South Western CFRAM Study

Hydraulics and Flood Mapping Appendices,
Unit of Management 20

February 2015

The Office of Public Works

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SOUTH WESTERN CFRAM STUDY
CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT

Mott MacDonald

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Issue and revision record

Revision	Date	Originator	Checker	Approver	Description	Standard
A	July 2014	M Piggott	R Gamble B O'Connor	R Gamble	Draft	
B	February 2015	M Piggott	R Gamble	R Gamble	Draft Final	

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Appendices

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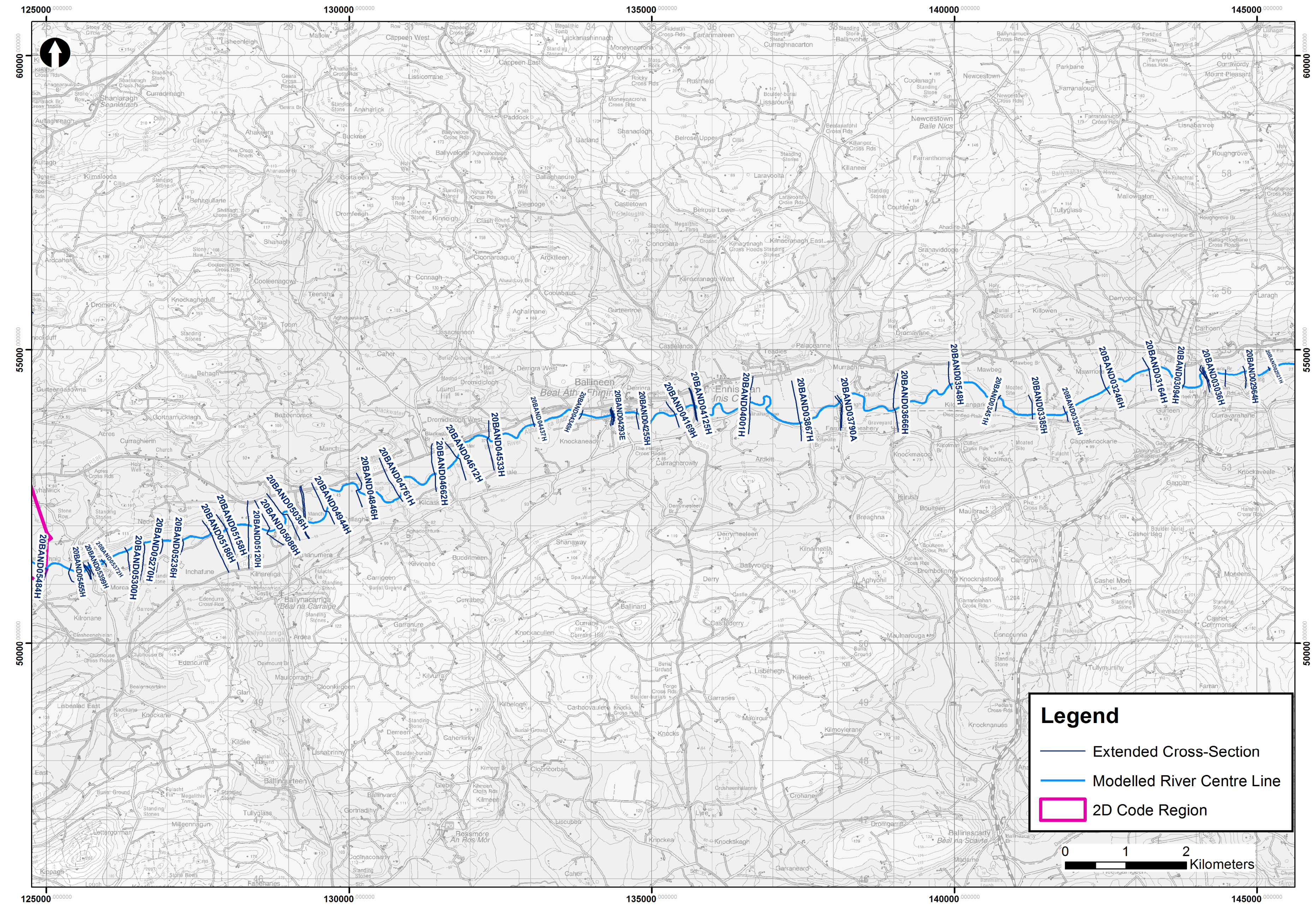
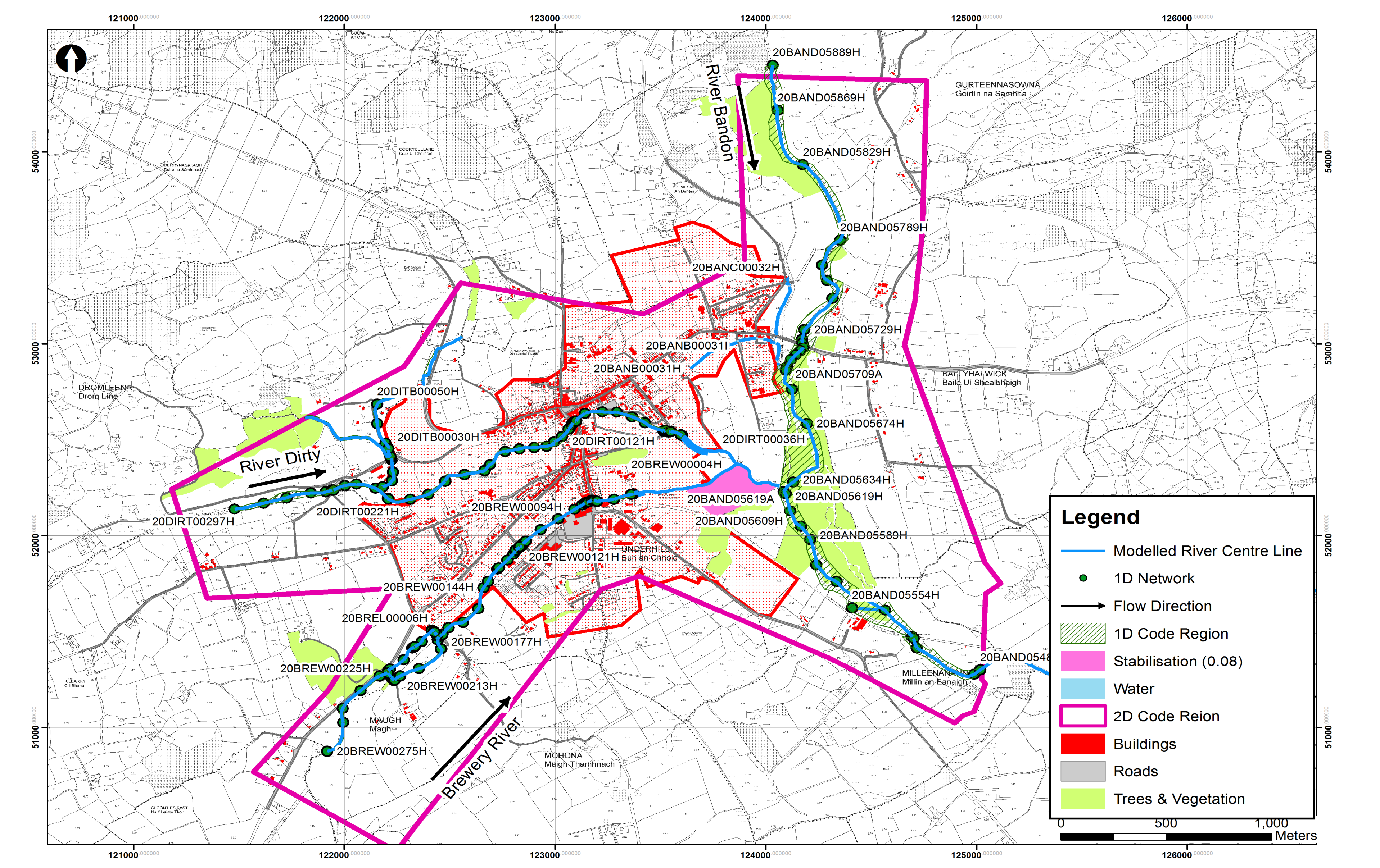
Appendix A. Dunmanway AFA Model Proformas

UOM	20		
AFA/ MPW Reach	AFA-Dunmaway and MPW-Bandon		
Model ID	I123DY		
Purpose of Model Build	Flood Mapping		
Main Watercourse	Bandon, Dirty and Brewery	FLUVIAL RISK	Yes
Length Modelled (km)	37.43	COASTAL RISK	No
2D Domain Area Modelled (km^2)	7.4	VULNERABLE TO WAVES	No

Input Data	
River Channel Topographic Data	River channel survey was undertaken by Murphy Surveys Limited as part of the CFRAM Study. 20DIRT_Dirty_River_V1 surveyed March 2013 : No errors or gaps were found within the survey. 20BREW_Brewery (River)_V1 surveyed January 2013 : No errors or gaps were found within the survey. 20BANB_Bandon_Trib_1_V0 surveyed April 2013 : No errors or gaps were found within the survey. 20BANC_Bandon_Trib_3_V0 surveyed May 2013 : No errors or gaps were found within the survey. 20BAND_B_Bandon_V0 surveyed February 2013 : The three flood relief arches under Long Bridge on the right bank were not included. LiDAR and site photographs have been used to determine the flood relief arch dimensions. 20BALL_Balyhalwick_V0 surveyed April 2013 : No errors or gaps were found within the survey. 20BREL_Brewery Loop_V1 surveyed in January 2013: No errors or gaps were found within the survey. 20DITB_DIrty (Trib)_V1 surveyed December 2012 : No errors or gaps were found within the survey. 20EENA_Dromleena_V1 surveyed January 2013 : No errors or gaps were found within the survey.
Floodplain Topographic Data	Filtered LiDAR DTM " Dunmanway2mdsm.asc" 2m grid resolution was based on data captured in April 2012. The LiDAR covered the entirety of the urban area. The River Bandon downstream of Dunmanway is not covered by LiDAR hence the OSI SAR data was combined with the LiDAR data in Dunmwanay itself to create a single DTM. The DTM for the entire Dunmanway model was compared with the available ground surface data and was subsequently adjusted to match the LiDAR and surveyed bank top levels where there is an overlap. The level adjustment led to small differences between the data sources (typically <0.1m). This DTM has been used to extend river cross-sections across the floodplain.
Map data	1:5000 OSI mapping tiles 6600, 6601 and 6630. The OSI mapping was found to include all current developments and was consistent with site observations, the river channel survey and aerial photography.

Model Build					
General Schematisation	A 1D/2D approach was taken for Dunmanway to model flow along the main watercourses and head loss through hydraulic structures whilst enabling multidirectional flow across the urban areas. The channels of the major tributaries in the urban area of Dunmanway, the River Dirty and Brewery River, are modelled explicitly using surveyed sections from their upstream reaches to their confluence. For model stability, the confluence of the River Dirty and Brewery River and downstream are modelled in the 2D domain to where they join the Bandon. The Bandon flows in a south easterly direction downstream of Dunmanway and then turns eastwards to meander gently through the MPW towards Bandon Town as far as Baxter's Bridge and is represented by a 1D model with extended sections. The flood defence embankment on the right bank of the Bandon near Long Bridge has been represented in the 2D model using a 3D breakline (zln) layer based on the surveyed levels. The 2D domain covers the AFA extent to consider the flood risk associated with the Bandon and main tributaries. The 2D model has a 5m grid size to represent the detailed urban area without compromising run time. Buildings were raised above the floodplain by 0.15m to represent the threshold and then a high Manning's 'n' value of 0.2 applied to represent the storage of the building. This approach means accurate flood depths can be extracted for flood damage analysis. A value of 0.08 was used to represent dense vegetation on the floodplain as shown in the survey photos and site visits which is within the recommended range for "medium to dense brush in the winter". Version D2: The model grid size was set to 5m for the draft final runs. The floodplain the south of the Dirty-Bandon confluence was stabilised by using a Manning's 'n' value of 0.08 to represent the inefficiencies in the flow circulation in this area. Weir coefficients have been made consistent, 1.7 for online spills representing bed drops, 1.1 for over parapet flow and 0.9 for floodplain bypass flow in the downstream reach.				
Software Versions Used	ISIS version 3.6 ESTRY & TUFLOW version 2012-05-AE-iDP-w64				
Total No of 1D nodes	**250**				
Open channel (H)	222				
Bridges (D)	18				
Orifice (o)	7				
Culverts (I)	2				
Weirs (W)	1				
Model Extent	Reach/Feature	Upstream Limit (ING)		Downstream Limit (ING)	
	River Bandon	123999, 55980		145196, 54676	
	River Dirty	121478, 52137		123601, 52519	
	Brewery River	121917, 50876		123372, 52216	
Roughness	Reach/Feature	Active Channel	River Banks	Floodplain	Source
	River Bandon	0.050	0.050 - 0.080	0.060	Schedule 1: Photographs
	River Dirty	0.050	0.050 - 0.080	0.060	Schedule 1: Photographs
	Brewery River	0.050	0.050 - 0.080	0.060	Schedule 1: Photographs
Structures	See Schedule 2 for Hydraulic Structure Parameters				
Upstream boundary	The River Bandon upstream boundary is a lumped inflow located at 20BAND06092H which is approximately 1km upstream of the AFA. Within the AFA there are three lateral inflow boundaries representing the intermediate catchments between the upstream end and Long Bridge, Long Bridge and River Dirty confluence, and River Dirty and Bealaboy Bridge. The River Dirty upstream boundary at 20DIRT00297H is located at the top of the available survey approximately 700m upstream of the AFA. The Brewery River upstream boundary is at 20BREW00275H which is located approximately 800m upstream of the AFA. Lumped catchment inflows at the upstream ends of each river have been located where all flows are within the confined valley and no flows are likely to enter the AFA across the floodplain from further upstream.				
Lateral inflows	The 1D reach of the Bandon between Dunmanway and Bandon has point inflows for major tributaries Bealanscart, Ballingurt, Blackwater, Enniskean and Kilowen. Distributed lateral inflows have been used for intermediate catchments along the Bandon.				
Downstream boundary	The downstream boundary of the Bandon was located at Baxter's Bridge which is approximately 9 km upstream of Bandon (and 24km downstream of Bealaboy). The downstream boundary is a normal depth boundary. The boundary has been set to a channel bed gradient of 1 in 450 which is representative of the reach.				
Run Settings	Unsteady simulation of the full 50 hour hydrograph on the Bandon. The 1D timestep was set to 1s which is divisible in to the 2D timestep of 2s which is less than half the grid cell size as recommended by TUFLOW. All other parameters have been set to default.				


Legend
Extended Cross-Section
Modelled River Centre Line
2D Code Region
0 1 2 Kilometers


River Bandon
River Dirty
Brewery River
20BAND05889H
20BAND05869H
20BAND05829H
20BAND05789H
20BANC00032H
20BAND05729H
20BAND05709A
20BAND05674H
20BAND05634H
20BAND05619A
20BAND05619H
20BAND05609H
20BAND05589H
20BAND05554H
20DITB00050H
20DITB00030H
20DIRT00121H
20DIRT00036H
20DIRT00297H
20DIRT00221H
20BREW00004H
20BREW00094H
20BREW00121H
20BREW00144H
20BREL00006H
20BREW00177H
20BREW00225H
20BREW00213H
20BREW00275H
Legend
Modelled River Centre Line
1D Network
Flow Direction
1D Code Region
Stabilisation (0.08)
Water
2D Code Reion
Buildings
Roads
Trees & Vegetation
0 500 1,000 Meters

SCHEDULE 1 : PHOTOGRAPHS (River Bandon)	SCHEDULE 1 : PHOTOGRAPHS (River Dirty)	SCHEDULE 1 : PHOTOGRAPHS (Brewery River)
Photo 1: Active Channel Upstream of AFA	**Photo 1: Active Channel and Banks Upstream of AFA**	**Photo 1: Active Channel and Banks Upstream of AFA**
		
Photo 2: Floodplain	**Photo 2: Active Channel and Banks within AFA**	**Photo 2: Floodplain with AFA**
		
Photo 3: Floodplain/riverine Area at Long Bridge	**Photo 3: Floodplain Upstream of AFA**	**Photo 3: Active Channel Within AFA**
		
Photo 4: Active Channel and Banks downstream of AFA	**Photo 4: Bank Downstream of AFA**	**Photo 4: Active Channel Within AFA (Urban Area)**
		

SCHEDULE 2: Structures

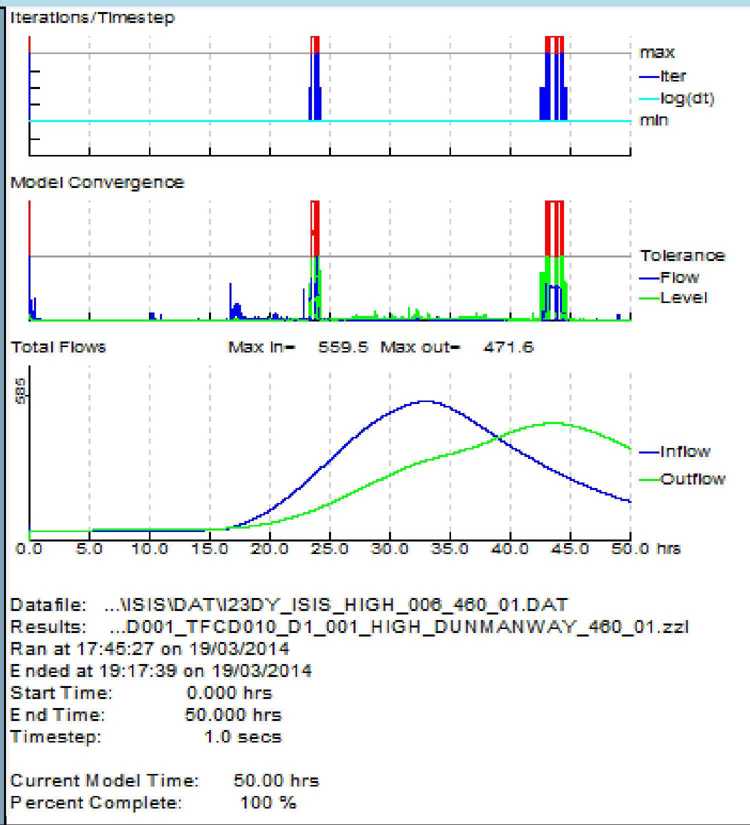
Data file P:\Cambridge\Demeter\EVT4\296241 S West CFRAMS EVT Code\Technical\Hydraulics\Build\I23DY\DESIGN\model\ISIS\I23DY_ISIS_high_006.dat

Node	Easting	Northing	Structure Type	Bridge Parameters				Weir Parameters				Spill Parameters			Culvert Parameters										Comments/ Justification
				Soffit Elevation (mAOD)	No of Openings	Skew Angle	Calibration Coefficients	Crest Elevation (mAOD)	Length	Modular Limit	Velocity Coeff.	Minimum. Crest Elevation (mAOD)	Modular Limit	Weir Coeff.	Soffit level (mAOD)	Invert u/s (mAOD)	Invert d/s (mAOD)	Width/ area (m) (m2)	Length (m)	K	Ki	M	Trash Screen?	Trash Screen coefficient	
20DITB00027D	122207	52454	Arched Bridge	60.725	1	0	1	N/A	N/A	N/A	N/A	59.3	0.9	1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Woodbrook House bridge. Associated Spill units = 0DITB00026S & 20DIT00027S.
												61.1	0.9	1.0											20DIT00027S - Woodbrook House over-bridge spill
DITB00022D1	122222	52413	Arched Bridge	61.5	3	0	1	N/A	N/A	N/A	N/A	61.5	0.9	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Associated Spill unit = 20DITB00022S.
20BREW00120D	122810	51920	Arched Bridge	62.321	2	0	1	N/A	N/A	N/A	N/A	62.2	0.9	1.1	62.18	61.51	61.51	0.848	N/A	N/A	N/A	N/A	N/A	N/A	Associated Spill unit = 20BREW00120S. Associated Orifice Unit = 20BREW00120I.
20BREW00115D	122842	51947	Arched Bridge	62.581	1	0	1	N/A	N/A	N/A	N/A	64.5	0.9	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ros Geal Road bridge = 11.8m wide. Associated Spill unit = 20BREW00115S.
20BREW00078I	123140	52169	Arched Bridge	60.31	1	0	1	N/A	N/A	N/A	N/A	60.6	0.9	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Timber decked bridge. Associated Spill unit = 20BREW00078S.
20BREW00074D	123173	52183	Arched Bridge	60.341	3	0	1	N/A	N/A	N/A	N/A	60.6	0.9	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Park Road Bridge - left arch is not full arch. Made into area-equivalent opening to work in ISIS. Associated Spill unit = 20BREW00074S.
DIRT00251D2	121940	52236	Arched Bridge	60.871	5	0	1	N/A	N/A	N/A	N/A	61.2	0.9	1.1	60.61	59.496	59.496	1.173	N/A	N/A	N/A	N/A	N/A	N/A	RIght side of Kilbarry Road Bridge - rightmost arch not surveyed on d/s face. Copied arch from upstream face. Associated Spill unit = 20DIRT00251S. Associated Orifice Unit = DIRT00251D1.
20DIRT00117D	123084	52586	Arched Bridge	59.14	3	0	1	N/A	N/A	N/A	N/A	60.2	0.9	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Bridge Street Bridge - Left arch springers not level so scaled in ISIS to match surveyed arch area. Associated Spill unit = 20DIRT00117S.
20DIRT00069D	123522	52546	Arched Bridge	57.8	3	0	1	N/A	N/A	N/A	N/A	60.0	0.9	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Sackville Street Bridge - Bridge pier abutments(caps?) used as width of base of arches, 17.156m wide. Associated Spill unit = 20DIRT0069S.
20BAND06057D	124235	55722	Arched Bridge	72.77	6	0	1	N/A	N/A	N/A	N/A	72.2	0.9	0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ardcahan Bridge (Gauge location). Associated Spill units = 20BAND06057S2, BAND06057S1 & 20BAND06056E
												74.2	0.9	1.1											BAND06057S1 - Parapet only - not extended
												70.1	0.9	1.1											20BAND06056E - Spill to represent steep river section d/s of Arcahan Bridge
20BAND05722D	124173	53004	Arched Bridge	59.762	6	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	The Long Bridge - dimensions of the three flood relief arches on the right bank have been estimated and included in ESTRY.
20BAND05520D	124694	51473	Arched Bridge	55.054	3	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Milleenanannig Bridge - Very narrow end-spans not modelled.
20BAND05406D	125662	51290	Arched Bridge	54	6	0	1	N/A	N/A	N/A	N/A	53.9	0.9	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Bealaboy Bridge. Associated Spill units = BAND05406S1 & BAND05406S2
												52.8	0.9	0.8											BAND05406S2 - Floodplain
20BAND04996D	129237	52099	Arched Bridge	47.76	3	0	1	N/A	N/A	N/A	N/A	42.3	0.9	1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Manch Bridge. Associated Spill units = 20BAND04992S, BAND04996S1 & BAND04996S2.
												47.0	0.9	1.1											
												44.7	0.9	0.8											
20BAND04298D	134341	53892	Arched Bridge	38.341	11	0	1	N/A	N/A	N/A	N/A	37.9	0.9	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Ballineen Bridge - dimensions for flood relief arch on left bank estimated from photography and survey. Associated Spill units = BAND04298S1 & BAND04298S2.
												37.0	0.9	0.9											BAND04298S2. - Ballineen Bridge floodplain bypass - road levels from OSI
20BAND04131D	135693	54042	Arched Bridge	34.814	6	0	1	N/A	N/A	N/A	N/A	31.5	0.9	1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Enniskean Bridge. Associated Spill unit = 20BAND04126S, BAND04131S1 & BAND04131S2.
												35.5	0.9	1.1											BAND04131S1 - Enniskean Bridge parapet
												34.2	0.9	0.9											BAND04131S2 - Enniskean Bridge floodplain bypass - road levels from OSI 5000k maps
20BAND03790D	138092	54116	Arched Bridge	31.146	8	0	1	N/A	N/A	N/A	N/A	26.9	0.9	1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Murragh Bridge. Associated Spill units = 20BAnD03786S, BAND03790S1, BAND03790S2.
												31.2	0.9	1.1											BAND03790S1 - Bridge parapet and wall on left bank
												28.8	0.9	0.9											BAND03790S2. - Murragh Bridge floodplain bypass - road levels from NDHM
20BAND03036D	144108	54620	Arched Bridge	24.616	3	0	1	N/A	N/A	N/A	N/A	19.214	0.9	1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Baxter's Bridge. Associated Spill unit = 20BAND03033S, BAND03036S1 & BAND03036S2.
												25.46	0.9	1.1											BAND03036S1 - Baxter's Bridge parapet
												21.417	0.9	0.9											BAND03036S2 - Baxter's Bridge floodplain bypass - road levels from NDHM
20BREW00116W	122829	51937	Weir	N/A	N/A	N/A	N/A	61.461	1	61.461	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Foot Bridge Weir. Crest set to highest point along weir crest to produce highest u/s levels. Low flow notch not modelled.
20BREL00036D	122207	51294	Orifice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	68.46	0.9	1.1	68.47	67.44	67.44	0.923	N/A	N/A	N/A	N/A	N/A	N/A	Farm track culvert. Associated spill = 20BREL00036S.
20BREL00020D	122329	51420	Orifice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	67.915	0.9	1	67.79	66.95	66.95	1.355	N/A	N/A	N/A	N/A	N/A	N/A	Farm field bridge - 2.94m wide. Associated spill = 20BREL00020S
20BREL00004D	122424	51499	Orifice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	66.833	0.9	1.1	66.67	66	66	1.11	N/A	N/A	N/A	N/A	N/A	N/A	Private bridge = 4.74m wide. Associated spill = 20BREL00004S
20BREW00216D	122233	51244	Orifice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	68.264	0.9	1.1	67.96	67.09	67.09	2.091	N/A	N/A	N/A	N/A	N/A	N/A	Track bridge with four low openings - combined flow area - 2.389m² u/s area larger than 2.091m² d/s area. Associated spill = 20BREW00216S
20BREW00180D	122447	51472	Orifice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	66.61	0.9	1.1	66.24	65.08	65.08	2.697	N/A	N/A	N/A	N/A	N/A	N/A	Kilbarry Road bridge - skew flow area = 2.976m² * cos(25°), 5.4m wide. Associated spill = 20BREW00180S

