Gavray Drive West
BICESTER

FLOOD RISK ASSESSMENT
& DRAINAGE ASSESSMENT
April 2015

Prepared by
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on behalf of **Gallagher Estates Ltd**
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Contract

This report describes work commissioned by Gallagher Estates Ltd in March 2014. Gallagher Estates Ltd representatives for the contract were Andrew Hawkes and Kevin Brown. Enora Lucas, Sophie Dusting and Olivier Saillofest of JBA Consulting carried out this work.

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Purpose

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Executive Summary

Background

JBA Consulting was commissioned by Gallagher Estates Ltd. in March 2014 to prepare a Flood Risk Assessment (FRA) for a proposed residential development at Gavray Drive West, Bicester.

The site is approximately 6.7ha in size and is classified as Greenfield. The site is bounded by the Langford Brook to the east, the Chiltern railway line to the north, the Oxford and Bletchley freight line to the west and Gavray Drive to the south. The proposed development comprises up to 180 dwellings.

Flood Risks

An assessment of historical flooding at the site has been undertaken. Table 7.1 of the 2009 Level 1 SFRA identifies a number of historic flood events which have occurred in Bicester. None are thought to have flooded the proposed development site.

The Level 1 SFRA produced by CDC Council and the Environment Agency flood maps show that the site lies within Flood Zones 1, 2 and 3.

The NPPF classifies residential infrastructure as "More Vulnerable" and their construction is permitted within Flood Zones 1 and 2.

Flooding from groundwater and sewer / drainage sources are considered to represent a low flood risk to the site.

Surface water flooding is currently considered to represent a low flood risk to the site. Development of a site will, however, increase the area of impermeable surfaces and will increase surface water flood risk if additional runoff is not attenuated.

Floodplain Compensation

The proposed development is shown to encroach within the 100-year with climate change floodplain. As such, a level-for-level floodplain compensation scheme will be provided to ensure water is not displaced elsewhere.

In a 100-year with climate change flood event, approximately 1512m^3 of floodplain capacity would be lost as a result of the development. An area located along the Langford Brook's Right Hand Bank and outside of the 100-year floodplain was selected to provide approximately 1513m^3 of floodplain compensatory volume during the same flood event. Intermediate water levels generated during more frequent flood events will benefit from up to 658m^3 of additional floodplain capacity.

The effect of the proposed level-for-level floodplain compensation scheme on 100-year with climate change levels was simulated using the Langford Brook hydraulic model. Results indicate a decrease of up to 80mm in peak water levels within the site boundary.

Mitigation of Flood Risk

The level-for-level floodplain compensation scheme will ensure that the proposed dwellings remain outside of the 1,000-year floodplain.

A review of modelled flood levels indicates that proposed ground levels within the site will remain at least 600mm higher than the 100-year plus climate change flood levels.

Therefore, as required by Part H of the Building Regulations, it is proposed to raise the minimum finished floor level of the proposed dwellings to a minimum of 150mm above the surrounding ground level to mitigate against surface water and groundwater flood risk. It is also recommended that all floors should be of solid construction or sealed beneath suspended floors to prevent the ingress of groundwater.

Surface Water Drainage Strategy

The proposed Surface Water Drainage Strategy will attenuate surface water runoff to a 1 in 2-year Greenfield rate for all storm events up to the 1 in 100-year with climate change event. Due to the low soil permeability rate, surface water runoff will be discharged into the Langford Brook. Surface water from roof areas will discharge via downpipes into the on-site drainage system. Crushed stone blankets located beneath highways and a storage basin on the site's eastern boundary will provide on-site storage. Additional attenuation may be provided by installing water butts immediately downstream of the downpipes. Attenuated runoff from the site will be discharged to the Langford Brook via a pipe from the storage basin.

The crushed stone blankets and the storage basin will both provide treatment to runoff. Additional treatment could be provided by source control features such as water butts or permeable paving on driveways. Overall, the proposed surface water drainage system is expected to provide 2 to 3 treatment drains for runoff pollution.

Benefit to Third Party Land

The proposed surface water drainage strategy and level-for-level floodplain compensation scheme will result in a reduction in fluvial flows leaving the site during both surface water and fluvial flood events. Residents from Langford Village will benefit from these peak flow attenuations.

Contents

Contents

List of Figures

List of Tables

Abbreviations

AEP ..... Annual Exceedance Probability

CC ..... Climate Change

CIRIA ..... Construction Industry Research and Information Association

DEM ..... Digital Elevation Model

EA ..... Environment Agency

FCS ..... Flood Compensation Scheme

FFL ..... Finished Floor Level

FRA ..... Flood Risk Assessment

Ha ..... Hectares

ISIS ..... 1D hydraulic modelling software

ISIS-TUFLOW ..... 1D-2D hydraulic modelling software

M AOD ..... Metres Above Ordnance Datum

PPS25 ..... Planning Policy Statement 25

rCWS ..... retained County Wildlife Site

SFRA ..... Strategic Flood Risk Assessment

SUDS ..... Sustainable Drainage Systems

WiNDES ..... MicroDrainage Software

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1 Introduction

1.1 Terms of reference

JBA Consulting was commissioned by Gallagher Estates Ltd. in March 2014 to prepare a Flood Risk Assessment (FRA) for a proposed residential development at Gavray Drive West, Bicester. The proposal is for approximately 180 dwellings including affordable housing, public open space, localised land remodelling and structure planting.

This FRA report provides information on the nature of flood risk at the site and follows Government guidance with regards to development and flood risk.

1.2 FRA Requirements

This FRA follows government guidance on development and flood risk, within the National Planning Policy Framework (NPPF).

It is a requirement for development applications to consider the potential risk of flooding to a proposed development over its expected lifetime and any possible impacts on flood risk elsewhere, in terms of its effects on flood flows and runoff. Where appropriate, the following aspects of flood risk should be addressed in all planning applications within flood risk areas:

- The area liable to flooding.
- The probability of flooding occurring now and over time.
- The extent and standard of existing flood defences and their effectiveness over time.
- The likely depth of flooding.
- The rates of flow likely to be involved.
- The likelihood of impacts to other areas, properties and habitats.
- The effects of climate change.
- The nature and expected lifetime of the development and the extent to which the development is designed to deal with flood risk.

This FRA follows government guidance on development and flood risk, within the NPPF.

All new developments must comply with the flood risk guidance set out in the NPPF. As the development is greater than 1ha in area and partially lies within the 1,000-year floodplain, a detailed flood risk assessment is required to consider the risk to the development from all sources of flooding including fluvial (river), tidal, coastal, pluvial (surface runoff / surcharging sewers) and groundwater. The NPPF advocates a risk-based approach to flood risk management in terms of appraising, managing and reducing the consequences of flooding both to and from a development site. The SFRA and Local Development Documents set out a series of requirements for site specific FRAs. These are aligned with the NPPF requirements and it is consider that the proposed development meets the requirements as part of this FRA.

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2 Site Details

2.1 Description

The proposed development site is located at Gavray Drive, approx. 1.3km east of Bicester town centre in Oxfordshire. The existing site is 6.7 ha in size and currently is Greenfield.

The proposed development site is bounded by the Langford Brook to the east, the Chiltern railway line to the north, the Oxford and Bletchley freight line to the west and Gavray Drive to the south (see Table 2- 1 Table 2- 1 for location).

A photograph of the proposed development site and the Langford Brook is shown in Figure 2- 1.

Table 2- 1: Site Details

Site name	Gavray Drive West, Bicester development
Site area	6.7 ha
Existing land-use	Greenfield
Purpose of development	Residential
OS NGR	SP 59450 22450
County	Oxfordshire
Country	England
Local Planning Authorities	Cherwell District Council
Lead Local Flood Authority	Oxfordshire County Council

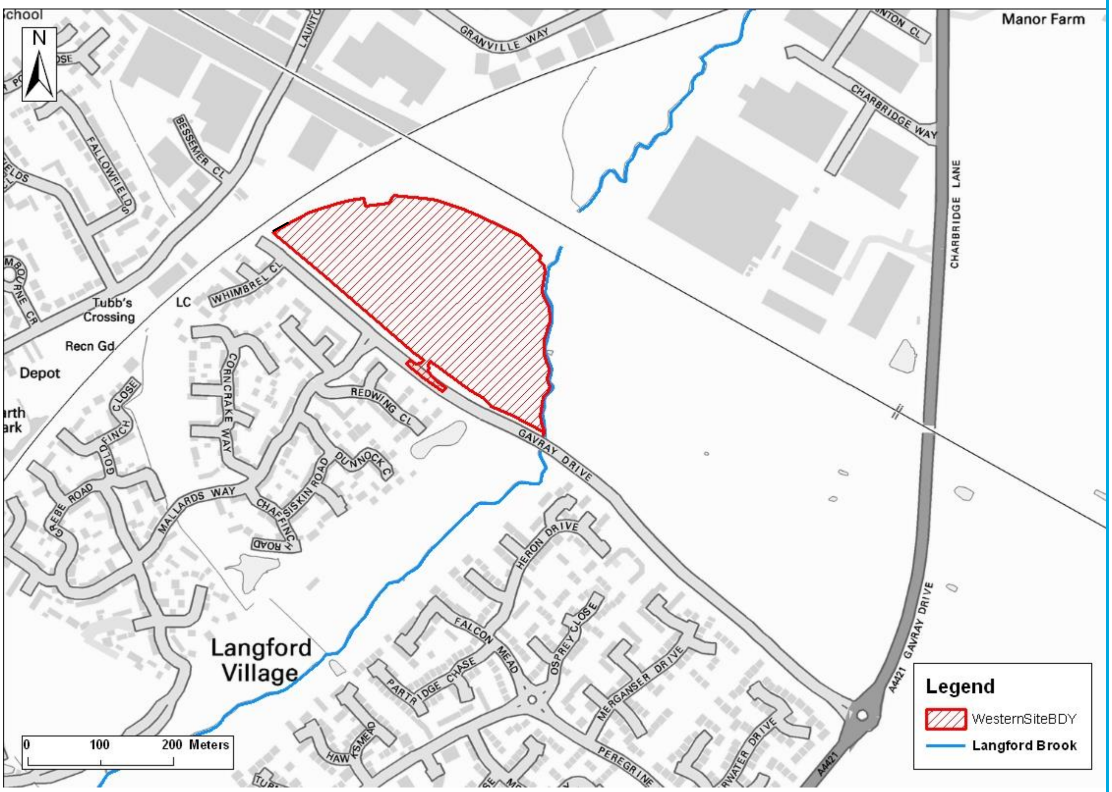

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Figure 2- 1: Photograph of the proposed development site at Gavray Drive West, Bicester

Description: View standing on Gavray Drive, looking north-west across the proposed development site. The line of trees marks the right bank of Langford Brook.

2.2 Proposed Development

The proposal is for approximately 180 dwellings including affordable housing, public open space, localised land remodelling and structure planting.

To comply with a request from Oxfordshire County Council, the design of drainage to all highways on site integrates porous block paving which allows surface waters to soakaway to an underlying stone blanket. This stone blanket is to be surrounded with a permeable geotextile which allows percolation of the surface water into the surround ground. The stone blankets are laid with a gradient of at least 1 in 500 to allow surface water to flow down to points of outfall before entering a surface water attenuation pond.

Appendix A shows the proposed development site layout.

3 Site Investigation Work

3.1 Site History

Historical mapping of the site indicates that little development has taken place on the site over the last 100 years. Maps dating back to 1881 indicate the presence of several farm buildings on the southern site boundary

3.2 Site Investigation

3.2.1 2006 Site Investigation (Wardell Amstrong LLP)

Site Investigation was carried out during 25 October and 2 November 2006 under full time supervision by Wardell Armstrong LLP and comprised the following:

- Light Percussion boreholes (small rig capable of 5.0m holes).
- Trial pits (excavated using JCB wheeled digger).
- California Bearing Ratio (CBR) tests (assessment of near surface strength).
- 1 Soakaway test (assessment of percolation of water into the ground).
- Geotechnical laboratory and in-situ testing (testing to determine the strength and physical characteristics of the soils).
- Geochemical laboratory testing (testing for likely contaminants).
- Ecological watching briefs.
- Archaeological watching briefs.

The materials encountered during the site investigation were generally as follows:

- Topsoil/Subsoil – topsoil and subsoil materials were noted to exist across the majority of the site to depths of between 0.09m and 0.55m although generally topsoil was found to be between 0.2m and 0.35m thick.
- Ploughed horizon (logged as made ground) – a relatively thin layer of reworked natural material with some brick and inert material was encountered up to a maximum depth of 1.30m below ground level (bgl) but generally around 0.50m bgl.
- Natural Relatively Recent Deposits – these materials were alluvial in origin and variable in nature, typically comprising brown sands and clays with sandstone and quartzite gravel encountered to depths of around 2.0m and 3.15m bgl.
- Solid geology – Firm to stiff grey and brown silty clays to depths of approximately 2.5m bgl.

3.2.2 In Situ Testing

Standard Penetration Tests (SPTs) were carried out within the boreholes drilled to assess the strength of the materials. These tests assess the strength of the materials in-situ during the drilling of the boreholes. SPT tests were performed in the ploughed horizon materials and indicated loose/soft in nature. The tests undertaken within the superficial clay indicated soft to stiff. The tests undertaken in the weathered Kellaways clay indicated firm to very stiff clay.

The SPT test results indicate that the superficial clays have variable strength characteristics. The strength characteristics generally improve with depth and the weathered Kellaways strata is considered to be moderately to highly weathered at shallow depth and generally firm to stiff. The materials are therefore considered to be predominantly clay materials with a low to very low permeability.

CBR tests were undertaken across the site to assist the preliminary design of roads and pavements. The tests were undertaken at between 0.60m and 0.95m bgl and indicated that shallow materials were low strength. This low strength within the cohesive materials at shallow depth is indicative of softening of clay materials at the surface which could be a result of poor drainage through the materials and therefore retention of water within these shallow materials during periods of wet weather.

A soakaway test was conducted to investigate the potential permeability of the near surface soils and to determine the suitability of the site for Sustainable Urban Drainage Systems (SUDS). The soakaway test was undertaken within the land to the west of the brook. The results of this test showed no drop in water level indicating negligible water ingress into the ground over the test period of 4 hours.

3.2.3 Groundwater

Groundwater was encountered within the majority of positions. Seepage was recorded at depths of between 0.45m and 2.4m bgl. Subsequent groundwater monitoring via standpipes installed during site investigation works indicated groundwater levels at between 0.1m and 0.7m bgl across the majority of the site. The deepest groundwater was recorded at 3.0m bgl in SL33.

This variability in the groundwater levels across the site may be due to perched groundwater within discrete isolated pockets of granular material within the clay materials. At the time of the groundwater monitoring there was evidence of surface ponding of water within areas of the site. It is therefore likely that some of the shallower groundwater levels are representative of the recharge of these isolated granular pockets within the clay materials by surface water.

As mentioned previously it is likely that there is little throughput of groundwater across the site although localised transmission may be possible through discontinuous and variable granular lenses as recorded in one of the ground investigation logs (e.g. SL16 0.6m – 1.0m).

3.3 Site Geology

The Environment Agency (EA) have included on their website aquifer designations which have been published by the British Geological Society (BGS) which replace the former groundwater vulnerability maps previously used to assess the potential permeability of the site as a whole. The majority of the site has been given an aquifer designation of “Unproductive Strata” by the BGS, however the plans indicate that the vicinity of the Langford Brook is considered to be Secondary A aquifer. This is strata capable of supplying water on a localised basis and also potentially active in supplying base flow to watercourses.

