Appendix A24.4 – Water Quality

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Contents

1 Introduction

1.1 General Background

1.1.1 This report is a technical appendix of the Chapter 24 (Water Environment) of the Environmental Statement for the Southern Leg 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.

1.1.8 In addition to the requirements of the WFD for promotion and maintenance of good aquatic ecological health, the Atlantic salmon (*Salmo salar*) (a European and UK protected species) is present in the River Dee. Salmon is typically used as a biological indicator of high quality water (SEPA guide to best practice).

1.2 Assessment Aims

1.2.1 The general aim of the water quality report is to assess the impact of the proposed road drainage outfalls on the water quality of the receiving watercourses before and after implementation of appropriate mitigation (Sustainable Urban Drainage Systems).

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 designed 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 24 (Water Environment), where the level of significance of a potential 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:
  - pollution (both soluble and insoluble); and
  - 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 proposed route on fluvial geomorphology, flood risk and surface water hydrology are to be investigated separately (refer to Appendix A24.3: Fluvial Geomorphology, Appendix A24.2: Hydrodynamic Modelling and Appendix A24.1: Surface Water Hydrology). The potential impacts to watercourses from fine sediment release is discussed in detail in the Fluvial Geomorphology assessment (Appendix A24.3).

2.1.3 An impact to water quality may have associated impacts upon aquatic ecology. These impacts are discussed in more detail in Chapter 25 (Ecology and Nature Conservation) and its associated appendices.

2.1.4 For the purpose of this assessment, the criteria used to assess the sensitivity of surface water features and the magnitude of the potential 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 assist in building 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 watercoursee with pristine or near pristine water quality, Class A1 and A2 (Annex 26), 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 26). 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 the 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 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 the 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 (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 The 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 all the 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 (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 A24.3) 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 (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 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 A24.3 (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 of Scotland's Water: 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 A25.9: Freshwater Ecology).

2.3.2 Baseline conditions for watercourses are reported by SEPA following their River Classification Scheme (Annex 26, SEPA Classification Scheme). This categorises watercourses on the basis of monitoring water chemistry, biology, nutrient status, aesthetic condition and concentration of toxic substances. 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 26, 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/or ecological surveys are taken and the aesthetic appearance recorded (Annex 26, 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 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 A25.9: Freshwater Ecology, section 2.4) 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 the 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 (discussed in detail in Chapter 23: Geology, Contaminated Land and Groundwater);
- impacts on fluvial geomorphology and sediment release (discussed in detail in Appendix A24.3: Fluvial Geomorphology);
- impacts on hydrology and flood risk (discussed in detail in Appendices A24.1 and A24.2 respectively); and
- impacts on water quality during construction.

<u>Routine Runoff</u>

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 some of 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).

General

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 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. The EQS are principally ecological standards, specified for a range of parameters at levels required to protect aquatic life. They 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 the potential pollution in the receiving watercourse 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 95^{th} percentile is the concentration that is exceeded for only 5% of the time and therefore would be expected to occur very rarely.

Calculations of the Annual Average Concentration

2.3.9 In addition to the Freshwater Fisheries Directive, the Dangerous Substance Directive sets statutory Environmental Quality Standards 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, personal communication 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, either 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 (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 provided in Table 4 (SEPA, personal communication, 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 (SI Circular No34/1985) as it is understood that those published on the website are not yet statutory.

Table 4 – National Environmental Quality Standards 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 (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 Dangerous Substances Directive (DSD) and Freshwater Fisheries Directive (FWFD).

Insoluble Pollutants, Suspended Solids

2.3.15 Currently, there are no 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 potential 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 mitigations. The probability of a serious accidental spillage leading to a serious pollution incident would 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 (Highways Agency et al., 1993).

Note: * Risk factor applies to all road lengths within 100m 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 (Highways Agency et al., 1993).

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

P_{acc} = RL x SS x (AADT x 365 x 10^{-6}) x (%HGV ÷ 100)

2.3.19 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 (or local data if available)
AADT = annual average daily traffic
%HGV = percentage of Heavy Goods Vehicles

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

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

2.3.21 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 fromTable 6, using the quality of the reach proposed to receive the discharge.

2.3.22 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

2.3.23 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

2.3.24 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

2.3.25 The construction impact assessment was carried out qualitatively. 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.

2.3.26 The watercourses that would be taken into pre-earthworks would be highly impacted 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.

Cumulative Impact Modelling on River Dee

2.3.27 An assessment of potential cumulative impacts on the River Dee for the three main road pollutants (dissolved copper, total zinc and supended solids) has been conducted (see Appendix A24.5: Water Quality Modelling). The assessment used SIMCAT (SIMulation of CATchments), which is a commercially available model developed by the Environment Agency (EA). SIMCAT is a Stochastic Optimisation Model, which calculates the water quality of a river throughout the catchment area. Cumulative pollutant levels within the river have been assessed without mitigation and then with proposed mitigation in place. The results are summarised in this report and provided in more detail in Appendix A24.5 (Water Quality Modelling).

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 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 A24.3) assess the impact to the watercourses of TSS.

2.4.2 The baseline water quality assessment was conducted using chemical data (for the period 1984–2005) and biological data (for the period 2000-2005) provided by SEPA (SEPA, 2005) and spot sampling measurements conducted by Jacobs in the summer of 2006. However, the data sets provided by SEPA for zinc refer only to the River Dee and Crynoch Burn. In addition, the Crynoch Burn data cover a limited set of measurements for the period 1984-2000. 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 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 A24.1). 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 Southern Leg of the proposed scheme passes over or within the vicinity of a number of watercourses. Some of these watercourses are currently open and run through rural areas while others are more heavily modified and partially culverted (Figures 24.1a-h).

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 The baseline study examines 19 watercourses and two waterbodies 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

Water Body	Southern Leg
Major Watercourse	River Dee
Minor Watercourse	Loirston Burn
	Greengate Ditch
	Jameston Ditch
	Burn of Ardoe
	Bishopston Ditch
	Heathfield Burn
	Whitestone Burn
	Burnhead Burn
	Blaikiewell Burn
	Kingcausie Burn
	Crynoch Burn
	Milltimber Burn
	Culter House Burn
	Beans Burn
	Upper Beanshill Burn and associated ponds
	Gairn Burn
	Moss of Auchlea Drainage System
	Westholme Burn
Lochs and Waterbodies	Hare Moss
	Moss of Auchlea

3.1.4 The River Dee and its tributaries flow in a northeast direction into the North Sea. All watercourses in the vicinity of the Southern Leg of the AWPR scheme are relatively small, with the exception of the River Dee. The Moss of Auchlea and Hare Moss have also been identified as important ecological habitats (refer to Chapter 25: Ecology and Nature Conservation) and Appendix A24.1 (Surface Water Hydrology).

3.1.5 The baseline section of this report describes each watercourse. It presents the upstream catchment area of each watercourse to the point it meets the proposed scheme. Additionally, it discusses the water quality based on the data provided by SEPA (for the period 1984-2005), 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 at the end of each section.

3.2 Major Watercourses

River Dee

3.2.1 The River Dee rises in the Cairngorms to the west of Braemar and flows eastwards before entering the North Sea at Aberdeen. The main channel of the river is approximately 126km in length and drains a catchment area of approximately 2,038km².

3.2.2 The section of the River Dee relevant to the assessment is situated between Park Bridge and Bridge of Dee (refer to Figure 24.1d). Within this section, the river flows through predominantly agricultural land collecting water from several small tributaries: Culter Burn, Crynoch Burn, Milltimber Burn, Murtle Burn, Shanna Burn, Bielside Burn and Burn of Ardoe. On the north riverbank, there are a number of residential areas: Peterculter, Milltimber, Milton of Murtle, Bielside, Cults, Garthdee and Kaimhill. The River Dee and its surrounding area are also used for recreational purposes. There is a campsite near Crynoch Burn, a golf course and a sports centre at Bieldside. The area contains several riverside walks and the river is used for fishing and canoeing.

3.2.3 Water is abstracted from the river at the Inchgarth Reservoir to supply drinking water to the Aberdeen area. The average water abstraction is 89.9 megalitres per day (Aberdeen City Council et al., 2002, cited in Mouchel, 2002).

3.2.4 The River Dee at Milltimber is classed as a Class A2 river with good biological, and excellent chemical and aesthetic characteristics (see Table 8). As mentioned previously, the class allocated to a particular stretch of watercourse defaults to the poorest class from the assessment. Therefore although the chemical and aesthetic parameters were classed as A1, the lower quality biological characteristics down-graded it to Class A2. The measured levels of dissolved oxygen, ammonia and BOD are typical for natural unpolluted rivers (Table 8).

- saturated oxygen above 80% (SEPA class A1);
- ammonia concentrations below 0.25mg/l (SEPA class A1); and
- BOD below 2.5mg/l (SEPA class A1).

3.2.5 In natural waters, phosphorus is usually found in the range of 0.005 to 0.1mg/l, unless water has passed through soil containing phosphate or has been polluted by organic matter (WHO, 1984 and Hammerton, 1996). Phosphorous compounds are present in fertilisers and in many detergents. Consequently, they can be carried into both ground and surface waters with sewage, industrial wastes and storm runoff (WHO, 1984). Following the EU Urban Wastewater Treatment Directive (91/271/EEC), the UK water quality standards for orthophosphates provide guideline annual values below 0.1mg/l. The measured annual average orthophosphates (0.01mg/l) in the River Dee are within the EU UWWT Directive guideline values.

