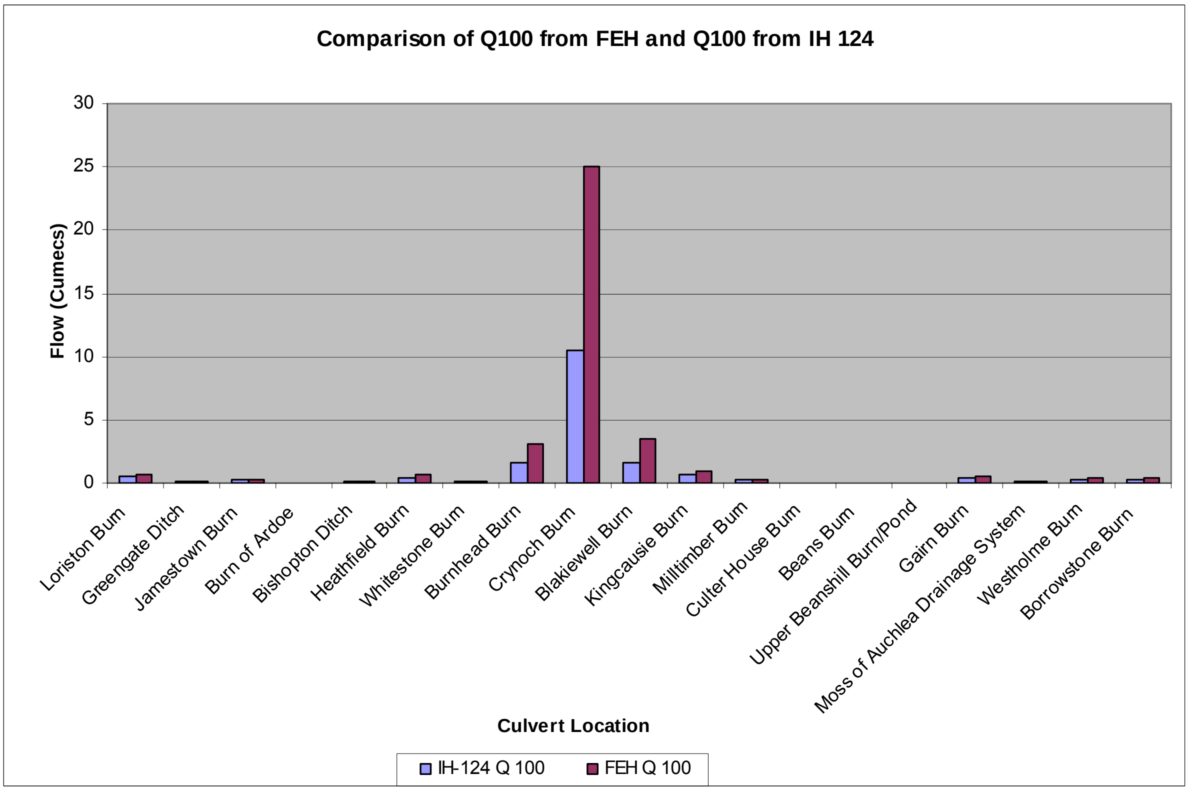
Aberdeen Western Peripheral Route
Environmental Statement Appendices 2007
Part C: Southern Leg
Appendix A24.7 - Water Environment Annexes

Contents

Annex 1 Hydrology – Summary of High Flow Calculations

As 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 have been used in the assessment. The results are presented here.



The differences between IH124 and FEH are generally relatively small, apart for Crynoch Burn.

The FEH flows were used in further analysis as 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 21 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, 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 two 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. five year flow)
V	Velocity (m/s)

Annex 3 Loirston Burn

Location: Construction of four culverts, associated realignments and outfall location.
Chainage: Culvert 1 is located at ch205580 on main carriageway

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 930 998
Area	km^2	3.5
SAAR	mm	783
BFIHOST	-	0.706
SPRHOST	%	24.2
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.051	Q-5yr	m^3/s	0.69
Q_{95}	m^3/s	0.007	Q-10yr	m^3/s	0.84
QMED	m^3/s	0.49	Q-25yr	m^3/s	1.05
QBAR	m^3/s	0.40	Q-50yr	m^3/s	1.24
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	1.42
Q_{EBF}	m^3/s	9.56	Q-200yr	m^3/s	1.64

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	0.063	0.068	0.051	0.033	0.028	0.021	0.014	0.016	0.077	0.086	0.077	0.075
v	m/s	0.89	0.91	0.83	0.71	0.67	0.61	0.53	0.56	0.95	0.98	0.95	0.94

Loirston Burn Continued

Location: Construction of four culverts, associated realignments and outfall location.
Chainage: Culvert 2 is located at ch340

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 930 998
Area	km^2	3.5
SAAR	mm	783
BFIHOST	-	0.706
SPRHOST	%	24.2
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.051	Q-5yr	m^3/s	0.69
Q_{95}	m^3/s	0.007	Q-10yr	m^3/s	0.84
QMED	m^3/s	0.49	Q-25yr	m^3/s	1.05
QBAR	m^3/s	0.40	Q-50yr	m^3/s	1.24
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	1.42
Q_{EBF}	m^3/s	9.56	Q-200yr	m^3/s	1.64

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	0.063	0.068	0.051	0.033	0.028	0.021	0.014	0.016	0.077	0.086	0.077	0.075
v	m/s	0.89	0.91	0.83	0.71	0.67	0.61	0.53	0.56	0.95	0.98	0.95	0.94

Loirston Burn Continued

Location: Construction of four culverts, associated realignments and outfall location.
Chainage: Culvert 3 is located at ch790

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 930 998
Area	km^2	3.5
SAAR	mm	783
BFIHOST	-	0.706
SPRHOST	%	24.2
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.051	Q-5yr	m^3/s	0.69
Q_{95}	m^3/s	0.007	Q-10yr	m^3/s	0.84
QMED	m^3/s	0.49	Q-25yr	m^3/s	1.05
QBAR	m^3/s	0.40	Q-50yr	m^3/s	1.24
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	1.42
Q_{EBF}	m^3/s	9.56	Q-200yr	m^3/s	1.64

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	0.063	0.068	0.051	0.033	0.028	0.021	0.014	0.016	0.077	0.086	0.077	0.075
v	m/s	0.89	0.91	0.83	0.71	0.67	0.61	0.53	0.56	0.95	0.98	0.95	0.94

Loirston Burn Continued

Location: Construction of four culverts, associated realignments and outfall location.
Chainage: Culvert 4 is located at ch207030

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 930 998
Area	km^2	3.5
SAAR	mm	783
BFIHOST	-	0.706
SPRHOST	%	24.2
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.051	Q-5yr	m^3/s	0.69
Q_{95}	m^3/s	0.007	Q-10yr	m^3/s	0.84
QMED	m^3/s	0.49	Q-25yr	m^3/s	1.05
QBAR	m^3/s	0.40	Q-50yr	m^3/s	1.24
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	1.42
Q_{EBF}	m^3/s	9.56	Q-200yr	m^3/s	1.64

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	0.063	0.068	0.051	0.033	0.028	0.021	0.014	0.016	0.077	0.086	0.077	0.075
v	m/s	0.89	0.91	0.83	0.71	0.67	0.61	0.53	0.56	0.95	0.98	0.95	0.94

Loirston 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 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 refer to the SEPA website.

At the proposed road crossing points, the Indicative River and Coastal Flood Maps (Scotland) indicate no risk of flooding at the 0.5% AEP (200-year return period event). Loirston Burn catchment area is larger than 3km². However, it is unclear whether the maps extend to the points of interest on Loriston Burn and represent the processes occurring at the location of the road crossing points.

Annex 4 Greengate Ditch

Location: Proposed area of catchment to be taken into pre-earthworks.
Chainage: ch205050 on main carriageway

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 918 995
Area	km^2	0.2
SAAR	mm	813
BFIHOST	-	0.451
SPRHOST	%	36.3
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.002	Q-5yr	m^3/s	0.08
Q_{95}	m^3/s	0.001	Q-10yr	m^3/s	0.09
QMED	m^3/s	0.05	Q-25yr	m^3/s	0.11
QBAR	m^3/s	0.06	Q-50yr	m^3/s	0.13
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.15
Q_{EBF}	m^3/s	3.86	Q-200yr	m^3/s	0.18

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	0.030	0.026	0.027	0.023	0.017	0.012	0.010	0.012	0.016	0.023	0.027	0.029
v	m/s	0.35	0.33	0.34	0.32	0.28	0.24	0.23	0.25	0.28	0.32	0.34	0.35

Annex 5 Jameston Ditch

Location: Outfall location.
Chainage: ch204500 on main carriageway

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 910 996
Area	km^2	0.2
SAAR	mm	813
BFIHOST	-	0.451
SPRHOST	%	36.3
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.003	Q-5yr	m^3/s	0.12
Q_{95}	m^3/s	0.001	Q-10yr	m^3/s	0.14
QMED	m^3/s	0.08	Q-25yr	m^3/s	0.18
QBAR	m^3/s	0.08	Q-50yr	m^3/s	0.21
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.24
Q_{EBF}	m^3/s	2.83	Q-200yr	m^3/s	0.28

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	0.005	0.004	0.004	0.004	0.003	0.002	0.002	0.002	0.002	0.004	0.004	0.004
v	m/s	0.214	0.202	0.205	0.194	0.172	0.07	0.150	0.142	0.153	0.169	0.207	0.210

Annex 6 Burn of Ardoe

Location: Proposed culvert and associated re-alignment.
Chainage: Culvert located at ch204040 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 908 993
Area	km^2	0.1
SAAR	mm	813
BFIHOST	-	0.451
SPRHOST	%	36.3
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.001	Q-5yr	m^3/s	0.03
Q_{95}	m^3/s	0.000	Q-10yr	m^3/s	0.04
QMED	m^3/s	0.03	Q-25yr	m^3/s	0.05
QBAR	m^3/s	0.02	Q-50yr	m^3/s	0.05
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.06
Q_{EBF}	m^3/s	2.95	Q-200yr	m^3/s	0.07

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	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001
v	m/s	0.09	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.07	0.08	0.09	0.09

Annex 7 Bishopston Ditch

Location: Proposed culvert and associated re-alignment.
Chainage: Culvert located at ch203900 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 907 992
Area	km^2	0.2
SAAR	mm	814
BFIHOST	-	0.467
SPRHOST	%	35.1
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.002	Q-5yr	m^3/s	0.09
Q_{95}	m^3/s	0.001	Q-10yr	m^3/s	0.10
QMED	m^3/s	0.06	Q-25yr	m^3/s	0.13
QBAR	m^3/s	0.06	Q-50yr	m^3/s	0.15
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.18
Q_{EBF}	m^3/s	4.33	Q-200yr	m^3/s	0.20

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	0.004	0.003	0.003	0.003	0.002	0.001	0.001	0.001	0.002	0.003	0.003	0.003
v	m/s	0.18	0.17	0.17	0.16	0.14	0.12	0.12	0.13	0.14	0.16	0.17	0.17

Annex 8 Heathfield Burn

Location: Proposed culvert and associated re-alignment.
Chainage: Culvert located at ch203650 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 905 991
Area	km^2	0.8
SAAR	mm	820
BFIHOST	-	0.522
SPRHOST	%	32.5
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.009	Q-5yr	m^3/s	0.31
Q_{95}	m^3/s	0.002	Q-10yr	m^3/s	0.37
QMED	m^3/s	0.22	Q-25yr	m^3/s	0.47
QBAR	m^3/s	0.19	Q-50yr	m^3/s	0.55
Q_{BF}	m^3/s	0.31	Q-100yr	m^3/s	0.63
Q_{EBF}	m^3/s	2.22	Q-200yr	m^3/s	0.73

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	0.015	0.013	0.011	0.010	0.008	0.005	0.005	0.005	0.006	0.009	0.013	0.015
v	m/s	0.46	0.44	0.42	0.40	0.36	0.31	0.30	0.30	0.32	0.38	0.44	0.46

Annex 9 Whitestone Burn

Location: Proposed culvert and associated re-alignment.
Chainage: Culvert located at ch200990 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 879 986
Area	km^2	0.2
SAAR	mm	820
BFIHOST	-	0.554
SPRHOST	%	28.6
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.002	Q-5yr	m^3/s	0.06
Q_{95}	m^3/s	0.001	Q-10yr	m^3/s	0.08
QMED	m^3/s	0.04	Q-25yr	m^3/s	0.09
QBAR	m^3/s	0.04	Q-50yr	m^3/s	0.11
Q_{BF}	m^3/s	Not Complete	Q-100yr	m^3/s	0.13
Q_{EBF}	m^3/s	Not Complete	Q-200yr	m^3/s	0.15

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	0.003	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.002	0.003	0.003
v	m/s												

Annex 10 Burnhead Burn

Location: Proposed culvert, associated re-alignment and outfall location.
Chainage: Culvert located at ch200100 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 870 986
Area	km^2	4.2
SAAR	mm	819
BFIHOST	-	0.551
SPRHOST	%	28.3
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.054	Q-5yr	m^3/s	1.53
Q_{95}	m^3/s	0.013	Q-10yr	m^3/s	1.86
QMED	m^3/s	1.08	Q-25yr	m^3/s	2.32
QBAR	m^3/s	0.65	Q-50yr	m^3/s	2.74
Q_{BF}	m^3/s	1.49	Q-100yr	m^3/s	3.14
Q_{EBF}	m^3/s	7.19	Q-200yr	m^3/s	3.63

Seasonal Flow Duration Curve

Not calculated for this site.

Mean Monthly Flow Velocities

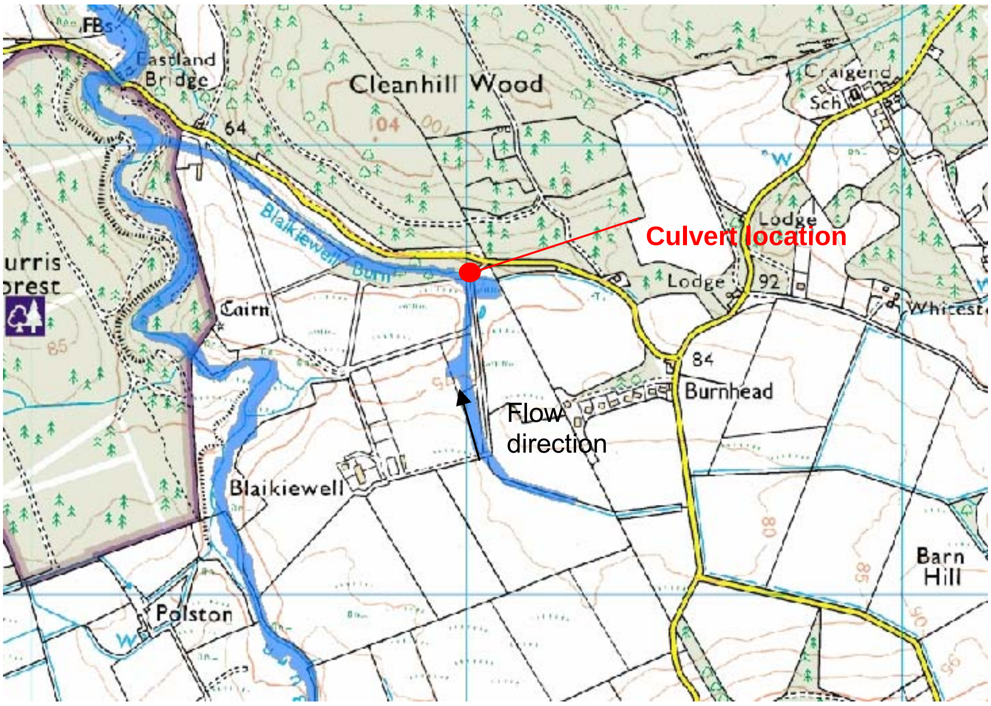
		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.083	0.074	0.064	0.054	0.042	0.029	0.026	0.026	0.032	0.051	0.077	0.083
v	m/s	0.60	0.57	0.55	0.51	0.46	0.40	0.39	0.39	0.42	0.50	0.58	0.60

Burnhead 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; or
- 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 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 refer to the SEPA website.