This assessment is based on the designation of the geological strata present and the generalised permeability of that strata. The designation of the majority of the site as Unproductive Strata is supported by the permeability testing

3.4 Site Topography

A topographic survey of the development site is provided in Appendix B. It shows that the site slightly slopes in an easterly direction towards the Langford Brook. The ground level at the nearest road (Gavray Drive) is approximately 68.1m AOD. The approximate ground level where the development is situated is between 66.6 and 69.2mAOD. The lowest point in the site is adjacent to the Langford Book, outside the security fence, and is at approximately 66.36m AOD.

3.5 Existing Drainage Regime

Within the site water ponding was noted following heavy rainfall within hollows and topographically low areas. This was noted also during the site works undertaken in August 2010.

4 Planning Policy and Flood Risk

4.1 Development Site Flood Zones

The Environment Agency (EA) states that the flood risk is a function of:

- *"The likelihood of a particular flood happening, best expressed as a chance or probability over a period of one year. For example, 'There is a 1 in 100 chance of flooding in any given year in this location'.*
- *The impact or consequences that will result if the flood occurs."*

The EA categorise the risk into a series of flood zones; a definition of the flood zones can be found in Table 4- 1. The EA has developed a Flood Map which shows the risk of flooding in England and Wales for different return period events. This map provides the basis for the assessment of flood risk and development suitability to NPPF. Section 4.3 shows how the Flood Zones relate to a sequential planning response, as advised by the NPPF.

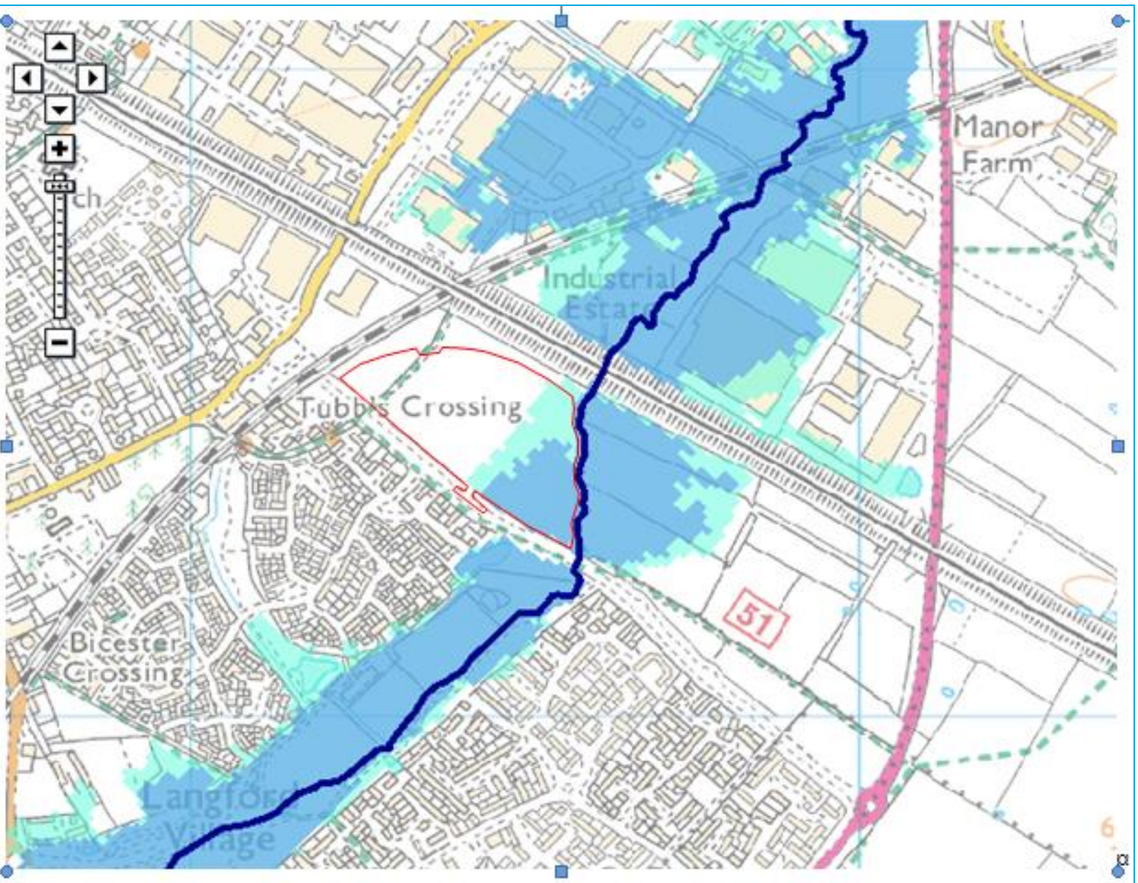
The EA Flood Zone Map does not take into account flood defences or the 'residual risk'. These are accounted for when the EA discuss the 'likelihood' of flooding, alongside predicted flood levels, and ground levels.

It is important to note that the EA's Flood Map is, in the majority of cases, based on broad-scale river modelling and provides an indication of the potential flood risk to a site rather than a detailed assessment. When a detailed river modelling study is undertaken, the broad-scale river model outputs are updated using the detailed river model.

Figure 4-1 is an extract from the EA website (http://maps.environment-agency.gov.uk/wiyby/) and shows the EA Flood Zones for the proposed development site and surrounding area. The EA Flood Maps show the proposed development site is at risk of fluvial flooding from the Langford Brook and is to be sited in Flood Zones 1, 2 and 3 (low, medium and high risk of fluvial and coastal flooding respectively).

The NPPF classifies residential infrastructure and associated car parking facilities as "More Vulnerable" and their construction is permitted within Flood Zones 1, 2 and 3a providing the Exception Test is passed. There are advisory notes placed upon this type of development, which are detailed in Table 4- 2. Details of Sequential and Exception Tests are provided in

Figure 4-1: Environment Agency Flood Zone maps at the proposed development site and surrounding area



Map legend:

Flooding from rivers or sea without defences

Extent of extreme flood

Main rivers

Flood defences (Not all may be shown*)

Areas benefiting from flood defences (Not all may be shown*)

Site boundary **

*The EA are gradually adding flood defences and areas benefiting from defences to the Flood Map through updates therefore not all may be shown.

**Approximate site boundary.

4.2 Planning Context

4.2.1 Applicable Planning Policy

The NPPF considers flood risk to developments using a sequential characterisation of risk, based on planning zones and the EA Flood Map. The main study requirement is to identify the flood zones and vulnerability classification relevant to the proposed development, based on an assessment of current and future conditions.

4.3 NPPF Flood Zones

Appendix C, Table 4- 1 shows how the Flood Zones relate to a sequential planning response. There are advisory noted placed upon this type of development, which are detailed in Appendix C, Table 4- 2. Details of Sequential and Exception Tests are provided in Appendix C,Table 4- 3.

4.4 Planning for flood risk

The NPPF classifies residential infrastructure as 'More Vulnerable' and their construction is permitted within Flood Zones 1 and 2.

When planning a development a sequential approach should be applied to identify suitable sites which are at minimal risk from flooding and avoid Flood Zones 2 and 3 wherever possible. The overall aim of decision-makers should be to steer new development to Flood Zone 1. If there are no suitable areas identified in Flood Zone 1 then sites with the lowest flood risk should be considered next. The Sequential Test aims to promote development in areas with low flood risk, and to direct more vulnerable developments away from flood risk zones. The SFRA is produced to help guide the basis for the application of the Sequential Test.

The Exception Test aims to demonstrate that a development located within a Flood Zone will remain safe and provide sustainability and community benefits. The Exception Test is only required to be passed for certain development types within specific Flood Zones (see Table 4-3). As the proposed development site currently lies within Flood Zones 1, 2 and 3, the Exception Test must be passed.

Surface water flood risk should also be considered when planning the site layout, ensuring that new development is directed away from surface water conveyance routes or areas of deep ponding. This is covered further in section 5.2.

Proposals for development should ensure that, if possible, emergency access to the site will be available at all times. For this reason there should be at least one access road which does not pass through an area at risk of flooding.

4.5 Sequential and Exception Tests

It has therefore been assumed that the Sequential Test has been passed for this development.

The Exception Test is used to demonstrate that a development site within a flood risk zone will be suitable; assuming it has already passed the Sequential Test, or that the Sequential Test is not required. The proposed residential development is required to pass the Exception Test as part of this FRA.

As the whole residential footprint will remain Table 3 of NPPF

The criteria which must be met to pass the Exception Test is as follows:

- It must 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.
- A site-specific FRA must demonstrate that the site will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere and, where possible, will reduce flood risk overall.

This site is deemed to have passed the Exception Test, as it meets the two conditions above by:

1. The proposals are for approximately 180 residential units, including affordable housing, contributing to CDC housing delivery targets. The proposed development is considered to be sustainable as it is situated east of Bicester town centre within an urban area, adjacent to existing residential development and is accessible to the main urban centre where development is generally focussed. Such a location is able to provide increased access to all types of facilities and a good level of public transport. The construction will also generate employment and socially the proposals contribute to any shortage of housing, meeting the aims of the Bicester Masterplan[1].

[1] http://www.cherwell.gov.uk/media/pdf/5/t/Bicester_Masterplan_-_Consultation_Draft_(August_2012)_resize_100.pdf

2. The whole residential footprint of the proposed development will be located outside of the 1,000-year floodplain, following the implementation of the proposed floodplain compensation scheme.
3. A formal drainage system will be provided to ensure effective drainage of the site and reduce runoff leaving the site during storm events.
4. The combination of 2. and 3. above will reduce flood risk to third party lands downstream of the proposed development

4.6 Regional and local policy and guidance review

4.6.1 Adopted Cherwell Local Plan

The 1996 Cherwell Local Plan is the adopted development plan for Cherwell District Council (CDC). A list of Saved Policies indicates that the saved flood risk policies are not applicable to the proposals and nature of flood risk at the development site.

4.6.2 Submission Cherwell Local Plan

The Submission Local Plan does not have Development Plan status - it has currently been submitted to the Secretary of State for Communities and Local Government - but it is a material planning consideration. The Submission Local Plan sets out CDC's strategy for the District until 2031. The policies considered to be material to the proposals and flood risk are listed below:

- ESD1: Mitigating and Adapting to Climate Change
- ESD6: Sustainable Flood Risk Management
- ESD7: Sustainable Drainage Systems
- ESD13: Protection & Enhancement of Biodiversity & the Natural Environment

Documents detailing the policies requirements were not available.

4.6.3 Non-Statutory Cherwell Local Plan

The Non Statutory Cherwell Local Plan 2011 was intended to review and update the Local Plan adopted in 1996. Due to changes to the planning system introduced by the Government, work on this plan was discontinued prior to adoption.

The Non Statutory Local Plan 2011 is not part of the statutory development plan but it has been approved as interim planning policy for development control purposes.

The policies considered to be material to the proposals and flood risk are listed below:

H1a: Location of New Housing. The proposals for new housing development will be considered against the physical and environmental constraints on development land including flood risk and climate change.

EN14: Flood Defence. In areas at risk from flooding, new development, the intensification of development or land raising will not be permitted if the proposals would:

- Result in a new loss of floodplain storage
- Impede the flow of flood water
- Increase the risk of flooding elsewhere

EN15: Surface Water Run-off and Source Control. New development generating increased surface water run-off likely to result in an adverse impact to surface drains and watercourses such as an increase in the risk of flooding, will not be permitted unless the proposals include appropriate source control and / or attenuation measures.

4.6.4 CDC and West Oxfordshire District Council Level 1 SFRA

The proposed development site has been identified as a Potential Development Site and was considered in the 2009 Level SFRA review for Cherwell and Oxfordshire District Council's (ID reference B1 31, Bicester SE quadrant). The information contained in the SFRA regarding flood risk and development, applicable to the proposed development site, is summarised below.

Sources of flood risk

- **Fluvial flood risk**: The SFRA mapping shows that the proposed development site is located within Flood Zones 1, 2, 3a and 3b. The SFRA mapping of the Langford Brook flood risk is based on EA detailed hydraulic modelling. Flood defences are shown on the SFRA maps. During flood events, considerable inter-relation resulting in backwater effect is known to have arisen upstream from the confluences of the Langford Brook.
- **Historical flooding**: A number of historic flood events in CDC are listed in Table 7.1 of the SFRA. None are thought to have flooded the proposed development site.
- **Pluvial / Surface Water and Sewer flood risk*:** No data available.
- **Groundwater flood risk:** No Aquifer. Not considered to be materially affected.
- **Flooding from artificial sources (reservoirs/canals/other)*:** Not affected.

*Note: SFRA categorised the data as "low confidence data".

The SFRA placed requirements on development in the Bicester SE quadrant, as detailed in section 1.2.1 of this report.

The proposed development site was not assessed within the 2012 Level 2 SFRA for CDC.

4.6.5 Catchment Flood Management Plan

The EAs River Thames Catchment Flood Management Plan (CFMP) was published in December 2009. This establishes current and future levels of flood risk within the River Thames catchment, setting appropriate flood risk management policies accordingly. The proposed development site lies within the Towns and villages in open floodplain (north and west) sub-area (policy unit), for which the preferred policy is policy option 6: areas of low to moderate flood risk where we will take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits. A number of specific actions were established to implement this policy, none of which have specific relevance for the site.

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5 Current flood risk

This study assesses the risk from different types of flooding to the proposed development and the risk of flooding elsewhere from the proposed development; as well as how these flood risks can be managed.

The main types of flooding that may apply to the proposed development site are: fluvial flooding (Langford Brook) and surface water flooding (overland flows due to impermeable surfaces).

The approach to assessing flood risk at the development site was informed by the requirements of NPPF in conjunction with the client and Environment Agency requirements. To meet the above objectives a desk-based study was used. The primary objectives of this FRA are to determine the following:

- Whether the site is at significant risk from any forms of flooding;
- If the site is at risk of flooding, determine if safe access to and from the site will be maintained during an extreme flood event; and,
- The impact of the development on flood risk to other sites, with particular focus on the effects of surface water from the site.

5.1 Historical flooding

An assessment of historical flooding at the proposed development site has been undertaken.

The British Hydrological Society's 'Chronology of British Hydrological Events' database was consulted; however, no site-specific historical records of flooding were found for the proposed development site.

A search on the Internet regarding flooding at the proposed development site was undertaken. No records of historic flooding were found pertaining to the site.

Proposals for development should ensure that emergency access to the site will be available at all times. For this reason there should be at least one access road which does not pass through an area at risk of flooding. The main access road, the Gavray Drive, is not shown to be at risk of flooding through the historical flood risk assessment.

No other records of historic flooding were found pertaining to the site.

5.2 Fluvial Flood Risk

In 2010, the Environment Agency developed a new hydraulic for Bicester that includes the Langford Brook. The model is based on the ISIS-TUFLOW software.

Model results indicate (see 100-year and 1,000-year flood outline in Figure 4-1) that the site is currently at risk of fluvial flooding from the Langford Brook, which flows along the eastern boundary of the site in a southerly direction, bounded by culverts at the northern and southern extents of the site boundary.

To mitigate against fluvial flood risks, a level-for-level floodplain compensation scheme was designed. This is further discussed under Section 6.

5.3 Surface Water Flood Risk to the site

The historical assessment did not show any records of surface water flooding within the proposed development site and the Level 1 SFRA did not have any data available regarding surface water flooding.

