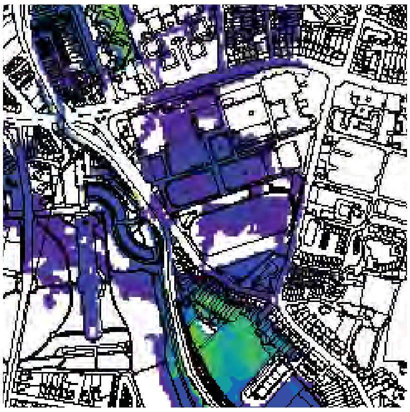
RPS

NORTH WESTERN
NEAGH BANN
CFRAM
STUDY
CATCHMENT FLOOD RISK
ASSESSMENT AND MANAGEMENT

# North Western - Neagh Bann CFRAM Study

## UoM 06 Hydraulics Report
## 4.3 Carrickmacross

IBE0700Rp0012

OPW
The Office of Public Works
Oifig na nOibreacha Poiblí

Photographs of flooding on cover provided by Rivers Agency

# NWNB CFRAM Study

# HA06 Hydraulics Report

## Carrickmacross Model

# DOCUMENT CONTROL SHEET

| | |
|---|---|
| Client | OPW |
| Project Title | NWNB CFRAM Study |
| Document Title | IBE0700Rp0012_ HA06 Hydraulics Report |
| Model Name | Carrickmacross |

| Rev. | Status | Author(s) | Modeller | Reviewed by | Approved By | Office of Origin | Issue Date |
|---|---|---|---|---|---|---|---|
| D01 | Draft | T. Carberry | J. Canavan | S. Patterson | G. Glasgow | Belfast/Limerick | 06/06/2014 |
| F01 | Draft Final | J. Canavan | J. Canavan | L. Arbuckle | G. Glasgow | Belfast | 20/02/2015 |
| F02 | Draft Final | J. Canavan | J. Canavan | L. Arbuckle | G. Glasgow | Belfast | 13/08/2015 |
| F03 | Draft Final | J. Canavan | J. Canavan | S. Patterson | G. Glasgow | Belfast | 07/07/2016 |

**Table of Reference Reports**

| **Report** | **Issue Date** | **Report Reference** | **Relevant Section** |
|---|---|---|---|
| North Western Neagh Bann CFRAM Study Flood Risk Review | May 2012 | 2011s5232 NW&NB CFRAM FRR Report_Final | 4 |
| North Western Neagh Bann CFRAM HA01_06_36 Survey Contract Report | October 2013 | IBE0700Rp0007_HA01_06_36 NWNB_CFRAM_Survey Contract Report | 6.4 |
| North Western Neagh Bann CFRAM Study UoM06 Inception Report | March 2013 | IBE0700Rp0003_UoM 06 Inception Report | 4.3.2 |
| North Western Neagh Bann CFRAM Study Hydrology Report UoM06 | October 2013 | IBE0700Rp0008_UoM 06 Hydrology Report | 4.6 |

# 4 HYDRAULIC MODEL DETAILS

## 4.3 CARRICKMACROSS

### 4.3.1 General Hydraulic Model Information

**(1) Introduction:**

The NWNB CFRAM Flood Risk Review (2011s5232 NW&NB CFRAM FRR Report_Final_v2.0) highlighted Carrickmacross in the Glyde catchment as an AFA for fluvial flooding based on a review of historic flooding and the extents of flood risk determined during the PFRA.

The Longfield River rises in the drumlins to the north west of Carrickmacross and flows in a south east direction through the AFA where it is joined by three tributaries, all of which are included in the model (refer to Section 4.3.2, Figure 4.3.1). Three small lakes are located along the Longfield River (Naglack, Moynalty and one smaller unnamed Lough) just downstream of the AFA extent. The Longfield River joins the Lagan River approximately 12km downstream from Carrickmacross to become the River Glyde. The model terminates at Tallanstown approximately 18km downstream from Carrickmacross. The downstream limit is denoted by gauging station 06014 on the River Glyde and has a total catchment area of 271km$^2$. The location of Station 06014 also marks the upstream limit of the Annagassan AFA model (refer to Chapter 4.8).

Figures 4.3.1 and 4.3.2 in Section 4.3.2 (1) illustrate the Carrickmacross model extents. Hydrometric station 06014 at the model downstream limit is operated by OPW, has over 40 years of data and is rated as A1 under FSU. Given the high confidence in the flow data it has been used as in the adjustment of initial $Q_{med}$ estimations on the Longfield River (reducing them by a factor of 0.65).

Hydrometric Station 06024, Aclint is located on the Lagan River and is an OPW station rated A1/A2 under FSU. Again, the data has been used as in the adjustment of initial $Q_{med}$ estimations on the Lagan River (reducing them by a factor of 0.57). However the small tributaries entering the Longfield River and/or its tributaries have not been adjusted using hydrometric data as a review of pivotal site options indicated no clear trend for doing so. Refer to UoM 06 Hydrology Report, Chapter 4.6 (IBE0700Rp0008_UoM 06 Hydrology Report_F01) for full details on hydrology estimation for the Carrickmacross model.

All watercourses except the lower reaches of the River Glyde and the Coolderry are HPWs. All HPWs and the Coolderry which is a MPW were modelled in 1D-2D using the MIKE suite of software. The lower reaches of the River Glyde is a MPW and was modelled in 1D. Channel markers have been located at the right and left banks of all cross sections. Flow within these markers is calculated by the 1D model component; however when the water level rises sufficiently to meet the bank markers flow can enter the 2D domain which represents the floodplain. Refer to Section 4.4.2 for further details on model schematisation.

| | |
|---|---|
| **(2) Model Reference:** | HA06_CARR6 |

| **(3) AFAs included in the model:** | Carrickmacross | |
|---|---|---|
| **(4) Primary Watercourses / Water Bodies (including local names):** | | |
| **Reach ID** | **Name** | **Local Name** |
| 0601M | River Glyde | River Glyde and Longfield River |
| 0608M | River Coolderry | |
| 0609M | River Lisanisk | |
| 0610M | Tullynaskeagh | |
| 0611A | Kilmactrasna Tributary 2 | |
| 0611M | River Kilmactrasna | |
| 0612M | Drummond | |
| Note that during the CFRAM Study channel and structure survey the River Glyde and the Longfield River were grouped under reach ID 0601M. Refer to Section 4.3.2(2) for all modelled watercourses. | | |
| **(5) Software Type (and version):** | | |
| **(a) 1D Domain:** MIKE 11 (2011) | **(b) 2D Domain:** MIKE 21 - Rectangular Mesh (2011) | **(c) Other model elements:** MIKE FLOOD (2011) |

### 4.3.2 Hydraulic Model Schematisation

| **(1) Map of Model Extents:** |
|---|
| Figure 4.3.1 and Figure 4.3.2 illustrate the model extent, river centre line, HEP locations and AFA extents. There are 6no. Upstream Limit HEPs, 8no. Tributary HEPs, 5no. Intermediate HEPs and 1 Gauging Station HEP (06014_RA). Gauging stations 06038_RA at Drummond and 06016_RA at Nicholastown were redefined as Intermediate HEPs as no data is available. Gauging Station and Intermediate HEPs have been used in anchoring the model to observed flows / hydrological estimates as discussed in Appendix A.3.<br>To enable a more accurate representation of the Q-h relationship at the downstream limit (gauging station 06014), the model was extended further downstream. However the model outputs are mapped only as far as Station 06014 as this is the upstream limit of the Annagassan Model, refer to Chapter 4.8. |

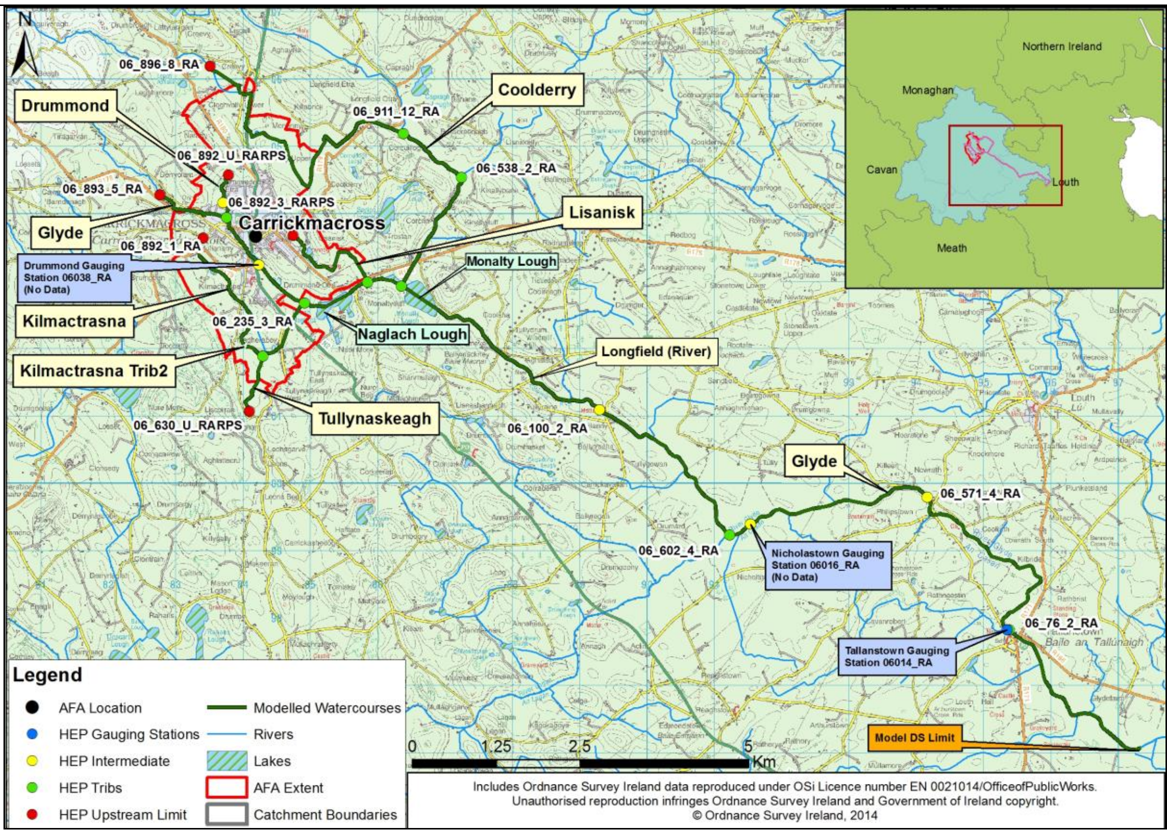



**Figure 4.3.1: Map of Model Extents**

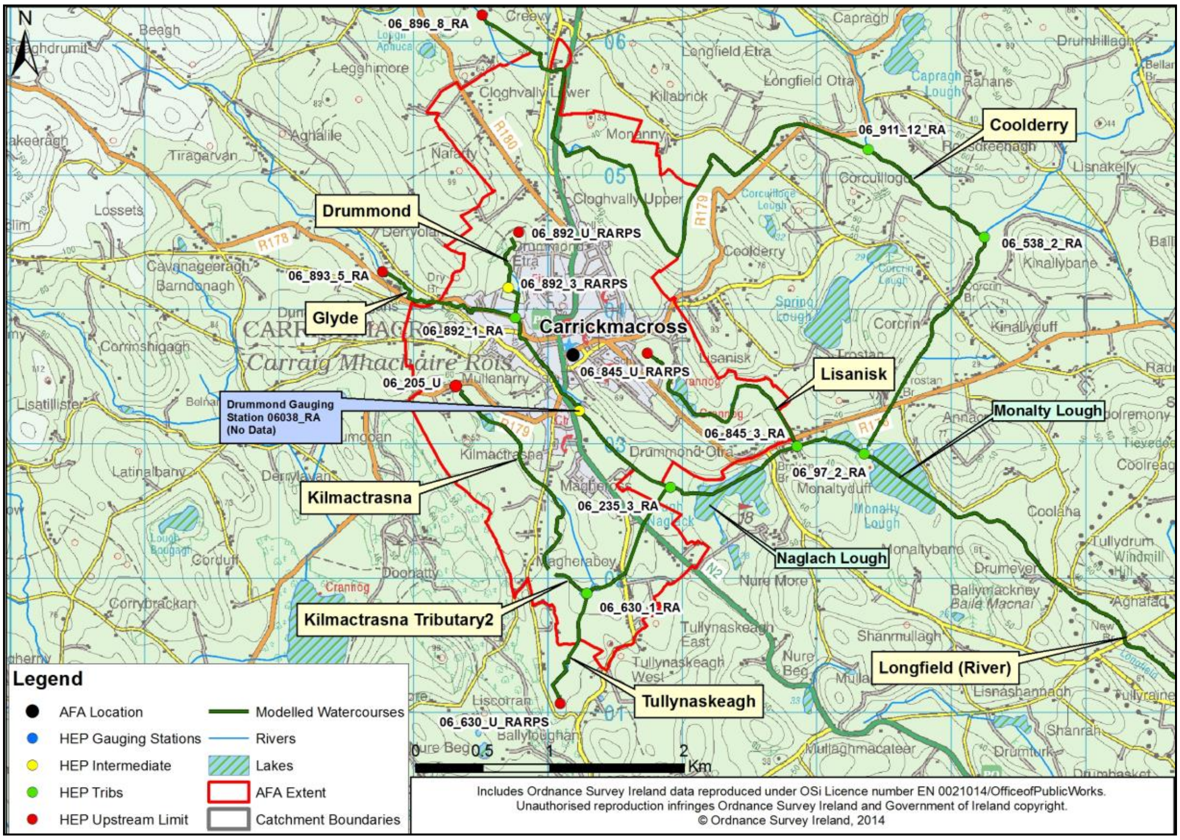



**Figure 4.3.2: Detail of AFA Extents**

**(2) x-y Coordinates of River (Upstream extent):**

| River Name | | x | y |
|---|---|---|---|
| **0601M** | R. Glyde | 282754.11 | 304288.02 |
| **0608M** | Coolderry | 283496.23 | 306203.39 |
| **0609M** | Lisanisk | 284755.04 | 303666.71 |
| **0610M** | Tullynaskeagh | 284087.33 | 301078.65 |
| **0611A** | Kilmactrasna Trib. | 284050.15 | 302033.22 |
| **0611M** | Kilmactrasna River (Carrickmacross) | 283365.22 | 303405.8 |
| **0612M** | Drummond | 283721.81 | 304536.52 |

| | | | |
|---|---|---|---|
| **(3) Total Modelled Watercourse Length:** | | 36km | |
| **(4) 1D Domain only Watercourse Length:** | 15.98km (approx) | **(5) 1D-2D Domain Watercourse Length:** | 14.79km (approx) |
| **(6) 2D Domain Mesh Type / Resolution / Area:** | | Rectangular / 5 metres (1652x1148) 47.41 $km^2$ | |

**(7) 2D Domain Model Extent:**

Figure 4.3.3 illustrates the modelled extents and general topography. The grid illustrates the 2D extent, the 1D model is illustrated as a light blue line. The LiDAR extent is the area shown within the black line. Buildings are excluded from the mesh and therefore represented as white spaces. Refer to Chapter 3 for details on representation of buildings in the model.

