Aberdeen Western Peripheral Route

A9.5 - Water Environment Annexes

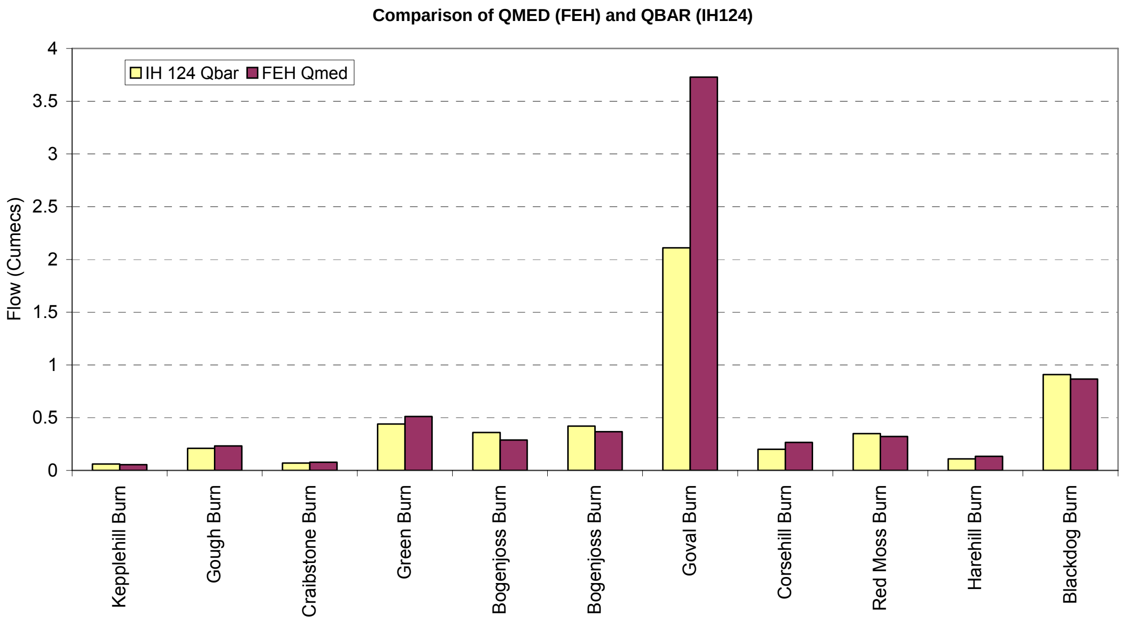
0010332   July 2007

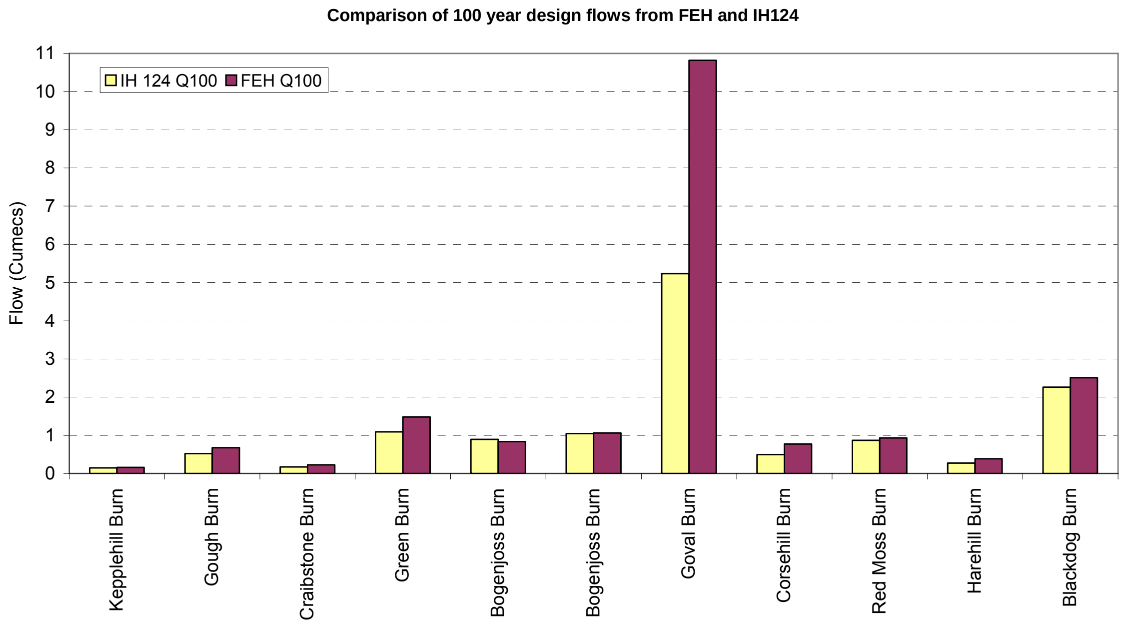
Jacobs UK Ltd. 95 Bothwell Street, Glasgow G2 7HX
Tel 0141 204 2511   Fax 0141 226 3109

Contents

Annex 1 Hydrology - Summary of High Flow Calculations

Since the DMRB Part 1 HA 106/04 advocates the use of the IH 124 method for 'Drainage runoff from natural catchments' and the DMRB Part 4 HA 107/04 advocates the use of the FEH method for the 'Design of outfall and culvert details' both approaches were used. The results are presented here.





The differences between IH124 and FEH are generally relatively small but for the Goval Burn (+107% at Q100yr).

The FEH flows were used in further analysis since the FEH methodology is now largely adopted as the present industry standard and in this case the FEH calculated flow values are more conservative (viz higher) than those calculated using IH 124.

Annex 2 Hydrology Guidance Note

Annexes 3 to 17 contain a summary of the hydrological parameters calculated for each watercourse deemed as being impacted upon by the proposed road scheme.

The following abbreviations/definitions are used within the annexes. For a full explanation of the methodologies adopted, the reader should refer to the specialist report and glossary that accompanies these annexes.

Chainage	Locations crossed by the proposed road can be identified by their Chainage. This is a distance in meters, measured from a specified reference point.
AREA	Catchment Drainage Area (km^2)
SAAR	1961-90 standard-period average annual rainfall (mm)
BFIHOST	Base Flow Index derived using the HOST classification.
SPRHOST	Standard Percentage Runoff (%) derived using HOST classification
FARL	Index of Flood Attenuation due to Reservoirs and Lakes
URBEXT1990	FEH index of fractional urban extent for 1990.
Q_{95}	Flow that is expected to be exceeded 95% of the time (m^3/s)
Qmean	Mean Flow (m^3/s)
Q_{BF}	Bankfull Flow: the bank is defined at the point where vegetation/soil cover obviously changes between water and air
Q_{EBF}	Embankmentfull Flow: the embankment (top of) is defined as the point where water would spill into wider areas (fields/road)
QMED	Median Flood Flow (m^3/s) (flow with a 2-year return period)
QBAR	Mean Annual Flood (m^3/s)
Q-Tyr (eg Q-5yr)	Flood flow associated with a T-year return period (e.g. 5-year flow)
V	Velocity (m/s)

Annex 3 Kepplehill Burn

Location: Proposed culvert and associated realignment.
Chainage: Culvert located at ch315200 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 868 091
Area	km^2	0.25
SAAR	mm	840
BFIHOST	-	0.609
SPRHOST	%	29.2
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.003	Q-5yr	m^3/s	0.08
Q95	m^3/s	0.001	Q-10yr	m^3/s	0.09
QMED	m^3/s	0.06	Q-25yr	m^3/s	0.12
QBAR	m^3/s	0.06	Q-50yr	m^3/s	0.14
QBF	m^3/s	n/a	Q-100yr	m^3/s	0.16
QEBF	m^3/s	5.16	Q-200yr	m^3/s	0.19

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.002	0.003	0.004	0.005
v	m/s	0.321	0.306	0.278	0.254	0.226	0.203	0.176	0.176	0.209	0.250	0.275	0.303

Annex 4 Kepplehill Ditch

Location: Ditch draining into Kepplehill Burn – will be taken into pre-earthworks drainage.
Chainage: ch315200 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 869 093
Area	km^2	0.15
SAAR	mm	840
BFIHOST	-	0.609
SPRHOST	%	29.2
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	Not calculated	Q-5yr	m^3/s	0.04
Q95	m^3/s	Not calculated	Q-10yr	m^3/s	0.05
QMED	m^3/s	0.03	Q-25yr	m^3/s	0.07
QBAR	m^3/s	0.04	Q-50yr	m^3/s	0.08
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	0.09
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	0.11

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Annex 5 Gough Burn

Location: Two proposed culverts and associated realignments.
Chainage: Culvert 1 is located at ch316390 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 870 103
Area	km^2	1.06
SAAR	mm	847
BFIHOST	-	0.615
SPRHOST	%	29
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.014	Q-5yr	m^3/s	0.33
Q95	m^3/s	0.003	Q-10yr	m^3/s	0.40
QMED	m^3/s	0.23	Q-25yr	m^3/s	0.49
QBAR	m^3/s	0.21	Q-50yr	m^3/s	0.58
QBF	m^3/s	0.52	Q-100yr	m^3/s	0.68
QEBF	m^3/s	9.24	Q-200yr	m^3/s	0.79

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.024	0.021	0.017	0.014	0.011	0.008	0.007	0.007	0.008	0.013	0.018	0.022
v	m/s	0.462	0.438	0.403	0.372	0.348	0.298	0.280	0.282	0.297	0.370	0.413	0.450

Gough Burn Continued

Location: Two proposed culverts and associated realignments.
Chainage: Culvert 2 is located at ch316430 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 870 103
Area	km^2	1.06
SAAR	mm	847
BFIHOST	-	0.615
SPRHOST	%	29
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.014	Q-5yr	m^3/s	0.33
Q95	m^3/s	0.003	Q-10yr	m^3/s	0.40
QMED	m^3/s	0.23	Q-25yr	m^3/s	0.49
QBAR	m^3/s	0.21	Q-50yr	m^3/s	0.58
QBF	m^3/s	0.52	Q-100yr	m^3/s	0.68
QEBF	m^3/s	9.24	Q-200yr	m^3/s	0.79

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.024	0.021	0.017	0.014	0.011	0.008	0.007	0.007	0.008	0.013	0.018	0.022
v	m/s	0.462	0.438	0.403	0.372	0.348	0.298	0.280	0.282	0.297	0.370	0.413	0.450

Annex 6 Parkhead Burn

Location: Crossing point on proposed road – will be taken into pre-earthworks drainage
Chainage: ch316700 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 869 105
Area	km^2	0.15
SAAR	mm	826
BFIHOST	-	0.694
SPRHOST	%	24.9
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.002	Q-5yr	m^3/s	0.03
Q95	m^3/s	< 0.001	Q-10yr	m^3/s	0.04
QMED	m^3/s	0.02	Q-25yr	m^3/s	0.05
QBAR	m^3/s	0.03	Q-50yr	m^3/s	0.06
Q_{BF}	m^3/s	0.40	Q-100yr	m^3/s	0.07
Q_{EBF}	m^3/s	0.40	Q-200yr	m^3/s	0.08

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Annex 7 Parkhead Ditch

Location: Crossing point on proposed road – will be taken into pre-earthworks drainage
Chainage: ch316850 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 869 105
Area	km^2	0.15
SAAR	mm	826
BFIHOST	-	0.694
SPRHOST	%	24.9
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	Not calculated	Q-5yr	m^3/s	0.03
Q95	m^3/s	Not calculated	Q-10yr	m^3/s	0.04
QMED	m^3/s	0.02	Q-25yr	m^3/s	0.05
QBAR	m^3/s	0.03	Q-50yr	m^3/s	0.06
Q_{BF}	m^3/s	0.4	Q-100yr	m^3/s	0.07
Q_{EBF}	m^3/s	0.4	Q-200yr	m^3/s	0.08

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Annex 8 Craibstone Burn

Location: Proposed culvert and associated realignment.
Chainage: Culvert located at ch316990 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 868 108
Area	km^2	0.50
SAAR	mm	826
BFIHOST	-	0.694
SPRHOST	%	24.9
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.007	Q-5yr	m^3/s	0.11
Q95	m^3/s	0.001	Q-10yr	m^3/s	0.13
QMED	m^3/s	0.08	Q-25yr	m^3/s	0.16
QBAR	m^3/s	0.07	Q-50yr	m^3/s	0.19
Q_{BF}	m^3/s	0.51	Q-100yr	m^3/s	0.23
Q_{EBF}	m^3/s	0.59	Q-200yr	m^3/s	0.26

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.013	0.011	0.008	0.006	0.006	0.004	0.003	0.003	0.003	0.006	0.008	0.011
v	m/s	0.504	0.473	0.426	0.385	0.368	0.308	0.287	0.298	0.298	0.385	0.429	0.473

Annex 9 Green Burn

Location: Three proposed culverts, associated realignments and outfall location.
Chainage: Culvert 1 is located at ch317330 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 868 112
Area	km^2	2.77
SAAR	mm	826
BFIHOST	-	0.646
SPRHOST	%	27.7
FARL	-	1.000
URBEXT1990	-	0.002

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.037	Q-5yr	m^3/s	0.71
Q95	m^3/s	0.005	Q-10yr	m^3/s	0.87
QMED	m^3/s	0.51	Q-25yr	m^3/s	1.07
QBAR	m^3/s	0.44	Q-50yr	m^3/s	1.28
Q_{BF}	m^3/s	0.86	Q-100yr	m^3/s	1.48
Q_{EBF}	m^3/s	37.73	Q-200yr	m^3/s	1.74

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.067	0.059	0.046	0.037	0.027	0.021	0.014	0.014	0.022	0.035	0.045	0.057
v	m/s	0.573	0.548	0.503	0.464	0.416	0.377	0.329	0.329	0.387	0.456	0.497	0.543

Green Burn Continued

Location: Three proposed culverts, associated realignments and outfall location.
Chainage: Culvert 2 is located under the A96 in close proximity to ch317330.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 868 112
Area	km^2	2.77
SAAR	mm	826
BFIHOST	-	0.646
SPRHOST	%	27.7
FARL	-	1.000
URBEXT1990	-	0.002

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.037	Q-5yr	m^3/s	0.71
Q95	m^3/s	0.005	Q-10yr	m^3/s	0.87
QMED	m^3/s	0.51	Q-25yr	m^3/s	1.07
QBAR	m^3/s	0.44	Q-50yr	m^3/s	1.28
Q_{BF}	m^3/s	0.86	Q-100yr	m^3/s	1.48
Q_{EBF}	m^3/s	37.73	Q-200yr	m^3/s	1.74

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.067	0.059	0.046	0.037	0.027	0.021	0.014	0.014	0.022	0.035	0.045	0.057
v	m/s	0.573	0.548	0.503	0.464	0.416	0.377	0.329	0.329	0.387	0.456	0.497	0.543

Green Burn Continued

Location: Three proposed culverts, associated realignments and outfall location.
Chainage: Culvert 3 is located on a side road in close proximity to ch317330.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 868 112
Area	km^2	2.77
SAAR	mm	826
BFIHOST	-	0.646
SPRHOST	%	27.7
FARL	-	1.000
URBEXT1990	-	0.002

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.037	Q-5yr	m^3/s	0.71
Q95	m^3/s	0.005	Q-10yr	m^3/s	0.87
QMED	m^3/s	0.51	Q-25yr	m^3/s	1.07
QBAR	m^3/s	0.44	Q-50yr	m^3/s	1.28
Q_{BF}	m^3/s	0.86	Q-100yr	m^3/s	1.48
Q_{EBF}	m^3/s	37.73	Q-200yr	m^3/s	1.74

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

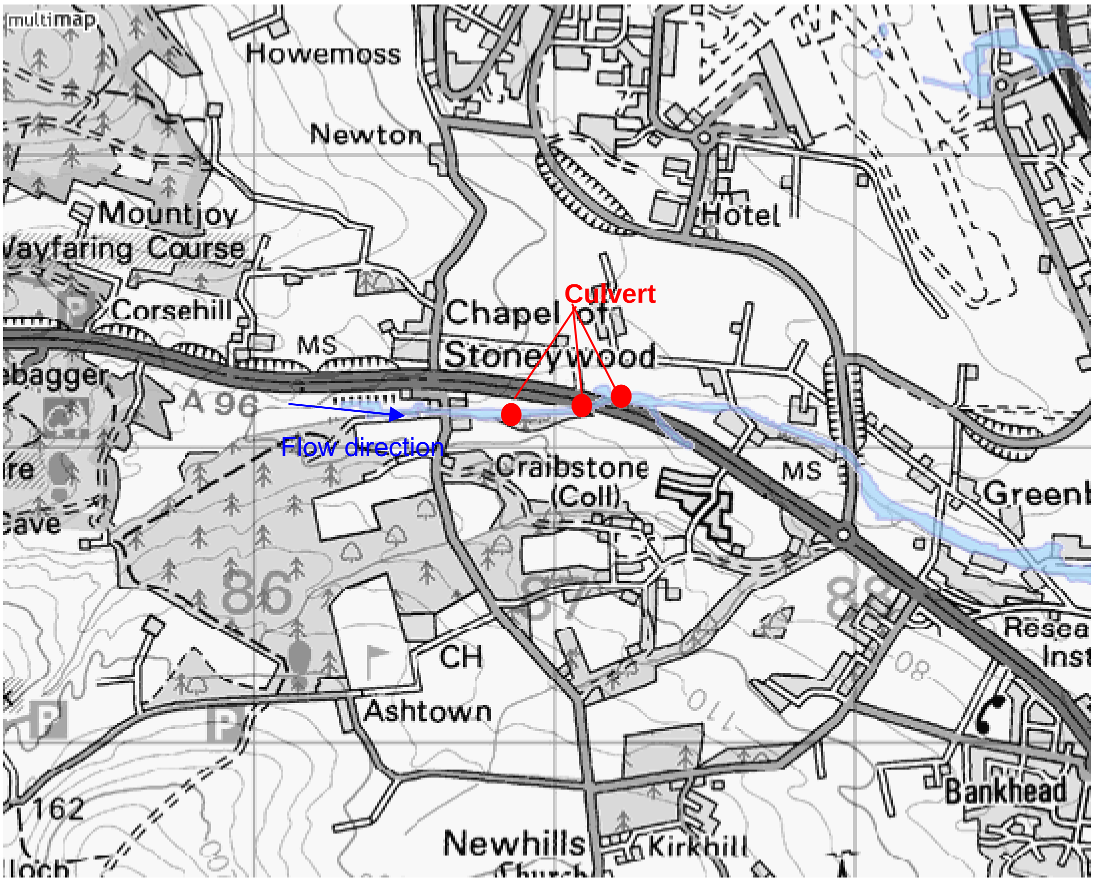
		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.067	0.059	0.046	0.037	0.027	0.021	0.014	0.014	0.022	0.035	0.045	0.057
v	m/s	0.573	0.548	0.503	0.464	0.416	0.377	0.329	0.329	0.387	0.456	0.497	0.543

Green Burn Continued - Indicative River and Coastal Flood Maps (Scotland)

The flood maps have been developed by SEPA using numerical modelling. SEPA Indicative River and Coastal Flood Maps (Scotland) are limited to predicting flood risk in catchments greater than 3km². The model results indicate areas that may be affected by flooding from either rivers or the sea. The scale of a flood can depend on a variety of things including:

- the rate and intensity of rainfall
- catchment conditions such as, topography, vegetation and ground water conditions can affect how much rain soaks into the ground and how much water runs directly into the river
- if there is a particularly high tide
- if there is a tidal surge or waves caused by strong winds and currents

The flood maps show an **estimate** of the areas of Scotland with a 0.5% or greater probability of being flooded in any given year, or put another way the areas that are estimated to have a 1 in 200 or greater chance of being flooded in any given year. For more information regarding the SEPA Indicative River and Coastal Flood Maps (Scotland) please see:
www.sepa.org.uk/flooding/mapping/how_to_use.htm
http://www.sepa.org.uk/flooding/mapping/about.htm#what



At the proposed crossing point of the AWPR the SEPA 'Indicative River and Coastal Flood Map (Scotland)' predicts a risk of flooding at the 0.5% AEP (200-year return period event). At the upstream crossing point of the road the flood maps predict that Green Burn will not encroach the floodplain in the location of the proposed road crossing points by more than approximately 25 meters. There are no properties predicted to be at risk of flooding within 150m of the proposed culvert location but an area of the A96 along with arable and pasture farm land are likely to flood.

Annex 10 Walton Field Ditch

Location: Walton Field Ditch on main carriageway – will be taken into pre-earthworks drainage.
Chainage: ch317800 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 866 115
Area	km^2	0.10
SAAR	mm	842
BFIHOST	-	0.646
SPRHOST	%	27.7
FARL	-	1.000
URBEXT1990	-	0.003

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.001	Q-5yr	m^3/s	0.026
Q95	m^3/s	< 0.001	Q-10yr	m^3/s	0.031
QMED	m^3/s	0.018	Q-25yr	m^3/s	0.039
QBAR	m^3/s	0.023	Q-50yr	m^3/s	0.046
Q_{BF}	m^3/s	0.23	Q-100yr	m^3/s	0.053
Q_{EBF}*	m^3/s	1.95	Q-200yr	m^3/s	0.062

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Walton Field Ditch - Continued

Location: Walton Field Ditch on Kirkhill Industrial Estate Link Road (by others).
Chainage: n/a – not on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 874 115
Area	km^2	0.30
SAAR	mm	842
BFIHOST	-	0.646
SPRHOST	%	27.7
FARL	-	1.000
URBEXT1990	-	0.003

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.004	Q-5yr	m^3/s	0.08
Q95	m^3/s	0.001	Q-10yr	m^3/s	0.10
QMED	m^3/s	0.058	Q-25yr	m^3/s	0.12
QBAR	m^3/s	0.061	Q-50yr	m^3/s	0.14
Q_{BF}	m^3/s	0.16	Q-100yr	m^3/s	0.17
Q_{EBF}	m^3/s	4.71	Q-200yr	m^3/s	0.20

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Annex 11 Howemoss Burn

Location: Proposed catchment severance and catchment taken into pre-earthworks.
Chainage: n/a – not on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 865 124
Area	km^2	0.36
SAAR	mm	820
BFIHOST	-	0.527
SPRHOST	%	36.1
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.004	Q-5yr	m^3/s	0.13
Q95	m^3/s	0.001	Q-10yr	m^3/s	0.16
QMED	m^3/s	0.10	Q-25yr	m^3/s	0.20
QBAR	m^3/s	0.12	Q-50yr	m^3/s	0.24
Q_{BF}	m^3/s	Not calculated.	Q-100yr	m^3/s	0.28
Q_{EBF}	m^3/s	Not calculated.	Q-200yr	m^3/s	0.32

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Annex 12 Bogenjoss Burn

Location: Six proposed culverts (2 on main carriageway and 4 on side roads), associated realignments and outfall location

Chainage: Culvert 1 is located at ch320100.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 858 139
Area	km^2	1.18
SAAR	mm	830
BFIHOST	-	0.488
SPRHOST	%	39.0
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.016	Q-5yr	m^3/s	0.49
Q95	m^3/s	0.004	Q-10yr	m^3/s	0.59
QMED	m^3/s	0.35	Q-25yr	m^3/s	0.73
QBAR	m^3/s	Not calculated	Q-50yr	m^3/s	0.87
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	1.01
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	1.18

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Bogenjoss Burn Continued

Location: Six proposed culverts (2 on main carriageway and 4 on side roads), associated realignments and outfall location

Chainage: Culvert 2 is located at ch320215.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 858 139
Area	km^2	1.18
SAAR	mm	830
BFIHOST	-	0.488
SPRHOST	%	39.0
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.016	Q-5yr	m^3/s	0.49
Q95	m^3/s	0.004	Q-10yr	m^3/s	0.59
QMED	m^3/s	0.35	Q-25yr	m^3/s	0.73
QBAR	m^3/s	Not calculated	Q-50yr	m^3/s	0.87
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	1.01
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	1.18

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Bogenjoss Burn Continued

Location: Six proposed culverts (2 on main carriageway and 4 on side roads), associated realignments and outfall location

Chainage: Culvert 3 is located at ch320260.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 858 139
Area	km^2	1.18
SAAR	mm	830
BFIHOST	-	0.488
SPRHOST	%	39.0
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.016	Q-5yr	m^3/s	0.49
Q95	m^3/s	0.004	Q-10yr	m^3/s	0.59
QMED	m^3/s	0.35	Q-25yr	m^3/s	0.73
QBAR	m^3/s	Not calculated	Q-50yr	m^3/s	0.87
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	1.01
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	1.18

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Bogenjoss Burn Continued

Location: Six proposed culverts (2 on main carriageway and 4 on side roads), associated realignments and outfall location

Chainage: Culvert 4 is located at ch320475.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 858 139
Area	km^2	1.18
SAAR	mm	830
BFIHOST	-	0.488
SPRHOST	%	39.0
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.016	Q-5yr	m^3/s	0.49
Q95	m^3/s	0.004	Q-10yr	m^3/s	0.59
QMED	m^3/s	0.35	Q-25yr	m^3/s	0.73
QBAR	m^3/s	Not calculated	Q-50yr	m^3/s	0.87
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	1.01
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	1.18

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Bogenjoss Burn Continued

Location: Six proposed culverts (2 on main carriageway and 4 on side roads), associated realignments and outfall location

Chainage: Culvert 5 is located at ch320500 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 858 139
Area	km^2	1.18
SAAR	mm	830
BFIHOST	-	0.488
SPRHOST	%	39.0
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.016	Q-5yr	m^3/s	0.49
Q95	m^3/s	0.004	Q-10yr	m^3/s	0.59
QMED	m^3/s	0.35	Q-25yr	m^3/s	0.73
QBAR	m^3/s	Not calculated	Q-50yr	m^3/s	0.87
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	1.01
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	1.18

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Bogenjoss Burn - Continued

Location: Six proposed culverts (2 on main carriageway and 4 on side roads), associated realignments and outfall location

Chainage: Culvert 6 is located at ch320870 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 859 143
Area	km^2	1.59
SAAR	mm	821
BFIHOST	-	0.518
SPRHOST	%	37.0
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.021	Q-5yr	m^3/s	0.60
Q95	m^3/s	0.005	Q-10yr	m^3/s	0.73
QMED	m^3/s	0.43	Q-25yr	m^3/s	0.90
QBAR	m^3/s	0.49	Q-50yr	m^3/s	1.07
Q_{BF}	m^3/s	0.9	Q-100yr	m^3/s	1.24
Q_{EBF}	m^3/s	11.3	Q-200yr	m^3/s	1.45

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.031	0.027	0.027	0.024	0.017	0.012	0.010	0.013	0.016	0.024	0.028	0.029
v	m/s	0.627	0.590	0.597	0.564	0.495	0.429	0.407	0.440	0.487	0.564	0.603	0.615

Annex 13 River Don

Location: Proposed Bridge and outfall location.
Chainage: Bridge located at ch323150 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 882 145
Area	km^2	1228.1
SAAR	mm	887
BFIHOST	-	0.579
SPRHOST	%	31.6
FARL	-	0.998
URBEXT1990	-	0.003

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	19.536	Q-5yr	m^3/s	201
Q95	m^3/s	5.200	Q-10yr	m^3/s	255
QMED	m^3/s	137.41	Q-25yr	m^3/s	322
QBAR	m^3/s	Not calculated	Q-50yr	m^3/s	371
Q_{BF}	m^3/s	n/a	Q-100yr	m^3/s	424
Q_{EBF}	m^3/s	200	Q-200yr	m^3/s	482

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	28.3	26.3	26.1	24.2	15.7	11.7	10.7	10.8	12.5	21.1	26.1	27.3
v	m/s	1.05	1.02	1.01	0.98	0.80	0.69	0.66	0.67	0.72	0.92	1.01	1.03

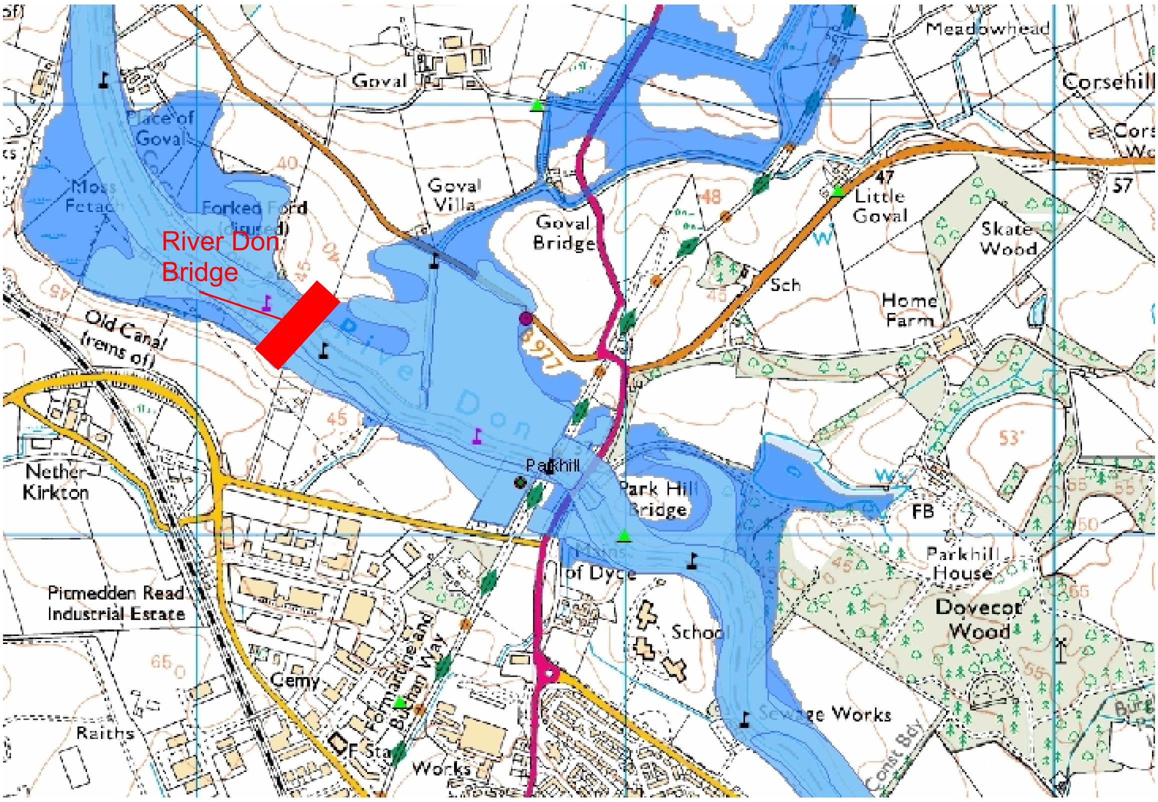
N.B. These values differ slightly from those used in the modelling exercises since those quated in Annex19 and appendix A9.2 are for the Parkhill Gauging station which is located downstream of the proposed bridge.