The EA website “what’s in your backyard” displays mapping that shows the risk of surface water. Figure 5- 1 represents the risk of flooding from Surface Water and shows that the proposed development site is largely at low risk of surface water flooding. Small, isolated areas at medium to high risk to surface water flooding are located around the vicinity of: the Langford Brook and the Chiltern railway line. An area of high risk to surface water is shown to the south-east corner of the site, around the vicinity of the culverts under Gavray Drive.

Figure 5- 1: Surface Water Flood Map

Map legend:

High

Low

Medium

Very Low

Site boundary **

The Surface Water Drainage Strategy for the site (see Section 9) will reduce flood risk to a 'Very Low' risk.

5.4 Surface Water Flood Risk from the site

The majority of the site is proposed to be covered in impervious surfaces, primarily the building itself and the surrounding concreted areas. The rate and volume of surface water runoff generated on-site will increase as a result of increasing the sizes of the impervious areas. If not properly managed, this additional runoff could increase flood risk to third party land, either by directing flows towards developments or by increasing flows, and therefore water levels, in sewers, ditches and watercourses.

An outline surface water drainage strategy and a Floodplain Compensation Scheme (FCS) have been developed which will manage this extra runoff and ensure that the rate and volume of discharge from the development will not exceed the predevelopment levels. This is discussed in Section 9.

5.5 Groundwater Flood Risk

The Strategic Flood Risk Assessment (SFRA) Level 1 for Cherwell and West Oxfordshire2 states the site will not be materially affected from groundwater flooding.

Sections 3.3 and 3.2.2 highlighted the presence of clay materials across the whole of the site. On the other hand, groundwater was encountered within the majority of the site, with seepages recorded at depths of between 0.45m and 2.4m below ground level (Section 3.2.3). Subsequent groundwater monitoring via standpipes installed during site investigation works also indicated groundwater levels at between 0.1m and 0.7m bgl across the majority of the site. The deepest groundwater was recorded at 3.0m bgl in SL33.

As part of in-situ testing (See Section 3.2.2), a soakaway test was conducted to investigate the potential permeability of the near surface soils and to determine the suitability of the site for Sustainable Urban Drainage Systems (SUDS). The soakaway test was undertaken within the land to the west of the brook, in similar ground conditions to those found to the east of the brook. The results of this soakaway showed no drop in water level indicating negligible water ingress into the ground over the test period of 4 hours.

The Environment Agency's Groundwater map[2] shows the site lies on top of a Secondary A aquifer[3].

The negligible water ingress observed as part of the soakaway test puts forward the effect of clay materials in the soil. Whilst clay layer may prevent deep groundwater pockets to reach the surface, groundwater pockets located within the top soil may equally not be able to infiltrate and hence could potentially resurface in various locations of the site.

5.6 Risk of flooding from Reservoirs

The EA website *"what's in your backyard"* displays mapping that shows the risk of reservoir failure. The proposed development site is not shown to be within an area at risk of flooding from reservoirs.

[2] http://maps.environment-agency.gov.uk/wiyby/wiybyController?topic=drinkingwater&layerGroups=default&lang=_e&ep=map&scale=7&x=458588&y=222385#x=460672&y=222464&lg=1,4,&scale=7

[3] Secondary A - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

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6 Level-for-level Floodplain Compensation Scheme

The residential footprint of the proposed development will encroach within the 100-year with climate change floodplain. As such, a floodplain compensation scheme is required to ensure water is not displaced elsewhere. A level-for-level floodplain compensation scheme meeting the design requirement set by the Environment Agency in March 2014 was developed.

6.1 Loss in Floodplain capacity

As part of the proposal, it is intended to disconnect the area labelled ‘zone B’ in Figure 6- 1 from the 100-year with climate change floodplain.

Figure 6- 1: Loss in 100-year with climate change floodplain

Using a Digital Elevation Model (DEM) representing ground levels within the site boundary and in-house GIS tools, a level-area-volume relationship was derived for the extent represented by zone B. Results are indicates in Table 6- 1.

Table 6- 1: Floodplain loss volumes

Elevation (m AOD)	Area (m²)	Volume (m³)
66.3	0	
66.4	0	
66.5	40	1.47
66.6	300	15.91
66.7	1564	98.45
66.8	3764	354.30
66.9	5984	844.44
67.0	7140	1511.79

Table 6- 1 indicates that approximately 1512 m^3 of floodplain storage capacity will be lost following the implementation of the proposal.

6.2 Available Floodplain compensation area

Figure 6- 2 shows an area located outside of the Langford Brook's 100-year with climate change floodplain (zone A in orange) which is available for floodplain compensation. The floodplain compensation area indicated a total area of approximately 2522m^2.

Figure 6- 2: Floodplain compensation area

Hydraulic Model Nodes

Option 5 Compensation Area

1 in 100-year with CC flood outline

To support the proposed development, it is intended to excavate the proposed floodplain compensation area down to 66.4m AOD, i.e. the minimum ground level observed within zone B. As part of the detailed design phase, deeper and wider excavation works (i.e. for landscaping purpose or to enhance hydraulic connectivity with the main channel) may be considered however their associated volumes were not considered in the floodplain compensation calculations.

6.3 Proposed levels for Floodplain compensation scheme

Table 6-1 compares the losses in the floodplain capacity from zone B to the gains from zone A.

Table 6-1: Floodplain compensation volumes vs. floodplain loss volumes

Elevation	Floodplain loss volumes (m^3)	Floodplain compensation volumes (if excavated down to 66.4) (m^3)	Loss (-) or Gain(+)
66.3	0.00	0.00	+0.00
66.4	0.00	0.00	+0.00
66.5	1.47	252.18	+251.00
66.6	15.91	504.35	+488.00
66.7	98.45	756.53	+658.00
66.8	354.30	1008.71	+654.00
66.9	844.44	1260.89	+416.00
67.0	1511.79	1513.06	+1.00

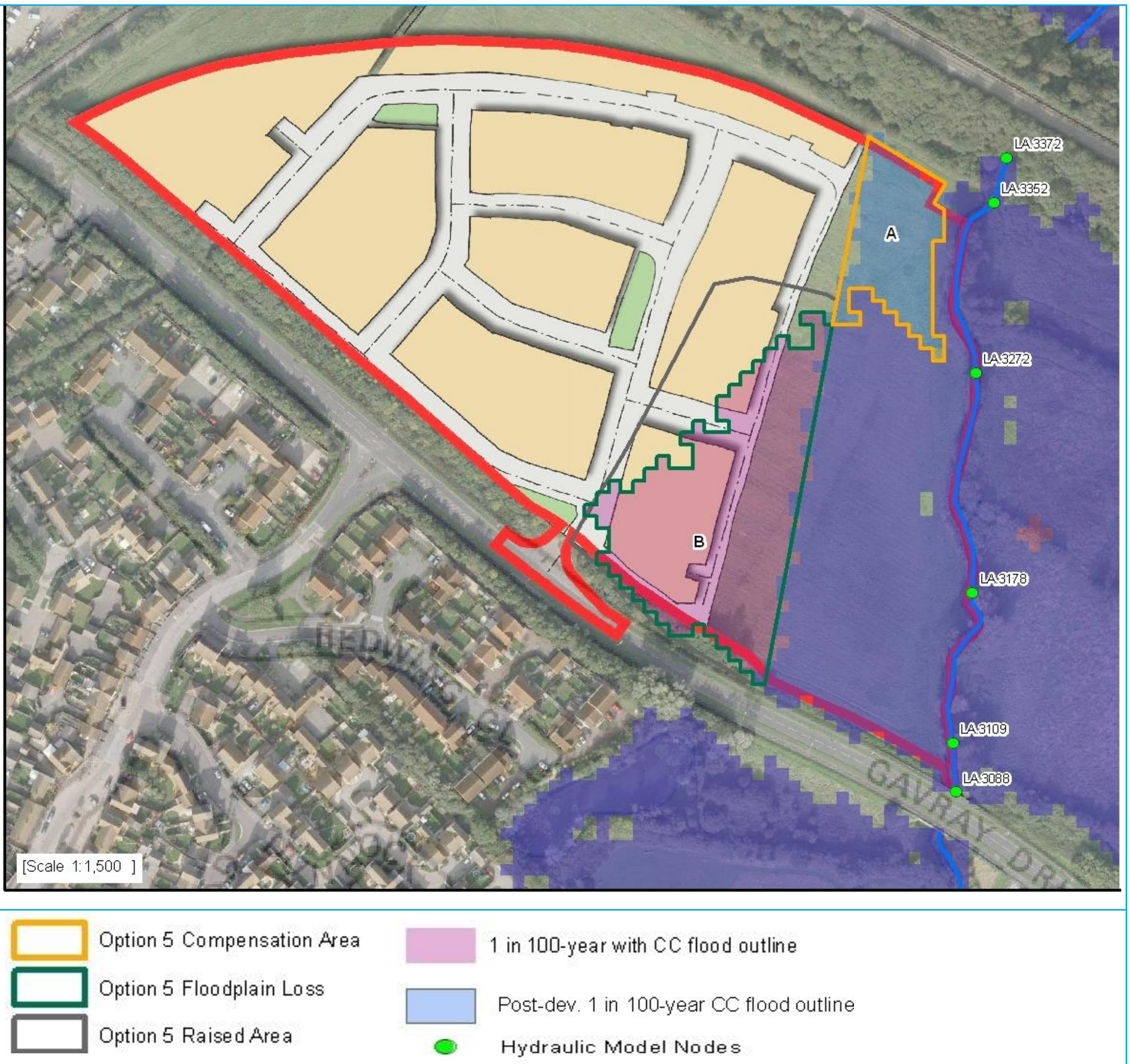
The level-for-level compensation indicates that the lost floodplain capacity can be compensated by the proposed floodplain compensation area.

As the above calculations remain largely based on volume-based calculation, the effect of the proposed FCA on peak water level was modelled.

6.4 Hydraulic modelling results

Figure 6-1 shows the 100-year with climate change prior to and following the implementation of the level-for-level floodplain compensation scheme (FCS).

Figure 6-1: Comparison of 100-year CC flood extents pre-and post-FCS



The pre-development flood extent shows flooding across the site as would be expected prior to raising the ground levels within the residential area. The floodplain compensation event shows the additional capacity made available along the Langford Brook's right hand bank, in the north eastern corner of the site.

Table 6-2: Pre- and post-FCS 100-year peak water levels (m AOD)

Node ID	100-year with climate change peak water level pre-FCS (m AOD)	100-year with climate change peak water level post-FCS (m AOD)
LA.3372	67.18	67.10
LA.3352	67.18	67.15
LA.3272	67.04	67.03
LA.3178	66.98	66.98
LA.3109	66.93	66.93
LA.3088	66.91	66.91
Note: Above values rounded up to nearest centimetre		

Table 6-2 shows that the 100-year with climate change peak water levels will decrease by up to 80mm following the implementation of the proposed floodplain compensation scheme.

7 Post-Development Flood Risks

The 100-year, 100-year with climate change and 1,000-year post-development (i.e. including the floodplain compensation scheme) flood scenarios were modelled. Flood extents are represented in Figure 7-1 and flood levels are indicated in Table 7-1.

Figure 7-1: 100-year, 100-year CC and 1,000-year post-development flood extents

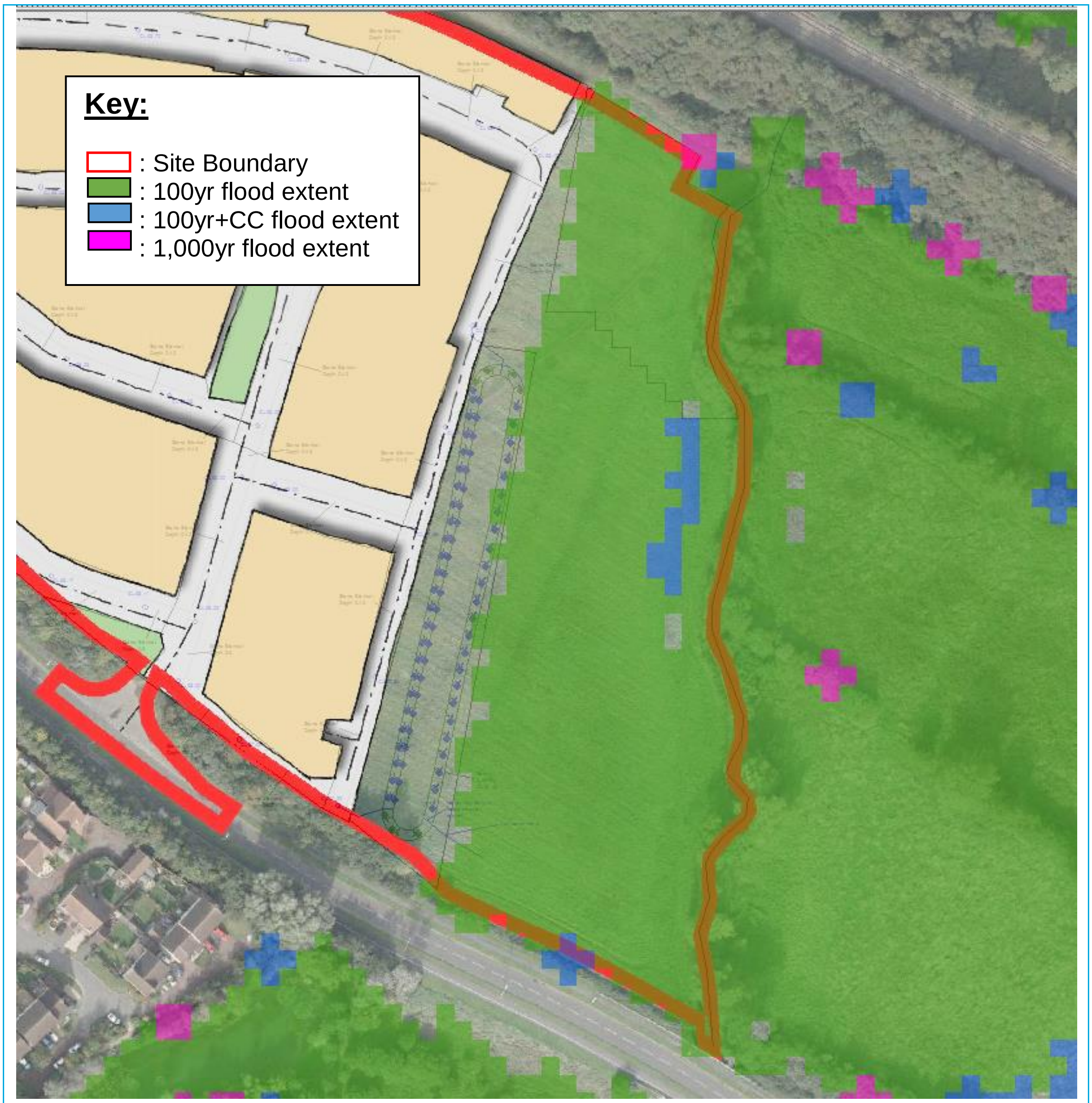


Table 7-1: Post-development flood levels

Node ID	Maximum 100-year peak water level (m AOD)	100-year with climate change peak water level (m AOD)	1,000-year with climate change peak water level (m AOD)
LA.3372	67.09	67.10	67.25
LA.3352	67.09	67.15	67.24
LA.3272	66.98	67.03	67.14
LA.3178	66.89	66.98	67.12
LA.3109	66.83	66.93	67.08
LA.3088	66.82	66.91	67.05
Note: Above values rounded up to nearest centimetre			

Figure 7-1 and Table 7-1 indicate that the residential footprint of the proposed development will be located in flood zone 1 (i.e. outside of the 1,000yr floodplain) in the post-development scenario.