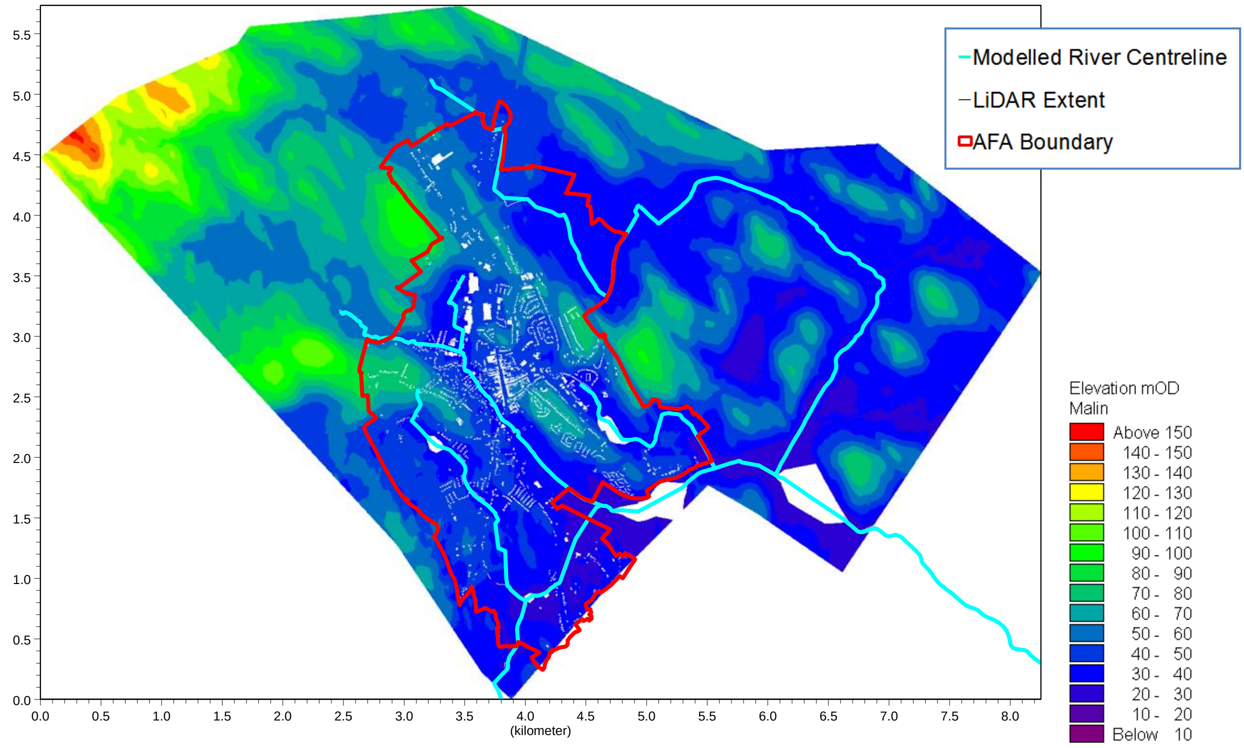



**Figure 4.3.3: 2D Domain Model Extent**

Figure 4.3.4 shows an overview drawing of the model schematisation. Figure 4.3.5 to Figure 4.3.9 show detailed views. The overview diagram covers the model extents, showing the surveyed cross-section locations, AFA boundary and river centre line. It also shows the area covered by the 2D model domain. The detailed views are provided where there is the most significant risk of flooding. These diagrams include the surveyed cross-section locations, AFA boundary and river centreline. They also show the location of the critical structures as discussed in section 4.3.3 (1), along with the location and extent of the links between the 1D and 2D models. For clarity in viewing cross-section locations, the model schematisation diagrams show the full extent of the surveyed cross-sections. Note that the 1D model considers only the cross-section between the 1D-2D links.

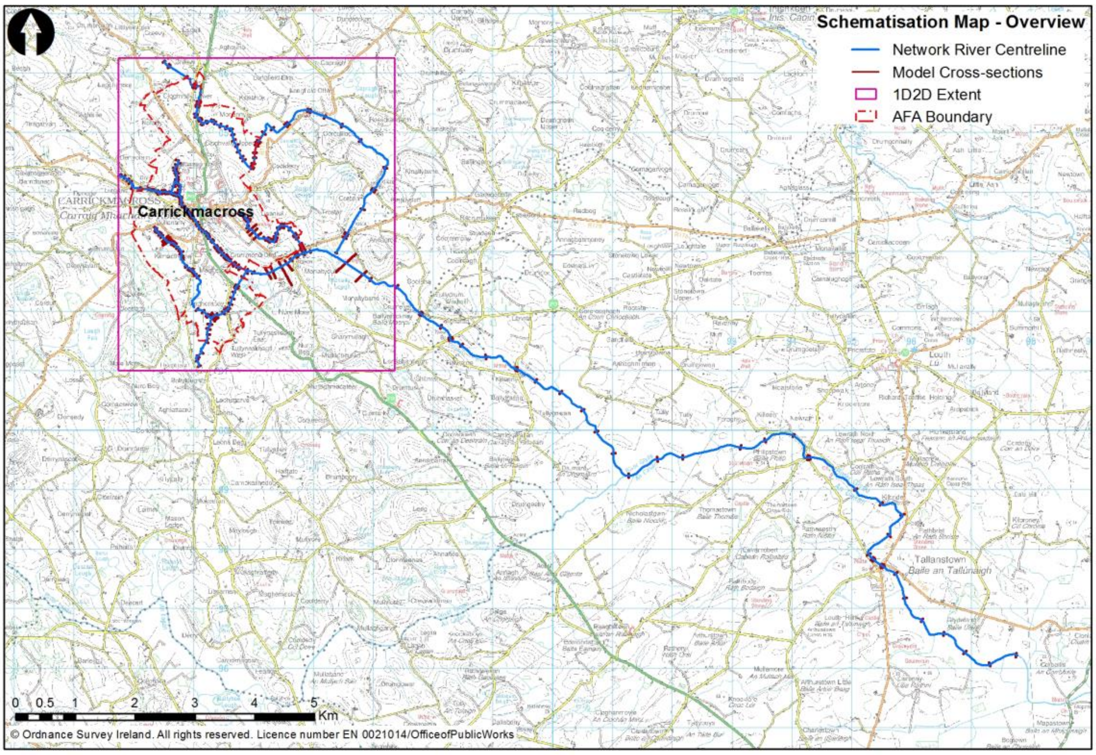



**Figure 4.3.4: Overview Drawing of Model Schematisation**

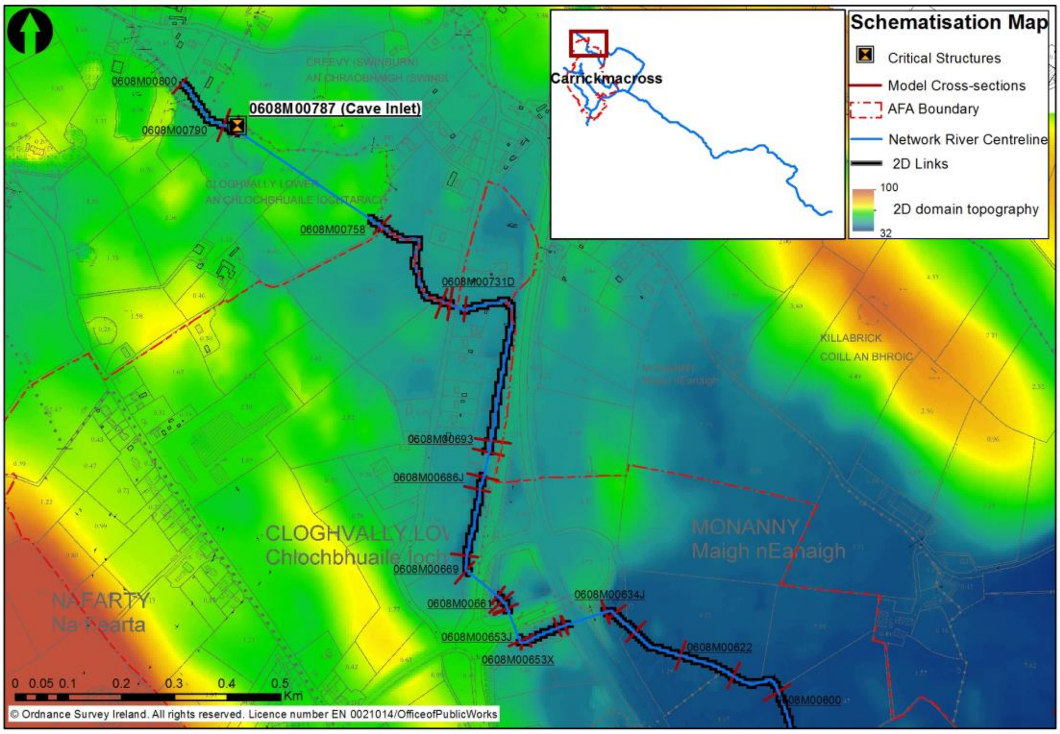



**Figure 4.3.5: Detailed Area of Model Schematisation showing Critical Structure (1 of 5)***

*For clarity in viewing cross-section locations, the model schematisation diagrams show the full extent of the surveyed cross-sections. Note that the 1D model considers only the cross-section between the 1D-2D links.

