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Dumfries and Galloway Council
Planning & Environment Services
Militia House
English Street
DUMFRIES
DG1 2HR

For the attention of Mr Ross Gibson,

31st January 2013

Dear Sir,

GELSTON VILLAGE – FLOOD RISK ASSESSMENT & CULVERT AT ROSE COTTAGE

Following receipt of additional topographic information provided by the Council we are pleased to provide an update on the outline flood risk assessment covering the Gelston Burn at Gelston issued in November 2012. This report includes information from the revised, more detailed, flood model and, as before, addresses the issue of historic and potential flooding in the village where the Gelston Burn crosses the B727. Appropriate mitigation measures are considered as part of the report.

Available Information & Methodology

The following sources were used in compiling this flood risk assessment:

- Site walkover (carried out on 6th November 2012)
- Discussions with Gelston school and village residents affected by recent flooding events;
- SEPA indicative flood map for the 1 in 200 year storm event;
- Detailed topographic cross sections for selected points supplied by the Council;
- LiDAR height data for the Gelston area supplied by the Council;
- Available published geographical information.

A revised 1D hydrological model was constructed for the Gelston Burn which included the principle features affecting localised flooding in the area. This model utilised both the detailed topographic survey data and the available LiDAR information coupled with recorded information from the site walkover.

Setting

The small village of Gelston lies some 2.5km to the south of Castle Douglas. The principal road through Gelston is the B727 which rises from a low in the north east to a high in the south west. Gelston Burn flows through the village from the south west crossing the B727 in a number of places prior to curving to the north just outside the village confines to enter the Carlingwark Loch about 1.8km to the north of the village. Salient hydrological features associated with the site are provided in Figure 2.

To the west, south and east of the village the land generally rises prior to falling down to Palnackie on the Solway coast. To the north of the village the land is lower lying and flat towards the Carlingwark Loch and the larger River Dee river system. The SEPA indicative flood map for the Gelston area indicates that during the design 1 in 200 year storm event the Gelston Burn will back up and much of the village may be at risk of flooding. The local topography suggests however that widespread flooding of the village is unlikely.

The Gelston Burn enters the village from the south west and passes to the north of the school and housing estate prior to passing below the B727 at Gelston Bridge via a rectangular culvert measuring 2.6m wide and 1.2m high. Residents report that drainage is inadequate to the north of Gelston Bridge during peak storm events and the local drainage may be via old drains and soakaways which are performing poorly.

From Gelston Bridge the burn flows to the south of the B727 until 'Rose Cottage' where it passes below the road via a smaller rectangular culvert measuring 1.6m wide and 0.8m high. Local residents report that during peak flow events the area immediately downstream of the Rose Cottage culvert is at risk of inundation. The burn then generally flows to the north of the houses prior to coming alongside the road near the edge of the village at which the burn flows below the access to 'Mill Burn Cottage' via a 1.3m diameter circular culvert. Beyond the village the burn flows close to the B727 before turning to the north close to the junction between the B727 and the B736. This latter junction is low lying and is known to be susceptible to flooding.

The former Gelston Mill lies just downstream of Rose Cottage. It is known that the culvert at Rose Cottage is undersized and susceptible to blockage. It is reported that recent flooding events entail a portion of the Gelston Burn flowing on the southern side of the B727 downstream of Rose Cottage to enter the former mill pond. Water from this mill pond then flows further downstream prior to passing north below the B727 at Mill House via a 600mm diameter pipe and re-entering the old mill lade system. This flow then joins the Gelston Burn. The Mill House culvert is undersized to accommodate the peak flow and an overspill prior to the culvert flows down the field boundary to the south of the B727 to enter the woods further to the south east. It is known that the area of the woods leading to the road at the B727 / B736 junction becoming flooded as the water flows to the north to re-join the Gelston Burn.

It is understood from local residents that the flow from the Mill Cottage culvert has resulted in considerable scouring along the edge of the B727 coupled with deposition of material further downstream. In addition, flow from the Mill House culvert has resulted in the direct risk of flooding to a number of houses in the vicinity.

The B727 / B736 junction is reported to be susceptible to flooding and is at times impassable. Local residents also note an additional recently formed drainage channel to the east which discharges to the road drainage system and results in additional water inundation and the deposition of material on the road.

