, ranging in ground level from 3m AOD in the north to approximately 8m AOD in the south. It is proposed that the development site is raised to a minimum level of 3.9m (where required) in order to allow for surface water drainage of the development and to reduce the level of flood risk to the site development.

Strategic Flood Risk Assessment

2.6 The Kent Thameside Strategic Flood Risk Assessment (SFRA) was completed in December 2005 by Entec (UK) Ltd to determine the flood risk at strategically allocated sites. It was updated in December 2009, in-line with PPS25.

2.7 The SFRA includes breach modelling of the River Thames within its study area, as the area forms part of the Thames Estuary floodplain. The Thames Estuary is protected by flood defences along the River Thames up to a design standard exceeding 1:1,000 year probability.

2.8 Of the breaches modelled in the SFRA, two are relevant to the Gravesend area: Gravesend Breach 7 (GR7) and Gravesend Breach 8 (GR8).

2.9 GR7 is located at the entrance of the canal basin at Gravesend and represents a failure of the gates to the canal basin. GR8 is located in the earth embankment defences protecting Eastcourt. This breach is significantly larger in size compared with GR7 at 50m wide and 1:2 side slopes, with the breach elevation set to normal ground level. The Tuflow modelling of the breach at GR8 showed widespread flooding across the Gravesend flood embayment for a breach based on 1 in 1,000 year tidal levels. Flooding from the breach at GR7 was significantly less than for that from the breach at GR8 and is shown in the SFRA not to reach the development location. Modelled breach extents for GR7 and GR8 derived from the SFRA are shown in **Appendix C**.

Other Previous Reporting

2.10 In 1996 a modelling report was produced by HR Wallingford detailing the level of tidal flood risk to the flood embayment at Gravesend. It stated that the River Thames flood defences are higher than the predicted 1 in 1,000 year tidal levels. It also concluded that any breach of the defences would be minor in flood volume with breached water likely to pond up behind the raised rail / canal embankment.

2.11 In 2007, HR Wallingford also prepared a technical note on the Applicant's behalf, reviewing the above-mentioned Kent Thameside SFRA, which was included as part of the Drainage Strategy and Flood Risk Assessment of "Land North of Dalefield Way, Westcourt, Gravesend" prepared by Ardent Consulting Engineers. The SFRA intended to consider flood risk and sequentially identify areas within the Kent Thameside area that are suitable for development whilst also considering a number of pre-determined development sites. The technical note assessed

that the statistical return period of a breach at GR8 together with a 1 in 1,000 year tidal event is likely to occur less than once every 100,000 years. Overtopping of the flood defences would also occur less than once every 10,000 years.

3 TUFLOW MODELLING METHODOLOGY

Model Geometry

3.1 A two-dimensional hydraulic model was built to simulate the flood embayment behind the flood defences using Tuflow version 2009-07-AF-iDP. The model has been built using an area of 35km^2 with 5m resolution Next Map digital terrain model (DTM). The area of the embayment is generally flat, so a resolution of 5m is sufficient for the modelling purposes. If the topography had been steeper or more undulating then a finer resolution would have been considered.

3.2 The Tuflow model was built using the following parameters:

Parameter	***Value***
Grid spacing	10 metres
Origin	563724 mE, 172355 mN
Model Width	10,109 metres
Model Height	3,582 metres
Time Step	2 seconds
Simulation Time	7.5 hours

Table 3-1: Tuflow Model Parameters

3.3 The extents of the model are limited by the River Thames's flood defences in the north, and areas of relatively higher ground (i.e. above 5m AOD) in the east, west, and south. The extents of the model are represented by a 2d_code command.

3.4 A railway and canal run east to west across the embayment and are raised above the natural ground level. The railway

embankment acts as a secondary form of flood defence as it retains water in the northern section of the embayment before it is overtopped. As the resolution of the DTM is not particularly detailed at 5m and the grid spacing within the built model is large in comparison to the embankment width, a z line represents the embankment in the Tuflow model by forcing grid point elevations to include the embankment levels. The embankment levels are set to 4.0m AOD based on spot levels obtained from Ordnance Survey and the HR Wallingford report produced in 1996.

3.5 There are numerous small culverts conveying water under the railway embankment. Surcharging of the culverts would occur during the breach of the flood defences. The impact of these culverts on the modelling has been assumed to be negligible as the capacity of the (surcharged) culverts is only a fractional proportion of the breach flow rates. Therefore, these culverts are not included within the modelling.

3.6 The raw DTM obtained does not represent the actual land levels associated with the recent development at Heron's Field (planning reference GR/99/168), the recent industrial development at Lion Business Park, or the consented filling to site known as Phase 3a (see **Drawing B142-05 Model Schematic**). Z shape polygons have been used in the model to enforce the Tuflow grid to represent the actual ground levels from 3.5m AOD to 4.0m AOD within these areas.

3.7 A recent planning application has been submitted for approval for a proposed industrial estate to the north of the proposed development site (Ref: GR/2010/0436). This includes an access road between the two sites. The Tuflow model assumes that this planning application will be approved and thereby the Tuflow model includes a z shape polygon raising the industrial site to a level of 2.5m AOD and the access road to 3.5m AOD. The recent planning application also included the removal of 100mm of

material from the damaged SSSI for the use of compensatory flood storage volume and this is also accounted for in the Tuflow model.

3.8 The roughness of the floodplain terrain has been represented in the Tuflow model using a 2d_mat file and utilising the OS map of the area to determine land use type. Roughness coefficients used in the model to represent the Manning's number 'n' are summarised below:

Land Use Type	***Manning's 'n'***
Open Space / marshes (default)	0.060
Buildings	0.250
Ponds and other water	0.025
Railway	0.050

Table 3-2: Floodplain Roughness Coefficients

Hydrological Input

3.9 Following a request for information, the Environment Agency has supplied a single-tide cycle hydrograph for the breach at GR8. The hydrograph is for the 1 in 1,000 year event and was the hydrograph used for the latest update of the SFRA according the the EA. This hydrograph is essentially the output file from a River Thames ISIS model. As a footnote, further requests were made to the EA to update the information received to include TE2100 considerations, three-tide cycle events, and the 1:200 year hydrographs. However, the EA has indicated that this information was not available and that a single tide cycle for the 1 in 1,000 year event as used in the SFRA is suitable (**see Appendix B**). The EA has also indicated that the hydrograph provided in 2009 was the same as the hydrograph used in the 2009 SFRA update.

3.10 Tidal breach analyses on the River Thames are required for the 1:200 year level only so this analysis is considered to be

conservative (see EA report "Requirements for completing computer river modelling for Flood Risk Assessments" Chapter 2.7, 2009).

3.11 The hydrograph obtained from the SFRA model has been represented in the Tuflow model as a 2d_bc line at the identified location of the breach GR8. It has been modelled using a flow time relationship as provided by the Environment Agency. This hydrograph was the output file from the spill reservoir used in the ISIS model.

Pre-Development Scenario

3.12 The pre-development (existing) scenario was modelled using all the baseline characteristics mentioned above.

Land Raising Scenario

3.13 A z shape polygon has been used in the Tuflow model to represent the proposed land raising at the proposed development site. For this model, the polygon enforces grid points to a level of 3.9m AOD at the development site where the existing grid points are below this. Any grid points within the polygon above 3.9m AOD remain at their existing levels.

Compensatory Storage Scenario

3.14 To mitigate against the effects on flood water depths as a result of land raising, compensatory flood storage has been proposed. It is proposed to lower areas within the damaged SSSI in the north-west of the Westcourt and the Great Clane Lane Marshes (see **Drawing B142-05 Model Schematic**). The extent of land level lowering will be covered in Section 5 and this land level lowering is enforced in the Tuflow model by a z shape polygon.

Output Locations for Result Files

3.15 Nine Plot Output (PO) points were placed within the model extents to record water levels (see **Drawing B142-05 Model Schematic**). These points were located in various locations across the model in order to assess the impact of land level raising.

4 MODEL OUTPUTS

4.1 For the model simulations, flooding is shown across the entire canal basin and large extents of the land to the south of the railway embankment (see **Drawings B142-06, B142-07, and B142-08**). The development site area is observed to lie partially within the modelled flood extents prior to land raising or compensation. The extents shown replicate the extents produced in the SFRA within the acceptable tolerances of the model.

4.2 Maximum output values at each of the PO locations at the site for the pre-development and post-development (with filling, but without compensation) simulations are summarised in the table below. For a map of the locations and general schematic of the Tuflow model refer to **Drawing B142-05**.

Location	***Maximum Flood Elevation (m AOD)***	
	Pre-development	Post-development
Denton	4.15	4.15
Westcourt	3.38	3.39
Great Clane Lane	3.38	3.39
Eastcourt	4.26	4.26
Filborough West	3.38	3.39
Filborough	3.38	3.39
"Danger Area"	3.95	3.95
Milton	4.15	4.15

Table 4-1: Tuflow Modelled Outputs

4.3 The raising of the land at the development site causes a slight increase in flood levels in the Gravesend embayment area in the vicinity of the development only. Specifically the increases are observed near the development site as noted by the locations "Westcourt", "Filborough", "Filborough West", and "Great Clane

Lane". No changes in flood levels are observed north of the railway.

4.4 A comparison between the flood levels over time is presented below in Chart 1.

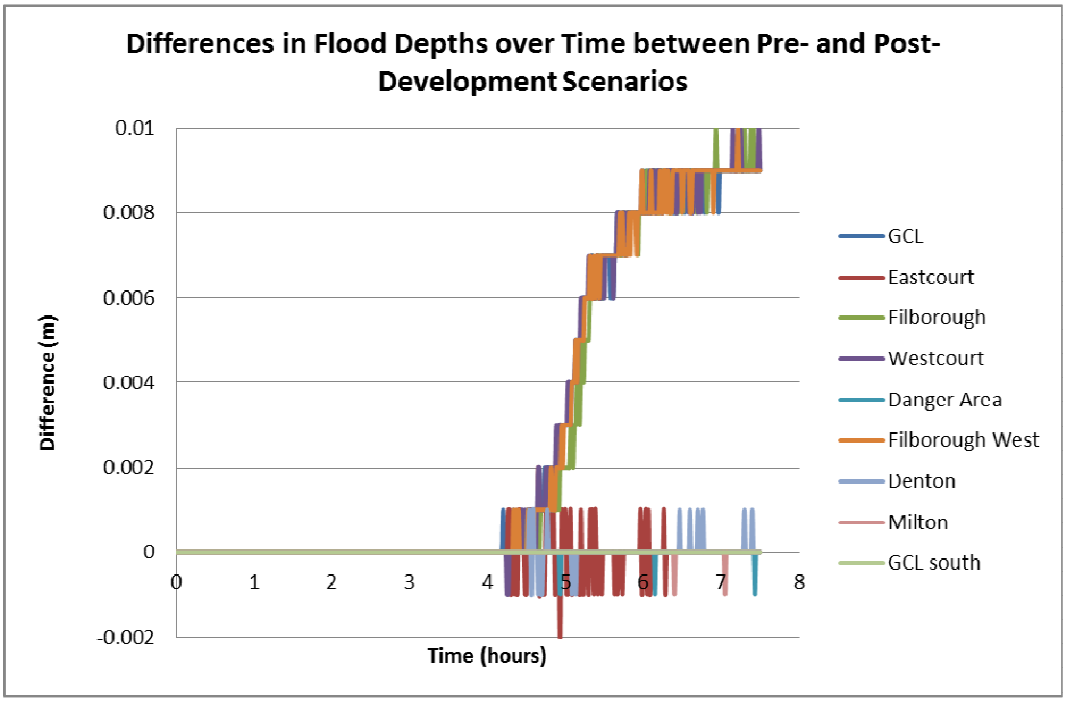

Chart 1: Difference in Post-development Flood Levels Compared With Pre-development Flood Levels

5 FLOOD MITIGATION MEASURES

5.1 The flooding of an embayment due to a breach failure of defences creates a situation where a flood cell fills with flood water. Generally this means that the required compensation for an area will be largely, if not wholly, volumetric.

5.2 The volume of fill used to raise the development site has been calculated to be approximately 18,500m^3. Land is available for compensatory land lowering within the damaged SSSI to the north-west of the site.

5.3 In order to provide verification that the level of compensation proposed is adequate, the model geometry was updated to include the land lowering. This was represented in the model by a z shape polygon. To maintain the characteristics as much as possible, it is proposed to lower the compensation areas by a generic height rather than lowering to a specific level and creating a flat surface.

5.4 For the purposes of this modelling exercise, land levels were reduced by 0.1m within the SSSI. Summary results are presented in Table 5-1 whilst Chart 2 presents a comparison between the flood levels over time.

Location	***Maximum Flood Elevation (m AOD)***	
	Pre-development	Compensation
Denton	4.15	4.15
Westcourt	3.38	3.38
Great Clane Lane	3.38	3.38
Eastcourt	4.26	4.26
Filborough West	3.38	3.38
Filborough	3.38	3.38
"Danger Area"	3.95	3.95
Milton	4.15	4.15

Table 5-1: Tuflow Modelled Outputs Including Compensation

5.5 As can be observed, the implementation of the land raising at the development site together with the land lowering compensation works results in a return to existing flood levels.

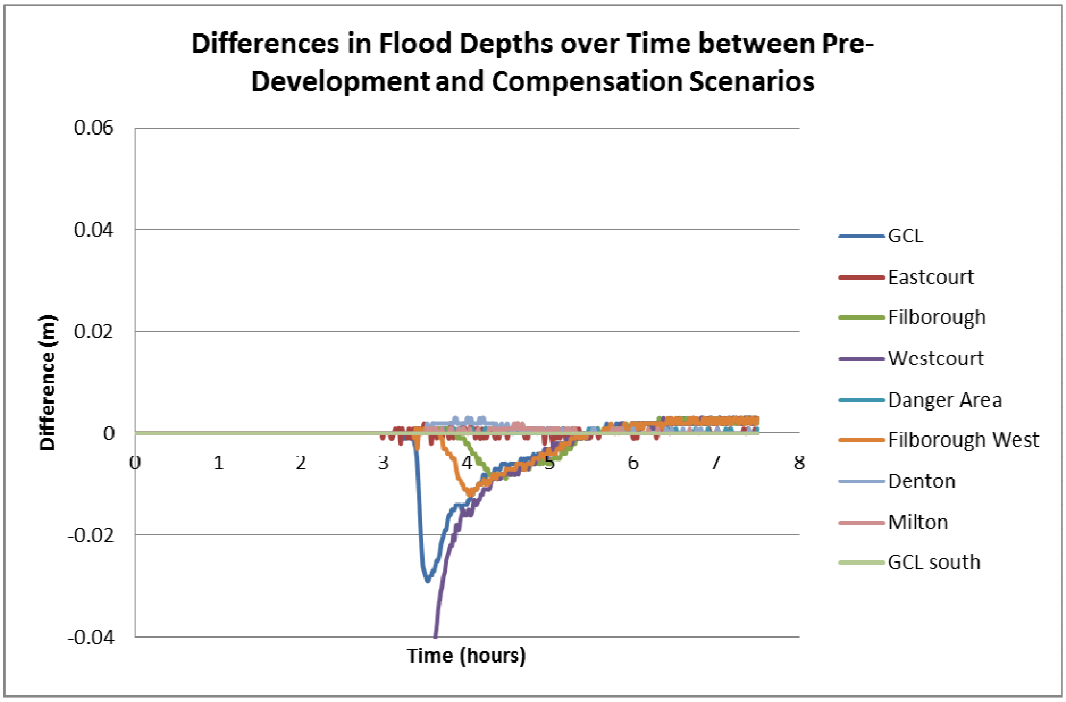

Chart 2: Difference in Compensation Scenario Flood Levels Compared With Pre-development Flood Levels

6 SENSITIVITY TESTING

6.1 To assess the accuracy of the Tuflow model, sensitivity testing to review the parameter assumptions was made. Variations to the input parameters have the potential to create a wider discrepancy between pre and post-development scenarios although this has largely been allowed for with the conservative approach outlined in Section 5.

6.2 Four additional simulations were made to test the sensitivity of the model to changes in the flow and roughness parameters. The four additional simulations were run using the 100 year event as the baseline event with a 20% increase and a 20% decrease to the Manning's number 'n' used and a 20% increase and 20% decrease to the breach hydrograph. A comparison of the flood level differences at the site locations are summarised in the tables below.

Location	***Scenario Flood Level Difference (m)***				
	Baseline	+20% flow	-20% flow	+20% 'n'	-20% 'n'
Denton	0	0	0	0	0
Westcourt	+0.01	+0.01	0	+0.02	0
Great Clane Lane	+0.01	+0.01	0	+0.02	0
Eastcourt	0	0	0	0	0
Filborough West	+0.01	+0.01	0	+0.02	0
Filborough	+0.01	0	0	+0.02	0
"Danger Area"	0	0	0	0	0
Milton	0	0	0	0	0

Table 6-1: Pre-development / Post-development Scenario Maximum Flood Level Differences

Location	***Scenario Flood Level Difference (m)***				
	Baseline	+20% flow	-20% flow	+20% 'n'	-20% 'n'
Denton	0	0	0	0	0
Westcourt	0	-0.01	-0.01	+0.01	-0.01
Great Clane Lane	0	-0.01	-0.01	+0.01	-0.01
Eastcourt	0	0	0	0	0
Filborough West	0	-0.01	-0.01	+0.01	-0.01
Filborough	0	-0.01	-0.01	+0.01	-0.01
"Danger Area"	0	0	0	0	0
Milton	0	0	0	0	0

Table 6-2: Pre-development / Compensation Scenario Maximum Flood Level Differences

6.3 As can be observed from the output results, there is only a minor difference between the output values and therefore it can be determined that the process of providing adequate floodplain compensation is largely unaffected by the roughness of the floodplain surface. Equally, the flood level differences with a reduction and increase in the flow also demonstrate that the mitigation measures provided are sufficient even if the flow hydrograph used in the simulations is inaccurate.

7 INTERPRETATION OF RESULTS AND IMPLICATIONS FOR SITE DEVELOPMENT

7.1 Through Tuflow modelling, the raising of land levels at the development site is shown to increase the flood depths across the Gravesend embayment by a negligible amount during a single cycle 1 in 1,000 year breach of the flood defences at Eastcourt (breach GR8). To offset these flood level increases, mitigation is proposed by lowering land levels within the damaged SSSI area.

7.2 The compensatory flood storage proposed in this report is for a further reduction in land levels of 100mm within the SSSI land. This is in addition to the 100mm reduction incorporated for the employment area to the north of the proposed residential application. For the 1 in 1,000 year breach of the flood defences at Eastcourt, the modelling of the development proposals taken together with the mitigation measures, demonstrate that flood levels are practically identical to existing modelled levels.

7.3 The volume of compensatory floodplain storage is less than the volume of fill proposed at the development site. However, the results of the modelling conclude that the volume of compensation provided is sufficient to not cause an increased risk of flooding to the development area or other areas within the flood embayment under breach conditions.

DRAWINGS

APPENDIX A
TUFLOW FILES

APPENDIX B
ENVIRONMENT AGENCY CORRESPONDENCE

APPENDIX B
SFRA DETAILS

Appendix F

Minutes of Meeting with Environment Agency
19th October 2009

ARDENT CONSULTING ENGINEERS

MINUTES OF MEETING

Date: **19 October 2009**

Subject: **Gravesend Masterplanning**

Ref: **B330 ss7427**

Those Present: **Kerry Wilkinson (KW), Chris Baker-Pearce (CBP) (Ardent Consulting Engineers)**

Bob Meek (BM) (Kember Loudon Williams)

Gary Horton (GH) (Landowner)

Nigel Pye (NP), Niall O'Connor (NO), Michael Wilkinson (MW) (Environment Agency)

Apologies: **Richard Bray (Barratt Eastern Counties)**

		ACTION
1.	Opening intros, roles, etc.	
2.	CBP outlined background to the site and recapped points raised from previous meeting minutes from June 4. Outlined proposal to raise land to the south of a proposed distributor road for residential development. The road would serve to unlock the canal basin area to the north of the railway/canal.	
3.	KW outlined the Tuflow modelling that was undertaken. Model was created using Lidar and based upon information gleaned from the local SFRA. Breach location GR8 modelled as this was shown to be the largest threat in the SFRA. A dummy hydrograph was used to simulate the breach as tidal curves from the EA are still to be received. This hydrograph used a volume of 4million m^3 compared with the SFRA hydrograph of 3.1million m^3. Modelling indicated a slight increase in flood levels across the site with the development of the land to the south of the distributor road. Further modelling indicated that floodplain compensation could be provided within the Great Clane Marsh (400mm depth) and the SSSI (200mm depth) which would reduce flood levels. MW wanted to see modelling recordings of flooding in the Denton area. Indicated that a 10mm difference in flood levels would be deemed to be negligible and thereby acceptable.	

	ACTION
4. NP: On a strategic scale development plans for a north-south flood defence are still works in progress with Gravesham. Gravesham will need to provide input for this to get going again.	
5. NP: Keen to see Natural England's reaction to land lowering, although he can't see too many reasons for possible objections. CBP echoed this by indicating that there was a desire to return the marshes to a more "wet" state and lowering the marshes would likely achieve this.	
6. CBP: Original objection was because of potential adverse increase in flood levels.	
7. NP: Can see some benefit in raising defences for some properties adjacent. Design of road to allow for tidal climate change increase as it would be acting as a tertiary form of flood defence.	
8. MW asked about land classification and whether it was greenfield or brownfield.	
9. BM explained that it is in part allocated in the adopted Local Plan for development as part of a regeneration area, and in part as a reserve area which could be brought forward for development if a clear "need to do so" could be shown. While the latter provision was omitted from a subsequent review of the adopted Local Plan, this review had not been adopted. The envisaged development of this area, and in particular the proposed relief road, would however support and allow the development potential of the Canal Basin area adjacent, to be realised through the Core Strategy process	
10. NP: Sequential Test to be covered.	
11. MW was unsure about Part B of the Exception Test and where land could be developed elsewhere.	
12. BM and NW suggested that the Core Strategy will clear up the allocation issues with the land.	
13. CBP: Part B of the Exception Test is for redevelopment of brownfield land for sustainability. Only way brownfield area north of the railway to be used is by the development of the site. Part C of the Exception Test will be fulfilled with the raising of the land to above the flood levels anticipated as a result of a breach in the flood defences.	
14. NP, MW: Generally happy with overall proposal provided Natural England is happy and that compensatory measures are demonstrated to be adequate.	
15. Meeting concluded with next action to be submission of the	

	ACTION
modelling report within a fortnight.	

Circulation:

Gary Horton

Niall O'Connor

Chris Baker-Pearce

Nigel Pye

Richard Bray

Bob Meek

Michael Wilkinson

Appendix G

Correspondence with Environment Agency and English Nature/Natural England

Our ref: CSC/KT/99/000729/bn
You Ref:

Date: 1 July 1999

ENVIRONMENT AGENCY

Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hill Gate
London
W11 3QD

JOB NO. M591	COPY TO:
05 JUL 1999	
DIRECTOR	CIRC. SAP

FAO Mr Simon Purcell

Dear Simon

DENTON MARSHES DEVELOPMENT AT DAMIGOES FIELD

Further to our telephone conversation of earlier today I can confirm that the proposed surface water drainage strategy, as detailed in your report dated March 1999, is acceptable to the Agency subject to the following comments:

1. The boundary of the application site is partially within the drainage district of the Commissioner of Sewers Gravesend (West), an Internal Drainage Board. All the drains within the site area are classified as ordinary watercourses and are not maintained by the Agency or by the Internal Drainage Board. In the absence of any express agreement to the contrary, maintenance is the responsibility of the riparian owners. Any culvert, diversion, weir, dam, or like obstruction to the flow of the watercourse requires the consent of the Agency under the Land Drainage Act 1991, either acting in its own right or acting as the Internal Drainage Board.

2. The infilling or diversion of any watercourse, therefore, requires Land Drainage Consent and will be subject to the Agency agreeing compensation, for example, a length of replacement open channel. It is likely that any Land Drainage Consent issued will carry a condition to the effect that continuity of drainage must be maintained at all times and that there is no net loss of open channel.

3. Furthermore, to safeguard conservation interests the Agency will request a condition of planning to ensure there is no net loss of open watercourse as a direct result of the development. For your information, the Agency does not consider roadside drainage as suitable compensatory habitat for loss of watercourse and for conservation reasons, the Agency seeks to avoid culverting and will not normally consent such works except for access.

Cont/d..

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH
Tel: 01732 875587 Fax: 01732 875057

4. The Agency has no objection to the widening and deepening of existing channels for surface water attenuation. The storage provided must be useable and account must be taken of the groundwater level, which we believe may be as high as 1.9 metres AOD. Storage will only be of use above the maximum potential ground water levels. Nor has it any objection to the installation of control structures at the location of the culverts under the railway. Maintenance responsibility for this storage area and the control structures should be agreed prior to the commencement of the development. Land Drainage Consent is required for the works and the Agency awaits information on the detailed design of the storage facility with supporting calculations clearly showing the adopted discharge rate, the available storage volumes and the adopted return period.

5. At the site inspection attended by Agency staff on 18 September 1998 there appeared to be hydraulic continuity in the ditch system. If, however, it is found that this is not the case, further work will be required to assess the continuity of drainage, in particular between the storage ditch system and the main Denton / Westcourt Marsh outfall. In addition, the hydraulic continuity beneath the railway will need to be established.

6. To safeguard the drainage interests of the area, the Agency will request a condition of planning that no development shall be commenced until a scheme for the provision of surface water drainage has been approved and implemented to the reasonable satisfaction of the Local Planning Authority.

You should be aware that the Environment Agency will be responding to the Planning Authority directly concerning this application.

Yours sincerely

BARRIE NEAVES
Team Leader - Development Control

Direct Dial 01732 223122

Our ref: KT/1999/001923(GR/99/168)bn
Your Ref: CBP/stm6060/M591

Date: 6 July 2000

ENVIRONMENT AGENCY

Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hill Gate
London
W11 3QD

JOB NO. M591 | COPY TO: BGdl
10 JUL 2000
DIRECTOR | CIRC

FAO Mr Chris Baker-Pearce

Dear Chris

PM9 DENTON MARSHES, LAND AT DAMIGOES ROAD, GRAVESEND, KENT

Further to our telephone conversation of earlier today I am pleased to enclose two application forms for land drainage consent at the above site.

I can also confirm that the Agency will not oppose development to the remainder of the site providing it is line with the previously agreed development brief and drainage strategy. The design principles already used on the first land allocation are applicable to the site as a whole.

The retention of 'green-corridors' along the watercourses shall be included for in the proposed layout. Preferably any modifications to the watercourses should be undertaken for short lengths on alternate banks. I understand that this will involve the permission of third party owners. However, the Agency asks that the feasibility of this is investigated.

I look forward to receiving your completed application form(s), in the meantime, should you wish to discuss any of the above please don't hesitate to contact me.

Yours sincerely

BARRIE NEAVES
Team Leader - Development Control

Direct Dial 01732 223122

Enc.

ENGLISH NATURE

Kent Team
The Countryside Management Centre Coldharbour Farm Wye Ashford Kent TN25 5DB
Tel +44(0)1233 812525 Fax +44(0)1233 812520
email kent@english-nature.org.uk
www.english-nature.org.uk

Mr C Baker-Pearce
Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hill Gate
London W11 3QD

JOB NO. BBC JAB	COPY TO:
10 JUL 2001	
DIRECTOR AJ Pwg	CIRC.

SAP

tq77-10cp1

6th July 2001

Dear Mr Baker-Pearce

Westcourt Marshes
Off site watercourse works
South Thames Estuary and Marshes Site of Special Scientific Interest and Thames Estuary and Marshes Wetland of International Importance under the Ramsar Convention

Thank you for your letter of 2nd July and for the accompanying plans, U481/01A and 02A.

To ensure that the works are neutral or positive for the nature conservation interest of the Site of Special Scientific Interest (SSSI) the important points are:

- The new shelf in the ditch bank should be covered by water constantly for at least the latter part of the winter, not just when there has been storm flow. The maximum level of water in the ditch is presumably dictated by the level at which the subsurface field drains discharge from the east bank of the ditch. Thus below this maximum level, the channel needs to be broad and deep enough to provide storm storage capacity and a further volume of water for constant cover of the shelf.

- The structure controlling discharge from the ditch should be set so that water cannot drain off below a level which provides a constant cover of water over the new shelf for most of the winter. This additional depth of water could be shown as another band of colour underneath the yellow band (extent of 250mm deep storage area) in the cross sections. It should be of sufficient depth for surface water to remain over the shelf until early to mid summer, but shallow enough for it to dry out in later summer (July or August).Before we accept the proposed works, we will need to agree on the minimum winter water level and a means of ensuring that this requirement is observed.

- The arisings from the excavation should either be moved from the SSSI or spread very thinly (less than 10cm) on the adjacent ground.

If any of these points are unclear, please do not hesitate to contact Lionel Solly or me. Lionel will await your call to arrange a site meeting.

Yours sincerely

Robert Cameron
Deputy Team Manager

Our ref: KT/2001/006047/002/AS
Your ref: AJH/BOB/SEG/9558
Date: 13 July 2001

ENVIRONMENT AGENCY

Brand Leonard
The Mill House
Bishop Hall Lane
Chelmsford
Essex
CM1 1LG

FAO Mr B Brewster

Dear Mr Brewster

Land Off Deering Way, Gravesend

Thank you for your letter of 2 July. We have been in negotiations with Buchanans concerning the drainage strategy for this development and it has been agreed that there will be free discharges from the development to the local watercourse but this will be widened and controlled beyond the development site so that downstream landowners will not be adversely affected by the increase in flows.

You have indicated in your letter the size of pipes to be installed together with the 1 in 2 year discharge flows. The storage to be provided in the downstream watercourse beyond the development will be sufficient to contain the 1 in 100 year storm and you will need to demonstrate to us that your pipe sizes are sufficient to pass this storm flow without causing flooding within the development. You will also need to check that the receiving watercourse within the development has capacity to receive the unattenuated discharge and it is quite possible some improvements will be required to contain the 1 in 100 year storm flows.

There is no water quality requirement for the discharges to be consented since the water is of a domestic nature. In addition the outfall structures do not require to be consented under land drainage legislation as long as they are constructed so that the structures and outfall pipes do not extend in to the natural flow of the stream. However the downstream storage provisions have not been finally agreed in detail with Buchanans as there are some conservation issues still to be resolved between ourselves and English Nature. The Consultants are also suggesting the downstream control structures will need to be increased in capacity as they believe the contributing area is larger than originally determined. These issues could result in amendments to the storage profile and we are anticipating meeting with Buchanans in the next few weeks to finalise these matters.

BRAND LEONARD
RECEIVED
24 JUL 2001
Job No. 9558
BOB.

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH
Tel: 01732 875587 Fax: 01732 875057

Copied to AJH

No connections to the stream shall be made until the flood storage compensating works have been agreed and carried out as the developer would be liable for any flooding which ensued if a connection was made prior to these works being completed.

I hope this has explained the current situation concerning this site as far as the Agency is concerned but if you have any queries I would be pleased to discuss them with you.

Yours sincerely

Anita Soloman
Development Control

Our ref: KT/1999/001923(GR/99/168)bn
Your Ref: CBP/lp7166/U481

Date: 7th August 2001

ENVIRONMENT AGENCY

Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hill Gate
London
W11 3QD

JOB NO.	COPY TO:
U481	
10 AUG 2001	
DIRECTOR	CIRC. SPP
RWG	CBP

security thru

FAO Mr Chris Baker-Pearce

Dear Chris

WESTCOURT MARSHES, GRAVESEND, KENT

Thank you for your letter of consultation regarding the above dated 10th July. I note the observations of English Nature.

I believe it should be possible to address the nature conservation concerns raised whilst not compromising the land drainage requirements of the Agency.

I await confirmation of the forthcoming site inspection.

Yours sincerely

BARRIE NEAVES
Team Leader - Development Control

Direct Dial 01732 223122

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH
Tel: 01732 875587 Fax: 01732 875057

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Dr Lionel Solley
English Nature (Kent Team)
The Countryside Management Centre
Coldharbour Farm
Wye
Ashford
Kent TN25 5DB

CBP/lp7358/U481

24 August 2001

Dear Dr Solley

Westcourt Marshes, Gravesend
Off Site Drainage Works

I refer to our most helpful meeting on Wednesday with you and your colleague Ms Smally.

By way of record, we note the following:-

1. The recent channel maintenance undertaken does not detract from the ecological value of the watercourse.

2. The Hawthorn and other vegetation which extends into the SSSI on the Western Bank can be fully cleared to facilitate excavation of the storage shelf.

3. It is acceptable during construction to reprofile/dredge the invert and remove foreign objects from the watercourse.

4. The hydraulic modelling undertaken by Buchanans to be approved by the Environment Agency should demonstrate that the requirements identified in your letter of 6 July 2001, can indeed be met.

Thank you once again for your assistance, I look forward to speaking to you as matters progress.

Yours sincerely

Chris Baker-Pearce

cc:	S Bailey	-	Barratt Eastern Counties
	B Neaves	-	Environment Agency East Malling
	J Lee	-	Gravesham BC
bcc:	P Horton	-	Fort Knight Group

Environment Agency
Kent Area Office
Orchard House
Endeavour Park, London Road
Addington, West Malling
Kent ME19 5SH
For the attention of B. Neaves

CBP/stm7549/U481

13th September 2001

Dear Sir

Westcourt Marshes, Gravesend
Off-Site Drainage Works

Thank you for your prompt issue of land drainage consent in respect of the above.

As discussed at our site meeting of 22nd August, there were a number of issues which required further investigation to conclude and I am pleased to advise you of our progress in these matters as follows :

1. **Existing Surface Water Piped Outfall**

   Barratts have cleared the area near the Bailey Bridge and exposed two 600 mmØ pipes. Their record of the investigation is appended for your information and we have recalculated the flow to be 0.578 m^3/s on the basis of their findings. We have also made enquiries of Southern Water, who, in the absence of the requisite data have suggested applying full bore flow conditions at the outfall.

   I have discussed this issue with Anita and I believe she is happy to accept this basis for the design of the flow control at point Z.

2. **Railtrack Culverts**

   Mike Manley has confirmed the presence of the main outfall (control structure X) but suggested, contrary to Gravesham Borough Council and the Agencies advice, that structures Y and Z are surplus to requirements (a point which we have contested). In addition, he has stated that the culvert is silted and requires jetting and requested that our Client should meet the cost of clearing. We have written under separate cover to Mr. Manley (copied to yourself) suggesting this is Railtracks responsibility under land drainage law and we trust this will be enforced if our Clients right of discharge is frustrated in any way.

3. **Removal of Dumped Waste**

   I have discussed with our Client the disposal of the household appliances etc, which have been removed from the watercourse. Barratts are inclined, as a gesture of good will, to remove the material and I hope to receive formal confirmation of this shortly.

4. **Modelling Simulations**

We have undertaken the final sensitivity tests as discussed, which demonstrate that even with the weir structure completely drowned out, the works are capable of accommodating the 1:100 yr post development flows. An explanation of the modelling methodology, results and amended drawings are appended for your information and I consider that the works, subject to your approval, can now be built.

Thank you for your continued support in this matter, I look forward to receiving confirmation of your approval to the enclosed at your earliest convenience.

With kind regards.

Yours faithfully

CBP

Chris Baker-Pearce

Encl.

cc.	S. Bailey Esq.	-	Barratt Eastern Counties
	Dr L Solley Esq	-	English Nature
	J Lee Esq	-	Gravesham BC

ENGLISH NATURE

Kent Team
The Countryside Management Centre Coldharbour Farm Wye Ashford Kent TN25 5DB
Tel +44(0)1233 812525 Fax +44(0)1233 812520
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www.english-nature.org.uk

COPY TO:

20 SEP 2001

DIRECTOR

Mr Chris Baker-Pearce
Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hill Gate
London W11 3QD

Our reference: BO4/6-43/22

19 September 2001

Dear Mr Baker-Pearce

Westcourt Marshes, Gravesend
Off-site watercourse works
South Thames Estuary and Marshes Site of Special Scientific Interest (SSSI) and Thames Estuary and Marshes Wetland of International Importance under the Ramsar Convention (Ramsar site)

Thank you for sending me a copy of the revised plans for the off-site drainage scheme, and for telephoning to explain the amendments to the proposed works.

From the revised plans, and our discussion, I understand that the concerns raised in our letter of 6 July 2001 have been addressed. On this understanding I am therefore satisfied that the works will be neutral or positive for the nature conservation interest of the Site of Special Scientific Interest and Ramsar site.

Please do not hesitate to contact me if there are other matters that you would like to discuss.

Yours sincerely

Dr Lionel Solly
Conservation Officer

ENVIRONMENT AGENCY

Our Ref : KT/2002/009147-12/2
Your Ref : TRF/STM8460/U484

Date : 12 August 2004

Tony Foreman
Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hil Gate
London
W11 3QD

JOB NO. U484	COPY TO:
18 AUG 2004	
DIRECTOR PWG	CIRC. TRF

Dear Mr Foreman

WESTCOURT DEVELOPMENT, GRAVESEND

Thank you for your letter of 6th July.

The Agency can confirm that previously agreed principles for the development at Westcourt Marshes are still acceptable.

The HR Wallingford report concluded that the railway acts as a secondary defence and therefore this accounts for the agreed slab levels (sleeping accommodation at 6.3 and groundfloor levels at 3.8m aODN). The stormwater drainage strategy principles are also acceptable, however, the Agency's engineer concludes that the drainage from this part of the site should be directed to the eastern drain. Therefore, should the scheme adhere to the original principles it is assumed that there should be no problems.

The Agency welcomes continued communications regarding the progress of the site and appreciates consultation on any revised plans.

Yours sincerely

LAURA FULTON
Planning Liaison Officer

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH, Tel no:01732 875587, Fax no:01732 875057

ENVIRONMENT AGENCY

Our Ref : KT/2005/021215-1/1
Your Ref : SJB/stk0105/B100

Date : 15 August 2005

Steve Burton
Ardent Consulting Engineers
4th Floor
Diamond House
36/38 Hatton Garden
London
EC1N 8EB

Job No	Date
B100	26-8-05
Director	Circulation
BR	SJB

Dear Sir

TOWN AND COUNTRY PLANNING ACT 1990
SURFACE WATER DRAINAGE STRATEGY
LAND NORTH OF DERING WAY, GRAVESEND

Thank you for your letter dated 28th July 2005. Please accept our apologies for the delayed response.

The Environment Agency would like to offer the following advice.

GROUNDWATER AND CONTAMINATED LAND

From the information provided, it would appear that the site is affected by contamination.

There must be no discharge into land impacted by contamination or land previously identified as being contaminated. There must be no direct discharge to groundwater, a controlled water. There should be no discharge to made ground.

It is also apparent that Southern Testing produced a site investigation report in 2004. The Groundwater and Contaminated Land would request that a copy of the report be submitted to us. Further more, we would also request the following condition is imposed on any permission granted:

Condition:
No development approved by this planning permission shall be commenced until:

a) A desktop study has been carried out which shall include the identification of previous site uses, potential contaminants that might reasonably be expected given those uses and other relevant information. And using this information a diagrammatical representation (Conceptual Model) for the site of all potential contaminant sources, pathways and receptors has been produced.
b) A site investigation has been designed for the site using the information obtained from the

Environment Agency
Orchard House, Endeavour Park, London Road, Addington,, West Malling,, Kent, ME19 5SH, Tel no:01732 223177

desktop study and any diagrammatical representations (Conceptual Model). This should be submitted to, and approved in writing by the LPA prior to that investigation being carried out on the site. The investigation must be comprehensive enough to enable:
· a risk assessment to be undertaken relating to groundwater and surface waters associated on and off the site that may be affected, and
· refinement of the Conceptual Model, and
· the development of a Method Statement detailing the remediation requirements.
c) The site investigation has been undertaken in accordance with details approved by the LPA and a risk assessment has been undertaken.
d) A Method Statement detailing the remediation requirements, including measures to minimise the impact on ground and surface waters, using the information obtained from the Site Investigation has been submitted to the LPA. This should be approved in writing by the LPA prior to that remediation being carried out on the site.

Reason:
To ensure that the proposed site investigations and remediation will not cause pollution of Controlled Waters.

For information
According to current records there is a historic landfill site (GR1) within 20 metres of this property, at grid ref. TQ 669 738. It should be noted that records for pre-1974 sites are from District and Archive records and some of these are incomplete. The site fill is thought to have included mainly inert with some putrescible material.

WATER QUALITY

Site Drainage
Construction Phase
It has been identified that groundwater at this location may be contaminated by previous land use at this site. This may also have implications for surface watercourses at this location.

During the construction phase appropriate measures must be in place to protect surface watercourses from contamination. All risks of contamination of surface watercourses must be assessed and a statement of the methodology for contamination removal/mitigation produced. This must be submitted to the Agency for consultation/approval prior to the commencement of the development.

Please refer to the Agency's Pollution Prevention Guidance (PPG) notes for 'Construction Sites' PPG6 and 'Oil Storage/Disposal' PPG8 for general pollution prevention advice for the construction phase of this development. These guidance notes are available from this office or from the Agency's website www.environment-agency.gov.uk.

Permanent Development
The Agency is unlikely to object to the discharge of uncontaminated site drainage from any permanent development at this site where it is proposed to be discharged to a surface watercourse. This should still pass through pollution prevention measures, i.e. trapped gullies before being discharged.

Any parts of the permanent development where site drainage is likely to become contaminated from the activities occurring on it should be directed to the mains foul sewer or to a sealed unit for off site disposal by a licensed contractor. The activities likely to cause contamination include: HGV parking/maintenance bays, loading/unloading bays and vehicle washdown facilities. In some instances (site specific) discharges from HGV bays can be discharged to surface watercourses, via appropriately sized oil interceptors. Any such discharge to controlled waters shall require the discharger to obtain the prior written Consent to Discharge, issued by the Agency, under the Water Resources Act 1991, Schedule 10 (as amended by the Environment Act 1995). Please be aware Consent may not be granted.

Full details of the proposed site drainage arrangements for the permanent development must be submitted to the Agency for their approval before construction commences.

DEVELOPMENT CONTROL

The Agency's records indicate that part of the site could be subject to tidal flooding should the defences be breached or overtopped or more severely under the '200 year' tidal condition, the estimated level of which is 6.08 metres above Ordnance Datum Newlyn for a design horizon of 2060. Therefore, any land on site below this level is considered to be at risk to tidal flooding under the above condition. Please find attached a map indicating the extent of the area considered to be at risk.

The site is offered protection by the presence of the Thames Tidal Defences. These defences offer a standard of protection in excess of the '200 year' standard up until the year 2060.

You may also wish to enquire of the Local Authority who may have further information on localised flooding and flooding from other sources, such as highway drainage.

Any watercourse within the boundary of the site would be classified as an ordinary watercourse and would not be maintained by the Agency or by an Internal Drainage Board. In the absence of any express agreement to the contrary, maintenance is the responsibility of the riparian owners. Any culvert, diversion, weir, dam, or like obstruction to the flow of the watercourse requires the consent of the Agency and/or Internal Drainage Board, under the Land Drainage Act 1991. For nature conservation reasons, the Agency seeks to avoid culverting and will not normally consent such works except for access.

The Agency would recommend that a minimum 4 metre buffer strip is left between the top of the watercourse banks and any built development. This margin would allow for an access strip for maintenance works and provide a wildlife corridor.

The principle of discharging surface water to a watercourse may be acceptable providing it can be demonstrated that the receiving watercourse has sufficient capacity and forms part of a continuous drainage system. Any outfall structure should not protrude into the channel or obstruct flows in any way and suitable toe and bank protection should be incorporated if necessary. As such, attenuation may be required but this would need to investigated further if any development at this site progressed. The Agency would encourage the use of Sustainable Urban Drainage systems where the site circumstances allowed.

In terms of any proposals for future development, unfortunately, the Agency would be unable to comment on requirements for minimum slab levels for the development site, without first

receiving further detail indicating the nature and scale of the development. The site does benefit from an appropriate standard of defence but the Agency is likely to recommend raising floor levels to a degree to offer an additional level of protection to any buildings on site. We would be pleased to comment further on any proposals as they were developed.

BIODIVERSITY

Water voles are present at locations throughout the Denton Marsh area. Water vole habitat is protected under the Wildlife and Countryside Act (1981 - as amended). As such, when works are proposed in the area, mitigation measures may be required in order to comply with the requirements of the legislation. The Agency would request that the following condition of planning is placed on any permission granted.

Condition:
Temporary protective fencing must be erected to clearly define the 3m buffer strip adjacent to the drainage ditch. Following the erection of protective fencing no material or plant must be stored within the 3m buffer strip.

Reason:
To protect the aquatic communities within the drainage ditch and reduce the risk of potentially damaging water vole habitat or disturbing water voles while they are using such habitat.

WASTE

It is unclear where the material to be used to raise ground levels has come from, and if this is flytipped material it will need to be tested and shown to be suitable before the Agency will authorise its use.

It is possible that the use of inert waste to form a level hardstanding may benefit from exemption from the need for a waste management licence. The applicant should seek to register an exemption prior to any use of waste.

Yours faithfully

JO HOWITT
Planning Liaison Officer

Environment Agency
Orchard House, Endeavour Park, London Road, Addington,, West Malling,, Kent, ME19 5SH, Tel no:01732 223177

creating a better place

Environment Agency

Gravesham Borough Council
132, Cygnet House
Windmill Street
Gravesend
Kent
DA12 1BQ

Our ref: KT/2006/024620/01-L01
Your ref: GR/20060671

Date: 10 November 2006

Job No	Date
8140/8330	30/11/06
Director	Circulation
CRP	TMF/SSB

Dear Sir/Madam

TOWN AND COUNTRY PLANNING ACT 1990
MIXED USE DEVELOPMENT.
LAND NORTH OF DALEFIELD WAY, GRAVESEND.

Thank you for your consultation, which was recorded as complete on 3rd October 2006. The Agency would like to make the following comments.

Flood Risk
The Agency's records indicate that the site lies within a Zone 3 tidal flood risk area as depicted by the Agency's flood risk mapping, this is a High Risk area with a statistical 0.5% or greater chance of flooding occurring in any one year.

The ground levels are very low in this area, between 2.0m – 2.5mAOD and the predicted '1000 year' flood level for this area, based upon the most recently available information, is given as 6.0mAOD for a design horizon of 2060. If inundation were to occur in this area, the potential depth of flooding experienced could be significant and therefore the consequences on any development and its occupants could be serious.

The Agency is aware of the previous planning history in this area and that planning decisions have been made for adjacent areas. However, since permission was granted for the last phase of development in this area, a significant amount of new and updated information has been published. This new data must be considered in detail, especially regarding the impacts and consequences for development in this area. The Flood Risk Assessment (FRA) states that the site is defended by the presence of the Thames Tidal Defences, and these defences do offer a high standard of defence for the general area. However, the upkeep of these defences is reliant on continuing long term funding and it should not be assumed that this money will always be forthcoming. The Agency's flood risk maps are produced as if there

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH.
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Email: enquiries@environmeht-agency.gov.uk
www.environment-agency.gov.uk

were no flood defences in place in order to determine the areas at risk should a breach or overtopping of the defences occur so that the residual risks can be fully accounted for. In summary, even though defences are in place there should not be a presumption that this makes a site suitable for development.

Putting this site into context it must be considered as being a greenfield site and by applying the sequential test under the guidance in PPG 25, the question should be raised as to whether this site would pass the criteria laid out within this test for allocating land for development. PPG 25 aims to guide development away from areas at risk to flooding by ensuring that sites within lower flood risk areas are developed first. PPG 25 places this land within a Zone 3 flood risk area which is clearly not a low risk flood zone. The recently published Kent Thameside Strategic Flood Risk Assessment contains further details of the nature and severity of the flood risk at this site.

The SFRA denotes this site as lying within a 'High Risk' residual flood risk area as well as confirming the land lies within a Zone 3 flood risk area. The SFRA states that within those high residual risk areas, that as a 'general principle there would be a presumption against development of those sites' and goes further to state 'detailed modelling work would be needed to decide whether the proposed sites are within the rapid inundation zone or in low lying areas and also to check whether, if development took place, flood risk to adjacent areas would be increased'. The following from the SFRA should also be noted 'In general a precautionary approach should be adopted to proposed development in Zone 3.' Reference is also made to the function of the sequential test and in the SFRA the Local Authorities recognise that as part of any Local Development Framework (LDF), consideration should be given to re-allocating sites outside the boundary of Zone 3. This is in line with the guidance given in PPG 25, and draft PPS 25, in steering development away from high flood risk areas.

The FRA introduces the principle of landraising in order to achieve a development platform to achieve suitable finished floor levels. The ground levels are low in relation to the predicted flood level and therefore a relatively significant volume of landraising would need to be undertaken to ensure the safety of any dwellings. The Agency does appreciate the guidance given up to now and the solution for existing development in the area, but it is vital to consider the implications of any new data and act on the best available information at a given time. In Section 8.4.2, the SFRA discusses the issue of landraising on the Marshes in light of the new modelling which has been undertaken. This states 'The use of landraising as mitigation measure must be considered on its merits depending on the local conditions of each embayment. As a general principle, partial land raising within an embayment is *not* a desirable option'.

Considering the Gravesend embayment as outlined in the SFRA in more detail, this study looked to determine the nature of the flood risk in more detail for this specific area. The conclusions and future recommendations were based on a breach analysis scenario tied in with LIDAR data. An important conclusion reached for a flood mitigating option is summarised as follows 'Land raising would not be suitable for any redevelopment in this area since it would reduce the local flood storage volume and increase the local extent and depth of flooding. It is therefore desirable to ensure that any flooding of the Marshes is contained within them, and that flooding elsewhere in the embayment is conveyed to the marshes as quickly as possible' This demonstrates the importance of the Marshes as a flood storage area and again raises the question regarding their suitability for development. The Agency does

Cont/d..

appreciate that modelling work was undertaken in 1999 by HR Wallingford within this area and reference is made to this within the FRA for the site. However, further information regarding the nature of the flood risk in the area has become available since this time and the modelling carried out for the 1999 study is no longer consistent with the latest guidance provided by the Agency on this type of modelling exercise.

We note the references made within the FRA to the surface water drainage strategy for the area, which falls in line with the approach taken to development in adjacent areas. The FRA demonstrates that the site area is linked to the surrounding watercourse and that any works and resultant effects on one part of the drainage system will be demonstrated in other areas due to hydraulic connectivity. However, the SFRA states 'Land raising could also be considered in areas that are hydraulically independent from the rest of the embayment'. The FRA clearly demonstrates that this is not the case.

The Agency is looking towards the imminent release of updated guidance on Development and Flood Risk in the form of PPS 25. The draft guidance considers residential housing as a 'more vulnerable' use within Table D2. As the site lies within a Zone 3 flood risk area, Table D1 in draft PPS 25 considers these 'more vulnerable' uses should only be permitted if the Exception Test is passed. The Agency would question whether this application should address those criteria as laid out within the Exception Test. It should also be noted that the Agency has received guidance from DEFRA based on the FCDPAG3 Economic Appraisal which updates the existing Climate change Policy for Flood and Coastal Management. This places greater emphasis on the precautionary approach and offers further guidance on design horizons when planning for climate change, and it has been concluded that development should look towards the year 2115 when considering the climate change implications. This places a greater emphasis on making sustainable decisions at the planning stage as the evidence base for climate change improves and allows for greater certainty in forward thinking.

With all the above in mind, the Agency would question the suitability of this proposal in the light of the new data and information available. The longer term management of the flood risk within the Gravesend area must be considered as part of this proposal and the issue of long term sustainability needs to be addressed, these considerations are beginning to be introduced with the Exception Test as part of PPS 25.

The Agency is therefore obliged to raise an objection to this proposal. If you intend to approve the application contrary to our objection, paragraph 65 of PPG25 advises that you should re-consult the Agency in order to explain why and to give us the opportunity to make further representations.

Biodiversity

Water vole habitat is protected under the Wildlife and Countryside Act 1981 (as amended) and was given further protection by the Countryside Rights of Way Act 2000. This means it is an offence to intentionally or recklessly damage or destroy or obstruct access to any structure or place which water voles use for shelter or protection, or disturb water voles while using such a place.

Disturbance is defined as any activity which affects the survival chances, the breeding success or the reproductive ability of one or more individuals or which leads to a reduction in the quality of occupied habitat. If the flood defence

Cont/d..

work/drainage plan adversely affect the water levels on the surrounding marsh, or the proposed plans reduce the continuity of the ditch systems, this can be classed as disturbance to water voles.

As water voles have been found to occupy the ditches on and around the site appropriate mitigation will need to be devised and agreed with the Agency before any work starts. If the council is minded to approve this application, we would therefore request the following conditions;

CONDITION: Prior to any works commencing a detailed water vole mitigation strategy must be submitted and approved in writing by the Local Authority in conjunction with the Environment Agency.

REASON: To protect water voles.

From the habitat description of the ditches on site it would indicate that they are ideal habitats for aquatic invertebrates. Many invertebrate species require different habitats at different stages in their lifecycles. The possibility of a brackish influence into the ditch would increase the diversity of the invertebrate species that could be present. We would like to see a full invertebrate survey of the ditches conducted. The methodology of this will need to be checked by the Agency before the survey is conducted.

In regards to the proposed hedge planting to create a buffer zone to the surrounding ditch networks we would like to see the hedge planted at least 5 metres from the water courses edge for 'ordinary water courses' and at least 8 metres from drains classed as 'Main River'. We would like to see the species used within this hedgerow to be in keeping with species that would be present in a marsh system. The proposed native wildflower meadow should also be planted with species that are suitable to the marshy environment of the current site.

CONDITION: A scheme for the provision of local native flora (that is in keeping with the marsh environment) within the planting scheme for the proposed development shall be submitted to and approved by in writing by the Local Authority prior to the commencement of works on site.

REASON: In order to ensure that: the visual quality and ecological diversity of the area is maintained, and to ensure that no species are introduced that will cause adverse impacts on the ecology of the nearby watercourse and the locality.

The Agency.are extremely concerned that there is no proposed mitigation or compensation for the loss of marsh habitat and Natural England should be contacted for further information regarding this issue.

Potential Contamination

According to current records there is a landfill site within 100metres of this proposal site. The site closed pre-1976and the fill included inert and putrescible materials. The site has not been extensively monitored, but we are unaware of any off-site problems being discovered at any significant distance around the site. However it is recommended, in line with good practise, that any building works are constructed to at least the minimum requirements of Approved Document C of the Building Regulations and the BRE Guidance document "New Building on Gas Contaminated Land".

Cont/d..

DECISION NOTICE: Please forward a copy of the full decision notice to this office, quoting our reference number. A copy of this letter has been sent to the applicant/agent.

Yours faithfully

MISS MICHAELA KENNARD
Senior Planning Liaison Officer

cc BARTON WILLMORE

End

The impact of additional flows on system performance was identified and compared to internal performance standards to determine whether the target level of performance was breached by the additional flows. Two scenarios have been considered in the assessment of this development:

Scenario 1. Investigate the development in isolation and determine improvements necessary to accommodate the proposed development.

Scenario 2. Assess all the Phased developments and determine improvements necessary to accommodate the proposed development.

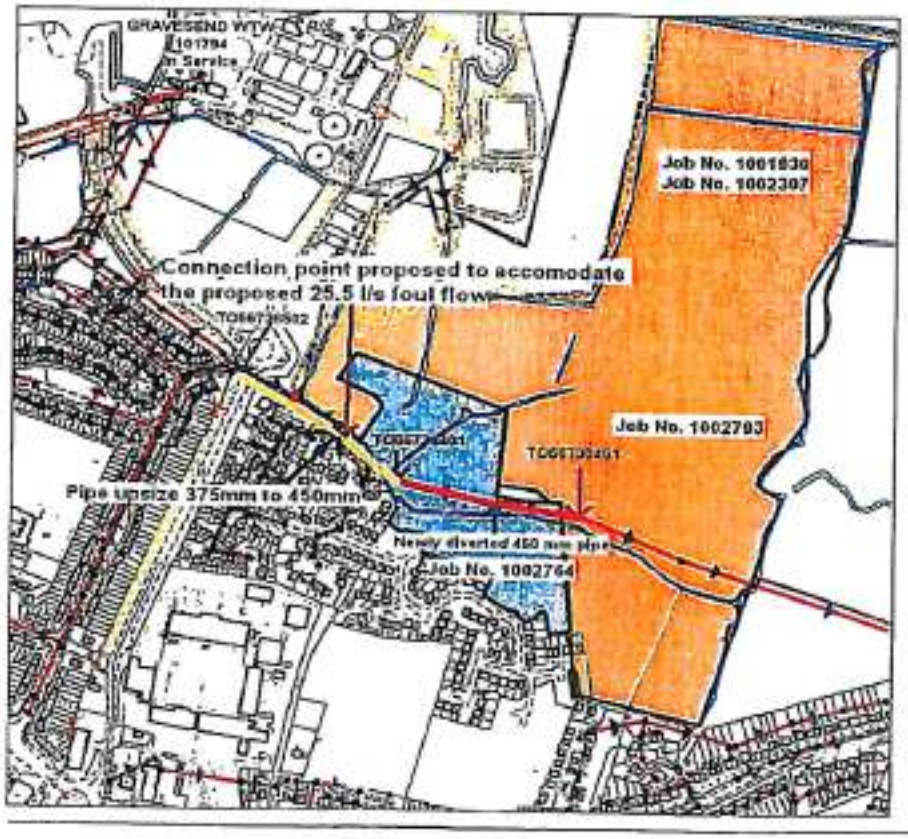
4. Results

Scenario 1:

This scenario considers discharging 25.5 l/s foul flow into manholes reference TQ66737501. The InfoWorks model result indicates that the sewerage system upstream the proposed connection point is surcharged and flooding is predicted at manhole reference TQ67733205 and manhole reference TQ67733206.

The improvements necessary to accommodate the proposed foul flow are shown in Figure 1. The proposal is to increase the existing 375mm sewer between TQ67738401 and TQ67736502 to 450 mm (Total length of 203 metres at approximately 2.75 metres average depth).

Figure 1 Proposed Improvements.



Scenario 2

This scenario considers flow from all phased developments added to the sewerage system as identified in the previous enquiries with exception of Job No 1002307.

Job No 1001930. Discharge 7.0 l/s split between manholes TQ67730**401** and manhole TQ66739**401**.

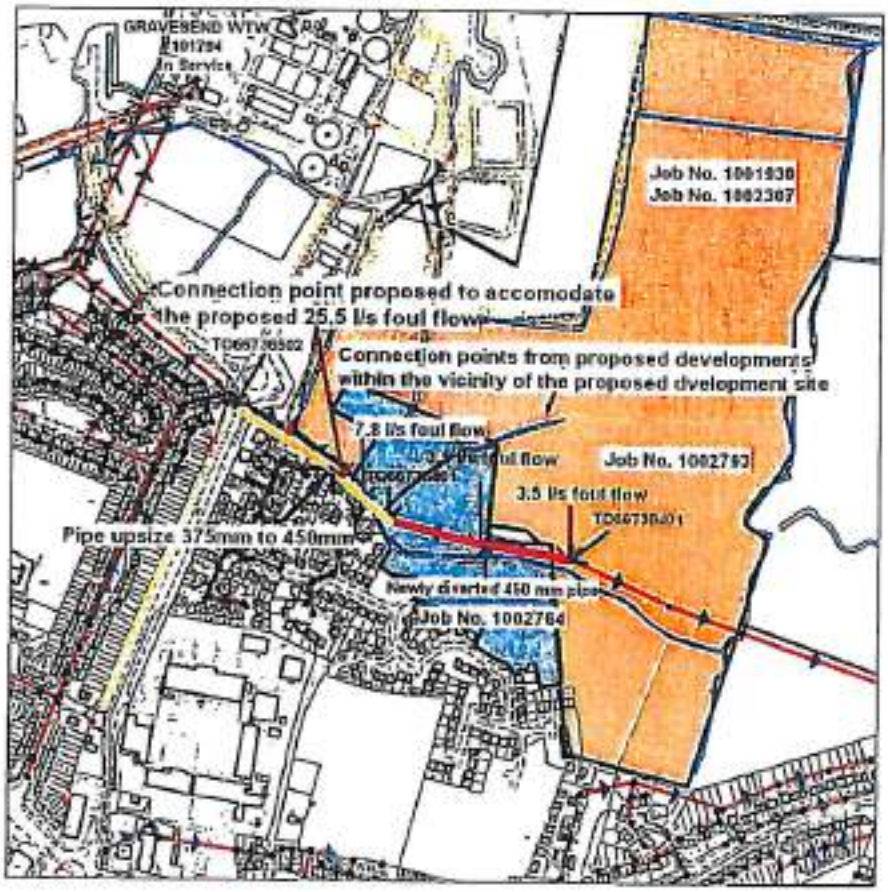
Job No 1002764. Discharge 7.9 l/s into manhole TQ66737**405**.

Current Job No 1002973. Discharge 25.5 l/s into manhole TQ66737**501**.

The InfoWorks model result indicates that the sewerage system upstream the proposed connection point is surcharged and flooding is predicted upstream at manhole reference TQ67733**205** and TQ67733**206**.

The improvements necessary to accommodate all the phased development foul flows are shown in Figure 2. The proposal is to increase the existing 375mm sewer between TQ67738**401** and TQ67736**502** to 450 mm (Total length of 203 metres at approximately 2.75m average depth).

Figure 2. Proposed Improvements.



Conclusion

There is no available capacity in the foul sewerage system at manhole TQ66737**501** to accommodate the 25.5 l/s foul flow. It is therefore necessary to increase the size of the existing 375-mm sewer between manhole **TQ67738401** and TQ67736**502** to 450 mm in diameter. The proposed improvements will also accommodate the proposed flow and flow from the other phased developments as shown in Figure 2.

Alternatively, connect to the proposed foul flow at manhole reference TQ66735**801** located by the Wastewater Treatment Works located approximately 500 metres north west of the proposed development site.

Appendix H

Southern Water's Foul Water Capacity Assessment Letter Report

Southern Water

B142 5/7/10

ATKINS

Atkins Limited
Anglo St James House
39A Southgate Street
Winchester
Hampshire SO23 9EH

Telephone +44 (0)1962 858688
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Applicant:
Ardent Consulting Engineers Limited
4th Floor
Diamond House
36/38 Hatton Garden
London
EC1N 8EB

Your Ref: SJ/ss8580/B142

Our Ref: CC/000554

Date:
1 July 2010

Dear Mr. Burton,

Site: Land off Dalefield Way, North-East Gravesend, Kent.

We have completed the capacity check for the above development site and the results are as follows:-

Foul capacity check:
There is currently inadequate capacity within the local foul sewerage network to accommodate a foul flow of 10 l/s at manhole reference TQ66739303. The proposed development would increase flows to the public sewerage system and existing properties and land may be subject to a greater risk of flooding as a result. Additional off-site sewers, or improvements to existing sewers, will be required to provide sufficient capacity to service the development.

