KERRY COUNTY COUNCIL
N21 Road Improvement Works – Ratass to Ballycarty
Culvert No. 8

APPLICATION FOR CONSENT UNDER SECTION 50
ARTERIAL DRAINAGE ACT 1945

OPW standards for Section 50 consent have been revised since the submission of this application. This application is for illustrative purposes only. Some amendments and annotations have been made. No drawings have been provided with the examples. Please refer to the current Section 50 brochure for current standards.

1.Introduction:

Proposed realignment of the County Road 303 at Ballyseedy, Tralee as part of the above scheme shall necessitate construction of new Culvert No 8 over the River Lee at the location indicated on enclosed drg. no. 0140-5008.

There is an existing masonry arch bridge located downstream of the proposed Culvert structure, also shown on the enclosed drawings.

A survey of the River Lee channel has been carried out and a longitudinal section and outline cross sections are plotted on the enclosed drg. No's 0140-5009 & 0140-5010 respectively. Outline cross sectional dimensions for the existing arched bridge structure are plotted on drg. no. 0140-5011.

Outline details of proposed Culvert No 8 are shown on drg. no. 0140-5012.

The design flood flow at the location of Culvert No 8 is calculated below at a value of 26.2m^3/sec.

It is also noted that finished road levels on the proposed realignment have been pre-determined by Kerry County Council based on various constraints including land purchase restrictions and tying into existing properties and roadways.

Hydraulic calculations for existing and post work scenarios upstream of the existing arched bridge are outlined below. In these scenarios, hydraulic calculations are based on the depth of design flood flow downstream of the masonry arched bridge.

2. Design Flood Flow (Q_{50}):

Flood flow calculations are based on the catchment characteristics method as outlined in the Design Manual for Roads and Bridges. (issued by the English Dept. of Transport). The calculations are based on Q, the mean annual flood, and the results modified for a return period of 50 years using equ (b) and (c). The six-variable equation (a) was used to calculate Q.

equ. (a) $Q = C1 \times Area^{0.94} \times STMFRQ^{0.27} \times SOIL^{1.23} \times RSMD^{1.03} \times (1 + Lake)^{-0.85} \times S^{0.16}$

Where Q = mean annual flow
C_1 = constant, Ireland ≈ 0.0172
Area = relevant catchment area for River Lee ≈ 27.132 km2.............ref: Catchment Map

STMFRQ = the number of channel junctions on the 1:25000
Map divided by the basin area = 1.106
Soil = Measure of soil types in the catchment with characteristic runoff potential (note 4)
RSMD = residual soil moisture deficit (mm) ....(note 5)
S = stream slope between the 10 and 85 percent locations ≈ 10.00m/km
Lake = the fraction of catchment area occupied by lakes.

The above parameters were evaluated by reference to Volume 4, Section 2, Park 1 HA 71/95 Appendices C & D of the above mentioned Design Manual for Roads and Bridges.(DMRB)

Note 4: The Soil parameter is calculated as follows:

$$Soil = (0.25S_1+0.30S_2+0.40S_3+0.45S_4+0.5S_5)/(S_1+S_2+S_3+S_4+S_5)$$

where S1....S5 denote the proportions of the catchment covered by each of the soil classes 1-5 as shown on figures D5A-p. The soils are classified according to the runoff potential (RP)

From Figure D5m. Soil Classes 1-5, Area 1RP1 (Derived from the Flood Studies Report, Vol. V, Figure 1.4.1.8)

$S_2 \approx 0.40, S_4 \approx 0.60$

⇒ Soil value = (0.3)(0.30) + (0.45)(0.60) = 0.390

Note 5: The residual soil moisture deficit RSMD is taken from Figure D6a-c. A single average value for the catchment area is required to be calculated.

