Aberdeen Western Peripheral Route

Appendix 24.4

Water Quality Report

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1 Introduction

1.1 General Background

1.1.1 Water is a resource that is essential to all animal and plant life. It is also necessary for industry, agriculture, 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.

1.1.2 The EC Water Framework Directive (WFD) – which is transposed into Scottish law by the Water Environment and Water Services (Scotland) Act, 2003 – aims to classify surface waters according to their ecological status and sets targets for restoring/improving the ecological status of water bodies. This is a radical departure from the traditional methods of measuring water quality using chemical parameters. Under the WFD, the status of water is to be assessed using a range of parameters including chemical, ecological, morphological and hydrological measures, which will provide a holistic evaluation of the aquatic ecological health. Furthermore, there is a requirement under the WFD that natural water features will have to reach good ecological status by 2015 (WFD, 2000/60/EC). Some water bodies 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, 2004).

1.1.3 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 a number of EC Directives: 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, and others, all of which were recently incorporated within the Water Framework Directive 2000/60/EC.

1.1.4 Since the formation of the Scottish Environmental Protection Agency (SEPA) in 1996 the river classification scheme has been enhanced and specific targets set up to protect watercourses with good and excellent water quality and to decrease the length of rivers classed as poor or seriously polluted (see SEPA website, www.sepa.org.uk).

1.1.5 This report presents the baseline conditions, potential impacts and mitigation proposals for the water quality of receiving watercourses within the vicinity of the Southern Leg of the proposed scheme. The River Dee, together with a number of small watercourses, is situated within the study area. Not all of these watercourses are under the monitoring supervision of SEPA but those that are mainly display water of a good quality.

1.1.6 In addition to the requirements of the WFD for promotion and maintenance of good aquatic ecological health, the Atlantic salmon (*Salmo salar*) (an 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) in the receiving watercourse concentrations for designated major indicator pollutants were calculated to identify the levels of mitigation required.

2 Approach and Methods

2.1 General Approach

2.1.1 This section sets out the methodology by which the water quality assessment is undertaken and should be read in conjunction with those covering fluvial geomorphology, hydrodynamics, ecology and hydrology.

2.1.2 The Environmental Impact 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.

2.1.3 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 impact to watercourses from fine sediment release is discussed in detail in the fluvial geomorphology assessment (Appendix A24.3).

2.1.4 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.

2.1.5 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 2-1 and Table 2-2. As part of the water quality criteria, the ecological designations of the watercourses and the surrounding areas (as detailed in Appendix A25.9: Freshwater Ecology) 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 2-3.

Table 2-1 – Criteria to Assess the Sensitivity of Water Features

Sensitivity	Surface Water Quality Criteria
High	Large or medium watercourse with pristine or near pristine water quality, Class A1 and A2 (Annex 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

Sensitivity	Surface Water Quality Criteria
	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 2-2 – Criteria to Assess the Magnitude of the Potential Impacts on Water Features

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 Run-off 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 1in 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 Run-off 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 1in 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 Run-off 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

Magnitude	Surface Water Quality Criteria
	through diffuse means, e.g. pollution via sub-surface paths or deposits from air borne road pollution near river crossings. Routine Run-off Specifically for the purposes of the soluble pollution assessment, a negligible impact will be classed as an increase to copper or zinc concentrations of 24% or less over the baseline situation but all EQS levels are met. Accidental Spillage For the purposes of this assessment, a negligible impact will be classed as an accidental spillage risk above probability threshold level of 1 in 1000 years.

Table 2-3 – 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 run-off 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 run-off are very diverse in form and origin, they can be grouped into categories (DMRB, The 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 run-off). The solid fraction of a road discharge may contain up to 70% of the all oil deposited onto a road by moving vehicles, over 90% of all the inorganic lead, 70% of the copper and 56% of the cadmium. Removing coarse solids and a significant proportion of the fine (insoluble) solids from the road discharge is understood to remove much of the potentially polluting load (DMRB, The 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 (The 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 (2026) 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 it is in its insoluble form, it has low toxicity such that biological impacts would not be anticipated (The 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 (The Highways Agency *et al*., 1993). Nutrients (ammonia, oxidised nitrogen and phosphates) are found in very small quantities in road run-off (The Highways Agency *et al*., 1993). Herbicides and pesticides treatment of the verge during road maintenance is also a potential source of contamination and should follow best environmental practice guidance with the selection of degradable compounds.

2.2.6 The water quality assessment of the operational phase impact of insoluble pollutants, such as suspended solids and hydrocarbons, was made using dilution factor criteria of the average flow Q_{mean} in the receiving watercourse. Further assessment was conducted in the fluvial geomorphology assessment (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 for Scotland's Waters, Guiding Principles on the Technical Requirements of the Water Framework Directive' (SEPA, 2002).

2.3 Impact Assessment Methodology

Baseline Assessment

2.3.1 Water quality baseline conditions for watercourses were identified through consultation with statutory consultees, review of relevant published literature, site visits and physiochemical and freshwater habitat sampling data collection undertaken in the summer of 2006 (see 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 (Annex 26: SEPA Classification Scheme). There are five classes comprising A1, A2, B, C and D in decreasing order of quality. Class A1 is excellent and Class D is seriously polluted. The class allocated to a particular reach of watercourse defaults to the poorest class determined from the water chemistry, biology, nutrient, aesthetics and toxicity assessments. No attempt is made to assign zones of intermediate quality between stretches differing by more than one class (SEPA website: www.sepa.org.uk, Annex 26: SEPA Classification Scheme)

2.3.3 The SEPA classification includes all rivers with a catchment area of 10 km^2 or more and specific smaller rivers where known pollution problems exist. This is called the "classification network" (SEPA website: www.sepa.org.uk). The classification network is divided into river stretches at confluences and pollution pressures. Every stretch is assigned a monitoring point where chemical and/ecological surveys are taken and the aesthetic appearance recorded (Annex 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 details 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 run-off 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.

2.3.6 These may cause indirect impacts upon freshwater ecology and fisheries (see Appendix A25.9: Freshwater Ecology). Groundwater resources have been assessed in Chapter 23 (Geology, Contaminated Land and Groundwater). The methods of assessment for potential impacts on water quality from routine runoff, accidental spillage and during construction works are outlined below.

<u>Routine Run-off</u>

2.3.7 Routine run-off is surface water collected from the road as a result of rain falling on the road and draining into the highway drainage system. Routine run-off contains some of the pollutants deposited on the road surface but does not include seriously polluted run-off assessed separately as a result of vehicular collision (accidental spillage).

General

2.3.8 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 Run-off on Highways; Expanding the Current The 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, personal communication, D. Caffery, 2005).

Calculations of the 95-percentile Concentration

2.3.9 The DMRB methodology specify 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 95th percentile is the concentration that is exceeded for only 5% of the time and would be expected to occur very rarely.

Calculations of the Annual Average Concentration

2.3.10 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, personal communication 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 3.1 of the DMRB (95 percent storm) and the Q_{95} flow in the receiving watercourse.

Assessment Process

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

2.3.12 The impact assessment of routine run-off 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 run-off coefficient of the proposed scheme;
- traffic flow data;
- rainfall data;
- the mean flow (Q_{mean}) of the receiving watercourse and the 95th percentile flow (Q_{95} or low flow); and
- The relevant statutory EQS values for the receiving watercourse (provided by SEPA, Table 2-4).

2.3.13 In the 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 River Dee were obtained from the long-term monitoring data provided by SEPA. For the rest of watercourses, which have no data available, these concentrations 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);
    - o since 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 above and below where possible. This was taken into consideration when designing the mitigation;

- the total impermeable area of road surface was provided by Highways Design Engineers;
- the run-off coefficient of the proposed scheme was assumed to be 0.75 (Maidment, 1992);
- traffic flow data for the design year; used traffic predictions for 2026 provided by traffic modellers;
- rainfall data were obtained from the DMRB (Figure 3.1: Depth of Rain for Assessing Pollutant Run-off (95% storm) and Figure 3.2: Average Annual Rainfall 1941 – 1970);
- the Q_{95} and Q_{mean} were estimated, using methods detailed in Appendix A24.1 (Surface Water Hydrology);
- relevant EQS for dissolved copper and total zinc are provided in Table 2-4. The assessment uses the statutory guidance to determine the level of impact of the scheme upon the receptor (receiving watercourse).

2.3.14 The magnitude of impact is assigned based on the criteria set out in Table 2-2. The values presented represent the more stringent target of either the Dangerous Substance Directive or the Freshwater Fish Directive.