River Don Continued - Indicative River and Coastal Flood Maps (Scotland)

The flood maps have been developed by SEPA using numerical modelling. SEPA Indicative River and Coastal Flood Maps (Scotland) are limited to predicting flood risk in catchments greater than 3km². The model results indicate areas that may be affected by flooding from either rivers or the sea. The scale of a flood can depend on a variety of things including:

- the rate and intensity of rainfall
- catchment conditions such as, topography, vegetation and ground water conditions can affect how much rain soaks into the ground and how much water runs directly into the river
- if there is a particularly high tide
- if there is a tidal surge or waves caused by strong winds and currents

The flood maps show an **estimate** of the areas of Scotland with a 0.5% or greater probability of being flooded in any given year, or put another way the areas that are estimated to have a 1 in 200 or greater chance of being flooded in any given year. For more information regarding the SEPA Indicative River and Coastal Flood Maps (Scotland) please see:
www.sepa.org.uk/flooding/mapping/how_to_use.htm
http://www.sepa.org.uk/flooding/mapping/about.htm#what



At the proposed crossing point of the AWPR the SEPA 'Indicative River and Coastal Flood Map (Scotland)' predicts a risk of flooding at the 0.5% AEP (200-year return period event). The Indicative SEPA Flood Risk Maps show that flooding may occur within 150 of each bank if an event of a 0.5% AEP occurs.

Annex 14 Goval Burn

Location: Three proposed bridges and outfall location.
Chainage: Bridge 1 is located at ch323700.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 886 147
Area	km^2	39.77
SAAR	mm	812
BFIHOST	-	0.738
SPRHOST	%	20.1
FARL	-	0.998
URBEXT1990	-	0.005

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.579	Q-5yr	m^3/s	5.6
Q95	m^3/s	0.079	Q-10yr	m^3/s	6.8
QMED	m^3/s	4.00	Q-25yr	m^3/s	8.4
QBAR	m^3/s	2.29	Q-50yr	m^3/s	10.0
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	11.6
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	13.6

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.71	0.76	0.58	0.37	0.32	0.24	0.16	0.18	0.87	0.97	0.87	0.84
v	m/s	0.79	0.81	0.73	0.62	0.58	0.52	0.45	0.47	0.85	0.89	0.85	0.84

Goval Burn - Continued

Location: Three proposed bridges and outfall location.
Chainage: Bridge 2 is located at ch324400.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 895 150
Area	km^2	36.64
SAAR	mm	814
BFIHOST	-	0.74
SPRHOST	%	19.9
FARL	-	0.998
URBEXT1990	-	0.005

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.534	Q-5yr	m^3/s	5.2
Q95	m^3/s	0.073	Q-10yr	m^3/s	6.3
QMED	m^3/s	3.73	Q-25yr	m^3/s	7.8
QBAR	m^3/s	2.11	Q-50yr	m^3/s	9.8
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	10.8
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	12.7

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Goval Burn - Continued

Location: Three proposed bridges and outfall location.
Chainage: Bridge 3 is located at ch324600 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 895 150
Area	km^2	36.64
SAAR	mm	814
BFIHOST	-	0.74
SPRHOST	%	19.9
FARL	-	0.998
URBEXT1990	-	0.005

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.534	Q-5yr	m^3/s	5.2
Q95	m^3/s	0.073	Q-10yr	m^3/s	6.3
QMED	m^3/s	3.73	Q-25yr	m^3/s	7.8
QBAR	m^3/s	2.11	Q-50yr	m^3/s	9.8
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	10.8
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	12.7

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

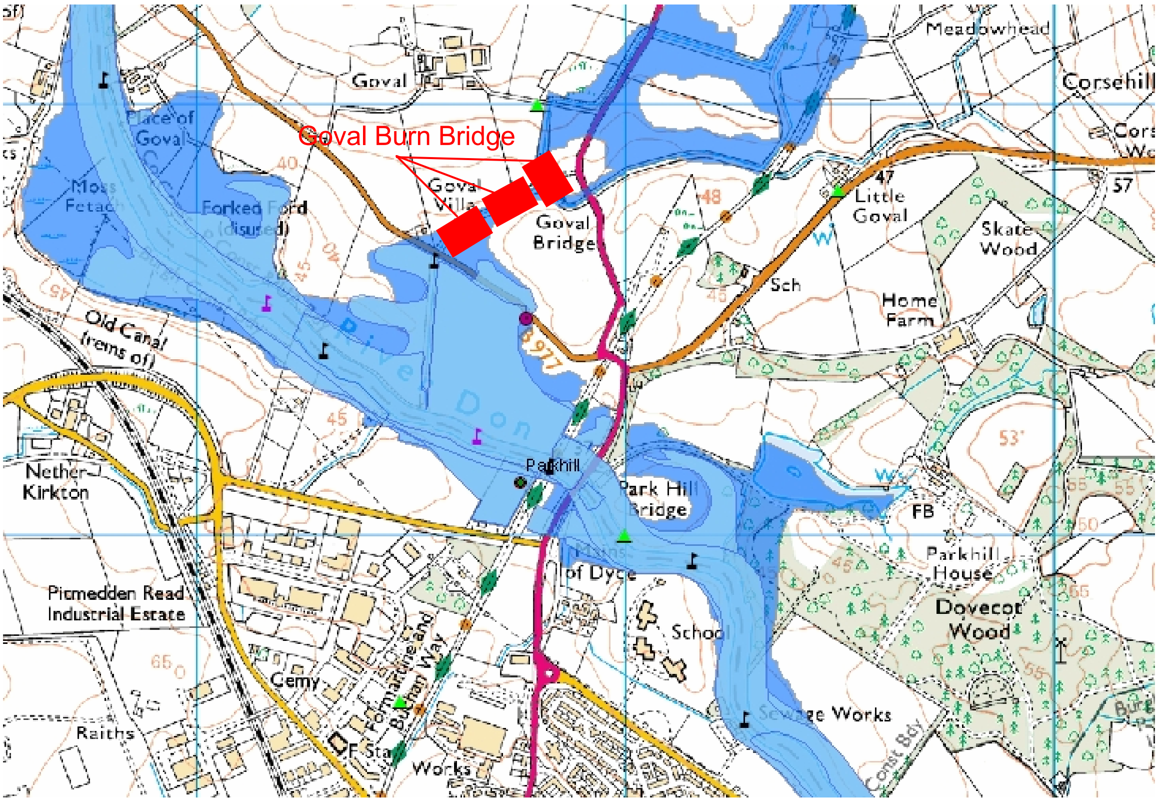
Not calculated for this site.

Goval Burn Continued - Indicative River and Coastal Flood Maps (Scotland)

The flood maps have been developed by SEPA using numerical modelling. SEPA Indicative River and Coastal Flood Maps (Scotland) are limited to predicting flood risk in catchments greater than 3km². The model results indicate areas that may be affected by flooding from either rivers or the sea. The scale of a flood can depend on a variety of things including:

- the rate and intensity of rainfall
- catchment conditions such as, topography, vegetation and ground water conditions can affect how much rain soaks into the ground and how much water runs directly into the river
- if there is a particularly high tide
- if there is a tidal surge or waves caused by strong winds and currents

The flood maps show an **estimate** of the areas of Scotland with a 0.5% or greater probability of being flooded in any given year, or put another way the areas that are estimated to have a 1 in 200 or greater chance of being flooded in any given year. For more information regarding the SEPA Indicative River and Coastal Flood Maps (Scotland) please see:
www.sepa.org.uk/flooding/mapping/how_to_use.htm
http://www.sepa.org.uk/flooding/mapping/about.htm#what



At the proposed crossing point of the AWPR the SEPA 'Indicative River and Coastal Flood Map (Scotland)' predicts a risk of flooding at the 0.5% AEP (200-year return period event). Three bridged crossing points have been proposed for the Goval Burn. Flood inundation varies between the proposed bridge locations between approximately 50–400m from the channel.

Within this region there is one property at risk of flooding at Goval Villa and two roads the B977 and the A947.

Annex 15 Corsehill Burn

Location: Three proposed culverts (one culvert is located on the main carriageway and two culverts are located on side roads), associated realignments and outfall location.

Chainage: Culvert 1 is located at ch325085.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 897 149
Area	km^2	1.79
SAAR	mm	794
BFIHOST	-	0.689
SPRHOST	%	24.0
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.026	Q-5yr	m^3/s	0.37
Q95	m^3/s	0.004	Q-10yr	m^3/s	0.45
QMED	m^3/s	0.27	Q-25yr	m^3/s	0.56
QBAR	m^3/s	0.20	Q-50yr	m^3/s	0.67
Q_{BF}	m^3/s	0.63	Q-100yr	m^3/s	0.77
Q_{EBF}	m^3/s	5.07	Q-200yr	m^3/s	0.91

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.032	0.034	0.026	0.017	0.014	0.011	0.007	0.008	0.039	0.044	0.039	0.038
v	m/s	0.670	0.688	0.622	0.526	0.496	0.445	0.381	0.404	0.720	0.751	0.720	0.713

Corsehill Burn Continued

Location: Three culverts proposed (one culvert is located on the main carriageway and two culverts are located on side roads), associated realignments and outfall location.

Chainage: Culvert 2 is located at Goval Junction.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 897 149
Area	km^2	1.79
SAAR	mm	794
BFIHOST	-	0.689
SPRHOST	%	24.0
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.026	Q-5yr	m^3/s	0.37
Q95	m^3/s	0.004	Q-10yr	m^3/s	0.45
QMED	m^3/s	0.27	Q-25yr	m^3/s	0.56
QBAR	m^3/s	0.20	Q-50yr	m^3/s	0.67
Q_{BF}	m^3/s	0.63	Q-100yr	m^3/s	0.77
Q_{EBF}	m^3/s	5.07	Q-200yr	m^3/s	0.91

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.032	0.034	0.026	0.017	0.014	0.011	0.007	0.008	0.039	0.044	0.039	0.038
v	m/s	0.670	0.688	0.622	0.526	0.496	0.445	0.381	0.404	0.720	0.751	0.720	0.713

Corsehill Burn Continued

Location: Three culverts proposed (one culvert is located on the main carriageway and two culverts are located on side roads), associated realignments and outfall location.

Chainage: Culvert 3 is located at Goval Junction.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 897 149
Area	km^2	1.79
SAAR	mm	794
BFIHOST	-	0.689
SPRHOST	%	24.0
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.026	Q-5yr	m^3/s	0.37
Q95	m^3/s	0.004	Q-10yr	m^3/s	0.45
QMED	m^3/s	0.27	Q-25yr	m^3/s	0.56
QBAR	m^3/s	0.20	Q-50yr	m^3/s	0.67
Q_{BF}	m^3/s	0.63	Q-100yr	m^3/s	0.77
Q_{EBF}	m^3/s	5.07	Q-200yr	m^3/s	0.91

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

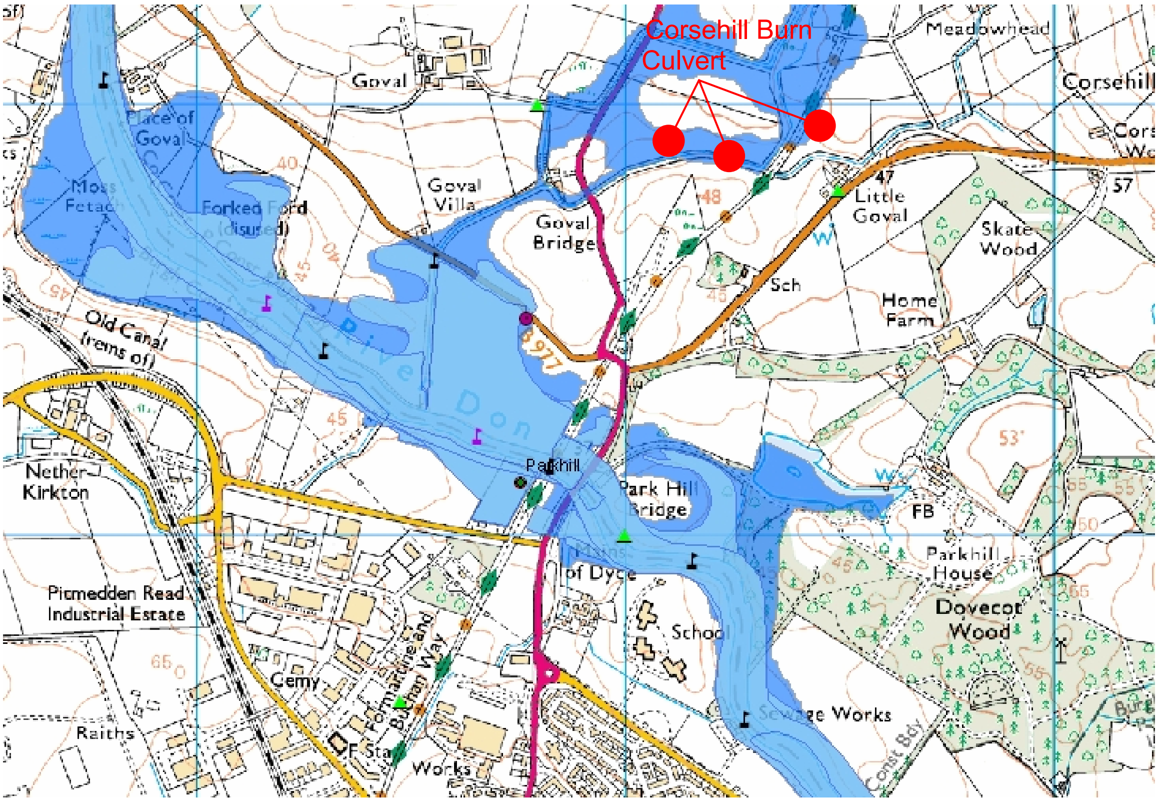
		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.032	0.034	0.026	0.017	0.014	0.011	0.007	0.008	0.039	0.044	0.039	0.038
v	m/s	0.670	0.688	0.622	0.526	0.496	0.445	0.381	0.404	0.720	0.751	0.720	0.713

Corsehill Burn Continued - Indicative River and Coastal Flood Maps (Scotland)

The flood maps have been developed by SEPA using numerical modelling. SEPA Indicative River and Coastal Flood Maps (Scotland) are limited to predicting flood risk in catchments greater than 3km². The model results indicate areas that may be affected by flooding from either rivers or the sea. The scale of a flood can depend on a variety of things including:

- the rate and intensity of rainfall
- catchment conditions such as, topography, vegetation and ground water conditions can affect how much rain soaks into the ground and how much water runs directly into the river
- if there is a particularly high tide
- if there is a tidal surge or waves caused by strong winds and currents

The flood maps show an **estimate** of the areas of Scotland with a 0.5% or greater probability of being flooded in any given year, or put another way the areas that are estimated to have a 1 in 200 or greater chance of being flooded in any given year. For more information regarding the SEPA Indicative River and Coastal Flood Maps (Scotland) please see:
www.sepa.org.uk/flooding/mapping/how_to_use.htm
http://www.sepa.org.uk/flooding/mapping/about.htm#what



At the proposed crossing point of the AWPR the SEPA 'Indicative River and Coastal Flood Map (Scotland)' predicts a risk of flooding at the 0.5% AEP (200-year return period event). Three culvert have been proposed for the Corsehill Burn at the proposed road crossing point. All three culvert also appear to be in flood risk locations. Flood inundation in the vicinity of the Corsehill culverts appears to vary between approximately 100-400m from the channel.

Within this region there is one property at risk of flooding at Goval Villa and two roads the B977 and the A947.

Annex 16 Red Moss Burn

Location: Proposed culvert, associated realignment and outfall location.
Chainage: The culvert is located at ch327500 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 924 149
Area	km^2	1.30
SAAR	mm	800
BFIHOST	-	0.548
SPRHOST	%	33.6
FARL	-	1.000
URBEXT1990	-	0.000

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.017	Q-5yr	m^3/s	0.45
Q95	m^3/s	0.004	Q-10yr	m^3/s	0.55
QMED	m^3/s	0.32	Q-25yr	m^3/s	0.68
QBAR	m^3/s	0.35	Q-50yr	m^3/s	0.80
Q_{BF}	m^3/s	n/a	Q-100yr	m^3/s	0.93
Q_{EBF}	m^3/s	3.08	Q-200yr	m^3/s	1.09

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.025	0.022	0.022	0.019	0.014	0.010	0.008	0.010	0.013	0.019	0.023	0.024
v	m/s	0.428	0.326	0.286	0.243	0.196	0.159	0.142	0.146	0.154	0.172	0.178	0.175

Annex 17 Blackdog Burn

Location: Two proposed culverts, associated realignments and outfall location.
Chainage: Culvert 1 is located at ch329950 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 946 144
Area	km^2	5.44
SAAR	mm	789
BFIHOST	-	0.724
SPRHOST	%	23.2
FARL	-	1.000
URBEXT1990	-	0.011

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.079	Q-5yr	m^3/s	0.96
Q95	m^3/s	0.011	Q-10yr	m^3/s	1.16
QMED	m^3/s	0.68	Q-25yr	m^3/s	1.44
QBAR	m^3/s	0.53	Q-50yr	m^3/s	1.71
Q_{BF}	m^3/s	n/a	Q-100yr	m^3/s	1.98
Q_{EBF}	m^3/s	9.15	Q-200yr	m^3/s	2.32

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Blackdog Burn - Continued

Location: Two proposed culverts, associated realignments and outfall location.
Chainage: Culvert 2 is located on a side road (A90 North).

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 956 141
Area	km^2	7.66
SAAR	mm	782
BFIHOST	-	0.724
SPRHOST	%	23.2
FARL	-	1.000
URBEXT1990	-	0.009

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.112	Q-5yr	m^3/s	1.29
Q95	m^3/s	0.015	Q-10yr	m^3/s	1.57
QMED	m^3/s	0.87	Q-25yr	m^3/s	1.82
QBAR	m^3/s	0.91	Q-50yr	m^3/s	2.31
Q_{BF}	m^3/s	n/a	Q-100yr	m^3/s	2.51
Q_{EBF}	m^3/s	9.15	Q-200yr	m^3/s	3.94

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

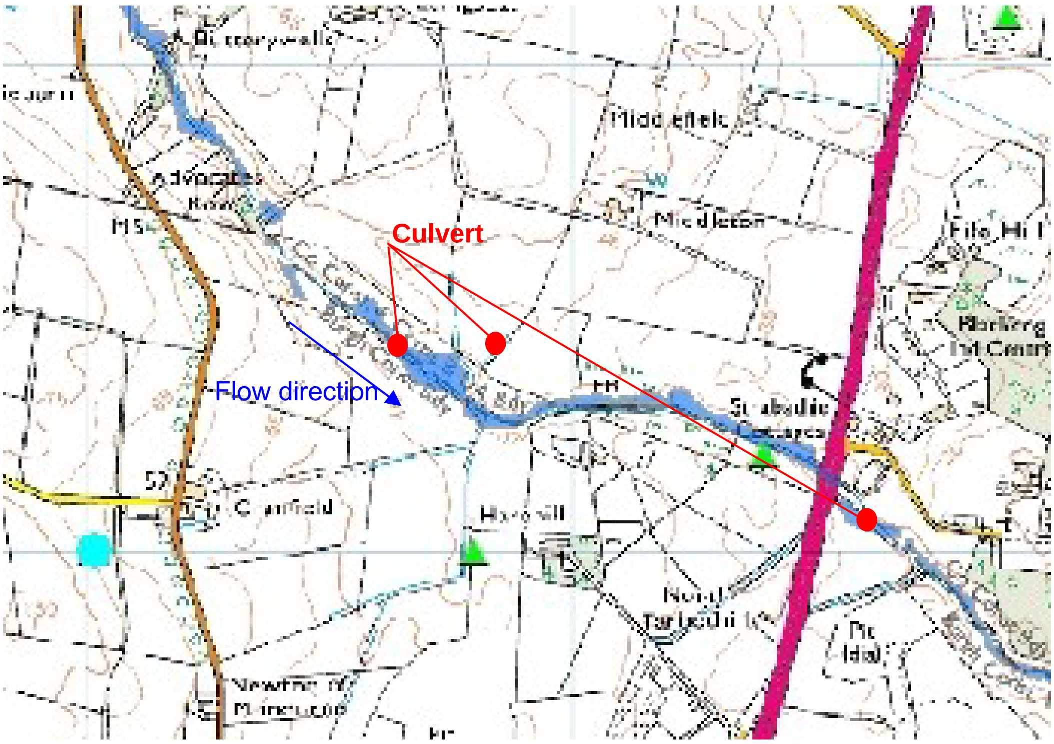
		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.137	0.147	0.112	0.071	0.061	0.046	0.030	0.036	0.167	0.188	0.167	0.162
v	m/s	0.811	0.833	0.750	0.631	0.594	0.532	0.454	0.482	0.875	0.914	0.875	0.865

Blackdog Burn - Indicative River and Coastal Flood Maps (Scotland)

The flood maps have been developed by SEPA using numerical modelling. SEPA Indicative River and Coastal Flood Maps (Scotland) are limited to predicting flood risk in catchments greater than 3km². The model results indicate areas that may be affected by flooding from either rivers or the sea. The scale of a flood can depend on a variety of things including:

- the rate and intensity of rainfall
- catchment conditions such as, topography, vegetation and ground water conditions can affect how much rain soaks into the ground and how much water runs directly into the river
- if there is a particularly high tide
- if there is a tidal surge or waves caused by strong winds and currents

The flood maps show an **estimate** of the areas of Scotland with a 0.5% or greater probability of being flooded in any given year, or put another way the areas that are estimated to have a 1 in 200 or greater chance of being flooded in any given year. For more information regarding the SEPA Indicative River and Coastal Flood Maps (Scotland) please see:
www.sepa.org.uk/flooding/mapping/how_to_use.htm
http://www.sepa.org.uk/flooding/mapping/about.htm#what



At the proposed crossing point of the AWPR the Indicative SEPA Flood Maps (Scotland) predict that Blackdog Burn will flood at the 0.5% AEP (200-year return period event). For approximately 100m upstream of the first culvert location flooding is predicted to be confined mainly to the left bank and flood inundation is likely to occur up to approximately 50m laterally from the channel. The second culvert on the Blackdog Ditch does not appear to be at risk from flooding at the 0.5% AEP. The third culvert however is shown by the flood risk map to be at risk of flooding. Flooding appears to be occurring at this location for approximately 50m laterally from the channel.

There appears to be no properties at risk of flooding in this location but arable and pasture farm land are likely to flood.

Annex 18 Blackdog Ditch

Location: Proposed culvert and associated realignment.
Chainage: The culvert is located at ch330065 on main carriageway

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 948 144
Area	km^2	0.22
SAAR	mm	782
BFIHOST	-	0.724
SPRHOST	%	23.2
FARL	-	1.000
URBEXT1990	-	0.009

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.003	Q-5yr	m^3/s	0.04
Q95	m^3/s	0.0004	Q-10yr	m^3/s	0.05
QMED	m^3/s	0.03	Q-25yr	m^3/s	0.06
QBAR	m^3/s	n/a	Q-50yr	m^3/s	0.072
Q_{BF}	m^3/s	n/a	Q-100yr	m^3/s	0.08
Q_{EBF}	m^3/s	n/a	Q-200yr	m^3/s	0.10

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Annex 19 Middlefield Burn

Location: Three proposed culverts, associated realignments and outfall location
Chainage: Culvert 1 is located on the A90 (North).

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 957 149
Area	km^2	0.35
SAAR	mm	746
BFIHOST	-	0.848
SPRHOST	%	16.9
FARL	-	1.000
URBEXT1990	-	0.008

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.005	Q-5yr	m^3/s	0.03
Q95	m^3/s	0.001	Q-10yr	m^3/s	0.04
QMED	m^3/s	0.020	Q-25yr	m^3/s	0.05
QBAR	m^3/s	0.021	Q-50yr	m^3/s	0.06
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	0.09
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	0.11

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Middlefield Burn Continued

Location: Three proposed culverts, associated realignments and outfall location
Chainage: Culvert 2 is also located on the A90 (North).

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 957 149
Area	km^2	0.35
SAAR	mm	746
BFIHOST	-	0.848
SPRHOST	%	16.9
FARL	-	1.000
URBEXT1990	-	0.008

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.005	Q-5yr	m^3/s	0.03
Q95	m^3/s	0.001	Q-10yr	m^3/s	0.04
QMED	m^3/s	0.020	Q-25yr	m^3/s	0.05
QBAR	m^3/s	0.021	Q-50yr	m^3/s	0.06
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	0.09
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	0.11

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Middlefield Burn Continued

Location: Three proposed culverts, associated realignments and outfall location
Chainage: Culvert 3 is also located on the A90 (North).