Dunmanway Model Performance

1D Convergence

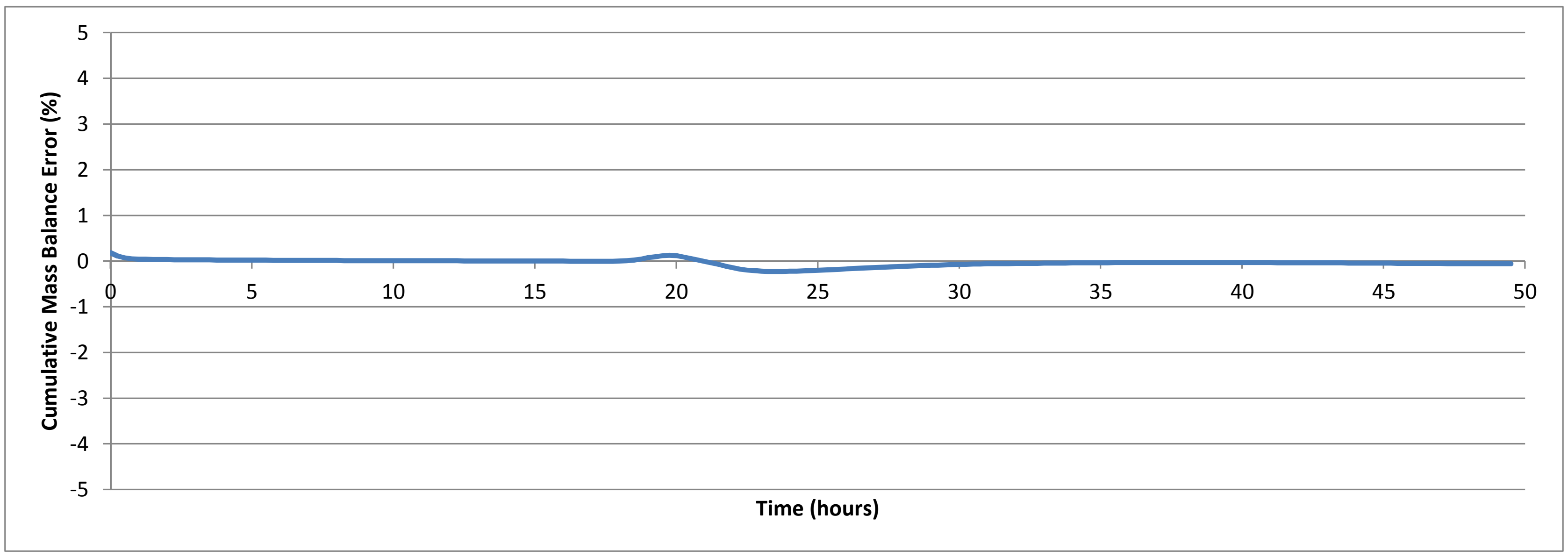
Convergence Plot 0.1% AEP Fluvial Event



Comments: The 1D model components were convergent and within the recommended tolerances for most of the event. The tolerance is exceeded at 23 and 43 hours because of high velocity in the steep approach to the Kilbarry Road Bridge. The instabilities are isolated spatially and are outside of the AFA. They do not affect the rest of the event which converges well.

2D Convergence

Mass Balance Plot 0.1%AEP Fluvial Event



Comments: The 2D model consistently remains within the recommended tolerance of ±1% cumulative mass error throughout the 0.1%AEP fluvial current event. Therefore the 2D results are deemed to be convergent and reliable

Hydrological Performance

Target Flows

HEP ID	Location	Model Node	10% AEP m3/s Design	10% AEP m3/s Modelled	10% AEP m3/s % Difference	1%AEP m3/s Design	1%AEP m3/s Modelled	1%AEP m3/s % Difference	0.1%AEP m3/s Design	0.1%AEP m3/s Modelled	0.1%AEP m3/s % Difference
20_2126_2	Long Bridge Gauge	20BAND05720E	102	107	5%	151	156	3%	222	225	2%
20_2096_1	Bandon- Dunmanway lake downstream	20BAND05712H	103	111	8%	153	167	9%	225	246	9%
20_2093_1	Bandon-Dirty Downstream	20BAND05619H	128	141	10%	197	206	5%	309	298	-4%
20_2140_2	Bealaboy Gauge	20BAND05406A	131	140	7%	201	204	2%	315	292	-7%
20_754_1	Bandon- Bealascartane Downstream	20BAND05285H	138	148	7%	212	213	0%	333	303	-9%
20_742_1	Bandon-Blackwater Downstream (Walter Bridge)	20BAND04612B	166	170	2%	256	250	-2%	401	356	-11%
20_664_3	Bandon upstream of Bandon Town (start of JBA's Bandon Town 1d-2d model)	20BAND02921H	184	177	-3%	283	257	-9%	443	368	-17%

Comments: The flows in the 1D ISIS channel were combined with 2D flows parallel to the channel within the 1D-2D model of the AFA. The 1D ISIS flow were extracted directly from the relevant cross-section in the 1D only reach of the Bandon (downstream of Bealaboy Bridge Gauge).

The model predicted flows were within 10% of the design flows through the AFA to Bealaboy Bridge. The model tended to underestimate design flows at the downstream HEP for the 0.1%AEP fluvial current event. The phasing has been altered to provide the best estimate for the majority of the model at the 1%AEP target event to ensure a consistent set of phasing for all model runs.

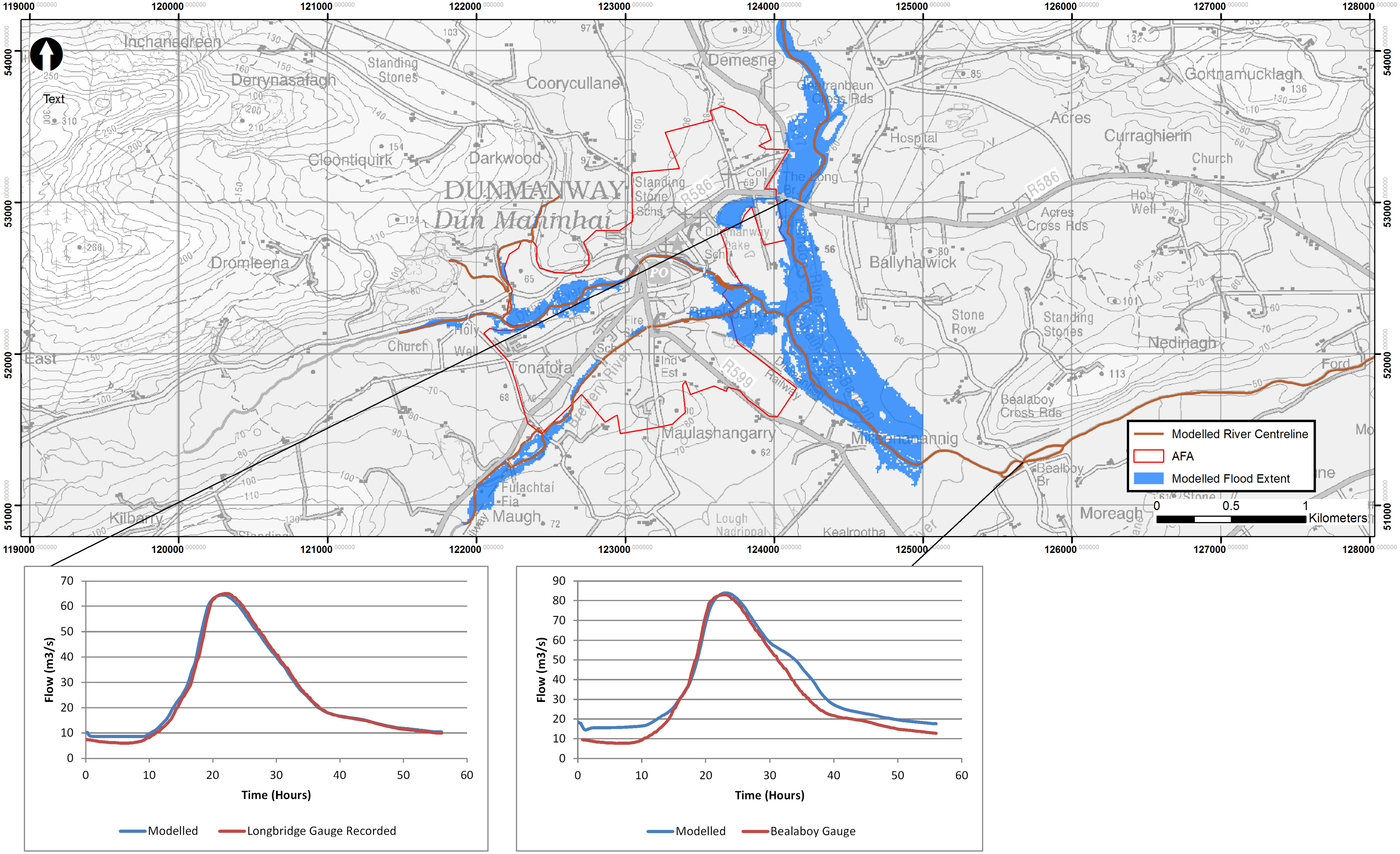
This phasing of inflows means that the peak flowsare underestimated for the 0.1%AEP. However this does not effect the flood risk and extent as the narow valley is already filled by the 1%AEP.The Bandon Flood Alleviation Scheme use the design inflow for the River Bandon through Bandon Town. Therefore this discrepancy does not affect flood risk downstream.

Calibration Event 1: 01 January 1991

Model Run ID: I23DY_FCC01011991_D2_high_Dunmanway

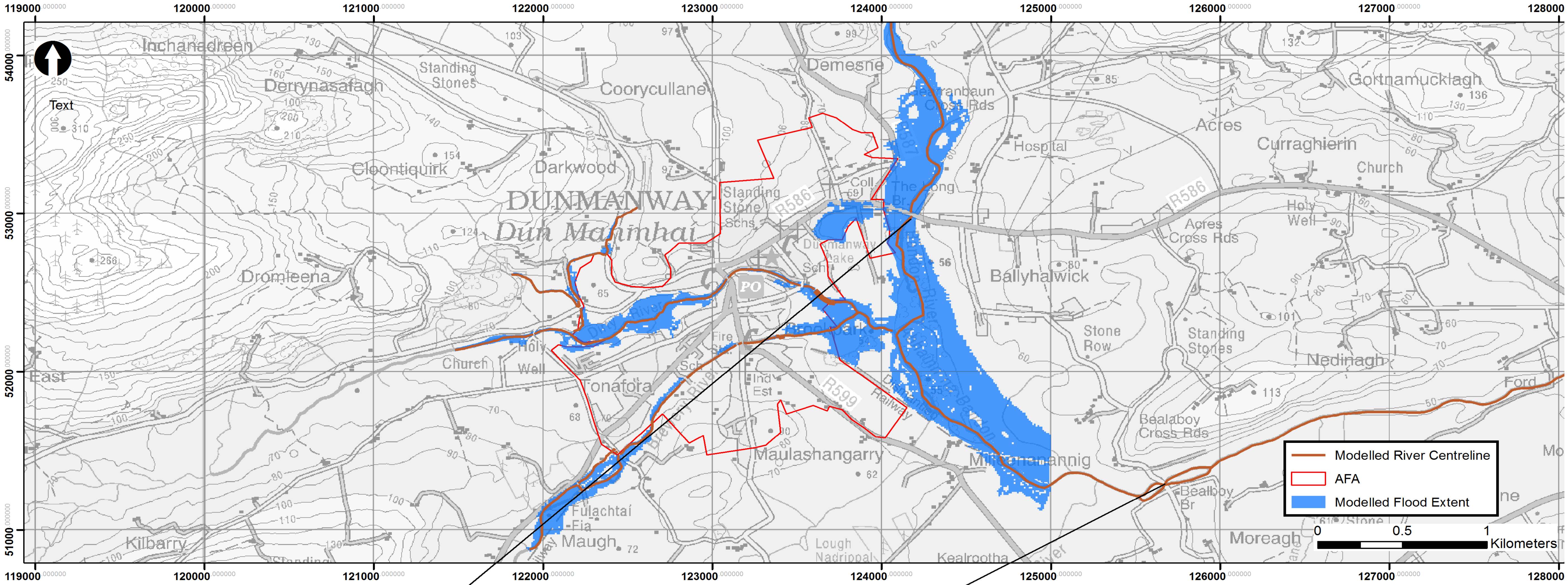
Period Modelled	01/01/1991 00:00 to 03/01/1991 08:00
Hydraulic Modification to Design Model	The design model was backdated to remove the raised embankments, the flood relief culverts under Long Bridge and the flapped culvert for flow from Dunmanway Lake that were installed on the right bank of the Bandon in 2001. The Dunmanway tributary Manning's 'n' calibrated to 0.033 to represent 1991 catchment configuration.
Hydrological inflows	The gauged level was converted to a flow hydrograph at Long Bridge to form the Bandon inflow.The gauged level was converted to a flow hydrograph at Bealaboy to form the target flow. The Dirty, Brewery, Dunmanway Lake and intermediate inflows were scaled to achieve the target flow at Bealaboy.
Calibration Plot	See Schedule 3 - Calibration and Sensitivity
Comments	The model was calibrated to reproduce the extent of flooding, flows and levels at Long Bridge by adjusting the Manning's 'n' and the inflow from Dunmanway Lake. At Long Bridge modelled flows were within 5% of the peak flow and 0.3m of the peak water level. The model extent and depths match well with reported flooding in 1991, flooding the right bank of the Bandon upstream of Long Bridge, but not affecting any of the properties along the Main Street. Overall, the model calibrates well with the mechanisms recorded in January 1991 and the flood extent and risk matches well with the flood evidence available.
Calibration Event 2: 12 October 1996	
Model Run ID	I23DY_FCC12101996_D2_high_Dunmanway
Period Modelled	12/10/1996 03:00 to 15/10/1996 15:00
Hydraulic Modification to Design Model	The design model was backdated to remove the raised embankments, the flood relief culverts under Long Bridge and the flapped culvert for flow from Dunmanway Lake that were installed on the right bank of the Bandon in 2001. The Dunmanway tributary Manning's 'n' calibrated to 0.033 to represent 1996 catchment configuration. The pipe that carries flow from Dunmanway Lake under the access road opposite Macroom Road was blocked to enable the modelled flow in Dunmanway Lake to meet the recorded peak
Hydrological inflows	The gauged level was converted to a flow hydrograph at Long Bridge to form the Bandon inflow.The gauged level was converted to a flow hydrograph at Bealaboy to form the target flow. The Dirty, Brewery and intermediate inflows were scaled to achieve the target flow at Bealaboy. Dunmanway Lake inflow was scaled to achieve recorded flood water levels.
Calibration Plot	See Schedule 3 - Calibration and Sensitivity
Comments	The model was calibrated to reproduce the extent of flooding, flows and levels at Long Bridge by adjusting the Manning's 'n' and the inflow from Dunmanway Lake and the blockage ratio of the pipe under the access road opposite Macroom Road. At Long Bridge the modelled flows were within 5% of the peak flow and 0.3m of the peak water level. The model extent and depths match well with reported flooding in 1996, flooding the right bank of the Bandon upstream of Long Bridge as far as Macroom Road. The modelled flood levels and extent associated with Dunmanway Lake are in agreement with the majority of the reported property flooding without accounting for surface water flooding. Overall, the model calibrates well with the mechanisms recorded in October 1996 and the flood extent and risk matches well with the flood evidence available.
Calibration Event 3: 19 November 2009	
Model Run ID	I23DY_FCC19112009_D2_high_Dunmanway
Period Modelled	18/11/2009 18:00 to 21/11/2009 09:00
Hydraulic Modification to Design Model	No hydraulic modifications were made to the design model.
Hydrological inflows	The gauged level was converted to a flow hydrograph at Long Bridge to form the Bandon inflow. The gauged flows at Bealaboy and Bandon Town formed the target flows. The Dirty, Brewery and Dunmanway Lake inflows were scaled to achieve the target flow at Bealaboy and the lower tributaries were scaled to achieve the target flow at Bandon
Calibration Plot	See Schedule 3 - Calibration and Sensitivity
Comments	The model was calibrated to reproduce the extent of flooding, flows and levels at Long Bridge by adjusting Manning's 'n and the culvert coefficients of the flood relief culverts under the R586. The modelled flows were within 5% of the peak flow and 0.3m of the peak water level. The modelled flood extent matches well with the video footage showing the flood waters contained within the embankments at Long Bridge, flooding at the Dirty River confluence and flooding up to but not over the Old Rail Bridge. The duration of flooding is slightly underestimated at Bealaboy due to assumptions in the tributary inflows downstream of the town however the flood extent and risk matches well with the flood evidence available. Overall, the model calibrates well with the mechanisms recorded in November 2009
Sensitivity Test 1: Increased Flow	
Model Run ID	I23DY_MFHD010_TFHD050_D2_high_Dunmanway
Hydraulic Modification to Design Model	No hydraulic modifications were made to the design model.
Hydrological inflows	All inflows were increased by 30% for the 1%AEP fluvial current design event to account for the uncertainty in the derivation of QMED and the pooling group selected.
Sensitivity Plot	See Schedule 3 - Calibration and Sensitivity
Comments	A 30% increase in flows resulted in 0.3m increase of flood levels within Dunmanway. The increased flows exceeded the capacity of the Dunmanway flood alleviation scheme, overtopped the embankments and the Bandon flooded Dunmanway Lake area via Chapel Street. The increased peak flow also lead to greater flooding along the Brewery River at Underhill Commercial Park Therefore flood risk in Dunmanway was found to be sensitive to the uncertainties in flow. However, the gauge records within AFA were used to estimate design flows so there is reasonable confidence in the results.
Sensitivity Test 2: Increased Downstream Boundary	
Model Run ID	I23DY_MFCSH01_T_D2_high_Dunmanway
Hydraulic Modification to Design Model	No hydraulic modifications were made to the design model.
Hydrological inflows	The gradient used in the Normal Depth Boundary at the downstream end of the model was flattened to a 1 in 1000 (from the original 1 in 450). No other hydrological inflows were modified.
Sensitivity Plot	See Schedule 3 - Calibration and Sensitivity
Comments	The flatter downstream boundary at Bandon Town increased water levels between Gurteen and Bandon Town but did not affect level or flood risk upstream of Gurteen. Therefore flood risk in Dunmanway was not deemed sensitive to the assumptions in the downstream boundary.
Sensitivity Test 3: Increased Manning's 'n'	
Model Run ID	I23DY_MFCSN01_T_D1_001_Dunmanway_477_01
Hydraulic Modification to Design Model	The Manning's 'n' values were increased to the upper limit of the industry recommended ranges. All active channels 0.050 to 0.055 All river banks 0.050-0.080 to 0.060-0.1 Pasture / parkland / garden 0.06 to 0.080 Buildings 0.200 to 0.300 Roads 0.033 to 0.040 Dense vegetation 0.080 to 0.10
Hydrological	No modifications were made to the design inflows.
Sensitivity Plot	See Schedule 3 - Calibration and Sensitivity
Comments	An increase in roughness values incerased water levels by 0.12m in Dunmanway but did not increase flooding as the flow was still contained within the flood alleviation scheme. Therefore Dunmanway is not deemed to be sensitive to the assumptions in Manning's 'n' values.

