Aberdeen Western Peripheral Route

Appendix 39.3 – Water Quality

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Contents

1 Introduction

1.1 General Background

1.1.1 This report is a technical appendix of Chapter 39 (Water Environment) of the Environmental Statement for the Fastlink section of the proposed Aberdeen Western Peripheral Route (AWPR).

1.1.2 This report presents the baseline conditions, potential impacts and mitigation to protect the water quality of watercourses that would be affected by the proposal. The assessment examines the potential impacts during construction and operation of the proposed scheme.

1.1.3 Water is a resource that is essential to all animal and plant life. It is also necessary for industry, agriculture, and waste disposal, many forms of transport, recreation and sport. The maintenance and improvement of the quality of our drinking water, watercourses, groundwater resources and coastal waters is central to Government and European policy.

1.1.4 The EC Water Framework Directive (WFD), which is transposed into Scottish law by the Water Environment and Water Services (Scotland) Act, 2003. The WFD aims to classify surface waters according to their ecological status and sets targets for restoring/improving the ecological status of waterbodies. Under the WFD, the status of water is to be assessed using a range of parameters including chemical, ecological, morphological and hydrological measures, which provides a holistic evaluation of the aquatic ecological health. Furthermore, there is a requirement under the WFD for natural water features to reach good ecological status by 2015 (WFD, 2000/60/EC). Some waterbodies may be designated as artificially/heavily modified and will have less stringent targets to meet. However, these areas will still need to demonstrate 'good ecological potential' by the year 2015 (SEPA, 2002).

1.1.5 In addition, under the WFD the Controlled Activities (Scotland) Regulations 2005 (CAR) state that it is an offence to discharge to all wetlands, surface waters and groundwaters without CAR authorisation. There are three different types of authorisation under CAR, General Binding Rules (GBR), Registration and License (both simple and complex). The level of regulation increases as the activity poses a progressively deleterious impact on the water environment. The level of authorisation required for the AWPR is dependent on the activity proposed, but is likely to range from GBR, covering some construction activities and outfalls, to licenses required for outfalls (draining over 1km of road in length), culverting and watercourse realignment.

1.1.6 In 1974, a river quality classification scheme was developed to monitor the quality of all rivers in Scotland. The scheme has been expanded over the years to reflect the implementations of relevant EC Directives such as the EC Directive 75/440/EEC relating to the quality of water for abstractions from watercourses for human consumption, the EC Dangerous Substances Directive 76/464/EEC, the EC Freshwater Fish Directive 78/659/EEC, the Nitrates Directive 91/676/EEC. These regulatory instruments are incorporated within the Water Framework Directive 2000/60/EC.

1.1.7 Since the formation of the Scottish Environment Protection Agency (SEPA) in 1996, the river classification scheme has been enhanced and specific targets have been set up to protect watercourses with good and excellent water quality and to improve the quality of rivers classed as poor or seriously polluted.

1.2 Assessment Aims

1.2.1 The aim of the water quality report is to assess the impact of the proposed road drainage system and outfalls on the water quality of the receiving watercourses.

1.2.2 The report presents the baseline water quality conditions of all the watercourses situated within the study area, followed by a pollution assessment. Using the procedure set out in the Design Manual for Roads and Bridges (DMRB), Volume 11, Section 3, Part 10, pollution calculations were performed for each of the road drainage outfalls. The potential annual average (AA) and ninety-five percentile (95-percentile) concentrations, for designated major indicator pollutants, were calculated to identify the levels of mitigation required in the receiving watercourse.

2 Approach and Methods

2.1 General Approach

2.1.1 The assessment was carried out using the general methodology detailed in Chapter 39 (Water Environment), where the level of significance of a predicted impact is assessed based on the sensitivity of the receptor and the magnitude of impact. The system of assessment used followed the basic methodology detailed below:

- assess the baseline;
- determine the potential impacts on water quality of water features:
  i. pollution (both soluble and insoluble); and
  ii. accidental spillage;
- suggest mitigation measures for the potential impacts; and
- assess the residual impacts, taking into account the stated mitigation measures.

2.1.2 Potential impacts of the scheme on fluvial geomorphology and surface water hydrology have been assessed separately (refer to Appendix A39.2: Fluvial Geomorphology and Appendix A39.1: Surface Water Hydrology). The potential impacts to watercourses from fine sediment release is discussed in detail in the Fluvial Geomorphology assessment (Appendix A39.2).

2.1.3 An impact to water quality may have associated impacts upon aquatic ecology. These impacts are discussed in more detail in Chapter 40 (Ecology and Nature Conservation) and its associated appendices.

2.1.4 For the purposes of this assessment, the criteria used to assess the sensitivity of surface water features and the magnitude of the predicted impact are defined in Table 1 and Table 2. As part of the water quality criteria, the ecological designations of the watercourses and the surrounding areas have also been included to build a more comprehensive sensitivity evaluation and to create a close link with the Freshwater Ecology assessment. The resultant impact significance is defined by reference to both the sensitivity of the water feature and the magnitude of impact, according to the matrix presented in Table 3.

Table 1 – Criteria to Assess the Sensitivity of Water Features

Sensitivity	Surface Water Quality Criteria
High	Large or medium watercourse with pristine or near pristine water quality, Class A1 and A2 (Annex 25), respectively. Water quality not significantly affected by anthropogenic factors. Water quality complies with Dangerous Substances Environmental Quality Standards (EQS). Water quality does not affect the diversity of species of flora and fauna. Natural or semi-natural ecosystem with sensitive habitats and sustainable fish population. Includes sites with international and European nature conservation designations due to water dependent ecosystems: e.g. Special Protection Area, Special Area of Conservation, Ramsar Site and EC designated freshwater fisheries. Also includes all nature conservation sites of national and regional importance designated by statute including Sites of Special Scientific Interest, National Nature Reserves and Natural Areas (part of the Regional BAP).
Medium	Medium or small watercourse with a measurable degradation in its water quality as a result of anthropogenic factors (may receive road drainage water), Class A2 or B (Annex 25). Ecosystem modified resulting in impacts upon the species diversity of flora and fauna in the watercourse. Moderately sensitive habitats. Includes non-statutory sites of regional or local importance designated for water dependent ecosystems.
Low	Heavily modified watercourses or drainage channel with poor water quality, resulting from anthropogenic factors, corresponding to Classes B, C and D. Major change in the species diversity of flora and fauna due to the significant water quality degradation. May receive road drainage water. Fish sporadically present. Low sensitivity ecosystem of local and less than local importance.

Table 2 – Criteria to Assess the Magnitude of Potential Impacts

Magnitude	Surface Water Quality Criteria
High	General Operational Impact Major shift away from the baseline conditions, fundamental change to water quality condition either by a relatively high amount over a long-term period or by a very high amount over an episode such that watercourse ecology is greatly changed from the baseline situation. Equivalent to downgrading from Class B to D or any change that downgrades a site from good status as this does not comply with the Water Framework Directive. Routine Runoff Specifically for the purposes of the soluble pollution assessment, a high impact will be classed as an increase to copper or zinc concentrations of 100% or greater over the baseline situation, plus/or a failure of EQS for either pollutant. Accidental Spillage For the purposes of this assessment, a high impact will be classed as an accidental spillage risk below the probability threshold level of 1 in 100 or 1 in 50 years (see the Impact Assessment Methodology section below).
Medium	General Operational Impact A measurable shift from the baseline conditions that may be long-term or temporary. Results in a change in the ecological status of the watercourse. Equivalent to downgrading one class, for example from C to D. Routine Runoff Specifically for the purposes of the soluble pollution assessment a medium impact will be classed as an increase to copper or zinc concentrations of 60%-99% over the baseline situation, plus/or a failure of EQS for either pollutant. Accidental Spillage For the purposes of this assessment, a medium impact will be classed as an accidental spillage risk above the probability threshold level of 1 in 100 or 1 in 50 years (see the Impact Assessment Methodology section below) with up to 1 in 200 years.
Low	General Operational Impact Minor shift away from the baseline conditions. Changes in water quality are likely to be relatively small, or be of a minor temporary nature such that watercourse ecology is slightly affected. Equivalent to minor, but measurable change within a class. Routine Runoff

Magnitude	Surface Water Quality Criteria
	Specifically for the purposes of the soluble pollution assessment a low impact will be classed as an increase to copper or zinc concentrations of 25%-59% from the baseline situation but all EQS levels are met. Accidental Spillage For the purposes of this assessment, a low impact will be classed as an accidental spillage risk above 1 in 200 and below 1 in 1000 years.
Negligible	General Operational Impact Very slight change from the baseline conditions such that no discernible effect upon the watercourse's ecology results. No change in classification Potential impact through diffuse means, e.g. pollution via sub-surface paths or deposits from air borne road pollution near river crossings. Routine Runoff Specifically for the purposes of the soluble pollution assessment, a negligible impact will be classed as an increase to copper or zinc concentrations of 24% or less over the baseline situation but all EQS levels are met. Accidental Spillage For the purposes of this assessment, a negligible impact will be classed as an accidental spillage risk above probability threshold level of 1 in 1000 years.

Table 3 – Impact Significance Matrix

Sensitivity / Magnitude	High	Medium	Low
High	Substantial	Moderate/Substantial	Moderate
Medium	Moderate/Substantial	Moderate	Slight
Low	Moderate	Slight	Negligible
Negligible	Slight/Negligible	Negligible	Negligible

2.2 Background to Potential Pollutants

2.2.1 Potential sources of road runoff contamination are diverse and may be generated from road construction works, traffic, maintenance (including the application of de-icing salts), accidental spillage and from other sources such as atmospheric deposition. Road-associated contaminants that are considered to have the greatest potential impact on receiving waters include suspended solids, hydrocarbons, metals, pesticides and herbicides, de-icing agents, nutrients and those arising from accidental spills. Although the pollutants present in road runoff are very diverse in form and origin, they can be grouped into categories (DMRB, Highways Agency et al., 1993):

- insoluble (likely to settle on the bed or float on the surface of a watercourse),
- soluble (affecting water quality and/or aesthetic values), and
- those arising from accidental spillage (which are concentrated).

2.2.2 Insoluble pollutants include vehicle oil and other hydrocarbons, and suspended solids (the solid fraction of the road runoff). The solid fraction of a road discharge may contain up to 70% of the all oil deposited onto a road by moving vehicles, over 90% of all the inorganic lead, 70% of the copper and 56% of the cadmium. Removing coarse solids and a significant proportion of the fine (insoluble) solids from the road discharge is understood to remove much of the potentially polluting load (DMRB, Highways Agency et al., 1993).

2.2.3 The soluble pollutants group comprise of dissolved metals, organic toxic substances such as most herbicides and pesticides, de-icing salt and alternative de-icing agents and nutrients. Some of these may enter the watercourse in high concentrations, causing localised acute impacts on the aquatic environment (e.g. accidental spillage) or could accumulate in the freshwater habitats and cause long term chronic damage to the organisms living in the river (e.g. heavy metals entering the watercourse through road drainage discharge). The DMRB sets out accepted methods for quantifying the risk of pollution arising from accidental spillage and indicative soluble pollutants, zinc and copper, in the road runoff. Additionally new research (Patel and Drieu, 2005) indicates that more determinants may be considered in the future, particularly total suspended solids (TSS), nutrients and biological oxygen demand (BOD). Where possible, this report and the Fluvial Geomorphology report (Appendix A39.2) include qualitative assessment of the potential impacts to watercourses from TSS.

2.2.4 The adopted methods for carrying out the assessment are described in the DMRB Volume 11, Section 3, Part 10 (Highways Agency et al., 1993). Quantification of the impacts of road drainage on water quality is based on calculating the accidental spillage risk (expressed as return periods) and the predicted concentrations of dissolved copper and total zinc in the receiving waters in the design year (2025) of the proposed scheme. These metals are used as indicators of the level of impact as they are generally the main metallic pollutants associated with road drainage and can be toxic to aquatic life in certain concentrations. Lead is not included as it has low solubility and, when in its insoluble form, its low toxicity means that biological impacts would not be anticipated (Highways Agency et al., 1993).

2.2.5 For the rest of the soluble pollutants (nutrients, de-icing agents, herbicides and pesticides), there are no uniform evaluation methods described in the DMRB, therefore the assessment was made qualitatively. Their adverse impact magnitude on water quality is considered to be localised and seasonal. The use of de-icing agents during the winter months would be rapidly diluted and dispersed causing temporary and highly localised adverse ecological effect (Highways Agency et al., 1993). Nutrients (ammonia, oxidised nitrogen and phosphates) are found in very small quantities in road runoff (The Highways Agency et al., 1993). Herbicides and pesticides treatment of the verge during road maintenance is also a potential source of contamination and should follow best environmental practice guidance with the selection of degradable compounds.

2.2.6 The water quality assessment of the impacts of insoluble pollutants, such as total suspended solids and hydrocarbons, released during the operational phase, was made using dilution factor criteria of the average flow Q_{mean} in the receiving watercourse. Further assessment is provided in Appendix 39.2 (Fluvial Geomorphology).

2.2.7 The requirements of the EC Water Framework Directive have also been taken into account when assessing the impacts of the proposed scheme on water resources, using the recent policy guidance 'The Future for Scotland's Waters, Guiding Principles on the Technical Requirements of the Water Framework Directive' (SEPA, 2002).

2.3 Impact Assessment Methodology

Baseline Assessment

2.3.1 Water quality baseline conditions for watercourses were identified through consultation with statutory consultees, review of relevant published literature, site visits and physiochemical and freshwater habitat sampling data collection undertaken in the summer of 2006 (refer to Appendix A40.9: Freshwater Ecology).

2.3.2 Baseline conditions for watercourses are reported by SEPA following their River Classification Scheme (Annex 25, SEPA Classification Scheme). This categorises watercourses on the basis of monitoring water chemistry, biology, nutrient status, aesthetic condition and concentration of toxic substances (Annex 25, SEPA Classification Scheme). There are five classes comprising A1, A2, B, C and D in decreasing order of quality. Class A1 is excellent and Class D is seriously polluted. The class allocated to a particular reach of watercourse defaults to the poorest class determined from the water chemistry, biology, nutrient, aesthetics and toxicity assessments. No attempt is made to assign zones of intermediate quality between stretches differing by more than one class (Annex 25, SEPA Classification Scheme).

2.3.3 The SEPA classification includes all rivers with a catchment area of 10km^2 or more and specific smaller rivers where known pollution problems exist. This is called the "classification network". The classification network is divided into river stretches at confluences and pollution pressures. Every stretch is assigned a monitoring point where chemical and ecological surveys are taken and the aesthetic appearance recorded (Annex 25, SEPA Classification Scheme). The quality or "class" of a length of river is calculated from the monitoring point results.

2.3.4 The freshwater habitat sampling was conducted as to provide a snap-shot of the conditions of the watercourses. The adopted methodology included a macroinvertebrate spot sampling (method described in detail in Appendix A40.9: Freshwater Ecology) to identify abundance and species richness and water chemistry measurements for dissolved oxygen, pH, conductivity, temperature and water hardness. Although the chemical measurements provide only information for the water quality of the passing water at the time of sampling, the biological samples indicate the longer term impact of the water quality on the freshwater organisms.

Impact Assessment

2.3.5 There are six main types of impacts to watercourses that could potentially arise from the proposed scheme:

- impacts due to routine road runoff on surface waters (both soluble and insoluble pollution);
- impacts of accidental spillage to surface waters;
- impacts on groundwater resources (which will be discussed in detail in Chapter 38: Geology, Contaminated Land and Groundwater);
- where necessary the impacts on fluvial geomorphology and sediment release (discussed in detail in Appendix A39.2: Fluvial Geomorphology);
- impacts on hydrology (discussed in detail in Appendix A39.1); and
- impacts on water quality during construction.

Routine Runoff

2.3.6 Routine runoff is surface water collected from the road as a result of rain falling on the road surface and draining into the highway drainage system. In this assessment, routine runoff contains the pollutants deposited on the road surface, but does not include seriously polluted runoff assessed separately as a result of vehicular collision (which is referred to as accidental spillage).

