

Appendix A.8.1

Hydrology Reports and Section 50 Approval

N6 Galway City Transport Project

***Hydrology Assessment
For OPW Section 50 Approval
Of proposed watercourse culverts***

Report No. HEL209001_v1.1

Galway County Council NRDO

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on behalf of
Galway Co. Council NRDO

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Report No.:	HEL209001
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Appendix 1 - OPW Section 50 Culvert applications

Appendix 2 - Section 50 Supporting Drawings of Culverts

1. INTRODUCTION

The proposed N6 Galway City Ring Road (GCRR) runs from the existing M6 at Coolagh on the east side of the city, passing to the north of the city and eventually joining with the R336 Coast Road, west of Bearna Village. The proposed route lies within hydrometric Areas 30 and 31. The proposed road intercepts a number of watercourses to the west of the River Corrib which will require culverting. To the east of the River Corrib due to the highly karst nature of the terrain there is a very sparse network of surface drainage channels and streams with rainwater generally infiltrating to ground through the porous karstified limestone bedrock rather than running off. As a consequence only one dry ditch was noted as being intercepted near the Coolagh lakes complex to the east of the River Corrib. Whereas, to the west of the River Corrib the bedrock and quaternary changes to a more impervious type resulting in a much higher density of surface water features with little ability for rainwater to infiltrate to groundwater. This gives rise to wetter conditions with peatlands and marshy areas common.

2. CULVERTS

Excluding the River Corrib there are a total of 16 stream culvert sites proposed, 15 culverts in the western section and 1 in the eastern section. The catchment areas of these watercourses is generally very small ranging from a number of hectares to the largest crossing of the Bearna River with a catchment area of 5.5 km². The majority of these watercourses flow in a general southerly direction discharging to Galway Bay with watercourses from the Bearna Stream east discharging to the Galway Bay SAC and watercourses west of the Bearna Stream to Galway Bay outside of the SAC.

The general guidelines provided by the OPW in respect to culverts and sizing of such have been applied to this study and generally as per the guidance whether required or not the minimum size exceeds 900 mm diameter pipe equivalent. This sizing avoids maintenance issues for small streams and drainage channel crossings and the obstruction of such by debris or silt build-up.

The catchment sizes involved are considered to represent very small catchments in terms of flood estimation and appropriate estimation methods for such small catchments have been used which include the IH 124 method and the recent OPW FSU method. As part of the ground survey for this road project a topographical survey of the drainage channels was carried out and this data is used in selection of the appropriate inverts both upstream and downstream and in assessing the capacity and hydraulic profile of the culvert under design flood conditions. Figure 1 presents a general location map of the proposed culverts labelled 1 to 17 (note reference 11 represents a channel long diversion of the Tonabrocky Stream). Figure 2 presents the estimated catchment areas for these culverts. It can be seen from Figure 2 that these catchments are generally to the north of the urban area and generally represent rural catchments.

Table 1 Proposed Culvert Details

Ref	N6 GCRR Ref	X	Y	Cat Area km ²	Qdesign cumec	Culvert type	Length m
1	C00/01	521324.58	723181.58	0.47	1.26	box 2.5m by 1.35	94.4
2	C00/02	521521.68	723446.01	0.324	0.89	1.2m diameter	46.1
3	C01/01	521983.64	723778.87	0.06	0.09	1.2m diameter	27.6
4	C02/01a	523086.54	724283.58	1.192	1.63	box 2.1m by 1.8m	36.66
5	C02/01b	523179.61	724198.04	1.192	1.63	box 2.5m by 2.5m	68.2
6	C03/01	523354.16	724244.47	0.08	0.12	box 2.5m by 1.2m	47.7
7	C03/02	523615.65	724390.32	0.15	0.23	0.9m diameter	15
8	C03/03	524066.24	724705.91	0.692	1.09	box 2.5m by 2.5m	53.4
	C03/04	524079.03	724722.20			box 2.5m by 2.5m	51.7
9	C04/01	524201.84	724845.74	5.485	7.58	box 5m by 2.5	34.9
10	C04/02	524895.00	725274.42	1.652	2.13	box 3.1m by 2.5	80.4
11	Channel Diversion	524918.98	725303.36	1.517	1.97	1.5m base width, 1:2 side slopes and 1.5m depth	250m
		525096.21	725475.14				
12	C06/01	526420.87	726389.37	0.138	0.20	box 2.5m by 2.5m	64.8
13	C07/02B	526710.48	726684.02	0.209	0.30	1.2m diameter	14
14	C07/02A	526698.49	726637.16	0.209	0.30	box 2.5m by 2.5m	82.1
15	C08/01	527663.93	727211.93	0.159	0.23	1.2m diameter	82.5
16	C10/02	529687.79	728412.26	0.629	0.19	1.2m diameter	41.8
17	C07/01a	527147.52	726262.40	0.38	0.55	1.2m diameter	37.2

Table 2 Invert Levels for Proposed Culverts

Ref	N6 GCRR Ref	Buried m	eff ht m	u/s invert mOD	d/s invert mOD	u/s soffit mOD	d/s soffit mOD
1	C00/01	0.30	1.05	32.99	30.9	34.34	32.25
2	C00/02	0.15	1.05	39.62	37.94	40.82	39.14
3	C01/01	0.15	1.05	48	46.82	49.20	48.02
4	C02/01a	0.30	1.5	39.73	39.04	41.53	40.84
5	C02/01b	0.30	2.2	38.48	37.25	40.98	39.75
6	C03/01	0.30	0.9	38.63	37.44	39.83	38.64
7	C03/02	0.00	0.9	36.83	36.58	37.73	37.48
8	C03/03	0.30	2.2	18.93	18.51	21.43	21.01
	C03/04	0.30	2.2	18.92	18.62	21.32	21.12
9	C04/01	0.30	2.2	21.17	20.69	23.67	23.19
10	C04/02	0.30	2.2	44.56	42.32	47.06	44.82
11	Diversion			50.1	45.9		
12	C06/01	0.30	2.2	53.6	51.69	56.1	54.19
13	C07/02B	0.15	1.05	57.84	57.65	59.04	58.85
14	C07/02A	0.30	2.2	56.88	55.79	59.38	58.29
15	C08/01	0.00	1.2	32.5	29.035	33.7	30.235
16	C10/02	0.15	1.05	11.58	11.3	12.78	12.5
17	C07/01a	0.15	1.05	35.89	35.57	37.09	36.77



Figure 1 Location Map of Culverts (note reference 11 represents a channel diversion to the northwest of alignment to achieve a single stream crossing at reference 10)



Figure 2 Contributing catchment area of culverts

3. ROAD DRAINAGE OUTFALLS

The proposed road drainage has been developed generally in accordance with the NRA Design Manual for Roads and Bridges and in particular in accordance with the NRA Addendum to HD33/06 Surface and Sub-Surface Drainage Systems for Highways.

The principal objectives for national road drainage systems include: -

- To ensure the speedy removal of surface water in order to provide safe driving conditions;
- To provide effective sub-surface drainage to maximise longevity of the road pavement and associated earthworks;
- To minimise the impact of the runoff on the receiving environment; and
- To maintain, as far as possible, the road drainage to the outfall separate from other catchment drainage (including land drains) in the interest of pollution control.

The proposed drainage design for the project incorporates Sustainable Drainage Systems (SuDS) which are aimed at the provision of volumetric and quality control of storm water runoff. The proposal includes the provision of a series of constructed linear wetlands and attenuation basins at the outfall locations prior to discharge to the receiving environment. The proposed attenuation for all drainage networks has been designed to achieve estimated Greenfield flood run-off rates up to the 100 year return period event.

The Flood Study Report (NERC 1975) Soil Runoff Classification is type 2 having a Soil Factor of 0.3 or 30% standard percentage runoff rate for the granite areas west of the Corrib and soil type I for the Karst limestone area east of the Corrib. The SAAR (seasonal annual average rainfall) is typically 1200 to 1300 mm increasing westward. This represents an annual average flood run-off rate of 0.8 l/s per ha, 3.6 l/s per ha and 6.7l/s per ha at Soil types 1, 2 and 3 respectively. Attenuation storage is provided to achieve these greenfield runoff rates up to the 100 year return period storm event. These will be maintained systems and therefore are designed not to increase peak flood flow conditions in the receiving rivers and streams.

The proposed road drainage outfalls discharge to watercourses in the vicinity of culvert references 1, 2, 3, 4/5, 8, 9, 10, 12, 13, 14, 15 and 17. A number of these watercourses are very small and of low capacity and therefore stormwater management in terms of attenuation and control of road drainage discharges is critical to protecting downstream reaches from additional flooding. A summary of the relevant road outfalls are presented below in Table 3, all of which will be attenuated to greenfield flood runoff rates.

Table 3 Road Outfall Details for Proposed Road

Drainage Network Outfall Reference	Catchment Area (ha)	Receiving Water and culvert location	Greenfield Discharge Rate, Qbar (m3/s)
S2	0.55	discharges Sruthán na Líbeirtí d/s of culvert 1	0.002
S3	2.31	discharges Sruthán na Líbeirtí d/s of culvert 2 and u/s of culvert 1	0.0083
S4A	0.96	discharges to Trusky trib u/s of culvert 3	0.0035
S5A	2.45	discharges to Trusky stream upstream of culvert ref 4 and 5	0.0088
S7A	0.3	discharges to a minor drain d/s of culvert 6	0.0011
S7B	2.94	Discharges to Bearna Stream tributary d/s of culvert 8	0.0106
S8	0.42	discharges to Bearna Stream tributary downstream of 8	0.0015
S9	1.75	discharges to Bearna Stream upstream of 9	0.0063
S10	2.19	discharges to Tonabrooky Stream downstream of culvert 10	0.0079
S12	3.15	Discharges to drain downstream of 12	0.0113
S13	0.91	Discharges to drain upstream of culvert 13 and 14 culverts	0.0033
S14A	5.66	Discharges to culvert downstream of culvert 15	0.0203
S16A	4.16	Discharges to storm sewer downstream of culvert 17	0.0149

4. DESIGN FLOWS

Description

The Drainage Catchments for the proposed culvert crossings of the N6 Galway City Ring Road are very small at 0.06 to 5.49 km² (Berna Stream). Consequently none of these catchments are gauged for the purpose of flood estimation. Of the 17 catchments the following culvert references: 1 and 2 on the Scruthán na Libeirti Stream, 3 and 4 on the Trusky Stream (method includes Lough Inch and catchment within Trusky catchment which is incorrect), 8 and 9 on the Berna stream, 10 on the Tonabrocky stream and 17 on the Ragoon stream are represented in the new Flood Study update FSU method on the OPW web portal site. The streams and the catchment areas and node estimation points are presented in Figures 4 to 8.

The FSU method uses as an index flood the Q_{med} (2 year return period flood or the median of the annual maxima series) value calculated by catchment descriptors and adjusted where an appropriate gauged site is available. The Q_{MED} estimate is multiplied up by the computed flood growth factor.

The other common method for flood estimation in small on gauged catchments is the use of the IH 124 equation using the SAAR, SOIL and catchment area parameters, obtained from the original FSR report or from more recent sources of meteorological information catchment mapping and site inspections to determine the run-off characteristics.

These methods are presented in the following sub-sections

IH-124 Flood Estimation Method

The mean annual maximum flood flow (Q_{bar}) for each of the watercourse crossings listed have been estimated using The **Institute of Hydrology 3-variable equation** as follows:

$$Q_{\text{BAR}} = 0.00108 \text{ AREA}^{0.89} \text{ SAAR}^{1.17} \text{ SOIL}^{2.17}$$

where

Area	Catchment area in km ²
SOIL	Typical proportion of rain contributing to flood runoff, based on mapped soil types Type 2 (SOIL = 0.3)
SAAR	long term mean annual rainfall amount for the catchment,
Q_{bar}	Calculated mean annual maximum flood in cumec.
Urban Factor (UF)	An index based on the % of the area covered by Urban Development
Standard Factorial Error (FE)	Factorial error from the regression equation: 1.65 for the IH-124 equation
CC	Climate Change Allowance +20%

The above method is combined with the Flood Study National Growth Curve to determine the 100year flood rate and the factorial error is included.

Table 4 Design Flow Estimates using IH124 Equation at Culvert Crossings

Culvert Ref	Area km2	SAAR mm	SOIL	Qbar cumec	Q100 cumec	Q100*FE*CC cumec
1	0.47	1280	0.3	0.17	0.35	0.69
2	0.324	1280	0.3	0.12	0.24	0.48
3	0.06	1280	0.3	0.02	0.04	0.09
4	1.188	1301	0.3	0.41	0.82	1.63
5	1.192	1301	0.3	0.41	0.82	1.63
6	0.08	1300	0.3	0.03	0.06	0.12
7	0.15	1300	0.3	0.06	0.11	0.23
8	0.692	1310	0.3	0.25	0.51	1.01
9	5.485	1310	0.3	1.60	3.23	6.40
10	1.652	1253	0.3	0.52	1.05	2.09
11	1.517	1253	0.3	0.48	0.98	1.93
12	0.138	1251	0.3	0.05	0.10	0.20
13	0.209	1249	0.3	0.07	0.15	0.30
14	0.209	1249	0.3	0.07	0.15	0.30
15	0.159	1249	0.3	0.06	0.12	0.23
16	0.629	1235	0.15	0.05	0.10	0.19
17	0.380	1249	0.3	0.14	0.28	0.55

CC = 1.2 and FE = 1.65 and Growth factor X100 = Q100/QBAR = 2.04

The FSR national Growth factor for the 100year flood event is 1.96 and the FSU pooling group using the most hydrologically similar catchments producing 500station years gives a growth factor of 2.04. The higher growth factor is used in the 100year flood flow estimation.

Flood Study Update (FSU) Method

The new (2015) OPW Flood Study Update method uses physical catchment descriptors (PCD's) and pivotal site adjustment to determine the ungauged index flood magnitude (Qmed (Q2)) at nearest nodal point to the culvert location. The principal physical descriptors are AREA, BFISOIL, SAAR, FARL, DRAIN, S1085, ARTDRAIN2, URBEXT. The pivotal site is the FSU gauged flow station that is most relevant to the particular estimation location. For this particular application given the relatively small catchment areas involved the most hydrologically similar gauged catchment was a 10km2 catchment to the north of Dundalk. Given its remoteness to the subject area it was rejected and the FSU Qmed estimates were used without adjustment.

The FSU method used to determine the index flood (Qmed – median flood flow) is based on detailed catchment descriptors accessed via a GIS system on the FSU Web Portal Site and provides an option to use a gauged site as a donor / pivotable site to adjust the Qmed estimate as presented in the equations below.

$$Q_{med} (rural) = 1.237 \times 10^{-5} AREA^{0.937} BFIsoils^{-0.922} SAAR^{1.306} FARL^{2.217} DRAIN2^{0.341} S1085^{-0.185} (1 + ARTDRAIN2)^{0.408}$$

The urban Adjustment to the rural Q_{med} is defined as follows:

$$UAF = (1 + URBEXT)^{1.482}$$

$$Q_{med} (urban) = Q_{med} (rural) \times UAF$$

Adjusted QMED estimate using Donor/Analogue Catchment

$$Q_{med}^s = Q_{med}^d \left(\frac{Q_{med}^s(model\ rural)}{Q_{med}^d(model\ rural)} \right)$$

The FSU method determines the Flood growth curve through a pooled analysis of hydrologically similar catchments (Euclidean distance using the above PCD's and distance between catchment centroids). Multiplying the Q_{Med} estimate by the flood growth curve produced the return period peak flood flow magnitudes. The FSU Flood Hydrograph width method was also used to generate the return period design flood hydrographs at the various nodal points along the study reach. Figures 4 to 8 shows the FSU catchment characteristics and the unadjusted Q_{med} values at different nodal locations within the respective catchments.