Environmental Quality Standards

2.3.15 The EQS for freshwater vary with water hardness, as hardness affects the solubility of metals. The relevant EQS for the protection of all freshwater aquatic life are given in Table 2-4 (SEPA, personal communication, D Caffery, 2005 and Statutory Instrument (SI) Circular No34/1985). These values differ slightly to those published on the SEPA website (www.sepa.org.uk). However, SEPA (SEPA, personal communication, D Caffery, 2005) directly advised Jacobs to use the values reported in Table 2-4 (SI Circular No34/1985) in preference to those published on the website, as it is understood that those on the website are not yet statutory.

Table 2-4 – 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 Statuatory 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 Fish Directive (FFD).

<u>Insoluble Pollutants, Suspended Solids</u>

2.3.16 Currently, there are no sediment quality or quantity standards to use as reference points for assessing the impacts of the solid load of road run-off. 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 run-off (The 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.

2.3.17 Further assessment of physical conditions downstream of proposed outfalls was conducted in the fluvial geomorphology assessment (Appendix A24.3: Fluvial Geomorphology).

Risk of Accidental Spillage

2.3.18 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.

2.3.19 The risks 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 2-5). 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 2-6).

Table 2-5 – Serious Accidental Spillages per Million HGV (km/year)

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

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

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

Table 2-6 – Probability of a Serious Accidental Spillage Leading to a Serious Pollution Incident

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

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

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

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

where:

P_{acc} = probability of a serious accidental spillage in 1yr over a given road length
RL = road length in kilometres
SS = serious spillage rates from Table 2-5 (or local data if available)
AADT = annual average daily traffic
%HGV = percentage of Heavy Goods Vehicles

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

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

2.3.22 Where, P_{pol} = the risk reduction factor, dependent upon emergency services response times, which determines whether a serious spillage will cause a serious pollution incident. The value is to be selected from Table 2-6, using the quality of the reach proposed to receive the discharge.

2.3.23 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 (The Highways Agency *et al.*, 1993).

<u>Pre-earthworks</u>

2.3.24 Pre-earthworks drainage comprises unlined or lined ditches, or filter drains. These drainage systems are constructed at the top of cutting slopes, or at the toe of embankments, subject to the requirements of the design in order to prevent surface water or groundwater entering the works. When placed at the top of cuttings, surface water carried by the pre-earthworks drainage would be clean and could be transferred directly to watercourses unless the rate of discharge has to be controlled. When placed at the toe of embankments, surface water carried by the pre-earthworks drainage would contain sediment from run-off from the embankments under construction and would be required to discharge water to temporary settlement ponds prior to it being discharged to a watercourse.

2.3.25 Some small watercourses and field drains would be taken into pre-earthworks. They would be crossed by the proposed scheme in their very upper reaches. Therefore, the upper catchment would be diverted and connected to the new drainage system. Watercourses that would be taken into pre-earthworks are not assessed for the operational phase as they would only be present during construction. They have thus only been assessed for the construction phase.

Construction Impact

2.3.26 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, and also the extent of the proposed works, was taken into consideration. Available dilution of the watercourse was considered when assessing the potential impact of suspended solids and accidental spillage during construction. Additionally flow patterns, fisheries or environmental status of the watercourse, receiving body and existing abstractions were also considered in the assessment.

2.3.27 The watercourses to 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 suspended solids downstream of the area of construction.

2.4 Limitations of Assessment

2.4.1 The conducted water quality assessment is limited, to a certain extent, by the amount of available data and by the predictive methods available to complete a more rigorous assessment. Following the DMRB guidance, the assessment was carried out only for the main indicator metals (copper and zinc) and accidental spillage risk using a simple calculation model to predict respectively the annual pollution concentrations and the return periods. Although these are 'conservative' methods, the predicted values are sensitive to potential changes in input concentrations and receiving flows. Additionally, new research (Patel and Drieu, 2005) indicates that more determinants may be considered in the future, particularly total suspended solids (TSS), nutrients and BOD. Where possible, this report, and the fluvial geomorphology report (Appendix A24.3) assess the impact to the watercourses of theTSS.

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. The data sets for zinc provided by SEPA refer only to the River Dee and Crynoch Burn. The Crynoch Burn data cover a limited set of measurements for the period 1984-2005. Spot sampling results provide only a snapshot of the water quality conditions in the watercourse at the time when the sample was obtained. These 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

3.1.1 The Southern Leg of the proposed scheme passes over or within the vicinity of a number of watercourses. Some are open watercourses in rural areas while others are more heavily modified and partially culverted (Figures 24.1a-h).

3.1.2 The study area is located mainly within River Dee catchment, comprising the River Dee with its tributaries and a number of smaller watercourses catchments. The surface water features of each catchment can be divided into three main types:

- Major watercourses
- Minor watercourses
- Lochs and waterbodies

3.1.3 The baseline study examines 19 watercourses together with a number of water bodies, all of which are affected during the construction phase or directly by the proposed road.These are summarised in Table 3-1.

Table 3-1 – Water courses and bodies 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
	Bishopton 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 Water Bodies	Hare Moss
	Moss of Auchlea

3.1.4 Moss of Auchlea and Hare Moss are important as ecological habitats and are thus further considered in the ecology section (see Chapter 25: Ecology and Nature Conservation) and Appendix A24.1 (Surface Water Hydrology).

3.1.5 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 reasonably small, with the exception of the River Dee.

3.1.6 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 2-1. The use of spot measurements provides an indication of the water quality for the burns that are not included in the SEPA monitoring network. However, as noted, spot sampling data only show a snapshot of the conditions; those present at the time of collecting the samples (see Appendix A25.9: Freshwater Ecology). The sensitivities of all watercourses are summarised at the end of each section. SEPA monitors the water quality in the River Dee and Crynoch Burn (Table 3-2). The River Dee was identified as receiving existing road drainage water from the A90. Results from the SEPA monitoring for both the River Dee and Crynoch Burn for the year 2005 are presented below.

Table 3-2 – 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 (0C)	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
	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)

3.2 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 2,039km².

3.2.2 The section of the River Dee directly relevant to the assessment is situated between Park Bridge and Bridge of Dee (Figure 24.1d shows the AWPR crossing). 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 the Crynoch Burn, a golf course and a sports centre at Bielside. 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 source Table 3-2, SEPA, 2005). The measured levels of dissolved oxygen, ammonia and BOD are typical for natural unpolluted rivers (Table 3-2).

- saturated oxygen above 80% (SEPA class A1);
- ammonia concentrations below 0.25mg/l (SEPA class A1);
- 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 0.1 mg/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 run-off (WHO, 1984). Following the EU Urban Wastewater Treatment Directive (91/271/EEC) the UK water quality standards for orthophosphates provide guideline annual values below 0.1 mg/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 Fish Directive (FFD, 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 95^{th}-percentile 52μg/l, DSD EQS 95% 200μg/l) and the FFD (200μg/l). 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 FFD (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 FFD (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 sustainable existence of populations of native brown trout, sea trout and migratory salmon (refer to Appendix A25.9: Freshwater Ecology). As it supports populations of freshwater pearl mussel (Appendix A25.10: Freshwater Pearl Mussel), Atlantic salmon (Appendix A25.9: Freshwater Ecology) and otters (Appendix A25.5: Otter Report), the river is considered to be a Natura 2000 site and is designated as a Special Area of Conservation. The boundary of the SAC designation is the edge of a zone that 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.

3.3 Minor Watercourses

Loirston Burn

3.3.1 Loirston Burn (Figure 24.1a) flows from its source to the southeast of Charleston into Loirston Loch, draining a catchment area at its lowest point of approximately 3.5 km^2. It is highly modified and acts predominantly as a drainage channel for the surrounding agricultural area. 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 / 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 and assumed to receive road run-off 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 The 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. At present, the Loch has a value as breeding and wintering wildfowl habit and is therefore designated as a District Wildlife Site (DWS).

3.3.3 Loirston Burn classed as medium sensitivity watercourse.

Greengate Ditch

3.3.4 It is a small and possibly ephemeral field ditch located just south of Greengate Farm and draining a catchment area of approximately 0.2km^2 (Figure 24.1a). Although it is close to Loirston Burn and Hare Moss it is not directly connected to their catchments (see Appendix A24.1: Surface Water Hydrology). Greengate Ditch is considered to be of low sensitivity.

Jameston Ditch

3.3.5 Jameston Ditch (Figures 24.1a-b) is a tributary of the Burn of Ardoe. It is part of the Hare Moss drainage system and runs along the north boundary of Hare Moss. The ditch was built for agricultural purposes therefore it is straightened along its entire length and follows 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 0.2 km^2. It is not classed by SEPA but spot sampling results (Jacobs, Summer 2006) show water quality class B (fair). The sensitivity of this burn is considered to be high due to its hydrological connectivity to Hare Moss (see Appendix A24.1: Surface Water Hydrology).