8 Mitigation

8.1 Fluvial Flood Risk Mitigation

The proposed development site lies within Flood Zones 1, 2 and 3 and is considered to be at risk from fluvial flooding. The proposed level-for-level floodplain compensation scheme will set the whole residential part of the development away from the 1,000-year floodplain.

Finished Floor Levels

The minimum finished floor level should be set at 600mm above the modelled 1 in 100-year plus climate change flood levels, as recommended by the EA. This 600mm freeboard will ensure that the flood risk remains at the same levels when considering the increase in flows due to climate change, wave action of flood waters or settlement of structures following construction.

The peak water level within the site for this 100-year plus climate change event is 67.18m AOD; therefore the minimum finished floor level (FFL) will be set to 67.78m AOD. As the western part of the site is already at a higher elevation, this design criteria should only be applied if excavated areas are considered as part of the proposal.

8.1.1 Safe access and egress

The availability of dry access and egress to and from the site was assessed in relation to the EA Flood Map. The main access road is the Gavray Drive; along the proposed development site north boundary, the road is shown not to be at risk from fluvial flooding. Safe access and egress should therefore to be maintained during the 1 in 1,000-year flood event to and from the proposed development, via Gavray Drive.

8.2 Surface water Flood Risk Mitigation

In line with Part H of the Building Regulations, it is recommended that finished floor levels should be set at least 150mm above the surrounding ground levels to prevent storm-water from flowing or ponding near doorways and other ingress routes such as vents and air bricks. When considering the landscaping of the site, ground levels should be designed such that surface water flows are directed away from buildings and towards the formal drainage system or less vulnerable areas such as highways and open space.

8.3 Groundwater Flood Risk Mitigation

Although the risk of groundwater flooding is considered to be low, if the new developments are to have basement levels beneath ground level, the design of these basements should ensure that a waterproof tanking layer is provided to prevent ingress of ground water. The floors of all new buildings should be made of solid construction materials or the ground beneath suspended floors should be sealed to prevent ingress of groundwater should water table levels increase directly beneath the site.

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9 Surface Water Drainage Strategy

Development of a site increases both the rate and volume of surface water runoff compared with its greenfield/non-developed condition. The additional surface water needs to be managed to prevent it flowing on to other properties or flowing unrestricted into watercourses, which could exacerbate flood risk elsewhere. Development can also reduce the water quality of runoff generated on site, which should be treated on-site to prevent adverse impacts on receiving watercourses.

A drainage strategy has been produced for the proposed development area, outlining the preferred options for disposal of storm water at the proposed development site. The surface water drainage system employed at the new development will provide flood risk mitigation and ensure that development of the site will not cause an increase in flood risk to other developments. It will ensure that adequate opportunities for water quality treatment will be provided throughout the site, whilst providing ecology benefits to the site and its surroundings. The surface water features included in the strategy will be located within the proposed site boundary.

9.1 Existing Drainage Regime

The site is currently Greenfield open space with no formal drainage system. There are several small field drains around the site perimeter which are not expected to be retained following development of the site. Drainage of surface water runoff occurs via percolation into the ground or through overland flows from saturated and impermeable surfaces which follow the site topography.

Site investigations carried out by Wardell Armstrong LLP in 2006 and 2010 showed the site to be underlain by brown sands and clays to a depth of around 2.0m below ground level with firm to stiff grey and brown silty clays beneath. Permeability of the ground was found to be low to very low and thus unsuitable for infiltration SUDS.

The site topography currently falls in an easterly direction towards the Langford Brook which flows south along the eastern boundary of the site. Topographic survey of the site shows the site's south east corner to be around 0.8m lower than adjacent road levels on Gavray Drive. Topographic survey for the site can be found in Appendix B.

Greenfield runoff rates

For estimating pre-development (Greenfield) runoff rates for the site, the Revitalised Flood Hydrograph (ReFH) methodology was adopted. In a 2011 paper published in the Journal of Flood Risk Management, Faulkner et al demonstrates how using evidence from 46 gauged small catchments in the United Kingdom, the methods most commonly used for estimating design flows and Greenfield runoff rates on small catchments (IH124, FSR and ADAS 345) do not perform as well as alternative methods. Their results show larger error and a bias towards underestimation of the median annual flood. In contrast, newer methods from the Flood Estimation Handbook (FEH), when applied to small catchments, tend to have lower error and less bias. The paper therefore recommends that Flood Estimation Handbook methods are used.

Pre-development (Greenfield) runoff rates were calculated as follows for a 1 hour storm event, considered to be the critical duration storm event for runoff rate. A summary of the calculated peak runoff rates is shown in Table 8-1 below.

Table 8-1: Greenfield runoff rates

Return Period	Peak Runoff Rate (l/s)
1 in 2-year	21.6
1 in 10-year	36.0
1 in 30-year	46.8
1 in 100-year	62.6
1 in 100-year (plus climate change)	81.4

9.2 Conceptual Drainage Design

A conceptual design of the surface water drainage system has been produced, which outlines the design criteria, SUDS proposals, flow routes through the site and opportunities for source control, attenuation and long-term storage. This design has been produced following current best practise in relation to SUDS and drainage design.

Under the Flood and Water Management Act (2010), Oxfordshire County Council will become the approving body for SUDS. At the time of writing this FRA report, a local SUDS design guidance document is not available. Similarly, a national SUDS guidance document is not yet available, therefore the CIRIA SUDS manual has been used as an example of best practice. Where surface water is managed through sewers, they will conform to guidance provided in Sewers for Adoption (currently 7th edition) or other recognised guidance.

9.2.1 Sustainable Drainage Systems

Sustainable Drainage Systems (SUDS) aim to mimic the natural processes of Greenfield surface water drainage, by allowing water to flow along natural flow routes and reducing the runoff rates and volumes during storm events, while providing some water treatment benefits. SUDS also have the advantage of providing effective Blue and Green Infrastructure, ecology and public amenity benefits when designed and maintained properly.

9.2.2 Design Criteria

Runoff Quantity

The surface water drainage system will ensure that the rate and volume of runoff from the site will not exceed the pre-development (Greenfield) values. There are typically two design storm events which should be considered when designing the SUDS system for managing flows and volumes, reflecting the design criteria set out in Sewers for Adoption for traditional sewered systems:

- 1 in 30-year storm event where surface water flows are generally managed below ground and / or in well-defined storage features.
- 1 in 100-year storm event with allowances for future climate change, where runoff should be managed within the extents of development site, ensuring that it cannot affect people or properties either within the development of surrounding developments.

Runoff Quality

The surface water drainage system will ensure that a sufficient level of water quality treatment is provided to ensure that development of the site does not cause significant contamination of receiving watercourses.

The CIRIA SUDS manual considers residential development to present a medium source of runoff pollution meaning that at least two treatment trains are required within the SUDS. During the water treatment event (5mm rainfall across the entire site) no runoff should leave the site. This is usually achieved through source control techniques such as green roofs, rainwater harvesting, permeable pavements and soakaways.

9.2.3 SUDS Proposal

A drawing of the proposed surface water drainage system for the site is included in Appendix D. Crushed stone blankets located beneath highways and a storage basin on the site's eastern boundary will provide on-site storage for events up to the 1 in 100-year climate change event, ensuring that flow from the site is limited to the 1 in 2-year Greenfield rate (21.6l/s). The depth of crushed stone blanket is shown on the drawing in Appendix D. Water butts overflowing into the on-site drainage system may be installed immediately downstream of the downpipes to provide further surface water runoff attenuation.

The proposed surface water drainage system will provide 2-3 treatment trains for runoff pollution. The crushed stone blankets and the storage basin will both provide treatment to runoff. Additional treatment could be provided by source control features such as water butts or permeable paving on driveways.

Runoff from the site will be discharged to the Langford Brook via a pipe from the storage basin. A vortex flow control (Hydrobrake or similar) will be required to limit flow to the 1 in 2-year Greenfield rate and a non-return valve will be used to prevent fluvial flooding from the Langford

Brook entering the storage basin. The level of the discharge point has been set to the 1 in 20-year fluvial flood level on the Langford Brook. This will allow water to be discharged from the site during moderate fluvial flood events on the Langford Brook. The probability of an extreme rainfall event at the site coinciding with an extreme fluvial flood event on the Langford Brook is considered to be extremely low.

Significant ground raising will be required to allow the site to drain to Langford Brook whilst providing sufficient cover above the crushed stone blankets. Cover levels across the site are shown on the drawing in Appendix D. Road levels have been assumed to be 300mm above the top of stone blankets to allow for construction of the road surface. Cover levels shown are at footway level (100mm above the road surface) to allow overflows in the 1 in 100-year with climate change event to be conveyed along the road surface below footway level.

WinDes has been used to model the proposed surface water drainage system and to ensure optimisation of the system to reduce the amount of ground raising required. Modelling confirms that events up to the 1 in 30-year event will be stored within the stone blankets and basin. The 1 in 100-year climate change event may exceed the capacity of the crushed stone blankets in some locations but overflows will be contained within the road system, below kerb level, and will be directed towards the storage basin on the site's eastern boundary. The low depth and velocities of these overflows mean that this is expected to present a Very Low hazard to people under the Environment Agency's Hazard to People Classification[4]. The capacity of the storage basin is such that overflows from the roads in the 1 in 100-year climate change event can be held on site in the basin and water can be released at the 1 in 2-year Greenfield rate to the receiving watercourse. This ensures no worsening to flood risk on third party land. WinDes modelling summary and results can be found in Appendix E.

[4] Environment Agency (2008). Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purpose - Clarification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1

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10 CDM Requirements

Under current CDM Regulation (note: CDM 2007 or CDM 2015 once enacted), it is the designer's duty to eliminate hazards and reduce risks, as far as reasonably practicable. To support this, the following design parameters were taken into consideration in the proposal:

- The floodplain compensation area should be designed with lateral slopes of 1 in 3 or shallower.
- The surface water attenuation pond should be designed with side slopes of 1 in 3 or shallower.
- The finished flood levels of the proposed dwellings should be set 150mm above surrounding ground levels.

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11 Conclusion

- JBA Consulting was commissioned by Gallagher Estates Ltd. in March 2014 to provide a Flood Risk Assessment for a proposed residential development at Gavray Drive West, Bicester. This FRA report provides information on the nature of flood risk at the site and follows Government guidance with regards to development and flood risk.
- The proposed development site is located at Gavray Drive, approx. 1.3km east of Bicester town centre in Oxfordshire. The existing site is 6.7 ha in size and is currently Greenfield. The site is bordered by Langford Brook to the east, the Chiltern railway line to the north, the Oxford and Bletchley freight line to the west and Gavray Drive, which is the main access road, to the south
- The proposal is for up to 180 dwellings including affordable housing, public open space, localised land remodelling and structure planting.
- The 2006 Site Investigation and the in-situ testing show the soil materials are predominantly clay material with low to very low permeability. The CBR tests undertaken to assist the preliminary design of roads and pavements show low strength within the cohesive materials at shallow depth which could result in the retention of water within these shallow materials during periods of wet weather.
- This FRA follows government guidance on development and flood risk, within the National Planning Policy Framework (NPPF). The NPPF classifies the proposed development as 'More Vulnerable'. The site lies within the Environment Agency's Flood Zones 1, 2 and 3 and therefore needs to pass the Sequential and Exception tests.
- The proposal encroaches within the 100-year with climate change floodplain. As such, a level-for-level floodplain compensation scheme was designed to ensure that flood water is not displaced elsewhere. The whole residential footprint of the proposed development will be outside of the 1,000-year floodplain following the implementation of the proposed floodplain compensation scheme.
- A surface water drainage strategy was designed for the whole development site. The strategy was designed to attenuate surface water runoff for up to the 100-year with climate change storm event down to the 1 in 2-year Greenfield rate. This will discharge to the Langford Brook during peak flow conditions.
- This site is deemed to have passed the Exception Test for the following reasons:
    - The proposals are for up to 180 residential units, including affordable housing, contributing to CDC housing delivery targets. The proposed development is considered to be sustainable as it is situated east of Bicester town centre within an urban area, adjacent to existing residential development and is accessible to the main urban centre where development is generally focussed. Such a location is able to provide good access to all types of facilities and a good level of public transport. The construction will also generate employment and socially the proposals contribute to housing objectives of both the emerging Cherwell Local Pan and the Bicester Masterplan.
    - The whole residential footprint of the proposed development will be located outside of the 1,000-year floodplain, following the implementation of the proposed floodplain compensation scheme.
    - A formal drainage system will be provided to ensure effective drainage of the site and reduce runoff leaving the site during storm events.
    - The combination of 2. and 3. above will reduce flood risk to third party lands downstream of the proposed development
- In line with Part H of the Building Regulations, the Finished Floor Level of the proposed units should be set to 150mm above surrounding ground levels. This will mitigate against surface water and groundwater flood risk. Unless excavated areas are considered within the residential area, this minimum finished floor level will exceed the standard 600mm plus 100-year with climate change value normally recommended by the Environment Agency (due to the site topography).
- All floors should be made of solid construction materials or sealed beneath suspended floors to prevent the ingress of groundwater from the ground below.

- An outline surface water drainage strategy has been developed which will manage the extra runoff due to the proposed development and ensure that the rate and volume of discharge from the development will not exceed the pre-development levels. Storage of surface water will be provided by a combination of crushed stone blankets located beneath highways and a storage basin located on the site's eastern boundary. The crushed stone blankets and the storage basin will both provide treatment to runoff. Additional treatment could be provided by source control features such as water butts or permeable paving on driveways.