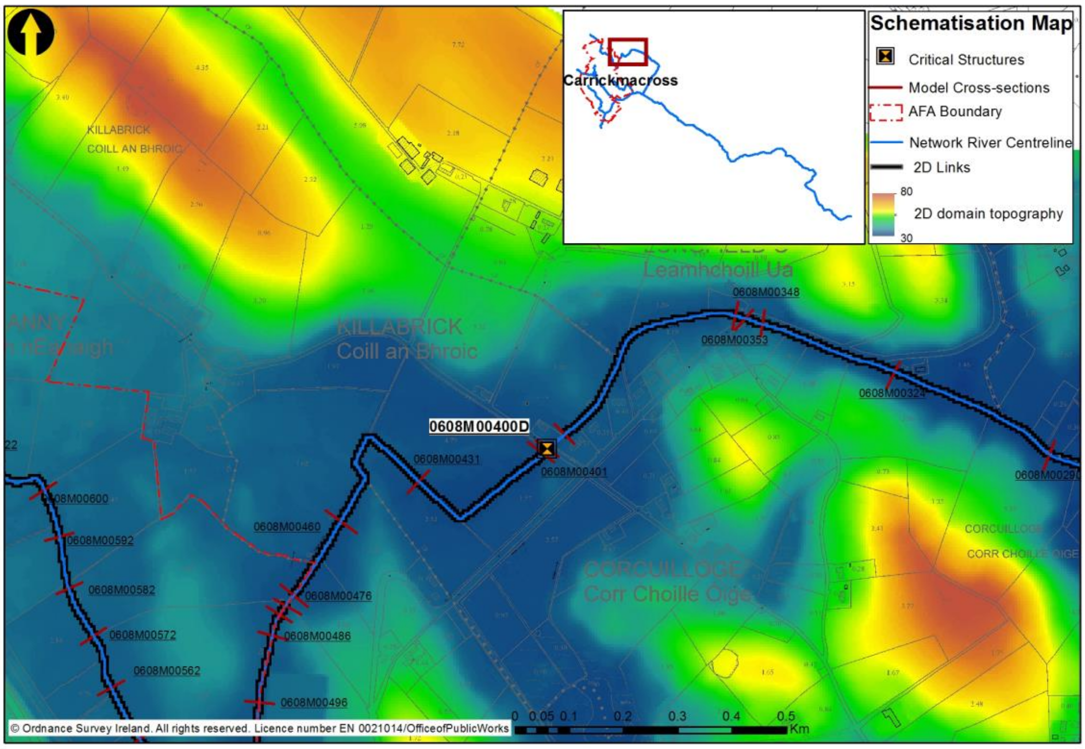



**Figure 4.3.6: Detailed Area of Model Schematisation showing Critical Structure (2 of 5)**

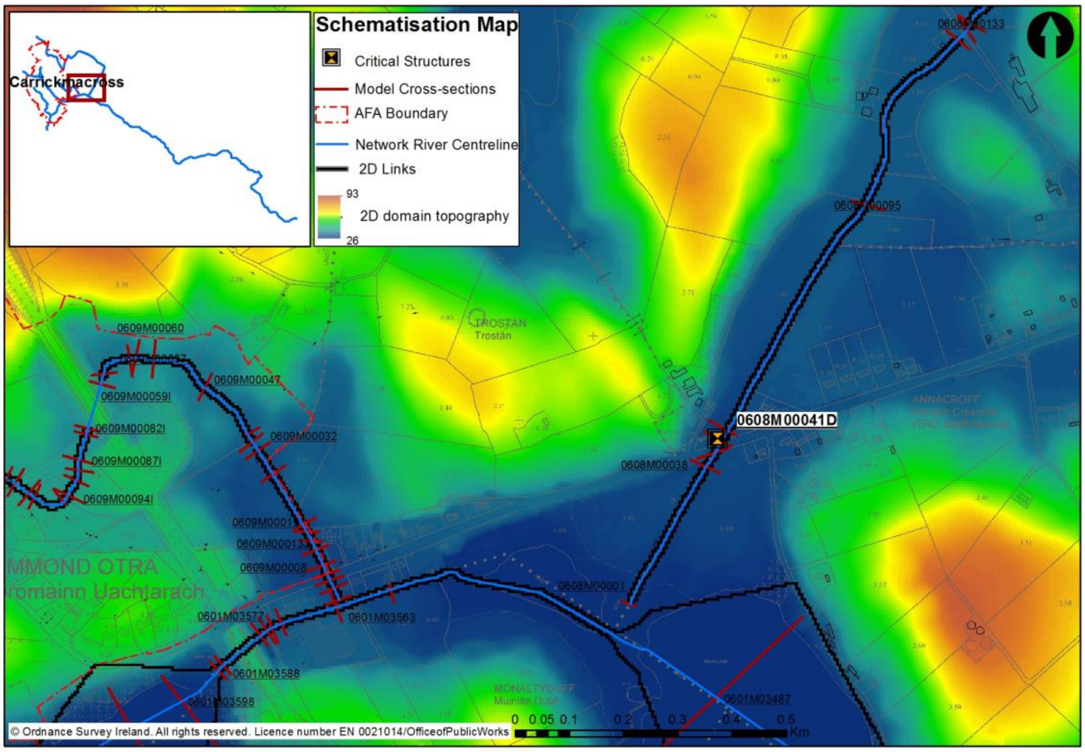



**Figure 4.3.7: Detailed Area of Model Schematisation showing Critical Structure (3 of 5)**

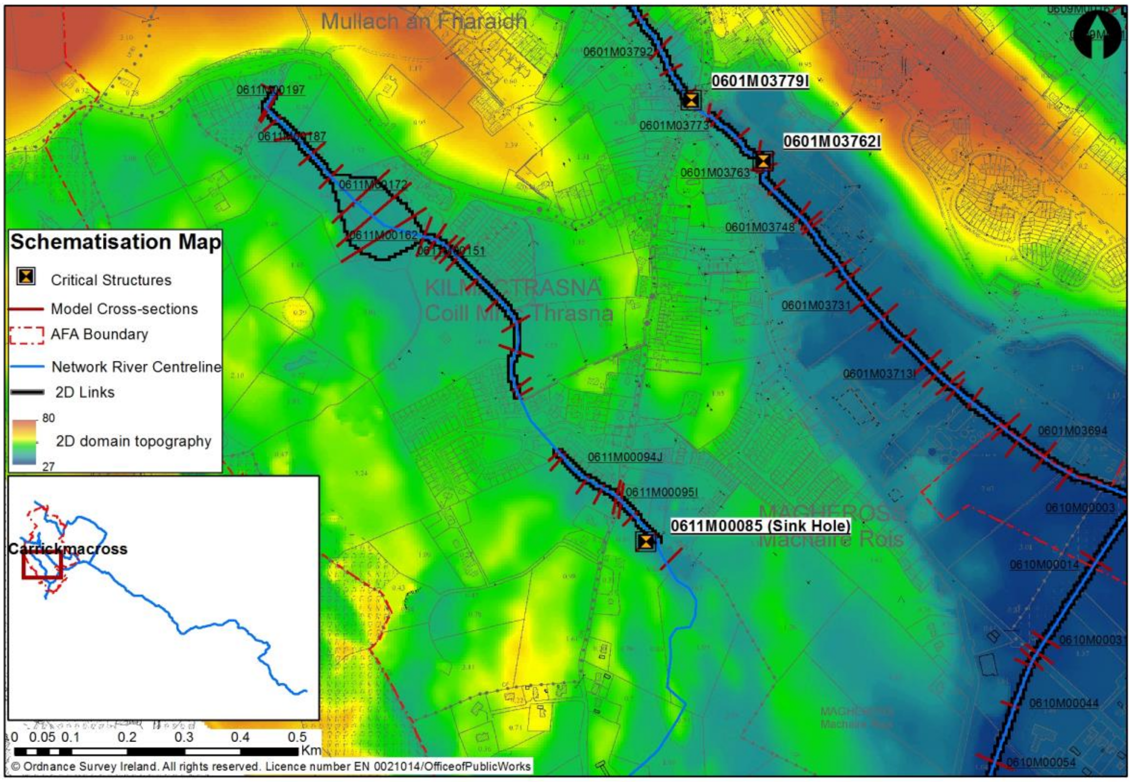



**Figure 4.3.8: Detailed Area of Model Schematisation showing Critical Structure (4 of 5)**

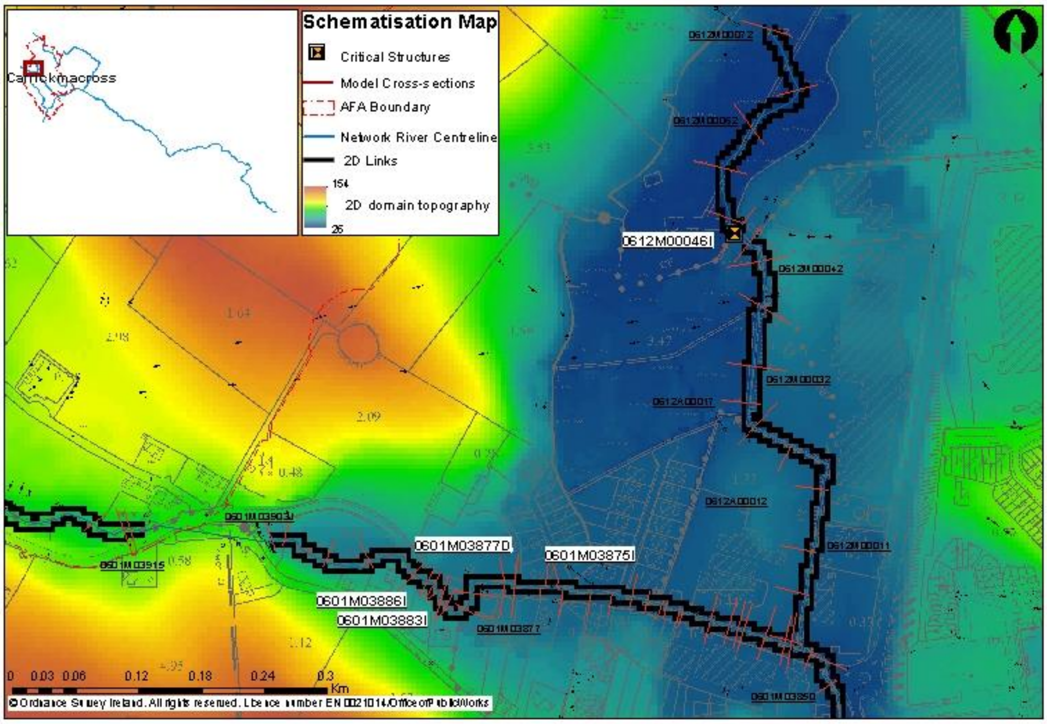



**Figure 4.3.9: Detailed Area of Model Schematisation showing Critical Structure (5 of 5)**

**(8) Survey Information**

**(a) Survey Folder Structure:**

| **First Level Folder** | **Second Level Folder** | **Third Level Folder** |
|---|---|---|
| Murphy_NW6_M06_WP6_0608_V1_130315<br>Carrickmacross<br>Murphy: Surveyor Name<br>NW6: North Western CFRAM Study Area, Hydrometric Area 6<br>M06: Model Number 6<br>0608: River Reference<br>WP6: Work Package 6<br>Version: Most up to date<br>130315– Date Issued (15th MAR 2013) | V0_20130308_Ascii | |
| | V0_20130308_GIS | Flood_Plain_Photos_and_Shapefile |
| | V0_20130308_Other | FP Photos |
| | Photos *(Naming convention is in the format of Cross-Section ID and orientation - upstream, downstream, left bank or right bank)* | |

**(b) Survey Folder References:**

| **<u>Reach ID</u>** | **<u>Name</u>** | **File Ref.** |
|---|---|---|
| 0608M | Coolderry | Murphy_NW6_M06_WP6_0608_V1_130315 |
| 0609M | Lisanisk | Murphy_NW6_M06_WP6_0609M_V0_130306 |
| 0610M | Tullynaskeagh | Murphy_NW6_M06_WP6A15_0610M_130306 |
| 0611A | Kilmactrasna TR_2 | Murphy_NW6_M06_WP6_0611A_V1_130306 |
| 0611M | Carrickmacross | Murphy_NW6_M06_WP6_0611M_V1_130227 |
| 0612M | Drummond | Murphy_NW6_M06_WP6A15_V1_0612M_130306 |
| 0601M | R. Glyde | Murphy_NW6_M06_WP6_V1_0601M_C_130306<br>Murphy_NW6_M06_WP6_V1_0601M_B_130313<br>Murphy_NW6_M06_WP6_V1_0601M_A_130313 |
| | | |

**(9) Survey Issues:**

A request for the clarification of survey information between OPW and RPS modeller was as follows.

**<u>On 06/03/2014 15:46, RPS Modeller wrote:</u>**

In Carrickmacross the surveyors state that the original river network showed the reach 0611M continuing south from Magheross and into the reach 0610M. This is not the case on the ground. There does not appear to be a connection between the upper area of reach 0611M and 0610M. No channel could be found downstream of point A (shown in Figure 4.3.10 below) The lower area is actually a different reach

which they have designated 0611A. This reach flows out of a nature spring at point B. (shown below).


**Figure 4.3.10: Kilmactrasna and Kilmastrasna Tributary**

It seems that there is a sink hole at point A and the watercourse flows underground coming back to the surface at point B. As the surveyors will not be able to survey this we propose assuming there are closed cross sections between point A and B to replicate the sink hole to achieve calibration and noting these assumptions in the hydraulic report. Both watercourses are HPW. Can you please confirm that this is acceptable?

**On 12/03/2014 13:47, OPW wrote:**

It may be a delicate area as very close to point A there is an estate called Foxfield which may/may not flood but I think that this is more a function of the watercourse being culverted under the estate rather than the exact (more downstream) point we are talking about here.

Your proposal outlined seems reasonable and I confirm that this is an acceptable representation/approach.

### 4.3.3 Hydraulic Model Construction

| | |
|---|---|
| **(1) 1D Structures (in-channel along modelled watercourses):** | See Appendix A.1<br>Number of Bridges and Culverts: 54<br>Number of Weirs: 5 |

The survey information recorded includes a photograph of each structure, which has been used to determine the Manning's n value. Further details are included in Chapter 3.5.1. A discussion on the way structures have been modelled is included in Chapter 3.3.4.

The location of critical structures included in the model is presented in Figure 4.3.5 to Figure 4.3.9. Details of these structures are also presented in Appendix A.1.

On the Kilmactrasna at cross-section 0611M00213D, chainage 1385m (Figure 4.3.11) does not have sufficient capacity to convey flow during fluvial events of 0.1% AEP or greater. The surveyors could not find an out flowing channel, this is discussed further in Section 4.3.2 (9).

**Figure 4.3.11: 0611M00085 Looking Downstream**

On the Coolderry watercourse, flooding occurs upstream of the cave inlet 0608M00787 (Figure 4.3.12), located at chainage 157m, inundating the surrounding fields during the 1% AEP and flooding properties upstream during the 0.1% AEP event.

**Figure 4.3.12: Looking Downstream at 0608M00787**

Flooding occurs along the Coolderry River due to a culvert crossing the L4520 road. The culvert (0608M00400D,Figure 4.3.13), is located at chainage 4100m. It restricts flow and causes flooding of the surrounding fields during a 1% AEP event. During a 0.1% AEP event the flooding also impacts the R179 (Donaghmoyne Road).

**Figure 4.3.13 Looking Downstream at 0608M00400D**

On the Coolderry River the capacity of structure 0608M00041I (chainage 7684m) shown in Figure 4.3.14 causes substantial flooding upstream, which impacts the surrounding fields during 1% and 0.1% AEP events.

**Figure 4.3.14: Looking Downstream 0608M00041D**

Flooding occurs along the River Glyde due to the culvert 0601M003886I (Figure 4.3.15) which is located at chainage 819m. This culvert restricts flow causing substantial flooding during the 1% and 0.1% AEP events. This flooding impacts surrounding field and the R178 (Shercock Road).

**Figure 4.3.15: Looking Downstream 0601M03886**

Flooding occurs due to the structure 0601M003883I shown in Figure 4.3.16 (located at chainage 851m). This culvert restricts floe causing flooding during the 0.1% AEP events. This flooding impacts surrounding properties and R178 (Shercock Road).

**Figure 4.3.16: Looking Downstream at 0601M03883I**

On the Glyde River, culvert 0605M03877D (Figure 4.3.17) is located on the upper reaches (at chainage

947m). It restricts flow during 0.1% AEP event resulting in flooding on the left bank, impacting Derryolam Court residential area.

**Figure 4.3.17: Looking Downstream at 0601M03877D**

Flooding occurs on the River Glyde due to the structure 0601M3875I (Figure 4.3.18) located at chainage 979m. This culvert restricts flow during the 0.1% AEP event and contributes to the flooding of properties in Derryolam Court on the left bank.

**Figure 4.3.18: Looking Downstream at 0601M03875I**

On the River Glyde there is flooding upstream of structure 0601M03762I, Figure 4.3.19 (chainage 2097m). This occurs on the left bank, flooding adjacent land.

**Figure 4.3.19: 0601M03762I Looking Downstream**

On the River Glyde, culvert 0601M03779I (chainage 1933m) restricts flow during fluvial events of 10% AEP or greater, resulting in flooding. This impacts the surrounding buildings on both the left and right bank.

**Figure 4.3.20: Looking Downstream at 0601M03779**

On the Drummond watercourse, culvert 0612M00046I is located at chainage 294m. It restricts flow resulting in extensive flooding during 1% and 0.1% AEP events. As shown in Figure 4.3.21 the culvert was surcharged during the survey therefore the inlet is not fully visible.

**Figure 4.3.21: Looking Downstream at 0612M00046I**

| | |
|---|---|
| **(2) 1D Structures in the 2D domain (beyond the modelled watercourses):** | N/A |
| **(3) 2D Model structures:** | N/A |

**(4) Defences:**

| **Type** | **Watercourse** | **Bank** | **Model Start Chainage (approx.)** | **Model End Chainage (approx.)** |
|---|---|---|---|---|
| N/A | | | | |

**(5) Model Boundaries - Inflows:**

Full details of the flow estimates are provided in the Hydrology Report (IBE0700Rp0008_UoM06 Hydrology Report_F01- Chapter 4.6 and Appendix D. The boundary conditions implemented in the model are shown Table 4.3.1.