Burn of Ardoe

3.3.7 The Burn of Ardoe (Figure 24.1b) is a tributary of the River Dee which 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 the confluence with the River Dee. Burn of Ardoe is crossed by Lochton-Auchlunies-Nigg Road (C5K), a farm track and the B9077 along its way. Its catchment area to the point of the crossing of the proposed road is approximately 0.1 km^2.

3.3.8 Although the Burn is not classed by SEPA, it flows through agricultural land in its upper reaches and is likely to receive agricultural run-off. 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 Bishopton Ditch (Figure 24.1b) is part of the Hare Moss drainage system. It was possibly 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 to the point of crossing of the proposed road of approximately 0.2 km^2.

3.3.10 Bishopton Ditch is not included in the SEPA Water Quality Classification Scheme but as it flows through agricultural land, it is likely to be impacted by agricultural run-off. The sensitivity of Bishopton Ditch is considered to be high due to its hydrological connectivity with Hare Moss (see Appendix A24.1: Surface Water Hydrology).

Heathfield Burn

3.3.11 Heathfield Burn (Figure 24.1b) 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 very edge of the west boundary of Hare Moss. It is straightened along its entire length and follows field boundaries of gently sloping, almost flat, land of rough pasture. Private water supply (groundwater wells) has been identified in the upper catchment area (see Chapter 23: Geology, Contaminated Land and Groundwater and Figure 23.2b).

3.3.12 The Burn begins just north of Bishopton farm at a Class C (U59K) road and flows in an easterly direction. Approximately halfway along its length, it changes course 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 0.8 km^2.

3.3.13 Heathfield Burn is not classed by SEPA. Due to its location, it is expected to receive agricultural and road drainage run-off. The sensitivity of this burn is considered to be high due to its hydrological connectivity to Hare Moss (see Appendix A24.1: Surface Water Hydrology).

Whitestone Burn

3.3.14 Whitestone Burn (Figure 24.1c) is a tributary of Burnhead Burn draining an area of approximately 0.2km^2 to the point of crossing of the proposed road. It begins near Ferniebrae farm, flowing in westerly direction along the edge of woodland area. At Whitestone farm the burn is crossed by a farm track changing its course in a south-westerly direction. It follows field boundaries alongside before discharging into Burnhead Burn.

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

Burnhead Burn

3.3.16 Burnhead Burn (Figure 24.1c) is the main tributary of the 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 tilled 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 not monitored by SEPA. Recent spot sampling results (Jacobs, Summer 2006) show good water quality, class A2 (see Appendix A25.9 Freshwater Ecology). Burnhead Burn is considered to have a high sensitivity as it is the main tributary of Blaikiewell Burn.

3.3.18 Burnhead Burn is impacted by both the Fastlink and the Southern Leg proposals. All assessment conclusion are reported here for consistency.

Blaikiewell Burn

3.3.19 Blaikiewell Burn (Figure 24.1c) is a moderately steep tributary of the 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 very upper reaches but has more natural channel halfway down and farther 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 of 2006; Appendix A25.9: Freshwater Ecology) showed that Blaikiewell Burn is of excellent quality (class A1). Additionally, the burn is known to be 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 (Figures 24.1c-d) is a tributary of the Crynoch Burn, draining an area of approximately 1.6 km^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. Its catchment becomes steeper near the confluence with Crynoch Burn. Private water supply wells have been identified in the catchment area (see both Chapter 23: Geology, Contaminated Land and Groundwater, and Figure 23.2d).

3.3.22 Kingcausie Burn is not included in the SEPA water quality monitoring network. The spot sampling (Jacobs, Summer 2006) found the water quality to be fair (class B) quality. However, being 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 31.7km^2. 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 (Figures 24.1c-d) it is only expected to be impacted indirectly via its tributaries and therefore, it is not included in the 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 5m inland boundary that extends 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 3-2) and the spot sampling results indicate class A1 (excellent) water conditions (see Appendix A25.9: Freshwater Ecology).

3.3.25 Crynoch Burn has been classed as high sensitivity watercourse

Milltimber Burn

3.3.26 This is a predominantly straightened and very small tributary of the River Dee (Figure 24.1d) 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 farther 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 A93.

3.3.27 Milltimber Burn is not monitored by SEPA. Spot sampling results (Jacobs, Summer 2006) showed its water quality to be of B standards (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 (Figures 24.1d-e) is a field drainage ditch running alongside the west edge of 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 (see Appendix A24.1: Surface Water Hydrology) and is therefore considered to be of low sensitivity.

Beans Burn

3.3.29 Beans Burn (Figure 24.1e) is a tributary of Murtle Den Burn, draining an area to the point of crossing of the proposed scheme of approximately 0.1 km^2. It begins in steep, agricultural land just south-west of Beans Hill and continues on in a south-westerly direction following field boundaries for its entire length. The watercourse is considered to be an important otter commuting route (see Appendix A25.5: Otter Report).

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

Upper Beanshill Burn

3.3.31 Upper Beanshill Burn (Figures 24.1e-f) 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 0.05 km^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 has not been monitored by SEPA. At the area of interest Upper Beanshill Burn was classed as low sensitivity.

Gairn Burn

3.3.32 Gairn Burn (Figures 24.1e-f) is a small tributary of Silver Burn and part of the Brodiach Burn catchment (Brodiach Burn is a designated salmonid river). It begins just 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 (see both Chapter 23: Geology, Contaminated Land and Groundwater, and Figure 23.2f).

3.3.33 Gairn Burn is not monitored by SEPA. Macroinvertebrate spot sampling (Jacobs, Summer 2006) indicates 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 (Figure 24.1f). One of these drains (catchment area of approximately 0.2km^2 to the point of crossing) would be crossed by the proposed scheme, therefore it might have a direct impact on its condition. A number of private water supply wells have been identified in the vicinity of the watercourse (see both Chapter 23: Geology, Contaminated Land and Groundwater, and Figure 23.2f).

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 (Figure 24.1g) is a small ephemeral tributary of Brodiach Burn; a designated salmonid river, which 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 (West Kingsford - industrial tip closed in 1991) 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 has not been monitored by SEPA. There are SEPA monitoring points 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 the Westholme Burn may be polluted as it has an adverse impact on the Brodiach Burn water quality and its water quality is considered to be in poor conditions. It is therefore classed as of low sensitivity.

3.4 Mosses

Hare Moss

3.4.1 Hare Moss (Figure 24.1b) is a wet modified raised bog situated North West of Duff's Hill. In the past, it has been heavily modified through draining the bog area and changing the local hydrology (see Appendix A24.1: Surface Water Hydrology). The Moss comprises 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 (see Chapter 25: Ecology and Nature Conservation). 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 (existence of plants communities associated with nutrients enriched environment, see Chapter 25: Ecology and Nature Conservation).

3.4.2 The moss system will be subject to additional assessments to further understand the functioning of the Moss (see Chapter 25: Ecology and Nature Conservation and Appendix A24.1 Surface Water Hydrology). It is considered to be of high sensitivity.

Moss of Auchlea

3.4.3 Moss of Auchlea (Grid Reference: NJ 848053) is located on the outskirts of Aberdeen, south of the main A944 near Kingswells at an average altitude of 132m (Figure 24.1f). 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 (salmonid river). The low lying nature of the site has led to water-logging, and over many years a build up of peat has occurred, creating small basin mire.

3.4.4 The Silver Burn flows through the middle of the site. It is 0.5m to 1.0m wide and has a slow flow. The site supports voluble wetland habitats and a range of wetland plants although none of the species presented are particularly rare. These habitats of fen and rush pasture have declined significantly within the area due to drainage and agricultural intensification. It is important to retain them and the range of plants that are present as they are locally uncommon.

3.4.5 The moss was identified by Aberdeen City to be of local value due to its important wetland habitats but did not qualify for SSSI. It was designated as a District Wildlife Site (DWS) by the Aberdeen City Council in the 1990s and, as such, is officially recognised as a place of wildlife importance and therefore 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 3-3 – Sensitivity of Surface Water Features for the Southern Leg

Watercourse	SEPA category	Spot sampling category	Sensitivity
Loirston Burn	-	D	Medium
Greengate Ditch	-	-	Low
Jameston Ditch	-	B	High
Burn of Ardoe	-	-	High
Bishopton Ditch	-	-	High
Heathfield Burn	-	-	High
Hare Moss	-	-	High
Whitestone Burn	-	-	Low
Burnhead Burn	-	A2	High
Crynoch Burn	A2	A1	High
Blaikiewell Burn	-	A1	High
Kingcausie Burn	-	B	High
River Dee	A2	A2	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
Moss of Auchlea	-	-	High

Watercourse	SEPA category	Spot sampling category	Sensitivity
Westholme Burn	-	-	Low

4 Potential Impacts

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 run-off 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 run-off 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 run-off (soluble pollutant assessment and insoluble pollutant assessment which can either cause chronic or acute impact) and risk of accidental spillage (accidental spillage of pollutants can cause acute impact), as well as impacts on water quality during construction.