The nearest point where capacity is currently available is at manhole reference TQ66736502 located approximately 428m west of the proposed development site.

Section 98 of the Water Industry Act 1991 provides a legal mechanism through which the appropriate infrastructure can be requested (by the developer) and provided to drain a specific location. Alternatively, carry out off site reinforcement works in order to provide capacity for the proposed foul flow to be accommodated within the local sewerage system. The extent of the works required to provide capacity for the development site could be obtained via a level 2 Capacity Assessment (Application forms enclosed).

Unfortunately, it may be several years before adequate infrastructure is provided via a prioritised capital expenditure programme. Therefore, this proposed development would be considered premature until such time adequate sewerage infrastructure could be provided.

Before any connections are made, an application form needs to be completed and approved by Southern Water Services.

Surface water capacity check:
As surface water capacity check has not been requested it is assumed that surface water will be disposed off by alternative means such as soakaways or any local drainage watercourses, subject to all interested parties approval.

Should you require any further information, please contact us at the above mentioned phone number or address.

Yours faithfully

Network Development

Please note: -
The information provided above does not grant approval for any designs/drawings submitted for the capacity analysis. The results quoted above are only valid for 12 months from the date of issue of this letter.

Appendix I

HR Wallingford's Report:
Hydraulic Assessment of the Existing Drainage Channels
13th September 2001

HR Wallingford

Fax

To:	Buchanan Consulting Engineers		
For Attention of:	Chris Baker-Pearce	**Date:**	13 September 2001
Fax No:	020 7309 9056	**No of Pages:**	7
Copy To:			
From:	Rob Cheetham		
Direct tel line:	01491 82 23 33	**Our Ref:**	MCM4918/RJC/4
Email:	R.Cheetham@hrwallingford.co.uk	**Your Ref:**	

You can reply to us by using FAX NUMBER +44 (0) 1491 825916 (Water Management)
If the message is unclear/incomplete telephone +44 (0) 1491 822499 (Carol King)

Subject: **WESTCOURT MARSHES - REPORT**

Dear Chris,

Further to our discussion on Friday 7 September 2001, please find attached a copy of the report describing our findings regarding water levels in the drainage channels to the north of the development at Gravesend.

Do not hesitate to contact me should you wish to discuss this fax in greater detail.

Yours sincerely

Rob Cheetham
River and Urban Catchments Group

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DEVELOPMENT AT WESTCOURT MARSHES
REPORT ON THE HYDRAULIC MODELLING

1. *Introduction and modelling assumptions*

Buchanan Consulting Engineers (BCE), commissioned HR Wallingford to construct an iSIS model of a network of drainage channels to determine the efficacy of channel compensation works on containing additional runoff from a new development in Gravesend.

An on-site surface water drainage strategy has been developed in accordance with design principles agreed with the Environment Agency (the Agency) and English Nature for 165 dwellings. The strategy is outlined in a report by Buchanan Consulting Engineers; 'Proposed Development PM9 Gravesend (M591)'.

The development site lies in low lying marsh, comprising of a network of inter-connected drainage channels and is part of developable land which is bordered by North Kent railway and Medway canal. For hydraulic modelling purposes, natural runoff from the marsh was agreed with the Agency at 7 litres/hectare for the 100 year event.

The northern limit of the developable land is the North Kent railway and the drainage ditches discharge beneath the railway via three outfalls. The Agency wishes to limit the discharge under the railway to the natural runoff rates. The limit of discharge for each outfall was calculated based on the 7 litres/hectares natural runoff.

The site of the new development is located to the south of the developable land and the runoff from the 165 houses was calculated by BCE using a HydroWorks urban drainage model. The critical 100 year storm duration for the development was calculated to be 4 hours and the peak runoff was $0.34 m^3/s$.

To comply with Agency requirements, the additional runoff from the new development will be contained within the drainage channels to the south of the railway line. BCE designed a berm for the drainage channel running to the east and north of the development to contain the runoff and the location and dimensions of this berm are given in drawings U481/001&002.

2. *Modelling methodology*

The hydraulic modelling for the investigation was carried out using the iSIS suite of software. Two hydraulic models were constructed: a pre-development and a post development model. The model included all the drainage channels and the three outfalls beneath the railway. In addition, the runoff from the developable land and the land to the east was represented using standard flow boundaries in iSIS.

The aim of the modelling was to determine whether the runoff from the development could be contained within the berm. In order to assess the impact of the development runoff on water levels in the drainage channels, simulations for both the pre and post development were carried out. The pre development model was constructed using cross section data as shown in Randall Surveys drawing 6759/A/SP/1&2. The post development model was constructed using cross section data shown in drawings U481-001&002. The berm extends from cross section 6 to the control structure X. Manning's n for the drainage channels for the initial simulation (baseline scenario) were 0.045.

A total of 9 inflows were included in the pre-development model. BCE Figure M591-07 shows the locations and rates of the 7 inflows for the contributing areas within the developable land and the runoff rates range between 7.91l/s to 43.05l/s. The 43.05l/s inflow represents the natural runoff from the area where the development will be located. The two remaining inflows are from the surface water sewer that drains to the west of the development (690 l/s) and the contributing area to the east of the site (134.95 l/s). These 9 inflows were included in the hydraulic model at the appropriate locations and were kept constant throughout the unsteady model simulations.

The downstream model boundaries were modelled using abstraction units, which allowed the discharge at the outfalls to be fixed at the agreed limits of discharge, which were:

Control Structure X – 144 l/s
Control Structure Y – 150 l/s
Control Structure Z – 717 l/s.

The limit of discharge for Control Structure Z also includes the 690 l/s contribution from a surface water sewer draining parts of Gravesend.

For the post development simulations, the 43.05 l/s inflow was replaced by the 4 hour post development hydrograph, from the BCE HydroWorks modelling. The peak flow from the development was 0.34m3/s and occurred 2.08 hours after the start of the rainfall.

For the pre development simulations, the natural runoff entering the drainage channels equalled the amount abstracted at the downstream boundaries. Under these steady conditions, the initial conditions in the channel are critical as they will also be the final water levels. In view of this, a separate simulation was carried out to determine the initial conditions using a model with weirs at the downstream boundaries (the weir model), the dimensions of which were based on the structure shown in drawing U481-001.

The crest levels of all the weirs were set at 1.35mAD, 100mm above the bed level at control structure X. Control structure X had a weir width of 0.25m and initial simulations were carried out to determine the widths of the other outfalls, ensuring each structure allowed only the maximum agreed discharge through. The result was weir crest widths of 0.26 and 1.20m for control structures Y and Z respectively. The bed levels at control structures Y and Z were lower than at X and to simplify the modelling methodology, the crest levels of each control structure were set at 1.35mAD.

On definition of the initial conditions, the pre and post development simulations were carried out using the models with abstraction units at the downstream boundaries. The following scenarios were carried out:

- Baseline scenario;
- Manning's n sensitivity test; and
- Drowned outfall sensitivity test.

For each scenario, initial conditions were generated using the weir model. For the Manning's n sensitivity test, Manning's n was increased from 0.045 to 0.055. For the drowned outfall scenario, the water downstream of the structure was set at 1.9mAD, a level sufficient to cause drowning of the weir.

The following section presents the results of the simulations.

3. *Results*

The following tables show the results of the hydraulic modelling simulations. Table 1 gives the pre and post development water levels for the baseline case, Table 2 shows the results of the Manning's n sensitivity test and Table 3 gives the results of the drowned outfall sensitivity test.

It can be seen from Tables 1-3 that post development water levels in the reach from cross section 1 to cross section 5 increase by up to 0.25m. This is because the channel improvement works commence at cross section 6 and the additional runoff from the development is not compensated for throughout this reach. Water levels in the reaches upstream of the outfall structures (including the reach containing the berm) are predicted to increase by up to 0.08m with the inclusion of the development runoff.

It can be seen by comparing the results presented in Tables 1 and 2 that changes in Manning's n have little impact on water levels in the drainage channels. This indicates water levels are predominantly controlled by the outfall structures. However, in the reach from cross section 1 to 6, the post development water levels are predicted to increase slightly.

For the drowned outfall conditions, the post development water levels increase by approximately 0.06m in the reach containing the berm.

Table 1 Baseline conditions

Section Label	Pre development water levels (mAOD)	Post development water levels (mAOD)	Difference (m)
CS1	1.99	2.22	0.23
CS2	1.99	2.22	0.22
CS3	1.99	2.22	0.22
CS4	1.97	2.14	0.17
CS5	1.96	2.03	0.06
CS6	1.96	1.98	0.02
CS7	1.96	1.98	0.02
CS8	1.96	1.98	0.02
CS9	1.96	1.98	0.02
CS10	1.96	1.98	0.02
CS11	1.96	1.98	0.02
CS12	1.96	1.98	0.02
CS13	1.96	1.98	0.02
CS14	1.94	1.98	0.04
CS15	1.93	1.98	0.06
CS16	1.91	1.98	0.07
CS17	1.91	1.98	0.07
CS18	1.91	1.98	0.07
CS19	1.91	1.98	0.07
CS20	1.91	1.98	0.07
CS21	1.91	1.98	0.07
CS22	1.90	1.98	0.08
CS23	1.90	1.98	0.07
CS24	1.90	1.98	0.08
CS25	1.90	1.98	0.08
CS26	1.90	1.98	0.08
CS27	1.90	1.98	0.08
CS28	1.90	1.98	0.08
CS29	1.91	1.98	0.07
CS30	1.91	1.98	0.07
CS31	1.91	1.98	0.07
CS32	1.91	1.98	0.07
CS33	1.91	1.98	0.07
CS34	1.91	1.98	0.07
CS35	1.91	1.98	0.07
CS36	1.91	1.98	0.07
CS37	1.91	1.98	0.07
CS38	1.94	1.99	0.05
CS39	1.99	2.00	0.01

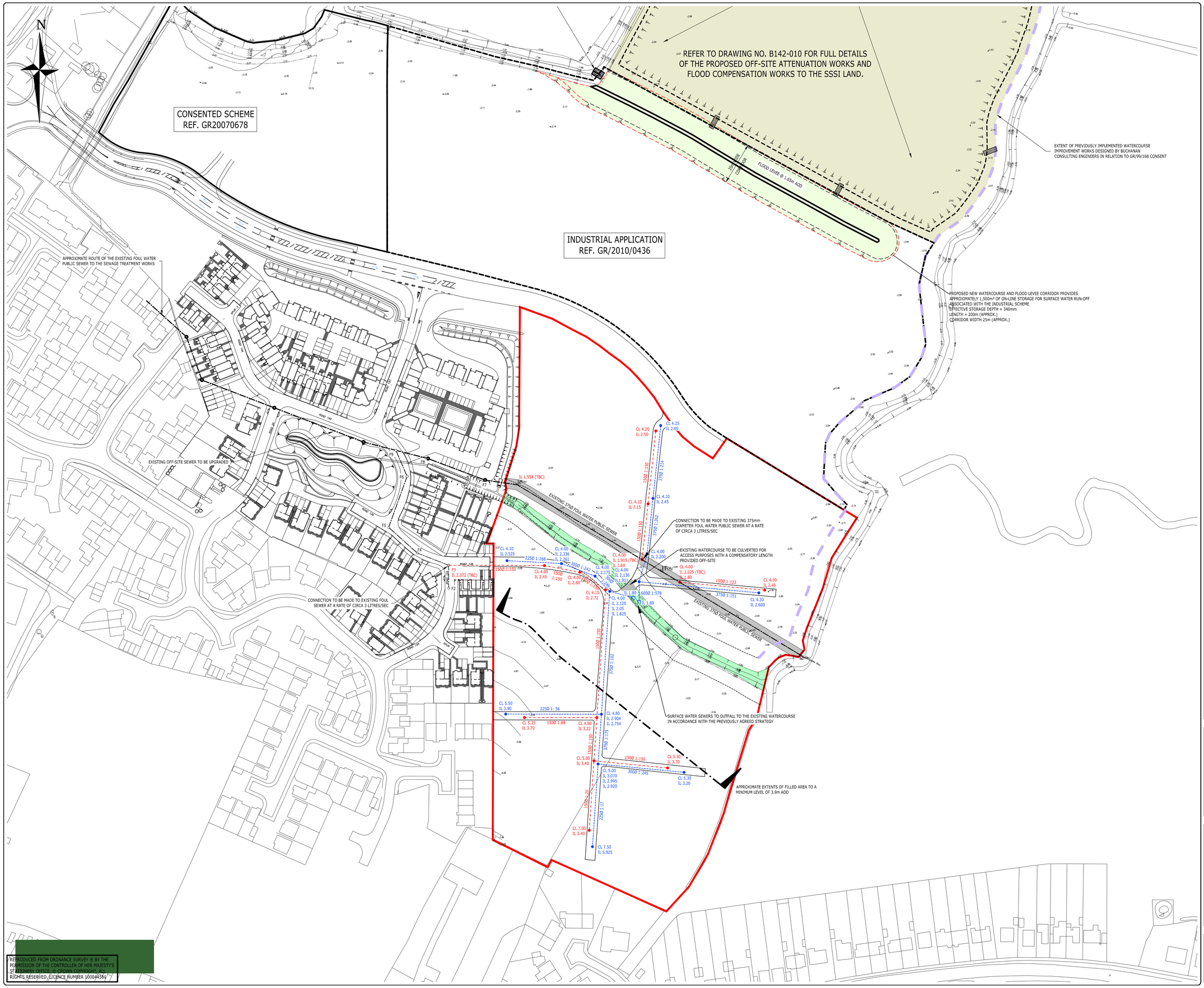
Table 2 Manning's n sensitivity test

Section Label	Pre development water levels (mAOD) GR-PRE4.dat	Post development water levels (mAOD) GR-POST6.dat	Difference (m)
CS1	1.99	2.24	0.25
CS2	1.99	2.24	0.25
CS3	1.99	2.24	0.25
CS4	1.98	2.16	0.19
CS5	1.97	2.04	0.08
CS6	1.96	1.99	0.03
CS7	1.96	1.99	0.03
CS8	1.96	1.99	0.03
CS9	1.96	1.99	0.03
CS10	1.96	1.99	0.03
CS11	1.96	1.99	0.03
CS12	1.96	1.99	0.03
CS13	1.96	1.99	0.03
CS14	1.96	1.99	0.03
CS15	1.94	1.99	0.04
CS16	1.93	1.98	0.06
CS17	1.91	1.98	0.07
CS18	1.91	1.98	0.07
CS19	1.91	1.98	0.07
CS20	1.91	1.98	0.07
CS21	1.91	1.98	0.07
CS22	1.91	1.98	0.07
CS23	1.90	1.98	0.08
CS24	1.90	1.98	0.08
CS25	1.90	1.98	0.08
CS26	1.90	1.98	0.08
CS27	1.90	1.98	0.08
CS28	1.90	1.98	0.08
CS29	1.90	1.98	0.08
CS30	1.91	1.98	0.07
CS31	1.91	1.98	0.07
CS32	1.91	1.98	0.07
CS33	1.91	1.98	0.07
CS34	1.91	1.98	0.07
CS35	1.91	1.98	0.07
CS36	1.91	1.98	0.07
CS37	1.91	1.98	0.07
CS38	1.92	1.99	0.07
CS39	1.94	2.02	0.08

Table 3 Drowned outfall sensitivity test

Section Label	Pre development water levels (mAOD)	Post development water levels (mAOD)	Difference (m)
CS1	2.04	2.22	0.18
CS2	2.04	2.22	0.18
CS3	2.04	2.22	0.18
CS4	2.03	2.15	0.13
CS5	2.02	2.07	0.05
CS6	2.02	2.04	0.02
CS7	2.02	2.04	0.02
CS8	2.02	2.04	0.02
CS9	2.02	2.04	0.02
CS10	2.02	2.04	0.02
CS11	2.02	2.04	0.02
CS12	2.02	2.04	0.02
CS13	2.02	2.04	0.02
CS14	2.01	2.04	0.03
CS15	2.00	2.04	0.04
CS16	1.99	2.04	0.05
CS17	1.99	2.04	0.05
CS18	1.99	2.04	0.05
CS19	1.99	2.04	0.05
CS20	1.99	2.04	0.05
CS21	1.99	2.04	0.05
CS22	1.98	2.04	0.06
CS23	1.98	2.04	0.05
CS24	1.98	2.04	0.06
CS25	1.98	2.04	0.06
CS26	1.98	2.04	0.06
CS27	1.98	2.04	0.06
CS28	1.98	2.04	0.06
CS29	1.99	2.04	0.05
CS30	1.99	2.04	0.05
CS31	1.99	2.04	0.05
CS32	1.99	2.04	0.05
CS33	1.99	2.04	0.05
CS34	1.99	2.04	0.05
CS35	1.99	2.04	0.05
CS36	1.99	2.04	0.05
CS37	1.99	2.04	0.05
CS38	2.01	2.05	0.04
CS39	2.04	2.06	0.02

Drawings



NOTES:

KEY:

- PROPOSED FOUL WATER SEWER
- EXISTING FOUL WATER SEWER
- PROPOSED SURFACE WATER SEWER
- EXTENT OF 8m WIDE BUFFER ZONE TO DESIGNATED MAIN RIVER/WATERCOURSE (FROM TOP OF BANK)
- 6m WIDE EASEMENT TO PUBLIC SEWER
- EXTENT OF ON-SITE DESIGNATED MAIN RIVER/ WATERCOURSE

NOTES:

1. ALL CONNECTIONS AND OUTFALLS SHALL BE SURVEYED/ VERIFIED BEFORE THE COMMENCEMENT OF THE DETAILED DESIGN WORKS.
2. FOR DETAILS OF THE PROPOSED DEVELOPMENT LAYOUT, REFER TO THE MASTERPLAN PREPARED BY KEMBER LOUDON WILLIAMS LTD.
3. REFER TO THE LANDSCAPING STRATEGY PREPARED BY DF CLARK FOR THE DEVELOPMENT SITE.

FLOOD COMPENSATORY WORKS TO BE DESIGNED AND IMPLEMENTED IN ACCORDANCE WITH THE PRINCIPLES OUTLINED WITHIN THE REPORT PRODUCED BY RSPB IN JUNE 2005 ENTITLED 'WET GRASSLAND PRACTICAL MANUAL : BREEDING WADERS'

HIGH LEVEL GRAVEL GRIP TO ALLOW STANDING WATER TO DRAIN OUT INTO THE ADJACENT WATERCOURSES FOLLOWING EXTREME EVENTS

ALL AS PREVIOUS FREE DISCHARGE WITH BALANCING TO BE PROVIDED ON-LINE IN NEW WATERCOURSES

NOTE:
ALL PROPOSED COVER LEVELS AND INVERT LEVELS ARE PRELIMINARY AT THIS STAGE AND ARE SUBJECT TO DETAILED DESIGN AND APPROVAL.

NOT FOR CONSTRUCTION - SUBJECT TO APPROVAL

REV	AMENDMENTS	DRN	CHK	APP	DATE

ARDENT
CONSULTING ENGINEERS
4th Floor, Diamond House
36/38 Hatton Garden
London
EC1N 8EB
t 020 7430 1209
f 020 7430 0318
w www.ardent-ce.co.uk
e enquiries@ardent-ce.co.uk

CLIENT:
FORT KNIGHT GROUP, SUNRAY DEVELOPMENTS & KENT COUNTY COUNCIL

PROJECT TITLE:
LAND SOUTH OF DALEFIELD WAY NORTH-EAST GRAVESEND

DRAWING TITLE:
PRELIMINARY FOUL AND SURFACE WATER DRAINAGE STRATEGY

SCALE:	DATE:	DESIGNED:
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DRAWN: SJB	CHECKED: ARF	APPROVED: CBP
DRAWING NO. B142-009		REV:

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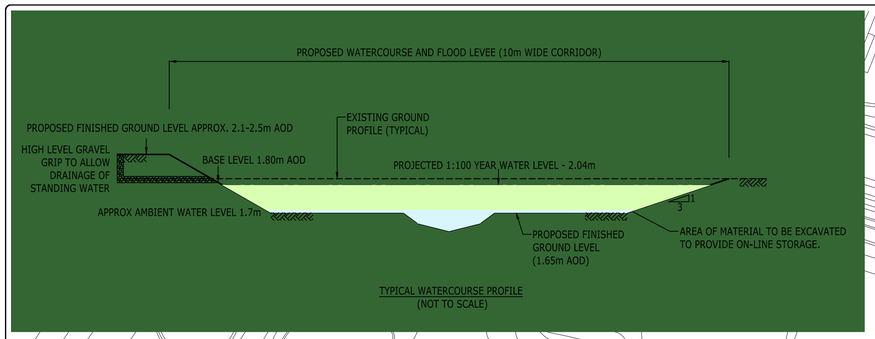
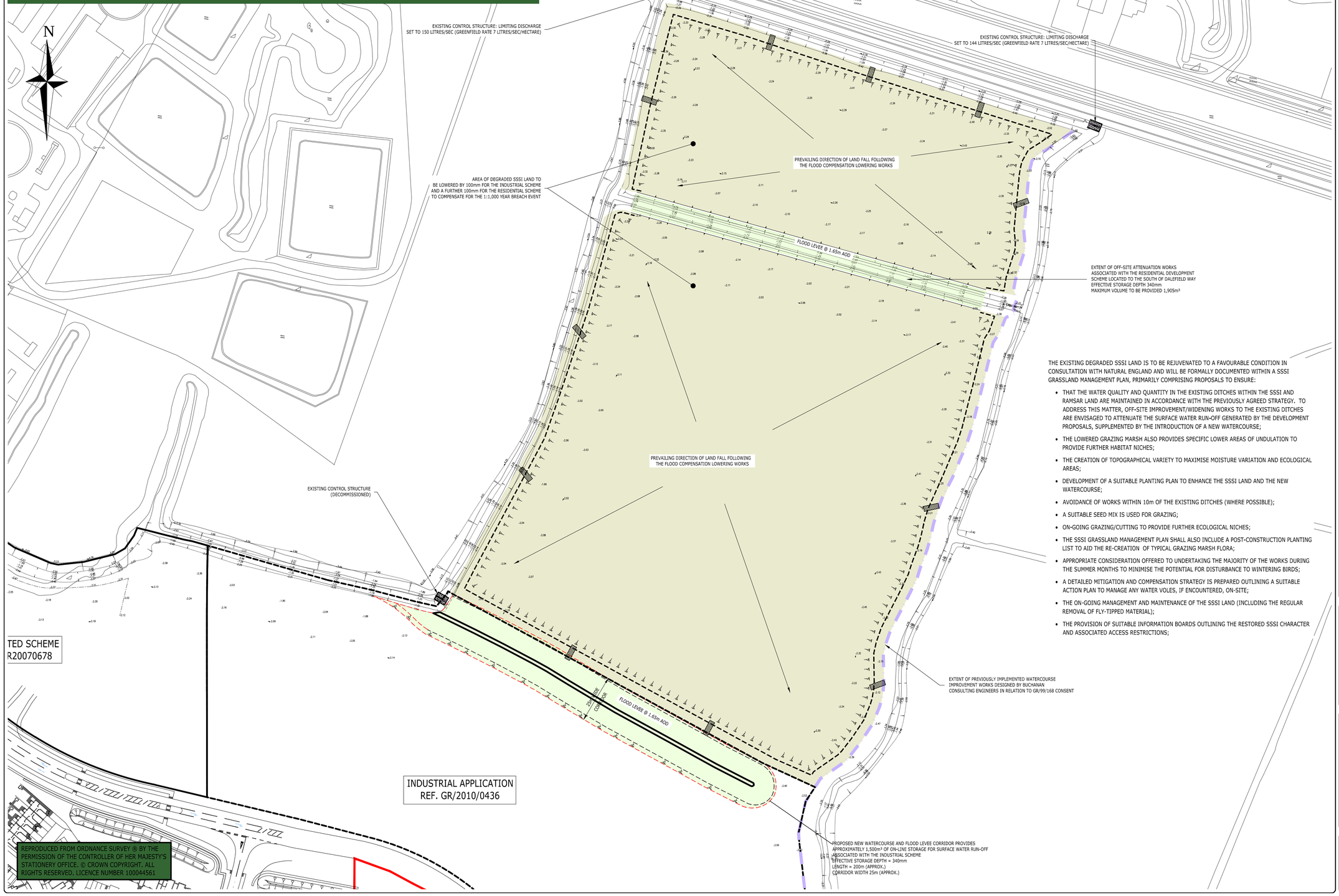


TYPICAL WATERCOURSE PROFILE
(NOT TO SCALE)



THE EXISTING DEGRADED SSSI LAND IS TO BE REJUVENATED TO A FAVOURABLE CONDITION IN CONSULTATION WITH NATURAL ENGLAND AND WILL BE FORMALLY DOCUMENTED WITHIN A SSSI GRASSLAND MANAGEMENT PLAN, PRIMARILY COMPRISING PROPOSALS TO ENSURE:

- THAT THE WATER QUALITY AND QUANTITY IN THE EXISTING DITCHES WITHIN THE SSSI AND RAMSAR LAND ARE MAINTAINED IN ACCORDANCE WITH THE PREVIOUSLY AGREED STRATEGY. TO ADDRESS THIS MATTER, OFF-SITE IMPROVEMENT/WIDENING WORKS TO THE EXISTING DITCHES ARE ENVISAGED TO ATTENUATE THE SURFACE WATER RUN-OFF GENERATED BY THE DEVELOPMENT PROPOSALS, SUPPLEMENTED BY THE INTRODUCTION OF A NEW WATERCOURSE;
- THE LOWERED GRAZING MARSH ALSO PROVIDES SPECIFIC LOWER AREAS OF UNDULATION TO PROVIDE FURTHER HABITAT NICHES;
- THE CREATION OF TOPOGRAPHICAL VARIETY TO MAXIMISE MOISTURE VARIATION AND ECOLOGICAL AREAS;
- DEVELOPMENT OF A SUITABLE PLANTING PLAN TO ENHANCE THE SSSI LAND AND THE NEW WATERCOURSE;
- AVOIDANCE OF WORKS WITHIN 10m OF THE EXISTING DITCHES (WHERE POSSIBLE);
- A SUITABLE SEED MIX IS USED FOR GRAZING;
- ON-GOING GRAZING/CUTTING TO PROVIDE FURTHER ECOLOGICAL NICHES;
- THE SSSI GRASSLAND MANAGEMENT PLAN SHALL ALSO INCLUDE A POST-CONSTRUCTION PLANTING LIST TO AID THE RE-CREATION OF TYPICAL GRAZING MARSH FLORA;
- APPROPRIATE CONSIDERATION OFFERED TO UNDERTAKING THE MAJORITY OF THE WORKS DURING THE SUMMER MONTHS TO MINIMISE THE POTENTIAL FOR DISTURBANCE TO WINTERING BIRDS;
- A DETAILED MITIGATION AND COMPENSATION STRATEGY IS PREPARED OUTLINING A SUITABLE ACTION PLAN TO MANAGE ANY WATER VOLES, IF ENCOUNTERED, ON-SITE;
- THE ON-GOING MANAGEMENT AND MAINTENANCE OF THE SSSI LAND (INCLUDING THE REGULAR REMOVAL OF FLY-TIPPED MATERIAL);
- THE PROVISION OF SUITABLE INFORMATION BOARDS OUTLINING THE RESTORED SSSI CHARACTER AND ASSOCIATED ACCESS RESTRICTIONS;

TED SCHEME
R20070678

INDUSTRIAL APPLICATION
REF. GR/2010/0436

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NOTES:

1. THIS DRAWING IS TO BE READ IN CONJUNCTION ARDENT CONSULTING ENGINEERS 'FLOOD RISK AND DRAINAGE STRATEGY REPORT' REFERENCED B142-003.

2. DO NOT SCALE FROM THIS DRAWING. WORK FROM FIGURED DIMENSIONS ONLY.

3. ALL DIMENSIONS SHOWN ON THIS DRAWING ARE IN METRES UNLESS OTHERWISE STATED.

4. ALL DIMENSIONS, LEVELS AND SURVEY GRID CO-ORDINATES ARE TO BE CHECKED ON SITE AND THE ENGINEER NOTIFIED IMMEDIATELY OF ANY DISCREPANCIES PRIOR TO THE COMMENCEMENT OF THE WORKS.

FLOOD COMPENSATORY WORKS TO BE DESIGNED AND IMPLEMENTED IN ACCORDANCE WITH THE PRINCIPLES OUTLINED WITHIN THE REPORT PRODUCED BY RSPB IN JUNE 2005 ENTITLED 'WET GRASSLAND PRACTICAL MANUAL : BREEDING WADERS'

HIGH LEVEL GRAVEL GRIP TO ALLOW STANDING WATER TO DRAIN OUT INTO THE ADJACENT WATERCOURSES FOLLOWING EXTREME EVENTS

ALL SITES TO FREELY DISCHARGE WITH BALANCING TO BE PROVIDED ON-LINE IN NEW WATERCOURSES IN ACCORDANCE WITH THE STRATEGY PREVIOUSLY AGREED WITH ENVIRONMENT AGENCY

NOT FOR CONSTRUCTION - SUBJECT TO APPROVAL

REV	AMENDMENTS	DRN	CHK	APP	DATE

ARDENT
CONSULTING ENGINEERS
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f 020 7430 0318
w www.ardent-ce.co.uk
e enquiries@ardent-ce.co.uk

CLIENT:
FORT KNIGHT GROUP, SUNRAY DEVELOPMENTS & KENT COUNTY COUNCIL

PROJECT TITLE:
LAND SOUTH OF DALEFIELD WAY
NORTH-EAST GRAVESEND

DRAWING TITLE:
OFF-SITE FLOOD COMPENSATION AND ATTENUATION WORKS

SCALE:	DATE:	DESIGNED:
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DRAWN: SJB	CHECKED: ARF	APPROVED: CBP
DRAWING NO. B142-010		REV:

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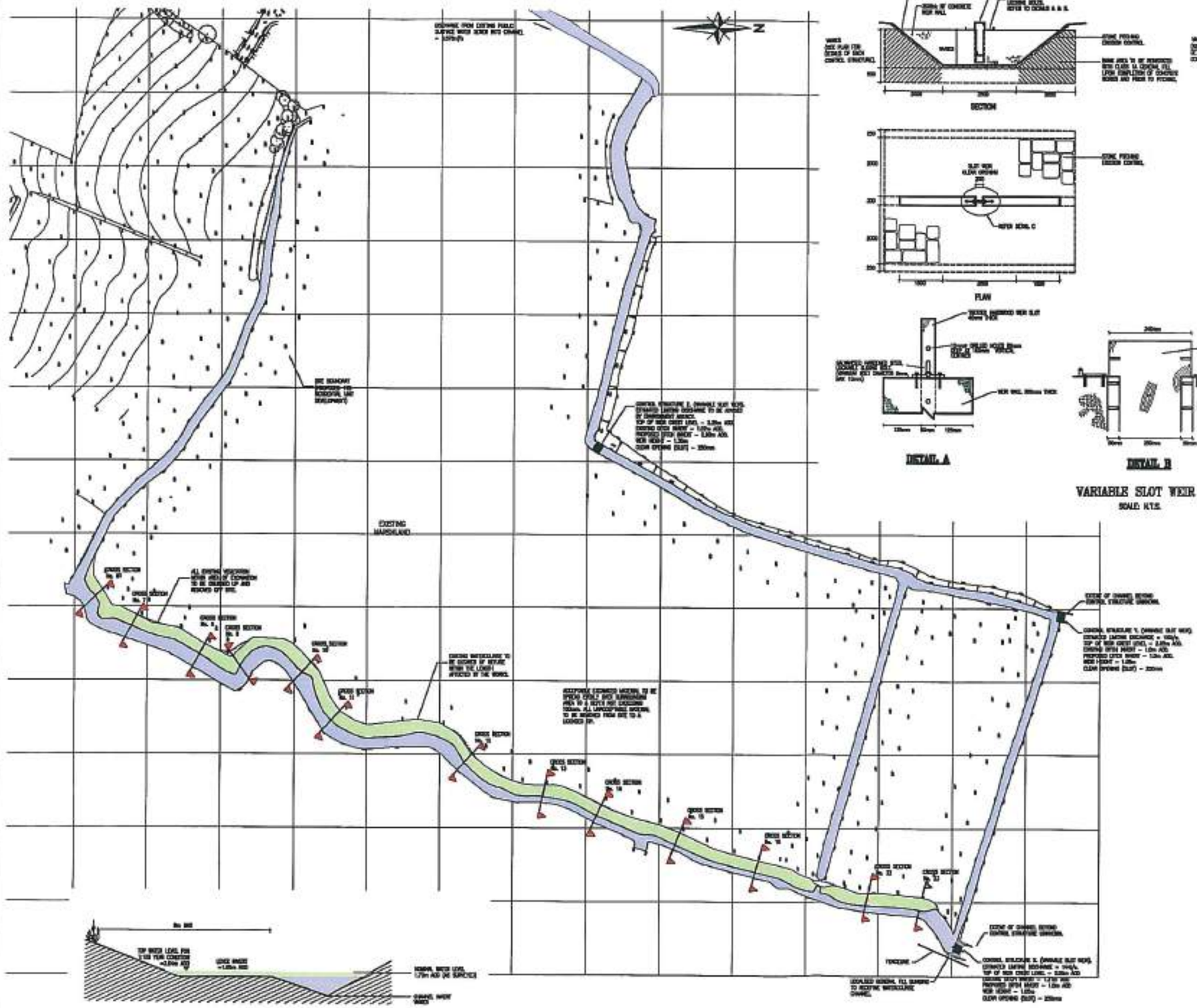
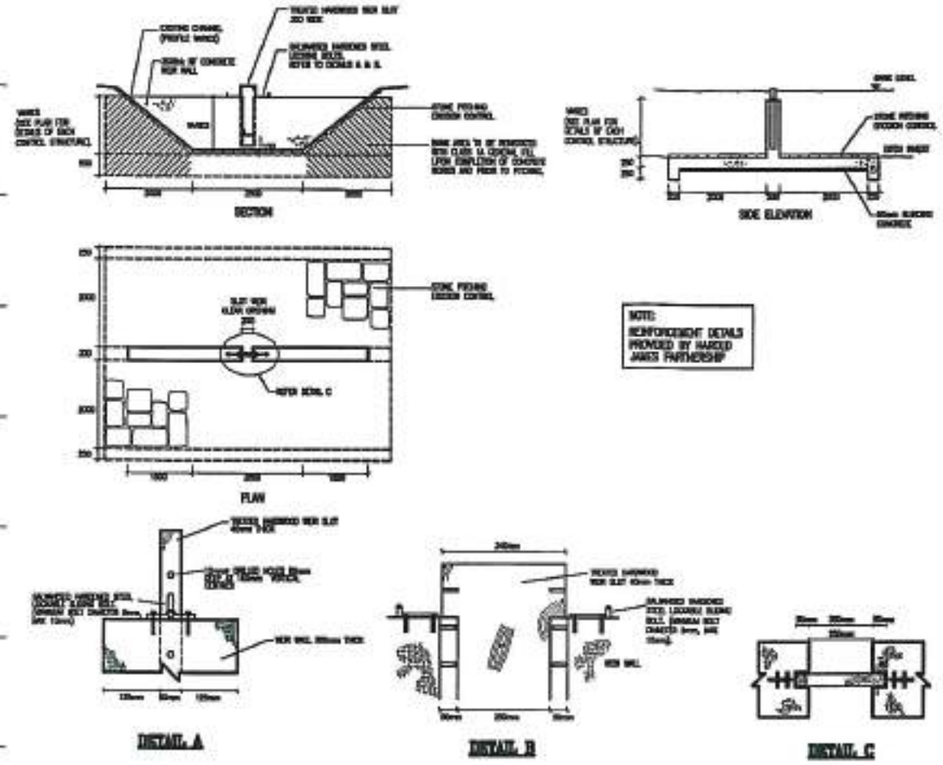




VARIABLE SLOT WEIR
SCALE: N.T.S.

NOTES:

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED.
2. ALL LEVELS GIVEN ARE IN METRES ABOVE ORDNANCE DATUM.
3. ALL DIMENSIONS SHALL BE SET OUT AND AGREED WITH THE SITE ENGINEER PRIOR TO THE COMMENCEMENT OF WORKS.
4. NO DEVIATION FROM THE DETAILS SHOWN ON THIS DRAWING SHALL BE PERMITTED WITHOUT THE PRIOR WRITTEN APPROVAL OF THE ENGINEER.
5. THE CONTRACTOR SHALL TAKE ALL NECESSARY PRECAUTIONS TO PROTECT THE DRAINAGE WORKS DURING ALL STAGES OF CONSTRUCTION.
6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR CONFIRMING THE EXISTING UNDERGROUND PRIOR TO THE COMMENCEMENT OF THE WORKS AND TO ESTABLISH THE EXACT POSITION OF THEIR PLANT, WHICH SHALL BE CONFIRMED BY HAND DUG TRIAL PITS IF NECESSARY.
7. CONTRACTORS MEANS OF ACCESS TO THE SITE TO BE AGREED WITH ENGINEER PRIOR TO THE COMMENCEMENT OF WORKS.
8. ALL WORKS SHALL BE UNDERTAKEN IN ACCORDANCE WITH THE CIVIL ENGINEERING SPECIFICATION FOR THE WATER INDUSTRY AN LEGISLATION FOR ACCEPTANCE AND SPECIFICATION FOR HIGHWAY WORKS. (WHERE APPROPRIATE).
9. ALL REINFORCED IN-SITU CONCRETE CLASS ST4 SHALL BE IN ACCORDANCE WITH THE C. 2002 OF SHA.
10. WITH REFERENCE TO THE DEPT. OF TRANSPORTS' SPECIFICATION FOR HIGHWAY WORKS, PART 5, CLT700 – ALL EXPOSED FORMED FACES OF CONCRETE TO BE CLASS F2 SURFACE FINISH, ALL UNEXPOSED FORMED FACES OF CONCRETE TO BE CLASS U2 SURFACE FINISH.
11. ALL EXPOSED EXTERNAL CORNERS OF CONCRETE SHALL BE FORMED WITH A 25 x 25mm CHAMFER.
12. THE COVER TO REINFORCEMENT SHALL BE 40mm UNLESS.
13. REINFORCEMENT WORK SHALL BE WITH TIES AND COUPLER WITH SEAMLESS.
14. ALL CONCRETE AND CONCRETE PRODUCTS SHALL BE CLASS 1 SULPHATE RESISTANT IN ACCORDANCE WITH BRE DIGEST 363.
15. CLASS A1 FILL TO BE IN ACCORDANCE WITH TABLE 6-1 OF SHA.
16. FOR CROSS SECTIONS REFER TO DWG No. 2002-004.
17. REPLANTING AND VEGETATION WORKS TO BE AGREED WITH THE ENVIRONMENT AGENCY AND ORMONDSHAL BLL PRIOR TO THE COMMENCEMENT OF THE WORKS.
18. ALL WORKS SUBJECT TO DETAILED STRUCTURAL, GEOTECHNICAL AND HYDROLOGICAL DESIGN.
19. SURVEY PROVIDED BY MARSHALL SURVEYS LTD. APRIL 2001.

NOTES FOR EXTENSIVE CONSTRUCTION

1. DEFINE CONSTRUCTION ADVICE RELATING TO THE SITE.
2. KEEP ALL EXCAVATION TO A MINIMUM.
3. LEAVE BANKS UNTOUCHED WHENEVER POSSIBLE, SPARING BANKSIDE VEGETATION UNLESS REPLACEMENTS BY PROVIDING WORKS.
4. COMPLY WITH RECOMMENDATIONS FROM THE FRIENDS/BOLLOCK/PARKER SURVEYS WHERE POSSIBLE.
5. LEAVE THE CHANNEL AS NATURAL AS POSSIBLE.
6. WORK FROM ONE BANK TO MINIMIZE CHANNEL DISTURBANCE AND RETAIN AREAS TO ACT AS A BANK FOR RECOLONISATION.
7. ENSURE CAREFUL STOCK PROTECTION, ACCURATE TRANSPORT AND DISPOSAL ON SENSITIVE AREAS.
8. AVOID CREATING SURFACE RUNOFF, SCALD, THIS MAY CAUSE SEVERE DISTURBANCE.
9. WORK FROM DOWNSTREAM UP SO THAT FLAKES FINE AS OPPORTUNITY TO RECOLONISE.
10. USE SUITABLE MACHINERY TO AVOID DAMAGE TO THE WATERCOURSE CORRIDOR.

KEY:

EXISTING WATERCOURSE

EXTENT OF CHANNEL IMPROVEMENT

CONSTRUCTION ISSUE

A	CHANNEL WATERLINE WORK AMENDED	JMF	CDF	10/01
B	CHANNEL WATERLINE 2 IMPROVED CHANNELLING WORK	JMF	CDF	10/01
C	GENERAL ALTERATIONS AND NOTES CHANGED	JMF	CDF	10/01
D	CHANNELLING WORK	JMF	CDF	10/01
E	TYPICAL CROSS SECTION AMENDED	JMF		10/01
Rev	Amendments	Drn	Chkd	Date

BOCKSMAN CONSULTING ENGINEERS

Bernanche House
49–53 Stirling Hill Gate
London, W11 3QD

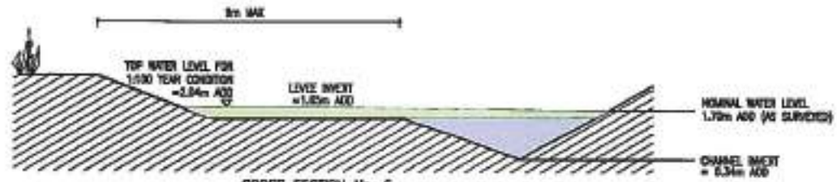
Telephone [illegible] Fax [illegible]

Job Title: LOD OFF SITE WW DRAINAGE

Drawing Title: OFF SITE CHANNEL IMPROVEMENTS

Sheet: MOUNT CROSS CORRIDOR

Date: 5/2001	Scale: 1:1250	Designed: CDF	
Drawn: JMF	Checked: CDF	Approved:	
Job No: 00001	Drawing No: 2002-001	Rev: E	



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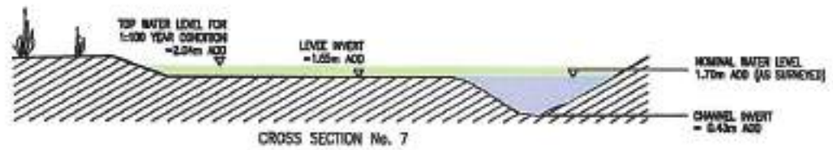

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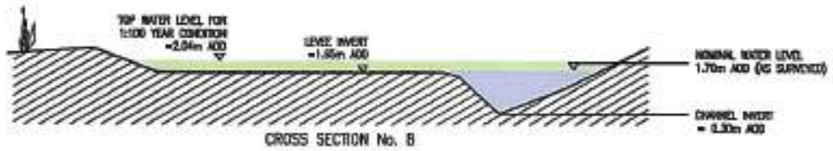

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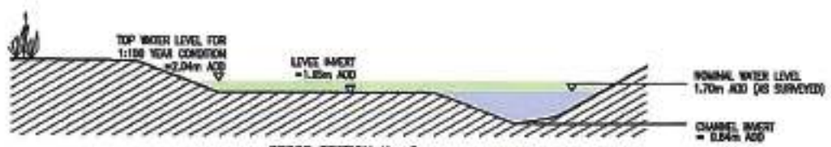

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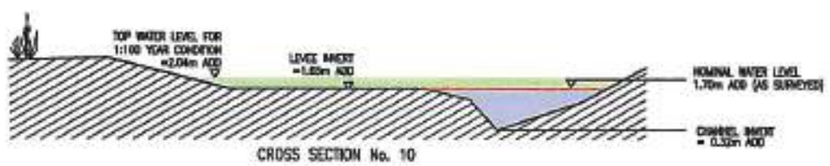

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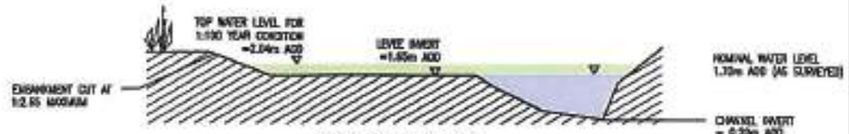

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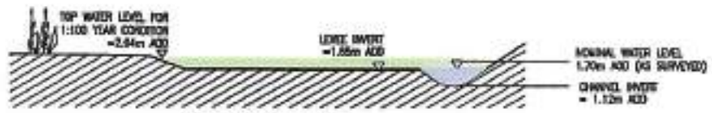

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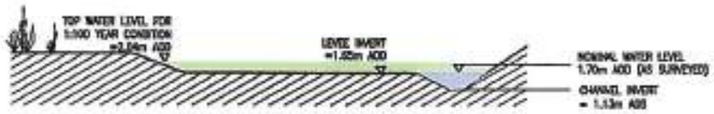

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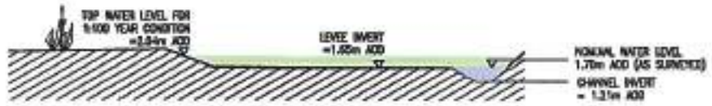

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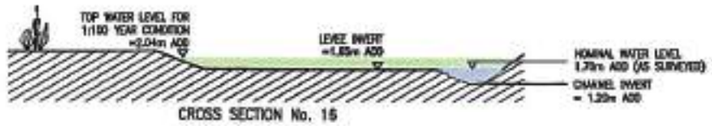

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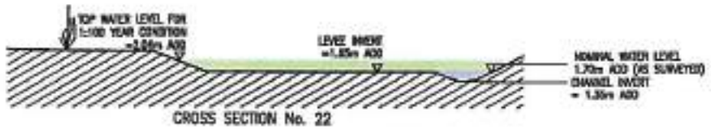

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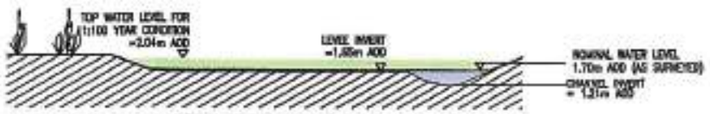

CROSS SECTION No. 23

NB: EMBANKMENT SLOPES TO BE CUT AT A MAXIMUM OF 1:2.65

NOTES FOR WATERCOURSE CONSTRUCTION

1. OBTAIN CONSERVATION ADVICE RELATING TO THE SITE.
2. KEEP ALL EXCAVATION TO A MINIMUM.
3. LEAVE BANKS UNTOUCHED WHEREVER POSSIBLE, SPARING BANKSIDE VEGETATION UNLESS IMPOVERISHED BY PREVIOUS WORKS.
4. COMPLY WITH RECOMMENDATIONS FROM THE FISHERY/BIOLOGY/HABITAT SURVEYS WHERE POSSIBLE.
5. LEAVE THE CHANNEL AS VARIED AS POSSIBLE.
6. WORK FROM ONE BANK TO MINIMISE OVERALL DISTURBANCE AND RETAIN AREAS TO ACT AS A BASIS FOR RECOLONISATION.
7. ENSURE CAREFUL SPOIL DISPOSAL AVOIDING TRANSPORT AND DESPOSITION ON SENSITIVE AREAS.
8. AVOID DREDGING THROUGH GRAVEL SEAMS. THIS MAY DRAIN NEARBY WETLANDS.
9. WORK FROM DOWNSTREAM UP SO THAT PLANTS HAVE AN OPPORTUNITY TO RECOLONISE.
10. USE GENTLE MACHINERY TO AVOID DAMAGE TO THE WATERCOURSE CORRIDOR.

KEY:

- STORAGE AREA (TOP WATER LEVEL RELATED TO PROVED OUTFALL CONDITION)
- EXCAVATED AREA FOR REGULAR WETTING CONDITION
- AMBIENT BASE FLOW WETTING CONDITION

NOTES:

1. ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE STATED.
2. ALL LEVELS STATED ARE IN METRES ABOVE ORDNANCE DATUM.
3. ALL DIMENSIONS SHALL BE SET OUT AND AGREED WITH THE SITE ENGINEER PRIOR TO THE COMMENCEMENT OF WORKS.
4. NO DEVIATION FROM THE DETAILS SHOWN ON THIS DRAWING SHALL BE PERMITTED WITHOUT THE PRIOR WRITTEN APPROVAL OF THE ENGINEER.
5. THE CONTRACTOR SHALL TAKE ALL NECESSARY PRECAUTIONS TO PROTECT THE DRAINAGE WORKS DURING ALL STAGES OF CONSTRUCTION.
6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR CONTACTING THE STATUTORY UNDERGRINDERS PRIOR TO THE COMMENCEMENT OF THE WORKS AND TO ESTABLISH THE EXACT POSITION OF THEIR PLANT, WHICH SHALL BE CONFIRMED BY HAND DUG TRIAL PITS IF NECESSARY.
7. CONTRACTORS MEANS OF ACCESS TO THE SITE TO BE AGREED WITH LANDOWNER PRIOR TO THE COMMENCEMENT OF WORKS.
8. ALL WORKS SHALL BE UNDERTAKEN IN ACCORDANCE WITH THE 'CIVIL ENGINEERING SPECIFICATION FOR THE WATER INDUSTRY' 4th EDITION,'SERIES FOR ADOPTION' AND SPECIFICATION FOR HIGHWAY WORKS. (WHERE APPROPRIATE).
9. ALL REINFORCED IN-SITU CONCRETE CLASS STA SHALL BE IN ACCORDANCE WITH THE CL 2802 OF SHW.
10. WITH REFERENCE TO THE DEPT. OF TRANSPORTS' SPECIFICATION FOR HIGHWAY WORKS', PART 5, CL1700 – ALL EXPOSED FORMED FACES OF CONCRETE TO BE CLASS F3 SURFACE FINISH. ALL UNEXPOSED FORMED FACES OF CONCRETE TO BE CLASS U3 SURFACE FINISH.
11. ALL EXPOSED EXTERNAL CORNERS OF CONCRETE SHALL BE FORMED WITH A 25 x 25mm CHAMFER.
12. THE COVER TO REINFORCEMENT SHALL BE 40mm MINIMUM.
13. REINFORCEMENT MESH SHALL BE HIGH YIELD AND COMPLY WITH BS4483.
14. ALL CONCRETE AND CONCRETE PRODUCTS SHALL BE CLASS 1 SULPHATE RESISTANT IN ACCORDANCE WITH BRE DIGEST 363.
15. CLASS 6B FILL TO BE IN ACCORDANCE WITH TABLE 6-1 OF SHW.
16. FOR GENERAL ARRANGEMENT REFER TO DRG No. U481-001.
17. REPLANTING AND VEGETATION WORKS TO BE AGREED BY THE CONTRACTOR WITH THE ENVIRONMENT AGENCY AND GRAVESHAM B.C. PRIOR TO THE COMMENCEMENT OF THE WORKS.
18. ALL WORKS SUBJECT TO DETAILED HYDRAULIC, STRUCTURAL AND GEOTECHNICAL DESIGN.
19. SURVEY PROVIDED BY RANDALL SURVEYS LTD. APRIL 2001.

CONSTRUCTION ISSUE

Rev	Amendments	Drn	Chkd	Date
D	EMBANKMENT SLOPES AMENDED	AMF	CEP	01.08.02
C	CONSTRUCTION ISSUE	AMF	CEP	24.05.02
B	CROSS SECTIONS AMENDED	AMF	CEP	15.08.01
A	SCALE ALTERED	AMF		06/01

BUCHANAN CONSULTING ENGINEERS
Newcombe House
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Job Title: LAND OFF DERING WAY GRAVESEND

Drawing Title: OFF SITE CHANNEL IMPROVEMENTS CROSS SECTIONS

Client: BARRATT EASTERN COUNTIES

Scale	Date	Designed
1:100&1	JUNE 2001	CEP
Drawn: AMF	Checked: CEP	Approved:

Job No	Drawing No	Rev
U481	U481-002	D

Appendix B – Phase 2 Flood Risk Assessment Addendum - November 2011

FORT KNIGHT GROUP DEVELOPMENTS LTD
AND KENT COUNTY COUNCIL

NORTH EAST GRAVESEND

FLOOD RISK ASSESSMENT ADDENDUM

REPORT REF. B142-05
PROJECT NO. B142
NOVEMBER 2011

NORTH EAST GRAVESEND

FLOOD RISK ADDENDUM

Ardent Consulting Engineers
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36/38 Hatton Garden
LONDON
EC1N 8EB
Tel: 020 7430 1209
Fax: 020 7430 0318
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REPORT REF. B142-05
PROJECT NO. B142
OCTOBER 2011

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Figure 3 – 3: Breach Levels & 1:200 Plus Climate Change Profile Page 7
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Figure 4 – 2: Flood Plain Extents 1:200, 2107 Page 10

APPENDICIES

Appendix A: DVD of TUFLOW Model Files

DOCUMENT CONTROL SHEET

REV	ISSUE PURPOSE	AUTHOR	CHECKED	APPROVED	DATE
-	For Comment	S.Br	S.Br	CBP	31.10.11
A	Preliminary Issue	S.Br	S.Br	CBP	09.11.11

1.0 INTRODUCTION

1.1 This Addendum to the Flood Risk Assessment has been written following the receipt of new data from the Environment Agency on the existing flood defence crest heights. The information was provided on the 12th October.

1.2 During the determination of planning applications 2010/0436 (Industrial) and 2010/0197 (residential) Gravesham Borough Council (BC) identified that portions of the tidal flood defences around Gravesend may be at a lower level than that stated in the HR Wallingford Technical Note MCM57553/01 published in 2007. This note had been used to support the Planning Applications and the Hydraulic Modelling, with the latter having been previously approved by the Environment Agency. At that time the proposals were confirmed as being safe.

1.3 On receipt of the information from Gravesham BC a joint meeting was held with senior representatives of the Council, the Environment Agency and Ardent Consulting Engineers. The meeting was held at the Environment Agency's offices on the 12 October 2011. During this meeting the impact of the lowered defence levels was discussed and it was agreed that:

- Gravesham Borough Council, would benefit from further evidence to support the Sequential Test for the Site from the Applicant; and,
- The impact of the lowered defences needs to be agreed with the Environment Agency.

1.4 The Sequential Test evidence is to be provided under a separate cover. The impact of the lowered defences is the subject of this Addendum.

2.0 BACKGROUND

2.1 The Environment Agency has provided copies of the Halcrow Survey undertaken in 2005. This survey data was inspected and interrogated using AutoCad and MapInfo. Regrettably, it was confirmed that portions of the defences were lower than that identified in the HR Wallingford Technical Note. HR Wallingford is in the process of verifying if the Halcrow 2005 survey data supersedes that used in its assessment. The data provided in the HR Wallingford report has been used in the development of the Environment Agency's TE2100 project, but is not considered, by HR Wallingford, to be significant.

2.2 During discussions with the Environment Agency and research into the potential failure mode of the defences it has been concluded that the worst case realistic failure mode would be as a result of overtopping of the defences triggering a progressive collapse of the defences.

2.3 During the research the following sources were consulted / reviewed:

- F.A. Buijs, H.A.J.M. van Gelder and J.W. Hall, Application of reliability-based flood defence design in the UK;
- Joint Defra / EA R&D; Performance and Reliability of Flood and Coastal Defences, FD2318/ TR2 & TR1, October 2005;
- Joint DEFRA / EA R&D, FD2411/TR1, Management of Flood Embankments, A good practice review;
- FLOODsite, Failure Mechanisms for Flood Defence Structures, T04-06-01, February 2007;
- Jonathan Simm, HR Wallingford, Fragility Curves and their Use in UK Flood Risk Management; and,
- Tony L Wahl, Uncertainty of Predictions of Embankment Dam Breach Parameters, JOURNAL OF HYDRAULIC ENGINEERING © ASCE / MAY 2004 / 389;

2.6 From research regarding the failure mode of earth embankments due to overtopping, including a review of various fragility curves it was concluded that a 200mm depth of overtopping would have a significantly high probability of failure. However, research into the rate and extent of a progressive collapse of earth embankments has failed to produce a relationship between overtopping and rate of collapse which is suitable for the modelling being undertaken.

2.5 In order to quantify the potential impact of the lower defence levels a review of the Environment Agency approved hydraulic model (TUFLOW) has been undertaken. The methodology for assessing the impact of the lower defence levels has been discussed with HR Wallingford and agreed with the Environment Agency. A summary of the methodology agreed with the Environment Agency (21 October 2011) is as follows:

- A 200mm level of water above the crest of the embankment is 85% likely to trigger a structural failure. Consequently this depth of water should be used for the trigger depth at the agreed breach locations;
- Four breach locations have been assumed to occur simultaneously, two are assumed to collapse to ground level (100%) and two to 50% of their height; and,
- The breach locations have been agreed with the Environment Agency; through detailed consultation.

2.6 As well as providing the Halcrow survey information the Environment Agency have also provided an updated hydrograph to be considered in the breach and overtopping analysis.

3.0 AMENDED MODEL PARAMETERS

3.1 The baseline geometry, manning's values and model set up follows the same methodology as that in the previously approved January 2011 modelling report (Ardent, B142-01).

3.2 At this stage it has not been possible to undertake the detailed sensitivity assessment presented in the previous modelling report. However, as the previous report identifies that the impact of the manning's values on the impact of the flood levels within the model is nominal, it is considered that similar results would be expected for the amendments to the model outlined below.

3.3 The Environment Agency have stated that the flood levels derived for Node 3.28 – Gravesend as being appropriate for the breach scenario. As this Addendum is proposed to supplement the Planning Applications for the two submissions for different land uses, two flood risk thresholds need to considered.

3.4 For industrial types of development it is usual to consider that the life of the development will be 50 years. Subsequently an allowance of 50 years of climate change should be considered when assessing the relevant flood risk design horizon.

3.5 For residential types of development 100 years is considered to be the usual life of the development. Therefore a climate change allowance equivalent to 100 years should be considered.

3.6 The most appropriate flood levels to be used are summarised as follows:

- 2005; 1:200 (present day 0.5%): 5.429m AOD
- 2055; 1:200 (industrial 0.5%): 5.798m AOD
- 2107; 1:200 (residential 0.5%): 6.416m AOD

3.7 The lowest flood defence height on the existing bund is 5.69m AOD this is 100mm lower than the peak 1:200, 2055 flood level of 5.789m AOD. Based on the review of existing literature on progressive collapse, 100mm of overtopping has a 20% probability

of causing a breach. Subsequently it is considered unlikely that a breach would occur up to the end of the Industrial Developments life-span. Consequently the TUFLOW model has only been run using the 2107 0.5% level i.e. the worst case that needs to be considered.

3.8 **Figure 3-1** below, provides the hydrograph used in the TUFLOW model and has been based on the hydrograph provided by the Environment Agency. In order to prevent any model instabilities the hydrograph has been cut at 2.8m AOD with any values below this level raised to 2.8m AOD. This fix solved early problems with large negative depth related instabilities in the amended model development. The peak water level is 6.416m AOD.

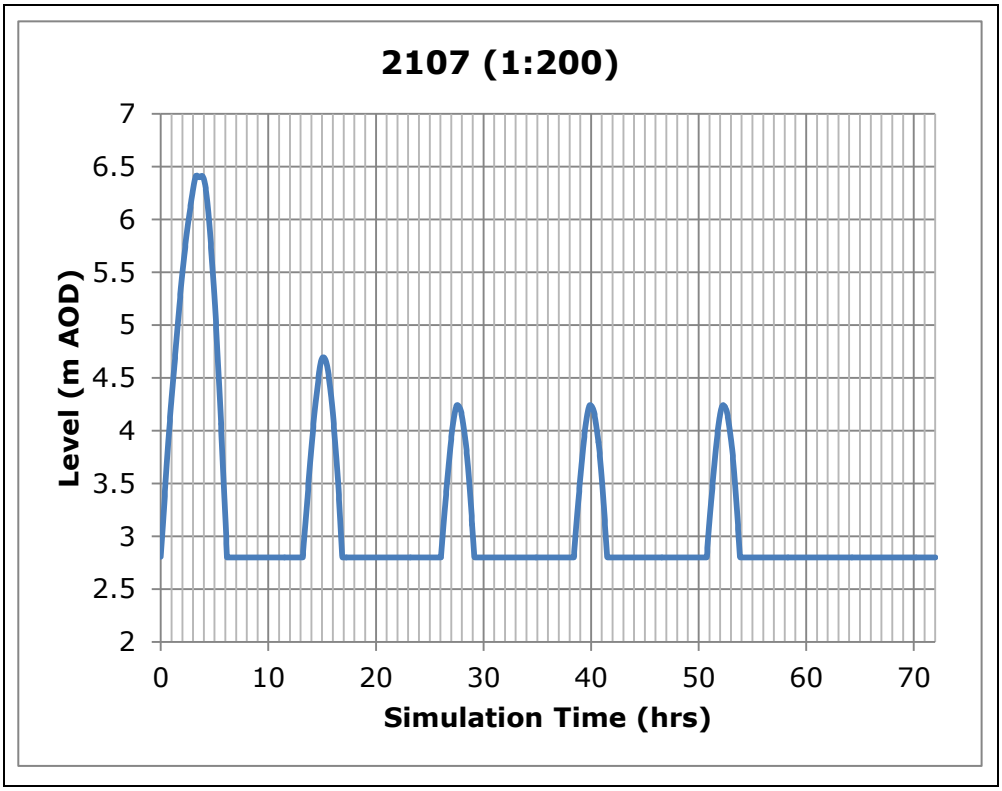

Figure 3-1: Hydrograph

3.9 **Figure 3-2** below, provides a schematic of the main features of the amended TUFLOW model. The four breaches (A to B) inclusive are shown and **Table 3-1** provides details of the geometry and model parameters used for these breaches. The entire length of the Halcrow survey has been modelled and the input hydrograph set along the top of this line. Consequently the model assess the

potential for overtopping of 5.1 Km of tidal flood defences along with the four breach locations agreed with the Environment Agency.

