Appendix A10.16 – Freshwater

B1033200 July 2007

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Contents

1 Introduction

1.1 General Background

1.1.1 This Appendix reports the assessment of potential impacts on freshwater ecology in the vicinity of the Northern Leg of the proposed scheme, supporting Chapter 10 (Ecology and Nature Conservation).

1.1.2 To aid the interpretation of the assessment, the AWPR Northern Leg study area has been divided into five route sections as follows:

- Section NL1 ch314800 – 316000 (Derbeth to Tulloch Road);
- Section NL2 ch316000 – 317400 (SAC Craibstone);
- Section NL3 ch317400 – 322600 (A96 to Nether Kirkton);
- Section NL4 ch322600 – 325370 (Nether Kirkton to Corsehill); and
- Section NL5 ch325370 – 331000 (Corsehill to Blackdog).

1.1.3 Studies on freshwater ecology were included as part of the Ecological Impact Assessment (EcIA), and were undertaken in accordance with the Design Manual for Roads and Bridges (DMRB) Volumes 10 and 11 and the Environment Impact Assessment (Scotland) Regulations 1999. The three stages of EcIA have been modified to be directly applicable to the proposed scheme, and are based on matrices from an early draft version of IEEM guidance on EcIA (IEEM, 2002) and Transport Advisory Guidance (STAG and WEBTAG). The bulk of the assessment for the AWPR Northern Leg was undertaken before the 2006 issue of the IEEM guidelines. This assessment therefore follows the general approach described in the IEEM 2002 guidelines, with cognisance of the later 2006 guidelines.

1.1.4 This report is concerned with the impacts on Freshwater Ecology and assesses the impact on the watercourses directly and indirectly affected by the Northern Leg of the proposed scheme, in terms of the ecological communities they support. As such this report is focused on impacts on overall aquatic ecosystem health measured by aquatic macro-invertebrate communities and habitat complexity. In addition to this assessment of freshwater ecology, a specific freshwater fish habitat and HABSCORE assessment has also been undertaken which should be read in conjunction with this report (see Appendix A10.15: Fish).

Aims

1.1.5 As stated above this report has the general aim of assessing potential impacts on aquatic ecosystem health of the watercourses crossed or otherwise affected by the proposed scheme.

1.1.6 Aquatic macro-invertebrate surveys and river habitat assessments of potentially impacted watercourses were conducted to:

- obtain baseline information on aquatic macro-invertebrate communities and river habitat condition, and infer general aquatic ecosystem conditions and water quality trends;
- identify any rare and/or protected aquatic species, or pollution indicator species;
- evaluate the ecological health/status of watercourses potentially affected by the Northern Leg of the proposed scheme;
- assess any impacts the Northern Leg of the proposed scheme may have on freshwater habitat and aquatic macro-invertebrate communities;
- identify appropriate mitigation measures to ameliorate these impacts; and

- determine any remaining residual impacts following the implementation of mitigation measures.

1.2 Background

Freshwater Biology

1.2.1 Aquatic macro-invertebrates are commonly used to provide a holistic assessment of river health (Wright et al*.,* 1984). Traditional water quality measures such as pH, dissolved oxygen, nutrient levels and toxic substances provide a snapshot of environmental conditions at the moment the samples are taken. However, as water quality conditions are variable; this type of monitoring can fail to detect occasional changes or intermittent pulses of pollution.

1.2.2 In contrast, biological monitoring provides an integrated assessment of ecosystem condition. Because aquatic macro-invertebrates live at a site for many months and cannot move great distances, the assemblage of animals present at a site reflects the build up of impacts on the river ecosystem over time - such as the surrounding land use or the effects of pollution. Aquatic macro-invertebrate samples, combined with an assessment of the available river habitat (River Habitat Survey (RHS) – see below) can provide an overall assessment of the ecological health of a watercourse.

Status

1.2.3 The Water Framework Directive (WFD) (European Directive 2000/60/EC) recognises that the ecosystem health is the most effective way to assess the environmental quality status of a watercourse. It has moved the focus away from chemical water quality targets to the requirement that all watercourses in Europe reach at least ‘good’ ecological status by 2015 (not including heavily modified or artificial waterways, which must reach ‘good’ ecological potential). The WFD also requires that watercourse ecological status do not deteriorate from their current condition. Under the WFD, the ecological status of watercourses is therefore now the focus of river management and impact assessment, the role of biological surveys has increased in importance.

1.2.4 In addition to the requirements of the WFD for promotion and maintenance of good aquatic ecological health, a number of freshwater species have been identified as being scarce in the UK including the stonefly *Brachyptera putata* (Bratton, 1990).

1.2.5 The North East Scotland Local Biodiversity Action Plan (LBAP) Priority Species list includes the UK Priority Species *Brachyptera putata*, a stonefly found in well-oxygenated flowing water. It also includes the following UK Species of Conservation Concern (SoCC) river lamprey *Lampetra fluviatilis* and brook lamprey *Lampetra planeri* (also addressed in the Fish Survey Report, Appendix 10.15, Fish Report). All the above LBAP species have actions addressed through a relevant Habitat Action Plan (HAP) rather than through a dedicated North East Scotland Species Action Plan (SAP).

2 Methods

2.1 Route Section

2.1.1 For ease of reporting, the Environmental Impact Assessment is reported using a geographical section rather than a catchment-based division to ensure a consistent approach across all environmental disciplines.

2.2 Consultation

2.2.1 Consultation was undertaken with statutory and non-statutory organisations including Scottish Natural Heritage (SNH), Scottish Environment Protection Agency (SEPA) North East Scotland Biological Records Centre (NESBReC), and City of Aberdeen Council to obtain any existing baseline data on the ecological status of watercourses potentially impacted by the proposed scheme. Table 1 shows which watercourses have existing baseline data and have been classified by SEPA.

2.2.2 In addition, data on 'likely fish species present' within the study area were sought from the Don District Salmon Fisheries Board. For more details please refer to Appendix 10.15 (Fish Report).

2.3 Desk Studies and Data Analysis

2.3.1 To assist the interpretation of biological data and to enable efficient targeting of sampling effort, physical parameters of watercourses potentially affected by the proposed scheme were calculated. Details of methods used in these calculations are given Chapter 9 (Water Environment). The following parameters (and units) were derived for use in this ecological assessment:

- catchment area upstream of proposed crossing point (km^2);
- Q mean flow (m^3/sec);
- Q95 flow (m^3/sec); and
- mean monthly velocities (m/sec).

2.4 Survey Methods

2.4.1 Sites were sampled for aquatic macro-invertebrates following standard methods (Wright et al*.,* 1984) in spring 2004. At the time of sampling simple physio-chemical parameters were measured, and in summer 2004 sites were revisited and a river habitat survey (RHS) was undertaken (Environment Agency (EA), 2003). Table 1 summarises which sampling methods were used and existing data available for each watercourse. All sampling points are shown on Figures 10.12a-g.

2.4.2 Aquatic macro-invertebrate sampling was undertaken by kick/sweep sampling for at least 10m (taking 3 minutes) with a 250µm mesh Freshwater Biological Association (FBA) net followed by visual observation to find any further specimens. Samples were emptied into a white tray and 'live picked' for 30 minutes to obtain a representative sample. Care was taken to search for small and/or cryptic species and specimens were preserved in 70% ethanol and retained for identification. Aquatic macro-invertebrates collected were identified to species level where possible using a low powered microscope and appropriate taxonomic keys.

2.4.3 At the time of sampling, simple water quality measurements (dissolved oxygen, electrical conductivity, pH and temperature) were taken in situ using field probes. Additionally, as part of the collection of baseline data for the Water Environment, total hardness was measured during summer 2004. Data collected are presented in Table 10 in the baseline section.

2.4.4 RHS comprised a survey of a 500m section of each watercourse and its riparian zone, usually at the proposed AWPR crossing point. The aim of this was to record the physical features present in the burn, as well as the adjacent land use. Data were recorded on standardised survey forms (EA, 2003). Results from the RHS were submitted to the central database administered by the EA for quality control and calculation of Habitat Indices (see the evaluation section below for more details).

2.4.5 Surveys were undertaken during the optimal survey period. Aquatic macro-invertebrates were sampled in spring to optimise the chances of collecting late instar (more developed) insects that are more easily identified. RHS was conducted between 15 June – 30 June 2004, during the season recommended by the RHS manual (EA, 2003).

2.5 Sampling Effort

2.5.1 Along the proposed route, additional watercourses that would be crossed were scoped out due to their small size, ephemeral nature or because they form part of an artificial channel. Typically, watercourses that were scoped out of this assessment were highly modified land drainage channels.

2.5.2 In addition, some watercourses were large enough to be sampled for aquatic macro-invertebrates and basic water quality, but since they were essentially highly modified land drainage channels, RHS was not undertaken. As such, Red Moss Burn and Kepplehill Burn have aquatic macro-invertebrate data but no RHS data.

Table 1 – Sampling Effort for Watercourses

Watercourse	Code	Macro-invertebrate and *in situ* WQ Sampling	Grid Reference of Sample Point	River Habitat Survey	Existing SEPA Data	Existing Discharge Data	Additional Water Quality Sampling	Impact Assessment in This Report?
Kepplehill Burn	KHB	Yes	NJ 874 092	No, Land Drain where route crosses	None	Yes	Yes	Yes
Gough Burn	GOB	Yes	NJ 870 102	Yes	None	Yes	Yes	Yes
Craibstone Burn	CSB	Yes	NJ 867 107	Yes	None	Yes	No	Yes
Green Burn	GRB	Yes	NJ 866 112	Yes	None	Yes	Yes	Yes
Bogenjoss Burn	BJB	Yes	NJ 859 135	Yes, at both crossing points at Kirkhill	None	Yes	Yes, at both crossing points	Yes
River Don	DON	Yes	NJ 879 146	Yes	Yes	Yes	Yes	Yes
Goval Burn	GOV	Yes	NJ 892 160 (Confluence Meadowhead Burn) NJ 895 153 (Next to Reservoir)	Yes	Yes	Yes	Yes	Yes
Mill Lead Aqueduct	MLA	None	NJ 889 150	No, artificial channel	None	Yes	Yes	Yes, inferred assessment using data from Goval Burn
Corsehill Burn	CHB	No, inferred from Goval Burn	NJ 896 149	None	None	Yes	Yes	Yes, inferred assessment using data from Goval Burn
Red Moss Burn	RMB	Yes	NJ 924 153	No, Land Drain	None	Yes	Yes	Yes
Tributary to Black Dog Burn	n/a	None	NJ 938 154	None	None	Yes	None	No, Land Drain
Black Dog Burn	BDB	Yes	NJ 944 146	Yes	Yes, WQ only	Yes	Yes	Yes
Middlefield Burn	n/a	None	NJ 958 149	None	None	Yes	None	No

2.6 Survey Limitations

2.6.1 SEPA routinely bases its classification of watercourses on two aquatic macro-invertebrate sampling seasons. However studies have shown that there is a considerable amount of redundancy in aquatic macro-invertebrate data and demonstrated that similar river health classification can be achieved with reduced sampling effort (e.g. Furse et al*.,* 1984). The single sampling approach was included in a scoping report submitted to SNH prior to the commencement of survey and was agreed in advance.

2.6.2 As stated above, the use of water quality spot measurement data taken during aquatic macro-invertebrate sampling must be approached with caution as these can only provide a snapshot of conditions. As such water quality measures were used to aid interpretation of biological data rather than *vice versa*.

2.7 Evaluation of Ecological Importance

2.7.1 A simple scheme for the ecological assessment of watercourses using the aquatic macro-invertebrate assemblage was used. The scheme is based on applying scores to different aquatic macro-invertebrate species according to their relative pollution tolerance. Adding these scores gives an index of the ecological quality of a watercourse, known as the Biological Monitoring Working Party (BMWP) score (ISO-BMWP 1979[1]). Dividing this score by the number of species sampled gives the Average Score Per Taxon (ASPT) value (Table 2). Additionally, a simple measure of species richness was used together with BMWP and ASPT scores to yield an assessment of ecological status.

Table 2 – River Health Categories

ASPT	River Health Category (SEPA)
>6	Excellent A1
5-6	Good A2
4-5	Fair B
3-4	Poor C
<4	Impoverished D

2.7.2 RHS data were used to calculate a Habitat Modification Score (HMS). The HMS is calculated using information on channel modification from each of the 10 spot checks along the 500m section in combination with records of any artificial features such as weirs. The calculation of this modification index is conducted at the Environment Agency's RHS office in Warrington based on data submitted to the national RHS database. HMSs can be interpreted following the system shown in Table 3.