**Table 4.3.1: Model Boundary Conditions**

| | Boundary Description | Boundary Type | Branch Name | Chainage | Chainage | Gate ID | Boundary ID |
|---|---|---|---|---|---|---|---|
| 1 | Open | Inflow | River Glyde | 4.745 | 0 | | 06_893_5_RA |
| 2 | Open | Inflow | Drummond | 54.545 | 0 | | 06_892_U_RARPS |
| 3 | Distributed Source | Inflow | Drummond | 54.545 | 469.971 | | Top-up flow between 06_892_U_RARPS & 06_892_3_RARPS |
| 4 | Distributed Source | Inflow | Drummond | 469.971 | 746.57 | | Top-up flow between 06_892_3_RARPS & 06_892_1_RA |
| 5 | Distributed Source | Inflow | River Glyde | 4.745 | 2249.086 | | Top-up flow between 06_893_5_RA & 06038_RA |
| 6 | Open | Inflow | Kilmactrasna | 256.912 | 0 | | 06_205_U |
| 7 | Open | Inflow | Tullynaskeagh | 9.478 | 0 | | 06_630_U_RARPS |
| 8 | Distributed Source | Inflow | Tullynaskeagh | 9.478 | 830.204 | | Top-up flow between 06_630_U_RARPS & 06_630_1_RA |
| 9 | Distributed Source | Inflow | Kilmactrasna | 256.912 | 2046 | | Top-up flow between 06_205_U & 06_630_1_RA |
| 10 | Distributed Source | Inflow | Tullynaskeagh | 953.603 | 1975.07 | | Top-up flow between 06_630_1_RA & 06_235_3_RA |
| 11 | Open | Inflow | Lisanisk | 18.624 | 0 | | 06_845_U_RARPS |
| 12 | Distributed Source | Inflow | Lisanisk | 18.624 | 1841.296 | | Top-up flow between 06_845_U_RA & 06_845_3_RA |
| 13 | Open | Inflow | Coolderry | 9.749 | 0 | | 06_896_8_RA |
| 14 | Point Source | Inflow | Coolderry | 5199.648 | 0 | | 06_911_12_RA |
| 15 | Point Source | Inflow | Coolderry | 6200 | 0 | | 06_538_2_RA |
| 16 | Distributed Source | Inflow | Coolderry | 9.749 | 8029.605 | | Top-up flow between 06_896_8_RA & 06_97_2_RA |
| 17 | Distributed Source | Inflow | River Glyde | 2249.086 | 8454.854 | | Top-up flow between 06038_RA & 06_100_2_RA |
| 18 | Point Source | Inflow | River Glyde | 11302.34 | 0 | | 06_602_4_RA |
| 19 | Distributed Source | Inflow | River Glyde | 8454.854 | 11875.256 | | Top-up flow between 06_100_2_RA & 06016_RA |
| 20 | Distributed Source | Inflow | River Glyde | 11875.256 | 14319.578 | | Top-up flow between 06016_RA & 06_571_4_RA |
| 21 | Distributed Source | Inflow | River Glyde | 14319.578 | 17313.089 | | Top-up flow between 06_571_4_RA & 06014_RA |
| 22 | Open | Water Level | River Glyde | 20846.183 | 0 | | Water Level TS downstream |

Details on inflow hydrograph generation are also outlined in IBE0700Rp0008_UoM 06 Hydrology Report_F01.

Figure 4.3.22 shows 1% AEP inflow hydrographs for the upstream HEP on the River Glyde (HEP 06_893_5_RA), Drummond (06_892_U_RARPS), Kilmactrasna (06_205_U) and Tullynaskeagh (06_630_U_RARPS) watercourses. These model nodes are located at the upstream extent of each watercourse where open inflows were applied. The model flow at HEP checkpoints (i.e. intermediate, gauging station and downstream limit HEP(s) was examined during initial development runs - adjustment of timing of inflow hydrographs was not required for anchoring of the model to estimated/gauged flows. Appendix A.3 contains further details of comparison of estimated/gauged flows with simulated flows in the model.

(Please view Section 4.3.4(2) which discusses model updates for Final)

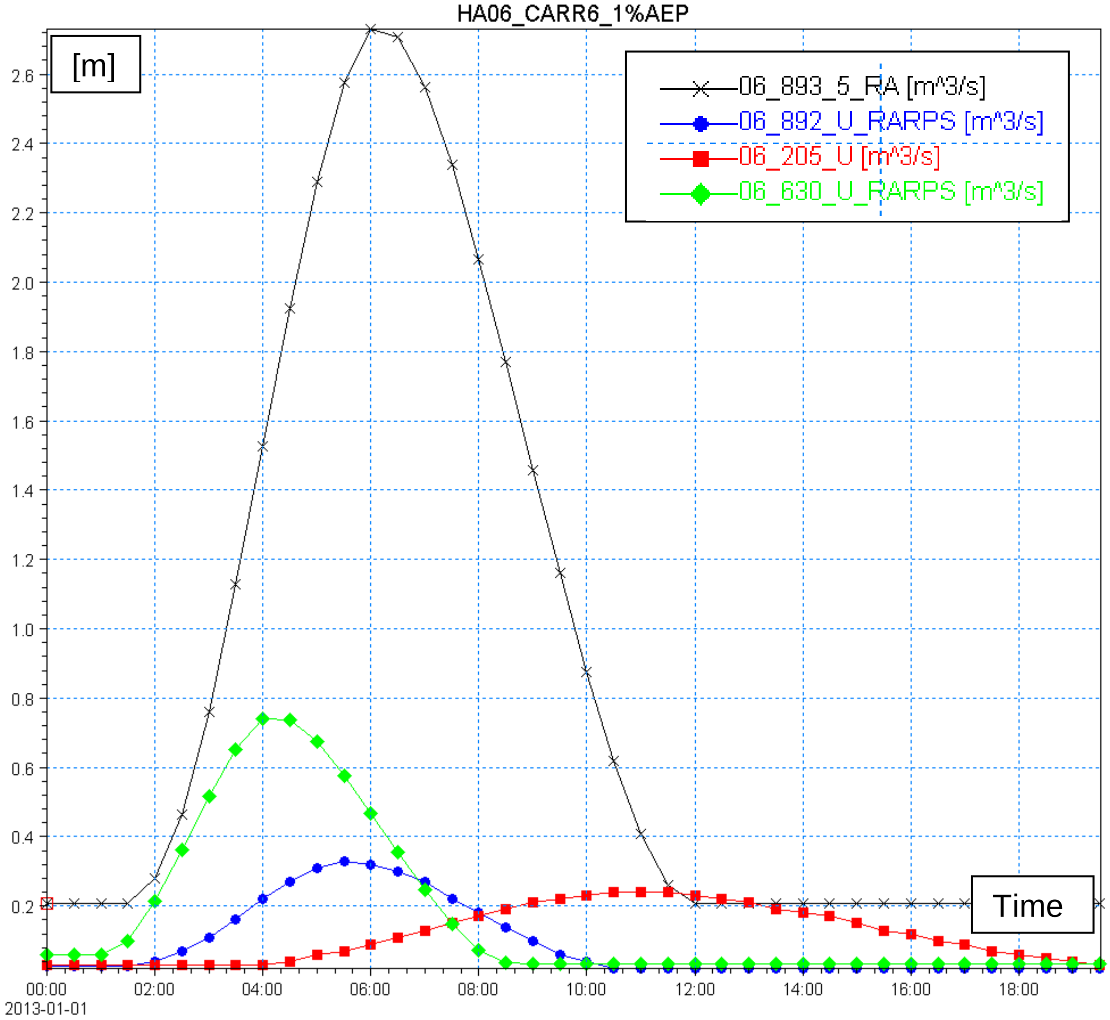



**Figure 4.3.22: 1% AEP Upstream Inflow Hydrographs**

| | |
|---|---|
| **(6) Model Boundaries – Downstream Conditions:** | A water level boundary was used at the downstream model extent on the River Glyde (chainage 20846m). The water level time series values from the downstream model, the Annagassan model (chainage 15806m) were used as the downstream boundary conditions. |

<table>
<tr><td></td><td colspan="2">

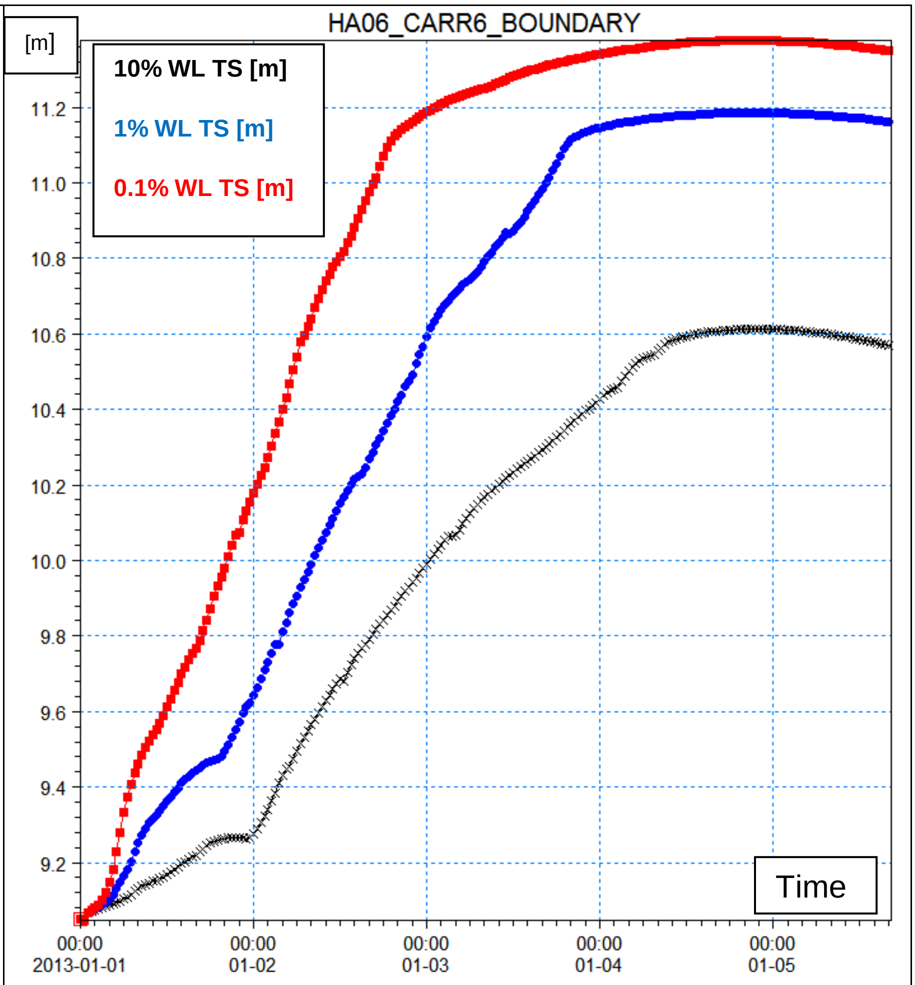



**Figure 4.3.23: Downstream Boundary (Water Level Time Series) for each AEP event at River Glyde (Chainage 20789m)**

</td></tr>
<tr><td colspan="3">(7) Model Roughness: (see Chapter 3.6.1 'Roughness Coefficients')</td></tr>
<tr><td>(a) In-Bank (1D Domain)</td><td>Minimum 'n' value: 0.030</td><td>Maximum 'n' value: 0.075</td></tr>
<tr><td>(b) MPW Out-of-Bank (1D)</td><td>Minimum 'n' value: 0.030</td><td>Maximum 'n' value: 0.040</td></tr>
<tr><td>(c) MPW/HPW Out-of-Bank (2D)</td><td>Minimum 'n' value: 0.030<br>(Inverse of Manning's 'M')</td><td>Maximum 'n' value: 0.071<br>(Inverse of Manning's 'M')</td></tr>
<tr><td colspan="3"></td></tr>
</table>

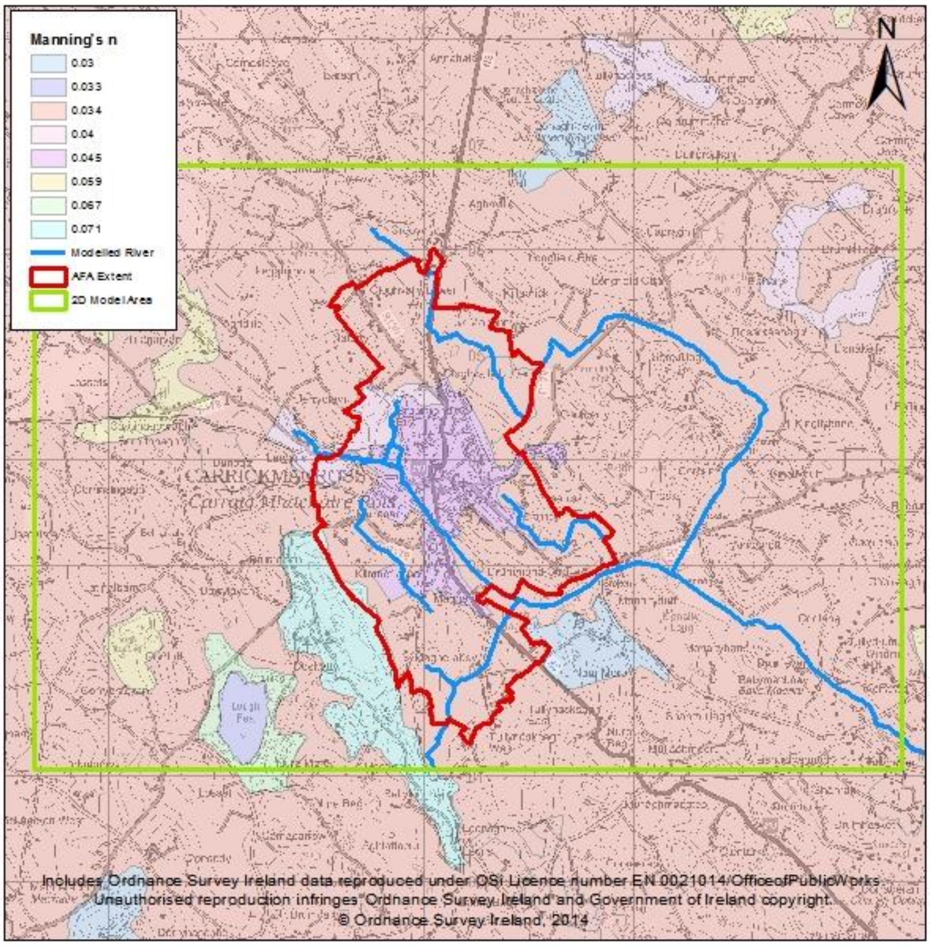



**Figure 4.3.24: Map of 2D Roughness (Manning's n)**

Figure 4.3.24 illustrates the roughness values applied within the 2D domain of the model. Roughness in the 2D domain was applied based on land type areas defined in the Corine Land Cover Map with representative roughness values associated with each of the land cover classes in the dataset. Null Manning's M values on inland water bodies were corrected to Manning's n of 0.033.

**(d) Examples of In-Bank Roughness Coefficients**

**Figure 4.3.25: River Drummond - 0612M00032_UP**

Manning's n = 0.070

Natural stream - Sluggish reach, weedy, deep pools

**Figure 4.3.26: Tullynaskeagh - 0610M00077_UP**

Manning's n = 0.045

Natural stream - clean, winding, some pools and shoals.

(Please view Section 4.3.4(2) which discusses model updates for Final)

**Figure 4.3.27:** River Coolderry - 0608M00043_UP

Manning's n = 0.040

Natural stream - weedy, winding, some pools and shoals.

**Figure 4.3.28: River Glyde - 0601M01837_UP**

Manning's n = 0.030

Natural stream - clean, winding, deep pools and shoals.

### 4.3.4 Sensitivity Analysis

To be completed for final version of report.

