



Hayling Island Coastal Defences Minor Channel Flood Risk Assessment

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CONTROL SHEET

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1 INTRODUCTION

1.1 Terms of Reference

Havant Borough Council have noted that some sections of proposed embankments cross minor watercourses/land drainage ditches within the site. While culverting is proposed to ensure these watercourses/ditches continue to drain eastwards to outfall into coastal waters, the Council are concerned that proposals may alter flood risk behaviour with respect to these watercourses/ditches. They require the flood risk impact of these crossings/culverts to be assessed.

1.2 Context & Methodology

The agreed scope of this desktop assessment is as follows:

- Use GIS methods to delineate catchments/subcatchments associated with each watercourse/ditch based on available LiDAR DTM (digital terrain model) data.
- Determine appropriate design flows for each watercourse/ditch for use in assessment.
- Create a pre-development 2D ground model from survey information of the watercourses/ditches, supplemented with LiDAR DTM data for floodplain areas.
- Undertake 2D modelling to obtain predictions of pre-development and post-development flood extents for all watercourses/ditches. For the post-development scenario, this will include iterative adjustments to culvert dimensions to determine appropriate sizing to ensure a neutral flood risk impact.

The following limitations to the scope apply:

- All modelling and analysis is undertaken assuming fixed low tidal levels, on the reasonable basis that the risk of culverts exacerbating watercourse/ditch flood risk reduces as tidal levels increase, and that the proposed development will (axiomatically) reduce flood risk on the landward side of proposed embankments at extreme high tides compared to current conditions.
- This assessment will be limited to consideration of the impact of proposals upon flood risk from the watercourses/ditches only; no assessment of other potential sources of flood risk has been undertaken (noting that coastal flood risk is likely to be the only other major source of flood risk impacting this location, and has been assessed as part of the Coastal Flood Level Assessment, dated 26 September 2022, submitted as part of this planning application).

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2 BACKGROUND

2.1 Site Description

The site (Figure 2.1 and Figure 2.2) is low-lying and gently undulating and is currently used for agriculture. It is defended from coastal flooding at the seaward boundary by a raised earth embankment with a vertical concrete wall. A Condition Assessment of the existing outer flood protection defences was undertaken by WSP engineers on 8th July 2021, which concluded that a number of sections along the existing bund are in need of patch repairs and upgrading. Several minor watercourses/land drainage ditches discharge through the embankment via piped outfalls with non-return flap valves.

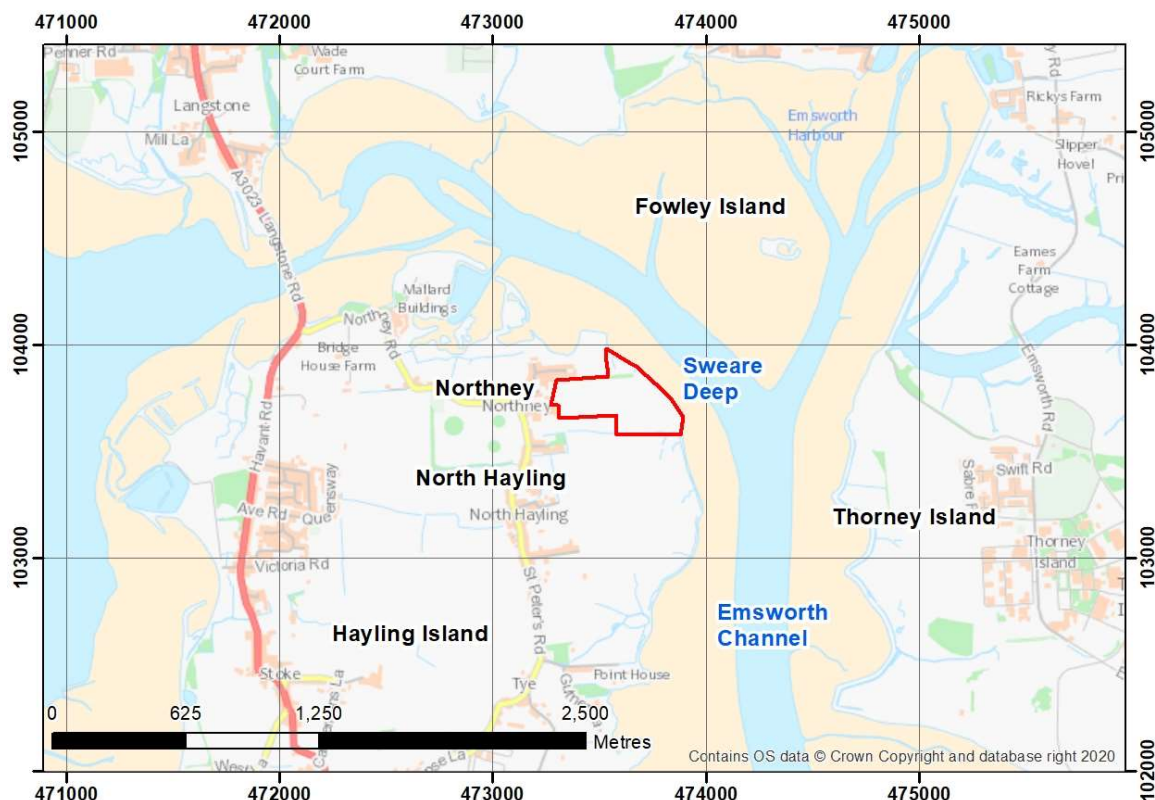


Figure 2.1: Site location (indicated by red boundary)



Figure 2.2: Site layout plan

2.2 Water Features

Figure 2.3 illustrates mapped and unmapped water channels passing through or near the site, as well as locations of existing culvert features, with the general direction of flow in all cases being from west to east, with all channels ultimately discharging eastwards to coastal waters. Some features, particularly the linear channel along the northern boundary of the site, are not represented in OS mapping, but have been picked up in topographic survey of the site. Survey coverage is not complete along some of the unmapped channels due to dense vegetation cover, such that some culverted or discontinuous sections may also exist along the unmapped lines; this uncertainty is considered in sensitivity scenarios and analysis. The exact line of culvert outfalls at the downstream end of the channel systems is not indicated on OS mapping or within the survey extent, with these outfalls inferred by the channels reaching a “dead end” adjacent to the existing coastal defence line.

Water features in the site vicinity may be divided into two systems:

- A northern channel system, draining eastwards towards the coast from properties on Spinnaker Grange, with tributary channels from the south merging with the system before its culverted outfall through existing coastal defences.
- A southern channel system, draining eastwards towards the coast from properties on Clovelly Road.

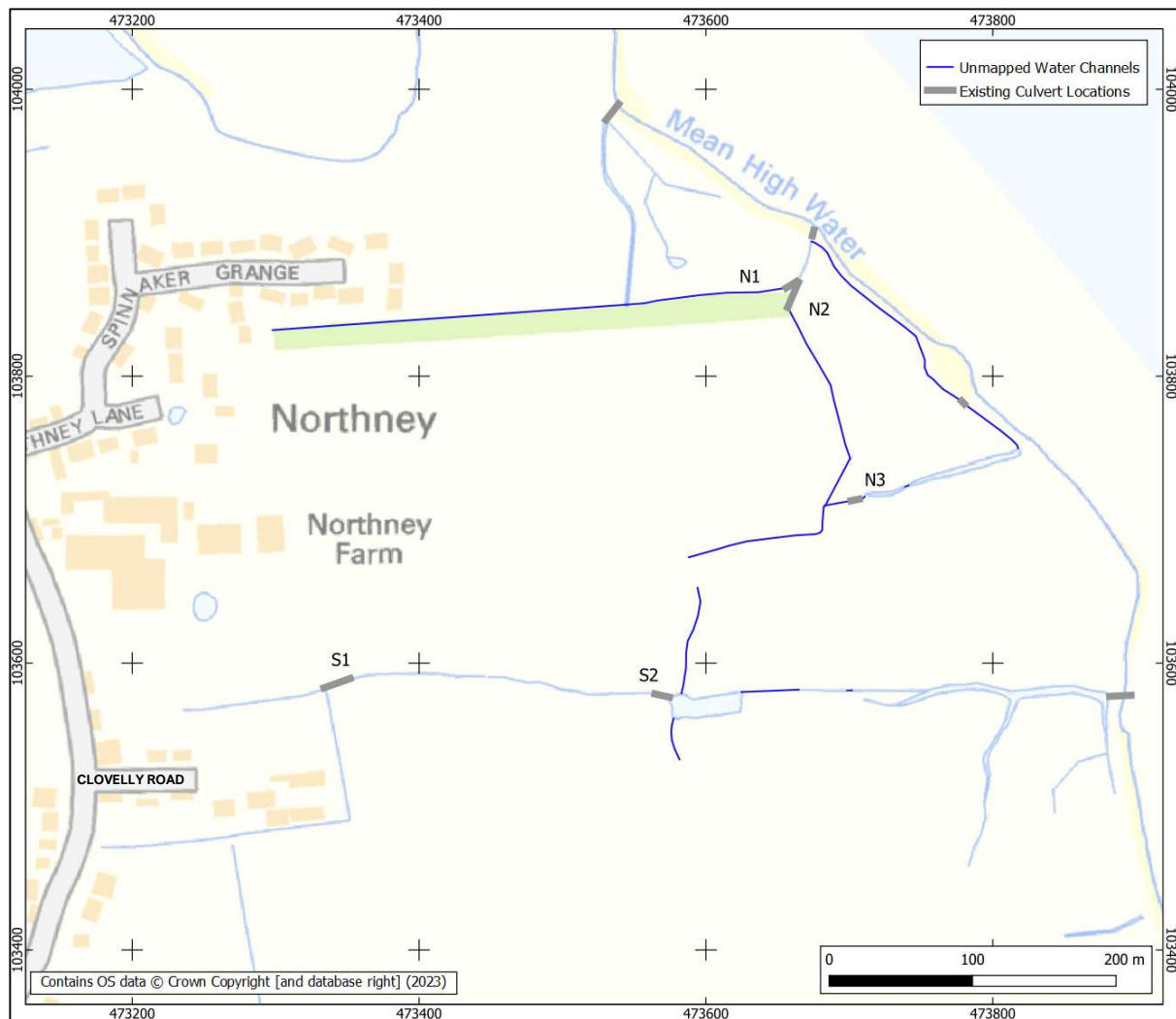


Figure 2.3: Water features and culvert structures in the site vicinity

The dimensions and shapes of existing culverts were not measured as part of surveying, but some information can be inferred from survey. The following culvert locations are of interest:

- Culvert S1: The upstream channel invert level is 2.3 mAOD, with downstream channel invert level of 1.93 mAOD and surrounding ground at 3.3 mAOD or above. This is represented as a 600 mm diameter culvert in modelling (assuming a minimal depth of cover).
- Culvert S2: The upstream channel invert level is 1.2 mAOD, with downstream channel invert level of 1.0 mAOD and surrounding ground at 1.8 mAOD or above. The structure at this location may be a penstock, but is represented in modelling as a 300 mm diameter culvert.
- Culvert N1: The upstream and downstream channels both have invert levels of approximately 1.5 mAOD, with surrounding ground of 1.9 mAOD or above. A minimal (150 mm diameter) culvert is assumed.
- Culvert N2: The upstream and downstream channels both have invert levels of approximately 1.5 mAOD, with surrounding ground of 1.9 mAOD or above. A minimal (150 mm diameter) culvert is assumed.
- Culvert N3: The upstream and downstream channels both have invert levels of approximately 1.6 mAOD, with surrounding ground of 1.9 mAOD or above. A minimal (150 mm diameter) culvert is assumed.