2.7.3 An assessment of habitat quality was made with the RHS data with the calculation of a Habitat Quality Assessment Score (HQA). This system is a broad measure of the diversity and 'naturalness' of the physical nature of a site, to include the channel and river corridor.

[1] Scores have since been slightly revised and refined and the values used in this study are those currently used by SEPA.

Table 3 – Habitat Modification Score (HMS) Categories

HMS	Descriptive Category of Channel
0-16	Pristine
17-199	Predominantly modified
200-499	Obviously modified
500-1399	Significantly Modified
1400+	Severely Modified

2.7.4 Assessment of the nature conservation value of each watercourse was largely based on the aquatic macro-invertebrate community present (using indices described above), water quality measures such as levels of dissolved oxygen and electrical conductivity, the degree of habitat modification, and the level of 'naturalness'. Additional reference was made to the 'likely species present' information and the fish habitat/HABSCORE assessment for each site (see Appendix A10.15: Fish) and whether the watercourses provide food resources for otters (see Appendix A10.6: Otter

2.7.5 The value of the local otter population was determined by reference to any designations and the results of the consultations, literature review and field surveys.

2.7.6 The criteria used were based on the Ratcliffe Criteria (Ratcliffe, 1977) used in the selection of biological Sites of Special Scientific Interest (SSSIs). Sites and features were classified according to the general criteria identified in Table 4. In addition to these measures, consideration was also given to the size of each watercourse and its ecological value assessed in terms of fish and otter interest.

Table 4 – Evaluation of Ecological Receptors

Value/ Importance	Criteria
International (European)	<u>Habitats</u> An internationally designated site or candidate site (SPA, pSPA, SAC, cSAC, Ramsar site, Biogenetic/Biosphere Reserve, World Heritage Site) or an area which would meet the published selection criteria for designation. A viable area of a habitat type listed in Annex I of the Habitats Directive, or smaller areas of such habitat which are essential to maintain the viability of a larger whole. Any river classified as excellent A1 and likely to support a substantial salmonid population. Any river with a Habitat Modification Score indicating that it is Pristine or Semi-Natural or Obviously Modified. <u>Species</u> Any regularly occurring population of internationally important species, threatened or rare in the UK. i.e. a UK Red Data Book species categories 1& 2 of UK BAP) or of uncertain conservation status or of global conservation concern in the UK BAP. A regularly occurring, nationally significant population/number of an internationally important species.
National (Scottish)	<u>Habitats</u> A nationally designated site (SSSI, ASSI, NNR, Marine Nature Reserve) or a discrete area which would meet the published selection criteria for national designation (e.g. SSSI selection guidelines). A viable area of a priority habitat identified in the UK BAP, or of smaller areas of such habitat essential to maintain wider viability. Any river classified as excellent A1 and likely to support a substantial salmonid population. Any river with a Habitat Modification Score indicating that it is Pristine or Semi-Natural or Obviously Modified. <u>Species</u> A regularly occurring, regionally or county significant population/number of an internationally/nationally important species. Any regularly occurring population of a nationally important species which is threatened or rare in the region or county (see local BAP). A feature identified as of critical importance in the UK BAP.

Value/ Importance	Criteria
Regional (North East Scotland)	Habitats Sites which exceed the County-level designations but fall short of SSSI selection criteria. Viable areas of key habitat identified in the Regional BAP or smaller areas of habitat essential to maintain wider viability. Viable areas of key habitat identified as of Regional value in the appropriate SNH Natural Heritage Future area profile. Any river classified as excellent A1 or good A2 and capable of supporting salmonid population. Any river with a Habitat Modification Score indicating that it is significantly modified or above. Species Any regularly occurring, locally significant population of a species listed as being nationally scarce which occurs in 16-100 10 km squares in the UK or in a Regional BAP or relevant SNH Natural Heritage Future area on account of its regional rarity or localisation. A regularly occurring, locally significant population/number of a regionally important species. Sites maintaining populations of internationally/nationally important species that are not threatened or rare in the region or county.
Authority Area (e.g. County or District) Aberdeenshire/ City of Aberdeen	Habitats Sites recognised by local authorities (e.g.) District Wildlife Sites (DWS) and Sites of Interest for Nature Conservation (SINS). County/District sites that the designating authority has determined meet the published ecological selection criteria for designation, including Local Nature Reserves (LNR). A viable area of habitat identified in County/District BAP or in the relevant SNH Natural Heritage Future area profile. A diverse and/or ecologically valuable hedgerow network. Semi-natural ancient woodland greater than 0.25 ha. Any river classified as good A2 or fair B and likely to support coarse fishery. Any river with a Habitat Modification Score indicating that it is significantly modified or above. Species Any regularly occurring, locally significant population of a species listed in a County/District BAP due to regional rarity or localisation. A regularly occurring, locally significant population of a County/District important species. Sites supporting populations of internationally/nationally/regionally important species that are not threatened or rare in the region or county, and not integral to maintaining those populations. Sites/features scarce in the County/District or which appreciably enrich the County/ District habitat resource
Local (immediate area or local village importance)	Habitats Areas of habitat that appreciably enrich the local habitat resource (e.g. species-rich hedgerows, ponds etc). Sites that retain other elements of semi-natural vegetation that due to their size, quality or the wide distribution within the local area are not considered for the above classifications. Semi-natural ancient woodland smaller than 0.25 ha. Any river classified as fair B or poor C and unlikely to support coarse fishery. Rivers with a Habitat Modification Score indicating that it is severely modified or above. Species Populations/assemblages of species that appreciable enrich the biodiversity resource within the local context. Sites supporting populations of county/district important species that are not threatened or rare in the region or county, and are not integral to maintaining those populations.
Less than Local (Limited ecological importance)	Sites that retain habitats and/or species of limited ecological importance due to their size, species composition or other factors. Any river classified as impoverished D and/or and with a Habitat Modification Score indicating that it is severely modified.

2.8 Impact Assessment

Impact Magnitude

2.8.1 Methods of impact prediction used included direct measurements, correlations, expert opinion and information from previous developments. Impacts include those that are predicted to be direct, indirect, temporary, permanent, cumulative, reversible or irreversible. The magnitude of each impact was assessed independently of its value or statutory status.

2.8.2 Magnitude criteria are presented in Table 5, and include positive impact criteria in accordance with IEEM guidance (2002).

Table 5 – Impact Magnitude

Impact Magnitude	Criteria
High negative	The change is likely to permanently, adversely affect the integrity of an ecological receptor, in terms of the coherence of its ecological structure and function, across its whole area that enables it to sustain the habitat, complex of habitats and/or the population levels of species of interest.
Medium negative	The change is not likely to permanently adversely affect the ecological receptor's integrity but the effect on the receptor is likely to be substantial in terms of its ecological structure and function and may be significant in terms of its ecological objectives. Likely to result in changes in the localised or temporary distribution of a species but not affect its population status at a regional scale or permanently.
Low negative	The change may adversely affect the ecological receptor, but there will probably be no permanent effect on its integrity and/or key attributes and is unlikely to be significant in terms of its ecological objectives.
Negligible	The change may slightly adversely affect the receptor but will have no permanent effect on the integrity of the receptor or its key attributes. There are no predicted measurable changes to the species assemblage or population and the effect is unlikely to result in an increased vulnerability of the receptor to future impacts.
Positive	The change is likely to benefit the ecological receptor, and/or enhance the biodiversity resource of the receptor.
High positive	The change is likely to restore an ecological receptor to favourable conservation status, contribute to meeting BAP objectives (local and national) and/or create a feature that is of recognisable value for biodiversity.

Impact Significance

2.8.3 In the assessment of significance of impact, consideration has been given both to the magnitude of impact and to the value of the receiving environment (receptor). For this assessment the value of a receptor (watercourse and the ecosystem it supports) was determined with reference to its level of importance although other elements (e.g. presence of protected species) have been taken into account where appropriate.

2.8.4 The significance of impact has been determined according to the system illustrated in Table 6. Impacts can be beneficial or adverse, either improving or decreasing the ecological status health or viability of a species, population or habitat.

Table 6 – Impact Significance

Magnitude / Importance	High Negative	Medium Negative	Low Negative	Negligible	Positive	High Positive
International	Major	Major	Moderate	Negligible	Moderate	Major
National	Major	Major	Moderate	Negligible	Moderate	Major
Regional	Major	Moderate	Minor	Negligible	Minor	Moderate
Authority Area	Moderate	Moderate	Minor	Negligible	Minor	Moderate
Local	Minor	Minor	Minor	Negligible	Minor	Minor
Less than Local	Minor	Negligible	Negligible	Negligible	Negligible	Negligible

2.8.5 The level of significance of impacts predicted on ecological receptors is an important factor in influencing the decision-making process and determining the necessity and/or extent of mitigation measures. Impacts can be beneficial or adverse, either improving or decreasing the ecological status, health or viability of a species, population or habitat.

2.8.6 Generally, negative impact significance greater than or equal to Moderate would require specific mitigation to be undertaken to ameliorate the impact significance to acceptable levels. .

3 Baseline

3.1 Existing Data and Desk Study

3.1.1 SEPA monitors a number of the watercourses in Table 1 for water quality and biological measures and has recent river classifications for three relevant watercourses along the Northern Leg of the route. These data have been used in the impact assessment both in terms of aquatic ecosystem health and water quality. A summary of SEPA's biological data is given below (Table 7). Refer to the Water Quality Report (Appendix A9.4) of the ES for more details and to Figure 9.2a-d for locations of SEPA sampling points.

Table 7 – Summary of SEPA Biological Data

Watercourse	Year	Classification
River Don at Riverview	2003	A2
	2004	A2
Goval Burn at B977 Bridge	2003	B
	2004	B
Blackdog Burn	2004	A2

3.1.2 This summary presents the 2003-2004 classification data for these three watercourses and shows that Goval Burn is classified as fair and the River Don and Blackdog Burn as good.

3.1.3 The LBAP species *Brachyptera putata* was recorded by SEPA as part of their routine monitoring of and the River Don between 1980 and 2003.

3.1.4 In addition to baseline information obtained from SEPA, physical parameters were also calculated for each watercourse and are shown in Table 8.

Table 8 – Physical Parameters of Watercourses

Watercourse	Area upstream (km^2)	Q mean flow (m^3/sec)	Q95 flow (m^3/sec)	Standard Deviation of Mean Monthly Velocities
Kepplehill Burn	0.25	0.003	0.001	0.050
Gough Burn	1.06	0.014	0.003	0.067
Craibstone Burn	0.5	0.007	0.001	0.076
Green Burn	2.77	0.037	0.005	0.084
Bogenjoss Burn	1.59	0.021	0.005	0.079
River Don	1228.1	19.536	5.200	0.159
Goval Burn	39.77	0.579	0.079	0.162
Corsehill Burn	1.79	0.026	0.004	0.136
Red Moss Burn	1.3	0.017	0.004	0.088
Blackdog Burn	7.66	0.112	0.015	0.169
Middlefield Burn	1.47	0.005	0.001	No data

3.1.5 Each of these four parameters provides information on the general nature of the watercourse. The first measure indicates the general size of the watercourse by providing an estimated catchment area upstream of the AWPR crossing point. From this it is clear that the Don River is a significantly larger watercourse with Goval Burn being the most substantial of the remaining watercourses.

3.1.6 The second and third parameters give an indication of the volume of water flowing down the channel during mean and low flow periods. From this it can be seen that the Don River has substantially greater discharge than the rest of the watercourses even during low flow periods. It is also clear from these discharge values that Kepplehill Burn and Craibstone Burns have very low mean and low flow discharges suggesting that during dry summers they may dry out completely.

3.1.7 The fourth parameter is a simple measure of the variation in mean monthly velocities for each watercourse. From these measures it can be seen that the most variable or 'flashy' watercourses are the River Don and Corsehill, Goval and Blackdog Burns.

3.2 Survey Results

Survey Results

<u>Aquatic Macro-Invertebrate Survey</u>

3.2.1 The aquatic macro-invertebrate survey was undertaken in April 2004 and sampling points are shown in Figures 10.12a-g. The aquatic macro-invertebrate assemblages of burns showed that most are in good or excellent ecological health with the exception of Red Moss Burn which is classified as fair (Table 9).

3.2.2 The straightened section of Kepplehill Burn is classified as being of good ecological quality following the ASPT scores (Table 9). The burn has a moderately diverse fauna comprising more pollution-tolerant stoneflies, mayflies and cased caddisflies with a range of true flies (dipterans) also present.

3.2.3 Gough, Craibstone and Green Burns are all located close together and all are assessed as being of excellent ecological health according to their Average Score Per Taxon (ASPT). Green Burn has the highest species richness of the three, most probably due to its larger size (Table 9). All three support a diverse assemblage of stoneflies including the LBAP species *Brachyptera putata*, and a suite of caddisflies and true flies with varying pollution tolerances. At both Craibstone and Green Burn the notable true bug *Velia saulii* was recorded indicating good quality edge habitat.

