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Bexhill to Hastings Link Road
Egerton Stream Flood Risk Assessment

Preliminary Report on the Egerton Stream Integrated Urban Drainage Model

December 2009

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Document control sheet — BPP 04 F8

Client: Hochtief/Vinci JV
Project: Bexhill to Hastings Link Road — Job No: B1297000
Document Title: Egerton Stream FRA
Preliminary Report on the Egerton Stream IUD Model

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DATE **December 2009**	SIGNATURE	SIGNATURE	SIGNATURE	SIGNATURE
Document Status	**DRAFT FOR CLIENT REVIEW**			

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1 Introduction

1.1 Background

The proposed Bexhill to Hastings Link Road development has previously been subject to flood risk assessments as required by PPS25.

In July 2004 Bullen Consultants (now AECOM) prepared a hydraulic model of the Egerton Stream catchment using MIKE11 software. The results and conclusions of this modelling formed part of the Flood Risk Assessment prepared by East Sussex County Council in April 2008.

The MIKE11 model predicted surface flooding along a disused railway corridor that is to be used for construction of the Bexhill to Hastings Link Road. The model indicated that extensive flooding would occur in the existing railway cutting through which the new road is proposed to pass. A condition of the development would be that the loss of floodplain resulting from the construction of the link road should be compensated for by a storage scheme. This is in compliance with Environment Agency policy. The current scheme proposal provides for a 7,250m^3 underground storage tank adjacent to London Road for compensation storage. This proposal has been agreed with the Environment Agency and forms part of the planning conditions for the scheme.

This report is a review of the hydraulic modelling conclusions using alternative InfoWorks CS2D software. The review considers that the conclusions drawn from the MIKE11 model are not representative for a number of reasons:

- *MIKE11 is intended for the modelling of river catchments in rural areas whereas the Egerton Stream catchment consists of urban development.*
- *The majority of the catchment is served by Southern Waters combined sewerage system and only 2 combined sewer overflows (CSO's) contribute flow directly to the Egerton Stream.*
- *There are only relatively small areas of the catchment that are served by surface water sewers draining to the Egerton Stream.*
- *Because the catchment is an urban development there is potential for only a small amount of natural run-off into the Egerton Stream.*

This report describes the 2D modelling that has been carried out, using existing available data, in order to increase confidence in the extent and volume of flooding in the disused railway cutting. (The model will also provide a basis for studying options for the management of urban flood risk in the Bexhill area if required.) The Egerton Stream catchment area is shown in Figure 1-A.

There is no existing storm drainage model for the Egerton Stream area. A new surface water sewer model has been developed using InfoWorks CS 2D (IWCS) for these areas.