2.3.7 The water quality assessment was carried out in accordance with the methods set out in DMRB Volume 11, Section 3, Part 10, taking cognisance of more recent research such as 'Pollutant Build up and Runoff on Highways: Expanding the Current Methodology for Additional Determinants' (Patel and Drieu, 2005). The DMRB method assesses the impact of the main metallic pollutants copper and zinc on the water quality of the receiving waters, following a series of calculations to predict the concentrations of dissolved copper and total zinc in the receiving watercourse. The predicted concentrations are compared with the baseline conditions and the Environmental Quality Standards (EQS). The EQS are principally ecological standards, specified for a range of parameters at levels required to protect aquatic life. These are set by the Freshwater Fisheries Directive (FWFD) and Dangerous Substances Directive (DSD), List II Substances and transposed into the Scottish law by Statutory Documents Circular No34/1995 (SEPA, pers.comm. D. Caffrey, 2005).

Calculations of the 95-percentile Concentration

2.3.8 The DMRB methodology specifies that potential pollution should be calculated assuming a high rainfall event coinciding with a low flow event in the receiving watercourse (Q_{95} low flow parameter). The DMRB states that this calculated concentration can then be compared to the statutory EQS that exist for the FWFD. These are expressed as 95-percentile values. The 95th percentile is the concentration that is exceeded for only 5% of the time and therefore would only be expected to occur very rarely.

Calculations of the Annual Average Concentration

2.3.9 In addition to the FWFD, the DSD sets statutory EQS for dissolved copper and total zinc, expressed as annual average values. To ensure that the drainage proposals conform to the DSD, the DMRB methodology requires a modification to predict a likely annual average concentration in the receiving watercourse. Consultation and ongoing discussion with SEPA, for this and other projects, resulted in an agreed modification to predict potential, indicative annual average values in the receiving watercourse (SEPA, pers.comm. D. Clark, 2004 and SEPA, pers.comm. N. Abrams, 2005). The modified methodology specifies that the potential pollution in the receiving watercourse is calculated assuming the annual average rainfall occurs on one day coinciding with a mean flow event in the receiving watercourse (Q_{mean} average flow in the watercourse). These replace the depth of rainfall indicated in Figure A.1 of the DMRB (2006) (95 percent storm) and the Q_{95} flow in the receiving watercourse.

Assessment Process

2.3.10 A precautionary approach has been adopted for the assessment of water quality along the route and both annual average and 95-percentile potential pollution calculations were performed for all receiving watercourses. These predicted concentrations were then used to inform the impact assessment, and therefore the mitigation design. Following the precautionary approach, the more stringent of the two methods (annual average or 95-percentile) was used to design mitigation.

2.3.11 The assessment of routine runoff requires data on:

- the upstream concentrations of dissolved copper and total zinc in each watercourse;
- an indication of receiving water's hardness;
- an estimate of the total impermeable area of road surface to be drained to each outfall;
- the runoff coefficient of the proposed scheme;
- traffic flow data;
- rainfall data;
- the mean flow (Q_{mean}) of the receiving watercourse and the 95th percentile flow (Q_{95} or low flow); and
- the relevant statutory EQS values for the receiving watercourse (provided by SEPA, Table 4).

2.3.12 Where there was an absence of long term monitoring data specific to the watercourses in the study area, the following approach was adopted:

- the upstream concentrations of dissolved copper and total zinc in each watercourse are assumed to be half the EQS (as detailed in DMRB guidance);
- receiving water hardness is based on the spot sampling results measured during the freshwater ecological survey (summer 2006, Jacobs). The data were only indicative and were used to

identify the hardness range in which each watercourse is situated (Annex 28 Pollution Calculation Sheets);

- as data were only available from spot sampling, rather than continued monitoring, a sensitivity check on the assumed hardness bandings was performed, i.e. calculations were undertaken for the assumed hardness banding, in addition to the bandings immediately above and below, where possible. This was taken into consideration when designing the mitigation.
- the total impermeable area of road surface is provided by highways design engineers;
- the runoff coefficient of the proposed scheme is 0.75 (Maidment, 1993);
- traffic flow data for the design year: used traffic predictions for 2025, provided by traffic modellers;
- rainfall data were obtained from the DMRB (2006) and DMRB (1993) (Figure A1: Depth of Rain for Assessing Pollutant Runoff (95% storm) and Figure 3.2: Average Annual Rainfall 1941 – 1970), respectively;
- the Q_{95} and Q_{mean} were estimated, using methods detailed in Appendix A39.1 (Surface Water Hydrology); and
- relevant EQS for dissolved copper and total zinc are provided in Table 4. The assessment uses the statutory guidance to determine the level of impact of the scheme upon the receptor (receiving watercourse).

2.3.13 The values presented represent the more stringent target of either the DSD or the FWFD.

Environmental Quality Standards

2.3.14 The EQS for freshwater vary with water hardness, as hardness affects the solubility of metals. The relevant EQS for the protection of all freshwater aquatic life are given in Table 4 (SEPA, pers.comm. D. Caffrey, 2005 and Statutory Instrument (SI) Circular No34/1985). These values differ slightly to those published on the SEPA website at the time of this assessment. However, SEPA (SEPA, pers. comm. D. Caffrey, 2005) directly advised Jacobs to use the values reported in Table 4 (SI Circular No34/1985) in preference to those published on the website, as it is understood that those on the website are not yet statutory.

Table 4 – National Environmental Quality Standards (EQS) for the Protection of all Freshwater Life

Parameter	Hardness Range (mg/l $CaCO_3$)	EQS (µg/l) (annual average)	EQS (µg/l) (95-percentile)
Copper (dissolved)	0-10	1	5
	10-50	6	22
	50-100	10	40
	100-250	28	112
	> 250	28	112
Total Zinc	0-10	8	30
	10-50	50	200
	50-100	75	300
	100-250	125	500
	> 250	125	500

Source: Guidelines for Copper and Total Zinc from DMRB, Table 2 River Ecosystem Classification (The Highways Agency *et al.*, 1993) and Statutory Levels as provided by SEPA (personal communication, SEPA, 2005). Taken from the statutory documents (Circular No34/1985) accompanying the DSD and FWFD.

Insoluble Pollutants, Suspended Solids

2.3.15 Currently, there are no recommended sediment quality or quantity standards to use as reference points for assessing the impacts of the solid load of road runoff. The removal of coarse and a significant proportion of the fine (settleable) solids from road discharges, using appropriate treatment systems, will remove much of the potentially polluting load. As most of the polluting load is associated with the solid and settleable phase of treatment, insoluble pollutants are considered to be of greater importance in assessing the environmental effects of runoff (Highways Agency et al., 1993). The assessment of the impact of solids on the watercourses is qualitative, with the greatest potential impacts being likely to occur in the following situations, where:

- the flow pattern in the receiving water is such that fine sediments may accumulate to significant levels within a short distance downstream of the proposed outfall and that area of watercourse has significant ecological or high amenity value;
- available dilution for the road discharge is low;
- the receiving water has existing discharges which are causing solids pollution in the immediate vicinity of the discharge; and
- there is water abstraction downstream of the outfall that could be affected.

Risk of Accidental Spillage

2.3.16 Along any road, there is a risk of vehicular collision that can result in spillage of fuels, oils or chemicals, particularly if tankers are involved. A risk assessment of a serious spillage causing pollution was undertaken using the methodology outlined in the DMRB guidance.

2.3.17 The risk was calculated assuming that an accident involving spillage of pollutants onto the carriageway would occur at an assumed frequency, based on the predicted traffic volumes for the design year and the type of road/junction (Table 5). It is also assumed that pollutants spilled on the carriageway would subsequently pass through the road drains and cause a pollution incident in the receiving watercourse without mitigation. The probability of a serious accidental spillage leading to a serious pollution incident would also depend upon the emergency services' response time. A risk factor is applied depending on the response time and the quality of the receiving watercourse (Table 6).

Table 5 – Serious Accidental Spillages per Million HGV (km/year)

Junction Type	Urban Motorway	Rural Motorway	All Purpose Road (Urban)	All Purpose Road (Rural)
No junction	0.0022	0.0014	0.0039	0.0017
Slip Road*	0.0032	0.0023	0.0058	0.0035
Side Road*	-	-	0.0106	0.0042
Roundabout*	-	-	0.0296	0.0119
Cross Road*	-	-	0.0159	0.0044
Overall	0.0024	0.0019	0.0075	0.0025

Source: DMRB Volume 11, Section 3 (The Highways Agency *et al*., 1993).

Note: * Risk factor applies to all road lengths within 100 m of these junction types and for a 200m length of the all purpose road centred on the junction itself.

Table 6 – Probability of a Serious Accidental Spillage Leading to a Serious Pollution Incident

Receiving Watercourse	Emergency services response time to site is within 20 minutes	Emergency services response time to site exceeds 20 minutes
High Quality Watercourse	0.45	0.75
Moderate Quality Watercourse	0.3	0.5
Aquifer	0.3	0.3

Source: DMRB Volume 11, Section 3 (The Highways Agency et al., 1993).

2.3.18 The probability of serious accidental spillage was calculated as follows:

$$P_{acc} = RL \times SS \times (AADT \times 365 \times 10^{-6}) \times (\%HGV \div 100)$$

where:

P_{acc} = probability of a serious accidental spillage in 1yr over a given road length

RL = road length in kilometres

SS = serious spillage rates from Table 5 (or local data if available)

AADT = annual average daily traffic

%HGV = percentage of Heavy Goods Vehicles

The probability that a spillage will cause a pollution incident is calculated thus:

$$P_{pol}/year = P_{acc} \times P_{pol}$$

Where, P_{pol} = the risk reduction factor, dependent upon emergency services response times, which determines whether a serious spillage will cause a serious pollution incident. The value is to be selected from Table 6, using the quality of the reach proposed to receive the discharge.

2.3.19 The acceptable risk of pollution incident should normally be at a level of 1 in 100 years for discharges to aquifers and to reaches of sensitive watercourses. For all other receiving waters, the acceptable risk should normally be 1 in 50 years. The calculations were performed using the worst-case scenario data (Highways Agency et al., 1993).

Pre-Earthworks

2.3.20 Pre-earthwork ditches are a series of drains which run alongside the road, either at the toe of embankments or the top of cuttings, collecting clean water runoff from the surrounding land. The ditches then discharge to the local larger watercourse. This can be thought of as a re-direction of predominantly ephemeral watercourses, or their severed catchments. Watercourses that would be taken into pre-earthworks are not assessed for the operational phase as a section of these burns would no longer exist during operation of the proposed scheme. However, construction impacts are considered in detail.

Loss of Watercourse

2.3.21 In some situations, part of the upper catchment of a watercourse may be lost during the construction phase as a result of catchment severance by the road. In this instance, the catchment feeding the watercourse will be cut off. Watercourses that would be affected by catchment severance, as with pre-earthwork ditches, are not considered during the operational phase as they are assumed to disappear after the construction phase.

Construction Impacts

2.3.22 For the purpose of this assessment, the combination of different engineering activities (construction of water crossings, realignment of the watercourse channel, modification of the riverbanks, vegetation removal) that would be carried out within the vicinity of a watercourse, as well as the extent of the proposed works, was taken into consideration. Available dilution of the watercourse was considered when assessing the potential impact of total suspended solids and accidental spillage during construction. Flow patterns, fisheries or environmental status of the watercourse, receiving body and existing abstractions were also considered in the assessment.

2.3.23 The watercourses to be taken into pre-earthworks would experience higher impacts during the construction phase. The earthworks involved could potentially result in sediment release and a large increase of total suspended solids downstream of the area of construction.

2.4 Limitations to Assessment

2.4.1 The water quality assessment is limited, to a certain extent, by the amount of available data and by the predictive methods available to complete a more rigorous assessment. Following the DMRB guidance, the assessment was carried out only for the main indicator metals (copper and zinc) and accidental spillage risk using a simple calculation model to predict, respectively, the annual pollution concentrations and the return periods. Although these are 'conservative' methods, the predicted values are sensitive to potential changes in input concentrations and receiving flows. Additionally, new research (Patel and Drieu, 2005) indicates that more determinants may be considered in the future, particularly total suspended solids (TSS), nutrients and BOD. Where possible, this report, and the Fluvial Geomorphology report (Appendix A39.2) assess the impact to the watercourses of TSS.

2.4.2 The baseline water quality assessment was conducted using chemical data (for the period 1988-2005) and biological data (for the period 2000-2005) data provided by SEPA (SEPA, 2005) and spot sampling measurements conducted by Jacobs in the summer of 2006. However, no zinc or copper monitoring data was provided by SEPA for the Burn of Muchalls. Spot sampling results provide only a snapshot of the water quality conditions in the watercourse at the time when the sample was obtained. These spot sampling results do not equate to monitoring data and they do not provide information on the long-term health of the watercourse.

2.4.3 There are a number of assumptions inherent in using the DMRB assessment methods. In the absence of upstream concentrations of copper and zinc in the affected watercourses, the concentrations have been assumed to be half the EQS, as recommended in the DMRB guidance. Flows also are generally represented using low flow data (details given in Surface Water Hydrology: Appendix A39.1). These methods, while simple, tend to err on the conservative side and have been used principally in the design of mitigation features as an indicator of the levels of treatment required.

3 Baseline

3.1 Introduction

3.1.1 The Fastlink section of the proposed scheme would pass over or within the vicinity of a number of watercourses. Some of these are open, vegetated watercourses running through predominantly rural areas, while others are more heavily modified and partially culverted (Figures 39.1a-f).

3.1.2 The surface water features of each catchment can be divided into three main types:

- major watercourses;
- minor watercourses; and

- lochs and waterbodies.

3.1.3 There are 19 watercourses and a wetland area that have the potential to be affected by construction or operation of the proposed scheme (refer to Table 7).

Table 7 – Waterbodies Potentially Affected by the Proposed Scheme

Type	Waterbody
Major Watercourse	Burn of Muchalls
Minor Watercourse	Megray Burn
	Limpet Burn
	Coneyhatch Burn
	Green Burn
	Green Ditch
	Allochie Burn
	Burn of Blackbutts
	Cookney Ditch
	Stoneyhill Ditch
	Balnagubs Burn
	Tributary of Elsick Burn
	Whiteside Burn
	Crossley Burn
	Cairns Burn
	Circle Burn
	Square Burn
	Wedderhill Burn
	Craigentath Burn
Lochs and Waterbodies	Fishermyre

3.1.4 Waterbodies within the vicinity of the proposed scheme that have been identified as important ecological habitats are assessed in this report and are also further detailed in Chapter 40 (Ecology and Nature Conservation and relevant appendices).

3.1.5 The Burn of Muchalls begins southeast of the Red Moss of Netherley SAC and flows in a south-easterly direction, collecting flow from a number of tributaries along its length including the Burn of Blackbutts, Green Burn and Back Burn, before flowing to the North Sea. Limpet Burn, of which Coneyhatch Burn is a tributary, drains a small catchment area located south of the Burn of Muchalls and discharges directly into the North Sea.

3.1.6 The Tributary of Elsick Burn is a watercourse that rises on the eastern slope of Stranog Hill and drains in an easterly direction through a ‘v’ shaped valley before entering the North Sea at Newtonhill Bay. Along its length, the Tributary of Elsick Burn is joined by other smaller watercourses such as Balnagubs Burn, North Rothnick and East Rothnick Burns. Cairns Burn, Whiteside Burn, Cairnfield Burn, Crossley and East Crossley Burns also form part of the Tributary of Elsick Burn catchment.

3.1.7 Megray Burn flows in a southerly direction and forms part of the Cowie Water catchment. All watercourses within the study area are relatively small, with the exception of the Burn of Muchalls.

3.1.8 The baseline section of this report describes each watercourse, providing the upstream catchment area of each watercourse to the point where it would meet the proposed scheme. Additionally, it discusses the water quality based on the data provided by SEPA (for the period 1988-2005) and on spot sampling measurements conducted by Jacobs (summer, 2006). A sensitivity value was also assigned to each watercourse in accordance with Table 1. The sensitivities of all watercourses are summarised in Table 9 at the end of this section.

3.2 Major Watercourses

Burn of Muchalls

3.2.1 The Burn of Muchalls begins southeast of Red Moss, draining an area of approximately 6.7km^2 to the point of crossing of the proposed scheme. Its upper catchment is located in a broad, moderately sloping, well-defined 'v' shaped valley. Further downstream near Burnorrachie Farm, the burn runs through an incised natural valley and flows down into the North Sea after crossing under the Bridge of Muchalls. Private water supplies (groundwater wells) have been identified in close proximity to the watercourse (refer to Chapter 38: Geology, Contaminated Land and Groundwater).