From Figure D6c. RSMD (mm) for Ireland (Derived From Flood And Reservoir Safety: An Engineering Guide, Institution of Civil Engineers, London, 1978)

RSMD ≈ 50mm

Q was calculated to be 10.041m3/sec, this value was then modified for a return period of 50 years using equ's (b) & ©.

equ (b) $Q_t/Q = -3.33 + 4.2e^{-0.05y}$

equ © y = In[-In(1-1/t)] where t = return period i.e. 50 years
⇒ y = -4.6
$\therefore Q_{50}/Q = 1.775$

Q_{50} the flood magnitude with a return period of 50 years was calculated to be 17.820m^3/sec. however this method has a factorial standard error associated with it, therefore the above result was increased by 47% giving Q_{50} = 26.962m^3/sec.

3. Depth of Flow Calculation:

As described above the hydraulic calculations are based on the depth of design flood flow downstream of the existing masonry arch bridge.

In order to estimate the tailwater level downstream of the existing bridge resulting from the design flood flow simple hand calculations were carried out. The method used is known as the 'Typical Section Method' and involves conveyance calculations and the 'divided channel method'. This method involves dividing the river channel and flood plains into segments and solving Manning's equation.

The river channel and flood plains were divided into 3 segments (main channel, left flood plain, right flood plain). Water levels were then calculated by trial and error until the design flow values were obtained.

The conveyance of a river section is defined by the equation:

$$Q = Ks^{1/2}$$

K is determined from the section properties and the channel roughness,

Manning equ. = $(aR.^{2/3}/n)s.^{1/2}$

where n = roughness coefficient
a = cross sectional area
r = hydraulic radius = area / wetted perimeter
s = slope of river bed

$$K = (aR.^{2/3})/n$$

The depth of flow downstream of the existing arched bridge was calculated to be 2.26m.

4. Hydraulic Calculations:

4a. Existing Scenario

Using the depth of flow downstream of the existing bridge calculated above, and 'Culvert Master' the computer software package, the following water levels were calculated.

Tailwater Level = 12.61m OD

Headwater Level = *12.98m OD (from Culvert Master)

**it is noted that existing ground levels upstream of this bridge are in the order of 11.60m OD and that the area is liable to flooding.*

4b. Post Works Scenario

Kerry County Council have indicated that the existing arched bridge must be retained. Based on the depth of flow at the existing bridge and also taking into account backwater lengths and estimated afflux reductions, the water levels in the post works scenario are estimated as follows:

Existing Bridge:

Tailwater Level = 12.61m OD

Headwater Level = 12.98m OD (from Culvert Master)

Culvert 8:

Afflux Reduction + 0.070m

Tailwater Level = 13.18m OD

Headwater Level = 13.30m OD (from Culvert Master)

*5.**Conclusions:***

Based on the above the following is noted;

- Taking into account that the existing bridge must be retained the computed headwater level upstream of the proposed Culvert No.8 is 13.30m OD at Q_{50} which is comfortably below the proposed soffit level of 14.0m OD. However this level significantly exceeds the general ground level in the area and it is therefore evident that the existing scenario with regard to flooding liability shall apply. However, to further ensure that the post works scenario does not cause any risk of an increase in flood levels on the eastern side of the proposed road embankment, it is proposed that large diameter concrete pipes shall be placed in the road embankment in the area liable to flooding.

*6. **Other Relevant Information:***

The land use in this catchment area is predominately agricultural and is likely to remain so for the foreseeable future.

Existing Arch Bridge

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	12.10 m	Headwater Depth/Height	1.18
Computed Headwater Elevation	12.98 m	Discharge	26.1960 m^3/s
Inlet Control HW Elev.	12.61 m	Tailwater Elevation	12.61 m
Outlet Control HW Elev.	12.98 m	Control Type	Outlet Control

Grades			
Upstream Invert	10.38 m	Downstream Invert	10.35 m
Length	7.50 m	Constructed Slope	0.004267 m/m

Hydraulic Profile			
Profile	Pressure Profile	Depth, Downstream	2.26 m
Slope Type	N/A	Normal Depth	1.11 m
Flow Regime	NA	Critical Depth	1.25 m
Velocity Downstream	2.18 m/s	Critical Slope	0.003076 m/m