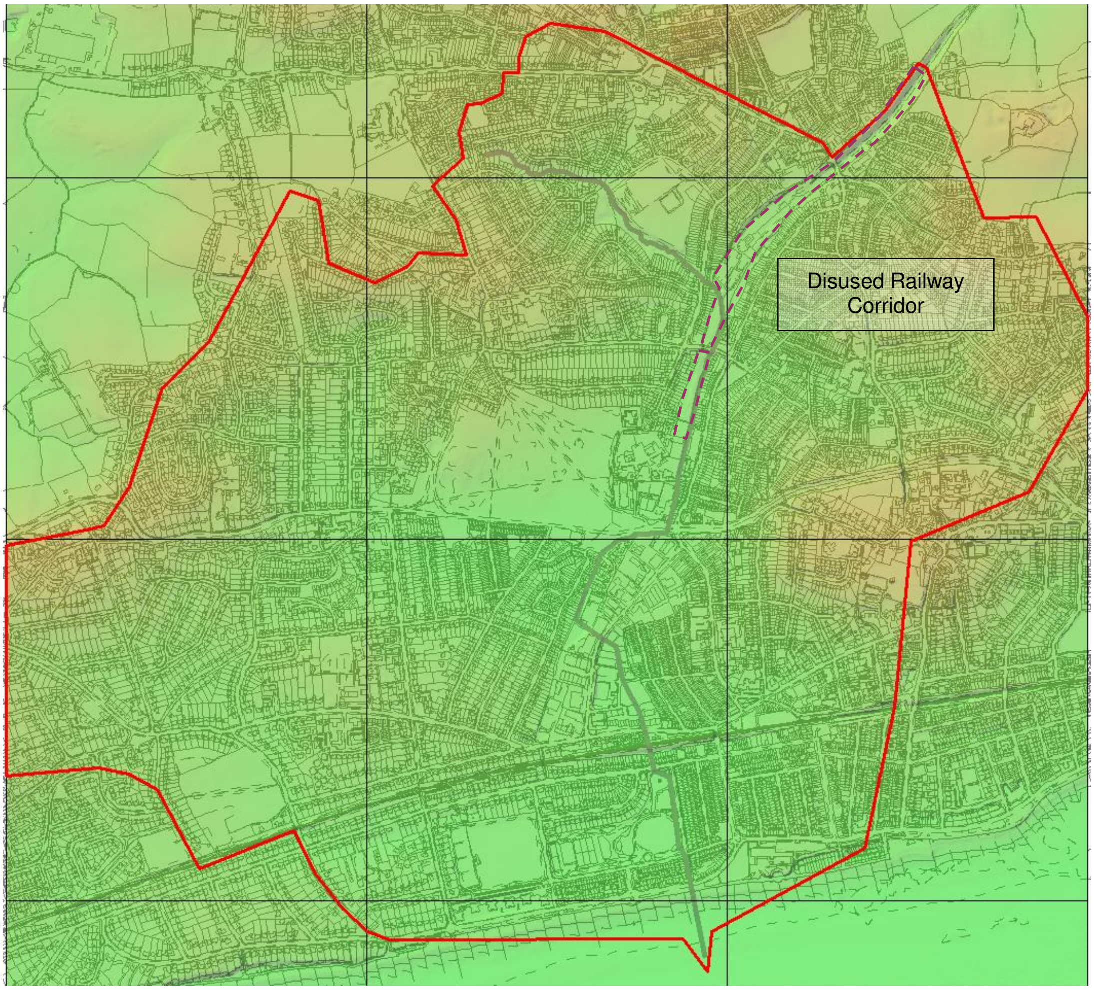

Figure 1-A Overview of Egerton Stream Catchment in Bexhill Town Area

2 Overview of Catchment

2.1 Catchment description

Egerton Stream is fed by a number of overland streams mainly rising at the clayey escarpment to the north. The overall natural catchment of the stream at Bexhill is approximately 500ha.

The watercourse is predominantly open channel until it reaches the Belle Hill area from where it is mainly culverted to the coast. The whole urban catchment drains to both the open channel and culverted sections of the Egerton Stream.

The Egerton Stream Catchment Area is urban and sub-urban and therefore the catchment surface is generally relatively impermeable generating rapid rainfall run-off.

The general trend in the catchment topography is a fall from north to south from around 45mAOD to 0mAOD, an overall gradient of around 1 in 50. The surface drainage network follows the topographical trend. The main channel of the Egerton Stream flows eastwards from around 35mAOD to 15mAOD and than southwards from around 15mAOD to 0mAOD where, at about 10mAOD, it enters the culverted section through the town centre. The fall in the first eastwards stretch occurs over a short distance of less than 1km giving a slope more than 0.2%.

2.2 Overall Modelling Strategy

In order to be able to model each part of the system using the most appropriate tools, it was decided to model the urban catchments draining in full by taking into account both the storm and foul/combined sewers as well as overland flows, which develops as exceedance of the sewer drainage capacity and surface water not entering into sewers. The areas of the catchment drained by surface water sewers, combined sewers and surface run off to the Egerton Stream are shown on Figure 2-A.