3.2.2 The burn flows mainly through agricultural land. It is crossed by the U88K road and the A90 likely receives road drainage at these locations. Approximately 200m downstream of the existing A90 crossing, the burn is crossed by the North East Mainline railway.

3.2.3 The Burn of Muchalls is currently monitored by SEPA and its water quality has been classified by SEPA as A2 (Good) (Table 8). It is a relatively natural burn that supports brown trout and therefore is classed as being of high sensitivity.

Table 8 – Water Quality Parameters for the Burn of Muchalls*

Parameter (Units)		Burn of Muchalls at Bridge of Muchalls
Category	2004	A2
Temperature (°C)	Aver.	8.6
	Max.	20
	Min.	1.0
BOD (mg/l)	Aver.	1.0
	Max.	7.2
	Min.	0.2
Conductivity (μS/cm)	Aver.	275
	Max.	377
	Min.	133
Dissolved Oxygen (mg/l)	Aver.	11.3
	Max.	13.9
	Min.	8.8
O_2 Saturation (%)	Aver.	96.2
	Max.	109.4
	Min.	72
Total Suspended Solids (TSS) (mg/l)	Aver.	5.46
	Max.	111
	Min.	0.6
pH	Aver.	7.3
	Max.	8.0
	Min.	5.9
Ammonia (mg/l)	Aver.	0.07
	Max.	0.32
	Min.	0.003

Parameter (Units)		Burn of Muchalls at Bridge of Muchalls
Nitrite (mg/l)	Aver.	0.016
	Max.	0.401
	Min.	0.002
O-phosphates (mg/l)	Aver.	0.03
	Max.	0.09
	Min.	0.004

*No data were provided by SEPA for total zinc and dissolved copper (Source: SEPA)
Source: Analysis of SEPA chemistry water quality data (SEPA, 1988 – 2004)

3.3 Minor Watercourses

Megray Burn

3.3.1 Megray Burn is a tributary of Cowie Water, draining an area of approximately 0.6km^2 up to the point of crossing of the proposed scheme. The watercourse rises in Megray Wood and continues to flow in a southerly direction through a ‘v’ shaped valley. It is surrounded mainly by agricultural land which slopes as the burn approaches Cowie Water. It is likely that the burn currently receives road runoff as the watercourse is crossed by an unnamed minor road and the A90. Private water supplies have been identified in the vicinity of the watercourse.

3.3.2 The Burn is currently not monitored by SEPA. The spot sampling results indicate ‘good’ water quality (class A2) and therefore, it has been classed as of medium sensitivity.

Limpet Burn

3.3.3 Limpet Burn begins in agricultural surroundings at the edge of woodlands southwest of Fishermyre, draining a catchment area of approximately 1.3km^2 to the point of crossing of the proposed scheme. It is straightened in its upper reaches, following field boundaries in a south-easterly direction until it reaches the northern boundary of Megray Wood. It then flows through the wood and is crossed by the U89K road, after which it flows through a narrow valley. Near Limpet Wood are two fishing ponds stocked with rainbow trout, which are popular fishing locations. Just before it flows into the North Sea, Limpet Burn is crossed by the A90 and the North East mainline railway.

3.3.4 In the area of interest, the burn flows through a u-shaped valley with a well-developed floodplain. The riparian zone on both riverbanks is comprised of localised wet areas that are likely to be fed by groundwater springs.

3.3.5 Currently, the burn is not monitored by SEPA. However, as this watercourse flows through predominantly agricultural land and woodland, and supports important fishing habitat, Limpet Burn is anticipated to have good water quality and be of high sensitivity.

Coneyhatch Burn

3.3.6 Coneyhatch Burn is a tributary of Limpet Burn that begins at the U88K road north of Fishermyre. Surrounding land use in the catchment is predominantly moorland and Fishermyre wetland with Fishermyre and Coneyhatch farms within close proximity to the watercourse. Coneyhatch Burn drains an area of approximately 0.02km^2 to the point of crossing of the AWPR. It is suspected to be ephemeral in nature and is considered to be of low sensitivity.

Green Burn

3.3.7 Green Burn is a tributary of the Burn of Muchalls, draining an area of approximately 0.8km^2 up to the point of crossing of the proposed scheme. The burn begins east of Fishermyre wetland running in a north-easterly direction through gently sloping moorland, mainly following field boundaries. Midstream, near Cantlayhill Farm, the burn reaches the incised valley of the Burn of Muchalls, where it continues flowing through a shallow 'v' shaped natural channel. Along its length, Green Burn is joined by a number of small field drains and watercourses, including Hillocks Burn and Howieshill Burn. Private water supplies have been identified in the vicinity of the watercourse.

3.3.8 Results from spot sampling in summer of 2006 (Jacobs) indicated the water quality in the upstream section of Green Burn is of category C (poor). It is suspected that this may primarily be due to road drainage discharge from the U167K road. However, as the burn flows through an area of important peatland habitats and supports a population of water voles, it has been classed as being of medium sensitivity.

Green Ditch

3.3.9 This is a small L-shaped ditch that follows field boundaries along its entire length. It begins southwest of Howieshill Farm and flows south through agricultural land until it reaches a farm track where it then flows on an easterly course. Green Ditch has a catchment of approximately 0.02km^2 to the point of crossing of the proposed scheme and likely receives road drainage from the adjacent farm track and agricultural runoff from surrounding lands. It is suspected to be an ephemeral ditch and therefore is considered to be of low sensitivity.

Fishermyre

3.3.10 Fishermyre is a wetland area situated predominantly to the west of the proposed scheme. The area is recognised as an important peatland habitat of dry heath, marsh, wet woodland and semi-natural mixed woodland. It also supports a colony of water voles.

3.3.11 The scheme would pass through the south-eastern corner of the wetland, which is likely to be fed by rainfall and groundwater. Surface water drains in a south-easterly direction through the moss before flowing into Green Burn. Fishermyre is considered to be an area of high sensitivity.

Allochie Burn

3.3.12 Allochie Burn is a straightened tributary of Back Burn draining a catchment area of less than 0.01km^2 to the point of crossing of the proposed AWPR. This watercourse appears to be of an ephemeral nature in its upper reaches. It begins on gently sloping agricultural land at Allochie Croft House, running along field boundaries. Land use in the surrounding area is predominantly agricultural and it is likely that Allochie Burn receives agricultural runoff. Results from spot sampling in the summer of 2006 (Jacobs) indicated good water quality (A2) downstream of the proposed scheme crossing. The burn would only be affected by the proposed scheme in its uppermost reaches. Due to the spot sampling results, this watercourse is considered to be of medium sensitivity.

Burn of Blackbutts

3.3.13 The Burn of Blackbutts is a tributary of the Burn of Muchalls rising near Kirkton on gently sloping land. It is a predominantly straightened burn that has a catchment of approximately 0.2km^2 to the point of the crossing of the proposed scheme and appears to be of an ephemeral nature in its upper catchment. It is crossed by Class C roads twice along its length and once by the A90. At the Bridge of Muchalls, the Burn of Blackbutts joins the Burn of Muchalls before flowing into the North Sea. Private groundwater supplies (groundwater wells) have been identified downstream of the proposed road crossing.

3.3.14 It is likely that the Burn of Blackbutts receives agricultural runoff and road drainage from the roads that cross over it. Although this watercourse is not monitored by SEPA, it is a tributary of the Burn of Muchalls and its condition has been inferred from information on the Burn of Muchalls. The Burn of Blackbutts would only be affected by the proposed road in its very upper reaches and it is classed as a low sensitivity watercourse.

Cookney Ditch

3.3.15 Cookney Ditch begins south of Stoneyhill and flows through moderately sloping land of rough pasture, following field boundaries and draining an area of approximately 0.2km^2 to the point of the proposed road crossing. The ditch is crossed by C24K road at Harecraig. It is likely to receive road drainage and agricultural runoff and therefore considered to be of low sensitivity.

Stoneyhill Ditch

3.3.16 Stoneyhill Ditch is a tributary of Tributary of Elsick Burn. This watercourse is a straightened field ditch that flows along field boundaries and drains a catchment area of approximately 0.2 km^2 up to the point of crossing of the proposed scheme. The burn begins north of Stoneyhill and flows into the Tributary of Elsick Burn. Halfway along its length, Stoneyhill Ditch is crossed by the C24K road.

3.3.17 Although Stoneyhill Ditch is not monitored by SEPA, the Tributary of Elsick Burn has been classed by SEPA as an A2 watercourse, indicating 'good' water quality. Stoneyhill Ditch is likely to receive agricultural runoff and road drainage, consequently it is considered to be of low sensitivity.

Balnagubs Burn

3.3.18 Balnagubs Burn is a tributary of the Tributary of Elsick Burn, draining a catchment area to the point of crossing of the proposed scheme of approximately 0.2km^2. The burn begins at a farm track south of South Rothnick farm and initially flows in an easterly direction over gently sloping ground mainly following field boundaries. Approximately 0.3km downstream, the burn changes course to flow in an overall north-easterly direction until it finally joins with the Tributary of Elsick Burn.

3.3.19 This watercourse is currently not monitored by SEPA and no spot sampling was carried out. However, although the burn may experience nutrient enrichment from surrounding agricultural activities and occasional bank erosion from poaching, its water quality is expected to good. Balnagubs Burn is considered to be of low sensitivity.

Tributary of Elsick Burn

3.3.20 This watercourse is a tributary of Elsick Burn that begins southwest of North Rothnick farm, draining an area of approximately 1.0km^2 to the point of the proposed road crossing. It flows in an easterly direction through predominantly agricultural land before joining Balnagubs Burn. The watercourse is crossed by farm tracks and a minor road. Spot sampling results indicated good water quality (class A2). The Tributary of Elsick Burn has been classed as being of medium sensitivity.

Whiteside Burn

3.3.21 Whiteside Burn is a small ditch that begins in farmland northeast of Whiteside Farm draining an area to the point of crossing of the proposed road of approximately 0.4km^2. The burn flows in an easterly direction through agricultural land before joining the Tributary of Elsick Burn. In its upper section, Whiteside Burn is crossed by a farm road and further downstream by a Class C road at the point of its confluence with the Tributary of Elsick Burn.

3.3.22 The water quality of the burn is currently not monitored by SEPA. However, spot sampling results indicated good (class A2) water quality. Whiteside Burn is considered to be of medium sensitivity.

Crossley Burn

3.3.23 Crossley Burn is a small, straightened burn that begins near Crossley Farm and has a catchment area of approximately 0.2km^2 to the point of crossing of the proposed scheme. The Burn flows through gently sloping agricultural land, following field boundaries before joining the Tributary of Elsick Burn. Crossley Burn is currently not crossed by any roads or railway tracks.

3.3.24 Crossley Burn is currently not monitored by SEPA. Spot sampling carried out by Jacobs in summer 2006 found the water quality to be of category B (fair). It is considered to be of low sensitivity.

Cairns Burn

3.3.25 Cairns Burn is a short, straightened tributary of Crossley Burn located in the upper catchment of the Tributary of Elsick Burn. It begins at Cairns and flows in a south-easterly direction for most of its length, draining an area of approximately 0.1km^2 to the point of the crossing of the AWPR. Just before its confluence with Crossley Burn, Cairns Burn changes its course to flow in a south-westerly direction.

3.3.26 Like Crossley Burn, Cairns Burn is currently not classified under the SEPA Water Quality Classification Scheme. Land use in its catchment is predominantly agricultural and the burn likely receives agricultural runoff. This, in addition to its heavily modified nature, leads to an assessment of low sensitivity.

Circle Burn and Square Burn

3.3.27 Circle Burn is a small ephemeral tributary that is considered likely to feed into the Tributary of Greens of Crynoch Burn during high flows. Land use in the catchment is predominantly agricultural and the watercourse likely receives agricultural runoff. The burn drains an area of approximately 0.1km^2 to the point of the crossing of the proposed scheme.

3.3.28 Square Burn is within close vicinity to Circle Burn draining an area of approximately 0.1km^2 to the point of the crossing of the proposed AWPR. It is a small ephemeral watercourse that follows agricultural field boundaries. It is suspected that the burn is connected downstream with Greens of Crynoch Burn. Although the OS map shows no direct connectivity between these two watercourses, the slope of the surrounding land suggests that Square Burn may flow into Greens of Crynoch Burn, if not directly into Crynoch Burn.

3.3.29 Neither of these burns are currently monitored by SEPA and both have been classed as of low sensitivity.

Wedderhill Burn

3.3.30 Wedderhill Burn is a predominantly straightened tributary of Crynoch Burn, draining a catchment area of approximately 0.1km^2 to the point of crossing of the proposed scheme. The burn flows in a north-westerly direction over gently sloping land, following field boundaries. It is suspected that the upper reaches of this watercourse are in close proximity to private groundwater supplies.

3.3.31 The water quality of Wedderhill Burn is currently not monitored by SEPA. It drains mainly farmland and is likely to be affected by agricultural runoff. It is considered to be of low sensitivity.

Craigentath Burn

3.3.32 Craigentath Burn is a tributary in Crynoch Burn catchment. It drains an area to the point of crossing of the proposed scheme of approximately 0.4km^2. The burn begins at Contlaw Road, north of Wedderhill Farm, in steep rural land which reduces in gradient on its approach to Craigentath Ditch. The watercourse is crossed by Lochton-Auchlunies-Nigg Road (C5K) and may receive road runoff. It is considered to be of low sensitivity.

3.4 Summary

3.4.1 A summary of the surface watercourses in the Fastlink section of the proposed AWPR scheme is presented in Table 9 below. Burnhead Burn and Blaikiewell Burn would also be affected by the Fastlink section of the scheme, however the assessments for these watercourses are reported in the Southern Leg Water Environment (Chapter 24) and Water Quality report (Appendix A24.4).

Table 9 – Sensitivity of Surface Water Features

Watercourse	SEPA Category	Spot Sampling Category *	Sensitivity
Megray Burn	-	A2	Medium
Limpet Burn	-	-	High
Coneyhatch Burn	-	-	Low
Green Burn	-	C	Medium
Green Ditch	-	-	Low
Fishermyre	-	-	High
Allochie Burn	-	A2	Medium
Burn of Muchalls	A2	A2	High
Burn of Blackbutts	-	-	Low
Cookney Ditch	-	-	Low
Stoneyhill Ditch	-	-	Low
Balnagubs Burn	-	-	Low
Tributary of Elsick Burn	-	A2	Medium
Whiteside Burn	-	A2	Medium
Crossley Burn	-	B	Low
Cairns Burn	-	-	Low
Circle Burn	-	-	Low
Square Burn	-	-	Low
Wedderhill Burn	-	-	Low
Craigentath Burn	-	-	Low

* based on Biological criteria only (see Annex 26)

4 Potential Impacts

4.1 Introduction

4.1.1 For the purposes of this assessment, potential impacts are divided into operational impacts and construction impacts. Operational impacts are considered to be those which are long-term and would influence the watercourses after completion of the proposed scheme. Construction impacts are shorter-term that would directly affect the watercourse during the construction phase.

4.1.2 In order to measure the potential impacts of the proposed scheme, this assessment is initially based on studying the direct effects of untreated road runoff on the water quality of watercourses without applying any form of treatment or mitigation measures. This assessment therefore presents a worst-case scenario of the potential impact of road runoff with no treatment, spillage reduction or attenuation measures. It is emphasised that this scenario does not represent the final scheme design that is being proposed. The sole purpose is to aid the design process, recommend appropriate mitigation measures and demonstrate the effectiveness of the proposed design.

4.1.3 The potential impacts of the proposed scheme on watercourses (without mitigation) within the study area are summarised below. The potential impacts have been subdivided into operational impacts, which include routine runoff (soluble and insoluble pollutant assessment which can result in either chronic or acute impact) and risk of accidental spillage (which can result in acute impact), as well as impacts on water quality during construction.

4.2 General

4.2.1 The road drainage system would allow road runoff to be collected and transported from the impermeable surface area to the receiving watercourse. The polluted flow would enter the receiving watercourse at a known point and could be defined as a point source pollutant with irregular flow (polluted flow being discharged only during rainfall and snowmelt events). Wherever point source pollution may occur as a result of direct discharge outfall, these impacts are assessed using the methods set out for routine runoff and accidental spillage.

