Bilbohall, Elgin

Flood Risk Assessment

Curtins Ref: 063882

Revision: 04

Issue Date: 01 November 2018

Client Name: Optimsed Environments

Client Address: Lister Square, Quartermile Two, Edinburgh, EH3 9GL

Site Address: Land at Elgin, Moray

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Control Sheet

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Rev	Description	Issued by	Checked	Date
01	First issue	CVB	PP	21/09/18
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Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 13 - Last updated 15/04/2015

This document should be attached within the front cover of any flood risk assessments issued to Local Planning Authorities (LPA) in support of a development proposal which may be at risk of flooding. The document will take only a few minutes to complete and will assist SEPA in reviewing FRAs, when consulted by LPAs. This document should not be a substitute for a FRA.

Development Proposal						
Site Name		Elgin masterplan				
Grid Reference	Easting:	320797	Northing:	861765		
Local Authority		Moray Council				
Planning Reference number (if known)						
Nature of the development		Residential	If residential, state type:			
Size of the development site		40.74 Ha				
Identified Flood Risk	Source:	Pluvial	Source name:	Some small areas of high water flood risk		
Supporting Information						
Have clear maps / plans been provided within the FRA (including topographic and flood inundation plans)		Yes				
Has a historic flood search been undertaken?		Yes				
Is a formal flood prevention scheme present?		No	If known, state the standard of protection offered			
Current / historical site use		Greenfield				
Hydrology						
Area of catchment		4.1 km^2				
Qmed estimate		m^3/s	Method:	Select from List		
Estimate of 200 year design flood flow		10.023 m^3/s				
Estimation method(s) used *		Rainfall-runoff	If other (please specify methodology used):			
			If Pooled analysis have group details been included	Select from List		
Hydraulics						
Hydraulic modelling method		1D dynamic	Software used:	ISIS		
If other please specify						
Modelled reach length		2,789 m				
Any structures within the modelled length?		Bridges	Specify, if combination	and Culverts		
Brief summary of sensitivity tests, and range:						
variation on flow (%)		%				
variation on channel roughness						
blockage of structure (range of % blocked)		%	Reference CIRIA culvert design guide R168, section 8.4			
boundary conditions:		**Upstream**		**Downstream**		
(1) type		Flow		Normal depth		
	Specify if other		Specify if other			
(2) does it influence water levels at the site?		No		Select from List		
Has model been calibrated (gauge data / flood records)?		No				
Is the hydraulic model available to SEPA?		Select from List				
Design flood levels	200 year	m AOD	200 year plus climate change	m AOD		

Flood Risk Assessment (FRA) Checklist

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Coastal						
Estimate of 200 year design flood level			m AOD			
Estimation method(s) used		Select from List	If other (please specify methodology used):			
Allowance for climate change (m)			m			
Allowance for wave action etc (m)			m			
Overall design flood level			m AOD			
Development						
Is any of the site within the functional floodplain? (refer to SPP para 255)		No	If yes, what is the net loss of storage			m^3
Is the site brownfield or greenfield		Greenfield				
Freeboard on design water level (m)			m			
Is the development for essential civil infrastructure or vulnerable groups?		No	If yes, has consideration been given to 1000 year design flood?	No		
Is safe / dry access and egress available?		Vehicular and Pedestrian	Min access/egress level			m AOD
If there is no dry access, what return period is dry access available?			years			
If there is no dry access, what is the impact on the access routes?	Max Flood Depth @ 200 year event:		m	Max Flood Velocity:		m/s
Design levels	Ground level		m AOD	Min FFL:		mAOD
Mitigation						
Can development be designed to avoid all areas at risk of flooding?		Yes				
Is mitigation proposed?		Yes				
If yes, is compenstory storage necessary?		No				
Demonstration of compensatory storage on a "like for like" basis?		No				
Should water resistant materials and forms of construction be used?		No				
Comments						
Any additional comments:						

Approved by: CVB
Organisation: Curtins
Date: 21/09/2018

Note: Further details and guidance is provided in 'Technical Flood Risk Guidance for Stakeholders' which can be accesssed here:- **CLICK HERE**

**** ReFH2 is now accepted by SEPA for flow estimates in Scotland. Any use of this method should be compared with other accepted methods.***

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1.0 Executive Summary

1.1.1 Curtins Consulting Limited has been appointed by Optimised Environments to prepare this Flood Risk Assessment to support the masterplan for development of an area of land outside Elgin, Moray.

1.1.2 There is no identified flood risk to most of the masterplan site, from any source. The only identified risk was the potential for the very western boundary of the area noted as R12 being in the 1 in 1,000 year flood extent of the River Lossie. The risk should have minimal impact on development proposals.

1.1.3 An overall infrastructure network, including roads and sewers, will be required for the masterplan area. The sewer design will need to accommodate design flows from each development site. A standalone Drainage Strategy report has been developed providing discussion on this and should be read in conjunction with this Flood Risk Assessment.

1.1.4 Surface water discharge will outfall directly both to the Tyock Burn and to the nature reserve, to the east of the masterplan. A 1D modelling exercise of the Tyock Burn has been undertaken to assess the impact of the proposed development.

1.1.5 Surface water discharge to ground may be possible in some development sites; available site investigation data in the north-eastern part of the masterplan area shows ground conditions of sands and gravels, which may have good infiltration potential, depending on the grading of the material. Groundwater levels are shown to be close to the surface around the burn and associated drainage channels, which could prevent infiltration drainage systems being used in proximity of the burn. Groundwater levels were shown to be lower, however, further away to the rear of properties at Fairfield Avenue, which may allow for infiltration measures. Further site investigation work, to include groundwater monitoring and infiltration testing to BRE 365 standards, will be required across the masterplan area. The proposed discharge rates from the site contained in this report have been based on no infiltration being possible at this stage.

2.0 Introduction

2.1 Project Background

2.1.1 Curtins Consulting Limited has been appointed by Optimised Environments to prepare a Flood Risk Assessment for an area of land outside Elgin, Moray. The report provides information on the nature of flood risk at the site and follows government guidance with regards to development and flood risk.

2.1.2 The report is based on currently available information and preliminary discussions.

2.1.3 Proposals contained or forming part of this report represent the design intent and may be subject to alteration or adjustment in completing the detailed design for this project. Where such adjustments are undertaken as part of the detailed design and are deemed a material deviation from the intent contained in this document, prior approval shall be obtained from the relevant authority in advance of commencing such works.

2.2 Scope of Assessment

2.2.1 The Flood Risk Assessment is to be undertaken in accordance with the standing advice and requirements of the Scottish Environment Protection Agency (SEPA), Scottish Planning Policy and Moray Council's planning guidance.

2.2.2 The scope of the report is to demonstrate the proposed development will not increase the flood risk downstream of the site, along the Tyock Burn.

2.2.3 The report will:

- Investigate all potential risks of flooding to the site;
- Consider outline design proposals to mitigate any potential risk of flooding determined to be present;
- Identify constraints and opportunities for the drainage design and how it may impact the overall site plan;
- Present a Flood Risk Assessment to support a planning application for the proposed development.

2.2.4 The report reviews the following information:

- The SEPA flood maps for river, coastal and surface water flooding likelihood;
- SEPA Technical Flood Risk Guidance for Stakeholders (July 2018);
- Moray Council local development plan and guidance;
- Scottish Water Public Sewer Records;

- Sewers for Scotland 3rd Edition;
- CIRIA Manual c753;
- Scottish Planning Policy (SPP) (June 2014);

2.3 Proposed Development

2.3.1 The Flood Risk Assessment is to support the development of a masterplan for a 40.74 ha greenfield site, at a strategic level. There are no fixed site layouts yet. It is anticipated though that the overall land use will be residential housing. The overall masterplan area will be divided into development plots that will be sold off separately and require individual planning applications.

2.3.2 The illustrative, proposed development drawings are included in Appendix A.

3.0 Existing site Details

3.1 History and Current Use

3.1.1 The development site is located on land outside Elgin, Moray. The site comprises greenfield land, situated between Fairfield Avenue to the north, the residential area of New Elgin to the east and Elgin High School to the south-east. The approximate grid reference is 320797,861765 and the overall site covers an area of approximately 41 ha. The site location is shown in Figure 3-1.

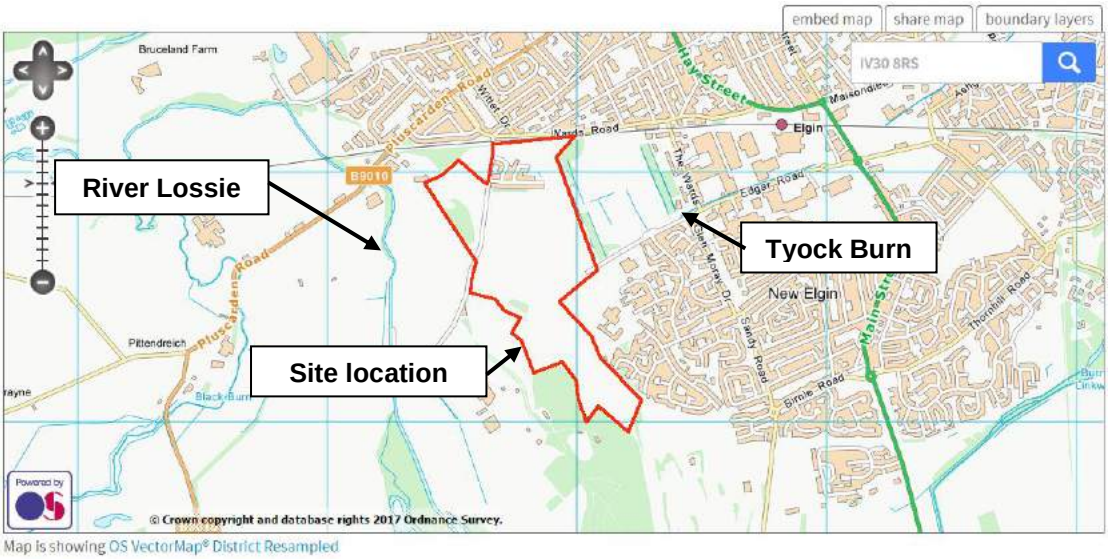

Figure 3-1. Site location (source: OS Open Data).

3.2 Existing Watercourses

3.2.1 The River Lossie runs to the west of the site, approximately 150 m from the closest point at the north-west site boundary. There are a series of open land drains in the nature reserve to the east of the site, appearing to feed into the Tyock Burn, which runs east alongside Edgar Road, discharging ultimately into the River Lossie at the east of the town.

3.3 Existing Drainage

3.3.1 Public sewer plans have been obtained from Scottish Water. They show the public sewers around the site are concentrated in the residential areas to the north, east and south-east.

3.3.2 Figure 3-2 shows the residential area in the north of the site. Foul waste is collected and pumped via a rising main north, to connect with the combined sewer at Wards Road. Surface water is drained via a separate network, discharging into the land drain system to the east.

Figure 3-2. Public sewers and water mains around residential area in the north of the site. Note surface water sewer discharging east to land drain system.

3.3.3 Figure 3-3 shows the public sewers and water mains around the residential area and primary school to the east of the site. The plan shows separate foul and surface water systems, draining east into the wider network.

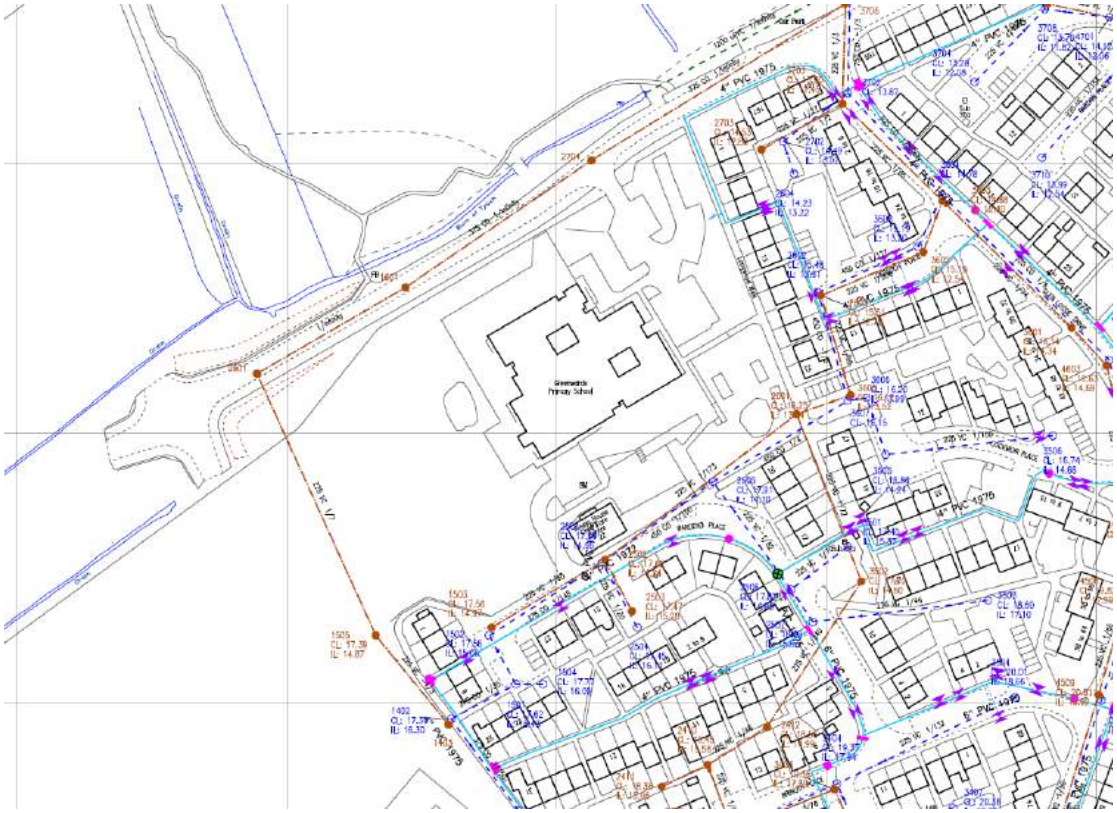

Figure 3-3. Public sewers and water mains around the residential area and primary school to the east of the site.