The Flood Model

The modelling of the watercourse, including the extent and location of the related cross sections, is relative to the key features identified during the site walkover and by the review of the available maps, LiDAR data and survey information.

The model length was established to be long enough to avoid any adverse affects on the water flow from any significant features along the watercourse. Cross sections through the burn were formed using the available topographic data as well as information collated during the site walkover. The number of cross sections utilised in the model is in relation to areas of restriction in flow and to construct a suitably representative analysis.

An important feature for the modelling of all structures with the hydrodynamic software used is that they must impose a constriction to the flow. That is, an inlet and an outlet loss must be present over the structure and the structures' geometry definition (with respect to flow-area) must be smaller than both the up and downstream cross sections for all levels defined in the structure.

A total of three culverts were included in the model together with a further four overtopping features relating to these culverts and overflow mechanisms. Further channels were included in the model to address the issue of overflow from the Gelston Burn.

In order to fully analyse the watercourse, runs were carried out at a variety of Manning numbers and peak flow rates.

The location of the downstream boundary corresponds with the final cross section on the watercourse. In this case the boundary has been placed sufficiently far downstream to be remote from the site buildings and any structures in the vicinity. The Hydrodynamic (HD) Module has been applied to the boundary and is defined by the Time series (TS). The Q-h relationship at the downstream boundary is then computed using the estimated conditions of 0.008m/m slope and a Manning 'n' of 0.04.

The section of the watercourse modelled together with the locations of the model cross sections is shown on Figure 1.

Peak Flow

Rainfall records and catchment descriptors have been obtained from the Flood Estimation Handbook (FEH) with flow rates calculated using the following methodologies.

- FEH (2007) QMED (Index Flood) calculation;
- Improved FEH estimate of QMED (2008);
- IHR 124 runoff methodology; and,
- FEH Rainfall Runoff method.

A summary of the outputs from these methodologies is provided in Table 1. For the Gelston Burn catchment the use of the IHR 124 methodology would generally be preferred in this instance, however, given the known peak flow entering the Carlingwark Loch to the north the more conservative Rainfall Runoff method is preferred in this instance.

The Scottish Executive guidance 'UKCIP02 Update (2003)' suggests that peak river flows may increase by between 15% and 20% in Scotland by the mid 2080's due to global climate change. The recently published UK Climate Projections (UKCP09) support the above percentage increase and therefore is in line with the current SEPA guidelines for the whole of Scotland. As such an additional allowance of 20% has been added to the estimated 0.5% probability flood event. This increases the design flow just downstream of the site to the following

		1 in 200 year flow (m^3/s)	1 in 200 year plus 20% flow (m^3/s)
Estimated Peak Flow	Gelston Burn	14	16.8

Additional peak flow estimates for lesser storm events are provided in Table 1a.

Model Results under Existing Conditions

The chief findings of the model are as follows:

- The Cross Road (Gelston Bridge) culvert has little history of flooding or blockage and is capable of accommodating the 1 in 75 year storm event. Storm events in excess of the 1 in 75 year are likely to result in inundation of the lower lying area to the north of the cross roads prior to flowing to the south and running down the B727.
- The Rose Cottage culvert is undersized and has a history of partial blockage due to leaf and wood litter. The capacity of this culvert is in the order of $3.8m^3/s$ and certainly less than $5m^3/s$ which is less than the 1 in 5 year storm event. This corresponds well with the local understanding of the frequency that the Gelston Burn over tops to the east at this point.
- The impact of the Rose Cottage culvert being undersized is that, during a peak storm event, a portion of the burn continues on the southern side of the B727 to enter the former mill pond and then to either pass below the road at Mill House or to flow down the edge of the field prior to passing over the B727 at the low lying area to the east. The flow below the road at Mill House results in considerable scouring close to the B727, and the risk of inundation to a number of properties further downstream.
- On the Gelston Burn and downstream of the former Mill the access to Mill Burn Cottage forms a 1.3m diameter circular culvert. This culvert is undersized and is capable of accommodating the 1 in 5 year storm event. In the event of this culvert being blocked or during a more severe storm event, portions of the Gelston Burn will pass over the house access and flow down the B727 to re-enter the burn further to the east.