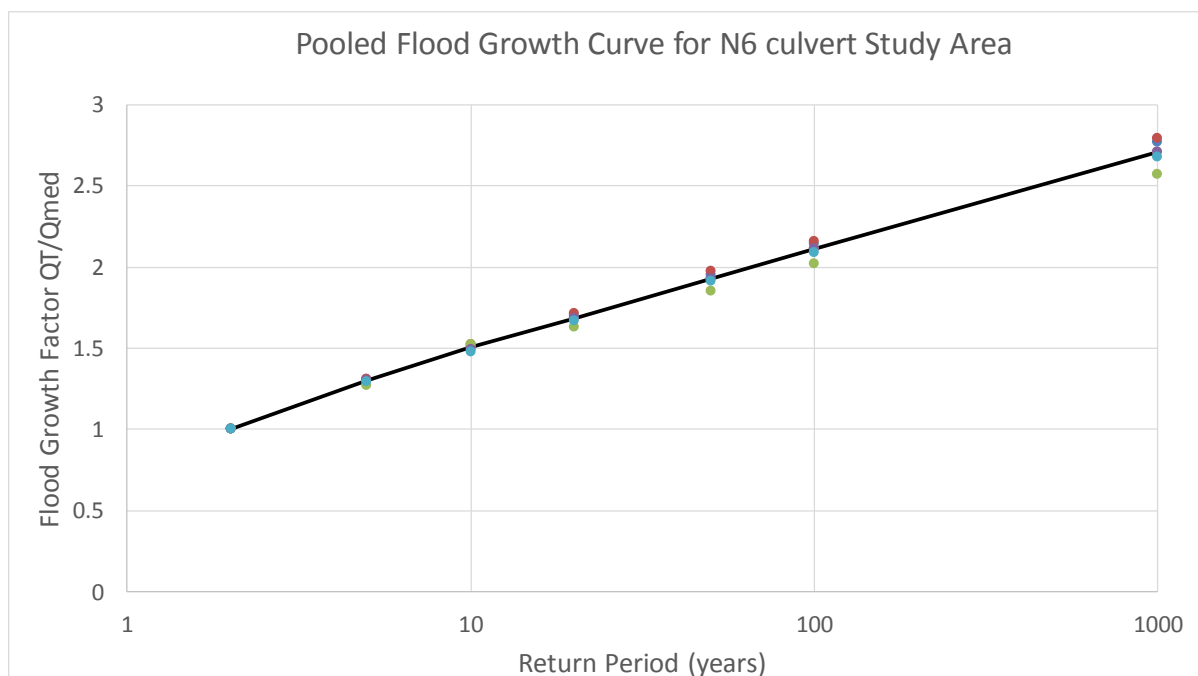


Figure 3 Pooled flood Growth curves derived for the various estimation points with the average for the study area shown as a solid line.

The FSU hydrological estimation nodal points are not available for every stream and particularly for small drain like sub-catchments. Also given the relatively small scale of the

catchments the available estimation point did not coincide with the required location (refer to Figure 4 to 8) and extrapolation was necessary to provide an estimate at the required culvert location.

Table 5 Design Flow Estimates using FSU Method at Culvert Crossings

Culvert Ref	Area km2	Qmed cumec	Q100 cumec	Q100*FE*CC cumec
1	0.47	0.36	0.76	1.26
2	0.324	0.26	0.54	0.89
3	0.06			
4	1.188	0.36	0.77	1.27
5	1.192	0.36	0.77	1.27
6	0.08			
7	0.15			
8	0.692	0.31	0.66	1.09
9	5.485	2.17	4.58	7.58
10	1.652	0.61	1.29	2.13
11	1.517	0.56	1.19	1.97
12	0.138			
13	0.209			
14	0.209			
15	0.159			
16	0.629			
17	0.38	0.11	0.23	0.39

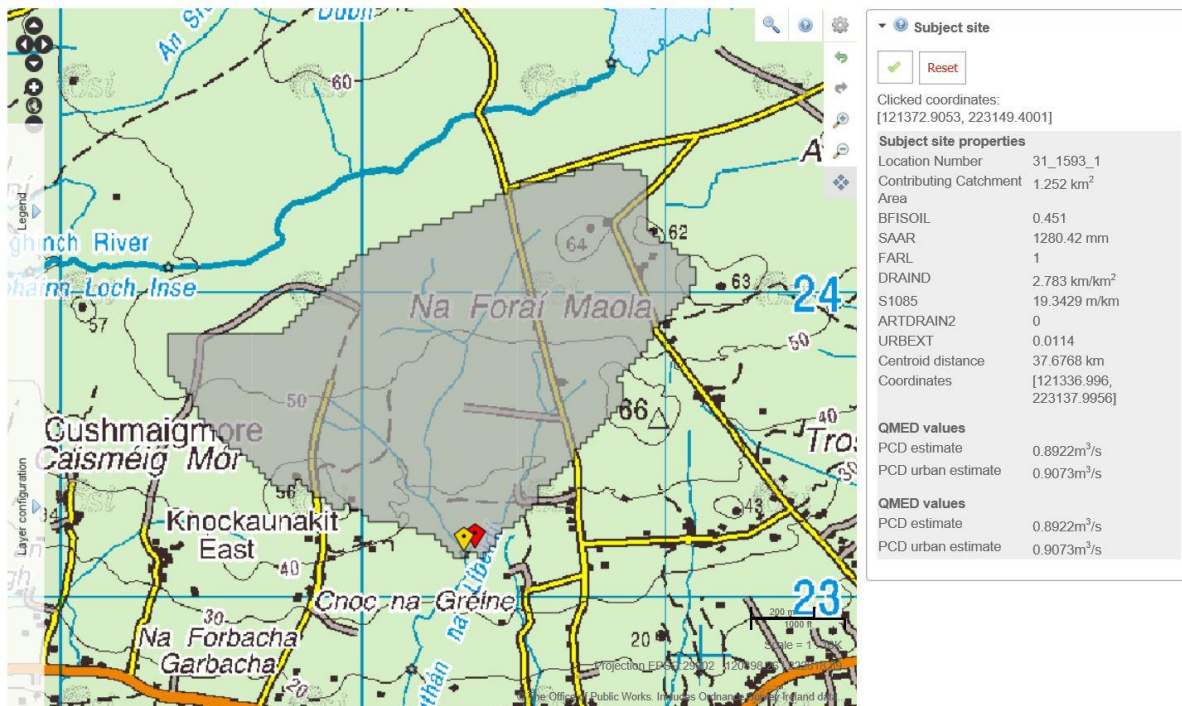


Figure 4 Estimation point on Sruthán na Líbeirtí nearest to culvert crossings

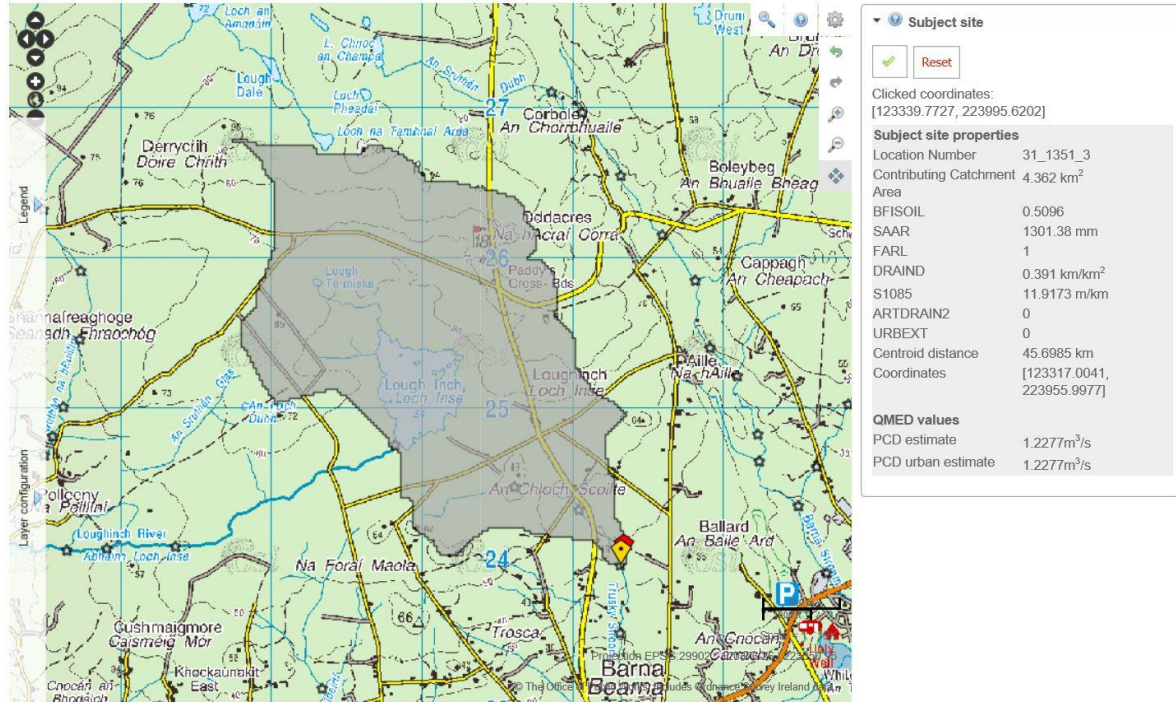


Figure 5 Estimation point on Trusky Stream nearest to culvert crossings (note error in catchment extent which includes the Lough Inch drainage area)

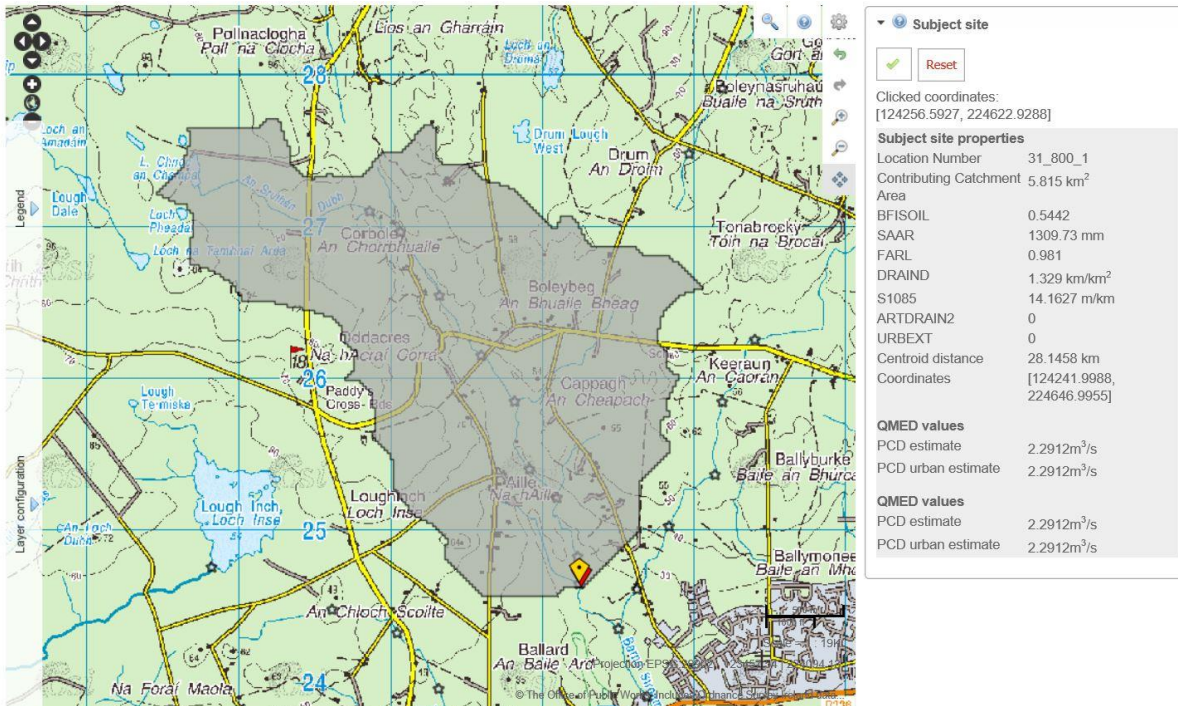


Figure 6 Estimation point on the Bearna Stream nearest to culvert crossings

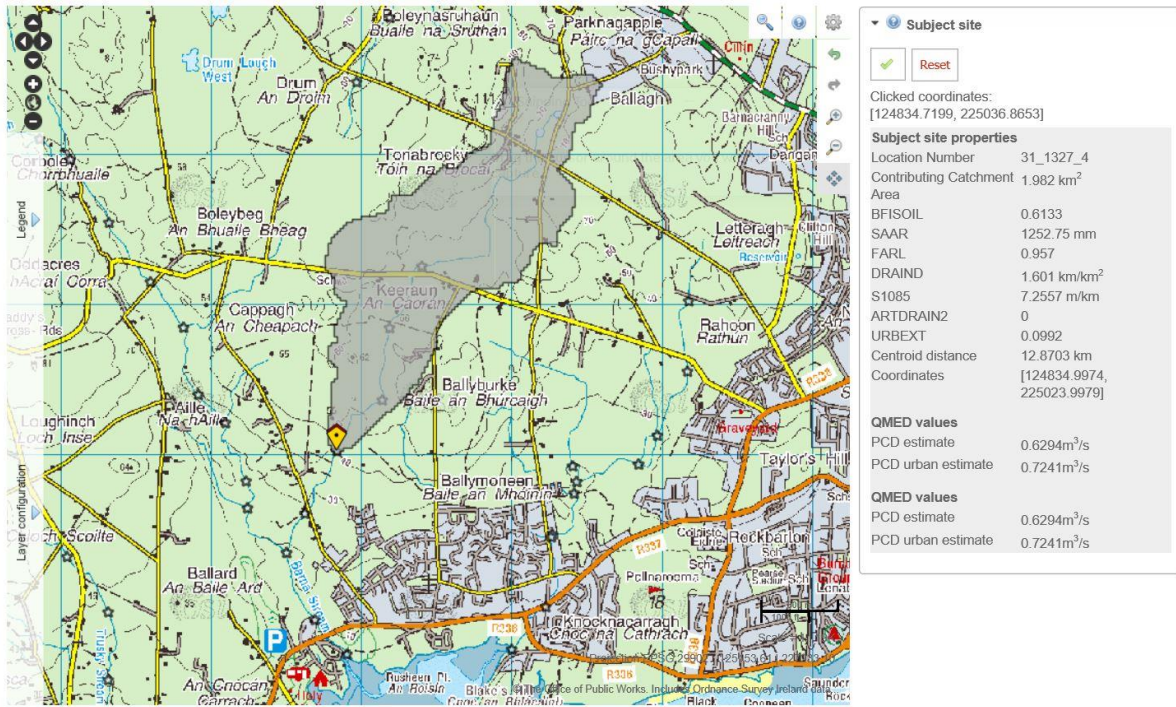


Figure 7 Estimation point on the Tonabrocky Stream nearest to culvert crossings

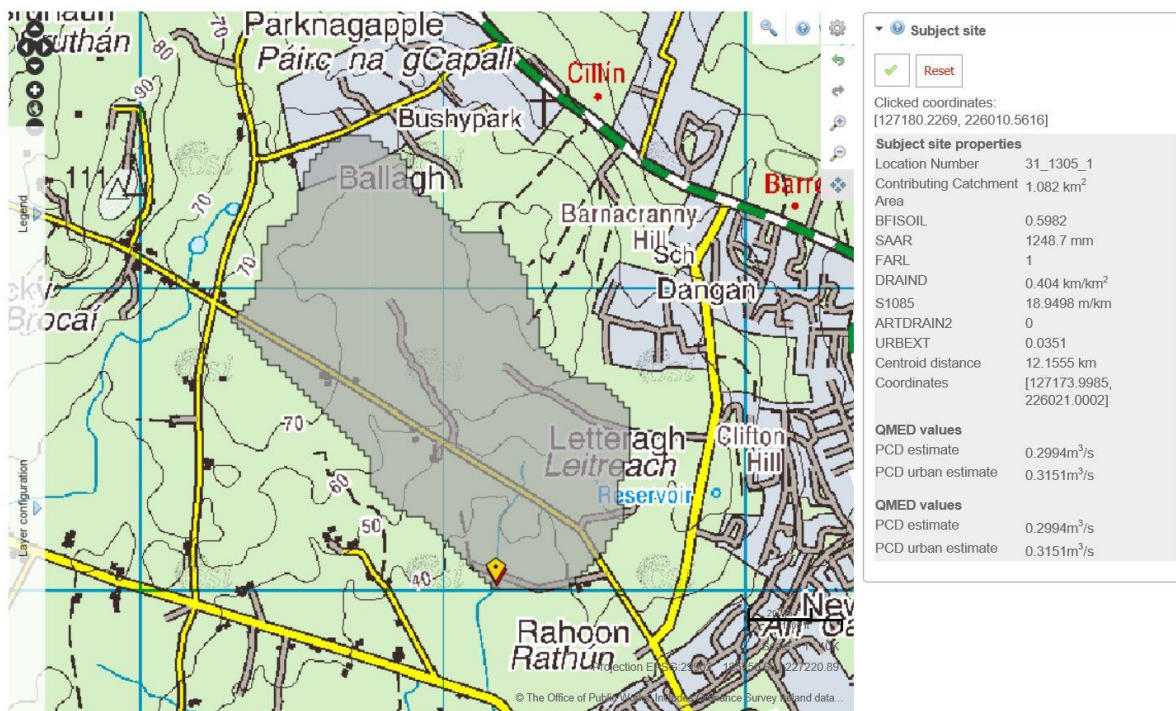


Figure 8 Estimation point on the Rahoan/Knocknacarra Stream nearest to culvert crossings

Recommended Design Flow

The maximum estimated flow magnitude from the various methods was selected as the design flow for sizing the proposed culvert and determining the flood levels at the culvert site and the resultant flood risk. The design flow includes the factorial error of the method and the climate change allowance and is presented below in Table 6

Table 6 Recommended Design Flow Magnitude for Proposed culverts

Culvert Ref	Area km2	IH 124 Equation		FSU CD Method		Design Q100 cumec
		Q100 cumec	Q100*FE*CC cumec	Q100 cumec	Q100*FE*CC cumec	
1	0.47	0.35	0.69	0.76	1.26	1.26
2	0.324	0.24	0.48	0.54	0.89	0.89
3	0.06	0.04	0.09			0.09
4	1.188	0.82	1.63	0.77	1.27	1.63
5	1.192	0.82	1.63	0.77	1.27	1.63
6	0.08	0.06	0.12			0.12
7	0.15	0.11	0.23			0.23
8	0.692	0.51	1.01	0.66	1.09	1.09
9	5.485	3.23	6.40	4.58	7.58	7.58
10	1.652	1.05	2.09	1.29	2.13	2.13
11	1.517	0.98	1.93	1.19	1.97	1.97
12	0.138	0.10	0.20			0.20
13	0.209	0.15	0.30			0.30
14	0.209	0.15	0.30			0.30
15	0.159	0.12	0.23			0.23
16	0.629	0.10	0.19			0.19
17	0.380	0.28	0.55	0.23	0.39	0.55

5. HYDRAULIC MODEL ANALYSIS

The proposed culverts were hydraulically assessed in terms of flow capacity and resultant upstream and downstream flood levels for the design flow condition using the 1-D river network hydraulic model HEC-RAS. Specific topographical channel surveys were conducted to provide the geometry information for the modelling exercise. Other sources of topographical information including lidar was also used in defining the geometry of the channel and floodplain area.