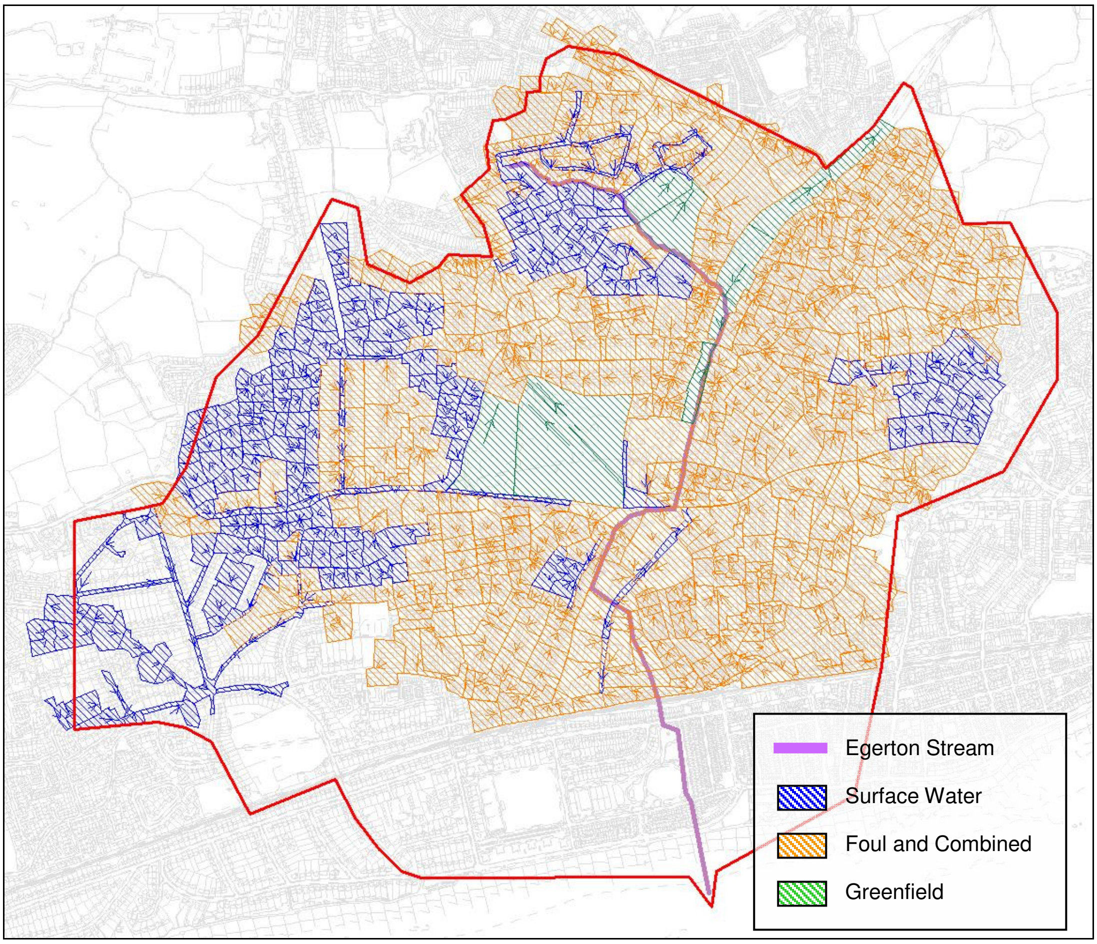

Figure 2-A Overview of the modelled drainage system in the Egerton Stream Catchment

3 Approach to Modelling

3.1 Objectives of Model

The objective of preparing this model is to ascertain the flood risk to the road development site within the railway cutting. To do this the model:

- simulates the overland flows and the performance of the Egerton Stream for the 100 Annual Exceedance Probability (AEP)
- includes and allowance for climate change
- considers that the capacity of the urban sewerage system is likely to be exceeded in events of 15 AEP or less.

The model should include sufficient detail to provide a thorough understanding of flood risk mechanisms and effects and allow for practicable mitigation measures to be assessed. The model should allow for future developments in flood risk assessment methodology.

3.2 Model Software Selection

The considerations above led to the construction of a 2D urban drainage model, coupled with a 2D model for simulating overland flows.

Based upon Jacobs' recent experience on similar projects, notably the Hogsmill Defra Integrated Urban Drainage Pilot Study, the software selected was InfoWorksCS (IWCS), incorporating a 2D overland flow capability.

This combination allows for the modelling of complex overland flow in urban areas linked with surface water and combined sewer flows, and includes the potential for modelling urban flood mitigation measures.

3.3 Catchment Characteristics

Overall catchment characteristics are taken from the FEH-CDROM Version 2, as well as available runoff parameters provided by Southern Water for a series of sub-catchments representing the various tributaries of the Egerton Stream.

4 Data Collection

4.1 Sources of Model Data

Data for the construction of the model was obtained from the following sources:

- *Environment Agency (EA)*
- *Southern Water (SWS)*
- *East Sussex County Council (ESCC)*

4.2 Environment Agency Data

The EA provided background information. Data specifically supplied for model construction was as follows:

- *LiDAR data – for the development of a Digital Terrain Model (DTM) and the determination of catchment areas*

4.3 Southern Water Data

Southern Water provided the following data:

- *Sewer network data – comprising pipe types and diameters, pipe lengths and invert levels, manhole locations and connections at manholes for the surface, foul and combined drainage systems with all the relevant ancillaries. The data was provided in GIS MapInfo format.*
- *The results of an Impermeable Area Study (IAS) of the Egerton catchment that defines areas of the urban catchment draining to the separate drainage system as well as to the system of soakaways.*
- *A model of the combined drainage system (but not including the surface drainage system).*

4.4 East Sussex County Council

ESSC provided the following data:

- *Mastermap to provide background mapping and to assist in the development of the rainfall-runoff modelling and urban drainage system*
- *"Bexhill to Hastings Link Road – Hydraulic Modelling" produced by Bullen Consultants to East Sussex County Council in July 2004*
- *Topographical survey information*

5 Model Construction

5.1 Overview

The hydraulic model was constructed using InfoWorks Version 10.5.

Data flags were used throughout the model to provide a record of the origin of data.

The extent of the drainage network and open channel included in the model is shown in Figure 5-A.