4.2.2 Diffuse pollution during road operation could also occur via sub-surface paths, where runoff is infiltrated and eventually reaches the groundwater table or is deposited directly into a watercourse near river crossings. A wide range of organic and inorganic chemicals may occur as diffuse pollutants.

Operational Impacts

4.2.3 During operation of the proposed scheme, pollutants contained in road runoff could include:

- total suspended solids;
- hydrocarbons from diesel, petroleum and lubricating oil leakages;
- hydrocarbons from exhaust emissions;
- heavy metals and trace metals (e.g. copper, zinc, cadmium, chromium, iron);
- tyre wear deposits including lead, zinc and hydrocarbons;
- de-icing agents (e.g. de-icing salt) during winter months;
- total suspended solids resulting from erosion of watercourse banks at outfall locations;
- chemicals used in windscreen washes such as detergents; and
- herbicides (i.e. if used on roadside verges).

4.2.4 Following the DMRB methodology, operational impacts were grouped into three categories: soluble, insoluble and those arising from accidental spillage. Overall, the assessment shows that if mitigation measures are not included, the proposed scheme would not comply to SEPA requirements during the operational phase and would result in an increase in:

- soluble pollutants within the receiving watercourses water column;
- insoluble pollutants such as hydrocarbons and total suspended solids within the watercourse; and
- spillage risk due to the increase in traffic.

Routine Runoff

Soluble Pollutants

4.2.5 Trace metals road runoff contaminants include copper, zinc, lead, nickel, etc which are extremely toxic to aquatic organisms, particularly when they are in the ionic form. Moreover, since metals may be precipitated into sediments near the outfalls, much higher concentrations may be built up than in the water above (Hammerton, 1996).

4.2.6 The behaviour of metals in natural waters is a function of the substrate sediment composition, the suspended sediment composition, and the water chemistry. Sediment composed of fine sand and silt will generally have higher levels of adsorbed metals than sediment composed of pebbles (Connell et al., 1984). The water chemistry system controls the rate of adsorption and desorption of metals to and from sediment. Adsorption removes the metal from the water column and stores the metal in the substrate. Desorption returns the metal to the water column, where bioassimilation (the accumulation of a substance within a habitat) and bioaccumulation (the process whereby certain chemicals in the environment accumulate in animal tissues) may take place.

4.2.7 Metals may be desorbed from sediment into the water column under an increase in salinity. A decrease in redox potential (redox potential is a measure of the potential of the water for oxidation or reduction – oxidation being a chemical reaction where molecules or ions lose electrons and reduction one where electrons are gained), or a decrease in pH. Decreased redox potential, as is often seen under oxygen deficient conditions, will change the composition of metal complexes and release the metal ions into the overlying water. A lower pH increases the competition between metal and hydrogen ions for binding sites. A decrease in pH may also dissolve metal-carbonate complexes, releasing free metal ions into the water column (Connell et al., 1984).

4.2.8 High metal concentrations can cause death or reproductive failure in fish, shellfish and wildlife. In addition, they can accumulate in animal and fish tissue, be absorbed in sediments, or find their way into drinking water supplies, posing long-term health risks to humans.

4.2.9 Dissolved copper and total zinc concentrations are used as indicators to assess the pollution levels from road runoff (Highways Agency et al., 1993). These were assessed quantitatively in accordance with the methods set out in the DMRB and detailed in Section 2 (Approach and Methods). The predicted values are then compared to the EQS limits set out by SEPA and the DSD. Detailed calculation sheets for the predicted copper and zinc effects are presented in Annex 28.

4.2.10 As stated in the DMRB, copper in a soluble form is particularly toxic to aquatic organisms. High concentrations (higher than the EQS standards) of dissolved copper could have acute (short-term and lethal) effects on the water environment while low concentrations (below the EQS values) may pose chronic pollution effects through bioaccumulation. The toxicity of copper to organisms and its sensitivity to changes in water chemistry, particularly hardness, make it a useful measure for potential impacts on water features. Similarly, measurements of total zinc can be used as an indicator to detect possible chronic (long-term, low level) pollution effects on the aquatic environment as it is known to be less soluble but also to bioassimilate (persist and accumulate in the environment). Additionally, zinc is strongly correlated with other metals of concern and the effects of some hydrocarbons.

4.2.11 The remaining soluble pollutants (nutrients, de-icing agents, herbicides and pesticides) were assessed qualitatively due to the lack of unified quantitative methods developed.

Insoluble Pollutants

4.2.12 The insoluble pollutants include total suspended solids, vehicle oil and other hydrocarbons and some organic materials such as vegetation debris and grass cuttings, among others. These are described below.

Total Suspended Solids

4.2.13 A significant proportion of the total pollutant load arising from a road is associated with the solid fraction of the runoff (Highways Agency et al., 1993). Insoluble and settleable materials may not cause failure of the water quality standards but could, under some circumstances, cause an unacceptable accumulation of solids on the bed of the receiving watercourse. Several researchers have determined that it is the fine sediment fraction (< 63μm), which is the most important source of pollution (Hamilton and Harrison, 1991).

4.2.14 Fine sediments can adversely affect fish, invertebrates and plants by smothering them (Highways Agency et al., 1993). Sediment smothering could lead to die back of water organisms and in turn increased organic loading and its associated impacts, including lowered levels of dissolved oxygen. Total suspended solids may also contain contaminants, which can cause pollution of the receiving watercourse. Associated pollutants can include: oils, heavy metals, pesticides, phosphorus, nitrogen, and other organic and inorganic pollutants.

4.2.15 The discharge of untreated road drainage to watercourses could potentially result in dramatic deterioration in water quality and the ecological status of the receiving watercourse. Such a change would not conform to the requirements of the Water Framework Directive.

Oils and Hydrocarbons

4.2.16 Oils and other hydrocarbons are complex organic compounds made essentially of carbon and hydrogen and classified as either aliphatic or aromatic. Aliphatic compounds represent 70-80% of hydrocarbons found in surface runoff (Highways Agency et al., 1993).

4.2.17 Oil contamination can have both physical and chemical impacts. The most well-known physical impacts involve the coating of organisms and the water surface which block respiration, photosynthesis and feeding. Biodegradation of oils in aquatic systems can lead to oxygen depletion. Many mineral oils and hydrocarbons are toxic, persistent and bioassimilate in the environment.

4.2.18 In road runoff, oils and hydrocarbons are bound to sediments and can be removed through subtraction of the solid runoff fraction. Direct oil pollution can only occur during accidental spills (including those from car engine leaks).

Biodegradable Organic Materials

4.2.19 Non-point sources of biodegradable organic materials include debris and grass cuttings. These materials contain high levels of nutrients (carbon, nitrogen, phosphorus and sulphur) and organic matter. They undergo fairly rapid microbiological degradation, consuming oxygen present within the water (measured as their Biochemical Oxygen Demand) and thus leading to oxygen sags.

4.2.20 The rapid oxygen sag that occurs as biodegradable material is broken down within a water feature can lead to fish and invertebrate fatalities. In the short term, the material may smother the river bottom, also leading to the death of benthic species.

Accidental Spillage

4.2.21 The high traffic volume could potentially lead to increased occurrence of accidents and possible acute spillage of pollutants, either from the vehicles engines or lorries cargo. The assessment was conducted using DMRB method, which is described in detail in Section 2. Detailed calculation sheets for the accidental spillage risk are presented in Annex 27.

Culverts and Realignments

4.2.22 Construction of the Fastlink of the proposed scheme would involve 13 watercourse crossings (11 culverts and two buried structures). The installation of culvert and realignments could potentially change the morphological diversity and the sediment regime of the watercourses, which may have an associated impact upon water quality. The number and length of culverts has the potential to affect water quality due to lack of light and rapid microbiological degradation of biodegradable material, leading to oxygen sags.

Changes to Discharge Regime

4.2.23 The proposed construction works would alter the local topography and slightly increase the local amount of impermeable surface through the construction of the road pavement. This has the potential to increase the total discharge via runoff to the watercourses.

4.2.24 Changes to discharge regimes could result in substantial changes to water quality. Substantial reduction in discharge levels could severely affect dilution leading to increased concentrations of inorganic and organic pollutants, and consequently to a decrease in dissolved oxygen. Similarly, increased discharge could lead to re-suspension of sediments and trapped contaminants resulting in high turbidity and possible secondary pollution. Increased discharge could also trigger erosion and affect the geomorphology of the watercourses. Impacts on aquatic ecology are addressed in Chapter 40 (Ecology and Nature Conservation) and relevant appendices.

Pre-Earthworks and Loss of Watercourse

4.2.25 As previously mentioned, watercourses that would be taken into pre-earthworks are not assessed for the operational phase as a part of these burns would no longer exist during operation of the proposed scheme. They have been assessed only for the construction phase. Similarly, any watercourse lost due to severance of its catchment by the road will not be assessed for the operational phase as they are assumed to disappear after the construction phase.

Construction Impacts

4.2.26 Table 10 illustrates the potential sources and effects of construction activities on water quality. Construction impacts are likely to be short-term and may have minimal effect on the water quality of a watercourse. However, there may be longer term, indirect impacts on river ecology.

Table 10 – Potential Impacts During Construction

Source of Impact	Potential Effects
Total Suspended Solids Total suspended solids could result from excavations, blasting, and runoff from stockpiles, plant and wheel washing, runoff from site roads, runoff during embankment construction, earthworks and landscaping. The risk of release of total suspended solids into watercourses or drainage ditches would be greatest where the proposed scheme crosses features such as watercourses.	Sediments could cause damage to fish, aquatic invertebrates and plants through deposition resulting in a smothering effect or by interference with feeding and respiratory apparatus. Total Suspended solids may also contain contaminants, which could cause pollution of the receiving watercourse.
Oils, Fuels and Chemicals Spillage from storage tanks or leakage from mobile or stationary plant.	Oils could form a film on the water surface resulting in an adverse effect on water quality. These oils could interfere with the gills of fish and cause loss of buoyancy to water birds as well as toxicity to other organisms. The oils/chemicals may also enter groundwater, reducing the potential for local groundwater utilization and affecting ecological habitats supported by groundwater.
Concrete, Cement and Admixtures Accidental release into watercourses of these materials, including release from the washings of plant and machinery.	Concrete/cement is highly alkaline and must not be allowed to enter any drain or watercourse or groundwater. Potential for adverse effects on aquatic organisms if pH elevated to/maintained above 8.5.
Watercourse/Drain Crossings and Diversions, Realignment of Watercourses Construction of structures such as culverts would be a potential source of pollution and construction debris could block land drains.	Blockage of land drains could result in waterlogging of soils. Culverts may cause flooding problems upstream. Diversions could cause long term impacts on the watercourse.
Sewerage Accidental/uncontrolled release of sewage from sewers through damage to pipelines during service diversion and uncontrolled release of sewage effluent from workers on site.	Pollution to watercourses/groundwater.
Contaminated Land and Sediment If not managed properly, disturbance of contaminated materials could lead to pollution of ground and surface waters.	Dependent on types and concentrations of contaminants. Potential loss of aquatic fauna and flora. Derogation of groundwater quality reducing its resource potential and potentially affecting groundwater-supported habitats.

4.2.27 The construction impact assessment on the watercourses was carried out qualitatively. Pollution during construction may be caused by accidental spillage of concrete, cement, oil, chemicals, sewage, excavation or through diffuse runoff. Small burns with limited flows and salmonid rivers were considered to be more sensitive to accidental and diffuse pollution. The scope of the proposed work for each watercourse (i.e. the number of the required culverts and the length of the realignments) was also taken into consideration when conducting the assessment. The potential for fine sediment release during construction and the impacts of culverting and realignments are addressed in detail in Appendix A39.2 Fluvial Geomorphology and summarised below. While hydrology is referred to in this section, the assessment of hydrological impacts is provided in the Surface Water Hydrology report (Appendix A39.1).

4.3 Specific Impacts

4.3.1 Table 13 provides information regarding the proposed modifications that would result from the scheme and the potential impacts on the watercourses situated in the study area.

Operation Impacts

4.3.2 Four drainage runs (A to D) would be located within the Fastlink section of the proposed scheme. The proposed road drainage is shown on Figures 39.3a-f. Eleven of the watercourses included in this water quality impact assessment would be crossed by the proposed scheme (see Table 13).

4.3.3 The following watercourses have not been assessed using the DMRB methods as they would not receive any direct road drainage. The potential impacts of diffuse pollution on these watercourses have been assessed qualitatively and are considered to be Negligible:

- Limpet Burn;
- Balnagubs Burn;
- Whiteside Burn;
- Crossley Burn;
- Cairns Burn;
- Craigentath Burn; and
- Green Ditch.

4.3.4 Fishermyre's surface water and groundwater quality would be highly sensitive to road runoff. Any pollutants that may enter the waterbody, even through diffuse means, have the potential to reside in the wetland system for a prolonged period of time, which could have a significant indirect impact on the wetland. Although filter drains are proposed as part of the road drainage design, these are not impermeable and there is a possibility that polluted runoff could infiltrate into the ground. Pollution impacts through diffuse means and accidental spillages for Fishermyre are considered to be of a high magnitude.

4.3.5 The following watercourses would be taken into pre-earthworks and the potential impact of the proposed scheme has been assessed qualitatively:

- Coneyhatch Ditch;
- Allochie Burn;
- Burn of Blackbutts;
- Circle Burn; and
- Square Burn.

4.3.6 A small upstream portion of Wedderhill Burn would be destroyed during construction of the road. This watercourse will be considered lost in the assessment as it is expected that the watercourse would run dry early in the operational phase due to source loss.

<u>Routine Runoff</u>

4.3.7 Due to the limited data available for the watercourses, a number of assumptions have been made in order to quantify the potential impacts based on the DMRB methodology (see details in Section 2). Details of the calculations are given in Annex 28 and are summarised in Table 11.

Table 11 – Estimated Impact of Total Zinc and Dissolved Copper in Road Runoff (Without Mitigation)

Site	Sensitivity	Parameter	EQS Annual Average (μg/l)	Inferred Upstream Conc. (μg/l)	Estimated Downstream Conc. (without mitigation) (μg/l)	Percentage Increase over Baseline Conc. Levels (%)	Magnitude	Significance of Impact (without nitigation)
Megray Burn	Medium	Copper	28	14	37*	162	High	Moderate/ Substantial
		Zinc	125	63	136*	118	High	Moderate/ Substantial
Limpet Burn	High	Diffuse	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Fishermyre	High	Diffuse	n/a	n/a	n/a	n/a	High	Substantial
Green Burn	Medium	Copper	10	5	13*	164	High	Moderate/ Substantial
		Zinc	75	38	64	71	Medium	Moderate
Green Ditch	Low	Diffuse	n/a	n/a	n/a	n/a	Negligible	Negligible
Burn of Muchalls	High	Copper	10	5	8	58	Low	Moderate
		Zinc	75	38	47	25	Low	Moderate
Balnagubs Burn	Low	Diffuse	n/a	n/a	n/a	n/a	Negligible	Negligible
Tributary of Elsick Burn	Medium	Copper	28	14	32*	126	High	Moderate/ Substantial
		Zinc	125	63	120	92	Medium	Moderate
Whiteside Burn	Medium	Diffuse	n/a	n/a	n/a	n/a	Negligible	Negligible
Crossley Burn	Low	Diffuse	n/a	n/a	n/a	n/a	Negligible	Negligible
Cairns Burn	Low	Diffuse	n/a	n/a	n/a	n/a	Negligible	Negligible
Craigentath Burn	Low	Diffuse	n/a	n/a	n/a	n/a	Negligible	Negligible

* Exceeds Annual Average EQS

4.3.8 Without the application of mitigation measures, the resultant concentrations of dissolved copper and total zinc in Megray Burn during operation would exceed the annual average EQS (Table 11) resulting in Moderate/Substantial impact significance. For Green Burn and Tributary of Elsick Burn, the road drainage would have an impact of high magnitude for copper, which would result in Moderate/Substantial significance. For zinc, a medium magnitude is predicted, which would be of Moderate significance.

4.3.9 The resultant concentrations of dissolved copper and total zinc in the Burn of Muchalls are predicted to be within the annual average EQS for copper (8μg/l) and zinc (47μg/l) due to a greater dilution capacity of the watercourses (Table 11). This would result in an impact of Moderate significance for copper and zinc levels.