All of the proposed stream crossings are considered to have small contributing catchment areas and therefore involve relatively small flood flows. None of these streams were assessed by the OPW as part of the Galway CFRAM study.

The design flood flow considered for each of the culverts is the estimated 100year return period flood flow multiplied by the factorial error of the estimation method and further multiplied by a climate change allowance factor of 1.2.

The channel roughness of the existing channels was specified as 0.1 Manning's n representing high roughness as they are generally unmaintained. The roughness of the proposed culverts as modelled using a roughness of 0.025 for the near bed section and 0.015 for the upper top section of the culvert.

A summary of the results for each of the culvert references is presented below in Table 7 and presents the computed upstream and downstream flood level relative to Malin Head datum.

Table 7 Estimated head and tailwater design flood levels for proposed N6 culverts

Culvert	N6 GCRR Ref	Design Q100	u/s invert	d/s invert	u/s Flood Level	d/s Flood Level	u/s soffit	d/s soffit
Ref		cumec	mOD	mOD	mOD	mOD	mOD	mOD
1	C00/01	1.26	32.99	30.9	33.68	32.10	34.34	32.25
2	C00/02	0.89	39.62	37.94	40.20	39.09	40.82	39.14
3	C01/01	0.09	48	46.82	48.34	47.8	49.20	48.02
4	C02/01a	1.63	39.73	39.04	40.88	40.08	41.53	40.84
5	C02/01b	1.63	38.48	37.25	39.3	38.18	40.98	39.75
6	C03/01	0.12	38.63	37.44	39.01	37.94	39.83	38.64
7	C03/02	0.23	36.83	36.58	37.26	37.29	37.73	37.48
8	C03/03	1.09	18.93	18.51	19.65	19.65	21.43	21.01
	C03/04	1.09	18.82	18.62	19.67	19.67	21.32	21.12
9	C04/01	7.58	21.17	20.69	22.51	22.16	23.67	23.19
10	C04/02	2.13	44.56	42.32	45.33	43.0	47.06	44.82
11*	Diversion	1.97	50.1	45.9	51.00	46.72		
12	C06/01	0.20	53.6	51.69	54.04	52.16	56.1	54.19
13	C07/02B	0.30	57.84	57.65	58.71	58.71	59.04	58.85
14	C07/02A	0.30	56.88	55.79	57.84	57.65	59.38	58.29
15	C08/01	0.23	32.5	29.035	33.74	29.435	33.7	30.235
16	C10/02	0.19	11.58	11.3	11.95	11.62	12.78	12.5
17	C07/01a	0.55	35.89	35.57	38.58	38.56	37.09	36.77

11* is a 250m channel realignment / diversion

Culvert 1 crosses the Sruthán na Líbeirtí stream in the townland of Cnoc na Gréine 2km west of Bearna Village. This section of stream channel is moderately steep and the design flow through the culvert will be supercritical. For fishery friendly design some baffles and a low flow channel may be required within the culvert.

Culvert 2 crosses the Sruthán na Líbeirtí stream upstream of Culvert 1 in the townland of Cnoc na Gréine 2km west of Bearna Village. This section of stream channel is moderately steep and the design flow through the culvert will be supercritical. For fishery friendly design some baffles and a low flow channel within the culvert may be required.

Culvert 3 is a very minor drain of 6ha catchment area and at 1200mm diameter culvert there is ample capacity available for this drain.

Culvert 4 and 5 cross the Trusky Stream in the townland of An Chloch Scoilte towards the upstream end of the catchment draining peaty lands to the east and south-east of Lough Inch. These culverts are aligned in series with culvert 5 located downstream of culvert 4. Two large box culverts are proposed, 2.1 m x 1.8 m and 2.5 m x 2.5 m respectively. The large culvert sizes is to facilitate Bat passage as opposed to flow conveyance or fishery requirements.

Culverts 6 and 7 in the townland of An Chloch Scoilte are located on minor drains with small contributing catchment and the proposed culvert sizes of 1200mm and 900mm diameter are generous and will not impede drainage or impact flooding.

Culvert 8 crosses the tributary branch of the Bearna Stream in the townland of Aille. At this location there are 2 branches both of which are to be culverted with a box section 2.5 m x 2.5 m and buried 0.3 m. This proposed sizing is very generous and will not impede drainage or impact locally on flooding.

Culvert 9 crosses the mainline channel of the Bearna Stream in the townland of Cappagh. This stream along its downstream reach has been identified as a fishery stream. A generous culvert size is proposed for this stream which is 5 m wide by 2.5 m in height. Mammal passage ledges are proposed on both sides of this culvert which effectively reduces the open width to 4m. The survey indicates a moderately steep channel and the hydraulic analysis shows supercritical flow through the culvert barrel. This culvert represents the biggest stream crossing the road scheme aside from the River Corrib bridge crossing. Given the fishery interest for this stream a low flow channel maybe provided within the culvert so as to avoid shallow depths and steep gradient which represents a barrier to fish passage.

Culvert 10 crosses the Tonabrocky Stream in the townland of Ballyburke. The survey shows this to be a narrow steep channel often cascading and jumping between critical and supercritical flow. A box culvert 3.1 m wide by 2.5 m high with mammal ledges along both sides of the culvert reducing the open width to 2.1 m. The hydraulic analysis shows flow to be at critical and supercritical resulting in shallow depths and high velocities. Through the culvert the flow goes supercritical due to the steep gradient.

Upstream a proposed diversion channel connects to this culvert. Culvert reference 11 is a diversion channel of the Tonabrocky Stream along the north edge of the road, which avoids the requirement of a second culvert crossing and facilitates the proposed road alignment which is on top of this stream channel for much of its length along this section. The new channel will have a trapezoidal shape of 1.5m base width, 1.5m deep and side slopes of 1 in 2. The longitudinal gradient for this diverted section of channel will complement the existing channel at a fall of 1 in 60. The hydraulic analysis shows that at the design flow moderately shallow depths and high velocities occur in this channel. To protect the channel a number of stone

weirs in a cascade like fashion should be constructed at various intervals along the channel so as to produce pools and shoals.

Culvert 12 conveys a moderately small drainage catchment, the provision of a 2.5 m x 2.5m box culvert is generously sized for this purpose and will not impede flow or impact on flooding as a result.

It should be noted that culvert Reference 17 discharges to a 450mm storm pipe at the edge of the existing Ragoon Road which connects to the local authority 600mm diameter storm sewer that runs southeast along the Ragoon Road. At the estimated design flow of 0.55cumec this 450mm culvert acts as a serious constriction causing the proposed 1200mm culvert under the proposed link Road to be fully submerged.

Culvert Reference 13 and 14 represent two culverts in series and a small channel diversion. The diversion including channel and culverts is almost 270m long and connects to the drain that discharges to culvert 17. The proposed channel is trapezoidal of 1m base width and side slopes of 1 in 2.

Culvert reference 15 is the culverting of a small minor stream/drain under the proposed road alignment at Barnacranny Hill, Bushypark. This stream / drain is very minor and is already culverted under the Ard an Locha estate road and under the N59 Moycullen Road in a 600mm diameter pipe culvert. The proposal is to increase the size of the culvert beneath the road structure from the existing 600mm storm line to a 1200mm. There is no capacity issue with the existing 600mm diameter culvert as the design flow is relatively small and the available hydraulic gradient large at a fall of 1 in 31 through the housing estate and across the N59.

Culvert 16 is located to the east of the River Corrib and represents the culverting of a generally dry ditch. The contributing catchment area is off the steep limestone slopes to the north-east of Coolagh. The run-off coefficient for this area is characterised as very low and therefore the design flow to be catered for is small. A 1200 mm diameter culvert is proposed which will not impede flows or impact on flooding.

6. CONCLUSIONS

The proposed culvert sizes are very generous in respect to the provision of effective open area and flow conveyance and do not for any of the 16 sites represent a constriction to flow. In a lot of cases they have been upsized further to cater for mammal passage with ledges and for bat passage. Where ledges have been included the width of the ledge included is 0.5m on both internal box culvert faces and were modelled hydraulically as being 1m narrower than the width specified (i.e. culvert ref 9 (Bearna Stream crossing) was modelled as 4m wide as opposed to 5m wide). Generally the minimum size provided for this scheme is a 1200mm diameter pipe which is buried by 150mm (except for culvert reference 7 which has a 900mm diameter). All of the structures have inlet and outlet wing and head wall structures. Potential for debris blockage is small given the nature of catchments involved and generous dimensions provided.

The hillside nature of the drainage catchments involved will in flood conditions result in supercritical flow occurring in a lot of cases and therefore where the stream bed is not sitting onto bedrock some armouring / channel protection may be required. Therefore all diversion channels and transitions to and from culverts will be designed and armoured so as to protect against scouring.

Appendix 1 OPW Section 50 Culvert applications



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C1 (C00/01)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Sruthan Na Libeirti	Catchment:	hydrometric Area 31
Address (Townland – County):	Cnoc Na Greine Bearna, Co. Galway		
Grid Reference	X: 521324.58	Y: 723181.58	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	0.47 Km²	Road Reference:	Proposed N6
Design Flood Flow:	1.26 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.17
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = 0.36
FSR <input type="checkbox"/>	FSU <input checked="" type="checkbox"/>	Other <input type="checkbox"/>
Comments : Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The FSU gives the higher estimate and was used		
		Type of Factor Climate Change 1.2 Irish Growth Curve 2.11 Factor for Standard Error 1.38 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the FSU method is taken as 1.38 Qdesign = 1.26 cumec

Hydraulic/Structure Details	
Description of Structure*3	2.5 by 1.35m high Box culvert buried by 300mm giving an open area of 2.625m². The culvert length is 94.4 m
Effective Conveyance Area *4	2.625m²
Upstream Invert Level 32.99 mOD	Downstream Invert Level 30.9 mOD
Upstream Soffit Level 34.34 mOD	Downstream Soffit Level 32.25 mOD
Upstream Design Flood Level 33.68 mOD	Downstream Design Flood Level 32.10 mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C2 (C00/02)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Clarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Sruthan Na Libeirti	Catchment:	hydrometric Area 31
Address (Townland – County):	Cnoc Na Greine, Bearna, Co. Galway		
Grid Reference	X: 521521.68	Y: 723446.01	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	0.32 Km²	Road Reference:	Proposed N6
Design Flood Flow:	0.89 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.12
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input checked="" type="checkbox"/>	Qmed = 0.26
FSR <input type="checkbox"/>	FSU <input checked="" type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The FSU gives the higher estimate and was used		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.11 Factor for Standard Error 1.38 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the FSU method is taken as 1.38 Qdesign = 0.89cumec

Hydraulic/Structure Details	
Description of Structure*3	1200mm diameter culvert buried by 150mm giving an open area of 1.05m². The culvert length is 46.1m.
Effective Conveyance Area *4	0.460 m²
Upstream Invert Level 39.62 mOD	Downstream Invert Level 37.94 mOD
Upstream Soffit Level 40.82 mOD	Downstream Soffit Level 39.14 mOD
Upstream Design Flood Level 40.02 mOD	Downstream Design Flood Level 39.09 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.
- The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
- Effective conveyance area is from channel bed level to design flood level (Min(inlet,outlet)).
- All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C3 (C01/01)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Clarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Minor drain	Catchment:	hydrometric Area 31
Address (Townland – County): Trosca, Bearna, Co Galway			
Grid Reference	X: 521983.64	Y: 723778.87	
Hydrometric Station(s) utilized (including reference number): None Available			
Area of Contributing Catchment:	0.06 Km²	Road Reference:	Proposed N6
Design Flood Flow:	0.09 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis				
Methodology Applied			Factors Applied	
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)	Type of Factor	Value Used
6 – Variable Catchment characteristics			Climate Change	1.2
3 – Variable Catchment Characteristics			Irish Growth Curve	2.04
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.17	Factor for Standard Error	1.65
Gauged Flow	<input type="checkbox"/>		Drained Channel	0
Unit Hydrograph	<input type="checkbox"/>		Other	0
Other	<input type="checkbox"/>			
FSU	<input type="checkbox"/>	Qmed = n/a		
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>		
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 method was used.			Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign = 0.09cumec.	

Hydraulic/Structure Details	
Description of Structure*3	1.2m diameter concrete culvert buried by 150mm giving an open area of 1.05m². The culvert length is 27.6 m.
Effective Conveyance Area *4	0.058 m²
Upstream Invert Level 48 mOD	Downstream Invert Level 46.82 mOD
Upstream Soffit Level 49.20 mOD	Downstream Soffit Level 48.02 mOD
Upstream Design Flood Level 48.34 mOD	Downstream Design Flood Level 47.80 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.
- The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
- Effective conveyance area is from channel bed level to design flood level.
- All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C4 (C02/01a)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Trusky Stream	Catchment:	hydrometric Area 31
Address (Townland – County):	An Chloch Scoilte, Bearnna Co. Galway		
Grid Reference	X: X=523086.54	Y: 724283.58	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	1.192 Km²	Road Reference:	Proposed N6
Design Flood Flow:	1.63 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2016

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.41
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = 0.36
FSR <input type="checkbox"/>	FSU <input checked="" type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 gives the higher estimate and was used for this culvert.		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.04 Factor for Standard Error 1.65 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign = 1.63cumec

Hydraulic/Structure Details	
Description of Structure*3	2.1 by 1.8m high Box culvert buried by 300mm giving an open area of 3.15m². The culvert length is 36.7 m.
Effective Conveyance Area *4	1.85.m²
Upstream Invert Level 39.73 mOD	Downstream Invert Level 39.04 mOD
Upstream Soffit Level 41.53 mOD	Downstream Soffit Level 40.84 mOD
Upstream Design Flood Level 40.88 mOD	Downstream Design Flood Level 40.08 mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C5 (C02/01b)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Trusky Stream	Catchment:	hydrometric Area 31
Address (Townland – County):	An Chloch Scoilte, Bearna Co. Galway		
Grid Reference	X: 523179.61	Y: 724198.04	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	1.192 Km²	Road Reference:	Proposed N6
Design Flood Flow:	1.63 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics	<input type="checkbox"/>	
3 – Variable Catchment Characteristics	<input type="checkbox"/>	
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.41
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = 0.36
FSR <input type="checkbox"/>	FSU <input checked="" type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 gives the higher estimate and was used for this culvert		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.04 – 2.11 Factor for Standard Error 1.65 - 1.38 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign = 0.41x1.2x2.04x1.65 = 1.63cumec

Hydraulic/Structure Details	
Description of Structure*3	2.5 by 2.5m high Box culvert buried by 300mm giving an open area of 5.5m² the height has been increase to cater for Bat passage. The length of the culvert is 68.24 m.
Effective Conveyance Area *4	1.58m²
Upstream Invert Level 38.48 mOD	Downstream Invert Level 37.25 mOD
Upstream Soffit Level 40.98 mOD	Downstream Soffit Level 39.75 mOD
Upstream Design Flood Level 39.30 mOD	Downstream Design Flood Level 38.18 mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C6 (C03/01)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Minor drain	Catchment:	hydrometric Area 31
Address (Townland – County):	An Chloch Scoilte , Bearna Co. Galway		
Grid Reference	X: 523354.16	Y: 724244.47	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	0.08 Km²	Road Reference:	Proposed N6
Design Flood Flow:	0.12 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow ^{*2} (m ³ /sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.03
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = n/a
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 estimate was used.		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.04 Factor for Standard Error 1.65 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign = 0.12 cumec.