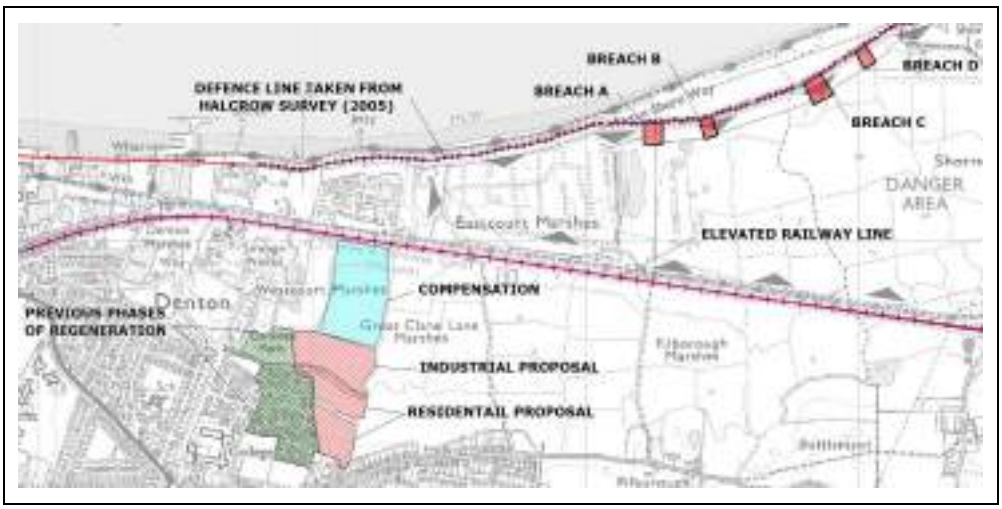

Figure 3-2: Hydraulic Model Schematic

BREACH REFERENCE	A	B	C	D
ORDNANCE SURVEY NGR	568231.26, 174430.30	568437.29, 174451.12	568799.56, 174575.47	569005.84, 174705.82
LENGTH (m)	68.4	46.7	66.6	44.3
WIDTH (m)	73.9	68.3	82.5	72.3
MIN. CREST LEVEL (m AOD)	5.73	5.84	5.69	5.79
BREACHED LEVEL (m AOD)	3.0	4.12	3.2	4.1
BREACH HIEGHT %	100%	50%	100%	50%
BREACH START TIME (HRS)	2.5	2.5	2.5	2.5
BREACH END TIME (HRS)	1.5	1.5	1.5	1.5

Table 3-1: Breach Parameters

3.10 Due to the spacing of the topographic points on the Halcrow Survey the length of the breach has been defined by using the node points in the Halcrow survey, and following the lower nodes along each section to identify the most likely locations for the breach. These breach locations were suggested by the Environment Agency and represent the most likely locations for a breach. The breach locations were selected based on the lowest defence height levels, which result in the maximum overtopping depth, therefore representing the most likely locations for a breach. **Figure 3-3** below, shows how once the flood level in the Thames is sufficient to

reach the 85% likelihood of breach (at 2.5 hours) the progressive collapse begins. After an additional 1.5 hours (4 hours total) the breach has reached its lowest point, this coincides with the highest level in the Thames being reached.

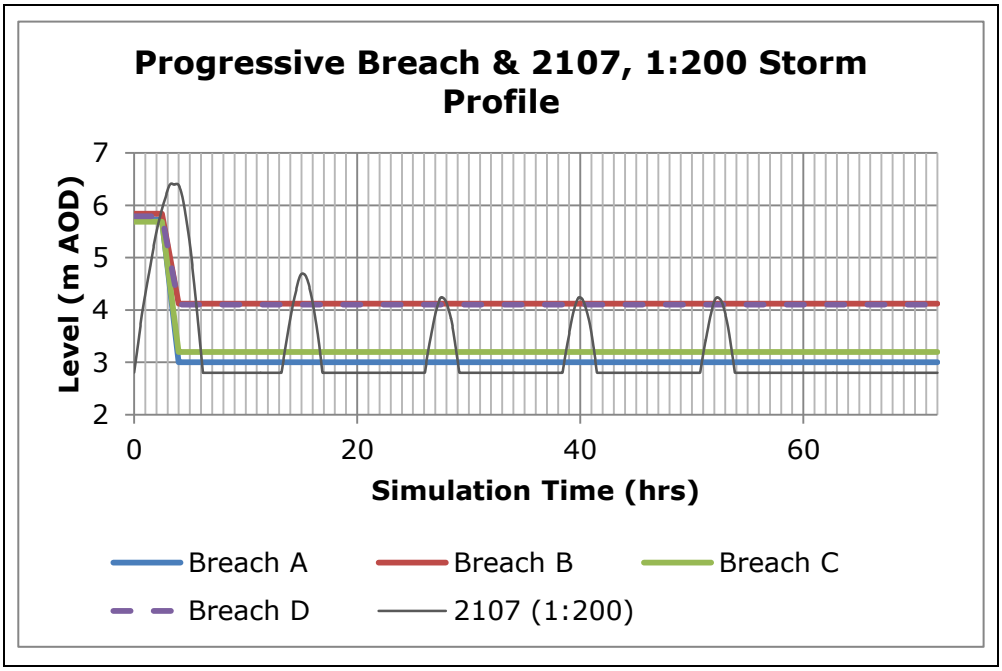

Figure 3-3: Breach Levels & 1:200+CC Profile

3.11 In order to model the worst case post development scenario the development plateau was set artificially high at 10m AOD. This enables the appropriate plateau level to be selected from comparison of the pre and post development flood levels, during inspection of the results.

4.0 IMPACT ON THE DEVELOPMENT

4.1 The hydraulic models have been re-run and indicate that as a consequence of the overtopping of the defences, flood waters are impounded by the existing elevated railway line, effectively providing a secondary defence. – offering further protection. Subsequently should the defences be overtopped (without failure) by a 2107 event the residential application site would remain dry. Therefore no mitigation measures are required for this scenario. The extents of inundation as a result of a 2107 overtopping event are presented as **Figure 4-1** below. It should be noted that these depths are the maximum depth occurring at any time during the simulation and may not occur concurrently.

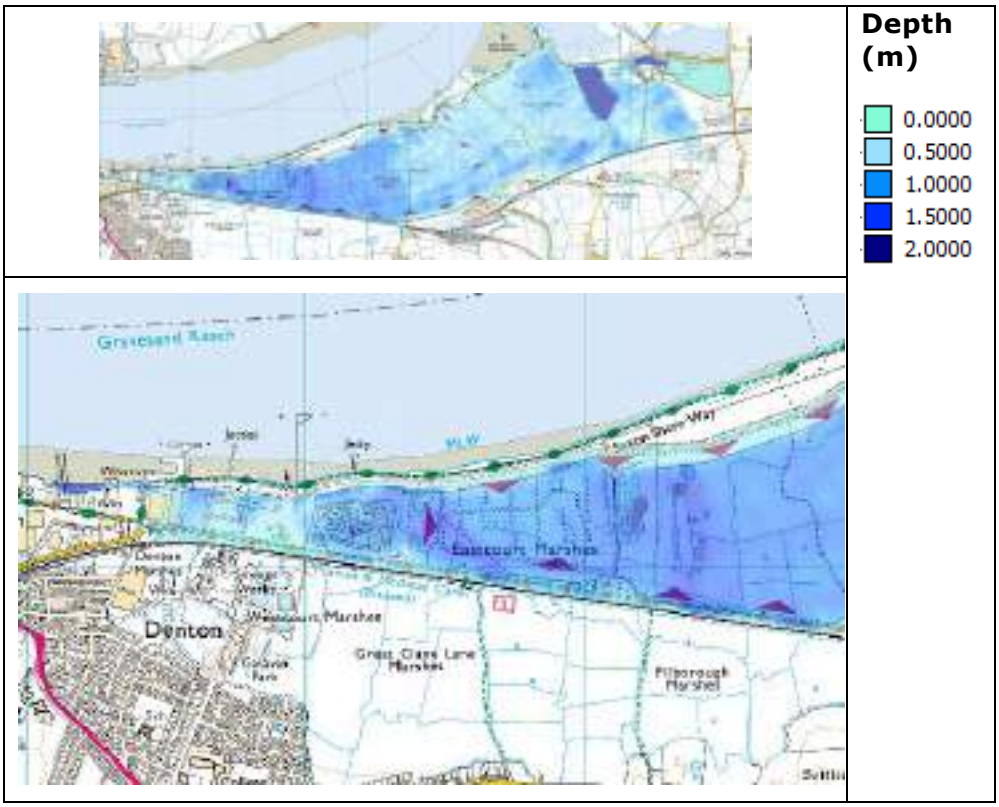

Figure 4-1: 2055, 1:200 Overtopping Flood Extent

4.2 Should the simulated overtopping event occur at the same time as the flood defences being breached, then a significant volume of water would pass through the defences. The additional breach water would be sufficient to overtop the railway and cause a significant area of land to be inundated. The Site would also be affected by the

predicted flood water levels. **Table 4-1** below, provides a summary of the flood levels at selected plot output points.

	Pre Development (B142_BASE_T200+CC_B_104)	**Post Development** (B142_PROP_T200+CC_B_104)	
GCL	5.574	5.578	0.005
Eastcourt	5.569	5.574	0.004
Filborough	5.555	5.558	0.004
Westcourt	5.579	5.585	0.006
Danger Area	5.518	5.525	0.007
Filborough West	5.567	5.571	0.004
Denton	5.595	5.603	0.008
Milton	5.612	5.618	0.006
GCL south	5.772	5.772	0.000

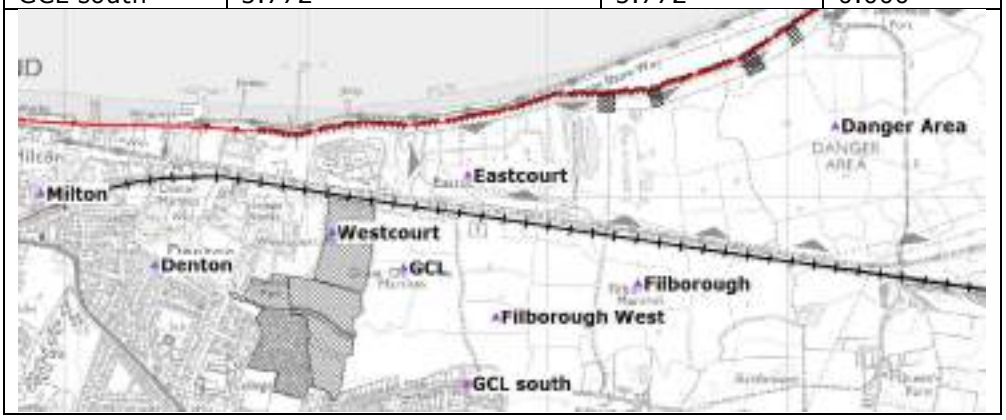

Table 4-1: Summary of Results 2107, 1:200

4.3 As can be seen from **Table 4-1** above, the increase in flood levels as a result of raising the residential element out of the floodplain, providing the compensation and improvements to the SSSI and lifting the industrial element to 2.8m AOD would result in a maximum increase in flood levels of 8mm, which is of a similar magnitude to that previously accepted by the Environment Agency. It is therefore considered that the mitigation proposals would have a negligible impact on flood levels around the residential site, and <u>would not perceptibly increase flood risk.</u>

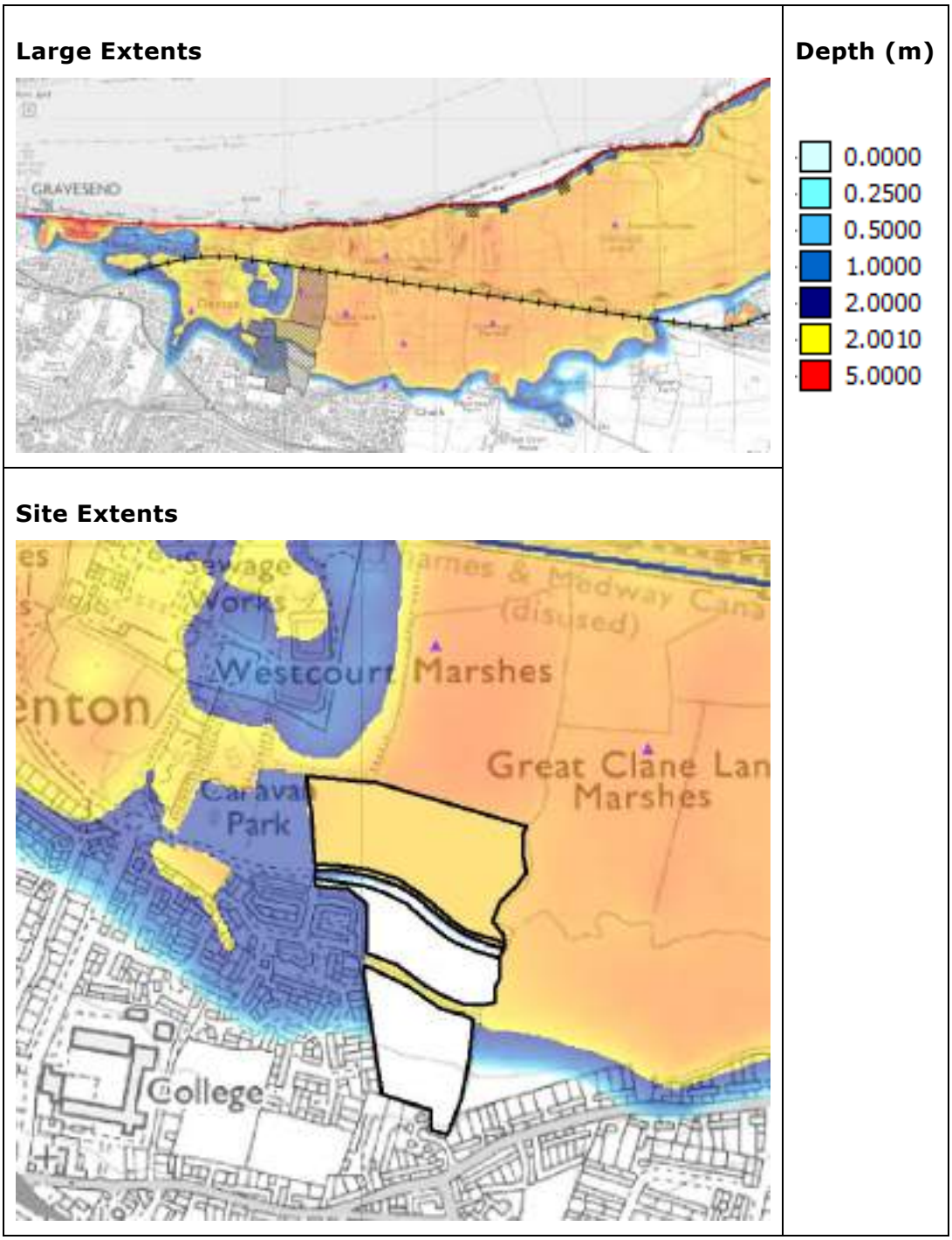

Figure 4-2: Flood Plain Extents 1:200, 2107

4.4 Although the Industrial element has been lifted to 2.8m AOD it is still at risk of flooding (around 2.7m), consequently the mitigation proposals for the Industrial element will need to include a detailed flood response plan, which is normally undertaken as part of the

discharge of planning conditions, prior to occupation, once the end user and their specific needs have been identified.

5.0 CONCLUSIONS AND RECOMENDATIONS

6.1 The existing flood defence infrastructure and alignment of the railway line provide an adequate level of flood defence for the residential and industrial proposals up to 2055. Consequently the industrial element is considered to be **safe** throughout its design life.

6.2 At the end of the residential lifespan, should a 1 in 200 year event occur within the predicted climate change conditions then the existing flood defences are likely to be compromised and cause a breach scenario.

6.3 From the agreed scenarios modelled the resultant peak flood level at the Site would be 5.6m AOD. This has arisen out of the "new" data on flood crest heights being made available by the EA in October 2011. In view of this the mitigation strategy for the residential units has been carefully re-evaluated with the Environment Agency. Discussions have been positive with solutions ranging from the provision of non-habitable accommodation on the ground floor of the previously proposed raised plateau (3.9 AOD), to the provision of contributions to support the improvement of the existing strategic flood defences. This could include provision for the provision of new defences under TE2100 project once finalised.

6.4 Placing non-habitable habitation at ground floor raises issues on the mechanics of treating the changes through the planning process. As a consequence discussions have focussed on the means to secure an appropriate level of contribution that is directly related in scale and kind to the proposed residential development. The Environment Agency has confirmed that this approach forms an appropriate and adaptive response to the predicted impacts of climate change.

6.5 The key word here is 'adaptive'. Setting aside a bonded sum, held in escrow account, through the mechanics of a Section 106 Planning Obligation, provides the means to embrace future change and enables the scheme to respond in a positive manner to future changes in the flood regime.

Appendix C – Phase 2 Flood Risk Assessment Addendum – May 2016

ARDENT CONSULTING ENGINEERS

RIVERDALE DEVELOPMENTS LIMITED

PROPOSED RESIDENTIAL DEVELOPMENT: LAND AT PM9, NORTH-EAST GRAVESEND

FLOOD RISK ASSESSMENT ADDENDUM

PROJECT NO. B142

REPORT REF. B142-05A

MAY 2016

NORTH EAST GRAVESEND

FLOOD RISK ADDENDUM

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REPORT REF. B142-05A
PROJECT NO. B142
MAY 2016

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APPENDICIES

Appendix A: DVD of TUFLOW Model Files

DOCUMENT CONTROL SHEET

REV	ISSUE PURPOSE	AUTHOR	CHECKED	APPROVED	DATE
-	For Comment	S.Br	S.Br	CBP	31.10.11
-	Preliminary Issue	S.Br	S.Br	CBP	09.11.11
A	Title Change	S.Br	SS	BC	09.05.16

1.0 INTRODUCTION

1.1 This Addendum to the Flood Risk Assessment has been written following the receipt of new data from the Environment Agency on the existing flood defence crest heights. The information was provided on the 12th October.

1.2 During the determination of planning applications 2010/0436 (Industrial) and 2010/0197 (residential) Gravesham Borough Council (BC) identified that portions of the tidal flood defences around Gravesend may be at a lower level than that stated in the HR Wallingford Technical Note MCM57553/01 published in 2007. This note had been used to support the Planning Applications and the Hydraulic Modelling, with the latter having been previously approved by the Environment Agency. At that time the proposals were confirmed as being safe.

1.3 On receipt of the information from Gravesham BC a joint meeting was held with senior representatives of the Council, the Environment Agency and Ardent Consulting Engineers. The meeting was held at the Environment Agency's offices on the 12 October 2011. During this meeting the impact of the lowered defence levels was discussed and it was agreed that:

- Gravesham Borough Council, would benefit from further evidence to support the Sequential Test for the Site from the Applicant; and,
- The impact of the lowered defences needs to be agreed with the Environment Agency.

1.4 The Sequential Test evidence is to be provided under a separate cover. The impact of the lowered defences is the subject of this Addendum.

2.0 BACKGROUND

2.1 The Environment Agency has provided copies of the Halcrow Survey undertaken in 2005. This survey data was inspected and interrogated using AutoCad and MapInfo. Regrettably, it was confirmed that portions of the defences were lower than that identified in the HR Wallingford Technical Note. HR Wallingford is in the process of verifying if the Halcrow 2005 survey data supersedes that used in its assessment. The data provided in the HR Wallingford report has been used in the development of the Environment Agency's TE2100 project, but is not considered, by HR Wallingford, to be significant.

2.2 During discussions with the Environment Agency and research into the potential failure mode of the defences it has been concluded that the worst case realistic failure mode would be as a result of overtopping of the defences triggering a progressive collapse of the defences.

2.3 During the research the following sources were consulted / reviewed:

- F.A. Buijs, H.A.J.M. van Gelder and J.W. Hall, Application of reliability-based flood defence design in the UK;
- Joint Defra / EA R&D; Performance and Reliability of Flood and Coastal Defences, FD2318/ TR2 & TR1, October 2005;
- Joint DEFRA / EA R&D, FD2411/TR1, Management of Flood Embankments, A good practice review;
- FLOODsite, Failure Mechanisms for Flood Defence Structures, T04-06-01, February 2007;
- Jonathan Simm, HR Wallingford, Fragility Curves and their Use in UK Flood Risk Management; and,
- Tony L Wahl, Uncertainty of Predictions of Embankment Dam Breach Parameters, JOURNAL OF HYDRAULIC ENGINEERING © ASCE / MAY 2004 / 389;

2.6 From research regarding the failure mode of earth embankments due to overtopping, including a review of various fragility curves it was concluded that a 200mm depth of overtopping would have a significantly high probability of failure. However, research into the rate and extent of a progressive collapse of earth embankments has failed to produce a relationship between overtopping and rate of collapse which is suitable for the modelling being undertaken.

2.5 In order to quantify the potential impact of the lower defence levels a review of the Environment Agency approved hydraulic model (TUFLOW) has been undertaken. The methodology for assessing the impact of the lower defence levels has been discussed with HR Wallingford and agreed with the Environment Agency. A summary of the methodology agreed with the Environment Agency (21 October 2011) is as follows:

- A 200mm level of water above the crest of the embankment is 85% likely to trigger a structural failure. Consequently this depth of water should be used for the trigger depth at the agreed breach locations;
- Four breach locations have been assumed to occur simultaneously, two are assumed to collapse to ground level (100%) and two to 50% of their height; and,
- The breach locations have been agreed with the Environment Agency; through detailed consultation.

2.6 As well as providing the Halcrow survey information the Environment Agency have also provided an updated hydrograph to be considered in the breach and overtopping analysis.

3.0 AMENDED MODEL PARAMETERS

3.1 The baseline geometry, manning's values and model set up follows the same methodology as that in the previously approved January 2011 modelling report (Ardent, B142-01).

3.2 At this stage it has not been possible to undertake the detailed sensitivity assessment presented in the previous modelling report. However, as the previous report identifies that the impact of the manning's values on the impact of the flood levels within the model is nominal, it is considered that similar results would be expected for the amendments to the model outlined below.

3.3 The Environment Agency have stated that the flood levels derived for Node 3.28 – Gravesend as being appropriate for the breach scenario. As this Addendum is proposed to supplement the Planning Applications for the two submissions for different land uses, two flood risk thresholds need to considered.

3.4 For industrial types of development it is usual to consider that the life of the development will be 50 years. Subsequently an allowance of 50 years of climate change should be considered when assessing the relevant flood risk design horizon.

3.5 For residential types of development 100 years is considered to be the usual life of the development. Therefore a climate change allowance equivalent to 100 years should be considered.

3.6 The most appropriate flood levels to be used are summarised as follows:

- 2005; 1:200 (present day 0.5%): 5.429m AOD
- 2055; 1:200 (industrial 0.5%): 5.798m AOD
- 2107; 1:200 (residential 0.5%): 6.416m AOD

3.7 The lowest flood defence height on the existing bund is 5.69m AOD this is 100mm lower than the peak 1:200, 2055 flood level of 5.789m AOD. Based on the review of existing literature on progressive collapse, 100mm of overtopping has a 20% probability

of causing a breach. Subsequently it is considered unlikely that a breach would occur up to the end of the Industrial Developments life-span. Consequently the TUFLOW model has only been run using the 2107 0.5% level i.e. the worst case that needs to be considered.

3.8 **Figure 3-1** below, provides the hydrograph used in the TUFLOW model and has been based on the hydrograph provided by the Environment Agency. In order to prevent any model instabilities the hydrograph has been cut at 2.8m AOD with any values below this level raised to 2.8m AOD. This fix solved early problems with large negative depth related instabilities in the amended model development. The peak water level is 6.416m AOD.

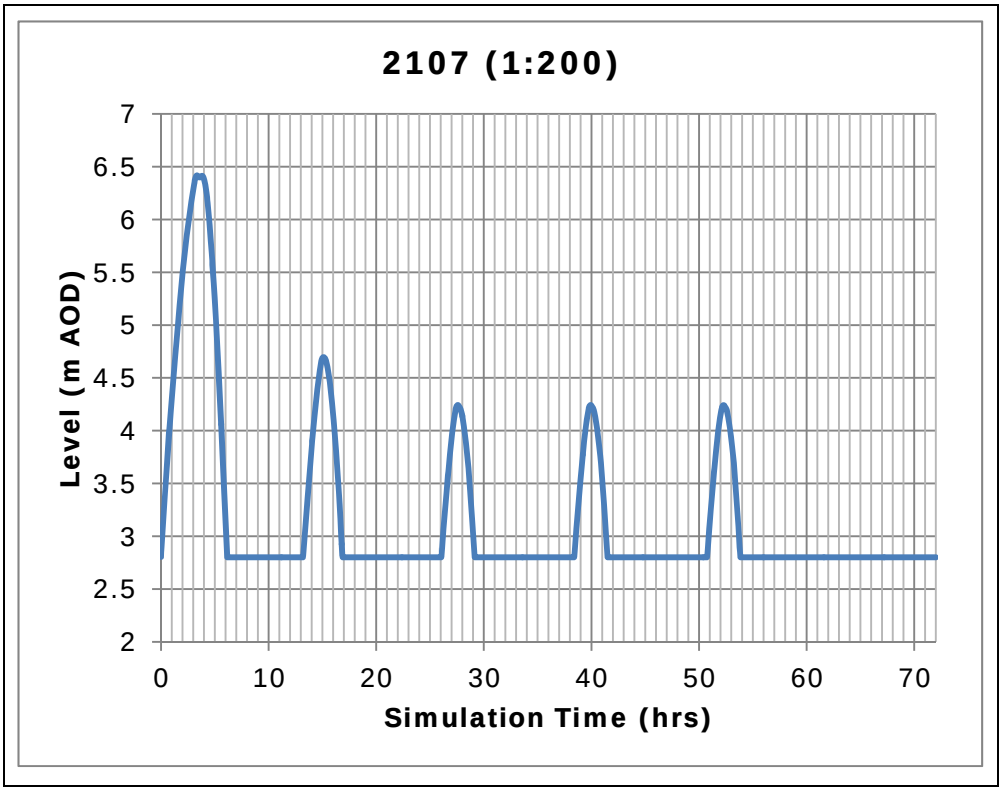

Figure 3-1: Hydrograph

3.9 **Figure 3-2** below, provides a schematic of the main features of the amended TUFLOW model. The four breaches (A to B) inclusive are shown and **Table 3-1** provides details of the geometry and model parameters used for these breaches. The entire length of the Halcrow survey has been modelled and the input hydrograph set along the top of this line. Consequently the model assess the

potential for overtopping of 5.1 Km of tidal flood defences along with the four breach locations agreed with the Environment Agency.

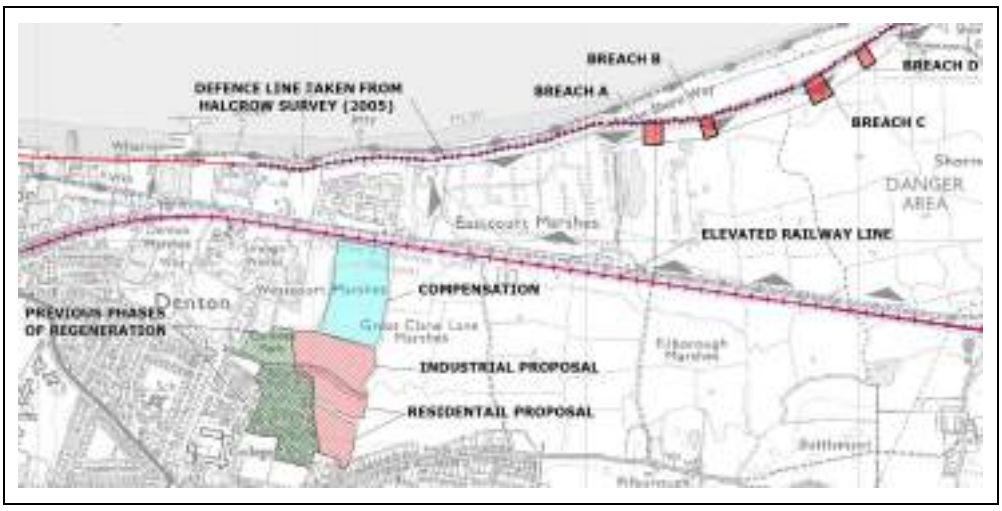

Figure 3-2: Hydraulic Model Schematic

BREACH REFERENCE	A	B	C	D
ORDNANCE SURVEY NGR	568231.26, 174430.30	568437.29, 174451.12	568799.56, 174575.47	569005.84, 174705.82
LENGTH (m)	68.4	46.7	66.6	44.3
WIDTH (m)	73.9	68.3	82.5	72.3
MIN. CREST LEVEL (m AOD)	5.73	5.84	5.69	5.79
BREACHED LEVEL (m AOD)	3.0	4.12	3.2	4.1
BREACH HIEGHT %	100%	50%	100%	50%
BREACH START TIME (HRS)	2.5	2.5	2.5	2.5
BREACH END TIME (HRS)	1.5	1.5	1.5	1.5

Table 3-1: Breach Parameters

3.10 Due to the spacing of the topographic points on the Halcrow Survey the length of the breach has been defined by using the node points in the Halcrow survey, and following the lower nodes along each section to identify the most likely locations for the breach. These breach locations were suggested by the Environment Agency and represent the most likely locations for a breach. The breach locations were selected based on the lowest defence height levels, which result in the maximum overtopping depth, therefore representing the most likely locations for a breach. **Figure 3-3** below, shows how once the flood level in the Thames is sufficient to

reach the 85% likelihood of breach (at 2.5 hours) the progressive collapse begins. After an additional 1.5 hours (4 hours total) the breach has reached its lowest point, this coincides with the highest level in the Thames being reached.

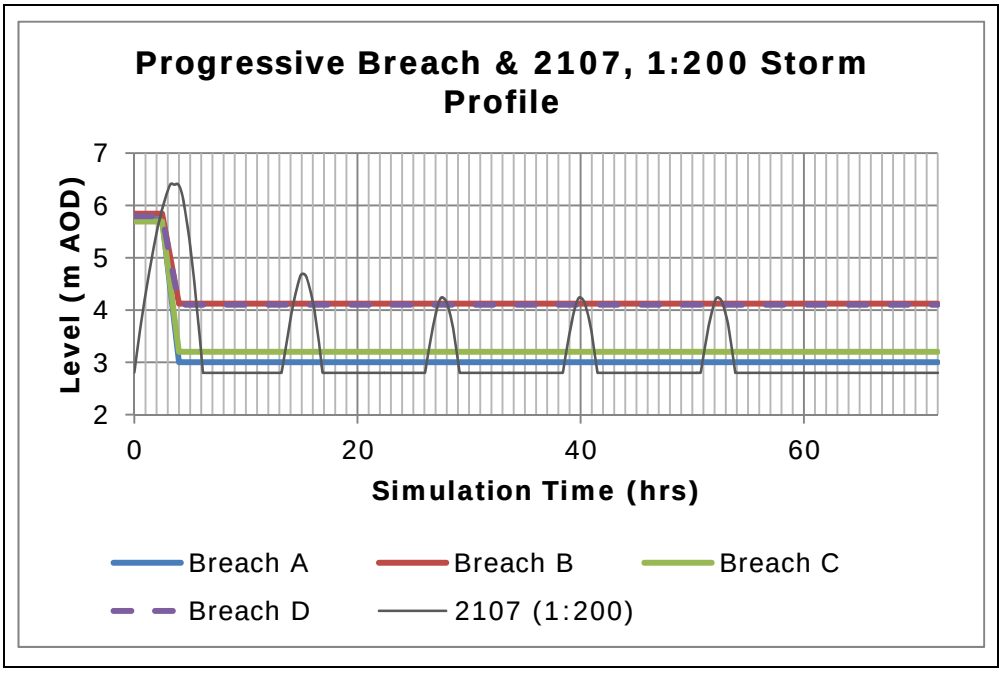

Figure 3-3: Breach Levels & 1:200+CC Profile

3.11 In order to model the worst case post development scenario the development plateau was set artificially high at 10m AOD. This enables the appropriate plateau level to be selected from comparison of the pre and post development flood levels, during inspection of the results.

4.0 IMPACT ON THE DEVELOPMENT

4.1 The hydraulic models have been re-run and indicate that as a consequence of the overtopping of the defences, flood waters are impounded by the existing elevated railway line, effectively providing a secondary defence. – offering further protection. Subsequently should the defences be overtopped (without failure) by a 2107 event the residential application site would remain dry. Therefore no mitigation measures are required for this scenario. The extents of inundation as a result of a 2107 overtopping event are presented as **Figure 4-1** below. It should be noted that these depths are the maximum depth occurring at any time during the simulation and may not occur concurrently.

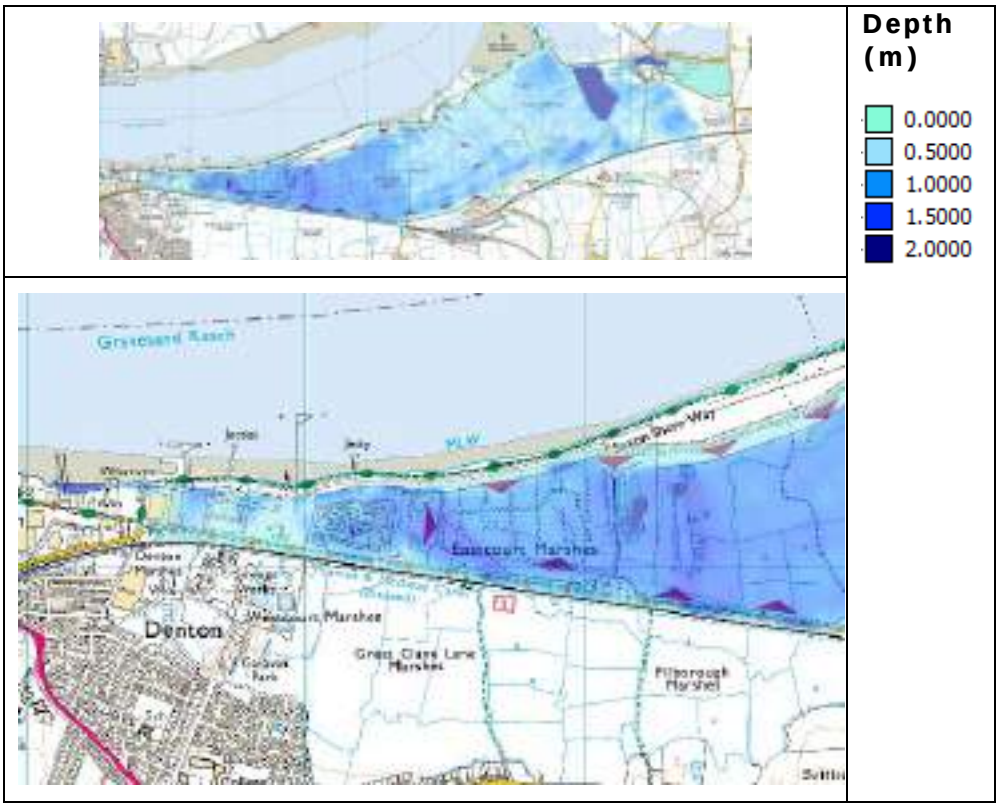

Figure 4-1: 2055, 1:200 Overtopping Flood Extent

4.2 Should the simulated overtopping event occur at the same time as the flood defences being breached, then a significant volume of water would pass through the defences. The additional breach water would be sufficient to overtop the railway and cause a significant area of land to be inundated. The Site would also be affected by the

predicted flood water levels. **Table 4-1** below, provides a summary of the flood levels at selected plot output points.

	Pre Development (B142_BASE_T200+CC_B_104)	**Post Development** (B142_PROP_T200+CC_B_104)	
GCL	5.574	5.578	0.005
Eastcourt	5.569	5.574	0.004
Filborough	5.555	5.558	0.004
Westcourt	5.579	5.585	0.006
Danger Area	5.518	5.525	0.007
Filborough West	5.567	5.571	0.004
Denton	5.595	5.603	0.008
Milton	5.612	5.618	0.006
GCL south	5.772	5.772	0.000

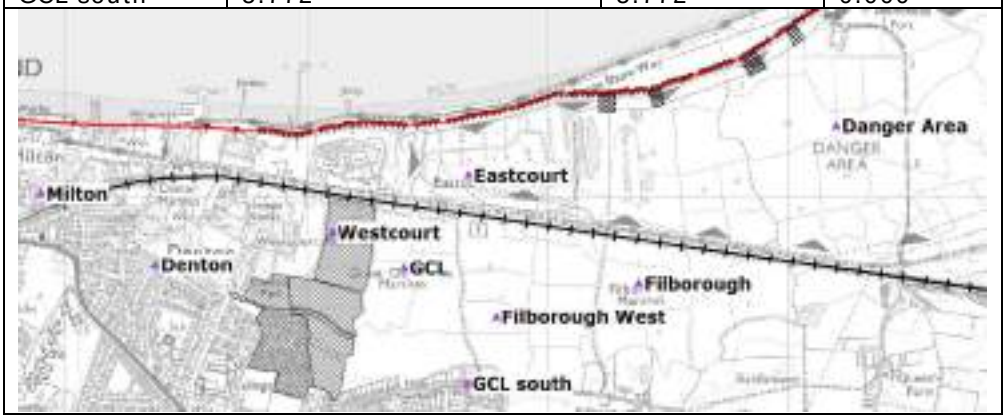

Table 4-1: Summary of Results 2107, 1:200

4.3 As can be seen from **Table 4-1** above, the increase in flood levels as a result of raising the residential element out of the floodplain, providing the compensation and improvements to the SSSI and lifting the industrial element to 2.8m AOD would result in a maximum increase in flood levels of 8mm, which is of a similar magnitude to that previously accepted by the Environment Agency. It is therefore considered that the mitigation proposals would have a negligible impact on flood levels around the residential site, and <u>would not perceptibly increase flood risk.</u>

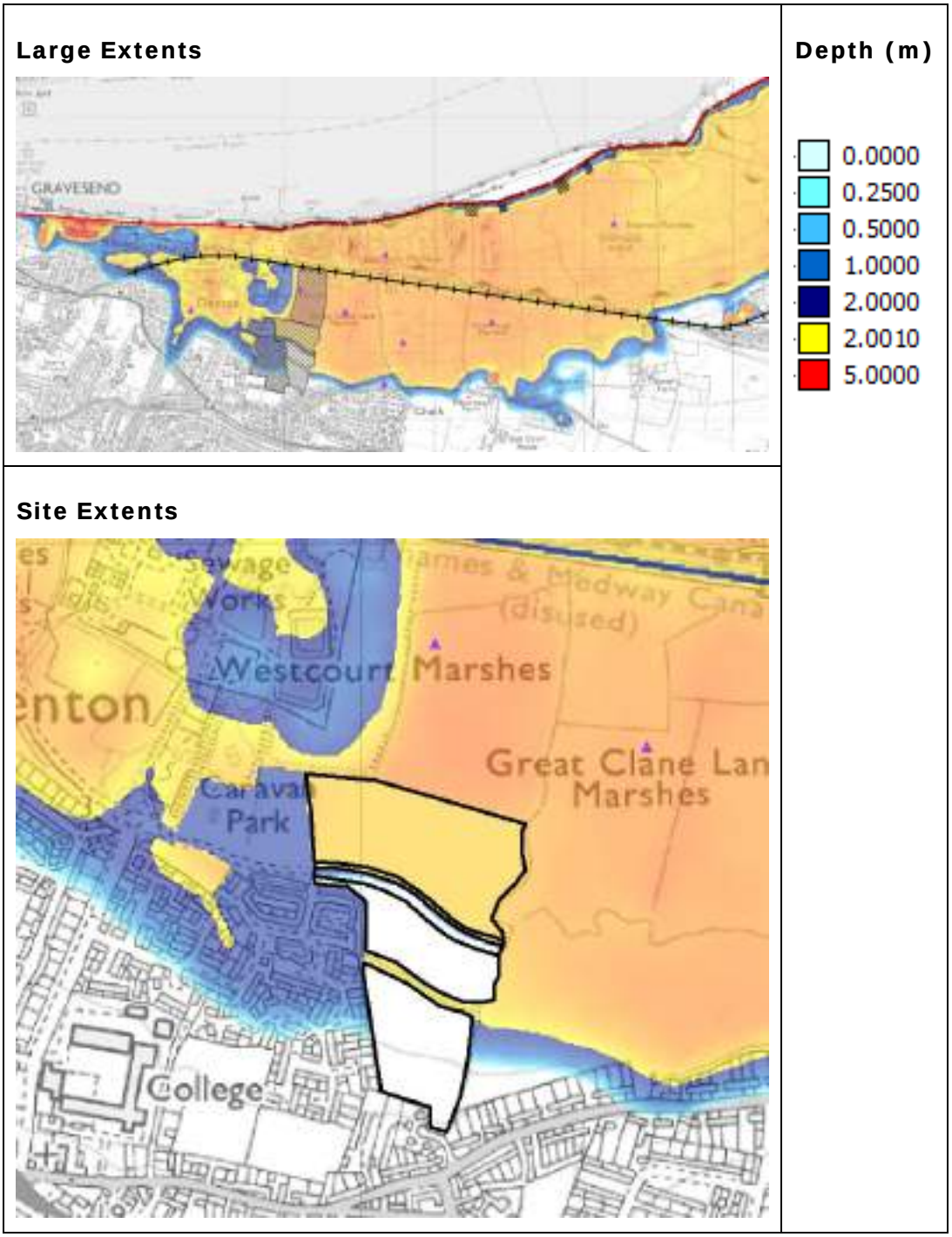

Figure 4-2: Flood Plain Extents 1:200, 2107

4.4 Although the Industrial element has been lifted to 2.8m AOD it is still at risk of flooding (around 2.7m), consequently the mitigation proposals for the Industrial element will need to include a detailed flood response plan, which is normally undertaken as part of the

discharge of planning conditions, prior to occupation, once the end user and their specific needs have been identified.

5.0 CONCLUSIONS AND RECOMENDATIONS

5.1 The existing flood defence infrastructure and alignment of the railway line provide an adequate level of flood defence for the residential and industrial proposals up to 2055. Consequently the industrial element is considered to be **safe** throughout its design life.

5.2 At the end of the residential lifespan, should a 1 in 200 year event occur within the predicted climate change conditions then the existing flood defences are likely to be compromised and cause a breach scenario.

5.3 From the agreed scenarios modelled the resultant peak flood level at the Site would be 5.6m AOD. This has arisen out of the "new" data on flood crest heights being made available by the EA in October 2011. In view of this the mitigation strategy for the residential units has been carefully re-evaluated with the Environment Agency. Discussions have been positive with solutions ranging from the provision of non-habitable accommodation on the ground floor of the previously proposed raised plateau (3.9 AOD), to the provision of contributions to support the improvement of the existing strategic flood defences. This could include provision for the provision of new defences under TE2100 project once finalised.

5.4 Placing non-habitable habitation at ground floor raises issues on the mechanics of treating the changes through the planning process. As a consequence discussions have focussed on the means to secure an appropriate level of contribution that is directly related in scale and kind to the proposed residential development. The Environment Agency has confirmed that this approach forms an appropriate and adaptive response to the predicted impacts of climate change.

5.5 The key word here is 'adaptive'. Setting aside a bonded sum, held in escrow account, through the mechanics of a Section 106 Planning Obligation, provides the means to embrace future change and enables the scheme to respond in a positive manner to future changes in the flood regime.

Appendix D – Phase 3A Flood Risk Assessment - January 2007

LAND NORTH OF DALEFIELD WAY, WESTCOURT, GRAVESEND
PROPOSED INDUSTRIAL DEVELOPMENT

Drainage Strategy & Flood Risk Assessment

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REPORT REF. B140-03
PROJECT NO. B140
JULY 2007

Gravesham Borough Council

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A. 1:30 Year Rainfall Simulations
B. 1:100 Year Rainfall Simulations
C. Win Des Foul Sewer Output Calculation Files
D. Relevant Correspondence
E. HR Wallingford Report – September 2001 and Environment Agency's Letter of 25th September 2001
F. HR Wallingford Report 'Assessment of Tidal Flooding' – February 1996
G. Public Sewer Record Plans

FIGURES

1. Site Location Plan
2. Indicative Floodplain Mapping (within the text)
3. Existing Watercourses and Phase II/IIIa Watercourse Modifications
4. Extract of Figure 7.3 of Kent Thameside Strategic Flood Risk Area (within the text)

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DRAWINGS

B140-004 Rev. A	**Existing Site and Survey**
B140-017 Rev. A	**Proposed Industrial Development Layout**
B140-018	**Surface Water Drainage Strategy Model**
B140-019	**Post-Development Catchment Boundaries**
B140-020	**Preliminary Surface Water Drainage Layout**
B140-021	**Preliminary Foul Water Drainage Layout**
B140-022	**SFRA Potential Floodwater Depths**
B140-023	**Development Impact**
B140-SK09	**Phase 3B Foul Drainage Proposal**
U481-001 Rev. E	**Off-site Channel Improvements**
U481-002 Rev. D	**Off-site Channel Improvements – Cross Sections**

DOCUMENT CONTROL SHEET

REV	ISSUE PURPOSE	AUTHOR	CHECKED	REVIEWED	APPROVED	DATE
	Draft	SJB	SJB	CB-P	CB-P	10/07/07
-	Planning Application	SJB	SJB	CB-P	CB-P	12/07/07

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1.0 INTRODUCTION

1.1 Ardent Consulting Engineers has been appointed by a consortium comprising Barratt Homes, Fort Knight Group and Kent County Council to develop and agree a flood risk assessment and strategy for the disposal of the foul and surface water run-off arising from the proposed industrial-use development at Westcourt in Gravesend, Kent.

1.2 The following report has been prepared to support the planning application for the renewal of an industrial-use development which was previously granted consent in 2002 but expired in 2006. Although the previous consent established the principle that the site is suitable for employment development, a Flood Risk Assessment (FRA) is required to support the planning application and demonstrate compliance with *Planning Policy Statement 25 – Development & Flood Risk* (PPS25).

1.3 The planning application for the proposed industrial-use development is to comprise B2/B8 general industrial/warehousing unit with a gross floor area of 3,333m^2, parking provision for 60 cars and 10 delivery vehicles with appropriate landscaping.

1.4 The report is submitted to the Local Planning Authority, Gravesham Borough Council and its Statutory Consultees to obtain an approval in principle to the drainage strategy for the proposed industrial-use development and associated flood risk matters. The objective of the report is to allow the planning application to progress without objection from the Authorities.

1.5 It is anticipated that the Authorities will recommend that standard planning applications be applied to the planning consent, where additional and/or further detailed information is required.

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2.0 EXISTING SITE & DEVELOPMENT PROPOSALS

Existing Site

2.1 The site which forms the basis of the planning application is situated approximately 600m north of the A226 Rochester Road, 300m south of the disused Thames and Medway Canal and also the London-Medway Towns North Kent Line railway – centred on an Ordnance Survey grid reference of TQ668738.

2.2 The site is also bounded to the south by Dalefield Way which is the recently constructed distributor road that will serve the Heronsfield residential development and any potential future development in the Westcourt area.

2.3 The site lies within an area known as Westcourt (refer to the location plan shown in Figure 1, appended to this report) which is situated to the north-east of Gravesend and occupies a proportion of land allocated as PM9 within Gravesham Borough Council's Local Plan.

2.4 The PM9 area is currently allocated in the Gravesham Local Plan First Review 1994 for industrial and residential development, open

space and further education facilities and also allocated in the Review Local Plan of 2000 (Policy MDS5).

2.5 The existing landform of the site is generally at a level of approximately 2.0-2.5m AOD of made ground above alluvium, underlain by clay and chalk materials.

2.6 The existing surface water drainage regime comprises a number of open watercourse channels which inter-connect with a wide network of watercourses within the north-east area of Gravesend i.e. Westcourt, East Shorne and beyond. Ultimately, the flows in the watercourse network drain in a northerly direction to the River Thames located approximately 500m north of the site, via culverts under the North Kent Line railway and the disused Thames and Medway Canal. However, when the outfall becomes tidal locked the surface water backwaters up the system of ditches and is naturally attenuated within the vast expanse of inter-connected watercourses. A copy of the original land drainage regime is shown in Figure 3 for reference.

2.7 Forming part of an inter-connected network of watercourses results in hydraulic continuity across the catchment area and any subsequent rise in water level locally, is naturally dissipated around the catchment until it reaches hydraulic equilibrium.

2.8 In March 1999, Buchanan Consulting Engineers (BCE) prepared a surface water drainage strategy to support an outline planning application for 165 residential dwellings and a detailed planning application for the first 65 of these units, for a site situated to the south-east of this development area (formerly known as Phases I and II – referenced GR99/168, Heronsfield Development). The surface water drainage strategy identified that improvement works were required to approximately 650m of an existing watercourse to provide the necessary on-line attenuation to facilitate the proposed development. The storage provision would essentially be formed by

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excavating flood levees marginally below the ambient water level of 1.70m AOD (@1.65m AOD). The methodology outlined within the BCE surface water drainage strategy was based on HR Wallingford's 'Assessment of Tidal Flooding' report of February 1996 (refer to Appendix F) and subsequently approved by the Environment Agency in July 1999 (refer to Appendix D).

2.9 Proposals within the above-mentioned surface water drainage strategy included the provision of two outfall structures that were limited to a discharge rate associated with greenfield run-off.

2.10 Detailed design drawings for the off-site watercourse works were subsequently produced and approved by both English Nature and Environment Agency in September 2001 and August 2002, respectively. A copy of the consented drawings (no.'s U481-001 Rev. E and U481-002 Rev. D) have been appended to this report for reference.

2.11 The approved works were implemented in early 2003 and continue to function as intended.

2.12 The surface water drainage strategy devised for this proposed development has been based on the principles previously agreed with the Environment Agency and English Nature, which ultimately seeks to demonstrate that the water level in the watercourses will not rise above the 1:100 year level as a result of implementing the development proposals and the on-line attenuation. Refer to the Environment Agency's letter dated 6th July 2000 included within Appendix D.

2.13 Slab levels for the development site have also been based on the historically agreed position for the Westcourt area that groundfloor accommodation should be provided at/above a level of 3.80m AOD (as agreed with the Environment Agency on 18th August 2004 – refer to Appendix D of this report. The Strategic Flood Risk

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Assessment of the Kent Thameside area now states however, that fluvial response to tidal inundation and displacement from filling should now be considered which is a reversal of the previously agreed position.

2.14 Along the northern and western boundaries of the development site, there are two existing watercourse channels which are approximately 80m and 140m in length. The routes of the existing watercourses have been identified on drawing no. B140-004 Rev. A for reference.

2.15 The current development proposals for the site, allows for the retention of the existing watercourses which will subsequently be improved to promote aquatic biodiversity throughout the site and to ensure that there is no net loss in watercourse length.

2.16 To the north-west of the site, lies the Sewage Treatment Works into which, the surrounding existing developments to the south and west, discharges the foul water. It is into this Sewage Treatment Works that the development will ultimately discharge.

2.17 A copy of the public sewer record plans has been included within Appendix G to illustrate the location of the existing sewers and Sewage Treatment Works mentioned above.

Development Proposals

2.18 The planning application for the proposed industrial-use development is to comprise B2/B8 general industrial/warehousing unit with a gross floor area of 3,333m^2, parking provision for 60 cars and 10 delivery vehicles with appropriate landscaping. A plan of the indicative industrial-use development layout has been prepared and presented in drawing no. B140-017 Rev. A, appended to this report for reference.

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2.19 The overall developable area is approximately 1.6 hectares with an associated impermeable area of 0.919 hectares which equates to approximately 57% of the total area. The remainder of the development will be soft landscaped.

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3.0 FLOOD RISK ASSESSMENT

3.1 Following an inspection of the Environment Agency's (EA) website, we have established that the development site lies within the indicative undefended floodplain of the River Thames which benefits from appropriate flood defence systems (as illustrated in Figure 2 below):

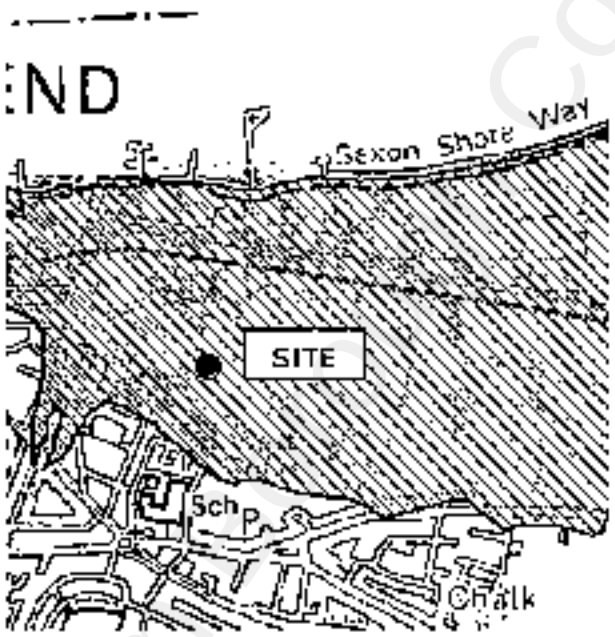

Figure 2 – Indicative Flood Data Mapping

3.2 PPS25 utilises the concept of risk-based sequential test approach to flood risk and development. Consulting Table D.1 of PPS25, in conjunction with the EA's indicative floodplain mapping, designates that the development should theoretically be considered as a flood risk zone 3 site (high probability), and described as having a 1:100 or greater annual probability of river flooding or a 1:200 or greater annual probability of tidal flooding in any year

3.3 As the site is the subject of a planning application and theoretically located within a Flood Risk Zone 3, a Flood Risk Assessment (FRA) is required to comply with paragraph E9 of PPS25.

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3.4 A FRA has been prepared in accordance with PPS25 which was formally published in December 2006. PPS25 is now the acknowledged standard for conducting FRA's and this study is based on the guidance stated on within the document referenced.

3.5 PPS25 primarily places the onus upon developers for:

- Providing a FRA which demonstrates:
  - i) whether any proposed development is likely to be affected by current or future flooding from any source;
  - ii) to the Local Authority that the development is safe and, where possible, reduces flood risk overall;
  - iii) whether the development will increase flood risk elsewhere;
  - iv) the measures proposed to deal with these effects and risks;
- Producing designs which reduce flood risk to the development and elsewhere by incorporating SUDS and, where necessary, flood resilience measures.
- Identifying opportunities to reduce flood risk, enhance biodiversity and amenity, protect the historic environment and seek collective solutions to managing flood risks.

Sequential Test

3.6 The guidance uses the concept of sequential testing and the risk based approach to flood risk and development. Development priorities are to be based on the specific flood risk zones outlined in Table D.1 of PPS25. These flood risk zones have been briefly outlined below, for reference:

Zone 1 - Low probability. Land assessed as having a less than 1 in 1000 year chance of river and sea flooding in any year (<0.1%)

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Zone 2 – Medium probability. Land assessed as having between a 1 in 100 and 1 in 1000 chance of river flooding (1%-0.1%) and between a 1 in 200 and 1 in 1000 chance of sea flooding (0.5%-0.1%) in any year.

Zone 3a – High probability. Land assessed as having a 1 in 100 year or greater chance of river flooding (>1%) and a 1 in 200 year or greater chance of flooding from the sea (>0.5%) in any year.

Zone 3b – Functional floodplain. Land where water has to flow or be stored in times of flood. Strategic Flood Risk Assessments (SFRA) should identify this zone of land that would flood with an annual probability of 1:20 or greater in any year or is designed to flood in an extreme flood (1:1000 event), or at an alternative probability agreed between the Local Planning Authority and the Environment Agency, including water conveyance routes.

3.7 Applying the Sequential Test specified in PPS25, Table D.2 classifies the proposed land-use of '*general industrial*', as 'less vulnerable' in terms of flood risk. Reviewing Table D.3 – *Flood Risk Vulnerability and Flood Zone Compatibility*' of PPS25, means that the ***development is appropriate*** and therefore the requirements of the Sequential Test are deemed to have been satisfactorily passed.

Strategic Flood Risk Assessment

3.8 The level of flood risk associated with the site has virtually been eradicated due to the protection offered by the Thames Tidal Defences which is estimated to prevent flooding to a level of 6.08m AOD under the 1:200 year tidal condition (for a design horizon of 2060). Refer to the Environment Agency's letter of 15th August 2005 included within Appendix D of this report.

3.9 A Strategic Flood Risk Assessment (SFRA) of the Kent Thameside area was commissioned by Kent County Council for the Kent Thameside Delivery Board and produced by Entec (UK) Limited in

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collaboration with JBA Consulting. The study analyses the main sources of flood risk in the area, together with a method of testing development allocations/existing planning policies for flood risk management and identifying mitigation options.

3.10 The SFRA identifies that the main pathways of flooding to the site will be overtopping, breaching of the flood defences and failure to close the flood protection gates at Canal basin.

3.11 From an inspection of Figure 7.3 contained within the SFRA report, the site is located within an area designated as a Zone 3 High Risk (HH), as illustrated in the extract below. A site classified as a residual high risk, is categorised as either:

- Being located within the 1:100 year undefended fluvial floodplain;
- Land within 200m of a tidal gate; and
- Land which is within the flood extent envelopes and floods to a depth between 0.6m and 2.5m.

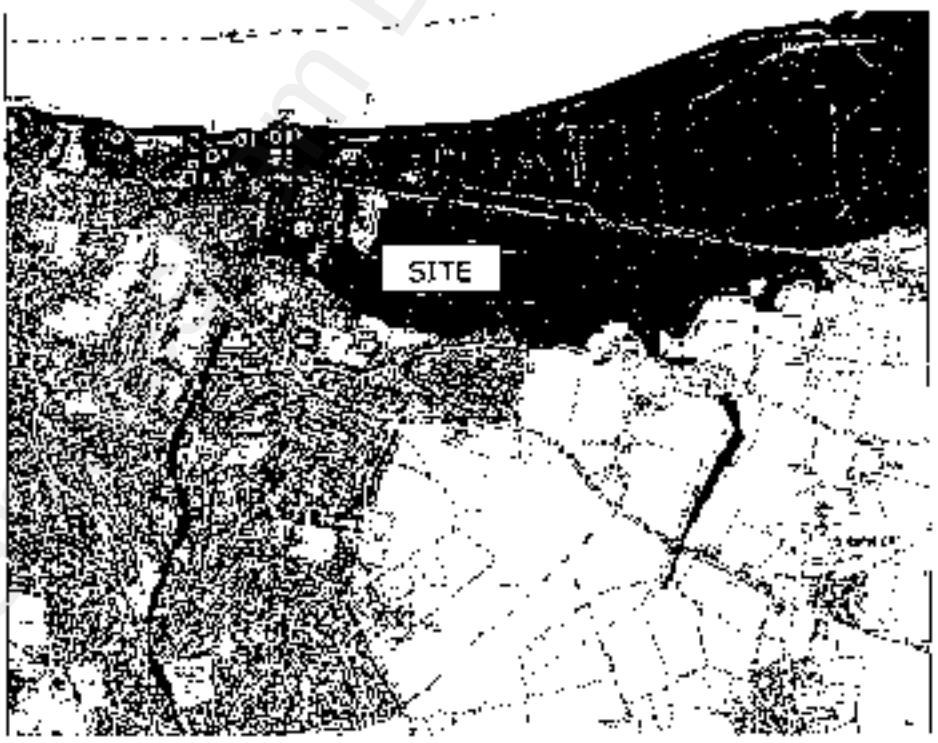

Figure 4 – Extract of Figure 7.3 of Kent Thameside SFRA

3.12 The application site was subjected to flooding scenarios in the SFRA whereby the tidal protection gate was not closed at Canal Basin (referenced GR_7) and a breach of the earth defences protecting the Shorne Marshes (referenced GR_8). Figure 5.11 contained within the Stage 2 SFRA report illustrates that the application site could potentially be subjected to a varying depth of floodwater ranging from 1-2.5m (maximum) when subjected to a breach at the GR_8 location. These floodwater depths have been overlaid on OS survey information and shown on drawing no. B140-022, appended to this report for reference.

3.13 An independent review of the SFRA report was undertaken by HR Wallingford in March 2007 on behalf of the Applicant, and the conclusions of the report have been summarised below:

- The overtopping model is an ISIS model of the River Thames with defence heights of approximately 6.7m AOD in Gravesend with lower defence levels of 5.6-6m AOD for the marshes.

- Spill units represent the defence system and connect to a reservoir that represent the entire Gravesend Embayment and the model does not consider the overtopping effect on other floodplains/ embayments of the Thames Estuary which will also be inundated during an extreme event.

- The flood tidal level used in the model is 6.4m AOD and significantly higher than the 1:10,000 year event level of 5.53m AOD stated within the Halcrow 2002 report.

- Existing defence data for the area of Gravesend shows that the crest levels are generally provided between 6.7-7.2m AOD and 6.5-6.7m AOD on the Eastcourt Marshes. The defence levels used in the SFRA are in the region of 0.5-1m lower than those stated in the records.

- The model shows flooding depths of approximately 1-2m over the entire Gravesend embayment and does not consider the effect of

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local topographical influences (i.e. secondary defences) and are shown to flood, regardless of whether a valid flow path exists or not.

3.14 Within the SFRA, a potential scenario has been simulated to assess the impact a 50m wide breach would have on the earth embankment protecting the Eastcourt Marshes (GR_8).

3.15 Due to the existing low-lying ground levels in the vicinity of the breach, significant volumes of floodwater are expected to pass onto the floodplain. The depth of flooding is anticipated to be in the region of 1-2.5m (maximum) and would be sufficient for the floodwater to overtop the railway embankment and flood the area to the south, including the development site. The presence of the railway embankment is however, anticipated to significantly delay the onset of floodwater to the development site.

3.16 Whilst the model assesses the extent of flooding during the simulation event, no consideration is given within the SFRA to determine the overall probability of the event occurring at the same time that a breach occurs in the primary flood defence system.

3.17 A breach scenario in the form of failure to close the flood gates was also simulated within the SFRA model at the Canal Basin in Gravesend (GR_7) but would only cause floodwater depths of up to 1m on the Eastcourt Marshes. The SFRA model appears to permit free-flow into the storage area for the entire area and may therefore over estimate the volume of floodwater that can be stored on the marshes due to the local topography constraints.

3.18 The independent report concludes that the Kent Thameside SFRA does not provide quantitative information on the variation of flood risk across the embayment, and that in actual fact, flood risk is defined in flood risk management as 'probability x consequence'. As the SFRA is concerned with the implementation of new development, the consequence is a function of the development design.

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3.19 The SFRA only provides qualitative information on flood risk and remains for the impact of the development to be considered. The standard of protection offered by the Thames Tidal Defences is unique compared to the rest of the UK (1:1000 year) and is far greater than elsewhere (compared with 1:100 year for non-tidal flooding and 1:200 year for tidal flooding).

3.20 Fragility curves have been derived for the defence system along the Shorne Marshes by HR Wallingford which illustrates that the probability of failure when the water levels are below the defence crest level may potentially be approximately 0.02% (i.e. 1:5,000). As the 1:1,000 year water level is however, considerably lower than the crest level, a breach of the defence systems is therefore considered unlikely. Once the water level approaches the crest level, the probability of a breach occurring increases significantly but it is envisaged that an event in the region of 1:10,000 years would need to be experienced before the likelihood of a breach occurring in the defence system could potentially be realised. The EA have also acknowledged in their letter of 10th November 2006, that these defences are maintained to a high standard.