3.2.6 The measured concentrations at Milltimber over the period 1984-2005 (NJ858003) for copper are below the limits set by the Freshwater Fisheries Directive (FWFD, EQS value 22μg/l) and the Dangerous Substances Directive (DSD, EQS value 6μg/l). The zinc annual concentrations at this sampling point for the same period are within the DSD limits (monitoring annual average concentration 16μg/l, EQS 50μg/l at hardness 10-50 mg/l) and the 95-percentile concentration (monitoring concentrations for the 95th-percentile 52μg/l, DSD EQS 95% 200μg/l) and the FWFD (200μg/l) (refer to Table). In summary, the concentrations of zinc in the River Dee:

- currently pass EQS for the DSD (both annual concentrations and 95-percentile values); and
- currently pass EQS for the FWFD (95-percentile values).

3.2.7 Additionally, concentrations of copper in the River Dee:

- currently pass EQS for the DSD (annual concentrations); and
- currently pass EQS for the FWFD (95-percentile values).

3.2.8 The River Dee provides exceptional natural habitat conditions and water quality (spot sampling water quality at Milltimber category A2 and SEPA category A1/A2 within the SAC area) for populations of native brown trout, sea trout and migratory salmon. As it supports populations of freshwater pearl mussels, Atlantic salmon and otters, the river is a Natura 2000 site and is designated as a Special Area of Conservation (SAC). The boundary of the SAC designation extends 5m inland from the riverbanks of the Dee and a number of its tributaries (refer to Figure 25.1b). It also has a status of District Wildlife Site (DWS) and Site of Interest to Natural Science (SINS). The sensitivity of the River Dee has been classed as high.

3.2.9 SEPA monitors the water quality in the River Dee and Crynoch Burn (Table 8). The River Dee is currently receiving road drainage from the A90. Results from the SEPA monitoring for both the River Dee and Crynoch Burn for the year 2005 are presented below.

Table 8 – Water Quality Parameters (SEPA) for the River Dee and Crynoch Burn

Parameter (Units)		River Dee at Milltimber	Crynoch Burn at Milton Bridge
Category*	2005	A2	A2
Temperature (°C)	Aver.	8.8	8.4
	Max.	20	19.5
	Min.	0	0
BOD (mg/l)	Aver.	0.8	0.97
	Max.	3.1	3.6
	Min.	0.1	0.2
Conductivity (µS/cm)	Aver.	92.5	236
	Max.	204	319
	Min.	43	137
Total Hardness (mg/l as $CaCO_3$)	Aver.	26	-
	Max.	44	-
	Min.	10	-
	5%	15	-
	95%	37	-
Dissolved Oxygen (mg/l)	Aver.	11.2	11.3
	Max.	14.1	16.6
	Min.	7.2	8.4
O_2 Saturation (%)	Aver.	96	95

Parameter (Units)		**River Dee at Milltimber**	**Crynoch Burn at Milton Bridge**
	Max.	113	109
	Min.	73	81
Total Suspended Solids (TSS) (mg/l)	Aver.	3	3.7
	Max.	26	33
	Min.	1	1
pH	Aver.	7.1	7.5
	Max.	8.2	8.9
	Min.	5.6	6.0
Ammonia (mg/l)	Aver.	0.03	0.03
	Max.	0.15	0.13
	Min.	0.001	0.001
Nitrite (mg/l)	Aver.	0.007	0.012
	Max.	0.025	0.09
	Min.	0.001	0.001
O-phosphates (mg/l)	Aver.	0.01	0.03
	Max.	0.22	0.08
	Min.	0.001	0.003
Dissolved Copper (mg/l)	Aver.	0.001	-
	Max.	0.01	-
	Min.	0.0	-
	95%	0.005	-
Total Zinc (mg/l)**	Aver.	0.012	0.0058
	Max.	0.175	0.017
	Min.	0.0002	0.0006
	95%	0.04	0.013

* River classification data obtained from SEPA website

** Total zinc analyses for Crynoch Burn are performed using a limited set of data for the period 1984-2000 (Source: SEPA)

Source: Analysis of SEPA chemistry water quality data (SEPA, 1984-2005)

3.3 Minor Watercourses

Loirston Burn

3.3.1 Loirston Burn flows from its source to the southeast of Charleston into Loirston Loch, draining a catchment area of approximately 3.5km² up to the crossing of the proposed road. It is highly modified and acts predominantly as a drainage channel for surrounding agricultural areas. Bankhead Landfill, which is licensed for domestic, commercial and inert waste, is located in the vicinity of the watercourse crossing (see both Chapter 23: Geology, Contaminated Land and Groundwater, and Figure 23.5a). Loirston Burn and Loirston Loch are not classified under the SEPA Water Quality Classification. Spot sampling results for Loirston Burn (Jacobs, Summer 2006) show water quality class D (impoverished). Currently, the watercourse is crossed by an number of roads and it is assumed that it receives runoff from the following roads: A956 Wellington Road, Cove Road (U168K), Craighill (Redmoss) Road (U168K) and A90 (T) Perth to Fraserburgh Trunk Road.

3.3.2 Loirston Loch was previously designated as a SSSI due to the presence of nationally scarce thread rush (*Juncus filiformis*), which has progressively disappeared as a result of overall habitat degradation (eutrophication). In 1983, the SSSI status was removed. However, the loch is a valuable breeding and wintering wildfowl habitat and is therefore designated as a District Wildlife Site (DWS).

3.3.3 Loirston Burn is classed as medium sensitivity watercourse.

Greengate Ditch

3.3.4 This watercourse is a small and possibly ephemeral field ditch located south of Greengate Farm and draining a catchment area of approximately 0.2km^2 up to the crossing of the proposed road. Although in close proximity to Loirston Burn and Hare Moss, it is not directly connected to their catchments. Greengate Ditch is considered to be of low sensitivity.

Jameston Ditch

3.3.5 Jameston Ditch is a tributary of the Burn of Ardoe and part of the Hare Moss drainage system, running along the north boundary of moss. The ditch was built for agricultural purposes and has been straightened along its entire length, following field boundaries.

3.3.6 Jameston Ditch begins south of Jameston Cottage and flows in a westerly direction until it joins the Burn of Ardoe. Its catchment to the point of drainage crossing is approximately 0.2km^2. It is currently not classed by SEPA, but spot sampling results (Jacobs, Summer 2006) indicated water quality class B (fair). The sensitivity of this burn is considered to be high due to its hydrological connectivity to Hare Moss.

Burn of Ardoe

3.3.7 The Burn of Ardoe begins within the Hare Moss drainage system and flows in a northerly direction through a mixture of agricultural land and woodland before joining the River Dee. The upper catchment is gently sloping to the northwest. Further downstream, the slopes gradually become steeper as the burn approaches its confluence with the River Dee. The Burn of Ardoe is crossed by Lochton-Auchlunies-Nigg Road (C5K), a farm track and the B9077 along its way. Its catchment area up to the crossing of the proposed road is approximately 0.1km^2.

3.3.8 The burn is currently not classed by SEPA. It flows through agricultural land in its upper reaches and is likely to receive agricultural runoff. It is also thought to be part of the Hare Moss drainage system and so is considered to be of high sensitivity.

Bishopston Ditch

3.3.9 Bishopston Ditch is part of the Hare Moss drainage system. It was possibly originally constructed to drain the moss for agricultural purposes. The ditch runs alongside a farm track located immediately east of Heathfield Burn and has a catchment area up to the crossing of the proposed road of approximately 0.2km^2.

3.3.10 Bishopston Ditch is not currently included in the SEPA Water Quality Classification Scheme. As it flows through agricultural land, it likely receives agricultural runoff. The sensitivity of Bishopston Ditch is considered to be high due to its hydrological connectivity with Hare Moss.

Heathfield Burn

3.3.11 Heathfield Burn is a tributary of the Burn of Ardoe. It is part of the Hare Moss drainage system in its downstream reaches and runs along the edge of the west boundary of the moss. It is straightened along its entire length and follows field boundaries of gently sloping land of rough pasture. Private water supplies (groundwater wells) have been identified in the upper catchment area.

3.3.12 The burn begins just north of Bishopston Farm at a Class C (U59K) road and flows in an easterly direction. Approximately halfway along its length, the watercourse changes direction and continues in a northerly direction until it joins the Burn of Ardoe. Its catchment to the point of crossing of the proposed scheme is approximately 0.8km^2.

3.3.13 Heathfield Burn is currently not classed by SEPA. Due to its location, it is likely that it receives agricultural and road drainage runoff. The sensitivity of this burn is considered to be high due to its hydrological connectivity to Hare Moss.

Whitestone Burn

3.3.14 Whitestone Burn is a tributary of Burnhead Burn and drains an area of approximately 0.2km^2 to the point of crossing of the proposed road. It begins near Ferniebrae Farm, flowing in a westerly direction along the edge of woodland area. At Whitestone Farm, the burn is crossed by a track changing its course to a southwesterly direction. It follows field boundaries alongside before discharging into Burnhead Burn.

3.3.15 Whitestone Burn is currently not included in the SEPA Water Quality Classification Scheme. It is considered to be of low sensitivity.

Burnhead Burn

3.3.16 Burnhead Burn is the main tributary of Blaikiewell Burn, draining a catchment area of approximately 4.2km^2 to the point of crossing of the proposed scheme. It flows in an easterly direction alongside gently sloping land following field boundaries. Midstream, near Blaikiewell Farmhouse, the burn changes course and flows in a northerly direction until it joins Blaikiewell Burn. South of Burnhead farm, the watercourse is crossed by the Lochton-Auchlunies-Nigg (C5K) class C road.

3.3.17 Burnhead Burn is currently not monitored by SEPA. Recent spot sampling results (Jacobs, Summer 2006) indicated good water quality, class A2. Burnhead Burn is considered to have a high sensitivity as it is the main tributary of Blaikiewell Burn.

3.3.18 Burnhead Burn would be affected by sections of both the Fastlink and the Southern Leg parts of the scheme. All assessment conclusions are reported in this report for consistency.