3.3.4 Figure 3-4 shows public sewers and water mains around the high school to the south east of the site.

3.3.5 It is anticipated these areas to the north, east and south-east will be used for new foul water connections, pending discussion with Scottish Water.

Figure 3-4. Public sewers and water mains around the high school to the east of the site.

3.3.6 The full surface water and foul sewer plans are included in Appendix B.

3.4 Topography

3.4.1 A topographical survey has been carried out for the site. It indicates varying levels across the wide area. The central part of the site is shown to be higher ground at around 32.0 mAOD, increasing to approximately 44.0 mAOD in the south west and falling to the eastern site boundary, around 14.0 mAOD.

3.4.2 The topographical survey plan is inserted as Appendix C.

3.4.3 Additionally, a height band analysis has been undertaken to identify the existing catchment areas along with the low points of the site. The Height Band Analysis is included within the Appendix D.

3.4.4 The Tyock Burn runs from the east site boundary crossing the Elgin town up to its confluence with the river Lossie at the north east of Elgin. 33 cross section of the Tyock Burn have been

surveyed by Property and Land Surveys (Highlands) Limited on August 2018 and the longitudinal section of the burn indicates levels falling from 12.817mAOD at Section XS3 to 6.8mAOD at XS36 (See figure 3-5).

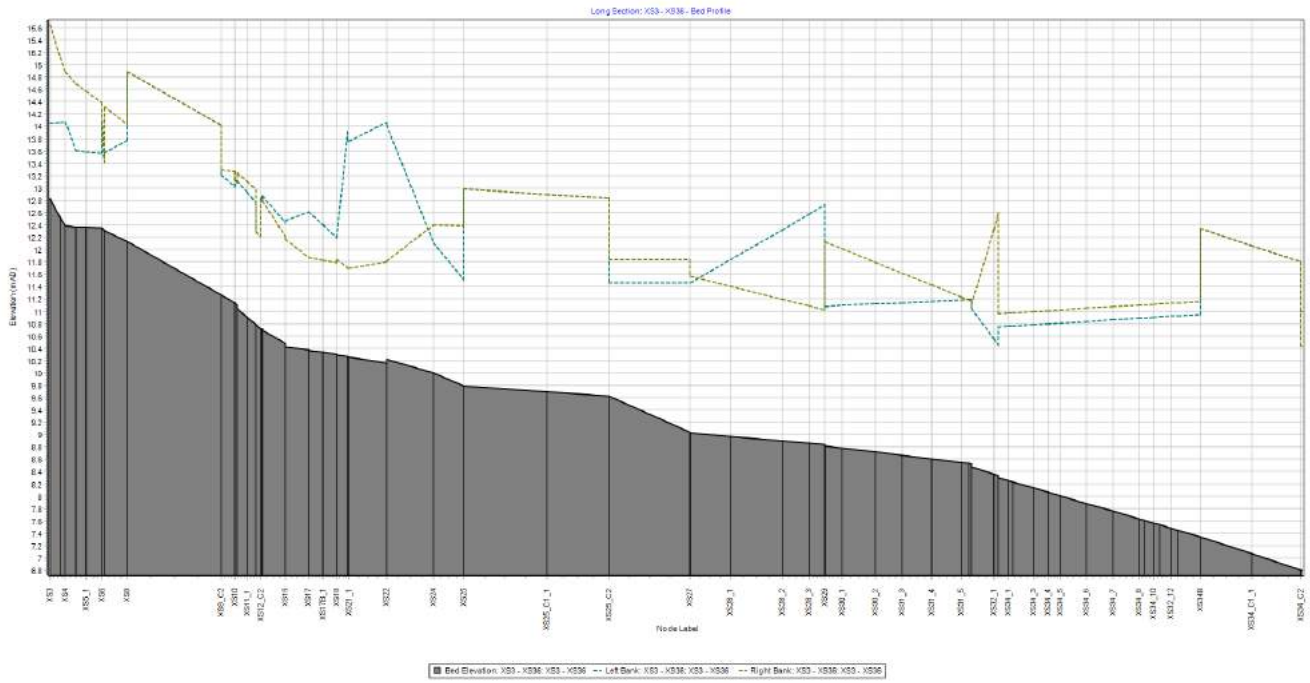

Figure 3-5. Tyock Burn Longitudinal Section (source: Property and Land Surveys (Highlands) Limited Topographical Survey).

3.5 Ground Conditions

3.5.1 A Ground Investigation Report was carried out in 2010 by Allied Exploration & Geotechnics Limited. It found general ground conditions of sand, with gravel, clays, cobbles and boulders. Groundwater was found at relatively shallow depths around the burn, rising to 0.65 – 1.60 m bgl after 20 minutes of being struck in boreholes. Groundwater in a borehole to the rear of properties on Fairfield Avenue was recorded at 8.87 m bgl, suggesting some variance across the site.

4.0 Development and Flood Risk

4.1 Scottish Planning Policy

4.1.1 The Scottish Planning Policy (SPP) is a statement of Scottish Government policy on nationally important land use. The SPP was published in 2014 and consolidated a series of topic specific policy statements into a single statement. This document is intended to be used in conjunction with the National Planning Framework (NPF) (2014), Planning Advice Notes (PANs), and Design Advice Guidance (DAG).

4.1.2 The guidance relating to flooding (SPP) is summarised in terms of the flood risk to a proposed development in the following extracts.

4.2 Risk Framework

4.2.1 1. Little to no risk area.

Definition: Annual probability of watercourse, tidal or coastal flooding: less than 0.1% (1:1000), i.e. less frequently than the so-called 1 in 1000 year flood.

Appropriate Planning Response:

No constraints due to watercourse, tidal or coastal flooding.

2. Low to medium risk area.

Definition: Annual probability of watercourse, tidal or coastal flooding: in the range 0.1% - 0.5% (1:1000 – 1:200).

Appropriate Planning Response:

Suitable for most development. A flood risk assessment may be required at the upper end of the probability range (i.e. close to 0.5%), and for essential infrastructure and the most vulnerable uses. Water resistant materials and construction may be required.

Generally, not suitable for civil infrastructure. Where civil infrastructure must be located within these areas or is being substantially extended, it should be designed to be capable of remaining operational and accessible during extreme flood events.

2. Medium to high risk area.

Definition: Annual probability of watercourse, tidal or coastal flooding: greater than 0.5% (1:200).

Appropriate Planning Response:

May be suitable for:

- Residential, institutional, commercial and industrial development within built-up areas provided flood protection measures to the appropriate standard already exist and are maintained, are under construction, or are a planned measure in a current flood risk management plan;
- Essential infrastructure within built-up areas, designed and constructed to remain operational during floods and not impede water flow;
- Some recreational, sport, amenity and nature conservation uses, provided appropriate evacuation procedures are in place and;
- Job related accommodation for;
- Civil infrastructure and the most vulnerable uses;
- Additional development in undeveloped and sparsely developed areas, unless allocation is essential for operational reason, e.g. for navigation and water based recreation, agriculture, transport or utilities infrastructure (which should be designed and constructed to be operational during floods and not impede water flow), and an alternative, lower risk location is not available; and
- New caravan and camping sites.

4.2.2 Where built development is permitted, measures to protect against or manage flood risk will be required and any loss of flood storage capacity mitigated to achieve a neutral or better outcome.

4.2.3 Water resistant materials in construction should be used where appropriate. Elevated buildings on structures such as stilts are unlikely to be acceptable.

4.3 Interpretation of the Risk Framework

a) The annual probabilities relate to the land at the time an application is submitted or a land allocation is made.

b) In the longer term, the calculated probabilities of flooding may be affected by climate change, improved data/methods and land uses elsewhere in the catchment.

c) This framework is a simplification of the situation as noted in SPP paragraph 258.

4.4 Moray Council Advisory Note for Planning Applicants on Flood Risk and Drainage

4.4.1 The Moray Council Advisory Note reflects that “the DIA should demonstrate, that the post-development runoff rate does not exceed the pre-development runoff rate or increase flood risk through discharge to a receiving watercourse”.

4.4.2 It is also notes that “Subsoil porosity test for proposed infiltration devices should be undertaken in line with the requirements in Building Research Establishment (BRE) Digest 365”, “the capacity of the drainage system including attenuation measures such as SuDS features should be designed to withstand a 1:30 year event, without surcharging” and “Exceedance events up to and including the 1 in 200 year event plus climate change should be contained and managed on site, such that they do not increase flood risk. Details of the method used to manage this flow should be provided in the DIA. This method should also be shown on the general arrangement drawing”.

4.5 Climate Change

4.5.1 In their Technical Flood Risk Guidance for Stakeholders, SEPA recommend flood risk assessments a climate change allowance of 20% be applied to the 1 in 200 year (0.5% annual probability) fluvial peak flow estimate. They also recommend a 20% allowance be applied to peak rainfall intensity estimates.

5.0 Flood Risk

5.1 Sources of Flood Risk

5.1.1 This study assesses the risk from different types of flooding to the development and the risk of flooding from the development, taking into consideration climate change, as well as how flood risks should be managed. The approach to assessing flood risk at the development site was informed by the requirements of SPP in conjunction with the client and the SEPA requirements.

5.2 Fluvial Flooding (Rivers and Streams)

5.2.1 The SEPA website provides flood mapping data as a general guide to the level of risk to a site from flooding from rivers and seas. This indicates areas which are associated with low, medium and high classifications of flood risk. Due to copyright issues, SEPA flood maps cannot be included as part of this report.

5.2.2 The SEPA map shows the vast majority of the site is at little to no risk of flooding from a watercourse. The 'low risk' (1 in 1,000 annual probability) flood extents of the River Lossie, to the west of the site, may extend just within the far north-western boundary of the site, in the area denoted as R12 in the masterplan.

5.3 Tidal Flooding (Coastal or Estuarine)

5.3.1 The site is inland and not subject to tidal flood risk.

5.4 Reservoir and Other Artificial Sources of Flooding

5.4.1 The SEPA flood maps do not include risk from reservoirs or other artificial sources. There are no identified reservoirs in vicinity of the site. The risk to the site is considered low.

5.5 Groundwater Flooding

5.5.1 Groundwater flooding generally occurs during intense, long-duration rainfall events, when infiltration of rainwater into the ground raises the level of the water table until it exceeds ground levels. It is most common in low-lying areas overlain by permeable soils and permeable geology, or in areas with a naturally high water table.

5.5.2 SEPA's online flood map does not indicate any risk to the site. However, the Ground Investigation Report carried out in 2010 by Allied Exploration & Geotechnics Limited shows that groundwater was found at relatively shallow depths around the burn, rising to 0.65 – 1.60 m bgl after 20 minutes of being struck in boreholes. Groundwater in a borehole to the rear of

properties on Fairfield Avenue was recorded at 8.87 m bgl, suggesting some variance across the site.

5.6 Private Drainage

5.6.1 Given the site is greenfield, it is not expected there will be any private drainage which could present a flood risk.

5.7 Surface Water Flooding to the site

5.7.1 Surface water flooding is caused when rainwater during extreme rainfall events does not drain away through the normal drainage system or infiltrate into the ground. Instead, the rainfall becomes surface water runoff, which follows natural flow paths and collects in ground depressions, potentially leading to flooding.

5.7.2 SEPA's online flood map indicates some small areas of high risk across the site. Most of the site is at little to no risk.

5.8 Surface Water Flooding from the site

5.8.1 Developers are responsible for ensuring that new development does not increase the flood risk elsewhere. The proposed surface water drainage network shall be designed so that flood water generated up to the 1 in 200 year plus climate change storm event shall be constrained within areas on a site so not to cause damage to buildings, essential services or adjoining developments and services.

5.8.2 It is encouraged to propose permeable areas and landscaping areas where possible throughout a site to minimise the potential for increases in surface water runoff.

5.9 Flood Defences

5.9.1 There are no identified flood defences protecting the site.

5.10 Historical Flooding

5.10.1 No historical records of flooding at the site were found at the time of writing.

6.0 Hydrological Analysis

6.1 Catchment Study

6.1.1 A study of the existing catchment areas of the Tyock Burn has been carried out to ascertain the proportions of the site currently discharging to the Tyock Burn as well as the inflow discharge points along the burn. The study has been based on the FEH webservice information, the topographical survey and visual inspection during a site walkover.