3.21 The presence of the Thames Tidal Defence System means that the annual probability of flooding at the development site is significantly less than 0.1% and the result of any breach scenario occurring under these conditions would, in actual fact, be less than 0.0001% probability.

Flood Risk Impact

3.22 The existing ground levels on the site are approximately 2m AOD and the land is intended to be filled using clean, inert material to facilitate a positive gravity drainage that discharges into the adjacent watercourses.

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3.23 The existing topography of the application site is relatively flat and the potential range of floodwater depths illustrated in the SFRA is considered to be unrealistic for design purposes. The slab levels have therefore been set above the average floodwater depth of 1.75m, at 3.8m AOD.

3.24 A meeting with the Environment Agency was held on 1st March 2007 with Ardent Consulting Engineers and HR Wallingford to discuss the findings of the Kent Thameside SFRA and the implications of developing the application land.

3.25 As PPS25 stipulates that a flood risk assessment should demonstrate that the development should not increase the risk of flooding elsewhere, an independent study was undertaken by HR Wallingford and established that the raising of the existing ground levels would only cause the floodwater level to rise by a notional depth of 0.010m across the marshland area located to the south of the railway line, as shown shaded in blue on drawing no. B140-023.

3.26 Considering that the site is protected by a maintained flood defence system which is only likely to experience a breach in an extreme event in excess of 1:10,000; and that the impact of filling the application land will only increase floodwater depths potentially by 0.010m across the existing marshland, it is considered that the requirements of PPS25 are satisfied as:

i) The development and it's occupants are not at an increased risk of flooding;

ii) The development will not increase the level of flood risk to any existing development/human life as the notional increase in floodwater depth will be contained to the existing marshland area; and

iii) The development can be drained in a sustainable manner (refer to Section 4.0 of this report).

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3.27 In view of this assessment, it is deemed that the requirements of PPS25 (in that the development and its occupants will not be at an increased risk of flooding, and the development does not increase flood risk elsewhere), are said to be satisfied.

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4.0 SURFACE WATER DRAINAGE STRATEGY

4.1 The basis upon which this surface water drainage strategy has been prepared utilises the flow conditions previously established by Buchanan Consulting Engineers, HR Wallingford, and the design parameters previously agreed with the Environment Agency and English Nature for the adjacent development sites i.e. the Heronsfield residential development.

4.2 In September 2001, HR Wallingford constructed an ISIS model of a network of drainage channels to establish the post-development water level in the watercourses. The analysis determined that the post-development water level in the watercourse will rise to approximately 2.04m AOD when subjected to a 1:100 year rainfall event. Refer to Appendix E of this report for Table 3 of HR Wallingford's report and the Environment Agency's approval of such (letter dated 25th September 2001).

4.3 As mentioned in the previous section of this report, the drainage channels modelled by HR Wallingford are inter-connected with the watercourses which traverse the development site and the wider area, thus providing hydraulic continuity. For the purposes of this strategy, the objective is to provide sufficient on-line attenuation to ensure that the water levels in the watercourses do not rise above 2.04m AOD when:

i) The site is developed;
ii) Run-off is restricted to a limited discharge rate of 7 l/sec/hectare (i.e. Greenfield run-off rate stipulated by the Environment Agency); and
iii) Subjected to various durations of a 1:100 year rainfall event.

4.4 Based on the previously agreed strategies, the following design principles/parameters have been adopted to produce a strategic network of spine sewers and watercourse channels which have been modelled using Micro Drainage's WinDes Suite Version W.10.4:

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- Ambient water level in the watercourse channel is 1.70m AOD.
- Post-development, 1:100 year water level shall not exceed 2.04m AOD.
- Post-development run-off to be restricted to greenfield run-off rate i.e. 7 l/sec/hectare (total of 10 l/sec) with resultant compensatory attenuation.
- Attenuation design parameters: M5-60min=20mm; Ratio, R=0.40; Cv (Summer)=0.75; Cv (Winter)=0.84; Maximum allowable discharge =10 l/sec.
- Attenuation of surface water run-off to be accommodated within the modified watercourse channels providing a flood levee for regular wetting at 1.65m AOD (storage only calculated above 1.70m AOD – the ambient water level).
- Spine sewers have been designed for a 1:2 year rainfall event and checked to ensure that no flooding occurs for a 1:30 year rainfall event to comply with the guidance stated within 'Sewers for Adoption', 6th Edition.
- Spine sewer outfalls have been designed to discharge into the watercourse above the 1:100 year water level of 2.04m AOD.
- Watercourses have been modelled to assess the impact for a 1:100 year rainfall event.
- Manning's 'n' roughness co-efficient set as 0.040 as per Ciria's report 168, Table D3.
- Model includes a surcharged outfall to replicate the fact that the downstream watercourse contains a constant base flow in the channel.
- Model also includes a hydro-brake that has been artificially raised to the ambient water level of 1.70m AOD to restrict the discharge rate at the outfall to 10 l/sec.
- Fill levels within the site have been established to allow the provision of gravitational drainage and to accord with flood risk requirements.
- Areas of aquatic habitat lost as a result of the site development will be replaced by compensatory habitat.

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4.5 To model the development, artificially raised invert levels have been introduced along the entire length of the watercourses to reflect the ambient water level of 1.70m AOD, which essentially excludes the continual base flows found within the existing watercourses, as these flows are present in both the upstream and downstream scenario. Therefore, in this instance, the invert levels stated for pipes reference 1.000 to 1.009 in the network model should be ignored.

4.6 Based on the above-mentioned design parameters, preliminary attenuation calculations envisage that a total of 455m^3 of storage will be required (which includes an allowance of +20% in volume for any potential climate change) to facilitate the industrial development.

4.7 The surface water drainage strategy for the development has been designed so that all of the run-off is conveyed to a strategic network of modified watercourse channels via spine sewers. These proposals are illustrated on drawing no. B140-020 appended to this report and primarily comprise:

- Regrading and improvement of approximately 220m of existing watercourse to provide on-line attenuation of approximately 455m^3 (which includes an allowance of +20% in volume for any potential climate change) for a development impermeable area of 0.919 hectares;
- A modified watercourse profile has been determined to provide surface water attenuation above the ambient water level (1.7m AOD) and incorporate 1:3 embankments with a flood levee, as shown by the typical section on drawing no. B140-020; and
- Existing watercourses to be retained and improved to ensure there is no net loss in length as a result of the development proposals.
- Bypass interceptors shall be installed at the downstream end of the sewer system prior to surface water flows being discharged into the

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receiving watercourse to prevent any contaminants polluting the habitat. These interceptors are proposed where surface water run-off from either the car park/delivery area is collected and locations indicated on drawing no. B140-020. The sewer system located adjacent to the eastern boundary of the development, will only be collecting surface water run-off from the building roof and therefore flows can be discharged untreated.

4.8 The possible implementation of infiltration drainage systems were considered at the conceptual stage of devising the strategy. However, having reviewed the content of the soil investigation report, the presence of a high groundwater table and low permeability rates of the sub-strata, it was considered that infiltration drainage systems were, unfortunately, deemed inappropriate for the development site in this instance.

Results

4.9 The simulation results demonstrate that:

- No flooding occurs throughout the spine sewers for a 1:30 year rainfall event;
- The provision of a flood levee is an effective means of attenuating the surface water run-off within the watercourse channel to accommodate the surface water run-off generated by the 1:100 year rainfall events.
- Limited discharge rate of 10 l/sec is not exceeded at the outfall and the water level of 2.04m AOD is maintained for the 1:100 year rainfall events.

4.10 A copy of the corresponding simulations for the 1:30 and 1:100 year events have been included within Appendix A and B of this report for reference.

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5.0 FOUL WATER DRAINAGE STRATEGY

5.1 The existing adopted foul infrastructure in the immediate vicinity of the site is shown on the public sewer record plans included within Appendix G of this report. The public sewer into which the development effluent will ultimately discharge consists of a 375mm diameter sewer that flows in an east to west direction, eventually discharging into the Sewage Treatment Works.

5.2 The proposed development foul sewer connects into the upstream manhole of the 225mm diameter sewer which crosses the recently constructed distributor road, built in advance as part of the previous development works. This in turn connects into the foul sewer network designed as part of the development, ultimately discharging into the 375mm diameter adopted sewer, in the manhole located within Medbury Gardens.

5.3 The Phase 3B foul sewer network and distributor road crossing are presently unadopted but designed and constructed with the approval of Southern Water in anticipation of future adoption. The existing network is shown on drawing no. B140-SK09, appended to this report.

5.4 An analysis of the flow capacity at this location in the adopted network (requested by Southern Water), determined that the capacity of the sewers downstream of this outfall point was sufficient to accommodate the proposed flows from the development (7.9 l/sec capacity analysed from the previous layout with increased residential units).

Proposed Foul Sewer Design

5.5 A foul water drainage strategy for the proposed industrial development has been prepared to discharge flows from the unit into the existing 225mm diameter foul sewer that crosses Dalefield Way.

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5.6 Preliminary foul drainage calculations have been produced to establish the peak flow from the proposed and future development aspirations, and have been derived adopting the following design parameters/assumptions:

- Hydraulic design of the strategic foul sewers have been designed in accordance with the requirements of '*Sewers for Adoption*' - 6th Edition;
- Discharge rates for the industrial unit has been established from advice provided by Southern Water as 400 litres/day/100m^2 (based on a 12-hour day);
- Minimum velocity within the strategic sewers i.e. excluding any private drainage connections, shall achieve 0.75 m/sec at one-third design flow (refer to Appendix C for the Win Des output calculation file);
- Pipe roughness value (Ks)=1.5mm;
- The preliminary foul drainage layout is shown on drawing no. B140-021 showing the adoptable foul network and indicative private network (shown to establish ground levels).

5.7 Based on a unit gross floor area of 3,333m^2, the anticipated peak foul design flow for the industrial development has been calculated at 2.5 l/sec.

5.8 Previous consultation has been held with Southern Water in order to confirm and agree the foul flows within the sewer system. The discharge rate previously agreed with Southern Water was 7.6 l/sec and was based on an original site proposal of 165 residential units, 5,000 sq ft of retail and 5,000 sq ft for a children's nursery.

Results

5.9 Based upon the design parameters and principles discussed previously within this report, the foul drainage strategy for this

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industrial-use parcel has been devised to demonstrate that the site can be satisfactorily drained without material impact on the existing drainage system.

5.10 The adoptable sewer is to be piled throughout its length in order to prevent any damage resulting from further settlement from the pre-consolidated ground.

5.11 The foul sewer is to discharge into the existing manhole situated to the north of the distributor road, recently constructed to accommodate the crossing of this road.

5.12 Southern Water have previously confirmed that there is sufficient spare capacity within the receiving downstream system to accept a foul water discharge of up to 7.6 l/sec and this allowance would be suitable to accommodate this particular phase of development (without requiring any off-site remediation works to the public network).

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6.0 SUMMARY

6.1 Following an Inspection of the Environment Agency's (EA) website, we have established that the development site lies within the indicative undefended floodplain of the River Thames which benefits from appropriate flood defence systems.

6.2 Consulting Table D.1 of PPS25, in conjunction with the EA's indicative floodplain mapping, designates that the development should theoretically be considered as a flood risk zone 3 site (high probability), and described as having a 1:100 or greater annual probability of river flooding or a 1:200 or greater annual probability of tidal flooding in any year.

6.3 Applying the Sequential Test specified in PPS25, Table D.2 classifies the proposed land-use of '*general industrial*', as 'less vulnerable' in terms of flood risk. Reviewing Table D.3 – *Flood Risk Vulnerability and Flood Zone Compatibility*' of PPS25, means that the ***development is appropriate*** and therefore the requirements of the Sequential Test are deemed to have been satisfactorily passed.

6.4 The level of flood risk associated with the site has virtually been eradicated due to the high standard of protection offered by the Thames Tidal Defences which was acknowledged by the EA in their letter of 10th November 2006.

6.5 The Strategic Flood Risk Assessment (SFRA) of the Kent Thameside area has established that the application site may potentially experience floodwater of an average depth of 1.75m when subjected to a breach occurring to the north of the land. The fragility curves prepared by HR Wallingford suggest however, that for a breach to occur, the floodwater levels would need to be in the order of a 1:10,000 year event, (far in excess of the 1:1,000 year event that is considered).

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6.6 An independent review of the SFRA was undertaken by HR Wallingford in March 2007 and concluded that in actual fact:

- For the overtopping scenario, the ISIS model does not consider the effect on other floodplains/embayments of the Thames Estuary which will also be inundated during an extreme event;
- The flood tidal level used in the model is 6.4m AOD and significantly higher than the 1:10,000 year event level of 5.53m AOD stated within the Halcrow 2002 report;
- The defence levels used in the SFRA are in the region of 0.5-1.0m lower, than those stated in the existing defence data records;
- The model for the overtopping scenario shows flooding depths over the entire Gravesend embayment and does not consider the effect of local topographical influences (i.e. secondary defences) and are shown to flood, regardless of whether a valid flow path exists or not;
- Whilst the model assesses the extent of flooding during the simulation breach event, no consideration is given within the SFRA to determine the overall probability of the event occurring at the same time that a breach occurs in the primary flood defence system.
- The SFRA model appears to permit free-flow into the storage area for the entire area and may therefore over estimate the volume of floodwater that can be stored on the marshes due to the local topography constraints.
- The presence of the Thames Tidal Defence System means that the annual probability of flooding at the development site is less than 0.1% and the result of any breach scenario occurring under these conditions would, in actual fact, be less than 0.0001% probability.
- An independent study was undertaken by HR Wallingford and established that the raising of the existing ground levels would only

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cause the floodwater level to rise by a notional depth of 0.010mm across the marshland area, south of the railway line.

6.7 Considering that the site is protected by a maintained flood defence system which is only likely to experience a breach in an extreme event in excess of 1:10,000; and that the impact of filling the application land will only increase floodwater depths potentially by 0.010m across the existing marshland, it is considered that the requirements of PPS25 are satisfied as:

i) The development and it's occupants are not at an increased risk of flooding;

ii) The development will not increase the level of flood risk to any existing development/human life as the notional increase in floodwater depth will be contained to the existing marshland area; and

iii) The development can be drained in a sustainable manner.

6.8 Based upon the parameters/design principles established within Sections 3.0 and 4.0 of this report, the following surface water drainage strategy has been devised and illustrated on drawing no. B140-020:

- Existing watercourses are to be retained and improved, to ensure there is no net loss in length as a result of the development proposals.
- Compensatory on-line storage of approximately 455m^3 to be provided in the form of flood levees above 1.65m AOD;
- Approximately 220m of existing watercourse to be regraded and reprofiled to provide a flood levee (an additional area of approximately 2,200m^2);
- Bypass interceptors shall be installed at the downstream end of the sewer system prior to surface water flows being discharged into the

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receiving watercourse to prevent any contaminants polluting the habitat.

6.9 Simulating the rainfall events for various durations of 1:30 and 1:100 year has established that:

- The strategic drainage model confirms that the spine sewers can be designed to ensure that no flooding occurs when the system is subjected to a variety of 1:30 year rainfall events

- The strategic drainage model confirms that the network of modified watercourses can be designed to ensure that the flows generated by 1:100 year rainfall events can be contained within the banks whilst maintaining the 1:100 year water level of 2.04m AOD.

6.10 Southern Water have previously confirmed that there is adequate capacity within the existing system to accommodate the predicted peak foul design flows for the industrial development.

6.11 The foul sewer is to discharge into the existing manhole to the north of the distributor road, constructed to accommodate the crossing of this road.

6.12 On the basis of this report, we conclude that the strategies presented herein satisfy the requirements stated within '*Sewers for Adoption*' – 6th Edition, whilst promoting the sustainable re-use of the existing drainage connections and provision of on-line surface water attenuation.

6.13 **We therefore recommend that the determining Planning Authority grant outline consent for the industrial-use scheme, as the development proposals comply with the requirements specified within *Planning Policy Statement 25 – Development & Flood Risk*.**

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Appendix A

1:30 Year Rainfall Simulations

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Summary Wizard of 15 Winter 30 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 30
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	15 Winter	30	0%	17				
2.000	15 Winter	30	0%	1	30/15 Summer			
2.001	15 Winter	30	0%	1	30/15 Summer			
1.001	15 Winter	30	0%	17				
1.002	15 Winter	30	0%	17				
1.003	15 Winter	30	0%	17				
1.004	15 Winter	30	0%	17				
1.005	15 Winter	30	0%	17				
1.006	15 Winter	30	0%	17				
3.000	15 Winter	30	0%	1	30/15 Summer			
3.001	15 Winter	30	0%	1	30/15 Summer			
3.002	15 Winter	30	0%	1	30/15 Summer			
3.003	15 Winter	30	0%	1	30/15 Summer			
1.007	15 Winter	30	0%	17				
1.008	15 Winter	30	0%	17				
1.009	15 Winter	30	0%	17				
4.000	15 Winter	30	0%	1				
4.001	15 Winter	30	0%	1				
4.002	15 Winter	30	0%	1	30/15 Summer			
4.003	15 Winter	30	0%	17				
4.004	15 Winter	30	0%	17				
4.005	15 Winter	30	0%	17				
4.006	15 Winter	30	0%	17				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.865	-0.435	0.000	0.00	0	0	O K
	2.000	2.753	0.110	0.000	1.19	0	121	SURCH'ED
	2.001	2.555	0.047	0.000	1.51	0	121	SURCH'ED
	1.001	1.866	-0.432	0.000	0.06	0	82	O K
	1.002	1.864	-0.433	0.000	0.05	0	70	O K
	1.003	1.863	-0.433	0.000	0.06	0	59	O K
	1.004	1.861	-0.434	0.000	0.05	0	46	O K
	1.005	1.861	-0.433	0.000	0.03	0	33	O K
	1.006	1.860	-0.433	0.000	0.03	0	26	O K
	3.000	3.031	0.150	0.000	0.37	0	24	SURCH'ED
	3.001	2.957	0.221	0.000	1.42	0	92	SURCH'ED
	3.002	2.710	0.098	0.000	1.24	0	122	SURCH'ED
	3.003	2.556	0.038	0.000	1.46	0	123	SURCH'ED
	1.007	1.859	-0.433	0.000	0.08	0	81	O K
	1.008	1.859	-0.432	0.000	0.06	0	63	O K
	1.009	1.859	-0.431	0.000	0.04	0	46	O K
	4.000	2.668	-0.116	0.000	0.46	0	18	O K
	4.001	2.503	-0.021	0.000	0.89	0	33	O K
	4.002	2.369	0.015	0.000	1.13	0	33	SURCH'ED
	4.003	1.859	-0.441	0.000	0.02	0	32	O K
	4.004	1.859	-0.440	0.000	0.02	0	29	O K
	4.005	1.859	-0.439	0.000	0.01	0	26	O K
	4.006	1.859	-0.438	0.000	0.01	0	23	O K

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Summary Wizard of 15 Winter 30 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	15 winter	30	0%	17				
4.008	15 winter	30	0%	17				
4.009	15 winter	30	0%	17				
4.010	15 winter	30	0%	17				
1.010	15 winter	30	0%	17				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.859	-0.437	0.000	0.01	0	19	O K
	4.008	1.859	-0.436	0.000	0.01	0	15	O K
	4.009	1.859	-0.435	0.000	0.00	0	6	O K
	4.010	1.859	-0.434	0.000	0.00	0	2	O K
	1.010	1.859	-0.430	0.000	0.00	0	2	O K

Gravesham Borough Council

Summary Wizard of 30 Winter 30 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 30
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	30 Winter	30	0%	15				
2.000	30 Winter	30	0%	4	30/15 Summer			
2.001	30 Winter	30	0%	4	30/15 Summer			
1.001	30 Winter	30	0%	15				
1.002	30 Winter	30	0%	15				
1.003	30 Winter	30	0%	15				
1.004	30 Winter	30	0%	15				
1.005	30 Winter	30	0%	15				
1.006	30 Winter	30	0%	15				
3.000	30 Winter	30	0%	4	30/15 Summer			
3.001	30 Winter	30	0%	4	30/15 Summer			
3.002	30 Winter	30	0%	4	30/15 Summer			
3.003	30 Winter	30	0%	4	30/15 Summer			
1.007	30 Winter	30	0%	15				
1.008	30 Winter	30	0%	15				
1.009	30 Winter	30	0%	15				
4.000	30 Winter	30	0%	4				
4.001	30 Winter	30	0%	4				
4.002	30 Winter	30	0%	4	30/15 Summer			
4.003	30 Winter	30	0%	15				
4.004	30 Winter	30	0%	15				
4.005	30 Winter	30	0%	15				
4.006	30 Winter	30	0%	15				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.893	-0.407	0.000	0.00	0	0	O K
	2.000	2.639	-0.004	0.000	0.95	0	97	O K
	2.001	2.508	0.000	0.000	1.21	0	97	O K
	1.001	1.893	-0.405	0.000	0.05	0	70	O K
	1.002	1.892	-0.405	0.000	0.05	0	61	O K
	1.003	1.892	-0.404	0.000	0.05	0	52	O K
	1.004	1.891	-0.404	0.000	0.04	0	40	O K
	1.005	1.891	-0.403	0.000	0.03	0	26	O K
	1.006	1.891	-0.402	0.000	0.02	0	17	O K
	3.000	2.810	-0.071	0.000	0.29	0	19	O K
	3.001	2.776	0.040	0.000	1.14	0	74	SURCH'ED
	3.002	2.616	0.004	0.000	1.01	0	99	SURCH'ED
	3.003	2.518	0.000	0.000	1.17	0	99	O K
	1.007	1.890	-0.402	0.000	0.08	0	83	O K
	1.008	1.890	-0.401	0.000	0.06	0	65	O K
	1.009	1.890	-0.400	0.000	0.04	0	47	O K
	4.000	2.653	-0.131	0.000	0.36	0	14	O K
	4.001	2.445	-0.079	0.000	0.74	0	28	O K
	4.002	2.303	-0.051	0.000	0.96	0	28	O K
	4.003	1.889	-0.411	0.000	0.02	0	26	O K
	4.004	1.889	-0.410	0.000	0.01	0	22	O K
	4.005	1.889	-0.409	0.000	0.01	0	18	O K
	4.006	1.889	-0.408	0.000	0.01	0	14	O K

Gravesham Borough Council

Date 15 June 2007 10:28 Designed By sburton
File 1JN30 REV B.SUM Checked By
Micro Drainage Simulation W.10.4

Summary Wizard of 30 Winter 30 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	30 winter	30	0%	15				
4.008	30 winter	30	0%	15				
4.009	30 winter	30	0%	15				
4.010	30 winter	30	0%	15				
1.010	30 winter	30	0%	15				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.889	-0.407	0.000	0.01	0	11	O K
	4.008	1.889	-0.406	0.000	0.01	0	7	O K
	4.009	1.889	-0.405	0.000	0.00	0	2	O K
	4.010	1.889	-0.404	0.000	0.00	0	1	O K
	1.010	1.889	-0.400	0.000	0.00	0	5	O K

Gravesham Borough Council

Summary Wizard of 60 Winter 30 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 30
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	60 Winter	30	0%	13				
2.000	60 Winter	30	0%	6	30/15 Summer			
2.001	60 Winter	30	0%	6	30/15 Summer			
1.001	60 Winter	30	0%	13				
1.002	60 Winter	30	0%	13				
1.003	60 Winter	30	0%	13				
1.004	60 Winter	30	0%	13				
1.005	60 Winter	30	0%	13				
1.006	60 Winter	30	0%	13				
3.000	60 Winter	30	0%	6	30/15 Summer			
3.001	60 Winter	30	0%	6	30/15 Summer			
3.002	60 Winter	30	0%	6	30/15 Summer			
3.003	60 Winter	30	0%	6	30/15 Summer			
1.007	60 Winter	30	0%	13				
1.008	60 Winter	30	0%	13				
1.009	60 Winter	30	0%	13				
4.000	60 Winter	30	0%	6				
4.001	60 Winter	30	0%	6				
4.002	60 Winter	30	0%	6	30/15 Summer			
4.003	60 Winter	30	0%	13				
4.004	60 Winter	30	0%	13				
4.005	60 Winter	30	0%	13				
4.006	60 Winter	30	0%	13				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.921	-0.379	0.000	0.00	0	0	O K
	2.000	2.490	-0.153	0.000	0.65	0	66	O K
	2.001	2.393	-0.115	0.000	0.82	0	66	O K
	1.001	1.923	-0.377	0.000	0.04	0	48	O K
	1.002	1.921	-0.376	0.000	0.03	0	42	O K
	1.003	1.921	-0.375	0.000	0.04	0	36	O K
	1.004	1.921	-0.374	0.000	0.03	0	27	O K
	1.005	1.920	-0.374	0.000	0.02	0	16	O K
	1.006	1.920	-0.373	0.000	0.01	0	6	O K
	3.000	2.682	-0.199	0.000	0.20	0	13	O K
	3.001	2.640	-0.096	0.000	0.79	0	51	O K
	3.002	2.478	-0.134	0.000	0.72	0	70	O K
	3.003	2.405	-0.113	0.000	0.83	0	70	O K
	1.007	1.920	-0.372	0.000	0.06	0	62	O K
	1.008	1.919	-0.372	0.000	0.05	0	48	O K
	1.009	1.919	-0.371	0.000	0.03	0	34	O K
	4.000	2.634	-0.150	0.000	0.24	0	9	O K
	4.001	2.411	-0.113	0.000	0.49	0	18	O K
	4.002	2.259	-0.095	0.000	0.63	0	18	O K
	4.003	1.918	-0.382	0.000	0.03	0	18	O K
	4.004	1.918	-0.381	0.000	0.01	0	13	O K
	4.005	1.918	-0.380	0.000	0.00	0	10	O K
	4.006	1.918	-0.379	0.000	0.00	0	7	O K

Gravesham Borough Council

Summary Wizarc of 60 Winter 30 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	60 Winter	30	0%	13				
4.008	60 Winter	30	0%	13				
4.009	60 Winter	30	0%	13				
4.010	60 Winter	30	0%	13				
1.010	60 Winter	30	0%	13				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.918	-0.378	0.000	0.00	0	5	O K
	4.008	1.918	-0.377	0.000	0.00	0	3	O K
	4.009	1.918	-0.376	0.000	0.00	0	1	O K
	4.010	1.918	-0.375	0.000	0.00	0	1	O K
	1.010	1.918	-0.371	0.000	0.00	0	7	O K

Gravesham Borough Council

Summary Wizard of 120 Winter 30 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 30
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	120 winter	30	0%	5				
2.000	120 winter	30	0%	8	30/15 Summer			
2.001	120 winter	30	0%	8	30/15 Summer			
1.001	120 winter	30	0%	5				
1.002	120 winter	30	0%	5				
1.003	120 winter	30	0%	5				
1.004	120 winter	30	0%	5				
1.005	120 winter	30	0%	5				
1.006	120 winter	30	0%	5				
3.000	120 winter	30	0%	8	30/15 Summer			
3.001	120 winter	30	0%	8	30/15 Summer			
3.002	120 winter	30	0%	8	30/15 Summer			
3.003	120 winter	30	0%	8	30/15 Summer			
1.007	120 winter	30	0%	5				
1.008	120 winter	30	0%	5				
1.009	120 winter	30	0%	6				
4.000	120 winter	30	0%	8				
4.001	120 winter	30	0%	8				
4.002	120 winter	30	0%	8	30/15 Summer			
4.003	120 winter	30	0%	5				
4.004	120 winter	30	0%	5				
4.005	120 winter	30	0%	5				
4.006	120 winter	30	0%	5				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.945	-0.355	0.000	0.00	0	0	O K
	2.000	2.433	-0.210	0.000	0.40	0	41	O K
	2.003	2.323	-0.185	0.000	0.51	0	41	O K
	1.003	1.945	-0.353	0.000	0.02	0	28	O K
	1.002	1.945	-0.357	0.000	0.02	0	24	O K
	1.003	1.945	-0.351	0.000	0.02	0	19	O K
	1.004	1.945	-0.350	0.000	0.01	0	13	O K
	1.005	1.944	-0.350	0.000	0.01	0	8	O K
	1.006	1.944	-0.349	0.000	0.01	0	5	O K
	3.000	2.651	-0.230	0.000	0.12	0	8	O K
	3.001	2.584	-0.152	0.000	0.49	0	32	O K
	3.002	2.413	-0.199	0.000	0.44	0	44	O K
	3.003	2.334	-0.184	0.000	0.52	0	44	O K
	1.007	1.944	-0.348	0.000	0.03	0	35	O K
	1.008	1.943	-0.348	0.000	0.03	0	26	O K
	1.009	1.942	-0.348	0.000	0.01	0	18	O K
	4.000	2.616	-0.168	0.000	0.15	0	6	O K
	4.001	2.384	-0.140	0.000	0.30	0	11	O K
	4.002	2.227	0.127	0.000	0.39	0	11	O K
	4.003	1.947	-0.358	0.000	0.01	0	11	O K
	4.004	1.942	-0.357	0.000	0.00	0	8	O K
	4.005	1.942	-0.356	0.000	0.00	0	6	O K
	4.006	1.942	-0.355	0.000	0.00	0	4	O K

Gravesham Borough Council

Summary Wizard of 120 Winter 30 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	120 Winter	30	0%	5				
4.008	120 Winter	30	0%	5				
4.009	120 Winter	30	0%	5				
4.010	120 Winter	30	0%	5				
1.010	120 Winter	30	0%	5				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.942	-0.354	0.000	0.00	0	3	O K
	4.008	1.947	-0.353	0.000	0.00	0	1	O K
	4.009	1.942	-0.352	0.000	0.00	0	1	O K
	4.010	1.942	-0.351	0.000	0.00	0	2	O K
	1.010	1.942	-0.347	0.000	0.00	0	9	O K

Gravesham Borough Council

Summary Wizard of 240 Winter 30 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 30
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	240 Winter	30	0%	3				
2.000	240 Winter	30	0%	10	30/15 Summer			
2.001	240 Winter	30	0%	10	30/15 Summer			
1.001	240 Winter	30	0%	3				
1.002	240 Winter	30	0%	3				
1.003	240 Winter	30	0%	3				
1.004	240 Winter	30	0%	3				
1.005	240 Winter	30	0%	3				
1.006	240 Winter	30	0%	3				
3.000	240 Winter	30	0%	11	30/15 Summer			
3.001	240 Winter	30	0%	10	30/15 Summer			
3.002	240 Winter	30	0%	10	30/15 Summer			
3.003	240 Winter	30	0%	10	30/15 Summer			
1.007	240 Winter	30	0%	3				
1.008	240 Winter	30	0%	3				
1.009	240 Winter	30	0%	3				
4.000	240 Winter	30	0%	11				
4.001	240 Winter	30	0%	11				
4.002	240 Winter	30	0%	10	30/15 Summer			
4.003	240 Winter	30	0%	3				
4.004	240 Winter	30	0%	3				
4.005	240 Winter	30	0%	3				
4.006	240 Winter	30	0%	3				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.958	-0.342	0.000	0.00	0	0	O K
	2.000	2.392	-0.251	0.000	0.24	0	25	O K
	2.001	2.275	-0.233	0.000	0.31	0	25	O K
	1.001	1.958	-0.340	0.000	0.01	0	17	O K
	1.002	1.958	-0.339	0.000	0.01	0	14	O K
	1.003	1.958	-0.338	0.000	0.01	0	12	O K
	1.004	1.958	-0.337	0.000	0.01	0	9	O K
	1.005	1.957	-0.337	0.000	0.01	0	6	O K
	1.006	1.957	-0.336	0.000	0.00	0	4	O K
	3.000	2.634	-0.247	0.000	0.07	0	5	O K
	3.001	2.546	-0.190	0.000	0.29	0	19	O K
	3.002	2.369	-0.243	0.000	0.27	0	26	O K
	3.003	2.285	-0.233	0.000	0.31	0	26	O K
	1.007	1.957	-0.335	0.000	0.02	0	21	O K
	1.008	1.956	-0.335	0.000	0.02	0	17	O K
	1.009	1.955	-0.335	0.000	0.01	0	13	O K
	4.000	2.604	-0.180	0.000	0.09	0	3	O K
	4.001	2.364	-0.160	0.000	0.18	0	7	O K
	4.002	2.203	-0.151	0.000	0.24	0	7	O K
	4.003	1.955	-0.345	0.000	0.00	0	7	O K
	4.004	1.955	-0.344	0.000	0.00	0	5	O K
	4.005	1.955	-0.343	0.000	0.00	0	4	O K
	4.006	1.955	-0.342	0.000	0.00	0	3	O K

Gravesham Borough Council

Summary Wizard of 240 Winter 30 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	240 winter	30	0%	3				
4.008	240 winter	30	0%	3				
4.009	240 winter	30	0%	3				
4.010	240 winter	30	0%	3				
1.010	240 winter	30	0%	3				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.955	-0.341	0.000	0.00	0	2	O K
	4.008	1.955	-0.340	0.000	0.00	0	1	O K
	4.009	1.955	-0.339	0.000	0.00	0	1	O K
	4.010	1.955	-0.338	0.000	0.00	0	2	O K
	1.010	1.955	-0.334	0.000	0.00	0	9	O K

Gravesham Borough Council

Summary Wizard of 360 Winter 30 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 30
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	360 Winter	30	0%	2				
2.000	360 Winter	30	0%	13	30/15 Summer			
2.001	360 Winter	30	0%	13	30/15 Summer			
1.001	360 Winter	30	0%	2				
1.002	360 Winter	30	0%	2				
1.003	360 Winter	30	0%	2				
1.004	360 Winter	30	0%	2				
1.005	360 Winter	30	0%	2				
1.006	360 Winter	30	0%	2				
3.000	360 Winter	30	0%	13	30/15 Summer			
3.001	360 Winter	30	0%	13	30/15 Summer			
3.002	360 Winter	30	0%	13	30/15 Summer			
3.003	360 Winter	30	0%	13	30/15 Summer			
1.007	360 Winter	30	0%	2				
1.008	360 Winter	30	0%	2				
1.009	360 Winter	30	0%	2				
4.000	360 Winter	30	0%	13				
4.001	360 Winter	30	0%	13				
4.002	360 Winter	30	0%	13	30/15 Summer			
4.003	360 Winter	30	0%	2				
4.004	360 Winter	30	0%	2				
4.005	360 Winter	30	0%	2				
4.006	360 Winter	30	0%	2				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.961	-0.339	0.000	0.00	0	0	O K
	2.000	2.373	-0.270	0.000	0.18	0	18	O K
	2.001	2.253	-0.255	0.000	0.22	0	18	O K
	1.001	1.961	-0.337	0.000	0.01	0	13	O K
	1.002	1.961	-0.336	0.000	0.01	0	11	O K
	1.003	1.961	-0.335	0.000	0.01	0	10	O K
	1.004	1.961	-0.334	0.000	0.01	0	8	O K
	1.005	1.961	-0.333	0.000	0.01	0	5	O K
	1.006	1.961	-0.332	0.000	0.00	0	4	O K
	3.000	2.626	-0.255	0.000	0.05	0	4	O K
	3.001	2.530	0.206	0.000	0.21	0	14	O K
	3.002	2.349	-0.263	0.000	0.19	0	19	O K
	3.003	2.263	-0.255	0.000	0.23	0	19	O K
	1.007	1.961	-0.331	0.000	0.02	0	17	O K
	1.008	1.960	-0.331	0.000	0.01	0	14	O K
	1.009	1.959	0.331	0.000	0.01	0	12	O K
	4.000	2.596	-0.188	0.000	0.07	0	2	O K
	4.001	2.353	-0.171	0.000	0.13	0	5	O K
	4.002	2.191	-0.163	0.000	0.17	0	5	O K
	4.003	1.958	-0.342	0.000	0.00	0	5	O K
	4.004	1.958	-0.341	0.000	0.00	0	4	O K
	4.005	1.958	-0.340	0.000	0.00	0	3	O K
	4.006	1.958	-0.339	0.000	0.00	0	2	O K

Gravesham Borough Council

Summary Wizard of 360 Winter 30 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	360 Winter	30	0%	2				
4.008	360 Winter	30	0%	2				
4.009	360 Winter	30	0%	2				
4.010	360 Winter	30	0%	2				
1.010	360 Winter	30	0%	2				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.958	-0.338	0.000	0.00	0	2	O K
	4.008	1.958	-0.337	0.000	0.00	0	1	O K
	4.009	1.959	-0.335	0.000	0.00	0	1	O K
	4.010	1.959	-0.334	0.000	0.00	0	2	O K
	1.010	1.959	-0.330	0.000	0.00	0	9	O K

Gravesham Borough Council

Summary Wizard of 480 Winter 30 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 30
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	480 Winter	30	0%	1				
2.000	480 Winter	30	0%	14	30/15 Summer			
2.001	480 Winter	30	0%	14	30/15 Summer			
1.001	480 Winter	30	0%	1				
1.002	480 Winter	30	0%	1				
1.003	480 Winter	30	0%	1				
1.004	480 Winter	30	0%	1				
1.005	480 Winter	30	0%	1				
1.006	480 Winter	30	0%	1				
3.000	480 Winter	30	0%	14	30/15 Summer			
3.001	480 Winter	30	0%	14	30/15 Summer			
3.002	480 Winter	30	0%	14	30/15 Summer			
3.003	480 Winter	30	0%	14	30/15 Summer			
1.007	480 Winter	30	0%	1				
1.008	480 Winter	30	0%	1				
1.009	480 Winter	30	0%	1				
4.000	480 Winter	30	0%	14				
4.001	480 Winter	30	0%	14				
4.002	480 Winter	30	0%	14	30/15 Summer			
4.003	480 Winter	30	0%	1				
4.004	480 Winter	30	0%	1				
4.005	480 Winter	30	0%	1				
4.006	480 Winter	30	0%	1				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.962	-0.338	0.000	0.00	0	0	O K
	2.000	2.362	-0.281	0.000	0.14	0	14	O K
	2.001	2.239	-0.269	0.000	0.18	0	14	O K
	1.001	1.962	-0.336	0.000	0.01	0	12	O K
	1.002	1.962	-0.335	0.000	0.01	0	9	O K
	1.003	1.962	-0.334	0.000	0.01	0	8	O K
	1.004	1.962	-0.333	0.000	0.01	0	6	O K
	1.005	1.962	-0.332	0.000	0.00	0	5	O K
	1.006	1.962	-0.331	0.000	0.00	0	4	O K
	3.000	2.621	-0.260	0.000	0.04	0	3	O K
	3.001	2.519	-0.217	0.000	0.17	0	11	O K
	3.002	2.335	-0.277	0.000	0.16	0	15	O K
	3.003	2.250	-0.268	0.000	0.18	0	15	O K
	1.007	1.962	-0.330	0.000	0.01	0	15	O K
	1.008	1.961	-0.330	0.000	0.01	0	12	O K
	1.009	1.960	-0.330	0.000	0.01	0	11	O K
	4.000	2.592	-0.192	0.000	0.05	0	2	O K
	4.001	2.348	-0.176	0.000	0.11	0	4	O K
	4.002	2.184	-0.170	0.000	0.14	0	4	O K
	4.003	1.959	-0.341	0.000	0.00	0	4	O K
	4.004	1.959	-0.340	0.000	0.00	0	3	O K
	4.005	1.959	-0.339	0.000	0.00	0	2	O K
	4.006	1.960	-0.337	0.000	0.00	0	2	O K

Gravesham Borough Council

Summary Wizard of 480 Winter 30 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	480 winter	30	0%	1				
4.008	480 winter	30	0%	1				
4.009	480 winter	30	0%	1				
4.010	480 winter	30	0%	1				
1.010	480 winter	30	0%	1				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.960	-0.336	0.000	0.00	0	1	O K
	4.008	1.960	-0.335	0.000	0.00	0	1	O K
	4.009	1.960	-0.334	0.000	0.00	0	1	O K
	4.010	1.960	-0.333	0.000	0.00	0	2	O K
	1.010	1.960	-0.329	0.000	0.00	0	9	O K

Gravesham Borough Council

Summary Wizard of 960 Winter 30 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status On Analysis Time Step Fine

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 30
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	960 Winter	30	0%	4				
2.000	960 Winter	30	0%	16	30/15 Summer			
2.001	960 Winter	30	0%	17	30/15 Summer			
1.001	960 Winter	30	0%	4				
1.002	960 Winter	30	0%	4				
1.003	960 Winter	30	0%	4				
1.004	960 Winter	30	0%	4				
1.005	960 Winter	30	0%	4				
1.006	960 Winter	30	0%	4				
3.000	960 Winter	30	0%	16	30/15 Summer			
3.001	960 Winter	30	0%	16	30/15 Summer			
3.002	960 Winter	30	0%	16	30/15 Summer			
3.003	960 Winter	30	0%	16	30/15 Summer			
1.007	960 Winter	30	0%	4				
1.008	960 Winter	30	0%	4				
1.009	960 Winter	30	0%	4				
4.000	960 Winter	30	0%	16				
4.001	960 Winter	30	0%	17				
4.002	960 Winter	30	0%	16	30/15 Summer			
4.003	960 Winter	30	0%	4				
4.004	960 Winter	30	0%	4				
4.005	960 Winter	30	0%	4				
4.006	960 Winter	30	0%	4				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.955	-0.345	0.000	0.00	0	0	O K
	2.000	2.339	-0.304	0.000	0.08	0	8	O K
	2.001	2.218	-0.295	0.000	0.10	0	8	O K
	1.001	1.955	-0.343	0.000	0.01	0	7	O K
	1.002	1.955	-0.342	0.000	0.01	0	7	O K
	1.003	1.955	-0.341	0.000	0.01	0	6	O K
	1.004	1.954	-0.341	0.000	0.00	0	5	O K
	1.005	1.954	-0.340	0.000	0.00	0	4	O K
	1.006	1.954	-0.339	0.000	0.00	0	4	O K
	3.000	2.613	-0.268	0.000	0.03	0	2	O K
	3.001	2.499	-0.237	0.000	0.10	0	6	O K
	3.002	2.323	-0.299	0.000	0.09	0	9	O K
	3.003	2.224	-0.294	0.000	0.12	0	9	O K
	1.007	1.954	-0.338	0.000	0.01	0	10	O K
	1.008	1.953	-0.338	0.000	0.01	0	9	O K
	1.009	1.953	-0.337	0.000	0.01	0	9	O K
	4.000	2.585	-0.199	0.000	0.03	0	1	O K
	4.001	2.335	-0.189	0.000	0.06	0	2	O K
	4.002	2.172	0.187	0.000	0.08	0	2	O K
	4.003	1.952	-0.348	0.000	0.00	0	2	O K
	4.004	1.952	-0.347	0.000	0.00	0	2	O K
	4.005	1.952	-0.346	0.000	0.00	0	2	O K
	4.006	1.952	-0.345	0.000	0.00	0	1	O K

Gravesham Borough Council

Summary Wizard of 960 Winter 30 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	960 Winter	30	0%	4				
4.008	960 Winter	30	0%	4				
4.009	960 Winter	30	0%	4				
4.010	960 Winter	30	0%	4				
1.010	960 Winter	30	0%	4				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.952	-0.344	0.000	0.00	0	1	O K
	4.008	1.952	-0.343	0.000	0.00	0	1	O K
	4.009	1.952	-0.342	0.000	0.00	0	1	O K
	4.010	1.952	-0.341	0.000	0.00	0	1	O K
	1.010	1.952	-0.337	0.000	0.00	0	9	O K

Gravesham Borough Council

Summary Wizard of 1440 Winter 30 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 30
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	1440 Winter	30	0%	8				
2.000	1440 Winter	30	0%	18	30/15 Summer			
2.001	1440 Winter	30	0%	18	30/15 Summer			
1.001	1440 Winter	30	0%	6				
1.002	1440 Winter	30	0%	6				
1.003	1440 Winter	30	0%	8				
1.004	1440 Winter	30	0%	8				
1.005	1440 Winter	30	0%	8				
1.006	1440 Winter	30	0%	8				
3.000	1440 Winter	30	0%	18	30/15 Summer			
3.001	1440 Winter	30	0%	18	30/15 Summer			
3.002	1440 Winter	30	0%	18	30/15 Summer			
3.003	1440 Winter	30	0%	18	30/15 Summer			
1.007	1440 Winter	30	0%	8				
1.008	1440 Winter	30	0%	8				
1.009	1440 Winter	30	0%	8				
4.000	1440 Winter	30	0%	18				
4.001	1440 Winter	30	0%	18				
4.002	1440 Winter	30	0%	18	30/15 Summer			
4.003	1440 Winter	30	0%	8				
4.004	1440 Winter	30	0%	8				
4.005	1440 Winter	30	0%	8				
4.006	1440 Winter	30	0%	8				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.942	-0.358	0.000	0.00	0	0	O K
	2.000	2.327	-0.316	0.000	0.06	0	6	O K
	2.001	2.201	-0.307	0.000	0.08	0	6	O K
	1.001	1.943	-0.355	0.000	0.00	0	5	O K
	1.002	1.942	-0.355	0.000	0.00	0	5	O K
	1.003	1.942	-0.354	0.000	0.00	0	4	O K
	1.004	1.942	-0.353	0.000	0.00	0	4	O K
	1.005	1.942	-0.352	0.000	0.00	0	4	O K
	1.006	1.942	-0.351	0.000	0.00	0	4	O K
	3.000	2.607	-0.274	0.000	0.02	0	1	O K
	3.001	2.489	-0.247	0.000	0.07	0	5	O K
	3.002	2.300	-0.312	0.000	0.07	0	6	O K
	3.003	2.211	-0.307	0.000	0.08	0	6	O K
	1.007	1.942	-0.350	0.000	0.01	0	9	O K
	1.008	1.942	-0.349	0.000	0.01	0	8	O K
	1.009	1.941	-0.349	0.000	0.01	0	8	O K
	4.000	2.582	-0.202	0.000	0.02	0	1	O K
	4.001	2.329	-0.195	0.000	0.05	0	2	O K
	4.002	2.164	-0.190	0.000	0.06	0	2	O K
	4.003	1.940	-0.360	0.000	0.00	0	2	O K
	4.004	1.940	-0.359	0.000	0.00	0	1	O K
	4.005	1.940	-0.358	0.000	0.00	0	1	O K
	4.006	1.940	-0.357	0.000	0.00	0	1	O K

Gravesham Borough Council

Summary Wizard of 1440 Winter 30 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	1440 Winter	30	0%	8				
4.008	1440 Winter	30	0%	8				
4.009	1440 Winter	30	0%	8				
4.010	1440 Winter	30	0%	8				
1.010	1440 Winter	30	0%	8				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.940	-0.356	0.000	0.00	0	1	O K
	4.008	1.940	-0.355	0.000	0.00	0	1	O K
	4.009	1.940	-0.354	0.000	0.00	0	1	O K
	4.010	1.941	-0.352	0.000	0.00	0	1	O K
	1.010	1.941	0.348	0.000	0.00	0	9	O K

Gravesham Borough Council

Appendix B

1:100 Year Rainfall Simulations

Gravesham Borough Council

Ardent Consulting Engineers
4th Floor, Diamond House
36-38 Hatton Garden
London EC1N 8EB

Date 15 June 2007 10:36
File 1in100 REV B.SUM
Micro Drainage

Designed By sburton
Checked By
Simulation W.10.4

Summary Wizard of 15 Winter 100 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 100
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	15 winter	100	0%	9				
2.000	15 winter	100	0%	1	100/15 Winter			
2.001	15 winter	100	0%	1	100/15 Winter			
1.001	15 winter	100	0%	9				
1.002	15 winter	100	0%	9				
1.003	15 winter	100	0%	9				
1.004	15 winter	100	0%	9				
1.005	15 winter	100	0%	9				
1.006	15 winter	100	0%	9				
3.000	15 winter	100	0%	1	100/15 winter			
3.001	15 winter	100	0%	1	100/15 winter			
3.002	15 winter	100	0%	1	100/15 winter			
3.003	15 winter	100	0%	1	100/15 winter			
1.007	15 winter	100	0%	9				
1.008	15 winter	100	0%	9				
1.009	15 winter	100	0%	9				
4.000	15 winter	100	0%	1				
4.001	15 winter	100	0%	1	100/15 winter			
4.002	15 winter	100	0%	1	100/15 winter			
4.003	15 winter	100	0%	9				
4.004	15 winter	100	0%	9				
4.005	15 winter	100	0%	9				
4.006	15 winter	100	0%	9				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.899	-0.401	0.000	0.00	0	0	O K
	2.000	2.958	0.315	0.000	1.54	0	157	SURCH'ED
	2.001	2.622	0.114	0.000	1.97	0	158	SURCH'ED
	1.001	1.899	-0.399	0.000	0.09	0	111	O K
	1.002	1.897	-0.400	0.000	0.07	0	96	O K
	1.003	1.896	-0.400	0.000	0.08	0	82	O K
	1.004	1.895	-0.400	0.000	0.07	0	65	O K
	1.005	1.894	-0.400	0.000	0.05	0	51	O K
	1.006	1.893	-0.400	0.000	0.04	0	35	O K
	3.000	3.384	0.503	0.000	0.48	0	31	SURCH'ED
	3.001	3.305	0.569	0.000	1.87	0	117	SURCH'ED
	3.002	2.585	0.273	0.000	1.62	0	159	SURCH'ED
	3.003	2.626	0.108	0.000	1.89	0	160	SURCH'ED
	1.007	1.892	-0.400	0.000	0.10	0	106	O K
	1.008	1.890	-0.401	0.000	0.08	0	63	O K
	1.009	1.890	-0.400	0.000	0.05	0	59	O K
	4.000	2.702	-0.082	0.000	0.59	0	23	O K
	4.001	2.617	0.093	0.000	1.10	0	41	SURCH'ED
	4.002	2.400	0.046	0.000	1.43	0	42	SURCH'ED
	4.003	1.889	-0.411	0.000	0.03	0	40	O K
	4.004	1.889	-0.410	0.000	0.02	0	36	O K
	4.005	1.889	-0.409	0.000	0.02	0	32	O K
	4.006	1.889	-0.408	0.000	0.01	0	27	O K

Gravesham Borough Council

Summary Wizard of 15 Winter 100 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	15 Winter	100	0%	9				
4.008	15 Winter	100	0%	9				
4.009	15 Winter	100	0%	9				
4.010	15 Winter	100	0%	9				
1.010	15 Winter	100	0%	9				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.889	-0.407	0.000	0.01	0	24	O K
	4.008	1.889	-0.406	0.000	0.01	0	18	O K
	4.009	1.889	-0.405	0.000	0.00	0	6	O K
	4.010	1.889	-0.404	0.000	0.00	0	2	O K
	1.010	1.889	-0.400	0.000	0.00	0	5	O K

Gravesham Borough Council

Summary Wizard of 30 Winter 100 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 100
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	30 Winter	100	0%	8				
2.000	30 Winter	100	0%	2	100/15 Winter			
2.001	30 Winter	100	0%	2	100/15 Winter			
1.001	30 Winter	100	0%	8				
1.002	30 Winter	100	0%	8				
1.003	30 Winter	100	0%	8				
1.004	30 Winter	100	0%	8				
1.005	30 Winter	100	0%	8				
1.006	30 Winter	100	0%	8				
3.000	30 Winter	100	0%	2	100/15 Winter			
3.001	30 Winter	100	0%	2	100/15 Winter			
3.002	30 Winter	100	0%	2	100/15 Winter			
3.003	30 Winter	100	0%	2	100/15 Winter			
1.007	30 Winter	100	0%	8				
1.008	30 Winter	100	0%	8				
1.009	30 Winter	100	0%	8				
4.000	30 Winter	100	0%	2				
4.001	30 Winter	100	0%	2	100/15 Winter			
4.002	30 Winter	100	0%	2	100/15 Winter			
4.003	30 Winter	100	0%	8				
4.004	30 Winter	100	0%	8				
4.005	30 Winter	100	0%	8				
4.006	30 Winter	100	0%	8				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.938	0.362	0.000	0.00	0	0	O K
	2.000	2.787	0.144	0.000	1.20	0	128	SURCH'ED
	2.001	2.564	0.056	0.000	1.60	0	128	SURCH'ED
	1.001	1.938	-0.360	0.000	0.07	0	94	O K
	1.002	1.937	-0.360	0.000	0.07	0	84	O K
	1.003	1.936	-0.360	0.000	0.07	0	72	O K
	1.004	1.935	-0.360	0.000	0.06	0	56	O K
	1.005	1.934	-0.360	0.000	0.04	0	39	O K
	1.006	1.933	-0.360	0.000	0.03	0	26	O K
	3.000	3.099	0.218	0.000	0.38	0	25	SURCH'ED
	3.001	3.023	0.287	0.000	1.49	0	96	SURCH'ED
	3.002	2.741	0.129	0.000	1.34	0	131	SURCH'ED
	3.003	2.569	0.051	0.000	1.55	0	131	SURCH'ED
	1.007	1.932	-0.360	0.000	0.11	0	111	O K
	1.008	1.930	-0.361	0.000	0.09	0	87	O K
	1.009	1.930	-0.360	0.000	0.05	0	62	O K
	4.000	2.669	-0.115	0.000	0.47	0	18	O K
	4.001	2.521	-0.093	0.000	0.92	0	35	O K
	4.002	2.375	0.021	0.000	1.19	0	35	SURCH'ED
	4.003	1.929	-0.371	0.000	0.02	0	33	O K
	4.004	1.929	-0.370	0.000	0.01	0	27	O K
	4.005	1.929	-0.369	0.000	0.01	0	22	O K
	4.006	1.929	-0.368	0.000	0.01	0	18	O K

Gravesham Borough Council

Summary Wizard of 30 Winter 100 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	30 winter	100	0%	8				
4.008	30 winter	100	0%	8				
4.009	30 winter	100	0%	8				
4.010	30 winter	100	0%	8				
1.010	30 winter	100	0%	8				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.929	-0.367	0.000	0.01	0	14	O K
	4.008	1.929	-0.366	0.000	0.01	0	10	O K
	4.009	1.929	-0.365	0.000	0.00	0	2	O K
	4.010	1.929	-0.364	0.000	0.00	0	1	O K
	1.010	1.929	-0.360	0.000	0.00	0	8	O K

Gravesham Borough Council

Summary Wizard of 60 Winter 100 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 100
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	60 Winter	100	0%	7				
2.000	60 Winter	100	0%	3	100/15 Winter			
2.001	60 Winter	100	0%	3	100/15 Winter			
1.001	60 Winter	100	0%	7				
1.002	60 Winter	100	0%	7				
1.003	60 Winter	100	0%	7				
1.004	60 Winter	100	0%	7				
1.005	60 Winter	100	0%	7				
1.006	60 Winter	100	0%	7				
3.000	60 Winter	100	0%	3	100/15 Winter			
3.001	60 Winter	100	0%	3	100/15 Winter			
3.002	60 Winter	100	0%	3	100/15 Winter			
3.003	60 Winter	100	0%	3	100/15 Winter			
1.007	60 Winter	100	0%	7				
1.008	60 Winter	100	0%	7				
1.009	60 Winter	100	0%	7				
4.000	60 Winter	100	0%	3				
4.001	60 Winter	100	0%	3	100/15 Winter			
4.002	60 Winter	100	0%	3	100/15 Winter			
4.003	60 Winter	100	0%	7				
4.004	60 Winter	100	0%	7				
4.005	60 Winter	100	0%	7				
4.006	60 Winter	100	0%	7				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.974	-0.326	0.000	0.00	0	0	O K
	2.000	2.598	-0.045	0.000	0.83	0	85	O K
	2.001	2.507	-0.001	0.000	1.02	0	82	O K
	1.001	1.974	-0.324	0.000	0.05	0	60	O K
	1.002	1.974	-0.323	0.000	0.04	0	52	O K
	1.003	1.973	-0.323	0.000	0.04	0	44	O K
	1.004	1.973	-0.322	0.000	0.03	0	32	O K
	1.005	1.972	-0.322	0.000	0.02	0	18	O K
	1.006	1.971	-0.322	0.000	0.01	0	8	O K
	3.000	2.739	-0.142	0.000	0.26	0	17	O K
	3.001	2.717	-0.019	0.000	1.00	0	65	O K
	3.002	2.590	-0.022	0.000	0.89	0	87	O K
	3.003	2.518	0.000	0.000	1.01	0	85	O K
	1.007	1.971	-0.321	0.000	0.08	0	77	O K
	1.008	1.969	-0.322	0.000	0.06	0	59	O K
	1.009	1.968	-0.322	0.000	0.03	0	40	O K
	4.000	2.646	-0.138	0.000	0.31	0	12	O K
	4.001	2.432	-0.092	0.000	0.65	0	24	O K
	4.002	2.286	-0.068	0.000	0.83	0	24	O K
	4.003	1.966	-0.334	0.000	0.01	0	23	O K
	4.004	1.966	-0.333	0.000	0.01	0	17	O K
	4.005	1.967	-0.331	0.000	0.01	0	12	O K
	4.006	1.967	-0.330	0.000	0.00	0	9	O K

Gravesham Borough Council

Summary Wizard of 60 Winter 100 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	60 Winter	100	0%	7				
4.008	60 Winter	100	0%	7				
4.009	60 Winter	100	0%	7				
4.010	60 Winter	100	0%	7				
1.010	60 Winter	100	0%	7				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.967	-0.329	0.000	0.00	0	6	O K
	4.008	1.967	-0.328	0.000	0.00	0	4	O K
	4.009	1.967	-0.327	0.000	0.00	0	2	O K
	4.010	1.967	-0.326	0.000	0.00	0	2	O K
	1.010	1.967	-0.322	0.000	0.00	0	9	O K

Gravesham Borough Council

Summary Wizard of 120 Winter 100 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 100
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	120 Winter	100	0%	5				
2.000	120 Winter	100	0%	4	100/15 Winter			
2.001	120 Winter	100	0%	4	100/15 Winter			
1.001	120 Winter	100	0%	5				
1.002	120 Winter	100	0%	5				
1.003	120 Winter	100	0%	5				
1.004	120 Winter	100	0%	5				
1.005	120 Winter	100	0%	5				
1.006	120 Winter	100	0%	5				
3.000	120 Winter	100	0%	4	100/15 Winter			
3.001	120 Winter	100	0%	4	100/15 Winter			
3.002	120 Winter	100	0%	4	100/15 Winter			
3.003	120 Winter	100	0%	4	100/15 Winter			
1.007	120 Winter	100	0%	5				
1.008	120 Winter	100	0%	5				
1.009	120 Winter	100	0%	5				
4.000	120 Winter	100	0%	4				
4.001	120 Winter	100	0%	4	100/15 Winter			
4.002	120 Winter	100	0%	4	100/15 Winter			
4.003	120 Winter	100	0%	5				
4.004	120 Winter	100	0%	5				
4.005	120 Winter	100	0%	5				
4.006	120 Winter	100	0%	5				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	2.006	-0.294	0.000	0.00	0	0	O K
	2.000	2.462	-0.181	0.000	0.53	0	54	O K
	2.001	2.359	-0.149	0.000	0.67	0	53	O K
	1.001	2.006	-0.292	0.000	0.03	0	36	O K
	1.002	2.006	-0.291	0.000	0.02	0	30	O K
	1.003	2.006	-0.290	0.000	0.02	0	24	O K
	1.004	2.005	-0.290	0.000	0.02	0	17	O K
	1.005	2.005	-0.289	0.000	0.01	0	9	O K
	1.006	2.005	-0.288	0.000	0.01	0	6	O K
	3.000	2.666	-0.215	0.000	0.16	0	11	O K
	3.001	2.611	-0.125	0.000	0.64	0	42	O K
	3.002	2.446	-0.166	0.000	0.58	0	57	O K
	3.003	2.370	-0.148	0.000	0.68	0	57	O K
	1.007	2.004	-0.288	0.000	0.04	0	44	O K
	1.008	2.003	-0.288	0.000	0.03	0	34	O K
	1.009	2.002	-0.288	0.000	0.02	0	24	O K
	4.000	2.626	-0.158	0.000	0.19	0	7	O K
	4.001	2.398	-0.126	0.000	0.40	0	15	O K
	4.002	2.244	-0.110	0.000	0.51	0	15	O K
	4.003	2.000	-0.300	0.000	0.01	0	14	O K
	4.004	2.000	-0.299	0.000	0.01	0	11	O K
	4.005	2.001	-0.297	0.000	0.00	0	8	O K
	4.006	2.001	-0.296	0.000	0.00	0	5	O K

Gravesham Borough Council

Summary Wizard of 120 Winter 100 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	D/F Act
4.007	120 Winter	100	0%	5				
4.008	120 Winter	100	0%	5				
4.009	120 Winter	100	0%	5				
4.010	120 Winter	100	0%	5				
1.010	120 Winter	100	0%	5				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	2.001	-0.295	0.000	0.00	0	4	O K
	4.008	2.001	-0.294	0.000	0.00	0	2	O K
	4.009	2.001	-0.293	0.000	0.00	0	2	O K
	4.010	2.001	-0.292	0.000	0.00	0	2	O K
	1.010	2.001	-0.288	0.000	0.00	0	9	O K

Gravesham Borough Council

Summary Wizard of 240 Winter 100 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 100
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	240 Winter	100	0%	3				
2.000	240 Winter	100	0%	5	100/15 Winter			
2.001	240 Winter	100	0%	5	100/15 Winter			
1.001	240 Winter	100	0%	3				
1.002	240 Winter	100	0%	3				
1.003	240 Winter	100	0%	3				
1.004	240 Winter	100	0%	3				
1.005	240 Winter	100	0%	3				
1.006	240 Winter	100	0%	3				
3.000	240 Winter	100	0%	5	100/15 Winter			
3.001	240 Winter	100	0%	5	100/15 Winter			
3.002	240 Winter	100	0%	5	100/15 Winter			
3.003	240 Winter	100	0%	5	100/15 Winter			
1.007	240 Winter	100	0%	3				
1.008	240 Winter	100	0%	3				
1.009	240 Winter	100	0%	3				
4.000	240 Winter	100	0%	5				
4.001	240 Winter	100	0%	5	100/15 Winter			
4.002	240 Winter	100	0%	5	100/15 Winter			
4.003	240 Winter	100	0%	3				
4.004	240 Winter	100	0%	3				
4.005	240 Winter	100	0%	3				
4.006	240 Winter	100	0%	3				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	2.026	-0.274	0.000	0.00	0	0	O K
	2.000	2.412	-0.231	0.000	0.31	0	32	O K
	2.001	2.297	-0.211	0.000	0.40	0	32	O K
	1.001	2.026	-0.272	0.000	0.02	0	22	O K
	1.002	2.026	-0.271	0.000	0.02	0	19	O K
	1.003	2.026	-0.270	0.000	0.02	0	16	O K
	1.004	2.025	-0.270	0.000	0.01	0	12	O K
	1.005	2.025	-0.269	0.000	0.01	0	7	O K
	1.006	2.025	-0.268	0.000	0.01	0	5	O K
	3.000	2.643	-0.238	0.000	0.10	0	6	O K
	3.001	2.564	-0.172	0.000	0.38	0	25	O K
	3.002	2.389	-0.223	0.000	0.35	0	34	O K
	3.003	2.308	-0.210	0.000	0.40	0	34	O K
	1.007	2.025	-0.267	0.000	0.03	0	29	O K
	1.008	2.024	-0.267	0.000	0.02	0	23	O K
	1.009	2.022	-0.268	0.000	0.01	0	18	O K
	4.000	2.610	-0.174	0.000	0.12	0	4	O K
	4.001	2.373	-0.151	0.000	0.24	0	9	O K
	4.002	2.214	-0.140	0.000	0.31	0	9	O K
	4.003	2.021	-0.279	0.000	0.01	0	9	O K
	4.004	2.021	-0.278	0.000	0.00	0	7	O K
	4.005	2.021	-0.277	0.000	0.00	0	5	O K
	4.006	2.021	-0.276	0.000	0.00	0	4	O K