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 957 149
Area	km^2	0.35
SAAR	mm	746
BFIHOST	-	0.848
SPRHOST	%	16.9
FARL	-	1.000
URBEXT1990	-	0.008

Summary of design parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.005	Q-5yr	m^3/s	0.03
Q95	m^3/s	0.001	Q-10yr	m^3/s	0.04
QMED	m^3/s	0.020	Q-25yr	m^3/s	0.05
QBAR	m^3/s	0.021	Q-50yr	m^3/s	0.06
Q_{BF}	m^3/s	Not calculated	Q-100yr	m^3/s	0.09
Q_{EBF}	m^3/s	Not calculated	Q-200yr	m^3/s	0.11

Seasonal Flow Duration Curve

Not calculated for this site.

Mean monthly flow velocities

Not calculated for this site.

Annex 20 FEH Pooling Group Analysis for the River Don at Parkhill

Catchment description
Grid Reference of the outflow: NJ88701420

FEH catchment descriptors:

AREA	1269.11
FARL	0.998
PROPWET	0.52
ALTBAR	262.0
ASPBAR	96
ASPVAR	0.100
BFIHOST	0.584
DPLBAR	59.69
DPSBAR	111.50
LDP	127.11
RMED-1H	8.3
RMED-1D	34.4
RMED-2D	47.2
SAAR	884
SAAR4170	964
SPRHOST	31.3
URBEXT1990	0.003

Presence of significant land-use or catchment factors:

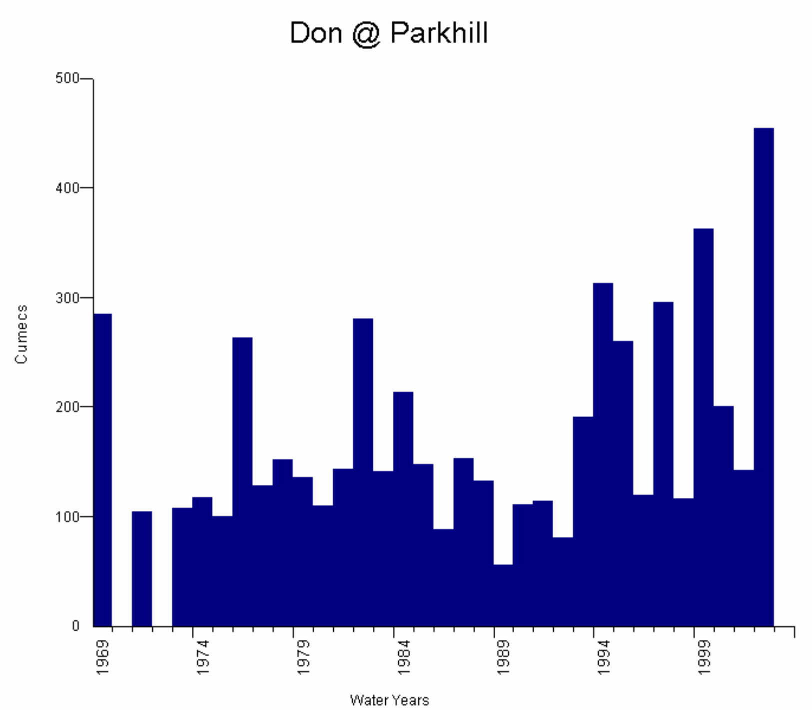
Factors	Comment	Potential Significance
Reservoir\lake	FARL=0.998	Minimal attenuation
Urban	URBEXT1990=0.003 (URBEXT2004=0.003), “Essentially rural”	Typical rural flood response can be expected
Land use	High moorland, pastoral and some arable in valley bottoms, 20% forest cover	Forest cover is relatively high but unlikely to be significant.
Flood plain	Notable floodplains, which may or may not be an issue - mainly in the lower reaches.	Flood attenuation may potentially be slightly larger than typical, but insufficient information to steer analysis.
Soils\Geology	Metamorphics with large amounts of intrusives and some Old Red Sandstone BFI(Hyd Reg)=0.68, SPRHOST=31.3	-
(Other)	Mountainous headwaters (872mAOD max). Often snowy in winter.	Floods generated by or partially by snow melt are more likely than elsewhere in UK.

Flow record:

Target site: Gauged \ ~~Ungauged~~ ?

11001 Don @ Parkhill

Attribute			Comment
Quality\suitability of record for flood analysis	Fit for QMED	✓	Hiflows-UK info: VA station, about 37m wide, natural control. Complex low flow rating history. Weed growth is a problem during summer half-year. Flow records for 1969-1986 reprocessed in 1987; significant revisions in high and low flow range.
	Fit for Pooling	✓	
Number of years of data	1969-2002 (32 readings)		Data from Draft Hiflows-UK database v2.7.9 (to date unpublished)



Estimation of QMED

Approach used

Used	Condition	Approach followed
✓	N >=30	Estimate QMED using annual maxima
	14=< N =<29	Estimate QMED from annual maxima & optionally adjust for climatic variation
	2=< N= <13	Estimate QMED from POT data & adjust for climatic variation
	N <2 & suitable donor site with 20 years or more of record	Ignore record at subject site; transfer QMED from donor site
	N <2 & suitable donor with 10 to 19 years of record & 12 month overlap between records	Estimate QMED using procedure based on flood peak regression
	N <2 & suitable donor with 10 to 19 years of record but no 12 month overlap	Ignore record at subject site; transfer QMED from donor site
	N <2 & no long-record site nearby	Estimate QMED from very short POT record
	N <2 & no long-record site nearby	Treat site as ungauged catchment
	N <2 & no long-record site nearby	Defer analysis until longer flow record available
	N <2 & no long-record site nearby	(Abstract flood event information and apply the UH rainfall-runoff model as an alternative, to the pooling group procedure. Particularly recommended when site is urbanised)
(✓)*	Ungauged catchment	Estimate QMED from catchment descriptors
	Ungauged catchment	Estimate QMED by data transfer from donor catchment
	Ungauged catchment	Estimate QMED by data transfer from analogue catchment
	Ungauged catchment	Estimate QMED from channel dimensions

* for comparison but not given weight

QMED estimation from annual maxima

Are there tied values? ~~Yes~~/No
If so does flood frequency curve solve problem? Yes/No

$QMED_{Annual\ max}$ = **141.8 m3/s**
68% confidence interval = (133.3, 150.3)
95% confidence interval = (125.3, 159.3)

Climatic variation adjustment? ~~Yes~~/No

If yes then give details of adjustment below:

$QMED_{\text{Annual max \& climatic variation}}$ =

QMED estimation from catchment descriptors

Attribute	Value
AREA	1269.11
SAAR	884
FARL	0.998
SPRHOST	31.3
BFIHOST	0.584
URBEXT	0.003

$QMED_{\text{Catchment descriptors – rural}}$ = 127.09 m^3/s
$QMED_{\text{Catchment descriptors – urban}}$ = 127.70 m^3/s

Ratio to QMED data = 1.1

Steps involved in construction and analysis of a pooling group

Pooling group construction

Site of interest

(a) Station Number	11001	(b) Name	Parkhill
Name of saved **.feh** group file	Don and Dee PG		
Target return period (years)	100		

Initial Pooling group details

Total number of sites:	22	Total number of years:	686

Total number of initial high discordancy sites: 1

List them: 55003

Sites removed: (None all merit further investigation)

Total number of short records (< 7 years) removed: 0

List them:

Number of pooled years after sites removed: 686

Note: The BG FEH database includes updated datasets. (I.e. gauging authorities were approached within different projects in the past to supply AMAX updated to the 2000s. Comments on suitability for high flow analysis are always sought).

Subject Site Details

Is subject site included as Rank 1 in pooled group: yes / no

If no state reason why:

Test statistics on validity of pooling group for flood frequency analysis

Heterogeneity test: H2 value = 0.7

Status:			
	Review not necessary	X	H2 < 1
	Review optional		1 < H2 < 2
	Review desirable		2 < H2 < 4
	Review essential		H2 > 4

					Value
Goodness-of-fit test:	Z values	GL	acceptable	/ not acceptable	0.55
		GEV	acceptable	/ not acceptable	-1.61
		PT3	acceptable	/ not acceptable	-2.06

(Note: in the FEH the GL is the generally favoured distribution for use)

ACTION is construction of flood frequency curve valid?

YES: / NO: The test statistics suggest it is okay, but also prudent to check for issues within the pooled group

Comment? Check FARL, station quality and doubling of sites along streams.

Revision of Pooling Group

Revision No. 1

Station Number	Reason for changes in pooling group
53003	Removed - Is included in 53018 (3rd ranked)
55003	Removed – not suitable for pooling due to bypassing (7th ranked)
27041	Removed –doubles 27015 (9th ranked)
28010	Removed – FARL=0.953, substantial flow modification owing to Derwent Reservoir
28011	Removed – FARL=0.951
55021	Removed – significant flood plain effects
54029	Removed –duplicates 54008
11002	Removed – duplicates 11001
11003	Removed – duplicates 11001

Note: The five highest ranked stations (11001, 54008, 53018, 54029, 11002) were updated using the MS Access based Draft Hiflows-UK database version 2.7.9 (to date unpublished).

Number of sites 16 Years 492

Heterogeneity test H2 value = 0.9

Status			
	Review not necessary	X	H2 < 1
	Review optional		1 < H2 < 2
	Review desirable		2 < H2 < 4
	Review essential		H2 > 4

					Value
Goodness-of-fit test	Z values	GL	acceptable	/ not acceptable	1.83
		GEV	acceptable	/ not acceptable	-0.44
		PT3	acceptable	/ not acceptable	-0.53

(Note: in the FEH the GL is the generally favoured distribution for use)

ACTION — is construction of flood frequency curve valid?

YES: / NO: review the pooling group further

Comment?

Flood frequency analysis of pooling group

Distributions selected:	GL	X	PT3	
	GEV	X	other	

Standardisation method selected: Median / Mean (this acts as a check as median is the only method allowed within the pooling group method)

Construct flood frequency curve

URBEXT updated yes / no If yes, from ___ to ___

Urban adjustment yes / no

Value of QMED = 141.8 m^3/s

GL

Return period[1] (yrs)	Growth factors	Design flows (m^3/s)
2	1.000	142
5	1.321	187
10	1.549	220
25	1.875	266
50	2.152	305
100	2.462	349
200	2.811	399
500	3.345	474

[1] The terminology used throughout this report is return period of floods e.g.100, 200 years. A 100-year event would be expected to occur about 10 times over a period of 1000 years, a 200-year event five times and so on. These concepts are frequently misunderstood; for the100-year return period there is 1% chance of a flood occurring in any given year and 40% chance in a period of 50 years. It is also important to note that over a longer period the probability that a flood will occur increases. For the 100-year return period there is a 1% chance of occurrence in any given year but a 26% chance of at least one such flood event occurring in a period of 30 years, 45% chance in a 60 year period and 64% chance over a period of 100 years.

GEV	for comparison	
Return Period (yrs)	Growth factors	Design flows (m^3/s)
2	1.000	142
5	1.353	192
10	1.592	226
25	1.898	269
50	2.128	302
100	2.360	335
200	2.595	368
500	2.908	412

Further Analysis

Comparison of single site analysis and pooling group analysis

A19.1 Comparison of growth curves (Figure 1) shows that the single site analysis (SS) at the Parkhill gauging station results in a much steeper growth curve than the pooling group (PG). The pooling group methodologies result in a similar growth curve as the old FSR regional growth curve. Note that FEH guidance suggests that single site analysis offers reasonably robust estimates only up to about the 0.5N return period where N is the number of years in record. For the Don @ Parkhill this equates to approximately the 20-year event. Even so, a distinct difference in the growth rates up to this reasonably low return period is evident.

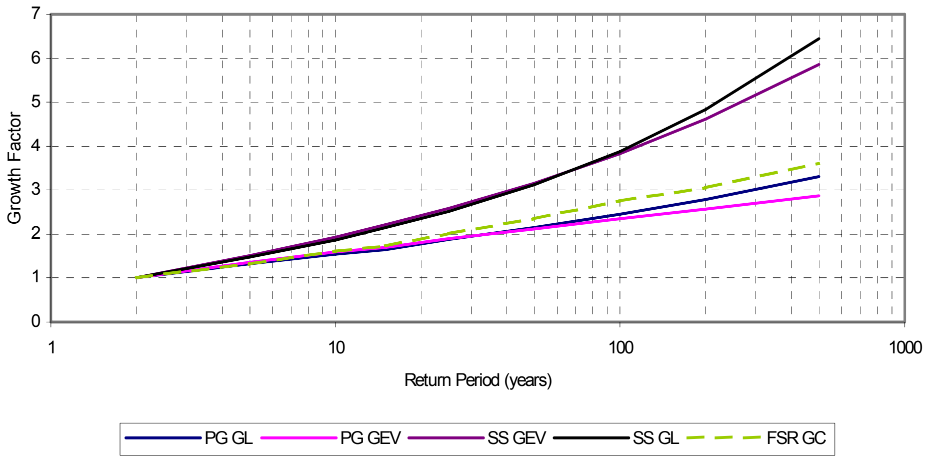


Figure 1: Comparison of the single site and pooling statistical analysis for the Don @ Parkhill

A19.2 In addition Appendix 2 (pooling group details) shows that the subject site (Parkhill) growth curve (rank 1) gives the steepest growth curve of the whole pool.

A19.3 It might be argued that the mountainous and snowy characteristics of the Don catchment render many of the pooled catchments from further south and west inappropriate. Therefore to test if the catchments in the North East of Scotland show distinct growth rate characteristics the top 7 catchments in the initial pooling group from the NE region were compared (Figure 3).

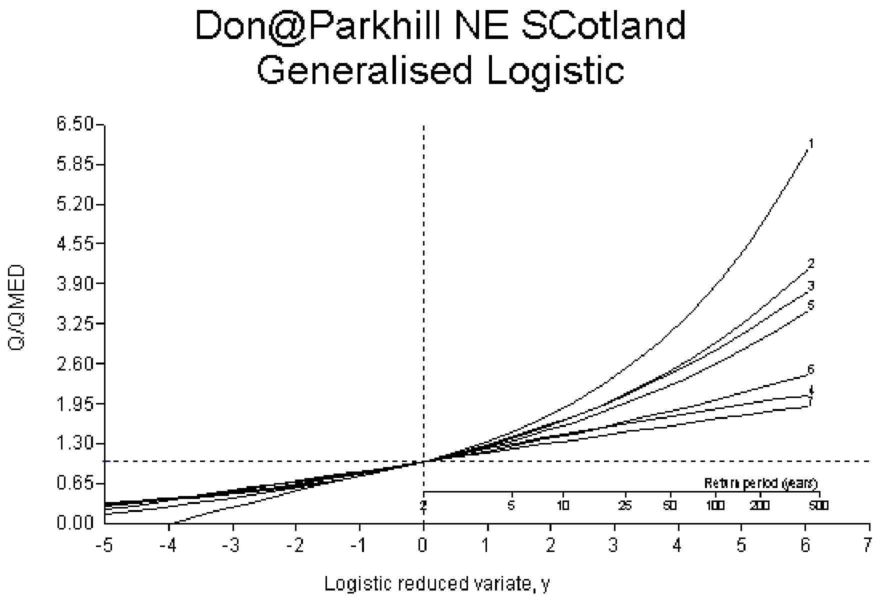


Figure 3: Comparison of the growth curves for the North East Scotland gauges in the Don @ Parkhill pooling group

1 = Don @ Parkhill
2 = Don @ Haughton
3 = Deveron @ Muiresk
4 = Ythan @ Ellon
5 = Don @ Bridge of Alford
6 = Ythan @ Ardlethan
7 = Dee @ Park

A19.4 Again remembering the FEH 0.5N threshold of single site robustness, it is evident that the hydrologically similar catchments in NE Scotland do not show an obvious similarity in growth rates. In particular the Don @ Parkhill appears to be significantly steeper than the others.

Comparison of single site analysis with u/s gauge analysis

A19.5 Included in the pooling group (5th and 13th ranking in the original pooling group before deselections were made) are 11002 Don at Haughton and 11003 Don at Bridge of Alford, which are both upstream of Parkhill (see Appendix 1 for locations). The records at these stations also extend to about 30 years. The Draft Hiflows-UK database indicates that both these stations offer good flood data suitable for flood frequency analyses.

A19.6 Single site analyses were conducted and compared to the growth curve at Parkhill (Figure 4). Both the upstream growth curves are similar and significantly less than the Parkhill gauge.

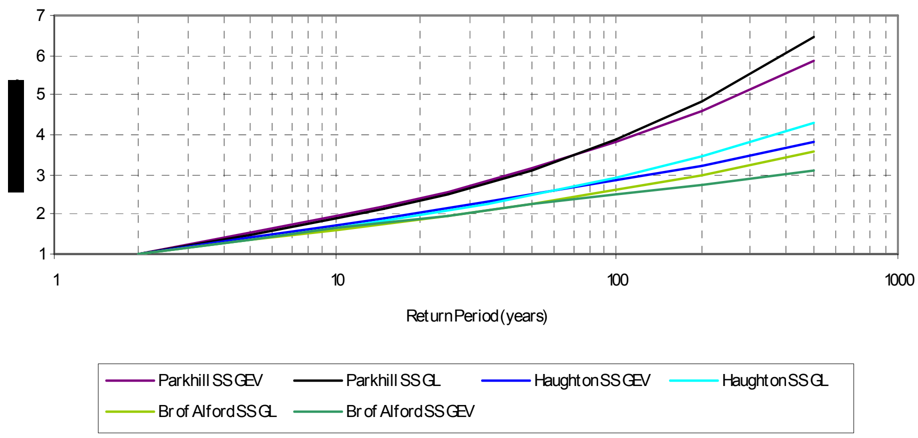


Figure 4: Comparison of single site analyses for the three Don gauges

A19.7 During the single site analysis a slightly abnormal plotting position pattern was seen in the data (Figure 5). Such patterns can indicate a problem with the data or be a result of statistical chance in the flood events experienced. To assess the veracity of the data the plotting positions of the immediately upstream Haughton gauge were compared (Figure 6). Since the plotting position feature is seen in both it strongly suggests that it does not indicate a particular problem with the Parkhill stage discharge relationship.

A19.8 (On some rivers a similar plotting position pattern is evident due to the influence of floodplain storage. This is not believed to be the cause in this case due to the notably rapid steepening greater than usual growth rates at low return periods which is not a characteristic of flood plain influence).

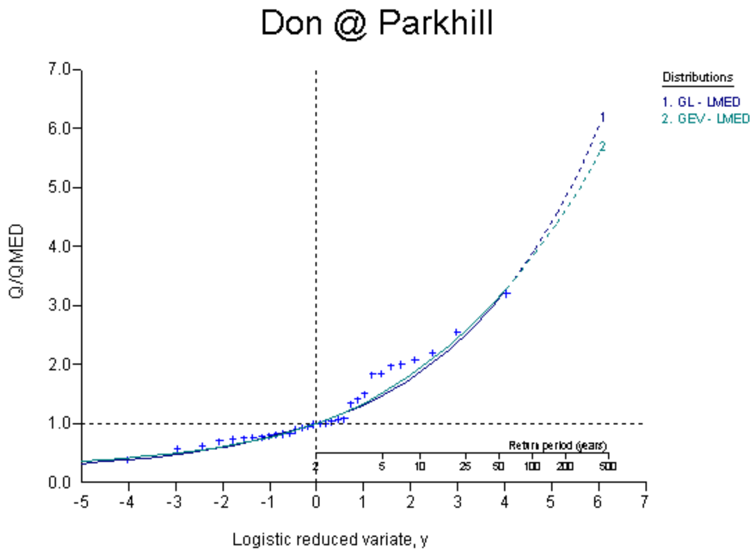


Figure 5: Single site analysis including plotting position for Don @ Parkhill

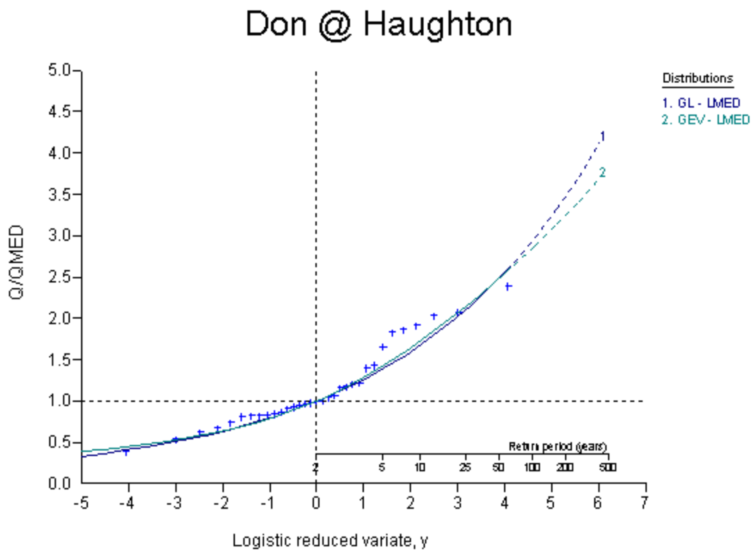


Figure 6: Single site analysis including plotting position for Don @ Haughton

A19.9 The accuracy of the stage discharge relationships at all the gauges on the Don were then investigated. From the Hiflows data the spot gauginigs used to derive the high flow ratings were compared (Figures 7, 8, and 9).

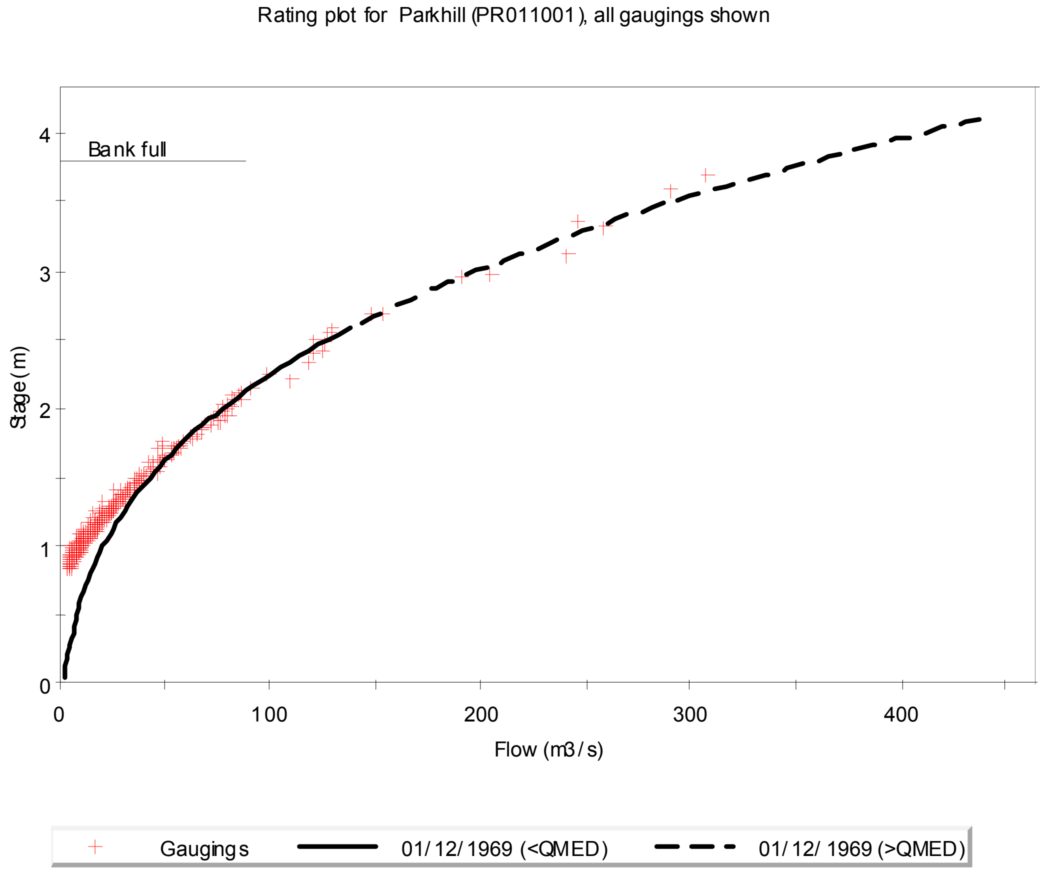


Figure 7: Don @ Parkhill high flow rating equation and spot gaugings.

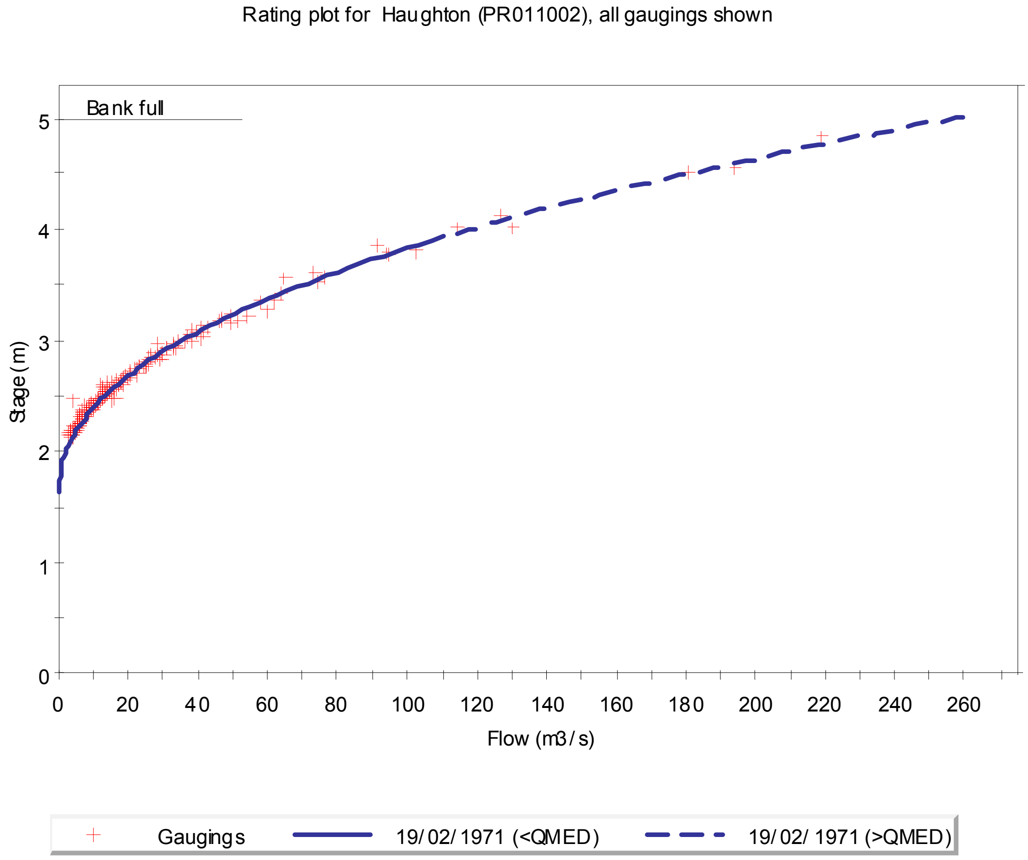


Figure 8: Don @ Haughton high flow rating equation and spot gaugings.