6.1.2 The FEH webservice provides catchment boundaries data as well as rainfall model outputs based on the Flood Estimation Handbook (FEH). Three catchment boundaries were obtained from the webservice and they show the proportion of the site currently draining directly to the source of the Tyock Burn (see Figure 6-1.1), the proportion of the site draining to the Tyock Burn through the nature reserve (see Figure 6-1.2) and the total Tyock Burn catchment area before its confluence with the River Lossie.

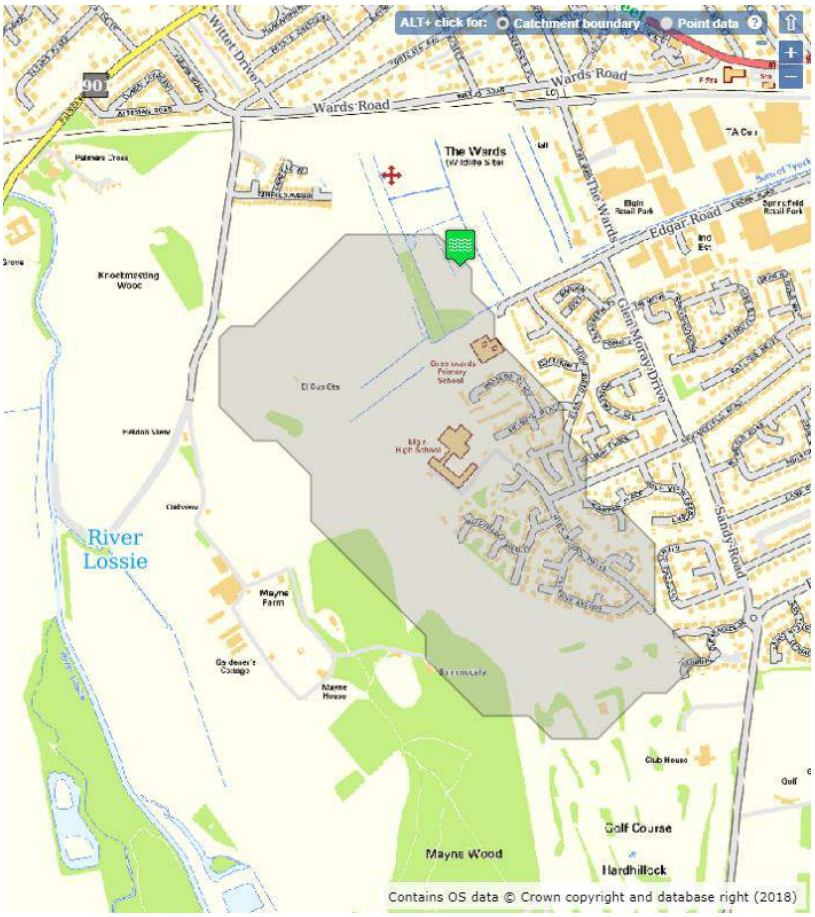

Figure 6-1.1. Catchment area draining directly to the source of the Tyock Burn (source: FEH Webservice).

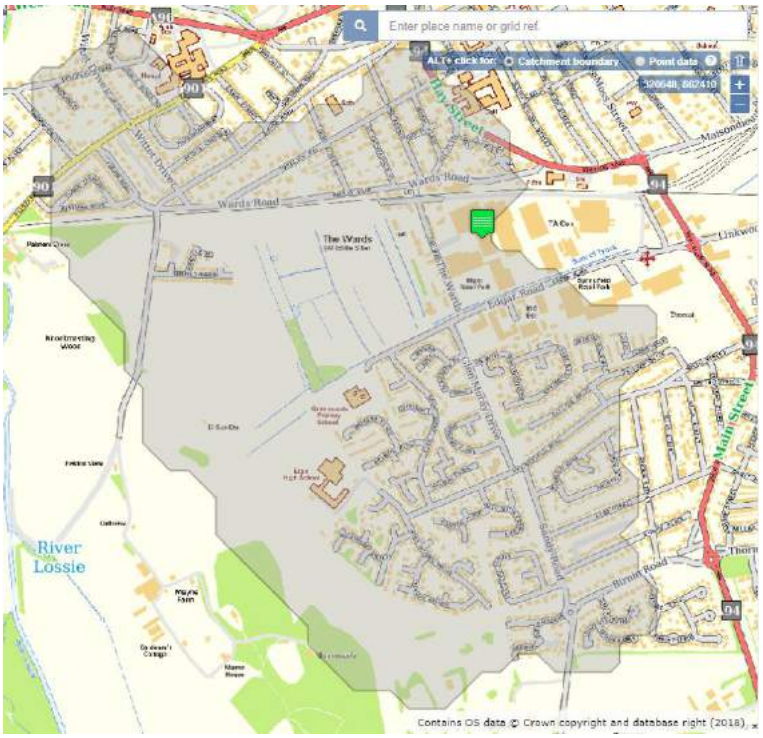

Figure 6-1.2. Catchment area draining directly to the Tyock Burn through the nature reserve (source: FEH Webservice).

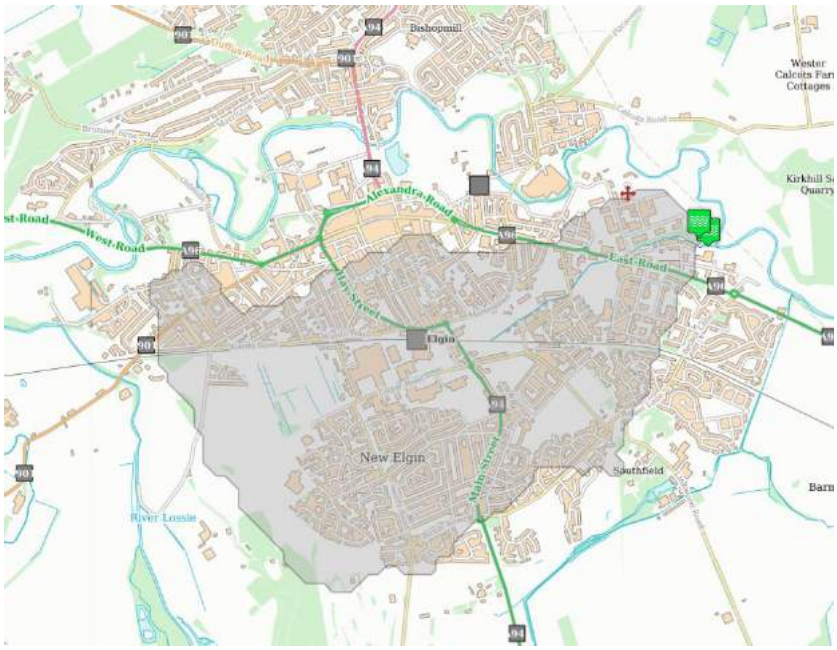

Figure 6-1.3. Total Tyock Burn catchment area (source: FEH Webservice).

6.1.3 A height band analysis was undertaken from the topographical survey information (refer to Appendix D) confirming the catchment information extracted from the FEH webservice. The analysis shows a central part of the site to be higher ground at around 32.0 mAOD, matching with the north boundary of the catchment area draining to the source of the Tyock Burn (see Figure 6-1.1). The analysis also shows a belt at the west of the site with higher levels which appears to be in accordance with the west catchment boundary in Figure 6-1.2. The height band analysis shows a low point for the south catchment area at the source of the Tyock Burn and low area for the north catchment which is draining to the nature reserve before its discharge into the Tyock Burn.

6.1.4 A site walkover was performed on the 19th June 2018 to support the FEH webservice information along with the height band analysis. Photographs from 40 to 45, included in Appendix E, show the topography of the site confirming the information from the FEH webservice and the height band analysis.

6.1.5 The conclusion indicates a north part of the site of 15.98 ha (Catchment North) is currently draining east to, ultimately, the Tyock Burn through the nature reserve and with the flows to be incorporated into Tyock Burn somewhere between the eastern site boundary and the Glen Moray Drive junction. A Catchment South of are 21.24 ha is currently draining to the source of the Tyock Burn and an area of 3.51 ha at the western boundary is discharging west to the River Lossie. Details of the catchment areas at the pre development scenario are included within Appendix H.

6.1.6 The catchment descriptions extracted from the FEW Webservice are shown in Table 6-1.4

PARAMETER	VALUE
NJ 23450 62700	
NJ 21875 61954	
AREA (km2)	4.1075
ALTBAR (m)	21
ASPBAR (°)	27
ASPVAR	0.34
BFIHOST	0.853
DPLBAR (km)	2.42
DPSBAR (m/km)	26.4
FARL	1
FPEXT	0.2246
FPDBAR	1.52
FPLOC	0.713
LDP	4.27
PROPWET	0.42
RMED-1H	8.5

RMED-1D	34.5
RMED-2D	44.1
SAAR (mm)	679
SAAR4170 (mm)	736
SPRHOST	18.36
URBCONC1990	0.797
URBEXT1990	0.2511
URBLOC1990	0.909
URBCONC2000	0.914
URBEXT2000	0.4243
URBLOC2000	0.88

Figure 6-1.4. Tyock Burn Catchment Descriptors (source: FEH Webservice).

6.2 Design Flow Estimates

6.2.1 As the Tyock Burn catchment is ungauged, there is no hydrometric data available for the hydrological analysis of the burn.

6.2.2 Two methods have been selected to calculate the predicted design flows: the FEH Rainfall-Runoff method and the Revitalized Flood Hydrograph (ReFH2).

6.2.3 The FEH Rainfall-Runoff provides good estimates for small, ungauged catchments in Scotland. The method requires the profile and the duration of the design rainfall and the antecedent soil moisture (CWI) to be estimated based on the attributes of the catchments.

6.2.4 For the FEH Rainfall-Runoff analysis, the critical storm of 1.1 hours duration has been calculated with a peak flow estimate for the total catchment of 10.023 m^3/s for the 0.5% AEP.

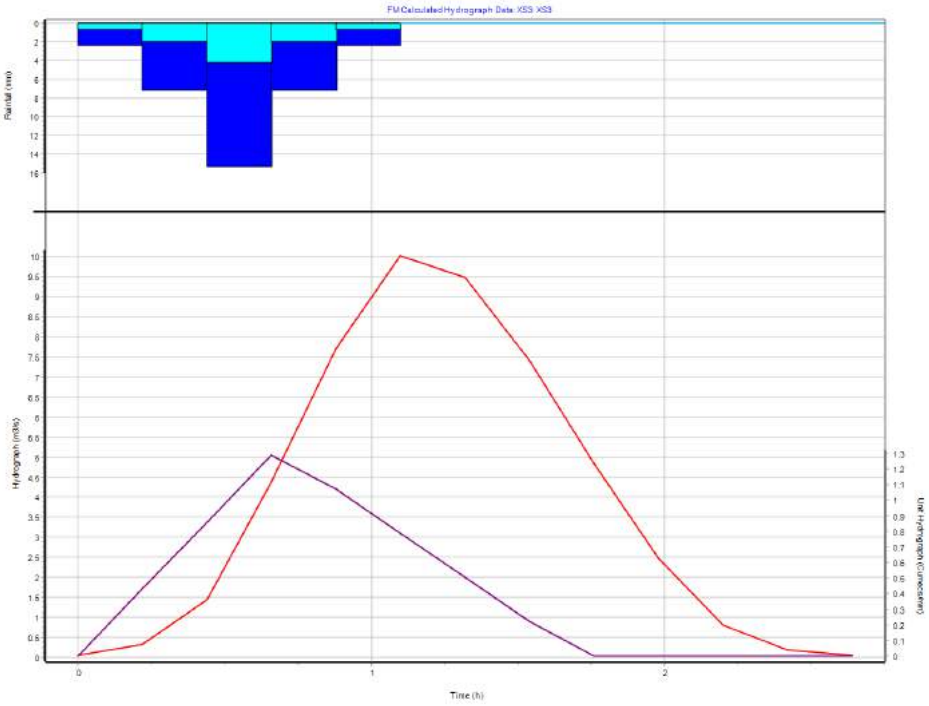

Figure 6-2.1. FEH Flow hydrograph 0.5% AEP.

6.2.5 For the Revitalized Flood Hydrograph (ReFH2) analysis, a critical storm of 6.5 hours duration has been calculated with a peak flow estimate of 8.88 m^3/s for the 0.5% AEP.