3.2.4 Bogenjoss Burn is also classified as excellent by its ASPT score, despite being such a small watercourse (Table 9). It supports a diverse stonefly fauna including *Brachyptera putata* and a variety of other pollution-sensitive, flow-reliant species.

3.2.5 The River Don has moderately high species richness with an ASPT score indicating that it is in good ecological health and this is consistent with SEPA's biological assessment (Table 7). The River Don supports a typical aquatic macro-invertebrate assemblage for its size.

3.2.6 Although Goval Burn's species richness is relatively low compared to other watercourses in the study area, the burn is assessed as being of good ecological health, a little higher than its recent SEPA classification of fair (Table 7). It supports an assemblage numerically dominated by pollution-tolerant species (e.g. *Baetis rhodani*) with a few pollution-sensitive taxa.

3.2.7 Red Moss Burn is classified as fair, mainly due to its low species richness and its assemblage being dominated by pollution-tolerant species such as the blackfly (*Simulidae* family) and the stonefly *Nemoura* sp.

3.2.8 Blackdog Burn is classified as being in good ecological health and this is consistent with SEPA's biological monitoring results (Table 7). For a small watercourse (Table 8) it supports a high species richness and a fauna comprising a range of pollution-sensitive, flow-reliant species, particularly stoneflies.

Table 9 – Aquatic Macro-Invertebrate Taxa

Aquatic Macro-Invertebrate Taxa	KHB	GOB	CSB	GRB	BJB	DON	GOV	RMB	BDB
OLIGOCHAETE	3	2	2	7	2	1		1	1
Dugesidae		5	3	3	2	1	4		2
Gammarus pulex L. (shrimp)		20	29	4	1	18	4		
Asellus aquaticus (Hog louse)						3			
HYDRACARINA (Water mite)					2	1	2		9
INSECTA									
Sialis sp. (Alderflies)								1	
Plecoptera (Stoneflies)									
Brachyptera putata		1	8	1	3				
Perlodes microcephala				1					
Isoperla grammatica	7	1		2	3	1	1		6
Siphonoperla torrentium		2	12	1	3	1	1		1
Nemoura spp	7	5	6	5	1			31	5
Amphinemura sulcicollis	6				2				10
Leuctridae		10	7		7				2
Ephemeroptera (Mayflies)									
Baetis rhodani	15	4	8	6	2	27	45		18
Rhithrogena semicolorata		3							
Leptophlebiidae	1							1	1
Coleoptera (Beetles)									
Dytiscidae									1
Hydrophildae				1					
Elmidae (l)		1		1		2	1		
Elmidae (a)	1	4					1		
Trichoptera (Caddisflies)									
Agapetus bifidus	9	2	1	1		4			
Brachycentridae						2			
Plectrocnemia sp			2	2					
Limnephilus sp									
Limnephilidae	9	3		5	9		2		2
Rhyacophila dorsalis				2			4		7
Philopotamidae			13	1					
Hydropsyche siltalia						3	24		
Odontoceridae			1	4					1
Diptera (Flies)									
Tipulidae	5		3	1	3				1
Chironimidae pupa	1						1		

Aquatic Macro-Invertebrate Taxa	**KHB**	**GOB**	**CSB**	**GRB**	**BJB**	**DON**	**GOV**	**RMB**	**BDB**
Tanypodinae spp			1	3	3	1		1	1
Orthocladinae spp	10	6	1	14	3	3	24	2	17
Chironominae spp	3	3		1	1	1			7
Simulidae	2	10	2	2	3	12	4	56	1
Hemiptera (True Bugs)									
Velia saulii (notable species)			1	2					
Velia sp					1				1
MOLLUSCA									
Sphaeridae (pea mussel)		1			2			5	2
Ancylus flucistilis (limpet)				1					
Lymnaea sp									1
Number of Species	15	18	17	24	19	18	14	10	21
Number of Individuals	84	83	101	63	50	114	116	104	87
BMWP Score	58	99	97	137	85	85	66	41	94
ASPT Score	5.8	6.19	6.47	6.52	6.1	5.67	6	4.56	5.88

KHB = Kepplehill Burn; GOB = Gough Burn; CSB = Craibstone Burn; GRB = Green Burn; BJB = Bogenjoss Burn; DON = River Don; GOV = Goval Burn; RMB = Red Moss Burn; BDB = Black Dog Burn.

Water Quality

3.2.9 Water quality measurements were taken during summer 2004 and are presented inTable 10 with sampling points shown on Figures 9.2a-g. As stated above since these are not repeated measures they are intended to give a broad indication of water quality only. All watercourses had high dissolved oxygen levels placing them indicatively in the excellent category for this parameter.

3.2.10 Electrical conductivity readings for all watercourses were at the lower end of the range typical for freshwater streams, particularly in Craibstone Burn and Blackdog burn, and were similar to those recorded by SEPA in watercourses in this area (Appendix A9.4: Water Quality). Water temperatures were typical for the time of year.

3.2.11 For all streams pH values were within the excellent category according to SEPA's river classification scheme, all being close to neutral. Total hardness values for the more northern burns were mostly below or around 60mg/L placing them in the soft water category which was in contrast with the Kepplehill Burn in the moderately hard category as were Mill Lade Aqueduct and Red Moss Burn.

Table 10 – Water Quality Data

Watercourse	DO (% sat)	Electrical Conductivity (µS/cm)	Temperature (°C)	pH	Total Hardness (mg/L)
KHB	81	250	15.3	6.82	105
GOB	97	290	14.9	7.24	61
CSB	93	30	15.1	7.06	61
GRB	91	240	13.7	6.87	18
BJB u/s	100	110	13.3	6.6	23
BJB d/s	106	120	13.6	7.04	23
DON	78	120	16.5	7.18	30
GOV	85	260	16.1	7.01	58
MLA	70	310	16.9	6.75	96
CHB	89	250	15.1	6.93	60
RMB	70	450	15.1	6.5	66
BDB	82	30	13.8	7.1	70

KHB = Keppelhill Burn; GOB = Gough Burn; CSB = Craibstone Burn; GRB = Green Burn; BJB = Bogenjoss Burn; DON = River Don; GOV = Goval Burn; MLA =Mill Lade Aqueduct; CHB = Corsehill Burn; RMB = Red Moss Burn; BDB = Blackdog Burn.

River Habitat Survey

3.2.12 A summary of the results of the river habitat survey is provided in Table 11. RHS was not undertaken for Kepplehill Burn since in the vicinity of the proposed route crossing it is functioning as a straightened, embanked land drain and as such it is inferred that it would fall into the severely modified category.

3.2.13 Gough Burn was assessed as being severely modified and this is largely due to the upstream half of the survey reach that consisted of a straightened channel running through the golf course. In contrast the downstream half was a naturally profiled, meandering burn running through mixed woodland.

3.2.14 Craibstone Burn was assessed as significantly modified as although there were areas where the banks had been reinforced with stonewalls and it was crossed by a couple of minor bridges. It was mainly a naturally profiled, meandering burn running through mixed woodland.

3.2.15 Green Burn was severely modified mainly by long culverts and bank re-profiling.

3.2.16 Bogenjoss Burn at the upstream reach was assessed as significantly modified by bank reinforcement using stonewalls and channel straightening for long sections even though it is essentially a small burn flowing through a conifer woodland. In contrast, at the downstream reach (the second crossing point for the proposed scheme) the burn has been assessed as obviously modified since it is a meandering burn with a complex riparian zone and a largely unmodified bank profile. The downstream reach is the least modified in the entire study zone as assessed by RHS.

3.2.17 The River Don was categorised as severely modified due to its extensive bank re-profiling and reinforcement (Table 11). The survey reach included one riffle section which provided natural in-stream habitat.

3.2.18 Goval Burn was categorised as severely modified because of its connection to Mill Lade Aqueduct and its extensively wholly-reinforced and re-profiled banks. Mill Lade Aqueduct was not subjected to RHS since it is an entirely artificial watercourse and is therefore severely modified.

3.2.19 RHS was not undertaken for Corsehill and Red Moss Burns since in the vicinity of the proposed route crossing both are entirely straightened, embanked land drains and as such it is inferred that they would fall into the severely modified category.

3.2.20 Blackdog Burn was severely modified as it was extensively straightened, re-profiled and wholly reinforced along both banks.

Table 11 – River Habitat Survey

Stream Code and HMS Score	Valley Form, Channel Dimensions, Bank Profile/Modification and Artificial Features	Substrate, Channel Form and Flow	Vegetation	Surrounding Land-use
Gough Burn GOB 2800 (severely modified)	Valley form concave/bowl shape with channel bankfull width averaging 3m with a water width of 1.5m and a depth of 5-10cm. Bank height averaging 1.5m throughout the reach. In the semi-natural, downstream section banks were vertical/undercut and steep in places mixed with areas of gently sloping bank profiles. In the modified upstream section the banks had been extensively resectioned and entirely reinforced along both banks with some areas of top only reinforcement on the right bank and a small area of artificial two stage profile on the left bank. Artificial features include three culverts and one bridge.	Substrate comprised loose unconsolidated bed material composed of 30% gravel/pebble, 40% cobble, 20% boulders and 10% sand. Throughout the survey reach two riffles, five pools and two vegetated point bars were recorded. Flow types comprised: 60% rippled and 40% smooth.	In the downstream section the riparian vegetation was complex along both banks while in the upstream section the vegetation complexity was a mix of simple and uniform. In the downstream section trees dominated the riparian zone while in the upstream section a semi-continuous line of trees was present along both banks. Extensive channel shading, overhanging boughs, exposed bankside roots, underwater tree roots was present, particularly in the downstream section. No in channel vegetation recorded.	In the downstream section land-use was dominated by broadleaf/mixed woodland with some areas of coniferous plantation. In the upstream section land-use was dominated by a golf course, with some small areas of scrub and shrubs, rough/unimproved grassland/pasture and tall herb/rank vegetation along both banks.
Craibstone Burn CSB 1229 (significantly modified)	Valley form concave/bowl shape with flat valley floor and channel bankfull width averaging 1.2m with a water width of 1m and a depth of 5-10cm. Bank height averaging 0.75m throughout the reach with both banks having areas of steep undercut profiles and extensive resectioning, wholly reinforced with some areas of poached bank. Additionally sections of the left bank had been reinforced at the top only and a set-back embankment was incorporated with a stonewall. Artificial features include two minor bridges, one intermediate and one minor outfall/intake.	Substrate comprised loose unconsolidated bed material composed of 10% gravel/pebble, 20% pebble and predominantly gravel, 30% cobble, 30% sand, 10% boulders and some small areas of silt. Throughout the survey reach two riffles, four pools, two unvegetated point bars and one vegetated point bar were recorded. Flow types comprised: 80% rippled and 20% smooth.	Throughout the survey reach riparian vegetation complexity was an even mix of simple and complex communities. Continuous tree cover present along both banks. Extensive shading of channel was observed and, overhanging boughs, exposed bankside roots and large woody debris; underwater tree roots were present. No in channel vegetation recorded.	Surrounding land-use is dominated by broadleaf/mixed woodland on both banks with scrub and shrubs also present. Additionally, small areas of rough/unimproved grassland/pasture, improved/semi-improved grassland and tall herb/rank vegetation were present on the left bank.