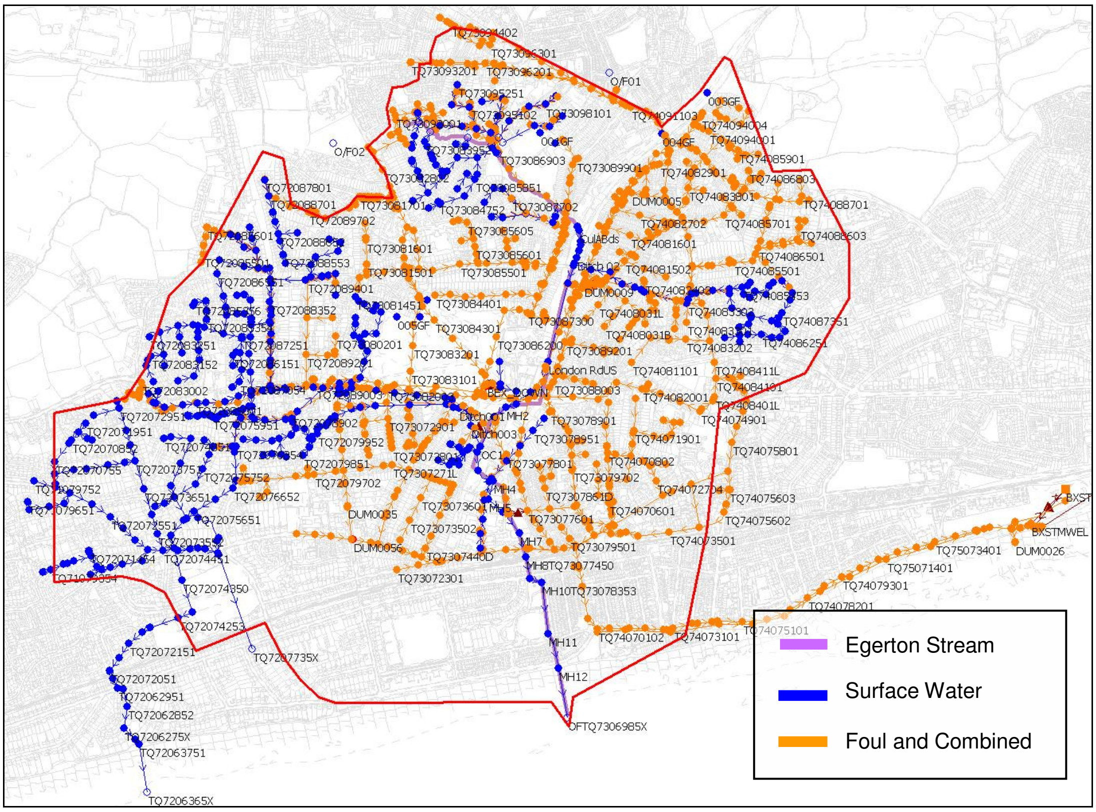

Figure 5-A Extents of pipe drainage network and open channel modelled

5.2 Model Construction

5.2.1 IWCS 1D Sewer Model

The sewer network was constructed by importing data received from Southern Water in MapInfo format into InfoWorks CS using import tools to define a set of nodes (manholes) and conduits (pipes) to create the drainage network. The data imported covered pipe diameters and upstream and downstream invert levels and the relative ground levels of the manholes. All the relevant structures and pumping stations with operational levels and discharge flows are included in the model. Particular attention was paid to the modelling of the fully functional Combined Sewer Overflows (CSO's) as their location and operational status was flagged up as important during the meetings with Southern Water.
The connectivity of the entire network was checked by investigating the long sections for every sewer branch within the model. In general, about 15% of pipe

diameters and 30% of levels were missing or suspect and had to be inferred using a combination of InfoWorks tools, LiDAR elevation data and expert judgement. The surface roughness of the pipes (Colebrook-White roughness type) was set globally at 3.0mm which both realistically represent the present condition of the pipeline and is consistent with the Southern Water recommendations.

The downstream boundary of the model was defined by a free outfall at the downstream end of the town centre culvert where it discharges into the sea. Also ,during the phase of model sensitivity testing, the high tide was modelled as a downstream control in order to check that flood risk is not increased when the culvert is tide-locked.

5.2.2 IWCS 2D Surface Drainage Model

A single 2D overland flow model was constructed to cover the entire urban catchment area as shown in Figure 5-B. This model excludes the sub-surface sewerage networks and can be compared to the MIKEII model previously constructed by Bullen Consultants. The LiDAR data was used to define the Egerton Stream catchment contributing area and thus the extent of the 2D Simulation model. The main purpose of this 2D model is to simulate overland flow, determine the flow paths, the extent and depth of flooding and so assess the potential flooding. In general, interconnection between the 1D and 2D models takes place at “2D Manholes” where surcharging of the 1D model drives flow out onto the surface in the 2D model at the place of 2D Manhole. Also surface flow can enter the 1D model via a 2D Manhole whenever there is capacity within the 1D network.