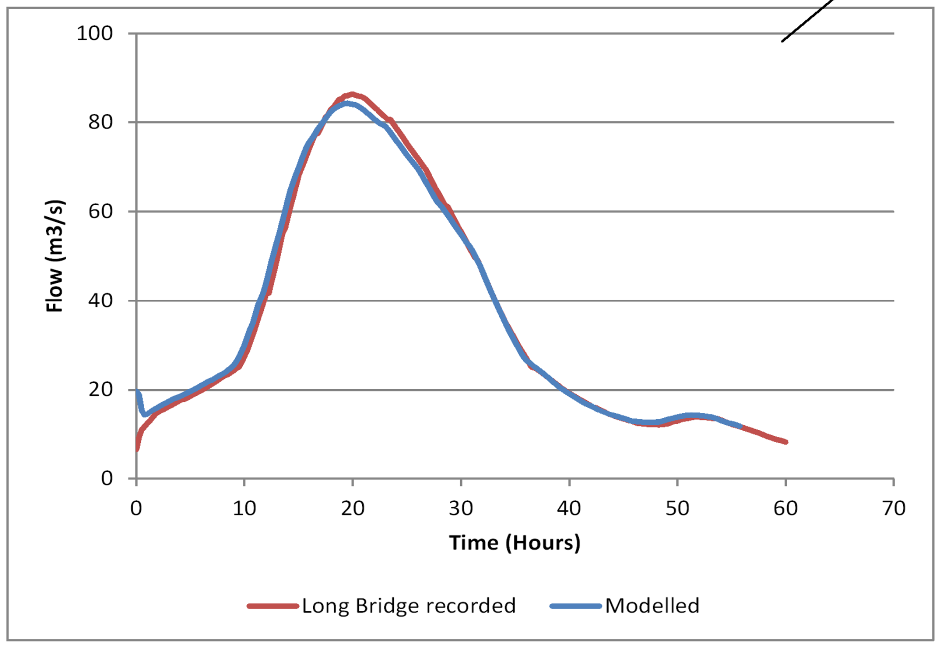
Map A.1: Calibration to 01/01/1991 Flood Event

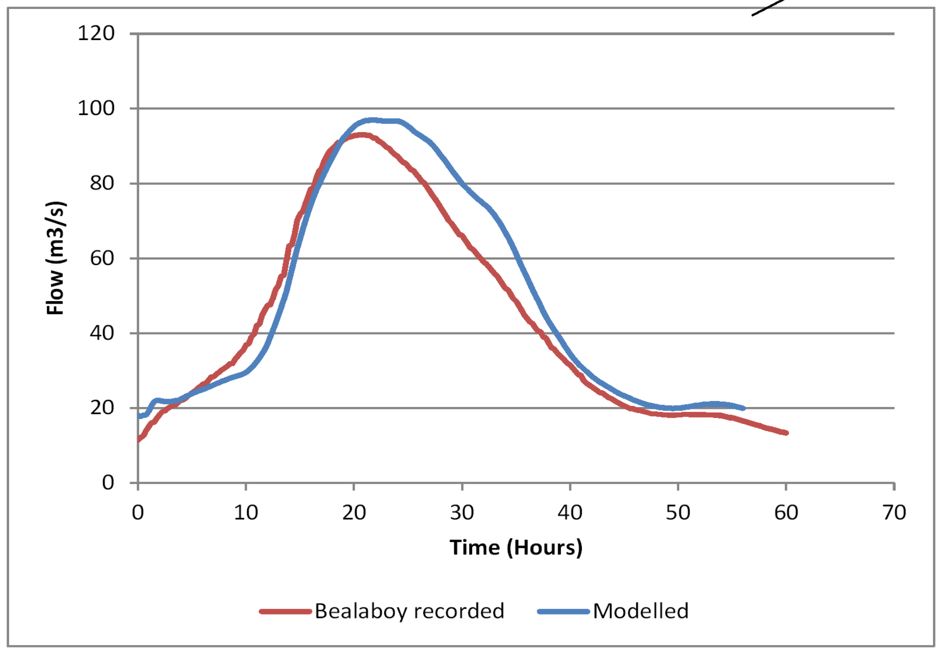


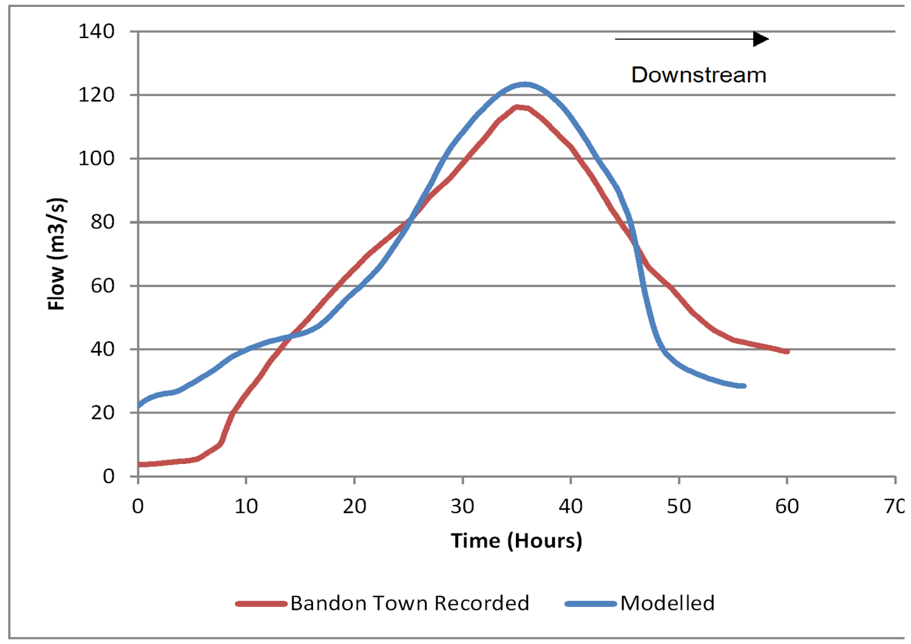
Location	Gauged Flow (m3/s)	Modelled Flow (m3/s)	% Difference	Gauged Level (m)	Modelled Level (m)	Difference (m)
Long Bridge	65	64	-1%	57.6	57.5	-0.1
Bealaboy	83	84	2%	53.3	53.3	0.0

Map A.2: Calibration to 12/10/1996 Flood Event



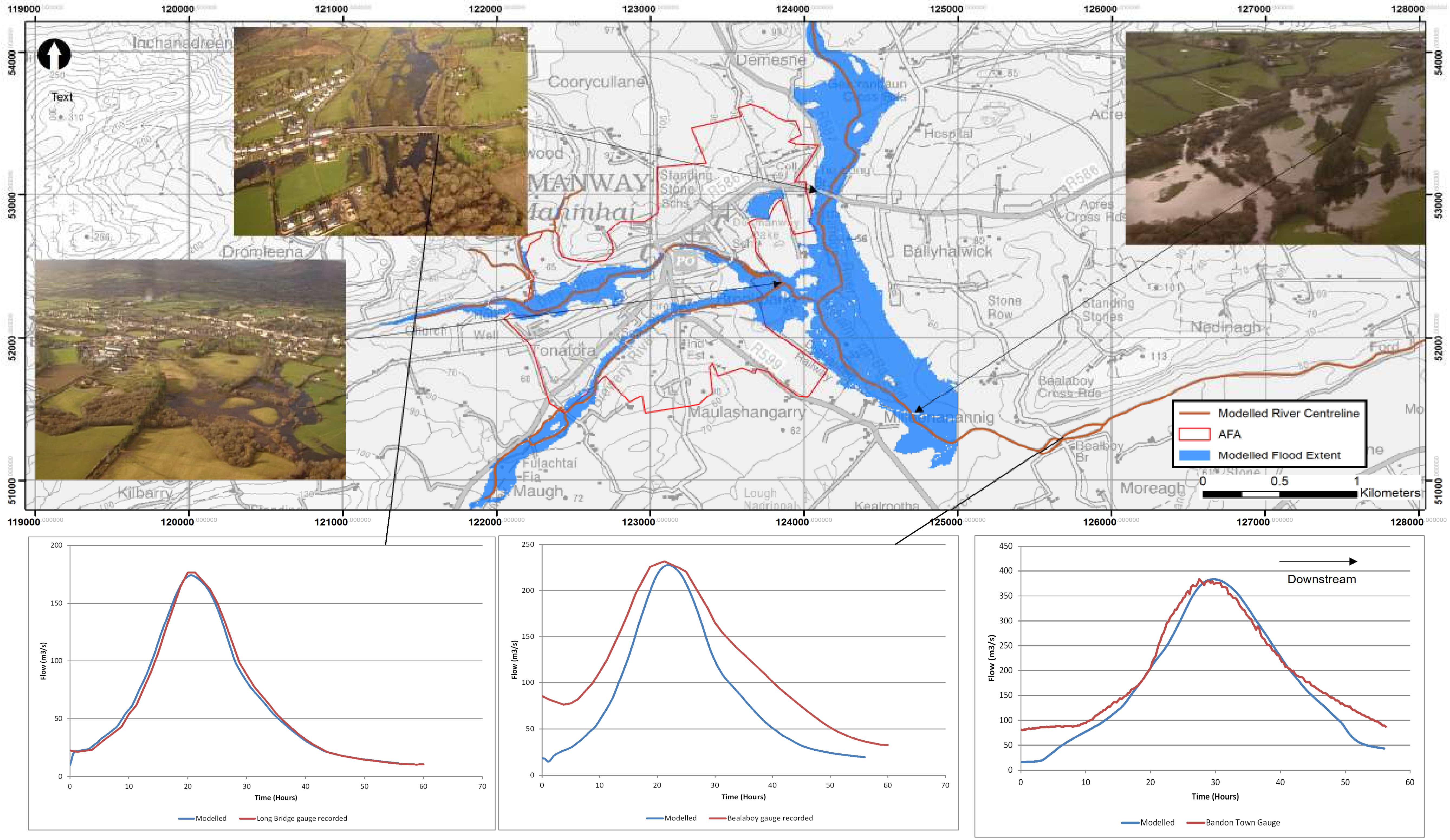






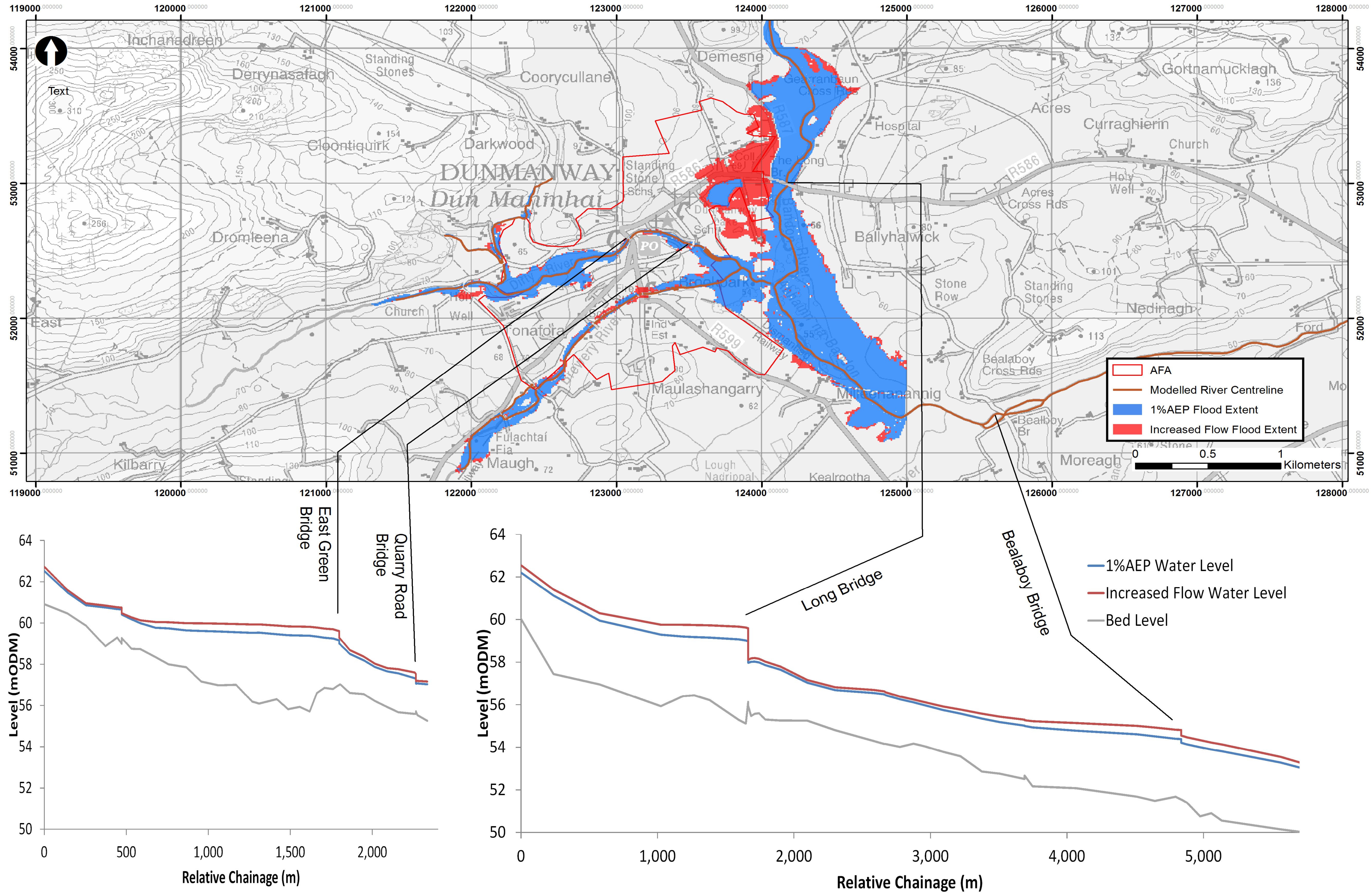
Location	Gauged Flow (m3/s)	Modelled Flow (m3/s)	% Difference	Gauged Level (m)	Modelled Level (m)	Difference (m)
Long Bridge	86	84	-2%	57.6	57.6	0.0
Bealaboy	93	97	4%	53.6	53.5	-0.1
Bandon Town	116	123	6%	N/A	N/A	N/A

Map A.3: Calibration to 19/11/2009 Flood Event

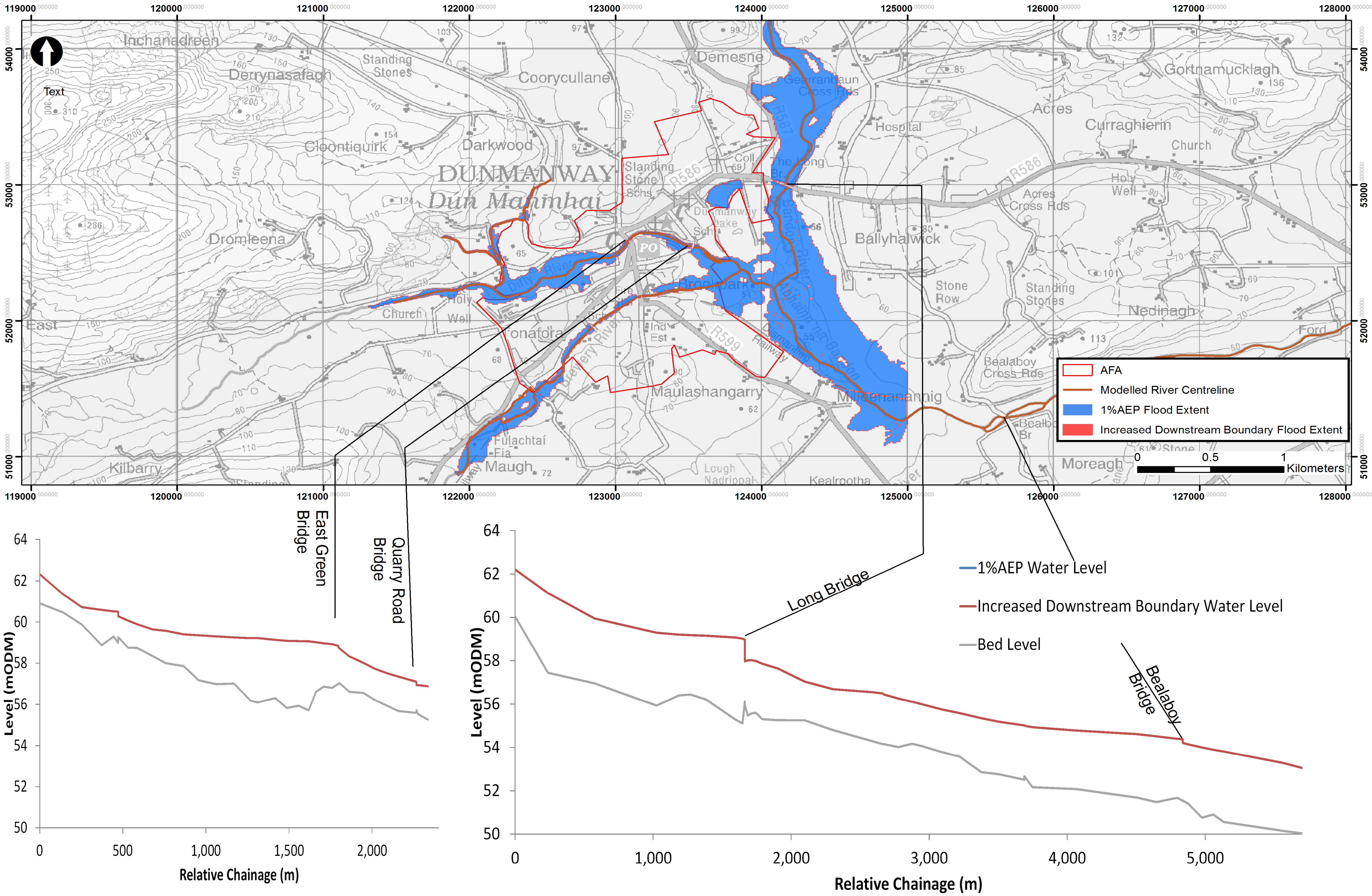


Location	Gauged Flow (m3/s)	Modelled Flow (m3/s)	% Difference	Gauged Level (m)	Modelled Level (m)	Difference (m)
Long Bridge	176	174	-1%	58.1	58.0	-0.1
Bealaboy	236	228	-4%	54.3	54.6	0.3
Bandon Town	384	383	0%	N/A	N/A	N/A

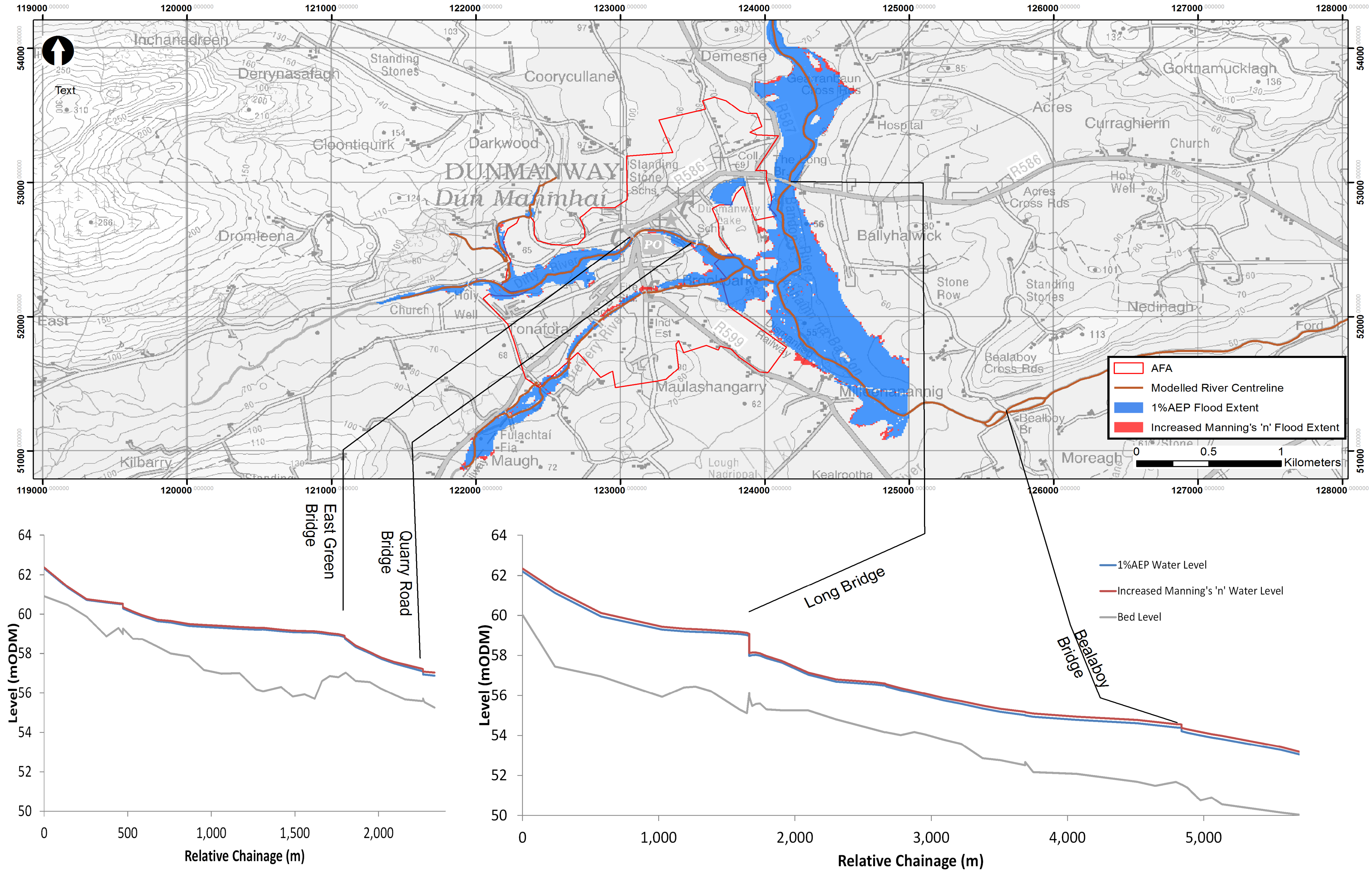
Map A.4: Sensitivity to Increased Flow



Map A.5: Sensitivity to Downstream Boundary Assumption



Map A.6: Sensitivity to Increased Manning's 'n'



Dunmanway Model Outputs	
Threshold of Property Flooding	The key thresholds and areas affected by flooding in Dunmanway are: - 50%AEP event inudates the floodplain upstream of Long Bridge and flows through the flood relief culverts but does not exceed the flood alleviation scheme. - 2%AEP fluvial current event overtops Sacksville Bridge on Dirty River and the bridge at Underhill Commerical Estate on Brewery River. - 0.5%AEP fluvial current event begins to inundated critical infrastructure at the water treament works at Long Bridge. - 0.5%AEP fluvial current event overtops the raised embankments upstream of Long Bridge and adds to flow along the Dunmanway Lake Tributary. - 0.1%AEP fluvial current event exceeds the flood alleviation scheme entirely to flood properties along Chapel Street from overtopping of the embankment upstream of Long Bridge and downstream by Church View. - 0.1%AEP fluvial current exceeds the capacity of the access bridge at Rock Springs on the Dirty River Tributary.
Critical Structures for Flood Risk	The critical structures in determining flood risk include: - The flood alleviation scheme comprising of the raised embankments, flood relief culverts on the Bandon River and flapped outfall on the Dunmanway Lake tributary. - Sacksville Bridge on the Dirty River. - Underhill Bridge on the Brewery River.
Areas affected by flooding	Flooding is expected to affect properties located at Underhill Commerical Estate and Chapel Street in extreme fluvial events.
Risk to people	The greatest risk to life is associated with deep and potentially fast flowing water upstream of the flood relief culverts at Long Bridge which is classed as extreme in 1%AEP fluvial current event but does not affect properties. The greatest risk to life at properties is located along Chapel Street and the Dunmanway Lake area in the extreme 0.1%AEP fluvial current event.
Consideration for Flood Risk Management Options	- The flood embankment upstream of Long Bridge at Macroom Road could be improved to protect against the 0.1%AEP if required. - Flood storage is a feasible option on the Bandon, Brewery and Dirty rivers upstream of the AFA given the available floodplain and position in the catchment to capture and store excess flows. - Flood warning on the Bandon is likely to be effective as the time to peak is over 6 hours ensuring sufficient lead time for flood warning actions.

Flood Map Outputs

The following table outlines the print-ready flood mapping deliverables provided in the accompanying digitial data.