Burnhead Burn is shown by the SEPA ‘Indicative River and Coastal Flood Risk Maps (Scotland)’ to be at risk of flooding at the 0.5% AEP (200-year return period event). At the site of the proposed culvert, flooding is indicated on both the right and left river bank. However, the area inundated is shown to be less than 50 metres either side of Burnhead Burn. There are no properties within 250m of the proposed culvert.

Annex 11 Blaikiewell Burn

Location: Proposed bridge (buried structure).
Chainage: ch100150 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 868 987
Area	km^2	4.5
SAAR	mm	818
BFIHOST	-	0.541
SPRHOST	%	28.1
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.056	Q-5yr	m^3/s	1.69
Q_{95}	m^3/s	0.012	Q-10yr	m^3/s	2.05
QMED	m^3/s	1.19	Q-25yr	m^3/s	2.56
QBAR	m^3/s	0.67	Q-50yr	m^3/s	3.03
Q_{BF}	m^3/s	0.90	Q-100yr	m^3/s	3.47
Q_{EBF}	m^3/s	5.91	Q-200yr	m^3/s	4.01

Seasonal Flow Duration Curve

Not calculated for this site.

Mean Monthly Flow Velocities

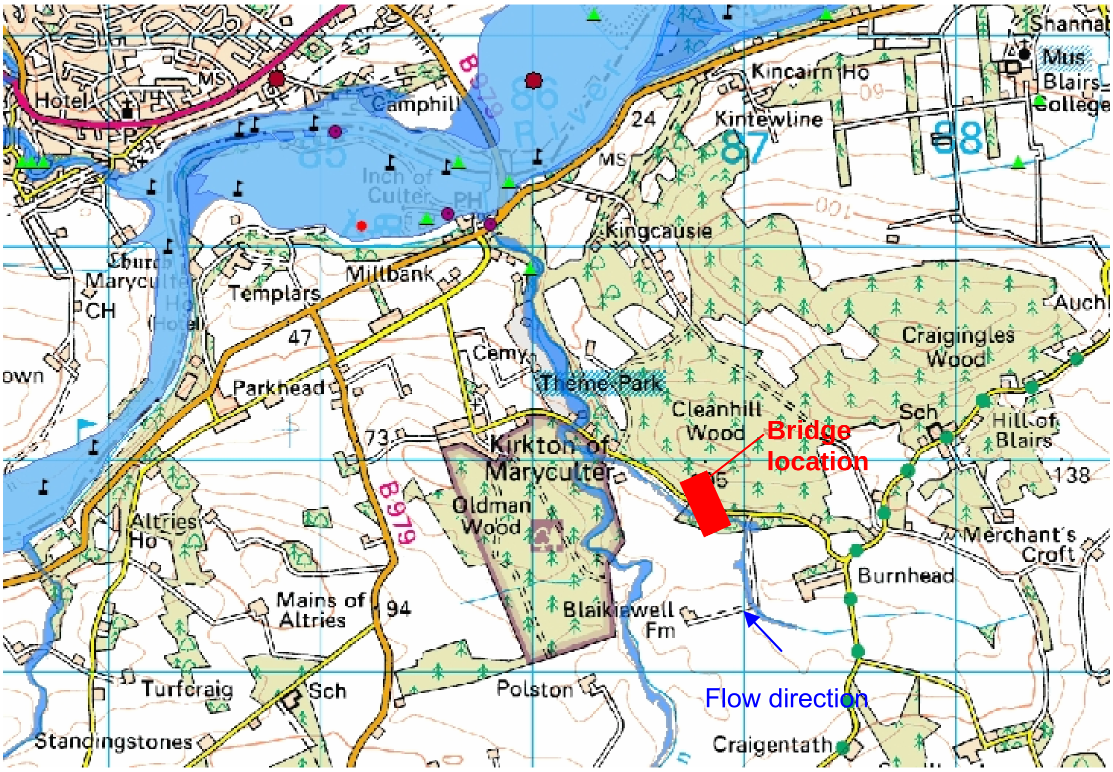
		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Qmean	m^3/s	0.089	0.079	0.068	0.080	0.046	0.031	0.027	0.027	0.033	0.054	0.079	0.087
v	m/s	0.60	0.57	0.54	0.52	0.46	0.40	0.39	0.39	0.42	0.50	0.58	0.60

Blaikiewell 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; or
- 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), refer to the SEPA website.



At the proposed crossing point of the AWPR, Blaikiewell Burn predicts a risk of flooding at the 0.5% AEP (200-year return period event). Flooding of the site is not predicted to exceed 50m on the right or left river banks. No properties are predicted to be at risk of flooding in the area surrounding the proposed bridge location.

Although Crynoch Burn would not be directly crossed by the scheme, there would be indirect impacts on the watercourses and surface water pathways draining to Crynoch Burn. Existing flood risk has been assessed using the SEPA 'Indicative River and Coastal Flood Maps (Scotland)' for the area downstream of the first point that would be indirectly affected by the scheme. The maps indicate flooding up to 100m out of bank during the 0.5% AEP event (1 in 200-year flood event). Forestry and agricultural land are predominantly at risk, but there are properties within Kirkton of Maryculter and near the confluence with the River Dee which are predicted to flood.

Kingcausie Burn

Location: Proposed culvert and associated re-alignment.
Chainage: Culvert located at ch101470 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NO 863 998
Area	km^2	1.6
SAAR	mm	808
BFIHOST	-	0.605
SPRHOST	%	28.9
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.021	Q-5yr	m^3/s	0.46
Q_{95}	m^3/s	0.004	Q-10yr	m^3/s	0.56
QMED	m^3/s	0.25	Q-25yr	m^3/s	0.70
QBAR	m^3/s	0.33	Q-50yr	m^3/s	0.83
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.95
Q_{EBF}	m^3/s	14.84	Q-200yr	m^3/s	1.10

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	0.035	0.031	0.025	0.020	0.017	0.011	0.010	0.010	0.011	0.020	0.026	0.033
v	m/s	0.773	0.734	0.675	0.620	0.581	0.499	0.466	0.473	0.497	0.617	0.691	0.752

Annex 12 Milltimber Burn

Location: One proposed culvert and associated re-alignment.
Chainage: Culvert located at ch102650 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 857 010
Area	km^2	0.6
SAAR	mm	814
BFIHOST	-	0.64
SPRHOST	%	28.5
FARL	-	1
URBEXT1990	-	0.012

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.008	Q-5yr	m^3/s	0.16
Q_{95}	m^3/s	0.001	Q-10yr	m^3/s	0.19
QMED	m^3/s	0.11	Q-25yr	m^3/s	0.24
QBAR	m^3/s	0.12	Q-50yr	m^3/s	0.28
Q_{BF}	m^3/s	0.05	Q-100yr	m^3/s	0.33
Q_{EBF}	m^3/s	7.56	Q-200yr	m^3/s	0.38

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	0.014	0.013	0.010	0.008	0.006	0.004	0.003	0.003	0.005	0.007	0.009	0.012
v	m/s	0.66	0.63	0.57	0.52	0.46	0.42	0.36	0.36	0.43	0.51	0.56	0.62

Annex 13 Culter House Burn

Location: Watercourse lost through catchment severance.
Chainage: ch103600 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 849 016
Area	km^2	0.1
SAAR	mm	830
BFIHOST	-	0.614
SPRHOST	%	28.9
FARL	-	1
URBEXT1990	-	0.002

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.001	Q-5yr	m^3/s	0.03
Q_{95}	m^3/s	0.000	Q-10yr	m^3/s	0.03
QMED	m^3/s	0.02	Q-25yr	m^3/s	0.04
QBAR	m^3/s	0.025	Q-50yr	m^3/s	0.05
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.06
Q_{EBF}	m^3/s	0.60	Q-200yr	m^3/s	0.07

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	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002
v	m/s	0.40	0.39	0.35	0.33	0.31	0.27	0.26	0.25	0.27	0.33	0.36	0.40

Annex 14 Beans Burn

Location: Proposed area of the catchment taken into pre-earthworks.
Chainage: ch105150 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 849 031
Area	km^2	0.08
SAAR	mm	832
BFIHOST	-	0.625
SPRHOST	%	28
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.001	Q-5yr	m^3/s	0.02
Q_{95}	m^3/s	0.000	Q-10yr	m^3/s	0.03
QMED	m^3/s	0.01	Q-25yr	m^3/s	0.03
QBAR	m^3/s	0.02	Q-50yr	m^3/s	0.04
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.04
Q_{EBF}	m^3/s	2.56	Q-200yr	m^3/s	0.05

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	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.002
v	m/s	0.31	0.30	0.27	0.25	0.24	0.23	0.21	0.21	0.23	0.25	0.27	0.29

Annex 15 Upper Beanshill Burn/Pond

Location: Proposed area of the catchment taken into pre-earthworks.
Chainage: ch106500 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 850 044
Area	km^2	0.05
SAAR	mm	833
BFIHOST	-	0.609
SPRHOST	%	29.2
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.001	Q-5yr	m^3/s	0.01
Q_{95}	m^3/s	0.000	Q-10yr	m^3/s	0.02
QMED	m^3/s	0.01	Q-25yr	m^3/s	0.02
QBAR	m^3/s	0.014	Q-50yr	m^3/s	0.02
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.03
Q_{EBF}	m^3/s	3.22	Q-200yr	m^3/s	0.03

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	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001
v	m/s	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.08

Annex 16 Gairn Burn

Location: Two proposed culverts, associated re-alignment and outfall location.
Chainage: Culvert 1 is located at ch163 (side road).

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 849 043
Area	km^2	0.8
SAAR	mm	831
BFIHOST	-	0.625
SPRHOST	%	28.3
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.011	Q-5yr	m^3/s	0.24
Q_{95}	m^3/s	0.002	Q-10yr	m^3/s	0.29
QMED	m^3/s	0.17	Q-25yr	m^3/s	0.36
QBAR	m^3/s	0.152	Q-50yr	m^3/s	0.43
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.49
Q_{EBF}	m^3/s	3.53	Q-200yr	m^3/s	0.56

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	0.02	0.017	0.014	0.011	0.008	0.006	0.004	0.004	0.007	0.01	0.013	0.017
v	m/s	0.62	0.60	0.55	0.50	0.45	0.41	0.35	0.35	0.42	0.49	0.54	0.59

Gairn Burn Continued

Location: Two proposed culverts, associated re-alignment and outfall location.
Chainage: Culvert 2 is located at ch270 (pond access road).

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 849 043
Area	km^2	0.8
SAAR	mm	831
BFIHOST	-	0.625
SPRHOST	%	28.3
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.011	Q-5yr	m^3/s	0.24
Q_{95}	m^3/s	0.002	Q-10yr	m^3/s	0.29
QMED	m^3/s	0.17	Q-25yr	m^3/s	0.36
QBAR	m^3/s	0.152	Q-50yr	m^3/s	0.43
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.49
Q_{EBF}	m^3/s	3.53	Q-200yr	m^3/s	0.56

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	0.02	0.017	0.014	0.011	0.008	0.006	0.004	0.004	0.007	0.01	0.013	0.017
v	m/s	0.62	0.60	0.55	0.50	0.45	0.41	0.35	0.35	0.42	0.49	0.54	0.59

Annex 17 Moss of Auchlea Drainage System

Location	Proposed culvert and associated re-alignment.
Chainage:	Culvert located at ch107440 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 851 054
Area	km^2	0.2
SAAR	mm	833
BFIHOST	-	0.609
SPRHOST	%	29.2
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.002	Q-5yr	m^3/s	0.05
Q_{95}	m^3/s	0.000	Q-10yr	m^3/s	0.06
QMED	m^3/s	0.04	Q-25yr	m^3/s	0.08
QBAR	m^3/s	0.04	Q-50yr	m^3/s	0.09
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.11
Q_{EBF}	m^3/s	6.11	Q-200yr	m^3/s	0.12

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	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002
v	m/s	0.32	0.30	0.28	0.26	0.25	0.23	0.23	0.23	0.23	0.26	0.29	0.31

Annex 18 Westholme Burn

Location:	Outfall location
Chainage:	ch108650 on main carriageway

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 852 065
Area	km^2	0.62
SAAR	mm	838
BFIHOST	-	0.609
SPRHOST	%	29.2
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.008	Q-5yr	m^3/s	0.19
Q_{95}	m^3/s	0.002	Q-10yr	m^3/s	0.23
QMED	m^3/s	0.14	Q-25yr	m^3/s	0.29
QBAR	m^3/s	0.128	Q-50yr	m^3/s	0.34
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.39
Q_{EBF}	m^3/s	2.16	Q-200yr	m^3/s	0.46

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	0.014	0.012	0.010	0.008	0.007	0.004	0.004	0.004	0.004	0.008	0.010	0.013
v	m/s	0.289	0.275	0.253	0.233	0.219	0.187	0.175	0.177	0.186	0.232	0.259	0.281

Annex 19 Borrowstone Burn

Location: Loss of a small area of catchment
Chainage: ch110540 on main carriageway.

Catchment Descriptors

Parameter	Unit	Value
Grid Reference		NJ 854 079
Area	km^2	0.6
SAAR	mm	857
BFIHOST	-	0.606
SPRHOST	%	29.1
FARL	-	1
URBEXT1990	-	0

Summary of Design Parameters

Parameter	Unit	Value	Parameter	Unit	Value
Qmean	m^3/s	0.008	Q-5yr	m^3/s	0.20
Q_{95}	m^3/s	0.002	Q-10yr	m^3/s	0.24
QMED	m^3/s	0.14	Q-25yr	m^3/s	0.30
QBAR	m^3/s	0.127	Q-50yr	m^3/s	0.35
Q_{BF}	m^3/s	N/A	Q-100yr	m^3/s	0.40
Q_{EBF}	m^3/s	1.35	Q-200yr	m^3/s	0.46

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	0.012	0.009	0.008	0.006	0.004	0.004	0.004	0.004	0.008	0.010	0.013
v	m/s	0.46	044	0.41	0.39	0.36	0.32	0.30	0.30	0.32	0.39	0.42	0.45

Annex 20 River Dee Audit Trail

Jacobs Flood Study Summary

FEH pooling group analysis

DEE@PARK

Project details

Project title: Aberdeen Western Peripheral Route
Project number: 0010332
Work Stage: F / 609
Client: Scottish Executive
Flood Study Site: Dee@Park

Catchment description

Grid Reference of the outflow
NO79809830

FEH catchment descriptors:

AREA	1833.21
FARL	0.981
PROPWET	0.58
ALTBAR	447.0
ASPBAR	82
ASPVAR	0.070
BFIHOST	0.507
DPLBAR	66.91
DPSBAR	169.50
LDP	127.69
RMED-1H	8.5
RMED-1D	38.5
RMED-2D	53.6
SAAR	1080
SAAR4170	1162
SPRHOST	39.7
URBEXT1990	0.001

Presence of significant land-use or catchment factors:

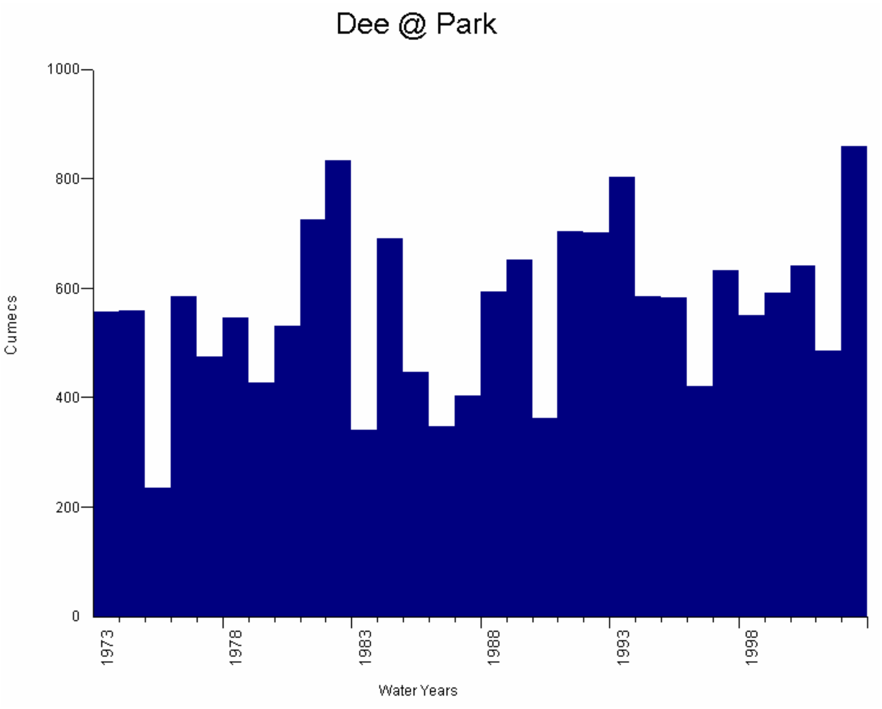
Factors	Comment	Potential Significance
Reservoir\lake	FARL=0.981	Some attenuation, though unlikely to have significant influence
Urban	URBEXT1990=0.001 (URBEXT2004=0.001), “Essentially rural”	Rural response expected
Land use	Moorland, pastoral and some arable in valley bottoms, 20% forest cover	Forest cover is relatively high but unlikely to be significant
Flood plain	Normal extends	-
Soils\Geology	Metamorphics along most of the valley, flanked by igneous intrusives, BFI (Hyd Reg)=0.54, SPRHOST=39.7	-
Other	Mountainous headwaters (1310mAOD max), often snowy in winter.	Floods generated by or partially by snow melt are more likely than elsewhere in the UK

Flow record:

Target site: Gauged \ ~~Ungauged~~ ?