3 DESIGN HYDROLOGY

3.1 Subcatchment Delineation

In order to assess flood risk associated with these water features, it is first necessary to determine the catchment areas associated with each feature. Subcatchment delineation was undertaken in GIS based on 1 m resolution LiDAR DTM data obtained from the National LiDAR Programme database and dated September 2020 (tile DTM_F0217932_20200919_20200920). The raw DTM was clipped to only consider the landward side of existing coastal defences, with sink filling then performed, and the catchment draining through the site thereafter divided into ten subcatchments based on dominant overland flowpath routes (Figure 3.1). Subcatchments 1, 2, 3, 4 and 6 are associated with the southern channel system with the remaining subcatchments associated with the northern channel system.

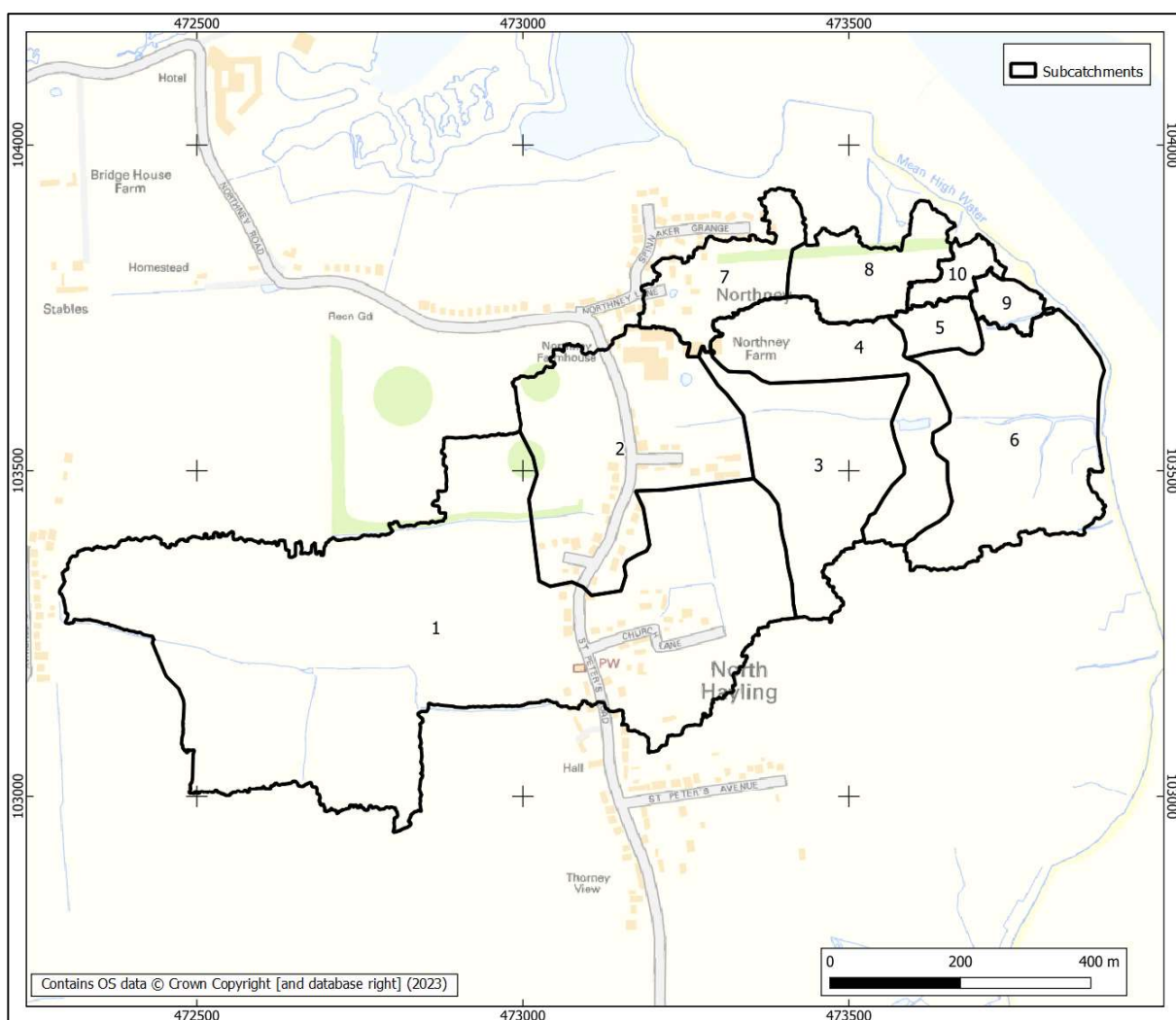


Figure 3.1: Subcatchment delineation

3.2 Donor Catchment Hydrology

The water channels within the site are ungauged and are not delineated with the FEH Web Service database. Therefore, design event hydrology must be estimated using the ReFH2 ungauged

catchment methodology using a nearby donor catchment. A 0.62 km² donor catchment to the south-west of the site (at National Grid Reference 471800,102750), which adjoins Subcatchment 1, was used for this purpose (Figure 3.2).

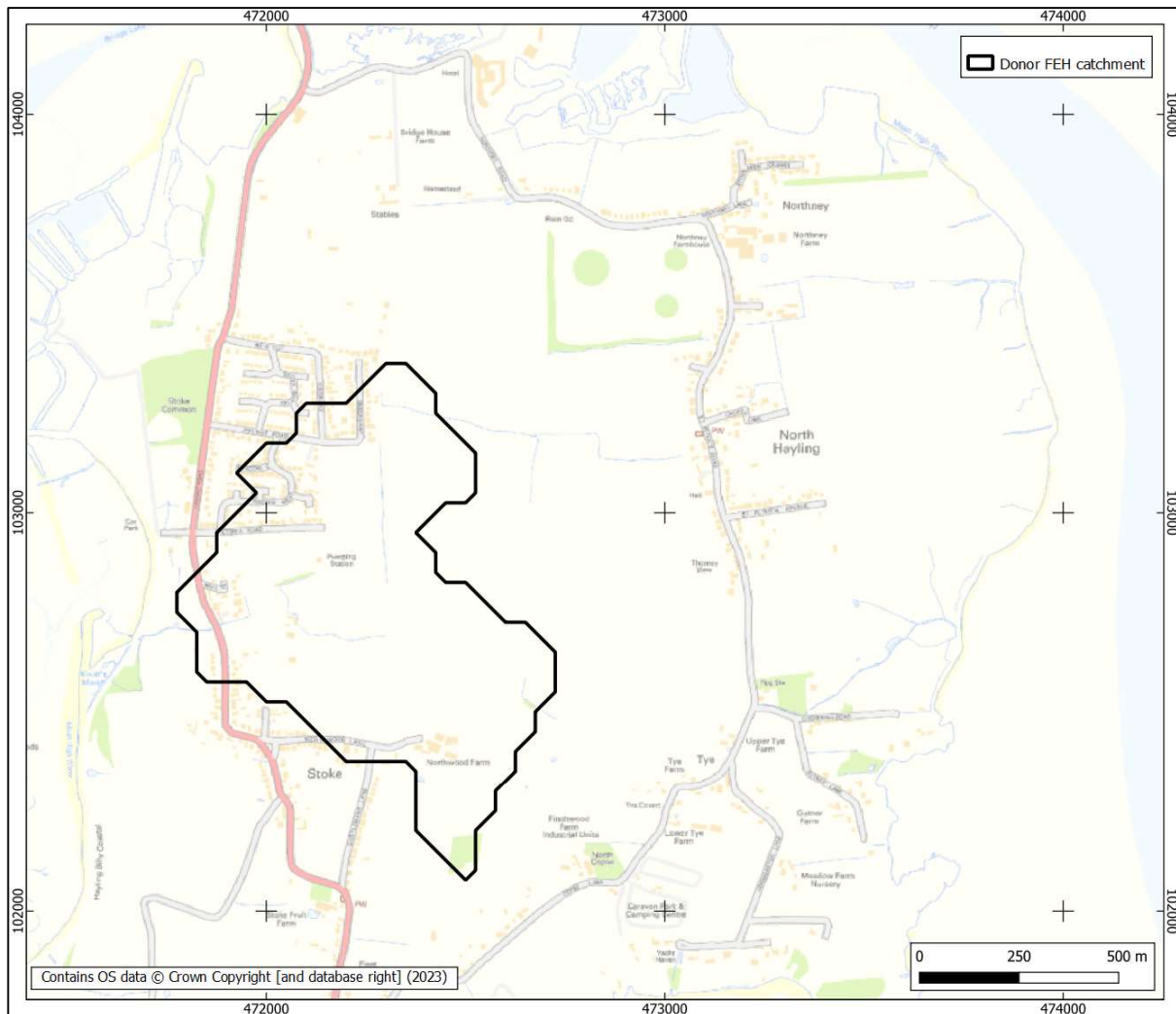


Figure 3.2: Donor FEH catchment

The 1 in 100 year (100 year return period or 1% Annual Exceedance Probability) ReFH2 design hydrograph for the donor catchment, based on a recommended 5.5 hour storm duration and the latest (FEH22) design rainfall data, is shown in Figure 3.3. Further information on the flood frequency terminology is presented in Appendix A, with ReFH2 software output for this event presented as Appendix B. The 1 in 100 year peak flow estimate for the donor catchment is 0.293 m³/s.

3.3 Climate Change

The design event for flood risk assessment in England is the 1 in 100 year event inclusive of an allowance for climate change. The central river flow allowance for the East Hampshire Management Catchment is 37%¹, and is used in analysis. The donor catchment design event peak is therefore 0.402 m³/s.