4.3.10 It is expected that all remaining watercourses would be affected by diffuse runoff, which is considered to have a Negligible impact on water quality. For Fishermyre, the potential diffuse pollution impact is considered to be of Substantial significance.

Total Suspended Solids

4.3.11 The total suspended solids (TSS) impact is considered to be of Moderate significance for Burn of Muchalls and Moderate/Substantial significance for Megray Burn (see Table 13). For the Tributary of Elsick Burn, the impact would be of Slight significance.

Risk of Accidental Spillage

4.3.12 The assessment indicates that the risk of accidental spillage for Burn of Muchalls would likely be of Moderate significance. For Megray Burn, Green Burn and Tributary of Elsick Burn the level of risk is considered to be of Slight significance. For Fishermyre, pollution impacts through accidental spillages are considered to be of Substantial significance.

4.3.13 Table 12 presents a summary of the spillage risk assessment (without mitigation) for the proposed road (for detailed calculations, refer to Annex 27).

Table 12 – Summary of Spillage Risk Assessment (Without Mitigation)

Watercourse	Sensitivity	Threshold of Acceptability	Spillage Risk in Design Year – Without Mitigation	Within Acceptable Limits?	Magnitude	Significance
Megray Burn	Medium	1:100	1:438	Yes	Low	Slight
Green Burn	Medium	1:100	1:816	Yes	Low	Slight
Burn of Muchalls	High	1:100	1:231	Yes	Low	Moderate
Tributary of Elsick Burn	Medium	1:100	1:265	Yes	Low	Slight

Construction Impacts

4.3.14 The provision of buried structures over Limpet Burn and Burn of Muchalls would assist in minimising potential impacts to these high sensitivity watercourses. Construction of the buried structure over Limpet Burn would also require the realignment of the watercourse which would increase the potential impact. There would be a limited amount of earthworks involved and the resulting impact is predicted to be of Moderate significance for the Burn of Muchalls and of Moderate/Substantial significance for Limpet Burn.

4.3.15 During the construction, the installation of a culvert and realignment of Megray Burn is expected to result in Moderate to Substantial impact. Potential impacts on Green Burn, Tributary of Elsick Burn and Whiteside Burn are predicted to be of Moderate significance. Construction activities associated with the installation of culverts on Cookney Ditch, Stoneyhill Ditch, Balnagubs Burn, Crossley Burn, Cairns Burn and Craigentath Burn would result in impacts of Slight to Negligible significance. The remaining watercourses would be taken into pre-earthworks. These watercourses would be severely affected during the construction phase which results in Moderate/Substantial impact significance for Allochie Burn and Moderate impact significance for the rest of the burns.

4.3.16 Construction of the route through Fishermyre wetland would be likely to result in impacts on the water quality regime. Surface water and groundwater quality in the vicinity of Fishermyre wetland is of high sensitivity and the magnitude of impact is, in the eventuality of accidental spillages events, considered to be high. This results in a prediction of Substantial impact significance, without the application of appropriate mitigation

4.4 Summary

4.4.1 The potential impacts on watercourses in the Fastlink section of the proposed AWPR are summarised in Table 13.

Table 13 – Potential Impacts on Watercourses

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Significance of Impact
Megray Burn	Medium	1 No. culvert: ch0 Extension of 1 No existing culvert: ch0	Major realignment resulting in overall lengthening of the watercourse.	1 proposed outfall draining total of 4.1ha at ch0.	Construction: Major potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of two culverts and the realignments would involve major earthworks, possibly resulting in high sediment and pollutants release and short-medium term increased turbidity in the water column. Small dilution capacity of the watercourse.	High	Moderate/ Substantial
					General Operation: A major shift from baseline conditions due to discharge of road runoff. Long-term adverse impact on water quality and ecology. Routine Runoff: High impact from routine runoff due increase of over 100% over baseline for copper and zinc resulting of EQS for both pollutants. Accidental Spillage: Low impact from accidental spillage as spillage risk is 1 in 438 years, which is above the probability threshold of 1 in 200 and below 1 in 1000 years. Total Suspended Solids: Q_{mean} for Megray Burn is 0.007 m^3/s which indicates a low dilution capacity therefore total suspended solids will pose a high impact magnitude.	High	Moderate/ Substantial
Limpet Burn	High	Buried structure, entirely spanning the channel ch1400	Realignment associated with buried structure construction resulting in slight shortening of the watercourse	No road drainage discharge to burn	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a buried structure and associated realignments would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Medium	Moderate/ Substantial
					General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of buried structure likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Negligible	Slight/Negligible

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Significance of Impact
Coneyhatch Burn	Low	Pre-earthworks	No realignment proposed	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	High	Moderate
					Operation: Taken into pre-earthworks	n/a	n/a
Fishermyre	High	n/a	n/a	Road drainage system crossing through the wetland	Construction: Surface and groundwater water quality in the vicinity of Fishermyre wetland is of high sensitivity. Potential high impact in the event of accidental pollution spillages from the road construction works.	High	Substantial
					Operation: High potential impact from the road drainage runoff entering the wetland and in the event of accidental spillages.	High	Substantial
Green Burn	Medium	2 No. culverts: ch3125 (mainline) ch213 (side road)	Realignment associated with culvert construction resulting in slight shortening of watercourse.	One proposed outfall draining total of 1.8 ha at ch2441.	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of two culverts and the realignments would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column. Medium dilution capacity of the watercourse.	Medium	Moderate
					General Operation: A major shift from baseline conditions due to discharge of road runoff. Temporary adverse impact on water quality and ecology. Routine Runoff: High impact from routine runoff due increase of > 100% over baseline for copper resulting of failure of EQS and medium impact for zinc (71% increase over the baseline concentration. Accidental Spillage: Low impact from accidental spillage as spillage risk is 1 in 816 years, which is above the probability threshold of 1 in 200 years and below 1 in 1000 years Total Suspended Solids: Q_{mean} for Green Burn is 0.010 m^3/s which indicates a medium dilution capacity therefore total suspended solids will pose a medium impact magnitude.	High	Moderate/ Substantial
Green Ditch	Low	n/a	Realignment resulting in shortening of the burn	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	High	Moderate

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Significance of Impact
					General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Negligible	Negligible
Allochie Burn	Medium	Pre-earthworks	No realignment proposed	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	High	Moderate/ Substantial
					Operation: Taken into pre-earthworks.	n/a	n/a
Burn of Muchalls	High	Buried structure, entirely spanning the channel ch4700	No realignment proposed	One Proposed outfall draining total of 6.5ha at ch4785.	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a buried structure would involve some earthworks, possibly resulting in sediment and pollutants release and short tem increased turbidity in the water column. High dilution capacity of the watercourse.	Low	Moderate
					General Operation: A measurable shift from baseline conditions due to discharge of road runoff. Temporary to long-term adverse impact on water quality and ecology. Routine Runoff: Low impact from routine runoff due increase of 58% over baseline for copper and 25% for zinc. Accidental Spillage: Low impact from accidental spillage as spillage risk is 1 in 231 years, which is above the probability threshold of 1 in 200 years and below 1 in 1000 years. Total Suspended Solids: Q_{mean} for Burn of Muchalls is 0.103 m^3/s which indicates a high dilution capacity therefore total suspended solids will pose a low impact magnitude.	Low	Moderate
Burn of Blackbutts	Low	Pre-earthworks	No realignment proposed	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	High	Moderate
					Operation: Taken into pre-earthworks.	n/a	n/a

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Significance of Impact
Cookney Ditch	Low	2 No. culverts: Ch 6480 (Mainline) Ch 6480 (side road)	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of two culverts and the realignments would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Medium	Slight
					Operation: General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of two culverts likely to have negligible impact upon water quality. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Negligible	Negligible
Stoneyhill Ditch	Low	1 No. culvert: Ch 6930	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a culvert and the realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Medium	Slight
					Operation: General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of culvert likely to negligible impact upon water quality. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Negligible	Negligible
Balnagubs Burn	Low	1 No. culvert: ch7550	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a culverts and the realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Medium	Slight
					General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of culvert likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Negligible	Negligible

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Significance of Impact
Tributary of Elsick Burn	Medium	1 No. culverts: ch7975	Realignment associated with culvert construction	One Proposed outfall draining total of 5.7ha at ch7911.	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a culvert and the realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column. Medium dilution potential of watercourse.	Medium	Moderate
					General Operation: A major shift from baseline conditions due to discharge of road runoff. Temporary to long-term adverse impact on water quality and ecology. Routine Runoff: High impact from routine runoff due increase of > 100% over baseline for copper resulting in failure of EQS. Medium impact regarding zinc concentrations – 92% increase over baseline. Accidental Spillage: Low impact from accidental spillage as spillage risk is 1 in 265 years, which is above the probability threshold of 1 in 200 years and below 1 in 1000 years. Total Suspended Solids: Q_{mean} for Burn of Elsick is 0.013 m^3/s which indicates a medium dilution capacity therefore total suspended solids will pose a medium impact magnitude.	High	Moderate/ Substantial
Whiteside Burn	Medium	1 No. culvert: ch8850	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a culvert and the realignment will involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Medium	Moderate
					General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of culvert likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Negligible	Negligible
Crossley Burn	Low	1 No. culvert: ch9170	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a culvert and the realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Medium	Slight

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Significance of Impact
					General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of culvert likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Negligible	Negligible
Cairns Burn	Low	No crossing proposed	Realignment proposed resulting in overall shortening of the watercourse.	No road drainage discharge to burn	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Medium	Slight
					General Operation: Change in water quality likely to be small and watercourse ecology expected to be impacted only slightly. Routine Runoff: Negligible impact due to routine runoff as there is no outfall planned. Accidental Spillage: Negligible impact due to routine runoff as there is no outfall planned. Total Suspended Solids: Negligible impact due to routine runoff as there is no outfall planned.	Negligible	Negligible
Circle Burn	Low	Pre-earthworks	No realignment proposed	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	High	Moderate
					Operation: Taken into pre-earthworks.	n/a	n/a
Square Burn	Low	Pre-earthworks	No realignment proposed	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	High	Moderate
					Operation: Taken into pre-earthworks.	n/a	n/a
Wedderhill Burn	Low	Watercourse source lost through catchment severance	No realignment proposed	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	High	Moderate

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Significance of Impact
					Operation: Watercourse lost through catchment severance	n/a	n/a
Craigentath Burn	Low	1 No. culvert: ch10630	Realignment associated with culvert construction	No road discharge to burn	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Culvert construction and realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Medium	Slight
					General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of culvert likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Negligible	Negligible

5 Mitigation

5.1 Introduction and Guiding Principles

5.1.1 The objective of the mitigation measures described in this section of the report is to convey surface water runoff from the road surface to receiving watercourses without detrimental effect on water quality, associated ecosystems and the underlying groundwater. Mitigation measures include those that aim to prevent, reduce or offset potential adverse impacts.

5.1.2 As set out in the EIA (Scotland) Regulations 1999 mitigation measures are intended 'to prevent, reduce or where possible, offset any significant adverse impacts on the existing drinking and bathing water quality, ecology and nature and conservation value of the surrounding area.'

5.1.3 The Water Framework Directive has been taken into account in the formulation of mitigation strategies. The requirements of EC Freshwater Fisheries Directive and the Dangerous Substances Directive have been taken into consideration when choosing the appropriate level of road runoff treatment. Implication of mitigation measures for all watercourses aims to gain and preserve 'good' water quality and ecological status of any watercourse.

5.1.4 Mitigation measures to prevent adverse impacts typically comprise solutions aimed at the source of the impact. The risk of causing deterioration in water quality can be reduced by 'designing out' any risk. This includes the choice of route location and road alignment to avoid significant impacts, by avoiding important/sensitive water features wherever possible, for example. This was taken into consideration throughout the design process for the proposed scheme.

5.1.5 Where potential adverse impacts cannot be prevented (i.e. where there is a need for road runoff to be discharged to local watercourses and drainage ditches) mitigation measures of carefully designed treatment trains will be implemented to reduce the risk. The mitigation measures are described below. Where the scheme intercepts existing field drainage that drains agricultural land, these ditches will be incorporated into the road drainage design and will discharge into the proposed Sustainable Urban Drainage Systems (SUDS).

5.1.6 In addition, SEPA and SNH have been consulted at key design stages to seek guidance on appropriate levels of road drainage, culverting and watercourse realignment.

5.2 Operational Mitigation

5.2.1 Without mitigation in place, operation of the proposed scheme could potentially impact adjacent watercourses through direct discharge of polluted surface runoff from traffic and accidental spills via road drainage outfalls (point source organic and inorganic pollution). The drainage system of the proposed road scheme has been designed in accordance with CIRIA C521 (2000), CIRIA C609 (2004) and CIRIA (C697 (2007).

5.2.2 Water quality mitigation measures have been developed continually throughout the design process. In particular major design components such as road drainage, locations of bridges, culverts and watercourse realignment details have been developed though an interactive process involving structural engineers, geomorphologists, ecologists and water quality specialists.

Road Drainage

5.2.3 SUDS techniques that would be implemented to reduce potential impacts during normal road operation (Figures 39.3a-f) are summarised in Table 16 and are detailed below. For each outfall, a treatment train is proposed which would comprise a series of mitigation measures. For example, this could involve a combination of both wet and dry detention basins and treatment ponds (up to four in series) to maximise pollutant removal efficiency. These drainage design proposals will be presented to SEPA for approval during the CAR licensing process before being finalised.

Table 14 – Summary of Mitigation Measures

Type of Measure	Description
Prevent	Consideration of route location and road alignment to avoid impact to sensitive areas.
Reduce	A Sustainable Urban Drainage System (SUDS) to be provided to filter out pollutants and reduce the level of pollution from operational runoff entering watercourses. Filter drains and catch-pits must be constructed, where feasible, along the entire length of the proposed scheme. Detention basins and treatment ponds will be provided at appropriate outfalls prior to the discharge of road drainage into the receiving watercourse. This will attenuate peak flows from runoff to pre-development levels and will provide a suitable level of treatment of the road drainage prior to discharge. Regular maintenance of these treatment structures and the filter trains must be undertaken to ensure ongoing mitigation efficiency and to ensure efficient operation and the settlement of solids and removal of pollutants (such as hydrocarbons). If herbicides are required, those recommended by SEPA for use near watercourses should be used, applied in line with manufacturer's instructions, to reduce pollution of watercourses. Provision of scour protection at the drainage discharge outfall to protect the banks and bed of the receiving ditch and to limit erosion. Mitigation Measures associated with contaminated areas and groundwater are presented in Chapter 38 (Geology, Contaminated Land and Groundwater)

Filter Drains and Catchpits

5.2.4 Filter drains consist of a perforated pipe laid in a trench backfilled with gravel and usually placed along the road verge. Filter drains can be used to convey highway drainage to the discharge point and also filter out pollutants such as total suspended solids, hydrocarbons, iron. According to the DMRB (Highways Agency et al., 1993), dissolved copper removal efficiency is 10-30% and total zinc removal efficiency is 70-80%. For the purpose of this assessment, the removal efficiencies assumed are 20% for dissolved copper and 75% for total zinc. Where necessary, piped carrier drains may be required to transfer surface water beneath the main carriageway and from the filter drains to designated outfall points.

5.2.5 Where the proposed scheme would be situated in a cutting, there is a greater risk of groundwater contamination. Where this is the case, the filter drain must be designed with an impermeable liner to minimise risk of pollution to groundwater.

5.2.6 All filter drains will be designed in accordance with the DMRB (Highways Agency et al., 1993), taking cognisance of guidance contained in the CIRIA SUDS Design Manual C697 (CIRIA, 2007) and C521 (CIRIA, 2000), CIRIA C609 (2004) and CIRIA C648 (2006).

5.2.7 Catchpits consist of a small chamber with a sediment collection sump. These are designed to trap sediments and other debris and retain a proportion of the total suspended solids present in the runoff and settle out hydrocarbons and metals. Catchpits are located at regular intervals, of no less than 90m, along filter drains and at the junctions of carrier drains.

Detention Basins/Treatment Ponds

5.2.8 Detention basins and treatment ponds must be constructed to treat road runoff prior to discharge to each outfall. These end-of-line treatment systems provide biological treatment and removal of dissolved contaminants and nutrients. Detention basins are principally used to attenuate flows, while treatment ponds are required to treat the more polluted first flush component of road runoff. Further information on this can be found in Appendix A39.1.