Blaikiewell Burn

3.3.19 Blaikiewell Burn is a moderately steep tributary of Crynoch Burn set within a shallow 'v' shaped valley, draining an approximate area to the point of crossing of the proposed scheme of 4.5km^2. The burn is straightened in its upper reaches, but has a more natural channel halfway down and further downstream, where it flows through a narrow and wooded gorge. Just south of Eastland Bridge it is crossed by a class C (U63K) road and may therefore receive road drainage. Its confluence with the Crynoch Burn is within the River Dee SAC boundary.

3.3.20 Although Blaikiewell Burn is not monitored by SEPA, the spot sampling results from the macroinvertebrate survey carried out by Jacobs (Summer 2006) indicated that Blaikiewell Burn is of excellent quality (class A1). Additionally, the burn is an important otter commuting route to the River Dee and Crynoch Burn. Consequently, the burn has been classed as high sensitivity for the purposes of this assessment.

Kingcausie Burn

3.3.21 Kingcausie Burn is a tributary of Crynoch Burn, draining an area of approximately 1.6km^2 to the point of crossing of the proposed scheme. It begins in a gently sloping northern part of Cleanhill Wood and flows through predominantly woodland area down to its confluence with Crynoch Burn. Its catchment becomes steeper near the confluence with Crynoch Burn. Private water supply wells have been identified in the catchment area.

3.3.22 Kingcausie Burn is currently not included in the SEPA water quality monitoring network. The spot sampling (Jacobs, Summer 2006) indicated that the water quality is of fair (class B) quality. However, as it is a tributary of Crynoch Burn, which is within the River Dee SAC, Kingcausie Burn is classed as a high sensitivity watercourse.

Crynoch Burn

3.3.23 Crynoch Burn is formed after the confluence of Cairnie Burn and Burn of Monquich and has a catchment area of approximately 31.7km². It flows northeast through Durris Forest and enters the River Dee near Culter camping site. Although Crynoch Burn is situated within the vicinity of the proposed road, it would only be affected indirectly via its tributaries and therefore, it is not assessed specficially in this impact assessment.

3.3.24 The burn is part of the River Dee SAC, providing valuable habitat for Atlantic salmon, brown and sea trout. The boundary of the SAC designation is delineated by a boundary that extends inland approximately 5m along the riverbanks and ends at the confluence of Cairnie Burn and Burn of Monquich (see both Chapter 25: Ecology and Nature Conservation, and Figure 25.1b). It also has a status of District Wildlife Site (DWS) and Site of Interest to Natural Science (SINS). SEPA monitoring data for Crynoch Burn show good (A2) water quality (Table 8) and the spot sampling results indicate class A1 (excellent) water conditions.

3.3.25 Crynoch Burn has been classed as a high sensitivity watercourse.

Milltimber Burn

3.3.26 This is a predominantly straightened and very small tributary of the River Dee situated in the northern side of the Dee Valley. It begins at the B979 and runs alongside an old quarry access track. Its catchment area to the point of the crossing of the proposed scheme is approximately 0.6km^2. The watercourse has been culverted in several locations within Milltimber and further downstream. It may also receive road and urban drainage via a small tributary which begins near Binghill, runs through Milltimber and is also crossed by the A93.

3.3.27 Milltimber Burn is currently not monitored by SEPA. Spot sampling results (Jacobs, Summer 2006) indicated water quality to be of Class B (fair). Although it is a tributary of the highly sensitive River Dee, the burn is considered to be a watercourse of low sensitivity due to the road drainage it currently receives.

Culter House Burn

3.3.28 Culter House Burn is a field drainage ditch running alongside the west edge of a small woodland near Culter House and draining an area of approximately 0.1km^2. The ditch is currently crossed by a class C road and may therefore receive road drainage. It is a free standing ditch that does not flow into any watercourses and is therefore considered to be of low sensitivity.

Beans Burn

3.3.29 Beans Burn is a tributary of Murtle Den Burn, draining an area to the point of crossing of the proposed scheme of approximately 0.1km^2. It begins in steep, agricultural land southwest of Beans Hill and continues on in a southwesterly direction following field boundaries for its entire length. The watercourse is considered to be an important otter commuting route.

3.3.30 At the area of interest, Beans Burn was classed as low sensitivity.

Upper Beanshill Burn

3.3.31 Upper Beanshill Burn is a small tributary of the Murtle Den Burn, situated in its upper catchment in a shallow ‘v’ shaped valley. The watercourse begins near Gairn Burn and drains an area of approximately 0.05km^2 to the point of crossing of the proposed scheme. It follows field boundaries for most of its length and is thought to be an important otter commuting route. At present, Upper Beanshill Burn is crossed by Silverburn Road (C127) and its water quality is currently not monitored by SEPA. At the area of interest, Upper Beanshill Burn was classed as low sensitivity.

Gairn Burn

3.3.32 Gairn Burn is a small tributary of Silver Burn and part of the Brodiach Burn catchment (Brodiach Burn is a designated salmonid river). It begins east of Gairn Farm and flows south along field boundaries of pastureland of a moderate to steep gradient draining an area of approximately 0.8km^2 to the point of crossing with the AWPR. A number of private water supply wells have been identified in the vicinity of the watercourse, located upstream from the proposed scheme crossing.

3.3.33 Gairn Burn is currently not monitored by SEPA. Macroinvertebrate spot sampling (Jacobs, Summer 2006) indicated that water quality is of Class B (fair). Therefore, the burn was considered to be of medium sensitivity.

Moss of Auchlea Drainage System

3.3.34 In addition to Silver Burn, there is a small network of drains flowing through the Moss of Auchlea. One of these drains (catchment area of approximately 0.2km^2 to the point of crossing) would be crossed by the proposed scheme. A number of private water supply wells have been identified in the vicinity of the watercourse.

3.3.35 The moss has been identified by Aberdeen City as of local value and is considered to be a place of wildlife importance. The Moss of Auchlea Drainage System is considered to be of high sensitivity.

Westholme Burn

3.3.36 Westholme Burn is a small ephemeral tributary of Brodiach Burn, which is a designated salmonid river that begins just north of East Kingsford. It flows in a westerly direction through land of a relatively low gradient and follows the boundary of Blackhill Tip before finally discharging into Brodiach Burn. The watercourse drains an area of approximately 0.6km^2. It is currently crossed by a minor road at Westholme Farm.

3.3.37 Westholme Burn is currently not monitored by SEPA. SEPA monitoring points are located on Brodiach Burn upstream and downstream from the Westholme-Brodiach Burn confluence. The water quality for Brodiach Burn above the confluence is classed as good (A2) quality and downstream of the confluence as poor (C) due to high concentrations of iron (SEPA website, 2005). This indicates that Westholme Burn may be polluted which may have an adverse impact on Brodiach Burn water quality. It is therefore classed as of low sensitivity.

3.4 Mosses

Hare Moss

3.4.1 Hare Moss is a wet modified raised bog situated North West of Duff's Hill. In the past, it has been heavily modified by draining the bog area and changing the local. The moss is comprised of a number of bog communities, with heather as a dominant species. Extensive marsh areas have been graded to swamps and these are mainly associated with vegetated drains. Scrub can be extensive and dense, particularly towards the south, whilst willow and birch occur across the bog. Part of the moss has been converted to amenity grassland for recreational activity. The west side of the moss is believed to receive a flow of nutrient-rich water through land drainage from fields situated to the south of the moss. This is indicated by the existence of plant communities associated with nutrient-enriched environment (refer to Chapter 25: Ecology and Nature Conservation).

3.4.2 Direct rainfall falling on the moss is considered to be a significant source of surface water to the moss area. The watercourses within the Hare Moss hydrological network are the Burn of Ardoe, Bishopston Ditch, Heathfield Burn and Jameston Ditch, which impact upon the hydrological regime of the moss environment. The central area of the moss is likely to receive water most prevalently during winter months when the Burn of Ardoe and Heathfield Ditch overtop their banks at the confluence during heavy periods of rainfall.

3.4.3 The moss system will be subject to additional assessments to further develop an understanding of its hydrological functions. It is considered to be of high sensitivity.

Moss of Auchlea

3.4.4 The Moss of Auchlea is located on the outskirts of Aberdeen, south of the main A944 near Kingswells at an average altitude of 132m. It is approximately 6ha and surrounded by farmland. The site is located in a low lying basin crossed by the Silver Burn, a tributary of Brodiach Burn. The low lying nature of the site has led to waterlogging and over many years a build up of peat has occurred, creating small basin mire.

3.4.5 The site supports valuable wetland habitats and a range of wetland plants, although none of the species present are particularly rare. These habitats of fen and rush pasture have declined significantly within the area due to drainage and agricultural intensification.

3.4.6 The moss has been designated as a District Wildlife Site (DWS) and provides important habitat. Therefore, it is thought to be of high sensitivity.

3.5 Summary

3.5.1 A summary of the surface watercourses in the Southern Leg of the proposed AWPR scheme is presented in the table below.

Table 9 – Sensitivity of Surface Water Features

Watercourse	SEPA category	Spot sampling category *	Sensitivity
River Dee	A2	A2	High
Loirston Burn	-	D	Medium
Greengate Ditch	-	-	Low
Jameston Ditch	-	B	High
Burn of Ardoe	-	-	High
Bishopston Ditch	-	-	High
Heathfield Burn	-	-	High
Whitestone Burn	-	-	Low
Burnhead Burn	-	A2	High
Blaikiewell Burn	-	A1	High
Kingcausie Burn	-	B	High
Crynoch Burn	A2	A1	High
Milltimber Burn	-	B	Low
Culter House Burn	-	-	Low
Beans Burn	-	-	Low
Upper Beanshill Burn and associated ponds	-	-	Low
Gairn Burn	-	B	Medium
Moss of Auchlea Drainage System	-	-	High
Westholme Burn	-	-	Low
Hare Moss	-	-	High
Moss of Auchlea	-	-	High

* based on Biological criteria only (see Annex 27)

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. The operational impacts are considered to be those which are long-term and would influence the watercourses after the completion of the proposed scheme. The construction impacts are shorter-term and would directly affect the watercourse during the construction phase.