### 4.3.5 Hydraulic Model Calibration and Verification

**(1) Key Historical Floods** (From IBE0700Rp0003_UoM Inception report) unless otherwise specified):

(a) **NOV 1980.**

The Irish Times reported that on 17th November 1980, several houses and business premises in Carrickmacross were flooded, while the Castleblaney Road was closed due to flood waters, as a consequence of heavy rain.

The location at which the rainfall was recorded is not stated and it may be anecdotal, therefore it is not possible to estimate with any accuracy frequency of the event. Records from Carrickmacross (Dunoge) daily rainfall station were checked. These records indicate that 18.4mm of rain fell within a 24 hour period, which equates to a rainfall event frequency of 90.9% AEP using the FSU DDF model. However this estimate is based on assumed 24 hour duration since higher temporal resolution is not available at daily rainfall stations.

The peak flow at Tallanstown (06014), the nearest gauging station, on 17th November 1980 was 7.98m$^3$/s. This flood event equates to an AEP fluvial event that is significantly less than $Q_{med.}$

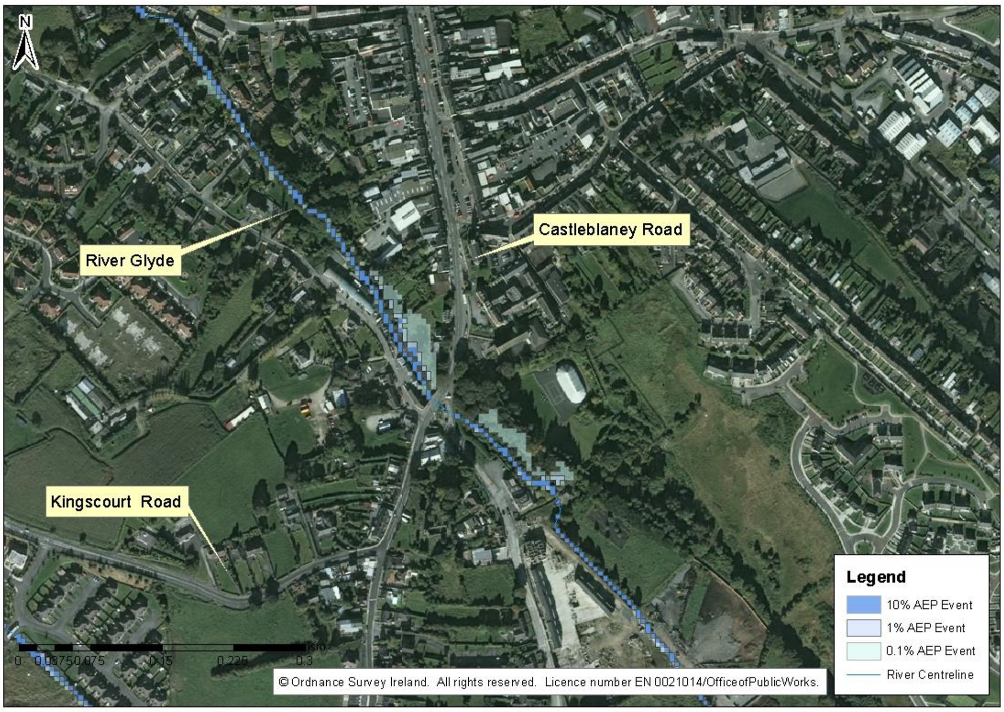



**Figure 4.3.29: Modelled Flood Extents for all AEP Events**

The modelled flood extent shows flooding off the Castleblaney Road during the 1% and 0.1% AEP scenarios as shown in Figure 4.3.29 but the road itself was not flooded.

(b) **DEC 1978.**

The Irish Times reported a flooding incident that occurred around Carrickmacross on

29th December 1978, following a period of intense heavy rainfall. The Ballybay (R180), Shercock (R183) and Castleblayney (R178) roads from Carrickmacross were flooded, with reports of 1.2m of water on the Ballybay (R180) road.

Tallanstown (06014) is the nearest gauging station located at the downstream limit of the model on the River Glyde. The recorded peak flow on 30th December 1978 was 39.40$m^3$/s. This is the largest flow recorded among 36 AMAX records and equates to a 1.81% AEP fluvial event.

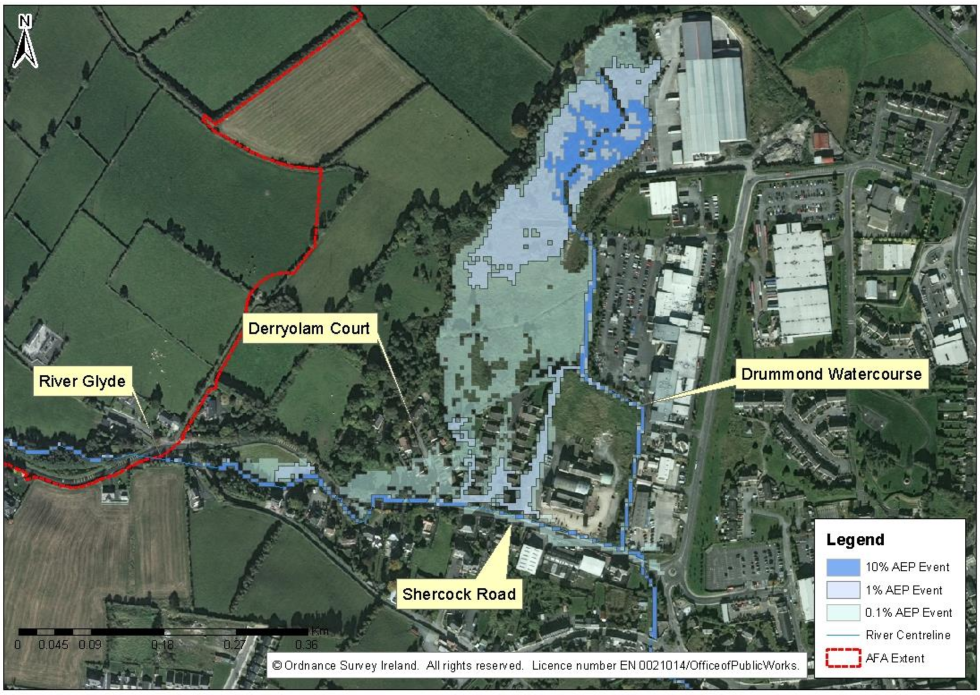



**Figure 4.3.30: Modelled Flood Extents for all AEP Events**

The modelled flood extents illustrate that there is extensive flooding along the Shercock Road during 1% and 0.1% AEP events as shown in Figure 4.3.30 which compares with the Irish Times report and provides some verification of the model. Similarly the reported flooding along the Castleblayney Road is reflected in the model during 1% AEP and 0.1% AEP design events as previously shown shown in Figure 4.3.29. Again this provides some verification of the model. However the model does not show flooding as reported along the Ballybay road (R180) as there are no modelled watercourses in the vicinity.

**Summary of Calibration**

The Carrickmacross model is not well calibrated since there is a limited amount of historical flooding accounts. Only two press reports extracted from the 'Irish Times', describe incidents of road, residential and business flooding in 1978 and 1980. The weakness with using these reports is that there is a lack of spatial reference, particularly street names. Whilst several road names have been given, a precise location has not provided. However there is some model verification in that roads reported to have flooded in 1978 (which was estimated as 1.8% AEP fluvial event), do flood during 1% and 0.1% AEP design event simulations.

No other relevant historical flooding data was identified. Despite the lack of calibration and verification data, the model is considered to be performing satisfactorily for design event simulation.

Model flows were checked against the estimated flows at HEP check points where possible to ensure the model is well anchored to the hydrological estimates. For example at Tallanstown Gauging Station 06014_RA, the estimated flow during the 1% AEP event is 41.31$m^3$/s and the modelled flow is 41.59$m^3$/s. A good correlation is found at many of the HEP check points but a noticeable difference is present in the Tullynaskeagh and Lisanisk tributaries. This is discussed further in Appendix A.3.

A mass balance calculation was carried out to quantify the quality of the model results, a mass balance plot was conducted to analyse the difference between the model discharge volume input compared to the output. Results showed a difference of -1.78%. Although, the Mass Balance assessment of this model, has indicated that there is a slight discrepancy between the flow in, the volume stored and the flow out, this result is still within the acceptable limits. Refer to Chapter 3.11 for details of acceptable limits.

There are minor instabilities located along the River Glyde may give rise to this calculated discrepancy. These instabilities do not impact the peak flow or water level of the model results overall and are discussed further in Section 4.3.6 (2). The difference of -1.78% is therefore deemed acceptable.

**(2) Post Public Consultation Updates:**

Following informal public consultation and formal S.I. consultation periods in 2015, the following changes were made to the model.

There were various changes to some of the hydraulic inputs. The peak for the Top-up flow between 06_892_3_RARPS & 06_892_1_RA was increased from 0.012 to 0.016. The hydrograph for 06_845_U_RARPS had its initial value changed from 0.01 to 0.1 to increase stability at the start of the model. The peak for the Top-up flow between 06_845_U_RA & 06_845_3_RA was increased from 1 to 1.8. For the following hydrographs, the duration over which the flood event occurs was increased, with peak flows remaining the same, to increase the volume of water in the model and subsequently increase flooding in the required areas:

- 06_893_5_RA
- 06038_RA
- Top-up between 06_893_5_RA & 06038_RA
- 06205_U

- 06_630_U_RARPS
- 06_630_1_RA
- Top-up between 06_630_U_RARPS & 06_630_1_RA
- 06_235_3_RA
- Top-up between 06_205_U & 06_630_1_RA
- Top-up between 06_630_1_RA & 06_235_3_RA

Manning's n of culvert 0610M00035I on the Tullynaskeag River, was increased from 0.013 to 0.025.

Manning's n of culvert 0610M00076I along the same river was increased from 0.013 to 0.017.

Manning's n values were increased for cross-sections along the Tullynaskeag River to increase flooding in the area.

Minor edits were also applied to the bathymetry file in the M21 model.

A revised set of flood hazard and flood risk mapping has been issued as Final to reflect these changes.

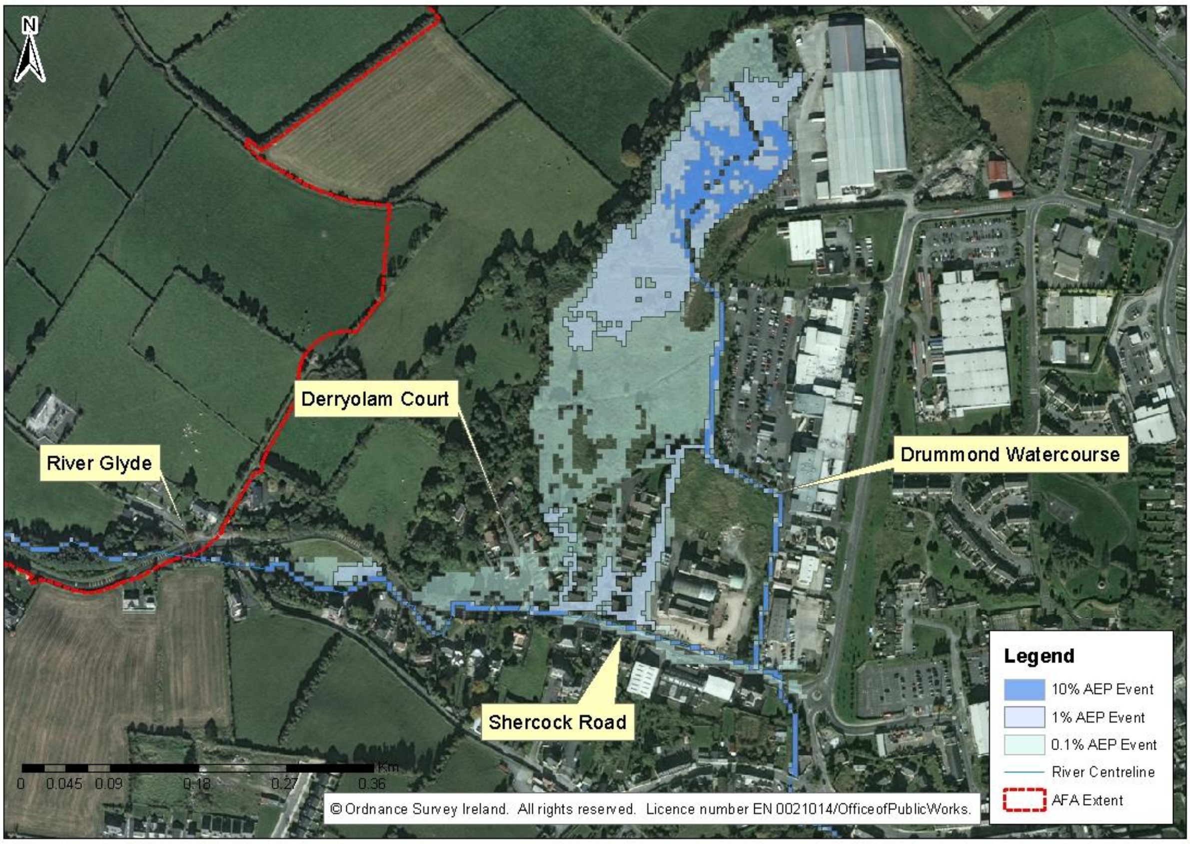



**Figure 4.3.31: Modelled Flood Extents for all AEP Events**

**(3) Standard of Protection of Existing Formal Defences:**

| Defence Reference | Type | Watercourse | Bank | Modelled Standard of Protection (AEP) |
|---|---|---|---|---|
| NA | | | | |

**(4) Gauging Stations:**

The only gauging station in the Carrickmacross model is Tallanstown (06014). This station is located at the model downstream extent on the River Glyde. Tallanstown is an OPW maintained station, with over 40 years of data; it has also been rated as A1 under FSU protocol. As stated in Section 4.3.2 (1) Gauging stations 06038_RA at Drummond and 06016_RA Nicholastown were redefined as Intermediate HEPs as no data is available.

The rating for this gauging station is excellent for flows in the range of 0.13-31.8 $m^3/s$, and therefore provides a good indication of the relationship for the estimated $Q_{med}$ of 21.46 $m^3/s$. The survey provides a cross-section at the gauge location, although the centre of the channel could not be surveyed due to dangerously fast flow. A point was added to the centre of the channel in order to deepen the bed by approximately 300mm and align the zero points of the existing rating curve and the model curve. This assumption was considered to be reasonable as the station is located on MPW, and the approach taken was approved by OPW on 28/02/2014.

Comparing the modelled Q-h relationship and the rating curve, as shown in Figure 4.3.32, it can be seen that there is good correlation between the curves, and they are always within 400mm of each other as required for MPWs. A Manning's n value of 0.013 at the weir was required in order to produce the Q-h relationship shown below. This value is within the normal range for a concrete lined section.