- At the junction of the B727 and the B736 to the east the low lying nature of the land results in it being susceptible to flooding. Such flooding is aggravated by the overflow water passing along the southern side of the B727. The flooding in the area is also aggravated by the proximity of the Gelston burn to the north of the B727 and the limitations of the Mill Burn Cottage access culvert. In addition the risk of flooding in this area is adversely affected by the additional inflow to the road drainage system from the new drainage channel from the east.

Details of the peak water levels under a number of scenarios are provided in Table 2.

Possible Mitigation Measures

Following discussions with the Council the broad aims of any mitigation measures are to reduce the general risk of flooding within the village of Gelston without adversely affecting the risk of flooding elsewhere. In addition any mitigation measures should not adversely affect the village itself and should result in minimum cost to maximum benefit ratio.

The purpose of any mitigation measures is therefore as follows:

- To increase the flow of water down the Gelston Burn at Rose Cottage;
- To stop the flow of water below the B727 at Mill House; and,
- To manage any overflow down the edge of the field to the south of the B727 via appropriate flood routing.

In order to reduce the risk of flooding within the village a number of practical mitigation measures were considered. Modelling of these measures was undertaken with the peak water level results shown in Table 3. As discussed with the Council, for the purposes of modelling the 1 in 100 year storm event was used for design purposes.

The principle changes entailed in the mitigation measures comprise an increasing of the size of the Rose Cottage culvert to mimic the size of the Cross Roads culvert (i.e. 2.6m wide and 1.2m high and capable of coping with the 1 in 75 year storm event). The burn bed on both the up and downstream sides of the Rose Cottage is lowered to accommodate the larger culvert at this location. Coupled with this measure is the removal of the Mill House culvert and the formalisation of the flood routing path along the southern side of the B727.

Under these conditions the overflow along the southern side of the B727 was active throughout and in order to reduce this flow to more extreme events the banks of the Gelston Burn immediately upstream of the Rose Cottage culvert were raised to allow overtopping at 60.4m OD. This feature increases the flow through the Rose Cottage culvert and reduces the flow along the overflow (former Mill Lade) thus reducing the risk of water flowing across the road junction to the east of the village. The proposed mitigation measures are presented in Table 3.

Under such conditions, The former Mill Lade becomes active during the peak part of the 1 in 100 year flood hydrograph so that a peak flow of some 8.9m^3/s passes through the Rose Cottage culvert and 3.2m^3/s flows along the flood route to the south of the B727. Under clear flow conditions the peak water level immediately upstream of the Rose Cottage will be similar to the road level at this point; minor flow across the road is anticipated. Should the Rose Cottage culvert become partially blocked the pathway to the south of the B727 provides an available flood route.

Three adverse impacts of the proposed mitigation measures are, firstly, an increase in peak water level in the Gelston Burn downstream of the Rose Cottage culvert; secondly, a possible increase in erosion in the Gelston Burn downstream of the Rose Cottage culvert and; thirdly, possible overtopping of the burn at the Mill Burn Cottage leading to a flow of water down the B727 to the east.

With respect to the first of these adverse effects the rise in peak water level is generally modest and with minor amendments to the watercourse downstream will not present a risk to the neighbouring properties. In order to address the increased risk of erosion in the Gelston Burn it is recommended that discussions are carried out with the local residents affected in order to consider how the burn can be adapted to accommodate the increased flow.

The overtopping of the burn downstream of the Mill Burn Cottage (due to the access culvert at this location and the shallowness of the burn further downstream) could be partly mitigated by increasing the size of the access culvert; however some increase in inundation of the B727 from the lower Gelston Burn may be anticipated. It is likely however that due to the decrease in flow to the south of the B727 the risk of inundation at the junction to the east of the village will be reduced during the majority of storm events.

Under the 1 in 200 year storm event the peak water levels following the proposed mitigation measures are generally similar to the same event without the mitigation measures. In addition, due to the size of the proposed Rose Cottage culvert consideration may be given to the removal of the existing trash screen in order to reduce the risk of blockage by leaf litter.

<u>*Conclusion*</u>

The proposed measures aim to reduce the risk of flooding in the eastern portion of the village of Gelston. The chief recommendation is to increase the size of the Rose Cottage culvert to 2.6m by 1.2 and to adjust the bed level of the burn accordingly at this point. In addition, it is recommended that the overflow point to the former Mill Lade s set at a level of 60.4m OD.