Hydraulic/Structure Details	
Description of Structure ^{*3}	2.5m by 1.2m high box culvert buried by 300mm giving an open area of 2.25m² (culvert size increased for bats). The culvert length is 47.7m.
Effective Conveyance Area ^{*4}	0.2 m²
Upstream Invert Level 38.63 mOD	Downstream Invert Level 37.44 mOD
Upstream Soffit Level 39.83 mOD	Downstream Soffit Level 38.64 mOD
Upstream Design Flood Level 39.01 mOD	Downstream Design Flood Level 37.94 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.
- The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
- Effective conveyance area is from channel bed level to design flood level.
- All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C7 (C03/02)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Minor drain	Catchment:	hydrometric Area 31
Address (Townland – County): Ballard, Bearna Co. Galway			
Grid Reference	X: 523615.65	Y: 724390.32	
Hydrometric Station(s) utilized (including reference number): None Available			
Area of Contributing Catchment:	0.15 km²	Road Reference:	Proposed N6
Design Flood Flow:	0.23 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics	<input type="checkbox"/>	
3 – Variable Catchment Characteristics	<input type="checkbox"/>	
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.06
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = n/a
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 estimate was used.		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.11 - 2.04 Factor for Standard Error 1.38 - 1.65 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign = 0.23cumec.

Hydraulic/Structure Details	
Description of Structure*3	900mm diameter concrete culvert provides an open area of 0.636m². The culvert length is 15m.
Effective Conveyance Area *4	0.390 m²
Upstream Invert Level 38.83 mOD	Downstream Invert Level 36.58 mOD
Upstream Soffit Level 37.73 mOD	Downstream Soffit Level 37.48 mOD
Upstream Design Flood Level 37.26 mOD	Downstream Design Flood Level 37.29 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.
- The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
- Effective conveyance area is from channel bed level to design flood level.
- All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C8 (C03/03&04)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Trib Channel of Bearna Stream	Catchment:	hydrometric Area 31
Address (Townland – County): Na hAille Bearna Galway			
Grid Reference	X: 524066.23 & 524079.03	Y:	724705.92 & 724722.20
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	0.69 Km²	Road Reference:	Proposed N6
Design Flood Flow:	1.09 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow ^{*2} (m ³ /sec)
6 – Variable Catchment characteristics	<input type="checkbox"/>	
3 – Variable Catchment Characteristics	<input type="checkbox"/>	
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.25
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = 0.31
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The FSU estimate was used.		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.11 - 2.04 Factor for Standard Error 1.38 - 1.65 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the FSU method is taken as 1.38 Qdesign = 0.31x1.2x2.11x1.38 = 1.09cumec.

Hydraulic/Structure Details	
Description of Structure ^{*3}	twin 2.5m by 2.5 m high box culverts buried by 300mm located on two separate channels providing a combined open area of 11m² (culvert size increased for bats). The culvert lengths are both 53.4 m and 51.7 m. The analysis shows the downstream channel causing a backwatering of the culverts.
Effective Conveyance Area ^{*4}	1.48 & 1.15 m²
Upstream Invert Level 18.93 & 18.82 mOD	Downstream Invert Level 18.51 & 18.62 mOD
Upstream Soffit Level 21.43 & 21.32 mOD	Downstream Soffit Level 21.01 & 21.12 mOD
Upstream Design Flood Level 19.65 & 19.67 mOD	Downstream Design Flood Level 19.65 & 19.67 mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C9 (C04/01)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Bearna Stream	Catchment:	hydrometric Area 31
Address (Townland – County):	Na hAille Bearna Galway		
Grid Reference	X: 524201.84	Y: 724845.74	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	5.485 Km²	Road Reference:	Proposed N6
Design Flood Flow:	7.58 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	<input checked="" type="checkbox"/>	QBAR = 1.60
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = 2.17
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments: Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The FSU estimate was used.		

Factors Applied	
Type of Factor	Value Used
Climate Change	1.2
Irish Growth Curve	2.11 - 2.04
Factor for Standard Error	1.38 - 1.65
Drained Channel	0
Other	0
Tidal	<input type="checkbox"/>
Comments The factor for Standard error associated with the FSU method is taken as 1.38 Qdesign = 2.17x1.2x2.11x1.37 = 7.58cumec.	

Hydraulic/Structure Details	
Description of Structure*3	Single 5m by 2.5m high box culvert buried by 300mm and mammal ledges along both culvert sides provided which reduce the effective width to 4m. The effective open area of 8.8m2. The culvert lengths is 34.9 m.
Effective Conveyance Area *4	4.48 m²
Upstream Invert Level 21.17 mOD	Downstream Invert Level 20.69 mOD
Upstream Soffit Level 23.67 mOD	Downstream Soffit Level 23.19 mOD
Upstream Design Flood Level 22.51 mOD	Downstream Design Flood Level 22.16 mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C10 (C04/02)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Tonabrocky Stream	Catchment:	hydrometric Area 31
Address (Townland – County):	Ballyburke, Knocknacarra, Galway		
Grid Reference	X: 524895	Y: 725274.42	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	1.65 km²	Road Reference:	Proposed N6
Design Flood Flow:	2.13 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.52
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = 0.61
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The FSU estimate was used.		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.11 - 2.04 Factor for Standard Error 1.38 - 1.65 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the FSU method is taken as 1.38 Qdesign 0.61x1.2x2.11x1.37 = = 2.13 cumec.

Hydraulic/Structure Details	
Description of Structure*3	Single 3.1m by 2.5m high box culvert buried by 300mm and mammal ledges along both culvert sides provided which reduce the effective width to 2.1m. The effective open area of 4.62 m2. The culvert lengths is 80.4 m. This Culvert is supplied by a realignment of the Tonabrocky Stream Channel to avoid the road alignment for a length of 250m.
Effective Conveyance Area *4	0.84 m²
Upstream Invert Level 44.56 mOD	Downstream Invert Level 42.32 mOD
Upstream Soffit Level 47.06 mOD	Downstream Soffit Level 44.82 mOD
Upstream Design Flood Level 45.33 mOD	Downstream Design Flood Level 43.0 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.
- The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
- Effective conveyance area is from channel bed level to design flood level.
- All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C12 (C06/01)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Minor drain	Catchment:	hydrometric Area 31
Address (Townland – County):	Rahoon Galway City		
Grid Reference	X: 526420.87	Y: 726389.37	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	0.14 Km²	Road Reference:	Proposed N6
Design Flood Flow:	0.20 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics	<input type="checkbox"/>	
3 – Variable Catchment Characteristics	<input type="checkbox"/>	
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.05
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = n/a
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 estimate is used.		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.04 Factor for Standard Error 1.65 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign = 0.20cumec.

Hydraulic/Structure Details	
Description of Structure*3	Single 2.5m by 2.5m high box culvert buried by 300mm giving an open area of 5.5m2. The Culvert length is 64.8m.
Effective Conveyance Area *4	0.525Ém²
Upstream Invert Level 53.6 mOD	Downstream Invert Level 51.69 mOD
Upstream Soffit Level 56.1 mOD	Downstream Soffit Level 54.19 mOD
Upstream Design Flood Level 54.04 mOD	Downstream Design Flood Level 52.16 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.
- The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
- Effective conveyance area is from channel bed level to design flood level.
- All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C13 (C07/02B)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Minor drain	Catchment:	hydrometric Area 31
Address (Townland – County):	Rahoon Galway City		
Grid Reference	X: 526710.48	Y: 726684.02	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	0.21 Km²	Road Reference:	Proposed N6
Design Flood Flow:	0.30 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.07
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = n/a
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 estimate is used.		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.04 Factor for Standard Error 1.65 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign = 0.30cumec.

Hydraulic/Structure Details	
Description of Structure*3	1.2m diameter concrete culvert buried by 150mm giving an open area of 1.05m². The Culvert length is 14 m.
Effective Conveyance Area *4	0.51m²
Upstream Invert Level 57.84 mOD	Downstream Invert Level 57.65 mOD
Upstream Soffit Level 59.04 mOD	Downstream Soffit Level 58.85 mOD
Upstream Design Flood Level 58.71 mOD	Downstream Design Flood Level 58.71 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.
- The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
- Effective conveyance area is from channel bed level to design flood level.
- All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C14 (C07/02A)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Minor drain	Catchment:	hydrometric Area 31
Address (Townland – County):	Rahoon Galway City		
Grid Reference	X: 526698.49	Y: 726637.16	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	0.21 Km²	Road Reference:	Proposed N6
Design Flood Flow:	0.30 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Flow *2 (m ³ /sec)
Method Used	Tick box if used or state other	
6 – Variable Catchment characteristics	<input type="checkbox"/>	
3 – Variable Catchment Characteristics	<input type="checkbox"/>	
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.07
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = n/a
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 estimate is used.		

Factors Applied	
Type of Factor	Value Used
Climate Change	1.2
Irish Growth Curve	2.04
Factor for Standard Error	1.65
Drained Channel	0
Other	0
Tidal	<input type="checkbox"/>
Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign = 0.30cumec.	

Hydraulic/Structure Details	
Description of Structure*3	2.5m by 2.5m concrete box culvert buried by 300mm giving an open area of 5.5m². The Culvert length is 82.1 m. The culvert dimensions have been increased for bats.
Effective Conveyance Area *4	0.425m²
Upstream Invert Level 56.88 mOD	Downstream Invert Level 55.79 mOD
Upstream Soffit Level 59.38 mOD	Downstream Soffit Level 58.29 mOD
Upstream Design Flood Level 57.84 mOD	Downstream Design Flood Level 57.65 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.
- The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
- Effective conveyance area is from channel bed level to design flood level.
- All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C15 (C08/01)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Minor drain	Catchment:	hydrometric Area 30
Address (Townland – County):	Bushypark, Galway City		
Grid Reference	X: 527663.93	Y: 727211.93	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	0.159 Km²	Road Reference:	Proposed N6
Design Flood Flow:	0.23 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics	<input type="checkbox"/>	
3 – Variable Catchment Characteristics	<input type="checkbox"/>	
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.06
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = n/a
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 estimate is used.		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.04 Factor for Standard Error 1.65 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign = 0.23cumec.

Hydraulic/Structure Details	
Description of Structure* ³	1.2m diameter concrete culvert giving an open area of 1.2m². The Culvert length is 82.5m. This culvert connects to a 600mm diameter storm culvert which due to its gradient (a fall of 1 in 31) has ample capacity to convey the design flow without backing up the flow through the proposed 1200mm culvert. An access chamber is required between the proposed 1200mm culvert and the existing 600mm storm sewer for maintenance purposes.
Effective Conveyance Area * ⁴	0.08m²
Upstream Invert Level 32.5 mOD	Downstream Invert Level 29.035 mOD
Upstream Soffit Level 33.7 mOD	Downstream Soffit Level 30.24 mOD
Upstream Design Flood Level 33.74 mOD	Downstream Design Flood Level 29.435 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C16 (C10/02)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Minor drain	Catchment:	Corrib hydrometric Area 30
Address (Townland – County):	Coolagh, Galway City		
Grid Reference	X: 529687.79	Y: 728412.26	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	0.63 Km²	Road Reference:	Proposed N6
Design Flood Flow:	0.19 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

<i>For OPW use only</i>	<i>Date of Receipt</i>							
<i>OPW Drainage Maintenance Region</i>	<i>East</i>	<input type="checkbox"/>	<i>South East</i>	<input type="checkbox"/>	<i>South West</i>	<input type="checkbox"/>	<i>West</i>	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics	<input type="checkbox"/>	
3 – Variable Catchment Characteristics	<input type="checkbox"/>	
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.05
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = n/a
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 estimate is used.		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.04 Factor for Standard Error 1.65 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign = 0.19cumec.

Hydraulic/Structure Details	
Description of Structure*3	1.2m diameter concrete culvert buried by 150mm giving an open area of 1.05m². The Culvert length is 41.84 m.
Effective Conveyance Area *4	0.16m²
Upstream Invert Level 11.58 mOD	Downstream Invert Level 11.3 mOD
Upstream Soffit Level 12.78 mOD	Downstream Soffit Level 12.5 mOD
Upstream Design Flood Level 11.95 mOD	Downstream Design Flood Level 11.62 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.
- The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
- Effective conveyance area is from channel bed level to design flood level.
- All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	C17 (C07/01A)
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO, Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 509594	Fax:	
E-mail:	fomeara@galwaycoco.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	Minor drain	Catchment:	hydrometric Area 31
Address (Townland – County):	Rahoon Galway City		
Grid Reference	X: 527147.5148	Y: 726262.3969	
Hydrometric Station(s) utilized (including reference number):	None Available		
Area of Contributing Catchment:	0.38 Km²	Road Reference:	Proposed N6 Rahoon link road
Design Flood Flow:	0.55 m³/s	Annual Exceedance Probability (AEP):	1 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	Hydro Environmental Ltd.
Signature:	
Date:	14 July 2017

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

For OPW use only	Date of Receipt							
OPW Drainage Maintenance Region	East	<input type="checkbox"/>	South East	<input type="checkbox"/>	South West	<input type="checkbox"/>	West	<input type="checkbox"/>

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	OPW Register No:	
	Consent Issued	<input type="checkbox"/>

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		Factors Applied
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics	<input type="checkbox"/>	
3 – Variable Catchment Characteristics	<input type="checkbox"/>	
IH 124	<input checked="" type="checkbox"/>	QBAR = 0.14
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other	<input type="checkbox"/>	
FSU	<input type="checkbox"/>	Qmed = 0.11
FSR <input type="checkbox"/>	FSU <input type="checkbox"/>	Other <input type="checkbox"/>
Comments Generally IH124 equation was used for all culverts and where the FSU was available for the larger streams this was also considered. The IH124 estimate is used.		
		Type of Factor Value Used Climate Change 1.2 Irish Growth Curve 2.11 - 2.04 Factor for Standard Error 1.38 - 1.65 Drained Channel 0 Other 0 Tidal <input type="checkbox"/> Comments The factor for Standard error associated with the IH124 method is taken as 1.65 Qdesign 0.14x1.2x2.04x1.65 = 0.55cumec.

Hydraulic/Structure Details	
Description of Structure*3	1.2m diameter concrete culvert giving an open area of 1.2m². The Culvert length is 37.2 m. This culvert discharge directly to the Galway Co. Council Storm inlet culvert which is a 450mm sewer that connects to a 600mm storm sewer. Under the design flow of 0.55cumec the 450mm diameter sewer requires considerable heading up to discharge this flow and therefore the proposed 1200mm culvert is shown to be fully submerged.
Effective Conveyance Area *4	1.13m²
Upstream Invert Level 35.89 mOD	Downstream Invert Level 35.57 mOD
Upstream Soffit Level 37.09 mOD	Downstream Soffit Level 36.77 mOD
Upstream Design Flood Level 38.585 mOD	Downstream Design Flood Level 38.56 mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Appendix 2 Section 50 Supporting Drawings of Culverts

Refer to Appendix A.1 of the Design Report for Section 50 Culvert and Bridge Application Drawings

Drawing References:

GCOB-500-D-500 to GCOB-500-D-523 for details

N6 Galway City Ring Road
Hydrology Assessment
For OPW Section 50 Approval
Of proposed River Corrib Bridge Crossing

Report No. HEL209002_v1.1

Galway County Council NRDO

October 2016



**No. 4 Caiseal Riada,
Clarinbridge,
Galway,
Ireland.**

Tel/Fax: 091 796734

***N6 Galway City Transport Project
Hydrology Assessment
For OPW Section 50 Approval
Of proposed River Corrib Bridge Crossing***

**on behalf of
Galway Co. Council NRDO**

Job No.:	209002
Report No.:	HEL209002
Prepared by:	Anthony Cawley BE, M.EngSc, CEng MIEI
Date:	25 th October 2016

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DISCLAIMER

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Appendix 1 - OPW Section 50 Culvert application

Appendix 2 - Section 50 Supporting Drawings

1. INTRODUCTION

The proposed N6 Galway City Ring Road runs from the existing M6 at Ardaun on the east side of the city, passing to the north of the city and eventually joining with this Spiddle coast road just east of Bearna Village. The proposed road development lies principally within hydrometric areas 30 and 31. The proposed road development crosses the River Corrib near Menlo Castle (approximately 160m to the southwest) on the eastern bank and on the western side it passes through NUIG Recreational Facilities at Dangan. The River Corrib channel at the crossing site is within the Lough Corrib Special Area of Conservation (SAC) (000268).

