Appendix A40.9 – Freshwater Ecology

B1033200 July 2007

Jacobs U.K. Limited 95 Bothwell Street, Glasgow G2 7HX

Tel 0141 204 2511 Fax 0141 226 3109

Contents

Tables

1 Introduction

1.1 General Background

1.1.1 This report is one of the appendices supporting Chapter 40 (Ecology and Nature Conservation) of the AWPR Environmental Statement (ES). This report considers the potential impacts associated with the AWPR on watercourses that would be directly and indirectly affected by the Fastlink section of the proposed scheme in terms of the freshwater ecological communities they support. As such, this report is focused on impacts on overall aquatic ecosystem health, which is measured by macroinvertebrate communities, habitat complexity and freshwater fish.

1.1.2 The three component route sections for the Fastlink study area of the proposed scheme are:

- Section FL1: Stonehaven to Howieshill (ch0-ch3200);
- Section FL2: Howieshill to Cookney (ch3200-ch6300); and
- Section FL3: Cookney to Cleanhill Junction (ch6300-ch10200).

1.1.3 All tables and figures are structured in this manner.

1.1.4 The Ecological Impact Assessment (EcIA) was undertaken in accordance with the Design Manual for Roads and Bridges (DMRB) Volume 10 and 11 (Highways Agency, 2001) and the Environmental Impact Assessment (Scotland) Regulations 1999. Studies on freshwater ecology were included as part of the EcIA with cognisance of draft Institute of Ecology and Environmental Management (IEEM) guidelines.

1.1.5 These studies included desk-based consultation to collate existing information about freshwater ecology in the area affected by the scheme and field surveys to provide current data about the status of freshwater ecology.

1.1.6 Cumulative impacts are assessed in a separate report combining the potential impacts for all habitats and species over the proposed route (refer to Part E of the ES).

Aims

1.1.7 Macroinvertebrate surveys, river habitat assessment and fish habitat assessment of potentially impacted watercourses were conducted to:

- obtain baseline information on macroinvertebrate communities and freshwater 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 proposed scheme;
- assess the potential impacts that the proposed scheme may have on freshwater habitat and macroinvertebrate communities; and
- identify mitigation measures to ameliorate these impacts.

1.2 Macroinvertebrate Background

Biology

1.2.1 Macroinvertebrates are commonly used to provide a holistic assessment of the health of watercourses (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. As macroinvertebrates can 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 pressures on an aquatic ecosystem over time (such as the surrounding land use or the effects of pollution). Macroinvertebrate samples, combined with an assessment of the available habitat (through river habitat surveys) can provide an assessment of the overall ecological health of a watercourse.

Status

1.2.3 The Water Framework Directive[1] (WFD) 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[2] watercourses in Europe reach at least "good" ecological status by 2015. The WFD also requires that the ecological status of watercourses do not deteriorate from their current condition. Given that, under the WFD, the ecological status of watercourses is 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 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 SoCC river lamprey *Lampetra fluviatilis* and brook lamprey *Lampetra planeri* (addressed in section 1.3). 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).

1.3 Fish Background

Biology and Distribution

1.3.1 The fish species present in the River Dee catchment, their migratory status and estimates of their relative abundances are provided in Table 1. The fish species present within the River Dee catchment are consistent with those species expected for an upland spate river in North East Scotland.

[1] European Directive 2000/60/EC

[2] Not including heavily modified or artificial waterways, these must reach 'good' ecological potential

Table 1 – Fish Species, Migratory Status and Likely Relative Abundance in the River Dee Catchment

Common Name	Scientific Name	Migratory Status	Relative Abundance	
			Lower River	Tributaries
Atlantic salmon	*Salmo salar*	Anadromous	abundant	abundant
Brown/sea trout	*Salmo trutta*	Potamodromous/anadromous	common	abundant
European eel	*Anguilla anguilla*	Catadromous	present	present
Brook lamprey	*Lampetra planeri*	Potamodromous	present	common
River lamprey	*Lampetra fluviatilis*	Anadromous	present	present
Sea lamprey	*Petromyzon marinus*	Anadromous	rare	rare
Minnow	*Phoxinus phoxinus*	Local	common	common
3-spined stickleback	*Gasterosteus aculeatus*	Local	common	rare
Pike	*Esox lucius*	Potamodromous	rare	rare
Perch	*Perca fluviatilis*	Potamodromous	rare	rare
Flounder	*Platychthys flesus*	Amphidromous	common	present

Atlantic salmon (*Salmo salar*)

1.3.2 The River Dee supports a significant proportion of the Scottish salmon resource. In recent years, it has contributed 4-5% of all salmon caught in Scotland. Spawning takes place at gravel bedded sites throughout the main stem and in all accessible tributaries from the head of tide up to altitudes of 500m (Webb and McLay, 1996). Consequently, juvenile salmon (parr) are found throughout the system except the uppermost and inaccessible reaches of tributaries.

1.3.3 In most rivers, salmon begin to enter the system in early spring, often as early as February, but the precise timing varies between catchments. These “springers” are often the biggest fish (multi-sea winter) and are the part of the population that has shown the biggest decline in recent years. In the Dee, some salmon are known to enter the river in the November of the year before they spawn, i.e. thirteen months prior to spawning (Adrian Hudson, Dee District Salmon Fisheries Board, pers.comm.). These are followed by the 2-sea winter salmon (summer salmon), usually from April onwards with grilse (1-sea winter salmon) appearing in May and June. A study of salmon entry into the Dee estuary showed that up-estuary movements leading to river entry were predominantly nocturnal and tended to occur on the ebb tide. Penetration into the non-tidal reaches of the river also occurred at night but was no longer associated with tidal phase (Smith and Smith, 1997).

1.3.4 The upstream progress of salmon within the River Dee system is influenced to some extent by man made obstructions, although the apparent slight delay caused by a Crump weir was considered to be “insignificant in terms of the overall progress of riverine migration” (Smith et al., 1997). The cumulative impact of repeated short delays could potentially be of greater concern.

1.3.5 Atlantic salmon are autumn and winter spawners, but the precise timing of their spawning season varies between and within catchments. In the River Dee, salmon are known to return to the same part of the river where they were born and are considered to represent distinct sub-populations (Youngson et. al., 1994). Furthermore, the fish that spawn in the headwaters do so earlier in the year than those spawning in the lower reaches (Webb and McLay, 1996).

1.3.6 At certain stages of their development, salmonid eggs are very sensitive to mechanical shock. Immediately after fertilisation the eggs are not sensitive, but within a few hours any shock or vibration can result in epiboly or yolk overgrowth. The eggs then remain sensitive for approximately the first third of the incubation period, until they are eyed (Jensen, 1997).

1.3.7 Atlantic salmon alevins hatch and emerge from the gravel during the spring, with the time of emergence being linked to temperature and incubation period. During the first few weeks after hatching, the alevins are poor swimmers and rely on their yolk sac for nutrition. In the next stage, salmon parr generally "drift feed" on aquatic invertebrates that they collect from the water column and water surface.

1.3.8 Juvenile salmon migrate to the sea after one, two, three and exceptionally four years in the river, as smolts. In the River Dee, the incidence of younger smolts is thought to be increasing (Adrian Hudson, DDSFB, pers. comm.). Downstream migration usually begins in April with fish moving at night, either individually or in small groups. As the season progresses (usually during May), migration occurs both day and night and the fish move in large shoals at the surface.

1.3.9 In the River Dee, there is also a large scale emigration of parr from tributary streams during the autumn. It is not known if these fish continue onto the sea as "autumn smolts", or remain within the main stem of the Dee.

Brown/sea trout (*Salmo trutta*)

1.3.10 Brown trout breed in winter, from October to January, in gravelly shallows (Wheeler, 1969). The seagoing form is known as sea trout. This species migrates seawards as smolts slightly earlier than salmon, usually during March and April. Brown trout and sea trout are found throughout the Dee catchment, but brown trout are surprisingly uncommon in the lower River Dee, where salmon predominate (Adrian Hudson, DDSFB, pers. comm.). Juvenile trout feed on aquatic invertebrates and can become piscivorous as they get older.

European eel (*Anguilla anguilla*)

1.3.11 The life cycle of the European eel involves a massive catadromous migration from their spawning grounds in the Sargasso Sea, which takes up to three years to complete. Larval eel arrive in Scottish estuaries during February (Wheeler, 1969) at which stage they are transparent and are referred to as glass eel. As they enter the rivers they become pigmented and are known as elvers. Eel feed almost exclusively on benthic invertebrates, although some individuals become predatory and switch to a fish based diet. They are commonly nocturnally active and are cryptic during the day. Eel spend a considerable period feeding and growing in freshwater (from seven to nineteen years), before turning silver and heading seawards in the autumn. Eel are present throughout the Dee catchment, including the upper river and small tributary streams. Research has shown that eel are relatively insensitive to sound (Turnpenny et al.,,1993), but that they do react to lights (Hadderingh and Smythe, 1997).

Brook lamprey (*Lampetra planeri*)

1.3.12 Brook lamprey spend their entire lives in freshwater, although they do migrate upstream to spawn and there is thought to be a tendency for the larvae (called ammocoetes) to move downstream during development (Wheeler, 1969). Spawning occurs during early April at partially shaded sites, in excavated depressions in sand and gravel. Where river lamprey and brook lamprey occur together, the brook lamprey occupy the headwaters and breed well upstream of the river lampreys (Wheeler, 1969). As both species are found in the River Dee, it is likely that brook lamprey are most prevalent in the upper river and in the tributaries. Brook lamprey metamorphose after six years buried in the sediment feeding on organic matter. Adult brook lamprey do not feed and die after spawning.

River lamprey (*Lampetra fluviatilis*)

1.3.13 River lamprey breed in freshwater in April and May and inhabit freshwaters throughout their larval stage. Spawning sites commonly have sand and gravel substrata, flowing water and are usually at least partly in the shade (Wheeler, 1969). The male creates a nest by removing pebbles with his sucker disc and excavating sand by shaking his tail. River lamprey are present in the River Dee and may penetrate into some of the larger tributaries. River lamprey larvae live buried in silty habitats where they feed on organic matter for five years. In early autumn, river lamprey ammocoetes metamorphose into the adult form and migrate downstream to the sea. As adults, river lamprey are parasitic, feeding on the blood and tissue of other fish, returning to rivers to spawn when 300-500mm in length.

Sea lamprey (*Petromyzon marinus*)

1.3.14 Sea lamprey breed in freshwater in May and June and inhabit freshwaters throughout their larval stage. Spawning requires a gravel substratum and clean fast flowing water, but adjacent silty areas are also required for the larvae. Sea lamprey are present in the River Dee but are probably most abundant in the main stem. Sea lamprey larvae are blind and toothless and live buried in silty and sandy substrata for around five years, feeding on organic matter (Wheeler, 1969). In late summer sea lamprey ammocoetes metamorphose into the adult form, during which phase they are referred to as transformers. After metamorphosis the adult sea lamprey, which now have eyes and teeth, migrate downstream to the sea and become parasitic, feeding on the blood and tissue of other fish. Maturity is reached after one or two years at sea, at which point the adults, approximately 600-800mm in length, return to rivers to spawn.

Minnow (*Phoxinus phoxinus*)

1.3.15 Minnows are found in most rivers and streams and in some still waters. They are a shoaling species, rarely larger than 100mm and living for a maximum of six years (Wheeler, 1969). They are likely to be found throughout much of the River Dee catchment, including some of the tributary streams and may be locally abundant where the habitat is suitable.

3-spined stickleback (*Gasterosteus aculeatus*)

1.3.16 One of the most widespread of the fishes of northern Europe, the three-spined stickleback is found in virtually all waters except fast flowing hill streams (Wheeler, 1969). In the River Dee, sticklebacks are present in the slower flowing reaches of the main stem and may also be found in the lower sections of slow flowing tributary streams. Three-spined sticklebacks rarely exceed 60mm in length and spawning occurs in April and May. Male sticklebacks build nests, fan the eggs with their pectoral fins and then guard a small brood of offspring.

Pike (*Esox lucius*)

1.3.17 Pike are solitary, ambush predators that prefer still or relatively slow flowing habitats with cover. Spawning occurs in the spring on vegetation in shallow water and often in inundated riparian vegetation in field margins and field drainage ditches. They are found in the lower reaches of the River Dee, but are only present in low numbers and are likely to be absent from the upper river and tributaries.

Perch (*Perca fluviatilis*)

1.3.18 Perch are found in stillwaters and slow flowing reaches of rivers and, like the pike, are restricted to the lower reaches of the River Dee where they are present in low numbers. Spawning occurs in April or May on submerged vegetation or branches. Perch live in small shoals and feed mainly on aquatic invertebrates, but they become increasingly piscivorous as they grow.

Flounder (*Pleuronectes flesus*)

1.3.19 Some flounder spend part of their lives in freshwater, but their movements between fresh and saltwater are not directly linked with reproduction. Although most abundant in the lower reaches of rivers and estuaries, some flounder are known to penetrate a long distance into freshwater and may enter the lower reaches of some tributary streams. In the River Dee, flounder are likely to be found in the lower sections of the main stem, where they may be seasonally common. They may also be present in the downstream sections of tributary streams that feed the lower rivers. The timing of entry into freshwater varies with region, but in Eastern Scotland flounder are known to spend the summer at sea (Dando, 1984).

Sensitive Periods for Fish

1.3.20 According to their biology and behaviour each species has one or more sensitive periods during the calendar year, during which time certain activities, in specific parts of their habitat, could have an impact on them. These sensitive periods have been agreed with a representative of the DDSFB and are summarised in Table 2.