4.2 Generic Impacts

4.2.1 The construction of the drainage system would allow road run-off 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 might occur as a result of direct discharge outfall, these impacts are assessed using the methods set out for routine run-off and accidental spillage.

4.2.2 Diffuse pollution from road operation could also occur via sub-surface paths, where run-off is infiltrated and eventually reaches the groundwater table or is deposited directly into a watercourse near river crossings. A wide range of organic and inorganic chemicals might occur as diffuse pollutants. The potential impact from diffuse means is expected to be Negligible.

Operational Impacts

4.2.3 During operation of the proposed scheme, pollutants contained in road run-off could include:

- 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;
- 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 (see section 2: Approach and Methods). 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 of traffic.

Routine Run-off

Soluble Pollutants

4.2.5 Trace metal road run-off 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 might 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. 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 run-off (The Highways Agency *et al*, 1993). These were assessed quantitatively in accordance with the methods set out in the DMRB and detailed in section 2 (Approach and Methods). The predicted values are then compared to the EQS limits set out by SEPA and the DSD. Detailed calculation sheets for the predicted copper and zinc effects are presented in Annex 28.

4.2.10 As stated in the DMRB, copper in a soluble form is particularly toxic to aquatic organisms. High concentrations (higher than the EQS standards) of dissolved copper could have acute (short-term and lethal) effects on the water environment while low concentrations (below the EQS values) may pose chronic pollution effects through bioaccumulation. Copper's toxicity 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 suspended solids, vehicle oil and other hydrocarbons and some organic materials such as vegetation debris, grass cuttings, etc. These are described below.

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

Biodegradable organic materials:

4.2.19 Non-point sources of biodegradable organic materials include debris and grass cuttings. These materials contain high levels of nutrients (carbon, nitrogen, phosphorus and sulphur) and organic matter. They undergo 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 biodegradeable material is broken down within a water feature can lead to fish and invertebrate deaths. In the short term, the material may smother the river bottom, also leading to the death of benthic species (see Appendix A25.9: Freshwater Ecology).

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 lories cargo. The assessment was conducted using DMRB method which is described in details in section 2: Approach and Methods. Detailed calculation sheets for the accidental spilage risk are presented in Annex 27.

Culverts and Realignments

4.2.22 Construction of the Southern Leg of the proposed scheme would involve 15 watercourse crossings. Culverting and realignment could potentially change the riverbed morphological diversity and the sediment regime of the watercourses, which might have an associated impact upon water quality (these impacts are discussed in more details in Appendix A24.3: Fluvial Geomorphology). The number and length of culverts could impact upon water quality due to lack of light and rapid microbiological degradation of biodegradeable 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 slightly increase the local amount of impermeable surface through the construction of the road pavement. This has the potential to increase the total discharge via run-off to the watercourses (see detail assessment in Appendix A24.1: Surface Water Hydrology).

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 decreased 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 (see Appendix A24.3: Fluvial Geomorphology). Impacts upon the aquatic ecology are detailed in Chapter 25 (Ecology and Nature Conservation).

Pre-earthworks

4.2.25 Watercourses that would be taken into pre-earthworks are not assessed for the operational phase. They have been assessed only for the construction phase.

Construction Impacts

4.2.26 Table 4-1 illustrates the potential sources and effects of construction activities on water quality. Construction impacts are likely to be short-term and might have minimal effect on the water quality of a watercourse; however, impacts might have a longer term indirect effect on the river ecology (see Chapter 25: Ecology and Nature Conservation and Appendix A25.9: Freshwater Ecology).

Table 4-1 – Potential Sources of Impact and Effects on Water Resources from Construction Activities

Source of Impact	Potential Effects
Suspended Solids Suspended solids could result from excavations,	Sediments could cause damage to fish, aquatic invertebrates and plants through deposition resulting in a

Source of Impact	Potential Effects
blasting, run-off from stockpiles, plant and wheel washing, run-off from site roads, run-off during embankment construction, earthworks and landscaping. The risk of release of suspended solids into watercourses or drainage ditches would be greatest where the proposed scheme crosses features such as watercourses.	smothering effect or by interference with feeding and respiratory apparatus. Suspended solids might also contain contaminants, which could cause pollution of the receiving watercourse. More details can be found in Appendix A24.3 (Fluvial Geomorphology).
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 might 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 or watercourse or groundwater. Potential for adverse effects on aquatic organisms if pH elevated to / maintained above 8.5.
Watercourse / Drain Crossings and Diversions, Realignment of Watercourses Construction of structures such as culverts would be a potential source of pollution and construction debris could block land drains.	Blockage of land drains could result in waterlogging of soils. Culverts might cause flooding problems upstream. Diversions could cause long term impacts on the watercourse. More details can be found in Appendix A24.3 (Fluvial Geomorphology).
Sewerage Accidental / uncontrolled release of sewage from sewers through damage to pipelines during service diversion.	Pollution to watercourses / groundwater (refer to Chapter 23: Geology, Contaminated Land and 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 (refer to Chapter 23: Geology, Contaminated Land and Groundwater).

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 fine sediment release during the construction phase, and the impacts of culverting and realignment are addressed in detail in Appendix A24.3 (Fluvial Geomorphology) and summarised in the impact assessment below. While hydrology and flood risk are touched upon in this section, the impacts are presented in detail in a separate report (Appendices A24.1 and A24.2 respectively).

4.2.28 The watercourses that would be taken into pre-earthworks would be highly impacted during construction phase. The earthworks involved could potentially result in sediment release and large increase of suspended solids downstream of the area of construction.

4.3 Specific Impacts on Watercourses

4.3.1 Table 4-4 sets out the proposed modifications and their impacts on the watercourses situated in the AWPR Southern Leg area.

Operation Impacts

4.3.2 There are five proposed drainage runs (named Run E, Run F, Run H, Run J, Run K) within the Southern Leg area of the proposed scheme. The designed road drainage outfalls of the proposed scheme are shown on Figures 24.5a-h. 15 watercourses included in this water quality impact assessment would be crossed by the proposed scheme (see Table 4-4).

4.3.3 The following watercourses have not been assessed using the DMRB methods, as the design is such that they would not receive any direct road drainage and as such the impact from diffuse pollution has been assessed qualitatively:

- Loirston Burn
- Burn of Ardoe
- Heathfield Burn
- Bishopston Ditch
- Heathfield Burn
- Whitestone Burn
- Blaikiewell Burn
- Kingcausie Burn
- Milltimber Burn
- Moss of Auchlea Drainage System

4.3.4 The following watercourses are expected to be taken into pre-earthworks and the potential impact of the proposed scheme has been assessed qualitatively:

- Greengate Ditch
- Culter House Burn
- Beans Burn
- Upper Beanshill Burn

Routine Run-off

4.3.5 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: Approach and Methods). Details of the calculations are given in Annex 28 and summarised in Table 4-2.

Table 4-2 – Estimated Impact of Total Zinc and Dissolved Copper in Road Run-off (Without Mitigation)

Site	Sensitivity	Parameter	EQS Annual Average (µg/l)	Inferred upstream concentrations (µg/l)	Estimated downstream conc. without mitigation (µg/l)	Percentage increase over baseline concentration levels (%)	Impact magnitude	Significance of Impact of proposed road without mitigation
Loirston Burn	Medium	Diffuse	n/a	n/a	n/a	n/a	Negligible	Slight
Jameston Ditch	High	Copper	10	5	100*	1899	High	Substantial
		Zinc	75	38	508*	1254	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
Whitestone Burn	Low	Diffuse	n/a	n/a	n/a	n/a	Negligible	Negligible
Burnhead Burn	High	Copper	10	5	35*	603	High	Substantial
		Zinc	75	38	163*	334	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
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

Site	Sensitivity	Parameter	EQS Annual Average (µg/l)	Inferred upstream concentrations (µg/l)	Estimated downstream conc. without mitigation (µg/l)	Percentage increase over baseline concentration levels (%)	Impact magnitude	Significance of Impact of proposed road without mitigation
		Zinc	75	38	688*	1735	High	Moderate

*** Exceeds Annual Average EQS**

4.3.6 During routine operation of the road without mitigation, the resultant concentrations of dissolved copper and total zinc for Jameston Ditch, Burnhead Burn, Gairn Burn and Westholme Burn would exceed the annual average EQS (Table 2-4). The effect 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, while for Gairn Burn (medium sensitivity) the impact significance would be Moderate/ Substantial and for Westholme Burn (low sensitivity) the impact significance would be Moderate.

