

**Persimmon Homes North Scotland**

**Proposed Development at  
Gillburn Road (Kingspark), Dundee**

**Flood Risk Assessment**

**Updated Final**

**January 2020**

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## Table of Contents

SEPA Checklist.....	iii
<b>1 Introduction .....</b>	<b>1</b>
1.1 SEPA Comments dated 2 November 2017 .....	1
1.2 Dundee City Council Comments.....	2
1.3 Revised Bypass Culvert.....	4
<b>2 Legislative and Policy Aspects.....</b>	<b>5</b>
2.1 National Planning Policy .....	5
2.2 SEPA Flood Maps.....	8
2.3 SEPA Technical Flood Risk Guidance.....	8
2.4 Flood Risk Management (Scotland) Act 2009 .....	8
2.5 Controlled Activities Regulations .....	8
2.6 Climate Change .....	9
<b>3 Site Location and Description .....</b>	<b>10</b>
<b>4 Hydrological Analysis.....</b>	<b>12</b>
<b>5 Flood Risk Assessment.....</b>	<b>13</b>
5.1 Flood Risk from Gelly Burn .....	13
5.1.1 2D Modelling .....	13
5.1.2 Modelling of Flows Surcharging from Manholes.....	15
5.2 Flood Risk from Small Drain .....	17
5.2.1 Revised Bypass Culvert Route .....	25
5.3 Surface Water Runoff from Adjacent Land .....	26
5.4 Groundwater .....	27
5.5 Site Access .....	27
5.6 Risk of Flooding from the Site Drainage System and Local Sewers .....	28
5.7 Note on SEPA and Council comments .....	28
<b>6 Summary and Conclusions .....</b>	<b>30</b>

## List of Figures

Figure 1: Location plan .....	4
Figure 2: Watercourses in the vicinity .....	10
Figure 3: Site topography (based on LiDAR) .....	11
Figure 4: 2D model extent and active area .....	13
Figure 5: Predicted 200 year plus climate change flood extent (assuming all flow runs overland) .....	14
Figure 6: Overland flows for 10 year flood .....	15
Figure 7: Overland flows for 200 year flood (3 hour).....	15
Figure 8: Overland flows for 200 year flood (1 hour).....	16
Figure 9: Overland flows for 200 year + climate change flow (1 hour).....	16
Figure 10: Cross section along small drain .....	18
Figure 11: Possible route of bypass sewer .....	20
Figure 12: Approximate route of 600mm sewer and existing ground profile along the line of the sewer .....	21

Figure 13: Predicted water level in diversion sewer ( $Q=0.53\text{m}^3/\text{s}$ , normal flow in Gelly Burn Culvert).	23
Figure 14: Predicted water level in diversion sewer ( $Q=0.82\text{m}^3/\text{s}$ , normal flow in Gelly Burn Culvert).	23
Figure 15: Predicted water level in diversion sewer ( $Q=0.53\text{m}^3/\text{s}$ , peak flow in Gelly Burn Culvert) ....	24
Figure 16: Predicted water level in diversion sewer ( $Q=0.82\text{m}^3/\text{s}$ , peak flow in Gelly Burn Culvert) ....	24
Figure 17: Amended route of bypass culvert (red line) .....	25
Figure 18: Predicted water level for a flow of $0.82\text{m}^3/\text{s}$ .....	26
Figure 19: Indicative surface water flow pathways within and around the site .....	27

## List of Tables

Table 1: Predicted flood depths (m) on Gillburn Road .....	17
Table 2: Estimated sewer capacity.....	22

## List of Photos

Photo 1 : Drain entering a 300mm culvert through back gardens .....	19
Photo 2: View of drain through back gardens .....	19




## 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	Former Kingspark School, Gillburn Road, Dundee		
Grid Reference	Easting: 339590	Northing: 733100	
Local Authority	Dundee City Council		
Planning Reference number (if known)			
Nature of the development	Residential	If residential, state type:	
Size of the development site	2.9 Ha		
Identified Flood Risk	Source: Fluvial	Source name:	Gelly Burn + Small Drain
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	Site of former Kingspark School		
Hydrology			
Area of catchment	3.6 km <sup>2</sup>		
Qmed estimate	m <sup>3</sup> /s	Method:	Select from List
Estimate of 200 year design flood flow	14.7 m <sup>3</sup> /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	2D	Software used:	Other
If other please specify	Flood Modeller Pro		
Modelled reach length	2200 m		
Any structures within the modelled length?	Select from List	Specify, if combination	
Brief summary of sensitivity tests, and range:			
variation on flow (%)	%		
variation on channel roughness	28%		
blockage of structure (range of % blocked)	100 %	<a href="#">Reference CIRIA culvert design guide R168, section 8.4</a>	
boundary conditions:	Upstream	Downstream	
(1) type	Flow	Normal depth	
(2) does it influence water levels at the site?	Specify if other	Specify if other	No
Has model been calibrated (gauge data / flood records)?	No		
Is the hydraulic model available to SEPA?	No		
Design flood levels	200 year	m AOD	200 year plus climate change
			m AOD

 <b>Flood Risk Assessment (FRA) Checklist</b> <span>(SS-NFR-F-001 - Version 13 - Last updated 15/04/2015)</span>	
<b>Coastal</b>	
Estimate of 200 year design flood level	<input type="text"/> m AOD
Estimation method(s) used	Select from List <input type="text"/> If other (please specify methodology used): <input type="text"/>
Allowance for climate change (m)	<input type="text"/> m
Allowance for wave action etc (m)	<input type="text"/> m
Overall design flood level	<input type="text"/> m AOD
<b>Development</b>	
Is any of the site within the functional floodplain? (refer to SPP para 255)	<input type="text"/> No <input type="text"/> If yes, what is the net loss of storage <input type="text"/> m <sup>3</sup>
Is the site brownfield or greenfield	<input type="text"/> Brownfield
Freeboard on design water level (m)	<input type="text"/> 0.6 m
Is the development for essential civil infrastructure or vulnerable groups?	<input type="text"/> No <input type="text"/> If yes, has consideration been given to 1000 year design flood? <input type="text"/> Select from List
Is safe / dry access and egress available?	<input type="text"/> Pedestrian Only <input type="text"/> Min access/egress level <input type="text"/> m AOD
If there is no dry access, what return period is dry access available?	<input type="text"/> years
If there is no dry access, what is the impact on the access routes?	Max Flood Depth @ 200 year event: <input type="text"/> m
Design levels	Ground level <input type="text"/> m AOD <input type="text"/> Max Flood Velocity: <input type="text"/> m/s <input type="text"/> Min FFL: <input type="text"/> mAOD
<b>Mitigation</b>	
Can development be designed to avoid all areas at risk of flooding?	<input type="text"/> Yes <input type="text"/>
Is mitigation proposed?	<input type="text"/> Yes <input type="text"/>
If yes, is compensatory storage necessary?	<input type="text"/> No <input type="text"/>
Demonstration of compensatory storage on a "like for like" basis?	<input type="text"/> Select from List <input type="text"/>
Should water resistant materials and forms of construction be used?	<input type="text"/> Select from List <input type="text"/>
<b>Comments</b>	
Any additional comments:	<input type="text"/> The site is not at risk of flooding even the entire Gelly Burn flow runs overland. The risk of flooding from the small drain will be significantly reduced by proposed diversion.
Approved by: <input type="text"/> Organisation: Kaya Consulting Limited Date: 11.01.2018	
Note: Further details and guidance is provided in 'Technical Flood Risk Guidance for Stakeholders' which can be accessed here:- <a href="#">CLICK HERE</a> * ReFH2 is now accepted by SEPA for flow estimates in Scotland. Any use of this method should be compared with other accepted methods.	

# 1 Introduction

Kaya Consulting Ltd. was commissioned by Persimmon Homes North Scotland to undertake a flood risk assessment for a proposed development site at Gillburn Road, Dundee.

The site is brownfield comprised of the former Kingspark School site and is located on the south side of Gillburn Road and to the north of the A90 Kingsway. A site location plan is shown in Figure 1.

The Gelly Burn runs along Gillburn Road in a culvert and discharges into an open channel some 415m to the east (on the east side of Old Glamis Road). The current OS maps indicate that the burn enters the culvert some 1.9km to the west of the site.

There is a small drain which issues just outside the south-western corner of the site and runs north in an open channel before entering the Gelly Burn culvert under Gillburn Road, Figure 1.

The main risk of fluvial flooding is from the above watercourses. However, the risk of flooding from other sources, such as surface water runoff, groundwater, surcharging sewer system and failure of infrastructure will also be assessed.

Information made available to Kaya Consulting Ltd for the study includes the following:

- Location plan showing boundaries of the site;
- Gelly Burn Hydrological Study Condition Report by City Engineers Division, 1997-98;
- A drawing of External Drainage layout of adjacent academy;
- Scottish Water service drawing; and
- LiDAR DTM specifically purchased for this study.

A draft report was submitted in September 2017. SEPA reviewed the draft report and responded on 2 November 2017. Dundee City Council also reviewed the draft report and responded on 31 October 2017. Comments made by SEPA and Dundee City Council are summarised in Section 1.1 and 1.2 respectively. This updated version of the report addresses both sets of comments.

The work carried out to assess the flooding risk of the site and main findings of the study are summarised in the following sections.

## 1.1 SEPA Comments dated 2 November 2017

SEPA in their letter of 2 November 2017 state that *“In summary we object to this planning application on the basis of lack of information in relation to flood risk and energy. We will review the objection once clarification on the following points is provided:*

- *Information should be provided to show that safe access/egress can be maintained during the event of flooding on Gillburn Road.*
- *Information should be provided to show the site has been designed in accordance with the recommendations in the Flood Risk Assessment (FRA) that properties adjacent to the small*

watercourse on the western boundary are raised above ground levels and flow pathways are maintained through the site without any flood risk to property.

- An Energy Statement informed by a Feasibility Study should be provided for assessment by your authority demonstrating how the proposal will meet the requirements for providing district heating onsite. See further details in Section 3 below.

## 1.2 Dundee City Council Comments

Dundee City Council in their email dated 31 October 2017 state that:

1. Flood Risk Assessment (FRA) dated 18/9/17 is only in draft form and has parts missing. Final FRA to be submitted along with completed/signed DCC Flood Risk Assessment "Compliance" and "Independent Check" certificates.

FRA to be updated to include/address the following:

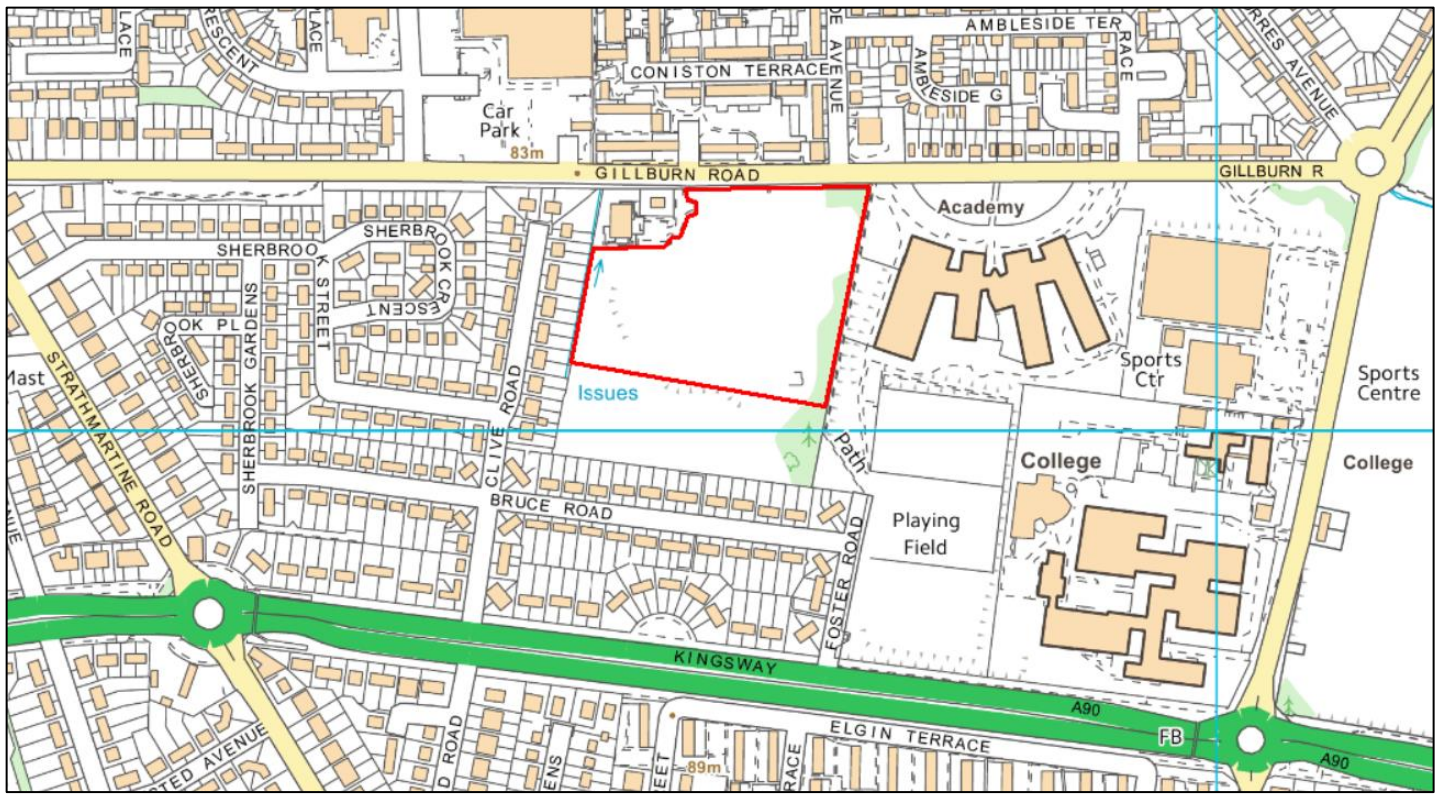
- SEPA Checklist
- Consideration to be given to the existing out of sewer flood risk in Gillburn Road and how this will affect new properties, vehicular and pedestrian access to the site. Below is a link to extracts from the Tayside Integrated Catchment Study (ICS) output drawings giving predicted out of sewer flood volumes at specific manholes for the return periods also listed below. Overland flow routes from this flooding source to be mapped on a drawing to ensure that any new properties are not at flood risk from this source.
- External Link '201506 Tayside ICS Needs Output Drawing RevA Extracts(STW001805\_NO3930) - Predicted Flood Volumes adjacent to former Kingspark School.pdf'
- 1:5 year predicted out of sewer flood volumes
- 1:10 year predicted out of sewer flood volumes
- 1:10 year plus climate change predicted out of sewer flood volumes
- 1:30 year predicted out of sewer flood volumes
- 1:30 year plus climate change predicted out of sewer flood volumes
- 1:100 year predicted out of sewer flood volumes
- 1:200 year predicted out of sewer flood volumes
- 1:200 year plus climate change predicted out of sewer flood volumes
- once receptor (existing culvert or existing Public Sewer) of the development site's surface water is confirmed, the post-development flood risk from Gelly Burn/existing sewer system must be considered. If surface water from the site currently discharges to the Public Sewer then Scottish Water may ask for this to be disconnected and taken to the Gelly Burn culvert. The post-development surface water discharge rate to the Gelly Burn must be no greater than any pre-development surface water discharge rate, or where any new/increased flow rate is proposed to the Gelly Burn, the FRA must demonstrate that there will be no increase to flood risk elsewhere.
- clarify the route/connection detail to the Gelly Burn culvert, at the downstream end of the drain running through the back gardens of the properties located to the west of the development site.
- the catchment of the drain running through the back gardens of properties located to the west of the site extends southwest/westwards to the Kingsway Retail Park (see links to

Scottish Water drainage plant record drawings below). The impermeable area draining/number of connections to the drain is not known. The FRA states that FFL's of properties adjacent to the small drain should be set at least 0.6m above the bank level of the drain, however, this is not currently achieved and the majority of FFL's adjacent to the drain as shown on Millard drawing 14325/02/001A are in fact lower than the bank level. At cross section (a) the bank level is approx. 86.75m and the proposed adjacent property FFL's are 85.00m and 84.20m, at cross section (b) the bank level is approx. 85.09m and the proposed adjacent property FFL's are 84.30m, 84.20m, and 84.10m, and at cross section (c) the bank level is approx. 83.80m and the proposed adjacent property FFL's are 83.90m and 83.40m. Details of measures to be introduced to protect properties within the development site from the flood risk associated with the drain must be provided. Drawings showing overland flow paths must also be submitted to demonstrate that FGL's can shed water away from buildings without affecting other properties, all as stated in paragraph 7 of the FRA Summary and Conclusions.

- *External Link '20171026 Scottish Water Drainage Plant Records - former Kingspark School - drain to west (downstream).pdf'*
  - *External Link '20171026 Scottish Water Drainage Plant Records - former Kingspark School - drain to west (upstream).pdf'*
  - *External Link '20171026 Scottish Water Drainage Plant Records - former Kingspark School - drain to west.pdf'*
  - *The FFL level of plot 1 and associated garage does not appear to provide 600mm freeboard from the worst case predicted 1:200 year Gelly Burn water level of 82.0m in this area.*
  - *Overland flow from the path to the east of the site onto Gillburn Road (to the east of the proposed SUDS basin shown Millard drawing 14325/02/001A) has been witnessed in the past. This should be investigated and included in the FRA if appropriate.*
2. *Full details of surface water drainage proposals (designed in compliance with the "DCC Sustainable Drainage Systems (SUDS) Design Criteria Guidance Note", and accompanied by the necessary drawings, calculations, certification, evidence of compliance with the Simple Index Approach etc.) to be submitted for review and to agree discharge rate if appropriate. Attenuation of the critical 1:200 year storm event to be provided on the development site if discharging surface water to the Gelly Burn Culvert and attenuation to Scottish Waters satisfaction to be provided if discharging surface water to the existing Public Sewer system.*
  3. *If the development site's surface water is to discharge to the Public Sewer then evidence of Scottish Water Technical Approval/Approval To Connect to be submitted.*
  4. *In the long term, maintenance of the surface water drainage system is likely to be undertaken through a joint maintenance agreement between DCC and Scottish Water. This agreement will make Scottish Water responsible for desilting the SUDS feature, any inlet/outlet forebay cleaning and repairs/maintenance to engineering structures. Therefore evidence to be provide (in the form of swept path analysis) to demonstrate that a Scottish Water maintenance vehicle can access the SUDS feature. The Scottish Water maintenance vehicle type is currently a DAF CF400, FAS 6x2 (axle configuration), rigid, double mounted training axle, 11.97m long but this should be confirmed with Scottish Water. See below link to DAF website where the above vehicle specification sheet can be found using the above vehicle information. <http://www.daf.co.uk/en-gb/trucks/specsheets-search-page>*

The draft report has been updated to include the comments raised by SEPA and Dundee City Council outlined above.

Figure 1: Location plan



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### 1.3 Revised Bypass Culvert

In January 2020, Kaya Consulting was asked to reassess the bypass culvert along a modified line. This involved updating the culvert model and the findings are provided in Section 5.2.1. All other parts of this report remain as the January 2018 version.

## 2 Legislative and Policy Aspects

### 2.1 National Planning Policy

The current version of the Scottish Planning Policy (SPP) was published in June 2014 and replaces the previous version which was published in February 2010. The SPP sets out national planning policies which reflect Scottish Government's priorities for operation of the planning system and for the development and use of land. It relates to:

- the preparation of development plans;
- the design of development, from initial concept through to delivery; and
- the determination of planning applications and appeals.

The National Planning Framework (NPF) provides a statutory framework for Scotland's long term spatial development and sets out the Scottish Government's spatial development priorities for the next 20 to 30 years. The SPP sets out the policy that will help to deliver the objectives of the NPF.

Relevant extracts from the SPP related to flood risk are listed below:

#### **Policy Principles**

255. *The planning system should promote:*

- *a precautionary approach to flood risk from all sources, including coastal, water course (fluvial), surface water (pluvial), groundwater, reservoirs and drainage systems (sewers and culverts), taking account of the predicted effects of climate change;*
- *flood avoidance: by safeguarding flood storage and conveying capacity, and locating development away from functional flood plains and medium to high risk areas;*
- *flood reduction: assessing flood risk and, where appropriate, undertaking natural and structural flood management measures, including flood protection, restoring natural features and characteristics, enhancing flood storage capacity, avoiding the construction of new culverts and opening existing culverts where possible; and*
- *avoidance of increased surface water flooding through requirements for Sustainable Drainage Systems (SuDS) and minimising the area of impermeable surface.*

256. *To achieve this, the planning system should prevent development which would have a significant probability of being affected by flooding or would increase the probability of flooding elsewhere. Piecemeal reduction of the functional floodplain should be avoided given the cumulative effects of reducing storage capacity.*

257. *Alterations and small-scale extensions to existing buildings are outwith the scope of this policy, provided that they would not have a significant effect on the storage capacity of the functional floodplain or local flooding problems.*

#### **Key Documents**

- *Flood Risk Management (Scotland) Act 2009*
- *Updated Planning Advice Note on Flooding 2015*
- *Delivering Sustainable Flood Risk Management (Scottish Government, 2011).*
- *Surface Water Management Planning Guidance (Scottish Government, 2013).*

### **Delivery**

258. Planning authorities should have regard to the probability of flooding from all sources and take flood risk into account when preparing development plans and determining planning applications. The calculated probability of flooding should be regarded as a best estimate and not a precise forecast. Authorities should avoid giving any indication that a grant of planning permission implies the absence of flood risk.
259. Developers should take into account flood risk and the ability of future occupiers to insure development before committing themselves to a site or project, as applicants and occupiers have ultimate responsibility for safeguarding their property.

### **Development Planning**

260. Plans should use strategic flood risk assessment (SFRA) to inform choices about the location of development and policies for flood risk management. They should have regard to the flood maps prepared by Scottish Environment Protection Agency (SEPA), and take account of finalised and approved Flood Risk Management Strategies and Plans and River Basin Management Plans.
261. Strategic and local development plans should address any significant cross boundary flooding issues. This may include identifying major areas of the flood plain and storage capacity which should be protected from inappropriate development, major flood protection scheme requirements or proposals, and relevant drainage capacity issues.
262. Local development plans should protect land with the potential to contribute to managing flood risk, for instance through natural flood management, managed coastal realignment, washland or green infrastructure creation, or as part of a scheme to manage flood risk.
263. Local development plans should use the following flood risk framework to guide development. This sets out three categories of coastal and watercourse flood risk, together with guidance on surface water flooding, and the appropriate planning approach for each (the annual probabilities referred to in the framework relate to the land at the time a plan is being prepared or a planning application is made):
- **Little or No Risk** – annual probability of coastal or watercourse flooding is less than 0.1% (1:1000 years)
    - No constraints due to coastal or watercourse flooding.
  - **Low to Medium Risk** – annual probability of coastal or watercourse flooding is between 0.1% and 0.5% (1:1000 to 1:200 years)
    - 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 in these areas or is being substantially extended, it should be designed to be capable of remaining operational and accessible during extreme flood events.
  - **Medium to High Risk** – annual probability of coastal or watercourse flooding is greater than 0.5% (1:200 years)
    - 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, e.g. for caretakers or operational staff.
- Generally, not suitable for:
  - civil infrastructure and the most vulnerable uses;
  - additional development in undeveloped and sparsely developed areas, unless a location is essential for operational reasons, 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.
- 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.
- Water-resistant materials and construction should be used where appropriate. Elevated buildings on structures such as stilts are unlikely to be acceptable.

### **Surface Water Flooding**

- Infrastructure and buildings should generally be designed to be free from surface water flooding in rainfall events where the annual probability of occurrence is greater than 0.5% (1:200 years).
- Surface water drainage measures should have a neutral or better effect on the risk of flooding both on and off the site, taking account of rain falling on the site and run-off from adjacent areas.

### **Development Management**

264. It is not possible to plan for development solely according to the calculated probability of flooding. In applying the risk framework to proposed development, the following should therefore be taken into account:

- the characteristics of the site;
- the design and use of the proposed development;
- the size of the area likely to flood;
- depth of flood water, likely flow rate and path, and rate of rise and duration;
- the vulnerability and risk of wave action for coastal sites;
- committed and existing flood protection methods: extent, standard and maintenance regime;
- the effects of climate change, including an allowance for freeboard;
- surface water run-off from adjoining land;
- culverted watercourses, drains and field drainage;
- cumulative effects, especially the loss of storage capacity;
- cross-boundary effects and the need for consultation with adjacent authorities;
- effects of flood on access including by emergency services; and
- effects of flood on proposed open spaces including gardens.

265. Land raising should only be considered in exceptional circumstances, where it is shown to have a neutral or better impact on flood risk outside the raised area. Compensatory storage may be required.

266. The flood risk framework set out above should be applied to development management decisions. Flood Risk Assessments (FRA) should be required for development in the medium to high category of flood risk, and may be required in the low to medium category in the circumstances described in the framework above, or where other factors indicate heightened risk. FRA will generally be required for applications within areas identified at high or medium likelihood of flooding/flood risk in SEPA's flood maps.

267. Drainage Assessments, proportionate to the development proposal and covering both surface and foul water, will be required for areas where drainage is already constrained or otherwise problematic, or if there would be off-site effects.

268. Proposed arrangements for SuDS should be adequate for the development and appropriate long-term maintenance arrangements should be put in place.