Gravesham Borough Council

Summary Wizard of 240 Winter 100 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	D/F Act
4.007	240 Winter	100	0%	3				
4.008	240 Winter	100	0%	3				
4.009	240 Winter	100	0%	3				
4.010	240 Winter	100	0%	3				
1.010	240 Winter	100	0%	3				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	2.021	-0.275	0.000	0.00	0	3	O K
	4.008	2.022	-0.273	0.000	0.00	0	2	O K
	4.009	2.022	-0.272	0.000	0.00	0	2	O K
	4.010	2.022	-0.271	0.000	0.00	0	2	O K
	1.010	2.022	-0.267	0.000	0.00	0	10	O K

Gravesham Borough Council

Summary Wizard of 360 Winter 100 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 100
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	360 Winter	100	0%	1				
2.000	360 Winter	100	0%	6	100/15 Winter			
2.001	360 Winter	100	0%	6	100/15 Winter			
1.001	360 Winter	100	0%	1				
1.002	360 Winter	100	0%	1				
1.003	360 Winter	100	0%	1				
1.004	360 Winter	100	0%	1				
1.005	360 Winter	100	0%	1				
1.006	360 Winter	100	0%	1				
3.000	360 Winter	100	0%	6	100/15 Winter			
3.001	360 Winter	100	0%	6	100/15 Winter			
3.002	360 Winter	100	0%	6	100/15 Winter			
3.003	360 Winter	100	0%	6	100/15 Winter			
1.007	360 Winter	100	0%	1				
1.008	360 Winter	100	0%	1				
1.009	360 Winter	100	0%	1				
4.000	360 Winter	100	0%	6				
4.001	360 Winter	100	0%	6	100/15 Winter			
4.002	360 Winter	100	0%	6	100/15 Winter			
4.003	360 Winter	100	0%	1				
4.004	360 Winter	100	0%	1				
4.005	360 Winter	100	0%	1				
4.006	360 Winter	100	0%	1				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	2.027	-0.273	0.000	0.00	0	0	O K
	2.000	2.389	-0.254	0.000	0.23	0	23	O K
	2.001	2.270	-0.238	0.000	0.29	0	23	O K
	1.001	2.027	-0.271	0.000	0.01	0	17	O K
	1.002	2.027	-0.270	0.000	0.01	0	15	O K
	1.003	2.027	-0.269	0.000	0.01	0	12	O K
	1.004	2.027	-0.268	0.000	0.01	0	9	O K
	1.005	2.027	-0.267	0.000	0.01	0	6	O K
	1.006	2.027	-0.266	0.000	0.00	0	5	O K
	3.000	2.633	-0.248	0.000	0.07	0	5	O K
	3.001	2.543	-0.193	0.000	0.28	0	18	O K
	3.002	2.364	-0.248	0.000	0.25	0	25	O K
	3.003	2.282	-0.236	0.000	0.29	0	25	O K
	1.007	2.026	-0.266	0.000	0.02	0	23	O K
	1.008	2.025	-0.266	0.000	0.02	0	19	O K
	1.009	2.024	-0.266	0.000	0.01	0	15	O K
	4.000	2.603	-0.181	0.000	0.08	0	3	O K
	4.001	2.362	-0.162	0.000	0.17	0	6	O K
	4.002	2.202	-0.152	0.000	0.22	0	6	O K
	4.003	2.023	-0.277	0.000	0.00	0	6	O K
	4.004	2.024	-0.275	0.000	0.00	0	5	O K
	4.005	2.024	-0.274	0.000	0.00	0	4	O K
	4.006	2.024	-0.273	0.000	0.00	0	3	O K

Gravesham Borough Council

Summary Wizard of 360 Winter 100 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	360 Winter	100	0%	1				
4.008	360 Winter	100	0%	1				
4.009	360 Winter	100	0%	1				
4.010	360 Winter	100	0%	1				
1.010	360 Winter	100	0%	1				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	2.024	-0.272	0.000	0.00	0	2	O K
	4.008	2.024	-0.271	0.000	0.00	0	1	O K
	4.009	2.024	-0.270	0.000	0.00	0	2	O K
	4.010	2.024	-0.269	0.000	0.00	0	2	O K
	1.010	2.024	-0.265	0.000	0.00	0	10	O K

Gravesham Borough Council

Summary Wizard of 480 Winter 100 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 100
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	480 winter	100	0%	2				
2.000	480 winter	100	0%	7	100/15 Winter			
2.001	480 winter	100	0%	7	100/15 Winter			
1.001	480 winter	100	0%	2				
1.002	480 winter	100	0%	2				
1.003	480 winter	100	0%	2				
1.004	480 winter	100	0%	2				
1.005	480 winter	100	0%	2				
1.006	480 winter	100	0%	2				
3.000	480 winter	100	0%	7	100/15 Winter			
3.001	480 winter	100	0%	7	100/15 Winter			
3.002	480 winter	100	0%	7	100/15 Winter			
3.003	480 winter	100	0%	7	100/15 Winter			
1.007	480 winter	100	0%	2				
1.008	480 winter	100	0%	2				
1.009	480 winter	100	0%	2				
4.000	480 winter	100	0%	2				
4.001	480 winter	100	0%	7	100/15 Winter			
4.002	480 winter	100	0%	7	100/15 Winter			
4.003	480 winter	100	0%	2				
4.004	480 winter	100	0%	2				
4.005	480 winter	100	0%	2				
4.006	480 winter	100	0%	2				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	2.027	-0.273	0.000	0.00	0	0	O K
	2.000	2.375	-0.268	0.000	0.18	0	19	O K
	2.001	2.255	-0.253	0.000	0.23	0	19	O K
	1.001	2.027	-0.271	0.000	0.01	0	14	O K
	1.002	2.027	-0.270	0.000	0.01	0	12	O K
	1.003	2.027	-0.269	0.000	0.01	0	11	O K
	1.004	2.027	-0.268	0.000	0.01	0	8	O K
	1.005	2.027	-0.267	0.000	0.01	0	6	O K
	1.006	2.026	-0.267	0.000	0.00	0	4	O K
	3.000	2.626	-0.255	0.000	0.06	0	4	O K
	3.001	2.531	-0.205	0.000	0.22	0	14	O K
	3.002	2.351	-0.261	0.000	0.20	0	20	O K
	3.003	2.266	-0.252	0.000	0.23	0	20	O K
	1.007	2.026	-0.266	0.000	0.02	0	19	O K
	1.008	2.025	-0.266	0.000	0.02	0	16	O K
	1.009	2.024	-0.266	0.000	0.01	0	14	O K
	4.000	2.397	-0.187	0.000	0.07	0	3	O K
	4.001	2.354	-0.170	0.000	0.14	0	5	O K
	4.002	2.192	-0.162	0.000	0.18	0	5	O K
	4.003	2.023	-0.277	0.000	0.00	0	5	O K
	4.004	2.023	-0.276	0.000	0.00	0	4	O K
	4.005	2.023	-0.275	0.000	0.00	0	3	O K
	4.006	2.023	-0.274	0.000	0.00	0	2	O K

Gravesham Borough Council

Summary Wizard of 480 Winter 100 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	480 Winter	100	0%	2				
4.008	480 Winter	100	0%	2				
4.009	480 Winter	100	0%	2				
4.010	480 Winter	100	0%	2				
1.010	480 Winter	100	0%	2				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	2.023	-0.273	0.000	0.00	0	2	O K
	4.008	2.024	0.271	0.000	0.00	0	1	O K
	4.009	2.024	-0.270	0.000	0.00	0	2	O K
	4.010	2.024	-0.269	0.000	0.00	0	2	O K
	1.010	2.024	0.265	0.000	0.00	0	10	O K

Gravesham Borough Council

Summary Wizard of 960 Winter 100 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 100
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	960 winter	100	0%	4				
2.000	960 winter	100	0%	8	100/15 Winter			
2.001	960 winter	100	0%	8	100/15 Winter			
1.001	960 winter	100	0%	4				
1.002	960 winter	100	0%	4				
1.003	960 winter	100	0%	4				
1.004	960 winter	100	0%	4				
1.005	960 winter	100	0%	4				
1.006	960 winter	100	0%	4				
3.000	960 winter	100	0%	8	100/15 Winter			
3.001	960 winter	100	0%	8	100/15 Winter			
3.002	960 winter	100	0%	8	100/15 Winter			
3.003	960 winter	100	0%	8	100/15 Winter			
1.007	960 winter	100	0%	4				
1.008	960 winter	100	0%	4				
1.009	960 winter	100	0%	4				
4.000	960 winter	100	0%	8				
4.001	960 winter	100	0%	8	100/15 Winter			
4.002	960 winter	100	0%	8	100/15 Winter			
4.003	960 winter	100	0%	4				
4.004	960 winter	100	0%	4				
4.005	960 winter	100	0%	4				
4.006	960 winter	100	0%	4				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	2.013	-0.287	0.000	0.00	0	0	O K
	2.000	2.349	-0.294	0.000	0.10	0	11	O K
	2.001	2.224	-0.284	0.000	0.13	0	11	O K
	1.001	2.013	-0.285	0.000	0.01	0	8	O K
	1.002	2.013	-0.284	0.000	0.01	0	8	O K
	1.003	2.013	-0.283	0.000	0.01	0	7	O K
	1.004	2.013	-0.282	0.000	0.01	0	6	O K
	1.005	2.013	-0.281	0.000	0.00	0	5	O K
	1.006	2.013	-0.280	0.000	0.00	0	4	O K
	3.000	2.616	-0.265	0.000	0.03	0	2	O K
	3.001	2.507	-0.229	0.000	0.13	0	8	O K
	3.002	2.322	-0.290	0.000	0.12	0	15	O K
	3.003	2.234	-0.284	0.000	0.13	0	11	O K
	1.007	2.013	-0.279	0.000	0.01	0	14	O K
	1.008	2.012	-0.279	0.000	0.01	0	12	O K
	1.009	2.011	-0.279	0.000	0.01	0	11	O K
	4.000	2.587	-0.197	0.000	0.04	0	1	O K
	4.001	2.347	-0.182	0.000	0.08	0	1	O K
	4.002	2.177	-0.177	0.000	0.10	0	3	O K
	4.003	2.010	-0.290	0.000	0.00	0	3	O K
	4.004	2.010	-0.289	0.000	0.00	0	2	O K
	4.005	2.010	-0.288	0.000	0.00	0	2	O K
	4.006	2.010	-0.287	0.000	0.00	0	2	O K

Gravesham Borough Council

Summary Wizard of 960 Winter 100 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	960 winter	100	0%	4				
4.008	960 winter	100	0%	4				
4.009	960 winter	100	0%	4				
4.010	960 winter	100	0%	4				
1.010	960 winter	100	0%	4				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	2.010	-0.286	0.000	0.00	0	1	O K
	4.008	2.010	-0.285	0.000	0.00	0	1	O K
	4.009	2.010	-0.284	0.000	0.00	0	1	O K
	4.010	2.010	-0.283	0.000	0.00	0	2	O K
	1.010	2.010	-0.279	0.000	0.00	0	9	O K

Gravesham Borough Council

Summary Wizard of 1440 Winter 100 year return period
Results for Design Storms

Margin for Flood Risk warning (mm) 300 Inertia Status OFF
DVD Status ON Analysis Time Step Fine

Profile(s) Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 100
Climate Change (%) 0

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
1.000	1440 Winter	100	0%	6				
2.000	1440 Winter	100	0%	9	100/15 Winter			
2.001	1440 Winter	100	0%	9	100/15 Winter			
1.001	1440 Winter	100	0%	6				
1.002	1440 Winter	100	0%	6				
1.003	1440 Winter	100	0%	6				
1.004	1440 Winter	100	0%	6				
1.005	1440 Winter	100	0%	6				
1.006	1440 Winter	100	0%	6				
3.000	1440 Winter	100	0%	9	100/15 Winter			
3.001	1440 Winter	100	0%	9	100/15 Winter			
3.002	1440 Winter	100	0%	9	100/15 Winter			
3.003	1440 Winter	100	0%	9	100/15 Winter			
1.007	1440 Winter	100	0%	6				
1.008	1440 Winter	100	0%	6				
1.009	1440 Winter	100	0%	6				
4.000	1440 Winter	100	0%	9				
4.001	1440 Winter	100	0%	9	100/15 Winter			
4.002	1440 Winter	100	0%	9	100/15 Winter			
4.003	1440 Winter	100	0%	6				
4.004	1440 Winter	100	0%	6				
4.005	1440 Winter	100	0%	6				
4.006	1440 Winter	100	0%	6				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	1.000	1.990	-0.310	0.000	0.00	0	0	O K
	2.000	2.336	-0.307	0.000	0.08	0	8	O K
	2.001	2.211	-0.297	0.000	0.10	0	8	O K
	1.001	1.990	-0.308	0.000	0.01	0	6	O K
	1.002	1.990	-0.307	0.000	0.00	0	6	O K
	1.003	1.990	-0.306	0.000	0.01	0	6	O K
	1.004	1.990	-0.305	0.000	0.01	0	5	O K
	1.005	1.990	-0.304	0.000	0.00	0	4	O K
	1.006	1.990	-0.303	0.000	0.00	0	4	O K
	3.000	2.612	-0.269	0.000	0.02	0	2	O K
	3.001	2.497	-0.239	0.000	0.09	0	6	O K
	3.002	2.309	-0.303	0.000	0.08	0	8	O K
	3.003	2.221	-0.297	0.000	0.10	0	8	O K
	1.007	1.990	-0.302	0.000	0.01	0	11	O K
	1.008	1.989	-0.302	0.000	0.01	0	10	O K
	1.009	1.988	-0.302	0.000	0.01	0	10	O K
	4.000	2.584	-0.200	0.000	0.03	0	1	O K
	4.001	2.334	-0.190	0.000	0.06	0	2	O K
	4.002	2.169	-0.185	0.000	0.07	0	2	O K
	4.003	1.987	-0.313	0.000	0.00	0	2	O K
	4.004	1.987	-0.312	0.000	0.00	0	2	O K
	4.005	1.987	-0.311	0.000	0.00	0	2	O K
	4.006	1.987	-0.310	0.000	0.00	0	1	O K

Gravesham Borough Council

Summary Wizard of 1440 Winter 100 year return period
Results for Design Storms

PN	Storm	Return Period	Climate Change	Rank	First X Surcharge	First Y Flood	First Z Overflow	O/F Act
4.007	1440 Winter	100	0%	6				
4.008	1440 Winter	100	0%	6				
4.009	1440 Winter	100	0%	6				
4.010	1440 Winter	100	0%	6				
1.010	1440 Winter	100	0%	6				

Lvl Ex.	PN	Water Lvl. (m)	Surcharged Depth (m)	Flooded Vol (m³)	Flow/ Capacity	Overflow (l/s)	Pipe Flow (l/s)	Status
	4.007	1.987	-0.309	0.000	0.00	0	1	O K
	4.008	1.987	-0.308	0.000	0.00	0	1	O K
	4.009	1.987	-0.307	0.000	0.00	0	1	O K
	4.010	1.987	-0.306	0.000	0.00	0	1	O K
	1.010	1.987	-0.302	0.000	0.00	0	9	O K

Gravesham Borough Council

Appendix C

Win Des Foul Sewer Output Calculations

Gravesham Borough Council

Ardert Consulting Engineers
4th Floor, Diamond House
36-38 Hatton Garden
London EC1N 8EB

Date 15 June 2007 16:17
File FW LAYOUT.FWS
Micro Drainage

Designed By sburton
Checked By
System 1 W.10.4

FOUL SEWERAGE DESIGN

Global Variables

Pipe Size File c:\winDes\STANDARD.PIP Manhole Size File c:\winDes\STANDARD.MHS

Industrial Flow (l/s/ha)	1.00	Depth from Soffit to G.L. (m)	1.200
Industrial Peak Flow Factor	3.00	Min Vel. (m/s - Auto Design Only)	0.75
Flow Per Person (l/per/day)	225.00	Min Slope (1:X - Optimisation)	500
Persons per House	2.70	Minimum Outfall Invert (m)	2.120
Domestic (l/s/ha)	0.00	Ground Level at Outfall (m)	3.595
Domestic Peak Flow Factor	6.60	Outfall Manhole Name	OUTFALL
Oflow Setting (*Foul only)	0	Outfall Manhole Dia/Length (mm)	1350
Infiltration %	0	Outfall Manhole Width (mm)	13540
Minimum Backdrop Height (m)	0.500		

Designed with Level Soffits

Network Design Table

PN	Length (m)	Fall (m)	Slope (1:X)	Area (ha)	Hse	DWF (l/s)	k (mm)	HYD SECT	DIA (mm)
1.000	35.00	0.194	180.4	0.167	700	0.0	1.500	o	225
1.001	29.96	0.167	179.4	0.000	0	0.0	1.500	o	225
2.000	30.23	0.203	148.9	0.167	0	0.0	1.500	o	150
1.002	18.50	0.102	181.4	0.000	0	0.0	1.500	o	225

Network Results Table

PN	US/IL (m)	E.Area (ha)	E.DWF (l/s)	E.Hse	Infil. (l/s)	P.Dep (mm)	P.Vel (m/s)	Vel (m/s)	CAP (l/s)	Flow (l/s)
1.000	2.583	0.167	0	700	0	179	0.97	0.85	34	33
1.001	2.389	0.167	0	700	0	179	0.97	0.86	34	33
2.000	2.500	0.167	0	0	0	21	0.34	0.72	15	1
1.002	2.222	0.334	0	700	0	183	0.97	0.85	34	33

Gravesham Borough Council

Ardent Consulting Engineers
4th Floor, Diamond House
36-38 Hatton Garden
London EC1N 8EB

Date 15 June 2007 15:18
File
Micro Drainage

Designed By sburton
Checked By
System1 W.10.4

FOUL SEWERAGE DESIGN @ 1/3 DESIGN FLOW

Global Variables

Pipe Size File c:\WinDes\STANDARD.PIP Manhole Size File c:\WinDes\STANDARD.MHS

Industrial Flow (l/s/ha)	1.00	Depth from Soffit to G.L. (m)	1.200
Industrial Peak Flow Factor	3.00	Min Vel. (m/s - Auto Design Only)	0.75
Flow Per Person (l/per/day)	225.00	Min Slope (1:X - Optimisation)	500
Persons per House	2.70	Minimum Outfall Invert (m)	2.120
Domestic (l/s/ha)	0.00	Ground Level at Outfall (m)	3.595
Domestic Peak Flow Factor	6.60	Outfall Manhole Name	OUTFALL
O'flow Setting (*Foul only)	0	Outfall Manhole Dia/Length (mm)	1350
Infiltration %	0	Outfall Manhole Width (mm)	13540
Minimum Backdrop Height (m)	0.500		

Designed with Level Soffits

Network Design Table

PN	Length (m)	Fall (m)	Slope (1:X)	Area (ha)	Hse	DWF (l/s)	k (mm)	HYD SECT	DIA (mm)
1.000	35.00	0.194	180.4	0.167	700	0.0	1.500	o	225
1.001	29.96	0.167	179.4	0.000	0	0.0	1.500	o	225
2.000	30.23	0.203	148.9	0.167	0	0.0	1.500	o	150
1.002	18.50	0.102	181.4	0.000	0	0.0	1.500	o	225

Network Results Table

PN	US/IL (m)	E.Area (ha)	E.DWF (l/s)	E.Hse	Infil. (l/s)	P.Dep (mm)	P.vel (m/s)	Vel (m/s)	CAP (l/s)	Flow (l/s)
1.000	2.583	0.167	0	700	0	88	0.76	0.85	34	11
1.001	2.389	0.167	0	700	0	88	0.76	0.86	34	11
2.000	2.500	0.167	0	0	0	12	0.24	0.72	13	0
1.002	2.222	0.334	0	700	0	89	0.76	0.85	34	11

Gravesham Borough Council

Appendix D

Relevant Correspondence

Gravesham Borough Council

Our ref: CSC/KT/99/000729/bn
You Ref:

Date: 1 July 1999

ENVIRONMENT AGENCY

Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hill Gate
London
W11 3QD

JOB NO. M591	COPY TO:
06 JUL 1999	
DIRECTOR	CIRC. 87AP

FAO Mr Simon Purcell

Dear Simon

DENTON MARSHES DEVELOPMENT AT DAMIGOES FIELD

Further to our telephone conversation of earlier today I can confirm that the proposed surface water drainage strategy, as detailed in your report dated March 1999, is acceptable to the Agency subject to the following comments:

1. The boundary of the application site is partially within the drainage district of the Commissioner of Sewers Gravesend (West), an Internal Drainage Board. All the drains within the site area are classified as ordinary watercourses and are not maintained by the Agency or by the Internal Drainage Board. In the absence of any express agreement to the contrary, maintenance is the responsibility of the riparian owners. Any culvert, diversion, weir, dam, or like obstruction to the flow of the watercourse requires the consent of the Agency under the Land Drainage Act 1991, either acting in its own right or acting as the Internal Drainage Board.

2. The infilling or diversion of any watercourse, therefore, requires Land Drainage Consent and will be subject to the Agency agreeing compensation, for example, a length of replacement open channel. It is likely that any Land Drainage Consent issued will carry a condition to the effect that continuity of drainage must be maintained at all times and that there is no net loss of open channel.

3. Furthermore, to safeguard conservation interests the Agency will request a condition of planning to ensure there is no net loss of open watercourse as a direct result of the development. For your information, the Agency does not consider roadside drainage as suitable compensatory habitat for loss of watercourse and for conservation reasons, the Agency seeks to avoid culverting and will not normally consent such works except for access.

Cont/d..

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH
Tel: 01732 875587 Fax: 01732 875057

Gravesham Borough Council

4. The Agency has no objection to the widening and deepening of existing channels for surface water attenuation. The storage provided must be useable and account must be taken of the groundwater level, which we believe may be as high as 1.9 metres AOD. Storage will only be of use above the maximum potential ground water levels. Nor has it any objection to the installation of control structures at the location of the culverts under the railway. Maintenance responsibility for this storage area and the control structures should be agreed prior to the commencement of the development. Land Drainage Consent is required for the works and the Agency awaits information on the detailed design of the storage facility with supporting calculations clearly showing the adopted discharge rate, the available storage volumes and the adopted return period.

5. At the site inspection attended by Agency staff on 18 September 1998 there appeared to be hydraulic continuity in the ditch system. If, however, it is found that this is not the case, further work will be required to assess the continuity of drainage, in particular between the storage ditch system and the main Denton / Westcourt Marsh outfall. In addition, the hydraulic continuity beneath the railway will need to be established.

6. To safeguard the drainage interests of the area, the Agency will request a condition of planning that no development shall be commenced until a scheme for the provision of surface water drainage has been approved and implemented to the reasonable satisfaction of the Local Planning Authority.

You should be aware that the Environment Agency will be responding to the Planning Authority directly concerning this application.

Yours sincerely

BARRIE NEAVES
Team Leader - Development Control

Direct Dial 01732 223122

Gravesham Borough Council

Our ref: KT/1999/001923(GR/99/168)bn
Your Ref: CBP/stm6060/M591

Date: 6 July 2000

ENVIRONMENT AGENCY

JOB NO. M591 | COPY TO: BGOL
10 JUL 2000
DIRECTOR | CIRC.

Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hill Gate
London
W11 3QD

FAO Mr Chris Baker-Pearce

Dear Chris

PM9 DENTON MARSHES, LAND AT DAMIGOES ROAD, GRAVESEND, KENT

Further to our telephone conversation of earlier today I am pleased to enclose two application forms for land drainage consent at the above site.

I can also confirm that the Agency will not oppose development to the remainder of the site providing it is line with the previously agreed development brief and drainage strategy. The design principles already used on the first land allocation are applicable to the site as a whole.

The retention of 'green-corridors' along the watercourses shall be included for in the proposed layout. Preferably any modifications to the watercourses should be undertaken for short lengths on alternate banks. I understand that this will involve the permission of third party owners. However, the Agency asks that the feasibility of this is investigated.

I look forward to receiving your completed application form(s), in the meantime, should you wish to discuss any of the above please don't hesitate to contact me.

Yours sincerely

BARRIE NEAVES
Team Leader - Development Control

Ditect Dial 01732 223122

Enc.

Gravesham Borough Council

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH

ENGLISH NATURE

Kent Team
The Countryside Management Centre Coldharbour Farm Wye Ashford Kent TN25 5DB
Tel +44(0)1233 812525 Fax +44(0)1233 812520
email kent@english-nature.org.uk
www.english-nature.org.uk

Mr C Baker-Pearce
Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hill Gate
London W11 3QD

JOB NO. BGC U481	COPY TO:
10 JUL 2001	
DIRECTOR AJ Pwg	CIRC.

SAP

tq77-10cpl

6th July 2001

Dear Mr Baker-Pearce

Westcourt Marshes
Off site watercourse works
South Thames Estuary and Marshes Site of Special Scientific Interest and Thames Estuary and Marshes Wetland of International Importance under the Ramsar Convention

Thank you for your letter of 2nd July and for the accompanying plans, U481/01A and 02A.

To ensure that the works are neutral or positive for the nature conservation interest of the Site of Special Scientific Interest (SSSI) the important points are:

- The new shelf in the ditch bank should be covered by water constantly for at least the latter part of the winter, not just when there has been storm flow. The maximum level of water in the ditch is presumably dictated by the level at which the subsurface field drains discharge from the east bank of the ditch. Thus below this maximum level, the channel needs to be broad and deep enough to provide storm storage capacity and a further volume of water for constant cover of the shelf.

- The structure controlling discharge from the ditch should be set so that water cannot drain off below a level which provides a constant cover of water over the new shelf for most of the winter. This additional depth of water could be shown as another band of colour underneath the yellow band (extent of 250mm deep storage area) in the cross sections. It should be of sufficient depth for surface water to remain over the shelf until early to mid summer, but shallow enough for it to dry out in later summer (July or August).Before we accept the proposed works, we will need to agree on the minimum winter water level and a means of ensuring that this requirement is observed.

- The arisings from the excavation should either be moved from the SSSI or spread very thinly (less than 10cm) on the adjacent ground.

If any of these points are unclear, please do not hesitate to contact Lionel Solly or me. Lionel will await your call to arrange a site meeting.

Yours sincerely

Robert Cameron
Deputy Team Manager

Gravesham Borough Council

Our ref: KT/2001/006047/002/AS
Your ref: AJH/BOB/SEG/9558
Date: 13 July 2001

ENVIRONMENT AGENCY

Brand Leonard
The Mill House
Bishop Hall Lane
Chelmsford
Essex
CM1 1LG

FAO Mr B Brewster

Dear Mr Brewster

Land Off Deering Way, Gravesend

Thank you for your letter of 2 July. We have been in negotiations with Buchanans concerning the drainage strategy for this development and it has been agreed that there will be free discharges from the development to the local watercourse but this will be widened and controlled beyond the development site so that downstream landowners will not be adversely affected by the increase in flows.

You have indicated in your letter the size of pipes to be installed together with the 1 in 2 year discharge flows. The storage to be provided in the downstream watercourse beyond the development will be sufficient to contain the 1 in 100 year storm and you will need to demonstrate to us that your pipe sizes are sufficient to pass this storm flow without causing flooding within the development. You will also need to check that the receiving watercourse within the development has capacity to receive the unattenuated discharge and it is quite possible some improvements will be required to contain the 1 in 100 year storm flows.

There is no water quality requirement for the discharges to be consented since the water is of a domestic nature. In addition the outfall structures do not require to be consented under land drainage legislation as long as they are constructed so that the structures and outfall pipes do not extend in to the natural flow of the stream. However the downstream storage provisions have not been finally agreed in detail with Buchanans as there are some conservation issues still to be resolved between ourselves and English Nature. The Consultants are also suggesting the downstream control structures will need to be increased in capacity as they believe the contributing area is larger than originally determined. These issues could result in amendments to the storage profile and we are anticipating meeting with Buchanans in the next few weeks to finalise these matters.

BRAND LEONARD
RECEIVED
2[illegible] JUL 2001
Job No. 19558
BOB

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH
Tel: 01732 875587 Fax: 01732 875057

Copied To AJH

Gravesham Borough Council

No connections to the stream shall be made until the flood storage compensating works have been agreed and carried out as the developer would be liable for any flooding which ensued if a connection was made prior to these works being completed.

I hope this has explained the current situation concerning this site as far as the Agency is concerned but if you have any queries I would be pleased to discuss them with you.

Yours sincerely

Anita Solomon
Development Control

Gravesham Borough Council

Our ref: KT/1999/001923(GR/99/168)bn
Your Ref: CBP/jp7166/U481

ENVIRONMENT AGENCY

Date: 7th August 2001

Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hill Gate
London
W11 3QD

JOB NO. U481 | COPY TO:
10 AUG 2001
DIRECTOR | CIRC. SHP CBP

FAO Mr Chris Baker-Pearce

Dear Chris

WESTCOURT MARSHES, GRAVESEND, KENT

Thank you for your letter of consultation regarding the above dated 10th July. I note the observations of English Nature.

I believe it should be possible to address the nature conservation concerns raised whilst not compromising the land drainage requirements of the Agency.

I await confirmation of the forthcoming site inspection.

Yours sincerely

BARRIE NEAVES
Team Leader - Development Control

Direct Dial 01732 223122

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH
Tel: 01732 875587 Fax: 01732 875057

Gravesham Borough Council

Dr Lionel Solley
English Nature (Kent Team)
The Countryside Management Centre
Coldharbour Farm
Wye
Ashford
Kent TN25 5DB

CBP/lp7358/U481

24 August 2001

Dear Dr Solley

Westcourt Marshes, Gravesend
Off Site Drainage Works

I refer to our most helpful meeting on Wednesday with you and your colleague Ms Smally.

By way of record, we note the following:-

1. The recent channel maintenance undertaken does not detract from the ecological value of the watercourse.

2. The Hawthorn and other vegetation which extends into the SSSI on the Western Bank can be fully cleared to facilitate excavation of the storage shelf.

3. It is acceptable during construction to reprofile/dredge the invert and remove foreign objects from the watercourse.

4. The hydraulic modelling undertaken by Buchanans to be approved by the Environment Agency should demonstrate that the requirements identified in your letter of 6 July 2001, can indeed be met.

Thank you once again for your assistance, I look forward to speaking to you as matters progress.

Yours sincerely

Chris Baker-Pearce

cc:	S Bailey	-	Barratt Eastern Counties
	B Neaves	-	Environment Agency East Malling
	J Lee	-	Gravesham BC
bcc:	P Horton	-	Fort Knight Group

Gravesham Borough Council

Environment Agency
Kent Area Office
Orchard House
Endeavour Park, London Road
Addington, West Malling
Kent ME19 5SH
For the attention of B. Neaves

CBP/stm7549/U481

13th September 2001

Dear Sir

Westcourt Marshes, Gravesend
Off-Site Drainage Works

Thank you for your prompt issue of land drainage consent in respect of the above.

As discussed at our site meeting of 22nd August, there were a number of issues which required further investigation to conclude and I am pleased to advise you of our progress in these matters as follows :

1. **Existing Surface Water Piped Outfall**

   Barratts have cleared the area near the Bailey Bridge and exposed two 600 mmØ pipes. Their record of the investigation is appended for your information and we have recalculated the flow to be 0.578 m^3/s on the basis of their findings. We have also made enquiries of Southern Water, who, in the absence of the requisite data have suggested applying full bore flow conditions at the outfall.

   I have discussed this issue with Anita and I believe she is happy to accept this basis for the design of the flow control at point Z.

2. **Railtrack Culverts**

   Mike Manley has confirmed the presence of the main outfall (control structure X) but suggested, contrary to Gravesham Borough Council and the Agencies advice, that structures Y and Z are surplus to requirements (a point which we have contested). In addition, he has stated that the culvert is silted and requires jetting and requested that our Client should meet the cost of clearing. We have written under separate cover to Mr. Manley (copied to yourself) suggesting this is Railtracks responsibility under land drainage law and we trust this will be enforced if our Clients right of discharge is frustrated in any way.

3. **Removal of Dumped Waste**

   I have discussed with our Client the disposal of the household appliances etc, which have been removed from the watercourse. Barratts are inclined, as a gesture of good will, to remove the material and I hope to receive formal confirmation of this shortly.

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4. **Modelling Simulations**

We have undertaken the final sensitivity tests as discussed, which demonstrate that even with the weir structure completely drowned out, the works are capable of accommodating the 1:100 yr post development flows. An explanation of the modelling methodology, results and amended drawings are appended for your information and I consider that the works, subject to your approval, can now be built.

Thank you for your continued support in this matter, I look forward to receiving confirmation of your approval to the enclosed at your earliest convenience.

With kind regards.

Yours faithfully

Chris Baker-Pearce

Encl.

cc.	S. Bailey Esq.	-	Barratt Eastern Counties
	Dr L Soilley Esq	-	English Nature
	J Loo Esq	-	Gravesham BC

Gravesham Borough Council

ENGLISH NATURE

Kent Team
The Countryside Management Centre Coldharbour Farm Wye Ashford Kent TN25 5DB
Tel +44(0)1233 812525 Fax +44(0)1233 812520
email kent@english-nature.org.uk
www.english-nature.org.uk

COPY TO:

20 SEP 2001

DIRECTOR

Mr Chris Baker-Pearce
Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hill Gate
London W11 3QD

Our reference: BO4/6-43/22

19 September 2001

Dear Mr Baker-Pearce

Westcourt Marshes, Gravesend
Off-site watercourse works
South Thames Estuary and Marshes Site of Special Scientific Interest (SSSI) and Thames Estuary and Marshes Wetland of International Importance under the Ramsar Convention (Ramsar site)

Thank you for sending me a copy of the revised plans for the off-site drainage scheme, and for telephoning to explain the amendments to the proposed works.

From the revised plans, and our discussion, I understand that the concerns raised in our letter of 6 July 2001 have been addressed. On this understanding I am therefore satisfied that the works will be neutral or positive for the nature conservation interest of the Site of Special Scientific Interest and Ramsar site.

Please do not hesitate to contact me if there are other matters that you would like to discuss.

Yours sincerely

Dr Lionel Solly
Conservation Officer

Gravesham Borough Council

ENVIRONMENT AGENCY

Our Ref : KT/2002/009147-12/2
Your Ref : TRF/STM8460/U484

Date : 12 August 2004

Tony Foreman
Buchanan Consulting Engineers
Newcombe House
43-45 Notting Hil Gate
London
W11 3QD

JOB NO	COPY TO
U484	
18 AUG 2004	
DIRECTOR	CIRC
PWG	RF

Dear Mr Foreman

WESTCOURT DEVELOPMENT, GRAVESEND

Thank you for your letter of 6th July.

The Agency can confirm that previously agreed principles for the development at Westcourt Marshes are still acceptable.

The HR Wallingford report concluded that the railway acts as a secondary defence and therefore this accounts for the agreed slab levels (sleeping accommodation at 6.3 and groundfloor levels at 3.8m aODN). The stormwater drainage strategy principles are also acceptable, however, the Agency's engineer concludes that the drainage from this part of the site should be directed to the eastern drain. Therefore, should the scheme adhere to the original principles it is assumed that there should be no problems.

The Agency welcomes continued communications regarding the progress of the site and appreciates consultation on any revised plans.

Yours sincerely

LAURA FULTON
Planning Liaison Officer

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH, Tel no:01732 875587, Fax no:01732 875057

Gravesham Borough Council

Our Ref : KT/2005/021215-1/1
Your Ref : SJB/stk0105/B100

ENVIRONMENT AGENCY

Date : 15 August 2005

Steve Burton
Ardent Consulting Engineers
4th Floor
Diamond House
36/38 Hatton Garden
London
EC1N 8EB

Job No	Date
B100	26-8-05
Director	Circulation
	SJB

Dear Sir

TOWN AND COUNTRY PLANNING ACT 1990
SURFACE WATER DRAINAGE STRATEGY
LAND NORTH OF DERING WAY, GRAVESEND

Thank you for your letter dated 28th July 2005. Please accept our apologies for the delayed response.

The Environment Agency would like to offer the following advice.

GROUNDWATER AND CONTAMINATED LAND

From the information provided, it would appear that the site is affected by contamination.

There must be no discharge into land impacted by contamination or land previously identified as being contaminated. There must be no direct discharge to groundwater, a controlled water. There should be no discharge to made ground.

It is also apparent that Southern Testing produced a site investigation report in 2004. The Groundwater and Contaminated Land would request that a copy of the report be submitted to us. Further more, we would also request the following condition is imposed on any permission granted:

Condition:
No development approved by this planning permission shall be commenced until:

a) A desktop study has been carried out which shall include the identification of previous site uses, potential contaminants that might reasonably be expected given those uses and other relevant information. And using this information a diagrammatical representation (Conceptual Model) for the site of all potential contaminant sources, pathways and receptors has been produced.
b) A site investigation has been designed for the site using the information obtained from the

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Orchard House, Endeavour Park, London Road, Addington,. West Malling,. Kent, ME19 5SH, Tel no:01732 223177

Gravesham Borough Council

desktop study and any diagrammatical representations (Conceptual Model). This should be submitted to, and approved in writing by the LPA prior to that investigation being carried out on the site. The investigation must be comprehensive enough to enable:
· a risk assessment to be undertaken relating to groundwater and surface waters associated on and off the site that may be affected, and
· refinement of the Conceptual Model, and
· the development of a Method Statement detailing the remediation requirements.
c) The site investigation has been undertaken in accordance with details approved by the LPA and a risk assessment has been undertaken.
d) A Method Statement detailing the remediation requirements, including measures to minimise the impact on ground and surface waters, using the information obtained from the Site Investigation has been submitted to the LPA. This should be approved in writing by the LPA prior to that remediation being carried out on the site.

Reason:
To ensure that the proposed site investigations and remediation will not cause pollution of Controlled Waters.

For information
According to current records there is a historic landfill site (GR1) within 20 metres of this property, at grid ref. TQ 669 738. It should be noted that records for pre-1974 sites are from District and Archive records and some of these are incomplete. The site fill is thought to have included mainly inert with some putrescible material.

WATER QUALITY

Site Drainage
Construction Phase
It has been identified that groundwater at this location may be contaminated by previous land use at this site. This may also have implications for surface watercourses at this location.

During the construction phase appropriate measures must be in place to protect surface watercourses from contamination. All risks of contamination of surface watercourses must be assessed and a statement of the methodology for contamination removal/mitigation produced. This must be submitted to the Agency for consultation/approval prior to the commencement of the development.

Please refer to the Agency's Pollution Prevention Guidance (PPG) notes for 'Construction Sites' PPG6 and 'Oil Storage/Disposal' PPG8 for general pollution prevention advice for the construction phase of this development. These guidance notes are available from this office or from the Agency's website www.environment-agency.gov.uk.

Permanent Development
The Agency is unlikely to object to the discharge of uncontaminated site drainage from any permanent development at this site where it is proposed to be discharged to a surface watercourse. This should still pass through pollution prevention measures, i.e. trapped gullies before being discharged.

Gravesham Borough Council

Any parts of the permanent development where site drainage is likely to become contaminated from the activities occurring on it should be directed to the mains foul sewer or to a sealed unit for off site disposal by a licensed contractor. The activities likely to cause contamination include: HGV parking/maintenance bays, loading/unloading bays and vehicle washdown facilities. In some instances (site specific) discharges from HGV bays can be discharged to surface watercourses, via appropriately sized oil interceptors. Any such discharge to controlled waters shall require the discharger to obtain the prior written Consent to Discharge, issued by the Agency, under the Water Resources Act 1991, Schedule 10 (as amended by the Environment Act 1995). Please be aware Consent may not be granted.

Full details of the proposed site drainage arrangements for the permanent development must be submitted to the Agency for their approval before construction commences.

DEVELOPMENT CONTROL

The Agency's records indicate that part of the site could be subject to tidal flooding should the defences be breached or overtopped or more severely under the '200 year' tidal condition, the estimated level of which is 6.08 metres above Ordnance Datum Newlyn for a design horizon of 2060. Therefore, any land on site below this level is considered to be at risk to tidal flooding under the above condition. Please find attached a map indicating the extent of the area considered to be at risk.

The site is offered protection by the presence of the Thames Tidal Defences. These defences offer a standard of protection in excess of the '200 year' standard up until the year 2060.

You may also wish to enquire of the Local Authority who may have further information on localised flooding and flooding from other sources, such as highway drainage.

Any watercourse within the boundary of the site would be classified as an ordinary watercourse and would not be maintained by the Agency or by an Internal Drainage Board. In the absence of any express agreement to the contrary, maintenance is the responsibility of the riparian owners. Any culvert, diversion, weir, dam, or like obstruction to the flow of the watercourse requires the consent of the Agency and/or Internal Drainage Board, under the Land Drainage Act 1991. For nature conservation reasons, the Agency seeks to avoid culverting and will not normally consent such works except for access.

The Agency would recommend that a minimum 4 metre buffer strip is left between the top of the watercourse banks and any built development. This margin would allow for an access strip for maintenance works and provide a wildlife corridor.

The principle of discharging surface water to a watercourse may be acceptable providing it can be demonstrated that the receiving watercourse has sufficient capacity and forms part of a continuous drainage system. Any outfall structure should not protrude into the channel or obstruct flows in any way and suitable toe and bank protection should be incorporated if necessary. As such, attenuation may be required but this would need to investigated further if any development at this site progressed. The Agency would encourage the use of Sustainable Urban Drainage systems where the site circumstances allowed.

In terms of any proposals for future development, unfortunately, the Agency would be unable to comment on requirements for minimum slab levels for the development site, without first

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receiving further detail indicating the nature and scale of the development. The site does benefit from an appropriate standard of defence but the Agency is likely to recommend raising floor levels to a degree to offer an additional level of protection to any buildings on site. We would be pleased to comment further on any proposals as they were developed.

BIODIVERSITY

Water voles are present at locations throughout the Denton Marsh area. Water vole habitat is protected under the Wildlife and Countryside Act (1981 - as amended). As such, when works are proposed in the area, mitigation measures may be required in order to comply with the requirements of the legislation. The Agency would request that the following condition of planning is placed on any permission granted.

Condition:
Temporary protective fencing must be erected to clearly define the 3m buffer strip adjacent to the drainage ditch. Following the erection of protective fencing no material or plant must be stored within the 3m buffer strip.

Reason:
To protect the aquatic communities within the drainage ditch and reduce the risk of potentially damaging water vole habitat or disturbing water voles while they are using such habitat.

WASTE

It is unclear where the material to be used to raise ground levels has come from, and if this is flytipped material it will need to be tested and shown to be suitable before the Agency will authorise its use.

It is possible that the use of inert waste to form a level hardstanding may benefit from exemption from the need for a waste management licence. The applicant should seek to register an exemption prior to any use of waste.

Yours faithfully

JO HOWITT
Planning Liaison Officer

Environment Agency
Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH. Tel no:01732 223111

Gravesham Borough Council

creating a better place

Environment Agency

Gravesham Borough Council
132, Cygnet House
Windmill Street
Gravesend
Kent
DA12 1BQ

Our ref: KT/2006/024620/01-L01
Your ref: GR/20060671

Date: 10 November 2006

Job No	Date
8140/B330	30/11/06
Director	Circulation
CRP	TMF/SSB

Dear Sir/Madam

TOWN AND COUNTRY PLANNING ACT 1990
MIXED USE DEVELOPMENT.
LAND NORTH OF DALEFIELD WAY, GRAVESEND.

Thank you for your consultation, which was recorded as complete on 3rd October 2006. The Agency would like to make the following comments.

Flood Risk
The Agency's records indicate that the site lies within a Zone 3 tidal flood risk area as depicted by the Agency's flood risk mapping, this is a High Risk area with a statistical 0.5% or greater chance of flooding occurring in any one year.

The ground levels are very low in this area, between 2.0m – 2.5mAOD and the predicted '1000 year' flood level for this area, based upon the most recently available information, is given as 6.0mAOD for a design horizon of 2060. If inundation were to occur in this area, the potential depth of flooding experienced could be significant and therefore the consequences on any development and its occupants could be serious.

The Agency is aware of the previous planning history in this area and that planning decisions have been made for adjacent areas. However, since permission was granted for the last phase of development in this area, a significant amount of new and updated information has been published. This new data must be considered in detail, especially regarding the impacts and consequences for development in this area. The Flood Risk Assessment (FRA) states that the site is defended by the presence of the Thames Tidal Defences, and these defences do offer a high standard of defence for the general area. However, the upkeep of these defences is reliant on continuing long term funding and it should not be assumed that this money will always be forthcoming. The Agency's flood risk maps are produced as if there

Environment Agency
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Email: enquiries@environment-agency.gov.uk
www.environment-agency.gov.uk

Gravesham Borough Council

were no flood defences in place in order to determine the areas at risk should a breach or overtopping of the defences occur so that the residual risks can be fully accounted for. In summary, even though defences are in place there should not be a presumption that this makes a site suitable for development.

Putting this site into context it must be considered as being a greenfield site and by applying the sequential test under the guidance in PPG 25, the question should be raised as to whether this site would pass the criteria laid out within this test for allocating land for development. PPG 25 aims to guide development away from areas at risk to flooding by ensuring that sites within lower flood risk areas are developed first. PPG 25 places this land within a Zone 3 flood risk area which is clearly not a low risk flood zone. The recently published Kent Thameside Strategic Flood Risk Assessment contains further details of the nature and severity of the flood risk at this site.

The SFRA denotes this site as lying within a 'High Risk' residual flood risk area as well as confirming the land lies within a Zone 3 flood risk area. The SFRA states that within those high residual risk areas, that as a 'general principle there would be a presumption against development of those sites' and goes further to state 'detailed modelling work would be needed to decide whether the proposed sites are within the rapid inundation zone or in low lying areas and also to check whether, if development took place, flood risk to adjacent areas would be increased'. The following from the SFRA should also be noted 'In general a precautionary approach should be adopted to proposed development in Zone 3.' Reference is also made to the function of the sequential test and in the SFRA the Local Authorities recognise that as part of any Local Development Framework (LDF), consideration should be given to re-allocating sites outside the boundary of Zone 3. This is in line with the guidance given in PPG 25, and draft PPS 25, in steering development away from high flood risk areas.

The FRA introduces the principle of landraising in order to achieve a development platform to achieve suitable finished floor levels. The ground levels are low in relation to the predicted flood level and therefore a relatively significant volume of landraising would need to be undertaken to ensure the safety of any dwellings. The Agency does appreciate the guidance given up to now and the solution for existing development in the area, but it is vital to consider the implications of any new data and act on the best available information at a given time. In Section 8.4.2, the SFRA discusses the issue of landraising on the Marshes in light of the new modelling which has been undertaken. This states 'The use of landraising as mitigation measure must be considered on its merits depending on the local conditions of each embayment. As a general principle, partial land raising within an embayment is ***not*** a desirable option'.

Considering the Gravesend embayment as outlined in the SFRA in more detail, this study looked to determine the nature of the flood risk in more detail for this specific area. The conclusions and future recommendations were based on a breach analysis scenario tied in with LIDAR data. An important conclusion reached for a flood mitigating option is summarised as follows 'Land raising would not be suitable for any redevelopment in this area since it would reduce the local flood storage volume and increase the local extent and depth of flooding. It is therefore desirable to ensure that any flooding of the Marshes is contained within them, and that flooding elsewhere in the embayment is conveyed to the marshes as quickly as possible' This demonstrates the importance of the Marshes as a flood storage area and again raises the question regarding their suitability for development. The Agency does

Cont/d..

appreciate that modelling work was undertaken in 1999 by HR Wallingford within this area and reference is made to this within the FRA for the site. However, further information regarding the nature of the flood risk in the area has become available since this time and the modelling carried out for the 1999 study is no longer consistent with the latest guidance provided by the Agency on this type of modelling exercise.

We note the references made within the FRA to the surface water drainage strategy for the area, which falls in line with the approach taken to development in adjacent areas. The FRA demonstrates that the site area is linked to the surrounding watercourse and that any works and resultant effects on one part of the drainage system will be demonstrated in other areas due to hydraulic connectivity. However, the SFRA states 'Land raising could also be considered in areas that are hydraulically independent from the rest of the embayment'. The FRA clearly demonstrates that this is not the case.

The Agency is looking towards the imminent release of updated guidance on Development and Flood Risk in the form of PPS 25. The draft guidance considers residential housing as a 'more vulnerable' use within Table D2. As the site lies within a Zone 3 flood risk area, Table D1 in draft PPS 25 considers these 'more vulnerable' uses should only be permitted if the Exception Test is passed. The Agency would question whether this application should address those criteria as laid out within the Exception Test. It should also be noted that the Agency has received guidance from DEFRA based on the FCDPAG3 Economic Appraisal which updates the existing Climate change Policy for Flood and Coastal Management. This places greater emphasis on the precautionary approach and offers further guidance on design horizons when planning for climate change, and it has been concluded that development should look towards the year 2115 when considering the climate change implications. This places a greater emphasis on making sustainable decisions at the planning stage as the evidence base for climate change improves and allows for greater certainty in forward thinking.

With all the above in mind, the Agency would question the suitability of this proposal in the light of the new data and information available. The longer term management of the flood risk within the Gravesend area must be considered as part of this proposal and the issue of long term sustainability needs to be addressed, these considerations are beginning to be introduced with the Exception Test as part of PPS 25.

The Agency is therefore obliged to raise an objection to this proposal. If you intend to approve the application contrary to our objection, paragraph 65 of PPG25 advises that you should re-consult the Agency in order to explain why and to give us the opportunity to make further representations.

Biodiversity

Water vole habitat is protected under the Wildlife and Countryside Act 1981 (as amended) and was given further protection by the Countryside Rights of Way Act 2000. This means it is an offence to intentionally or recklessly damage or destroy or obstruct access to any structure or place which water voles use for shelter or protection, or disturb water voles while using such a place.

Disturbance is defined as any activity which affects the survival chances, the breeding success or the reproductive ability of one or more individuals or which leads to a reduction in the quality of occupied habitat. If the flood defence

Cont/d..

work/drainage plan adversely affect the water levels on the surrounding marsh, or the proposed plans reduce the continuity of the ditch systems, this can be classed as disturbance to water voles.

As water voles have been found to occupy the ditches on and around the site appropriate mitigation will need to be devised and agreed with the Agency before any work starts. If the council is minded to approve this application, we would therefore request the following conditions;

CONDITION: Prior to any works commencing a detailed water vole mitigation strategy must be submitted and approved in writing by the Local Authority in conjunction with the Environment Agency.

REASON: To protect water voles.

From the habitat description of the ditches on site it would indicate that they are ideal habitats for aquatic invertebrates. Many invertebrate species require different habitats at different stages in their lifecycles. The possibility of a brackish influence into the ditch would increase the diversity of the invertebrate species that could be present. We would like to see a full invertebrate survey of the ditches conducted. The methodology of this will need to be checked by the Agency before the survey is conducted.

In regards to the proposed hedge planting to create a buffer zone to the surrounding ditch networks we would like to see the hedge planted at least 5 metres from the water courses edge for 'ordinary water courses' and at least 8 metres from drains classed as 'Main River'. We would like to see the species used within this hedgerow to be in keeping with species that would be present in a marsh system. The proposed native wildflower meadow should also be planted with species that are suitable to the marshy environment of the current site.

CONDITION: A scheme for the provision of local native flora (that is in keeping with the marsh environment) within the planting scheme for the proposed development shall be submitted to and approved by in writing by the Local Authority prior to the commencement of works on site.

REASON: In order to ensure that: the visual quality and ecological diversity of the area is maintained, and to ensure that no species are introduced that will cause adverse impacts on the ecology of the nearby watercourse and the locality.

The Agency are extremely concerned that there is no proposed mitigation or compensation for the loss of marsh habitat and Natural England should be contacted for further information regarding this issue.

Potential Contamination

According to current records there is a landfill site within 100metres of this proposal site. The site closed pre-1976and the fill included inert and putrescible materials. The site has not been extensively monitored, but we are unaware of any off-site problems being discovered at any significant distance around the site. However it is recommended, in line with good practise, that any building works are constructed to at least the minimum requirements of Approved Document C of the Building Regulations and the BRE Guidance document "New Building on Gas Contaminated Land".

DECISION NOTICE: Please forward a copy of the full decision notice to this office, quoting our reference number. A copy of this letter has been sent to the applicant/agent.

Yours faithfully

MISS MICHAELA KENNARD
Senior Planning Liaison Officer

cc BARTON WILLMORE

Gravesham Borough Council

End

The impact of additional flows on system performance was identified and compared to internal performance standards to determine whether the target level of performance was breached by the additional flows. Two scenarios have been considered in the assessment of this development:

Scenario 1. Investigate the development in isolation and determine improvements necessary to accommodate the proposed development.

Scenario 2. Assess all the Phased developments and determine improvements necessary to accommodate the proposed development.

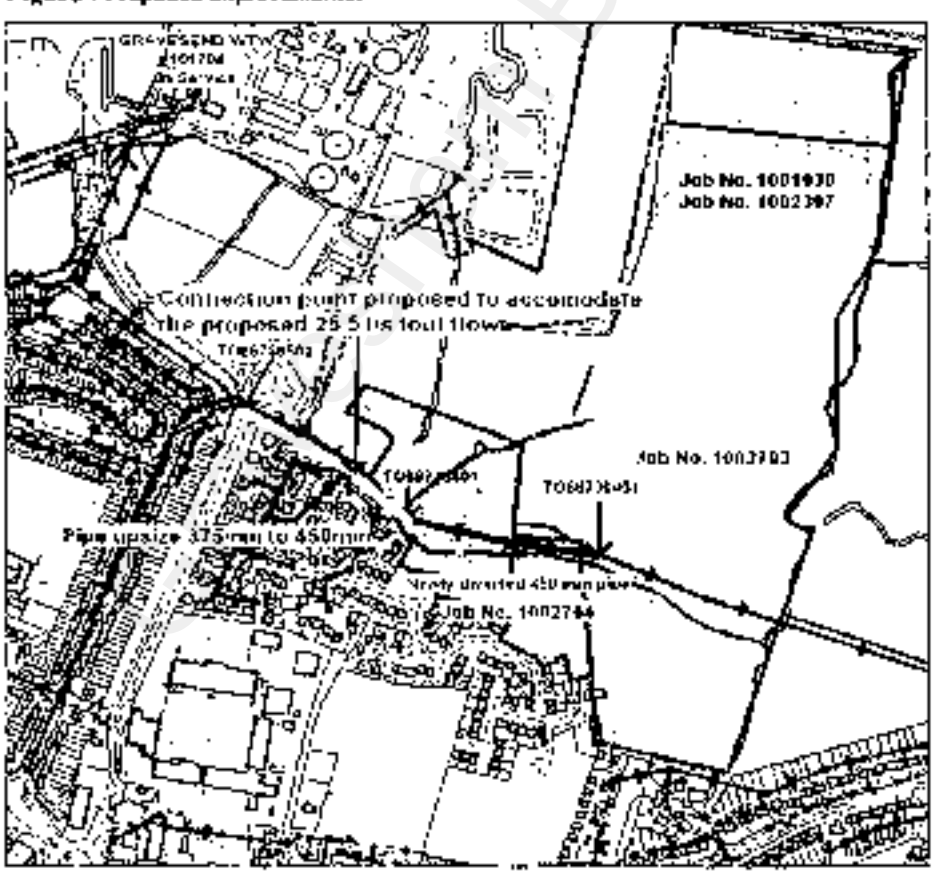
4. Results

Scenario 1:

This scenario considers discharging **25.5** l/s foul flow into manholes reference **TQ66737501.** The InfoWorks model result indicates that the sewerage system upstream the proposed connection point is surcharged and flooding is predicted at manhole reference **TQ67733205** and manhole reference TQ67733206.

The improvements necessary to accommodate the proposed foul flow are shown in Figure 1. The proposal is to increase the existing 375mm sewer between **TQ67738401** and **TQ67736502** to 450 mm (Total length of 203 metres at approximately 2.75 metres average depth).

Figure 1 Proposed Improvements.



Scenario 2

This scenario considers flow from all phased developments added to the sewerage system as identified in the previous enquiries with exception of Job No 1002307.

Job No 1001930. Discharge 7.0 l/s split between manholes TQ67730401 and manhole TQ66739401.

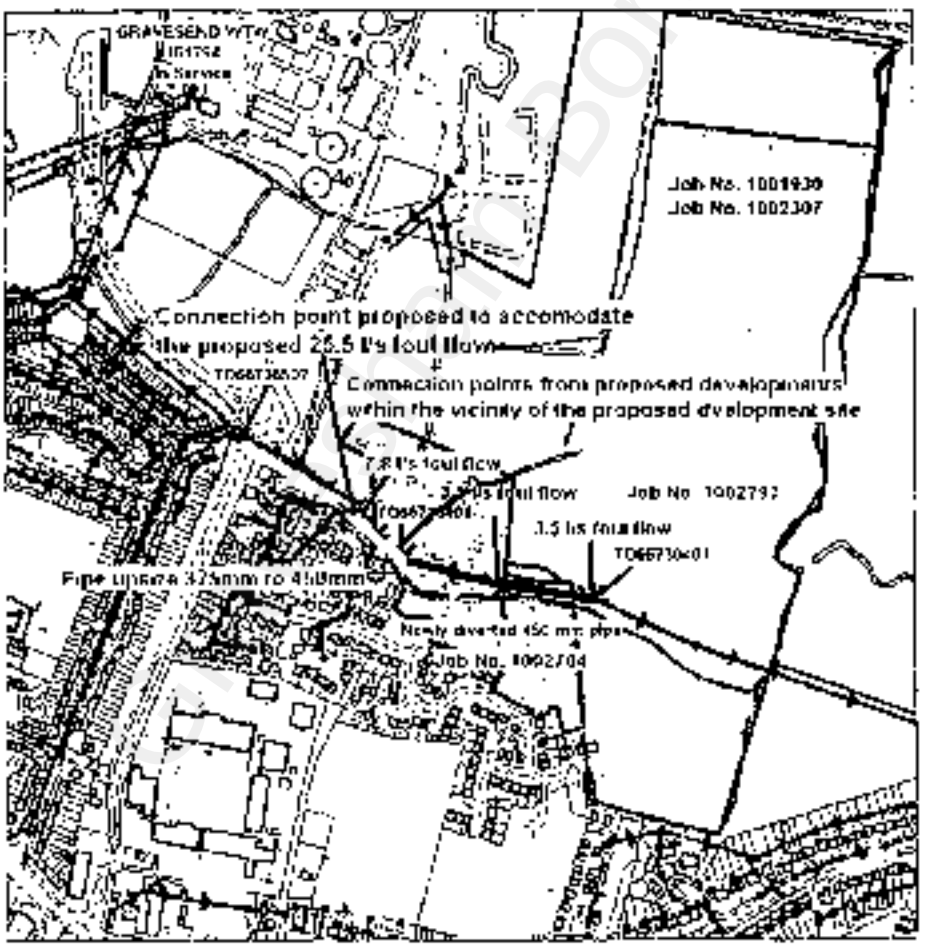
Job No 1002764. Discharge 7.9 l/s into manhole TQ66737405.

Current Job No 1002973. Discharge 25.5 l/s into manhole TQ66737501.

The InfoWorks model result indicates that the sewerage system upstream the proposed connection point is surcharged and flooding is predicted upstream at manhole reference TQ67733205 and TQ67733206.

The improvements necessary to accommodate all the phased development foul flows are shown in Figure 2. The proposal is to increase the existing 375mm sewer between TQ67738401 and TQ67736502 to 450 mm (Total length of 203 metres at approximately 2.75m average depth).

Figure 2. Proposed improvements.



Conclusion

There is no available capacity in the foul sewerage system at manhole TQ66737501 to accommodate the 25.5 l/s foul flow. It is therefore necessary to increase the size of the existing 375-mm sewer between manhole TQ67738401 and TQ67736502 to 450 mm in diameter. The proposed improvements will also accommodate the proposed flow and flow from the other phased developments as shown in Figure 2.

Alternatively, connect to the proposed foul flow at manhole reference TQ66735801 located by the Wastewater Treatment Works located approximately 500 metres north west of the proposed development site.

Gravesham Borough Council

Appendix E

HR Wallingford Report – September 2001

Environment Agency's Letter of 25th September 2001

Gravesham Borough Council

HR Wallingford

Fax

To:	Buchanan Consulting Engineers		
For Attention of:	Chris Baker-Pearce	**Date:**	13 September 2001
Fax No:	020 7309 9056	**No of Pages:**	7
Copy To:			
From:	Rob Cheetham		
Direct tel line:	01491 82 23 33	**Our Ref:**	MCM4918/RJC/4
Email:	R.Cheetham@hrwallingford.co.uk	**Your Ref:**	

You can reply to us by using FAX NUMBER +44 (0) 1491 825916 (Water Management)
If the message is unclear/incomplete telephone +44 (0) 1491 822499 (Carol King)

Subject: **WESTCOURT MARSHES - REPORT**

Dear Chris,

Further to our discussion on Friday 7 September 2001, please find attached a copy of the report describing our findings regarding water levels in the drainage channels to the north of the development at Gravesend.

Do not hesitate to contact me should you wish to discuss this fax in greater detail.

Yours sincerely

Rob Cheetham
River and Urban Catchments Group

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DEVELOPMENT AT WESTCOURT MARSHES
REPORT ON THE HYDRAULIC MODELLING

1. *Introduction and modelling assumptions*

Buchanan Consulting Engineers (BCE), commissioned HR Wallingford to construct an iSIS model of a network of drainage channels to determine the efficacy of channel compensation works on containing additional runoff from a new development in Gravesend.

An on-site surface water drainage strategy has been developed in accordance with design principles agreed with the Environment Agency (the Agency) and English Nature for 165 dwellings. The strategy is outlined in a report by Buchanan Consulting Engineers; 'Proposed Development PM9 Gravesend (M591)'.

The development site lies in low lying marsh, comprising of a network of inter-connected drainage channels and is part of developable land which is bordered by North Kent railway and Medway canal. For hydraulic modelling purposes, natural runoff from the marsh was agreed with the Agency at 7 litres/hectare for the 100 year event.