Table 2 – Extent of Potentially Sensitive Periods for Fish

Species / Stage	January		February		March		April		May		June		July		August		September		October		November		December	
MSW (spring) salmon																								
2-SW (summer) salmon																								
1-SW salmon (grilse)																								
Salmon spawning																								
Salmon eggs																								
Salmon smolt emigration																								
Autumn ”smolt” emigration																								
Sea trout																								
Sea trout spawning																								
Sea trout eggs																								
Sea trout smolt emigration																								
Brown trout spawning																								
Brown trout eggs																								
Elver immigration																								
Silver eel emigration																								
Brook lamprey spawning																								
Sea lamprey immigration																								
Sea lamprey spawning																								

Aberdeen Western Peripheral Route

Environmental Statement Appendices

Part D: Fastlink

Appendix A40.9 - Freshwater

Species / Stage	January		February		March		April		May		June		July		August		September		October		November		December	
Sea lamprey ammocoete emigration																								
River lamprey immigration																								
River lamprey spawning																								
River lamprey ammocoetes emigration																								
Minnow spawning																								
Stickleback spawning																								
Pike spawning																								
Perch spawning																								
Flounder migration																								

Status

1.3.21 Atlantic salmon have declined throughout much of their range and some populations have reached critically low levels. A wide range of factors have been implicated in this decline including reduced survival at sea due to overfishing and reduced production in freshwaters through deterioration of habitats and barriers to migration.

1.3.22 Sea and river lamprey have also declined in abundance in many catchments, with barriers to migration and reduced habitat quality again being implicated.

1.3.23 There is also concern over eel populations, which have declined substantially across much of western Europe in recent years and stocks are now considered to be outside safe biological limits.

1.3.24 Brown trout, minnow, 3-spined stickleback, pike, perch and flounder are widespread and are not currently considered to be in decline throughout much of their normal range.

1.3.25 Some fish species are afforded specific legal protection. Salmon are protected under the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003. The relevant parts of this Act are that it is an offence:

- "to knowingly take, injure or destroy; any smolt, parr, salmon fry or alevin."
- "to injure or disturb any salmon spawn during the annual close time."
- "to obstruct or impede salmon in their passage to any spawning bed or any bank or shallow in which the spawn of salmon may be."

1.3.26 A local Species Action Plan (SAP) has been prepared for Atlantic salmon by the Northeast Scotland Biodiversity Partnership. Although the SAC measures contribute to the conservation of the Atlantic salmon, additional measures are needed to ensure future conservation within the UK.

1.3.27 As a consequence of declining populations, all three lamprey species are now listed in Annexes IIa and Va of the Habitats Directive, Appendix III of the Bern Convention and as Species of Conservation Concern in the UK Biodiversity Action Plan (BAP) (Maitland, 2003). All three species of lamprey are also listed on the North East Scotland Local Biodiversity Action Plan (NESLBAP).

1.3.28 Brown trout, eel, minnow, 3-spined stickleback, pike, perch and flounder are not nationally scarce and are afforded no specific legal protection.

Table 3 – Inclusion of Species in Conservation Legislation

Common Name	River Dee SAC	Salmon and Freshwater Fisheries Act	Habitats Directive	UK BAP	NESLBAP
Atlantic salmon	✔	✔	✕	✕	✔
Brown/sea trout	✕	✔ (sea)	✕	✕	✕
European eel	✕	✕	✕	✕	✕
Brook lamprey	✕	✕	✔	✔	✔
River lamprey	✕	✕	✔	✔	✔
Sea lamprey	✕	✕	✔	✔	✔
Minnow	✕	✕	✕	✕	✕
3-spined stickleback	✕	✕	✕	✕	✕
Pike	✕	✕	✕	✕	✕
Perch	✕	✕	✕	✕	✕
Flounder	✕	✕	✕	✕	✕

2 Approach and Methods

2.1 Introduction

2.1.1 This section describes the approach to the assessment of the watercourses in the study area of the Fastlink section of AWPR.

2.1.2 It should be noted that there are several watercourses geographically located within the Fastlink study area that form part of the catchment area of the River Dee. Watercourses associated with the River Dee catchment and reported in the Chapter 25 (Ecology and Nature Conservation) are: Craigentath Ditch, Craigentath Burn, Wedderhill Burn and the Greens of Crynoch.

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), Aberdeen City Council and the Dee District Salmon Fishery Board (DDSFB) to obtain any existing baseline data on the ecological status of watercourses that may potentially be affected by the scheme. Table 4 lists the watercourses that have existing baseline data and have been classified by SEPA.

2.3 Desk Studies

2.3.1 To assist the interpretation of biological data and to enable the 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 provided in Chapter 39 (Water Environment) and its appendices. 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 macroinvertebrates in summer and autumn of 2006 following standard methods (Wright et al., 1984). At the time of sampling, simple physicochemical parameters were also measured. In conjunction with the macroinvertebrate sampling, sites were also visited for river habitat surveys and fish habitat assessments. Table 4 summarises which sampling methods were used and the existing data was available for each watercourse. All sampling points are shown on Figures 40.13 a-f.

Macroinvertebrates

2.4.2 Macroinvertebrate sampling was undertaken by kick/sweep sampling for at least 10 metres (taking 3 minutes) with a 250µm mesh Freshwater Biological Association (FBA) net followed by visual observation to find any further specimens. The net was carefully lifted to the bank and samples were emptied into sample jars and preserved in industrial Methylated Spirit for transport back to the laboratory. Samples were then sorted following procedures recommended by the SEPA Riccarton laboratory (pers. comm., Aug 2005). Samples were washed through a 250µm and 500µm mesh sieve, retaining all material. The contents of the sieves were then washed into a white tray for picking, examining the sieve to ensure that no organisms had been missed. These survey methods (”live pick”) differ slightly from those for the Northern Leg section of the AWPR as a result of feedback from statutory consultees. It is anticipated that this slight change in methods will not cause significant changes to the results obtained.

2.4.3 Macroinvertebrates collected were identified to species level where possible using a low powered microscope and appropriate taxonomic keys (e.g. Croft 1986, Hynes 1993). All material collected was preserved and will be retained for a period of at least one year.

2.4.4 At the time of macroinvertebrate 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 assessment (Chapter 39: Water Environment), total hardness was measured during previous surveys carried out in summer 2004.

River Habitat Survey

2.4.5 River habitat surveys (RHS) were carried out in June 2006 according to standard methodology (EA, 2003). This consists of recording modifications to channel and banks, vegetation structure, substrate and flow type and adjacent land-use. River habitat surveys comprised a survey of a 500m section of each watercourse and its riparian zone, usually along the reach of the watercourse where the proposed scheme would cross. Data were recorded on standardised survey forms (EA, 2003). Results from the river habitat surveys were submitted to the central database administered by the Environment Agency for quality control and calculation of Habitat Indices (see the evaluation section below for more details).

Fish Habitat Assessment

2.4.6 Fish habitat assessment surveys were carried out on all watercourses within the study area along with HABSCORE assessments of those watercourses that were considered likely to support salmonids (namely salmon and sea trout).

2.4.7 Electric fishing surveys were carried in August and September 2006 by the DDSFB on selected watercourses (Table 4) where the habitat assessment results are uncertain regarding the suitability for fish or where suitable habitat is present upstream and/or downstream of the crossing point (following discussions with SNH). The purpose of the electric fishing surveys was to clarify the status of fish species in that watercourse.

2.5 Sampling Effort

2.5.1 All watercourses falling within the study area were visited to assess their suitability for sampling. Those watercourses that were less than 30cm in channel width were scoped out due to their small size and any dry watercourses were noted. Typically, watercourses that were scoped out of this assessment were highly modified or artificial land drainage channels.

2.5.2 Some small tributaries of major watercourses were indirectly assessed using data from the main channel near to their confluences.

2.5.3 Some watercourses were large enough to be sampled for macroinvertebrates and basic water quality. However, as they were essentially highly modified land drainage channels, river habitat surveys were not undertaken.

Table 4 – Sampling Effort for Watercourses

Route Section	Watercourse	Code	Macro-invertebrate and *in situ* WQ Sampling	Grid Reference of Sample Point	River Habitat Survey	Habitat Assessment	Electric Fishing	Existing SEPA Data	Existing Discharge Data	Additional Water Quality Sampling	Included in Assessment
Section FL1	Megray Burn	MEG 01	Yes	NO 87426 87723	Yes	No	Yes	None	Yes	Yes	Yes
		MEG 02	Yes	NO 87447 87564		No		None		Yes	Yes
	Limpet Burn	LIM U	No – no suitable sampling point	NO 87302 88792	Yes, upstream and downstream of proposed crossing point	No	No	None	Yes	Yes	Yes, based on RHS and water quality
	Coneyhatch	CON	No, Dry (June 2006)	n/a	No	No	No	None	No	No	No, dry channel
	Green Burn	GRN B	Yes	NO 86846 90429	Yes	No	No	None	Yes	Yes	Yes
Section FL2	Allochie Burn	ALL	Yes	NO 86941 91210	No	No	No	None	Yes	Yes	Yes
	Back Burn	BACK	Yes	NO 87111 91702	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Burn of Muchalls	MUC	Yes	NO 87287 91889	Yes, upstream and downstream of proposed crossing point	Yes	Yes	Yes	Yes	Yes	Yes
Section FL3	Burn of Blackbutts	BLKBTS	No	n/a	Yes	No	No	None	No	No	Yes, based on RHS only.
	Cookney Ditch	COOK	No	n/a	Yes	No	No	None	No	No	Yes, based on RHS only.
	Stoneyhill Burn	STNHL	No, dry channel (June 2006).	n/a	No – land access issues	No	No	None	No	No	No, dry channel.
	Balnagubs Burn	BALNA	No, small	NO 87344 94691	Yes	No	No	None	No	No	No, small field

Route Section	Watercourse	Code	Macro-invertebrate and *in situ* WQ Sampling	Grid Reference of Sample Point	River Habitat Survey	Habitat Assessment	Electric Fishing	Existing SEPA Data	Existing Discharge Data	Additional Water Quality Sampling	Included in Assessment
			field drain.								drain.
	South Rothnick	SRTH	No, small field drain.	n/a	No	No	No	None	No	No	No, small field drain.
	Burn of Elsick	ELS	Yes	NO 87471 95091	Yes	No	No	Yes	Yes	Yes	Yes
	North Rothnick	NRTH	No, heavily polluted channel.	n/a	No	No	No	None	No	No	No, heavily polluted channel.
	East Rothnick	ERTH	No, heavily polluted channel.	n/a	No	No	No	None	No	No	No, heavily polluted channel.
	Whiteside Burn	WSDE	Yes	NO 87635 95927	Yes	No	No	None	No	Yes	Yes
	Crossley Burn / Cairns Burn	CRO U	Yes (June only)	NO 87524 96156	Yes	Yes	No	None	Yes	Yes	Yes
	Crossley Burn	CRO D	Yes	NO 87661 96163		Yes	No	None	Yes	Yes	Yes
	Stranog Burn	STNG	No, small field drain.	n/a	No, small field drain.	No	No	None	No	No	No, small field drain.
	Cairnfield Ditch	CNDH	No	n/a	No, watercourse not visible.	No	No	None	No	No	No, dry channel.

2.6 Evaluation of Health and Nature Conservation Value of Watercourses

2.6.1 A simple scheme for the ecological assessment of watercourses using the aquatic macroinvertebrate assemblage was used. The scheme is based on applying scores to different macroinvertebrate 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[3]) and dividing this score by the number of species sampled gives the Average Score Per Taxon (ASPT) value (Table 5). Additionally, a simple measure of species richness was used together with BMWP and ASPT scores to yield an assessment of ecological status.

Table 5 – 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

2.6.2 River habitat survey data were used to calculate a Habitat Modification Score (HMS). The HMS is calculated using information on channel modification from each of the ten spot checks along the 500m section in combination with records of any artificial features such as weirs. Full details of the methods of calculating this score are given in Appendix 3 of EA 1998. HMSs can be interpreted following the system shown in Table 6.

Table 6 – 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

2.6.3 Assessment of the nature conservation value of each watercourse was largely based on the macroinvertebrate community present (using indices described above), water quality and degree of habitat modification, Additional reference was made to the fish community present at each site and whether it provided food resources for otters (refer to Appendix A40.5).

2.6.4 The criteria used were based on the Ratcliffe Criteria (Ratcliffe, 1977) used in the selection of biological Sites of Special Scientific Interest (SSSI). Sites and features were classified according to the criteria identified in Table 7, which is considered appropriate when applied to designated sites such as the River Dee SAC. This is an approach supported by the Guidelines for Ecological Impact Assessment (IEEM, July 2005).

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

Table 7 – Evaluation of Ecological Receptors

Ecological Importance	Attributes of Ecological Receptor
International (European)	Habitats An internationally designated site or candidate site i.e. Special Protection Area (SPA), provisional SPA (pSPA), Special Areas of Conservation (SAC), candidate SAC (cSAC), Ramsar site, Biogenetic/Biosphere Reserve, World Heritage Site or an area which meets the published selection criteria for such designation. A viable area of a habitat type listed in Annex I of the Habitats Directive, or smaller areas of such habitat that 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. Species Any regularly occurring population of an internationally important species, which is threatened or rare in the UK, i.e. a UK Red Data Book species or listed as occurring in 15 or fewer 10km squares in the UK (categories 1 and 2 in the UK BAP) or of uncertain conservation status or of global conservation concern in the UK BAP. A regularly occurring, nationally significant population/number of any internationally important species.
National (Scottish)	Habitats A nationally designated site (SSSI, ASSI, NNR, Marine Nature Reserve) or a discrete area, which meets the published selection criteria for national designation (e.g. SSSI selection guidelines) irrespective of whether or not it has yet been notified A viable area of a priority habitat identified in the UK BAP, or of 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 Predominantly Unmodified. Species 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.
Regional (North East Scotland)	Habitats Sites which exceed the county-level designations but fall short of SSSI selection guidelines, where these occur Viable areas of key habitat identified in the Regional BAP or smaller areas of such habitat which are essential to maintain the viability of a larger whole Viable areas of key habitat identified as being 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 Obviously Modified or above. Species Any regularly occurring, locally significant population of a species listed as being nationally scarce which occurs in 16-100 10km 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 that are recognised by local authorities e.g. Sites of Interest for Nature Conservation (SINS) and District Wildlife Sites (DWS). 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 0.25ha. 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 that is listed in a County/District BAP on account of its regional rarity or localisation. A regularly occurring, locally

Ecological Importance	**Attributes of Ecological Receptor**
	significant population of a county/district important species (particularly during a critical phase of its life cycle). Sites supporting populations of internationally/nationally/regionally important species that are not threatened or rare in the region or county, and are not integral to maintaining those populations. Sites/features that are scarce within the county/district or which appreciably enrich the county/ district habitat resource.
Local (Immediate local area of village importance)	Habitats Areas of habitat considered to appreciably enrich the 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 of such habitats within the local area are not considered for the above classifications. Semi-natural ancient woodland smaller than 0.25ha. 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 that are 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.