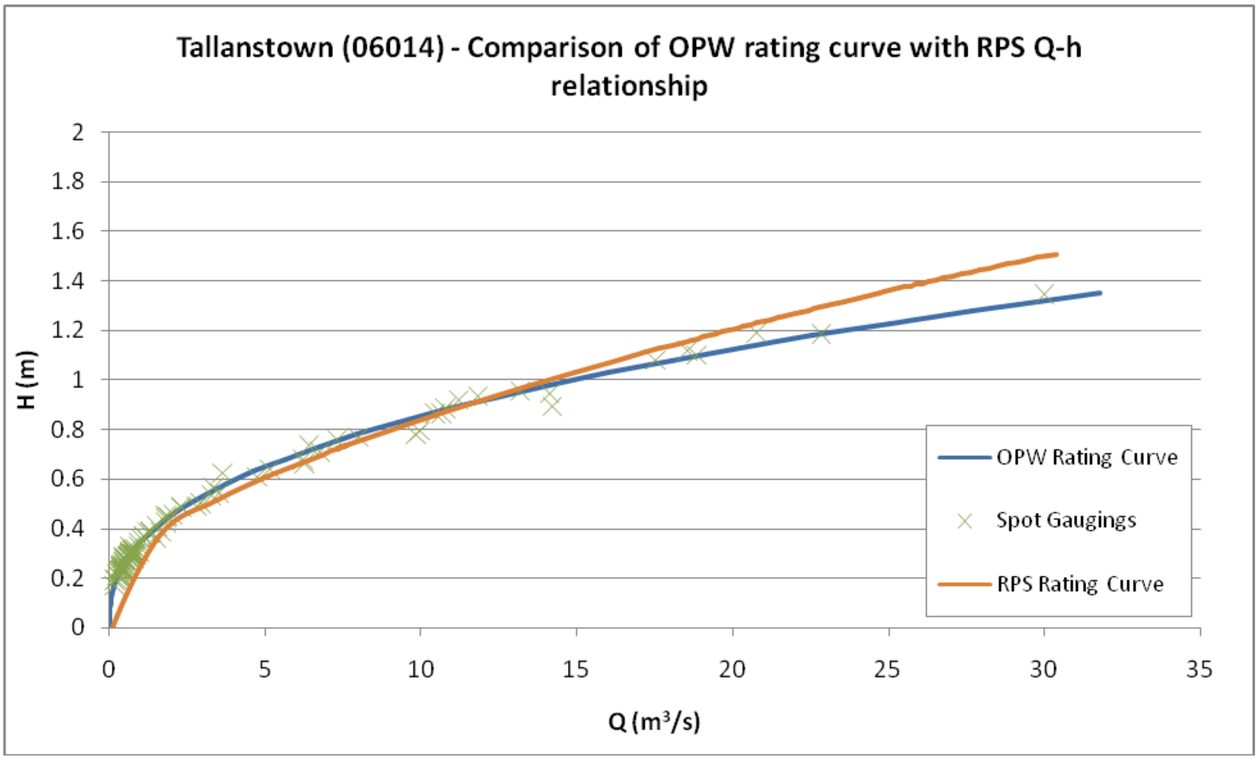



**Figure 4.3.32: Comparison of Existing OPW Rating Curve and Modelled Q-h**

**(5) Other Information:**

None

### 4.3.6 Hydraulic Model Assumptions, Limitations and Handover Notes

**(1) Hydraulic Model Assumptions:**

(a) A sink hole located (0611M) Kilmactrasna (chainage 1385m to 1995m) was modelled as a long culvert. Refer to Section 4.3.2 (9).

(b) A cave inlet in the upstream reach of the Coolderry watercourse was modelled as a long culvert. The upstream cross-section was surveyed at the natural cave inlet. The river goes underground at cross-section 0608M00787, (ch. 157m) this section of the reach is 295m in length. There was no visible opening at the downstream face, it is possibly covered by a landslide with water flowing from the bottom of the hill's face, through a mound of piled stone. No cross section was surveyed due to dense vegetation, fallen rocks and trunks in the channel. The closest cross section 0608M00758 (ch. 478m) was relocated 25m downstream.

**Figure 4.3.33: At Cross Section 0608M00787 Looking downstream at the cave inlet**

(c) Several cross-sections were added to prevent bed level differences. These include, Kilmactrasna (chainage 2046m); Kilmactrasna Tributary 2 (chainage 340m); Lisanisk (chainage 350m);Tullynaskeagh (chainage 940m); River Glyde (chainage 940m, 1084m, 1230m, 3036m, 3265m, 4096m and 4635m).

(d) The in-channel roughness coefficients were selected based on normal bounds using photos received from the survey and have been reviewed during the calibration process - it is considered that the final selected values are representative.

(e) The Drummond Tributary contained only two sections, as access could not be obtained to survey downstream of section 0612A00012 due to the area being heavily overgrown and a 2m high fence and wall either side of the channel. This branch was excluded from the model since it contained no structures and was hydraulically insignificant. This was considered acceptable as the watercourse was blocked at the downstream extent showing no evidence of it flowing into the River Glyde.

(f) It has been assumed that all culverts and screens are free of debris and sediment.

(g) There are minor instabilities along the River Glyde, at chainage 3470m and 7136m during all design runs. It was not possible to eradicate these instabilities, so a review of their significance was undertaken. These instabilities are caused by the increase/decrease in bed level. This causes the discharge to flicker, however it should be noted that there is no impact on the peak water levels. See Appendix A.2 for the location of all instabilities.

**(2) Hydraulic Model Limitations and Parameters:**

(a) The calibration of the model could be improved if more historical information was available.

(b) A grid resolution of 5 metres has been selected. It is considered that the 5m resolution is best suited for modelling purposes. It is recognised that some detail relating to Carrickmacross AFA may have been too small of a resolution to be 'picked up' by LiDAR information e.g. fences, walls, paths and minor roads. Consequently, it is recognised that complex hydraulic processes of a finer resolution may not be represented in this model.

(c) Observed flooding to rural roads and outlying properties may be represented less accurately than within the AFA. The MPW is modelled using cross section data only. It was found during the Draft modelling stage that the cross sections did contain enough data on the left and right banks. As water levels increased, the floodplain could not be accurately represented as water was not able to spill as required. During the draft final modelling stage, the necessary cross-sections on the River Glyde from chainage 5850m were extended with the use of the NDHM to provide enough information of the floodplain and allow water to spill as necessary. Background mapping from the NDHM was applied to the MPW which allowed for more accurate floodplain representation between the 1D cross sections. This methodology is further discussed in Chapter 3.

(d) Cross sections along the Drummond watercourse could not be surveyed due to very dense woodland that was flooded at the time of survey. Multiple channels of similar size were found but no defined channel could be located

(e) The model has not currently undergone sensitivity testing.

**MIKE 11**

| | |
|---|---|
| Timestep (seconds) | 1 |
| Wave Approximation | High Order Fully Dynamic |
| Delta | 0.85 |

| **MIKE 21** | |
|---|---|
| Timestep (seconds) | 1 |
| Drying / Flooding (metres) | 0.02 / 0.03 |
| Eddy Viscosity (and type) | Constant eddy formulation varying in space based on equation $0.02\Delta x^2/\Delta t$. |
| **MIKE FLOOD** | |
| Link Exponential Smoothing Factor<br>(where non-default value used) | All default (1) |
| Lateral Length Depth Tolerance (m)<br>(where non-default value used) | All default (0.1) |
| | |
| **(3) Design Event Runs & Hydraulic Model Handover Notes:** | |

(a) The Network and Cross Section files linked to the Mike 11 setup are identical for all event runs.

(b) The model runs best when the Mike 11 initial condition is set to Steady State.

(c) The influence of the Carrickmacross Sewerage Scheme may need to be considered.

(d) The size of the culvert used to replicate the sink hole located on the Kilmactrasna could be reviewed during the sensitivity analysis.

(e) The Upper reaches of the Coolderry watercourse can convey flows up to 0.1% AEP, localised flooding occurs here due to the constraining effects of cross-section 0608M00787 at chainage 157m, as shown in Figure 4.3.34.

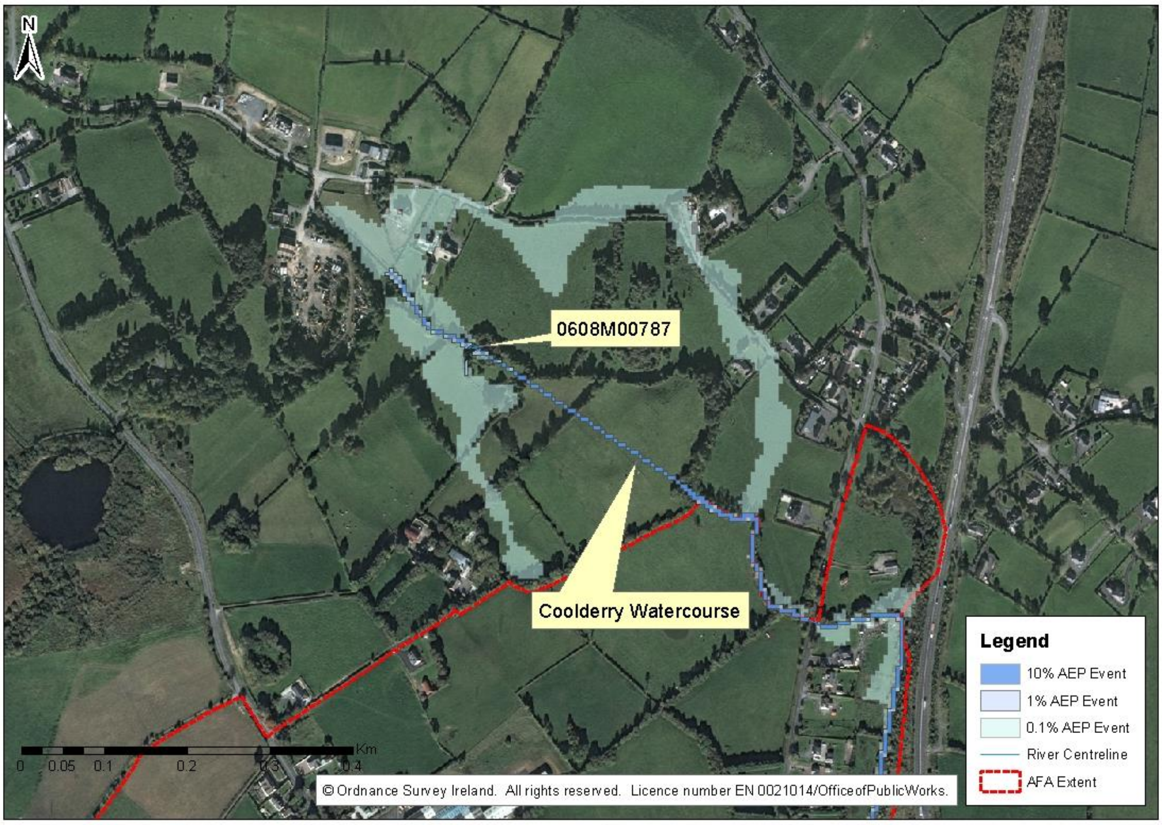



**Figure 4.3.34: Modelled Flood Extents along the Upper reaches of the Coolderry for all AEP Events**

(f) Further downstream the channel has insufficient capacity to convey flows of 1% or greater. Many of the structures along the downstream extent constrict flows of 1% and 0.1% AEP causing the surrounding areas to flood, as shown in Figure 4.3.35


**Figure 4.3.35: Modelled Flood Extents along the Coolderry during all AEP Events**

(g) The modelled flood extents have illustrated that there is some flooding at the junction of Castleblaney Road and Mullinary road this is due to the culvert 0601M03779I at chainage 1933m on the River Glyde constricting the flow at higher return periods.

(h) Flooding occurs in the upper reaches of the River Glyde adjacent to the Shercock Road (R178), this is due to the insufficient capacity of a series of structures at return periods greater than 1% AEP, These structures include 0601M03886I (ch.819m), 0601M3883I (ch.851m) and 0601M03877D (ch.947m). This has an impact on surrounding roads and properties, as shown in Figure 4.3.36.

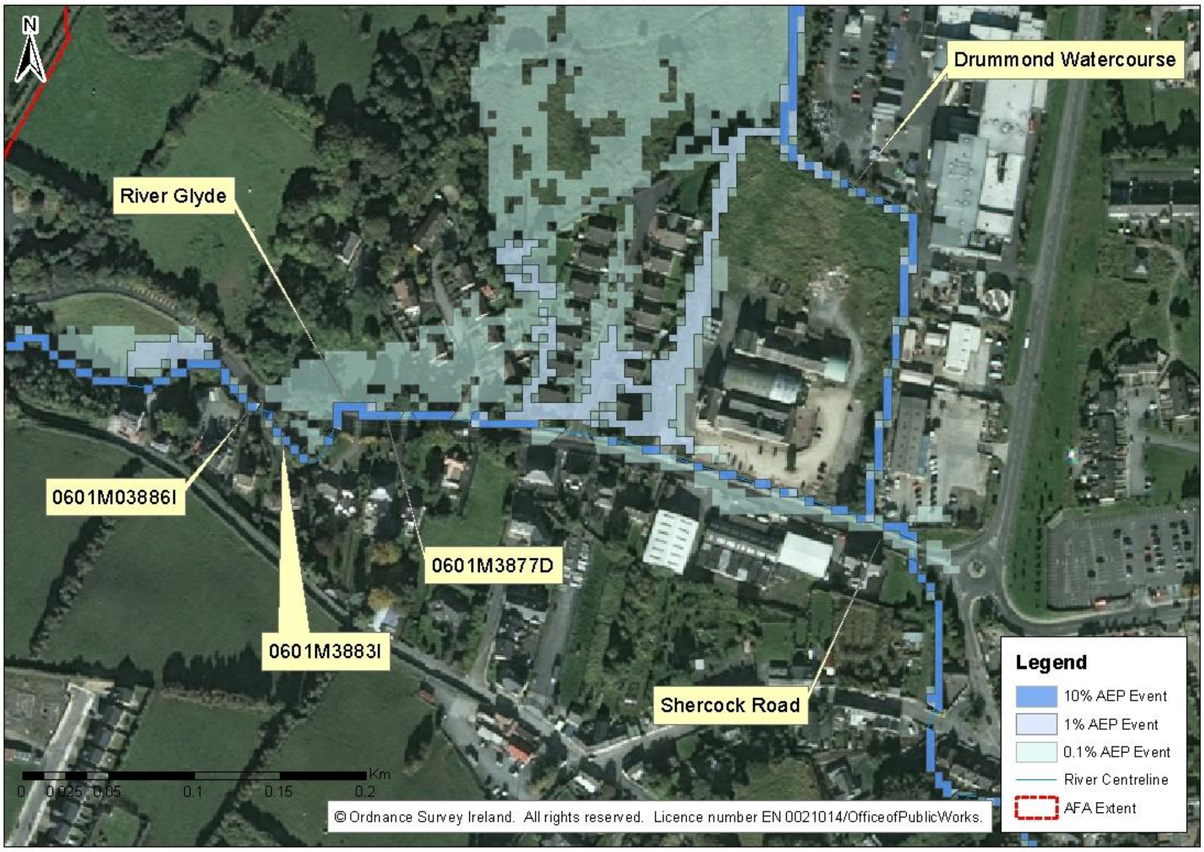



**Figure 4.3.36: Modelled Flood Extents for all AEP Events**

(i) The Drummond watercourse shows extensive flooding upstream at 10%, 1% and 0.1% AEP events due to the structure 0612M00046I at chainage 294m restricting the flow and the channel having insufficient capacity, as shown in Figure 4.3.37.