4.1.2 In order to measure the potential impacts of the proposed scheme, the assessment is initially based on studying the direct effects of the 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) 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 construction of the drainage system would allow road runoff to be collected and transported from the impermeable surface area to the receiving watercourse. This way 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 from road operation could also occur via sub-surface paths, where runoff infiltrates into the ground, eventually reaching the groundwater table or is deposited directly into a watercourse near river crossings. Although filter drains are proposed as part of the road drainage design, these are not impermeable and therefore any polluted runoff may still infiltrate into the ground. 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 suspended solids within the watercourse; and
- spillage risk due to the increase in traffic.

Routine Runoff

Soluble Pollutants

4.2.5 Trace metal 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 could be built up than in the water upstream (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 metal (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 the 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 risk 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. 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 29.

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, grass cuttings, etc. 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. It is commonly associated with other pollutants, which adsorb and bind on to particulate matter. 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.

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 OrganicMmaterials

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 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 any lorries cargo. The assessment was conducted using DMRB method which is described in detail in Section 2. Detailed calculation sheets for the accidental spilage risk are presented in Annex 28.

Culverts and Realignments

4.2.22 Construction of the Southern Leg of the proposed scheme would involve 16 watercourse crossings (14 culverts and two bridges). Culverting and realignment could potentially change the riverbed morphological diversity and the sediment regime of the watercourses, which may have an associated impact upon water quality. The number and length of culverts could impact upon 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 slope of the surrounding land and 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 resuspension of sediments and trapped contaminants resulting in high turbidity and possible secondary pollution. Increased discharge could also trigger riverbank erosion and effect the geomorphology of the riverbed.

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	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.

Source of Impact	Potential Effects
watercourses.	
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 washing of plant and machinery.	Concrete/cement is highly alkaline and must not be allowed to enter any drain, 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 the construction phase could 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 impact assessment. The potential for fine sediment release during construction and the impacts of culverting and realignments are addressed in detail in Appendix A24.3 (Fluvial Geomorphology) and summarised below. While hydrology is referred to in this section, the impacts are presented in detail in Surface Water Hydrology (Appendix A24.1).

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 Six drainage runs (Run E, Run F, Run G, Run H, Run J, Run K) would be required in the Southern Leg area of the proposed scheme. The proposed road drainage is shown on Figures 24.5a-h. Twelve watercourses included in this water quality impact assessment would be crossed by the proposed scheme, although there are sixteen individual watercourse crossings within the study area (refer to 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 has been assessed qualitatively:

- Burn of Ardoe;
- Bishopston Ditch;
- Heathfield Burn;
- Whitestone Burn;
- Blaikiewell Burn;
- Kingcausie Burn;
- Milltimber Burn; and
- Moss of Auchlea Drainage System.

4.3.4 The proposed road would cross to the south of Hare Moss and is not anticipated to have a direct impact on the moss environment. However, there is potential for the road to affect water quality through the proposed drainage outfall to Jameston Ditch. The surface water and groundwater quality of Hare Moss would be highly sensitive to road runoff and any pollutants that entered the waterbody would have the potential to reside in the sensitive environment for a prolonged period of time. The potential impact to this sensitive environment is therefore considered to be of high magnitude and Substantial significance.

4.3.5 The following watercourses would be taken into pre-earthworks. The potential impacts of the scheme have been assessed qualitatively and are considered to be Negligible:

- Greengate Ditch;
- Beans Burn; and
- Upper Beanshill Burn.

Culter House Burn is expected to run dry and disappear during construction as its catchment would be severed. It has therefore been assessed qualitatively.

<u>Routine Runoff</u>

4.3.6 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 29 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 mitigation)
Loirston Burn	Medium	Copper	28	14	32*	130	High	Moderate/ Substantial
		Zinc	125	63	138*	121	High	Moderate/ Substantial
Jameston Ditch	High	Copper	10	5	76*	1415	High	Substantial
		Zinc	75	38	266*	609	High	Substantial
Burn of Ardoe	High	Diffuse	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Bishopston Ditch	High	Diffuse	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Heathfield Burn	High	Diffuse	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Hare Moss	High	Diffuse/ through connectivity to Jameston Ditch	n/a	n/a	n/a	n/a	High	Substantial
Whitestone Burn	Low	Diffuse	n/a	n/a	n/a	n/a	Negligible	Negligible
Burnhead Burn	High	Copper	10	5	15*	199	High	Substantial
		Zinc	75	38	87*	131	High	Substantial
Blaikiewell Burn	High	Diffuse	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Kingcausie Burn	High	Diffuse	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
River Dee	High	Copper	6	1	1	4	Negligible	Slight/ Negligible
		Zinc	50	12	12	2	Negligible	Slight/ Negligible
Milltimber Burn	Low	Diffuse	n/a	n/a	n/a	n/a	Negligible	Negligible
Gairn Burn	Medium	Copper	10	5	79*	1482	High	Moderate/ Substantial
		Zinc	75	38	345*	819	High	Moderate/ Substantial

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 mitigation)
Moss of Auchlea Drainage System	High	Diffuse	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Westholme Burn	Low	Copper	10	5	162*	3139	High	Moderate
		Zinc	75	38	688*	1735	High	Moderate

* Exceeds Annual Average EQS

4.3.7 During routine operation of the road without mitigation, the resultant concentrations of dissolved copper and total zinc for Loirston Burn, Jameston Ditch, Burnhead Burn, Gairn Burn and Westholme Burn would exceed the annual average EQS. The impacts of road drainage is considered to be of high magnitude for copper and zinc in all cases. For Jameston Ditch and Burnhead Burn, both of high sensitivity, the impact significance would be Substantial for both zinc and dissolved copper concentrations. For Loirston Burn and Gairn Burn, the impact significance would be Moderate/Substantial, while for Westholme Burn, the impact significance would be Moderate.

4.3.8 Due to the greater dilution capacity of the River Dee, the resultant concentrations of dissolved copper and total zinc were below the annual average EQS and their increase over the baseline situation was less than 24% (see Table 11) (4% for copper and 2% for zinc). This indicates impacts of negligible magnitude. Thus, for River Dee, the impact significance is Slight/Negligible for both total zinc and dissolved copper concentrations.

4.3.9 All remaining watercourses would be affected only through diffuse runoff, which is considered to have a Slight/Negligible or Negligible effect on the water quality. For Hare Moss, the potential diffuse pollution impact is considered to be of high magnitude and therefore of Substantial significance when considered in combination with the impact upon Jameston Ditch.

Suspended Solids

4.3.10 The potential impacts from total suspended solids (TSS) is of medium magnitude and high magnitude for Gairn Burn and Westholme Burn, respectively, resulting in an impact of Medium significance for both. Impacts of high magnitude and medium magnitude for Jameston Ditch and Burnhead Burn, result in an impact of Substantial significance and Moderate/Substantial significance, respectively. For the River Dee, the impact would be low magnitude and therefore of Moderate significance due to its high dilution capacity. An impact magnitude of negligble is classed for some watercourses with no road drainage, but because of their high sensitivities, have a significance of Slight/Negligible. These watercourses are Burn of Ardoe, Bishopston Ditch, Heathfield Burn, Blakiewell Burn, Kingcausie Burn and Moss of Auchlea Drainage System.

Risk of Accidental Spillage

4.3.11 The assessment indicates that the risk of accidental spillage for the River Dee and Westholme Burn would be likely to exceed the threshold of acceptability, and therefore the impacts are assessed to be of high magnitude. This results in an impact of Substantial significance and Moderate significance for the River Dee and Westholme Burn, respectively. Burnhead Burn is considered to be of medium magnitude and therefore of Moderate/Substantial significance, while for Jameston Ditch which has a low impact magnitude, impact is considered to be Moderate significance. For Loirston Burn and Gairn Burn, the impact magnitude is low, resulting in an impact of Slight significance for both. For Hare Moss, pollution impacts through accidental spillages are considered to be of high magnitude and therefore of Substantial significance.

4.3.12 Table 12 presents a summary of the spillage risk assessment (without mitigation) for the proposed scheme (for detailed calculations refer to Annex 28).

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
Loirston Burn	Medium	1:100	1:423	Yes	Low	Slight
Jameston Ditch	High	1:100	1:724	Yes	Low	Moderate
Burnhead Burn	High	1:100	1:195	Yes	Medium	Moderate/ Substantial
River Dee	High	1:100	1:88	No	High	Substantial
Gairn Burn	Medium	1:100	1:201	Yes	Low	Slight
Westholme Burn	Low	1:100	1:47	No	High	Moderate

Cumulative Impact Modelling on River Dee

4.3.13 The model predicts the increase in pollutant concentration levels in the River Dee over baseline levels will result in an impact of high magnitude, and consequently, an impact of Slight/Negligible significance, with no mitigation in place. The two main tributaries to the River Dee, Culter House Burn and Crynoch Burn (which are also within the SAC boundary), would be more highly affected by the scheme. Culter House Burn is predicted to be moderately impacted with an increase in assessed pollutant concentrations by up to 27%, while Crynoch Burn is would be substantially impacted with an increase in pollutant values of up to 107% above baseline conditions.

Construction Impacts

4.3.14 The assessment indicates that there is potential for high magnitude impacts, resulting in impacts of Substantial significance, on the River Dee during construction of the road bridge. Construction of the crossing structure would involve sediment release or accidental spillage of other polluting material into the river. The buried structure that would be constructed to cross Blaikiewell Burn would would also require similar activities, but on a lesser scale. The potential impacts on Blaikiewell Burn are assessed as being medium magnitude and of Moderate/Substantial significance.