¹ <https://environment.data.gov.uk/hydrology/climate-change-allowances/river-flow?mgmtcatid=3034>

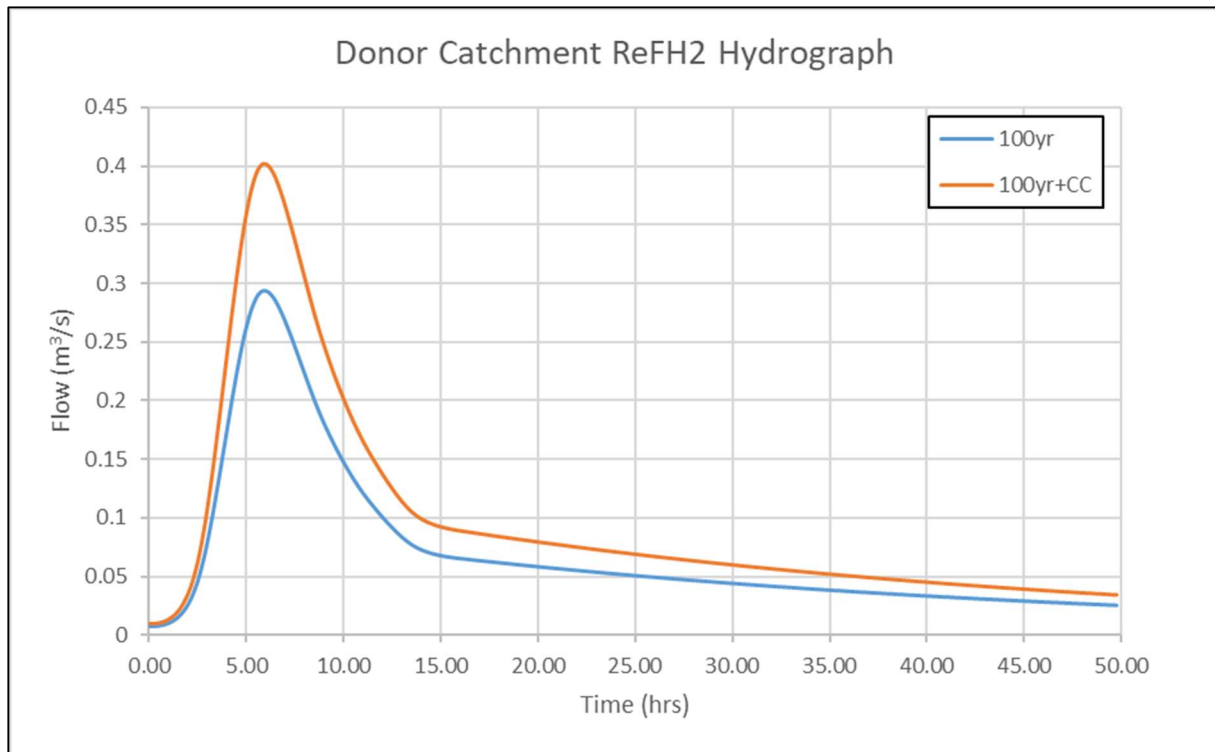


Figure 3.3: Donor catchment ReFH2 design hydrograph for the 1 in 100 year event with and without climate change (CC)

3.4 Subcatchment Hydrology

Inflows for each subcatchment were determined by simple scaling by area, with the multiplier applied to the donor catchment 1 in 100 year plus climate change hydrograph summarised in Table 1.

Table 1: Flow multiplier applied to each subcatchment inflow, and resultant 100 year plus climate change (CC) peak flow

Subcatchment	Area (ha)	Multiplier	Peak Flow (m³/s)
Donor	62.000	1	0.402
1	34.036	0.549	0.221
2	9.407	0.152	0.061
3	6.149	0.099	0.040
4	4.995	0.081	0.032
5	0.920	0.015	0.006
6	8.191	0.132	0.053
7	2.970	0.048	0.019
8	2.707	0.044	0.018
9	0.725	0.012	0.005
10	0.774	0.012	0.005

4 MODELLING METHODOLOGY

4.1 Software & Overall Approach

Modelling was undertaken in Flood Modeller Version 4.5. Modelling was undertaken using a 2D approach, with inflows applied at appropriate locations within water channels, and thereafter Flood Modeller's 2D ADI solver calculating the lateral movement of flows along the water channels, through represented culverts and – where channel capacity is exceeded – spill over banks onto the landscape.

Given gaps in existing survey information for existing culverts and specific sections of water channels, it should be noted that predicted flooding is impacted by this uncertainty. As the primary objective of the assessment is to identify and resolve detriment posed by proposed development, this uncertainty is only material if it has the potential to impact comparative assessment of pre- and post-development predictions. This is considered as part of analysis.

4.2 Extents, Inflows & 2D Boundaries

Figure 4.1 illustrates the 2D model extent, inflow lines (corresponding to each subcatchment as shown in Figure 3.1) and 2D outfall boundaries within the model. The 2D extent has been iterated to reduce the extent as much as possible, in order to allow as fine a grid resolution as possible within the constraints of the Flood Modeller licence. Each subcatchment inflow hydrograph is applied as inflow distributed evenly over all cells crossed by each inflow line. The 2D outfall boundaries are normal depth boundaries with an assumed gradient of 0.1, allowing representation of discharge via culverted outfall into coastal waters.

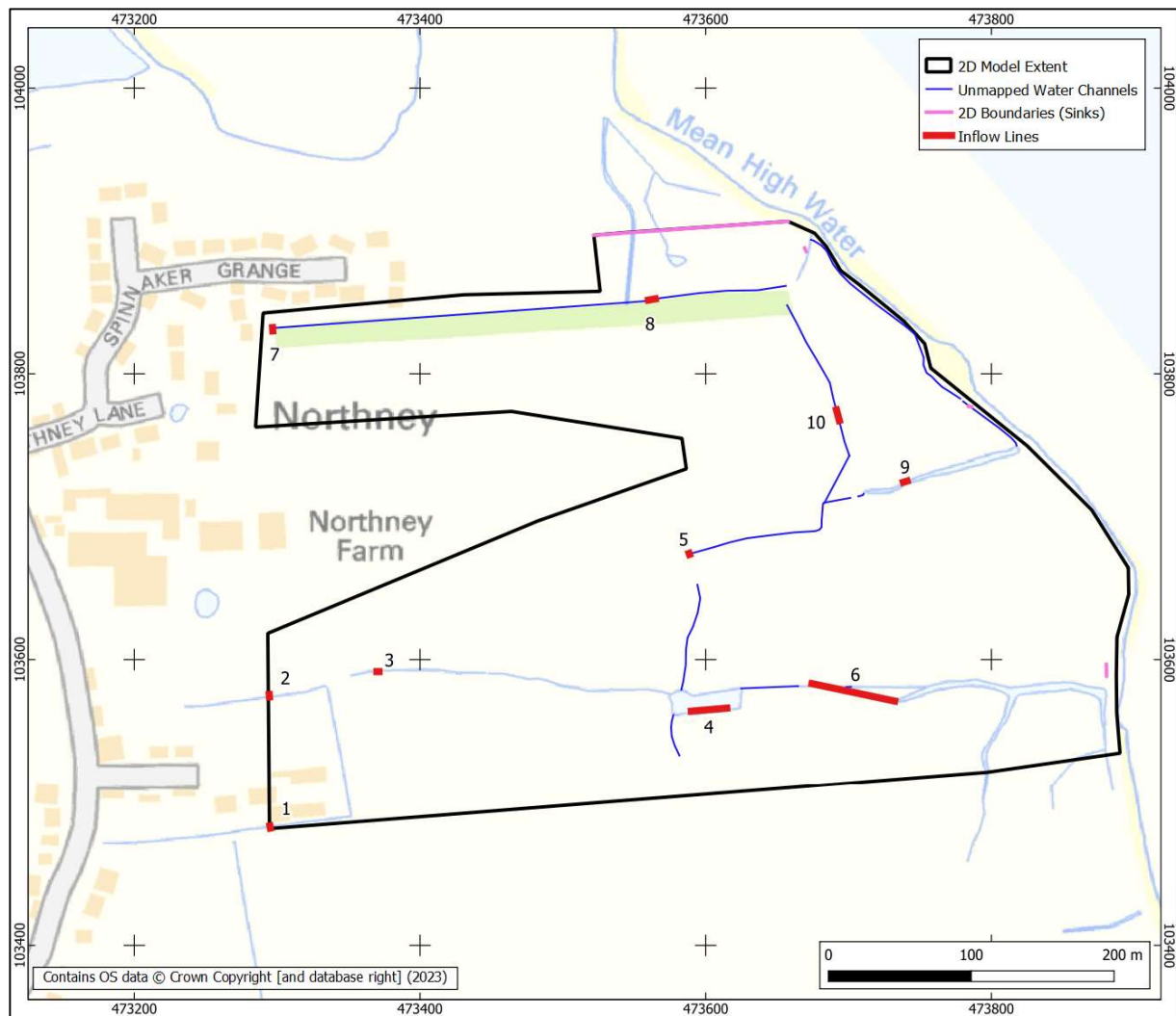


Figure 4.1: Model extent and inflow and outflow (sink) boundary locations

4.3 Ground Model

The 2D ground model was created from rasterised (triangulated) point survey data. The resulting ground model was extended by mosaicking with LiDAR DTM data, with LiDAR used to represent:

- The area in the vicinity of the pond (at inflow line 4 in Figure 4.1), which could not be accessed for surveying.
- The western end of the northern water channel, which was beyond the survey extent.
- The south-western corner of the 2D domain, upstream of the culvert above inflow line 3 in Figure 4.1, which was beyond the survey extent.

The baseline model scenarios further amend the ground model by “burning over” discontinuities in channel sections due to access constraints during surveying, based on average ground levels between surveyed upstream and downstream points; these DTM adjustments are applied only for baseline pre- and post-development scenarios, with sensitivity testing performed without these adjustments, to ensure analysis considers the possibility of actual discontinuities or undersized culverts in these unsurveyed locations (Figure 4.2).