Scenario	Flood Extent Map	Flood Zone Map	Flood Depth Map	Flood Velocity Map	Flood Hazard Map
Fluvial Current Design 10%AEP	I18HDY23_EXFCDEXF_D2		I18HDY23_DPFCD100_D2	I18HDY23_VLFCD100_D2	I18HDY23_HZFCD100_D2
Fluvial Current Design 1%AEP	I18HDY23_EXFCDEXF_D2	I18HDY23_ZN_D2	I18HDY23_DPFCD010_D2	I18HDY23_VLFCD010_D2	I18HDY23_HZFCD010_D2
Fluvial Current Design 0.1%AEP	I18HDY23_EXFCDEXF_D2	I18HDY23_ZN_D2	I18HDY23_DPFCD001_D2	I18HDY23_VLFCD001_D2	I18HDY23_HZFCD001_D2
Fluvial Mid Range Future Design 10%AEP	I18HDY23_EXFMDEXF_D2				
Fluvial Mid Range Future Design 1%AEP	I18HDY23_EXFMDEXF_D2				
Fluvial Mid Range Future Design 0.1%AEP	I18HDY23_EXFMDEXF_D2				

GIS Outputs

The following table outlines the GIS deliverables and model run files provided in the accompanying digital handover.

Scenario	Model Run	Main River %AEP	Tributary River %AEP	Flood Extent Polygon	Flood Zone Polygon	Flood Depth Grid	Flood Velocity Grid	Flood Hazard Grid
		50	50					
Fluvial Current Design 50%AEP	I12RC_MFCD500_TFCD500_D2_high_Dunmanway.ief	50	50	I23EXFCD500D2		I23DPFCD500D2	I23VLFCD500D2	I23HZFCD500D2
	I12RC_MFCD200_TFCD500_D2_high_Dunmanway.ief	20	50					
Fluvial Current Design 20%AEP	I12RC_MFCD500_TFCD200_D2_high_Dunmanway.ief	50	20	I23EXFCD100D2		I23DPFCD100D2	I23VLFCD100D2	I23HZFCD100D2
	I12RC_MFCD100_TFCD200_D2_high_Dunmanway.ief	10	20					
Fluvial Current Design 10%AEP	I12RC_MFCD200_TFCD100_D2_high_Dunmanway.ief	20	10	I23EXFCD200D2		I23DPFCD200D2	I23VLFCD200D2	I23HZFCD200D2
	I12RC_MFCD050_TFCD200_D2_high_Dunmanway.ief	5	20					
Fluvial Current Design 5%AEP	I12RC_MFCD200_TFCD050_D2_high_Dunmanway.ief	20	5	I23EXFCD050D2		I23DPFCD050D2	I23VLFCD050D2	I23HZFCD050D2
	I12RC_MFCD020_TFCD100_D2_high_Dunmanway.ief	2	10					
Fluvial Current Design 2%AEP	I12RC_MFCD100_TFCD020_D2_high_Dunmanway.ief	10	2	I23EXFCD020D2		I23DPFCD020D2	I23VLFCD020D2	I23HZFCD020D2
	I12RC_MFCD010_TFCD050_D2_high_Dunmanway.ief	1	5					
Fluvial Current Design 1%AEP	I12RC_MFCD050_TFCD010_D2_high_Dunmanway.ief	5	1	I23EXFCD010D2	I23ZN_A_D2	I23DPFCD010D2	I23VLFCD010D2	I23HZFCD010D2
	I12RC_MFCD005_TFCD050_D2_high_Dunmanway.ief	0.5	5					
Fluvial Current Design 0.5%AEP	I12RC_MFCD050_TFCD005_D2_high_Dunmanway.ief	5	0.5	I23EXFCD005D2		I23DPFCD005D2	I23VLFCD005D2	I23HZFCD005D2
	I12RC_MFCD001_TFCD010_D2_high_Dunmanway.ief	0.1	1					
Fluvial Current Design 0.1%AEP	I12RC_MFCD010_TFCD001_D2_high_Dunmanway.ief	1	0.1	I23EXFCD001D2	I23ZN_B_D2	I23DPFCD001D2	I23VLFCD001D2	I23HZFCD001D2
		50	50					
Fluvial Mid Range Future Design 50%AEP	I12RC_MFMD500_TFMD500_D2_high_Dunmanway.ief	50	50	I23EXFMD500D2		I23DPFMD500D2		
	I12RC_MFMD200_TFMD500_D2_high_Dunmanway.ief	20	50					
Fluvial Mid Range Future Design 20%AEP	I12RC_MFMD500_TFMD200_D2_high_Dunmanway.ief	50	20	I23EXFMD100D2		I23DPFMD100D2		
	I12RC_MFMD100_TFMD200_D2_high_Dunmanway.ief	10	20					
Fluvial Mid Range Future Design 10%AEP	I12RC_MFMD200_TFMD100_D2_high_Dunmanway.ief	20	10	I23EXFMD200D2		I23DPFMD200D2		
	I12RC_MFMD050_TFMD200_D2_high_Dunmanway.ief	5	20					
Fluvial Mid Range Future Design 5%AEP	I12RC_MFMD200_TFMD050_D2_high_Dunmanway.ief	20	5	I23EXFMD050D2		I23DPFMD050D2		
	I12RC_MFMD020_TFMD100_D2_high_Dunmanway.ief	2	10					
Fluvial Mid Range Future Design 2%AEP	I12RC_MFMD100_TFMD020_D2_high_Dunmanway.ief	10	2	I23EXFMD020D2		I23DPFMD020D2		
	I12RC_MFMD010_TFMD050_D2_high_Dunmanway.ief	1	5					
Fluvial Mid Range Future Design 1%AEP	I12RC_MFMD050_TFMD010_D2_high_Dunmanway.ief	5	1	I23EXFMD010D2		I23DPFMD010D2		
	I12RC_MFMD005_TFMD050_D2_high_Dunmanway.ief	0.5	5					
Fluvial Mid Range Future Design 0.5%AEP	I12RC_MFMD050_TFMD005_D2_high_Dunmanway.ief	5	0.5	I23EXFMD005D2		I23DPFMD005D2		
	I12RC_MFMD001_TFMD010_D2_high_Dunmanway.ief	0.1	1					
Fluvial Mid Range Future Design 0.1%AEP	I12RC_MFMD010_TFMD001_D2_high_Dunmanway.ief	1	0.1	I23EXFMD001D2		I23DPFMD001D2		
	I12RC_MFHD100_TFCD200_D2_high_Dunmanway.ief	10	20					
Fluvial High End Future Design 10%AEP	I12RC_MFCD200_TFHD100_D2_high_Dunmanway.ief	20	10	I23EXFHD100D2		I23DPFHD100D2		
	I12RC_MFHD010_TFCD050_D2_high_Dunmanway.ief	1	5					
Fluvial High End Future Design 1%AEP	I12RC_MFCD050_TFHD010_D2_high_Dunmanway.ief	5	1	I23EXFHD010D2		I23DPFHD010D2		
	I12RC_MFHD001_TFCD010_D2_high_Dunmanway.ief	0.1	1					
Fluvial High End Future Design 0.1%AEP	I12RC_MFCD010_TFHD001_D2_high_Dunmanway.ief	1	0.1	I23EXFHD001D2		I23DPFHD001D2		

Note on CFRAM Studies Naming Conventions

Model File Naming Convention:

B MN ID _ S C R PPP _St N
B = River Basin District code: I for South Western (Iardheisceart)
MN = **M**odel **N**umber: A sequential number for all models across the SW CFRAM study area.
ID = Model **ID**entifier: The first and last letters of the model name e.g. Ballingeary is shortened to BY
S = **S**ource code: F=fluvial C=coastal W=wave overtopping
C = **Sc**enario code: C= current M= Mid Range Future Scenario H= High End Future Scenario
R = **R**un Type: D = design, C = Calibration O= Option Assessment Run
PPP= Probability , expressed as a X in 1000 chance e.g. 50%AEP = 500 , 0.5% AEP = 005
St = **S**tatus , D = draft, F = final
N = Revision **N**umber a single digit revision number

Additional Map Naming Convention:
B UoM H MN _ TT S C R PPP _St N

Additional GIS Naming Convention:
B MN TT S C R PPP St N

Codes a**s** above with the addition of:
UoM= Unit of Management number e.g. 18 = River Blackwater catchment
H = **High** Priority Watercourse / **Medium** Priority Watercourse
TT = Map **T**ype Ex = Extent, ZN = Zone, DP = Depth, VL = Velocity, HZ = Hazard

Appendix B. Innishannon AFA Model Proformas

UOM	20		
AFA/ MPW Reach	AFA-Innishannon		
Model ID	I125IN		
Purpose of Model Build	Flood Mapping		
Main Watercourse	River Bandon (Lower)	FLUVIAL RISK	Yes
Length Modelled (km)	23.6	COASTAL RISK	Yes
2D Code Region (km^2)	0.9	VULNERABLE TO WAVES	No

Input Data	
River Channel Topographic Data	Topographic survey by Maltby Land Surveys Ltd. Data captured in October 2010 as part of the Bandon Flood Relief Scheme Study (JBA).Refer to drawings 10836_XS_(series) Topographic survey by Murphy Surveys Limited. Data captured in March 2014. Refer to Drawings 8967_20BAND_BANDON_RIVER_V1, 8967_20BAND_BANDON_RIVER_MOUTH_V1, and 8967_20INSH_INISHANNON_RIVER_V1 Innishannon was classified as an AFA (HPW) since the completion of the original MPW strategic survey by Maltbys (2010) for the Bandon Flood Relief Scheme. Therefore, an additional infill survey was undertaken in March 2014 which captured data at more regular intervals within the AFA and extended the length of MPW surveyed down to the Sea at Kinsale.
Floodplain Topographic Data	2m DTM LIDAR provided by OPW was converted from ITM to ING. Elevations on hard standing were compared with river channel survey and found to be within 0.11 m. The LIDAR DTM has been smoothed to the top of the slope at Bridge House Quarry using a 2d_ZSH based on the LIDAR and OSI map levels to ensure stability of any ponding water during the future scenario runs. Outside the AFA boundaries, IFSAR was used to extend 1D sections for the MPW reach to Kinsale to ensure no glass-walling in the 1D model. The ISFAR data was found to be within 0.2m of the LIDAR and did not required further adjustment. The IFSAR and LIDAR dadt was combined for flood mapping purposes and the final DTMs provided (Bandon2mdtmING4.asc and nDHM_Lowerbandon5m.asc)
Map data	Ordnance Survey Ireland 1:1000, 1:2500 and 1:5000 and 1:50000 data Vector mapping at 1:1000, 1:2500 and 1:5000 were converted from DWG/DXF to GIS files to identify material layers

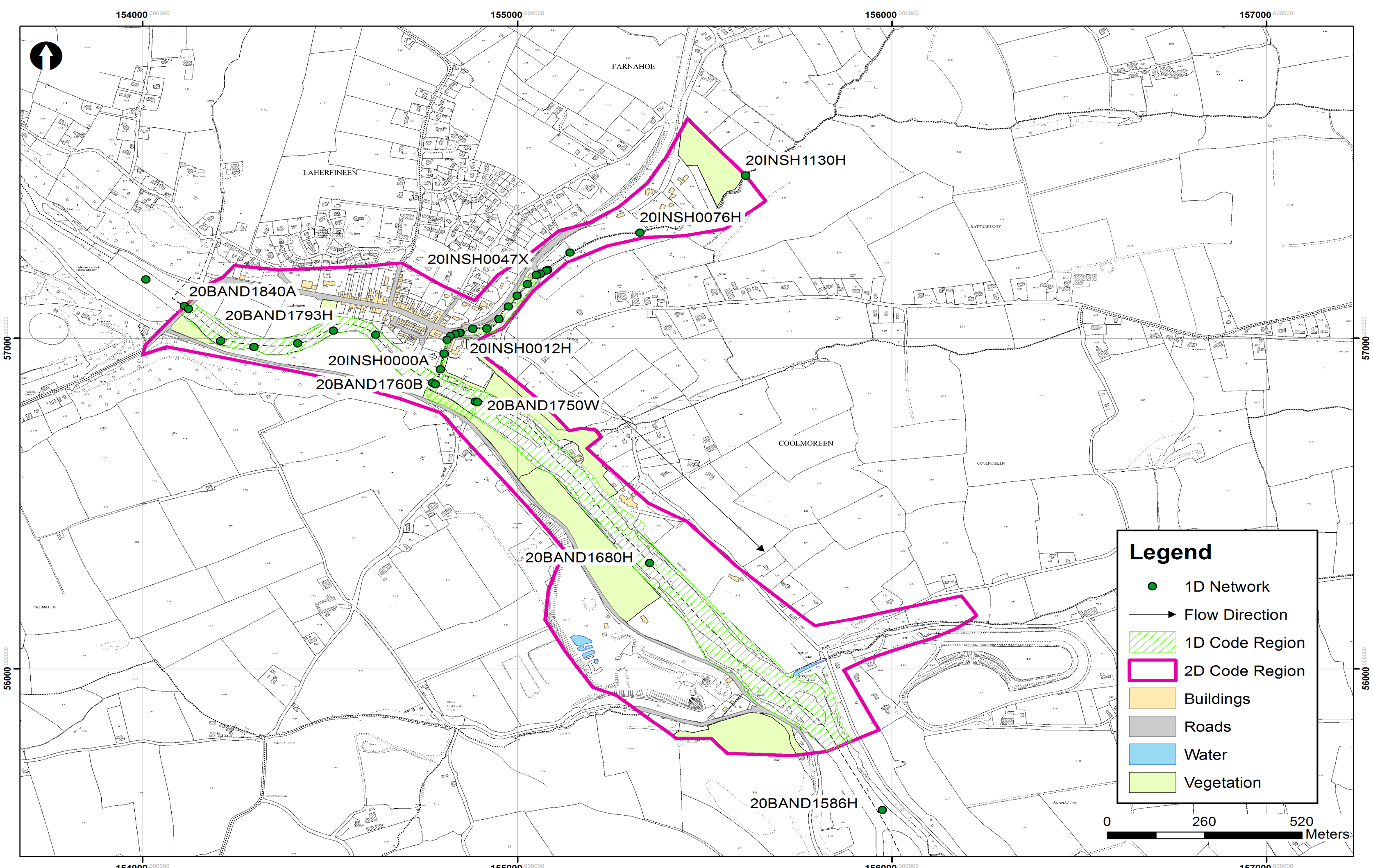
Model Build	
General Schematisation	A 1D/2D ISIS/TUFLOW approach was taken for Innishannon to accurately model head loss through the various hydraulic structures on the Innishannon tributary whilst enabling multidirectional flow across the floodplain and roads from the Bandon. The Bandon downstream of the old ford crossing was classified as a MPW. This reach of the Bandon is contained within a narrow valley and a 1D approach is deemed sufficient to derive flood depth and extent for this MPW. The 2D floodplain was set to 5m to represent the urban area without compromising run time. The 1D approach has been used to represent the Innishannon Stream up to the road level and valley side where properties are located and then linked to the 2D model beyond this point. This minimises instability caused by rapid oscillation between the 1D and 2D components. The 1D approach has been used to represent the River Bandon active channel linked to the 2D model along the river banks. The quarry at bridge house has been smoothed to ensure model stability and avoid glass walling using a 2d_zsh layer. The Old Kinsale Bridge crossing has not been modelled as the old pier structures are below MHWS water levels and the sill is drowned out. Therefore, the remnants of the bridge piers do not constrict flows or alter levels for the AEP events modelled. Buildings thresholds have been raised by 0.15m above the DTM level based on site observations and a higher Manning's 'n' value applied to the building footprints to simulate the storage of water once flooded. A floodplain value of 0.06 for pasture/garden/agricultural land has been selected based on Chow 1959 recommended ranges to represent both the field/gardens and the light brush/trees around the field boundaries. Version D2 was run for the design fluvial dominat scenarios to ensure that the flood extent was not constrained by the 2D code region at Frankford.
Software Versions Used	ISIS version 3.6 TUFLOW version 2012-05-AC-iSP-w32
Total No of 1D nodes	**81**
Open channel (H)	74
Bridges (D)	2
Orifice (O)	2
Culverts (I)	0
Weirs (W)	3

Model Extent	Reach/Feature	Upstream Limit (ING)	Downstream Limit (ING)
	River Bandon	152924, 57186	165532, 47354
	Innishannon Stream	155609, 57491	154804, 56956

Roughness	Reach/Feature	Active Channel	River Banks	Floodplain	Source
	River Bandon	0.030 - 0.040	0.040 - 0.07	0.060 - 0.085	Schedule 1: Photographs
	Innishannon Stream	0.040	0.040	0.060 - 0.070	Schedule 1: Photographs
	Open pasture	N/A	N/A	0.060	Schedule 1: Photographs
	Dense vegetation	N/A	N/A	0.085	Schedule 1: Photographs
	Buildings	N/A	N/A	0.200	Schedule 1: Photographs
	Roads	N/A	N/A	0.030	Schedule 1: Photographs

Structures	See Schedule 2 for Hydraulic Structure Parameters
Upstream boundary	The gauged inflow at Curranure (20002) is applied directly to the upstream limit of the model at the gauge location
Lateral inflows	The intermediate inflows have been areally weighted down the modelled reach and input at minor tributary inflows.
Downstream boundary	The derived tidal boundaries have been applied to the downstream limit of the Bandon to define the tidal influence in all scenarios.
Run Settings	Unsteady simulation of full 48 hour hydrograph starting at 1 hour to ensure stability with the tidal level. 1s timestep Minimum flows of 20m3/s on the Bandon and , 0.5m3/s on Innishannon Stream to enable stable flows over the weirs and steep bed gradients. This takes up less than 10% of the channel capacity and does not reduce the volume available for flood storage. All other parameters set to default.

Model Geoschematic



SCHEDULE 1 : PHOTOGRAPHS (River Bandon)	SCHEDULE 1 : PHOTOGRAPHS (Innishannon Stream)
Photo 1: Active Channel and River Banks at Innishannon	**Photo 1: Active River Channel , River Banks and Urban Floodplain on Innishannon Stream**
	
Photo 2: Floodplain at Innishannon (Flooded at time of survey)	
	
Photo 3: Tidal Channel at Kinsale	
	

SCHEDULE 2: Structures

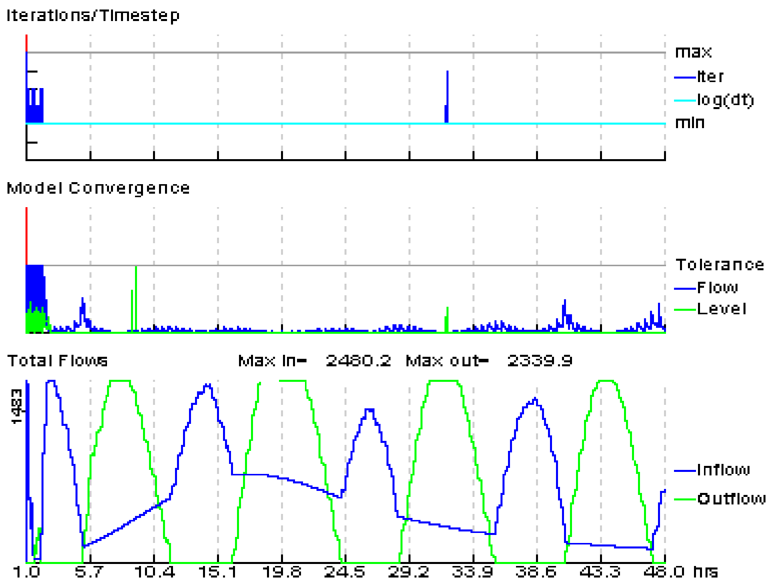
Data file P:\Cambridge\Demeter\EVT4\296241 S West CFRAMS EVT Code\Technical\Hydraulics\Build\I25IN_Inishannon\DESIGN\model\ISIS\I25IN_D1.DAT

Node	Easting	Northing	Structure Type	Bridge Parameters				Weir Parameters				Spill Parameters			Culvert Parameters											Comments/ Justification
				Soffit Elevation (mAOD)	No of Openings	Skew Angle	Calibration Coefficients	Crest Elevation (mAOD)	Length	Modular Limit	Velocity Coeff.	Minimum. Crest Elevation (mAOD)	Modular Limit	Weir Coeff.	Soffit level (mAOD)	Invert u/s (mAOD)	Invert d/s (mAOD)	Width/ area (m) (m2)	Length (m)	K	Ki	M	Trash Screen?	Trash Screen coefficient		
20BAND0234D	163714	49005	USBPR Bridge	15	13	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		Kinsale Bridge.
20BAND1839D	154088	57084	Arched Bridge	6.2	6	0	1	N/A	N/A	N/A	N/A	7.36	0.9	0.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N71 Bridge. Associated spill unit = 20BAND1839S & 20BAND1838E 20BAND1838E - online spill to represent weir /bed drop under N71 bridge
												0.643	0.9	1.2												
20BAND1750W	154763	56861	Weir	N/A	N/A	N/A	N/A	0.251	1.05	0.251	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		0.251m crest set to represnet ford exit level on RB and effect of The Scour Island d/s.
20INSH0049W	155078	57207	Weir	N/A	N/A	N/A	N/A	7.42	1.5	7.42	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		Coefficient of velocity calibrated to meet he recorded water level profile form the survey.
20INSH0016W	154846	57015	Weir	N/A	N/A	N/A	N/A	2.605	1	2.605	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		weir cerst to average bed level in surveyed section 20INS0016H.
20INSH0046O	155060	57194	Orifice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.78	0.9	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		Arched bridge modelled as orifice to represent oepnign constriction and stabilise transition to orifice flow. Sill level set by surveyed bed
20INSH0015O1	154832	57013	Orifice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.02	2.01	1.62	1.351	N/A	N/A	N/A	N/A	N/A	N/A		
20INSH0015O2	154832	57013	Orifice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.06	1.927	1.62	2.244	N/A	N/A	N/A	N/A	N/A	N/A		

Innishannon Model Performance

1D Convergence

Convergence Plot 0.1% AEP Fluvial Event



Datafile: ...\DESIGN\MODEL\ISIS\I25IN_D1.DAT
Results: ...\RESULTS\1D\I25IN_MFCD001_D1_INISHANNON.zzl
Ran at 16:48:43 on 08/07/2014
Ended at 17:36:13 on 08/07/2014
Start Time: 1.000 hrs
End Time: 48.000 hrs
Timestep: 1.0 secs

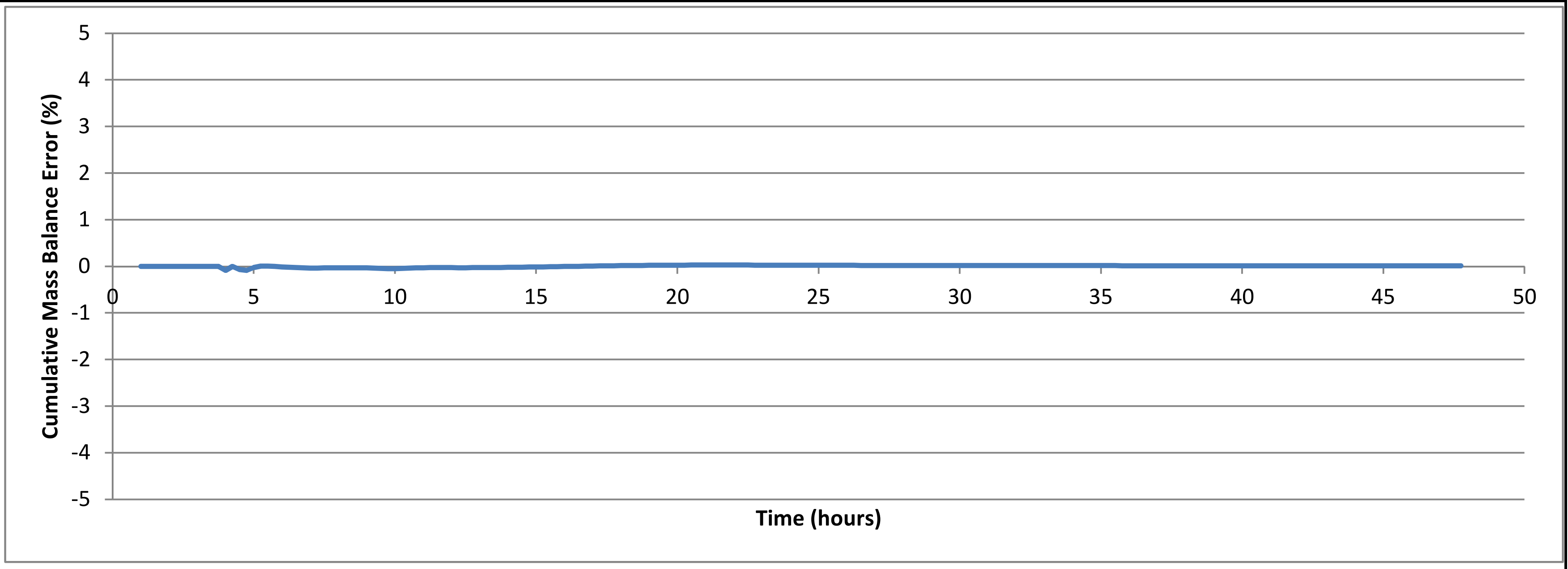
Current Model Time: 48.00 hrs
Percent Complete: 100 %

Comments

The 1D model components were convergent and within the recommended tolerances for most of the event. The initial spike in poor convergence is associated with using average initial conditions and a varying tide at the downstream boundary. However, the model converges before the start of the fluvial flooding event at 5 hours and does not affect the peak flow.