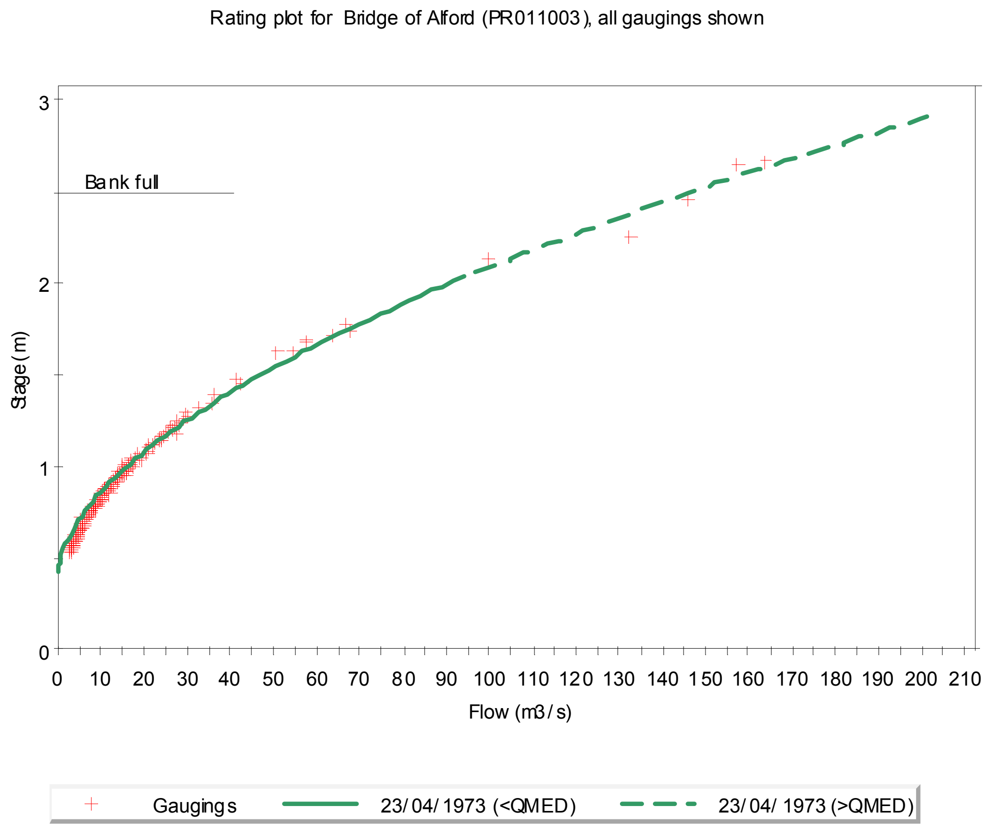


Figure 9: Don @ Bridge Alford high flow rating equation and spot gaugings.

A19.10 The availability of high flow spot gaugings to substantiate the rating relationships for all three gauges are remarkable good. Few gauges in the UK will have a better range. It is also notable that the degree of scatter in the high flow spot gaugings is relatively small again leading to heightened confidence in the relationship. The highest flows recorded at Parkhill go up o about 450 cummecs, about 50% higher than the highest spot gauging.

A19.11 The intersite performance of the Don gauges are given in Figures 10, 11, and 12. Such plots can help identify performance issues if anomalies appear in the relationship. Hiflows POT data was used to generate the relationships.

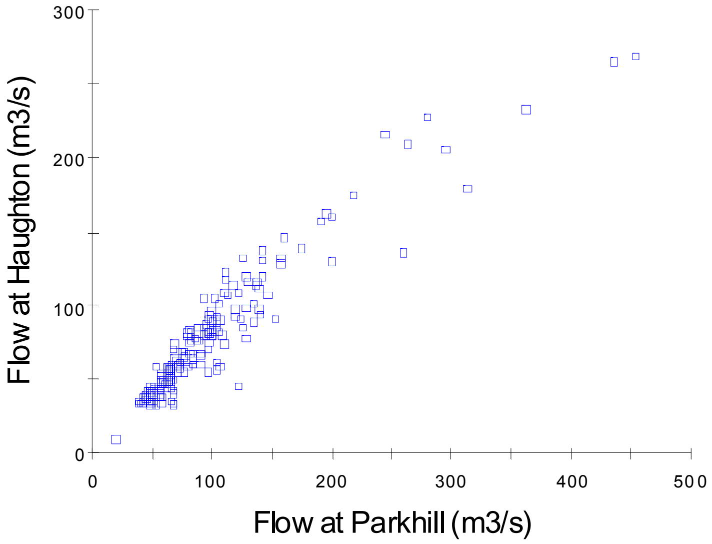


Figure 10: Intersite comparison of flood flows between Parkhill and Haughton.

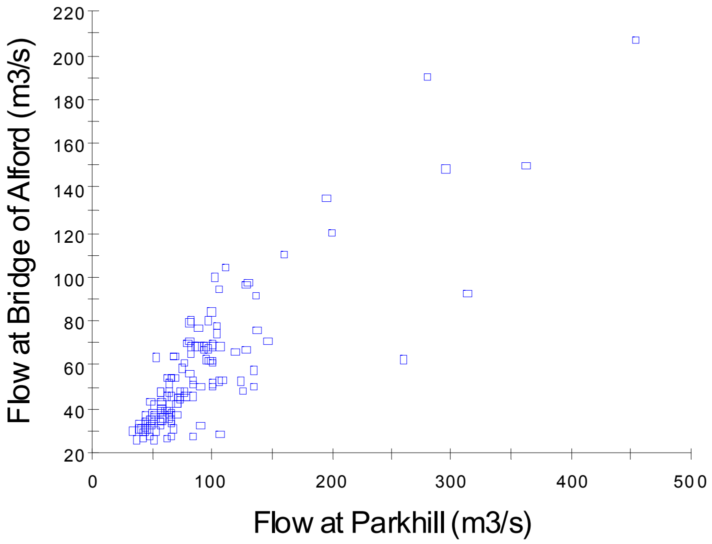


Figure 11: Intersite comparison of flood flows between Parkhill and Bridge of Alford.

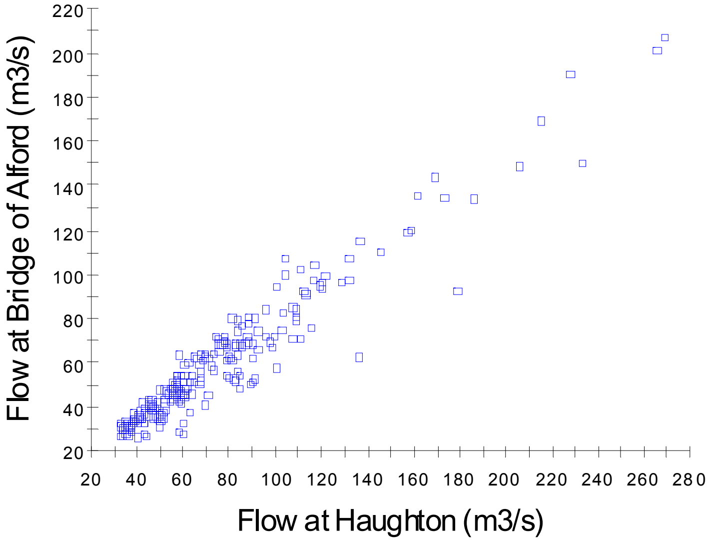


Figure 12: Intersite comparison of flood flows between Haughton and Bridge of Alford.

A19.12 The Haughton and Bridge of Alford gauges appear to be consistent. Parkhill appears fairly consistent with Haughton flows though the relationship does not seem to be as linear as that for Haughton \ Bridge of Alford. The slightly curved relationship particularly for the highest flows may suggest that Parkhill is estimating too high or Haughton is too low. Based on this speculation the Parkhill flows above 300 cumecs were adjusted to maintain an almost linear intersite relationship with Haughton to test the sensitivity of the analysis (Figure 13). Although the steepness of the growth rate is reduced it still remains steeper than the other two gauges and significantly steeper than the pooling group.

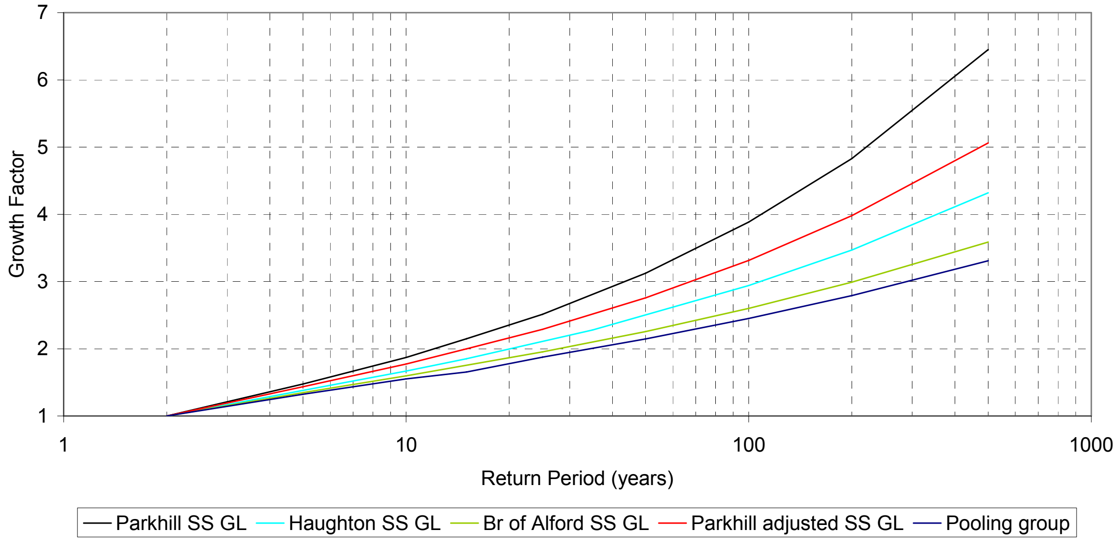


Figure 13: Comparison of Parkhill adjusted flows single site analysis growth rate to those of the other gauges and the pooling group.

Selection of final growth curve for the Don @ Parkhill

A19.13 The above analyses raise significant doubts about the suitability of the pooling group growth rate for the Don @ Parkhill. The single site analyses on the three Don gauges suggests the grow curves slightly steepens the further downstream one goes. These growth curves are likely to be reasonably robust up about the 20-year return period (based on the FEH 0.5N guidance). It is possible that the 30-year period of record analysed includes some significantly greater than average floods from the last decade (refer to timeseries plot in section 1.3) and that this may have lead to a steeper growth rate than would have occurred had a longer time series been available.

A19.14 For the purposes of this project the following means of generating the final growth curve has been followed:

i) The growth curve at Parkhill up to the 15 year event is accepted

ii) The 15-year design flow is then taken as the index flood from which the pooling group relationship to its 15-year event (ie Q_T/Q_{15}) is applied.

A19.15 This approach accepts that the local gauge data has a more important role in the final flood frequency curve than the FEH pooling procedure would use, and that the single site analysis cannot be regarded as particularly reliable for the rarer events (ie 100 and 200 year). A comparison of the Parkhill flood growth rates are given in Figure 14, and the final flood frequency curve is given in Table 1.

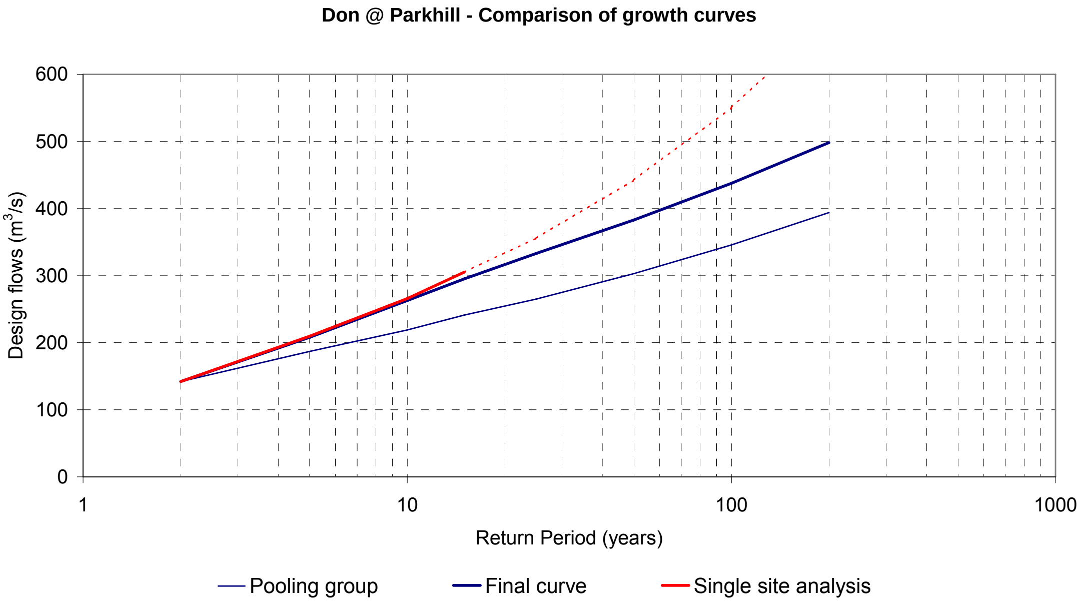
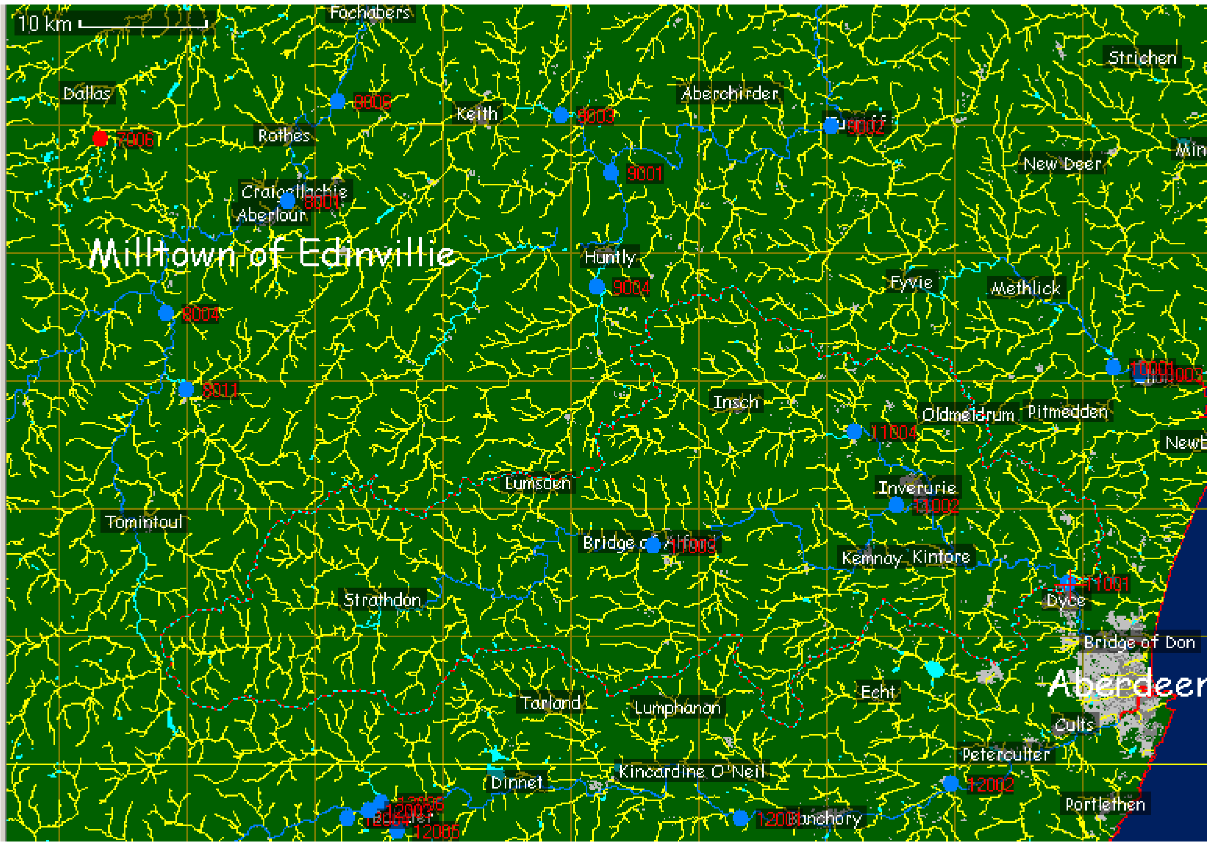


Figure 14: Final flood frequency curve compared to the FEH pooling group and single site estimates. (Single site curve is dotted beyond the 0,5N threshold indicating less reliable. All plotted using the GL distribution)

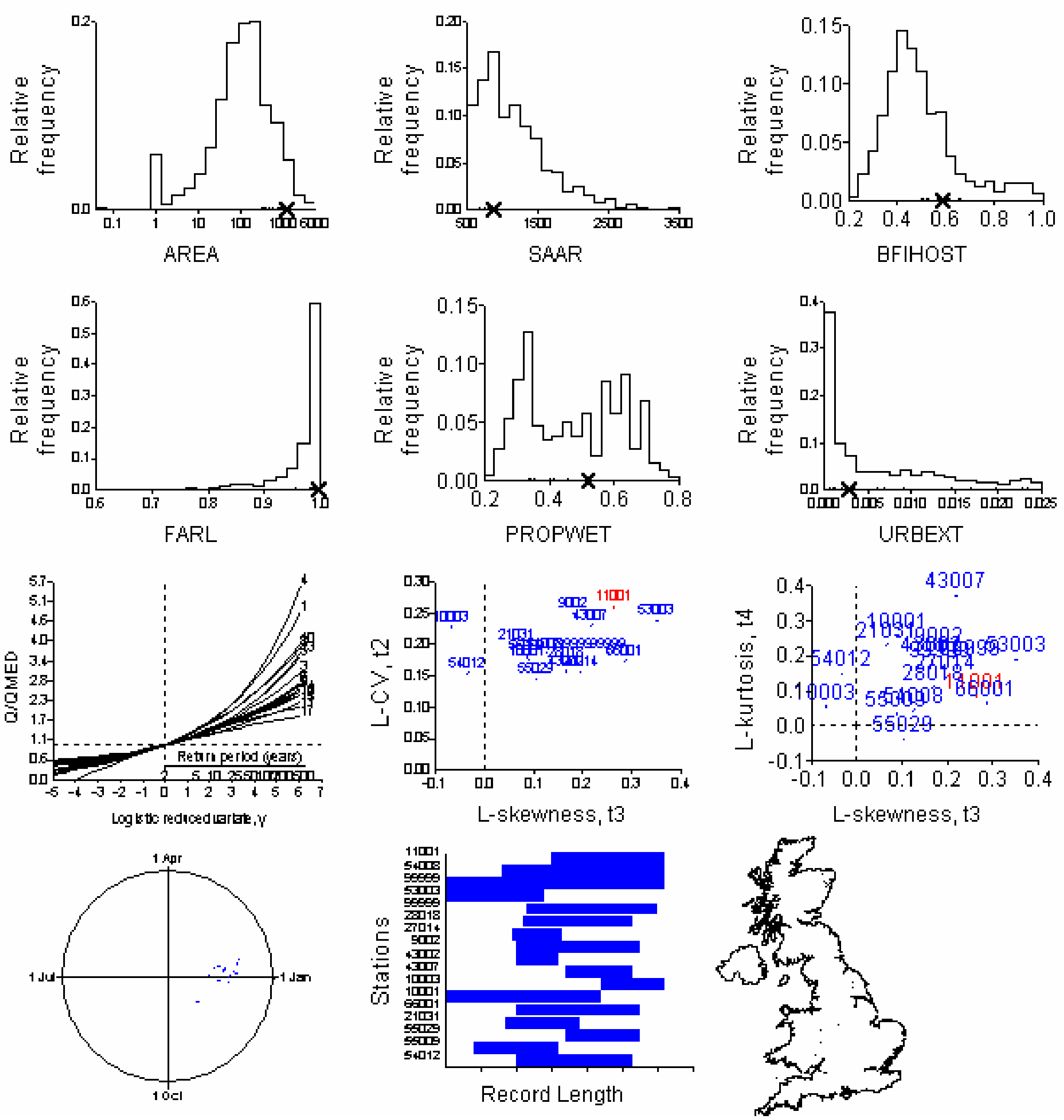
Table 1 – Final Don @ Parkhill flood frequency curve details

GL		
Return period (yrs)	Growth factors	Design flows (m^3/s)
2	1	142
5	1.46	208
10	1.85	263
25	2.35	333
50	2.70	383
100	3.08	438
200	3.51	498

Appendix 1: Location of catchment



Appendix 2: Pooling Group Details – Graphs



Appendix 3: Pooling Group Details – Table

Station	Yrs	L-CV	L-Skew	L-Kurt	Discordance	Distance
11001 (Don @ Parkhill)	32	0.279	0.325	0.154	2.697	0
54008 (Teme @ Tenbury)	47	0.187	0.124	0.045	0.387	0.237
99999 (Avon @ Bathford/bath st James)	62	0.187	0.185	0.179	0.106	0.243
99999 (Derwent @ Stamford Bridge)	38	0.185	0.251	0.18	0.447	0.433
28018 (Dove @ Marston on Dove)	32	0.17	0.166	0.112	0.175	0.451
27014 (Rye @ Little Habton)	15	0.156	0.193	0.14	0.518	0.493
9002 (Deveron @ Muiresk)	35	0.249	0.18	0.219	0.865	0.524
43002 (Stour @ Ensbury)	12	0.158	0.165	0.191	0.553	0.54
43007 (Stour @ Throop Mill)	21	0.232	0.218	0.372	1.805	0.546
10003 (Ythan @ Ellon)	19	0.228	-0.069	0.056	2.747	0.548
10001 (Ythan @ Ardlethen)	45	0.175	0.088	0.258	0.842	0.598
66001 (Clwyd @ Pont-y-cambwll)	36	0.175	0.286	0.067	1.158	0.609
21031 (Till @ Etal)	22	0.2	0.067	0.235	0.607	0.67
55029 (Monnow @ Grosmont)	19	0.145	0.103	-0.037	1.349	0.703
55009 (Monnow @ Kentchurch)	22	0.181	0.087	0.037	0.482	0.703
54012 (Tern @ Walcot)	35	0.155	-0.034	0.151	1.265	0.704

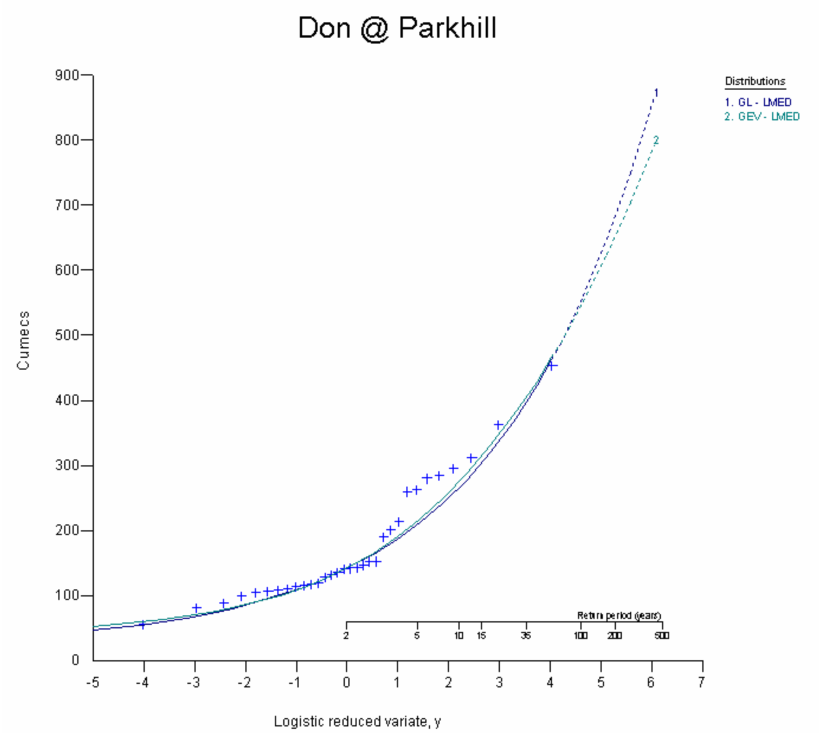
Total	492					
Weighted means		0.2	0.182	0.151		

Appendix 4: Single Site Analysis

No years: 32
QMED: 141.8 m^3/s

	GEV	GEV	GL	GL
Return period (yrs)	Growth factors	Design flows (m^3/s)	Growth factors	Design flows (m^3/s)
2	1.000	141.8	1.000	141.8
5	1.514	214.6	1.476	209.2
10	1.934	274.2	1.871	265.3
25*	2.579	365.7	2.511	356.0
50*	3.156	447.5	3.123	442.8
100*	3.828	542.7	3.883	550.5
200*	4.611	653.8	4.829	684.6
500*	5.855	830.1	6.451	914.6

*return periods > ½ N



Addendum: Updated Single Site Analysis

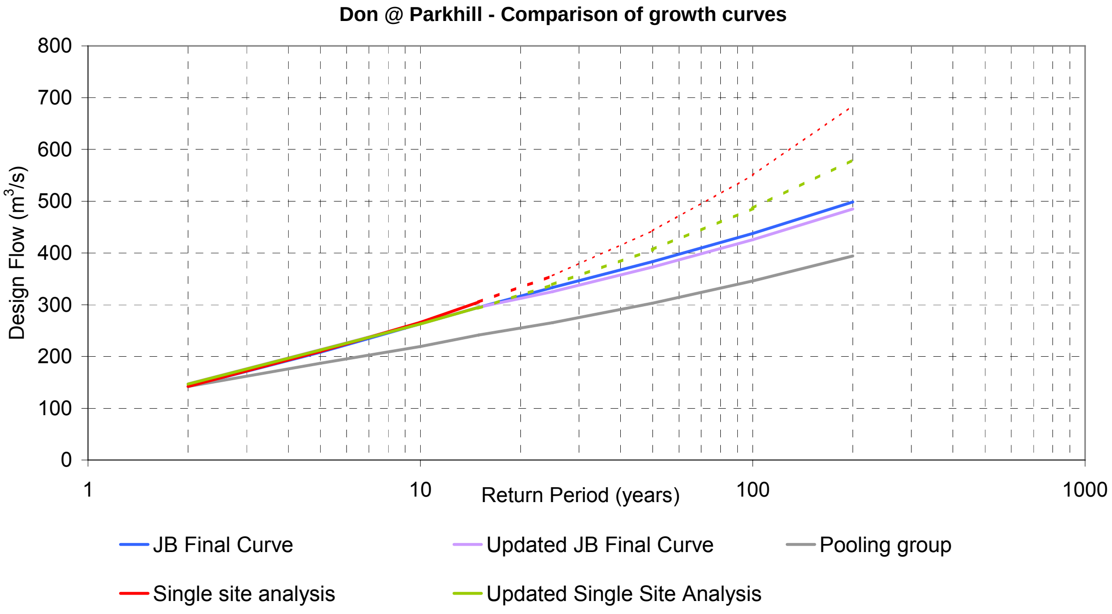
SEPA revised the rating curve for high flow end at the beginning of 2005. An updated AMAX series was received in May 2005. The new single site analysis is presented here for completeness of this study.

No years: 35

QMED: 146.7 m^3/s

	GL	GL
Return period (yrs)	Growth factors	Design flows (m^3/s)
2	1.000	147
5	1.449	213
10	1.791	263
25*	1.990	293
50*	2.308	339
100*	2.771	407
200*	3.313	486
500*	3.952	580

*return periods > ½ N



Final curve is that produced prior to the provision of the revised AMAX series by SEPA at the beginning of 2005.

Consequences of the revised flood data

The above graph suggests that the growth rate for the final flood frequency curve, prior to the provision of the updated annual maximum series, still holds. However the QMED has changed from 142 m^3/s to 147 m^3/s. Although this addendum comes after our modelling of the design flood levels in the vicinity of the proposed road crossing of the Don it is not viewed as significant in that analysis since the capacity issues were shown not to be at all sensitive to the higher design flows. However for completeness the following table provides our revised final design flow estimates.

Return period (yrs)	Growth factors	Conclusion of this audit trail prior to SEPA revision of AMAX series in early 2005	Amended growth factors	Final flood frequency curve based on this addendum
		Design flows (m^3/s)		Design flows (m^3/s)
2	1	142	1	147
5	1.46	208	1.45	213
10	1.85	263	1.79	263
25	2.35	333	2.21	325
50	2.70	383	2.54	373
100	3.08	438	2.90	426
200	3.51	498	3.30	485

Annex 21 The Goval Burn and Mill Lade System

Site Visit 21/07/05

A20.1 The Goval Burn is a major tributary of the River Don, flowing north to south and draining a catchment area of more than 30km^2. Two to three kilometres upstream of the confluence of the Goval Burn with the River Don, there exists a separate and entirely artificial system known locally as the Mill Lade.