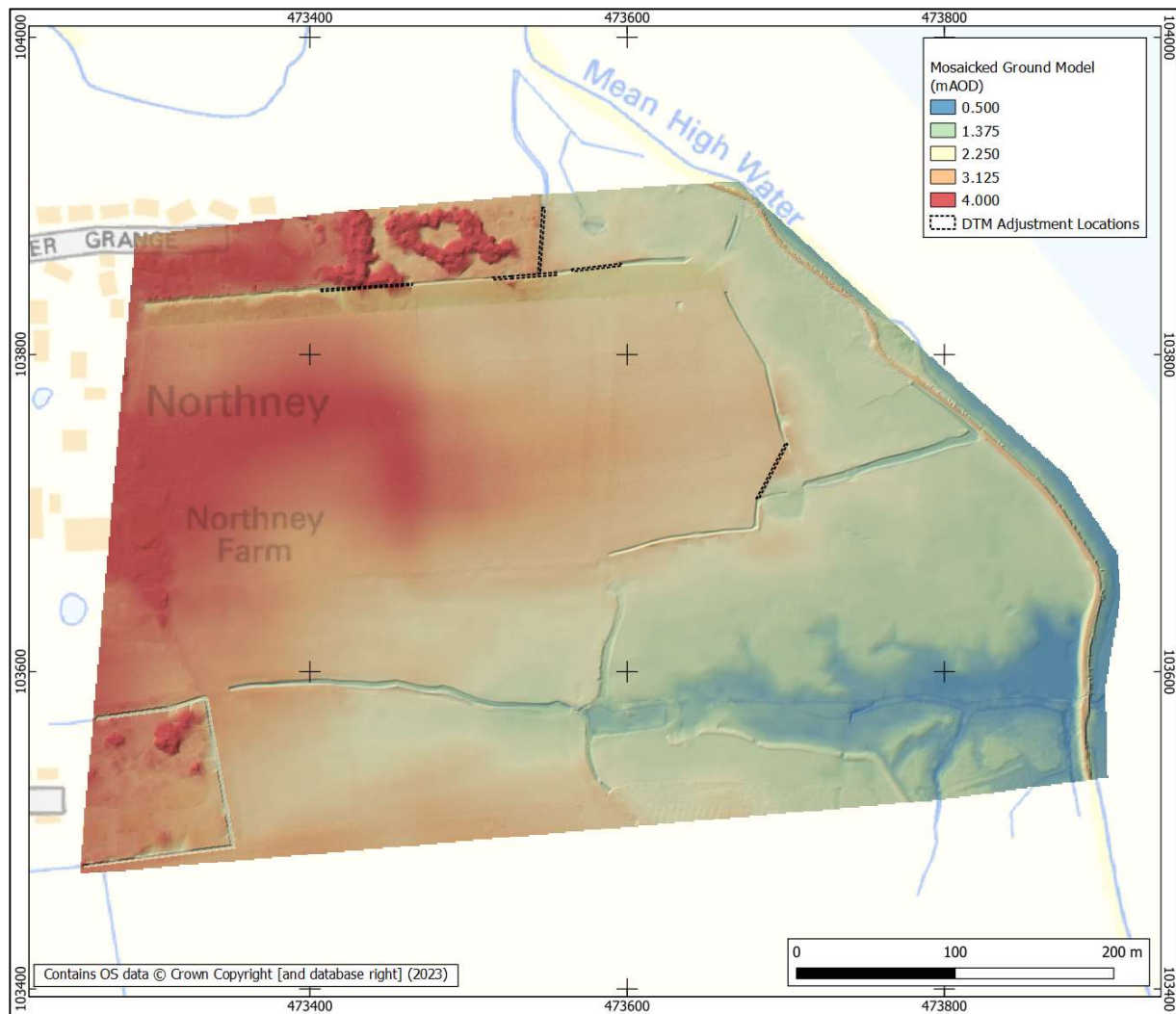


Figure 4.2: Ground model, generated by mosaicking of survey DTM data and LiDAR DTM data

4.4 Roughness

The following Manning's roughness values were applied to the model domain:

- In-channel areas were assigned a Manning's roughness of 0.05 (a conservative value for minor water channels typically subject to slow flow, which may accumulate silt or be impacted by in-channel vegetation growth).
- Areas of tree cover were assigned a Manning's roughness of 0.10 (corresponding to dense brush).
- Rough ground at the south-eastern corner of the 2D domain was assigned a Manning's roughness of 0.07 (corresponding to medium brush and/or heavy ground-level vegetation).
- Remaining ground largely comprises agricultural land, and was assigned a Manning's roughness of 0.04 (corresponding to pasture).

4.5 Representation of Culverts

Flood Modeller recommends representation of culverts within 2D models using stand-alone 1D orifice units linked to the 2D domain at the inlet and outlet location. Upstream sill and orifice invert levels were

based on the surveyed upstream channel invert level and the downstream sill level based on the surveyed downstream channel invert level.

The dimensions and shapes of existing culverts were not measured as part of surveying, and are assumed to be circular with dimension of 600 mm or below based on the surveyed depth of the adjacent channel sections (Section 2.2), noting that actual culvert dimensions may be smaller than channel depth would imply or may be impacted by partial debris blockage and/or partial sediment embedment. In terms of assessing the potential impact of proposed embankments upon flood risk, the conservative assumption is to assume that existing culverts are sufficiently sized to cause minimal risk of flooding due to backup for current conditions; recommendations for the sizing of new or replacement culverts through proposed embankments will then either have a neutral flood risk impact (if existing culverts are indeed adequately sized) or else will provide a beneficial reduction in flood risk upstream of the culvert (if existing culverts are actually undersized and at risk of backup, and replacement culverts are at reduced risk of backup).

4.6 Representation of Post-Development Scenario

Development entails raising of additional coastal defence embankments. The line of proposed embankments crosses open-channel and culverted sections of water channels through the site at various locations. The following amendments were made to the model to represent development elements (Figure 4.3):

- The embankments themselves are represented as raised barriers which cannot be overtopped by minor channel flows; this is reasonable, noting that predicted flood levels associated with the minor channels are well below design coastal flood levels.
- Culvert S1 is extended in a downstream direction, to ensure the outlet is beyond the eastern edge of the embankment.
- An additional culvert through the embankment (Culvert S3) is added to the east of Culvert S2.
- An additional culvert through the embankment (Culvert N4) is added to the west of Culvert N1, to retain a coastal discharge route along this minor channel.
- Culverts N1 and N2 are extended in a downstream direction, to ensure the outlet is beyond the eastern edge of the embankment.

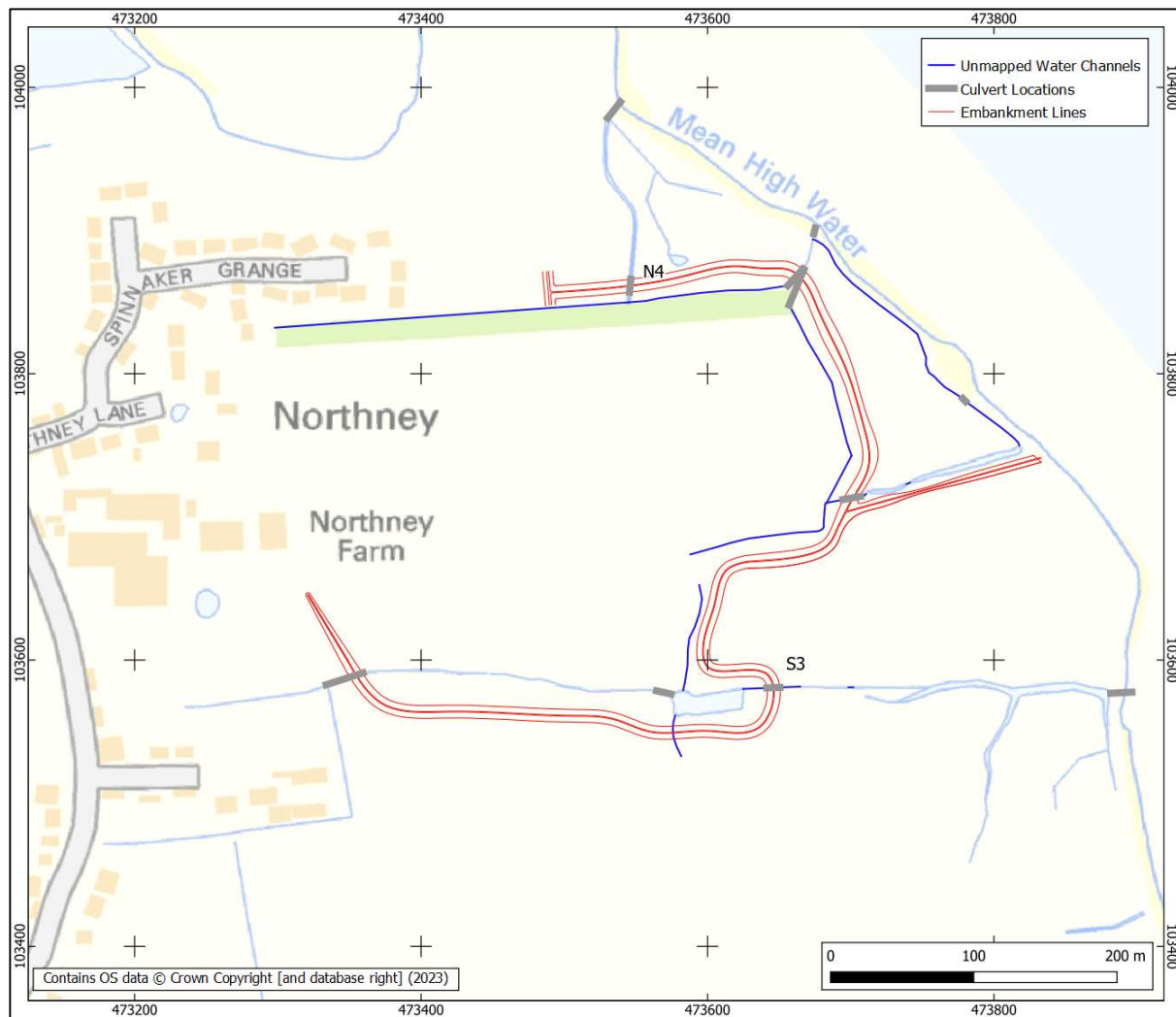


Figure 4.3: Post-development model scenario elements

4.7 Run Parameters

Simulations were run for a 15 hr duration, which is sufficient for flooding within the system to peak and begin to recede. A 1.2 m grid resolution was employed, representing the minimum resolution achievable within the software licence limit for the modelled 2D domain. Flood Modeller advises that the 2D timestep (in seconds) should be half of the grid resolution (in metres), and therefore a 0.6 second 2D timestep was employed. Flood Modeller advises that the 1D timestep should be half the 2D timestep, and therefore a 0.3 second 1D timestep was used for the 1D model elements (i.e. the embedded culverts). All other simulation parameters were left at default values.

4.8 Initialisation

The water channels represented in the model were initialised by running a full simulation with constant low inflows, to generate appropriate initial water levels within all channels. The design flood scenario was then run with 2D water levels initialised to the final values predicted by the initialisation run.