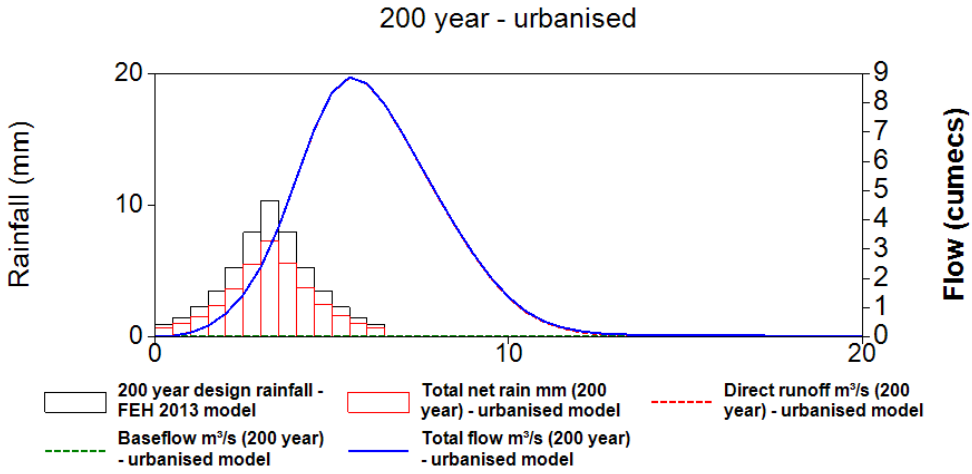

Figure 6-2.2. ReFh2 Flow hydrograph 0.5% AEP.

6.2.6 In accordance with the SEPA Technical Flood Risk Guidance (July 2018) a 20% allowance for Climate Change has been considered to the calculated flows. The peak flows for each method have been summarised in Table 6-2.

Method	Peak 0.5% AEP (m3/s)	Peak 0.5% AEP + 20% CC (m3/s)
FEH Rainfall-Runoff	10.023	12.027
ReFH2	8.880	10.656

Table 6-2.3. Peak 0.5% AEP and 0.5% AEP + 20% Climate Change flow estimates.

6.2.7 The design flow of 12.027 m^3/s has been selected for the 1 in 200 year + 20% Climate Change event, as the most conservative approach based on the FEH Rainfall-Runoff method and has been applied to the model for the predevelopment scenario.

6.2.8 The total existing contributing area for the Tyock Burn has been split into 6 sub catchments based on the Elgin Surface Water Drainage Plan (see Appendix B) provided by Moray Council along with the points of the surface water discharge found during the site walkover. Catchment North and nature reserve is bounded at the north with the existing railway track, east with the eastern boundary of the nature reserve and west and south with western and southern boundary of the catchment area from the FEH webservice and height band analysis. The Catchment South is bounded north and west with the information from the FEH webservice along with the height band analysis and east with the eastern site boundary. Catchment area 1 is limiting east with Sandy Road, a section of Glen Moray Drive and the east housing along Springfield Drive and north with the railway tracks. Catchment 2 limits east with the Main Street and Catchment 3 is bounded east with Ashgrove Road and Shaw Place. The inflow points have been incorporated to the model at the first surface water discharge point for each sub catchment based on the Elgin Surface Water Drainage Plan.

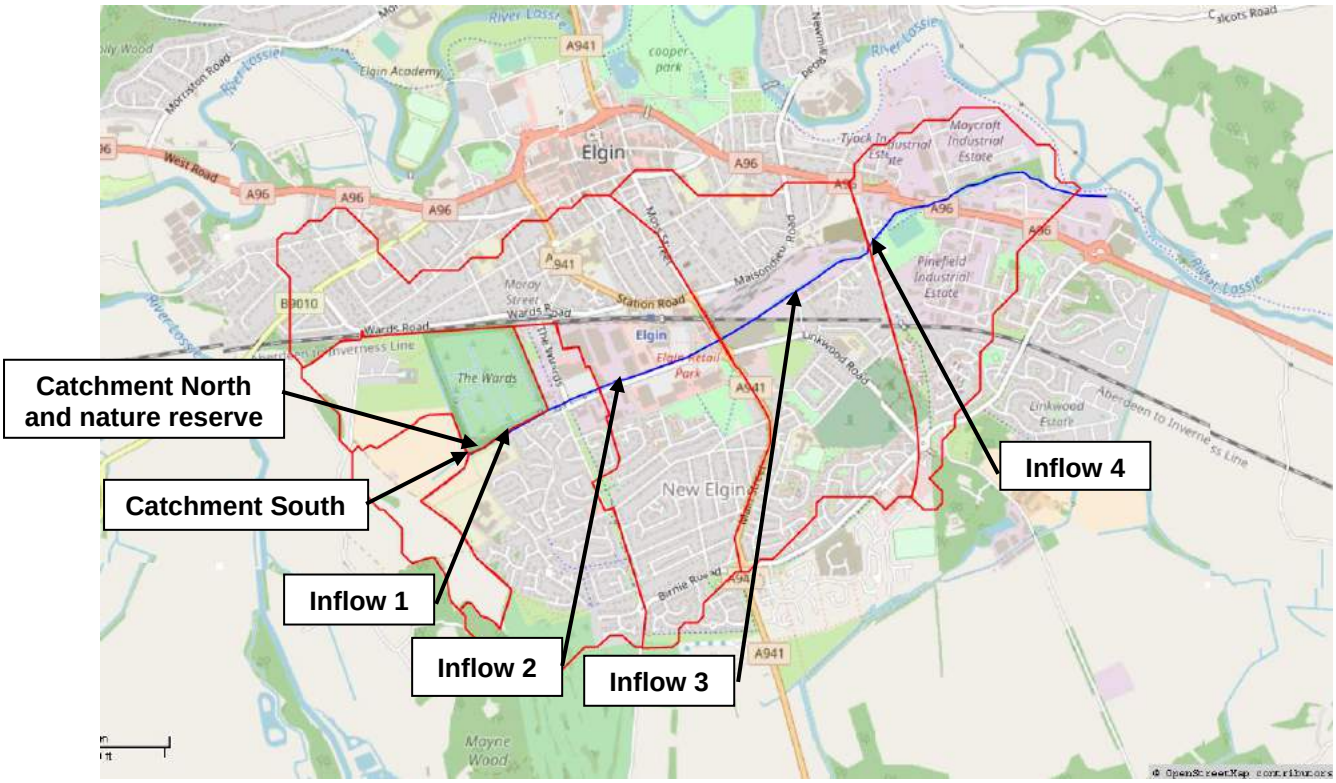

Figure 6-2.3. Catchment boundaries and inflow points at the predevelopment scenario.

6.2.9 The design flows for each sub catchment area for the 1 in 200 year + 20% Climate Change event have been included in Table 6-2.4.

Sub catchment	Peak 0.5% AEP (m3/s)	Peak 0.5% AEP + 20% CC (m3/s)
Catchment North and nature reserve	0.540	0.649
Catchment South	0.811	0.974
Catchment 1	1.617	1.941
Catchment 2	2.963	3.553
Catchment 3	2.381	2.857
Catchment 4	1.711	2.053

7.0 Hydraulic modelling

7.1 Mathematical Model

7.1.1 A 1D hydraulic modelling has been developed, using Flood Modeller software, to represent the Tyock Burn. As the main scope of the report is to demonstrate that the proposed drainage strategy will not increase the flood risk downstream of the site and along the Tyock Burn, the 1D approach has been considered to be the most suitable method.

7.1.2 Eigth scenarios have been considered for the modelling:

- The 1 in 30 year event + 30% Climate change pre development scenario;
- the 1 in 200 year event + 20% Climate change pre development scenario;
- the 1 in 200 year event + 30% Climate change pre development scenario;
- the 1 in 30 year event + 30% Climate change post development scenario;
- the 1 in 200 year event + 20% Climate change post development scenario;
- the 1 in 200 year event + 30% Climate Change post development scenario;
- the 1 in 200 year event + 30% Climate Change + 40% Blockage pre development scenario;
- and the 1 in 200 year event + 30% Climate Change + 40% Blockage post development scenario.

7.2 1D Hydraulic Modelling

7.2.1 The 1D hydraulic model has been designed based on the Tyock Burn survey carried out on August 2018 by Property and Land Surveys (Highlands) Limited, which includes cross sections at regular intervals of the channels and banks, as well as structures, such as culverts and bridges.

7.2.2 A Manning's roughness value of 0.04 was set for the 1D domain representing a natural stream running sluggish and with deep pools

7.2.3 As agreed with Moray Council, a 2,879m river channel length has been considered for the 1D model, from the source of the Tyock Burn up to the new culvert through Linkwood Industrial Estate built as part of the Elgin Flood Alleviation Scheme in 2011. Its extent is shown in Figures 7-2, 3, 4, 5, 6 and 7 along with the node labels.

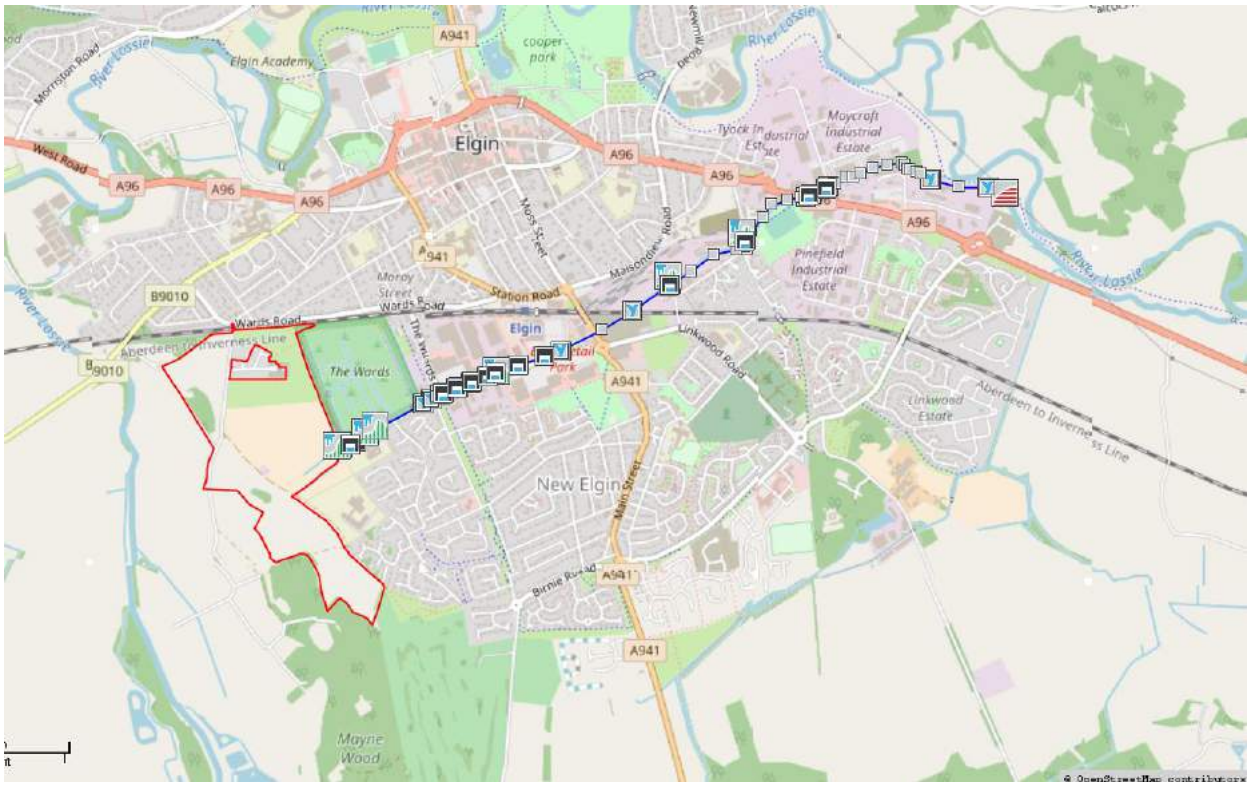

Figure 7-2. 1D modelling extent.