A large bridge superstructure is proposed at this proposed River Corrib crossing which will clear span the entire river channel and continues on piers west of the River Corrib to maintain access for the NUIG Recreational Facilities. The structure provides a full clear span of the river of 150m from pier to pier. The riverside support piers are located a distance of 5m from the river bank edge on the eastern (Menlo) side and over 10m from the river edge on the western (Dangan) side. The location of the bridge crossing is presented in Figure 1.

Section 50 approval from the Office of Public Works (OPW) is required for all proposed watercourse bridge and culvert structures, either new or upgraded under the Arterial Drainage ACT 1945. The OPW Section 50 requirement is that the proposed bridge structure be sufficiently sized to convey the 100 year design flood without causing any significant upstream afflux (<0.1m) and should provide sufficient clearance between the bridge soffit level and the design flood level to allow floating debris to pass underneath.

The Section 50 consent process requires a minimum design flood flow capacity to cater for the 1% flood (100 year return period flood event) with suitable allowances for uncertainty and climate change and potential other catchment change effects. As part of the application process a technical hydrological report prepared by a competent hydrologist is required, which sets out in a clear manner the estimation of the design flow magnitude and the estimation of the resulting flood level at the bridge site with and without the structure.

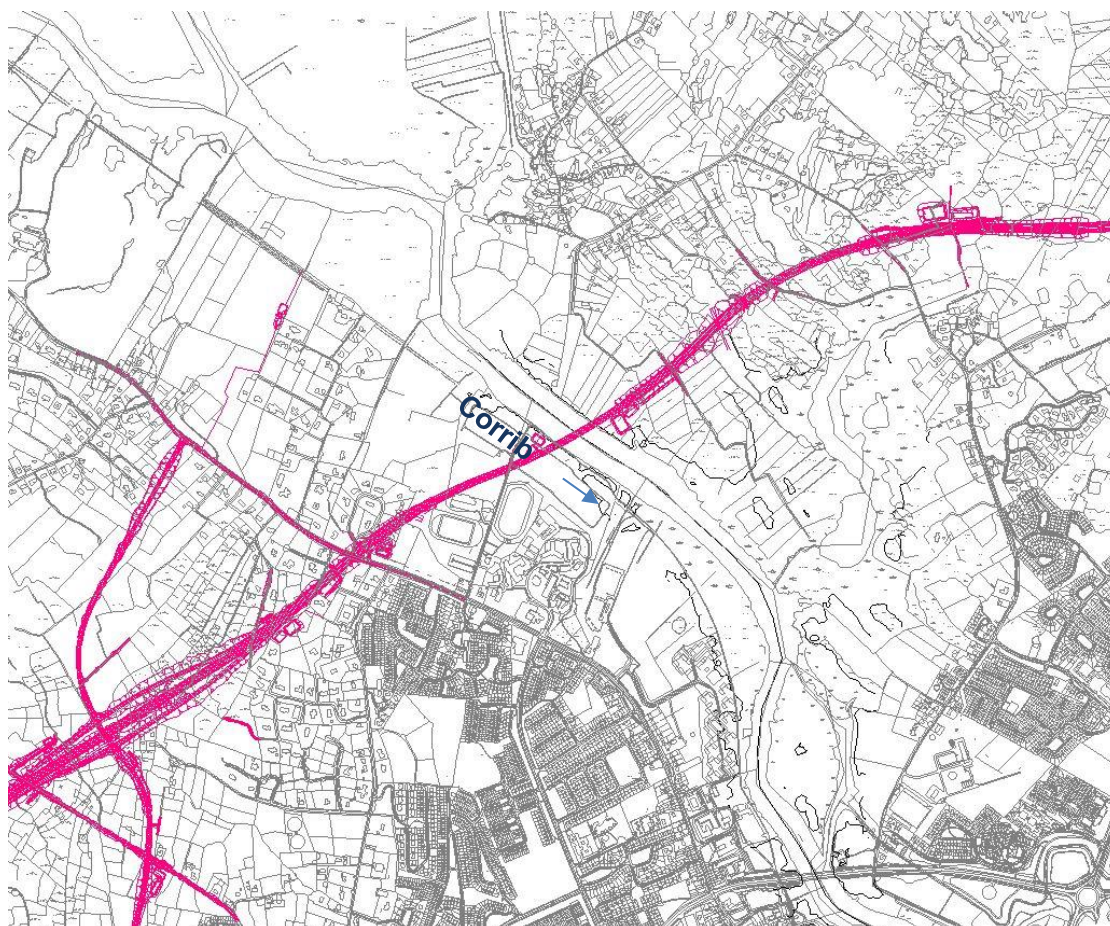


Figure 1 Location map of proposed N6 Galway City Ring Road alignment and River Corrib crossing point.

2. PROPOSED BRIDGE

The proposed bridge structure is a balanced cantilevered structure spanning over the river banks and provides a clear span between support piers of 150m. This clear span is sufficient to allow the support piers to be set back from the channel bank and thereby substantially reduce any potential encroachment into the River Corrib channel and its effective floodplain area and allows for continuous access along the river bank edge on both banks. On the eastern bank the minimum setback distance from the pier face to channel edge is 5m and on the western bank the minimum setback is slightly in excess of 10m. Such setbacks meet Inland Fisheries Ireland (IFI) requirements.

The bridge deck is to be a post-tensioned in-situ concrete deck which can be built using travelling formwork over river channel and the side spans and therefore constructional impact risks to the Lough Corrib SAC are minimised as it will avoid the requirement of instream works, temporary or otherwise.

The bridge soffit level at the pier support on the eastern bank is c. 14.1m OD Malin, 17.8m OD Malin at midspan in the channel and 15.5m OD Malin at the pier support on the western river bank. Even at times of serious flood this

provides over 10m clearance between soffit and water level which ensures navigation requirements are met and reduces shadowing effects.

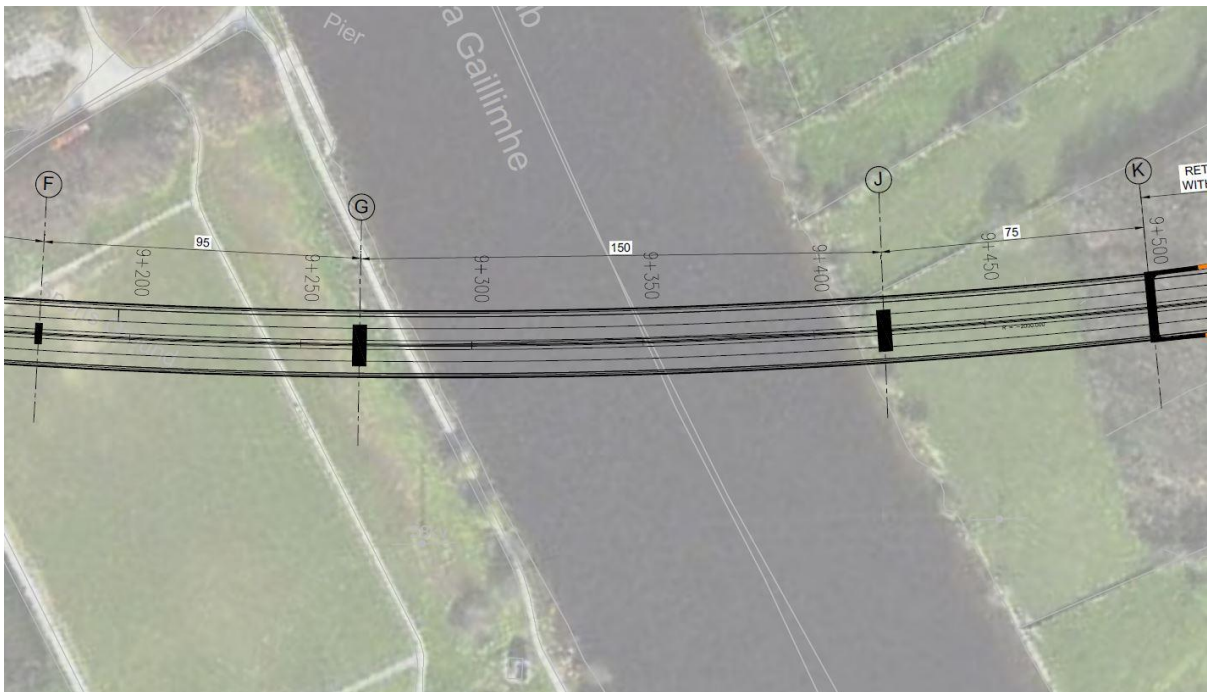


Figure 2 Plan view of proposed pier locations at River Corrib channel crossing

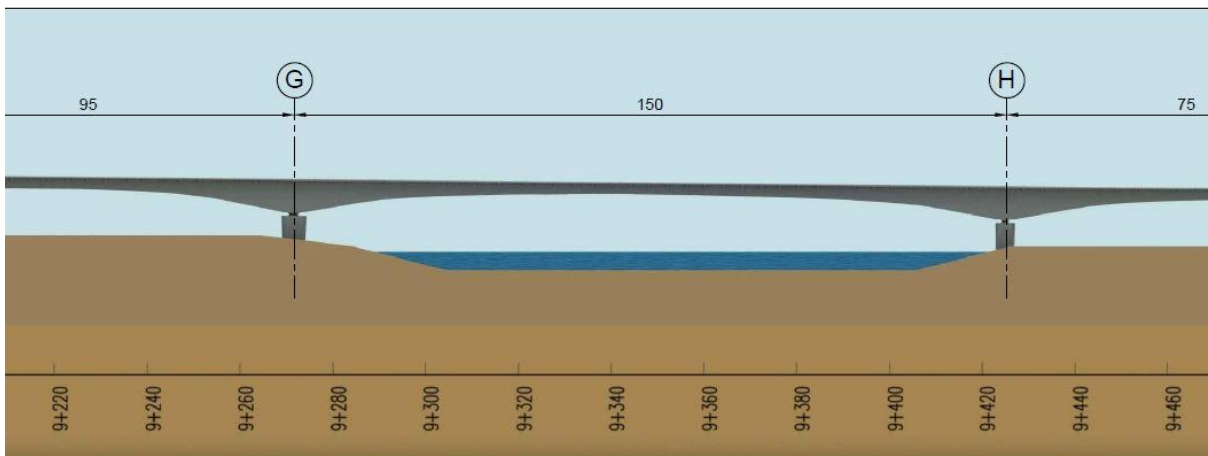


Figure 3 Section view of proposed bridge facing upstream with Dangan located on left side

3. FLOOD LEVEL PREDICTIONS

3.1 CFRAM Flood Risk Mapping

As part of the CFRAM study for Galway City the River Corrib Reach from the Claddagh basin upstream to Dangan has been modelled and draft mapping prepared of the flood extents for 10, 100 and 1000 year flood events. An excerpt from this mapping for the Dangan area is presented in Figure 4 and predicted flood levels at key locations are presented in Table 1.

Table 1 CFRAM predictions at key reference locations

Return period years	Dangan Flows cumec	Salmon Weir Barrage Gauge (mOD)	Quincentenary Bridge (mOD)	Dangan Gauge (mOD)
10yr	309	6.13	6.30	6.87
100yr	404	6.44	6.67	7.38
1000yr	616	6.93	7.24	8.02

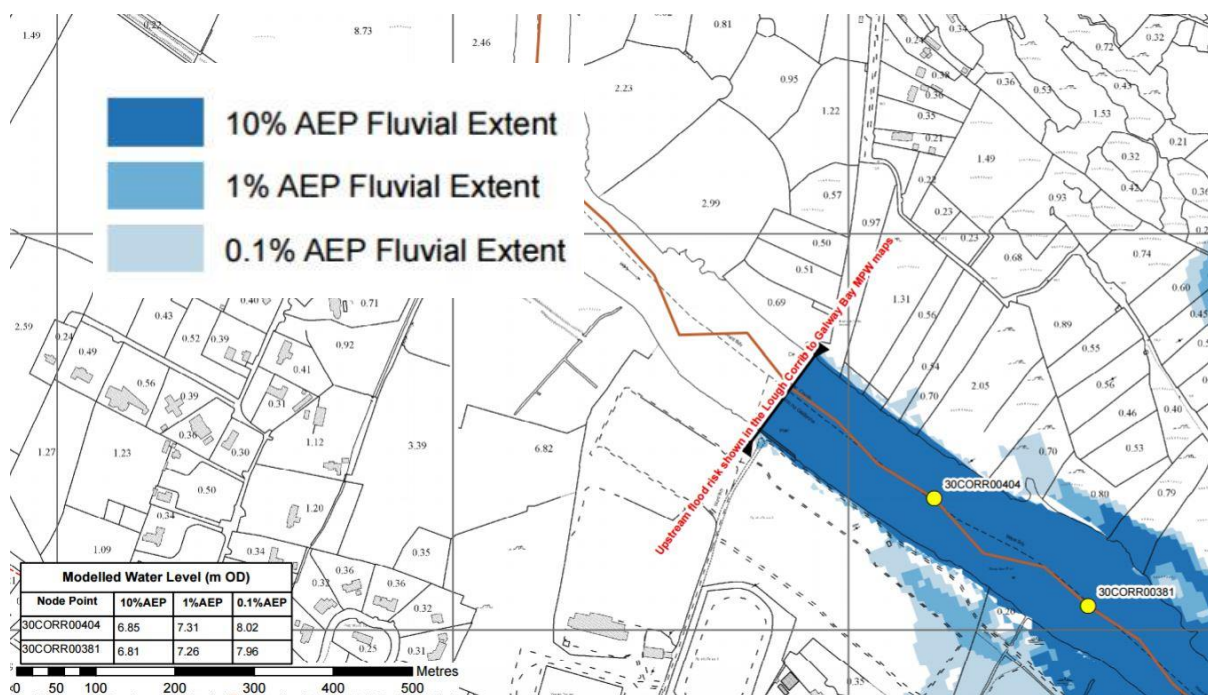


Figure 4 CFRAM Flood Extent Maps

3.2 At-Site Statistical Analysis of Dangan Gauge

A statistical analysis of annual maximum flood levels recorded at the Dangan Gauge was carried out fitting an EV1 statistical distribution to the data. The total record length for this analysis is 30 years and this length of record is sufficient to

provide a reasonable estimate of the 10 year flood level and possibly up to the 50 year return period, but would be considered short in respect to the 100 year and 1000 year predictions. The results are presented below in Table 2. This record length would not be considered to be sufficiently long to provide a reliable estimate of the 100 year and 1000 year flood levels and therefore the estimates should include the addition of the statistical error.

Table 2 Statistical Analysis of 30years of flood Level data for Dangan Gauge

Return Period years	Dangan Gauge Flood level (mOD)	Statistical Error (m)	Statistical Error Upper 67% confidence Interval (mOD)
10yr	6.69	0.072	6.76
100yr	7.05	0.136	7.19
1000yr	7.39	0.200	7.59

Even with the inclusion of the statistical error this shows the 10 year, 100 year and 1000 year flood levels at the Dangan Gauge to be consistently lower than the CFRAM estimates, particularly the 1000 year CFRAM estimate of 8.02m OD Malin. The 10 year estimate from the at site data is considered reliable as there is 30 years of Annual Maxima (AM) data available and even for the 10 year flood event the CFRAM estimate is almost 0.2m higher.