12002 Dee @ Park

Attribute			Comment
Quality\suitability of record for flood analysis	Fit for QMED	✓	Hiflows-UK info: VA station, about 50m wide, unstable natural control causing frequent changes in low and medium flow rating
	Fit for Pooling	✓	
			Rating derived from current-meter gaugings up to 4m (1.2QMED) and simple extrapolation beyond
Number of years of data	1973-2002 (30 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	Estimate QMED from very short POT record

Used	Condition	Approach followed
	& no long-record site nearby	
	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$_{\text{Annual max}}$ **= 571.2 m^3/s**

68% confidence interval = (536.9, 605.5)

95% confidence interval = (504.7, 641.8)

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	1833.21
SAAR	1080
FARL	0.981
SPRHOST	39.7
BFIHOST	0.507
URBEXT	0.001

QMED$_{\text{Catchment descriptors – rural}}$ = 258.9 m^3/s

QMED$_{\text{Catchment descriptors – urban}}$ = 259.3 m^3/s

Ratio to QMED data = 2.2

Steps involved in construction and analysis of a pooling group.

Pooling group construction

Site of interest

(a) Station Number	12002	(b) Name	Park

Name of saved **.feh** group file: Don and Dee PG
Target return period (years): 100

Initial Pooling group details

Total number of sites	17	Total number of years	754

Total number of initial high discordancy sites: 0
List them:
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:

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 = = 1.9

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

Goodness-of-fit test:	Z values:	GL	acceptable	/	not acceptable	1.36
		GEV	acceptable	/	not acceptable	-1.05
		PT3	acceptable	/	not acceptable	-1.53
	other					

(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? 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
12001	Kept – doubles 12002 but covers additional years of data
21010	Removed – poor quality, not in Hiflows-UK (2nd ranked)
67020	Removed – fit for QMED but not fit for pooling (5th ranked)
8006	Removed – doubles 8001 which is 6th ranked (9th ranked)
8010	Removed – FARL=0.947, doubles 8001 (10th ranked)
21021	Removed – doubles 21006 which is 4th ranked
76002	Removed – doubles 76007 which is 8th ranked
84806	Removed – poor quality, not in Hiflows-UK
55023	Removed – doubles 55002 which is 12th ranked
47001	Added – next ranked station, to fulfil 5T rule

Note: The five highest ranked stations (12002, 12001, 21006, 8001, 54005) were updated using the MS Access based Draft Hiflows-UK database version 2.7.9 (to date unpublished).

Number of sites 10 Years 500

Heterogeneity test, H2 value = 1.1

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

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

				Value
Goodness-of-fit test	Z values	GL	acceptable / not acceptable	-0.39
		GEV	acceptable / not acceptable	-2.32
		PT3	acceptable / not acceptable	-2.63
	Other			

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	(this acts as a check as median is the only method allowed within
Mean	the pooling group method)

Construct flood frequency curve

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

Urban adjustment yes / no

Value of QMED = 571.2 m^3/s

GL

Return period[1] (yrs)	Growth factors	Design flows (m^3/s)
2	1.000	571
5	1.284	733
10	1.476	843
25	1.740	993
50	1.955	1116
100	2.189	1250
200	2.445	1396
500	2.822	1610

GEV (for comparison)

Return Period (yrs)	Growth factors	Design flows (m^3/s)
2	1.000	571
5	1.314	750
10	1.512	864
25	1.752	1000
50	1.922	1097
100	2.085	1190
200	2.242	1280
500	2.441	1393

---

[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.

Further Analysis

Comparison of Single Site Analysis and Pooling Group Analysis

A21.1 Comparison of growth curves (Figure A21.1) shows that the single site analysis (SS) at the Park gauging station results in a much flatter growth curve than the pooling group (PG). Both methodologies result in flatter growth curves than the old FSR regional growth curve.

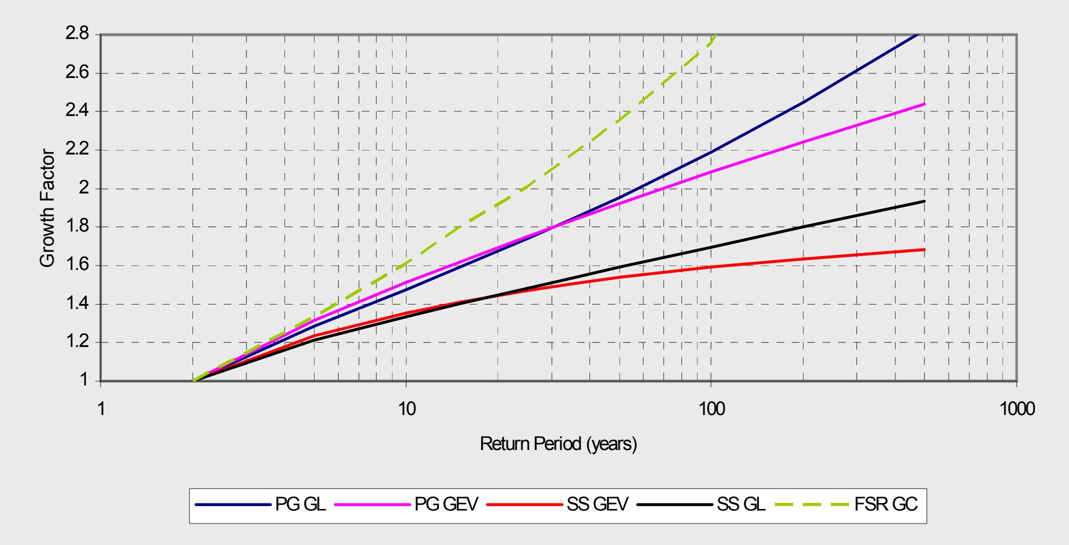


Figure A21.1: Comparison of pooling group, single site growth curves for Dee at Park, together with the FSR Regional Growth curve 1. (PG = pooling group, SS = single site analysis)

A21.2 Appendix 2 (pooling group details) shows that the subject site growth curve (rank 1) gives the flattest growth curve of the whole pool.

Comparison of single site analysis with u/s gauge analysis

A21.3 The second ranked station of the pooling group, 12001 Dee at Woodend (catchment area 1370 km^2), is upstream of Park (which has a catchment area of 1844 km^2). The record at this station extends to 70 years. The Draft Hiflows-UK database valuates this station as fit for QMED and fit for pooling, ie suitable for flood frequency analysis. However, a key feature of the 12001 annual maximum series is that two extraordinarily large flood peaks exist in the early record: 24 January 1937 (1133 cumecs) and 6 November 1951 (1018 cumecs).

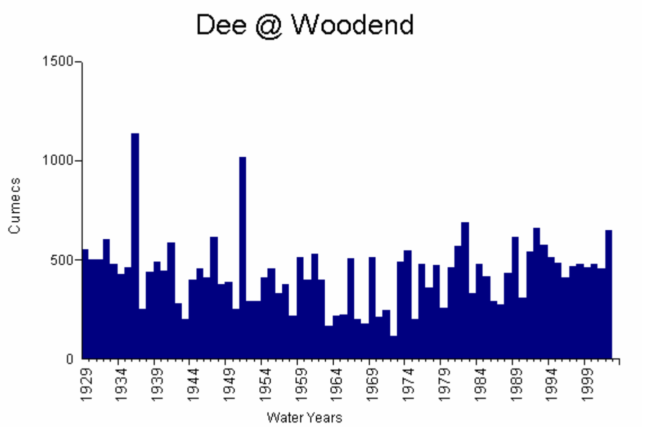


Figure A21.2: Annual maximum series for Dee at Park (data source Draft Hiflows-UK database v2.7.9

A21.4 It is difficult to confirm the magnitude of these floods, and the Hiflows data capture consultants comment that these two large events have been accepted in the amax series since no evidence to the contrary was available. It would also be wrong to eliminate “outliers” simply because they do not conveniently fit the analysis of the rest of the series.

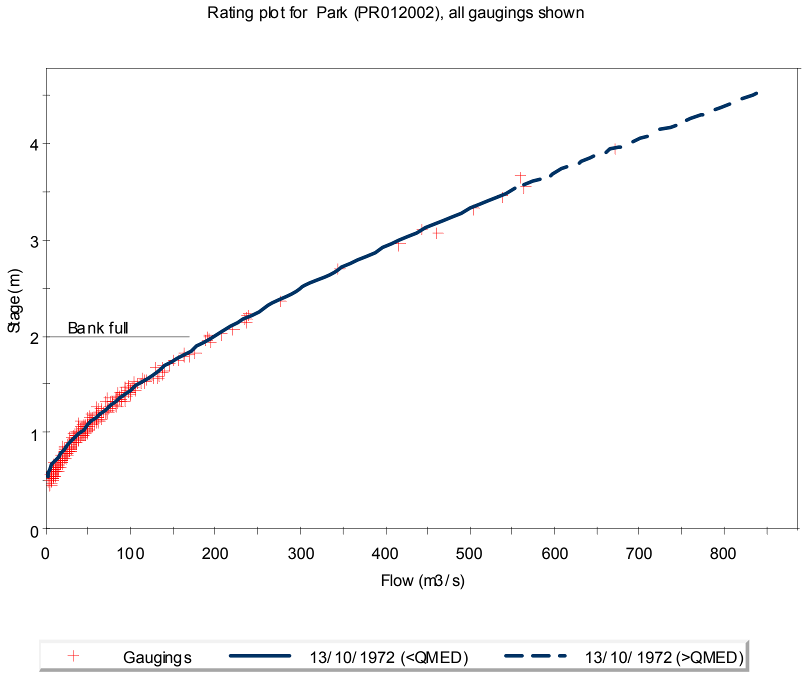


Figure A21.3: Rating relationship and spot gaugings for Dee at Park

A21.5 Figures A21.3 and A21.4 show the rating relationships and spot gaugings at both the Park and Woodend gauges.

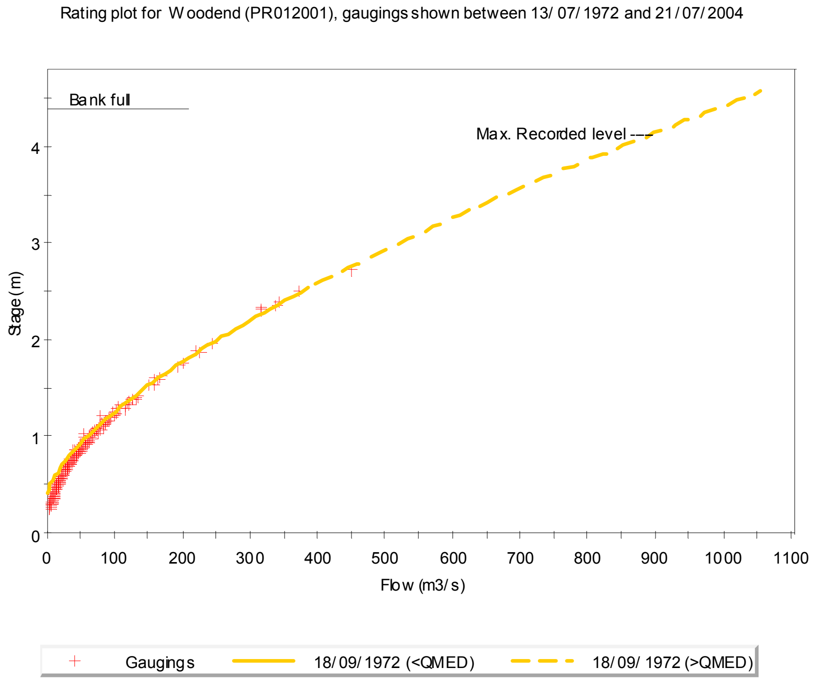


Figure A21.4: Rating relationship and spot gaugings for the River Dee at Woodend

A21.6 Spot gauging data are only available for 12001 from 1972 onwards. SEPA do not hold the equivalent data from the period 1930s –1970s and their high flow rating for this earlier period has been taken from FSR records (and used in the Draft Hiflows-UK database). It is therefore difficult to investigate the validity of the pre-1972 record.

A21.7 Both stations for the 1972 onwards period have good quality high flow ratings with spot gaugings slightly higher than QMED. Little scatter is evident. Both rating relationships suggest that during the period 1972 to present that the annual maximum series will be well estimated.

A21.8 Figure A21.5 shows the intersite relationship between the two sites (using data held in the Draft Hiflows Version v2.7.9 dataset). This shows reasonable consistency between the two data sets and does not highlight any potential problems in the estimation of high flows during the 1972 to 2002 period.

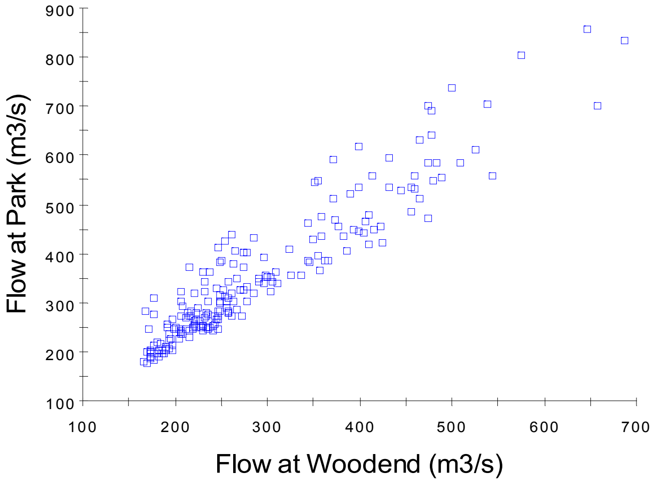


Figure A21.5: Intersite comparison of flood flows at Park and Woodend.

A21.9 Figure 6 shows how the single site flood frequency analyses compare for both sites, with the Woodend analysis undertaken for two periods of record (1973 to present, and full period of record) and the two extreme peaks included and excluded from the data.

A21.10 Both sites have the same growth rate for the period 1973 to 2002. Similarly, the growth rate with the two extreme peaks removed is consistent. With the two extreme events included, the growth rate increases (but it should also be noted that neither the GL nor the GEV distributions fit the data in a convincing manner).