2.7 Impact Assessment

2.7.1 In the assessment of significance of impact, consideration has been given both to the magnitude of impact and to the sensitivity of the receiving environment or species. The sensitivity of a feature was determined with reference to its level of importance although other elements have been taken into account where appropriate. Methods of impact prediction used indirect 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.

Impact Magnitude

2.7.2 The magnitude of an impact has been assessed for each element of the development. A definition of the magnitude impacts is presented in Table 8 and includes positive impact criteria in accordance with IEEM guidance (2002). The magnitude of each impact was assessed independently of value or statutory status.

Table 8 – Impact Magnitude

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 integrity of an ecological receptor, but the effect 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 species assemblage or populations but not affect the 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. Impacts are unlikely to result in changes to the species assemblage or populations, but core species more vulnerable to future impacts
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

2.7.3 The significance of an impact was determined according to the matrix of importance and magnitude as illustrated in Table 9.

Table 9 – 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
County	Moderate	Moderate	Minor	Negligible	Minor	Moderate
Local	Minor	Minor	Minor	Negligible	Minor	Minor
Less than Local	Minor	Negligible	Negligible	Negligible	Negligible	Negligible

2.7.4 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. In general, impact significance greater than or equal to Moderate would require specific mitigation to be undertaken to ameliorate the impact significance to acceptable levels.

2.8 Limitations to Assessment

2.8.1 The use of water quality spot measurement data 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.

2.8.2 Due to time constraints, one macroinvertebrate sample was taken in summer 2006. Repeat autumn sampling was carried out in September 2006.

2.8.3 At the time of writing this report, full Environment Agency data and calculations of habitat indices were not available for the updated Habitat Modification Scores (HMS) and Habitat Quality Assessment (HQA). As such, three burns are awaiting scoring. Assessments of these burns have been inferred from knowledge gained from other watercourses within the area.

3 Baseline

3.1 Consultation Information

3.1.1 SEPA monitors a number of the watercourses in Table 11 for water quality and biological measures and has recent river classifications for five relevant watercourses along 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 (refer to Table 10). Chapter 39 (Water Environment) contains further details.

Table 10 – Summary of SEPA Biological Data

Route Section	Watercourse	Year	Classification
FL3	Burn of Elsick	2005	A2
	Back Burn	2005	A2
	Burn of Muchalls	2005	A2

3.1.2 The LBAP species *Brachyptera putata* was recorded by SEPA as part of their routine monitoring of the River Dee between 1981 and 2004 and in the River Don between 1980 and 2003.

3.1.3 In addition to baseline information obtained from SEPA, physical parameters were also calculated for each watercourse and are shown in Table 11.

Table 11 – Physical Parameters of Watercourses

Route Section	Watercourse	Area Upstream (km^2)	Qmean Flow (m^3/sec)	Q95 Flow (m^3/sec)	Standard Deviation of Mean Monthly Velocities
FL1	Megray Burn	0.57	0.007	0.002	0.069
	Limpet Burn	1.37	0.018	0.004	0.012
	Green Burn	0.75	0.01	0.002	0.045
FL2	Allochie Burn	0.01	0	0	0.002
	Back Burn	2.76	0.036	0.008	0.011
	Burn of Muchalls	6.74	0.103	0.024	0.089
FL3	Burn of Elsick	0.98	0.013	0.003	0.092
	Whiteside Burn	0.40	0.005	0.001	0.051
	Crossley Burn	0.20	0.003	0.001	0.199

3.1.4 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 where the watercourse would be crossed by the scheme. All watercourses in the study area are relatively small with the most significant being the Burn of Muchalls at 6.74km^2.

3.1.5 The second and third parameters give an indication of the volume of water flowing down the channel during mean and low flow periods. Most of the watercourses within the study area have very low mean flows and therefore indicate that they may dry out during certain periods of the year, particularly Megray Burn, Whiteside Burn and Crossley Burn.

3.1.6 The fourth parameter is a simple measure of the variation in mean monthly velocities for each watercourse. Most of the watercourses appear to have stable monthly flows with the exception of Crossley Burn, which appears to be “flashy” in nature.

3.2 Survey Results

Macroinvertebrate Survey

3.2.1 Macroinvertebrate surveys were undertaken in June and September of 2006, sampling points are shown in Figures 40.13a-f and results are illustrated in Tables 12 and 13. Ecological health has been assessed based on both seasons of sampling and the highest status has been reported. Macroinvertebrate assemblages of burns indicated that most were in good ecological health, with a few exceptions. Back Burn was found to be of excellent ecological health with Crossley Burn and Green Burn assessed as fair.

3.2.2 Megray Burn, at the most southerly point of the study area, is variable in habitat flowing through woodland at the upstream end and as a field boundary downstream. Both of these sites were sampled for macroinvertebrates and the ASPT scores indicated good ecological health. The fauna comprised a range of pollution tolerant and intolerant families including caddis flies, mayflies, bloodworms, true fly larvae and adult and larval beetles.

3.2.3 Green Burn was sampled very close to its source, where the channel was narrow though supported a moderate flow. The ASPT scores resulted in a classification of fair ecological health. The fauna comprised mayflies, beetles, bugs and caddis flies all largely pollution tolerant species.

3.2.4 Allochie Burn was found to be in good ecological health based on the ASPT scores that were calculated. The faunal assemblage comprised of caddies flies, stoneflies, mayflies, snails, beetles and true bugs. These taxa showed variations in flow preferences and also in pollution tolerance.

3.2.5 Back Burn runs through agricultural land before flowing into the Burn of Muchalls. Back Burn was found to be of excellent biological status, whilst the Burn of Muchalls was found to be of good status. Back Burn showed an improvement to the status identified by SEPA in 2005, where it was then said to be in good biological status. Both sites were dominated by pollution intolerant flow reliant species including the stonefly *Isoperla grammatica* and mayfly *Ephemerella ignita*.

3.2.6 Surveys of the Burn of Elsick indicated that it possesses good ecological health, which is consistent with the 2005 SEPA assessment. The macroinvertebrate assemblage consisted dominantly of the tolerant freshwater shrimp (*Gammarus pulex*), though other pollution intolerant species were also identified.

3.2.7 Whiteside Burn, Crossley Burn and Cairns Burn are in close proximity to each other. Whiteside was found to be in good ecological health, with both sites on Crossley Burn assessed as being of fair biological health. Cairns Burn was not directly sampled. However, this watercourse flows into Crossley Burn and therefore the health of Cairns Burn was inferred. Crossley Burn is a modified straightened channel though supported a diverse macroinvertebrate assemblage with caddisflies, beetles and stoneflies being identified.

Table 12 – Macroinvertebrate Taxa identified from June 2006 (abbreviations for watercourses as for Table 4)

Invertebrate Family	MEG 01	MEG 02	GRN B	ALL	BAC	MUC	ELS	SIDE	CRO U	CRO D
Nematoda						1				
Oligochaeta			1			1				
Gammaridae *Gammarus pulex*							63	8	12	332
Hirudinae										
Glossiphoniidae										
Glossiphonia heteroclita									1	
Trichoptera										
unindentifiable										
Limnephilidae										
Limnephilus lunatus				2						
Chaetopteryx villosa	1			1			2	2		15
Halesus sp.						1				
Limnephilus auricula										11
Drusus annulatus								1		
Limnephilus sp.									2	
Rhyacophilidae										
Rhyacophila dorsalis										
Rhyacophila obliterata					2					
Lepidostomatidae										
Crunoecia irrorata	1									
Hydropsychidae										
pupa								1		
Polycentropodidae	1									
Plectrocnemia conspersa			1	3			1	1		
Plecoptera (Stoneflies)										
Leuctridae										
Leuctra inermis						1				
Leuctra fusca						3				
Leuctra geniculata										
Leuctra sp.										
Nemouridae										
Nemoura sp.								1		
Nemurella picteti				27						2
Perlodidae										
Isoperla grammatica					1	1				
Chloroperlidae										
Chloroperla torrentium		1				1				
Mollusca										
Lymnaeidae										
Lymnaea peregra				12				5		
Sphaeridae							3			
Ephemeroptera (Mayflies)										
Caenidae										
Caenis sp.										
Caenis rivulorum										

Invertebrate Family	MEG 01	MEG 02	GRN B	ALL	BAC	MUC	ELS	SIDE	CRO U	CRO D
Ephemerellidae										
Ephemerella ignita					95					
Baetidae										
Baetis spp.	8	19	1	29	51	35				1
Siphlonuridae										
Siphlonurus sp.					2			1		
Heptageniidae										
Heptagenia sp.										
Ecdyonurus sp.					6					
Diptera (True flies)										
Unientified larvae	2	1		3	1	5	3	1		
Unientified pupa				1	1	6	1		1	11
Chironominae (Chironomidae)			1			10		1	5	
Orthocladiinae (Chironomidae)	3	1	3		5	53		2		5
Tanypodinae (Chironomidae)	4			2	3	12		1	2	
Chironomidae pupa	1							1		
Tipulidae						1				
Simulidae Larvae						2				
Simulidae Pupa		1								
Coleoptera (Beetles)										
Unidentified larvae						3				
Curculionidae (A)										
Pelenomus sp.									3	
Dytiscidae								1		
Unidentified larvae										2
Rhantus sp. (L)						2			7	
Agabus sp. (L)										5
Agabus brunneus (A)									2	
Agabus bipustulatus (A)			1							
Agabus guttatus (A)	1									
Agabus melanocarnis								1		
Ilybius sp. (L)			1							2
Colymbetes sp. (L)									1	
Coelambus nigrolineatus (A)					1					
Hydroporus sp. (A)										
Oreodytes sanmarkii (A)										
Hydraenidae										
Hydraena gracilis (A)										
Hydrophilidae										
Anacaena globulus (A)								2		
Hydrobius fuscipes (A)									1	
Helophorus brevipalpis (A)				2					1	2
Haliplidae										
Haliplus lineatocollis (A)										1
Elmidae										
Limnius volckmari (L)						1				
Limnius volckmari (A)									1	

Invertebrate Family	MEG 01	MEG 02	GRN B	ALL	BAC	MUC	ELS	SIDE	CRO U	CRO D
Limnebius sp.		3								
Elmis aenea (A)										3
Elmis aenea (L)					2					5
Elodes sp. (L)	2									
Hempitera (True Bugs)										
Unidentified										1
Gerridae			1							
Velidae										
Immature velia			1	2				3		7
Microvelia sp.										
BMWP Score	**40**	**26**	**24**	**35**	**63**	**64**	**23**	**57**	**38**	**34**
Number scoring families	**7**	**5**	**6**	**7**	**9**	**11**	**4**	**10**	**8**	**7**
ASPT Score	**5.7**	**5.2**	**4.0**	**5.0**	**7.0**	**5.8**	**5.8**	**5.7**	**4.8**	**4.9**
Number of species	**8**	**6**	**7**	**10**	**11**	**14**	**6**	**12**	**9**	**12**

Table 13 – Macroinvertebrate Taxa identified from September 06 (abbreviations for watercourses as for Table 4)

Invertebrate Family	MEG 01	MEG 02	GRN B	ALL	BAC	MUC	ELS	SIDE	CRO D
Nematoda									
Oligochaeta	13	1				1	5	1	2
Gammaridae *Gammarus pulex*		1					80		6
Asellidae *Asellus aquaticus*						4			
Acari		8							
Arrenuridae *Arrenurus*	2								
Pyralidae							3		
Ptychopteridae									
Hymenoptera									
Isotima sp	1								
Podura sp	1								
Neuroptera									
Sisyra sp	2								
Sialidae									
Sialis lutaria									
Odonata									
Platycnemidae									
Platycnemis pennipes			2						
Hirudinea									
Erpobdellidae									
Erpobdella octoculata									
Erpobdella sp.									
Glossiphoniidae									
Helobdella stagnalis									
Glossiphonia heteroclita									
Glossiphonia complanata	2								
Trichoptera									
Instar 1 larvae						1			
unidentifiable									

Invertebrate Family	**MEG 01**	**MEG 02**	**GRN B**	**ALL**	**BAC**	**MUC**	**ELS**	**SIDE**	**CRO D**
early instar caseless caddis	57				3				
early instar caased caddis					3				
Limnephilidae				1					
Instar II				1				2	1
Apatania sp.									
Limnephilus lunatus									
Chaetopteryx villosa									
Halesus sp.									
Limnephilus auricula									
Limnephilus extricatus				2				1	
Potamophylax rotundipennis									
Drusus annulatus				7					
Micropterna sp.				1				4	
Micropterna sequax				1					
Limnephilus sp.									
Rhyacophilidae									
Rhyacophila dorsalis					2	1			
Rhyacophila obliterata									
Lepidostomatidae									
Crunoecia irrorata									
Leptoceridae									
Hydropsychidae									
pupa									
Hydropsyche siltalia									
Hydropsyche instabilis									
Glossosomatidae									
Agapetus fuscipes									
Odontoceridae									
Odontocerum albicorne									
Polycentropodidae									
Plectrocnemia conspersa								1	
Plectrocnemia sp.							5	1	
Polycentropus kingi									
Psychomyiidae									
Lype reducta									
Tinodes waenari									
Plecoptera (Stoneflies)									
plecoptera early instar									
unidentified plecoptera					2				
Leuctridae									
Leuctra inermis									
Leuctra nigra									
Leuctra fusca									
Leuctra geniculata									
Leuctra moselyi									
Leuctra sp.	2	4		1	1	1		2	
Nemouridae									