4.3.15 The construction of a culvert and/or a large realignment on watercourses of high sensitivity and low dilution capacity would have an impact of high magnitude and Substantial significance. These watercourses are Burn of Ardoe, Bishopston Ditch, Heathfield Burn, Burnhead Burn, and Moss of Auchlea Drainage System. The installation of a culvert on Kingcausie Burn would be of medium magnitude and Moderate/Substantial significance. For Whitestone Burn and Milltimber Burn, the potential impacts of installing culverts has been assessed as being of high magnitude and Moderate significance. Similarly for Loirston Burn and Gairn Burn, the potential impacts of installing culverts has been assessed as being of medium magnitude and Moderate significance.

4.3.16 Construction impacts for the watercourses that would not be crossed by the scheme, but would receive road drainage (Jameston Ditch and Westholme Burn), have been assessed as being of negligible and low impact magnitude, resulting in Slight/Negligible and Negligible significance, respectively.

4.3.17 Impacts on the quality of Hare Moss may occur as a result of impacts on any of its feeder burns. The potential high magnitude impacts from construction activities on Heathfield Burn, Bishopston Ditch, Jameston Ditch and the Burn of Ardoe may impact the moss, due to their hydrological connectivity with the moss (see paragraph 3.4.2).

4.3.18 Those watercourses taken into pre-earthworks would be subject to impacts of high magnitude as there would be a risk of spillage of pollutants and sediment release downstream of the proposed scheme. Therefore, the impact significance has been assessed as Moderate.

4.4 Summary

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

Table 13 – Potential Impacts on Watercourses

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Impact Significance
Loirston Burn	Medium	2 No. culverts: Mainline ch205580 and side road ch340 Extension of 2 No. existing culverts at A956, ch207030 and A90, ch790	Realignments associated with culvert construction	1 proposed outfall at chainage 800 draining total of 2.6 ha	Construction: Medium potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of four culverts would involve major earthworks, possibly resulting in high sediment and pollutant release and short-medium term increased turbidity in the water column. Medium dilution capacity of the watercourse.	Medium	Moderate
					General Operation: Change in water quality would be 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: High impact from routine runoff due to increase of copper and zinc concentrations > 100% over baseline situation. Accidental Spillage: Low impact from accidental spillage as spillage risk would be 423; above the probability threshold of 1 in 200 years and below 1 in 1000 years. Total suspended solids: Q_{mean} for Loirston Burn is 0.026m^3/s, which indicates a medium dilution capacity; therefore total suspended solids would pose a low impact magnitude.	High	Moderate/ Substantial
Greengate Ditch	Low	This watercourse will be taken into pre-earthworks	No realignment proposed	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in increased downstream suspended solid loads in the short-term. Possible impact from the potential risk of accidental spillage of pollutants downstream during construction. High impact magnitude.	High	Moderate
					Operation: Taken into pre-earthworks	n/a	n/a
Jameston Ditch	High	No crossing proposed	No realignment proposed	1 proposed outfall at ch204601 draining total of	Construction: Slight/negligible potential for accidental spillage of fuel and concrete during construction due to the distance of works to watercourse.	Negligible	Slight/ Negligible

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Impact Significance
				7.1ha	General Operation: A major shift from baseline conditions due to discharge of road runoff. Fundamental change of water quality and ecology. Routine Runoff: High impact from routine runoff due to increase of copper and zinc concentrations > 100% over baseline situation. Accidental Spillage: Low impact from accidental spillage as spillage risk would be 724; above the probability threshold of 1 in 200 years and below 1 in 1000 years. Total suspended solids: Q_{mean} for Jameston Ditch is 0.003m^3/s, which indicates a low dilution capacity.	High	Substantial
Burn of Ardoe	High	1 No. culvert ch204040	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Burn of Ardoe is 0.001m^3/s, which indicates a low dilution capacity.	High	Substantial
					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	Slight/ Negligible
Bishopston Ditch	High	1 No. culvert ch203900	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Bishopston Ditch is 0.002m^3/s, which indicates a low dilution capacity.	High	Substantial
					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	Slight/ Negligible

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Impact Significance
Heathfield Burn	High	1 No. culvert ch203650	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Heathfield Burn is 0.009m^3/s, which indicates a low dilution capacity	High	Substantial
					General Operation: Change in water quality is 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	Slight/ Negligible
Hare Moss	High	n/a	n/a	n/a	Construction: Culverting of 3 burns (Burn of Ardoe, Bishopston Ditch and Heathfield Burn) may result in polluted runoff entering the moss, and construction of outfall at Jameston Ditch is considered to result in high potential for pollution of the moss.	High	Substantial
					Operation: Although the road does not have a direct impact on Hare Moss there is potential for the road to alter the quality of water reaching the moss as a result of the proposed outfall to Jameston Ditch. Long-term inputs of road runoff to the moss are considered to have a high impact on the feature.	High	Substantial
Whitestone Burn	Low	1 No. culvert: ch200990	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: High impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Whitestone Burn is 0.002m^3/s which indicates a low dilution capacity.	High	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

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Impact Significance
Burnhead Burn	High	1 No. culvert ch200100	Realignment associated with culvert construction	1 proposed outfall at ch200300 draining total of 8.95ha	Construction: Major potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of culvert and the realignments would involve major earthworks, possibly resulting in high sediment and pollutant release and short-medium term increased turbidity in the water column. Medium dilution capacity of the watercourse (Q_{mean} =0.054m^3/s).	High	Substantial
					General Operation: A major shift from baseline conditions due to discharge of road runoff. Fundamental change of water quality and ecology. Routine Runoff: High impact from routine runoff due to increase of over 100% over baseline for copper and zinc resulting of failure of EQS for both pollutants. Accidental Spillage: Medium impact from accidental spillage as spillage risk would be 195, which is above the probability threshold of 1 in 100 years and below 1 in 200 years. Total suspended solids: Q_{mean} for Burnhead Burn is 0.054 m^3/s, which indicates a medium dilution capacity; therefore total suspended solids would pose a medium impact magnitude.	High	Substantial
Blaikiewell Burn	High	1 No. Bridge ch100150	No realignment is proposed	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 bridge would involve some earthworks, possibly resulting in sediment and pollutants release and short term increased turbidity in the water column. Medium dilution capacity of the watercourse.	Medium	Moderate/ Substantial
					General Operation: Change in water quality likely to be negligible due to diffuse pollution. Length of bridge 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
Kingcausie Burn	High	1 No. culvert: ch101470	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Slight impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Kingcausie Burn is 0.021m^3/s, which indicates a medium dilution capacity.	Medium	Moderate/ Substantial

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	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.	Negligible	Slight/ Negligible
River Dee	High	1 No Bridge ch102000	No realignment proposed	1 Proposed outfall at ch102830, draining total of 10.7ha	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Bridging would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Potential for pollutant release during excavation and construction of outfall ditch and structure (location of outfall still pending decision).	High	Substantial
					General Operation: A minor shift from baseline conditions due to discharge of road runoff. Temporary adverse impact on water quality and ecology. Routine Runoff: Negligible impact from routine runoff due to increase of less than 24% over baseline for copper and zinc and complying with EQS for both pollutants. Accidental Spillage: High impact from accidental spillage as spillage risk would be 88, which is below the probability threshold of 1 in 100 years. Total suspended solids: Q_{mean} for River Dee is 46.11m^3/s, which indicates a high dilution capacity therefore total suspended solids will pose a low impact magnitude.	High	Substantial
Milltimber Burn	Low	1 No. culvert: ch102670	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in high sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Milltimber Burn is 0.008m^3/s, which indicates a low dilution capacity.	High	Moderate

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	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.	Negligible	Negligible
Culter House Burn	Low	Watercourse lost due to catchment severance	No realignment proposed	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in short-term high increase of suspended solid loads downstream from the construction site. Possible high impact from the potential risk of accidental spillage of pollutants downstream during construction.	High	Moderate
					Operation: Watercourse lost due to catchment severance	n/a	n/a
Beans Burn	Low	This watercourse will be taken into pre-earthworks	No realignment proposed	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in short-term high increase of suspended solid loads downstream from the construction site. 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
Upper Beanshill Burn and associated ponds	Low	This watercourse will be taken into pre-earthworks	No realignment proposed	No road drainage discharge to burn	Construction: This would involve earthworks, possibly resulting in short-term high increase of suspended solid loads downstream from the construction site. 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
Gairn Burn	Medium	2 No. culverts: side road ch163 and	Realignment associated with culvert construction	1 Proposed outfall at ch106085, draining total of 4.75ha.	Construction: Medium potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of culvert and the realignments would involve major earthworks, possibly resulting in high sediment and pollutant release and short-medium term increased turbidity in the water column.	Medium	Moderate

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Impact Significance
		pond access road ch270			General Operation: A major shift from baseline conditions due to discharge of road runoff. Fundamental change of water quality and ecology. Routine Runoff: High impact from routine runoff due to increase of > 100% over baseline for copper and zinc, resulting of failure of EQS for both pollutants. Accidental Spillage: Low impact from accidental spillage as spillage risk would be 201, which is above the threshold probability of 1:200 and below 1:1000. Total suspended solids: Q_{mean} for Gairn Burn is 0.011 m^3/s, which indicates a medium dilution capacity; therefore total suspended solids would pose a medium impact.	High	Moderate/ Substantial
Moss of Auchlea Drainage System	High	1 No. culvert: ch107440	Realignment associated with culvert construction	No road drainage discharge to burn	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column. Q_{mean} for Moss of Auchlea Drainage System is 0.002m^3/s which indicates a low dilution capacity.	High	Substantial
					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	Slight/ Negligible
Westholme Burn	Low	No crossing proposed	No realignment proposed	1 Proposed outfall at ch108757,	Construction: Slight potential for accidental spillage of fuel and concrete during construction due to the distance of works to watercourse.	Low	Negligible

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Potential Impact Description	Magnitude	Impact Significance
				draining total of 8.25ha.	General Operation: A major shift from baseline conditions due to discharge of road runoff. Fundamental change of water quality and ecology. Routine Runoff: High impact from routine runoff due to increase of copper and zinc concentrations over 100% over baseline situation. Accidental Spillage: High impact from accidental spillage as spillage risk would be 47, which is below the probability threshold of 1 in 100 years. Total suspended solids: Q_{mean} for Westholme Burn is 0.008m^3/s which indicates a low dilution capacity.	High	Moderate

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 the principles contained in Sustainable Urban Drainage Systems (SUDS): Design Manual for Scotland and Northern Ireland CIRIA C521 (Construction Industry Research and Information Association, 2000), The SUDS Manual CIRIA C697 (2007) and Sustainable Urban Drainage Systems: Hydraulic, Structural and Water Quality Advice, CIRIA C609 (Construction Industry Research and Information Association, 2004).