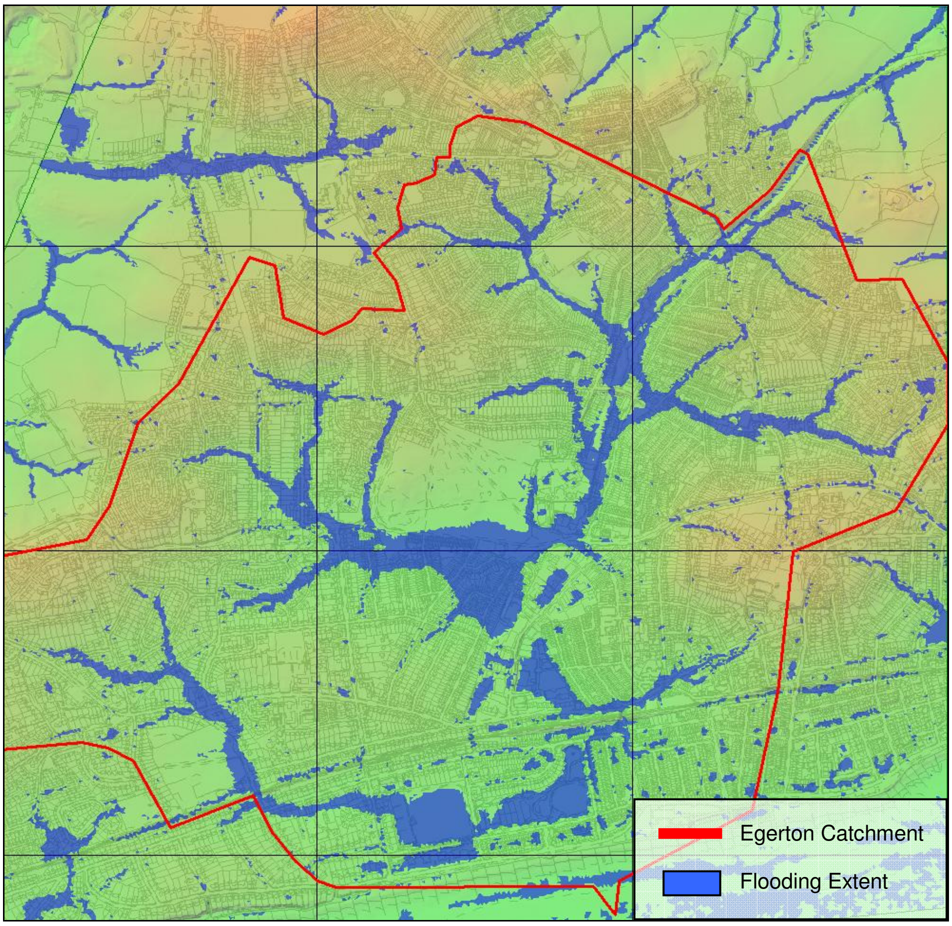

Figure 5-B Extent of Flooding M100-120+CC(ignoring sewer systems)

The 2D model was based on bare earth LiDAR Digital Terrain Model (DTM) data, with all structures and vegetation removed. A global Manning's n value of 0.05 was adopted to represent surface roughness and different obstacles in an urban area.

Typical details of a 2D mesh are as follows:

Number of Triangular Mesh Elements	77,001
Maximum Triangle Element Area	100m^2
Minimum Triangle Element Area	25m^2
Minimum Triangle Element Angle	25°

5.2.3 IWCS Sub-catchments

The sewered and non-sewered catchment areas draining to the Egerton Stream are shown in Figure 5-C. The blue areas drain to surface water sewers and brown areas drain to foul/combined sewers.

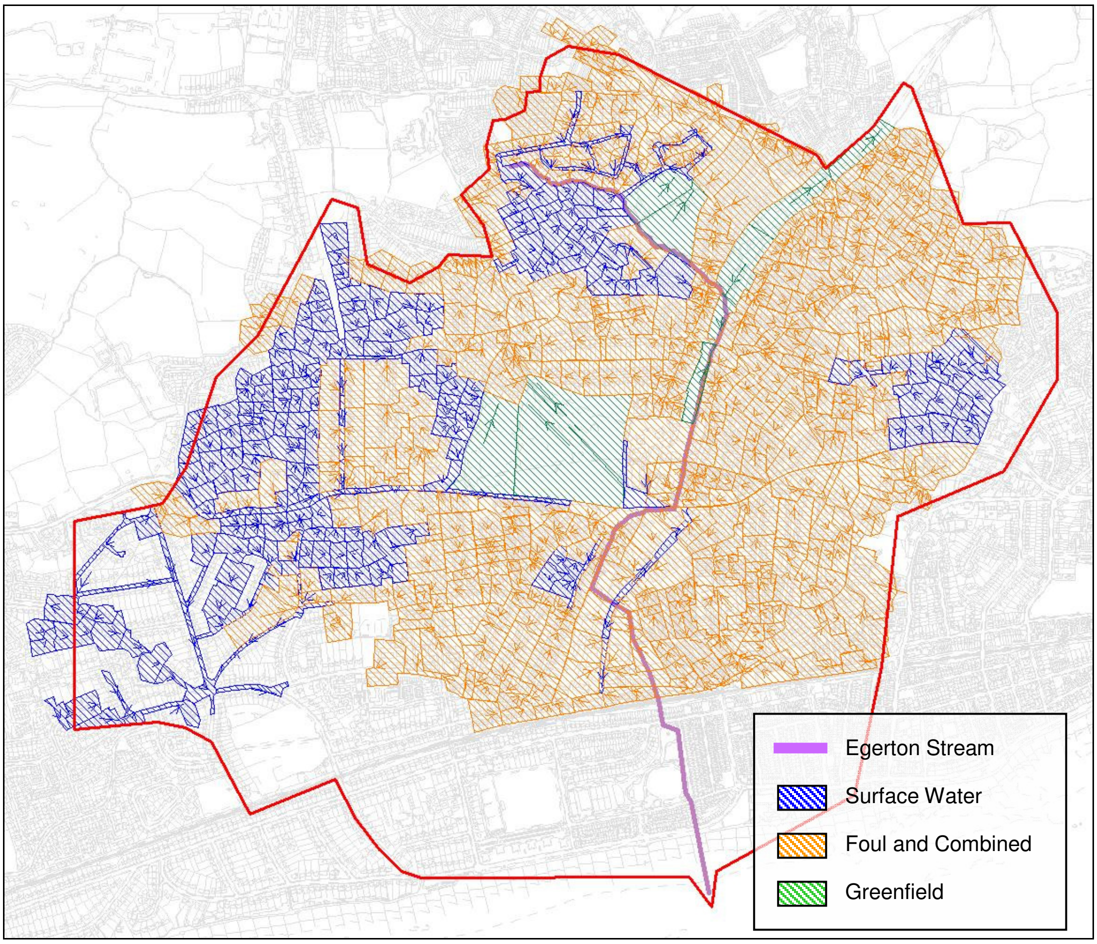

Figure 5-C Overview of the modelled drainage systems

IWCS sub-catchments represent areas which drain to model nodes (manholes). The sub-catchment areas were defined after close examination of three sets of data; LiDAR, OS mapping and Southern Water sewer records.