4.3.7 Due to a greater dilution capacity of 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% (4% for copper and 2% for zinc), indicating negligible magnitude of the potential impact. Thus, for River Dee (high sensitivity) the impact significance was classed as Slight/Negligible for both total zinc and dissolved copper concentrations.

4.3.8 All remaining watercourses would be impacted only through diffuse run-off considered to have a Slight/Negligible or Negligible effect on the water quality.

Suspended Solids

4.3.9 Given the low, medium and high sensitivity of the watercourses, the potential suspended solids (SS) impact is considered to be of Moderate significance for Gairn Burn and Westholme Burn, Substantial significance for Jameston Ditch and Moderate/Substantial significance for Burnhead Burn (see Table 4-4). For the River Dee the impact would be of Slight/Negligible significance due to the high dilution capacity (see Table 4-4). The significance of the suspended solids impact would be classed as Slight/Negligible for some watercourses with no road drainage because of their high sensitivity. These watercourses are Burn of Ardoe, Heathfield Burn, Blakiewell Burn, Kingcausie Burn and Moss of Auchlea Drainage System.

Risk of Accidental Spillage

4.3.10 The assessment indicates that the risk of accidental spillage for Burnhead Burn, River Dee and Westholm Burn would be likely to exceed the threshold of acceptability. Therefore, for Burnhead Burn and River Dee, both of high sensitivity, the impacts would be of Substantial significance, while for Westholm Burn (low sensitivity) the impacts would be of Moderate significance. For Jameston Ditch and Gairn Burn the impact significance is considered to be Moderate.

4.3.11 Table 4-3 presents a summary of the spillage risk assessment (without mitigation) for the proposed scheme (for detailed calculations please refer to Annex 27).

Table 4-3 – Summary of Spillage Risk Assessment (Without Mitigation)

Watercourse	Sensitivity	Threshold of Acceptability	Spillage Risk in design year – Without Mitigation	Within Acceptable Limits?	Impact Magnitude	Significance
Jameston Ditch	High	1:100	1:451	Yes	Low	Moderate
Burnhead Burn	High	1:100	1:62	No	High	Substantial
River Dee	High	1:100	1:62	No	High	Substantial
Gairn Burn	Medium	1:100	1:174	Yes	Moderate	Moderate
Westholme Burn	Low	1:100	1:46	No	High	Moderate

Construction Impacts

4.3.12 The assessment indicates that there could be a Substantial adverse effect on the River Dee during the construction of the road bridge. Bridging would involve earthworks, possibly resulting in high sediment release, concrete or cement spillage into the watercourse. Blaikiewell Burn would also be bridged but due to the limited earthworks (relatively smaller size of the burn) the resulting impact could be of Moderate/Substantial significance.

4.3.13 The construction of a culvert and/or a large realignment on watercourses of high sensitivity and low dilution capacity would have an impact of Substantial significance. Such watercourses are Burn of Ardoe, Bishopton Ditch, Heathfield Burn, Burnhead Burn, and Moss of Auchlea Drainage System. During the construction of culverts Loirston Burn and Kingcausie Burn would suffer impacts of Moderate/ Substantial significance, while for Whitestone Burn, Miltimber Burn, and Gairn Burn the impact significance would be Moderate.

4.3.14 Construction impact for the watercourses not crossed by the proposed scheme but proposed to have an outfall (Jameston Ditch and Westholme Burn) would be of Slight/Negligible or Negligible significance.

4.3.15 Those watercourses taken into pre-earthworks would go through a high impact magnitude as there would be a risk of spillage of pollutants and sediment release downstream of the proposed scheme. Therefore the impact significance would be Moderate (see Table 4-4).

4.4 Summary

4.4.1 The potential impacts to receiving watercourses in the Southern Leg section of the AWPR are summarised in Table 4-4 below.

Table 4-4 – Assessment of potential impacts on key watercourses

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Impact Description	Impact 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	No road drainage discharge to burn	Construction: Major 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/ Substantial
					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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Negligible	Negligible
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 ch204600 draining total of 7.1ha	Construction: Slight/negligible potential for accidental spillage of fuel and concrete during construction due to the distance of works to watercourse.	Negligible	Slight/ Negligible
					General Operation: A major shift from baseline conditions due to discharge of road run-off. Fundamental change of water quality and ecology. Routine Run-off: High impact from routine run-off due to increase of copper and zinc concentrations > 100% over baseline situation. Accidental Spillage: Low impact from accidental spillage as spillage risk would be 451; 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.	High	Substantial

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Impact Description	Impact Magnitude	Impact Significance
Burn of Ardoe	High	1No. 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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Negligible	Slight/ Negligible
Bishopton Ditch	High	1 No. culverts 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 Bishopton 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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Negligible	Slight/ Negligible
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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Negligible	Slight/ Negligible

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Impact Description	Impact Magnitude	Impact Significance
Whitestone Burn	Low	1 No. culvert: ch200990	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 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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Negligible	Negligible
Burnhead Burn	High	1 No. culvert ch200100	Major realignment (overall length maintained).	1 proposed outfall at ch200366 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 (Qmean=0.054m^3/s).	High	Substantial
					General Operation: A major shift form baseline conditions due to discharge of road run-off. Fundamental change of water quality and ecology. Routine Run-off: High impact from routine run-off due increase of over 100% over baseline for copper and zinc resulting of failure of EQS for both pollutants. Accidental Spillage: High impact from accidental spillage as spillage risk would be 62, which is below the probability threshold of 1 in 100 years. Suspended solids: Q_{mean} for Burnhead Burn is 0.054 m^3/s, which indicates a medium dilution capacity; therefore 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

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Impact Description	Impact Magnitude	Impact Significance
					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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. 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
					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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Negligible	Slight/ Negligible
River Dee	High	1 No Bridge ch102000	No realignment proposed	1Proposed outfall at ch102824. Total of 10.7 Ha	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.	High	Substantial
					General Operation: A minor shift from baseline conditions due to discharge of road run-off. Temporary adverse impact on water quality and ecology. Routine Run-off: Negligible impact from routine run-off 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 62, 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.	High	Substantial

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Impact Description	Impact Magnitude	Impact Significance
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 Miltimber Burn is 0.008m^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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Negligible	Negligible
Culter House 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
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. in the. 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. in the. 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	1 No. culvert: side road ch150	Realignment associated with culvert construction	1 Proposed outfall at ch106085. 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 dilution capacity of the watercourse (Qmean=0.011m^3/s).	Medium	Moderate

Watercourse	Sensitivity	Crossing	Realignment	Road Outfall	Impact Description	Impact Magnitude	Impact Significance
					General Operation: A major shift from baseline conditions due to discharge of road run-off. Fundamental change of water quality and ecology. Routine Run-off: High impact from routine run-off due increase of > 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 174, which is above 1:100 and below 1:200. Suspended solids: Q_{mean} for Gairn Burn is 0.011 m^3/s, which indicates a medium dilution capacity; therefore 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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. 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	Impact Description	Impact Magnitude	Impact Significance
				Total of 8.25ha.	General Operation: A major shift form baseline conditions due to discharge of road run-off. Fundamental change of water quality and ecology. Routine Run-off: High impact from routine run-off 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 46, which is below the probability threshold of 1 in 100 years. Suspended solids: Q_{mean} for Westholme Burn is 0.007m^3/s which indicates a low dilution capacity.	High	Moderate

5 Mitigation and Recommendations

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

5.2 Introduction and Guiding Principles

5.2.1 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.'

5.2.2 For the purposes of this assessment, for any adverse impact assessed as being of greater than slight significance, specific mitigation measures will be implemented to ameliorate this impact and reduce the impact significance for water quality to Slight or Negligible.

5.2.3 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 run-off treatment. Implication of mitigation measures for all watercourses aims to gain and preserve 'good' water quality and ecological status of any watercourse. In the light of the new Controlled Activities Regulation transposing the WFD into Scottish law, from April 2006 SEPA requires any new culvert or bridge to be licensed (SEPA website).

5.3 Mitigation Methodology

5.3.1 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 impacts, for example the avoidance of important/sensitive water features where possible. This was taken into consideration throughout the design process for the proposed scheme.

5.3.2 Where potential adverse impacts cannot be prevented, i.e. where there is a need for road run-off 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).

5.3.3 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.