Section			
Section Shape	Arch	Mannings Coefficient	0.013
Section Material	Concrete	Span	3.50 m
Section Size	3500 x 2200 mm	Rise	2.20 m
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	12.98 m	Upstream Velocity Head	0.24 m
Ke	0.50	Entrance Loss	0.12 m

Inlet Control Properties			
Inlet Control HW Elev.	12.61 m	Flow Control	N/A
Inlet Type	Square edge w/headwall(arch)	Area Full	12.0 m^2
K	0.00980	HDS 5 Chart	0
M	2.00000	HDS 5 Scale	0
C	0.03980	Equation Form	1
Y	0.67000		

Culvert No. 8

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	14.00 m	Headwater Depth/Height	0.79
Computed Headwater Elevation	13.30 m	Discharge	26.1960 m^3/s
Inlet Control HW Elev.	13.18 m	Tailwater Elevation	13.18 m
Outlet Control HW Elev.	13.30 m	Control Type	Outlet Control

Grades			
Upstream Invert	10.70 m	Downstream Invert	10.65 m
Length	12.30 m	Constructed Slope	0.004228 m/m

Hydraulic Profile			
Profile	S1	Depth, Downstream	2.53 m
Slope Type	Steep	Normal Depth	0.80 m
Flow Regime	Subcritical	Critical Depth	0.99 m
Velocity Downstream	1.22 m/s	Critical Slope	0.002199 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	8.50 m
Section Size	(8.5mx3.300)m	Rise	3.30 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	13.30 m	Upstream Velocity Head	0.08 m
Ke	0.50	Entrance Loss	0.04 m

Inlet Control Properties			
Inlet Control HW Elev.	13.18 m	Flow Control	N/A
Inlet Type	90° w 45° bevels	Area Full	28.1 m^2
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

KERRY COUNTY COUNCIL
N21 Road Improvement Works – Ratass to Ballycarty
Culvert No's 9 & 10

APPLICATION FOR CONSENT UNDER SECTION 50
ARTERIAL DRAINAGE ACT 1945

OPW standards for Section 50 consent have been revised since the submission of this application. This application is for illustrative purposes only. Some amendments and annotations have been made. No drawings have been provided with the examples. Please refer to the current Section 50 brochure for current standards.

1. Introduction:

Proposed realignment of the N21 carriageway and of County Road 303 at Ballyseedy, Tralee shall necessitate construction of new Culvert No's 9 & 10 over a tributary of the River Lee at the locations indicated on enclosed drg. no. 0140-5008.

There is an existing box culvert located downstream of the proposed Culvert structures, also shown on the enclosed drawings.

Outline cross sections are plotted on enclosed drg. no. 0140-5010. Outline cross sectional dimensions for the existing box culvert are plotted on drg. no. 0140-5011.

Outline details of the proposed Culvert No's 9 & 10 are shown on drg. no. 0140-5013.

The design flood flow at the location of Culvert No's 9 & 10 is calculated below at a value of $6.46m^3/sec$.

It is also noted that finished road levels on the proposed realignment have been pre-determined by Kerry County Council.

Hydraulic calculations for existing and post work scenarios upstream of the existing box culvert are outlined below and are based on the depth of design flood flow downstream.

2. Design Flood Flow (Q_{50}):

Flood flow calculations are based on the Poots Cochrane method which is suitable for small rural catchments $<20km^2$. The calculations are based on Q, the mean annual flood, and the results modified for a return period of 50 years using equ (b) and (c). The Poots Cochrane equ (a) was used to calculate Q.

equ. (a) $Q = 0.0136 \times Fn \times Area^{0.866} \times SOIL^{1.521} \times RSMD^{1.413}$

Where Q = mean annual flow
Fn = 2.7 for a 95% confidence
Area = $1.594km^2$
Soil = Measure of soil types in the catchment with characteristic runoff potential...(Note 4)
RSMD = residual soil moisture deficit (mm) .... (Note 5)

The above parameters were evaluated by reference to Volume 4, Section 2, Part 1 HA 71/95 Appendices C & D of the above mentioned Design Manual for Roads and Bridges.(DMRB)