2D Convergence

Mass Balance Plot 0.1%AEP Fluvial Event



Comments

The final cumulative mass error is -0.02% or -15104m^3 for the 0.1%AEP fluvial current event.
The 2D model consistently remains within the recommended tolerance of ±1% throughout the flood event. Therefore, the results are deemed to be convergent and reliable.

Hydrological Performance

Hydrological Performance				10% AEP m3/s			1%AEP m3/s			0.1%AEP m3/s		
Target Flows	HEP ID	Location	Model Node	Design	Modelled	% Difference	Design	Modelled	% Difference	Design	Modelled	% Difference
	20_652_6	Curranure (20002)	20BAND1994H	204	204	0%	356	356	0%	604	604	0%
	20_2232_4	Innishannon Stream Downstream	20INSH0012H	2.5	2.5	0%	4.4	4.4	0%	7.5	7.4	-1%
	20_2230_3	Bandon downstream of Innishannon stream	20BAND1760B	231	230	0%	403	395	-2%	683	693	1%
	20_147_2+	Bandon at Rockhouse Creek	20BAND1304H	277	248	-11%	483	405	-16%	820	673	-18%
	20_2236_5+	Bandon at Ballinadee Creek	20BAND0891H	290	389	34%	506	600	19%	858	854	0%
	20_2224_3+	Bandon at Whitecastle Creek (Kinsale)	20BAND-0202H	295	1917	550%	515	2070	302%	872	2339	168%

Comments

The flows in the 1D ISIS channel were combined with 2D flows parallel to the channel where there were out-of-bank flows and compared to the design hydrology.
The design hydrology does not consider backwater effects from the tide which limit the discharge of the River Bandon in its lower reaches.
Therefore the modelled flow differs to design flows at HEP locations affected by the tide (i.e. downstream of Rockhouse Creek) which are highlighted in yellow above.

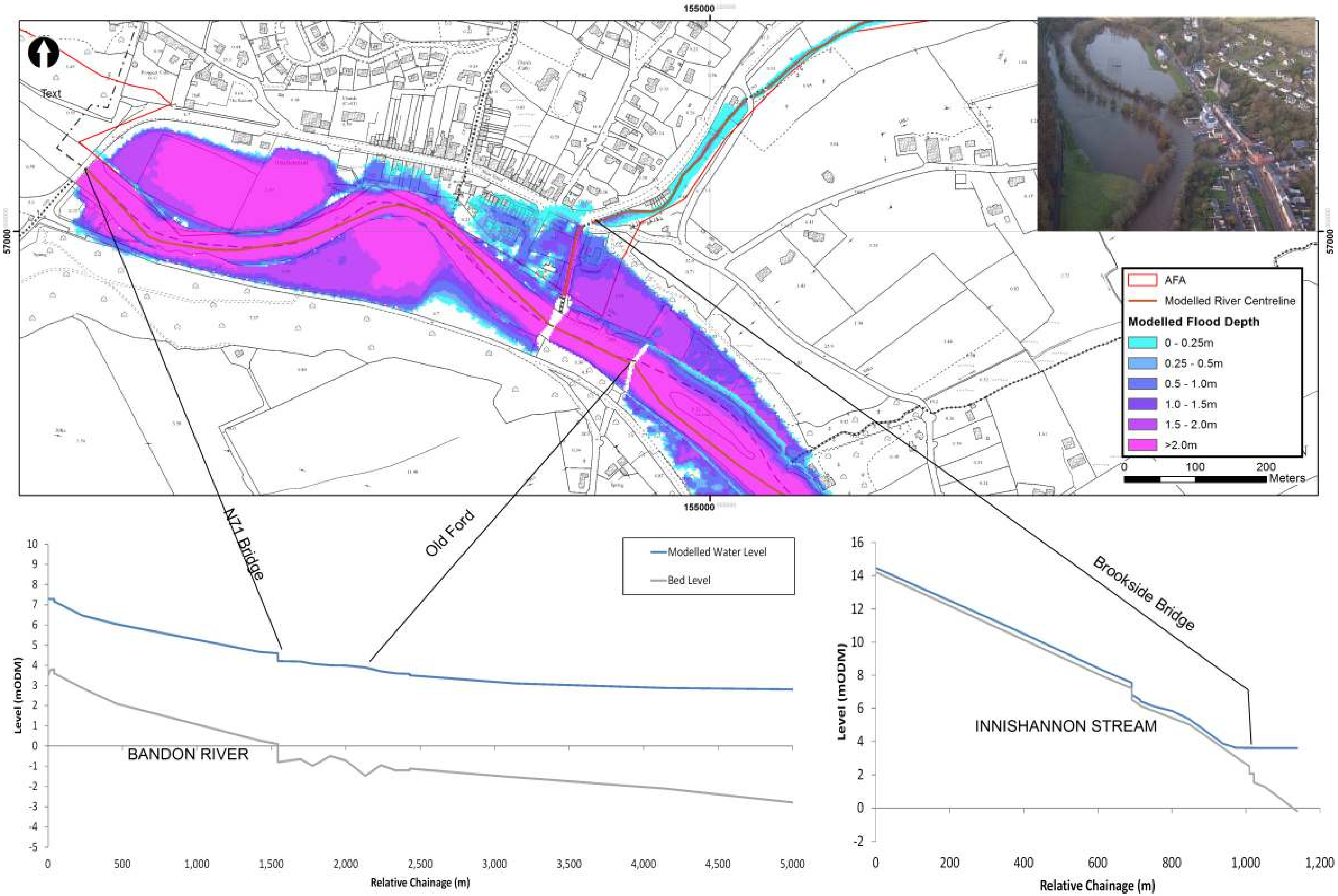
Therefore, the hydrological routing of the Innishannon model is deemed representative of the design flows upstream of Rockhouse Creek.

Calibration Event

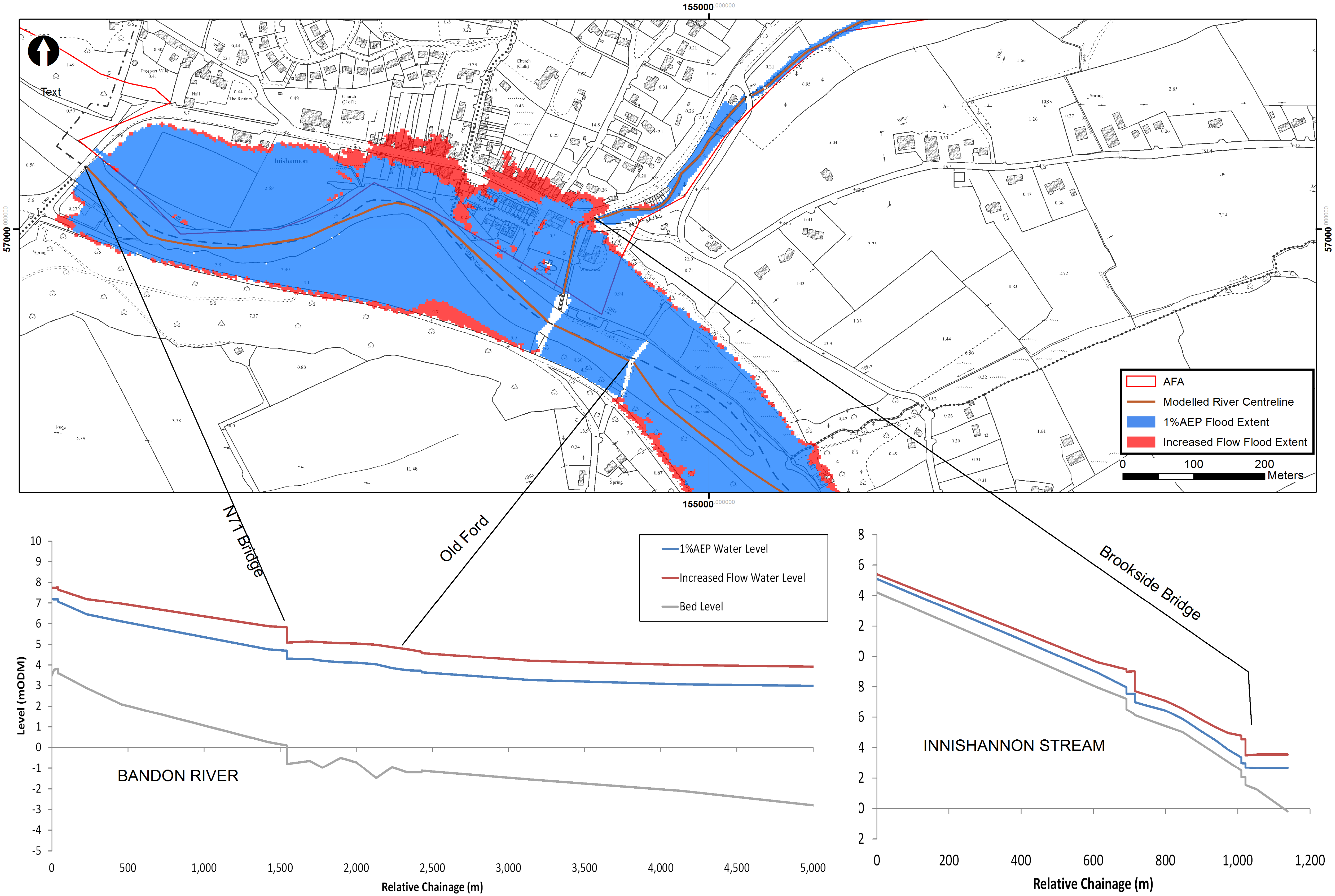
Model Run ID	I25IN_FCC19112009_D1_INISHANNON
Period Modelled	19/11/2009 00:00 to 21/11/2009 12:00
Hydraulic Modification to Design Model	No hydraulic modifications were made to the design model.

Hydrological inflows	The recorded flow at Curranure forms the inflow to the model. A similar %AEP event was applied along the Innishannon Stream and other tributaries. The predicted tide from the Admiralty Tide Tables was applied to the downstream boundary since there was negligible surge recorded at Ballycotton along the coast.
Calibration Plot	See Schedule 3 - Calibration and Sensitivity
Comments	The weir coefficients and Manning's 'n' values were adjusted to reproduce the extent of flooding in Innishannon based on the aerial footage provided and the interviews with residents in the Flood Risk Review. The model extent matches well with the video footage of flooding at the playing field and at the back of the Art Gallery on Main Street. The model predicted flood depths of 0.14m at properties south of Main Street which agrees with depths 0.1m reported during the Bandon Flood Relief Scheme public information day. Overall, the model calibrates well with the mechanisms recorded in November 2009.
Sensitivity Test 1: Increased Flow	
Model Run ID	I25IN_MFHD010_D1_Inishannon
Hydraulic Modification to Design Model	No hydraulic modifications were made to the design model.
Hydrological inflows	All inflows were increased by 30% for the 1%AEP fluvial current design event to account for the uncertainty in the derivation of QMED and the pooling group selected.
Sensitivity Plot	See Schedule 3 - Calibration and Sensitivity
Comments	A 30% increase in flows resulted in a significant 0.8m increase in level and greater flooding along Main Street from the River Bandon. Therefore flood risk in Innishannon was found to be sensitive to the uncertainties in flow. However, the design inflows are derived from the long gauge record at Curranure as a best estimate for peak flows.
Sensitivity Test 2: Increased Downstream Boundary	
Model Run ID	I25IN_CMD010_D1_Inishannon
Hydraulic Modification to Design Model	No hydraulic modifications were made to the design model.
Hydrological inflows	A 0.5m increase in water level was applied to the downstream boundary. This is broadly equivalent to the MRFS which increases sea level by 0.55m. Therefore, the MRFS 1%AEP results (CMD010) have been used to conduct the sensitivity test.
Sensitivity Plot	See Schedule 3 - Calibration and Sensitivity
Comments	An increased downstream boundary resulted in raised levels by 0.5m through Innishannon up to the Ballymahane tributary but does not affect flows at Curranure Gauge. This increased flooding at The Lawn and in the playing fields at Innishannon. Therefore, flood risk in Innishannon was deemed sensitive to the assumptions in the downstream boundary. However, the ICPSS total tide plus surge levels were agreed with OPW as the best estimate of coastal risk in the absence of long term gauge records at Kinsale.
Sensitivity Test 3: Increased Manning's 'n'	
Model Run ID	I25IN_FCSN01_D1_Inishannon
Hydraulic Modification to Design Model	The Manning's 'n' values were increased to the upper limit of the industry recommended ranges. All active channels 0.040 to 0.050 All river banks 0.080 to 0.100 Pasture / parkland / garden 0.060 to 0.080 Buildings 0.200 to 0.300 Roads 0.033 to 0.040
Hydrological	No modifications were made to the design inflows.
Sensitivity Plot	See Schedule 3 - Calibration and Sensitivity
Comments	The increase in Manning's 'n' did not significantly increase flood levels(<0.2m) or flood extent in Innishannon as the 1%AEP design extent already fills the majority of the floodplain. Downstream, the increase in Manning's 'n' did not change flood levels and flood risk because of the increasing tidal influence. Therefore, flood risk in Innishannon and downstream is not deemed sensitive to assumptions in Manning's 'n' at the 1%AEP.

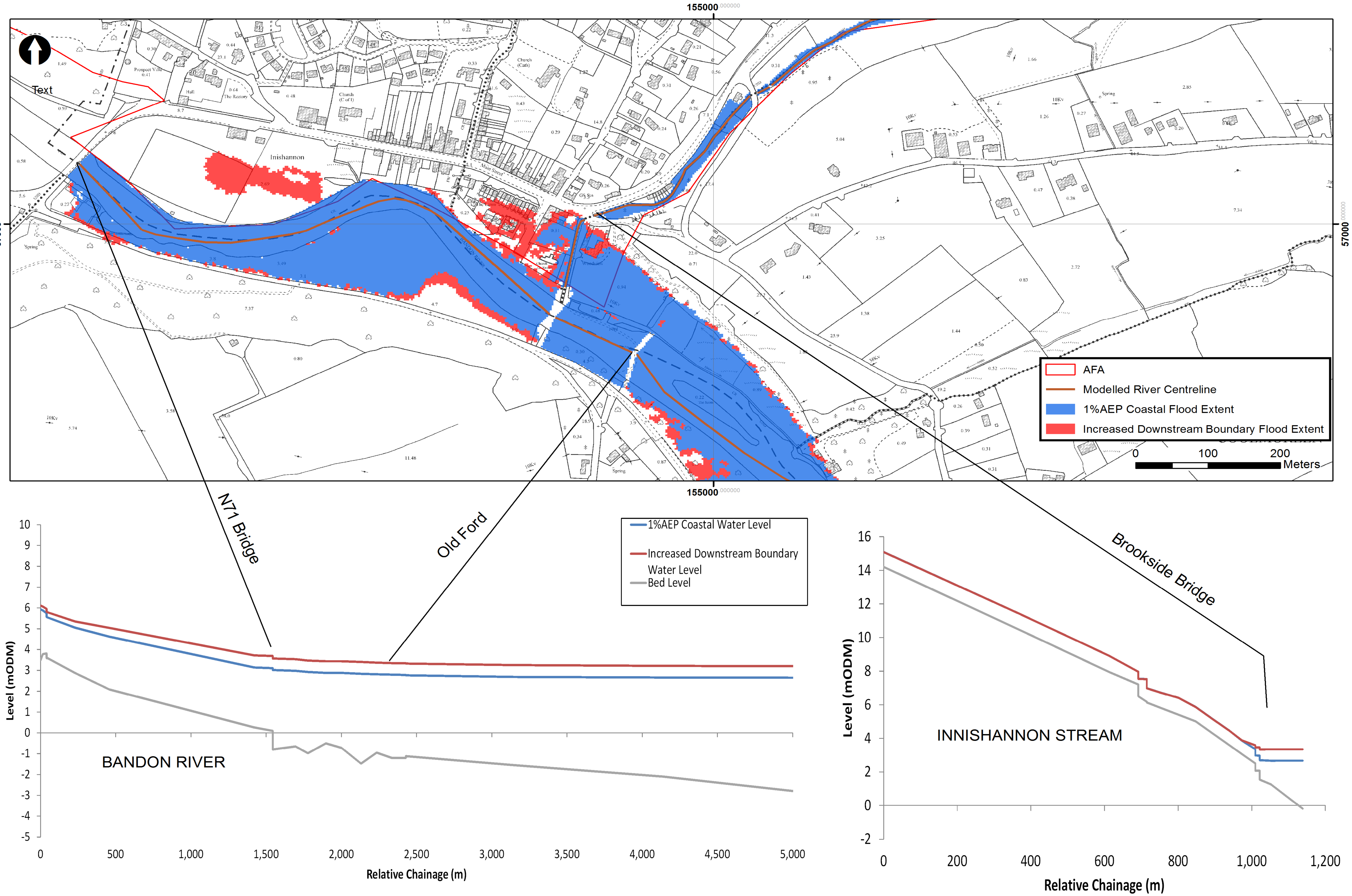
Map B.1: Calibration to 19/11/2009 Flood Event



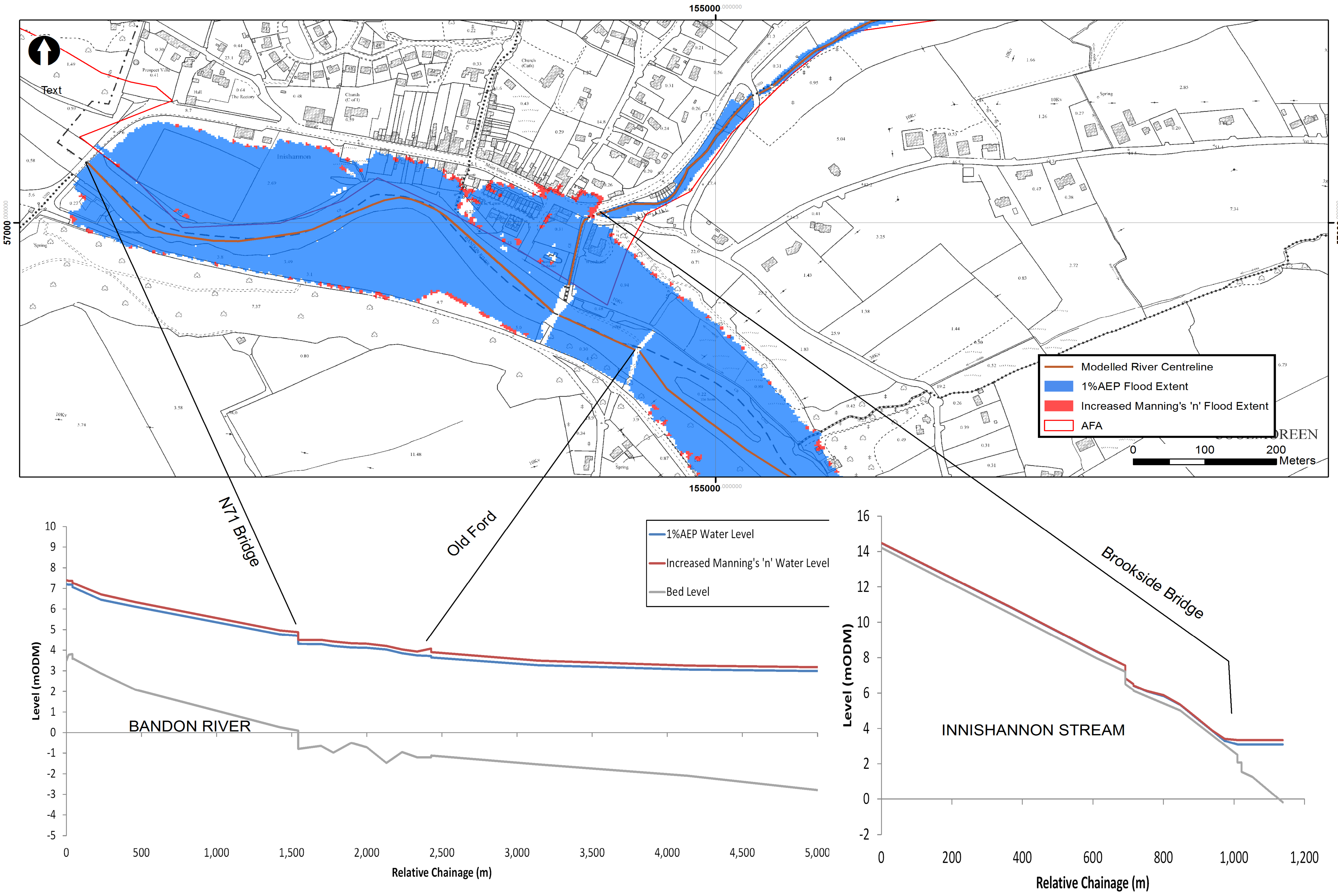
Map B.2: Sensitivity to 30% Increased Peak Flow



Map B.3: Sensitivity to Increased Downstream Boundary



Map B.4: Sensitivity to Increased Manning's 'n'



Innishannon Model Outputs	
Threshold of Property Flooding	The key thresholds and areas affected by flooding in Innishannon are: - 10%AEP fluvial current floods the playing fields from the River Bandon. Pluvial flooding may occur more frequently but this is not considered in the CFRAM Study. -10%AEP fluvial current begins to flood along The Lawn but does not affect properties until the 2%AEP fluvial current. - 1%AEP fluvial current floods the N71 along Main Street from Brookside Bridge and The Lawn. - 2%AEP coastal current event begins to flood the road at The Lawn but properties are not affected. The N71 bridge is not overtopped in any fluvial current or tidal current scenario modelled.
Critical Structures for Flood Risk	The critical structures in determining flood risk include: - The capacity of the channel at the old ford crossing and the island downstream - The access gate on the downstream of Brookside Bridge Catchment changes since 2010, such as topographic refporifling of the floodpain at DunDaniel, are recommended to be included in any future updates of this mapping.
Areas affected by flooding	Flooding is expected to affect properties at The Lawn and along Main Street.
Risk to people	The greatest risk to life associated with deep and fast flowing water on the playing fields and at the back of the houses on Main Street. Flood water spills over Main Street in the 1%AEP and 0.1%AEP fluvial current which may pose a hazard to road users.
Consideration for Flood Risk Management Options	- Flood warning on the Bandon is likely to be effective as the fluvial time to peak is over 6 hours and the tidal conditions can be predicted several days in advance. '- The extent of the proposed dredging in the Bandon Flood Releif Scheme has been designed to ensure a minimal increase in water levels downstream of the scheme during flood events.Therefore, the residual impact of the Bandon River (Bandon) Drainage Scheme on downstream water levels is quoted as "slight" in the Bandon Flood Relief Scheme.It is anticipated that this slight increase will not result in additional flood risk to property or infrastructure.