Invertebrate Family	MEG 01	MEG 02	GRN B	ALL	BAC	MUC	ELS	SIDE	CRO D
Protonemora sp.		1							
Nemoura sp.				4					
Nemurella picteti				11					
Perlidae									
Perla sp									
Perla bipunctata	1								
Perlodidae									
Isoperla grammatica	134								
Chloroperlidae									
Chloroperla torrentium									
Mollusca									
Lymnaeidae									
Radix balthica				3				20	2
Lymnaea trunculata									
Lymnaea sp.								1	
Potamopyrgus antipodarum									
Potamopyrgus jenkinsi	1								
Hydrobia jenkinsi									
Ancylidae									
Ancylus fluviatilis	14				6				
Sphaeridae									
Pisidium spp.				5			108	10	
Planorbidae									
Planorbis sp.	1				1		3		
Ephemeroptera (Mayflies)									
unidentified mayfly									
Caenidae									
Caenis horaria									
Caenis sp.									
Caenis rivulorum									
Ephemerellidae									
Ephemerella ignita									
Baetidae									
Baetidae sp					3				
Baetis spp.	14			5		4			
Baetis scambus									
Baetis rhodani	10								
Baetis fuscatus									
Siphlonuridae									
Siphlonurus sp.									
Leptoplebiidae				13				1	
Paraleptophlebia sp.				2					
Heptageniidae									
Heptagenia sp.									
Ecdyonurus sp.					8				
Rithrogena semicolorata									
Diptera (True flies)									

Invertebrate Family	**MEG 01**	**MEG 02**	**GRN B**	**ALL**	**BAC**	**MUC**	**ELS**	**SIDE**	**CRO D**
Athericidae									
Atherix sp									
Dixidae	3				2	1	1	1	
Dicranota	2					1	2		
Ceratopogonidae									
Culicinae								7	
Culicidae pupa									
Psychodidae	2								
Pericoma sp.		1				4			
Unidentified larvae sp. 1		2				4			
Unidentified larvae sp. 2									
Unidentified larvae sp. 3									
Unidentified larvae sp.4					2				
Unidentified larvae sp. 5							8		
Unidentified pupa									
Chironomidae									
Chironominae	11	8	19		1	43	436	18	
Orthocladiinae	66	12		1	3	59	146	11	
Tanypodinae	17			1	3	10	158	94	2
pupa					1	3	28	20	
Tipulidae	3				5	2		1	
Simulidae					1				
Simulium sp. Adult									
Simulium sp. Larvae						2			
Simulium sp. Pupa									
Coleoptera (Beetles)									
Unidentified larvae									
Curculionidae (A)								1	
Litodactylus leucogaster									
Pelenomus sp.									
Dytiscidae			1						
Unidentified larvae									
Potamonectes depressus elegans (A)									
Rhantus grapii									
Rhantus frontalis									
Rhantus sp. (L)									
Rhantus suturellus (A)			1						
Agabus sp. (L)					1			2	
Agabus sp. (A)								1	
Agabus brunneus (A)									
Agabus bipustulatus (A)				1					1
Agabus guttatus (A)				1					
Agabus melanocarnis									
Ilybius sp. (L)						1			
Ilybius fuliginosus (A)			8	1					
Colymbetes sp. (L)									
Coelambus nigrolineatus (A)									

Invertebrate Family	MEG 01	MEG 02	GRN B	ALL	BAC	MUC	ELS	SIDE	CRO D
Stictotarsus duodecimpustulatus (A)									
Hydroporus sp. (A)									
Hydroporus nigrita (A)				1					
Platambus sp. (L)						3			
Oreodytes sanmarkii (A)					2				2
Hydroporinae larvae									
Hydraenidae									
Limnebius truncatellus (A)								2	
Hydraena sp. (A)								1	
Hydraena gracilis (A)									
Scirtidae					1				
Scirtes sp. (L)	2		19				1		
Hydrophilidae									
Anacaena globulus (A)	3			2					
Hydrobius fuscipes (A)			1						
Helophorus sp (A)									
Helophorus aequalis (A)									
Helophorus dorsalis (A)								1	
Helophorus nigrita (A)									
Helochares sp. (A)									
Helophorus brevipalpis (A)									
Hygrobiidae									
Hygrobia hermanni									
Haliplidae									
Haliplus lineatocollis (A)								2	
Elmidae									
Limnius volckmari (L)									
Limnius volckmari (A)									
Oulimnius sp. (L)						1			
Limnebius sp.									
Elmis aenea (A)								6	1
Elmis aenea (L)		1			1	1		8	
Elodes sp. (L)	4			1				3	
Elodes marginata									
Riolus cupreus									
Hydracarina									
Hempitera (True Bugs)									
Unidentified									
Corixidae (juveniles)									
Gerridae									
Velidae							1		
Immature velia				1				3	
Velia sp. (♂)	4								
Velia caprai (♀)	5		2	1	1			5	
Microvelia sp.									
BMWP	**62**	**31**	**23**	**61**	**62**	**42**	**27**	**73**	**29**
Number of Scoring families	**13**	**6**	**5**	**11**	**12**	**10**	**7**	**14**	**7**

Invertebrate Family	MEG 01	MEG 02	GRN B	ALL	BAC	MUC	ELS	SIDE	CRO D
ASPT	**4.8**	**5.2**	**4.6**	**5.5**	**5.2**	**4.2**	**3.9**	**5.2**	**4.1**
Number of species	**18**	**6**	**5**	**17**	**11**	**9**	**6**	**19**	**6**

Water Quality

3.2.8 Water quality samples were taken during summer 2006 and are presented in Table 14 with sampling points shown on Figures 40.13 a-f. This sampling is intended to give a broad indication of water quality only. Most watercourses were found to have high dissolved oxygen levels, placing them indicatively in the excellent category for this parameter. Some of the smaller waterbodies were very slow flowing with a large degree of turbidity and as such the dissolved oxygen levels were very low (less 50%).

3.2.9 Electrical conductivity readings were all at the lower end of the typical range for freshwater streams and were similar to those recorded by SEPA in watercourses in this area. The water temperatures recorded were typical of those found for the time of year and were consistent with those recorded by SEPA.

3.2.10 The pH values recorded at all streams were within the excellent category according to SEPAs river classification scheme, all being close to neutral. The total hardness values varied between watercourses, with all being within the moderately hard category.

Table 14 – Water Quality Data

Watercourse	DO (% sat)	Electrical Conductivity (μm/cm))	Temperature (°C)	pH	Total Hardness (mg/L)
MEG 01	91	264	12.2	7.67	91
MEG 02	100	288	11.7	8.3	120
LIM U	75	303	11.3	6.98	110
GRN B	69	242	18.4	6.6	88
ALL	76	268	12.3	7.6	120
BAC	114	176	15.3	7.46	65
MUC	85	192	15.2	7.2	72
ELS	84	265	11.4	7.2	120
SIDE	89	174	15.2	7.8	76
CRO U	66	191	17	7.5	78
CRO D	n/a	183	16.4	7.6	71

River Habitat Survey

3.2.11 River habitat surveys were conducted to describe the physical parameters of 500m sections of each of the watercourses that would be crossed by the proposed scheme. Locations of river habitat surveys are shown in Figures 40.13 a-f with site descriptions and Habitat Modification Scores (HMSs) presented in Table 15.

3.2.12 Megray Burn was categorised as significantly modified as the surveyed reach has been extensively realigned and over-deepened with re-sectioned banks and the presence of a major sluice.

3.2.13 Limpet Burn, downstream of the proposed crossing point, is classed as pristine as it does not appear to have been modified. Confirmation of this was being verified with the Environment Agency database at the time of writing this report. The channel was not always distinct and for most of the surveyed reach, the burn seeped through wet grassland in a steep, v-shaped valley. Limpet Burn, upstream of the proposed crossing point, was classed as significantly modified due to the presence of a culvert and evidence of bank re-sectioning.

3.2.14 Green Burn is a relatively small burn flowing through heathland and rough pasture. It was classed as significantly modified, largely due to the presence of a culvert under an existing local road. The classification of this watercourse has been inferred from knowledge gained from other similar burns nearby (refer to Section 2.7).

3.2.15 Back Burn was classed as severely modified due to the presence of re-sectioned and reinforced banks. One intermediate weir, two minor weirs and one minor bridge were observed along the surveyed reach.

3.2.16 The Burn of Muchalls, downstream of the proposed crossing point, was classed as severely modified. This was due to it being historically realigned along part of the surveyed reach, with one minor weir and one intermediate bridge also present.

3.2.17 The Burn of Muchalls, upstream of the proposed crossing point, is classified as severely modified. This was due to its realigned channel with areas of re-sectioned and reinforced (top only) banks. One minor weir and one intermediate bridge were also present. The classification of this watercourse has been inferred from knowledge gained from other similar burns nearby (refer to Section 2.7).

3.2.18 The Burn of Blackbutts was classed as severely modified. It has been extensively realigned and over-deepened and is essentially a modified field drain.

3.2.19 Cookney Ditch was classed as severely modified. This was due to the channel being extensively realigned and over-deepened as well as embanked and reinforced (top only) in places.

3.2.20 Stoneyhill Burn was not surveyed due to land access issues. It is inferred to be of a similar nature to nearby Cookney Ditch, which is a straightened, over-deepened land drain.

3.2.21 Balnagubs Burn is a field drain that was classed as severely modified due to extensive realigning and over-deepening. Both banks have been re-sectioned, embanked and reinforced (top only) in places.

3.2.22 Burn of Elsick is a drainage channel that has been classed as severely modified due to extensive realignment and over-deepened channel. Both banks are extensively reinforced and embanked. The classification of this watercourse has been inferred from knowledge gained from other similar burns nearby (refer to Section 2.7).

3.2.23 Whiteside Burn is a field drain that was classed as severely modified. It has been extensively realigned and over-deepened with both banks reinforced and embanked.

3.2.24 Crossley Burn is a drainage channel that was classed as severely modified as it has been extensively realigned and over-deepened. Both banks have been re-sectioned and areas of reinforcement, embankment and poaching by cattle were observed.

Table 15 – River Habitat Survey

Watercourse, Code and Habitat Modification Score	Valley Form, Channel Dimensions, Bank Profile/Modification and Artificial Features	Substrate, Channel Form and Flow	Vegetation	Surrounding Land-use
Megray Burn MEG 1120 (significantly modified)	Shallow 'v' valley form. Bankfull width 20m. Water width 0.85m. Depth 0.25m. Bank height ranged from 2.5m to 4m. Both banks resectioned at downstream end of surveyed reach. Channel meanders through upstream reach. Bank profiles included vertical/undercut, steep, gentle and composite. Major sluice with large ponded area downstream. Channel dry immediately downstream of sluice.	Substrate comprised 40% gravel/pebble, 10% cobble, 10% sand, 10% boulder and 30% not visible. One riffle and one pool were recorded within the survey reach. Flow types included 40% rippled, 20% smooth, 10% dry and 30% not visible.	Bank-face vegetation simple to complex in structure with gorse and conifer plantation along banks in upstream reach. Uniform vegetation structure within 5m of banktop (tilled land). Semi-continuous trees on both banks providing extensive channel shading. Overhanging boughs, exposed bankside roots, fallen trees and large woody debris present. Limited channel vegetation dominated by liverworts/mosses/lichens with some emergent reeds/sedges/grasses/horsetails.	Tilled land and coniferous plantation extensive along both banks.
Limpet Burn LIM D 0 (pristine)	U-shape valley form. Bankfull width 2m. Water width 1.5m. Depth 0.1m. Bank height approximately 0m. Gentle bank profile extensive with some steep and vertical/undercut on both banks. No bank modification recorded. No artificial features were recorded within the survey reach.	Substrate not visible for 70% of spot checks. 20% earth and 10% gravel/pebble. No riffles, pools or point bars were recorded. Flow type not visible for 70% of spot checks. 20% smooth and 10% rippled.	Bank-face vegetation structure predominantly simple on the left and complex on the right. Banktop vegetation structure simple on the left and simple/complex on the right. Isolated/scattered trees on both banks provide some channel shading. Overhanging boughs and large woody debris present. Channel extensively choked with emergent reeds/sedges/grasses/horsetails.	Wetland and scrub and shrubs extensive along both banks. Broad-leaved /mixed woodland, coniferous plantation and improved/semi-improved grassland present on both banks. Suburban/urban development (house/farmstead) present on left bank.
Limpet Burn LIM U 560 (significantly modified)	Concave valley form. Bankfull width 1.9m. Water width 1.1m. Depth 0.05m. Bank height 0.6–0.8m. Bank profiles included vertical/undercut, vertical with toe, steep, gentle (extensive) and composite. Both banks resectioned at upstream end of reach. One culvert was recorded within the survey reach.	Substrate comprised 40% silt, 20% cobble, 10% gravel/pebble and 30% not visible. One riffle and one pool were recorded within the survey reach. Flow types included 50% rippled, 30% smooth and 10% not visible.	Bank-face vegetation structure simple/complex on both banks. Banktop structure predominantly complex along both banks. Semi-continuous trees along both banks providing extensive shading. Overhanging boughs, exposed bankside roots, fallen trees and large woody debris present. Channel vegetation comprised extensive emergent reeds/sedges/grasses/horsetails.	Wetland extensive along both banks. Broad-leaved/mixed woodland, coniferous woodland, coniferous plantation, scrub and shrubs, rough/unimproved grassland/pasture and tall herb/rank vegetation present on both banks.