The properties of each IWCS sub-catchment define the runoff contribution. Two different types of sub-catchment were defined for the Egerton stream model. For each sub-catchment type, three different runoff surfaces were specified as shown in

Table 5-A. The percentage of the sub-catchment allocated to each runoff surface type is also given in this table. The sub-catchment types range from “Greenfield” (permeable - with no roads or roofs) to “Residential” representing the range of development density across the catchment.

Three runoff surfaces were defined each with an allocated Identification (ID) number. A fixed runoff coefficient is assumed for paved (ID = 50), roofed (ID = 60) and a variable runoff coefficient for permeable (ID =62) surface type, as given in Table 5-B:

Sub-catchment	Runoff Surface ID - Roads	Area (%)	Runoff Surface ID - Roofs	Area (%)	Runoff Surface ID - Green	Area (%)
Greenfield All	-	0	-	0	62	100
Residential All	50	40	60	20	62	40

Table 5-A Sub-catchment types, runoff surface IDs and areas

Runoff Surface ID	Description	Fixed Runoff Coefficient (%)
50	Impermeable Surfaces	75
60	Impermeable Surfaces	85
62	Permeable Surfaces	NewUK (NAPI = 5mm)

Table 5-B Surface IDs and runoff coefficients

The runoff coefficient determines the percentage of rainfall that does not infiltrate into the ground and will contribute to overland flow from each surface type. It could be modelled as fixed or variable. It is common to apply a fixed percentage of runoff for the paved and roofed areas but in the case of permeable surfaces a variable percentage was adopted in order to replicate the variable soil saturation before, during and after a rainfall event.

The variable runoff coefficient for permeable surfaces (NewUK Runoff Routing Model) was adopted because within the fixed equation (Wallingford Runoff Routing Model) the percentage of runoff remains constant throughout a rainfall event, irrespective of catchment wetness. Also, this equation takes into account the soil wetness prior a storm event and in this case it is defined by Net Antecedent Precipitation Index (NAPI).

The runoff coefficient parameters for permeable surfaces were provided from Southern Water and are based on an extensive impermeable area connectivity survey conducted during the foul/combined model calibration and verification process. It should be noted that the Southern Water foul/combined IWCS model has been verified using flow data.

5.3 Flood Hydrology

For these initial studies, Flood Estimation Handbook (FEH) rainfall has been used over the whole catchment.

The critical duration for the IWCS urban drainage model was determined by running a range of event durations and was found to be two hours, which is consistent with the Southern Water findings.

5.4 Model Validation and Calibration

Calibration of the model is not possible because there are no gauging stations on the Egerton Stream.

For the purposes of the present study a more informal method for assessing the acceptability of the model was adopted. This is based upon the following:

- Development of a model that represents the drainage system
- Engineering judgement in relation to the values adopted for the various model parameters that are usually adjusted to obtain model purpose
- On comparison with the Southern Water's calibrated and verified foul/combined model.

Formal calibration would require:

- The establishment of one or more flow gauges on both the Egerton Stream and within the urban drainage system
- Installing recording rain-gauges within the catchment
- Collection of data of a period of time sufficient to capture some reasonably large storm events.

This is however beyond the scope of this study.

5.5 Further Development of the Model

Certain assumptions, based on FEH, were made in the model building process about the existing flood hydrology e.g. rainfall-runoff routing. To improve confidence in the parameters assumed further work may be necessary to confirm the appropriate rainfall inputs. It may be necessary to collate historical rainfall data and possibly install a set of rain-gauge stations across the Egerton Catchment.

Other assumptions made for model build parameters (e.g. pipe surface roughness) are considered reasonable but flow metering of surface water sewers may be require for calibration.

The Environment Agency's agreement to the parameters used in the model would almost certainly be required for the existing conditions model to be.

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6 Basic Model Runs and Flood Maps

6.1 Existing Conditions

This model represents the existing conditions of the Egerton Stream catchment and the existing flood risk at this stage and does not incorporate future development.

6.2 Model Runs

Two simulations for downstream boundary conditions were run, one assuming discharge with a free outfall and the other assuming that the system was tide-locked.

The model simulations were run for the 100 AEP rainfall event including an allowance for climate change (30% additional rainfall intensity) and storm duration of 120 minutes.

For the both downstream boundary conditions, flood inundation maps were generated and exported to a GIS environment.

The following plans provide an overview of the flood extent for 1 in 100 AEP with climate change and 120 minutes storm duration.