The northern limit of the developable land is the North Kent railway and the drainage ditches discharge beneath the railway via three outfalls. The Agency wishes to limit the discharge under the railway to the natural runoff rates. The limit of discharge for each outfall was calculated based on the 7 litres/hectares natural runoff.

The site of the new development is located to the south of the developable land and the runoff from the 165 houses was calculated by BCE using a HydroWorks urban drainage model. The critical 100 year storm duration for the development was calculated to be 4 hours and the peak runoff was $0.34m^3/s$.

To comply with Agency requirements, the additional runoff from the new development will be contained within the drainage channels to the south of the railway line. BCE designed a berm for the drainage channel running to the east and north of the development to contain the runoff and the location and dimensions of this berm are given in drawings U481/001&002.

2. *Modelling methodology*

The hydraulic modelling for the investigation was carried out using the iSIS suite of software. Two hydraulic models were constructed: a pre-development and a post development model. The model included all the drainage channels and the three outfalls beneath the railway. In addition, the runoff from the developable land and the land to the east was represented using standard flow boundaries in iSIS.

The aim of the modelling was to determine whether the runoff from the development could be contained within the berm. In order to assess the impact of the development runoff on water levels in the drainage channels, simulations for both the pre and post development were carried out. The pre development model was constructed using cross section data as shown in Randall Surveys drawing 6759/A/SP/1&2. The post development model was constructed using cross section data shown in drawings U481-001&002. The berm extends from cross section 6 to the control structure X. Manning's n for the drainage channels for the initial simulation (baseline scenario) were 0.045.

A total of 9 inflows were included in the pre-development model. BCE Figure M591-07 shows the locations and rates of the 7 inflows for the contributing areas within the developable land and the runoff rates range between 7.91l/s to 43.05l/s. The 43.05l/s inflow represents the natural runoff from the area where the development will be located. The two remaining inflows are from the surface water sewer that drains to the west of the development (690 l/s) and the contributing area to the east of the site (134.95 l/s). These 9 inflows were included in the hydraulic model at the appropriate locations and were kept constant throughout the unsteady model simulations.

The downstream model boundaries were modelled using abstraction units, which allowed the discharge at the outfalls to be fixed at the agreed limits of discharge, which were:

Control Structure X – 144 l/s
Control Structure Y – 150 l/s
Control Structure Z – 717 l/s.

The limit of discharge for Control Structure Z also includes the 690 l/s contribution from a surface water sewer draining parts of Gravesend.

For the post development simulations, the 43.05 l/s inflow was replaced by the 4 hour post development hydrograph, from the BCE HydroWorks modelling. The peak flow from the development was 0.34m3/s and occurred 2.08 hours after the start of the rainfall.

For the pre development simulations, the natural runoff entering the drainage channels equalled the amount abstracted at the downstream boundaries. Under these steady conditions, the initial conditions in the channel are critical as they will also be the final water levels. In view of this, a separate simulation was carried out to determine the initial conditions using a model with weirs at the downstream boundaries (the weir model), the dimensions of which were based on the structure shown in drawing U481-001.

The crest levels of all the weirs were set at 1.35mAD, 100mm above the bed level at control structure X. Control structure X had a weir width of 0.25m and initial simulations were carried out to determine the widths of the other outfalls, ensuring each structure allowed only the maximum agreed discharge through. The result was weir crest widths of 0.26 and 1.20m for control structures Y and Z respectively. The bed levels at control structures Y and Z were lower than at X and to simplify the modelling methodology, the crest levels of each control structure were set at 1.35mAD.

On definition of the initial conditions, the pre and post development simulations were carried out using the models with abstraction units at the downstream boundaries. The following scenarios were carried out:

- Baseline scenario;
- Manning's n sensitivity test; and
- Drowned outfall sensitivity test.

For each scenario, initial conditions were generated using the weir model. For the Manning's n sensitivity test, Manning's n was increased from 0.045 to 0.055. For the drowned outfall scenario, the water downstream of the structure was set at 1.9mAD, a level sufficient to cause drowning of the weir.

The following section presents the results of the simulations.

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3. *Results*

The following tables show the results of the hydraulic modelling simulations. Table 1 gives the pre and post development water levels for the baseline case, Table 2 shows the results of the Manning's n sensitivity test and Table 3 gives the results of the drowned outfall sensitivity test.

It can be seen from Tables 1-3 that post development water levels in the reach from cross section 1 to cross section 5 increase by up to 0.25m. This is because the channel improvement works commence at cross section 6 and the additional runoff from the development is not compensated for throughout this reach. Water levels in the reaches upstream of the outfall structures (including the reach containing the berm) are predicted to increase by up to 0.08m with the inclusion of the development runoff.

It can be seen by comparing the results presented in Tables 1 and 2 that changes in Manning's n have little impact on water levels in the drainage channels. This indicates water levels are predominantly controlled by the outfall structures. However, in the reach from cross section 1 to 6, the post development water levels are predicted to increase slightly.

For the drowned outfall conditions, the post development water levels increase by approximately 0.06m in the reach containing the berm.

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Table 1 Baseline conditions

Section Label	Pre development water levels (mAOD)	Post development water levels (mAOD)	Difference (m)
CS1	1.99	2.22	0.23
CS2	1.99	2.22	0.22
CS3	1.99	2.22	0.22
CS4	1.97	2.14	0.17
CS5	1.96	2.03	0.06
CS6	1.96	1.98	0.02
CS7	1.96	1.98	0.02
CS8	1.96	1.98	0.02
CS9	1.96	1.98	0.02
CS10	1.96	1.98	0.02
CS11	1.96	1.98	0.02
CS12	1.96	1.98	0.02
CS13	1.96	1.98	0.02
CS14	1.94	1.98	0.04
CS15	1.93	1.98	0.06
CS16	1.91	1.98	0.07
CS17	1.91	1.98	0.07
CS18	1.91	1.98	0.07
CS19	1.91	1.98	0.07
CS20	1.91	1.98	0.07
CS21	1.91	1.98	0.07
CS22	1.90	1.98	0.08
CS23	1.90	1.98	0.07
CS24	1.90	1.98	0.08
CS25	1.90	1.98	0.08
CS26	1.90	1.98	0.08
CS27	1.90	1.98	0.08
CS28	1.90	1.98	0.08
CS29	1.91	1.98	0.07
CS30	1.91	1.98	0.07
CS31	1.91	1.98	0.07
CS32	1.91	1.98	0.07
CS33	1.91	1.98	0.07
CS34	1.91	1.98	0.07
CS35	1.91	1.98	0.07
CS36	1.91	1.98	0.07
CS37	1.91	1.98	0.07
CS38	1.94	1.99	0.05
CS39	1.99	2.00	0.01

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Table 2 Manning's n sensitivity test

Section Label	Pre development water levels (mAOD) GR-PRE4.dat	Post development water levels (mAOD) GR-POST6.dat	Difference (m)
CS1	1.99	2.24	0.25
CS2	1.99	2.24	0.25
CS3	1.99	2.24	0.25
CS4	1.98	2.16	0.19
CS5	1.97	2.04	0.08
CS6	1.96	1.99	0.03
CS7	1.96	1.99	0.03
CS8	1.96	1.99	0.03
CS9	1.96	1.99	0.03
CS10	1.96	1.99	0.03
CS11	1.96	1.99	0.03
CS12	1.96	1.99	0.03
CS13	1.96	1.99	0.03
CS14	1.96	1.99	0.03
CS15	1.94	1.99	0.04
CS16	1.93	1.98	0.06
CS17	1.91	1.98	0.07
CS18	1.91	1.98	0.07
CS19	1.91	1.98	0.07
CS20	1.91	1.98	0.07
CS21	1.91	1.98	0.07
CS22	1.91	1.98	0.07
CS23	1.90	1.98	0.08
CS24	1.90	1.98	0.08
CS25	1.90	1.98	0.08
CS26	1.90	1.98	0.08
CS27	1.90	1.98	0.08
CS28	1.90	1.98	0.08
CS29	1.90	1.98	0.08
CS30	1.91	1.98	0.07
CS31	1.91	1.98	0.07
CS32	1.91	1.98	0.07
CS33	1.91	1.98	0.07
CS34	1.91	1.98	0.07
CS35	1.91	1.98	0.07
CS36	1.91	1.98	0.07
CS37	1.91	1.98	0.07
CS38	1.92	1.99	0.07
CS39	1.94	2.02	0.08

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Table 3 Drowned outfall sensitivity test

Section Label	Pre development water levels (mAOD)	Post development water levels (mAOD)	Difference (m)
CS1	2.04	2.22	0.18
CS2	2.04	2.22	0.18
CS3	2.04	2.22	0.18
CS4	2.03	2.15	0.13
CS5	2.02	2.07	0.05
CS6	2.02	2.04	0.02
CS7	2.02	2.04	0.02
CS8	2.02	2.04	0.02
CS9	2.02	2.04	0.02
CS10	2.02	2.04	0.02
CS11	2.02	2.04	0.02
CS12	2.02	2.04	0.02
CS13	2.02	2.04	0.02
CS14	2.01	2.04	0.03
CS15	2.00	2.04	0.04
CS16	1.99	2.04	0.05
CS17	1.99	2.04	0.05
CS18	1.99	2.04	0.05
CS19	1.99	2.04	0.05
CS20	1.99	2.04	0.05
CS21	1.99	2.04	0.05
CS22	1.98	2.04	0.06
CS23	1.98	2.04	0.05
CS24	1.98	2.04	0.06
CS25	1.98	2.04	0.06
CS26	1.98	2.04	0.06
CS27	1.98	2.04	0.06
CS28	1.98	2.04	0.06
CS29	1.99	2.04	0.05
CS30	1.99	2.04	0.05
CS31	1.99	2.04	0.05
CS32	1.99	2.04	0.05
CS33	1.99	2.04	0.05
CS34	1.99	2.04	0.05
CS35	1.99	2.04	0.05
CS36	1.99	2.04	0.05
CS37	1.99	2.04	0.05
CS38	2.01	2.05	0.04
CS39	2.04	2.06	0.02

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Our ref: KT/1999/001923(GR/99/168)bn
Your Ref: CBP/lp7549/U481

Date: 25th September 2001

ENVIRONMENT AGENCY

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U481	
27 [illegible] 2001	
DIRECTOR	CIRC. CB

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FAO Mr Chris Baker-Pearce

Dear Chris

WESTCOURT MARSHES, GRAVESEND, KENT

Thank you for your letter of consultation regarding the above dated 13th September. Using your numbering system I have the following comments:

1. **Existing Surface Water Piped Outfall**

   I can confirm that the principle of applying full bore flow conditions at the outfalls is acceptable. In your letter you state that the recalculated flow is 0.578 m3/s yet in the HR Wallingford calculation the figure of 0.690 m3/s is used.

2. **Railtrack Culverts**

   The whole drainage strategy is based on the hydraulic continuity between the marshes to the south and north of the railway. You are correct in your assertion that maintenance of culverts is the responsibility of the riparian owner, in this case Railtrack. I note the separate correspondence between yourselves and Railtrack.

3. **Removal of Dumped Waste**

   Noted.

4. **Modelling Simulations**

   The submitted report on the hydraulic modelling is acceptable in principle. The inherent uncertainties of the modelling, such as the green-field run-off rate, the discharge from the existing surface water sewers (see note 1) and the sensitivity to surface friction (Manning's 'n') can be accommodated within the flexibility of the control structures.

Cont/d..

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Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH
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Appendix F

HR Wallingford Report 'Assessment of Tidal Flooding'

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Development site, North East Gravesend, Kent

Assessment of tidal flooding

Report EX 3378
February 1996

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Development site, North East Gravesend, Kent

Assessment of tidal flooding

Report EX 3378
February 1996

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Contract

This report describes work commissioned by Fort Knight Group plc and Kent County Council. Mr Peter A Horton represented both parties. The HR job number was ABM 3580. The work was undertaken by Mr Ian C Meadowcroft and the project was managed by Mr Keith Mann.

Prepared by Ian Meadowcroft (name) Project Engineer (job title)

Approved by KMann Project Manager

Date 14 March 1996

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Summary

Development site, North East Gravesend, Kent

Assessment of tidal flooding

Report EX 3378
February 1996

This report contains an assessment of tidal flooding at a proposed development site near Gravesend, Kent. The report is intended to provide an objective view of the possibility of tidal flooding.

The report supplements and builds on an assessment carried out by HR Wallingford in September 1995.

The key arguments are as follows:

The main Thames defences provide a high level of protection against tidal flooding. The crest level is at least 0.3m above the water level with a return period of 1000 years. The quantity of water overtopping has been calculated for a range of extreme water levels.

In the highly unlikely event that the main defence would breach at these extreme levels, it may result in higher flood volumes. However, the volume of water flowing through a typical breach would be small, and it is almost inconceivable that a large number of breaches will develop over the frontage during a single high tide.

Any water that does cross the line of the main defence will tend to flood the area of marsh land to the north of the Thames and Medway Canal. This area, referred to in this report as the 'reservoir' will act as a storage basin. The 'reservoir' is bounded to the south by the banks of the canal. These are raised above the surrounding ground level, and serve as water retaining structures for the canal. The maximum flood level in the 'reservoir' will be lower than the high tide level due to the limited flow rate of flood water across the defence line and due to the large area in plan of the 'reservoir'. It is this which is a special feature of the site and which provides an even higher standard of defence to the development site than is given by the main defences alone.

The assessment in this report has taken these factors into account to give estimates of return periods of extreme water levels in the reservoir, and an assessment of the overall standard of protection provided to the development site. This shows that the probability of tidal inundation of the development site is negligible and may be considered to be virtually non-existent.

The assessment applies to the defences and site at present, with the exception that it is assumed that any culverts are fitted with working tidal flaps.

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Appendices

Appendix A	Assessment of tidal flooding at north-east Gravesend for Fort Knight Group plc and Kent County Council. HR Wallingford, September 1995.

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1 Introduction

This report presents an assessment of flood risk at a proposed development site east of Gravesend, Kent, adjacent to the Thames estuary. The site is protected by Thames tidal defences owned and maintained by the NRA. These provide a high level of protection, and were designed on the basis of defending against a 1:1000 year tidal water level.

In the event of very extreme tidal levels occurring, any water that may cross the line of the main defence will tend to flood the area of marsh land to the north of the Thames and Medway Canal. This area, referred to in this report as the 'reservoir' will act as a storage basin. The 'reservoir' is bounded to the south by the banks of the canal. These are raised above the surrounding ground level, and serve as water retaining structures for the canal.

The proposed development site lies to the south of the canal. The canal is disused but currently the subject of a restoration programme. The northern canal bank is a right of way and is metalled along part of its length. The southern bank is used by the railway between Chatham and London, which is a twin line

The development site is at Westcourt and Great Clane Lane Marshes. A plan of the site is shown in Figure 1. The land level of the site is generally above 2.0mOD. The level of the canal banks is about 4.0mOD, and the crest level of the main defence is between about 6.6mOD and 7.6mOD. Extreme high water levels in the estuary at Tilbury are estimated to be 4.55mOD, 5.25mOD and 5.23mOD for 10, 100 and 1000 year return periods respectively (Coles and Tawn, 1990).

The proposed development site, like other residential developments in the locality, is below the level of high tide levels. But in assessing the possibility of flooding of the site, we have taken account of the defences protecting the site, and the special features of the site which affect the passage of flood water. This report is intended to provide a realistic assessment of the actual risk of tidal flooding at the site, taking account of the particular characteristics of the site.

HR carried out an assessment of tidal flooding of the site in September 1995 based on the possible failure of the Thames tidal defences in a mode similar to the failure that occurred in the 1953 event. This brief report is included in this more comprehensive report as Appendix A. This earlier report contains some background information to the main report and should be read in conjunction with it.

It should be mentioned here that the September report was written before the northern side of the canal was visited by HR when it became clear that the canal had raised banks on both sides, each with a crest at about 4m ODN. Previously we had assumed that the railway embankment was the only bank between the river tidal defences and the proposed development site

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2 Flood risk issues

2.1 Definitions

Environmental variables such as extreme water levels are often expressed as values with a certain return period. Thus the water level which is exceeded, on average, once every 1000 years is known as the '1000 year water level'. This phrase can induce false security in the lay person, who may feel that such an event is unlikely to occur for 1000 years into the future. In fact, the 1000 year event can occur in any year. In any one year, there is a (1/1000) chance that the 1000 year water level will be exceeded.

A tidal level with a particular return period may or may not cause flooding, depending on the defences, their condition, and other conditions for example waves. The topography of the potential flood area may also be important. Assessment of flood risk is concerned with assimilating environmental, hydraulic, structural and topographic features to estimate the overall probability that a particular area will flood, and to what depth and duration.

The impact of risks is expressed as a combination of probability multiplied by consequence (Royal Society, 1992).

2.2 Criteria for risk

It is widely accepted that many risks can be reduced but not eliminated entirely. This leads to the concept of 'tolerable risk' which is widely used in the design and siting of industrial plants and power stations. While the acceptable risk should not be regarded as a target, we can use risks encountered in other walks of life to examine the significance of the risks from tidal flooding, and to judge whether these can be accepted.

The concept of tolerable risk implies that criteria must be found for the probability and consequences of undesirable events. In view of the high standard of the main flood defences in the reach adjacent to the site, it is only the very extreme storm surge conditions that could result in any significant flow across the main defence line. Under these vary rare events, (typically less frequent than once every 1000 years on average) minor flooding is unlikely to be of any concern. The risk in terms of 'probability times consequence' would be very low. The real concern here is to show that the likelihood of catastrophic flooding of the site is so low as to be insignificant compared to other hazards. Catastrophic flooding is taken to be inundation to a depth greater than about 2m.

Guidance on acceptable risk levels for developments close to industrial plants is available from the Health and Safety Executive (eg HSE, 1989) and information on risk from a number of 'everyday' hazards is given by Hambly and Hambly (1994). Although there is no firm guidance on tolerable risk from tidal flood inundation, comparison with other hazards and guidance indicates that a flood frequency of lower than 1 in 1000 (annual) might be tolerable, whereas a frequency of less than 1 in 10,000 could be considered to be 'negligible' compared with other risks accepted by individuals and society.

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3 Evaluation of flood risk

3.1 Overview

This section considers the overall possibility that the development site at Westcourt and Great Clane Lane Marshes will be inundated by tidal flooding. The assessment takes account of both the main sea defences and also the existence of the canal banks. Although they are not NRA flood defence structures, the canal banks presently serve a water-retaining function and would certainly provide additional protection to the site if required in the unlikely event of overtopping or a breach in the main river defence bank.

An 'event tree' for tidal flooding is shown in Figure 2. This shows possible mechanisms by which the site may be flooded. The following assessment is based on establishing probabilities and consequences for relevant parts of the event tree to identify the possibility of tidal inundation.

As discussed in Section 2.2, the assessment covers only the possibility of serious inundation, to a depth of at least 2m

3.2 Thames tide levels

The following extreme tide levels are given for Tilbury (Coles and Tawn, 1990):

Exceedence Frequency (yr^{-1})	Return Period (yr)	Water level (mOD)
0.1	10	4.55
0.01	100	5.25
0.001	1000	6.23

These levels are based on 46 years of data.

HR Wallingford have extended and developed this data to give a table of 'events' (nos 1-7) which can be used as a basis for the risk assessment procedure. Each 'event' represents a storm surge condition with a particular annual occurrence frequency. Conversion from exceedence to occurrence frequency is convenient for the subsequent risk methodology.

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Water Level (mOD)	Exceedence frequency (yr^{-1})	Return Period (yr)	Event No.	Water Level (mOD)	Occurrence frequency (yr^{-1})
4.75	0.048	21			
			1	5.0	0.037
5.25	0.010	97			
			2	5.5	0.0074
5.75	0.0029	343			
			3	6.0	0.0020
6.25	0.00095	1050			
			4	6.5	0.00061
6.75	0.000345	2900			
			5	7.0	0.00021
7.25	0.000134	7480			
			6	7.5	0.000079
7.75	0.000055	18200			
			7	8.0	0.000031
8.25	0.000024	42300			

The fourth column of the above table identifies the event, the fifth column gives the corresponding water level, and the final column shows the annual occurrence frequency of the event. The subsequent risk assessment procedure is based on this data.

3.3 Main flood defences

Information on the main sea defences has been obtained from NRA Southern Region in the form of a recent report which included a records investigation and site survey (Babtie Group, 1995).

The site is protected by Thames tidal defences which were constructed in the late 1970s and early 1980s at the same time as the construction of the Thames Barrier. The defence which protects the site is an earth (clay) embankment although to the west end of the frontage there are a number of concrete walls, and gates. The crest levels of the defence are summarised below:

Design crest level	6.8mOD
Minimum surveyed crest level (1995)	6.60mOD
Maximum surveyed crest level (1995)	7.62mOD

A longitudinal profile showing the variation of crest level along the frontage is shown in Figure 3. This is Length 7 identified in the Babtie report, from Denton in the west to Shornmead Fort at the eastern end. There is a marked lowering of the embankment between chainage 1400m and 2400m, although even here the level remains above the 1000 year water level.

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The condition survey reported that overall the main earth embankments of the Thames Tidal Defences 'were generally in very good condition. The grass cover was good and there were no signs anywhere of any instability.'

The main embankment along Length 7 was reported to be in good condition with no evidence of surface or deep-seated instability.

The main embankment is fronted by the original embankment which now forms a primary defence. This showed some signs of damage, with some localised areas with damage to the Essex blockwork and ragstone protecting the seaward slope and toe of this original embankment. The saltings in front of the original embankment were reported to be badly eroded in places. The report recommended a number of remedial measures and further investigations to be carried out.

Failure mechanisms

There are several possible flow routes for flow across the main defence. These are summarised and discussed below.

Overtopping, occurring when the water level is above the main defence crest level. The following table gives approximate potential volumes of overtopping, making the approximation that the tide level is at the high water level for a duration of 2 hours:

Event Number	Water Level (mOD)	Volume overtopping (Mm^3)
1	5.0	0.00
2	5.5	0.00
3	6.0 (1:1000 yrs 6.23)	0.00
4	6.5	0.00
5	7.0	0.12
6	7.5	2.83
7	8.0	16.4

Breaching, resulting from structural failure of the main embankment. The most likely causes of breaching are erosion of the landward face due to overtopping flows, and geotechnical failure. Geotechnical failure mechanisms include seepage through the embankment leading to weakening and slumping of the back face, and high internal pressures leading to deep-seated instability and slipping of the embankment or foundations.

Guidance on the stability of the landward slope to erosion is available (Bettess and Reeve, 1993). This suggests that the landward slope may erode during Event 5 (equivalent to 1:4760 yr return period) at the location where the crest level is lowest depending on the quality of the grass cover. For less severe events, there will be no erosion. For more severe events, the grass may be eroded by overtopping flows, leading to increased likelihood of breaching.

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If all the grass is eroded, breaching is made more likely but not inevitable.

At locations where the crest level is higher, erosion due to overtopping will be both less likely and less severe.

Geotechnical failure mechanisms have not been analysed in detail here. The following observations help to estimate the likelihood of this:

- Slips can occur when the water level is below the crest, but are relatively unlikely
- There will be variability in soil conditions along the bank which means that the factor of safety varies along the embankment under given water level conditions
- The crest level varies along the embankment, and the resistance to geotechnical failure will in general be related to the crest level. This implies a higher failure probability between chainage 1400 and 2300 (Fig 3)
- The embankment was designed and constructed fairly recently. Although details of the design assumptions are not available, it appears that the defence has been designed and built to a high standard which gives confidence in its integrity.

A typical breach dimension of 18m wide and 2m deep was assumed for the earlier HR assessment based on the 1953 event (see Appendix A). This is compatible with recent research on full scale tidal embankment undertaken by HR Wallingford. A water level difference of 2m in that case lead to a breach approximately 3m deep and 3m wide. The breach showed a surprising resistance to further widening, as the clay core resisted further erosion. A higher head difference would be expected to give a larger breach. The dimensions assumed for the earlier study, based on typical breach dimensions from 1953, are therefore considered to be reasonable. The breach sill level was assumed to be 4.2mOD.

The above factors have been incorporated into the analysis method in order to estimate the probabilities of different water levels within the 'reservoir' (Figure 4). The difference between this curve and the curve of extreme tide levels is due to the presence of the main NRA defence. The curve of extreme water levels in the 'reservoir' has been used as the basis for the part of the risk assessment, that is to assess the possibility of flooding of the development site itself. The approximate level of the canal banks has been added to the figure which indicates a return period of over 1 . 17000 years for overtopping.

3.4 Wind-generated waves

This section contains an assessment of wind wave heights at the canal embankment. These could be generated in the 'reservoir' by a wind blowing from the northern sector following inundation of the 'reservoir'. The wave height at the canal embankment will depend on:

a) the wind speed and duration
b) the wind direction and fetch length
c) the water depth in the 'reservoir'

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'Deep water' waves

This section assesses the potential wave height assuming deep water conditions. The section following this suggests reduction factors to account for shallow water frictional losses.

A simple method for estimating the potential wave height, ignoring depth-limiting effects, is given for reservoirs. (ICE / DoE). This is based on recommendations for wind speed assessment given in BS 6399, together with a formula for wave generation, the Donelan/JONSWAP method.

The wind speed depends on the return period. For this broad-brush assessment, the hourly 50-year wind speed at the site may be taken as 22 ms^{-1}. This can be scaled to other return periods if required, but for this assessment a 50-year return period was considered to be appropriate.

The wind speed will be increased somewhat because the fetch is over water. An adjustment factor of 1.1 is applied, corresponding to a 1000m fetch, giving a wind speed of 24 m^{-1}.

A further correction is needed to account for the shorter duration than 1 hour that will be applicable in this case, for the relatively short fetch length. A duration factor of 1.05 gives a revised wind speed of 25 ms^{-1}.

Finally, a direction factor is applied to account for the fact that winds from a predominantly northerly sector have lower speeds than those from the south west. A factor of 0.78 gives a final estimated 50-year wind speed of 20 ms^{-1}.

The Donelan/JONSWAP method gives the significant wave height, H_s, as a function of wind speed U and fetch length F:

$$H_s = U F^{0.5}/1760$$

where U is in ms^{-1}, and F is in metres. The significant wave height, H_s, is the average of the highest third of all waves.

In this case the fetch length is difficult to define as it depends on what location of the canal embankment we are considering. The fetch is taken across the reservoir only, as it is assumed that the primary tidal defence will remain sufficiently intact to prevent significant wave transmission. A reasonable value for fetch length was taken to be 1000m.

The 50-year significant wave height is therefore:

$$H_s = 20*1000^{0.5}/1760$$
$$= 0.36m$$

This is a best estimate, and the following sensitivity analysis shows deep water wave heights for a range of return periods:

Return period of wind speed (years)	Significant wave height (m)
5	0.28
10	0.31
20	0.34
50	0.36
100	0.37
200	0.39

These wave heights are deep water wave heights, assuming the waves are unaffected by bed friction, and are the highest that could be expected.

Shallow water effects

Waves generated in shallow water are lower than those generated in deep water, due to frictional losses at the bed. The US Shore Protection Manual (SPM) gives charts which can be used to estimate reduction factors for various water depth / wave conditions, and these show that for water depths greater than 1.5m there is no significant reduction from the deep water wave height. At shallower depths, wave heights generated by a given wind speed are lower due to higher bed friction. For example, a depth of 0.5m in the 'reservoir' results in a wave height of about 0.25m for the 50-year wind speed.

Conclusion

The relatively short fetch means that potential wave heights generated across the 'reservoir', in the event of a major failure of the main defence, are less than 0.4m.

3.5 Canal banks

General description

The general condition of the canal banks was inspected during a visit on 17 January 1996. The main findings are summarised below:

The Thames and Medway Canal is disused, but has water in it. The canal was built around 1834. It is contained within banks which are built up above the surrounding ground level. A road / footpath is provided on top of the northern bank, and there is a twin line railway on the southern bank. Both embankments are built to a similar level and to similar dimensions, except at the eastern end of the canal where the railway embankment is considerably wider. Over most of the length of interest, the crest width is about 3.5 - 4m, with side slopes estimated to be about 1:2.5.

Some additional data was available from a survey of the railway embankment carried out for Gravesham Borough Council (Hayes-Watkins, Hunt and Partners, 1993). This shows the slope of the southern canal bank to be generally shallower than 20°. The survey covers the western length of canal to just beyond Milton Rifle Range. It is not clear exactly what datum was used for height information, but the cross sections appear to show the canal water level to be about 2.4mOD, with a 'possible water level' some 200mm higher.

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The banks are well-vegetated. The road / footpath is tarmac at the western end, changing to concrete then gravel. The railway tracks are laid on ballast, thickness about 0.3m.

No signs of instability or major settlement were observed.

There are believed to be a number of culverts running beneath the canal draining the land to the south, but these were not clearly identified during the visit. They are evidently small in size.

There has been some discussion about the 1953 flood outline as represented in Allen, Price and Inglis, 1965. This shows the 'reservoir' of land to the north of the canal to be flooded. South of the canal, the only area of flooding is to the east of the track and the drain from Filborough to the canal (approximately 568200mE) see Figure 2 in Appendix A. The site visit revealed that this track is raised very slightly above the surrounding ground, by probably less than 1m. It is suggested that, following breaching of the main defence and flooding of the adjacent land (the 'reservoir'), water flowed through one or more of the drainage culverts beneath the canal, possibly near to Old King's Farm. The boundary of flooding near Filborough would indicate that the depth of flooding south of the canal was small, otherwise the flooding would have extended to the west of the track. This indicates a peak water level 2m or more *below* the peak level in the estuary, which was about 5.2mOD in 1953. This scenario illustrates the 'damping' effect of the combined system comprising the main defence breach, the 'reservoir', and the canal bank in protecting land south of the canal from catastrophic inundation.

3.6 Integration: assessment of the possibility of flooding

The crest level of the banks has not been surveyed in detail, but is approximately 4mOD. Based on the lower curve in Figure 4, this is equivalent to a return period of about 17,000 years. In other words, if it is assumed that the banks provide complete protection against flooding if the water level is below the crest level, but no protection if the water level is above the crest level, then the probability of inundation of the site is about 0.00006 yr^{-1}.

In view of the fact that the canal banks are not classified as flood defence structures, it may be prudent to assume a lower level of service. If an allowance of 1.0m is made, to account for any fissuring or other structural weakness, than the effective crest level becomes 3.0mOD, with an equivalent return period of 14,000 years and annual inundation probability of 0.00007.

4 Conclusions

This report gives an assessment of tidal flooding of a proposed development site in North East Gravesend, Kent.

The site is unusual in that, despite being at a low level relative to extreme tide levels, it is protected by an NRA flood defence it also lies to the south of a canal with raised banks which provide important additional protection against tidal flooding.

The site is protected by a main NRA embankment constructed in the late 70's and early 80s, as part of the Thames Tidal Flood defences. The minimum crest

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level of this defence is equivalent to a water level with a return period well in excess of 1000 years. We have considered the possible failure mechanisms of the main defence banks and associated probabilities to estimate the extreme water levels in the 'reservoir' bounded by the main defence and the Thames and Medway canal to the south. This illustrates the high level of protection provided by the main defence against catastrophic inundation of the 'reservoir'.

The development site lies to the south of the Thames and Medway Canal. This has banks which were presumably raised at the time that the canal was constructed. The additional level of protection provided for the site by the canal banks has been estimated from their crest levels which, allowing a safety factor of 1m below their crest level, indicates an equivalent return period of 14000 years and an annual inundation probability of 0.00007.

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5 References

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Figures

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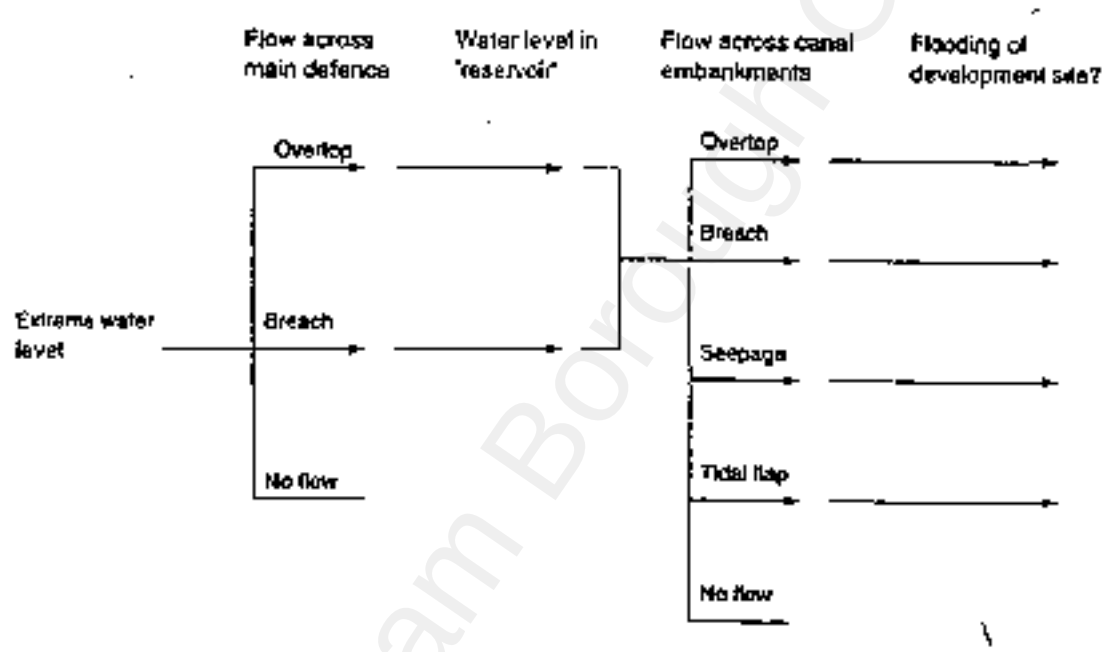
Figure 1 Plan of site



'igure 2 'Event tree' for tidal flooding

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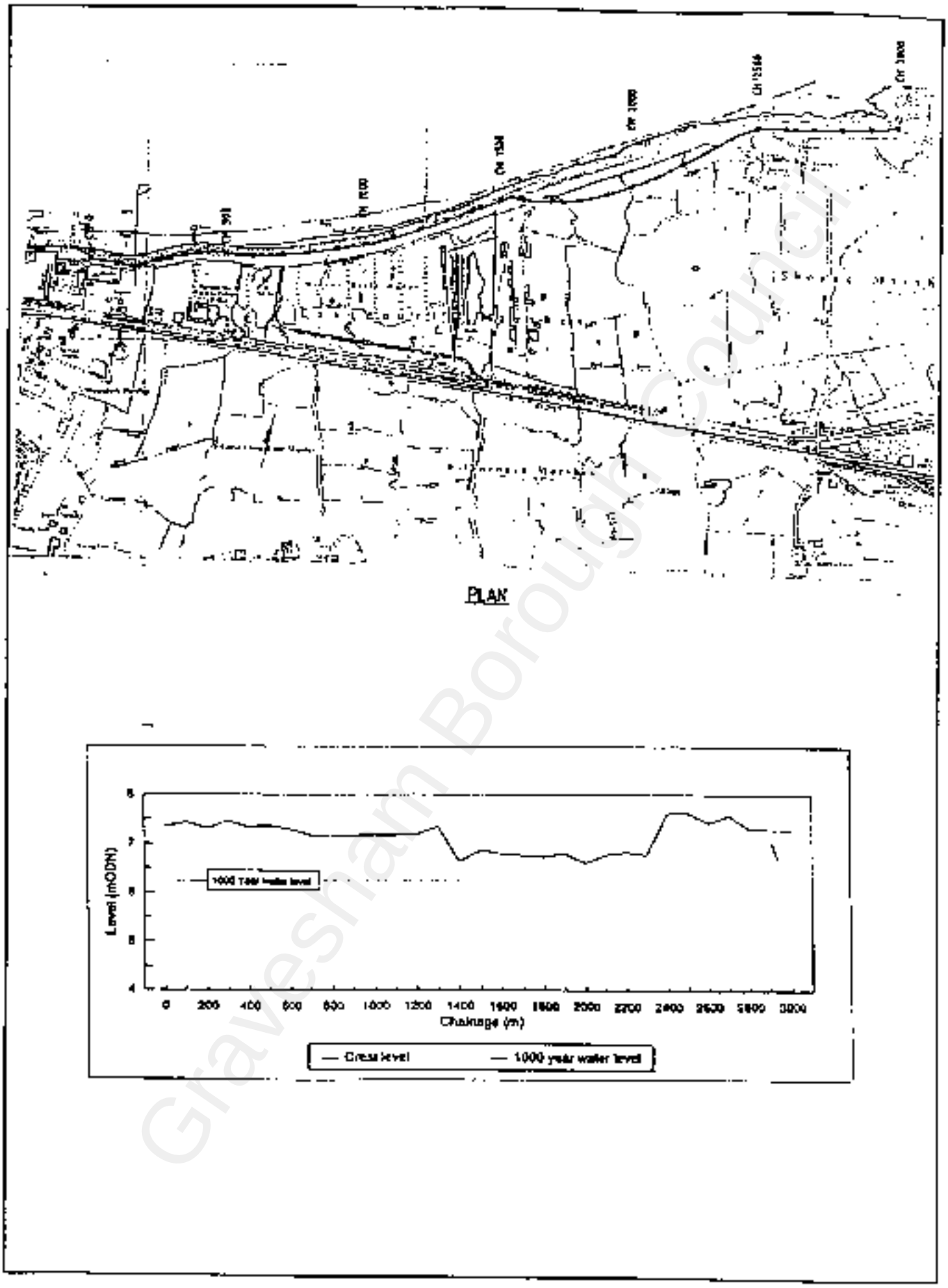

Figure 3 Longitudinal profile of main defence crest level

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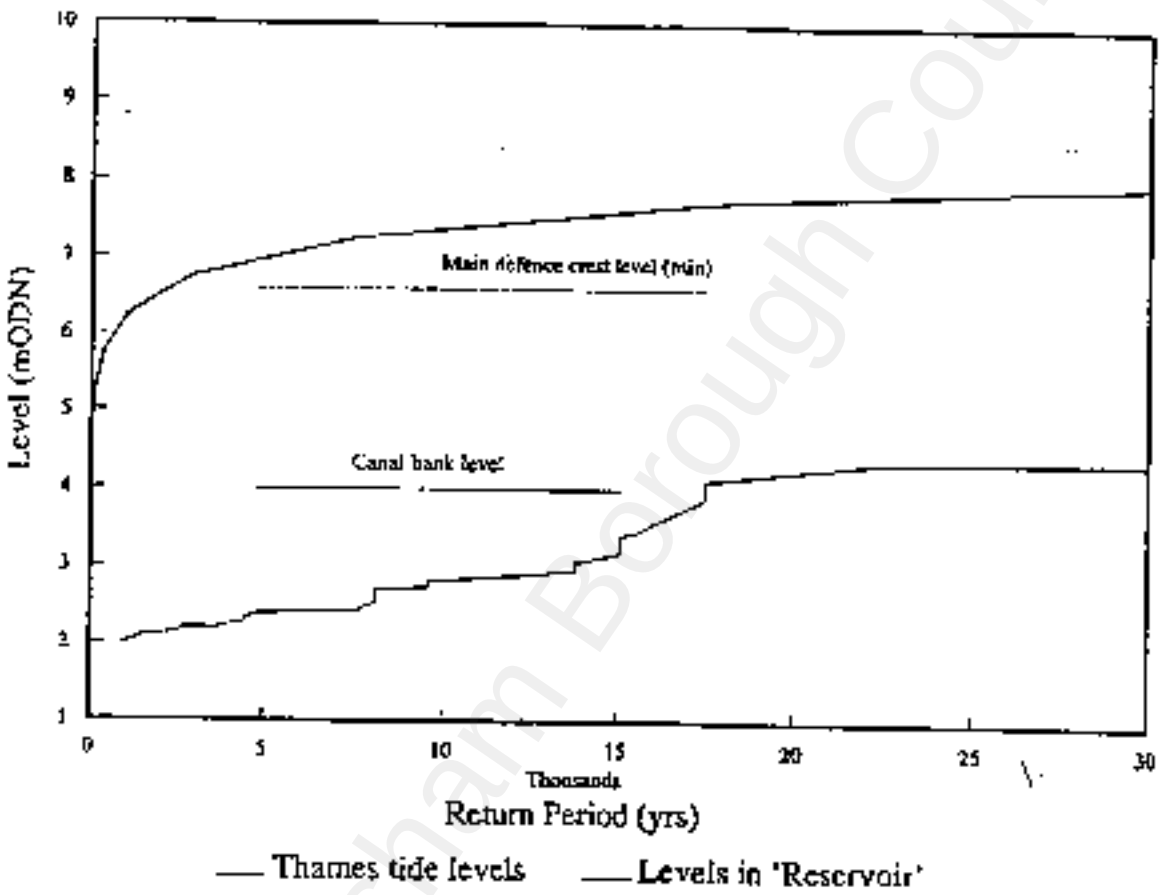

.gure 4 Extreme tidal levels and predicted extreme water levels in 'reservoir' to north of site

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Appendices

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Appendix A

Assessment of tidal flooding at North East Gravesend for Fort Knight Group plc and Kent County Council.
HR Wallingford, September 1995

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Appendix A *Assessment of tidal flooding at North East Gravesend for Fort Knight Group plc and Kent County Council, HR Wallingford, September 1995*

Assessment of tidal flooding at

north-east Gravesend for

Fort Knight Group plc and

Kent County Council

September 1995

Gravesham Borough Council

Address and Registered Office: HR Wallingford Ltd, Howbery Park, Wallingford, Oxon OX10 8BA, UK
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This assessment has been carried out

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Mr K Mann of HR Wallingford

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ASSESSMENT OF TIDAL FLOODING AT NORTH EAST GRAVESEND, KENT

This assessment refers to the area of land shown in Fig 1 outlined in pink which encompasses part of Westcourt Marshes and Great Clane Lane Marshes. This area is referred to as "the site".

The objective of this assessment is to determine the likelihood of this area flooding as a result of failure of the river defence bank along the River Thames at Gravesend. The likelihood of the site flooding as a result of managed-retreat or set-back further down river may be discounted because this will only be carried out in areas where the natural contours limit the amount of inundation by the tide to particular, specified areas. The area immediately landward of the river defence bank at Gravesend contains light industrial development and would not be considered for managed-retreat. The NRA has a duty, defined in the Water Resources Act 1991, "to provide effective flood defence" and as such keep the bank properly maintained. Thus, the flood defence bank, which was raised after the 1953 tidal surge to provide protection from a 1:1000 year surge provides protection for the site from tidal inundation.

The level of the 1:1000 year return period water level at Tilbury is 6.23m OD (HR Wallingford estimate based on paper by Coles and Tawn, Ref 1). We understand that the sea defence bank level at Gravesend has a crest level of between 6.5m OD and 7.2m OD.

If the flood defence bank is "properly maintained" it should not fail except in extraordinary

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circumstances eg vessel collision or an act of war. Both of these are extremely unlikely.

It is noted that the site is in an area of "conjectural" flooding on the local authority flooding map. Conjectural flooding areas are those areas of land that could be theoretically flooded if there were no sea or tidal defences and a 1:1000 year surge tide occurred. These areas are simply the landward limit of the relevant contour of the 1:1000 year level ie about 6.2 or 6.3m OD in this case. Whether this area would actually be flooded in the event of a breach of the tidal defence bank may be a very different matter. In this case the "site" did not flood in 1953 as indicated in Fig 2 which shows the areas flooded as hatched and the site outlined in pink. Although the surge level in 1953 was well below that of the 1:1000 year return period it is clear that the railway embankment to the north of the site provided complete protection for the site. How much protection would it provide for a 1:1000 year tidal surge?

Examination of OS 1:25,000 maps of the area indicated that, subject to flapping of culverts under the railway embankment, the area between the river defence bank and the railway embankment acts as a"reservoir" for spill from any breaches in the river bank. Only when this "reservoir" is filled would water begin to reach the site. The level of the top of the railway embankment is about 4.2m OD.

The area covered by the "reservoir" for this assessment has been estimated from OS 1:25,000 maps as the area between the river flood bank and the railway embankment between 564000m E and the old quarry at West Court at 573000m E. This gives an area of 7.05 x

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$10^6 m^2$ and, assuming a ground level of 2m OD, the volume of the reservoir up to 4 m OD ≈ $14.1 \times 10^6 m^3$.

The limits were defined by either a river defence bank or the 25ft (7.62m OD) contour on the assumption that they will not be transgressed by the 1:1000 year level.

For an assessment of the likelihood of the reservoir filling and causing overtopping on to the site we have considered hypothetical breaches in the river flood defence bank. That is, we assume that the river bank will not be overtopped as its crest is at 6.5 - 7.2m OD. The dimensions of the breaches have been obtained from a paper by Allen, Price and Inglis (1955) which indicates that breaches in the bank in 1953 "were typically 60ft long and 6ft deep" for one of the larger breaches. In metric units this is 18.3m x 1.8m. Almost all the breaches occurred at HW or afterwards. In the first instance we consider one such breach.

If we assume that the breach occurred at HW we need to know the duration of flow through the breach to estimate the volume of water passing into the "reservoir" during the surge.

Assuming the bank level is 6.2m OD (it is actually a little higher at 6.5 - 7.2m OD) the invert level of a 2m (6ft) breach would be about 4.2m (13.8ft).

Fig 7 in Allen et al (see Fig 3 attached) shows tidal levels at Tilbury for the 1953 flood to which has been added a curve for a conjectured 1:1000 year surge. This curve has its peak taken

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from Fig 9 of EX 479/A (Ref 3) which shows simulated peak levels along the estuary for several hypothetical scenarios one of which is the 1953 surge + 4ft (1.22m) at Southend which yields a peak water level at Tilbury of 6.28m (20.6ft) which is practically identical to the 1:1000 year surge level at Tilbury of 6.23m OD.

Using this conjectured curve the tidal level would be above the breach invert (13.8ft or 4.2m) for about 2½ hours after HW.

Calculations, which were based on the broad crested weir equation with modular flow, were then made for various scenarios and the results shown in Table 1. We have covered a range of possible scenarios ranging from a single typical breach up to 30 breaches in the river defence bank at Gravesend. In 1953 we understand that there was one breach in this immediate reach.

Table 1 shows the estimated rise in the "reservoir" over the first HW period for a single breach and up to 30 such breaches. These results indicate that for a 1:1000 year flood, if there was only one breach, the level in "reservoir" would be only 6cm deep over the first HW period and it would require 30 such breaches to fill it by 1.80m in this period. Quite clearly the 1953 flood would not have overtopped the railway embankment which is why the site remained dry.

We have also estimated the total volume of water that would pass through one such breach over three successive high water periods (similar to those in 1953) for a 1:1000 year event if

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the breach were not repaired. This volume would raise the level in the reservoir by only about 14cm or 6 inches ie well below the railway embankment level. On subsequent tides the tide level in the river would not have reached the invert of the breach.

Conclusions

The "site" is protected from tidal flooding by the Thames river defence bank with a crest level of 6.5 - 7.2m OD and properly maintained it will protect the "site" from tidal flooding up to a level of the 1:1000 year flood. Should the bank fail, and "breaches" (as specified earlier) occur in the river defence bank, it will take more than 30 to fill the "reservoir" by 180cm (1.80m) ie still below the crest of railway embankment.

An estimate of the quantity of water that would pass through a typical breach over three successive high water periods following the breach such as those that occurred in 1953, following a 1:1000 year surge, indicates that the level in the "reservoir" would be raised by only about 14cm or 6 inches.

Bearing in mind the several assumptions made in the calculations this assessment has indicated that the "site" would not flood in the event of a "typical" breach of the river defence bank at Gravesend in a 1:1000 year flood event in the River Thames.

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3. Hydraulics Research Station, Thames Estuary Flood Prevention Investigation. First report on hydraulic model studies, January-September 1969. Report EX 479/A October 1969.

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Table 1

Estimated Effects of 1:1000 year Flood in "Reservoir" Area Between the River Defence Bank and the Railway Embankment

No. of breaches in the river defence bank	1	2	5	10	20	30
Rise in "reservoir" whilst tide above breach invert (cm) 1st HW only	6	12	30	60	120	180

Notes:

1. Plan area of "reservoir" 7.05 x $10^6 m^2$ (estimated)
2. Allowable rise in "reservoir" +2 to +4m OD say = 2m (estimated) ∴ capacity of reservoir = 14.1 x $10^6 m^3$.
3. Breach size – 18.3m x 1.83 (60ft x 6ft)

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Figures

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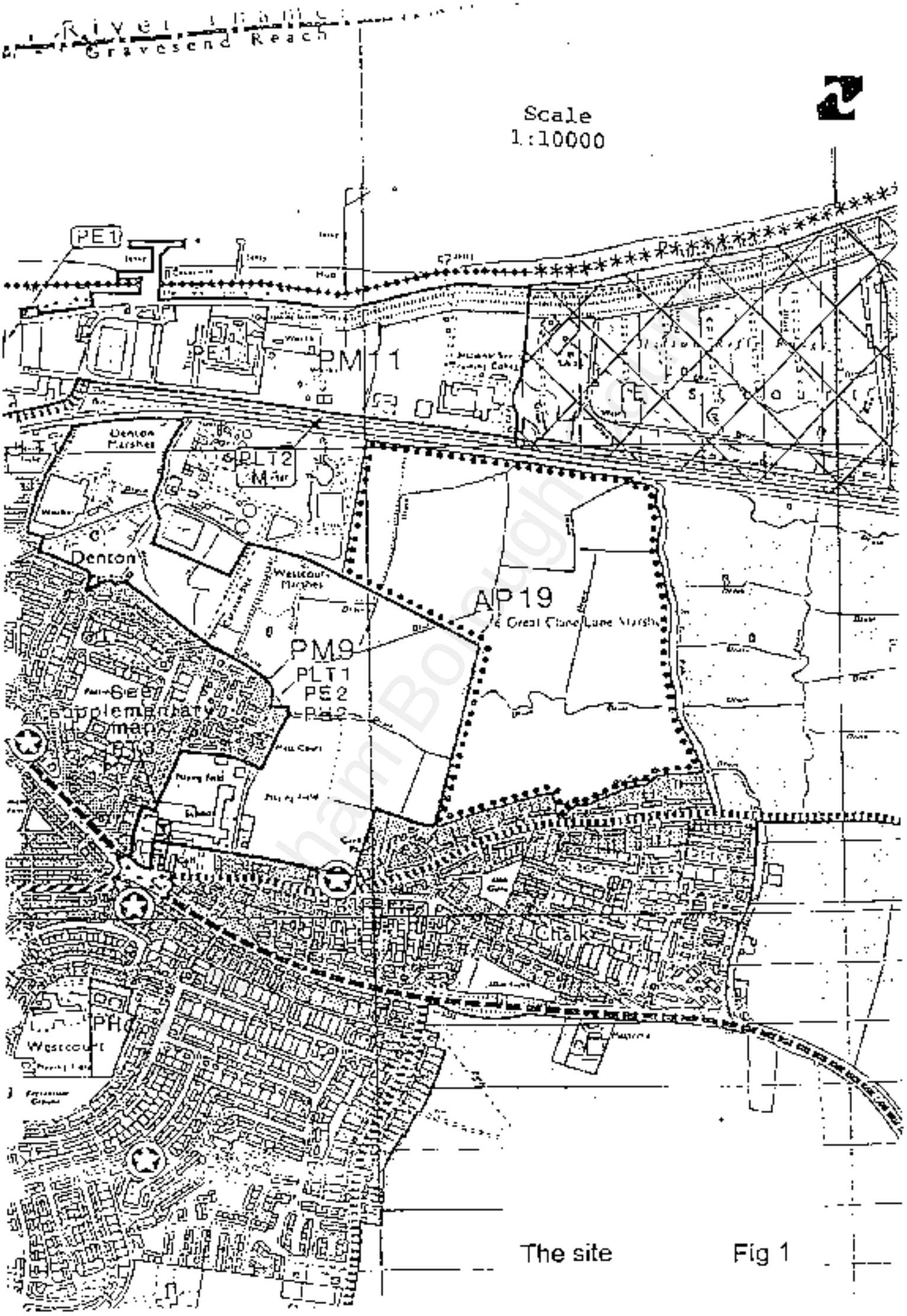

The site Fig 1

Estimated 1:1000 year surge at Tilbury

Fig 3

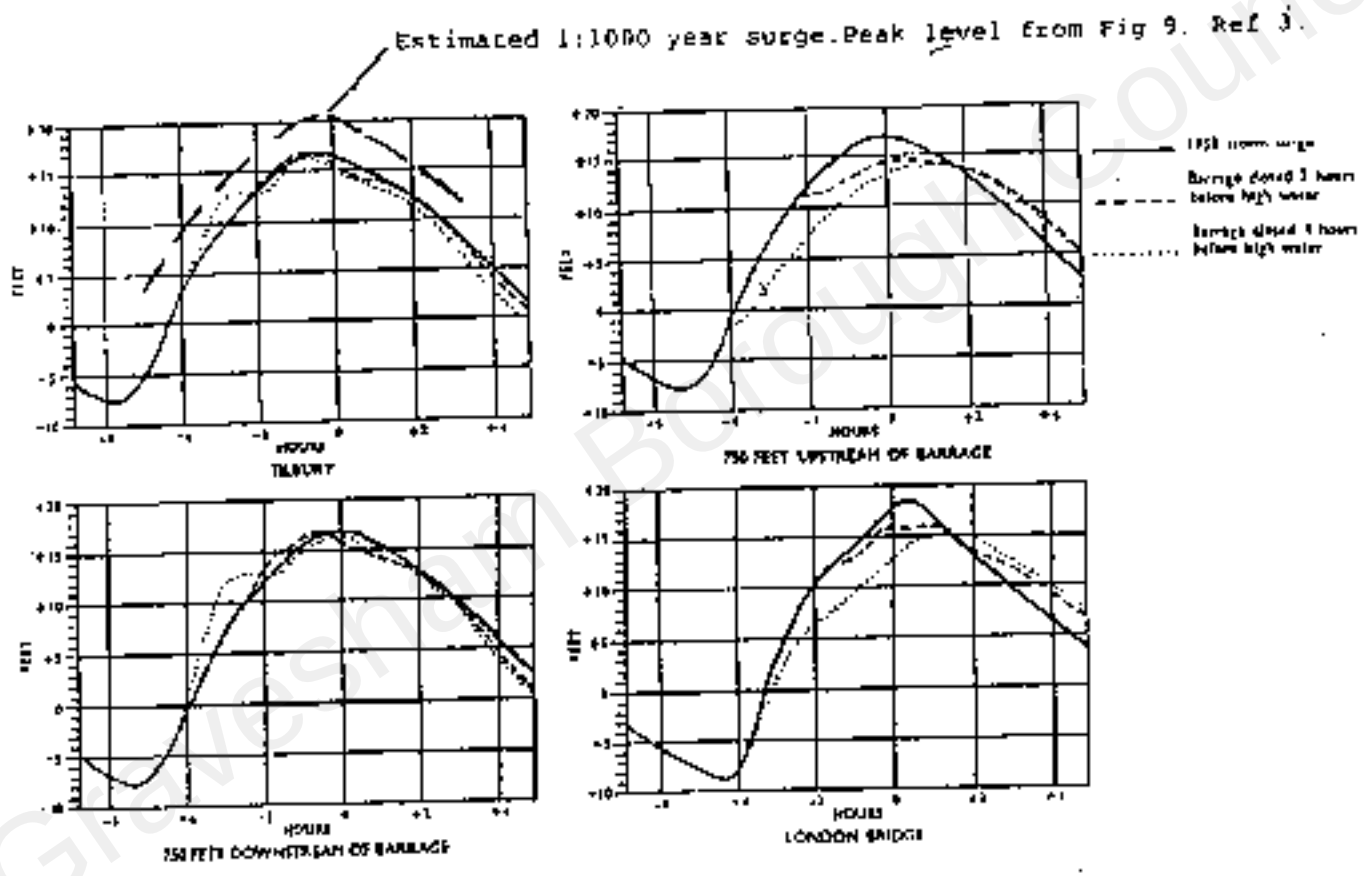

FIG. 7.—CURVES SHOWING THE EFFECT OF CLOSING A SURGE-REDUCING BARRAGE IN LONG REACH ON WATER LEVELS UPSTREAM AND DOWNSTREAM (barrage closure: 80 per cent of mean tide cross-section)

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Appendix G

Public Sewer Record Plans

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Figures

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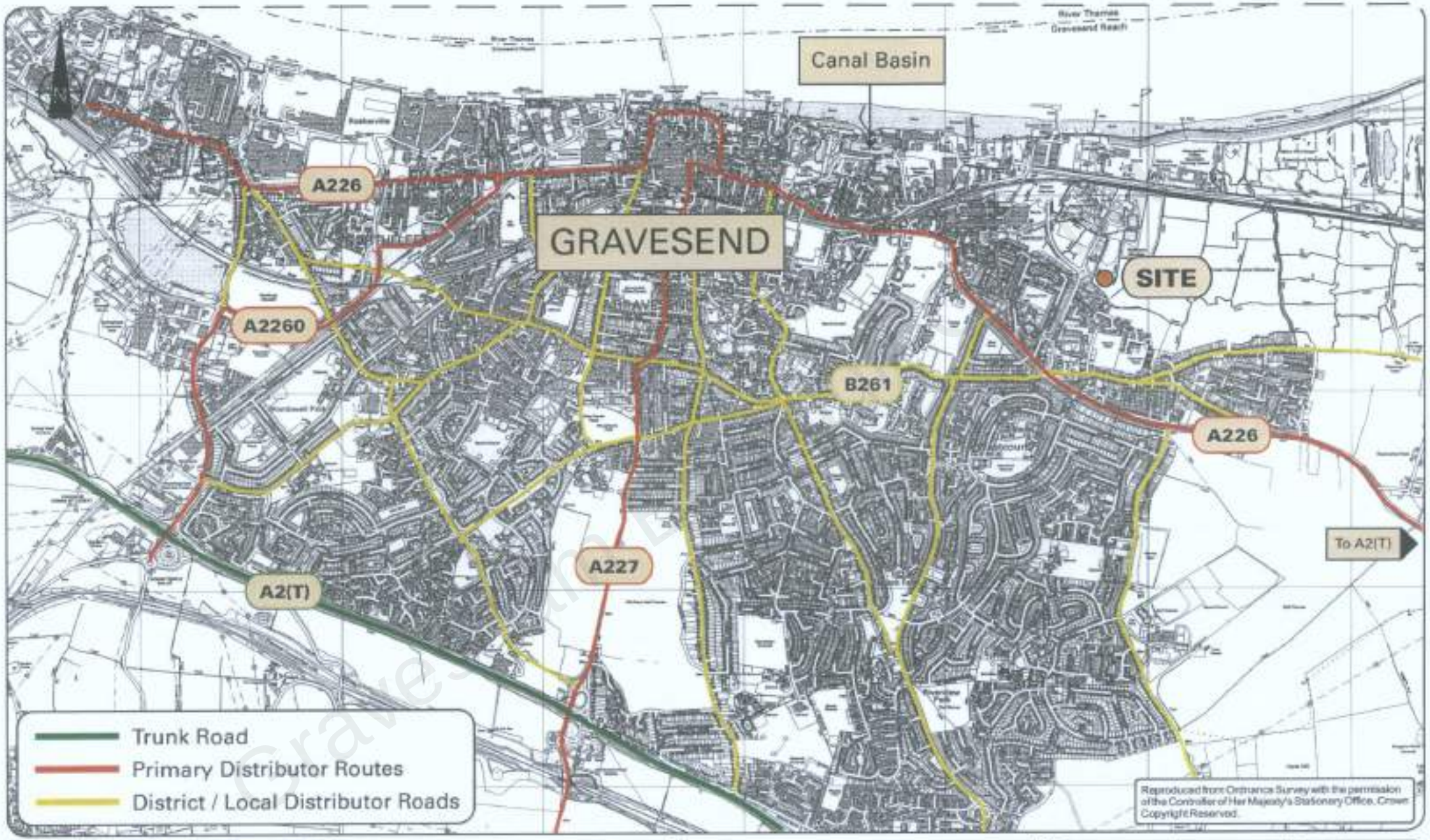

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Project Title: Dering Way Phase IIIa Planning	Client: Barratt Eastern Counties		
Drawing Title: Site Location Plan			
Scale: NTS	Date: 11/08/05	Designed: ML	
Drawn: AB	Checked: ML	Approved: ML	
Drawing No: B140-01 (FIG. 1)			Rev:

Drawings

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Flood areas on 1.2.53 from paper by Allen, Price and Inglis, Institution of Civil Engineers 1953.