Watercourse, Code and Habitat Modification Score	**Valley Form, Channel Dimensions, Bank Profile/Modification and Artificial Features**	**Substrate, Channel Form and Flow**	**Vegetation**	**Surrounding Land-use**
Green Burn GRN B 400 (significantly modified)	No obvious valley sides. Bankfull width 1.2m. Water width 0.35m. Depth 0.02m. Bank height 0.7m. Bank profiles included steep and composite (extensive on both banks), vertical/undercut. One culvert was recorded within the survey reach.	Substrate comprised 60% gravel/pebble, 30% sand and 10% not visible. No riffles, pools or point bars were recorded. Flow types included 70% smooth, 10% rippled, 10% not perceptible and 10% not visible.	Bank-face vegetation structure uniform/simple on both banks. Banktop structure simple along both banks. Occasional clumps of trees present on left bank only providing some channel shading. Channel vegetation included liverworts/mosses/lichens, emergent broad-leaved herbs, emergent reeds/sedges/grasses/horsetails and floating-leaved (rooted).	Scrub and shrubs, moorland/heath and rough/unimproved grassland/pasture extensive on both banks. Suburban/urban development present on both banks (road).
Back Burn BACK 1530 (severely modified)	Shallow ‘v’ valley form. Bankfull width 3m. Water width 2m. Depth 0.1m. Bank height 2m. Bank profiles included steep (both banks) and vertical with toe (left bank). Re-sectioned banks and reinforced – toe only present on both banks. Poaching present on left bank. Artificial features included one intermediate and two minor weirs/sluices and one intermediate bridge.	Substrate comprised 80% cobble and 20% artificial with small areas of gravel/pebble. Seven pools, 0 riffles and point bars were recorded. Flow types included 70% rippled, 20% smooth and 10% unbroken standing waves.	Riparian vegetation was of a simple structure along both banks. Isolated/scattered trees present on left bank only providing some channel shading. Channel vegetation included and emergent broad-leaved herbs and extensive liverworts/mosses/lichens.	Improved/semi-improved grassland and tilled land extensive along both banks. Scrub and shrubs, rough/unimproved grassland/pasture and tall herb/rank vegetation present along both banks.
Burn of Muchalls MUC D/S 1380 (severely modified)	Shallow ‘v’ valley form. Bankfull width 3m. Water width 2m. Depth 0.25m. Bank height 3m. Bank profiles included steep and composite (extensive on both banks), vertical/undercut. Reinforced (toe only) present and re-sectioned extensive on both banks. Artificial features included one minor weir/sluice and one intermediate bridge.	Substrate comprised 50% gravel/pebble and 50% cobble. Six riffles, 14 pools and one unvegetated point bar were recorded. Flow types included 60% unbroken standing waves, 30% smooth and 10% rippled.	Riparian vegetation structure was simple/complex on both banks. Trees were semi-continuous along both banks providing extensive channel shading. Overhanging boughs, exposed bankside roots, fallen trees and large woody debris present. Channel vegetation comprised extensive liverworts/mosses/lichens.	Tall herb/rank vegetation and tilled land extensive along both banks. Broad-leaved/mixed woodland, scrub and shrubs and rough/unimproved grassland/pasture present along both banks. Suburban/urban development present along right bank.

Watercourse, Code and Habitat Modification Score	**Valley Form, Channel Dimensions, Bank Profile/Modification and Artificial Features**	**Substrate, Channel Form and Flow**	**Vegetation**	**Surrounding Land-use**
Burn of Muchalls MUC U/S 2185 (severely modified)	Shallow 'v' valley form. Bankfull width 3m. Water width 1.5m. Depth 0.15m. Bank height 2.5m. Bank profiles included steep (extensive on both banks), vertical with toe (right bank) and composite (extensive on left). Re-sectioned bank present on left and extensive on right. Reinforced (top only)and embanked present on left bank. Artificial features included one minor weir/sluice and one intermediate bridge.	Substrate comprised 70% gravel/pebble and 30% sand. No riffles, pools or point bars were recorded. Flow types included 60% rippled, 30% smooth and 10% not perceptible.	Riparian vegetation structure was predominantly complex on the left and simple on the right. Trees were continuous along the left and semi-continuous on the right providing extensive channel shading. Overhanging boughs, exposed bankside roots and large woody debris were present. Channel vegetation comprised extensive liverworts/mosses/lichens.	Improved/semi-improved grassland extensive on the left and present on the right. Tilled land extensive along both banks. Suburban/urban development present on both banks. Coniferous plantation, scrub and shrubs, artificial open water and tall herb/rank vegetation present on left bank. Parkland/gardens present on right bank.
Burn of Blackbutts BLKBTSS 2800 (severely modified)	No obvious valley sides. Bankfull width 4m. Water width 0.5m. Depth 0.05m. Bank height 1.5m. Bank profiles were entirely re-sectioned. No artificial features were recorded within the survey reach.	Substrate comprised 40% sand, 30% gravel/pebble, 20% earth, gravel/pebble and 10% not visible. No riffles, pools or point bars were recorded. Flow types included 60% smooth, 30% dry and 10% rippled.	Riparian vegetation structure varied between uniform, simple and complex on both banks. Trees were continuous along the right bank only providing extensive channel shading. Overhanging boughs were present. Channel vegetation comprised extensive emergent reeds/sedges/grasses/horsetails with emergent broad-leaved herbs, amphibious and liverworts/mosses/lichens also present.	Scrub and shrubs and tilled land were extensive on the right bank. Tall herb/rank vegetation and suburban/urban development were present on the right. Improved/semi-improved grassland was extensive on the left bank.
Cookney Ditch COOK 3040 (severely modified)	No obvious valley sides. Bankfull width 2.5m. Water width 0.4m. Depth 0.05m. Bank height 1.5m. Bank profiles were extensively re-sectioned. Reinforcement (top only) was present on the left. Both banks were embanked in places. Artificial features included one culvert.	Substrate comprised 40% gravel/pebble, 40% earth and 20% not visible. No riffles, pools or point bars were recorded. Flow types included 80% not perceptible and 20% not visible.	Riparian vegetation structure was predominantly simple on both banks. Trees were absent from both banks. Channel vegetation comprised extensive emergent reeds/sedges/grasses/horsetails with emergent broad-leaved herbs and free-floating also present.	Tall herb/rank vegetation and suburban/urban development were present on both banks. Scrub and shrubs were present and Tilled land extensive on the left. Improved/semi-improved grassland was extensive on the right bank.

Watercourse, Code and Habitat Modification Score	Valley Form, Channel Dimensions, Bank Profile/Modification and Artificial Features	Substrate, Channel Form and Flow	Vegetation	Surrounding Land-use
Balnagubs Burn BALNA 40 (severely modified)	No obvious valley sides. Bankfull width 4m. Water width 0.8m. Depth 0.05m. Bank height 2-3m. Both banks were extensively re-sectioned. Reinforcement (top only) was present on the left. Embanking was present on the left and extensive on the right. No artificial features were recorded within the survey reach.	Substrate comprised 70% earth, 20% gravel/pebble and 10% not visible. No riffles, pools or point bars were recorded. Flow types included 40% not perceptible, 30% rippled, 20% smooth and 10% not visible.	Riparian vegetation structure was predominantly complex on the left and simple on the right. Trees were absent from both banks. Channel vegetation comprised extensive emergent broad-leaved herbs and emergent reeds/sedges/grasses/horsetails with floating-leaved (rooted), free-floating and amphibious also present.	Tilled land and tall herb/rank vegetation present and improved/semi-improved grassland extensive on both banks. Scrub and shrubs present on left bank.
Burn of Elsick ELS 37 (Severely modified)	No obvious valley sides. Bankfull width 2.5m. Water width 0.3m. Depth 0.03m. Bank height 1.25m. Both banks were extensively re-sectioned. Reinforcement (top only, toe only and whole bank) was present on the left. Top only reinforcement extensive on the right. Poaching present on the right. Embanking was extensive on both banks. No artificial features were recorded within the survey reach.	Substrate comprised 30% sand, 10% gravel/pebble and 60% not visible. No riffles, pools or point bars were recorded. Flow types included 30% not perceptible, 10% rippled and 60% not visible.	Riparian vegetation structure was simple/complex along both banks. Trees were absent from both banks. Channel vegetation comprised extensive emergent reeds/sedges/grasses/horsetails with amphibious and liverworts/mosses/lichens also present.	Improved/semi-improved grassland extensive on both banks. Scrub and shrubs present on both banks.
Whiteside Burn WSDE 3510 (severely modified)	No obvious valley sides. Bankfull width 2m. Water width 1m. Depth 0.1m. Bank height 1.3 - 2m. Both banks were extensively re-sectioned. Reinforcement (top only) present on both banks. Embanking was present on both banks. Artificial features included one culvert and two minor bridges.	Substrate comprised 50% gravel/pebble, 30% cobble, 10% silt and 10% not visible. No riffles, pools or point bars were recorded. Flow types included 70% not perceptible, 20% smooth and 10% rippled.	Riparian vegetation structure was predominantly simple/complex along the left and simple along the right bank. Trees were absent from both banks. Channel vegetation comprised extensive emergent reeds/sedges/grasses/horsetails with liverworts/mosses/lichens, emergent broad-leaved herbs, floating-leaved (rooted), amphibious and filamentous algae also present.	Improved/semi-improved grassland extensive on both banks. Scrub and shrubs and suburban/urban development present on left. Parkland/gardens present on the right bank.

Watercourse, Code and Habitat Modification Score	Valley Form, Channel Dimensions, Bank Profile/Modification and Artificial Features	Substrate, Channel Form and Flow	Vegetation	Surrounding Land-use
Crossley Burn CRO 2060 (severely modified)	No obvious valley sides. Bankfull width 2m. Water width 0.5m. Depth 0.1m. Bank height 0.5 - 1m. Both banks were extensively re-sectioned. Poaching present on both banks. Embanking was present on left. No artificial features were recorded within the survey reach.	Substrate comprised 70% earth, 20% gravel/pebble and 10% sand. No riffles, pools or point bars were recorded. Flow types included 60% smooth and 40% not perceptible.	Riparian vegetation structure was predominantly uniform/simple along both banks. Trees were absent from both banks. Channel vegetation comprised extensive emergent reeds/sedges/grasses/horsetails with liverworts/mosses/lichens, emergent broad-leaved herbs and filamentous algae also present.	Improved/semi-improved grassland extensive on both banks. Scrub and shrubs present on left bank.

Freshwater Fish

3.2.25 Only three of the burns within the vicinity of the proposed route were considered suitable for HABSCORE and electric fishing assessments. The rest were either deemed too small to support salmonids or were ephemeral in nature. Those watercourses that were suitable for HABSCORE are shown in Table 16, with the likely possibility of salmon and trout age classes being present. In addition, the results of electric fishing surveys are also shown.

3.2.26 The surveyed reach of Megray Burn appeared to run dry in parts. The watercourse flows through conifer plantation and downstream through a field drain. There appears to be suitable substrate present to support fish though the amount of water present appeared to be a limiting factor. No HABSCORE assessment was completed for this burn, though electric fishing surveys were completed. The surveys however, yielded no fish.

3.2.27 Back Burn forms, in part, a meandering burn through semi-improved grassland. The channel predominately forms small pools and riffles with large loose boulders with small waterfalls that will not cause major barriers to fish migration. HABSCORE assessments of the burn indicated that it is unlikely to support salmon though all age-classes of trout are possibly present. Electric fishing results confirm the presence of trout with 0+ and 1+ age classes being present, though no salmon were identified. No other species were identified in the surveys though suitable habitat was identified in which to support minnows and stickleback, therefore it cannot be assumed that they are absent.

3.2.28 The Burn of Muchalls is a more natural channel with evidence of some realignment. The burn flows through semi-improved grassland with the channel composed of large cobbles and some boulders interspersed with smaller cobbles and pebbles and small sand banks on the margins. Suitable habitat to support lamprey and bank cover for salmonids was observed. Several small salmonids (10-12cm) were seen during the survey, possibly trout. Results of the HABSCORE assessment indicated that the burn is unlikely to support salmon, though it possibly supports all age classes of trout. Electric fishing surveys confirmed the presence of trout within the burn with 0+, 1+ and 2+ age classes being identified. No other species were found within the surveys. However, the presence of suitable substrate means that it cannot be assumed that they are absent.

3.2.29 Crossley Burn is a relatively small burn flowing along the edge of pasture with sections of poaching by cattle. Sticklebacks were observed during the habitat assessment and were also caught whilst completing kick sweep sampling. The HABSCORE assessment indicated that the burn is unlikely to support salmon, though it will possibly support all age classes of trout. No electric fishing surveys were conducted on Crossley Burn due to its ephemeral nature.

Table 16 – Likelihood of the Presence of Salmon and Trout Age Classes (based on HABSCORE and Electric Fishing Results)

Section	Watercourse	Code	Salmon				Trout			
			Likely	Possibly	Unlikely	EF Results	Likely	Possibly	Unlikely	EF Results
FL1	Megray Burn	MEG	Not assessed		No fish		Not assessed		No fish	
FL2	Back Burn	BAC	-	-	✓	None	0+ <20 cm	>20 cm	-	Trout 0+, 1+
FL2	Burn of Muchalls	MUC	-	-	✓	No fish	0+ <20 cm	>20 cm	-	Trout 0+, 1+, 2+
FL3	Crossley Burn	CRO	-	-	✓	Not Sampled	0+ <20 cm	>20 cm	-	Not Sampled

Key: 0+ = fry, 1+ and 2+ = parr, <3+ adult.

4 Evaluation

In order to form evaluations of the ecological value of freshwater habitats, individual burns that are at risk of being affected by the proposed scheme are referred to as freshwater habitat areas. Each freshwater habitat area is assessed for its ecological value to the receptor, with a final assessment of the ecological value of the section being made.

Overall, the watercourses surveyed within the study area ranged in ecological importance from regional to local, with ecological health ranging from excellent to impoverished. A summary of the evaluation of the watercourses in the study area is provided in Table 17.

4.1 Section FL1

4.1.1 Megray Burn has been assessed as significantly modified due to areas of re-sectioning and the presence of a major sluice. No fish were found during the electric fishing surveys. Megray Burn was classified as good biological status based on the macroinvertebrate assemblages and as such has been evaluated as county importance.

4.1.2 Limpet Burn exhibited variation in its degree of modification. The upstream section forms an obviously modified channel with areas of culverting and the downstream section was inferred to be pristine wetland habitat. No macroinvertebrate sample was taken from the crossing point as there was no discernable channel. As the burn appeared to be in relatively pristine condition in the vicinity of the crossing point, it has been evaluated as regional value.

4.1.3 Green Burn was examined near its source where the watercourse flows as a small shallow channel through scrub. The present of a culvert led to an evaluation of the burn as obviously modified. Green Burn was classified as possessing fair biological status from the results of the macroinvertebrate assemblage and as such has been evaluated as county importance.

4.2 Section FL2

4.2.1 Sampling of Allochie Burn indicated good biological status from the macroinvertebrate assemblage identified. No river habitat survey was conducted on the burn as it was found to be a field drain. Allochie Burn’s good biological classification leads to an evaluation of county value.