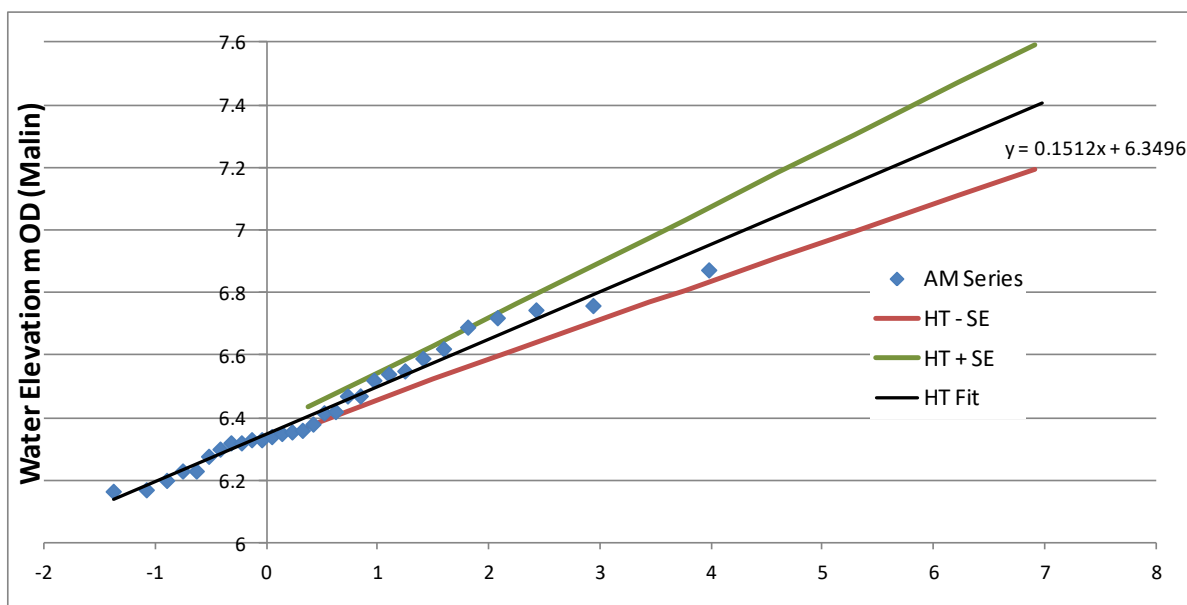


Figure 5 EV1 Fit to Annual Maxima Water Level Series at Dangan including the statistical error (67% confidence) limits

4. FLOOD ESTIMATES FOR THE RIVER CORRIB

4.1 Draft CFRAM

The estimated flood flows for the River Corrib in the CFRAM study are 248cumec, 309cumec, 404cumec and 616cumec for the median, 10 year, 100 year and 1000 year flood events. This represents growth factors of 1.63 and 2.48 for the 100 and 1000 year events respectively. The CFRAM hydrology report Appendix B page B18 presents the following design flows for the River Corrib of 248, 329, 441 and 579cumec which is a growth factor of 1.8 and 2.3 respectively. These reported flows are somewhat at variance to what is reported as being used in the draft CFRAM flood extent mapping.

4.2 FSU Method

The recent OPW Flood Studies Update (FSU) method for flood flow estimation gives the following estimates of 243, 329, 435, and 540cumec for the median, 10 year, 100 year and 1000 year flood events for the River Corrib at Dangan.

4.3 At-Site Statistical Analysis

A statistical analysis of annual maximum flood levels recorded at the Dangan Gauge was carried out fitting an EV1 statistical distribution to the data. The total record length for this analysis is 30 years and this length of record is sufficient to provide a reasonable estimate of the 10 year flood level and possibly up to the 50 year return period, but would be considered short in respect to the 100 year and 1000 year predictions.

The River Corrib flow rate is determined at Wolfe Tone Bridge gauge site. Due to inconsistencies in the rating relationship for this site there is no available flood flow data for the River Corrib post the 2003 hydrometric year. This represents a serious deficiency as the wettest period on record is not currently available in terms of annual flood flows.

To provide such a record of AM flows a flood rating relationship for the Dangan Gauge was developed using data from flow rating exercise performed by the OPW in February and March 1990. This flood rating site at Dangan is considered to be an improvement over the Wolfe Tone OPW site during flood conditions where all gates are opened at the Salmon Weir Barrage. The Wolfe Tone site is problematic as a site as it is subject to standing waves, steep gradient, and located within the tidal zone. From the Dangan flood rating the Annual Maxima flood levels for the entire 30 year record (1986 to 2015) were converted to flow rate and a frequency analysis carried out to determine return period flow estimates. The median flood flow Q_{med} for the full 30 year record is 264.6cumec at Dangan.

A relationship between the estimated annual maximum flows at Dangan and the stage height (water level) at Salmon Weir Barrage Gauge (30098) was developed for the available period 2005 to 2015. This is presented below in Figure 6 and was derived for the case of all gates fully opened (all 16 gates).

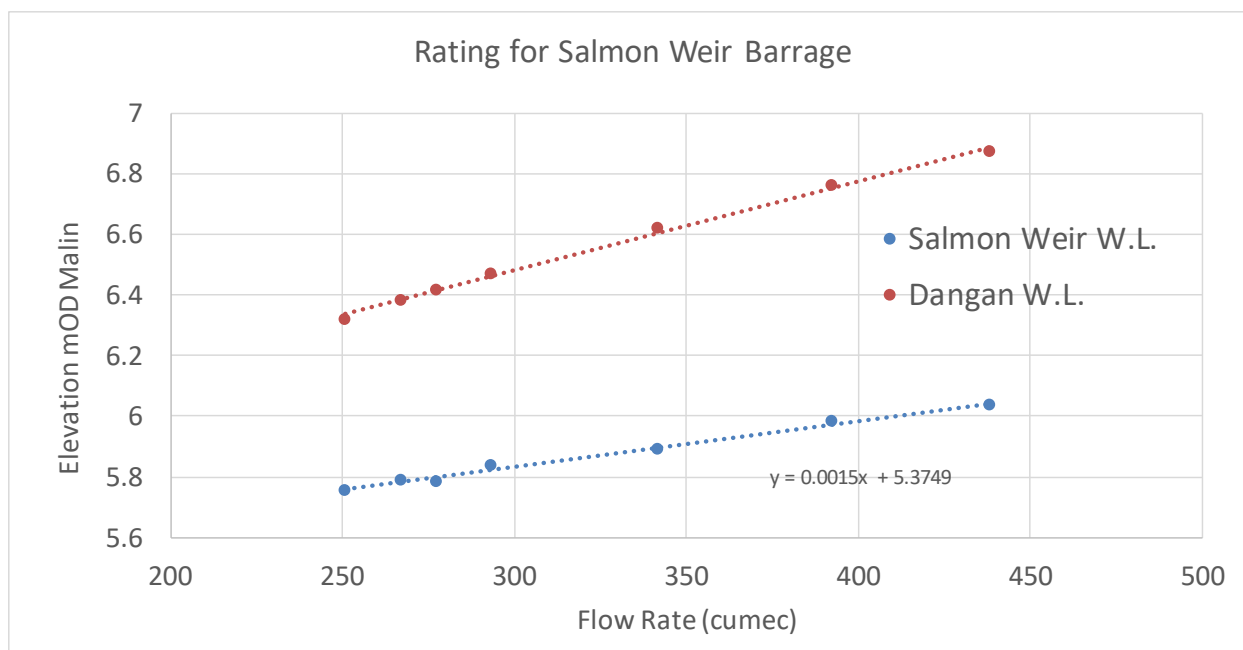


Figure 6 Derived Rating Relationships between Dangan and the Salmon Weir Gauges for the larger flows when all gates on the Salmon Weir Barrage remain open

The common overlapping period between Wolfe Tone Bridge and Dangan in terms of Annual Maxima data is 1986 to 2003 and the calculated median flood flows for Wolfe Tone and Dangan during this period are 255cumec and 260cumec respectively (standard error is 10.7cume). These estimates are in reasonable agreement and therefore demonstrate that the Dangan Gauge is fit for purpose. The AM flow series single site frequency analysis gives a 1000 year flow rate of 586cumec. The OPW FSU pooling group relationship gives a 1000 year growth factor of 2.22 which when applied to the Median Flood Flow estimate of 264.6cumec gives a Q1000 of 587cumec which is very similar to the at-site frequency estimate.

Table 3 Statistical Analysis of 30 years of flood Flow data for Dangan Gauge

Return Period years	Dangan Gauge Flood Flow (cumec)	Statistical Error (cumec)	Statistical Error Upper 67% confidence Interval (cumec)
10yr	366.9	22.4	389.3
100yr	477.3	42.1	519.5
1000yr	585.8	62.0	647.9

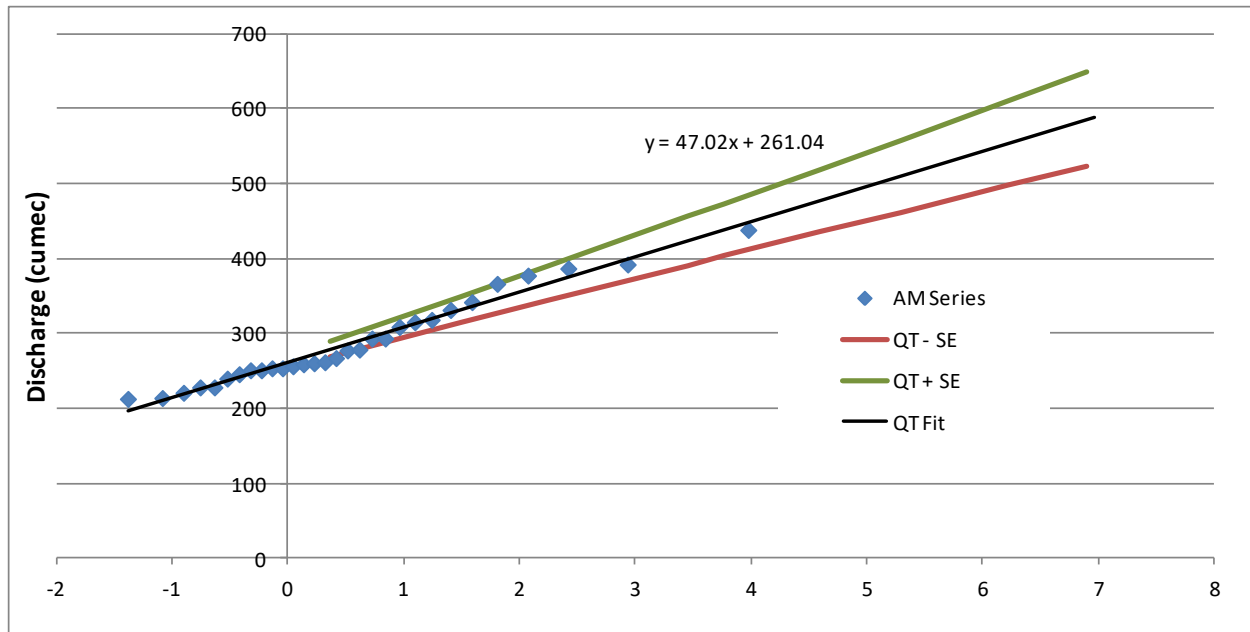


Figure 7 EV1 Fit to Annual Maxima Estimated Flood Flow Series at Dangan including the statistical error (67% confidence) limits

5. HYDRAULIC MODELLING

5.1 Introduction

A detailed 2-dimensional hydraulic model of the River Corrib Reach from upstream of Menlo Castle to downstream of the Galway Barrage was developed using the industry standard hydraulic model TELEMAC2D. This model is a variable density grid finite element scheme which allows high resolution where required such as at bridge pier locations and confined river channels. The modelled reach and the triangular mesh is presented in Figure 8 below.

A bed level survey carried out by Aquafact of the River Corrib channel, Coolagh Lakes and Jordan’s Island (March 2016) was used to define the river channel geometry within the model domain and the OPW CFRAM lidar set was used to define the overbank areas.