## 2.2 SEPA Flood Maps

The SEPA third generation flood maps show the likely extent of flooding for high, medium and low likelihood events for fluvial, pluvial (surface water) and tidal flows. Consultation of the maps shows the site is outside of any mapped fluvial and coastal floodplains. However, risk of surface water (pluvial) flooding is shown along Gillburn Road and at a couple of small spots within the site.

It should be noted that the SEPA maps are indicative and detailed studies are required to assess flooding risk of the site from possible sources.

## 2.3 SEPA Technical Flood Risk Guidance

The latest version of SEPA 'Technical Flood Risk Guidance for Stakeholders' would need to be consulted when undertaking flood risk assessments (current version is 9.1, June 2015). This technical guidance document is intended to outline methodologies that may be appropriate for hydrological and hydraulic modelling and sets out what information SEPA requires to be submitted as part of a Flood Risk Assessment.

SEPA Policy 41 sets out roles and responsibilities of SEPA and Planning Authorities.

## 2.4 Flood Risk Management (Scotland) Act 2009

The Flood Risk Management (Scotland) Act 2009 came into force on 26 November 2009. The Act repealed the Flood Prevention (Scotland) Act 1961 and introduces a more sustainable and streamlined approach to flood risk management, suited to present and future needs and to the impact of climate change. It encourages a more joined up and coordinated process to manage flood risk at a national and local level.

The Act brings a new approach to flood risk management including a framework for coordination and cooperation between all organisations involved in flood risk management, new responsibilities for SEPA, Scottish Water and local authorities in relation to flood risk management, a revised and streamlined process for flood protection schemes, new methods to enable stakeholders and the public to contribute to managing flood risk; and SEPA to act as a single enforcement authority for the safe operation of Scotland's reservoirs.

## 2.5 Controlled Activities Regulations

The Water Environment (Controlled Activities) (Scotland) Amended Regulations 2013 (CAR) brings new controls for discharges, abstractions, impoundments and engineering works in or near inland waters. Any such work requires authorisation (licence) from the Scottish Environment Protection Agency (SEPA) who are responsible for the implementation of the Act. The Regulations include a requirement that surface water discharge must not result in pollution of the water environment. It also makes Sustainable Drainage Systems (SuDS) a requirement for new development, with the exception of runoff from a single dwelling and discharges to coastal waters.

## 2.6 Climate Change

The SPP states that “*planning system should promote a precautionary approach to flood risk from all sources, including coastal, water course (fluvial), surface water (pluvial), groundwater, reservoirs and drainage systems (sewers and culverts), taking account of the predicted effects of climate change.*”

One of the sustainable policy principles within the National Planning Framework is supporting climate change mitigation and adaptation including taking account of flood risk.

SEPA recommend a 20% increase in peak flow for the 0.5% AEP (1:200) event, in accordance with DEFRA (Department of Environment, Food and Rural Affairs) and recent Scottish Government research. Although the 2009 climate change predictions (UKCP09) provides information on spatial variations, for current studies a 20% increase in peak flows is assumed.

It is recommended that any site drainage design considers future estimates of increased precipitation and follows an adaptive approach.

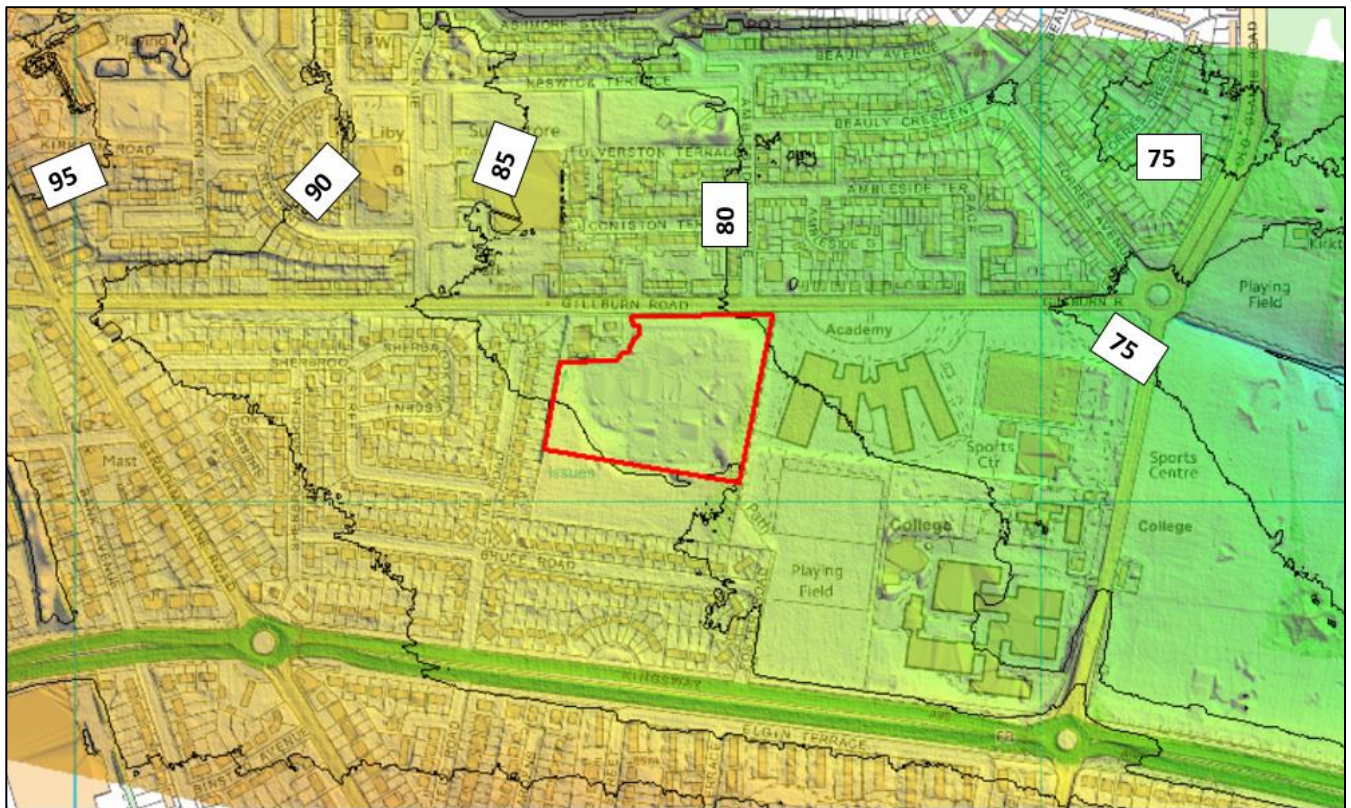
The Climate Change (Scotland) Act 2009 also makes reference to adaptation to climate change.



The ground elevation along the line of the culvert drops 34.5m over a distance of some 2.1km. This gives an average gradient of 1 in 63.

Topography in the area slopes east and north towards Gillburn Road beyond which ground level gently rises to north, Figure 3.

**Figure 3: Site topography (based on LiDAR)**



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## 4 Hydrological Analysis

The hydrological assessment makes estimates of design flows for the Gelly Burn at site.

The catchment area of Gelly Burn was extracted from the Flood Estimation Handbook (FEH) webservice as 4.2km<sup>2</sup> at the start of the open channel some 415m downstream of the site where the rectangular brick culvert discharges. At site, the catchment area reduces to 3.6km<sup>2</sup>.

The 200 year flow for the burn was estimated using FEH rainfall-runoff method and 2013 rainfall data. This gives a peak flow of 17.16m<sup>3</sup>/s at the open channel on the east side of Old Glamis Road and 14.7m<sup>3</sup>/s at the site. This indicates a unit flow of 4.08m<sup>3</sup>/s/km<sup>2</sup> and appears on the conservative side.

The Institute of Hydrology Small Catchment Method (IH124) gives a 200 year flow estimate of 7.7m<sup>3</sup>/s, while the ReFH2 method gives a 200 year flow of 5.42m<sup>3</sup>/s. Both are significantly smaller than the FEH rainfall-runoff flow.

The rectangular culvert at site has an internal flow area of approximately 0.72m<sup>2</sup>. Flow capacity of this culvert at site is of the order of 2-3m<sup>3</sup>/s. This is significantly less than the estimated 200 year flow based on FEH rainfall-runoff method, indicating that the FEH flow is likely to be conservative. However, flows estimated based on the other two methods (i.e. IH124 and ReFH2) are also in excess of the estimated culvert capacity, indicating that flooding from the Gelly Burn culvert is likely. It should be noted that as a large percentage of the catchment is urbanised, a significant portion of the flow may be draining through the urban drainage system, thus reducing the frequency of flooding along the line of the Gelly Burn culvert.

The Scottish Water waste water service drawing of the area indicates that a 600mm surface water sewer discharges at the top of the small drain. It is believed that the drain connects to Gelly Burn culvert via an 800mm pipe. The exact catchment area draining to the 600mm sewer is not known. Therefore, it is assumed that flows discharging from the sewer cannot exceed its full-bore capacity. This is likely to be conservative as the drain enters smaller 300mm culverts through private properties, and if discharged at full-bore capacity of a 600mm culvert, there would be frequent flooding through these private properties. There are no records of such flooding of these properties.

## 5 Flood Risk Assessment

The flood risk assessment considers flooding from:

- Gelly Burn;
- Small drain;
- Surface water runoff;
- Groundwater;
- Site access; and
- Site drainage and local sewer.

### 5.1 Flood Risk from Gelly Burn

The risk of flooding from the Gelly Burn culvert was assessed based on the following:

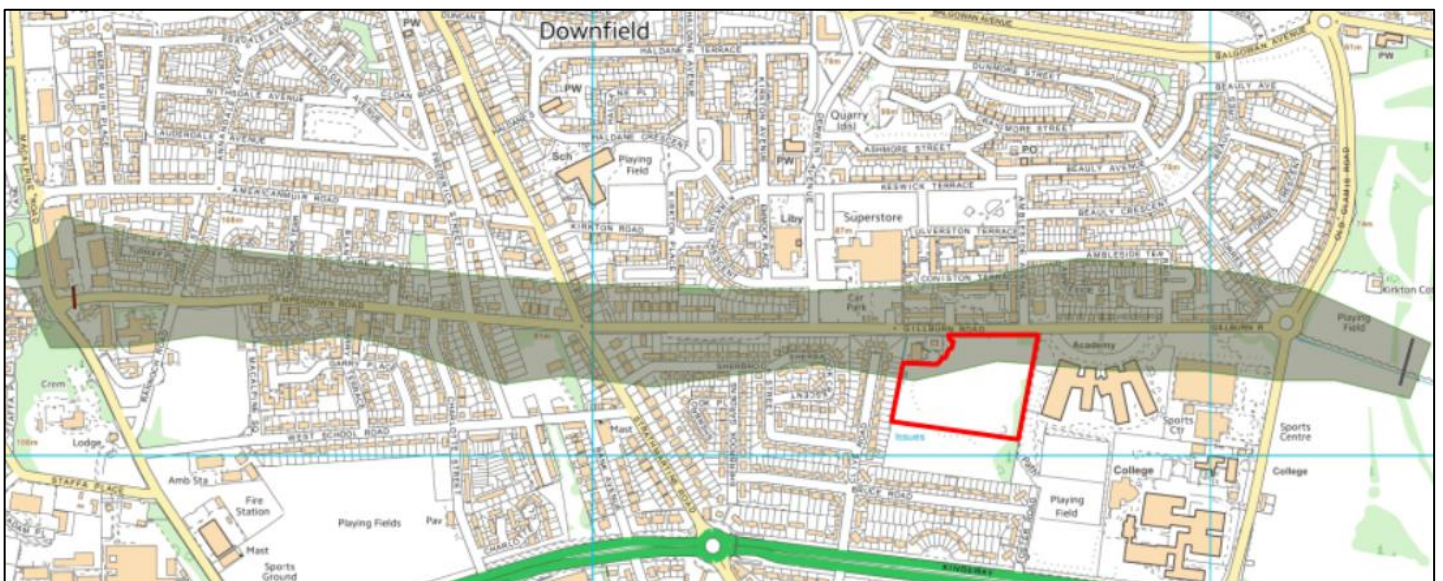
- 1) Using 2D overland flow modelling assuming the culvert is 100% blocked and all flows run overland; and
- 2) Modelling flows surcharged from manholes provided by the Council, based on Integrated Catchment Modelling. This model takes account of the existing Gelly Burn culvert and flows surcharging from the manholes are those exceeding capacity of the culvert.

#### 5.1.1 2D Modelling

A 2D overland flow model was set up using Flood Modeller Pro software and 1m horizontal resolution LiDAR DTM (specifically purchased for this study).

The model extent and active area are shown in Figure 4.