5.2.9 A large proportion of pollutants in operational runoff are associated with sediment and therefore it is likely that the majority will accumulate in the filter drains and catchpits. Treatment ponds and detention basin systems provide both biological treatment and the removal, by settlement, of dissolved contaminants and nutrients.

5.2.10 Treatment ponds are reported to remove 50-80% of total zinc and dissolved copper from road drainage (CIRIA, 2004). For the purpose of this assessment, it is assumed that the efficiency removal is 65% for both total zinc and dissolved copper. The provision of detention basins in the treatment train will provide attenuation of peak flows, thereby reducing the risk of flooding in the receiving watercourse and promoting the deposition and removal of total suspended solids.

5.2.11 In general, all treatment systems are designed to attenuate flows for between 39 and 192 hours (design dependent) and to release water back into the receiving watercourse at pre-development rates. Treatment times are recommended for between 24-48 hours depending on the number of ponds and level of treatment required. Pollution removal rates decrease in efficiency as detention time in ponds increases and studies have shown that a detention time beyond 24 hours does not result in a significant improvement in quality (CIRIA, 2004).

5.2.12 The required storage volume to treat road drainage (the treatment volume) is calculated based on the guidance contained in the CIRIA SUDS Design Manual (CIRIA, 2007) and the design guidance given in Treatment of Highway Runoff Using Constructed Wetlands (Environment Agency, 1998). CIRIA guidance states that ponds should be designed with storage volume, Vt (the volume generated by a mean annual flood) or in exceptional circumstances, 4Vt (four times the volume generated by a mean annual flood). In agreement, SEPA recommends that ponds draining particularly sensitive catchments be designed for storage volume 4Vt. Best design practice for pollutant removal, as detailed in CIRIA C609 (2004) and CIRIA C697 (2007), should be adhered to.

5.2.13 According to the Design Manual for Roads and Bridges (DMRB, 1993), the spillage risk removal efficiencies were determined to be 65% reduction for both total zinc and dissolved copper, irrespective of the treatment method.

Swales

5.2.14 Swales are vegetated surface features that drain water evenly off impermeable areas. The swale channel is broad and shallow and covered by grass or other suitable vegetation to slow down flows and trap pollutants (CIRIA, 2004). Swales can also be designed for a combination of conveyance, infiltration, detention and treatment of runoff (CIRIA, 2004). They are typically located next to highways but can also be constructed in landscaped areas within car parks and elsewhere.

5.2.15 Swales are generally effective at removing pollutants through filtration and sedimentation for frequent small storm events (CIRIA, 2004). For larger, less frequent storms of between a 50 and 10 per cent annual probability (1 in 2 and 1 in 10 year return period), they can act as a storage and conveyance mechanism. For larger storms with an annual probability of less than 10 per cent (return periods greater than 1 in 10 years), providing storage in swales may become impractical as catchment size increases and they are often used in conjunction with other techniques. They are reported to remove 70-90% total zinc and 50-70% dissolved copper from the road drainage (DMRB, 1998). For the purpose of this assessment, the removal efficiencies are assumed to be 70% for total zinc and 50% for dissolved copper.

5.2.16 Swales are often integrated into the surrounding land use, for example public open space or road verges. Local wild grass and flower species can be introduced for visual interest and to provide a wildlife habitat. Care should be taken in the choice of vegetation as tussocks create local eddies, increasing the potential for erosion on slopes. Shrubs and trees can be planted but in this case the vegetated area will need to be wider and have a gentler slope (CIRIA, 2004).

Maintenance of Road Drainage Network

5.2.17 To avoid failure or sub-optimal operation of the road drainage network, the following will be provided:

- regular maintenance of treatment structures and filter drains to ensure ongoing mitigation efficiency;
- maintenance of filter drains including inspection and weed control, annual sediment and vegetation build up removal, replacement of clogged filter material (typically once in ten years or more);
- regular maintenance of detention basins and treatment ponds including inspections and site rubbish removal; bank side and pond vegetation clearance at least every three years; removal of sediment from forebay when 50% full (at least once in seven years); and removal of sediment from the pool when volume reduced by 25% (25 years or greater);
- regular maintenance of receiving watercourses and culverts to reduce the risk of blockages and thus increased flood risk; and
- scour protection at the drainage discharge outfall to protect the banks and bed of the receiving ditch and to limit erosion.

5.2.18 Further details regarding morphological diversity mitigation requirements, creation and maintenance of a complex riparian zone are provided in Appendix A39.2 (Fluvial Geomorphology) and Appendix A40.9 (Freshwater Ecology).

Other Operational Measures

5.2.19 It is preferable that herbicides are not used on highway embankments, cutting or verges as these substances, once in the watercourses, can accumulate in sediments and bioaccumulate in a large range of organisms. However, if the Contractor responsible for verge maintenance considers that the use of herbicides is necessary for the adequate management of vegetation on the highway verge, the Contractor should only use those products recommended by SEPA for use near watercourses. Any herbicides should be used in accordance with the manufacturer's instructions.

5.2.20 At the location of road drainage outfalls, scour protection measures such as revetments and river bed protection may be necessary to minimise erosion of the banks and bed of receiving watercourses.

5.2.21 Water quality/sedimentation/ecological monitoring downstream of key outflows will be undertaken to provide an indication for potential problems.

Adherence to Best Practice near Watercourses

5.2.22 Maintenance is an important factor in pollutant removal efficiency of treatment structures. An appropriate level of ongoing maintenance must be implemented to maximise removal efficiency over the life of the structure. Guidance on the minimum requirements is detailed in SEPA Pollution Prevention Guidelines (PPG 01, PPG 09, PPG 18, PPG 21 and PPG 22) and CIRIA guidance C697 (2007).

Water Crossings

5.2.23 The provision of bridges or buried structures to cross high sensitivity watercourses assists in avoiding adverse long-term changes to water quality, morphological diversity and minimising construction impacts. Buried structures are proposed for scheme crossings over Limpet Burn and the Burn of Muchalls, which are high sensitivity watercourses. The river crossing designs have been developed by a team including structural engineers, hydraulic modellers, environmental scientists and aesthetic advisors. Details of design features are given in Chapter 4 (The Proposed Scheme) and construction and operation mitigation measures specific to water quality are outlined below.

5.2.24 The buried structures proposed for Limpet Burn and the Burn of Muchalls have been designed to span the watercourse at the crossing point, meaning that no piers will be located in the water column. This will reduce the risk of accidental spillage and sediment release within the water channel, prevent river diversion or pumping water away during construction. In addition, the structures have been designed to minimise damage to the surrounding riparian zone.

5.2.25 Many of the watercourses that would be culverted are small and of low sensitivity, with a large proportion being straightened land drains.

Culvert Design

5.2.26 Culvert design follows SEPA policy and the guidelines set out in the Culvert Design Manual, Report 168 (CIRIA, 1997). In addition, culverts will be designed to facilitate fish passage following guidance from River Crossings and Migratory Fish Design Guidance: A Consultation Paper for the Scottish Executive (SEERAD 2000) (see Appendix A40.9 Freshwater Ecology).

5.2.27 Appropriate culvert design is aimed at avoiding deterioration in water quality and morphological diversity and the associated total suspended solids release. Appropriately sized culverts should allow debris and sediment material to pass through the culvert unhindered. The proposed crossings design will ensure that there is minimal disruption to the existing flow regime of the affected watercourse and will be designed to pass the 1:200 year return period flow.

5.2.28 The culvert design that would be used for the proposed scheme follows the new Controlled Activities Regulations (CAR) and the Scottish Executive guidance on culverts and migratory fish (SEERAD, 2000). Culverts are proposed at most crossing points except for those watercourses being taken into pre-earthworks.

5.2.29 Culvert bases will be set at below streambed level to allow natural substrate to be used within the culvert and provide limited in-stream morphological diversity. Substrate in the culvert will be new material of a similar size to that of the original channel in order to ensure that sediment will not wash out at times of high flow or silt up in times of low flow.

5.2.30 All culverts have been designed to ensure that gradients do not differ markedly from existing conditions to avoid excessive siltation or erosion. In addition, the culverts will have mammal ledges installed to allow mammal passage through the culverts during most typical flow.

Watercourse Realignments

5.2.31 Realignments are generally used where necessary to reduce crossing (culvert) lengths and associated potential long term adverse water quality impacts. In the case of Megray Burn, the proposed route will cross a large portion of the watercourse if left in its existing state. The burn will therefore undergo a major realignment to run alongside the road for most of its length before being crossed at Stonehaven Junction. The proposed realignments will be designed to cause minimal disturbance to flow patterns and minimise adverse impacts on water quality, mirroring where possible the original alignment with minimal change to hydraulic gradient.

5.2.32 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.

5.2.33 The realignment design will aim to incorporate geomorphological features present in the original watercourse and also introduce additional features such as pool and riffle sequences, where possible.

Monitoring of Realigned and Culverted Watercourses

5.2.34 Although river realignments and culverts have been designed to minimise the risk of sedimentation and erosion, a monitoring programme will be conducted to flag any potential geomorphological, ecological or water quality problems. This approach aims to reducing the risk of dramatic changes to the geomorphological diversity and water quality of watercourses. The monitoring approach and detailed design will be agreed with SEPA prior to commencement of the construction works.

5.3 Construction Mitigation

5.3.1 The implementation of effective mitigation measures to avoid, minimise or control pollution of surface water and groundwater are required during the construction of the scheme. These will incorporate SEPA's requirements for pollution control including Pollution Prevention Guidelines (PPGs).

5.3.2 As mentioned above, detailed Method Statements will be provided and agreed with SEPA prior to the start of works on site. In the event of large oil spills that cannot be dealt with at the local level, a detailed contingency plan will be provided. Detailed method statements will likely also be required as part of the CAR licensing process, setting out the techniques to minimise sediment release into watercourses. An Ecological Clerk of Works will be on site during construction to monitor the effectiveness of mitigation measures.

5.3.3 Ponds to treat work site runoff (Figures 39.3a-f) will be constructed early during the construction period in order to be in operation for construction activities. The ponds will act to allow settlement and treatment of any pollutants contained in runoff and control the rate of flow before water is discharged into the receiving watercourses. The addition of any temporary SUDS during construction will be determined by the contractor and will be agreed with SEPA prior to the start of works on site.

5.3.4 Temporary SUDS are also likely to be used, where possible, to control surface water runoff during construction which will also help to control erosion, sedimentation or discolourisation of local watercourses. This is part of the Employer's Requirements and the Contractor will provide monitoring proposals and contingency plans prior to commencement of operations on site.

5.3.5 The Employer's Requirements will also require the Contractor to monitor water quality prior to, and during, construction assessing chemical (temperature, pH, conductivity, total suspended solids, heavy metals, etc.) and biological parameters (macroinvertebrate communities and macrophytes). Monitoring locations, parameters, frequency of sampling and discharge limits will be agreed with SEPA in advance of construction.

5.3.6 Arrangements for the safe storage and disposal of sewage effluent from workers on site, such as chemical toilets or other forms of system with no discharge (PPG 4: Treatment and Disposal of Sewage Where No Foul Sewer is Available, July 2006), will also be agreed with SEPA in advance of works on site.

Adherence to Best Practice near Watercourses

5.3.7 The types of mitigation measures that will be used to reduce potential impacts during construction are summarised in Table 15. The mitigation required for each watercourse is provided in Table 16.

Table 15 – Mitigation Measures During Construction

Source of Impact	Mitigation
Total Suspended Solids	Runoff and erosion control measures will include perimeter cut-off ditches; ditches at the base of embankments (where the adjacent ground slopes towards the embankment); settlement lagoons; the installation of silt fences on cut slopes in the proximity of watercourses, around drainage inlets and any drainage path; placement of hay bales; mulching; erosion control blankets; sediment fencing and hydro-seeding. Should chemical flocculants be proposed for settlement, SEPA will be consulted to obtain the necessary approvals. Stockpiles will not be located near watercourses, stockpiles must be covered when not in use and silt fencing must be provided around the perimeter of all stockpiles. Vehicles or vehicle wheels must not be washed near watercourses. Temporary bridges should be used to cross watercourses rather than temporary culverts and fording watercourses must be avoided. A method statement will be provided and agreed with SEPA prior to commencement of construction.
Oils, Fuels and Chemicals	Bunded areas with impervious walls and floor lining for the storage of fuel, oil and chemicals must be provided. These bunded areas will have a value of at least 110% that of the storage tanks. In the event of large oil spills that cannot be dealt with at the local level, a detailed contingency plan will be provided to ensure effective mitigation.
Concrete, Cement and Admixtures	Storing potential pollutants or undertaking potentially polluting activities (e.g. concrete batching and mixing) will be completed away from watercourses, ditches and surface water drains.
Watercourse/Drain Crossings and Diversions	Construction of culverts will be undertaken in the dry to minimise potential contamination of the watercourse. Temporary diversions should be in place before culvert construction is undertaken. Temporary culverts (like permanent ones) must be appropriately sized to ensure adequate passage of water during high flow condition (designed to the 0.5% AEP) and must be designed to ensure fish and mammal passage is facilitated. Where land drains are interrupted they will be incorporated into the pre-earthworks drainage ditches. Minimal disturbance to the banks and beds of watercourses and minimal disturbance to existing land drainage systems must be ensured. If the new road blocks existing drainage, the existing land drainage will be culverted or diverted as appropriate.
Sewerage	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. Arrangements for safe storage and disposal of sewage effluent from workers on site will be agreed with SEPA in advance of construction in accordance with PPG 4.
Contaminated Land and Sediment	The ground investigation has identified areas of contamination and actions will been taken to ensure disturbed sediment does not enter watercourses (similar methods to those outlined to reduce total suspended solids entering watercourses).

5.3.8 One of the key mitigation strategies during construction are 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 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 Site;

- 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.

Pre-Earthworks

5.3.9 The re-direction of watercourses into pre-earthworks will require sediment control measures to be applied to reduce the potential impact downstream of the construction area. These may include cut-off ditches and sediment fencing around the perimeter of earth works to minimise sediment release into the watercourse. Additionally, implementation of best practice at site and adherence to the PPGs listed above should be undertaken. The diversion of the watercourse into the pre-earthworks ditches will only be undertaken after sediment and pollution control measures (sediment traps/lagoons) have been established at the downstream end of these ditches prior to outfall.

Diversion of Watercourses during Construction of Culverts

5.3.10 During installation of culverts, watercourses will be diverted to a temporary channel. This will result reduce the potential risk of concrete and chemical spillage, sedimentation and erosion to that section of the watercourse. Temporary channels will be lined with geotextile and new similar sized inert granular material in areas where the ground investigation has indicated that fine particles are present.

Timing of Works

5.3.11 In general, works should be avoided during periods of very high and very low flow to minimise potential impacts from construction activities. In salmonid watercourses, spawning periods (between October and May should also be avoided. More detailed information on this can be found in Chapter 40 (Ecology and Nature Conservation) along with specific figures on work timing for particular species.