It is concluded that by increasing the flow below the B727 at Rose Collage and removing the existing culvert at Mill House the flow will be increased along the Gelston Burn.

Flood routing is supplied along the southern side of the B727 during extreme storm events or should the Rose Cottage culvert become blocked. Flow to the flood routing path is controlled by the height of the burn bank immediately upstream of the Rose Cottage culvert.

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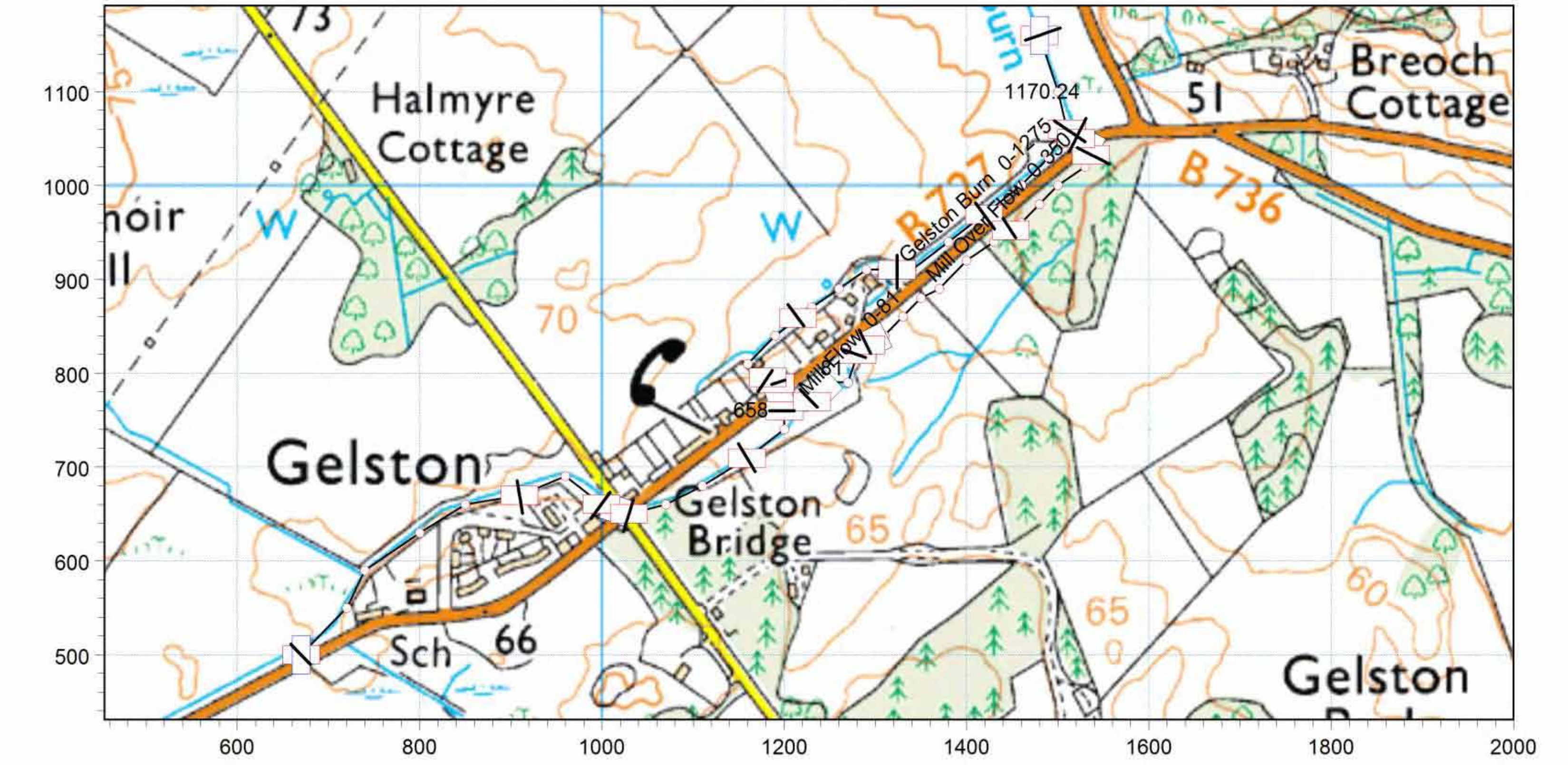
We trust that the above is in order, however, should you have any queries then please do not hesitate to contact the undersigned.