**Figure 4: 2D model extent and active area**



Key model parameters were:

- Grid size: 2m
- Roughness (Manning's n): 0.07
- Timestep: 1seconds
- Upstream flow boundary based on hydrograph estimated using FEH rainfall-runoff method with a peak flow of 17.2m<sup>3</sup>/s (i.e. 200 year + climate change)
- Downstream boundary: normal depth (0.01)

Assumption:

- All flow runs overland with no culvert flow (culvert assumed to be 100% blocked) and no flow entering local drainage system.

The predicted extent of inundation for 200 year flow plus climate change is shown in Figure 5.

**Figure 5: Predicted 200 year plus climate change flood extent (assuming all flow runs overland)**

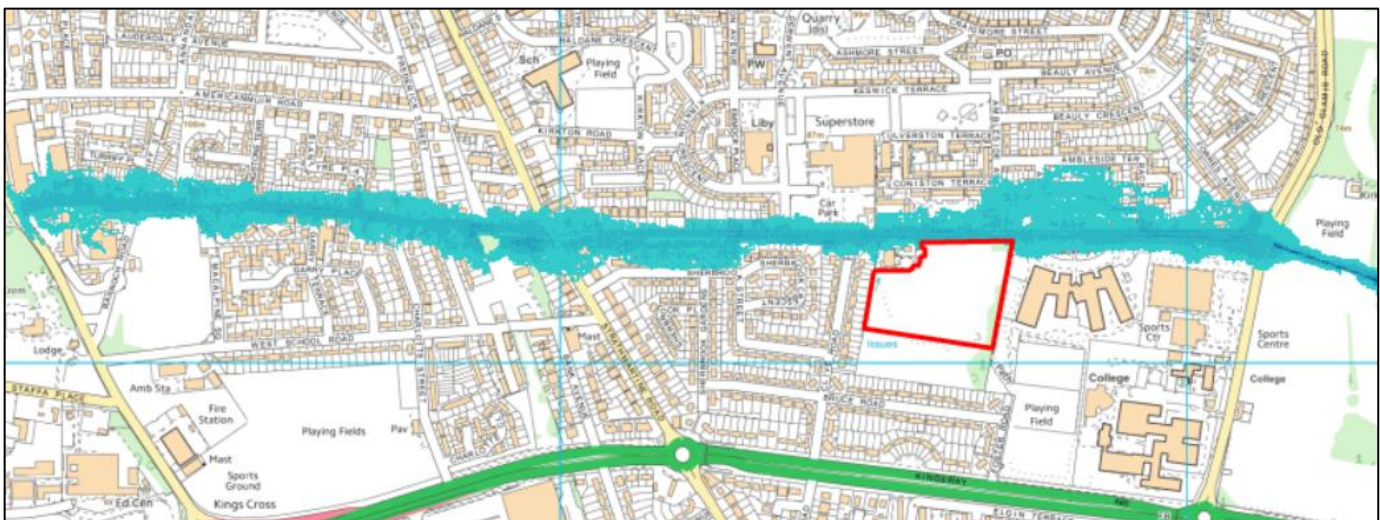


Figure 5 shows that for an extreme case of 100% culvert blockage with the entire Gelly Burn flow running overland, the site is not at risk of flooding from a 200 year flood (including climate change).

The design flow assumed for the above model run is probably the absolutely worst case, because:

- a) Flow estimate from upstream catchment based on rainfall-runoff method is likely to be conservative (i.e. high); and
- b) It is likely that some flows will be conveyed through local sewer system and Gelly Burn culvert, even with culvert/sewer blockage.

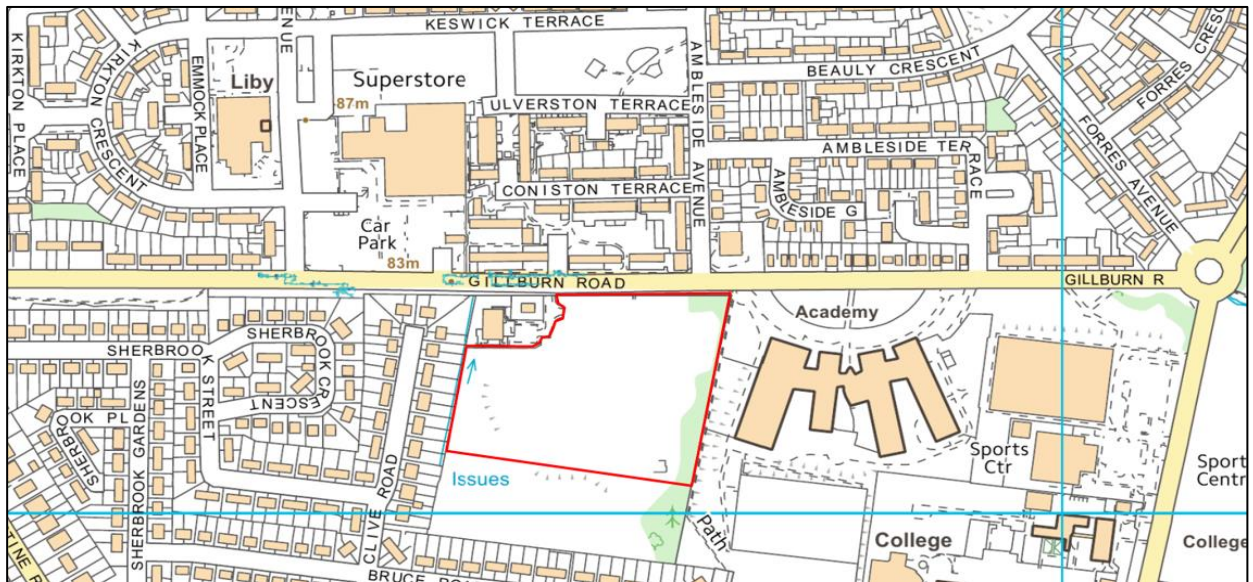
As the model run represents a worst-case scenario, no sensitivity analysis was deemed necessary, other than an increased global roughness to 0.09, resulting in similar flood extent as shown in Figure 5.

The predicted water levels on Gillburn Road at the north-west and north-east corners adjacent to road are 82.0m AOD and 79.6m AOD respectively.

### 5.1.2 Modelling of Flows Surcharging from Manholes

Dundee City Council kindly provided volumes of water surcharging from manholes in the area for a range of return period flows (see Section 1.2). These were obtained from Integrated Catchment Model (ICM) developed by Scottish Water. Overland flow simulations were carried out assuming flood volumes surcharging over 3 and 1 hour periods and staying overland (i.e. not re-entering the culvert or drainage system). It was also assumed that all manholes surcharge at the same time, resulting in conservative flood extent and depth. Model results are shown in Figures 6 to 9 inclusive for the 10 and 200 year events respectively.

**Figure 6: Overland flows for 10 year flood**



**Figure 7: Overland flows for 200 year flood (3 hour)**

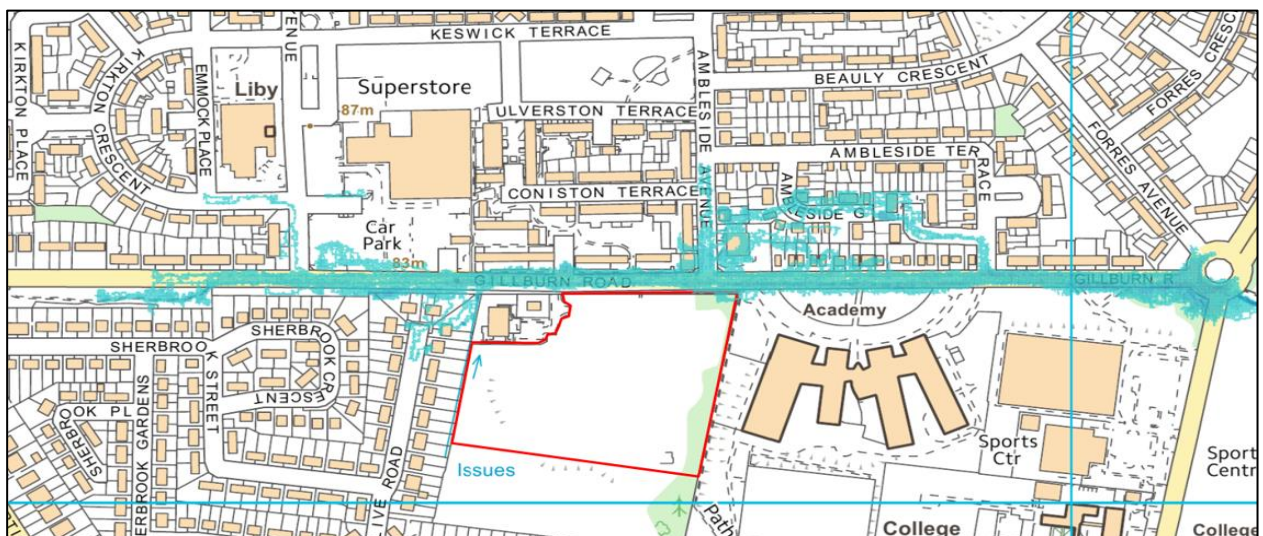


Figure 8: Overland flows for 200 year flood (1 hour)

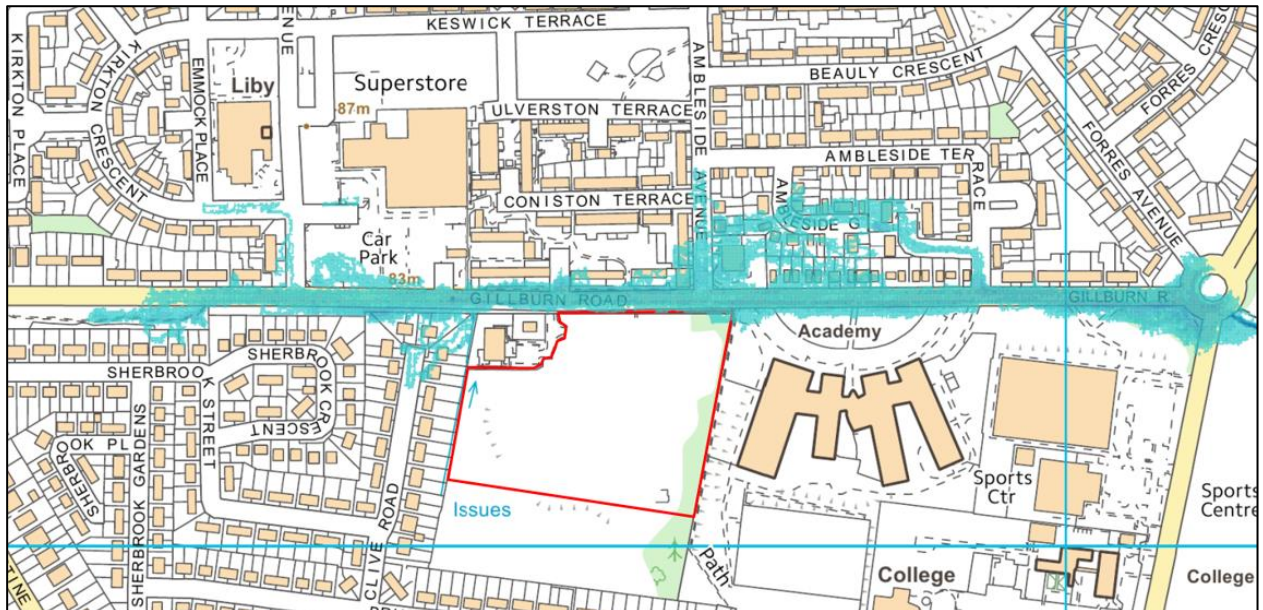
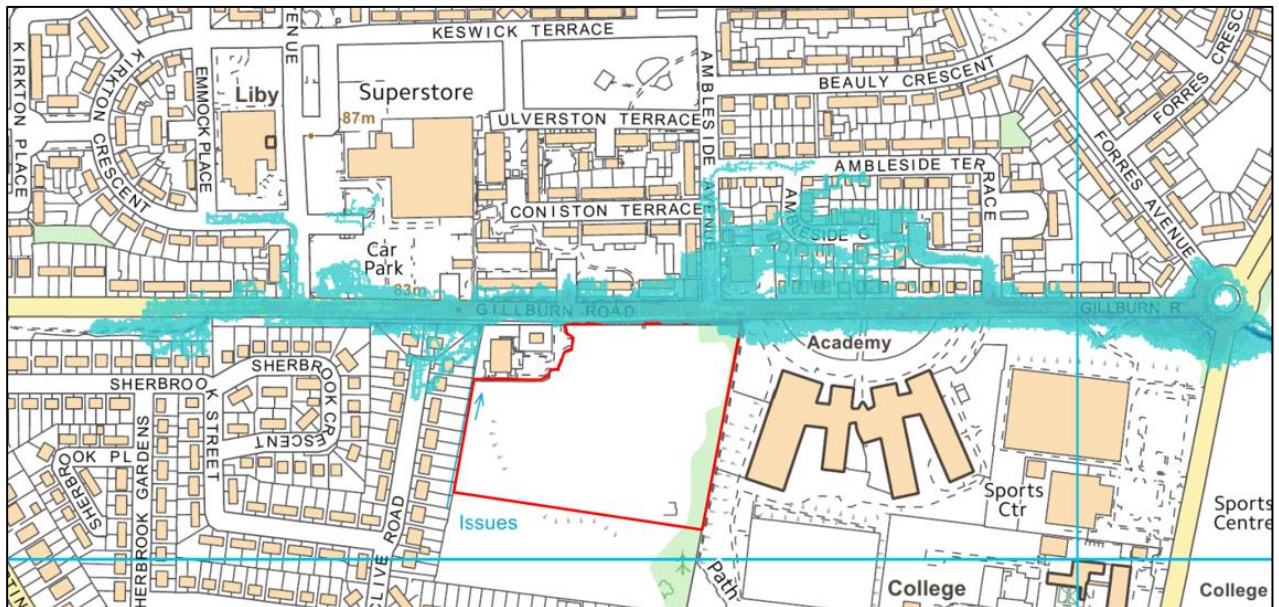