5 MODEL PREDICTIONS

5.1 Pre-Development Flood Predictions

Figure 5.1 shows predicted 1 in 100 year plus climate change flooding extents and depths for the baseline pre-development scenario. Flows are predicted to generally be retained within the banks of the water channels, excepting for the reach of the southern system downstream of Culvert S2. This area was not surveyed due to access issues, with ground elevations in this area instead taken from LiDAR which is generally poor at representing narrow channels, such that actual flooding may be less extensive than predicted.

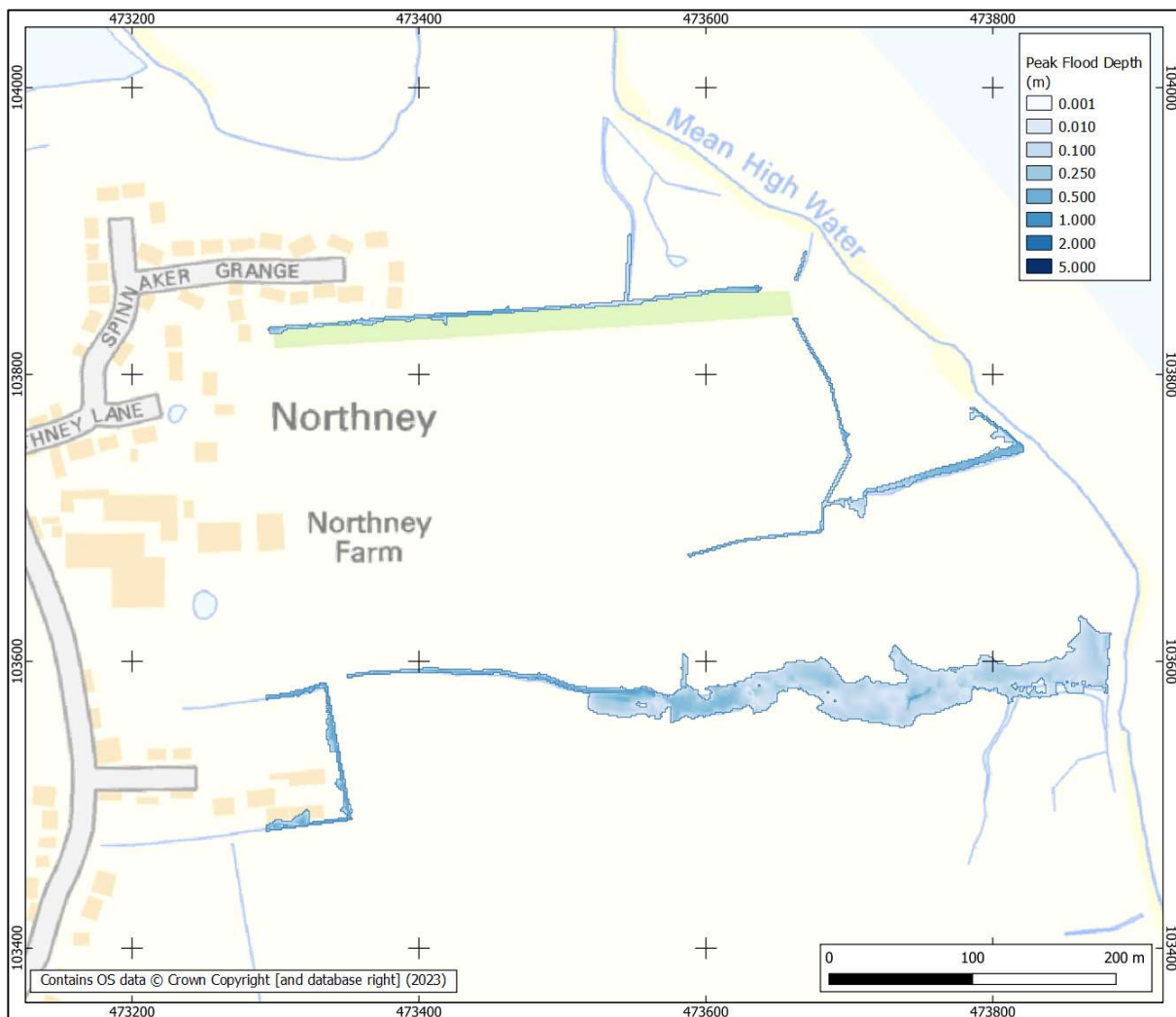


Figure 5.1: Predicted pre-development 1 in 100 year plus climate change flood predictions (baseline scenario)

The baseline scenario can otherwise be considered to be optimistic in representing flood risk to the existing site. Actual flood risk may be higher if the dimensions of culverts (particularly Culvert S1) are smaller than assumed and/or if the northern channel is discontinuous or has undersized culverts within non-surveyed sections, noting that the baseline scenario assumes this channel to be continuous. A sensitivity scenario was therefore undertaken, with predictions (Figure 5.2) confirming that:

- Predicted peak 1 in 100 year plus climate change water levels at the western end of the northern system (adjacent to housing on Spinnaker Grange) increase from 3.07 mAOD to 3.21 mAOD if the channel is discontinuous, but this increase does not increase flood risk to adjacent properties which are located on ground at or above 3.9 mAOD. Discontinuity in the channel instead causes spill southwards from the channel, with this floodwater subsequently returning to the channel further east.
- Predicted peak 1 in 100 year plus climate change water levels at the inlet of Culvert S1 increase from 2.80 mAOD to 2.94 mAOD if the assumed culvert diameter is reduced from 600 mm to 300 mm. Further reductions in assumed diameter do not cause significantly greater increases, as backed-up flows spill from a low point in the channel south of this culvert inlet where bank crest levels (as well as ground levels eastwards beyond the bank) are less than 2.90 mAOD.

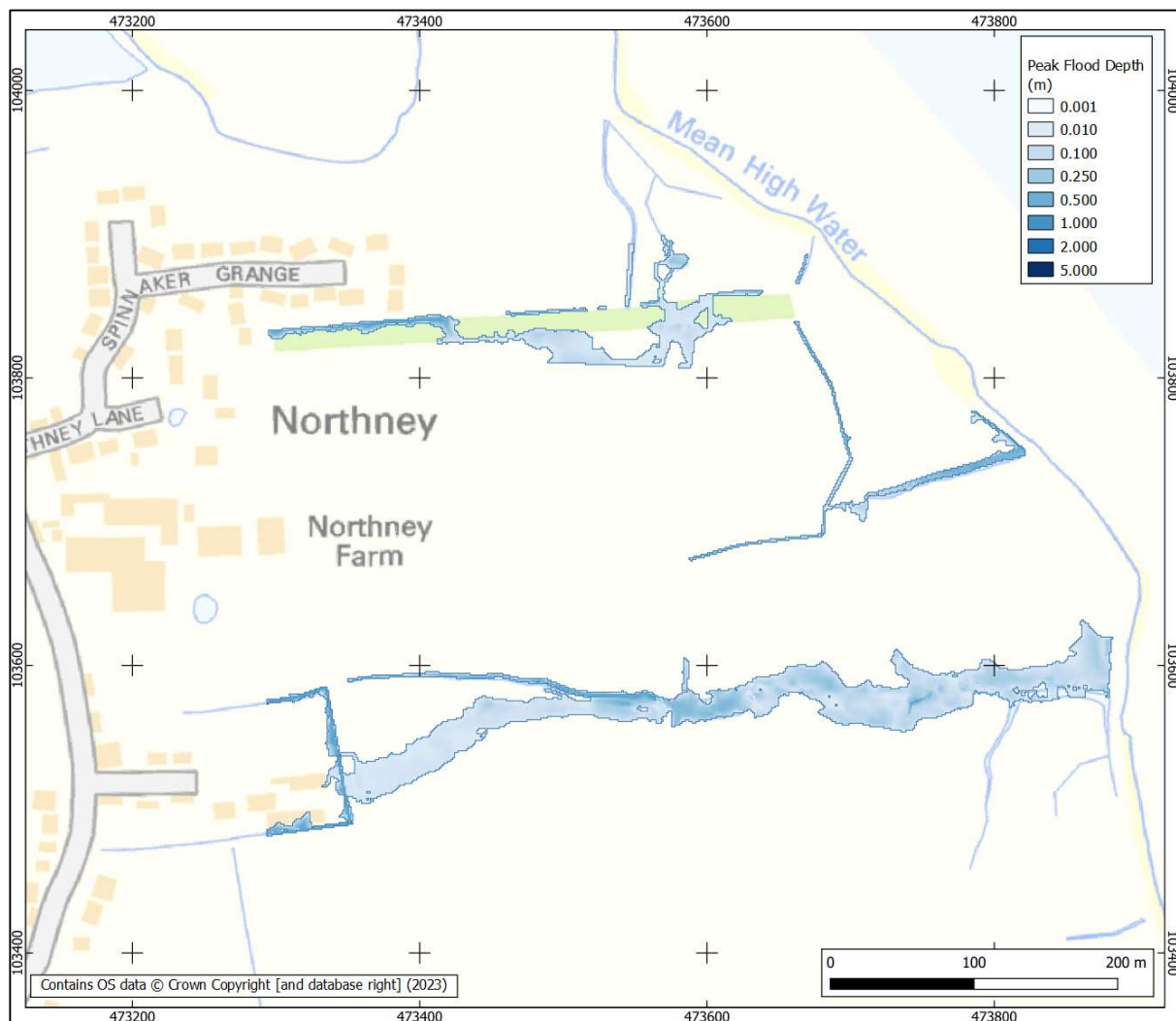


Figure 5.2: Predicted pre-development 1 in 100 year plus climate change flood predictions (sensitivity scenario)

5.2 Post-Development Flood Predictions

Figure 5.3 and Figure 5.4 show corresponding predicted 1 in 100 year plus climate change flooding extents and depths for the baseline and equivalent sensitivity scenario, respectively, for the post-development scenario. Baseline scenario predictions are identical to pre-development predictions

excepting for more extensive (and deeper) peak flooding caused by the embankment acting as a barrier to eastward flow upstream of Culvert S3 and (to a lesser degree) Culvert N3. There are no changes to predicted peak water levels or flood extents at the north-western and southern-western corners of the model extent adjacent to existing residential areas, with development therefore having no impact upon flood risk to these receptors for this scenario.