Yours faithfully,

William Hume
Terrenus CDH Ltd

Appendix

Untitled



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Client: Dumfries & Galloway Council

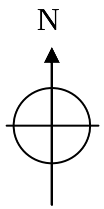
Project: Gelston Flood Risk Assessment

Site Name : Gelston Village

Site Grid Ref : NX 771 587

Figure 1

Not to Scale



Note:

Proposed Mitigation measures include increasing the Rose Cottage culvert to 2.6x1.2m and regulating the flow to the former Mill Lade.

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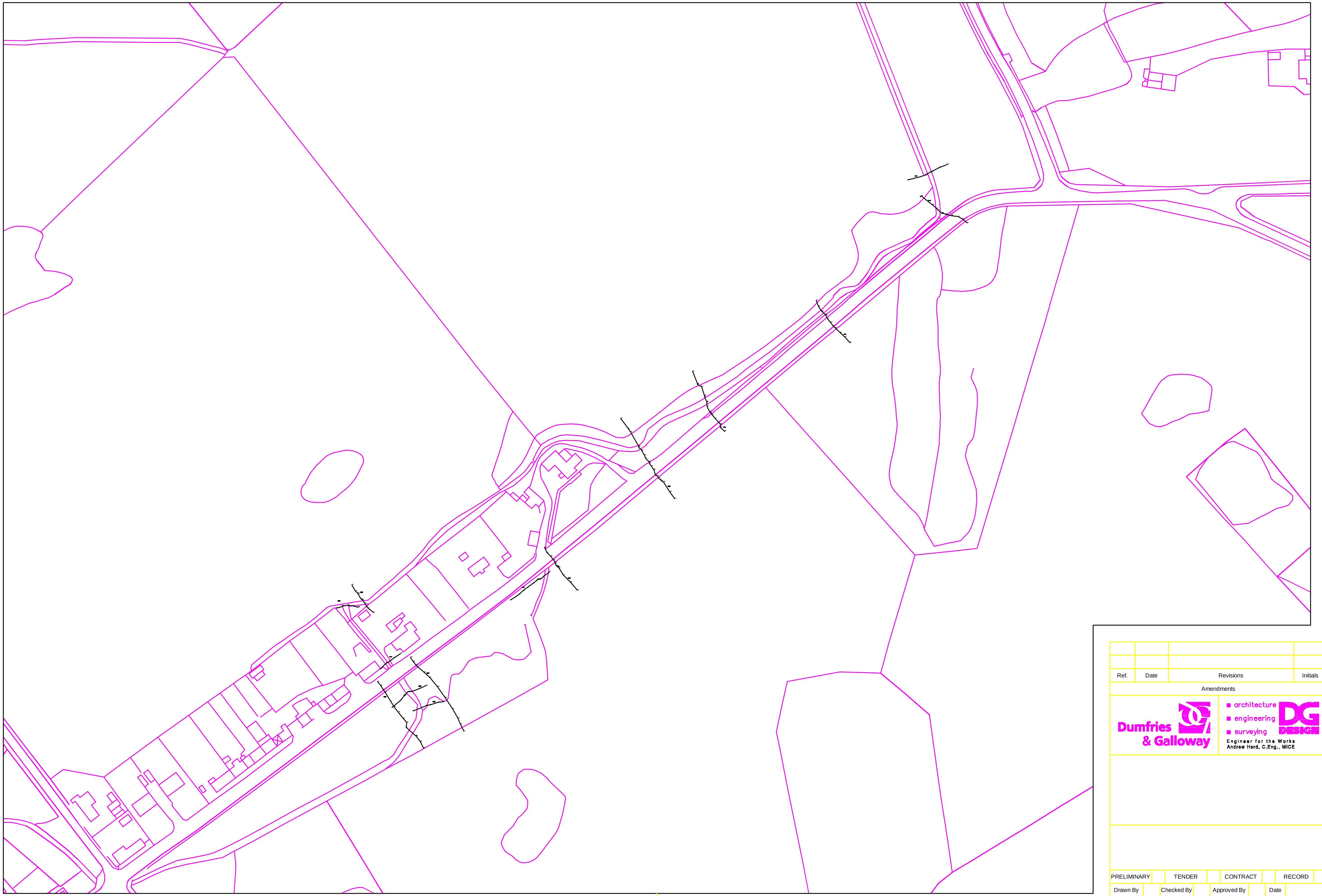
Figure 2 Rev1

Not to Scale



Ref.	Date	Revisions	Initials

Amendments

Dumfries & Galloway

- architecture
- engineering
- surveying

DG DESIGN

Engineer for the Works
Andrew Herd, C.Eng., MICE

PRELIMINARY	TENDER	CONTRACT	RECORD
Drawn By	Checked By	Approved By	Date

SCALE :

DRG. No.