Note 4: The parameter Soil is calculated as follows:

$$Soil = (0.15S_1+0.30S_2+0.40S_3+0.45S_4+0.5S_5) / (S_1+S_2+S_3+S_4+S_5)$$

where $S_1....S_5$ denote the proportions of the catchment covered by each of the soil classes 1-5 as shown on figures D5a-p. The soils are classified according to the runoff potential (RP)

From Figure D5m. Soil Classes 1-5, Area 1RP1 (Derived from the Flood Studies Report, Vol. V, Figure 1.4.1.8)

$S_2 \approx 0.40, S_4 \approx 0.60$

$\Rightarrow$ Soil value = (0.3)(0.30) + (0.45)(0.60) = 0.390

Note 5: The residual soil moisture deficit RSMD is read off Figure D6a-c. A single average value for the catchment area is required to be calculated.

From Figure D6c. RSMD (mm) for Ireland (Derived From Flood And Reservoir Safety: An Engineering Guide, Institution of Civil Engineers, London, 1978)

RSMD $\approx$ 50mm

Q was calculated to be 3.303m^3/sec, this value was then modified for a return period of 50 years using equ's (b) & (c).

equ (b) $Q_t/Q = -3.33 + 4.2e^{-0.05y}$

equ (c) $y = In[-In(1-1/t)]$ where t = return period i.e. 50 years
$\Rightarrow y = -4.6$
$\therefore Q_{50}/Q = 1.775$

Q_{50} the flood magnitude with a return period of 50 years was calculated to be 6.461m^3/sec.

***3. Depth of Flow Calculation*:**

As described above the hydraulic calculations are based on the depth of design flood flow downstream of the existing box culvert.

In order to estimate the tailwater level downstream of this culvert resulting from the design flood flow simple hand calculations were carried out. The method used is known as the 'Typical Section Method' and involves conveyance calculations and the 'divided channel method'. This method involves dividing the river channel and flood plains into segments and solving Manning's equation.

The river channel and flood plains were divided into 3 segments (main channel, left flood plain, right flood plain). Water levels were then calculated by trial and error until the design flow values were obtained.

The conveyance of a river section is defined by the equation:

$$Q = Ks^{1/2}$$

K is determined from the section properties and the channel roughness,

Manning equ. = $(aR.^{2/3}/n)s.^{1/2}$

where n = roughness coefficient
a = cross sectional area
r = hydraulic radius = area / wetted perimeter
s = slope of river bed

$K = (aR.^{2/3})/n$

The depth of flow downstream of the existing box culvert was calculated to be 2.26m.

4. Hydraulic Calculations:

4a. Existing Scenario

Using the depth of flow downstream of the existing bridge box culvert calculated above, and 'Culvert Master' software, the water levels at the existing structure were calculated as follows:

Tailwater Level = 11.49m OD

Headwater Level = 11.52m OD (from Culvert Master)

4b. Post Works Scenario

Based on the depth of flow at the existing box culvert and also talking into account backwater lengths and estimated afflux reductions' the water levels in the post works scenario are estimated as follows:

Existing Culvert:

Tailwater Level = 11.49m OD

Headwater Level = 11.52m OD (from Culvert Master)

Culvert 9:

Afflux Reduction = 0.018m

Tailwater Level = 12.172m OD

Headwater Level = 12.25m OD (from Culvert Master)

Culvert 10:

Afflux Reduction = 0.037m

Tailwater Level = 12.613m OD

Headwater Level = 12.97m OD (from Culvert Master)

5. Conclusions:

Based on the above the following is noted;

●Computed headwater levels exceed the general ground level in this area, similar to the scenario described for Culvert No.8 except that computed headwater levels in this case are lower than those computed for the River Lee. Headwater levels are also approximately the same as the porposed soffit levels of Culvert No's 9 & 10. It is proposed that the existing scenario with regard to flood levels shall remain unchanged by the proposed culvert installations.

6. Other Relevant Information:

- Refer to paragraph 6 of the Culvert No. 8 analysis.