Stream Code and HMS Score	Valley Form, Channel Dimensions, Bank Profile/Modification and Artificial Features	Substrate, Channel Form and Flow	Vegetation	Surrounding Land-use
Green Burn GRB 1835 (severely modified)	Valley form concave/bowl shape with channel bankfull width averaging 2.5m with a water width of 2m and a depth of 10cm. Along both banks (averaging 1m high), extensive areas are vertical/undercut in addition to areas of gentle slopes. The burn had been extensively resectioned and reinforced at the top only with some areas also being embanked along the right bank. Artificial features include one minor weir (Kiddies Weir); two culverts (one short - minor road crossing and one long - >20m); one bridge and one minor outfall/intake.	Substrate comprised loose unconsolidated bed material composed of 50% sand; 20% cobble; 10% silt; 10% gravel pebble; 10% artificial substrate (concrete). Throughout the survey reach 10 riffles and eight pools were recorded. Flow types comprised: 50% rippled, 40% smooth and 10% not visible (in long culvert).	Along both banks the riparian zone is an even mix of simple and complex vegetation. Trees are continuously distributed along both banks leading to extensive shading of the channel with overhanging boughs, exposed bankside roots, large woody debris, underwater tree roots and fallen trees all present. In channel vegetation dominated by areas of liverworts/mosses/lichens and filamentous algae.	Extensive areas of broadleaf/ mixed woodland and tall herb/rank vegetation are present along both banks with scrub and shrubs and improved/ semi-improved grassland also present. Set back from the riparian zone there are also extensive areas of rough/unimproved grassland/pasture on the left bank. A small area of hard standing is present at the upstream end of the survey reach.
Bogenjoss Burn upstream BJB u/s 1300 (significantly modified)	Burn with no obvious valley sides with bankfull width averaging 0.75m with a water width of 0.75m and an average depth of 10cm. Bank height averaging 0.5m. Both banks are steeply sloping and extensively resectioned. Large sections are wholly reinforced with laid stone and some smaller sections have top only and toe only reinforcement. Additionally some areas of poached bank are present on the right bank.	Substrate comprised loose unconsolidated bed material composed of 40% cobble, 30% sand and 30% gravel/pebble with some small areas of less than 1% boulders and silt. Throughout the survey reach 20 riffles and 10 pools were recorded. Flow types comprised 40% smooth and 60% rippled.	Riparian vegetation is predominantly complex with small areas of simple structure. Trees are semi-continuous along the right bank with continuous tree cover along the left bank. The channel is extensively shaded with frequent overhanging boughs, exposed bankside roots and large woody debris. Underwater tree roots and fallen trees are also occasionally present. In channel vegetation included some small areas of liverworts/mosses/lichens with associated filamentous algae.	Extensive areas of coniferous plantation on both banks and extensive areas of rough unimproved grassland/pasture on the right bank. Broadleaf/mixed woodland, scrub/shrubs, wetland and tall herb/rank vegetation were also present on both banks.

Stream Code and HMS Score	Valley Form, Channel Dimensions, Bank Profile/Modification and Artificial Features	Substrate, Channel Form and Flow	Vegetation	Surrounding Land-use
Bogenjoss Burn downstream BJB d/s 406 (obviously modified)	Deep vee valley form with channel bankfull width averagely 1m with a water width of 1m and a depth of 20cm. Bank height was typically around 50cm. Semi-natural areas with steeply sloping and vertical/undercut profiles along both banks. Some areas of whole bank reinforcement along both banks incorporated with short section of stone wall on right bank.	Substrate comprised loose unconsolidated bed material composed of 30% cobble, 20% boulder, 30% sand, 20% pebble and gravel. Throughout the survey reach 28 riffles and 17 pools were recorded. Flow types comprised 40% rippled, 40% unbroken standing waves, 10% smooth and 10% broken standing waves.	The riparian zone along both banks was composed of an even mix of simple and complex vegetation communities. Continuous trees present on both banks. Extensive shading of the channel was observed with some overhanging boughs, exposed bankside roots, underwater tree roots, fallen trees and large woody debris.	Extensive areas of broadleaf/mixed woodland were present in the immediate riparian zone with tall herb/rank vegetation occurring along both banks surrounded by rough/unimproved grassland/pasture.
River Don DON 2840 (severely modified)	Valley form concave/bowl shape with flat valley floor and channel bank full width averaging 30m with a water width of 22m and a depth of 30-60cm. Bank height averages 2.5m along the survey reach and both banks have been extensively resectioned and reinforced at the toe only on the right bank. In addition a small area of poached bank was present on the right bank. No artificial features were recorded.	Substrate comprised loose unconsolidated bed material composed of 60% boulder, 40% cobble, with some small areas of sand/gravel/pebble/silt present within the site. Throughout the survey reach one riffle and a long section of glide was recorded. Flow types comprised: 70% smooth and 30% rippled.	Along the left bank the riparian vegetation is mainly uniform with some areas of simple and complex habitat. In contrast along the right bank the riparian vegetation is entirely uniform. No trees occur along the right bank and occasional isolated/ scattered trees are present along the left bank. There is evidence of bank mowing, fisheries management and sheep grazing, In channel vegetation included substantial areas of reeds/grasses, submerged broad-leaved and submerged fine-leaved macrophytes. Also present were submerged linear-leaved macrophytes and filamentous algae.	The land-use dominating both banks is unimproved/improved grassland/pasture. Scrub and shrubs and tall herb/rank vegetation are also extensively present along the left bank.

Stream Code and HMS Score	Valley Form, Channel Dimensions, Bank Profile/Modification and Artificial Features	Substrate, Channel Form and Flow	Vegetation	Surrounding Land-use
Goval Burn GOV 3104 (severely modified)	Valley form asymmetrical for entire survey reach with flat valley floor and channel bankfull width averaging 10m with a water width of 5m and a depth of 30cm. Bank height averaging 1m although some areas along the right bank are up to 5m high. Both banks have been extensively resectioned (reprofiled), and large sections of the left bank have been wholly reinforced while the right bank has been reinforced at the toe only and embanked. Aside from the connected Mill Lead Aqueduct, one intermediate outfall/intake was recorded.	Substrate comprised loose unconsolidated bed material composed of 60% boulder, 40% cobble, with some small areas of sand/gravel/pebble/silt present within the site. Throughout the survey reach eight riffles and six pools were recorded. Flow types comprised: 50% unbroken standing waves, 40% rippled and10% smooth.	Riparian vegetation is largely complex with some small areas of simple habitat along the bank face. Occasional clumps of trees present along the left bank with semi-continuous trees on right bank. Small areas of channel shading, occasional overhanging boughs, exposed bankside roots, underwater tree roots, fallen trees and large woody debris are present. In channel vegetation included some small areas of liverworts/mosses/lichens.	Extensive areas of broadleaf/mixed woodland, scrub and shrubs present along both banks. Also present are extensive areas of artificial open water along the right bank (Mill Lead aqueduct), rough/unimproved grassland/pasture along the left bank, tall herb/rank vegetation along both banks, and small areas of tilled land on the right bank.
Blackdog Burn BDB 2490 (severely modified)	Valley form concave/bowl shape with flat valley floor and channel bankfull width averaging 1m with a water width of 1m and a depth of 15cm. Bank height approximately 0.75m with the entire reach resectioned and whole reinforcement extensively undertaken along both banks. Artificial features included one culvert.	Substrate comprised loose unconsolidated bed material composed of 30% cobble, 50% gravel/pebble and 20% sand. Throughout the survey reach 20 riffles and 10 pools were recorded. Flow types comprised 50% rippled, 30% unbroken standing waves and 20% smooth.	Both bank faces support uniform riparian vegetation while at the banktop some small areas of simple vegetation are present. Trees isolated/scattered along both banks with small areas of channel shading overhanging boughs present. In channel vegetation included extensive areas of liverworts/mosses/lichens with associated filamentous algae.	The dominant surrounding land-use is improved/semi-improved grassland with some areas of scrub/shrubs, rough/unimproved grassland/pasture and tall herb/rank vegetation present along both banks.

4 Evaluation

4.1 Introduction

4.1.1 Individual burns within each section that are at risk of being impacted are referred to as Freshwater Habitat Areas (FHA). Each FHA was assessed for its ecological value to the receptor, with a final assessment of the ecological value of the section being made.

4.1.2 Overall the FHAs in the vicinity of the proposed scheme are of good ecological health and this is reflected in the generally high evaluations of ecological value (Table 12). The FHAs were evaluated as being between local and regional value.

4.2 Freshwater Habitat Evaluation

Section NL1: ch314800 – 316000 (Derbeth to Tulloch Road)

4.2.1 This section of the proposed scheme is very short, with only one burn falling within it, Kepplehill Burn. The freshwater habitat within this section has been collectively evaluated as **local** value, based on the assessment of Kepplehill Burn (discussed below).

4.2.2 The section of Kepplehill Burn falling within the vicinity of the proposed route is severely modified and comprises a straightened embanked land drain. Keppelhill Burn has been assessed as being of good ecological status on the basis of the aquatic macro-invertebrate communities present. Due to the burns highly modified nature it has been evaluated as being of **local** value, despite the good ecological status.

Section NL2: ch316000 – 317400 (SAC Craibstone)

4.2.3 A total of three freshwater habitats were assessed within this section; Gough Burn, Craibstone Burn and Green Burn. The nationally scarce stonefly *Brachyptera putata* was identified from each of the burns. In addition to this the notable bug species *Velia saulii* was identified from Craibstone Burn and Green Burn. The burns within this section are in close proximity and are associated with each other, sharing common links. The three burns offer a variety of habitats and form a representative of the habitat offered within the section. The evaluations of each individual burn are discussed below, and have been used to form an overall evaluation of freshwater habitat within the section.

4.2.4 The excellent biological status of each of the watercourses within the section and the presence of nationally scarce and notable species has led to the overall evaluation of freshwater habitat within the section as being of **regional** value.

4.2.5 Gough Burn was assessed as having excellent ecological value on the basis of aquatic macro-invertebrate communities present, though was found to be severely modified in the vicinity of the proposed crossing, comprising a straightened channel. Despite the modification of the channel, the burn has been evaluated as **regional** value due to the ecological value of the habitat and complexity of riparian zones providing good otter and fish habitat.

4.2.6 Craibstone Burn also had excellent ecological value, with *B. putata* and the notable bug species *Velia saulii* being present. This burn was the least modified out of the three within this section, with the majority of the reach following a natural meandering profile. Evidence of modification was apparent with some bank reinforcement and several minor bridges, resulting significant modification. The excellent ecological value of the habitat, not only for aquatic macro-invertebrates, but also fish and otters, means that the freshwater habitat has been evaluated as **regional** value.

4.2.7 Green Burn was also assessed as having excellent ecological value as a result of the aquatic macro-invertebrate assemblages present. *B. putata* and *V. sualii* were present within the burn, enhancing its value. Although Green Burn was found of excellent ecological value, it was severely modified with long culverts and bank re-profiling within the vicinity of the proposed route. Despite the modification of the channel, the freshwater habitat of Green Burn has been evaluated at **regional** value, due to the importance of the habitat to aquatic macro-invertebrates as well as fish and otters.

Section NL3: ch317400 – 322600 (A96 to Nether Kirkton)

4.2.8 One burn within this section was identified as being potentially affected by the proposed route at two locations: Bogenjoss Burn. The nationally scarce *B. putata* was identified from within the vicinity of each of the proposed crossing points.

4.2.9 The habitat offered by Bogenjoss Burn varied throughout the reach with the upstream section comprising a significantly modified channel with straightening and bank reinforcement, whereas the downstream section offered a complex riparian zone and obviously modified habitat. The variation of habitat offered by the burn and the presence of *B. putata* at both sample locations leads to an overall freshwater habitat assessment of **regional** value for this stretch.

4.2.10 Both sites on the burn were assessed as being of good ecological value for aquatic macro-invertebrates and also provides habitat for fish and otters due to the complex riparian zone, and as such has been evaluated of **regional** value.

Section NL4: ch322600 – 325370 (Nether Kirkton to Corsehill)

4.2.11 Within this section four watercourses have been identified as being potentially affected: the River Don, Goval Burn, Mill Lade Aqueduct and Corsehill Burn. All watercourses were identified as having good ecological status on the basis of the aquatic macro-invertebrate assemblages present, though there is variation in the degree of modification. All four of these watercourses run in close proximity to each other, and all burns ultimately feed into the River Don.

4.2.12 In order to assess the ecological value of the freshwater habitat as a whole within this section, account must be taken of the variation in the individual assessments of the burns (discussed below). The evaluations of individual burns ranged from national (River Don) to local, showing the degree of variation. Due to the fact that all of the burns assessed feed into the River Don, it is necessary to assess the freshwater habitat in this section as being of **regional** value.

4.2.13 The River Don was assessed as being of good ecological health, and was identified as being severely modified due to the bank re-profiling and reinforcement. It has been evaluated as **national** value due to it supporting a salmon fishery all three species of lamprey (sea, river and brook lamprey), and its otter population (refer to Otter Report, A10.6 and Fish Report A10.15).

4.2.14 Goval Burn, the largest of the burns, was found to have good ecological value, though was severely modified. The Burn had reinforced and re-profiled banks and leads in to the Mill Lade aqueduct. The burn has been evaluated as being of **county** value because of its good ecological health and its importance for otters and fish.

4.2.15 Mill Lade Aqueduct flows from Gough Burn and is an artificial watercourse, thus it was identified as severely modified. The aqueduct was identified as having good ecological health on the basis of the aquatic macro-invertebrate assemblages present. The freshwater habitat offered was evaluated as being of only **local** value due to it being entirely artificial, with little in-stream and bankside habitat and a regulated flow regime.