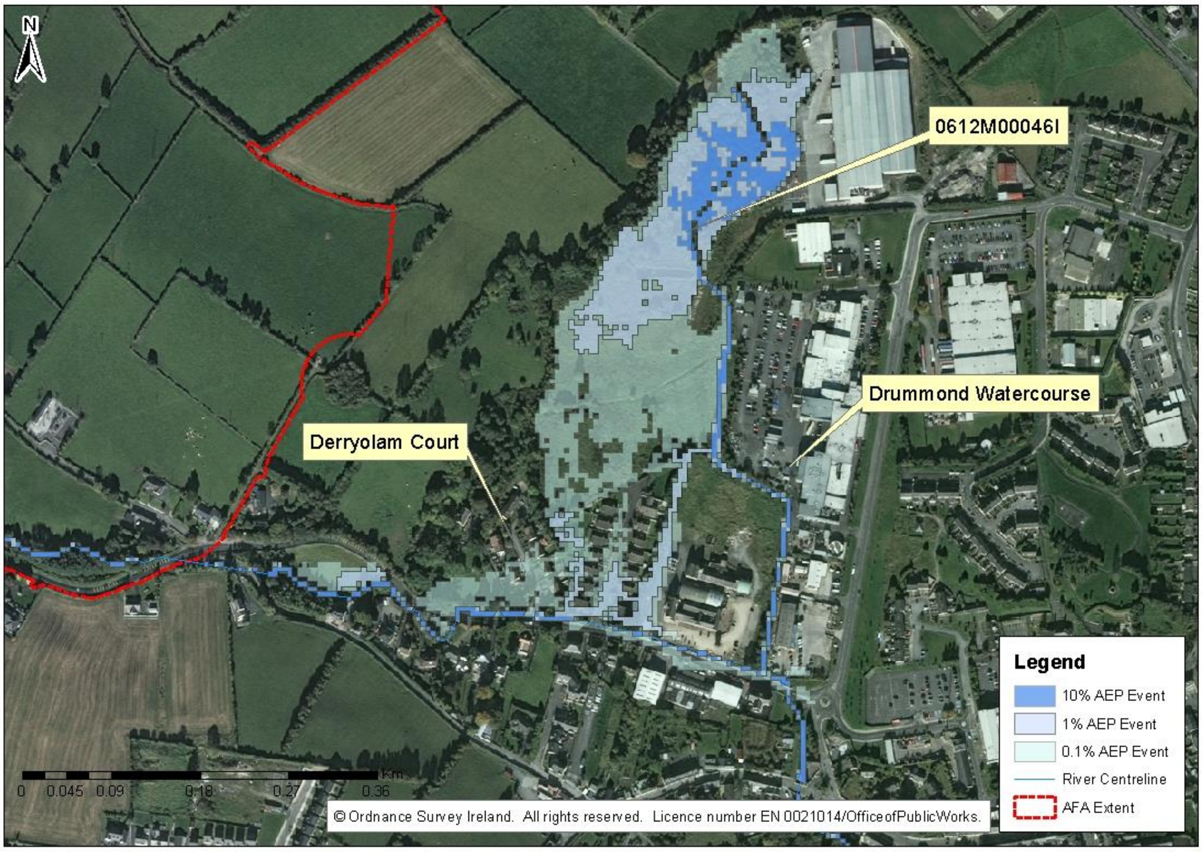



**Figure 4.3.37: Modelled Flood Extents for all AEP Events**

(j) There are some instabilities within the model as discussed within the Hydraulic Model Limitations and Parameters Section. All of the instabilities occur at structures where there is an increase in bed level and occur along The River Glyde. The instabilities cause a slight fluctuation in water level but do not have an overall impact on the flood extent.

**(4) Hydraulic Model Deliverables:**

Please see Appendix A.4 for a list of all model files provided with this report.

**(5) Quality Assurance:**

| | |
|---|---|
| Model Constructed by: | Jen Canavan |
| Model Reviewed by: | Stephen Patterson |
| Model Approved by: | Andrew Jackson |

# APPENDIX A.1

| **Structure Details – Bridges and Culverts** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **RIVER BRANCH** | **CHAINAGE** | **ID**** | **LENGTH (m)** | **OPENING SHAPE** | **HEIGHT (m)** | **WIDTH (m)** | **SPRING HEIGHT FROM INVERT (m)** | **MANNING'S n** |
| River Glyde | 6467.201 | 0601M03325D_struct | 6.00 | Archx2 | 30.32, 30.34 | 3.79, 3.84 | 4.55, 4.65 | 0.02 |
| River Glyde | 7146.853 | 0601M03258D_struct | 8.20 | Archx3 | 28.84, 29.06, 28.84 | 2.41, 3.32, 2.3 | 3.3, 3.6, 3.3 | 0.02 |
| River Glyde | 8469.195 | 0601M03126D_struct | 7.30 | Archx1 | 28.84 | 4.67 | 3.2 | 0.02 |
| River Glyde | 14851.419 | 0601M02487D_struct | 9.50 | Archx1 | 24.2 | 11.1 | 5.6 | 0.013 |
| River Glyde | 2097.428 | 0601M03762I_struct | 3.60 | Archx1 | 32.1 | 1.52 | 1.6 | 0.02 |
| River Glyde | 2106.12 | 0601M03761D_struct | 1.20 | Irregularx1 | 32.5 | 2.25 | N/A | 0.013 |
| River Glyde | 3965.035 | 0601M03576D_struct | 8.40 | Archx1 | 30.12 | 6.82 | 3.76 | 0.02 |
| COOLDERRY | 724.404 | 0608M00731D_struct | 13.00 | Archx2 | 41.28, 41.33 | 1.68, 1.56 | 1.92, 1.89 | 0.025 |
| COOLDERRY | 2846.751 | 0608M00521D_struct | 3.30 | Irregularx1 | 34.2 | 2.38 | N/A | 0.02 |
| COOLDERRY | 3294.577 | 0608M00479D_struct | 2.85 | Irregularx1 | 33.31 | 2.27 | N/A | 0.02 |
| COOLDERRY | 4099.572 | 0608M00400D_struct | 7.95 | Archx1 | 32.32 | 2.05 | 2.03 | 0.02 |

| Structure Details – Bridges and Culverts | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **RIVER BRANCH** | **CHAINAGE** | **ID**** | **LENGTH (m)** | **OPENING SHAPE** | **HEIGHT (m)** | **WIDTH (m)** | **SPRING HEIGHT FROM INVERT (m)** | **MANNING'S n** |
| COOLDERRY | 4586.234 | 0608M00352D_struct | 12.25 | Archx2 | 32.96, 32.96 | 1.75, 1.66 | 2.6, 2.58 | 0.02 |
| COOLDERRY | 6782.785 | 0608M00132D_struct | 8.05 | Archx3 | 30.33, 30.35, 30.24 | 1.48, 2.16, 1.46 | 2.16, 2.24, 2.17 | 0.02 |
| COOLDERRY | 7696.303 | 0608M00041D_struct | 24.26 | Archx3 | 27.43, 27.59, 27.73 | 1.04, 1.62, 1.14 | 1.38, 1.56, 1.38 | 0.02 |
| Lisanisk | 1224.67 | 0609M00059I_struct | 3.17 | Circularx1 | 32.7 | 0.5 | N/A | 0.013 |
| Lisanisk | 1510.405 | 0609M00034D_struct | 3.69 | Archx1 | 29.51 | 0.78 | 0.36 | 0.02 |
| Lisanisk | 1711.637 | 0609M00015I_struct | 19.78 | Archx1 | 28.14 | 1.29 | 1.3 | 0.02 |
| Lisanisk | 1795.054 | 0609M00007D_struct | 13.45 | Archx1 | 27.71 | 0.98 | 1.17 | 0.02 |
| *Lisanisk | 1045.72 | 0609M00082I | 84.61 | Circularx1 | 1.5 | 1.5 | N/A | 0.02 |
| KILMACTRASNA | 1278.389 | 0611M00095I_struct | 8.50 | Archx1 | 35.51 | 0.9 | 0.96 | 0.02 |
| *KILMACTRASNA | 1385 | Inserted- as discussed in report | 610 | Circularx1 | 0.8 | 0.8 | N/A | 0.013 |
| River Glyde | 826.766 | 0601M03886I_struct | 7.00 | Irregularx1 | 40.15 | 1.81 | N/A | 0.02 |
| River Glyde | 850.512 | 0601M03883I_struct | 8.00 | Archx1 | 40.07 | 2.82 | 0.87 | 0.02 |

| Structure Details – Bridges and Culverts | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **RIVER BRANCH** | **CHAINAGE** | **ID**** | **LENGTH (m)** | **OPENING SHAPE** | **HEIGHT (m)** | **WIDTH (m)** | **SPRING HEIGHT FROM INVERT (m)** | **MANNING'S n** |
| River Glyde | 898.961 | 0601M03881I_struct | 11.00 | Archx1 | 40.07 | 2.82 | N/A | 0.02 |
| River Glyde | 947.355 | 0601M03877D_struct | 6.00 | Archx2 | 39.24, 39.19 | 1.07, 1.77 | 0.63, 0.72 | 0.02 |
| River Glyde | 979.392 | 0601M03875I_struct | 15.00 | Irregularx1 | 38.73 | 3.88 | N/A | 0.02 |
| River Glyde | 1045.481 | 0601M03868I_struct | 16.00 | Irregularx1 | 38.35 | 2.27 | N/A | 0.02 |
| River Glyde | 1097.698 | 0601M03863I_struct | 13.58 | Irregularx1 | 37.97 | 2.2 | N/A | 0.02 |
| River Glyde | 1157.732 | 0601M03856I_struct | 9.00 | Irregularx1 | 37.67 | 1.91 | N/A | 0.02 |
| River Glyde | 1259.319 | 0601M03846I_struct | 11.00 | Archx2 | 36.33, 36.31 | 1.21, 1.12 | 0.81, 0.93 | 0.02 |
| River Glyde | 1362.955 | 0601M03836D_struct | 11.00 | Archx3 | 36.14, 36.07, 36.02 | 1.1, 2.95, 2.11 | 0.79, 1.06, 0.62 | 0.02 |
| River Glyde | 1377.139 | 0601M03834I_struct | 4.50 | Irregularx1 | 37.1 | 2.51 | N/A | 0.02 |
| River Glyde | 1597.448 | 0601M03812I_struct | 5.50 | Archx1 | 36.84 | 2.66 | 2.12 | 0.02 |
| River Glyde | 1678.046 | 0601M03804I_struct | 4.66 | Irregularx1 | 35.67 | 2.66 | N/A | 0.013 |
| Tullynaskeagh | 1664.987 | 0610M00035I_struct | 15.10 | Archx1 | 28.69 | 1.81 | 2.13 | 0.013 |
| Drummond | 302.057 | 0612M00046I_struct | 15.50 | Circularx1 | 36.4 | 0.9 | N/A | 0.013 |

| Structure Details – Bridges and Culverts | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **RIVER BRANCH** | **CHAINAGE** | **ID**** | **LENGTH (m)** | **OPENING SHAPE** | **HEIGHT (m)** | **WIDTH (m)** | **SPRING HEIGHT FROM INVERT (m)** | **MANNING'S n** |
| KILMACTRASNA | 293.721 | 0611M00194I_struct | 4.00 | Irregularx1 | 36.28 | 0.31 | N/A | 0.02 |
| KILMACTRASNA | 691.624 | 0611M00155I_struct | 23.00 | Circularx1 | 36.26 | 1.0 | M/A | 0.013 |
| Lisanisk | 212.575 | 0609M00164I_struct | 33.46 | Circularx1 | 35.23 | 0.5 | N/A | 0.013 |
| Lisanisk | 811.516 | 0609M00106I_struct | 30.88 | Circularx1 | 35.53 | 1.5 | N/A | 0.013 |
| Lisanisk | 930.669 | 0609M00094I_struct | 30.38 | Circularx1 | 35.39 | 1.5 | N/A | 0.013 |
| Lisanisk | 1009.61 | 0609M00087I_struct | 48.57 | Circularx1 | 35.18 | 1.5 | N/A | 0.013 |
| Tullynaskeagh | 1245.646 | 0610M00076I_struct | 32.70 | Circularx1 | 28.06 | 1.2 | N/A | 0.013 |
| River Glyde | 18118.314 | 0601M02161D_struct | 7.90 | Archx2 | 15.85, 15.88 | 5.61, 5.51 | 2.9, 2.7 | 0.013 |
| *River Glyde | 525 | 0601M03913I_struct | 127 | Circularx2 | 45.891,45.864 | 1.0 | N/A | 0.013 |
| *River Glyde | 1933 | 0601M03779I_struct | 31.35 | Arch | 35.41 | 0.83 | 35.18 | 0.025 |
| *River Glyde | 2592.679 | 0601M03713I_struct | 27.52 | Irregularx1 | 29.816 | 2.93 | N/A | 0.02 |
| *River Glyde | 3847.426 | 0601M03587I_struct | 85.574 | Irregularx1 | 29.225 | 7.95 | N/A | 0.013 |
| River Glyde | 2336.64 | 0601M03747I_struct | 87.3 | Irregularx1 | 30.246 | 3.6 | N/A | 0.025 |

| Structure Details – Bridges and Culverts | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **RIVER BRANCH** | **CHAINAGE** | **ID**** | **LENGTH (m)** | **OPENING SHAPE** | **HEIGHT (m)** | **WIDTH (m)** | **SPRING HEIGHT FROM INVERT (m)** | **MANNING'S n** |
| *COOLDERRY | 157 | 0608M00787_struct | 295.27 | Irregularx1 | 43.08 | 2.5@ widest points | N/A | 0.025 |
| *COOLDERRY | 1125 | 0608M00691I_struct | 43 | Circularx3 | 38.935, 38.981, 39006 | 1.5 | N/A | 0.013 |
| *COOLDERRY | 1355 | 0608M00668I_struct | 69.74 | Circularx3 | 38.254, 38.409,38.356 | 1.5 | N/A | 0.013 |
| *COOLDERRY | 1465 | 0608M00659I_struct | 50 | Irregularx1 | 37.486 | 2.94 | N/A | 0.02 |
| COOLDERRY | 1625 | 0608M00644I_struct | 65 | Irregularx1 | 36.159 | 2.97 | N/A | 0.02 |

* Denotes structures incorporated as closed cross-sections only (and therefore not included in the Network file).