5.4 Generic Operation Mitigation

5.4.1 Without mitigation in place, operation of the proposed scheme could potentially impact adjacent watercourses through direct discharge of polluted surface run-off 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); and Sustainable Urban Drainage Systems: Hydraulic, Structural and Water Quality Advice CIRIA C609 (Construction Industry Research and Information Association, 2004).

5.4.2 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 structures engineers, geomorphologists, ecologists and water quality specialists.

Road drainage

5.4.3 SUDS techniques that would be implemented to reduce potential impacts during normal road operation (Figures 24.5a-h) are summarised in Table 5-1 and are detailed below. For each outfall a treatment train is proposed which would comprise a train of mitigation measures, for example a combination of both wet and dry detention basins and treatment ponds (up to four in series) to maximise removal through different types of mitigation.

Table 5-1 – Summary of Mitigation Measures to Address Potential Impacts on Water Quality/Flooding/Groundwater

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 run-off 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 run-off 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)

<u>Filter Drains and Catchpits</u>

5.4.4 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 suspended solids, hydrocarbons, iron. According to the DMRB (The 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.

5.4.5 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.

5.4.6 All filter drains must be designed in accordance with the DMRB (The Highways Agency *et al*., 1993), taking cognisance of guidance contained in the CIRIA SUDS Design Manual (CIRIA, 2000) and CIRIA C609 (CIRIA, 2004) and new guidance C648.

5.4.7 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 run-off 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

5.4.8 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. Further information on this can be found in Appendix A24.1 (Surface Water Hydrology).

5.4.9 A large proportion of pollutants in operational run-off 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.

5.4.10 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. 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 Run-off Using Constructed Wetlands (Environment Agency, 1998). In addition to this best design practice for pollutant removal, as detailed in CIRIA C609 (CIRIA, 2004) should be adhered to.

5.4.11 According to the Design Manual for Roads and Bridges (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

5.4.12 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 run-off (CIRIA, 2004). They are typically located next to highways but can also be constructed in landscaped areas within car parks and elsewhere.

5.4.13 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).

5.4.14 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

5.4.15 To avoid failure or sub-optimal operation of the road drainage network, it is necessary to ensure:

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

5.4.16 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

5.4.17 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.

5.4.18 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.

5.4.19 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 and SNH).

Adherence to Best Practice near Watercourses

5.4.20 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).

5.4.21 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 please refer to the Surface Water Hydrology report and the Hydrodynamic Modelling report respectively (Appendices 24.1 and 24.2). Similarly for mitigation specific to ecology please refer to Chapter 25 (Ecology and Nature Conservation).

Water Crossings

5.4.22 Bridging high sensitivity watercourses aims at avoiding adverse long-term changes in water quality, morphological diversity and minimising construction impact. The River Dee and Blaikiewell Burn are high sensitivity watercourses; therefore, it is proposed to be bridged. The river crossing designs have been developed by a team including structural engineers, hydraulic modellers, environmental scientists and aesthetic advisors. Details of design features are given in Chapter 4 (The Proposed Scheme) and construction and operation mitigation measures specific to water quality are outlined below.

5.4.23 In all cases, bridges have been designed to entirely span the watercourse at the crossing point, meaning that no piers will be located in the water column and no in-channel works at any of these crossing points will be carried out. These measures will reduce the risk of accidental spillage and sediment release within the water channel, prevent river diversion or pumping water away during the bridge construction. In addition, bridges have been designed to minimise damage to the surrounding riparian zone, with piers set back from the water's edge and viaduct options being preferred over the construction of large embankments on floodplains (refer to Appendix A24.3: Fluvial Geomorphology).

5.4.24 The 15 watercourse crossings include:

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

5.4.25 Many of the watercourses crossed are very small and of low sensitivity with a large proportion being straightened land drains. These crossings are discussed in detail in Appendix A24.3 (Fluvial Geomorphology).

Culvert Design

5.4.26 Culvert design will follow SEPA policy and the guidelines set out in Culvert Design Manual, Report 168 (CIRIA, 1997). In addition the culvert will be designed to facilitate fish passage following guidance from River Crossings and Migratory Fish Design Guidance: A Consultation Paper for the Scottish Executive (Scottish Executive Development Department, 2000) (see Appendix A25.9: Freshwater Ecology).

5.4.27 Appropriate culvert design is aimed at avoiding deterioration in water quality and morphological diversity and the associated suspended solids release. Appropriately sizes culverts should allow debris and sediment material to pass through the culvert unhindered. The proposed crossings design should also ensure that there is minimal disruption to the existing flow regime of the affected watercourse (Appendix A24.1: Surface Water Hydrology) and should be designed to pass the 0.5% AEP (1:200 years) return period flow.

5.4.28 Depressed invert box culvert design will be used for the majority of the watercourses that would be crossed by the proposed scheme and culverted. The culverts will be design following the Scottish Executive guidance on culverts and migratory fish (SEERAD 2000). These culverts are proposed at most crossing points except for very small land drains with little or no geomorphological or ecological interest (Appendix A24.3: Fluvial Geomorphology and Chapter 25: Ecology and Nature Conservation).

5.4.29 Depressed invert culverts will be used to provide limited in-stream morphological diversity (Appendix A24.3: Fluvial Geomorphology). The culvert base will be set at below streambed level to allow natural substrate to be used within the culvert. Substrate in the culvert will be new material of a similar size to that of the original channel which will be specified to ensure that the sediment does not wash out at times of high flow or silt up in times of low flow.

5.4.30 All culverts have been designed to allow flows through during a 0.5% AEP (1:200) year flood and ensure that gradients do not differ markedly from existing conditions to avoid excessive siltation or erosion. In addition most culverts have mammal ledges installed to allow mammal passage through the culverts during most typical flow conditions (see Appendix A25.5: Otter).

Watercourse Realignments

5.4.31 Realignments are only used where necessary to reduce crossing (culvert) lengths and associated potential long term adverse water quality impact (see Appendix A24.3: Fluvial Geomorphology and Appendix A25.9: Freshwater Ecology). Any realignments are designed to cause minimal disturbance to flow patterns and adverse changes 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. Geomorphological features present in the original watercourse are to be recreated and features such as pool and riffle sequences introduced where possible. New material will be used in the new channel. Appendix A24.3 (Fluvial Geomorphology) discusses any detailed mitigation required for proposed realignments.

<u>Sedimentation/Erosion Monitoring of Realigned and Culverted Watercourses</u>

5.4.32 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 monitoring approach will be agreed with SEPA prior to commencement of the construction works.

5.5 Construction Mitigation

5.5.1 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).

5.5.2 Treatment ponds included as part of scheme design (Figures 24.5a-h) will be constructed early during the construction period to allow settlement and treatment of any pollutants contained in the run-off and control the rate of flow before water is discharged into the receiving watercourses.

5.5.3 The Employer’s Requirements will 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.

<u>Adherence to Best Practice near Watercourses</u>

5.5.4 The mitigation measures to reduce potential impacts during construction are summarised in Table 5-2.

Table 5-2 – Mitigation Measures to Reduce Impacts during Construction Activities

Source of Impact	Mitigation
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.
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.
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. More information can be found in Appendix A24.3: Fluvial Geomorphology.
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.
Contaminated Land and Sediment	The ground investigation, which will be carried out, will identify areas of contamination and similar methods to those outlined to reduce suspended solids entering watercourses will be used to ensure disturbed sediment does not enter the watercourses. More information can be found in Appendix A24.3: Fluvial Geomorphology.

5.5.5 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
- 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 run-off; and
- PPG21 Pollution Incident Response Planning.

Pre-earthworks

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

Diversion of watercourses during construction of culverts

5.5.7 Watercourses to be culverted will be diverted to a temporary channel during culvert construction. This will result in lessening of the potential risk of concrete and chemical spillage, sedimentation and erosion. 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 (see Appendix A24.3: Fluvial Geomorphology for further mitigation measures).

Timing of Works

5.5.8 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 (from Oct-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.