6.3 Results

6.3.1 Free outfall condition

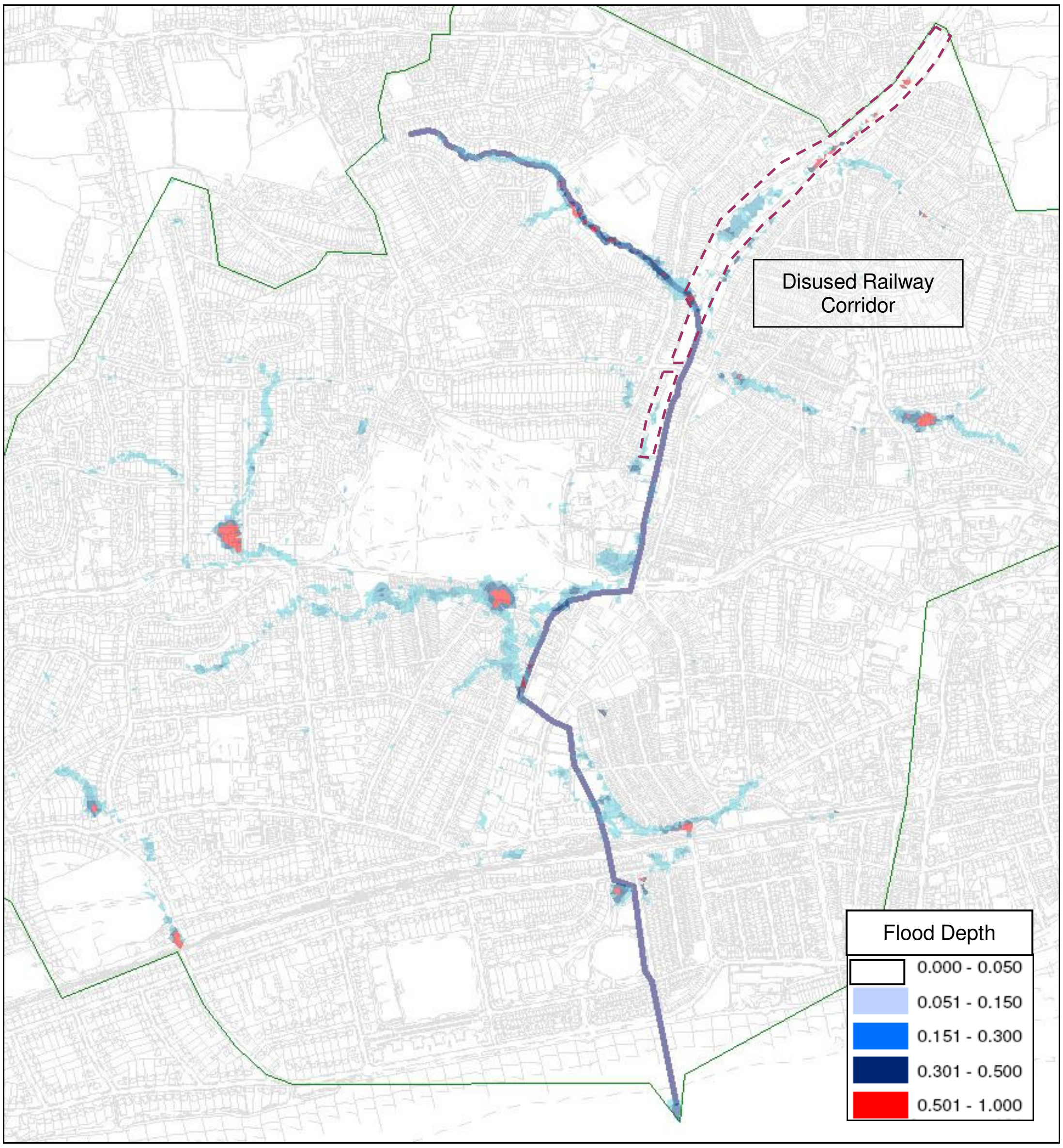

Figure 6-A Extent of Flooding - Condition with Free Outfall (Low Tide), M100-120+cc

Figure 6-A shows the flood extent plan for the 120 minutes 1 in100 AEP plus climate change event for the condition that the Egerton Stream has a free outfall (low tide).