A20.2 The following is an account of the operation of the Mill Lade system.

Upper Section: Mill Lade Reservoir

A20.3 The Mill Lade system is privately owned and originates at a reservoir (inlet is at NGR NJ 894 154) located behind Bridgehaugh House, alongside the Goval Burn. The reservoir is fed by water from the Goval Burn via a sluice gate located behind the house, controlled by the owner of the house who also owns the Mill Lade. The Goval Burn flows past the back of the house where most of the flow then falls over a small stone faced weir and continues along the course of the burn. However water can be diverted via the sluice immediately upstream of the weir into the reservoir.

A20.4 The Mill Lade reservoir appears deep and at the time of the visit was fairly full, although there was still the potential for the water level to rise approximately 2-3 feet before nearing bankfull. The land at this point, gently slopes from west to east and it is believed that the reservoir is also fed directly via rainwater as well as from runoff from the adjacent land/fields to the west that prior to the reservoir construction would have run directly into the Goval Burn.

Account from resident of the house at Bridgehaugh (daughter of the owner of the Mill Lade):

A20.5 The sluice from the Goval Burn into the Mill Lade reservoir is not permanently active and is only opened periodically. The sluice is not used for flood alleviation. During times of spate the Goval Burn is left to flow out of its banks and due to the lie of the land floods the lower lying field and waste ground on the left hand bank to the east. There is a small man made bridge over the Goval Burn, just downstream of the reservoir outlet. This bridge is about 1.2m above the bed level and water levels have been observed to flow over the height of this bridge during times of spate.

A20.6 The Mill Lade watercourse and reservoir have no previous history of flooding problems due to the fact they are artificially controlled. The reservoir itself has in the past been drained and cleared by the owners.

<table>
<tr><td></td><td>Goval Burn   NJ 894 156

Photos taken at access road/bridge over the Formartine and Buchan Way (public footpath)

View upstream to the North</td></tr>
<tr><td></td><td>Goval Burn continued

View downstream to the South.

This upstream location on the Goval Burn was visited to confirm that there is no connection between the Goval Burn and Mill Lade upstream of the reservoir.</td></tr>
<tr><td></td><td>Goval Burn   NJ 894 154

View downstream. Photo taken just downstream of the sluice, weir and intake into the reservoir.

Bridge is approximately 1.2m above the bed. During times of spate, water has been observed flowing over the bridge.

When the banks of the Goval Burn are breached, the field/waste ground on the left hand side is allowed to flood.</td></tr>
</table>

	**Goval Burn continued** View upstream. Taken from sluice gate. The sluice is old and rusted, opened only periodically.
	**Goval Burn continued** Stone clad weir behind the house. Most of the water flows over this structure and on down the natural course of the Goval Burn.
	**Goval Burn continued** At times some water from the Goval Burn passes through the sluice gate (centre of photo) and into the Mill Lade reservoir (background of photo).

	**Goval Burn continued** Sluice, weir and Mill Lade reservoir. This is the only point of connection from the Goval Burn into the Mill Lade. Sluice is approximately 2m wide with a double gate.
	**Mill Lade reservoir** View South
	**Mill Lade reservoir** View South Gently sloping stone reinforced banks. Water level could rise approximately 2-3 feet before banks would be over topped.

	**Mill Lade reservoir** Inlet of the reservoir. During the visit the water at the inlet of the reservoir was notably agitated with some swirling. Although the sluice appeared shut, it is suspected that some water from the Goval Burn was entering the reservoir (perhaps sluice was opened slightly or is not fully watertight).

Mid Section: Mill Lade (from outlet of reservoir to crossing point under existing A947)

A20.7 The reservoir outlet is located at NGR NJ 894 152. The outlet channel is wide (8-10m) with stone reinforced banks and is trapezoidal shaped. At this point the height difference between the Mill Lade and the Goval Burn is approximately 7-8m.

A20.8 The artificial construction of the Mill Lade channel bends almost at right angles at four points along its course. At the first bend (NGR NJ 893 150), on the outside left-hand bank there is a gravity fed overflow spillway with a culvert allowing water from the Mill Lade to be returned to the Goval Burn should the water level in the Mill Lade rise too high. The culvert is approximately 350mm in diameter with a trash screen. During the conditions observed whilst on site, the water level would need to rise by approximately 30cm before the spillway would have come into operation. There was no evidence that the Mill Lade had over topped recently - the spillway was dry and becoming overgrown.

A20.9 The Mill Lade progresses ‘downstream’ towards the existing A947. The channel remains wide (5-6m), almost canal-like and is well maintained from the reservoir outlet to the road. No real flow was observed although the water appeared deep.

A20.10 At the crossing point of the Mill Lade under the existing A947 (NGR NJ 890 151) another sluice gate was observed at the bridge. This sluice appeared closed, appearing to impound the reservoir and the water in the reservoir outlet channel.

	**Goval Burn** View 'down' towards the Goval Burn taken from the reservoir outlet.
	**Mill Lade NJ 894 152** View 'upstream' towards the reservoir and the beginning of the outlet channel.
	**Mill Lade NJ 894 152** View 'downstream'. Photo taken from the reservoir outlet. No real flow observed but water is deep.

	**Mill Lade NJ 893 150** Concrete apron serving as spillway from Mill Lade into the Goval Burn. Located on first right-angle bend on the burn. Spillway is dry and overgrown-no evidence of recent use.
	**Mill Lade** Culvert at the end of the spillway to accommodate water from Mill Lade to the Goval Burn. Culvert is approximately 350mm diameter.
	**Mill Lade NJ 890 151** Bridge over Mill Lade at existing A947. Sluice appears shut, effectively impounding the water from the reservoir. Sluice is approximately 1m wide, single gate.

Mill Lade

View looking back ‘upstream’, photo taken from the bridge at the A947.

Lower Section: Mill Lade (from downstream of A947 to the aqueduct)

A20.11 On the downstream side of the A947 bridge, the characteristics of the Mill Lade change. Under the bridge there is an arch culvert, and water can be heard trickling, presumably through the sluice (sluice appears shut but is probably not watertight) and although there is water in the downstream channel of the Mill Lade there is no real flow from the upstream channel. The water level is higher on the upstream side of the bridge.

A20.12 This lower section of the channel appears more natural than the upstream reach. The banks are still stone reinforced but the channel is much narrower (1-2m wide) and very overgrown. The channel is wet but has ponded in many sections and algae have formed on the surface. At this point the burn appears to be fed largely by runoff and road drainage (from the A947); at least three pipes were observed.

A20.13 With the progression downstream, alongside the existing A947 the channel becomes progressively narrower and remains overgrown.

A20.14 The Mill Lade is culverted under Goval Farm access (NGR NJ 888 150) and on the downstream side of the access road the channel has been cleared. Although the banks remain heavily vegetated the bed can be seen and the water was observed to be slowly flowing form north to south.

Mill Lade

Arch culvert on downstream side of the existing A947. Arch is approximately 1m wide by 0.8m high.

Water can be heard trickling-presumably coming from upstream through the sluice (perhaps not watertight).

(Photo taken from bank)

Mill Lade

View downstream, photo taken from the bridge.

Channel is much narrower and more vegetated than upstream. There is significantly less water.

Mill Lade

Ponded area with algal growth, downstream of A947.

	**Mill Lade** Photo taken at entrance to Goval Farm. View 'downstream' towards the farm.
	**Mill Lade** View upstream – taken at farm access bridge over the burn.
	**Mill Lade** View downstream looking south towards the aqueduct. Photo taken from farm access bridge. Flow was observed on the downstream reach, slowly trickling from north to south.

<table>
<tr>
<td></td>
<td>Mill Lade

View upstream of downstream face of culvert under farm access.

Culvert exit is heavily vegetated although channel has been cleared just downstream of this point.</td>
</tr>
</table>

Aqueduct and former pumping station

A20.15 From the culvert under Goval Farm access the Mill Lade progresses another 80-100m to the beginning of the aqueduct (NJ 888 147). The fields on either side of the channel slope away however the Mill Lade remains elevated and the aqueduct is approximately 8m above the ground level below. The aqueduct itself is no longer in use and the pump house has been de-commissioned. The beginning of the aqueduct has been sealed off from the Mill Lade and a spillway with two pipes has been added to the right hand bank of the Mill Lade in order to evacuate the water back into the Goval Burn on the downstream side of the former pumping station. The concrete spillway structure houses two pipes. The intake of the 'primary' pipe is located on the bank of the Lade and will constantly be out-flowing if there is water in the channel. The 'secondary' pipe is located on the actual spillway and is only in use if the water level in the Mill Lade approaches bankfull. Both pipes are approximately 300mm diameter.

A20.16 As the Mill Lade is privately owned, the level of the water in the channel is ultimately dependent on the upstream control at the two sluice gates. A previous high water level was observed on the dividing wall between the aqueduct and the end of the Mill Lade. This indicates that in the past the water level was sufficiently high to have brought the secondary pipe into action.

Account from the owner of Goval Farm:

A20.17 In the past the aqueduct and pumping station were used to pump water slightly uphill to Dyce in the west where it was used for domestic water supply. The height difference between the Mill Lade and the pumping station below provided sufficient hydraulic head to drive the turbines within the pumping station. Excess water from the Mill Lade that wasn't used to drive the turbines was simply discharged directly back into the Goval Burn. The pumped water originated from springs approximately 1km to the east – Kennel Park Spring, Aryburn Spring and Todhill Spring. Water was piped (gravity fed) from the springs and stored in large holding tanks alongside the pumping station before being pumped to Dyce.

A20.18 Under present conditions, the pumping station has been de-commissioned and the holding tanks have been sealed off. Water from the springs is still piped to this site and now appears to be discharged directly into the Goval Burn (NGR NJ 888 148).

	**Mill Lade** Beginning of aqueduct/end of Mill Lade. Aqueduct is no longer in use and has been sealed off. Note the high water level on the dividing wall between the aqueduct and the Mill Lade channel.
	**Mill Lade** View along aqueduct.
	**Mill Lade** View upstream to the north.

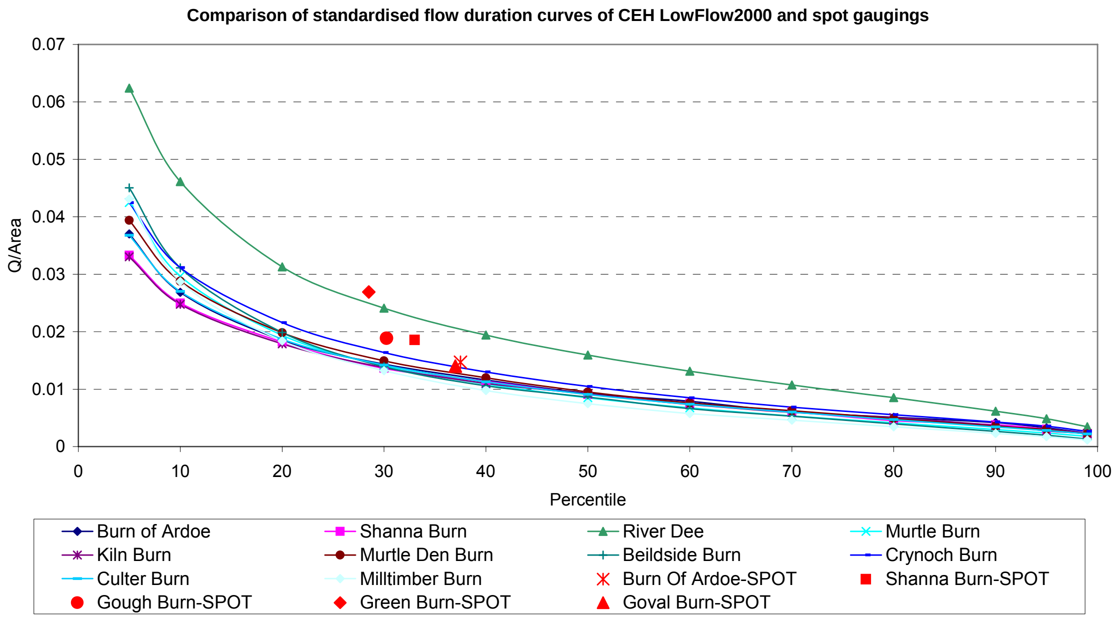
	**Mill Lade** Spillway structure used to convey water back into the Goval Burn. Primary pipe is located on the channel wall and is constantly discharging if there is water in the Mill Lade. Secondary pipe is utilised when water level reaches top of channel wall.
	**Mill Lade** Rusted 'key' observed on the spillway. This is presumably used to close off the primary pipe if required.
	**Mill Lade** Pipe emerging from western side of the pump house. Presumably part of the system used to transport the water to Dyce.

	**Mill Lade** Pipe used to carry water from aqueduct and into pumping station. Hydraulic head of approximately 8m. Aqueduct and pumping station are no longer in use.
	**Mill Lade** Concrete storage tanks where spring water from east was stored prior to being pumped. These tanks are now not in use.
	**Mill Lade** View to the east where the springs originate.

	**Mill Lade** View to the west to where the spring water was pumped.

Annex 22 Summary of Flow Duration Curves

A21.1 Flow duration curves were estimated for the River Dee and selected tributaries for use in the water quality assessment of the River Dee. Due to uncertainties inherent in desk based estimates of flow duration curves, check spot gaugings were taken in April 2005 and compared to the Low Flows 2000 predicted curves[#] (see below figure).



A21.2 The above figure shows that apart from the River Dee all standardised LF2000 derived flow duration curves are similar. This is not surprising as the River Dee is likely to hydrologically differ from the other catchments since it has a much larger catchment area that extends into the wetter mountains to west. A different flow duration curve for the River Dee is therefore to be expected. Catchment characteristics such as soils and land use do not greatly differ between the other ungauged watercourses, so no large differences would be expected between their standardised curves.

A21.3 The spot gaugings taken on the five streams lend support to the LF2000 predicted flow duration curves, though may suggest that the predictions slightly underestimate the flows. However some error in the estimation of the percentile flow is likely since some localised rainfall was known to have been present in the Aberdeen area prior to the spot gaugings and this could not be easily accounted for. Given the recognised uncertainties these spot gaugings suggest that the LF2000 estimates are likely to be about right. The Green Burn spot gauging appears to differ from the others; however more gaugings would be required to confirm whether this was significant.

A21.4 (# The Low Flows 2000 estimates were supplied by CEH Wallingford. Basic input information such as catchment area and boundaries were checked and where necessary refined in line with understanding gained during site visits and mapped information.)

Annex 23 Fluvial Geomorphology: explanation/overview

A22.1 Fluvial processes operate over a range of spatial and temporal scales and involve the interaction of a range of processes and landforms. Sediment regime (erosion, transport and deposition) is a key element of the fluvial system which varies in response to external and internal controls usually in conjunction with the hydrological regime. A key concern with the construction and operation of this road scheme is the potential consequences of an increase in fine sediment supply on the sensitive ecological communities of the river. However, changes in the sediment and hydrological regime can also lead to changes in channel morphology. The diversity of morphological features in a river channel is a key control on habitat quality. Salmon, for example, require variable flow conditions generated by alternating sequences of pools and riffles. Pools act as holding grounds for mature fish, while the riffles provide habitat for fry and par (juveniles). Morphological diversity also extends to exposed features such as the channel deposits (bars) and bank and riparian areas. Dynamic (laterally active) gravel-bed rivers for example support a range of habitats as the morphological forms they contain are variable in age. Such rivers can support a range of ecological communities from pioneer communities on exposed gravel bars to mature vegetation communities on older bars and islands.

A22.2 Man made structures can alter morphological quality either directly, through features such as concrete banks or bed, or indirectly by altering natural fluvial processes such as the distribution of erosion and deposition and channel planform evolution such as migration. Bank and bed protection can inhibit the ability of a river to migrate or adjust its planform in response to external influences and this can lead to a reduction in morphological diversity. In contrast however, realigning river channels can lead to an increase in fluvial processes (erosion and deposition) as the river channel adjusts to changes in cross-sectional form and gradient.

A22.3 The division of fluvial geomorphology into sediment regime, channel morphology and natural fluvial processes is a simplification to suit the WFD criteria and provide clarity. In reality each of the elements are intimately interrelated, (Figure 1). For the purposes of this investigation changes to the sediment regime are considered in terms of the potential increase in sediment supply caused by the construction and operation of the road scheme. Other, indirect changes to the sediment regime may occur and these are considered in terms of changes to natural fluvial processes, such as erosion and deposition.

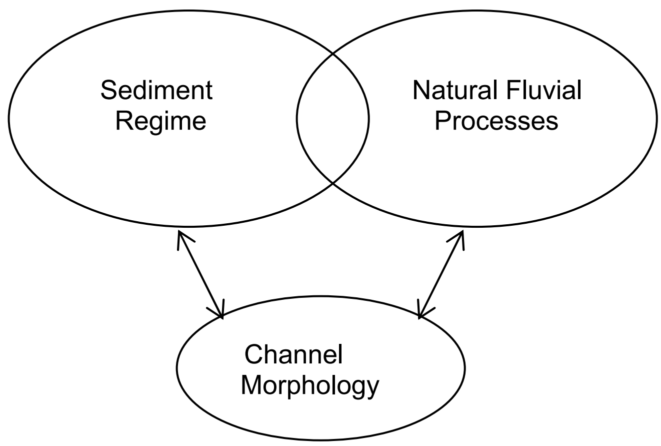


Figure 1: Simplified interrelationships in the fluvial system

Annex 24 Fluvial Geomorphology Additional Baseline Information

Table 1 – Geomorphological characteristics of each watercourse.

Watercourse	Bankfull Width (m)	Wetted Width (m)	Depth (m)	Bed Material	Bank Material	Modification	Gradient (average over 1 km)	Flow/ Morphological Diversity
Kepplehill Burn	1.0	0.5	1.0	Gravel and silt	Walled	Realigned, resectioned	000357	Poor
Gough Burn	3.0	1.5	1.5	Cobble and gravel	Walled and natural (fine material)	Realigned, resectioned	0.0450	Good
Craibstone Burn	1.2	1.0	0.75	Cobble and gravel	Walled and natural (fine material)	Realigned, resectioned (lower reach)	0.0394	Good
Green Burn	2.5	2.0	1.0	Cobble, gravel, sand	Walled	Realigned, resectioned	0.0148	Moderate
Howemoss Burn	Heavily Modified							
Bogenjoss Burn (Upper)	0.75	0.75	0.5	Coarse and fine gravel	Natural (fine material)		0.0493	Good
Bogenjoss Burn (Lower)	1.0 m	1.0	0.5	Cobble and gravel	Natural (Fine and coarse material)		0.0591	Good
River Don	30.0	22.0	2.5	Boulder and cobble	Natural (coarse and fine material)		0.0001	Good
Mill Lade	2.0-6.0	0.5 – 6.0	1.0 – 1.5	Artificial (concrete)	Walled/ concrete	Artificial watercourse	0.0314	Poor
Goval Burn	3.5	3.0	1.0	Cobble and gravel	Walled and natural (fine material)	Realigned, resectioned	0.0133	Good
Corsehill Burn	1.5	1.0	1.25	Cobble and gravel	Walled	Realigned, resectioned	0.0343	Moderate
Red Moss Burn	1.5 – 3.5	1.5	1.5	Gravel and silt	Walled	Realigned and resectioned	0.0110	Moderate
Middlefield Ditch	3.0	0.75	1.5	Gravel	Natural cobbles with fine matrix	Realigned, resectioned	0.019	Poor
Blackdog Burn	1.0 - 3.0	1.0	0.75	Coarse and fine gravel	Walled	Realigned, resectioned	0.0196	Moderate
Blackdog Ditch	Heavily Modified							

Table 2 – Surface Geology at each crossing point based on the geological maps of the area.

Watercourse	Surface Geology
Kepplehill Burn	Till
Gough Burn	Till
Craibstone Burn	Till
Green Burn	Sand and gravel (melt water deposits)
Howemoss Burn	Till
Bogenjoss Burn	Upper = Bedrock Lower = Bedrock (u/s) / Till (d/s) boundary (Valley is mapped as a glacial melt water channel on the Geological Map.
River Don	Alluvium – slopes composed of sand and gravel (melt water deposits)
Mill Lade	Sand and gravel (melt water deposits)
Goval Burn	Alluvium along watercourse Surrounding land = Sand and gravel (melt water deposits)
Corsehill Burn	Till (u/s) sand and gravel (d/s) flows across boundary.
Red Moss Burn	Till (u/s) sand and gravel (d/s) flows across boundary.
Middlefield Ditch	Sand and gravel (meltwater deposits)
Blackdog Burn and Ditch	Alluvium along watercourse Surrounding land = Sand and gravel (melt water deposits)

Table 3 – Ground conditions at each crossing point based on bore hole data.

Watercourse	Ground conditions (Drift Geology)	Geomorphological Implications
Kepplehill Burn	0-1.2m Granular glacial deposits comprising gravelly SAND 1.2 – 3.8 Cohesive glacial deposits of gravelly sandy clays	The dominance of sand in the upper layers means these deposits may be vulnerable to water erosion during excavations when vegetation is absent. However, due to the grain size, the resulting sediment inputs are only likely to have an impact over a short distance.
Gough Burn	0-0.7 Made ground – localised in extent. 0.7-8m+ Glacial deposits comprising gravelly sandy CLAY.	The ground consists primarily of cohesive deposits which will be relatively resistant to runoff erosion. However should quantities of this sediment enter the watercourses, perhaps following a phase of desiccation and disturbance these sediments will be readily transported downstream
Craibstone Burn	The ground conditions in this location are highly varied. 0-0.5m Soil 0.5 – 1.2m gravelly fine to coarse SAND with some SILT. 1.2-4m Cohesive glacial deposits comprising sandy gravelly CLAY. *Water table* averages 3.1m.	The dominance of sand in the upper layers means these deposits may be vulnerable to water erosion during excavations when vegetation is absent. However, due to the grain size, the resulting sediment inputs are only likely to have an impact over a short distance. Excavations below 1.3 m will encounter more cohesive sediments which are likely to be more resistant to water erosion.
	The ground to the north of the burn (left slope) also consists of SAND but contains more gravel. Significantly three boulder beds are present at 0.3-0.8m, 1.6-2.6m, and 4.45-5.9m respectively.	The presence of boulder beds to the north of the channel may complicate channel realignment and the increased proportion of coarse sediment means this area will be more vulnerable to sediment release. However, as these deposits are coarse grained, the resulting sediment inputs are only likely to have an impact over a short distance.
Green Burn	0-1.6m Granular glacial deposits of silty gravelly SAND with occasional cobbles.	These sandy sediments will have relatively low cohesion. These may be vulnerable to fluvial erosion when vegetation is absent. However, due to the grain size, the resulting sediment inputs are only likely to have an impact over a short distance and the sediment will be deposited locally.
Howemoss Burn	NO DATA	
Bogenjoss Burn	Upper crossing Section where diversion channel will contour the valley side slope: 0-1.6m Sandy slightly gravelly SILT with closely spaced thick beds of GRAVEL. Moving north the ground become characterised by a more uniform sandy GRAVEL with some large cobbles. BEDROCK lies at a depth of between 1.5m and 2m	These sands and gravels will have relatively low cohesion and will be vulnerable to fluvial erosion when vegetation is absent. However, due to the grain size, the resulting sediment inputs are only likely to have an impact over a short distance and the sediment will be deposited locally.

Watercourse	Ground conditions (Drift Geology)	Geomorphological Implications
	Location where new alignment will flow down slope and cross the bypass: 0-1.25m silty SAND and gravel. 1.25-3.7m gravelly SILT with some pockets of clay. 3.7-4.2m silty SAND BEDROCK at 4.2m. Lower crossing Valley floor (?) 0-2.9m SAND Valley side (?) 0-2.5 Boulder CLAY	These silty sands and gravels will have relatively low cohesion and will be vulnerable to fluvial erosion. However, due to the grain size, the majority of the sediment inputs are only likely to have an impact over a short distance and the sediment will be deposited locally. The finer sediments are likely to be transported further downstream. The sands will be relatively vulnerable to erosion particularly when vegetation is absent due a lack of cohesion. The majority of any sediment entrained by flow will be deposited relatively locally. The boulder clay will be more resistant to erosion due to it cohesive nature.
Goval Burn	Upper crossing 0-0.8m Soil 0.8-1m Silty gravelly SAND 1-3.9m SAND and GRAVEL Lower crossing 0-03m Soil 0.3-0.9m silty fine SAND with some gravel 0.9-2m SAND and GRAVEL	These sands and gravels will have relatively low cohesion and will be vulnerable to fluvial erosion particularly when vegetation is absent. However, due to the grain size, the majority of the sediment inputs are only likely to have an impact over a short distance and the sediment will be deposited locally. The finer sediments are likely to be transported further downstream.
Corsehill Burn	0-0.3m Soil 0.3-2.2m silty SAND and gravel 2.2-3.85 silty sandy GRAVEL occasional cobbles	These sands and gravels will have relatively low cohesion and will be vulnerable to fluvial erosion particularly when vegetation is absent. However, due to the grain size, the majority of the sediment inputs are only likely to have an impact over a short distance and the sediment will be deposited locally. The finer sediments are likely to be transported further downstream.
Middlefield Ditch	NO DATA	
Red Moss Burn	0-0.35 Soil 0.35-1.9 Clayey gravelly sand. 1.9-3.m Cohesive glacial deposits of sandy gravelly CLAY	The presence of clay in this area lends cohesion to the deposits. These will therefore be relatively resistant to runoff and fluvial erosion. However if fine sediments are entrained by flow, they are likely to be transported to Corby Loch and deposited.
Blackdog Burn and Ditch	NO DATA	

Annex 25 Fluvial Geomorphology Site Photographs

Kepplehill Burn

View of Kepplehill Burn looking downstream at crossing point location. The stream is located within a deep channel located between the track to the right and the fields to the left. The channel shows evidence of past realignment and localised walling.

Gough Burn

View of Gough Burn looking downstream showing the character of the channel and riparian zone in the vicinity of the crossing point. The channel has a varied substrate with sinuous planform and localised channel deposits. The river corridor is wooded and contains a wide range of vegetation types. The banks are frequently bound by tree roots.

Craibstone Burn

View of Craibstone Burn looking downstream showing the character of the burn and riparian zone in the vicinity of the crossing point. The channel is steep and set within a wooded riparian corridor. The channel has a sinuous planform and is morphologically diverse, showing varied bed sediments and a well developed pool and riffle sequence.

Green Burn

View of Green Burn taken from the right bank (flow is from left to right) showing the character in the channel and riparian zone in the location of the road crossing. The channel is very straight, which is a reflection of past realignment, and exhibits generally low morphological diversity.

Howemoss Burn

View of Howemoss Burn looking downstream. The channel shows evidence of straightening and over deepening. The watercourse is obscured by Gorse.

Bogenjoss Burn

View of the upper section of Bogenjoss Burn affected by the road looking downstream. The channel is very narrow although the width and depth are locally variable.

View of Bogenjoss Burn looking downstream showing the character of the channel in the location of the lower road crossing. The stream is steep and set within a narrow vee shaped valley which contains a wooded riparian corridor. The channel has a sinuous planform and is morphologically diverse, showing varied width and depth and a range of bed sediments and a pool and riffle sequence.

River Don

View of the River Don looking upstream showing the character of the river and riparian zone at the crossing point. The channel is wide and has a low gradient. In this location the channel is of low sinuosity although the channel width is variable, and this provides some flow diversity.

Goval Burn

View looking upstream showing the valley of the Goval Burn in the location of the upper crossing point. The stream is located at the base of the steep slope visible to the left of the picture.