4.2.2 The reach of Back Burn that was surveyed was found to be a significantly modified channel flowing through semi-improved and unimproved grassland. The burn was classified as excellent biological status on the basis of the macroinvertebrate assemblages identified. The burn is considered unlikely to support salmon, however it was found to support trout. Although the burn has been significantly modified, its excellent biological status and the presence of trout led to an evaluation of the burn being of regional value.

4.2.3 The Burn of Muchalls is variable in its degree of modification between the upstream and downstream stretches. Upstream of the crossing point, while the burn retains a degree of semi-naturalness, evidence of a realignment led to an evaluation of significantly modified. Downstream of the crossing point, the burn is severely modified. The macroinvertebrate results indicated that the burn possesses good biological status. Small salmonids were observed during the surveys. HABSCORE assessments indicated that burn is unlikely to support salmon, although it could support trout. This was confirmed during the electric fishing surveys with 0+, 1+ and 2+ trout being identified. Despite the severely modified nature of the downstream section, the burn has been evaluated as regional importance as a result of its semi-natural upstream section, the good biological status and the presence of trout.

4.3 Section FL3

4.3.1 Burn of Blackbutts has been identified as a severely modified field drain that follows a field boundary. The channel was not sampled for macroinvertebrates as there was little water present. The burn has been assessed as being of local value based on the river habitat survey assessment.

4.3.2 Cookney Ditch and Balnagubs Burn are both severely modified field drains. No macroinvertebrate samples were collected due to low flows at time of sampling. These watercourses have been assessed as being of local value based on the river habitat survey assessment.

4.3.3 The Burn of Elsick is essentially a straightened field drain and has been severely modified. The burn was classified as possessing good biological status based on the macroinvertebrate assemblage and has been evaluated as local value.

4.3.4 Whiteside Burn is a severely modified field drain, with extensive re-sectioning. The burn flows through private land with urban developments and areas of rough pasture. The burn was assessed as having good biological status based on the macroinvertebrate assemblage and as such the burn was evaluated as being of local value.

4.3.5 Crossley Burn is a severely modified field drain with extensive re-sectioning. Poaching by cattle was evident on both left and right banks. Macroinvertebrate samples were taken from two points downstream of the crossing point that offer differing habitat. The burn was found to be of fair biological status as a result of the macroinvertebrate assemblages present. It is considered unlikely that the burn supports salmon, although it is possible that it supports trout. Although the burn is severely modified and is of fair biological status, the possible presence of trout leads to an evaluation of county value.

Table 17 – Watercourse Evaluation

Route Section	Watercourse	Code	Size (km2)	ASPT		Biological Classification	Habitat Classification	HABSCORE Salmon/Trout Presence	Electric Fishing Presence	Evaluation	Comment
				April	Sept						
FL1	Megray Burn	MEG 01	0.57	5.7	4.8	Good	Significantly modified	n/a	No fish	County	None
		MEG 02		5.2	5.2			n/a			
	Limpet Burn	LIM D	1.37	n/a		n/a	Pristine (inferred)	n/a	n/a	Regional	The burn has been evaluated as regional due to the pristine nature of the downstream sections in the vicinity of the crossing point.
		LIM U		n/a		n/a	Significantly modified	n/a			
	Green Burn	GRN B	0.75	4.0	4.6	Fair	Obviously modified	n/a	n/a	County	Although the burn is small and culverted, it retains a degree of semi-naturalness. Classified as Poor ecological health.
FL2	Allochie	ALL	0.01	5.0	5.5	Good	n/a	n/a	n/a	County	None
	Back Burn	BAC	2.76	7.0	5.2	Excellent	Severely modified	Salmon - unlikely Trout – possible	Trout 0+, 1+	Regional	Although burn is severley modified, survey results indicate excellent ecological health.
	Burn of Muchalls	MUC	6.74	5.8	4.2	Good	Upstream - Significantly modified	Salmon - unlikely Trout – possible	Trout 0+, 1+, 2+	Regional	Although historically realigned, burn retains a degree of semi-naturalness, with good ecological health.
							Downstream - Severely modified	n/a			
FL3	Burn of Blackbutts	BLKBTS	n/a	n/a		n/a	Severely modified	n/a	n/a	Local	None
	Cookney Ditch	COOK	n/a	n/a		n/a	Severely modified	n/a	n/a	Local	None

Route Section	Watercourse	Code	Size (km2)	ASPT		Biological Classification	Habitat Classification	HABSCORE Salmon/Trout Presence	Electric Fishing Presence	Evaluation	Comment
				April	Sept						
	Stoneyhill Ditch		n/a	n/a		n/a	Severely modified	n/a	n/a	Local	Not surveyed, condition inferred from Cookney Ditch.
	Balnagubs Burn	BALNA	n/a	n/a		n/a	Severely modified (inferred)	n/a	n/a	Local	None
	Burn of Elsick	ELSK	0.98	5.8	3.9	Good	Severely modified (inferred)	n/a	n/a	Local	None
	Whiteside Burn	WSDE	0.40	5.7	5.2	Good	Severely modified	n/a	n/a	Local	None
	Crossley Burn	CRO U & CRO D	0.20	4.8/4.9	4.1	Fair	Severely modified	Salmon - unlikely Trout – possible	n/a	County	Possibly supports trout.

5 Potential Impacts

5.1 Introduction

5.1.1 This section describes the types of potential impacts that may affect freshwater communities. A summary of potential impacts that would result from the proposed scheme, in the absence of appropriate mitigation, is also provided.

5.1.2 Potential impacts on aquatic ecosystem health from construction and operation of the scheme include:

- point source and/or diffuse organic/inorganic pollution;
- increased sediment loading and changes to sediment transport;
- introduction of suspended solids (also referred to as finely divided solids) into the water column;
- decrease in stream and bankside habitat complexity;
- habitat fragmentation;
- substantial changes to discharge regime;
- direct mortality; and
- disturbance.

5.1.3 Other impacts such as dust deposition, spread of alien species, changes to groundwater flow are addressed in the Terrestrial Habitats Report (Appendix A40.1) and Water Environment (Chapter 39), respectively.

5.1.4 In general, direct impacts are where the impacts of the proposed scheme would result in a direct change to the status of an ecological receptor, during construction or operation e.g. loss of salmon spawning redds as a result of bridge construction. Indirect effects of the proposed scheme generally relate to secondary effects, e.g. deterioration of water quality for watercourses receiving diffuse road runoff.

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

5.2 General

Point Source and/or Diffuse Organic/Inorganic Pollution

5.2.1 During construction of the proposed scheme, there is potential for accidental pollution release to adjacent waterways such as oil and fuel from plant, liquid concrete, uncontrolled sewage release and fine sediment release. The effect of any given pollutant is likely to have greater impacts in smaller watercourses that have lower dilution potential.

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 may 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 There is potential for accidental/uncontrolled release of sewage 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, polluted road runoff (inorganic) and accidental spills (inorganic and organic) generated during operation of the proposed scheme have the potential to adversely affect local watercourses. Road runoff and accidental spills from traffic using the new road would raise levels of inorganic pollution entering watercourses and lead to decreased macroinvertebrate species richness. As stated above, inorganic point source pollution can result in the loss of pollution sensitive/rare species and ultimately leads to fish kills if toxicity reaches lethal levels.

5.2.6 Accidental spills of organic pollution (e.g. from a milk tanker crash) can lead to decreased macroinvertebrate 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 macroinvertebrates are able to drift away from pollution hotspots. Increased organic pollution can also lead to nuisance plant growth 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.

5.2.7 The European Inland Fisheries Advisory Commission (EIFAC) conducted a series of reviews on the effects of water pollutants on fish and established standards and guidelines that have been adopted by the European Commission. These refer to two levels of water quality, one (more stringent) pertaining to waters containing salmonid fisheries, the other to waters containing only cyprinid fisheries. Water quality standards for salmonids, based on the EIFAC water quality criteria, are covered under the Surface Waters (Fishlife) (Classification) (Scotland) Regulations 1997 (refer to Table 18). These Regulations, however, make no mention of total suspended solids and there are no regulatory standards for total suspended solids in the UK.

Table 18 – Summary of Surface Waters for Fish

Parameter	Requirements for Salmonid Waters	Methods of Analysis	Minimum Sampling Frequency	Observations
Temperature (^oC)	21.5 for 98% of the time	Thermometry	Weekly	Over-sudden variations in temperature must be avoided.
pH	6 to 9	Electrometry calibration using two known standards.	Monthly	n/a
Dissolved oxygen (mg/l O_2)	50% ≥ 9	Winkler's method or specific electrodes.	Monthly	Twice per day where major daily variations are expected.

Increased Sediment Loading and Changes to Sediment Transport

5.2.8 During construction, there is potential for increased sediment loading to adjacent watercourses to occur in the absence of suitable mitigation. Suspended solids would be generated from activities such as excavation, 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 generally highest at road crossings where earthworks will be required for the construction of culverts, bridges and watercourse diversions. There is potential for increases in watercourse flow velocities during temporary stream diversions which can lead to increases in erosion and sedimentation.

5.2.9 Sediment 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. This is of critical importance for species such as freshwater pearl mussels, which have a specific suspended solids tolerance of around 25 mg/L (Cosgrove et al, 2000) and this level cannot be exceeded for long periods without deleterious effects on the mussels. Similarly salmonids, on which the Freshwater Pearl Mussels rely for their dispersal, have a suspended solids tolerance of around 30mg/L. Alabaster and Lloyd (1982) summarise that long-term levels of suspended sediment below 25mg/L will have no harmful effects on fish. Levels of 25-80mg/L are acceptable as a rule of thumb, 80-400mg/L^{-1} are unlikely to support good fisheries and levels over 400mg/L generally will not support substantial fish populations (refer to Table 19).

5.2.10 Suspended solids may also contain contaminants that can result in 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 macroinvertebrates' search for prey. Additionally, increased turbidity as sediment is entrained in the water column and can lead to decreased dissolved oxygen (DO) levels.

5.2.11 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 has the potential to result in a substantial change to local discharge regimes (see below) which could permanently alter the sediment transport and geomorphological character of some of the watercourses (refer to Chapter 39: Water Environment). This would indirectly affect aquatic organisms specifically adapted to microhabitats that 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.

Suspended Solids

5.2.12 Alabaster and Lloyd (1982) list four ways in which excessive levels of suspended solids (also referred to as Finely Divided Solids) can be harmful to fish:

- act directly on the fish and either killing them, reducing their growth or resistance to disease;
- prevent the successful development of fish eggs and larvae;
- modify natural movements and migrations of fish; and
- reduce the abundance of food available to the fish.

5.2.13 Fish show varying tolerances to suspended solids according to species. Although exposure to several thousand mg/l may not kill fish during hours or days of exposure (Alabaster and Lloyd, 1982), exposure to a very high suspended solids load for extended periods can be fatal.

Table 19 – Effects of Finely Divided Solids (Total Suspended Solids) on Fish and Fish Habitat (Alabaster and Lloyd, 1982)

FDS (Mg/l)	Risk to Fish and Fish Habitat
0	No risk
<25	No harmful effects
25-100	Generally acceptable
80-400	Unlikely to support good fisheries
>400	Not compatible with substantial fish populations

5.2.14 Sediment released during the construction phase could settle over bed gravels, killing invertebrates, fish eggs and alevins. Accumulations of fine sediments could also make habitats unsuitable for fish spawning. This could represent a high adverse impact on the population at sites downstream of the works.

5.2.15 The impact of accidental spillages during construction will depend on a wide range of variables including the nature and volume of the chemical and the volume of the receiving water (the dilution factor). Consequently, the magnitude of impacts on sites downstream of works could vary from low to high adverse, but is likely to decline with increasing distance from source. It is likely to be the smallest tributaries that could be impacted most heavily. Large volume flow watercourses with a high pollutant load adjoining small burns have the potential for high adverse impacts on the burn downstream of the inflow. Chemical spillages during the key fish migration period could prevent or delay migration beyond that point, potentially having a high adverse impact on the population. This could also constitute an offence under the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003.

5.2.16 As lamprey ammocoetes spend a period of five or more years buried in bed sediments feeding on detritus and this species could be particularly sensitive to an accumulation of pollutants during operation of the scheme. This could result in a high adverse impact at localised sites downstream of the crossing points.

5.2.17 During operation, a major accident (such as spillage from a fuel tanker, milk tanker, etc.) close to one of the water crossings has the potential to result in toxic chemicals reaching local watercourses. Depending on the nature of the release, the dilution factor and the timing of the event, this could constitute a high adverse impact on all species and habitats exposed.

Decrease in Stream and Bank Side Habitat Complexity

5.2.18 Construction of the proposed scheme would involve over 40 watercourse crossings and at each of these crossing points there would be a degree of habitat simplification/modification. This would occur as a result of activities associated with the installation of road crossings such as culverting, channel straightening, bank reinforcement or reprofiling, watercourse diversion, over deepening and clearing of riparian zone. These activities have the potential to reduce habitat and food availability for aquatic species, in turn leading to decreases in species richness and mortality.

5.2.19 As the road is likely to be at least 30m wide (wider in the embanked sections), each watercourse that requires the installation of a culvert must be straightened across at least the length of the culvert, which would result in the loss of riparian habitat, reduced channel sinuosity and decreased flow heterogeneity. The realignment of watercourses during this construction phase would also result in reaches being straightened and loss of riparian habitat. Realignments can also reduce the total channel 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.

5.2.20 Operation of the proposed scheme includes maintenance of the road and verges that 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.

Habitat Fragmentation

5.2.21 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. Without appropriate design, these structures could pose a barrier to fish, otter and invertebrate movement.

5.2.22 In addition to culverts, the creation of new realigned channels can also cause habitat fragmentation by reducing channel sinuosity and potentially changing the discharge regime. This may stop or hamper the movement of fauna that require specific flow conditions to migrate up or down watercourses. Temporary diversion channels that would be created as an alternative route while the stream is being realigned and culvert constructed would result in temporary fragmentation of habitat.

5.2.23 Habitat fragmentation is particularly relevant to salmonid fish (i.e. salmon and trout), which need to migrate upstream to breed. The migration of fish may be hindered or prevented through the formation of a physical barrier, a psychological barrier or by significantly increasing water velocity or reducing water depth. In the case of the River Dee and its tributaries, this is of critical importance to freshwater pearl mussels, which rely on salmonids during their parasitic life stage when immature mussels (glochidia) attach to the gills to disperse to suitable habitats for recruitment.