Appendices

A Site Layout

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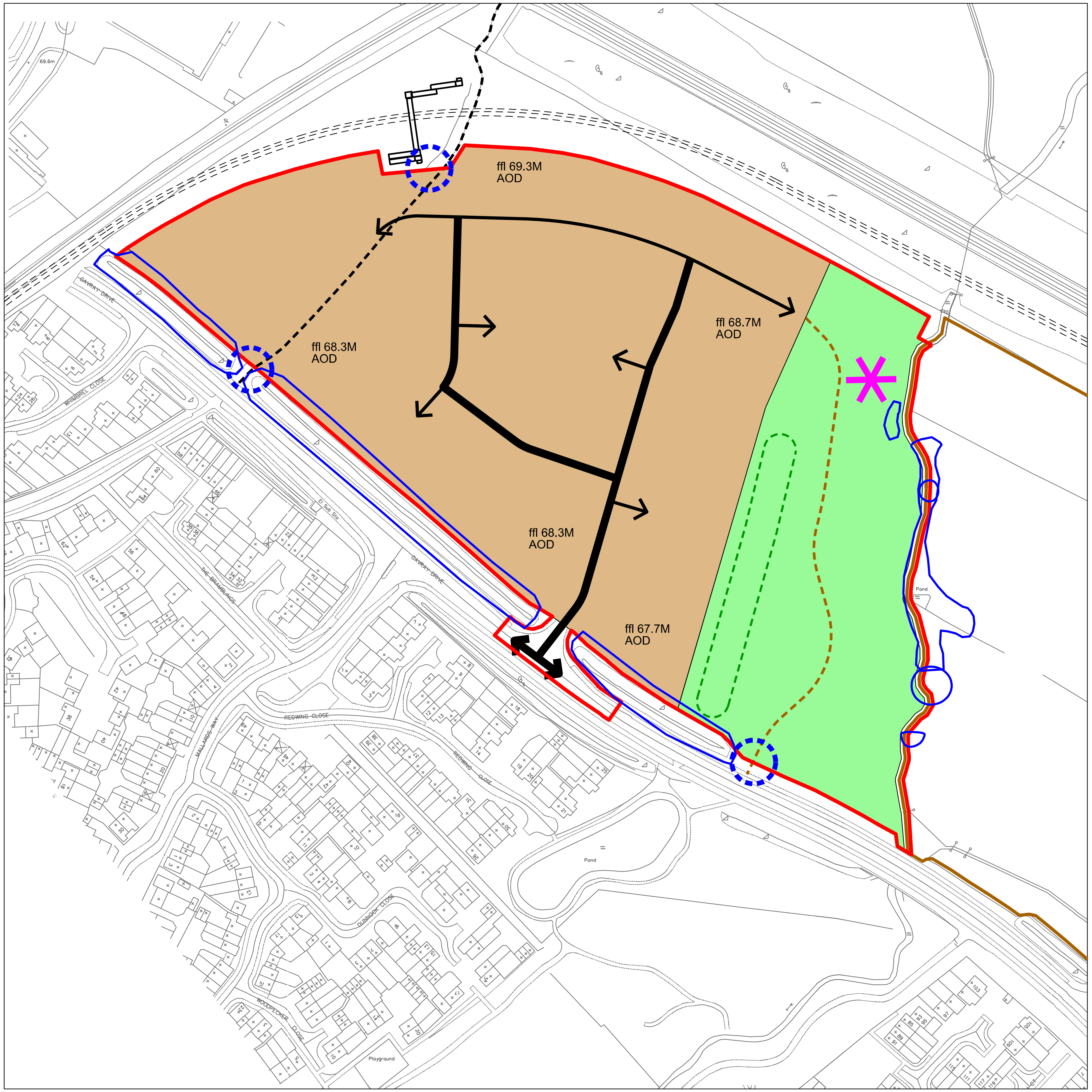

Application boundary - area - 6.92Ha including access

Use - Residential - area - 4.62Ha

Use - Public open space - area - 2.0Ha

Area of surface water run-off within public open space

Play Area

Main residential street - made up of 5.5m wide carriageway and two footways of 2m width

Access to minor lanes and mews streets

Retained footpath

Proposed footpath

Footpath connections at application boundary

Hedgerow canopy (Catagory B)

Local Wildlife Site

Scale and massing of buildings by types: in meters and are additional to approximate finished ground level (AOD) indicated on plan.

Building Type		Length (m)	Width (m)	Ridge Heights (m)	Storeys
		Distance across frontage	Depth from front to back	Highest point above AOD	
Typical terraces	Minimum	13.5	5.5	8.5	1
	Maximum	48	10	11	2.5
Semi-detached	Minimum	10	5.5	8.5	1
	Maximum	20	10	11	2.5
Detached	Minimum	8	8	6	1
	Maximum	12	11	11	2.5
Dwelling over Garage	Minimum	10	6	5.5	2
	Maximum	13	8	12	2.5
Garage	Minimum	3	6	1.5	1
	Maximum	12	6	6	1
Bin Stores / Ancillary	Minimum	2	3	3	1
	Maximum	5	5	3.5	1

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Project
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Job Ref. Ge.GD.W
Drawn Pd

Drawing Title
Parameters Plan

Scale 1:2,000 @ A3
Date 22.10.2014

Drawing no. 001
Rev. D 13.02.2015

B Topographic survey

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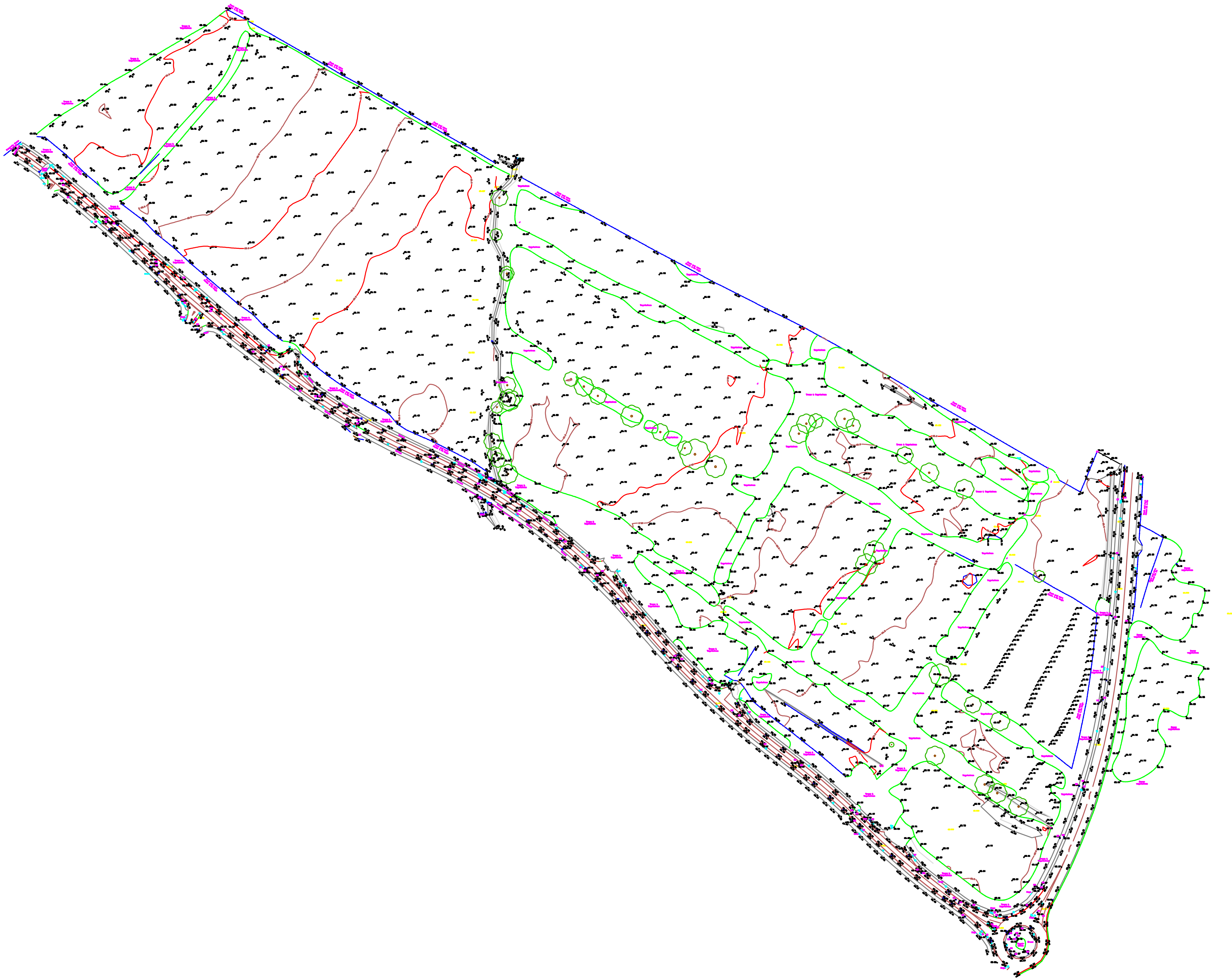

C Extract from NPPF

Table 4- 1: NPPF Flood Zones

Zone 1: Low Probability	
Land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding in any year (<0.1%). (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)	Appropriate uses All uses of land are appropriate in this zone. FRA requirements For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a FRA. This need only be brief unless factors above or other local considerations require particular attention. Policy aims Developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of sustainable drainage systems.
Zone 2: Medium Probability	
Land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year. (Land shown in light blue on the Flood Map)	Appropriate uses The water-compatible, less vulnerable and more vulnerable uses of land and essential infrastructure in Table 2 are appropriate in this zone. Highly vulnerable uses in Table 2 are only appropriate in this zone if the Exception Test is passed. FRA requirements All proposals in this zone should be accompanied by a FRA. Policy aims Developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area through the layout and form of the development, and the appropriate application of sustainable drainage techniques.
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Zone 3a: High Probability	
Land assessed as having a 1 in 100 or greater probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year. (Land shown in dark blue on the Flood Map)	Appropriate uses The water-compatible and less vulnerable uses of land in Table 2 are appropriate in this zone. The highly vulnerable uses Table 2 should not be permitted in this zone. The more vulnerable and essential infrastructure uses in Table 2 should only be permitted in this zone if the Exception Test is passed. Essential infrastructure permitted in this zone should be designed and constructed to remain operational and safe for users in times of flood. FRA requirements All proposals in this zone should be accompanied by a FRA. Policy aims Developers and local authorities should seek opportunities to: reduce the overall level of flood risk through the layout and form of the development and the appropriate application of sustainable drainage techniques; relocate existing development to land in zones with a lower probability of flooding; create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage.
Zone 3b: Functional Floodplain	
Land where water has to flow or be stored in times of flood. Local Planning Authorities should identify in their SFRAs areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designated to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify functional floodplain.	Appropriate uses Only the water-compatible uses and the essential infrastructure listed in Table 2 that has to be there should be permitted. It should be designed and constructed to: remain operational and safe for users in times of flood; result in no net loss of floodplain storage; not impede water flows; and not increase flood risk elsewhere. Essential infrastructure in this zone should pass the Exception Test. FRA requirements All proposals in this zone should be accompanied by a FRA. Policy aims In this zone, developers and local authorities should seek opportunities to: reduce the overall level of flood risk through the layout and form of the development and the appropriate application of sustainable drainage techniques; relocate existing development to land with a lower probability of flooding.

Table 4- 2: Flood Risk Vulnerability Classification

Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind turbines.
Highly Vulnerable	• Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use (Sequential and Exception Tests required for any change of land use to these sites). • Installations requiring hazardous substances consent (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the faculties should be classified as "Essential Infrastructure").
More Vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels • Non-residential uses for health services, nurseries and educational establishments • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravan and camping, *subject to a specific warning and evacuation plan.*
Less Vulnerable	• Police, ambulance and fire stations which are *not* required to be operation during flooding. • Buildings used for: shops; financial, professional and other services; restaurants and cafes; hot food takeaways; offices; general industry; storage and distribution; non-residential institutions not included in 'more vulnerable'; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works and which do *not* need to remain operation during times of flood. • Sewerage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place).
Continued on next page…	

Water-compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel workings. • Docks, marinas and wharves. • Navigation facilities. • MOD defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, *subject to a specific warning and evacuation plan.*

Source: Table 2, NPPF Planning Guidance

Notes:

1. This classification is based partly on Defra/Environment Agency research on Flood Risks to People (FD2321/TR2) and also on the need of some uses to keep functioning during flooding.

2. Buildings that combine a mixture of uses should be placed into the higher of the relevant classes of flood risk sensitivity. Developments that allow uses to be distributed over the site may fall within several classes of flood risk sensitivity.

3. The impact of a flood on the particular uses identified within this flood risk vulnerability classification will vary within each vulnerability class. Therefore, the flood risk management infrastructure and other risk mitigation measures needed to ensure the development is safe may differ between uses within a particular vulnerability classification.

Table 4- 3: Flood Risk Vulnerability and Flood Zone 'Compatibility'

Vulnerability Classification (Table 2)		Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water compatible
Flood Zone (Table 1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	Exception Test	✓	✓	✓
	Zone 3a +	Exception Test	×	Exception Test	✓	✓
	Zone 3b	Exception Test	×	×	×	✓*

Table 3, NPPF Technical Guidance

✓ Development is appropriate

× Development should not be permitted

Notes:

- *This table does not show the application of the Sequential Test which should be applied first to guide development to Flood Zone 1, then Zone 2, and then Zone 3; nor does it reflect the need to avoid flood risk from sources other than rivers and the sea;*
- *The Sequential and Exception Tests do not need to be applied to minor developments and changes of use, except for a change of use to a caravan, camping or chalet site, or to a mobile home or park home site;*
- *Some developments may contain different elements of vulnerability and the highest vulnerability category should be used, unless the development is considered in its component parts.*

† In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

** In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:*

- *remain operational and safe for users in times of flood;*
- *result in no net loss of floodplain storage;*
- *not impede water flows and not increase flood risk elsewhere.*

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D Surface Water Drainage Strategy Drawing

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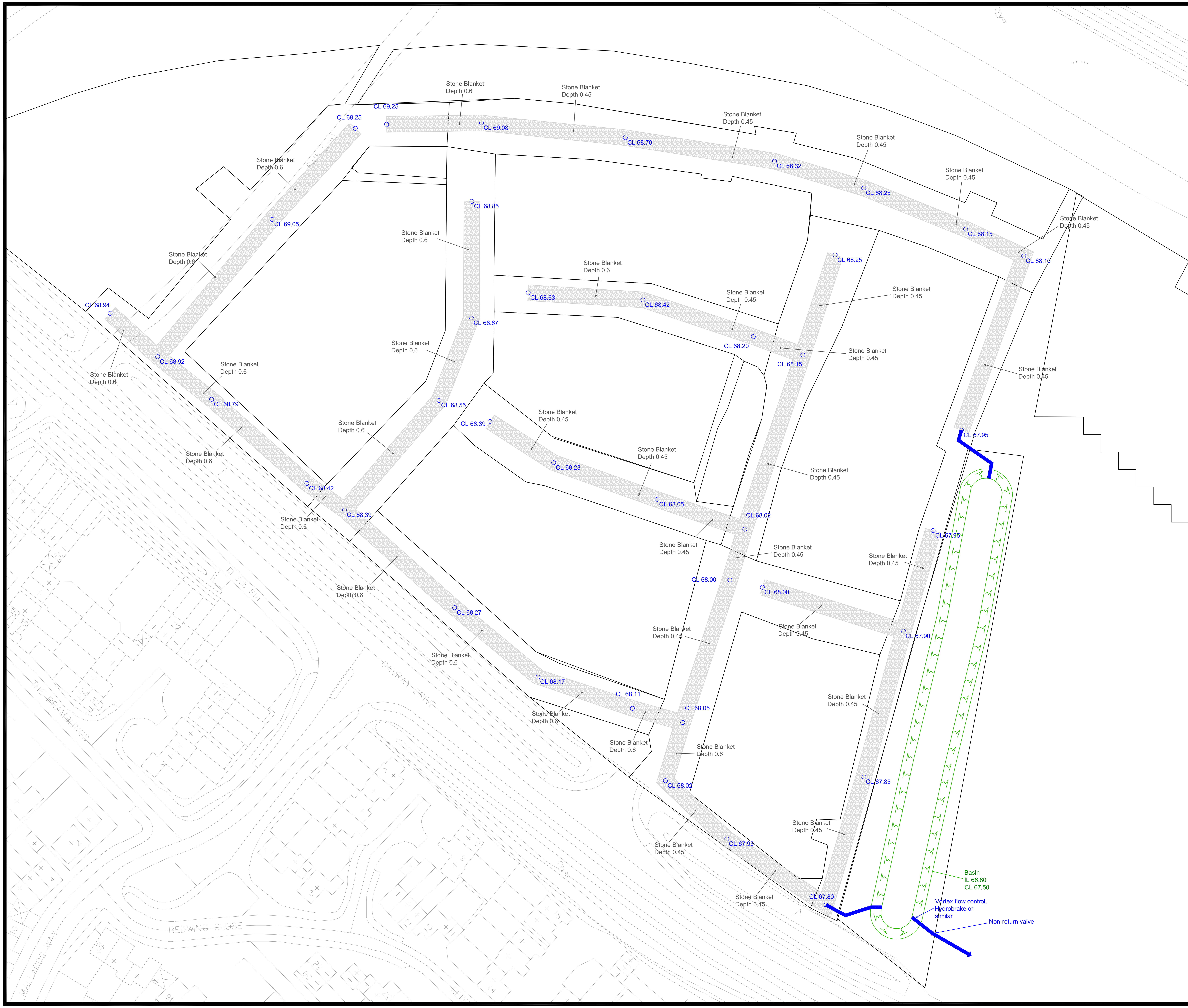

General Notes

1. All dimensions shown are in metres unless otherwise stated and levels in metres to Ordnance Datum.
2. Do not scale from this drawing. Indicative layout only - THIS DRAWING IS NOT FOR CONSTRUCTION.