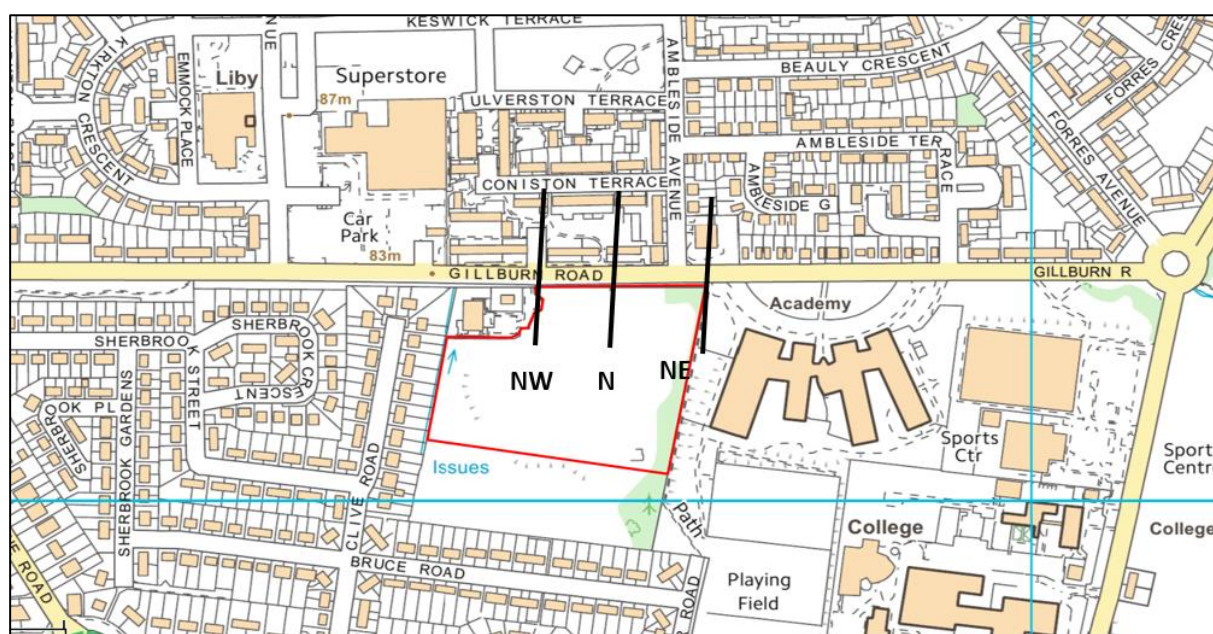
Figure 9: Overland flows for 200 year + climate change flow (1 hour)



The above figures show that other than a very small area at the north-east corner of the site (where there is a surcharging manhole), no other parts of the site is predicted to flood. The predicted flood depths at the north-east, centre and north-west corner of the site are presented in Table 1. The predicted maximum depth of water on Gillburn Road adjacent to site is of the order of 0.3-0.35m. These are 0.15-0.20m lower than water level predictions based on full flow modelling outlined in Section 5.1.1.

**Table 1: Predicted flood depths (m) on Gillburn Road**

	10 YEAR (1HR)	200 YEAR (1HR)	200 YEAR (3HR)	200 YEAR+CC (1HR)	200 YEAR+CC (3HR)
<b>NORTH- WEST (NW)</b>	0.05	0.25	0.2	0.35	0.3
<b>NORTH (CENTRE) (N)</b>	0	0.27	0.2	0.35	0.3
<b>NORTH- EAST (NE)</b>	0	0.3	0.28	0.4	0.37



## 5.2 Flood Risk from Small Drain

The small drain is of the order of 1-1.5m wide and 0.5-0.7m deep. Three cross sections extracted from LiDAR DTM along the drain fronting the western boundary of the site are shown in Figure 10.

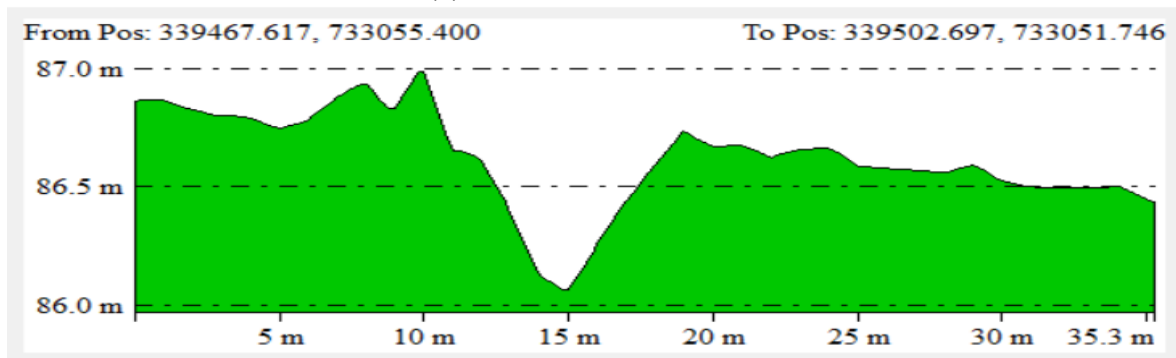
The natural catchment area of the drain appears to be very small. Considering relatively large size of the drain and small catchment area, the risk of flooding from the drain appears low.

Both SEPA and Dundee City Council commented on the potential risk of flooding from the drain and requested additional information. The drain runs through private properties and there is no access to it other than through these properties. An attempt was made to access the drain and survey it. However, this only resulted in partial access and other parts of the drain could not be accessed. Those areas were able to be accessed indicated that the drain runs through a number of culverted and open channel sections through the back gardens of the properties, Photos 1 and 2. Some of these short section culverts were measured to be 300mm in diameter. The Scottish Water waste water service drawing indicates that surface water sewer discharging at the top of the drain may be 600mm in diameter. The internal flow area of this culvert is some 3.9 times larger than the 300mm culvert.

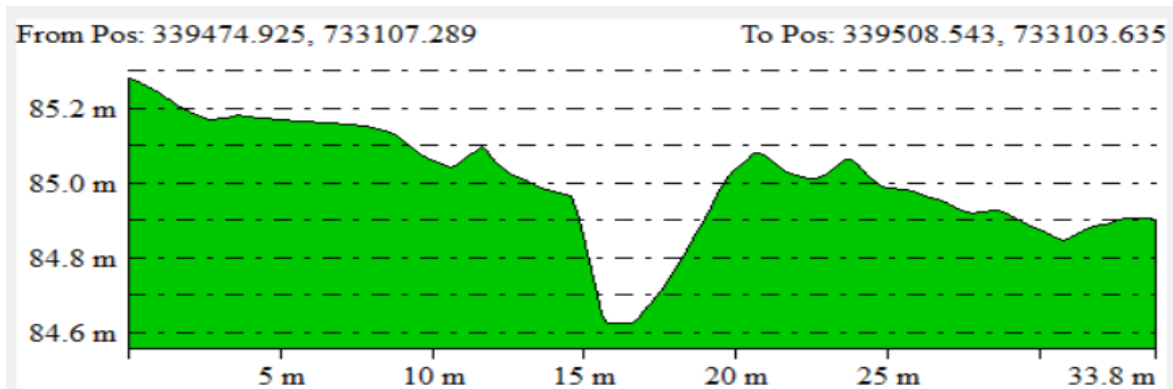
Therefore, peak flows discharging from a 600mm culvert would not be able to pass through the 300mm pipes. As there is no record of frequent flooding in this area and there was no sign of large volumes of flows in the drain in the recent past, it is likely that the 600mm sewer does not flow in full bore capacity. However, as the short section culverts are significantly smaller and open sections of the drain do not appear to be regularly maintained (presumably due to access restriction), it is suggested to divert the sewer through the site and connect into Gelly Burn culvert at the northern boundary of the site. An indicative line for bypass sewer is shown in Figure 11. Within the site, the diversion sewer will run along proposed internal road of the development.

**Figure 10: Cross section along small drain**

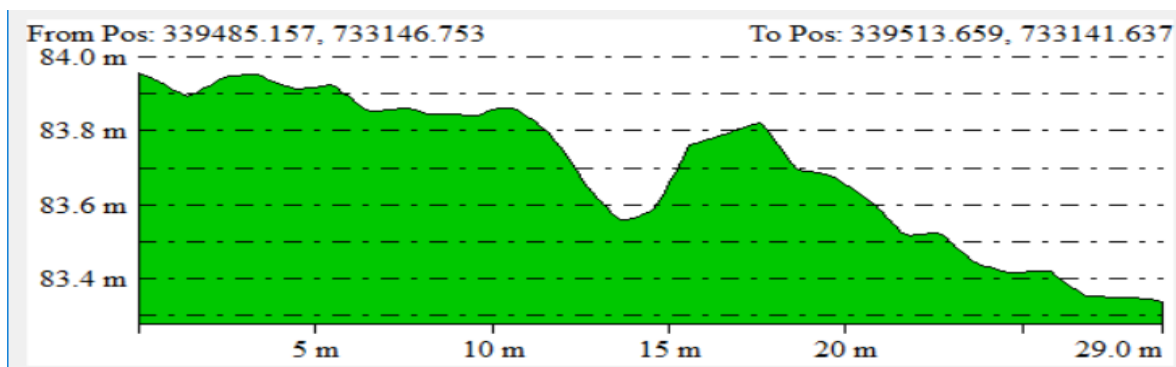
(a): at south-west corner of site



(b): at the middle of western boundary



(c): at north-west corner of site



**Photo 1 : Drain entering a 300mm culvert through back gardens**



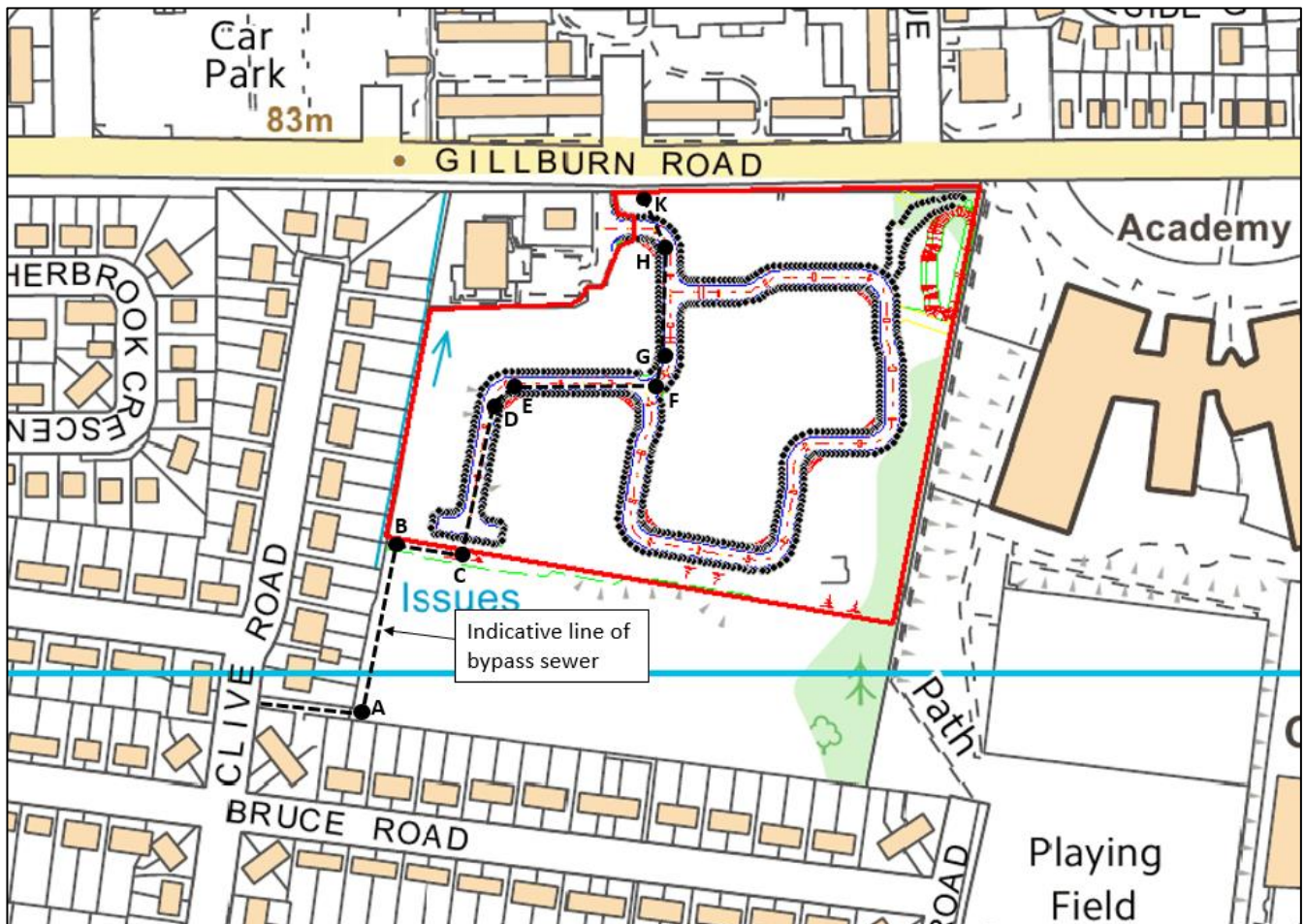
**Photo 2: View of drain through back gardens**