4.2.16 Corsehill Burn was found to have good ecological status despite it being a severely modified channel. The reach was an entirely straightened embanked field drain, and as such the freshwater habitat was evaluated as being of **local** value**.**

Section NL5: ch325370– 331000 (Corsehill to Blackdog)

4.2.17 The final section of the proposed route includes two potentially impacted watercourses. Red Moss Burn and Blackdog Burn. The ecological status and degree of modification differed between these two burns.

4.2.18 Evaluations of the burns identified within this final section were consistent with both being identified as **county** value. The two burns were variable, with Red Moss burn being a highly modified land drain and Blackdog Burn showing some degree of modification. The presence of important lochs within this Section and the network of watercourses, mean the freshwater habitat is assessed as being of **county** value.

4.2.19 Red Moss Burn was found to be of fair ecological status and was a small straightened field drain. It does drain into Corby Loch which is part of an SSSI (see Breeding Bird Report, A10.4), and therefore the freshwater habitat has been evaluated as **county** value.

4.2.20 Finally, Blackdog Burn was identified as having good ecological health based on the aquatic macro-invertebrate assemblages identified. The burn is severely modified with extensive re-profiling and straightening. The freshwater habitat was evaluated as being of **county** value because of its size and good ecological health.

Table 12 – Freshwater Watercourse Evaluation

Section	Watercourse	Code	Size (km^2)	ASPT	SEPA Classification	HMS	Habitat Classification	Watercourse Evaluation	Comment
NL1 Local	Kepplehill Burn	KHB	0.25	5.8	A2 Good	-	Severely modified*	Local	Although this burn meets the biological criteria for county value in Table 5, its very small size and its severely modified habitat mean it is assessed as being of local value.
NL2 Regional	Gough Burn	GOB	1.06	6.19	A1 Excellent	2800	Severely modified	Regional	Classified on the basis of excellent ecological health and the burn supporting *Brachyptera putata*.
	Craibstone Burn	CSB	0.5	6.47	A1 Excellent	1229	Significantly modified	Regional	Classified on the basis of excellent ecological health and the burn supporting *Brachyptera putata*.
	Green Burn	GRB	2.77	6.52	A1 Excellent	1835	Severely modified	Regional	Although this burn is classified as excellent using biological data it is significantly modified and, outside the survey reach, extensively culverted and straightened.
NL3 Regional	Bogenjoss Burn upstream	BJB u/s	-	6.1	A2 Good	1300	Significantly modified	Regional	Classified on the basis of good ecological health, and the burn supporting *Brachyptera putata*.
	Bogenjoss Burn downstream	BJB d/s	1.59	6.1	A2 Good	406	Obviously modified	Regional	Classified on the basis of good ecological health, and the burn supporting *Brachyptera putata*.
NL4 Regional	River Don	DON	1228.1	5.67	A2 Good	2840	Severely modified	National	Classified on the basis of the river being of good ecological health, and subsequently supporting salmonids.
	Goval Burn	GOV	39.77	6	A2 Good	3104	Severely modified	County	None.
	Mill Lade Aqueduct	MLA	-	-	A2 Good*	-	Severely modified*	Local	None
	Corsehill Burn	CHB	1.79	-	A2 Good*	-	Severely modified*	Local	None
NL5 County	Red Moss Burn	RMB	-	4.56	B Fair	-	Severely modified*	County	None
	Blackdog Burn	BDB	-	5.88	A2 Good	2490	Severely modified	County	None

5 Potential Impacts

5.1 Introduction

5.1.1 The range of potential impacts of road schemes on aquatic ecology, and their significance, depends on the individual circumstances of each scheme. However, it is possible to identify a number of main areas of concern, which have general applicability. An assessment of the likely impacts on the water quality of the watercourses is given in Chapter 9 (Water Environment Chapter). Key potential impacts on aquatic ecosystem health are set out in this section in the following order point source and/or diffuse organic/inorganic pollution; increased sediment loading and changes to sediment transport; decrease in stream and bankside habitat complexity; habitat fragmentation and substantial changes to discharge regime. Other impacts such as dust deposition, spread of alien species, changes to groundwater flow are addressed in the Terrestrial Habitats Report (Appendix 10.1) and Water Environment (Chapter 9).

5.1.2 It should be noted that the impacts associated with the operational phase of the scheme are considered to be permanent, whereas temporary impacts, which are only apparent while the road is being built, are discussed in association with the construction phase.

5.2 Potential Generic Impacts

Point Source and/or Diffuse Organic/Inorganic Pollution

5.2.1 During construction of the proposed scheme there is a potential for accidental pollution release to adjacent waterways including oil and fuel from plant, liquid concrete, uncontrolled sewage release and fine sediment release (see below). The effect of any given pollution is likely to have greater impacts in smaller watercourses which have lower dilution.

5.2.2 Oils, fuels and chemicals can enter watercourses via accidental spillage from storage tanks or leakage from mobile or stationary plant. Oils can form a film on the water surface resulting in an adverse effect on water quality. These oils can interfere with the gills of invertebrates and fish and inorganic pollutants may have a lethal effect on aquatic flora and fauna.

5.2.3 Concrete, cement and admixtures could be released to watercourses through accidental spills or from the washings of plant and machinery. Concrete and cement are highly alkaline and may adversely affect aquatic organisms if the pH is elevated to or maintained above 8.5.

5.2.4 Accidental/uncontrolled release of sewage could result from damage to pipelines during service diversion. Release of sewage to watercourses would result in organic loading and could lead to increased biological oxygen demand and decreases in dissolved oxygen.

5.2.5 Without mitigation in place, operation of the proposed scheme could potentially impact adjacent watercourses through polluted road runoff (inorganic) and accidental spills (inorganic and organic).

5.2.6 Road runoff and some accidental spills from traffic using the new road are likely to raise levels of inorganic pollution entering the watercourses and lead to decreased aquatic macro-invertebrate species richness. As stated above inorganic point source pollution leads to the loss of pollution sensitive/rare species and ultimately leads to fish kills if toxicity reaches lethal levels.

5.2.7 Accidental spills of organic pollution (e.g. from a milk tanker crash) are likely to lead to decreased aquatic macro-invertebrate species richness and the increased abundance and dominance of a few pollution-tolerant species in the short term. For localised events impacts are less likely to permanently affect the faunal assemblage as aquatic macro-invertebrates are able to drift away from pollution hotspots. Increased organic pollution can also lead to nuisance plant growth (e.g. algal blooms) and increased biological activity as organic material is broken down. Increased biological activity causes increased biological demand and results in decreased dissolved oxygen, which can potentially lead to fish kills.

Increased Sediment Loading and Changes to Sediment Transport

5.2.8 During construction, increased sediment loading to adjacent watercourses could occur in the absence of suitable mitigation. Suspended solids can result from excavations, runoff from stockpiles, plant and wheel washing, runoff from site roads, runoff during embankment construction, earthworks and landscaping. The risk of release of suspended solids into watercourses or drainage ditches is greatest at road crossings where earthworks would be involved in the construction of culverts, bridges and river diversions. Changes in water velocities resulting from temporary stream diversions during construction are also predicted to affect sediment transport.

5.2.9 Sediments can cause damage to aquatic invertebrates and fish through deposition resulting in a smothering effect, reducing microhabitat availability or by interference with feeding and respiratory apparatus. Salmonids have a suspended solids tolerance of around 30mg/L (refer to Fish Survey Report A10.15 for more details). Alabaster and Lloyd (1982) summarise that long-term levels of suspended sediment below 25mg/L^{-1} will have no harmful effects on fish. 25-80mg/L^{-1} levels are acceptable as a rule of thumb, 80-400mg/L^{-1} are unlikely to support good fisheries and levels over 400mg/L^{-1} generally will not support substantial fish populations.

5.2.10 During road construction, suspended solids reaching the water column are likely to originate principally from sediment laden runoff. For example, the contractor would strip off the topsoil to prepare the ground for road construction, leaving the earth bare. During a rain event, water falling on this surface would pick up loose sediment on its way to the receiving watercourses. Where it is possible to assess these impacts quantitatively, this has been completed using sediment modelling (please refer to Appendix A9.5, Annex 27). Otherwise, potential impacts on receiving watercourses have been assessed qualitatively and are addressed in Chapter 9 (Water Environment) and Appendix A9.3 (Fluvial Geomorphology Report).

5.2.11 Suspended solids may also contain contaminants, which can cause pollution of the receiving watercourse. Sediment smothering can also reduce light availability for aquatic plants which can lead to die back and in turn increase organic loading and its associated impacts including lowered levels of dissolved oxygen (see above). Increased turbidity can hamper predatory aquatic macro-invertebrates' search for prey. Additionally, increased turbidity as sediment is entrained in the water column can lead to decreased dissolved oxygen (DO) levels.

5.2.12 During operation, increased sediment loading could result from road runoff, particularly during and following heavy rain when road drainage systems may not function optimally. In addition, the proposed scheme may result in a substantial change to the discharge regime (see below) and this could permanently alter the sediment transport and geomorphological character of some of the watercourses (refer to Fluvial Geomorphology Report, Appendix 9.3). This could indirectly impact on aquatic organisms specifically adapted to microhabitats which may be lost through changes in sediment dynamics. For example, increased scour may adversely affect a caddis fly species that relies on fine sand to build its case or an area may become unsuitable for salmon egg laying.

Decrease in Stream and Bank Side Habitat Complexity

5.2.13 Construction of the proposed scheme would involve numerous watercourse crossings and at each of these crossing points there is likely to be a degree of habitat simplification/modification. This can occur through culverting, channel straightening, bank reinforcement or re-profiling, river diversion, over deepening, and clearing of riparian zone. All of these activities have the potential to reduce habitat and food availability for aquatic species, in turn leading to decreases in species richness and mortality.

5.2.14 In particular, the use of culverts with smooth substrates, rather than those which allow the natural river bed to remain, would substantially reduce in stream habitat complexity and thus niche availability for aquatic macro-invertebrates. Also since the road is likely to be at least 30m wide (wider in the embanked sections), this length of each watercourse to be crossed using culverts must be straightened and the riparian habitat lost resulting in reduced channel sinuosity and decreased flow heterogeneity. River diversions would also result in reaches being straightened and riparian habitat loss. More seriously however, some river diversions may substantially reduce the total river length, leading to changes in discharge regime and sediment transport (see below), which may in turn simplify in-stream and marginal habitat characteristics and lead to increased erosion and flooding.

5.2.15 Operation of the proposed scheme would include maintenance of the road and verges and this could potentially impact on riparian zone habitat complexity through bank mowing. Also the spread of exotic species such as Japanese knotweed could result in simplification of riparian habitat. In other respects operation is not likely to substantially affect in-stream and bankside habitat complexity apart from through changes to the discharge or sediment transport regimes. These impacts are addressed in the relevant sections below.

5.2.16 Estimated areas of habitat loss of specific terrestrial habitat types including permanent and temporary habitat loss have been included in Table 11 of the Terrestrial Habitats Report (Appendix A10.1).

Habitat Fragmentation

5.2.17 Habitat fragmentation in watercourses usually involves some kind of physical barrier, which can stop free movement of fauna. Culverts under duel carriageway roads typically constitute long straightened reaches of smooth substrate with no in-stream or bankside habitat complexity and associated food resources and may also result in changes in slope and faster flow conditions. In addition to habitat modification, substantial shading can also be a key impact of long culverts. All of these factors could pose a barrier to fish, otter and invertebrate movement.

5.2.18 In addition to culverts, river diversions can also cause habitat fragmentation by reducing channel sinuosity and potentially changing the discharge regime which may stop or hamper the movement of fauna which require specific flow conditions to migrate up or down the river system.

5.2.19 Habitat fragmentation is particularly relevant to salmonid fish (i.e. salmon and trout), which need to migrate upstream to breed.

5.2.20 In addition to the habitat fragmentation impacts described above, operation of the proposed scheme may also result in the culverts becoming blocked if not properly maintained, particularly following periods of heavy rain.

Substantial Changes to Discharge Regime

5.2.21 The proposed construction works would alter the slope of the surrounding land and slightly increase the local amount of impermeable surface through the construction of the road pavement, across the whole scheme including junctions but not including embankments and road drainage infrastructure (refer to Appendix A10.1: Terrestrial Habitat). This has the potential to increase the total discharge via runoff to the watercourses, possibly constituting a negative impact on the aquatic ecosystem. Additionally, temporary and permanent river diversions can also substantially alter the discharge regime through changes in slope and channel sinuosity, affecting water velocities and discharge volumes. Detention basins associated with road drainage also have the potential to change the natural discharge regime of watercourses.

5.2.22 Changes to discharge regime can result in substantially changed local habitat and food availability and water quality. Substantial reduction in discharge levels can severely affect flow-reliant species and those sensitive to decreases in dissolved oxygen. Similarly, increased discharge can have negative impacts on species reliant on slow flow areas such as pools and marginal dead water for feeding and resting (i.e. migratory fish). Increased discharge can also have a microhabitat simplification effect due to scouring and increased flood frequency that can also reduce the number of species able to survive in a variable discharge environment.