Key

- Stone blanket
- Pipe
- Swale

Notes

- Stone blankets assumed to be at least 4.5m wide in all locations
- Stone blankets to be laid at a gradient of at least 1:500
- Cover levels represent footway level - road level assumed to be 100mm below footway to allow overflows in extreme rainfall events to be contained in roads
- Road surface construction has been assumed to have 300mm depth
- Overflows into swale from road on site's eastern boundary in extreme rainfall events

Rev.	Modifications	Date	Drawn	Designed	Checked	Approved
A	Minor alterations to ground levels following review	08/10/14	RH	RH	OS	

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for

GALLAGHER ESTATES

GAVRAY DRIVE WEST SITE
SURFACE WATER DRAINAGE STRATEGY
INDICATIVE GROUND LEVELS AND LAYOUT

Scale: 1:500 @ A1	Drawn:	RH	25/09/14
	Designed:	RH	25/09/14
	Checked:	OS	25/09/14
	Approved:		

Digital File Name: 2013s7196-001 - Gavray Drive West SW Layout.dwg

Drawing Number:	Rev.:	Sheet No.:	Status:
2013s7196-001	A	1 of 1	DRAFT

E WinDes Model Summary

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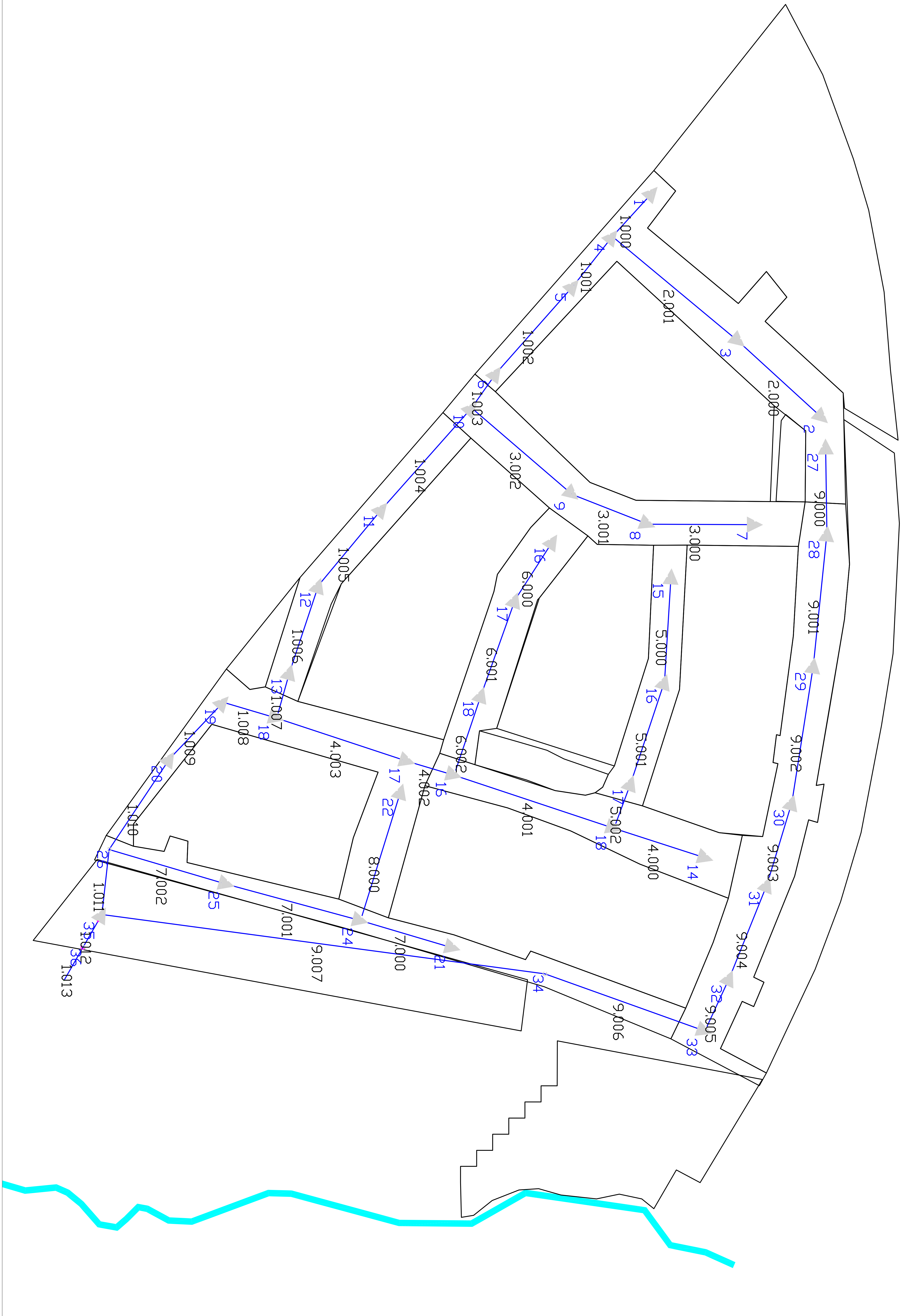
1.000
1.001
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1.012
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9.000
9.001
9.002
9.003
9.004
9.005
9.006
9.007

STORM SEWER DESIGN by the Modified Rational Method

Network Design Table for Storm

« - Indicates pipe capacity < flow

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Auto Design
1.000	18.357	0.050	367.1	0.133	5.00	0.0	0.600	o	300	
2.000	35.154	0.100	351.5	0.077	5.00	0.0	0.600	o	300	
2.001	50.923	0.114	446.7	0.161	0.00	0.0	0.600	o	300	
1.001	19.578	0.100	195.8	0.000	0.00	0.0	0.600	o	300	
1.002	36.179	0.366	98.8	0.081	0.00	0.0	0.600	o	300	
1.003	13.169	0.050	263.4	0.068	0.00	0.0	0.600	o	300	
3.000	33.238	0.100	332.4	0.069	5.00	0.0	0.600	o	300	
3.001	25.221	0.050	504.4	0.058	0.00	0.0	0.600	o	300	
3.002	41.202	0.080	515.0	0.072	0.00	0.0	0.600	o	300	
1.004	41.908	0.100	419.1	0.000	0.00	0.0	0.600	o	300	
1.005	30.869	0.100	308.7	0.082	0.00	0.0	0.600	o	300	
1.006	28.342	0.060	472.4	0.055	0.00	0.0	0.600	o	300	
1.007	14.896	0.060	248.3	0.076	0.00	0.0	0.600	o	300	
4.000	29.915	0.100	299.2	0.073	5.00	0.0	0.600	o	300	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	75.00	5.38	67.936	0.133	0.0	0.0	0.0	0.81	57.6	27.0
2.000	74.32	5.70	68.100	0.077	0.0	0.0	0.0	0.83	58.9	15.5
2.001	65.44	6.85	68.000	0.238	0.0	0.0	0.0	0.74	52.1	42.2
1.001	63.58	7.15	67.886	0.371	0.0	0.0	0.0	1.12	79.2	63.8
1.002	61.33	7.53	67.786	0.451	0.0	0.0	0.0	1.58	111.8	75.0
1.003	60.08	7.75	67.420	0.519	0.0	0.0	0.0	0.96	68.1«	84.5
3.000	74.84	5.65	67.600	0.069	0.0	0.0	0.0	0.86	60.6	14.1
3.001	69.74	6.25	67.500	0.127	0.0	0.0	0.0	0.69	49.0	24.0
3.002	62.92	7.25	67.450	0.199	0.0	0.0	0.0	0.69	48.5	33.9
1.004	55.61	8.67	67.370	0.719	0.0	0.0	0.0	0.76	53.8«	108.2
1.005	53.18	9.25	67.270	0.800	0.0	0.0	0.0	0.89	62.9«	115.3
1.006	50.70	9.91	67.170	0.856	0.0	0.0	0.0	0.72	50.7«	117.5
1.007	49.84	10.16	67.110	0.932	0.0	0.0	0.0	0.99	70.2«	125.8
4.000	75.00	5.55	67.400	0.073	0.0	0.0	0.0	0.90	63.9	14.9

STORM SEWER DESIGN by the Modified Rational Method

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Auto Design
5.000	32.730	0.050	654.6	0.093	5.00	0.0	0.600	o	225	🔒
5.001	33.160	0.050	663.2	0.063	0.00	0.0	0.600	o	225	🔒
5.002	15.023	0.050	300.5	0.088	0.00	0.0	0.600	o	225	🔒
4.001	52.331	0.130	402.5	0.045	0.00	0.0	0.600	o	300	🔒
6.000	21.591	0.050	431.8	0.071	5.00	0.0	0.600	o	225	🔒
6.001	31.253	0.050	625.1	0.084	0.00	0.0	0.600	o	225	🔒
6.002	26.401	0.030	880.0	0.058	0.00	0.0	0.600	o	225	🔒
4.002	15.076	0.020	753.8	0.075	0.00	0.0	0.600	o	300	🔒
4.003	42.773	0.100	427.7	0.040	0.00	0.0	0.600	o	300	🔒
1.008	17.298	0.050	346.0	0.053	0.00	0.0	0.600	o	300	🔒
1.009	24.091	0.050	481.8	0.000	0.00	0.0	0.600	o	300	🔒
1.010	33.930	0.050	678.6	0.036	0.00	0.0	0.600	o	300	🔒
7.000	29.861	0.050	597.2	0.089	5.00	0.0	0.600	o	225	🔒
8.000	42.078	0.100	420.8	0.052	5.00	0.0	0.600	o	225	🔒

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
5.000	71.08	6.08	67.450	0.093	0.0	0.0	0.0	0.50	20.0	17.9
5.001	63.33	7.19	67.400	0.156	0.0	0.0	0.0	0.50	19.9«	26.7
5.002	61.36	7.52	67.350	0.244	0.0	0.0	0.0	0.75	29.8«	40.6
4.001	55.73	8.64	67.300	0.362	0.0	0.0	0.0	0.78	55.0	54.7
6.000	75.00	5.58	67.300	0.071	0.0	0.0	0.0	0.62	24.8	14.4
6.001	67.26	6.59	67.250	0.155	0.0	0.0	0.0	0.52	20.5«	28.3
6.002	60.90	7.60	67.200	0.213	0.0	0.0	0.0	0.43	17.2«	35.2
4.002	53.83	9.09	67.170	0.651	0.0	0.0	0.0	0.57	39.9«	94.8
4.003	50.27	10.03	67.150	0.690	0.0	0.0	0.0	0.75	53.3«	94.8
1.008	48.70	10.50	67.050	1.675	0.0	0.0	0.0	0.84	59.3«	221.0
1.009	46.97	11.07	67.000	1.675	0.0	0.0	0.0	0.71	50.2«	221.0
1.010	44.37	12.02	66.950	1.712	0.0	0.0	0.0	0.60	42.1«	221.0
7.000	72.24	5.94	67.100	0.089	0.0	0.0	0.0	0.53	21.0	17.4
8.000	70.85	6.11	67.150	0.052	0.0	0.0	0.0	0.63	25.1	10.0

STORM SEWER DESIGN by the Modified Rational Method

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Auto Design
7.001	43.049	0.075	574.0	0.048	0.00	0.0	0.600	o	225	
7.002	38.038	0.075	507.2	0.050	0.00	0.0	0.600	o	300	
1.011	20.290	0.100	202.9	0.061	0.00	0.0	0.600	o	450	
9.000	27.025	0.175	154.4	0.097	5.00	0.0	0.600	o	225	
9.001	41.179	0.150	274.5	0.067	0.00	0.0	0.600	o	225	
9.002	43.045	0.382	112.7	0.081	0.00	0.0	0.600	o	225	
9.003	26.539	0.068	390.3	0.122	0.00	0.0	0.600	o	300	
9.004	31.305	0.150	208.7	0.064	0.00	0.0	0.600	o	300	
9.005	18.225	0.050	364.5	0.035	0.00	0.0	0.600	o	300	
9.006	52.686	0.150	351.2	0.087	0.00	0.0	0.600	o	300	
9.007	138.761	0.150	925.1	0.094	0.00	0.0	0.600	o	450	
1.012	11.816	0.050	236.3	0.000	0.00	0.0	0.600	o	450	
1.013	11.816	0.050	236.3	0.000	0.00	0.0	0.600	o	450	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
7.001	61.81	7.44	67.050	0.189	0.0	0.0	0.0	0.54	21.4«	31.6
7.002	57.04	8.36	66.975	0.239	0.0	0.0	0.0	0.69	48.9	36.9
1.011	43.77	12.25	66.900	2.011	0.0	0.0	0.0	1.42	226.4«	238.4
9.000	75.00	5.43	68.250	0.097	0.0	0.0	0.0	1.05	41.7	19.7
9.001	69.34	6.30	68.000	0.164	0.0	0.0	0.0	0.78	31.2	30.7
9.002	65.22	6.89	67.850	0.244	0.0	0.0	0.0	1.23	48.9	43.1
9.003	61.79	7.45	67.468	0.366	0.0	0.0	0.0	0.79	55.8«	61.3
9.004	59.17	7.93	67.400	0.430	0.0	0.0	0.0	1.08	76.7	68.9
9.005	57.32	8.30	67.300	0.465	0.0	0.0	0.0	0.82	57.8«	72.1
9.006	52.77	9.35	67.250	0.551	0.0	0.0	0.0	0.83	58.9«	78.8
9.007	42.34	12.86	67.100	0.645	0.0	0.0	0.0	0.66	105.0	78.8
1.012	42.00	13.01	66.800	2.657	0.0	0.0	0.0	1.32	209.6«	302.2
1.013	41.67	13.15	66.750	2.657	0.0	0.0	0.0	1.32	209.6«	302.2

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
1.000	User	-	60	0.221	0.133	0.133
2.000	User	-	60	0.129	0.077	0.077
2.001	User	-	60	0.268	0.161	0.161
1.001	-	-	100	0.000	0.000	0.000
1.002	User	-	60	0.134	0.081	0.081
1.003	User	-	60	0.113	0.068	0.068
3.000	User	-	60	0.116	0.069	0.069
3.001	User	-	60	0.096	0.058	0.058
3.002	User	-	60	0.120	0.072	0.072
1.004	-	-	100	0.000	0.000	0.000
1.005	User	-	60	0.136	0.082	0.082
1.006	User	-	60	0.092	0.055	0.055
1.007	User	-	60	0.127	0.076	0.076
4.000	User	-	60	0.122	0.073	0.073
5.000	User	-	60	0.155	0.093	0.093
5.001	User	-	60	0.105	0.063	0.063
5.002	User	-	60	0.147	0.088	0.088
4.001	User	-	60	0.075	0.045	0.045
6.000	User	-	60	0.118	0.071	0.071
6.001	User	-	60	0.140	0.084	0.084
6.002	User	-	60	0.097	0.058	0.058
4.002	User	-	60	0.125	0.075	0.075
4.003	User	-	60	0.067	0.040	0.040
1.008	User	-	60	0.089	0.053	0.053
1.009	-	-	100	0.000	0.000	0.000
1.010	User	-	60	0.060	0.036	0.036
7.000	User	-	60	0.148	0.089	0.089
8.000	User	-	60	0.087	0.052	0.052
7.001	User	-	60	0.080	0.048	0.048
7.002	User	-	60	0.083	0.050	0.050
1.011	User	-	60	0.102	0.061	0.061
9.000	User	-	60	0.161	0.097	0.097
9.001	User	-	60	0.111	0.067	0.067
9.002	User	-	60	0.134	0.081	0.081
9.003	User	-	60	0.203	0.122	0.122
9.004	User	-	60	0.106	0.064	0.064
9.005	User	-	60	0.058	0.035	0.035
9.006	User	-	60	0.144	0.087	0.087
9.007	User	-	60	0.157	0.094	0.094
1.012	-	-	100	0.000	0.000	0.000
1.013	-	-	100	0.000	0.000	0.000
				Total	Total	Total
				4.428	2.657	2.657