Table 16 – Mitigation for Water Quality Impacts

Watercourse	Proposed Works	Potential Impact Description	Mitigation
Megray Burn	Road Drainage	One proposed outfall draining total of 4.1ha.	Filter Drain, Detention Basin, 2 x treatment ponds (storage volume Vt – see paragraph 5.2.12 for details)
	Crossing	1 No. culvert: ch0 – 92m length Extension of 1 No. existing culvert (B979 roundabout): ch0 – 60m length	Culverts designed to carry a 0.5% AEP (1:200 year flow), with mammal ledge. Maintains bed continuity throughout the structure.
	Realignment	Realignment associated with culvert construction, and one major realignment – length 951m (lengthening of burn by 49m).	With regards to major realignment, geomorphological features must be reproduced and hydraulic gradient and length must be maintained. Sensitive realignment design reintroducing meanders, alternating pool and riffle sequences, and morphological diversity where possible to offset straightening of channel and other culverting proposed on the watercourse. Regular maintenance and clearance of debris.
	Construction	Increased risk of pollution from concreting and fuel and oil spills. Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of a similarly sized material to cover the bottom of the culvert. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Early construction of treatment ponds during construction period to allow settlement and treatment of pollutants and control flow rate of runoff before discharge into watercourse. Contractor to monitor water quality prior to, and during, construction.
Limpet Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	Buried structure spanning the watercourse:	Buried structure with no piers in the river to maintain good water quality and morphological diversity during operation and reduce the damage to riparian

Watercourse	Proposed Works	Potential Impact Description	Mitigation
		ch1400	habitats. No in channel works to reduce the risk of accidental spillage, water diversion and sediment release.
	Realignment	Realignment associated with buried structure construction – length 123m (original length 124m).	Use of new similarly sized material to cover the new channel. For required geomorphological features (refer to Appendix A39.2: Fluvial Geomorphology).
	Construction	High risk of pollution from concreting and fuel and oil spills. High risk of sediment release from earthworks.	Adherence to best practice. Generic mitigations apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Cut-off ditches; sediment fencing; sediment trap (settling lagoons). Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Contractor to monitor water quality prior to, and during, construction. See also specific mitigation section below.
Coneyhatch Burn	Road Drainage	n/a	n/a
	Crossing	n/a	n/a
	Realignment	Taken into pre-earthworks	n/a
	Construction	Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5, with particular reference to paragraph 5.5.10, and Table 5.2. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) when diverting watercourse into drainage ditches.
Fishermyre	Road Drainage	Road drainage system crossing through the wetland	Lining of the filter drains.
	Crossing	n/a	n/a
	Realignment	n/a	n/a
	Construction	High risk of pollution from accidental spillage.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Contractor to monitor water quality prior to, and during, construction. Refer to Appendix 40.7 (Ecology: Water Voles) for specific mitigation for the colony of water voles in the area.

Watercourse	Proposed Works	Potential Impact Description	Mitigation
Green Burn	Road Drainage	One proposed outfall draining total of 1.8 ha	Filter Drain, 2 x 60m swales
	Crossing	2 No. culverts: Mainline ch3125 – length 84m Side road ch213 – length 19m	Culverts designed to carry a 0.5% AEP (1:200 year flow), with mammal ledge. Maintains bed continuity throughout the structure. Further assessment and specific mitigations regarding water voles can be found in Appendix A39.1 Surface Water Hydrology.
	Realignment	One realignment associated with culvert construction – length 342m (shortening of burn by 8m).	Regular maintenance and clearance of debris.
	Construction	Increased risk of pollution from concreting and fuel and oil spills. Increased risk of fine sediment release during earthworks. Possible drain crossings and diversions. Sewerage. Possible slight impact from land contamination (see Chapter 38: Geology, Contaminated Land and Groundwater) and sediments.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culverts/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of similarly sized material to cover the bottom of the culvert. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Early construction of treatment ponds during construction period to allow settlement and treatment of pollutants and control flow rate of runoff before discharge into watercourse. Contractor to monitor water quality prior to, and during, construction. The landfill in the vicinity must not be disturbed. Further information on mitigation required can be found in Chapter 38: Geology, Contaminated Land and Groundwater.
Green Ditch	Road Drainage	n/a	n/a
	Crossing	n/a	n/a
	Realignment	Realigned length 36m (shortening of ditch by 59m)	
	Construction	Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) when diverting watercourse into drainage ditches.
Allochie Burn	Road Drainage	n/a	n/a

Watercourse	Proposed Works	Potential Impact Description	Mitigation
	Crossing	n/a	n/a
	Realignment	Taken into pre-earthworks	n/a
	Construction	Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5, with particular reference to paragraph 5.5.10, and Table 5.2. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) when diverting watercourse into drainage ditches.
Burn of Muchalls	Road Drainage	One proposed outfall draining total of 6.5ha	Filter Drain, Detention Basin, 1 x treatment pond (storage volume, Vt – see paragraph 5.2.12 for details)
	Crossing	Buried structure spanning the watercourse: ch4700	Buried structure with no piers in the river to maintain good water quality and morphological diversity during operation and reduce the damage to riparian habitats. No in channel works to reduce the risk of accidental spillage, water diversion and sediment release.
	Realignment	n/a	n/a
	Construction	Increased risk of pollution from concreting, fuel and oil spills. Fine sediment release from earthworks.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Cut-off ditches; sediment fencing; sediment trap (settling lagoons). Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Early construction of treatment ponds during construction period to allow settlement and treatment of pollutants and control flow rate of runoff before discharge into watercourse. Contractor to monitor water quality prior to, and during, construction. See also Specific Mitigation section below.
Burn of Blackbutts	Road Drainage	n/a	n/a
	Crossing	n/a	n/a
	Realignment	Taken into pre-earthworks	n/a
	Construction	Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5, with particular reference to paragraph 5.5.10, and Table 5.2. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) when diverting watercourse into drainage ditches.
Cookney Ditch	Road Drainage	No road drainage discharge to burn	n/a

Watercourse	Proposed Works	Potential Impact Description	Mitigation
	Crossing	2 No culverts: ch6480 – lengths 42m and 53m	Culverts designed to carry a 0.5% AEP (1:200 year flow), with mammal ledge. Maintains bed continuity throughout the structure.
	Realignment	One realignment associated with culvert construction – length 244m	Regular maintenance and clearance of debris.
	Construction	Increased risk of potential pollution from concreting, fuel and oil spills. Increased risk of sediment release during earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of a similarly sized material to cover the bottom of the culvert. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Contractor to monitor water quality prior to, and during, construction.
Stoneyhill Ditch	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culvert: ch6930 – length 36m	Culverts designed to carry a 0.5% AEP (1:200 year flow), with mammal ledge. Maintains bed continuity throughout the structure.
	Realignment	Realignment associated with culvert construction – length 203m	Regular maintenance and clearance of debris.
	Construction	Increased risk of potential pollution from concreting and fuel and oil spills. Increased risk of sediment release during earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of a similarly sized material to cover the bottom of the culvert. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of

Watercourse	Proposed Works	Potential Impact Description	Mitigation
			large oil spills that cannot be dealt with on a local level. Early construction of treatment ponds during construction period to allow settlement and treatment of pollutants and control flow rate of runoff before discharge into watercourse. Contractor to monitor water quality prior to, and during, construction.
Balnagubs Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culverts: ch7550 – length 48m	Culverts designed to carry a 0.5% AEP (1:200 year flow), with mammal ledge. Maintains bed continuity throughout the structure.
	Realignment	Realignment associated with culvert construction – length 117m.	Regular clearance and maintenance of debris.
	Construction	Increased risk of potential pollution from concreting and fuel and oil spills. Increased risk of sediment release during earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of a similarly sized material to cover the bottom of the culvert. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Contractor to monitor water quality prior to, and during, construction.
Tributary of Elsick Burn	Road Drainage	One proposed outfall draining total of 5.7ha	Filter Drain, Detention Basin, 1 x treatment pond (storage volume, Vt – see paragraph 5.2.12 for details)
	Crossing	1 No. Culverts: ch7975 – length 53m	Culverts designed to carry a 0.5% AEP (1:200 year flow), with mammal ledge. Maintains bed continuity throughout the structure.
	Realignment	Realignment associated with culvert construction – length 150m.	Regular clearance and maintenance of debris.
	Construction	Increased risk of pollution from concreting and fuel and oil spills. Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls.

Watercourse	Proposed Works	Potential Impact Description	Mitigation
			Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of a similarly sized material to cover the bottom of the culvert. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Early construction of treatment ponds during construction period to allow settlement and treatment of pollutants and control flow rate of runoff before discharge into watercourse. Contractor to monitor water quality prior to, and during, construction.
Whiteside Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. Culverts: ch8850 – length 62m	Culverts designed to carry a 0.5% AEP (1:200 year flow), with mammal ledge. Maintains bed continuity throughout the structure.
	Realignment	Realignment associated with culvert construction – length 121m.	Regular clearance and maintenance of debris.
	Construction	Increased risk of pollution from concreting and fuel and oil spills. Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of a similarly sized material to cover the bottom of the culvert. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Early construction of treatment ponds during construction period to allow settlement and treatment of pollutants and control flow rate of runoff before discharge into watercourse. Contractor to monitor water quality prior to, and during, construction.
Crossley Burn	Road Drainage	No road drainage discharge to burn	n/a

Watercourse	Proposed Works	Potential Impact Description	Mitigation
	Crossing	1 No. Culverts: ch9170 – length 87m	Culverts designed to carry a 0.5% AEP (1:200 year flow), with mammal ledge. Maintains bed continuity throughout the structure.
	Realignment	Realignment associated with culvert construction – length 161m.	Regular clearance and maintenance of debris.
	Construction	Increased risk of pollution from concreting and fuel and oil spills. Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of a similarly sized material to cover the bottom of the culvert. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Early construction of treatment ponds during construction period to allow settlement and treatment of pollutants and control flow rate of runoff before discharge into watercourse. Contractor to monitor water quality prior to, and during, construction.
Cairns Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	No crossings planned	n/a
	Realignment	Realigned length 192m (shortening of burn by 40m)	With regards to major realignment, morphological features must be reproduced and hydraulic gradient and length must be maintained. Regular maintenance and clearance of debris.
	Construction	Increased risk of pollution from fuel and oil spills Fine sediment releasing from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Cut-off ditches; sediment fencing; sediment trap (settling lagoons). Diversion or pumping away during construction of culvert/realignments; Geotextile lining and new similar sized inert granular material at the temporary realignment to reduce erosion and sedimentation. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level.

Watercourse	Proposed Works	Potential Impact Description	Mitigation
			Early construction of treatment ponds during construction period to allow settlement and treatment of pollutants and control flow rate of runoff before discharge into watercourse. Contractor to monitor water quality prior to, and during, construction.
Circle Burn	Road Drainage	n/a	n/a
	Crossing	n/a	n/a
	Realignment	Taken into pre-earthworks	n/a
	Construction	Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5, with particular reference to paragraph 5.5.10, and Table 5.2. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) when diverting watercourse into drainage ditches.
Square Burn	Road Drainage	n/a	n/a
	Crossing	n/a	n/a
	Realignment	Taken into pre-earthworks	n/a
	Construction	Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5, with particular reference to paragraph 5.5.10, and Table 5.2. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) when diverting watercourse into drainage ditches.
Wedderhill Burn	Road Drainage	n/a	n/a
	Crossing	n/a	n/a
	Realignment	n/a	n/a
	Construction	Fine sediment release from earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) when diverting watercourse into drainage ditches.
Craigentath Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. Culverts: ch10630 – length 67m	Culverts designed to carry a 0.5% AEP (1:200 year flow), with mammal ledge. Maintains bed continuity throughout the structure.
	Realignment	Realignment associated with culvert construction – length 216m.	Regular clearance and maintenance of debris.

Watercourse	Proposed Works	Potential Impact Description	Mitigation
	Construction	Risk of pollution from concreting and fuel and oil spills. Low impact from fine sediment release during earthworks. Possible drain crossings and diversions.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 5.2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation. Cut-off ditches; sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of a similarly sized material to cover the bottom of the culvert. Detailed method statements to be provided for all aspects of work impacting upon Water Environment during CAR process, including method statement for the release of total suspended solids. Detailed contingency plan to be provided for mitigation of large oil spills that cannot be dealt with on a local level. Early construction of treatment ponds during construction period to allow settlement and treatment of pollutants and control flow rate of runoff before discharge into watercourse. Contractor to monitor water quality prior to, and during, construction.

Specific Mitigation

5.3.12 The mitigation described in the preceding sections will be applied to all watercourses considered. In addition to these measures, further site specific mitigation for the watercourses of high value are provided below.

<u>Limpet Burn and Burn of Muchalls</u>

5.3.13 The following additional mitigation measures are proposed to enhance sediment management, reduce erosion and impacts on the morphological diversity of these watercourses:

- Ecological Clerk of Works should be present on site during construction, to ensure the implementation of appropriate environmental safeguards;
- use of plastic sleeve and double falsework/shuttering when working over the watercourse to ensure minimal concrete spillage;
- enclosed spraying when waterproofing preventing from chemicals entering the watercourse; and
- works with a high potential of sediment release should be carried out between May and September where practicable (refer to Chapter 40: Ecology and Nature Conservation). Long term water quality/ecological monitoring before, during and after construction (to be agreed with SEPA prior to work commencement).

6 Residual Impacts

The residual impacts section presents the likely impacts of the proposed scheme with the implementation of the mitigation measures detailed in the previous section.

6.1 Operation Residual Impacts

Routine Runoff

6.1.1 Following treatment and settlement, it is considered that the residual impact of insoluble pollutants entering the Tributary of Elsick Burn would be of low and negligible magnitudes for copper and zinc respectively, resulting in Slight and Negligible significances. Impacts on Megray Burn and Burn of Muchalls would be of negligible magnitude, which would result in an impact of Negligible to Slight/Negligible significance. The impacts on Green Burn are considered to be of low magnitude for copper and negligible magnitude for zinc, with an overall impact of Slight significance. The remaining watercourses may be affected by diffuse pollution, however these impacts are considered to be of Negligible to Slight/Negligible significance. Details of the calculations are given in Annex 28.

Table 17 – Estimated Residual Impact of Total Zinc and Dissolved Copper

Site	Sensitivity	Parameter	EQS Annual Average (µg/l)	Inferred Upstream Conc. (µg/l)	Estimated Downstream Conc. without Mitigation (µg/l)	Estimated Downstream Conc. with Mitigation (µg/l)	Percentage Increase over Baseline Conc. Levels (%)	Magnitude (with Mitigation)	Significance of Impact (with Mitigation)
Megray Burn	Medium	Copper	28	14	37*	15	5	Negligible	Negligible
		Zinc	125	63	136*	57	0	Negligible	Negligible
Limpet Burn	High	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Fishermyre	High	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Green Burn	Medium	Copper	10	5	13*	6	30	Low	Slight
		Zinc	75	38	64	37	0	Negligible	Negligible
Green Ditch	Low	Diffuse	n/a	n/a	n/a	n/a	n/a	Low	Negligible
Burn of Muchalls	High	Copper	10	5	8	6	15	Negligible	Slight/ Negligible
		Zinc	75	38	47	38	1	Negligible	Slight/ Negligible
Balnagubs Burn	Low	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Negligible
Tributary of Elsick Burn	Medium	Copper	28	14	32*	18	29	Low	Slight
		Zinc	125	63	120	62	0	Negligible	Negligible
Whiteside Burn	Medium	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Negligible
Crossley Burn	Low	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Negligible
Cairns Burn	Low	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Negligible
Craigentath Burn	Low	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Negligible

* Exceeds Annual Average EQS

6.1.2 With the inclusion of scour protection at outfalls, the potential impact of erosion on watercourse banks is considered to be Negligible.

6.1.3 The results of the sensitivity tests on the assumed hardness values indicated that the levels of mitigation proposed would be sufficient even if the water hardness is reduced.

Risk of Accidental Spillage

6.1.4 The residual risk of accidental spillage with mitigation measures in place are summarised in Table 18 (refer to Annex 27 for details of the calculations).

Table 18 – Summary of Residual Spillage Risk Assessment

Watercourse	Sensitivity	Threshold of Acceptability	Spillage Risk in Design Year – without Mitigation	Spillage Risk in Design Year – with Mitigation	Within Acceptable Limits?	Magnitude	Residual Impact
Megray Burn	Med	1:100	1:438	1:10207	Yes	Negligible	Negligible
Green Burn	Med	1:100	1:816	1:19030	Yes	Negligible	Negligible
Burn of Muchalls	High	1:100	1:231	1:1888	Yes	Negligible	Slight/ Negligible
Tributary of Elsick Burn	Med	1:100	1:265	1:2161	Yes	Negligible	Negligible

6.1.5 With mitigation, the residual impact on all watercourses as a result of accidental spillage is considered to be of Negligible to Slight/Negligible significance.

6.1.6 The results of the sensitivity tests on the assumed hardness values indicated that the levels of mitigation proposed would be sufficient even if the water hardness were reduced. However, given the level of potential impacts indicated without the application of mitigation, mitigation measures must be robustly implemented.

6.2 Construction Residual Impacts

6.2.1 The residual impact assessment shows that construction impacts are considered to be of Slight or Slight/Negligible significance on Limpet Burn and the Burn of Muchalls. The residual impact for Fishermyre during construction is also considered to have Slight/Negligible significance. All remaining watercourses, including those taken into pre-earthworks, have a residual impact assessment during construction of Slight or Negligible significance (Table 19).