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 24.5a-h) 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 a filter drain and wet and dry detention basins and treatment ponds (up to four in series) to maximise pollutant removal efficiency. These drainage proposals will require a CAR license and will need to be presented to SEPA for approval 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 must 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 23 (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 and 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 suspended solids present in the runoff and settle out hydrocarbons and metals. Catchpits are located at regular spacings (at 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 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.

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 suspended solids. 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).

5.2.11 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, 2000) 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.

5.2.12 According to the DMRB (1998), the spillage risk removal efficiencies were determined to be 65% reduction for both total zinc and dissolved copper, irrespective of the treatment method.

Swales

5.2.13 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.

5.2.14 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 (DMRB, 1998).

5.2.15 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

5.2.16 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
- provision of scour protection at the drainage discharge outfall to protect the banks and bed of the receiving ditch and to limit erosion.

5.2.17 Further details regarding morphological diversity mitigation requirements, creation and maintenance of a complex riparian zone are provided in Appendix A24.3 (Fluvial Geomorphology) and Appendix A25.9 (Freshwater Ecology).

Other Operational Measures

5.2.18 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.

5.2.19 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.

5.2.20 Water quality/sedimentation/ecological monitoring downstream of key outflows will be undertaken to provide an indication for potential problems (monitoring schedule will be further agreed with SEPA during the CAR licensing process).

Adherence to Best Practice near Watercourses

5.2.21 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 Guidance (PPG 01, PPG 09, PPG 18, PPG 21 and PPG 22) and CIRIA guidance C609 (CIRIA, 2004).

5.2.22 For mitigation specific to geomorphological impacts (sediments, culverts and realignments) please refer to the Fluvial Geomorphology report (Appendix A24.3). For mitigation specific to surface water hydrology and flooding issues, refer to the Surface Water Hydrology report and the Hydrodynamic Modelling report (Appendices 24.1 and 24.2, respectively). Similarly for mitigation specific to ecology, refer to Chapter 25 (Ecology and Nature Conservation).

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. The structures are proposed for the crossings over the River Dee and Blaikiewell Burns, which are high sensitivity watercourses. The 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 structures proposed the River Dee and Blaikiewell Burns 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 The 16 watercourse crossings include:

- two bridge crossings – one at River Dee and one at Blaikiewell Burn; and
- 14 culvert crossings.

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

<u>Culvert Design</u>

5.2.27 Culvert design follows SEPA policy and the guidelines set out in 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).

5.2.28 Appropriate culvert design is aimed at avoiding deterioration in water quality and morphological diversity and the associated 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 0.5% AEP (1:200 year) return period flow.

5.2.29 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.

5.2.30 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.

5.2.31 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

5.2.32 Realignments are generally used where necessary to reduce crossing (culvert) lengths and associated potential long term adverse water quality impact. The proposed realignments will be designed to cause minimal disturbance to flow patterns and minimise adverse imipacts on water quality, mirroring where possible the original alignment with minimal change to hydraulic gradient. 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 geomorphological/ecological/water quality monitoring programme will be undertaken to flag any potential problems. This approach is aimed at reducing the risk of dramatic changes to the geomorphological diversity and water quality of watercourses. Details of the monitoring approach will be agreed with SEPA prior to commencement of the construction works.

Cumulative Impact Modelling on River Dee

5.2.35 In order to assess the cumulative predicted impacts (with mitigation) on the River Dee as a result of the AWPR, an estimate of predicted pollutant removal efficiencies was utilised. Removal efficiencies were based on best practice information from recent research, detailed in Appendix A24.5 Water Quality Modelling. Pollutant values were reduced by the relevant percentage based on the proposed treatment trains for the scheme outfalls, as detailed in Table 16. The discharge rate of the outfalls was capped at 4.3 l/s/ha, which has been calculated as the Greenfield runoff rate for the Southern Leg (refer to Appendix A24.5 for detailed information).

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 also require the Contractor to monitor water quality prior to, and during, construction assessing chemical (temperature, pH, conductivity, 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 safe storage and disposal of sewage effluent from workers on site, such as chemical toilets or other forms of system with no discharge (PPG4: 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 PPG4.
Contaminated Land and Sediment	The ground investigation has identified areas of contamination and actions will be 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 is to avoid 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 earthworks 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 during culvert construction. 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 – see Appendix A25.9: Freshwater Ecology) should also be avoided. More detailed information on this can be found in Chapter 25 (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
Loirston Burn	Road Drainage	One proposed outfall draining total of 2.6ha	Filter Drain, Detention Basin, one Treatment Pond (storage volume Vt – see paragraph 5.4.11 for details)
	Crossing	2 No. culverts: Loirston Burn 1 (main line, ch205580) – 34m length; Loirston Burn 2 (side road ch340) – 24m length; Extension of 2 No. existing culverts: Loirston Burn 4 (A956, ch207030) – 45m length; Loirston Burn 3 (A90, ch790) – 47m length.	Depressed invert box culverts designed to carry a 0.5% AEP (1:200 year flow), with mammal ledge. Maintains bed continuity through the structure.
	Realignment	A major realignment of 778m length: Loirston Burn 1 – length 88 (maintained); Loirston Burn 2 – length 105 (maintained); Loirston Burn 3 – length 376 (maintained); Loirston Burn 4 – length 209 (maintained);	With regards to major realignment, geomorphological features must be reproduced and hydraulic gradient and length must be maintained. Sensitive realignment design reintroducing meanders, alternating pools 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 Possible impact from land contamination (See Chapter 23: Geology, Contaminated Land and Groundwater) and sediments.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 15. 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. 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 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.

Watercourse	Proposed Works	Potential Impact Description	Mitigation
			Cut-off ditches and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new similarly sized material to cover the bottom of the culvert. The landfill in the vicinity must not be disturbed.
Greengate Ditch	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 15. Cut-off ditches; sediment fencing; sediment trap (settling lagoons); when diverting watercourse into drainage ditches.
Jameston Ditch	Road Drainage	One proposed outfall draining total of 7.1ha	Filter Drain, Detention Basin, three Treatment Ponds (storage volume, Vt – see paragraph 5.4.11 for details). Lining of the filter drain.
	Crossing	n/a	n/a
	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 15. Cut-off ditches; sediment fencing around earthworks perimeter. 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 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.
Burn of Ardoe	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culvert: ch204040 – 59m length;	Depressed invert box culverts designed to carry a 0.5%AEP (1:200 year flow) with mammal ledge. Maintains bed continuity through the structure.
	Realignment	Realignment associated with culvert construction – length 80m (maintained)	Regular maintenance and clearance of debris.
	Construction	Increased risk of pollution from concreting and fuel and oil	Adherence to best practice. Generic mitigation measures apply – refer to

Watercourse	Proposed Works	Potential Impact Description	Mitigation
		spills. Fine sediment release from earthworks. Possible drain crossings and diversions.	Section 5.5 and Table 15. 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 and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new 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 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.
Bishopston Ditch	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culvert: ch203900 – 55m length;	Depressed invert box culverts designed to carry a 0.5% AEP (1:200 year flow) with mammal ledge. Maintains bed continuity through the structure.
	Realignment	Realignment associated with culvert construction – length 95m (maintained)	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.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 15. 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 and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new 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 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
			Contractor to monitor water quality prior to, and during, construction.
Heathfield Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culvert: ch203650 – 46m length;	Depressed invert box culverts designed to carry a 0.5% AEP (1:200 year flow) with mammal ledge. Maintains bed continuity through the structure.
	Realignment	Realignment associated with culvert construction – length 89m (maintained)	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. Groundwater supply in the vicinity (See Chapter 23: Geology, Contaminated Land and Groundwater).	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 15. 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 and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new 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 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.
Hare Moss	Road Drainage	Proposed outfall at Jameston Ditch (see above). Long-term input of road runoff to the moss through outfall at Jameston Ditch. Potential for outfall to impact quality of the moss due to proposed drainage outfall	Ensure appropriate mitigation is in place before outfall to Jameston Ditch (see Table 14). Line filter drains in the area to prevent infiltration to groundwater. Refer to each of the 4 watercourses with hydrological connectivity with Hare Moss for specific mitigation.
	Crossing	n/a	Provide suitable connectivity to the moss area and maintain the existing catchment size draining to the moss.
	Realignment	n/a	n/a
	Construction	Increased risk of pollution from concreting, fuel and oil spills from construction of outfall at Jameston Ditch and culverts at 3	Adherence to best practice – refer to each of the 4 watercourses with hydrological connectivity with Hare Moss for specific mitigation.