5.2.23 Substantial increases or decreases in water velocities of a river can have adverse impacts on the ecosystems it supports. Many species are adapted for specific ranges of water velocities for feeding, breeding, and migratory cues. Also, changes in discharge regime can substantially alter the benthic microhabitat available and cause substantial changes in water quality parameters, particularly dissolved oxygen and biochemical oxygen demand.

5.2.24 Operation of the road is not predicted to substantially affect the discharge regime of local watercourses except potentially through the maintenance of road drainage however this impact would be infrequent and temporary.

5.3 Specific Impacts

5.3.1 The road runoff would enter Gough Burn, Green Burn, Craibstone Burn, Bogenjoss Burn, the River Don, and Goval, Corsehill, Red Moss and Blackdog Burns with outfall locations shown on Figures 9.6a-g and in Chapter 9 (Water Environment). There would be no road runoff discharged to Kepplehill Burn or the Mill Lade Aqueduct. Gough Burn and Green Burn currently already receive untreated road drainage from the A944, the C89C and the A96 respectively.

5.3.2 Kepplehill Burn, Gough Burn and Craibstone Burn would all be crossed by the mainline at one point. Each of these burns would be culverted at the mainline crossing chainages. In addition, Gough Burn would be re-aligned and lengthened.

5.3.3 Green Burn would be crossed three times using culverts, once by the AWPR mainline once by the A96 mainline, and once by the slip road associated with the A96 Craibstone Junction and would also undergo extensive re-alignment.

5.3.4 Bogenjoss Burn would be crossed twice by the mainline; with both crossing points being culverted with an associated substantial realignment. In addition to these main crossings Bogenjoss Burn would be crossed a further four times in the upstream realigned sections where short culverts would be employed at side roads.

5.3.5 The River Don would be bridged using a single span viaduct with minimal alteration to the surrounding floodplain.

5.3.6 Goval Burn would be bridged by the mainline and crossed by two side roads. All three crossings would be bridges As buried structures) with no piers in the water column. Re-alignment would be needed, resulting in the straightening and shortening of the burn.

5.3.7 Mill Lade Aqueduct would be stopped up and dismantled at the crossing point for road construction and would be entirely reinstated over the proposed route following completion.

5.3.8 It is proposed that Corsehill Burn would be crossed three times, once on the mainline and on two link roads; all locations are proposed to be culverted. The burn would also require substantial re-alignment which would result in straightening and lengthening of the burn. Red Moss Burn would be culverted once at the mainline crossing.

5.3.9 Blackdog Burn would be culverted in two places; once at the mainline crossing and once at the Blackdog Access Road. Finally the existing culvert at the A90 crossing would be upgraded.

Table 13 – Impact Assessment of Key Watercourses Potentially Affected by the Proposed Scheme

Section	Water-course	Watercourse Ecological Value	Crossing	Realignment	Road Discharge	Habitat Area Lost (m^2)	Impact Description	Potential Impact	
								Magnitude	Significance
NL1	Kepplehill Burn KHB	Local	154m long culvert at ch315200	No realignment of burn	No road drainage discharge to burn	~ 980	Construction: Culverting of existing straightened channel would involve some earthworks, possibly resulting in sediment and/or other pollution release and short-medium term slight decrease in bankside and in-stream habitats complexity. Operation: Long-term slightly decreased habitat complexity for culverted section which may lead to habitat fragmentation for any migratory species, and localised changes to species distributions.	Medium negative	Minor adverse
NL2	Gough Burn GOB	Regional	62m long culvert at ch316390	Realigned length 232m resulting in lengthening the burn by 48m	2565m length of road drainage to discharge to burn at ch316330.	~ 1560	Construction: Culverting of existing straightened channel would involve some earthworks, possibly resulting in sediment and/or other pollution release and short-medium term loss in-stream habitat complexity Operation: Long-term decreased habitat complexity for culverted section leading to localised changes in invertebrate distributions. A slight change to discharge regime due to road drainage is possible, as is decreased water quality resulting from road runoff carrying sediment load and heavy metals.	Medium negative	Moderate adverse
	Craibstone Burn CSB	Regional	106m long culvert at ch316990	Minimal realignment planned	Length of road drainage to discharge to burn Pending	~ 8410	Construction: Culverting of partially modified channel would involve some earthworks, possibly resulting in sediment and/or other pollution release and short-medium term loss of bankside habitat and in-stream habitat complexity. Operation: Long term decreased bankside habitat complexity from culverted section, leading to localised changes in distribution of species. Decreased water quality could result from road runoff carrying sediment load and heavy metals.	Medium negative	Moderate adverse

Section	Water-course	Watercourse Ecological Value	Crossing	Realignment	Road Discharge	Habitat Area Lost (m^2)	Impact Description	Potential Impact	
								Magnitude	Significance
	Green Burn GRB	Regional	113m long culvert on the mainline at ch317330, 40m long culvert and on A96 mainline and 69m long culvert on the A96 link road	Realigned length 702m resulting in lengthening of burn by 40m	4855m Length of road drainage to discharge to burn at ch17470. pending	~ 21110	Construction: Extensive culverting and realignment would involve major earthworks, possibly resulting in sediment and/or other pollution release and short-medium term loss of bankside and in-stream habitat complexity.	Medium negative	Moderate adverse
							Operation: Long term decreased habitat complexity due to culverting leading to changes in localised invertebrate distributions. This could also lead to habitat fragmentation due to proximity of long culverts via a barrier effect. Substantial change to discharge regime due to lengthening and realignment of burn may lead to siltation and the requirement for dredging. Decreased water quality resulting from road runoff carrying sediment load and heavy metals may also occur.		
NL3	Bogenjoss Burn BJB (u/s and d/s)	Regional	9m long culvert at ch319950, 8m long culvert at ch320100, 11m long culvert at ch320200, 10m long culvert at ch3204500, 56m long culvert on the mainline at ch320520, and 170m long culvert on mainline bridge at ch320870	Realignment of 889m length resulting in substantial straightening of the channel and shortening of burn by 140m	980m length of road drainage to discharge to burn at ch320805.	~18660	Construction: Realignment and culverting in the upstream reach would involve extensive earthworks and could result in the release of sediment and/or other pollution to the burn. It would also result in short-medium term habitat simplification of an existing straightened channel.	Medium negative	Moderate adverse
							Operation: Long term decreased habitat complexity due to burn realignment, shortening and straightening, combined with one long section of culverting and four short sections in close proximity leading to localised changes in invertebrate distribution. Habitat fragmentation due to proximity of five culverts. Substantial change to discharge regime due to lengthening and realignment of burn may lead to siltation and the requirement for dredging. Decreased water quality resulting from road runoff carrying sediment load and heavy metals may also occur.		

Section	Water-course	Watercourse Ecological Value	Crossing	Realignment	Road Discharge	Habitat Area Lost (m^2)	Impact Description	Potential Impact	
								Magnitude	Significance
NL4	River Don DON	National	Bridge spanning river and floodplain	No realignment planned	2200m length of road drainage to discharge to river at ch322930.	area lost to pier foundation on floodplain	Construction: Bridging would involve earthworks, possibly resulting in sediment and/or other pollution release leading to short term loss of in-stream habitat complexity and decreased water quality. Sediment modelling team assessed this impact as High Magnitude Operation: No long term decreased habitat complexity or fragmentation is predicted since the river is to be bridged. Slightly decreased water quality resulting from road runoff carrying sediment load and heavy metals may occur.	Medium negative	Major adverse
	Goval Burn GOV	County	147.5m culvert at the mainline at ch324600, 92m long culvert at ch323610, 49m long culvert at ch324400.	Realignment length 202m resulting in substantial straightening and shortening watercourse by 138m	2430m length of road drainage to discharge to river at ch323900.	None	Construction: Bridging and culverting would involve some earthworks, possibly resulting in sediment and/or other pollution release leading to short-medium term habitat loss and decreased water quality. Operation: Decreased habitat complexity or fragmentation is predicted where the burn is being culverted leading to changes in invertebrate distribution. Slightly decreased water quality resulting from road runoff carrying sediment load and heavy metals may occur.	Medium negative	Moderate adverse
	Mill Lade Aqueduct MLA	Local	Aqueduct section of approximately 100m to be dismantled during construction and reinstated over the AWPR mainline following construction	No realignment proposed	Aqueduct not proposed to receive road drainage	None	Construction: Aqueduct to be partially dismantled to allow construction of the road, resulting in loss of all ecological interest in this section. Construction activities may also result in accidental pollution and or sediment release. Operation: Aqueduct to be reinstated following road construction and would gradually recover pre construction ecological interest	Temporary high negative leading to low negative long term	Minor adverse

Section	Water-course	Watercourse Ecological Value	Crossing	Realignment	Road Discharge	Habitat Area Lost (m^2)	Impact Description	Potential Impact	
								Magnitude	Significance
	Corsehill Burn CHB	Local	Three culverts: one of 71m on the mainline at ch325005 , one of 32m and one of 35m on the link roads	Realignment of 505m length resulting in substantial straightening of the channel and lengthening of burn by 19m	2765m length of road drainage to discharge to burn at Goval Junction South ch20 (roundabout)	~8530	Construction: Culverting and realignment would involve major earthworks, possibly resulting in sediment and/or other pollution release and short-medium term loss of bankside and in-stream habitat complexity Operation: Long term decreased habitat complexity due to culverting potentially leading to habitat fragmentation due to proximity of three culverts resulting in a barrier effect. Possible slight change to discharge regime due to lengthening and realignment of burn. Decreased water quality resulting from road runoff carrying sediment load and heavy metals.	Medium negative	Minor adverse
NL5	Red Moss Burn RMB	County	One 58m culvert at ch327500	No realignment proposed	1260m length of road drainage to discharge to burn at ch327240.	~950m^2	Construction: Culverting and realignment would involve earthworks, possibly resulting in sediment and/or other pollution release and short-medium term loss of bankside and in-stream habitat complexity Operation: Slight long term decreased habitat complexity due to culverting potentially leading to habitat fragmentation. Decreased water quality resulting from road runoff carrying sediment load and heavy metals.	Low negative	Minor adverse
	Blackdog Burn BDB	County	Two culverts: one of 61m on the mainline at ch329950 and one of 38m on the access road.	None	3965m length of road drainage to discharge to burn at ch329940 and A90 North Junction ch375.	~3600	Construction: Culverting of existing straightened channel would involve some earthworks, possibly resulting in sediment and/or other pollution release and short-medium term loss of bankside and in-stream habitat complexity Operation: Long term decreased habitat complexity due to culverting. potentially leading to habitat fragmentation due to proximity of culverts.. Decreased water quality resulting from road runoff carrying sediment load and heavy metals.	Low negative	Minor adverse

6 Mitigation

6.1 Introduction and Guiding Principles

6.1.1 As outlined in the EIA (Scotland) Regulations 1999 mitigation measures are intended "to prevent, reduce or where possible, offset any significant adverse impacts on the existing ecology and nature and conservation value of the surrounding area."

6.1.2 For the purposes of impact assessment, specific mitigation has been developed where potential adverse impacts of greater than Moderate significance have been identified, with the objective of reducing the impact significance for ecology to Minor or Negligible.

6.1.3 The Nature Conservation (Scotland) Act 2004 has added the requirement for the Scottish Executive to enhance biodiversity as part of any development by having regard to the Rio Convention and the Scottish Biodiversity strategy.

6.1.4 The WFD has also been taken into account in the formulation of mitigation strategies. In particular its aim for all watercourses to gain ‘good’ ecological status and its requirement that there must be no deterioration in ecological status of any watercourse. It should also be noted that it is likely that SEPA will require any new culvert or bridge to be licensed under the Controlled Activities (Scotland) Regulations 2005 (refer to Chapter 9: Water Environment).

6.2 Mitigation Incorporated into the Proposed Scheme Design

6.2.1 For the AWPR scheme, ecological measures have been developing continually throughout the design process. In particular major design components such as road drainage, locations of bridges and culverts and watercourse realignment details have been developed though an iterative process involving structures engineers, geomorphologists, ecologists and water quality specialists.

6.2.2 Consultation with SEPA and SNH has been undertaken at key design stages to seek guidance on appropriate levels of road drainage, culverting and watercourse realignment before the publication of the ES.