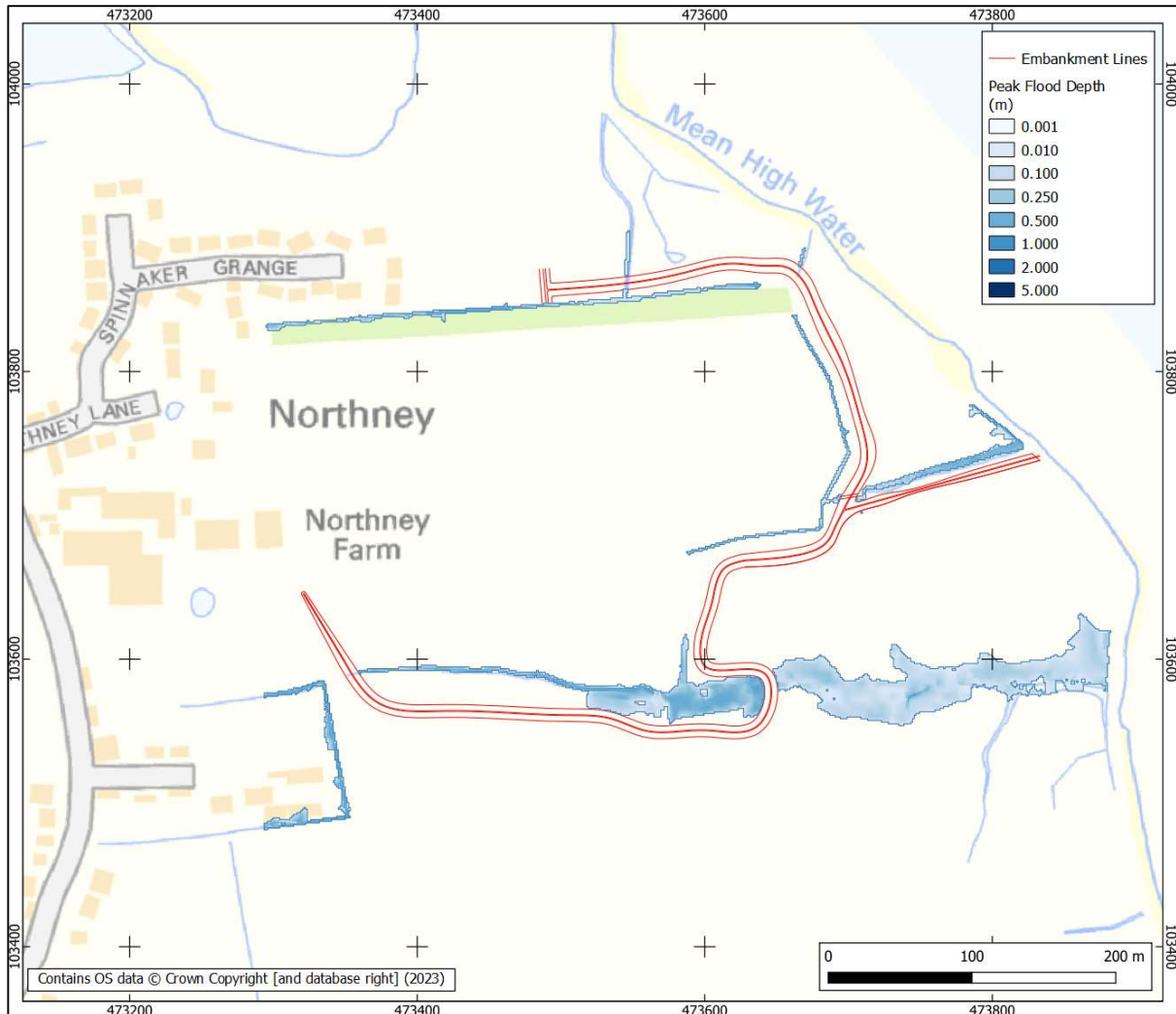


Figure 5.3: Predicted post-development 1 in 100 year plus climate change flood predictions (baseline scenario)

For the sensitivity scenario (i.e. assuming the northern channel is discontinuous and that Culvert S1 has a 300 mm diameter and is therefore undersized), the embankment acts to deflect out-of-bank flooding from the channel upstream (south) of Culvert S1 to flow in a more easterly direction, without having any impact upon predicted peak water levels at or near the channel itself. Likewise, floodwater at the north-eastern corner of the modelled extent is contained to the south of the proposed embankment, but without having any predicted impact upon peak water levels or flood extents at the western end of the northern channel.

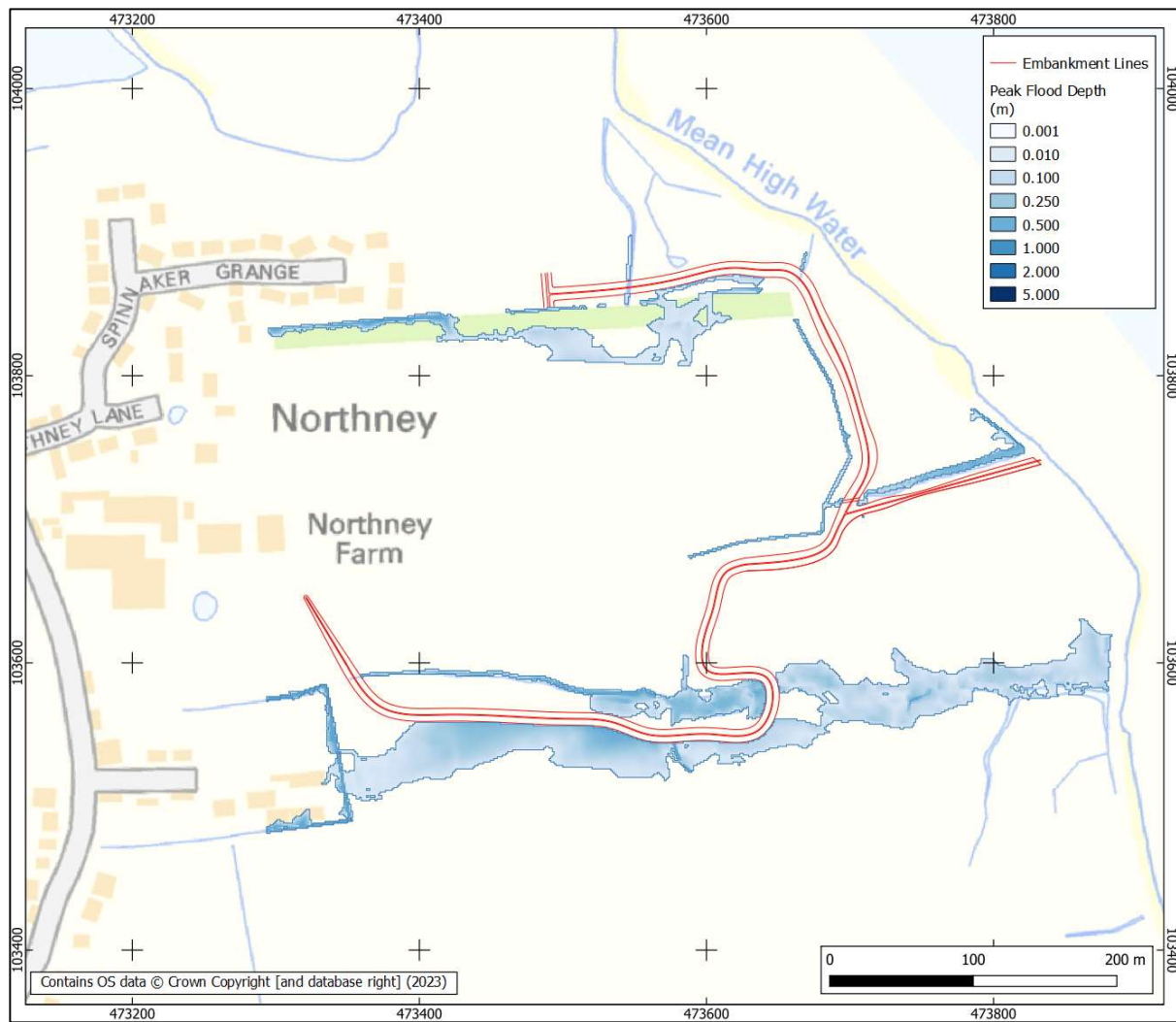


Figure 5.4: Predicted post-development 1 in 100 year plus climate change flood predictions (sensitivity scenario)

5.3 Impact of Proposed Development Upon Minor Channel Flood Risk

Due to gaps in survey information, there is some uncertainty in prediction of flood risk associated with the water channels flowing through the site. However, for either an optimistic or pessimistic baseline representation of these channels and their culverts, proposed development is not predicted to cause any increase in flood risk to existing receptors. Specifically:

- The dimensions of the existing Culvert S1 may or may not be sufficient to convey 1 in 100 year plus climate change flows without backing up and posing flood risk to properties on Clovelly Road. Development will entail extending this culvert in a downstream (north-easterly) direction. Provided culvert extension does not reduce the dimension or longitudinal gradient of the culvert, development will not cause flood risk detriment to these properties. Any enlargement of the culvert relative to its current dimension(s) will result in a reduction in flood risk to these properties.
- The new culvert crossing Culvert S3 has been modelled as a 600 mm diameter culvert, although diameters as low as 450 mm are predicted to cause no increase in flood risk at existing receptors.

- The new culvert crossing Culvert N4 has been modelled as a 300 mm diameter culvert. This is sufficient to avoid accumulation of floodwater at the culvert's southern end for the design (1 in 100 year plus climate change) flood event.
- All other culvert locations are too distant from existing receptors to pose any flood risk, even if undersized.

5.4 Mass Balance

The baseline simulations report a moderate mass balance errors of +5-6% (i.e. mass creation). However, a majority of reported error occurs during recession of design hydrograph, with mass balance errors at the peak much lower (+2%). Attempts to reduce these errors through reductions in the 1D and 2D timestep were unsuccessful, so it should be noted that predictions are slightly conservative in this respect, but with mass balance error impacting pre- and post-development predictions to a very similar degree.

6 CONSIDERATION OF POTENTIAL COMPLICATIONS

6.1 Concurrent Channel-Coastal Flood Risk

All assessment has been undertaken on assumption of low tidal levels. In the event of high flows occurring concurrently with extreme high tides, flood risk to existing receptors will be higher due to “drowning” of the outlets of the Culverts S3, N1, N2, N3 and N4. However, the impact of proposed development will be to reduce flood risk on the landward side of the embankments relative to pre-development conditions, as coastal waters are contained on the seaward side; “no detriment” can therefore be asserted without further analysis.

6.2 Culvert Blockage

All assessment has been undertaken on the assumption that existing and proposed culverts are unblocked. Partial blockage of culverts, particularly Culvert S1, may have a detrimental impact upon flood risk to residential properties on Clovelly Road. However, analysis undertaken as part of this assessment demonstrates that incapacity in Culvert S1 (due to either undersizing or partial blockage) will result in out-of-bank flows from the open channel to the south of the culvert inlet, with proposed embankments not exacerbating this flood behaviour or causing any additional backing-up of floodwaters. Therefore, provided the lengthened/replacement Culvert S1 has the same or greater dimension than the existing culvert, then:

- the risk of blockage of the culvert will be the same or less than current conditions; and
- the impact of a given quantity of blockage upon increasing flood risk to residential properties will be the same or less than current conditions.