Flood Map Outputs

The following table outlines the print-ready flood mapping deliverables provided in the accompanying digitial data.

Scenario	Flood Extent Map	Flood Zone Map	Flood Depth Map	Flood Velocity Map	Flood Hazard Map
Fluvial Current Design 10%AEP	I18HIN25_EXFCDEXF_D2		I18HIN25_DPFCD100_D2	I18HIN25_VLFCD100_D2	I18HIN25_HZFCD100_D2
Fluvial Current Design 1%AEP	I18HIN25_EXFCDEXF_D2	I18HIN25_ZN_D2	I18HIN25_DPFCD010_D2	I18HIN25_VLFCD010_D2	I18HIN25_HZFCD010_D2
Fluvial Current Design 0.1%AEP	I18HIN25_EXFCDEXF_D2	I18HIN25_ZN_D2	I18HIN25_DPFCD001_D2	I18HIN25_VLFCD001_D2	I18HIN25_HZFCD001_D2
Fluvial Mid Range Future Design 10%AEP	I18HIN25_EXFMDEXF_D2				
Fluvial Mid Range Future Design 1%AEP	I18HIN25_EXFMDEXF_D2				
Fluvial Mid Range Future Design 0.1%AEP	I18HIN25_EXFMDEXF_D2				
Coastal Current Design 10%AEP	I18HIN25_EXCCDEXC_D1		I18HIN25_DPCCD100_D1	I18HIN25_VLCCD100_D1	I18HIN25_HZCCD100_D1
Coastal Current Design 1%AEP	I18HIN25_EXCCDEXC_D1	I18HIN25_ZN_D2	I18HIN25_DPCCD010_D1	I18HIN25_VLCCD010_D1	I18HIN25_HZCCD010_D1
Coastal Current Design 0.1%AEP	I18HIN25_EXCCDEXC_D1	I18HIN25_ZN_D2	I18HIN25_DPCCD001_D1	I18HIN25_VLCCD001_D1	I18HIN25_HZCCD001_D1
Coastal Mid Range Future Design 10%AEP	I18HIN25_EXCMDEXC_D1				
Coastal Mid Range Future Design 1%AEP	I18HIN25_EXCMDEXC_D1				
Coastal Mid Range Future Design 0.1%AEP	I18HIN25_EXCMDEXC_D1				

GIS Outputs

The following table outlines the GIS deliverables and model run files provided in the accompanying digital handover.

Scenario	Model Run	Main River %AEP	Tributary River %AEP	Flood Extent Polygon	Flood Zone Polygon	Flood Depth Grid	Flood Velocity Grid	Flood Hazard Grid
		50	50					
Fluvial Current Design 50%AEP	I25IN_MFCD500_D2_Innishannon.ief	50	50	I25EXFCD500D2		I25DPFCD500D2	I25VLFCD500D2	I25HZFCD500D2
	I25IN_MFCD200_D2_Innishannon.ief	20	50					
Fluvial Current Design 20%AEP	I25IN_TFCD200_D2_Innishannon.ief	50	20	I25EXFCD100D2		I25DPFCD100D2	I25VLFCD100D2	I25HZFCD100D2
	I25IN_MFCD100_D2_Innishannon.ief	10	20					
Fluvial Current Design 10%AEP	I25IN_TFCD100_D2_Innishannon.ief	20	10	I25EXFCD200D2		I25DPFCD200D2	I25VLFCD200D2	I25HZFCD200D2
	I25IN_MFCD050_D2_Innishannon.ief	5	20					
Fluvial Current Design 5%AEP	I25IN_TFCD050_D2_Innishannon.ief	20	5	I25EXFCD050D2		I25DPFCD050D2	I25VLFCD050D2	I25HZFCD050D2
	I25IN_MFCD020_D2_Innishannon.ief	2	10					
Fluvial Current Design 2%AEP	I25IN_TFCD020_D2_Innishannon.ief	10	2	I25EXFCD020D2		I25DPFCD020D2	I25VLFCD020D2	I25HZFCD020D2
	I25IN_MFCD010_D2_Innishannon.ief	1	5					
Fluvial Current Design 1%AEP	I25IN_TFCD010_D2_Innishannon.ief	5	1	I25EXFCD010D2	I25ZN_A_D2	I25DPFCD010D2	I25VLFCD010D2	I25HZFCD010D2
	I25IN_MFCD005_D2_Innishannon.ief	0.5	5					
Fluvial Current Design 0.5%AEP	I25IN_TFCD005_D2_Innishannon.ief	5	0.5	I25EXFCD005D2		I25DPFCD005D2	I25VLFCD005D2	I25HZFCD005D2
	I25IN_MFCD001_D2_Innishannon.ief	0.1	1					
Fluvial Current Design 0.1%AEP	I25IN_TFCD001_D2_Innishannon.ief	1	0.1	I25EXFCD001D2	I25ZN_B_D2	I25DPFCD001D2	I25VLFCD001D2	I25HZFCD001D2
		50	50					
Fluvial Mid Range Future Design 50%AEP	I25IN_MFMD500_D2_Innishannon.ief	50	50	I25EXFMD500D2		I25DPFMD500D2		
	I25IN_MFMD200_D2_Innishannon.ief	20	50					
Fluvial Mid Range Future Design 20%AEP	I25IN_TFMD200_D2_Innishannon.ief	50	20	I25EXFMD100D2		I25DPFMD100D2		
	I25IN_MFMD100_D2_Innishannon.ief	10	20					
Fluvial Mid Range Future Design 10%AEP	I25IN_TFMD100_D2_Innishannon.ief	20	10	I25EXFMD200D2		I25DPFMD200D2		
	I25IN_MFMD050_D2_Innishannon.ief	5	20					
Fluvial Mid Range Future Design 5%AEP	I25IN_TFMD050_D2_Innishannon.ief	20	5	I25EXFMD050D2		I25DPFMD050D2		
	I25IN_MFMD020_D2_Innishannon.ief	2	10					
Fluvial Mid Range Future Design 2%AEP	I25IN_TFMD020_D2_Innishannon.ief	10	2	I25EXFMD020D2		I25DPFMD020D2		
	I25IN_MFMD010_D2_Innishannon.ief	1	5					
Fluvial Mid Range Future Design 1%AEP	I25IN_TFMD010_D2_Innishannon.ief	5	1	I25EXFMD010D2		I25DPFMD010D2		
	I25IN_MFMD005_D2_Innishannon.ief	0.5	5					
Fluvial Mid Range Future Design 0.5%AEP	I25IN_TFMD005_D2_Innishannon.ief	5	0.5	I25EXFMD005D2		I25DPFMD005D2		
	I25IN_MFMD001_D2_Innishannon.ief	0.1	1					
Fluvial Mid Range Future Design 0.1%AEP	I25IN_TFMD001_D2_Innishannon.ief	1	0.1	I25EXFMD001D2		I25DPFMD001D2		
	I25IN_MFHD100_D2_Innishannon.ief	10	20					
Fluvial High End Future Design 10%AEP	I25IN_TFHD100_D2_Innishannon.ief	20	10	I25EXFHD100D2		I25DPFHD100D2		
	I25IN_MFHD010_D2_Innishannon.ief	1	5					
Fluvial High End Future Design 1%AEP	I25IN_TFHD010_D2_Innishannon.ief	5	1	I25EXFHD010D2		I25DPFHD010D2		
	I25IN_MFHD001_D2_Innishannon.ief	0.1	1					
Fluvial High End Future Design 0.1%AEP	I25IN_TFHD001_D2_Innishannon.ief	1	0.1	I25EXFHD001D2		I25DPFHD001D2		
Coastal Current Design 0.1%AEP	I25IN_CCD001_D1_Innishannon.ief	50	0.1	I25EXCCD500D1		I25DPCCD500D1	I25VLCCD500D1	I25HZCCD500D1
Coastal Current Design 0.5%AEP	I25IN_CCD005_D1_Innishannon.ief	50	0.5	I25EXCCD100D1		I25DPCCD100D1	I25VLCCD100D1	I25HZCCD100D1
Coastal Current Design 1%AEP	I25IN_CCD010_D1_Innishannon.ief	50	1	I25EXCCD100D1		I25DPCCD100D1	I25VLCCD100D1	I25HZCCD100D1
Coastal Current Design 2%AEP	I25IN_CCD020_D1_Innishannon.ief	50	2	I25EXCCD050D1		I25DPCCD050D1	I25VLCCD050D1	I25HZCCD050D1
Coastal Current Design 5%AEP	I25IN_CCD050_D1_Innishannon.ief	50	5	I25EXCCD020D1		I25DPCCD020D1	I25VLCCD020D1	I25HZCCD020D1
Coastal Current Design 10%AEP	I25IN_CCD100_D1_Innishannon.ief	50	10	I25EXCCD010D1		I25DPCCD010D1	I25VLCCD010D1	I25HZCCD010D1
Coastal Current Design 20%AEP	I25IN_CCD200_D1_Innishannon.ief	50	20	I25EXCCD005D1	I25ZN_A_D2	I25DPCCD005D1	I25VLCCD005D1	I25HZCCD005D1
Coastal Current Design 50%AEP	I25IN_CCD500_D1_Innishannon.ief	50	50	I25EXCCD001D1	I25ZN_B_D2	I25DPCCD001D1	I25VLCCD001D1	I25HZCCD001D1
Coastal Mid Range Future Design 0.1%AEP	I25IN_CMD001_D1_Innishannon.ief	50	0.1	I25EXCMD500D1		I25DPCMD500D1	I25VLCMD500D1	I25HZCMD500D1
Coastal Mid Range Future Design 0.5%AEP	I25IN_CMD005_D1_Innishannon.ief	50	0.5	I25EXCMD200D1		I25DPCMD200D1	I25VLCMD200D1	I25HZCMD200D1
Coastal Mid Range Future Design 1%AEP	I25IN_CMD010_D1_Innishannon.ief	50	1	I25EXCMD100D1		I25DPCMD100D1	I25VLCMD100D1	I25HZCMD100D1
Coastal Mid Range Future Design 2%AEP	I25IN_CMD020_D1_Innishannon.ief	50	2	I25EXCMD050D1		I25DPCMD050D1	I25VLCMD050D1	I25HZCMD050D1
Coastal Mid Range Future Design 5%AEP	I25IN_CMD050_D1_Innishannon.ief	50	5	I25EXCMD020D1		I25DPCMD020D1	I25VLCMD020D1	I25HZCMD020D1
Coastal Mid Range Future Design 10%AEP	I25IN_CMD100_D1_Innishannon.ief	50	10	I25EXCMD010D1		I25DPCMD010D1	I25VLCMD010D1	I25HZCMD010D1
Coastal Mid Range Future Design 20%AEP	I25IN_CMD200_D1_Innishannon.ief	50	20	I25EXCMD005D1		I25DPCMD005D1	I25VLCMD005D1	I25HZCMD005D1
Coastal Mid Range Future Design 50%AEP	I25IN_CMD500_D1_Innishannon.ief	50	50	I25EXCMD001D1		I25DPCMD001D1	I25VLCMD001D1	I25HZCMD001D1
Coastal High End Future Design 0.1%AEP	I25IN_CHD001_D1_Innishannon.ief	50	0.1	I25EXCHD100D1		I25DPCHD100D1	I25VLCHD100D1	I25HZCHD100D1
Coastal High End Future Design 0.5%AEP	I25IN_CHD005_D1_Innishannon.ief	50	0.5	I25EXCHD010D1		I25DPCHD010D1	I25VLCHD010D1	I25HZCHD010D1
Coastal High End Future Design 10%AEP	I25IN_CHD100_D1_Innishannon.ief	50	10	I25EXCHD001D1		I25DPCHD001D1	I25VLCHD001D1	I25HZCHD001D1

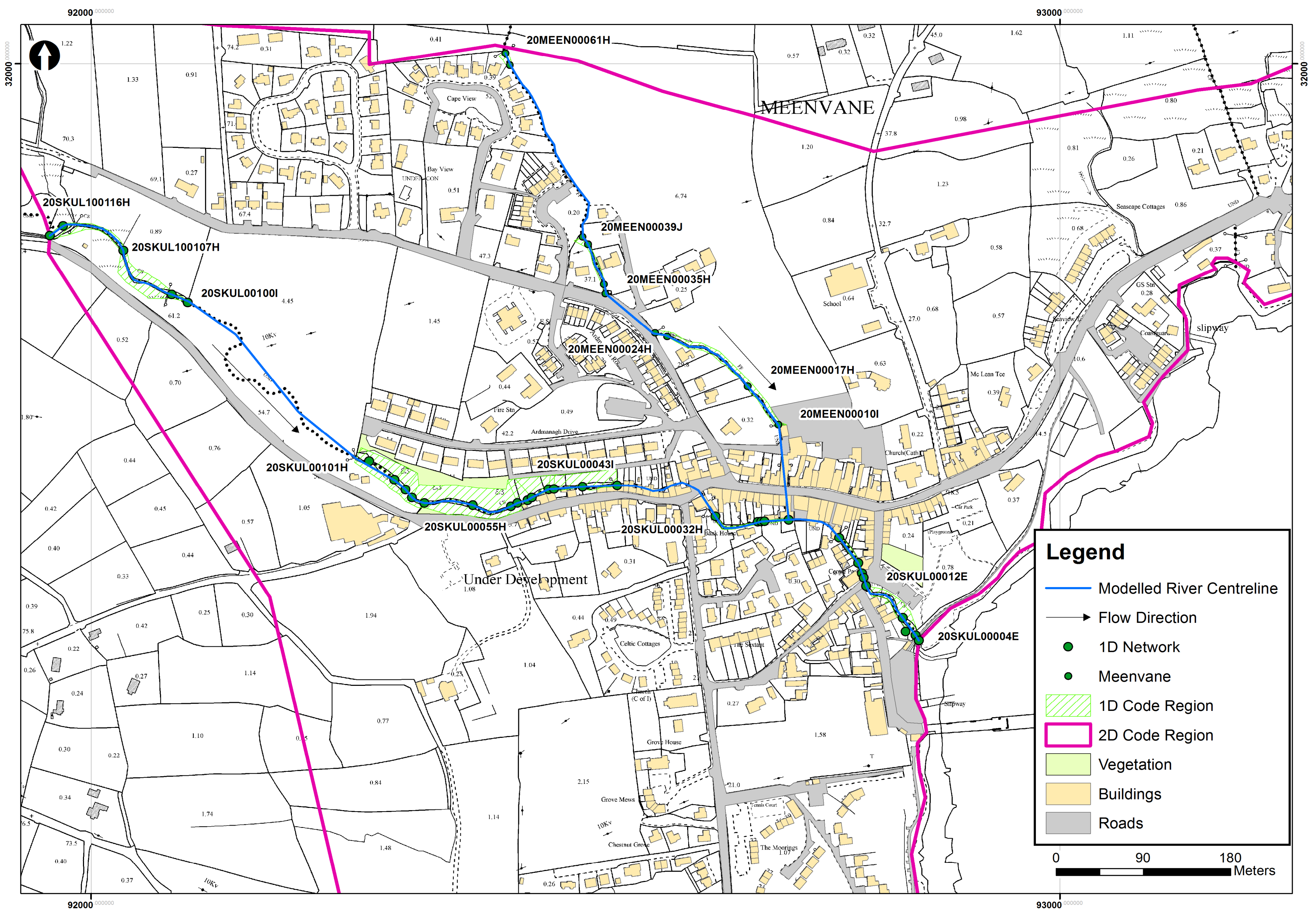
Appendix C. Schull AFA Model Proformas

UOM	20		
AFA/ MPW Reach	AFA-Schull		
Model ID	I28SL		
Purpose of Model Build	Flood Mapping		
Main Watercourse	Schull Stream	FLUVIAL RISK	Yes
Length Modelled (km)	1.76	COASTAL RISK	No
Area Modelled (km^2)	0.98	VULNERABLE TO WAVES	No

Input Data	
River Channel Topographic Data	River channel survey was undertaken by Murphy Surveys Limited as part of the CFRAM Study. 20MEEN_Meevane_V1 surveyed Feb 2013: No errors or gaps were found within the survey. 20SKUL_Skull_V1 surveyed Feb 2013: No errors or gaps were found within the survey
Floodplain Topographic Data	Filtered LIDAR DTM "Skull2mdtm.asc" 2m grid resolution captured in April 2012. The LIDAR DTM covered the entirety of the urban area
Map data	1:5000 Osi mapping tiles used. There appears to be a new area of development in the area of 'Copper Point' towards the upstream area of the main town. This is currently still and area under development but was not within the modelled predicted flood outlines.

Model Build					
General Schematisation	A hydro dynamically linked 1D ESTRY - 2D TUFLOW model approach was taken for Schull to accurately model flow along the main watercourses and head loss through various steep culvert whilst enabling multidirectional flow along roads and across the urban floodplain. ESTRY was agreed with the OPW as the 1D software for Schull because it is better able to model the supercritical flows along steep culverts and channel such as found in Schull and enables the incorporation of manholes such as those that cause flooding by the Bunratty Inn. Buildings thresholds have been raised by 0.15m above the DTM level based on site observations and a higher Manning's 'n' value applied to the building footprints to simulate the storage of water once flooded. Areas of dense vegetation have been assigned higher Manning's 'n' to represent the increased roughness. The 2D floodplain was set to 5m to represent the urban area without compromising run time. Version D 2: Improved stability by reconfiguration of bank locations; adding manually interpolated reach to the 20SKUL00100i culverts; specifiying the length of bridge/culverts in the vicinity 20SKUL0052D to avoid errors in automatically calculation length and additional stability commands in the run settings (discussed below).				
Software Versions Used	ESTRY and TUFLOW version 2012-05-AC-iSP-w32				
Total No of 1D nodes	**43**				
Open channel (H)	26				
Bridges (D)	0				
Culverts (I)	16				
Weirs (W)	1				
Model Extent	Reach/Feature	Upstream Limit (ING)		Downstream Limit (ING)	
	Schull Stream	91957, 31815		92854, 31385	
	Meevane Stream	92427, 32010		92709, 31616	
Roughness	Reach/Feature	Active Channel	River Banks	Floodplain	Source
	Schull Stream	N/A	N/A	N/A	Schedule 2 Photos
	Meevane Stream	N/A	N/A	N/A	Schedule 2 Photos
Structures	See Schedule 2 for Hydraulic Structure Parameters				
Upstream boundary	The inflows were applied as a flow-time (QT) boundary was located at 20SKUL00116H on the Schull Stream at the upstream of the AFA and at Meevane Stream 20MEEN00061H. The flows upstream of the confluence have been lumped to the upstream limit because the intermediate catchment is less than 1km2.				
Lateral inflows	Flows at the upstream end of the Schull Stream/Meevane Stream have been applied as the more conservative lumped point flow as the intermediate catchments are small. The intermediate flows downstream of the confluence have been distributed evenly between the open channel sections as the catchment area and therefore flow contribution increases linearly.				
Downstream boundary	The downstream boundary of the Schull Stream is located at the point of the outfall into the sea in Schull Bay, located at 20SKUL00004E. The MHWS has been applied a water level-time (HT) boundary based on the design tidal conditions. Flooding from tidal scenarios have not been simulated because the outfall of Schull Stream is elevated some 2m above the design total tide plus surge levels.				
Run Settings	Unsteady simulation of the full 20 hour hydrograph. The 1D timestep was set to 1s which is divisible in to the 2D timestep of 2s which is less than half the grid cell size as recommended by TUFLOW. Version D2 includes the command " Set Culvert Critical H/D == 1.8" to improve stability along the steep cuvert 20SKUL00100i. The value of 1.8 was set based on the culvert diameter/ channel depth.				