Road Drainage

6.2.3 The main mitigation strategy for the aquatic environment is the new road drainage system, which is designed to substantially reduce pollution entering watercourses and also minimise risk of accidental spills, in most cases avoiding this potential impact entirely. Road drainage is designed in accordance with the principles contained in the Sustainable Urban Drainage Systems (SUDS): Design Manual for Scotland and Northern Ireland (CIRIA C521 and CIRIA C609). Details of the proposed road drainage are provided in Chapter 9 (Water Environment) and Appendix A9.4 (Water Quality). In summary, SUDS techniques to be implemented to avoid and reduce potential impacts during normal road operation include the following:

- filter drains and catchpits along the entire road;
- attenuation basins and treatment ponds to treat all road runoff;
- swales; and
- the provision of scour protection at the drainage discharge outfall.

6.2.4 The removal of efficiencies from the various treatment systems are given in Chapter 9 (Water Environment). For common road runoff contaminants zinc, copper, iron, lead, suspended solids and hydrocarbons removal efficiencies are generally around 70-90%. In addition, the proposed road drainage is predicted to reduce the risk of spillage causing pollution by 65% (DMRB, 1998; CIRIA C609, 2004).

Bridges and Culverts

6.2.5 Bridging watercourses of ecological value is aimed at avoiding habitat loss and minimising disturbance. The River Don is assessed as being of national ecological value and it is proposed that a bridge will be required. The design of the river crossing has been developed by a team including structural engineers, environmental scientists and aesthetic advisors. Details of design features are given in Chapter 9 and construction and operation mitigation measures specific to aquatic ecology are outlined below.

6.2.6 Bridges have been designed to entirely span the watercourse at the crossing point, meaning that no piers would be located in the channel and there would be no need for in-channel works at any of these crossing points. In addition, bridges have been designed to minimise damage to the surrounding riparian zone, with piers set back from the water's edge and viaduct options being preferred over the construction of large embankments on floodplains.

Culvert Design

6.2.7 Appropriate culvert design is aimed at avoiding habitat fragmentation and reducing habitat loss. For the majority of the watercourses crossed by the proposed scheme that would be culverted, a depressed invert box culvert design will be used. This follows guidance from Scottish Executive on culverts and migratory fish (SEERAD, 2000). Depressed invert culverts have the base of the culvert set below bed level to allow natural substrate to be used within the culvert, thus providing in-stream habitat diversity. Initially, substrate in the culvert would comprise imported material of a similar size to that of the original channel, which will be specified to ensure that the sediment doesn't wash out at times of high flow or silt up in times of low flow (refer to Appendix 9.3, Fluvial Geomorphology Report). During the operation of the road, natural substrate is also likely to accumulate in the culvert. These culverts are proposed at most crossing points except very small land drains with little or no geomorphological or ecological interest.

6.2.8 All culverts have been designed to accommodate a 1:200 year flood and also allow DMRB guideline headroom for out-of-water mammal ledges, which are present within each culvert. Gradients do not differ markedly from existing conditions to avoid excessive siltation or erosion. Guidelines in SEERAD (2000) have been followed to ensure that flow conditions allow for the passage of migratory fish (refer to Appendix 10.15: Fish).

Watercourse Realignments

6.2.9 Watercourse realignments are aimed at reducing impacts elsewhere in the catchment by minimizing crossing lengths and can also represent substantial opportunities for offsetting impacts through habitat creation and enhancement. During the design of the watercourse crossings, several workshops were conducted with engineers, ecologists and geomorphologists at key design stages to ensure that watercourse realignments were limited to essential works and minimized adverse impacts. Details of realignment requirements are given in Appendix A9.3 (Fluvial Geomorphology). The following broad principles were adhered to in the design of watercourse realignments:

- realignments were only used where necessary to reduce crossing (culvert) lengths and associated long term habitat loss and fragmentation by allowing the watercourse to cross the mainline AWPR at 90 degrees;
- realignments were designed to ensure that the realigned lengths were similar to original lengths as far as possible;
- realignments in low gradient areas were designed to minimise sedimentation, e.g. by allowing the realigned section to be either straighter or shorter than the original;
- realignments in high gradient areas were designed to minimise erosion, e.g. by allowing the realigned section to either meander more or be longer than the original; and

- realignments were designed to maximise habitat creation potential through the inclusion of meander bends, secondary channels, riparian zones, backwaters and oxbow lakes where appropriate.

6.3 Construction Mitigation

Adherence to Best Practice Near Watercourses

6.3.1 Avoidance and reduction of construction impacts on watercourses throughout the proposed scheme will be achieved by:

- minimising the duration and spatial extent of works in the vicinity of watercourses;
- the presence of an aquatic ecological clerk of works on site during construction, to ensure the implementation of appropriate environmental safeguards;
- progressive rehabilitation of exposed areas throughout the construction period as soon as possible after the work has been completed;
- where appropriate, the installation of temporary treatment ponds to ensure minimum water quality standards throughout construction;
- inspection and maintenance of all erosion controls weekly and after heavy rainfall events;
- any abstractions from the river will be identified and quantified and formal consent from SEPA will be sought for any abstractions from watercourses;
- location of site compounds away from watercourses and floodplains; and
- regulation of the storage of any materials on the floodplain or near tributaries to reduce risk of pollutants/fine sediment entering watercourses.

6.3.2 One of the key mitigation strategies during construction is aimed at avoiding pollution release to watercourses and reducing this impact should it occur. The key mechanism for this will be through best practice at site and adherence to the following Pollution Prevention Guidelines (PPG) published by SEPA:

- PPG01 General Guide to the Prevention of Water Pollution;
- PPG04 Disposal of Sewage Where No Mains Drainage is Available;
- PPG05 Works in, Near or Liable to Affect Watercourses;
- PPG06 Working at Construction and Demolition;
- PPG07 Refuelling Facilities;
- PPG08 Storage and Disposal of Used Oils;
- PPG10 Highways Depots;
- PPG13 High Pressure Water and Steam Cleaners;
- PPG18 Control of Spillages and Fire Fighting runoff; and
- PPG21 Pollution Incident Response Planning.

6.3.3 In particular, to ameliorate key potential impacts, mitigation described in Table 14 will be undertaken. More details are available in Chapter 9 (Water Environment).

Table 14 – Impact Specific Construction Mitigation for Watercourses

Source of Impact	Mitigation
Suspended Solids	provide sediment fencing were appropriate; avoid positioning stockpiles near the channel bank; cover the stockpiles when not in use; contain the stockpiles with bunds or sediment fences; prior to construction, establish sediment removal features (attenuation basins/treatment ponds) to treat surface runoff; prohibit vehicle washing near watercourses; prohibit channel fording; wheel washing from mobile pressure washers will be conducted remote from watercourses; limit the use of temporary culverts; where possible, use temporary bridges rather than culverts to cross watercourses; connection of drains to watercourses only on completion; enforce exclusion zones between earthworks and watercourses; and minimization of vegetation clearance on banks and surrounding riparian zone.
Oils, Fuels and Chemicals	Provision of bunded areas with impervious walls and floor lining for the storage of fuel, oil and chemicals. Bunded areas will have a storage capacity of at least 110% that of the storage tanks; Use pollutant removal features (attenuation basins/treatment ponds) to treat surface runoff. These features will be established and functional before construction commenced: storage of fuel, oil and chemicals will not be on a watercourse floodplain or near a watercourse
Concrete, Cement and Admixtures	Storing potential pollutants or undertaking potentially polluting activities (e.g. concrete batching and mixing) away from watercourses, ditches and surface water drains; Preventative measures such as scaffolding screens will ensure that in situ concrete will be placed accurately and concrete pumps will not discharge into local watercourses
Sewage	If service diversions need to be carried out, the diversion will be undertaken prior to construction and will be undertaken using good engineering practices to ensure spillage risk is minimised. It is likely that statutory bodies may undertake the diversion works under their own access rights: Chemical toilets for the use on the construction site will be waterless and any waste will be dealt with following PPG 4.
Grouting	Cut-off ditches and settlement ponds will be constructed in the vicinity of the grouting activities to intercept the run-off. Sediment that has settled in such ponds will be transported off-site, if ponds become too full.

Diversion of Watercourses During Construction of Culverts

6.3.4 Diversion of watercourses represents considerable disturbance and habitat loss and fragmentation impacts which can be greatly reduced by following the simple procedures outlined below. Watercourses to be culverted will be diverted to a temporary channel during culvert construction. Temporary channels will be lined with geotextile in areas where the ground investigation has indicated that fine particles are present. Appropriately sized particles from the main channel will be used in the diversion channel to provide temporary habitat during works and to ensure the geotextile will not be washed away. Additionally the translocation of some of the main channel substrate will enable a proportion of the aquatic macro-invertebrate assemblage present in the substrate to survive the dewatering process. For many species this level of disturbance, while not likely to result in mortality, will trigger a drift response allowing aquatic macro-invertebrates to relocate to suitable habitats downstream of the crossing point.

6.3.5 Once the diversion channel is in place, water will be diverted at the upstream end of the channel. The main channel will then be bunded at the upstream and downstream ends and electric fished to remove any resident fish from the crossing point. The fish will be relocated downstream (refer to Appendix 10.15, Fish Report). Once all fish have been removed the downstream bund will be removed and water at the crossing point will be allowed to flow. An ecological clerk of works will be present during this process to ensure that all fish species have been removed from the dewatered channel. At the end of the works, when the water is returned to the main channel, the temporary channel will also be electric fished to remove any fish which may have moved into the diversion channel during the works.

Timing of Works

6.3.6 The impact of the proposed scheme can be greatly reduced or avoided altogether through appropriate timing of works. Advice from SNH states that no in-channel works should be conducted on watercourses likely to support migratory fish between October 14 and May 31 (Appendix A10.15). For day to day operation, avoiding work in the hours of darkness allows free fish, otter and bat movement along watercourses without disturbance. Works near a natal otter holt will not be permitted for three months from the birth of cubs (refer to A10.6 for details). For all watercourses, works must be avoided during periods of low flow (i.e. $<Q_{95}$) to reduce the risk of a pollution event causing a dissolved oxygen sag, since this can lead to fish kills.

Pre Earthworks Drainage

6.3.7 Although small watercourses that will be incorporated into pre earthworks drainage are not formally considered as part of this report, mitigation measures are necessary to avoid potential fish mortality during construction (especially brook lamprey) and these are described in A10.15.

6.4 Operation Mitigation

Maintenance of Road Drainage Network

6.4.1 To avoid failure or sub-optimal operation of the road drainage network maintenance of its components is necessary. The following Pollution Prevention Guidelines will be adhered to throughout the operation of the proposed scheme:

- PPG01 General Guide to the Prevention of Water pollution;
- PPG09 Pesticides;
- PPG18 Control of Spillages and Fire Fighting runoff;
- PPG21 Pollution Incident Response Planning; and
- PPG 22 Dealing with Spillages on Highways.

6.4.2 Treatment ponds will need to be periodically dredged and contaminated sediment removed from site. In addition, filter drains and catchpits need to be regularly inspected and repaired if necessary. Water quality monitoring downstream of key outflows will be undertaken to provide an early warning system for potential problems. Details are given in Chapter 9 Water Environment.

Sedimentation/Erosion Monitoring of Realigned and Culverted Watercourses

6.4.3 Although river diversions and culverts have been designed to minimize the risk of sedimentation and erosion, a monitoring program will be undertaken to provide an early warning system to flag any potential problems. This approach is aimed at reducing the risk of dramatic changes to the geomorphological character of watercourses which may lead to habitat loss or simplification. Details of the monitoring approach are given in Appendix A9.3.

Riparian Zone Management

6.4.4 The creation and maintenance of a complex riparian zone can reduce the disturbance impact of the proposed scheme and is also aimed at offsetting impacts of habitat loss and fragmentation particularly associated with culverting. Riparian complexity provides cover for otters and bats; shade and bankside complexity for fish and important allocthonous input for aquatic macro-invertebrate shredders. Riparian zone planting both as part of river realignments and as existing habitat enhancement has been described in A10.1 and A10.6.

6.4.5 As part of the scheme maintenance schedule a riparian zone management plan must be developed to ensure that channels do not become choked with vegetation that pest species such as Japanese knotweed do not establish and that riparian zone diversity is maintained. If herbicides are used as part of the road maintenance program, those recommended by SEPA for use near watercourses are to be applied in line with the manufacturer's instructions.

7 Residual Impacts

7.1.1 All watercourses in the Northern Leg have predicted residual impacts of Minor adverse to Negligible with the exception of Bogenjoss Burn, which has a predicted residual impact of Moderate adverse.

7.1.2 Gough and Craibstone Burns will be culverted where the mainline crosses them with some riparian habitat simplification being unavoidable. In addition these burns support *Brachyptera putata* whose distribution will be affected by the construction of culverts .The residual impacts for these burns are predicted to be Minor adverse.