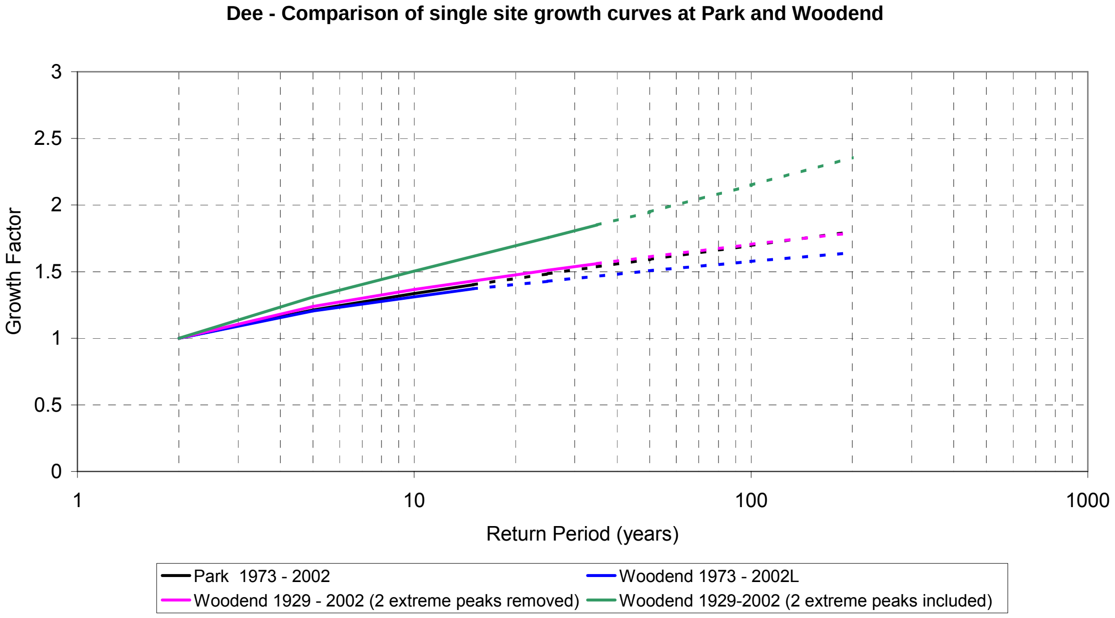


Figure A21.6: Comparison of single site analysis grow curves for i) Park 1973-2002, ii) Woodend 1973 – 2002, iii) Woodend 1929 - 2002 with the two extreme peaks removed, iv) Woodend 1929 - 2002 with the two extreme peaks included. (GL distribution is used in all cases. Dotted lines indicate return period beyond 0.5N where N is the number of years in record)

Final Flood Frequency Curve Used

A21.11 The single site analysis at Park and Woodend for the 30-year period 1973-2002 raises doubt about the suitability of the steeper pooling group curve. Both stations have robust rating relationships for this period and the data are believed to be accurate. If the full record of Woodend is analysed then the two extraordinarily large events recorded begin to suggest that a steeper growth curve would be more suitable for Park. However it is difficult to be sure of the validity of the two Woodend outliers; there will certainly be an appreciable level of uncertainty in their flow estimates, but in the same context it would be wrong just to ignore them.

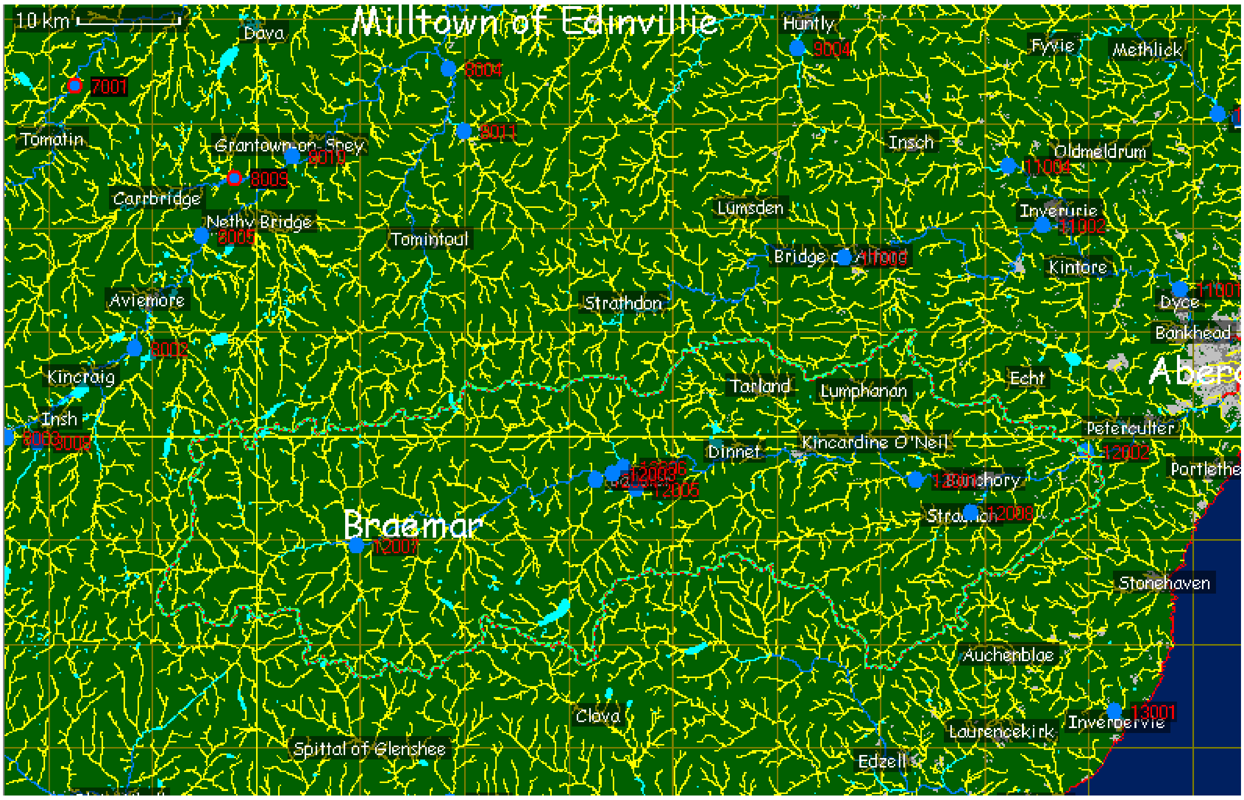
A21.12 In terms of the pooling group, the target site has the shallowest growth rate out of all the catchments pooled. It could be argued that it is rather difficult to pool similar catchments to the River Dee from the available UK catchments.

A21.13 Based on the above, this study gives equal weighting to the Park single site analysis and the pooling group analysis. The final flood frequency curves are given in Table 21.1.

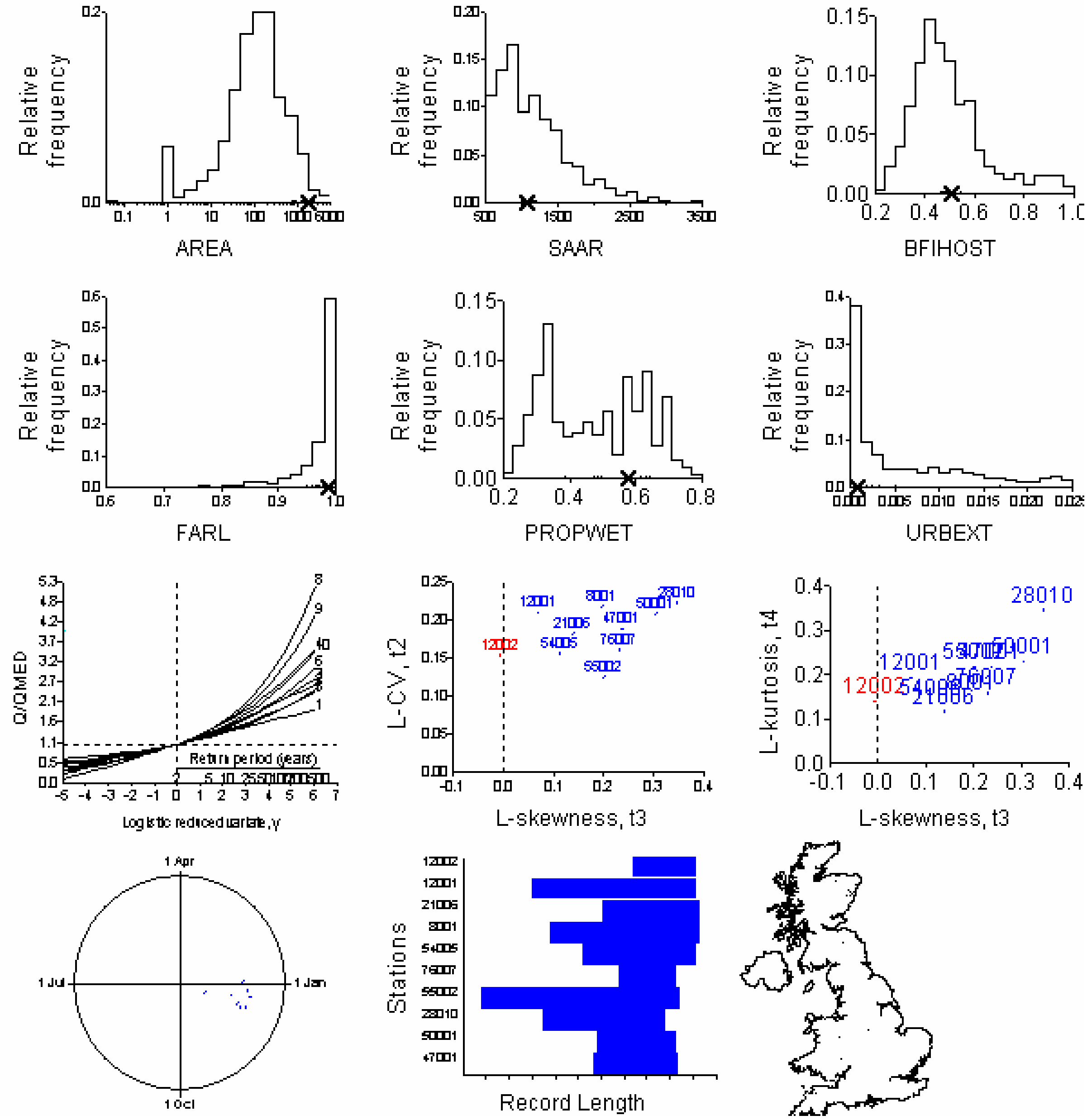
Table 21.1 – Final Flood Frequency Curve for Dee at Park

GL		
Return period (yrs)	Growth factors	Design flows (m^3/s)
2	1	571
5	1.248	713
10	1.406	803
25	1.612	921
50	1.773	1013
100	1.942	1110
200	2.122	1212

Appendix A21.1: Location of Catchment



Appendix A21.2: Pooling Group Details – Graphs



Appendix 21.3 - Pooling Group Details

Station	Yrs	L-CV	L-Skew	L-Kurt	Discordancy	Distance
12002 (Dee @ Park)	30	0.154	0.007	0.141	1.400	0.000
12001 (Dee @ Woodend)	74	0.210	0.068	0.194	1.425	0.164
21006 (Tweed @ Boleside)	44	0.182	0.138	0.117	0.617	0.229
8001 (Spey @ Aberlour)	64	0.218	0.196	0.151	1.048	0.278
54005 (Severn @ Montford)	51	0.156	0.112	0.137	0.345	0.285
76007 (Eden @ Sheepmount)	27	0.160	0.229	0.160	0.730	0.291
55002 (Wye @ Belmont)	84	0.126	0.200	0.218	1.706	0.399
28010 (Derwent @ Longbridge Weir)	52	0.223	0.345	0.346	2.032	0.444
50001 (Taw @ Umberleigh)	36	0.208	0.305	0.230	0.599	0.508
47001 (Tamar @ Gunnislake)	38	0.188	0.236	0.219	0.097	0.508
Total	500					
Weighted means		0.183	0.137	0.175		

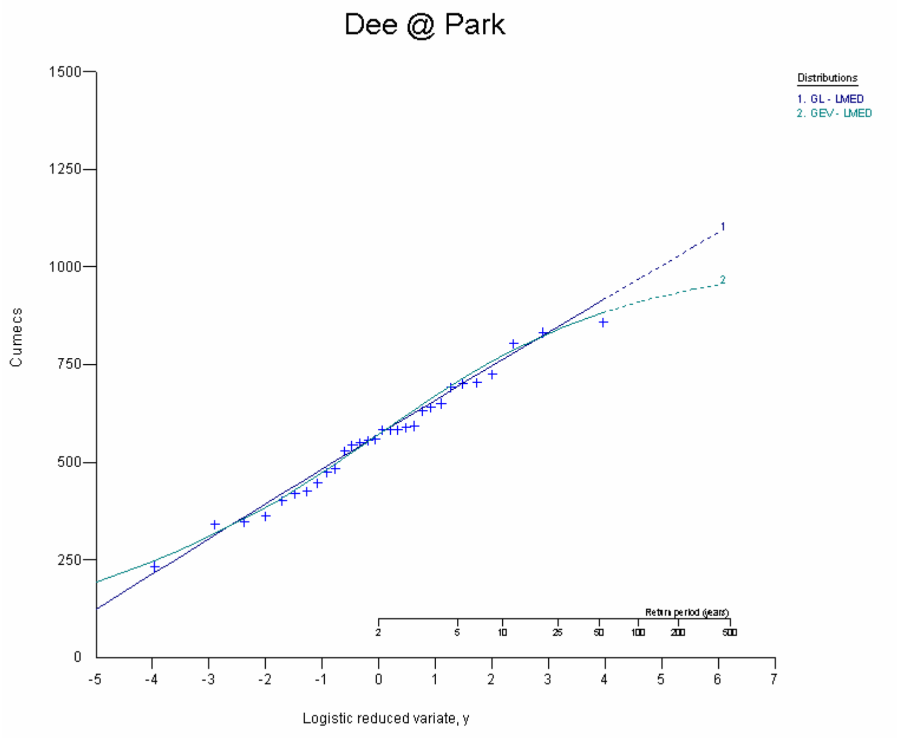
Appendix 21.4: Single Site Analysis

No years: 30

QMED: 571.2 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	571.2	1.000	571.2
5	1.236	706.3	1.212	692.5
10	1.354	773.7	1.336	762.9
25*	1.471	840.1	1.484	847.5
50*	1.538	878.5	1.591	908.7
100*	1.592	909.6	1.696	968.7
200*	1.636	934.7	1.800	1028.0
500*	1.682	960.8	1.936	1105.6

*return periods > ½ N



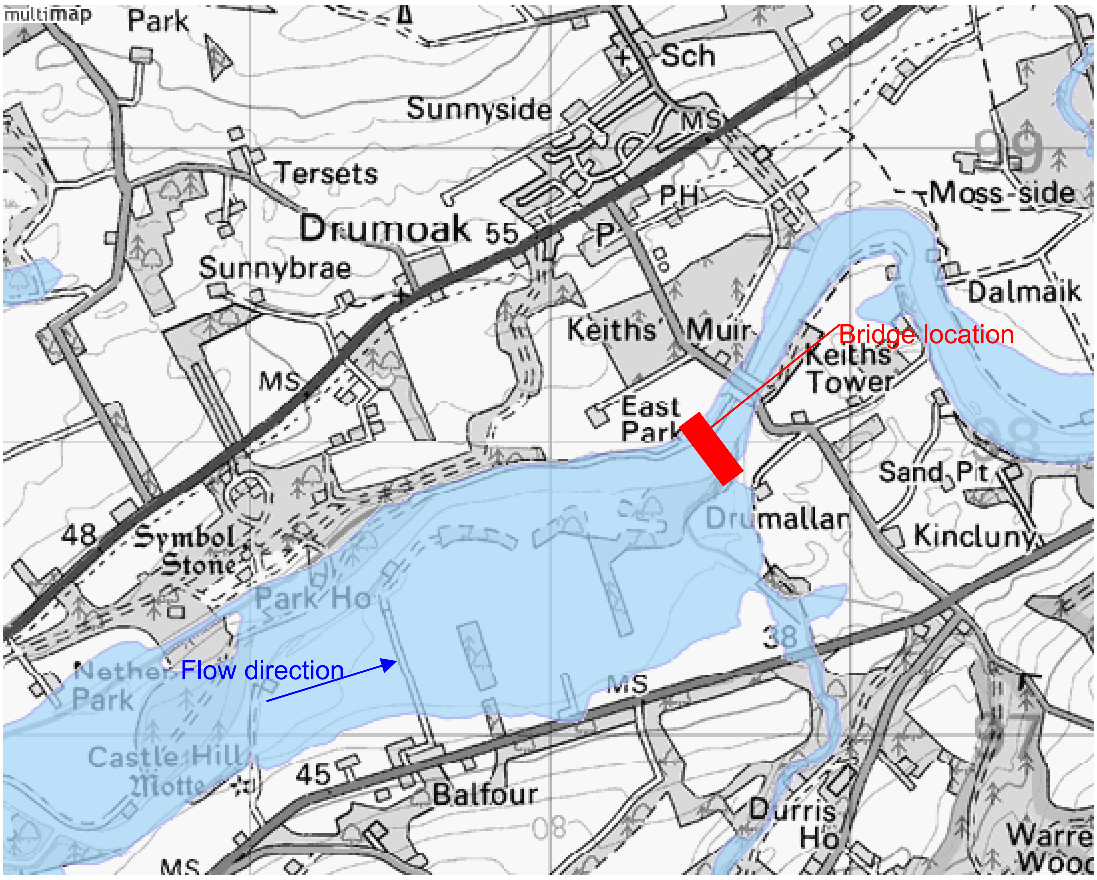
Indicative River and Coastal Flood Maps (Scotland)

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; or
- 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 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), refer to the SEPA website.