View of the stream channel looking upstream showing the character of the channel in the location of the lower road crossing. River channel is cobble-gravel bedded with good flow diversity and a varied riparian zone.

View of Goval Burn showing the character of the watercourse in the vicinity of the new crossing point of the B977. The channel in this location shows evidence of past realignment and deepening (resectioning), however the bed morphology is relatively good, resulting in a range of flow types.

Corsehill Burn

View looking upstream of Corsehill Burn in the location of the road. The channel is straight and deep which reflects past modification.

Red Moss Burn

View looking downstream of the channel of the Red Moss Burn at the location of the proposed road crossing. The channel shows evidence of past straightening, widening and deepening. The bed of the channel is obscured by dense vegetation which as grown on silt deposits within the channel.

Blackdog Burn

View looking upstream illustrating the general character of the Blackdog Burn. The channel shows evidence of past deepening and realignment and in some places localised walling. As a result of these alterations the channel currently exhibits low morphological diversity.

Middlefield Burn

View illustrating the general character of the Middlefield Burn. The channel has been straightened and deepened and as a result exhibits extremely poor morphology.

Annex 26 Water Quality – SEPA Classification Tables

More details could be found on SEPA website (www.sepa.org.uk).

Notes relating to the Annex 24

a Based upon data for 3 years, minimum of 12 samples, unless there has been a significant change in circumstances (e.g. a discharge eliminated or an identified major pollution incident in a previous year) which justifies an assessment based upon a lesser data set collected after a step change. In such circumstances a minimum monitoring period of 12 months must have elapsed since the change and where there are fewer than 12 samples the significance of the step change should be confirmed by a statistical test. Estimation of percentiles to be by parametric method, assuming DO and pH are normal distributions and BOD and ammoniacal nitrogen are log normal. For pH the 5, 10 and 95 %iles must be determined from the 3 years data and compared with the class determining limits in the Classification table. Again, the parametric percentile estimation must be made, using the method of moments, and as assumed normal distribution.

b Based on data for 1 year, preferably 3 samples (spring, summer and autumn), minimum of 2 (spring and autumn).

c Based on 1 year's monitoring data, preferably 3 samples, minimum of 2. The overall class is determined from the mean field score and mean ASPT (Average Score per Taxon) of the individual samples.

d Aesthetic conditions to be based on 1 year's data from a minimum of 3 observations and will be assessed and recorded during ecological and/or chemical sampling visits to programmed sampling points. Aesthetic contamination is assessed as either discharge related (List A) or general (List B).

List A contaminants

- Sewage derived litter and solids, including:
    - faeces
    - toilet paper
    - contraceptives
    - sanitary towels
    - tampons
    - cotton buds
- Oils
- Non natural foam, scum or colour
- Sewage fungus
- Sewage or oily smells

List B contaminants

- General non sewage derived litter
- Builders' waste
- Gross litter, including:

- shopping trolleys
- furniture
- motor vehicles
- road cones
- bicycles/prams

e No list A contaminants, possibly minor List B litter present.

f Traces of List A and/ or occasional List B contamination, especially at easy access points.

g List A contamination widespread and/or occasional conspicuous quantities, and/or widespread or gross amounts of List B contamination. Likely to be the cause of justified public complaints. The annual aesthetics classification is derived from the individual spot samples in the following way. Spot classifications are assigned a numerical value:

Class	Value
A1	1
A2	2
C	4

The arithmetic mean value of the spot classes for the year is calculated and the annual class assigned using the following bands:

Mean value	Class
>3.0	C
>1.5	A2
< 1.5	A1

A minimum of 3 spot values is required for an annual class to be assigned.

Annex 27 Parameters used in the classification water quality at a monitoring point

		WATER CHEMISTRY [a]					**ECOLOGY**				**NUTRIENTS[a]**	**AESTHETIC[d]**	**TOXIC SUBSTANCES**	**COMMENT**
Class	**Description**	**Dissolved Oxygen (DO) (% sat.) (10%ile)**	**Ecological Oxygen Demand (BOD) (mg/l) (90%ile)**	**Ammonia (NH4-N) (mg/l) (90%ile)**	**Iron (mg/l) Mean**	**pH %ile**	**Lab Analysed [b]**		**Bankside [c]**		**SRP (µg/l) Mean**	**Condition (Contaminated)**		
							ASPT[1] EQI	TAXA EQI	ASPT	Field Score				
A1	Excellent	≥80	≤2.5	≤0.25	≤1	5%ile≥6 95%ile≤9	≥1.0	≥0.85	≥6.0	≥85	≤20	No A Minor B[e]	Complies with Dangerous Substances EQS's	Sustainable fish population. Natural ecosystem.
A2	Good	≥70	≤4	≤0.6	≤1	10%ile ≥5.2	≥0.9	≥0.70	≥5.0	≥70	≤100	Trace/ Occasional A or B[f]	Complies with Dangerous Substances EQS's	Sustainable fish population. Ecosystem may be modified by human activity.
B	Fair	≥60	≤6	≤1.3	≤2	10%ile <5.2	≥0.77	≥0.55	≥4.2	≥50	>100	-	Complies with Dangerous Substances EQS's	Fish may be present. Impacted ecosystem.
C	Poor	≥20	≤15	≤9.0	>2	-	≥0.50	≥0.30	≥3.0	≥15	-	Gross A or B[g]	>EQS for dangerous substance	Fish sporadically present. Poor ecosystem.
D	Seriously Polluted	<20	>15	>9.0	-	-	<0.50	<0.30	<3.0	<15	-	-	>10 x EQS for dangerous substance	Fish absent or seriously restricted.

[1]. Average Score per Taxon

Aberdeen Western Peripheral Route

Environmental Statement Appendices 2007

Part B: Northern Leg

Appendix A9.5 - Water Environment Annexes

Annex 28 Spillage Risk Calculations

Scheme: Aberdeen Western Peripheral Route Northern Leg **Job No:** **10332**
Spillage Risk Assessment
Without Mitigation

Item	**Description**	**Units**											
Probability of a serious accidental spillage			**Green**	**Green**	**Green**	**Green**	**Green**	**Bogenjoss Burn**	**River Don**	**Goval Burn**	**Goval Burn**	**Goval Burn**	**Goval**
Section of Road or Junction			**Burn**	**Burn**	**Burn**	**Burn**	**Burn**						**Burn**
			Run I	**Run I**	**Run I**	**Run J**	**Run I and J**	**Run K**	**Run L**	**Run M**	**Run M**	**Run M**	
			Mainline	Sliproads	A96 Underbridge	Mainline	**Total**	Mainline	Mainline	Mainline	Sliproads	Roundabout	**Total**
Formula	P_{acc} = RL x SS x (AADT x 365 x 10^{-6}) x (% HGV /100)												
P_{acc}	Probability of a serious accidental spillage in one year over a given road length		0.0083	0.0018	0.0076	0.0030		0.0012	0.0028	0.0018	0.0002	0.0000	
P_{acc} as a probability factor	$1 / P_{acc}$		120	569	131	335		806	359	548	6018	32830	
RL	Road length in kilometres	km	2.78	1.238	0.99	2.36	7.368	0.98	2.2	1.32	0.725	0.385	2.43
SS	Serious spillage rates (from Volume 11 DMRB: Table 3.2, p A3/4)		0.0022	0.0032	0.0106	0.0022		0.0022	0.0022	0.0022	0.0032	0.0296	
AADT	Annual average daily traffic		46526	17370	33152	17520		17520	17520	19145	2453	2441	
% HGV	Percentage of heavy goods vehicles	%	8	7	6	9		9	9	9	8	0.3	
Acceptable risk of a pollution incident - for discharge to aquifers and sensitive watercourses			*2 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*		*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	
Acceptable risk of a pollution incident - for discharge to all other watercourses			*2 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*		*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	
Probability that a spillage will cause a pollution incident													
Formula	$P_{pol\ per\ year} = P_{acc} \times P_{pol}$		0.0062	0.0013	0.0057	0.0022		0.0009	0.0021	0.0014	0.0001	0.0000	
P_{acc}	see above												
P_{pol}	Risk reduction factor Vol 11 DMRB: Table 3.3, p A3/4; assumed emergency response time >20min		0.75	0.75	0.75	0.75		0.75	0.75	0.75	0.75	0.75	
P_{pol} as a probability factor	**$1 / P_{pol}$ per year**		160	758	175	446	**64**	**1075**	**479**	730	8024	43773	**659**
Is the spillage risk within acceptable limits?			**Y**	**Y**	**Y**	**Y**	**N**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**

Item	**Description**	**Units**														
Probability of a serious accidental spillage			**Corsehill**	**Corsehill**	**Corsehill**	**Corsehill**	**Corsehill**	**Red Moss Burn**	**Blackdog**	**Blackdog**	**Blackdog**	**Blackdog**	**Blackdog**	**Middlefield**	**Middlefield**	**Middlefield**
Section of Road or Junction			Burn	Burn	Burn	Burn	Burn		**Burn**	**Burn**	**Burn**	**Burn**	**Burn**	**Burn**	**Burn**	**Burn**
			Run N	**Run N**	**Run N**	**Run N**		**Run O**	**Run P and Q**	**Run Q**	**Run Q**	**Run Q**		**Run R**	**Run R**	
			Mainline	Sliproads	A947 Roundabout	Side Road	**Total**	Mainline	Mainline	Sliproads	Roundabout	A90	**Total**	Side Road	Roundabout	Total
Formula	P_{acc} = RL x SS x (AADT x 365 x 10^{-6}) x (% HGV /100)															
P_{acc}	Probability of a serious accidental spillage in one year over a given road length		0.0020	0.0002	0.0000	0.0000		0.0017	0.0047	0.0000	0.0077	0.0005		0.0004	0.0032	
P_{acc} as a probability factor	$1 / P_{acc}$		505	4269	28160	263793		574	214	314840	131	2192		2656	317	
RL	Road length in kilometres	km	1.43	0.74	0.59	0.005	2.765	1.26	3.37	0.56	0.655	0.3	4.885	0.09	0.27	0.36
SS	Serious spillage rates (from Volume 11 DMRB: Table 3.2, p A3/4)		0.0022	0.0032	0.0296	0.0106		0.0022	0.0022	0.0032	0.0296	0.0022		0.0106	0.0296	
AADT	Annual average daily traffic		19145	4517	5571	4899		19145	19145	2428	10814	21042		10814	10814	
% HGV	Percentage of heavy goods vehicles	%	9	6	0.1	4		9	9	0.2	10	9		10	10	
Acceptable risk of a pollution incident - for discharge to aquifers and sensitive watercourses			*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*		*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*		*1 in a 100 years*	*1 in a 100 years*	
Acceptable risk of a pollution incident - for discharge to all other watercourses			*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*		*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*		*1 in 50 years*	*1 in 50 years*	
Probability that a spillage will cause a pollution incident																
Formula	$P_{pol\ per\ year} = P_{acc} \times P_{pol}$		0.0015	0.0002	0.0000	0.0000		0.0013	0.0035	0.0000	0.0057	0.0003		0.0003	0.0024	
P_{acc}	see above															
P_{pol}	Risk reduction factor Vol 11 DMRB: Table 3.3, p A3/4; assumed emergency response time >20min		0.75	0.75	0.75	0.75		0.75	0.75	0.75	0.75	0.75		0.75	0.75	
P_{pol} as a probability factor	**$1 / P_{pol}$ per year**		674	5692	37546	351724	**592**	**765**	286	419787	174	2923	**104**	3541	423	**378**
Is the spillage risk within acceptable limits?			**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**

Scheme: Aberdeen Western Peripheral Route Northern Leg **Job No:** **10332**
Spillage Risk Assessment
With Mitigation

Item	Description	Units	Green Burn Run I Mainline	Green Burn Run I Sliproads	Green Burn Run I A96 Underbridge	Green Burn Run J Mainline	Green Burn Run I and J Total	Bogenjoss Burn Run K Mainline	River Don Run L Mainline	Goval Burn Run M Mainline	Goval Burn Run M Sliproads	Goval Burn Run M Roundabout	Goval Burn Total
Probability of a serious accidental spillage													
Section of Road or Junction													
Formula	P_{acc} = RL x SS x (AADT x 365 x 10^{-9}) x (% HGV /100)												
P_{acc}	Probability of a serious accidental spillage in one year over a given road length		0.0083	0.0018	0.0076	0.0030		0.0012	0.0028	0.0018	0.0002	0.0000	
P_{acc} as a probability factor	1 / P_{acc}		120	569	131	335		806	359	548	6018	32830	
RL	Road length in kilometres	km	2.78	1.238	0.99	2.36	7.368	0.98	2.2	1.32	0.725	0.385	2.43
SS	Serious spillage rates (from Volume 11 DMRB: Table 3.2, p A3/4)		0.0022	0.0032	0.0106	0.0022		0.0022	0.0022	0.0022	0.0032	0.0296	
AADT	Annual average daily traffic		46526	17370	33152	17520		17520	17520	19145	2453	2441	
% HGV	Percentage of heavy goods vehicles	%	8	7	6	9		9	9	9	8	0.3	
Acceptable risk of a pollution incident - for discharge to aquifers and sensitive watercourses			*2 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*		*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	
Acceptable risk of a pollution incident - for discharge to all other watercourses			*2 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*		*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	
Probability that a spillage will cause a pollution incident													
Formula	$P_{pol\ per\ year}$ = P_{acc} x P_{pol}		0.0062	0.0013	0.0057	0.0022		0.0009	0.0021	0.0014	0.0001	0.0000	
P_{acc}	see above												
P_{pol}	Risk reduction factor Vol 11 DMRB: Table 3.3, p A3/4; assumed emergency response time >20min		0.75	0.75	0.75	0.75		0.75	0.75	0.75	0.75	0.75	
P_{pol} as a probability factor	**1 / P_{pol} per year**		160	758	175	446	**64**	1075	479	730	8024	43773	**659**
Is the spillage risk within acceptable limits?			Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
WITH MITIGATION MEASURES:													
Control Measure 1:	$P_{pol\ per\ year}$ (reduced by 65%)		0.0022	0.0005	0.0020	0.0008		0.0003	0.0007	0.0005	0.0000	0.0000	
(FILTER DRAIN)	P_{pol} as a probability factor		458	2167	500	1275		3070	1368	2086	22925	125065	
Control Measure 2:	$P_{pol\ per\ year}$ (reduced by 65%)		0.0008	0.0002	0.0007	0.0003		0.0001	0.0003	0.0002	0.0000	0.0000	
(TREATMENT POND)	P_{pol} as a probability factor		1310	6191	1429	3642		8772	3907				
Control Measure 3:	$P_{pol\ per\ year}$ (reduced by 65%)		0.0003	0.0001	0.0002	0.0001		0.0000	0.0001				
(TREATMENT POND)	P_{pol} as a probability factor		3743	17688	4082	10407							
Control Measure 4:	$P_{pol\ per\ year}$ (reduced by 65%)		0.0001	0.0000	0.0001	0.0000							
(TREATMENT POND)	P_{pol} as a probability factor		10694	50537	11662	29735	**4298**	**25062**	**11164**	5960	65499	357329	**5380**
Is the spillage risk with mitigation within acceptable limits?			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Item	Description	Units	Corsehill Burn Run N Mainline	Corsehill Burn Run N Sliproads	Corsehill Burn Run N A947 Roundabout	Corsehill Burn Run N Side Road	Corsehill Burn Total	Red Moss Burn Run O Mainline	Blackdog Burn Run P and Q Mainline	Blackdog Burn Run Q Sliproads	Blackdog Burn Run Q Roundabout	Blackdog Burn Run Q A90	Blackdog Burn Total	Middlefield Burn Run R Side Road	Middlefield Burn Run R Roundabout	Middlefield Burn Total
Probability of a serious accidental spillage																
Section of Road or Junction																
Formula	P_{acc} = RL x SS x (AADT x 365 x 10^{-9}) x (% HGV /100)															
P_{acc}	Probability of a serious accidental spillage in one year over a given road length		0.0020	0.0002	0.0000	0.0000		0.0017	0.0047	0.0000	0.0077	0.0005		0.0004	0.0032	
P_{acc} as a probability factor	1 / P_{acc}		505	4269	28160	263793		574	214	314840	131	2192		2656	317	
RL	Road length in kilometres	km	1.43	0.74	0.59	0.005	2.765	1.26	3.37	0.56	0.655	0.3	4.885	0.09	0.27	0.36
SS	Serious spillage rates (from Volume 11 DMRB: Table 3.2, p A3/4)		0.0022	0.0032	0.0296	0.0106		0.0022	0.0022	0.0032	0.0296	0.0022		0.0106	0.0296	
AADT	Annual average daily traffic		19145	4517	5571	4899		19145	19145	2428	10814	21042		10814	10814	
% HGV	Percentage of heavy goods vehicles	%	9	6	0.1	4		9	9	0.2	10	9		10	10	
Acceptable risk of a pollution incident - for discharge to aquifers and sensitive watercourses			*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*		*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*	*1 in a 100 years*		*1 in a 100 years*	*1 in a 100 years*	
Acceptable risk of a pollution incident - for discharge to all other watercourses			*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*		*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*	*1 in 50 years*		*1 in 50 years*	*1 in 50 years*	
Probability that a spillage will cause a pollution incident																
Formula	$P_{pol\ per\ year}$ = P_{acc} x P_{pol}		0.0015	0.0002	0.0000	0.0000		0.0013	0.0035	0.0000	0.0057	0.0003		0.0003	0.0024	
P_{acc}	see above															
P_{pol}	Risk reduction factor Vol 11 DMRB: Table 3.3, p A3/4; assumed emergency response time >20min		0.75	0.75	0.75	0.75		0.75	0.75	0.75	0.75	0.75		0.75	0.75	
P_{pol} as a probability factor	**1 / P_{pol} per year (witout mitigation)**		674	5692	37546	351724	**592**	765	286	419787	174	2923	**104**	3541	423	**378**
Is the spillage risk within acceptable limits?			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
WITH MITIGATION MEASURES:																
Control Measure 1:	$P_{pol\ per\ year}$ (reduced by 65%)		0.0005	0.0001	0.0000	0.0000		0.0005	0.0012	0.0000	0.0020	0.0001		0.0001	0.0008	
(FILTER DRAIN)	P_{pol} as a probability factor		1925	16263	107276	1004927		2185	817	1199392	498	8350		10117	1208	
Control Measure 2:	$P_{pol\ per\ year}$ (reduced by 65%)		0.0002	0.0000	0.0000	0.0000		0.0002	0.0004	0.0000	0.0007	0.0000		0.0000	0.0003	
(TREATMENT POND)	P_{pol} as a probability factor															
Control Measure 3:	$P_{pol\ per\ year}$ (reduced by 65%)															
(TREATMENT POND)	P_{pol} as a probability factor															
Control Measure 4:	$P_{pol\ per\ year}$ (reduced by 65%)								0.0004	0.0000	0.0007	0.0000		0.0000	0.0003	
(TREATMENT POND)	P_{pol} as a probability factor		5501	46465	306502	2871220	**4833**	**6243**	2334	3426834	1422	23858	**852**	28905	3450	**3082**
Is the spillage risk with mitigation within acceptable limits?			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Annex 29 Pollution Risk Calculations

Scheme: Aberdeen Western Peripheral Route Northern Leg **Job No:** **10332**
Routine Runoff Pollution Risk Assessment (Dangerous Substance Directive)
Without Mitigation
95-Percentile EQS

Item	**Description**	**Units**	**Green Burn Runs I and J**	**Bogenjoss Burn Run K**	**River Don Run L**	**Goval Burn Run M**	**Corsehill Burn Run N**	**Red Moss Burn Run O**	**Blackdog Burn Runs P and Q**	**Middlefield Burn Run R**
Water Quality Prediction										
Data from Regulatory Authority										
Q95 i.e. 95-percentile flow (flow exceeded 95% of the time)		m^3/sec	0.005	0.005	5.2	0.079	0.004	0.004	0.011	0.001
Existing Water Quality Class	River Quality Objective				A2	B				
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*50-100 assumed*	*50-100 assumed*	65	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*
C_b	Upstream dissolved copper data as mg/l (assume half of EQS; River Don - SEPA data)	mg/l	0.020	0.020	0.013	0.020	0.020	0.020	0.020	0.020
Zn_b	Upstream total zinc as mg/l (assume half of EQS; River Don - SEPA data)	mg/l	0.150	0.150	0.029	0.150	0.150	0.150	0.150	0.150
EQS Cu based on RQO	*Permitted Environmental Quality Standard for copper as mg/l (95 percentile)*	*mg/l*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*
EQS Zn based on RQO	*Permitted Environmental Quality Standard for zinc as mg/l (95 percentile)*	*mg/l*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*
Other data										
AADT	Annual average daily traffic		46526	17520	17520	19145	19145	19145	19145	10814
RL	Road length (m)	m	7368	980	2200	2430	2765	1260		
RW	Road width (m)	m		2 x 9.3	2 x 9.3					
RC	Runoff coefficient		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Rain	Rainfall depth (from Volume 11, page A3/5 Fig 3.1) (mm)	mm	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
PBUR (pollutant build up rate)	See page A3/2 Table 3.1 in Vol.11 - based on traffic flow Cu (dissolved)	kg/ha/annum	1.2	0.4	0.4	0.4	0.4	0.4	0.4	0.3
	Zn (total)	kg/ha/annum	5.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0
Calculations										
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	126618	18228	40920	35175	38869	23436	83074	3427
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	1282.01	184.56	414.32	356.15	393.55	237.29	841.12	34.70
3. Q95 in m^3/day	= Q_5 flow x 3600 x 24	m^3/day	432	432	449280	6825.6	345.6	345.6	950.4	86.4
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.2081	0.0100	0.0224	0.0193	0.0213	0.0128	0.0455	0.0014
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.8672	0.0499	0.1121	0.0964	0.1065	0.0642	0.2276	0.0047
Resulting dissolved copper concentration in the water course downstream (C_r):										
Formula	C_r = {(C_b x Q_{95}) + (1000 x M_{cu})} / (Q95 +V) mg/l (1000 x M_{cu})		208.14	9.99	22.42	19.27	21.30	12.84	45.52	1.41
	(Q95 + V)		1714.01	616.56	449694.32	7181.75	739.15	582.89	1791.52	121.10
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.126**	**0.030**	**0.013**	**0.022**	**0.038**	**0.034**	**0.036**	**0.026**
Resulting total zinc concentration in the watercourse (Zn_r):										
Formula	Zn_r = {Zn_b x Q_{95})+ {(1000 x M_{zn})} / (Q95 +V) mg/l		867.25	49.94	112.11	96.37	106.49	64.21	227.60	4.69
	(Q95 + V)		1714.01	616.56	449694.32	7181.75	739.15	582.89	1791.52	121.10
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.544**	**0.186**	**0.029**	**0.156**	**0.214**	**0.199**	**0.207**	**0.146**
Does predicted dissolved copper concentration comply with the EQS?			**N**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Does predicted total zinc concentration comply with the EQS?			**N**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**

Percentage over Base Line Value	**Copper**	**%**	532%	51%	0%	8%	91%	69%	80%	29%
	Zinc	**%**	263%	24%	1%	4%	43%	33%	38%	-3%

Note: Spreadsheet incorporates Volume 11 of Design Manual for Roads and Bridges amendment dated November 2002
RW (road width) values were not required to calculate TIA (Total Impermeable Area) as these were provided by the engineers
A conservative value of 0.75 has been assumed for the run-off co-efficient

NOTES:

Run I	Used AADT for mainline to the North of North Kingswells junction
Run J	Used AADT for mainline to the North of North Kingswells junction
Run K	Used AADT for mainline to the South of East Woodlands
Run L	Used AADT at the crossing of the River Don
Run M	Used AADT for mainline to the East of Goval junction
Run N	Used AADT for mainline to the East of Goval junction
Run O	Used AADT for mainline to the East of Goval junction
Run P	Used AADT for mainline to the East of Goval junction
Run Q	Used AADT for mainline to the East of Goval junction
Run R	Used AADT for roundabout at Blackdog junction

Scheme: Aberdeen Western Peripheral Route Northern Leg **Job No:** **10332**
Routine Runoff Pollution Risk Assessment (Dangerous Substance Directive)
Without Mitigation
Annual Average EQS (Using DMRB Method but based on Annual Averages)

Item	**Description**	**Units**	**Green Burn** Runs I and J	**Bogenjoss Burn** Run K	**River Don** Run L	**Goval Burn** Run M	**Corsehill Burn** Run N	**Red Moss Burn** Run O	**Blackdog Burn** Runs P and Q	**Middlefield Burn** Run R
Water Quality Prediction										
Data from Regulatory Authority										
Qmean i.e. mean flow		m^3/sec	0.037	0.021	19.536	0.579	0.026	0.017	0.079	0.005
Existing Water Quality Class	River Quality Objective				A2	B			A2	
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*50-100 assumed*	*50-100 assumed*	*65*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*
C_b	Upstream dissolved copper data as mg/l (assume half of EQS; River Don - SEPA data)	mg/l	0.005	0.005	0.006	0.005	0.005	0.005	0.005	0.005
Zn_b	Upstream total zinc as mg/l (assume half of EQS; River Don - SEPA data)	mg/l	0.038	0.038	0.026	0.038	0.038	0.038	0.038	0.038
EQS Cu based on RQO	*Permitted Environmental Quality Standard for copper as mg/l (Annual Average)*	*mg/l*	*0.010*	*0.010*	*0.010*	*0.010*	*0.010*	*0.010*	*0.010*	*0.010*
EQS Zn based on RQO	*Permitted Environmental Quality Standard for zinc as mg/l (Annual Average)*	*mg/l*	*0.075*	*0.075*	*0.075*	*0.075*	*0.075*	*0.075*	*0.075*	*0.075*
Other data										
AADT	Annual average daily traffic		46526	17520	17520	19145	19145	19145	19145	10814
RL	Road length (m)	m	7368							
RW	Road width (m)	m		2 x 9.3	2 x 9.3					
RC	Runoff coefficient		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Rain	Rainfall depth (from Volume 11, page A3/6 Fig 3.2) (mm)	mm	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
PBUR (pollutant build up rate)	See page A3/2 Table 3.1 in Vol.11 - based on traffic flow Cu (dissolved)	kg/ha/annum	1.2	0.4	0.4	0.4	0.4	0.4	0.4	0.3
	Zn (total)	kg/ha/annum	5.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0
Calculations										
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	126618	18228	40920	35175	38869	23436	83074	3427
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	256.40	36.91	82.86	71.23	78.71	47.46	168.22	6.94
3. Q50 in m^3/day	= Q_{50} flow x 3600 x 24	m^3/day	3196.8	1814.4	1687910.4	50025.6	2246.4	1468.8	6825.6	432
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.2081	0.0100	0.0224	0.0193	0.0213	0.0128	0.0455	0.0014
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.8672	0.0499	0.1121	0.0964	0.1065	0.0642	0.2276	0.0047
Resulting dissolved copper concentration in the water course downstream (C_r):										
Formula	C_r = {(C_b x Q_{50}) + (1000 x M_{cu})} / (Q50 +V) mg/l (1000 x M_{cu})		208.14	9.99	22.42	19.27	21.30	12.84	45.52	1.41
	(Q50 + V)		3453.20	1851.31	1687993.26	50096.83	2325.11	1516.26	6993.82	438.94
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.065**	**0.010**	**0.006**	**0.005**	**0.014**	**0.013**	**0.011**	**0.008**
Resulting total zinc concentration in the watercourse (Zn_r):										
Formula	Zn_r = {Zn_b x Q_{50})+ {(1000 x M_{zn})} / (Q50 +V) mg/l		867.25	49.94	112.11	96.37	106.49	64.21	227.60	4.69
	(Q50 + V)		3453.20	1851.31	1687993.26	50096.83	2325.11	1516.26	6993.82	438.94
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.286**	**0.064**	**0.026**	**0.039**	**0.082**	**0.079**	**0.069**	**0.048**
Does predicted dissolved copper concentration comply with the EQS?			**N**	**N**	**Y**	**Y**	**N**	**N**	**N**	**Y**
Does predicted total zinc concentration comply with the EQS?			**N**	**Y**	**Y**	**Y**	**N**	**N**	**Y**	**Y**
	Percentage over Base Line Value **Copper**	**%**	1198%	106%	0%	8%	180%	166%	128%	63%
	Zinc	**%**	662%	70%	0%	5%	119%	110%	84%	27%