5.2.24 During operation of the proposed scheme, culverts may become blocked if not properly maintained, particularly following periods of heavy rain, which may result in severance between upstream and downstream habitat.

Substantial Changes to Discharge Regime

5.2.25 The proposed construction works would alter the local topography and slightly increase the amount of impermeable surface area in catchments through the construction of the road pavement. The area of road surface is estimated as being approximately 1.5km^2 across the whole scheme including junctions, but not including embankments and road drainage infrastructure (total area of 4.2km^2). This has the potential to increase the volume of runoff to watercourses, adversely affecting aquatic ecosystems. Additionally, temporary and permanent watercourse diversions can also substantially alter the discharge regime through changes in slope and channel sinuosity, affecting water velocities and discharge volumes. The detention ponds that would collect road drainage will be designed to avoid changes to the natural discharge regime of watercourses.

5.2.26 Changes to the discharge regimes of watercourses have the potential to lead to substantial changes in local habitat, food availability and water quality. Substantial reductions in flow levels can severely affect flow-reliant species and those sensitive to decreases in dissolved oxygen. Increased flows to watercourses has the potential to adversely affect species reliant on slow flow areas such as pools and marginal dead water for feeding and resting (i.e. migratory fish). There is potential for microhabitat simplification due to scouring and increased flood frequency which can also reduce the number of species able to survive in a variable discharge environment.

Direct Mortality

5.2.27 The installation of culverts at proposed road crossing points would require the dewatering and mechanical excavation of sections of watercourses. These activities have the potential to result in local mortalities, which would be an impact during construction and operation if the fish are not moved to the temporary diversion channel beforehand. Were salmon or sea trout to be present at a given crossing point, impacts on these species could constitute an offence under the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003. Fish eggs cannot easily be moved and could be lost from the dewatered area, resulting in a high adverse impact locally. It is possible that noise and vibration from construction works during the sensitive stages of salmonid egg incubation could result in damage to eggs close to the source of the vibration. This would have a high adverse impact locally but only a low adverse impact on the population as a whole. Unless appropriately managed, these activities could also constitute an offence under the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003.

Disturbance

5.2.28 Fish are sensitive to a number of disturbances including sound pressure, vibration and light, with the degree of sensitivity varying between species and life stage. The potential for disturbance to some species and life stages during the construction phase is high. Resident fish, some of which are territorial, are likely to leave the area adjacent to the works and will need to find new territories, resulting in increased competition elsewhere. Without appropriate mitigation, this disturbance would likely result in a local impact on resident fish within the affected area.

5.3 Specific Impacts

5.3.1 This section assesses the potential site specific impacts that would be likely to affect the freshwater environment during both construction and operation of the proposed scheme. The impacts are summarised in Table 20. The general impacts discussed above will apply to all relevant watercourses during construction.

5.3.2 In Section FL1, the realignment of Megray Burn would result in substantial loss of current habitat and species assemblages. Additionally, an outfall from the road drainage system would discharge to this burn, which could potentially alter water quality and the biological status of the watercourse.

5.3.3 Limpet Burn, an important wildlife corridor, would require a realignment to allow the proposed buried structure to be minimal in length. This structure has been designed to be as open as possible in order to minimise potential impacts on riparian habitat and connectivity.

5.3.4 The installation of two culverts on Green Burn would result in habitat loss and fragmentation. In addition, treated road runoff would be discharged to swales and then into the burn, potentially affecting water quality in the burn.

5.3.5 In Section FL2, the section of Allochie Burn immediately upstream the scheme would be cut off from its existing course and diverted into pre-earthworks. This would alter the hydrological flow regime of the burn and the habitat it offers. Back Burn would not be crossed by the proposed route and would not receive any road runoff. Therefore, there would be no potential impacts from the scheme.

5.3.6 The Burn of Muchalls would be bridged and would receive road runoff from an outfall in the vicinity of the crossing. The bridge structure would not require a realignment of the channel and would minimise impacts on riparian habitat and connectivity. Other than temporary adverse impacts during construction of the bridge, no main impacts are predicted for this watercourse.

5.3.7 In Section FL3, the Burn of Elsick would be culverted, which would result in habitat loss and fragmentation. As the burn flows through a previously straightened channel at this location, this is not expected to result in major changes to the watercourse. The discharge of treated road runoff to the Burn of Elsick via an outfall may result in minor changes to water quality.

5.3.8 Whiteside Burn is an existing straightened channel that would be culverted. Although the proposed works would result in habitat loss and fragmentation, this is anticipated to be a minor adverse impact.

5.3.9 Crossley and Cairn Burns would be realigned for the installation of a culvert on Crossley Burn. The potential impacts associated with the proposed activities would mainly be loss and fragmentation of habitat. Given the existing modified condition of both watercourses, this is not anticipated to result in adverse impacts on their overall ecological health.

Table 20 – Impact Assessment of Key Watercourses Potentially Affected by the Proposed Scheme

Section and Ecological Value	Watercourse	Watercourse Ecological Value	Crossing	Realignment	Road Discharge	Impact Description	Magnitude	Impact Significance
FL 1	Megray Burn MEG	County	92m long culvert on the mainline at ch0	Realigned length of 951 resulting in lengthening the burn by 49m	Drainage from 2507m of road via detention ponds	Construction: Extensive realignment of the existing channel will remove almost a kilometre of the existing watercourse which although significantly modified is also a 'good' quality habitat for aquatic invertebrates and water quality. The creation of the re-aligned channel and culvert will involve some earthworks, resulting in sediment and/or other pollution release.	Medium negative	Moderate
						Operation: There will be a localised impact upon habitat complexity within the length of culvert, which may also lead to localised changes in species distribution. The re-aligned channel will be slow to recover the existing 'good' quality and with different substrate, shading and gradient, the aquatic invertebrate assemblage may never return to current conditions.		
	Limpet Burn LIM	Regional	Buried structure (bridge) 69.5m long at ch1400	Realigned length of 123m resulting in an overall shortening of 1m	n/a	Construction: The creation of the buried structure will involve some earthworks, resulting in sediment and/or other pollution release. Some physical damage to the complex wetland habitat around the burn may result from construction.	Medium negative	Moderate
						Operation: The structure is likely to alter the hydrological regime of the burn and its wetlands by constricting its width. It will shade a large area of the burn and wetland such that the plants that currently proliferate in the valley will not longer grow.		

Section and Ecological Value	Watercourse	Watercourse Ecological Value	Crossing	Realignment	Road Discharge	Impact Description	Magnitude	Impact Significance
	Green Burn GRN B	County	Two culverts, one of 84m at ch3125 (mainline) and one of 19m at ch213 (side road).	Realigned length of 342m resulting in lengthening the burn by 258m (mainline) and 323m (side road)	Drains 994m of road via a swale	Construction: The creation of the re-aligned channel and culverts and drainage discharge will involve some earthworks, resulting in sediment and/or other pollution release.	Medium negative	Moderate
						Operation: The culverts will increase shading of the burn, reducing the habitat suitability and may cause fragmentation of the habitat. The realignment of channel will result in a loss of current fauna and flora and the road runoff may adversely affect water quality in the burn.		
FL2	Allochie Burn ALL	County	Pre-earthworks	n/a	n/a	Construction: The burn will be bisected by the road and will go to pre-earthworks. Sediment will be carried downstream by the construction of the road.	Low negative	Minor
						Operation: The burn will be bisected by the road resulting in habitat loss and fragmentation. The burn is of 'good' ecological quality and will be cut-off from flowing downstream leading to a complete change to hydrological regime.		
FL2	Burn of Muchalls	Regional	Under-bridge 34m approx.long at ch4700	n/a	Drains 3500m of road via detention	Construction: The underbridge construction will involve some earthworks, resulting in sediment and/or other pollution release.	Low negative	Minor

Section and Ecological Value	Watercourse	Watercourse Ecological Value	Crossing	Realignment	Road Discharge	Impact Description	Magnitude	Impact Significance
					ponds	Operation: The structure will shade a section of the burn resulting in a decrease in habitat suitability and fragmentation in this burn of 'good' ecological quality. Discharge of road runoff from the detention ponds may also affect water quality of the burn.		
FL3	Burn of Blackbutts	Local	Pre-earthworks	n/a	n/a	Construction: The upper reaches of the burn will be bisected by the road and will go to pre-earthworks. Sediment will be carried downstream by the construction of the road.	Low negative	Minor
						Operation: This obviously modified burn will be bisected by the road in its upper reaches resulting in a small degree of habitat loss.		
FL3	Cookney Ditch	Local	Two culverts: one 42m long on the mainline at ch6480 and one 53m long on side road at ch6480. Pre-earthworks at side road.	Realigned length of 244m resulting in lengthening the burn by 202m (mainline) and 191m (side road).	n/a	Construction: The upper reaches of the burn will be bisected by the road and will go to pre-earthworks. The side road and culvert construction will result in the transport downstream of sediment and pollution.	Medium negative	Minor
						Operation: The structures will shade a section of the burn resulting in a decrease in habitat suitability and fragmentation in this already significantly modified burn.		
FL3	Stoneyhill Ditch	Local	One culvert of 36m long at ch6700	Realigned length of 203m resulting in	n/a	Construction: The culvert construction will involve some earthworks, resulting in sediment and/or other pollution release.	Low negative	Minor

Section and Ecological Value	Watercourse	Watercourse Ecological Value	Crossing	Realignment	Road Discharge	Impact Description	Magnitude	Impact Significance
				lengthening the burn by 167m.		Operation: The structure will shade a short section of the burn resulting in a decrease in habitat suitability and fragmentation in this already significantly modified burn.		
FL3	Balnagub Burn	Local	One culvert of 48m long at ch7550	Realigned length of 117m resulting in lengthening the burn by 69m.	n/a	Construction: The culvert construction will involve some earthworks, resulting in sediment and/or other pollution release.	Low negative	Minor
						Operation: The structure will shade a short section of the burn resulting in a decrease in habitat suitability and fragmentation in this already significantly modified burn.		
FL3	Burn of Elsick	Local	One culvert 53m long at ch7975	Realigned length of 150m resulting in lengthening the burn by 97m.	Drains 3064m of road via detention ponds	Construction: Construction of the culvert and road drainage structures will involve some earthworks, resulting in sediment and/or other pollution release.	Low negative	Minor
						Operation: The structure will shade a section of the burn resulting in a decrease in habitat suitability and fragmentation in this burn currently of 'good' ecological quality. Discharge of road runoff from the detention ponds may also affect water quality of the burn.		
FL3	Whiteside Burn	Local	One culvert 62m long at ch8850	Realigned length of 244m resulting in lengthening the burn by 121m	n/a	Construction: The culvert construction will involve some earthworks, resulting in sediment and/or other pollution release.	Low negative	Minor
						Operation: The structure will shade a short section of the burn resulting in a decrease in habitat suitability and fragmentation in this 'good' ecological quality but significantly modified burn.		

Section and Ecological Value	Watercourse	Watercourse Ecological Value	Crossing	Realignment	Road Discharge	Impact Description	Magnitude	Impact Significance
FL3	Crossley (& Cairns) Burn	County	One culvert 87m long at ch9170	Realigned length of 161m resulting in lengthening the burn by 74m.	N/A	Construction: The culvert construction and burn realignment will involve some earthworks, resulting in sediment and/or other pollution release.	Low negative	Minor
						Operation: The structure will shade a short section of the burn resulting in a decrease in habitat suitability and fragmentation in this 'fair' ecological quality but significantly modified burn. The realignment of channel will result in a loss of current fauna and flora.		

6 Mitigation

6.1 Introduction

6.1.1 This section describes the mitigation proposed to address the potential impacts that have been identified in Section 5. Generic mitigation measures will be implemented throughout the areas affected by the proposed scheme. Additional site specific mitigation measures are proposed where impacts of Moderate or above magnitude are predicted.

6.1.2 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." 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.

6.1.3 The Water Framework Directive 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 the requirement that there must be no deterioration in ecological status of any watercourse. It should also be noted that SEPA requires engineering activities near most watercourses or waterbodies and road outfalls to be licensed under the terms of the Controlled Activities Regulations (CAR) 2005.

6.2 Mitigation and Scheme Design

6.2.1 The development of mitigation to avoid or reduce impacts on aquatic communities has been a continuous process during scheme design. In particular, the development of major design components such as road drainage, locations of bridges and culverts, as well as watercourse realignment details, have been though an iterative design process involving structural engineers, geomorphologists, ecologists and water quality specialists.

6.2.2 Consultation with SEPA and SNH to seek guidance on appropriate levels of road drainage, culverting and watercourse realignment has been undertaken throughout the design and EIA process.

Road Drainage

6.2.3 The main mitigation strategy for protection of the aquatic environment during operation of the scheme is the provision of the road drainage system, which is designed to substantially reduce polluted road runoff entering local watercourses. The road drainage system will also minimise the 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 39 (Water Environment). SUDS techniques that will be implemented to avoid and reduce potential impacts during normal road operation include the following:

- filter drains and catchpits along the entire road;
- detention 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 efficiencies of the various treatment systems are provided in Chapter 39 (Water Environment) and Appendix A39.2 (Fluvial Geomorphology). 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 Limpet and the Burn of Muchalls bridge crossings will take the form of buried structures, which have been designed to entirely span the watercourse at the crossing point. No piers will be located in the channel and there will be no need for in-channel works to construct the structures. The crossing structures have been designed to reduce damage to the riparian zone as their abutements would be set back from the edge of the bank.

6.2.6 Specific activities (such as piling) resulting in particular disturbances (such as noise and vibration) will be avoided during sensitive periods for fish (e.g. the first third of salmonid egg incubation, see Table 2). This will apply to all watercourses where salmonids may be present (see Table 16 and 17). Any works that have the potential to generate high levels of noise (e.g. piling) will be initiated using a soft start approach, allowing sensitive animals to move away from the sound source prior to the noise reaching peak volumes. Night working will be avoided, allowing a quiet period for migratory fish to pass the construction site. Lights on the construction sites will be directed away from the water.