7.1.3 The already modified and straightened Green Burn will be extensively culverted and realigned. Mitigation outlined above is aimed at reducing impact and minimizing risk of pollution through sediment release. In addition to this, the burn supports *Brachyptera putata* whose distribution will be affected by the construction of culverts. The residual significance of these impacts is assessed as being Minor.

7.1.4 Bogenjoss Burn will also be extensively realigned and culverted in six locations. The burn supports *Brachyptera putata* and as such disturbance will be caused to their localised distribution, therefore the residual impact remains at Moderate adverse.

7.1.5 The River Don has a raft of mitigation measures aimed at avoiding any adverse impact and as such the resulting residual impact is predicted to be Negligible.

7.1.6 Goval Burn, despite the three bridges in close proximity, is predicted to have a Minor residual impact resulting from the scheme, due to the habitat enhancement proposed along the riparian zone for otters. The associated Mill Lade Aqueduct is also assessed with a Minor residual impact despite a temporary minor adverse impact during construction.

7.1.7 Corsehill Burn is predicted to have a Minor adverse residual impact. This is because, even with successful implementation of mitigation, the burn will be realigned and culverted three times in close proximity leading to unavoidable habitat simplification.

7.1.8 Red Moss will also be culverted but in a location that is already straightened. As such the residual impact is considered Minor adverse. Finally, Blackdog Burn will be culverted twice and realigned and, similar to Corsehill Burn, this will inevitably lead to habitat simplification, constituting a residual impact of Minor adverse.

Table 15 – Residual Impact Assessment of Key Watercourses Potentially Affected By the Proposed Scheme Including Mitigation

Watercourse	Ecological Value	Impact Description	Impact Significance	Residual Impact Description	Residual Impact Significance
Kepplehill Burn KHB	Local	Construction: Culverting of existing straightened channel would involve some earthworks, possibly resulting in sediment release and short-medium term slight decrease in bankside and in-stream habitat complexity.	Minor adverse	Construction: Risk of sediment release will be minimised through best practice. Loss of bankside habitat would occur in culverted sections, although the existing straightened channel does not offer extensive habitat complexity.	Minor adverse
		Operation: Long-term slightly decreased habitat complexity for culverted section which may lead to habitat fragmentation for any migratory species, and localised changes to species distributions		Operation: Change to discharge regime will be minimised through careful design of culvert.	
Gough Burn GOB	Regional	Construction: Culverting of existing straightened channel would involve some earthworks, possibly resulting in sediment and/or other pollution release and short-medium term loss in-stream habitat complexity	Moderate adverse	Construction: Risk of sediment release will be minimised through Best Practice. The use of depressed invert box culverts would reduce the loss of habitat complexity, and therefore reduce the impact on the macroinverterate species, though the use of culverts would result in a localised change to the distribution of *B. putata*.	Minor adverse
		Operation: Long-term decreased habitat complexity for culverted section leading to localised changes in invertebrate distributions. A slight change to discharge regime due to road drainage is possible, as is decreased water quality resulting from road runoff carrying sediment load and heavy metals.		Operation: Change to discharge regime will be minimised through careful design of small realignment will be monitored to reduce risk of significant changes in habitat. Road drainage system will ensure that road runoff entering burn complies with Environmental Quality Standards.	
Craibstone Burn CSB	Regional	Construction: Culverting of partially modified channel would involve some earthworks, possibly resulting in sediment and/or other pollution release and short-medium term loss of bankside habitat and in-stream habitat complexity.	Moderate adverse	Construction: Risk of sediment release will be minimised through Best Practice. Small areas of Bankside habitat complexity will be lost in short culverted sections, though in-stream complexity can be maintained through using depressed invert box culverts. The use of culverts will cause a localised change to the distribution of *B. putata*.	Minor adverse
		Operation: Long term decreased bankside habitat complexity from culverted section, leading to localised changes in distribution of species. Decreased water quality could result from road runoff carrying sediment load and heavy metals.		Operation: Road drainage system will ensure that road runoff entering burn complies with Environmental Quality Standards.	

Watercourse	Ecological Value	Impact Description	Impact Significance	Residual Impact Description	Residual Impact Significance
Green Burn GRB	Regional	Construction: Extensive culverting and realignment would involve major earthworks, possibly resulting in sediment release and short-medium term loss of bankside and in-stream habitat complexity	Moderate adverse	Construction: Risk of sediment release will be minimised through best practice. Bankside habitat complexity will be reduced in extensive culverted sections, and local distribution of *B. putata* will change.	Minor adverse
		Operation: Long term decreased habitat complexity due to culverting leading to changes in localised invertebrate distributions. This could also lead to habitat fragmentation due to proximity of long culverts via a barrier effect. Substantial change to discharge regime due to lengthening and realignment of burn may lead to siltation and the requirement for dredging. Decreased water quality resulting from road runoff carrying sediment load and heavy metals may also occur.		Operation: Habitat loss through culverting will be offset by vegetation planting in realigned section. Change to discharge regime will be minimised through careful design of realignment and culverts and will be monitored to reduce risk of significant changes in habitat. Road drainage system will ensure that road runoff entering burn complies with Environmental Quality Standards.	
Bogenjoss Burn BJB (u/s and d/s)	Regional	Construction: Realignment and culverting in the upstream reach would involve extensive earthworks and could result in the release of sediment to the burn and would result in short-medium term habitat simplification of an existing straightened channel. Bridging of the downstream reach would be largely remote from the burn's edge and would allow for the retention of a wide riparian strip thus minimizing the risk of sediment release	Moderate adverse	Construction: Risk of sediment release will be minimised through Best Practice. Bankside habitat complexity will be lost in culverted and realigned and straightened sections. Culverting will result in changes to the local distribution of *B. putata*.	Moderate adverse
		Operation: Long term decreased habitat complexity due to burn realignment, shortening and straightening, combined with one long section of culverting and four short sections in close proximity leading to localised changes in invertebrate distribution. Habitat fragmentation due to proximity of five culverts. Substantial change to discharge regime due to lengthening and realignment of burn may lead to siltation and the requirement for dredging. Decreased water quality resulting from road runoff carrying sediment load and heavy metals may also occur.		Operation: Habitat loss through culverting will be offset by extensive riparian vegetation planting in realigned section. Change to discharge regime will be minimised through careful design of realignment and culvert and will be monitored to reduce risk of significant changes in habitat. Road drainage system will ensure that road runoff entering burn complies with Environmental Quality Standards.	
River Don DON	National	Construction: Bridging would involve earthworks, possibly resulting in sediment release leading to short term loss of in-stream habitat complexity and decreased water quality. Sediment modelling assessed this impact as potentially High Magnitude	Major adverse	Construction: Risk of sediment release will be minimised through best practice and sediment modelling assessed this residual impact as slight/nNgligible. No In channel working will be permitted	Negligible

Watercourse	Ecological Value	Impact Description	Impact Significance	Residual Impact Description	Residual Impact Significance
		Operation: No long term decreased habitat complexity or fragmentation is predicted since the river is to be bridged. Slightly decreased water quality resulting from road runoff carrying sediment load and heavy metals may occur.		Operation: Road drainage system will ensure that road runoff entering burn complies with Environmental Quality Standards.	
Goval Burn GOV	County	Construction: Bridging would involve some earthworks, possibly resulting in sediment and/or other pollution release leading to short-medium term habitat loss and decreased water quality.	Moderate adverse	Construction: Risk of sediment release will be minimised through best practice.	Minor adverse
		Operation: Decreased habitat complexity or fragmentation is predicted where the burn is being culverted leading to changes in invertebrate distribution. Slightly decreased water quality resulting from road runoff carrying sediment load and heavy metals may occur.		Operation: Slightly increased habitat complexity through extensive riparian habitat enhancement targeted at ameliorating impacts on otters following holt destruction and relocation. Road drainage system will ensure that road runoff entering burn complies with Environmental Quality Standards.	
Mill Lade Aqueduct MLA	Local	Construction: Aqueduct to be partially dismantled to allow construction of the road, resulting in loss of all ecological interest in this section.	Minor adverse	Construction: Best Practice will ensure efficient dismantling of aqueduct to ensure minimal essential loss of in channel ecological interest	Minor adverse
		Operation: Aqueduct to be reinstated following road construction and would gradually recover pre construction ecological interest		Operation: Aqueduct to be reinstated following road construction and will gradually recover pre construction ecological interest	
Corsehill Burn CHB	Local	Construction: Culverting and realignment would involve major earthworks, possibly resulting in sediment release and short-medium term loss of bankside and in-stream habitat complexity	Minor adverse	Construction: Risk of sediment release will be minimised through best practice. Bankside habitat complexity will be lost in three culverted sections	Minor adverse
		Operation: Long term decreased habitat complexity due to culverting potentially leading to habitat fragmentation due to proximity of three culverts resulting in a barrier effect. Possible slight change to discharge regime due to lengthening and realignment of burn. Decreased water quality resulting from road runoff carrying sediment load and heavy metals.		Operation: Habitat loss through culverting will be offset by introduction of meander bends and riparian vegetation planting in realigned section. Change to discharge regime will be minimised through careful design of realignment and culvert and will be monitored to reduce risk of significant changes in habitat. Road drainage system will ensure that road runoff entering burn complies with Environmental Quality Standards.	
Red Moss Burn RMB	County	Construction: Culverting and realignment would involve earthworks, possibly resulting in sediment release and short-medium term loss of bankside and in-stream habitat complexity	Minor adverse	Construction: Risk of sediment release will be minimised through best practice. Existing limited bankside habitat complexity will be lost in culverted sections.	Minor adverse
		Operation: Slight long term decreased habitat complexity due to		Operation: Road drainage system will ensure that road runoff	

Watercourse	Ecological Value	Impact Description	Impact Significance	Residual Impact Description	Residual Impact Significance
		culverting potentially leading to habitat fragmentation. Decreased water quality resulting from road runoff carrying sediment load and heavy metals.		entering burn complies with Environmental Quality Standards.	
Blackdog Burn BDB	County	Construction: Culverting of existing straightened channel would involve some earthworks, possibly resulting in sediment and/or other pollution release and short-medium term loss of bankside and in-stream habitat complexity.	Minor	Construction: Risk of sediment release will be minimised through best practice. Bankside habitat complexity will be lost in culverted sections	Minor adverse
		Operation: Long term decreased habitat complexity due to culverting. Potentially leading to habitat fragmentation due to proximity of culverts. Decreased water quality resulting from road runoff carrying sediment load and heavy metals.		Operation: Habitat loss through culverting will be offset by introduction of meander bends and riparian vegetation planting in realigned section. Change to discharge regime will be minimised through careful design of realignment and culvert and will be monitored to reduce risk of significant changes in habitat. Road drainage system will ensure that road runoff entering burn complies with Environmental Quality Standards.	

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9 Abbreviation List

ASPT – Average Score Per Taxon.

AWPR – Aberdeen Western Peripheral Route

BAP – Biodiversity Action Plan

BMWP – Biological Monitoring Working Party

CITES – Convention on the International Trade in Endangered Species

cSAC – Candidate Special Area for Conservation

DMRB – Design Manual for Roads and Bridges

EA – Environment Agency

EIA – Environmental Impact Assessment

ES – Environmental Statement

HAP – Habitat Action Plan

HMS – Habitat Modification Score

LBAP – Local Biodiversity Action Plan

NESBReC – North East Scotland Biological Records Centre

PPG – Pollution Prevention Guideline

RHS – River Habitat Survey

SAC – Special Area for Conservation

SAP – Species Action Plan

SEPA – Scottish Environmental Protection Agency

SoCC – Species of Conservation Concern

SNH – Scottish Natural Heritage

SPA – Special Protection Area

SSSI – Site of Special Scientific Interest

SUDS – Sustainable Urban Drainage System

WCA – Wildlife and Countryside Act (1981)

WFD – Water Framework Directive

10 Glossary of Terms

Allochthonous – of rocks/deposits; found in a place other than where they/their constituents were formed.

Ecosystem – the complex of a community of organisms and its environment functioning as an ecological unit.

Groyne – a stone/concrete structure extending into the river channel to deflect flow/scour the riverbed/provide an angling station.

Aquatic macro-invertebrate – an animal without a backbone that can be seen with the naked eye eg. snails, waterfleas, shrimps, insects etc.

Resectioned/reprofiled bank – bank modified, often to accommodate flood flow or maintenance machinery. Recent resectioning produces a smooth, uniformly angled bank slope.

Resectioned channel – obvious over-deepening of the channel bed resulting from lowering the river bed.

Riffle – a shallow section of a river/stream where the water is fast-flowing over a gravel/cobble substrate.

Riparian – of, or associated with the riverbank.

Water hardness – a measure of the amount of calcium and magnesium in water.