** Structure ID Key:

D – Bridge Upstream Face

E – Bridge Downstream Face

I – Culvert Upstream Face

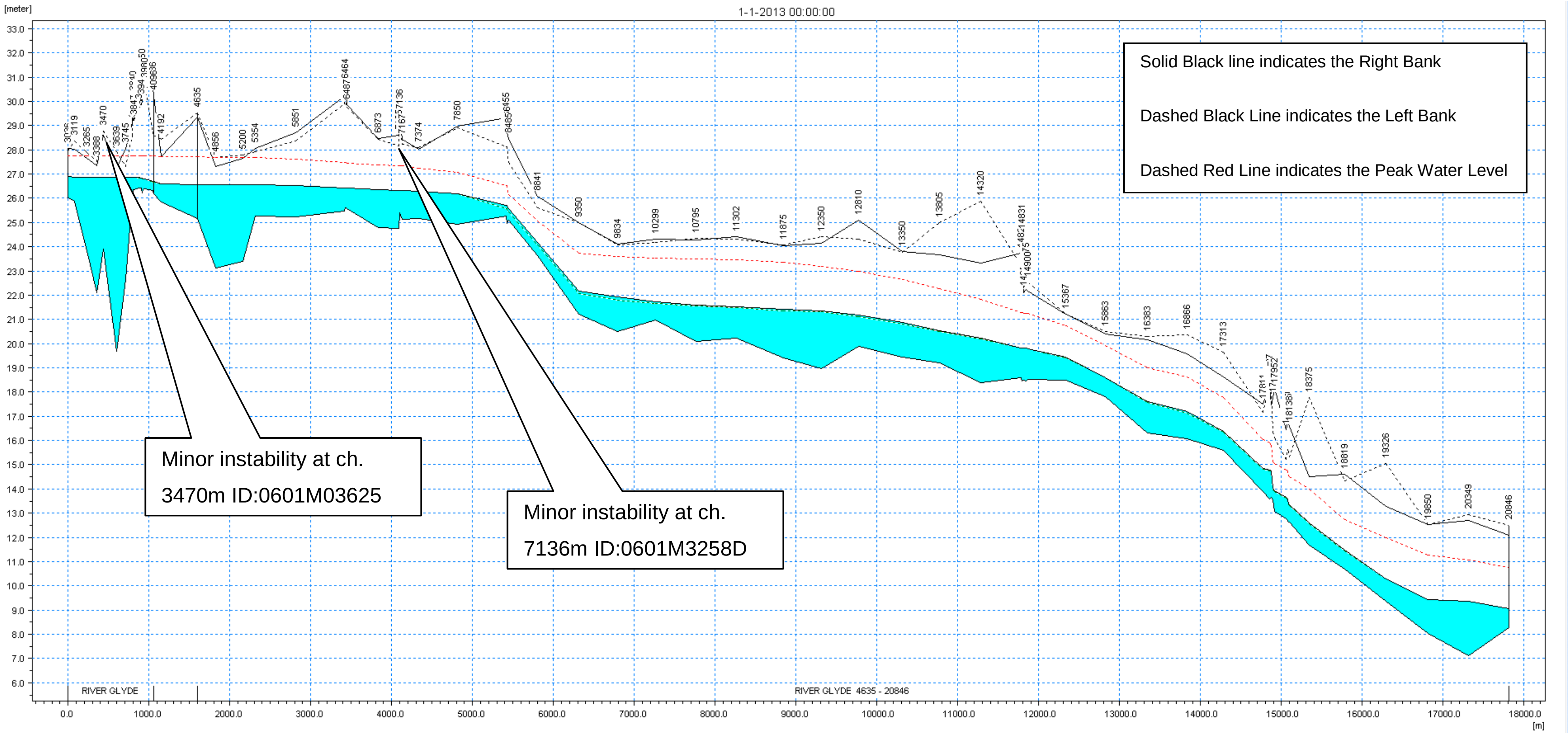
J – Culvert Downstream Face

| **1D Structures modelled in the 2D domain**<br>Structure Details - Weirs: | | | | |
|---|---|---|---|---|
| **RIVER BRANCH** | **CHAINAGE** | **ID** | **TYPE** | **MANNING'S n** |
| COOLDERRY | 1450 | 0608M00659W Weir | Broad Crested Weir | 0.04 |

| | | | | |
|---|---|---|---|---|
| COOLDERRY | 1526 | 0608M00653W Weir | Broad Crested Weir | 0.04 |
| COOLDERRY | 1610 | 0608M00644W Weir | Broad Crested Weir | 0.04 |
| COOLDERRY | 1700 | 0608M00634W Weir | Broad Crested Weir | 0.04 |
| RIVER GLYDE | 17920 | 0601M02180W Weir | Broad Crested Weir | 0.03 |

NB: All other weirs in the Network file are over topping weirs which form part of a composite structure with the culvert/bridge at the corresponding chainage.

# APPENDIX A.2




**River Glyde 1% AEP Fluvial Flow**

The River Glyde is the largest reach associated with the Carrickmacross model. The above figure shows the 1% fluvial flow along the Glyde River Dee, all instabilities are highlighted and are discussed within Section 4.3.6 (1).

# APPENDIX A.3

**Carrickmacross Peak Flow Table**

| | Peak Water Flows | | | |
|---|---|---|---|---|
| **River Name & Chainage** | **AEP** | **Check Flow ($m^3$/s)** | **Model Flow ($m^3$/s)** | **Diff (%)** |
| **RIVER GLYDE 2133.57** | 10% | 2.51 | 2.26 | -10.16 |
| **06038_RA** | 1% | 4.62 | 3.93 | -15.04 |
| | 0.1% | 8.16 | 6.37 | -21.96 |
| **RIVER GLYDE 11588.8** | 10% | 29.59 | 28.55 | -3.51 |
| **06016_RA** | 1% | 41.31 | 39.28 | -4.91 |
| | 0.1% | 56.27 | 53.25 | -5.37 |
| **RIVER GLYDE 14569.8** | 10% | 29.59 | 29.42 | -0.56 |
| **06_571_4_RA** | 1% | 41.31 | 41.92 | +1.49 |
| | 0.1% | 56.27 | 56.86 | +1.05 |
| **RIVER GLYDE 17919.9** | 10% | 29.59 | 29.69 | +0.33 |
| **06014_RA** *Gauging Stn HEP* | 1% | 41.31 | 42.31 | +2.41 |
| *(Model D/S Limit)* | 0.1% | 56.27 | 57.44 | +2.09 |
| **COOLDERRY 7740.01** | 10% | 7.81 | 8.40 | +7.54 |
| **06_97_2_RA** | 1% | 12.17 | 13.87 | +13.99 |
| | 0.1% | 18.41 | 17.76 | -3.55 |
| **LISANISK 1829.29** | 10% | 0.78 | 0.57 | -26.67 |
| **06_845_3_RA** | 1% | 1.43 | 0.87 | -38.88 |
| | 0.1% | 2.54 | 1.33 | -47.56 |
| **TULLYNASKEAGH 1920.06** | 10% | 1.28 | 1.25 | -2.19 |
| **06_235_3_RA** | 1% | 2.36 | 2.34 | -0.76 |
| | 0.1% | 4.18 | 4.36 | +4.23 |
| **KILMACTRASNA_TRIBUTARY2 312.54** | 10% | 0.64 | 0.60 | -6.41 |
| **06_630_1_RA** | 1% | 1.19 | 1.11 | -6.89 |
| | 0.1% | 2.10 | 1.56 | -25.81 |
| **DRUMMOND 515.46** | 10% | 0.42 | 0.35 | -15.71 |
| **06_892_3_RARPS** | 1% | 0.77 | 0.53 | -30.78 |
| | 0.1% | 1.36 | 2.75 | +101.84 |
| **DRUMMOND 722.903** | 10% | 0.42 | 0.35 | -15.71 |
| **06_892_1_RA** | 1% | 0.78 | 0.53 | -31.79 |
| | 0.1% | 1.37 | 2.74 | +99.64 |

The table above provides details of the flow in the model at HEP intermediate check points. These flows have been compared with the hydrology flow estimation and a percentage difference provided.

At the downstream limit of the model at HEP Gauging Station 06014_RA the model outputs for the 10%, 1% and 0.1% AEP design events compare well with the check flows at this Gauging Station. The

percentage difference is 0.3% during a 10% AEP event, 2.4% during a 1% AEP event and 2.1% during a 0.1% AEP event. The modelled flows are slightly greater than the check flows. Model flows along the Glyde and Tullynaskeagh Rivers are also well anchored to hydrological estimates at checkpoints 06016_RA, 06_571_4_RA and 06_235_3_RA with percentage differences less than 10%.

Model outputs for the 10%, 1% and 0.1% AEP design events have a percentage difference of up to 22% for 0.1% AEP event at check flow 06038_RA. Modelled flows are lower than the check flows due to the flood attenuation effect within the fluvial network upstream being captured more effectively in hydraulic modelling than hydrological estimation. This is also the case at 06_630_1_ RA on the Kilmactrasna Tributary where the modelled flow is up to 26% different than the check flow during the 0.1% AEP event and on the Coolderry River (06_97_2_RA) where the modelled flow is up to 14% different than the check flow during the 1% AEP event.

The HEP checkpoint at the downstream extent of the Lisanisk (06_845_3_RA) ranges up to 48% difference during the 0.1% AEP event, there is less flow recorded in the model than estimated because of the attenuation properties of the online lakes. This is because the effect of lake attenuation is much greater in the model than is reflected in the hydrologically based check flows. The attenuation effect is captured within the hydrological estimates through a FARL (Flood Attenuation of Reservoirs and Lakes) factor within the $Q_{med}$ catchment descriptor equation which is then multiplied by growth factors to arrive at design event estimates. As a result it can be considered that the attenuation performance of each Lough is crudely represented within the hydrological peak flow estimates. It is considered that the performance of Lough attenuation is much better captured through the hydraulic model and the model would indicate that the Lough has a greater attenuating effect than the FARL factor would suggest.

The HEP checkpoints along the Drummond watercourse show a lower modelled flow during the 10% and 1% AEP due to the out-of-bank flooding causing attenuation. For example at 06_892_3_RARPS the percentage difference is -16% during the 10% AEP event. Whereas, the 0.1% AEP checkpoints show a higher modelled flow, for example at checkpoint 06_892_1_RA the modelled flow is +100%. This is due to flood water rejoining the river resulting in double conveyance at this point, giving a significantly higher model flow result.

# APPENDIX A.4

## FLUVIAL MODEL FILES

| MIKE FLOOD | MIKE 21 | MIKE 21 RESULTS |
|---|---|---|
| HA06_CARR6_MF_DES_12_Q10 | HA06_CARR6_M21_DES_3_Q10 | HA06_CARR6_M21_DES_3_Q10.dfs2 |
| HA06_CARR6_MF_DES_12_Q100 | HA06_CARR6_M21_DES_3_Q100 | HA06_CARR6_M21_DES_3_Q100.dfs2 |
| HA06_CARR6_MF_DES_12_Q1000 | HA06_CARR6_M21_DES_3_Q1000 | HA06_CARR6_M21_DES_3_Q1000.dfs2 |
| | HA06_ CARR6_DFS2_Bathy_ DEV_6 (BATHYMETRY)<br>HA06_ CARR6_roughness (RESISTANCE)<br>HA06_BackgroundDEM (HD MAPS BACKGROUND MAPPING) | |

| MIKE 11 - SIM FILE & RESULTS FILE | MIKE 11 - NETWORK FILE | MIKE 11 - CROSS-SECTION FILE | MIKE 11 - BOUNDARY FILE |
|---|---|---|---|
| HA06_CARR6_M11_DES_7_Q10<br>HA06_CARR6_M11_DES_7_Q10.res11<br>HA06_CARR6_M11_DES_7_Q100<br>HA06_CARR6_M11_DES_7_Q100.res11<br>HA06_CARR6_M11_DES_7_Q1000<br>HA06_CARR6_M11_DES_7_Q1000.res11 | HA06_CARR6_NWK_DES_10 | HA06_CARR6_XNS_DES_10 | HA06_CARR6_BND_DES_5_Q10<br>HA06_CARR6_BND_DES_5_Q100<br>HA06_CARR6_BND_DES_5_Q1000 |
| **MIKE 11 - DFS0 FILE** | | **MIKE 11 - HD FILE & RESULTS FILE** | |
| HA06_CARR6_DFS0_Q10<br>HA06_CARR6_DFS0_Q100<br>HA06_CARR6_DFS0_Q1000<br>HA06_HA06_DFS0_WL_TS | | HA06_CARR_DES_5_HD_Q10<br>HA06_CARR6_HD_DES_5_Q10_A.dfs2<br>HA06_CARR6_HD_DES_5_Q10_B.dfs2<br>HA06_CARR_DES_5_HD_Q100<br>HA06_CARR6_HD_DES_5_Q100_A.dfs2<br>HA06_CARR6_HD_DES_5_Q100_B.dfs2<br>HA06_CARR_DES_5_HD_Q1000<br>HA06_CARR6_HD_DES_5_Q1000_A.dfs2<br>HA06_CARR6_HD_DES_5_Q1000_B.dfs2 | |

## GIS DELIVERABLES

| **GIS Deliverables - Hazard** | | |
|---|---|---|
| **Flood Extent Files (Shapefiles)** | **Flood Depth Files (Raster)** | **Water Level and Flows (Shapefiles)** |
| Fluvial<br><br>N15EXFCD001F0<br>N15EXFCD010F0<br>N15EXFCD100F0 | Fluvial<br><br>N15DPFCD001F0<br>N15DPFCD010F0<br>N15DPFCD100F0 | Fluvial<br><br>N15NFCDF0 |
| **Flood Zone Files (Shapefiles)** | **Flood Velocity Files (Raster)** | **Flood Defence Files (Shapefiles)** |
| Fluvial<br>N15ZNFCD001F0<br>N15ZNFCD010F0 | N15VLFCD001F0<br>N15VLFCD010F0<br><br>N15VLFCD100F0 | N/A |
| **GIS Deliverables - Risk** | | |
| **Specific Risk - Inhabitants (Raster)** | **General Risk - Economic (Shapefiles)** | **General Risk-Environmental (Shapefiles)** |
| Fluvial<br><br>N15RIFCCD001<br>N15RIFCCD010 | | |