Model Geoschematic



SCHEDULE 1 : PHOTOGRAPHS (Schull Stream)	SCHEDULE 1 : PHOTOGRAPHS (Meenvane Stream)
Photo 1: Active Channel Upstream of AFA	**Photo 5: Upstream Meenvane Active Channel**
	
Photo 2: Active Channel Through Urban Area	**Photo 6: Urban Active Channel**
	
Photo 3: Active channel and Banks at AFA (South Terrace Bridge)	**Photo 7: Urban Bank**
	
Photo 4: Banks and Floodplain Upstream of AFA	**Photo 8: Urban Bank and Floodplain**
	

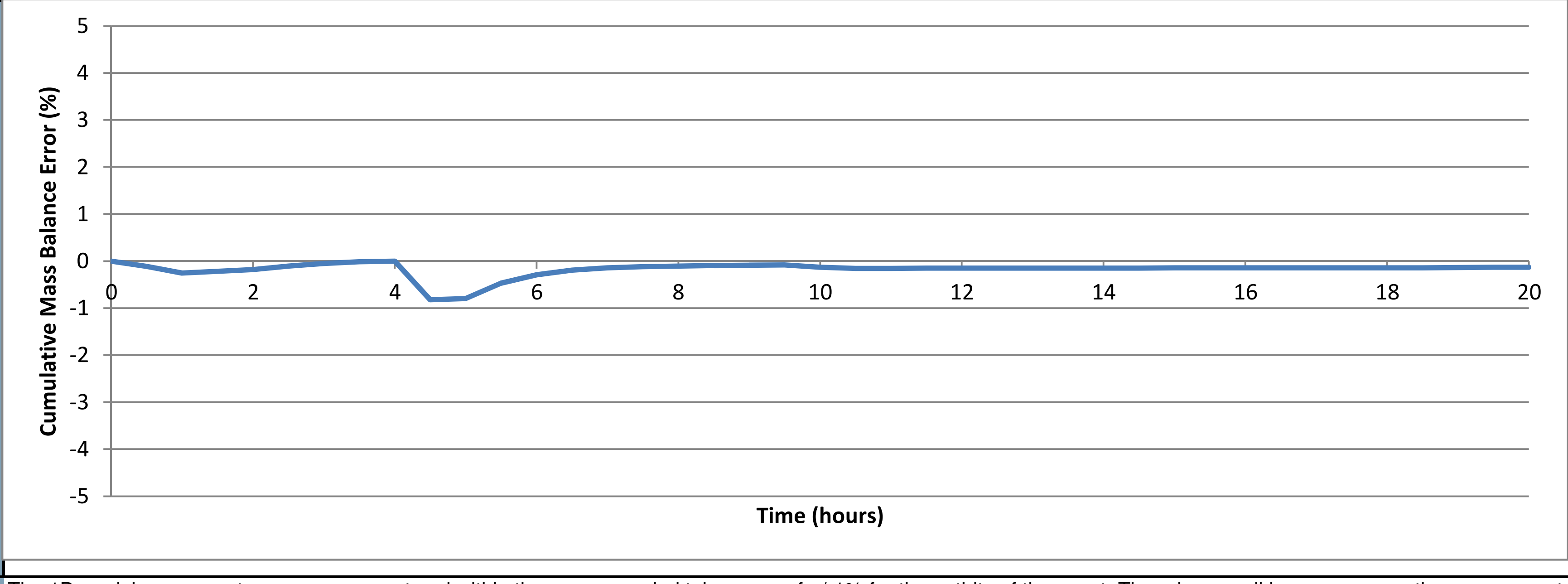
SCHEDULE 2: Structures

Model file	P:\Cambridge\Demeter\EVT4\296241 S West CFRAMS EVT Code\Technical\Hydraulics\Build\I28SL_Schull\DESIGN\run\I28SL_FCD010_T_D1_001_Schull_001.tcf																								
Node	Easting	Northing	Structure Type	Bridge Parameters				Weir Parameters				Spill Parameters			Culvert Parameters										Comments/ Justification
				Soffit Elevation (mAOD)	No of Openings	Skew Angle	Calibration Coefficients	Crest Elevation (mAOD)	Length	Modular Limit	Velocity Coeff.	Minimum. Crest Elevation (mAOD)	Modular Limit	Weir Coeff.	Soffit level (mAOD)	Invert u/s (mAOD)	Invert d/s (mAOD)	Width (m)	Length (m)	K	Ki	M	Trash Screen?	Trash Screen coefficient	
SKUL00100I	92153	31707	Circular Culvert	NA	NA	NA	NA	NA	NA	NA	NA	53.47	N/A	1	53.47	52.27	46.9	1.2	119	0.5	1	N/A	N/A	N/A	Long steep pipe under field. Likely to be critical therefore manually interpolated section added to improve stability.
SKUL00100I	92153	31707	Circular Culvert	NA	NA	NA	NA	NA	NA	NA	NA	48.1	N/A	1	48.1	46.9	41.44	1.2	119	0.5	1	N/A	N/A	N/A	Long steep pipe under field. Likely to be critical therefore manually interpolated section added to improve stability.
MEEN00060I	92464	31929	Circular Culvert	NA	NA	NA	NA	NA	NA	NA	NA	51.21	N/A	1	51.21	51.21	39.03	0.9	202.6	0.5	1	NA	NA	NA	
MEEN00032I	92560	31725	Circular Culvert	NA	NA	NA	NA	NA	NA	NA	NA	34.05	N/A	1	34.05	34.05	29.81	0.6	62.8	0.5	1	NA	NA	NA	
MEEN00010I	92714	31570	Circular Culvert	NA	NA	NA	NA	NA	NA	NA	NA	18.66	N/A	1	18.66	18.66	13.94	1.1	104.3	0.5	1	NA	NA	NA	Culvert entrance towards Schull Stream
SKUL00043I	92587	31542	Rectangular Culvert	NA	NA	NA	NA	NA	NA	NA	NA	26.35	N/A	1	26.35	25.04	21.34	2.05	63.4	0.5	1	NA	NA	NA	High Street Culvert under the backs of the houses from Airhill House to Old Bank House. Mainholes inserted by the Bunratty Inn based on site visits observations and the recent flood reports.
SKUL00042I	92622	31547	Rectangular Culvert	NA	NA	NA	NA	NA	NA	NA	NA	22.65	N/A	1	22.65	21.34	21.34	2.05	25	0.5	1	NA	NA	NA	
SKUL00041I	92635	31530	Rectangular Culvert	NA	NA	NA	NA	NA	NA	NA	NA	22.65	N/A	1	22.65	21.34	17.45	2.05	32.5	0.5	1	NA	NA	NA	
SKUL00023I	92758	31507	Rectangular Culvert	NA	NA	NA	NA	NA	NA	NA	NA	16.202	N/A	1	15.402	13.99	12.45	1.92	58.6	0.5	1	NA	NA	NA	
SKUL00014W	92791	31468	Weir	NA	NA	NA	NA	10.145	5.178	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Weir upstream of Pier Road Bridge
SKUL00013D2	92798	31448	Rectangular Culvert	NA	NA	NA	NA	NA	NA	NA	NA	10.45	N/A	1	10.45	9.26	9.07	1.34	8.7	0.5	1	NA	NA	NA	Pier Road Bridge. No spill modelled as the bridge parapaet is bypassed before the water level reaches the parapet.
SKUL00065I	92326	31542	Rectangular Culvert with Weir	NA	NA	NA	NA	NA	NA	NA	NA	39.11	N/A	1	38.91	37.89	37.89	1.72	9.7	0.5	1	NA	NA	NA	
SKUL00053D	92326	31542	Rectangular Culvert with Weir	NA	NA	NA	NA	NA	NA	NA	NA	31.78	N/A	1	31.71	30.73	30.7	1.43	10.9	0.5	1	NA	NA	NA	
SKUL00052D	92453	31537	Rectangular Culvert with Weir	NA	NA	NA	NA	NA	NA	NA	NA	31.34	N/A	1	31.24	30.27	30.2	1.72	4.9	0.6	1	NA	NA	NA	Length specified to improve stability and more accuerately match survey. Entrance loss set to 0.6 to represent that the channel is not obstructed until the soffit
SKUL00051D	92474	31546	Rectangular Culvert with Weir	NA	NA	NA	NA	NA	NA	NA	NA	30.63	N/A	1	30.565	29.25	29.2	2.09	5.5	0.6	1	NA	NA	NA	Length specified to improve stability and more accuerately match survey. Entrance loss set to 0.6 to represent that the channel is not obstructed until the soffit
SKUL00026D	92693	31512	Rectangular Culvert with Weir	NA	NA	NA	NA	NA	NA	NA	NA	17.03	N/A	1	16.06	14.66	14.66	2.78	3.5	0.5	1	NA	NA	NA	
SKUL00013D1	92798	31448	Rectangular Culvert with Weir	NA	NA	NA	NA	NA	NA	NA	NA	9.42	N/A	1	8.18	9.33	9.07	1.42	8.7	0.5	1	NA	NA	NA	Bridge modelled as a culvert. Weir represents spill over deck
SKUL00005D	92853	31386	Rectangular Culvert with Weir	NA	NA	NA	NA	NA	NA	NA	NA	5.661	N/A	1	3.161	1.03	0.8	3.46	7.7	0.5	1	NA	NA	NA	Bridge modelled as a culvert. Weir represents spill over deck

Schull Model Performance

1D Convergence

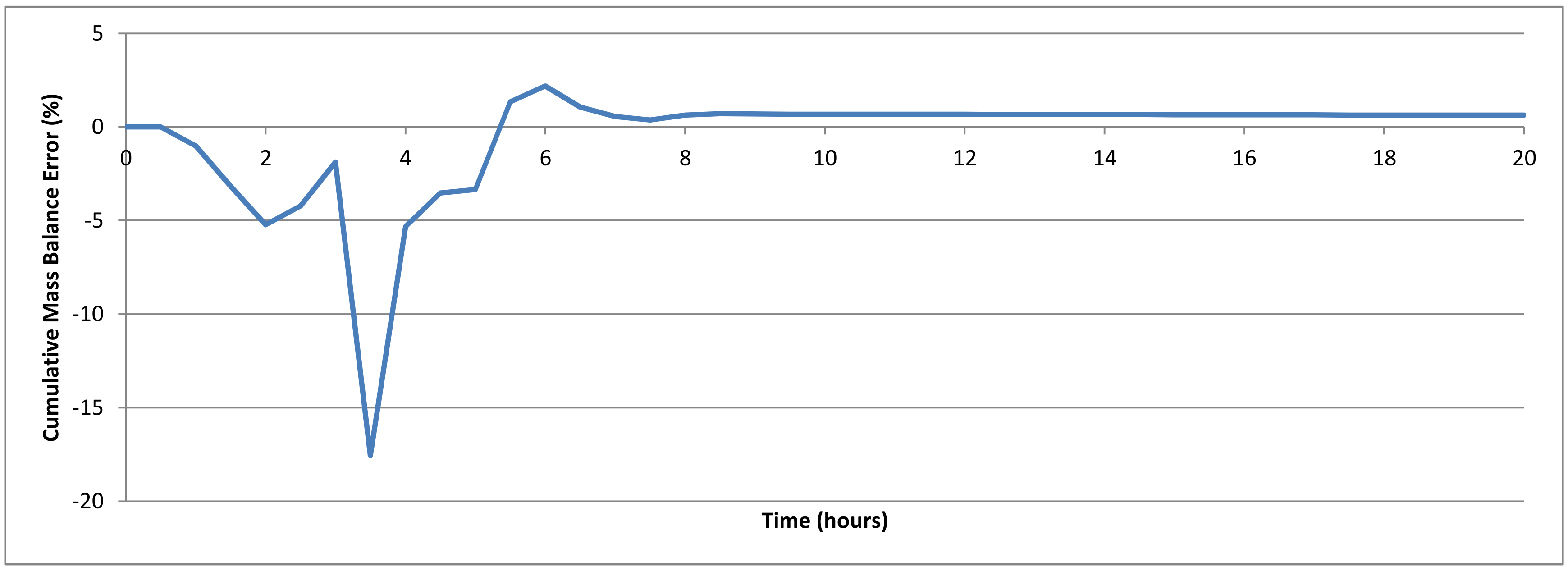
Convergence Plot 0.1% AEP Fluvial Event



Comments: The 1D model components were convergent and within the recommended tolerances of +/-1% for the entirity of the event. There is a small increase n negative mass error to -0.8% at 4.5 hours as water overtops the river banks. However this quickly reduces to -0.1% before the peak flow at 8 hours.
Therefore the 1D results are deemed to be convergent and reliable.

2D Convergence

Mass Balance Plot 0.1%AEP Fluvial Event



Comments: The total culmulative mass error in the 2D components is 0.3% or 1230 m^3 for the 0.1%AEP fluvial current event.
There is an initial spike in 2D mass error between 1 and 5 hours as the 2D cells begin to wet at the upstream of the High Street culvert and culverts upstream of the AFA on Schull Stream. However, this reduces to 0.6% before the peak at 8 hours. Therefore the 2D results are deemed convergent and reliable.

Hydrological Performance				10% AEP m3/s			1%AEP m3/s			0.1%AEP m3/s		
Target Flows	HEP ID	Location	Model Node	Design	Modelled	% Difference	Design	Modelled	% Difference	Design	Modelled	% Difference
	20_1990_3	Schull Stream upstream of the Meevane confluence	SKUL00043I	2.8	2.8	0%	4.2	4.2	0%	6.4	6.4	1%
	22_1916_1+	Meenvane Stream Upstream	MEEN00061H	1.3	1.3	-2%	1.9	1.9	0%	2.9	2.9	-1%
	22_1916_1	Downstream of Schull/Meenvane Confluence	20SKUL00018J	4.1	4.0	-3%	6.1	6.3	3%	9.2	9.7	5%
	22_1916_2	Schull Stream Downstream Boundary	20SKUL00004E	4.4	4.2	-4%	6.7	6.9	3%	10.0	10.9	9%

Comments: The flows in the 1D element of the model are similar to the design hydrology (within 10%) at all HEPs. 20_1990_1 has not been compared as this froms the inflow to the model.

Calibration Event 1

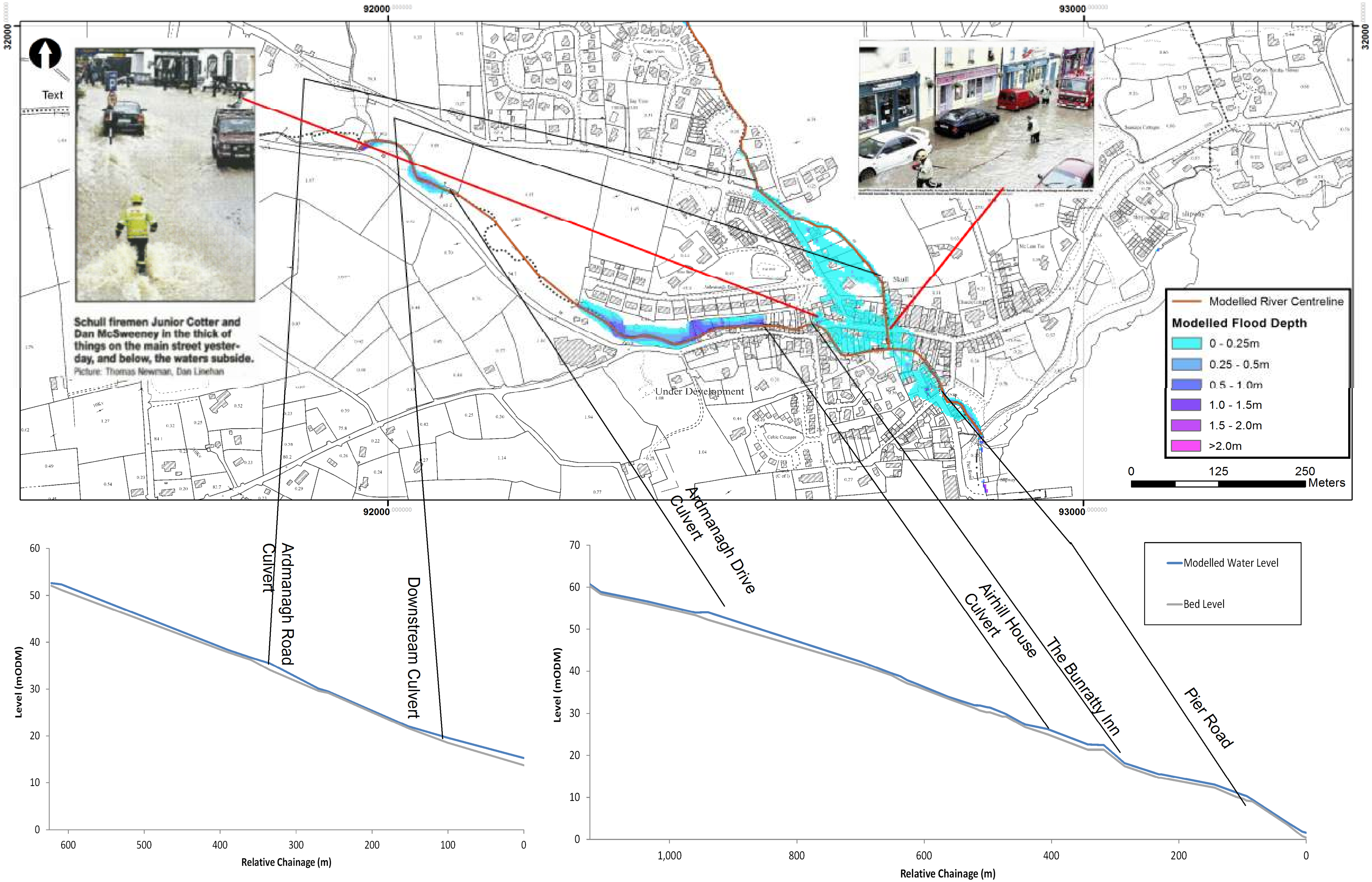
Model Run ID	I28SL_FCC_20091006_D1
Period Modelled	05/10/2009 to 06/10/2009
Hydraulic Modification to Design Model	No hydraulic modifications were made to the design model.
Hydrological inflows	Calibrated Rainfall runoff FSSR units have been applied to the inflows based on 72% runoff at Sherkin island nearby to Schull. The design downstream tidal conditions were used as the tide level did not affect flooding along Schull Stream.
Calibration Plot	See Schedule 3 - Calibration and Sensitivity
Comments	The manhole and culvert coefficients were calibrated to reproduce the flooding up through the paving over the river channel by Bunratty Inn to reproduce flooding along Main Street. The areas flooded match well with the newspaper clippings and modelled depths were comaprable to the 6 inches (0.15m) reported. However, the CFRAM model underestimated flooding at O'Keefe's by 0.3m because the model assumes flow through buildings once water reaches the thresholds (i.e. no sandbags are considered) and the model does not account for the additional surface water flowing along Ardmanagh Road from Cape View which added to flooding on Main Street. Overall, the model calibrates well with the mechanisms reported in October 2009.

Calibration Event 2

Model Run ID	I28SL_FCC_20120815_D1
Period Modelled	15/08/2012
Hydraulic Modification to Design Model	No hydraulic modifications were made to the design model.

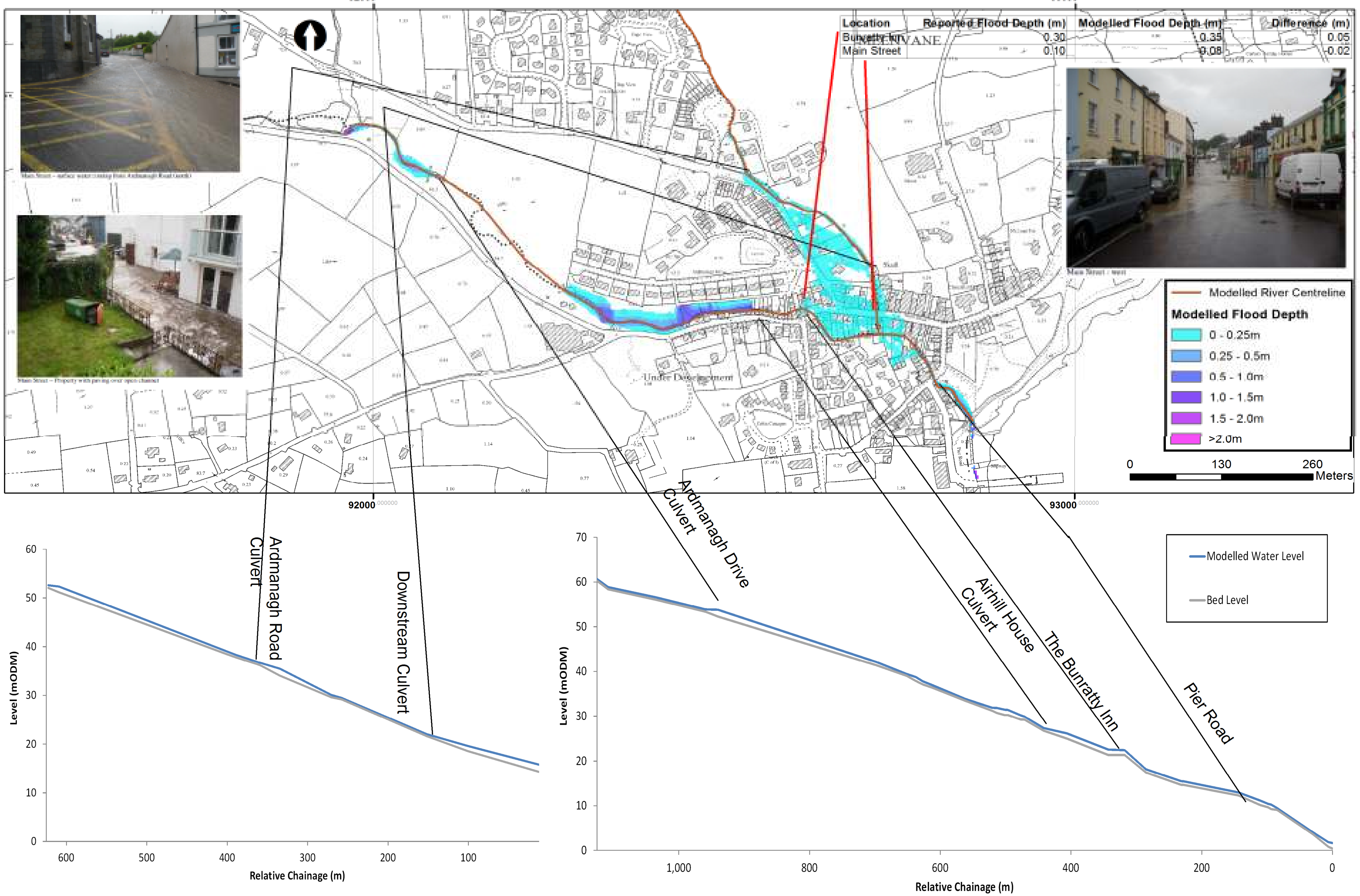
Hydrological inflows	Calibrated Rainfall runoff FSSR units have been applied to the inflows based on 75% runoff at Sherkin island nearby to Schull. The design downstream tidal conditions were used as the tide level did not affect flooding along Schull Stream.
Calibration Plot	See Schedule 3 - Calibration and Sensitivity
Comments	The manhole and culvert coefficients were calibrated to reproduce the flooding up through the paving over the river channel by Bunratty Inn to reproduce flooding along Main Street as detailed in the flood report. The areas flooded match well with the mechnaims described in the flood report andflood depths were within 0.1m of the recorded depths takne from photographs. However, the CFRAM models does not account for the additional surface water flowing along roads which flooded properties along Gubben Road and Colla Road. Overall, the model calibrates well with the fluvial mechanisms reported in August 2012.
Sensitivity Test 1: Increased Flow	
Model Run ID	I28SL_FHD010_T_D1_001_Schull_001
Hydraulic Modification to Design Model	No hydraulic modifications were made to the design model.
Hydrological inflows	All inflows were increased by 30% for the 1%AEP fluvial current design event to account for the uncertainty in the derivation of QMED and the pooling group selected. This is broadly equivalent to the HEFS 1%AEP as the increase in urban extent has less the 1% impact on peak flow. Therefore, the HEFS 1%AEP results (FHD010) have been used as the sensitivity test results.
Sensitivity Plot	See Schedule 3 - Calibration and Sensitivity
Comments	A 30% increase in flows increased flood levels by 0.4m which exceeded the capacity of the upstream culverts on Schull Stream and Meevane Stream. This resulted in greater flooding to fields upstream of Ardmanagh Drive and greater flooding to properties on the left bank of Meevane Stream flowing down the fields towards the High Street. Therefore flood risk in Schull was found to be sensitive to the uncertainties in flow.
Sensitivity Test 2: Increased Downstream Boundary	
Model Run ID	I28SL_FCSH01_T_D1_001_Schull_001
Hydraulic Modification to Design Model	No hydraulic modifications were made to the design model.
Hydrological inflows	The downstream boundary was raised by 0.5m to assess the sensitivity of the model to assumptions in the tidal conditions.
Sensitivity Plot	See Schedule 3 - Calibration and Sensitivity
Comments	An increased downstream boundary resulted in raised levels up to the downstream face of the Riverside Bridge but did not affect flows or levels through the AFA upstream. The increase in downstream level results in a small increase in flooding at Riverside car park but flood risk and extent does not change significantly within the AFA upstream. Therefore, flood risk in Schull was not deemed sensitive to the assumptions in the downstream boundary.
Sensitivity Test 3: Increased Manning's 'n'	
Model Run ID	I28SL_FCSN01_T_D1_001_Schull_001
Hydraulic Modification to Design Model	The Manning's 'n' values were increased to the upper limit of the industry recommended ranges. All active channels 0.040 to 0.045 All river banks 0.060 to 0.080 All culverts 0.018 to 0.020 Pasture / parkland / garden 0.060 to 0.080 Buildings 0.200 to 0.300 Roads 0.033 to 0.040 Dense vegetation 0.080 to 0.10
Hydrological	No modifications were made to the design inflows.
Sensitivity Plot	See Schedule 3 - Calibration and Sensitivity
Comments	An increase in roughness values resulted in a 0.04m increase in flood levels which caused slightly greater flooding upstream of the High Street on the Meevane Stream but did not affect additional properties. Therefore, flood risk in Schull was not deemed sensitive Manning's 'n' values at the 1%AEP.