6.3.2 Tide-locked condition

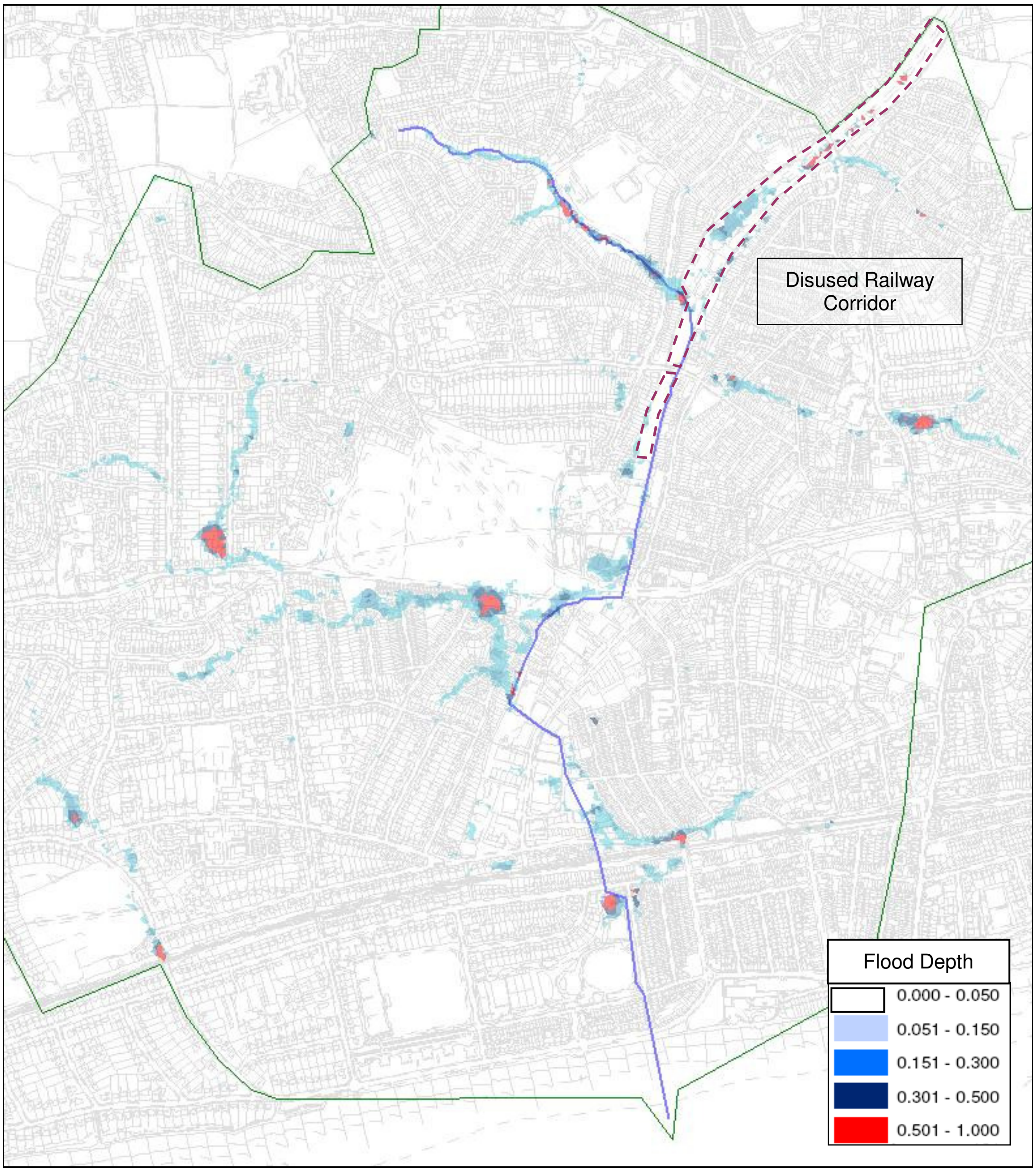

Figure 6-B Extent of Flooding - Condition with High Tide, M100-120+cc

Figure 6-B shows the flood extent plan for the 120 minutes 1 in100 AEP plus climate change event for the condition that the Egerton Stream is tide locked to a high tide level of 3.80mAOD.

Both models produce similar results indicating the downstream control condition is not critical.

For either condition, the volume of flooding in the railway cutting, and therefore the approximate volume required for Compensation Storage, is estimated to be 2,000m^3.

7 Conclusions and Recommendations

7.1 Conclusions

An integrated urban drainage modelling approach using IWCS has enabled a more representative estimation of flooding within the catchment. In particular we estimate that the volume of flood water within the disused railway cutting to be occupied by the proposed Bexhill to Hastings Link Road is approximately 2,000m^3. This is a considerable reduction from the 7,250m^3 required for Compensation Storage by the earlier modelling in MIKE11.

Because flooding occurs in the catchment downstream of the disused railway cutting further investigations are required to confirm if discharging this exceedance flood volume into the Egerton Stream culvert at Chapel Path (which has sufficient capacity) will worsen the flooding of properties downstream.

7.2 Recommendations

It is anticipated that the EA will require an independent review of this model and a brief modelling report to accompany the submission should be prepared for this purpose.

We recommend that, once the EA accepts this model and results of the modelling, further work is carried out to assess options for managing the exceedance flow and optimise compensation storage.

Appendix A – Summary of Model Runs and Outputs

With the Report an accompanied CD is enclosed and it contains flowing:

- *Bexhill FRA Modelling Report*
- *InfoWorks Models with both downstream boundary conditions*

<u>IWCS</u>

In the *IWCS Bexhill FRA Dec2009.iwc* IWCS 2D model draining from the Whole Urban Catchment to the shoreline named:

<Bexhill FRA Dec2009>

Two set of runs have been carried out for storm 1 in 100 AEP with the climate change and durations of 120 minutes:

<Bexhill FRA Dec2009 Existing Conditions Low Tide M100-120+cc>
<Bexhill FRA Dec2009 Existing Conditions M100-120+cc>