Note: Spreadsheet incorporates Volume 11 of Design Manual for Roads and Bridges amendment dated November 2002
RW (road width) values were not required to calculate TIA (Total Impermeable Area) as these were provided by the engineers
A conservative value of 0.75 has been assumed for the run-off co-efficient

NOTES:

Run I	Used AADT for mainline to the North of North Kingswells junction
Run J	Used AADT for mainline to the North of North Kingswells junction
Run K	Used AADT for mainline to the South of East Woodlands
Run L	Used AADT at the crossing of the River Don
Run M	Used AADT for mainline to the East of Goval junction
Run N	Used AADT for mainline to the East of Goval junction
Run O	Used AADT for mainline to the East of Goval junction
Run P	Used AADT for mainline to the East of Goval junction
Run Q	Used AADT for mainline to the East of Goval junction
Run R	Used AADT for roundabout at Blackdog junction

Scheme: Aberdeen Western Peripheral Route Northern Leg **Job No:** **10332**
Routine Runoff Pollution Risk Assessment (Freshwater Fisheries Directive)
Without Mitigation
95-Percentile EQS

Item	Description	Units	Green Burn Runs I and J	Bogenjoss Burn Run K	River Don Run L	Goval Burn Run M	Corsehill Burn Run N	Red Moss Burn Run O	Blackdog Burn Runs P and Q	Middlefield Burn Run R
Water Quality Prediction										
Data from Regulatory Authority										
Q95 i.e. 95-percentile flow (flow exceeded 95% of the time)		m^3/sec	0.005	0.005	5.2	0.079	0.004	0.004	0.011	0.001
Existing Water Quality Class	River Quality Objective				A2	B				
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*50-100 assumed*	*50-100 assumed*	65	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*
C_b	Upstream dissolved copper data as mg/l (assume half of EQS; River Don - SEPA data)	mg/l	0.020	0.020	0.013	0.020	0.020	0.020	0.020	0.020
Zn_b	Upstream total zinc as mg/l (assume half of EQS; River Don - SEPA data)	mg/l	0.150	0.150	0.029	0.150	0.150	0.150	0.150	0.150
EQS Cu based on RQO	*Permitted Environmental Quality Standard for copper as mg/l (95 percentile)*	*mg/l*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*
EQS Zn based on RQO	*Permitted Environmental Quality Standard for zinc as mg/l (95 percentile)*	*mg/l*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*
Other data										
AADT	Annual average daily traffic		46526	17520	17520	19145	19145	19145	19145	10814
RL	Road length (m)	m	7368	980	2200	2430	2765	1260		
RW	Road width (m)	m								
RC	Runoff coefficient		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Rain	Rainfall depth (from Volume 11, page A3/5 Fig 3.1) (mm)	mm	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
PBUR (pollutant build up rate)	See page A3/2 Table 3.1 in Vol.11 - based on traffic flow Cu (dissolved)	kg/ha/annum	1.2	0.4	0.4	0.4	0.4	0.4	0.4	0.3
	Zn (total)	kg/ha/annum	5.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0
Calculations										
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	126618	18228	40920	35175	38869	23436	83074	3427
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	1282.01	184.56	414.32	356.15	393.55	237.29	841.12	34.70
3. Q95 in m^3/day	= Q_5 flow x 3600 x 24	m^3/day	432	432	449280	6825.6	345.6	345.6	950.4	86.4
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.2081	0.0100	0.0224	0.0193	0.0213	0.0128	0.0455	0.0014
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.8672	0.0499	0.1121	0.0964	0.1065	0.0642	0.2276	0.0047
Resulting dissolved copper concentration in the water course downstream (C_r):										
Formula	C_r = {(C_b x Q_{95}) + (1000 x M_{cu})} / (Q95 +V) mg/l (1000 x M_{cu})		208.14	9.99	22.42	19.27	21.30	12.84	45.52	1.41
	(Q95 + V)		1714.01	616.56	449694.32	7181.75	739.15	582.89	1791.52	121.10
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.126**	**0.030**	**0.013**	**0.022**	**0.038**	**0.034**	**0.036**	**0.026**
Resulting total zinc concentration in the watercourse (Zn_r):										
Formula	Zn_r = {Zn_b x Q_{95})+ {(1000 x M_{zn})} / (Q95 +V) mg/l		867.25	49.94	112.11	96.37	106.49	64.21	227.60	4.69
	(Q95 + V)		1714.01	616.56	449694.32	7181.75	739.15	582.89	1791.52	121.10
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.544**	**0.186**	**0.029**	**0.156**	**0.214**	**0.199**	**0.207**	**0.146**
Does predicted dissolved copper concentration comply with the EQS?			N	Y	Y	Y	Y	Y	Y	Y
Does predicted total zinc concentration comply with the EQS?			N	Y	Y	Y	Y	Y	Y	Y

Percentage over Base Line Value	**Copper**	**%**	532%	51%	0%	8%	91%	69%	80%	29%
	Zinc	**%**	263%	24%	1%	4%	43%	33%	38%	-3%

Note: Spreadsheet incorporates Volume 11 of Design Manual for Roads and Bridges amendment dated November 2002
RW (road width) values were not required to calculate TIA (Total Impermeable Area) as these were provided by the engineers
A conservative value of 0.75 has been assumed for the run-off co-efficient

NOTES:

Run I	Used AADT for mainline to the North of North Kingswells junction
Run J	Used AADT for mainline to the North of North Kingswells junction
Run K	Used AADT for mainline to the South of East Woodlands
Run L	Used AADT at the crossing of the River Don
Run M	Used AADT for mainline to the East of Goval junction
Run N	Used AADT for mainline to the East of Goval junction
Run O	Used AADT for mainline to the East of Goval junction
Run P	Used AADT for mainline to the East of Goval junction
Run Q	Used AADT for mainline to the East of Goval junction
Run R	Used AADT for roundabout at Blackdog junction

Scheme: Aberdeen Western Peripheral Route Northern Leg **Job No:** **10332**
Routine Runoff Pollution Risk Assessment (Dangerous Substance Directive)
With Mitigation
95-Percentile EQS

Item	Description	Units	Green Burn Runs I and J	Bogenjoss Burn Run K	River Don Run L	Goval Burn Run M	Corsehill Burn Run N	Red Moss Burn Run O	Blackdog Burn Runs P and Q	Middlefield Burn Run R
Water Quality Prediction										
Data from Regulatory Authority										
Q95 i.e. 95-percentile flow (flow exceeded 95% of the time)		m^3/sec	0.005	0.005	5.2	0.079	0.004	0.004	0.011	0.001
Existing Water Quality Class	River Quality Objective				A2	B				
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*50-100 assumed*	*50-100 assumed*	65	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*
C_b	Upstream dissolved copper data as mg/l (assume half of EQS - River Don SEPA data)	mg/l	0.020	0.020	0.013	0.020	0.020	0.020	0.020	0.020
Zn_b	Upstream total zinc as mg/l (assume half of EQS - River Don SEPA data)	mg/l	0.150	0.150	0.029	0.150	0.150	0.150	0.150	0.150
EQS Cu based on RQO	*Permitted Environmental Quality Standard for copper as mg/l (95 percentile)*	*mg/l*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*
EQS Zn based on RQO	*Permitted Environmental Quality Standard for zinc as mg/l (95 percentile)*	*mg/l*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*
Other data										
AADT	Annual average daily traffic		46526	17520	17520	19145	19145	19145	19145	10814
RL	Road length (m)	m								
RW	Road width (m)	m		2 x 9.3	2 x 9.3					
RC	Runoff coefficient		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Rain	Rainfall depth (from Volume 11, page A3/5 Fig 3.1) (mm)	mm	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
PBUR (pollutant build up rate)	See page A3/2 Table 3.1 in Vol.11 - based on traffic flow Cu (dissolved)	kg/ha/annum	0.041	0.090	0.039	0.112	0.112	0.112	0.112	0.084
	Zn (total)	kg/ha/annum	0.054	0.123	0.061	0.175	0.175	0.175	0.175	0.088
Calculations										
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	126618	18228	40920	35175	38869	23436	83074	3427
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	1282.01	184.56	414.32	356.15	393.55	237.29	841.12	34.70
3. Q95 in m^3/day	= Q_5 flow x 3600 x 24	m^3/day	432	432	449280	6825.6	345.6	345.6	950.4	86.4
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.0071	0.0022	0.0022	0.0054	0.0060	0.0036	0.0127	0.0004
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.0093	0.0031	0.0034	0.0084	0.0093	0.0056	0.0199	0.0004
Resulting dissolved copper concentration in the water course downstream (C_r):										
Formula	$C_r = \{(C_b \times Q_{95}) + (1000 \times M_{cu})\} / (Q95 + V)$ mg/l (1000 x M_{cu})		7.14	2.24	2.20	5.40	5.96	3.60	12.75	0.39
	(Q95 + V)		1714.01	616.56	449694.32	7181.75	739.15	582.89	1791.52	121.10
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.009**	**0.018**	**0.013**	**0.020**	**0.017**	**0.018**	**0.018**	**0.018**
Resulting total zinc concentration in the watercourse (Zn_r):										
Formula	$Zn_r = \{Zn_b \times Q_{95}\} + \{(1000 \times M_{zn})\} / (Q95 + V)$ mg/l		9.30	3.06	3.43	8.43	9.32	5.62	19.92	0.41
	(Q95 + V)		1714.01	616.56	449694.32	7181.75	739.15	582.89	1791.52	121.10
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.043**	**0.110**	**0.029**	**0.144**	**0.083**	**0.099**	**0.091**	**0.110**
Does predicted dissolved copper concentration comply with the EQS?			Y	Y	Y	Y	Y	Y	Y	Y
Does predicted total zinc concentration comply with the EQS?			Y	Y	Y	Y	Y	Y	Y	Y
Percentage over Base Line Value	**Copper**	**%**	0%	0%	0%	0%	0%	0%	0%	0%
	Zinc	**%**	0%	0%	0%	0%	0%	0%	0%	0%

		Green Burn	Bogenjoss Burn	River Don	Goval Burn	Corsehill Burn	Red Moss Burn	Blackdog Burn	Middlefield Burn
	Diss Cu	1.2	0.4	0.4	0.4	0.4	0.4	0.4	0.3
	Total Zinc	5.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0
	With Filter Drain reduction								
20% reduction	Diss Cu	0.96	0.32	0.32	0.32	0.32	0.32	0.32	0.24
75% reduction	Total Zinc	1.3	0.5	0.5	0.5	0.5	0.5	0.5	0.3
	With Treatment Pond reduction								
65% reduction	Diss Cu	0.336	0.112	0.112	0.112	0.112	0.112	0.112	0.084
65% reduction	Total Zinc	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.1
	With Treatment Pond reduction								
65% reduction	Diss Cu	0.1176	0.0896	0.0392					
65% reduction	Total Zinc	0.2	0.1	0.1					
	With Treatment Pond reduction								
65% reduction	Diss Cu	0.04116							
65% reduction	Total Zinc	0.05359375							
			Swale						

NOTES:

Spreadsheet incorporates Volume 11 of Design Manual for Roads and Bridges amendment dated November 2002
RW (road width) values were not required to calculate TIA (Total Impermeable Area) as these were provided by the engineers
A conservative value of 0.75 has been assumed for the run-off co-efficient

Run I	Used AADT for mainline to the North of North Kingswells junction
Run J	Used AADT for mainline to the North of North Kingswells junction
Run K	Used AADT for mainline to the South of East Woodlands
Run L	Used AADT at the crossing of the River Don
Run M	Used AADT for mainline to the East of Goval junction
Run N	Used AADT for mainline to the East of Goval junction
Run O	Used AADT for mainline to the East of Goval junction
Run P	Used AADT for mainline to the East of Goval junction
Run Q	Used AADT for mainline to the East of Goval junction
Run R	Used AADT for roundabout at Blackdog junction

Mitigation assumes the following:
Filter drains: 20% reduction in dissolved copper
75% reduction in total zinc
Treatment Pond: 65% reduction in dissolved copper
65% reduction in total zinc
Swale: 20% reduction in dissolved copper
30% reduction in total zinc

Aberdeen Western Peripheral Route

Environmental Statement Appendices 2007

Part B: Northern Leg

Appendix A9.5 - Water Environment Annexes

Scheme: Aberdeen Western Peripheral Route Northern Leg **Job No:** **10332**

Routine Runoff Pollution Risk Assessment (Dangerous Substance Directive)

With Mitigation

Annual Average EQS (Using DMRB Method but based on Annual Averages)

Item	Description	Units	Green Burn Runs I and J	Bogenjoss Burn Run K	River Don Run L	Goval Burn Run M	Corsehill Burn Run N	Red Moss Burn Run O	Blackdog Burn Runs P and Q	Middlefield Burn Run R
Water Quality Prediction										
Data from Regulatory Authority										
Qmean i.e. mean flow		m^3/sec	0.037	0.021	19.536	0.579	0.026	0.017	0.079	0.005
Existing Water Quality Class	River Quality Objective				A2	B				
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*50-100 assumed*	*50-100 assumed*	*65*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*
C_b	Upstream dissolved copper data as mg/l (assume half of EQS - River Don SEPA data)	mg/l	0.005	0.005	0.006	0.005	0.005	0.005	0.005	0.005
Zn_b	Upstream total zinc as mg/l (assume half of EQS - River Don SEPA data)	mg/l	0.038	0.038	0.026	0.038	0.038	0.038	0.038	0.038
EQS Cu based on RQO	*Permitted Environmental Quality Standard for copper as mg/l (Annual Average)*	*mg/l*	*0.010*	*0.010*	*0.010*	*0.010*	*0.010*	*0.010*	*0.010*	*0.010*
EQS Zn based on RQO	*Permitted Environmental Quality Standard for zinc as mg/l (Annual Average)*	*mg/l*	*0.075*	*0.075*	*0.075*	*0.075*	*0.075*	*0.075*	*0.075*	*0.075*
Other data										
AADT	Annual average daily traffic		46526	17520	17520	19145	19145	19145	19145	10814
RL	Road length (m)	m		1660	1530					
RW	Road width (m)	m		2 x 9.3	2 x 9.3					
RC	Runoff coefficient		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Rain	Rainfall depth (from Volume 11, page A3/6 Fig 3.2) (mm)	mm	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
PBUR (pollutant build up rate)	See page A3/2 Table 3.1 in Vol.11 - based on traffic flow Cu (dissolved)	kg/ha/annum	0.04116	0.0896	0.0392	0.112	0.112	0.112	0.112	0.084
	Zn (total)	kg/ha/annum	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1
Calculations										
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	126618	18228	40920	35175	38869	23436	83074	3427
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	256.40	36.91	82.86	71.23	78.71	47.46	168.22	6.94
3. Q50 in m^3/day	= Q_{50} flow x 3600 x 24	m^3/day	3196.8	1814.4	1687910.4	50025.6	2246.4	1468.8	6825.6	432
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.0071	0.0022	0.0022	0.0054	0.0060	0.0036	0.0127	0.0004
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.0093	0.0031	0.0034	0.0084	0.0093	0.0056	0.0199	0.0004
Resulting dissolved copper concentration in the water course downstream (C_r):										
Formula	$C_r = \{(C_b \times Q_{50}) + (1000 \times M_{cu})\} / (Q50 + V)$ mg/l (1000 x M_{cu})		7.14	2.24	2.20	5.40	5.96	3.60	12.75	0.39
	(Q50 + V)		3453.20	1851.31	1687993.26	50096.83	2325.11	1516.26	6993.82	438.94
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.007**	**0.006**	**0.006**	**0.005**	**0.007**	**0.007**	**0.007**	**0.006**
Resulting total zinc concentration in the watercourse (Zn_r):										
Formula	$Zn_r = \{Zn_b \times Q_{50}\} + \{(1000 \times M_{zn})\} / (Q50 + V)$ mg/l		9.30	3.06	3.43	8.43	9.32	5.62	19.92	0.41
	(Q50 + V)		3453.20	1851.31	1687993.26	50096.83	2325.11	1516.26	6993.82	438.94
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.037**	**0.038**	**0.026**	**0.038**	**0.040**	**0.040**	**0.039**	**0.038**
Does predicted dissolved copper concentration comply with the EQS?			Y	Y	Y	Y	Y	Y	Y	Y
Does predicted total zinc concentration comply with the EQS?			Y	Y	Y	Y	Y	Y	Y	Y

			Green Burn	Bogenjoss Burn	River Don	Goval Burn	Corsehill Burn	Red Moss Burn	Blackdog Burn	Middlefield Burn
Percentage over Base Line Value	**Copper**	**%**	34%	22%	0%	2%	48%	44%	34%	16%
	Zinc	**%**	0%	2%	0%	0%	7%	7%	5%	1%

		Green Burn	Bogenjoss Burn	River Don	Goval Burn	Corsehill Burn	Red Moss Burn	Blackdog Burn	Middlefield Burn
	Original PBUR (pollutant build up rate)								
	Diss Cu	1.2	0.4	0.4	0.4	0.4	0.4	0.4	0.3
	Total Zinc	5.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0
	With Filter Drain reduction								
20% reduction	Diss Cu	0.96	0.32	0.32	0.32	0.32	0.32	0.32	0.24
75% reduction	Total Zinc	1.3	0.5	0.5	0.5	0.5	0.5	0.5	0.3
	With Treatment Pond reduction								
65% reduction	Diss Cu	0.336	0.112	0.112	0.112	0.112	0.112	0.112	0.084
65% reduction	Total Zinc	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.1
	With Treatment Pond reduction								
65% reduction	Diss Cu	0.1176	0.0896	0.0392					
65% reduction	Total Zinc	0.2	0.1	0.1					
	With Treatment Pond reduction								
65% reduction	Diss Cu	0.04116							
65% reduction	Total Zinc	0.05359375							
			Swale						

NOTES:

Spreadsheet incorporates Volume 11 of Design Manual for Roads and Bridges amendment dated November 2002

RW (road width) values were not required to calculate TIA (Total Impermeable Area) as these were provided by the engineers

A conservative value of 0.75 has been assumed for the run-off co-efficient

Run I	Used AADT for mainline to the North of North Kingswells junction
Run J	Used AADT for mainline to the North of North Kingswells junction
Run K	Used AADT for mainline to the South of East Woodlands
Run L	Used AADT at the crossing of the River Don
Run M	Used AADT for mainline to the East of Goval junction
Run N	Used AADT for mainline to the East of Goval junction
Run O	Used AADT for mainline to the East of Goval junction
Run P	Used AADT for mainline to the East of Goval junction
Run Q	Used AADT for mainline to the East of Goval junction
Run R	Used AADT for roundabout at Blackdog junction

Mitigation assumes the following:

Filter drains:	20% reduction in dissolved copper
	75% reduction in total zinc
Treatment Pond:	65% reduction in dissolved copper
	65% reduction in total zinc
Swale:	20% reduction in dissolved copper
	30% reduction in total zinc

Aberdeen Western Peripheral Route

Environmental Statement Appendices 2007

Part B: Northern Leg

Appendix A9.5 - Water Environment Annexes

Scheme: Aberdeen Western Peripheral Route Northern Leg **Job No:** **10332**

Routine Runoff Pollution Risk Assessment (Freshwater Fisheries Directive)

With Mitigation

95-Percentile EQS

Item	Description	Units	Green Burn Runs I and J	Bogenjoss Burn Run K	River Don Run L	Goval Burn Run M	Corsehill Burn Run N	Red Moss Burn Run O	Blackdog Burn Runs P and Q	Middlefield Burn Run R
Water Quality Prediction										
Data from Regulatory Authority										
Q95 i.e. 95-percentile flow (flow exceeded 95% of the time)		m^3/sec	0.005	0.005	5.2	0.079	0.004	0.004	0.011	0.001
Existing Water Quality Class	River Quality Objective				A2	B				
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*50-100 assumed*	*50-100 assumed*	65	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*	*50-100 assumed*
C_b	Upstream dissolved copper data as mg/l (assume half of EQS - River Don SEPA data)	mg/l	0.020	0.020	0.013	0.020	0.020	0.020	0.020	0.020
Zn_b	Upstream total zinc as mg/l (assume half of EQS - River Don SEPA data)	mg/l	0.150	0.150	0.029	0.150	0.150	0.150	0.150	0.150
EQS Cu based on RQO	*Permitted Environmental Quality Standard for copper as mg/l (95 percentile)*	*mg/l*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*	*0.040*
EQS Zn based on RQO	*Permitted Environmental Quality Standard for zinc as mg/l (95 percentile)*	*mg/l*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*	*0.300*
Other data										
AADT	Annual average daily traffic		46526	17520	17520	19145	19145	19145	19145	10814
RL	Road length (m)	m								
RW	Road width (m)	m		2 x 9.3	2 x 9.3					
RC	Runoff coefficient		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Rain	Rainfall depth (from Volume 11, page A3/5 Fig 3.1) (mm)	mm	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
PBUR (pollutant build up rate)	See page A3/2 Table 3.1 in Vol.11 - based on traffic flow Cu (dissolved)	kg/ha/annum	0.04116	0.0896	0.0392	0.112	0.112	0.112	0.112	0.084
	Zn (total)	kg/ha/annum	0.1	0.1	0.1	0.2	0.2	0.2	0.175	0.1
Calculations										
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	126618	18228	40920	35175	38869	23436	83074	3427
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	1282.01	184.56	414.32	356.15	393.55	237.29	841.12	34.70
3. Q95 in m^3/day	= Q_5 flow x 3600 x 24	m^3/day	432	432	449280	6825.6	345.6	345.6	950.4	86.4
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.0071	0.0022	0.0022	0.0054	0.0060	0.0036	0.0127	0.0004
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.0093	0.0031	0.0034	0.0084	0.0093	0.0056	0.0199	0.0004
Resulting dissolved copper concentration in the water course downstream (C_r):										
Formula	$C_r = \{(C_b \times Q_{95}) + (1000 \times M_{cu})\} / (Q95 + V)$ mg/l (1000 x M_{cu})		7.14	2.24	2.20	5.40	5.96	3.60	12.75	0.39
	(Q95 + V)		1714.01	616.56	449694.32	7181.75	739.15	582.89	1791.52	121.10
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.009**	**0.018**	**0.013**	**0.020**	**0.017**	**0.018**	**0.018**	**0.018**
Resulting total zinc concentration in the watercourse (Zn_r):										
Formula	$Zn_r = \{Zn_b \times Q_{95}\} + \{(1000 \times M_{zn})\} / (Q95 + V)$ mg/l		9.30	3.06	3.43	8.43	9.32	5.62	19.92	0.41
	(Q95 + V)		1714.01	616.56	449694.32	7181.75	739.15	582.89	1791.52	121.10
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.043**	**0.110**	**0.029**	**0.144**	**0.083**	**0.099**	**0.091**	**0.110**
Does predicted dissolved copper concentration comply with the EQS?			Y	Y	Y	Y	Y	Y	Y	Y
Does predicted total zinc concentration comply with the EQS?			Y	Y	Y	Y	Y	Y	Y	Y
Percentage over Base Line Value	**Copper**	%	0%	0%	0%	0%	0%	0%	0%	0%
	Zinc	%	0%	0%	0%	0%	0%	0%	0%	0%

	Diss Cu	1.2	0.4	0.4	0.4	0.4	0.4	0.4	0.3
	Total Zinc	5.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0
	With Filter Drain reduction								
20% reduction	Diss Cu	0.96	0.32	0.32	0.32	0.32	0.32	0.32	0.24
75% reduction	Total Zinc	1.3	0.5	0.5	0.5	0.5	0.5	0.5	0.3
	With Treatment Pond reduction								
65% reduction	Diss Cu	0.336	0.112	0.112	0.112	0.112	0.112	0.112	0.084
65% reduction	Total Zinc	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.1
	With Treatment Pond reduction								
65% reduction	Diss Cu	0.1176	0.0896	0.0392					
65% reduction	Total Zinc	0.2	0.1	0.1					
	With Treatment Pond reduction								
65% reduction	Diss Cu	0.04116							
65% reduction	Total Zinc	0.05359375							
		Swale							

NOTES:

Spreadsheet incorporates Volume 11 of Design Manual for Roads and Bridges amendment dated November 2002

RW (road width) values were not required to calculate TIA (Total Impermeable Area) as these were provided by the engineers

A conservative value of 0.75 has been assumed for the run-off co-efficient

NOTES:

Run I	Used AADT for mainline to the North of North Kingswells junction
Run J	Used AADT for mainline to the North of North Kingswells junction
Run K	Used AADT for mainline to the South of East Woodlands
Run L	Used AADT at the crossing of the River Don
Run M	Used AADT for mainline to the East of Goval junction
Run O	Used AADT for mainline to the East of Goval junction
Run P	Used AADT for mainline to the East of Goval junction
Run Q	Used AADT for mainline to the East of Goval junction
Run R	Used AADT for roundabout at Blackdog junction

Mitigation assumes the following:

Filter drains: 20% reduction in dissolved copper
75% reduction in total zinc

Treatment Pond: 65% reduction in dissolved copper
65% reduction in total zinc

Swale: 20% reduction in dissolved copper
30% reduction in total zinc

Annex 30 Sediment Modelling Assessment of the Construction of the River Don Mainline Approach Roads

30.1 Introduction

General Background

A29.1 Jacobs Babtie has been commissioned by the Aberdeen Western Peripheral Route (AWPR) Managing Agent to undertake the Stage 3 Environmental Impact Assessment of a proposed road scheme near Aberdeen, Scotland. The proposed route will form a new 30km dual carriageway bypassing Aberdeen city on the western side of Aberdeen City with a 15km fast link to Stonehaven. The entire scheme is divided in three sections:

- Northern Leg including the main line from Kingswells to the A90 Blackdog Junction;
- Southern Leg comprising of Charleston to Kingswells main line section; and,
- Fastlink connecting Stonehaven with the Southern Leg route at Milltimber.

A29.2 The Northern Leg comprises a 15km route from Kingswells and Blackdog to the west and north of the City of Aberdeen. Further information about the road scheme is contained in Chapter 4. This report presents an assessment of the risk to the water quality of the River Don as a result of potential sediment release into the River from the proposed mainline approach roads construction site.

A29.3 This report details the findings of the sediment transport modelling of the River Don, to determine potential impacts as a result of released sediment during the construction of the mainline approach roads, and provides possible mitigation measures along with an indication of the overall impact magnitude. Further assessment of the impact of fine sediment release, and impact to morphological diversity is presented in the geomorphology appendix (Appendix A9.3).

Assessment Aims

A29.4 The aim of the sediment modelling is to:

- assess the potential change to suspended sediment concentration levels within the River Don, as a result of sediment being released into the watercourse from the construction site of the mainline approach roads, due to surface water runoff (Figure 9.4 shows the modelling extents).

A29.5 Mathematical modelling, with respect to sediment transport, of the downstream watercourse will enable assessment of the possible impact to sensitive species. Sensitive species in the Don River identified for this assessment are migratory salmonids (e.g. *Salmo salar)*.

A29.6 This report should be read in conjunction with those on Freshwater Ecology, Water Quality, Fluvial Geomorphology and Surface Water Hydrology.

30.2 Approach and Methods

General Approach

A29.7 This section sets out the methodology by which the sediment modelling assessment will be undertaken and should read in conjunction with those covering the general water quality, geomorphology, hydrodynamics, freshwater ecology and hydrology (Appendices A9.4, A9.2, A9.3, A10.16 and A9.1 respectively).