The River Dee is indicated as having a risk of flooding at the 0.5% AEP (200 year return period event) at the proposed bridge crossing by the SEPA 'Indicative River and Coastal Flood Map (Scotland)'. These indicate that the River Dee experiences out of bank flooding covering approximately 100m on the left bank and extensive flooding along the right bank up to 800m. There are properties located in close proximity to the proposed bridge and the predicted 0.5% AEP flood inundation.

Annex 21 Fluvial Geomorphology: Background

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. 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, or those of 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 (see Figure 10.1). 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 proposed scheme. Other, indirect changes to the sediment regime might occur and these are considered in terms of changes to natural fluvial processes, such as erosion and deposition.

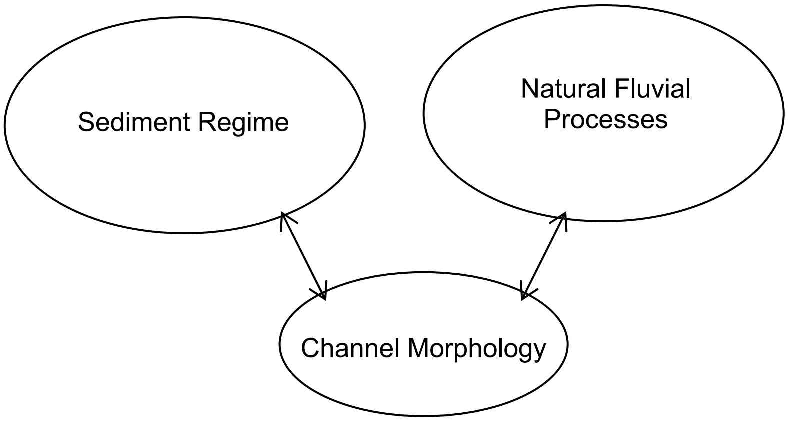


Figure 22.1 Simplified Interrelationships in the Fluvial System

Annex 22 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	Existing Modification	Gradient (average over 1 km)	Flow/ Morphological Diversity
Loirston Burn	1-3	0.5	1.5-3	Gravel and cobble	Natural (fine and coarse material)	Realigned, resectioned	0.015	Poor
Greengate Ditch	3	0.4	2	Fines and gravel	Natural (fine material)	Realigned, resectioned	Negligible	Poor
Burn of Ardoe	1.5	0.2	1	Grasses and rushes	Natural (fine and coarse material)	Realigned, resectioned	0.01	Poor
Jameston Ditch	1.2	0.4	0.8	Fines and vegetation	Natural (fine material)	Realigned, resectioned	Negligible	Poor
Bishopston Ditch	0.75	0.2	0.75	Grasses	Natural (fine material)	Realigned, resectioned	0.003	Poor
Heathfield Burn	2	0.3	1	Silt	Natural (fine material)	Realigned, resectioned	0.010	Poor
Whitestone Burn	1	0.3	1	Silt and pebbles	Natural (fine material) and walled	Realigned, resectioned	0.03	Poor
Burnhead Burn	4-10	1	2-4	Gravel, cobble	Natural (fine and coarse material)	Realigned, resectioned, bridge	0.010	Moderate
Blaikiewell Burn	2-2.5	1	1	Gravel, cobble	Natural (fine and coarse material)	Realigned, resectioned, bridges	0.016	Good
Kingcausie Burn	0.5-4	0.5-3	0.2-1	Gravel, some sand and cobble	Natural (fine and coarse material) and walled	Realigned, resectioned, culverted	0.026	Very good
Crynoch Burn (not crossed)	5-10	2-5	1-5	Gravel, cobble, boulder	Natural (fine and coarse material), some rip-rap	In places - Realigned, resectioned, walled, weir, bridges	Locally variable	Very good
River Dee	c.30-75	c.25-60	c.1-5	Cobble	Natural (fine material), some rip-rap	Bridges, some bank re-enforcement, set-back embankment	Low	Good
Milltimber	1.5	0.6	0.8	Sand,	Natural	Realigned,	0.010	Poor

Watercourse	Bankfull Width (m)	Wetted Width (m)	Depth (m)	Bed Material	Bank Material	Existing Modification	Gradient (average over 1 km)	Flow/ Morphological Diversity
Burn				gravel, silt	(fine material)	resectioned, culverted		
Culter House Burn	2	0.3	1.25	Vegetation filled	Natural (fine material) and walled	Realigned, resectioned	0.02	Poor
Beans Burn	1	0.3	0.75	Vegetation filled	Natural (fine material) and walled	Realigned, resectioned	0.02	Poor
Upper Beans Hill Burn	1.25	0.3	1.25	Vegetation filled	Natural (fine material) and walled	Realigned, resectioned	0.013	Poor
Gairn Burn	0.5	0.4	0.4	Coarse blocks	Natural (fine material) and walled	Realigned, resectioned, bridges	0.040	Moderate
Westholme Burn	2	Dry (1.25m)	1.5	Mixed fines and gravel	Natural (fine material) and walled	Realigned, resectioned	0.013	Poor

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

Watercourse/Water Feature Within Route Corridor	Grid Reference	Geology
Loirston Burn	NO923999	Till overlies bedrock (Aberdeen formation)
Greengate Ditch	NO917996	Till
Burn of Ardoe	NO904996	Peat and till
Jameston Ditch	NO905996	Peat
Bishopston Ditch	NO904990	Till
Heathfield Burn	NO903990	Till (Banchory Till Formation)
Whitestone Burn	NO880987	Till
Burnhead Burn	NO870986	Lacustrine Deposits. Downstream, alluvium and till (Banchory Till Formation)
Blaikiewell Burn	NO868987	Alluvium
Kingcausie Burn	NO864996	Alluvium overlies till
River Dee	NJ859004	Alluvium
Milltimber Burn	NJ858010	Glacial Meltwater Deposits
Culter House Burn	NJ849017	Till

Watercourse/Water Feature Within Route Corridor	Grid Reference	Geology
Beans Burn	NJ850035	Till
Upper Beanshill Burn	NJ851045	Till and Glacial Meltwater Deposits
Gairn Burn	NJ849042	Till
Westholme Burn	NJ853065	Till and Glacial Meltwater Deposits

Annex 23 Fluvial Geomorphology Site Photographs

Loirston Burn

NO9223699917: Very narrow and over deepened burn, due to realignment through a small plantation. Photo looking downstream towards potential crossing point.

Greengate Ditch

View downstream

Burn of Ardoe

View downstream. The channel is obscured by both bed and bank vegetation.

Jameston Ditch

View upstream. The channel contains little flow, dominated by boggy fine material and vegetation.

Bishopston Ditch

NO9074398973: View downstream. The channel is ditch-like and is filled by dense vegetation.

Heathfield Burn

NO9049798968: View upstream just upstream of crossing. Straight, deep ditch, silt on channel bed.

Whitestone Burn

NO8792598583: View upstream. Straightened burn – aligned along field boundaries.

Burnhead Burn

NO8709298244: Photo across channel. Upper reach straightened, uniform field ditch. Lower reach (to be crossed) is straight but has more diversity of bed, flow types, bank vegetation, etc. Confluence with Blaikiewell Burn is immediately downstream of potential crossing point.

Blaikiewell Burn

NO8684498710: View upstream. Local changes in gradient, sinuosity created by channel vegetation and mixed substrates contribute to a reach with small-scale but varied geomorphology.

NO8684298754: View across Blaikiewell Valley (looking south-east) at approximate crossing location.

Kingcausie Burn

NO8626699893: View upstream. Re-naturalising wooded section with undercutting banks, riffle-glide sequences and natural debris.

NO8616699942: View downstream, around potential crossing location. Realigned along field boundary, just upstream of cascade to confluence with Crynoch Burn.

Crynoch Burn

NO8717196299: View upstream. Upper reaches meander but are confined by steep valley sides (sourcing fine sediment by cliff erosion). Coarse sediment (mostly cobbles) dominate, with bars and pools. Some reinforcement using blockstone on outside of meanders.

NO8596499736: View downstream. Middle reaches historically realigned/straightened through theme park, although channel dimensions remain similar to natural reaches. Large cobble deposits and boulders, and extensive channel shading. The channel descends through a short gorge section.

NJ8576600336: View upstream. On exiting the gorge, the gradient drops and the channel has been historically altered for milling – weirs and old offtake channels are evident. A straight and overdeep/embanked course goes under the road bridge and down to confluence with the Dee, however coarse sediment deposits are still present.

River Dee

NO8580000400: View downstream from Peterculter Road Bridge at location of proposed road crossing. Large gravel bed river, good morphology and habitat diversity.

Milltimber Burn

NJ8567200973: View upstream in vicinity of proposed road. Straightened ditch, vegetation filled.

Culter House Burn

NJ8494701694 View downstream, illustrating the dense vegetation within the channel.

Beans Burn

NOJ85222 03120 View looking upstream toward location of proposed crossing. Note the straight ditch-like form of the watercourse.

Upper Beanshill Burn

NJ85007004351 View looking at angle across the channel in a downstream direction. The channel is obscured by dense vegetation growth along both banks of the watercourse.

Gairn Burn

NO8499604409: View upstream. Relatively steep, gravel bed channel. Gorse and shrubs on banks.

Westholme Burn

View looking downstream. The photograph illustrates the ditch-like form of the channel.

Annex 24 River Dee Geomorphology Survey

25.1 Objectives

A25.1.1 A geomorphological survey of the River Dee, from Inch of Culter (NGR: NJ 004 856) to Haugh of Ardoe (NGR: NJ900 026) was undertaken to understand the geomorphological forms and adjustment of the river channel in this reach. The study had three primary objectives:

- Describe the baseline conditions along the River Dee at the site of the proposed road crossing and further downstream.
- Assess the adjustment of the river and evaluate the likelihood for future changes in the river channel which may have implications for bridge design.
- Locate sites where fine sediment, released as a result of the scheme, is likely to be deposited in the channel.

Methodology

A25.1.2 A detailed reconnaissance study was undertaken which comprised of a desk study and a walk over survey of the study reach.

Desk study

A25.1.3 The desk study focused on review of documentary data relevant to this section of the River Dee. Data sources included:

- The 2002 Ordnance Survey Map
- The 1869 First Edition Ordnance Survey Map
- Aerial photographs from 1948, 1960 and 2006.
- Historical flood records
- Hydrological data
- Published reports and papers

A25.1.4 These data sources were used, in conjunction with the site survey, to characterise the existing baseline river environment. In addition, a historical trend analysis using map evidence was undertaken to examine adjustment of the River Dee during the nineteenth and twentieth centuries. These changes were then compared to the historic flood record and hydrological data to assess the significance of flow variations, particularly floods, as a cause of channel change. This analysis was used to provide an indication of the long-term trends in channel behaviour and reveal the response of the river to flood events. This enabled the risk of adjustment (likelihood of change) of the river to be determined.

Field survey

A25.1.5 A walk-over survey was undertaken along the left bank of the river with the aim of producing detailed geomorphological and flow maps of the study reach. The field mapping was augmented by note taking, focusing on interpretations made in the field and digital photography to document key sites in detail.

A25.1.6 The field survey was conducted under low flow conditions (close to base flow). This was advantageous as the morphological features of the river could be observed with ease. The river channel is most vulnerable to fine sediment inputs during low flows as the potential for dilution is limited and low flow velocities restrict dispersal downstream, this increases the likelihood of sediment deposition on the bed.

Limitations

A25.1.7 A detailed geomorphological survey (geo-dynamics assessment), involving a full intensive data search and field based monitoring of river channel changes in three dimensions, was not conducted along the reach. The study provides a qualitative review of river channel form and behaviour in plan only.

A25.1.8 Monitoring of flow patterns and velocities over a range of flows was not undertaken. Similarly the method did not include hydrodynamic modelling. The study provides a qualitative assessment of flow patterns and velocities based primarily on a single site visit conducted during low flow conditions.

25.2 Results

Baseline Description

A25.2.1 The source of the River Dee is at 1200m AOD in the Cairngorm Mountains and flows east for 141 km before entering the North Sea in Aberdeen. The catchment has an area of 2100km^2 of which 60% is upland in character. The river has a steep concave profile, reflecting the high gradients in the upland section of the catchment and the relatively low gradients of the lower catchment. The mean annual precipitation ranges from 2000mm in the mountains to 700mm at the coast (Moir et al., 2002).

A25.2.2 The river has a flashy flow regime. Mean daily flow at Park is 46m^{3}s^{-1}. However, floods have exceeded 1000 m^{3}s^{-1} and base flows have been recorded as low as 3.5m^{3}s^{-1} (Moir, et al., 2002). The 1 year return interval flood at Park gauging station has a discharge of approximately 571m^{3}s^{-1} while the 100 year return flood is estimated to be 1110m^{3}s^{-1}.

A25.2.3 Along the study reach, the River Dee is a substantial cobble/gravel-bed river. The channel along the study reach has a large-scale sequence of deep glides and shallow riffles with numerous channel deposits including side bars and vegetated islands. The glides are longer than the riffles (Map 1). Fine sediment is generally absent from the bed and side bars suggesting the river has is a relatively low fine load. Although the channel gradient is low (0.003), the numerous active gravel deposits along the river indicate that bed load movement occurs regularly. Bed load transport is likely to be concentrated during periods of bankfull flow.

A25.2.4 The river banks are dominated by sandy sediments with occasional gravel layers toward the bank toe. The banks are generally stable although localised erosion does occur, primarily as a result of livestock poaching (Figure 1).

Figure 1: Right bank of river in the location of the proposed crossing showing evidence of livestock poaching.

A25.2.5 The channel is partly connected to its floodplain which inundates during floods. However, the degree of inundation is restricted by the presence of embankments.

A25.2.6 The channel has been subjected to localised modifications. There are occasional croys (rock groynes) along the river channel which appear to have been installed as fisheries improvements. Rip-rap (rock armour) is present in two locations to prevent bank erosion (Map 1). To the west of the Murtle Estate, this has been used to stop bend growth. Elsewhere full bank protection is absent. Small boulders are frequently present along the toe of the banks along the reach. The origin of these is unclear but they may represent minor bank protection measures.

A25.2.7 Despite the installation of rip-rap on the outer bank of the bend, a large point bar growth has continued to form through deposition on the inner bank, leading to the incorporation of a former island into the point bar (Figure 2). This progressive build-up of sediment reveals that the river currently conveys a coarse sediment load downstream, some of which is deposited on this point bar.

Figure 2: View of the river bend to the west of Murtle Estate (looking upstream). The former vegetated island which is now set within a point bar is indicated with an arrow.

A25.2.8 There are several palaeochannels on the floodplain along the left side of the river indicating past changes in the location of the active channel.

River Channel Change and Stability

A25.2.9 Over decadal and century-long timescales, natural river channels adjust their form, both vertically and horizontally, in response to changes in external influences such as:

- climate induced changes in hydrological regime;
- land use induced changes in the sediment and/or hydrological regime; and
- river channel engineering.

A25.2.10 Field evidence in the form of palaeochannel and contemporary map evidence suggests that the river channel along the study reach has shifted position.

A25.2.11 The first edition Ordnance Survey map, dating from 1869, indicates that significant changes in the river channel occurred in the early to mid nineteenth century. Here the map shows a number of water filled back waters which follow the alignment of former bends in the river. Significantly these backwaters also follow the line of the constituency boundary, marked on the most recent Ordnance Survey Map. This boundary generally follows the centre line of the river channel except in these locations. This provides further evidence of changes in the course of the river. Using the evidence from these two map editions, it is possible to reconstruct the course of the river in the early nineteenth century. This and the later map evidence allow the trends in river channel behaviour over approximately the past 200 years to be reconstructed (Figure 3).