6.3 Summary

6.3.1 The residual impacts on watercourses within the Fastlink study area are summarised in Table 19.

Table 19 – Residual Impact Assessment (Residual Impact of Pollutant Release Included in Overall Assessment)

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
Megray Burn	Medium	Construction: Major potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of new culvert and associated realignment and extension of existing culvert would involve major earthworks, possibly resulting in high sediment and pollutant release and short-medium term increased turbidity in the water column. Small dilution capacity of the watercourse.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Low residual impact.	Slight
		General Operation: A major shift from baseline conditions due to discharge of road runoff. Long-term adverse impact on water quality and ecology. Routine Runoff: High impact from routine runoff due to an increase of > 100% over baseline for copper and zinc, resulting in failure of EQS for both pollutants. Accidental Spillage: Low impact from accidental spillage as spillage risk is 1 in 438 years, which is above the probability threshold of 1 in 200 and below 1 in 1000 years. Total Suspended Solids: Q_{mean} for Megray Burn is 0.007 m^3/s which indicates a low dilution capacity therefore total suspended solids will pose a high impact magnitude.	Operation: Road runoff will be treated through SUDS to ensure compliance with EQS and that the pollution risk from accidental spillage is within acceptable limits. Routine Runoff: Negligible impact from routine runoff – increase of 5% over baseline for copper. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 1 in 10207 years, which is above the probability threshold of 1 in 1000 years. Total Suspended Solids: SUDS will remove up to 90% of total suspended solids therefore negligible impact.	Negligible
Limpet Burn	High	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a buried structure and associated realignments would involve earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice. Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact.	Slight/Negligible
		General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of buried structure likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Operation: No outfall planned therefore Negligible impact due to diffuse pollution. Change to discharge regime will be minimised through careful design of realignment and buried structures. Length of buried structure likely to impact upon water quality due to lack of light.	Slight/Negligible

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
Coneyhatch Burn	Low	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		Operation: Taken into pre-earthworks.	Operation: Taken into pre-earthworks.	n/a
Fishermyre	High	Construction: Surface and groundwater water quality in the vicinity of Fishermyre wetland is of high sensitivity. Potential high impact in the event of accidental pollution spillages from the road construction works.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice. Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Slight/Negligible
		Operation: High potential impact from the road drainage runoff entering the wetland and in the event of accidental spillages.	Operation: Negligible impact from the road drainage runoff due to the lining of the filter drains.	Slight/Negligible
Green Burn	Medium	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of two culverts and the realignments would involve earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Medium dilution capacity of the watercourse.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice. Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Low residual impact.	Slight
		General Operation: A major shift from baseline conditions due to discharge of road runoff. Temporary adverse impact on water quality and ecology. Routine Runoff: High impact from routine runoff due to an increase of > 100% over baseline for copper resulting in failure of EQS, and medium impact for zinc (71% increase over the baseline concentration). Accidental Spillage: Low impact from accidental spillage as spillage risk is 1 in 816 years, which is above the probability threshold of 1 in 200 years and below 1 in 1000 years Total Suspended Solids: Q_{mean} for Green Burn is 0.010 m^3/s which indicates a medium dilution capacity therefore total suspended solids will pose a medium impact magnitude.	Operation: Road runoff will be treated through SUDS to ensure compliance with EQS and that the pollution risk from accidental spillage is within acceptable limits. Routine Runoff: Low impact from routine runoff – increase of 30% over baseline for copper. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 1 in 19030 years, which is above the probability threshold of 1 in 1000 years. Total Suspended Solids: SUDS will remove up to 90% of total suspended solids therefore negligible impact.	Slight
Green Ditch	Low	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
		Operation: Change in water quality likely to be Negligible due to diffuse pollution. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Operation: No outfall planned therefore Negligible impact due to diffuse pollution.	Negligible
Allochie Burn	Medium	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		Operation: Taken into pre-earthworks.	Operation: Taken into pre-earthworks.	n/a
Burn of Muchalls	High	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a buried structure would involve some earthworks, possibly resulting in sediment and pollutants release and short term increased turbidity in the water column. High dilution capacity of the watercourse.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice. Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Slight/Negligible
		General Operation: A measurable shift from baseline conditions due to discharge of road runoff. Temporary to long-term adverse impact on water quality and ecology. Routine Runoff: Low impact from routine runoff due to increase of 58% over baseline for copper and 25% for zinc. Accidental Spillage: Low impact from accidental spillage as spillage risk is 1 in 231 years, which is above the probability threshold of 1 in 200 years and below 1 in 1000 years. Total Suspended Solids: Q_{mean} for Burn of Muchalls is 0.103 m^3/s which indicates a high dilution capacity therefore total suspended solids will pose a low impact magnitude.	Operation: Road runoff will be treated through SUDS to ensure compliance with EQS and that the pollution risk from accidental spillage is within acceptable limits. Routine Runoff: Negligible impact from routine runoff – 15% increase over baseline for copper and 1% for zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 1 in 1888 years, which is above the probability threshold of 1 in 1000 years. Suspended Solids: SUDS will remove up to 90% of total suspended solids therefore negligible impact.	Slight/Negligible
Burn of Blackbutts	Low	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		Operation: Taken into pre-earthworks.	Operation: Taken into pre-earthworks.	n/a

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
Cookney Ditch	Low	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of two culverts and the realignments would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		Operation: General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of two culverts likely to have negligible impact upon water quality. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Operation: No outfall planned therefore Negligible impact due to diffuse pollution. Change to discharge regime will be minimised through careful design of realignment and culverts. Culverts will be designed to carry a 0.5% AEP (1:200 year flow).	Negligible
Stoneyhill Ditch	Low	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a culvert and the realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		Operation: General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of culvert likely to have negligible impact upon water quality. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Operation: No outfall planned therefore Negligible impact due to diffuse pollution. Change to discharge regime will be minimised through careful design of realignment and culverts. Culverts will be designed to carry a 0.5% AEP (1:200 year flow).	Negligible
Balnagubs Burn	Low	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a culverts and the realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of culvert likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Operation: No outfall planned therefore Negligible impact due to diffuse pollution. Change to discharge regime will be minimised through careful design of realignment and culverts. Culverts will be designed to carry a 0.5% AEP (1:200 year flow). Length of culvert likely to impact upon water quality due to lack of light	Negligible

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
Tributary of Elsick Burn	Medium	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a culvert and the realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column. Medium dilution potential of watercourse.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		General Operation: A major shift form baseline conditions due to discharge of road runoff. Temporary to long-term adverse impact on water quality and ecology. Routine Runoff: High impact from routine runoff due to an increase of > 100% over baseline for copper resulting in failure of EQS. Medium impact regarding zinc concentrations – 92% increase over baseline. Accidental Spillage: Low impact from accidental spillage as spillage risk is 1 in 265 years, which is above the probability threshold of 1 in 200 years and below 1 in 1000 years. Total Suspended Solids: Q_{mean} for Burn of Elsick is 0.013 m^3/s which indicates a medium dilution capacity therefore total suspended solids will pose a medium impact magnitude.	Operation: Road runoff will be treated through SUDS to ensure compliance with EQS and that the pollution risk from accidental spillage is within acceptable limits. Routine Runoff: Low impact from routine runoff – increase of 29% over baseline for copper. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 1:2161, which is above the probability threshold of 1 in 1000 years. Total Suspended Solids: SUDS will remove up to 90% of total suspended solids therefore negligible impact.	Slight
Whiteside Burn	Medium	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a culvert and the realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of culvert likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Operation: No outfall planned therefore Negligible impact due to diffuse pollution. Change to discharge regime will be minimised through careful design of realignment and culverts. Culverts will be designed to carry a 0.5% AEP (1:200 year flow). Length of culvert likely to impact upon water quality due to lack of light.	Negligible
Crossley Burn	Low	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a culvert and the realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
		General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of culvert likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Operation: No outfall planned therefore Negligible impact due to diffuse pollution. Change to discharge regime will be minimised through careful design of realignment and culverts. Culverts will be designed to carry a 0.5% AEP (1:200 year flow). Length of culvert likely to impact upon water quality due to lack of light	Negligible
Cairns Burn	Low	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		General Operation: Change in water quality likely to be small and watercourse ecology expected to only be impacted Slightly. Routine Runoff: Negligible impact due to routine runoff as there is no outfall planned. Accidental Spillage: Negligible impact due to routine runoff as there is no outfall planned. Total Suspended Solids: Negligible impact due to routine runoff as there is no outfall planned.	Operation: No outfall planned therefore Negligible impact due to diffuse pollution. Change to discharge regime will be minimised through careful design of realignment	Negligible
Circle Burn	Low	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		Operation: Taken into pre-earthworks.	Operation: Taken into pre-earthworks.	n/a
Square Burn	Low	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		Operation: Taken into pre-earthworks.	Operation: Taken into pre-earthworks.	n/a
Wedderhill Burn	Low	Construction: This would involve earthworks, possibly resulting in a large increase in downstream suspended solid loads in the short-term. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		Operation: Watercourse lost through catchment severance.	Watercourse lost through catchment severance.	n/a

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
Craigentath Burn	Low	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Culvert construction and realignment would involve earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column.	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible
		General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of culvert likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. Total Suspended Solids: no outfall planned.	Operation: No outfall planned therefore Negligible impact due to diffuse pollution. Change to discharge regime will be minimised through careful design of realignment and culverts. Culverts will be designed to carry a 0.5% AEP (1:200 year flow). Length of culvert likely to impact upon water quality due to lack of light	Negligible

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Water Framework Directive (2000/60/EC)

Water Environment and Water Services (Scotland) Bill (2003)

World Health Organisation (1994) http://www.who.int/en/

8 Glossary

Acute pollution	occurs as a result of a severe, usually transient, impact.
Adjustment	modification of river channel shape through erosion and deposition.
Adsorption	process of removal of heavy metals from the water column.
Annual Average Concentration	the average of the measured concentration for a period of one year.
BAP	Biodiversity Action Plan
Bioassimilation	process of accumulation of a substance within a habitat.
Bioaccumulation	process whereby certain chemicals in the environment accumulate in animal tissues.
BOD	biological oxygen demand mg/l.
Boulder particle of diameter > 256 mm	"human head" size and above.
Buffer Strip	an area of land between the river channel and cultivated land that is uncultivated and often fenced off.
Channel Capacity	the volume of water that can be contained within a given section of river channel.
Catchment	the total area of land that drains into any given river.
Channel	the course of a river including the bed and banks.
Chronic pollution	the result of ongoing low levels of pollution which may result in the accumulation of pollutants over a longer period of time (months/years).
Clay	particle of diameter < 0.002mm.
Coarse sediment	sediment of grain diameter greater than 2 mm.
Cobble	particle of diameter 64mm to 256mm, approximately "fist" sized.
Continuity	relates to how continuous the flow or sediment transfer is within a particular watercourse. Culverts often break the continuity through promoting deposition.
Conveyance	how water is transported downstream (e.g. volume, speed).
Culvert	artificial structure, often concrete, for carrying water underground or under bridges.
Debris	coarse woody debris blocking the channel and causing water to pond back.
Discharge	the volume of water flow per unit time usually expressed in cubic metres per second ($m^3 s^{-1}$).
Desorption	process of reintroduction of heavy metals to the water column.

Diffuse pollution	pollution that originates from sources that are difficult to measure directly, e.g. agricultural runoff from fields.
Embankment	artificial flood bank built for flood defence purposes, which can be flush with the channel or set back on the floodplain.
Ephemeral stream	usually low order, water only during and immediately after heavy rainfall
EQS	environmental quality standards.
Erosion	the process by which sediments are mobilised and transported by rivers.
EU Water Framework Directive	
	Under this Directive, Member States must achieve "good ecological potential" in modified systems and prevent deterioration in the status of surface waters. Ecological status is to be assessed using a number of parameters, including hydromorphological (or fluvial geomorphological and hydrological) quality elements.
Hydrological regime	the quality and connection to groundwater reflect totally or neat totally undisturbed conditions.
River continuity	the continuity of the river is not disturbed by human activities and allows the undisturbed migration of aquatic organisms and sediment transport.
Morphological conditions	channel patterns and dimensions, flow velocities, substrate conditions and the structure and condition of the riparian zone correspond totally or nearly totally to undisturbed conditions (Source: EU Directive 2000/60/EC – The Water Framework Directive).
Exclusion zone	an area of land beside the river which is out of bounds during construction operations. In the AWPR case, the zone includes the 5 m width from the river bank which forms the SAC and a further 4 m totalling 9 m.
Fine sediment	sediment of grain diameter finer than 2 mm.
Flood	a high river flow following rainfall or snowmelt where a river flows out of its channel, sometimes affecting human activity.
Floodplain	area of the valley bottom inundated by water when a river floods.
Flow regime	description of how the flow in a river varies over time and how frequently and for how long high flows (floods) and low flows (during droughts) occur.
Fluvial geomorphology	the branch of geomorphology that describes the characteristics of river systems and examines the processes sustaining them.
Geomorphology	the study of features and processes operating upon the surface of the Earth.
Geotextile	fabric membrane used for bank stabilisation, usually to aid re-vegetation.
Gravel	particle of diameter between 2 mm and 64 mm.

Hydraulic	the force exerted by flowing water.
Hydrological	referring to the flow of water, specifically its routing and speed.
In-stream	that part of the channel covered by water in normal flow conditions.
Load	the amount of sediment that is being carried by the river.
Meander	a bend in the river formed by natural river processes e.g. erosion and deposition.
Modification	channel features that have been created by management interventions and often involve river engineering.
Oxidation	chemical reaction which results in the addition of oxygen to a molecule.
Pool	discrete areas of deep water, typically formed on the outside of meanders.
Reach	a length of an individual river which shows broadly similar physical characteristics.
Realignment	alteration of the planform channel (often by straightening) to speed up flows and reduce flood risk.
Redox potential	measure of the potential of the water for oxidation or reduction.
Reduction	chemical process where molecule gain an electron.
Re-naturalising	a formally modified channel that is adjusting to represent a more natural channel in terms of geometry and vegetation.
Reprofiling	reshaping a bank to improve its stability and potential habitat value (usually by reducing the angle of the slope).
Resectioning	alteration of the cross-sectional profile of a channel, often to speed up flows and reduce flood risk.
Riffle	a shallow, fast flowing section of water with a distinctly disturbed surface forming upstream-facing unbroken standing waves, usually over a gravel substrate.
Riparian	land on the side of the river channel.
River corridor	land to either side of the main river channel, including associated floodplain(s).
Rock armour	angular stone placed to protect eroding banks.
Routine Runoff	the normal runoff from roads that may include the contaminants washed off the surface in a rainfall event and can result in either acute or chronic impacts.
Runoff	surface flow after rain which entrains and transports fine sediment from the slope to the channel.
Salmonid	the family of fish species that includes the salmon trout and char.

Sedimentation	the accumulation of sediment (fine or/and coarse) which was formerly being transported.
Scour	erosion caused by hydraulic action.
Side bars	gravel or other shallow deposits along the edges of straight sections of river channels.
Siltation	deposition of fine sediment (comprising mainly silt) on the channel bed often promoting vegetation growth if it is not flushed downstream regularly.
Sink	a deposit of sediment in the channel – the location where sedimentation is occurring.
Sinuous	a channel displaying a meandering course. High sinuosity relates to a channel with many bends over a short distance; low sinuosity is often used to describe a fairly straight channel.
Source	where sediment is supplied to a river channel.
Suspended solids	typically fine sediment which is transported in suspension.
Treatment train	the application of a selection of drainage systems which provides treatment of the surface runoff such that the pollution impact on the receiving waters is minimised
TSS	total suspended solids (mg/l).
Turbidity	a density flow of water and sediment (suspended solids).
Two stage channel	a channel containing a bench like feature or features (berms) which create a low flow channel within a wider high flow channel.
Woody Debris	accumulations of woody material derived from trees, usually fragments of the branches, trunk and roots.
Qmean	mean flow (m^3/s).
QMED	median annual flood flow (m^3/s) (flow with a 2 year return period).
Q95	flow that is expected to be exceeded 95% of the time (m^3/s).
SAC	special area of conservation.
SSSI	site of special scientific interest.
SUDS	sustainable urban drainage systems.
95-percentile concentration	the value below which statistically 95% of the measured concentrations will lie.
Waterbody	any water feature, i.e. river, lake, burn, loch, pond, moss etc.
Watercourse	any brook, stream, or artificially constructed water channel.