Watercourse	Proposed Works	Potential Impact Description	Mitigation
		other watercourses. Fine sediment release from earthworks.	
Whitestone Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culvert: ch200990 – length 51m;	Culverts designed to carry a 0.5% AEP (1:200 year flow) with mammal ledge. Maintains bed continuity through the structure.
	Realignment	Realignment associated with culvert construction – length 123m (maintained)	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. Possible slight impact from land contamination and sediments (refer to Chapter 23: Geology, Contaminated Land and Groundwater).	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 15. 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 and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new 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 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.
Burnhead Burn	Road Drainage	One proposed outfall draining total of 8.95ha	Filter Drain, Detention Basin, two Treatment Ponds (storage volume, Vt – see paragraph 5.4.11 for details).
	Crossing	1 No. Culverts ch200100 (mainline) – length 65m;	Depressed invert box culverts designed to carry a 0.5% AEP (1:200 year flow) with mammal ledge. Maintains bed continuity through the structure.
	Realignment	Realignment associated with culvert construction – length 118m (maintained).	With regards to major realignment geomorphological features must be reproduced and hydraulic gradient and length must be maintained. Regular maintenance and clearance of debris.
	Construction	Increased 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 15. 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 and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new 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 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.
Blaikiewell Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	Bridge spanning the watercourse ch100150	Bridge 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	No realignment proposed	n/a
	Construction	High risk of pollution from concreting and fuel and oil spills. High risk of sediment release during earthworks.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 15. 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 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.
Kingcausie Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culvert:	Depressed invert box culverts designed to carry a 0.5% AEP (1:200 year

Watercourse	Proposed Works	Potential Impact Description	Mitigation
		ch101470 – 47m length;	flow) with mammal ledge. Maintains bed continuity through the structure.
	Realignment	Realignment associated with culvert construction – length 404m (original length 441m)	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. Groundwater supply in the vicinity (See Chapter 23: Geology, Contaminated Land and Groundwater).	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 15. 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 and sediment fencing, sediment trap (settling lagoons) to reduce sediment release. Use of new 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 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.
River Dee	Road Drainage	One proposed outfall draining total of 10.7ha	Filter Drain, Detention Basin, two Treatment Ponds (storage volume, Vt – see paragraph 5.4.11 for details)
	Crossing	Bridge spanning the river and floodplain ch102000	Bridge 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	No realignment planned	n/a
	Construction	High risk of pollution from concreting and fuel and oil spills. High risk of pollution during potential excavation and construction of outfall ditch and structure (location of outfall pending decision). High risk of sediment release during earthworks.	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 15. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Construction of a small cofferdam (using sheet piles) around the proposed outfall construction area would prevent the transfer of pollutants into the river and maintain integrity of SAC. 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

Watercourse	Proposed Works	Potential Impact Description	Mitigation
			for the release of 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.
Milltimber Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culvert: ch102670 – 77m length;	n/a
	Realignment	Realignment associated with culvert construction – length 107m (maintained).	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 15. 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 and sediment fencing, sediment trap (settling lagoons) to reduce sediment release. Use of new 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 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.
Culter House 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, with particular reference to paragraph 5.5.10, and Table 15.

Watercourse	Proposed Works	Potential Impact Description	Mitigation
			Cut-off ditches; sediment fencing; sediment trap (settling lagoons); when diverting watercourse into drainage ditches.
Beans 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 15. Cut-off ditches; sediment fencing; sediment trap (settling lagoons); when diverting watercourse into drainage ditches.
Upper Beanshill Burn and associated ponds	Road Drainage	n/a	n/a
	Crossing	n/a	n/a
	Realignment	Small section of the Burn 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 15. Cut-off ditches; sediment fencing; sediment trap (settling lagoons); when diverting watercourse into drainage ditches.
Gairn Burn	Road Drainage	One proposed outfall draining total of 4.75 ha.	Filter drain, Detention Basin, four Treatment Ponds (storage volume, Vt – see paragraph 5.4.11 for details). Lining of the filter drain.
	Crossing	2 No. culverts ch163 (side road) – 12m length; ch270 (pond access road) – 8m length	Depressed invert box culverts designed to carry a 0.5% AEP (1:200 year flow) with mammal ledge. Maintains bed continuity through the structure.
	Realignment	One realignment proposed – 163m (original length 176m)	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. Groundwater supply in the vicinity (See Chapter 23: Geology, Contaminated Land and Groundwater).	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 15. 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 and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new similarly sized material to cover the bottom of the culvert. Detailed method statements to be provided for all aspects of work impacting

Watercourse	**Proposed Works**	**Potential Impact Description**	**Mitigation**
			upon Water Environment during CAR process, including method statement for the release of 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.
Moss of Auchlea Drainage System	Road Drainage	Road drainage system crossing through the moss	Lining of the filter drains
	Crossing	1 No. culvert ch107440 – 75m length;	Depressed invert box culverts designed to carry a 0.5% AEP (1:200 year flow) with mammal ledge. Maintains bed continuity through the structure.
	Realignment	Realignment associated with culvert construction – length 84m (original length 93m)	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. Groundwater supply in the vicinity (See Chapter 23: Geology, Contaminated Land and Groundwater).	Adherence to best practice. Generic mitigation measures apply – refer to Section 5.5 and Table 15. 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 and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new 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 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.
Westholme Burn	Road Drainage	One proposed outfall draining total of 8.25 ha.	Filter Drain, Detention Basin, three Treatment Ponds (storage volume, Vt – see paragraph 5.4.11 for details) and one Swale.
	Crossing	No crossing	n/a
	Realignment	No realignment proposed	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 15.

Watercourse	Proposed Works	Potential Impact Description	Mitigation
		Possible slight impact from land contamination and sediments.	Cut-off ditches; sediment fencing around earthworks perimeter. 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 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.

River Dee and Blaikiewell Burn

5.3.13 River Dee and Blakiewell Burn will be bridged due to their high sensitivity. The following additional mitigation measures are proposed to enhance sediment management, reduce erosion and adverse impacts on the morphological diversity of the watercourse:

- use of plastic sleeve and double falsework/shuttering when working over the watercourse to ensure minimal concrete spillage;
- enclosed spraying when waterproofing preventing chemicals from entering the watercourse;
- works with a high potential of sediment release should be carried out between May and September where practicable (refer to Chapter 25: Ecology and Nature Conservation); and
- long term water quality/ecological monitoring before, during and after construction (to be agreed with SEPA prior to work commencement);
- the design and micrositing details for the proposed outfall that would discharge treated road runoff into the River Dee will be agreed with SEPA prior to commencement of construction. This activity will also require consent under the Controlled Activities Regulations.

6 Residual Impacts

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

6.1 Operation Residual Impacts

Routine Runoff

6.1.1 Following treatment and settlement, the residual impacts of insoluble pollutants entering Loirston Burn and Westholme Burn would be of low magnitude for copper and negligible for zinc, resulting in either Slight or Negligible significances. Residual impacts on Loirston Burn, Jameston Ditch, Burnhead Burn, River Dee and Gairn Burn would be of negligible magnitude, resulting in an impact of Negligible to Slight/Negligible significance. The remaining waterbodies 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 29.

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

Site	Sensitivity	Parameter	EQS Annual Average (µg/l)	Inferred upstream concentrations (µg/l)	Estimated downstream conc. without mitigation	Estimated downstream conc. with mitigation (µg/l)	Percentage increase over baseline concentration levels	Impact magnitude with mitigation	Significance of Impact of proposed road with mitigation
Loirston Burn	Medium	Copper	28	14	32*	19	35	Low	Slight
		Zinc	125	63	138*	68	9	Negligible	Negligible
Jameston Ditch	High	Copper	10	5	76*	6	14	Negligible	Slight/ Negligible
		Zinc	75	38	266*	27	0	Negligible	Slight/ Negligible
Burn of Ardoe	High	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Bishopston Ditch	High	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Heathfield Burn	High	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Hare Moss	High / through connectivity to Jameston Ditch	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Whitestone Burn	Low	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Negligible
Burnhead Burn	High	Copper	10	5	15*	6	16	Negligible	Slight/ Negligible
		Zinc	75	38	87*	38	0	Negligible	Slight/ Negligible
Blaikiewell Burn	High	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Kingcausie Burn	High	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
River Dee	High	Copper	6	1	1	1	0	Negligible	Slight/ Negligible
		Zinc	50	12	12	12	0	Negligible	Slight/ Negligible
Milltimber Burn	Low	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Negligible
Gairn Burn	Medium	Copper	10	5	79*	5	9	Negligible	Negligible

Site	Sensitivity	Parameter	EQS Annual Average (µg/l)	Inferred upstream concentrations (µg/l)	Estimated downstream conc. without mitigation	Estimated downstream conc. with mitigation (µg/l)	Percentage increase over baseline concentration levels	Impact magnitude with mitigation	Significance of Impact of proposed road with mitigation
		Zinc	75	38	345*	35	0	Negligible	Negligible
Moss of Auchlea Drainage System	High	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Slight/ Negligible
Westholme Burn	Low	Copper	10	5	162*	7	35	Low	Negligible
		Zinc	75	38	688*	32	0	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 indicate that the levels of mitigation proposed would be sufficient even if water hardness were reduced.

Risk of Accidental Spillage

6.1.4 The residual risk of accidental spillage with mitigation measures in place is summarised in Table 18 below (please refer to Annex 28 for details of the calculations).

Table 18 – Summary of Spillage Risk Assessment, With Mitigation

Watercourse	Sensitivity	Threshold of Acceptability	Spillage Risk in Design Year – Without Mitigation	Spillage Risk in Design Year – With Mitigation	Within Acceptable Limits?	Magnitude	Significance
Loirston Burn	Medium	1:100	1:423	1:3456	Yes	Negligible	Negligible
Jameston Ditch	High	1:100	1:724	1:48221	Yes	Negligible	Slight/ Negligible
Burnhead Burn	High	1:100	1:195	1:4546	Yes	Negligible	Slight/ Negligible
River Dee	High	1:100	1:88	1:2046	Yes	Negligible	Slight/ Negligible
Gairn Burn	Medium	1:100	1:201	1: 4677	Yes	Negligible	Negligible
Westholme Burn	Low	1:100	1:47	1:1104	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 significant impacts indicated at potential impact stage, it should be noted that the mitigation measures must be robustly implemented.