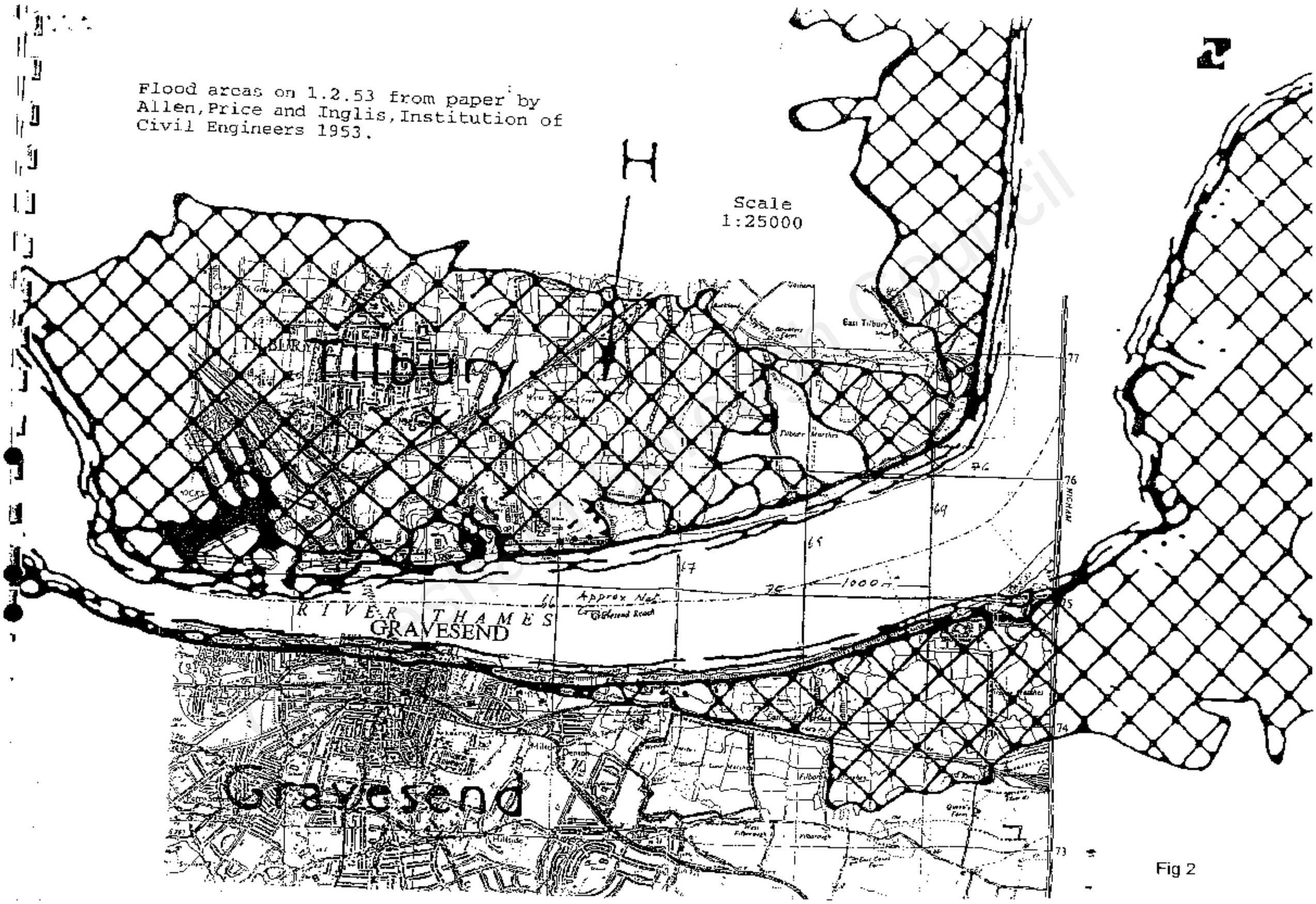
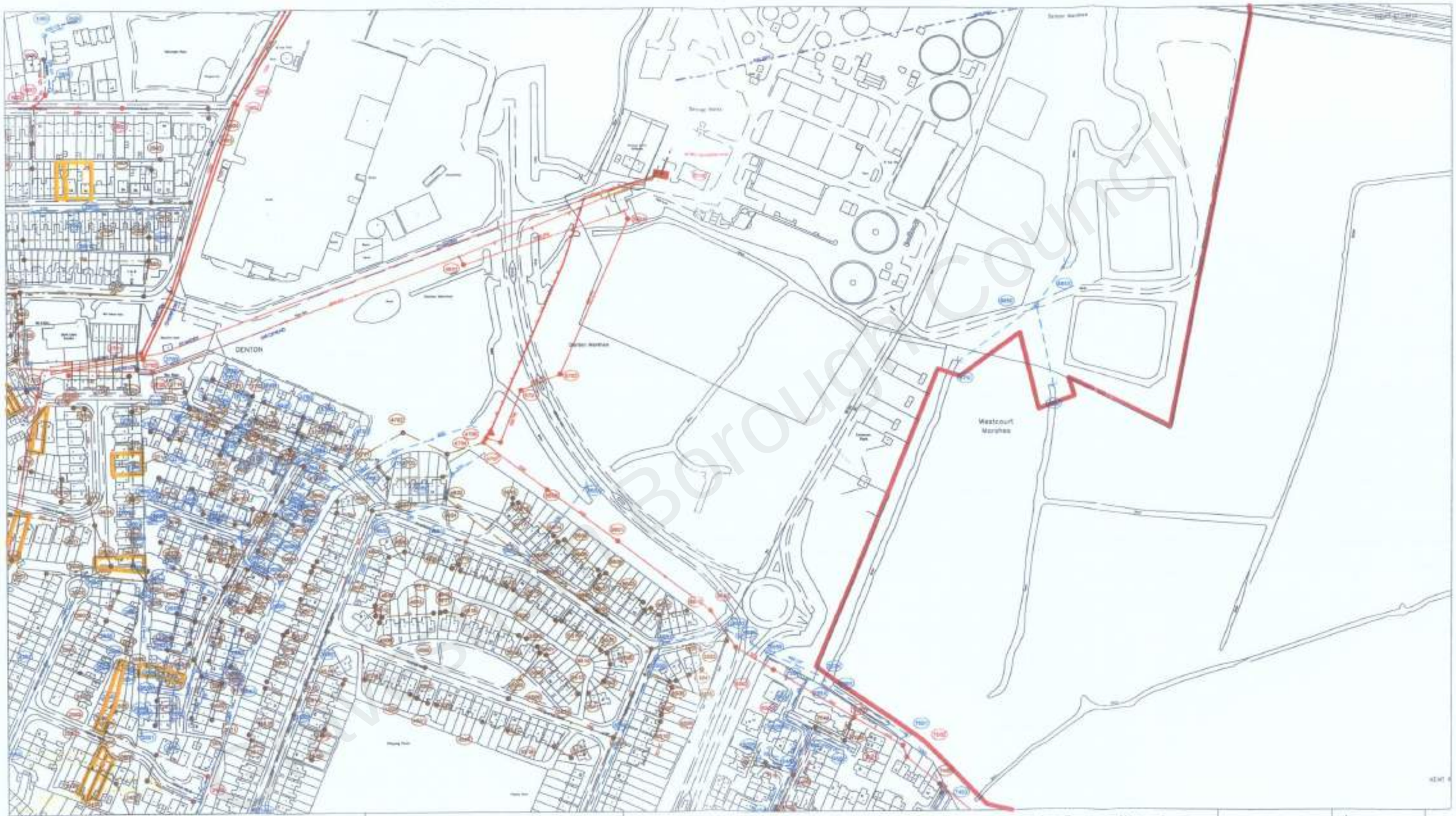


Fig 2

SEWER RECORDS PAGE 1 OF 2



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566167

567134

O.S. REF. TQ6673NE	Drawn by: sewer	The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy. The actual positions should be determnined on site. WARNING: FHC pipes are constructed of Bonded Asbestos Cement WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement
	Scale: 1:2500	
Title: MD GRAVESEND	Date: 01-08-2005	Based upon Ordnance Survey Digital Data with the permission of the controller of H.M.S.O. Crown Copyright Reserved Licence No. WU 298530.

Southern Water

N

SEWER RECORDS - PAGE 2 OF 2

	Cover	Invert	Size	Material	Shape
0X	3.414	1.55	525	CP	CIRC
03X	5.524	3.894	225	UNK	CIRC
604X	8.63	5.15	150	UNK	CIRC
1607X	5.35	2.99	225	UNK	CIRC
1707X	7.084	5.794	225	UNK	CIRC
1708X	7.074	5.604	OTHER	BRC	CIRC
1711X	8.38	7.8	UNK	UNK	CIRC
1712X	7.692	6.762	UNK	UNK	CIRC
1801X	4.645	3.355	150	UNK	CIRC
1802X	6.106	4.855	150	UNK	CIRC
1803X	7.141	5.901	UNK	UNK	CIRC
1804X	7.056	3.606	150	UNK	CIRC
1805X	5.981	3.871	150	UNK	CIRC
1850X	4.556	3.376	225	UNK	CIRC
1902X	3.247	0.637	225	UNK	CIRC
1903X	3.481	0.891	225	UNK	CIRC
1905X	3.697	1.017	225	UNK	CIRC
1906X	3.449	1.22	150	VC	CIRC
1907X	3.135	1.04	150	VC	CIRC
1950X	3.205	1.33	150	VC	CIRC
2050X	3.404	1.59	525	CP	CIRC
2406X	3.408	1.908	225	UNK	CIRC
2407X	4.066	3.212	100	UNK	CIRC
2408X	3.807	2.617	150	UNK	CIRC
2501X	4.011	3.021	150	UNK	CIRC
2502X	3.413	1.793	225	UNK	CIRC
25	3.453	1.743	225	UNK	CIRC
25	3.309	1.699	225	UNK	CIRC
2506X	3.434	2.374	150	UNK	CIRC
2508X	3.384	2.164	UNK	UNK	CIRC
2509X	3.241	1.701	150	UNK	CIRC
2510X	3.166	1.946	100	UNK	CIRC
2511X	3.392	2.102	100	UNK	CIRC
2512X	3.361	1.641	150	UNK	CIRC
2513X	3.223	1.573	150	UNK	CIRC
2514X	3.276	1.708	100	UNK	CIRC
2515X	3.269	1.379	150	UNK	CIRC
2601X	3.62	2.06	225	UNK	CIRC
2602X	3.577	1.867	225	UNK	CIRC
2604X	3.062	2.042	100	UNK	CIRC
2605X	3.212	1.912	100	UNK	CIRC
2608X	3.242	1.142	225	UNK	CIRC
2611X	5.198	2.898	150	UNK	CIRC
2614X	5.11	3.11	150	UNK	CIRC
2616X	3.147	1.917	UNK	UNK	CIRC
2617X	3.09	2.13	100	UNK	CIRC
2618X	3	2.21	100	UNK	CIRC
2702X	6.342	5.352	100	UNK	CIRC
2705X			900	ST	CIRC
2706X	4.6	3.48	150	UNK	CIRC
2708X	6.175	5.045	100	UNK	CIRC
2711X	3.234	2.214	150	UNK	CIRC
2712X	3.063	1.339	UNK	UNK	CIRC
27	3.196	1.936	100	UNK	CIRC
271	98	92.75	150	VC	CIRC
2715X	98	92	150	VC	CIRC
2801X	3.6	1.76	225	UNK	CIRC
2802X	3.266	1.916	225	UNK	CIRC
2803X	3.281	2.001	225	UNK	CIRC
2804X	3.761	2.221	225	UNK	CIRC
2805X	4.101	2.361	225	UNK	CIRC
2806X	3.72	2.46	225	UNK	CIRC
2851X	4.138	3.148	225	UNK	CIRC
2852X	3.763	2.973	150	UNK	CIRC
2853X	3.718	2.948	150	UNK	CIRC

Node	Cover	Invert	Size	Material	Shape
2902X	3.279	1.009	225	UNK	CIRC
3403X	4.067	3.207	150	UNK	CIRC
3501X	3.268	2.118	100	UNK	CIRC
3503X	3.233	2.333	100	UNK	CIRC
3509X	4.487	3.847	100	UNK	CIRC
3511X	4.617	3.977	UNK	UNK	CIRC
3513X	4.565	1.655	225	UNK	CIRC
3515X	5.519	4.199	150	UNK	CIRC
3516X	4.64	2.07	225	UNK	CIRC
3601X	4.473	3.313	150	UNK	CIRC
3602X	4.219	2.859	150	UNK	CIRC
3604X	3.931	2.971	150	UNK	CIRC
3605X	3.588	2.358	150	UNK	CIRC
3606X	3.417	2.577	150	UNK	CIRC
3607X	3.033	1.983	100	UNK	CIRC
3608X	2.984	1.454	100	UNK	CIRC
3609X	3.042	0.992	150	UNK	CIRC
3610X	2.922	0.862	150	UNK	CIRC
3611X	3.068	1.848	100	UNK	CIRC
3612X	2.913	1.723	150	UNK	CIRC
3614X	3.021	1.861	150	UNK	CIRC
3615X	3.069	1.499	UNK	UNK	CIRC
3618X	3.225	1.036	150	UNK	CIRC
3620X	3.042	2.082	100	UNK	CIRC
3621X	3.243	1.893	100	UNK	CIRC
3622X	3.23	1.13	225	UNK	CIRC
3623X	3.012	1.432	150	UNK	CIRC
3702X	2.999	1.529	UNK	UNK	CIRC
3703X	3.03	1.32	150	UNK	CIRC
3704X	2.918	0.978	150	UNK	CIRC
3705X	3.059	1.339	UNK	UNK	CIRC
3708X	2.979	1.419	150	UNK	CIRC
3709X	2.947	1.117	UNK	UNK	CIRC
3711X	2.948	0.778	150	UNK	CIRC
3712X	2.959	0.579	UNK	UNK	CIRC
3714X	3.05	1.27	150	UNK	CIRC
3715X	2.99	0.91	150	UNK	CIRC
3716X	3.012	0.752	150	UNK	CIRC
3718X	3.088	1.738	100	UNK	CIRC
3903X	3.217	1.277	225	UNK	CIRC
3904X	3.387	2.377	150	UNK	CIRC
4502X	5.849	5.019	150	UNK	CIRC
4503X	5.539	4.979	UNK	UNK	CIRC
4505X	5.724	3.384	150	UNK	CIRC
4506X	6.28	5.69	150	UNK	CIRC
4507X	6.252	5.182	UNK	UNK	CIRC
4601X	3.499	2.329	UNK	UNK	CIRC
4602X	3.816	0.956	225	UNK	CIRC
4603X	3.747	2.887	150	UNK	CIRC
4604X	3.886	0.636	225	UNK	CIRC
4605X	5.12	4	UNK	UNK	CIRC
4611X	4.265	3.255	150	UNK	CIRC
4612X	5.499	4.399	150	UNK	CIRC
4615X	5.603	4.443	UNK	UNK	CIRC
4704X	2.807	0.157	UNK	UNK	CIRC *
4704X	2.807	0.2	450	UNK	CIRC *
4706X	2.8	0.103	OTHER	PE	CIRC
4707X	2.75	0.046	OTHER	PE	CIRC
470PX			300	UNK	CIRC *
470PX			450	UNK	CIRC *
4801X	2.8	-0.25	1000	PE	CIRC
480ZX			1000	PE	CIRC
5504X	5.538	4.858	150	UNK	CIRC
5505X	5.529	4.689	150	UNK	CIRC
5506X	6.001	4.051	150	UNK	CIRC

Node	Cover	Invert	Size	Material	Shape
5507X	5.478	2.756	150	UNK	CIRC
5508X	3.467	1.487	225	UNK	CIRC
5511X	4.998	3.668	150	UNK	CIRC
5512X	4.247	3.407	150	UNK	CIRC
5514X	3.776	2.916	150	UNK	CIRC
5517X	5.873	5.263	UNK	UNK	CIRC
5519X	6.021	4.041	UNK	UNK	CIRC
5603X	3.361	2.341	150	UNK	CIRC
5604X	3.418	2.288	150	UNK	CIRC
5606X	3.485	2.255	150	UNK	CIRC
5607X	3.478	2.088	150	UNK	CIRC
5608X	3.658	2.928	UNK	UNK	CIRC
5611X	3.699	1.039	225	UNK	CIRC
5613X	4.269	3.649	150	UNK	CIRC
5615X	3.691	2.291	UNK	UNK	CIRC
5616X	3.71	2.31	150	UNK	CIRC
5617X	3.666	2.236	150	UNK	CIRC
5701X	2.2	-0.12	OTHER	PE	CIRC
5702X	2.18	-0.5	OTHER	PE	CIRC
5801X	2.21	-0.929	OTHER	PE	CIRC
6405X	4.931	2.269	225	VC	CIRC
6406X	4.251	2.015	225	VC	CIRC
6454X	5.1	2.669	450	CP	CIRC
6455X	4.26	2.479	450	CP	CIRC
6501X	3.02	0.88	375	UNK	CIRC
6502X	3.305	0.865	375	UNK	CIRC
6503X	3.632	2.082	225	UNK	CIRC
6504X	3.504	2.934	150	UNK	CIRC
6505X	3.682	2.812	150	UNK	CIRC
6506X	3.792	2.812	150	UNK	CIRC
6509X	4.459	3.819	UNK	UNK	CIRC
6511X	4.384	2.478	150	VC	CIRC
6553X			UNK	UNK	CIRC
6555X		3.004	225	VC	CIRC
6556X	3.92	2.14	600	CP	CIRC
6557X		2.007	600	CP	CIRC
6558X	4	2.073	450	CP	CIRC
6601X	3.34	2.51	150	UNK	CIRC
7406X	4.572	2.685	225	VC	CIRC
7503X	3.951	1.991	375	UNK	CIRC
7504X	4.008	1.696	225	VC	CIRC
7505X		1.459	225	VC	CIRC
7552X	3.9	2.828	225	VC	CIRC
7553X	3.92	2.315	600	CP	CIRC

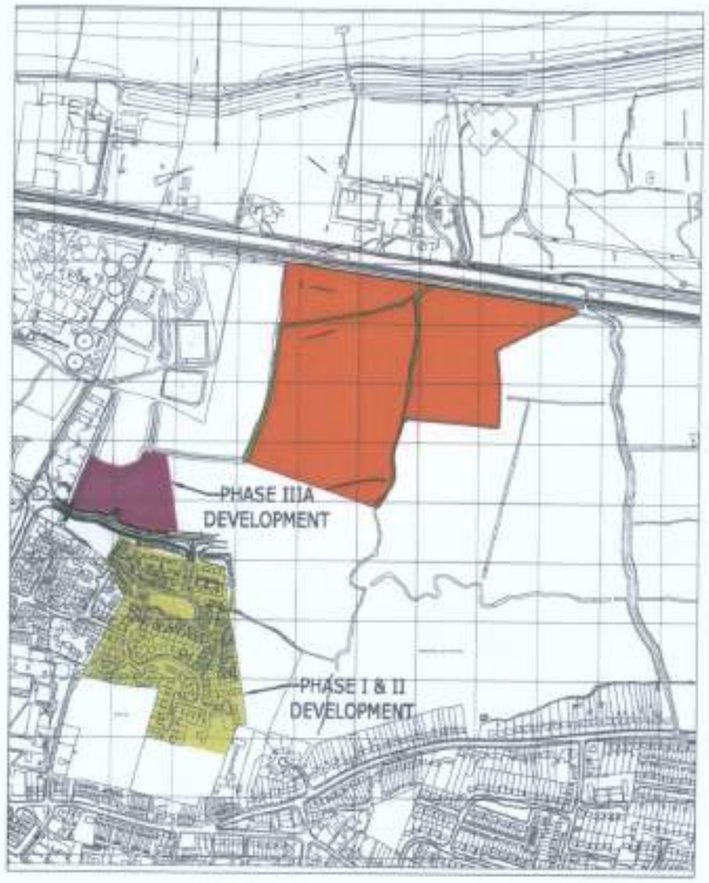
Node	Cover	Invert	Size	Material	Shape

Drawn by: sewer

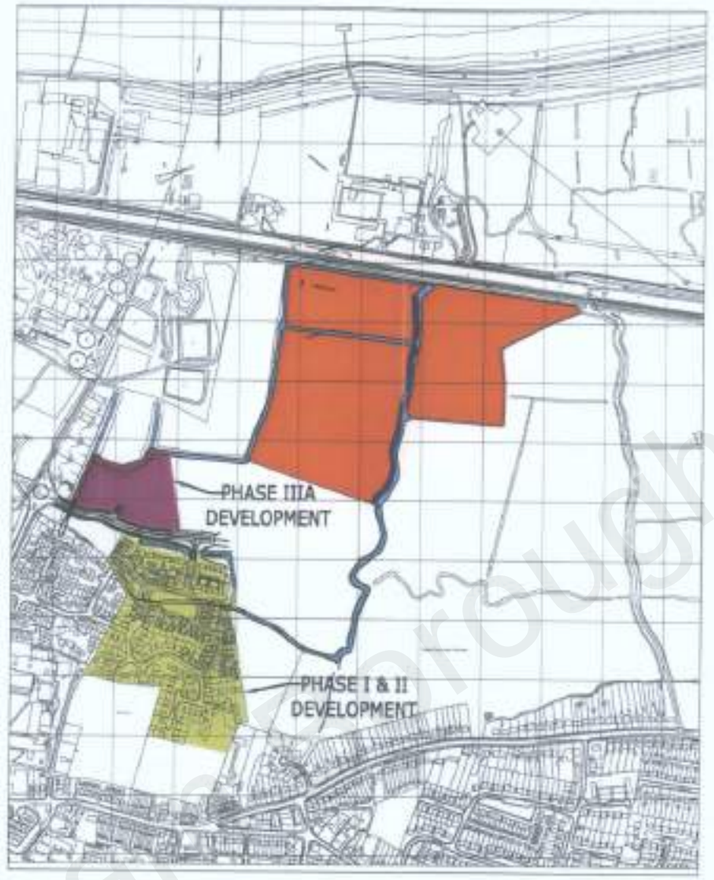
Date : 01-08-2005

Title : MD GRAVESEND

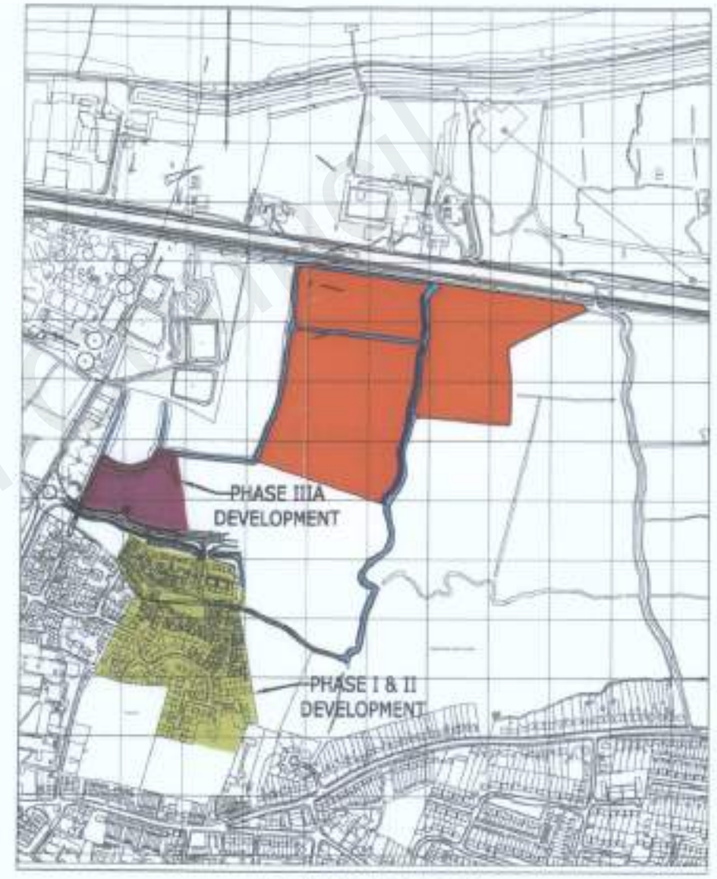
Gravesham Borough Council



ORIGINAL WATERCOURSE LAYOUT



PRESENT WATERCOURSE LAYOUT
(PHASE II DEVELOPMENT)



FUTURE PROPOSED
WATERCOURSE LAYOUT
(PHASE IIIa DEVELOPMENT)

KEY

- ORIGINAL WATERCOURSES
- PRESENT WATERCOURSES
- WATERCOURSE WIDENING
- SITE OF SPECIAL SCIENTIFIC INTEREST (SSSI)

DRAFT -
FOR DISCUSSION ONLY

REV.	AMENDMENTS	DRN	CHK	APP	DATE

ARDENT
CONSULTING ENGINEERS
4th Floor, Diamond House, 36/38 Hatton Garden, London, EC1N 8EB
t 020 7430 1209 f 020 7430 0318
w www.ardent-ce.co.uk e enquiries@ardent-ce.co.uk

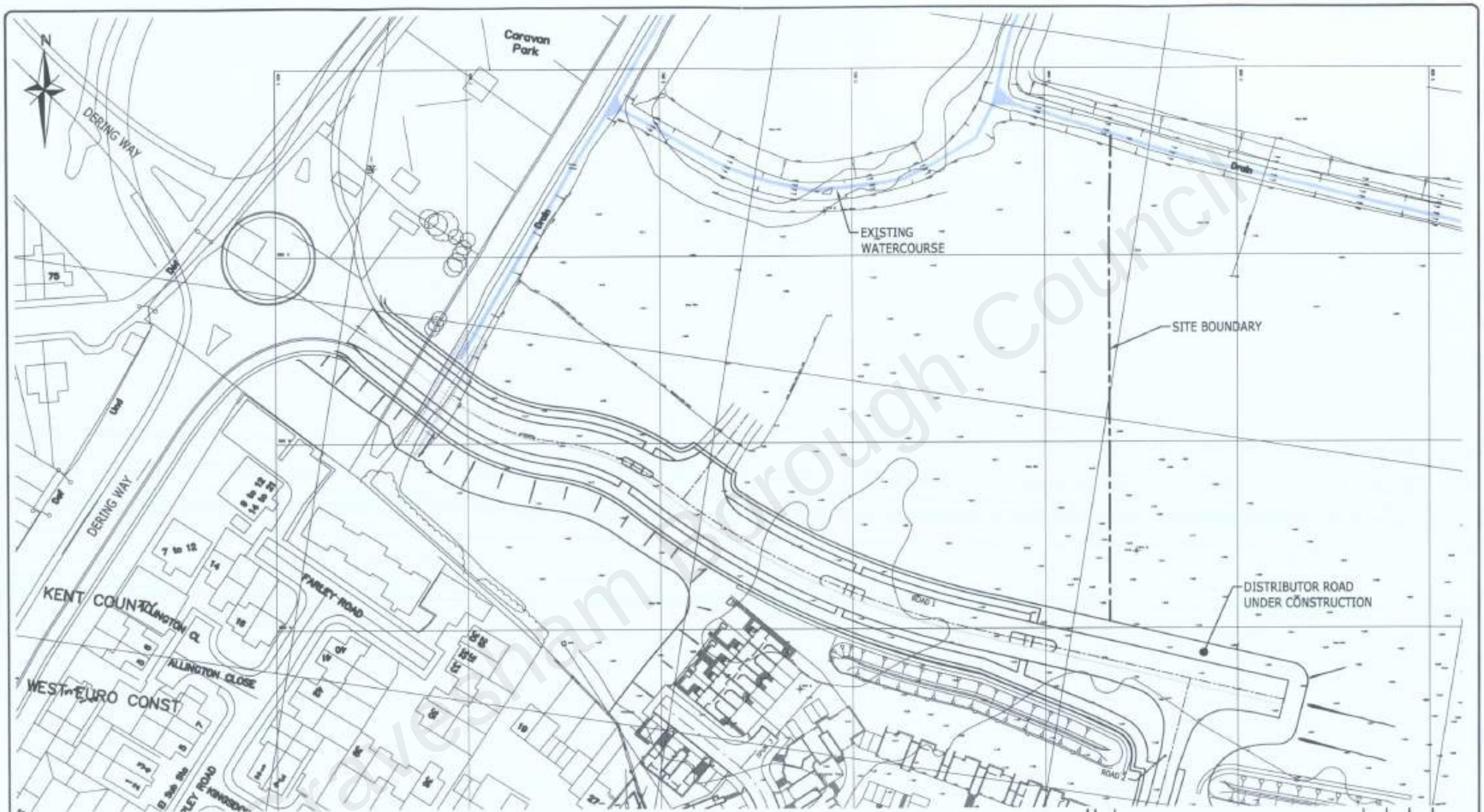
PROJECT TITLE: DERING WAY PHASE IIIa PLANNING

DRAWING TITLE: EXISTING WATERCOURSES & PHASE II/IIIa WATERCOURSE MODIFICATIONS

CLIENT: BARRATT EASTERN COUNTIES

SCALE:	DATE:	DESIGNED:
1:10000	NOV 2005	SJB
DRAWN: ARB	CHECKED: SJB	APPROVED:
DRAWING NO. B140-009 (FIG. 3)		REV:

Gravesham Borough Council



REV	AMENDMENTS	DRN	CHK	APP	DATE
A	BOUNDARY UPDATED	RMA	SJB		10/07/07

ARDENT
CONSULTING ENGINEERS
4th Floor, Diamond House, 36/38 Hatton Garden, London, EC1N 8EB
t 020 7430 1209 f 020 7430 0318
w www.ardent-ce.co.uk e enquiries@ardent-ce.co.uk

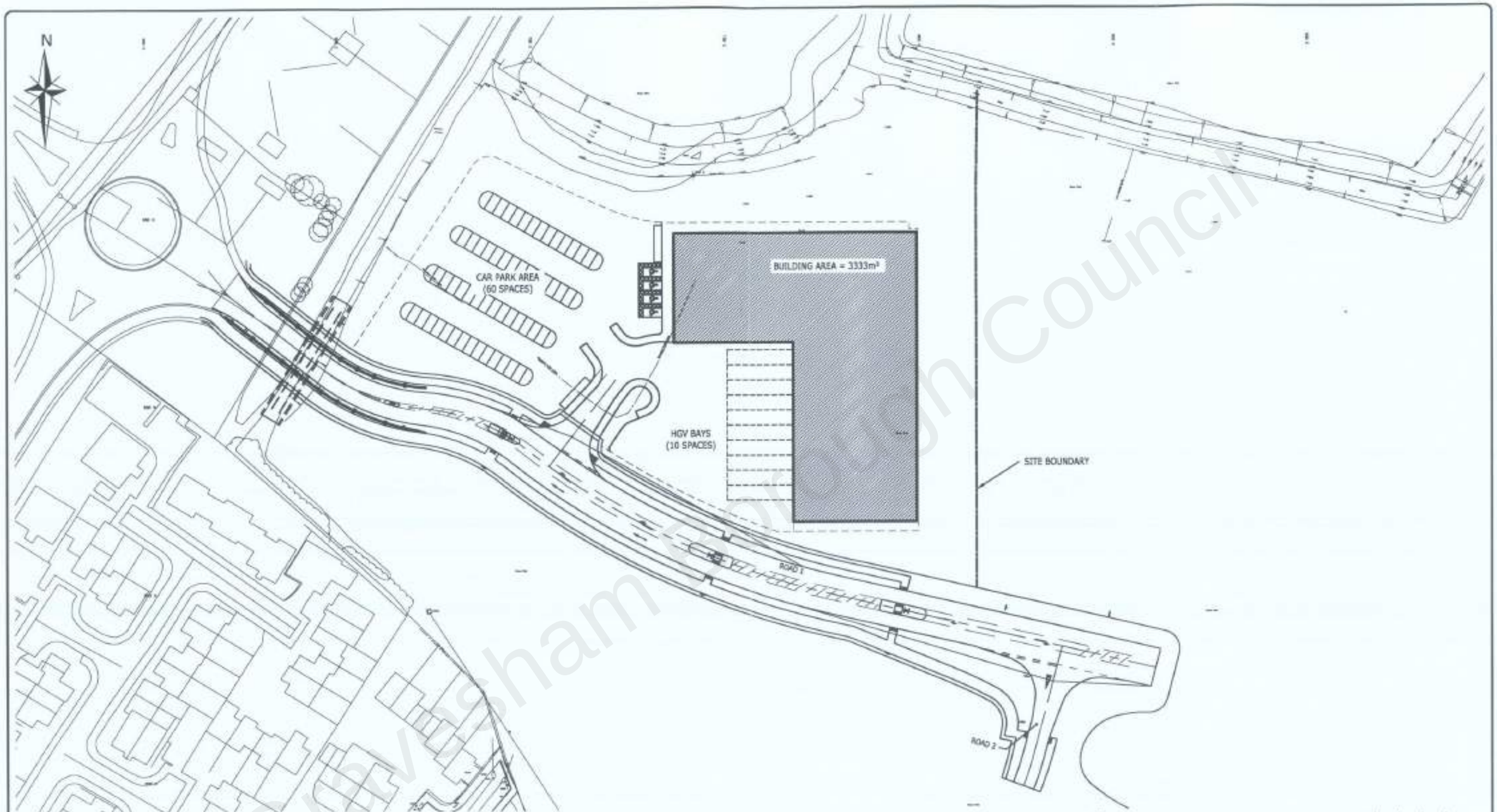
PROJECT TITLE: LAND NORTH OF DALEFIELD WAY, WESTCOURT, GRAVESEND

DRAWING TITLE: EXISTING SITE & SURVEY

CLIENT: BARRATT EASTERN COUNTIES

SCALE:	DATE:	DESIGNED:
1:1000 @ A3	28/04/06	SJB
DRAWN: DF	CHECKED: SJB	APPROVED:
DRAWING NO. B140-004		REV: A

Gravesham Borough Council



REV.	AMENDMENTS	DRN	CHK	APP	DATE
A	NOTES REVISED.	NRT	CMB	CBP	02.07.07

ARDENT
CONSULTING ENGINEERS
4th Floor, Diamond House, 36/38 Hatton Garden, London, EC1N 8EB
t 020 7430 1209 f 020 7430 0318
w www.ardent-ce.co.uk e enquiries@ardent-ce.co.uk

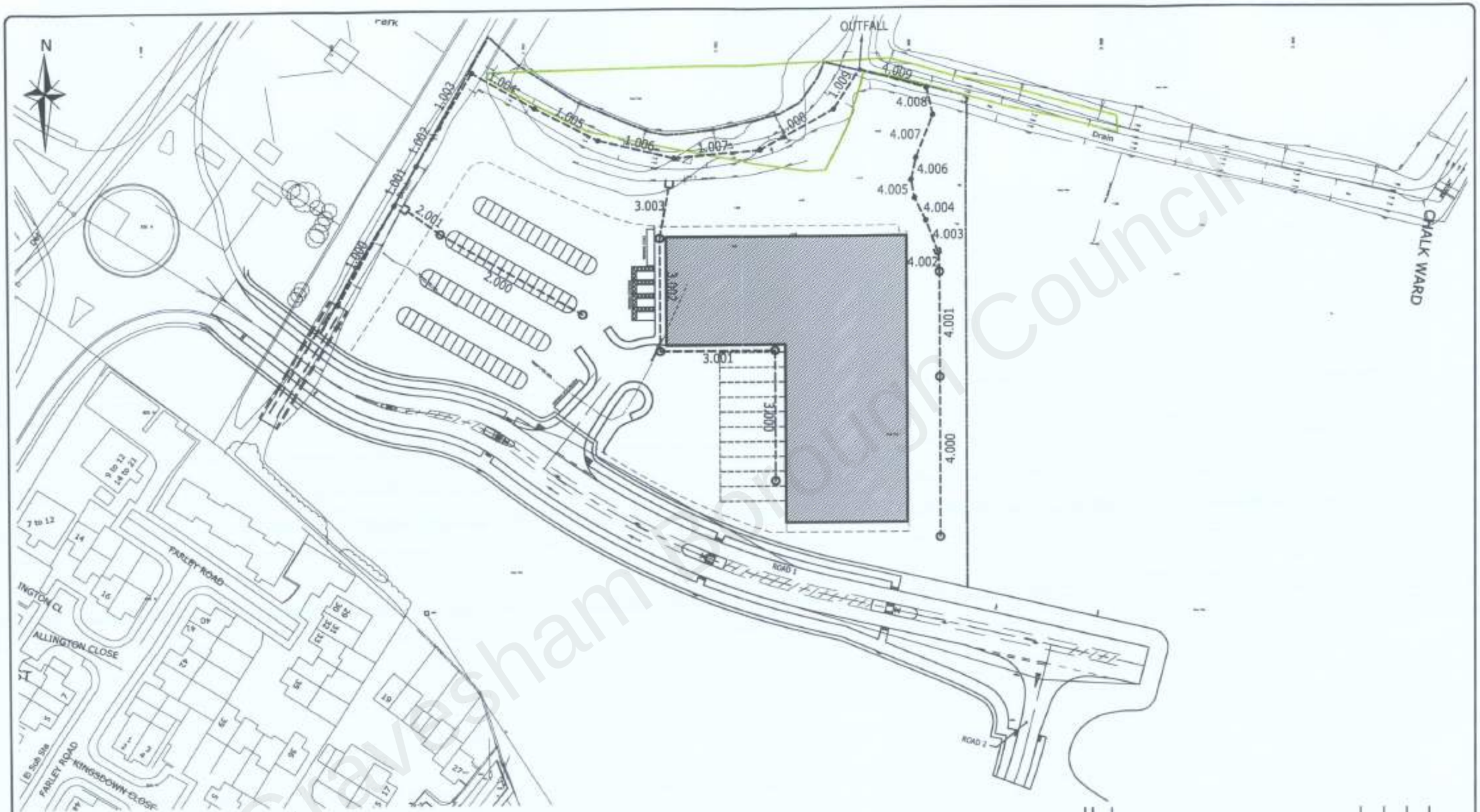
PROJECT TITLE:
LAND NORTH OF DALEFIELD WAY
WESTCOURT, GRAVESEND.

DRAWING TITLE:
PROPOSED INDUSTRIAL DEVELOPMENT
LAYOUT

CLIENT:
BARRATT EASTERN
COUNTIES

SCALE:	DATE:	DESIGNED:
1:1000@A3	04/06/07	CMB
DRAWN: NRT	CHECKED: CMB	APPROVED: SJB
DRAWING NO. B140-017		REV: A

Gravesham Borough Council



DRAFT - FOR COMMENT

KEY:

9.001 - PIPE REFERENCE IN DRAINAGE MODEL

REV.	AMENDMENTS	DRN	CHK	APP	DATE

ARDENT
CONSULTING ENGINEERS
4th Floor, Diamond House, 36/38 Hatton Garden, London, EC1N 8EB
t 020 7430 1209 f 020 7430 0318
w www.ardent-ce.co.uk e enquiries@ardent-ce.co.uk

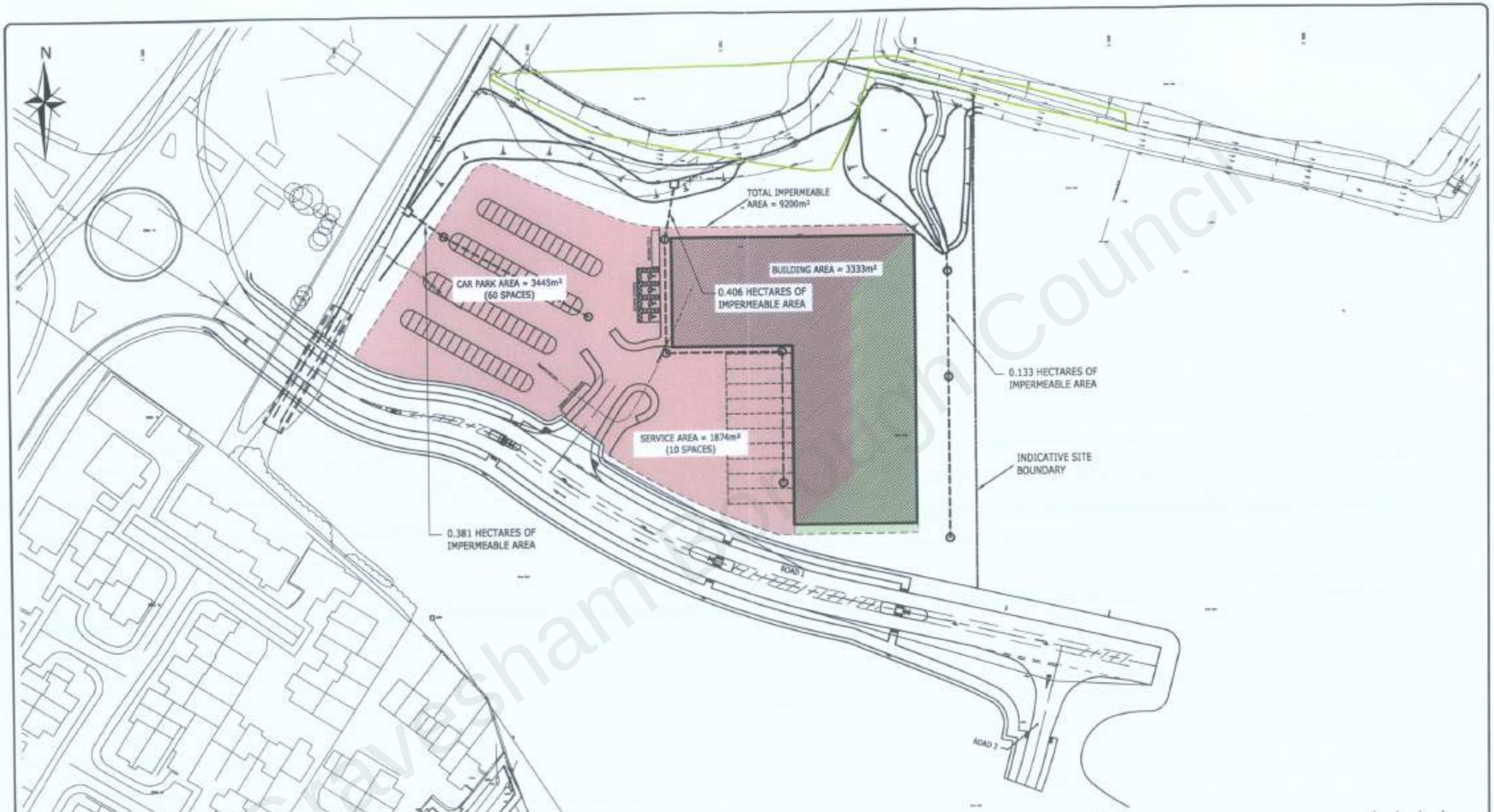
PROJECT TITLE: LAND NORTH OF DALEFIELD WAY WESTCOURT, GRAVESEND

DRAWING TITLE: SURFACE WATER DRAINAGE STRATEGY MODEL (INDUSTRIAL USE)

CLIENT: BARRATT EASTERN COUNTIES

SCALE: 1:1000@A3	DATE: 04/06/07	DESIGNED: SJB
DRAWN: RMA	CHECKED: SJB	APPROVED: CBP
DRAWING NO. B140-018		REV: -

Gravesham Borough Council



DRAFT - FOR COMMENT

REV.	AMENDMENTS	DRN	CHK	APP	DATE

ARDENT
CONSULTING ENGINEERS
4th Floor, Diamond House, 36/38 Hatton Garden, London, EC1N 8EB
t 020 7430 1209 f 020 7430 0318
w www.ardent-ce.co.uk e enquiries@ardent-ce.co.uk

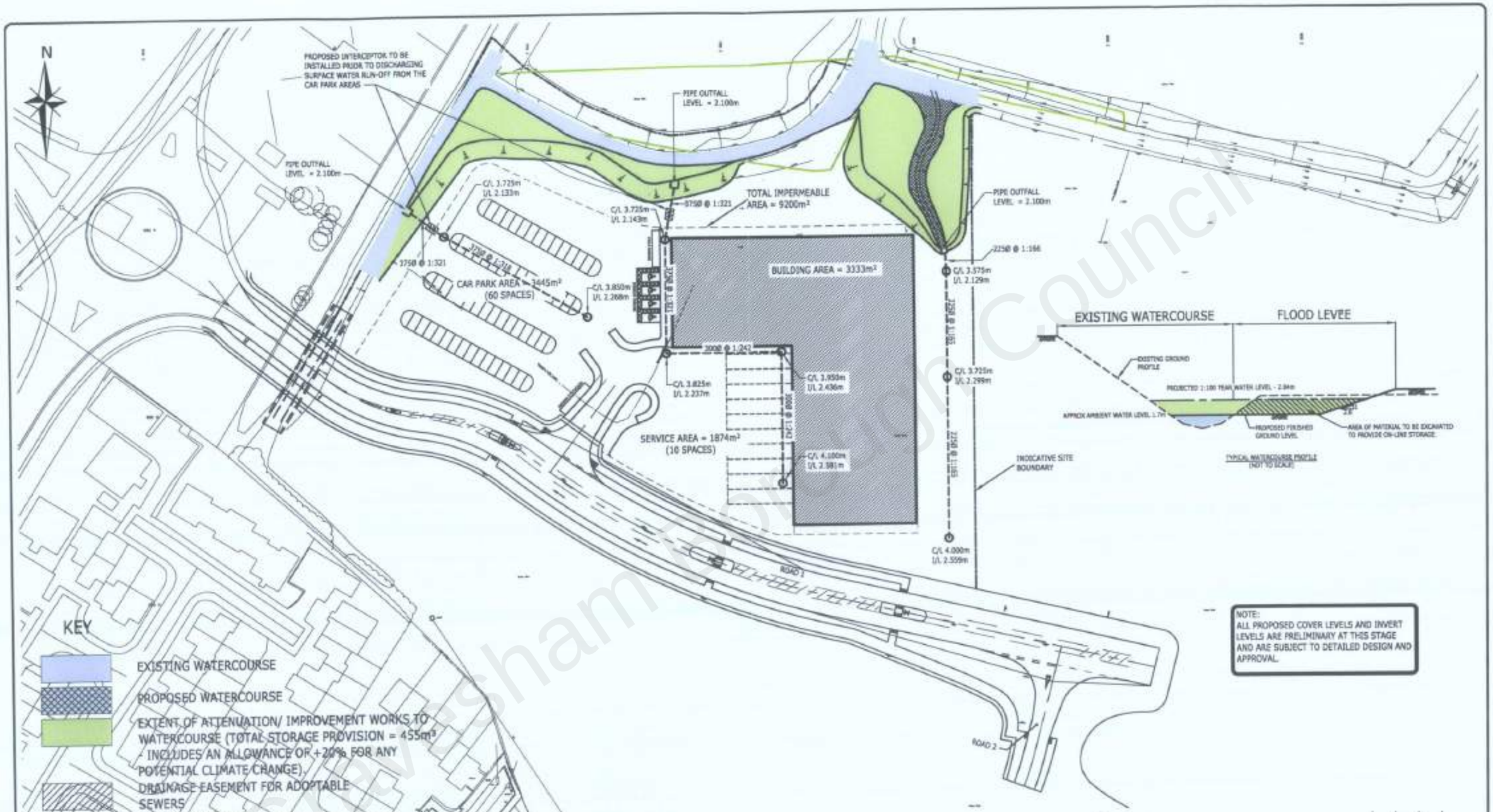
PROJECT TITLE: LAND NORTH OF DALEFIELD WAY WESTCOURT, GRAVESEND

DRAWING TITLE: POST-DEVELOPMENT CATCHMENT BOUNDARIES (INDUSTRIAL USE)

CLIENT: BARRATT EASTERN COUNTIES

SCALE:	DATE:	DESIGNED:
1:1000@A3	04/06/07	SJB
DRAWN: RMA	CHECKED: SJB	APPROVED: CBP
DRAWING NO. B140-019		REV: -

Gravesham Council



NOTE:
ALL PROPOSED COVER LEVELS AND INVERT LEVELS ARE PRELIMINARY AT THIS STAGE AND ARE SUBJECT TO DETAILED DESIGN AND APPROVAL.

REV.	AMENDMENTS	DRN	CHK	APP	DATE

ARDENT
CONSULTING ENGINEERS
4th Floor, Diamond House, 36/38 Hatton Garden, London, EC1N 8EB
t 020 7430 1209 f 020 7430 0318
w www.ardent-ce.co.uk e enquiries@ardent-ce.co.uk

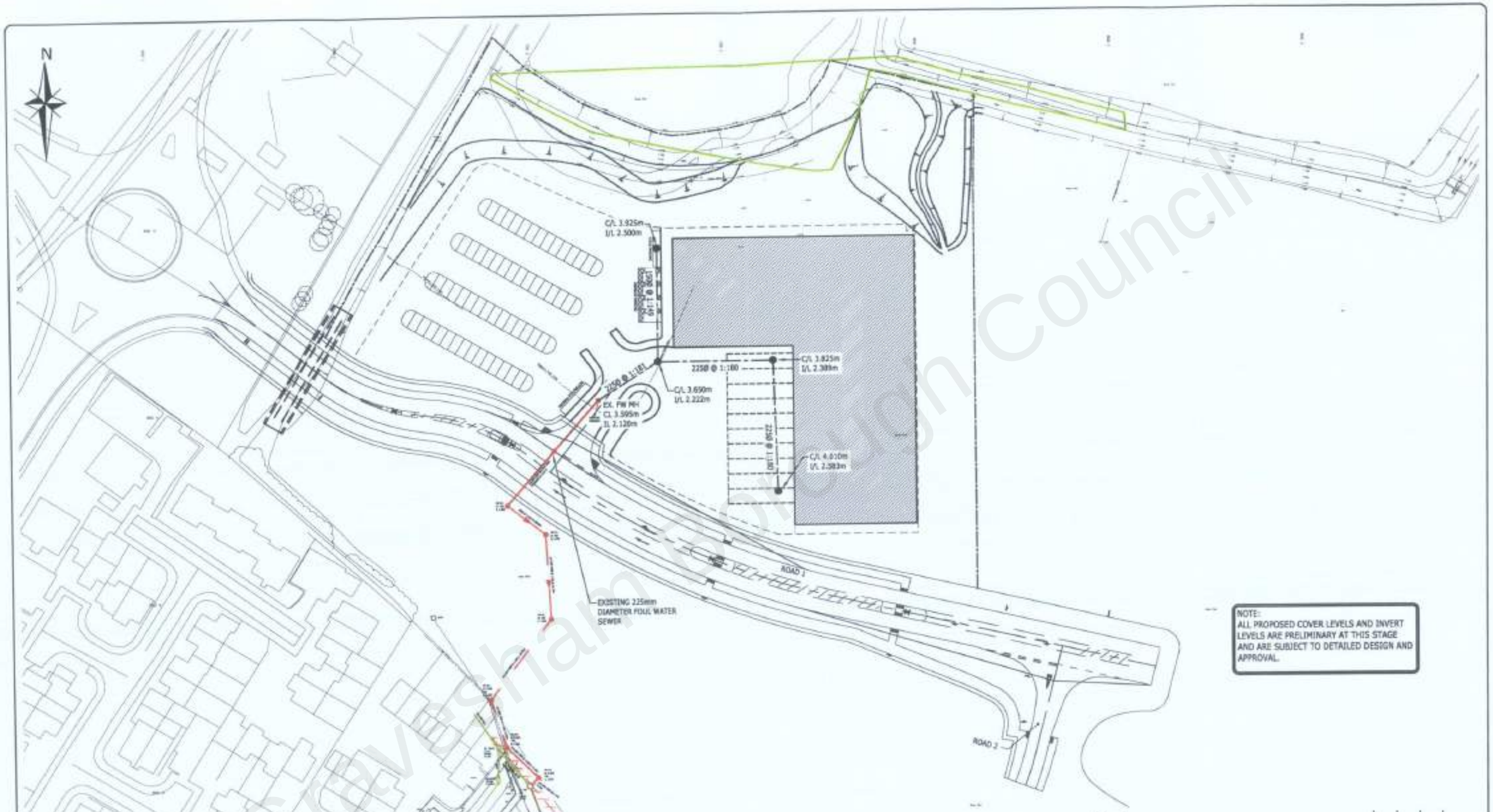
PROJECT TITLE: LAND NORTH OF DALEFIELD WAY WESTCOURT, GRAVESEND

DRAWING TITLE: PRELIMINARY SURFACE WATER DRAINAGE LAYOUT (INDUSTRIAL USE)

CLIENT: BARRATT EASTERN COUNTIES

SCALE:	DATE:	DESIGNED:
1:1000@A3	04/06/07	SJB
DRAWN: RMA	CHECKED: SJB	APPROVED: CBP
DRAWING NO. B140-020		REV: -

Gravesham Borough Council



KEY:

EXISTING FOUL WATER SEWER

PROPOSED FOUL WATER SEWER

DRAFT - FOR COMMENT

REV.	AMENDMENTS	DRN	CHK	APP	DATE

ARDENT
CONSULTING ENGINEERS
4th Floor, Diamond House, 36/38 Hatton Garden, London, EC1N 8EB
t 020 7430 1209 f 020 7430 0318
w www.ardent-ce.co.uk e enquiries@ardent-ce.co.uk

PROJECT TITLE: LAND NORTH OF DALEFIELD WAY WESTCOURT, GRAVESEND

DRAWING TITLE: PRELIMINARY FOUL WATER DRAINAGE LAYOUT (INDUSTRIAL USE)

CLIENT: BARRATT EASTERN COUNTIES

SCALE: 1:1000@A3	DATE: 04/06/07	DESIGNED: SJB
DRAWN: RMA	CHECKED: SJB	APPROVED: CBP
DRAWING NO. B140-021		REV: -

Gravesham Borough Council

NOTES

1. POTENTIAL FLOODWATER DEPTH INFORMATION TAKEN FROM KENT THAMESIDE SFRA PREPARED BY ENTEC (UK) LTD IN COLLABORATION WITH JBA CONSULTANTS (BASED ON FIGURE 5.11 OF THE STAGE 2 SFRA REPORT)

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DEPTH OF POTENTIAL FLOODWATER:

- < 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- 2.0m - 2.5m
- > 2.5m

ISO 9001 BUREAU VERITAS Certification

REV.	AMENDMENTS	DRN	CHK	APP	DATE

ARDENT
CONSULTING ENGINEERS
4th Floor, Diamond House, 36/38 Hatton Garden, London, EC1N 8EB
t 020 7430 1209 f 020 7430 0318
w www.ardent-ce.co.uk e enquiries@ardent-ce.co.uk

PROJECT TITLE: LAND NORTH OF DALEFIELD WAY, WESTCOURT, GRAVESEND

DRAWING TITLE: SFRA POTENTIAL FLOODWATER DEPTHS

CLIENT: BARRATT HOMES

SCALE:	DATE:	DESIGNED:
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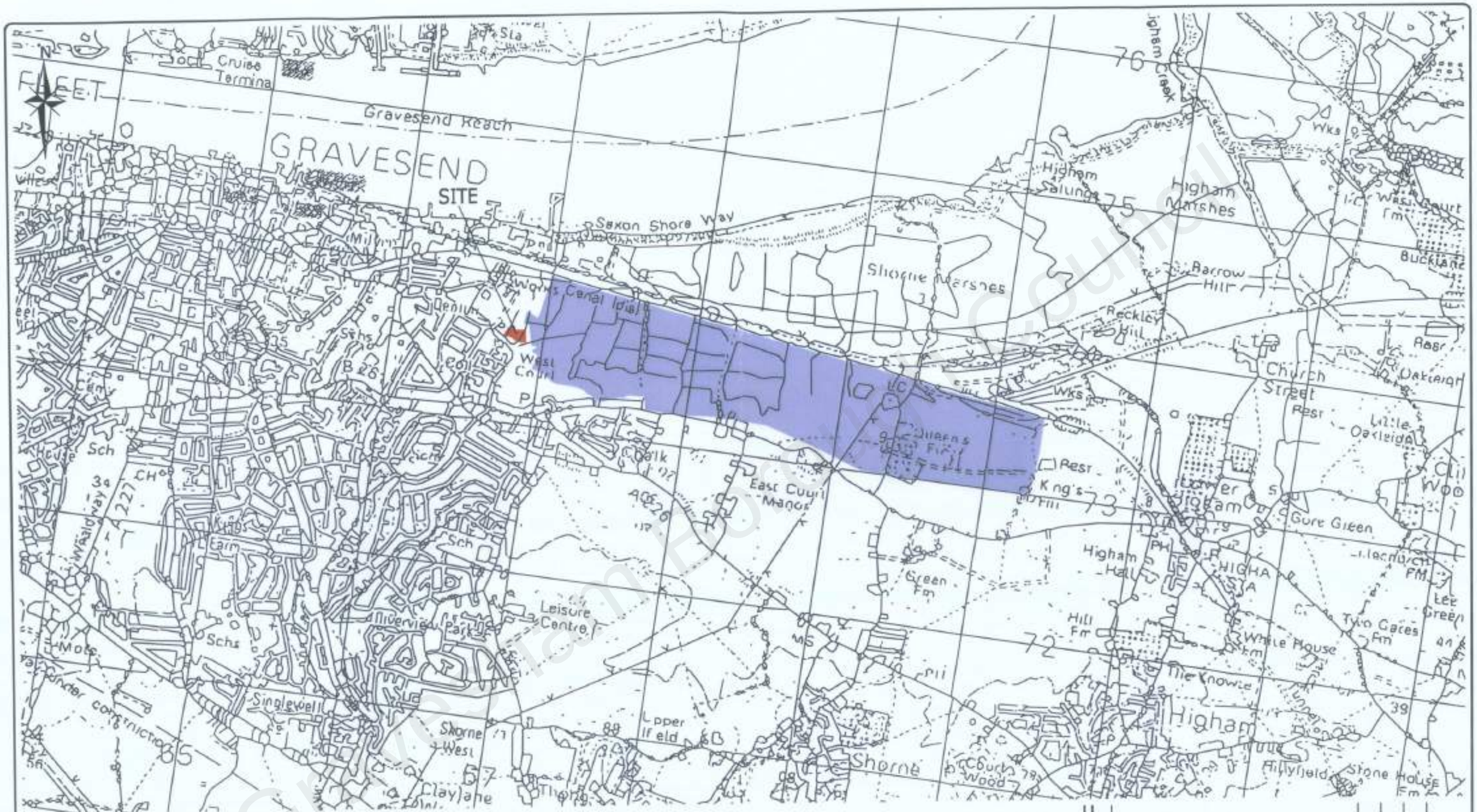
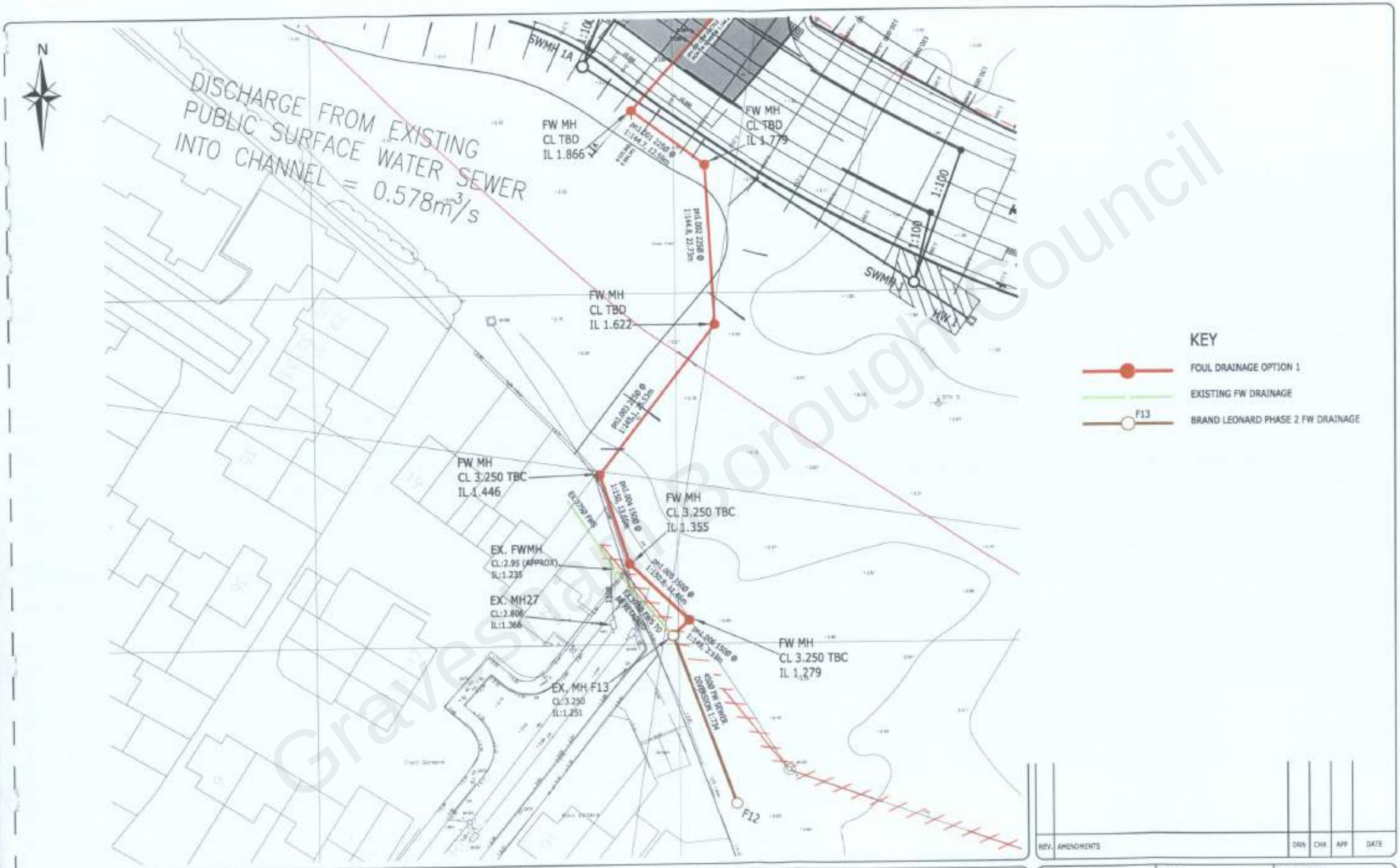
DRAWN: RMA	CHECKED: SJB	APPROVED:
DRAWING NO. B140-022		REV:


GRAVESEND
SITE
Gravesend Reach
Saxon Shore Way
Shorne Marshes
Higham Marshes
Barrow Hill
Church Street
Higham
Shorne
Leisure Centre
Singlewell
Claylane
Upper Ifield
Stone House Fm
Hillyfield
Queens Fm
East Court Manor
Gore Green
Higham Hall
Green Fm
Hill Fm
Two Gates Fm
The Knowle
Lee Green
Oakleigh
Little Oakleigh
Buckland
Riverview Park
Under construction
Cruise Terminal
Sta
Wks
Sch
Mill
Pond
Rest
Farm
Church
Wood
Shorne Wood
Thorne
Dene
Creek
Higham Creek
West Court
Manor Court
Cemetery
Pumping Station
Sewage Works
Canal (dis)
Tunnel
Viaduct
Bridge
Footbridge
Weir
Lock
Pier
Jetty
Slipway
Mooring
Moat
Tumulus
Earthwork
Cliff
Quarry
Pit
Spring
Well
Tank
Mast
Pylon
Pole
Post
Stile
Gate
Cattle Grid
Boundary Stone
Milestone
Bench Mark
Trig Point
Spot Height
Contour
Footpath
Bridleway
Road
Track
Path
Steps
Ford
Footway
Cycle Track
Public Footpath
Public Bridleway
Public Road
Public Path
Private Road
Private Path
Unclassified Road
Classified Road
Motorway
Railway
Tramway
Cable Railway
Monorail
Funicular Railway
Chairlift
Ski Tow
Ski Jump
Toilet
Telephone
Telephone Kiosk
Post Box
Post Office
Pub
Hotel
Inn
Restaurant
Cafe
Shop
Supermarket
Petrol Station
Garage
Car Park
Coach Park
Bus Station
Bus Stop
Taxi Rank
Airport
Heliport
Helipad
Landing Strip
Runway
Apron
Hangar
Control Tower
Radar
Radio Station
TV Station
Transmitter
Mast
Antenna
Satellite Dish
Weather Station
Observatory
Telescope
Planetarium
Observatory
Museum
Gallery
Theatre
Cinema
Concert Hall
Opera House
Ballroom
Dance Hall
Nightclub
Casino
Bingo Hall
Amusement Park
Theme Park
Zoo
Aquarium
Botanical Garden
Arboretum
Nature Reserve
National Park
Forest
Woodland
Plantation
Orchard
Vineyard
Allotment
Cemetery
Crematorium
Mausoleum
Tomb
Memorial
Monument
Statue
Fountain
Pump
Tap
Hydrant
Manhole
Cover
Grid
Sector
Tile
Sheet
Reference
Scale
Bar
Compass
Rose
Arrow
Legend
Key
Title
Block
Frame
Margin
Fold
Line
Dot
Point
Area
Zone
Region
Province
County
Parish
Ward
Constituency
Electoral
Boundary
Administrative
Jurisdiction
Territory
Country
Nation
State
Province
Region
Zone