A29.8 The Environmental Impact Assessment is being carried out using the general methodology detailed in Chapter 5, where the level of significance of a predicted impact is assessed based on the sensitivity of the receptor and the magnitude of impact. The system of assessment used will follow the basic methodology detailed below;

- assess the baseline;
- assess potential impact on the River Don;
- suggest mitigation measures for the potential impacts; and,
- assess the residual impact on the River Don as a result of the suggested mitigation measures.

A29.9 Potential impacts on water quality for all small watercourses in the study area are presented in the Water Quality Appendix, while impacts from geomorphological change are presented in Appendix A9.3. Only the predicted impact on the River Don as a result of the construction of the mainline approach roads is presented in this report.

A29.10 For the purposes of this assessment, the indicative criteria used to assess the sensitivity of the receiving watercourses and the magnitude of the predicted impacts is defined in Tables 29-1 and 29-2. The resultant significance of impact is defined by reference to both the sensitivity of the feature and the magnitude of impact, according to the matrix detailed in the water quality assessment. The magnitudes of impact detailed in Table 30-2 are assigned based on the tolerance information of the sensitive species (detailed in Table 30-3 and Table 30-4). The assessment methodology has been discussed and agreed with SEPA.

Table 30-1 – Criteria to Assess the Sensitivity of Water Features

Sensitivity	Criteria
High	Surface Water Quality Large or medium watercourse with pristine or near pristine water quality, Class A1 and A2, respectively. Water quality not significantly affected by anthropogenic factors. Water quality complies with Dangerous Substances EQS's. Water quality does not affect the diversity of species of flora and fauna. Natural or semi-natural ecosystem with sensitive habitats and sustainable fish population. Includes sites with international and European nature conservation designations due to water dependent ecosystems: e.g. Special Protection Area, Special Area of Conservation, Ramsar Site and EC designated freshwater fisheries. Also includes all nature conservation sites of national importance designated by statute including Sites of Special Scientific Interest and National Nature Reserves.
Medium	Surface Water Quality Medium or small watercourse with a measurable degradation in its water quality as a result of anthropogenic factors (may receive road drainage water), Class A2 or B. Ecosystem modified resulting in impacts upon the species diversity of flora and fauna in the watercourse. Moderately sensitive habitats. Includes non-statutory sites of regional or local importance designated for water dependent ecosystems.
Low	Surface Water Quality Heavily modified watercourses or drainage channel with poor water quality, resulting from anthropogenic factors, corresponding to Classes B, C and D. Major change in the species diversity of flora and fauna due to the significant water quality degradation; may receive road drainage water. Fish sporadically present. Low sensitive ecosystem.

Table 30-2 – Criteria to Assess the Magnitude of the Predicted Impact on Water Features

Magnitude	Criteria
High	Surface Water Quality Major shift away from the baseline conditions, fundamental change to water quality condition either by a relatively high amount over a long-term period or by a very high amount over an episode such that watercourse ecology is greatly changed from the baseline situation. Equivalent to downgrading from Class B to D or any change that downgrades a site from good status as this does not comply with the Water Framework Directive. For the purposes of this assessment, a predicted suspended solids concentration of above 30mg/l (exposure longer than 12 hours) will be considered a high magnitude impact (refer to Table 30-3).
Medium	Surface Water Quality A measurable shift from the baseline conditions that may be long-term or temporary. Results in a change in the ecological status of the watercourse. Equivalent to downgrading one class, for example from C to D. For the purposes of this assessment, a predicted suspended solids concentration of above 30 mg/l (exposure for 0-12 hours) will be considered a medium magnitude impact (refer to Table 30-3).
Low	Surface Water Quality Minor shift away from the baseline conditions. Changes in water quality are likely to be relatively small, or be of a minor temporary nature such that watercourse ecology is slightly affected. Equivalent to minor but measurable change within a class. For the purposes of this assessment, a predicted suspended solids concentration of between 20-29mg/l over a short period of time will be considered a low magnitude impact (refer to Table 30-3).
Negligible	Surface Water Quality Very slight change from the baseline conditions such that there is no discernible effect upon the watercourse's ecology results. No change in classification. For the purposes of this assessment, a predicted suspended solids concentration of between 0-19mg/l over a short period of time will be considered a negligible magnitude impact (refer to Table 30-3).

A29.11 Guidance on the tolerances of freshwater pearl mussels to suspended solids was taken from literature prepared by Scottish Natural Heritage (SNH) and the Scottish Environmental Protection Agency (SEPA): Ecology of the Freshwater Pearl Mussel, Conserving Natura 2000 Rivers, Ecology Series No. 2 (Skinner, Young and Hastie 2003)

Table 30-3 – Guidelines for Tolerance of Selected Freshwater Species to Suspended Solid load Freshwater Species

Suspended sediment (mg/l)	Risk to freshwater pearl mussels and their habitat
>30	Unacceptable risk

Source: published advice from the Life in UK Rivers, Conserving Natura 2000 Rivers project.

A29.12 Guidance on the tolerances of salmon to suspended solids was taken from the Canadian Department of Fisheries and Oceans (DFO, 2000). This was based on an assessment of risk to fish and their habitat of elevated levels of suspended solids from mining operations in the Yukon. Table 30-4 summarises the level of risk ascribed to various ranges of increase in suspended solids levels. Alabaster and Lloyd (1982) summarise that levels of suspended sediment below 25 mgl^{-1} will have no harmful effects on fish. 25-80 mgl^{-1} levels are acceptable as a rule of thumb, 80-400 mgl^{-1} are unlikely to support good fisheries and levels over 400 mgl^{-1} generally will not support substantial fish populations (please refer to the freshwater ecology and fish appendices A10.16 and A10.15 for more information). Table 30-4 indicates that the constraints in terms of suspended load concentrations are more stringent for freshwater pearl mussels therefore the magnitude of impact has been assigned based on these concentration levels.

Table 30-4 – Assessment of risk to fish and their habitat, check of elevated levels of suspended solids from mining operations in the Yukon

Suspended sediment (mg/l)	Risk to fish and their habitat
<25	Negligible risk
25-100	Low risk
100-200	Moderate risk
200-400	High risk
>400	Unacceptable risk

Impact Assessment Methodology

A29.13 The methodology adopted to assess the potential impact of sediment being released into the River Don, from the mainline approach roads construction site, includes the following stages;

- data collation i.e. proposed construction site alignment, dimensions, slope, site bed gradation;
- hydrological assessment of the construction site drainage area for a range of return period events;
- construction of mathematical models to represent the area of disturbance during construction of the mainline approach roads for the River Don(Figure 9.4);
- assessment of sediment concentrations for input into the mathematical models representing the main pathway for runoff to the main watercourse from the construction area;
- construction of the main sediment model to include the construction site sediment generation together with the main watercourse upstream flow sediments (coupled with the hydraulic model Figure 9.4);
- assessment of the sediment concentrations within the main watercourse and the magnitude of the predicted impacts on water quality and associated habitats based on the criteria given in Table 30-2; then,
- assessment of the sediment concentration within the main watercourse and magnitude of residual impacts, including mitigation measures, on water quality and associated habitats based on the criteria given in Table 30-2.

A29.14 Potential impacts during operation of fine sediment release are addressed in the fluvial geomorphology appendix (Appendix A9.3) and summarised in the water quality appendix (Appendix A9.4)

Construction Site Details

A29.15 The construction of the River Don mainline approach roads located on either side of the watercourse have been designated as ‘north’ and ‘south’ for the purposes of mathematical modelling. Separate one-dimensional mathematical models, using ISIS software, have been constructed to represent the areas of the construction site on either side of the watercourse. Figure 9.4 shows graphically the area considered for these models.

A29.16 It has also been assumed that the construction programme will be phased, such that only one side on the watercourse would be opened up for construction, at a time. The sub-catchment characteristics of the assumed construction sites are summarised in Table 30-5.

Table 30-5 - Summary features of the construction sites

Item	River Don South	River Don North
Length (m)	Approx 1350	Approx 1250
Average width (m)	Approx 70	Approx 80
Area (m^2)	Approx 94,500	Approx 100,000
Slope (%)	Approx 2.70% between chainages 21400 and 22750 m	Approx 1.11% between chainages 23350 and 24600 m
Figures	Figure 9.4	Figure 9.4

Hydrology

A29.17 Hydrological analysis of the proposed construction site drainage areas, associated with the mainline approach roads, has assumed that the ground surface is 'bare and untilled', i.e., with no vegetation (Rational Method).

It is considered that the most onerous case, with respect to the impact of sediment being released into the River Don, would be when a localised high magnitude rainfall event occurs over the construction site while the flow in the receiving watercourse is not in spate. This combination of factors would result in least dilution of released sediments.

Therefore, sediment input to the receiving watercourse is assumed to be driven by a localised severe rainfall event, not affecting the whole catchment, with the assumption that the flow in the receiving watercourse is not in spate. The range of rainfall events that have been considered are designed to give an overview of possible suspended load concentrations from the construction site. The summary flows for the events considered; 1:2 year event (low), 1:10 year event, 1:50 year event and the 1:100 year event (high) are summarised in Table 30-6.

The predicted peak design flows for each construction drainage area has been calculated, assuming a localised rainfall event occurring over the whole construction site. The peak flows associated with either the southern or northern construction site for the mainline approach roads for the River Don have been factored based on their area ratio.

Table 30-6 – Summary of hydrology

Return Period (years)	Predicted Peak Flows (Bare and Untilled)		
	River Don North (m^3/s)	River Don South (m^3/s)	Total Don Construction drainage area (m^3/s)
1:100	0.332	0.312	0.644
1:50	0.313	0.294	0.607
1:10	0.241	0.226	0.467
1:2	0.157	0.148	0.305

Hydraulic Model

A29.18 A simple one-dimensional hydraulic model has been constructed, using ISIS software, to represent the construction site. ISIS software is widely recognised and utilised within the water industry. To simulate the distribution of released sediments within the River Don, the mathematical model previously constructed for the flood risk assessment have been used (refer to Appendix A9.2 Hydrodynamics). The main River Don mathematical model have been calibrated to a low flow condition, recorded during the topographic survey (undertaken in May 2004).

A29.19 In general, the following modelling assumptions have been made;

- base flow in the main river hydraulic model is $20.3m^3/s$ for the River Don. This is considered to represent a mean flow condition and therefore offer reduced dilution of any released sediments;
- mathematical model has been constructed based on topographical survey data from May 2004 (i.e., cross sections);
- main river hydraulic model have been coupled with a sediment transport model to model sediment concentrations and transport;
- sediment load from the construction sites is assumed to enter the main river at the proposed bridge crossing locations; and,
- during the mean flow condition in the main river, the movement of bed sediments is considered to be minimal as both rivers are assumed to be armoured and relatively stable. This assumption is based on discussions with Professor Brian Willets, formerly of Aberdeen University[2].

Sediment Model

Model of Construction Site

A29.20 As described previously, a simple uncalibrated mathematical model representing the construction drainage areas has been constructed.

A29.21 The model assumes an average slope, following the proposed road gradient, and discharges directly into the main river. It is also assumed that the construction activities would be programmed such that each side of the construction site (either North or South) would be constructed in sequence and not concurrently.

A29.22 In order to model potential sediment transport from the construction site, a representative soil particle size distribution is required, which is assumed to form the bed of the mathematical model.

A29.23 The representative particle size distribution for the bed of the construction site on the banks of the River Don was taken from the bore hole (BH21, 0.5m depth) sample results supplied by Norwest Holst Soil Engineering Limited. The stratum was described as 'very dense, dark brown, slightly silty, slightly gravely, fine to coarse sand'. The grading analysis of a sample taken at 0.5m depth is:

	% of sediment passing sieve size
Silt (0.06 mm)	7%
Sand (2.65 mm)	35%
Gravel (65 mm)	58%
Cobbles (250 mm)	0%

A29.24 In general, the following sediment transport modelling assumptions have been made;

- as the mean diameter of the sediment is greater than 0.15 mm, Engelund-Hansen sediment transport equation (note: to asses the suitability of this method, sensitivity test were carried out using the Ackers – White (1990) sediment transport equation) has been used to compute sediment transport within the watercourses, as recommended by the software manufacturers[3]; and,
- sediment transport has been modelled assuming a moderately graded, sorted algorithm with an active layer distribution.

[2] Personal communication, 2004, Professor Brian Willets Aberdeen University
[3] Halcrow/HR Wallingford 1999 ISIS Sediment User Manual

Main River Model

A29.25 The main river one-dimensional mathematical model was constructed for the purposes of the AWPR flood risk assessment, using ISIS software. During investigation no continuous dataset was available for sediment trends in the River Don, only the discrete suspended solid concentration readings, undertaken by SEPA on average 12 times yearly, was available. This data was of insufficient detail to calibrate the sediment model therefore sensitivity analyses has been undertaken. Whilst this is a generally accepted method in the absence of calibration data, it would be preferable to calibrate the model for sediment transport purposes, rather than simply for hydraulic conditions. However, this would require suspended and bed sediment samples to be taken from the river, together with flow readings, for a range of river flows, and ideally for the duration of a storm at more than one location.

A29.26 Whilst the Engelund – Hansen sediment transport model is considered the most applicable to the sediment characteristics under investigation its sensitivity should be assessed. This was achieved through comparisons with the Ackers – White (1990) sediment transport equation.

A29.27 As the purpose of the sediment transport modelling is to assess the concentrations and distribution of sediment released into the main river due to construction activities, it is assumed that the main river bed is fixed, i.e. bed erosion of the natural river bed is prohibited. This is considered to be a conservative approach, as stream energy is not lost by moving the existing river bed.

Impact Assessment

A29.28 The predicted impact assessment was conducted assuming no mitigation would be in place during the construction of the mainline approach roads.

A29.29 For the residual impact assessment, it was assumed that water quality treatment train mitigation would be in place at the outfall of the construction drainage to the receiving watercourse. Published guidance (Section 9.1.1, Ponds and Detention Basins, Sustainable Drainage Systems, CIRIA C609, 2004) on removal efficiency for SUDS measures was consulted and employed to reflect the effect of possible mitigation measures. The residual model simulations were carried out by considering a reduction factor equal to the mitigation efficiencies to the sediment loads reaching the watercourse.

Mathematical Model Limitations

A29.30 In general, mathematical models are based on assumptions made during their development and application. Therefore they have limitations which should be taken into account when interpreting the model results. One-dimensional (1-D) river models, such as ISIS, calculate a single average velocity and a single water level for each model cross section. However, in some areas the flow structure may be complex, particularly near structures where three-dimensional effects may be dominant. Such localised effects including bridge scours, effects of dunes and ripples cannot be simulated in 1-D models and this should be taken into account when using model predictions for flood risk and sedimentation assessment purposes.

30.3 Baseline

A29.31 River Don is considered to be of high sensitivity with respect to water quality, please refer to Appendix A9.4 Water Quality for a more detailed description of the watercourse.

A29.32 The baseline sediment loads in the water courses has been abstracted from the suspended solid monitoring data provided by SEPA for the River Don. The estimated base suspended solids corresponding to Q mean flow in River Don is 9.8 parts per million (ppm).

30.4 Potential impacts

General

A29.33 It must be emphasised that the potential impacts on water quality from sediment generated by runoff from the construction sites would be a short term impact upon water quality. However elevated levels would have long-term detrimental effects on sensitive ecosystems which are dependent on water quality, such as the atlantic salmon.

A29.34 For the purposes of the modelling assessment it was assumed that sheet flow of the surface water runoff occurs over the whole construction area following a rainfall event. Since the hydraulics drive the sediment transport this method means that surface of the whole construction site was available to be transported by the flow. This approach resulted in a large quantity of material being transported and released into the main watercourse, which was considered to be unlikely.

A29.35 A sensitivity test was carried out between 2 different sediment transport equations within the model. The Engelund – Hansen sediment transport equation estimates sediment concentrations to be 64% greater than the Ackers – White (1990) sediment transport equation. The Engelund – Hansen equation is considered the most appropriate equation for the sediment characteristics under investigation and offers a more conservative prediction of the potential impacts. This equation is applied throughout this investigation.

A29.36 A number of sensitivity runs were undertaken, considering the potential area of the construction sites that may contribute to sediment transport. Although it is difficult to quantify, it may be realistic to consider that 25% of the construction site area would be likely to be mobile for the transport of surface sediments. This approach is based on the following;

- It is likely that underlying soils within a large proportion of the construction site will be consolidated (i.e. compacted) due to the movement of heavy construction plant. This is likely to reduce the erodability of the soil, which cannot be simulated within the mathematical model; and,
- it is likely that uniform overland sheet flow over the whole construction area would not occur, as this would require the soil strata to be fully saturated and the contours of the construction site to be even, with a gradient in one direction. It is more likely that the construction site will be irregular and surface water runoff would initially following the contours of the construction site and after a period of time collate in naturally formed channels.

Impact Assessment - River Don

Table 30-7 River Don – Sediment Concentrations at the Proposed Crossing

Sediment concentration (ppm) released into the watercourse at the proposed crossing						
Return Period (years)	**Percentages of mobile bed construction site areas**					**Magnitude of Impact 25%**
	100%	**75%**	**50%**	**25%**	**10%**	
Don North						
100yr	275	208	139	**71**	30	High
50yr	249	188	126	**64**	27	High
10yr	171	127	87	**45**	19	High
2yr	94	71	48	**26**	12	Low
Don South						
100yr	1098	824	550	**276**	112	High
50yr	978	735	487	**246**	100	High
10yr	648	487	326	**164**	67	High
2yr	353	266	177	**90**	38	High

A29.37 The results would suggest that for almost all conditions, if no mitigation is implemented, sediment concentrations within the River Don at the point of release exceeds the maximum concentrations set for this assessment i.e. 30ppm, for short durations (Table 30-3). In addition, the magnitude of direct impact on water quality is considered to be high, with reference to the defined criteria, for all the return periods. The indirect impact of this upon associated aquatic ecology is also considered high according to Table 30-2.

30.5 Mitigation and Recommendations

General

A29.38 Sediment release into the main watercourse from the proposed construction site is predicted to exceed the maximum threshold concentration value of 30ppm. To reduce the level of potential impact, mitigation measures must be considered.

Water Quality Mitigation

A29.39 Mitigation, as a minimum, should consist of two treatment ponds in series before outfall, along with phasing the works such that only one mainline approach road is constructed at a time. The sediment removal efficiency of each individual pond must be in excess of 75% (Section 9.1.1, Ponds and Detention Basins, Sustainable Drainage Systems, CIRIA C609, 2004) this should be ensured by adhering to best practice at the design stage. Additionally, ponds should be established and functional before construction commences. Further guidance on this is given in Appendix A9.4 Water Quality.

A29.40 In order to control surface water runoff from the site, the surface water runoff would be collected in temporary constructed drainage channels leading into the mitigation treatment ponds.

A29.41 During the assessment SEPA requested that real time monitoring of the surface water runoff sediment concentrations during construction is undertaken before and after treatment to assess if the sediment load being released into the watercourse is within the acceptable limits, particularly during rainfall events. This mitigation measure would allow for early warning of concentrated sediment release. The monitoring station would be installed upstream of the first treatment pond and downstream of the final treatment pond. A warning trigger value and absolute maximum would be employed, at which works would be stopped and emergency response plan enacted.

A29.42 In addition to the site specific mitigation defined above, prior to the works commencing the following would be employed:

- silt fences or gravel bags will be erected around all stockpiles;
- stockpiles of materials will be located away from watercourse;
- upslope silt fences or catch drains would be used where there is more significant risk from polluted runoff, in order to divert clean runoff away from work areas; and,
- erection of exclusion fencing to prevent damage to adjacent areas.

A29.43 During the proposed works the following should be employed:

- inspect all erosion controls weekly and after rainfall events and clean out. Erosion control devices will be maintained and regularly (minimum weekly) inspected and cleaned of silt as necessary;
- progressive rehabilitation of exposed areas throughout the construction period. Restoration will take place as soon as possible after the work has been completed; and,
- the width of area to be disturbed is to be kept to a minimum.

A29.44 Pollution control through best practice at site would be in liaison with SEPA follow the Pollution Prevention Guidelines (PPG) listed below:

- PPG01 General guide to the prevention of water pollution;
- PPG04 Disposal of sewage where no mains drainage is available;
- PPG05 Works in near or liable to affect watercourses;
- PPG06 Working at construction and demolition sites;
- PPG07 Refuelling Facilities;
- PPG08 Storage and disposal of used oils;
- PPG10 Highway depots;
- PPG13 High pressure water and steam cleaners;
- PPG18 Control of spillages and fire fighting run-off; and,
- PPG21 Pollution Incident Response Planning.

In summary, the following mitigation would be employed:

- only one mainline approach road (North or South) should be constructed at any one time;
- at least 2 treatment ponds (in series) would be constructed for each outfall location. Ponds would be established and functional before construction commences;
- surface runoff must be controlled on site by the use of temporary constructed drainage channels;
- real-time monitoring immediately upstream and downstream of treatment ponds; and,
- adherence to the relevant PPGs and liaison with SEPA.

Ecological Mitigation

A29.45 A summary of the required ecological mitigation measures are listed below. Further information on these can be found in Appendix A10.16

- best practice pollution control would be implemented on site in addition to the SEPA Pollution Prevention Guidelines (as detailed above);
- timing of the works such that periods of extreme low flow are avoided;
- aquatic ecological clerk of works will be present on site during construction, to ensure the implementation of appropriate environmental safeguards;
- temporary treatment ponds (at least two in series before outfall) to accommodate runoff from a 1:100 year event to be installed to ensure minimum water quality standards would be adhered to throughout construction. Ponds would be established and functional before construction commences;
- installation of continuous monitoring equipment for of suspended solids. This unit would incorporate a warning trigger value and absolute maximum value. If these values are reached, works would be stopped and emergency response plan would be enacted;
- baseline information on substrate particle size would be collected before and after construction works and upstream and downstream of the proposed crossing site. If an impact form construction is detected gravel cleaning could be undertaken to restore benthic microhabitats to preconstruction conditions (refer to the Appendix A10.15: Fish and A10.16: Freshwater Ecology); and
- close regulation of the storage of any materials on the floodplain or near tributaries to reduce risk of pollutants/fine sediment entering the Don.

30.6 Residual Impacts

Impact Assessment – River Don

A29.46 Table 6.2 presents the predicted sediment concentration being released into the River Don with the implementation mitigation measures; specifically the phasing of works such that only one mainline approach road is constructed at one time (i.e. North or South) and the installation of two treatment ponds in series before outfall to the receiving watercourse. These ponds would be installed and functional before works commence.

A29.47 The results suggest that with mitigation including two treatment ponds, sediment concentrations associated with Don South and Don North construction sites are predicted to be below the maximum allowable sediment concentration of 30ppm.

A29.48 The magnitude of impact is negligible/low in the receiving watercourse in accordance with the defined criteria.

Table 30-8 – River Don – Sediment Concentrations at the Proposed Crossing

Sediment concentration (ppm) in the water courses at the proposed crossing, considering various percentages of mobile bed construction site areas					Magnitude of Impact
Return Period (years)	**100%**	**75%**	**50%**	**25%**	**10%**	**25%**
Don North						
100yr	19	15	11	**7**	4	Negligible
50yr	18	14	10	**6**	4	Negligible
10yr	13	10	8	**5**	3	Negligible
2yr	8	7	5	**4**	3	Negligible
Don South						
100yr	71	54	37	**20**	9	Negligible
50yr	63	48	33	**18**	8	Negligible
10yr	43	33	23	**13**	6	Negligible
2yr	24	19	13	**8**	5	Negligible

Note: In River Don, although the baseline sediment load at the upstream boundary for a mean flow is 9.8 ppm; it drops down to about 2.5 ppm due to sediment deposition in the initial reaches of the river, where the bed profile is significantly non uniform (for more information please refer to the Geomorphology assessment Appendix A9.3).

Summary

A29.49 The River Don is a ecologically sensitive river with the presence of migratory fish. The significance of the predicted sediment impacts with reference to the sensitivity of the river and the magnitude of the sediment loads including appropriate mitigation measures for various return periods, in accordance with the defined criteria, are presented in the matrix below.

A29.50 The significance of the potential short term sediment impact on water quality in River Don, from both the North and South construction sites is considered to be slight/negligible. Similarly the indirect impact significance upon aquatic ecology in the River Don is considered to be slight/negligible.

Table 30-9 – Watercourse Predicted Impact Evaluation

Water Course	Factors considered	Sensitivity	Magnitude	Period of Impact	Significance
River Don North					
Sediment Impact	Construction site short term sediment impacts with mitigation measures				
	100yr	High	Negligible	Short-term/long-term	Slight/Negligible
	50yr	High	Negligible	Short-term/long-term	Slight/Negligible
	10yr	High	Negligible	Short-term/long-term	Slight/Negligible
	2yr	High	Negligible	Short-term/long-term	Slight/Negligible
River Don South					
Sediment Impact	Construction site short term sediment impacts with mitigation measures				
	100yr	High	Low	Short-term/long-term	Slight/Negligible
	50yr	High	Low	Short-term/long-term	Slight/Negligible
	10yr	High	Low	Short-term/long-term	Slight/Negligible
	2yr	High	Negligible	Short-term/long-term	Slight/Negligible

30.7 References

Centre for Hydrology and Ecology (2003). Hydrological Data United Kingdom: Hydrometric Register and Statistics, 1996-2000, Wallingford.

CIRIA (2000). Sustainable Urban Drainage Systems: Design manual for Scotland and Northern Ireland, Report No CIRIA C521, Construction Industry Research and Information Association, London.

Institute of Hydrology (1994). Flood estimation for small catchments. Report No IH124, Wallingford.

Institute of Hydrology (1999). Flood Estimation Handbook Vol1-5 and associated software. Wallingford.

Scottish Executive ‘Scottish Planning Policy (2004). Scottish Planning Policy SPP 7: Planning and Flooding.

The Highways Agency, Scottish Executive, Welsh Assembly Government, The Department for Regional Development Northern Ireland (2004). Design Manual for Roads and Bridges (DMRB) Volume 4, Section 2 “Drainage”.

Young A. R., Grew R. and Holmes M.G.R. (2003). Low Flows 2000: A national water resources assessment and decision support. Water Science and Technology, 48 (10).

30.8 Glossary

AREA	Catchment Drainage Area (km2)
AWPR	Aberdeen Western Peripheral Road
Baseflow	is the continual contribution of groundwater to rivers and is an important ` source of flow between rainstorms.
BFIHOST	Base Flow Index derived using the HOST classification.
FARL	Index of Flood Attenuation due to Reservoirs and Lakes
FDC	Flow Duration Curve - A cumulative frequency curve that shows the percentage of time that specified discharges are equalled or exceeded.
FEH	Flood Estimation Handbook (see references)
FFC	Flood Frequency Curve – A graph showing the recurrence intervals (return periods) that floods of magnitude are equalled or exceeded
HOST	Hydrology of Soil Types Classification
LF2000	Low Flows 2000
OS	Ordnance Survey
QBAR	Mean Annual Flood (m3/s)
QBF	Bankfull Flow: the bank is defined at the point where vegetation/soil cover obviously changes between water and air

QEBF	Embankmentfull Flow: the embankment (top of) is defined as the point where water would spill into wider areas (fields/road)
q green	Greenfield runoff rate (l/s/ha)
Qmean	Mean Flow (m3/s)
QMED	Median Annual Flood Flow (m3/s) (flow with a 2 year return period)
Q95	Flow that is expected to be exceeded 95% of the time (m3/s)
Q-Tyr (eg Q-5yr)	Flow associated with a T-year return period (eg 5-year flow)
SAAR	1961-90 standard-period average annual rainfall (mm)
SAC	Special Area of Conservation
SPRHOST	Standard Percentage Runoff (%) derived using HOST classification
SSSI	Site of Special Scientific Interest
SUDS	Sustainable Urban Drainage Systems
URBEXT1990	FEH index of fractional urban extent for 1990.
V	Velocity (m/s)