Provided replacement culverts are sized to have the same or greater capacity than existing culverts, with the same or improved inlet screening arrangements, and that inlet screening is incorporated into the design of new culverts (particularly Culvert S3), the risk of flooding due to partial culvert blockage for post-development conditions will be the same or less than current risk.

7 SUMMARY OF MINOR CHANNEL FLOOD RISK AND RECOMMENDATIONS

Assessment of flood risk from the water channels within and adjacent to the site using a 2D modelling methodology demonstrates that the proposed development will not pose flood risk detriment, provided extension/replacement of the Culvert S1 does not reduce its conveyance capacity relative to the existing culvert.

The following recommendations are made in relation to design of the culverts through the proposed embankments:

- Enlargement of Culvert S1 relative to its existing dimension should be considered, to provide a beneficial reduction in flood risk from this minor channel to properties on Clovelly Road.
- While a 450 mm diameter is sufficient to ensure Culvert S3 does not cause flood risk detriment to existing receptors, it is recommended that a culvert of 600 mm diameter or larger is used to minimise the depth of water backing up against the western face of the embankment for design flood conditions to below approximately 0.6 m. This will reduce structural/progressive scour risks to the embankment and thereby reduce maintenance requirements over the operation life of the embankment, and will also reduce the risk of significant blockage.
- Amendment to all other existing culverts should aim to retain their existing dimension at a minimum, enlarging if practicable.
- The outlets of downstream culverts (Culverts S3, N1, N2, N3 and N4) should be fitted with non-return ("flap") valves, to ensure coastal floodwaters cannot utilise these culverts as flow pathways.
- Screening arrangements for existing culvert inlets should be retained, or enhanced if possible. For new culverts, particularly Culvert S3, inlet screening should be incorporated into the design, to minimise the risk of significant debris blockage.
- All existing and new culverts through proposed embankments should be subject to periodic inspection and maintenance, to remove any accumulated debris at inlet trash screens, check the function of flap valves and identify the need for any other repairs or maintenance work.

APPENDICES

A ANNUAL EXCEEDANCE PROBABILITY – RETURN PERIOD CONVERSION

Flood Frequency Statistics

The magnitude of flood flows are typically presented as ‘return periods’ (e.g. 1 in 200 year flood) or ‘annual exceedance probabilities’ (e.g. 0.5% AEP).

The return period (or recurrence interval) of a flood is the **long-term average** period between flood conditions of such magnitude (or greater).

The annual exceedance probability of particular flood conditions is the chance these conditions (or more severe) occur **in any given year**.

Relationship between return periods and annual exceedance probability

Return period, T (year)	Annual exceedance probability, AEP (%)	Probability of occurrence over a 50 year period (%)	Comment
2	50	100	Median annual flood (also known as QMED). In the long-term this occurs every other year, on average. As a rule of thumb, this flow generally equates to ‘bankfull’ conditions in most natural channels.
5	20	100	
10	10	99	
20	5	92	
30	3.3	82	Typical design standard for urban drainage systems.
50	2	64	
100	1	39	
200	0.5	22	Typical design standard for river or coastal flooding for most developments. Defines “functional floodplain” under Scottish Planning Policy.
500	0.2	10	
1,000	0.1	4.9	Typical design conditions standard for sensitive or vulnerable developments/contexts.

Lifetime Probabilities, or Design Life Probabilities

The probability of a flood event occurring at least once over a set period of time (e.g. an individual's lifetime or the design life of a built structure) can be evaluated against the following table.

Age, or Design Period (years)	Flood Return period (years)				
	2	10	30	200	1000
10	100%	65%	29%	5%	1%
25	100%	93%	57%	12%	2%
80	100%	100%	93%	33%	8%
100	100%	100%	97%	39%	10%

B REFH2 DONOR CATCHMENT OUTPUT (1 IN 100 YEAR EVENT)

UK Design Flood Estimation

Generated on 22 August 2023 09:44:03 by RChibanga
Printed from the ReFH2 Flood Modelling software package, version 4.0.8560.23190

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH2)

Site details

Checksum: 60B0-779A

Site name: FEH_Catchment_Descriptors_471800_102750_v5_0_1

Easting: 471800

Northing: 102750

Country: England, Wales or Northern Ireland

Catchment Area (km²): 0.62

Using plot scale calculations: No

Model: 2.3

Site description: None

Model run: 100 year

Summary of results

Rainfall - FEH22 (mm):	59.59	Total runoff (ML):	5.28
Total Rainfall (mm):	40.60	Total flow (ML):	15.42
Peak Rainfall (mm):	9.23	Peak flow (m ³ /s):	0.30

Parameters

*Where the user has overridden a system-generated value, this original value is shown in square brackets after the value used.
* Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH22)

Name	Value	User-defined?
Duration (hh:mm:ss)	05:30:00	No
Timestep (hh:mm:ss)	00:30:00	No
SCF (Seasonal correction factor)	0.69	No
ARF (Areal reduction factor)	0.98	No
Seasonality	Winter	No

Loss model parameters

Name	Value	User-defined?
Cini (mm)	78.8	No
Cmax (mm)	572.55	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	2.99	No
Up	0.65	No
Uk	0.8	No
Baseflow model parameters		
Name	Value	User-defined?
BF0 (m ³ /s)	0.01	No
BL (hr)	35.5	No
BR	2.44	No
Urbanisation parameters		
Name	Value	User-defined?
Sewer capacity (m ³ /s)	0	No
Exporting drained area (km ²)	0	No
Urban area (km ²)	0.1	No
Urbext 2000	0.1	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
00:00:00	0.891	0.000	0.156	0.000	0.007	0.007
00:30:00	1.493	0.000	0.267	0.001	0.007	0.008
01:00:00	2.489	0.000	0.453	0.003	0.007	0.010
01:30:00	4.116	0.000	0.771	0.008	0.007	0.015
02:00:00	6.698	0.000	1.315	0.018	0.007	0.025
02:30:00	9.227	0.000	1.934	0.036	0.008	0.043
03:00:00	6.698	0.000	1.493	0.065	0.009	0.074
03:30:00	4.116	0.000	0.955	0.106	0.010	0.116
04:00:00	2.489	0.000	0.591	0.152	0.013	0.165
04:30:00	1.493	0.000	0.360	0.197	0.017	0.214
05:00:00	0.891	0.000	0.216	0.234	0.021	0.255
05:30:00	0.000	0.000	0.000	0.257	0.027	0.284
06:00:00	0.000	0.000	0.000	0.262	0.033	0.295
06:30:00	0.000	0.000	0.000	0.251	0.039	0.291
07:00:00	0.000	0.000	0.000	0.230	0.045	0.276
07:30:00	0.000	0.000	0.000	0.205	0.051	0.255
08:00:00	0.000	0.000	0.000	0.177	0.055	0.233
08:30:00	0.000	0.000	0.000	0.150	0.059	0.210
09:00:00	0.000	0.000	0.000	0.126	0.063	0.189
09:30:00	0.000	0.000	0.000	0.105	0.065	0.170
10:00:00	0.000	0.000	0.000	0.087	0.067	0.154
10:30:00	0.000	0.000	0.000	0.070	0.069	0.139
11:00:00	0.000	0.000	0.000	0.056	0.070	0.126
11:30:00	0.000	0.000	0.000	0.044	0.071	0.115
12:00:00	0.000	0.000	0.000	0.033	0.071	0.105
12:30:00	0.000	0.000	0.000	0.024	0.072	0.095
13:00:00	0.000	0.000	0.000	0.016	0.071	0.087
13:30:00	0.000	0.000	0.000	0.009	0.071	0.080
14:00:00	0.000	0.000	0.000	0.005	0.070	0.075
14:30:00	0.000	0.000	0.000	0.002	0.069	0.072
15:00:00	0.000	0.000	0.000	0.001	0.068	0.069
15:30:00	0.000	0.000	0.000	0.000	0.067	0.068
16:00:00	0.000	0.000	0.000	0.000	0.066	0.066
16:30:00	0.000	0.000	0.000	0.000	0.066	0.066
17:00:00	0.000	0.000	0.000	0.000	0.065	0.065

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
17:30:00	0.000	0.000	0.000	0.000	0.064	0.064
18:00:00	0.000	0.000	0.000	0.000	0.063	0.063
18:30:00	0.000	0.000	0.000	0.000	0.062	0.062
19:00:00	0.000	0.000	0.000	0.000	0.061	0.061
19:30:00	0.000	0.000	0.000	0.000	0.060	0.060
20:00:00	0.000	0.000	0.000	0.000	0.059	0.059
20:30:00	0.000	0.000	0.000	0.000	0.059	0.059
21:00:00	0.000	0.000	0.000	0.000	0.058	0.058
21:30:00	0.000	0.000	0.000	0.000	0.057	0.057
22:00:00	0.000	0.000	0.000	0.000	0.056	0.056
22:30:00	0.000	0.000	0.000	0.000	0.055	0.055
23:00:00	0.000	0.000	0.000	0.000	0.055	0.055
23:30:00	0.000	0.000	0.000	0.000	0.054	0.054
24:00:00	0.000	0.000	0.000	0.000	0.053	0.053
24:30:00	0.000	0.000	0.000	0.000	0.052	0.052
25:00:00	0.000	0.000	0.000	0.000	0.052	0.052
25:30:00	0.000	0.000	0.000	0.000	0.051	0.051
26:00:00	0.000	0.000	0.000	0.000	0.050	0.050
26:30:00	0.000	0.000	0.000	0.000	0.049	0.049
27:00:00	0.000	0.000	0.000	0.000	0.049	0.049
27:30:00	0.000	0.000	0.000	0.000	0.048	0.048
28:00:00	0.000	0.000	0.000	0.000	0.047	0.047
28:30:00	0.000	0.000	0.000	0.000	0.047	0.047
29:00:00	0.000	0.000	0.000	0.000	0.046	0.046
29:30:00	0.000	0.000	0.000	0.000	0.045	0.045
30:00:00	0.000	0.000	0.000	0.000	0.045	0.045
30:30:00	0.000	0.000	0.000	0.000	0.044	0.044
31:00:00	0.000	0.000	0.000	0.000	0.044	0.044
31:30:00	0.000	0.000	0.000	0.000	0.043	0.043
32:00:00	0.000	0.000	0.000	0.000	0.042	0.042
32:30:00	0.000	0.000	0.000	0.000	0.042	0.042
33:00:00	0.000	0.000	0.000	0.000	0.041	0.041
33:30:00	0.000	0.000	0.000	0.000	0.041	0.041
34:00:00	0.000	0.000	0.000	0.000	0.040	0.040
34:30:00	0.000	0.000	0.000	0.000	0.039	0.039
35:00:00	0.000	0.000	0.000	0.000	0.039	0.039