Job No: 1168-203

Table 1 - Summary of Peak Flow Volumes

		All flow volumes are expressed in m3/s					
		FEH QMED (using 2007 methodology)	FEH QMED (using 2008 methodology)	IHR 124 Rural (Catchments <25km2)	IHR 124 Urban (Catchments <25km2)	Rainfall Runoff Methodology (MIKE)	Estimated Peak Flow (using Council estimate)
Gelston Burn	200 year	5.4	12.1	10.8	10.8	14.0	10.80
	200 year plus potential Global Climate Change (GCC) of 20%	6.43	14.56	12.91	13.01	16.80	12.96

Note: FEH CD-ROM 3 Dataset used

Gelston Village
Job No: 1168-203
Table 1a - Summary of Peak Flow Rates for a Variety of Return Periods

	All flow volumes are expressed in m3/s						
	2 year	5 year	10 year	50 year	100 year	200 year	200 year plus potential Global Climate Change (GCC) of 20%
Gelston Burn	4.0	5.8	7.0	10.6	12.2	14.0	16.8

Job No: 1168-203

Table 2 - FRA Model Outputs

	Section number	Cross Section with chainage (m)	Peak Water Level (mOD) for Existing Ground Levels: 1 in 2 yr (4m3/s) at Mannings of 0.040	1 in 5 yr (5.8m3/s) at Mannings of 0.040	1 in 10 yr (7m3/s) at Mannings of 0.040	1 in 50 yr (10.6m3/s) at Mannings of 0.040	1 in 100 yr (12.2/s) at Mannings of 0.040	1 in 200 yr (14m3/s) at Mannings of 0.035	1 in 200 yr (14m3/s) at Mannings of 0.040	1 in 200 yr (14m3/s) at Mannings of 0.045	1 in 200 yr plus 20% GCC (16.8m3/s) at Mannings	Comments
Gelston Burn	1	0	65.6	65.8	65.8	66.2	66.2	66.2	**66.2**	66.3	66.4	
	2	307	64.8	65.0	65.0	65.6	65.7	65.6	**65.7**	65.8	65.9	
	3	411	64.4	64.6	64.6	65.5	65.6	65.6	**65.6**	65.6	65.8	Cross Road Box Culvert with overtop at 65.5m OD
	4	443	63.6	63.8	63.8	64.1	64.2	64.1	**64.2**	64.2	64.4	
	5	600	61.1	61.2	61.2	61.4	61.6	61.6	**61.6**	61.6	62.2	
	6	658	61.1	61.2	61.2	61.4	61.6	61.6	**61.6**	61.6	62.2	Linkage with Mill Lade Flow at 60.4m OD
	7	689	61.0	61.2	61.2	61.4	61.6	61.6	**61.6**	61.6	62.1	Rose Cottage Box Culvert (1.6x0.8m) with overtop accross road at 61.0m OD prior to re-entering the burn
	8	695	61.0	61.2	61.2	61.4	61.6	61.6	**61.6**	61.6	62.1	
	9	710	57.2	57.3	57.3	57.3	57.4	57.4	**57.4**	57.4	57.5	
	10	720	56.9	56.9	56.9	57.0	57.1	57.0	**57.1**	57.1	57.2	
	11	950	51.8	51.9	51.9	52.0	52.0	52.0	**52.0**	52.1	52.2	
	12	1000	51.0	51.0	51.0	51.1	51.2	51.1	**51.2**	51.2	51.3	
	13	1100	49.5	49.5	49.5	49.6	49.7	49.7	**49.7**	49.7	49.8	
	14	1170	48.0	48.1	48.1	48.4	48.5	48.4	**48.5**	48.5	48.6	Water input from Mill Overflow
	15	1275	47.3	47.4	47.4	47.6	47.7	47.7	**47.7**	47.7	47.8	
Mill Lade Flow	a	0	61.1	61.2	61.2	61.4	61.6	61.6	**61.6**	61.6	62.2	Linkage with Gelston Burn at 60.4m OD
	b	81	59.8	60.2	60.2	61.1	61.2	61.2	**61.2**	61.2	61.6	Mill House circular culvert below road. No overtop accross road but linkage to Mill Overflow at 58.7m OD
	c	101	57.2	57.2	57.2	57.3	57.3	57.3	**57.3**	57.3	57.3	
	d	145	51.8	51.9	51.9	52.0	52.0	52.0	**52.0**	52.1	52.2	
Mill Overflow	w	0	59.8	60.2	60.2	61.1	61.2	61.2	**61.2**	61.2	61.6	Overtop to Mill Overflow at 58.7m OD
	x1	100	53.9	54.0	54.0	54.0	54.1	54.0	**54.1**	54.1	54.1	
	x	200	50.8	50.9	50.9	51.0	51.0	51.0	**51.0**	51.0	51.0	
	x2	240	49.1	49.2	49.2	49.3	49.4	49.4	**49.4**	49.4	49.4	
	y	320	48.9	49.0	49.0	49.3	49.3	49.3	**49.3**	49.3	49.4	Overtop at 48.49m OD over B727 to Gelston Burn
	z	350	48.0	48.1	48.1	48.4	48.5	48.4	**48.5**	48.5	48.6	