Figure 7-3. 1D modelling extent. Section 1 of 5

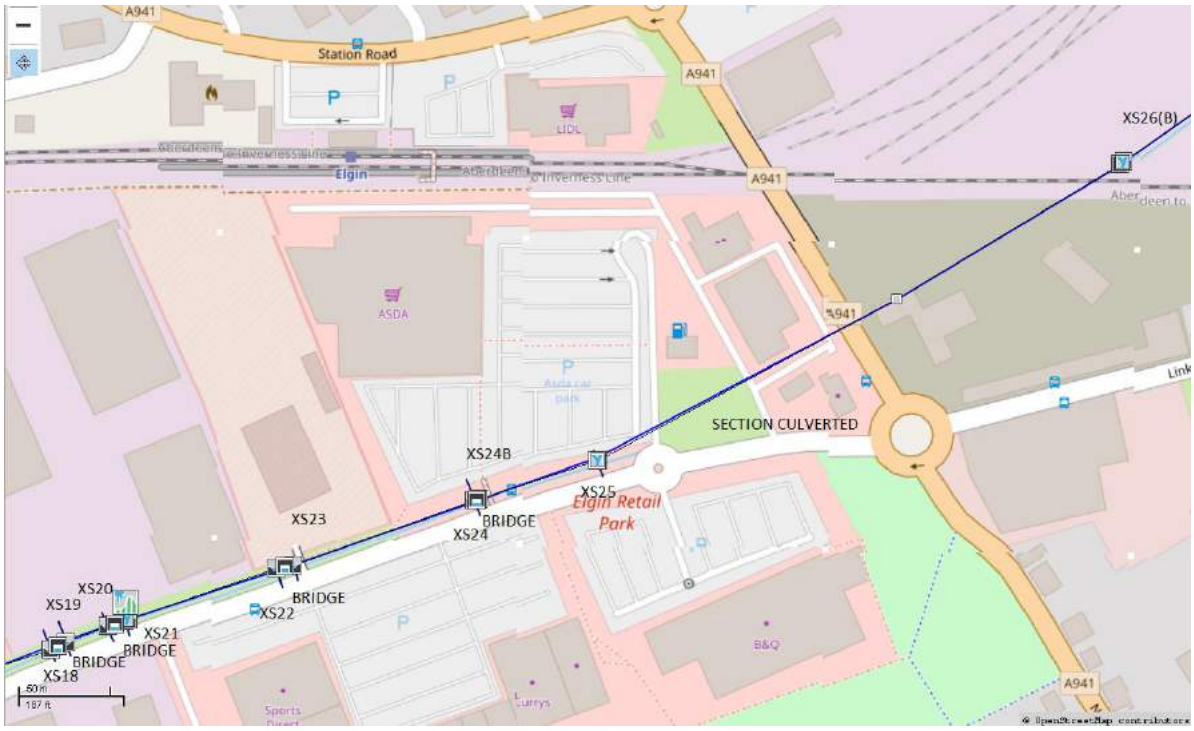

Figure 7-4. 1D modelling extent. Section 2 of 5

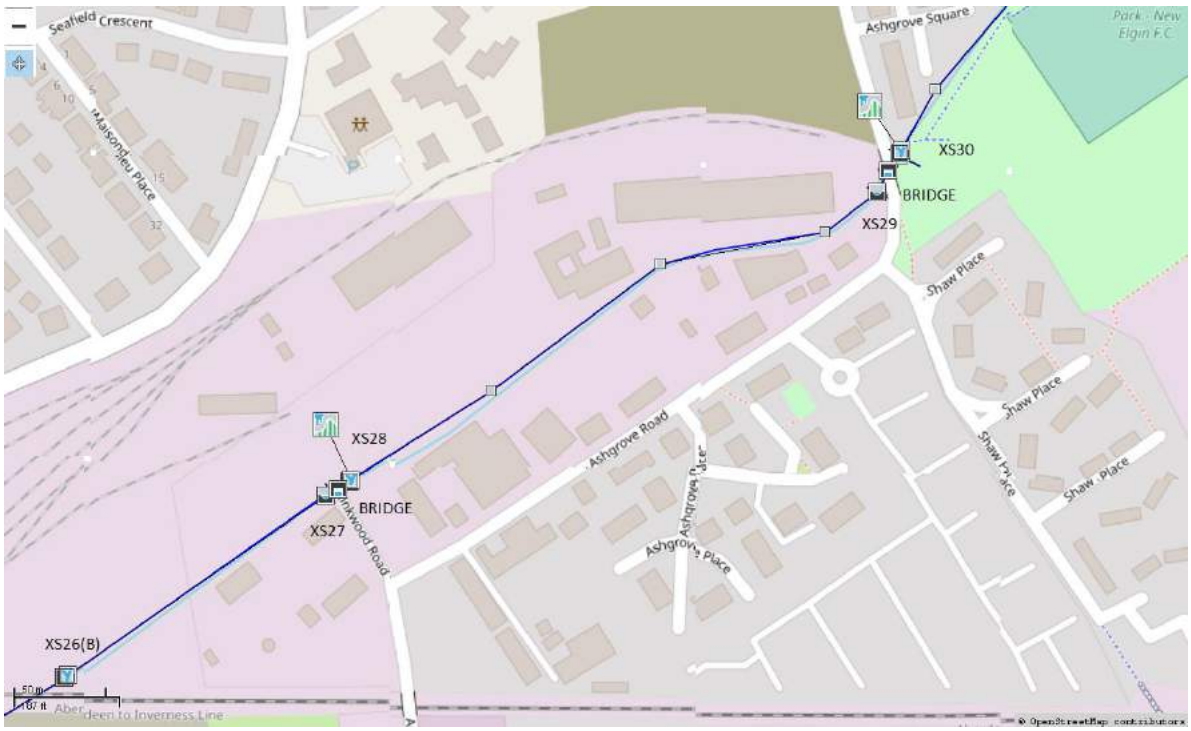

Figure 7-5. 1D modelling extent. Section 3 of 5

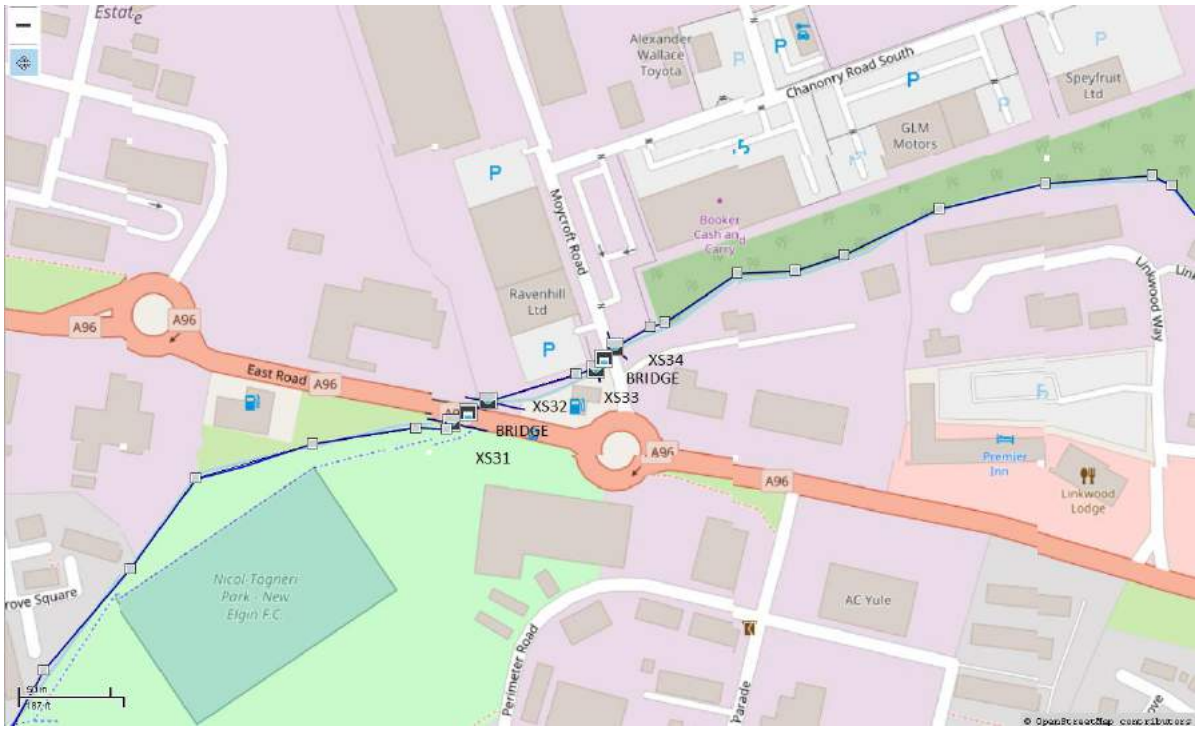

Figure 7-6. 1D modelling extent. Section 4 of 5

Figure 7-7. 1D modelling extent. Section 5 of 5

7.2.4 Many structures have been identified during the site walkover and on the PLS topographical survey and they have been included in the model. A summary of all structures has been listed below:

1. Bridge at Section XS4.
2. 1250mm DIA circular culvert between Sections XS6 and XS7.
3. 1250mm DIA circular culvert between Sections XS8 and XS9.
4. 1500mm DIA circular culvert between Sections XS10 and XS11.
5. 1500mm DIA circular culvert between Sections XS12 and XS12B.
6. Bridge between Section XS13 and XS14.
7. Bridge between Section XS15 and XS16.
8. Bridge between Section XS17 and XS17B.
9. Bridge between Section XS18 and XS19.
10. Bridge between Section XS20 and XS21.
11. Bridge between Section XS22 and XS23.
12. Bridge between Section XS24 and XS24B.
13. 1300x3200mm rectangular culvert between Section XS25 and XS26B.
14. Bridge between Section XS27 and XS28.
15. Bridge between Section XS29 and XS30.
16. Bridge between Section XS31 and XS32.
17. Bridge between Section XS33 and XS34.
18. 3000mm DIA circular culvert between Sections XS34B and XS35.

7.2.5 The outflow of the model has been represented as a normal depth boundary.

8.0 Model Results

8.1 Predevelopment scenario. 1 in 200 year event plus 20% Climate Change

8.1.1 A predevelopment scenario has been modelled based on the hydrological analysis developed within paragraph 6.0 and using the design flow contained in Table 6-2.4.

8.1.2 The model shows out of the bank flooding at Sections XS3, XS4, XS5, XS6, XS7, XS8, XS10, XS12, XS12B, XS13, XS14, XS15, XS16, XS17, XS17B XS18, XS19, XS20, XS21, XS22, XS23, XS24, XS25, XS26(B), XS27, XS29, XS30 and XS33 with the XS6, the XS8, the XS10, the X10 and the XS25 culverts discharging full capacity.

8.1.3 The maximum top water level extents for the 1 in 200 year event plus 20% Climate Change event are shown in Figure 8-1.

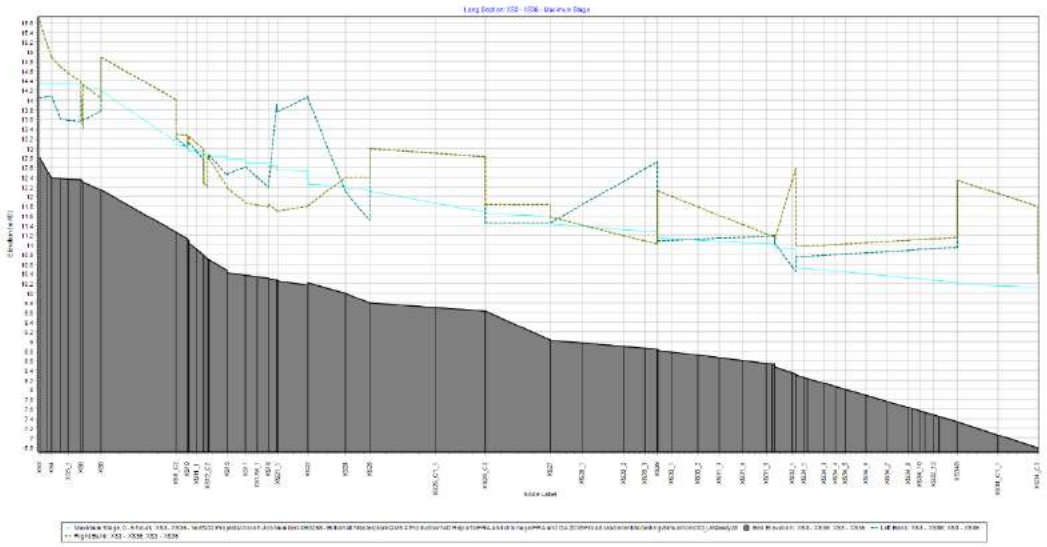

Figure 8-1. Predevelopment scenario. Top water levels for the 1 in 200 year event plus 20% Climate Change.

8.1.4 The peak water levels and flows table for the 1D model is included within appendix F along with the cross and longitudinal section results.

8.2 Post development scenario. 1 in 200 year event plus 20% Climate Change

8.2.1 A post development scenario has been modelled based on the Drainage Strategy report submitted in conjunction with this document. Attenuated flows for the 1 in 200 year event + 30% Climate Change from the site at the post development stage have been added to the model as a constant peak flow. This is 13.6 l/s from basin at Catchment area D and 52.3 l/s for the basin for Catchment areas from E to M. The green area at the north east of the site has been maintained discharging unattenuated to the nature reserve as existing. Details of the discharge rates for the post development scenario are included within Appendix I.

8.2.2 The model shows out of the bank flooding at Sections XS5, XS6, XS7, XS8, XS12, XS15, XS16, XS17, XS17B XS18, XS19, XS20, XS21, XS22, XS23, XS24, XS25, XS26(B), XS27, XS29, XS30 and XS33 with the XS6, the XS8, the XS10, the X10 and the XS25 culverts discharging full capacity.

8.2.3 The maximum top water level extents for the 1 in 200 year event plus 20% Climate Change event are shown in Figure 8-2.