It is suggested that the bypass sewer should be slightly larger in size than the existing culvert (i.e. 750mm in diameter). As the Gelly Burn culvert is predicted to surcharge (as indicated by ICM output), at times flows entering the Gelly Burn culvert from the bypass sewer will be limited. Having a larger diameter pipe will provide some additional storage within the sewer and reduce the risk of flooding of the road.

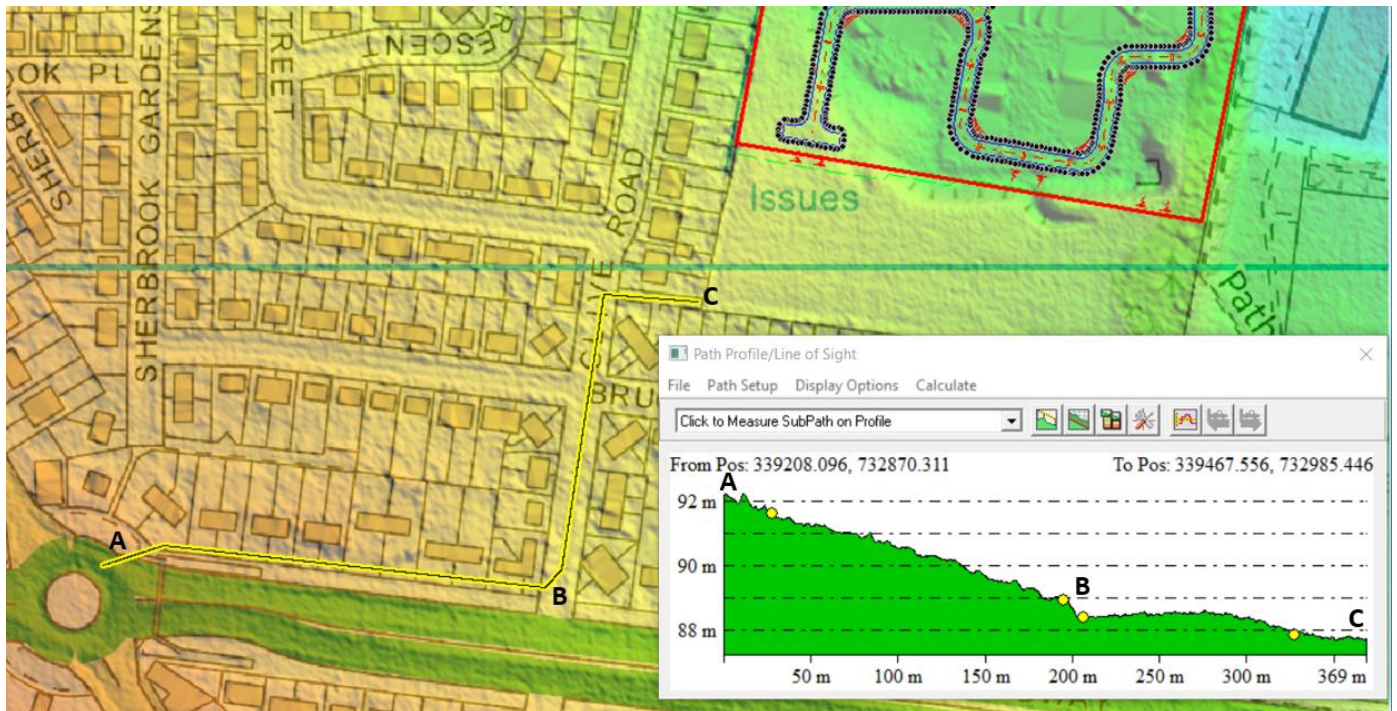
It is suggested that the existing drain is maintained, and the new sewer inlet designed in such a way that any excess flows that could arrive from upstream and unable to pass through the bypass sewer could spill into the existing drain and flow as at present.

**Figure 11: Possible route of bypass sewer**



Scottish Water waste water service drawings indicates the route of the 600mm sewer upstream of site as shown in Figure 12. Also shown in Figure 12 is ground profile along the line of the sewer.

**Figure 12: Approximate route of 600mm sewer and existing ground profile along the line of the sewer**



The average gradients between points A and B and points B and C are approximately 1 in 57 and 1 in 142 respectively. This indicates a much shallower gradient as the sewer approaches the site.

Full bore capacity of the sewer was calculated using Colebrook-White equation. The results are summarised in Table 2. These indicate that full bore capacity of the sewer is approximately  $0.82\text{m}^3/\text{s}$  within the steeper upstream section and  $0.53\text{m}^3/\text{s}$  for the flatter downstream section. The assumed parameters are shown in Table 2.

A HECRAS model was constructed of the bypass sewer to determine if the proposed sewer is able to convey the flows that could potentially enter it from upstream. The model extends from the inlet at Clive Road to manhole K at Gelly Burn culvert at the northern boundary of the site (Figure 11), over a distance of over 350m.

The following parameters were assumed:

- Roughness for manholes (Manning's n) 0.025, and for pipes 0.018
- Manhole inlet/exit loss coefficients: 0.3/1.0
- Upstream boundary: constant flow (set to peak)
- Downstream boundary: Water level set to normal flow and flood flow conditions in Gelly Burn culvert (i.e. 80.5m AOD and 82.0m AOD)

Table 2: Estimated sewer capacity

## Upstream section

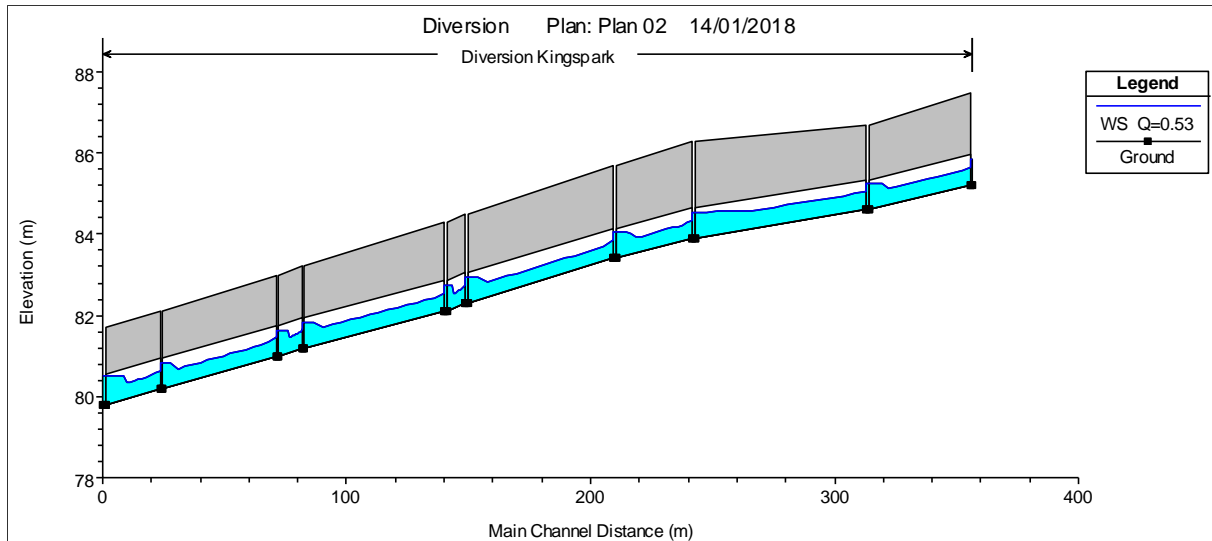
## Downstream section

CULVERT FLOW CALCULATION (Based on full pipe flow equations and Colebrook-White transition formula)				CULVERT FLOW CALCULATION (Based on full pipe flow equations and Colebrook-White transition formula)			
INPUT DATA				INPUT DATA			
No of Circular Culverts	1			No of Circular Culverts	1		
No of Rectangular Culverts	0			No of Rectangular Culverts	0		
Circular Culvert Diameter (m)	0.6			Circular Culvert Diameter (m)	0.6		
Rectangular Culvert Dimensions	0	0		Rectangular Culvert Dimensions	0	0	
Upstream Invert Level (mAOD)	91.8			Upstream Invert Level (mAOD)	88.5		
Downstream Invert level (mAOD)	88.5			Downstream Invert level (mAOD)	87.1		
Culvert Length (m)	195			Culvert Length (m)	200		
Downstream Water Level (mAOD)	89.2			Downstream Water Level (mAOD)	87.7		
Friction Coefficient, Ks (mm)	0.5			Friction Coefficient, Ks (mm)	0.5		
Entry Loss Co-efficient	0.3			Entry Loss Co-efficient	0.3		
Exit Loss Co-efficient	1			Exit Loss Co-efficient	1		
Upstream Surge Height (m)	0			Upstream Surge Height (m)	0		
Density of Water (kg/m <sup>3</sup> )	1000			Density of Water (kg/m <sup>3</sup> )	1000		
Dynamic Viscosity (kg/(ms))	0.00114			Dynamic Viscosity (kg/(ms))	0.00114		
pi	3.1415926			pi	3.1415926		
g	9.80665			g	9.80665		
CALCULATED PARAMETERS				CALCULATED PARAMETERS			
Equivalent Pipe Diameter (m)	0.600			Equivalent Pipe Diameter (m)	0.600		
Culvert Area (m <sup>2</sup> )	0.283			Culvert Area (m <sup>2</sup> )	0.283		
Slope	0.0164	60.94		Slope	0.0070	142.86	
Lamda1 (pipe friction factor)	0.019			Lamda1 (pipe friction factor)	0.019		
Parameter :Length/(2gD)	16.570			Parameter :Length/(2gD)	16.995		
Parameter :1/(2g)	0.051			Parameter :1/(2g)	0.051		
Flow (First attempt) (m <sup>3</sup> /s)	0.823			Flow (First attempt) (m <sup>3</sup> /s)	0.539		
Reynolds Number	1532012			Reynolds Number	1002786		
Lamda (pipe friction factor)	0.019			Lamda (pipe friction factor)	0.019		
Flow (second attempt) (m <sup>3</sup> /s)	0.817			Flow (second attempt) (m <sup>3</sup> /s)	0.533		
Reynolds Number	1521644			Reynolds Number	992989		
Lamda (pipe friction factor)	0.019			Lamda (pipe friction factor)	0.019		
Calculated Flow (m <sup>3</sup> /s)	0.817			Calculated Flow (m <sup>3</sup> /s)	0.533		

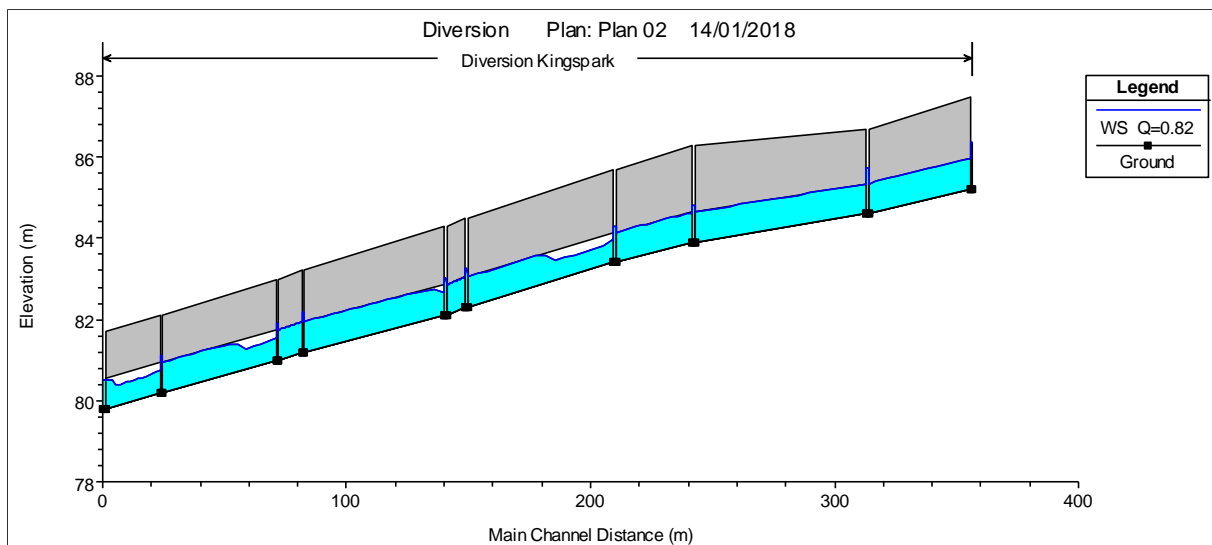
The results are shown in Figures 13 to 16. These indicate that no significant flooding would be expected from the sewer, except from Manholes H and K during a 200 year flow in Gelly Burn culvert. Any water surcharging from manholes H and K would spill on Gillburn Road. A flow rate of 0.82m<sup>3</sup>/s appears to be the maximum flow capacity before flooding occurring from manholes.