REV.	AMENDMENTS	DRN	CHK	APP	DATE

ARDENT
CONSULTING ENGINEERS
4th Floor, Diamond House, 36/38 Hatton Garden, London, EC1N 8EB
t 020 7430 1209 f 020 7430 0318
w www.ardent-ce.co.uk e enquiries@ardent-ce.co.uk

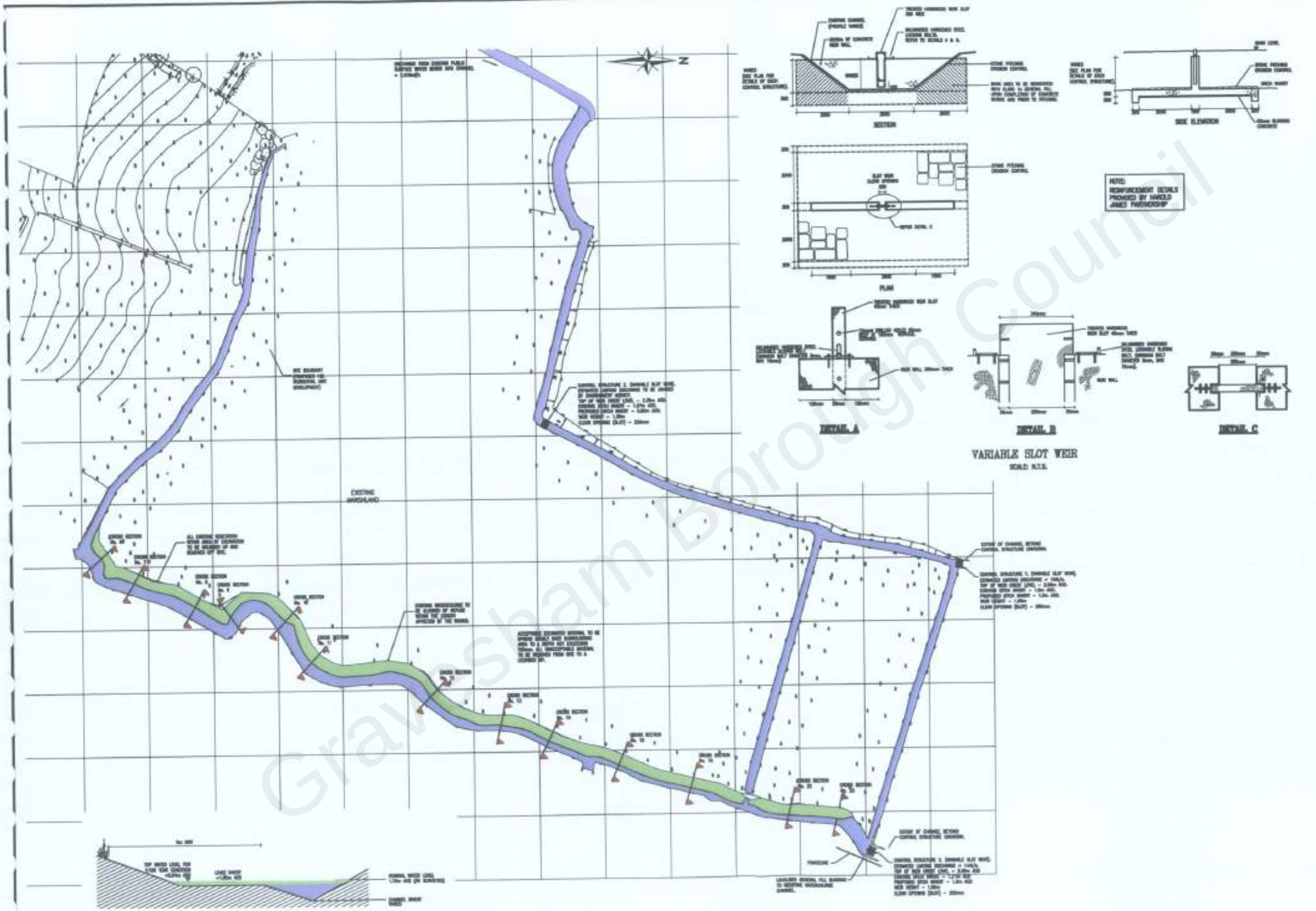
PROJECT TITLE: LAND NORTH OF DALEFIELD WAY, WESTCOURT, GRAVESEND

DRAWING TITLE: PHASE 3B FOUL DRAINAGE LAYOUT

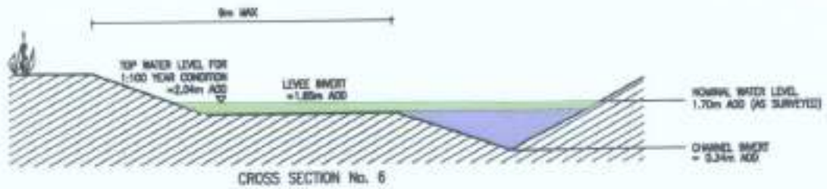
CLIENT: BARRATT EASTERN COUNTIES

SCALE: 1:500	DATE: 26.1.06	DESIGNED: KGS
DRAWN: KGS	CHECKED: -	APPROVED: ARF
DRAWING NO. B140-SK09		REV:

Gravesham Borough Council



Grayesham Borough Council



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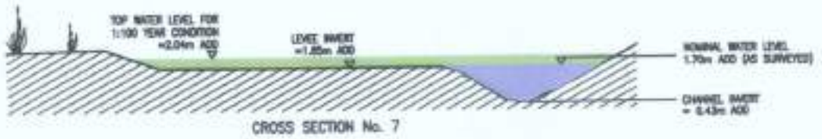

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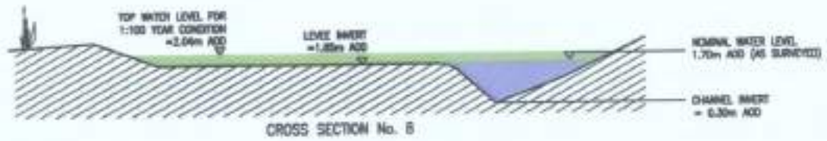

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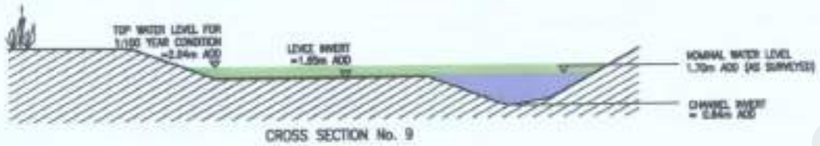

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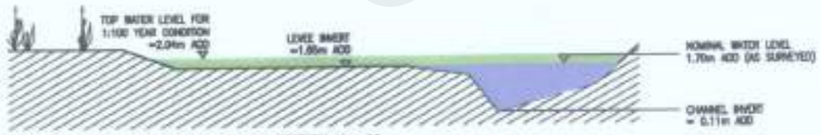

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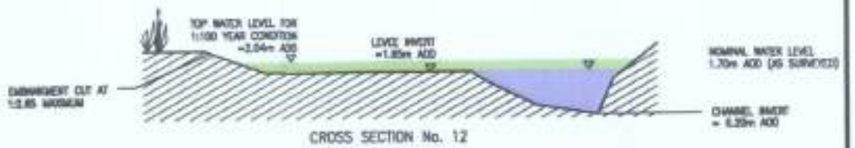

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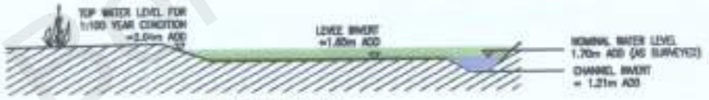
CROSS SECTION No. 14



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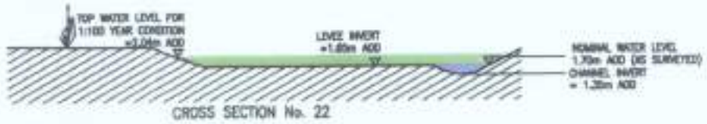


CROSS SECTION No. 22

CROSS SECTION No. 23

NB: EMBANKMENT SLOPES TO BE CUT AT A MAXIMUM OF 1:2.65

NOTES FOR WATERCOURSE CONSTRUCTION

1. OBTAIN CONSERVATION ADVICE RELATING TO THE SITE.
2. KEEP ALL EXCAVATION TO A MINIMUM.
3. LEAVE BANKS UNTOUCHED WHENEVER POSSIBLE, SPARING BANKSIDE VEGETATION UNLESS IMPOVERISHED BY PREVIOUS WORKS.
4. COMPLY WITH RECOMMENDATIONS FROM THE FISHERY/BIOLOGY/HABITAT SURVEYS WHERE POSSIBLE.
5. LEAVE THE CHANNEL AS NARROW AS POSSIBLE.
6. WORK FROM ONE BANK TO MINIMISE OVERALL DISTURBANCE AND RETAIN AREAS TO ACT AS A BASIS FOR RECOLONIZATION.
7. ENSURE CAREFUL SPOIL DISPOSAL AVOIDING TRANSPORT AND DESPOSITION ON SENSITIVE AREAS.
8. AVOID DREDGING THROUGH DRAINS, SEWAS. THIS MAY DRAIN NEARBY WETLANDS.
9. WORK FROM DOWNSTREAM UP SO THAT PLANTS HAVE AN OPPORTUNITY TO RECOLONISE.
10. USE SUITABLE MACHINERY TO AVOID DAMAGE TO THE WATERCOURSE CORRIDOR.

KEY:

- STORAGE AREA (TOP WATER LEVEL RELATED TO SHOWED OUTFALL CONDITION)
- EXCAVATED AREA FOR REGULAR WETTING CONDITION
- AMBIENT BASE FLOW WETTING CONDITION

NOTES:

1. ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE STATED.
2. ALL LEVELS STATED ARE IN METRES ABOVE ORDNANCE DATUM.
3. ALL DIMENSIONS SHALL BE SET OUT AND AGREED WITH THE SITE ENGINEER PRIOR TO THE COMMENCEMENT OF WORKS.
4. NO DEVIATION FROM THE DETAILS SHOWN ON THIS DRAWING SHALL BE PERMITTED WITHOUT THE PRIOR WRITTEN APPROVAL OF THE ENGINEER.
5. THE CONTRACTOR SHALL TAKE ALL NECESSARY PRECAUTIONS TO PROTECT THE DRAINAGE WORKS DURING ALL STAGES OF CONSTRUCTION.
6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR CONTACTING THE STATUTORY UNDERTAKERS PRIOR TO THE COMMENCEMENT OF THE WORKS AND TO ESTABLISH THE EXACT POSITION OF THEIR PLANT, WHICH SHALL BE CONFIRMED BY HAND DUG TRIAL PITS IF NECESSARY.
7. CONTRACTORS MEANS OF ACCESS TO THE SITE TO BE AGREED WITH LANDOWNER PRIOR TO THE COMMENCEMENT OF WORKS.
8. ALL WORKS SHALL BE UNDERTAKEN IN ACCORDANCE WITH THE "DWL ENGINEERING SPECIFICATION FOR THE WATER INDUSTRY" 4th EDITION,"SEWERS FOR ADOPTION" AND SPECIFICATION FOR HIGHWAY WORKS. (WHERE APPROPRIATE).
9. ALL REINFORCED IN-SITU CONCRETE CLASS ST4 SHALL BE IN ACCORDANCE WITH THE CL 2802 OF SWA.
10. WITH REFERENCE TO THE DEPT. OF TRANSPORTS' SPECIFICATION FOR HIGHWAY WORKS", PART 5, CL1708 – ALL EXPOSED FORMED FACES OF CONCRETE TO BE CLASS F3 SURFACE FINISH. ALL UNEXPOSED FORMED FACES OF CONCRETE TO BE CLASS U3 SURFACE FINISH.
11. ALL EXPOSED EXTERNAL CORNERS OF CONCRETE SHALL BE FORMED WITH A 25 x 25mm CHAMFER.
12. THE COVER TO REINFORCEMENT SHALL BE 40mm MINIMUM.
13. REINFORCEMENT MESH SHALL BE HIGH YIELD AND COMPLY WITH BS4483.
14. ALL CONCRETE AND CONCRETE PRODUCTS SHALL BE CLASS 1 SULPHATE RESISTANT IN ACCORDANCE WITH BRE DIGEST 363.
15. CLASS A1 FILL TO BE IN ACCORDANCE WITH TABLE 6-1 OF SWA.
16. FOR GENERAL ARRANGEMENT REFER TO DRG No. U481-001.
17. REPLANTING AND VEGETATION WORKS TO BE AGREED BY THE CONTRACTOR WITH THE ENVIRONMENT AGENCY AND GRAVESHAM B.C. PRIOR TO THE COMMENCEMENT OF THE WORKS.
18. ALL WORKS SUBJECT TO DETAILED HYDRAULIC, STRUCTURAL AND GEOTECHNICAL DESIGN.
19. SURVEY PRODUCED BY RANDALL SURVEYS LTD. APRIL 2001.

CONSTRUCTION ISSUE

Rev	Amendments	Drn	Chkd	Date
D	EMBANKMENT SLOPES AMENDED	AMF	CBF	08.08.02
C	CONSTRUCTION ISSUE	AMF	CBF	24.05.02
B	CROSS SECTIONS AMENDED	AMF	CBF	15.05.02
A	SCALE ALTERED	AMF		06/01

HUCHANAN CONSULTING ENGINEERS
Newcombe House
45 – 45 Notting Hill Gate
London W11 3QD
Telephone [illegible] Fax [illegible]

Job Title: LAND OFF DERING WAY GRAVESEND

Drawing Title: OFF SITE CHANNEL IMPROVEMENTS CROSS SECTIONS

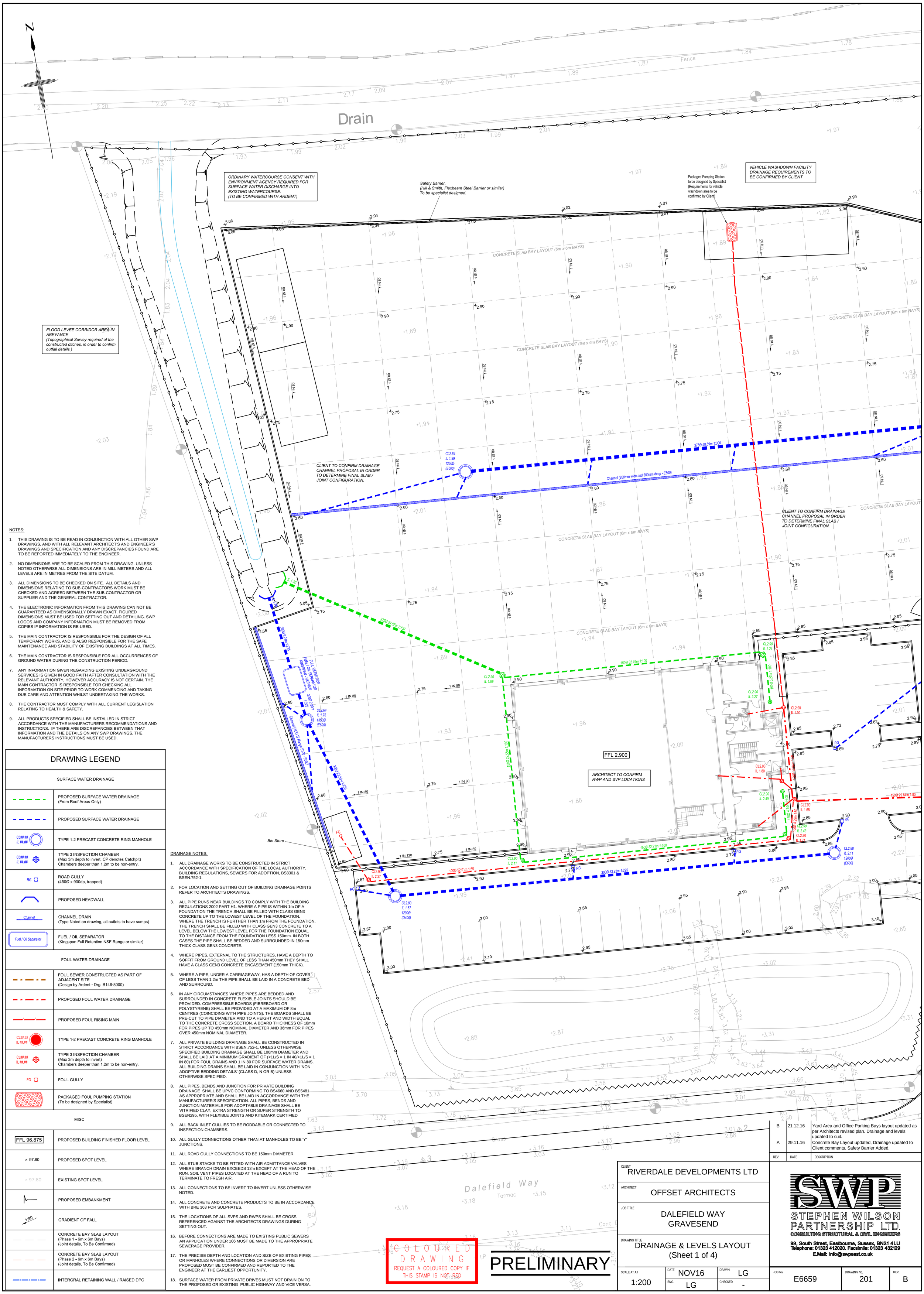
Client: BARRATT EASTERN COUNTIES

Scale	Date	Designed
1:100@A1	JUNE 2001	CBF
Drawn: AMF	Checked: CBF	Approved:

Job No	Drawing No	Rev
U481	U481-002	D

Gravesham Borough Council

Appendix E – Phase 2 SWP Underground Drainage Layouts



NOTES:

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3. ALL DIMENSIONS TO BE CHECKED ON SITE. ALL DETAILS AND DIMENSIONS RELATING TO SUB-CONTRACTORS WORK MUST BE CHECKED AND AGREED BETWEEN THE SUB-CONTRACTOR OR SUPPLIER AND THE GENERAL CONTRACTOR.
4. THE ELECTRONIC INFORMATION FROM THIS DRAWING CAN NOT BE GUARANTEED AS DIMENSIONALLY DRAWN EXACT. FIGURED DIMENSIONS MUST BE USED FOR SETTING OUT AND DETAILING. SWP LOGOS AND COMPANY INFORMATION MUST BE REMOVED FROM COPIES IF INFORMATION IS RE-USED.
5. THE MAIN CONTRACTOR IS RESPONSIBLE FOR THE DESIGN OF ALL TEMPORARY WORKS, AND IS ALSO RESPONSIBLE FOR THE SAFE MAINTENANCE AND STABILITY OF EXISTING BUILDINGS AT ALL TIMES.
6. THE MAIN CONTRACTOR IS RESPONSIBLE FOR ALL OCCURRENCES OF GROUND WATER DURING THE CONSTRUCTION PERIOD.
7. ANY INFORMATION GIVEN REGARDING EXISTING UNDERGROUND SERVICES IS GIVEN IN GOOD FAITH AFTER CONSULTATION WITH THE RELEVANT AUTHORITY, HOWEVER ACCURACY IS NOT CERTAIN. THE MAIN CONTRACTOR IS RESPONSIBLE FOR CHECKING ALL INFORMATION ON SITE PRIOR TO WORK COMMENCING AND TAKING DUE CARE AND ATTENTION WHILST UNDERTAKING THE WORKS.
8. THE CONTRACTOR MUST COMPLY WITH ALL CURRENT LEGISLATION RELATING TO HEALTH & SAFETY.
9. ALL PRODUCTS SPECIFIED SHALL BE INSTALLED IN STRICT ACCORDANCE WITH THE MANUFACTURERS RECOMMENDATIONS AND INSTRUCTIONS. IF THERE ARE DISCREPANCIES BETWEEN THAT INFORMATION AND THE DETAILS ON ANY SWP DRAWINGS, THE MANUFACTURERS INSTRUCTIONS MUST BE USED.

DRAWING LEGEND

SURFACE WATER DRAINAGE	
	PROPOSED SURFACE WATER DRAINAGE (From Roof Areas Only)
	PROPOSED SURFACE WATER DRAINAGE
CL##.## IL ##.##	TYPE 1-2 PRECAST CONCRETE RING MANHOLE
CL##.## IL ##.##	TYPE 3 INSPECTION CHAMBER (Max 3m depth to invert, CP denotes Catchpit) Chambers deeper than 1.2m to be non-entry.
RG	ROAD GULLY (450Ø x 900dp, trapped)
	PROPOSED HEADWALL
Channel	CHANNEL DRAIN (Type Noted on drawing, all outlets to have sumps)
Fuel / Oil Separator	FUEL / OIL SEPARATOR (Kingspan Full Retention NSF Range or similar)
FOUL WATER DRAINAGE	
	FOUL SEWER CONSTRUCTED AS PART OF ADJACENT SITE (Design by Ardent - Drg. B146-8000)
	PROPOSED FOUL WATER DRAINAGE
	PROPOSED FOUL RISING MAIN
CL##.## IL ##.##	TYPE 1-2 PRECAST CONCRETE RING MANHOLE
CL##.## IL ##.##	TYPE 3 INSPECTION CHAMBER (Max 3m depth to invert) Chambers deeper than 1.2m to be non-entry.
FG	FOUL GULLY
	PACKAGED FOUL PUMPING STATION (To be designed by Specialist)
MISC	
FFL 96.875	PROPOSED BUILDING FINISHED FLOOR LEVEL
× 97.80	PROPOSED SPOT LEVEL
× 97.80	EXISTING SPOT LEVEL
	PROPOSED EMBANKMENT
1:80	GRADIENT OF FALL
	CONCRETE BAY SLAB LAYOUT (Phase 1 - 6m x 6m Bays) (Joint details, To Be Confirmed)
	CONCRETE BAY SLAB LAYOUT (Phase 2 - 6m x 6m Bays) (Joint details, To Be Confirmed)
	INTERGRAL RETAINING WALL / RAISED DPC

DRAINAGE NOTES:

1. ALL DRAINAGE WORKS TO BE CONSTRUCTED IN STRICT ACCORDANCE WITH SPECIFICATION OF THE LOCAL AUTHORITY, BUILDING REGULATIONS, SEWERS FOR ADOPTION, BS8301 & BSEN.752-1.
2. FOR LOCATION AND SETTING OUT OF BUILDING DRAINAGE POINTS REFER TO ARCHITECTS DRAWINGS.
3. ALL PIPE RUNS NEAR BUILDINGS TO COMPLY WITH THE BUILDING REGULATIONS 2002 PART H1. WHERE A PIPE IS WITHIN 1m OF A FOUNDATION THE TRENCH SHALL BE FILLED WITH CLASS GEN3 CONCRETE UP TO THE LOWEST LEVEL OF THE FOUNDATION. WHERE THE TRENCH IS FURTHER THAN 1m FROM THE FOUNDATION, THE TRENCH SHALL BE FILLED WITH CLASS GEN3 CONCRETE TO A LEVEL BELOW THE LOWEST LEVEL FOR THE FOUNDATION EQUAL TO THE DISTANCE FROM THE FOUNDATION LESS 150mm. IN BOTH CASES THE PIPE SHALL BE BEDDED AND SURROUNDED IN 150mm THICK CLASS GEN3 CONCRETE.
4. WHERE PIPES, EXTERNAL TO THE STRUCTURES, HAVE A DEPTH TO SOFFIT FROM GROUND LEVEL OF LESS THAN 450mm THEY SHALL HAVE A CLASS GEN3 CONCRETE ENCASEMENT (150mm THICK).
5. WHERE A PIPE, UNDER A CARRIAGEWAY, HAS A DEPTH OF COVER OF LESS THAN 1.2m THE PIPE SHALL BE LAID IN A CONCRETE BED AND SURROUND.
6. IN ANY CIRCUMSTANCES WHERE PIPES ARE BEDDED AND SURROUNDED IN CONCRETE FLEXIBLE JOINTS SHOULD BE PROVIDED. COMPRESSIBLE BOARDS (FIBREBOARD OR POLYSTYRENE) SHALL BE PROVIDED AT A MAXIMUM OF 8m CENTRES (COINCIDING WITH PIPE JOINTS). THE BOARDS SHALL BE PRE-CUT TO PIPE DIAMETER AND TO A HEIGHT AND WIDTH EQUAL TO THE CONCRETE CROSS SECTION. A BOARD THICKNESS OF 18mm FOR PIPES UP TO 450mm NOMINAL DIAMETER AND 36mm FOR PIPES OVER 450mm NOMINAL DIAMETER.
7. ALL PRIVATE BUILDING DRAINAGE SHALL BE CONSTRUCTED IN STRICT ACCORDANCE WITH BSEN.752-1. UNLESS OTHERWISE SPECIFIED BUILDING DRAINAGE SHALL BE 100mm DIAMETER AND SHALL BE LAID AT A MINIMUM GRADIENT OF (<1L/S = 1 IN 40/>1L/S = 1 IN 80) FOR FOUL DRAINS AND 1 IN 80 FOR SURFACE WATER DRAINS. ALL BUILDING DRAINS SHALL BE LAID IN CONJUNCTION WITH 'NON ADOPTIVE BEDDING DETAILS' (CLASS D, N OR B) UNLESS OTHERWISE SPECIFIED.
8. ALL PIPES, BENDS AND JUNCTION FOR PRIVATE BUILDING DRAINAGE SHALL BE UPVC CONFORMING TO BS4660 AND BS5481 AS APPROPRIATE AND SHALL BE LAID IN ACCORDANCE WITH THE MANUFACTURER'S SPECIFICATION. ALL PIPES, BENDS AND JUNCTION MATERIALS FOR ADOPTABLE DRAINAGE SHALL BE VITRIFIED CLAY, EXTRA STRENGTH OR SUPER STRENGTH TO BSEN295, WITH FLEXIBLE JOINTS AND KITEMARK CERTIFIED
9. ALL BACK INLET GULLIES TO BE RODDABLE OR CONNECTED TO INSPECTION CHAMBERS.
10. ALL GULLY CONNECTIONS OTHER THAN AT MANHOLES TO BE 'Y' JUNCTIONS.
11. ALL ROAD GULLY CONNECTIONS TO BE 150mm DIAMETER.
12. ALL STUB STACKS TO BE FITTED WITH AIR ADMITTANCE VALVES WHERE BRANCH DRAIN EXCEEDS 12m EXCEPT AT THE HEAD OF THE RUN. SOIL VENT PIPES LOCATED AT THE HEAD OF A RUN TO TERMINATE TO FRESH AIR.
13. ALL CONNECTIONS TO BE INVERT TO INVERT UNLESS OTHERWISE NOTED.
14. ALL CONCRETE AND CONCRETE PRODUCTS TO BE IN ACCORDANCE WITH BRE 363 FOR SULPHATES.
15. THE LOCATIONS OF ALL SVPS AND RWPS SHALL BE CROSS REFERENCED AGAINST THE ARCHITECTS DRAWINGS DURING SETTING OUT.
16. BEFORE CONNECTIONS ARE MADE TO EXISTING PUBLIC SEWERS AN APPLICATION UNDER 106 MUST BE MADE TO THE APPROPRIATE SEWERAGE PROVIDER.
17. THE PRECISE DEPTH AND LOCATION AND SIZE OF EXISTING PIPES OR MANHOLES WHERE CONNECTIONS OR DIVERSION ARE PROPOSED MUST BE CONFIRMED AND REPORTED TO THE ENGINEER AT THE EARLIEST OPPORTUNITY.
18. SURFACE WATER FROM PRIVATE DRIVES MUST NOT DRAIN ON TO THE PROPOSED OR EXISTING PUBLIC HIGHWAY AND VICE VERSA.

COLOURED DRAWING
REQUEST A COLOURED COPY IF THIS STAMP IS NOT RED

PRELIMINARY

REV.	DATE	DESCRIPTION
B	21.12.16	Yard Area and Office Parking Bays layout updated as per Architects revised plan. Drainage and levels updated to suit.
A	29.11.16	Concrete Bay Layout updated, Drainage updated to Client comments. Safety Barrier Added.

CLIENT
RIVERDALE DEVELOPMENTS LTD

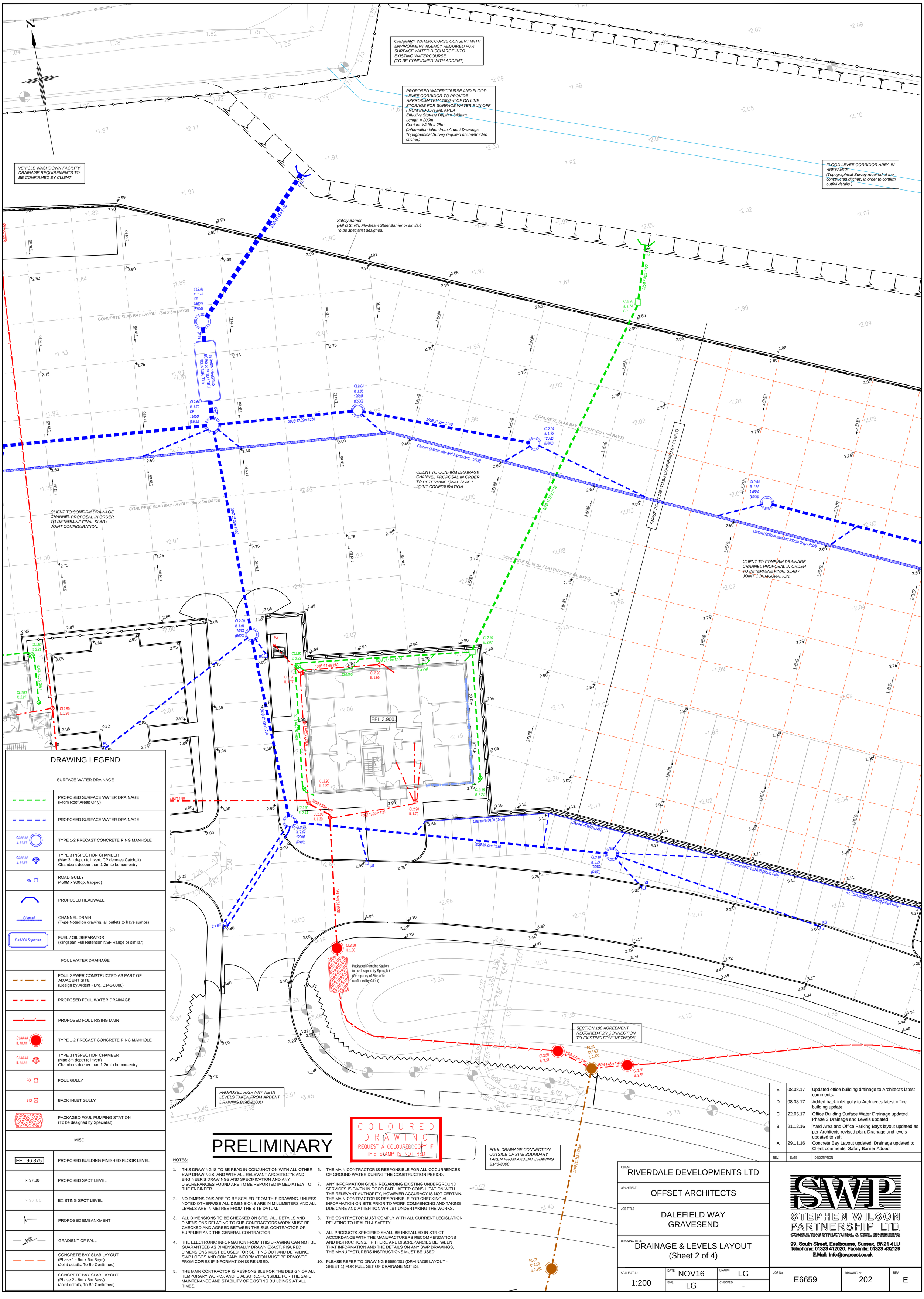
ARCHITECT
OFFSET ARCHITECTS

JOB TITLE
DALEFIELD WAY
GRAVESEND

DRAWING TITLE
DRAINAGE & LEVELS LAYOUT
(Sheet 1 of 4)

SCALE AT A1	DATE	DRAWN	JOB No.	DRAWING No.	REV.
1:200	NOV16	LG	E6659	201	B
	ENG. LG	CHECKED -			

SWP
STEPHEN WILSON PARTNERSHIP LTD.
CONSULTING STRUCTURAL & CIVIL ENGINEERS
99, South Street, Eastbourne, Sussex, BN21 4LU
Telephone: 01323 412020. Facsimile: 01323 432129
E.Mail: info@swpeast.co.uk



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	PROPOSED SURFACE WATER DRAINAGE
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BIG	BACK INLET GULLY
	PACKAGED FOUL PUMPING STATION (To be designed by Specialist)
MISC	
FFL 96.875	PROPOSED BUILDING FINISHED FLOOR LEVEL
× 97.80	PROPOSED SPOT LEVEL
× 97.80	EXISTING SPOT LEVEL
	PROPOSED EMBANKMENT
1:80	GRADIENT OF FALL
	CONCRETE BAY SLAB LAYOUT (Phase 1 - 6m x 6m Bays) (Joint details, To Be Confirmed)
	CONCRETE BAY SLAB LAYOUT (Phase 2 - 6m x 6m Bays) (Joint details, To Be Confirmed)

PRELIMINARY

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10. PLEASE REFER TO DRAWING E6659/201 (DRAINAGE LAYOUT - SHEET 1) FOR FULL SET OF DRAINAGE NOTES.

REV.	DATE	DESCRIPTION
E	08.08.17	Updated office building drainage to Architect's latest comments.
D	08.08.17	Added back inlet gully to Architect's latest office building update.
C	22.05.17	Office Building Surface Water Drainage updated. Phase 2 Drainage and Levels updated
B	21.12.16	Yard Area and Office Parking Bays layout updated as per Architects revised plan. Drainage and levels updated to suit.
A	29.11.16	Concrete Bay Layout updated, Drainage updated to Client comments. Safety Barrier Added.

CLIENT
RIVERDALE DEVELOPMENTS LTD

ARCHITECT
OFFSET ARCHITECTS

JOB TITLE
DALEFIELD WAY
GRAVESEND

DRAWING TITLE
DRAINAGE & LEVELS LAYOUT
(Sheet 2 of 4)

SCALE AT A1	DATE	DRAWN
1:200	NOV16	LG
	ENG. LG	CHECKED -

SWP
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99, South Street, Eastbourne, Sussex, BN21 4LU
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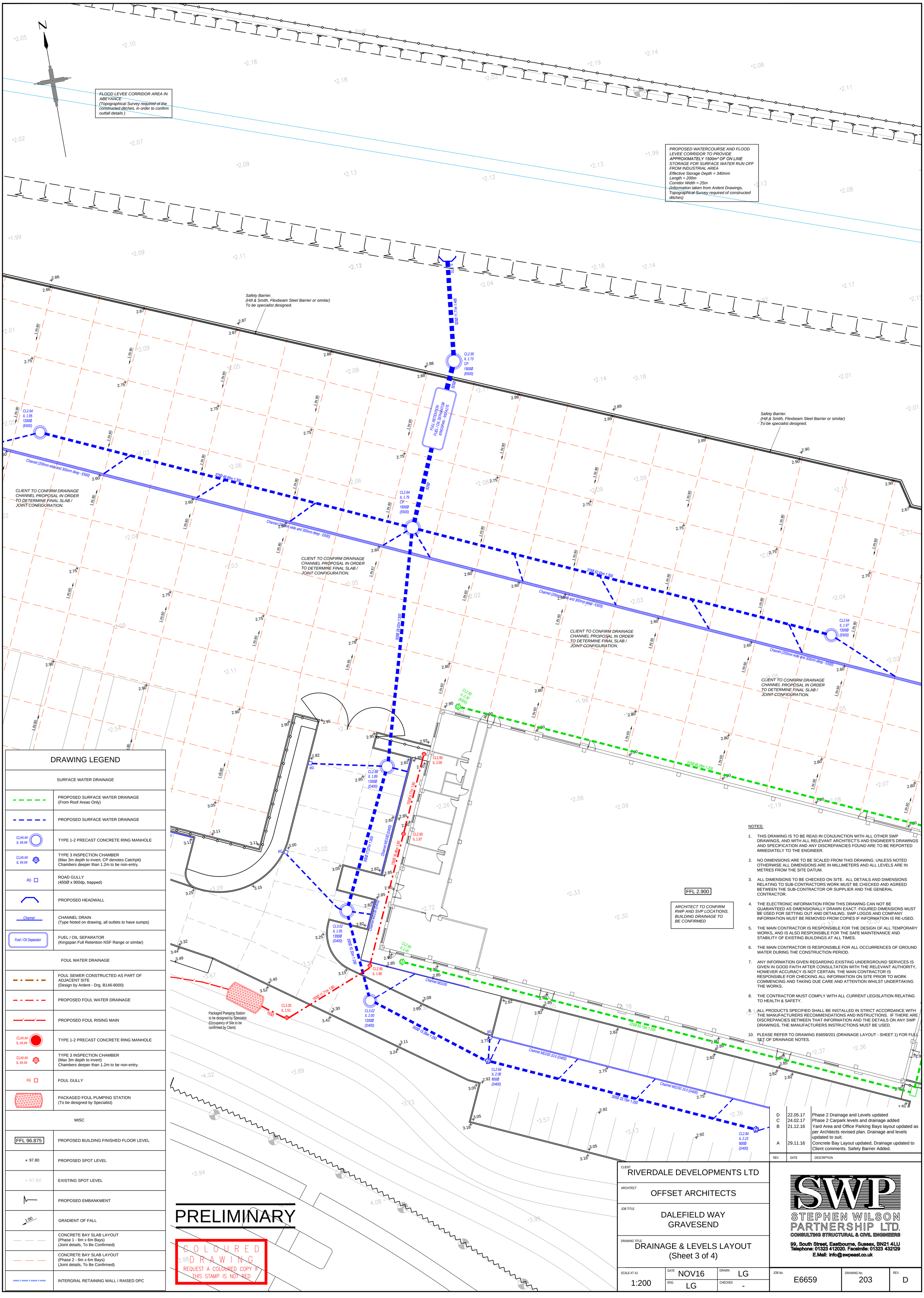
E.Mail: info@swpeast.co.uk

JOB No.	DRAWING No.	REV.
E6659	202	E



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NOTES:

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2. NO DIMENSIONS ARE TO BE SCALED FROM THIS DRAWING. UNLESS NOTED OTHERWISE ALL DIMENSIONS ARE IN MILLIMETERS AND ALL LEVELS ARE IN METRES FROM THE SITE DATUM.
3. ALL DIMENSIONS TO BE CHECKED ON SITE. ALL DETAILS AND DIMENSIONS RELATING TO SUB-CONTRACTORS WORK MUST BE CHECKED AND AGREED BETWEEN THE SUB-CONTRACTOR OR SUPPLIER AND THE GENERAL CONTRACTOR.
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5. THE MAIN CONTRACTOR IS RESPONSIBLE FOR THE DESIGN OF ALL TEMPORARY WORKS, AND IS ALSO RESPONSIBLE FOR THE SAFE MAINTENANCE AND STABILITY OF EXISTING BUILDINGS AT ALL TIMES.
6. THE MAIN CONTRACTOR IS RESPONSIBLE FOR ALL OCCURRENCES OF GROUND WATER DURING THE CONSTRUCTION PERIOD.
7. ANY INFORMATION GIVEN REGARDING EXISTING UNDERGROUND SERVICES IS GIVEN IN GOOD FAITH AFTER CONSULTATION WITH THE RELEVANT AUTHORITY, HOWEVER ACCURACY IS NOT CERTAIN. THE MAIN CONTRACTOR IS RESPONSIBLE FOR CHECKING ALL INFORMATION ON SITE PRIOR TO WORK COMMENCING AND TAKING DUE CARE AND ATTENTION WHILST UNDERTAKING THE WORKS.
8. THE CONTRACTOR MUST COMPLY WITH ALL CURRENT LEGISLATION RELATING TO HEALTH & SAFETY.
9. ALL PRODUCTS SPECIFIED SHALL BE INSTALLED IN STRICT ACCORDANCE WITH THE MANUFACTURERS RECOMMENDATIONS AND INSTRUCTIONS. IF THERE ARE DISCREPANCIES BETWEEN THAT INFORMATION AND THE DETAILS ON ANY SWP DRAWINGS, THE MANUFACTURERS INSTRUCTIONS MUST BE USED.
10. PLEASE REFER TO DRAWING E6659/201 (DRAINAGE LAYOUT - SHEET 1) FOR FULL SET OF DRAINAGE NOTES.

REV.	DATE	DESCRIPTION
D	22.05.17	Phase 2 Drainage and Levels updated
C	24.02.17	Phase 2 Carpark levels and drainage added
B	21.12.16	Yard Area and Office Parking Bays layout updated as per Architects revised plan. Drainage and levels updated to suit.
A	29.11.16	Concrete Bay Layout updated, Drainage updated to Client comments. Safety Barrier Added.

CLIENT
RIVERDALE DEVELOPMENTS LTD

ARCHITECT
OFFSET ARCHITECTS

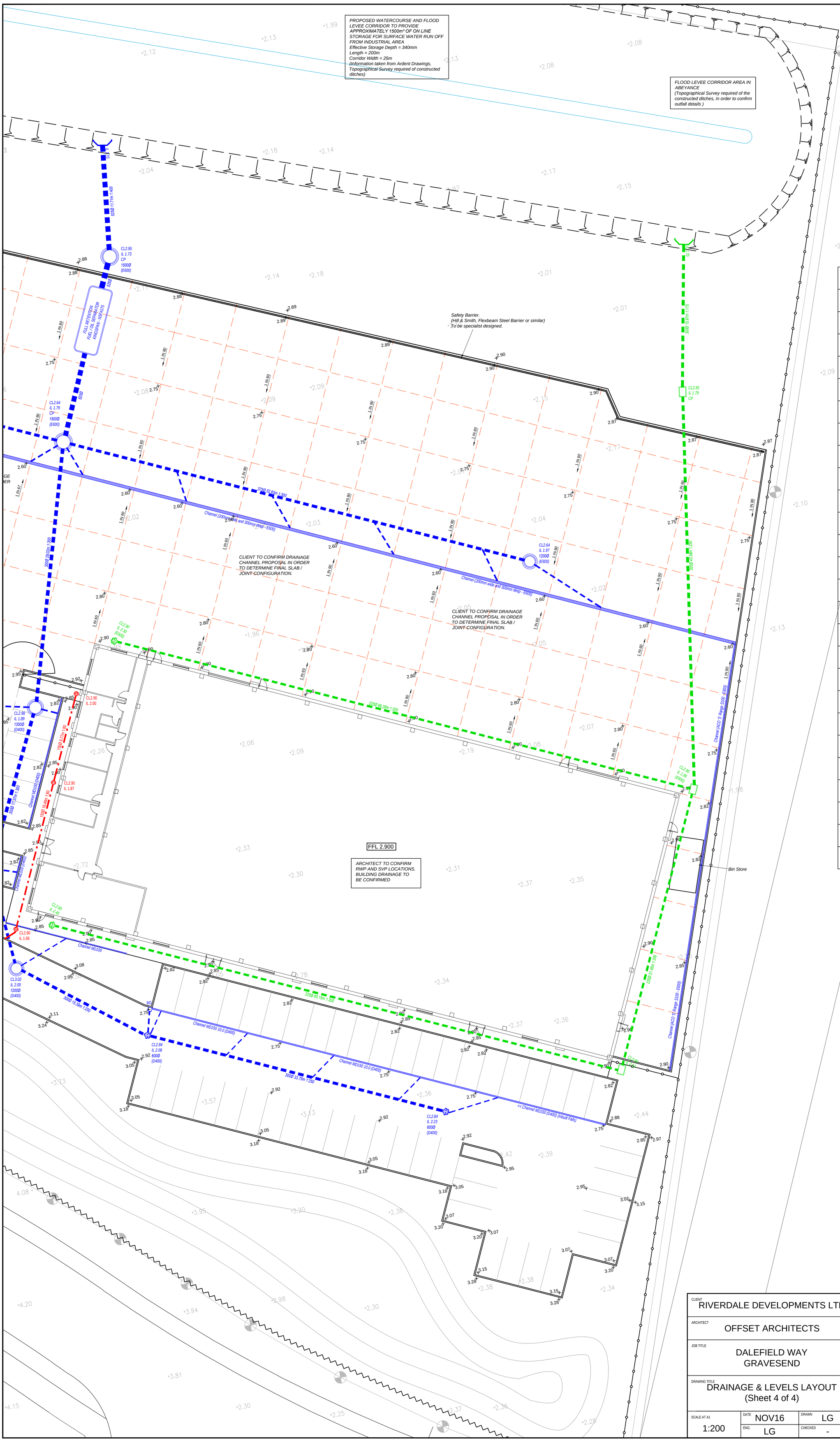
JOB TITLE
DALEFIELD WAY
GRAVESEND

DRAWING TITLE
DRAINAGE & LEVELS LAYOUT
(Sheet 3 of 4)

SCALE AT A1	DATE	DRAWN
1:200	NOV16	LG
	ENG. LG	CHECKED -

SWP
STEPHEN WILSON PARTNERSHIP LTD.
CONSULTING STRUCTURAL & CIVIL ENGINEERS
99, South Street, Eastbourne, Sussex, BN21 4LU
Telephone: 01323 412020. Facsimile: 01323 432129
E.Mail: info@swpeast.co.uk

JOB No.	DRAWING No.	REV.
E6659	203	D



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10. PLEASE REFER TO DRAWING E6659/201 (DRAINAGE LAYOUT - SHEET 1) FOR FULL SET OF DRAINAGE NOTES.

DRAWING LEGEND

SURFACE WATER DRAINAGE	
	PROPOSED SURFACE WATER DRAINAGE (From Roof Areas Only)
	PROPOSED SURFACE WATER DRAINAGE
CL##.## IL ##.##	TYPE 1-2 PRECAST CONCRETE RING MANHOLE
CL##.## IL ##.##	TYPE 3 INSPECTION CHAMBER (Max 3m depth to invert, CP denotes Catchpit) Chambers deeper than 1.2m to be non-entry.
RG	ROAD GULLY (450Ø x 900dp, trapped)
	PROPOSED HEADWALL
Channel	CHANNEL DRAIN (Type Noted on drawing, all outlets to have sumps)
Fuel / Oil Separator	FUEL / OIL SEPARATOR (Kingspan Full Retention NSF Range or similar)
FOUL WATER DRAINAGE	
	FOUL SEWER CONSTRUCTED AS PART OF ADJACENT SITE (Design by Ardent - Drg. B146-8000)
	PROPOSED FOUL WATER DRAINAGE
	PROPOSED FOUL RISING MAIN
CL##.## IL ##.##	TYPE 1-2 PRECAST CONCRETE RING MANHOLE
CL##.## IL ##.##	TYPE 3 INSPECTION CHAMBER (Max 3m depth to invert) Chambers deeper than 1.2m to be non-entry.
FG	FOUL GULLY
	PACKAGED FOUL PUMPING STATION (To be designed by Specialist)
MISC	
FFL 96.875	PROPOSED BUILDING FINISHED FLOOR LEVEL
× 97.80	PROPOSED SPOT LEVEL
× 97.80	EXISTING SPOT LEVEL
	PROPOSED EMBANKMENT
1:80	GRADIENT OF FALL
	CONCRETE BAY SLAB LAYOUT (Phase 1 - 6m x 6m Bays) (Joint details, To Be Confirmed)
	CONCRETE BAY SLAB LAYOUT (Phase 2 - 6m x 6m Bays) (Joint details, To Be Confirmed)
	INTERGRAL RETAINING WALL / RAISED DPC

N

COLOURED DRAWING
REQUEST A COLOURED COPY IF THIS STAMP IS NOT RED

PRELIMINARY

REV.	DATE	DESCRIPTION
D	22.05.17	Phase 2 Drainage and Levels updated
C	24.02.17	Phase 2 Carpark levels and drainage added
B	21.12.16	Yard Area and Office Parking Bays layout updated as per Architects revised plan. Drainage and levels updated to suit.
A	29.11.16	Concrete Bay Layout updated, Drainage updated to Client comments. Safety Barrier Added.

CLIENT
RIVERDALE DEVELOPMENTS LTD

ARCHITECT
OFFSET ARCHITECTS

JOB TITLE
DALEFIELD WAY
GRAVESEND

DRAWING TITLE
DRAINAGE & LEVELS LAYOUT
(Sheet 4 of 4)

SWP
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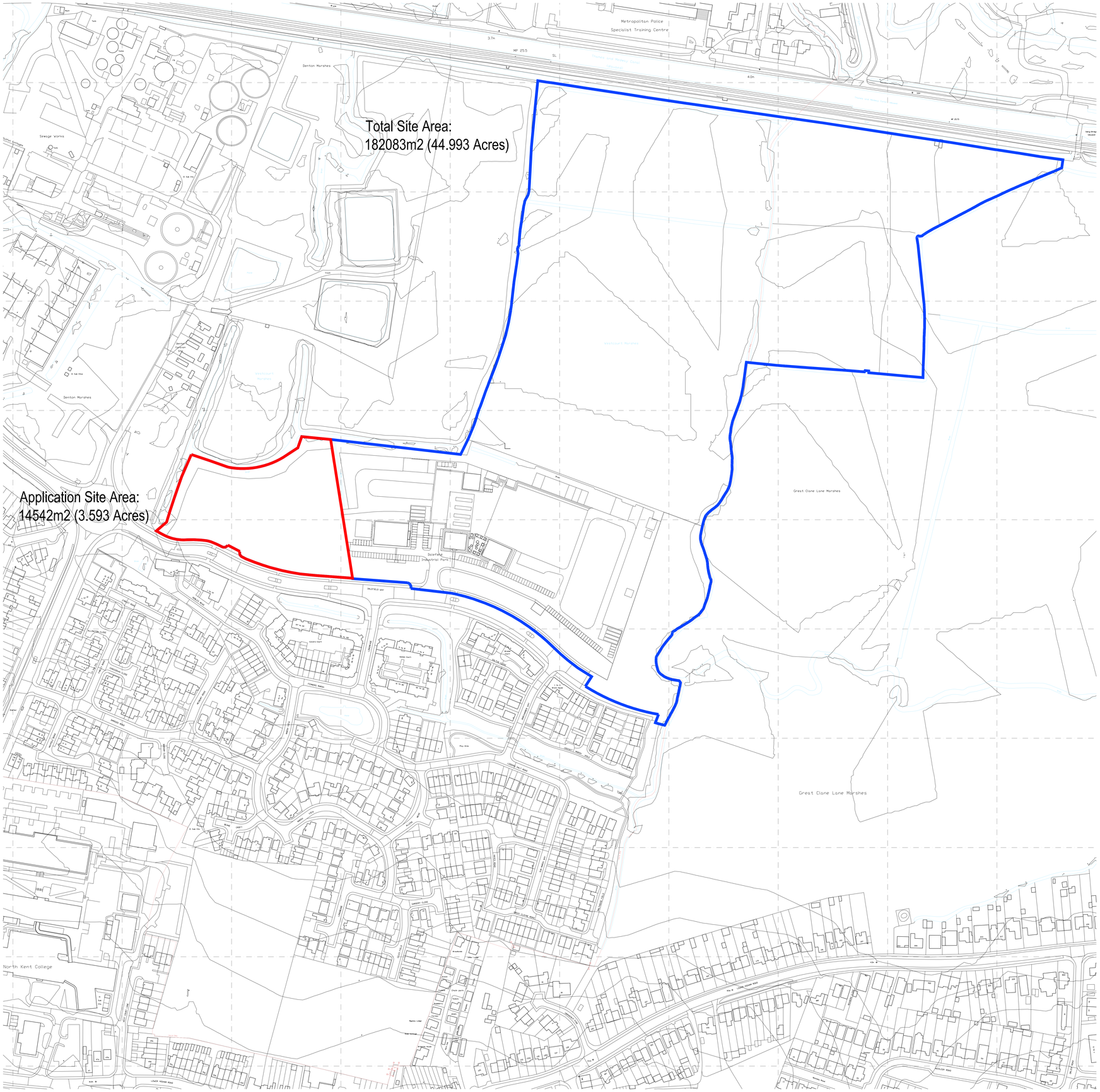
SCALE AT A1	DATE	DRAWN	JOB No.	DRAWING No.	REV.
1:200	NOV16	LG	E6659	204	D
	ENG. LG	CHECKED -			

Appendix F – Proposed Architectural Site Layout - West



Site Ownership

Application Site

N

General Notes

The drawing is copyright of Darling Associates. This drawing shall not be scaled. All dimensions are in mm unless otherwise stated. All dimensions shall be checked on site prior to commencing the works and any discrepancies to be reported to Darling Associates. All works shall conform to the current edition of the building regulations and other statutory requirements. All materials and workmanship shall conform with the relevant British Standard specifications and codes of practice. If this drawing forms part of an application for planning permission, it shall not be used for any other purpose without the express permission of Darling Associates. This drawing may incorporate information supplied by professionals, Darling Associates cannot accept responsibility for the integrity and accuracy of such information. Any clarification and/or additions that are required appertaining to such information should be sought from the relevant profession or their appointment representatives.
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0 12.5m 62.5m 125m 150m

Notes

REV	NOTES	DATE	BY	AUTH

DARLING ASSOCIATES
ARCHITECTS

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London SW1P 1PQ
UK

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DRAWING STATUS
Planning

TITLE
Existing
Site Location Plan

PROJECT
Land at Dalefield Way (West), Gravesend

SCALE AT A0:	SCALE AT A3:	
1:1250	N.T.S.	
JOB NO.	DRAWING	REV.
25008	**00-0-00**	**-**

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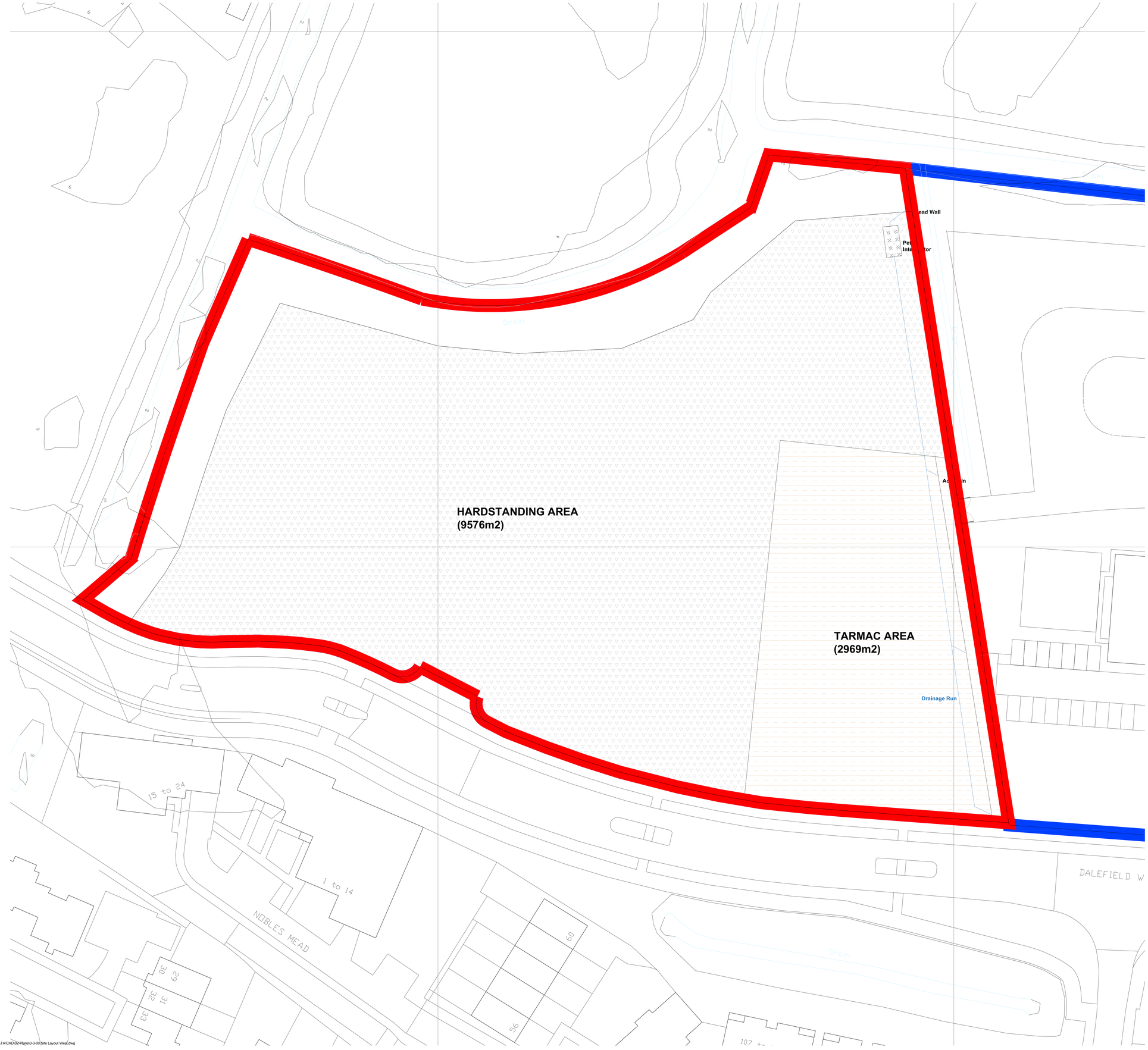
G:\Project Data\25008 Gravesend Yard - Open Storage\DATA\CAD\02-Plans\0-0-00 Site Location Plan - West.dwg



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0 2.5m 12.5m 25m 30m

Notes

HARDSTANDING AREA

TARMAC AREA

APPLICATION BOUNDARY

REV	NOTES	DATE	BY	AUTH

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ARCHITECTS

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DRAWING STATUS
Planning

TITLE
Proposed
Site Layout

PROJECT
Land at Dalefield Way (West), Gravesend

SCALE AT A0: 1:250
SCALE AT A3: N.T.S.

JOB NO. **25008**
DRAWING **0-3-00**
REV. **-**

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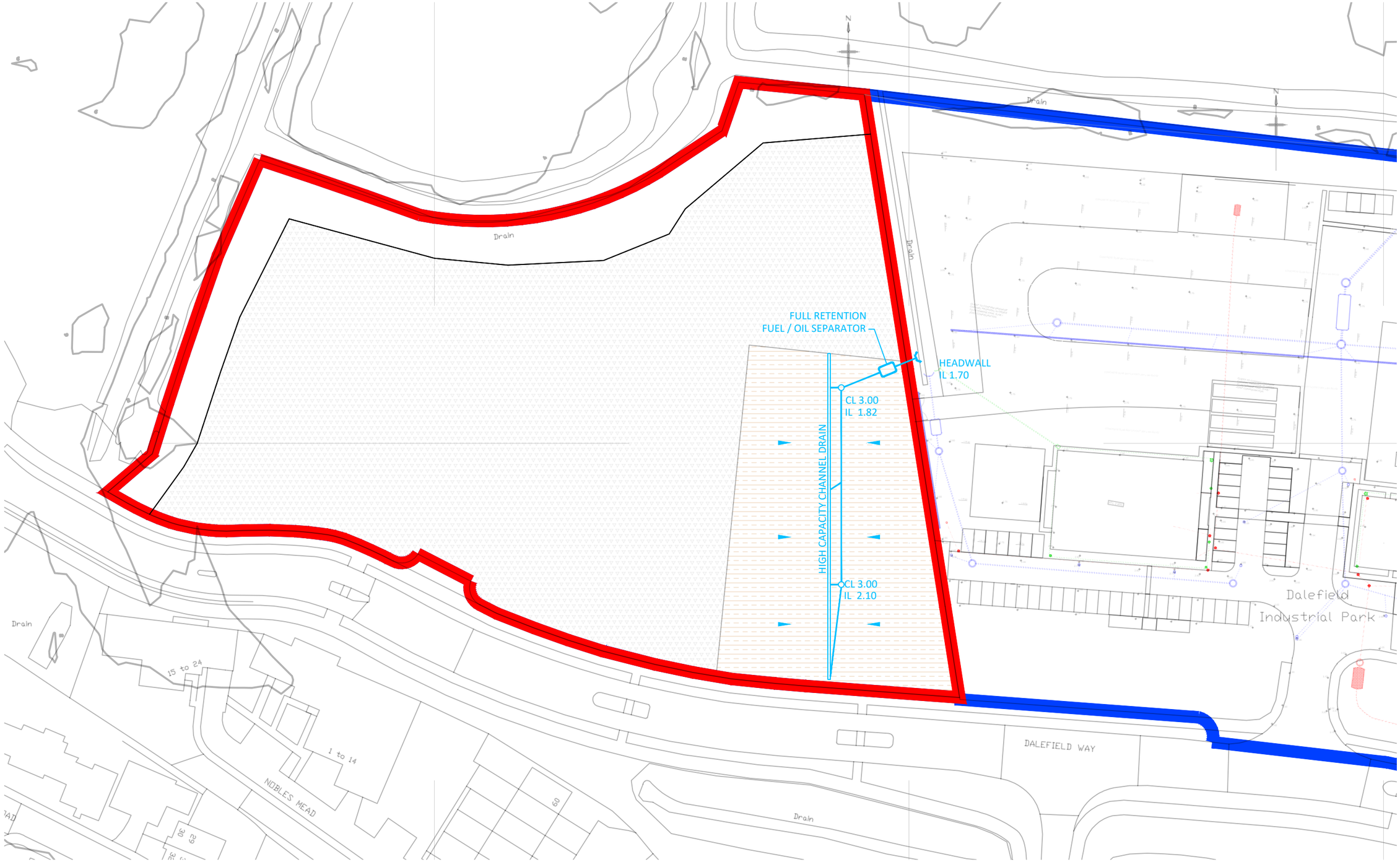
G:\Project Data\25008 Gravesend Yard - Open Storage\DATA\CAD\02-Plans\0-3-00 Site Layout West.dwg

Appendix G – Proposed Drainage Strategy



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CONSULTING ENGINEERS

Manhire Associates Limited
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76 Coombe Road, Norbiton
Kingston Upon Thames, KT2 7AZ

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F: +44 20 8390 7888
E: enquiries@manhireassociates.co.uk

NOTES

REV	DATE	DESCRIPTION	BY

PROJECT LAND AT DALEFIELD WAY (WEST) GRAVESEND

TITLE PRELIMINARY DRAINAGE STRATEGY

PROJECT NO 24054

DRG NO PSK800

DATE MAY 25

REV 00

BY GMC

CHK –