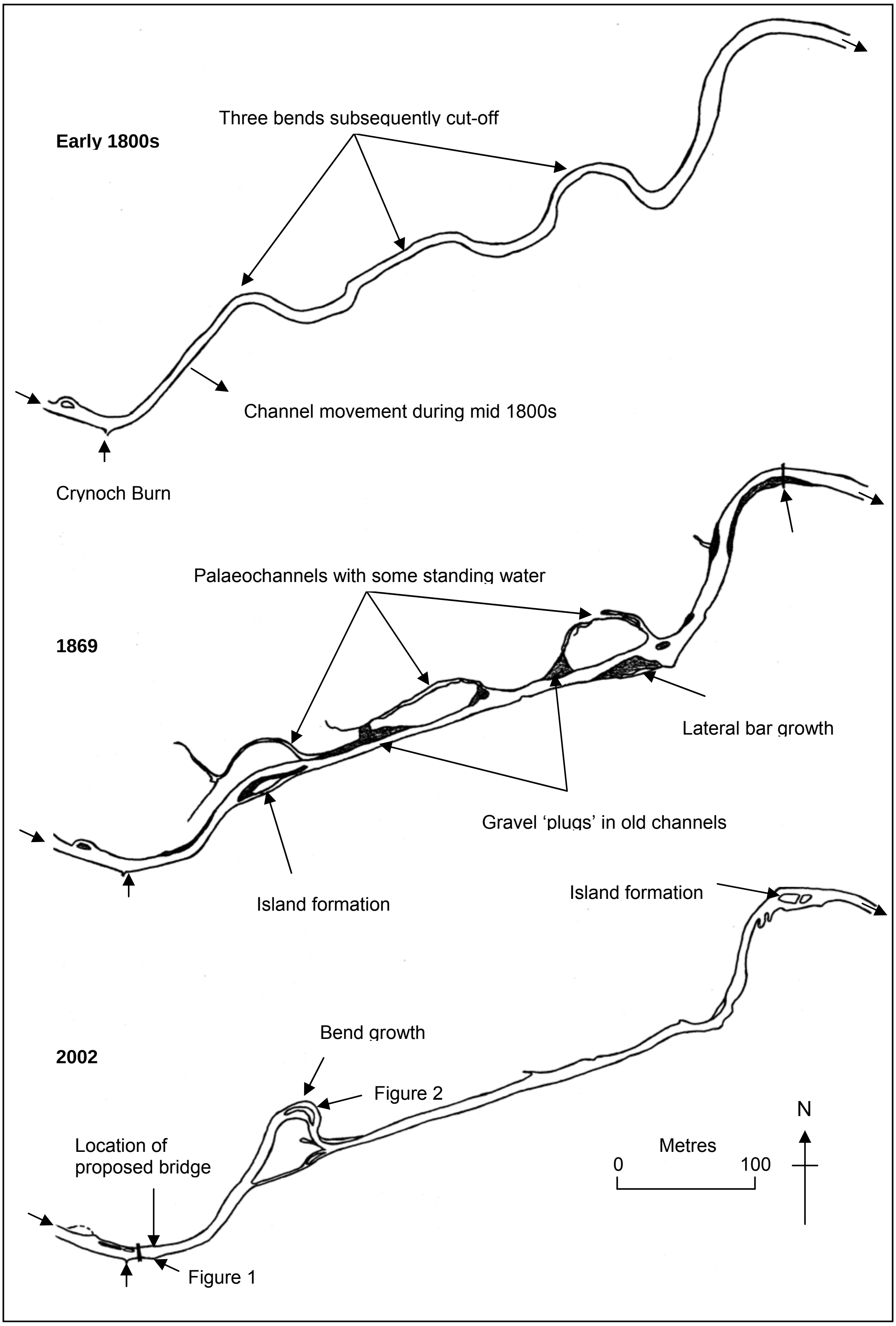


Figure 3: Reconstructions of channel planform along the Study reach from the early nineteenth century to 2002. The locations of Figures 1 and 2 are located on the 2002 map.

A25.2.12 These reconstructions reveal that the most widespread channel changes occurred during the early to mid-nineteenth century, when three bends in the river were cut-off. These bend cut-offs do not appear to reflect the typical mechanism of cut-off in meandering rivers, which involves gradual bank erosion around the outside of bends at the neck of the meander (Figure 4). Instead, they occurred through long straight breaches across the neck of the bends with no prior narrowing at the neck. Such channels are often referred to as chute channels. Following these breaches, and perhaps during their formation, the entrance to the old bends became plugged with river sediments.

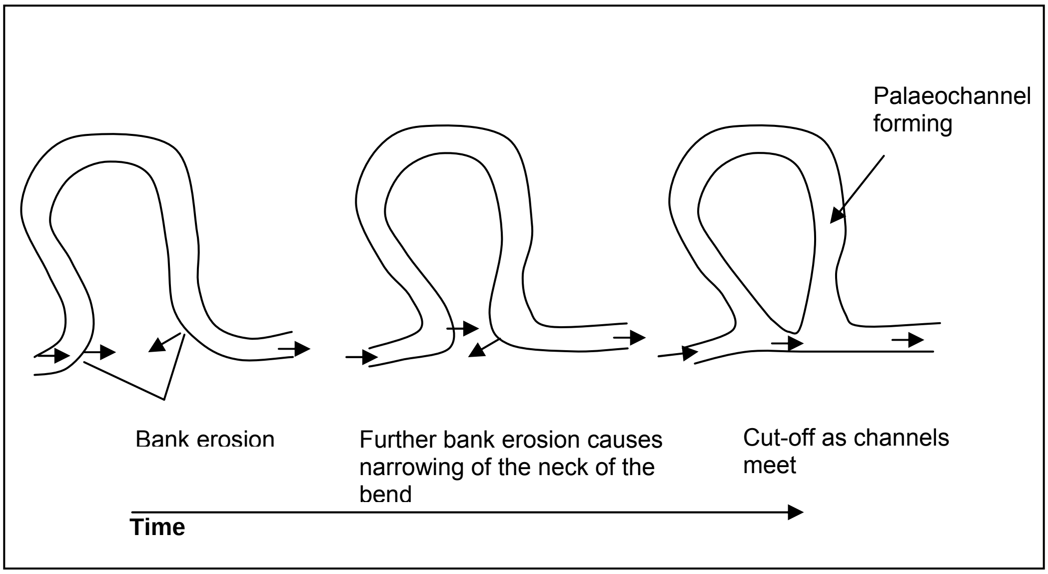


Figure 4: Conceptual model illustrating the typical mode of gradual bend (meander) cut-off in alluvial rivers.

A25.2.13 This dynamic mode of channel change suggests that it was triggered by a flood event. A review of the documented floods in the River Dee catchment (Table 1) reveals there were a number of recorded floods in the catchment during the early nineteenth century, including the largest recorded flood on the river in 1829. It is therefore likely that this flood caused the changes in the course of the river. It is possible that the change in river course was a result of human intervention in the form of realignment. However, such an extensive realignment would have required widespread bank protection works to 'train' the river into a new course and it is not clear why realignment would be required as there is no development on the floodplain. The absence of bank protection along this length suggests that deliberate realignment was not undertaken. In addition, the extensive channel deposits along the reach in 1869 suggest high sediment supply at this time. This and the nature of the channel change are consistent with the style of channel change commonly induced by high magnitude flood events in gravel-bed rivers.

A25.2.14 Between 1869 and 2002, channel change was limited to two locations (Figure 3). The bend in the western half of the study reach to the west of the Murtle Estate grew progressively larger and developed a greater size than the bend which was present in the early 1800s.Toward the eastern limit of the study reach, two islands formed in the location of Morrison's Bridge at Cults (sometime referred to as Cults Bridge). Significantly, the documentary accounts of flooding reveal that this bridge was partially destroyed by a flood in 1894. Map and field evidence suggests that the bridge was outflanked by erosion of the right bank during this flood. It is possible that the islands were remnants of floodplain which had become incorporated in the channel as the land to the south was eroded. This mode of channel change is similar to that which led to the bend cut-offs in the nineteenth century.

A25.2.15 This bend growth is likely to have occurred in response to the increased channel gradient caused by bend cut-off in the mid-nineteenth century, which caused an increase in stream power and associated increases in bank erosion rates. This bank erosion has subsequently been checked by rip-rap.

A25.2.16 Aerial photography and field evidence suggests the river is currently in a state of dynamic equilibrium. The side bars along the river channel appear to have been a relatively constant size for the past five years (allowing for differences in stage). This suggests the river's coarse sediment load is relatively constant and that at present the river channel is not exhibiting evidence of any progressive change.

Table 1 – Flood history of the River Dee as recorded by Law et al. (1998)

Year	Date	Details (where available)
1768	August	-
1774	9th September	Floodplain inundation recorded
1829	August	Largest recorded flood along the River Dee Ballater Bridge destroyed 1900 m^3s^{-1} at Cairnton "phenomenal flood"
1865	February 16th	-
1866	March	-
1868	31st January	-
1868	September	
1869	October	-
1872	26th February	-
1872	25th October	-
1873	15th September	-
1873	7th November	-
1874	12th / 13th August	-
1876	5th April	-
1877	August	"phenomenal flood"
1881		481 m^3s^{-1} at Cairnton "phenomenal flood"
1885	12th August	Floodplain inundation recorded
1894	2nd August	Several bridges carried away in Aberdeenshire. The Dee at Cults Bridge (now only partially standing) rose 12 ft above its ordinary level.
1903	27th October	Floodplain inundation recorded
1906	May	Floodplain inundation recorded
1913	7th May	"River Dee in flood"
1913	9th May	317 m^3s^{-1} at Cairnton The flood caused considerable damage to bridges, fields, roads, etc. and carried away a great amount of sand, gravel and other material.
1915	May	-
1915	28th October	-
1920	4th October	1133 m^3s^{-1} at Cairnton
1922	March	Floodplain inundation recorded – snow melt event
1937	24th January	1133 m^3s^{-1} at Woodend
1951	6th November	1018 m^3s^{-1} at Woodend
2002	22ndNovember	Floodplain inundation recorded

A25.2.17 The majority of the channel changes recorded along the River Dee appear to have occurred rapidly as a result of large flood events, rather than occurring gradually. The frequency and magnitude of flooding is therefore likely to be the primary control on river channel form in the lower River Dee.

Twenty nine large flood events are recorded in the historic record between 1774 and present. Comparing recorded flows for these large historic events with the flood frequency and magnitude data for the River Dee at Park (Table 2) located approximately 16km downstream of Cairnton, with an additional catchment area of 474 km^2, suggests the event of 1829 was greater than a 200 year return event and the 1920 and 1937 floods had a return period in the region of 200 years.

Table 2 – Flood Frequency and Magnitude Data for the River Dee at Park

Return Period (yrs)	Flow (m^3s^{-1})
2	571
5	713
10	803
25	921
50	1013
100	1110
200	1212

A25.2.18 The geomorphological evidence indicates that floods do not always cause significant channel changes. The November 2002 flood event caused extensive floodplain inundation (Figure 5), although no significant channel change occurred as a result of this event. While the flood of 1829 is likely to have been the cause of the widespread channel changes in the first half of the nineteenth century, other high magnitude floods did not cause significant channel changes. The 1894 flood appears to have led to the changes recorded at Cults Bridge. However, other large floods such as the 1829, 1881 and 1920 events do not appear to have driven significant channel changes, although they are likely to have contributed to the gradual bend growth to the west of the Murtle Estate.

(a)

(b)

Figure 5: Floodplain inundation during the November 2002 flood event at (a) Peterculter Bridge and (b) Deeside Golf Club, both views are towards the northeast.

A25.2.19 With the exception of extreme floods (> 200 yr return) channel planform change is likely to be influenced by a range of other factors, such as human modifications to the channel, degree of flow confinement, antecedent weather conditions and seasonal variations in channel vegetation density. On the basis of the past changes, the locations that are most vulnerable to changes are tight bends in the river, where flow is concentrated against one bank. These locations are vulnerable both to sudden rapid change during large floods and progressive bank erosion caused by a series of smaller floods. The growth in the river bend to the west of Murtle Estate since the mid-nineteenth century is likely to reflect progressive retreat caused by the sequence of flood events since the mid-nineteenth century.

Potential Sites of Fine Sediment Accumulation

A25.2.20 Fine sediment deposition in the river channel is primarily controlled by flow velocities which control the sediment transport capacity of flow. The relatively diverse channel morphology (Map 1) leads to a range of flow patterns, types and velocities (Map 2). The flow patterns recorded in this study represent low flow conditions. The river is dominated by an alternation between deep glides with smooth flow, and shallow riffles where the flow is more turbulent. The riffles have a steeper surface slope than the glides. Flow velocities are lower in the glides than the riffles. There are three locations, where flow is very rapid, where the channel narrows or splits around mid-channel bars (Map 2). In contrast, there are also sites along the river margins where flow velocities are close to zero.

A25.2.21 The sites where fine sediment deposition is most likely are the areas of still water such as back waters and secondary channels where the flow is very limited especially at low flow. These areas of vulnerability are concentrated along the channel margins (Map 2). The backwater located at the confluence of the Milltimber Burn will be particularly vulnerable to fine sediment accumulation as here fine sediment may be transported to this location by both the River Dee and the Milltimber Burn.

A25.2.22 The downstream sections of glides are also particularly vulnerable to sediment deposition where the flow slows as it approaches the shallower riffle sections. Immediately downstream of the riffles the flow velocities as the flow moves away from the steeper riffles appear to be sufficient to transport fine sediment downstream.

A25.2.23 Where the river channel is curved, the thalweg (line of maximum depth) is routed around the outer side of the channel (Map 2). In the straight section in the middle of the study reach, the thalweg is located toward the right bank while flow velocities are generally lower along the left side of the channel. This is because the channel has a slightly asymmetrical cross-section; being deeper toward the right bank and shallower along the left bank. The left side of the channel in this section is therefore more likely to experience sediment accumulation on the bed than the right.

A25.2.24 During the field survey, conducted at low flow, dense filamentous algae growth was observed growing from the riverbed (Figure 6). This algal bloom may reflect relatively high nutrient levels. The presence of filamentous algae is likely to trap fine sediment in the water column, further encouraging fine sediment deposition. However, algal blooms such as this are temporary and will only have short lived impacts on sediment transport.

A25.2.25 In general, the likelihood of sediment deposition on the bed of the river would diminish with distance downstream from the road crossing point.

(a)

(b)

Figure 6: Examples of filamentous algae blooms along the left bank of the river channel approximately 200 metres downstream of the proposed crossing point, (a) looking downstream and (b) viewed across the channel.

25.3 Implications

Proposed Bridge

A25.3.1 The historic evidence suggests that low frequency high magnitude flood events can lead to dramatic localised changes in the river channel. It is therefore possible that such an event could lead to bank erosion on a scale that is large enough to damage the proposed road bridge structure (refer to Chapter 4 and Figure 4.2d). Historic trend analysis suggests that the most significant channel changes that occur during large floods occur in locations where tight bends are present. Although the proposed crossing is located on a bend, it is relatively gradual and the river channel has not changed appreciably in this location for over 150 years, despite the occurrence of several very large flood events. The right bank shows evidence of bank erosion, but this is due to livestock poaching rather than progressive movement of the river channel. The lack of channel change in this location is likely to reflect the low tightness of the bend at this location and the relatively extensive area of floodplain (Figure 5a) which is likely to have attenuated flow velocities during high magnitude floods (out of bank), limiting the potential for channel change.

Sediment Release

A25.3.2 The flow patterns and velocities recorded during the field survey (Map 2) suggest the river will be most vulnerable to sediment release during low flows and this is likely to be deposited on the channel bed in the following locations:

- channel margin locations where flow velocities are very low;
- toward the downstream limit of glides;
- along the opposite side of the channel to the thalweg (such as the left bank downstream of the proposed crossing and along the Murtle Estate); and
- in the backwater where Milltimber Burn joins the River Dee.

A25.3.3 Fine sediment deposition will be greatest and most obvious during low flows. Observations made during higher flows suggest that a combination of increased dilution and higher flow velocities will be sufficient to reduce the potential for sediment deposition at higher flows.

A25.3.4 As the river has a relatively flashy hydrological regime, it is likely that fine sediment deposited on the channel bed during periods of low flow will be remobilised during high flows, diluted and transferred downstream.

Further Work

A25.3.5 It is recommended that sediment transport modelling is conducted for the entire study length, ideally under a range of different flows to provide a more quantitative analysis.