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
35:30:00	0.000	0.000	0.000	0.000	0.038	0.038
36:00:00	0.000	0.000	0.000	0.000	0.038	0.038
36:30:00	0.000	0.000	0.000	0.000	0.037	0.037
37:00:00	0.000	0.000	0.000	0.000	0.037	0.037
37:30:00	0.000	0.000	0.000	0.000	0.036	0.036
38:00:00	0.000	0.000	0.000	0.000	0.036	0.036
38:30:00	0.000	0.000	0.000	0.000	0.035	0.035
39:00:00	0.000	0.000	0.000	0.000	0.035	0.035
39:30:00	0.000	0.000	0.000	0.000	0.034	0.034
40:00:00	0.000	0.000	0.000	0.000	0.034	0.034
40:30:00	0.000	0.000	0.000	0.000	0.033	0.033
41:00:00	0.000	0.000	0.000	0.000	0.033	0.033
41:30:00	0.000	0.000	0.000	0.000	0.032	0.032
42:00:00	0.000	0.000	0.000	0.000	0.032	0.032
42:30:00	0.000	0.000	0.000	0.000	0.032	0.032
43:00:00	0.000	0.000	0.000	0.000	0.031	0.031
43:30:00	0.000	0.000	0.000	0.000	0.031	0.031
44:00:00	0.000	0.000	0.000	0.000	0.030	0.030
44:30:00	0.000	0.000	0.000	0.000	0.030	0.030
45:00:00	0.000	0.000	0.000	0.000	0.029	0.029
45:30:00	0.000	0.000	0.000	0.000	0.029	0.029
46:00:00	0.000	0.000	0.000	0.000	0.029	0.029
46:30:00	0.000	0.000	0.000	0.000	0.028	0.028
47:00:00	0.000	0.000	0.000	0.000	0.028	0.028
47:30:00	0.000	0.000	0.000	0.000	0.027	0.027
48:00:00	0.000	0.000	0.000	0.000	0.027	0.027
48:30:00	0.000	0.000	0.000	0.000	0.027	0.027
49:00:00	0.000	0.000	0.000	0.000	0.026	0.026
49:30:00	0.000	0.000	0.000	0.000	0.026	0.026
50:00:00	0.000	0.000	0.000	0.000	0.026	0.026
50:30:00	0.000	0.000	0.000	0.000	0.025	0.025
51:00:00	0.000	0.000	0.000	0.000	0.025	0.025
51:30:00	0.000	0.000	0.000	0.000	0.024	0.024
52:00:00	0.000	0.000	0.000	0.000	0.024	0.024
52:30:00	0.000	0.000	0.000	0.000	0.024	0.024
53:00:00	0.000	0.000	0.000	0.000	0.023	0.023

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
53:30:00	0.000	0.000	0.000	0.000	0.023	0.023
54:00:00	0.000	0.000	0.000	0.000	0.023	0.023
54:30:00	0.000	0.000	0.000	0.000	0.022	0.022
55:00:00	0.000	0.000	0.000	0.000	0.022	0.022
55:30:00	0.000	0.000	0.000	0.000	0.022	0.022
56:00:00	0.000	0.000	0.000	0.000	0.022	0.022
56:30:00	0.000	0.000	0.000	0.000	0.021	0.021
57:00:00	0.000	0.000	0.000	0.000	0.021	0.021
57:30:00	0.000	0.000	0.000	0.000	0.021	0.021
58:00:00	0.000	0.000	0.000	0.000	0.020	0.020
58:30:00	0.000	0.000	0.000	0.000	0.020	0.020
59:00:00	0.000	0.000	0.000	0.000	0.020	0.020
59:30:00	0.000	0.000	0.000	0.000	0.020	0.020
60:00:00	0.000	0.000	0.000	0.000	0.019	0.019
60:30:00	0.000	0.000	0.000	0.000	0.019	0.019
61:00:00	0.000	0.000	0.000	0.000	0.019	0.019
61:30:00	0.000	0.000	0.000	0.000	0.018	0.018
62:00:00	0.000	0.000	0.000	0.000	0.018	0.018
62:30:00	0.000	0.000	0.000	0.000	0.018	0.018
63:00:00	0.000	0.000	0.000	0.000	0.018	0.018
63:30:00	0.000	0.000	0.000	0.000	0.017	0.017
64:00:00	0.000	0.000	0.000	0.000	0.017	0.017
64:30:00	0.000	0.000	0.000	0.000	0.017	0.017
65:00:00	0.000	0.000	0.000	0.000	0.017	0.017
65:30:00	0.000	0.000	0.000	0.000	0.016	0.016
66:00:00	0.000	0.000	0.000	0.000	0.016	0.016
66:30:00	0.000	0.000	0.000	0.000	0.016	0.016
67:00:00	0.000	0.000	0.000	0.000	0.016	0.016
67:30:00	0.000	0.000	0.000	0.000	0.016	0.016
68:00:00	0.000	0.000	0.000	0.000	0.015	0.015
68:30:00	0.000	0.000	0.000	0.000	0.015	0.015
69:00:00	0.000	0.000	0.000	0.000	0.015	0.015
69:30:00	0.000	0.000	0.000	0.000	0.015	0.015
70:00:00	0.000	0.000	0.000	0.000	0.015	0.015
70:30:00	0.000	0.000	0.000	0.000	0.014	0.014
71:00:00	0.000	0.000	0.000	0.000	0.014	0.014

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
71:30:00	0.000	0.000	0.000	0.000	0.014	0.014
72:00:00	0.000	0.000	0.000	0.000	0.014	0.014
72:30:00	0.000	0.000	0.000	0.000	0.014	0.014
73:00:00	0.000	0.000	0.000	0.000	0.013	0.013
73:30:00	0.000	0.000	0.000	0.000	0.013	0.013
74:00:00	0.000	0.000	0.000	0.000	0.013	0.013
74:30:00	0.000	0.000	0.000	0.000	0.013	0.013
75:00:00	0.000	0.000	0.000	0.000	0.013	0.013
75:30:00	0.000	0.000	0.000	0.000	0.012	0.012
76:00:00	0.000	0.000	0.000	0.000	0.012	0.012
76:30:00	0.000	0.000	0.000	0.000	0.012	0.012
77:00:00	0.000	0.000	0.000	0.000	0.012	0.012
77:30:00	0.000	0.000	0.000	0.000	0.012	0.012
78:00:00	0.000	0.000	0.000	0.000	0.012	0.012
78:30:00	0.000	0.000	0.000	0.000	0.011	0.011
79:00:00	0.000	0.000	0.000	0.000	0.011	0.011
79:30:00	0.000	0.000	0.000	0.000	0.011	0.011
80:00:00	0.000	0.000	0.000	0.000	0.011	0.011
80:30:00	0.000	0.000	0.000	0.000	0.011	0.011
81:00:00	0.000	0.000	0.000	0.000	0.011	0.011
81:30:00	0.000	0.000	0.000	0.000	0.011	0.011
82:00:00	0.000	0.000	0.000	0.000	0.010	0.010
82:30:00	0.000	0.000	0.000	0.000	0.010	0.010
83:00:00	0.000	0.000	0.000	0.000	0.010	0.010
83:30:00	0.000	0.000	0.000	0.000	0.010	0.010
84:00:00	0.000	0.000	0.000	0.000	0.010	0.010
84:30:00	0.000	0.000	0.000	0.000	0.010	0.010
85:00:00	0.000	0.000	0.000	0.000	0.010	0.010
85:30:00	0.000	0.000	0.000	0.000	0.009	0.009
86:00:00	0.000	0.000	0.000	0.000	0.009	0.009
86:30:00	0.000	0.000	0.000	0.000	0.009	0.009
87:00:00	0.000	0.000	0.000	0.000	0.009	0.009
87:30:00	0.000	0.000	0.000	0.000	0.009	0.009
88:00:00	0.000	0.000	0.000	0.000	0.009	0.009
88:30:00	0.000	0.000	0.000	0.000	0.009	0.009
89:00:00	0.000	0.000	0.000	0.000	0.009	0.009

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m ³ /s)	Net Rain (mm)	Runoff (m ³ /s)	Baseflow (m ³ /s)	Total Flow (m ³ /s)
89:30:00	0.000	0.000	0.000	0.000	0.008	0.008
90:00:00	0.000	0.000	0.000	0.000	0.008	0.008
90:30:00	0.000	0.000	0.000	0.000	0.008	0.008
91:00:00	0.000	0.000	0.000	0.000	0.008	0.008
91:30:00	0.000	0.000	0.000	0.000	0.008	0.008
92:00:00	0.000	0.000	0.000	0.000	0.008	0.008
92:30:00	0.000	0.000	0.000	0.000	0.008	0.008
93:00:00	0.000	0.000	0.000	0.000	0.008	0.008
93:30:00	0.000	0.000	0.000	0.000	0.007	0.007
94:00:00	0.000	0.000	0.000	0.000	0.007	0.007
94:30:00	0.000	0.000	0.000	0.000	0.007	0.007
95:00:00	0.000	0.000	0.000	0.000	0.007	0.007

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km ²)	0.62	No
ALTBAR	4	No
ASPBAR	280	No
ASPVAR	0.46	No
BFIHOST	0.66	No
BFIHOST19	0.63	No
DPLBAR (km)	0.7	No
DPSBAR (mkm ⁻¹)	6.2	No
FARL	1	No
LDP	1.32	No
PROPWET	0.34	No
RMED1H	9	No
RMED1D	33.4	No
RMED2D	42	No
SAAR (mm)	704	No
SAAR4170 (mm)	710	No
SPRHOST	33.58	No
Urbext2000	0.1	No
Urbext1990	0.08	No
URBCONC	0.62	No
URBLOC	0.87	No
DDF parameter C	-0.03	No
DDF parameter D1	0.44	No
DDF parameter D2	0.29	No
DDF parameter D3	0.38	No
DDF parameter E	0.31	No
DDF parameter F	2.23	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.45	No
DDF parameter D2 (1km grid value)	0.3	No
DDF parameter D3 (1km grid value)	0.37	No
DDF parameter E (1km grid value)	0.31	No
DDF parameter F (1km grid value)	2.22	No