Cumulative Impact Modelling on River Dee

6.1.7 The residual impact assessment demonstrates that with the effective implementation of mitigation, the cumulative impact on the water quality of the River Dee SAC is considered to be of Slight/Negligible significance. With the proposed scheme in place, pollutant concentration levels are predicted to remain below EQS values for all determinants investigated. Refer to Appendix A24.5 (Water Quality Modelling) for detailed information.

6.2 Construction Residual Impacts

6.2.1 The residual impact assessment shows that construction impacts are estimated to be of Slight/Negligible significance for the high sensitivity waterbodies: Jameston Ditch, Burn of Ardoe, Bishopston Ditch, Heathfield Burn, Hare Moss, Burnhead Burn, Blaikiewell Burns, Kingcausie Burn, River Dee and Moss of Auchlea Drainage System. The residual impacts on all remaining watercourses, including those taken into pre-earthworks, have been assessed as Negligible significance. The exception is Loirston Burn, where impacts are considered to be of Slight significance.

6.3 Summary

6.3.1 The residual impacts on watercourses for the Southern Leg 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
Loirston Burn	Medium	Construction: Medium potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of four culverts would involve major earthworks, possibly resulting in high 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 magnitude.	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: 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 would be 423; above the probability threshold of 1 in 200 years and below 1 in 1000 years. Suspended Solids: Q_{mean} for Loirston Burn is $0.026m^3/s$, which indicates a medium dilution capacity.	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 – 35% increase over baseline for copper and 9% increase for zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 3456, which is above the probability threshold of 1 in 1000 years. Suspended solids: SUDS will remove up to 90% of suspended solids; therefore Negligible impact.	Slight
Greengate Ditch	Low	Construction: This would involve earthworks, possibly resulting in increased downstream suspended solid loads in the short-term. Possible impact from the potential risk of accidental spillage of pollutants downstream during construction. High impact magnitude.	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
Jameston Ditch	High	Construction: Slight/Negligible potential for accidental spillage of fuel and concrete during construction due to the distance of works to 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

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
		General Operation: A major shift from baseline conditions due to discharge of road runoff. Fundamental change of water quality and ecology. Routine Runoff: High impact from routine runoff due to increase of copper and zinc concentrations > 100% over baseline situation. Accidental Spillage: Low impact from accidental spillage as spillage risk would be 724, which is above the probability threshold of 1 in 200 years and below 1 in 1000 years. Suspended solids: Q_{mean} for Jameston Ditch is $0.003m^3/s$, which indicates a low dilution capacity.	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 – 14% increase over baseline for copper and no increase for zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 48221, which is above the probability threshold of 1 in 1000 years. Suspended solids: SUDS will remove up to 90% of suspended solids; therefore Negligible impact.	Slight/ Negligible
Burn of Ardoe	High	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Burn of Ardoe is $0.001m^3/s$, which indicates a low dilution capacity.	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: 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. 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.	Slight/ Negligible
Bishopston Ditch	High	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Bishopston Ditch is $0.002m^3/s$, which indicates a low dilution capacity.	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

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. 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.	Slight/ Negligible
Heathfield Burn	High	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Heathfield Burn is 0.009m^3/s, which indicates a low dilution capacity	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: 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. 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.	Slight/ Negligible
Hare Moss	High	Construction: Culverting of 3 burns (Burn of Ardoe, Bishopston Ditch and Heathfield Burn) may result in polluted runoff entering the moss, and construction of outfall at Jameston Ditch is considered to result in high potential for pollution of the moss.	Construction: Risk of pollutant release minimised through best practice and minimising extent and duration of works. Ongoing monitoring during construction phase will identify any impacts at an early stage. Assuming specific mitigation measures are undertaken for the 4 watercourses with hydrological connectivity to the moss (see above), anticipated Negligible residual impact magnitude.	Slight/ Negligible
		General Operation: Although the road does not have a direct impact on Hare Moss there is potential for the road to alter the quality of water reaching the moss as a result of the proposed outfall to Jameston Ditch. Long-term inputs of road runoff to the moss are considered to have a high impact on the feature.	General Operation: Maintain hydrological connectivity through culverting, providing extra water through drainage outfall to Jameston Ditch and sufficient treatment and lining of drainage runoff. Assuming specific mitigation measures are undertaken for the 4 watercourses with hydrological connectivity to the moss (see above), anticipated Negligible residual impact magnitude.	Slight/ Negligible

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
Whitestone Burn	Low	Construction: High impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutants release and short-medium term increased turbidity in the water column. Q_{mean} for Whitestone Burn is 0.002m^3/s which indicates a low dilution capacity.	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. 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
Burnhead Burn	High	Construction: Major potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of culvert and the realignments would involve major earthworks, possibly resulting in high sediment and pollutant release and short-medium term increased turbidity in the water column. Medium dilution capacity of the watercourse (Qmean=0.054m^3/s).	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 major shift from baseline conditions due to discharge of road runoff. Fundamental change of 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: Medium impact from accidental spillage as spillage risk would be 195, which is above the probability threshold of 1 in 100 years and below 1 in 200 years. Suspended solids: Q_{mean} for Burnhead Burn is 0.054 m^3/s, which indicates a medium dilution capacity therefore 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: Negligible impact from routine runoff – 16% increase over baseline for copper and no increase for zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 4546, which is above the probability threshold of 1 in 1000 years. Suspended solids: SUDS will remove up to 90% of suspended solids therefore negligible impact.	Slight/ Negligible

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
Blaikiewell Burn	High	Construction: Potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of a bridge would involve some earthworks, possibly resulting in sediment and pollutant release and short 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. Negligible residual impact magnitude.	Slight/ Negligible
		General Operation: Change in water quality likely to be Negligible due to diffuse pollution. Length of bridge likely to Slightly impact upon water quality due to lack of light. Routine Runoff: no outfall planned. Accidental Spillage: no outfall planned. 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 bridges.	Slight/ Negligible
Kingcausie Burn	High	Construction: Slight impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Kingcausie Burn is 0.021m^3/s, which indicates a medium dilution capacity.	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: 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. 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.	Slight/ Negligible
River Dee	High	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Bridging would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Potential for pollutant release during excavation and construction of outfall ditch and structure (outfall location still pending decision).	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. If outfall is planned at the River Dee, pollution risk will be minimised by construction of small cofferdam around the construction area.	Slight/ Negligible

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
		General Operation: A minor shift from baseline conditions due to discharge of road runoff. Temporary adverse impact on water quality and ecology. Routine Runoff: Negligible impact from routine runoff due increase of less than 24% over baseline for copper and zinc and complying with EQS for both pollutants. Accidental Spillage: High impact from accidental spillage as spillage risk would be 88, which is below the probability threshold of 1 in 100 years. Suspended solids: Q_{mean} for River Dee is 46.11m^3/s, which indicates a high dilution capacity therefore 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 – no increase over baseline for copper and zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 2046 which is above the probability threshold of 1 in 1000 years. Suspended solids: SUDS will remove up to 90% of suspended solids therefore negligible impact.	Slight/ Negligible
Milltimber Burn	Low	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in high sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Milltimber Burn is 0.008m^3/s, which indicates a low dilution capacity.	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. 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
Culter House Burn	Low	Construction: This would involve earthworks, possibly resulting in short-term high increase of suspended solid loads downstream from the construction site. 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.	Operation: Watercourse lost through catchment severance.	n/a

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
Beans Burn	Low	Construction: This would involve earthworks, possibly resulting in short-term high increase of suspended solid loads downstream from the construction site. 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
Upper Beanshill Burn and associated ponds	Low	Construction: This would involve earthworks, possibly resulting in short-term high increase of suspended solid loads downstream from the construction site. 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
Gairn Burn	Medium	Construction: Medium potential for accidental spillage of fuel and concrete during construction due to proximity of works to watercourse. Construction of culvert and the realignments would involve major earthworks, possibly resulting in high sediment and pollutant release and short-medium term increased turbidity in the water column. Medium dilution capacity of the watercourse (Qmean=0.011m^3/s).	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 from baseline conditions due to discharge of road runoff. Fundamental change of 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 201, which is above the probability threshold of 1:200 and below 1:1000. Suspended solids: Q_{mean} for Gairn Burn is 0.011 m^3/s, which indicates a medium dilution capacity therefore suspended solids will pose a medium impact.	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 – 9% increase over baseline for copper and no increase for zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 4677, which is above the probability threshold of 1 in 1000 years. Suspended solids: SUDS will remove up to 90% of suspended solids therefore negligible impact.	Negligible

Watercourse	Sensitivity	Potential Impact	Mitigation	Residual Impact Significance
Moss of Auchlea Drainage System	High	Construction: Impact from the potential risk of accidental spillage of pollutants during construction due to proximity of works to watercourse. Culverting and realignment would involve some earthworks, possibly resulting in sediment and pollutant release and short-medium term increased turbidity in the water column. Q_{mean} for Moss of Auchlea Drainage System is 0.002m^3/s which indicates a low dilution capacity.	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: 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. 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.	Slight/ Negligible
Westholme Burn	Low	Construction: Slight potential for accidental spillage of fuel and concrete during construction due to the distance of works to 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 from baseline conditions due to discharge of road runoff. Fundamental change of water quality and ecology. Routine Runoff: High impact from routine runoff due to increase of copper and zinc concentrations over 100% over baseline situation. Accidental Spillage: High impact from accidental spillage as spillage risk is 47, which is below the probability threshold of 1 in 100 years. Suspended solids: Q_{mean} for Westholme Burn is 0.008m^3/s which indicates a low dilution capacity.	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 – 35% increase over baseline for copper and no increase for zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 1104, which is above the probability threshold of 1 in 1000 years. Suspended solids: SUDS will remove up to 90% of suspended solids therefore negligible impact.	Negligible

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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.
Diffuse pollution	pollution that originates from sources that are difficult to measure directly, e.g. agricultural runoff from fields.

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.
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 farther 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.