5.6 Mitigation Recommendations

Table 5-3 – Potential Impacts to Water Quality to Receiving Watercourses and Proposed Mitigations

Watercourse	Potential Impact	Specification	Mitigation Measurers
Loirston Burn / Loch	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	2 No. culvert: 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) – 48m length; Loirston Burn 3 (A90, ch790) – 44m 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 including of 858m length: Loirston Burn 1 – length 152 (maintained); Loirston Burn 2 – length 105 (maintained); Loirston Burn 3 – length 392 (original length 387m); 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. Further assessment and design is ongoing with the aim of introducing geomorphological features such as pool and riffle sequences to enhance the watercourse. Detailed assessment must be completed by a geomorphologist (see Appendix A24.3: Fluvial Geomorphology).
	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 – Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation;

Watercourse	Potential Impact	Specification	Mitigation Measurers
			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. Preliminary investigation for contaminants needed.
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 – paragraph 5.4.6.and** Table 5-2. 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	One Detention Basin, three Treatment Ponds and one Swale
	Crossing	n/a	n/a
	Realignment	n/a	n/a
	Construction	One proposed outfall	**Adherence to best practice. Generic mitigation measures apply –**

Watercourse	Potential Impact	Specification	Mitigation Measurers
			Table 5-2. Cut-off ditches; sediment fencing around earthworks perimeter.
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 171m (maintained)	Regular maintenance and clearance of debris. Further assessment and design is ongoing.
	Construction	Increased risk of pollution from concreting and fuel and oil spills. Fine sediment release from earthworks. Possible drain crossings and diversions.	**Adherence to best practice. Generic mitigation measures apply –** Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation; Cut-off ditches and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new similarly sized material to cover the bottom of the culvert.
Bishopton 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.

Watercourse	Potential Impact	Specification	Mitigation Measurers
	Realignment	Realignment associated with culvert construction – length 95m (maintained)	Regular maintenance and clearance of debris. Further assessment and design is ongoing.
	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 –** Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation; Cut-off ditches and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new similarly sized material to cover the bottom of the culvert.
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 137m (maintained)	Regular maintenance and clearance of debris. Further assessment and design is ongoing.
	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 –**

Watercourse	Potential Impact	Specification	Mitigation Measurers
			Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation; Cut-off ditches and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new similarly sized material to cover the bottom of the culvert.
Whitestone Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culvert: ch200990 – length 55m;	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 178m (maintained)	Regular maintenance and clearance of debris. Further assessment and design is ongoing.
	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	**Adherence to best practice. Generic mitigation measures apply –** Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments;

Watercourse	Potential Impact	Specification	Mitigation Measurers
			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.
Burnhead Burn	Road Drainage	One Proposed outfall draining total of 8.95ha	Detention Basin, three Treatment Ponds
	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	Major realignment– realigned length 177m (length 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. Further assessment and design is ongoing (see Appendix A24.3: Fluvial Geomorphology).
	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 –** Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation; Cut-off ditches and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new similarly sized material to cover the bottom of the culvert.
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

Watercourse	**Potential Impact**	**Specification**	**Mitigation Measurers**
			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 –** Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Cut-off ditches; sediment fencing; sediment trap (settling lagoons). See also Specific Mitigation section below.
Kingcausie Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culvert: ch101470 – 36m 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 proposed – length 107m (original length 135m)	Regular maintenance and clearance of debris. Further assessment and design is ongoing.
	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 –**

Watercourse	Potential Impact	Specification	Mitigation Measurers
			Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation; Cut-off ditches and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new similarly sized material to cover the bottom of the culvert.
River Dee	Road Drainage	One Proposed outfall. Total of 10.7ha	One Detention Basin and two Treatment Ponds
	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 sediment release during earthworks.	**Adherence to best practice. Generic mitigation measures apply –** Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Cut-off ditches; sediment fencing; sediment trap (settling lagoons). See also Specific Mitigation section below.

Watercourse	Potential Impact	Specification	Mitigation Measurers
Milltimber Burn	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culvert: ch102670 –60m length;	n/a
	Realignment	Realignment associated with culvert construction – 67m length.	Regular maintenance and clearance of debris. Further assessment and design is ongoing.
	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 –** Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation; Cut-off ditches and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new similarly sized material to cover the bottom of the culvert.
Culter House 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 – paragraph 5.4.6.and**

Watercourse	Potential Impact	Specification	Mitigation Measurers
			Table 5-2. 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 – paragraph 5.4.6.and** Table 5-2. 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 – paragraph 5.4.6.and**

Watercourse	Potential Impact	Specification	Mitigation Measurers
			Table 5-2. Cut-off ditches; sediment fencing; sediment trap (settling lagoons); when diverting watercourse into drainage ditches.
Gairn Burn	Road Drainage	One Proposed outfall. Total of 4.75 ha.	Detention Basin and four Treatment Ponds.
	Crossing	1 No. culverts ch150 (side road) – 12m 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 – 156m (original length 176m)	Regular maintenance and clearance of debris. Further assessment and design is ongoing.
	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 –** Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation; Cut-off ditches and sediment fencing; sediment trap (settling lagoons) to

Watercourse	Potential Impact	Specification	Mitigation Measurers
			reduce sediment release. Use of new similarly sized material to cover the bottom of the culvert.
Moss of Auchlea Drainage System	Road Drainage	No road drainage discharge to burn	n/a
	Crossing	1 No. culverts ch107440 – 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	One Realignment proposed associated with culvert construction – length 84m (original length 93m)	Regular maintenance and clearance of debris. Further assessment and design is ongoing.
	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 –** Table 5-2. Batching and mixing off site, using quick setting cement mixes; bunded areas with impervious walls. Diversion or pumping away during construction of culvert/realignments; Geotextile lining at the temporary realignment to reduce erosion and sedimentation; Cut-off ditches and sediment fencing; sediment trap (settling lagoons) to reduce sediment release. Use of new similarly sized material to cover the bottom of the culvert.
Westholme Burn	Road Drainage	One Proposed outfall. Total of 8.25 ha.	Detention Basin, three Treatment Ponds 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. Possible slight impact from land contamination and sediments.	**Adherence to best practice. Generic mitigation measures apply – paragraph 5.4.6.and**

Watercourse	Potential Impact	Specification	Mitigation Measurers
			Table 5-2. Cut-off ditches; sediment fencing around earthworks perimeter.

Specific Mitigation

5.6.1 Mitigation specified above will be applied to all watercourses considered in this impact assessment. In addition to these measures there are specific measures that will be applied to burns and rivers of high value and these are outlined below.

River Dee and Blaikiewell Burn

5.6.2 River Dee and Blakiewell Burn will be bridged due to their high sensitivity. The following special mitigation measures are proposed to provide better sediment management, less erosion and reduce the adverse impact on the morphological diversity of the watercourse:

- only one mainline approach road (North or South) should be constructed at any one time to minimise the risk of sediment release and oil and chemical spillage;
- sediment fencing should be applied to reduce the sediment release. This should be installed around the circumference of the working area;
- temporary treatment ponds should be constructed to reduce the run-off pollution from the approach road construction;
- adherence to the relevant PPG's and liaison with SEPA ;
- ecological clerk of works should be present on site during construction, to ensure the implementation of appropriate environmental safeguards;
- concrete mixing and batching outside the floodplain to minimise potential risk of accidental spillage;
- use of plastic sleeve and double falsework/shuttering when working over the watercourse to ensure minimal concrete spillage;
- enclosed spraying when waterproofing preventing from chemicals entering the watercourse;
- works with a high potential of sediment realease 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).

5.6.3 Further ecological assessment will be carried out to determine any additional specific mitigation required for these watercourses.

6 Residual Impacts

6.1.1 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. This mitigation will be included, where feasible, through the scheme to conform to SEPA requirements (also refer to Chapter 25: Ecology and Nature Conservation, Chapter 23: Geology, Contaminated Land and Groundwater and Appendix A24.3: Fluvial Geomorphology).

6.2 Operation Residual Impacts

Routine Run-off

6.2.1 Following treatment and settlement, it is considered that the residual impact of insoluble pollutants entering Westholme Burn would be of low magnitude for copper and zinc, resulting in Negligible significances. Residual impacts on 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 watercourses might be impacted through diffuse means, however these impacts are considered to be of Negligible to Slight/Negligible significance. Details of the calculations are given in Annex 28.

Table 6-1 – 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	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Negligible
Jameston Ditch	High	Copper	10	5	100*	5	0	Negligible	Slight/ Negligible
		Zinc	75	38	508*	26	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
Whitestone Burn	Low	Diffuse	n/a	n/a	n/a	n/a	n/a	Negligible	Negligible
Burnhead Burn	High	Copper	10	5	35*	6	17	Negligible	Slight/ Negligible
		Zinc	75	38	163*	37	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

6.2.2 Additionally, with the inclusion of scour protection at outfalls, the impact of erosion on watercourse banks is considered to be Negligible.

6.2.3 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

6.2.4 The residual risk of accidental spillage with mitigation measures in place is summarised in Table 6-2 below (please refer to Annex 27 for details of the calculations).

Table 6-2 – 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?	Impact Magnitude	Significance
Jameston Ditch	High	1:100	1:451	1:85903	Yes	Negligible	Slight/Negligible
Burnhead Burn	High	1:100	1:62	1:4137	Yes	Negligible	Slight/Negligible
River Dee	High	1:100	1:62	1:1443	Yes	Negligible	Slight/Negligible
Gairn Burn	Medium	1:100	1:174	1: 4051	Yes	Negligible	Negligible
Westholme Burn	Low	1:100	1:46	1:1069	Yes	Negligible	Negligible

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

6.2.6 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.