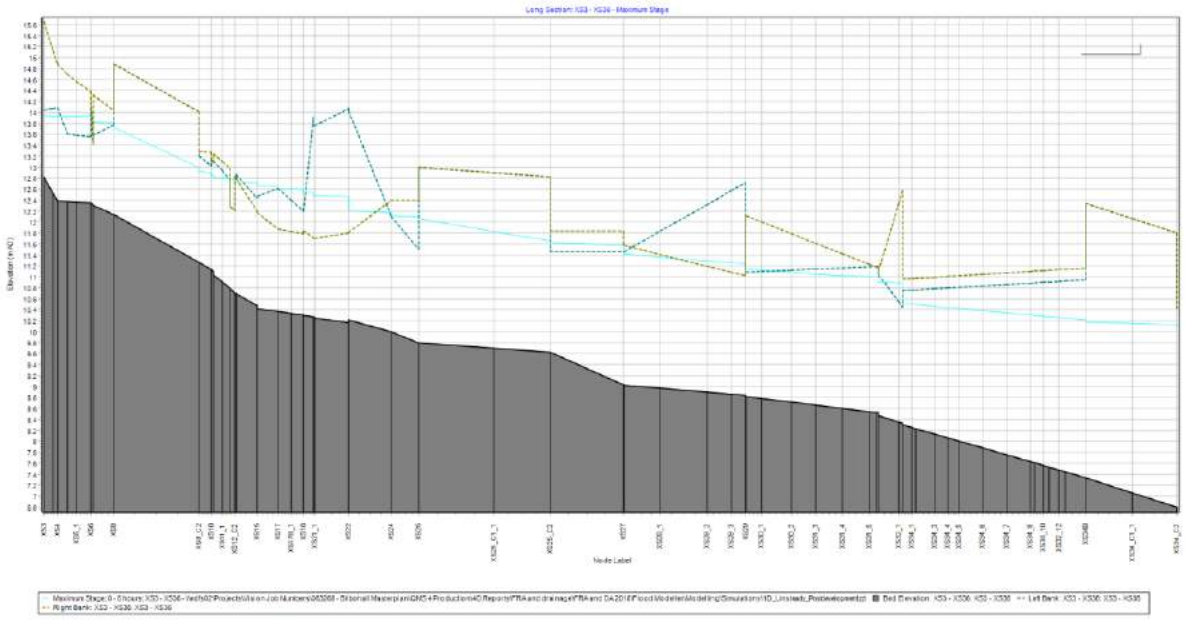

Figure 8-2. Postdevelopment scenario. Top water levels for the 1 in 200 year event plus 20% Climate Change.

8.2.4 The peak water levels and flows table for the 1D model is included within appendix G along with the cross and longitudinal section results.

8.3 1 in 200 year event plus 30% Climate Change + 40% Blockage scenario.

8.3.1 As requested by the Moray Council two additional scenarios have been considered within the assessment:

- the 1 in 200 year event + 30% Climate Change + 40% Blockage pre development scenario;
- and the 1 in 200 year event + 30% Climate Change + 40% Blockage post development scenario.

8.3.2 The 40% blockage scenario has been modelled at the critical section XS25, at the inlet of the 1300x3200mm rectangular culvert crossing the A941 road. The results show of reduction in peak water levels of 44mm at the critical section XS25 at the post development scenario furthermore, this reduction increases further downstream of the blockage scenario showing for example a reduction of 132mm at section XS9. Full details are included within Appendix N and O.

8.3.3 Therefore, the blockage scenario confirms the reduction in flood risk along the Tyock Burn at the post development scenario.

8.4 Results comparison

8.4.1 The model shows, based on the proposed strategy, a reduction on top water levels along the Tyock Burn at all post development scenarios. For the 1 in 200 year event + 20% Climate Change the level of reduction varies along the burn showing 329 mm reduction for the Section XS5 (at approximately the Greenwards Primary School location) and 17 mm reduction for the section downstream of the Ashgrove Rd Bridge.

Node	Peak 0.5% AEP + 20% CC (mAOD) Predevelopment	Peak 0.5% AEP + 20% CC (mAOD) Postdevelopment
XS3	14.332	14.019
XS5	14.331	14.002
XS10	13.039	12.903
XS15	12.843	12.720
XS20	12.621	12.546
XS25	12.144	12.097
XS30	11.161	11.144
XS34B	10.220	10.212
XS35	10.107	10.101

Table 8-3. Pre and postdevelopment scenario comparison table.

8.4.2 The peak water levels and flows table for the 1D model for others scenarios are included within the following appendices:

- Pre development 1 in 30 year event + 30% Climate Change is included within appendix J.
- Pre development 1 in 200 year event + 30% Climate Change is included within appendix K.
- Post development 1 in 30 year event + 30% Climate Change is included within appendix L.
- Post development 1 in 200 year event + 30% Climate Change is included within appendix M.
- Pre development 1 in 200 year event + 30% Climate Change + 40% Blockage scenario is included within appendix N.
- Post development 1 in 200 year event + 30% Climate Change + 40% Blockage scenario is included within appendix O.

8.5 Sensitivity Check

8.5.1 A sensitivity check has been carried out to the model, peak water levels have been calculated for the 1 in 200 year event plus 20% Climate change with the Manning's roughness value increased and decreased by 20%. This indicates little sensitivity to variation in Manning's roughness values.

Node	Peak 0.5% AEP + 20% CC (mAOD)	Peak 0.5% AEP + 20% CC with Manning's n + 20% (mAOD)	Peak 0.5% AEP + 20% CC with Manning's n - 20% (mAOD)
XS5	14.331	14.358	14.283
XS15	12.843	12.910	12.780
XS30	11.161	11.229	11.088

Table 8-4. Comparison of peak water levels with variations in Manning's value.

8.5.2 A flow sensitivity check has been carried out considering a 20% increase and decrease in flows in addition to the 20% Climate Change. This also indicates little sensitivity to variation in flow values.

Node	Peak 0.5% AEP + 20% CC (mAOD)	Peak 0.5% AEP + 20% CC + 20% (mAOD)	Peak 0.5% AEP + 20% CC - 20% (mAOD)
XS5	14.331	14.674	13.976
XS15	12.843	13.077	12.575
XS30	11.161	11.288	10.980

Table 8-5. Comparison of peak water levels with variations in flows.

8.5.3 The model has been assessed for numerical instability and the mass balance error has been extracted from the simulations results files showing a figure below 0.71% at all scenarios.

8.6 Discharge volumes comparison table

8.6.1 A table showing the total boundary inflow volumes during the critical hydrograph for each scenario considered has been extracted from Flood Modeller and included in the report. The model shows a decrease in boundary inflow volumes at the post development stage for all events.

Scenario	Inflow volume (m^3)
Pre development 1 in 30 year event + 30% CC	34,362.2
Pre development 1 in 200 year event + 20% CC	49,360.6
Pre development 1 in 200 year event + 30% CC	53,317.8
Post development 1 in 30 year event + 30% CC	33,169.1
Post development 1 in 200 year event + 20% CC	47,108.9
Post development 1 in 200 year event + 30% CC	50,801.9

Table 8-6. Comparison of total boundary inflow volume during the critical hydrograph at each scenario.

9.0 Flood Risk Mitigation / Residual Risk

9.1 River Flood Mitigation

9.1.1 As indicated by SEPA's flood map, almost the entire site is predicted to be at little to no risk of flooding from rivers and no mitigation measures are required. It is advised that the masterplan steers development away from the very western boundary of area R12, as it potentially falls within the River Lossie's 1 in 1,000 annual probability flood extent.

9.2 Groundwater Flood Mitigation

9.2.1 Groundwater is generally a contributing factor to flooding rather than the primary source. Groundwater flooding tends to be more persistent than other sources of flooding, typically lasting for weeks or months rather than hours or days. Groundwater flooding does not generally pose a significant risk to life due to the slow rate at which the water level rises; however, it can cause significant risk to property.

9.2.2 It is recommended that finished floor levels are set at or above existing ground levels where possible to ensure that the groundwater flood risk is not increased.

9.2.3 A site investigation with groundwater monitoring would help levels and whether any mitigation measures are necessary.

9.3 Surface Water Flooding Mitigation

9.3.1 Any new development site drainage should be designed in accordance with current best practice to provide adequate capacity so that flood water generated from up to the 1 in 200 year plus climate change storm event shall be constrained within the areas on site so not to cause damage to buildings, essential services or adjoining developments and services.

9.3.2 To minimise localised flooding within the site, the drainage design should ensure that gullies, drainage channels and drains are all suitably sized to accommodate peak storm flows. Also, all inlet features should have suitably sized sumps to catch silts and should be subject to a documented routine maintenance and cleansing regime.

9.3.3 If the proposed drainage system is designed to provide adequate capacity and the private and adopted sewers area adequately maintained by the relevant body then, it can be assumed the risk of flood from blockage or overloading is minimal.

9.3.4 As the Tyock Burn is currently at fluvial flood risk, a flap valve must be installed at all surface water direct discharge outfalls into the Tyock in order to prevent further flows entering the Burn and maintaining the flood flows within the site.

9.3.5 The final design of the drainage networks shall be in accordance with the legislation set by SEPA, Moray Council and Scottish Water.

10.0 Conclusions and Recommendations

10.1 Conclusions

10.1.1 This report has been prepared to support a masterplan for a 40.74 ha area of land at Elgin, Moray.

10.1.2 The SEPA flood map shows the overall area is at little to no risk of flooding from rivers, barring the south-western boundary line of the site area identified as R12, which is shown to potentially be within the 1 in 1,000 year flood extent of the River Lossie.

10.1.3 SEPA flood maps indicate some small areas of high surface water flood risk within the area. The overall post development surface water drainage system will be designed to mitigate this, ensuring that flooding does not occur to buildings or services up to the 1 in 200 year plus 30% climate change level.

10.1.4 The masterplan site has been divided into a number of development plots. These smaller plots will be sold and developed individually, but will need to tie into an overall drainage infrastructure.

10.1.5 Each development plot will have allowable discharge rates for surface and foul water, which will form the design flows for the overall masterplan sewerage infrastructure.

10.1.6 The drainage proposal will consider infiltration techniques, when available, as the first option and, as a secondary option, the whole site is proposed to discharge to two outfalls, the nature reserve to the east of the site and directly to the Tyock Burn.

10.1.7 A 1D hydraulic modelling has been developed, using Flood Modeller software, to represent the Tyock Burn. As the main scope of the report is to demonstrate that the proposed drainage strategy will not increase the flood risk downstream of the site and along the Tyock Burn, the 1D approach has been considered to be the most suitable method.

10.1.8 Eight scenarios have been considered for the modelling:

- The 1 in 30 year event + 30% Climate change pre development scenario;
- the 1 in 200 year event + 20% Climate change pre development scenario;
- the 1 in 200 year event + 30% Climate change pre development scenario;
- the 1 in 30 year event + 30% Climate change post development scenario;
- the 1 in 200 year event + 20% Climate change post development scenario;
- the 1 in 200 year event + 30% Climate Change post development scenario;

- the 1 in 200 year event + 30% Climate Change + 40% Blockage pre development scenario;
- and the 1 in 200 year event + 30% Climate Change + 40% Blockage post development scenario.

10.1.9 The model shows, based on the proposed strategy, a reduction on top water levels along the Tyock Burn at all the post development scenarios. For the 1 in 200 year event + 20% Climate Change the reductions vary in magnitude along the burn showing 329mm reduction for the Section XS5 (at approximately the Greenwards Primary School location) and 17mm reduction for the section downstream of the Ashgrove Rd Bridge.

10.1.10 A sensitivity check has been carried out to the model, peak water levels have been calculated for the 1 in 200 year event plus 20% Climate change with the Manning's roughness value increased and decreased by 20%. This indicates little sensitivity to variation in Manning's roughness values. A additional flow sensitivity check has been also undertaken considering a 20% increase and decrease in flows in addition to the 20% Climate Change. This also indicates little sensitivity to variation in flow values.

10.2 Recommendations

10.2.1 The masterplan area can be considered suitable for residential development, from a flooding perspective. It would be preferable to avoid developing properties along the previously mentioned south-western boundary line of the site area R12, due to the identified low risk of flooding from the River Lossie.

10.2.2 The water impact assessment (WIA) and drainage impact assessment (DIA) with Scottish Water should be reviewed with ongoing proposals for the development sites.

10.2.3 Design foul and surface water discharge rates for the development sites will require confirmation, pending discussion and agreement with Moray Council and Scottish Water, in conjunction with the design for the infrastructure across the masterplan site.

10.2.4 As the Tyock Burn is currently at fluvial flood risk, a flap valve must be installed at all surface water direct discharge outfalls into the Tyock in order to prevent further flows entering the Burn and maintaining the flood flows within the site.

10.2.5 A site investigation with groundwater monitoring would help levels and whether any mitigation measures are necessary.

10.2.6 Further site investigation work should be carried out, to assess soil infiltration potential (soakaway testing to BRE 365 standard) and groundwater levels across the entire masterplan area.

Appendix A – Proposed Development

Bilbohall Masterplan

Site aerial
17th January 2017

open
optimised environments

DEVELOPMENT FRAMEWORK

Legend

- Primary Street (bus route)
- Secondary Street
- Tertiary Street / private access
- Pedestrian / cycle route
- Safeguarded area and indicative alignment for replacement rail bridge if/when electrification / dualling occurs
- Potential Future Expansion outwith LDP
- Development block
- Low Density (c 20-25 units/ha)
- Medium Density (c 30 units/ha)
- Medium - High Density (c 35-45 units/ha)
- Existing woodland
- Proposed multi-functional open space
- New structural landscape planting (woodland buffer)
- Landscape on undevelopable steep slopes between blocks
- Neighbourhood Park. Includes play equipment and 60x40m kickabout area
- Pocket park. Includes play space and 30x20m kickabout area
- Allotments
- Key Vistas
- Indicative location for SUDS
- Potential route for swale / conveyance channel

NOTES

1. This drawing is to be read in conjunction with all other drawings and specifications.
2. Do not scale off this drawing. Written dimensions to be taken only.
3. Any discrepancies found between this drawing and other drawings and specifications in the construction documents must be referred to the Landscape Architect prior to work commencing.
4. This drawing must not be copied in whole or in part without prior written consent of Optimised Environments Ltd.
5. Survey information is based upon aspect surveyors Topographical as Survey.