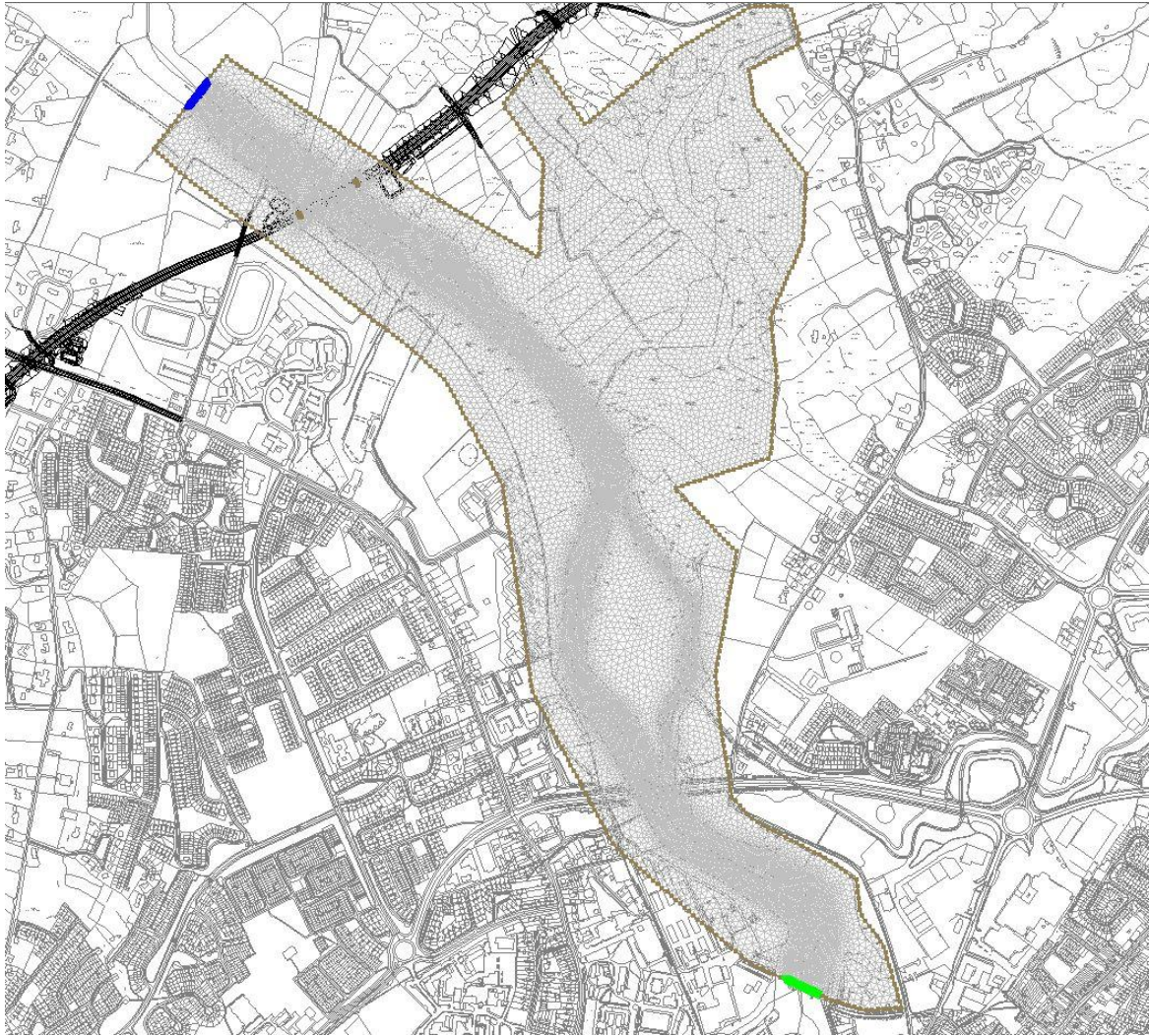


Figure 8 2-D model domain



Figure 9 Model Grid Density in the vicinity of the River Corrib Bridge crossing

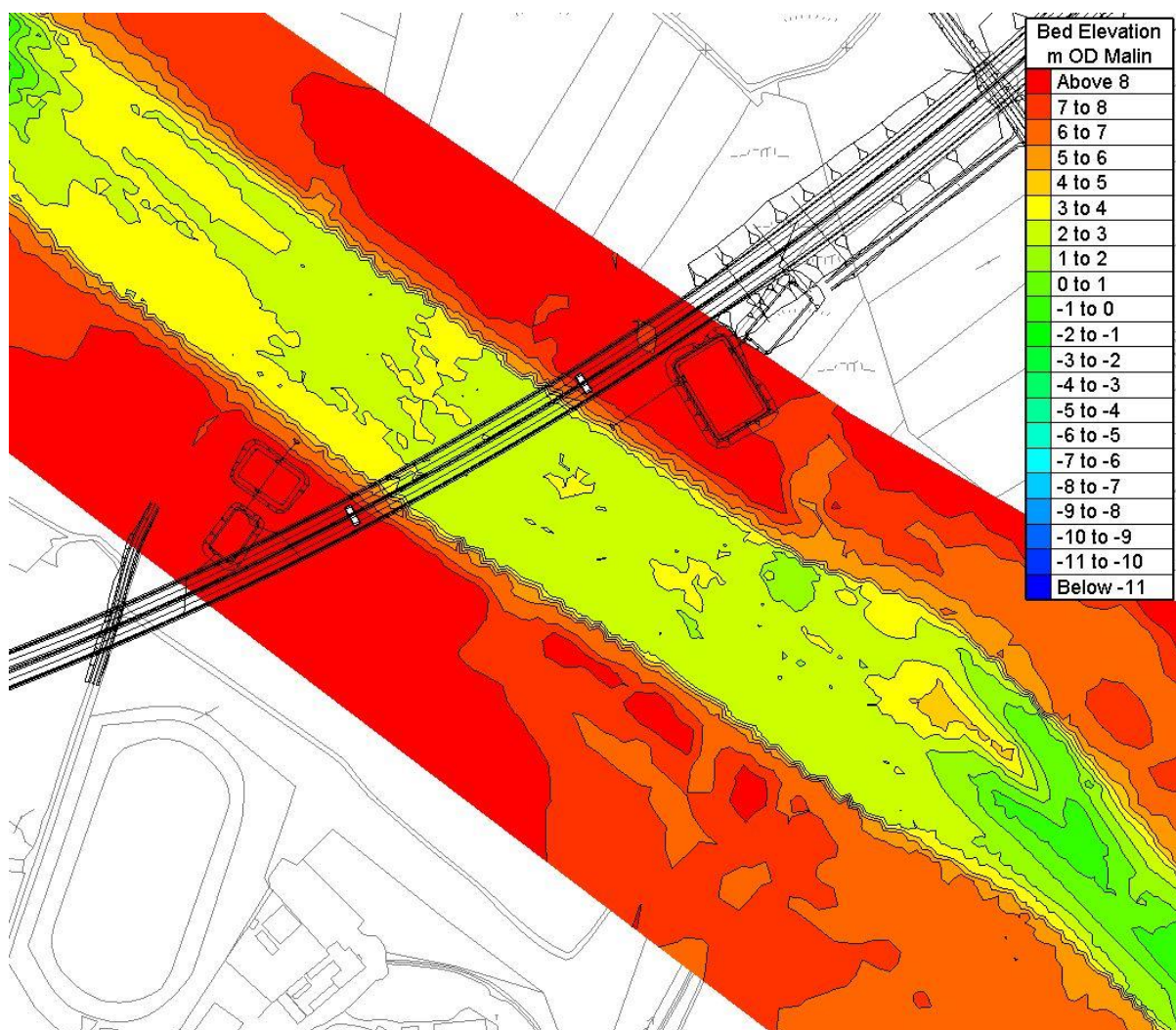


Figure 10 Bathymetry Plot in vicinity of the River Corrib Bridge crossing

5.2 Model calibration

The recent flood event with the peak flood occurring on 2nd January 2016 gave a flood level at Dangan Gauge of 6.87 mOD Malin, which based on the statistical analysis of the AM series represents a 32 year return period flood event based on water level records (note it is the largest recorded flood in at least 60 years (since at least the commencement of the arterial drainage scheme in 1959). The estimated flood flow peak for this event is 438cumec and the return period associated with such a flow is 44 years based on the estimated AM flow series Q-T relationship. The out of bank flooding in the vicinity of the NUIG Engineering Building upstream of the Quincentenary Bridge indicates a flood level of circa 6.45 to 6.5m OD Malin and further downstream adjacent to the Environmental Change Institute NUIG, the out of bank flooding indicates a flood level of circa 6.2 to 6.25 m OD Malin. The recorded peak flood level at the Galway Barrage Gauge was 6.04m OD Malin for this event. All gates in the barrage were fully opened during this flood event.

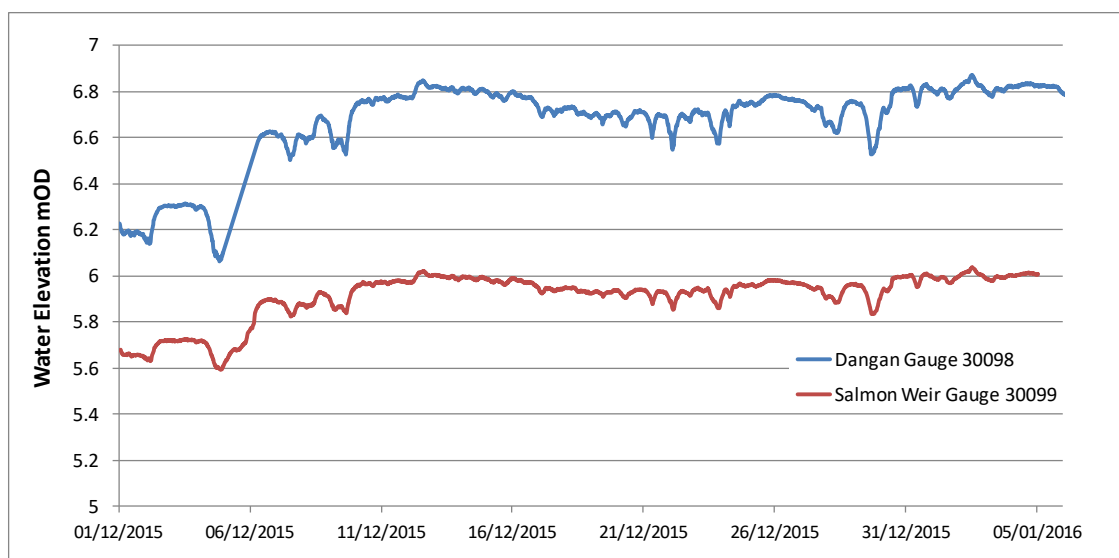


Figure 11 Recorded Flood Hydrograph for 2015/2016 Flood Event at Salmon Weir and Dangan Gauges

The 2-D Telemac model was run as a calibration exercise for a peak discharge rate of 438 cumec observed on 2 January 2016. The computed flood levels at the Clifden Railway Line piers upstream of the Salmon Weir Barrage, on the western bank adjacent to the Environmental Change Institute NUIG, at the upstream end of the NUIG Engineering Building near St Anthony’s NUIG and at Dangan Gauge are 6.12m OD Malin, 6.21m OD Malin, 6.55m OD Malin and 6.87m OD Malin.

These predicted flood levels show good agreement with the observed flood levels described earlier for a Manning’s coefficient of 0.024 as a surface roughness in the 2-D model. This magnitude of channel roughness is a reasonable value for the River Corrib in a 2-D model representation.

5.3 Design Flood Simulations and results

The at-site flow estimates from the Dangan Gauge are considered to provide the more reliable estimate of the median and 10 year flood flow magnitude over the FSU and CFRAM methods. The pooling group method available from the FSU method is considered the most reliable for estimating the flood growth curve and providing appropriate multipliers to factor up the median flood (Index flood) to the more extreme 100 and 1000 year flood flow magnitudes. This pooling group method combines the statistics from other similar gauging stations to provide 500 station years of data from which to derive the flood growth curve. This FSU pooling group gives the following growth factors 1.28, 1.79 and 2.22 for the 10, 100 and 1000 year flood events. The CFRAM study appears to use the following growth factors 1.26, 1.63 and 2.48 and the Dangan Gauge statistical analysis gives the following growth factors 1.42, 1.89, 2.36.

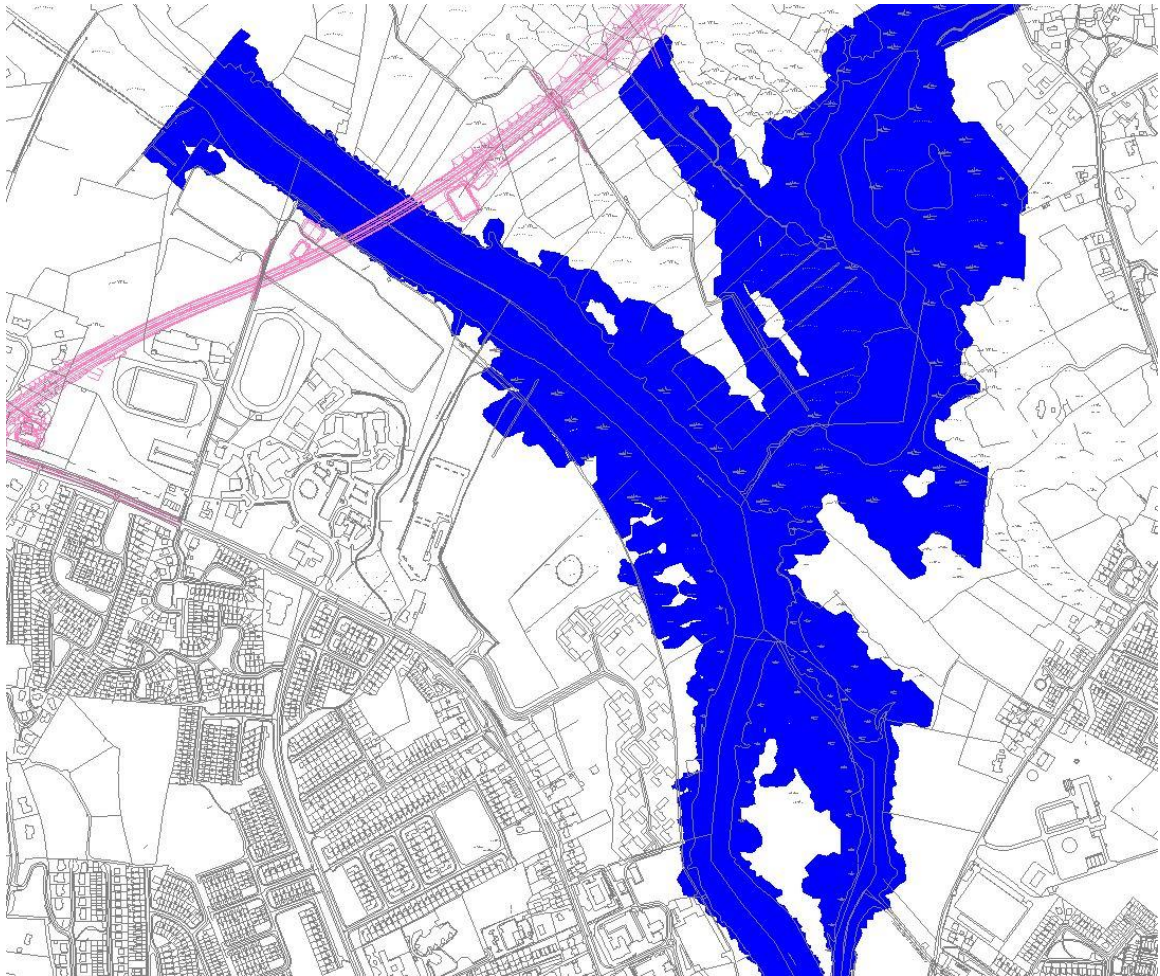


Figure 12 Peak Flood Extent during the 2nd January 2016 flooding

The following peak flows are used in the modelling to predict flood data levels at the River Corrib Bridge site 150m downstream of the Dangan Gauge. The inundation maps for each of these events is presented in Figures 13 to 16 and show that floodplain area at the crossing location is constrained to the river channel section.

Table 4 Computed Flood level Results for Proposed River Corrib Bridge Site

Return Period years	Specified QT Flood Flow (cumec)	Computed Flood Level Bridge upstream (m OD)	Computed Flood Level Bridge downstream (m OD)
10yr	389	6.716	6.697
100yr	520	7.197	7.180
1000yr	648	7.619	7.607
100yr+CC	624	7.538	7.526