Job No: 1168-203

Table 3 - FRA Model Mitigation Outputs

Peak Water Level (mOD)

	Section number	Cross Section with chainage (m)	Existing Ground Levels at Mannings of 0.040		Proposed Mitigation Measures at Mannings of 0.040		Comments
			1 in 100 yr (12.2/s)	1 in 200 yr (14m3/s)	1 in 100 yr (12.2m3/s)	1 in 200 yr (14m3/s)	
Gelston Burn	1	0	66.2	**66.2**	66.2	**66.3**	
	2	307	65.7	**65.7**	65.7	**65.8**	
	3	411	65.6	**65.6**	65.6	**65.7**	Cross Road Box Culvert with overtop at 65.5m OD
	4	443	64.2	**64.2**	64.2	**64.2**	
	5	600	61.6	**61.6**	61.2	**61.3**	
	6	658	61.6	**61.6**	61.1	**61.2**	Linkage with Mill Lade Flow at 60.4m OD
	7	689	61.6	**61.6**	60.2	**60.3**	Rose Cottage Box Culvert (2.6x1.2m) with overtop accross road at 61.0m OD prior to re-entering the burn
	8	695	61.6	**61.6**	60.1	**60.2**	
	9	710	57.4	**57.4**	57.6	**57.6**	
	10	720	57.1	**57.1**	57.3	**57.3**	
	11	950	52.0	**52.0**	52.2	**52.3**	
	12	1000	51.2	**51.2**	51.3	**51.4**	
	13	1100	49.7	**49.7**	49.8	**49.8**	
	14	1170	48.5	**48.5**	48.5	**48.5**	Water input from Mill Overflow
	15	1275	47.7	**47.7**	47.7	**47.7**	
Mill Lade Flow	a	0	61.6	**61.6**	61.1	**61.2**	Linkage with Gelston Burn at 60.4m OD
	b	81	61.2	**61.2**	60.2	**60.4**	Mill House circular culvert below road. No overtop accross
Mill Overflow	w	0	61.2	**61.2**	60.2	**60.4**	Overtop to Mill Overflow at 58.7m OD
	x1	100	54.1	**54.1**	54.0	**54.0**	
	x	200	51.0	**51.0**	50.9	**50.9**	
	x2	240	49.4	**49.4**	49.2	**49.2**	
	y	320	49.3	**49.3**	49.0	**49.1**	Overtop at 48.49m OD over B727 to Gelston Burn
	z	350	48.5	**48.5**	48.5	**48.5**	

NOTES

Proposed Mitigation: Rose Cottage culvert increased to same size as Cross Road culvert (2.6m x 1.2m) with deepening of channel immediately downstream of Rose Cottage culvert. Removal of Mill House culvert.