As the section of the existing 600mm sewer running along Clive Road has a full-bore capacity of 0.53m<sup>3</sup>/s, flows significantly in excess of this would not be expected to enter the diversion sewer. Therefore, it is unlikely that flows as high as 0.82m<sup>3</sup>/s would enter the diversion sewer. However, model simulations have shown that the proposed sewer would be able to convey such high flows, albeit surcharged but without flooding (except manholes H and K due to high water level at Gelly Burn culvert as indicated before).

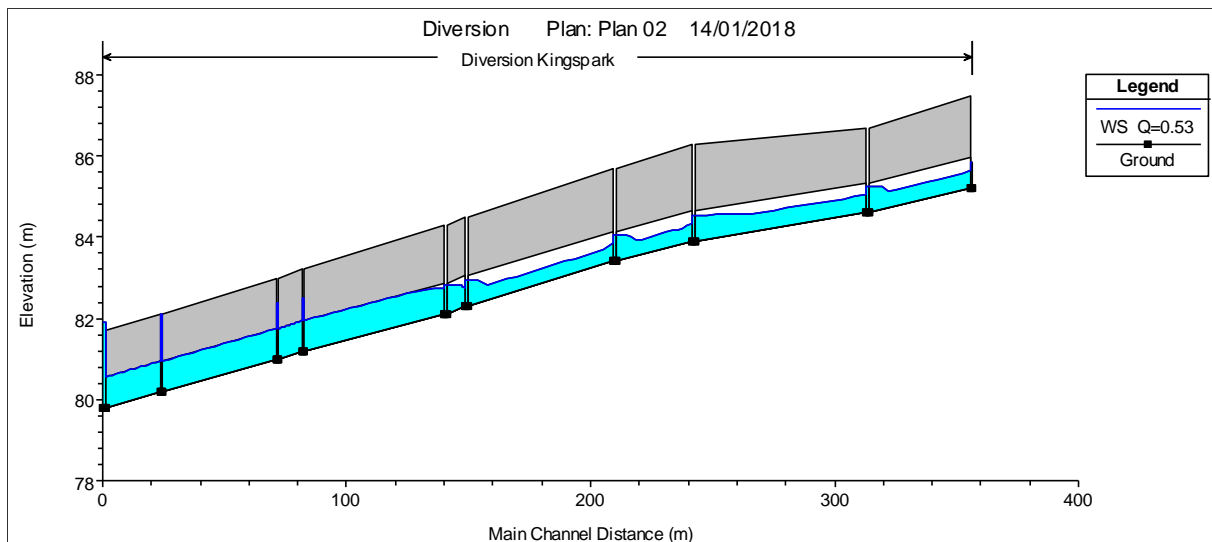
**Figure 13: Predicted water level in diversion sewer ( $Q=0.53\text{m}^3/\text{s}$ , normal flow in Gelly Burn Culvert)**



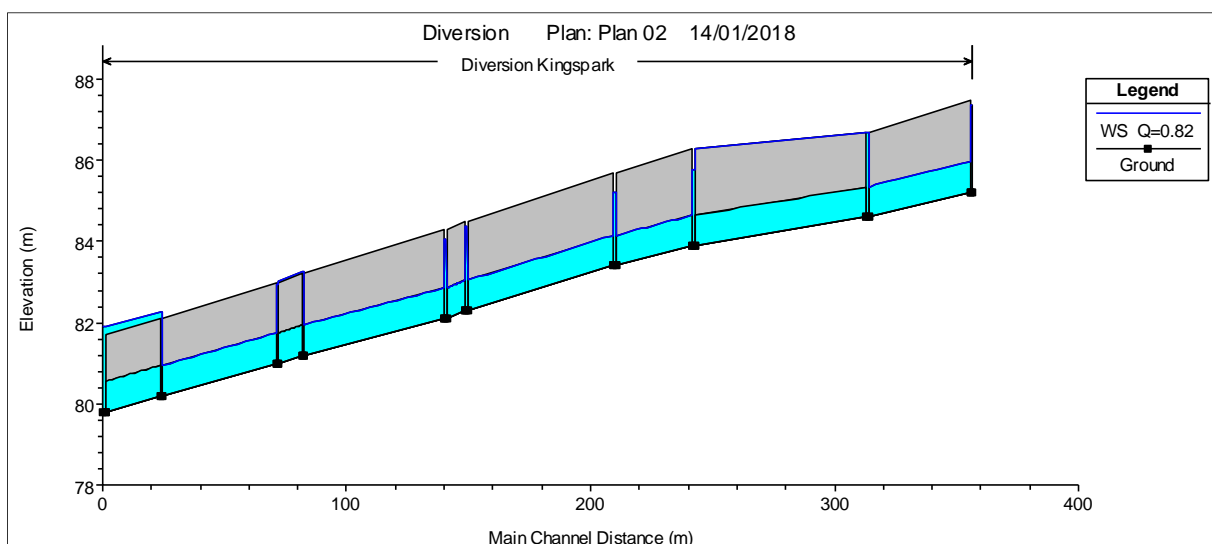
**Figure 14: Predicted water level in diversion sewer ( $Q=0.82\text{m}^3/\text{s}$ , normal flow in Gelly Burn Culvert)**



**Figure 15: Predicted water level in diversion sewer ( $Q=0.53\text{m}^3/\text{s}$ , peak flow in Gelly Burn Culvert)**



**Figure 16: Predicted water level in diversion sewer ( $Q=0.82\text{m}^3/\text{s}$ , peak flow in Gelly Burn Culvert)**



A bypass sewer arrangement as outline above will:

- Reduce the risk of flooding to existing properties at Clive Road and including Children's Respite Unit;
- Reduce the risk of flooding to the new development; and
- Reduce the risk of flooding to Gillburn Road.

The proposed bypass sewer will not increase flows arriving at Gelly Burn culvert. At present, flows arriving through the drain will either enter the culvert through the 800mm connection pipe, or spill onto Gillburn Road. Post development, same flows will enter the culvert, and those unable to enter the culvert will be stored within the larger diameter sewer and with any excess flows spilling onto Gillburn Road as at present. So, there will be no increase to flows entering the culvert or surcharging on

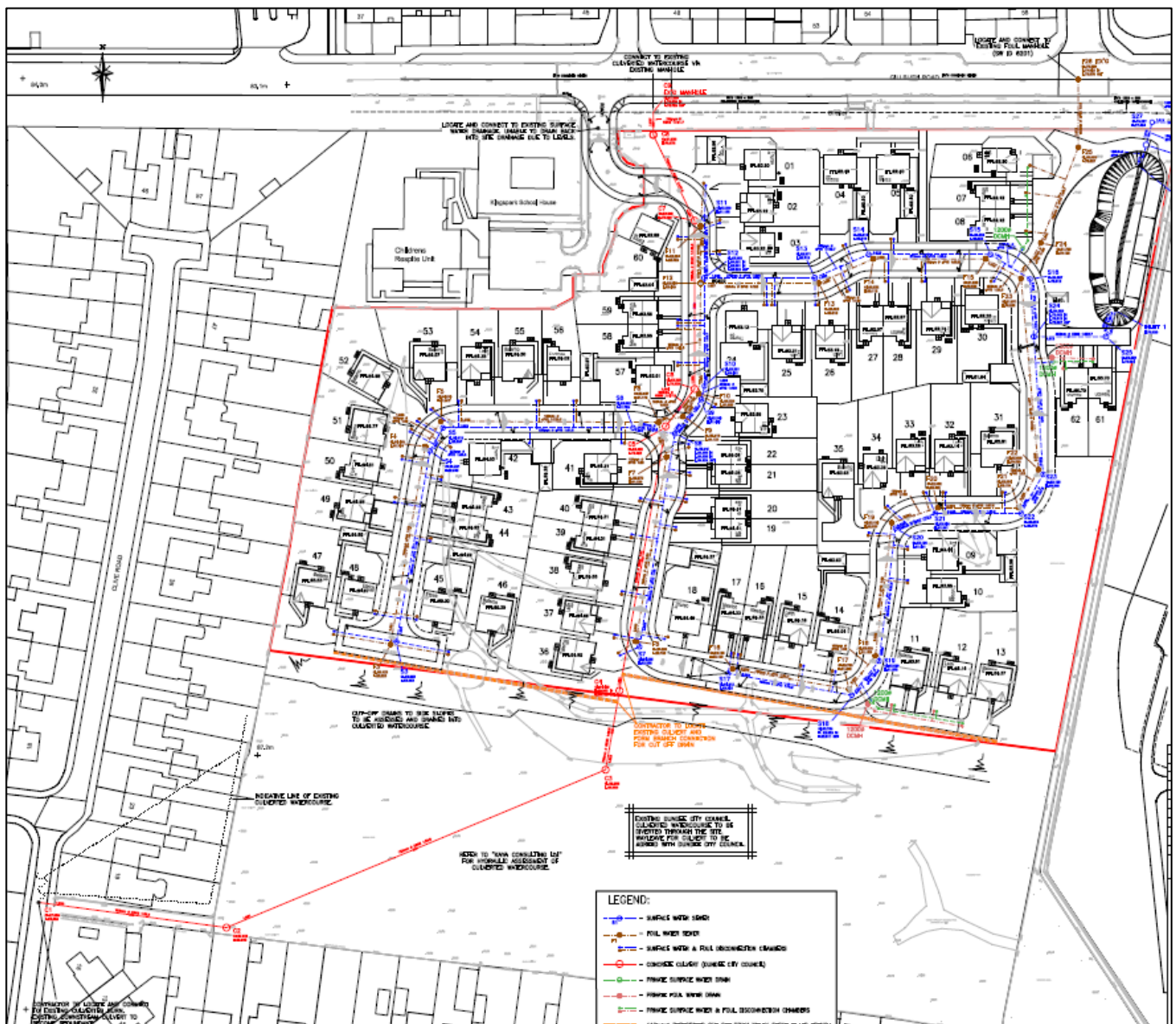
Gillburn Road. As indicated above, there will be a slight reduction in flows on the road during extreme events.

It is assumed that, the inlet structure to diversion sewer will be designed to allow excess flows unable to entering the diversion sewer to flow through the existing drain as at present.