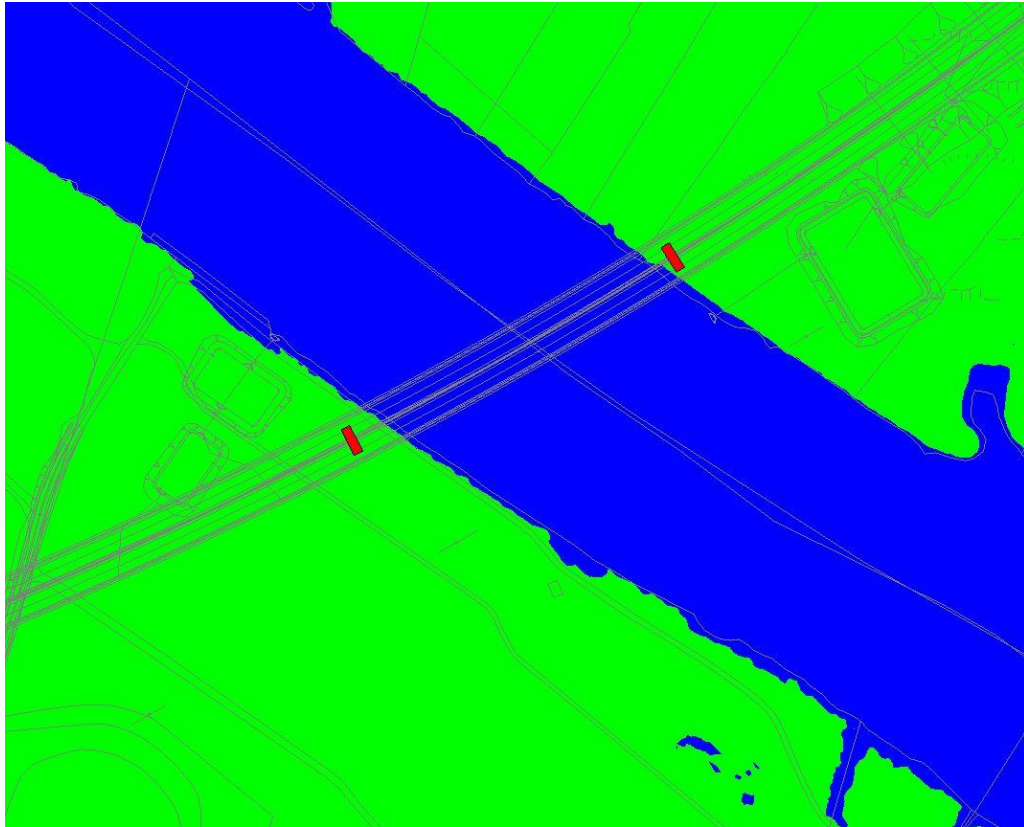


Figure 13 Flood Inundation at River Corrib Crossing for the 10 year flood event

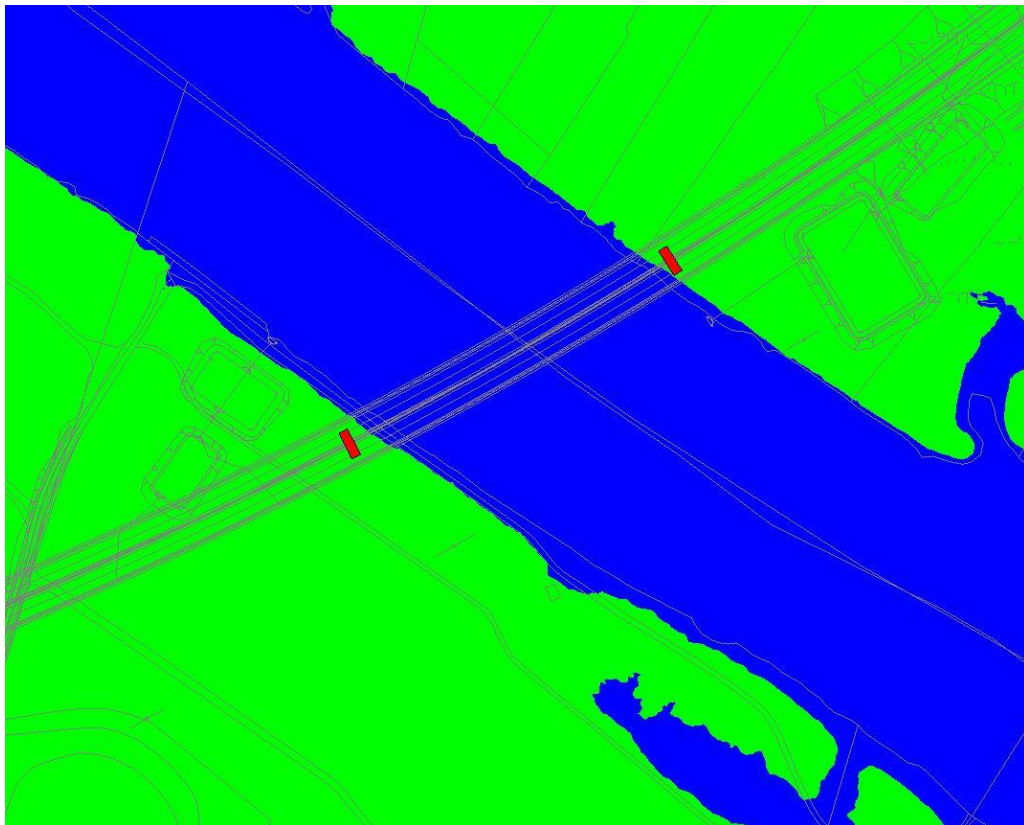


Figure 14 Flood Inundation at River Corrib Crossing for the 100 year flood event

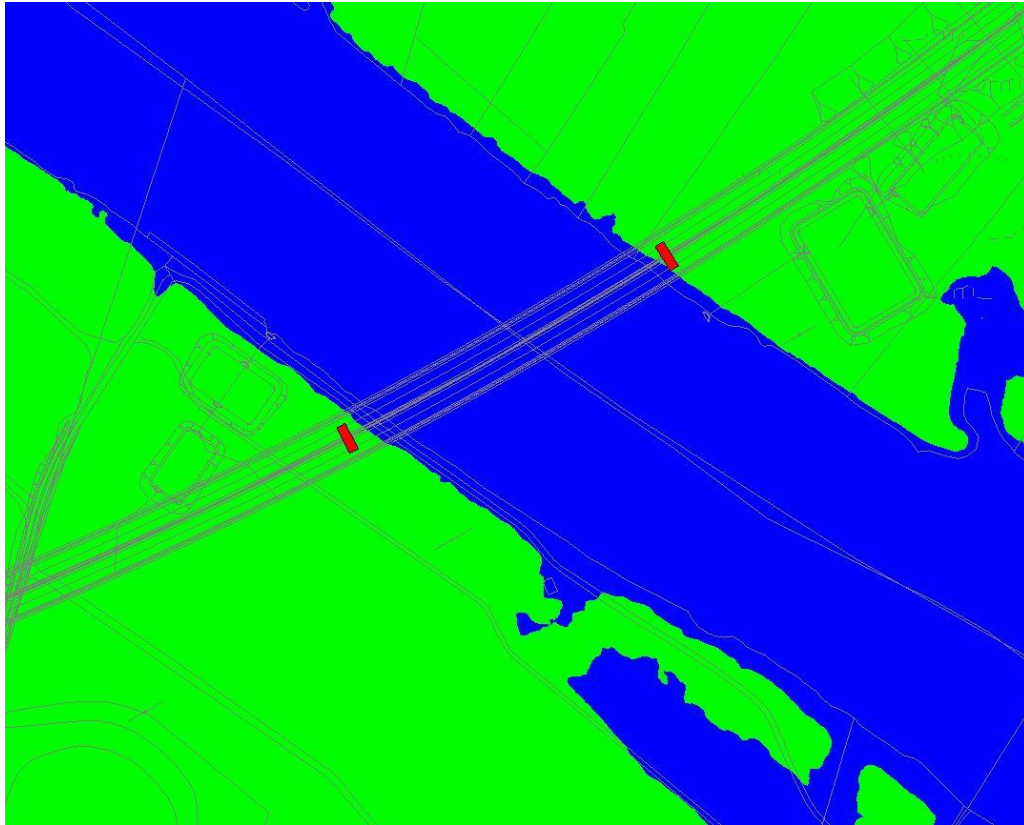


Figure 15 Flood Inundation at River Corrib Crossing for the 100 year with Climate Change flood event

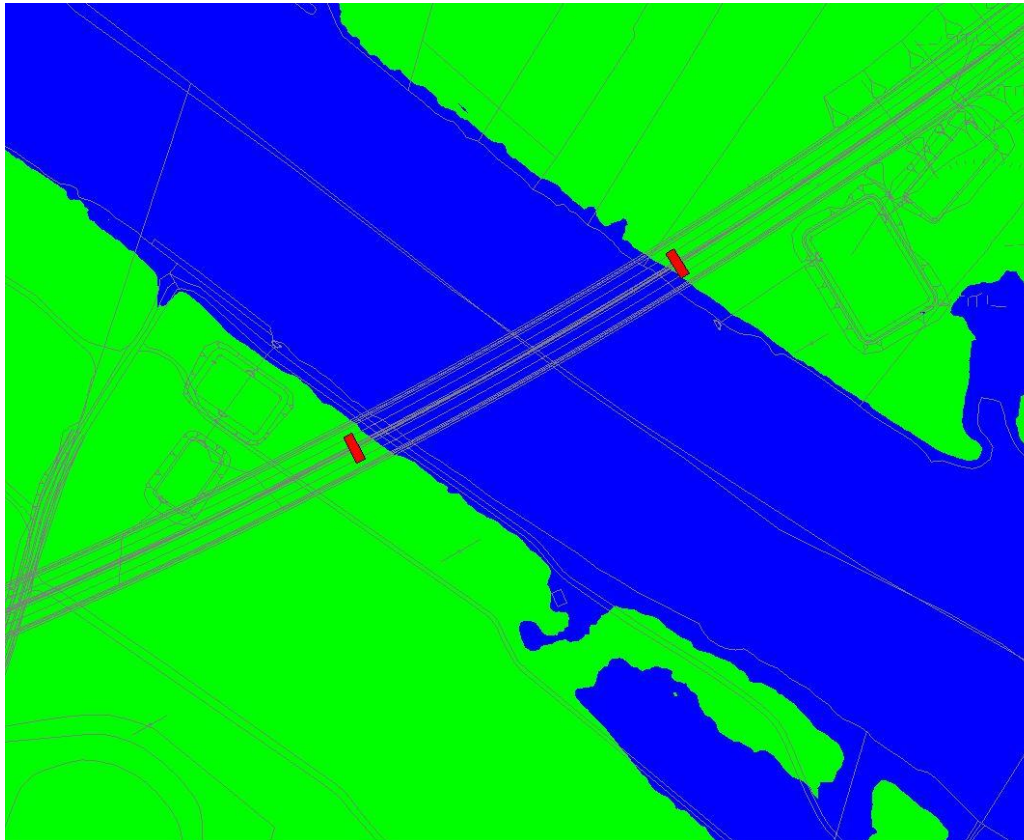


Figure 16 Flood Inundation at River Corrib Crossing for the 1000 year flood event

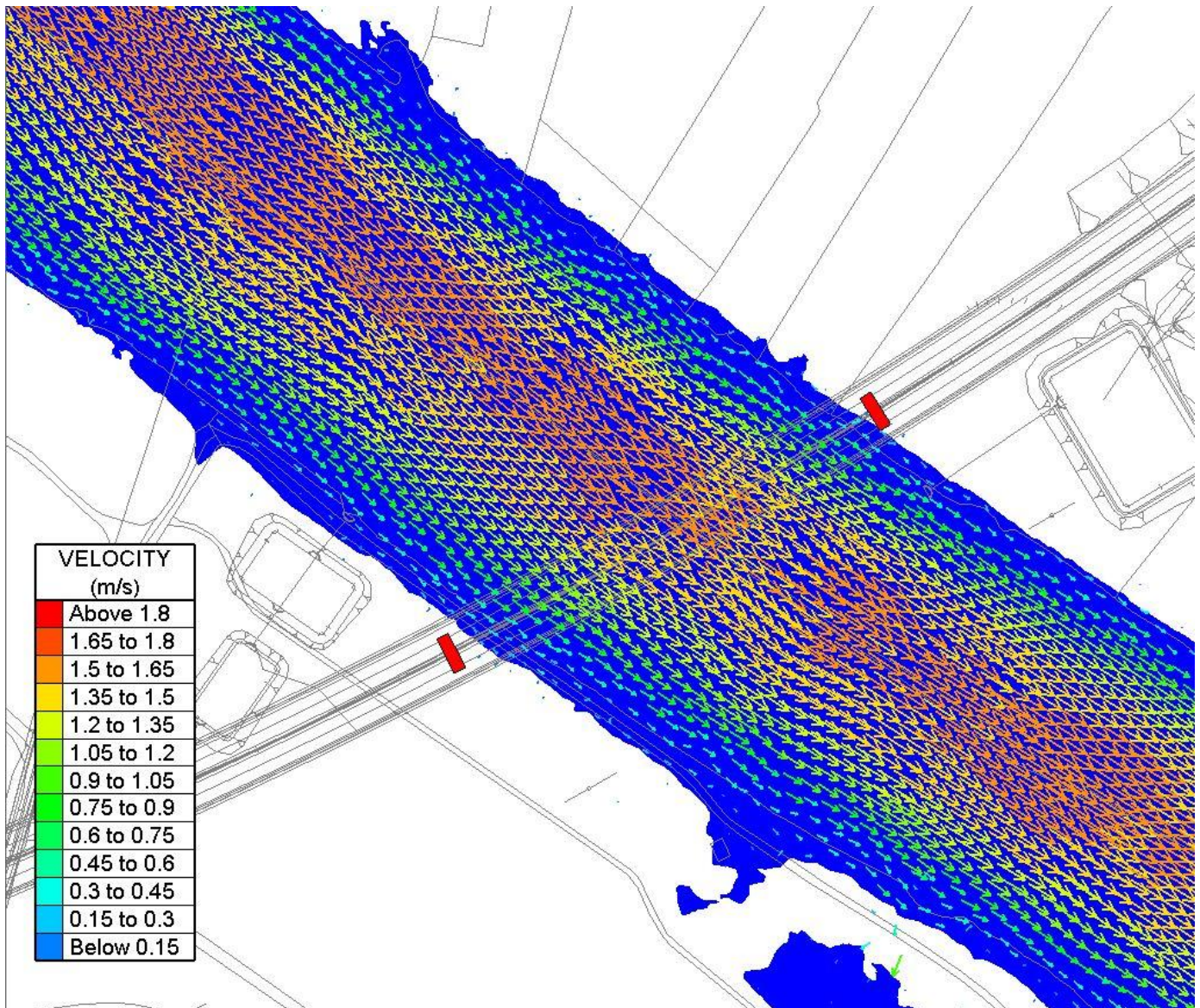


Figure 17 Velocity Plot of 100 year with CC peak flow condition at River Corrib Bridge Site

6. CONCLUSIONS

The predicted flood level for the 100 year + Climate Change of 624cume design flood event is 7.54m OD Malin. The proposed 150m clear span structure and the location of the support piers on the river bank will not result in any encroachment into the active floodplain area, being located just to the edge of the floodplain. The 1000 year flood level which defines Flood Zone C (low probability of flooding) is 7.62m OD Malin. The support piers based on the OPW 2m lidar dataset remain outside the active floodplain area for this 1000 year flood flow condition.

It is also concluded that the CFRAM flood levels and in particular the 1000 year flood level at Dangan Gauge of 8.02m OD Malin is likely to be overly conservative. Notwithstanding this higher flood level estimate from the CFRAM study the proposed large single span structure of 150m will not result in any potential impact to flood levels and flood risk either locally or in the upstream and downstream reaches with no discernible impact on flow depths or velocities as a result of the bridge support piers.

The proposed River Corrib Bridge provides significant freeboard of c. 10m above the design flood level at mid span which easily meets OPW freeboard requirements.

Appendix 1 OPW Section 50 Culvert applications

Refer to Volume 2 of the Design Report for River Corrib Bridge Detail Drawings

Drawing References:

GCOB-1700-D-S08-04-001 to GCOB-1700-D-S08-04-004




**Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment
and Management of Flood Risks) Regulations SI 122 of 2010**

Project Name	N6 Galway Transport Project	Structure Ref No.	ST9/02
Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	Galway County Council		
Postal Address:	NRDO Corporate House, Ballybrit Business Park, Co. Galway		
Contact Person:	Fintan O'Meara		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	Hydro Environmental Ltd		
Postal Address:	4 Caiseal Riada, Cloarinbridge, Co. Galway		
Contact Person:	Tony Cawley		
Phone:	091 796734	Fax:	
E-mail:	tony@hydroe.ie		

Location and Parameters of crossing			
Watercourse:	River Corrib	Catchment:	Hydrometric Area 30
Address (Townland – County):	Menlough/Dangan Galway		
Grid Reference	X: 128535	Y: 227708	
Hydrometric Station(s) utilized	30061, 30098, 30099, 30089		
Area of Contributing Catchment:	3125 km²	Road Reference:	Proposed N6
Design Flood Flow:	624 m³/s	Annual Exceedance Probability (AEP):	100 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Anthony Cawley
Company/Organisation:	N6 Galway Transport Project
Signature:	
Date:	25 October 2016

Application Check List	<input type="checkbox"/>
COMPLETED APPLICATION FORM	<input type="checkbox"/>
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	<input type="checkbox"/>
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	<input type="checkbox"/>
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	<input type="checkbox"/>
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	<input type="checkbox"/>
DETAILS OF RELEVANT EXISTING STRUCTURES	<input type="checkbox"/>
COMPLETED STATEMENT OF AUTHENTICITY	<input type="checkbox"/>
PLAN OF CATCHMENT AREA	<input type="checkbox"/>
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	<input type="checkbox"/>

For OPW use only	Date of Receipt							
OPW Drainage Maintenance Region	East	<input type="checkbox"/>	South East	<input type="checkbox"/>	South West	<input type="checkbox"/>	West	<input type="checkbox"/>
Correspondence Number	OPW Register No:			<input type="checkbox"/>				
	Consent Issued			<input type="checkbox"/>				

ADDITIONAL INFORMATION

Hydrological Analysis		
Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m ³ /sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	<input type="checkbox"/>	
Gauged Flow	<input type="checkbox"/>	
Unit Hydrograph	<input type="checkbox"/>	
Other (Qmed) HEL	<input checked="" type="checkbox"/>	265cumec
FSU (Qmed)	<input checked="" type="checkbox"/>	245cumec
FSR <input type="checkbox"/>	FSU <input checked="" type="checkbox"/>	Other <input checked="" type="checkbox"/>
<p>The QMed from statistical analysis of 30years of AM data was used to estimate the QMED as it provided the highest flow estimate and more accurate than the FSU method as it uses a revised rating applied to Dangan Gauge for all gates open on the Salmon weir barrage during flood conditions</p>		

Factors Applied	
Type of Factor	Value Used
Climate Change allowance	1.2
Flood Growth Curve	1.89
Factor for Statistical Standard Error for 100year flow from frequency analysis	1.09
Drained Channel (included for in the gauged data)	0
Other	0
Tidal	<input type="checkbox"/>
<p>Comments The statistical error for the QMED was determined from the frequency analysis and represents a factor of 1.09. The flood growth curve used the highest estimate from the FSU, CFRAM and HEL single site analysis giving a factor of 1.89 and as per OPW guidelines on Climate change allowance a factor of 1.2 is used. Qdesign = 624cumec</p>	

Hydraulic/Structure Details	
Description of Structure*3	Full Span Superstructure having a single channel span width of 150m across the River Corrib channel. The support piers are setback 5 and 10m from the channel bank edge on the eastern and western banks respectively. These piers are located just outside the floodplain area and therefore the structure does not encroach the conveyance zone of the river.
Effective Conveyance Area *4	575m²
Upstream bed Level (typical at mid span) 2.98mOD	Downstream Invert Level (mid span) 2.86 mOD
Upstream Soffit Level (mid span) 19.25 mOD	Downstream Soffit Level (midspan) 19.25 mOD
Upstream Design Flood Level (mid span) N6 Galway Transport Project mOD	Downstream Design Flood Level (mid span) 7.526 mOD

NOTES :

- In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
- Flow is the estimated flow from the catchment, without any factors applied.
- The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
- Effective conveyance area is from channel bed level to design flood level.
- All levels must be given to Ordnance Datum, Malin Head.

4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.



OPW

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The Office of Public Works



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Suíomh gréasáin/website: www.opw.ie

Our Ref: 452-2017

Your Ref: 233985

Arup,
Corporate House,
City East Business Park,
Ballybrit,
Galway
H91 KSYD

ARUP		Job No: 233985-00			
Galway	File A	B	C		
Proj. Owner	NH	Init:	Date	11/8	
Date: 11 AUG 2017					
To.	Init.	Date	To.	Init.	Date

Re: N6 Galway City Transport Project

Dear Ms. Ní Mhurchu,

I refer to your recent Section 50 application. The documentation submitted has been examined.

I am to confirm that the consent of the Commissioners of Public Works under Section 50 of the Arterial Drainage Act, 1945 is given as follows and should be noted; not all items on the Section 50 application checklist were provided.

The consultant engineer should be informed that the note on page 16 of the Hydrology report indicating a potential issue at culvert 17 due to an undersized pipe downstream should be brought to the attention of the local authority for their consideration.

Permission was previously granted, after some minor alterations to the design, permission is being sought again for 17 No. Culverts, the crossing of the river Corrib remains unchanged from the original Section 50 application. The following should be noted;

It should be noted that consent is given only for the purpose of Section 50 and does not absolve the recipient of responsibility for any adverse effects caused by this installation to any third party.

The Commissioners of Public Works are not responsible and accept no liability for any loss or damage whatsoever caused as a result of this development.

Yours sincerely

A handwritten signature in black ink that reads "Nora Carey". The signature is written in a cursive style and is positioned above a horizontal line.

Nora Carey
Engineering Services Administration Unit
9th August 2017