6.3 Construction Residual Impacts

6.3.1 The residual impact assessment shows that construction impacts are estimated to be of Slight/Negligible significance on the high sensitivity watercourses (Jameston Ditch, Burn of Ardoe, Bishopton Ditch, Heathfield Burn, Burnhead Burn, Blaikiewell Burns, Kingcausie Burn, River Dee and Moss of Auchlea Drainage System). All remaining watercourses including those taken into pre-earthworks would be impacted upon by construction activities with Negligible significance – with the exception of Loirston Burn, where impacts are considered to be of Slight significance (Table 6-3).

6.4 Summary

6.4.1 The residual impacts to receiving watercourses for the Southern Leg section of the proposed AWPR are summarised in the table below.

Table 6-3 – Residual Impact Assessment of key watercourses potentially affected by the proposed scheme (residual impact of pollutant release included in overall assessment)

Watercourse	Sensitivity	Potential Impact Description	Impact Significance	Residual Impact Description	Residual Impact Significance
Loirston Burn / Loch	Medium	Construction: Major 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 pollutants release and short-medium term increased turbidity in the water column. Medium dilution capacity of the watercourse.	Moderate/ Substantial	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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Negligible	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
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.	Moderate	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	n/a	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.	Slight/ Negligible	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 Description	Impact Significance	Residual Impact Description	Residual Impact Significance
		General Operation: A major shift from baseline conditions due to discharge of road run-off. Fundamental change of water quality and ecology. Routine Run-off: High impact from routine run-off due to increase of copper and zinc concentrations > 100% over baseline situation. Accidental Spillage: Low impact from accidental spillage as spillage risk would be 451, 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.	Substantial	Operation: Road run-off will be treated through SUDS to ensure compliance with EQS and that the pollution risk from accidental spillage is within acceptable limits. Despite the mitigations taken the impact on Hare Moss is not known. Routine Run-off: Negligible impact from routine run-off - no increase over baseline for copper and zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 85903, 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 pollutants 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.	Substantial	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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Slight/ Negligible	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 pollutants release and short-medium term increased turbidity in the water column. Q_{mean} for Bishopton Ditch is $0.002m^3/s$, which indicates a low dilution capacity.	Substantial	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 Description	Impact Significance	Residual Impact Description	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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Slight/ Negligible	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 pollutants 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	Substantial	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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Slight/ Negligible	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
Whitestone Burn	Low	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 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.	Moderate	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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Negligible	Operation: No outfall planned therefore Negligible impact due to diffuse pollution. Change to discharge regime will be minimised through careful design of realignment and culverts. Culverts will be designed to carry a 0.5% AEP (1:200 year flow). Length of culvert likely to impact upon water quality due to lack of light.	Negligible

Watercourse	Sensitivity	Potential Impact Description	Impact Significance	Residual Impact Description	Residual Impact Significance
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 pollutants release and short-medium term increased turbidity in the water column. Medium dilution capacity of the watercourse (Qmean=0.054m^3/s).	Substantial	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 run-off. Fundamental change of water quality and ecology. Routine Run-off: High impact from routine run-off due to an increase of > 100% over baseline for copper and zinc resulting in failure of EQS for both pollutants. Accidental Spillage: High impact from accidental spillage as spillage risk would be 62, which is below the probability threshold of 1 in 100 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.	Substantial	Operation: Road run-off will be treated through SUDS to ensure compliance with EQS and that the pollution risk from accidental spillage is within acceptable limits. Routine Run-off: Negligible impact from routine run-off – 17% increase over baseline for copper and no increase for zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 4137, 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
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 pollutants release and short term increased turbidity in the water column. Medium dilution capacity of the watercourse.	Moderate/ Substantial	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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Slight/ Negligible	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

Watercourse	Sensitivity	Potential Impact Description	Impact Significance	Residual Impact Description	Residual Impact Significance
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 pollutants 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.	Moderate/ Substantial	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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Slight/ Negligible	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	Substantial	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	Slight/ Negligible
		General Operation: A minor shift from baseline conditions due to discharge of road run-off. Temporary adverse impact on water quality and ecology. Routine Run-off: Negligible impact from routine run-off 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 62, 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.	Substantial	Operation: Road run-off will be treated through SUDS to ensure compliance with EQS and that the pollution risk from accidental spillage is within acceptable limits. Routine Run-off: Negligible impact from routine run-off - no increase over baseline for copper and zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 1443 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 pollutants release and short-medium term increased turbidity in the water column. Q_{mean} for Miltimber Burn is 0.008m^3/s, which indicates a low dilution capacity.	Moderate	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice. Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible

Watercourse	Sensitivity	Potential Impact Description	Impact Significance	Residual Impact Description	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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Negligible	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.	Moderate	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	n/a	Taken into pre-earthworks	n/a
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.	Moderate	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	n/a	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.	Moderate	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.	n/a	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 pollutants release and short-medium term increased turbidity in the water column. Medium dilution capacity of the watercourse (Qmean=0.011m^3/s).	Moderate	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice. Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible

Watercourse	Sensitivity	Potential Impact Description	Impact Significance	Residual Impact Description	Residual Impact Significance
		General Operation: A major shift from baseline conditions due to discharge of road run-off. Fundamental change of water quality and ecology. Routine Run-off: High impact from routine run-off 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 is 174, which above 1:100 and below 1:200. 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.	Moderate/ Substantial	Operation: Road run-off will be treated through SUDS to ensure compliance with EQS and that the pollution risk from accidental spillage is within acceptable limits. Routine Run-off: Negligible impact from routine run-off – 9% increase over baseline for copper and no increase for zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 4051, 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
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 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.	Substantial	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 Run-off: no outfall planned. Accidental Spillage: no outfall planned. Suspended Solids: no outfall planned.	Slight/ Negligible	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.	Negligible	Construction: Risk of sediment release or pollutant spillage will be minimised through best practice. Ongoing monitoring during the construction phase will identify any impact upon the water column at an early stage. Negligible residual impact magnitude.	Negligible

Watercourse	Sensitivity	Potential Impact Description	Impact Significance	Residual Impact Description	Residual Impact Significance
		General Operation: A major shift from baseline conditions due to discharge of road run-off. Fundamental change of water quality and ecology. Routine Run-off: High impact from routine run-off due to increase of copper and zinc concentrations over 100% over baseline situation. Accidental Spillage: High impact from accidental spillage as spillage risk is 46, which is below the probability threshold of 1 in 100 years. Suspended solids: Q_{mean} for Westholme Burn is $0.007m^3/s$ which indicates a low dilution capacity.	Moderate	Operation: Road run-off will be treated through SUDS to ensure compliance with EQS and that the pollution risk from accidental spillage is within acceptable limits. Routine Run-off: Low impact from routine run-off – 35% increase over baseline for copper and no increase for zinc. Accidental Spillage: Negligible impact from accidental spillage as spillage risk is 1069, 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.
Bioassimilation	process of accumulation of a substance within a habitat.
Bioaccumulation	process whereby certain chemicals in the environment accumulate in animal tissues.
BOD	biological oxygen demand mg/l.
Boulder particle of diameter > 256 mm	"human head" size and above.
Buffer Strip	an area of land between the river channel and cultivated land that is uncultivated and often fenced off.
Channel Capacity	the volume of water that can be contained within a given section of river channel.
Catchment	the total area of land that drains into any given river.
Channel	the course of a river including the bed and banks.
Chronic pollution	the result of ongoing low levels of pollution which may result in the accumulation of pollutants over a longer period of time (months/years).
Clay	particle of diameter < 0.002mm.
Coarse sediment	sediment of grain diameter greater than 2 mm.
Cobble	particle of diameter 64mm to 256mm, approximately "fist" sized.
Continuity	relates to how continuous the flow or sediment transfer is within a particular watercourse. Culverts often break the continuity through promoting deposition.
Conveyance	how water is transported downstream (e.g. volume, speed).
Culvert	artificial structure, often concrete, for carrying water underground or under bridges.
Debris	coarse woody debris blocking the channel and causing water to pond back.
Discharge	the volume of water flow per unit time usually expressed in cubic metres per second ($m^3 s^{-1}$).
Desorption	process of reintroduction of heavy metals to the water column.

Embankment	artificial flood bank built for flood defence purposes, which can be flush with the channel or set back on the floodplain.
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 Run-off	the normal run-off from roads that may include the contaminants washed off the surface in a rainfall event and can result in either acute or chronic impacts.
Run-off	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.