Surcharged Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.013		67.500	66.700	66.700	0	0

Datum (m) 0.000 Offset (mins) 0

Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)
1440	66.700	4320	66.700	7200	0.000	10080	0.000
2880	66.700	5760	66.700	8640	0.000		

Online Controls for Storm

Hydro-Brake® Manhole: 35, DS/PN: 1.012, Volume (m³): 25.1

Design Head (m) 0.600 Hydro-Brake® Type Md1 Invert Level (m) 66.800
Design Flow (l/s) 21.0 Diameter (mm) 156

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.2	1.200	29.7	3.000	46.9	7.000	71.7
0.200	16.2	1.400	32.1	3.500	50.7	7.500	74.2
0.300	19.6	1.600	34.3	4.000	54.2	8.000	76.6
0.400	18.3	1.800	36.3	4.500	57.5	8.500	79.0
0.500	19.3	2.000	38.3	5.000	60.6	9.000	81.3
0.600	21.0	2.200	40.2	5.500	63.5	9.500	83.5
0.800	24.2	2.400	42.0	6.000	66.4		
1.000	27.1	2.600	43.7	6.500	69.1		

Non Return Valve Manhole: 36, DS/PN: 1.013, Volume (m³): 2.8

Offline Controls for Storm

Pipe Manhole: 1, DS/PN: 1.000, Loop to PN: 1.001

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	1150.0	Coefficient of Contraction	0.600
Length (m)	18.000	Upstream Invert Level (m)	68.836

Pipe Manhole: 2, DS/PN: 2.000, Loop to PN: 2.001

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	175.0	Coefficient of Contraction	0.600
Length (m)	35.000	Upstream Invert Level (m)	69.250

Pipe Manhole: 3, DS/PN: 2.001, Loop to PN: 1.001

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	400.0	Coefficient of Contraction	0.600
Length (m)	50.000	Upstream Invert Level (m)	68.950

Pipe Manhole: 4, DS/PN: 1.001, Loop to PN: 1.002

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	75.0	Coefficient of Contraction	0.600
Length (m)	19.000	Upstream Invert Level (m)	68.820

Pipe Manhole: 5, DS/PN: 1.002, Loop to PN: 1.003

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	150.0	Coefficient of Contraction	0.600
Length (m)	36.000	Upstream Invert Level (m)	68.550

Pipe Manhole: 6, DS/PN: 1.003, Loop to PN: 1.004

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	475.0	Coefficient of Contraction	0.600
Length (m)	13.000	Upstream Invert Level (m)	68.320

Pipe Manhole: 7, DS/PN: 3.000, Loop to PN: 3.001

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	175.0	Coefficient of Contraction	0.600
Length (m)	42.000	Upstream Invert Level (m)	68.750

Pipe Manhole: 8, DS/PN: 3.001, Loop to PN: 3.002

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	200.0	Coefficient of Contraction	0.600
Length (m)	25.000	Upstream Invert Level (m)	68.573

Pipe Manhole: 9, DS/PN: 3.002, Loop to PN: 1.004

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	250.0	Coefficient of Contraction	0.600
Length (m)	41.000	Upstream Invert Level (m)	68.449

Pipe Manhole: 10, DS/PN: 1.004, Loop to PN: 1.005

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	175.0	Coefficient of Contraction	0.600
Length (m)	42.000	Upstream Invert Level (m)	68.292

Pipe Manhole: 11, DS/PN: 1.005, Loop to PN: 1.006

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	600.0	Coefficient of Contraction	0.600
Length (m)	31.000	Upstream Invert Level (m)	68.050

Pipe Manhole: 12, DS/PN: 1.006, Loop to PN: 1.007

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	950.0	Coefficient of Contraction	0.600
Length (m)	28.000	Upstream Invert Level (m)	68.000

Pipe Manhole: 13, DS/PN: 1.007, Loop to PN: 1.008

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	750.0	Coefficient of Contraction	0.600
Length (m)	15.000	Upstream Invert Level (m)	67.970

Pipe Manhole: 14, DS/PN: 4.000, Loop to PN: 4.001

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	1000.0	Coefficient of Contraction	0.600
Length (m)	30.000	Upstream Invert Level (m)	68.000

Pipe Manhole: 15, DS/PN: 5.000, Loop to PN: 5.001

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	150.0	Coefficient of Contraction	0.600
Length (m)	32.000	Upstream Invert Level (m)	68.529

Pipe Manhole: 16, DS/PN: 5.001, Loop to PN: 5.002

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	100.0	Coefficient of Contraction	0.600
Length (m)	33.000	Upstream Invert Level (m)	68.320

Pipe Manhole: 17, DS/PN: 5.002, Loop to PN: 4.001

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	500.0	Coefficient of Contraction	0.600
Length (m)	15.000	Upstream Invert Level (m)	68.000

Pipe Manhole: 18, DS/PN: 4.001, Loop to PN: 4.002

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	1050.0	Coefficient of Contraction	0.600
Length (m)	52.000	Upstream Invert Level (m)	67.970

Pipe Manhole: 16, DS/PN: 6.000, Loop to PN: 6.001

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	125.0	Coefficient of Contraction	0.600
Length (m)	21.000	Upstream Invert Level (m)	68.293

Pipe Manhole: 17, DS/PN: 6.001, Loop to PN: 6.002

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	175.0	Coefficient of Contraction	0.600
Length (m)	31.000	Upstream Invert Level (m)	68.126

Pipe Manhole: 18, DS/PN: 6.002, Loop to PN: 4.002

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	875.0	Coefficient of Contraction	0.600
Length (m)	26.000	Upstream Invert Level (m)	67.950

Pipe Manhole: 16, DS/PN: 4.002, Loop to PN: 4.003

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	750.0	Coefficient of Contraction	0.600
Length (m)	15.000	Upstream Invert Level (m)	67.920

Pipe Manhole: 17, DS/PN: 4.003, Loop to PN: 8.000

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	500.0	Coefficient of Contraction	0.600
Length (m)	42.000	Upstream Invert Level (m)	67.900

Pipe Manhole: 18, DS/PN: 1.008, Loop to PN: 1.009

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	575.0	Coefficient of Contraction	0.600
Length (m)	17.000	Upstream Invert Level (m)	67.950

Pipe Manhole: 19, DS/PN: 1.009, Loop to PN: 1.010

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	150.0	Coefficient of Contraction	0.600
Length (m)	24.000	Upstream Invert Level (m)	67.920

Pipe Manhole: 20, DS/PN: 1.010, Loop to PN: 1.011

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	675.0	Coefficient of Contraction	0.600
Length (m)	34.000	Upstream Invert Level (m)	67.750

Weir Manhole: 21, DS/PN: 7.000, Loop to PN: None

Discharge Coef 0.544 Width (m) 2.000 Invert Level (m) 67.850

Pipe Manhole: 21, DS/PN: 7.000, Loop to PN: 7.001

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	600.0	Coefficient of Contraction	0.600
Length (m)	30.000	Upstream Invert Level (m)	67.850

Pipe Manhole: 22, DS/PN: 8.000, Loop to PN: 7.001

Diameter (m)	-8	Length (m)	42.000
Section Type	Pipe/Conduit	Manning's n	0.017
Slope (1:X)	850.0	Entry Loss Coefficient	0.500

Pipe Manhole: 22, DS/PN: 8.000, Loop to PN: 7.001

Coefficient of Contraction 0.600 Upstream Invert Level (m) 67.850

Weir Manhole: 24, DS/PN: 7.001, Loop to PN: None

Discharge Coef 0.544 Width (m) 2.000 Invert Level (m) 67.800

Pipe Manhole: 24, DS/PN: 7.001, Loop to PN: 7.002

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	850.0	Coefficient of Contraction	0.600
Length (m)	43.000	Upstream Invert Level (m)	67.800

Weir Manhole: 25, DS/PN: 7.002, Loop to PN: None

Discharge Coef 0.544 Width (m) 2.000 Invert Level (m) 67.750

Pipe Manhole: 25, DS/PN: 7.002, Loop to PN: 1.011

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	750.0	Coefficient of Contraction	0.600
Length (m)	38.000	Upstream Invert Level (m)	67.750

Weir Manhole: 26, DS/PN: 1.011, Loop to PN: 1.012

Discharge Coef 0.544 Width (m) 2.000 Invert Level (m) 67.700

Pipe Manhole: 27, DS/PN: 9.000, Loop to PN: 9.001

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	150.0	Coefficient of Contraction	0.600
Length (m)	27.000	Upstream Invert Level (m)	69.150

Pipe Manhole: 28, DS/PN: 9.001, Loop to PN: 9.002

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	100.0	Coefficient of Contraction	0.600
Length (m)	41.000	Upstream Invert Level (m)	68.975

Pipe Manhole: 29, DS/PN: 9.002, Loop to PN: 9.003

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	100.0	Coefficient of Contraction	0.600
Length (m)	43.000	Upstream Invert Level (m)	68.600

Pipe Manhole: 30, DS/PN: 9.003, Loop to PN: 9.004

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	125.0	Coefficient of Contraction	0.600
Length (m)	26.000	Upstream Invert Level (m)	68.218

Pipe Manhole: 31, DS/PN: 9.004, Loop to PN: 9.005

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	625.0	Coefficient of Contraction	0.600
Length (m)	31.000	Upstream Invert Level (m)	68.000

Pipe Manhole: 32, DS/PN: 9.005, Loop to PN: 9.006

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	350.0	Coefficient of Contraction	0.600
Length (m)	18.000	Upstream Invert Level (m)	67.950

Pipe Manhole: 33, DS/PN: 9.006, Loop to PN: 9.007

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	1050.0	Coefficient of Contraction	0.600
Length (m)	52.000	Upstream Invert Level (m)	67.900

Pipe Manhole: 34, DS/PN: 9.007, Loop to PN: 7.000

Diameter (m)	-8	Manning's n	0.017
Section Type	Pipe/Conduit	Entry Loss Coefficient	0.500
Slope (1:X)	200.0	Coefficient of Contraction	0.600
Length (m)	10.000	Upstream Invert Level (m)	67.850

Storage Structures for Storm

Infiltration Basin Manhole: 1, DS/PN: 1.000

Invert Level (m) 67.936 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	81.0	0.600	81.0	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 2, DS/PN: 2.000

Invert Level (m) 68.100 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	157.5	0.600	157.5	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 3, DS/PN: 2.001

Invert Level (m) 67.970 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	225.0	0.600	225.0	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 4, DS/PN: 1.001

Invert Level (m) 67.550 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	85.5	0.600	85.5	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 5, DS/PN: 1.002

Invert Level (m) 67.510 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	162.0	0.600	162.0	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 6, DS/PN: 1.003

Invert Level (m) 67.420 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	58.5	0.600	58.5	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 7, DS/PN: 3.000

Invert Level (m) 67.600 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	148.5	0.600	148.5	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 8, DS/PN: 3.001

Invert Level (m) 67.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	112.5	0.600	112.5	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 9, DS/PN: 3.002

Invert Level (m) 67.450 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	184.5	0.600	184.5	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 10, DS/PN: 1.004

Invert Level (m) 67.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	189.0	0.600	189.0	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 11, DS/PN: 1.005

Invert Level (m) 67.150 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	135.0	0.600	135.0	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 12, DS/PN: 1.006

Invert Level (m) 67.100 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	126.0	0.600	126.0	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 13, DS/PN: 1.007

Invert Level (m) 67.070 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	67.5	0.600	67.5	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 14, DS/PN: 4.000

Invert Level (m) 67.250 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	135.0	0.450	135.0	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 15, DS/PN: 5.000

Invert Level (m) 67.350 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	144.0	0.600	144.0	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 16, DS/PN: 5.001

Invert Level (m) 67.300 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	148.5	0.450	148.5	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 17, DS/PN: 5.002

Invert Level (m) 67.250 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	67.5	0.450	67.5	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 18, DS/PN: 4.001

Invert Level (m) 67.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	234.0	0.450	234.0	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 16, DS/PN: 6.000

Invert Level (m) 67.300 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 1.00
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	94.5	0.450	94.5	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 17, DS/PN: 6.001

Invert Level (m) 67.250 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	139.5	0.450	139.5	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 18, DS/PN: 6.002

Invert Level (m) 67.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	117.0	0.450	117.0	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 16, DS/PN: 4.002

Invert Level (m) 67.170 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	67.5	0.450	67.5	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 17, DS/PN: 4.003

Invert Level (m) 67.150 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	189.0	0.450	189.0	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 18, DS/PN: 1.008

Invert Level (m) 67.050 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	76.5	0.600	76.5	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 19, DS/PN: 1.009

Invert Level (m) 67.020 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	108.0	0.450	108.0	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 20, DS/PN: 1.010

Invert Level (m) 67.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	148.5	0.450	148.5	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 21, DS/PN: 7.000

Invert Level (m) 67.100 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	135.0	0.450	135.0	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 22, DS/PN: 8.000

Invert Level (m) 67.100 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	189.0	0.450	189.0	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 24, DS/PN: 7.001

Invert Level (m) 67.050 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	193.5	0.450	193.5	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 25, DS/PN: 7.002

Invert Level (m) 67.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	171.0	0.450	171.0	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 27, DS/PN: 9.000

Invert Level (m) 68.250 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	121.5	0.600	121.5	0.601	1.0	0.900	1.0

Infiltration Basin Manhole: 28, DS/PN: 9.001

Invert Level (m) 68.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	184.5	0.450	184.5	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 29, DS/PN: 9.002

Invert Level (m) 67.850 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	193.5	0.450	193.5	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 30, DS/PN: 9.003

Invert Level (m) 67.468 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	117.0	0.450	117.0	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 31, DS/PN: 9.004

Invert Level (m) 67.250 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	139.5	0.450	139.5	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 32, DS/PN: 9.005

Invert Level (m) 67.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	81.0	0.450	81.0	0.451	1.0	0.750	1.0

Infiltration Basin Manhole: 33, DS/PN: 9.006

Invert Level (m) 67.150 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.30
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	234.0	0.450	234.0	0.451	1.0	0.750	1.0

Tank or Pond Manhole: 35, DS/PN: 1.012

Invert Level (m) 66.800

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1200.0	0.600	2000.0

30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor 1.000 Additional Flow - % of Total Flow 0.000
Hot Start (mins) 0 MADD Factor * 10m³/ha Storage 5.000
Hot Start Level (mm) 0 Inlet Coeffiecient 0.800
Manhole Headloss Coeff (Global) 0.500 Flow per Person per Day (l/per/day) 0.000
Foul Sewage per hectare (l/s) 0.000