### 5.2.1 Revised Bypass Culvert Route

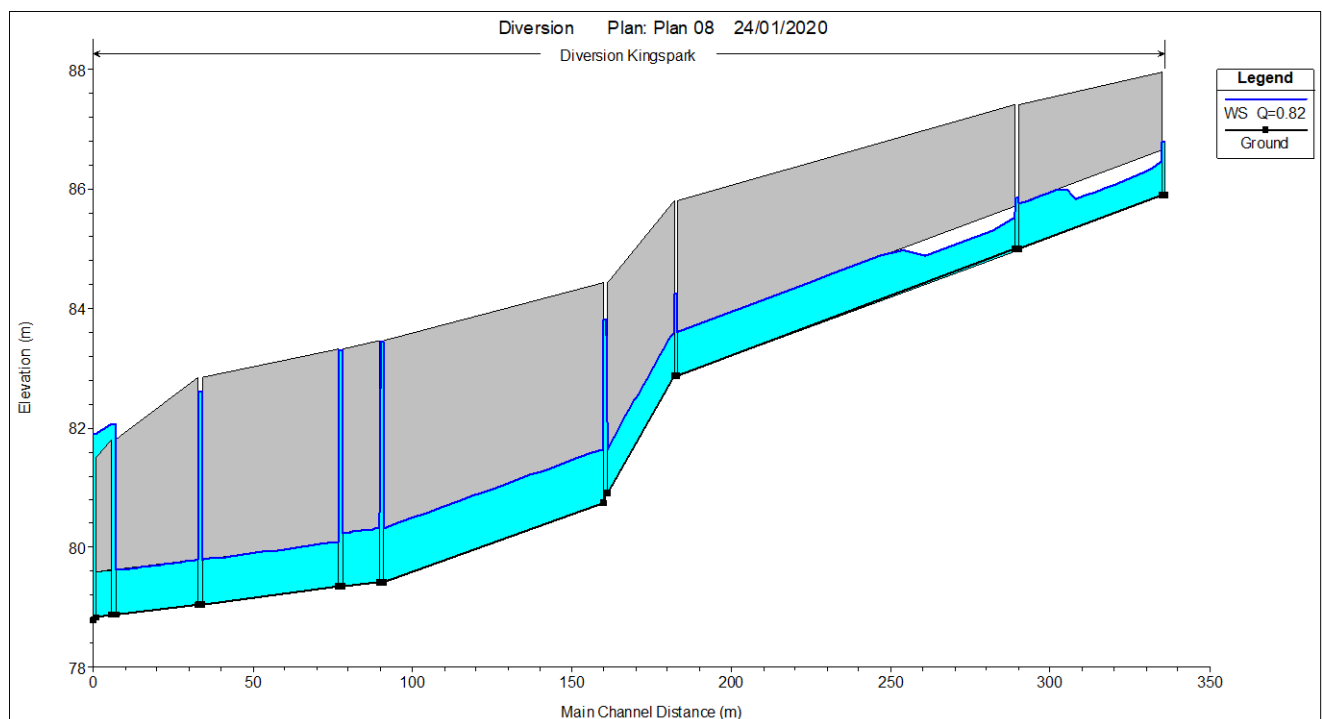
The route of the bypass culvert shown in Figure 11 has been amended as shown in Figure 17 (Drawing 14325/02/001).

Figure 17: Amended route of bypass culvert (red line)



The model was updated to reflect the amended culvert route and corresponding cover and invert levels. The results are shown in Figure 18 for a flow of  $0.82\text{m}^3/\text{s}$ , which is the maximum flow that could possibly arrive at the diversion culvert. The culvert modelled is a 750mm circular culvert with the section between Manholes D and F (C4 and C6) being 900mm diameter where gradient of the culvert is shallower. This indicates that water remain within the culvert and manholes without flooding, except the last section of the culvert where it connects to Gelly Burn culvert. Flooding in this area is caused by backing up from the Gelly Burn culvert. For this simulation Gelly Burn culvert water level was set to 200 year water level obtained from Integrated Catchment Model (ICM). Any water coming out of this manhole runs on Gillburn Road, as it would at present albeit slightly to the west. The amended culvert does not increase flooding risk downstream.

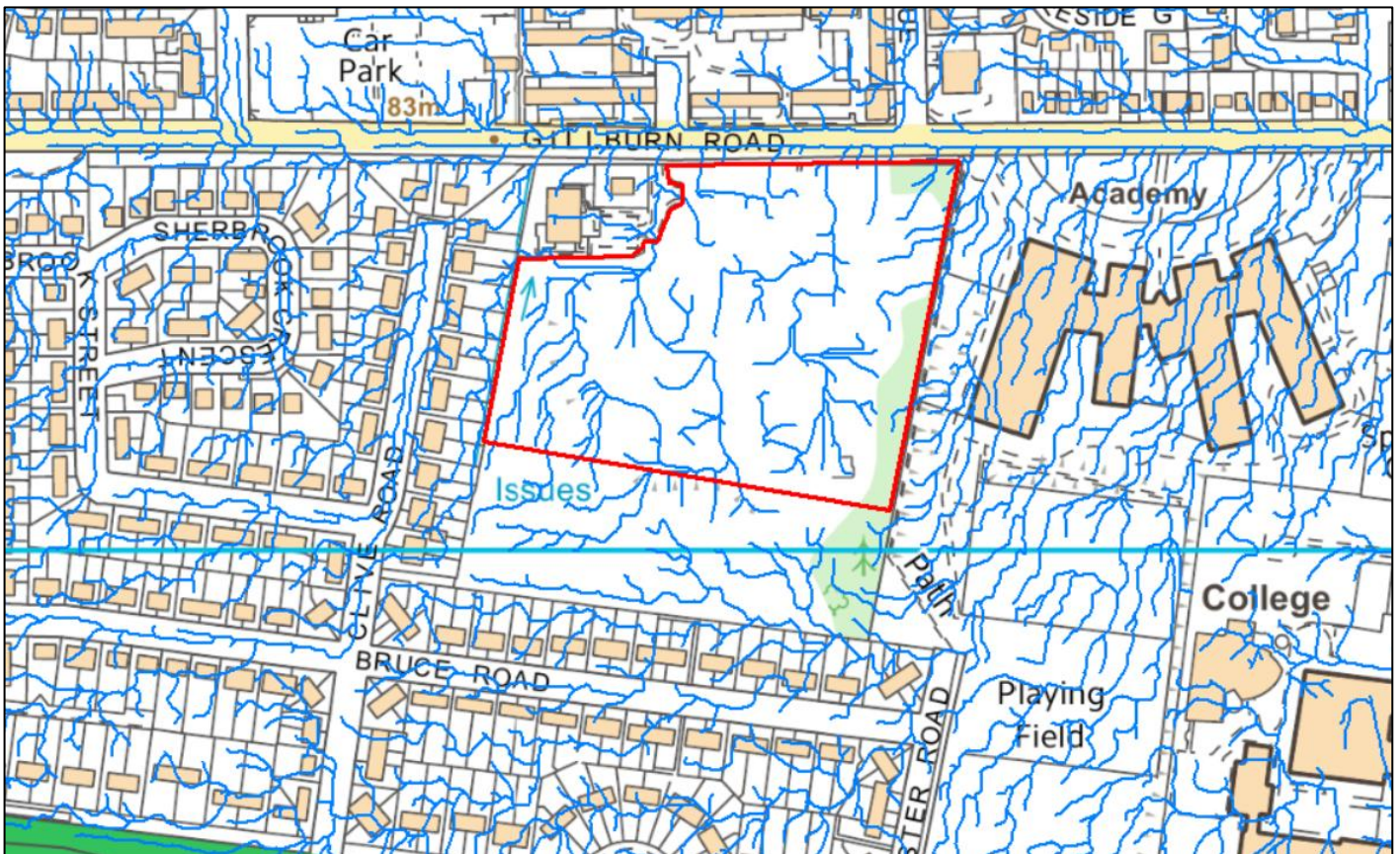
**Figure 18: Predicted water level for a flow of  $0.82\text{m}^3/\text{s}$**



### 5.3 Surface Water Runoff from Adjacent Land

A detailed watershed analysis was undertaken using Global Mapper GIS software to assess the risk of surface water flooding to the site. This analysis is summarised in Figure 19 which illustrates the indicative surface water pathways around the site. This indicates that surface water runoff from a small undeveloped area to the south could enter the site. This will need to be taken into account in the design of the site.

Figure 19: Indicative surface water flow pathways within and around the site



## 5.4 Groundwater

There is no information available on groundwater levels in the area at present. No springs or wet ground was observed within the site.

It is suggested that groundwater measurements taken during site investigation be used in the design of the site. If elevated groundwater levels are observed during site investigations, appropriate measures would need to be taken with regards to the design of appropriate types of foundations, and SuDS measures will need to take account of ground water conditions.

## 5.5 Site Access

Access to site is from the north via Gillburn Road. The road is lower than the site and there is no risk of excess surface water on the road entering the site. However, care will need to be exercised in the design of the access not to allow excess surface water from the site to run onto the road.

Gillburn Road is predicted to flood during extreme events, up to about 0.3-0.35m in extreme cases. Therefore, it is suggested that consideration be given to providing pedestrian access to and egress from the site to the east (to/from existing footpath between the site and the college).

## 5.6 Risk of Flooding from the Site Drainage System and Local Sewers

Design of the site drainage system is not part of this commission.

At present, surface water runoff from the site drains to Gelly Burn culvert or to local surface water sewer system either directly via drainage system which served the former school development, or through road gullies. Post development, attenuated surface water runoff will be discharged to the existing outfall. Discharge will need to be limited to greenfield runoff rate, which should be discussed and agreed with Dundee City Council.

It is suggested that design of the site drainage system take into account likely surcharged conditions of the Gelly Burn culvert during extreme events.

Any excess water surcharging from local drainage system will follow similar flow paths as those overland flow paths showing in Figure 7. Therefore, the site is not considered at significant risk of flooding from water surcharging from local sewer system.

## 5.7 Note on SEPA and Council comments

### SEPA Comments

SEPA requested information on safe access/egress, confirmation that properties adjacent to the drain raised above ground levels, and flow pathways are maintained through the site, and onsite district heating. Although Gillburn Road will flood during extreme events with water depth up to 0.3-0.35m, pedestrian access to the existing footpath adjacent to eastern boundary will be provided.

The drain will now be diverted, and therefore any issues associated with the open channel adjacent to the site will no longer be relevant. The existing drain will be retained and function as normal, albeit flows entering it from the upstream will be stopped or significantly reduced. Comments on onsite district heating will be provided by others.

### Council Comments

Flood Risk Assessment (FRA) report is now finalised, with SEPA checklist included. Compliance and Independent Check Certificates are provided separately.

Out of sewer flows provided by the Council has been modelled for cases up to and including 200 year plus climate change and this showed that such flows would not flood the site, although Gillburn Road would flood to a depth of up to 0.3-0.35m. Details are provided in Section 5.2.

It is likely that surface water runoff from the former school entered Gelly Burn culvert either directly or indirectly through local sewer system. It is not known if the former drainage system is still operating. However, as the site is higher than Gillburn Road, surface water runoff from the site runs onto the road and enters road gullies, which discharge to the culvert. During extreme events when the culvert is surcharged, runoff from the site flows down Gillburn Road. Post development, attenuated surface water runoff from the site will be discharged to the Gelly Burn culvert. As flows will be attenuated to greenfield runoff rate, flows entering the culvert or flowing down the road will be reduced compared to those at present. Therefore, the development will not increase flows entering the culvert or running down the road.

As shown in Figure 12, overland flows would run north along the path adjacent to the eastern boundary. Watershed analysis show that such flows spill onto Gillburn Road. Post development, this will not be altered.

Surface water drainage drawings and relevant calculations will be provided separately.

Maintenance of the site drainage system will be discussed and agreed with the Council and Scottish Water.

## 6 Summary and Conclusions

This report describes a flood risk assessment for a proposed residential development at Gillburn Road, Dundee. The site is brownfield, comprised of the former Kingspark school site.

The Gelly Burn runs in a culvert along the northern boundary of the site and is the main source of fluvial flood risk.

Standard FEH rainfall-runoff method was used to estimate design flows for the Gelly Burn at site. A 2D overland flow model was constructed to estimate flooding risk of the site as well as modelling of surcharged flows obtained from Integrated Catchment Model kindly provided by Dundee City Council.

The model results indicated that the site is not at risk of flooding, even during a conservative flow case with 100% culvert blockage.

Diversion of the existing surface water drain is proposed through the site. Initial modelling of diversion sewer indicated that the proposed 0.75m diameter sewer would be able to convey potential flows arriving at it from upstream. Surcharging of last two manholes on the diversion sewer was predicted during 200 year flow in Gelly Burn culvert. Such flows would spill onto Gilburn Road (as at present) and not affect any properties. The diversion sewer will not increase flooding risk to others as outlined in Section 5.2. Detailed design of diversion sewer will be carried out as part of detailed design of the site drainage system. However, it is suggested that inlet structure is designed in such a way that any excess flows unable to enter the diversion sewer continue to run through the existing drain as at present.

It is suggested that Finished Floor Levels of properties be set at least 0.6m above the predicted peak water levels of 82.0m AOD and 79.6m AOD on Gillburn Road at the north-west and north-east corners respectively. It is suggested that Finished Floor Levels of properties be set an appropriate height above adjacent ground level and finished ground levels designed to shed water away from buildings without affecting other properties.

The site is not considered to be at significant risk from surface water runoff generated outside of the site, groundwater or adjacent drainage infrastructure.

Design of the site drainage system was not part of this commission. Surface water runoff from the developed site will be discharged to Gelly Burn or local sewer system through a SuDS system which will need to be agreed with local council.

As with any design, maintenance is an important requirement for an effective drainage system. Regular maintenance programs need to be implemented for all components of the drainage system.