Culvert Design

6.2.7 Culverts have been designed following guidance from Scottish Executive on culverts and migratory fish (SEERAD, 2000) to prevent habitat fragmentation and reduce the loss of habitat complexity. This will reduce impacts in watercourses with notable species such as the notable weevil species *Litodactylus leucogaster*, found within Kingcausie Burn and Bellenden Burn. Culverts will be installed with the base of the structure 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 will comprise imported material of a similar size to that of the original channel, which will be specified to ensure that the sediment does not wash out at times of high flow or silt up in times of low flow. More information is available in Appendix A24.3 (Fluvial Geomorphology). During the operation of the road, natural substrate is also likely to accumulate in the culvert. Depressed invert culverts are proposed for the majority of watercourses that would be crossed by the scheme except the Burn of Blackbutts and Allochie Burn, which are small land drains with little or no geomorphological or ecological interest. The road would cross over Limpet Burn and the Burn of Muchalls using buried bridge structures.

6.2.8 All culverts have been designed to accommodate a 1:200 year flood and to allow 30mm additional headroom for out-of-water mammal passage. Gradients will 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.

Watercourse Realignments

6.2.9 Watercourse realignments can alter the length of watercourse and in the case of Megray Burn, the proposed realignment has been designed to keep the channel length as close to the original burn as possible. Watercourse realignments can also present an opportunity to improve modified watercourses 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 minimised adverse impacts. Details of realignment requirements are provided in Chapter 39 (Water Environment). The following broad principles have been applied during the design of watercourse realignments:

- reduce crossing (culvert) lengths and associated long term habitat loss and fragmentation by allowing the watercourse to cross the mainline AWPR at 90 degrees;
- ensure that the realigned lengths are similar to original lengths, as far as possible;
- realignments in low gradient areas must be 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 must be designed to minimise erosion, e.g. by allowing the realigned section to either meander more or be longer than the original; and
- 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 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 watercourses will be identified and quantified. 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 mitigation strategies during construction is aimed at avoiding pollution release to watercourses and reducing this impact should it occur. The chief 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 addition, to ameliorate potential impacts, mitigation described in Table 21 will be implemented. More details are available in Chapter 39 (Water Environment).

Table 21 – 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 (detention 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 Minimisation 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 (detention basins/treatment ponds) to treat surface runoff. These features would be established and functional before construction commenced; and Storage of fuel, oil and chemicals would not be on a watercourse floodplain.
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; and 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; and Chemical toilets for the use on the construction site will be waterless and any waste would 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 runoff. 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 Watercourses to be culverted will be diverted to a temporary channel during culvert construction. Diversion of watercourses represents considerable disturbance and habitat loss and fragmentation impacts which can be greatly reduced by following the simple procedures outlined below. 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. The translocation of some of the main channel substrate will enable a proportion of the macroinvertebrate 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 macroinvertebrates 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. 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. Dewatering or realignment should not be carried out during the spawning or egg incubation seasons (October to May inclusive for salmonids). Any fish translocation will be agreed in advance with the DDSFB.

6.3.6 Where temporary diversions are to be created, e.g. during the installation of culverts, the same protocol for dewatering must be followed with the additional requirement that electric fishing is also carried out within the temporary diversion before the watercourse is returned to its original route.

Timing of Works

6.3.7 Potential impacts of the proposed scheme on freshwater species can be greatly reduced through the appropriate timing of works. No in-channel works should be conducted on watercourses likely to support migratory fish between 14 October and 31 May as this will protect the migratory, spawning and sensitive egg incubation phases. 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 Appendix A40.6: Otter Survey Report). 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, as this can lead to fish kills.

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 will 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 provided in Chapter 39 (Water Environment).

Sedimentation/Erosion Monitoring

6.4.3 Although watercourse diversions and activities associated with the installation of culverts have been designed to minimise 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 aims at reducing the risk of dramatic changes to the geomorphological character of watercourses that may lead to habitat loss or simplification. Details of the monitoring approach are provided in Chapter 39 (Water Environment).

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 migratory fish and important allocthonous input for macroinvertebrate shredders. Riparian zone planting both as part of watercourse realignments and as existing habitat enhancement has been described in Appendix A40.1 (Terrestrial Habitats Survey Report) and Appendix A40.5 (Otter Survey Report).

6.4.5 As part of the scheme maintenance schedule, riparian zone management plans must be developed to ensure that:

- channels do not become choked with vegetation;
- pest species such as Japanese knotweed do not establish; and
- riparian zone diversity is maintained.

6.4.6 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 Where mitigation measures are not completely effective in dealing with the source of potential adverse impacts, residual impacts may be evident. The predicted residual impacts for watercourses that were assessed with potential impacts of Moderate or above (in Section 5) are presented in Table 22.

Direct Mortality

7.1.2 If spawning and egg incubation periods are avoided and resident fish are translocated before any de-watering or dredging operations, the magnitude of the local impact would be reduced to low negative and the overall impact would be Negligible.

7.1.3 By avoiding sensitive periods direct mortality from vibration during construction can be prevented, such that residual impacts on direct mortality are Negligible, though behavioural impacts may be of Minor significance.

Habitat Loss

7.1.4 The use of depressed invert culverts will reduce habitat fragmentation as a natural substrate will be retained throughout the structure. The buried structures proposed for Limpet Burn and the Burn of Muchalls will allow the retention of the existing bed and channel structure and minimise habitat loss. Shading by these structures could result in a slight negative impact on aquatic macroinvertebrate species assemblage at currently unshaded sites, potentially reducing food availability for fish. Overall, the impact is likely to be negligible, but where more than one culvert is used for one watercourse (such as Green Burn and Cookney Ditch) the residual impact would increase.

Habitat Fragmentation and Isolation

7.1.5 The use of culverts containing natural substrates and/or single span bridges will avoid the creation of physical barriers or changes to water velocities. Culvert construction will avoid the sensitive periods for migratory fish species in relevant watercourses to avoid behavioural effects and delays in migration resulting in a minor or negligible impact on fish migration (depending upon the value of the watercourse for migratory species).

Disturbance

7.1.6 Avoidance of particular sources of disturbance during sensitive periods (e.g. spawning and the first one third of egg incubation) will result in a Negligible impact.

Pollution and Other Indirect Impacts

7.1.7 Road drainage will be collected and treated using SUDS to minimise the risk of pollution during the operational phase, reducing the risk of accumulation of pollutants in sediment.

Table 22 – Residual Impact Significance for Watercourses in the Fastlink

Watercourse and Evaluation	Crossing(s)	Realignment	Road Drainage	Impact Description	Potential Impact	Mitigation	Residual Impact Significance	
							Construction	Operation
Megray Burn County	92m long culvert at ch0	Realigned length of 951m resulting in lengthening the burn by 49m	Drainage from 2507m of road via detention basins	Release of sediment or pollutants during culvert construction	Moderate	Use best practice during construction to protect water environment such as: minimise area of disturbance, implementation of erosion control measures, periodic monitoring of effectiveness of mitigation (refer to Chapter 39).	Minor	n/a
				Loss of almost 1km of current burn habitat and species		Replacement substrate and transplantation of current substrate. Fish removal prior to works.	Minor	Minor
				Reduction in habitat complexity and alteration of species distribution		Depressed invert culverts with suitable replacement substrate to be installed.	n/a	Minor
Limpet Burn Regional	Buried structure of 69.5m long at ch1400	n/a	n/a	Release of sediment or pollutants during culvert construction	Moderate	Use best practice during construction to protect water environment such as: minimise area of disturbance, implementation of erosion control measures, periodic monitoring of effectiveness of mitigation (refer to Chapter 39).	Minor	n/a
				Reduction in habitat and the complexity of remaining habitat and alteration of species distribution due to shading		Ensure substrate and habitat complexity is retained through minimising disturbance to habitat during construction.	n/a	Minor
Green Burn County	Two culverts, one of 84m long at ch3125 (mainline) and one of 19m at	Realigned length of 342m resulting in lengthening the burn by 258m (mainline) and 323m (side road)	Drains 994m of road (possibly via a swale)	Release of sediment or pollutants during culvert construction and realignment	Moderate	Use best practice during construction to protect water environment such as: minimise area of disturbance, implementation of erosion control measures, periodic monitoring of effectiveness of mitigation (refer to Chapter 39).	Minor	n/a

Watercourse and Evaluation	Crossing(s)	Realignment	Road Drainage	Impact Description	Potential Impact	Mitigation	Residual Impact Significance	
							Construction	Operation
	ch213 (side road).			Reduction in habitat and the complexity of remaining habitat and alteration of species distribution due to shading		Create suitable habitat within, and transfer substrate to, the new realignment channel. Depressed invert culverts with suitable replacement substrate to be installed.	n/a	Minor

8 References

Alabaster, J.S. and Lloyd, R. (1980) Water Quality Criteria for Freshwater Fish. Butterworths, pp. 297

Bratton, J.H. (1990) A Review of the Scarcer Ephemeroptera and Plecoptera of Great Britain. Research and Survey in Nature Conservation No 29. Nature Conservancy Council, Peterborough UK, pp. 40

CIRIA (2000) Sustainable Urban Drainage Systems: Design Manual for Scotland and Northern Ireland. CIRIA C521, Construction Industry Research and Information Association, Dundee.

Croft, P.S. (1986) A Key to the Major Groups of British Freshwater Invertebrates. Field Studies 6: 531-579

Cosgrove, P.J., Young, M.R., Hastie, L.C., Gaywood, M. and Boon, P.J. (2000) The Status of the Freshwater Pearl Mussels *M. margaritifera* Linn. in Scotland. Aquatic Conservation: Marine and Freshwater Ecosystems 10: 197-208

Dando, P.R. (1984) Reproduction in Estuarine Fish. In G.W. Potts and R.J. Wootton (eds), Fish Reproduction – Strategies and Tactics. Academic Press, London, pp. 155-70

Highways Agency (1998) Design Manual for Roads and Bridges: Water Quality and Drainage, Volume 11, Section 3, Part 10. HMSO, London.

Environment Agency (1998) River Habitat Quality; the Physical Character of Rivers and Streams in the UK and Isle of Man. Environment Agency, Bristol.

Environment Agency (2003) River Habitat Survey Methodology. Environment Agency, Bristol.

Extence, C.A., Balbi, D.M. and Chadd, R.P. (1999) Fiver Flow Indexing using British Benthic Macroinvertebrates: A framework for setting hydroecological objectives. Regulated Rivers: Research and Management 15: 543-574

Furse, M.T., Moss, D., Wright, J.F. and Armitage, P. (1984) The Influence of Seasonal and Taxonomic Factors on the Ordination and Classification of Running-Water Sites and on the Prediction of their Macro-Invertebrate Communities. Freshwater Biology 14: 257-280

Hadderingh, R.H. and Smythe, A.G. (1997) Deflecting Eels from Power Stations with Light. Paper presented at the EPRI Fish Passage Workshop, Millwaukee, Wisconsinm May 6th-8th 1997. Electric Power Research Institute, Palo Alto, USA

Highways Agency (1998) Design Manual for Roads and Bridges: Volume 11 Environmental Assessment. HMSO, London.

Hynes, H.B.N. (1993) Adults and Nymphs of British Stonefiles (*Plecoptera*) Freshwater Biological Association Publication 17.

IEEM (2005) Guidelines for Ecological Impact Assessment. Consultation Draft. Institute of Ecology and Environmental Management, Winchester, UK.

ISO-BMWP (1979) Assessment of the Biological Quality of Rivers by a Macro- invertebrate Score. ISO/TC147/SC5/WG6/N5, International Organization for Standardization, Geneva

Jensen, J. (1997) Mechanical Shock Sensitivity in salmonid eggs. In: C.Clarke; Aquaculture Update. No 78.

Maitland, P.S. (2003) Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough

McDowall, R.W. (1988) Diadromy in Fishes: Migrations between Freshwater and Marine Environments. Croom Helm, London pp. 308

Ratcliffe, D.A. (ed) (1977) A Nature Conservation Review, Vol 2. Cambridge University Press, Cambridge

Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003. HMSO, London.

SEERAD (2000) River Crossings and Migratory Fish: Design Guidance. A Consultation Paper for the Scottish Executive, Edinburgh.

SEPA (2002) The Future for Scotland's Waters, Guiding Principles on the Technical Requirements of the Water Framework Directive, Scottish Environment Protection Agency, Stirling.

SEPA (2002) SEPA River Classifications (1996-2002). SEPA, Stirling. www.sepa.org.uk

Smith, I.P. and Smith, G.W. (1997) Tidal and Diel Timing of River Entry by Adult Atlantic Salmon and Returning to the Aberdeenshire Dee, Scotland. Journal of Fish Biology 50, (3) 463-474

Smith, I.P. Johnstone, A.D.F. and Smith, G.W. (1997) Upstream Migration of Adult Atlantic Salmon Past a Fish Counter Weir in the Aberdeenshire Dee, Scotland. Journal of Fish Biology 51, (2) 266-274

Turnpenny, A.W.H., Thatcher, K.P., Wood. R. and Loeffelman, P.H. (1993) Experiments on the Use of Sound as a Fish Deterrent. Fawley Aquatic Research Laboratories Ltd, report on the Energy Technology Support Unit (ETSU), Harwell, Didcot, Oxfordhsire, Contractors Report No. ETSU T/04/00171/REP

Webb, J.H. and McLay, H.A. (1996) Variation in the Time of Spawning Atlantic Salmon (*Salmo salar* L.) and its Relationship to Temperature in the Aberdeenshire Dee, Scotland. Canadian Journal of Fisheries and Aquatic Sciences 53, 2739-2744

Wheeler, A. (1969) The Fishes of the British Isles and North West Europe. Macmillan, pp. 613

Wright J.F., Moss D., Armitage, P.D. and Furse M.T. (1984) A Preliminary Classification of Running Water Sites in Great Britain based on Macro-Invertebrate Species and Prediction of Community Type using Environmental Data. Freshwater Biology, 14, 221-256.

Youngson, A.F. Jordan, W.C. and Hay, D.W. (1994) Homing of the Atlantic salmon (*Salmo salar* L.) to a Tributary Spawning Stream in a Major River Catchment. Aquaculture, 121, 259-267