Number of Input Hydrographs 0 Number of Storage Structures 38
Number of Online Controls 2 Number of Time/Area Diagrams 0
Number of Offline Controls 42 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FEH
Site Location	GB 459800 222850 SP 59800 22850
C (1km)	-0.022
D1 (1km)	0.323
D2 (1km)	0.320
D3 (1km)	0.249
E (1km)	0.289
F (1km)	2.479
Cv (Summer)	0.750
Cv (Winter)	0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440
Return Period(s) (years)	30, 100
Climate Change (%)	0, 30

PN	Storm	Return Period	Climate Change	First X Surcharge	First Y Flood	First Z Overflow	O/F Act.	Lvl Exc.
1.000	15 Winter	30	0%	100/15 Summer			0	
2.000	15 Winter	30	0%	100/15 Summer			0	
2.001	15 Winter	30	0%	100/15 Summer			0	
1.001	15 Winter	30	0%	100/15 Summer			0	
1.002	30 Winter	30	0%	100/15 Summer			0	
1.003	60 Winter	30	0%	30/30 Winter			0	
3.000	15 Winter	30	0%	100/30 Summer			0	
3.001	60 Winter	30	0%	100/15 Summer			0	
3.002	60 Winter	30	0%	100/15 Summer			0	
1.004	60 Winter	30	0%	30/30 Winter			0	
1.005	120 Winter	30	0%	30/60 Winter		100/60 Winter	3	
1.006	120 Winter	30	0%	30/30 Winter		100/60 Winter	2	
1.007	120 Winter	30	0%	30/30 Summer			0	
4.000	120 Winter	30	0%	100/30 Winter		100/60 Winter	3	
5.000	15 Winter	30	0%	100/15 Summer			0	

30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	Storm	Return Period	Climate Change	First X Surcharge	First Y Flood	First Z Overflow	O/F Act.	Lvl Exc.
5.001	60 Winter	30	0%	100/15 Summer				0
5.002	120 Winter	30	0%	100/15 Summer		100/60 Winter		3
4.001	120 Winter	30	0%	100/15 Summer		100/60 Winter		4
6.000	180 Winter	30	0%	100/15 Summer				0
6.001	180 Winter	30	0%	30/30 Winter				0
6.002	120 Winter	30	0%	30/15 Winter		100/60 Winter		4
4.002	120 Winter	30	0%	30/60 Winter		100/60 Winter		4
4.003	120 Winter	30	0%	30/60 Winter		100/60 Winter		4
1.008	120 Winter	30	0%	30/15 Winter				0
1.009	120 Winter	30	0%	30/15 Winter				0
1.010	120 Winter	30	0%	30/15 Winter				0
7.000	15 Winter	30	0%	100/15 Summer				0
8.000	600 Winter	30	0%	100/30 Winter				0
7.001	600 Winter	30	0%	100/15 Summer				0
7.002	600 Winter	30	0%	100/60 Winter				0
1.011	600 Winter	30	0%	100/120 Winter				0
9.000	15 Winter	30	0%	100/15 Summer				0
9.001	15 Winter	30	0%	100/15 Summer				0
9.002	30 Winter	30	0%	100/15 Summer				0
9.003	15 Winter	30	0%	100/15 Summer				0
9.004	30 Winter	30	0%	100/15 Summer		100/15 Winter		3
9.005	30 Winter	30	0%	100/15 Summer		100/30 Winter		2
9.006	60 Winter	30	0%	100/15 Summer		100/30 Winter		1
9.007	60 Winter	30	0%					0
1.012	600 Winter	30	0%	100/60 Winter				
1.013	120 Winter	30	0%					

PN	US/MH Name	Water Level (m)	Surch'ed Depth (m)	Flooded Volume (m³)	Flow / Cap.	O'flow (l/s)	Pipe Flow (l/s)	Status
1.000	1	68.165	-0.071	0.000	0.92	0.0	45.8	OK
2.000	2	68.248	-0.152	0.000	0.31	0.0	16.8	OK
2.001	3	68.220	-0.080	0.000	0.86	0.0	42.4	OK
1.001	4	68.114	-0.072	0.000	0.93	0.0	64.1	OK
1.002	5	67.960	-0.126	0.000	0.63	0.0	65.2	OK
1.003	6	67.741	0.021	0.000	1.14	0.0	63.5	SURCHARGED
3.000	7	67.726	-0.174	0.000	0.33	0.0	18.1	OK
3.001	8	67.703	-0.097	0.000	0.40	0.0	17.4	OK
3.002	9	67.698	-0.052	0.000	0.52	0.0	23.6	OK
1.004	10	67.690	0.020	0.000	1.15	0.0	57.6	SURCHARGED
1.005	11	67.616	0.046	0.000	0.85	0.0	48.8	SURCHARGED
1.006	12	67.565	0.095	0.000	0.96	0.0	43.9	SURCHARGED
1.007	13	67.515	0.105	0.000	0.76	0.0	44.5	SURCHARGED
4.000	14	67.530	-0.170	0.000	0.10	0.0	5.5	OK
5.000	15	67.608	-0.067	0.000	0.81	0.0	15.3	OK
5.001	16	67.574	-0.051	0.000	0.83	0.0	15.5	OK
5.002	17	67.543	-0.032	0.000	0.71	0.0	18.6	OK
4.001	18	67.527	-0.073	0.000	0.37	0.0	19.3	OK
6.000	16	67.524	-0.001	0.000	0.18	0.0	4.1	OK

30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Water Level (m)	Surch'ed Depth (m)	Flooded Volume (m³)	Flow / Cap.	O'flow (l/s)	Pipe Flow (l/s)	Status
6.001	17	67.522	0.047	0.000	0.32	0.0	6.2	SURCHARGED
6.002	18	67.516	0.091	0.000	0.65	0.0	8.2	SURCHARGED
4.002	16	67.510	0.040	0.000	1.28	0.0	27.1	SURCHARGED
4.003	17	67.496	0.046	0.000	0.44	0.0	21.6	SURCHARGED
1.008	18	67.474	0.124	0.000	1.20	0.0	61.2	SURCHARGED
1.009	19	67.402	0.102	0.000	1.36	0.0	60.6	SURCHARGED
1.010	20	67.311	0.061	0.000	1.58	0.0	61.3	SURCHARGED
7.000	21	67.290	-0.035	0.000	1.00	0.0	19.6	OK
8.000	22	67.250	-0.125	0.000	0.07	0.0	1.7	OK
7.001	24	67.249	-0.026	0.000	0.29	0.0	5.8	OK
7.002	25	67.246	-0.029	0.000	0.15	0.0	7.0	OK
1.011	26	67.245	-0.105	0.000	0.30	0.0	52.9	OK
9.000	27	68.404	-0.071	0.000	0.80	0.0	30.8	OK
9.001	28	68.213	-0.012	0.000	1.00	0.0	29.6	OK
9.002	29	68.010	-0.065	0.000	0.83	0.0	38.7	OK
9.003	30	67.751	-0.017	0.000	1.00	0.0	50.2	OK
9.004	31	67.656	-0.044	0.000	0.75	0.0	52.2	OK
9.005	32	67.583	-0.017	0.000	1.00	0.0	49.8	OK
9.006	33	67.490	-0.060	0.000	0.98	0.0	54.4	OK
9.007	34	67.350	-0.200	0.000	0.59	0.0	59.8	OK
1.012	35	67.239	-0.011	0.000	0.12	0.0	19.6	FLOOD RISK*
1.013	36	66.857	-0.343	0.000	0.13	0.0	19.6	OK

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	5.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Storage Structures	38
Number of Online Controls	2	Number of Time/Area Diagrams	0
Number of Offline Controls	42	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FEH
Site Location	GB 459800 222850 SP 59800 22850
C (1km)	-0.022
D1 (1km)	0.323
D2 (1km)	0.320
D3 (1km)	0.249
E (1km)	0.289
F (1km)	2.479
Cv (Summer)	0.750
Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0	DVD Status	OFF
Analysis Timestep	Fine	Inertia Status	OFF
DTS Status	ON		

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440
Return Period(s) (years)	30, 100
Climate Change (%)	0, 30

PN	Storm	Return Period	Climate Change	First X Surcharge	First Y Flood	First Z Overflow	O/F Act.	Lvl Exc.
1.000	15 Winter	100	+30%	100/15 Summer			0	
2.000	15 Winter	100	+30%	100/15 Summer			0	
2.001	15 Winter	100	+30%	100/15 Summer			0	
1.001	30 Winter	100	+30%	100/15 Summer			0	
1.002	60 Winter	100	+30%	100/15 Summer			0	
1.003	60 Winter	100	+30%	30/30 Winter			0	
3.000	60 Winter	100	+30%	100/30 Summer			0	
3.001	60 Winter	100	+30%	100/15 Summer			0	
3.002	60 Winter	100	+30%	100/15 Summer			0	
1.004	60 Winter	100	+30%	30/30 Winter			0	
1.005	60 Winter	100	+30%	30/60 Winter		100/60 Winter	3	
1.006	120 Winter	100	+30%	30/30 Winter		100/60 Winter	2	
1.007	120 Winter	100	+30%	30/30 Summer			0	
4.000	120 Winter	100	+30%	100/30 Winter		100/60 Winter	3	
5.000	120 Winter	100	+30%	100/15 Summer			0	

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	Storm	Return Period	Climate Change	First X Surcharge	First Y Flood	First Z Overflow	O/F Act.	Lvl Exc.
5.001	120 Winter	100	+30%	100/15 Summer			0	
5.002	120 Winter	100	+30%	100/15 Summer		100/60 Winter	3	
4.001	120 Winter	100	+30%	100/15 Summer		100/60 Winter	4	
6.000	120 Winter	100	+30%	100/15 Summer			0	
6.001	120 Winter	100	+30%	30/30 Winter			0	
6.002	120 Winter	100	+30%	30/15 Winter		100/60 Winter	4	
4.002	120 Winter	100	+30%	30/60 Winter		100/60 Winter	4	
4.003	120 Winter	100	+30%	30/60 Winter		100/60 Winter	4	
1.008	120 Winter	100	+30%	30/15 Winter			0	
1.009	120 Winter	100	+30%	30/15 Winter			0	
1.010	240 Winter	100	+30%	30/15 Winter			0	
7.000	720 Winter	100	+30%	100/15 Summer			0	
8.000	720 Winter	100	+30%	100/30 Winter			0	
7.001	720 Winter	100	+30%	100/15 Summer			0	
7.002	720 Winter	100	+30%	100/60 Winter			0	
1.011	720 Winter	100	+30%	100/120 Winter			0	
9.000	15 Winter	100	+30%	100/15 Summer			0	
9.001	15 Winter	100	+30%	100/15 Summer			0	
9.002	30 Winter	100	+30%	100/15 Summer			0	
9.003	30 Winter	100	+30%	100/15 Summer			0	
9.004	30 Winter	100	+30%	100/15 Summer		100/15 Winter	3	
9.005	30 Winter	100	+30%	100/15 Summer		100/30 Winter	2	
9.006	30 Winter	100	+30%	100/15 Summer		100/30 Winter	1	
9.007	60 Winter	100	+30%				0	
1.012	720 Winter	100	+30%	100/60 Winter				
1.013	720 Winter	100	+30%					

PN	US/MH Name	Water Level (m)	Surch'ed Depth (m)	Flooded Volume (m³)	Flow / Cap.	O'flow (l/s)	Pipe Flow (l/s)	Status
1.000	1	68.398	0.162	0.000	1.70	0.0	84.4	SURCHARGED
2.000	2	68.470	0.070	0.000	0.38	0.0	20.7	SURCHARGED
2.001	3	68.445	0.145	0.000	1.10	0.0	54.2	SURCHARGED
1.001	4	68.369	0.183	0.000	1.40	0.0	96.0	SURCHARGED
1.002	5	68.304	0.218	0.000	0.76	0.0	78.2	SURCHARGED
1.003	6	68.213	0.493	0.000	1.51	0.0	84.7	FLOOD RISK
3.000	7	68.193	0.293	0.000	0.30	0.0	16.6	SURCHARGED
3.001	8	68.191	0.391	0.000	0.59	0.0	26.0	SURCHARGED
3.002	9	68.186	0.436	0.000	0.66	0.0	29.8	SURCHARGED
1.004	10	68.178	0.508	0.000	1.30	0.0	65.1	FLOOD RISK
1.005	11	68.090	0.520	0.000	1.15	8.0	65.8	FLOOD RISK
1.006	12	68.036	0.566	0.000	1.24	3.0	57.0	FLOOD RISK
1.007	13	67.970	0.560	0.000	1.09	0.0	64.1	FLOOD RISK
4.000	14	68.021	0.321	0.000	0.15	1.1	8.5	FLOOD RISK
5.000	15	68.096	0.421	0.000	0.56	0.0	10.5	SURCHARGED
5.001	16	68.074	0.449	0.000	0.73	0.0	13.6	SURCHARGED
5.002	17	68.038	0.463	0.000	0.96	7.1	25.0	FLOOD RISK
4.001	18	68.015	0.415	0.000	0.51	7.0	26.7	FLOOD RISK
6.000	16	68.045	0.520	0.000	0.25	0.0	5.6	SURCHARGED

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Water Level (m)	Surch'ed Depth (m)	Flooded Volume (m³)	Flow / Cap.	O'flow (l/s)	Pipe Flow (l/s)	Status
6.001	17	68.032	0.557	0.000	0.60	0.0	11.5	FLOOD RISK
6.002	18	67.998	0.573	0.000	0.78	8.5	9.8	FLOOD RISK
4.002	16	67.981	0.511	0.000	2.01	22.2	42.7	FLOOD RISK
4.003	17	67.955	0.505	0.000	0.69	19.2	34.5	FLOOD RISK
1.008	18	67.910	0.560	0.000	1.86	0.0	94.6	FLOOD RISK
1.009	19	67.735	0.435	0.000	2.12	0.0	94.7	FLOOD RISK
1.010	20	67.530	0.280	0.000	2.31	0.0	89.6	SURCHARGED
7.000	21	67.514	0.189	0.000	0.19	0.0	3.6	SURCHARGED
8.000	22	67.514	0.139	0.000	0.09	0.0	2.1	SURCHARGED
7.001	24	67.513	0.238	0.000	0.33	0.0	6.7	SURCHARGED
7.002	25	67.509	0.234	0.000	0.16	0.0	7.2	SURCHARGED
1.011	26	67.506	0.156	0.000	0.35	0.0	62.0	FLOOD RISK
9.000	27	68.578	0.103	0.000	1.12	0.0	43.2	SURCHARGED
9.001	28	68.439	0.214	0.000	1.14	0.0	33.9	SURCHARGED
9.002	29	68.294	0.219	0.000	0.96	0.0	44.8	SURCHARGED
9.003	30	68.142	0.374	0.000	1.46	0.0	73.2	FLOOD RISK
9.004	31	68.058	0.358	0.000	1.19	24.7	83.4	FLOOD RISK
9.005	32	67.998	0.398	0.000	1.83	14.8	91.1	FLOOD RISK
9.006	33	67.922	0.372	0.000	1.64	0.7	91.4	FLOOD RISK
9.007	34	67.548	-0.002	0.000	1.00	0.0	101.3	OK
1.012	35	67.500	0.250	0.000	0.13	0.0	21.6	FLOOD RISK*
1.013	36	66.862	-0.338	0.000	0.14	0.0	21.6	OK

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