25.4 Conclusion

A25.4.1 The channel of the River Dee between Inch of Culter (NGR: NJ 004 856) and Haugh of Ardoe (NGR: NJ900 026) is characterised by high morphological diversity (Map 1) and as a result a variety of flow patterns (Map 2). The potential patterns and rates of fine sediment deposition will be controlled by the prevailing discharge and resulting flow patterns at the time of sediment release. The channel is most likely to experience fine sediment deposition during low flow conditions. The contemporary morphology of the river channel reflects past channel changes which appear to be driven primarily by high magnitude floods. The channel in the location of the proposed road has not experienced significant change for over 150 years, despite the occurrence of some very large floods, and therefore represents a suitable location for the bridge.

References

Law, F.M., Black, A.R., Scarrott, R.M.J., Miller, J.B., Bayliss, A.C. 1998 Chronology of British Hydrological Events. http://www.dundee.ac.uk/geography/cbhe/ Accessed 5th September 2006.

Moir, H.J., Souslby, C., Youngson, A.F. 2002 Hydraulic and sedimentary controls on the availability and use of Atlantic salmon (Salmo salar) spawning habitat in the River Dee system, north-east Scotland. Geomorphology, 45, 291-308.

Annex 25 Water Quality – SEPA Classification Tables

More details are provided on the SEPA website.

Notes relating to the Annex 33

a Based upon three years data and a 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. 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 percentiles 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 one year, preferably three samples (spring, summer and autumn), minimum of two (spring and autumn).

c Based on one year’s monitoring data, preferably three samples, minimum of two. 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 one year’s data from a minimum of three 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; and
- sewage or oily smells.

List B Contaminants

General non-sewage-derived litter.

Builders’ waste.

Gross litter, including:

- shopping trolleys;
- furniture;
- motor vehicles;
- road cones; and
- 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 as indicated in Table 1.

Table 1 – Spot Classification Values

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 bands in Table 2.

Table 2 – Annual Class

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 26 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

Annex 27 Spillage Risk Calculations

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

Item	**Description**	**Units**									
Probability of a serious accidental spillage			**Burnhead Burn**	**Burnhead Burn**	**Burnhead Burn**	**Jameston Ditch**	**Loirston Burn**	**Loirston Burn**	**Loirston Burn**	**River Dee**	**River Dee**
Section of Road or Junction											
			Run E	**Run E**	**Run E**	**Run F**	**Run G**	**Run G**	**Run G**	**Run H**	**Run H**
			Mainline (Stonehaven to Burnhead)	Roundabout	**Total**	Mainline	Mainline	Sliproads	**Total**	Mainline	Roundabout
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		0.0067	0.0001		0.0018	0.0004	0.0028		0.0136	0.0000
P_{acc} as a probability factor	1 / P_{acc}		149	7842		543	0.0000	0.0000		74	21500
RL	Road length in kilometres	km	4.083	0.851	4.934	3.829	0.205	1.863	2.068	4.694	0.557
SS	Serious spillage rates (from Volume 11 DMRB: Table 3.2, p A3/4)		0.0022	0.0296		0.0022	0.0022	0.0032		0.0022	0.0296
AADT	Annual average daily traffic		12796	13870		14982	26810	9730		36054	7729
% HGV	Percentage of heavy goods vehicles	%	16	0.1		4	9	13		10	0.1
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*
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*
Probability that a spillage will cause a pollution incident											
Formula	$P_{pol\ per\ year} = P_{acc} \times P_{pol}$		0.0050	0.0001		0.0014	0.0003	0.0021		0.0102	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
P_{pol} as a probability factor	**1 / P_{pol} per year**		199	10456	**195**	**724**	3357	484	**423**	98	28667
Is the spillage risk within acceptable limits?			**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**N**	**Y**

Item	**Description**	**Units**								
Probability of a serious accidental spillage			**River Dee**	**River Dee**	**Gairn Burn**	**Westholme Burn**	**Westholme Burn**	**Westholme Burn**	**Westholme Burn**	**Westholme Burn**
Section of Road or Junction										
			Run H	**Run H**	**Run J**	**Run K**	**Run K**	**Run K**	**Run K**	**Run K**
			Sliproads	**Total**	Mainline	Mainline	Roundabout	Sliproads	Side Road	**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		0.0016		0.0066	0.0062	0.0165	0.0019	0.0035	
P_{acc} as a probability factor	1 / P_{acc}		640		150	162	61	513	285	
RL	Road length in kilometres	km	2.828	5.251	2.552	2.375	1.332	3.014	0.783	7.504
SS	Serious spillage rates (from Volume 11 DMRB: Table 3.2, p A3/4)		0.0032		0.0022	0.0022	0.0296	0.0032	0.0106	
AADT	Annual average daily traffic		6754		36054	36054	22950	7907	28959	
% HGV	Percentage of heavy goods vehicles	%	7		9	9	5	7	4	
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*	
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*	
Probability that a spillage will cause a pollution incident										
Formula	$P_{pol\ per\ year} = P_{acc} \times P_{pol}$		0.0012		0.0050	0.0046	0.0124	0.0015	0.0026	
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	
P_{pol} as a probability factor	**1 / P_{pol} per year**		854	**98**	**201**	215	81	684	380	**47**
Is the spillage risk within acceptable limits?			**Y**	**N**	**Y**	**Y**	**N**	**Y**	**Y**	**N**

Aberdeen Western Peripheral Route
Environmental Statement Appendices 2007
Part C: Southern Leg
Appendix A24.7 - Water Environment Annexes

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

Item	**Description**	**Units**																	
Probability of a serious accidental spillage			**Burnhead Burn**	**Burnhead Burn**	**Burnhead Burn**	**Jameston Ditch**	**Loirston Burn**	**Loirston Burn**	**Loirston Burn**	**River Dee**	**River Dee**	**River Dee**	**River Dee**	**Gairn Burn**	**Westholme Burn**	**Westholme Burn**	**Westholme Burn**	**Westholme Burn**	**Westholme Burn**
Section of Road or Junction																			
			Run E	**Run E**	**Run E**	**Run F**	**Run G**	**Run G**	**Run G**	**Run H**	**Run H**	**Run H**	**Run H**	**Run J**	**Run K**	**Run K**	**Run K**	**Run K**	**Run K**
			Mainline (Stonehaven to Burnhead)	Roundabout	**Total**	Mainline	Mainline	Sliproads	**Total**	Mainline	Roundabout	Sliproads	**Total**	Mainline	Mainline	Roundabout	Sliproads	Side Road	**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		0.0067	0.0001		0.0018	0.0004	0.0028		0.0136	0.0000	0.0016		0.0066	0.0062	0.0165	0.0019	0.0035	
P_{acc} as a probability factor	1 / P_{acc}		149	7842		543	0.0000	0.0000		74	21500	640		150	162	61	513	285	
RL	Road length in kilometres	km	4.083	0.851	4.934	3.829	0.205	1.863	2.068	4.694	0.557	2.828	8.079	2.552	2.375	1.332	3.014	0.783	7.504
SS	Serious spillage rates (from Volume 11 DMRB: Table 3.2, p A3/4)		0.0022	0.0296		0.0022	0.0022	0.0032		0.0022	0.0296	0.0032		0.0022	0.0022	0.0296	0.0032	0.0106	
AADT	Annual average daily traffic		12796	13870		14982	26810	9730		36054	7729	6754		36054	36054	22950	7907	28959	
% HGV	Percentage of heavy goods vehicles	%	16	0.1		4	9	13		10	0.1	7		9	9	5	7	4	
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 y*	*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 year*	*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	$P_{pol\ per\ year} = P_{acc} \times P_{pol}$		0.0050	0.0001		0.0014	0.0003	0.0021		0.0102	0.0000	0.0012		0.0050	0.0046	0.0124	0.0015	0.0026	
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	0.75	0.75	
P_{pol} as a probability factor	**1 / P_{pol} per year**		199	10456	**195**	**724**	3357	484	**423**	98	28667	854	**88**	**201**	215	81	684	380	**47**
Is the spillage risk within acceptable limits?			**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**N**	**Y**	**Y**	**N**	**Y**	**Y**	**N**	**Y**	**Y**	**N**
WITH MITIGATION MEASURES:																			
Control Measure 1:	$P_{pol\ per\ year}$ (reduced by 65%)		0.0018	0.0000		0.0005	0.0001	0.0007		0.0036	0.0000	0.0004		0.0017	0.0016	0.0043	0.0005	0.0009	
(FILTER DRAIN)	P_{pol} as a probability factor		568	29873		2067	9591	1384						573	616	231	1955	1086	
Control Measure 2:	$P_{pol\ per\ year}$ (reduced by 65%)		0.0006	0.0000		0.0002	0.0000	0.0003		0.0012	0.0000	0.0001		0.0006	0.0006	0.0015	0.0002	0.0003	
(TREATMENT POND)	P_{pol} as a probability factor		1621	85352		5907				801	234013	6970		1637	1759	659	5586	3102	
Control Measure 3:	$P_{pol\ per\ year}$ (reduced by 65%)		0.0002	0.0000		0.0001				0.0004	0.0000	0.0001		0.0002	0.0002	0.0005	0.0001	0.0001	
(TREATMENT POND)	P_{pol} as a probability factor					16877								4677	5025	1883	15960	8862	
Control Measure 4:	$P_{pol\ per\ year}$ (reduced by 65%)					0.00002								0.0001	0.0001	0.0002	0.0000	0.0000	
														0.0002	0.0002	0.0005	0.0001	0.0001	
(TREATMENT POND)	P_{pol} as a probability factor		4633	243862	**4546**	**48221**	27403	3954	**3456**	2288	668608	19914	**2046**	**4677**	5025	1883	15960	8862	**1104**
Is the spillage risk with mitigation within acceptable limits?			**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**

Annex 28 Pollution Risk Calculations

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

Item	**Description**	**Units**	**Burnhead Burn**	**Jameston Ditch**	**Loirston Burn**	**River Dee**	**Gairn Burn**	**Westholme Burn**
			Run E	**Run F**	**Run G**	**Run H**	**Run J**	**Run K**
Water Quality Prediction								
Data from Regulatory Authority								
Q95 i.e. 95-percentile flow (flow exceeded 95% of the time)		m^3/sec	0.013	0.001	0.004	9.94	0.002	0.002
Existing Water Quality Class	River Quality Objective					A1		
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*59*	*66*	*520*	*26*	*52*	*50-100 assumed*
C_b	Upstream dissolved copper data as mg/l (assume half of EQS; River Dee - SEPA data)	mg/l	0.020	0.020	0.056	0.005	0.020	0.020
Zn_b	Upstream total zinc as mg/l (assume half of EQS; River Dee - SEPA data)	mg/l	0.150	0.150	0.250	0.040	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*	*0.112*	*0.022*	*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*	*0.500*	*0.200*	*0.300*	*0.300*
Other data								
AADT	Annual average daily traffic		27701	14982	43075	36054	36054	39219
RL	Road length (m)	m	4934	3829	2068	8079	2552	7504
RW	Road width (m)	m						
RC	Runoff coefficient		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	2.7	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	0.4	0.3	1.2	1.2	1.2	1.2
	Zn (total)	kg/ha/annum	2.0	1.0	5.0	5.0	5.0	5.0
Calculations								
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	89517	71219	25925	107190	47467	82452
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	906.36	721.09	52.50	1085.30	480.60	834.83
3. Q95 in m^3/day	= Q_5 flow x 3600 x 24	m^3/day	1123.2	86.4	345.6	858816	172.8	172.8
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.0491	0.0293	0.0426	0.1762	0.0780	0.1355
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.2453	0.0976	0.1776	0.7342	0.3251	0.5647
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})		49.05	29.27	42.62	176.20	78.03	135.54
	(Q95 + V)		2029.56	807.49	398.10	859901.30	653.40	1007.63
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.035**	**0.038**	**0.156**	**0.005**	**0.125**	**0.138**
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 (1000 x Mzn)		245.25	97.56	177.57	734.18	325.12	564.74
	(Q95 + V)		2029.56	807.49	398.10	859901.30	653.40	1007.63
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.204**	**0.137**	**0.663**	**0.041**	**0.537**	**0.586**
Does predicted dissolved copper concentration comply with the EQS?			Y	Y	N	Y	N	N
Does predicted total zinc concentration comply with the EQS?			Y	Y	N	Y	N	N

Percentage over Base Line Value	**Copper**	**%**	76%	92%	178%	4%	524%	590%
	Zinc	**%**	36%	-9%	165%	2%	258%	291%

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
Upstream copper and zinc concentrations for the River Dee are actual values and have not been assumed to be half the EQS

NOTES:
NOTES:

Run E	Used AADT for mainline to the North of Blaikiewell junction
Run F	Used AADT for mainline to the Charleston junction
Run G	Used AADT for mainline East of the Charleston junction
Run H	Used AADT for mainline to the North of Milltimber junction
Run J	Used AADT for mainline between Milltimber junction and South Kingswells junction
Run K	Used AADT for mainline to the north of South Kingswells junction

Scheme: Aberdeen Western Peripheral Route Southern 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	Burnhead Burn	Jameston Ditch	Loirston Burn	River Dee	Gairn Burn	Westholme Burn
			Run E	**Run F**	**Run G**	**Run H**	**Run J**	**Run K**
Water Quality Prediction								
Data from Regulatory Authority								
Q50 i.e. 50-percentile flow (flow exceeded 50% of the time)		m^3/sec	0.054	0.003	0.026	46.11	0.011	0.008
Existing Water Quality Class	River Quality Objective					A1		
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*59*	*66*	*520*	*26*	*52*	*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	0.014	0.001	0.005	0.005
Zn_b	Upstream total zinc as mg/l (assume half of EQS; River Dee - SEPA data)	mg/l	0.038	0.038	0.063	0.012	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*	*0.028*	*0.006*	*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*	*0.125*	*0.050*	*0.075*	*0.075*
Other data								
AADT	Annual average daily traffic		27701	14982	43075	36054	36054	39219
RL	Road length (m)	m	4934	3829	2068	8079	2552	7504
RW	Road width (m)	m						
RC	Runoff coefficient		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
PBUR (pollutant build up rate)	See page A3/2 Table 3.1 in Vol.11 - based on traffic flow Cu (dissolved)	kg/ha/annum	0.4	0.3	1.2	1.2	1.2	1.2
	Zn (total)	kg/ha/annum	2.0	1.0	5.0	5.0	5.0	5.0
Calculations								
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	89517	71219	25925	107190	47467	82452
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	181.27	144.22	52.50	217.06	96.12	166.97
3. Q50 in m^3/day	= Q_{50} flow x 3600 x 24	m^3/day	4665.6	259.2	2246.4	3983904	950.4	691.2
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.0491	0.0293	0.0426	0.1762	0.0780	0.1355
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.2453	0.0976	0.1776	0.7342	0.3251	0.5647
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})		49.05	29.27	42.62	176.20	78.03	135.54
	(Q50 + V)		4846.87	403.42	2298.90	3984121.06	1046.52	858.17
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.015**	**0.076**	**0.032**	**0.001**	**0.079**	**0.162**
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 (1000 X Mzn)		245.25	97.56	177.57	734.18	325.12	564.74
	(Q50 + V)		4846.87	403.42	2298.90	3984121.06	1046.52	858.17
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.087**	**0.266**	**0.138**	**0.012**	**0.345**	**0.688**
Does predicted dissolved copper concentration comply with the EQS?			**N**	**N**	**N**	**Y**	**N**	**N**
Does predicted total zinc concentration comply with the EQS?			**N**	**N**	**N**	**Y**	**N**	**N**

Percentage over Base Line Value	**Copper**	**%**	199%	1415%	130%	4%	1482%	3139%
	Zinc	**%**	131%	609%	121%	2%	819%	1735%

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
Upstream copper and zinc concentrations for the River Dee are actual values and have not been assumed to be half the EQS

NOTES:

Run E	Used AADT for mainline to the North of Blaikiewell junction
Run F	Used AADT for mainline to the Charleston junction
Run G	Used AADT for mainline East of the Charleston junction
Run H	Used AADT for mainline to the North of Milltimber junction
Run J	Used AADT for mainline between Milltimber junction and South Kingswells junction
Run K	Used AADT for mainline to the north of South Kingswells junction

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

Routine Runoff Pollution Risk Assessment (Freshwater Fisheries Directive)