Issue	Revision	Initial	Date
-	-	-	-

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Client
Bilbohall Consortium

Project
BILBOHALL MASTERPLAN
Elgin

Drawing Title
Development Framework
WITH REVISIONS FOR REVIEW

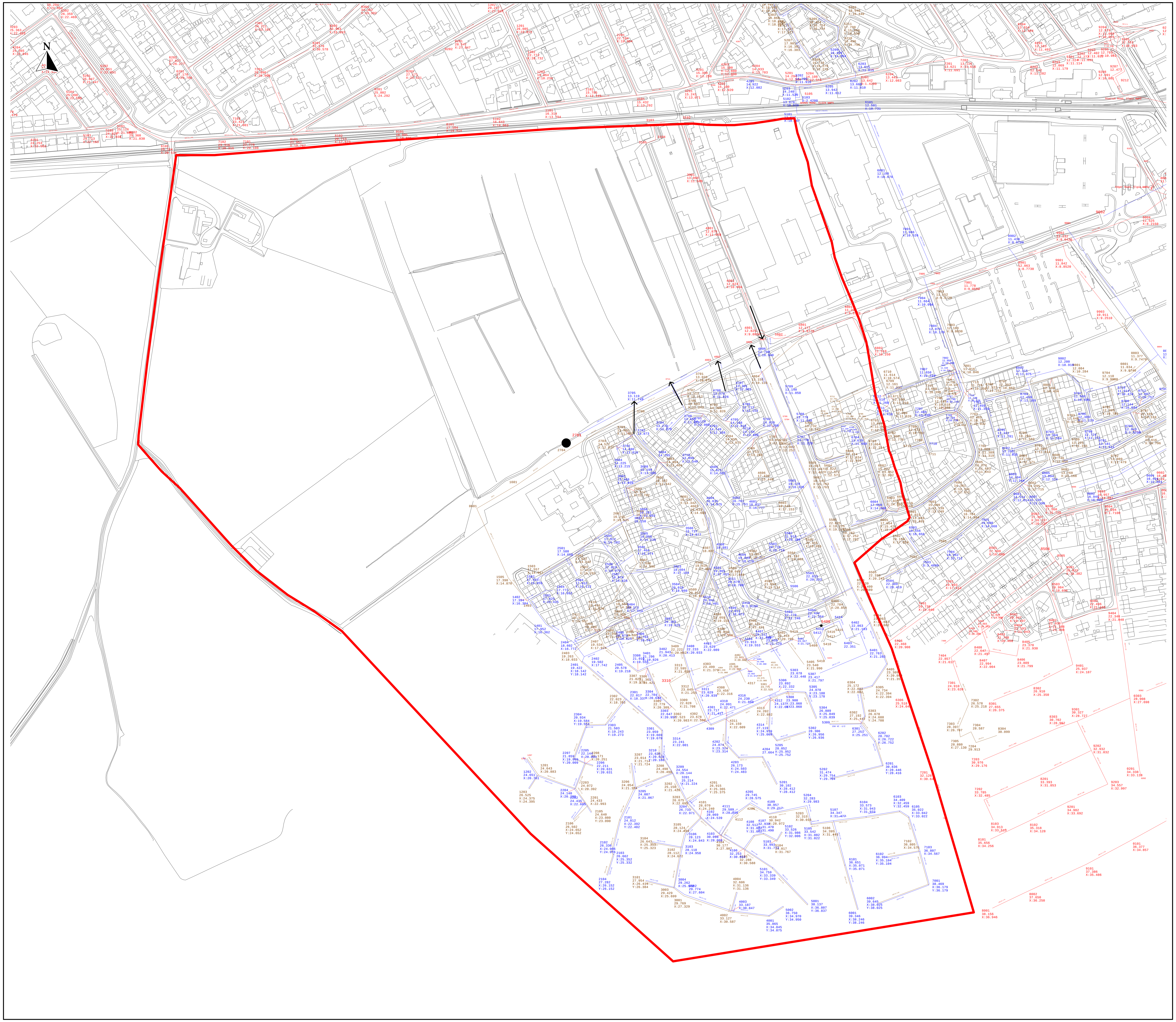
Scale Bar — North

Scale:	**1:2500@A1**	Date:	**July 2018**
By:	**CS**	Status:	**INFORMATION**
Checked:	**CG**	Approved:	**PMac**

Drawing Number **161009-DF** — Rev **-**

Computer File: P:\2016\161009_Bilbohall\CAD\SHEET

Appendix B – Public Sewer Plans



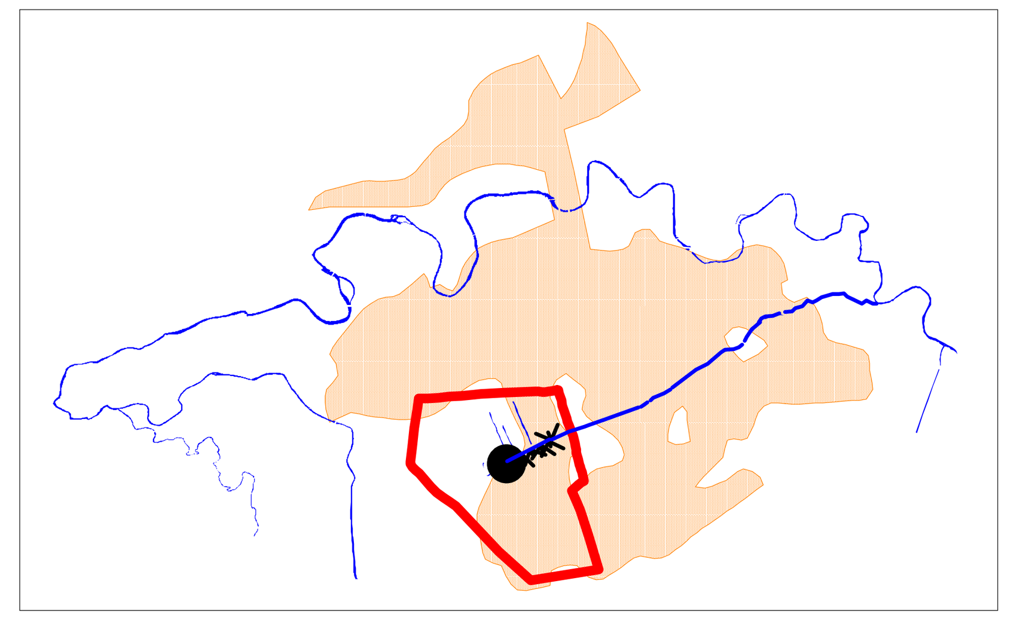


Figure Location Plan

Key:

- MODELLING INFLOW POINT
- SURFACE WATER DRAINAGE INFLOW
- TYOCK BURN ZONE A

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Title:
TYOCK BURN ZONE A

Project:
MORAY FLOOD ALLEVIATION SCHEMES

Client:
THE MORAY COUNCIL ENVIRONMENTAL SERVICES DEPARTMENT

Date:
AUGUST 2002

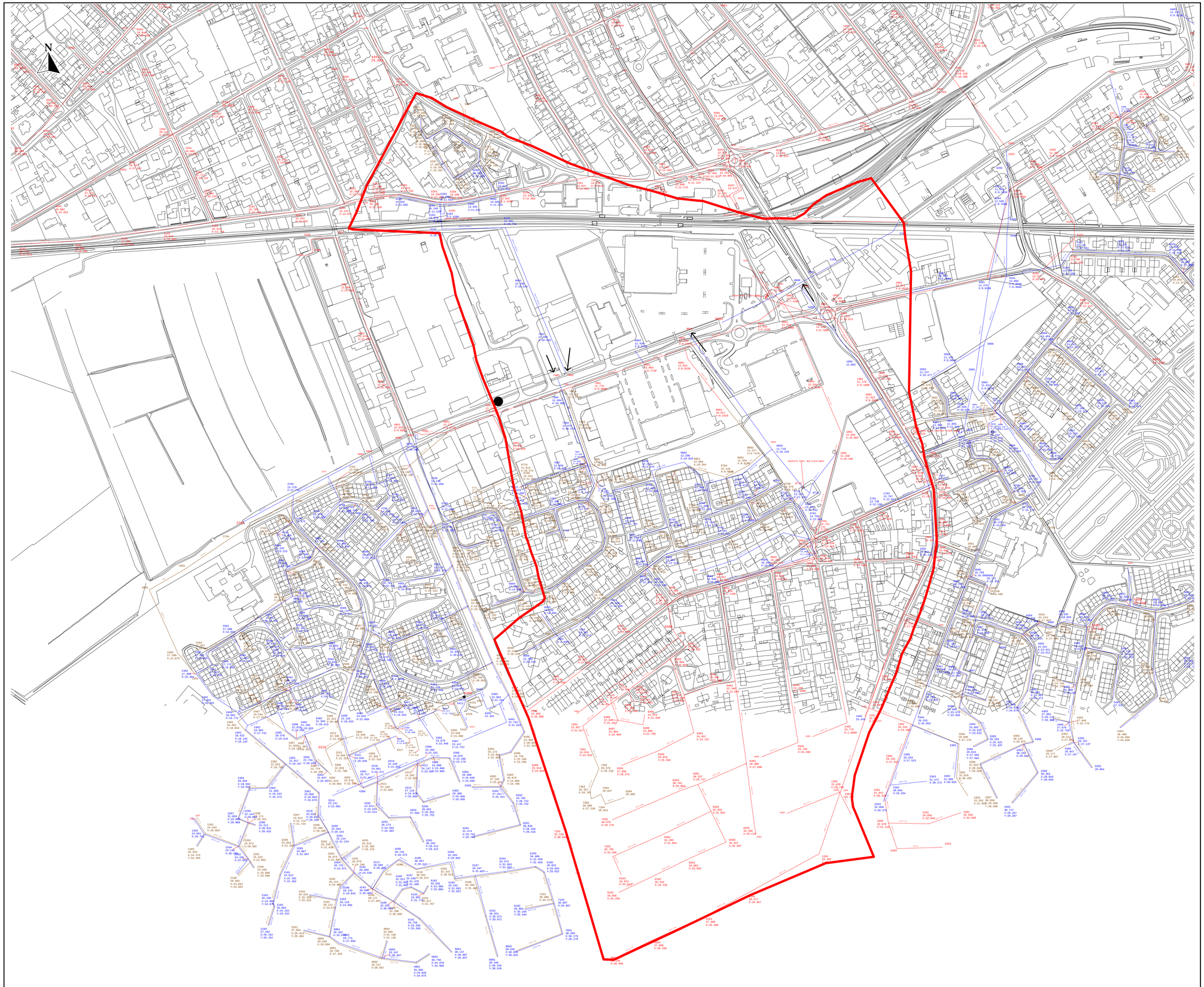
Scale:
1:2,500

Figure:
ELGIN SURFACE WATER DRAINAGE PLAN

ROYAL HASKONING

POSFORD HASKONING

GIS Drive/projects/HB128/Figures/Drainage Plans/Figures/Figure A1 Zone A Tyock Burn.wor



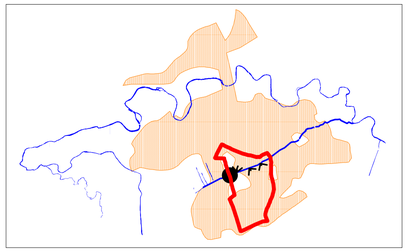


Figure Location Plan

Key:

- MODELLING INFLOW POINT
- SURFACE WATER DRAINAGE INFLOW
- TYOCK BURN ZONE B

the moray Council

Title:
TYOCK BURN ZONE B

Project:
MORAY FLOOD ALLEVIATION SCHEMES

Client:
THE MORAY COUNCIL ENVIRONMENTAL SERVICES DEPARTMENT

Date:
AUGUST 2002

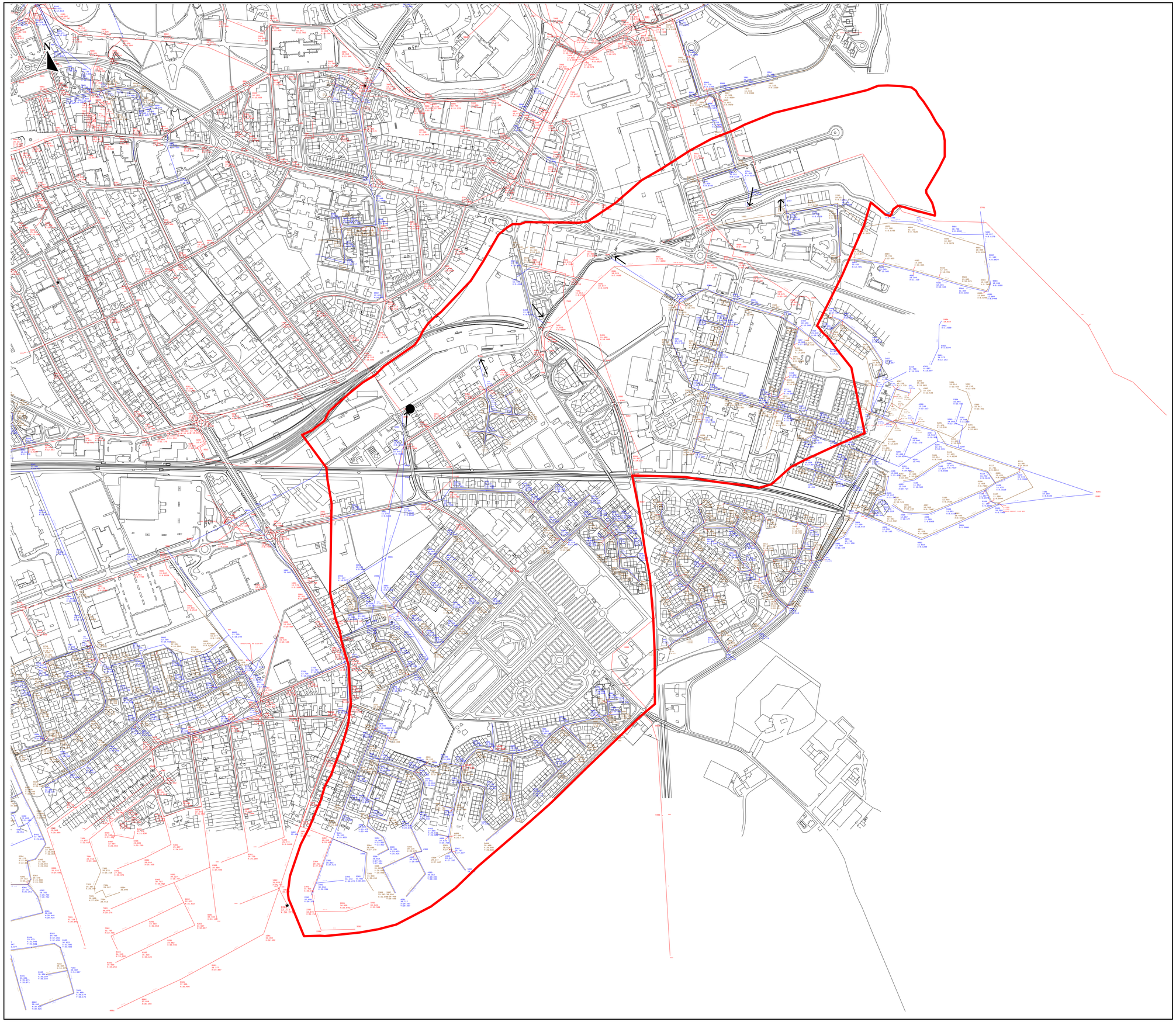
Scale:
1:2,800

Figure:
ELGIN SURFACE WATER DRAINAGE PLAN

ROYAL HASKONING

POSFORD HASKONING

GIS Drive/projects/H6128/Figures/Drainage Plans/Figures/Figure A1 Zone B Tyock Burn.wor



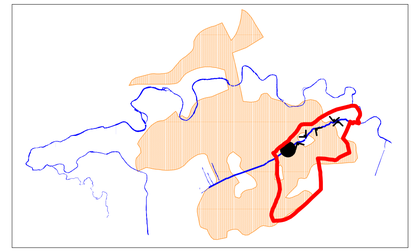


Figure Location Plan

Key:

- MODELLING INFLOW POINT
- SURFACE WATER DRAINAGE INFLOW
- TYOCK BURN ZONE C

the moray Council

Title:
TYOCK BURN ZONE C

Project:
MORAY FLOOD ALLEVIATION SCHEMES

Client:
THE MORAY COUNCIL ENVIRONMENTAL SERVICES DEPARTMENT

Date:
AUGUST 2002

Scale:
1:3,700

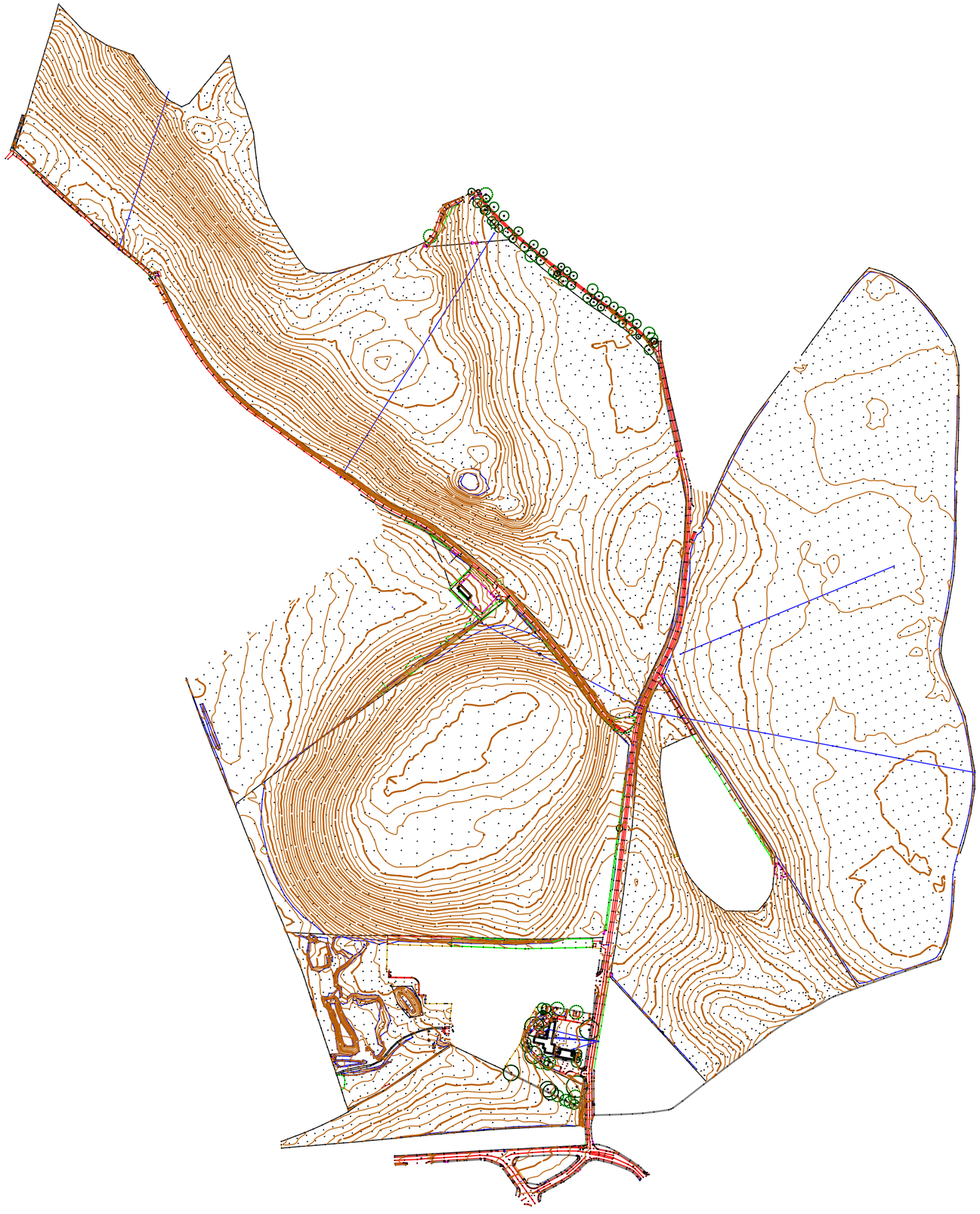
Figure:
ELGIN SURFACE WATER DRAINAGE PLAN

ROYAL HASKONING

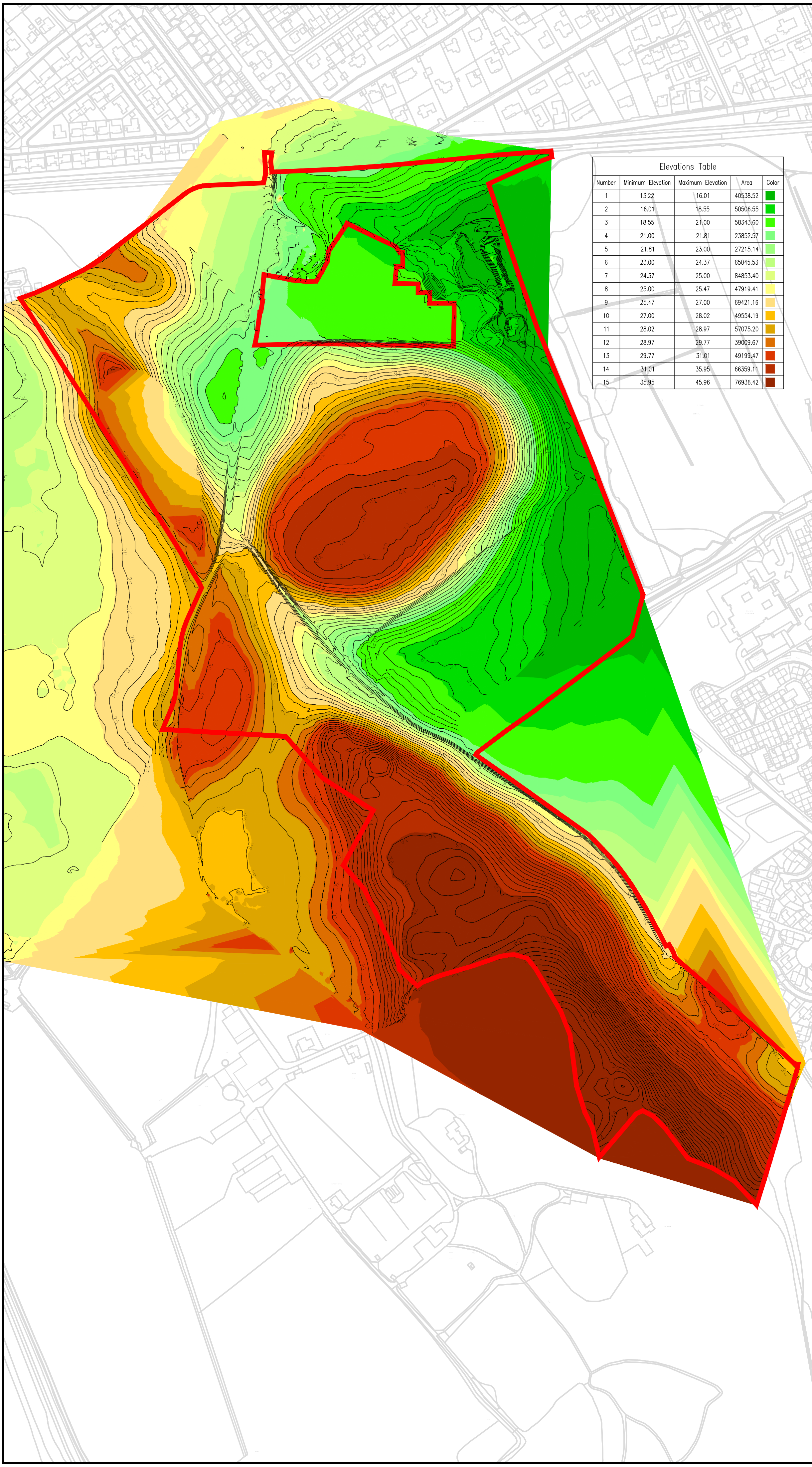
POSFORD HASKONING

GIS Drive\projects\H61226\Figures\Drainage Plans\Figure A1 Zone C Tyock Burn.wor

Appendix C – Topographical Survey



Appendix D – Height Band Analysis



Elevations Table

Number	Minimum Elevation	Maximum Elevation	Area	Color
1	13.22	16.01	40538.52	
2	16.01	18.55	50506.55	
3	18.55	21.00	58343.60	
4	21.00	21.81	23852.57	
5	21.81	23.00	27215.14	
6	23.00	24.37	65045.53	
7	24.37	25.00	84853.40	
8	25.00	25.47	47919.41	
9	25.47	27.00	69421.16	
10	27.00	28.02	49554.19	
11	28.02	28.97	57075.20	
12	28.97	29.77	39009.67	
13	29.77	31.01	49199.47	
14	31.01	35.95	66359.11	
15	35.95	45.96	76936.42	

GENERAL NOTES:

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS AND ENGINEERS DRAWINGS AND SPECIFICATIONS.
2. DO NOT SCALE THIS DRAWING. ANY AMBIGUITIES, OMISSIONS AND ERRORS ON DRAWINGS SHALL BE BROUGHT TO THE ENGINEERS ATTENTION IMMEDIATELY. ALL DIMENSIONS MUST BE CHECKED / VERIFIED ON SITE.
3. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
4. FOR GENERAL NOTES REFER TO DRAWING.

Rev:	Description:	Date:	By:	Chkd:

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Status: PRELIMINARY

Project: Bilbohall, Masterplan

Drg Title: Drainage Strategy - Height Band Analysis

Project No:	Size:	Date:	Drawn By:	Designed By:	Checked By:
	A0	17/07/18	CVB	CVB	PP
	Scale: 1:2500				

Project No:	Originator:	Volume:	Level:	Type:	Role:	Category / Number:	Rev:
063268	- CUR	- XX	- XX	- DR	- C	- 92004	- P01

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