Map C.1: Calibration to 06/10/2009 Flood Event

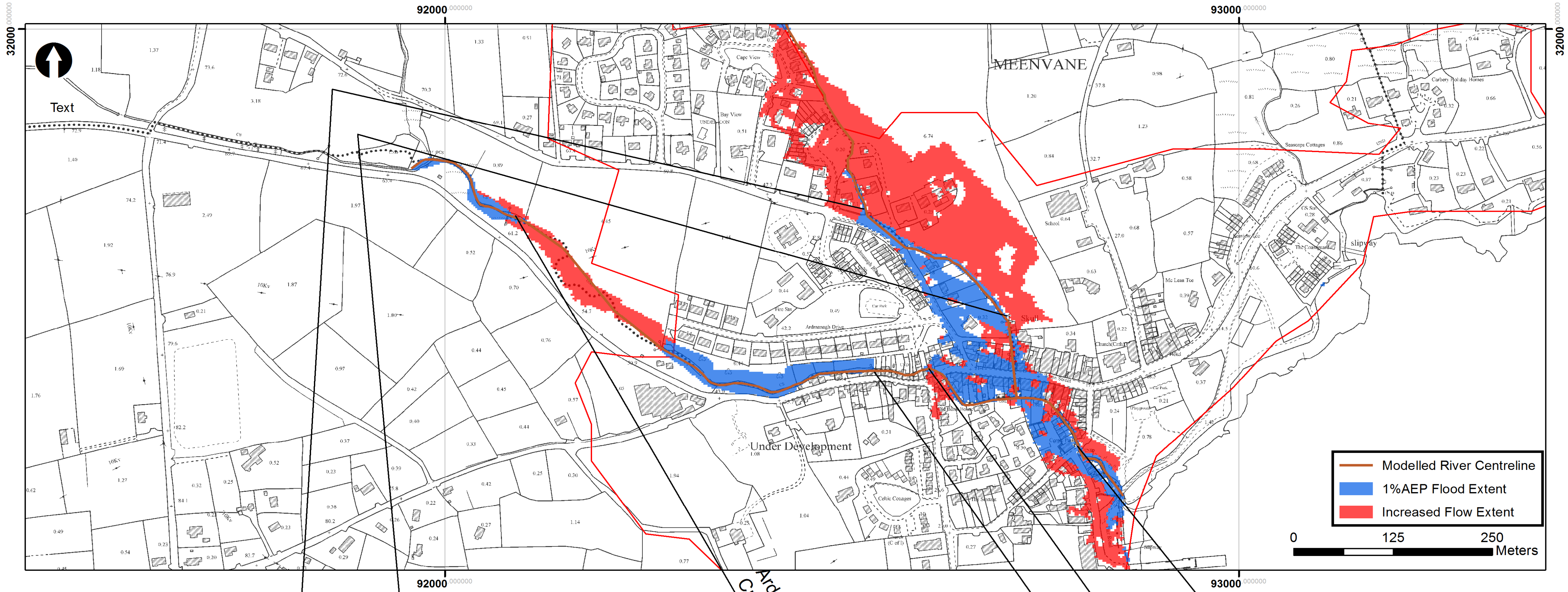


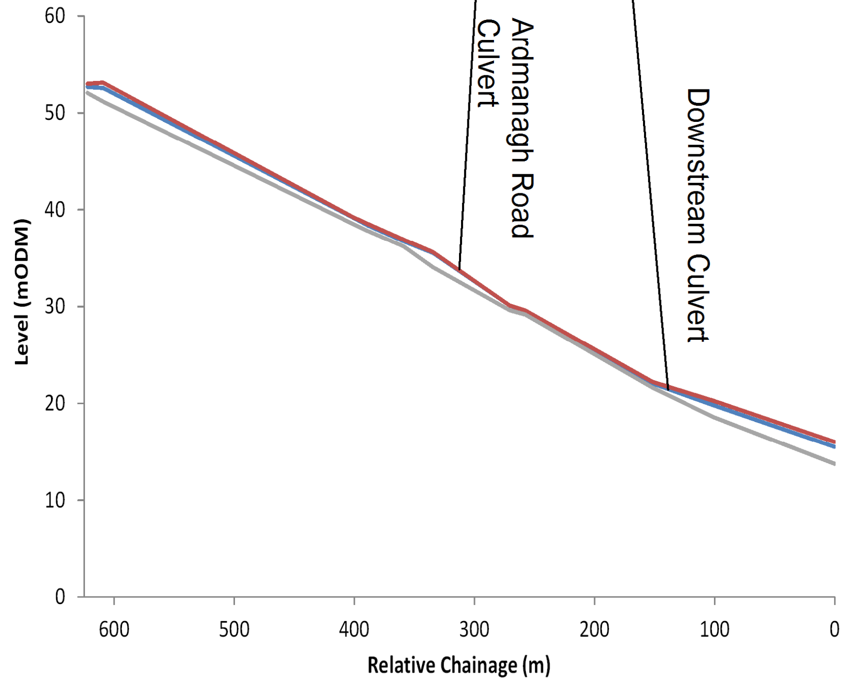
Map C.2: Calibration to 15/08/2012 Flood Event

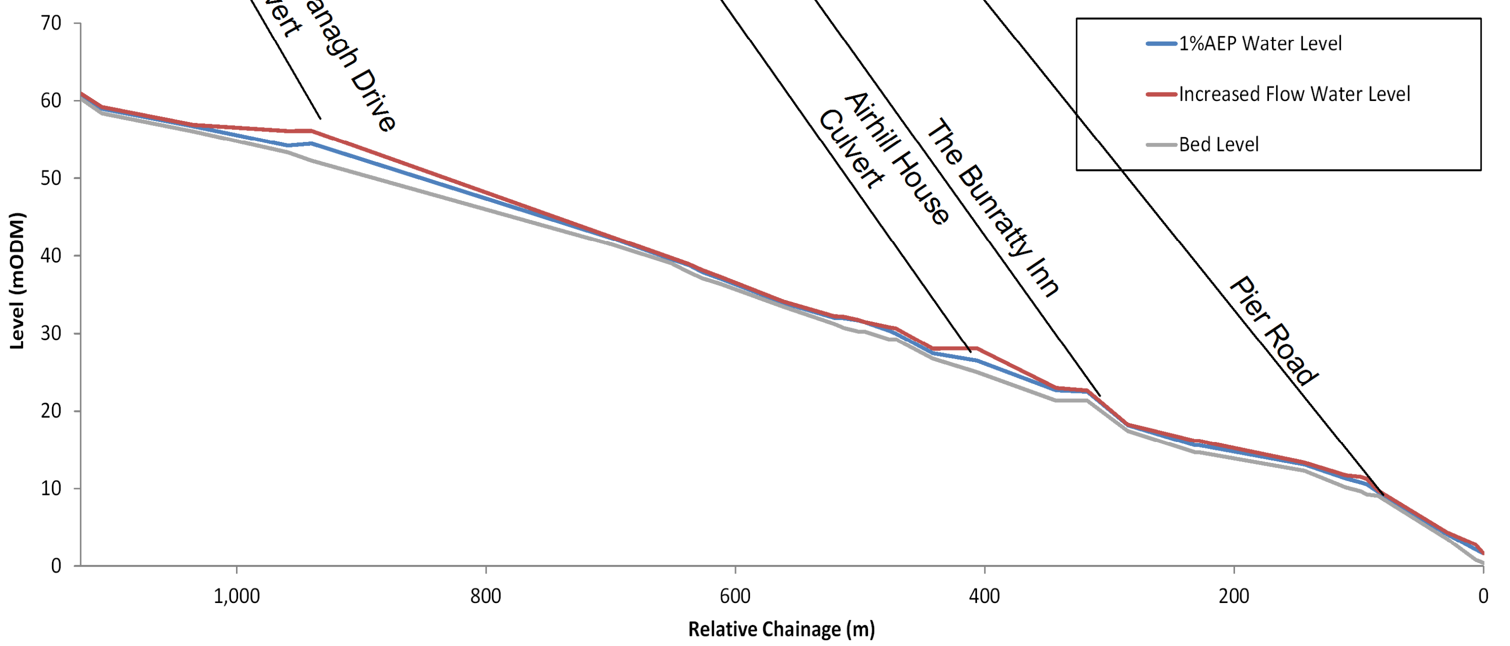
Location	Reported Flood Depth (m)	Modelled Flood Depth (m)	Difference (m)
Bunratty Inn	0.30	0.35	0.05
Main Street	0.10	0.08	-0.02



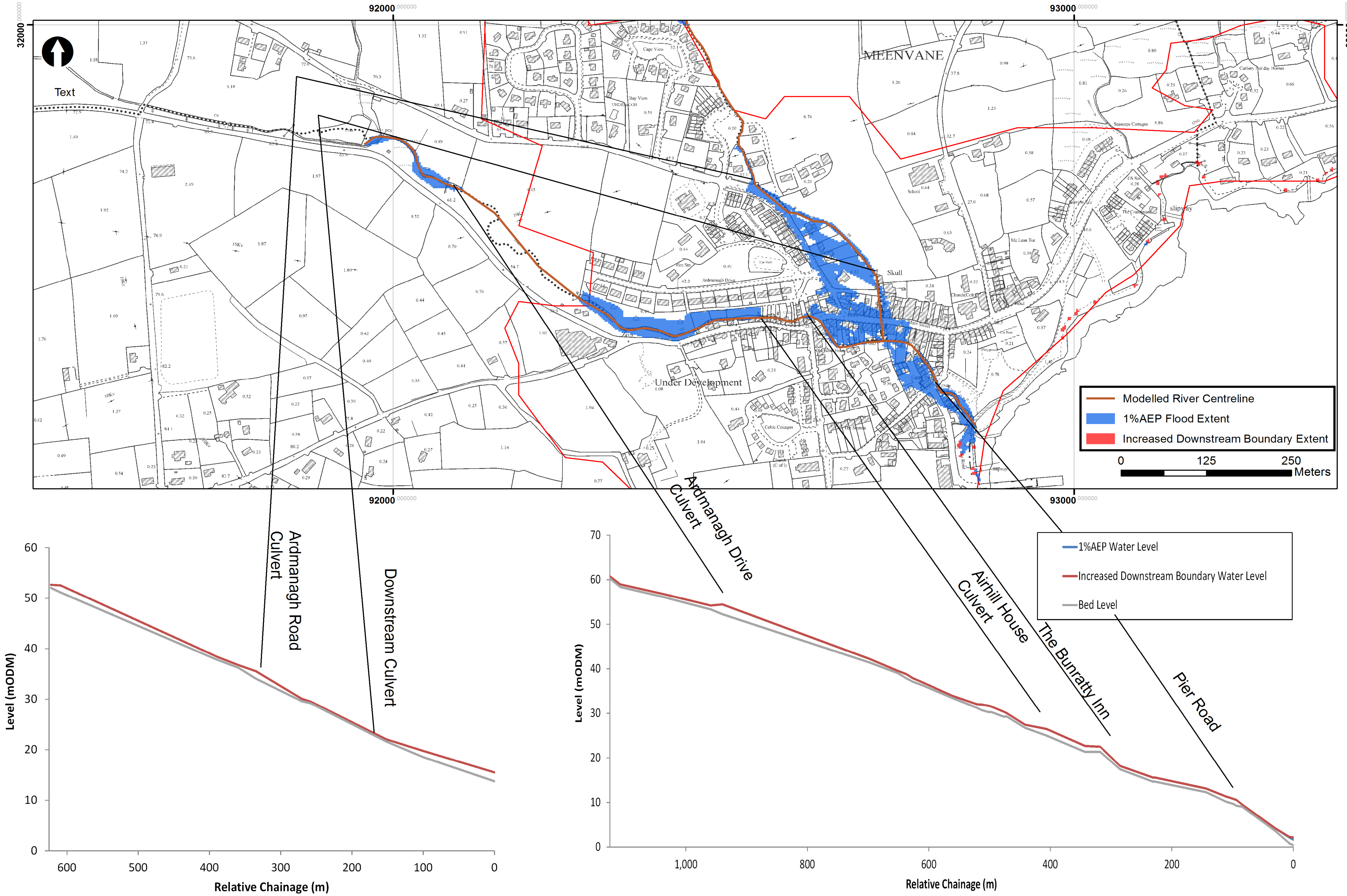
Map C.3: Sensitivity to Increased Peak Flow



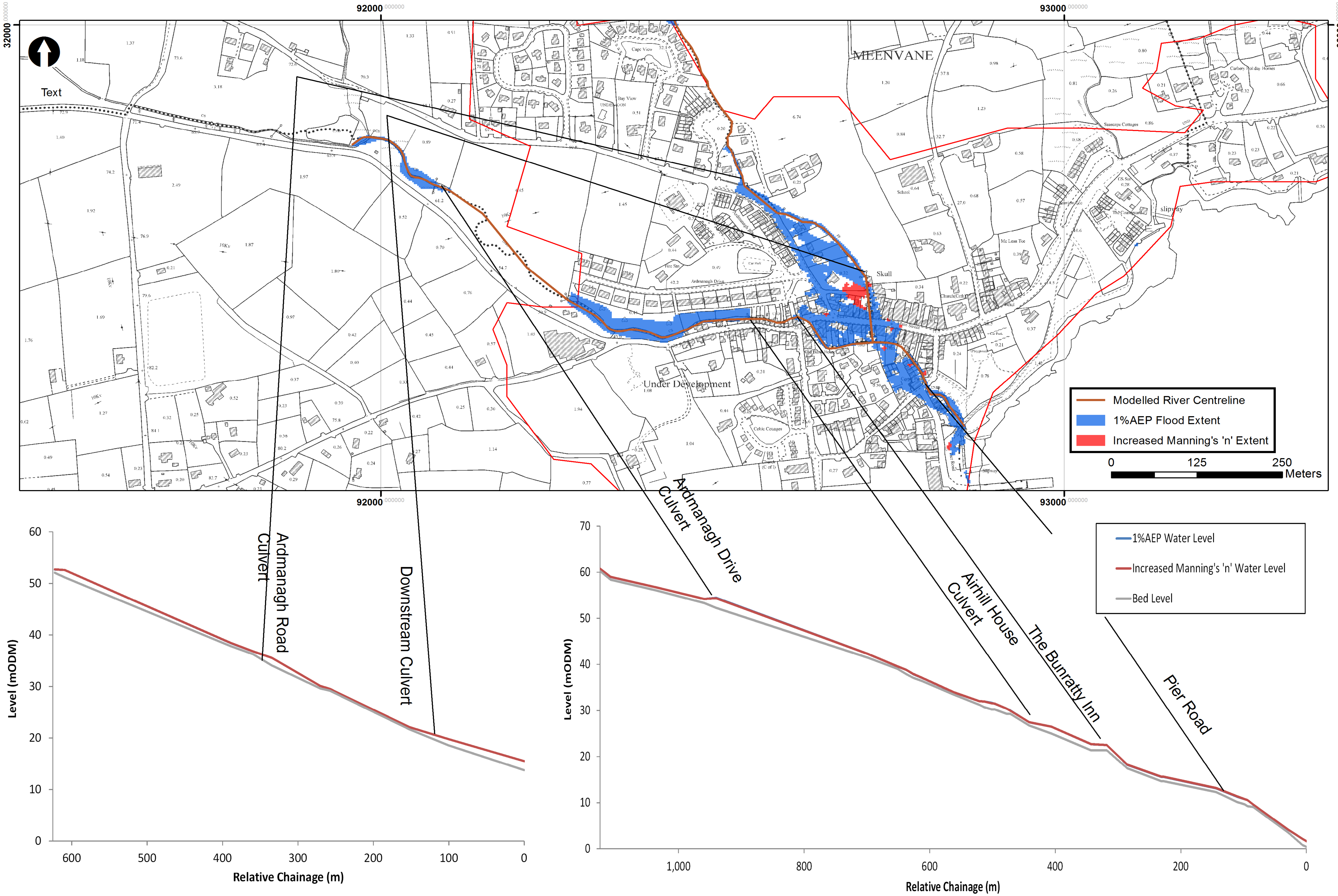




Map C.4: Sensitivity to Increased Downstream Boundary



Map C.5: Sensitivity to Increased Manning's 'n'



Schull Model Outputs	
Threshold of Property Flooding	The key thresholds and areas affected by flooding in Schull are: - 20%AEP fluvial current event exceeds the capacity of the manholes by the Bunratty Inn on Schull Stream and downstream culvert on the Meevane Stream to cause flooding along the High Street. - 5%AEP fluvial current event exceeds the capacity of the Pier Road Bridge to flood Pier Road Cottages. - 0.5%AEP fluvial current event flood properties on the left and right banks of Meevane Stream upstream of Ardmanagh Road - 0.1%AEP fluvial current event exceeds the capacity of the culvert upstream of Ardmanagh Drive on Schull Stream to flood fields upstream of the AFA but does not affect properties.
Critical Structures for Flood Risk	The critical structures in determining flood risk include: - The High Street culvert on Schull Stream and associated manholes - Culverts on the Meevane Stream - Pier Road Bridge on Schull Stream
Areas affected by flooding	Flooding is expected to affect properties located along the High Street, Pier Road and Ardmanagh Beg area.
Risk to people	The greatest risk to life is associated with fast flowing water from the Bunratty Inn down the High Street in the 1%AEP and greater magintude events. Flood water along the High Street and Ardmanagh Road may also form a hazard to road users.
Consideration for Flood Risk Management Options	- Increased conveyance at the key structures identified is likely to reduce flood risk. - Flood warning for Schull is likely to be ineffective as the flood risk is driven by a small flashy catchment.

Flood Map Outputs

The following table outlines the print-ready flood mapping deliverables provided in the accompanying digitial data.

Scenario	Flood Extent Map	Flood Zone Map	Flood Depth Map	Flood Velocity Map	Flood Hazard Map
Fluvial Current Design 10%AEP	I18HSL28_EXFCDEXF_D2		I18HSL28_DPFCD100_D2	I18HSL28_VLFCD100_D2	I18HIN25_HZFCD100_D2
Fluvial Current Design 1%AEP	I18HSL28_EXFCDEXF_D2	I18HSL28_ZN_D2	I18HSL28_DPFCD010_D2	I18HSL28_VLFCD010_D2	I18HIN25_HZFCD010_D2
Fluvial Current Design 0.1%AEP	I18HSL28_EXFCDEXF_D2	I18HSL28_ZN_D2	I18HSL28_DPFCD001_D2	I18HSL28_VLFCD001_D2	I18HIN25_HZFCD001_D2
10%AEP	I18HSL28_EXFMDEXF_D2				
Fluvial Mid Range Future Design 1%AEP	I18HSL28_EXFMDEXF_D2				
0.1%AEP	I18HSL28_EXFMDEXF_D2				

GIS Outputs

The following table outlines the GIS deliverables provided in the accompanying digital handover.

Model Run ID	Scenario	Fluvial %AEP	Coastal %AEP	Flood Extent Polygon and Nodes	Flood Zone Polygon	Flood Depth Grid	Flood Velocity Grid	Flood Hazard Grid
Fluvial Current Design 0.1%AEP	I28SL_FCD500_D2_Schull.tcf	50	n/a	I28EXFCD500D2		I28DPFCD500D2	I28VLFCD500D2	I28HZFCD500D2
Fluvial Current Design 0.5%AEP	I28SL_FCD200_D2_Schull.tcf	20	n/a	I28EXFCD200D2		I28DPFCD200D2	I28VLFCD200D2	I28HZFCD200D2
Fluvial Current Design 1%AEP	I28SL_FCD100_D2_Schull.tcf	10	n/a	I28EXFCD100D2		I28DPFCD100D2	I28VLFCD100D2	I28HZFCD100D2
Fluvial Current Design 2%AEP	I28SL_FCD050_D2_Schull.tcf	5	n/a	I28EXFCD050D2		I28DPFCD050D2	I28VLFCD050D2	I28HZFCD050D2
Fluvial Current Design 5%AEP	I28SL_FCD020_D2_Schull.tcf	2	n/a	I28EXFCD020D2		I28DPFCD020D2	I28VLFCD020D2	I28HZFCD020D2
Fluvial Current Design 10%AEP	I28SL_FCD010_D2_Schull.tcf	1	n/a	I28EXFCD010D2	I28ZN_A_D2	I28DPFCD010D2	I28VLFCD010D2	I28HZFCD010D2
Fluvial Current Design 20%AEP	I28SL_FCD005_D2_Schull.tcf	0.5	n/a	I28EXFCD005D2		I28DPFCD005D2	I28VLFCD005D2	I28HZFCD005D2
Fluvial Current Design 50%AEP	I28SL_FCD001_D2_Schull.tcf	0.1	n/a	I28EXFCD001D2	I28ZN_B_D2	I28DPFCD001D2	I28VLFCD001D2	I28HZFCD001D2
Fluvial Mid Range Future Design 0.1%AEP	I28SL_FMD500_D2_Schull.tcf	50	n/a	I28EXFMD500D2		I28DPFMD500D2	I28VLFMD500D2	I28HZFMD500D2
Fluvial Mid Range Future Design 0.5%AEP	I28SL_FMD200_D2_Schull.tcf	20	n/a	I28EXFMD200D2		I28DPFMD200D2	I28VLFMD200D2	I28HZFMD200D2
Fluvial Mid Range Future Design 1%AEP	I28SL_FMD100_D2_Schull.tcf	10	n/a	I28EXFMD100D2		I28DPFMD100D2	I28VLFMD100D2	I28HZFMD100D2
Fluvial Mid Range Future Design 2%AEP	I28SL_FMD050_D2_Schull.tcf	5	n/a	I28EXFMD050D2		I28DPFMD050D2	I28VLFMD050D2	I28HZFMD050D2
Fluvial Mid Range Future Design 5%AEP	I28SL_FMD020_D2_Schull.tcf	2	n/a	I28EXFMD020D2		I28DPFMD020D2	I28VLFMD020D2	I28HZFMD020D2
Fluvial Mid Range Future Design 10%AEP	I28SL_FMD010_D2_Schull.tcf	1	n/a	I28EXFMD010D2		I28DPFMD010D2	I28VLFMD010D2	I28HZFMD010D2
Fluvial Mid Range Future Design 20%AEP	I28SL_FMD005_D2_Schull.tcf	0.5	n/a	I28EXFMD005D2		I28DPFMD005D2	I28VLFMD005D2	I28HZFMD005D2
Fluvial Mid Range Future Design 50%AEP	I28SL_FMD001_D2_Schull.tcf	0.1	n/a	I28EXFMD001D2		I28DPFMD001D2	I28VLFMD001D2	I28HZFMD001D2
Fluvial High End Future Design 0.1%AEP	I28SL_FHD100_D2_Schull.tcf	10	n/a	I28EXFHD100D2		I28DPFHD100D2	I28VLFHD100D2	I28HZFHD100D2
Fluvial High End Future Design 0.5%AEP	I28SL_FHD010_D2_Schull.tcf	1	n/a	I28EXFHD010D2		I28DPFHD010D2	I28VLFHD010D2	I28HZFHD010D2
Fluvial High End Future Design 10%AEP	I28SL_FHD001_D2_Schull.tcf	0.1	n/a	I28EXFHD001D2		I28DPFHD001D2	I28VLFHD001D2	I28HZFHD001D2