Without Mitigation

95-Percentile EQS

Item	**Description**	**Units**	**Burnhead Burn**	**Jameston Ditch**	**Loirston Burn**	**River Dee**	**Gairn Burn**	**Westholme Burn**
			Run E	**Run F**	**Run G**	**Run H**	**Run J**	**Run K**
Water Quality Prediction								
Data from Regulatory Authority								
Q95 i.e. 95-percentile flow (flow exceeded 95% of the time)		m^3/sec	0.013	0.001	0.004	9.94	0.002	0.002
Existing Water Quality Class	River Quality Objective					A1		
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*59*	*66*	*520*	*26*	*52*	*50-100 assumed*
C_b	Upstream dissolved copper data as mg/l (assume half of EQS; River Dee - SEPA data)	mg/l	0.020	0.020	0.056	0.005	0.020	0.020
Zn_b	Upstream total zinc as mg/l (assume half of EQS; River Dee - SEPA data)	mg/l	0.150	0.150	0.250	0.040	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*	*0.112*	*0.022*	*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*	*0.500*	*0.200*	*0.300*	*0.300*
Other data								
AADT	Annual average daily traffic		27701	14982	43075	36054	36054	39219
RL	Road length (m)	m	4934	3829	2068	8079	2552	7504
RW	Road width (m)	m						
RC	Runoff coefficient		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	2.7	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	0.4	0.3	1.2	1.2	1.2	1.2
	Zn (total)	kg/ha/annum	2.0	1.0	5.0	5.0	5.0	5.0
Calculations								
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	89517	71219	25925	107190	47467	82452
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	906.36	721.09	52.50	1085.30	480.60	834.83
3. Q95 in m^3/day	= Q_5 flow x 3600 x 24	m^3/day	1123.2	86.4	345.6	858816	172.8	172.8
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.0491	0.0293	0.0426	0.1762	0.0780	0.1355
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.2453	0.0976	0.1776	0.7342	0.3251	0.5647
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})		49.05	29.27	42.62	176.20	78.03	135.54
	(Q95 + V)		2029.56	807.49	398.10	859901.30	653.40	1007.63
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.035**	**0.038**	**0.156**	**0.005**	**0.125**	**0.138**
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 (1000 x M_{zn})		245.25	97.56	177.57	734.18	325.12	564.74
	(Q95 + V)		2029.56	807.49	398.10	859901.30	653.40	1007.63
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.204**	**0.137**	**0.663**	**0.041**	**0.537**	**0.586**
Does predicted dissolved copper concentration comply with the EQS?			**Y**	**Y**	**N**	**Y**	**N**	**N**
Does predicted total zinc concentration comply with the EQS?			**Y**	**Y**	**N**	**Y**	**N**	**N**

Percentage over Base Line Value	**Copper**	%	76%	92%	178%	4%	524%	590%
	Zinc	%	36%	-9%	165%	2%	258%	291%

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
Upstream copper and zinc concentrations for the River Dee are actual values and have not been assumed to be half the EQS

NOTES:

Run E	Used AADT for mainline to the North of Blaikiewell junction
Run F	Used AADT for mainline to the Charleston junction
Run G	Used AADT for mainline East of the Charleston junction
Run H	Used AADT for mainline to the North of Milltimber junction
Run J	Used AADT for mainline between Milltimber junction and South Kingswells junction
Run K	Used AADT for mainline to the north of South Kingswells junction

Aberdeen Western Peripheral Route

Environmental Statement Appendices 2007

Part C: Southern Leg

Appendix A24.7 - Water Environment Annexes

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

Item	**Description**	**Units**	**Burnhead Burn**	**Jameston Ditch**	**Loirston Burn**	**River Dee**	**Gairn Burn**	**Westholme Burn**
			Run E	**Run F**	**Run G**	**Run H**	**Run J**	**Run K**
Water Quality Prediction								
Data from Regulatory Authority								
Q95 i.e. 95-percentile flow (flow exceeded 95% of the time)		m^3/sec	0.013	0.001	0.004	9.94	0.002	0.002
Existing Water Quality Class	River Quality Objective					A1		
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*59*	*66*	*520*	*26*	*52*	*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	0.056	0.005	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	0.250	0.040	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*	*0.112*	*0.022*	*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*	*0.500*	*0.200*	*0.300*	*0.300*
Other data								
AADT	Annual average daily traffic		27701	14982	43075	36054	36054	39219
RL	Road length (m)	m	4934	3829	2068	8079	2552	7504
RW	Road width (m)	m						
RC	Runoff coefficient		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	2.7	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	0.0392	0.01029	0.336	0.1176	0.014406	0.02058
	Zn (total)	kg/ha/annum	0.1	0.010719	0.4	0.2	0.0	0.0
Calculations								
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	89517	71219	25925	107190	47467	82452
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	906.36	721.09	52.50	1085.30	480.60	834.83
3. Q95 in m^3/day	= Q_5 flow x 3600 x 24	m^3/day	1123.2	86.4	345.6	858816	172.8	172.8
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.0048	0.0010	0.0119	0.0173	0.0009	0.0023
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.0075	0.0010	0.0155	0.0225	0.0012	0.0018
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})		4.81	1.00	11.93	17.27	0.94	2.32
	(Q95 + V)		2029.56	807.49	398.10	859901.30	653.40	1007.63
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.013**	**0.003**	**0.079**	**0.005**	**0.007**	**0.006**
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		7.51	1.05	15.54	22.48	1.22	1.82
	(Q95 + V)		2029.56	807.49	398.10	859901.30	653.40	1007.63
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.087**	**0.017**	**0.256**	**0.040**	**0.042**	**0.028**
Does predicted dissolved copper concentration comply with the EQS?			Y	Y	Y	Y	Y	Y
Does predicted total zinc concentration comply with the EQS?			Y	Y	Y	Y	Y	Y
	Percentage over Base Line Value **Copper**	%	-33%	-83%	40%	0%	-66%	-71%
	Zinc	%	-42%	-88%	2%	0%	-72%	-82%

	Original PBUR (pollutant build up rate)						
	Diss Cu	0.4	0.3	1.2	1.2	1.2	1.2
	Total Zinc	2.0	1.0	5.0	5.0	5.0	5.0
	With Filter Drain reduction						
20% reduction	Diss Cu	0.32	0.24	0.96	0.96	0.96	0.96
75% reduction	Total Zinc	0.5	0.3	1.3	1.3	1.3	1.3
	With Treatment Pond reduction						
65% reduction	Diss Cu	0.112	0.084	0.336	0.336	0.336	0.336
65% reduction	Total Zinc	0.2	0.1	0.4	0.4	0.4	0.4
	With Treatment Pond reduction						
65% reduction	Diss Cu	0.0392	0.0294		0.1176	0.1176	0.1176
65% reduction	Total Zinc	0.1	0.0		0.2	0.2	0.2
	With Treatment Pond reduction						
65% reduction	Diss Cu		0.01029			0.04116	0.04116
65% reduction	Total Zinc		0.01071875			0.05359375	0.05359375
	With 60m Swale reduction						
50% reduction	Diss Cu					0.014406	0.02058
70% reduction	Total Zinc					0.018757813	0.016078125
		2 TP	3TP	1TP	2 TP	4TP	3TP + 1 swale

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
Upstream copper and zinc concentrations for the River Dee are actual values and have not been assumed to be half the EQS

Mitigation assumes the following:
Filter drains: 75% reduction total zinc and 20% reduction dissolved copper
Treatment Pond: 65% reduction total zinc and 65% reduction dissolved copper
Swale: 70% reduction total zinc and 50% reduction dissolved copper

Scheme: Aberdeen Western Peripheral Route Southern 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**	**Burnhead Burn**	**Jameston Ditch**	**Loirston Burn**	**River Dee**	**Gairn Burn**	**Westholme Burn**
			Run E	**Run F**	**Run G**	**Run H**	**Run J**	**Run K**
Water Quality Prediction								
Data from Regulatory Authority								
Q50 i.e. 50-percentile flow (flow exceeded 50% of the time)		m^3/sec	0.054	0.003	0.026	46.11	0.011	0.008
Existing Water Quality Class	River Quality Objective					A1		
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*59*	*66*	*520*	*26*	*52*	*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	0.014	0.001	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	0.063	0.012	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*	*0.028*	*0.006*	*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*	*0.125*	*0.050*	*0.075*	*0.075*
Other data								
AADT	Annual average daily traffic		27701	14982	43075	36054	36054	39219
RL	Road length (m)	m	4934	3829	2068	8079	2552	7504
RW	Road width (m)	m						
RC	Runoff coefficient		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
PBUR (pollutant build up rate)	See page A3/2 Table 3.1 in Vol.11 - based on traffic flow Cu (dissolved)	kg/ha/annum	0.0392	0.01029	0.336	0.1176	0.014406	0.02058
	Zn (total)	kg/ha/annum	0.1	0.0	0.4	0.2	0.0	0.0
Calculations								
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	89517	71219	25925	107190	47467	82452
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	181.27	144.22	52.50	217.06	96.12	166.97
3. Q50 in m^3/day	= Q_{50} flow x 3600 x 24	m^3/day	4665.6	259.2	2246.4	3983904	950.4	691.2
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.0048	0.0010	0.0119	0.0173	0.0009	0.0023
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.0075	0.0010	0.0155	0.0225	0.0012	0.0018
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})		4.81	1.00	11.93	17.27	0.94	2.32
	(Q50 + V)		4846.87	403.42	2298.90	3984121.06	1046.52	858.17
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.006**	**0.006**	**0.019**	**0.001**	**0.005**	**0.007**
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		7.51	1.05	15.54	22.48	1.22	1.82
	(Q50 + V)		4846.87	403.42	2298.90	3984121.06	1046.52	858.17
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.038**	**0.027**	**0.068**	**0.012**	**0.035**	**0.032**
Does predicted dissolved copper concentration comply with the EQS?			Y	Y	Y	Y	Y	Y
Does predicted total zinc concentration comply with the EQS?			Y	Y	Y	Y	Y	Y
Percentage over Base Line Value	**Copper**	%	16%	14%	35%	0%	9%	35%
	Zinc	%	0%	-29%	9%	0%	-6%	-14%

	Original PBUR (pollutant build up rate)						
	Diss Cu	0.4	0.3	1.2	1.2	1.2	1.2
	Total Zinc	2.0	1.0	5.0	5.0	5.0	5.0
	With Filter Drain reduction						
20% reduction	Diss Cu	0.32	0.24	0.96	0.96	0.96	0.96
75% reduction	Total Zinc	0.5	0.3	1.3	1.3	1.3	1.3
	With Treatment Pond reduction						
65% reduction	Diss Cu	0.112	0.084	0.336	0.336	0.336	0.336
65% reduction	Total Zinc	0.2	0.1	0.4	0.4	0.4	0.4
	With Treatment Pond reduction						
65% reduction	Diss Cu	0.0392	0.0294		0.1176	0.1176	0.1176
65% reduction	Total Zinc	0.1	0.0		0.2	0.2	0.2
	With Treatment Pond reduction						
65% reduction	Diss Cu		0.01029			0.04116	0.04116
65% reduction	Total Zinc		0.01071875			0.05359375	0.05359375
	With 60m Swale reduction						
50% reduction	Diss Cu					0.014406	0.02058
70% reduction	Total Zinc					0.018757813	0.016078125
		2 TP	3TP	1TP	2 TP	4TP	3TP + 1 swale

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
Upstream copper and zinc concentrations for the River Dee are actual values and have not been assumed to be half the EQS

Mitigation assumes the following:

Filter drains:	75% reduction total zinc and 20% reduction dissolved copper
Treatment Pond:	65% reduction total zinc and 65% reduction dissolved copper
Swale:	70% reduction total zinc and 50% reduction dissolved copper

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

Item	**Description**	**Units**	**Burnhead Burn**	**Jameston Ditch**	**Loirston Burn**	**River Dee**	**Gairn Burn**	**Westholme Burn**
			Run E	**Run F**	**Run G**	**Run H**	**Run J**	**Run K**
Water Quality Prediction								
Data from Regulatory Authority								
Q95 i.e. 95-percentile flow (flow exceeded 95% of the time)		m^3/sec	0.013	0.001	0.004	9.94	0.002	0.002
Existing Water Quality Class	River Quality Objective					A1		
Hardness	Hardness of watercourse (affects solubility of metals)	mg/l	*59*	*66*	*520*	*26*	*52*	*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	0.056	0.005	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	0.250	0.040	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*	*0.112*	*0.022*	*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*	*0.500*	*0.200*	*0.300*	*0.300*
Other data								
AADT	Annual average daily traffic		27701	14982	43075	36054	36054	39219
RL	Road length (m)	m	4934	3829	2068	8079	2552	7504
RW	Road width (m)	m						
RC	Runoff coefficient		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	2.7	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	0.0392	0.01029	0.336	0.1176	0.014406	0.02058
	Zn (total)	kg/ha/annum	0.1	0.0	0.4	0.2	0.0	0.0
Calculations								
1. Total impermeable area (TIA)	= RL x RW (m^2)	m^2	89517	71219	25925	107190	47467	82452
2. Runoff volume (V)	= TIA x RC x (rain / 1000)	m^3	906.36	721.09	52.50	1085.30	480.60	834.83
3. Q95 in m^3/day	= Q_5 flow x 3600 x 24	m^3/day	1123.2	86.4	345.6	858816	172.8	172.8
4. Cu build up rate	5 day build up (M_{cu}) = (PBURCu /365) x 5 x (TIA / 10000)	kg	0.0048	0.0010	0.0119	0.0173	0.0009	0.0023
5. Zn build up rate	5 day build up (M_{zn}) = (PBURZn /365) x 5 x (TIA / 10000)	kg	0.0075	0.0010	0.0155	0.0225	0.0012	0.0018
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})		4.81	1.00	11.93	17.27	0.94	2.32
	(Q95 + V)		2029.56	807.49	398.10	859901.30	653.40	1007.63
Resulting dissolved copper concentration in the water course downstream (C_r)		**mg/l**	**0.013**	**0.003**	**0.079**	**0.005**	**0.007**	**0.006**
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		7.51	1.05	15.54	22.48	1.22	1.82
	(Q95 + V)		2029.56	807.49	398.10	859901.30	653.40	1007.63
Resulting total zinc concentration in the watercourse (Zn_r)		**mg/l**	**0.087**	**0.017**	**0.256**	**0.040**	**0.042**	**0.028**
Does predicted dissolved copper concentration comply with the EQS?			Y	Y	Y	Y	Y	Y
Does predicted total zinc concentration comply with the EQS?			Y	Y	Y	Y	Y	Y
Percentage over Base Line Value	**Copper**	%	-33%	-83%	40%	0%	-66%	-71%
	Zinc	%	-42%	-88%	2%	0%	-72%	-82%

	Original PBUR (pollutant build up rate)						
	Diss Cu	0.4	0.3	1.2	1.2	1.2	1.2
	Total Zinc	2.0	1.0	5.0	5.0	5.0	5.0
	With Filter Drain reduction						
20% reduction	Diss Cu	0.32	0.24	0.96	0.96	0.96	0.96
75% reduction	Total Zinc	0.5	0.3	1.3	1.3	1.3	1.3
	With Treatment Pond reduction						
65% reduction	Diss Cu	0.112	0.084	0.336	0.336	0.336	0.336
65% reduction	Total Zinc	0.2	0.1	0.4	0.4	0.4	0.4
	With Treatment Pond reduction						
65% reduction	Diss Cu	0.0392	0.0294		0.1176	0.1176	0.1176
65% reduction	Total Zinc	0.1	0.0		0.2	0.2	0.2
	With Treatment Pond reduction						
65% reduction	Diss Cu		0.01029			0.04116	0.04116
65% reduction	Total Zinc		0.01071875			0.05359375	0.05359375
	With 60m Swale reduction						
50% reduction	Diss Cu					0.014406	0.02058
70% reduction	Total Zinc					0.018757813	0.016078125
		2 TP	3TP	1TP	2 TP	4TP	3TP + 1 swale

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
Upstream copper and zinc concentrations for the River Dee are actual values and have not been assumed to be half the EQS

Mitigation assumes the following:
Filter drains: 75% reduction total zinc and 20% reduction dissolved copper
Treatment Pond: 65% reduction total zinc and 65% reduction dissolved copper
Swale: 70% reduction total zinc and 50% reduction dissolved copper