Existing Box Culvert

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	11.74 m	Headwater Depth/Height	1.09
Computed Headwater Elevation	11.52 m	Discharge	6.4610 m^3/s
Inlet Control HW Elev.	11.49 m	Tailwater Elevation	11.49 m
Outlet Control HW Elev.	11.52 m	Control Type	Outlet Control

Grades			
Upstream Invert	9.77 m	Downstream Invert	9.69 m
Length	7.94 m	Constructed Slope	0.010585 m/m

Hydraulic Profile			
Profile	Pressure Profile	Depth, Downstream	1.80 m
Slope Type	N/A	Normal Depth	0.29 m
Flow Regime	NA	Critical Depth	0.46 m
Velocity Downstream	0.60 m/s	Critical Slope	0.002553 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	6.70 m
Section Size	N21 (6.7x1.6) m	Rise	1.60 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	11.52 m	Upstream Velocity Head	0.02 m
Ke	0.50	Entrance Loss	0.01 m

Inlet Control Properties			
Inlet Control HW Elev.	11.49 m	Flow Control	N/A
Inlet Type	0° wingwall flares	Area Full	10.7 m^2
K	0.06100	HDS 5 Chart	8
M	0.75000	HDS 5 Scale	3
C	0.04230	Equation Form	1
Y	0.82000		

Culvert No. 9

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	12.20 m	Headwater Depth/Height	1.09
Computed Headwater Elevation	12.25 m	Discharge	6.4610 m^3/s
Inlet Control HW Elev.	12.01 m	Tailwater Elevation	11.88 m
Outlet Control HW Elev.	12.25 m	Control Type	Outlet Control

Grades			
Upstream Invert	10.51 m	Downstream Invert	10.44 m
Length	17.76 m	Constructed Slope	0.003941 m/m

Hydraulic Profile			
Profile	S1	Depth, Downstream	1.44 m
Slope Type	Steep	Normal Depth	0.92 m
Flow Regime	Subcritical	Critical Depth	1.01 m
Velocity Downstream	2.12 m/s	Critical Slope	0.002965 m/m

Section			
Section Shape	Horizontal Ellipse	Mannings Coefficient	0.013
Section Material	Concrete	Span	2.49 m
Section Size	1590 x 2490 mm	Rise	1.59 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	12.25 m	Upstream Velocity Head	0.24 m
Ke	0.50	Entrance Loss	0.12 m

Inlet Control Properties			
Inlet Control HW Elev.	12.01 m	Flow Control	N/A
Inlet Type	Groove end with headwall (horizontal ellipse)	Area Full	3.2 m^2
K	0.00180	HDS 5 Chart	29
M	2.50000	HDS 5 Scale	2
C	0.02920	Equation Form	1
Y	0.74000		

Culvert No. 10

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	12.41 m	Headwater Depth/Height	1.22
Computed Headwater Elevation	12.97 m	Discharge	6.4610 m^3/s
Inlet Control HW Elev.	12.61 m	Tailwater Elevation	12.61 m
Outlet Control HW Elev.	12.97 m	Control Type	Outlet Control

Grades			
Upstream Invert	11.02 m	Downstream Invert	10.91 m
Length	28.00 m	Constructed Slope	0.004000 m/m

Hydraulic Profile			
Profile	Pressure Profile	Depth, Downstream	1.70 m
Slope Type	N/A	Normal Depth	0.91 m
Flow Regime	N/A	Critical Depth	1.01 m
Velocity Downstream	2.01 m/s	Critical Slope	0.002965 m/m

Section			
Section Shape	Horizontal Ellipse	Mannings Coefficient	0.013
Section Material	Concrete	Span	2.49 m
Section Size	1590 x 2490 mm	Rise	1.59 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	12.97 m	Upstream Velocity Head	0.21 m
Ke	0.50	Entrance Loss	0.10 m

Inlet Control Properties			
Inlet Control HW Elev.	12.61 m	Flow Control	N/A
Inlet Type	Groove end with headwall (horizontal ellipse)	Area Full	3.2 m^2
K	0.00180	HDS 5 Chart	29
M	2.50000	HDS 5 Scale	2
C	0.02920	Equation Form	1
Y	0.74000		